



Labels on seafood products in different European countries and their compliance to EU legislation

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ABSTRACT

The increasing consumption of seafood products raises concerns over their sustainability and the conservation of marine resources. Seafood traceability, enabled by a regulated labelling system, is important to prevent over-exploitation of these resources. The regulations (EU) No.1169/2011 and (EU) No 1379/2013 are the European legislative tools that specify the mandatory information that must be present on seafood labels. The present study analysed the labels of seafood products sold in different European countries in order to verify the presence of mandatory information required by EU regulations currently in place. The results show that there is a difference in compliance among groups of products and among countries. The country with the lowest level of compliance was The United Kingdom (still part of EU when the study was carried out), with an overall compliance of 63.7%. The country with the highest level of compliance was Portugal (87.2%). Across all the countries analysed, supermarkets were more compliant than fishmonger's shops and Processed Prepacked products were more conformed best to the EU labelling legislation when compared to Unprocessed Non-Prepacked products. Differences among different areas of the same country were also observed. Fishing gear, scientific name, fishing/production method and date of freezing were the types of information most frequently missing on the labels examined. The results of this study pose the bases for further actions, that can be taken by relevant institutions, to improve compliance throughout the supply chain.

1. Introduction

The EU supply of domestic and imported seafood utilised for direct

human consumption reached 14.22 million tonnes in 2016 [1], resulting in a record-high per capita consumption of 24.3 kg [2], four kilograms higher than the world average consumption during the same year. Some

Abbreviations: UNP, Unprocessed non- prepacked products; UPP, Unprocessed prepacked products; PPP, Processed and prepacked products; CN, Commercial name; SN, Scientific name; PM, Production method; FG, Fishing gear; CP, Catch Production Area; A, Allergens; DF, Date of freezing; BB, Best before date; LI, List of ingredients; NW, Net weight; ON, Operator's name and address; ND, Nutrition Declaration; ID, identification Mark; CMO, Common organisation of the markets.

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EU member states, such as Portugal and Spain, had among the highest rates in the world [2]. However, the sustainability of seafood and aquaculture production is a major concern. One of the Sustainable Development Goals (SDGs) included in the 2030 Agenda for Sustainable Development [3], focuses specifically on the conservation and sustainable use of the ocean, sea and marine resources (SDG 14, Life Below Water).

Traceability and labelling of seafood are key elements to protect the interests and health of consumers and to ensure the sustainability of stock exploitation [4,5]. Moreover, it has been recently proposed that consumers may play an important role in the conservation of marine resources as they can be considered another relevant stakeholder in the governance of marine species sustainability through their choices and purchasing preferences [6]. Consumer's desire for sustainable seafood can play a major role in driving the change toward traceability and sustainability [7,8]. Traceability, supported by a proper labelling system, enables transparency and prevents illegal, unreported and unregulated fisheries [9]. On the other hand, the lack of regulation and controls can favour fraud with a series of negative consequences [10]. Several studies highlighted cases of threatened or endangered species used in fish products labelled as 'sustainable' [11–13]. The illegal overexploitation of these species is a major biodiversity and ecological concern. Seafood fraud has been identified as one of the major concerns related with seafood supply by the European Parliament [14] and INTERPOL/EUROPOL [15], who identified seafood among the highest risk categories for food fraud. In fact, the fisheries sector is well-recognised as one of the most vulnerable to fraudulent practices, fraud being consistently reported over the years by governments, Non-Governmental Organizations (NGOs), academics and media [16]. Levels of fraud have varied with species, countries, the geographical area where the seafood is marketed and whether or not a detailed

labelling legislation is in place [17,18]. Fish fraud can lead to the introduction of cheaper products in the market, with consequent unfair advantage for the producers [19]. Fish fraud and mislabelling can also produce mistrust and concerns among consumers [16] and can result in lost revenue for governments. Finally, the incorrect labelling of species can simulate that one species is abundant when it is not. In the same way, the apparent abundance of the resource can cause a decrease in its value [20].

A FAO review [16] suggests that setting mandatory labelling requirements can help to reduce fish fraud and also provide enough data to enable consumers to make informed choices about the products they buy. Therefore, food regulations must be reinforced and the compliance to the EU regulations on seafood labelling should be monitored.

Seafood labelling is regulated in the EU by two specific legislative tools: regulations (EU) No.1169/2011 [21] and (EU) No 1379/2013 [22] (Table 1). Some articles of the regulation No. 853/2004 [23] are also still in force. According to EU food labelling regulations for fish and fishery products, the label should not mislead consumers, especially regarding the features of the product. The information provided must be honest and accurate in terms of identity, properties, composition, quantity, durability, country of origin or place of provenance, and method of manufacture or production [16].

The Regulation (EU) 1169/2011 includes general rules about the information that has to be contained in labels of seafood products and also assesses that the mandatory information on food must be available and easily accessible (Art. 12). This mandatory varies according to the type of product.

The Regulation (EU) No. 1379/2013 entered into force the first of January 2014, except chapter IV (consumer information) that was obligatory from the 13th December 2014, and it specifies rules and classification for fishery and aquaculture products which are

Table 1
Summary of European regulations on seafood labelling.

Regulation	Issued by	Applies to	Description	Content
Regulation (EU) 1169/2011 (European Union, 2011)	European Parliament and of the Council	Common Legislation on food labelling for of European member states applicable to all foods	General principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Basis for consumers to make informed choices in relation to food they consume and to prevent any practices that may mislead the consumer. Relevant information for food labelling is provided in Chapter IV Mandatory food information Sect. 1 Art. 9 List of mandatory particulars and Art. 10 Additional mandatory particulars for specific types or categories of foods.	<ul style="list-style-type: none"> • Name of the food • List of ingredients • Name of any possible allergen • Quantity of certain ingredients or categories of ingredients • Net quantity of the food (Net weight) • Date of minimum durability or the 'use by' date • Any special storage conditions and / or conditions of use • Name or business name and address of the food business operator • Country of origin or place of provenance • Instructions for use if necessary • Nutrition declaration • Date of freezing (frozen unprocessed fishery products)
Regulation (EU) 1379/2013 (European Union, 2013)	European Parliament and of the Council	The common organisation of the markets in fishery and aquaculture products is part of the Common Fisheries Policy (CFP) and should contribute to achieving its objective	The regulation applies to all unprocessed and some processed fishery and aquaculture products (e.g. unpeeled, salted, or smoked products). These can be both prepacked or non-prepacked products. Chapter IV Consumer information Art. 35 describes mandatory particulars for fishery and aquaculture products, without prejudice to Regulation (EU) No. 1169/2011. Accordingly, fishery and aquaculture products which are marketed within the Union, irrespective of their origin and marketing method, may be offered for sale to the consumer if the labelling is appropriate.	<ul style="list-style-type: none"> • Commercial and scientific name • Production method • Catching area (wild, (FAO fishing area plus Subdivision [24]) / farmed (country of production) • Fishing gear • Whether product has been defrosted • Minimum date of durability

unprocessed or only slightly processed. According to Art. 35 of this regulation, the products included are live, fresh, chilled and frozen fish/ filets/fish muscle. These can be dried, salted, in brine or smoked. Other seafood products such as crustaceans or molluscs are also included in the regulation. This regulation specifies that the relevant information must be provided also for non-prepacked fishery and aquaculture products, using billboards or panels. The details of these two Regulations are summarised in table 1.

The aim of this study was to verify the compliance to the current EU legislation of labels on seafood products sold across markets of different European regions. Labels on seafood products were monitored in Portugal, Spain, France, Germany and Ireland. The United Kingdom was also included in this study as, at the time the study was designed and conducted (2019), they were still part of the EU and subjected to its legislation and were required to meet EU requirements for export. These countries are all located in the Atlantic area, with the only exception of Germany.

The study poses the bases for the identification of European areas more at risk of seafood fraud and it highlights the types of information more susceptible to be left out from labels of different seafood products.

2. Material and methods

2.1. Study area

The data were collected in 42 cities from 6 European countries: Portugal (PT), Spain (ES), France (FR), Germany (DE), United Kingdom (UK) and Ireland (IE) (Fig. 1). For each country, samples were collected in cities from 3 NUTS level 2 (Nomenclature for territorial units for statistics) shown in Table 2. From each city, samples were observed in 3 supermarkets and 3 fishmongers' shops. The label information regarding species obtained across the different European regions was recorded according to the approved official name of the fish product in each country (<https://ec.europa.eu/fisheries/cfp/market/consumer-inf>



Fig. 1. Study area. The geographical names of the sampling locations are indicated on the map.

Table 2
NUTS 2 (Nomenclature for territorial units for statistics) surveyed.

Country	NUTS2 code	NUTS2 name	City/town surveyed
Ireland	IE04	Northern and West	Oranmore Doughiska
	IE05	Southern	Galway Bantry Skibereen Union Hall Cork
France	IE06	Eastern and Midland	Dublin
	FR51	Pays de la Loire	Nantes Le mans La Roche/Yon
	FR52	Brittany	Rennes Fouesnant Quimper
Spain	FR61	Aquitane	Bordeaux Agen Mimizan Vigo
	ES11	Galicia	Ourense Coruña
United Kingdom	ES21	Basque Country	Erandio Baracaldo Bilbao
	ES61	Andalusia	Cadiz
	UKM6	Highlands and Islands	Inverness Orkney
Portugal	UKN0	Northern Ireland	Belfast
	UKD3	Greater Manchester	Manchester
Germany	PT17	Lisbon Metropolitan Area	Amadora Cascais Carcavelos Cais Do Sodré Setubal
	PT11	Norte	Vila Real Lamego
	PT15	Algarve	Porto Albufeira Olhão Faro
Germany	DE60	Hamburg	Hamburg
	DEF0	Schleswig-Holstein	Kiel
	DE71	Darmstadt	Frankfurt

ormation/names en). The species of seafood products included in this study were selected following a criteria of easily availability across the study area and market relevance.

The visit of the supermarkets and fishmongers' shops in the areas of study resulted in a total of 824 seafood samples surveyed between March and July 2019. The number of samples collected in each country, for each seafood species and for each category of product are shown in Table 3.

Three categories of fishery and aquaculture products were assessed in the study:

Table 3
Samples collected in this study.

Product	Unprocessed non- prepacked						Unprocessed prepacked						Processed prepacked					TOTAL	
	PT	ES	FR	DE	GB	IE	PT	ES	FR	DE	GB	IE	PT	ES	FR	DE	GB	IE	
Sole	15	13	18	12	16	12	2	1	9	1	8	–	–	–	–	–	–	–	107
Salmon	18	18	18	17	17	18	9	9	9	8	9	9	–	–	–	–	–	–	159
Hake	18	18	18	–	11	18	9	9	9	3	8	8	–	–	–	–	–	–	129
Shrimps/Prawns	16	18	18	15	12	16	9	9	9	8	8	4	9	9	9	9	9	9	196
Mussels	3	15	18	17	13	13	9	9	9	8	6	5	–	–	–	–	–	–	125
Tuna can	–	–	–	–	–	–	–	–	–	–	–	–	9	9	9	9	9	9	54
Fish fingers	–	–	–	–	–	–	–	–	–	–	–	–	9	9	9	9	9	9	54
TOTAL SAMPLES	70	82	90	61	69	77	38	37	45	28	39	26	27	27	27	27	27	27	824
TOTAL/CATEGORY	449						213						162						

- 1) Unprocessed Non-Prepacked (UNP), which includes products without any type of packaging or processing (those included in the CMO regulation, Annex I, letters a and c [22]);
- 2) Unprocessed Prepacked (UPP) which includes products that are on sale in a package but that did not undergo any process after being caught or harvested (those included in the CMO regulation, Annex I, letters a and c [22]);
- 3) Processed Prepacked (PPP), which includes products that have been processed with different methods before being sold (those included in the CMO regulation, Annex I, letters a,b, c and e [22]).

The information assessed on the label of the products are listed in Table 4. The table includes the mandatory labelling information examined in the study, divided by the above-mentioned categories.

For the UNP and UPP products, the targeted species were Atlantic salmon (*Salmo salar*), common sole (*Solea solea*), European hake (*Merluccius merluccius*), any prawn species of the suborder Dendrobranchiata found across the market, and mussels (*Mytilus* spp.). For the PPP group, the brands were chosen randomly and the targeted products were fish fingers, canned tuna (any species) and processed prawns (any species of the Dendrobranchiata suborder found across the markets).

2.2. Label analysis

The samples were assessed following a visual inspection of the labels. In the case of UNP, those displayed on counters, billboards and panels showing the product information were evaluated. The type of information present, absent or incomplete on the labels was recorded. An evaluation form (see Supplementary Material 1) was prepared to record the data from the labels and to determine whether the required information was accessible to consumers or not. Each one of those categories

Table 4
Categories assessed in the study for the three different groups of products, in light of Regulation (EU) 1169/2011 and Regulation (EU) 1379/2013.

Information assessed	Unprocessed non-prepacked	Unprocessed prepacked	Processed prepacked
Commercial name	X	X	X
Scientific name	X	X	
Production method	X	X	
Fishing gear	X	X	
Catch/production area	X	X	
Allergens		X	X
Date of freezing		X	
Best before date		X	
List of ingredients		X	X
Net weight		X	X
Operator's name / address		X	X
Nutrition declaration		X	X
ID mark		X	X

shown in Table 3 was assessed for presence/absence on the label. In the case that mandatory information was not complete, the categories were assessed as “incomplete” (I). For example, the labelling for wild fish caught in the Northeast Atlantic (FAO 27) and Mediterranean and Black Sea (FAO 37) must display the name of the sub-area or division. In these cases, if the sub-area was missing, it was registered as “I” (incomplete).

The products with at least one type of mandatory information missing or incomplete on the label were considered non-compliant. While the products with all the required information present on the label was considered compliant to the EU legislation. All the information on labels or billboards not available in English was translated into English.

2.3. Statistical analysis

The number of missing mandatory information on labels or billboards was compared among countries, categories of product and types of information. The differences were analysed using chi-squared tests of independence performed with R version 4.0.3. Chi-squared test was used to test the null hypothesis in all cases that the compliance level was independent of (or not associated to) the categorical variable of interest (e.g. country, labelling category).

In particular, the following comparisons were analysed:

- 1) Differences in compliance among countries (all data collected both in fishmonger's shops and supermarkets, for the three categories of products, were grouped together and sorted only by country of collection).
- 2) Differences in compliance among NUTS 2 for each single country (the same as above, but within countries).
- 3) Differences in compliance between fishmonger's shops and supermarkets (these analyses were run both for all the countries collectively and for single countries. The three categories of products were grouped together).
- 4) Differences in compliance among the three categories of products (these analyses were run both for all the countries collectively and for single countries. All data collected both in fishmonger's shops and supermarkets grouped together and sorted only by category).
- 5) Differences in compliance among type of mandatory information required (all data collected in all countries, both in fishmonger's shops and supermarkets, for the three categories of products were grouped together and sorted only by type of mandatory information).

3. Results

The labels on different types of seafood products (UNP, UPP and PPP) analysed in the present study highlighted important and significant differences in compliance to the legislation ($p < 0.01$), with UNP products having lower level of compliance (76%) than UPP and PPP (96% and 97% respectively) (Fig. 2). UNP products were less compliant than the other two categories also when the data was analysed only within supermarkets ($p < 0.01$).

Within UNPs, the labels of 89% of products observed in supermarkets across the study area were compliant with European legislation, while 11% had at least one type of information missing. For UNPs sampled in fishmongers' shops, the level of compliance was 64%. The difference between fishmongers' shops and supermarkets was highly significant ($p < 0.01$) (Fig. 2). The detailed results of the study are included in Supplementary Table 1.

3.1. Differences among countries

The data collected were analysed separately for the different countries and the results were compared. When the three groups of product were analysed together, Pearson's chi-squared test showed that there

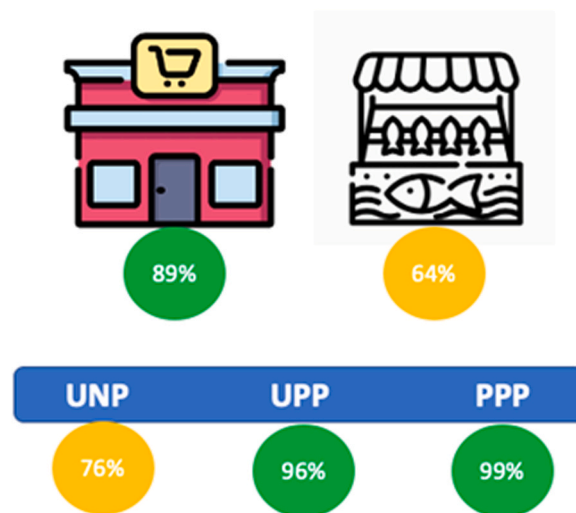


Fig. 2. Compliance with EU food labelling regulation in supermarkets and fishmonger's shops and in the three categories of product analysed: Unprocessed Non-Prepacked (UNP), Unprocessed Prepacked (UPP) and Processed Prepacked (PPP).

was a strong likelihood that there was an association between Country and compliance in across all countries ($p < 0.01$). Spain and the UK showed disproportionately low levels of compliance and Portugal disproportionately high but, there was not a significant association between France, Germany and Ireland and their level of compliance ($p = 0.08$).

When the data were analysed separately for the three groups of product (Fig. 3), the level of compliance for UNP varied between 87.2% (Portugal) and 63.6% (UK). For UPP, the compliance varied between 97.9% (Portugal) and 93.5% (Ireland), while for PPP the highest level of compliance was observed in the UK and Ireland (98.6% and 99.1% respectively) and the lowest was observed in Portugal (94.2%). The compliance in UNPs and PPPs among different countries was significantly different ($p < 0.001$ and $p < 0.05$ respectively).

3.2. Differences among NUTS (nomenclature for territorial units for statistics)

Internal differences within countries surveyed were also analysed and compliance to the EU labelling legislation varied between different geographical areas within national borders. Three NUTS were surveyed in each country and a significant difference between NUTS was found in all the countries surveyed, the only exception being the United Kingdom. In Portugal, the south of the country was significantly more compliant than the other two NUTS surveyed ($p < 0.01$). In Spain the Basque Country were significantly more compliant than Galicia and Andalusia ($p < 0.01$). In France, Brittany and Aquitaine were significantly more compliant than Pays de la Loire ($p < 0.01$). A significant difference in compliance between NUTS was also found in Ireland ($p < 0.01$), where the south of the country was more compliant than the north and Dublin region, and in Germany, where samples collected in Kiel were more compliant to EU labelling legislation ($p = 0.01$). The percentages of compliance and non-compliance for each NUTS are shown in Fig. 4. The Northern Ireland NUTS was compared both with the UK NUTS and with the Irish NUTS. As anticipated, this NUTS was not different from the rest of the UK NUTS. However, it was different from the NUTS in the south of Ireland.

3.3. Differences among the types of information assessed

The levels of compliance were not the same for all the types of mandatory information assessed on the labels. The statistical analysis

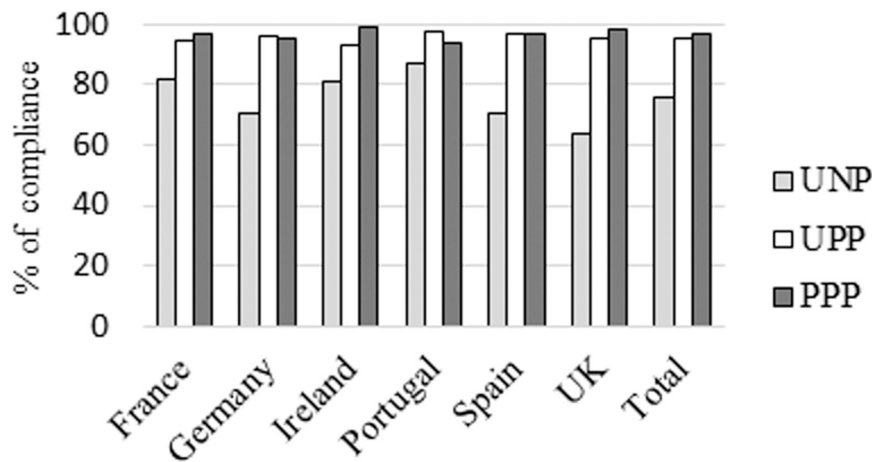


Fig. 3. Compliances to labelling legislation for each country and for the three different groups of product assessed. UNP means Unprocessed non-prepacked products, UPP means Unprocessed prepacked products, and PPP means Processed and prepacked products. The residuals calculated for each group of product and for each country are shown in [Supplementary Material 2](#).

highlighted that the level of compliance to European legislation varied significantly ($p < 0.01$) among the types of information assessed and within each type of product ($p < 0.01$). Overall, Fishing Gear (FG), Scientific name (SN), Production method (PM) and the Date of Freezing (DF) were the types of information most frequently missing on the labels examined (Fig. 5). In particular, in UNP products the lowest compliance to legislation was in FG, SN and CP (59%, 66%, and 73%, respectively). In UPP products the DF was the type of information frequently missing (78% of compliance). The labels on PPP products had the highest levels of compliance for all the types of mandatory information, among the three groups of product, the Identification Mark (ID) had the lowest percentage of compliance (86%).

4. Discussion

The European legislation on labelling of seafood products aims to provide consumers with the necessary indications to make an informed choice at the moment of purchase. The labels are an important tool to select products that are healthier and more environmentally sustainable [4,5,25], at least for consumers interested in these aspects. The present study analysed labels on seafood present in supermarkets and fishmongers' shops in different European countries highlighting issues of compliance with UNP, particularly in the fishmonger sector. It is important to highlight that this study investigated the presence/absence of information on the labels, but it did not verify its reliability. As an example, the problem of species substitution was not studied since it was not the objective of this work.

It is also necessary to note that some relevant mandatory categories (Table 1) were excluded from the analyses for different reasons: the information that could not be visually verified (e.g. if the product has been defrosted) and the categories that only apply to particular type of products (e.g. date of packaging is only mandatory in packaged live bivalves) were not taken into account in the statistical analysis, but the information gathered was recorded and can be accessed in the [Supplementary Information](#). The Portuguese Institute for Sea and Atmosphere reported that several cases of fish fraud were detected in Portugal [26]. The study reports that at least ten fish species were regularly replaced by less expensive ones in Portugal.

The high compliance of Portugal to EU seafood labelling legislation could be linked to the high fish consumption in the country. Portugal ranks first in Europe and third in the world for seafood consumption [27]. Portuguese consumers eat on average 59 kg of fish per year, while the per capita fish consumption in the UK is 25 kg per year [27]. The rationale behind the link between high compliance to labelling

legislation and high seafood consumption is that a familiarity with the products consumed leads to a higher attention level for the information contained on the label [28]. Thus, the consumers' tendency to read labels could drive compliance to the legislation. On the other hand, the familiarity with the product, especially when it is fresh, may lead an expert buyer to overlook the label and focus more on the appearance of the product to judge its quality. The tendency to read labels could be also linked to environmental concerns [29]. The level of compliance is likely to be associated with a number of other factors, including the level of law enforcement and sociological, as well as cultural factors. Portugal has historically a high level of legislative protection of consumers, with strong enforcement of this legislation [30]. The authorities inspect the markets where most of the UNP is sold, particularly outside of Lisbon, which could explain the higher level of compliance in the Algarve. The fear of losing money in fines might be an important incentive for fishmongers to comply with the legislation. Accessibility to the information also plays a role. When a UNP fish enters the commercial circuit through the official auctions of DOCAPESEA (Portuguese State company supervised by the Ministry of Finance and the Ministry of the Sea), the first buyers have access to all the information referred to in the regulation and they hand it to the fishmongers. Furthermore, Portuguese people have a general good knowledge of fish species and they also do not have traditionally a big resistance to regulations.

A low attention to traceability and correct labelling was observed in the UK. The data could reflect a general political aversion to EU regulation and the Common Fisheries Policy [31]. Food fraud and quality issues have been of serious concern to consumers in the UK. Vandamme et al. [32], who performed DNA barcoding of sushi sampled in restaurants across the UK, reported that critically endangered species of tuna and eel were sold without adequate information to consumers in restaurants in the UK. Helyar et al. [9] used DNA barcoding techniques to examine fish products from major supermarket chains in the UK and found that, in a significant proportion of the samples, the species reported on the labels had been replaced with cheaper alternatives. The UK is also well known for mislabelling other categories of food. The most famous cases were the horsemeat discovered in products labelled as beef [33] and the Halal meat, destined for Muslim consumers, containing pork meat [34]. Moreover, Cusa et al. [35] showed that UK citizens are unfamiliar with the appearance of commercial fish species which could be reflected in a low interest in reading the labels on seafood. In the UK, there is evidence of a decline in fishmongers and fish counters in supermarkets [36] and a change in the (sea)food system to more processed products and replacement of counters with ready to go products (UPP, PPP) via supermarket shelves. In 2019–20 the main supermarkets in the

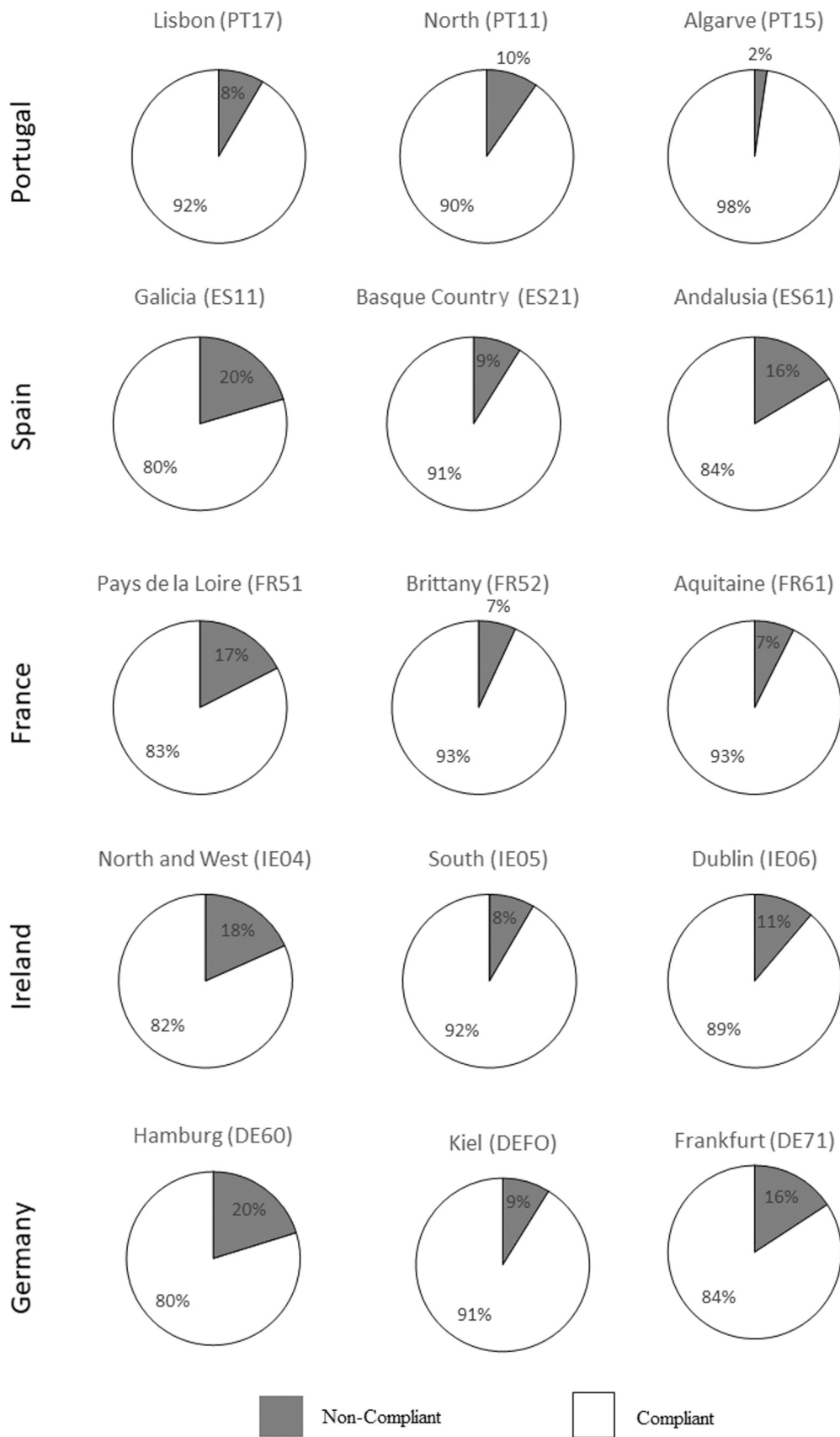


Fig. 4. Percentages of compliance (white area) and non-compliance (grey area) to EU labelling legislation in the NUTS surveyed in each country, the NUTS significantly more compliant are highlighted with a bold font. There were no significant differences among the NUTS surveyed in the United Kingdom.

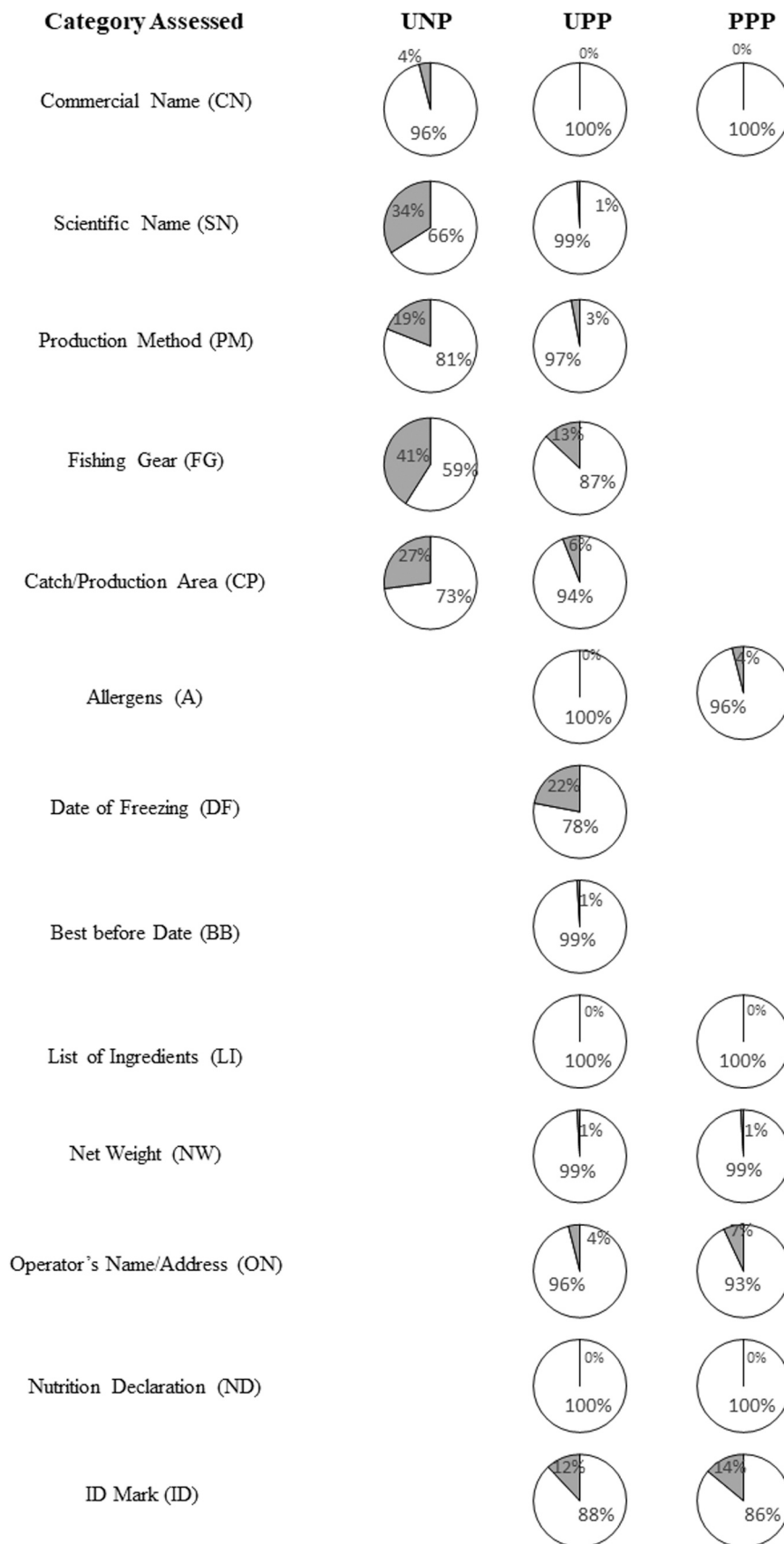


Fig. 5. Percentage of compliance to European legislation of the different types of information assessed in the study, for the three groups of products assessed (Unprocessed non- prepacked products, Unprocessed Prepacked products and Processed and prepacked products. CN: Commercial name, SN: Scientific name, PM: Production method, FG: Fishing gear, CP: Catch Production Area, A: Allergens, DF: Date of freezing, BB: Best before date, LI: List of ingredients, NW: Net weight, ON: Operator's name and address, ND: Nutrition Declaration, ID: identification Mark.

UK began the closure of fish counters [37] in response to changing consumer habits and preferences for packaged products reflecting the change in the UK shopping habits and further exacerbated by the Covid-19 lockdown. There may be several cultural, economic, and regulatory reasons to explain this lack of compliance which are beyond the scope of this paper, combined with a lack of strict enforcement by seafood authorities. The evidence suggests that this is a changing culture of seafood consumption in the UK combined with structural shifts in the seafood sector from Brexit and pessimism over EU regulation and the Common Fisheries Policy [31].

Regarding the differences among different NUTS2, in some countries such as Portugal and Spain, there are different regional authorities with varying competences in seafood control. This could be a factor for the differences in compliance. As it was discussed for Portugal, the reasons for the internal differences are difficult to explain without using speculative hypothesis. Many factors, most of which not easily quantifiable, probably concur to the different compliance levels observed among NUTS within the same country. Specific studies should be designed and carried out in each country in order to understand the reasons behind these local differences.

This study also highlighted that supermarkets are generally more compliant to labelling legislation than fishmongers. Most of the studies comparing seafood in supermarkets and fishmongers' shops present in the literature, focus on mislabelling and not on presence/absence of mandatory information. A study was conducted in 2015 with the aim to detect fish mislabelling in France [38]. The authors analysed more than 300 fish samples collected in supermarkets, fishmongers' shops, and restaurants. The authors did not detect any case of species mislabelling among the frozen fillets or in industrially prepared meals. All the cases of mislabelling were observed in products sold in fishmongers' shops or restaurants. On the other hand, Acutis et al. [39] observed the highest rate of species substitution occurred in seafood sold in supermarkets in Italy. This suggests that, however more compliant to the EU labelling legislation, seafood bought in supermarkets is not less likely to be mislabelled. Similar results were observed by Pardo et al. [18] who tested fish mislabelling in 180 mass caterer outlets in 23 European countries and found that 31% of the outlets sold mislabelled seafood.

Another aspect that could play a role in determining the lower compliance to EU legislation observed in fishmongers' shops is the tendency of consumers to trust fishmongers and to take into account fishmongers' advice for their buying decisions [40]. In a study published in 2007, Pieniak et al. [41] highlighted that seafood consumers mostly select the seafood products they buy based on information gathered from personal sources such as fishmongers, family and friends. This suggested that a trusting relationship exists between consumer and fishmonger that might lead the consumers to pay less attention to the exposed information when buying from fishmongers. The results of the present study do not show that fishmongers cannot be trusted, but only that they have a higher tendency to not provide the information required on labels and/or billboards, probably because they provide the information requested by the consumers verbally. When fishmongers were questioned about the lack of mandatory information exposed, they gave two main reasons. The first reason is the lack of resources for making labels (e.g., printers); the second reason is the illegibility of the despatch notes they receive with the products they sell.

The types of mandatory information more often left out of the labels of UNP products were Scientific Name, Fishing Gear and Catching/Production area. All information strongly linked to the sustainability of the fishery. Robust traceability mechanisms are important to identify environmentally-responsible seafood [4] and the correct identification of seafood is important in preventing commercial fraud [42,43]. The absence of the Scientific Name on the label/panel is a warning signal for species substitution [44] and the substitute species are often endangered species caught out of Europe that struggle to restore because of intensive fishing [13,45].

Failing to specify the FG on the labels prevents consumers from

making informed choices in terms of sustainability when buying seafood. For example, bottom towed gear often consists of a net dragged on the ocean floor with a negative impact on all the benthonic communities. On the contrary, passive gear (e.g. gill nets, trammel nets, traps, longlines) has a lower impact on the seabed habitat [46].

Another type of information with low levels of compliance across the three groups analysed was the Production Method. For farmed fish, different Production Methods can have a diversified impact on the environment, especially on natural waters. Aquaculture sustainability depends on the type of fish feed used, the density of the fish farmed, and the management of the wastewater generated [47].

The three categories assessed most directly relate to health (list of ingredients, nutritional information and presence of allergens) reached 100% compliance in almost all pre-packaged food categories (UPP and PPP) (allergens was 96% in PPP). This type of information is demanded by those consumers who are interested in the relationship between food and health, so operators may try to achieve a higher degree of compliance in these categories to satisfy them. On the contrary, in the case of fresh fish sold in fishmongers (UNP), in which its beneficial effect on health per se is presumed, consumers could value its quality (freshness) more than other information that can be shown on the label. Regulation 1169/2011, on the provision of food information to consumers, highlights the importance of education and information campaigns for consumers to improve their understanding of food information. Better understanding of the information contained in the labels and its importance could increase consumer concern for good and comprehensive labelling.

Overall, the present study, performed in six European countries, found a generally good compliance to EU labelling legislations for seafood products, but it also highlighted some weak points that need to be reinforced. The UNPs products showed the lowest compliance, with reduced compliance in fishmonger's shops, where increased monitoring is required. A step that has already proven to be effective in other EU Countries such as Portugal. On the other hand, our results have shown the need for improving the presence on the labels, of information more linked to the sustainability of the product offered since it is more frequently missing. This prevents consumers from making a product selection based on their environmental concerns and the government to control illegal activities related to fishing. The information gathered here provides an updated vision of current compliance with EU labelling seafood legislations, as well as valuable guidelines to the relevant institutions regarding where they should pay more attention to improve compliance, to safeguard the rights of consumers and to improve the protection of natural resources.

CRediT authorship Contribution Statement

Simona Paolacci: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Rogério Mendes:** Conceptualization, Funding acquisition, Supervision, Validation. **Regina Klapper:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Amaya Velasco:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Graciela Ramilo-Fernandez:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Marta Muñoz-Colmenero:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Tavis Potts:** Conceptualization, Funding acquisition, Supervision, Validation. **Sandra Martins:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Solene Avignon:** Conceptualization, Data curation, Methodology, Writing – review & editing, Investigation. **Julie Maguire:** Conceptualization, Funding acquisition, Supervision, Validation, editing. **Enrique De Paz:** Conceptualization, Data curation, Investigation, Methodology. **Martin Johnson:** Formal analysis, review. **Francoise Denis:** Conceptualization, Funding acquisition, Supervision, Validation. **Miguel A. Pardo:** Conceptualization, Supervision,

Validation. **Dee McElligott**: Conceptualization, Investigation, Methodology. **Carmen Gonzalez Sotelo**: Conceptualization, Funding acquisition, Project administration, Supervision, Validation, review.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2021.104810.

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