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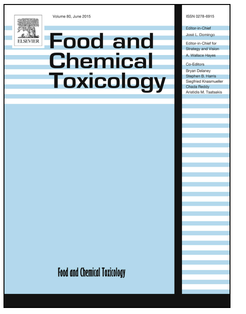

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Risk assessment of methylmercury in five European countries considering the national seafood consumption patterns

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Abstract

Although seafood is a nutritious protein source, due to marine environmental pollution, seafood may also be a source of contaminants. The results obtained within the FP7-ECsafeSEAFOOD-project show that among the range of studied environmental contaminants certainly methylmercury (MeHg) requires deeper investigation. This paper presents the results of a probabilistic risk assessment for MeHg based on: (1) primary concentration data, as well as secondary data from published papers, and (2) primary species-specific consumption data collected in five European countries (Belgium, Ireland, Italy, Portugal and Spain). The results indicated that in the southern European countries, larger subgroups of the population (up to 11% in Portugal) are potentially at risk for a MeHg exposure above the Tolerable Weekly Intake (TWI) value, while this risk is much lower in Ireland and Belgium. This research confirms the substantial contribution of tuna to MeHg exposure in each of the countries. Also hake, cod, sea bream, sea bass and octopus are identified as important contributors. From this study, it is concluded that a country-specific seafood consumption frequency advice is needed. Policy makers may adopt the results of this study in order to develop consumer advices that optimise health benefits versus potential health risks by providing species-specific information.

Keywords: European consumers, exposure, methylmercury, risk assessment, seafood species

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Highlights:

- Highest exposure to methylmercury (MeHg) is assessed in Portugal, followed by Spain, Italy, Ireland and Belgium
- 11% of the Portuguese population is potentially at risk for a MeHg exposure above the Tolerable Weekly Intake (TWI) value
- Species contributing most to MeHg exposure are tuna, hake, cod, sea bream, sea bass and octopus

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1. Introduction

In recent years, a number of studies have focused on the nutritional-toxicological conflict of frequent seafood consumption. While the health benefits of consuming seafood are well established, attention has also been paid to environmental contamination of seafood, as well as the impact of this contamination on consumers' health. Guidelines regarding seafood consumption frequency in different countries follow a consensus, however differing to a small extent. In a review about risk-benefit analysis of seafood consumption, it was stated that the benefits outweigh the risks when a variety of fish is consumed at least twice per week (Hellberg et al., 2012). In addition, a targeted communication approach for certain populations (e.g. pregnant women and young children) is warranted in order to ensure that these groups consume fish species that are low in contaminants, but high in omega-3 fatty acids (Hellberg et al., 2012). In turn, Hoekstra et al. (2013) concluded that the overall benefits to the Dutch population of eating 200 g of fish per week, instead of the current (lower) consumption amounts in the Netherlands, outweigh the risks. According to the method used in this study, eating 500 g of fish per week would even be more beneficial, despite the larger risks of being exposed to higher levels of contaminants. However, Domingo (2016) highlights the importance of specific seafood species consumed, the frequency of consumption, as well as the portion and meal size, in order to adequately balance the health benefits and risks of regular seafood consumption. Moreover, the EFSA Scientific Committee compared the benefits of seafood consumption regarding omega-3 long-chain polyunsaturated fatty acids (LCPUFA), with the risks to MeHg in seafood and recommended a weekly intake of fish of 1-2 servings (equivalent to 150-300 g) to meet the Dietary Reference Value (DRF) for n-3 LCPUFA. Notwithstanding, when consuming species with a high MeHg content, only a few servings (<1-2) per week can be consumed before reaching the Tolerable Weekly Intake (TWI). Hence, EFSA emphasized the need that seafood species with a high content of MeHg should be limited in a healthy diet (EFSA, 2015).

In this study, we present the results of a risk assessment on MeHg present in seafood. The possible health risks from exposure through the seafood consumption pattern were assessed in five European countries: Belgium, Ireland, Italy, Portugal and Spain. The reason to focus on MeHg was twofold. Firstly, within the ECsafeSEAFOOD-project, exposure and risk assessment estimations were performed for different environmental contaminant groups present in seafood, namely for methylmercury, polycyclic aromatic hydrocarbons, musks, endocrine disruptors, perfluorinated compounds, brominated flame retardants, UV-filters, inorganic arsenic and pharmaceuticals. The assessment was conducted to screen for which contaminants the seafood consumption pattern could be of concern for public health. Based on the pragmatic approach and the obtained results, it was concluded that refinement of the exposure assessment through seafood intake and risk reduction measurements are certainly needed for MeHg. Secondly, in a recent EFSA report, it was recommended that risk assessment of MeHg should be performed at national level considering the national seafood consumption pattern, focussing on the specific species consumed within each country (EFSA, 2015).

MeHg exposure assessment has been the main topic of a number of studies (Afonso et al., 2015; Brambilla et al., 2013; Cardoso et al., 2013; Cardoso et al., 2010; Di Leo et al., 2010; Kuballa et al., 2011; Maycock and Benford, 2007; Miklavcic et al., 2011; Nunes et al., 2014; Olmedo et al., 2013; Ortega-Garcia et al., 2009; Perello et al., 2014; Ruiz-de-Cenzano et al., 2014; Sioen et al., 2008; Storelli et al., 2003; Storelli et al., 2005; Strom et al., 2011). However, it is stated that the substantial intake of MeHg, which is linked to the high consumption of fish and shellfish, deserves further investigation, while several population subgroups need better guidelines to base their seafood choices explicitly on mercury content (Groth, 2010; Perello et al., 2014). On the other hand, until recently, few research considered risk assessment in different countries with distinct seafood consumption patterns, and using a detailed collection of consumption data covering the diversity of species with different contamination levels.

The present study means a novel contribution to the evaluation of the potential risk of MeHg exposure through seafood consumption by considering five European countries with different

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seafood consumption patterns, and by considering detailed data on consumption levels of 32 different seafood species. For this purpose, MeHg concentration data collected within the ECsafeSEAFOOD-project, as well as data from the scientific literature were used. Seafood species vary greatly in their level of MeHg while there is also a wide variation in the seafood species consumed in different countries across the EU, as well as in the overall seafood consumption frequency (Cardoso et al., 2010; EFSA, 2015; Storelli et al., 2003). Consequently, an additional goal of this investigation was to provide insight in the contribution of different seafood species to the MeHg exposure, and hence to the potential health risk, in each country individually. Thus, we addressed the advice of EFSA that each country should consider the specific species consumed in order to make a recommendation for each country, specifically regarding the human health risks and benefits (EFSA, 2015).

2. Material and methods

2.1. Concentration data

A database for MeHg in seafood was compiled based on concentration data (from pooled samples) collected within the ECsafeSEAFOOD-project (52 data points) (methodology; Aznar et al., submitted) combined with additional data from scientific literature (Afonso et al., 2015; Barrento et al., 2008; Brambilla et al., 2013; Cardoso et al., 2010; Kwasniak et al., 2012; Miklavcic et al., 2011; Perello et al., 2014; Ruiz-de-Cenzano et al., 2014; Storelli et al., 2003; Storelli et al., 2005). In total, 94 data points from scientific literature data were collected. The concentration data includes data originating from measurements performed in raw and canned samples of species commercially relevant in Europe. Data from two species were missing: dry/salted cod and lobster. To bridge this gap, missing concentration data for dry/salted cod were completed by assigning the data of fresh cod. For lobster, it was assumed that the MeHg concentration would be equal to the reported total mercury (Hg) concentration. Contaminant data for the different species considered in the exposure estimations are summarized in Table 1 .

- Insert Table 1. MeHg contents (mean, standard deviation, µg/kg ww) in the different species analysed.

2.2. Consumption data

In the framework of the ECsafeSEAFOOD-project, a web-based consumer survey was performed in October 2013 in five European countries: Belgium, Ireland, Italy, Portugal and Spain. These countries were selected to cover western, northern and southern Europe. Consequently, the data cover a heterogeneous population in terms of seafood consumption frequency and dietary habits. The samples were nationally representative regarding gender, region and age within the range 18-75 years (Table 2) (Jacobs et al., 2015).

- Insert Table 2. Socio-demographic profile of the sample (n=2824).

Within this survey, the total seafood consumption frequency, as well as the seafood consumption frequency of 32 different seafood species, were inquired using self-reported items. The 32 species selected in collaboration with the study partners, were based on the seafood consumption pattern in the five involved countries, and also on the susceptibility of certain species to contain considerable concentrations of certain environmental contaminants. The participants reported their consumption frequency as the number of portions per week or per month, assuming that a portion of seafood per meal is about 150-200 g. The information about portion size was explicitly communicated to the study participants. The reported seafood consumption frequencies were transformed into a continuous scale. As a result of this transformation, mean scores (frequency per week) were calculated. For this purpose “Daily” was replaced by a value of 7.0, “5-6 times a week” was replaced by 5.5, “3-4 times a week” by 3.5, “2 times a week” by 2.0, “Once a week” by 1.0, “Less frequently” by 0.25, and “Never” by 0. The same was done for the consumption frequency of each of the 32 species. Therefore, “2-3 times a month”, “Once a month”, “1-5 times every 6 months”, were also replaced by 0.6, 0.25, 0.15, respectively. Subsequently, consumption frequencies of the 32 species were corrected based on the total consumption frequency reported in the first question because of overestimation of the consumption when considering separate species. The consumption frequency was transformed from times per week to grams per week by multiplying by 175 g, assuming this value as the mean portion size.

For each country, at least 85% of the total seafood diet (based on the median) is represented by the 15 most consumed species. Consequently, only these 15 most consumed seafood species in each country were considered for exposure assessment. For each country, a distribution was fitted to the consumption frequency data of each species using @RISK version 6 (Palisade Corporation, USA). The distribution fitting was performed in two subsequent steps. Firstly, a distribution was fitted to the consumption frequency data of the species, when only the consumers of the species were considered. This distribution was truncated with the lowest consumption frequency as the truncated minimum, and the maximum consumption frequency as the truncated maximum. Secondly, the distribution was combined with the data of the non-consumers (zero intake), taking into account the proportion of consumers and non-consumers of the considered species. Table 1 to Table 5 presented in Appendix I show, for each country, the best fitted distributions to the consumption data.

Furthermore, the body weight (bw) of the participants was also assessed in this survey and a distribution was fitted to these data using @RISK version 6. Table 6 in Appendix I shows the best fitted distributions for body weight for each country. The distribution was truncated with the minimum body weight and the maximum body weight of the data. The ratios of mean body weights between countries, and the ranking of the mean values across countries, are fairly compatible with the Eurobarometer data (Special Eurobarometer 246, 64.3 Health and food, 2006). However, mean values reported in the Eurobarometer are lower. A potential explanation is that the Eurobarometer sample includes respondents from the age of 15 years onwards, while our study included respondents from the age of 18 years onwards. Given the fact that weight increases with age, this would explain (at least partially) the higher mean values in this study. In addition, the fieldwork of the Eurobarometer was done in 2005, while the fieldwork of the current survey was conducted in

2013. Within the Belgian population, a significant linear increase in the mean Body Mass Index (BMI) is shown based on data from 1997 until 2013 (Scientific Institute of Public Health (WIV-ISP), 2013). Hence, it is likely that population weight continued to increase during the time period of 2005-2013.

The best fitted distributions for the consumption and body weight data were determined using the Chi-square statistics, probability/probability (P/P) and quantile/quantile (Q/Q) plots.

The seafood consumption frequency distributions were divided by the body weight distributions, resulting in a consumption dataset (expressed in kg/kg bw/day) for each country.

2.3. Exposure assessment

To estimate the exposure to MeHg through seafood consumption in each country, the consumption frequency data of the species are combined with the concentration data of the contaminants in the samples according to the following formula:

$$Y_{i,c} = \sum_{v=1}^{v=15} C_{c,v} \times X_{i,v}$$

$C_{c,v}$ = concentration of contaminant c in seafood species v [μg/kg ww]

$X_{i,v}$ = consumption of seafood species v by individual i [kg/kg bw/day]

$Y_{i,c}$ = exposure to contaminant c for individual i [μg/kg bw/day]

No adjustments were made for intra-individual correlations in this aggregated exposure model, meaning that an “upper bound” estimation of the exposure was calculated.

2.3.1. Probabilistic exposure assessment

Calculations were performed using the software package @RISK version 6 (Palisade Corporation, US) for Microsoft Excel. As earlier described, best fit distributions are used for the consumption frequency and for the body weight data. For the concentration data a probabilistic approach is used instead of a deterministic approach (point estimate, mean value) when distribution fitting is possible and a good fit is obtained in order to take into account the variability and uncertainty in both consumption and contaminant concentration. Distribution fitting was feasible when at least five concentration data points were available, among which three data values had to be above the detection limit and above the quantification limit. A probabilistic approach was possible for 11 species (see Appendix II for the applied distributions). Best fit distributions for the concentration data were determined using Kolmogorov-Smirnov and Anderson-Darling statistics, the P/P and Q/Q plots. The distributions were truncated with the truncated minimum equal to the lowest concentration at the lower end of the distribution, and with the truncated maximum equal to two times the highest concentration, at the higher end of the distribution. A deterministic approach was used for the species Alaska pollock, canned sardine, clams, cuttlefish, haddock, herring, lobster, mussels, pangasius, sea bass, squid and tuna.

First order Monte Carlo simulations were performed considering 100,000 iterations to estimate the MeHg intake through the seafood diet for the two scenarios: lower bound (LB) and upper bound (UB). Non-detects (<LOD) and non-quantified (<LOQ) were considered as zero and LOD or LOQ for LB and UB scenarios, respectively. Only for pangasius, the measured concentration was lower than the LOQ, while for all the other species, the measured concentrations were above the LOQ. The estimated daily intake was expressed in µg/kg bw/day.

2.4. Risk characterisation

To evaluate the potential health risks of MeHg exposure, a health based guidance value can be applied. The European Food Safety Agency (EFSA) established a Tolerable Weekly Intake (TWI) for oral exposure to MeHg in humans equal to 1.3 µg/kg bw/day (based on neurodevelopmental outcomes) (EFSA, 2012). The use of this TWI value was chosen for this study as the value is generally accepted in a European context, whereas in the US a Reference Dose (RfD) of 1.0 µg/kg bw/day is generally applied to evaluate the potential health risk of MeHg exposure (Rice et al., 2000).

3. Results and discussion

3.1. Occurrence of MeHg in seafood species

Data for the different species considered in the exposure estimations are summarized in Table 1. The variation between species is due to biotic (size, sex, longevity, growth rate, feeding habits, trophic position, habitat) and abiotic parameters (e.g. process of sedimentation and persistence of MeHg in sea depths, environmental conditions) (Kasper et al., 2009; Ruiz-de-Cenzano et al., 2014; Storelli et al., 2005). The highest mean levels of MeHg were found in tuna (462 µg/kg ww), monkfish (227 µg/kg ww), sea bass (222 µg/kg ww), sea bream (208 µg/kg ww), canned tuna (167 µg/kg ww), octopus (126 µg/kg ww), hake (123 µg/kg ww), lobster (121 µg/kg ww) and cuttlefish (104 µg/kg ww).

3.2. Exposure assessment

The most common form of human exposure to MeHg is from seafood consumption (Hellberg et al., 2012). Table 3 shows the results of the exposure assessment for MeHg in the study countries. Mean values, standard deviations and the percentiles (P 50, P 75, P 90, P 95, P 99) of the exposure distributions are described in Table 3.

- Insert Table 3. Results of the exposure assessment for MeHg in the five countries.

The assessed exposure estimates from this study are comparable with the estimates provided by EFSA (EFSA, 2012). EFSA assessed MeHg exposure across different age groups based on dietary surveys from 17 EU countries. The mean medium bound MeHg exposure ranged from 0.06 µg/kg bw/week (for elderly) to 1.57 µg/kg bw/week (for toddlers). The P 95 ranged from 0.14 µg/kg bw/week (very elderly) to 5.05 µg/kg bw/week (adolescents). It must be noted that higher exposure levels were assessed for children, while dietary exposure to MeHg in women of childbearing age was reported not to be different from adults in general (EFSA, 2012). Children may be relatively more exposed than adults due to their relatively higher food consumption in relation to their lower body weights. Table 3 indicates that Portuguese adults have the highest exposure to MeHg, followed by

Spanish adults. By contrast, Irish and Belgian adults show the lowest exposure to MeHg through seafood consumption.

3.3. Risk characterisation

The estimated mean seafood exposure to MeHg is lower than the provided TWI of 1.3 µg/kg bw/week in each of the study countries (Table 3), which is in agreement with the results of EFSA (EFSA, 2012). However, the P 95 for Irish, Italian, Portuguese and Spanish adults are close to, or above, the TWI. Specifically, exposure to MeHg through seafood consumption may be of concern for about 11% of the Portuguese population, 5% of the Spanish population, 4% of the Italian population, 3% of the Irish population and 1% of the Belgian population (Table 3). These numbers follow the order of the total seafood consumption frequency as Portugal has the highest seafood consumption (2.8 times per week; about 490 g), followed by Spain (2.6 times per week; about 455 g) and Italy (2.1 times per week; about 368 g), whereas the Irish and Belgian populations have the lowest total seafood consumption frequency: 1.6 (about 280 g) and 1.1 (193 g) times per week, respectively.

The finding that a larger subgroup of the southern European country's population is potentially at risk due to a MeHg exposure through seafood intake is in agreement with the results of a previous investigation (Cardoso et al., 2010), indicating that the probability of exceeding the MeHg toxicological reference value was higher for Portugal (6.7%) and Spain (4.5%), compared to Germany (0.2%), the Netherlands (0.2%) and the UK (0.04%).

Most of the research on MeHg exposure via seafood consumption has been performed in southern European countries such as Portugal, Spain and Italy (countries with a high seafood consumption frequency) (Afonso et al., 2015; Brambilla et al., 2013; Cardoso et al., 2013; Cardoso et al., 2010; Nunes et al., 2014; Olmedo et al., 2013; Ortega-Garcia et al., 2009; Perello et al., 2014; Ruiz-de-Cenzano et al., 2014; Storelli et al., 2003; Storelli et al., 2005). The results of these studies are comparable with our current findings, namely that a potential health concern exists regarding MeHg exposure via seafood consumption for certain subpopulations in some countries, especially for vulnerable groups including children and women of childbearing age. It must be noted that children may have a higher exposure to MeHg than that estimated for the adult population in the considered countries. Moreover, it was shown that women aged 18 - 45 years (women of childbearing age) participating in the consumption surveys included in the EFSA report appeared to have similar dietary exposure as the general adult population (EFSA, 2012). Furthermore, pregnant women can be present in the group of high and frequent seafood consumers and unborn children constitute the most vulnerable group.

The results of the present study support and emphasize the need for targeted, species-specific and country-specific recommendations in order to mitigate the risk of MeHg exposure through seafood consumption.

3.4. Contribution of seafood species to MeHg exposure

To develop and optimise country-specific risk mitigation communication strategies and dietary recommendations, the contribution of the seafood species to the total MeHg exposure was determined for each country (Table 4). In each of the five countries, tuna and canned tuna are the biggest contributors to MeHg exposure through seafood consumption. Tuna has the highest mean concentration level, while canned tuna has a relatively high mean MeHg concentration (Table 1). Canned tuna is highly consumed, especially in Italy, Portugal and Spain, while fresh tuna is consumed to a lesser, but still substantial extent in those countries. Discouraging the consumption of top predator fish species, such as tuna, is a frequently drawn conclusion, especially for susceptible groups (Brambilla et al., 2013; Cardoso et al., 2010; EFSA, 2012; Nunes et al., 2014; Olmedo et al., 2013; Ortega-Garcia et al., 2009; Ruiz-de-Cenzano et al., 2014).

- Insert Table 4. Contribution of the considered species to MeHg exposure through the seafood pattern in the five countries (based on the mean exposure). The shading indicates the five species contributing most to MeHg exposure.

The highest potential health risk for the Portuguese population may be attributed to the higher total seafood consumption frequency in Portugal compared to the other four countries. However, the Portuguese population has not a substantial higher seafood consumption than that of Spain, but the amount of consumers potentially at risk is about two times higher for Portugal than for Spain. Comparing the seafood consumption pattern in these two southern European countries, the consumption of cod (and to some extent that of monkfish) in Portugal is an important explanatory factor for the higher amount of consumers potentially at risk. Cardoso et al. (2010) recently concluded that cod consumption in Portugal should be reduced in order to reduce the potential risks related with MeHg exposure. In Belgium and Ireland, cod is also identified as an important contributor to MeHg exposure since in both countries, cod is one of the most consumed species. Furthermore, EFSA also reports cod as one of the most important contributors to MeHg exposure through seafood consumption (EFSA, 2012).

Table 4 shows that hake is also an important contributor to MeHg exposure in Spain, Portugal and Ireland, which is in agreement with the results of previous surveys (Cardoso et al., 2013; Cardoso et al., 2010; EFSA, 2012; Nunes et al., 2014; Storelli et al., 2005). In Italy, octopus is an important contributor to MeHg exposure through seafood consumption. Research performed regarding MeHg exposure through cephalopods consumption in Portugal revealed that squid does not present a serious health concern, but cuttlefish and octopus consumption should not exceed two 150 g meals per week (Cardoso et al., 2012). Noteworthy, due to the high MeHg levels in sea bass and sea bream (Table 1), sea bass is identified as an important contributor to MeHg exposure for Italy and Ireland, and both species being important contributors in Italy, Portugal and Spain. To the best of our knowledge, the latter finding has not been observed in previous studies, and hence, to some extent it is surprising. This result likely reflects the dynamics of seafood consumption trends in the last years in the southern European countries compared to previous consumer surveys. Nonetheless, in a consumer guide focusing on mercury levels in seafood developed by Groth (2010), sea bream (porgy) and sea bass have been listed as “higher-mercury fish”.

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3.5. Uncertainties and limitations

Although this study includes the consumption frequency of a rather large set of seafood species in different regions of Europe, some limitations should be acknowledged.

When consuming seafood, people are exposed to both contaminants and nutrients influencing specific health outcomes (*i.e.* neurological, cardiovascular, immunological systems). Therefore, balanced assessments of contaminants and nutrients are recommended (Domingo, 2016; Gribble et al., 2016). This study aimed at assessing the potential health risks due to MeHg exposure. However, results from previous studies focussing on both MeHg and nutrients (omega-3 LCPUFA and/or selenium), highlighted that seafood species high in MeHg levels should be reduced -or avoided- to a certain extent (especially in vulnerable groups) in order to limit MeHg exposure. A frequent consumption of these seafood species may imply exceeding the toxicological threshold value for MeHg before reaching the recommended level of omega-3 LCPUFA and/or selenium (Cardoso et al., 2013; Cardoso et al., 2010; Hellberg et al., 2012; Nunes et al., 2014; Strom et al., 2011). Therefore, this study investigated whether a potential health risk exists in different European countries. The contribution of about 85% most consumed seafood species to MeHg exposure was assessed in five countries representing different seafood consumption patterns. Such approach is highly relevant in order to optimise species- and country- specific recommendations to assure that consumers benefit from the nutritional assets of seafood while lowering the potential health risks.

An important limitation of the current study is that the exposure and risk assessments were performed based on data of MeHg concentrations measured in raw (and canned) samples. Of course, it is of interest to know the concentrations of MeHg after processing, as in most cases and in line with most EU-consumers' seafood consumption habits, seafood is not consumed raw. Within another part of the ECsafeSEAFOOD-project, 18 steamed seafood samples were analysed regarding MeHg levels. In about 55% of the samples, the concentrations of MeHg increased at least 10%, compared to the same raw samples (Alves et al., submitted). This emphasises the need for more data on processed seafood samples in order to be able to draw more robust conclusions based on a larger data set of processed samples. On the other hand, Afonso et al. (2015) showed that bioaccessibility also influences the risk-benefit evaluation of tuna regarding selenium and MeHg. Recently, Cano-Sancho et al. (2015) reported a rather low MeHg bioaccessibility in marine species, concluding that potential health risks for the adult population might be overestimated if bioaccessibility is not considered. Therefore, further monitoring and exposure studies taking into account processing and bioaccessibility are advised, especially for those seafood species identified as high contributors to MeHg exposure.

Inherently associated to exposure assessments are uncertainties that should be considered for the interpretation of the current results. Intrinsic factors related with food consumption such as misreporting of consumed foods, and erroneous estimation of consumed quantities (based on portion size) contribute to uncertainty. In addition, the MeHg concentration data file is composed of primary data obtained from the ECsafeSEAFOOD-project, as well as data from available scientific literature. The primary data collected within the project is expected to be of good quality, as quality assurance procedures and validated techniques were employed, and therefore, the uncertainty in the values is considered to be low as a specific sampling plan/framework was followed to collect the samples in the different countries. This primary data was combined with data from literature (different sources), in which for example other analytical methods might have been used (Kroes et al., 2002). Nonetheless, combining the data was essential to have a higher degree of representativeness of contaminant levels in the seafood species addressed. Despite not explicitly considered in the current study, the data included in the exposure model corresponded to levels of MeHg from seafood species collected in different seasons and in geographical locations, since both aspects are of relevance for European consumers.

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4. Conclusion

Regarding MeHg exposure through seafood consumption, the results of the present study indicate that a country-specific approach is highly relevant in risk management and communication interventions. The largest subgroup of population exposed to potential health risks due to MeHg exposure was identified in Portugal. Taking into account that vulnerable groups may be present among this potential risk subgroup, species-specific advice is recommended in order to reduce the health risk. Our results confirm that an excessive consumption of large predatory fish species, such as tuna, should be discouraged, while consumption of hake and cod in Portugal should be moderated. In Spain, although a similar advice should be followed, the consumption of cod is of less concern. Among the southern European countries, the potential risk of MeHg exposure through seafood is the lowest for Italy. However, to decrease the potential risk to MeHg exposure for a certain subpopulation, it should be advised to reduce the consumption of octopus, in addition to that of tuna and hake. The finding that sea bream and sea bass, due to the high MeHg levels, are substantial contributors to MeHg exposure in these three southern countries is surprising. Due to the important contribution of these species, further monitoring of the MeHg levels in sea bream and sea bass would be relevant, however, this also applies for other species. For the countries with a lower general seafood consumption frequency, such as Ireland and Belgium, the potential health risks due to MeHg exposure are lower, being for Belgium almost negligible. However, in both countries, seafood consumption advice to increase the seafood consumption frequency in order to profit from the health benefits should focus on species low in MeHg content and high in omega-3 LCPUFA levels. The latter applies to all countries and it generally implies the recommendation to consume lower trophic, small, fatty seafood species, such as sardine, Atlantic mackerel, herring and salmon, while minimising the risk of exposure to methylmercury without reducing the benefits of the intake of nutrients (Cardoso et al., 2013; Cardoso et al., 2010; Gribble et al., 2016; Nunes et al., 2014; Strom et al., 2011). Earlier studies in particular European countries indicated that consuming fatty fish more than twice per week can result in an intake of dioxin-like compounds approximating the TWI

(Hellberg et al., 2012; Sioen et al., 2008). Consequently, to balance the potential health benefits and risks of seafood consumption, small fatty fish are recommended to be consumed instead of large predatory fish and large white fish, but not to an unlimited extent. The findings and conclusions of the present study, and their integration in food and health policy should be especially relevant for vulnerable groups of the population, such as pregnant women, children and women of childbearing age.

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Tables

Table 1. MeHg contents (mean, standard deviation, µg/kg ww) in the different species analysed.

Species	N		MeHg (µg/kg ww)	
	Analysed	≥ LOD	Mean	Std. Deviation
Alaska pollock	1	1	95.00	0.00
Canned sardine	4	4	45.25	18.46
Canned tuna	13	13	166.65	135.75
Clams	2	2	14.00	2.83
Cod (dry/salted)[a]	0		85.46	71.79
Cod	9	9	85.46	71.79
Cuttlefish	2	2	104.00	100.41
Haddock	1	1	66.00	0.00
Hake	17	17	123.45	42.02
Herring	3	3	28.67	13.32
Lobster[b]	2	2	121.28	26.23
Mackerel	19	19	80.64	71.32
Monkfish	7	7	227.04	78.62
Mussels	3	3	11.33	6.03
Octopus	6	6	126.47	98.94
Pangasius[c]	1	0	1.33	0.00
Salmon	6	6	20.74	8.40
Sardine	5	5	59.40	25.33
Sea bass	2	2	221.50	183.14
Sea bream	5	5	208.12	167.85
Shrimps and prawns	5	5	53.12	57.67
Sole (and plaice)	17	17	50.21	21.00
Squid	4	4	46.25	27.15
Tuna	12	12	461.98	338.89

[a] The concentration value of fresh cod is assigned to dry/salted cod due to missing data.

[b] data from total Hg are used

[c] Only for pangasius a concentration level < LOQ was measured. For pangasius the concentration <LOQ is replaced by the LOQ value, hence the upper bound (UB) scenario is presented for pangasius in this table.

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Table 2. Socio-demographic profile of the sample (n=2824).

		Belgium (n=540)	**Ireland** (n=575)	**Italy** (n=560)	**Spain** (n=561)	**Portugal** (n=588)	**Total** (n=2824)
Gender (%)	Female	49.8	50.4	51.1	49.2	49.5	50.0
	Male	50.2	49.6	48.9	50.8	50.5	50.0
Age (%)	18-24 years	11.5	15.7	10.0	10.3	12.1	11.9
	25-39 years	28.9	36.0	27.3	35.1	35.0	32.5
	40-50 years	22.4	21.4	23.9	21.6	22.6	22.4
	51-60 years	17.4	15.3	18.9	16.9	17.2	17.1
	61-75 years	19.8	11.7	19.8	16.0	13.1	16.0

Table 3. Result of the exposure assessment for MeHg in the five countries.

	MeHg intake (µg/kg bw/week)							
	Mean	*Std Dev*	*P50*	*P75*	*P90*	*P95*	*P99*	% > 1.3 (TWI)
Belgium								
Seafood diet (UB)[a]	0.198	0.217	0.140	0.231	0.374	0.524	1.098	0.7
Ireland								
Seafood diet	0.360	0.393	0.249	0.424	0.714	1.003	2.019	2.8
Italy								
Seafood diet	0.546	0.355	0.459	0.685	0.979	1.207	1.785	3.8
Portugal								
Seafood diet	0.796	0.426	0.707	0.997	1.347	1.604	2.220	11.3
Spain								
Seafood diet	0.641	0.365	0.560	0.793	1.086	1.316	1.918	5.2

[a] For Belgium, the UB scenario is presented as pangasius is only part of the top 15 most consumed species in Belgium, and only for pangasius a concentration level < LOQ was measured. For pangasius the concentration <LOQ is replaced by the LOQ value.

Table 4. Contribution of the considered species to MeHg exposure through the seafood pattern in the five countries (based on the mean exposure). The shading indicates the five species contributing to the highest extent.

Species (% contribution to MeHg exposure through the seafood pattern)				
Belgium	**Ireland**	**Italy**	**Portugal**	**Spain**
Tuna (40.76)	Tuna (40.04)	Tuna (32.51)	Tuna (26.48)	Tuna (29.53)
Canned tuna (18.34)	Canned tuna (16.16)	Canned tuna (19.59)	Canned tuna (14.83)	Canned tuna (21.17)
Cod fresh (11.02)	Cod fresh (8.29)	Sea bream (11.76)	Sea bream (11.48)	Hake (10.46)
Shrimps and prawns (5.86)	Sea bass (6.83)	Sea bass (8.53)	Hake (9.66)	Sea bream (9.28)
Alaska pollock (5.48)	Hake (4.42)	Octopus (5.49)	Sea bass (7.70)	Sea bass (7.49)
Mackerel (3.12)	Haddock (4.28)	Hake (3.74)	Cod dry/salted (7.37)	Octopus (4.88)
Salmon (2.95)	Cod dry/salted (3.49)	Cuttlefish (3.54)	Octopus (5.78)	Cuttlefish (3.58)
Sole (2.58)	Shrimps and prawns (3.45)	Cod fresh (3.39)	Monkfish (4.77)	Shrimps and prawns (2.75)
Lobster (2.37)	Mackerel (3.16)	Cod dry/salted (2.80)	Sardine (2.92)	Sardine (2.57)
Sardine (2.16)	Salmon (2.60)	Shrimps and prawns (2.58)	Cuttlefish (2.65)	Squid (2.48)
Canned sardine (1.93)	Sardine (2.46)	Squid (2.00)	Squid (1.92)	Canned sardine (1.87)
Herring (1.36)	Canned sardine (1.66)	Sole (1.83)	Shrimps and prawns (1.76)	Sole (1.77)
Squid (1.28)	Sole (1.50)	Salmon (1.08)	Salmon (1.34)	Salmon (1.09)
Mussels (0.71)	Lobster (1.42)	Clams (0.69)	Canned sardine (1.02)	Mussels (0.57)
Pangasius (0.08)	Mussels (0.24)	Mussels (0.48)	Clams (0.33)	Clams (0.49)

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Appendix I

Table 1. Best fit distributions, minimum, maximum and median determined for the consumption (g/week) of the 15 most consumed seafood species in Belgium (fit on the consumption data > 0).

Species	Variable (fraction consumers)	Function	Min	Max	Median
Salmon	Intake consumers (0.84)	RiskInvgauss(22.724;11.73;RiskTruncate(0.95583;240.04583);RiskShift(-0.51583))	0.44	239.53	11.32
Shrimps and prawns	Intake consumers (0.86)	RiskInvgauss(19.303;12.731;RiskTruncate(1.2798;227.4198);RiskShift(-0.5698))	0.71	226.85	10.68
Cod	Intake consumers (0.80)	RiskLognorm(22.721;46.871;RiskTruncate(0.16341;947.22341);RiskShift(0.28659))	0.45	947.51	10.21
Canned tuna	Intake consumers (0.77)	RiskLognorm(19.974;29.083;RiskTruncate(0.29591;408.56591);RiskShift(-0.23591))	0.06	408.33	11.07
Mussels	Intake consumers (0.80)	RiskInvgauss(12.232;12.784;RiskTruncate(1.23568;91.80567);RiskShift(-0.89568))	0.34	90.91	7.50
Tuna	Intake consumers (0.71)	RiskPearson5(1.6907;15.157;RiskTruncate(2.5748;478.6048);RiskShift(-2.2148))	0.36	476.39	8.95
Sole	Intake consumers (0.69)	RiskPearson5(1.8126;11.213;RiskTruncate(1.7125;93.3225);RiskShift(-1.4225))	0.29	91.90	6.06
Alaska pollock	Intake consumers (0.55)	RiskLognorm(15.716;24.963;RiskTruncate(0.25242;250.19242);RiskShift(-0.19242))	0.06	250.00	8.18
Pangasius	Intake consumers (0.55)	RiskInvgauss(16.75;9.0888;RiskTruncate(1.13685;167.46685);RiskShift(-0.79685))	0.34	166.67	8.22
Herring	Intake consumers (0.55)	RiskLognorm(12.608;23.121;RiskTruncate(0.15351;239.39351);RiskShift(0.13649))	0.29	239.53	6.17
Mackerel	Intake consumers (0.51)	RiskInvgauss(11.917;5.9171;RiskTruncate(0.45494;127.14494);RiskShift(-0.29494))	0.16	126.85	5.80
Squid	Intake consumers (0.51)	RiskLoglogistic(0.24353;4.5708;1.529;RiskTruncate(0.29;68.85))	0.29	68.85	4.73
Lobster	Intake consumers (0.51)	RiskInvgauss(5,601;3,6832;RiskTruncate(0,254089;98,384089);RiskShift(-0,094089))	0.16	98.29	3.16
Canned sardine	Intake consumers (0.50)	RiskInvgauss(12.431;6.29;RiskTruncate(0.55558;215.67558);RiskShift(-0.22558))	0.33	215.45	6.21
Sardine	Intake consumers (0.50)	RiskInvgauss(10.636;5.9735;RiskTruncate(0.60303;91.53303);RiskShift(-0.24303))	0.36	91.29	5.52

Table 2. Best fit distributions, minimum, maximum and median determined for the consumption (g/week) of the 15 most consumed seafood species in Ireland (fit on the consumption data > 0).

Species	Variable (fraction consumers)	Function	Min	Max	Median
Salmon	Intake consumers (0.79)	RiskInvgauss(39.722;19.859;RiskTruncate(2.211;453.161);RiskShift(-1.841))	0.37	451.32	18.66
Cod	Intake consumers (0.82)	RiskInvgauss(33.678;19.065;RiskTruncate(2.1142;351.8542);RiskShift(-1.8542))	0.26	350.00	16.55
Canned tuna	Intake consumers (0.70)	RiskInvgauss(37.408;16.614;RiskTruncate(2.0238;512.0738);RiskShift(-1.6538))	0.37	510.42	16.64
Haddock	Intake consumers (0.74)	RiskGamma(0.91177;25.344;RiskTruncate(;175);RiskShift(0.15))	0.15	175.00	15.54
Shrimps and prawns	Intake consumers (0.69)	RiskLognorm(28.728;54.734;RiskTruncate(0.34758;257.02758);RiskShift(-0.28758))	0.06	256.74	12.92
Tuna	Intake consumers (0.68)	RiskLognorm(36.562;86.595;RiskTruncate(0.21396;674.37396);RiskShift(-0.01396))	0.20	674.36	14.17
Mackerel	Intake consumers (0.64)	RiskInvgauss(18.167;7.5802;RiskTruncate(0.68891;173.46891);RiskShift(-0.62891))	0.06	172.84	7.86
Sardine	Intake consumers (0.58)	RiskInvgauss(19.596;7.689;RiskTruncate(0.77411;209.98411);RiskShift(-0.58411))	0.19	209.40	8.31
Sea bass	Intake consumers (0.60)	RiskLognorm(14.961;29.051;RiskTruncate(0.122;154.922);RiskShift(0.13805))	0.26	155.06	6.93
Hake	Intake consumers (0.57)	RiskInvgauss(17.382;7.0422;RiskTruncate(0.666;255.816);RiskShift(-0.60613))	0.06	255.21	7.45
Sole	Intake consumers (0.58)	RiskInvgauss(14.056;6.2994;RiskTruncate(0.68949;138.35949);RiskShift(-0.35949))	0.33	138.00	6.49
Canned sardine	Intake consumers (0.55)	RiskInvgauss(18.513;6.4035;RiskTruncate(0.76942;279.25942);RiskShift(-0.39942))	0.37	278.86	7.51
Cod dry/salted	Intake consumers (0.53)	RiskInvgauss(23.878;5.8664;RiskTruncate(0.641;233.711);RiskShift(-0.38106))	0.26	233.33	7.76
Mussels	Intake consumers (0.51)	RiskInvgauss(12,025;6,3474;RiskTruncate(0,50353;97,66353);RiskShift(-0,44353))	0.06	97.22	5.85
Lobster	Intake consumers (0.51)	RiskLoglogistic(0,22282;3,3542;1,5968;RiskTruncate(0,26;84,7))	0.26	84.7	3.56

Table 3. Best fit distributions, minimum, maximum and median determined for the consumption (g/week) of the 15 most consumed seafood species in Italy (fit on the consumption data > 0).

Species	Variable (fraction consumers)	Function	Min	Max	Median
Canned tuna	Intake consumers (0.95)	RiskInvgauss(48.412;41.508;RiskTruncate(4.4281;616.6081);RiskShift(-4.1081))	0.32	612.50	27.15
Tuna	Intake consumers (0.85)	RiskGamma(0.80043;38.127;RiskTruncate(;448.71);RiskShift(0.24))	0.24	448.71	19.37
Shrimps and prawns	Intake consumers (0.90)	RiskExpon(20.184;RiskTruncate(0.039968;236.179968);RiskShift(0.050032))	0.09	236.23	14.08
Clams	Intake consumers (0.89)	RiskExpon(20.459;RiskTruncate(0.04125;161.37125);RiskShift(0.12875))	0.17	161.50	14.34
Salmon	Intake consumers (0.88)	RiskGamma(0.99039;19.599;RiskTruncate(;170.93);RiskShift(0.08))	0.08	170.93	13.48
Squid	Intake consumers (0.89)	RiskExpon(17.898;RiskTruncate(0.035725;154.615725);RiskShift(0.094275))	0.13	154.71	12.53
Mussels	Intake consumers (0.90)	RiskGamma(0.96087;18.243;RiskTruncate(;161.49);RiskShift(0.17))	0.17	161.49	12.12
Sea bream	Intake consumers (0.86)	RiskGamma(0.85325;22.937;RiskTruncate(;271.12);RiskShift(0.24))	0.24	271.36	12.90
Octopus	Intake consumers (0.85)	RiskExpon(15.157;RiskTruncate(0.03171;128.03171);RiskShift(0.23829))	0.27	128.27	10.77
Sea bass	Intake consumers (0.82)	RiskGamma(0.8343;20.715;RiskTruncate(;139.66);RiskShift(0.34))	0.34	140.00	11.39
Sole	Intake consumers (0.82)	RiskInvgauss(17.201;10.182;RiskTruncate(1.14429;140.84429);RiskShift(-0.84429))	0.30	140.00	8.71
Cuttlefish	Intake consumers (0.80)	RiskInvgauss(17.367;10.979;RiskTruncate(1.2633;161.7533);RiskShift(-1.1733))	0.09	160.58	8.79
Cod	Intake consumers (0.77)	RiskGamma(0.75897;24.622;RiskTruncate(;140);RiskShift(0.33))	0.33	140.00	11.69
Cod dry/salted	Intake consumers (0.78)	RiskInvgauss(16,211;8,6989;RiskTruncate(0,99471;265,46471);RiskShift(-0,80471))	0.19	264.66	7.87
Hake	Intake consumers (0.71)	RiskInvgauss(16,715;9,2571;RiskTruncate(1,06801;250,14801);RiskShift(-0,87801))	0.19	249.27	8.20

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Table 4. Best fit distributions, minimum, maximum and median determined for the consumption (g/week) of the 15 most consumed seafood species in Portugal (fit on the consumption data > 0).

Species	Variable (fraction consumers)	Function	Min	Max	Median
Canned tuna	Intake consumers (0.92)	RiskInvgauss(60.15;79.898;RiskTruncate(9.04;399.35);RiskShift(-8.7685))	0.27	390.58	35.74
Cod dry/salted	Intake consumers (0.95)	RiskExpon(48.888;RiskTruncate(0.08777;487.79777);RiskShift(0.42223))	0.51	488.22	34.39
Hake	Intake consumers (0.90)	RiskExpon(47.264;RiskTruncate(0.08935;426.80935);RiskShift(0.11065))	0.20	426.92	32.96
Salmon	Intake consumers (0.84)	RiskExpon(37.125;RiskTruncate(0.074849;342.644849);RiskShift(0.015151))	0.09	342.66	25.82
Tuna	Intake consumers (0.79)	RiskExpon(39.696;RiskTruncate(0.085;287.735);RiskShift(0.195))	0.28	287.93	27.77
Sardine	Intake consumers (0.85)	RiskGamma(0.90182;33.632;RiskTruncate(;331.81);RiskShift(0.09))	0.09	331.90	20.22
Squid	Intake consumers (0.85)	RiskInvgauss(29.729;28.094;RiskTruncate(3.2158;316.1058);RiskShift(-3.1458))	0.07	312.96	16.75
Sea bream	Intake consumers (0.85)	RiskExpon(28.965;RiskTruncate(0.05793;289.90793);RiskShift(0.03207))	0.09	289.94	20.17
Octopus	Intake consumers (0.86)	RiskGamma(1.0169;23.38;RiskTruncate(0.000835;180.890835);RiskShift(0.019165))	0.02	180.91	16.60
Shrimps and prawns	Intake consumers (0.89)	RiskExpon(20.838;RiskTruncate(0.039995;201.709995);RiskShift(0.050005))	0.09	201.76	14.53
Sea bass	Intake consumers (0.77)	RiskInvgauss(26.907;14.677;RiskTruncate(1.8803;322.6203);RiskShift(-1.7903))	0.09	320.83	12.77
Clams	Intake consumers (0.80)	RiskGamma(1.0252;15.656;RiskTruncate(0.00094;103.78094);RiskShift(0.11906))	0.12	103.90	11.33
Cuttlefish	Intake consumers (0.73)	RiskExpon(19.11;RiskTruncate(0.045;139.365);RiskShift(0.12545))	0.17	139.49	13.40
Monkfish	Intake consumers (0.71)	RiskInvgauss(16,271;9,9532;RiskTruncate(1,01388;234,86388);RiskShift(-0,92388))	0.09	233.94	8.27
Canned sardine	Intake consumers (0.64)	RiskInvgauss(21.75;10.476;RiskTruncate(1.12711;172.28711);RiskShift(-0.95711))	0.17	171.33	9.97

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Table 5. Best fit distributions, minimum, maximum and median determined for the consumption (g/week) of the 15 most consumed seafood species in Spain (fit on the consumption data > 0).

Species	Variable (fraction consumers)	Function	Min	Max	Median
Canned tuna	Intake consumers (0.95)	RiskInvgauss(65.533;82.034;RiskTruncate(8.288;503.528);RiskShift(-8.128))	0.16	495.40	39.41
Hake	Intake consumers (0.94)	RiskExpon(39.219;RiskTruncate(0.07414;336.59414);RiskShift(0.28586))	0.36	336.88	27.54
Tuna	Intake consumers (0.92)	RiskExpon(30.572;RiskTruncate(0.05902;299.67902);RiskShift(0.15098))	0.21	299.83	21.40
Squid	Intake consumers (0.95)	RiskGamma(1.2051;20.669;RiskTruncate(0.02236;192.26236);RiskShift(0.23764))	0.26	192.50	18.70
Mussels	Intake consumers (0.91)	RiskGamma(1.0641;22.988;RiskTruncate(0.0041;172.0341);RiskShift(0.3559))	0.36	172.39	17.71
Shrimps and prawns	Intake consumers (0.95)	RiskExpon(24.298;RiskTruncate(0.04559;180.76559);RiskShift(0.21441))	0.26	180.98	17.09
Salmon	Intake consumers (0.91)	RiskExpon(22.386;RiskTruncate(0.04407;259.91407);RiskShift(0.22593))	0.27	260.14	15.79
Sardine	Intake consumers (0.90)	RiskGamma(1.0584;19.028;RiskTruncate(0.0057;142.0857);RiskShift(0.3543))	0.36	142.44	14.61
Canned sardine	Intake consumers (0.83)	RiskExpon(21.79;RiskTruncate(0.04666;207.82666);RiskShift(0.28334))	0.33	208.11	15.43
Clams	Intake consumers (0.88)	RiskInvgauss(19.609;18.459;RiskTruncate(1.8438;336.7938);RiskShift(-1.7938))	0.05	335.00	11.26
Sole	Intake consumers (0.89)	RiskGamma(1.0417;15.823;RiskTruncate(0.00161;123.79161);RiskShift(0.20839))	0.21	124.00	11.81
Cuttlefish	Intake consumers (0.87)	RiskExpon(17.636;RiskTruncate(0.036288;127.346288);RiskShift(0.013712))	0.05	127.36	12.26
Octopus	Intake consumers (0.89)	RiskInvgauss(16.836;12.798;RiskTruncate(1.2567;150.8567);RiskShift(-1.0467))	0.21	149.81	9.32
Sea bream	Intake consumers (0.86)	RiskInvgauss(19.533;10.34;RiskTruncate(1.388;484.488);RiskShift(-1.038))	0.35	483.45	9.43
Sea bass	Intake consumers (0.83)	RiskExpon(17.78;RiskTruncate(0.03824;288.95824);RiskShift(0.32176))	0.36	289.28	12.68

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Table 6. Best fit distributions, minimum, maximum, mean and median of the best fitted distribution for body weight (kg) for each country.

Country	Variable	Function	Min	Max	Mean	Median
Belgium	Weight (kg)	RiskWeibull(2.5004;42.274;RiskTruncate(1.522;105.522);RiskShift(38.478))	40	144	75.99	74.99
Ireland	Weight (kg)	RiskExtvalue(69.203;17.219;RiskTruncate(40;150))	40	150	78.51	75.39
Italy	Weight (kg)	RiskWeibull(2.4156;38.056;RiskTruncate(2.607;92.607);RiskShift(37.393))	40	130	71.17	70.12
Portugal	Weight (kg)	RiskLoglogistic(-35.559;105.93;13.437;RiskTruncate(40;150))	40	150	71.68	70.53
Spain	Weight (kg)	RiskGamma(7.6996;5.5585;RiskTruncate(10.5061;102.5061);RiskShift(29.4939))	40	132	72.22	70.45

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Appendix II

Table 1. Best fit distributions, minimum, maximum and mean determined for MeHg contents in different species (μg/kg ww).

Species	Variable	Function	Min	Max	Mean
Canned tuna	MeHg LB and UB	RiskPearson5(3.6945;594.75;RiskTruncate(79.89;1129.727);RiskShift(-49.727))	30.16	1080.00	172.45
Cod (and dry/salted cod)	MeHg LB and UB	RiskInvgauss(76.734;108.55;RiskTruncate(15.2215;525.2715);RiskShift(8.7285))	23.95	534.00	86.82
Hake	MeHg LB and UB	RiskGamma(5.41;17.615;RiskTruncate(27.847;404.067);RiskShift(28.153))	56.00	432.22	124.42
Mackerel	MeHg LB and UB	RiskInvgauss(61.073;29.377;RiskTruncate(4.821;614.431);RiskShift(19.569))	24.39	634.00	79.36
Monkfish	MeHg LB and UB	RiskNormal(227.043;78.624;RiskTruncate(127.53;719.8))	127.53	719.80	242.74
Octopus	MeHg LB and UB	RiskExtvalueMin(172.217;84.1765;RiskTruncate(11;532.14))	11.00	532.14	155.36
Salmon	MeHg LB and UB	RiskExtvalueMin(24.6019;6.9599;RiskTruncate(12.17;64))	12.17	64.00	23.44
Sardine	MeHg LB and UB	RiskInvgauss(110.32;2470.76;RiskTruncate(78.916;230.916);RiskShift(-50.916))	28.00	180.00	62.12
Sea bream	MeHg LB and UB	RiskNormal(208.12;167.85;RiskTruncate(41.58;880))	41.58	880.00	256.86
Shrimps and prawns	MeHg LB and UB	RiskExpon(44.515;RiskTruncate(8.90743;274.29743);RiskShift(-0.29743))	8.61	274.00	52.44
Sole	MeHg LB and UB	RiskNormal(50.211;20.996;RiskTruncate(17.09;170))	17.09	170.00	52.77