ECsafeSEAFOOD

Priority environmental contaminants in seafood: safety assessment, impact and public perception

Grant agreement no: 311820

Deliverable D3.5

Online tool to provide information about risks and benefits of seafood consumption

Due date of deliverable: M40

Actual submission date: M42

Start date of the project: 02/2013 **Duration:** 48 months

Organisation name of lead contractor: URV, UGent

Revision: V1

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)	
Dissemination Level	
PU Public	x
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

Table of Contents

Background

URV developed a pilot on-line tool for consumers regarding exposure to contaminants as well as nutrients through seafood consumption, using contamination data and a selection of fish species. The main goal of this first draft of the online tool was to check if the basic structure complies with the ECsafeSEAFOOD goals. The preliminary version includes 25 seafood species highly consumed in Europe, 16 contaminants and several nutrients, taking into account the results gathered in the framework of the project. It was presented at the 34M Coordination meeting in Bilbao.

The first step was to decide the name. For this purpose, URV sent a doodle file, which contained all the suggestions received from partners, in order to choose the best name for our online tool. There were a total of 19 participants, of which 17 voted for the option: **FishChoice.** According to these results, the second step was to check if the domain FishChoice was available. Fortunately, we could buy it and now our website is: **www.fishchoice.eu.**

The preliminary version was also presented at ECsafeSEAFOOD First Stakeholder Workshop, held in Genova, Italy.

URV managed to register the online tool name as a brand. For this reason, URV needed to appoint the owner of the brand, which could be physical or juridical person. WP leaders gave their opinion on this issue and finally URV is the owner.

The initial idea was to develop three different versions according to the target stakeholder, one for the general public, one for health professionals and finally one for the industry sector. However, when URV contacted with several Official Medical College from Catalonia and Official College of Dietitians-Nutritionists of Catalonia, as health professional sector, no inputs were received. On the other hand, conversations have been maintained with people from the industry ANFACO-CECOPESCA as representative of the producer/processor sector. Finally, after talking with ANFACO members, we arrived at the conclusion that maybe it was not necessary to develop three different versions according to stakeholders, because all of us are consumers. Therefore, it could be more interesting to improve the temporal version. URV tested the online tool and checked if the results were correct. Whenever incoherencies were fund the online tool was amended and a new improved version was created.

A preliminary version was presented at the ECsafeSEAFOOD policy workshop organized in Brussels (21st January 2016).

After the 36M coordination meeting of ECsafeSEAFOOD, the online tool received several suggestions of improvements, especially from the SAC members, and all the recommendations were very welcome, as it was a constructive criticism. Consequently, URV started to prepare two different versions of the online tool (one for the general public and another for targeted stakeholders such as health professionals, risk managers and seafood industrials) taking into account each comment. One version aimed at the general public and another version aimed at the health professionals. In the end, the vision of these external reviewers was essential to consolidate the software tool before being released for further tests within the consortium and with the collaboration of food safety authorities.

The most important suggestions that URV has incorporated were:

- To consider the same concentrations and species used in task 3.2. Human health risk assessment**.**
- To include user's life stage.
- To include the option for pregnant or nursing women.
- To include recommendations (further details will be provided in the following chapters).
- To include the nutrient database that UGent has compiled based on different national food composition databases (references mentioned in the following chapters).
- The online tool for general public should be much easier and should not contain detailed information. On the other hand, the version for health professionals (extended version) should show more interesting and detailed information for scientists or health professionals, such as the references related to the data considered.

One suggestion received was to consider bioaccessibility results. According to the data obtained in the WP2, URV did not considered necessary to include these results, because the levels were low in seafood samples. Therefore, it is expected to be obtained even lower concentrations in bioaccessible samples.

Summary

According to the importance of seafood as part of a healthy diet, there has been during last decades a notable promotion of seafood consumption. However, a number of current studies have shown that seafood might be a potential source of exposure to environmental pollutants. Some of them have well-known adverse effects on human health. In contrast, there is still a lack of information regarding the levels of emerging contaminants in seafood.

A wide variety of emerging contaminants, including pollutants specifically associated with litter, inorganic arsenic (As), organic mercury (Hg), brominated flame retardants, pharmaceuticals, perfluorinated compounds, musk fragrances, polycyclic aromatic hydrocarbons, UV-filters and endocrine disruptors have been analysed in seafood collected around Europe within ECsafeSEAFOOD project (Deliverable 2.4. Presence and levels of priority contaminants in seafood).

In order to inform consumers on the health benefits and risks related to seafood consumption and to help them find out with seafood species are more preferable, an easy to use online tool was designed based on scientific information, called FishChoice. Via this tool a consumer can calculate on an individual basis the intake of these pollutants (risks) versus that of different nutrients (e.g. polyunsaturated fatty acids (PUFAs), essential minerals and vitamins (benefits)) via seafood consumption. The average concentrations of several nutrients and the chemical pollutants per seafood species were introduced in the software. This document presents how FISHCHOICE was developed and can be used as an easy tool to optimize seafood consumption: most suitable species, frequency of consumption, and portion sizes of meals. It is still a draft version that will be optimized and released by M48. FISHCHOICE can be useful not only for professionals (cardiologists, general physicians, nutritionists, toxicologists, etc.), but also for the general population.

1. Introduction

The activities reported in this deliverable were performed in Work Package 3 (WP3).

European consumers have in general a positive attitude towards consuming seafood and they perceive seafood as beneficial for their personal health (Jacobs et al., 2015). Seafood is an important source of nutrients due to the presence of proteins, omega-3 polyunsaturated fatty acids (n-3 PUFAs), vitamins and minerals (Matos et al., 2015; Sirot et al., 2012). The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations (UN) recommend a regular fish consumption of 1–2 servings per week in order to provide an equivalent of 200–500 mg of n-3 PUFA, notably eicosapentaenoic (EPA) and docosahexaenoic acids (DHA) (FAO/WHO, 2011). Furthermore, a diet high in seafood has been accepted to cut down on risk of cardiovascular diseases (CVD), mainly due to the effects of the n-3 PUFA, EPA and DHA (Tediosi et al., 2015). In addition, it has become increasingly evident that the beneficial effects of seafood consumption are not restricted to fatty acids and lipids. Proteins, peptides and amino acids, together with vitamins and even unknown bioactive constituents may also be important for disease prevention by controlling circulating levels of cholesterol, lipoproteins and triglycerides, rising endogenous antioxidants and lowering blood pressure (Larsen et al., 2011). Moreover, the presence of minerals in seafood is also an important asset.

For example, fish is considered to be the best source of selenium (Se) in the human diet, due to its ability to accumulate considerable amounts of this element (Karimi et al., 2014; Navarro-Alarcon and Cabrera-Vique, 2008). Selenium is essential for normal functioning of many systems in human body, principally due to its antioxidant capacity, since its presence is associated with the diminution of certain types of cancer and other diseases, and its deficiency can have adverse consequences (Pedrero and Madrid, 2009; Ralston and Raymond, 2010; Riaz and Mehmood, 2012; Santhosh Kumar and Priyadarsini, 2014). Iodine is another essential element in human diet, and a deficiency of this element can cause a set of health problems that collectively are termed iodine deficiency disorders (IDD). It seems that in places where seafood is a major dietary component, their population present an adequate iodine intake (Fuge and Johnson, 2015).

In addition, fish and shellfish are an important source of vitamins, among them, vitamin D, A and E. Vitamin D deficiency is a global problem and is associated with an increased risk of cardiovascular diseases, autoimmune diseases, type 1 diabetes osteoporosis, and likely various types of cancer (Lehmann et al., 2015). A deficiency of vitamin A is often associated with protein calorie malnutrition (PCM) (Mohanty et al., 2016).Finally, vitamin E is the major lipid-soluble antioxidant in the cell antioxidant defence system and is only obtained from the diet. The most important biologic role of vitamin E is to protect PUFAs and other components of cell membranes and low-density lipoprotein (LDL) from oxidation by free radicals (Mohanty et al., 2016).

On the other hand, a number of recent studies have shown that seafood can also be a potential source of human exposure to harmful environmental contaminants, such as, polychlorinated biphenyls (PCBs), dioxins, pesticides, toxic elements, new emerging contaminants, etc. (Barone et al., 2014; Cunha et al., 2015; Domingo et al., 2007a; Gil and Gil, 2015; Rodríguez-Hernández et al., 2016; Vassiliadou et al., 2015). The presence of contaminants in seafood for human consumption at values above the regulatory levels may have a negative impact on consumers health (Vandermeersch et al., 2015). Maximum levels for a range of contaminants are established in the legislation and monitoring programs certify that seafood is regularly examined for the presence of a selection of environmental pollutants. To date, the focus has been on well-known chemical pollutants including polycyclic aromatic hydrocarbons (PAHs), PCBs, marine bio-toxins and toxic elements. However, there is an increasing demand for knowledge about the presence and potential effect of the so called “contaminants of emerging concern” in seafood (Squadrone et al., 2015; Vandermeersch et al., 2015; Wille et al., 2012).

Contaminants of emerging concern in seafood are substances that are raising the interest of the scientific community and regulatory authorities. They are new substances for which no maximum levels have been established in EU legislation, and for which a potential risk cannot be ignored. The emerging contaminant group includes pharmaceuticals, personal care products, hormone disrupting substances, brominated flame retardants, toxic elemental species, microplastics, perfluorinated compounds, etc. Because of the persistence, bioactivity and bioaccumulation potential of several substances, concern is increasing about the potential harmful effects on ecosystems and human health.

In order to inform the general public on the health benefits and risks associated with food consumption and to help them balance between the benefits (intake of micro- and macronutrients) and risks (intake of contaminants), different online tools have already been developed in the past. A first example is RIBEPEIX, a tool which considers only fish and seafood (Domingo et al., 2007b). A second example is RIBEFOOD, which includes a wide variety of foodstuffs (Martí-Cid et al., 2008). Based on these previous initiatives, an easy to use online tool for the general public is designed within the framework of the EU FP7 project ECsafeSEAFOOD, named FishChoice (www.fishchoice.eu). This tool is developed to give consumers an idea on their weekly intake of n-3 PUFAs, as well as, proteins, vitamins and minerals (health benefits) versus environmental pollutants (health risks) through fish and seafood consumption. The main aim of this tool is to help consumers optimizing their seafood consumption regarding potential health risks and benefits by selecting the most suitable species, consumption frequency, and portion sizes.

2. Materials and Methods

2.1. Data

In 2013, within the ECsafeSEAFOOD project, a consumer survey was performed in five European countries: Belgium, Ireland, Italy, Portugal and Spain. These countries were selected to cover western, northern and southern Europe, covering a heterogeneous population in terms of seafood consumption, frequency and habits. Seafood species were selected based on the most frequently consumed species in these five countries (Jacobs et al., 2015). Based on the results of this survey, the 24 mostly consumed species were selected to be included in the online tool.

2.1.1. Selected species

The following seafood species were included: Alaska Pollock (*Theragra chalcogramma*), mussels (*Mytilus galloprovincialis*), plaice or sole (*Pleuronectes platessa* or *Solea solea*), tuna (*Thunnus*

Thynnus) (both fresh and canned), sardine (*Sardina pilchardus*) (both fresh and canned), hake (*Merluccius merluccius*), monkfish (*Lophius sp.*), pangasius (*Pangasius hypophthalmus*), cod (*Gadus sp.*) (fresh and dry or salted), mackerel (*Scomber scombrus*), shrimp and prawns (*Aristeus antennatus* and *Penaeus spp.*), octopus (*Octopus vulgaris*), salmon (*Oncorhynchus sp.*), seabream (*Sparus aurata*), clams (*Molluscans*), cuttlefish (*Sepia officinalis*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), lobster (*Homarus sp.*), seabass (*Dicentrarchus labrax*) and squid (*Loligo vulgaris*).

2.1.2. Chemical levels

The contaminant selection was mainly based on the concentration levels measured in the commercial sampling performed within ECsafeSEAFOOD project, as well as, additional data from scientific literature gathered in the ECsafeSEAFOOD database (Vandermeersch et al., 2015). The levels of endocrine disruptors (bisphenol A, methylparaben, and triclosan), musk fragrances (galaxolide and tonalide), brominated flame retardants (BFRs; 2,2’,4,4’,-tetra-bromodiphenyl ether-PBDE47, 2,2’,4,4’,5-penta-bromodiphenyl ether-PBDE99, tetrabromobisphenol A-TBBPA and α-β-γ-hexabromocyclododecane-HBCD), pharmaceuticals (venlafaxine), perfluoroalkyl substances (PFAs; perfluorootanoic acid-PFOA, perflurooctane sulfonate-PFOS, perfluorononanoic acid-PFNA and perfluoroundecanoic acid-PFUnA), polycyclic aromatic hydrocarbons (benzo[a]pyrene, chrysene, benz[a]anthracene and benzo[b]fluoranthene), metylmercury, and UV-filters (benzophenone 1-BP1; 2,4-dihydroxybenzophenone, benzphenone 3-BP3; Oxybenzone, 4-methylbenzylidene camphor-4-MBC, 2-ethylhexyl-4-methoxycinnamate-IMC), as well as metal species (inorganic arsenic and methylmercury) (not emerging but of concern to public health) were included in the online tool.

On the other hand, the average content of the following micro- and macronutrients: vitamins A, D and E, Iodine (I) and Se, two kinds of n-3 PUFAs, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and proteins were obtained from a database the food table compositions of the same five European countries: Belgium (NUBEL, 2009), Ireland (McCance and Widdowson, 2015), Italy (BDA, 2015), Spain (BEDCA, 2007) and Portugal (INSA, 2010). Average concentrations per seafood species were computed. Except for EPA and DHA acids, these values were obtained only from McCance and Widdowson database.

2.2. Design of the software FishChoice

Data regarding pollutants, as well as nutrients were introduced into a new software called FishChoice. The design of FishChoice was developed to quantitatively establish the weekly intake of the above-mentioned pollutants versus that of micro- and macronutrients. The specific process was the following: (1) to determine the intake of several endocrine disruptors, musk fragrances, brominated flame retardants, pharmaceuticals, perfluorinated compounds, polycyclic aromatic hydrocarbons, UV-filters inorganic arsenic, and methylmercury, by any consumer through his/her usual weekly habits; (2) to compare the weekly intakes of these pollutants with their tolerable/acceptable intakes, when these have been already established by international regulatory organizations such as European Food Safety Authority, US Food and Drug Administration, WHO, etc. (EFSA, 2016; FDA, 2016; WHO, 2016); (3) to determine the weekly intake of micro- and macronutrients according to the dietary habits; (4) to compare the intakes of these nutrients with those recommended by international nutritional organizations and health promoting associations; and (5) to offer the possibility to any subject to perform changes in his/her particular weekly habits so as to optimize the balance between health benefits (nutrients) and chemical risks (pollutants). To sum up, FishChoice could help people to decrease health risks and to raise the potential benefits derived from specific seafood consumption.

3. FISCHOICE layout

Two versions have been developed according to different stakeholders, one for the general public and a more extended version for health professionals. Users can access Fishchoice by means of the following website address: http://www.fishchoice.eu. This online tool has been structured in several screens to which the users can go browsing.

3.1. Main screen

General public can select the calculator tab, which is found at the top left of the first screen and select their profile. The profile considers the following groups: Children (0-9 y), Boys (10-19 y), Girls (10-19 y), Men (20-65 y), Women (20-65 y), Pregnant or nursing women, Senior male (>65 y) and Senior female (>65 y). Health professionals can select the professional access required tab in order to get credentials to log in to pro version. Afterwards, health professionals can select the calculator pro tab and also select their profile. In contrast, health professionals can select the professional access required tab in order to get credentials to log in to pro version

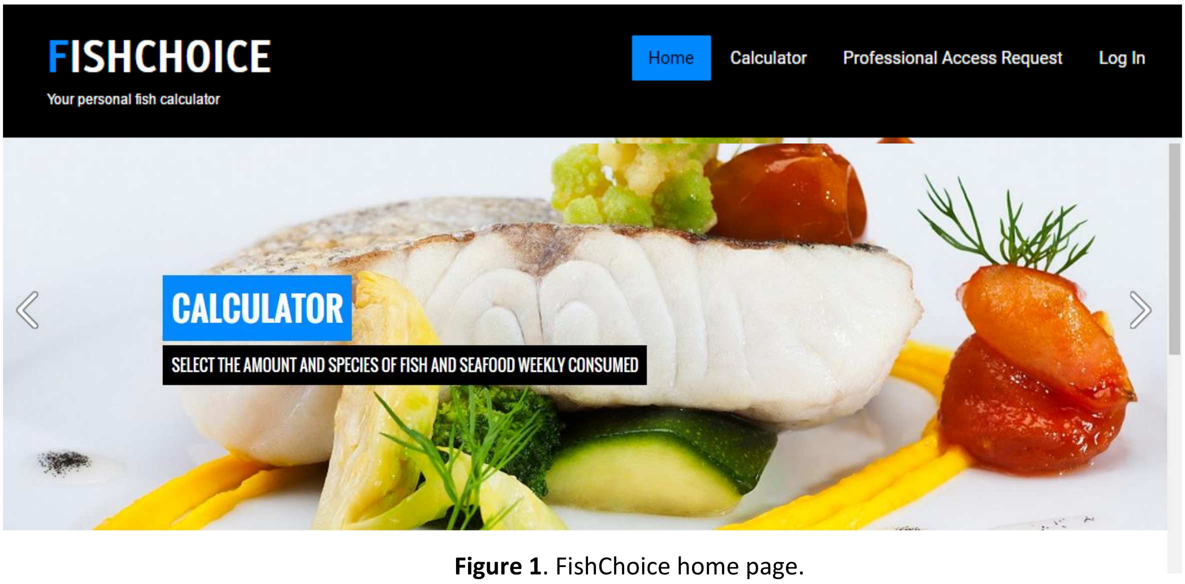
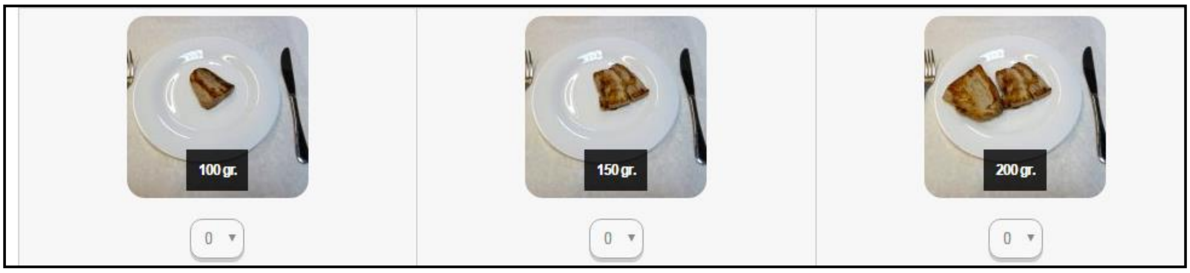


Figure 1. FishChoice home page.

Users must select for each of 24 seafood species included, their weekly frequency of consumption, and the portion size. Since in some cases this can be highly difficult, three pictures corresponding to three different portion sizes are shown for each species (see example in Figure 2).



Small portion Medium portion Large portion

Figure 2. Different portion sizes included in FishChoice for consumers' selection.

Once users have selected their seafood consumption, the next step is to click the calculator symbol located at the bottom of the screen.

3.2. Nutrients screen

POLLUTANTS | POLLUTANTS GRAPH | NUTRIENTS | NUTRIENTS GRAPH

Your current intake of fish and seafood is healthy. (green fish)

You should eat more fish and seafood. (blue fish)

		Other foods with a high potential contribution
Protein	green	Meat/Eggs/Milk and Dairy Products
Omega-3 polyunsaturated fatty acid (n-3 PUFA)	green	Cultivated Marine Algae/Linseeds/Rapeseed Oil and Walnuts
Vitamin A	blue	Meat/Dairy Products/Eggs/Vegetables and Fruits
Vitamin D	green	Fungi and Egg Yolk
Vitamin E	green	Vegetables Oils/Nuts and Seeds/Egg Yolk and Whole Grain Cereals
Iodine	blue	Eggs and Milk
Selenium	green	Milk and Dairy Products/Meat and Meat Products and Grains

Figure 3. FishChoice Nutrient Screen.

3.2.1. General public

Micro- and macronutrient intakes are displayed in this screen. General public can see the list of micro- and macronutrients considered on the left. Clicking each nutrient, a brief summary of information about this nutrient is shown. In addition, if their intake is found above the recommended dietary allowances (RDA) or the Adequate Intake (AI) values (NAP, 2016), for each nutrient, then green fish will be shown on the right of the screen (see Figure 3). Otherwise, if their nutrient intake via seafood consumption is found below these recommended levels, fish would be shown in blue, as well as the screen will show a message encouraging that they should eat more seafood species. It has to be taken into account that this program only considers the consumption of seafood. Therefore, it was searched on the scientific literature the percentage of each nutrient that comes from seafood intake and, a recalculation was applied for the recommended values (Ruiz et al., 2016). Finally, at the bottom of the screen an arrow icon offers the possibility to go back in order to modify the consumption data.

3.2.2. Health professionalsFor health professionals' version, the program works the same way as for the general public. However, this version supplies users with additional information. In this case, the intake value for each nutrient is shown considering the contribution of all species consumed (see Figure 4). Moreover, the RDA or AI for each nutrient is also shown.

3.3 Nutrients Graph screen

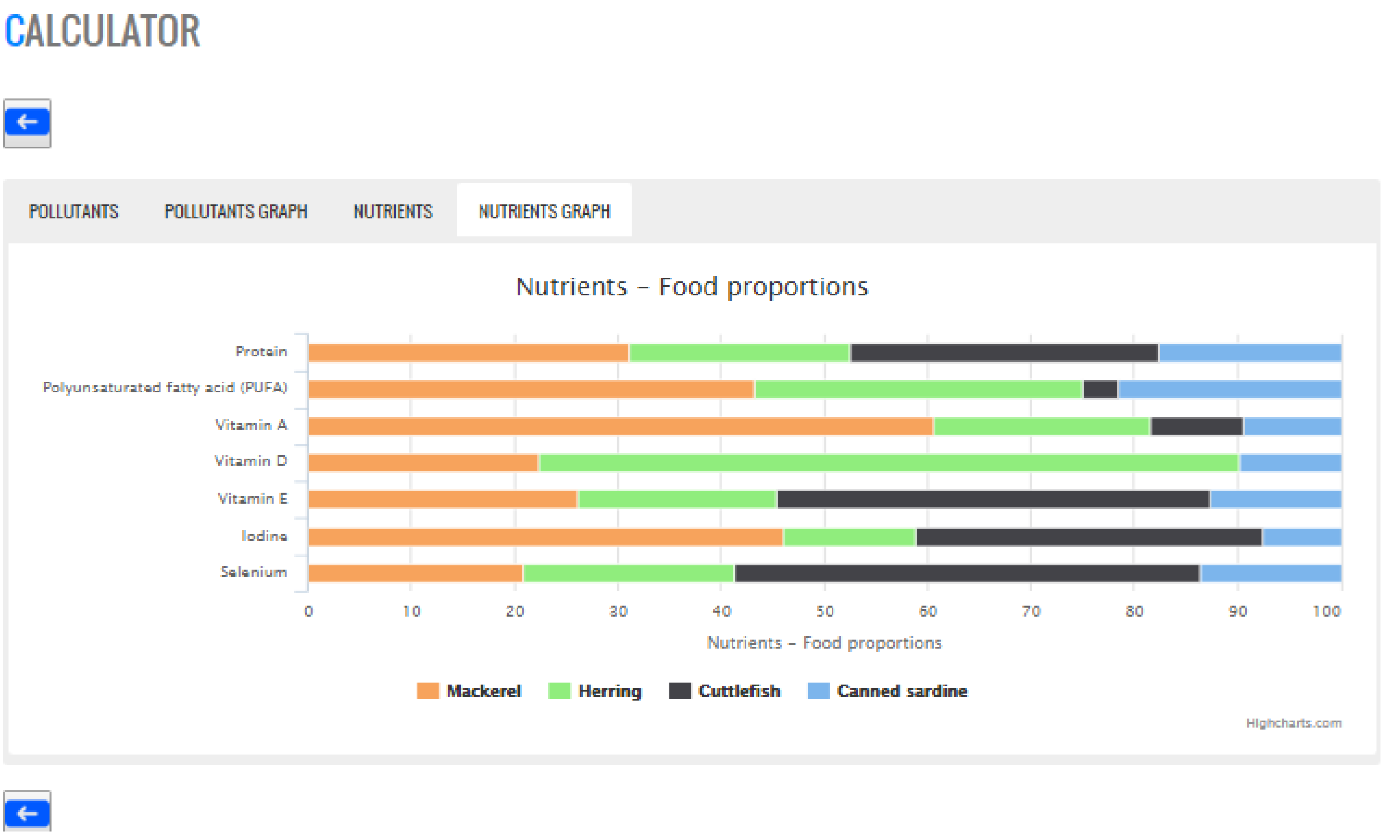


Figure 4. FishChoice Nutrient Graph Screen.

3.3.1. General Public

The program also shows another icon regarding nutrients. If users click the Nutrients Graph tab, a new screen will appear where consumers can see the contribution of each species indicated in their diet for each nutrient.

3.3.2. Health Professionals

Within the Nutrient Graph display, if health professionals move the mouse cursor over the different colours of the bars they will see the nutrient intake for each species consumed individually.

3.4. Pollutants screen

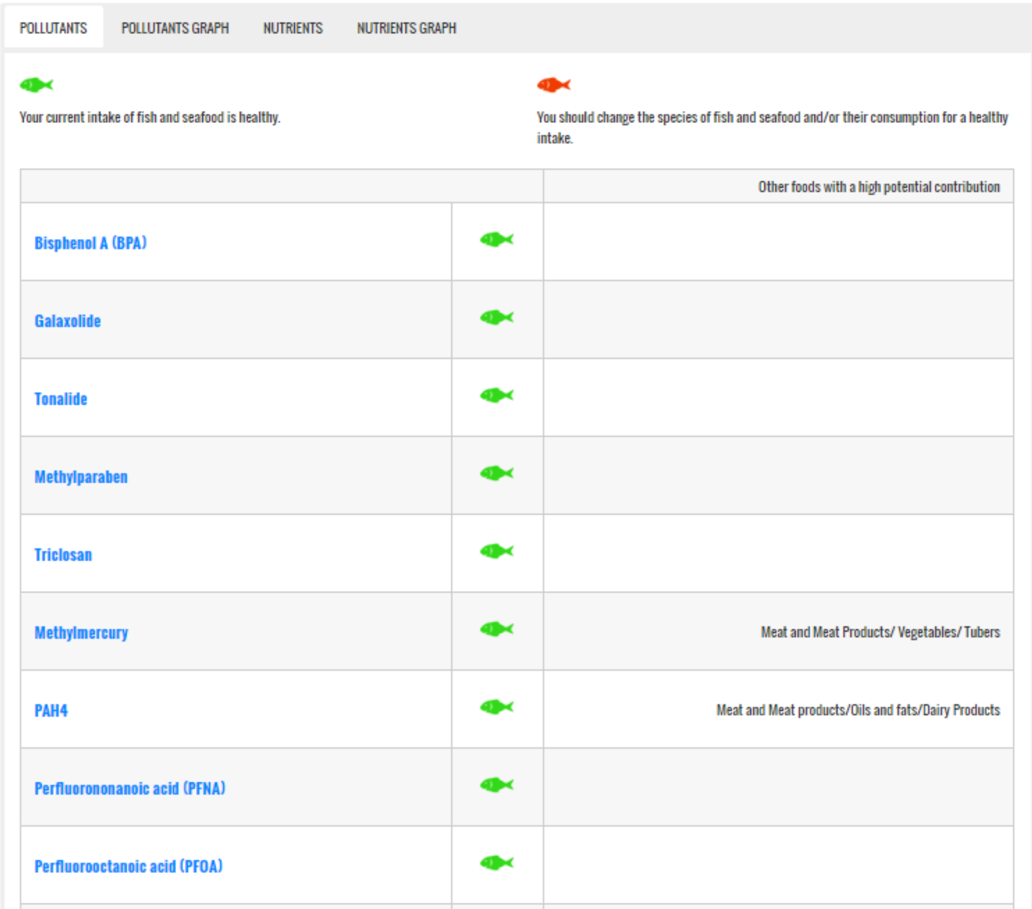


Figure 5. FishChoice Pollutants Screen.

3.4.1. General public

In this screen, user can see the list of pollutants on the left. Clicking each one, a brief summary of information about this contaminant can be found. Furthermore, if their intake is below the maximum allowable values for each contaminant, according to different international organizations, then green fish will be shown on the right of the screen, indicating that the consumption is safe (see Figure 5). Otherwise, if their consumption is found above the maximum established values, fish would be shown in red (see Figure 5). The pollutant intakes are based on the respective body weight according to the consumer profile selected, the weekly seafood consumption, and the portion size. Finally, at the bottom of the screen a narrow icon offers the possibility to go back in order to modify the consumption data.

3.4.2. Health professionals

For the health professionals' version, the program works likewise for general public, although, this version gives users additional information. In this case, above the fish legend, in the screen appears the intake value for each pollutant considering the contribution of the sum of species consumed (see Figure 10). Moreover, the maximum values established according to different international organizations for each pollutant are also shown (see Figure 10).

3.5. Pollutants Graph screen

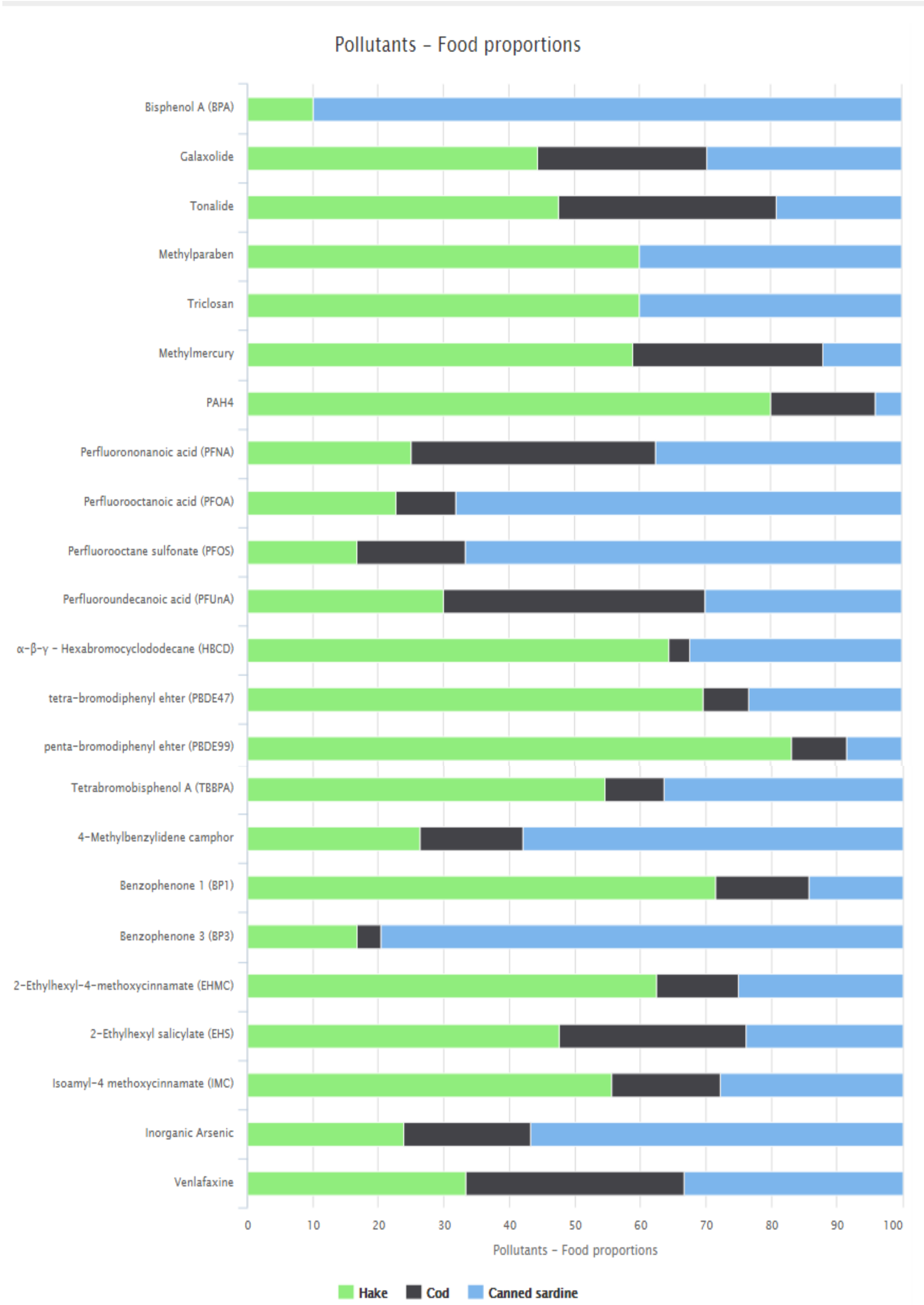


Figure 6. FishChoice Pollutants Graph Screen.

3.5.1. General public

The program also presents another icon regarding pollutants. If a user clicks on the Pollutant Graph tab, a new screen will appear where users can see the contribution of each consumed species for each contaminant (see Figure 6).

3.5.2. Health professionals

For health professionals' version the software also allows the users to move the mouse cursor over the different colours of the bars, and then the user will see the pollutant intake for each species consumed individually (see Figure 11).

3.6. Recommendations

For some species, such as Tuna or other top predatory fish, The European Food Safety Authority (EFSA) recommends avoiding their consumption for pregnant or nursing women and children due to its high MeHg content. In both versions, FishChoice shows in these particular cases a message recommending not consuming over than 250g of tuna per week. This considers also no consuming any other seafood species in order to do not exceed the tolerable weekly intake (TWI) of 1.3 µg/kg bw/week for methyl mercury (EFSA, 2012).

In addition, the software will also provide recommendations for those cases where users exceed the maximum level established for methylmercury or any other contaminant. In this way, a message will appear indicating which is the species being in the risky area according to the consumption pattern, and suggesting to diversify the seafood consumption, reducing the weekly intake of the specific species or shifting to other species with similar nutritional properties, but lower concentrations of the specific contaminant in order to reduce its intake (See figure 10).

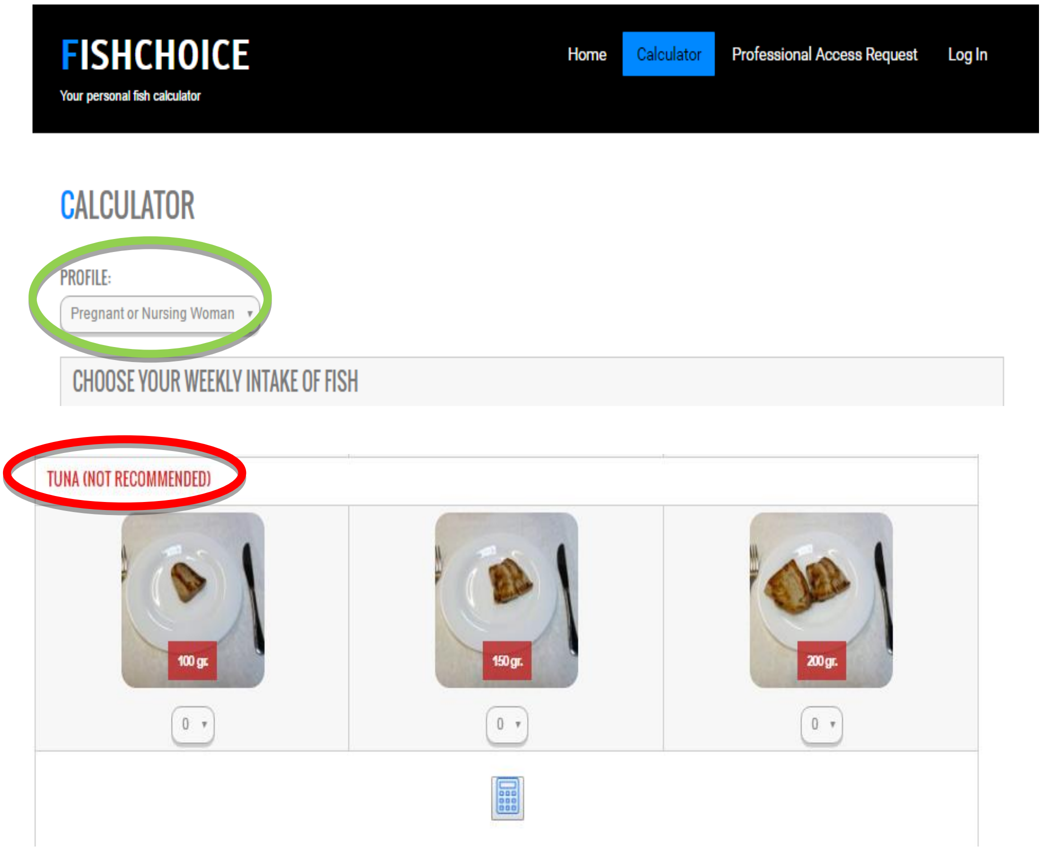


Figure 7. Species not recommended for pregnant or nursing women.

3.7. Any need to change? Screen

According to the results concerning the intake of pollutants, only for health professionals' version, user can decide optimizing the balance between benefits and risks. In this screen, the most and least polluted seafood species are listed. With this information, users can adjust their seafood consumption habits in order to reduce the risks derived from exposure to pollutants.

4. FishChoice use: an example

A hypothetical situation is created in order to illustrate how the tool works: a boy has been chosen as an example of health professional version.

This boy has consumed a medium portion of Alaska Pollock (once a week), a medium portion of canned tuna (twice a week), and a large portion of tuna (once a week). Figure 9 presents this selection.

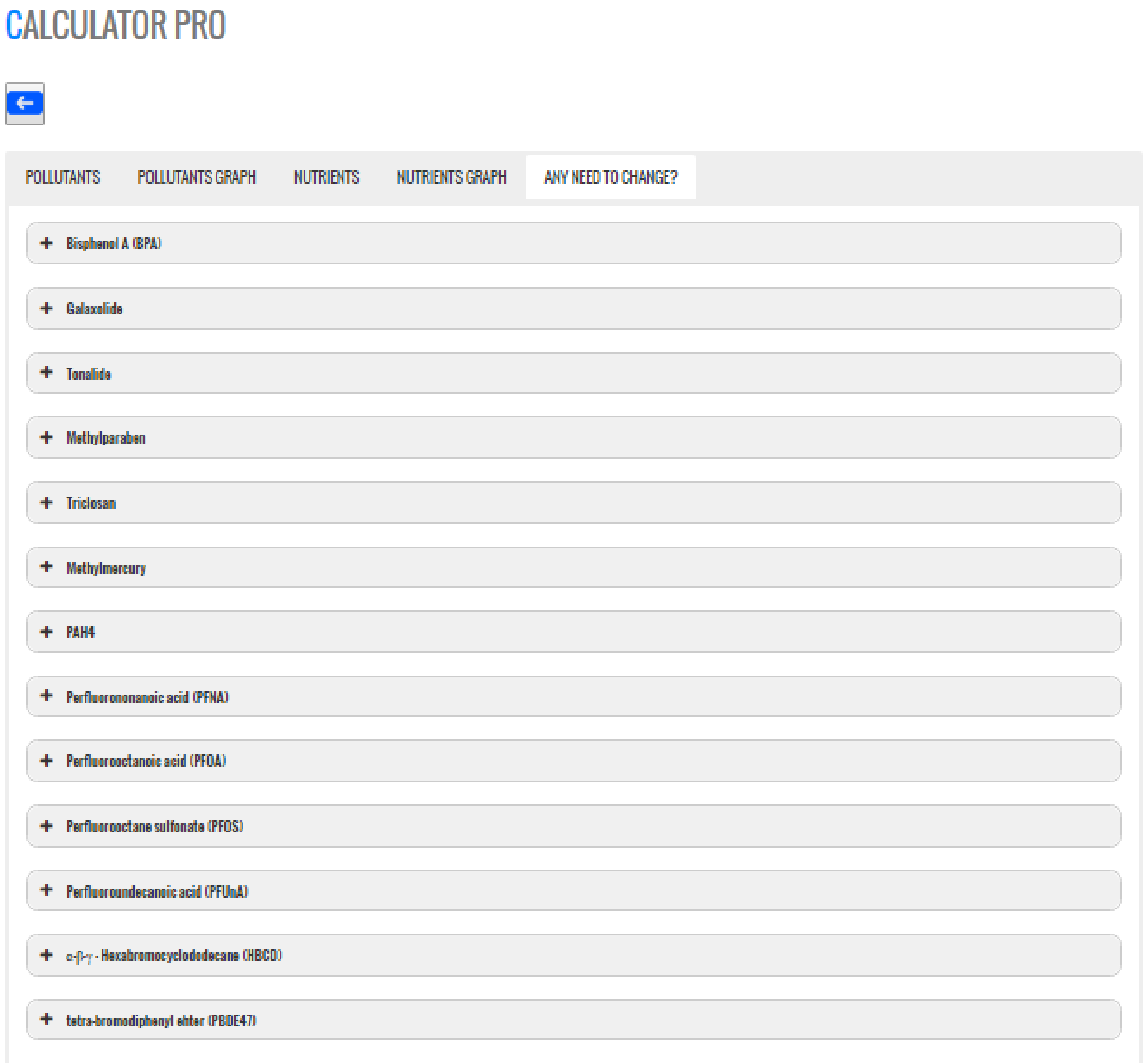
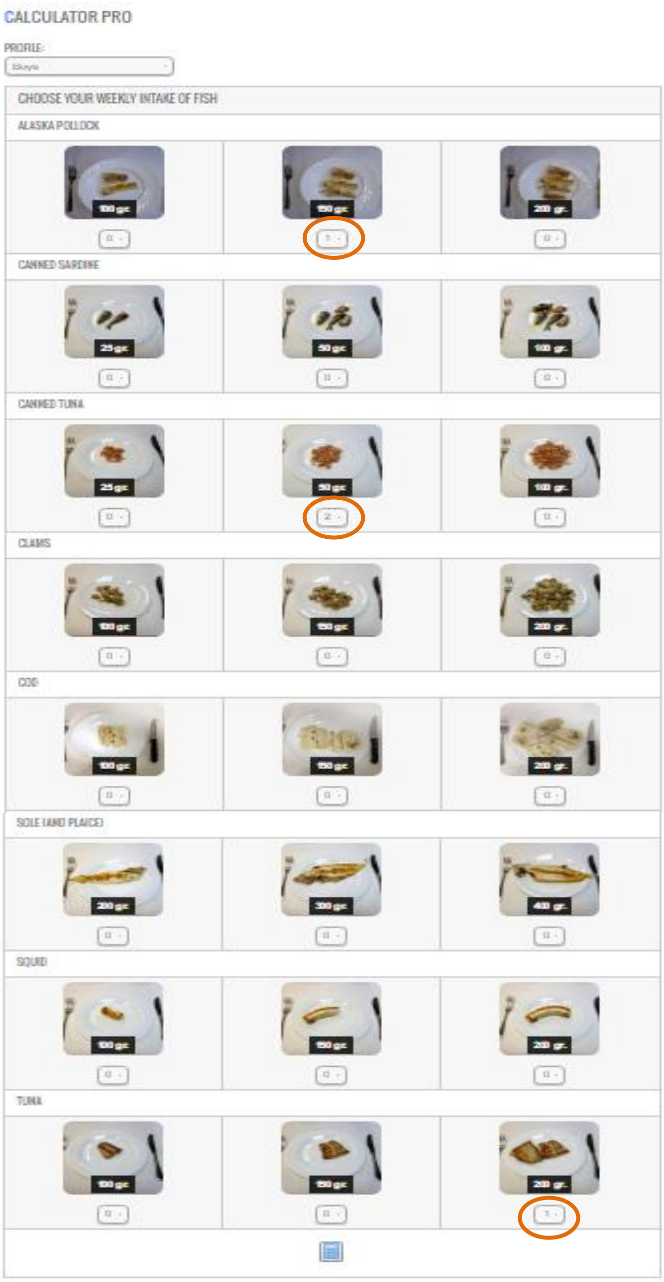
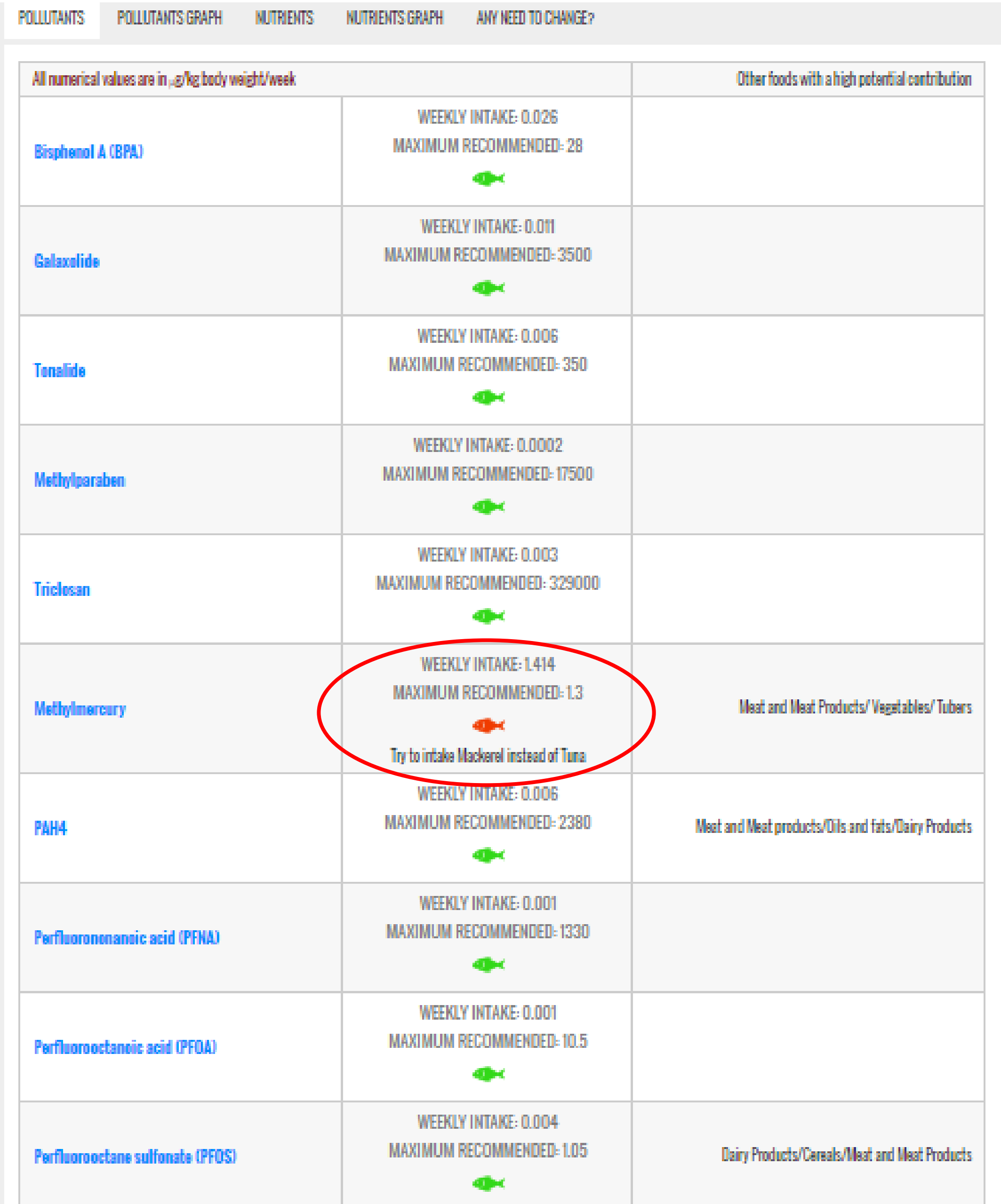


Figure 8. FishChoice Any need to change Screen.



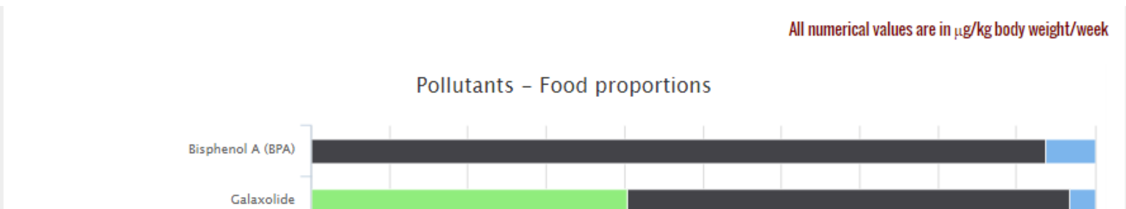
When the calculator tab is clicked, a new screen can be seen regarding pollutants (Fig. 10).



POLLUTANTS | POLLUTANTS GRAPH | NUTRIENTS | NUTRIENTS GRAPH | ANY NEED TO CHANGE?

All numerical values are in μg/kg body weight/week		Other foods with a high potential contribution
Bisphenol A (BPA)	WEEKLY INTAKE: 0.026 MAXIMUM RECOMMENDED: 28	
Galaxolide	WEEKLY INTAKE: 0.011 MAXIMUM RECOMMENDED: 3500	
Tonalide	WEEKLY INTAKE: 0.006 MAXIMUM RECOMMENDED: 350	
Methylparaben	WEEKLY INTAKE: 0.0002 MAXIMUM RECOMMENDED: 17500	
Triclosan	WEEKLY INTAKE: 0.003 MAXIMUM RECOMMENDED: 329000	
Methylmercury	WEEKLY INTAKE: 1.414 MAXIMUM RECOMMENDED: 1.3 Try to intake Mackerel instead of Tuna	Meat and Meat Products/ Vegetables/ Tubers
PAH4	WEEKLY INTAKE: 0.006 MAXIMUM RECOMMENDED: 2380	Meat and Meat products/Oils and fats/Dairy Products
Perfluorononanoic acid (PFNA)	WEEKLY INTAKE: 0.001 MAXIMUM RECOMMENDED: 1330	
Perfluorooctanoic acid (PFOA)	WEEKLY INTAKE: 0.001 MAXIMUM RECOMMENDED: 10.5	
Perfluorooctane sulfonate (PFOS)	WEEKLY INTAKE: 0.004 MAXIMUM RECOMMENDED: 1.05	Dairy Products/Cereals/Meat and Meat Products

Figure 10. Pollutant screen for a boy (health professional version).



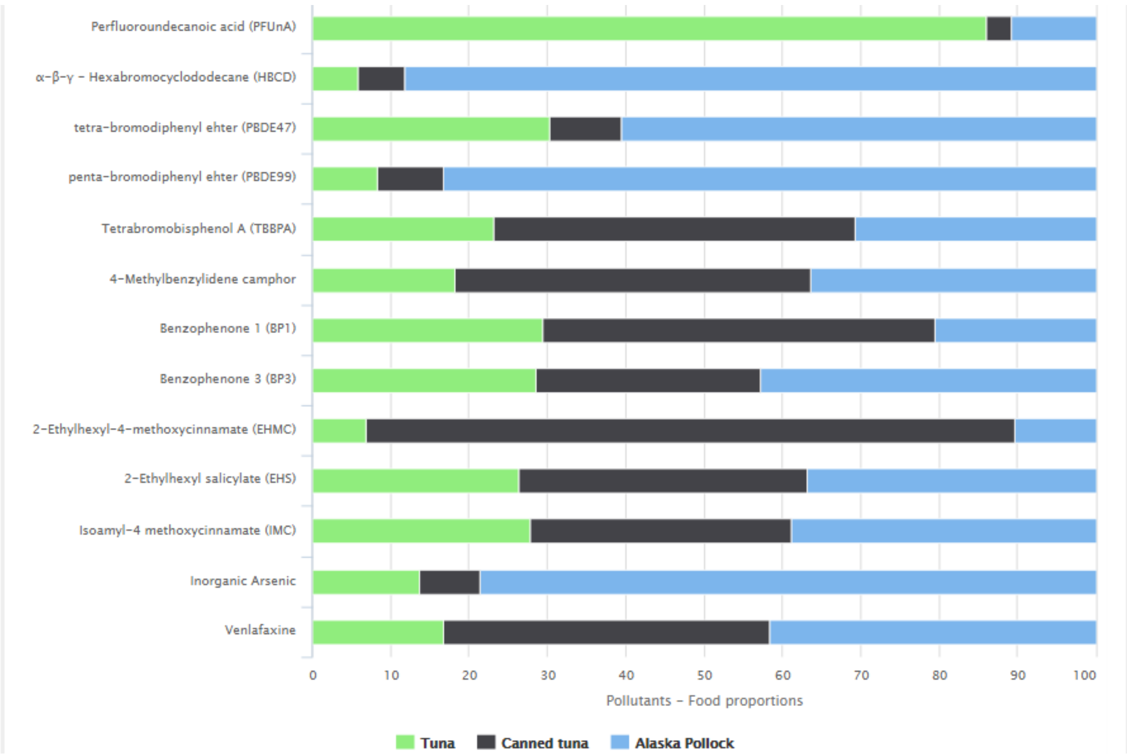


Figure 11. Pollutant graph for health professionals.

Moreover, clicking the nutrient tab, it can be seen the macro- and micronutrient consumption, as well as, the minimum recommended values for each nutrient, considering the proportion for each nutrient that should provide only based on seafood consumption (Figure 12).

POLLUTANTS | POLLUTANTS GRAPH | NUTRIENTS | NUTRIENTS GRAPH | ANY NEED TO CHANGE?

All numerical values are in µg/kg body weight/week		Other foods with a high potential contribution
Protein	WEEKLY INTAKE: 1227739.286 MINIMUM RECOMMENDED: 763637	Meat/Eggs/Milk and Dairy Products
Omega-3 polyunsaturated fatty acid (n-3 PUFA)	WEEKLY INTAKE: 7866.071 MINIMUM RECOMMENDED: 31818.5	Cultivated Marine Algae/Linseeds/Rapeseed Oil and Walnuts
Vitamin A	WEEKLY INTAKE: 5.34 MINIMUM RECOMMENDED: 2.38	Meat/Dairy Products/Eggs/Vegetables and Fruits
Vitamin D	WEEKLY INTAKE: 0.197 MINIMUM RECOMMENDED: 0.21	Fungi and Egg Yolk
Vitamin E	WEEKLY INTAKE: 59.468 MINIMUM RECOMMENDED: 50.82	Vegetables Oils/Nuts and Seeds/Egg Yolk and Whole Grain Cereals
Iodine	WEEKLY INTAKE: 2.107 MINIMUM RECOMMENDED: 3.01	Eggs and Milk
Selenium	WEEKLY INTAKE: 4.308 MINIMUM RECOMMENDED: 1.61	Milk and Dairy Products/Meat and Meat Products and Grains

Figure 12. Nutrient screen for a boy (health professional version). Blue fish – below the minimum recommended; green fish – above the minimum recommended

These results suggest the interest of adjusting seafood consumption habits for this boy. A potential new seafood consumption pattern could consider replacing the large portion of tuna by a large portion of mackerel in order to avoid the high consumption of MeHg. Only considering this minor change, the consumption of MeHg for the boy could be reduced from 1.473 µg/kg bw/week to 0.677 µg/kg bw/week, being below the established tolerable weekly intake value. In this case, it has only changed one of the species consumed. By clicking the pollutant screen, it can be now observed that any contaminant surpass the respective maximum recommended value (Figure 13).

POLLUTANTS | POLLUTANTS GRAPH | NUTRIENTS | NUTRIENTS GRAPH | ANY NEED TO CHANGE?

All numerical values are in µg/kg body weight/week		Other foods with a high potential contribution
Bisphenol A (BPA)	WEEKLY INTAKE: 0.027 MAXIMUM RECOMMENDED: 28	
Galaxolide	WEEKLY INTAKE: 0.023 MAXIMUM RECOMMENDED: 3500	
Tonalide	WEEKLY INTAKE: 0.007 MAXIMUM RECOMMENDED: 350	
Methylparaben	WEEKLY INTAKE: 0.001 MAXIMUM RECOMMENDED: 17500	
Triclosan	WEEKLY INTAKE: 0.002 MAXIMUM RECOMMENDED: 329000	
Methylmercury	WEEKLY INTAKE: 0.618 MAXIMUM RECOMMENDED: 1.3	Meat and Meat Products/ Vegetables/ Tubers
PAH4	WEEKLY INTAKE: 0.013 MAXIMUM RECOMMENDED: 2380	Meat and Meat products/Oils and fats/Dairy Products
Perfluorononanoic acid (PFNA)	WEEKLY INTAKE: 0.001 MAXIMUM RECOMMENDED: 1330	
Perfluorooctanoic acid (PFOA)	WEEKLY INTAKE: 0.001 MAXIMUM RECOMMENDED: 10.5	
Perfluorooctane sulfonate (PFOS)	WEEKLY INTAKE: 0.005 MAXIMUM RECOMMENDED: 1.05	Dairy Products/Cereals/Meat and Meat Products
Perfluoroundecanoic acid (PFUnA)	WEEKLY INTAKE: 0.002 MAXIMUM RECOMMENDED: 7	
penta-bromodiphenyl ehter (PBDE99)	WEEKLY INTAKE: 0.003 MAXIMUM RECOMMENDED: 84	
Tetrabromobisphenol A (TBBPA)	WEEKLY INTAKE: 0.015 MAXIMUM RECOMMENDED: 112000	
4-Methylbenzylidene camphor	WEEKLY INTAKE: 0.012 MAXIMUM RECOMMENDED: 1750	
Benzophenone 1 (BP1)	WEEKLY INTAKE: 0.025 MAXIMUM RECOMMENDED: 7000	
Benzophenone 3 (BP3)	WEEKLY INTAKE: 0.022 MAXIMUM RECOMMENDED: 14000	
2-Ethylhexyl-4-methoxycinnamate (EHMC)	WEEKLY INTAKE: 0.026 MAXIMUM RECOMMENDED: 31500	
2-Ethylhexyl salicylate (EHS)	WEEKLY INTAKE: 0.021 MAXIMUM RECOMMENDED: 1750	
Isoamyl-4 methoxycinnamate (IMC)	WEEKLY INTAKE: 0.02 MAXIMUM RECOMMENDED: 31500	
Inorganic Arsenic	WEEKLY INTAKE: 0.126 MAXIMUM RECOMMENDED: 2.1	Cereals/Dairy Products/ Vegetables
Venlafaxine	WEEKLY INTAKE: 0.0002 MAXIMUM RECOMMENDED: 37.8	

Figure 13. Pollutant screen for a boy (health professional version) after changing the consumption habits.

In addition, the program offers another tab called Any need to change? When the user clicks here, the list of all contaminants considered is shown. Clicking one of them reveals the list of species ordered from the highest to the lowest levels of pollutants (Figure 14). Considering this information, the user can also modify his seafood consumption habits in order to reduce the exposure to environmental pollutants.

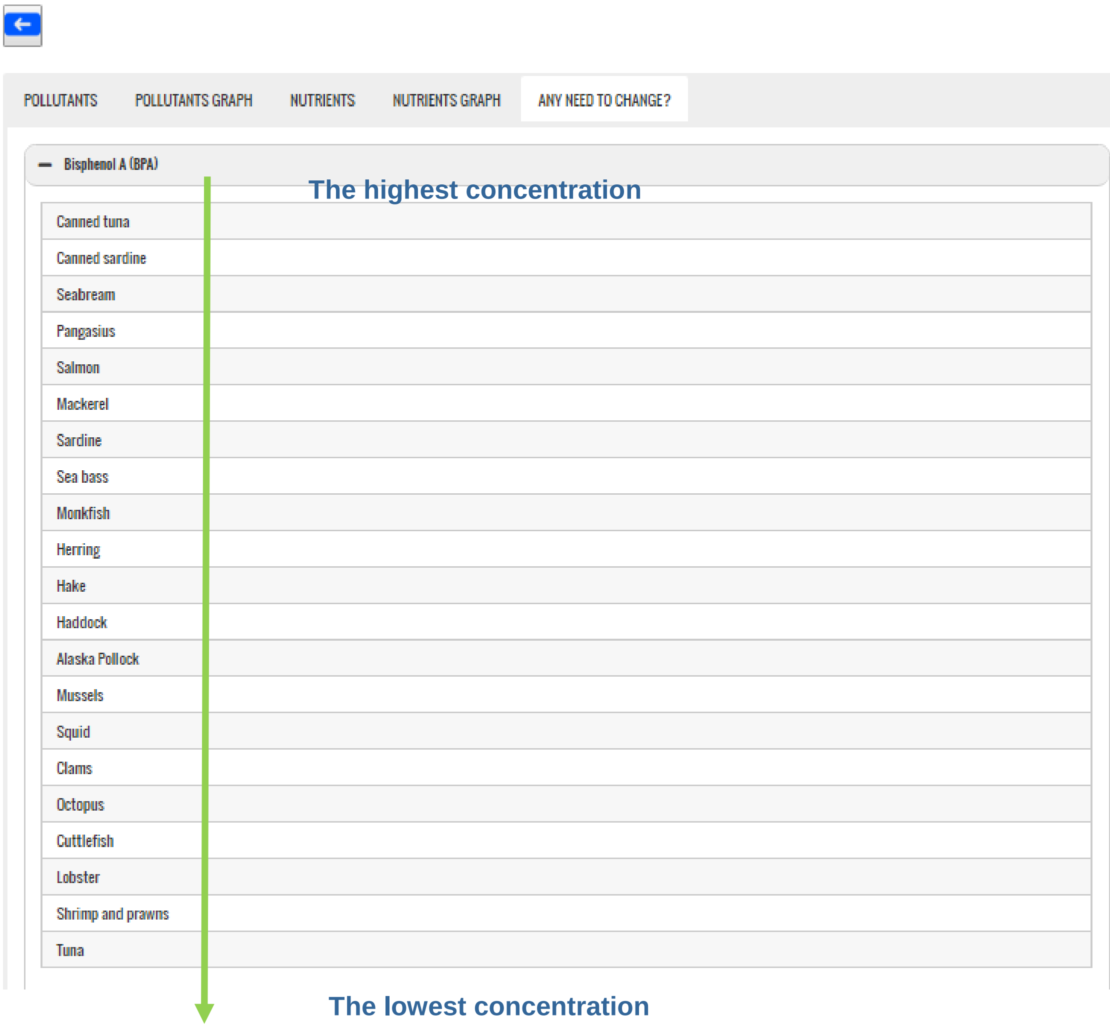


Figure 14. The list of species ordered from the highest bisphenol A concentration to the lowest bisphenol A concentration.

5. Discussion and Conclusions

According to many scientific studies, it has been demonstrated that benefits associated with seafood consumption exceeds the risks derived from the presence of environmental contaminants in fish and shellfish. Anyhow, the specific fish and shellfish species consumed, the frequency of consumption, as well as the portion size, are essential for adequately balancing the health benefits and risks of regular seafood consumption (Domingo, 2016).

Improving the diet and lifestyle is a critical point of view for the strategy of The American Heart Association (AHA), and other international Heart Associations for cardiovascular disease reduction in the society. Consumption of seafood at least twice per week is one of the main dietary recommendations. Nevertheless, it is clear that many studies supporting this guidance, did not sufficiently consider the potential risks derived from seafood consumption. Hence, the main message is that for the general population the benefits of eating fish far surpass the risks (Hellberg et al., 2012; Oken et al., 2012; Pohjola et al., 2012). Despite the fact that some researches have shown certain questions regarding this general statement, concern has been only focused on few pollutants, mainly methylmercury. According to Cohen et al. (2005) the replacement of fish species with major MeHg levels by seafood containing less MeHg among women at childbearing age yielded substantial developmental benefits and few negative impacts. On the other hand, the same authors highlighted that if the general population also reduce their seafood consumption, the net public health impact would be negative.

Regarding the emerging pollutants considered in this online tool, it has been found that the current concentrations determined for the majority of species studied revealed that the values are far below compared with the values presently set. However, more studies are needed in order to define tolerable weekly intakes for these environmental pollutants of emerging concern that due to the lack of evidences are still not established.

To sum up, we recommend seafood consumption due to all their nutritional benefits, not only for the PUFA content, but also for proteins, vitamins, iodine and selenium elements. Notwithstanding, the health risks arising from the concurrent exposure to chemical pollutants must also be taken into account. Therefore, FISHCHOICE can be used as a useful online tool to improve the balance between benefits (nutrients) and risks (pollutants) of seafood consumption and guide consumers and health professionals in a healthy, nutritious and balanced selection of seafood.

6. Foreseen Tasks

URV will establish how the health professionals can access to Pro version. In addition, URV will establish how it will be regulated the access to the professionals.

For validation, the first idea is to obtain answers from the same participants in the consumer survey. Alternatively, URV has thought in a smaller group of population, for instance, nutrition and dietetic students. URV will prepare a survey in order to ask to the participants what their perception about the online tool is. And at the beginning of July, WP3 members will have a Skype meeting in order to define how to perform this survey. URV will be able to send the protocol to the participants in order to testing the software when the final version is accepted. Then, the surveys will be done for a period of three months in order to receive all the inputs. The next step will be to study all the suggestions and to implement improvements, if necessary, during the next month after receiving the inputs.

References

Cohen, J.T., Bellinger, D.C., Connor, W.E., Kris-Etherton, P.M., Lawrence, R.S., Savitz, D.A., Shaywitz, B.A., Teutsch, S.M., Gray, G.M., 2005. A quantitative risk-benefit analysis of changes in population fish consumption. American Journal of Preventive Medicine 29, 325-334.

Domingo, J.L., 2016. Nutrients and Chemical Pollutants in Fish and Shellfish. Balancing Health Benefits and Risks of Regular Fish Consumption. Critical Reviews in Food Science and Nutrition 56, 979-988.

Domingo, J.L., Bocio, A., Falcó, G., Llobet, J.M., 2007a. Benefits and risks of fish consumption. Part I. A quantitative analysis of the intake of omega-3 fatty acids and chemical contaminants. Toxicology 230, 219-226.

Domingo, J.L., Bocio, A., Martí-Cid, R., Llobet, J.M., 2007b. Benefits and risks of fish consumption. Part II. RIBEPEIX, a computer program to optimize the balance between the intake of omega-3 fatty acids and chemical contaminants. Toxicology 230, 227-233.

EFSA, 2012. "Scientific Opinion on the risk for public health related to the presence of mercury and methylmercury in food, EFSA Panel on Contaminants in the Food Chain (CONTAM)." EFSA Journal 10(12).

FAO/WHO, 2011. Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption. Rome, Food and Agriculture Organization of the United Nations; Geneva, World Health Organization, 50 pp.

Fuge, R., Johnson, C.C., 2015. Iodine and human health, the role of environmental geochemistry and diet, a review. Applied Geochemistry 63, 282-302.

Hellberg, R.S., Dewitt, C.A.M., Morrissey, M.T., 2012. Risk-Benefit Analysis of Seafood Consumption: A Review. Comprehensive Reviews in Food Science and Food Safety 11, 490-517.

Jacobs, S., Sioen, I., Pieniak, Z., De Henauw, S., Maulvault, A.L., Reuver, M., Fait, G., Cano-Sancho, G., Verbeke, W., 2015. Consumers' health risk-benefit perception of seafood and attitude toward the marine environment: Insights from five European countries. Environmental Research 143, 11-19.

Karimi, R., Fisher, N.S., Meliker, J.R., 2014. Mercury-nutrient signatures in seafood and in the blood of avid seafood consumers. Science of the Total Environment 496, 636-643.

Larsen, R., Eilertsen, K.E., Elvevoll, E.O., 2011. Health benefits of marine foods and ingredients. Biotechnology Advances 29, 508-518.

Lehmann, U., Gjessing, H.R., Hirche, F., Mueller-Belecke, A., Gudbrandsen, O.A., Ueland, P.M., Mellgren, G., Lauritzen, L., Lindqvist, H., Hansen, A.L., Erkkilä, A.T., Pot, G.K., Stangl, G.I., Dierkes, J., 2015. Efficacy of fish intake on Vitamin D status: A meta-analysis of randomized controlled trials. American Journal of Clinical Nutrition 102, 837-847.

Lopez De Alda, M.J., Díaz-Cruz, S., Petrovic, M., Barceló, D., 2003. Liquid chromatography-(tandem) mass spectrometry of selected emerging pollutants (steroid sex hormones, drugs and alkylphenolic surfactants) in the aquatic environment. Journal of Chromatography A 1000, 503-526.

Matos, J., Lourenço, H.M., Brito, P., Maulvault, A.L., Martins, L.L., Afonso, C., 2015. Influence of bioaccessibility of total mercury, methyl-mercury and selenium on the risk/benefit associated to the consumption of raw and cooked blue shark (Prionace glauca). Environmental Research 143, 123-129.

Mohanty, B.P., Sankar, T.V., Ganguly, S., Mahanty, A., Anandan, R., Chakraborty, K., Paul, B.N., Sarma, D., Dayal, J.S., Mathew, S., Asha, K.K., Mitra, T., Karunakaran, D., Chanda, S., Shahi, N., Das, P., Das, P., Akhtar, M.S., Vijayagopal, P., Sridhar, N., 2016. Micronutrient Composition of 35 Food Fishes from India and Their Significance in Human Nutrition. Biological Trace Element Research, 1-11.

Navarro-Alarcon, M., Cabrera-Vique, C., 2008. Selenium in food and the human body: A review. Science of the Total Environment 400, 115-141.

Oken, E., Choi, A.L., Karagas, M.R., Mariën, K., Rheinberger, C.M., Schoeny, R., Sunderland, E., Korrick, S., 2012. Which fish should I eat? Perspectives influencing fish consumption choices. Environmental Health Perspectives 120, 790-798.

Pedrero, Z., Madrid, Y., 2009. Novel approaches for selenium speciation in foodstuffs and biological specimens: A review. Analytica Chimica Acta 634, 135-152.

Pohjola, M.V., Leino, O., Kollanus, V., Tuomisto, J.T., Gunnlaugsdóttir, H., Holm, F., Kalogeras, N., Luteijn, J.M., Magnússon, S.H., Odekerken, G., Tijhuis, M.J., Ueland, Ø., White, B.C., Verhagen, H., 2012. State of the art in benefit-risk analysis: Environmental health. Food and Chemical Toxicology 50, 40-55.

Ralston, N.V.C., Raymond, L.J., 2010. Dietary selenium's protective effects against methylmercury toxicity. Toxicology 278, 112-123.

Riaz, M., Mehmood, K.T., 2012. Selenium in human health and disease: A review. Journal of Postgraduate Medical Institute 26, 120-133.

Ruiz, E., Ávila, J., Valero, T., del Pozo, S., Rodriguez, P., Aranceta-Bartrina, J., Gil, Á., González-Gross, M., Ortega, R., Serra-Majem, L., Varela-Moreiras, G., 2016. Macronutrient Distribution and Dietary Sources in the Spanish Population: Findings from the ANIBES Study. Nutrients 8, 177.

Santhosh Kumar, B., Priyadarsini, K.I., 2014. Selenium nutrition: How important is it? Biomedicine and Preventive Nutrition 4, 333-341.

Sirot, V., Leblanc, J.C., Margaritis, I., 2012. A risk-benefit analysis approach to seafood intake to determine optimal consumption. British Journal of Nutrition 107, 1812-1822.

Tediosi, A., Fait, G., Jacobs, S., Verbeke, W., Álvarez-Muñoz, D., Diogene, J., Reuver, M., Marques, A., Capri, E., 2015. Insights from an international stakeholder consultation to identify informational needs related to seafood safety. Environmental Research 143, 20-28.

Vandermeersch, G., Lourenço, H.M., Alvarez-Muñoz, D., Cunha, S., Diogène, J., Cano-Sancho, G., Sloth, J.J., Kwadijk, C., Barcelo, D., Allegaert, W., Bekaert, K., Fernandes, J.O., Marques, A., Robbens, J., 2015. Environmental contaminants of emerging concern in seafood - European database on contaminant levels. Environmental Research 143, 29-45.

Wille, K., De Brabander, H.F., Vanhaecke, L., De Wulf, E., Van Caeter, P., Janssen, C.R., 2012. Coupled chromatographic and mass-spectrometric techniques for the analysis of emerging pollutants in the aquatic environment. TrAC - Trends in Analytical Chemistry 35, 87-108.