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Undesirable substances in seafood products – results from the Icelandic marine monitoring activities in the year 2011

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Öryggi, umhverfi og erfðir

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Report summary

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Ágrip á íslensku:	Árið 2003 hófst, að frumkvæði sjávarútvegsráðuneytisins, vöktun fyrir óæskilegum efnum í sjávarafurðum, bæði afurðum til manneldis sem afurðum til lýsis- og mjöliðnaðar. Matís hefur verið falin umsjón með vöktunarverkefninu. Tilgangur vöktunarinnar er að meta ástand íslenskra sjávarafurða með tilliti til magns aðskotaefna. Einnig er markmið að safna óháðum vísindagögnum um óæskileg efni í sjávarafurðum fyrir stjórnvöld, fiskiðnaðinn og kaupendur og neytendur íslensks sjávarfangs. Gögnin sem safnað er í vöktunarverkefninu verða einnig notuð í áhættumat og til að byggja upp gagnagrunn um aðskotaefni í íslensku lífríki. Umfjöllun um aðskotaefni í sjávarafurðum, bæði í almennum fjölmiðlum og í vísindaritum, hefur margoft krafist viðbragða íslenskra stjórnvalda. Nauðsynlegt er að hafa til taks vísindaniðurstöður sem sýna raunverulegt ástand íslenskra sjávarafurða til þess að koma í veg fyrir tjón sem af slíkri umfjöllun getur hlotist. Ennfremur eru mörk aðskotaefna í sífelldri endurskoðun og er mikilvægt fyrir Íslendinga að taka þátt í slíkri endurskoðun og styðja mál sitt með vísindagögnum. Þetta sýnir mikilvægi þess að regluleg vöktun fari fram og að á Íslandi séu stundaðar sjálfstæðar rannsóknir á eins mikilvægum málaflokki og mengun sjávarafurða er. Þessi skýrsla er samantekt niðurstaðna vöktunarinnar fyrir árið 2011. Mat á ástandi íslenskra sjávarafurða með tilliti til aðskotaefna er langtímaverkefni og verður einungis framkvæmt með sívirkri vöktun. Á hverju ári er því farið vandlega yfir hvaða gögn vantar og þannig stefnt að því að fylla inní eyðurnar. Árið 2011 voru í fyrsta skipti mæld svokölluð PFC efni í íslenskum sjávarafurðum sem ætlaðar eru til manneldis sem og afurðum til lýsis- og mjöliðnaðar, en PFC efni eru yfirborðsvirk efni sem hafa fengið aukna athygli vegna þrávirkni og eitrunaráhrifa þeirra. Einnig voru eftirfarandi efni mæld: dioxin, dioxinlík PCB og bendi PCB efni, PBDEs, málmar, auk þess 12 mismunandi tegundir varnarefna. Árið 2011 voru einnig mæld grásleppuhrogn ásamt þorskhrognum, svili og lifur til að meta dreifingu mengandi efna í þessi líffæri. Af PCF efnunum var PFOS eina PFC efnið sem greindist yfir greiningarmörkum og var styrkur PFOS yfirleitt lágur. Eins og áður mældist almennt lítið magn óæskilegra efna í íslensku sjávarfangi árið 2011 og ekkert sýni mældist með óæskileg efni yfir viðmiðunarmörkum.		
Lykilorð á íslensku:	*Sjávarfang, vöktun, Díoxín, díoxínlík PCB, PCB, varnarefni, PBDEs, málmar*		

Skýrsluágrip Matís ohf
Icelandic Food and Biotech R&D

Report summary

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Summary in English:	This screening of undesirable substances in seafood products was initiated by the Icelandic Ministry of Fisheries and Agriculture in the year 2003. Until then, this type of monitoring had been limited in Iceland. Matis was assigned the responsibility of carrying out the surveillance program, which has now been ongoing for eight consecutive years. The purpose of the project is to gather information and evaluate the status of Icelandic seafood products in terms of undesirable substances. Further, the aim of the project is to provide independent scientific data on undesirable substances in Icelandic seafood for food authorities, fisheries authorities, industry, markets and consumers. The information will also be utilized for a risk assessment and gathering of reference data. This report summarizes the results obtained in the year 2011 for the screening of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. The evaluation of the status of the Icelandic seafood products in terms of undesirable substances is a long term project which can only be reached through continuous gathering of data. For this reason, both the undesirable substances and seafood samples are carefully selected each year with the aim to fill in the gaps of the available data. Thus, the project fills in gaps of knowledge regarding the level of undesirable substances in economically important marine catches for Icelandic export. In the year 2011, PFCs were analyzed for the first time in the edible part of fish, fish oil and meal for feed from Icelandic fishing grounds but PFCs is a group of surfactants that have received increased attention due to their persistency and toxic effects. In addition, data was collected on dioxins, dioxin-like PCBs, marker PCBs, 12 different types of pesticides, PBDEs and trace metals. Samples collected in 2011 contained generally low concentrations of undesirable substances. The year 2011, lumpfish roes as well as roes, sperm and liver of cod were analyzed in order to estimate the organ distribution of pollutants. PFOS was the only PFC analyzed above limits of detection and its concentration was generally low. These results are in agreement with our previous results obtained in the monitoring program in the years 2003 to 2010. No sample contained undesirable compounds exceeding the maximum level set by the EU.
English keywords:	*Marine catches, monitoring, dioxin, PCB, pesticides, PBDEs, metals*

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1 Introduction

In 2003, the Icelandic Ministry of Fisheries initiated a project aimed at screening for undesirable substances in the edible portion of marine catches, as well as in fish meal and fish oil for feed, captured in Icelandic waters. Matis was assigned the responsibility of carrying out the surveillance programme, which has now been on-going for eight consecutive years. The goal of the surveillance programme is to gather information and evaluate the status of Icelandic seafood products regarding undesirable substances. The project is funded by the Ministry of Fisheries and Agriculture in Iceland. The project includes measurements on various undesirable substances in a number of economically important marine species from Icelandic fishing grounds in order to gather information for Icelandic export. Special emphasis was on poly- and perfluorinated compounds (PFC), where limited knowledge is available on levels and distribution of these compounds in the Icelandic marine environment. This is the first time PFCs are included in the present screening program. The substances investigated in this monitoring project are: poly- and perfluorinated compounds, polychlorinated dibenzo dioxins and dibenzo furans (commonly called dioxins), dioxin-like polychlorinated biphenyls (PCBs), marker PCBs, polybrominated flame retardants (PBDEs), 30 pesticides and breakdown products (i.e. HCB, DDTs, HCHs, dieldrin, endrin, chlordanes, toxaphenes and endosulfan substances) and inorganic trace elements such as heavy metals.

The purpose of this work is:

A) To gather information and evaluate the status of Icelandic seafood products in terms of undesirable substances.
B) Provide scientific evidence that Icelandic seafood products conform to regulations on seafood safety. That is, to evaluate how products measure up to limits currently in effect for inorganic trace elements, organic contaminants and pesticides in the EU (Regulation (EC) No 1881/2006, Commission Regulation (EC) No 629/2008, Commission Directive 2002/32/EC, Commission Directive 2003/100/EC).
C) To utilize the data gather in the programme for a risk assessment and the setting of maximum values that are now under consideration within EU e.g. for PAHs, PCBs, inorganic arsenic and brominated flame retardants, etc.
D) Provide independent scientific data on undesirable substances in Icelandic seafood for food authorities, fisheries authorities, industry, markets and consumers.

This report summarizes results from the screening programme in the year 2011. The results obtained in the years 2003 to 2010 have already been published and are accessible at the Matis website (http://www.matis.is: Auðunsson, 2004, Ásmundsdóttir *et al*., 2005, Ásmundsdóttir and Gunnlaugsdóttir, 2006, Ásmundsdóttir *et al.*, 2008, Jörundsdóttir *et al.*, 2009, Jörundsdóttir *et al.*, 2010a, Jörundsdóttir *et al.*, 2010b, Baldursdóttir *et al.*, 2011). The above mentioned EU regulations have now been implemented in the Icelandic legal framework regarding undesirable substances in food and feed (Reglugerð 265/2010).

2 Summary

This report summarizes the results obtained in 2011 for the screening of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. The surveillance program began in 2003 and has now been carried out for eight consecutive years. The project fills in gaps of knowledge regarding the level of undesirable substances in economically important marine catches for Icelandic export. It is considered to be a long-term project where extension and revision is constantly necessary.

In the year 2011 emphasis was laid on gathering information on the organic compounds PFCs and inorganic trace elements in the edible part of marine catches as well as in the fish meal and fish oil for feed. Generally, the results obtained in 2011 are in agreement with our previous results on undesirable substances in the edible part of marine catches, fish meal and fish oil for feed obtained in the monitoring years 2003 to 2010. The results show that the edible parts of Icelandic seafood products contain negligible amounts of persistent organic pollutants (POPs) such as; dioxins, dioxin like PCBs and pesticides. The results for PBDEs reveal that these compounds are also in very low amounts in fish and fish products. This is the first time PFCs are analysed in Icelandic seafood and fish products and the results show that the main PFC compound, perfluorooctane sulfonate (PFOS) was the only congener detected, all other congeners (10 in total) were under limit of detection (LOD). Emphasis was laid on studying the PFCs concentration in different cod organs, the results show that only PFOS was detected and that the highest concentration was measured in cod roes while sperm and liver have similar concentrations. Further, the concentration of marker PCBs was found to be low in the edible part of fish muscle, compared to the maximum limits in the European countries, where such limits exist. The results showed that the concentrations of heavy metals, e.g. cadmium (Cd), lead (Pb) and mercury (Hg) in Icelandic seafood products was always well below the maximum limits set by EU.

The samples of fish meal and fish oil for feed measured are subjected to different maximum limits by the EU. This year all samples measured were below the EU maximum limits for feed components of marine origin.

3 Contaminants measured in the project

The following contaminants are measured in edible parts of seafood and fish oil for human consumption, as well as in fish meal and fish oils used as feed ingredients:

Dioxins, PCDD/Fs: Dioxins (dibenzo-p-dioxins) and dibensofurans (17 congeners according to WHO): 2.3.7.8-Tetra-CDD, 1.2.3.7.8-Penta-CDD, 1.2.3.4.7.8-Hexa-CDD, 1.2.3.6.7.8-Hexa-CDD, 1.2.3.7.8.9-Hexa-CDD, 1.2.3.4.6.7.8-Hepta-CDD, OCDD, 2.3.7.8-Tetra-CDF, 1.2.3.7.8-Penta-CDF, 2.3.4.7.8-Penta-CDF, 1.2.3.4.7.8-Hexa-CDF, 1.2.3.6.7.8-Hexa-CDF, 1.2.3.7.8.9-Hexa-CDF, 2.3.4.6.7.8-Hexa-CDF, 1.2.3.4.6.7.8-Hepta-CDF, 1.2.3.4.7.8.9-Hepta-CDF, OCDF.

Dioxin like PCB (12 congeners according to WHO):
non-ortho (CB-77, CB-81, CB-126, CB-169) and mono-ortho (CB-105, CB-114, CB-118, CB-123, CB-156, CB-157, CB-167, CB-189).

Marker- PCB (7 congeners):
CB-28, CB-52, CB-101, CB-118, CB-138, CB-153, CB-180.

Pesticides:
DDT-substances (6 congeners: pp-DDT, op-DDT, pp-DDD, op-DDD, pp-DDE and op-DDE), HCH-substances (4 isomers: α-, β-, γ-(Lindane), and δ-hexachlorocyclohexan), HCB, chlordanes (4 congeners and isomers: α- and γ-chlordane, oxychlordane and trans-nonachlor), toxaphenes (3 congeners, P 26, 50 and 62), aldrin, dieldrin, endrin, endosulfan (3 congeners and isomers: α- and β-endosulfan and endosulfansulfat) and heptachlor (3 congeners: heptachlor, cis-hepatchlorepoxid, trans-heptachlorepoxid).

PBDEs (10 congeners):
BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153, BDE-183, BDE-209.

Inorganic trace elements:
Hg (mercury), Cd (cadmium), Pb (lead), total As (organic and inorganic arsenic), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn) and selenium (Se).

PFCs (11 congeners):
Perfluorobutane sulfonat (PFBS), Perfluorodecanoate (PFDA), Perfluorodecane sulfonate (PFDS), Perfluorododecanate (PFDoA), Perfluoroheptanoate (PFHpA), Perfluorohexanoate (PFHxA), Perfluorohexane sulfonate (PFHxS), Perfluorononaoate

(PFNA) Perfluoroctanoate (PFOA), Perfluoroctane sulphonamide (PFOSA), Perfluoroctane sulfonate (PFOS).

4 Sampling and analysis

4.1 Sampling

The collection of samples and the quality criteria for the analytical methods were in accordance with conditions set out by the EU for the information gathering campaign on dioxins and dioxin-like PCBs as well as for metals (Commission Directive 2001/22/EC, Commission directive 2002/69/EC). Fish samples were collected by the Marine Research Institute (MRI) in Iceland. Mackerel (*Scomber scombrus*) samples were gathered from commercial industrial fish processor. Fish meal and fish oil were gathered by collaborating partners in the industry.

4.1.1 Seafood

All the analysis was done on the edible parts of the seafood products. The fish was collected from the fishing grounds around Iceland which are divided into five areas, as illustrated on

Figure 1. All samples were identified with the location of the fishing area, except when the sample contained individuals from more than one area. Each seafood sample consisted of a pooled sample from the entire edible part (e.g. skinless fish fillet) from at least ten individuals of a specific length distribution. For the internal organs the livers consisted of a pooled sample from 10 individuals, while number of roes and sperm in the pooled samples depended on the ratio of males and females. Cod roe sample no 1 and cod sperm sample no 3 (see Table 2 in the Appendix) consisted of five individuals each. Cod roe sample no 4 and cod sperm sample no 6 consisted of two and eight individuals, respectively. Lumpfish roe samples no 7, 8 and 9 consisted of 10 individuals each.

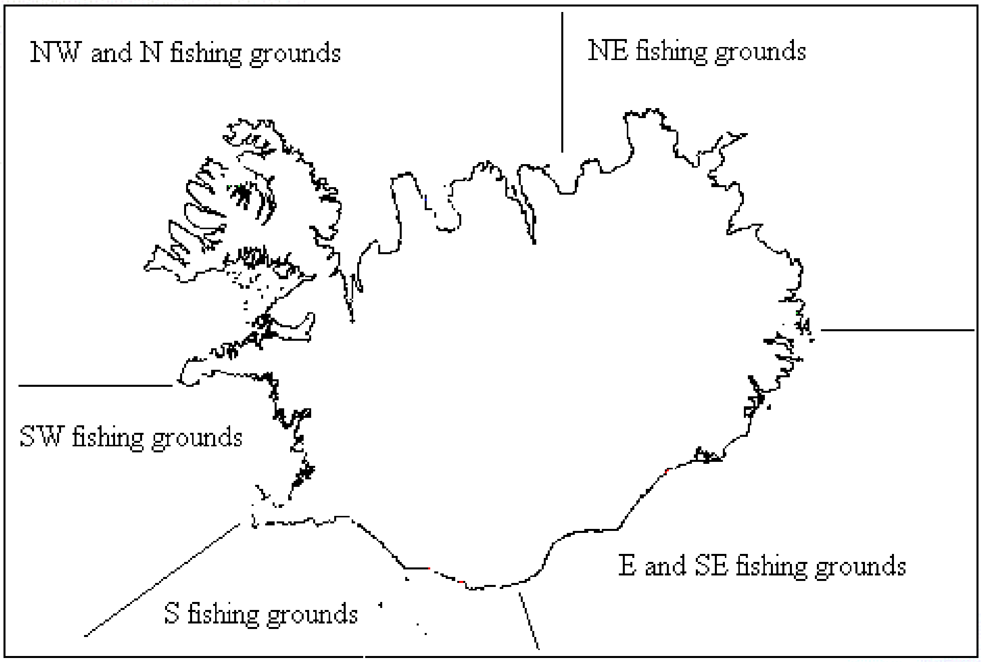

Figure 1: The division of the fishing grounds around Iceland used in this research.

4.1.2 Fish meal and fish oil for feed

The fish meal and fish oil samples were taken at the production sites and, when possible, sampling was distributed over the year. When possible, the fish meal and fish oil samples originate from the same batch.

4.2 Analysis

The organic contaminants were measured by Eurofins, Hamburg, Germany. Eurofins has taken part in international inter-laboratory quality control study organized by WHO and EU and uses accredited methods for analyzing dioxin, WHO-PCBs, marker-PCBs, pesticides and PBDEs.

Results are expressed as upper bond level, which means that when the concentration of a substance is measured to be below limit of detection (LOD) or limit of quantification (LOQ) of the analytical method, the concentration is set to be equal to the LOD/LOQ. In the case of dioxins and dioxin-like PCBs, the analytical data are converted to pg/g WHO-TEQ where the toxicity of each congener has been calculated using WHO-TEF (Toxic Equivalence Factor) based on the existing knowledge of its toxicity (Van den Berg et al., 1998). WHO-TEQ values have been adapted by the World Health Organization (WHO) in 1997 and by EU in its legislations.

5 Results of monitoring of fish and seafood products in Iceland

All results of the monitoring program in 2011 are listed in Tables 1-16 in the Appendix.

5.1 Dioxins (PCDD/Fs) and dioxin like PCBs

5.1.1 Dioxins and dioxin like PCBs in seafood

All the fish species measured are far below the limits set by EU for the sum of dioxins and dioxin like PCBs (Figure 2 and Table 1 in the Appendix). As in previous years, a considerable difference was observed in the dioxin content between different fish species. The species that accumulate fat in the muscle, like for example Greenland halibut (sample no. 4), contain more dioxins and dioxin like PCBs than species which accumulate fat in the liver and thus have almost no fat in the muscle. Mackerel and lumpfish have also higher lipid content in the muscle and therefore higher dioxin and dioxin like PCB concentrations. The level of dioxin in the edible part of the fish increases as the fat percentage in the muscle increases, but other important variables are age (length) and habitat. Greenland halibut can become quite old, which probably contributes considerably to the high dioxins and dioxin-like PCBs value obtained for this species (Figure 2).

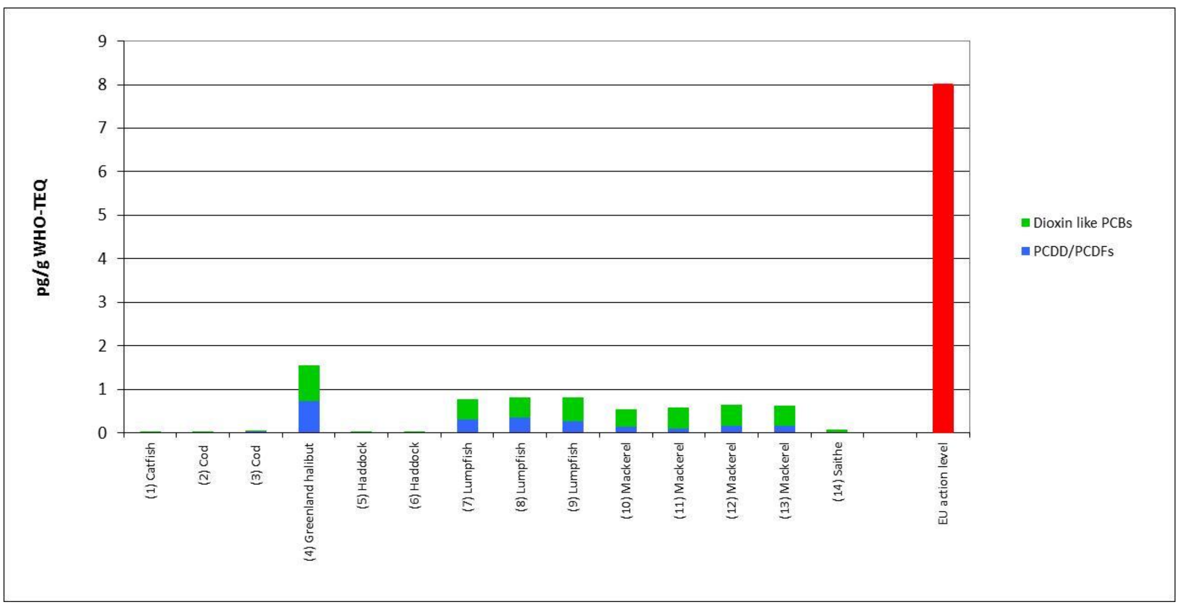

Figure 2: Dioxins and dioxin-like PCBs in the edible part of fish muscle from Icelandic fishing grounds in 2011 in relation to maximum EU limit in WHO-TEQ pg/g wet weight. The number within parenthesis is the sample number indicated in Table 1.

5.1.2 Dioxins and dioxin like PCBs in fish oil for human consumption

There were no samples of fish oil for human consumption analysed or collected from the fish oil industry this year. Earlier results from 2005 and 2006 showed concentrations below the EU maximum limit of 2 pg/g WHO-TEQ for dioxins or the EU maximum limit of 10 pg/g WHO-TEQ for the sum of dioxins and dioxin like PCBs (Ásmundsdóttir and Gunnlaugsdóttir, 2006, Ásmundsdóttir et al., 2008, Regulation (EC) No 1881/2006).

5.1.3 Dioxins and dioxin like PCBs in liver, roes and sperm

Two pooled samples of each of the following cod organs; cod livers, roes and sperm were collected and analysed this year. The reason for this selection was that these organs are all used for human consumption and limited data is available regarding the content of undesirable substances in them. Samples no. 1-3 in Table 2 correspond to cod sample no. 2 in Table 1 in the Appendix, samples no. 4-6 in Table 2 correspond to cod sample no. 3 in Table 1 in the Appendix. Concentrations of dioxins and dioxin like PCBs are below the EU maximum limit of 25 pg/g WHO-TEQ for cod liver.

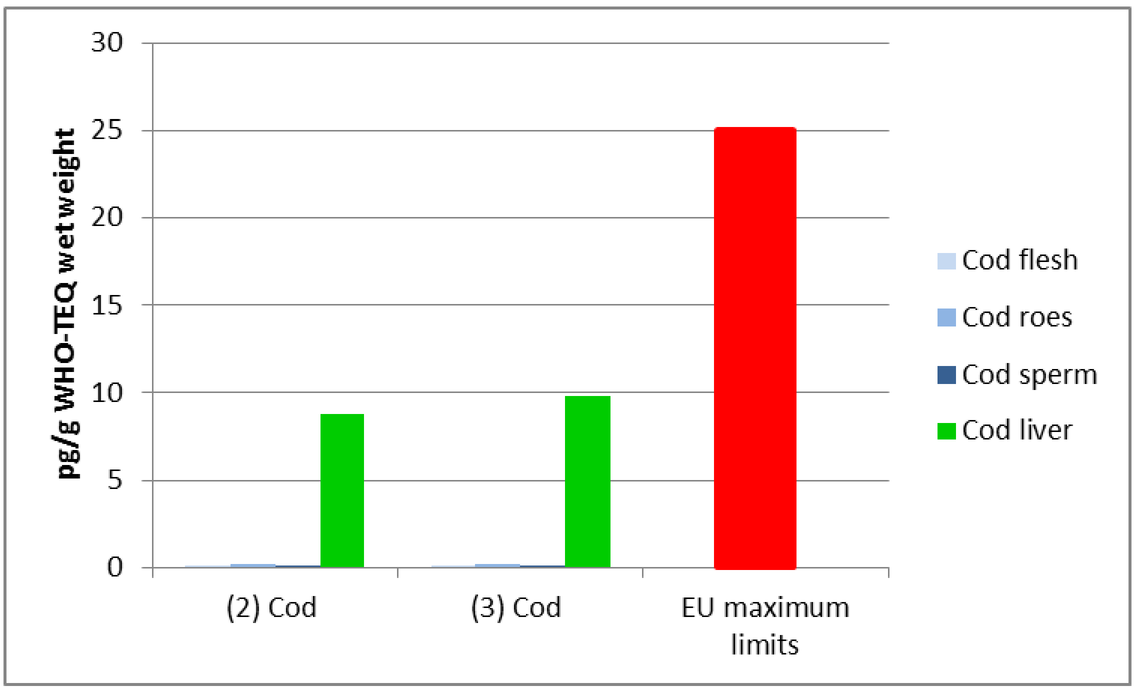

Figure 3: Comparison of sum of dioxins and dioxin like PCBs between different organs from of cod in pg/g WHO-TEQ wet weight.

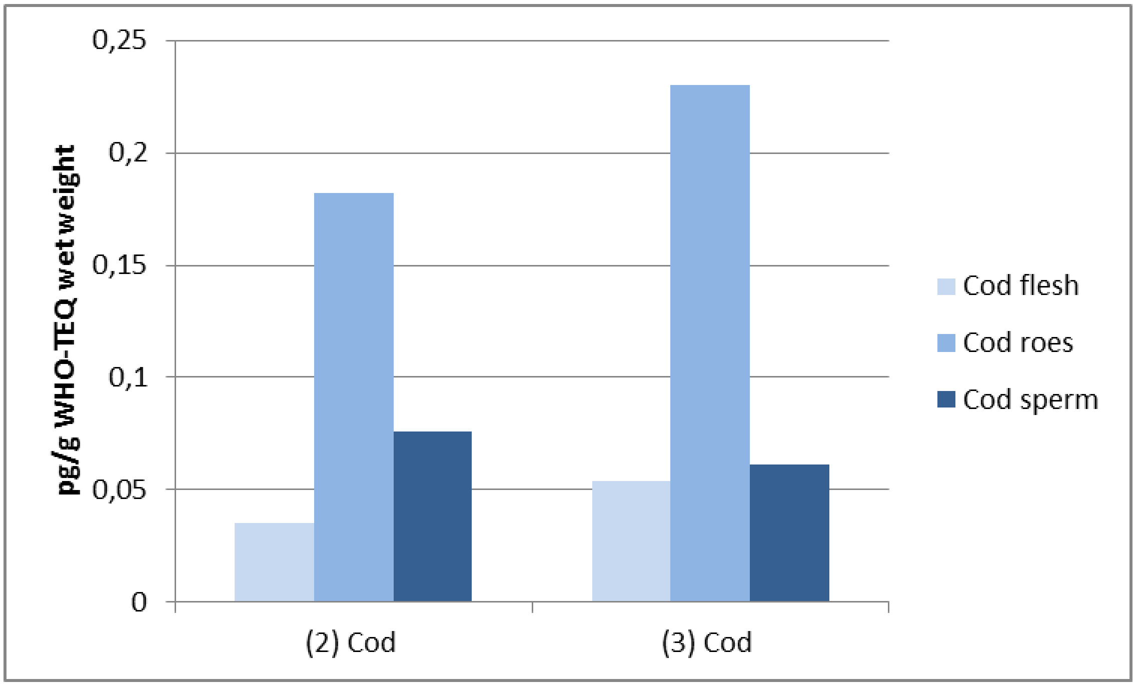

Figure 4: Comparison of sum of dioxins and dioxin like PCBs between cod flesh, cod roes and sperm excluding the results for cod liver in pg/g WHO-TEQ wet weight.

Figure 3 and Figure 4 show comparison of sum of dioxin and dioxin like PCB levels in different organs from cod. Cod accumulates fat in the liver which is clearly reflected in the dioxin and dioxin like PCB concentration. Lumpfish roes were also collected (Table 2 in the Appendix. Lumpfish roe no. 7 in Table 2 corresponds to lumpfish sample no. 7 in Table 1, lumpfish roe sample no. 8 in Table 2 corresponds to lumpfish sample no. 8 in Table 1 and lumpfish roe sample no. 9 Table 2 corresponds to lumpfish sample no. 9 in Table 1.

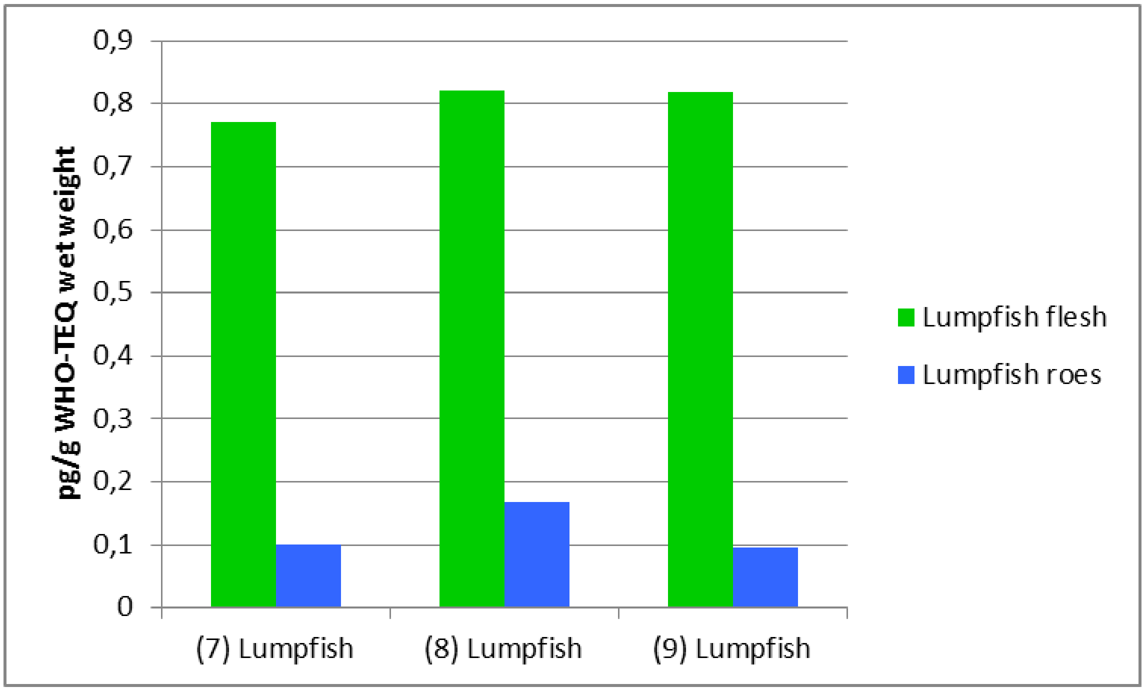

Figure 5: Comparison of sum of dioxin and dioxin like PCB between lumpfish flesh and lumpfish roes.

Figure 5 shows comparison in sum of dioxin and dioxin like PCBs between lumpfish flesh and lumpfish roes. The flesh has higher lipid content compared to the roes, 15% compared to 6.1%, respectively. This only explains a part of the difference in dioxin and dioxin like PCB concentration between the two organs where the dioxin concentration is almost seven times higher in flesh compared to roes, but the lipid content is only 2-3 times higher in flesh compared to roes.

5.1.4 Dioxins and dioxin like PCBs in fish meal and fish oil for feed

Samples of fish meal and fish oil are taken annually. The samples taken in the year 2011 consisted of capelin meal and herring meal and corresponding capelin oil. Concentration of dioxins and dioxin like PCBs are shown in Tables 3 and 4 in the Appendix. The EU maximum limits for dioxins and dioxin-like PCBs in fish meal and fish oil for feed are set relatively low in order to prevent the accumulation of these toxic substances in the food chain (Commission Directive 2006/13/EC). For this reason, results for these products are closer to the maximum limits than in the edible part of the fish muscle discussed in chapter 5.1.1.

The sum of dioxin and dioxin-like PCB was lower than the EU maximum limit in all fish meals tested (Figure 6). The same was observed for the fish oil (Figure 7).

All fish oil samples measured in this study are can be paired with specific fish meal samples, i.e. these fish oil and meal samples were obtained from the same original raw material and samples of the oil and meal were taken during production of this raw material. The fish oil samples correspond to the fish meal sample with the same number.

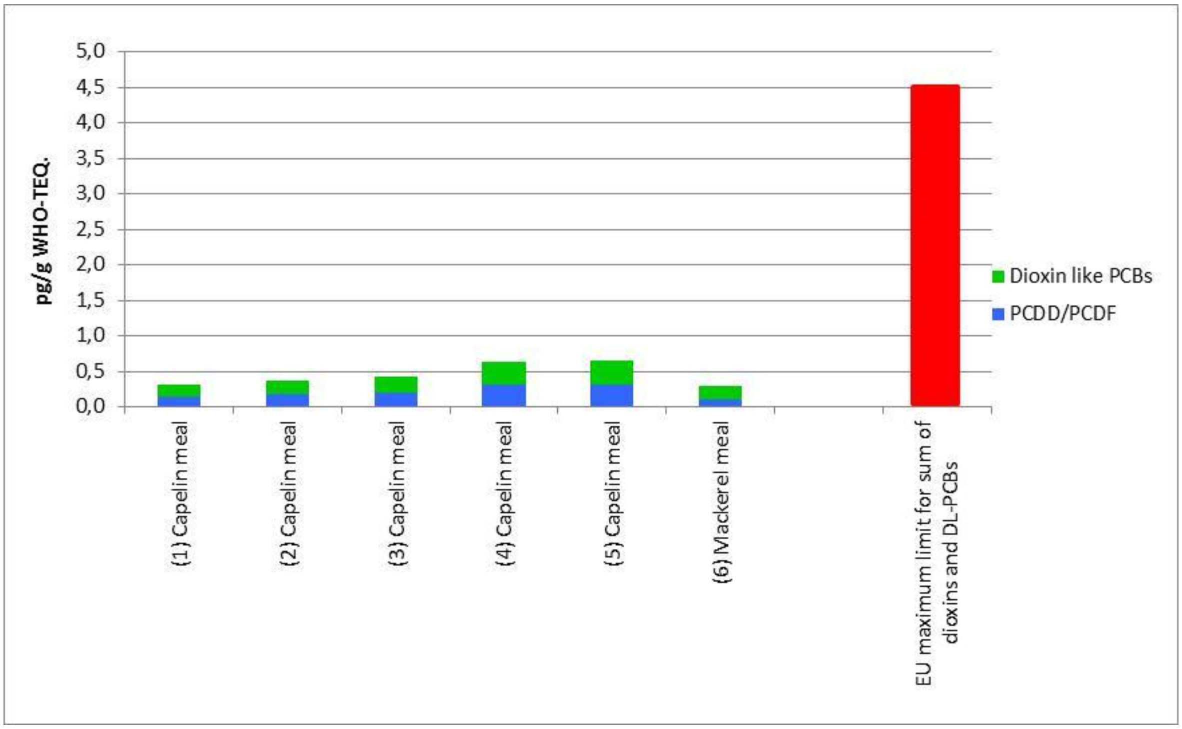

Figure 6: Dioxins and dioxin-like PCBs (in pg/g WHO-TEQ) in samples of fish meal from Iceland 2011 calculated in relation to 12% moisture compared to the EU maximum limit.

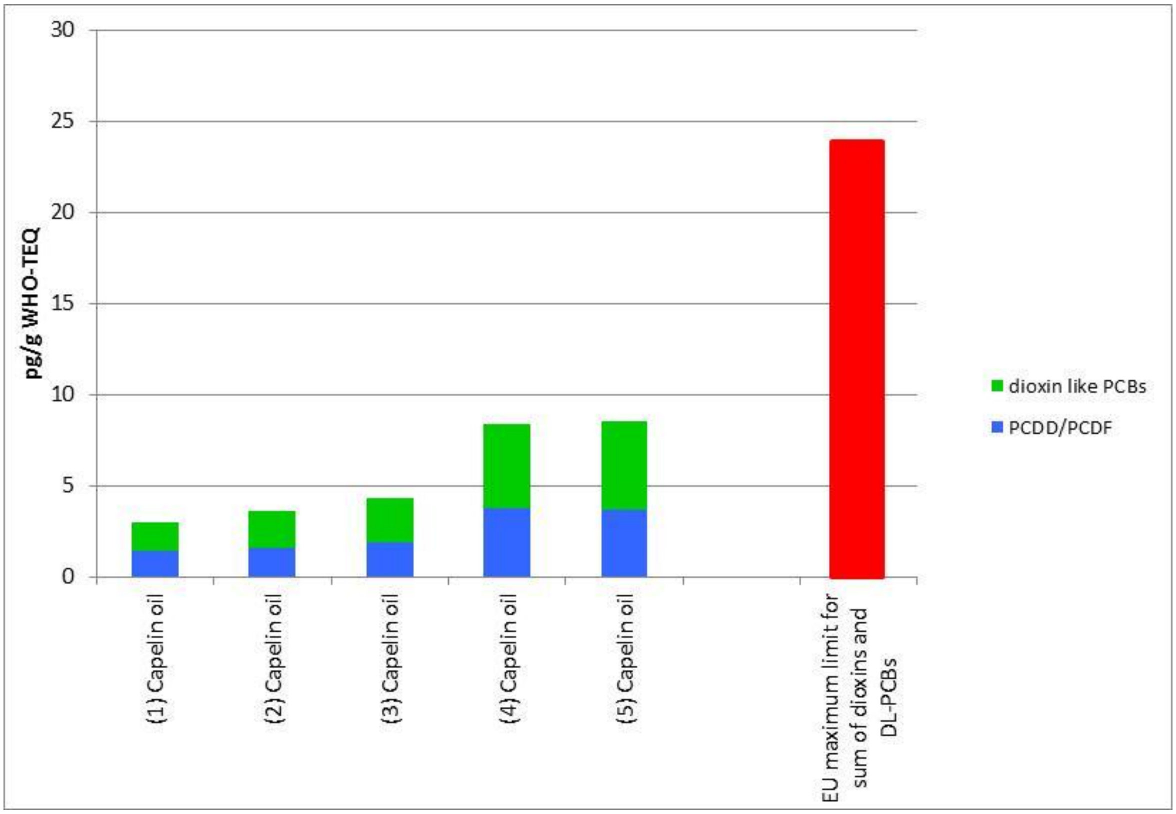

Figure 7: Dioxins and dioxin-like PCBs in samples of fish oil for feed from Iceland in 2011 (in pg/g WHO-TEQ) compared to the EU maximum limit.

5.2 Marker PCBs

Marker PCBs, sometimes called "Dutch seven" or ICES7, are seven PCBs that have been measured for many years as an indication of the total PCB contamination. One of these seven, PCB-118, is classified as a dioxin-like PCB, but the toxicity factor of the other six has not yet been estimated. The EU is working on a risk assessment for marker PCBs in order to establish a maximum level in the nearest future. Maximum levels of marker PCBs exist for some or all seven marker PCBs in several European countries and in USA.

5.2.1 Marker PCBs in seafood

The results obtained for the majority of the Icelandic fish species are well below the available limits for marker PCBs mentioned above. The maximum level of each of the individual PCB congeners range from 40 µg/Kg to 120 µg/Kg in Germany, Holland and Sweden. In this research, the highest total concentration for the sum of all seven marker PCBs was measured in Greenland halibut (sample no. 4, Figure 8), a total of 6.7 µg/kg wet weight, the highest individual PCB congener measured in the halibut was PCB-153 with 1.9 µg/kg wet weight, or approximately one third of the total. As for the dioxins and dioxin-like PCBs, the highest concentrations of PCBs are found in fish with high lipid content in the filet. For details, see Table 1 in the Appendix.

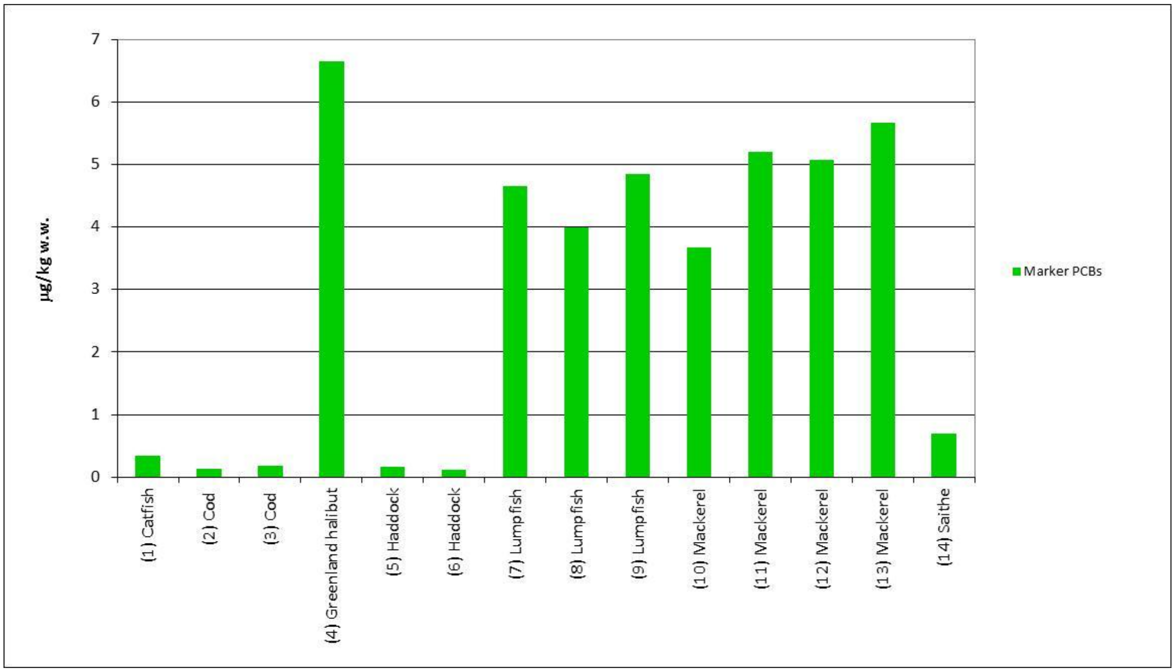

Figure 8: Marker PCBs in the edible part of fish muscle from Iceland in 2011 (in µg/kg wet weight). Number in parenthesis is the sample number designated to each sample, see Table 1 in Appendix.

5.2.2 Marker PCBs in fish oil for human consumption

There were no samples of fish oil for human consumption analysed this year. Earlier results from 2005 and 2006 were reported in previous reports from the Icelandic monitoring program (Ásmundsdóttir and Gunnlaugsdóttir, 2006, Ásmundsdóttir et al., 2008).

5.2.3 Marker PCBs in liver, roes and sperm

Figure 9 shows a comparison between the sum of all seven marker PCBs concentrations measured in different cod organs. As for the dioxin and dioxin like PCBs, the highest concentration is measured in the liver, which also contains the highest lipid content. When the results for the cod liver are excluded, Figure 10, the highest marker PCBs concentration is measured in the cod roes. Of these three organs, the cod roes have the highest lipid content, but the difference in the marker PCB concentration is nevertheless greater than can be accounted for by the difference in lipid content in these organs i.e. cod roes 2,7% lipid vs. cod sperm 2,4% lipid. The reason for this difference in marker PCB concentration between cod roes and sperm could be due to difference in their lipid composition e.g. lipid classes in these organs, but this needs to be investigated further. Further details can be found in Table 2 in the Appendix.

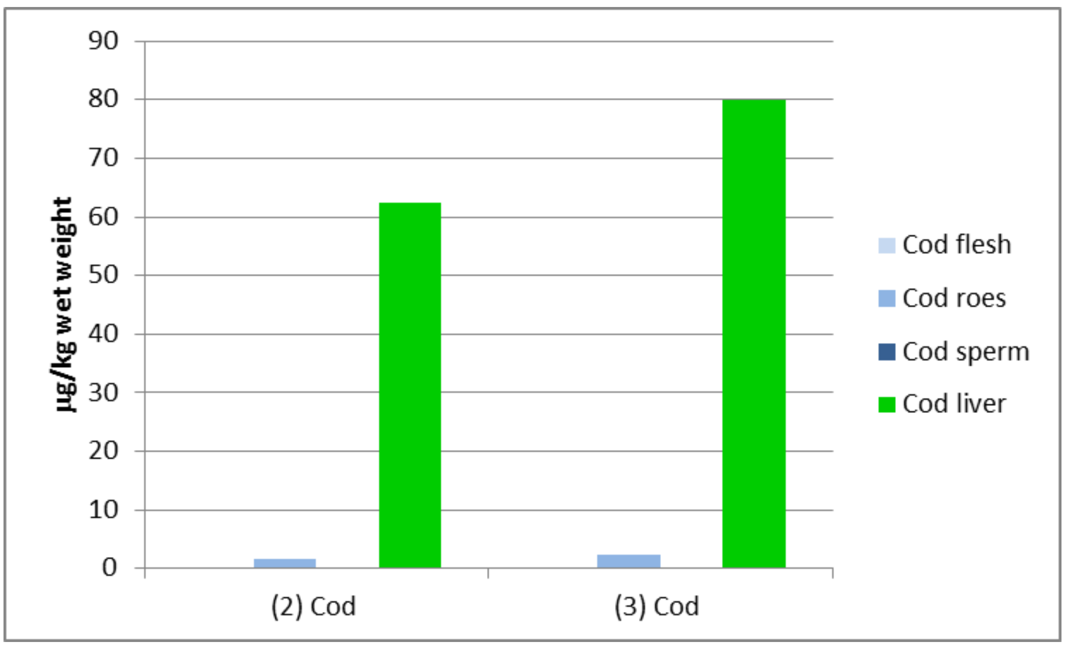

Figure 9: Marker PCBs concentration in different cod organs in µg/kg wet weight

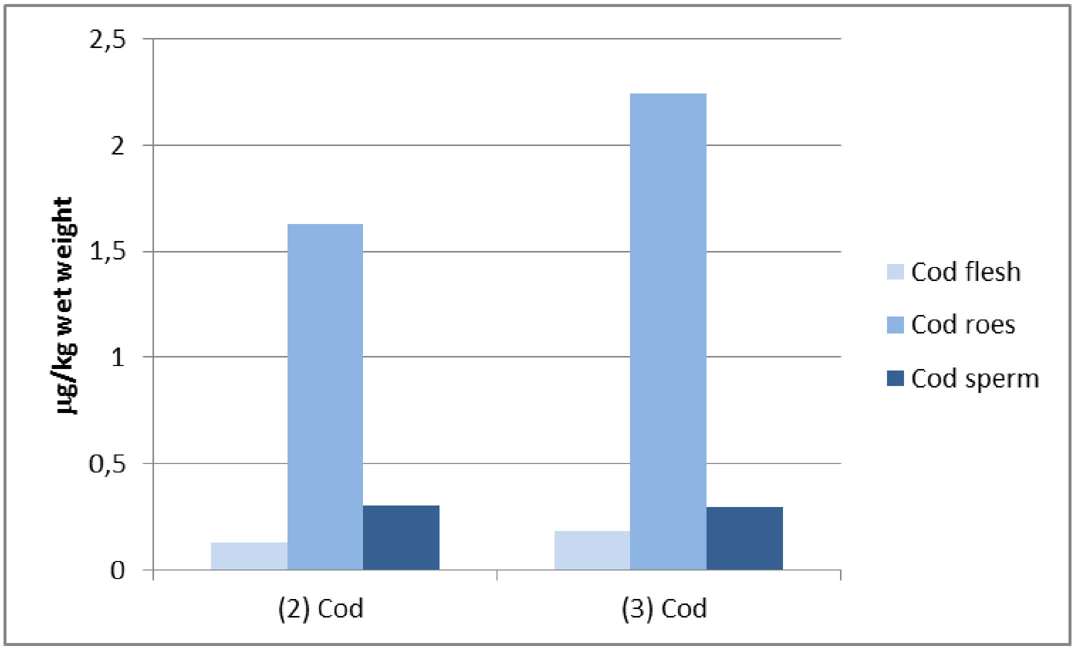

Figure 10: Marker PCBs concentration in different cod organs excluding cod liver in µg/kg wet weight

Figure 11 shows a comparison between the sum of all seven marker PCBs concentration measured in different lumpfish organs. As for the dioxins and dioxin like PCBs, the marker PCBs concentration is higher in the flesh compared to the roes and this is most likely due to difference in lipid content. For details refer to Table 1 and 2 in the Appendix.

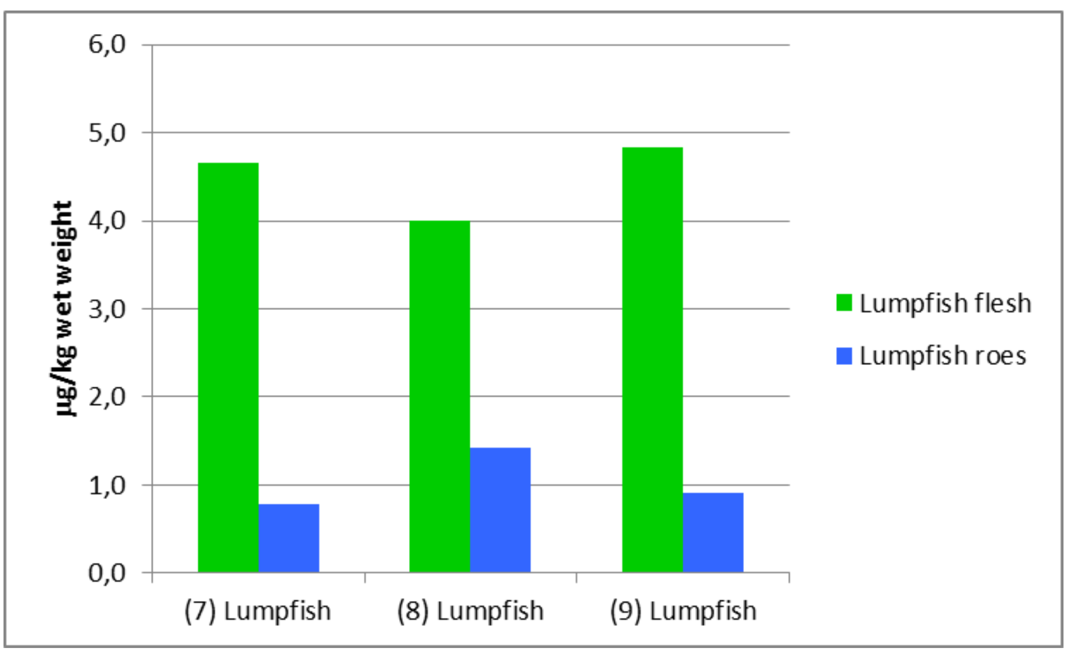

Figure 11: Marker PCBs concentration in different lumpfish organs in µg/kg wet weight

5.2.4 Marker PCBs in fish meal and fish oil for feed

The results for the marker PCBs in fish meal and fish oil samples measured in this study are shown in Tables 3 and 4 in the Appendix and in Figure 12 and Figure 13 below. No limits have yet been set for these substances in fish meal and fish oil for feed in the EU. The same patterns that are seen in different capelin meal samples are observed in the corresponding capelin oil.

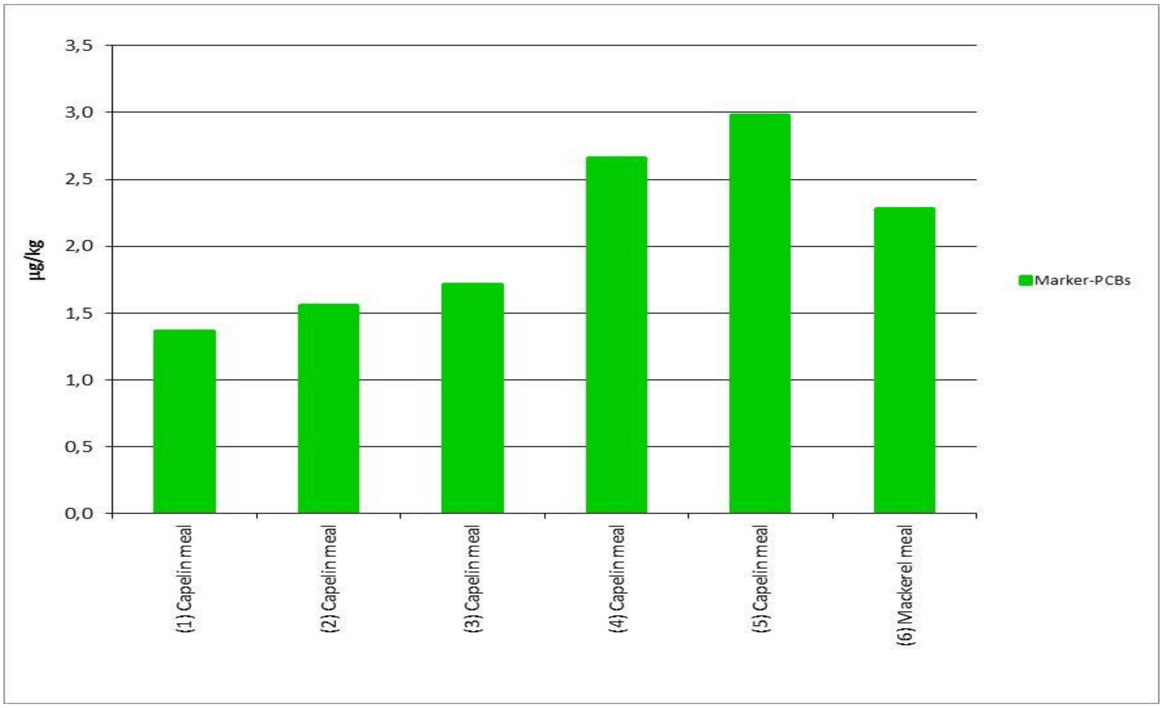

Figure 12: Marker PCBs in fish meal from Iceland in 2011 calculated in relation to 12% moisture

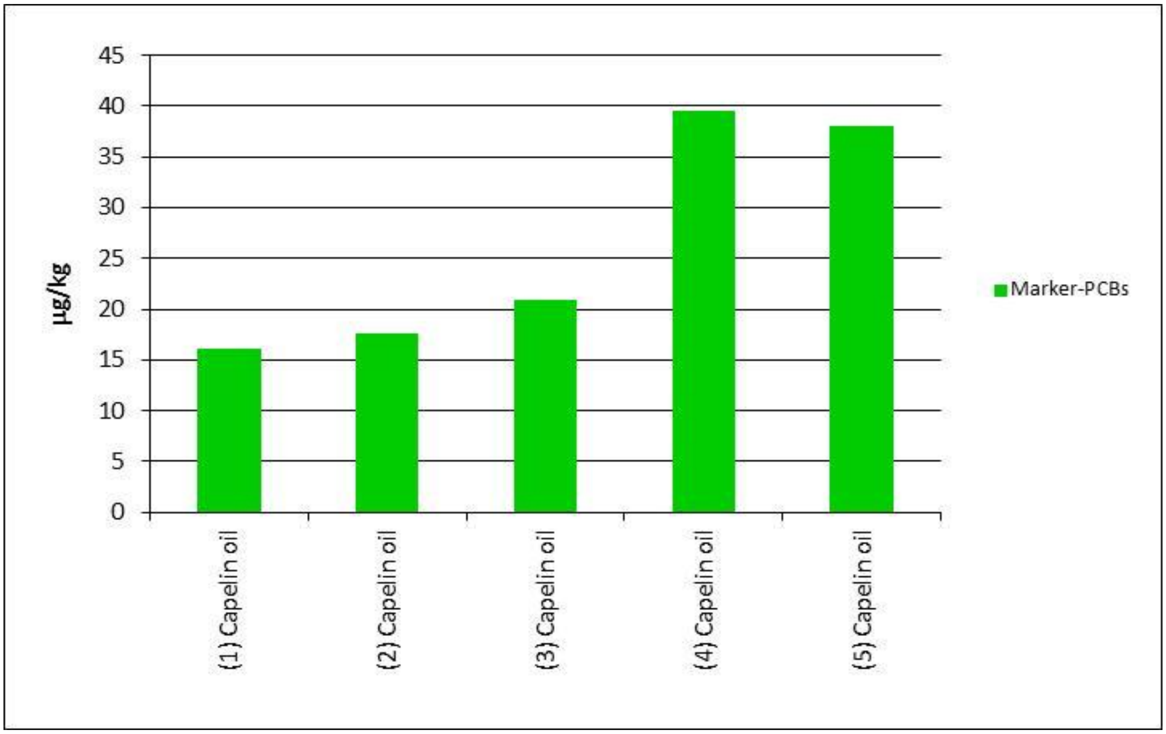

Figure 13: Marker PCBs in fish oils from Iceland in 2011.

5.3 *Brominated flame retardants (BFRs)*

Brominated diphenyl ethers (BFRs) have been accumulating in the environment over the last decade as their use in industry has increased. One group of BFR is Polybrominated dipheynyl ethers (PBDEs). No maximum limits have yet been set in the EU, but they have been estimated to be ten times less toxic than the pesticide DDT (Scientific Advisory Committee on Nutrition (SACN, 2005). There were three major PBDE products (PentaBDE, OctaBDE and DecaBDE) available on the global market and two of them, PentaBDE and OctaBDE, have been banned in the EU and all use of PBDEs has been restricted by the RoHS directive (Restriction of the use of certain Hazardous substances in electrical and electronic equipment).

5.3.1 PBDE in seafood

There is still limited data available on PBDEs in seafood from Iceland (Ásmundsdóttir et al., 2008; Rabieh et al., 2008, Jörundsdóttir et al., 2010 a, Jörundsdóttir *et al*., 2010b). Therefore a special emphasis was laid on gathering information on PBDE in 2009, 2010 and again in 2011. PBDEs were measured in 9 samples of fish muscle and three different cod organs and lumpfish roes. The PBDE are reported here as the upper bound sum of BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-

183. BDE-209 is not included in the sum as it was only detected in three of four mackerel samples tested but not in any other fish muscle or fish organs investigated in this study. No maximum limits have been set for PBDEs in seafood.

The results in Figure 14 showed in general very low level of PBDEs in fish muscle from Icelandic fishing grounds except for the species that accumulate fat in the muscle, like the lumpfish and mackerel. The results are reported in detail in Table 1 in the Appendix.

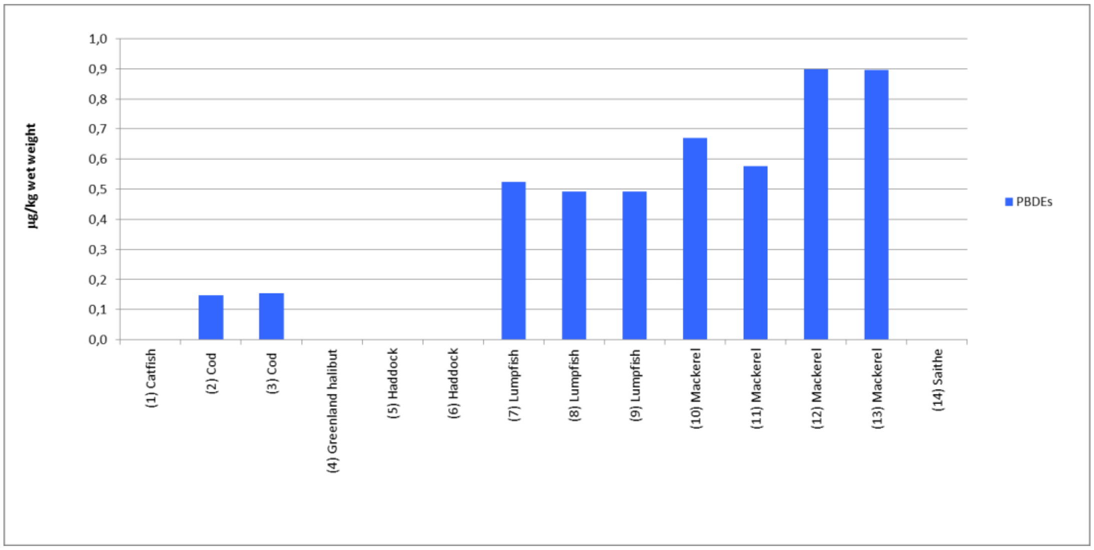

Figure 14: PBDE in fish muscle from Icelandic fishing ground in 2011 in µg/kg wet weight sum of: BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-183.

5.3.2 PBDEs in liver, roes and sperm

Concentrations of PBDEs in different fish organs are shown in Table 2 in Appendix. The concentration trend of PBDEs is the same as for dioxins and PBCs i.e. highest in cod liver of the four cod organs investigated, and higher in lumpfish flesh compared to lumpfish roes.

5.3.3 PBDEs in fish oil and fish meal for feed

PBDEs were only analysed in the mackerel meal where the sum concentration is 0.91 µg/kg wet weight, Table 3 in the Appendix. PBDE in Table 3 is the upper bound sum of BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-183. BDE-209 is not included in the sum as it was not detected in most samples.

5.4 PAH

PAHs were not analysed in the samples this year. Results on PAHs in Icelandic seafood have been published in previous reports (Jörundsdóttir et al., 2010).

5.5 Pesticides

In this chapter, the results for 12 different classes of pesticides are discussed. Results are shown in Tables 5 to 8 in the Appendix. Without exception, the fish muscle samples contained negligible amount of pesticides (Regulation (EC) No 396/2005). All samples of seafood contained pesticides below the EU maximum limits (Commission Directive 2002/32/EC, Commission Directive 2003/100/EC).

12 different pesticides or groups of pesticides were measured in the monitoring program.

DDT (dichloro diphenyl trichloroethan) is probably the best known insecticide. The technical product DDT is fundamentally composed of p,p'-DDT (80%) (Buser, 1995). DDT breaks down in nature, mostly to DDE but also to DDD. The concentration of DDT presented in this report is the sum of p,p'-DDT, o,p´-DDT, p,p'-DDE, o,p´-DDE, p,p´-DDD and o,p´-DDD.

HCH (hexachlorocyclohexan) is an insecticide which has been used since 1949. It is still produced and used in many countries, although it has been banned in many other countries since the 1970s. Technical-grade HCH is a mixture of mainly four isomers: α-, β-, γ-(Lindane), and δ-HCH. Of these, only Lindane is an active substance comprising of approximately 15% of the total mixture, while α-HCH is 60-70% of the mixture. The Food and Agriculture Organization of the UN (FAO) has prohibited the use of the HCH mixture since in the 1980s, after that it was only allowed to use 99% pure Lindane. In this report the concentration of α-, β-, γ-(Lindane), and δ-HCH in the samples are reported.

HCB (hexachlorobenzene) is a fungicide, but it has also been used for industrial purpose and was e.g. produced in Germany until 1993. Today, HCB is mainly a by-product in different industrial processes, as production of pesticides but also from waste incineration and energy production from fossil fuel.

Chlordanes is a group of compounds and isomers where α- and γ-chlordane, oxychlordane and trans-nonachlor are the most common, but over 140 different Chlordanes were produced from 1946 until 1988 when the production was banned. Chlordanes have been widely used all over the world as insecticides. In this report the concentration of Chlordanes is reported as the sum of α-chlordane, γ-chlordane and oxychlordane. trans-Nonachlor is reported separately.

The **Toxaphenes** measured in the samples are the so-called parlar 26, 50 and 62. Toxaphene was used as an insecticide after the use of DDT was discontinued. Toxaphenes use was widespread and the toxaphene congeners are numerous. Several hundred have been analyzed but they are thought to be tens of thousands. The substances measured, i.e. the parlar 26, 50 and 62, are the most common toxaphenes (about 25% of the total amount in nature) and these are used as indicators of toxaphene pollution. In this report the concentration of toxaphenes is reported as the sum of toxaphene 26, 50 and 62.

Aldrin and Dieldrin are widely used insecticides, but in plants and animals aldrin is transformed to dieldrin. Hence, the concentration of aldrin was below LOD in all the samples measured, while dieldrin was always above LOD. The maximum value in the EU is set for the sum of aldrin and dieldrin and the results are therefore presented as the sum of these two.

Two E**ndosulfans** were measured, α- and β-endosulfan, as well as endosulfansulfat which is the breakdown product of endosulfan. Endosulfans are not as persistent as the other insecticides measured in this project. In this report the concentration of endosulfans is reported as the sum of α-endusulfan, β-endusulfan and endosulfansulfat.

Other pesticides measured were **Endrin**, the sum of **Heptachlores** (cis-heptachlorepoxide, trans-heptachlorepoxide and heptachlor), **Pentachlorobenzene**, **Mirex** and **Octachlorostyrene**.

5.5.1 Pesticides in seafood

The results showed very low concentration of all pesticide groups measured in fish muscle from Icelandic waters (see Table 5 in the Appendix). As mentioned before, the results are expressed as upper bond, but most of the pesticides were below the limit of detection and therefore the results presented are likely to be an overestimation. Negligible amounts of ΣDDT, Pentachlorobenzene, HCB, Heptachlores, Aldrin/Dieldrin, Toxaphene, Chlordane and *trans*-Nonachlore were measured in almost all fish species and δ-HCH was always below LOQ except in one sample of mackerel. Figure 15 shows the level of DDT in fish muscle. All fish samples have ΣDDT concentration lower than the EU maximum limit of 500 μg/kg w.w. Of the fish species analysed, Greenland halibut, lumpfish and mackerel have the highest concentrations of all the pesticides investigated.

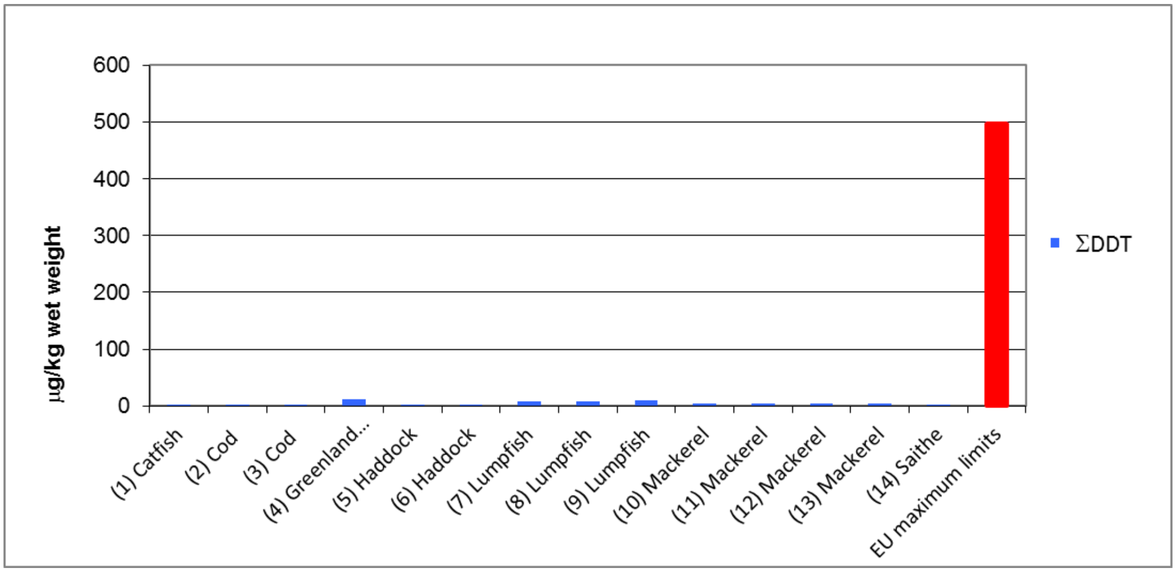

Figure 15: ΣDDT in fish muscle from Icelandic fishing grounds in 2011 in µg/kg wet weight.

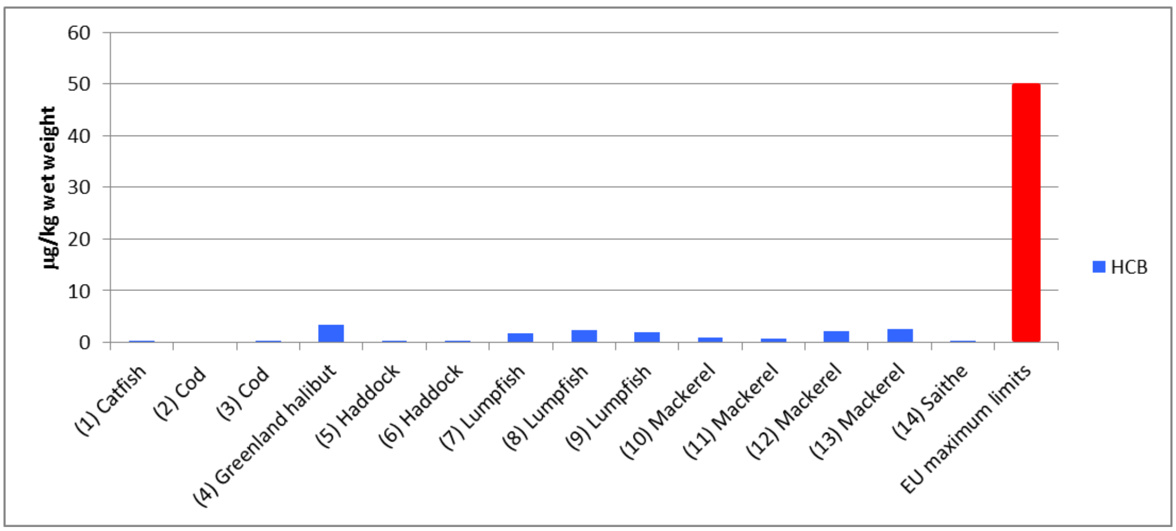

Figure 16: HCB in fish muscle from Icelandic fishing grounds in 2011 in µg/kg wet weight.

5.5.2 Pesticides in fish oil for human consumption

There were no samples of fish oil for human consumption analysed in the monitoring program in the year 2011.

5.5.3 Pesticides in fish meal and fish oil for feed

Several pesticides were measured in fish meal and fish oil for feed (see Tables 7 and Table 8 in the Appendix). There is some variation in the pesticide concentration in different capelin meal samples and the pesticide concentration is generally lower in the mackerel meal sample. No mackerel oil sample was analysed, but similar variation is seen in the pesticide concentration in different capelin oil samples. No meal or oil samples exceed the maximum allowed pesticide level according to EU regulations.

As shown in Figure 17 and Figure 18, there is a difference in concentration of DDT and HCB in the fishmeal samples originating from different fish species. It is difficult to determine why the concentration of these substances varies in the capelin meal (Figure 17, Figure 18 and Figure 19), but factors such as season and condition of the fish are likely contributors.

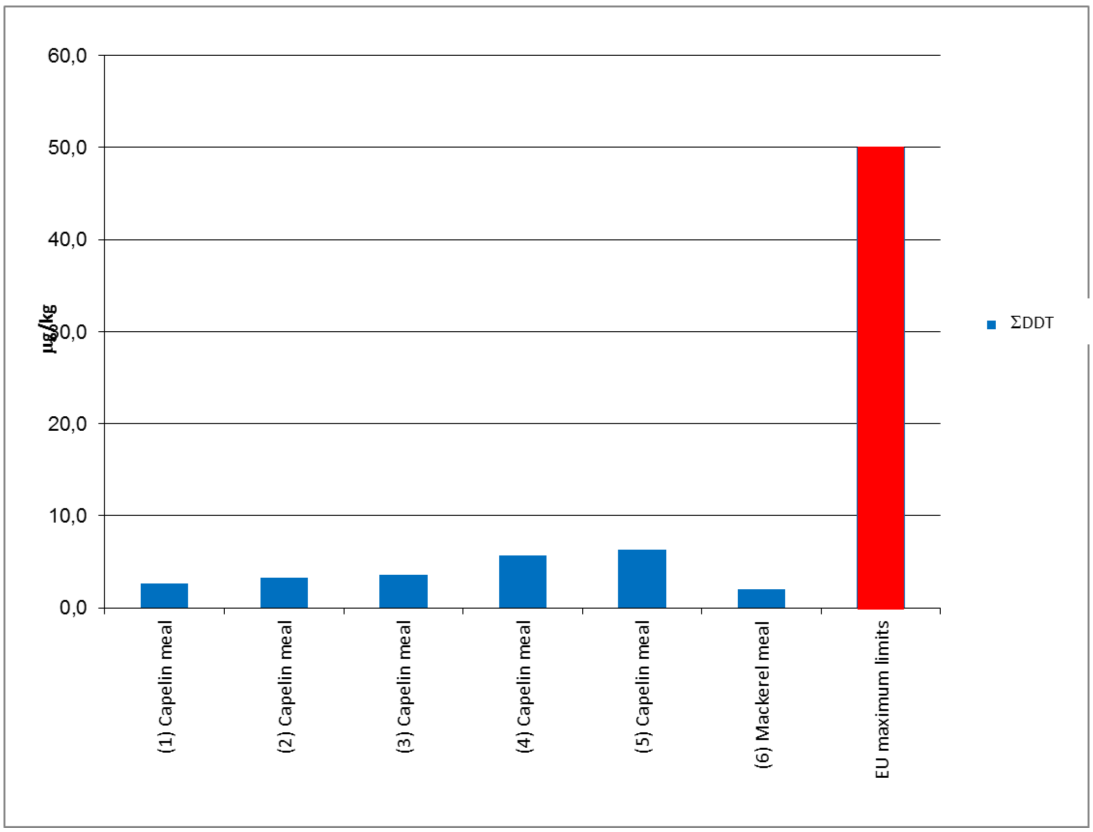

Figure 17: ΣDDT in samples of fish meal from Iceland 2011 calculated in relation to 12% moisture compared to the EU maximum limit.

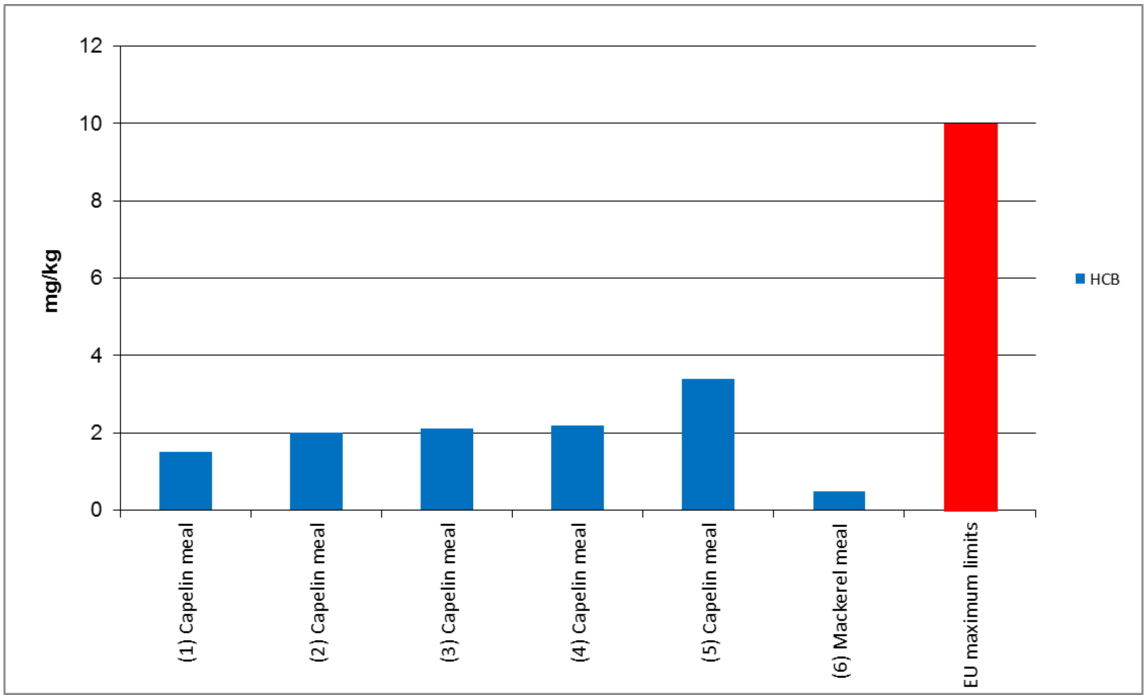

Figure 18: HCB in samples of fish meal from Iceland 2011 calculated in relation to 12% moisture compared to the EU maximum limit.

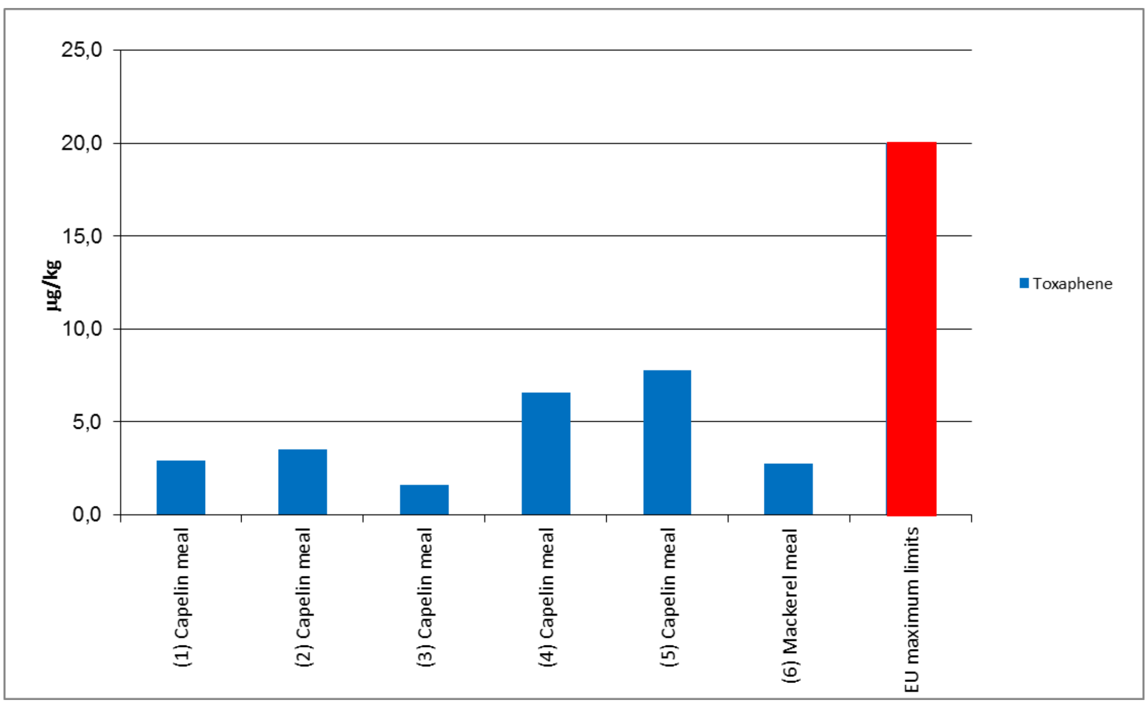

Figure 19: Toxaphene in samples of fish meal from Iceland 2011 calculated in relation to 12% moisture compared to the EU maximum limit.

Concentration of pesticides in fish oil were below EU maximum limits all cases (Commission Directive 2006/77/EC, Table 8 in Appendix).

5.6 *Inorganic trace elements*

Inorganic trace elements were analysed in all samples from the year 2011. The following inorganic trace elements were analysed: Hg (mercury), Cd (cadmium), Pb (lead), As (arsenic), Se (selenium), Zn (zinc), Cu (copper) and Fe (iron). Some of the elements like Se, Zn, Cu and Fe are essential minerals and thus do not fall into the category undesirable substances, however, the ICP-MS technology used to measure the trace elements enables us to measure these elements as well for relatively little extra cost. Therefore, all the previously mentioned trace elements are reported in Table 9-12 in Appendix.

5.6.1 Inorganic trace elements in seafood

In short, the concentration of heavy metals like Hg, Pb and Cd in all the samples of the edible part of fish muscle was well below the maximum limits set by EU (Commission regulation 1881/2006, Commission Regulation (EC) No 629/2008). The concentration of mercury (Hg) in the fish samples is shown in Figure 20.

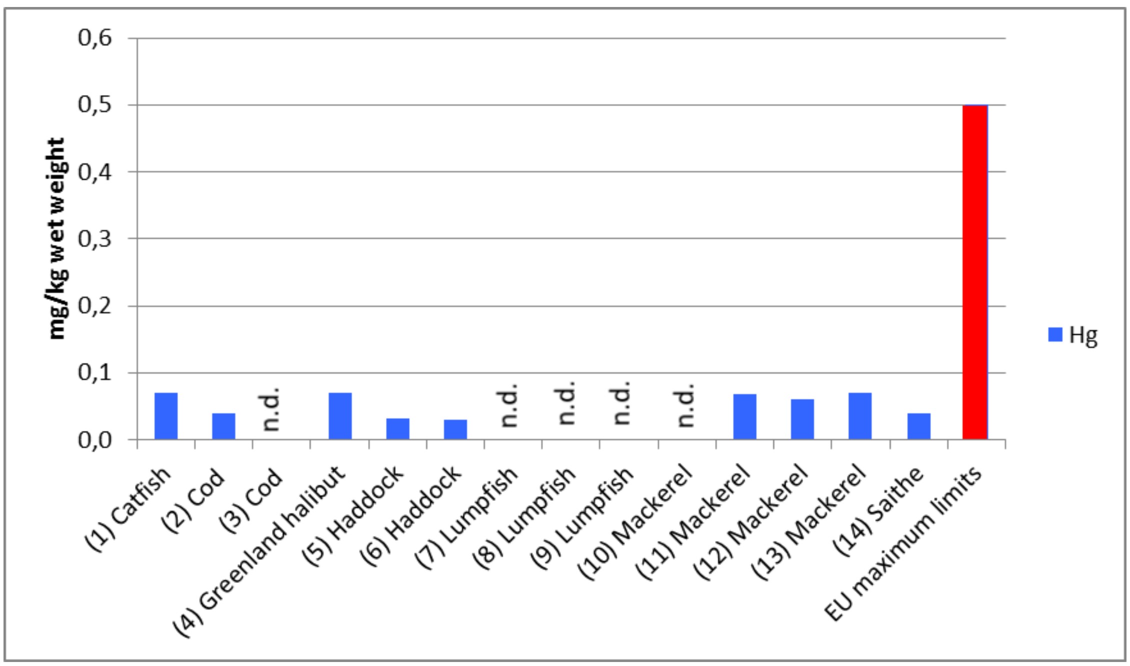

Figure 20: Hg in fish muscle from Icelandic fishing grounds in 2011 in mg/kg wet weight.

The concentration of lead (Pb) in fish muscle was very low as can be seen in Table 9 in the Appendix, in fact only two samples contained lead in concentrations above limits of detection, Greenland halibut and haddock.

No limits have yet been set for arsenic, but results from the monitoring in 2011, which are shown in Figure 21 were in agreement with earlier measurements (Auðunsson, 2004, Ásmundsdóttir et al. 2005, Ásmundsdóttir and Gunnlaugsdóttir, 2006, Jörundsdóttir et al., 2009, Baldursdóttir, 2011). The results obtained this year showed that the level of arsenic was well below 25 mg/kg and in all cases below 4 mg/kg except for catfish and haddock with concentrations around 9-11 mg/kg (Table 9). The total arsenic concentration was measured in the samples, but not the concentration of the toxic form i.e. inorganic arsenic.

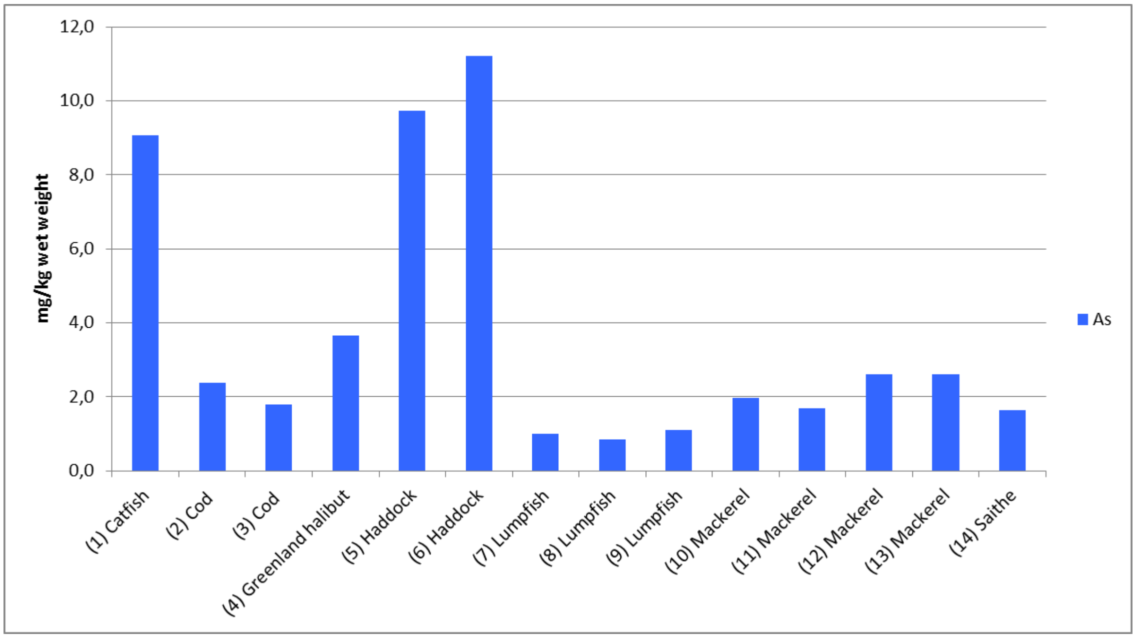

Figure 21: As in fish muscle from Icelandic fishing grounds in 2011 in mg/kg wet weight.

5.6.2 Inorganic trace elements in liver, roes and sperm

Results for inorganic trace elements in liver, roes and sperm are presented in Table 10 in the Appendix. For simplicity the results and discussion about the results obtain for inorganic trace elements in the internal fish organs (liver, roes and sperm) are grouped together in this section. Nevertheless, it is not possible to state that all these elements behave in a similar manner, as can be done for the organic compounds. This can be seen in Figure 22 and Figure 23. Roes have high iron content but low arsenic content compared to other organs investigated.

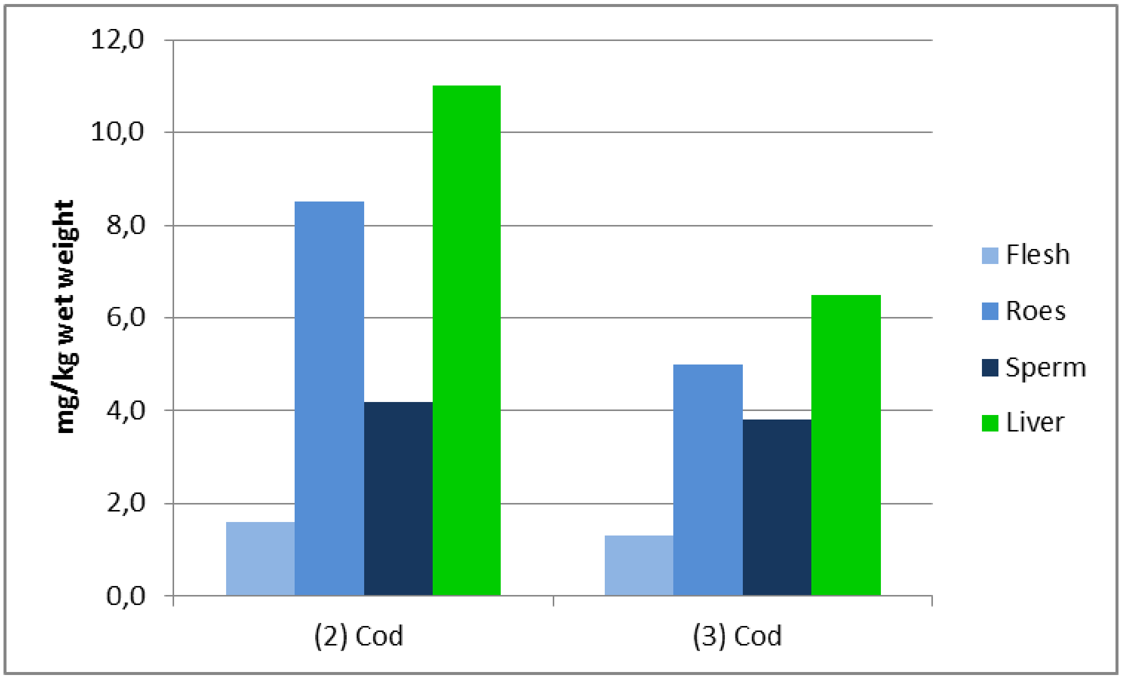

Figure 22: Iron in different organs from cod in mg/kg wet weight.

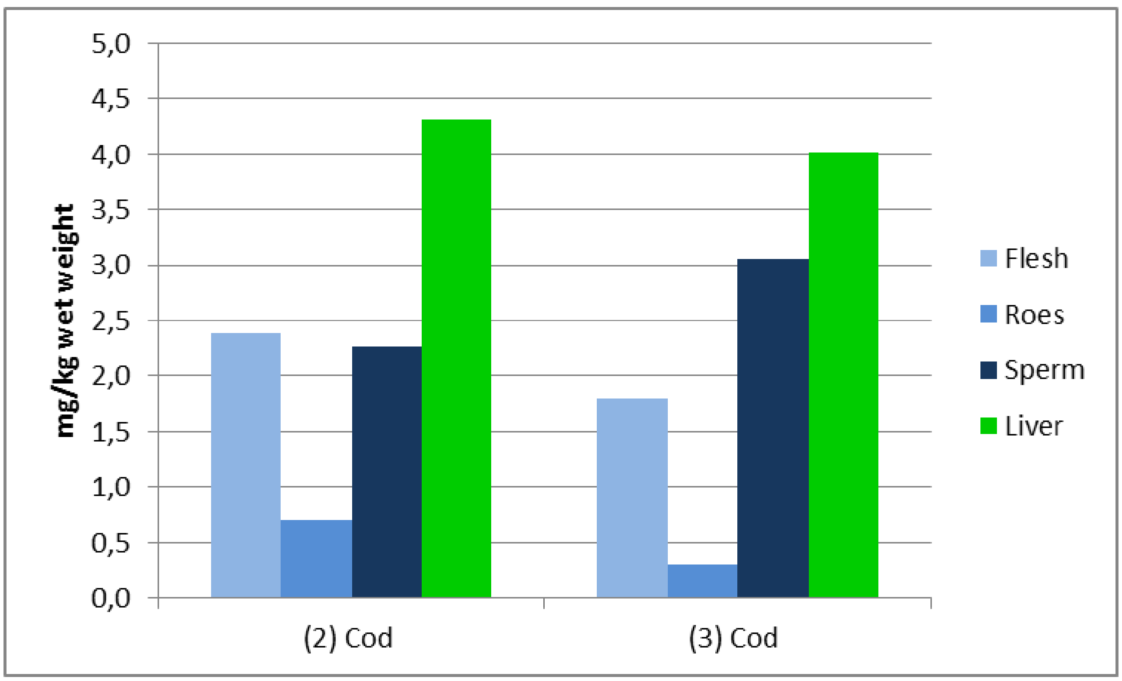

Figure 23: Arsenic in different organs from cod in mg/kg wet weight.

Generally, the cod liver seems to contain the highest concentration of most inorganic trace elements on wet weight basis (for details refer to Table 10 in the Appendix)

Same trend was observed for iron and arsenic content in lumpfish flesh and roes as for the cod, i.e. higher concentration of iron in roes and lower in flesh, and vice versa for arsenic, Figure 24 and Figure 25. The difference in inorganic trace element concentration between these two organs is greater in cod compared to lumpfish.

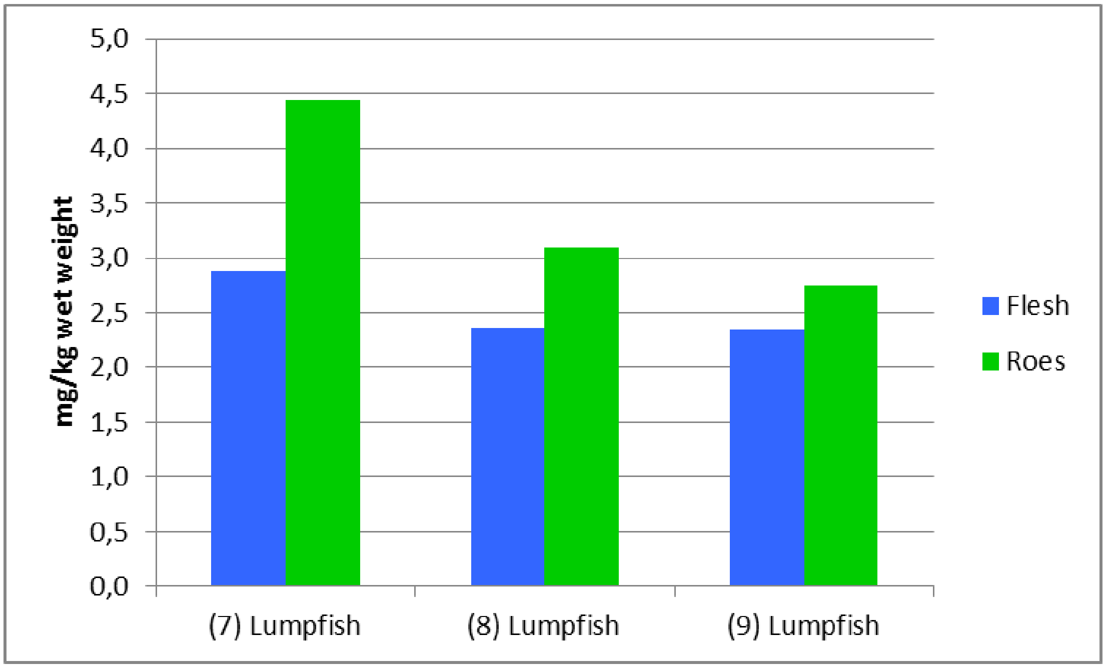

Figure 24: Iron in lumpfish flesh and roes in mg/kg wet weight.

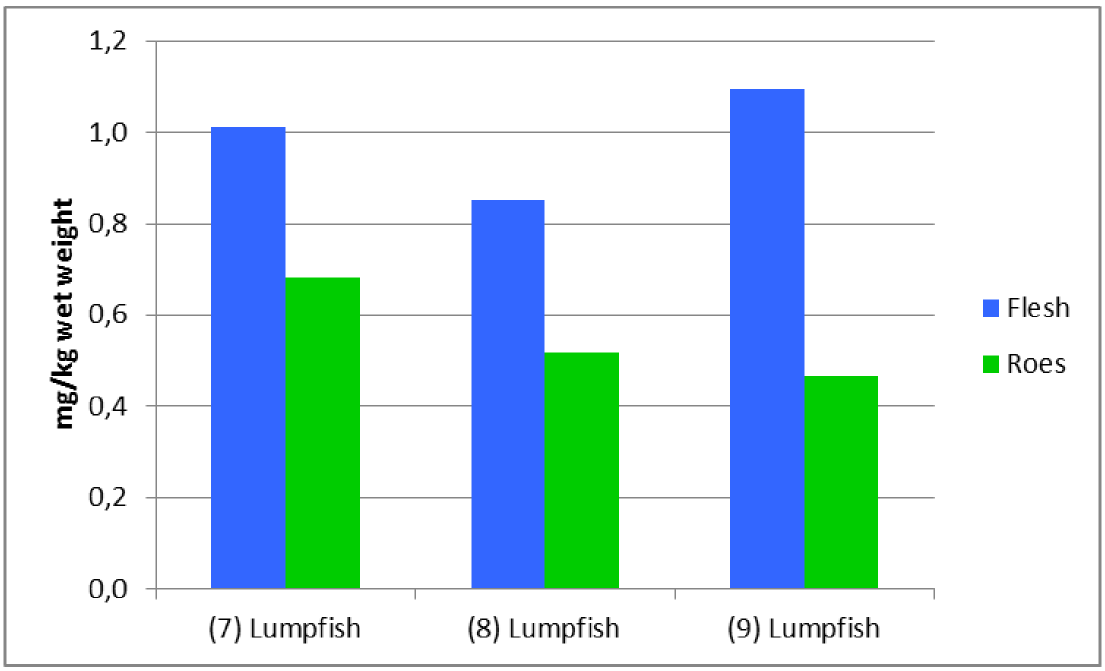

Figure 25: Arsenic in lumpfish flesh and roes in mg/kg wet weight.

5.6.3 Inorganic trace elements in fish oil and fish meal

Inorganic trace elements were analysed in fish oil and fish meal as shown in Table 11 and 12 in the Appendix. Both undesirable and essential metals as well as metalloids were analysed. Maximum limits exist for arsenic, cadmium, mercury and lead in fish meal and oil (Directive 2002/32/EC, Commission Directive 2003/100/EC, Commission Directive 2005/87/EC, Commission Directive 2009/141/EC). Levels of these metals were low in both meal and oil samples and in all cases well below the EU maximum level (Figure 26 and Figure 27).

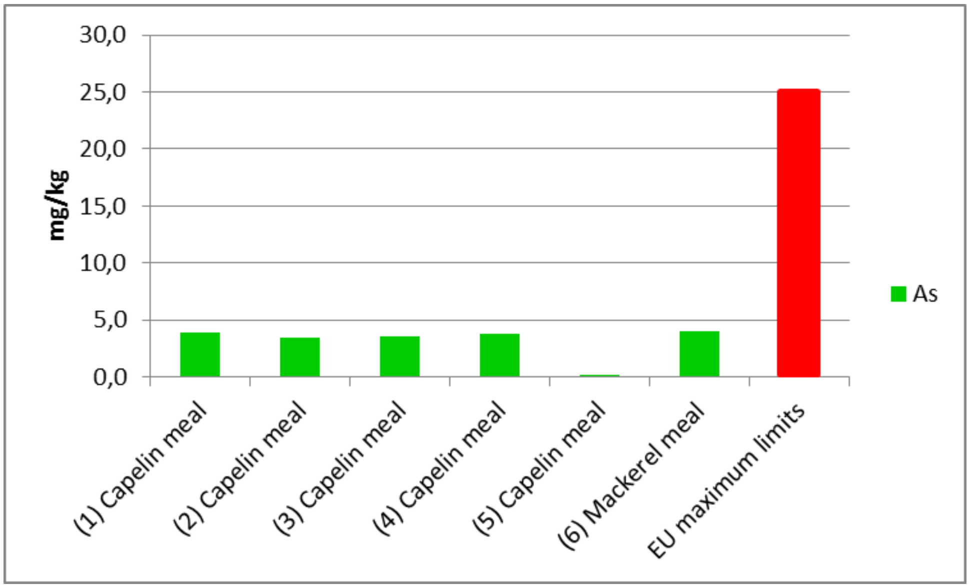

Figure 26: As in fish meal from Icelandic fishing grounds in 2011 in mg/kg wet weight (i.e. meal measured as received from industrial partner)

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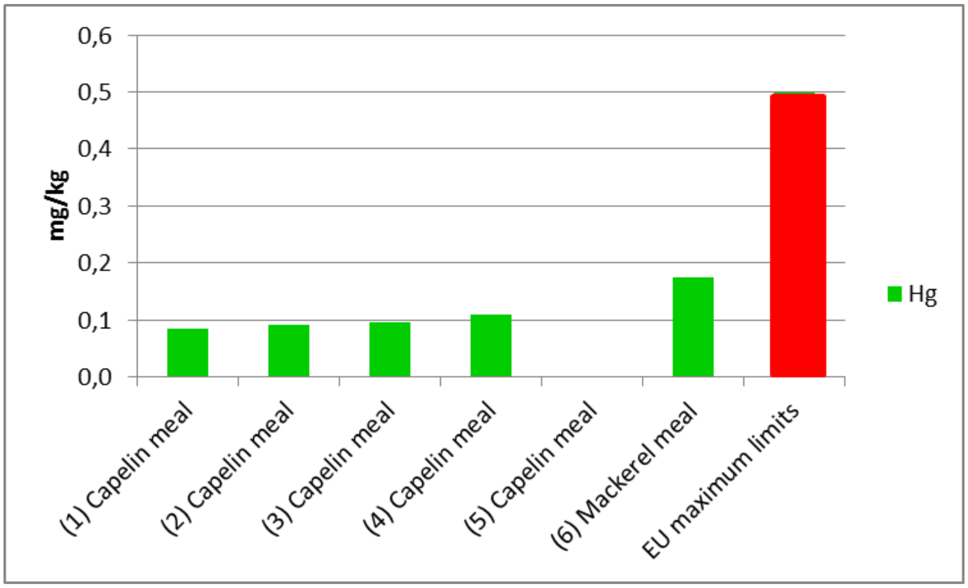

Figure 27: Hg in fish meal from Icelandic fishing grounds in 2011 in mg/kg wet weight (i.e. meal measured as received from industrial partner)

5.7 *Poly- and perfluorinated compounds*

Poly- and perfluorinated compounds (PFC) are receiving more and more attention since they were first analysed in environmental samples (Giesy and Kannan, 2001; Hansen *et al.*, 2001). The group consists of long chain alkane compounds where most or all chain hydrogens have been exchanged for fluorine. One of the major compound, perfluorooctane sulfonate (PFOS) has been included into the Stockholm Convention on persistent organic pollutants. Very limited information is available on PFCs in Icelandic environment and this is the first data on the concentration of these undesirable substances in Icelandic fish and seafood products. For this reason we laid emphasis on gathering information about PFCs in the edible part of marine catches as well as in the fish meal and fish oil for feed in the year 2011. No maximum levels have yet been issued for PFCs by the EU in food or feed products.

5.7.1 PFCs in seafood

PFCs were not detected in the muscle tissue of any of the fish species origination from Icelandic waters and investigated 2011 as shown in Table 13 in the Appendix.

5.7.2 PFCs in liver, roes and sperm

PFOS was the only PFC above limit of quantification as shown in Table 14 in the Appendix. Further, PFOS was only detected in cod organs, but not in lumpfish roes.

Figure 28 shows the PFOS concentration in different cod organs. Highest concentration was measured in cod roes while sperm and liver have similar concentrations. PFOS is not lipophilic and does therefore not follow the lipids in organs and tissues like the persistent organic pollutants. PFOS has a known protein binding ability and it is therefore most likely that the different distribution of PFOS to organs is due to protein binding of PFOS to different proteins in these organs (Jones *et al.*, 2003).

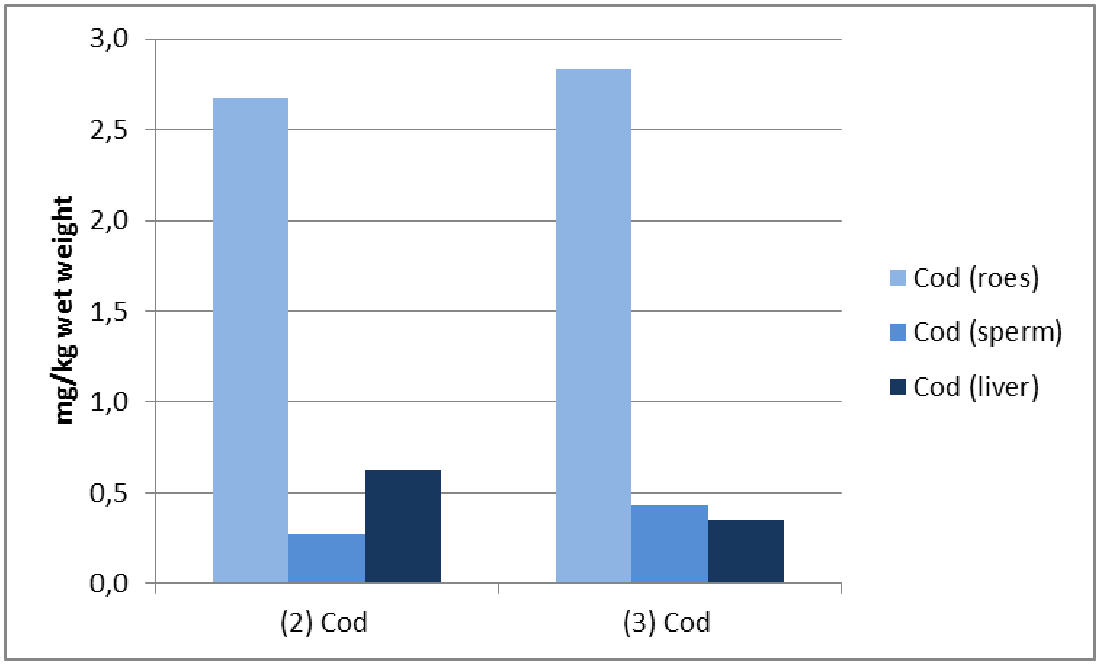

Figure 28: PFOS in different organs from cod in mg/kg wet weight.

5.7.3 PFC in fish meal and oil for feed

Table 15 and 16 in the Appendix show PFC concentrations in fish meal and oil for the year 2011 calculated in relation to 12% moisture. PFCs were not detected in any of the fish oil for feed samples analysed in this study and PFOS was the only compound detected in fish meal. The absence of PFCs in fish oil is due to the fact that and PFCs are not lipophilic and bind to proteins (Jones *et al.*, 2003) and the fish oil contains virtually no proteins. Mackerel meal contained lower levels of PFOS compared to capelin meal, even though there is some variation between capelin meal samples, however only one Mackerel meal was included in this study and therefore more data is need to confirm these results.

6 References

Anon. 2003. Dioxins and PCBs in four commercially important pelagic fish stocks in the North East Atlantic. NORA project report 1-57. http://www.sf.is/attachments/045_Nora-lokaskyrsla.pdf

Auðunsson, G. A. 2004. Vöktun á óæskilegum efnum í sjávarafurðum 2003. IFI report 06-04:1-34

Ásmundsdóttir, Á. M., Auðunsson, G. A. and Gunnlaugsdóttir, H. 2005. Undesirable substances in seafood products -Results from monitoring activities in year 2004. IFI report 05-33

Ásmundsdóttir, Á. M. and Gunnlaugsdóttir, H. 2006. Undesirable substances in seafood products -Results from monitoring activities in year 2005. IFI report 06-22

Ásmundsdóttir, Á. M. Baldursdóttir, V., Rabieh, S. and Gunnlaugsdóttir, H. 2008. Undesirable substances in seafood products -Results from monitoring activities in year 2006. Matis report 17-08.

Baldursdóttir, V., Desnica, N., Ragnarsdóttir, Þ., Gunnlaugsdóttir, H. 2011. Undesirable substances in seafood products. Results from the monitoring activities in 2010. Matis report 28-11.

Buser, H. R. 1995. DDT, a potential source of environmental tris(4-chlorophenyl) methane and tris(4-chlorophenyl) methanol. Environ. Sci. Technol. 29, 2133-2139.

Giesy, J.P., Kannan, K. 2001. Global distribution of perfluorooctane sulfonate in wildlife. Environ. Sci. Technol. 35, 1339-1342.

Hansen, K.J., Clemen, L.A., Ellefson, M.E., Johnson, H.O. 2001. Compound-specific, quantitative characterization of organic fluorochemicals in biological matrices. Environ. Sci, Technol. 35, 766-770.

Jones, P.D., Hu, W.Y., De Coen, W., Newsted, J.L., Giesy, J.P. 2003. Binding of perfluorinated fatty acids to serum proteins. Environ. Toxicol. Chem. 22, 2639-2649.

Jörundsdóttir, H., Rabieh, S., Gunnlaugsdóttir, H. 2009. Undesirable substances in seafood products. Results from the monitoring activities in 2007. Matis report 28-09.

Jörundsdóttir, H., Hauksdóttir, K., Desnica, N., Gunnlaugsdóttir, H. 2010a. Undesirable substances in seafood products. Results from the monitoring activities in 2008. Matis report 16-10.

Jörundsdóttir, H., Desnica, N., Ragnarsdóttir, Þ. and Gunnlaugsdóttir, H. 2010b. Undesirable substances in seafood products. Results from the monitoring activities year 2009. Matis report 38-10.

Linley-Adams, G. The accumulation and impact of organotins on marine mammals, seabirds and fish for human consumption. WWF-UK project No. 98054. May 1999.

Rabieh, S., Jónsdóttir, I., Ragnarsdóttir, Þ. and Gunnlaugsdóttir, H. 2008. Monitoring of the marine biosphere around Iceland 2006 and 2007. Matis report 21-08.

Van den Berg, M., Birnbaum, L., Bosveld A. T. C., Brunström, B., Cook, P., Feeley, M., Giesy, J.P., Hanberg, A., Hasegawa, R., Kennedy, S.W., Kubiak, T., Larsen, J. C., van Leeuwen, F. X. R., Liem, A. K. D., Nolt, C., Peterson, R. E., Poellinger, L., Safe, S., Schrenk, D., Tillitt, D., Tysklind, M., Younes, M., Wærn, F., and Zacharewski, T. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ. Health Perspect. 106, 775-792.

The Environment and Food Agency of Iceland, Regulation No **372/2008** about traces of pesticides in food

Commission Directive 2001/22/EC of March 2001

Commission Directive 2002/69/EC of 26th July 2002

Commission Directive 2003/100/EC of 31th October 2003

Commission Directive 2005/87/EC of 5th December 2005

Commission Directive 2006/13/EC of 3th February 2006

Commission Directive 2006/77/EC of 29th September 2006

Commission Directive 2009/141/EC of 23th November 2009

Commission of the European Communities. SANCO/4546/01 – rev3

Commission Regulation (EC) No 1881/2006 of 19th of December 2006.

Commission Regulation (EC) No 629/2008 of 2nd of July 2008

Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002

Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 of February 2005

Reglugerð um gildistöku reglugerðar framkvæmdastjórnarinnar (EB) nr. 1881/2006 um hámarksgildi fyrir tiltekin aðskotaefni í matvælum. Nr 265/2010.

7 Appendix

Table 1: Dioxins PCBs and PBDE in fish muscle on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fishing ground	Size [cm]	Lipid content %	PCDD/PCDFs pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker PCBs µg/kg	PBDEs µg/kg	BDE-209 µg/kg
R11-994-3	1	Catfish	*Anarhichas lupus*	*NW*	30-50	0,55	0,020	0,018	0,038	0,35	n.a.	n.a.
R11-710-1	2	Cod	*Gadus morhua*	*SW*	60-74	0,41	0,018	0,017	0,035	0,131	0,15	< 1
R11-782-1	3	Cod	*Gadus morhua*	*SW*	75+	0,93	0,034	0,020	0,054	0,18	0,15	< 0,6
R11-994-4	4	Greenland halibut	*Reinhardtius hippoglossoides*	*N*	50-60	13	0,74	0,82	1,6	6,7	n.a.	n.a.
R11-994-1	5	Haddock	*Melanogrammus aeglefinus*	*NE*	50-60	0,53	0,020	0,021	0,041	0,17	n.a.	n.a.
R11-994-2	6	Haddock	*Melanogrammus aeglefinus*	*NE*	40-50	0,47	0,021	0,017	0,038	0,12	n.a.	n.a.
R11-666-1	7	Lumpfish	*Cyclopterus lumpus*	*NW*	35-45	20	0,30	0,47	0,77	4,7	0,52	< 0,7
R11-932-1	8	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	14	0,36	0,46	0,82	4,0	0,49	< 0,5
R11-1276-1	9	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	12	0,27	0,55	0,82	4,8	0,49	< 0,4
R11-2567-1	10	Mackerel	*Scomber scombrus*	*S*	33-35	12	0,15	0,39	0,54	3,7	0,67	0,22
R11-2567-2	11	Mackerel	*Scomber scombrus*	*SE*	30-36	12	0,11	0,49	0,60	5,2	0,58	0,20
R11-2567-3	12	Mackerel	*Scomber scombrus*	*NE*	33-37	25	0,16	0,50	0,65	5,1	0,90	< 0,3
R11-2567-4	13	Mackerel	*Scomber scombrus*	*NE*	33-37	21	0,16	0,46	0,62	5,7	0,90	0,48
R11-747-1	14	Saithe	*Pollachius virens*	*SW*	60-70	0,89	0,025	0,058	0,08	0,69	n.a.	n.a.
		EU action level					3,00	3,00	*	*	*	*
		EU maximum limits					4,00	*	8,00	*	*	*

*No maxinmum limits exist in the EU for the substances

n.a. Not analysed

PCDD/PCDFs are 2,3,7,5,8-PCDDs and PCDFs.

DL-PCBs are CB-77, -81, -126, -169, -105, -114, -118, -123, -156, -157, -167 and -189

Marker PCBs are CB-28, -52, -101, -118, -138, -153 and -180

PBDEs are BDE-170, -28, -47, -49, -66, -71, -85, --99, -100, -119, -126, -138, -153, -154, -183, -184, -196, -197, -206 and -207. BDE-209 was not detected in any sample.

Table 2: Dioxins, PCBs and PBDE in different fish organs on wet weight

Sample code	Sample no.	Sample name	Latin name	Fishing ground	Size [cm]	Lipid content %	PCDD/PCDFs pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker PCBs µg/kg	PBDEs µg/kg
R11-710-2	1	Cod (roes)	*Gadus morhua*	*SW*	60-74	2,5	0,070	0,11	0,18	1,6	0,28
R11-710-3	2	Cod (liver)	*Gadus morhua*	*SW*	60-74	82	2,8	6,0	8,8	62	1,3
R11-710-4	3	Cod (sperm)	*Gadus morhua*	*SW*	60-74	2,2	0,053	0,023	0,076	0,31	0,1
R11-782-3	4	Cod (roes)	*Gadus morhua*	*SW*	75+	2,8	0,074	0,16	0,23	2,2	0,33
R11-782-2	5	Cod (liver)	*Gadus morhua*	*SW*	75+	86	2,9	7,0	9,9	80	7,5
R11-782-4	6	Cod (sperm)	*Gadus morhua*	*SW*	75+	2,6	0,030	0,031	0,061	0,30	0,14
R11-666-2	7	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	6,3	0,049	0,052	0,10	0,78	0,22
R11-932-2	8	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	8,4	0,073	0,094	0,17	1,4	0,29
R11-1276-2	9	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	3,7	0,041	0,055	0,096	0,91	0,20
	EU action level for cod liver										
	EU maximum limits for cod liver								25		

* No maximum limits exist in the EU for the substance

N/A Not analysed

PCDD/PCDFs are 2,3,7,8-PCDDs and PCDFs.

DL-PCBs are CB -77, -81, -126, -169, -105, -114, -118, -123, -156, -157, -167 and -189.

Marker PCBs are CB -28, -52, -101, -118, -138, -153 and 180.

Table 3: Dioxins and PCBs in fish meal for feed calculated in relation to 12% moisture

Sample code	Meal sample no.	Sample name	Latin name	PCDD/PCDF pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker-PCBs µg/kg	PBDEs µg/kg
R11-1335-1	1	Capelin meal	*Mallotus villosus*	0,15	0,16	0,30	1,4	n.a.
R11-1335-3	2	Capelin meal	*Mallotus villosus*	0,17	0,19	0,36	1,6	n.a.
R11-1335-5	3	Capelin meal	*Mallotus villosus*	0,20	0,22	0,42	1,7	n.a.
R11-1335-7	4	Capelin meal	*Mallotus villosus*	0,32	0,31	0,63	2,7	n.a.
R11-593-1	5	Capelin meal	*Mallotus villosus*	0,31	0,35	0,66	3,0	n.a.
R11-2732-1	6	Mackerel meal	*Scomber scombrus*	0,11	0,19	0,30	2,3	0,91
		EU action level		1,00	2,50	3,50	*	*
		EU maximum limits		1,25		4,50	*	*

* No maximum limits exist in the EU for substances

PCDD/PCDFs are 2,3,7,8-PCDDs and PCDFs.
DL-PCBs are CB -77, -81, -126, -169, -105, -114, -118, -123, -156, -157, -167 and -189.
Marker PCBs are CB -28, -52, -101, -118, -138, -153 and 180.
PBDEs are BDE -170, -28, -47, -49, -66, -71, -77, -85, -99, -100, -119, -126, -138, -153, -154, -183, -184, -196, -197, -206, and -207. BDE-209 was not detected in any sample

Table 4: Dioxin, PCB and PBDE in fish oil for feed

Sample code	Fish oil sample no.	Sample name	Latin name	PCDD/PCDF pg/g WHO-TEQ	dioxin like PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker-PCBs µg/kg	PBDEs µg/kg
R11-1335-2	1	Capelin oil	*Mallotus villosus*	1,4	1,6	3,0	16	n.a.
R11-1335-4	2	Capelin oil	*Mallotus villosus*	1,6	2,1	3,6	18	n.a.
R11-1335-6	3	Capelin oil	*Mallotus villosus*	1,9	2,4	4,3	21	n.a.
R11-1335-8	4	Capelin oil	*Mallotus villosus*	3,7	4,6	8,4	40	n.a.
R11-593-2	5	Capelin oil	*Mallotus villosus*	3,7	4,8	8,5	38	n.a.
		EU action level		5,0	14		*	*
		EU maximum limits		6,0		24	*	*

* No maxinum limits exist in the EU for the substances.

PCDD/PCDFs are 2,3,7,8-PCDDs and PCDFs.
DL-PCBs are CB -77, -81, -126, -169, -105, -114, -118, -123, -156, -157, -167 and -189.
Marker PCBs are CB -28, -52, -101, -118, -138, -153 and 180.

Table 5: Pesticides in fish mucle on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fishing ground	Size [cm]	Lipid content %	β-HCH µg/kg	α-HCH µg/kg	γ-HCH µg/kg	δ-HCH µg/kg	Σ DDT µg/kg	Pentachlor benzene µg/kg	HCB µg/kg	Σ Heptachlores µg/kg
R11-994-3	1	Catfish	*Anarhichas lupus*	*NW*	30-50	0,55	< 0,0020	0,0027	< 0,0030	< 0,0020	0,21	0,0063	0,079	0,30
R11-710-1	2	Cod	*Gadus morhua*	*SW*	60-74	0,41	0,03	< 0,0020	< 0,010	< 0,0020	0,15	0,032	< 0,0020	0,22
R11-782-1	3	Cod	*Gadus morhua*	*SW*	75+	0,93	< 0,0020	< 0,0020	< 0,0047	< 0,0020	0,24	0,010	0,19	0,44
R11-994-4	4	Greenland halibut	*Reinhardtius hippoglossoides*	*N*	50-60	13	0,14	0,42	0,14	< 0,020	12	0,33	3,4	16
R11-994-1	5	Haddock	*Melanogrammus aeglefinus*	*NE*	50-60	0,53	< 0,0020	0,0046	< 0,0032	< 0,0020	0,064	0,0066	0,23	0,30
R11-994-2	6	Haddock	*Melanogrammus aeglefinus*	*NE*	40-50	0,47	< 0,0020	0,0034	< 0,0034	< 0,0020	0,038	0,0062	0,19	0,23
R11-666-1	7	Lumpfish	*Cyclopterus lumpus*	*NW*	35-45	20	0,20	0,39	0,11	< 0,023	7,4	0,070	1,8	9,3
R11-932-1	8	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	14	0,14	0,28	< 0,069	< 0,020	7,9	0,060	2,4	10
R11-1276-1	9	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	12	0,095	0,23	0,047	< 0,020	9,6	0,046	2,0	12
R11-2567-1	10	Mackerel	*Scomber scombrus*	*S*	33-35	12	0,10	0,27	0,054	< 0,013	3,6	0,13	0,91	0,44
R11-2567-2	11	Mackerel	*Scomber scombrus*	*SE*	30-36	12	0,075	0,24	< 0,034	< 0,013	4,2	0,10	0,73	0,40
R11-2567-3	12	Mackerel	*Scomber scombrus*	*NE*	33-37	25	0,21	0,72	0,24	< 0,020	5,0	0,22	2,1	0,66
R11-2567-4	13	Mackerel	*Scomber scombrus*	*NE*	33-37	21	0,21	0,62	0,20	< 0,020	4,8	0,20	2,5	0,69
R11-747-1	14	Saithe	*Pollachius virens*	*SW*	60-70	0,89	0,0047	0,0047	< 0,0052	< 0,0020	0,80	0,014	0,28	1,1
		EU maximum limits					50	50	50		500		50	50

Table 5 (cont): Pesticides in fish muscle on wet weight

Sample code	Fish sample no.	Sample name	Date of catch	Fishing ground	Size [cm]	Lipid content %	Aldrin/ dieldrin µg/kg	Toxaphene µg/kg	Octachloro styrene µg/kg	Endrin µg/kg	Endo-sulfane µg/kg	Chlordane µg/kg	*trans*-Nonachlor µg/kg	Mirex µg/kg
R11-994-3	1	Catfish	*Anarhichas lupus*	*NW*	30-50	0,55	0,10	0,21	0,0026	0,0050	0,065	0,031	0,078	0,03
R11-710-1	2	Cod	*Gadus morhua*	*SW*	60-74	0,41	0,078	0,094	0,0045	0,0067	0,069	0,028	0,030	0,0086
R11-782-1	3	Cod	*Gadus morhua*	*SW*	75+	0,93	0,074	0,18	0,0031	0,012	0,1	0,04	0,036	0,0028
R11-994-4	4	Greenland halibut	*Reinhardtius hippoglossoides*	*N*	50-60	13	3,5	11	0,097	0,53	0,7	3,17	2,7	0,13
R11-994-1	5	Haddock	*Melanogrammus aeglefinus*	*NE*	50-60	0,53	0,040	0,036	0,0041	< 0,0020	0,08	0,01	0,015	< 0,0020
R11-994-2	6	Haddock	*Melanogrammus aeglefinus*	*NE*	40-50	0,47	0,034	0,031	0,0027	< 0,0020	0,07	0,01	0,011	< 0,0020
R11-666-1	7	Lumpfish	*Cyclopterus lumpus*	*NW*	35-45	20	4,3	9,0	0,057	0,92	0,8	2,6	1,4	0,036
R11-932-1	8	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	14	4,0	9,3	0,059	0,73	0,694	2,4	1,7	0,041
R11-1276-1	9	Lumpfish	*Cyclopterus lumpus*	*NW*	39-45	12	4,2	8,3	0,071	0,86	0,78	2,8	1,6	0,053
R11-2567-1	10	Mackerel	*Scomber scombrus*	*S*	33-35	12	1,3	6,0	0,03	0,28	0,52	1,11	0,75	0,03
R11-2567-2	11	Mackerel	*Scomber scombrus*	*SE*	30-36	12	1,1	5,8	0,03	0,29	0,52	1,03	0,94	0,02
R11-2567-3	12	Mackerel	*Scomber scombrus*	*NE*	33-37	25	2,5	5,0	0,05	0,36	1,00	1,44	1,30	< 0,020
R11-2567-4	13	Mackerel	*Scomber scombrus*	*NE*	33-37	21	1,9	4,3	0,05	0,55	0,90	1,25	1,10	0,02
R11-747-1	14	Saithe	*Pollachius virens*	*SW*	60-70	0,89	0,20	0,8	0,012	0,02	0,07	0,2	0,18	0,011
		EU maximum limits					50			50		100		

Table 6: Pesticides in different fish organs on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fishing ground	Size [cm]	Lipid content %	β-HCH µg/kg	α-HCH µg/kg	γ-HCH µg/kg	δ-HCH µg/kg	Σ DDT µg/kg	Pentachlor benzene µg/kg	HCB µg/kg	Σ Heptachlo res µg/kg
R11-710-2	1	Cod (roes)	*Gadus morhua*	*SW*	60-74	2,5	0,013	0,028	0,012	< 0,0040	2,1	0,079	1,1	3,2
R11-710-3	2	Cod (liver)	*Gadus morhua*	*SW*	60-74	82	0,70	2,3	0,32	< 0,080	88	1,2	24	113
R11-710-4	3	Cod (sperm)	*Gadus morhua*	*SW*	60-74	2,2	< 0,0040	< 0,0040	< 0,0062	< 0,0040	0,41	0,014	0,22	0,65
R11-782-3	4	Cod (roes)	*Gadus morhua*	*SW*	75+	2,8	0,013	0,045	0,019	< 0,0040	2,8	0,094	1,4	4,3
R11-782-2	5	Cod (liver)	*Gadus morhua*	*SW*	75+	86	0,91	2,7	0,40	< 0,080	130	1,7	29	161
R11-782-4	6	Cod (sperm)	*Gadus morhua*	*SW*	75+	2,6	0,0048	0,0059	< 0,0087	< 0,0040	0,46	0,011	0,20	0,67
R11-666-2	7	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	6,3	0,049	0,18	0,052	< 0,010	1,5	0,048	0,80	2,4
R11-932-2	8	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	8,4	0,059	0,19	0,045	< 0,010	2,6	0,16	1,5	4,3
R11-1276-2	9	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	3,7	0,026	0,077	0,023	< 0,010	1,9	0,061	0,70	2,7
		EU maximum limits												

N/A Not analysed

Table 6 (cont): Pesticides in different fish organs on wet weight

Sample code	Fish sample no.	Sample name	Date of catch	Fishing ground	Size [cm]	Lipid content %	Aldrin/ dieldrin µg/kg	Toxaphene µg/kg	Octachlor o styrene µg/kg	Endrin µg/kg	Endo-sulfane µg/kg	Chlordane µg/kg	*trans*-Nonachlor µg/kg	Mirex µg/kg
R11-710-2	1	Cod (roes)	*Gadus morhua*	*SW*	60-74	2,5	1,7	1,5	0,016	0,61	0,13	1,82	1	0,018
R11-710-3	2	Cod (liver)	*Gadus morhua*	*SW*	60-74	82	23	83	0,55	2,9	2,58	21,5	22	0,97
R11-710-4	3	Cod (sperm)	*Gadus morhua*	*SW*	60-74	2,2	0,21	0,29	0,0048	0,025	0,13	0,1	0,078	0,0046
R11-782-3	4	Cod (roes)	*Gadus morhua*	*SW*	75+	2,8	2,2	2,1	0,78	3,8	4,7	28,80	31	1,3
R11-782-2	5	Cod (liver)	*Gadus morhua*	*SW*	75+	86	29	109	0,023	0,71	0,2	2,26	1,4	0,024
R11-782-4	6	Cod (sperm)	*Gadus morhua*	*SW*	75+	2,6	0,20	0,33	< 0,0040	0,021	0,1	0,09	0,07	0,0063
R11-666-2	7	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	6,3	1,3	1,5	0,013	0,20	0,38	0,63	0,32	< 0,010
R11-932-2	8	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	8,4	1,9	3,4	0,025	0,33	0,30	0,780	0,55	0,013
R11-1276-2	9	Lumpfish (roes)	*Cyclopterus lumpus*	*NW*	N/A	3,7	1,2	1,8	0,016	0,19	0,33	0,6	0,29	< 0,010
		EU maximum limits												

N/A Not analysed

Table 7: Pesticides in fish meal for feed on wet weight

Sample code	Meal sample no.	Sample name	β-HCH µg/kg	α-HCH µg/kg	γ-HCH µg/kg	δ-HCH µg/kg	Σ DDT µg/kg	Pentachlor benzene µg/kg	HCB µg/kg	Σ Heptachlores µg/kg
R11-1335-1	1	Capelin meal	0,10	0,14	0,073	< 0,020	2,6	0,15	1,5	0,52
R11-1335-3	2	Capelin meal	0,13	0,098	0,071	< 0,020	3,3	0,15	2,0	0,56
R11-1335-5	3	Capelin meal	0,083	0,094	< 0,020	< 0,020	3,5	0,18	2,1	0,59
R11-1335-7	4	Capelin meal	0,055	0,038	0,025	< 0,020	5,7	0,15	2,2	0,62
R11-593-1	5	Capelin meal	0,048	0,089	0,037	< 0,020	6,4	0,22	3,4	0,67
R11-2732-1	6	Mackerel meal	0,076	0,43	0,035	< 0,013	2,0	0,099	0,49	0,30
		EU maximum limits	10	20	200		50		10	

Table 7 (cont.): Pesticides in fish meal for feed on wet weight.

Sample code	Meal sample no.	Sample name	Aldrin/ dieldrin µg/kg	Toxaphene µg/kg	Octachloro styrene µg/kg	Endrin µg/kg	Endo-sulfane µg/kg	Chlordane µg/kg	*trans*-Nonachlor µg/kg	Mirex µg/kg
R11-1335-1	1	Capelin meal	2,2	2,9	< 0,020	0,33	0,65	1,2	0,72	< 0,020
R11-1335-3	2	Capelin meal	2,8	3,5	0,028	0,41	0,65	1,5	0,76	0,021
R11-1335-5	3	Capelin meal	2,8	1,6	0,03	0,41	0,66	1,7	0,94	< 0,020
R11-1335-7	4	Capelin meal	3,1	6,6	0,042	0,51	0,65	2,2	1,3	0,039
R11-593-1	5	Capelin meal	3,8	7,8	0,064	0,63	0,65	2,7	1,5	0,040
R11-2732-1	6	Mackerel meal	0,9	2,7	0,0	0,2	0,4	0,6	0,6	0,0
		EU maximum limits	10	20		10	100	20		

Table 8: Pesticides in fish oil for feed

Sample code	Fish oil no.	Sample name	β-HCH µg/kg	α-HCH µg/kg	γ-HCH µg/kg	δ-HCH µg/kg	Σ DDT µg/kg	Pentachlor benzene µg/kg	HCB µg/kg	Σ Heptachlores µg/kg
R11-1335-2	1	Capelin oil	1,1	3,9	3,0	< 0,10	33	2,5	21	4,4
R11-1335-4	2	Capelin oil	1,2	3,4	2,9	< 0,10	37	2,8	25	4,5
R11-1335-6	3	Capelin oil	1,1	2,5	4,1	< 0,10	43	2,9	28	5,6
R11-1335-8	4	Capelin oil	1,0	1,8	7,2	< 0,10	88	2,9	42	6,6
R11-593-2	5	Capelin oil	0,87	1,8	6,2	< 0,10	80	3,0	41	6,5
		EU maximum limits	100	200	2000		500		200	

Table 8 (cont): Pesticides in fish oil for feed

Sample code	Fish oil no.	Sample name	Aldrin/ dieldrin µg/kg	Toxaphene µg/kg	Octachloro styrene µg/kg	Endrin µg/kg	Endo- sulfane µg/kg	Chlordane µg/kg	*trans*-Nonachlor µg/kg	Mirex µg/kg
R11-1335-2	1	Capelin oil	26	45	0,26	4,2	3,4	15	8,4	0,28
R11-1335-4	2	Capelin oil	27	48	0,37	4,1	7,4	16	9,8	0,33
R11-1335-6	3	Capelin oil	35	52	0,39	5,0	3,3	20	12	0,36
R11-1335-8	4	Capelin oil	49	117	0,74	6,4	4,0	36	22	0,78
R11-593-2	5	Capelin oil	40	96	0,62	5,2	4,3	32	19	0,65
		EU maximum limits	100	200		50	100	50		

Table 9: Trace elements in fish muscle on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fe mg/kg	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Hg mg/kg	Pb mg/kg
R11-994-3	1	Catfish	*Anarhichas lupus*	1,5	0,1	6,3	9,1	0,6	<0,006	0,07	<0,007
R11-710-1	2	Cod	*Gadus morhua*	1,6	0,2	3,6	2,4	0,3	<0,006	0,04	<0,008
R11-782-1	3	Cod	*Gadus morhua*	1,3	0,2	2,5	1,8	0,3	<0,006	<0,006	<0,008
R11-994-4	4	Greenland halibut	*Reinhardtius hippoglossoides*	1,0	0,1	4,0	3,7	0,3	<0,03	0,07	0,14
R11-994-1	5	Haddock	*Melanogrammus aeglefinus*	1,0	0,1	2,6	9,7	0,4	<0,006	0,03	0,09
R11-994-2	6	Haddock	*Melanogrammus aeglefinus*	1,2	0,1	2,7	11,2	0,5	<0,006	0,03	<0,008
R11-666-1	7	Lumpfish	*Cyclopterus lumpus*	2,9	0,2	2,7	1,0	0,1	<0,03	<0,08	<0,04
R11-932-1	8	Lumpfish	*Cyclopterus lumpus*	2,4	0,2	3,0	0,9	0,1	<0,03	<0,06	<0,04
R11-1276-1	9	Lumpfish	*Cyclopterus lumpus*	2,3	0,2	3,3	1,1	0,1	<0,03	<0,06	<0,04
R11-2567-1	10	Mackerel	*Scomber scombrus*	7,9	0,8	7,2	2,0	0,4	<0,03	<0,06	<0,04
R11-2567-2	11	Mackerel	*Scomber scombrus*	8,7	0,7	8,4	1,7	0,4	<0,03	0,07	<0,04
R11-2567-3	12	Mackerel	*Scomber scombrus*	9,0	0,7	8,1	2,6	0,5	<0,03	0,06	<0,04
R11-2567-4	13	Mackerel	*Scomber scombrus*	9,7	0,90	9,4	2,6	0,4	<0,03	0,07	<0,04
R11-747-1	14	Saithe	*Pollachius virens*	2,7	0,35	3,0	1,6	0,2	<0,006	0,04	<0,008
		EU maximum limits, flesh							0,05	0,5	0,3

Table 10: Trace elements in different fish organs on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fe mg/kg	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Hg mg/kg	Pb mg/kg
R11-710-2	1	Cod (roes)	*Gadus morhua*	8,5	0,7	37,3	0,7	1,2	<0,009	<0,02	<0,01
R11-710-3	2	Cod (liver)	*Gadus morhua*	11,0	3,0	9,7	4,3	4,3	0,23	0,04	<0,04
R11-710-4	3	Cod (sperm)	*Gadus morhua*	4,2	0,3	6,7	2,3	0,4	0,01	0,01	<0,006
R11-782-3	4	Cod (roes)	*Gadus morhua*	5,0	0,4	19,3	0,3	0,6	<0,009	<0,02	<0,01
R11-782-2	5	Cod (liver)	*Gadus morhua*	6,5	2,2	6,9	4,0	0,5	0,19	0,09	<0,04
R11-782-4	6	Cod (sperm)	*Gadus morhua*	3,8	0,3	7,9	3,1	0,4	<0,005	0,01	<0,006
R11-666-2	7	Lumpfish (roes)	*Cyclopterus lumpus*	4,4	0,5	14,9	0,7	0,9	<0,007	<0,02	<0,009
R11-932-2	8	Lumpfish (roes)	*Cyclopterus lumpus*	3,1	0,3	13,1	0,5	0,6	<0,006	<0,01	0,01
R11-1276-2	9	Lumpfish (roes)	*Cyclopterus lumpus*	2,7	0,4	15,1	0,5	0,5	<0,006	<0,01	<0,007

Table 11: Trace elements in fish meal for feed on wet weight.

Sample code	**Meal sample no.**	**Sample name**	**Fe mg/kg**	**Cu mg/kg**	**Zn mg/kg**	**As mg/kg**	**Se mg/kg**	**Cd mg/kg**	**Hg mg/kg**	**Pb mg/kg**
R11-1335-1	1	Capelin meal	72	2,0	68	3,9	1,3	0,15	0,085	0,046
R11-1335-3	2	Capelin meal	71	2,2	59	3,4	1,2	0,14	0,091	0,0075
R11-1335-5	3	Capelin meal	91	1,7	65	3,5	1,2	0,15	0,095	0,0091
R11-1335-7	4	Capelin meal	56	1,6	69	3,7	1,0	0,13	0,11	0,059
R11-593-1	5	Capelin meal	21	0,57	12	0,0014	0,23	0,0014	<0,08	0,0014
R11-2732-1	6	Mackerel meal	187	3,5	66	4,0	5,0	0,62	0,17	0,039
		EU maximum limits				25		2	0,5	10

Table 12: Trace elements in fish oil for feed

Sample code	Fish oil sample no.	Sample name	Fe mg/kg	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Hg mg/kg	Pb mg/kg
R11-1335-2	1	Capelin oil	0,55	0,0028	0,0069	10	0,055	0,003	<0,08	0,025
R11-1335-4	2	Capelin oil	0,56	0,057	<0,002	9,9	0,092	0,021	<0,08	0,0021
R11-1335-6	3	Capelin oil	1,2	0,059	0,18	11	0,10	0,019	<0,08	0,016
R11-1335-8	4	Capelin oil	1,3	0,0026	0,0025	14	0,098	0,024	<0,08	0,0078
R11-593-2	5	Capelin oil	1,9	0,11	0,20	19	0,098	0,0029	0,098	0,0029
		EU maximum limits				25		2	0,5	10

Table 13: Perfluorninated compounds in fish muscle on wet weight

Sample code	Fish sample no.	Sample name	PFBS µg/kg	PFDA µg/kg	PFDS µg/kg	PFDoA µg/kg	PFHpA µg/kg	PFHxA µg/kg	PFHxS µg/kg	PFNA µg/kg	PFOA µg/kg	PFOSA µg/kg	PFOS µg/kg
R11-994-3	1	Catfish	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-710-1	2	Cod	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-782-1	3	Cod	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-994-4	4	Greenland halibut	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	0,26
R11-994-1	5	Haddock	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-994-2	6	Haddock	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-666-1	7	Lumpfish	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-932-1	8	Lumpfish	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-1276-1	9	Lumpfish	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-2567-1	10	Mackerel	< 0,1	< 0,2	< 0,1	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
R11-2567-2	11	Mackerel	< 0,1	< 0,2	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
R11-2567-3	12	Mackerel	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
R11-2567-4	13	Mackerel	< 0,1	< 0,3	< 0,1	< 0,3	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1
R11-747-1	14	Saithe	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15

Table 14: Perfluorninated compounds in different fish organs on wet weight

Sample code	Fish sample no.	Sample name	PFBS µg/kg	PFDA µg/kg	PFDS µg/kg	PFDoA µg/kg	PFHpA µg/kg	PFHxA µg/kg	PFHxS µg/kg	PFNA µg/kg	PFOA µg/kg	PFOSA µg/kg	PFOS µg/kg
R11-710-2	1	Cod (roes)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,20	< 0,10	< 0,15	2,7
R11-710-3	2	Cod (liver)	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	< 0,30	0,62
R11-710-4	3	Cod (sperm)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	0,27
R11-782-3	4	Cod (roes)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	2,83
R11-782-2	5	Cod (liver)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,20	< 0,10	< 0,15	0,35
R11-782-4	6	Cod (sperm)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	0,43
R11-666-2	7	Lumpfish (roes)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-932-2	8	Lumpfish (roes)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15
R11-1276-2	9	Lumpfish (roes)	< 0,15	< 0,20	< 0,15	< 0,20	< 0,10	< 0,10	< 0,15	< 0,10	< 0,10	< 0,15	< 0,15

Table 15: Perfluorinated compounds in fish meal for feed

Sample code	Meal sample no.	Sample name	PFBS µg/kg	PFDA µg/kg	PFDS µg/kg	PFDoA µg/kg	PFHpA µg/kg	PFHxA µg/kg	PFHxS µg/kg	PFNA µg/kg	PFOA µg/kg	PFOSA µg/kg	PFOS µg/kg
R11-1335-1	1	Capelin meal	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	6,5
R11-1335-3	2	Capelin meal	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	7,5
R11-1335-5	3	Capelin meal	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	2,3
R11-1335-7	4	Capelin meal	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	13
R11-593-1	5	Capelin meal	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	6,9
R11-2732-1	6	Mackerel meal	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,3	1,3

Table 16: Perfluorinated compounds in fish oil for feed

Sample code	Fish oil no.	Sample name	PFBS µg/kg	PFDA µg/kg	PFDS µg/kg	PFDoA µg/kg	PFHpA µg/kg	PFHxA µg/kg	PFHxS µg/kg	PFNA µg/kg	PFOA µg/kg	PFOSA µg/kg	PFOS µg/kg
R11-1335-2	1	Capelin oil	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50
R11-1335-4	2	Capelin oil	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50
R11-1335-6	3	Capelin oil	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50
R11-1335-8	4	Capelin oil	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50
R11-593-2	5	Capelin oil	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50	< 0,50