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Undesirable substances in seafood products. Results from the monitoring activities in 2007

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Öryggi og umhverfi

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Titill / Title	**Undesirable substances in seafood products. Results from the monitoring activities in 2007**		
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Ágrip á íslensku:	Árið 2003 hófst, að frumkvæði sjávarútvegsráðuneytisins, vöktun á óæskilegum efnum í sjávarafurðum, bæði afurðum sem ætlaðar eru til manneldis sem og afurðum til lýsis- og mjöliðnaðar. Tilgangurinn með vöktuninni er að meta ástand íslenskra sjávarafurða með tilliti til magns aðskotaefna. Gögnin sem safnað er í vöktunarverkefninu verða einnig notuð í áhættumati 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 fram á 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 árið 2007. 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 inn í eyðurnar. Árið 2007 voru mæld: dioxin, dioxinlík PCB og bendi PCB efni, PBDEs, PAH, auk þess tíu mismunandi tegundir varnarefna, auk þungmálma og annarra snefilefna, í sjávarafurðum sem ætlaðar eru til manneldis sem og afurðum til lýsis- og mjöliðnaðar		
Lykilorð á íslensku:	*Sjávarfang, vöktun, Díoxín, díoxínlík PCB, PCB, snefilefni ,varnarefni*		
Summary in English:	This project was started in 2003 at the request of the Icelandic Ministry of Fisheries and Agriculture. Until then, monitoring of undesirable substances in the edible portion of marine catches had been rather limited in Iceland. The purpose of the project is to gather information and evaluate the status of Icelandic seafood products in terms of undesirable substances. The information will also be utilized in a risk assessment and gathering reference data. This report summarizes the results obtained in 2007 for the monitoring of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. The monitoring began in 2003 and has now been carried out for five consecutive years. The evaluation of the status of the Icelandic seafood producs in terms of undesirable substances is a long term project which can only be reached through continuous monitoring. For this reason, we carefully select which undesirable substances are measured in the various seafood samples each year with the aim to fill in the gaps in the available data over couple of year time.In 2007 data was collected on dioxins, dioxin-like PCBs, marker PCBs, ten different types of pesticides, PBDE, PAH, as well as trace elements and heavy metals in the edible part of fish, fish liver, fish oil and fish meal for feed.		
English keywords:	*Marine catches, monitoring, dioxin, PCB, trace elements, pesticides*		

Table of Contents

1 Introduction

The monitoring of various undesirable substances in the edible part of marine catches, as well as in fish meal and fish oil for feed started in 2003 and has thus been carried out for four years. The project is funded by the Ministry of Fisheries and Agriculture in Iceland. The monitoring project is the first comprehensive study on the status of Icelandic seafood products in terms of undesirable substances. The project includes measurements of many marine species from Icelandic fishing grounds that have never been studied before. In addition, information is gathered on numerous substances that have not been previously measured. The substances investigated in this monitoring project are: trace metals (mercury, lead, cadmium, total arsenic and more), polyaromatic hydrocarbons (PAHs), polychlorinated dibenzo dioxins and dibenzo furans (commonly called dioxins), dioxin-like polychlorinated biphenyls (PCBs), marker PCBs, polybrominated flame retardants (PBDEs) and 29 pesticides and breakdown products (i.e. HCB, DDTs, HCHs, dieldrin, endrin, chlordanes, toxaphenes and endosulfan substances).

The purpose of this work is:

A) To gather information and evaluate the status of Icelandic seafood products in terms of undesirable substances.
B) To examine how products measure up against the limits set by EU for dioxins (polychlorinated dibenzodioxins and dibenzofurans) (Regulation (EC) No 1882/2003).
C) To gather information on the concentration of marker PCBs for the purpose of setting limits, but a risk assessment is now in progress in EU regarding this class of substances.
D) To evaluate how products measure up to limits currently in effect for inorganic trace elements, organic contaminants and pesticides in the EU. The information will also be utilized for a risk assessment and the setting of maximum values that are now under consideration within EU (e.g. PAHs, inorganic arsenic and brominated flame retardants).

This report summarizes results from the monitoring programme in 2007. The results obtained in 2003-2006 have already been published and are accessible at the Matis website. (Auðunsson, 2004, Ásmundsdóttir et al., 2005, Ásmundsdóttir and Gunnlaugsdóttir, 2006, Ásmundsdóttir et al., 2008).

2 Summary

This report summarizes the results obtained in 2007 for the monitoring of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. This project began in 2003 and has now been carried out for four years.

In the year 2007 emphasis was laid on gathering information on heavy metals and nutrients as well as the organic compounds PBDE and PAHs in the edible part of marine catches. The results obtained in 2007 are in concordance with the results obtained in the previous years.

This report shows that the edible part of Icelandic seafood products contain negligible amounts of persistent organic pollutants (POPs) like dioxins, dioxin like PCBs and pesticides. The concentration of marker PCBs is also found to be low in the edible part of fish muscle, compared to the maximum limits in the European countries, where such limits exist. Cadmium (Cd), lead (Pb), mercury (Hg) were also measured in fish muscle but the concentration of these trace metals 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. The fish meal and oil from blue whiting was found to be high in dioxin and dioxin like PCBs compared to the maximum limits in the period around spawning and in few cases the samples exceed the EU limits. These results are in accordance with previous findings in a project financed by the Nordic Atlantic Co-operation (Anon. 2003) and the monitoring report from year 2004 (Ásmundsdóttir et al., 2005). The trace metal measurements of fish oil and meal for feed revealed that these products contain a very low concentration of lead (Pb), but the level of cadmium (Cd) and arsenic (As) is slightly higher in relation to the maximum limits, but nonetheless always well below the EU limits .

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 types 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 types 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:
CB-28, CB-52, CB-101, CB-118, CB-138, CB-153, CB-180.

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

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).

PBDE-substances (10 types):
BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153, BDE-183, BDE-209.

PAH-substances (17 types):
Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(b)naphto(2,1d)thiophene, Benzo(c)phenanthrene, Benzo(a)anthracene, Chrysen/Triphenylen, Benzo(ghi)fluoranthene, Benzo(bjk)fluoranthene, Benzo(e)pyrene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Benzo(ghi)perylene, Anthanthrene, Dibenzo(a,h)anthracene, Coronene.

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 (Commission directive 2002/69/EC). Fish and liver samples were collected by the Marine Research Institute in Iceland. 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 are identified with the location of the fishing area, except when the sample contains individuals from more than one area. Each fish sample consists of at least ten individuals of a specific length distribution.

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, the sampling was distributed over the year.

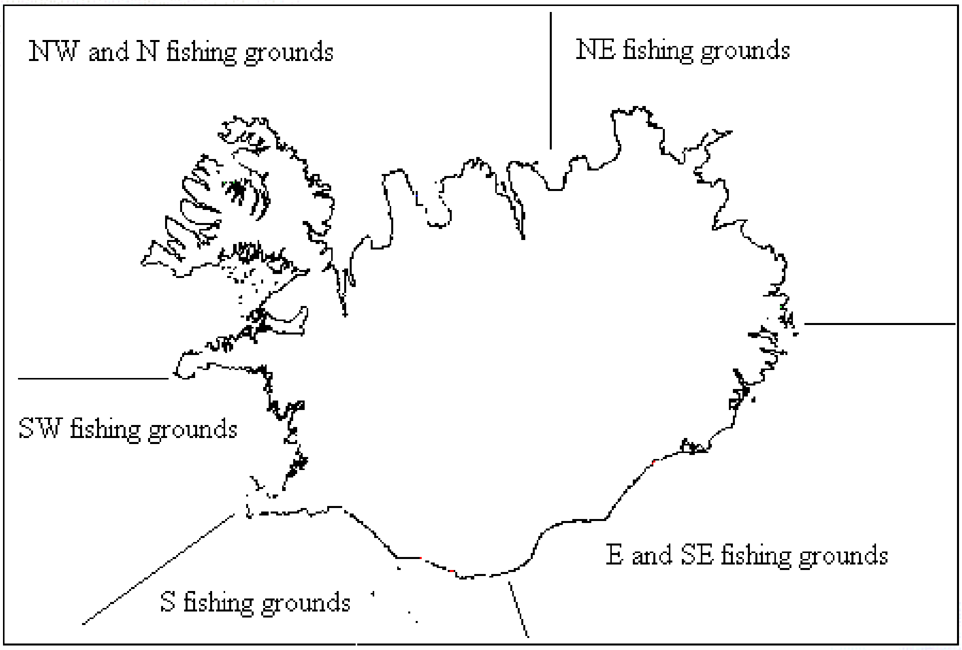

Figure 1: The division of the fishing grounds around Iceland used in this research

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, PBDEs and PAHs.

Inorganic trace elements (Hg, Cd, Pb, As, Se, Zn, Cu, Fe, Cr, Ca, K, P, Mg and Na) in the samples were determined at Matis using ICP-MS technology after mineralization of the samples with closed vessel acid digestion. The quality of the trace elements analysis was checked in several ways. Certified reference materials are routinely treated and analysed in the same manner as the samples. The trace analytical laboratory at Matis participates annually in proficiency testing programs (e.g. Swedish National Food Administration (SLV) and Quasimeme) with satisfactory results (Rabieh et al., 2008).

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). The WHO-TEQ has 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 2007 are expressed in details in Tables 1-11 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. This can be seen in Figure 2 and in 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 and redfish (samples no. 10, 11 and 24), contain more dioxins and dioxin like PCBs than species which accumulate fat in the liver and thus have almost no fat in the muscle. Herring has 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.

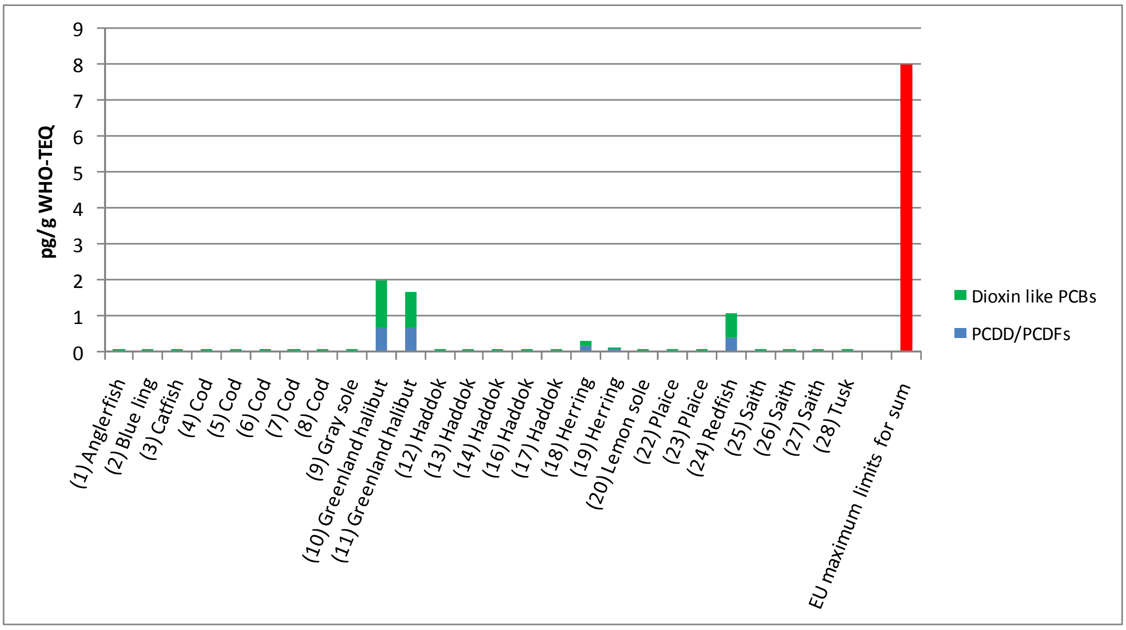

Figure 2: Dioxins and dioxin-like PCBs in the edible part of fish muscle from Icelandic fishing grounds in 2007 in relation to maximum limit in EU and action limits in WHO-TEQ pg/g wet weight. The number within parenthesis is the sample number indicated in Table 1.

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

No samples of fish oil for human consumption were 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).

5.1.3 Dioxins and dioxin like PCBs in cod liver

Cod livers from four individuals were analysed for dioxins and dioxin like PCBs. Two livers were from small individuals and two were from large individuals. The concentration of dioxins and dioxin like PCBs lower than the EUs maximum concentration but two of the cod livers contained concentration close to the EU maximum limit for sum of dioxins and dioxin like PCBs.

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

Maximum limits in EU 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. 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 is lower than the EU maximum limit in all fish meals tested (Figure 4). The same is observed for the fish oil (Figure 5).

It has been shown that the level of persistent organic pollutants in fish meal and fish oil for feed is related to the fat content of the fish used as raw material. The fat content of the fish, on the other hand, depends very much on the nutritional condition of the fish and consequently varies through the seasons (Anon., 2003, Ásmundsdóttir et al., 2005). Figures 4 and 5 show the amount of dioxins and dioxin-like PCBs in fish meal and fish oil samples compared to the new EU limit. The samples were taken throughout the year 2007 and details on the results for dioxins and dioxin-like PCBs in these samples can be found in Tables 3 and 4 in the Appendix. Fish meal samples nr. 1 and 2 contain higher amounts of dioxin and dioxin-like PCBs compared to the other meal species. These samples are taken from meal of blue whiting caught in April/ May which is the period just after spawning and when the fat content in the fish is low.

The level of dioxins and dioxin-like PCBs in the fish oil samples no 3 and 4 (blue whiting) is high (Figure 5). This fish was caught in the summer, from April/May 2007. The other samples are of capelin, herring or herring/mackerel oil are caught in a different season when the fish is in good nutritional condition.

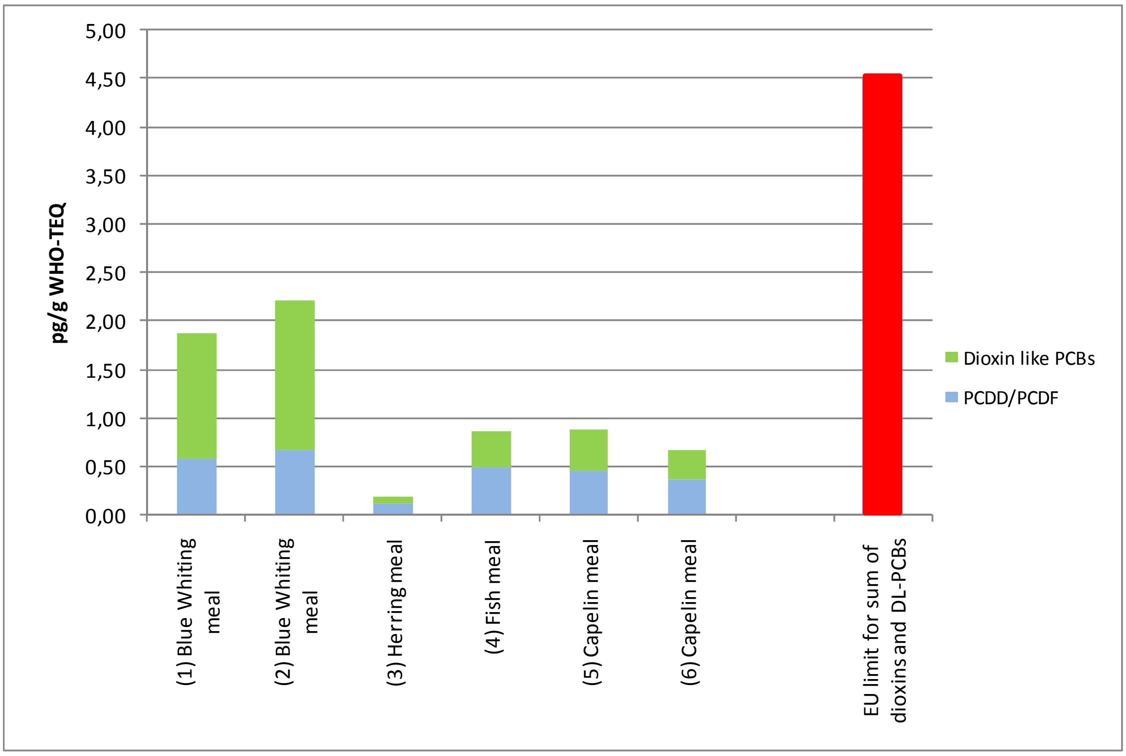

Figure 4: Dioxins and dioxin-like PCBs in samples of fish meal from Iceland in 2007 (in pg/g WHO-TEQ) in relation to maximum limit in EU) and action limits

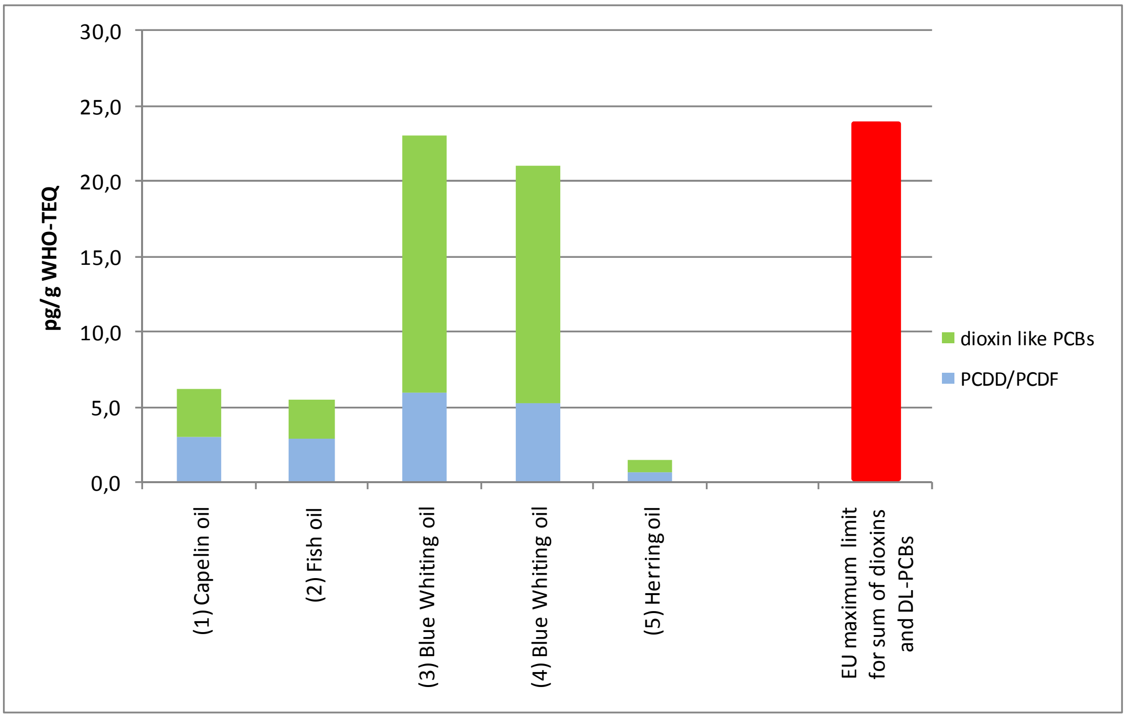

Figure 5: Dioxins and dioxin-like PCBs in samples of fish oil for feed from Iceland in 2007 (in WHO-TEQ) in relation to maximum limit in EU and action limits

Blue whiting meal nr 1 and 2 are paired with oil samples nr 3 and 4, respectively, that is the meal and oil are from the same batch. The same is for herring meal nr 3 and herring oil nr 5.

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 of the seven marker PCBs in Germany, Holland, Sweden, USA and Iceland for instance.

5.2.1 Marker PCBs in seafood

The results obtained for the Icelandic fish species are far below the limits for marker PCBs in the countries 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 Iceland the limits are much lower. The maximum limit in Iceland for the sum of all seven marker PCBs is 200 µg/Kg wet weight and the maximum limit for the individual congeners range from 10 µg/Kg to 60 µg/Kg. In this research, the highest total concentration for the sum of all seven marker PCBs was measured in Greenland halibut (sample nr. 10), a total of 14 µg/Kg wet weight. That level is less than one tenth of the maximum limits in Iceland. 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.

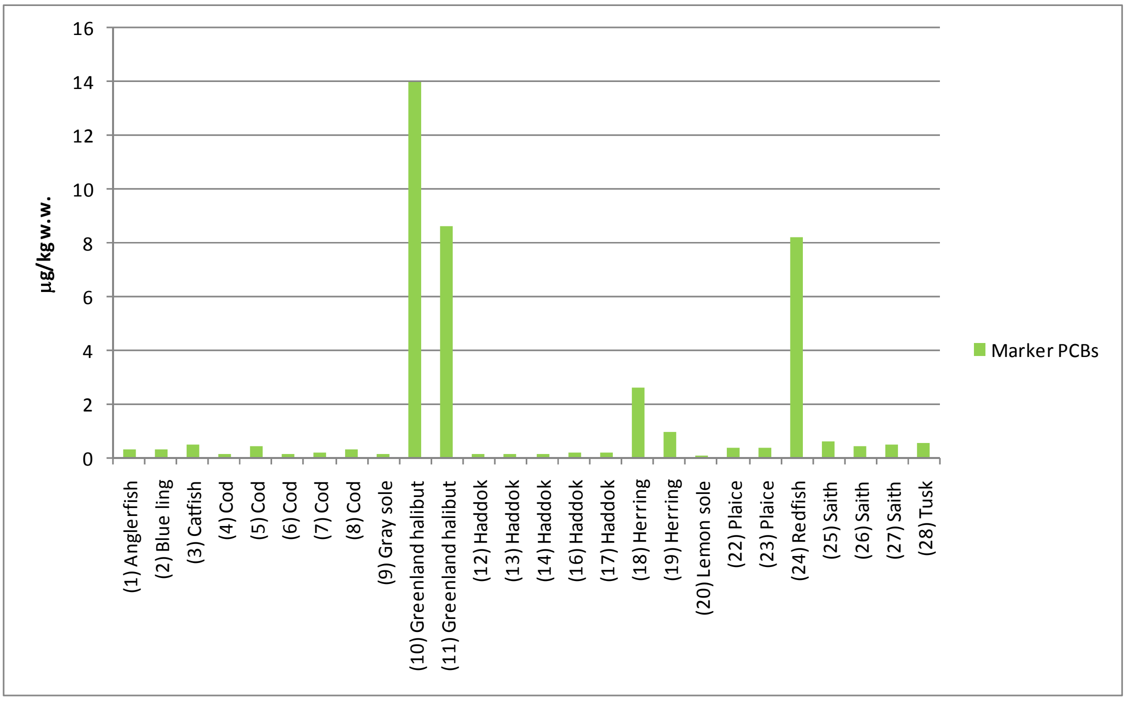

Figure 6: Marker PCBs in the edible part of fish muscle from Iceland in 2007 (in µg/kg wet weight). Number in parenthesis is the sample number designated to each sample, see in Table 1 in Appendix.

5.2.2 Marker PCBs in fish oil for human consumption

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

5.2.3 Marker PCBs in cod liver

The concentration of marker PCBs in the cod liver is given in Table 2. The concentrations are comparable to what is found in fish oil, ranging from 62 to 230 µg/kg. No maximum limits have been set for marker PCBs in fish liver or products derived from fish liver by the EU.

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 Figures 8 and 9 below. No limits have yet been set for these substances in the EU. As for the dioxins and dioxin like PCBs, blue whiting meal and oil has the highest concentration of marker PCBs.

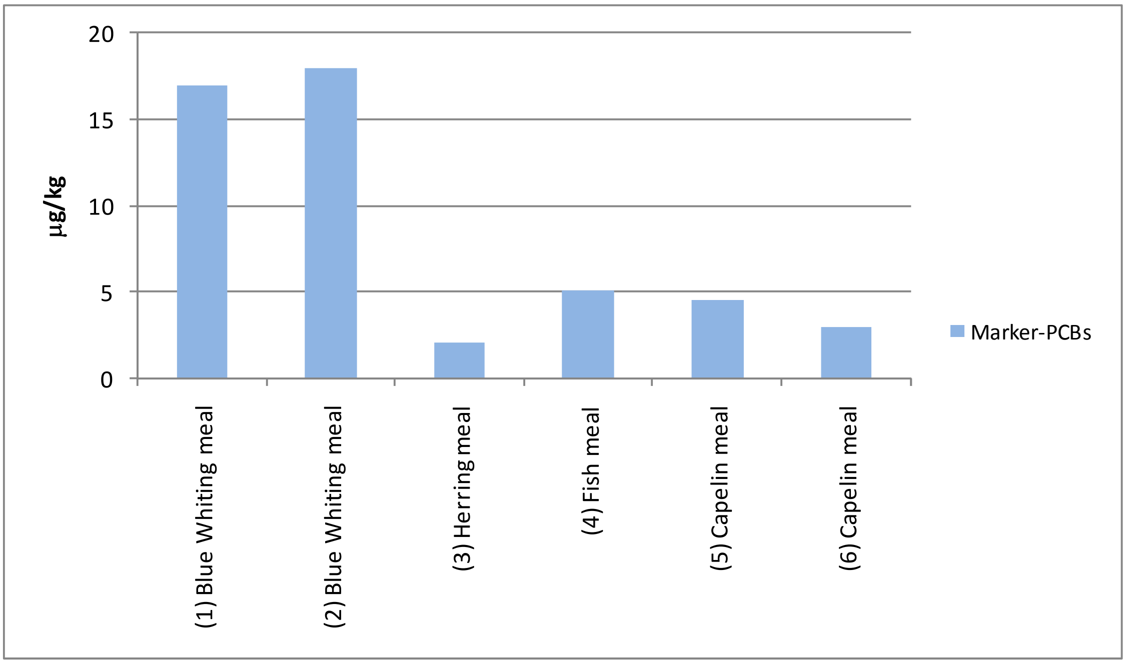

Figure 8: Marker PCBs in fish meal from Iceland in 2007.

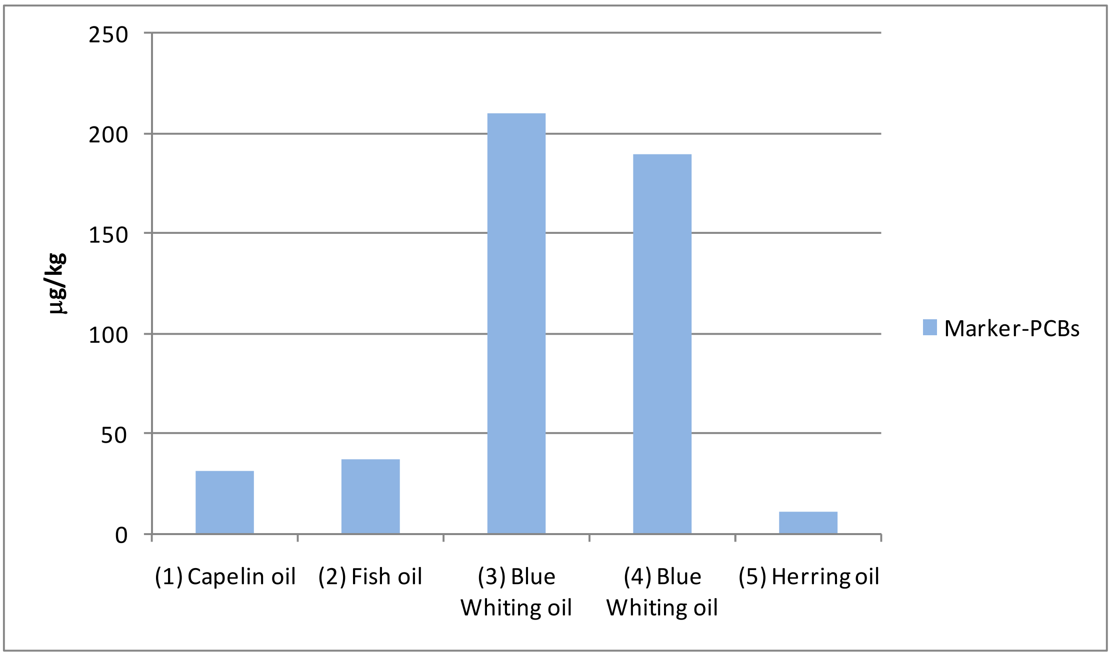

Fig.9: Marker PCBs in fish oils from Iceland in 2007.

5.3 Brominated flame retardants (PBDE)

Brominated diphenyl ethers or PBDE have been accumulating in the environment over the last decade as their use in industry has increased. 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 are three major PBDE products (PentaBDE, OctaBDE and DecaBDE) available on the global market and two of them, PentaBDE and OctaBDE, have been restricted in the EU by the RoHS directive.

5.3.1 PBDE in seafood

PBDE was measured in 26 samples of fish muscle. There is still limited data on PBDEs in seafood from Iceland (Ásmundsdóttir et al., 2008; Rabieh et al., 2008). Therefore a special emphasis was laid on gathering information on PBDE this year. The PBDE are here reported 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 not detected in any of the samples tested. No maximum limits have been set for PBDE in seafood

The results in Figure 10 show very low level of PBDE in general, with halibut and redfish as an exception. The results are reported in detail in Table 1 in the appendix.

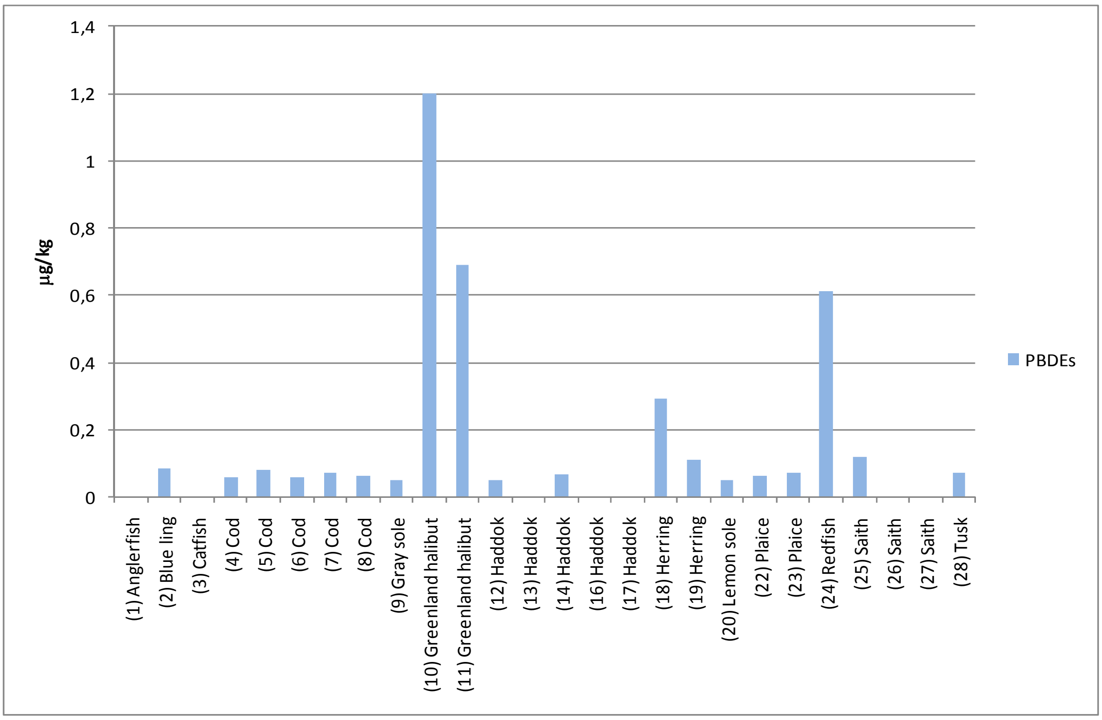

Figure 10: PBDE in fish muscle from Icelandic fishing ground in 2007 in µg/kg wet weight sum of: BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-183.

5.3.2 PBDEs in cod liver

PBDEs were measured in four cod livers and the results are presented in Table 2. The concentrations are low, especially compared to marker PCBs.

5.3.3 PBDEs in fish oil and fish meal for feed

This year (2007) a special emphasis was also laid on gathering information on PBDEs in fish meal and fish oil. The results are shown in Table 3 and 4. PBDE in the table 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 any sample.

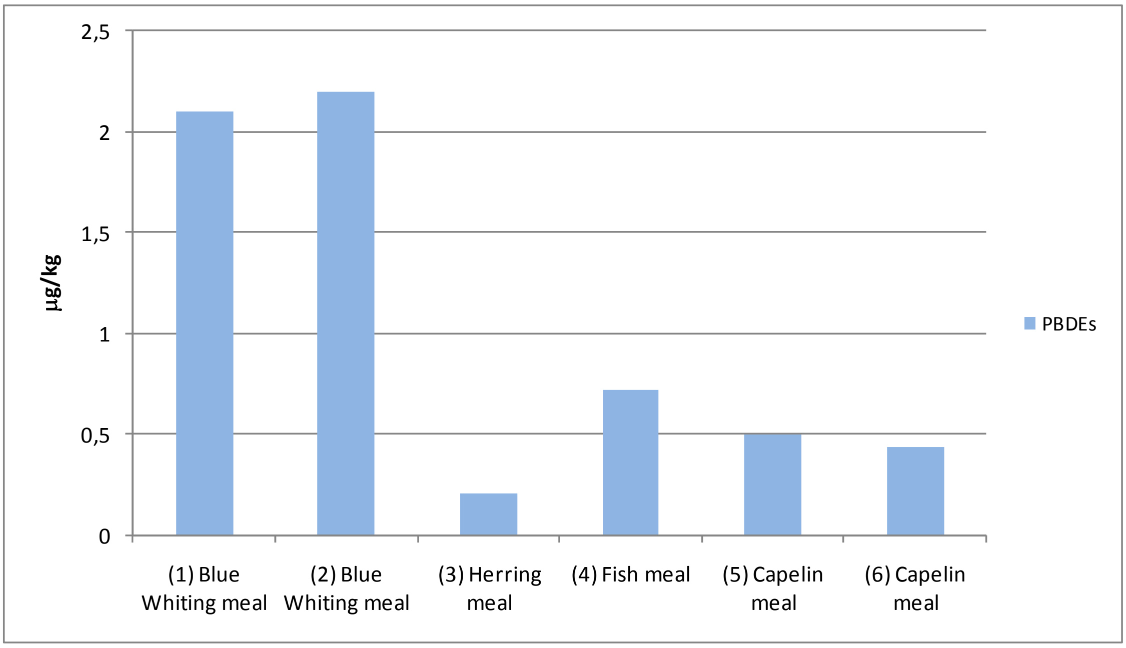

Figure 11: PBDE in fish meal from feed from Icelandic fishing ground in 2007 in µg/kg wet weight sum of: BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-183.

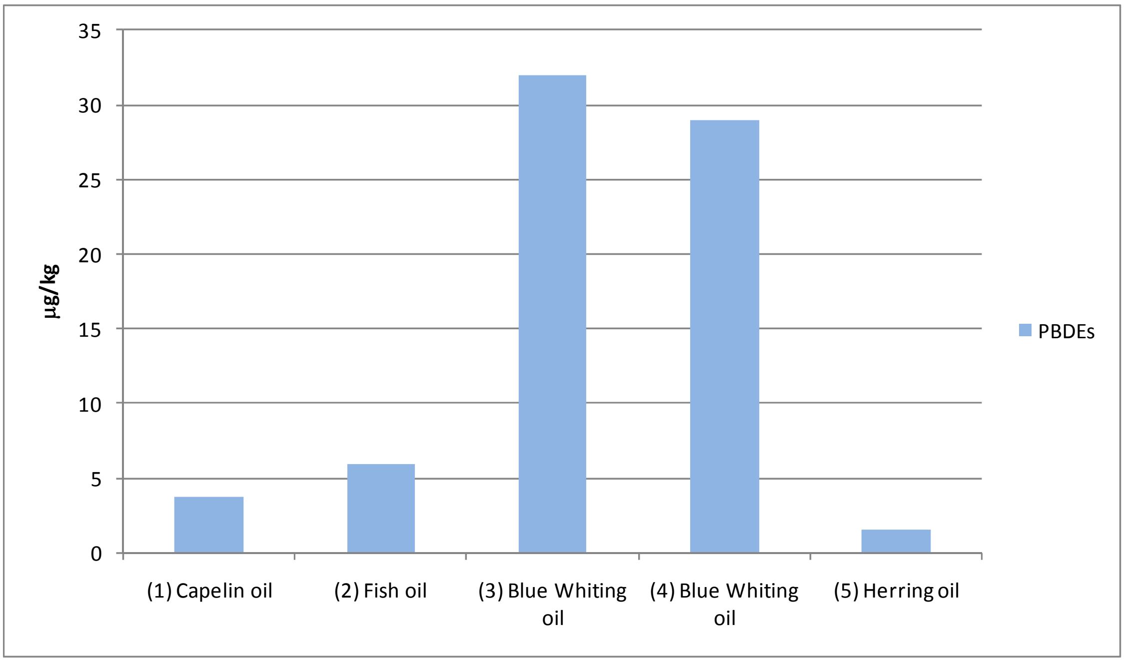

Figure 12: PBDE in fish oil from Icelandic fishing ground in 2007 in µg/kg wet weight sum of: BDE-28, BDE-47, BDE-66, BDE-100, BDE-99, BDE-85, BDE-154, BDE-153 and BDE-183.

5.4 PAH

In the year 2007 emphasis was laid on gathering information on Polyaromatic hydrocarbons (PAH) in edible part of the fish, fish oil and fish meal samples from Iceland. The results are shown in Tables 10 and 11. No PAH were detected in the fish samples and most PAHs are below the LOQ in the fish meal and fish oil. The European Union has agreed up on maximum limits for PAH in food (EU regulation No. 208/2005 amending EU regulation No. 466/2001). The new regulation defines maximum limits for benzo(a)pyrene of 2 µg/kg in fish oils for food where this fish oil is for feed but the results so far are well below these limits.

5.5 Pesticides

In this chapter, the results for ten different classes of pesticides are discussed. Results are shown in Tables 5 to 7 in the appendix. Without exception, the fish samples contain negligible amount of pesticides. The fish meal and fish oil samples contain more pesticides and in exceptional cases the concentration is considerable in relation to the maximum limits set by EU.

Ten different groups of pesticides are 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.

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.

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.

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.

Two E**ndosulfans** are 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.

Other pesticides measured are **Endrin, Heptachlores and Octachlorostyrene**

5.5.1 Pesticides in seafood

The results show very low concentration of all pesticide groups measured in fish from Icelandic waters (for details see Table 5 in the Appendix). As mentioned before, the results are expressed as upper bond, but most of the pesticides are below the limit of detection and therefore the results presented are like to be an overestimation. Only negligible amounts of ΣDDT, HCB, Chlordane and dieldrin were measured in almost all fish species, δ-HCH was always below LOQ. Figure 13 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, herring had the highest concentrations of all pesticides.

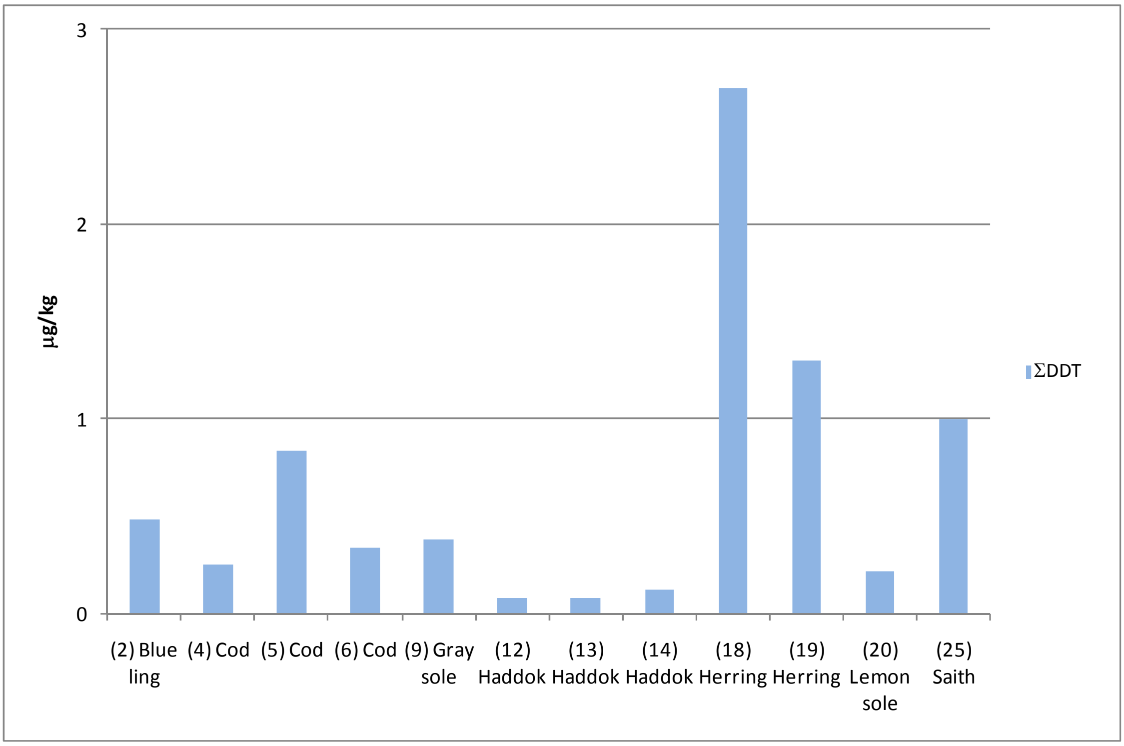

Figure 13: ΣDDT in fish muscle from Icelandic fishing grounds in 2007 in µg/kg wet weight

5.5.2 Pesticides in fish oil for human consumption

No samples of fish oil for human consumption were analysed in the monitoring program this year.

5.5.3 Pesticides in fish meal and fish oil for feed

Several pesticides were measured in fish oil and fish meal for feed (see Table 6 in the Appendix). The concentration of toxaphene in blue whiting meal and blue whiting oil were either close to or above the maximum EU level of 20 and 200 µg/kg, respectively. ΣDDT and HCB concentration was also higher in blue whiting meal and oil, but under the maximum limits set by the EU.

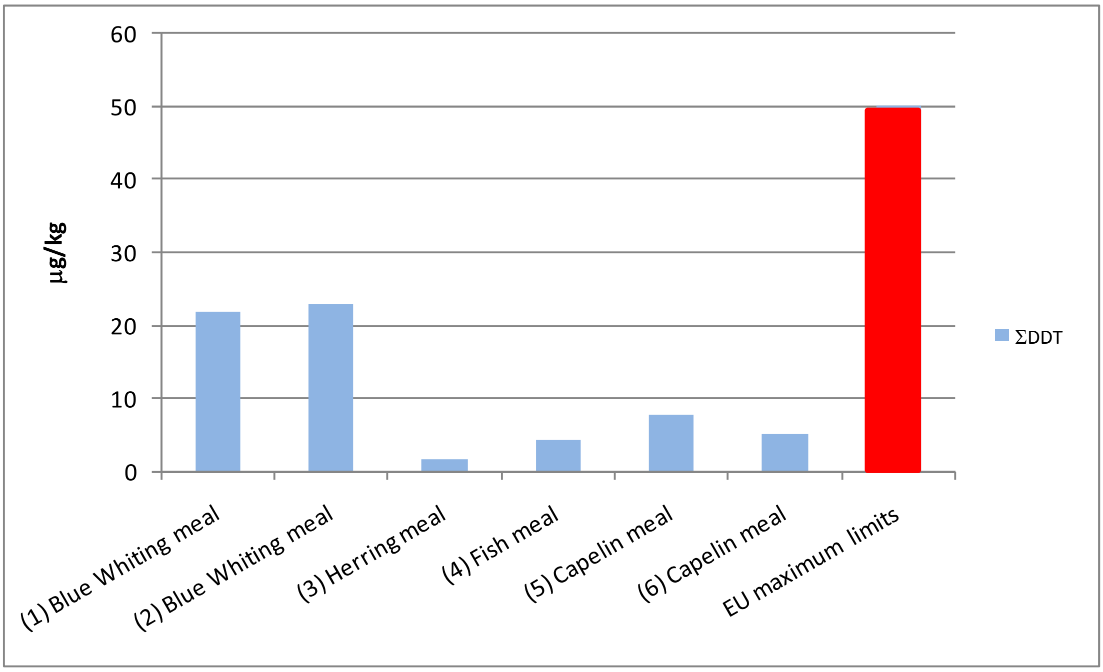

Figure 14: ΣDDT in fish meal from Icelandic fishing grounds in 2007 in µg/kg wet weight

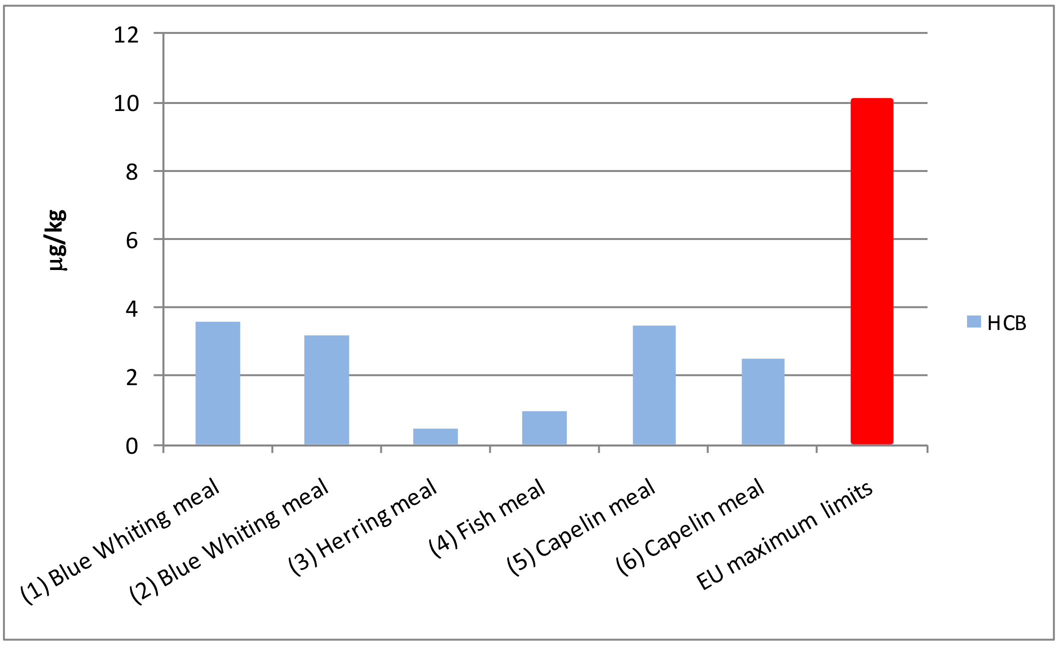

Figure 15: HCB in fish meal from Icelandic fishing grounds in 2007 in µg/kg wet weight

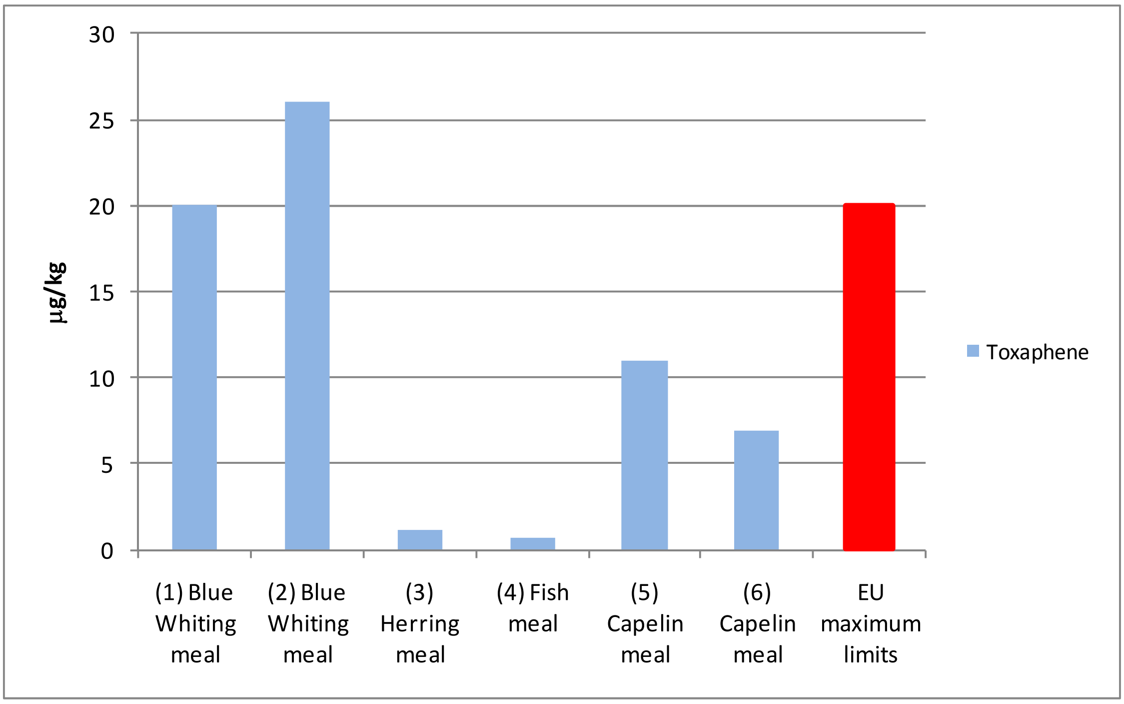

Figure 16: Toxaphene in fish meal from Icelandic fishing grounds in 2007 in µg/kg wet weight

5.6 Inorganic trace elements

Year 2007 all the twenty nine fish samples were measured for the following inorganic trace elements; Hg (mercury), Cd (cadmium), Pb (lead), As (arsenic), Se (selenium), Zn (zinc), Cu (copper), Fe (iron), Cr (chromium), Ca (calcium), K (calcium), P (phosphorous), Mg (magnesium) and Na (sodium).

Some of the elements like Ca, Se, P, Mg and Na 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 8 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 (EU regulation No 78/2005 amending EU regulation No 466/2001). The concentration of Mercury (Hg) in the fish samples is shown in Figure 17 and in Figure 18 as there are higher maximum limits for the fish species presented in Figure 18 according to the above mentioned regulation.

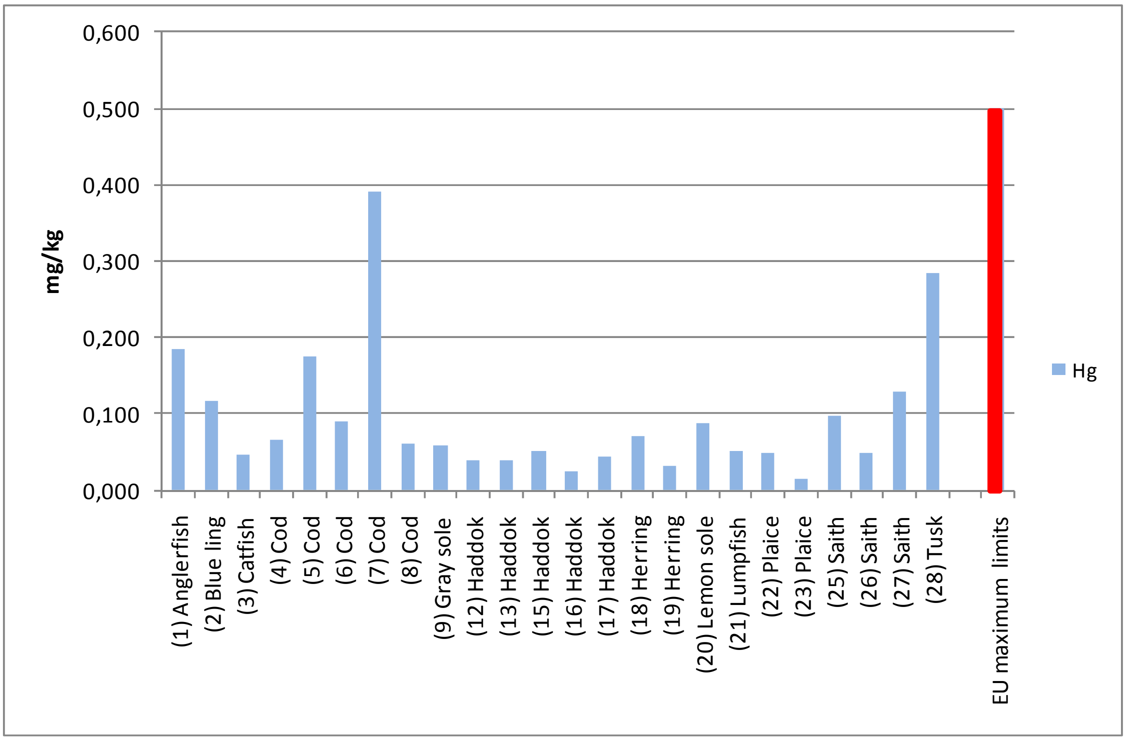

Figure 17: Mercury in fish muscle from Icelandic fishing grounds in 2007 in mg/kg wet weight

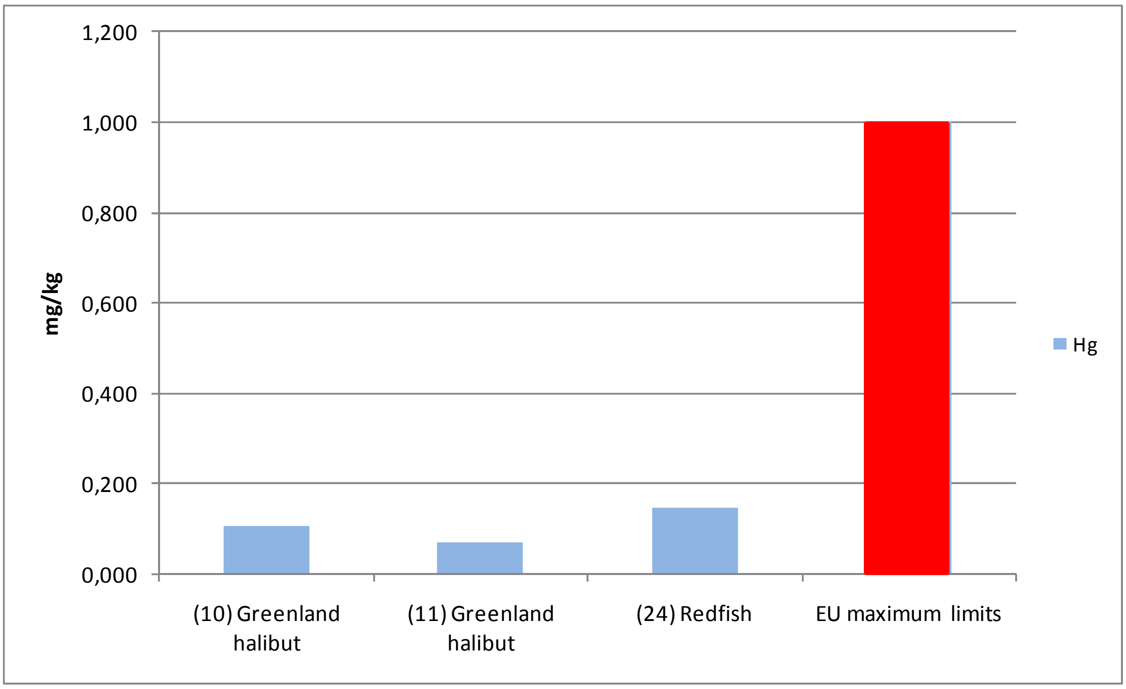

Figure 18: Mercury in fish muscle from Icelandic fishing grounds in 2007 in mg/kg wet weight with different EU maximum limits than in Figure 17.

Figure 19 shows the concentration of cadmium (Cd) in the fish samples that are above the limit of quantification (LOQ). All the samples measured were well below the set maximum limits for Cd.

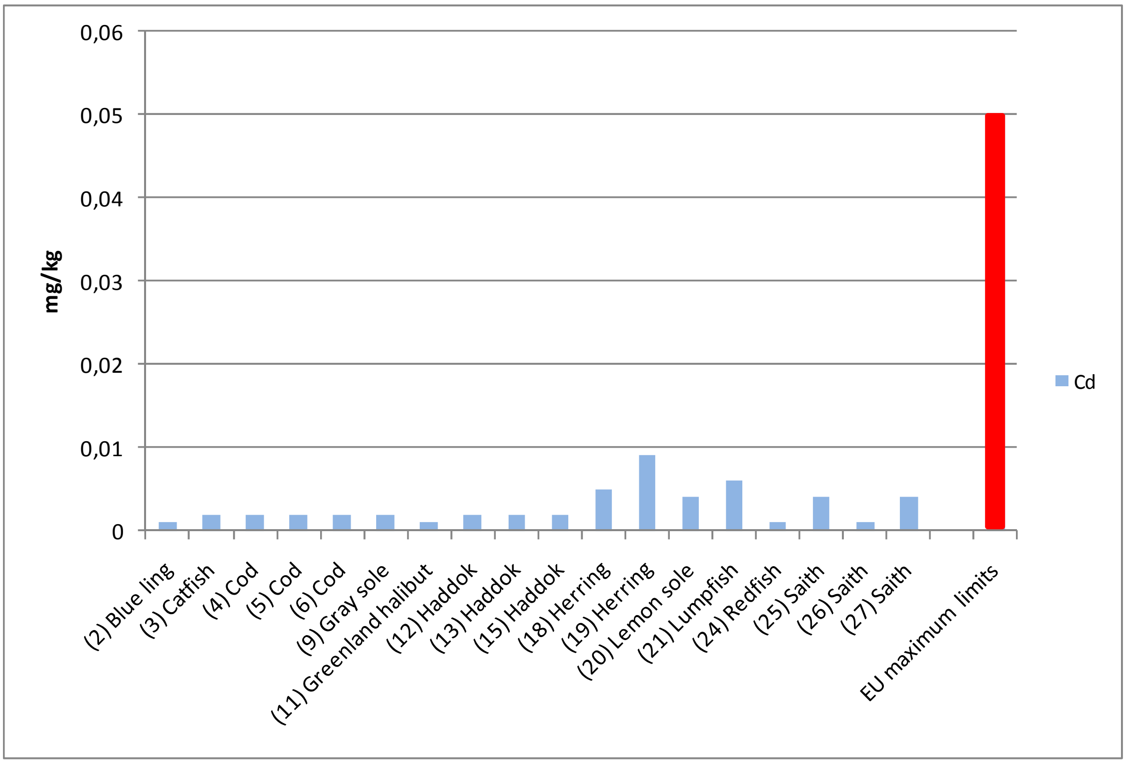

Figure 19: Cadmium in fish muscle from Icelandic fishing grounds in 2007 in mg/kg wet weight.

The concentration of lead (Pb) in fish muscle is very low for fish muscle as can be seen in Table 9 in the Appendix.

No limits have yet been set for arsenic, but results from the monitoring in 2007, which are shown in Figure 20 are in agreement with earlier measurements (Auðunsson, 2004, Ásmundsdóttir et al. 2005, Ásmundsdóttir and Gunnlaugsdóttir, 2006). The results obtained year 2007 show the level of arsenic well below 25 µg/Kg and in most cases between 5-10 µg/Kg except for lemon sole with concentrations of 46 mg/kg. The total arsenic concentration is measured, but not the concentration of inorganic arsenic that is the toxic form.

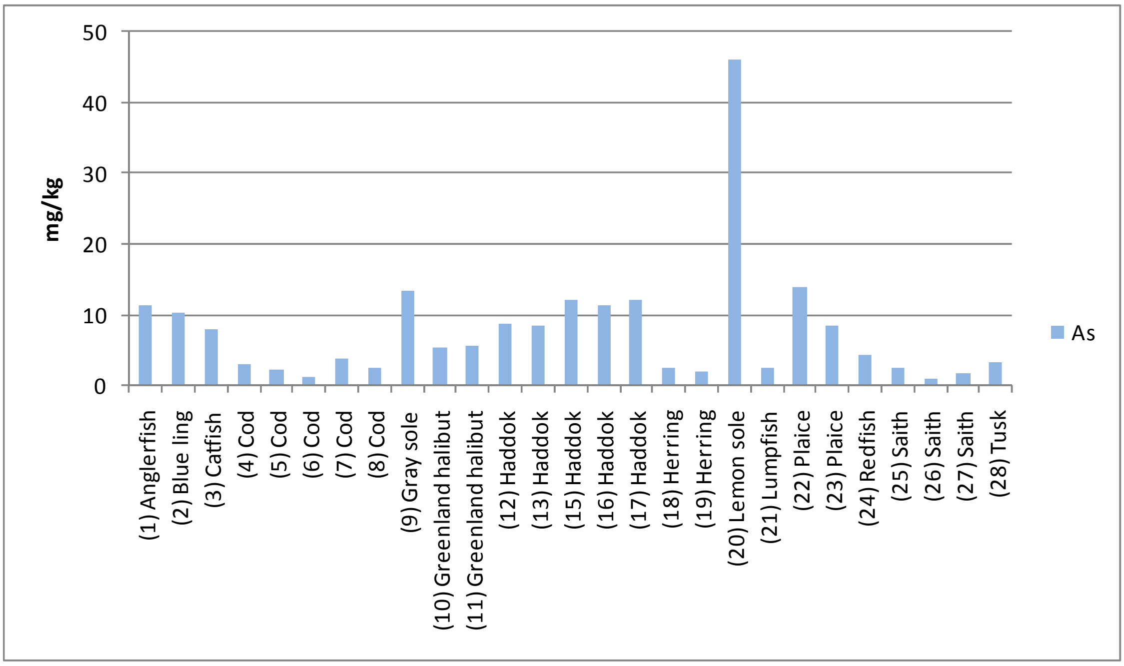

Figure 20: Arsenic in fish muscle from Icelandic fishing grounds in 2007 in mg/kg wet weight.

Minerals were also analysed in eight fish samples as shown in Figure 21.

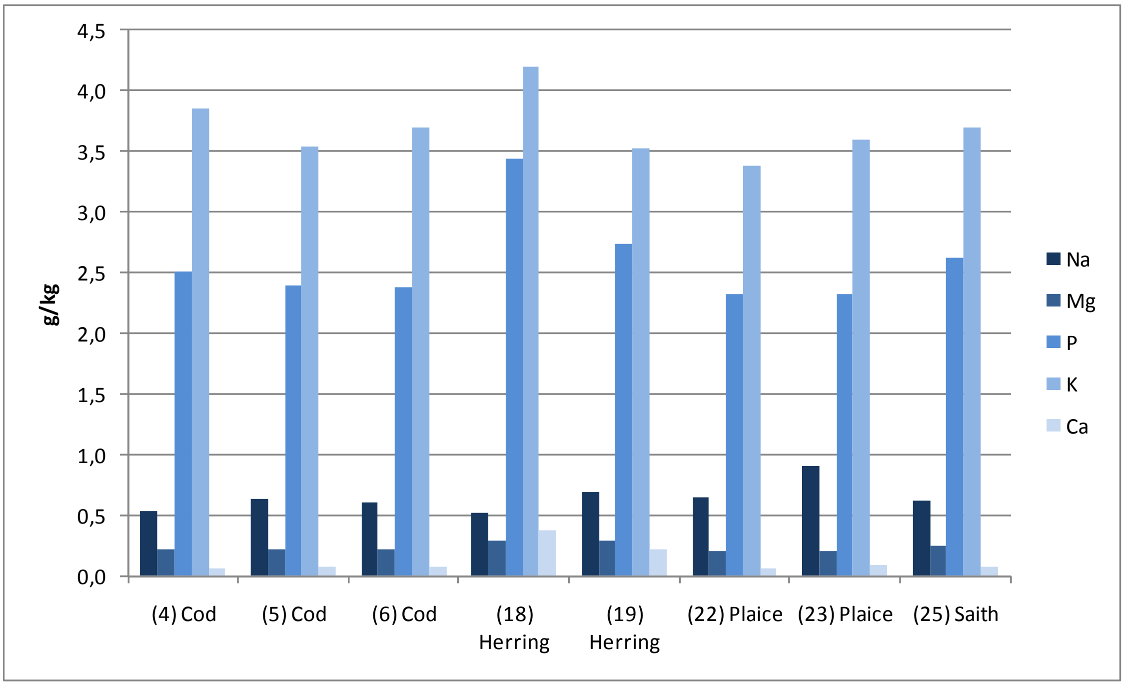

Figure 21: Minerals in fish muscle from Icelandic fishing grounds in 2007 in g/kg wet weight.

5.6.2 Inorganic trace elements in cod liver

Inorganic trace elements were analysed in the individual cod livers as shown in Table 9. There are some variations between different individuals that can be explained with biological variance. The concentrations of mercury and lead are low, average of 0,06 and 0,01 mg/kg, respectively. The concentration of cadmium ranges between 0,026 to 2,83 mg/kg.

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7 Appendix

7.1 Table 1: Dioxin, PCBs and PBDEs in fish muscle

7.2 Table 2: Dioxin, PCBs and PBDEs in cod liver

7.3 Table 3: Dioxin, PCBs and PBDEs in fish meal for feed

7.4 Table 4: Dioxin, PCBs and PBDEs in fish oil for feed

7.5 Table 5: Pesticides in fish muscle

7.6 Table 6: Pesticides in fish meal for feed

7.7 Table 7: Pesticides in fish oil for feed

7.8 Table 8: Minerals in fish muscle

7.9 Table 9: Trace elements and heavy metals in fish muscle

7.10 Table 10: PAH in fish oil for feed

7.11 Table 11: PAH in fish meal for feed

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	DL-PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker PCBs µg/kg	PBDEs µg/kg
M-2007-3296	1	Anglerfish	*Lophius piscatorius*	*S*	*21-82*	1,4	0,027	0,028	0,055	0,30	n.a.
M-2007-1755	2	Blue ling	*Molva dypterygia*	*S*	*53-92*	0,50	0,030	0,022	0,052	0,33	0,086
M-2007-3295	3	Catfish	*Anarhichas lupus*	*E-SE*	*31-51*	1,2	0,036	0,025	0,061	0,48	n.a.
M-2007-1675	4	Cod	*Gadus morhua*	*S*	*46-57*	0,30	0,032	0,018	0,05	0,17	0,057
M-2007-1676	5	Cod	*Gadus morhua*	*S*	*75-85*	0,10	0,030	0,038	0,068	0,42	0,080
M-2007-1679	6	Cod	*Gadus morhua*	*S*	*59-72*	0,30	0,029	0,019	0,048	0,15	0,057
M-2007-3262	7	Cod	*Gadus morhua*	*NA*	*45-56*	0,40	0,027	0,018	0,045	0,20	0,072
M-2007-3263	8	Cod	*Gadus morhua*	*NA*	*75-83*	0,30	0,029	0,022	0,051	0,33	0,061
M-2007-1754	9	Gray sole	*Glyptocephalus cynoglossus*	*S*	*34-44*	0,40	0,027	0,016	0,043	0,14	0,051
M-2007-3239	10	Greenland halibut	*Reinhardtius hippoglossoides*	*E-SE*	*68-75*	12	0,68	1,3	1,98	14	1,2
M-2007-3240	11	Greenland halibut	*Reinhardtius hippoglossoides*	*E*	*50-57*	10	0,69	0,98	1,67	8,6	0,69
M-2007-1695	12	Haddok	*Melanogrammus aeglefinus*	*S*	*48-56*	0,30	0,034	0,021	0,055	0,14	0,048
M-2007-1706	13	Haddok	*Melanogrammus aeglefinus*	*S*	*34-38*	0,30	0,028	0,017	0,045	0,13	n.d.
M-2007-1707	14	Haddok	*Melanogrammus aeglefinus*	*S*	*40-47*	0,20	0,028	0,054	0,082	0,14	0,067
M-2007-3276	16	Haddok	*Melanogrammus aeglefinus*	*NE*	*30-39*	0,80	0,027	0,017	0,044	0,18	n.a.
M-2007-3277	17	Haddok	*Melanogrammus aeglefinus*	*NA*	*51-58*	0,30	0,029	0,018	0,047	0,18	n.a.
M-2007-1865	18	Herring	*Clupea harengus*	*N-NW*	*29-35*	5,9	0,164	0,147	0,311	2,6	0,29
M-2007-1866	19	Herring	*Clupea harengus*	*N-NW*	*18-28*	2,1	0,074	0,08	0,154	1,0	0,11
M-2007-1720	20	Lemon sole	*Microstomus kitt*	*S*	*26-41*	0,20	0,026	0,016	0,042	0,088	0,051
M-2007-3278	22	Plaice	*Pleuronectes platessa*	*N-NW*	*43-49*	0,90	0,042	0,055	0,097	0,41	0,061
M-2007-3279	23	Plaice	*Pleuronectes platessa*	*S*	*31-35*	0,20	0,030	0,030	0,06	0,38	0,073
M-2007-3228	24	Redfish	*Sebastes mentalla*		*40-44*	4,3	0,40	0,69	1,09	8,2	0,61
M-2007-1708	25	Saith	*Pollachius virens*	S-SW	*58-71*	0,40	0,031	0,037	0,068	0,61	0,12
M-2007-3229	26	Saith	*Pollachius virens*	S/SW/N-NW	*52-57*	0,80	0,033	0,027	0,06	0,43	n.a.
M-2007-3230	27	Saith	*Pollachius virens*	W/SW	*70-77*	1,1	0,033	0,025	0,058	0,48	n.a.
M-2007-3211	28	Tusk	*Brosme brosme*	E-SE	*36-69*	0,30	0,029	0,046	0,075	0,59	0,071
		EU action level					3,00	3,00	*	*	*
		EU maximum limits					4,00	*	8,00	*	*

* No maximum 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.

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 2: Dioxins, PCBs and PBDE in cod liver on wet weight

Sample code	Cod liver no.	Size	Lipid content %	PCDD/PCDFs pg/g WHO-TEQ	DL-PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker PCBs µg/kg	PBDEs ng/kg
M-2007-3334	1	Small	73	1,5	5,4	6,9	62	0,0049
M-2007-3335	2	Large	62	4,2	18	22,2	190	0,013
M-2007-3336	3	Small	53	2,1	19	21,1	230	0,016
M-2007-3337	4	Large	68	1,7	10	11,7	160	0,011
	EU action level							
	EU maximum limits					25		

* No maximum 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.
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 3: Dioxins, PCBs and PBDEs in fish meal for feed on wet weight

Sample code	Meal sample no.	Sample name	Latin name	PCDD/PCDF pg/g WHO-TEQ	DL-PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker-PCBs µg/kg	PBDEs µg/kg
M-2007-3196	1	Blue Whiting meal	*Micromesistius poutassou*	0,58	1,3	1,9	17	2,1
M-2007-3197	2	Blue Whiting meal	*Micromesistius poutassou*	0,66	1,5	2,2	18	2,2
M-2007-3199	3	Herring meal	*Clupea harengus*	0,11	0,084	0,2	2,1	0,21
M-2007-3202	4	Fish meal	*herring:mackerel (8:2)*	0,49	0,38	0,9	5,1	0,72
M-2007-3203	5	Capelin meal	*Mallotus villosus*	0,46	0,42	0,9	4,5	0,5
M-2007-3204	6	Capelin meal	*Mallotus villosus*	0,36	0,30	0,7	3,0	0,44
		EU action level		1,00	2,50	3,50	*	
		EU maximum limits		1,25		4,50	*	

* No maximum 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.
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 on wet weight

Sample code	Oil sample no.	Sample name	Latin name	PCDD/PCDF pg/g WHO-TEQ	DL-PCBs pg/g WHO-TEQ	Sum of Dioxins and DL-PCBs pg/g WHO-TEQ	Marker-PCBs µg/kg	PBDEs µg/kg
M-2007-1918	1	Capelin oil	*Mallotus villosus*	3,0	3,1	6,2	31	3,8
M-2007-1919	2	Fish oil	*herring:mackerel (8:2)*	2,9	2,6	5,5	37	5,9
M-2007-3195	3	Blue Whiting oil	*Micromesistius poutassou*	6,0	17	23,1	210	32
M-2007-3198	4	Blue Whiting oil	*Micromesistius poutassou*	5,3	16	21,1	190	29
M-2007-3200	5	Herring oil	*Clupea harengus*	0,64	0,82	1,5	11	1,6
		EU action level		5,0	14			
		EU maximum limits		6,0		24	*	

* No maximum 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.

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 5: Pesticides in fish muscle 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	HCB µg/kg	Σ Heptachlores µg/kg
M-2007-1755	2	Blue ling	*Molva dypterygia*	*S*	*53-92*	0,50	0,003	0,01	0,0043	<0,001	0,48	0,46	0,025
M-2007-1675	4	Cod	*Gadus morhua*	*S*	*46-57*	0,30	0,0021	0,012	0,0043	<0,0005	0,25	0,21	0,024
M-2007-1676	5	Cod	*Gadus morhua*	*S*	*75-85*	0,10	0,0019	0,012	0,0039	<0,0005	0,83	0,29	0,027
M-2007-1679	6	Cod	*Gadus morhua*	*S*	*59-72*	0,30	0,0020	0,011	0,0040	<0,0005	0,34	0,24	0,023
M-2007-1754	9	Gray sole	*Glyptocephalus cynoglossus*	*NA*	*34-44*	0,40	0,0033	0,016	0,0061	<0,0007	0,38	0,065	0,065
M-2007-1695	12	Haddok	*Melanogrammus aeglefinus*	*S*	*48-56*	0,30	0,0025	0,017	0,0044	<0,0006	0,076	0,23	0,015
M-2007-1706	13	Haddok	*Melanogrammus aeglefinus*	*S*	*34-38*	0,30	0,0035	0,021	0,0041	<0,0006	0,081	0,34	0,022
M-2007-1707	14	Haddok	*Melanogrammus aeglefinus*	*S*	*40-47*	0,20	0,0049	0,020	0,0055	<0,0006	0,12	0,38	0,024
M-2007-1865	18	Herring	*Clupea harengus*	*N-NW*	*29-35*	5,9	0,0022	0,16	0,022	<0,01	2,7	0,98	0,30
M-2007-1866	19	Herring	*Clupea harengus*	*N-NW*	*18-28*	2,1	0,017	0,070	0,021	<0,01	1,3	0,67	0,16
M-2007-1720	20	Lemon sole	*Microstomus kitt*	*S*	*26-41*	0,20	0,0018	0,011	0,0037	<0,001	0,22	0,13	0,021
M-2007-1708	25	Saith	*Pollachius virens*	S-SW	58-71	0,40	0,0042	0,019	0,0055	<0,0008	1,0	0,28	0,037
		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
M-2007-1755	2	Blue ling		*S*	*53-92*	0,50	0,10	0,34	0,017	0,015	n.d.	0,12	0,14
M-2007-1675	4	Cod	*Gadus morhua*	*S*	*46-57*	0,30	0,12	0,25	0,0032	0,016	n.d.	0,071	0,058
M-2007-1676	5	Cod	*Gadus morhua*	*S*	*75-85*	0,10	0,15	0,60	0,023	0,021	n.d.	0,16	0,17
M-2007-1679	6	Cod	*Gadus morhua*	*S*	*59-72*	0,30	0,13	0,31	0,0065	0,020	n.d.	0,086	0,064
M-2007-1754	9	Gray sole		*NA*	*34-44*	0,40	0,039	0,70	0,0025	0,077	0,060	0,11	0,10
M-2007-1695	12	Haddok	*Melanogrammus aeglefinus*	*S*	*48-56*	0,30	0,060	0,090	0,012	0,0018	n.d.	0,023	0,018
M-2007-1706	13	Haddok	*Melanogrammus aeglefinus*	*S*	*34-38*	0,30	0,064	0,033	<0,03	<0,004	n.d.	0,044	0,022
M-2007-1707	14	Haddok	*Melanogrammus aeglefinus*	*S*	*40-47*	0,20	0,081	0,080	0,016	<0,004	n.d.	0,031	0,019
M-2007-1865	18	Herring	*Clupea harengus*	*N-NW*	*29-35*	5,9	1,4	0,55	0,0023	0,0038	0,665	1,9	1,5
M-2007-1866	19	Herring	*Clupea harengus*	*N-NW*	*18-28*	2,1	0,85	2,6	0,019	0,10	0,24	0,59	0,48
M-2007-1720	20	Lemon sole	*Microstomus kitt*	*S*	*26-41*	0,20	0,068	0,084	0,0006	0,0067	n.d.	0,083	0,12
M-2007-1708	25	Saith		S-SW	58-71	0,40	0,20	0,99	0,023	0,036	n.d.	0,24	0,24
		EU maximum limits					50			50		100	

Table 6: Pesticides in fish meal for feed on wet weight

Sample code	Fish sample no.	Sample name	β-HCH µg/kg	α-HCH µg/kg	γ-HCH µg/kg	δ-HCH µg/kg	Σ DDT µg/kg	HCB µg/kg	Σ Heptachlores µg/kg
M-2007-3196	1	Blue Whiting meal	0,050	0,09	0,043	<0,006	22	3,6	0,38
M-2007-3197	2	Blue Whiting meal	0,047	0,078	0,048	<0,006	23	3,2	0,62
M-2007-3199	3	Herring meal	0,058	0,10	0,031	<0,006	1,6	0,45	0,36
M-2007-3202	4	Fish meal	0,054	0,17	0,019	<0,006	4,3	0,97	0,40
M-2007-3203	5	Capelin meal	0,093	0,13	0,066	0,010	7,9	3,5	0,33
M-2007-3204	6	Capelin meal	0,097	0,11	0,079	0,0089	5,2	2,5	0,51
		EU maximum limits	10	20	200		50	10	

Table 6 (cont.): Pesticides in fish meal for feed on wet weight

Sample code	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
M-2007-3196	Blue Whiting meal	2,4	20	0,30	0,42	n.d	9,1	6,7
M-2007-3197	Blue Whiting meal	2,4	26	0,26	0,46	n.d	7,4	6,6
M-2007-3199	Herring meal	1,2	1,2	0,011	0,15	n.d	1,1	0,45
M-2007-3202	Fish meal	1,8	0,65	0,038	0,19	n.d	3,5	2,1
M-2007-3203	Capelin meal	4,9	11	0,060	1,2	n.d	6,4	3,4
M-2007-3204	Capelin meal	3,6	6,9	0,045	0,82	n.d	4,9	2,0
	EU maximum limits	10	20		10	100	20	

LOQ for Endosulfane sulfate = 0,1 µg/kg, α-endosulfane = 0,04 µg/kg, β-endusulfane = 0,7 µg/kg

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

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	HCB µg/kg	Σ Heptachlores µg/kg
M-2007-1918	1	Capelin oil	1,2	2,8	0,82	<0,1	62	30	5,0
M-2007-1919	2	Fish oil	0,70	2,3	0,74	<0,006	41	8,7	4,5
M-2007-3195	3	Blue Whiting oil	0,76	3,0	0,72	<0,1	320	45	9,2
M-2007-3198	4	Blue Whiting oil	0,86	2,6	0,69	<0,1	330	47	9,2
M-2007-3200	5	Herring oil	0,62	2,3	0,46	<0,1	17	5,2	3,8
		EU maximum limits	100	200	2000		500	200	

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

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
M-2007-1918	1	Capelin oil	38	90	0,53	9,0	n.d.	35	15
M-2007-1919	2	Fish oil	16	54	0,33	2,5	n.d	13	9,0
M-2007-3195	3	Blue Whiting oil	35	240	4,0	6,6	n.d.	75	62
M-2007-3198	4	Blue Whiting oil	37	180	3,9	7,3	n.d.	160	140
M-2007-3200	5	Herring oil	12	25	0,11	1,4	n.d.	11	7,1
		EU maximum limits	100	200		50	100	50	

LOQ for Endosulfane sulfate = 1 µg/kg, α-endosulfane = 0,5 µg/kg, β-endusulfane = 6 µg/kg

Table 8: Minerals in fish muscle on wet weight

Sample code	Fish sample no.	Sample name		Fishing ground	Size [cm]	Na g/kg	Mg g/kg	P g/kg	K g/kg	Ca g/kg
M-2007-1675	4	Cod	*Gadus morhua*	*S*	*46-57*	0,532	0,223	2,510	3,86	0,066
M-2007-1676	5	Cod	*Gadus morhua*	*S*	*75-85*	0,640	0,220	2,390	3,54	0,076
M-2007-1679	6	Cod	*Gadus morhua*	*S*	*59-72*	0,603	0,214	2,380	3,69	0,075
M-2007-1865	18	Herring	*Clupea harengus*	*N-NW*	*29-35*	0,515	0,294	3,440	4,20	0,383
M-2007-1866	19	Herring	*Clupea harengus*	*N-NW*	*18-28*	0,696	0,290	2,740	3,53	0,227
M-2007-3278	22	Plaice	*Pleuronectes platessa*	*N-NW*	*43-49*	0,655	0,212	2,320	3,38	0,066
M-2007-3279	23	Plaice	*Pleuronectes platessa*	*S*	*31-35*	0,903	0,211	2,330	3,59	0,093
M-2007-1708	25	Saith	*Pollachius virens*	S-SW	*58-71*	0,616	0,251	2,62	3,69	0,071

Table 9: Trace elements and heavy metals in fish muscle on wet weight

Sample code	Fish sample no.	Sample name	Latin name	Fishing ground	Size [cm]	Cr mg/kg	Fe mg/kg	Cu mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Cd mg/kg	Hg mg/kg	Pb mg/kg
M-2007-3296	1	Anglerfish	*Lophius piscatorius*	*S*	*21-82*	0,054	1,41	0,139	4,88	11,2	0,449	-	0,184	0,001
M-2007-1755	2	Blue ling	*Molva dypterygia*	*S*	*53-92*	0,054	1,00	0,149	4,43	10,2	0,438	0,001	0,116	0,002
M-2007-3295	3	Catfish	*Anarhichas lupus*	*E-SE*	*31-51*	0,589	4,52	0,285	9,24	7,91	0,931	0,002	0,047	0,010
M-2007-1675	4	Cod	*Gadus morhua*	*S*	*46-57*	0,023	1,49	0,201	4,14	3,12	0,327	0,002	0,065	0,002
M-2007-1676	5	Cod	*Gadus morhua*	*S*	*75-85*	0,047	2,22	0,254	4,72	2,17	0,393	0,002	0,174	0,002
M-2007-1679	6	Cod	*Gadus morhua*	*S*	*59-72*	0,071	1,82	0,228	3,90	1,21	0,344	0,002	0,089	0,001
M-2007-3262	7	Cod	*Gadus morhua*	*NA*	*45-56*	0,007	1,33	0,206	3,62	3,65	0,257	-	0,390	0,002
M-2007-3263	8	Cod	*Gadus morhua*	*NA*	*75-83*	0,010	1,35	0,243	4,08	2,40	0,275	-	0,060	0,001
M-2007-1754	9	Gray sole	*Glyptocephalus cynoglossus*	*S*	*34-44*	0,048	1,36	0,132	3,52	13,4	1,40	0,002	0,059	0,002
M-2007-3239	10	Greenland halibut	*Reinhardtius hippoglossoides*	*E-SE*	*68-75*	0,012	1,10	0,172	4,35	5,21	0,522	-	0,106	0,001
M-2007-3240	11	Greenland halibut	*Reinhardtius hippoglossoides*	*E*	*50-57*	0,015	1,01	0,157	4,01	5,48	0,457	0,001	0,070	0,001
M-2007-1695	12	Haddok	*Melanogrammus aeglefinus*	*S*	*48-56*	0,027	1,36	0,167	3,02	8,83	0,533	0,002	0,040	0,001
M-2007-1706	13	Haddok	*Melanogrammus aeglefinus*	*S*	*34-38*	0,020	1,37	0,179	2,81	8,41	0,517	0,002	0,039	0,002
M-2007-3272	15	Haddok	*Melanogrammus aeglefinus*			0,026	1,41	0,162	3,52	12,0	0,558	0,002	0,051	0,001
M-2007-3276	16	Haddok	*Melanogrammus aeglefinus*	*NE*	*30-39*	0,012	1,66	0,215	3,69	11,2	0,501	-	0,025	0,002
M-2007-3277	17	Haddok	*Melanogrammus aeglefinus*	*NA*	*51-58*	0,009	1,53	0,220	3,57	12,2	0,474	-	0,044	0,002
M-2007-1865	18	Herring	*Clupea harengus*	*N-NW*	*29-35*	0,023	12,7	1,060	6,44	2,49	0,490	0,005	0,070	0,001
M-2007-1866	19	Herring	*Clupea harengus*	*N-NW*	*18-28*	0,026	9,72	1,030	8,49	1,97	0,522	0,009	0,031	0,002
M-2007-1720	20	Lemon sole	*Microstomus kitt*	*S*	*26-41*	0,054	1,62	0,136	3,91	46,0	1,420	0,004	0,087	0,001
SN-2006-74	21	Lumpfish	*Cyclopterus lumpus*			0,052	4,14	0,747	5,18	2,50	0,307	0,006	0,051	0,002
M-2007-3278	22	Plaice	*Pleuronectes platessa*	*N-NW*	*43-49*	0,012	1,13	0,128	4,79	13,8	0,489	-	0,049	0,004
M-2007-3279	23	Plaice	*Pleuronectes platessa*	*S*	*31-35*	0,015	1,99	0,147	4,79	8,43	0,424	-	0,015	0,002
M-2007-3228	24	Redfish	*Sebastes mentalla*		*40-44*	0,014	1,81	0,207	3,70	4,40	0,745	0,001	0,148	0,002
M-2007-1708	25	Saith	*Pollachius virens*	S-SW	*58-71*	0,069	4,40	0,565	4,74	2,57	0,400	0,004	0,097	0,001
M-2007-3229	26	Saith	*Pollachius virens*	S/SW/N-NW	*52-57*	0,03	4,76	0,683	5,70	1,00	0,388	0,001	0,049	0,001
M-2007-3230	27	Saith	*Pollachius virens*	W/SW	*70-77*	0,035	4,31	0,842	5,36	1,81	0,385	0,004	0,130	0,008
M-2007-3211	28	Tusk	*Brosme brosme*	E-SE	*36-69*	0,023	1,34	0,146	4,81	3,19	0,604	-	0,284	0,001
M-2007-3334	29	Cod liver	*Gadus morhua*			0,209	9,43	2,82	10,9	2,53	0,641	2,83	0,034	0,009
M-2007-3335	30	Cod liver	*Gadus morhua*			0,154	17,9	2,75	15,8	5,08	0,733	0,079	0,059	0,017
M-2007-3336	31	Cod liver	*Gadus morhua*			0,152	10,4	5,67	23,5	5,47	0,983	0,484	0,087	0,016
M-2007-3337	32	Cod liver	*Gadus morhua*			0,016	4,39	3,07	16,0	2,60	0,941	0,026	0,053	0,004
		Eu action level												
		EU maximum limits										0,05	0,50	0,30
		EU m.l. crustacean										0,05	0,50	0,50
		EU m.l. halibut & redfish											1,00	

Table 10: PAH in fish oil on wet weight

Sample code	Oil sample no.	Sample name	Phenanthrene µg/kg	Anthracene µg/kg	Fluoranthene µg/kg	Pyrene µg/kg	Benzo[b]naphtho [2,1-d] thiophene µg/kg	Benzo[c] phenanthrene µg/kg	Benzo[a] anthracene µg/kg	Chrysene - Triphenylene µg/kg	Benzo[b+j+k] fluoranthene µg/kg
M-2007-1918	1	Capelin oil	3,7	0,3	2,0	<2	0,15	<0,10	0,33	1,7	0,68
M-2007-1919	2	Fish oil	<2,0	<0,10	<1,0	<1,0	0,16	<0,10	0,24	0,83	0,43
M-2007-3195	3	Blue Whiting oil	<2,0	<0,10	<1,0	<1,0	<0,10	<0,10	<0,10	0,95	<0,10
M-2007-3198	4	Blue Whiting oil	12,0	0	2,1	<4,0	0,97	<0,10	0,38	3	0,25
M-2007-3200	5	Herring oil	<2,0	<0,10	<1,0	<0,80	<0,10	<0,10	<0,10	0,25	<0,10
		EU maximum limits									

Table 10 (cont): PAH in fish oil on wet weight

Sample code	Oil sample no.	Sample name	Benzo[ghi] fluoranthene µg/kg	Benzo[e] pyrene µg/kg	Benzo[a] pyrene µg/kg	Indeno[1,2,3-cd] pyrene µg/kg	Benzo[ghi] perylene µg/kg	Anthanthrene µg/kg	Dibenz[ah] anthracene µg/kg	Coronene µg/kg
M-2007-1918	1	Capelin oil	<0,10	0,34	0,23	0,20	<0,20	<0,10	<0,10	<0,50
M-2007-1919	2	Fish oil	<0,10	0,14	0,12	0,13	<0,20	<0,10	<0,10	<0,50
M-2007-3195	3	Blue Whiting oil	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3198	4	Blue Whiting oil	<0,10	0,25	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3200	5	Herring oil	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
		EU maximum limits								

Table 11: PAH in fish meal on wet weight

Sample code	Meal sample no.	Sample name	Phenanthrene µg/kg	Anthracene µg/kg	Fluoranthene µg/kg	Pyrene µg/kg	Benzo[b]naphtho [2,1-d] thiophene µg/kg	Benzo[c] phenanthrene µg/kg	Benzo[a] anthracene µg/kg	Chrysene - Triphenylene µg/kg	Benzo[b+j+k] fluoranthene µg/kg
M-2007-3196	1	Blue Whiting meal	<2,0	<0,20	1,2	<0,70	<0,10	<0,10	<0,10	0,24	0,13
M-2007-3197	2	Blue Whiting meal	3,1	0,47	<0,70	<0,70	<0,10	<0,10	0,18	0,65	0,11
M-2007-3199	3	Herring meal	6,7	0,18	<0,70	<0,90	<0,10	<0,10	0,13	0,35	<0,10
M-2007-3202	4	Fish meal	<2,0	<0,20	<0,60	<0,40	<0,10	<0,10	<0,10	<0,10	<0,10
M-2007-3203	5	Capelin meal	24	0,73	1,3	<0,90	<0,10	<0,10	<0,10	0,25	<0,10
M-2007-3204	6	Capelin meal	61	1,8	2	<0,90	<0,10	<0,10	<0,10	0,22	<0,10
		EU maximum limits									

Table 11 (cont): PAH in fish meal on wet weight

Sample code	Meal sample no.	Sample name	Benzo[ghi] fluoranthene µg/kg	Benzo[e] pyrene µg/kg	Benzo[a] pyrene µg/kg	Indeno[1,2,3-cd] pyrene µg/kg	Benzo[ghi] perylene µg/kg	Anthanthrene µg/kg	Dibenz[ah] anthracene µg/kg	Coronene µg/kg
M-2007-3196	1	Blue Whiting meal	0,47	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3197	2	Blue Whiting meal	0,19	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3199	3	Herring meal	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3202	4	Fish meal	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3203	5	Capelin meal	0,19	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
M-2007-3204	6	Capelin meal	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,10	<0,50
		EU maximum limits								