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Undesirable substances in seafood products - Results from the monitoring activities in 2004

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Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins
Icelandic Fisheries Laboratories Report Summary

Titill / Title	Undesirable substances in seafood products– results from the monitoring activities in 2004		
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Ágrip á íslensku:	Vöktun á óæskilegum efnum í sjávarafurðum, bæði afurðum til manneldis og afurðum lýsis- og mjöliðnaðar, hófst árið 2003 að frumkvæði Sjávarútvegsráðuneytisins. Þetta er í fyrsta skipti sem upplýsingum um mikinn fjölda aðskoatefna í helstu tegundum sjávarfangs af Íslandsmiðum er safnað á kerfisbundinn hátt. Mæld voru dioxin, dioxinlík PCB- og bendi PCB efni, en auk þess tíu mismunandi tegundir varnarefna, kvikasilfur og arsen. Þessi skýrsla er samantekt niðurstaðna vöktunarinnar árið 2004.. Gagnaöflun af þessu tagi verður sífellt mikilvægari í ljósi tíðra frétta um aðskotaefni í matvælum. Íslensk stjórnvöld þurfa að geta brugðist hratt og fumlaust við slíkum fréttum til að tryggja áframhaldandi aðgang okkar afurða að mörkuðum og koma í veg fyrir tjón, sem af slíkri umræðu gæti hlotist ef ekki liggja fyrir bæði gögn og þekking. Umfjöllun, bæði í almennum fjölmiðlum og í vísindaritum, hefur margoft krafist slíkra viðbragða íslenskra stjórnvalda og óyggjandi sýnt fram á hve mikilvægt það er að regluleg vöktun fari fram og að á Íslandi séu stundaðar sjálfstæðar rannsóknir í eins mikilvægum málaflokk og mengun sjávarafurða er		
Lykilorð á íslensku:	*sjávarfang, vöktun, Díoxín, díoxínlík PCB, PCB, snefilefni ,varnarefni*		
Summary in English:	The monitoring of undesirable substances in seafood products began in 2003, at the request of the Icelandic Ministry of Fisheries. Until then, such monitoring of the edible portion of marine catches had been rather limited in Iceland. This report summarizes the results obtained in 2004. Data was collected on various substances, such as mercury, arsen, polychlorinated dibenzodioxins and dibenzofurans (17 substances), dioxin-like PCBs (12 substances), marker PCBs (7 substances), as well as 10 different types of pesticides This was the second year of the monitoring programme and further data collection is underway and the aim is to continue this program for several years to come		
English keywords:	*Marine catches, monitoring, dioxin, PCB, trace elements, pesticides*		

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1 Introduction

In a project, which started in 2003 and which is being funded by the Ministry of Fisheries in Iceland, monitoring of various undesirable substances in the edible part of marine catches, as well as in fish meal and fish oil for feed has been systematically carried out. This is the first time that measurements of such a great number of undesirable substances has been carried out in so many species of marine catches from Icelandic fishing grounds. In addition, information is being gathered on numerous substances that have not been previously measured. The substances investigated in this project are: trace metals (mercury, led, cadmium and total arsen), PAHs, polychlorinated dibenzo dioxins and dibenzo furans (commonly called dioxins), dioxin-like PCBs, marker PCBs, polybrominated flame retardants (PBDEs), organotins and numerous organochlorines, mostly pesticides (HCB, DDTs, HCHs, dieldrin, endrin, chlordanes, toxaphenes, endosulfan substances and mirex. In all, 29 pesticides and breakdown products.
The purpose of this work is:

A) To examine how products measure up against the limits set by EU for dioxins (polychlorinated dibenzodioxins and dibenzofurans) (Regulation (EC) No 1882/2003).
B) To measure the concentration of dioxin-like PCBs as a basis for setting maximum values within the EU before the end of 2005. New limits for total TEQ of dioxin and dioxinlike PCB´s will apply before end 2006 amending Regulation (EC) No 466/2001.
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 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, organotins and brominated flame retardants).
E) To evaluate the status of Icelandic seafood products in terms of undesirable substances.

The project started year 2003 (Guðjón Atli Auðunsson, 2004) and this report summarizes results from the monitoring programme in 2004.

2 Summary

This report summarizes the results obtained in the year 2004 from the monitoring of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. It was the second year of a monitoring program called “Undesirable substances in seafood products” financed by the Ministry of fisheries of Iceland. The purpose of this monitoring program is to evaluate the status of Icelandic seafood products in terms of undesirable substances and to gather information on concentration of different substances for the purpose of setting limits or lowering existing limits in the European Union (EU) in the future.

A substantial amount of information was collected on dioxins, dioxin like PCBs, marker PCBs, and pesticides in the edible part of marine catches, fish meal and fish oil. In addition, information was gathered on the concentration of the trace metals mercury and total arsen in these samples. The results obtained in the monitoring program in 2003 were published in a detailed report in Icelandic in October 2004. (Guðjón Atli Auðunsson, 2004).
The results obtained in 2004 are similar with the results from the year 2003 for the different undesirable substances investigated. They show 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 are also found to be low in the edible part of fish muscle, compared to maximum, allowed limits where they exist, for example in Germany, Holland, Sweden and Iceland. The measured concentration of mercury was also well below the maximum limit set by EU, in fact the concentration of mercury is in most cases at least ten times below the present maximum limits. The fish species, evaluated in this study, contained from 0,2% to 12% fat in the fish muscle and the results showed that the level of the Persistent Organic pollutants (POPs), increased with higher fat content in the fish muscle. Other variables of interest are age and habitat, but the data gathered so far is not sufficient to conclude anything about these two variables.
The fish meal and fish oil measured as part of the monitoring program in 2004 are products used as feed ingredients, hence they are subjected to different limits by the EU. In all cases, the fish meal samples measured in this study were within the limits set by EU for dioxins, PCBs and pesticides, albeit higher than in the fish samples. A project financed by NORA (Nordic Atlantic Co-operation), has shown that the level of dioxins and dioxin-like PCBs in fish meal and fish oil depends considerably on the season, as well as the spawning and nutritional condition of the pelagic fish stocks (Anon. 2003). In the monitoring program in 2004, pesticides were measured in the fish meal and fish oil samples obtained in the Nora study and the results show exactly the same trend for pesticides as were previously reported for the dioxins and dioxin-like PCBs in the Nora study.
The results reveal that three samples of blue whiting oil from the Nora study exceeded the EU maximum limits for Toxaphene and Chlordane. Furthermore, one sample of herring oil from the Nora study exceeded the EU maximum limits for Toxaphene: In all four cases, the fish was caught during the spawning period when the fish is in poor nutritional condition and therefore the POPs concentration is high, especially in the oil samples. This was also observed for dioxins and dioxin-like PCBs in the Nora study (Anon. 2003).

3 Contaminants measured in the project

The following contaminants were 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: Dioxns (dibenzo-p-dioxins) og díbensofurans (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.

Dioxinlike-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:
CB28, CB52, CB101, CB 118, CB 138, CB 153, CB 180.

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

Inorganic trace elements:
Hg (mercury), Cd (cadmium), Pb (led) and total As (organic and inorganic arsen).

PBDE-substances (10 types):
PBDE 28, PBDE 47, PBDE 66, PBDE 100, PBDE 99, PBDE 85, PBDE 154, PBDE 153, PBDE 183, PBDE 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). The collection of samples was divided among the EU member states, plus Iceland and Norway, in proportion to the production in each country. According to EC recommendation, Iceland should measure at least 29 samples of fish and 12 samples of fish oil each year or a total of at least 41 samples of seafood for human consumption. According to EU, Iceland should also measure samples of compound feeds and feed components originated from pelagic fish stocks, or at least 16 samples of fishmeal and 19 samples of fish oil every year, a total of 35 samples. (SANCO/4546/01 – rev3). The EU campaign continues until 2006.

4.1.1 Seafood

All the analysis was done on the edible part of the seafood products. The fish was collected from the fishing grounds around Iceland which are divided in five areas, as illustated on Figure 1a. All samples are identified with the location of the fishing area, except when the sample contains individuals from different areas. Seafood identified with the letter W is from the NW and N fishing grounds, other identifications, i.e. S, SW, E and NE, correspond to the identification used for the fishing ground in Figure 1a. Each fish sample consists of at least ten individuals of a specific length distribution. Data on dioxins and PCBs for fish oil for human consumption were obtained directly from the Icelandic producers of these products.

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. It is important to point out that the capelin, blue whiting and herring fish meal and fish oil samples, which were analyzed for dioxins and PCBs are **not the same** samples as those analyzed for pesticides. The samples of oil and meal from herring, capelin and blue whiting used for pesticides analyzes are actually **from the same raw material,** i.e. capelin oil samples nr. 300-307 correspond to capelin meal samples nr. 206-213, blue whiting oil samples nr. 308-311 correspond to meal samples nr. 214-218 and herring oil samples nr. 313-316 correspond to meal samples nr. 219-222 . These samples are from the NORA project and have previously been measured for dioxins and PCBs (Anon. 2003). In the feed industry this research is often referred to as “the Nora study” as it is considered to be one of the most comprehensive studies carried out for undesirable substances in raw material and processed feed components from the pelagic fish stocks. In the monitoring program in 2004, it was decided to use these exceptionally well defined samples and measure pesticides in the fish meal and fish oil samples obtained in the Nora study.

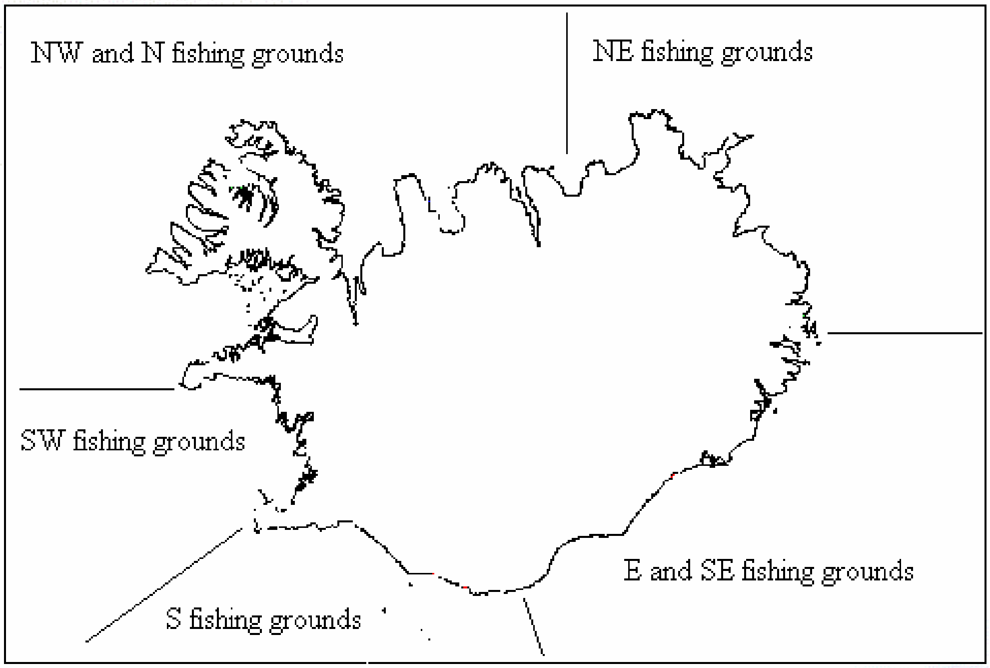

Fig 1a: The division of the fishing grounds around Iceland used in this research

4.2 Analysis

Inorganic trace elements: Hg, Cd, Pb, and As were measured by the Icelandic Fisheries Laboratories. All other contaminants were measured by ERGO Forschungsgesellschaft mbH, Hamborg. ERGO has taken part in international inter laboratory quality control study organized by WHO and EU and uses accredited methods for analyzing dioxin, WHO-PCB, marker-PCB, pesticides, BPDE, PAH and inorganic trace elements.

5 Results of monitoring of seafood and seafood products in Iceland

Results in the histograms are expressed as upper bond level, which means that when the concentration of a substance is measured to be below limit of detection (LOD) of the analytical method the concentration is set to be equal to the LOD. Histograms show the concentration of each substance in comparison to maximum levels permitted by EU where they exist. In the case of Dioxins and dioxin-like PCBs the results are expressed in WHO-TEQ which is the toxic equivalency of the substances agreed upon by the World Health Organization (WHO) in 1997 and adapted by EU in its legislations. The analytical data are converted to 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). More details regarding the results obtained can be found in Tables 1-9 in the Appendix.

5.1 Dioxins (PCDD/Fs) and dioxin like PCB

5.1.1 Seafood

All the fish species measured are far below the limits set by EU for dioxins, as can be seen from Figure 1 and 2. The Greenland halibut that contains by far the most dioxins, contains however six times less than EU action limits. Most of the species, such as cod, haddock, etc. contain negligible amount of dioxins in the muscle.

A considerable difference was observed in the dioxin content between different fish species. The species that accumulate fat in the muscle, like redfish, herring, halibut and Greenland halibut, contain more dioxins than species that accumulate fat in the liver and thus have almost no fat in the muscle. The level of dioxin increases almost in the same proportion as the fat percentage in the muscle, this was to be expected since dioxin and other organochlorine substances are fat solvable. Other important variables are age and habitat.

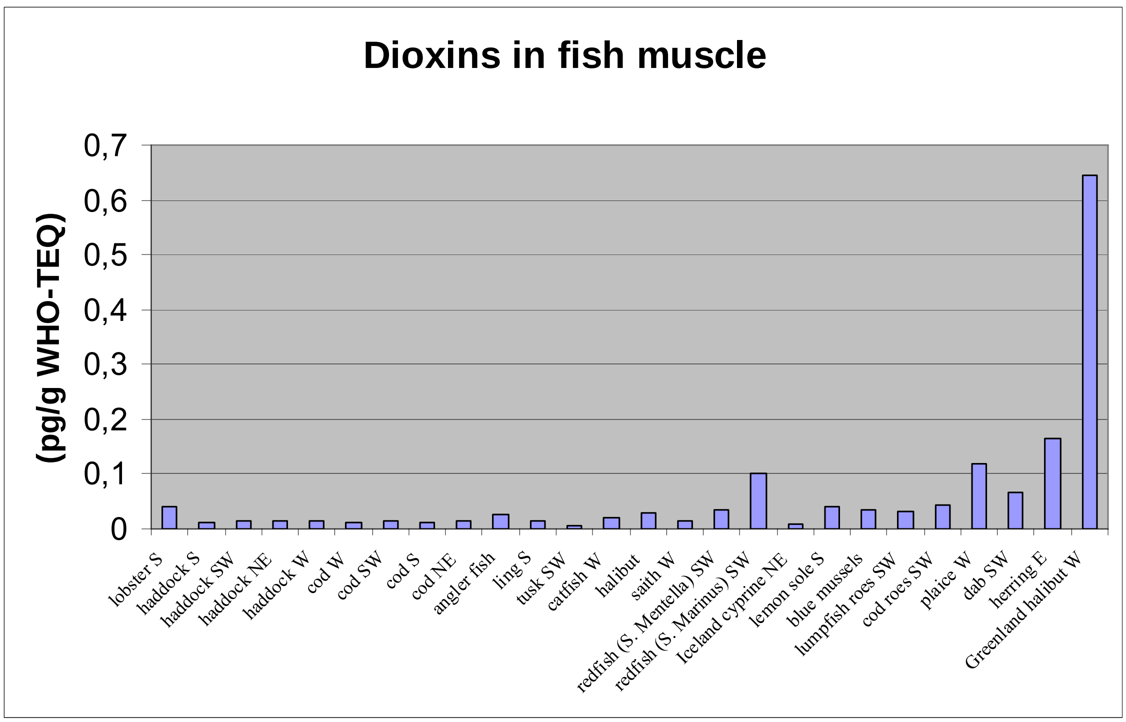

Fig. 1: Dioxins in the edible part of fish muscle from Icelandic fishing grounds 2004(in WHO-TEQ pg/g wet weight)

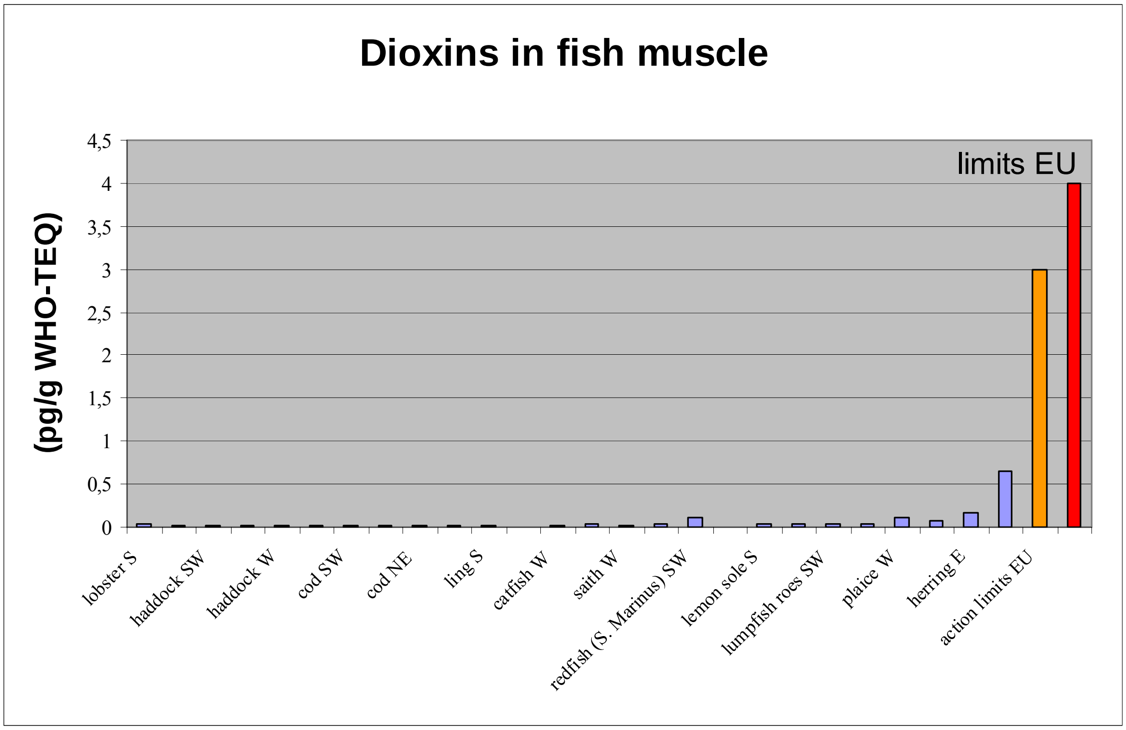

Fig. 2: Dioxins in the edible part of fish muscle from Icelandic fishing grounds in 2004 in relation to action limit and maximum limit in EU (in WHO-TEQ pg/g wet weight)

No maximum limit is currently in effect for dioxin-like PCBs in the EU but maximum limit for the sum of dioxins and dioxin-like PCBs is foreseen in the year 2006.

The Toxic Equivalent (TEQ) of dioxin-like PCBs in the fish muscle is proportionally higher than for the dioxin itself (Figure 3). Nevertheless, the total TEQ of dioxin and dioxin-like PCB's is in all cases far below the maximum level to be set by EU in 2006 (Figure 4).

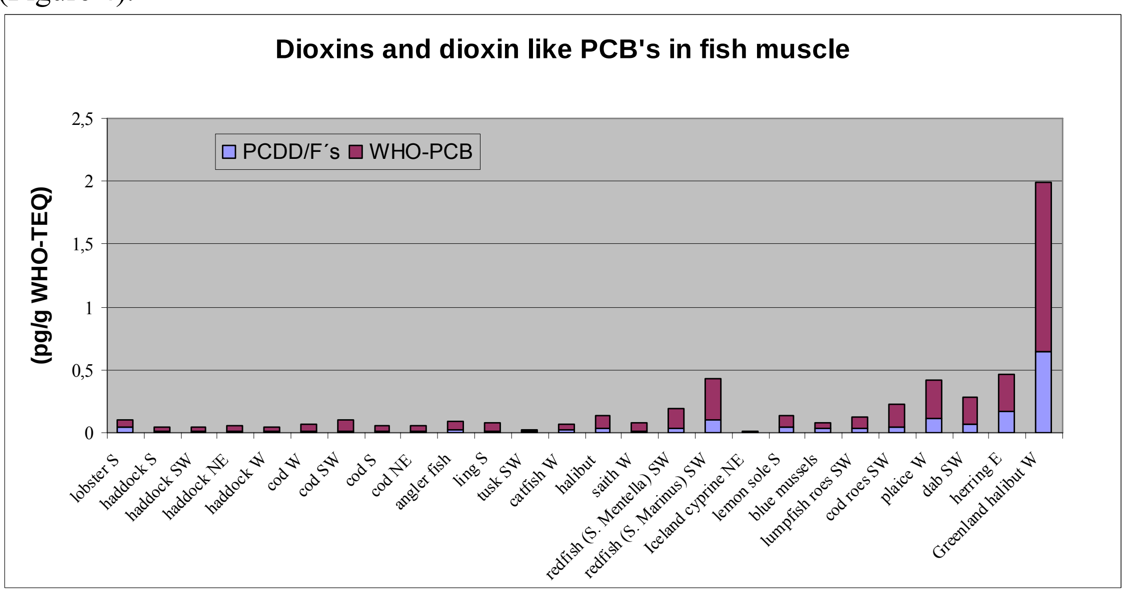

Fig. 3: Dioxins and dioxin like PCBs in the edible part of fish muscle from Icelandic fishing grounds 2004 (in WHO-TEQ pg/g wet weight)

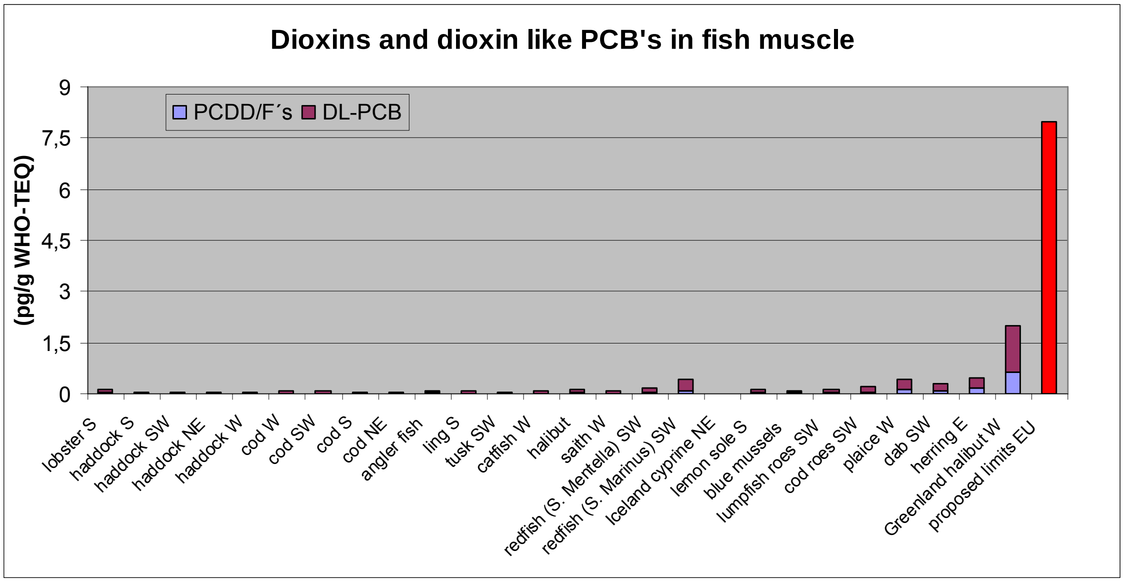

Fig. 4: Dioxins and dioxin-like PCBs in the edible part of fish muscle from Icelandic fishing grounds 2004 in relation to proposed limit of EU (in WHO-TEQ pg/g wet weight)

5.1.2 Fish oil for human consumption

Twenty different refined fish oil samples and one sample of not deodorized fish oil were analyzed in this study. In the deodorization process a part of PCBs are cleaned out, but the major part of dioxins and a part of dioxin-like PCBs are filtered out in an earlier stage of the production process. As can be seen in Figure 5, the amount of dioxins in most of the samples are between 0,2 and 0,3 pg/g and only one sample contains more than 0,3 pg/g. All of the oil samples analyzed are thus far below the maximum limits of 2 pg/g, and action limits of 1,5 pg/g set by EU.

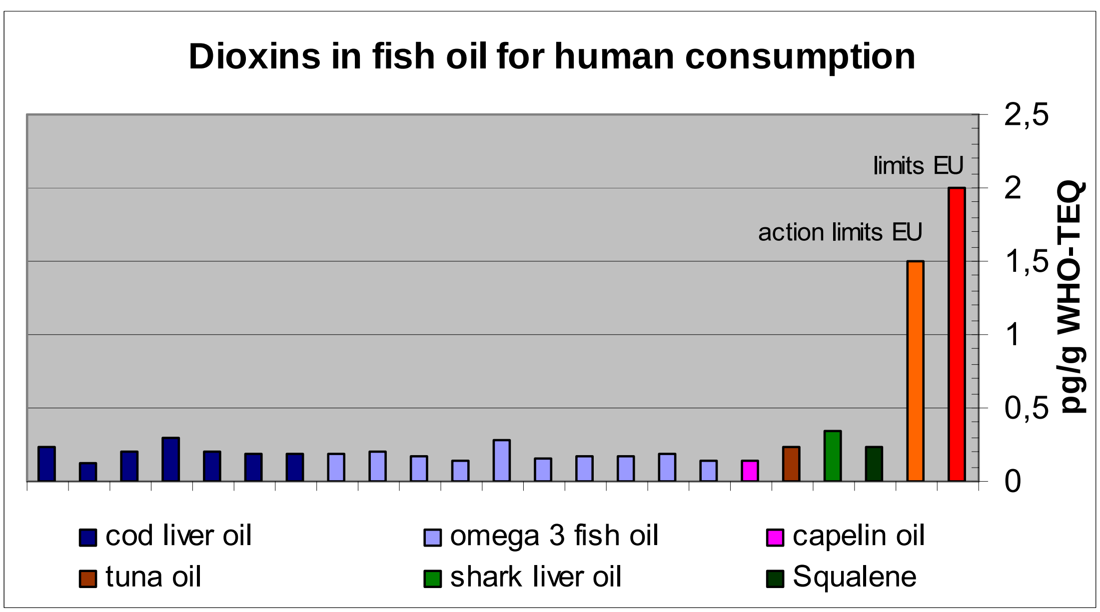

Fig. 5: Dioxins in fish oil for human consumption samples taken in 2004 (in WHO-TEQ pg/g wet weight)

Figure 6 shows the sum of dioxins and dioxin-like PCBs in the fish oil samples compared to the maximum limits that will be set by EU in 2006. As can be seen the refined fish oil samples are far below the limit, while the sample which is not deodorized contains more dioxin-like PCBs.

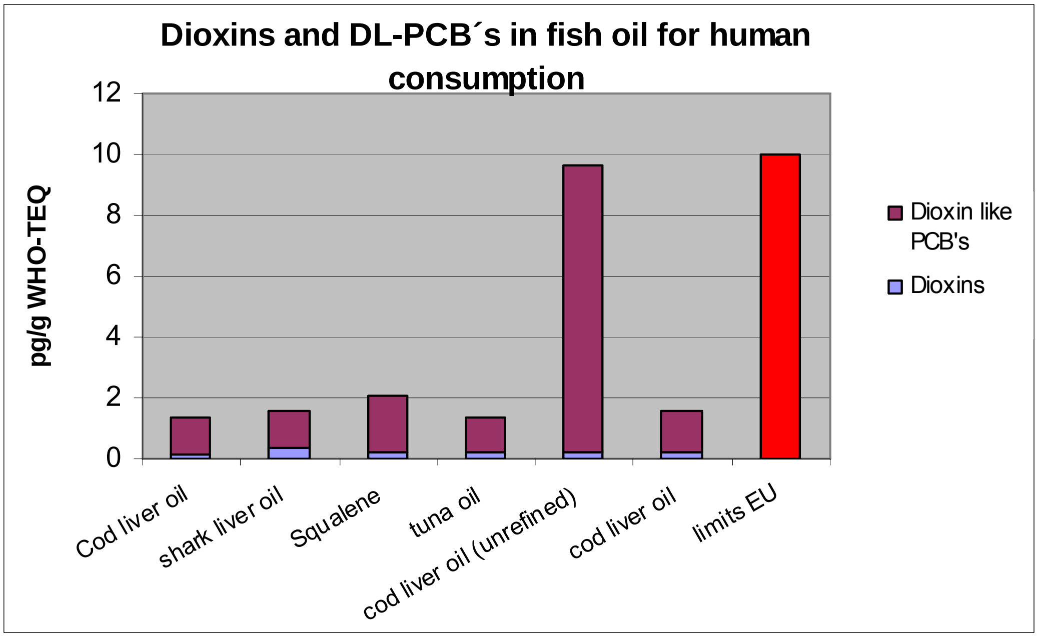

Fig. 6: Dioxins and dioxin-like PCBs in fish oil for human consumption in Iceland in 2004 (in WHO-TEQ pg/g wet weight)

5.1.3 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 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 the fish samples. It has also been shown that the level of dioxins 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). Figures 7 and 8 show the amount of dioxins in fish meal and fish oil samples compared to the EU limit. The samples were taken throughout the year 2004. All of the 18 fish meal samples, except for one, contained less than 0,5 pg/g which is half the action limit. The sample of blue whiting meal nr.225 contains the most dioxin or 0,83 pg/g which is close to the action limit. This sample was taken in April which is the period just after the spawning of the capelin when the fat content in the fish is at its lowest and the undesirable substances concentrate in the fat. (Anon. 2003)
The level of dioxins in the fish oil samples exceeds half the action limit of 4,5 pg/g set by EU in several cases but the majority of the samples contain less than 2 pg/g. The blue whiting oil samples are all taken during the winter, when the fat content of the fish is high, which is also reflected in the relatively low concentration of dioxins.

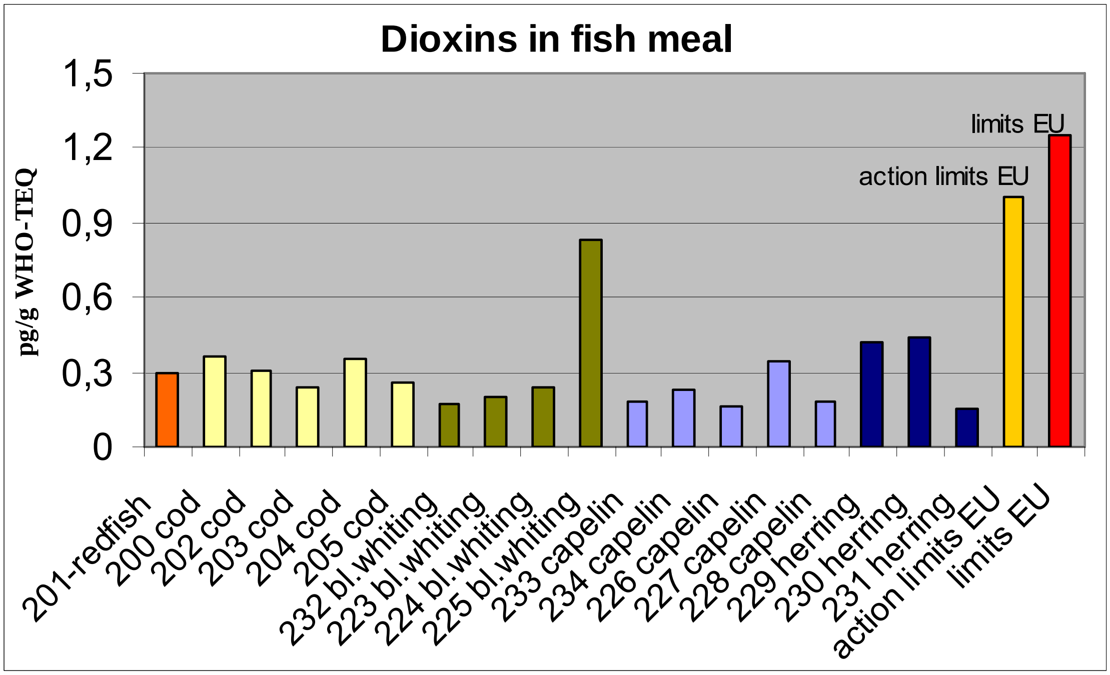

Fig. 7: Dioxins in samples of fish meal from Iceland 2004 (in WHO-TEQ pg/g calculated for 12% moisture content)

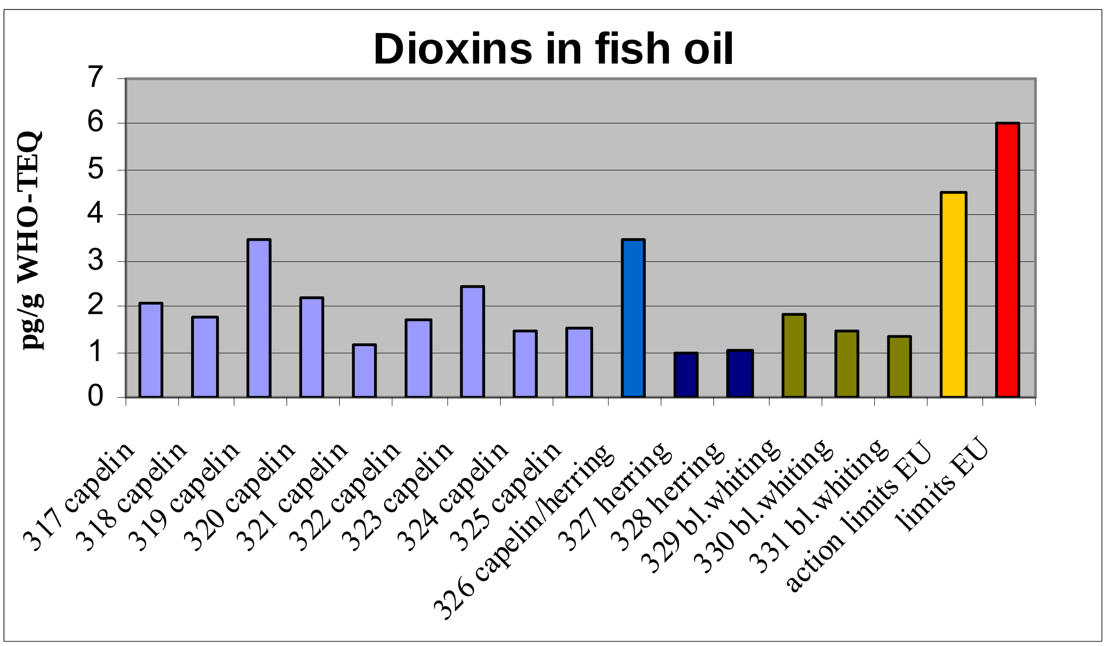

Fig. 8: Dioxins in samples of fish oil for feed from Iceland in 2004 (in WHO-TEQ pg/g calculated for 12% moisture content))

No limit has yet been set for the dioxin-like PCBs in the EU, but for comparison the proposed limits for the sum of dioxins and dioxin-like PCBs are shown in Figures 9 and 10 with the results for fish meal and fish oil. The fish meal samples in Figure 9 are all well below the proposed maximum limit, with one exception, the sample of blue whiting meal taken in April which contains dioxins and dioxin-like PCBs just below the proposed limits.

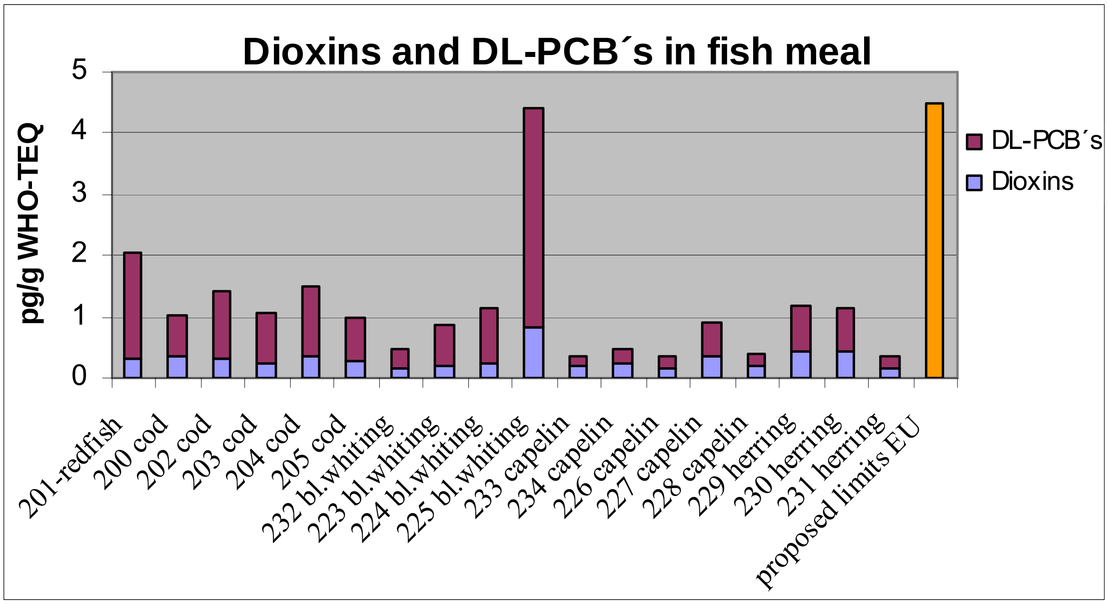

Fig. 9: Dioxins and dioxin-like PCBs in samples of fish meal from Iceland in 2004 (in WHO-TEQ pg/g calculated for 12% moisture content)

As can be seen in Figure 10, all the fish oil samples are below the maximum limits for the sum of dioxins and dioxin-like PCBs proposed by EU.

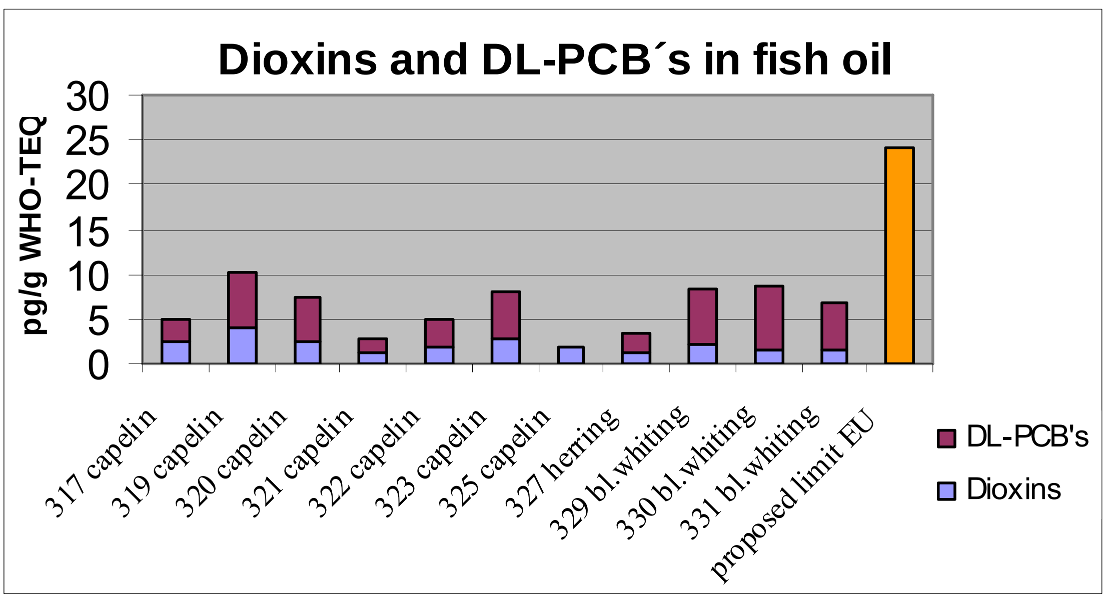

Fig. 10: Dioxins and dioxin-like PCBs in samples of fish oil for feed from Iceland in 2004 (in WHO-TEQ pg/g calculated for 12% moisture content)

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, PCB118, 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 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 in Germany, Holland and Sweden are from 40 µg/Kg to 120 µg/Kg. In Iceland the limits are much lower. The limits in Iceland are for all seven marker PCBs 200 µg/Kg and the maximum limit for the individual congeners are from 10 µg/Kg to 60 µg/Kg. In this research, the highest total concentration of all seven marker PCBs was measured in the Greenland halibut, a total of 10,5 – 11 µg/Kg wet weight. That level is still only one tenth of the limits in force in Iceland. (Figure 11).

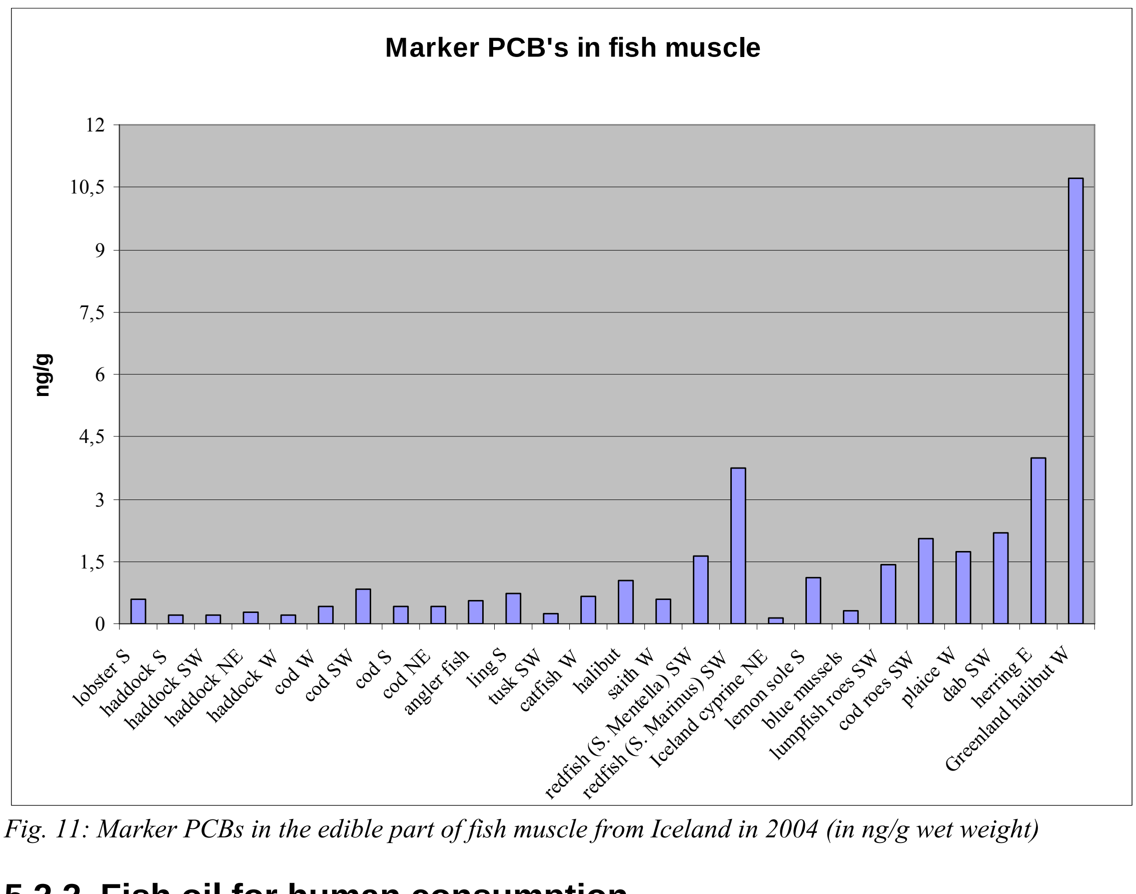

Fig. 11: Marker PCBs in the edible part of fish muscle from Iceland in 2004 (in ng/g wet weight)

5.2.2 Fish oil for human consumption

Figure 12 shows the level of marker PCB in six different fish oils. In four of the samples the PCB values are below 30 ng/g while the non-deodorized cod liver oil and squalene have higher levels of marker PCBs or 249,4 ng/g and 1060 ng/g respectively. This demonstrates the capacity of the deodorization to clean out PCBs. In the case of squalene, the production of squalene consists of distillation of shark oil which actually concentrates PCBs in the product.

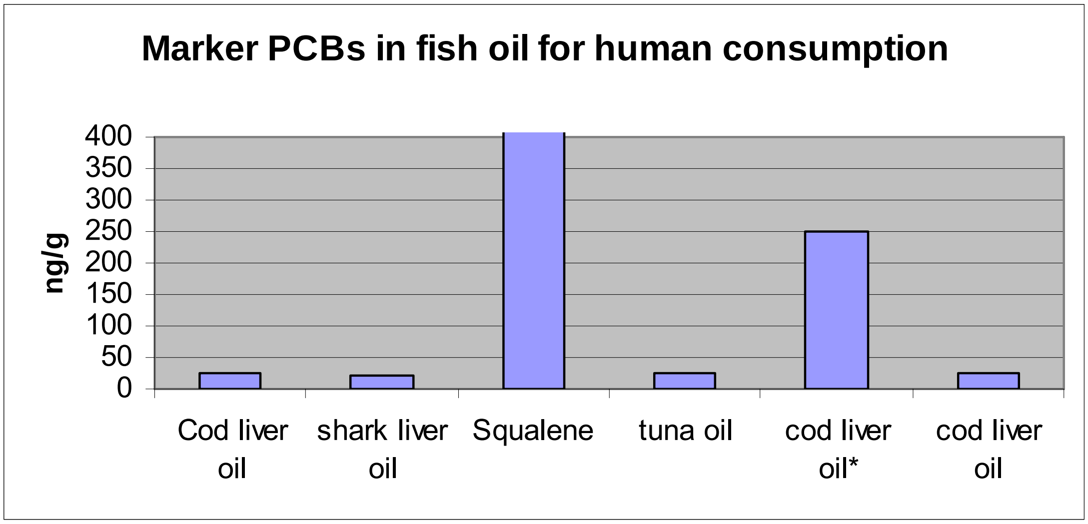

Fig. 12: Marker PCBs in fish oil for human consumption from Iceland in ng/g wet weight (non-deodorized cod liver oil)*

5.2.3 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 Figure 13. The median values are 29,6 ng/g for fish oil and 6,4 ng/g for fish meal. No limits have yet been set for these substances in the EU.

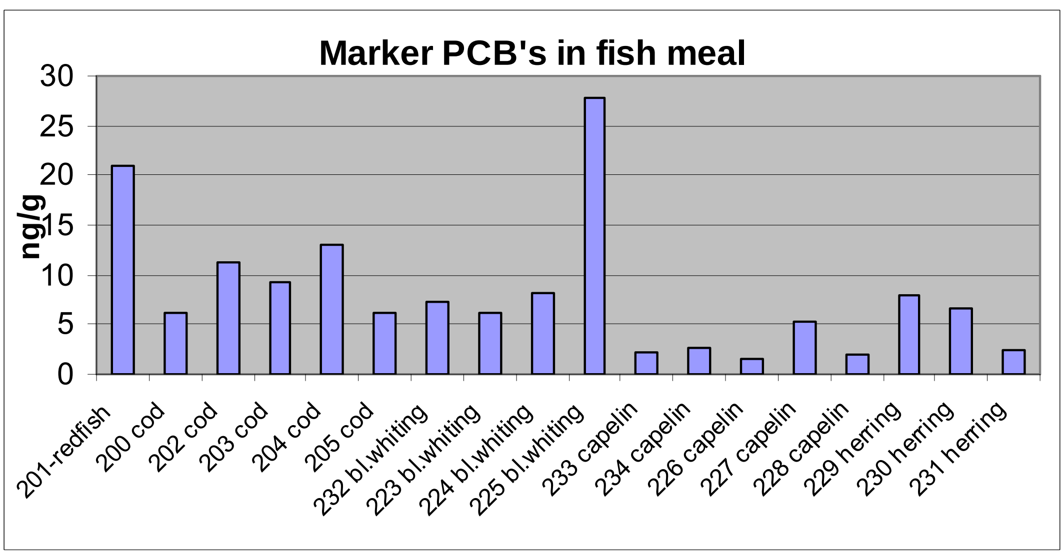

Fig. 13: Marker PCBs in fish meal from Iceland in 2004 (in ng/g calculated for 12% moisture content)

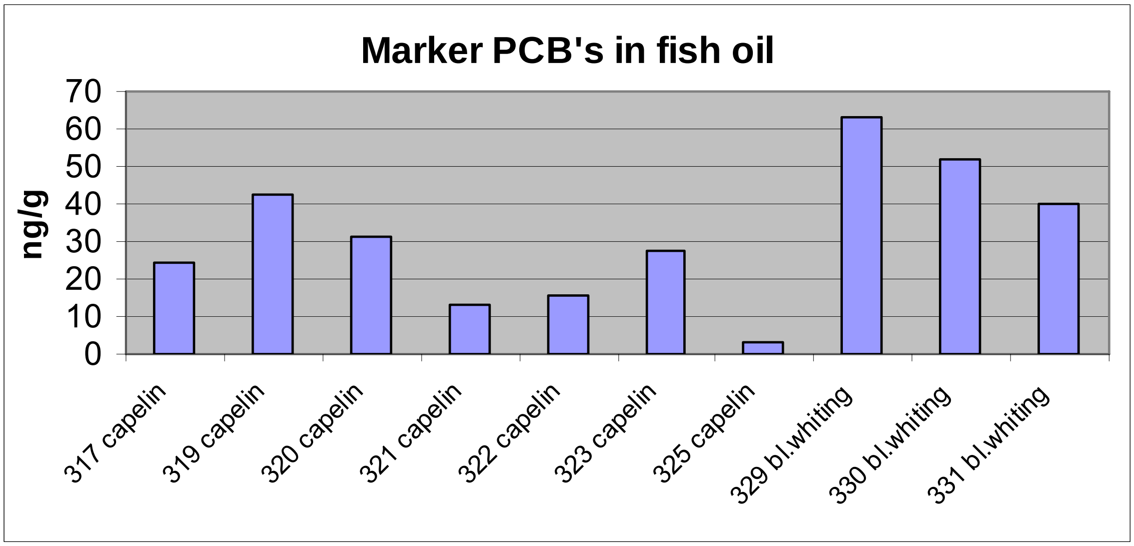

Fig.14: Marker PCBs in fish oils from Iceland in 2004 (in ng/g calculated for 12% moisture content)

5.3 Brominated flame retardants (PBDE)

Brominated diphenyl ethers or PBDE have been accumulating in nature in the last few years as their use in industry has grown. No maximum limits have been set in the EU but they have been estimated in the UK to be ten times less toxic than the pesticide DDT (Scientific Advisory Committee on Nutrition (SACN, 2005). PBDE were not measured in the Icelandic monitoring activitiesin 2004, but measurements from 2003 showed very low concentration in the edible part of fish muscle from fish caught in Icelandic fishing grounds. The following results in µg/Kg were obtained in 2003. These results are a slightly lower than results from Norway for Cod and S. Marinus.(http://www.nifes.no, 1/12 2005)

Species	Number of samples	Average (min.-max.)
Haddock	4	0,02 (0,002 – 0,06)
Cod	4	0,05 (0,03 - 0,06)
S. Marinus	1	0,3
S. Mentella	2	0,4 (0,2 – 0,5)
Greenl. halib.	2	0,8 (0,5 – 1,1)

5.4 PAH

Poly aromatic hydrocarbons or PAH were measured in three sample of refined fish oil in 2003. Benzo(a)pyrene was in all three cases below LOD which was < 0,3 µg/Kg, but the proposed limits which are being discussed within the EU are 2 µg/Kg .

5.5 Pesticides

In this chapter, the results for nine different classes of pesticides are discussed. Results are shown in Tables 5-7 in Appendix 2. Without exception, the fish samples contain negligible amount of pesticides. The fish meal and fish oil samples contain more

pesticides and in some cases the concentration is considerable. The critical cases, the results presented in the Figures, are discussed in the subchapter for the pesticide. It should be pointed out that the samples of oil and meal from herring, capelin and blue whiting used for pesticides analyzes are actually **from the same raw material,** i.e. capelin oil samples nr. 300-307 correspond to capelin meal samples nr. 206-213, blue whiting oil samples nr.308-311 correspond to meal samples nr. 214-218 and herring oil samples nr. 313-316 correspond to meal samples nr. 219-222. These samples are from the NORA project and have previously been measured for dioxins and PCBs (Anon. 2003). In the monitoring program for 2004 it was decided to use these exceptionally well defined samples and measure pesticides in the fish meal and fish oil samples obtained in the Nora study.
The results of pesticides measurements are expressed in µg/Kg wet weight in case of seafood, fish meal and fish oil.

5.5.1 DDT substances

DDT (dichloro diphenyl trichloroethan) is probably the best known insecticide. DDT is a group of substances fundamentally composed of p,p'-DDT (75%) and o,p´-DDT (15%). DDT breaks down in nature, mostly to DDE. 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.

5.5.1.1 Seafood

The results show very low concentration of DDT in fish from Icelandic waters (for details see Table 5 in Appendix). Furthermore, the high proportion (more than 50%) of the breakdown product DDE indicates that the mixture is old. The samples of Greenland halibut contains 25 and 50 times less DDT than the maximum level set in EU of 500 µg/Kg and other fish species contain much less.

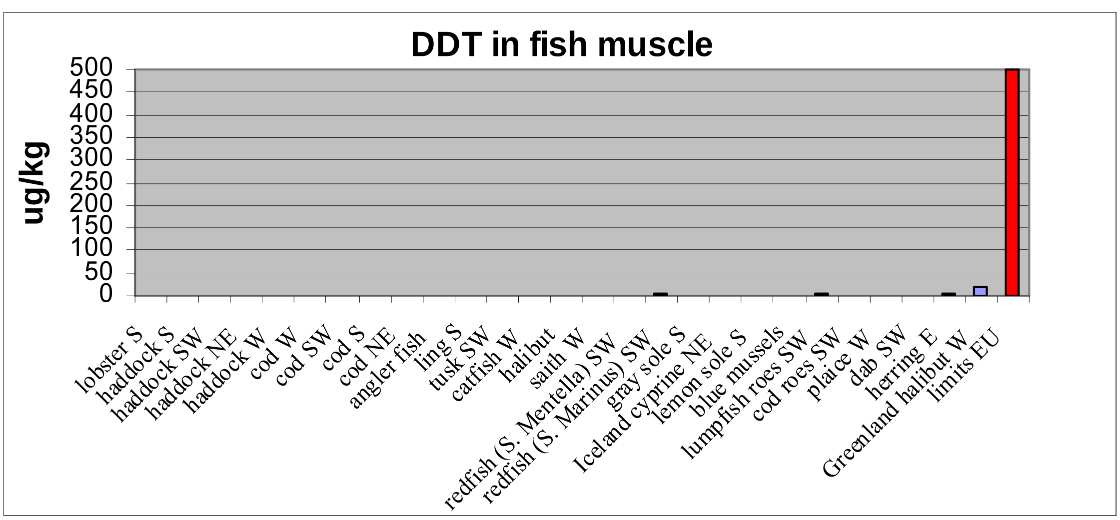

Fig. 15: DDT in fish muscle from Icelandic fishing grounds in 2004 in relation to the limit effectuated in EU in µg/Kg wet weight

5.5.1.2 Fish oil and fish meal for feed

Figures 16 and 17 show the level of DDT in fish meal and fish oil samples. The maximum limit in EU for DDT in feed is 50 µg/Kg but in fish oil used for feed it is 500 µg/kg. The fish meal samples all contain less than half the maximum limit, with the exception of red fish meal, which is however also well below the limit. Three samples of blue whiting oil contain an amount of DDT that is close to the limit (Figure 17), but other fish oils like capelin oil and herring oil are well below the limit. The three blue whiting samples nr. 214-216 containing the highest concentration in both products, meal and oil, are caught during and just after the spawning or from 18th of March to 5th of May, which explains the high values. The other blue whiting samples, nr. 217 and 218, are taken in late August and November.

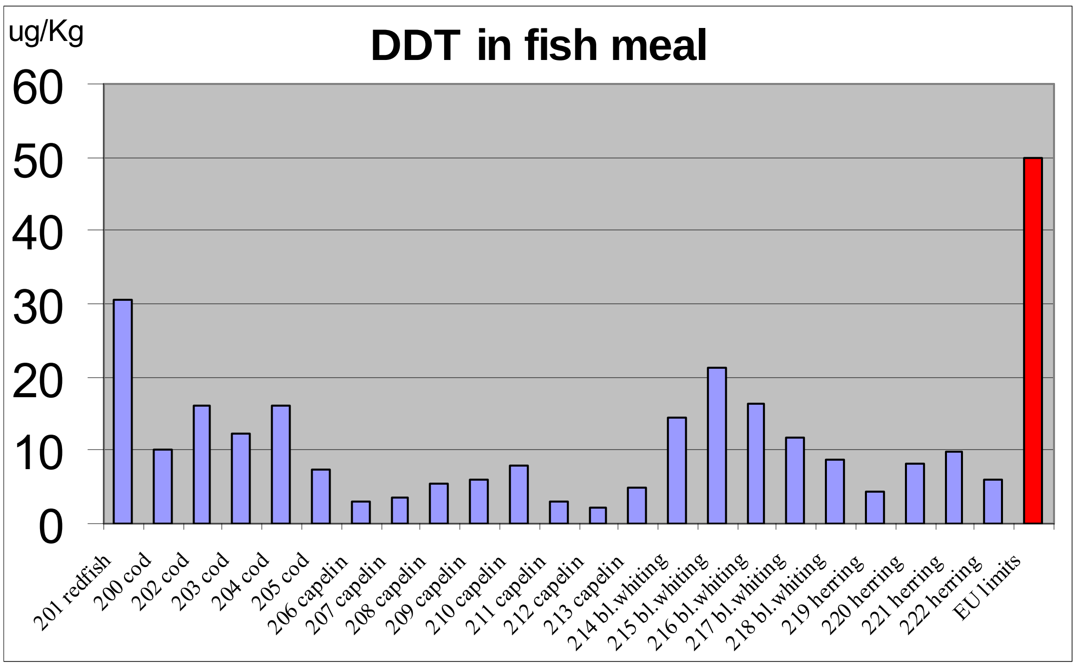

Fig. 16: DDT in samples of fish meal (nr. 201-205) and samples from NORA study (nr.206-222) in µg/Kg calculated for 12% moisture content

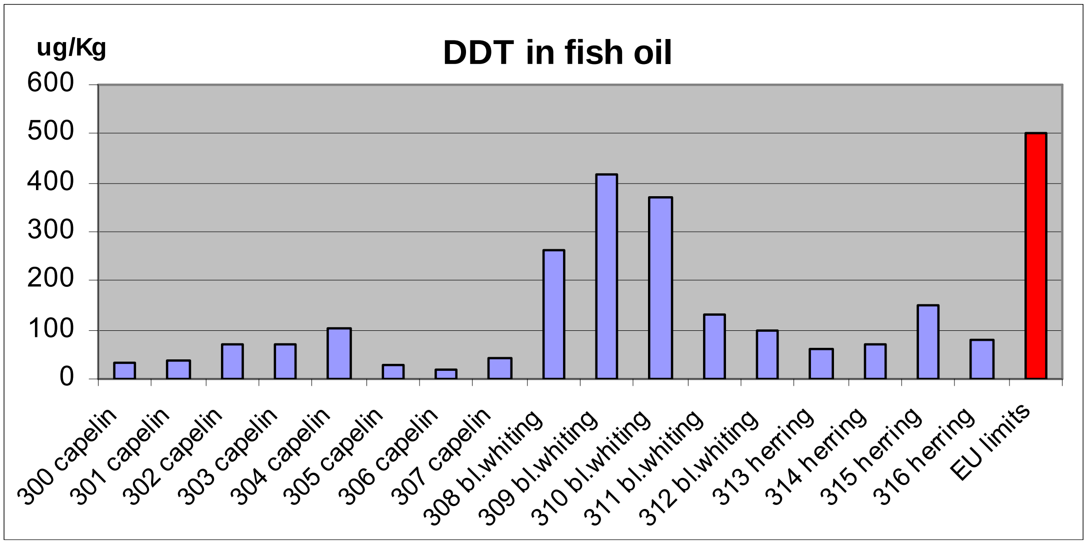

Fig. 17: DDT in samples of fish oil from NORA study in µg/Kg calculated for 12% moisture content

5.5.2 HCH substances

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. To begin with, HCH was a mixture of four substances: α-, β-, γ-(Lindane), and δ-HCH. Of these only Lindane was as an active substance consisting of approximately 15% of the total mixture, while α-HCH was 60-70% of the mixture. The Food and Agriculture Organization of the UN (FAO) has banned the use of the HCH mixture since in the 1980s, after that it was only allowed to use 99% pure Lindane. .

5.5.2.1 Seafood

In Table 5 in Appendix 2, the sum of the concentration of the different types of HCH in fish muscle is shown. In most samples the results were below LOD, except for α-HCH, as could be expected. The EU has set maximum limits for α-, β-, γ- HCH of 50 µg/Kg for each of them. Compared to these limits, the concentration found in fish from Iceland is very low. Only four fish species have total concentration of the three HCH substances higher than 0,5 µg/Kg. The highest total concentration was measured in samples of Greenland halibut and Iceland cyprine or 1,7 and 2,3 µg/Kg respectively, which is around 20 times lower than the maximum limits set for the individual congeners.

5.5.2.2 Fish oil and fish meal for feed

In all of the samples of fish oil and fish meal analyzed, γ- and δ- HCH were below LOD but some β- and especially α- HCH congeners were detected in the meal samples. All the fish oil samples contained α-, β- HCH above LOD. However, the concentrations are very low in relation to the maximum limits in EU. In Figure 18 the concentration of α-HCH in fish oil is illustrated and compared to the maximum limit set by EU.

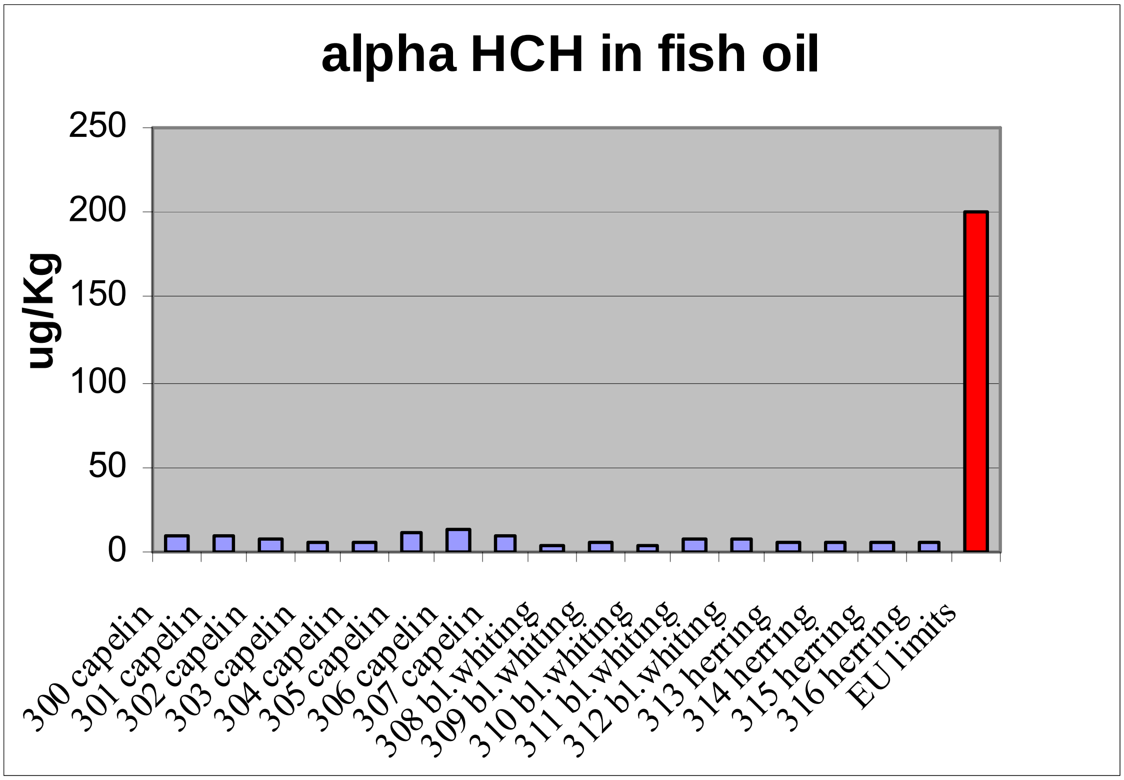

Fig. 18: α-HCH in samples of fish oil from NORA study in µg/Kg calculated for 12% moisture content

5.5.3 HCB

HCB (hexachlorobenzene) is a fungicide but it has also been used for industrial purpose and was for example produced in Germany until 1993. To date the main source of HCH pollution is in production of different chemicals such as pesticides and other where it is a by-product.

5.5.3.1 Seafood

The results of HCB measurements in fish samples are listed in details in Table 5 in Appendix. About 75% of the measurements were below LOD. The limits that are in force in the EU (50 µg/Kg) are more than 10 times higher than the highest value measured in the Greenland halibut fish muscle (3,7 µg/Kg).

5.5.3.2 Fish oil and fish meal for feed

The concentration of HCB in fish meal and fish oil are shown in Figures 19 and 20 in relation to the maximum limits of EU. The measured values are well below the set limits.

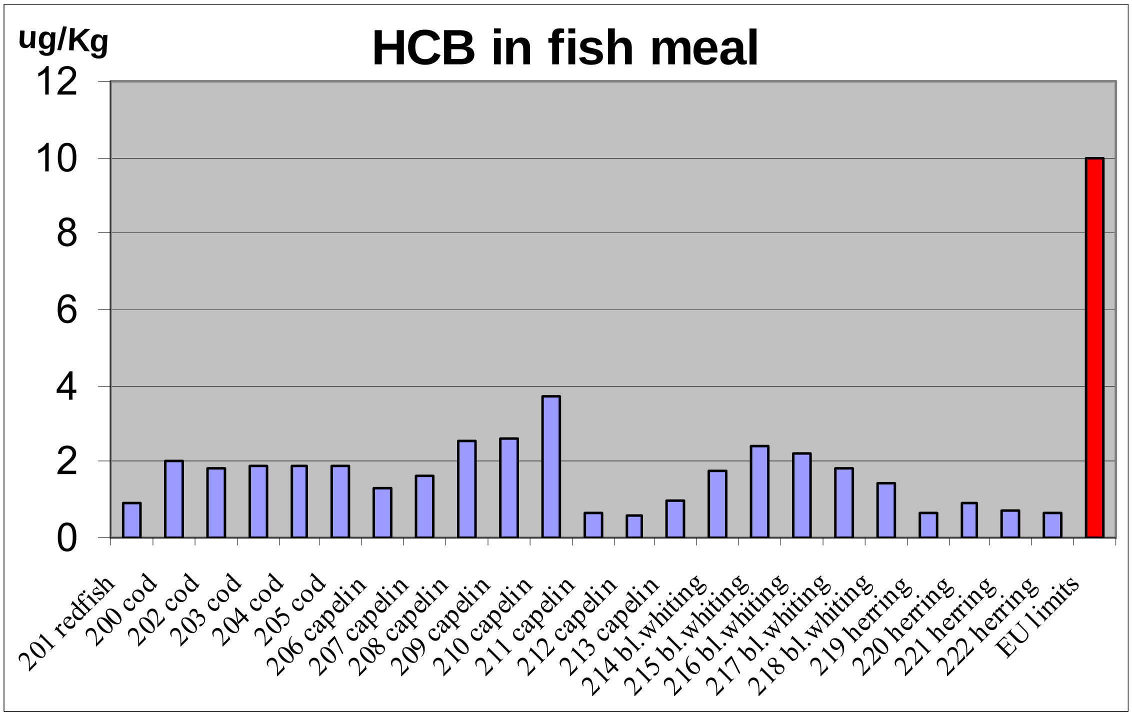

Fig. 19: HCB in samples of fish meal (nr. 201-205) and samples from NORA study (nr.206-222) in µg/Kg calculated for 12% moisture content

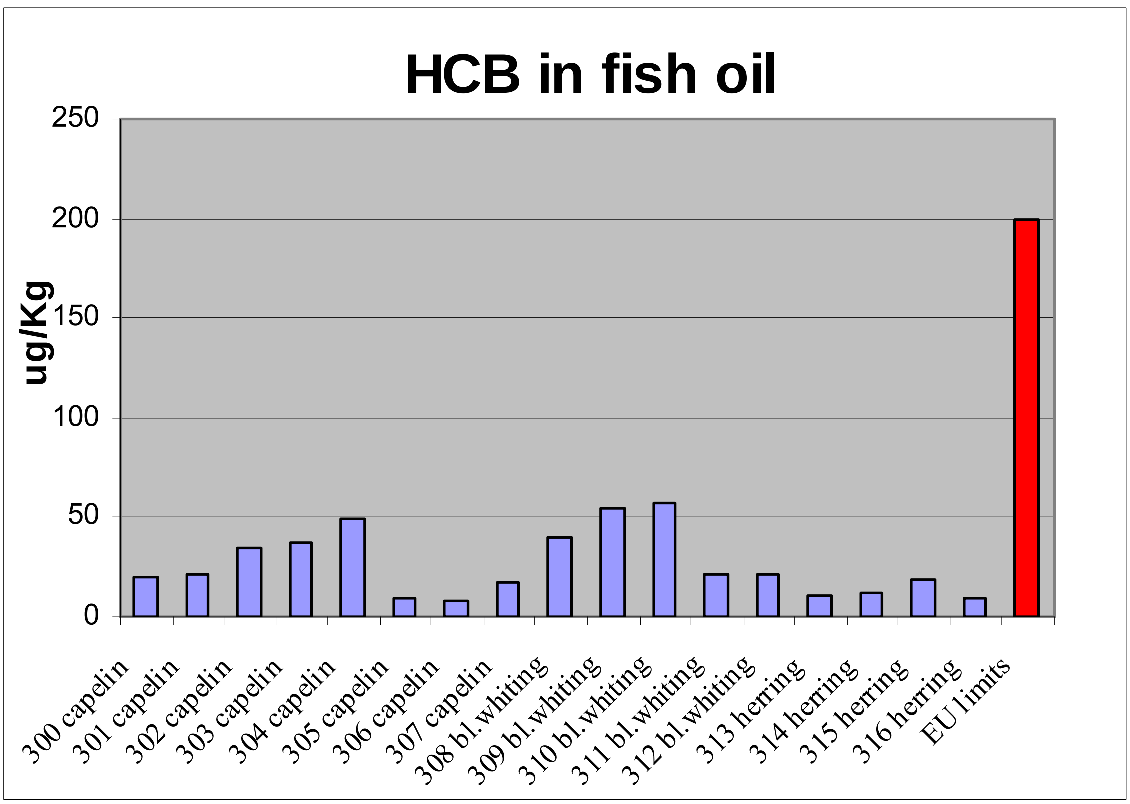

Fig. 20: HCB in samples of fish oil from NORA study in µg/Kg calculated for 12% moisture content

5.5.4 Chlordanes

Chlordanes measured are α- og γ-chlordane, oxychlordane og trans-nonachlor which 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.

5.5.4.1 Seafood

Chlordanes in Icelandic fish are in most cases measured above LOD but in very low concentrations. The Greenland halibut fish muscle contains 9,6 µg/kg which is 20 times lower than the EU limit of 100 µg/kg, other species contain less than 2,5 µg/Kg.

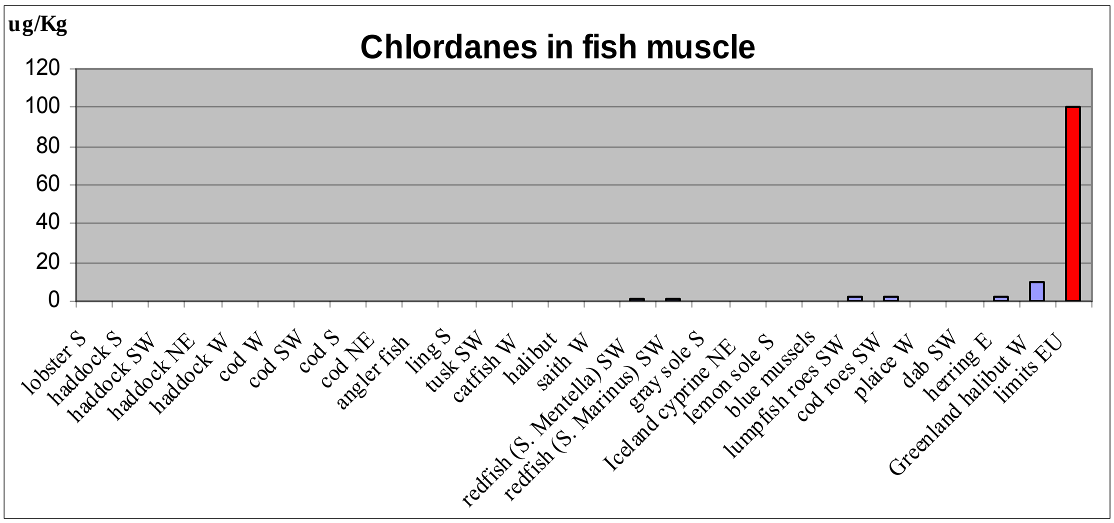

Fig. 21: Chlordanes in the edible part of the fish muscles from Icelandic waters in 2004 in µg/Kg wet weight

5.5.4.2 Fish oil and fish meal for feed

Chlordane in fish meal was also well below the EU maximum limit of 20 µg/Kg in all samples as can be seen on Figure 22. This was, however not the case for fish oil as can be seen in Figure 23, where some of the samples are close to the limits and for three samples of blue whiting oil the concentration of chlordane actually exceeded the set limit of 50 µg/Kg. The trend observed in the histogram in Figure 23 for the capelin oil is in accordance with nutritional condition of the fish. The first five samples (nr. 300-304) are taken in the period from January to end of March when the fat content of the fish is gradually decreasing, while the last three are taken after spawning or in the period from July to December when the nutritional condition of the fish is much better. Corresponding trend is observed for the blue whiting samples and the results from this study confirm the results from the Nora study, i.e. that in certain periods of the year (around spawning) the blue whiting meal and oil contains high concentrations of undesirable substances (Anon. 2003). This trend was also discussed for DDT in fish meal and fish oil in chapter 5.5.1.2.

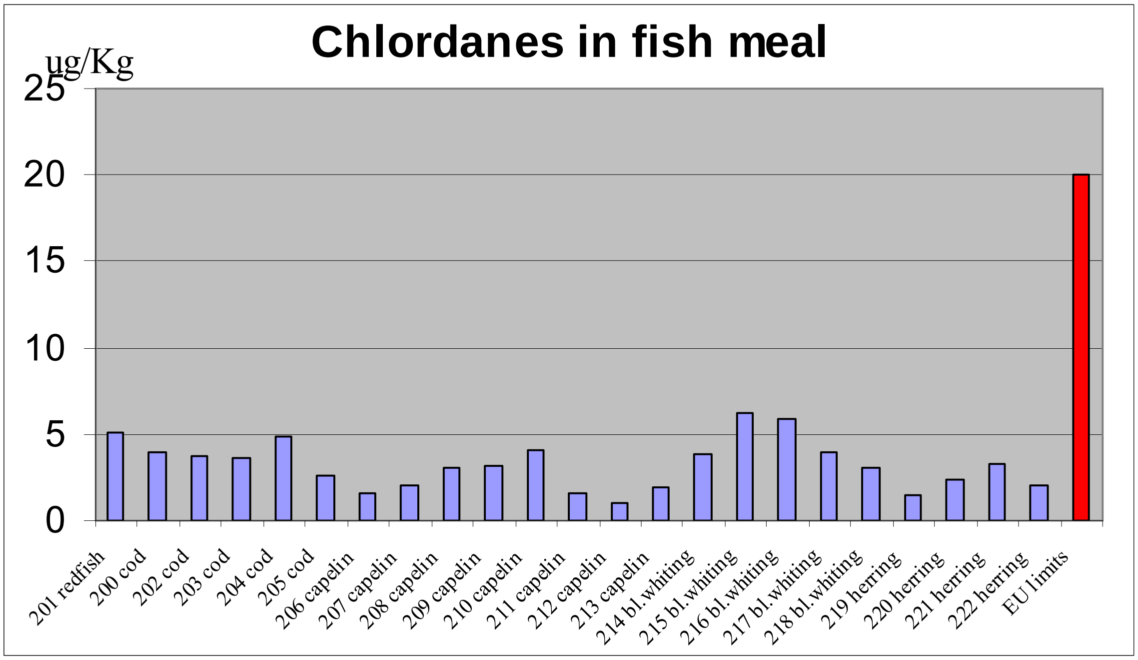

Fig. 22: Chlordanes in samples of fish meal (nr. 201-205) and samples from NORA study (nr.206-222) in µg/Kg calculated for 12% moisture content

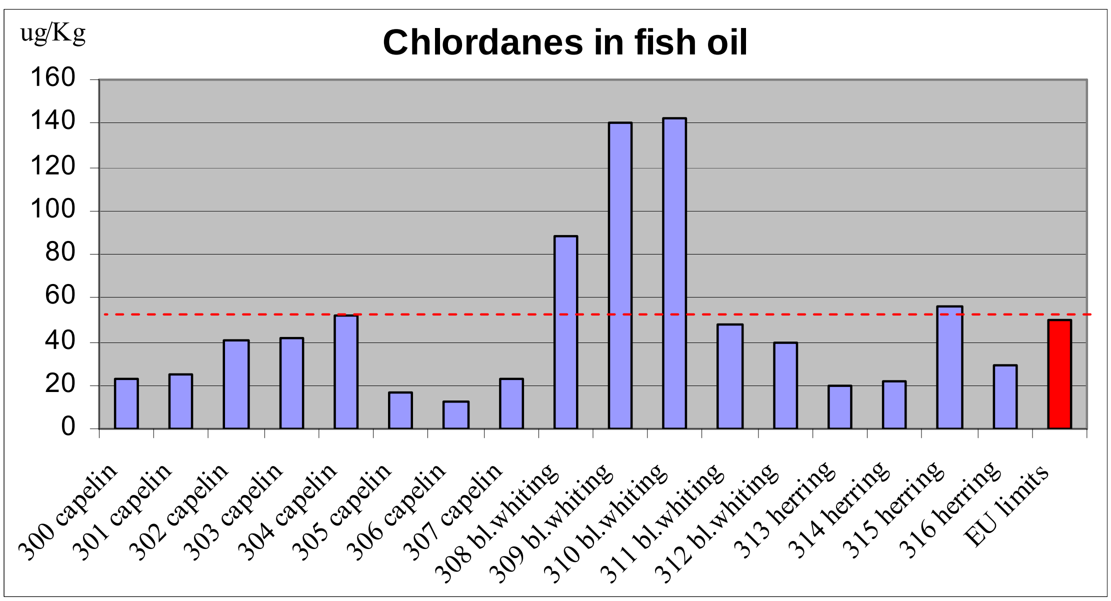

Fig. 23: Chlordanes in samples of fish oil from NORA study in µg/Kg calculated for 12% moisture content

5.5.5 Toxaphenes

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. Its use was widespread and the toxaphene substances are numerous. Several hundreds 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.

5.5.5.1 Seafood

There are no limits for toxaphenes in fish in the EU. The results of measurements in the edible part of fish muscle from fish caught in Icelandic waters showed very low levels of toxaphene ,where 75% of the samples contained < 1 ug/Kg of the substance (see Table 5 in Appendix). Only Greenland halibut contained considerable amount of toxaphene or 24,35 µg/Kg, which is one fourth of the limits set in Germany (100µg/Kg)for this substance in food.

5.5.5.2 Fish oil and fish meal for feed

The EU has recently agreed upon new limits for toxaphene in fishmeal, fish oil and in fish feed of 20 µg/Kg, 200 µg/Kg and 50 µg/Kg respectively these limits became effective in December 2006.. The old limits are 100 µg/Kg for all. The concentration of toxaphene in fish meal in relation to these new limits is shown in Figure 24. There are very high LOD for some of the meal samples or 9 µg/Kg for the cod and redfish meal. For the other samples, LOD is lower but the analytical technique which is used in most laboratories today allow at the best LOD of 5 µg/Kg which is very high considering these new limits of 20 µg /Kg (IFFO 2005). The Figure reflects this fact and does not show the pattern expected for the NORA samples.

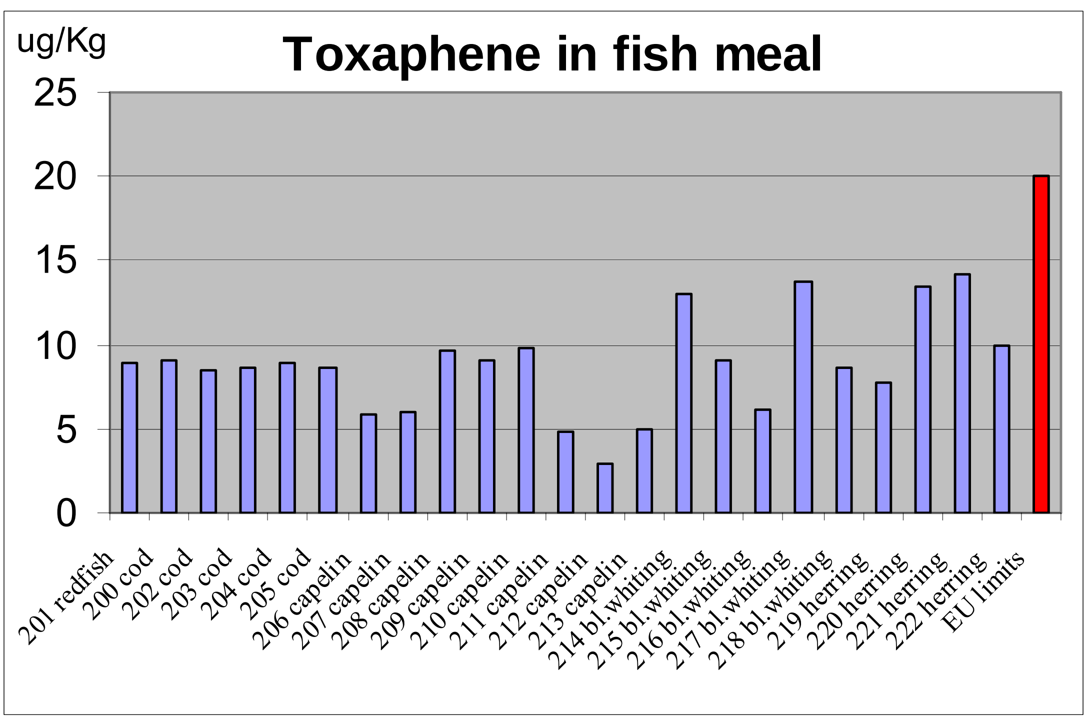

Fig. 24: Toxaphene in samples of fish meal (nr. 201-205) and samples from NORA study (nr.206-222) in µg/Kg calculated for 12% moisture content

In Figure 25 the results of Toxaphene analysis of fish oil samples are shown in relation to the new limit of 200 µg/Kg. In the oil samples, the concentration is much higher than LOD and the relation between the toxaphene content of the oil and the period in which the NORA samples were taken is as for the other pesticides (e.g. chlordanes and DDT), i.e. depending on the nutritional condition of the fish stock. Four samples, three of blue whiting (nr. 308-310) and one of herring (nr.315) that exceed the limits are taken in the spawning period.

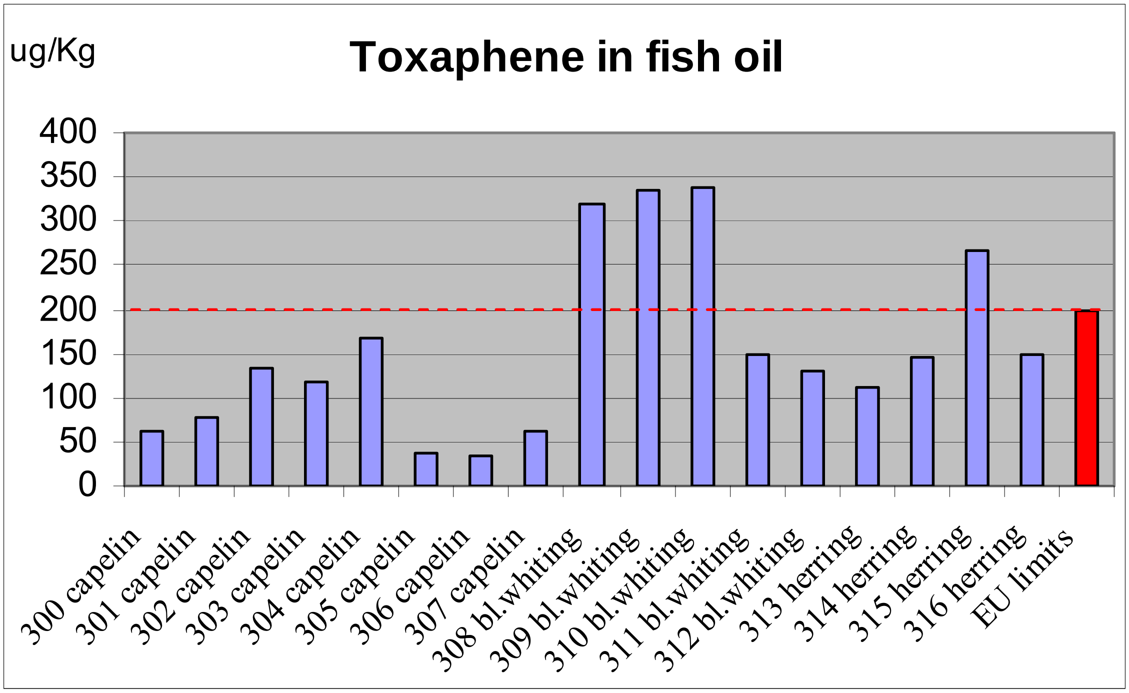

Fig. 25: Toxaphene in samples of fish oil from NORA study in µg/Kg calculated for 12% moisture content

5.5.6 Aldrin and dieldrin

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 eldrin was always above LOD. The maximum value in the EU is set for the sum of aldrin and dieldrin.

5.5.6.1 Seafood

The maximum level for the sum of aldrin and dieldrin has been set in the EU at 50 µg/Kg in fish. In this study, the results for the sum of aldrin and dieldrin measurements were the highest in Greenland halibut fish muscle,or 5,4 ug/Kg, which is nevertheless well below the EU limits. All other fish species, except Greenland halibut, herring and cod roes, contained less than 1ug/Kg of aldrin and dieldrin (see Table 5 in Appendix).

5.5.6.2 Fish oil and fish meal for feed

Maximum level set by the EU for aldrin and dieldrin is 10 µg/Kg for fish meal and 200 µg/Kg for fish oil. The concentration measured in the most polluted Icelandic fish oil is less than half of the EU limit. The fish meal contained aldrin and dieldrin which is lower than the EU limit in all cases. The highest value was 4,9 µg/Kg in one of the capelin meal samples, which is less than half the limit value.

5.5.7 Endrin

5.5.7.1 Seafood

Endrin was measured slightly above LOD for most fish species investigated in this study, but the measured concentration was nonetheless very low. In four species, (Greenland halibut, herring, cod roes and lumpfish roes) the concentration was between 0,1 and 1 µg/Kg, but in all the others it was less than 0,1 µg/Kg. The maximum limit in the EU is 50 µg/Kg, hence the results are in the worst case less than 50 times this limit.

5.5.7.2 Fish oil and fish meal for feed

EU limits for Endrin are 10 µg/Kg and 50 µg/Kg for fish meal and fish oil, respectively. The results presented here show low levels of endrin. The highest measured value for fish meal was 1,5 µg/Kg in capelin meal sample and the highest value for fish oil was in blue whiting oil, 18 µg/Kg.

5.5.8 Endosulfan

Two endosulfans 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.

5.5.8.1 Seafood

No measurement were over the LOD, which was between 0,2 ug/Kg and 3,6 ug/Kg as can be seen in Table 5 in Appendix. No limits have taken effect for endosulfans in fish in the EU.

5.5.8.2 Fish oil and fish meal for feed

No measurement were over the LOD for neither fish meal nor fish oil. However, the LOD is high especially for beta-endosulphan in fish oil, or up to 31 ug/Kg (see Table 6-7 in Appendix). The EU limit in feed is set at 100 µg/Kg, but the limit for fish feed is 5 µg/Kg. Limits of endosulphan for fish oil is 100 µg/Kg in EU.

5.5.9 Heptachlor

(3 types: heptachlor, cis-hepatchlorepoxid, trans-heptachlorepoxid)

5.5.9.1 Seafood

The measured values for heptachlor was herring and Greenland halibut, 1,6 and 1,3 ug/Kg, respectively, while the EU limit is set at 50 ug/Kg in fish. In this study 80% of the fish species contain less than 0,3 ug/Kg.

5.5.9.2 Fish oil and fish meal for feed

The measured values for Heptachlor in fish meal and fish oil were also far below the EU limits of 10 ug/Kg and 200 ug/Kg respectively (see Table 6-7 in Appendix).

5.5.10 Mirex

5.5.10.1 Seafood

Mirex is below a very low LOD for the majority of the fish species studied. The highest concentration (0,173 µg/Kg) was measured in the Greenland halibut, while all other fish species contained less than 0,06ug/Kg.

5.5.10.2 Fish oil and fish meal for feed

Mirex was also measured in low concentrations in fish meal and fish oils. (see Table 6-7 in Appendix)

5.6 Inorganic trace elements: Hg, Pb, Cd and As

In this study, Hg and As have been measured in different fish species and in fish meal. An attempt was also made to measure Pb and Cd in the fish muscle samples, but the levels of these two trace elements were very low in these samples and the uncertainties in the measured values with the equipment available were so high that it was decided to exclude them from this report. Provisions were made to have these metals measured in samples taken in 2005.

5.6.1 Hg, mercury

5.6.1.1 Seafood

Results of mercury analysis have been plotted in Figure 26 and compared to the limits effectuated in the EU. A different (higher) limit is valid for specific fish species, here catfish gray sole and redfish. (EU Directive 2001/22)

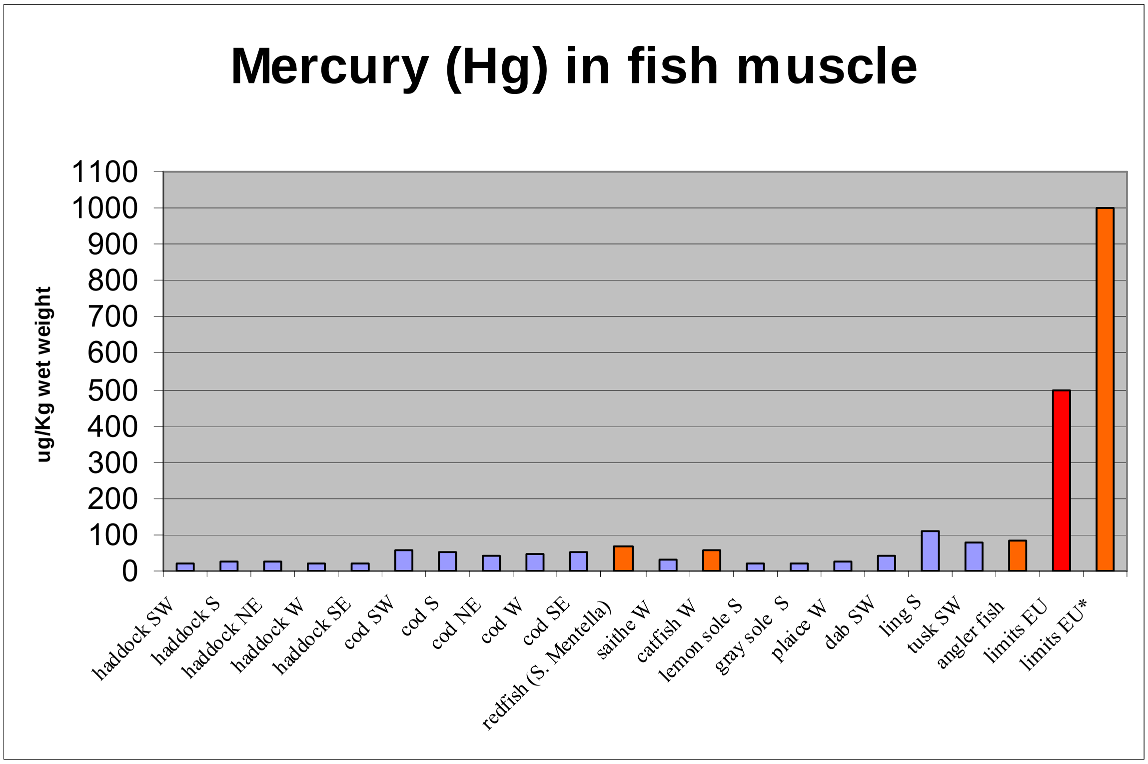

Fig. 26: Mercury (Hg) in in the edible part of fish muscle from Icelandic fishing grounds in 2003-2004 (limits EU are valid for catfish, gray sole and redfish)*

5.6.1.2 Fish oil and fish meal for feed

Only six samples of fish meal were analyzed for mercury in 2004 and no sample of fish oil. The results were below the maximum limit of EU as can be seen on Figure 27.

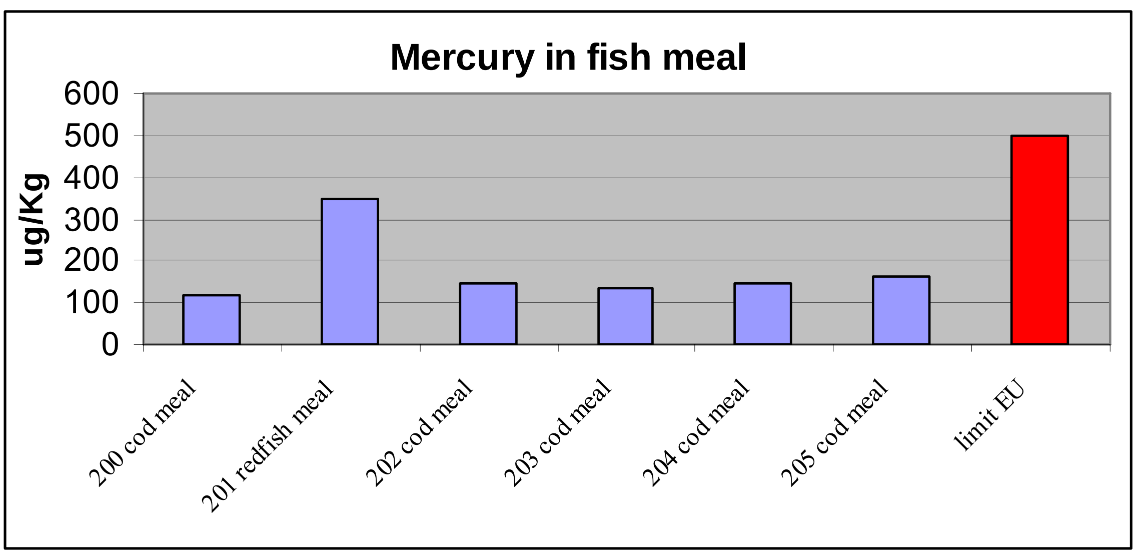

Fig. 27: Mercury (Hg) in fish meal from Icelandic fishing grounds 2004 in µg/Kg calculated for 12% moisture content

5.6.2 Total Arsen

Different fish species were analyzed for total arsen but no samples of fish meal and fish oil were analyzed for arsen in 2004.

5.6.2.1 Seafood

No limit has yet been set for arsen in fish. Arsen in fish is bound in different compounds organic- and inorganic. It is the inorganic arsen that is toxic and the EU is discussing maximum limit for the inorganic part of arsen. Total Arsen (organic and inorganic) was measured in different fish species in 2003 and 2004. The results are illustrated in Figure 28.

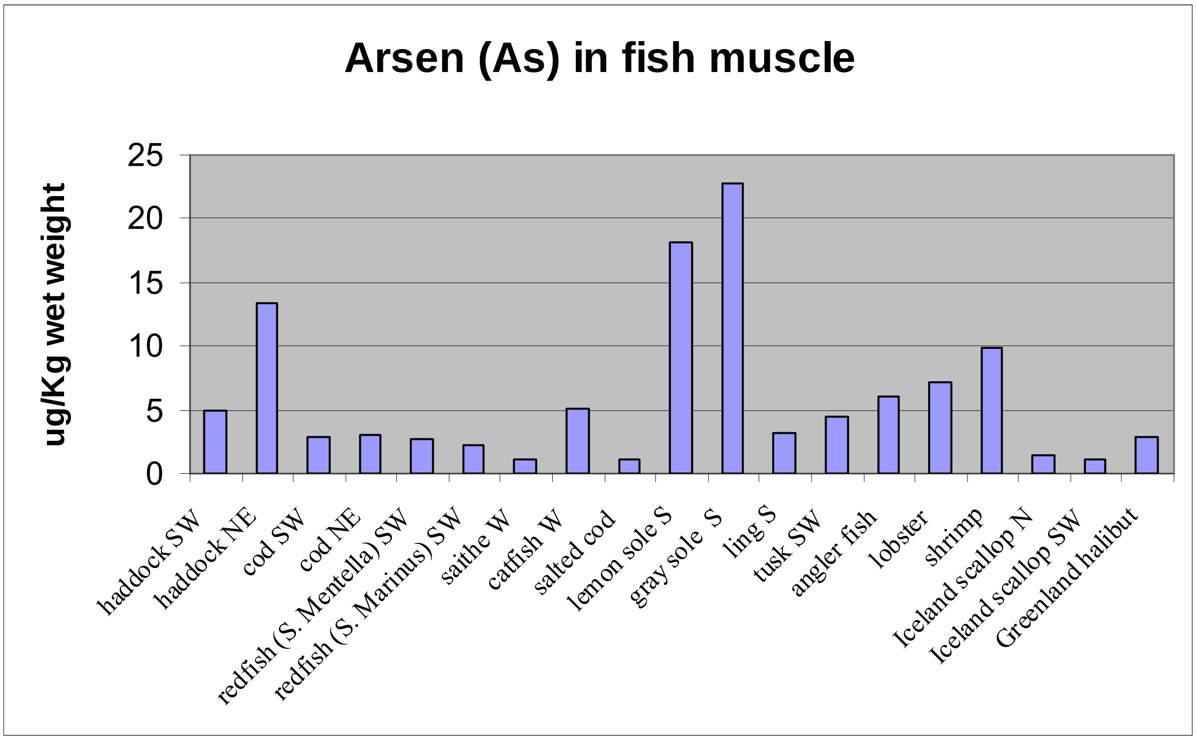

Fig. 28: Arsen (As) in the edible part of fish muscle from Icelandic waters in 2004 in µg/Kg wet weight

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IFFO International Fishmeal and Fish oil Organization iffo update 162, September 2005.

Van den Berg M, Birnbaum L, Bosveld ATC, Brunström B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, et al. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106:775-792 (1998).

Web pages:
http://www.nifes.no
http://www.ust.is
http://www.sacn.gov.uk/

7 Appendix

Table 1: Dioxins, dioxin like PCBs and Marker PCBs in fish from Iceland in 2004 (WHO-TEQ per wet weight, upper bond levels)

Sample code SN-DF-04	Samples:	fat %	Dioxins pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Marker PCBs ng/g
132	lobster S	0,18	0,04	0,07	0,61
102-103	haddock S	0,21	0,01	0,03	0,22
100-101	haddock SW	0,22	0,01	0,03	0,20
104-105	haddock NE	0,23	0,02	0,04	0,29
106-107	haddock W	0,24	0,01	0,03	0,20
114-115	cod W	0,27	0,01	0,05	0,43
108-109	cod SW	0,29	0,02	0,09	0,83
110-111	cod S	0,33	0,01	0,05	0,42
112-113	cod NE	0,34	0,01	0,04	0,43
145	angler fish	0,29	0,03	0,06	0,57
143	ling S	0,31	0,01	0,06	0,73
144	tusk SW	0,32	0,01	0,02	0,24
131	catfish W	0,56	0,02	0,05	0,65
140-141	halibut	0,73	0,03	0,11	1,05
128-129	saith W	0,73	0,02	0,06	0,58
126-127	redfish (S. Mentella) SW	0,79	0,03	0,15	1,64
124-125	redfish (S. Marinus) SW	1,24	0,10	0,33	3,73
151-152	Iceland cyprine NE	0,95	0,01	0,01	0,14
136	lemon sole S	1,00	0,04	0,10	1,09
150	blue mussels	1,23	0,04	0,04	0,33
149	lumpfish roes SW	1,27	0,03	0,09	1,43
148	cod roes SW	1,44	0,04	0,19	2,06
138-139	plaice W	1,50	0,12	0,30	1,73
142	dab SW	1,52	0,07	0,21	2,20
146-147	herring E	9,93	0,16	0,30	3,97
134-135	Greenland halibut W	11,80	0,65	1,35	10,73
	action limits EU	*	3	*	*
	limit EU	*	4	*	*

Table 2: Results of analysis of fish oil for human consumption (WHO-TEQ per fat weight, upper bond level)

Samples code SN-DFO-04-	Samples:	Dioxins pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Marker PCBs ng/g
332	cod liver oil	0,23	*	*
333	cod liver oil	0,12	1,24	26,37
334	cod liver oil	0,21	9,4	249,43
335	cod liver oil	0,3	*	*
336	cod liver oil	0,2	1,39	25,9
337	cod liver oil	0,18	*	*
338	cod liver oil	0,18	*	*
339	omega 3 fish oil	0,19	*	*
340	omega 3 fish oil	0,2	*	*
341	omega 3 fish oil	0,17	*	*
342	omega 3 fish oil	0,14	*	*
343	omega 3 fish oil	0,28	*	*
344	omega 3 fish oil	0,16	*	*
345	omega 3 fish oil	0,17	*	*
346	omega 3 fish oil	0,17	*	*
347	omega 3 fish oil	0,19	*	*
348	omega 3 fish oil	0,14	*	*
349	capelin oil	0,14	*	*
350	tuna oil	0,24	1,13	25,57
351	shark liver oil	0,34	1,24	21,09
352	Squalene	0,23	1,82	1060
	action limits EU	1,5	*	*
	limits EU	2		

*) not measured

Table 3: Dioxins, dioxin like PCBs and Marker PCBs in fish oil for feed from Iceland in 2004 (pg/g WHO-TEQ calculated for 12% moisture content, upper bond levels , upper bond levels)

Sample code	Samples:	Dioxins pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Marker PCBs ng/g
317	capelin oil	2,07	2,17	24,39
318	capelin oil	1,77	*	*
319	capelin oil	3,48	5,61	42,39
320	capelin oil	2,20	4,27	31,49
321	capelin oil	1,13	1,29	13,11
322	capelin oil	1,70	2,72	15,70
323	capelin oil	2,41	4,63	27,61
324	capelin oil	1,45	*	*
325	capelin oil	1,50	0,25	2,85
326	capelin/herring oil	3,44	0,00	*
327	herring oil	0,96	2,01	*
328	herring oil	1,01	*	*
329	blue whiting oil	1,80	5,64	62,98
330	blue whiting oil	1,45	6,16	52,09
331	blue whiting oil	1,36	4,53	40,19
	action limits EU	4,5		
	limits EU	6		

*) not measured

Table 4: Dioxins, dioxin like PCBs and Marker PCBs in fish meal for feed from Iceland in 2004 (in pg/g WHO-TEQ calculated for 12% moisture content, upper bond levels)

Sample code SN-DFM-04-	Samples:	Dioxins pg/g WHO-TEQ	Dioxin like PCBs pg/g WHO-TEQ	Marker PCBs ng/g
201	redfish meal	0,3	1,75	20,89
200	cod meal	0,36	0,67	6,1
202	cod meal	0,31	1,1	11,35
203	cod meal	0,24	0,82	9,19
204	cod meal	0,35	1,16	12,91
205	cod meal	0,26	0,72	6,18
232	blue whiting meal	0,17	0,3	7,3
223	blue whiting meal	0,2	0,68	6,15
224	blue whiting meal	0,24	0,91	8,08
225	blue whiting meal	0,83	3,56	27,71
233	capelin meal	0,18	0,19	2,31
234	capelin meal	0,23	0,26	2,57
226	capelin meal	0,16	0,18	1,53
227	capelin meal	0,34	0,55	5,37
228	capelin meal	0,18	0,2	2,08
229	herring meal	0,42	0,78	7,84
230	herring meal	0,44	0,69	6,65
231	herring meal	0,15	0,21	2,42
	action limits EU	1		
	limits EU	1,25		

Table 5: Pesticides in fish from Iceland in 2004 in µg/Kg wet weight, upper bond levels

sample code SN-DF-04-	Matrix	% fat	DDT µg/Kg	HCH µg/Kg	HCB µg/Kg	Chlordanes µg/Kg	Toxaphene µg/Kg	Aldrin/Dieldrin µg/Kg	Endrin µg/Kg	Endosulphan µg/Kg	Heptachlor µg/Kg	Mirex µg/Kg
132	lobster S	0,18	0,361	0,340	0,075	0,117	0,105	0,540	0,007	0,174	0,200	0,011
102-103	haddock S	0,21	0,128	0,353	0,500	0,171	0,256	0,140	0,003	0,500	0,200	0,020
100-101	haddock SW	0,22	0,120	0,342	0,314	0,118	0,161	0,140	0,005	0,315	0,200	0,015
104-105	haddock NE	0,23	0,133	0,363	0,491	0,203	0,391	0,199	0,004	0,510	0,200	0,020
106-107	haddock W	0,24	0,128	0,355	0,500	0,178	0,307	0,156	0,007	0,510	0,200	0,020
114-115	cod W	0,27	0,371	0,340	0,271	0,157	0,286	0,169	0,010	0,140	0,200	0,009
108-109	cod SW	0,29	0,704	0,340	0,250	0,276	0,930	0,175	0,009	0,510	0,200	0,020
110-111	cod S	0,33	0,642	0,342	0,450	0,335	1,105	0,249	0,027	0,565	0,200	0,020
112-113	cod NE	0,34	0,531	0,348	0,409	0,276	0,639	0,231	0,023	0,150	0,200	0,009
145	angler fish	0,29	0,565	0,280	0,100	0,270	0,399	0,140	0,013	0,180	0,200	0,008
143	ling S	0,31	0,751	0,280	0,200	0,349	0,661	0,169	0,008	0,160	0,200	0,007
144	tusk SW	0,32	0,273	0,280	0,060	0,145	0,175	0,140	0,006	0,160	0,200	0,003
131	catfish W	0,56	0,521	1,345	0,200	0,439	0,688	0,197	0,026	1,290	0,200	0,030
140-141	halibut	0,73	1,038	0,457	0,300	0,469	1,040	0,190	0,038	1,450	0,200	0,030
128-129	saith W	0,73	0,717	0,353	0,463	0,421	0,972	0,224	0,038	0,184	0,203	0,009
126-127	redfish (S. Mentella) SW	0,79	1,976	0,455	0,350	0,788	2,245	0,327	0,030	0,570	0,206	0,030
124-125	redfish (S. Marinus) SW	1,24	5,266	0,463	0,650	1,628	5,323	0,641	0,023	0,625	0,237	0,054
151-152	gray sole S	0,93	0,340	0,290	0,100	0,105	0,202	0,140	0,009	0,310	0,200	0,015
136	Iceland cyprine NE	0,95	0,299	2,292	0,200	0,368	0,229	0,523	0,079	0,465	0,558	0,010
150	lemon sole S	1,00	0,511	0,307	0,200	0,411	1,001	0,622	0,095	0,310	0,274	0,008
149	blue mussels	1,23	0,221	0,344	0,050	0,314	0,261	0,339	0,081	0,510	0,200	0,010
148	lumpfish roes SW	1,27	2,493	0,552	1,000	1,905	2,519	1,521	0,293	0,410	0,412	0,010
138-139	cod roes SW	1,44	1,877	0,376	0,600	2,006	1,631	1,356	0,365	0,410	0,326	0,010
142	plaice W	1,50	0,935	0,325	0,265	0,509	0,954	0,427	0,032	0,375	0,229	0,013
146-147	dab SW	1,52	1,125	0,312	0,300	0,468	0,938	0,381	0,032	0,320	0,203	0,013
134-135	herring E	9,93	4,527	1,411	0,647	2,572	6,495	1,931	0,229	1,750	1,605	0,029
	Greenland halibut W	11,80	19,469	1,719	3,698	9,501	24,350	5,408	0,707	3,600	1,283	0,173
	limits in EU		500	*	50	100	*	50	50	*	50	*

*) not measured

**) total amount of α, β, γ and δ HCH

Table 6: Pesticides in fish meal from Iceland in 2004 and from the NORA project in µg/Kg calculated for 12% moisture content. upper bond levels

Sample code SN-DFM-04	Matrix	DDT µg/Kg	β-HCH µg/Kg	α-HCH µg/Kg	γ-HCH µg/Kg	δ-HCH µg/Kg	HCB µg/Kg	Chlordanes µg/Kg	Toxaphene µg/Kg	Aldrin/Dieldrin µg/Kg	Endrin µg/Kg	Endosulphan µg/Kg	Heptachlor µg/Kg	Mirex µg/Kg
201	redfish meal	30,5	0,04	0,05	0,2	0,1	0,92	5,05	8,86	1,7	0,15	2,2	0,63	*
200	cod meal	10,0	0,12	0,38	0,2	0,1	2,00	3,98	9,00	3,8	0,58	2,5	0,67	*
202	cod meal	16,0	0,07	0,13	0,2	0,1	1,83	3,76	8,53	2,1	0,22	2,3	0,71	*
203	cod meal	12,3	0,06	0,14	0,2	0,1	1,90	3,61	8,55	1,8	0,16	2,5	0,41	*
204	cod meal	16,2	0,06	0,20	0,2	0,1	1,89	4,89	8,98	2,2	0,20	3,5	0,51	*
205	cod meal	7,5	0,04	0,07	0,2	0,1	1,92	2,60	8,65	1,5	0,10	2,3	0,62	*
206	capelin meal	2,9	0,10	0,07	0,4	0,1	1,31	1,62	5,87	2,5	0,68	1,2	0,73	0,030
207	capelin meal	3,7	0,10	0,08	0,4	0,1	1,60	2,05	5,93	2,9	0,90	1,2	0,65	0,026
208	capelin meal	5,3	0,09	0,08	0,4	0,1	2,53	3,06	9,67	4,0	0,99	1,3	0,73	0,037
209	capelin meal	6,1	0,07	0,35	0,4	0,1	2,58	3,18	9,04	3,6	1,02	1,2	0,79	0,033
210	capelin meal	7,9	0,09	0,10	0,4	0,1	3,71	4,05	9,80	4,6	1,41	1,2	0,84	0,049
211	capelin meal	3,0	0,10	0,11	0,4	0,1	0,63	1,54	4,77	1,6	0,53	2,3	0,63	0,019
212	capelin meal	2,1	0,10	0,29	0,4	0,1	0,57	1,06	2,89	1,8	0,46	2,2	0,48	0,017
213	capelin meal	4,9	0,11	0,08	0,4	0,1	1,01	1,90	4,95	2,6	0,76	2,3	0,70	0,041
214	blue whiting meal	14,6	0,05	0,07	0,4	0,1	1,79	3,90	13,01	2,9	0,43	2,2	0,66	0,147
215	blue whiting meal	21,3	0,05	0,08	0,4	0,1	2,41	6,18	9,05	3,3	0,50	2,3	0,81	0,291
216	blue whiting meal	16,3	0,03	0,08	0,4	0,1	2,20	5,92	6,14	3,0	0,44	2,2	0,60	0,230
217	blue whiting meal	11,8	0,06	0,11	0,4	0,1	1,80	3,94	13,68	2,1	0,60	2,3	0,68	0,163
218	blue whiting meal	8,6	0,07	0,29	0,4	0,1	1,44	3,04	8,62	2,3	0,54	2,3	0,68	0,110
219	herring meal	4,3	0,04	0,25	0,3	0,1	0,66	1,45	7,68	1,3	0,20	1,2	0,51	0,037
220	herring meal	8,3	0,12	0,41	0,4	0,1	0,93	2,38	13,52	2,3	0,37	2,2	0,79	0,075
221	herring meal	9,8	0,03	0,21	0,4	0,1	0,74	3,23	14,11	3,0	0,43	1,2	0,67	0,087
222	herring meal	6,1	0,03	0,09	0,4	0,1	0,67	2,06	9,88	2,0	0,32	2,2	0,57	0,068
	EU limits	50	10	20			10	20	20	10	10			

Table 7: Pesticides in fish oil from the NORA project in µg/Kg calculated for 12% moisture content, upper bond levels

Sample code SN-DFO-04-	Matrix	DDT µg/Kg	β-HCH µg/Kg	α-HCH µg/Kg	γ-HCH µg/Kg	δ-HCH µg/Kg	HCB µg/Kg	Chlordanes. µg/Kg	Toxaphene µg/Kg	Aldrin/Dieldrin µg/Kg	Endrin µg/Kg	Endosulf µg/Kg	Heptachlor µg/Kg	Mirex µg/Kg
300	capelin oil	34,2	1,4	9,20	3,5	0,3	20,0	22,8	63,6	28	10,4	18	6,6	0,21
301	capelin oil	39,0	1,3	9,08	2,6	0,3	21,9	24,7	78,3	26	10,2	18	7,0	0,26
302	capelin oil	69,6	0,9	6,55	2,6	0,4	34,7	40,1	132,8	38	13,1	18	7,7	0,34
303	capelin oil	72,5	1,0	5,56	3,5	0,4	37,7	41,2	117,1	45	16,5	28	8,4	0,54
304	capelin oil	103,2	1,1	5,35	2,6	0,3	49,1	51,5	166,3	50	16,7	25	8,0	0,77
305	capelin oil	27,8	1,3	9,88	2,6	0,4	9,6	16,4	37,7	13	5,2	18	5,5	0,10
306	capelin oil	20,4	1,0	10,94	2,6	0,3	8,3	13,0	33,1	15	7,5	32	5,0	0,09
307	capelin oil	44,1	1,3	8,31	2,6	0,3	16,8	22,4	63,0	23	8,2	36	6,5	0,30
308	blue whiting oil	261,2	0,80	3,70	2,6	0,3	40,3	88,5	319,8	48	14,0	36	11,4	3,00
309	blue whiting oil	418,6	0,80	4,73	2,6	0,3	54,2	139,8	334,2	63	17,5	28	12,3	4,37
310	blue whiting oil	369,5	0,78	4,13	2,6	0,3	57,0	142,2	337,6	55	13,1	26	13,2	4,70
311	blue whiting oil	130,5	0,9	6,03	3,5	0,3	21,8	48,0	149,4	23	7,3	24	6,2	1,49
312	blue whiting oil	98,7	0,78	6,66	3,5	0,3	21,7	39,8	130,5	22	8,7	31	7,0	1,18
313	herring oil	59,8	0,9	5,34	2,6	0,4	10,2	19,4	111,5	20	3,9	24	6,0	0,54
314	herring oil	69,7	1,0	5,37	2,6	0,3	12,3	22,1	147,0	22	4,4	32	6,5	0,63
315	herring oil	150,4	0,79	4,96	2,6	0,3	18,9	55,7	267,1	44	7,3	26	8,1	1,31
316	herring oil	79,1	0,82	4,94	3,5	0,3	9,4	28,7	148,6	26	6,2	35	6,4	0,58
	EU limits	500	100	200	*	*	200	50	200	200	50	*	*	*

Table 8: Mercury in Icelandic fish in 2004 in µg/Kg wet weight

Sample-code SN-DF-04	Matrix	Hg (mercury) ug/Kg
100-101	haddock SW	23,15
102-103	haddock S	27,08
104-105	haddock NE	25,76
106-107	haddock W	19,58
2003	haddock SE	20,83
108-109	cod SW	59,88
110-111	cod S	53,54
112-113	cod NE	41,98
114-115	cod W	44,91
2003	cod SE	50,54
126-127	redfish (S. Mentella)	68,13
128-129	saithe W	29,13
131	catfish W	57,34
150	lemon sole S	23,21
151-152	gray sole S	19,39
142	plaice W	23,80
146-147	dab SW	42,84
143	ling S	107,51
144	tusk SW	77,55
145	angler fish	86,21
	limits EU	500
	limits EU*	1000

***) limit for specific fish species here redfish, catfish and angler fish