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Undesirable substances in seafood products – Results from the monitoring activities in 2005

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Titill / Title	**Undesirable substances in seafood products– results from the monitoring activities in 2005**		
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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. 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 fyir 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 málaflokk og mengun sjávarafurða er. Þessi skýrsla er samantekt niðurstaðna vöktunarinnar árið 2005. Mæld voru dioxin, dioxinlík PCB og bendi PCB efni, auk þess tíu mismunandi tegundir varnarefna, þungmálmar, PBDE efni og lífræn tinsambönd.		
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. 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 for a risk assessment and the setting of maximum values that are now under consideration within EUThis report summarizes the results obtained in the year 2005. The results obtained in 2003 and 2004 have already been published and are accessible at the IFL website. (IFL Report 06-04 and IFL Report 33-05, respectively). In 2005, data was collected on mercury, arsen, polychlorinated dibenzodioxins and dibenzofurans (17 substances), dioxin-like PCBs (12 substances), marker PCBs (7 substances),ten different types of pesticides, polybrominated flame retardants PBDE and organao til substances.		
English keywords:	*Marine catches, monitoring, dioxin, PCB, trace elements, pesticides*		

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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 three years. The project is funded by the Ministry of Fisheries 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 and total arsenic), PAHs, polychlorinated dibenzo dioxins and dibenzo furans (commonly called dioxins), dioxin-like PCBs, marker PCBs, polybrominated flame retardants (PBDEs), organotins and 29 pesticides and breakdown products (HCB, DDTs, HCHs, dieldrin, endrin, chlordanes, toxaphenes, endosulfan substances and mirex).

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 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 the end of 2006 amending Regulation (EC) No 466/2001.
D) 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.
E) 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).

This report summarizes results from the monitoring programme in 2005. The results obtained in 2003 and 2004 have already been published and are accessible at the IFL website. (IFL Report 06-04 and IFL Report 33-05, respectively).

2 Summary

This report summarizes the results obtained in 2005 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 three years.

This year (2005) emphasis was laid on gathering information on dioxins, dioxin like PCBs, marker PCBs, pesticides, PBDE and organotin compounds 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, lead and cadmium.

The results obtained in 2005 are in concordance with the results obtained in the two previous years, i.e.2003 and 2004.

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. This year emphasis was laid on measureing pesticides in the edible part of fish muscle and the results show levels below limits of detection for most of the pesticides measured. Cadmium (Cd) and lead (Pb) were also measured in fish muscle but the concentration of these trace metals was always below the limits of detection of the method used. In 2004 and 2003, the mercury (Hg) and arsenic (As) content had also been determined to be very low (Auðunsson, Guðjón Atli 2004 and Ásmundsdóttir Ásta M. et.al. 2005). Organotin substances were below limits of quantification in all fish samples.

Fish oil for human consumption was measured for dioxin and PCB substances. In all cases the samples were below the maximum limits. The difference between the oil originated from the North Atlantic and other oceans was striking. The concentration of dioxin and PCBs was much higher in the North Atlantic than in the Pacific Ocean and the South Atlantic.

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 dioxinlike 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, Ásta M. 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) og 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.

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-DDD, 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 (lead) and total As (organic and inorganic arsenic).

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.

Organotin-substances:

MBT, DBT, TBT, TTBT, MOT, DOT, TCyT, TPhT

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 the end of 2006.

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. 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.

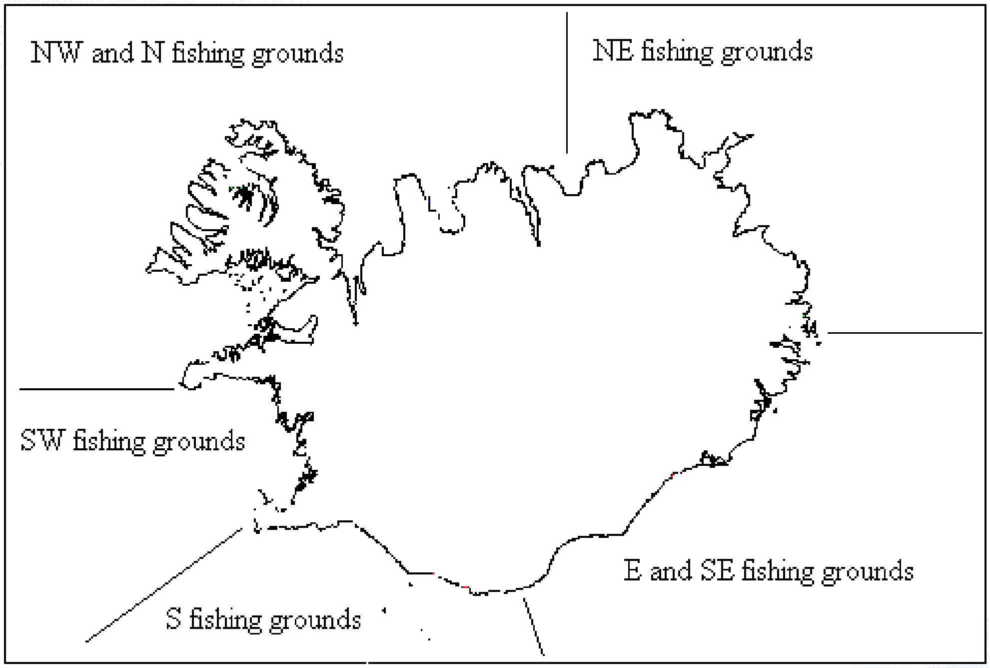

Fig 1: The division of the fishing grounds around Iceland used in this research

4.2 Analysis

The contaminants were measured by ERGO Forschungsgesellschaft mbH, Hamborg, Germany. 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, organotin and inorganic trace elements.

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 2005 are expressed in details in Tables 1-5 in the appendix.

5.1 Dioxins (PCDD/Fs) and dioxin like PCB

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 dioxinlike PCBs that will be valid from the 4^{th} of November 2006. This can be seen from 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, spotted catfish and redfish (samples no. 2, 4 and 6), contain more dioxins and PCBs than species which accumulate fat in the liver and thus have almost no fat in the muscle. This was to be expected since dioxin and other organochlorine substances are fat solvable. 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.

Maximum limit for the sum of dioxins and dioxinlike PCBs in EU is 8 pg/g in WHO-TEQ (EU regulation No. 199/2006).

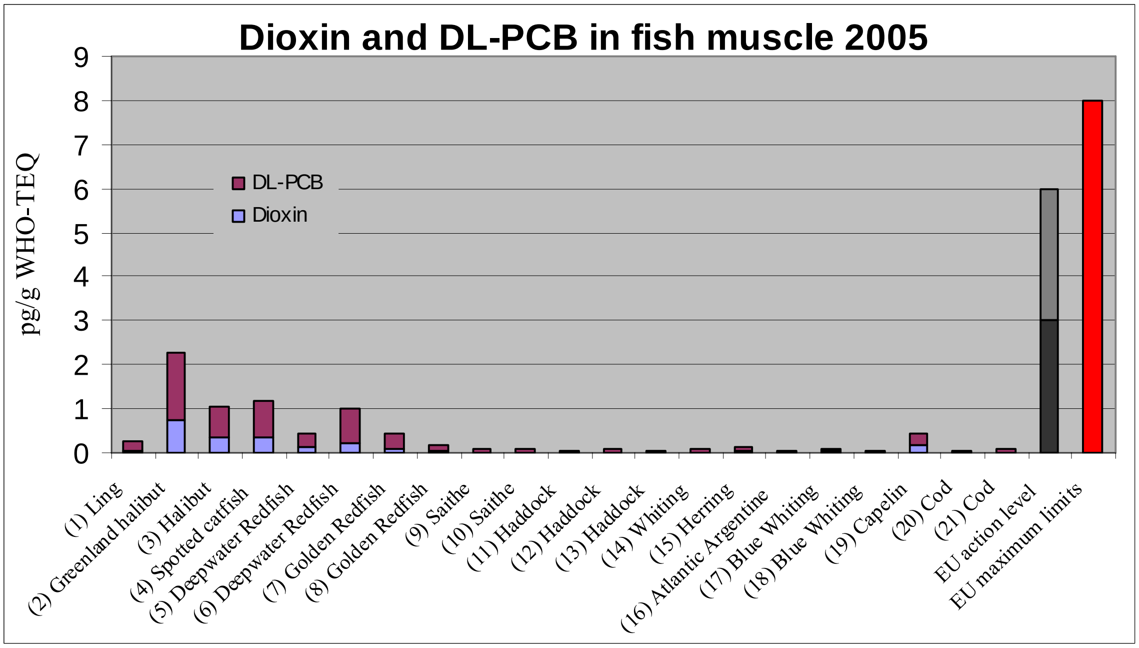

Fig. 2: Dioxins and dioxin-like PCBs in the edible part of fish muscle from Icelandic fishing grounds in 2005 in relation to maximum limit in EU and action limits in WHO-TEQ pg/g wet weight.

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

Nineteen samples of fish oil for human consumption were analyzed in 2005. As can be seen in Table 2 in the appendix, the amount of dioxins in all the samples are between 0,2 and 0,3 pg/g. All of the fish oil samples for human consumption analyzed are thus far below the maximum limits for dioxin of 2 pg/g, and action limits of 1,5 pg/g set by EU. Figure 3 shows the sum of dioxins and dioxin-like PCBs in the fish oil samples compared to the new maximum limits in EU that will be valid from the 4th of November 2006 (EU regulation No. 199/2006). The omega 3 fish oil contains much less dioxin-like PCBs than the other types of fish oils for human consumption. The samples of omega 3 fish oil and tuna oil are made from fish originating from the Pacific Ocean and South Atlantic. The samples that contain the higher amount of dioxin-like PCBs are on the other hand of cod liver oil from the North Atlantic. Samples no; 8,12, 13 and 14 are of cod liver oil that has been deodorized, a process which removes a part of the dioxin-like PCBs, but the other samples of cod liver oil contain rather high levels of dioxin and dioxin-like PCBs in relation to the new maximum level. The different level of dioxin-like PCBs in the fish oil samples reflects the different conditions of the oceans in respect to the persistent substances investigated in this study.

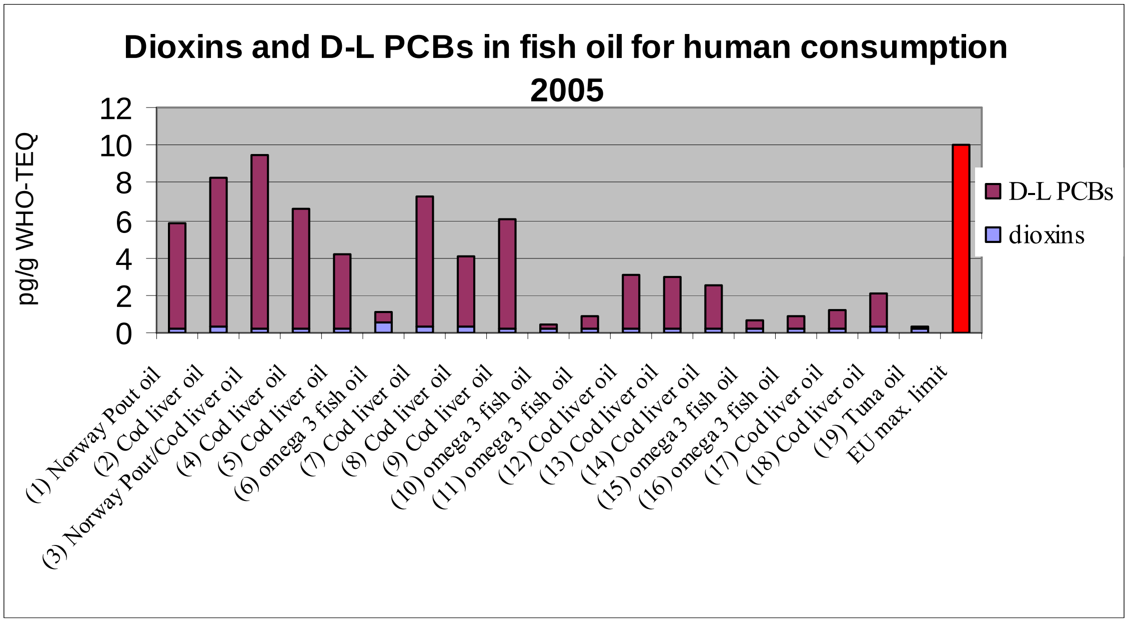

Fig 3: Dioxins and dioxin-like PCBs in fish oil for human consumption in Iceland in 2005 (in WHO-TEQ pg/g wet weight.

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 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 the fish samples. In 2005 the European Union agreed upon new limits for the sum of dioxin and dioxin-like PCBs in feed of 24 pg/g WHO-TEQ and action level of 5 pg/g WHO-TEQ for dioxin and 14 pg/g WHO-TEQ for dioxin-like PCBs. However, the EU maximum limit for dioxin only, of 6pg/g WHO-TEQ and action level of 5pg/g WHO-TEQ from the year 2001, will also be valid until end of 2008.

It is interesting to note that while all the fish meal samples are lower than the EU maximum limits set in 2001 and all except one are lower than the action level for dioxin from 2001, one sample exceeds the new maximum limit for the sum of dioxin and dioxin-like PCBs and two others exceed the action level (Figure 4). The same is observed for the fish oil (Figure 5), where only one sample exceeds the maximum level for dioxin from 2001, but two samples exceed the new maximum level for the sum of dioxin and dioxin-like PCBs..

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 and Ásta M. 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 2005 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. 8 to 12 all containl high amounts of dioxin and dioxin-like PCBs in relation to the EU maximum level. 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.

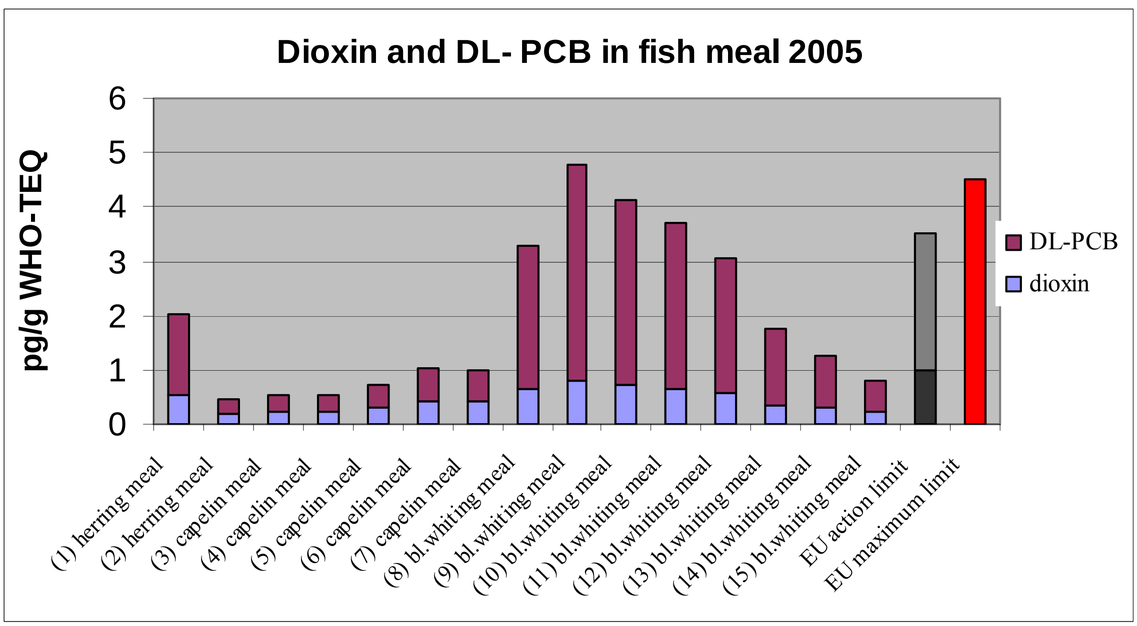

Fig. 4: Dioxins and dioxin-like PCBs in samples of fish meal from Iceland in 2005 (in WHO-TEQ pg/g calculated for 12% moisture content) in relation to maximum limit in EU) and action limits

The level of dioxins and dioxin-like PCBs in the fish oil samples no; 4, 5 and 6 (blue whiting) is high. This fish was caught in the summer, from June to August 2005. The other samples are of capelin and blue whiting oil from the winter period when the fish is in good nutritional condition.

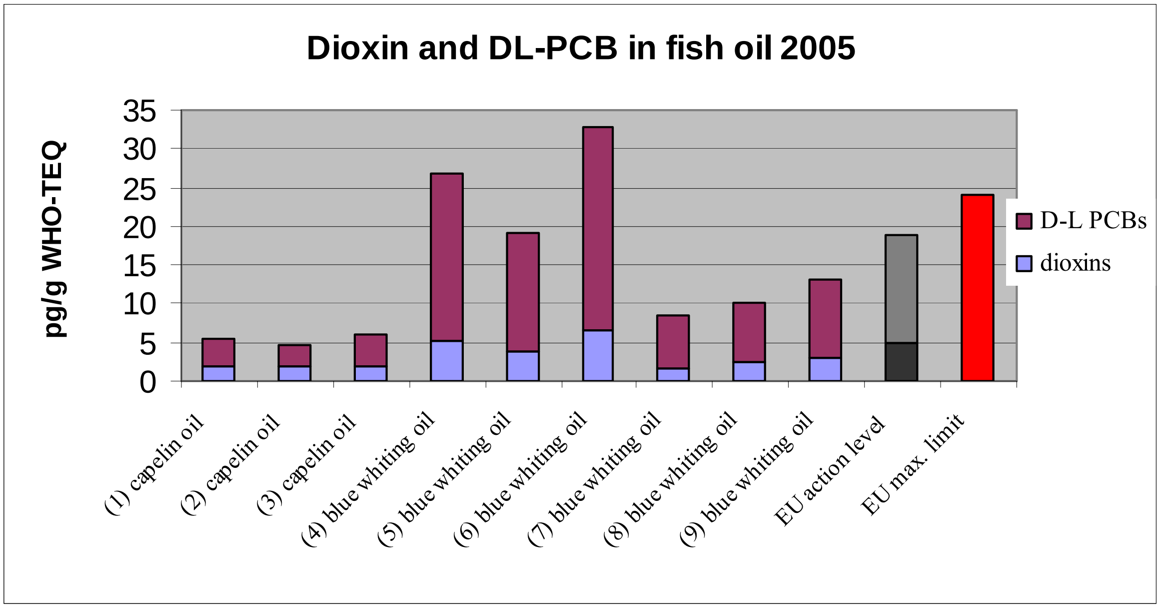

Fig. 5: Dioxins and dioxin-like PCBs in samples of fish oil for feed from Iceland in 2005 (in WHO-TEQ pg/g calculated for 12% moisture content)) in relation to maximum limit in EU and action limits

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 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 in Germany, Holland and Sweden range 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 range 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 (sample nr.2), a total of 10,2 µg/Kg wet weight. That level is still only one tenth of the maximum limits in Iceland. For details see Table 1 in appendix.

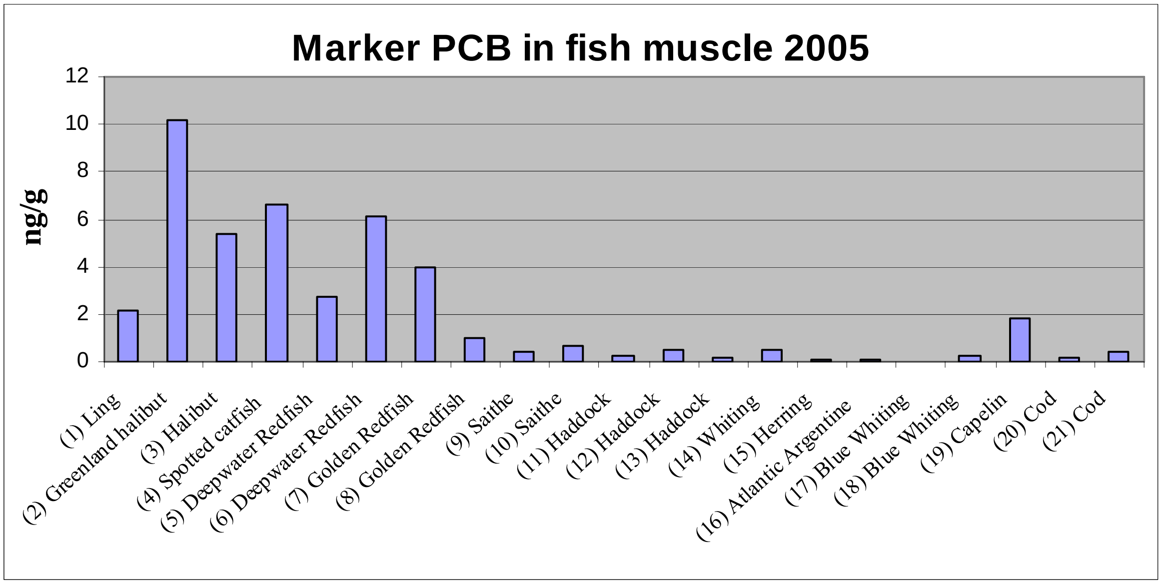

Fig 6: Marker PCBs in the edible part of fish muscle from Iceland in 2005 (in ng/g wet weight).

5.2.2 Marker PCBs in fish oil for human consumption

Figure 7 shows the level of marker PCB in the samples of fish oil for human consumption but further details can be seen in Table 2 in the appendix. As already mentioned, no maximum limits have been set in EU for marker-PCBs. The pattern observed in Figure 7 is similar to the pattern for dioxin and dioxin-like substances in the same oil samples (chapter 5.1.2.). Again, there is a striking difference between the oil originating from the Pacific or South Atlantic Oceans compared to the cod liver oil samples from North Atlantic. The samples of cod liver oil containing below 85 µg/Kg marker PCB, have been deodorized.

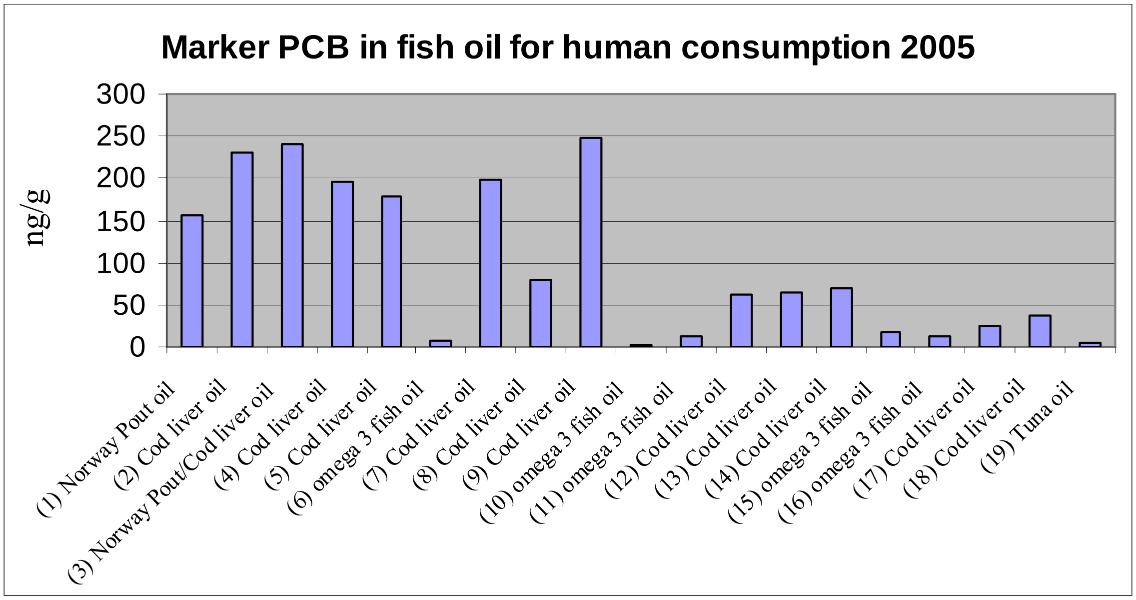

Fig. 7: Marker PCBs in fish oil for human consumption from Iceland in ng/g wet weight

5.2.3 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. The histogram illustrated in Figures 8 and 9 are similar to the histograms (Figures 4 and 5) showing the level of dioxin and dioxin-like PCBs in fish oil and fish meal.

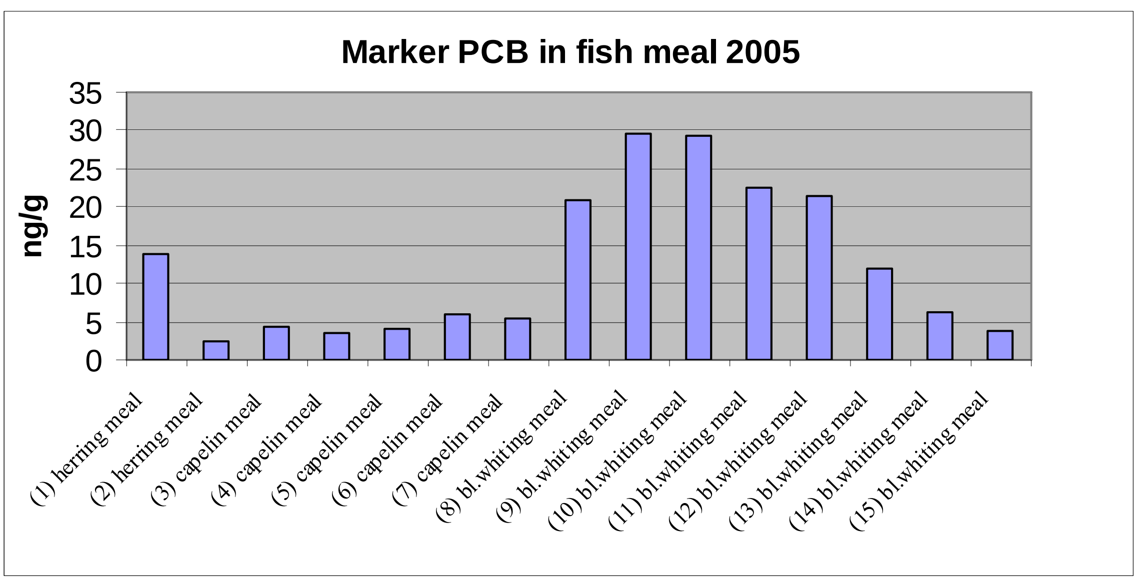

Fig. 8: Marker PCBs in fish meal from Iceland in 2005 (in ng/g calculated for 12% moisture content)

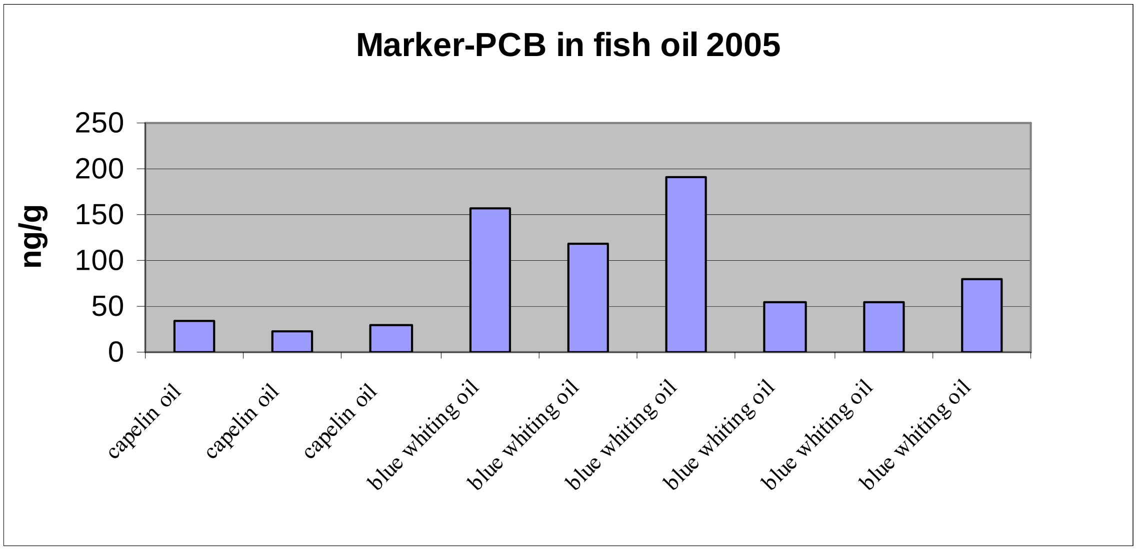

Fig.9: Marker PCBs in fish oils from Iceland in 2005 (in ng/g calculated for 12% moisture content)

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).

5.3.1 PBDE in seafood

PBDE was measured in twenty three samples of fish muscle. This is the first time so much data are obtained on this class of substances, but PBDE was measured in five fish species (Greenland halibut, cod, haddock, and two species of redfish) in 2003 (Auðunsson, Guðjón Atli 2004ref). The results in Figure 10 show very low level of PBDE in general, with halibut as an exception. The results are reported in detail in Table 1 in the appendix. It will be interesting to see how the concentration of PBDE will change with time since the use of the substances is growing, as mentioned already.

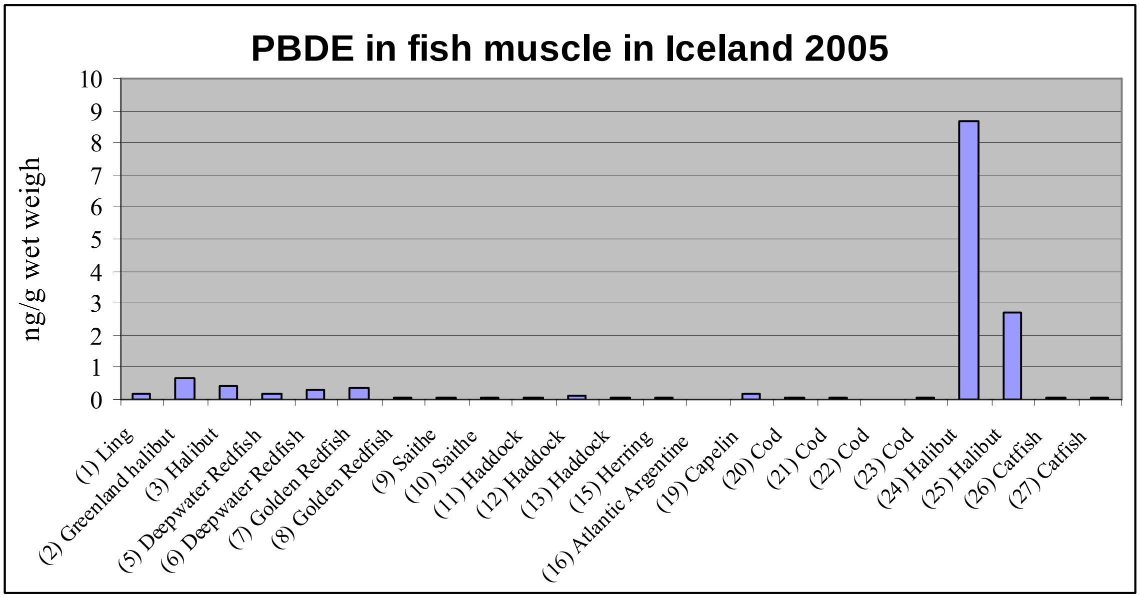

Fig. 10: PBDE in fish muscle from Icelandic fishing ground in 2005 in µg/Kg wet weight sum of: PBDE 28, PBDE 47, PBDE 66, PBDE 100, PBDE 99, PBDE 85, PBDE 154, PBDE 153, PBDE 183, PBDE 209.

5.3.2 PBDE in fish oil and fish meal for feed

PBDE were measured in two samples of fish meal and two samples of fish oil in the Icelandic monitoring activities in 2005. The following results in µg/Kg were obtained in 2005. PBDE in the table is the sum of PBDE 28, PBDE 47, PBDE 66, PBDE 100, PBDE 99, PBDE 85, PBDE 154, PBDE 153, PBDE 183, PBDE 209.

Species	Number of samples	PBDE (ng/g wet weight)
Capelin meal	1	0,28
Blue whiting meal	1	1,2
Blue whiting oil	1	8,3
Blue whiting oil	1	8,2

5.4 PAH

Polyaromatic hydrocarbons or PAH were not measured in 2004 and 2005, nevertheless three samples of refined fish oil were measured in 2003. Benzo(a)pyrene was in all three cases below LOD which was < 0,3 μg/Kg. 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 benso(a)pyrene of 2 μg/Kg in fish oils so the results so far are well below the limits.

5.5 Pesticides

In this chapter, the results for nine different classes of pesticides are discussed. Results are shown in Tables 4 and 5 in 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. 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.

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 an active substance comprising 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 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 the main source of HCB pollution is in the production of different chemicals such as pesticides and others, where it is a by-product.

Chlordanes measured are α- and γ-chlordane, oxychlordane and 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.

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 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, Heptachlor and Mirex**

5.5.1 Pesticides in seafood

The results show very low concentration of all ten pesticide groups measured in fish from Icelandic waters (for details see Table 5 in appendix). As noted before, the results are expressed as upper bond, but most of the pesticides are below the limit of detection. Only negligible amounts of DDT, Chlordane and dieldrin were measured in almost all fish species, HCB, heptachlor, endrin and Mirex are measured in the fat fish species while the rest of the pesticides are always below limits of detection. Figure 11 shows the level of DDT in fish muscle in relation to the maximum limit in EU.

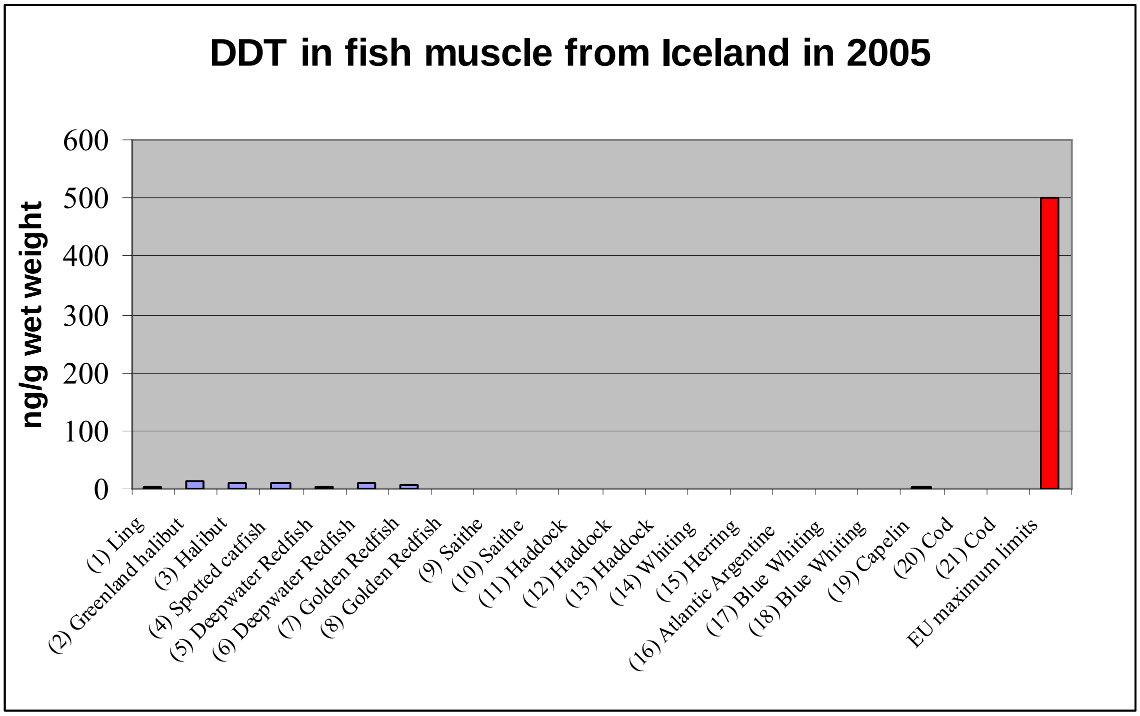

Fig. 11: DDT in fish muscle from Icelandic fishing grounds in 2005 in µg/Kg wet weight

5.5.2 Pesticides in fish oil for human consumption

No results of fish oil for human consumption are reported this year.

5.5.3 Pesticides in fish meal and fish oil for feed

This year (2005) only few measurements were carried out for pesticides in fish oil for feed and no measurement were carried out for pesticides in fish meal. The pesticides Toxaphene, Aldrin and Dieldrin were measured and always resulted far below the EU limits (see Table 4 in appendix). The sample measured for pesticides are samples of Capelin oil which were not very high in dioxin. Samples of blue whiting, which were very high in dioxin and PCBs, were not measured for pesticides but these samples are likely to be near or exceed the EU maximum limit for some of the pesticides,for example Toxaphene and Chlordane. (Ásta M. Ásmundsdóttir et. al. 2005)

5.6 *Inorganic trace elements*

This year (2005) different species of fish have been measured for trace metals, i.e. cadmium (Cd) and lead (Pb). Furthermore, a few fish meal samples and fish oil samples have been measured for Pb, Cd and arsenic (As).

5.6.1 Inorganic trace elements in seafood

Cadmium and lead was measured in 21 samples of fish. In short, all the measurements were lower than the limits of detection or limits of quantification, or at least ten times lower than maximum limits for the substances. (for details refer to Table 1 in the appendix). In the previous years of the program, measurments have been made on arsenic and mercury (Hg). Results have shown that the level of mercury in Icelandic seafood is ten to twenty times lower than the allowed maximum limit in the EU. No limits have yet been set for arsenic, but results from the monitoring in 2003 and 2004 show the level of arsenic well below 25 μg/Kg and in most cases between 5-10 μg/Kg. (Auðunsson, Guðjón Atli 2004 and Ásmundsdóttir Ásta M. et.al. 2005).

5.6.2 Inorganic trace elements in fish meal and fish oil for feed

The fish meal samples contain very little Pb. The level of Pb in the fish meal samples were either below or just above the limit of detection. However, the level of Cd was higher, as can be seen in Figure 12. The highest level was found in herring meal or 0,689 mg/Kg. Arsenic was measured in one sample of herring meal, capelin meal and blue whiting meal. The highest level was found in the blue whiting meal or 8,16 mg/Kg compared to maximum limit of 15 mg/Kg in the EU.

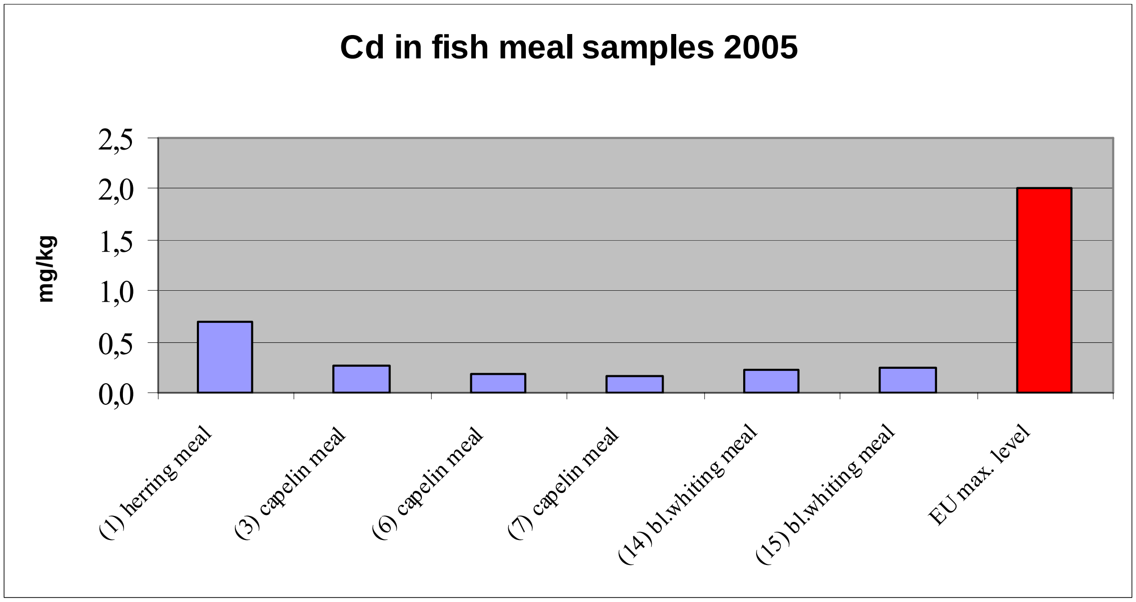

Fig. 12: Cadmium (Cd) in fish meal samples in 2005 (in mg/Kg original sample)

The fish oil samples measured contained negligible amount of Pb and Cd, but the Arsenic content was measured up to 8,6 mg/Kg which exceeds half the limit value (15 mg/Kg). For the results in detail see Tables 3 and 4 in the appendix.

5.7 Organotin substances

The best known organotin substance is tributyltin (TBT). Tributyltin has been used as anti-fouling agent in paints used on ships for decades. After recognition of the harmful environmental effects of organotin compounds around 1990, their use as anti-fouling agents was restricted to ships longer than 25 m in most countries. EU regulation No. 782/2003 prohibits all use of TBT as an anti-fouling agent on ships from 2003 and the same regulation prohibits all use of the substance from 1st January 2008.

TBT is not considered persistant since it is metabolized rather easely by many organisms in the sea. However, even in low concentrations it is very toxic, especially to molluscs and has caused serious deformation on them. The deformation has been reported in the Dogwhelk (*Nucella lapillus*) around the Icelandic coast since 1993. The frequency of deformation has been declining in most places around Iceland, as the use of TBT diminishes. (Svavarsson 2000)

5.7.1 Organotin in seafood

Organotin was measured in all the fish samples taken in 2005. Fish accumulate TBT mostly in the liver, but TBT has also been measured up to several hundred µg/Kg wet weight in fish muscle near to big harbours (Linley-Adams 1999). This is, however, the first time that TBT is measured in samples of fish muscle from Icelandic waters. Results show that all the samples contained TBT under the limits of quantification, but all the samples were taken relatively far from big harbour areas. Table 6 and 7 in the appendix, shows the results in detail. The results are given as µg/Kg wet weight (Table 6) and in µg Sn/Kg wet weight (Table 7). Quanitfication limits are given in the parenthesis.

5.7.2 Organotin in fish meal and fish oil for feed

Four samples of fish meal and four samples of fish oil were measured for organotin. The results are reported in Table 8-9 in the appendix. The results are given as µg/Kg wet weight (Table 6) and in µg Sn/Kg wet weight (Table 7). Quanitfication limits are given in the parenthesis. It is interesting to note that the four fish oil samples (oil of Blue whiting) contain only TBT, above quantification limits, but the fish meal samples contain only monooctyltin and dioctyltin abowe the limits of quantification.

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Commission Regulation (EC) No. 466/2001.

Commission Regulation (EC) No. 782/2003

Commission Regulation (EC) No 199/2006 of 3 February 2006

Website December 2005: http://www.sacn.gov.uk/

7 Appendix

7.1 Table 1: Dioxin, PCB, PBDE, Pb and Cd in fish muscle

7.2 Table 2: Dioxin and PCB in fish oil for human consumption

7.3 Table 3: Dioxin, PCB, PBDE and heavy metals in fish meal for feed

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

7.5 Table 5: Pesticides in fish muscle

7.6 Table 6: Organotin in fish muscle in µg/Kg wet weight

7.7 Table 7: Organotin in fish muscle in µg Sn/Kg wet weight

7.8 Table 8: Organotin in fish oil and fish meal for feed in µg/Kg wet weight

7.9 Table 9: Organotin in fish oil and fish meal for feed in µg Sn/Kg wet weight

Table 1

Sample code SN-2005-	fish sample No.	Sample name	fishing ground	length (cm)	fat (%)	PCDD/PCDF (pg/g WHO-TEQ)	DL-PCB (pg/g WHO-	sum of Dioxin and Dl-PCB	Marker-PCB (µg/Kg)	PBDE (µg/Kg)	Pb (mg/Kg)	Cd (mg/Kg)
286	1	Ling *(Molva molva)*	E and SE	38-97	0,24	0,045	0,231	0,277	2,167	0,18	0,02	0,002
287	2	Greenland halibut *(Reinhardtius hippoglossoides)*	N and NW	60-69	11	0,734	1,516	2,250	10,212	0,66	0,02	0,004
288	3	Greenland halibut *(Reinhardtius hippoglossoides)*	N and NW	50-59	11	0,362	0,689	1,051	5,360	0,43	0,02	0,002
289	4	Spotted catfish *(Anarhichas minor)*	N and NW	40-89	3,0	0,335	0,840	1,176	6,604		0,02	0,004
290	5	Deepwater Redfish *(Sebastes mentella)*	S	30-35	3,0	0,130	0,304	0,435	2,729	0,21	0,02	0,004
291	6	Deepwater Redfish *(Sebastes mentella)*	S	40-45	2,0	0,235	0,754	0,989	6,100	0,30	0,02	0,004
292	7	Golden Redfish *(Sebastes marinus*)	S	40-49	3,8	0,098	0,353	0,451	3,940	0,35	0,02	0,004
293	8	Golden Redfish *(Sebastes marinus*)	S	30-39	1,2	0,040	0,124	0,163	0,979	0,081	0,02	0,004
294	9	Saithe *(Pollachius virens)*	E and SE	50-60	0,76	0,011	0,060	0,070	0,450	0,049	0,02	0,004
295	10	Saithe *(Pollachius virens)*	E and SE	70-80	0,60	0,012	0,087	0,099	0,661	0,063	0,02	0,004
296	11	Haddock *(Melanogrammus aeglefinus*)	SW	30-39	0,24	0,010	0,039	0,049	0,236	0,037	0,02	0,002
297	12	Haddock *(Melanogrammus aeglefinus*)	SW	40-49	0,20	0,010	0,064	0,074	0,503	0,096	0,02	0,004
298	13	Haddock *(Melanogrammus aeglefinus*)	SW	50-59	0,13	0,008	0,033	0,040	0,182	0,053	0,02	0,002
299	14	Whiting (Merlangius merlangus)	E and SE	40-50	0,11	0,012	0,062	0,074	0,475		0,02	0,004
300	15	Herring *(Clupea harengus)*	S	20-30	7,0	0,042	0,096	0,138	0,077	0,063	0,02	0,004
301	16	Atlantic Argentine *(Argentina silus)*	S	30-40	0,29	0,018	0,026	0,044	0,062	0,018	0,02	0,002
302	17	Blue Whiting *(Micromesistius poutassou)*	E and SE	20-30	0,090	0,022	0,044	0,066	0,017		0,02	0,004
303	18	Blue Whiting *(Micromesistius poutassou)*	E and SE	30-40	0,12	0,012	0,032	0,044	0,231		0,02	0,004
304	19	Capelin *(Mallotus villosus)*	E and SE		20	0,185	0,233	0,418	1,828	0,20	0,02	0,031
305	20	Cod *(Gadus morhua)*	E and SE	45-59	0,39	0,013	0,037	0,050	0,170	0,045	0,02	0,002
306	21	Cod *(Gadus morhua)*	E and SE	75+	0,37	0,017	0,060	0,077	0,431	0,064	0,02	0,002
307	22	Cod *(Gadus morhua)*	NE	45-59	0,36					0,027	0,02	0,002
308	23	Cod *(Gadus morhua)*	NE	75+	0,40					0,063	0,02	0,002
309	24	(24) Halibut *(Hippoglossus hippoglossus)*		30+	15					8,7	0,02	0,002
310	25	(24) Halibut *(Hippoglossus hippoglossus)*		44+	6,6					2,7	0,02	0,002
311	26	(26) Catfish *(Anarhichas lupus)*	N and NW	50-59	0,53					0,062	0,02	0,004
312	27	(26) Catfish *(Anarhichas lupus)*	N and NW	70-79	0,61					0,037	0,02	0,004
313	28	(28) European plaice *(Pleuronectes platessa)*									0,02	0,002
314	29	(28) European plaice *(Pleuronectes platessa)*									0,02	0,002
		EU action level				3	3	*	*	*	*	*
		EU maximum limits				4	*	8	*	*	0,3	0,05

* No maximum limits exist in the EU for the substance

Table 2

Sample id.	oil sample No.	Sample name	PCDD/PCDF (pg/g WHO-TEQ)	DL-PCB (pg/g WHO-TEQ)	Dioxin and D-L PCB (pg/g TEQ)	Marker-PCB (µg/Kg)
(75) 5N034801	1	Norway Pout oil	0,21	5,64	5,85	156,5
556938A/155	2	Cod liver oil	0,31	7,95	8,26	229,83
batch 4141	3	Norway Pout/Cod liver oil	0,27	9,14	9,41	241,39
556937A/155	4	Cod liver oil	0,25	6,34	6,59	196,62
703-2005-00577602	5	Cod liver oil	0,27	3,87	4,14	179,51
703-2005-00568427	6	omega 3 fish oil	0,57	0,48	1,05	6,8
HB014	7	Cod liver oil	0,29	6,95	7,24	197,32
7,3-2005-00577600	8	Cod liver oil	0,29	3,73	4,02	80,36
703-2005-00571934	9	Cod liver oil	0,22	5,84	6,06	248,29
703-2005-00571930	10	omega 3 fish oil	0,19	0,28	0,47	1,54
batch No B5065 (24-05-2005)	11	omega 3 fish oil	0,19	0,69	0,88	11,88
703-2005-00579700	12	Cod liver oil	0,26	2,83	3,09	63,13
703-2005-00579699	13	Cod liver oil	0,2	2,81	3,01	63,81
703-2005-00573144	14	Cod liver oil	0,2	2,35	2,55	70,06
703-2006-00027248	15	omega 3 fish oil	0,19	0,52	0,71	16,76
batch no B5065 (24-05-2005)	16	omega 3 fish oil	0,19	0,69	0,88	11,88
703-2005-00579698	17	Cod liver oil	0,19	1,00	1,19	23,71
703-2005-00591566	18	Cod liver oil	0,31	1,78	2,09	36,12
703-2005-00571932	19	Tuna oil	0,19	0,19	0,38	5,51
	EU m.l.			10,00	10,00	

Table 3

Sample id.	meal sample	Sample name	date of caching	PCDD/PCDF	dioxinlike PCB	sum of Dioxin and Dl-PCB	Marker PCB	PBDE	Pb	Cd	As	Hg
	No.			pg/g TEQ	pg/g TEQ	pg/g TEQ	µg/Kg	µg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
RF-2005-01883	1	herring meal	31.05.05	0,54	1,47	2,01	13,70		0	0,689		
RF-2005-03443	2	hering meal	10.11.05	0,20	0,27	0,48	2,32					
RF-2005-00408	3	capelin meal	04.02.05	0,23	0,30	0,54	4,43	0,28	0,02	0,258		
RF-2005-00525	4	capelin meal	11.02.05	0,24	0,31	0,55	3,46					
RF-2005-00651	5	capelin meal	21.02.05	0,31	0,40	0,71	4,16					
RF-2005-00742	6	capelin meal	22.02.05	0,44	0,60	1,04	5,98		0,02	0,188		
RF-2005-00923	7	capelin meal	07.03.05	0,42	0,57	0,99	5,50		0,02	0,155		
RF-2005-01682	8	blue whiting meal	13.05.05	0,81	3,96	4,77	29,60					
RF-2005-01825	9	blue whiting meal	24.05.05	0,74	3,38	4,12	29,20					
RF-2005-01844	10	blue whiting meal	27.05.05	0,64	3,05	3,69	22,51					
RF-2005-01884	11	blue whiting meal	31.05.05	0,59	2,47	3,06	21,51					
RF-2005-02495	12	blue whiting meal	06.07.05	0,36	1,40	1,76	11,87					
SN-2005-00351	13	blue whiting meal	05.12.05	0,32	0,93	1,25	6,35	1,2	0,02	0,228		
SN-2005-00332	14	blue whiting meal	12.12.05	0,21	0,58	0,80	3,78		0,02	0,242		
Rpv 2005-0397	15	herring meal	3.6.2005						0,525		4,99	0,17
Rpv 2005-0066	16	capelin meal	17.2.2005						0,165		2,37	0,08
vinnslust	17	blue whiting meal	03.05-05.05	0,71								
AA1111-7805	18	blue whiting meal	15.4.2004	0,65	2,65	3,30	21,00					
Rpv 2005-0416	19	blue whiting meal	22.6.2005						0,374		8,16	0,17
		Eu maximum limits		1,25		4,50	*	*	10	2	15	0,5
		EU action level		1	2,50	3,50	*	*	*	*	*	*

* No maximum limits exist in the EU for the substance

Table 4

Sample id.	oil sample No.	Sample name	date of caching	PCDD/PCDF pg/g TEQ	dioxinlike PCB pg/g TEQ	sum of Dioxin and Dl-PCB pg/g TEQ	Marker PCB µg/Kg	PBDE µg/Kg	Pb mg/Kg	Cd mg/Kg	As mg/Kg	Toxaphen µg/Kg	Aldrin and Dieldrin µg/Kg
SR-mjöl	1	capelin oil	winter	2	3,40	5,40	33,00				8,0	63	27,9
SVN Sey.	2	capelin oil	winter	1,79	2,73	4,52	22,00					86	36,8
Nesk.	3	capelin oil	winter	1,9	4,00	5,90	29,00					83	38,2
SN-2005-00352	4	blue whiting oil	22.06.04	5,3	21,47	26,75	156,45		0,05	0,002			
SN-2005-00353	5	blue whiting oil	18.07.04	3,9	15,20	19,05	118,70		0,07	0,011			
SN-2005-00358	6	blue whiting oil	12.08.05	6,6	26,31	32,89	191,74		0,02	0,002			
SN-2005-00354	7	blue whiting oil	28.10.04	1,7	6,87	8,58	54,62	8,3	0,02	0,002			
SN-2005-00331	8	blue whiting oil	12.12.05	2,5	7,70	10,23	54,10	8,2	0,02	0,002			
SN-2005-00350	9	blue whiting oil	05.12.05	3,1	10,02	13,11	78,71		0,04	0,002			
	10	capelin oil	18.2.2005	1,7								66	32,8
Eskja	11	capelin oil	tank	1,7									
Eskja	12	capelin oil	tank	2,6									
vinnslust	13	capelin oil	25.1.2005	1,88								<10	<20
vinnslust	14	capelin oil	19.1.2005	2,06								<10	<20
Rpv 2005-0497	15	herring oil	30.10.2005	1,2									
L050201402	16	herring oil	1.2.2005	3,25									
L050201145	17	herring oil	autumn	1,04									
	18	capelin oil	winter	2,8								94	46,1
?	19	capelin oil	winter	1,7									
L050604378	20	herring oil	4.6.2005	6,0									
L050806284	21	herring oil	6.8.2005	1,93							8,6	<10	<20
L050806285	22	blue whiting oil	6.8.2005	L4-L5							4	<10	<20
		EU action level		5	14,00								
		Eu maximum limits		6		24,00	*	*	10	2	15	200	200

* No maximum limits exist in the EU for the substance

Table 5

						2	1	3	10		5	12	8	11	9	4
Sample code SN-2005-	**fish sample No.**	**Sample name**	**fishing ground**	**Size cm**	**Lipid content %**	**δ-HCH µg/Kg**	**total DDT µg/Kg**	**Hexachloro-benzene µg/Kg**	**Hepta-chlores µg/Kg**	**Aldrin/ Dieldrin µg/Kg**	**Toxa-phene µg/Kg**	**Octachlor styrene µg/Kg**	**Endrin µg/Kg**	**Mirex µg/Kg**	**Endo-sulphane µg/Kg**	**Chlordane µg/Kg**
286	1	Ling *(Molva molva)*	E and SE	38-97	0,24	0,060	2,03	0,5	0,29	0,14	1,54	0,05	0,02	0,048	1,3	0,849
287	2	Greenland halibut *(Reinhardtius hippoglossoides)*	N and NW	60-69	11	0,07	14,78	3,3	1,25	3,89	17,16	0,13	1,2	0,16	5,9	8,283
288	3	Greenland halibut *(Reinhardtius hippoglossoides)*	N and NW	50-59	11	0,07	9,53	2,7	1,19	4,34	15,11	0,09	1,4	0,10	38,3	8,783
289	4	Spotted catfish *(Anarhichas minor)*	N and NW	40-89	3,0	0,06	11,00	1,0	0,66	2,05	11,77	0,06	0,32	0,28	1,3	5,152
290	5	Deepwater Redfish *(Sebastes mentella)*	S	30-35	3,0	0,06	4,41	1,0	0,48	1,15	6,40	0,04	0,16	0,050	1,3	2,745
291	6	Deepwater Redfish *(Sebastes mentella)*	S	40-45	2,0	0,06	8,34	0,9	0,41	0,87	8,09	0,06	0,097	0,15	1,3	3,461
292	7	Golden Redfish *(Sebastes marinus*)	S	40-49	3,8	0,06	5,53	0,7	0,43	0,94	7,21	0,05	0,16	0,099	1,3	2,306
293	8	Golden Redfish *(Sebastes marinus*)	S	30-39	1,2	0,06	1,41	0,3	0,32	0,34	2,26	0,02	0,038	0,018	1,3	0,871
294	9	Saithe *(Pollachius virens)*	E and SE	50-60	0,76	0,06	0,39	0,1	0,29	0,15	0,33	0,02	0,028	0,007	1,3	0,229
295	10	Saithe *(Pollachius virens)*	E and SE	70-80	0,60	0,06	0,77	0,3	0,29	0,17	0,61	0,02	0,024	0,0073	1,3	0,399
296	11	Haddock *(Melanogrammus aeglefinus*)	SW	30-39	0,24	0,06	0,07	0,1	0,29	0,06	0,34	0,02	0,02	0,007	1,3	0,090
297	12	Haddock *(Melanogrammus aeglefinus*)	SW	40-49	0,20	0,09	0,12	0,2	0,43	0,10	0,45	0,03	0,02	0,008	4,8	0,160
298	13	Haddock *(Melanogrammus aeglefinus*)	SW	50-59	0,13	0,09	0,07	0,2	0,43	0,09	0,44	0,03	0,02	0,008	4,8	0,160
299	14	Whiting (Merlangius merlangus)	E and SE	40-50	0,11	0,09	0,51	0,1	0,43	0,10	0,28	0,03	0,02	0,008	4,8	0,289
300	15	Herring *(Clupea harengus)*	S	20-30	7,0	0,20	0,92	0,5	1,25	0,87	1,80	0,08	0,14	0,020	12,	0,816
301	16	Atlantic Argentine *(Argentina silus)*	S	30-40	0,29	0,09	0,28	0,1	0,43	0,14	0,24	0,03	0,02	0,008	4,8	0,198
302	17	Blue Whiting *(Micromesistius poutassou)*	E and SE	20-30	0,090	0,09	0,17	0,1	0,43	0,09	0,09	0,03	0,02	0,008	4,8	0,169
303	18	Blue Whiting *(Micromesistius poutassou)*	E and SE	30-40	0,12	0,09	0,38	0,2	0,43	0,11	0,26	0,03	0,02	0,008	4,8	0,251
304	19	Capelin *(Mallotus villosus)*	E and SE		20	0,40	4,32	2,0	3,00	3,09	6,44	0,20	1,0	0,040	24,	3,126
305	20	Cod *(Gadus morhua)*	E and SE	45-59	0,39	0,09	0,33	0,3	0,43	0,21	0,36	0,03	0,032	0,008	4,8	0,317
306	21	Cod *(Gadus morhua)*	E and SE	75+	0,37	0,09	0,68	0,4	0,43	0,20	0,59	0,03	0,024	0,0094	4,8	0,429
		EU maximum limits				*	500,00	50,0	50,00	50,00	*	*	50,000	*	*	100,000

*No maximum limits exist in the EU for the substances

Table 6: Data in µg/kg, original sample

Sample code SN 2005-	Sample name (number)	fishing ground	Size (cm)	Lipid content (%)	Monobutyltin (MBT)	Dibutyltin (DBT)	Tributyltin (TBT)	Tetrabutyltin (TTBT)	Monooctyltin (MOT)	Dioctyltin (DOT)	Tricyclohexyltin (TCyT)	Triphenyltin (TPhT)
286	(1) Ling	E and SE	38-97	0,24	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
287	(2) Greenland halibut	N and NW	60-69	11	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
288	(3) Halibut	N and NW	50-59	11	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
289	(4) Spotted catfish	N and NW	40-89	3,0	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
290	(5) Deepwater Redfish	S	30-35	3,0	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
291	(6) Deepwater Redfish	S	40-45	2,0	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
292	(7) Golden Redfish	S	40-49	3,8	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
293	(8) Golden Redfish	S	30-39	1,2	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
294	(9) Saithe	E and SE	50-60	0,76	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
295	(10) Saithe	E and SE	70-80	0,60	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
296	(11) Haddock	SW	30-39	0,24	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
297	(12) Haddock	SW	40-49	0,20	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
298	(13) Haddock	SW	50-59	0,13	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
299	(14) Whiting	E and SE	40-50	0,11	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
300	(15) Herring	S	20-30	7,0	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
301	(16) Atlantic Argentine	S	30-40	0,29	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
302	(17) Blue Whiting	E and SE	20-30	0,090	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
303	(18) Blue Whiting	E and SE	30-40	0,12	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
304	(19) Capelin	E and SE		20	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
305	(20) Cod	E and SE	45-59	0,39	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
306	(21) Cod	E and SE	75+	0,37	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
307	(22) Cod	NE	45-59	0,36	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
308	(23) Cod	NE	75+	0,40	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
309	(24) Halibut		30+	15	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
310	(25) Halibut		44+	6,6	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
311	(26) Catfish	N and NW	50-59	0,53	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)
312	(27) Catfish	N and NW	70-79	0,61	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)	n.q. (10)

Table 7: Data in µg Sn/kg, original sample

Sample code SN 2005-	Sample name (number)	fishing ground	Size (cm)	Lipid content (%)	Monobutyltin (MBT)	Dibutyltin (DBT)	Tributyltin (TBT)	Tetrabutyltin (TTBT)	Monooctyltin (MOT)	Dioctyltin (DOT)	Tricyclohexyl tin (TCyT)	Triphenyltin (TPhT)
286	(1) Ling	E and SE	38-97	0,24	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
287	(2) Greenland halibut	N and NW	60-69	11	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
288	(3) Halibut	N and NW	50-59	11	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
289	(4) Spotted catfish	N and NW	40-89	3,0	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
290	(5) Deepwater Redfish	S	30-35	3,0	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
291	(6) Deepwater Redfish	S	40-45	2,0	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
292	(7) Golden Redfish	S	40-49	3,8	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
293	(8) Golden Redfish	S	30-39	1,2	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
294	(9) Saithe	E and SE	50-60	0,76	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
295	(10) Saithe	E and SE	70-80	0,60	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
296	(11) Haddock	SW	30-39	0,24	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
297	(12) Haddock	SW	40-49	0,20	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
298	(13) Haddock	SW	50-59	0,13	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
299	(14) Whiting	E and SE	40-50	0,11	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
300	(15) Herring	S	20-30	7,0	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
301	(16) Atlantic Argentine	S	30-40	0,29	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
302	(17) Blue Whiting	E and SE	20-30	0,090	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
303	(18) Blue Whiting	E and SE	30-40	0,12	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
304	(19) Capelin	E and SE		20	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
305	(20) Cod	E and SE	45-59	0,39	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
306	(21) Cod	E and SE	75+	0,37	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
307	(22) Cod	NE	45-59	0,36	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
308	(23) Cod	NE	75+	0,40	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
309	(24) Halibut		30+	15	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
310	(25) Halibut		44+	6,6	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
311	(26) Catfish	N and NW	50-59	0,53	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)
312	(27) Catfish	N and NW	70-79	0,61	n.q. (6,75)	n.q. (5,10)	n.q. (4,09)	n.q. (3,42)	n.q. (5,12)	n.q. (3,44)	n.q. (3,22)	n.q. (3,39)

Table 8

Data in µg/kg, original sample

Sample Code	Sample name (number)	date of caching	Monobutyltin (MBT)	Dibutyltin (DBT)	Tributyltin (TBT)	Tetrabutyltin (TTBT)	Monooctyltin (MOT)	Dioctyltin (DOT)	Tricyclohexyltin (TCyT)	Triphenyltin (TPhT)
RF-2005-01883	(1) herring meal	31.05.05	n.q. (1,5)	n.q. (1,5)	n.q. (1,5)	n.q. (1,5)	1,3	18,8	n.q. (3,7)	n.q. (1,5)
RF-2005-00408	(3) capelin meal	04.02.05	n.q. (1,5)	n.q. (1,5)	n.q. (1,5)	n.q. (1,5)	3,1	21,6	n.q. (3,8)	n.q. (1,5)
RF-2005-00742	(6) capelin meal	22.02.05	n.q. (1,4)	n.q. (1,4)	n.q. (1,4)	n.q. (1,4)	2,3	21,7	n.q. (3,6)	n.q. (1,4)
SN-2005-00351	(14) bl.whiting meal	05.12.05	n.q. (1,3)	n.q. (1,3)	n.q. (1,2)	n.q. (1,3)	n.q. (1,3)	8,5	n.q. (3,2)	n.q. (1,3)
SN-2005-00331	(8) blue whiting oil	12.12.05	n.q. (9,4)	n.q. (9,4)	11,6	n.q. (9,4)	n.q. (9,4)	n.q. (9,4)	n.q. (23,4)	n.q. (9,4)
SN-2005-00350	(9) blue whiting oil	05.12.05	n.q. (8,6)	n.q. (8,6)	17,3	n.q. (8,6)	n.q. (8,6)	n.q. (8,6)	n.q. (21,4)	n.q. (8,6)
SN-2005-00352	(4) blue whiting oil	22.06.04	n.q. (9,5)	n.q. (9,5)	50,1	n.q. (9,5)	n.q. (9,5)	n.q. (9,5)	n.q. (23,7)	n.q. (9,5)
SN-2005-00353	(5) blue whiting oil	18.07.04	n.q. (8,8)	n.q. (8,8)	30,3	n.q. (8,8)	n.q. (8,8)	n.q. (8,8)	n.q. (22,0)	n.q. (8,8)

Table 9

Data in µg Sn/kg, original sample

Sample Code	Sample name (number)	date of caching	Monobutyltin (MBT)	Dibutyltin (DBT)	Tributyltin (TBT)	Tetrabutyltin (TTBT)	Monooctyltin (MOT)	Dioctyltin (DOT)	Tricyclohexyltin (TCyT)	Triphenyltin (TPhT)
RF-2005-01883	(1) herring meal	31.05.05	n.q. (1,0)	n.q. (0,8)	n.q. (0,6)	n.q. (0,5)	0,8	6,5	n.q. (1,2)	n.q. (0,5)
RF-2005-00408	(3) capelin meal	04.02.05	n.q. (1,0)	n.q. (0,8)	n.q. (0,6)	n.q. (0,5)	1,8	7,4	n.q. (1,2)	n.q. (0,5)
RF-2005-00742	(6) capelin meal	22.02.05	n.q. (1,0)	n.q. (0,7)	n.q. (0,6)	n.q. (0,5)	1,4	7,5	n.q. (1,2)	n.q. (0,5)
SN-2005-00351	(14) bl.whiting meal	05.12.05	n.q. (0,9)	n.q. (0,7)	n.q. (0,5)	n.q. (0,4)	n.q .(0,7)	2,9	n.q. (1,0)	n.q. (0,4)
SN-2005-00331	(8) blue whiting oil	12.12.05	n.q. (6,3)	n.q. (4,8)	4,7	n.q. (3,2)	n.q. (4,8)	n.q. (3,2)	n.q. (7,6)	n.q. (3,2)
SN-2005-00350	(9) blue whiting oil	05.12.05	n.q. (5,8)	n.q. (4,4)	7,1	n.q. (2,9)	n.q. (4,4)	n.q. (2,9)	n.q. (6,9)	n.q. (2,9)
SN-2005-00352	(4) blue whiting oil	22.06.04	n.q. (6,4)	n.q. (4,8)	20,5	n.q. (3,2)	n.q. (4,9)	n.q. (3,3)	n.q. (7,7)	n.q. (3,2)
SN-2005-00353	(5) blue whiting oil	18.07.04	n.q. (5,9)	n.q. (4,5)	12,4	n.q. (3,0)	n.q. (4,5)	n.q. (3,0)	n.q. (7,1)	n.q. (3,0)