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Food Safety

# Undesirable substances in seafood products –
## Results from monitoring activities in 2006


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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 lýsis- og mjöliðnaðar.<br><br>Tilgangurinn með vöktuninni er að meta ástand íslenskra sjávarafurða með tilliti til magns aðskotaefna. Gögnin sem safnað er í vöktunarverkefninu verða einnig notuð í áhættumati og til að hafa áhrif á setningu hámarksgilda óæskilegra efna t.d í Evrópu.<br><br>Umfjöllun um aðskotaefni í sjávarafurðum, bæði í almennum fjölmiðlum og í vísindaritum, hefur margoft krafist viðbragða íslenskra stjórnvalda. Nauðsynlegt er að hafa til taks vísindaniðurstöður sem sýna fram á raunverulegt ástand íslenskra sjávarafurða til þess að koma í veg fyrir tjón sem af slíkri umfjöllun getur hlotist. Ennfremur eru mörk aðskotaefna í sífelldri endurskoðun og er mikilvægt fyrir Íslendinga að taka þátt í slíkri endurskoðun og styðja mál sitt með vísindagögnum. Þetta sýnir mikilvægi þess að regluleg vöktun fari fram og að á Íslandi séu stundaðar sjálfstæðar rannsóknir á eins mikilvægum málaflokki og mengun sjávarafurða er.<br><br>Þessi skýrsla er samantekt niðurstaðna vöktunarinnar árið 2006. Það er langtímamarkmið að meta ástand íslenskra sjávarafurða m.t.t. magns óæskilegra efna. Þessu markmiði verður einungis náð með sívirkri vöktun í langan tíma. Á hverju ári miðast vöktunin við að bæta við þeim gögnum sem helst vantar og gera gagnagrunninn þannig nákvæmari og ýtarlegri með ári hverju.. Árið 2006 voru mælddioxin, dioxinlík PCB, bendi PCB,, auk þess tíu mismunandi tegundir varnarefna, þungmálmar og önnur snefilefni, í sjávarafurðum sem ætlaðar eru til manneldis og í afurðum lýsis- og mjöliðnaðar. | | |
| *Lykilorð á íslensku:* | *Sjávarfang, vöktun, Díoxín, díoxínlík PCB, PCB, snefilefni ,varnarefni* | | |

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*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 EU.

This report summarizes the results obtained in 2006 for the monitoring of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. This project began in 2003 and has now been carried out for four consecutative years. One of the goals of this annual monitoring program of various undesirable substances in seafood is to gather information on the status Icelandic seafood products in terms of undesirable substances, this is a long term goal which can be reached through continuous monitoring by filling in the gaps of data available over many years. For this reason, we carefully select which undesirable substances are measured in the various seafood samples each year with the aim to eventually fill in the gaps in the available data over couple of year time.

The results obtained in 2003, 2004 and 2005 have already been published and are accessible at the Matis website (IFL Report 06-04, IFL Report 33-05 and IFL Report 22-06, respectively).

In 2006, data was collected on, polychlorinated dibenzodioxins and dibenzo-furans (17 substances), dioxin-like PCBs (12 substances), marker PCBs (7 substances), 10 different types of pesticides, polybrominated flame retardants PBDE as well as trace elements and heavy metals.

*English keywords:* *Marine catches, monitoring, dioxin, PCB, trace elements, pesticides*

# Table of contents

# 1 Introduction

The monitoring of various undesirable substances in the edible part of marine catches, as well as in fishmeal and fish oil for feed started in 2003 and this report contains the results from the fourth year of this monitoring program. The project is funded by the Ministry of Fisheries in Iceland and is the first comprehensive study on the status of Icelandic seafood products in terms of undesirable substances in the edible part of the seafood. The project includes measurements of many marine species from Icelandic fishing grounds that have never been studied before. In addition, information is gathered on numerous substances that have not been previously measured. The substances investigated in this monitoring project are: trace metals (mercury, lead, cadmium, total arsenic and other trace elements), 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)

C) To gather information on the concentration of marker PCBs for the purpose of setting limits, 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).

This report summarizes results from the monitoring programme in 2006. The results obtained in 2003, 2004 and 2005 have already been published and are accessible at the Matis website.(IFL Report 06-04, IFL Report 33-05 and IFL Report 22-06, respectively).

## 2 Summary

This report summarizes the results obtained in 2006 for the monitoring of various undesirable substances in the edible part of marine catches, fish meal and fish oil for feed. This project began in 2003 and has now been carried out for four consecutative years. One of the goals of this annual monitoring program of various undesirable substances in seafood is to gather information on the status Icelandic seafood products in terms of undesirable substances, this is a long term goal which can be reached through continuous monitoring by filling in the gaps of data available over many years. For this reason, we carefully select which undesirable substances are measured in the various seafood samples each year with the aim to fill in the gaps in the available data over couple of year time.

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. In the year 2006 emphasis was laid on gathering information on heavy metals and other trace elements in the edible part of marine catches. The concentration of cadmium (Cd), lead (Pb), and mercury (Hg) in the fish samples was always below the maximum limits set by EU. Further, the concentration of lead (Pb) was under the limits of detection in most cases.

Fish oil for human consumption was measured for dioxin and PCB substances, in all cases these samples were below the maximum limits.

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. The blue whiting oil exceeded the EU limits in that period but the blue whiting meal was below the limits with one exception.These results are in accordance with previous findings in a project

financed by the Nordic Atlantic Co-operation (Anon. 2003) and the monitoring reports from year 2004 and 2005 (Ásmundsdóttir, et.al. 2005 and Ásmundsdóttir, et.al. 2006).

# 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:** 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 (3 types: α- og γ-chlordane, oxychlordane), 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), As (arsenic), Se (selenium), Zn (zink), Cu (copper), Fe (iron), Cr (chromium), Ca (calcium), K (kalium), P (phosphorous), Mg (magnesium) and Na (sodium).

**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 continued 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 in all cases 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.

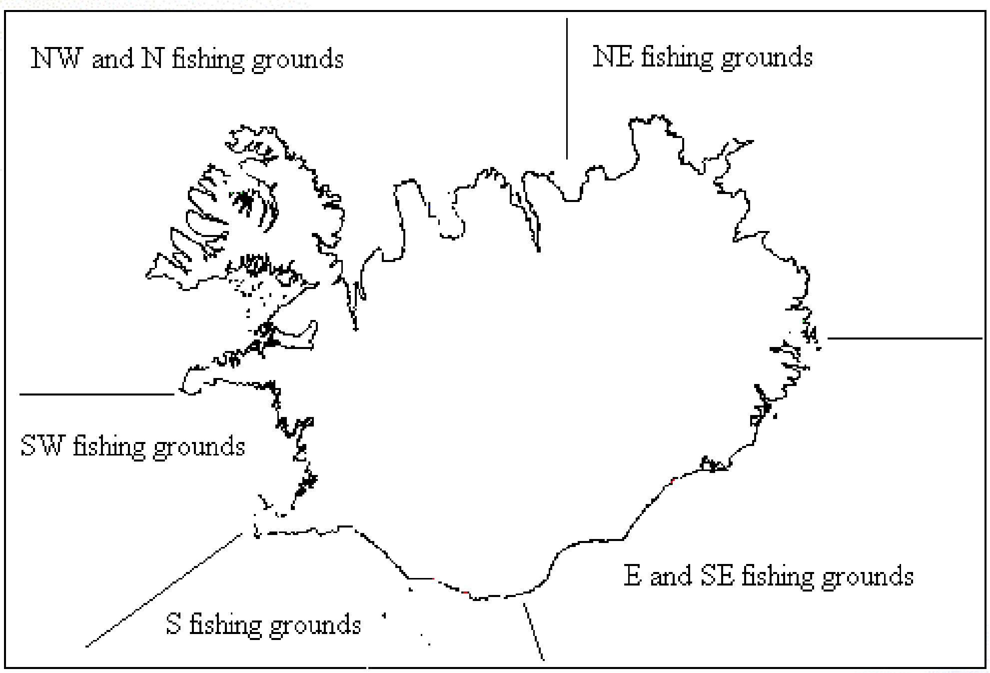


**Fig. 1: The division of the fishing grounds around Iceland used in this research.**

## 4.2 Analysis

The organic 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.

Inorganic trace elements (Hg, Cd, Pb, As, Se, Zn, Cu, Fe, Cr, Ca, K, P, Mg and Na) in the samples were determined at Matís using ICP-MS technology after mineralization of the samples with closed vessel acid digestion. The quality of the trace elements analysis was checked in several ways. Certified reference materials are routinely treated and analysed in the same manner as the samples. For all the elements measured, standard additions to tissue homogenates prior to decomposition were implemented. The additions corresponded to 50, 100 and 150% increase of the expected concentrations. The trace analytical laboratory at Matís participates annually in proficiency testing programs (e.g. NFA & Quasimeme) with satisfactory results..

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 2006 are expressed in details in Tables 1-8 in the appendix. Furthermore, some of the results are shown in histograms in the figures in the following chapters. The numbers in brackets before the sample name in the histograms referes to the number in the tables in appendix where details about the sample can be seen.

## 5.1 Dioxins (PCDD/Fs) and dioxin like PCB

### 5.1.1 Dioxins and dioxin-like PCBs in seafood

All the twenty nine fish samples measured in 2006 contain dioxin and dioxinlike PCBs far below the limits set by EU (EU regulation No. 199/2006) This can be seen from Figure 2 and Table 1 in the appendix. A considerable difference was observed in the dioxin content between different fish species., the fish species that accumulate fat in the muscle, like for example Greenland halibut, halibut and lumpfish, 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. These results are also in agreement with our previous results (Ásmundsdóttir, et.al. 2005 and Ásmundsdóttir, et.al. 2006). 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 of the fish.

Maximum limit for the sum of dioxins and dioxinlike PCBs in fish in EU is 8 pg/g in WHO-TEQ and the maximum limit for dioxins is 4 pg/g in WHO-TEQ ( EU regulation No. 199/2006). On Figure 2 only the maximum limit of the sum of dioxin and dioxin like PCBs is shown.

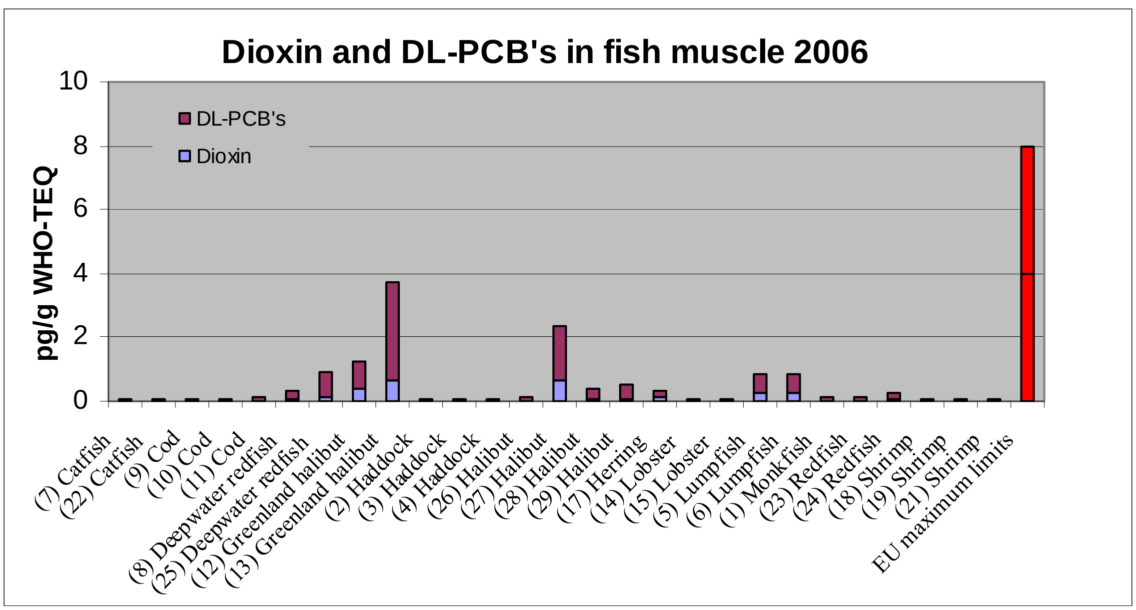


**Fig. 2: Dioxins and dioxin-like PCBs in the edible part of fish muscle from Icelandic fishing grounds in 2006 in relation to maximum limit for the sum of dioxin and dioxinlike PCBs (8 pg/g WHO-TEQ wet weight) in EU.**

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

Nine samples of fish oil for human consumption were analyzed in 2006. As can be seen in Table 2 in the appendix and in Figure 3 below, all the fish oil samples measured are below the maximum limits of the sum of dioxins and dioxin like PCBs (10 pg/g in WHO-TEQ) in EU ( EU regulation No. 199/2006). The maximum limits for dioxins (2 pg/g in WHO-TEQ) is also not exceeded.

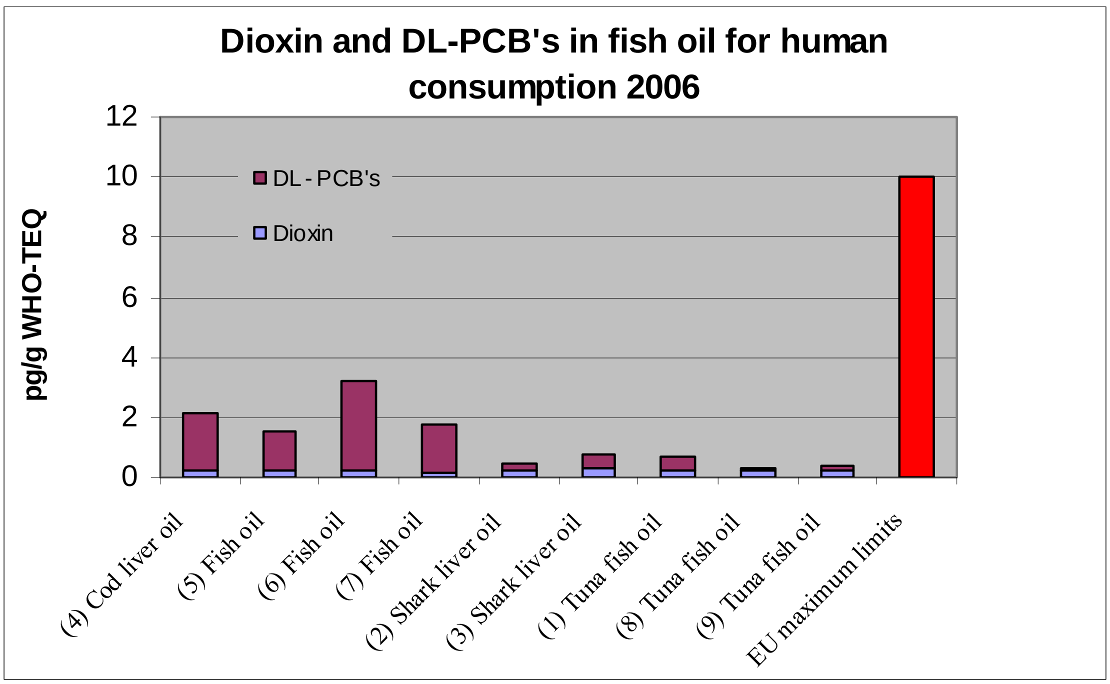


***Fig. 3: Dioxins and dioxin-like PCBs in fish oil for human consumption in Iceland in 2006 (in WHO-TEQ pg/g wet weight).***

### 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. Year 2005 the European Union agreed upon new maximum limits for the sum of dioxin and dioxin-like PCBs in fish oil of 24 pg/g WHO-TEQ and an 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, 6 pg/g WHO-TEQ , from the year 2001 will also be valid until end of 2008. The maximum limits for the sum of dioxin and dioxin-like PCBs in fish meal is 4,5 pg/g WHO-TEQ, action level is 1 pg/g WHO-TEQ for dioxin and 2,5 pg/g WHO-TEQ for dioxin-like PCBs. (Commission directive 2006/13/EC)

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 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 maximum limits for the sum of the substances in pg/g WHO-TEQ, the action levels for each of them are shown in the grey columns. The samples were taken throughout the year 2006 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.

In short, all the fish meal samples are below the EU maximum limits for the sum of dioxin and dioxin like PCBs and the action levels as well.

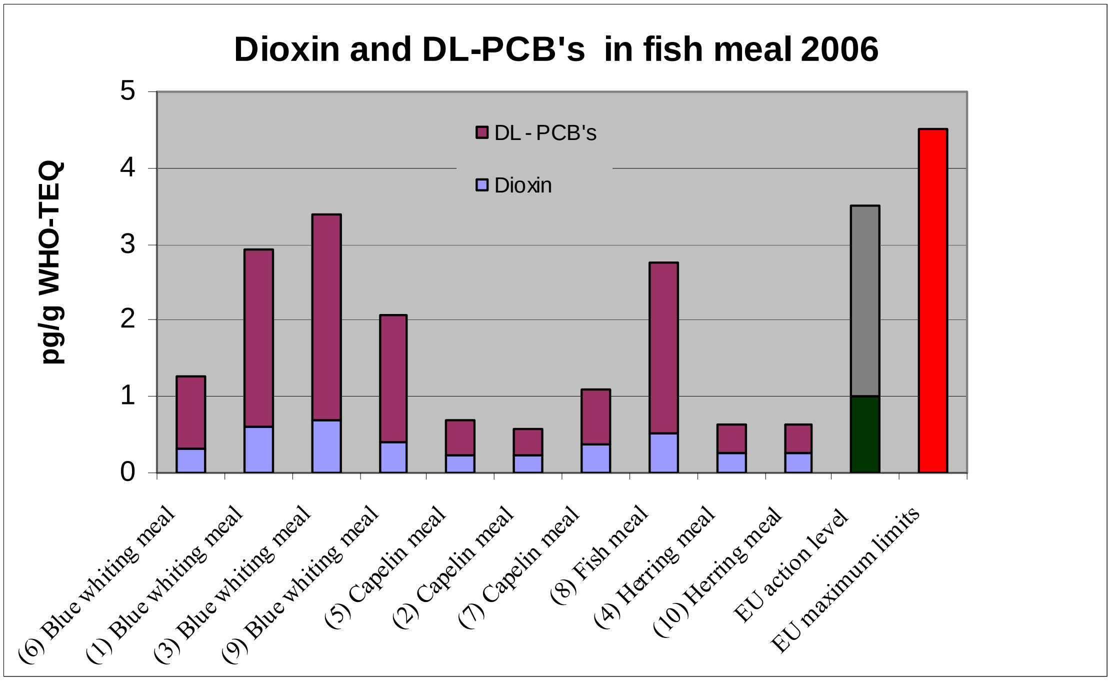


**Fig. 4: Dioxins and dioxin-like PCBs in samples of fish meal from Iceland in 2006 (in WHO-TEQ pg/g calculated for 12% moisture content) in relation to maximum limit in EU and action levels.**

The fish oil for feed exceeds the maximum limit for the sum of dioxin and dioxin like PCBs in four samples of blue whiting oil taken during the spawing period of the fish i.e. from the end of April to beginning of June (samples nr. 4, 6 and 9). Undefined fish oil sample (nr.8) from August also exceeds the maximum limits.

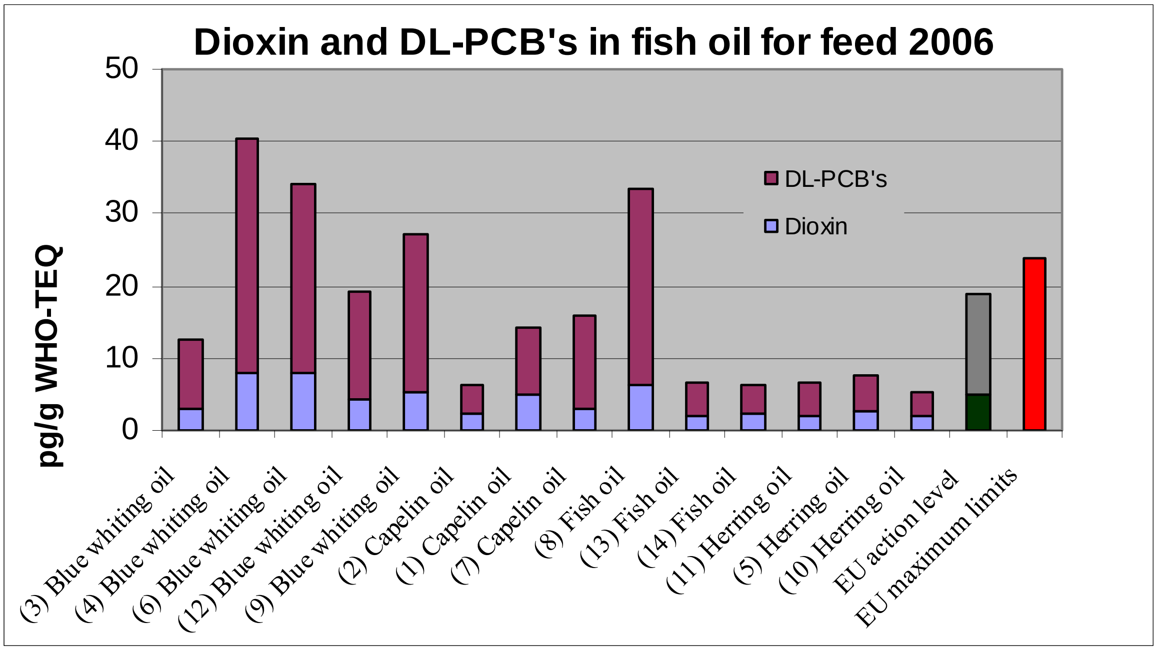


**Fig. 5: Dioxins and dioxin-like PCBs in samples of fish oil for feed from Iceland in 2006 (in WHO-TEQ pg/g calculated for 12% moisture content)) in relation to maximum limit in EU and action levels.**

## 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, while 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.13), a total of 24,6 µg/Kg wet weight. All the other samples contained much less marker PCBs. For details see Table 1 in appendix.

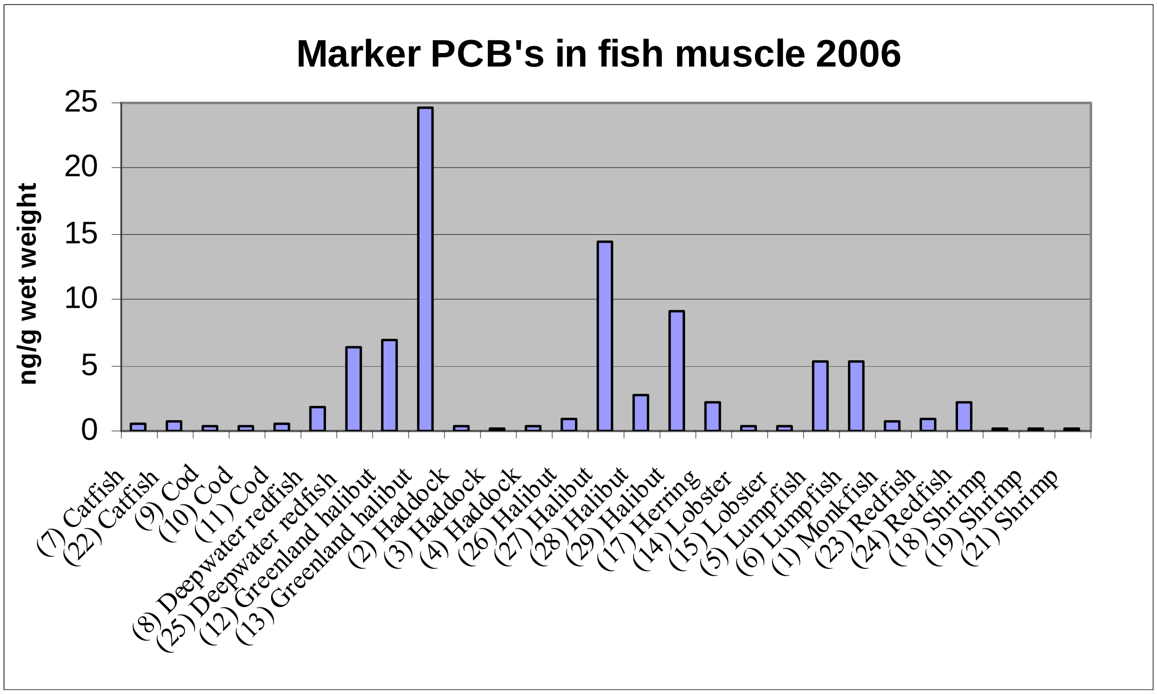


**Fig. 6: Marker PCBs in the edible part of fish muscle from Iceland in 2006 (in ng/g WHO-TEQ wet weight).**

### 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 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.).

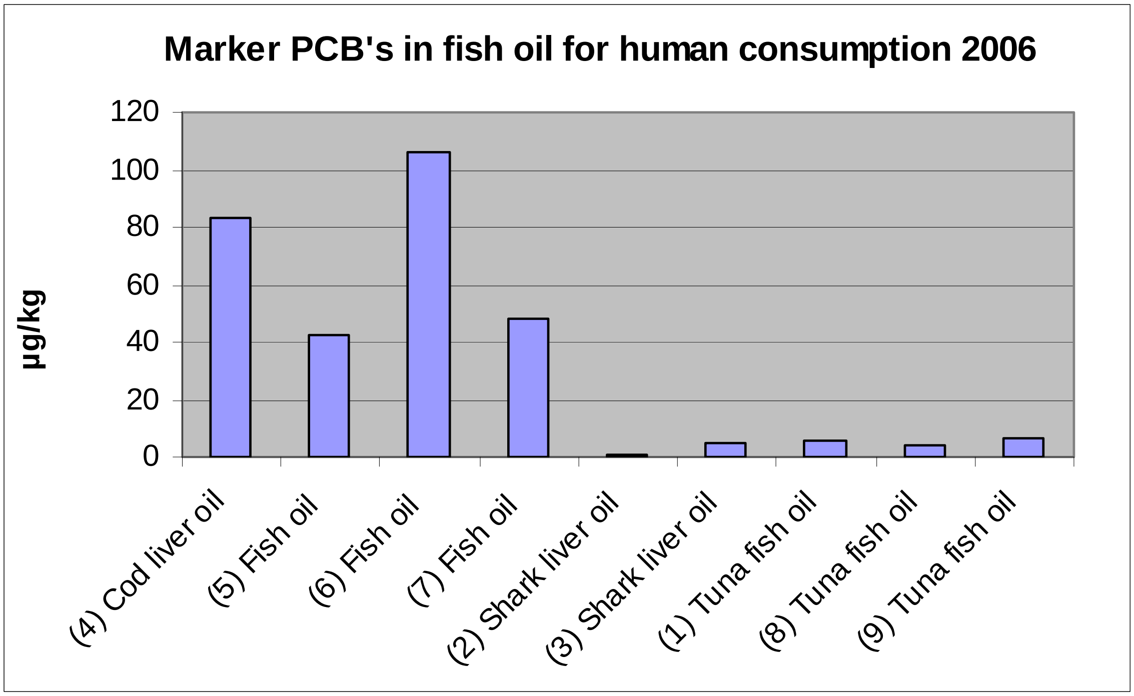


**Fig. 7: Marker PCBs in fish oil for human consumption from Iceland in 2006 in ng/g wet weight.**

### 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 appendix and in Figures 8 and 9 below. No limits have yet been set for these substances in the EU. The histograms illustrated in Figures 8 and 9 coincide with the histograms in Figures 4 and 5, showing the level of dioxin and dioxin-like PCBs in fish oil and fish meal. This is especilly the case for the fish meal samples.

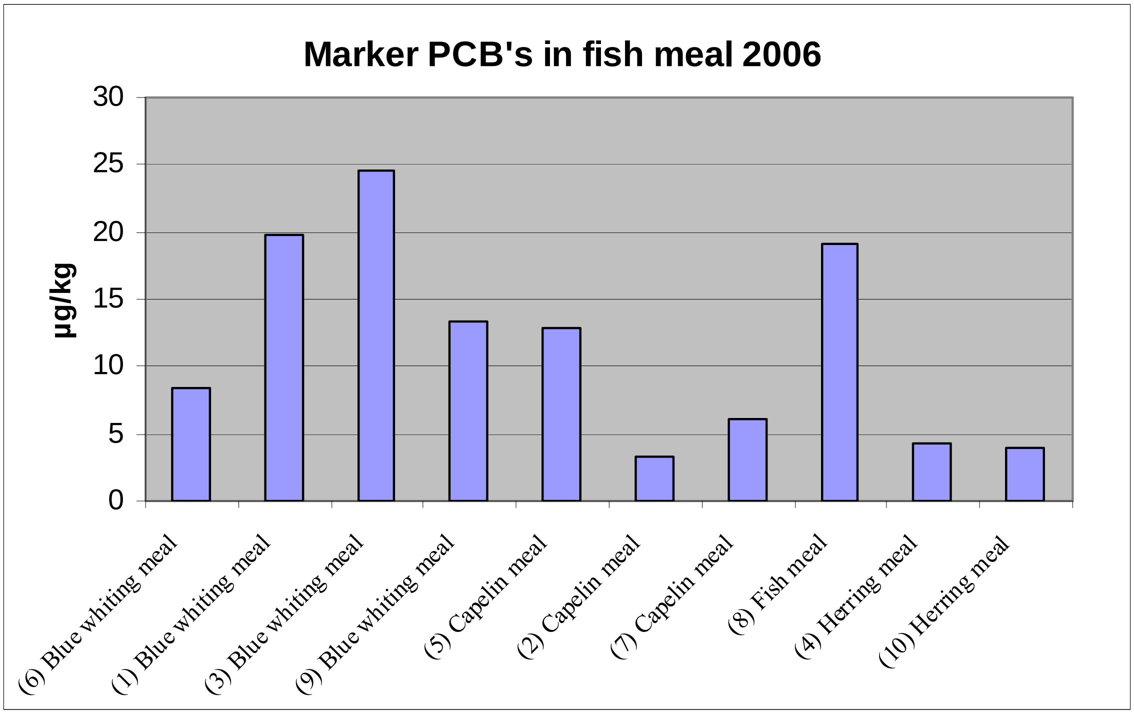


**Fig. 8: Marker PCBs in fish meal from Iceland in 2006 (in ng/g calculated for 12% moisture content).**

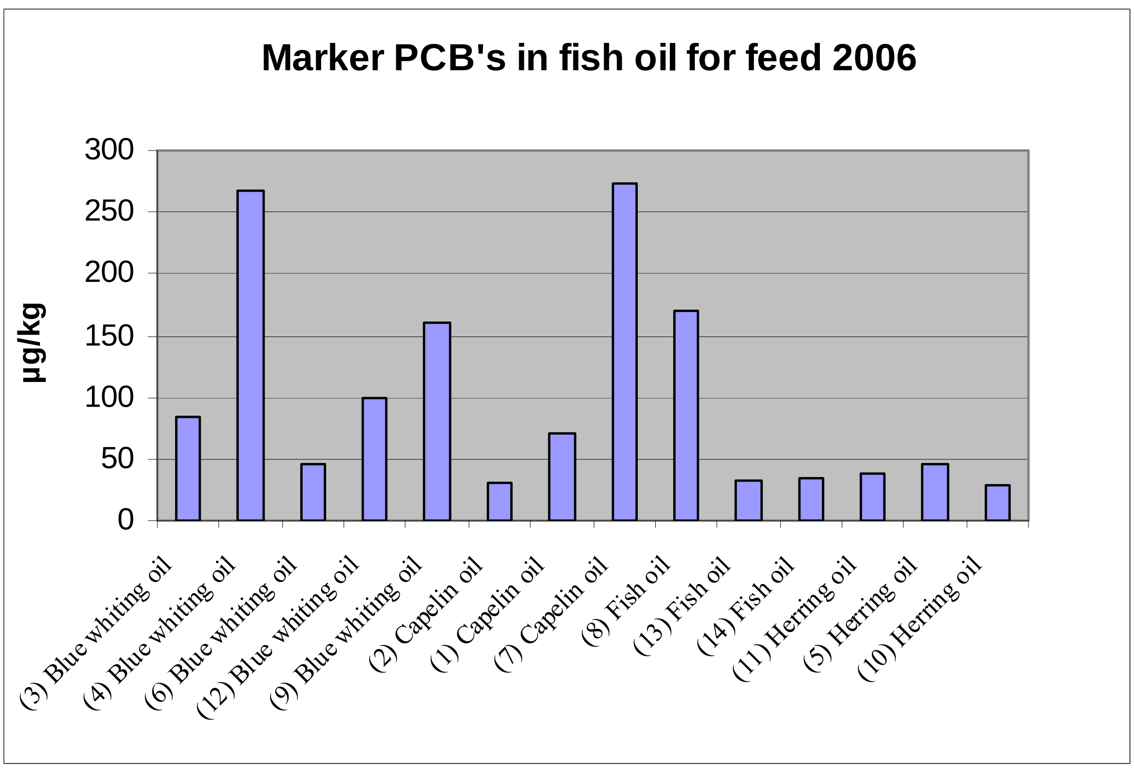


**Fig. 9: Marker PCBs in fish oils from Iceland in 2006 (in ng/g calculated for 12% moisture content).**

## 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 for example (Scientific Advisory Committee on Nutrition (SACN, 2005).

### 5.3.1 PBDE in seafood

PBDE was only measured in three fish samples in 2006 (lumpfish, Greenland halibut and lobster) for details refer to Table 1 in appendix. In contrast, twenty three samples of fish muscle were measured year 2005 (Ásmundsdóttir et.al 2006) and that was the first time that so much data was obtained on this class of substances. Year 2003 PBDE was measured in five fish species (Greenland halibut, cod, haddock, and two species of redfish) (Auðunsson, 2004).

### 5.3.2 PBDE in fish oil and fish meal for feed

PBDE were measured in three samples of fish meal and five samples of fish oil in the Icelandic monitoring activities in 2006. The results are reported in Tables 3 and 4 in appendix. The amount of PBDE listed 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.

## 5.4 PAH

Polyaromatic hydrocarbons or PAH were not measured in 2004, 2005 and 2006, but 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

This chapter gives some background information regarding the different classes of pesticides and here the results obtained 2006 for different classes of pesticides are discussed. The detailed results are shown in Tables 5, 6 and 7 in appendix. Without exception, the fish muscle 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 comparison to the maximum limits set by EU (EU regulation No 199/2006 amending EU regulation No 466/2001).

Ten different groups of pesticides are measured in this 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 tends to be below LOD in the food samples measured., 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, Octachlorstyrene and Transnonaclor.**

### 5.5.1 Pesticides in seafood

The results show very low concentration of all ten pesticide groups measured in the edible part of fish muscle from Icelandic waters (for details see Table 5 in appendix). As mentioned before, the results are expressed as upper bond and some of the pesticides are below the limit of detection. The result from 2006 are in agreement with our previous results for pesticides in fish muscle (Ásmundsdóttir et.al. 2005 and 2006) and only small amounts of the pesticides were detected in all the fish species when compared to the maximum limits in EU where they exist.

Figures 10 - 12 show the level of DDT, Chlordane and Toxaphene in fish muscle in relation to the maximum limit in EU where they exist.

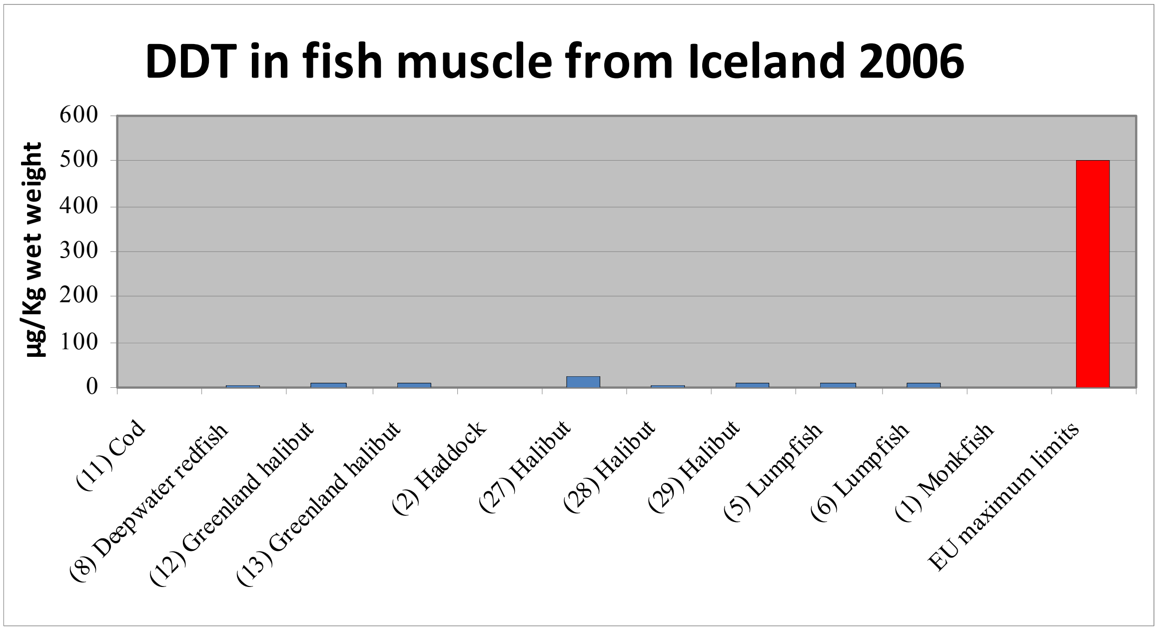


**Fig. 10: DDT in the edible part of fish muscle from Iceland in 2006 in µg/Kg wet weight.**

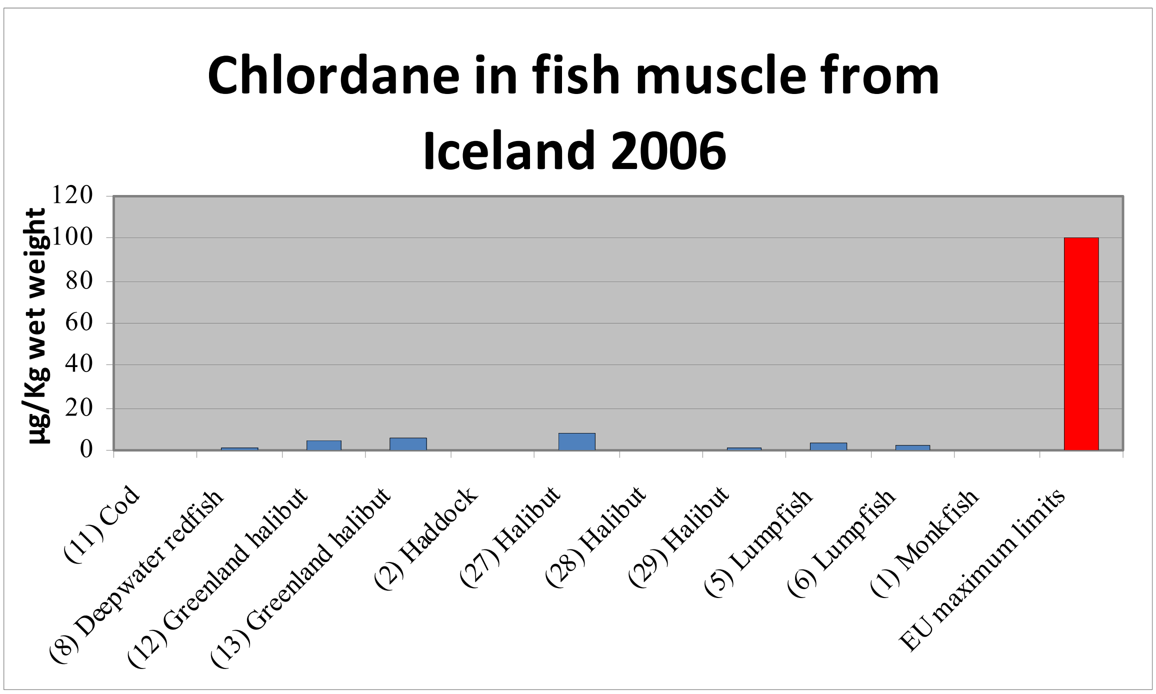


**Fig. 11: Chlordane in the edible part of fish muscle from Iceland in 2006 in µg/Kg wet weight.**

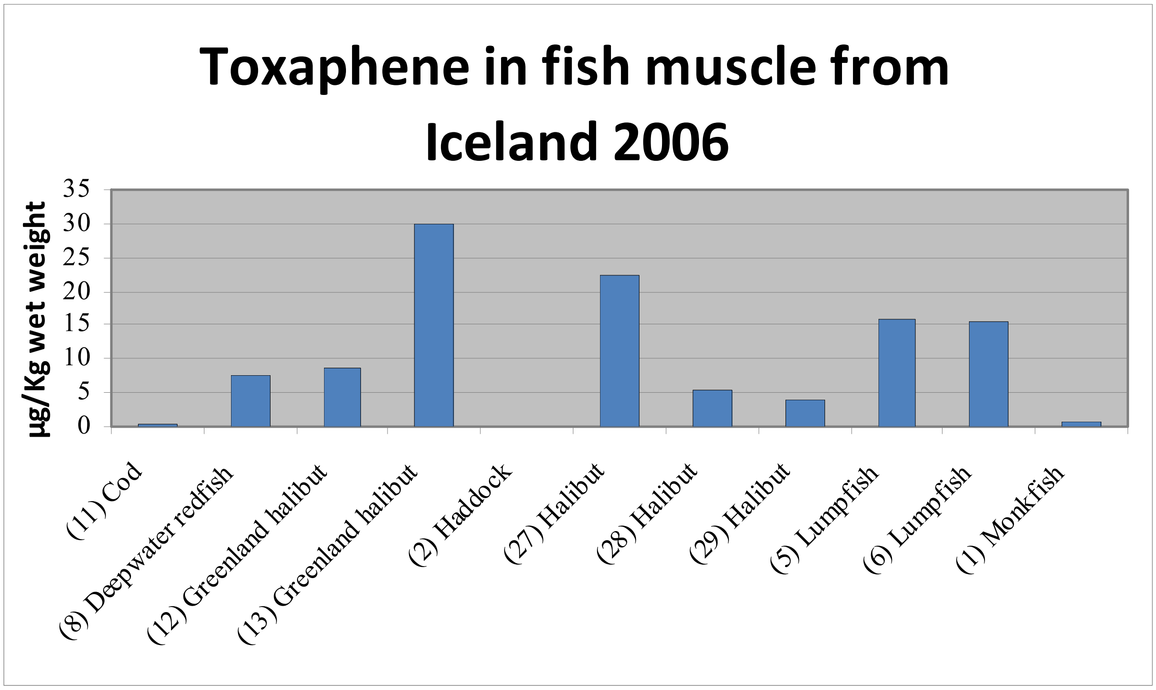


**Fig. 12: Toxaphene in the edible part of fish muscle from Iceland in 2006 in µg/Kg wet weight.**

### 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

Year 2006 seven samples of fish meal and seven samples of fish oil were measured for pesticides and results are reported in Table 6 and 7 in appendix. Previous results from the monitoring programm have revealed that Toxaphene and Chlordane exceed the maximum limits in blue whiting oil and in capelin oil during and just before spawing (Ásmundsdóttir et. al. 2005), this trend was also observed this year (Figures 15 and 16) Figure 13 – 18 show the concentration of DDT, Chlordane and Toxaphene in fish meal and fish oil for feed compared to the maximum limits in EU (Commission Directive 2006/77/EC amending to Directive 2002/32/EC).

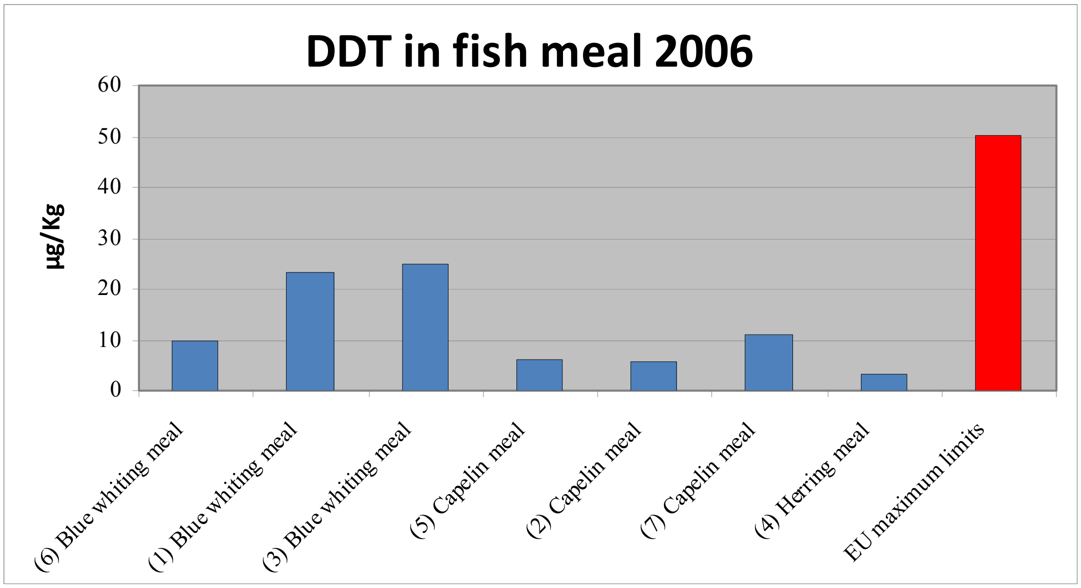


**Fig. 13: DDT in fish meal from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

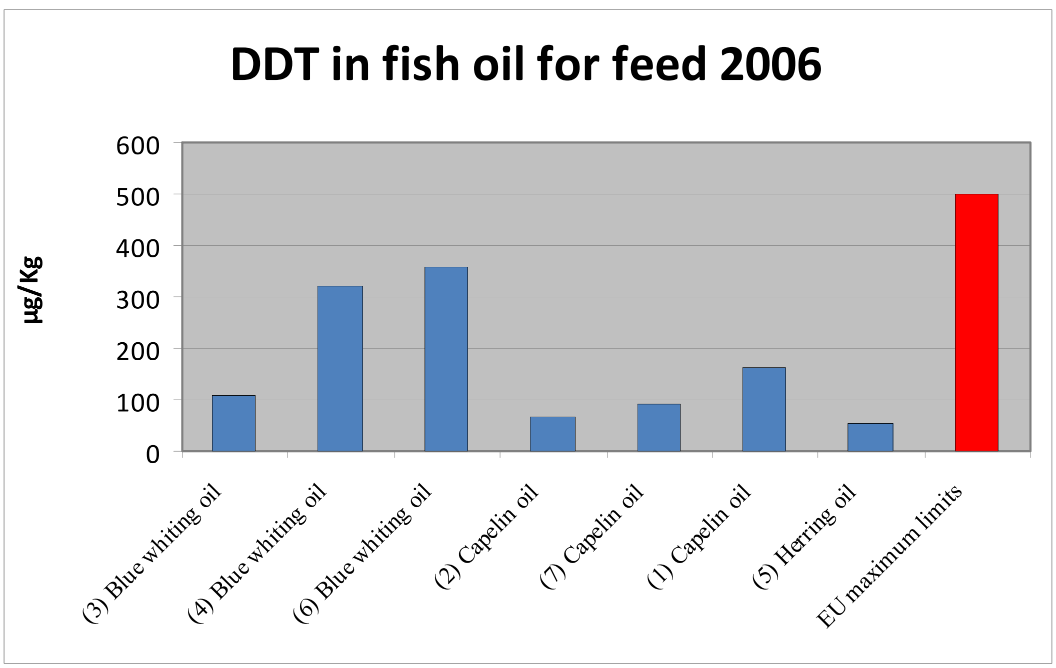


**Fig. 14: DDT in fish oils from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

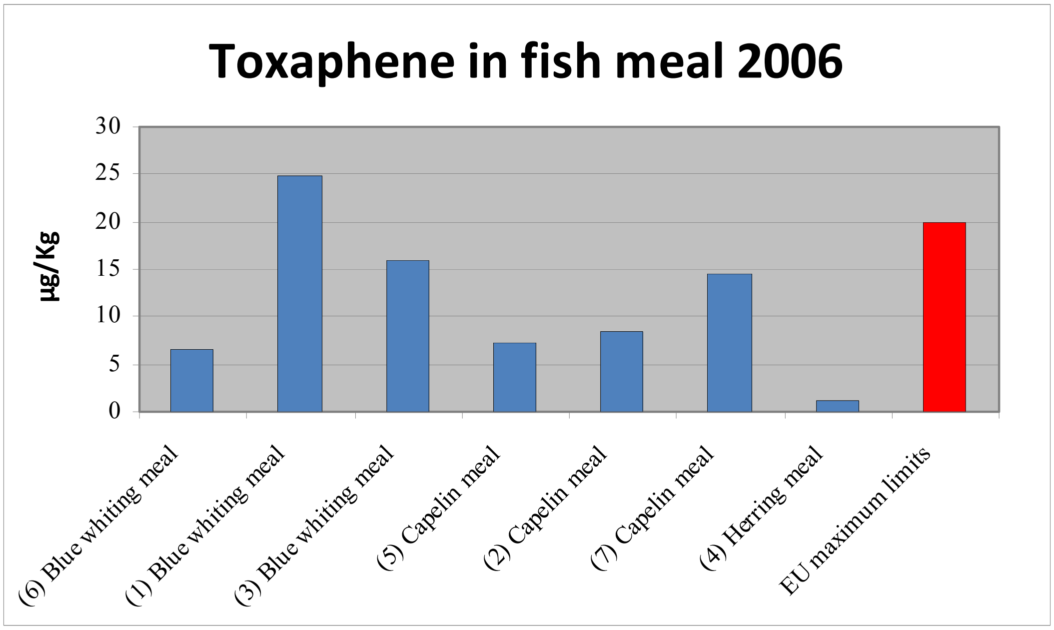


**Fig. 15: Toxaphene in fish meal from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

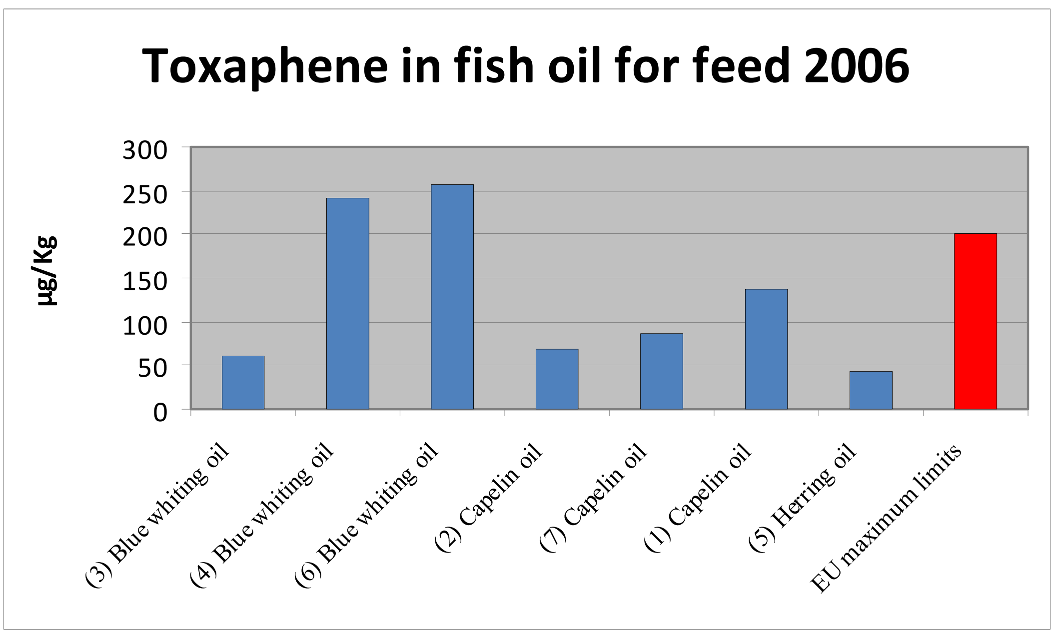


**Fig. 16: Toxaphene in fish oils from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

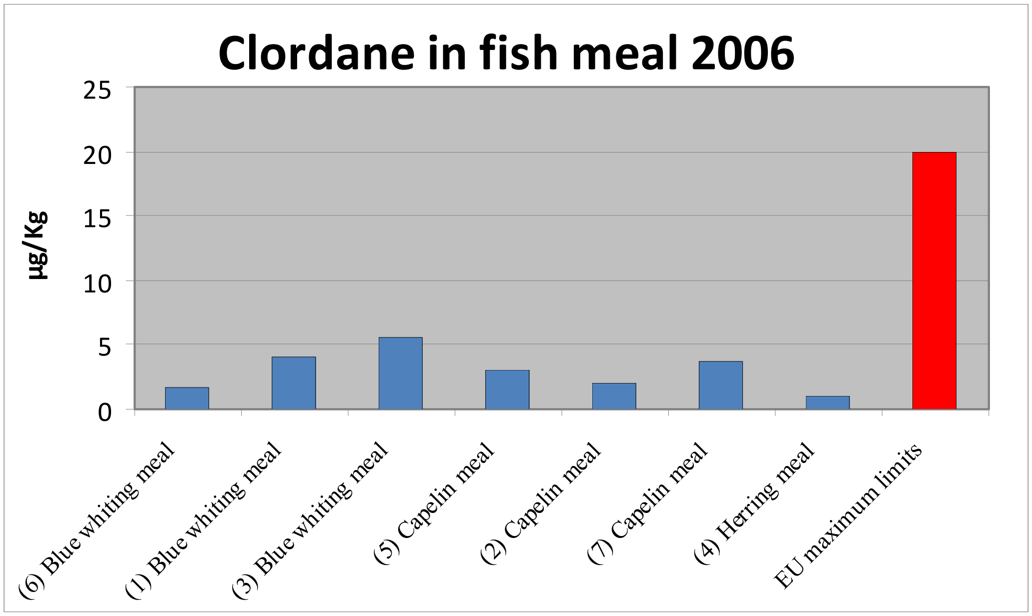


**Fig. 17: Clordane in fish meal from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

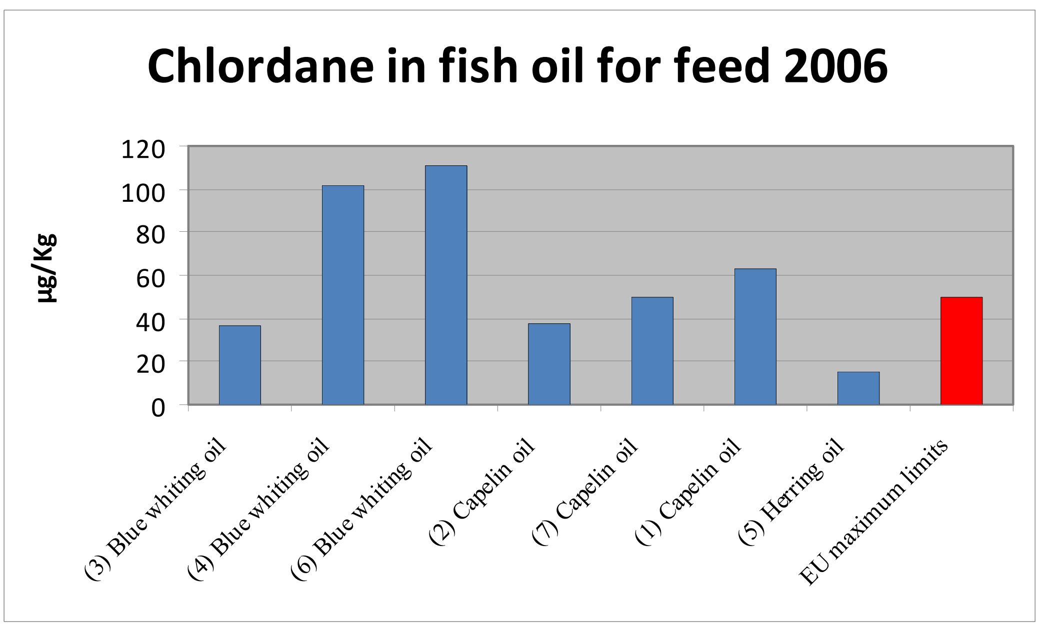


**Fig. 18: Clordane in fish oils from Iceland in 2006 (in µg/Kg calculated for 12% moisture content).**

## 5.6 Inorganic trace elements

Year 2006 all the twenty nine fish samples were measured for the following inorganic trace elements; Hg (mercury), Cd (cadmium), Pb (lead), As (arsenic), Se (selenium), Zn (zink), Cu (copper), Fe (iron), Cr (chromium), Ca (calcium), K (kalium), P (phosphorous), Mg (magnesium) and Na (sodium).

Some of the elements like Ca, Se, P, Mg and Na are essential minerals and thus do not fall into the category undesirable substances, however, the ICP-MS technology used to measure the trace elements enables us to measure these elements as well for relatively little extra cost. Therefore, all the previously mentioned trace elements are rapported in Table 8 in appendix.

### 5.6.1 Inorganic trace elements in seafood

In short, all the samples of the edible part of fish muscle contained heavy metals like Hg, Pb and Cd below the maximum limits set by EU (EU regulation No 78/2005 amending EU regulation No 466/2001).

The concentration of Mercury (Hg) in the fish samples is shown in Figure 19 and 20 but there are higher maximum limits for the fish species in Figure 20 according to the abowe mentioned regulation.

Figures 21 and 22 show the concentration of cadmium (Cd) in the fish samples and crustaceans respectively, but higher maximum limits are effective for crustaceans as can be seen on the histograms. All the samples measured were well below the set maximum limits for Cd.

The concentration of lead (Pb) in fish muscle is very low and in most cases below the limits of detection as can bee seen in Figure 23 and 24 for fish muscle and crustaceans respectively.

No limits have yet been set for arsenic, but results from the monitoring in 2006, which are shown in Figure 25 are in agreement with the measurements made in 2003 and 2004 (Auðunsson 2004 and Ásmundsdóttir et al. 2005). The results obtained year 2006 show the level of arsenic well below 25 µg/Kg and in most cases between 5-10 µg/Kg.

In the previous years of the monitoring program, measurments have been carried out for cadmium, lead and mercury .  The results have shown that the concentration of these metals in Icelandic seafood is well below the allowed maximum limit in the EU (Auðunsson, 2004, Ásmundsdóttir. et.al. 2005 and 2006).

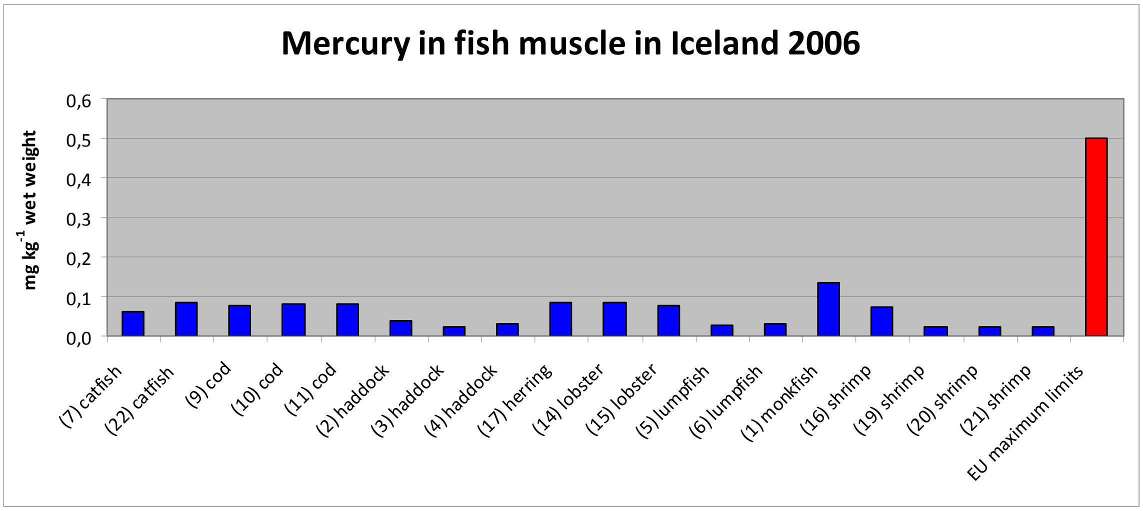


**Fig. 19: Mercury (Hg) in fish muscle in 2006 (in mg/Kg original sample).**

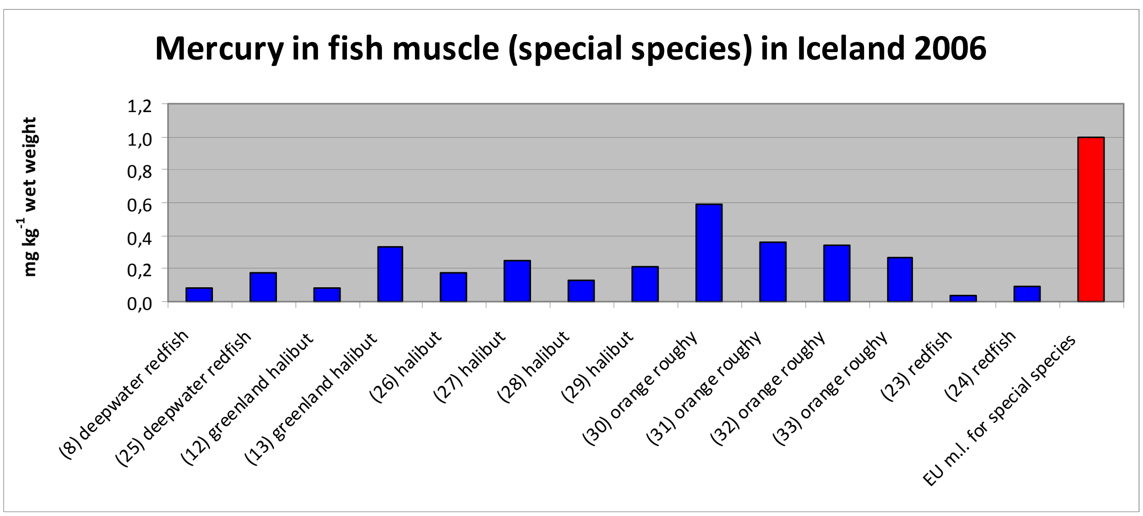


**Fig. 20: Mercury (Hg) in fish muscle(special species) in 2006 (in mg/Kg original sample).**

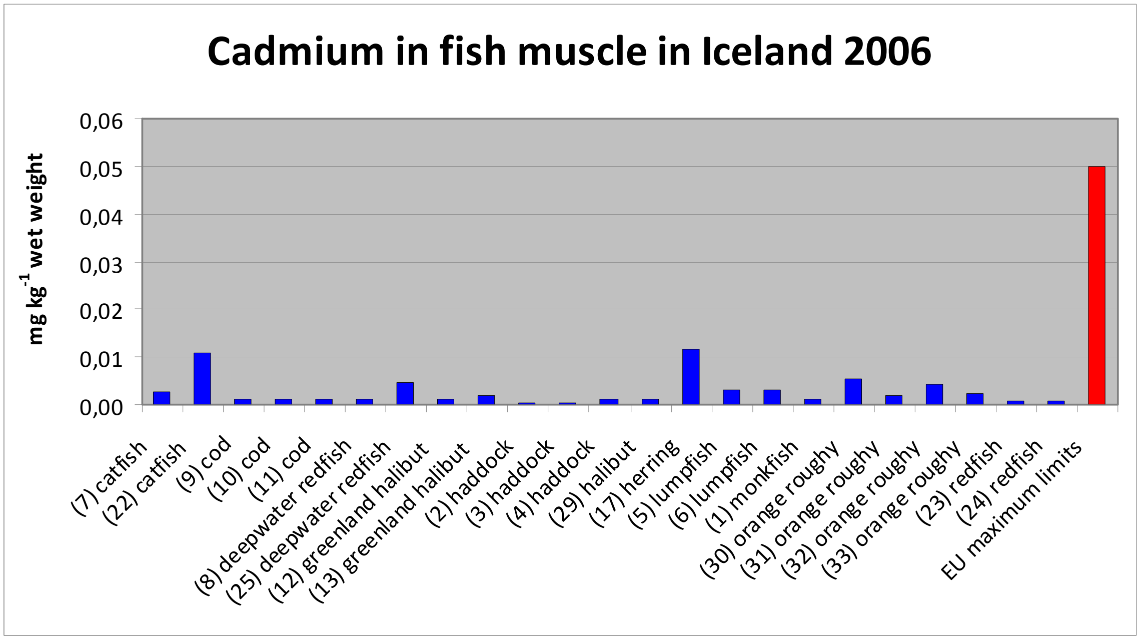


**Fig. 21: Cadmium (Cd) in fish muscle in 2006 (in mg/Kg original sample).**

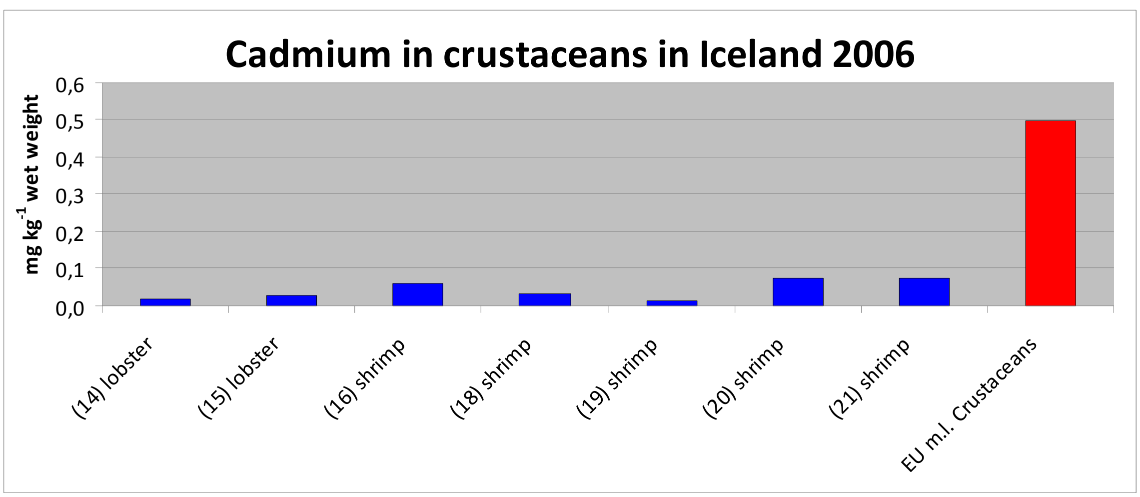


**Fig. 22: Cadmium (Cd) in crustaceans fish muscle in 2006 (in mg/Kg original sample).**

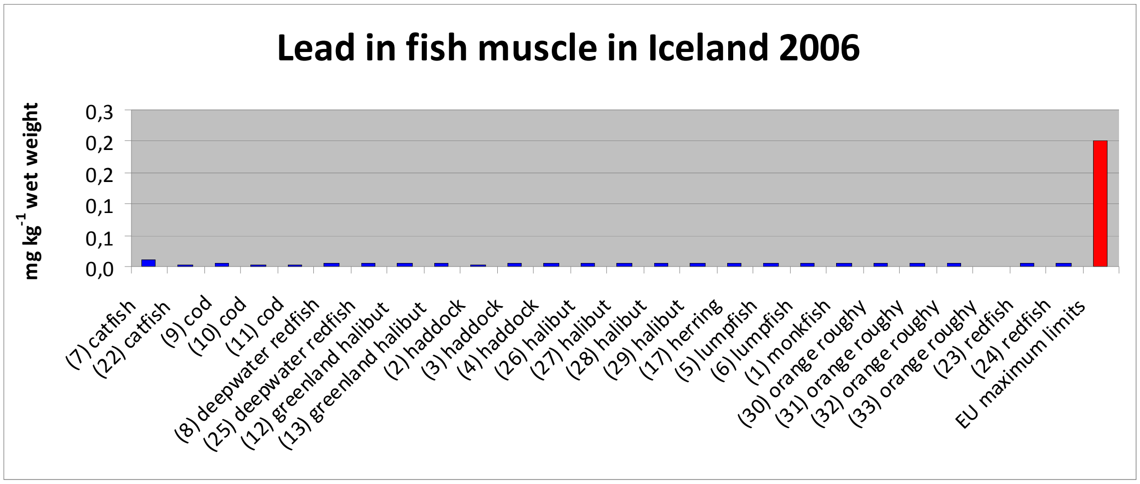


**Fig. 23: Led (Pb) in fish muscle in 2006 (in mg/Kg original sample).**

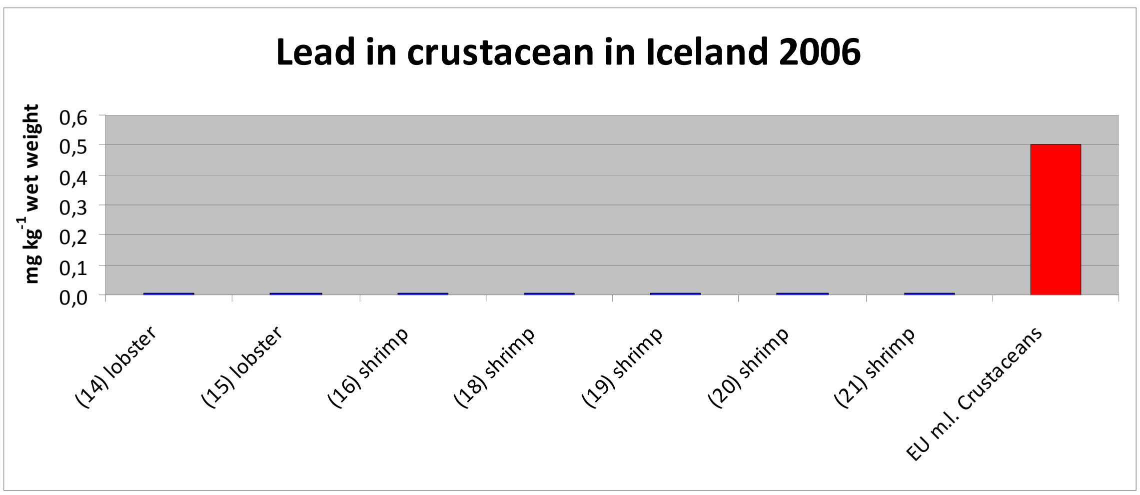


**Fig. 24: Led (Pb) in crustaceans in 2006 (in mg/Kg original sample).**

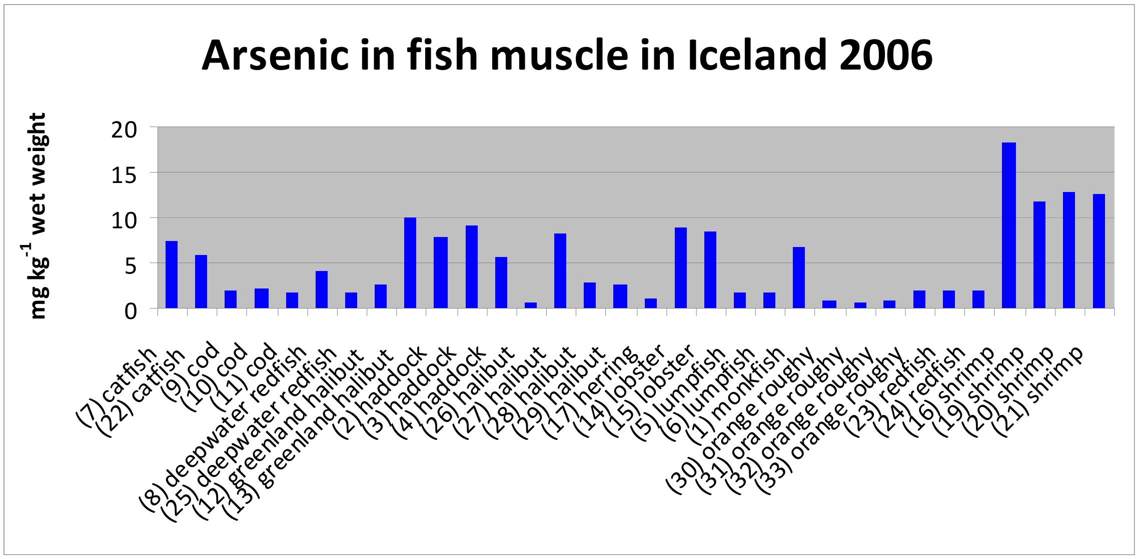


**Fig. 25: Arsenic (As) in fish muscle in 2006 (in mg/Kg original sample).**

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

This year no measurements were made of inorganic trace elements in fish meal and fish oil. In the previous years of the program , samples of fish meal and fish oil have been analysed for Hg, Pb, Cd and As.  All the samples analysed contained these substances in concentrations well below the EU maximum limits (Ásmundsdóttir Ásta M. et.al. 2005 and 2006).

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The Environment and Food Agency of Iceland, Regulation No **121/2004** about traces of pesticides in food

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

Commission Directive 2001/22/EC of March 2001

Commission Directive 2002/69/EC of 26 July 2002

Commission Directive 2003/57/EC of 17 June 2003

Commission Directive 2003/100/EC of 31 October 2003

Commission Directive 2005/8/EC 27 January 2005

Commission Directive 2005/86/EC of 5 December 2005

Commission Directive 2005/87/EC of 5 December 2005

Commission Directive 2006/13/EC of 3 February 2006

Commission Directive 2006/77/EC of 29 September 2006

Council Regulation (EC) 2375/2001 of 29 November 2001

Commission Regulation (EC) No 466/2001 of 8 March 2001

Commission Regulation (EC) No 78/2005 of 19 January 2005

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

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

Regulation (EC) No 782/2003 of the European Parliament and of the Council of 14 April 2003

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

# 7 Appendix

## 7.1 Table 1: Dioxin, PCB, PBDE in fish muscle

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

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

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

## 7.5 Table 5: Pesticides in fish muscle

## 7.6 Table 6: Pesticides in fish meal for feed

## 7.7 Table 7: Pesticides in fish oil for feed

## 7.8 Table 8a & 8b: Trace elements and heavy metals in fish muscle

**TABLE 1 Dioxin, PCB, PBDE in fish muscle**

| Sample code | fish sample | Sample name | | fishing ground | length | fat | PCDD/PCDF | DL-PCB | sum of Dioxin and Dl-PCB | Marker-PCB | PBDE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SN-2006- | No. | | | | cm | % | pg/g WHO-TEQ | pg/g WHO-TEQ | pg/g WHO-TEQ | µg/Kg | µg/Kg |
| 68 | 1 | Monkfish | *Lophius piscatorius* | | 33-70 | 0,42 | 0,021 | 0,101 | 0,122 | 0,706 | - |
| 69 | 2 | Haddock | *Melanogrammus aeglefinus* | S | 50-59 | 0,39 | 0,012 | 0,054 | 0,066 | 0,302 | - |
| 70 | 3 | Haddock | *Melanogrammus aeglefinus* | S | 40-49 | 0,32 | 0,009 | 0,027 | 0,036 | 0,264 | - |
| 71 | 4 | Haddock | *Melanogrammus aeglefinus* | S | 30-39 | 0,38 | 0,009 | 0,045 | 0,054 | 0,387 | - |
| 72 | 5 | Lumpfish | *Cyclopterus lumpus* | NE | 25-29 | 18,3 | 0,290 | 0,529 | 0,818 | 5,362 | - |
| 74 | 6 | Lumpfish | *Cyclopterus lumpus* | NE | 30-35 | 19,1 | 0,288 | 0,585 | 0,874 | 5,329 | 0,52 |
| 75 | 7 | Catfish | *Anarhichas lupus* | N and NW | 30-35 | 0,38 | 0,025 | 0,046 | 0,071 | 0,550 | - |
| 76 | 8 | Deepwater redfish | *Sebastes mentalla* | SW | 32-36 | 1,8 | 0,095 | 0,215 | 0,310 | 1,814 | - |
| 77 | 9 | Cod | *Gadus morhua* | SW | 45-59 | 0,35 | 0,008 | 0,049 | 0,057 | 0,354 | - |
| 78 | 10 | Cod | *Gadus morhua* | SW | 60-74 | 0,4 | 0,013 | 0,074 | 0,087 | 0,447 | - |
| 79 | 11 | Cod | *Gadus morhua* | SW | +75 | 0,3 | 0,013 | 0,129 | 0,142 | 0,560 | - |
| 80 | 12 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | 50-59 | 10 | 0,412 | 0,860 | 1,272 | 6,850 | 0,57 |
| 123 | 13 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | +60 | 9 | 0,644 | 3,103 | 3,747 | 24,563 | - |
| 124 | 14 | Lobster | *Homarus gammarus* | S | +60 g | 0,5 | 0,028 | 0,057 | 0,086 | 0,425 | 0,017 |
| 125 | 15 | Lobster | *Homarus gammarus* | S | -60 g | 0,55 | 0,027 | 0,042 | 0,069 | 0,291 | - |
| 260 | 17 | Herring | *Clupea harengus* | NE | 30-35 | 6,3 | 0,107 | 0,208 | 0,315 | 2,151 | - |
| 267 | 18 | Shrimp | *pandalus borealis* | N and NW | | 0,58 | 0,023 | 0,025 | 0,048 | 0,127 | - |
| 268 | 19 | Shrimp | *pandalus borealis* | NE | | 0,21 | 0,021 | 0,032 | 0,053 | 0,137 | - |
| 270 | 21 | Shrimp | *pandalus borealis* | NE | | 0,34 | 0,027 | 0,039 | 0,065 | 0,180 | - |
| 277 | 22 | Catfish | *Anarhichas lupus* | | 40-45 | 0,65 | 0,016 | 0,046 | 0,062 | 0,666 | - |
| 278 | 23 | Redfish | *Sebastes mentalla* | SW | 30-40 | 1,2 | 0,030 | 0,113 | 0,143 | 0,866 | - |
| 279 | 24 | Redfish | *Sebastes mentalla* | SW | 40-44 | 2,5 | 0,053 | 0,238 | 0,291 | 2,242 | - |
| 280 | 25 | Deepwater redfish | *Sebastes mentalla* | N and NW | 39-47 | 1,4 | 0,161 | 0,757 | 0,918 | 6,415 | - |
| 306 | 26 | Halibut | *Hippoglossus hippoglossus* | S | 119 | 0,67 | 0,025 | 0,118 | 0,142 | 0,959 | 0,17 |
| 307 | 27 | Halibut | *Hippoglossus hippoglossus* | N and NW | 141 | 12 | 0,660 | 1,682 | 2,343 | 14,507 | 0,84 |
| 308 | 28 | Halibut | *Hippoglossus hippoglossus* | E and SE | 100 | 2,5 | 0,070 | 0,348 | 0,418 | 2,674 | 0,23 |
| 309 | 29 | Halibut | *Hippoglossus hippoglossus* | S | 99 | 2,1 | 0,094 | 0,443 | 0,537 | 9,047 | 0,33 |
| | | EU action level | | | | | 3,00 | 3,00 | * | * | * |
| | | EU maximum limits | | | | | 4,00 | * | 8,00 | * | * |

*** No maximum limits exist in the EU for the substance**

**TABLE 2 Dioxin and PCB in fish oil for human consumption**

| Sample code | Oil sample<br>No. | Sample name | PCDD/PCDF<br>pg/g WHO-TEQ | DL-PCB<br>pg/g WHO-TEQ | Sum of Dioxin and DL-PCB<br>pg/g WHO-TEQ | Marker-PCB<br>µg/Kg |
|---|---|---|---|---|---|---|
| 703-2006-00012454 | 1 | Tuna fish oil | 0,20 | 0,47 | 0,67 | 6,1 |
| 703-2006-00021328 | 2 | Shark liver oil *(Somniousus microcephalus)* | 0,19 | 0,30 | 0,49 | 1,0 |
| 703-2006-00027246 | 3 | Shark liver oil *(Somniousus microcephalus)* | 0,27 | 0,51 | 0,78 | 4,9 |
| 703-2006-00027247 | 4 | Cod liver oil *(Gadus morhua)* | 0,21 | 1,9 | 2,1 | 83 |
| 703-2006-00027249 | 5 | Fish oil | 0,21 | 1,3 | 1,5 | 43 |
| 703-2006-00027250 | 6 | Fish oil | 0,21 | 3,0 | 3,2 | 106 |
| 703-2006-00027251 | 7 | Fish oil | 0,19 | 1,6 | 1,8 | 48 |
| 703-2006-00042319 | 8 | Tuna fish oil | 0,19 | 0,13 | 0,32 | 4,0 |
| 703-2006-00042320 | 9 | Tuna fish oil | 0,20 | 0,22 | 0,42 | 6,4 |
| | | EU maximum limits | | 10 | 10 | |

**TABLE 3 Dioxin, PCB and PBDE in fish meal for feed**

| Sample code<br>SN-2006- | Meal sample<br>No. | Sample name | Date of catch | PCDD/PCDF<br>pg/g WHO-TEQ | DL-PCB<br>pg/g WHO-TEQ | Sum of Dioxin and DL-PCB<br>pg/g WHO-TEQ | Marker-PCB<br>µg/Kg | PBDE<br>µg/Kg |
|---|---|---|---|---|---|---|---|---|
| 109 | 1 | Blue whiting meal *(Micromesistius poutassou)* | 20.4.2006 | 0,60 | 2,3 | 2,9 | 20 | 2,3 |
| 110 | 2 | Capelin meal *(Mallotus villosus)* | 10.2.2006 | 0,24 | 0,35 | 0,59 | 3,2 | - |
| 111 | 3 | Blue whiting meal *(Micromesistius poutassou)* | 1.5.2006 | 0,69 | 2,7 | 3,4 | 24 | - |
| 112 | 4 | Herring meal *(Clupea harengus)* | 7.6.2006 | 0,25 | 0,39 | 0,63 | 4,2 | 0,41 |
| 113 | 5 | Capelin meal *(Mallotus villosus)* | 2.2.2006 | 0,24 | 0,44 | 0,68 | 13 | - |
| 114 | 6 | Blue whiting meal *(Micromesistius poutassou)* | 8.2.2006 | 0,33 | 0,94 | 1,3 | 8,3 | - |
| 115 | 7 | Capelin meal *(Mallotus villosus)* | 3.3.2006 | 0,37 | 0,72 | 1,1 | 6,0 | - |
| 126 | 8 | Fish meal | 19.6.2006 | 0,53 | 2,2 | 2,8 | 19 | - |
| 127 | 9 | Blue whiting meal *(Micromesistius poutassou)* | 7.6.2006 | 0,40 | 1,7 | 2,1 | 13 | - |
| 304 | 10 | Herring meal *(Clupea harengus)* | 1-4.08.2006 | 0,27 | 0,38 | 0,6 | 4,0 | 0,53 |
| | | EU action level | | 1,00 | 2,50 | 3,50 | * | |
| | | EU maximum limits | | 1,25 | | 4,50 | * | |

*** No maximum limits exist in the EU for the substance**

**TABLE 4 Dioxin, PCB and PBDE in fish oil for feed**

| Sample code SN-2006- | Oil sample No. | Sample name | Date of catch | PCDD/PCDF pg/g WHO-TEQ | DL-PCB pg/g WHO-TEQ | Sum of Dioxin and DL-PCB pg/g WHO-TEQ | Marker-PCB µg/Kg | PBDE µg/Kg |
|---|---|---|---|---|---|---|---|---|
| 116 | 1 | Capelin oil *(Mallotus villosus)* | 3.3.2006 | 5,1 | 9,3 | 14 | 70 | - |
| 117 | 2 | Capelin oil *(Mallotus villosus)* | 10.2.2006 | 2,3 | 3,9 | 6,3 | 30 | - |
| 118 | 3 | Blue whiting oil *(Micromesistius poutassou)* | 8.2.2006 | 3,0 | 9,6 | 13 | 85 | - |
| 119 | 4 | Blue whiting oil *(Micromesistius poutassou)* | 20.4.2006 | 8,0 | 33 | 41 | 268 | 32 |
| 120 | 5 | Herring oil *(Clupea harengus)* | 7.6.2006 | 2,8 | 4,8 | 7,6 | 45 | 5,0 |
| 121 | 6 | Blue whiting oil *(Micromesistius poutassou)* | 1.5.2006 | 7,8 | 26 | 34 | 46 | - |
| 122 | 7 | Capelin oil *(Mallotus villosus)* | 22.2.2006 | 3,1 | 13 | 16 | 273 | - |
| 128 | 8 | Fish oil | 19.6.2006 | 6,3 | 27 | 33 | 170 | 24 |
| 129 | 9 | Blue whiting oil *(Micromesistius poutassou)* | 7.6.2006 | 5,2 | 22 | 27 | 160 | 21 |
| 305 | 10 | Herring oil *(Clupea harengus)* | 1-4.8.2006 | 2,0 | 3,2 | 5,2 | 29 | 3,7 |
| 310 | 11 | Herring oil (Clupea harengus) | 30.5.2006 | 1,9 | 4,6 | 6,5 | 38 | - |
| 311 | 12 | Blue whiting oil *(Micromesistius poutassou)* | 30.5.2006 | 4,1 | 14,9 | 19 | 100 | - |
| 312 | 13 | Fish oil | 25.7.2006 | 2,1 | 4,4 | 6,6 | 33 | - |
| 313 | 14 | Fish oil | 8.9.2006 | 2,2 | 4,2 | 6,4 | 34 | - |
| | | EU action level | | 5,0 | 14 | | | |
| | | EU maximum limits | | 6,0 | | 24 | * | |

*** No maximum limits exist in the EU for the substance**

**TABLE 5: Pesticides in fish muscle**

| Sample code SN-2006- | Fish sample No. | Sample name | | Fishing ground | Size cm | Lipid content % | β-HCH µg/Kg | α-HCH µg/Kg | γ-HCH µg/Kg | δ-HCH µg/Kg | total DDT µg/Kg | Hexachloro-benzene µg/Kg | Hepta-chlores µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | 1 | Monkfish | *Lophius piscatorius* | | 33-71 | 0,42 | 0,0080 | 0,020 | 0,20 | 0,030 | 0,67 | 0,10 | 0,20 |
| 69 | 2 | Haddock | *Melanogrammus aeglefinus* | S | 47-58 | 0,39 | 0,0080 | 0,020 | 0,20 | 0,030 | 0,21 | 0,20 | 0,20 |
| 72 | 5 | Lumpfish | *Cyclopterus lumpus* | NE | 27-29 | 18 | 0,22 | 0,97 | 1,0 | 0,20 | 9,3 | 3,0 | 2,3 |
| 74 | 6 | Lumpfish | *Cyclopterus lumpus* | NE | 30-33 | 19 | 0,20 | 0,78 | 1,0 | 0,20 | 9,0 | 3,0 | 2,2 |
| 76 | 8 | Deepwater redfish | *Sebastes mentella* | SW | 32-36 | 1,8 | 0,034 | 0,11 | 0,50 | 0,090 | 6,5 | 1,0 | 0,75 |
| 79 | 11 | Cod | *Gadus morhua* | SW | 75-96 | 0,30 | 0,0080 | 0,020 | 0,20 | 0,030 | 0,48 | 0,30 | 0,20 |
| 80 | 12 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | 50-59 | 10 | 0,087 | 0,59 | 0,80 | 0,20 | 11 | 4,0 | 1,5 |
| 123 | 13 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | 78-90 | 9,0 | 0,14 | 0,66 | 0,40 | 0,070 | 12 | 4,0 | 1,4 |
| 307 | 27 | Halibut | *Hippoglossus hippoglossus* | N and NW | 141 | 12 | 0,096 | 0,44 | 0,80 | 0,20 | 26 | 6,0 | 1,7 |
| 308 | 28 | Halibut | *Hippoglossus hippoglossus* | E and SE | 100 | 2,5 | 0,025 | 0,078 | 0,060 | 0,030 | 3,1 | 1,0 | 0,15 |
| 309 | 29 | Halibut | *Hippoglossus hippoglossus* | S | 99 | 2,1 | 0,028 | 0,080 | 0,060 | 0,030 | 10 | 0,90 | 0,20 |
| | | EU maximum limits | | | | | 50 | 50 | 50 | * | 500 | 50 | 50 |

*** No maximum limits exist in the EU for the substance**

**TABLE 5 (cont.): Pesticides in fish muscle**

| Sample code SN-2006- | Fish sample No. | Sample name | | Fishing ground | Size cm | Lipid content % | Aldrin/ Dieldrin µg/Kg | Toxaphene µg/Kg | Octachlor styrene µg/Kg | Endrin µg/Kg | Endo-sulphane µg/Kg | Chlordane µg/Kg | Transnonachlor µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | 1 | Monkfish | *Lophius piscatorius* | | 33-71 | 0,42 | 0,098 | 0,72 | 0,0090 | 0,020 | 2,2 | 0,11 | 0,14 |
| 69 | 2 | Haddock | *Melanogrammus aeglefinus* | S | 47-58 | 0,39 | 0,055 | 0,078 | 0,0090 | 0,020 | 2,2 | 0,016 | 0,017 |
| 72 | 5 | Lumpfish | *Cyclopterus lumpus* | NE | 27-29 | 18 | 4,4 | 16 | 0,055 | 1,2 | 16 | 3,2 | 1,8 |
| 74 | 6 | Lumpfish | *Cyclopterus lumpus* | NE | 30-33 | 19 | 3,6 | 16 | 0,050 | 0,92 | 16 | 2,7 | 1,5 |
| 76 | 8 | Deepwater redfish | *Sebastes mentella* | SW | 32-36 | 1,8 | 0,82 | 7,6 | 0,025 | 0,077 | 7,5 | 1,1 | 1,1 |
| 79 | 11 | Cod | *Gadus morhua* | SW | 75-96 | 0,30 | 0,14 | 0,42 | 0,0090 | 0,020 | 2,2 | 0,13 | 0,098 |
| 80 | 12 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | 50-59 | 10 | 4,3 | 8,7 | 0,11 | 1,4 | 2,8 | 4,9 | 3,8 |
| 123 | 13 | Greenland halibut | *Reinhardtius hippoglossoides* | N and NW | 78-90 | 9,0 | 4,4 | 30 | 0,092 | 1,1 | 0,015 | 5,9 | 4,5 |
| 307 | 27 | Halibut | *Hippoglossus hippoglossus* | N and NW | 141 | 12 | 5,5 | 22 | 0,18 | 1,2 | 1,7 | 7,9 | 9,4 |
| 308 | 28 | Halibut | *Hippoglossus hippoglossus* | E and SE | 100 | 2,5 | 0,51 | 5,3 | 0,048 | 0,044 | 0,41 | 0,48 | 0,95 |
| 309 | 29 | Halibut | *Hippoglossus hippoglossus* | S | 99 | 2,1 | 0,61 | 4,1 | 0,035 | 0,035 | 0,76 | 0,82 | 2,2 |
| | | EU maximum limits | | | | | 50 | * | * | 50 | * | 100 | * |

*** No maximum limits exist in the EU for the substance**

**TABLE 6: Pesticides in fish meal for feed**

| Sample code SN-2006- | Fish sample No. | Sample name | Date of catch | β-HCH µg/Kg | α-HCH µg/Kg | γ-HCH µg/Kg | δ-HCH µg/Kg | total DDT µg/Kg | Hexachloro-benzene µg/Kg | Hepta-chlores µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|
| 109 | 1 | Blue whiting meal *(Micromesistius poutassou)* | 20.4.2006 | 0,062 | 0,093 | 0,28 | 0,0084 | 23 | 3,7 | 0,53 |
| 110 | 2 | Capelin meal *(Mallotus villosus)* | 10.2.2006 | 0,13 | 0,16 | 0,28 | 0,017 | 5,6 | 2,6 | 0,33 |
| 111 | 3 | Blue whiting meal *(Micromesistius poutassou)* | 1.5.2006 | 0,065 | 0,079 | 0,29 | 0,011 | 25 | 4,6 | 0,57 |
| 112 | 4 | Herring meal *(Clupea harengus)* | 7.6.2006 | 0,039 | 0,051 | 0,28 | 0,0083 | 3,4 | 0,52 | 0,17 |
| 113 | 5 | Capelin meal *(Mallotus villosus)* | 2.2.2006 | 0,083 | 0,061 | 0,28 | 0,0083 | 6,1 | 2,7 | 0,31 |
| 114 | 6 | Blue whiting meal *(Micromesistius poutassou)* | 8.2.2006 | 0,086 | 0,041 | 0,28 | 0,013 | 9,7 | 2,6 | 0,41 |
| 115 | 7 | Capelin meal *(Mallotus villosus)* | 3.3.2006 | 0,090 | 0,092 | 0,28 | 0,0083 | 11 | 3,4 | 0,37 |
| | | EU maximum limits | | 10 | 20 | 200 | * | 50 | 10 | * |

*** No maximum limits exist in the EU for the substance**

**TABLE 6 (cont.): Pesticides in fish meal for feed**

| Sample code SN-2006- | Fish sample No. | Sample name | Date of catch | Aldrin/ Dieldrin µg/Kg | Toxaphene µg/Kg | Octachlor styrene µg/Kg | Endrin µg/Kg | Endo-sulphane µg/Kg | Chlordane µg/Kg | Transnonachlor µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|
| 109 | 1 | Blue whiting meal *(Micromesistius poutassou)* | 20.4.2006 | 3,5 | 25 | 0,30 | 0,74 | 1,5 | 4,0 | 4,8 |
| 110 | 2 | Capelin meal *(Mallotus villosus)* | 10.2.2006 | 4,1 | 8,5 | 0,045 | 1,1 | 1,3 | 2,0 | 1,4 |
| 111 | 3 | Blue whiting meal *(Micromesistius poutassou)* | 1.5.2006 | 3,8 | 16 | 0,31 | 0,76 | 1,5 | 5,6 | 5,7 |
| 112 | 4 | Herring meal *(Clupea harengus)* | 7.6.2006 | 1,7 | 1,2 | 0,021 | 0,20 | 1,3 | 0,94 | 0,82 |
| 113 | 5 | Capelin meal *(Mallotus villosus)* | 2.2.2006 | 3,7 | 7,2 | 0,051 | 1,0 | 1,5 | 3,1 | 2,1 |
| 114 | 6 | Blue whiting meal *(Micromesistius poutassou)* | 8.2.2006 | 3,2 | 6,6 | 0,10 | 0,66 | 1,2 | 1,7 | 1,8 |
| 115 | 7 | Capelin meal *(Mallotus villosus)* | 3.3.2006 | 4,6 | 15 | 0,088 | 1,3 | 1,6 | 3,7 | 3,0 |
| | | EU maximum limits | | 10 | 20 | * | 10 | 100 | 20 | * |

*** No maximum limits exist in the EU for the substance**

**TABLE 7: Pesticides in fish oil for feed**

| Sample code SN-2006- | Fish sample No. | Sample name | Date of catch | β-HCH µg/Kg | α-HCH µg/Kg | γ-HCH µg/Kg | δ-HCH µg/Kg | total DDT µg/Kg | Hexachloro-benzene µg/Kg | Hepta-chlores µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|
| 116 | 1 | Capelin oil *(Mallotus villosus)* | 3.3.2006 | 0,86 | 1,6 | 0,62 | 0,33 | 162 | 45 | 8,0 |
| 117 | 2 | Capelin oil *(Mallotus villosus)* | 10.2.2006 | 1,2 | 3,7 | 1,1 | 0,088 | 65 | 26 | 8,4 |
| 118 | 3 | Blue whiting oil *(Micromesistius poutassou)* | 8.2.2006 | 0,88 | 2,3 | 0,47 | 0,18 | 108 | 23 | 6,4 |
| 119 | 4 | Blue whiting oil *(Micromesistius poutassou)* | 20.4.2006 | 0,83 | 2,4 | 0,62 | 0,18 | 323 | 50 | 10 |
| 120 | 5 | Herring oil *(Clupea harengus)* | 7.6.2006 | 0,85 | 1,8 | 0,88 | 0,26 | 54 | 8,8 | 4,3 |
| 121 | 6 | Blue whiting oil *(Micromesistius poutassou)* | 1.5.2006 | 0,82 | 2,4 | 0,55 | 0,18 | 357 | 50 | 11 |
| 122 | 7 | Capelin oil *(Mallotus villosus)* | 22.2.2006 | 1,1 | 2,1 | 0,63 | 0,18 | 94 | 33 | 10 |
| | | EU maximum limits | | 100 | 200 | 2000 | * | 500 | 200 | * |

*** No maximum limits exist in the EU for the substance**

**TABLE 7 (cont.): Pesticides in fish oil for feed**

| Sample code SN-2006- | Fish sample No. | Sample name | Date of catch | Aldrin/ Dieldrin µg/Kg | Toxaphene µg/Kg | Octachlor styrene µg/Kg | Endrin µg/Kg | Endo-sulphane µg/Kg | Chlordane µg/Kg | Transnonachlor µg/Kg |
|---|---|---|---|---|---|---|---|---|---|---|
| 116 | 1 | Capelin oil *(Mallotus villosus)* | 3.3.2006 | 59 | 136 | 1,1 | 15 | 14 | 63 | 47 |
| 117 | 2 | Capelin oil *(Mallotus villosus)* | 10.2.2006 | 36 | 69 | 0,53 | 7,7 | 12 | 37 | 23 |
| 118 | 3 | Blue whiting oil *(Micromesistius poutassou)* | 8.2.2006 | 27 | 60 | 1,1 | 4,0 | 9,3 | 36 | 21 |
| 119 | 4 | Blue whiting oil *(Micromesistius poutassou)* | 20.4.2006 | 55 | 242 | 3,3 | 7,7 | 18 | 102 | 112 |
| 120 | 5 | Herring oil *(Clupea harengus)* | 7.6.2006 | 18 | 43 | 0,28 | 3,4 | 12 | 15 | 15 |
| 121 | 6 | Blue whiting oil *(Micromesistius poutassou)* | 1.5.2006 | 55 | 256 | 3,3 | 7,4 | 13 | 111 | 114 |
| 122 | 7 | Capelin oil *(Mallotus villosus)* | 22.2.2006 | 43 | 85 | 0,76 | 10 | 16 | 50 | 33 |
| | | EU maximum limits | | 100 | 200 | * | 50 | 100 | 50 | * |

*** No maximum limits exist in the EU for the substance**

## TABLE 8: Trace elements and heavy metals in fish muscle

g kg$^{-1}$ wet weight

| Sample code SN-2006- | Fish sample No. | Sample name | | Fishing ground | length cm | fat % | Na | Mg | P | K | Ca |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | g kg$^{-1}$ wet weight | | | | |
| **68** | **1** | **monkfish** | *Lophius piscatorius* | | 33-70 | 0,42 | 1,13 | 0,20 | 1,68 | 2,87 | 0,08 |
| **69** | **2** | **haddock** | *Melanogrammus aeglefinus* | S | 50-59 | 0,39 | 0,63 | 0,25 | 2,30 | 4,14 | 0,10 |
| **70** | **3** | **haddock** | *Melanogrammus aeglefinus* | S | 40-49 | 0,32 | 0,69 | 0,26 | 2,33 | 4,23 | 0,10 |
| **71** | **4** | **haddock** | *Melanogrammus aeglefinus* | S | 30-39 | 0,38 | 0,69 | 0,28 | 2,33 | 4,08 | 0,10 |
| **72** | **5** | **lumpfish** | *Cyclopterus lumpus* | NE | 25-29 | 18,3 | 1,47 | 0,15 | 1,61 | 2,13 | 0,07 |
| **74** | **6** | **lumpfish** | *Cyclopterus lumpus* | NE | 30-35 | 19,1 | 1,47 | 0,15 | 1,49 | 2,17 | 0,07 |
| **75** | **7** | **catfish** | *Anarhichas lupus* | N and NW | 30-35 | 0,38 | 0,99 | 0,24 | 2,35 | 3,78 | 0,12 |
| **76** | **8** | **deepwater redfish** | *Sebastes mentalla* | SW | 32-36 | 1,8 | 0,75 | 0,29 | 2,05 | 3,84 | 0,11 |
| **77** | **9** | **cod** | *Gadus morhua* | SW | 45-59 | 0,35 | 0,86 | 0,24 | 2,21 | 4,02 | 0,11 |
| **78** | **10** | **cod** | *Gadus morhua* | SW | 60-74 | 0,4 | 0,93 | 0,30 | 2,71 | 4,83 | 0,11 |
| **79** | **11** | **cod** | *Gadus morhua* | SW | +75 | 0,3 | 0,78 | 0,24 | 2,23 | 4,10 | 0,08 |
| **80** | **12** | **greenland halibut** | *Reinhardtius hippoglossoides* | N and NW | 50-59 | 10 | 0,62 | 0,21 | 1,91 | 3,42 | 0,07 |
| **123** | **13** | **greenland halibut** | *Reinhardtius hippoglossoides* | N and NW | +60 | 9 | 0,98 | 0,20 | 1,77 | 3,17 | 0,06 |
| **124** | **14** | **lobster** | *Homarus gammarus* | S | +60 g | 0,5 | 2,46 | 0,38 | 2,89 | 3,11 | 0,52 |
| **125** | **15** | **lobster** | *Homarus gammarus* | S | -60 g | 0,55 | 2,21 | 0,40 | 3,12 | 3,47 | 0,35 |
| **257** | **16** | **shrimp** | *pandalus borealis* | | | | 2,93 | 0,35 | 2,33 | 2,98 | 0,61 |
| **260** | **17** | **herring** | *Clupea harengus* | NE | 30-35 | 6,3 | 0,65 | 0,30 | 2,69 | 3,79 | 0,39 |
| **267** | **18** | **shrimp** | *pandalus borealis* | N and NW | | 0,58 | 2,66 | 0,38 | 2,74 | 3,39 | 0,54 |
| **268** | **19** | **shrimp** | *pandalus borealis* | NE | | 0,21 | 2,52 | 0,40 | 2,66 | 3,52 | 0,47 |
| **269** | **20** | **shrimp** | *pandalus borealis* | N and NW | | | 3,41 | 0,36 | 2,15 | 3,42 | 0,67 |
| **270** | **21** | **shrimp** | *pandalus borealis* | NE | | 0,34 | 3,19 | 0,48 | 2,50 | 3,26 | 0,68 |
| **277** | **22** | **catfish** | *Anarhichas lupus* | | 40-45 | 0,65 | 0,90 | 0,23 | 2,30 | 3,75 | 0,13 |
| **278** | **23** | **redfish** | *Sebastes mentalla* | SW | 30-40 | 1,2 | 0,72 | 0,29 | 2,28 | 4,01 | 0,14 |
| **279** | **24** | **redfish** | *Sebastes mentalla* | SW | 40-44 | 2,5 | 0,62 | 0,30 | 2,39 | 4,22 | 0,15 |
| **280** | **25** | **deepwater redfish** | *Sebastes mentalla* | N and NW | 39-47 | 1,4 | 0,74 | 0,27 | 1,93 | 3,71 | 0,10 |
| **306** | **26** | **halibut** | *Hippoglossus hippoglossus* | S | 119 | 0,67 | 0,52 | 0,25 | 2,73 | 4,61 | 0,05 |
| **307** | **27** | **halibut** | *Hippoglossus hippoglossus* | N and NW | 141 | 12 | 0,31 | 0,22 | 2,43 | 4,28 | 0,03 |
| **308** | **28** | **halibut** | *Hippoglossus hippoglossus* | E and SE | 100 | 2,5 | 0,28 | 0,28 | 2,85 | 4,83 | 0,04 |
| **309** | **29** | **halibut** | *Hippoglossus hippoglossus* | S | 99 | 2,1 | 0,34 | 0,25 | 2,71 | 4,71 | 0,04 |
| **319** | **30** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 57 | | 1,00 | 0,20 | 1,61 | 3,11 | 0,07 |
| **322** | **31** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 50 | | 0,73 | 0,21 | 1,60 | 3,12 | 0,07 |
| **326** | **32** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 49 | | 0,94 | 0,19 | 1,46 | 2,84 | 0,07 |
| **328** | **33** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 51 | | 0,99 | 0,20 | 1,56 | 2,88 | 0,08 |
| | | EU action level | | | | | | | | | |
| | | EU maximum limits | | | | | | | | | |
| | | EU m.l. Crustacean | | | | | | | | | |
| | | EU m.l. Halibut & redfish | | | | | | | | | |

* No maximum limits exist in the EU for the substance

**TABLE 8 (cont): Trace elements and heavy metals in fish muscle**

mg $kg^{-1}$ wet weight

| Sample code SN-2006- | Fish sample No. | Sample name | | Fishing ground | length cm | Cr | Fe | Cu | Zn | As | Se | Cd | Hg | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | mg $kg^{-1}$ wet weight | | | | | | | | |
| **68** | **1** | **monkfish** | *Lophius piscatorius* | | 33-70 | 0,073 | 1,40 | 0,15 | 3,73 | 6,84 | 0,34 | 0,001 | 0,133 | 0,005 |
| **69** | **2** | **haddock** | *Melanogrammus aeglefinus* | S | 50-59 | 0,023 | 0,87 | 0,12 | 2,95 | 7,74 | 0,46 | 0,001 | 0,038 | 0,003 |
| **70** | **3** | **haddock** | *Melanogrammus aeglefinus* | S | 40-49 | | 1,24 | 0,14 | 2,99 | 9,12 | 0,46 | 0,001 | 0,024 | 0,005 |
| **71** | **4** | **haddock** | *Melanogrammus aeglefinus* | S | 30-39 | 0,103 | 1,55 | 0,18 | 3,14 | 5,56 | 0,43 | 0,001 | 0,030 | 0,005 |
| **72** | **5** | **lumpfish** | *Cyclopterus lumpus* | NE | 25-29 | | 3,34 | 0,47 | 4,86 | 1,65 | 0,24 | 0,003 | 0,027 | 0,005 |
| **74** | **6** | **lumpfish** | *Cyclopterus lumpus* | NE | 30-35 | | 2,29 | 0,49 | 4,08 | 1,81 | 0,23 | 0,003 | 0,033 | 0,005 |
| **75** | **7** | **catfish** | *Anarhichas lupus* | N and NW | 30-35 | | 1,35 | 0,23 | 5,95 | 7,47 | 0,48 | 0,003 | 0,062 | 0,010 |
| **76** | **8** | **deepwater redfish** | *Sebastes mentalla* | SW | 32-36 | 0,008 | 1,34 | 0,15 | 3,00 | 4,03 | 0,55 | 0,001 | 0,085 | 0,005 |
| **77** | **9** | **cod** | *Gadus morhua* | SW | 45-59 | 0,016 | 0,93 | 0,17 | 3,37 | 1,88 | 0,30 | 0,001 | 0,075 | 0,005 |
| **78** | **10** | **cod** | *Gadus morhua* | SW | 60-74 | | 1,39 | 0,23 | 4,50 | 2,21 | 0,36 | 0,001 | 0,081 | 0,003 |
| **79** | **11** | **cod** | *Gadus morhua* | SW | +75 | | 0,97 | 0,17 | 3,65 | 1,67 | 0,29 | 0,001 | 0,083 | 0,003 |
| **80** | **12** | **greenland halibut** | *Reinhardtius hippoglossoides* | N and NW | 50-59 | 0,420 | 2,84 | 0,13 | 2,80 | 2,62 | 0,40 | 0,001 | 0,085 | 0,005 |
| **123** | **13** | **greenland halibut** | *Reinhardtius hippoglossoides* | N and NW | +60 | 0,010 | 0,99 | 0,13 | 3,12 | 10,09 | 0,64 | 0,002 | 0,336 | 0,005 |
| **124** | **14** | **lobster** | *Homarus gammarus* | S | +60 g | 0,009 | 14,63 | 2,38 | 11,51 | 8,99 | 0,70 | 0,020 | 0,083 | 0,003 |
| **125** | **15** | **lobster** | *Homarus gammarus* | S | -60 g | | 26,48 | 2,19 | 11,81 | 8,43 | 0,70 | 0,029 | 0,077 | 0,005 |
| **257** | **16** | **shrimp** | *pandalus borealis* | | | | 2,31 | 3,93 | 10,85 | 18,22 | 0,37 | 0,061 | 0,071 | 0,006 |
| **260** | **17** | **herring** | *Clupea harengus* | NE | 30-35 | 0,152 | 7,69 | 0,84 | 7,87 | 1,11 | 0,35 | 0,011 | 0,084 | 0,005 |
| **267** | **18** | **shrimp** | *pandalus borealis* | N and NW | | 0,062 | 10,23 | 6,17 | 12,36 | 6,74 | 0,34 | 0,031 | | 0,005 |
| **268** | **19** | **shrimp** | *pandalus borealis* | NE | | 0,065 | 7,07 | 3,22 | 10,53 | 11,72 | 0,31 | 0,015 | 0,021 | 0,005 |
| **269** | **20** | **shrimp** | *pandalus borealis* | N and NW | | 0,071 | 7,76 | 3,66 | 10,82 | 12,79 | 0,40 | 0,075 | 0,024 | 0,004 |
| **270** | **21** | **shrimp** | *pandalus borealis* | NE | | 0,032 | 7,71 | 3,64 | 10,75 | 12,71 | 0,40 | 0,074 | 0,024 | 0,004 |
| **277** | **22** | **catfish** | *Anarhichas lupus* | | 40-45 | | 2,11 | 0,18 | 6,88 | 5,83 | 0,74 | 0,011 | 0,085 | 0,003 |
| **278** | **23** | **redfish** | *Sebastes mentalla* | SW | 30-40 | | 1,82 | 0,22 | 3,47 | 2,00 | 0,79 | 0,001 | 0,039 | 0,005 |
| **279** | **24** | **redfish** | *Sebastes mentalla* | SW | 40-44 | | 1,93 | 0,27 | 3,71 | 1,90 | 0,85 | 0,001 | 0,093 | 0,005 |
| **280** | **25** | **deepwater redfish** | *Sebastes mentalla* | N and NW | 39-47 | 0,014 | 1,47 | 0,11 | 2,84 | 1,77 | 0,60 | 0,005 | 0,178 | 0,005 |
| **306** | **26** | **halibut** | *Hippoglossus hippoglossus* | S | 119 | | 1,08 | 0,19 | 3,99 | 0,64 | 0,50 | | 0,176 | 0,005 |
| **307** | **27** | **halibut** | *Hippoglossus hippoglossus* | N and NW | 141 | 0,086 | 1,16 | 0,19 | 3,76 | 8,34 | 0,40 | | 0,247 | 0,005 |
| **308** | **28** | **halibut** | *Hippoglossus hippoglossus* | E and SE | 100 | 0,045 | 0,93 | 0,16 | 3,60 | 2,80 | 0,73 | | 0,133 | 0,005 |
| **309** | **29** | **halibut** | *Hippoglossus hippoglossus* | S | 99 | | 1,13 | 0,16 | 3,62 | 2,58 | 0,69 | 0,001 | 0,216 | 0,005 |
| **319** | **30** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 57 | 0,064 | 0,85 | 0,07 | 2,33 | 0,84 | 0,72 | 0,006 | 0,587 | 0,005 |
| **322** | **31** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 50 | | 0,87 | 0,11 | 2,55 | 0,58 | 0,60 | 0,002 | 0,359 | 0,005 |
| **326** | **32** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 49 | 0,025 | 0,89 | 0,08 | 2,34 | 0,81 | 0,60 | 0,004 | 0,340 | 0,005 |
| **328** | **33** | **orange roughy** | *Hoplostethus atlanticus* | N and NW | 51 | | | 0,08 | 2,36 | 1,98 | 0,63 | 0,002 | 0,263 | 0,001 |
| | | EU action level | | | | | | | | | | | | |
| | | EU maximum limits | | | | | | | | | | 0,05 | 0,50 | 0,20 |
| | | EU m.l. Crustacean | | | | | | | | | | 0,50 | | 0,50 |
| | | EU m.l. Halibut & redfish | | | | | | | | | | | 1,00 | |

* No maximum limits exist in the EU for the substance