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BROMINATED CHEMICALS IN FARMED & WILD FISH & SHELLFISH AND FISH OIL DIETARY SUPPLEMENTS

Summary

In order to allow the dietary intake of brominated chemicals from fish and fisheries products to be estimated, composite samples of 48 species of farmed and wild fish and shellfish consumed in the UK, together with ten samples of fish oil dietary supplements, were analysed for brominated dioxins, polybrominated biphenyls (PBBs) and brominated flame retardants (BFRs). Some of the flame retardants were detected in all of the fish species analysed, with the highest concentrations generally being found in dogfish, eels and sprats. Other compounds were detected less frequently or not at all. The results are considered to be of low concern for health and do not affect the Agency's current advice on fish consumption.

Key Facts

- This work was carried out following an increasing number of reports of brominated flame retardants (BFRs) and occasional reports of brominated dioxins being found in fish.
- Brominated dioxins, polybrominated biphenyls (PBBs) and BFRs (polybrominated diphenyl ethers (PBDEs), hexabromocyclododecanes (HBCDs) and tetrabromobisphenol A (TBBP-A)) were analysed in composite samples of 48 fish and shellfish and 10 samples of fish oil dietary supplements. These included farmed and wild oily fish and white fish, shellfish, canned fish and fish paste, and supplements based on cod liver, halibut liver, shark liver, salmon and tuna oils.
- Certain PBDEs were present in most or all of the samples analysed, the most abundant congeners being PBDEs 28, 47, 49, 66, 99, 100, 153 and 154. HBCDs and PBBs were detected less frequently (alpha-HBCD being the most abundant) and brominated dioxins only occasionally. TBBP-A was not found above the limit of detection in any samples.
- Based on the results of this survey, the independent expert Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) concluded that the

- estimated exposure to brominated compounds by consumers following the Food Standards Agency's advice on fish consumption was unlikely to represent a risk to health and there was no need for the Agency to amend its advice on fish consumption.

Background

Brominated Flame Retardants (BFRs)

BFRs are used to reduce the risk from fire in a wide variety of materials and appliances including plastics, textiles and electronic equipment, and this usage contributes to the saving of many lives.[1] Common BFRs currently in use include polybrominated diphenyl ethers (PBDEs), hexabromocyclododecanes (HBCDs) and tetrabromobisphenol A (TBBP-A). Certain PBDE formulations (based on penta-BDE and octa-BDE) are being banned from use in the EU under the Restriction of Hazardous Substances Directive which comes into force in July 2006.[2,3] The continued use of deca-BDE is the subject of ongoing debate. Further information on these chemicals is provided in Food Survey Information Sheet Nos. 52/04.

Polybrominated biphenyls (PBBs) are the bromine analogues of polychlorinated biphenyls (PCBs). Although originally manufactured for use as flame retardants, their manufacture was banned in the 1970s (around the same time as the ban on PCB manufacture). However, PBBs are still present in older materials and equipment and are also environmentally persistent. The International Agency for Research on Cancer (IARC) has classified PBBs as possible human carcinogens[5] and, under the US National Toxicology Program, some PBBs have been classified as reasonably anticipated to be human carcinogens.[6]

Polybrominated dibenzodioxins and dibenzofurans (brominated dioxins, PBDD/PBDFs) can be produced during the combustion of materials containing BFRs, particularly at very high temperatures. Significant levels of brominated dioxins were reported in fire water run-off from Ground Zero following the attack on the World Trade Centre in September 2001.[7]

At a recent European Food Safety Authority (EFSA) scientific colloquium on dioxins it was concluded that compounds such as brominated dioxins and dioxin-like PBBs should be considered for Toxic Equivalency Factors, but that this should be prioritised on the basis of exposure, for which very few data are currently available.[8]

Although there have been a number of reports of PBDEs[9-40] and a few of HBCDs,[31-36,41,42] TBBP-A,[36] PBBs[37-39] and brominated dioxins[40,43-46] in fish in other countries, this is the first

comprehensive survey carried out in the UK for all of these brominated chemicals in fish. but this is the first comprehensive survey carried out in the UK for all of these brominated chemicals in fish. In its only previous related study, the Food Standards Agency investigated levels of BFRs in trout and eels from the Skerne-Tees river system.[47] This followed findings by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) of elevated concentrations of PBDEs and HBCDs in fish and sediment from some UK rivers and, by other workers, from the North Sea,[48-50] In this case, however, the observed contamination was linked to a specific source, a BFR manufacturing facility located on the River Skerne and operated by Great Lakes until its closure in December 2003.

The present survey was carried out to determine background concentrations of BFRs and other brominated compounds in fish, shellfish and fish oil dietary supplements on sale in the UK, in order to enable the estimate of dietary intakes of brominated compounds from these foods.

Methodology

Sampling

The sampling plan, covering most of the fish and shellfish species commonly available on the UK market, was produced by the University of Bristol[51] for a survey for dioxins and PCBs and it is described in more detail in Food Survey Information Sheet 03/06.[52] A total of 24 species of fresh wild fish, seven of farmed fish, seven of fresh shellfish and ten of canned or processed fish and shellfish were sampled between 2002 and 2004 by Direct Laboratories (Table 1), where possible from retail outlets throughout the UK, otherwise from specialised suppliers. Further details can be found in the contractor's final report for the sampling.[51]

The samples that were analysed comprised composites consisting of 30 or 60 individual samples (Table 1). Further details of the portions of the fish taken and other aspects of sample preparation can be found in analytical contractor's final report for the survey for dioxins and PCBs.[53] No individual fish samples and no organic fish were tested in the current survey.

Ten fish oil dietary supplements including products based on cod liver oil, halibut liver oil, salmon oil, tuna oil and shark liver oil, were also tested (Table 2). These were chosen to

cover a range of products derived from different fish species and were purchased by the Central Science Laboratory.

Preparation

The preparation of the fish and shellfish samples as composites for analysis has already been described.[53] For encapsulated fish oil dietary supplements, the oil was extracted from the capsule material prior to analysis. Brand names are not available for the fish and shellfish since only composite samples were analysed, but are provided for the fish oil dietary supplements (Table 2).[54] This was survey was far from comprehensive and was only intended to provide a snapshot. No inference should be drawn from the inclusion or absence of any specific product or brand.

Analysis

Samples were analysed by the Central Science Laboratory (CSL). Brominated dioxins, PBBs and PBDEs were analysed using gas chromatography-high resolution mass spectrometry (GC-HRMS) and HBCDs and TBBP-A by high pressure liquid chromatography-mass spectrometry (HPLC-MS). Table 3 contains details of the individual congeners and enantiomers measured. The laboratory gained UKAS accreditation for the analysis of brominated dioxins and PBBs during the course of this work. Full details of the analytical methodology for measuring all of the brominated compounds are presented in the contractor's final report.[53]

Results

Results for individual samples are provided in Tables 4-7 (fish and shellfish) and 8-11 (fish oils). Details of measurement uncertainty can be found in the contractor's final report for the work.[53]

Fish and shellfish

In the case of brominated dioxins/furans and PBBs, the TEFs for the chlorinated analogues have been used to generate TEQ values (Table 12). The COT has advised that there are considerable uncertainties in these values. However, because they are likely to be over-conservative they give an indication of protection of public health. Useable TEFs for the tribromo congeners are not available and the data for these compounds are therefore reported separately. The concepts of TEFs, TEQ, *upper* and *lower bound*

concentrations are explained in the Information Sheet 03/06 for the survey of chlorinated dioxins and PCBs in fish and shellfish.[52]

All of the values reported in tables 4-11 are expressed on a fresh or whole weight basis. The highest concentrations for total brominated compounds were found in dogfish, eel and sprats.

Of the PBDEs, PBDE 47 was usually found most often, with PBDEs 49, 99, 100, 153 and 154 also detected in the majority of samples. PBDEs 71, 77, 85, 126 and 138 occurred the least frequently. When present, PBDE 209 (deca-BDE) tended to be the most abundant congener. The concentrations of PBDEs in farmed trout and eels were generally much lower than those found in the samples from the Skerne-Tees river system, even when compared with samples taken upstream from the manufacturing site.[47]

Alpha-HBCD was the most frequently occurring HBCD enantiomer. TBBP-A was not detected in any of the fish species or fish oil dietary supplements.

Brominated dioxins were detected less often and at lower concentrations than the analogous chlorinated dioxins and PCBs in the same samples. However, the tri-bromo congeners, for which information on the trichloro- analogues is not available, were among the more frequently occurring congeners and contributed significantly to the total brominated dioxin levels in a number of species, notably oysters and mussels but also crab, whitebait, sea bass and sprats in the case of 238-triBDF. Other brominated dioxins were reported to be present in some samples but it was not possible to quantify them or confirm their identities due to the unavailability of reference standards. Concentrations of dioxin-like PBBs were very low, PBBs 49, 52, 77, 101 and 153 being the most prevalent.

The results for the flame retardants are consistent with those for PBDEs[9-10,19-28,32,34] and HBCDs[10,32] reported in fish by other workers and similar to those found in a recent Irish survey.[32] Brominated dioxins have generally not been detected in the few instances they have been analysed in fish[44-46] but, where detected, concentrations of the tribromo congeners have been relatively high[43,44] The results for fish oil dietary supplements are consistent with other studies.[15,55]

Fish oils

Brominated dioxin and PBB levels in the fish oil products were negligible. This may be attributable in part to the purification that they undergo to reduce the level of other contaminants present in the crude oil, such as chlorinated dioxins and PCBs.

PBDEs generally followed the same pattern as for fish and shellfish, with congeners 47, 49, 66, 99, 100 and 154 being detected in all ten samples and 28 and 153 in eight. PBDE 209 was detected in only one sample (tuna* oil), but at a much higher concentration than any other congeners in any of the samples (52.5 microgram/kg compared with the next highest at 9.9 microgram/kg).

HBCDs were not often found, the alpha-enantiomer occurring most frequently, in four samples. As for fish and shellfish, there were no positive results for TBBP-A.

Intakes

Dietary intakes were estimated from the concentrations found in the various fish and shellfish species tested. Portion sizes of 140 g were assumed for most fresh fish, 70 g for sardines, pilchards, whitebait, eels, shellfish and canned fish and 30 g for anchovy, fish paste and surimi. The intakes from the non-fish part of the diet were estimated from the results of the 2003 or 2004 brominated compounds Total Diet Study, which will be published shortly.

Table 13 contains the estimated intakes of brominated dioxins and furans from oysters and mussels, the species that contained the highest measured levels. The intake from a single 70g portion of shellfish is shown, together with the average daily exposure from one or two portions per week on top of the rest of the diet.

Table 14 contains the estimated intakes for the fish species containing the highest levels of ortho-PBBs, PBDEs and HBCDs. Again, values are given for the exposure from single portions (70g for eel, 140 g for the others) and from one or two portions per week on top of the rest of the diet.

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In the case of TBBP-A, no positive results were obtained and the estimated upper bound data are therefore relatively uninformative. All of the upper bound estimates were small in relation to the rest of the diet.

Intakes from the fish oil dietary supplements were estimated from the manufacturers' recommended dosages at different age groups. Intakes from the fish oil dietary supplements were in all cases much lower than the estimated intakes from the whole diet.

Interpretation

The estimated dietary intakes of BFRs and HBCDs from consuming up to 4 portions of the different fish species per week were submitted to the independent expert Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT). COT has previously concluded that, because only limited toxicological data are available, no Tolerable Daily Intakes (TDIs) can be set for either PBDEs or HBCDs.[56]

COT has been able to recommend a TDI for TBBP-A of 1 mg/kg bodyweight/day.[57] All of the estimated intakes, including the contribution from the rest of the diet, were 5-6 orders of magnitude below this figure.

The concentrations of PBDEs[9,26,31,33,36-39] and HBCDs[31,33,36,41] and brominated dioxins[40] (Ashizuka, 2005) are comparable with those found in surveys in other countries. However, TBBP-A was detected in all of the samples analysed by Swedish workers (Schlabach, 2004).[36]

Conclusion

The COT has reviewed the results of this survey and considered that the new data did not indicate a need to change existing advice on oily fish consumption.[58] All of the results from this work will be reported to the European Food Safety Authority for evaluation.

Summary of Units

ppb	parts per billion, equivalent to one microgram per kilogram (kg)
kg	a kilogram (kg) is one thousand grams (g)
µg	microgram, one millionth of a gram
ng	a nanogram is one thousand millionth of a gram
ng/kg bw/day	nanograms per kilogram of bodyweight per day; equivalent to parts per million million (parts per trillion) by weight.
TEQ	Toxic Equivalents
pg	a picrogram one million millionth of a gram
pg TEQ/ kg bw/day	picograms per kilogram of bodyweight per day; equivalent to parts per thousand million million (parts per quadrillion) by weight.

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Table 1 – Fish and shellfish samples tested

Species / presentation	Latin name	Samples	Species / presentation	Latin name	Samples
Anchovy (canned)		60	Salmon (canned)		60
Cod	Gaddus morhua	60	Salmon (farmed)	Salmo salar	30
Coley	Pallohius virens	60	Salmon (wild Alaskan)	Oncorhynchus spp	60
Crab (brown/white)	Cancer pagurus	60	Salmon (wild Atlantic)	Salmo salar	30
Crab (white, canned)	"	60	Sardine/Pilchard	Sardina pilchardus	60
Dogfish	Squalus spp	60	Sardines (canned)		60
Eel	Anguilla spp	60	Scallops	Pecten & Chlamys spp	60
Fish paste		60	Scampi	Nephrops norvegicus	60
Haddock	Melanogammus aeglefinus	60	Sea Bass (farmed)	Dicentrarchus labrax	60
Hake	Merluccius merluccius	60	Sea Bass (wild)	Dicentrarchus labrax	60
Halibut (farmed)	Hippoglossus hippoglossus	60	Sea Bream	Sparus aurata	60
Halibut (wild)	Hippoglossus hippoglossus	60	Sea Trout	Oncorhynchus mykiss	60
Herring	Clupea harengus	30	Shark	Various spp	60
Herring (Rollmops)		60	Sprat	Sprattus sprattus	60
Lemon Sole	Microstomus Kitt	60	Surimi		60
Mackerel	Scomber scombrus	30	Swordfish	Xiphias gladius & Istrophous spp	60
Mackerel (canned)		60	Trout (farmed)	Oncorhynchus mykiss	30
Mussels	Mytilus edulis	60	Tuna	Thunnus & Katsuwonus spp	60
Oysters	Ostrea edulis and Crassostrea gigus	60	Tuna (canned)		60
Pilchards (canned)		60	Turbot (UK, farmed)	Psetta maxima	60
Plaice	Pleuronectus platessa	60	Turbot (Greenland)	Reinhardtius hippoglossoides	60
Prawns (cold water)	Pandalid spp	60	Turbot (wild, UK)	Psetta maxima	60
Prawns (warm water)	Pandalid spp	60	Whitebait	Juveniles of various spp.	60
Red snapper	Lutjanus spp	60	Whiting	Merlangius merlangus	60

Table 2 – Fish oil supplement products tested

Sample Code	Product as described	Brand
11915	Everyday Joint Care, Pure Cod liver oil	Superdrug
11916	Omega 3 Liquid strawberry flavour	Power Health
11917	Salmon Oil	Power Health
11918	Halibut Liver Oil	Holland & Barrett
11919	High strength pure cod liver oil	Seven Seas
11920	Health product Junior Fish Oil Omega 3 rich	Nature's Aid
11921	Shark Liver Oil	Nulife UK
11922	Health Tuna cap	WellCene
11923	Cod liver oil with vitamins A, D and E	Sainsbury
11995	Eye q Marine fish oil and Virgin Evening Primrose Oil	Equazen

Table 3 Brominated compounds measured in the survey

Dioxin/furan congeners	**TEF***
2,3,7-TriBDD	-
2,3,7,8-TetraBDD	1
1,2,3,7,8-PentaBDD	1
1,2,3,4,7,8-/1,2,3,6,7,8-HexaBDD	0.1
1,2,3,7,8,9-HexaBDD	0.1
2,3,8-TriBDF	-
2,3,7,8-TetraBDF	0.1
1,2,3,7,8-PentaBDF	0.05
2,3,4,7,8-PentaBDF	0.5
1,2,3,4,7,8-HexaBDF	0.1
1,2,3,4,6,7,8-HeptaBDF	0.01
Polybrominated biphenyls	
PBB 77 (3,3',4,4')	0.0001
PBB 126 (3,3',4,4',5)	0.1
PBB 169 (3,3',4,4',5,5')	0.01
PBB 15 (4,4')	-
PBB 49 (2,2',4,5')	-
PBB 52 (2,2',5,5')	-
PBB 80 (3,3',5,5')	-
PBB 101 (2,2',4,5,5')	-
PBB 153 (2,2',4,4',5,5')	-
PBB 209 (2,2',3,3',4,4',5,5',6,6')	-
* TEFs quoted are the WHO-TEFs that apply to the chlorinated analogues	

Tetrabromo-bisphenol A (TBBP-A)

Polybrominated diphenyl ethers
Tri-BDE
17 (2,2',4)
28 (2,4,4')
Tetra-BDE
47 (2,2',4,4')
49 (2,2,4',5')
66 (2,3',4,4')
71 (2,3',4',6)
77 (3,3',4,4')
Penta-BDE
85 (2,2',3,4,4')
99 (2,2',4,4',5)
100 (2,2',4,4',6)
119 (2,3',4,4',6)
126 (3,3',4,4',5)
Hexa-BDE
138 (2,2',3,4,4',5')
153 (2,2',4,4',5,5')
154 (2,2',4,4',5,6')
Hepta-BDE
183 (2,2',3,4,4',5',6)
Deca-BDE
209 (2,2',3,3',4,4',5,5',6,6')
Hexabromocyclododecane enantiomers
Alpha-HBCD
Beta-HBCD
Gamma-HBCD

Table 4 Brominated dioxins and furans in fish and shellfish

	237-TriBDD	2378-TBDD	12378-PeBDD	123478-+123678-HxBDD	123789-HxBDD	238-TriBDF	2378-TBDF	12378-PeBDF	23478-PeBDF	123478-HxBDF	1234678-HpDF
Anchovy (canned)	<0.01	<0.004	<0.02	<0.02	<0.03	0.01	<0.01	<0.02	*0.02*	<0.03	0.23
Cod	0.004	0.003	<0.01	<0.01	<0.01	*0.01*	0.004	<0.01	0.01	<0.01	0.24
Coley	<0.002	<0.003	<0.004	<0.01	<0.01	*0.02*	<0.004	<0.02	0.01	<0.01	<0.07
Crab (brown/white)	*0.09*	<0.01	<0.01	<0.01	<0.02	0.36	0.05	<0.01	<0.01	<0.01	0.09
Crab (white, canned)	0.04	<0.001	<0.01	<0.01	<0.02	0.01	<0.003	<0.01	<0.01	<0.01	<0.05
Dogfish	<0.003	<0.003	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.45
Eel	<0.002	<0.01	<0.01	<0.02	<0.02	*0.03*	0.01	<0.01	0.01	<0.02	<0.12
Fish paste	0.02	<0.004	<0.02	<0.03	<0.03	0.02	0.01	<0.02	*0.02*	<0.03	<0.14
Haddock	<0.003	<0.002	<0.01	<0.01	<0.01	<0.01	<0.004	<0.003	0.02	<0.01	0.08
Hake	<0.005	<0.01	<0.01	<0.01	<0.02	*0.02*	<0.01	<0.005	<0.01	<0.01	0.13
Halibut (farmed)	0.01	<0.01	<0.02	<0.03	<0.03	*0.04*	0.01	<0.005	<0.01	<0.01	<0.13
Halibut (wild)	<0.001	<0.002	<0.01	<0.02	<0.01	*0.01*	0.003	<0.005	<0.01	<0.02	<0.11
Herring	<0.01	<0.01	<0.02	<0.02	<0.03	<0.01	<0.01	<0.01	<0.02	<0.02	<0.11
Herring (Rollmops)	<0.01	<0.003	<0.01	<0.02	<0.03	*0.01*	<0.004	<0.02	<0.01	<0.02	<0.16
Lemon Sole	0.003	<0.003	<0.01	<0.01	<0.01	*0.01*	0.01	<0.003	<0.005	<0.02	<0.07
Mackerel	0.005	<0.006	<0.02	<0.04	<0.03	*0.01*	*0.03*	<0.04	<0.05	<0.14	ND
Mackerel (canned)	<0.004	<0.01	<0.02	<0.04	<0.03	<0.01	<0.01	<0.01	<0.02	<0.04	<0.11
Mussels	1.17	<0.02	<0.04	<0.04	<0.06	0.25	0.11	*0.07*	0.08	<0.04	0.78
Oysters	6.27	0.08	<0.06	<0.05	<0.04	1.29	0.5	0.09	*0.09*	<0.05	0.61
Pilchards (canned)	<0.01	<0.003	<0.01	<0.02	<0.02	<0.01	<0.004	<0.01	<0.01	<0.02	0.12
Plaice	<0.003	<0.002	<0.01	<0.01	<0.01	*0.01*	0.01	*0.01*	0.01	<0.01	0.14
Prawns (cold water)	<0.005	<0.01	<0.01	<0.01	<0.02	<0.005	<0.01	<0.01	<0.01	<0.01	0.06
Prawns (warm water)	0.03	<0.01	<0.01	<0.01	<0.02	<0.005	0.01	0.01	*0.01*	<0.01	<0.06
Red snapper	<0.001	<0.002	<0.01	<0.02	<0.01	<0.003	0.003	<0.005	<0.01	<0.02	*0.06*
Salmon (canned)	0.005	<0.004	<0.01	<0.02	<0.02	<0.01	<0.004	<0.01	*0.01*	<0.02	0.23

1. All results expressed as ng/kg on a fresh weight basis
2. Figures in italics are indicative values, i.e. approximate due to interferences in the analysis.

Table 4 (cont.)

	237-TriBDD	2378-TBDD	12378-PeBDD	123478-+123678-HxBDD	123789-HxBDD	238-TriBDF	2378-TBDF	12378-PeBDF	23478-PeBDF	123478-HxBDF	1234678-HpDF
Salmon (farmed)	<0.003	<0.004	<0.02	<0.04	<0.02	0.07	<0.004	<0.01	<0.02	<0.04	<0.1
Salmon (wild Alaskan)	<0.003	<0.01	<0.02	<0.02	<0.02	*0.02*	<0.01	<0.01	<0.01	<0.01	<0.13
Salmon (wild Atlantic)	0.003	<0.01	<0.01	<0.02	<0.02	*0.03*	0.01	<0.01	<0.01	<0.02	<0.13
Sardine/Pilchard	<0.01	<0.01	<0.01	<0.02	<0.02	*0.03*	<0.01	<0.01	<0.01	<0.02	<0.13
Sardines (canned)	<0.01	<0.002	<0.01	<0.02	<0.03	<0.01	<0.005	<0.02	<0.01	<0.02	<0.14
Scallops	0.03	<0.01	<0.01	<0.01	<0.01	0.06	0.02	<0.01	<0.01	<0.01	0.16
Scampi	<0.005	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.03	0.13
Sea Bass (farmed)	<0.005	<0.003	<0.01	<0.01	<0.01	*0.3*	0.004	<0.01	<0.01	<0.01	<0.07
Sea Bass (wild)	<0.003	<0.003	<0.01	<0.02	<0.01	<0.01	<0.003	<0.01	<0.01	<0.02	<0.1
Sea Bream	*0.01*	<0.003	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	<0.02	*0.17*
Sea Trout	<0.002	<0.003	<0.01	<0.03	<0.01	<0.005	0.01	<0.01	<0.01	<0.03	<0.07
Shark	<0.003	<0.002	<0.01	<0.01	<0.01	*0.01*	<0.004	<0.003	<0.01	<0.01	<0.07
Sprat	<0.003	<0.01	<0.01	<0.01	<0.02	*0.15*	0.01	<0.01	<0.01	<0.02	<0.12
Surimi	<0.003	<0.001	<0.01	<0.01	<0.02	<0.004	<0.003	<0.01	<0.01	<0.01	<0.05
Swordfish	<0.002	<0.002	<0.01	<0.01	<0.01	0.02	0.004	<0.01	<0.01	<0.01	0.09
Trout (farmed)	<0.002	<0.003	<0.01	<0.02	<0.01	<0.004	0.01	*0.02*	<0.01	<0.02	0.08
Tuna	<0.003	<0.002	<0.01	<0.01	<0.01	0.01	<0.004	<0.005	<0.01	<0.01	<0.07
Tuna (canned)	<0.004	<0.003	<0.01	<0.01	<0.02	<0.004	<0.003	<0.01	<0.01	<0.01	<0.05
Turbot (UK, farmed)	<0.005	<0.004	<0.01	<0.02	<0.02	<0.003	<0.002	<0.01	<0.01	<0.02	<0.06
Turbot (Greenland)	<0.003	<0.002	<0.01	<0.01	<0.01	<0.01	0.01	<0.004	<0.01	<0.01	ND
Turbot (UK)	<0.003	<0.003	<0.01	<0.01	<0.01	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.07
Whitebait	0.01	<0.01	<0.01	<0.02	<0.02	*0.27*	<0.01	<0.01	<0.01	<0.03	<0.12
Whiting	<0.005	<0.01	<0.01	<0.01	<0.02	*0.02*	<0.01	<0.01	<0.01	<0.01	0.13

1. All results expressed as ng/kg on a fresh weight basis
2. Figures in italics are indicative values
3. ND – not possible to establish presence or absence of peak due to interference

Table 5 Polybrominated biphenyls in fish and shellfish

	Non-ortho, ng/kg			Ortho, microgram/kg						
	PBB 77	PBB 126	PBB 169	PBB-15	PBB-49	PBB-52	PBB-80	PBB-101	PBB-153	PBB-209
Anchovy (canned)	<0.01	<0.01	<0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003
Cod	0.01	<0.01	<0.01	<0.00004	<0.0001	<0.0001	<0.00004	<0.0003	<0.0003	<0.001
Coley	0.01	*0.01*	<0.01	<0.0002	0.001	0.001	<0.0002	0.0004	<0.0004	<0.01
Crab (brown/white)	0.02	<0.02	<0.01	0.002	0.001	0.001	0.001	0.002	0.01	<0.003
Crab (white, canned)	0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0002	<0.001
Dogfish	0.02	<0.01	<0.01	<0.001	0.01	0.02	0.001	0.01	0.04	<0.0007
Eel	0.01	<0.01	<0.01	<0.002	<0.002	0.004	<0.002	*0.002*	0.002	<0.01
Fish paste	0.02	<0.01	<0.02	<0.001	0.002	0.01	<0.001	0.002	<0.003	<0.004
Haddock	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0003	<0.0003	<0.001
Hake	0.01	<0.01	<0.01	<0.0002	0.003	0.004	0.0005	<0.0005	0.001	0.02
Halibut (farmed)	0.02	<0.01	<0.01	<0.0005	0.003	0.003	0.0005	0.005	0.005	<0.01
Halibut (wild)	0.01	<0.01	<0.005	<0.0004	0.01	0.01	<0.0004	0.01	0.005	<0.01
Herring	0.08	<0.02	<0.02	<0.002	0.01	0.02	<0.002	0.01	0.004	<0.004
Herring (Rollmops)	0.04	*0.02*	<0.02	<0.001	0.003	0.011	<0.001	0.004	0.002	<0.002
Lemon Sole	0.01	0.01	<0.003	<0.0001	0.0003	0.001	<0.0001	0.0004	0.0003	<0.01
Mackerel	0.05	<0.01	<0.01	<0.002	0.005	0.01	<0.002	<0.01	<0.005	<0.01
Mackerel (canned)	0.06	<0.02	<0.01	<0.001	0.001	0.004	<0.001	0.003	<0.001	<0.01
Mussels	0.05	<0.04	<0.04	<0.0003	<0.001	0.003	<0.0003	<0.001	<0.001	0.01
Oysters	0.13	<0.03	<0.03	0.001	0.002	0.01	<0.001	0.002	<0.004	0.03
Pilchards (canned)	0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Plaice	0.01	<0.01	<0.01	<0.0002	0.001	0.001	0.0002	0.002	0.004	<0.001
Prawns (cold water)	<0.01	<0.01	<0.01	<0.0002	<0.0003	<0.0002	<0.0002	<0.001	<0.0003	<0.002
Prawns (warm water)	0.01	<0.01	<0.01	<0.0002	0.01	0.01	0.001	0.004	0.004	<0.002
Red snapper	<0.01	<0.01	<0.005	<0.0002	<0.0004	<0.0004	<0.0002	<0.001	<0.001	<0.01
Salmon (canned)	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002

1. All results expressed on a fresh weight basis
2. Figures in italics are indicative values.

Table 5 (cont.)

	Non-ortho, ng/kg			Ortho, microgram/kg						
	PBB 77	PBB 126	PBB 169	PBB-15	PBB-49	PBB-52	PBB-80	PBB-101	PBB-153	PBB-209
Salmon (farmed)	0.03	<0.02	<0.01	<0.001	0.01	0.02	<0.001	0.01	0.01	<0.01
Salmon (wild Alaskan)	0.01	0.01	<0.01	<0.0004	<0.0004	0.001	<0.0004	0.0004	0.001	<0.01
Salmon (wild Atlantic)	0.02	<0.01	<0.01	<0.001	0.004	0.01	<0.001	0.01	0.01	<0.01
Sardine/Pilchard	0.02	0.01	<0.01	<0.001	0.003	0.01	<0.001	0.003	0.001	<0.01
Sardines (canned)	0.01	<0.01	<0.02	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.002
Scallops	0.01	<0.01	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0003	<0.0003	<0.002
Scampi	0.01	<0.01	<0.01	<0.0001	<0.0003	<0.0001	<0.0002	<0.001	<0.0002	0.02
Sea Bass (farmed)	0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002
Sea Bass (wild)	<0.01	<0.01	<0.01	<0.001	0.003	0.01	<0.001	0.003	0.002	<0.01
Sea Bream	<0.01	<0.01	<0.01	<0.001	0.002	0.01	<0.001	0.01	0.003	<0.01
Sea Trout	0.03	<0.01	<0.01	<0.001	0.005	0.01	<0.001	0.01	0.004	<0.01
Shark	<0.01	0.01	<0.01	<0.0001	0.0004	0.0004	<0.0001	<0.0004	0.001	0.01
Sprat	0.02	0.01	<0.01	<0.001	0.02	0.05	0.001	0.01	0.005	<0.01
Surimi	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0003	<0.0003	<0.001
Swordfish	0.01	<0.01	<0.01	<0.001	<0.001	<0.001	0.002	0.002	0.002	<0.001
Trout (farmed)	0.03	<0.01	<0.01	<0.001	0.003	0.01	<0.001	0.003	0.003	0.01
Tuna	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0003	0.0004	<0.0012
Tuna (canned)	<0.01	<0.01	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.001
Turbot (UK, farmed)	<0.01	<0.01	<0.01	<0.0002	0.003	0.01	0.001	0.002	0.003	0.02
Turbot (Greenland)	0.04	<0.01	<0.01	<0.001	0.002	0.004	<0.001	0.004	0.004	<0.001
Turbot (UK)	0.01	<0.01	<0.01	<0.0003	0.003	0.005	0.001	0.003	0.003	0.01
Whitebait	0.02	<0.01	<0.01	<0.0005	0.005	0.02	<0.0005	0.005	0.002	<0.01
Whiting	0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0004	<0.0001	<0.0004	<0.0003	0.02

1. Figures in italics are indicative values

Table 6a Polybrominated diphenyl ethers in fish and shellfish, PBDE 17 - 99

	PBDE-17	PBDE-28	PBDE-47	PBDE-49	PBDE-66	PBDE-71	PBDE-77	PBDE-85	PBDE-99
Anchovy (canned)	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Cod	<0.0002	0.003	0.05	0.01	0.002	<0.0002	<0.0002	<0.0002	0.01
Coley	0.001	0.01	0.13	0.02	0.003	<0.001	<0.001	<0.001	0.02
Crab (brown/white)	<0.003	0.07	0.61	0.02	0.02	<0.003	0.005	<0.003	0.28
Crab (white, canned)	<0.001	0.001	0.02	0.002	0.001	<0.001	<0.001	<0.001	0.01
Dogfish	0.01	0.17	3.37	0.25	0.26	<0.004	0.01	<0.004	0.56
Eel	<0.01	0.06	3.18	0.36	0.07	<0.01	<0.01	<0.01	0.19
Fish paste	0.01	0.04	0.66	0.16	0.04	<0.01	<0.01	<0.01	0.15
Haddock	<0.0005	0.001	0.02	0.003	0.002	<0.0005	<0.0005	<0.0005	0.01
Hake	0.002	0.02	0.55	0.14	0.02	<0.001	<0.001	<0.001	0.06
Halibut (farmed)	<0.002	0.02	0.45	0.06	0.01	<0.002	<0.002	<0.002	0.04
Halibut (wild)	0.003	0.08	1.54	0.35	0.08	<0.002	0.003	<0.002	0.24
Herring	<0.01	0.12	2.11	0.85	0.1	<0.01	<0.01	<0.01	0.34
Herring (Rollmops)	<0.01	0.09	1.7	0.79	0.09	<0.01	0.01	<0.01	0.33
Lemon Sole	<0.001	0.01	0.12	0.02	0.01	<0.001	<0.001	<0.001	0.01
Mackerel	<0.01	0.06	0.95	0.28	0.13	<0.01	<0.01	<0.01	0.36
Mackerel (canned)	<0.01	0.04	0.56	0.14	0.11	<0.01	<0.01	<0.01	0.23
Mussels	0.01	0.01	0.25	0.05	0.02	<0.001	<0.001	<0.001	*0.13*
Oysters	0.01	0.01	0.3	0.08	0.02	<0.001	<0.001	*0.002*	*0.2*
Pilchards (canned)	<0.01	0.01	0.12	0.03	<0.01	<0.01	<0.01	<0.01	0.01
Plaice	0.002	0.01	0.27	0.03	0.01	<0.001	<0.001	<0.001	0.01
Prawns (cold water)	<0.001	0.002	0.03	0.002	0.001	<0.001	<0.001	<0.001	<0.005
Prawns (warm water)	<0.001	0.001	0.02	0.001	0.001	<0.001	<0.001	<0.001	0.01
Red snapper	<0.001	0.001	0.05	0.004	0.002	<0.001	<0.001	<0.001	0.03

1. All results expressed as microgram/kg on a fresh weight basis
2. Figures in italics are indicative values

Table 6a cont.

	PBDE-17	PBDE-28	PBDE-47	PBDE-49	PBDE-66	PBDE-71	PBDE-77	PBDE-85	PBDE-99
Salmon (canned)	<0.005	0.01	0.07	0.01	<0.005	<0.005	<0.005	<0.005	0.02
Salmon (farmed)	0.02	0.11	2.01	0.48	0.11	<0.01	<0.01	<0.01	0.48
Salmon (wild Alaskan)	<0.002	0.01	0.2	0.03	0.01	<0.002	<0.002	<0.002	0.05
Salmon (wild Atlantic)	0.01	0.05	0.93	0.18	0.06	<0.01	<0.01	<0.01	0.24
Sardine/Pilchard	0.01	0.04	0.74	0.19	0.02	<0.01	<0.01	<0.01	0.06
Sardines (canned)	<0.01	0.01	0.28	0.08	0.01	<0.01	<0.01	<0.01	0.03
Scallops	0.002	0.004	0.06	0.02	0.005	<0.001	<0.001	<0.001	0.03
Scampi	<0.001	0.002	0.04	0.01	0.004	<0.001	<0.001	0.001	0.01
Sea Bass (farmed)	0.01	0.11	2.39	0.38	0.02	<0.003	<0.003	<0.003	0.02
Sea Bass (wild)	*0.01*	0.07	1.01	0.25	0.01	<0.004	<0.004	<0.004	0.01
Sea Bream	<0.005	0.04	0.83	0.1	0.03	<0.005	<0.005	<0.005	0.06
Sea Trout	<0.005	0.06	1.21	0.3	0.06	<0.005	<0.005	<0.005	0.26
Shark	<0.001	0.03	0.2	0.01	0.01	<0.001	<0.001	0.001	0.01
Sprat	*0.01*	0.13	2.22	0.93	0.13	<0.005	0.01	<0.005	0.43
Surimi	<0.001	<0.001	0.01	0.001	0.001	<0.001	<0.001	<0.001	0.01
Swordfish	<0.003	0.01	0.08	0.02	0.01	<0.003	<0.003	<0.003	0.02
Trout (farmed)	*0.01*	0.05	0.78	0.14	0.04	<0.004	<0.004	<0.004	0.23
Tuna	<0.0004	0.001	0.01	0.003	0.002	<0.0004	<0.0004	<0.0004	0.01
Tuna (canned)	<0.001	<0.001	0.01	0.001	<0.001	<0.001	<0.001	<0.001	0.01
Turbot (UK, farmed)	*0.002*	0.03	0.57	0.1	0.03	0.001	<0.001	0.01	0.07
Turbot (Greenland)	<0.01	0.06	0.62	0.09	0.03	<0.01	<0.01	<0.01	0.04
Turbot (UK)	<0.001	0.02	0.62	0.07	0.03	<0.001	<0.001	0.01	0.07
Whitebait	<0.002	0.09	1.71	0.97	0.04	0.003	<0.002	<0.002	0.37
Whiting	<0.0004	0.002	0.05	0.01	0.003	<0.0004	<0.0004	<0.0004	0.01

1. All results expressed as microgram/kg on a fresh weight basis
2. Figures in italics are indicative values

Table 6b Polybrominated diphenyl ethers in fish and shellfish, PBDE 100 - 209

	PBDE-100	PBDE-119	PBDE-126	PBDE153	PBDE138	PBDE 154	PBDE-183	PBDE-209
Anchovy (canned)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.12
Cod	0.01	0.0004	<0.0002	0.002	0.0002	0.003	0.01	0.13
Coley	0.03	0.001	<0.001	0.003	<0.001	0.01	0.003	0.17
Crab (brown/white)	0.19	0.01	<0.003	0.15	ND	0.18	<0.01	<0.05
Crab (white, canned)	0.003	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.04
Dogfish	1.41	0.02	<0.004	0.19	<0.004	0.26	<0.01	2.19
Eel	1.02	0.03	<0.01	0.15	<0.01	0.26	<0.02	0.03
Fish paste	0.14	0.01	<0.01	0.03	<0.01	0.06	<0.01	0.09
Haddock	0.003	<0.0005	<0.0005	0.002	<0.0005	0.002	0.01	0.06
Hake	0.15	0.01	<0.001	0.01	<0.001	0.05	<0.002	0.11
Halibut (farmed)	0.07	0.004	<0.002	0.01	<0.002	0.03	0.01	0.12
Halibut (wild)	0.27	0.01	<0.002	0.05	<0.002	*0.07*	<0.004	<0.03
Herring	0.47	0.03	<0.01	0.04	<0.01	0.1	<0.02	0.11
Herring (Rollmops)	0.44	0.02	<0.01	0.04	<0.01	0.09	<0.01	0.07
Lemon Sole	0.07	0.002	<0.001	0.003	<0.001	0.02	0.002	0.07
Mackerel	0.23	0.02	<0.01	0.05	<0.01	0.09	<0.02	0.07
Mackerel (canned)	0.12	0.01	<0.01	0.03	<0.01	0.05	<0.01	<0.07
Mussels	*0.11*	<0.001	<0.001	0.01	0.003	0.02	<0.003	0.19
Oysters	0.22	0.01	<0.001	0.01	0.002	0.05	<0.002	0.1
Pilchards (canned)	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05
Plaice	0.06	0.003	<0.001	0.01	<0.001	0.05	0.01	0.05
Prawns (cold water)	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	0.05
Prawns (warm water)	0.002	<0.001	<0.001	0.001	<0.001	0.001	<0.002	0.06
Red snapper	0.01	<0.001	<0.001	0.005	<0.001	0.004	<0.002	0.04

1. All results expressed as microgram/kg on a fresh weight basis
2. Figures in italics are indicative values

Table 6b (cont.)

	PBDE-100	PBDE-119	PBDE-126	PBDE153	PBDE138	PBDE 154	PBDE-183	PBDE-209
Salmon (canned)	0.01	<0.005	<0.005	<0.005	<0.005	0.01	<0.01	0.07
Salmon (farmed)	0.4	0.02	<0.01	0.07	<0.01	*0.17*	<0.01	0.41
Salmon (wild Alaskan)	0.03	<0.002	<0.002	0.01	<0.002	0.02	<0.004	0.04
Salmon (wild Atlantic)	0.2	0.01	<0.01	0.04	<0.01	0.11	<0.01	0.06
Sardine/Pilchard	0.2	0.01	<0.01	0.02	<0.01	0.03	<0.01	0.09
Sardines (canned)	0.08	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.06
Scallops	0.02	0.001	<0.001	0.01	<0.001	0.01	<0.002	<0.03
Scampi	0.01	<0.001	<0.001	0.002	<0.001	0.002	<0.001	0.1
Sea Bass (farmed)	0.67	0.01	<0.003	0.02	<0.003	0.19	<0.01	0.08
Sea Bass (wild)	0.16	0.01	<0.004	0.01	<0.004	0.05	<0.01	0.07
Sea Bream	0.17	0.01	<0.005	0.02	<0.005	0.06	<0.01	0.06
Sea Trout	0.29	0.02	<0.005	0.04	<0.005	*0.09*	<0.01	0.22
Shark	0.04	0.002	<0.001	0.01	<0.001	0.02	<0.001	<0.03
Sprat	0.45	*0.01*	<0.005	0.05	<0.005	0.08	<0.01	0.04
Surimi	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.04
Swordfish	0.03	0.01	<0.003	0.01	<0.003	0.03	0.01	0.04
Trout (farmed)	0.14	0.01	<0.004	0.03	<0.004	0.07	<0.01	<0.04
Tuna	0.003	0.001	<0.0004	0.002	<0.0004	0.003	0.004	0.04
Tuna (canned)	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.04
Turbot (UK, farmed)	0.07	0.002	<0.001	0.02	<0.001	0.06	<0.002	<0.03
Turbot (Greenland)	0.09	0.01	<0.01	0.02	<0.01	0.05	0.02	1.68
Turbot (UK)	0.16	0.01	<0.001	0.02	<0.001	0.06	0.003	<0.03
Whitebait	0.45	0.01	<0.002	0.04	0.005	0.07	0.005	0.23
Whiting	0.01	<0.0004	<0.0004	0.01	0.001	0.004	0.03	0.08

1. All results expressed as microgram/kg on a fresh weight basis
2. Figures in italics are indicative values

Table 7 Hexabromocyclododecanes in fish and shellfish

	Alpha-HBCD	Beta-HBCD	Gamma-HBCD
Anchovy (canned)	<0.11	<0.05	<0.05
Cod	*0.15*	*0.17*	*0.12*
Coley	*0.16*	0.07	<0.03
Crab (brown/white)	0.31	<0.03	<0.03
Crab (white, canned)	<0.07	<0.03	<0.03
Dogfish	2.49	0.06	0.08
Eel	5.11	0.07	0.11
Fish paste	0.37	<0.05	<0.05
Haddock	*0.24*	0.09	0.11
Hake	*2.31*	< 0.04	< 0.04
Halibut (farmed)	<0.07	<0.03	<0.03
Halibut (wild)	0.26	0.39	<0.04
Herring	1.6	<0.05	0.13
Herring (Rollmops)	2.34	<0.05	<0.05
Lemon Sole	<0.07	<0.03	<0.03
Mackerel	1.38	<0.05	0.1
Mackerel (canned)	0.43	<0.05	<0.05
Mussels	0.77	0.11	*0.13*
Oysters	1.17	0.18	0.1
Pilchards (canned)	<0.11	<0.05	<0.05
Plaice	<0.07	< 0.04	0.05
Prawns (cold water)	<0.07	<0.03	<0.03
Prawns (warm water)	<0.07	0.05	0.05
Red snapper	<0.07	<0.03	<0.03

	Alpha-HBCD	Beta-HBCD	Gamma-HBCD
Salmon (canned)	<0.11	<0.05	<0.05
Salmon (farmed)	1.13	*0.12*	0.09
Salmon (wild Alaskan)	0.19	< 0.07	0.08
Salmon (wild Atlantic)	0.56	< 0.06	< 0.09
Sardine/Pilchard	0.58	<0.05	<0.05
Sardines (canned)	<0.11	<0.05	<0.05
Scallops	0.25	0.11	0.07
Scampi	0.12	0.04	0.04
Sea Bass (farmed)	2.32	0.13	0.14
Sea Bass (wild)	0.53	0.06	0.06
Sea Bream	0.23	<0.05	<0.05
Sea Trout	1	0.18	0.12
Shark	0.15	0.07	0.1
Sprat	3.59	0.15	0.22
Surimi	<0.07	<0.03	<0.03
Swordfish	0.21	0.23	<0.04
Trout (farmed)	1.46	0.34	0.15
Tuna	0.12	0.08	*0.1*
Tuna (canned)	<0.07	<0.03	<0.03
Turbot (UK, farmed)	*0.22*	*0.23*	<0.03
Turbot (Greenland)	0.42	0.44	0.09
Turbot (UK)	0.14	0.05	*0.15*
Whitebait	1.45	0.09	0.2
Whiting	0.09	0.04	0.04

1. All results expressed as microgram/kg on a fresh weight basis
2. Figures in italics are indicative values

Table 8 Brominated dioxins and furans in fish oil supplements

Sample Code	Description	237-TriBDD	2378-TBDD	12378-PeBDD	123478-+123678-HxBDD	123789-HxBDD	238-TriBDF	2378-TBDF	12378-PeBDF	23478-PeBDF	123478-HxBDF	1234678-HpDF
11915	Cod liver oil	<0.04	<0.02	<0.05	<0.12	<0.11	<0.03	<0.05	<0.08	<0.05	<0.12	1.05
11916	Fish oil	<0.04	<0.02	<0.05	<0.09	<0.08	<0.03	<0.04	<0.07	<0.09	<0.11	0.97
11917	Salmon Oil	<0.04	<0.02	<0.05	<0.1	<0.14	0.13	0.07	<0.08	0.09	<0.11	0.84
11918	Halibut Liver Oil	<0.04	<0.02	<0.08	<0.14	<0.11	<0.03	<0.05	<0.08	<0.09	<0.12	0.92
11919	Cod liver oil	<0.04	<0.02	<0.05	<0.1	<0.09	<0.03	<0.05	<0.08	0.06	<0.12	1.71
11920	Fish oil	<0.04	<0.02	<0.05	<0.09	<0.08	<0.03	0.06	<0.08	<0.05	<0.12	<0.78
11921	Shark Liver Oil	<0.04	<0.02	<0.05	<0.12	<0.14	<0.03	<0.04	<0.07	<0.05	<0.11	1.57
11922	Tuna oil	<0.04	<0.02	<0.14	<0.1	<0.08	0.04	<0.05	<0.08	<0.1	<0.13	4.61
11923	Cod liver oil	<0.04	<0.02	<0.14	<0.14	<0.14	<0.03	<0.05	<0.08	<0.07	<0.12	<0.78
11995	Marine fish oil + EPO	0.06	<0.02	<0.07	<0.09	<0.08	<0.03	0.06	<0.08	<0.05	<0.12	1.07

1. All results expressed as ng/kg on a whole weight basis

Table 9 Polybrominated biphenyls in fish oil supplements

Sample Code	Description	Non-ortho, ng/kg			Ortho, microgram/kg						
		PBB 77	PBB 126	PBB 169	PBB-15	PBB-49	PBB-52	PBB-80	PBB-101	PBB-153	PBB-209
11915	Cod liver oil	0.08	<0.05	<0.12	<0.01	0.06	0.05	<0.01	0.06	0.06	<0.01
11916	Fish oil	<0.06	<0.06	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
11917	Salmon Oil	0.11	<0.06	<0.12	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.03
11918	Halibut Liver Oil	0.08	<0.05	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
11919	Cod liver oil	<0.06	<0.05	<0.12	<0.01	0.02	0.02	<0.01	0.02	0.02	<0.01
11920	Fish oil	<0.06	<0.05	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
11921	Shark Liver Oil	<0.06	<0.05	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.02
11922	Tuna oil	<0.06	<0.05	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
11923	Cod liver oil	0.07	<0.05	<0.17	<0.01	0.03	0.04	<0.01	0.04	0.06	<0.03
11995	Marine fish oil + EPO	0.1	<0.05	<0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.04

1. All results expressed on a whole weight basis

Table 10 Polybrominated diphenyl ethers in fish oil supplements

Sample Code	Description	PBDE-17	PBDE-28	PBDE-47	PBDE-49	PBDE-66	PBDE-71	PBDE-77	PBDE-85	PBDE-99
11915	Cod liver oil	<0.02	0.4	9.9	1.83	0.34	<0.01	<0.01	<0.01	1.16
11916	Fish oil	<0.01	0.03	0.64	0.16	0.04	<0.01	<0.01	<0.01	0.26
11917	Salmon Oil	0.01	0.14	3.5	0.78	0.13	<0.01	<0.01	<0.01	0.47
11918	Halibut Liver Oil	<0.01	0.04	1.16	0.12	0.04	<0.01	<0.01	<0.01	0.33
11919	Cod liver oil	0.02	0.19	4.77	0.89	0.17	<0.01	<0.01	<0.01	0.66
11920	Fish oil	<0.01	0.02	0.45	0.1	0.03	<0.01	<0.01	<0.01	0.19
11921	Shark Liver Oil	<0.01	<0.01	0.17	0.02	0.01	<0.01	<0.01	<0.01	0.06
11922	Tuna oil	<0.01	<0.01	0.23	0.05	0.01	<0.01	<0.01	<0.01	0.09
11923	Cod liver oil	0.03	0.29	7.72	1.3	0.38	<0.01	<0.01	<0.01	1.97
11995	Marine fish oil + EPO	0.01	0.04	0.62	0.17	0.02	<0.01	<0.01	<0.01	0.11

Sample Code	Description	PBDE-100	PBDE-119	PBDE-126	PBDE153	PBDE138	PBDE 154	PBDE-183	PBDE-209
11915	Cod liver oil	2.01	0.13	<0.01	0.22	<0.01	1.37	<0.01	<0.59
11916	Fish oil	0.15	0.02	<0.01	0.05	<0.01	0.06	<0.01	<0.58
11917	Salmon Oil	0.63	0.01	<0.01	0.06	<0.01	0.14	<0.01	<0.59
11918	Halibut Liver Oil	0.18	<0.01	<0.01	0.06	<0.01	0.07	<0.01	<0.59
11919	Cod liver oil	0.76	0.05	<0.01	0.12	<0.01	0.56	<0.01	<0.59
11920	Fish oil	0.11	<0.01	<0.01	0.02	<0.01	0.05	<0.01	<0.59
11921	Shark Liver Oil	0.02	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.59
11922	Tuna oil	0.09	<0.01	<0.01	<0.02	<0.01	0.06	<0.01	52.54
11923	Cod liver oil	1.76	0.13	<0.01	0.36	<0.01	1.16	0.03	<0.59
11995	Marine fish oil + EPO	0.12	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.75

1. All results expressed as microgram/kg on a whole weight basis

Table 11 Hexabromocyclododecanes in fish oil supplements

Sample Code	Description	Alpha-HBCD	Beta-HBCD	Gamma-HBCD
11915	Cod liver oil	5.04	0.41	0.36
11916	Fish oil	<0.48	<0.20	<0.21
11917	Salmon Oil	0.54	<0.19	<0.20
11918	Halibut Liver Oil	<0.58	<0.24	<0.25
11919	Cod liver oil	1.51	<0.21	<0.22
11920	Fish oil	<0.49	<0.20	<0.22
11921	Shark Liver Oil	<0.58	<0.24	<0.25
11922	Tuna oil	<0.59	<0.24	0.44
11923	Cod liver oil	3.46	0.31	<0.21
11995	Marine fish oil + EPO	<0.42	<0.17	<0.18

1. All results expressed as microgram/kg on a whole weight basis

Table 12 Highest estimated intakes of brominated dioxins and dioxin-like PBBs

Most significant species	Amount consumed	Brominated dioxins + dioxin-like PBBs, pg WHO-TEQ/kg BW		TriBDD, pg/kg BW	TriBDF, pg/kg BW
		Lower bound	Upper bound		
(Rest of diet)[1]		0.08	0.40	0.07	0.2
Oysters	single portion[2]	0.21	0.30	7.3	1.5
	1 weekly portion[3]	0.11	0.45	1.1	0.4
	2 weekly portions[4]	0.14	0.49	2.2	0.6
Mussels	single portion[2]	0.07	0.16	1.4	0.3
	1 weekly portion[3]	0.10	0.43	0.3	0.2
	2 weekly portions[4]	0.11	0.45	0.5	0.3

1. Daily intake from rest of diet estimated from Total Diet Study due for publication March 2006.
2. Estimated intake from the consumption of a single portion.
3. Estimated average daily intake from the consumption of one portion per week in addition to normal dietary intake.
4. Estimated average daily intake from the consumption of two portions per week in addition to normal dietary intake.

Table 13 Highest estimated intakes of flame retardants and non-dioxin-like PBBs

Most significant species	Amount consumed	ortho-PBB, ng/kg BW		PBDEs, ng/kg BW[1]	HBCDs, ng/kg BW[1]
		lower bound	upper bound		
(Rest of diet)[1]		0.18	0.31	5.6	5.8
Dogfish	single portion[2]	0.18	0.18	20	6.1
	1 weekly portion[3]	0.20	0.33	8.5	6.67
	2 weekly portions[4]	0.23	0.36	11.4	7.54
Sprat	single portion[2]	0.19	0.23	11	9.2
	1 weekly portion[3]	0.21	0.34	7.1	7.11
	2 weekly portions[4]	0.23	0.37	8.6	8.43
Herring	single portion[2]	0.10	0.12	10	4.0
	1 weekly portion[3]	0.19	0.32	7.1	6.37
	2 weekly portions[4]	0.21	0.34	8.5	6.94
Eel	single portion[2]	negligible	negligible	6.3	6.2
	1 weekly portion[3]			6.5	6.6
	2 weekly portions[4]			7.4	7.5

1. Daily intake from rest of diet estimated from Total Diet Study due for publication March 2006.
2. Estimated intake from the consumption of a single portion.
3. Estimated average daily intake from the consumption of one portion per week in addition to normal dietary intake.
4. Estimated average daily intake from the consumption of two portions per week in addition to normal dietary intake.