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DIOXINS AND DIOXIN-LIKE PCBs IN FISH OIL SUPPLEMENTS

Key Facts

- Dioxins and PCBs were analysed by the Food Standards Agency in retail samples of fish oil supplements in a follow-up survey to those carried out in 1994 and 1996.
- Concentrations of dioxins and dioxin-like PCBs in fish oil supplements were in the range 1.9 to 46 ng WHO-TEQ/kg oil.
- The estimated upper bound intakes of adults to dioxins and dioxin-like PCBs from the recommended dosages of fish oil supplements were in the range <0.1 to 7.1 pg WHO-TEQ/kg bodyweight/day. These estimated intakes do not take account of intakes from the whole diet. The estimated intakes of consumers from consumption of fish oil supplements have generally fallen since 1996 where the same product is still available.
- The Agency sought advice from members of the UK independent Committee on Toxicity of Chemicals in Food Consumer Products and the Environment (COT).
- In the light of COT members' advice the Agency has asked manufacturers to withdraw affected batches of 2 products which, on their own, could result in intakes of dioxins and dioxin like PCBs by consumers that would exceed twice the Tolerable Daily Intake (TDI);
- The Agency will continue to work with producers to reduce the intakes of dioxins and dioxin like PCBs from fish oil supplements through a range of measures.
- Intakes of dioxins at the highest levels found in the survey are a relatively low health risk for most adults. The TDI is set below levels of dioxin exposure that are likely to be harmful and risks relate to long-term exposure.

Summary

A recent survey for dioxins and PCBs in fish oil supplements has been carried out by the Food Standards Agency. Fish oil supplements are available as unlicensed supplements and as licensed medicinal products on general sale. This is a follow-up to previous surveys for dioxins and PCBs in fish oil supplements that were carried out in 1994 and 1996.¹ The results of both the previous surveys showed that for most consumers the estimated intakes of dioxins and dioxin-like PCBs from fish oil supplements in combination with the rest of the diet would not have exceeded the UK Tolerable Daily Intake (then 10 pg I-TEQ/kg bodyweight/day). However, in the case of toddlers who took some bottled formulations of fish oil supplements, their total intakes of dioxins and dioxin-like PCBs could have exceeded the UK TDI.

In the light of these findings, officials from MAFF held discussions with representatives of the fish oils industry, who agreed to pursue measures to reduce the estimated intakes of dioxins and dioxin-like PCBs from fish oil supplements. This current follow-up survey was carried out to check whether the measures taken by the fish oil industry have been successful.

Where direct comparisons can be made with brands available to consumers today, and based on the manufacturers' recommended dosages, the estimated intakes of dioxins and PCBs have fallen. In addition, the recommended dosages for these products for children have been reduced, or, these products are no longer recommended for use by children. This indicates that the actions taken by the manufacturer to reduce intakes of dioxins and dioxin like PCBs from its products have been successful.

The Agency sought advice from members of the COT on the results of the survey and their implications for intakes of dioxins and dioxin like PCBs by consumers of fish oil supplements. As a result producers of the two samples (CLO16 & CLO14), which would lead to the highest intakes – more than twice the TDI in virtually all age groups from the oil alone - have been asked to withdraw the relevant batches of these products. The Agency has also asked fish oil supplement producers to consider what measures might be taken to reduce the intakes of dioxins and dioxin like PCBs from other products. Approaches which might be adopted include: sourcing oil with lower dioxin and dioxin like PCB concentrations; oil treatment to

reduce the levels of these contaminants; changes to recommended dosages and age ranges of products, or a combination of these steps.

Background

Dioxins and PCBs are groups of chemicals that do not break down easily and so are widespread in the environment. They are generally present at low concentrations in foods, especially fat-containing foods such as milk and meat. The use of World Health Organization Toxic Equivalents (WHO-TEQs)² allows an assessment of the toxicological significance of the complex mixtures of dioxin and dioxin-like PCB congeners found in foods. Dioxins and dioxin-like PCBs occur as mixtures of chemicals with differing toxicity. The sum of these chemicals, weighted on the basis of the most toxic dioxin, gives the Toxic Equivalent (TEQ). International Toxic Equivalents (I-TEQs) were widely used until 1997 when a new system was set by the World Health Organisation (WHO-TEQs). These typically give 15% higher values. Further background information on dioxins and PCBs and on the concept of Toxic Equivalents can be found in Food Surveillance Information Sheet No. 4/00.³

Surveys for dioxins and PCBs in food have previously been carried out by MAFF and the Food Standards Agency. These surveys have concentrated on foods eaten by people of most age groups. They have included surveys of the whole diet, in which samples of the composite food groups from the 1982, 1992 and 1997 Total Diet Study (TDS) were analysed. These showed that the estimated intakes of adults, schoolchildren and toddlers to dioxins and dioxin-like PCBs have declined over this period.³ Overall average dietary exposure to dioxins and PCBs of the UK population has fallen by about 75% since 1982; it is now estimated to be 1.8 pg TEQ/kg bodyweight/day. Preliminary data indicates that intakes are still falling.

In 1994, MAFF carried out a survey for dioxins and dioxin-like PCBs in fish oil supplements.¹ The samples for that survey included cod liver oil, halibut liver oil, salmon oil and other fish body oil products, and bottled and capsule formulations. The concentrations of dioxins and dioxin-like PCBs found in those samples in which both sets of chemicals were analysed, re-expressed as WHO-TEQs, were in the range 2.7 to 17 ng WHO-TEQ/kg oil in capsule products and 7.4 to 34 ng WHO-TEQ/kg oil in bottled products. The results showed that for

most consumers the estimated dietary exposures to dioxins and dioxin-like PCBs from fish oil dietary supplements in combination with the rest of the diet in 1992^{1,4} would not have exceeded the UK Tolerable Daily Intake (then 10 pg I-TEQ/kg bodyweight/day). However, in the case of toddlers who took certain bottled formulation fish oil supplements, their total intakes of dioxins and dioxin-like PCBs could have exceeded the old UK TDI.^{1,4} This was mainly the result of larger recommended dosages of the bottled formulations when compared to capsules. MAFF carried out a follow-up survey in 1996, and the results showed that concentrations of dioxins and dioxin-like PCBs in the 1996 samples (0.5 to 41 ng WHO-TEQ/kg oil in capsule products and 2.9 to 39 ng WHO-TEQ/kg oil in bottled products, when re-expressed as WHO-TEQs) were similar to those in the 1994 samples.¹ For the majority of the products in both 1994 and 1996, the concentrations of dioxins would have exceeded the maximum limit of 2 ng WHO-TEQ/kg oil that will apply to products placed on the market after 1st July 2002.⁵

Following this assessment that toddlers may have elevated intakes of dioxins and dioxin-like PCBs from fish oil supplements, officials from MAFF held discussions with representatives of the fish oils industry. The industry agreed to pursue measures to reduce the estimated intakes of dioxins and dioxin-like PCBs from these products. A Norwegian study has shown that whereas neither deodourisation by steam stripping nor filtration through adsorbents affected concentrations of dioxins in cod liver oils, distillation reduced concentrations by an order of magnitude.⁶ There is also evidence that fish sourced from the southern hemisphere are less contaminated than fish sourced from the Atlantic Ocean.⁶ It has also been found that cod liver oil from the Baltic Sea contains higher concentrations of PCBs than cod liver oil from the Atlantic Ocean.⁷ Treatment of oils or changes in sourcing, therefore offered potential means of achieving the reductions that MAFF was seeking. Reductions in estimated dietary intake might also be achieved by reducing the recommended dosages of the products, especially in the case of the bottled formulations.

This current follow-up survey was designed to check whether the measures taken by the fish oil industry to reduce intakes of dioxins and dioxin-like PCBs from its products had been successful. The current study involves analysis of all the fish oil supplements products previously sampled that are still on sale, plus a number of additional mail order and supermarket own brand products some of which are relatively new to the market.

Methodology

A total of 33 samples of fish oil supplements (20 capsule, 11 bottled and 2 syrup formulations), representing 24 different cod liver oil, salmon and other fish oil products, were purchased during the period October 2000-February 2002. In the case of three cod liver oil products, four samples of each product were analysed, otherwise single samples were analysed. All the products previously sampled in 1994 and/or 1996 were included where they were still on sale, but ten were found to have been discontinued or no longer available over the counter. This was the case for the only halibut liver oil products previously sampled. The selection of additional products to those previously sampled, including supermarket own brands and mail order products, was based on market share information. The samples were purchased in York, close to the laboratory that analysed the samples. As national distribution of fish oil supplements is practised, the same batches of the same products would have been on sale throughout the UK.

A full list of all the samples, including full brand names, is given in Annex 1. The absence of a particular product means only that the product was not included in the survey. No further meaning should be read into the absence of that product from this survey.⁸

The analytical methodology for determining dioxin and PCB concentrations in food has been reported previously.^{4,9} In the current survey the 17 dioxin congeners of toxicological significance and the following PCB congeners were analysed: PCBs 77, 81, 126 and 169 (non-*ortho* PCBs); and 18, 28, 31, 47, 49, 51, 52, 99, 101, 105, 114, 118, 123, 128, 138, 153, 156, 157, 167, 180 and 189 (*ortho* PCBs). All dioxin and PCB congeners to which a WHO-TEF has been assigned were included.²

All samples were analysed by high resolution gas chromatography coupled with high or low resolution mass spectrometry (GC-MS) at Central Science Laboratory (CSL) in York. The laboratory has participated in inter-laboratory trials of measurement of dioxins and PCBs in human milk and human blood organised by the WHO and has recognised expertise in the analysis of foods for dioxins and PCBs. The reporting limit for *ortho*-PCBs in this survey was set to 0.10 microgramme/kg fat. Analytical difficulties led to variation in the limits of

determination (LODs) for dioxins and non-*ortho*-PCBs, on a fat basis. In these cases the reporting limit was the LOD that prevailed in that instance. All analytical data were assessed for compliance with published acceptance criteria.¹⁰

The coefficients of variation from analyses of reference materials, obtained by the laboratory over a long period of time, are approximately 10 per cent for dioxins and non-*ortho*-PCBs and 5 per cent for *ortho*-PCBs. The coefficients of variation for the analysis of the fish oil dietary supplement samples in the current study are likely to be of a similar order.

Results

This report presents the results for dioxins and dioxin-like PCBs in samples of fish oil dietary supplements, expressed as WHO-TEQs. The *upper bound* concentrations of dioxins and dioxin-like PCBs found in each of the samples are presented in Annex 1. A summary of the average concentrations by product is provided in Table 1. Full congener specific data for the current survey are available in the contractor's final report of the survey.¹¹ The concept of *upper bound* concentrations is explained in Food Surveillance Information Sheet No **4/00**³ and assumes that all congeners that were present at concentrations below the LOD were present at the LOD. This assumption will overestimate the true concentrations but represents a worst case scenario for risk assessment purposes.

In summary, the results were:

- *Upper bound* concentrations of dioxins were in the range 0.2 to 8.4 ng WHO-TEQ/kg fat.
- *Upper bound* concentrations of dioxin-like PCBs were in the range 1.1 to 41 ng WHO TEQ/kg fat.
- *Upper bound* concentrations of dioxins and dioxin-like PCBs were in the range 1.9 to 46 ng WHO-TEQ/kg fat.

In the case of three products (CLO4, CLO5 and CLO6) which were analysed in previous surveys the combined concentrations of dioxins and dioxin-like PCBs have fallen from 15 to 34 ng WHO TEQ/kg oil in 1994 and 1996 to 3.6 to 5.0 ng WHO TEQ/kg oil in 2001 respectively. For the other products sampled in more than one year, there has generally been little change in the concentrations.

The concentrations are similar to the ranges found in surveys in other countries^{6,7,12,13} The concentrations of dioxins and/or dioxin-like PCBs in the cod liver oil products were generally higher than those in fish body oil products.

Average intakes of dioxins and dioxin-like PCBs were estimated from the mean *upper bound* concentrations found in each of the products using the manufacturers' recommended dosages for each product at the different age groups for which they are recommended. Where a range of dosages is recommended for a given age group, the higher or highest one has been used.

Intakes from the whole diet were estimated from the results of the 1997 TDS survey for the adults and schoolchildren.³ Since Food Surveillance Information Sheet No. 4/00 was published, the National Diet and Nutrition Survey (NDNS) of young people aged 4-18 years has been published.¹⁴ The intakes by schoolchildren of dioxins and dioxin-like PCBs have therefore been re-estimated using consumption data from this newer survey of schoolchildren's food consumption rather than the data from the Diets of British Schoolchildren, which date from 1983. The earlier survey did not allow the intakes of separate age groups to be estimated. In addition, since a significant proportion of consumers of fish oil supplements are senior citizens, the intakes of dioxins and dioxin-like PCBs by this age group have also been estimated using consumption data from the NDNS Survey of People Aged 65 Years and Older.¹⁵ The average intakes of dioxins and dioxin-like PCBs of consumers of fish oil supplements alone and in combination with the rest of the diet, based on the 1997 Total Diet Study (TDS), are presented in Tables 5 and 6. In contrast to the previous surveys, none of the products sampled is recommended for children under the age of five years old, toddlers or infants, so no estimates of exposure for those age groups have been made.

The estimated *upper bound* intakes of dioxins and dioxin-like PCBs by consumers of bottled supplements formulations alone (Table 2) were in the following ranges:

- <0.1 to 6.9 pg WHO-TEQ/kg body weight/day for senior citizens;
- <0.1 to 7.1 pg WHO-TEQ/kg body weight/day for adults;
- 0.1 to 10 pg WHO-TEQ/kg body weight/day for schoolchildren;

The estimated *upper bound* intakes of adult and schoolchildren consumers of bottled supplements formulations in combination with the rest of the diet in 1997 to dioxins and dioxin-like PCBs (Table 2) were in the following ranges:

- 1.4 to 8.6 pg WHO-TEQ/kg body weight/day for senior citizens;
- 1.9 to 8.9 pg WHO-TEQ/kg body weight/day for adults;
- 1.5 to 14 pg WHO-TEQ/kg body weight/day for schoolchildren;

For one of the products (CLO23), for which the normal manufacturer's recommended dose is one capsule a day, the dosage instructions state that 'Two or three capsules a day may be taken for higher levels of cardio-care Omega 3 fatty acids. Do not exceed six capsules per day'. The estimated exposures of adults and senior citizens to dioxins and dioxin-like PCBs from this product are <0.1 pg WHO-TEQ/kg bodyweight/day from 3 capsules daily and 0.1 pg WHO-TEQ/kg bodyweight/day from 6 capsules daily respectively.

There have been few estimates of dietary intakes of dioxins and PCBs from fish oil supplements in other countries, but those estimated from the current survey are broadly similar to those found in Spain¹³ but lower than those resulting from cod liver oil products sourced from the Baltic Sea⁷ (Table 2).

Interpretation

In 12 of the 33 samples the concentrations of dioxins exceeded the European Commission's limit for dioxins in fish oil for human consumption due to come into effect on 1 July 2002.⁵ This compares with 10 out of 15 samples in a recent Irish study.¹² The concentrations of dioxins and dioxin-like PCBs in the three market leading products (CLO4, CLO5 and CLO6) were all lower than those found in previous surveys, and the recommended dosages for children, toddlers and infants have been reduced or withdrawn. This indicates that the actions taken by the manufacturer to reduce intakes from its products have been successful. However, for the other products that have been sampled in more than one year, there has been little change in the concentrations, and in one case the concentrations both of dioxins and of dioxin-like PCBs in the most recent sample were higher than those found previously. Other measures

that have been taken to reduce dietary exposures are to reduce the recommended dosages of some other products, and withdraw them entirely for children aged under five.

The COT has recently revised the UK TDI for mixtures of dioxins and dioxin-like PCBs from 10 pg WHO-TEQ/kg bodyweight per day¹⁶⁻¹⁹ to 2 pg WHO-TEQ/kg bodyweight/day.²⁰

The results of the survey and estimated intakes from the products, at the manufacturers recommended dosages, were considered by members of the COT, in the light of the TDI of 2 pg TEQ/kg bodyweight/day, and their views noted by the Committee at its June 2002 meeting.

The COT members noted that some of the fish oil samples surveyed would provide a higher intake of dioxins than from dietary sources, which was estimated from the 1997 TDS to be on average 1.8 pg TEQ/kg bodyweight/day. The problem was particularly evident with two samples (CLO16, CLO14), for which intakes from the oil alone would exceed twice the TDI in virtually all age groups. On the basis of the COT members' advice, the Agency recommended that manufacturers withdraw affected batches of these 2 products from the market. The Agency has also asked fish oil supplements producers to consider what measures might be taken to reduce the intakes of dioxins and dioxin like PCBs from other products. Approaches which might be adopted include: sourcing of oil with lower dioxin and dioxin like PCB concentrations; oil treatment to reduce the levels of these contaminants; changes to recommended dosages and age ranges of products, or a combination of these steps. The Agency accepts the COT members advice that dosages and age recommendations need to be clearly stated to minimise the potential for excessive intakes of dioxins.

Intakes of dioxins at the highest levels found in the survey are a relatively low health risk for most adults, as the TDI is set below levels of dioxin exposure that are likely to be harmful and risks relate to long-term exposure. The risk is slightly increased for women who have been exposed to high levels of dioxins for many years and who become pregnant. However a number of studies reviewed by expert committees have investigated possible effects of dioxins and PCBs on pregnant women and their developing children. There has been no convincing evidence of harmful effects at the levels to which the general populations is exposed from food and other sources.

Medicinal products are the responsibility of the Medicines Control Agency. Details of the survey results and dietary intake estimates for all the medicinal products surveyed (CLO2, CLO4, CLO5, CLO11 and FO8) and the COT members views have been passed to the Medicines Control Agency, for consideration.

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Further Information

Units

kg	a kilogram (kg) is one thousand grams (g).
ng	a nanogram (ng) is one thousand millionth of a gram (g).
ng I-TEQ/kg	nanograms of International Toxic Equivalents per kilogram; equivalent to parts per million million (parts per trillion) by weight
ng WHO-TEQ/kg	nanograms of WHO Toxic Equivalents per kilogram; equivalent to parts per million million (parts per trillion) by weight
pg	a picogram (pg) is one million millionth of a gram (g).
pg I-TEQ/kg bodyweight/day	picograms of International Toxic Equivalents per kilogram of bodyweight per day; equivalent to parts per thousand million million (parts per quadrillion) by weight.
pg WHO-TEQ/kg bodyweight/day	picograms of WHO Toxic Equivalents per kilogram; equivalent to parts per thousand million million (parts per quadrillion) by weight.

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Copies of the full COT statement on the results of this survey can be obtained from:

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A copy of the full report of this survey has been placed in the Library, Aviation House, 125 Kingsway, London, WC2B 6NH Tel. No. + 44 (0) 20 7276 8181/8282. If you wish to consult it please contact the library for an appointment giving at least 24 hours notice or alternatively copies can be obtained from the library: a charge will be made to cover photocopying and postage.

Table 1: Concentrations (ng WHO-TEQ/kg oil) of dioxins and dioxin-like PCBs in fish oil dietary supplements and medicinal products

a) Cod liver oil products												
Chemical	Concentrations (ng TEQ/kg oil)											
	Bottled formulations (& syrup formulation in 2000/01)						Capsule formulations*					
	1994 n=4		1996 n=8		2000/01 n=6		1994 n=3		1996 n=5		2000/01 n=12	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Dioxins	6.8	0.5-12	8.0	6.7-10	3.3	0.3-8.4	-	-	3.9	1.6-6.7	3.71	0.3-7.9
Non- <i>ortho</i> -PCBs	13.6	4.8-20	20	17-22	11.7	0.2-31	[44]	-	16	11 - 26	8.7	0.6-20
<i>Ortho</i> -PCBs	1.7	0.5-2.9	7.8	6.6-8.5	4.3	0.3-10	[2.4]	[2.3-2.5]	6.7	3.5-11	3.23	1.0-7.4
Total TEQ	22	7.3-34	36	32-39	19	0.8-46	[16]	[2.3-44]	27	18-41	16	1.9-34

b) Other fish oil products												
Chemical	Concentrations (ng TEQ/kg oil)											
	Bottled formulations						Capsule formulations*					
	1994 n=0		1996 n=3		2000/01 n=1		1994 n=5		1996 n=6		2000/01 n=5	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Dioxins	-	-	2.3	0.6-4.8	0.8	-	14.4	1.3-44	2.3	0.3-6.9	1.9	0.2-6.3
Non- <i>ortho</i> -PCBs	-	-	5.1	1.0-10	1.7	-	5.0	0.1-14	2.3	0.09-4.8	4.5	0.8-14
<i>Ortho</i> -PCBs	-	-	2.2	0.3-3.4	0.4	-	[0.4]	[0.1-1.0]	0.8	0.09-1.3	1.3	0.3-4.6
Total TEQ	-	-	10	2.9-18	2.9	-	[17]	[0.3-61]	6.7	0.5-16	7.7	2.0-25

Notes: Combined concentrations of dioxins and dioxin-like PCBs may not equal the sum of the separate concentrations due to rounding.
n= Number of samples analysed. For bottled cod liver oils (1996 data) this included 6 samples of one branded product, the mean of which is used here.
* Only four of the eleven 1994 capsules samples were analysed for all three groups of chemicals due to insufficient sample size. Values shown in brackets [] are those derived from incomplete data sets - see text.

Table 2: Upper bound dietary exposures of consumers of recommended dosages of fish oil supplements to dioxins and dioxin-like PCBs in 2000-01 (pg WHO-TEQ/kg bodyweight/day)

a) Cod liver oil products - bottled and syrups

Age group Product code: Formulation:	Estimated dietary exposures (pg WHO-TEQ/kg bodyweight/day)					
	CLO2	CLO5	CLO 6	CLO11	CLO14	CLO16
	Bottled	Bottled	Bottled	Syrup	Bottled	Bottled
<i>From cod liver oils alone:</i>						
Institutional elderly	2.5	0.7	0.6	0.1	4.1	6.9
Free living elderly	2.1	0.6	0.5	0.1	3.6	6.0
Adults	2.5	0.8	0.6	0.1	4.2	7.1
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	3.7	1.1	0.9	0.2	N/R	10
Schoolchildren (7-10)	2.6	0.8	0.6	0.1	N/R	7.2
Schoolchildren (11-14)	1.7	0.5	0.4	0.08	5.6	4.7
Schoolchildren (14-18)	2.4	0.7	0.6	0.1	4.0	6.8
<i>From cod liver oils and average consumption of the whole diet:</i>						
Institutional elderly	4.2	2.4	2.3	1.8	5.8	8.6
Free living elderly	3.4	1.9	1.8	1.4	4.9	7.3
Adults	4.3	2.6	2.4	1.9	6.0	8.9
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	6.9	4.3	4.1	3.4	N/R	14
Schoolchildren (7-10)	5.1	3.3	3.1	2.6	N/R	9.7
Schoolchildren (11-14)	3.4	2.2	2.1	1.8	7.3	6.4
Schoolchildren (14-18)	3.8	2.1	2.0	1.5	5.4	8.2
<i>From cod liver oils and high level consumption of the whole diet:</i>						
Institutional elderly	5.4	3.6	3.5	3.0	7.0	9.8
Free living elderly	4.4	2.9	2.8	2.4	5.9	8.3
Adults	5.6	3.9	3.7	3.2	7.3	10
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	9.4	6.8	6.6	5.9	N/R	16
Schoolchildren (7-10)	7.0	5.2	5.0	4.5	N/R	12
Schoolchildren (11-14)	4.9	3.7	3.6	3.3	8.8	7.9
Schoolchildren (14-18)	4.9	3.2	3.1	2.6	6.5	9.3

Notes: Dietary exposures were estimated by multiplying the average concentrations found in the various products by the manufacturers' recommended dosages for consumption. N/R Not recommended for these age ranges. None of the products is recommended for children under 5 years old.

**Table 2 (continued): Upper bound dietary exposures of consumers of fish oil supplements to dioxins and dioxin-like PCBs
(pg WHO-TEQ/kg bodyweight/day)
b) Cod liver oil products - capsules**

Age group Product code: Formulation:	Estimated dietary exposures (pg WHO-TEQ/kg bodyweight/day)											
	CLO 4	CLO10	CLO13	CLO15	CLO17	CLO18	CLO19	CLO20	CLO21	CLO22	CLO23	CLO24
	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules	Capsules
<i>From cod liver oils alone:</i>												
Institutional elderly	0.04	0.3	1.1	0.1	0.2	0.1	0.2	0.3	0.2	0.07	0.02	0.1
Free living elderly	0.03	0.2	1.0	0.09	0.2	0.1	0.1	0.3	0.2	0.06	0.01	0.09
Adults	0.04	0.3	1.1	0.1	0.2	0.1	0.2	0.3	0.2	0.08	0.02	0.1
<i>Schoolchildren:</i>												
Schoolchildren (5-6)	0.1*	N/R	3.4	0.3	0.7	N/R	N/R	N/R	0.5	0.2	0.05	0.3
Schoolchildren (7-10)	0.07*	N/R	2.3	0.2	0.5	N/R	N/R	N/R	0.4	0.2	0.04	0.2
Schoolchildren (11-14)	0.05*	0.4	1.5	0.1	0.3	0.1	0.2	0.4	0.2	0.1	0.02	0.1
Schoolchildren (14-18)	0.03*	0.3	1.1	0.1	0.2	0.1	0.2	0.3	0.2	0.07	0.02	0.1
<i>From cod liver oils and average consumption of the whole diet:</i>												
Institutional elderly	1.7	2.0	2.8	1.8	1.9	1.8	1.9	2.0	1.9	1.8	1.7	1.8
Free living elderly	1.3	1.5	2.3	1.4	1.5	1.4	1.4	1.6	1.5	1.4	1.3	1.4
Adults	1.8	2.1	2.9	1.9	2.0	1.9	2.0	2.1	2.0	1.9	1.8	1.9
<i>Schoolchildren:</i>												
Schoolchildren (5-6)	3.3*	N/R	6.6	3.5	3.9	N/R	N/R	N/R	3.7	3.4	3.3	3.5
Schoolchildren (7-10)	2.6*	N/R	4.8	2.7	3.0	N/R	N/R	N/R	2.9	2.7	2.5	2.7
Schoolchildren (11-14)	1.7*	2.1	3.2	1.8	2.0	1.8	1.9	2.1	1.9	1.8	1.7	1.8
Schoolchildren (14-18)	1.4*	1.7	2.5	1.5	1.6	1.5	1.6	1.7	1.6	1.5	1.4	1.5
<i>From cod liver oils and high level consumption of the whole diet:</i>												
Institutional elderly	2.9	3.2	4.0	3.0	3.1	3.0	3.1	3.2	3.1	3.0	2.9	3.0
Free living elderly	2.3	2.5	3.3	2.4	2.5	2.4	2.4	2.6	2.5	2.4	2.3	2.4
Adults	3.1	3.4	4.2	3.2	3.3	3.2	3.3	3.4	3.3	3.2	3.1	3.2
<i>Schoolchildren:</i>												
Schoolchildren (5-6)	5.8*	N/R	9.1	6.0	6.4	N/R	N/R	N/R	6.2	5.9	5.8	6.0
Schoolchildren (7-10)	4.5*	N/R	6.7	4.6	4.9	N/R	N/R	N/R	4.8	4.6	4.4	4.6
Schoolchildren (11-14)	3.2*	3.6	4.7	3.3	3.5	3.3	3.4	3.6	3.4	3.3	3.2	3.3
Schoolchildren (14-18)	2.5*	2.8	3.6	2.6	2.7	2.6	2.7	2.8	2.7	2.6	2.5	2.6

Notes: Dietary exposures were estimated by multiplying the average concentrations found in the various products by the manufacturers' recommended dosages for consumers of different ages.

It is assumed that parents would not give capsule formulaions to toddlers and infants.

N/R Not recommended for these age ranges. None of the products is recommended for children under 5 years old.

*CLO4 is only recommended for children (over 6 years old) in the two newer samples

*CLO23 states that higher dosages (2 or 3 times manufacturers recommended dosage (MRD)) may be taken for higher levels of "cardio-care omega-3 fatty acids".

Such patients are advised by the manufacturer not to exceed 6 times the MRD. Adults or senior citizens who took

such dosages would not exceed the UK TDI for dioxins and dioxin-like PCBs when the rest of the diet is taken into consideration.

Table 2 (continued): Upper bound dietary exposures of consumers of fish oil dietary supplements and licensed medicines to dioxins and dioxin-like PCBs (pg WHO-TEQ/kg bodyweight/day)

c) Salmon oil and all other fish oil products - capsules and bottled

Age group Product code: Formulation:	Estimated dietary exposures (pg WHO-TEQ/kg bodyweight/day)					
	FO8	FO2	FO9	FO10	SO2	SO3
	Bottled	capsules	Capsules	Capsules	Capsules	Capsules
<i>From fish oils alone:</i>						
Institutional elderly	0.4	0.06	0.04	0.1	1.6	0.1
Free living elderly	0.4	0.05	0.03	0.1	1.4	0.1
Adults	0.4	0.06	0.04	0.1	1.7	0.1
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	N/R	0.2	0.1	N/R	4.9	0.3
Schoolchildren (7-10)	N/R	0.1	0.07	N/R	3.4	0.2
Schoolchildren (11-14)	N/R	0.09	0.05	N/R	2.2	0.1
Schoolchildren (14-18)	N/R	0.06	0.04	N/R	1.6	0.1

<i>From fish oils and average consumption of the whole diet:</i>						
Institutional elderly	2.1	1.8	1.7	1.8	3.3	1.8
Free living elderly	1.7	1.4	1.3	1.4	2.7	1.4
Adults	2.2	1.9	1.8	1.9	3.5	1.9
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	N/R	3.4	3.3	N/R	8.1	3.5
Schoolchildren (7-10)	N/R	2.6	2.6	N/R	5.9	2.7
Schoolchildren (11-14)	N/R	1.8	1.7	N/R	3.9	1.8
Schoolchildren (14-18)	N/R	1.5	1.4	N/R	3.0	1.5

<i>From fish oils and high level consumption of the whole diet:</i>						
Institutional elderly	3.3	3.0	2.9	3.0	4.5	3.0
Free living elderly	2.7	2.4	2.3	2.4	3.7	2.4
Adults	3.5	3.2	3.1	3.2	4.8	3.2
<i>Schoolchildren:</i>						
Schoolchildren (5-6)	N/R	5.9	5.8	N/R	11	6.0
Schoolchildren (7-10)	N/R	4.5	4.5	N/R	7.8	4.6
Schoolchildren (11-14)	N/R	3.3	3.2	N/R	5.4	3.3
Schoolchildren (14-18)	N/R	2.6	2.5	N/R	4.1	2.6

Notes: Dietary exposures were estimated by multiplying the average concentrations found in the various products by the manufacturers' recommended dosages for consumers of different ages. It is assumed that parents would not give capsule formulaions to toddlers and infants.
N/R Not recommended for these age ranges. None of the products is recommended for children under 5 years old.

ANNEX I

Concentrations of dioxins and dioxin-like PCBs in individual retail samples of fish oil dietary supplements

Sample Code	Product code	Description	Formulation	Size (g or ml)	Lot/Batch No.	Purchase date	Best before date	Retailer	Concentration (ng WHO-TEQ/kg fat basis)		
									Dioxins	PCBs	Total
5897	CLO17	Tesco cod liver oil High Strength 1000mg capsules (one a day)	Capsule		35250	16/10/2000	Jul-02	Tesco, York (16.10.00)	4.84	9.79	14.63
5898	CLO19	Sainsbury's cod liver oil one a day capsules 550mg	Capsule		35643	16/10/2000	Jul-02	Sainsbury's Fossbank, York	4.58	13.44	18.02
5899	CLO18	Asda cod liver oil 525mg capsules	Capsule		L48711	16/10/2000	Jul-03	ASDA, York	1.52	11.35	12.87
5900	CLO15	Holland and Barrett (naturally inspired) Cod liver oil with multivitamins capsules	Capsule		4477001	16/10/2000	May-03	Holland & Barrett, York	2.54	9.65	12.19
5901	CLO16	Holland and Barrett pure cod liver oil 250mls	Bottled	250 ml	L0229	16/10/2000	Aug-02	Holland & Barrett, York	4.55	41.46	46.01
5902	CLO5	Seven Seas pure cod liver oil (ocean gold) 450mls [LM]	Bottled	450 ml	301696	16/10/2000	Jul-03	Boots, Coney Street, York	0.38	2.86	3.24
5903	CLO4	Seven Seas pure cod liver oil (ocean gold) capsules. 320mg	Capsule		301491	16/10/2000	Jun-03	Boots, Coney Street, York	0.85	3.49	4.34
5908	FO2	Seven Seas pulse high strength concentrated fish oils capsules	Capsule		300097	16/10/2000	Jan-03	Superdrug, York	0.23	3.01	3.24
5909	FO9	Superdrug pure fish oil with omega-3 550mg capsules	Capsule		32465	16/10/2000	Feb-03	Superdrug, York	0.86	1.12	1.98
5910	CLO13	Superdrug pure cod liver oil 340mg capsules	Capsule		29818	16/10/2000	Dec-02	Superdrug, York	5.90	27.65	33.55

ANNEX I (continued)

Concentrations of dioxins and dioxin-like PCBs in individual retail samples of fish oil dietary supplements

Sample Code	Product code	Description	Formulation	Size (g or ml)	Lot/Batch No.	Purchase date	Best before date	Retailer	Concentration (ng WHO-TEQ/kg fat basis)		
									Dioxins	PCBs	Total
5911	CLO14	Superdrug pure cod liver oil with vitamins A, D & E lemon flavour 300mls	Bottled	300 ml	300909	16/10/2000	Apr-03	Superdrug, York	5.29	22.04	27.33
6465	CLO21	GNC Cod liver oil, one a day 550mg Capsules	Capsule		01059A	24/08/2001	Aug-03	General Nutrition Centres, Europa Park, Radcliff, Manchester	6.47	13.27	19.74
6466	CLO22	GOLDSHIELD Natural Care Cod Liver Oil capsules 400 mg	Capsule		5022	April-May 2001	May-03	Goldshield Healthcare Direct, PO Box 789, Thornton Heath CR7 7WY	0.87	4.79	5.66
6467	FO10	Vitamin World Naturally Inspired EPA Natural Fish oil 1000mg High in Omega-3 fatty acids, Cholesterol free 250 softgel capsules	Capsule		46724C1	April-May 2001	Aug-03	Vitamin World Inc., Oakdale, N.Y., 11769 USA	0.49	2.25	2.74
6468	FO8	Seven Seas Maxepa Liquid 150mls [LM]	Bottled	150 ml	301290	April-May 2001	May-03	Moss Chemist, York	0.77	2.13	2.90
6469	CLO24	Healthchecks Pure cod liver oil one a day capsules, 400mg	Capsule		L89274	April-May 2001	Aug-03	Poundstretcher West Yorkshire BD17 7YS	5.11	11.13	16.24
6470	CLO20	SAFEWAY Cod liver Oil 550mg capsules	Capsule		41964	08/08/2001	Jan-03	Safeway, Acomb	3.92	12.92	16.84

Concentrations of dioxins and dioxin-like PCBs in individual retail samples of fish oil dietary supplements

ANNEX I (continued)

Sample Code	Product code	Description	Formulation	Size (g or ml)	Lot/Batch No.	Purchase date	Best before date	Retailer	Concentration (ng WHO-TEQ/kg fat basis)		
									Dioxins	PCBs	Total
6471	CLO6	Seven Seas High strength pure Cod liver oil 150ml	Bottled	150 ml	310925	08/08/2001	Feb-04	Superdrug, Acomb	0.61	3.11	3.72
6472	CLO6	Seven Seas High strength pure Cod liver oil 300ml	Bottled	300 ml	311313	08/08/2001	Mar-04	Safeway, Acomb	0.93	5.07	6.00
6473	CLO6	Seven Seas High strength pure Cod liver oil 300ml	Bottled	300 ml	311138	08/08/2001	Mar-04	Safeway, Acomb	0.50	3.13	3.63
6474	CLO5	Seven Seas pure Cod liver oil 170ml [LM]	Bottled	170 ml	311655	08/08/2001	May-04	Superdrug, Acomb	0.73	5.17	5.9
6475	CLO5	Seven Seas pure Cod liver oil 300ml [LM]	Bottled	300 ml	311362	08/08/2001	Apr-04	Safeway, Acomb	0.53	4.46	4.99
6476	CLO5	Seven Seas pure Cod liver oil 450ml [LM]	Bottled	450 ml	311757	08/08/2001	May-04	Superdrug, Acomb	0.57	5.10	5.67
6477	CLO4	Seven Seas pure Cod liver oil, capsules, 0.32ml [LM]	Capsule		311697	08/08/2001	May-04	Superdrug, Acomb	0.70	2.42	3.12
6478	CLO4	Seven Seas pure Cod liver oil, capsules, 0.32ml [LM]	Capsule		311439	08/08/2001	Apr-04	Boots, Front Street, Acomb	0.73	2.92	3.65
6479	CLO4	Seven Seas pure Cod liver oil, capsules, 320mg	Capsule		301985	08/08/2001	Aug-03	Boots, Kings Sq., Yor	0.18	3.04	3.22
6480	SO2	Holland and Barrett Naturally inspired Salmon oil 1000mg Capsules	Capsule		48732-03	08/08/2001	Dec-03	Holland & Barret, Coney St., York	6.34	18.77	25.11

ANNEX I (continued)

Concentrations of dioxins and dioxin-like PCBs in individual retail samples of fish oil dietary supplements

Sample Code	Product code	Description	Formulation	Size (g or ml)	Lot/Batch No.	Purchase date	Best before date	Retailer	Concentration (ng WHO-TEQ/kg fat basis)		
									Dioxins	PCBs	Total
6481	CLO2	Boots Cod liver oil 200ml Bottle	Bottled		1GG3	09/08/2001	Aug-02	Boots, Monks Cross, York	8.40	24.56	32.96
6710	CLO10	Boots Cod liver oil One a Day 497mg capsules	Capsule		14161M	29/11/2001	Mar-03	Boots, Acomb	7.87	24.90	32.77
6711	CLO11	Seven Seas, Orange Syrup & Cod Liver Oil 150ml [LM]	Syrup	150 ml	312820	29/11/2001	Apr-03	Tesco's, Clifton Moor, York	0.32*	0.45*	0.77*
6712	CLO6	Seven Seas High Strength pure Cod Liver Oil- Ocean Gold ULTRA PURE 150ml	Bottled	150 ml	312332	29/11/2001	Aug-04	Superdrug, Acomb	0.22	1.81	2.03
6731	SO3	Salmon Oil 500mg capsules Nature's Aid Health Products	Capsule		363810	21/12/2001	Feb-03	York Nut Centre, Market Street, York	1.33	4.00	5.33
6995	CLO23	Healthspan Cod liver oil 570mg high strength	Capsule		92729	03/02/2002	Jun-03	Healthspan, Guernsey	0.31	1.54	1.85

Notes: * Syrup formulation. Concentrations reported on a fresh weight basis.

[LM = Licensed medicine