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Evaluation of Contaminants in Meat and Blubber of Minke Whales

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Evaluation of Contaminants in Meat and Blubber of Minke Whales in Relation to Regulatory Limits Applied to Food and Human Intake

1 Background

In spite of the International Whaling Commission (IWC) moratorium on all commercial whaling two countries, Norway and Japan, continue whaling. The Norwegian whalers target the minke whale (*Balaenoptera acutorostrata*). Several studies have shown the presence of various halogen-organic contaminants (HOCs) in the meat and blubber of minke whales. Simmonds et al. (1994) investigated the contamination of pilot whale blubber and meat and concluded that whale blubber can significantly contribute to the body burden with organochlorines in the Faroe Islands population and that tolerance values for food are exceeded in case of polychlorinated bihphenyls and other organochlorines. Meat from the Norwegian minke hunt is marketed in Norway, but the main driver for the continuation of the Norwegian whaling industry is the prospect of exporting whale products to Japan, where both whale meat and blubber are consumed.The guidance values for tolerable intake or limit values in foodstuffs of some selected HOCs (based on their identification in minke whale meat and blubber) are compared with the analytical data of HOC concentrations in these tissues as determined in analyses commissioned by Greenpeace and conducted by independent laboratories. Finally, the results and the significance of the comparisons are discussed.

2 Characterization of HOCs considered

The following halogen-organic contaminants (HOCs) are considered:

- Polychlorinated biphenyls (PCBs)
- 1,1,1-Trichloro-2,2-bis-(4-chlorophenyl)-ethane (p-,p'- DDT) and metabolites
- Chlorinated paraffins (CPs)
- Brominated Flame Retardants (BFR)

2.1 PCBs

The PCBs are a group of 209 related substances (congeners) differing widely in their properties and toxic potential. Their production and use is nowadays forbidden. In former times, they were used widely as dielectric fluids in electrical transformers and capacitors, as components in hydraulic and heat transfer fluids and in sealing compounds. Commercial mixtures, marketed under some 58 trade names generally had a chlorine content of between 20 and 68 %. The Aroclor range manufactured by Monsanto was probably the most widely used range of technical mixtures.

Observed effects in humans are either the result of occupational exposure to PCBs or of the general public exposure of contaminated foodstuff or to environmental mixtures in food. In the latter case, the composition of congeners usually differs from that of the commercial Aroclor mixtures. Animal experiments were done with commercial mixtures, simulated environmental mixtures and individual congeners.

2.2 DDT and metabolites

In former times, DDT was frequently used as an insecticide. Nowadays, its application is restricted in industrial countries, but it is still used in developing countries. The observed effects in humans are either the result of occupational exposure to DDT or of the general public exposure to environmental mixtures. The human environmental exposure occurs mostly via food containing a mixture of DDT and different metabolites (DDD, DDE).

2.3 Chlorinated Paraffins (CPs)

Chlorinated paraffins (CPs) are used as flame retardants, plasticizers and paint additives. They are a heterogeneous class of compounds with 10–38 carbons and 10-70 % chlorine content. They are subdivided in 6 groups depending on the length of the carbon chains (short 10–13, intermediate 13–17 and long 17– >30) and the degree of chlorination (low < 50 % and high > 50 %). Studies on animals using technical mixtures represent most of the existing toxicological data.

2.4 Brominated Flame Retardants (BFR)

The BFR are added to polymers and textiles for their flame retardant properties. The focus in this study is on BFR of the polybrominated diphenyl ether (PBDE) type, but there are a lot of other substances used as BFR. According to a bromination pattern ranging from one to ten bromine atoms per molecule, there are a lot of different

substances in this class. Forty-six different isomers of pentabromodiphenylether (PeBDE) are known. Commercial mixtures of PeBDE vary in their composition of the different isomers of PeBDE and are contaminated with other PBDE (up to 40 % of tri- to hexa-BDE). Toxicity data for PeBDE result from experiments with chemical mixtures of PeBDE, which also contain significant amounts of tri-, tetra- and hexabrominated diphenyl ethers. On the basis of structural similarity to PCBs, it is suspected that there is a changing pattern of environmental occurrence of the different isomers, which results from differences in environmental transformation and degradation.

3 Guidance and limit values for tolerable intake

This chapter summarizes existing guidance and limit values for tolerable intake of the HOCs (on basis of body dose, maximal tolerable concentrations in food are listed separately in chapter 4). Japanese guidance values for several compounds are obviously derived according to the ADI- or TDI-approach of the World Health Organisation (WHO), in most cases using the same values (Okada and Peterson, 2000). For PCBs and DDT (incl. metabolites) Japanese ADI-values have been stated to be both at 5 µg/kg • d (JMWL, 1972). A search in the literature gave no further information about these values. The following tables are summarizing the evaluations performed by World Health Organisation (WHO), US Environmental Protection Agency (EPA), the German Umweltbundesamt (Federal Environmental Agency, FEA), and others on the HOCs regarded here.

Guidance and limit values for polychlorinated biphenyls			
Guidance / limit value	**Value**	**Remarks**	**Reference**
Reference dose (U.S. EPA)	70 ng/kg • d 20 ng/kg • d	Aroclor 1016 Aroclor 1254 for non-carcinogenic effects	EPA, 2002
Tolerable absorbed dose (German FEA)	15 ng/kg • d	Uncertainty of quantification of carcinogenic effects	Hassauer and Kalberlah, 1999

Remark: The WHO has established a Tolerable Daily Intake only for dioxin-like compounds (1 – 4 pg/kg • d TCDD-equivalents; WHO, 1999; Schrenk and Fürst, 1999). If PCBs are evaluated by this value, only the dioxin-like effects of PCBs are considered.

This table provides the basis for the comparisons with the intake of PCBs by minke whale meat or blubber. These values are based on the effects of technical PCB-mixtures. The difference between the values of the German FEA and the reference dose of the EPA for Aroclor 1254 is due to rounding only. Different formulations of PCB lead to a range of reference doses of factor 3.5, reflecting differences in the congener profile and hence toxicity. Unlike the EPA the German FEA did not discriminate between PCB-mixtures of different chlorine content. Unfortunately, the relevance of guidance values which are based on technical mixtures to the congener profiles found in environmental samples (which itself can differ remarkably) is somewhat questionable. The evaluation of PCBs on the basis of dioxin-like PCBs is generally complicated by additional, not dioxin-like effects of the PCBs.

Guidance and limit values for DDT (and metabolites)			
Guidance / limit value	**Value**	**Remarks**	**Reference**
Tolerable daily intake (WHO)	10 µg/kg • d [1)]	Provisional value	IPCS, 2001
Reference dose (U.S. EPA)	0,5 µg/kg • d	for non-carcinogenic effects	EPA, 2002
Tolerable absorbed dose (German FEA)	1 µg/kg • d	Provisional value, Uncertainty of quantification of carcinogenic effects	Schneider and Kalberlah, 1999

Remark: values for DDT were originally derived on the basis of effects of exposure to pure DDT, but are mostly also taken for exposure to DDT and the sum of metabolites (e.g. sum of p,p'- und o,p'-DDT, p,p'-DDE and p,p'-DDD)

[1)]The Codex Alimentarius for pesticides (WHO/FAO, 2002) still cites the former valid PTDI of 0,02 mg/kg • d, which was lowered to 0,01 mg/kg • d in 2001 (IPCS, 2001).

Guidance and limit values for CPs			
Guidance / limit value	**Value**	**Remarks**	**Reference**
Tolerable daily intake (WHO)	0,1mg/kg • d	Derived separately for differing chain length, identical TDI	WHO, 1996
Others: Reference dose (US National Research Council)	0,3 mg/kg • d		NRC, 2000

Guidance and limit values for PeDBE			
Guidance / limit value	**Value**	**Remarks**	**Reference**
Reference dose (U.S. EPA)	2 µg/kg • d	for non-carcinogenic effects of a technical mixture	EPA, 2002

4 Limit values for foodstuffs

Limit values for fish or marine mammals were only found for PCBs and DDT (incl. metabolites).

4.1 PCBs

FDA (U.S. Food And Drug Administration): Tolerances for PCB residues (ATSDR, 2000):

0,2 mg/kg in infant and junior foods

2 mg/kg in fish and shell fish (edible portion)

(3 mg/kg in red meat (fat basis, action level))

4.2 DDT and metabolites (values for the sum of p,p'- und o,p'-DDT, p,p'-DDE and p,p'-DDD)

WHO: Codex Alimentarius for pesticides (WHO/FAO, 2002):

5 mg/kg fat in meat of mammals or sea mammals

Remark: basis is a PTDI of 0,02 mg/kg • d, meanwhile updated to 0,01 mg/kg • d (see chapter 3)

FDA: Action level (ATSDR, 1994):

5 mg/kg fat in fish

EU-MRL: Maximum Residue Limits for Pesticides Residues in Food Commodities (EU, 2002):

1 mg/kg in (various) meats

0,04 mg/kg in butter, other fats and oils

Remark: These limit values are not derived on toxicological data, but on "good agricultural practice".

5 Concentrations of HOCs in whale meat and blubber

The data for the contents of HOCs in whale meat and blubber (Minke whale, Balaenoptera acutorostrata) come from the publication of Kleivane and Skaare (1998) and analytical data determined by RIVO – Netherlands Institute for Fisheries Research (2002) and were kindly provided by Greenpeace.

The concentrations of PCBs in the publication of Kleivane and Skaare (1998) were published as undifferentiated sum of 18 PCB-congeners (66, 99, 101, 105, 110, 118, 128, 138, 149, 153, 156, 157, 170, 180, 187, 194, 206, 209) and for DDT as undifferentiated sum of p,p'- und o,p'-DDT, p,p'-DDE and p,p'-DDD).

Sixteen different BDE were listed separately, together with other brominated flame retardants. The sum of the 16 BDE (designated here as PBDE) were used for comparison with guidance and limit values.

Contents in whale meat

Short chain CPs (C10 - C13) were present in whale meat, but the levels were below the limit of quantification (< 7,2 µg/kg). The medium and long chain CPs (C > 14) were not detectable (RIVO, 2002).

The sum of PBDE in meat was determined in 2 separate samples (RIVO, 2002, no further information about age or sex). One of these samples did not contain BDE above the limit of detection (0,1 µg/kg). The result of the other sample is listed in the following table (values < 0,1 were rated as 0).

Contents of HOCs in whale meat			
Substance	**PCB and DDT**	**CPs**	**PBDE**
Concentration		µg/kg wet weight	µg/kg wet weight
value	No data	Below limit of quantification	4,9

Contents in whale blubber

Kleivane and Skaare (1998) analysed four different groups of whales separately for PCB- and DDT-contamination (15 male and 13 female juveniles as well as 22 male and 22 female adult animals). This leads to a range of mean values for PCBs and DDT which is given in the following table. The lowest mean values for both pollutants were found in female adults (possibly due to excretion during lactation), the highest in male adults. PCBs and DDT in blubber were also analysed in another study on 7 minke whales (RIVO, Greenpeace). The concentrations per lipid weight were within in the range of values which were determined by Kleivane and Skaare (1998), with the exception of one lower value for PCBs (but this was obtained by an incomplete analysis of the congeners) and one slightly lower for DDT. These values are not listed separately.

Short chain CPs (C10 - C13) were present, but the levels were below the limit of quantification in whale blubber (< 290 µg/kg). The medium and long chain CPs (C > 14) were not detectable (RIVO, 2002). PBDE were determined in 5 separate samples (RIVO, 2002), which are given as range in the following table and are transformed to one mean value. With PBDE and CP the contamination of whale blubber is higher than that of whale meat.

Contents of HOCs in whale blubber				
Substance	**PCBs**	**DDT**	**CPs**	**PBDE**
Concentration	mg/kg lipid weight	mg/kg lipid weight	µg/kg wet weight	µg/kg wet weight
mean value (range of mean values)	3,7 (2,3 – 5,8)	2,5 (1,5 – 3,9)	no data	160,1
Total range	0,6 – 20,8 (corresponding to 0,5 – 18,7 on a wet weight basis)	0,5 - 14,8 (corresponding to 0,5 – 13,3 on a wet weight basis)	Below limit of quantification	13,0 – 573,7

Kleivane and Skaare (1998) mentioned a lipid content of 71 - 97 % in minke whale blubber. Obviously the fat content of minke whale blubber can vary remarkably. The other sources (EU, 2001; RIVO, 2002) report an even greater range of lipid contents of 14 – 83 % in minke whale blubber. For calculation on a wet weight basis (see above) a fat content of 90 % was used.

In EC (2001) the reported sum of PeBDE and Te(tetra)BDE in minke whale blubber is 122 µg/kg and so within the range of values reported above.

6 Background exposure

The data for background exposure are listed in the following table. The values represent typical exposure of European or U.S. American adults. The references are Hassauer and Kalberlah (1999) for PCBs, Schneider and Kalberlah (1999) for DDT and EC (2001) for PBDE. Children could be exposed to even higher values through mother's milk.

Typical oral background exposure to HOCs (in ng/kg • d)			
PCBs	**DDT (incl. metabolites)**	**CPs**	**PBDE**
60 – 120	< 30	no data	35 – 40

The U.S. American and German guidance values for tolerable intake of PCBs are 20–70 ng/kg • d (EPA, 2002) and 15 ng/kg • d (Hassauer and Kalberlah, 1999), respectively (see chapter 3). Considering the background of 60–120 ng/kg • d, it is obvious that the typical background alone exceeds these guidance values and any further exposure is undesirable.

7 Calculation of the intake of HOCs of whale meat and/or blubber in relation to guidance values and background

The purpose of this study was to assess

- what amount of consumed meat or blubber exceeds existing guidance or limit values and whether food contaminant levels are exceeded (international, Japanese)
- what exposure results (in percent of guidance or limit values) from consumption of 50 g whale meat or blubber.

7.1 Which amount of whale meat and/or blubber exceeds the guidance or limit values for HOCs and which food contaminant levels are exceeded?

PCBs:. Considering the range of PCB-contamination in whale blubber of 0,6 - 20,8 mg/kg fat (at about 90 % lipid content corresponding to 0,5 - 18,7 mg/kg blubber) and neglecting the background, the guidance value of 15 ng/kg • d (900 ng/d for a Japanese adult of 60 kg) is reached by the uptake of only 0,05 - 1,8 g. The reference dose of the EPA of 70 ng/kg • d (4200 ng/d) is reached by the uptake of 0,2 - 8,4 g.

The Japanese ADI-value of 5 µg/kg • d (5000 ng/kg • d) is much higher than the guidance values mentioned above and is obviously not supported by up-to-date toxicological information on PCBs (EPA, 2002; Hassauer and Kalberlah, 1999). Because of this and because no further details are given in relation to the Japanese ADI, it should not be considered as a valid guidance level. But even this value is reached by consumption of only 16 g of the highest PCB-contaminated whale blubber (20,8 mg/kg fat, at about 90 % lipid content corresponding to 18,7 mg/kg blubber). At the lowest degree of contamination, the ADI is reached by consumption of an amount of 550 g. These amounts lead to intakes of about 300 µg/d, which represents the ADI-value (5 µg/kg • d for a Japanese adult with an estimated body weight of 60 kg).

An evaluation of the dioxin-like effects of the PCBs in comparison to the TDI-value of 1 – 4 pg/kg • d TCDD-equivalents for dioxin-like compounds (WHO, 1999; Schrenk and Fürst, 1999) is not possible, since only 4 of 12 relevant dioxin-like PCBs are listed in the publication of Kleivane and Skaare (1998) which report the highest contamination levels.

The tolerance value of the FDA for foodstuff residues of 0,2 mg/kg (for infant and junior food) is exceeded for all samples and the tolerance value of 2 mg/kg for fish is exceeded for mean and higher values of PCB-concentrations in whale blubber. The highest measured concentrations (18,7 mg/kg) are more than 90-times the infant food value and still 9,4-times the value for edible fish parts.

The data for PCBs are summarized in the following table.

Comparison of PCB contamination and guidance or limit values			
Guidance values for tolerable intake reached by consumption of x g whale blubber per day			**Food contaminant levels exceeded?**
	Most conservative value	**Least conservative value (unsure)**	
Lowest contamination	1,8	(550)	FDA-tolerance value for infant and junior food exceeded
Highest contamination	0,05	(16)	FDA-values for infant and junior food and for fish exceeded

DDT: The guidance values for tolerable intake of DDT (incl. metabolites) range from 0,5 µg/kg • d (EPA, 2002) to 10 µg/kg • d (IPCS, 2001) i.e. 30 - 600 µg/d for a Japanese adult of 60 kg. The range of the reported values for DDT in whale blubber is 0,5 – 14,8 mg/kg lipid. Based on a lipid content of about 90 % in whale blubber, this corresponds to DDT-concentrations of 0,5 -13,3 mg/kg in whale blubber. At the lowest DDT-concentration reported 67 g – 1333 g whale blubber could be eaten before the guideline values are reached (depending on the range of existing guidance values). But at the highest DDT-concentration reported, amounts of only 2,3 – 45 g whale blubber exceed the reported guidance levels.

There are several limit values for DDT concentrations (incl. metabolites) in foodstuff. The value in the Codex Alimentarius of the WHO (WHO/FAO, 2002) and also the FDA value is 5 mg/kg fat, which is somewhat higher than the mean values of DDT contamination. The value in the Codex Alimentarius, however, is based on an ADI (0,2 µg/kg • d) which was revised in the meantime (0,1 mg/kg • d, IPCS, 2001).

The EU-MRL for various meat is 1 mg/kg, for fat 0,04 mg/kg. If the blubber is regarded as fat, all sources exceed the corresponding MRL (up to 333-times the EU-MRL for fat). Even if it is regarded as meat, only the lowest contaminations found do not exceed the corresponding EU-MRL. The higher contaminations exceed the EU-MRL for meat up to 13-times. The higher values of the WHO and FDA are exceeded up to 3-times at the highest reported concentrations.

The data for DDT are summarized in the following table.

Comparison of DDT contamination and guidance values				
Guidance values for tolerable intake reached by consumption of x g whale blubber per day			**Food contaminant levels exceeded?**	
	Most conservative value	**Least conservative value**	**Levels for meat**	**Levels for fat**
Lowest contamination	67	1333	Not exceeded	Exceeded
highest contamination	2,3	45	Exceeded	Exceeded

CPs: The guidance values for tolerable intake of CPs range from 0,1 mg/kg • d (WHO, 1996) to 0,3 mg/kg • d (NRC, 2000). Short chain CPs (C10 - C13) were present in concentrations below the limit of quantification in whale meat and blubber. The medium and long chain CPs (C > 14) were not detectable (RIVO, 2002). On the basis of the assumption of contamination at the highest possible concentration of 7,2 µg/kg in meat and 290 µg/kg in blubber the guidance values for tolerable intake (6 – 18 mg/d for a Japanese adult) are only exceeded by consumption of unrealistic high amounts of meat or blubber.

PBDE: The reference dose of the EPA for PeBDE is 2 µg/kg • d (EPA, 2002), that means 120 µg/d for a Japanese adult. Whale meat (4,9 µg/kg PBDE) could be eaten in unrealistic amounts in the kg-range to reach this guidance value. The intake of PBDE following consumption of whale blubber with contaminations ranging from about 12 – 550 µg/kg reaches the reference dose only at amounts of 218 g – 10 kg whale blubber.

7.2 What dose results from a consumption of whale meat or blubber?

The doses taken up by consumption of a meal of 50 g (0,05 kg) are listed in the following table. They are calculated as follows:

concentration • 0,05 kg (meal) : 60 kg body weight

(assumed weight of a Japanese adult), transformed to the unit ng/kg • d. The concentrations of HOCs refer to the values given in chapter 5. The concentrations of PCBs and DDT in whale blubber were given on a mg/kg lipid weight basis, these values were first transformed to mg/kg blubber according to the information of Kleivane and Skaare (1998) of a lipid content of about 90 % in mink whale blubber.

Intake of HOCs (in ng/kg • d) by consumption of 50 g whale meat or blubber					
		PCBs	**DDT (incl. metabolites)**	**CPs**	**PeBDE**
meat		no data	no data	< 6	4
blubber	minimal	450	375	-	11
	mean	2775	1875	-	139
	maximal	15600	11100	< 242	478

These exposure levels can be compared with the guidance or limit levels and background values (chapter 3).

PCBs: The PCB-intake by a meal is 450 to 15600 ng/kg • d, depending on the reported concentrations in whale blubber. The (more conservative) guidance values for PCBs are 15 (Hassauer and Kalberlah, 1999) and 20 – 70 ng/kg • d (EPA, 2002), respectively. Therefore, the intake by consumption of 50 g blubber even at the lowest contamination level considerably exceeds these guidance values. Doses of 450 – 15600 ng/kg • d represent intakes of 30- to > 1000-times the most conservative guidance value. Consumption of 50 g whale blubber with a PCB-contamination

greater than 6 mg/kg blubber (6,7 mg/kg lipid) also exceeds the much higher Japanese ADI-value (5000 ng/kg • d).

DDT: The DDT-intake by a meal is 375 – 11100 ng/kg • d, depending on the range of reported concentrations in whale blubber. The reference doses are 0,5 to 10 µg/kg • d = 500 – 10000 ng/kg • d (see chapter 3). The intake by a meal of 50 g blubber thus exceeds the more conservative guidance values of EPA (2002; 500 ng/kg • d) and Schneider and Kalberlah (1999; 1000 ng/kg • d), respectively, at DDT-concentrations greater than 0,6 and 1,2 mg/kg whale blubber. Highest observed contaminations exceed the EPA value 22-times. The highest value (TDI of the WHO: 10000 ng/kg • d) is exceeded at blubber concentrations greater than 12 mg/kg.

CPs: The CP-concentrations in whale meat or blubber are not exactly to quantify. If the maximal contamination level is assumed, the intake would be 242 ng/kg • d or less. This is well below the guidance values for tolerable intake of 0,1 - 0,3 mg/kg • d (see chapter 3).

PBDE: The PBDE-data show a margin between the intake (4 to 478 ng/kg • d by a meal, background 35 – 40 ng/kg • d) and the guidance value of the EPA for technical mixtures of PeBDE (2 µg/kg • d = 2000 ng/kg • d). Therefore, tolerable guidance levels for intake are not exceeded by the contamination of whale meat or blubber reported by RIVO (2002).

8 Summary

Several studies showed the presence of various halogen-organic contaminants (HOCs) in meat and blubber of minke whales, namely polychlorinated biphenyls (PCBs), DDT, and metabolites, chlorinated paraffins (CPs) and polybrominated diphenyl ethers (PBDE), especially pentabrominated derivates (PeBDE). The aim of the study was to compare the levels of contamination with guidance and limit values for tolerable intakes and food residues.

Estimating the amounts of whale meat and blubber that can be consumed which do not exceed guidance values

On the basis of the concentrations of HOCs in whale meat or blubber the amount of these contaminants can be estimated at which the tolerable intake of HOCs are not exceeded.

The PCB-data show that the more conservative values for tolerable intake are exceeded by consumption of very small amounts of whale blubber (both for high and low contamination). Even the least conservative Japanese ADI-value is exceeded by consumption of only 16 g of highly contaminated blubber.

The limit values for foodstuffs for PCB of the FDA for infant food (0,2 mg/kg wet weight) are exceeded for whale blubber even with the lowest contaminations. The highest reported concentrations exceed this value for infant food 90-times. Also the value for fish (2 mg/kg wet weight) is exceeded at relatively low contamination levels (reported range: 0,5 – 18,7 mg/kg wet weight) with a maximum of 9,5-times the food limit value for fish.

Comparison of PCB contamination and guidance or limit values			
Guidance values for tolerable intake reached by consumption of x g whale blubber per day			**Food contaminant levels exceeded?**
	Most conser-vative value	**Least conservative value (unsure)**	
Lowest contamination	1,8	(550)	FDA-tolerance value for infant and junior food exceeded
Highest contamination	0,05	(16)	FDA-values for infant and junior food and for fish exceeded

The more conservative values for tolerable intake of DDT are also exceeded by consumption of few grams of highly contaminated whale blubber. The amounts that can be consumed until the guidance values for tolerable intake of DDT are exceeded are somewhat higher than the amounts concerning PCB.

For DDT the higher food limit values (WHO, FDA: 5 mg/kg fat) are exceeded by contamination in the medium range of the reported concentrations (0,5 – 14,8 mg/kg fat, 0,5 – 13,3 mg/kg wet weight). The EU-MRL for various meats is 1 mg/kg, for fat 0,04 mg/kg (on wet basis). If the blubber is regarded as fat, all sources exceed the

corresponding MRL, maximal up to 333-times. Even if it is regarded as meat, only the lowest contaminations found do not exceed the corresponding EU-MRL.

Comparison of DDT contamination and guidance values				
Guidance values for tolerable intake reached by consumption of x g whale blubber per day			**Food contaminant levels exceeded?**	
	Most conservative value	**Least conservative value**	**Levels for meat**	**Levels for fat**
Lowest contamination	67	1333	Not exceeded	Exceeded
Highest contamination	2,3	45	Exceeded	Exceeded

For PBDE there are data reported for both meat and blubber. The reference dose by the EPA (2002) is reached only at high consumption amounts of whale meat and blubber. There are no food limit values.

CP are detected in amounts which are not exactly to quantify. But it can be estimated that even with the upper range of the contamination the reference doses for tolerable intake are only exceeded by consumption of unrealistic high amounts of whale meat or blubber. There are no food limit values.

Calculating the intake of HOCs by a meal

On basis of the assumption of a meal of 50 g whale meat or blubber, the corresponding intake of HOCs was calculated. The results are listed in the following table.

Intake of HOCs (in ng/kg • d) by a 50 g whale meat or blubber					
		PCBs	**DDT (incl. metabolites**	**CPs**	**PeBDE**
Meat		no data	no data	less than 6	4
blubber	minimal	450	375	-	11
	mean	2775	1875	-	139
	maximal	15600	11100	less than 242	478

Comparison with the corresponding guidance levels shows the following relations:

PCBs: The (more conservative) guidance values for tolerable intake of PCBs of 15 – 70 ng/kg • d are considerably exceeded by these intake values. Doses of 450 – 15600 ng/kg • d represent intakes of 30- to > 1000-times the most conservative guidance value.

DDT: The intake by meals exceeds the more conservative guidance values for tolerable intake of 500 – 1000 ng/kg • d at DDT-concentrations greater than 0,6 - 1,2 mg/kg whale blubber. Consumption of 50 g whale blubber at the highest observed contamination level exceed the EPA value 22-times.

CPs: The intake of the CPs cannot be estimated exactly, the intake by a meal is less than 6 ng/kg • d for meat and less than 242 ng/kg • d for blubber. So there is a great margin between the guidance values for tolerable intake of 100 000 – 300 000 ng/kg • d and the expected exposure of maximal 242 ng/kg • d.

PBDE: The PBDE-data show that there is still a margin between the guidance value of 2000 ng/kg • d and the sum of intake (4 to 478 ng/kg • d by a meal of whale meat or blubber).

9 Conclusions

Whale blubber is contaminated with various halogen-organic contaminants.

The most conservative guidance value for tolerable intake of PCB is exceeded by consumption of only 0,05 g of the highest contaminated blubber. Even the least conservative value is exceeded by consumption of only 16 g of the blubber of the highest contamination level. Food limit values for PCB are exceeded up to 90-times.

The most conservative guidance value for tolerable intake of DDT is exceeded by consumption of only 2,3 g of the highest contaminated blubber. Even the least conservative value is exceeded by consumption of 45 g of the blubber of the highest contamination level. Food limit values for DDT are exceeded 3-times (WHO, FDA-value) to 333-times (EU-value for fat).

The contaminations in whale meat (only data for CPs and PBDE) do not exceed guidance values for tolerable intake. These values are also not exceeded by CPs or PBDE in blubber.

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