Report on Contamination of Fish with Pollutants in the Catchment Area of the Rhine

Ongoing and Completed Studies in the Rhine States

(2000 – 2010)

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Internationale Kommission zum Schutz des Rheins

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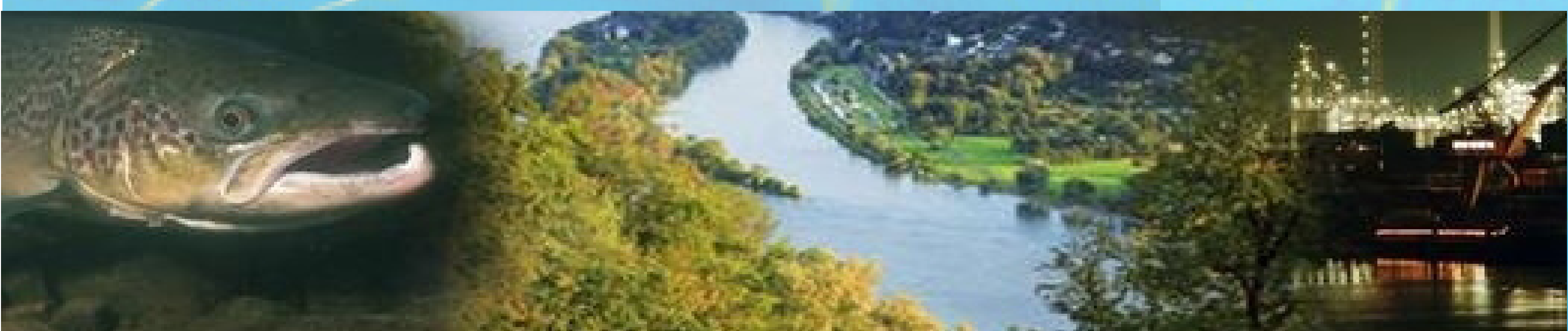

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Summary

The present report brings together data from the Rhine States, for the period 2000 to 2010, on the contamination with various pollutants of fish in that river and its tributaries. In the case of **eel**, a virtually **area-wide violation** of the **total highest value permissible under foodstuffs legislation** was determined in the Rhine and many of its tributaries for **dioxins, furans, and dioxin-like PCBs** (WHO TEQ, 12 g/g fresh weight (FW)). Eel samples from Lake Constance and a former branch of the Rhine are an exception, consistently displaying no excess. Overall, significant fluctuations in the content of dioxins and PCBs were found in all the species of fish studied. The values range from less than 1 g/g FW in the case of carp species to more than 70 g/g FW in eel. The contamination is not species-specific but depends on the pollution situation of the water body concerned at the sampling site and on the age and fat content of the individual fish.

In the course of the ICPR's **suspended matter** measurement programme (1991 to 2007), the sole dioxin-like PCB congener measured was PCB 118. The results indicate a **decrease in contamination** with PCB 118.

The limits for **indicator PCBs** under German and Dutch law are **sporadically exceeded** in the Rhine itself and in the Moselle and Main, namely in older, fat-rich eel and bream, but not in other fish species. In eel from the Delta Rhine (sedimentation area in the Waal and in the Ketelmeer), contamination of eel with indicator PCBs (6 congeners, 1978 to 2009) has **decreased significantly** since the 1980s, from values in excess of 3 mg/kg FW to values below 0.5 mg/kg FW. A similar trend is apparent in the Moselle and, to a lesser extent, in the Saar.

In the High, Upper, and Middle Rhine, 2008 was the first time that no violation of the maximum levels permissible under the (German) ordinance on maximum quantities of residue [*Rückstandshöchstmengenverordnung, RHmV*] was determined for **hexachlorobenzene (HCB)** (0.05 mg/kg FW or 0.5 mg/kg fat). These levels are still sporadically exceeded in eel in the Main area and in the Middle Rhine. In the Delta Rhine, a **major decrease** since the 1970s in HCB contamination of yellow eel was apparent, from more than 0.1 mg/kg FW to values of about 0.01 mg/kg FW. In Lake IJsselmeer, the environmental quality standard (EQS) for biota according to Directive 2008/105/EC was achieved, namely 0.01 mg/kg FW.

Studies of **perfluorinated tensides (PFTs)** found **clearly raised** quantities in particular in Rhine fish (Delta Rhine, Lower Rhine, Upper Rhine, High Rhine) of **perfluorooctanesulfonic acids (PFOS**, 3 µg/kg to more than 70 µg/kg, with occasional extreme values of up to 126 µg/kg FW; EQS proposed value: 9.1 µg/kg FW). The trend analysis in the Netherlands showed an increase since the 1970s until the mid-1990s, followed by a **decrease** to values of 7 to 58 µg/kg FW. For other PFTs, the values in the whole of the Rhine area were generally below the detection limit.

The maximum levels of **mercury** permissible under foodstuffs legislation (according to EU Regulation 1881/2006: 1 mg/kg FW for eel and 0.5 mg/kg FW for other fish species) were only **sporadically exceeded** during the reporting period; values were generally between 0.7 and 0.35 mg/kg. However, the decrease in the concentration of mercury in Rhine fish that was observed in the 1980s and 1990s has not continued. The **EQS for biota** of 0.02 mg/kg FW for mercury is exceeded comprehensively and systematically in all parts of the catchment area of the Rhine.

Despite the extensive data available, the studies concerned revealed **patterns of distribution** at no more than regional level. A **standardised procedure** for sampling through to analysis could make possible assessment of the contamination of fish **at the level of the catchment area of the Rhine**. Well-founded conclusions with **relevance for the aquatic ecosystem** would require data derived from **scientific approaches to investigation**.

1. Introduction

1.1 Objective and task

In the past few decades, extensive discharges of pollutants have led to large quantities of contaminated sediments being deposited in the Rhine and its tributaries, particularly in the sections where the flow is regulated. Despite production and use of most of these substances having been terminated, with no more direct discharges being known, sediment quality continues to be negatively affected by the presence of these substances at sites contaminated in the past, and they can be expected to continue to be present in the water bodies concerned for a long time. Old sediments can be whirled up during flooding or dredging, for example. Fish reflect the pollution of sediments. Under the Rhine Convention, ecosystem aspects are of interest to the ICPR, in particular the accumulation of pollutants in the food chain and the assessment of fish health and the ecosystem.

It was against this background that the ICPR's Strategy Group (SG) requested the Ecology Working Group (WG B) – or in fact its Fish Experts Group (EG FISH) – to first of all assemble the data available in the Rhine States for the years 2000 to 2010 so as to survey the contamination of Rhine fish (and also fish from the Rhine tributaries) with "dioxin-like PCBs" and other pollutants. The assembled data would be analysed and the trend in recent years would be described.

The aim of the present report is to provide an overview of the large-area distribution of the contamination of Rhine fish with dioxins, furans and dioxin-like PCBs, as well as indicator PCBs in the Rhine catchment area and also – insofar as this is known – to provide an overview of the trend in that contamination. Where sufficient data is available, statements would also be made regarding HCB, HCBD, PFTs and other organic pollutants as well as heavy metals, especially mercury. The trends in contamination with these substances are ecologically significant and EC Directive 2008/105/EC requires that they be monitored (for example heavy metals, HCB, HCBD).[1]

Due to the great heterogeneity of the available data, most of the data is not comparable; a textual explanation of the situation in the individual Rhine States (or the relevant German federal states) is therefore given. Reliable values for the sum of dioxins, furans and dioxin-like PCBs (WHO TEQ, see 2.2) have been provided in Appendix 5.

Between 1995 and 2000, the Member States of the ICPR also carried out coordinated programmes for measuring the contamination of fish in the Rhine, after the available Rhine fish data had been compiled and evaluated in 1990.[2] The results are summarised in Section 1.3.

Based on the combined results presented in this report, consideration will be given within the ICPR to whether there should be studies of contamination of Rhine fish in the framework of the next international Rhine measurement programme (2012/2013).

[1] Directive 2008/105/EC on environmental quality standards in the field of water policy ("WFD Priority Substances Daughter Directive"/"EQS Directive"/"Biota standard").
[2] See ICPR Report No. 124, www.iksr.org – *Documents/Archive - Technical reports*

1.2 Origin of the pollutants studied and their effect on the environment

Dioxins, furans and polychlorinated biphenyls

Polychlorinated dibenzo-p-dioxins (PCDDs) and **dibenzofurans (PCDF)** are formed as by-products of combustion processes and industrial processes in the presence of chlorine. In the past, the main emission sources were plants involving chlorine chemistry, domestic waste incineration (a source that has now been greatly reduced), power generation, and metal smelting. Dioxins and furans are persistent in the environment; they are not very water soluble and accumulate in sediments and organic matter as well as in organisms. They are taken up mainly via food, especially via more heavily polluted benthic organisms, but also directly via water, the gills, and the skin.

Polychlorinated biphenyls (PCBs) are industrially produced substances that were used, for example, in transformers, hydraulic systems, refrigerators, as softeners in plastics and as flame retardants in paints and varnishes. Production and use of PCBs have long been prohibited (NL: since 1985, CH: since 1986, FR: since 1987, DE: since 1989, whole EU: since 2004), but they are still sporadically released from PCB-containing materials (for example building facades) and sites contaminated in the past, and can also be formed during thermal processes. Some PCBs (dioxin-like PCBs) can have similar toxic effects to dioxins (see Table 1).

PCBs are in generally poorly soluble in water. The intake of dioxins, furans, PCBs and other lipophilic pollutants in fish occurs both via their diet and through their gills and skin (bioconcentration). The significance of these two entry pathways, which together account for bio-accumulation (accumulation in the organism), differs depending on the species, age and life stage. If the pollutants accumulate further up in the food web, one refers to "biomagnification" (see Figure 1). This increases the risk of toxic effects.

Another important factor is the species-specific metabolism of organic pollutants (biotransformation): non-excretable substances (mostly lipophilic) can be converted with varying degrees of intensity by means of chemical processes into excretable substances. Biotransformation and/or excretion mean, however, that higher trophic levels sometimes have a comparable or even lower quantity of residue.[3] In the case of biomagnification, the decisive mechanism is either bioconcentration or biotransformation is less intense and the pollutants are not excreted but accumulate in fat. In the case of absorption via body surfaces (bioconcentration), there is first a partition equilibrium between water and blood, and then between blood and fat in the organs. Intake of pollutants through food and excretion are initially in equilibrium; however, if the body fat content increases and the habitat is polluted, the quantity of residue in the organism also increases. Nevertheless, final links in the food chain that do not live purely aquatically – including not only fish-eating birds but also humans – do not have the corresponding excretion routes (because of their pulmonary respiration) – meaning that intake through food and consequently accumulation in the food web is decisive here.

[3] See Parey 1986: Pike and roach from the Upper Rhine – two fish species that are in a predator-prey relationship – displayed a similar level of contamination and a similar fat content.

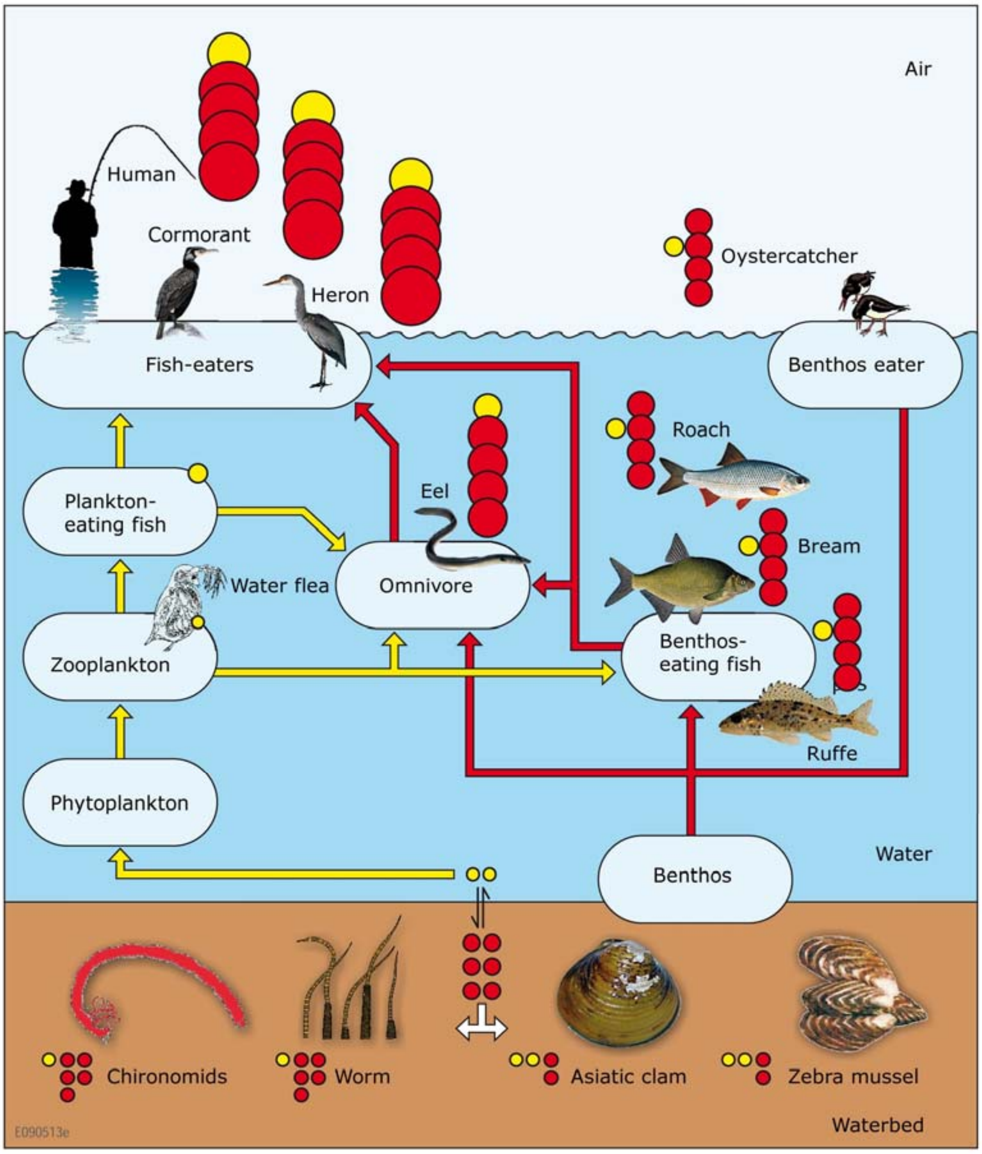

Figure 1*: Pollutants in the aquatic food web.* Simplified food web of the eel. Red circles symbolise contaminant exposure via sediments. Yellow circles symbolise exposure via water. The number of circles indicates the relationship between intake via sediments and intake via water. That relationship is variable and depends on the particular contaminant. The more circles or the larger an individual circle, the higher the concentration of pollutant. At the higher levels of the food web – particularly in top predators (which include not only predatory fish and birds but also humans) – the pollutants accumulate and biomagnification occurs. (Source: Van den Heuvel-Greve et al. 2009)

The habits of a fish also play a role in this connection. Fish that spend their time primarily at the bottom of the water body, for example, are in close contact with recent sediments and take up pollutants that may be stored there – not only if their diet includes benthic organisms – more readily than fish that spend most of their time in the main part of the water body.

Fat-rich fish therefore basically have a greater potential for accumulating PCBs. A higher fat content is in turn typical of some species such as eel and fish of the Salmonidae family (salmon and trout-like species such as whitefish and char, see Figure 2, Appendix 3). Because hardly any breakdown of dioxins or PCBs occurs in cold-blooded animals, increasing age means that residues accumulate in their fatty tissue. Older and larger individuals, which generally have a higher fat content, therefore tend to be more highly contaminated with PCBs.

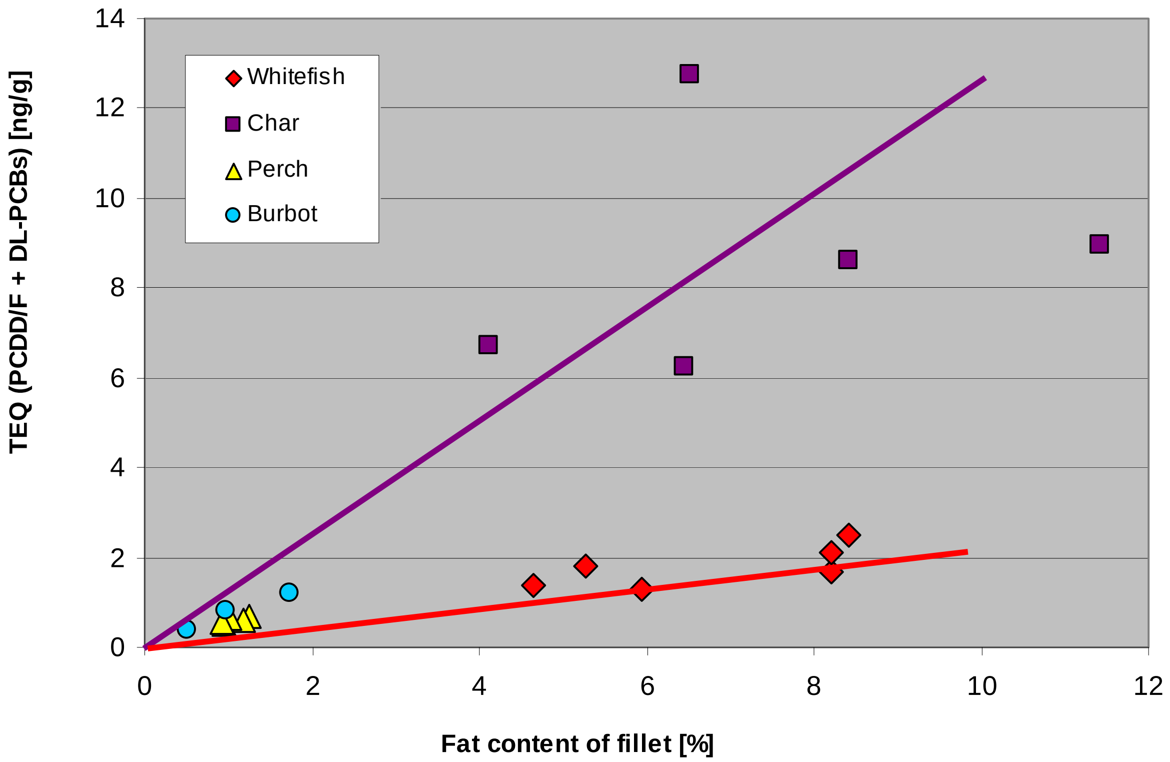

Figure 2*: Dependence of TEQ (PCDD/F + DL-PCBs) value on fat content of fish*. All samples from Lake Geneva. Source: BAFU (Schmid et al. 2010)

As long as pollutants are stored in the fat deposits, their toxic effects are relatively limited. If the fat reserves are reduced, however, the PCBs are remobilized and toxic PCB metabolites (breakdown products) are created. Pollutant concentrations in the blood plasma increase, resulting in physiological stress. PCBs are stored at increased levels in other tissues and organs, where they can also have adverse effects. The toxic effects of PCBs are based, amongst other things, on interactions with receptors, proteins, or DNA.

In laboratory experiments, deformities and increased mortality in fish embryos due to exposure to organic chlorine compounds such as PCDD/F and PCBs were observed in pike, carp, lake trout, rainbow trout, and eel.[4] An incubation and rearing experiment with pike from the Upper Rhine revealed a high correlation between contamination of spawning fish with organochlorines (primarily PCBs, but also hexachlorobenzene) and the fertilization rate, the percentage of normally developed embryos at hatching time and the hatch rate overall. No such correlation could be demonstrated in the case of roach.[5] There is no evidence for such effects on fish in the field because such experiments are very difficult or practically impossible.

In the case of the eel – whose high fat content means that it is generally the most heavily polluted species of fish in the Rhine catchment area – contamination with DL-

[4] Various sources, in Schmid et al. 2010
[5] See Parey 1986

PCBs and other anthropogenic pollutants may be one of the reasons for declining stocks.[6] In particular, about half the fish's fat reserves are consumed during the spawning migration and also as preparation for spawning. This leads to the release of stored persistent pollutants such as PCBs.

Hexachlorobenzene (HCB)

HCB was used as a plant protection product (fungicide), in the treatment of seeds, in wood preservatives, and as an additive for PVC, insulation materials, and adhesives. It is also created during the production, processing, and incineration of other substances containing chlorine, for example as a by-product of the production of plastics and solvents. Since the 1980s, HCB has no longer been permitted as a plant protection product in the Rhine States. It is now only produced and utilised industrially on a limited scale, and it enters the environment primarily from sites contaminated in the past. HCB displays high toxicity particularly in small crustaceans and fish.

Perfluorinated tensides (PFTs)

PFTs (PFOA = perfluorooctanoic acid, perfluorooctane sulphonate = PFOS) are produced industrially and are contained in a large number of products. Waste water from electroplating plants, waste water containing solvents, and waste water from textile or paper finishing or waste disposal operations/landfills can be particularly polluted. In 2006, a high level of PFT pollution was found in the Ruhr and its tributary the Möhne (North Rhine-Westphalia); this consisted primarily of PFOA and could be traced to the illegal addition of industrial waste to fertilisers or soil additives. Since 2006, PFTs have been detected as part of the official measurement programme. Since 2008, PFOS can only be utilised within the EU in a few exceptional cases.

PFTs are toxic to humans and animals, accumulate in the blood and organ tissues, and are suspected of causing cancer. The lowest level of an average acute lethal concentration (LC50) of PFOS in water was found in shrimp (*Americamysis bahia*) at 3.6 mg/l. As a chronic effect, negative effects on the hatching of midge larvae (*Chironomus tentans*) have been documented from a concentration of 21.7 µg/l (NOEC).[7]

No maximum limits or guideline limits for perfluorinated tensides (PFTs) in fish have yet been specified. In Germany only a guidance value of 30 µg/kg FW has been derived.[8]

Concentrations of PFOS in water are in the nanogram range, and in the Rhine usually below the detection limit. Species-specific bio-accumulation factors for fish can be calculated as a quotient from the concentration of PFOS in fish muscle tissue (µg/kg DM) and water (µg/kg water). In the Lower Rhine (using half the detection limit for the PFOS concentration in water) and its tributaries these are at a factor of 1000 to 2000 and are highest in perch (2284), eel (1799) and bream (1731) and lowest in chub (539) (see Appendix 6).[9]

[6] See Belpaire et al. 2011
[7] See MacDonald, M. M., Warne, A. L., Stock, N. L., Mabury, S. A., Solomon, K. R., Sibley, P. K. (2004): Toxicity of perfluorooctane sulfonic acid and perfluorooctanoic acid to *Chironomus tentans*. Environ. Toxicol. Chem., 23, 2116-2123
[8] See BfR 2008
[9] LAWA 2010

Intake of PFOS from consumption of fish can account for more than 90% of total exposure from food, although only 1.5% to 2.5 of the tolerable lifelong intake is used up.[10]

Mercury (Hg)

Mercury is a heavy metal that occurs in nature, for example in rocks of volcanic origin. Major anthropogenic sources include the burning of coal, the chlorine/alkali industry, and use in products including dental fillings (amalgam), measuring and control equipment, and batteries. Most of the mercury in water bodies is bound inorganically in sediments. Microorganisms in the bed of the water body can convert mercury into methylmercury. This is more easily absorbed by organisms and accumulates in the food web.

[10] See BfR 2008; calculation based on current measurements of PFT levels in foods and the average intakes of different food groups determined by the Robert Koch Institute in 1998 as part of a Germany-wide nutrition survey.

Table 1: Ecotoxicological characteristics of PCBs, dioxins, furans, HCB, PFOS, and mercury

Substance group	Dioxins, furans, DL-PCBs	Indicator PCBs	HCB	PFOS	Methylmercury
Behaviour	Binds to organic matter (PFOS: tenside properties)				complex, binding both organic and inorganic
Breakdown	very slow			no	not at all
Intake in organisms	via food, suspended matter, water			via food and water	via food, sediments, water
Storage	in fatty tissue, in the liver	in fatty tissue, in the liver, kidneys and lymph glands		in muscle and fatty tissue, in the liver	in fatty tissue, the liver, the skin
Bio-accumulation	throughout the food web				
Toxicity in water bodies	Negative effects on food intake, weight, reproduction, development, immune system, behaviour	Damage to nervous system (including narcotic effects), negative effects on the skin, liver, kidneys, digestive system	Toxic to fish and small organisms in water bodies	Acutely poisonous (for example for shrimps), chronic effects, for example on the hatching of midge larvae	Acutely poisonous for invertebrates in water bodies. Negative effects on reproduction, growth, behaviour, metabolism, osmoregulation, oxygen balance
Toxicity in humans	Skin rash (chloracne), damage to the liver, reproductive organs and immune system, developmental disorders, carcinogenic. Some PCBs stimulate the growth of tumours.	Damage to nervous system, liver, lungs, reproductive organs; carcinogenic	Lethal at high doses	Suspected of being carcinogenic	Negative effects on development of nerves, heart, blood vessels, immune system, and reproductive organs; possibly carcinogenic

1.3 Pollution of fish in the Rhine main stream in 2000

(Excerpts from ICPR report No. 124)

In 2000, the ICPR programme for measuring contamination of fish in the Rhine catchment area showed that pollution by polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB) and mercury (sporadically) must be viewed as problematic from the point of view of foodstuffs legislation, whereas contamination by the other pollutants considered (pesticides, other semi-volatile hydrocarbons, tri- and tetrachlorobenzenes, nitro-musk compounds, lead, cadmium, bromocyclen, triphenyl- and tributyltin) were of comparatively minor importance. This finding was in line with the outcome of the measurement programme carried out by the ICPR in 1995.
Concentrations of **lower chlorinated polychlorinated biphenyls (PCBs)** showed a spatial focus of contamination in the Lower Rhine and Delta Rhine. No differences were observed in this spatial distribution between the situation in 2000 and that in 1995; in the Lower Rhine, however, a highly significant decrease in pollution was observed for that period. Comparatively high levels of higher chlorinated PCBs were observed downstream of Mannheim (Rhine km 432). No significant decrease over time was apparent as far as the Middle Rhine. In the case of the Lower Rhine and all sections of the Rhine taken together, there was a significant decrease in contamination. The maximum levels of higher chlorinated PCBs permissible under foodstuffs legislation were exceeded at virtually all the measurement locations on the Middle and Lower Rhine. The applicable Dutch maxima were not found to be exceeded in eel from the Delta Rhine; in the case of roach, they were only exceeded sporadically.[11] The overall percentage of legally relevant individual samples for the major congeners **PCB 138** and **PCB 153** was 21% or 28%, i.e. the same as in 1995.

Over the course of the Rhine, contamination of eel samples with **hexachlorobenzene** (HCB) showed a steep rise commencing in the lower Upper Rhine and continuing into the northern Upper Rhine. The highest HCB levels were found in the Upper and Middle Rhine as far as Koblenz, with the majority of the eel examined exceeding the maximum permissible under foodstuffs legislation. Levels then fell clearly in the further course of the river. The roach examined were within the norm from the point of view of foodstuffs legislation. Pollution had decreased significantly compared to 1995 in the vicinity of the former specific discharger on the Upper Rhine. At the start of the southern Upper Rhine (Grißheim, Rhine km 210), the concentrations measured remained the same, namely at a very high level. However, for the rest of the Rhine as far as Bad Honnef (Rhine km 642), a significant increase in pollution was observed at all the measurement locations. In the northern Upper Rhine, the average level of pollution was in fact higher than that in 1990.

Contamination of eel with **mercury** showed an increase beginning in the Upper Rhine and continuing in the southern Upper Rhine. The average level of contamination decreased slightly further downstream. Compared to 1995 and also 1990, a clear increase was observed in the level of mercury in eel in the Upper Rhine. By contrast, contamination of eel in the Middle Rhine was significantly lower than the value observed in 1995. Throughout the course of the Rhine, the maximum levels for mercury that applied back then[12] were not exceeded. The German Environmental Specimen Bank's [*Umweltprobenbank*] data for bream – which were used for comparison – lead to similar interpretations for the main pollutants, in particular for hexachlorobenzene and mercury.

[11] The maximum levels for PCB-153 in mg/kg FW at that time were: in the Netherlands, for eel 0.5 and for other fish 0.1; in Germany, 0.2 for all species of fish (in terms of fat in fish with a fat content of > 10%).
[12] Maximum levels for mercury at the time in mg/kg FW: Switzerland, 0.5; Germany 0.5 or 1.0 for eel, pike and perch; Netherlands 1.0.

2. Underlying data

2.1 Participating organisations in Rhine catchment area

The following organisations made contributions to this report:

Switzerland: Bundesamt für Umwelt (BAFU), Bern – www.bafu.ch

France : Office National de l'Eau et des Milieux Aquatiques (ONEMA), Vincennes (Île-de-France) – www.onema.fr
Agence Nationale de Sécurité Sanitaire (ANSES, previously AFSSA), Maisons-Alfort (Île-de-France) – www.anses.fr

Germany: ***Baden-Württemberg*****:** Chemisches und Veterinäruntersuchungsamt Freiburg (CVUA) – www.ua-bw.de
Bavaria**:** Bayerisches Landesamt für Umwelt (LfU), Dienststelle Wielenbach
Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), Oberschleißheim
Saarland: Landesamt für Umwelt- und Arbeitsschutz (LUA), Saarbrücken – http://www.saarland.de/landesamt_umwelt_arbeitsschutz.htm
Rhineland-Palatinate**:** Landesamt für Umwelt, Wasserwirtschaft und Gewerbeaufsicht (LUWG), Mainz – www.luwg.rlp.de
Hesse**:** Landesbetrieb Hessisches Landeslabor (LHL), Wiesbaden – www.lhl.hessen.de
North Rhine-Westphalia: Landesamt für Natur, Umwelt und Verbraucherschutz NRW (LANUV), Recklinghausen – www.lanuv.nrw.de
Federal**:** Umweltbundesamt, Dessau – www.umweltbundesamt.de

Moselle-Saar area: International Commission for the Protection of the Moselle and Saar (ICPMS), Trier – www.iksms-cipms.org

Luxembourg: Ministère de l'Intérieur/Administration de la Gestion de l'Eau – www.waasser.lu
Ministère de la Santé/Service de la Sécurité Alimentaire – www.securite-alimentaire.public.lu/actualites/communiques

Netherlands: Rijkswaterstaat/Waterdienst (RWS), Lelystad – www.rijkswaterstaat.nl
Institute for Marine Resources & Ecosystem Studies (IMARES), Wageningen – http://www.imares.wur.nl
Instituut voor Voedselveiligheid (RIKILT) – http://www.rikilt.wur.nl

The technical contacts are listed in Appendix 1.

Some reports and/or data are publicly available on the organisations' websites (for further details, see Section 3).

2.2 Pollutants, parameters, and maximum levels studied

Appendix 2 shows which pollutants were studied in fish in which Rhine States. In addition to indicator PCBs, dioxins/furans and DL-PCBs, most states also recorded HCB and mercury in fish. Levels of other persistent organic pollutants were also measured.

Table 2 shows the maximum levels for eel and other fish that are relevant to evaluation. The maximum levels permissible under foodstuffs legislation are taken from
- EU Contaminants Regulation No 1881/2006, which also applies by analogy in Switzerland;
- Commission Recommendation 2006/88/EC;
- the proposal by the European Commission's Directorate-General for Health and Consumer Protection (DG SANCO);
- national regulations.

The **environmental quality standards (EQS)** for biota pursuant to the WFD "Priority Substances" Daughter Directive (Directive No. 2008/105/EC, Article 3(2) are also included. The lipophilic nature of the substances concerned makes them difficult to measure in water. Measurements in biota are simpler and also give a better time-integrated picture of the water quality than random measurements in water. The standards in Table 2 for biota (fish, shellfish) in the European water bodies subject to the Water Framework Directive listed in Table 2 were therefore drawn up in 2007.[13] Application of the "biota standards" is left to the Member States.[14]

The toxicity of the **sum of dioxins, furans and dioxin-like PCBs** relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is given in toxicity equivalent quantities (WHO TEQ ng/kg SC). This sum parameter was calculated in the most recent studies by all the Rhine States and is therefore used in the present report as a comparison parameter. The results for the WHO TEQ are not comparable because measurement of DL-PCBs was not foreseen in the ICPR measurement programme in 2000.

Of the **non-dioxin-like PCBs**, the congener PCBs 28, 52, 101, 138, 153, and 180 were combined as **indicator PCBs**. Of this group, it is normally congener PCB 153 that has the highest level, and it is therefore often utilised as a guide congener. At present, the assessment of the indicator PCBs according to foodstuffs legislation takes place in Germany according to the individual congeners; in future, however, it will be harmonised for all EU Member States on the basis of the sum of the indicator PCBs. DG SANCO is currently considering extension of the Regulation with maximum levels for the sum of the six indicator PCBs.[15] A draft biota standard is also being derived, according to a harmonized European method, for the sum of seven indicator PCBs congeners. [16]

The TEQ levels of **polycyclic aromatic hydrocarbons (PAHs)** are generally very low; they have not therefore been considered below.

[13] Fraunhofer Institute fact sheets
[14] 2008/105/EC, footnote (9) on page 10
[15] Sum TEQ according to SANCO/13329/2010 + SANCO/13331/2010 revision 2
[16] Duinhoven et al. 2007

Table 2: Maximum levels, action levels, environmental quality standards (EQS), EQS proposals and guidance values for dioxins, furans and DL-PCBs, indicator PCBs, HCB, hexachlorobutadiene, PFOS and mercury in eel and other fish according to EU and national legislation

Substance	Type of fish	Legal basis	Maximum level[17]	Unit
Dioxins, furans, DL-PCBs	all	EU Regulation	4.0	ng WHO-PCDD/F-TEQ/kg FW [18]
		Com. Rec.	3.0	
DL-PCBs	eel	Com. Rec.	6.0	ng WHO-PCB-TEQ/kg FW
	other fish	Com. Rec.	3.0	
Σ dioxins/furans/DL-PCBs	eel	EU Regulation	12.0	ng WHO-PCDD/F-PCB-TEQ/kg FW
	other fish	EU Regulation	8.0	
PCB 28, 52, 101, 180	freshwater fish	Kont.-VO D	0.2	mg/kg FW
PCB 138, 153			0.3	mg/kg FW
6 indicator PCBs (ICES 6): PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180	eel in the wild	DG SANCO proposal	0.3	mg/kg FW
	diadromous fish caught in freshwater		0.075	mg/kg FW
	other freshwater fish in the wild		0.125	mg/kg FW
7 indicator PCBs (see above + PCB 118)	all (for the present)	Draft biota standard	0.335	mg/kg FW
Hexachlorobenzene	all	Biota standard	0.01	mg/kg FW
		RHmV	0.5	mg/kg fat
			0.05	mg/kg FW
Hexachlorbutadiene	all	Biota standard	0.055	mg/kg FW
PFOS	all	EQS proposal	9.1	µg/kg FW
		BfR orientation value	30	µg/kg FW
Mercury/methylmercury	eel, pike	EU Regulation	1.0	mg/kg FW
	other fish	EU Regulation	0.5	
	all	Biota standard	0.02	mg/kg FW

Conversion factors:
1 mg = 1000 µg = 1,000,000 ng
1 kg = 1000 g = 1,000,000 mg

EU Regulation: EU Contamination Regulation No. 1881/2006 of 19 December 2006;
Com. Rec. = Commission Recommendation (2006/88/EC) regarding action levels for DL-PCBs of 6 February 2006;
Kont-VO D = German ordinance to limit contaminants in food of 19 March 2010;
Biota standard = environmental quality standard for biota according to Directive No. 2008/105/EC;
RHmV = German ordinance on maximum quantities of residue [*Rückstandshöchstmengenverordnung*] of 21 October 1999, most recently amended on 19 March 2010;
EQS proposal for PFOS according to the outcome of discussion of new candidate substances by the E 14 Working Group on 22 June 2011
BfR orientation value for PFOS according to statement by the Federal Institute for Risk Assessment (*BfR*) of 11 September 2008, see BfR 2008.

[17] For DL-PCBs und dioxins: action levels
[18] WHO TEQ of 1998

Appendix 4 shows the standards for assessing the results of studies on fish contamination in the Rhine States.

Dealing with measurement uncertainties

Before the measurement results are compared with the maximum levels (for example according to the EU Regulation), with measurements consequently being imposed regarding the marketability of fish, a defined percentage is usually deducted from the numerical measurement value to allow for measurement uncertainty. Different percentages are deducted in the various Rhine States (see Table 3).

In the EU Member States, the relevant provisions of Regulation (EC) No. 1883/2006 regarding dioxins, furans and DL-PCBs in food are applied to check whether maximum levels have been exceeded in the fish studied.[19] The Regulation requires a first analysis to be used to determine whether maximum levels have been adhered to. A duplicate analysis is necessary to exclude the possibility of internal cross-contamination or an accidental mix-up of samples. There is a case of non-compliance if, after deduction of the measurement uncertainty from the results of the first analysis, the value is greater than the maximum level.

In the case of samples that are only slightly higher than the maximum, it is possible that different laboratories (regardless of national boundaries) have assessed the samples differently due to analytical fluctuations in the samples.

Table 3: Percentages (+/-) of measurement uncertainty for various parameters in fish which are applied, depending on national legal frameworks and interpretation, to raw analytical data

Country/federal state	Dioxins/furans/DL-PCBs	NDL-PCBs/Indicator PCBs	HCB	Heavy metals	Organochlorine pesticides
CH	0%				
FR	17.% (dioxins) 20.% (DL-PCBs)	22.7	15.5		
DE-BW[20]	20%	20%	50%	20%	50%
DE-RP[21]	20%	20%	50%	10%	50%
DE-HE	20%	25%	25%	5%	25%
DE-NW[22]	15%	15%	50%	10 – 20%	50%
NL[23]	10%				

[19] EC Regulation No. 1883/2006, Annex I, Section 5

[20] DE-BW: The measurement uncertainty for the organochlorine pesticides, including HCB – according to document No. SANCO/10684/2009 "Method Validation and Quality Control Procedures for Pesticide Residues in Food and Feed Analysis" – is basically given as 50% for all pesticides in foods of animal and vegetable origin, which corresponds to a single regime within the EU.

[21] DE-RP: heavy metals: only Hg is measured

[22] DE-NW: % in heavy metals according to analysis method in each case

[23] NL: previously 15%

Unless indicated otherwise the presentation in the texts and figures in Section 3 ("Results") and in Appendix 5 ("Measurements"), raw data is without the measurement uncertainty being subtracted; this is because the present report aims at an ecosystem approach and does not focus on the consequences under foodstuffs legislation of a maximum level being exceeded. The intention is also to ensure comparability of values as far as possible.

In many of the figures and in the text, reference is nevertheless frequently made to limits under foodstuffs legislation – and to those limits being exceeded – which were calculated using values *after* deduction of the above country-specific measurement uncertainty.

2.3 Fish species studied and criteria for selecting them

The fish species studied were selected primarily because of their availability and frequency in the section of the Rhine or tributary concerned. A number of institutions deliberately restrict their studies to only a single species or only a few species so as to increase the level of statistical certainty. Other institutions have investigated a wide variety of fish in accordance with the natural biodiversity, so as to optimise the likelihood of catching them and to cover all the proposed measurement locations, or to study a representative "basket of fish" containing the most important fish used for human consumption. Selection was also based on species-specific fat content or different habits (see 1.2).

When presenting the results, some studies distinguish between carp species (generally with a low proportion of fat, only occasionally a higher proportion of fat) and eel (in all cases a higher proportion of fat) or between fish used for human consumption and the remaining fish species. In France, a division of fish into strongly and weakly bio-accumulating species is usual.[24]

Appendix 3 shows which fish in which Rhine States were investigated for pollutants. The following table gives the characteristics of the most important fish species that were studied.

[24] AFSSA 2010

Tab. 4: Characteristics of the most important fish species studied
Sources: Bauch 1966, ICPR 2009, Lelek & Buhse 1992, Muus & Dahlström 1998, Pelz & Brenner 2002.

Type of fish	Eel	Roach	Bream	Chub
Scientific name	*Anguilla anguilla*	*Rutilus rutilus*	*Abramis brama*	*Squalius cephalus*
Table fish	yes	yes (regionally)*	yes (occasionally)*	yes (occasionally)*
Frequency in Rhine	hitherto high; declining	hitherto sufficient population density for sampling; declining in some sections of the Rhine; not in Upper Rhine	wide distribution but not common everywhere	wide distribution, normally present
Habitat	flowing and standing water, in particular in former channels with banks reinforced by dumping rock	flowing and standing water	prefers calmer areas with soft bed and former channels; flowing and standing water	adults also in standing water
Site fidelity	elvers: slight; yellow eel: high silver eel migrate downstream	moderate to high	high	slight to high
Primarily found	at bottom of water body	close to banks, in open water	at bottom of water body, bank-oriented	as juvenile, close to bank; as older fish, in open water
Contact with sediment	intensive	slight	intensive	slight
Food	pointed-nosed eel: benthic organisms; large-headed eel: fish, crustaceans, fish spawn**	macro-invertebrates, aquatic plants, plankton	benthic organisms; aquatic plants	macro-invertebrates, aerial insects, fish (small), amphibians, some aquatic plants and fruit; with increasing age, more fish
Lifespan	on average 10 to 15 years, sometimes more than 20 (occasionally 50) years	10 to 15 years	high (up to 25 years)	8 to 10 (15) years
Fat content	very high (> 8%, up to 32%)	slight to moderate (up to 6%)	slight to high (up to 10%)	slight to high (up to 8%)
Bio-accumulation	high to very high***	slight to high***	slight to high***	slight to high***

Continuation of **Table 4: Characteristics of the most important fish species studied**

Type of fish	Eel	Roach	Bream	Chub
Miscellaneous	regional catch restrictions because of threat to stocks and in contaminated areas	comparable with ICPR study in 2000	no catch restrictions because not endangered	no catch restrictions because not endangered

* The fact that they are so bony means that roach, bream, and chub are not popular as table fish. However, young fish (< 20 cm), in particular roach, are popular as fried fish, for example in South Germany and in the Benelux countries.
** There is greater development, as a percentage, of pointed-nosed eel and large-headed eel depending on the food supply in their habitat.
*** Age-dependent: with increasing age, all species of fish have a higher fat content.

3. Contamination of fish: results of studies in the Rhine States

3.1 Switzerland

Dioxins, furans, DL-PCBs

In Switzerland, 1300 records from the past 20 years were analysed as part of a report[25] on the contamination of fish and water bodies with PCBs and dioxins. For most fish species and water bodies (including the Alpine Rhine and tributaries, the Aare to the mouth of the Sarine), the values for dioxin-like PCBs and dioxins are in a range of the background levels or slightly above. Significant violations of the maximum concentration laid down in food legislation (analogous to EU Food Regulation No. 1881/2006) were observed in fish from the Birs (a High Rhine tributary), the Sarine (an Aare tributary) and the Upper Rhine (see Figure 3). The high proportion of DL-PCBs was decisive for the violations of the maximum (see Figure 4).

Time series of PCBs in sediment cores from Swiss lakes and in breast milk show that contamination of the environment and of humans with PCBs has decreased significantly in recent decades but that the PCB residues in fish from certain water bodies necessitate further measures to eliminate PCBs.

Outlook

The locations where the food standards are exceeded are polluted by point sources (municipal waste tips with PCB contamination from the past). A monitoring programme covering not only fish but also sediments and measures to contain or remove sources of pollution (especially one known, large landfill on the Sarine) are currently being planned. Consumption recommendations (maximum weekly fish consumption) have been determined with a view to limiting exposure of the population through ingestion of PCDD/F and DL-PCBs.

[25] Schmid P. et al. 2010

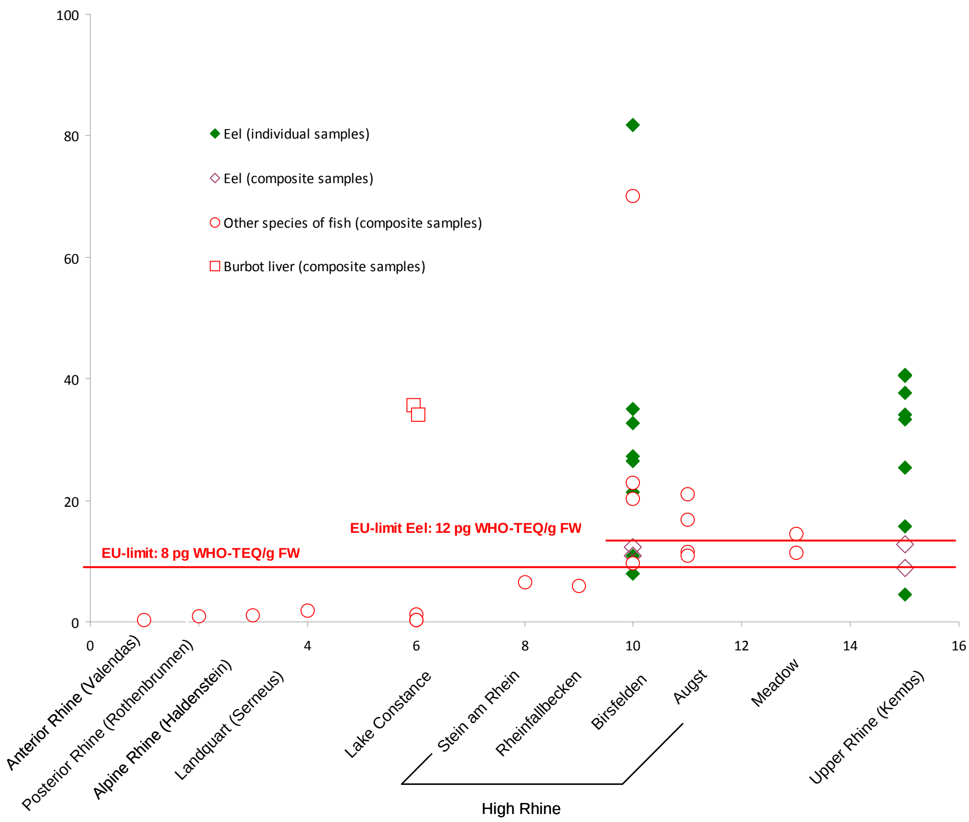

Figure 3*: PCDD/F and DL-PCBs contamination of fish in the Swiss section of the Rhine catchment area* Source: BAFU (Schmid et al. 2010)

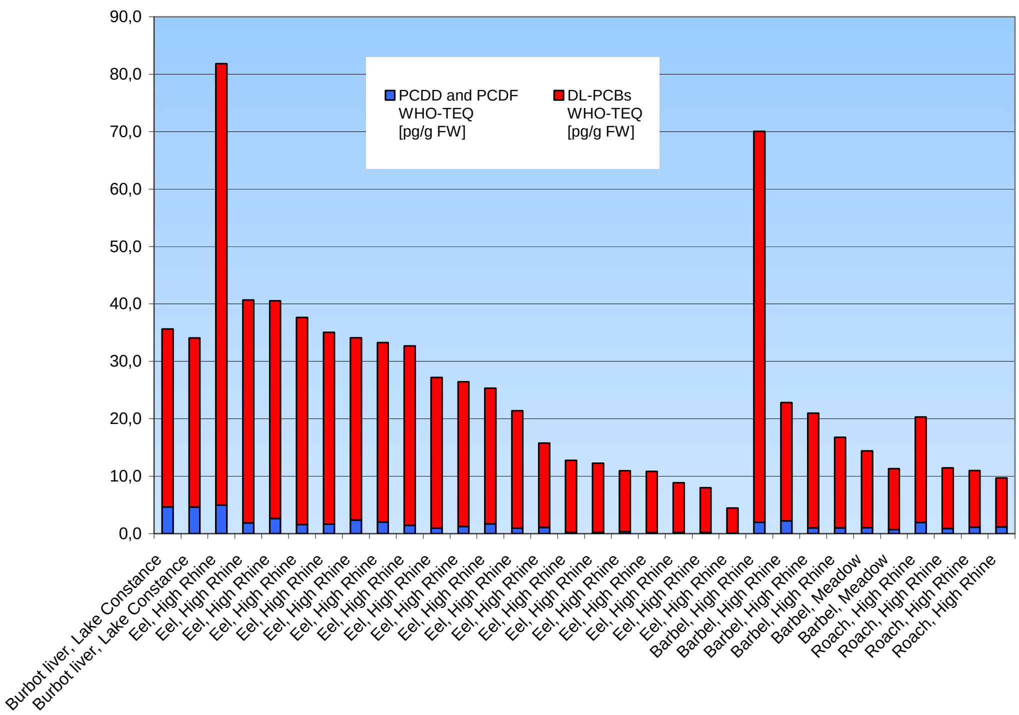

Figure 4*: Proportion of DL-PCBs and PCDD/F in contamination of various fish species in water bodies of the Swiss section of the Rhine catchment area.* Source: BAFU (Schmid et al. 2010)

3.2 France

As part of the National PCB Action Plan, more intensive analysis has been carried out since 2008 in the French part of the Rhine catchment area in order to monitor fish species that are consumed by humans and to develop appropriate measures to contain possible health risks. Mercury, HCB and HCBD are analyzed in addition to PCBs.

Dioxins, furans, DL-PCBs

The food regulatory standards adopted by the EU for the sum of dioxins, furans and dioxin-like PCBs (PCDD/F DL-PCBs) are exceeded by a factor of 2 to 5 in most of the eel samples studied. In other species, the values were generally below the limit of 8 g/g FW. Interpretation of the analysis results for fish from the point of view of food legislation is carried out by the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) after consultation with the Ministries of Agriculture and Health. The interpretation is published as a statement. The method used aims to assess the risk of long-term excessive exposure of fish consumers for every water system, with average contamination levels being compared with the maximum levels for the sum of dioxins, furans and DL-PCBs laid down in law. It is not the intention to test every single sample to determine whether it keeps within the limit. The statements issued may lead to the prefecture issuing a decree prohibiting fishing for consumption and the sale of fish.

Mercury

Studies of mercury levels were carried out on predatory fish, which were caught for the purpose of PCB analysis. Studies of samples of eel and pike (59 individuals) showed that in the case of two samples all the values were below the European food standard of 1 mg/kg FW. In the other species, the standard of 0.5 mg/kg FW was only exceeded in a single pike-perch and a single brown trout sample; these values still remained below 1 mg/kg FW. The EU biota standard of 0.02 mg/kg FW was systematically exceeded in all samples, however.

Hexachlorobenzene and hexachlorobutadiene

Of the 168 samples in which the level of HCB and HCBD was analysed, the standard for HCB of 0.01 mg/kg FW was exceeded in 38 eel samples (23%), with maximum values of up to 0.08 mg/kg FW, while the standard for HCBD was not found to be exceeded.

Outlook

A decree issued by the prefecture in 2009 prohibited consumption and marketing of eel – the most strongly accumulating species – from the French Rivers Ill and Andlau. In the French section of the Moselle (below the dam at Argancy) and in the Moselle tributaries, this prohibition applies to all species of fish.

Statements issued by ANSES can be found out http://www.anses.fr.

The results regarding indicator PCBs, DL-PCBs, PCDD/F and PCDD/F+DL-PCBs are available at http://www.pollutions.eaufrance.fr/pcb/ (Excel and PDF).

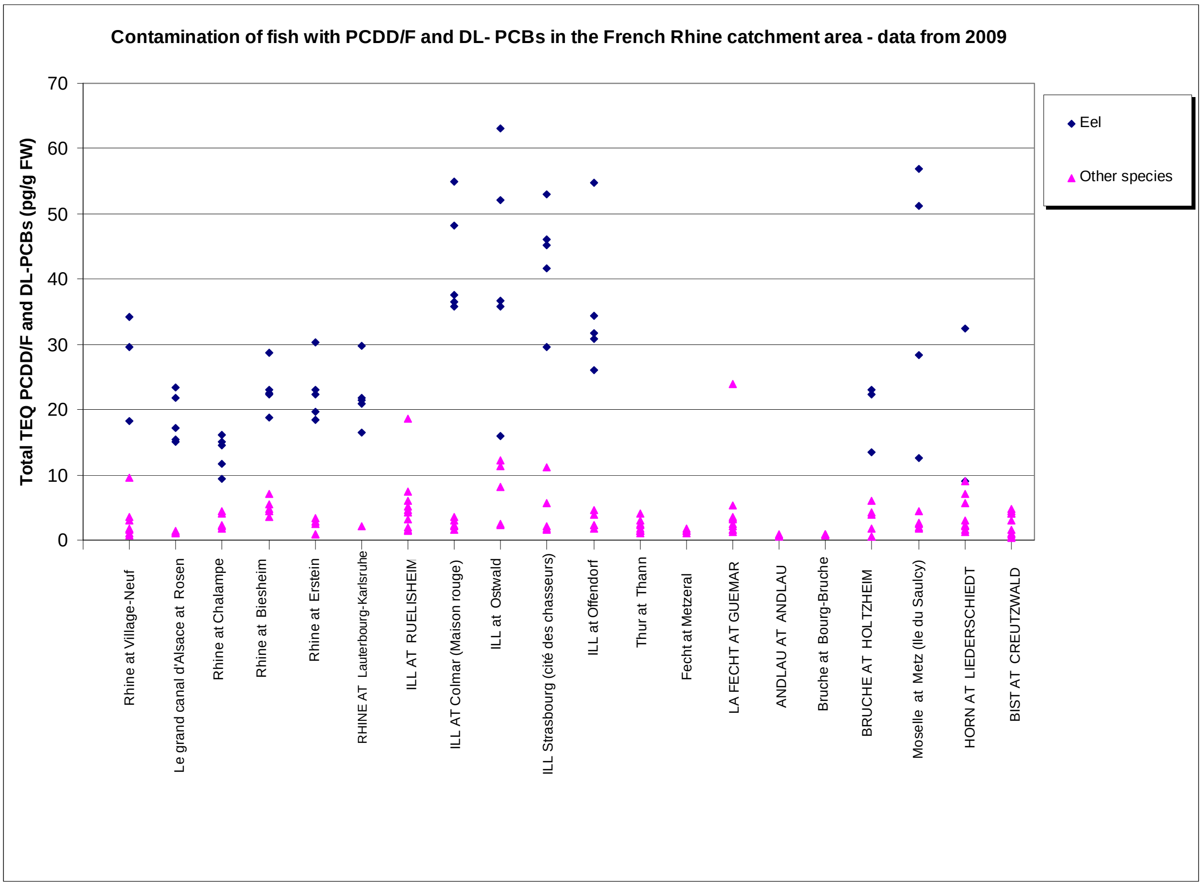

Figure 5*:* Contamination of fish with PCDD/F and DL-PCBs in the French Rhine catchment area – raw data from 2009, without the measurement uncertainty being subtracted. Source: ONEMA

3.3 Germany

In Germany, regional marketing prohibitions and consumption recommendations are based on the criteria set by the Federal Office of Consumer Protection and Food Safety (BVL) and the Federal Institute for Risk Assessment (BfR). Germany does not have a system of consumption prohibitions; such prohibitions would affect animal protection aspects because no vertebrate may be killed without good reason (for example consumption) and would therefore be equivalent to a prohibition on angling.

3.3.1 Baden-Württemberg

Study programmes 2003 to 2008

The ICPR's Rhine fish research programme of 2000 recommenced in 2005/2006, with the number of measurement locations being reduced and the research being limited to eel and roach. In 2003, studies of a variety of fish species were carried out at one measurement location. In 2008, there were studies of eel at three measurement locations.

In each case, the range of analysis included a large number of persistent organic substances (see Appendix 2); only the assessment of dioxins, furans, dioxin-like PCBs, indicator PCBs, HCB and mercury will be considered below.

Dioxins, furans, DL-PCBs

In the High and Upper Rhine, a total of 20 samples of eel (single and composite samples) were investigated in 2005–2008 at six different measurement locations for dioxins, furans, and dioxin-like PCBs. In 17 of the 20 eel samples (85%), the maximum for the sum of dioxins, furans and dioxin-like PCBs (in WHO-PCDD/F-PCB-TEQ) was exceeded, taking into account a measurement uncertainty of approximately 20%. Two other eel samples exceeded the above-mentioned sum TEQ numerically, i.e. they fell within the measurement uncertainty.

The action level for the TEQ for DL-PCBs (6.0 ng/kg FW) was exceeded in all 20 eel samples (100%). Furthermore, the action level for the dioxin TEQ was exceeded in two eel samples.

Of four composite samples of other fish (bream, pike, roach, pike-perch) which were analyzed for dioxins, furans and dioxin-like PCBs, one (bream) exceeded the maximum for the sum TEQ.

Indicator PCBs

Investigation of 70 eel samples (single samples) at 9 different measurement locations for indicator PCBs (2005 to 2008) revealed two violations (2 eel = 3%) of the ordinance to limit contaminants (the former *SHm-VO*). Determination of the level of indicator PCBs in 21 composite samples of other fish (roach, perch, bream, chub, pike, pike-perch) did not reveal any cases in which the maximum was exceeded.

Hexachlorobenzene

Whereas in 2008 the maximum for HCB was no longer exceeded in any of the 15 eel studied, in 2005 that was still the case in 27% and in 2000 in 36% (total number of numerical and statistically significant cases in which the maximum according to the ordinance on maximum quantities of residue was exceeded).

Table 5 shows that since 1995 the proportion of eel in which the maximum was exceeded has decreased.

Table 5: Numerically and statistically based cases of violation of maximum for indicator PCBs and HCB in Baden-Württemberg. Number of eel with violations of the limit/proportion of eel with violations of the limit in total number of eel studied (%)

Year	Number of samples	Indicator PCBs		HCB	
1995	41	5	12%	18	44%
2000	105	2	2%	38	36%
2005/2006	55	1	2%	15	27%
2008	15	1	7%	0	0%

Mercury

Analysis of 70 eel samples and 21 composite samples of other fish for mercury showed no cases in which the maximum set in EU Contamination Regulation No. 1881/2006 was exceeded.

Study programme 2010: "Basket of fish"

In order to have the broadest possible spectrum of fish caught professionally and by anglers, two monitoring programmes were performed in Baden-Württemberg in 2010. These involved 46 samples of fish species relevant to human consumption (perch, grayling, pike, pike-perch, roach, whitefish, rudd, bream and brown trout) from the Rhine, Lake Constance, and other quarters. The samples were analysed for the following spectrum of substances: dioxins and DL-PCBs, NDL-PCBs, chlorine and organobromine pesticides and contaminants, nitro-musk compounds, pyrethroids and heavy metals, as well as perfluorinated tensides (PFTs). Selection of the water bodies, location of the sampling sites, selection of the fish types and species, and the size and age of the fish were according to their relevance to fishing (catch lists of professional fishermen, consumption relevance of each type of fish). Fat-rich fish with a fat content of more than 10% – which are more critical as regards accumulation of fat-soluble contaminants – were not among the fish sampled; such high fat content is generally only found in fillets of freshwater fish in the case of large, old individuals.[26]

Dioxins, furans, DL-PCBs

The applicable maximum for dioxins in fish was not exceeded in any of the samples analysed. The maximum for the sum of dioxins and dioxin-like PCBs was only exceeded (numerically) in a single bream sample from a reservoir (see Figure 3). That sample was a composite sample of two bream, each of which was more than seven years old (see 2.3). Some of the fish samples from the Rhine displayed levels of dioxin-like PCBs that were in the area of the established action level. By comparison, the findings from other water bodies were lower.

[26] A detailed report of the investigations can be found on the homepage of the Baden-Württemberg Research Agencies under *CVUA Freiburg, Rückstände, Dioxine* (www.ua-bw.de).

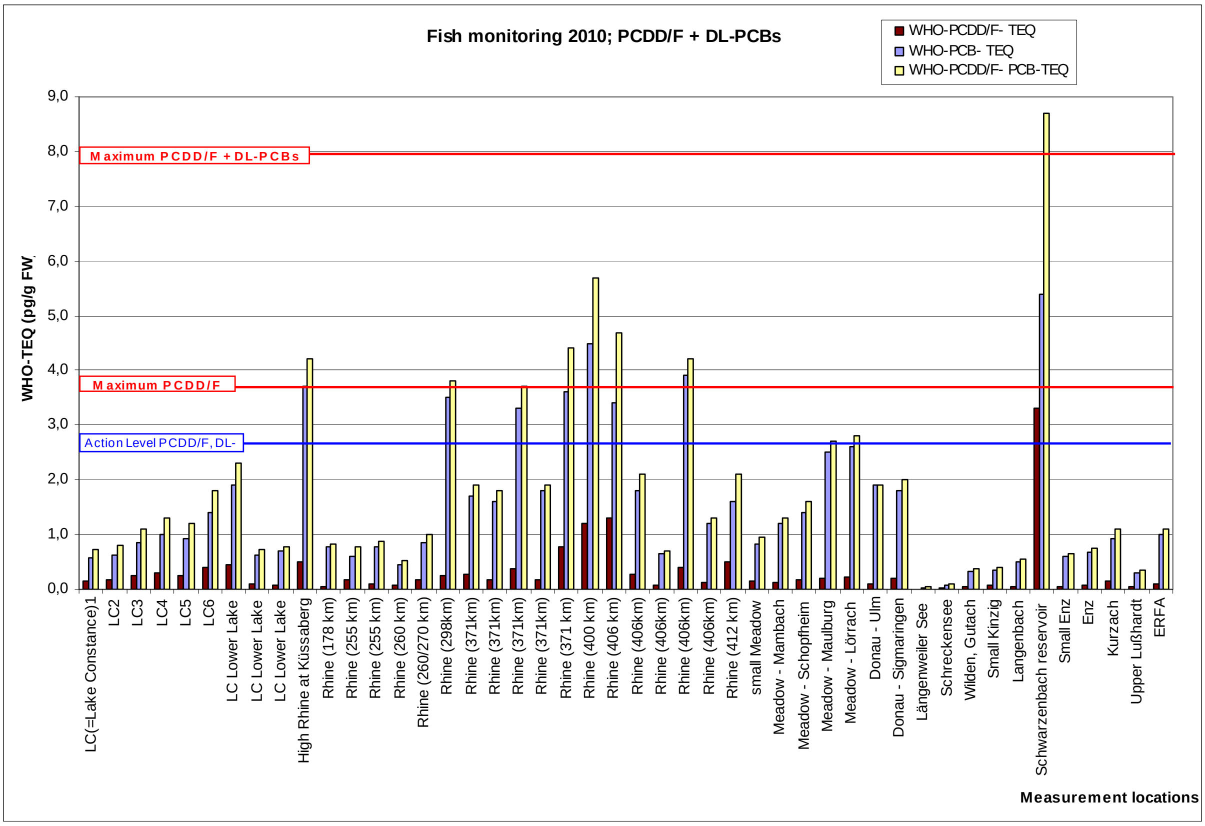

Figure 6: Dioxins, DL-PCBs, and total dioxins + DL-PCBs (in pg WHO TEQ/g fresh weight), categorised according to water bodies and increasing Rhine-km in Baden-Württemberg. Source: CVUA Freiburg

Perfluorinated tensides

The highest concentrations of PFOS (perfluorooctanesulfonic acids) were found in fish from the Rhine (maximum value: 124 µg/g FW). In the samples from Lake Constance (lower lake), PFOS concentrations were an average of 15 µg/kg, whereas the mean PFOS content determined for freshwater fish in Germany is 22 µg/g FW (determined in the context of the control and inspection of foodstuffs in the period 2006–2008).[27]

Pesticides and heavy metals

In the case of pesticides, all the findings are well below the legal maximum. The highest level of mercury was found in the fish from the Rhine that were studied, with the level in those fish already being just below the maximum; in the other water bodies, the average accumulation is significantly lower.

Summary

Overall, considerable variation of the levels of dioxins, PCBs, pesticides, heavy metals, and PFT was identified in the samples. This can be explained, on the one hand, by the different pollution situation of the water bodies and the different species of fish and, on the other hand, by the extremely heterogeneous make-up of the composite samples. By focusing on the specific "basket of fish" produced by professional fishermen and anglers, the studies concerned provide a good estimate of the human intake of contaminants via freshwater fish. Given the nature of the sampling, however, the monitoring that was

[27] BfR 2008

carried out is not representative for the water bodies studied in the sense of environmental monitoring.

3.3.2 Rhineland-Palatinate

Monitoring of pollutants was carried out routinely until 2003 and in 2004 there was a measurement programme by ICPMS members for the Moselle and Saar rivers including tributaries (see 3.4). Single studies were carried out in 2006 and 2007. The report on the systematic study of fish along the course of the Rhine, Moselle and Saar in 2010 is currently in the course of production. Random sampling is also carried out in the framework of the official inspection of foodstuffs.

Dioxins, furans and PCBs, hexachlorobenzene, mercury

In the systematic studies in 2009 and 2010, it was possible to identify temporal and spatial trends compared to the data from 1991, 1992, 1995 and 2004 for indicator PCBs: in Palzem/Moselle, the concentration in eel fell to a fifth in the course of this period; in Schoden/Saar, however, it fell by only 20%. In roach and perch, this temporal trend can also be identified to a lesser extent. As previously, there is a fall in concentration down the Moselle, on which the inflow of the Saar is superimposed.

The results of the Rhine measurement programme of 2010 show a significantly lower concentration in eel (<30%) in a former arm of the Rhine connected only upstream at Otterstadt – which is affected by groundwater due to extensive dredging – as compared to eel from the Rhine itself. Similarly low values are found in bream, perch and young roach, pike and pike-perch. Large pike and pike-perch in the former arm of the Rhine also appear to catch prey in the Rhine itself; their contamination level is similar to fish from the Rhine itself. The pollutant content in perch and roach as well as in eel (standard method) displays a rising trend from the northern Upper Rhine to the Middle Rhine. The increase in pollution is very clear below the mouth of the Main but less clear below the mouths of the Neckar and the Moselle. The findings for the Nahe and Ahr are based on only a few fish studied which exceed the maximum level.

Sporadically, it was also established that the maximum levels for PCB 153, HCB, and mercury were exceeded.

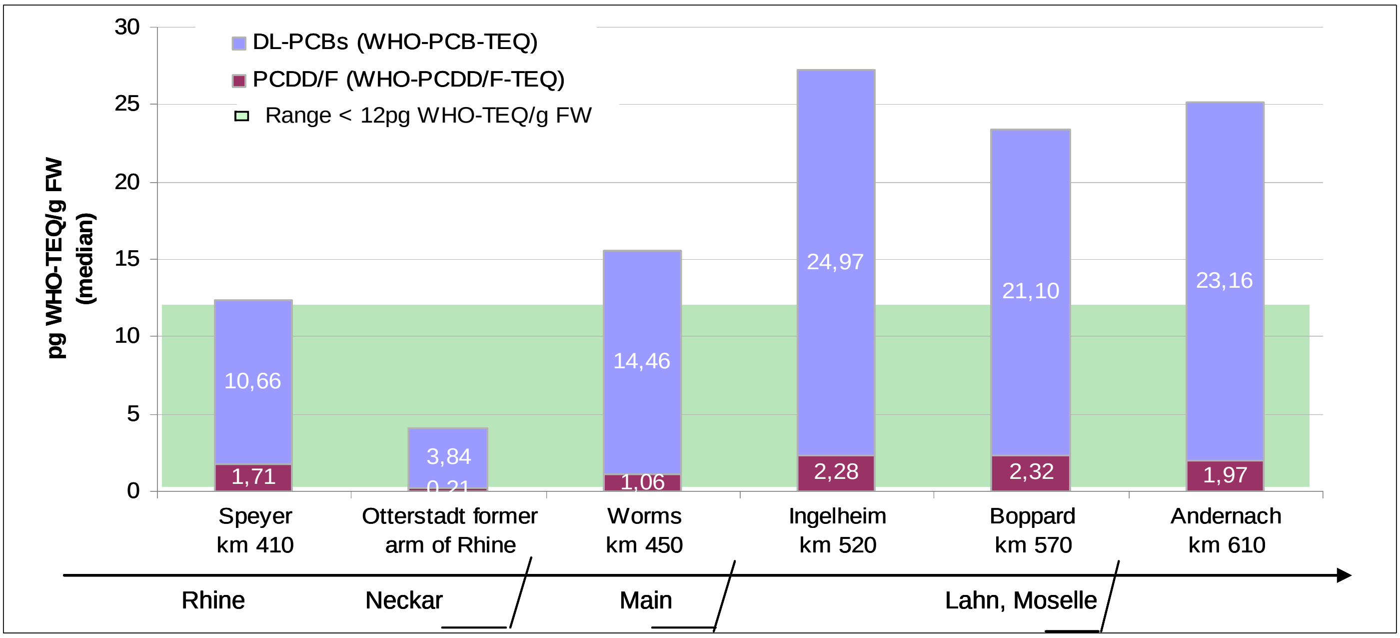

Figure 7*: Dioxins, furans and DL-PCBs (WHO TEQ) in eel from the Rhineland-Palatinate section of the Rhine in 2010. Source: LUWG*

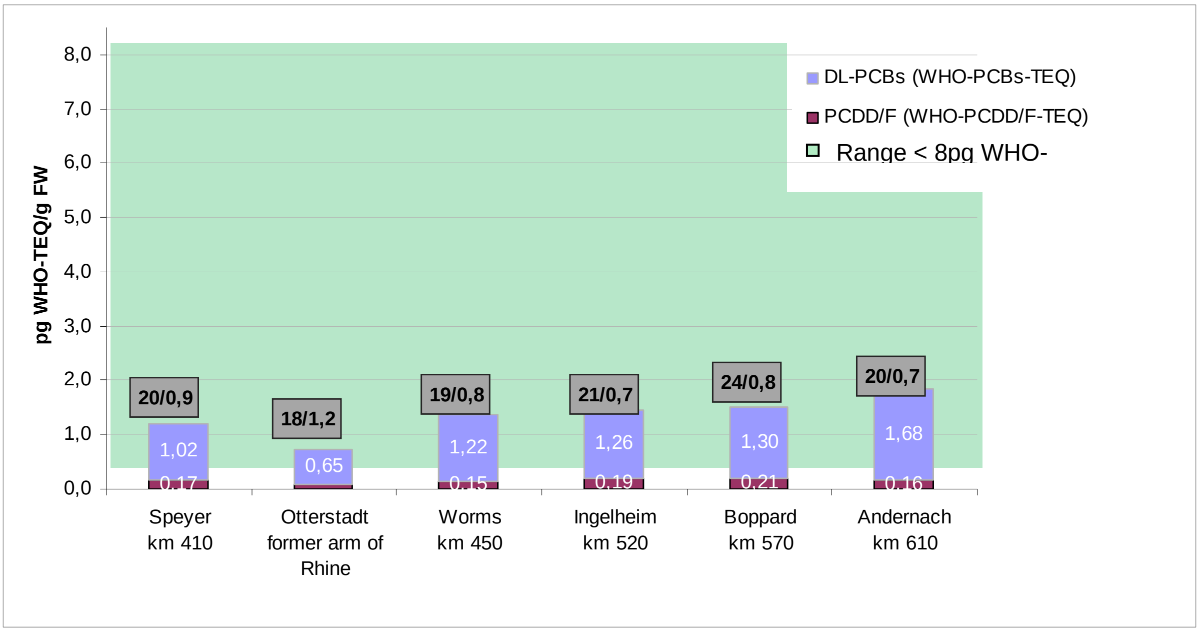

Figure 8*: Dioxins, furans and DL-PCBs (WHO TEQ) in perch from the Rhineland-Palatinate section of the Rhine in 2010.* Grey box: Fish length in cm/fat content in % (composite samples). **Source: LUWG**

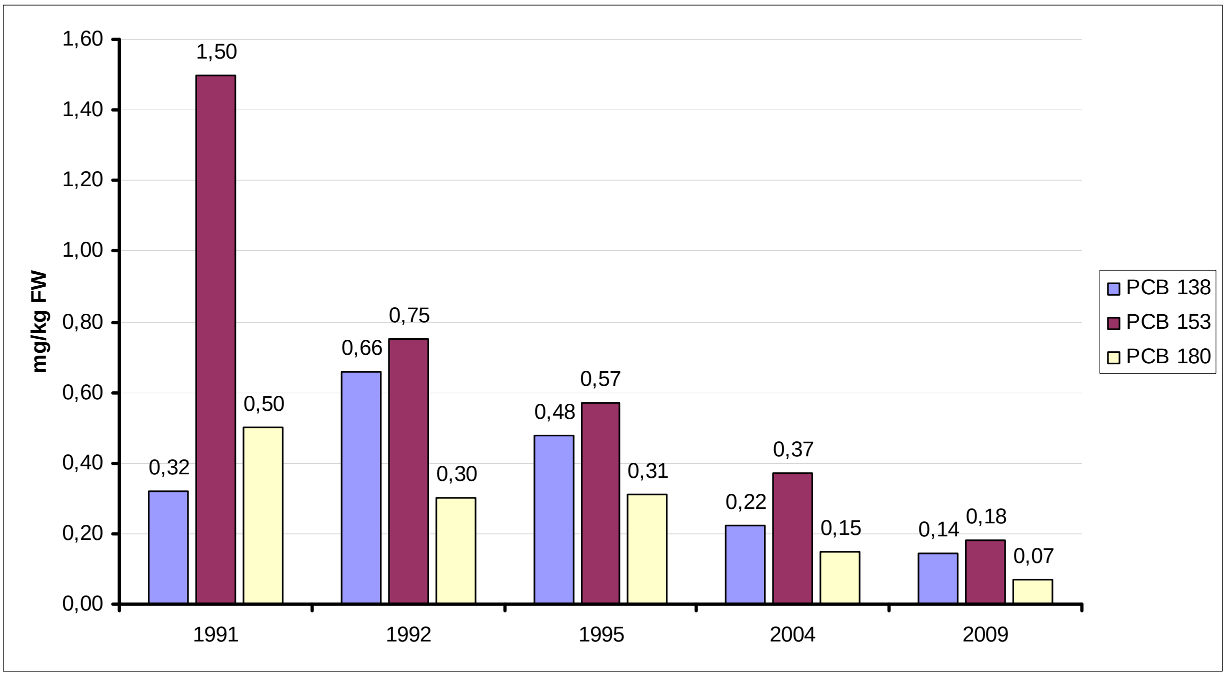

Figure 9*: Indicator PCBs in eel in Palzem/Moselle in various measurement years from 1991 to 2009.* Source: LUWG

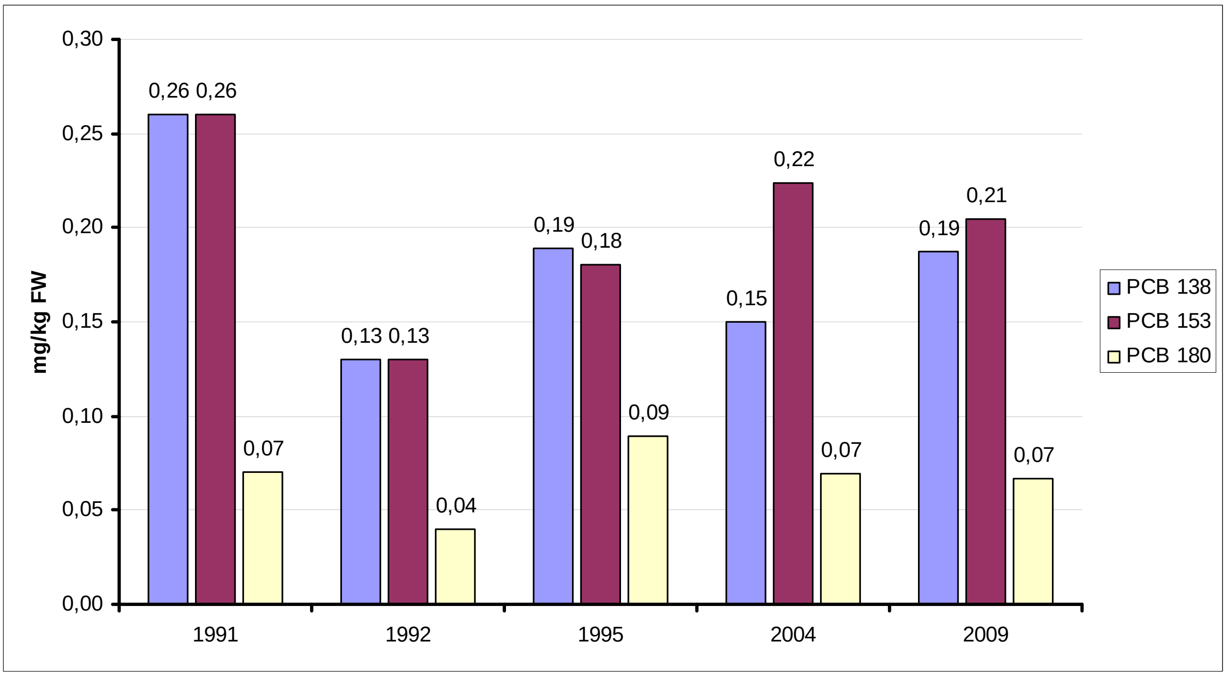

Figure 10*: Indicator PCBs in eel in Schoden/Moselle in various measurement years from 1991 to 2009.* Source: LUWG

Outlook

Based on the study results, the marketing of eel was prohibited. A recommendation not to eat eel had already been issued in 2006 because that fish can basically be assumed to contain too high a level of PCB contamination. A consumption recommendation for other fish species was issued in April 2010 as an updated information sheet giving the following maximum consumption quantities:

Table 6: Consumption recommendations for fish from the Rhine and its tributaries in Rhineland–Palatinate

River	Fish species/group	Size	Portions*
Ahr, Lahn	Carp species		2
Rhine	Carp species		1
Nahe	Carp species		2
Moselle	Roach	< 20 cm	4
	Barbel, bream, chub	> 40 cm	½**
	Wels catfish	> 40 cm	2
	Perch	on average 20 cm	8
Saar	Roach	on average 20 cm	6
	Wels catfish	50 – 60 cm	1
	Perch	< 20 cm	8

* maximum allowable number of 200 g portions per month
** maximum of one 200 g portion in 2 months
See information sheet for anglers in Rhineland-Palatinate, April 2010, http://www.wasser.rlp.de/servlet/is/2027/

In addition, a programme of biota trend monitoring based on EU Directive 2008/105/EC (EQS) is also planned, taking account of the WFD survey measurement locations. Fish samples from the impounded sections at Koblenz and Palzem (Moselle) and at Schoden (Saar) will also be taken into consideration. Currently, the intention is to carry out studies every six years, commencing in 2010 or 2011.

3.3.3 Hesse

In 1999 and 2000, the Hesse Institute for Environment and Geology (HLUG) studied a total of 6 eel samples for various environmental chemicals and 7 perch and 2 roach samples for organotin compounds. The permissible limits for hexachlorobenzene, PCB 138, PCB 153 and PCB 180 were exceeded in 4 eel samples. The results are available on the Internet at http://www.hlug.de/medien/wasser/messwerte.htm (title of study: "Belastungen von Fischen mit verschiedenen Umweltchemikalien in Hessischen Fließgewässern").

In 2009, the Hesse Federal State Laboratory (LHL) carried out a study in fish from 4 measurement locations in the Rhine of environmental pollutants relevant from the point of view of foodstuffs legislation. Three of the measurement locations were in former branches of the Rhine. The Rhine constantly flows through the Erfeld and Ginsheim branches, but the Lampertheim branch is only subject to the fluctuations in the level of the river, and the Rhine only flows through it when the level is very high. None of the three former branches of the Rhine is affected by groundwater. The fourth sampling location is in the harbour at Rüdesheim. The outcome of this study is dealt with below.

Table 7: Fish from the Rhine in Hesse 2009

Catch location	Type of fish	Number of fish	OCP/NDL-PCB	DXN/DL-PCB	PFT	HME
Lampertheim arm of Rhine (km 440)	Eel	1	X	X	X	
	Perch	50 (small)	X		X	
	Roach	29	X		X	
	Wels catfish (2 samples)	2 x 1	X	X	X	X
Erfeld arm of Rhine (km 473)	Orfe	1	X		X	
	Perch	4	X		X	
	Roach	1	X		X	
Ginsheim arm of Rhine (km 490)	Eel	2	X	X	X	X
	Perch	4	X		X	
	Tench	1	X		X	
	Wels catfish	1	X	X	X	X
Rüdesheim harbour (km 525)	Eel	2	X	X	X	
	Orfe	1	X		X	
	Perch	4	X		X	X
	Roach	21	X		X	

OCP/NDL-PCBs = investigation of organochlorine pesticides and non-dioxin-like PCBs
DXN/DL-PCB = investigation of dioxins and non-dioxin-like PCBs
PFT = investigation of perfluorinated tensides
HME = investigation of heavy metals (lead, cadmium, mercury)

Dioxins, furans, DL-PCBs

Only eel and wels catfish were investigated. Neither the action level nor the maximum for the TEQ for dioxins were exceeded, in either species. The action level for the TEQ for DL-PCBs was exceeded in the eel and in two wels catfish even after deduction of the measurement uncertainty of +/-20%. The proportion of DL-PCBs is also responsible for the violations of the maximum levels of TEQ for the sum of dioxins and DL-PCBs in the eel and in 2 wels catfish. After deduction of the measurement uncertainty, the sum TEQ only exceeds the permissible maximum in the eel.

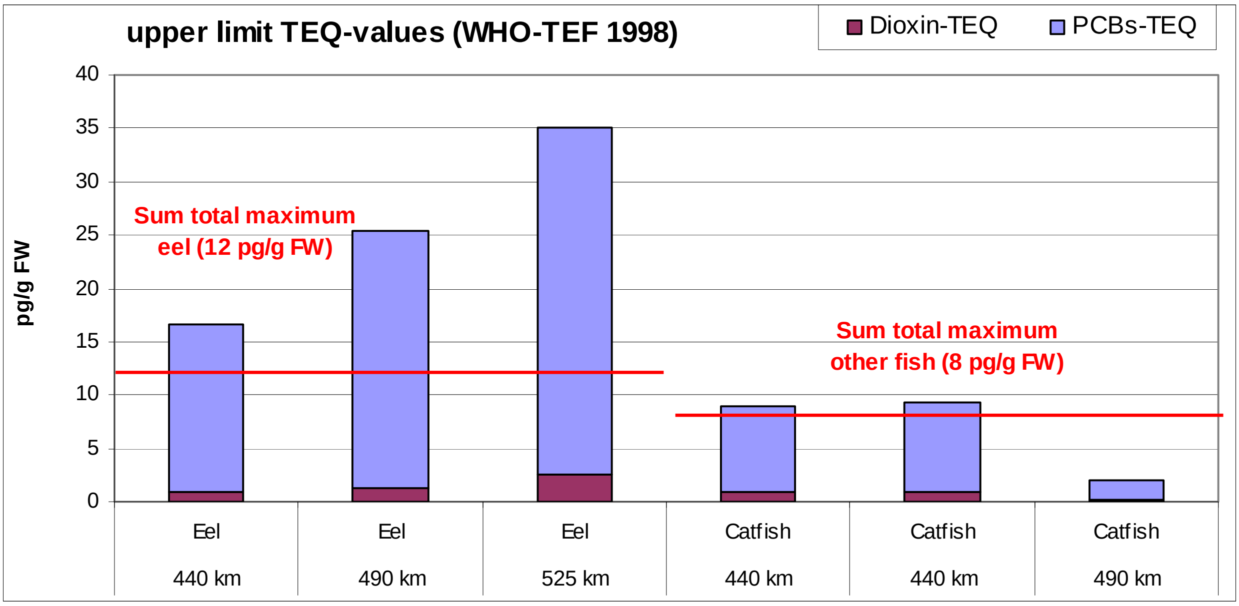

Figure 11*: Dioxins/DL-PCBs in fish from the Rhine in Hesse 2009*

Organochlorine pesticides

The permissible maximums in the ordinance on maximum quantities of residue was found to be exceeded in only one case. In an eel from the Ginsheim arm of the Rhine, the quantity of beta-HCH (0.141 mg/kg fat) was slightly above the limit of 0.1 mg/kg fat after deduction of the measurement uncertainty (+/-25%).

Indicator PCBs

No violation was observed of the permissible maximums for the individual NDL-PCB congeners as set out in the contaminants ordinance. The maximums currently under discussion by the EU for the sum of 6 indicator PCBs in fish muscle tissue (see 2.2) were exceeded, however, in 2 of the eel samples studied (Rüdesheim harbour: 0.393 mg/kg FW; Ginsheim former arm of Rhine: 0.350 mg/kg FW). After deduction of the measurement uncertainty, however, none of these samples exceeded the maximum.

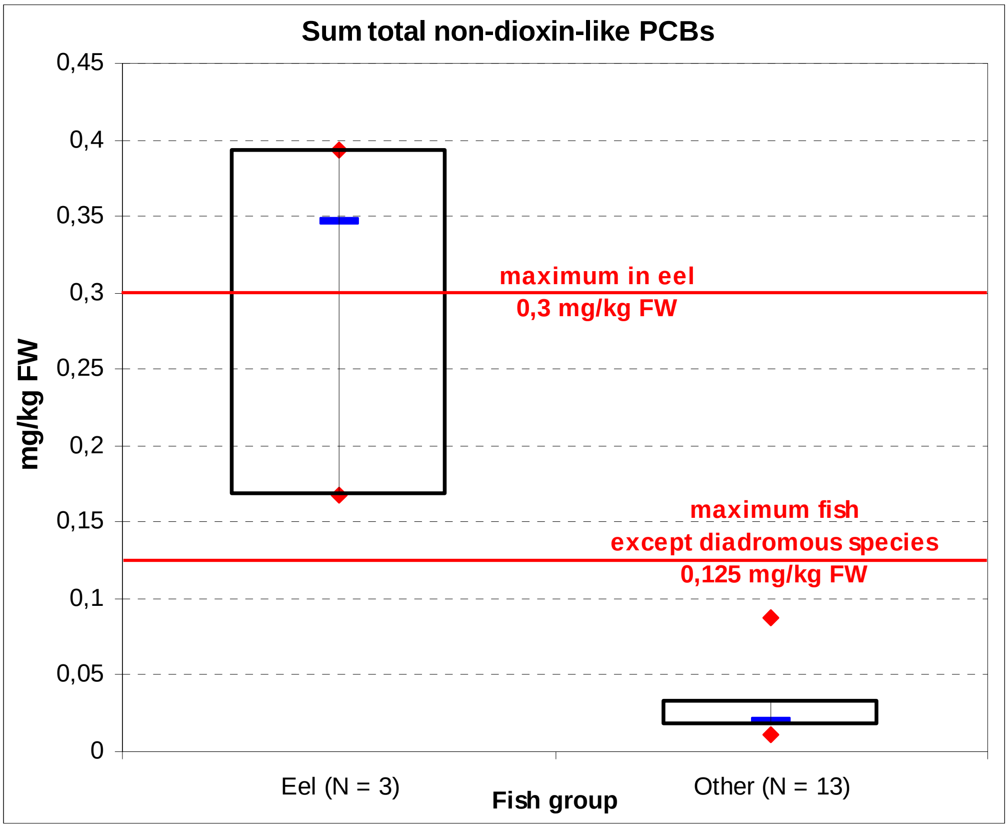

Figure 12*:* NDL-PCBs in fish from the Rhine in Hesse 2009

Perfluorinated tensides

All the samples were investigated for 10 perfluorinated tensides. PFOS (perfluorooctanesulfonic acid, maximum = 126 µg/kg FW) was identified most frequently and in the highest concentrations. To a lesser extent, the substances PFDA (perfluorodecanoic acid; maximum value = 11 µg/kg FW) and PFDOA (perfluordodecanoic acid; maximum value = 6.5 µg/kg FW) and PFOA (perfluorooctanoic acid, maximum value = 3.3 µg/kg FW) were detected. The values for the other compounds were below the detection limit in all the samples.

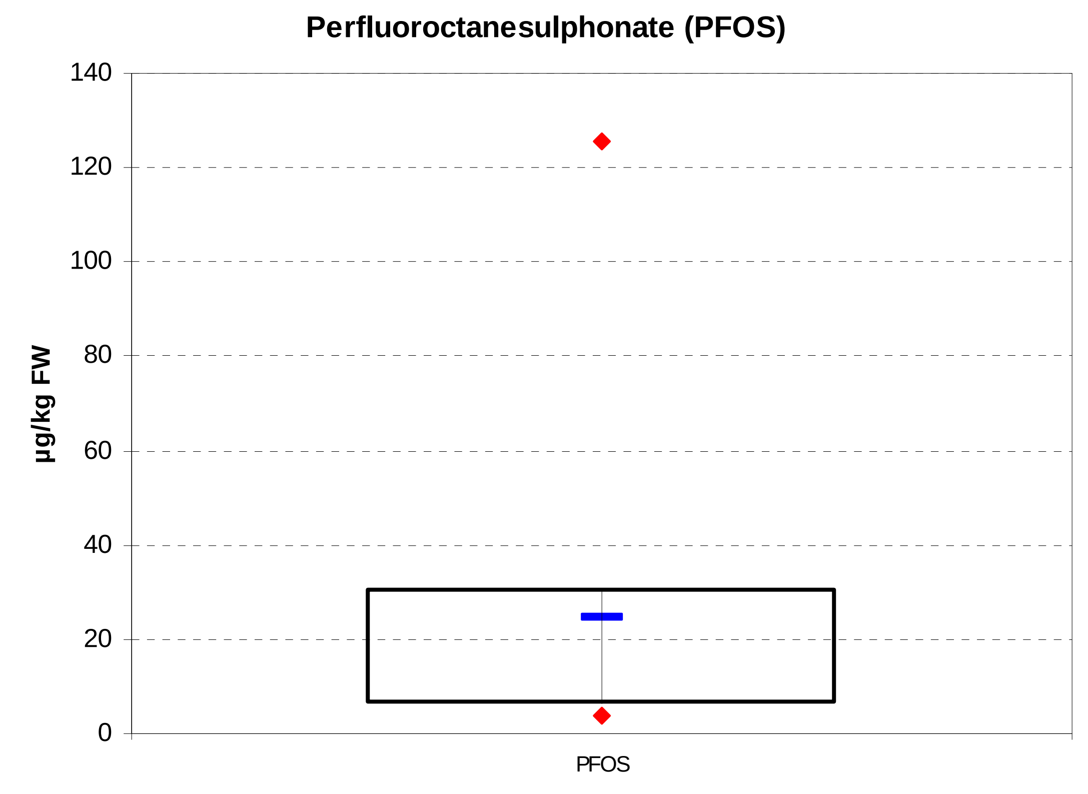

Figure 13*: PFOS in fish from the Rhine in Hesse 2009.* N = 16, see Table 7.

Heavy metals

The permissible maximum set in the EU Regulation on maximum levels for lead, cadmium, and mercury was found to be exceeded in only one case. In a wels catfish from the Lampertheim arm of the Rhine, the quantity of mercury (0.577 mg/kg FW) exceeded the limit of 0.5 mg/kg FW after deduction of the measurement uncertainty (+/-5%).

Outlook

The known high level of contamination of eel with dioxin-like PCBs was confirmed by the studies. PFTs today represent another problem as regards the contamination of fish. The studies did not lead to any prohibitions on marketing or consumption because the fish concerned are not in fact intended for marketing.

3.3.4 North Rhine-Westphalia

As part of annual residue testing of fish from the Rhine, an extensive list of contaminants has been analysed since 2000 at varying measurement locations. The objective of the measurement programme was to survey the contamination situation and to answer a number of specific questions. In 2008 and 2010, measurements were carried out in order to implement EU Directive 2008/105/EC at the survey measurement locations on the Rhine and at the mouths of the tributaries (2008: 46 fish investigations at 9 measurement locations for the parameters of lead, cadmium and mercury; 2010: for hexachlorobenzene and hexachlorobutadiene).

Dioxins, furans, DL-PCBs

Violations of the maximum for the sum of dioxins, furans, and dioxin-like PCBs were identified in 2008 to 2010; they were based on a high proportion of DL-PCBs in the samples studied. Violations of the maximums for dioxins were only sporadic.

Indicator PCBs

Six indicator PCBs were investigated in eel taken from the Rhine in 2002 and 2005. Violations of the maximums permitted under foodstuffs legislation were determined for PCB-101, PCB-138, and PCB-153.

Hexachlorobenzene and hexachlorobutadiene

In 2010, the EQS of 0.01 mg/kg FW for HCB and 0.055 mg/kg FW for HCBD was achieved in all the fish samples (muscular tissue) analysed from the Rhine measurement locations in 2010. Where the trend in HCB contamination is concerned, there would appear to be a reduction in the quantity in relation to fat content. This trend requires statistical confirmation, however. The extent to which statements regarding trends for other parameters are possible on the basis of the available data is still under investigation.

Perfluorinated tensides

In the period from 2006 to 2009, PFOS was investigated in muscle samples from 100 fish (13 different species from the Rhine that are used for human consumption). The findings were between 3.1 µg/kg and 71 µg/kg (median 16.7 µg/kg).

Table 8: Investigation of Rhine fish for PFOS in North Rhine-Westphalia.
a. Data on sampling; b. results

a.

River	River km	Number of measurement locations in Rhine	Period	Number of fish species	Number of samples
Rhine	640 to 781	5	2006 to 2009	13	100

b.

Average PFOS level µg/kg	Minimum PFOS µg/kg	10 percentile PFOS µg/kg	Median PFOS µg/kg	90 percentile PFOS µg/kg	Maximum PFOS µg/kg
23.2	3.1	8.2	16.7	48.0	71.0

Testing was also carried out at other measurement locations throughout the network of waterways in North Rhine-Westphalia. The figure below compares the results for the survey measurement locations in the Rhine catchment area and for the Rhine measurement locations. It shows that fish from the measurement locations on the Rhine are on average contaminated to a greater extent than those from most other water bodies. However, fish from certain water bodies (for example the Lenne and the middle section of the Ruhr) display even higher contamination.

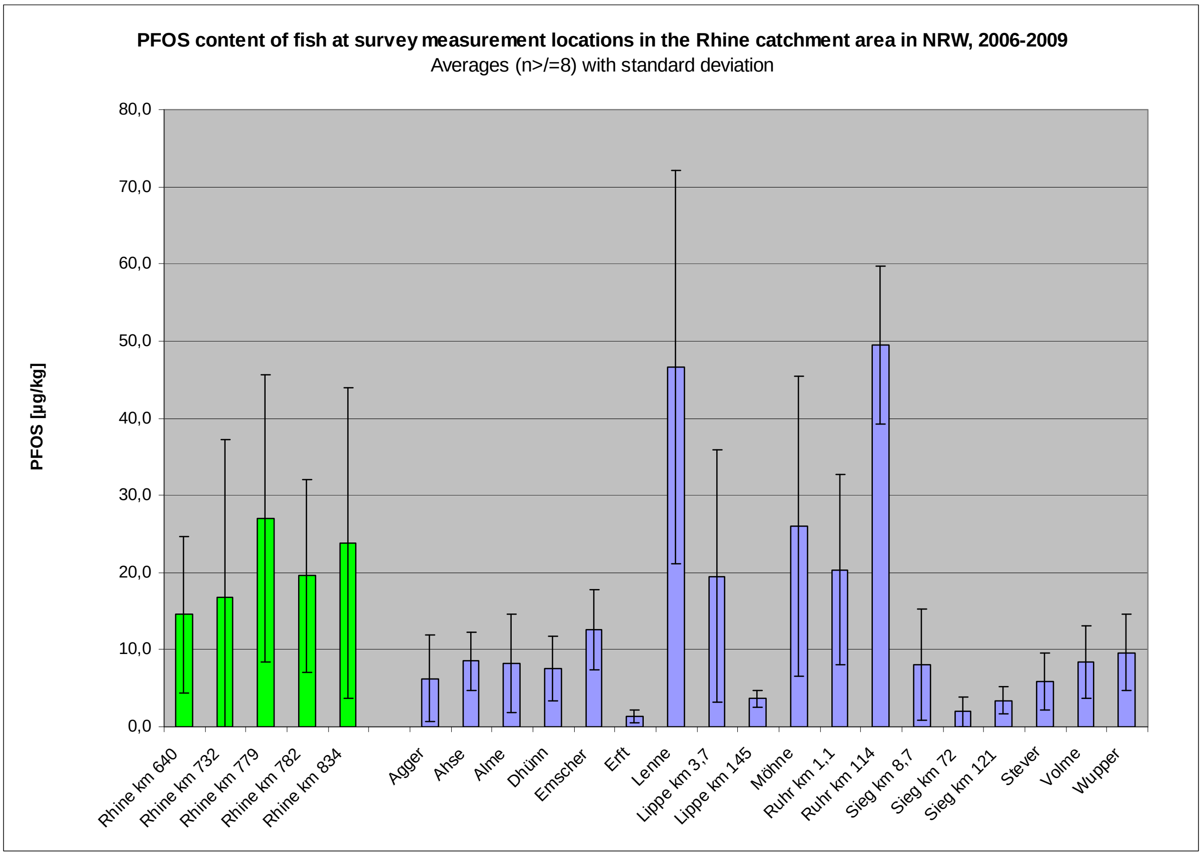

Figure 14: Investigations of PFOS content in fish at survey measurement locations in the Rhine catchment area in North Rhine-Westphalia. Comparison of contents in the Rhine and in tributaries. The averages ($n \geq 8$) are shown for each catch location for the period 2006–2009, with the standard deviation.

The results correlate with the PFOS contaminations in water, which are in the nanogram area, whereas PFOS in fish are accumulated by a factor 1000 (see 1.2 and Appendix 6, where the calculation of bio-accumulation factors for PFOS in fish is presented in full).[28]

Mercury

The Environmental Quality Standard for mercury according to the biota standard specified in Directive 2008/105/EC was exceeded at all the survey measurement locations in 2008. Violations were also identified of the EU Contaminants Regulation No. 466/2001 or EU Regulation No. 1881/2006 and the Pollutants Limits Ordinance.

[28] See LAWA 2010

Table 9: Violations of limits for individual pollutants at measurement locations in the Rhine catchment area in North Rhine-Westphalia according to EU Food Regulation No. 1881/2006 (EU Reg.) or the Environmental Quality Standard for biota according to Directive No. 2008/105/EC ("Biota standard")

		Standards exceeded		
Substance	**Year**	Biota standard	EC Reg.**	**Violations and individual measurement locations/details**
Lead	2008	-	-	
Cadmium	2008	-	-	
Mercury	2008	X*	X	Bad Honnef
PCDD/F	2002	-	X	some significant violations -> recommendation to avoid consumption of eel from Rhine (28 March 2003)
	2003	-	X	Emmerich
	2004	-	-	
	2008	-	-	
	2009	-	X	Düsseldorf-Flehe, Rhine below mouth of Ruhr, Bad Honnef
Σ Dioxins + DL-PCBs	2008	-	X	Düsseldorf-Flehe
	2009	-	X	Emmerich, Düsseldorf-Flehe, Rhine below mouth of Ruhr, Bad Honnef
NDL-PCBs	2002	-	-	
PCB 101		-	-	
PCB 138		-	X	Bad Honnef, Hitdorf, Kaiserswerth, Walsum, Emmerich
PCB 153		-	X	Bad Honnef, Hitdorf, Kaiserswerth, Walsum, Emmerich
PCB 180		-	X	Emmerich
HCB		-	-	
HCB/HCBD	2010	-		
NDL-PCBs	2003	-	-	
PCB 138		-	-	
PCB 153		-	-	
NDL-PCBs	2005	-	-	
PCB 101		-	X	Emmerich
PCB 138		-	X	Hitdorf, Kaiserswerth, Walsum, Emmerich
PCB 153		-	X	Hitdorf, Kaiserswerth, Walsum, Emmerich
PCB 180		-	X	Hitdorf, Kaiserswerth, Emmerich
DDT		-	-	for total DDT, the level of 1 mg/kg in fat was (on average) not exceeded
Musk xylene		-	-	minor violations of the intervention level of 10 µg/kg fish according to federal/federal state commission
Musk ketone		-	X	violations of the intervention level of 10 µg/kg fish according to federal/federal state commission at Kaiserswerth and Walsum
PFOS	2006–2009	-	-	
		*Violations at all survey measurement locations		
		**Also violation of Pollutants Limits Ordinance		

Outlook

Elevated dioxin and PCB contamination already led in 28 March 2003 to the Ministry for Consumer Protection of the German State of North Rhine-Westphalia issuing a recommendation to refrain from eating eel from the Rhine.

Investigations in the framework of the food monitoring project (LM-PM) and the fish inspection programme (LUP) were continued. In the context of implementation of Directive 2008/105/EC, a trending investigation programme will be added to the investigation programme for monitoring Environmental Quality Standards.

3.3.5 Bavaria

As part of the Bavarian programme for monitoring contaminants in fish, the State Agency for Environmental Protection (LfU) carries out an annual survey at 16 measurement locations in the catchment area of the Main. Its aim is to improve the health of fish, to identify substances in water bodies, to trace the causes of pollution, to implement measures, to clarify long-term trends, to document remediation successes, and to make recommendations should permissible limits under food legislation be exceeded. A large range of fish species are sampled. The heavy metal concentrations in muscle tissue and the spleen are determined for 3 to 6 individual fish per sampling location, as well as the levels of as well as the levels of HCB, HCBD, indicator PCBs, 1,2,4-trichlorobenzene and pentachlorobenzene in muscle tissue and the liver. At a number of locations, analysis is also carried out for other substances (DEHP, HHCB, nonylphenol, octylphenol, triclosan, methyl triclosan). Some of the fish samples taken in the years 2009/2010, mainly of eel, will also be reanalysed, as in 2002 and 2003, for DL-PCBs.

The State Agency for Public Health and Food Safety (LGL) also investigated fish that is marketed as a food, particularly originating from fish farming, for such aspects as the residue levels of organochlorine compounds (indicator PCBs, HCB) and heavy metals. Since 2002, fish samples have also been regularly analysed to determine the level of dioxins and furans; since 2006 this has also been done for PFTs and since 2007 for dioxin-like PCBs. If not otherwise indicated, the results described below refer to 11 eel samples taken in 2009 from the catchment area of the Main.

Dioxins, furans, DL-PCBs

The maximum levels for dioxins, furans, and DL-PCBs (WHO-PCDD/F-PCB) were exceeded in all 8 eel samples from the catchment area of the Main in 2002. The totals (WHO-PCDD/F-PCB-TEQ) varied from von 31.2 to 77.7 pg/g FW. In the 4 samples from other species, the maximum level for dioxins, furans, and DL-PCBs was exceeded numerically in a silver bream with a WHO-PCDD/F-PCB-TEQ of 8.3 pg/g FW, meaning that it remained within the measurement uncertainty of approx 20%.

The maximum levels for dioxins, furans, and DL-PCBs were exceeded in 6 of the 7 eel samples taken by the LfU in 2003. The totals (WHO-PCDD/F-PCB-TEQ) varied from 4.6 to 46.3 pg/g FW. The 5 samples from other species were unremarkable.

The maximum levels for dioxins, furans, and DL-PCBs were exceeded in all 11 of the eel samples taken by the LGL in 2009. The totals (WHO-PCDD/F-PCB-TEQ) varied from 16.2 to 60.7 pg/g FW.

Indicator PCBs

The foodstuffs limits for indicator PCBs were sporadically exceeded in samples taken by the LfU (approx. 65 fish annually) from the Main and Schwarzach. No violations of the maximum levels were found in the tests carried out by the LGL (11 eel in 2009) for indicator PCBs.

HCB

The LFU only found violations of the HCB biota standard (10 ng g/FW) according to Directive 2008/105/EC in the Main and its catchment area in the muscle tissue of eel. HCB levels of > 10 ng/g FW were also only measured sporadically in the liver of nase, pike and dace. Muscle and liver samples from other species all displayed an HCB level of < 10 ng/g FW.

Heavy metals

Since 2005, the EQS for mercury in biota according to Directive 2008/105/EC has been regularly and largely significantly exceeded at all of the LfU's measurement locations. Measurements were made of both chub and bream, and also of other species. The foodstuffs limits for mercury and lead were only exceeded very sporadically.

Outlook

Investigations in the framework of the Bavarian system for monitoring contaminants in fish will continue. Changes are planned in the sampling strategy and the range of materials investigated with a view to surveillance monitoring according to the WFD and the EQS for biota. Statistical analysis of data from the past 10 years has yet to be effected. All expectations are that the trend for the substances investigated will be downward or stable.

A condensed version of the reports from the LfU's most recent reporting period (2005 and 2006) is available at

- http://www.lfu.bayern.de/analytik_stoffe/daten/stoffanreicherung_wassertiere/doc/bericht_fischmonitoring.pdf

  http://www.lfu.bayern.de/analytik_stoffe/fachinformationen/akkumulationsmonitoring/stoffanreicherung_wassertierchen/doc/fimo_messstellen_2005.pdf

  The LfU reports for 2002 and 2003 on DL-PCB and PCDD/PCDF can be found at http://www.lfu.bayern.de/analytik_stoffe/forschung_und_projekte/untersuchung_bewertung_proben/doc/pcb_abschlussbericht_100807.pdf

The contaminant combination dioxins, furans, and dioxin-like PCBs was first measured by the LGL in 2009. It is not therefore possible to make any statement regarding a trend. Given the limit violations that have been observed, further investigations are planned for fish from the Main for 2010. Fish that are marketed for human consumption will also be investigated.

Overview data for these investigations are available in the LGL's annual reports: http://www.lgl.bayern.de/publikationen/jahresberichte.htm
All the individual data is reported to the database operated by the federal government and the federal states and can be viewed there: http://www.pop-dioxindb.de

3.3.6 Saarland

In 2009 and 2010, fish (primarily chub but in Saarlouis bream) from the Saar and its tributaries and from the Moselle were investigated for contaminants.

Dioxins, furans, PCBs

The limit specified in the relevant EU regulation (8 pg/g PCDD/F-PCB WHO TEQ) was exceeded in 4 samples. In all cases, this was due to raised levels of PCBs. The highest levels of both NDL-PCBs and DL-PCBs were found in a bream from the Saarlouis sampling location on the Saar.

Perfluorinated tensides

Only PFOS and to some extent PFHxS were detected in significant quantities, namely in bream, crucian carp, and roach or carp in two ponds at Sankt Wendel, which were contaminated with extinguisher foam after a major fire in May 2007. The samples from the watercourses definitely keep to the guidance value of 30 µg /kg.[29]

Mercury

Nine of the 10 samples investigated were below the limit for foodstuffs of 500 ng/g FW; it was only in a chub from the sampling location at Reinheim (on the Blies) that a slight violation (520 ng/g FW) was identified.

Outlook

The results for dioxins and PCBs deviated greatly from the much lower values from the previous years and resulted in a consumption recommendation being issued in July 2010, advising against consumption of fish caught in the Saar downstream of the barrage at Saarbrücken-Burbach.

3.3.7 Federal Environmental Specimen Bank

The Federal Environmental Specimen Bank (UPB) collects samples from the environment and from humans and stores them for the long term so as to provide ecotoxicological and toxicological evidence. Before being stored, all samples are analysed for a specific set of inorganic and organic substances ("real-time monitoring"); the data can be accessed via the UPB's website www.umweltprobenbank.de.[30]

Dioxins, furans, DL-PCBs

In 2008, the permissible maximum (4 pg/g FW) for dioxins/furans was only exceeded in bream from the measurement location at Bimmen. At that location, there was a rising trend in dioxin content between 1995 and 2000. Between 1995 and 2005, bream from the measurement location at Weil displayed dioxin concentrations that were up to a factor of 3 higher than the maximum level. Concentrations decreased abruptly from 2006 on because since then it has only been relatively young bream that could be caught at the Bimmen measurement location. Dioxin levels in fish from the Iffezheim measurement location have remained fairly constant over the years, namely at or just under the limit. Bream from the Koblenz measurement location were only slightly contaminated with

[29] At an average consumption of 300 g of fish per day and a body weight of 60 kg, the TDI of 0.15 µg of PFOS per kg body weight and day proposed by the BfR would be used up with a contamination of 30 µg/kg.

[30] Data can be provided as Excel files on request. Data on dioxins, furans, and DL-PCBs is not uploaded to the UPB's database but to the dioxin database of the federal government and the federal states. The results can be provided on request in the desired form (WHO-PCDD/F-TEQ, WHO-PCDD/F-DL-PCB-TEQ).

dioxins in 2004; shifts in the fish sampled towards older and more fat-rich individuals led to dioxin concentrations of around the limit.

In 2008, the maximum (8 pg/g FW) for dioxins/furans/DL-PCBs – calculated as WHO-PCDD/F-PCB-TEQ – was exceeded in bream from Iffezheim, Koblenz, and Bimmen (see Figure 15).

Trends over time of total TEQ in bream from the 4 Rhine measurement locations basically correspond with those of the PCCD/F-TEQ, with the difference that the inclusion of DL-PCBs more frequently leads to the maximum being exceeded.

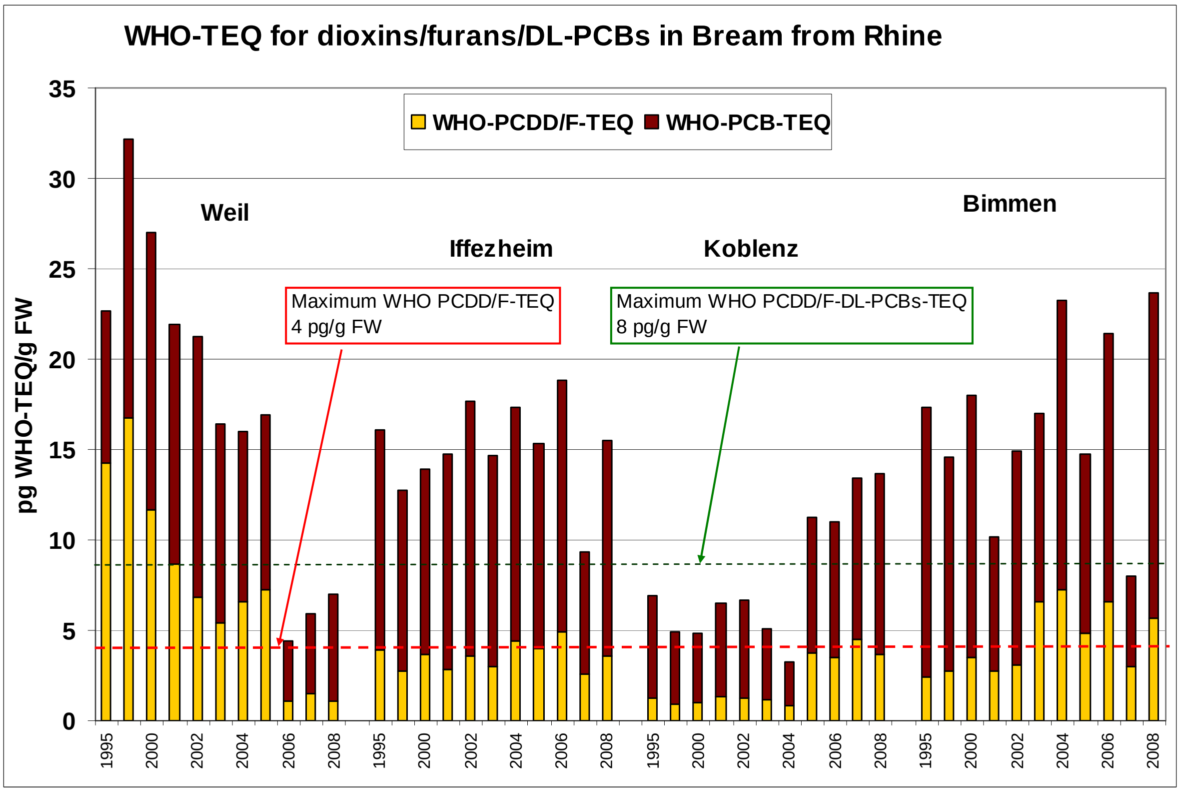

Figure 15*: Trend over time in contamination of bream from the Rhine itself with dioxins, furans, and DL-PCBs.* Source: UBA

Indicator PCBs

Indicator PCB concentrations in the muscle tissue of bream from all the Rhine locations are clearly below the current maximum levels according to the ordinance on the maximum quantities of pollutants.[31] If the EU value that is currently under discussion of 110 ng/g FW for the sum of the 6 indicator PCBs (see 2.2) is introduced, bream from the measurement locations at Iffezheim, Koblenz, and Bimmen would be unfit for human consumption. As regards fresh weight, there were widely varying values over the observation period from 1995 to 2009, with rising trends in concentrations in fish from Iffezheim, Koblenz, and Bimmen. Where fat content is concerned, the curves level off, but here too no significant consistent decrease in PCBs has been observed in bream since 2000.

[31] 200 ng/g FW each for PCB congeners 28, 52, 101, 180 and 300 ng/g FW each for PCB congeners 138 and 153

Hexachlorobenzene

HCB concentrations in the muscle tissue of bream from the Rhine locations of Weil, Koblenz, and Bimmen are around or below the HCB biota standard according to Directive 2008/105/EC (10 ng/g FW). At Iffezheim, the standard was exceeded by a factor of up to 5 from 1999 to 2008; in 2009, the HCB concentrations measured were only slightly higher than the standard. Since there were hardly any differences between the bream sampled at Iffezheim with respect to age, weight and fat content, this finding may indicate a sustained decrease in HCB contamination at that location.

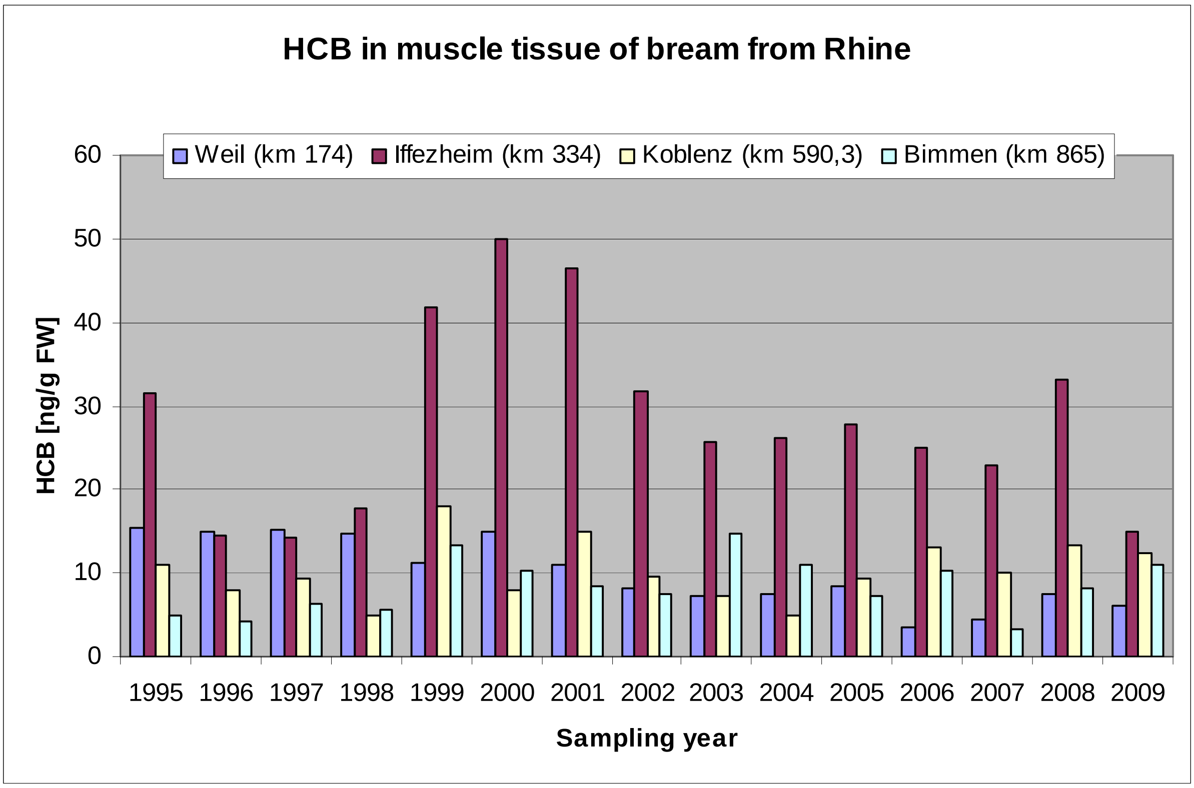

Figure 16*:* Hexachlorobenzene contamination of bream from the Rhine itself (source: UBA)

Mercury

Mercury concentrations in the muscle tissue of bream from all Rhine sampling locations were significantly higher than the biota standard for mercury according to Directive 2008/105/EC, namely 0.02 mg/kg FW; that standard was exceeded by 5 to 17 times. No decreasing trend in mercury concentrations can be observed for the period from 1995 to 2009. The abrupt drop in the mercury concentration at Weil between 2005 and 2006 is explicable by the fact that only relatively young bream could be sampled there in recent years.

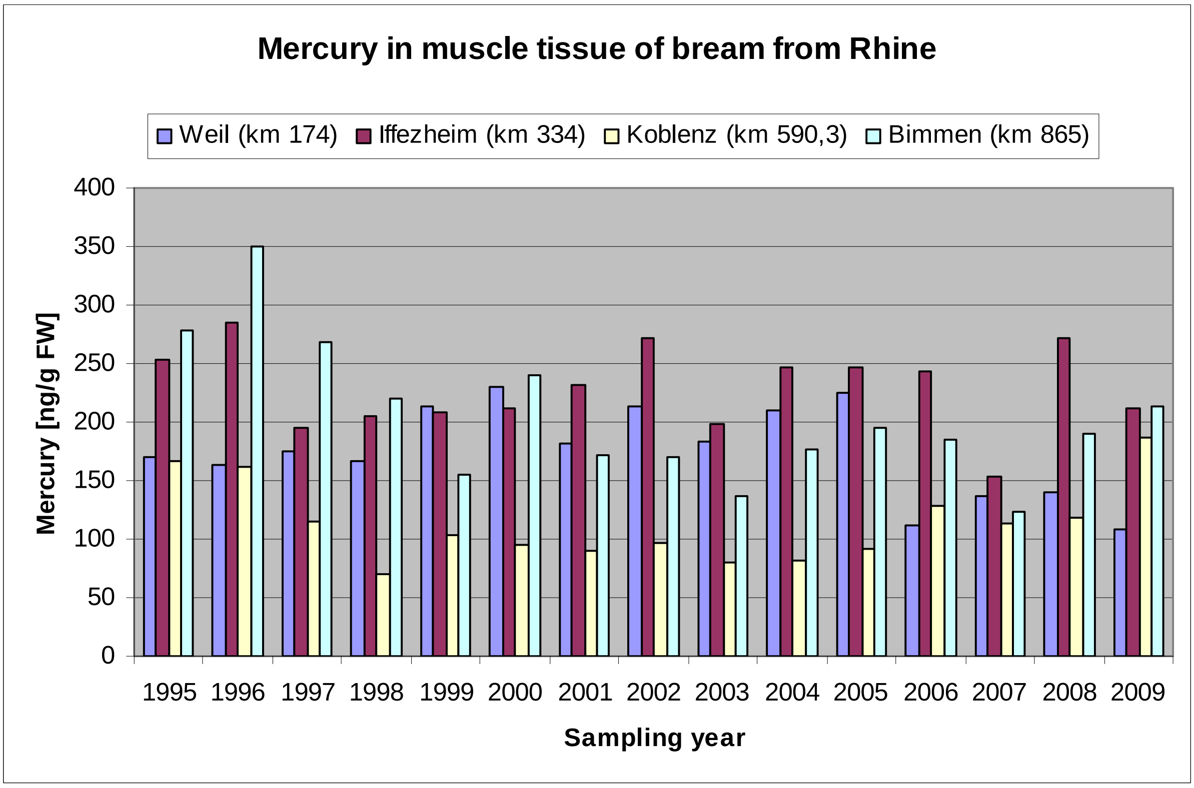

Figure 17*: Mercury contamination of bream from the Rhine itself (source: UBA)*

Outlook

The long-term studies by the Environmental Specimen Bank of contaminant levels in bream show that assessment of trends in concentrations over time must always take account of the age and fat content of the fish sampled. This reveals the limits of standardisation of sampling when, for example, "old" bream populations can no longer be sampled at Weil or when fish become more fatty due to improved living conditions. This phenomenon has been observed in the context of the Environmental Specimen Bank not only in the Rhine but also in other watercourses.

3.4 Moselle-Saar area

In the spring of 2004, an international programme for monitoring suspended matter and fish for dioxins, furans and PCBs, including the WHO-PCBs, was carried out throughout the catchment area of the Moselle and Saar.[32] The programme revealed that the analysis results are distributed more unequally spatially for pollutants in fish than for pollutants in suspended matter. They differ for eel and carp species, with some locations displaying very high levels that have no equivalent in the results for suspended matter. The distribution of congeners also varies greatly. Comparison of the results for fish with the limits and guidance values revealed clear violations in eel from virtually all measurement locations. The values for carp species also displayed violations of the guidance values in individual cases.

[32] International monitoring programme for "PCBs and related substances in suspended matter and fish in the Moselle and Saar 2004", ICPMS, see http://www.iksms-cipms.org => Publikationen => Inter_Messprogrammem_Schwebstoffe_Fische_2004.pdf

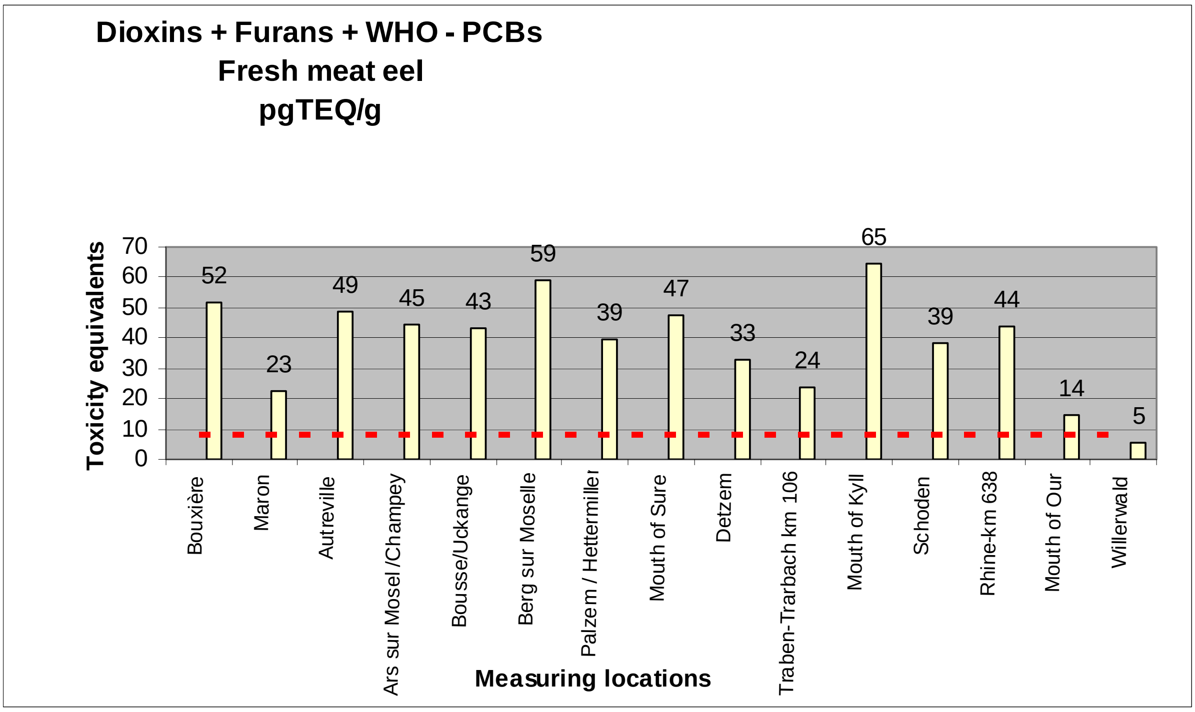

Figure 18*: Contamination of eel from water bodies of the Moselle-Saar catchment area with dioxins, furans, and PCBs*. Source: ICPMS report 2005

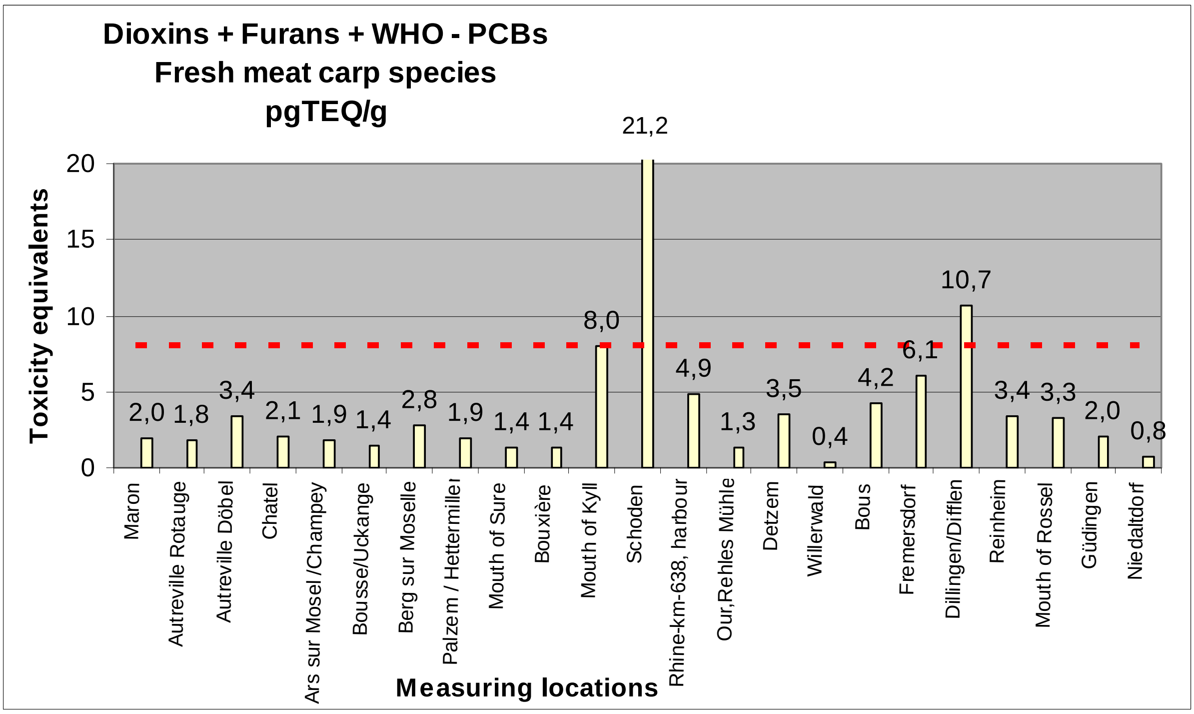

Figure 19*: Contamination of carp species from water bodies of the Moselle-Saar catchment area with dioxins, furans, and PCBs*. Source: ICPMS report 2005

3.5 Luxembourg

In 2000, 2002 and 2003, fish from the Sûre and its tributaries were investigated with the following aims: (1) to identify contamination of fish with persistent, bio-accumulating pollutants as completely as possible; (2) to determine geographically the potential sources for the pollutants measured; and (3) to be able to estimate the risks to health from consuming fish from Luxembourg watercourses.

Dioxins, furans, DL-PCBs

The samples of eel all displayed major violations of the EU limit of 12 pg/g FW; the extreme values were between 21 pg/g FW and 160 pg/g FW. In the case of carp species (various species), the EU limit of 8 pg/g FW was only sporadically violated; the extreme values were from 0.43 pg/g FW to 10 pg/g FW.[33]

The following watercourses are considered to be contaminated with PCBs: the Moselle, the Middle and Border Sûre, the lower Our and the Wiltz, and also – to a lesser extent – the Alzette, the Clerve, and the Syre. Besides the man-made lake on the upper Sûre, the following watercourses are the least contaminated with PCBs: the Upper Sûre (especially below the man-made lake), the Eisch, the Mamer, the upper Our, the Attert, and the Wark.

Compared with previous surveys in 1993/1994 and 1998/1999, no trend in contamination over time could be detected; it is therefore assumed that the main sources of pollution are of a chronic and persistent nature.

Outlook

There is no commercial fishing in Luxembourg, and Luxembourg fish are therefore not marketed. Nevertheless, the survey in 2003 led to a consumption recommendation being issued; this was updated in 2010: http://www.securite-alimentaire.public.lu/actualites/communiques/2011/06/pcb_consommation_poissons/index.html. The recommendation advises people not to eat eel and recommends only moderate consumption of carp species in accordance with the WHO-TWI of 14 pg/g TEQ per kg of bodyweight.

3.6 Netherlands

Up to 2006, the Netherlands carried out a programme for monitoring the quality of water and ecosystems. In particular, eel were studied to determine the presence of persistent organic pollutants (POPs) – the concentration of which in water is very low – in the environment. HCB and mercury, which accumulates in organisms as methylmercury, have also been measured in eel since 1977. The concentrations in eel are compared in the reports with values for MTR and HC_5.

The angling monitoring programme conducted on behalf of the Ministry of Agriculture, Nature and Food Quality focused on the quality of eel (and some pike-perch) as food. The fish were tested for, amongst other things, PCBs, certain organochlorine pesticides (OCPs), and mercury. Substances were also investigated for which there were no statutory standards. Since the EU Directive came into force, dioxins, furans, and DL-PCBs in eel have also been analysed. Other surveys of eel have also been carried out.

[33] The values from older investigations have been converted to WHO TEQ. The surveys in 2000 to 2003 involved dry matter; the relevant values have been converted to fresh weight.

At a number of measurement locations, fish have been investigated since 1980. The following figures display the trends for the most important substances/groups of substances compared to the relevant limit.

Dioxins, furans, DL-PCBs

Since EU Regulation No. 1881/2006 came into force, the EU limit of 12 ng/kg FW TEQ for dioxins, furans, and DL-PCBs for eel has been consistently exceeded in the Dutch section of the Rhine catchment area. In the western section, violations of the limit are considerable, with even small (thin) eel displaying high TEQ levels. In large eel, maximum TEQ values of more than 80 ng/kg had been measured.

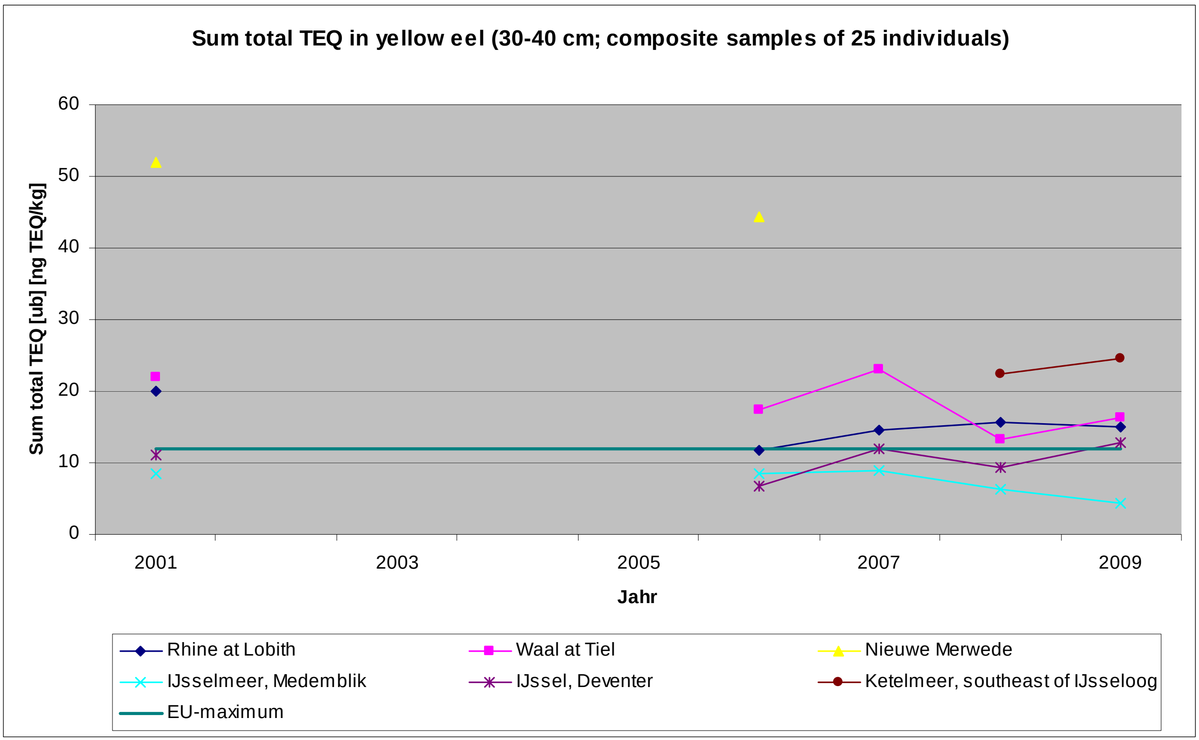

Figure 20*:* Contamination of yellow eel from the Delta Rhine (NL) with dioxins, furans, and dioxin-like PCBs in the period 2001–2009. Sum parameter PCDD/F + DL-PCB TEQ. Yellow eel with a length of 30 to 40 cm, composite samples of 25 individuals. Source: RIKILT/IMARES reports 1993 to 2010

Indicator PCBs

In the 1980s, the then applicable limits under Dutch food legislation were regularly exceeded, particularly that for PCB 153 (500 µg/kg). These violations have become less frequent. It is only in the lower reaches of the Rhine (sedimentation area) that the contamination level is still comparably high, especially in large fat-rich eel.

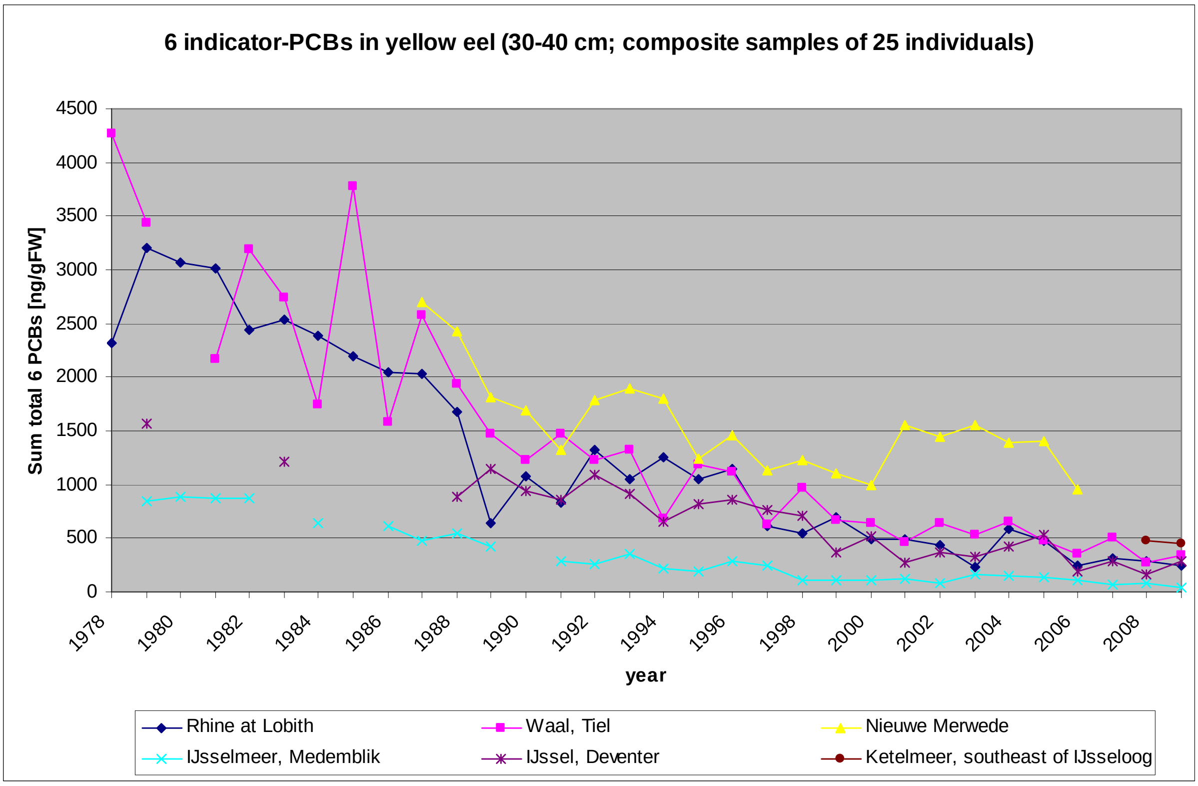

Figure 21*: Contamination of yellow eel from the Delta Rhine (NL) with indicator PCBs in the period 1978–2009.* Sum of 6 indicator PCB congeners. Yellow eel with a length of 30 to 40 cm, composite samples of 25 individuals. Source: RIKILT/IMARES reports 1993 to 2010[34]

Hexachlorobenzene

The following figure shows the HCB concentration at measurement locations in the Dutch section of the Rhine catchment area compared to the biota standard according to Directive 2008/105/EC. This is almost achieved for HCB (limit: 10 µg/kg). In recent years, concentrations have been between 11 µg/kg and 16 µg/kg. The HCB concentrations in eel from Lake IJsselmeer have in fact been below the biota limit since 1990.

[34] Source for Figures 14 to 16: RIKILT/IMARES reports 1993 to 2010. The studies were financed by the Ministry of Agriculture, Nature and Food Quality and by the Directorate General for Public Works and Water Management [*Rijkswaterstaat*].

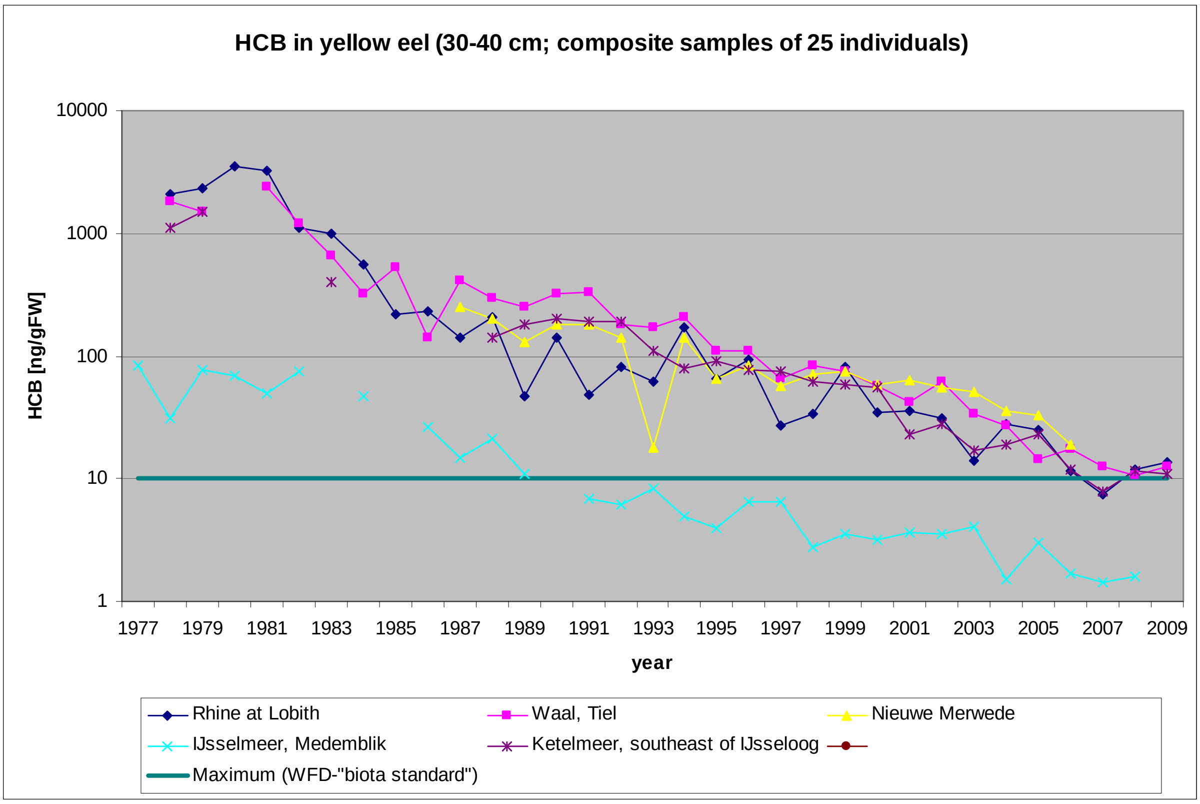

Figure 22: Contamination of yellow eel from the Delta Rhine (NL) with HCB in the period 1977–2009. Yellow eel with a length of 30 to 40 cm, composite samples of 25 individuals. Source: RIKILT/IMARES reports 1993 to 2010

Perfluorinated tensides

In 2007, 15 perfluorinated compounds were investigated in eel, water, and sediments in Dutch water bodies. For 3 measurement locations, new analytical methods were also used to investigate PFOS in eel samples taken over the course of the past 30 years. Between 1978 and the mid-1990s, the concentration of PFOS in the samples doubled or even quadrupled, then returning to the baseline values (see Figure 23). In recent samples, PFOS was the predominant compound amongst the PFTs; the PFOS concentrations in the muscle tissue of eel were between 7 ng/g FW and 58 ng/g FW.

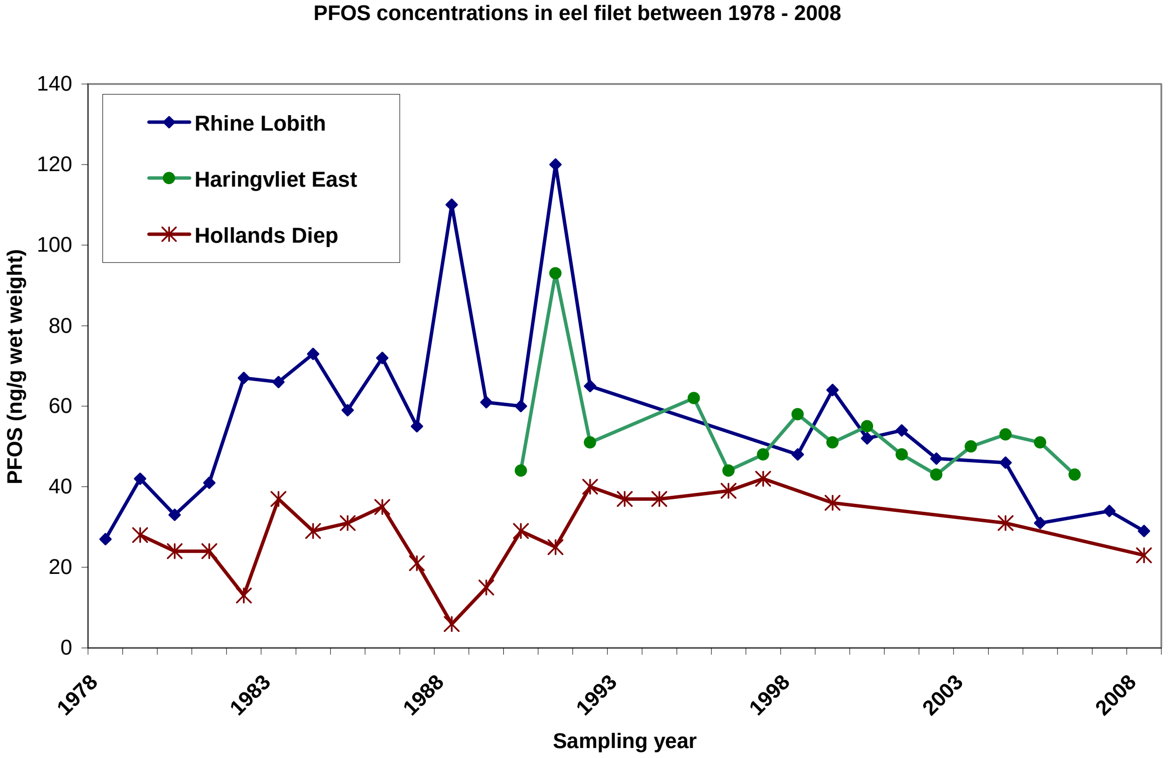

Figure 23*: PFOS concentrations in eel (n = 25) in Delta Rhine between 1997 and 2008.*
Source: Kwadijk et al. 2010

Mercury

As Figure 24 shows, concentrations of mercury/methylmercury in eel have decreased since the 1980s. Since 2000, no further improvement has been determined at the majority of measurement locations. The biota standard of 0.02 µg/kg FW is systematically exceeded throughout the Dutch section of the Rhine catchment area.

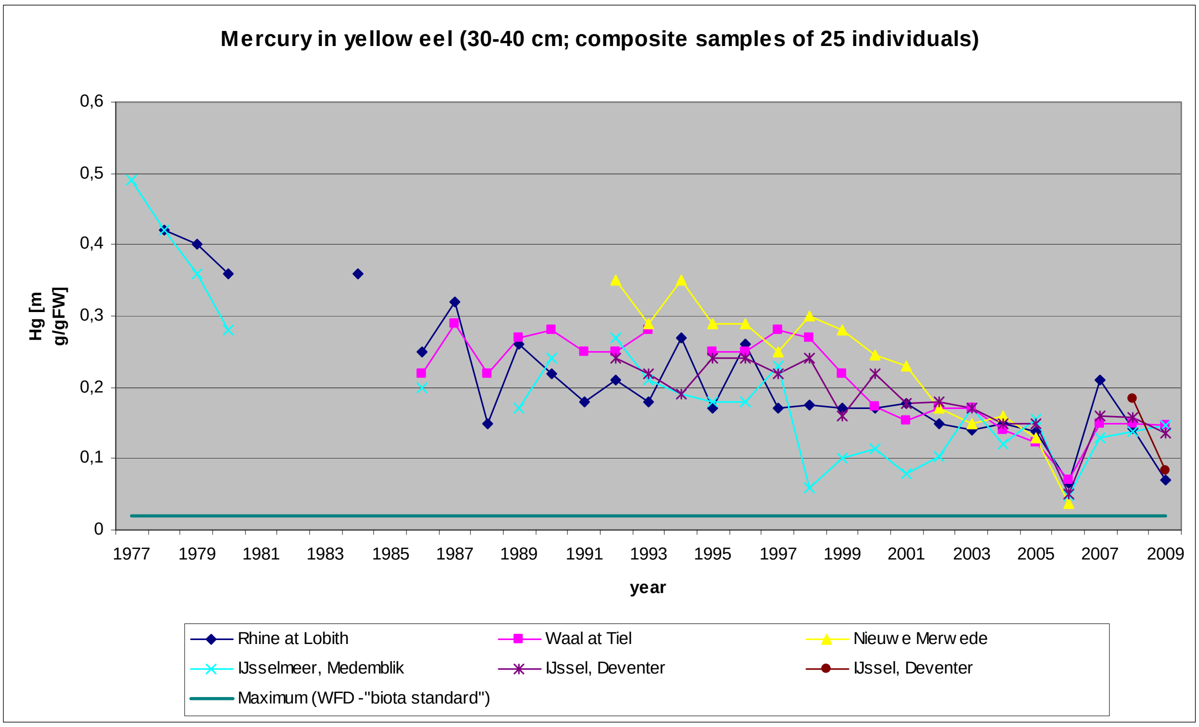

Figure 24*: Contamination of yellow eel from the Delta Rhine (NL) with mercury in the period 1977–2009.* Yellow eel with a length of 30 to 40 cm, composite samples of 25 individuals. Source: RIKILT/IMARES reports 1993 to 2010

Outlook

Other Dutch food standards are not exceeded. In September 2000, the Ministry of Agriculture, Nature and Food Quality recommended that anglers should not consume eel that they caught in the country's major rivers because of the analysis results for PCDD/F + DL-PCBs. For the past few years, anglers have also been required to release eel that they catch. Since 1 April 2011, fishing for eel in all areas contaminated with dioxins (TEQ) has been prohibited. The areas concerned are designated on the basis of the investigation results, and include all the major rivers of the Netherlands. The prohibition also includes a ban on the use of 10 specific types of gear used to catch eel; possession of eel in the areas concerned and their immediate vicinity is also prohibited. The prohibition on fishing for eel applies to everyone, not just professional fishermen but also anglers.[35]

In the view of the Netherlands, coordinated monitoring of pollution concentrations in biota should continue. Not all OCPs are still relevant; some (for example lindane) were taken off the market long ago, meaning that their concentrations have quickly diminished to well below the applicable standards. PCB concentrations in eel remain high, however, constituting 70% to 90% of the total TEQ values in eel in Dutch water bodies. PFTs, in particular PFOS, should continue to be monitored despite the downward trend; here, eel are a suitable bio-indicator.

[35] Kotterman & van der Lee 2011

4. Assessment of the ICPR's suspended matter measurement programme as regards PCB 118

In the course of the international Rhine chemicals measurement programme, the sole dioxin-like PCB measured since 1991 has been PCB 118. The sampling frequency is 13 to 26 samples annually, meaning that the calculated annual averages are representative for the PCB pollution of the Rhine. The PCB levels of suspended matter are representative for the PCB pollution of recent sediments. Since 2000, the PCB 118 levels in suspended matter have not decreased as much as in the 1990s. The accumulation of PCBs over the course of the Rhine is also not as marked as it was back then.

At the measurement location at Weil on the German-Swiss border, the annual average level of PCB 118 has been approx. 1 µg/kg. Fluctuations have been only slight; the maximum levels are 2 µg/kg to 2.5 µg/kg.

At the three other measurement locations (Lauterbourg/Karlsruhe, Koblenz, Bimmen), average levels decreased by half between 1994 (4 µg/kg) and 2007 (2 µg/kg to 2.5 µg/kg). Levels at Bimmen on the German-Dutch border are partly well above the levels at Koblenz and Karlsruhe.

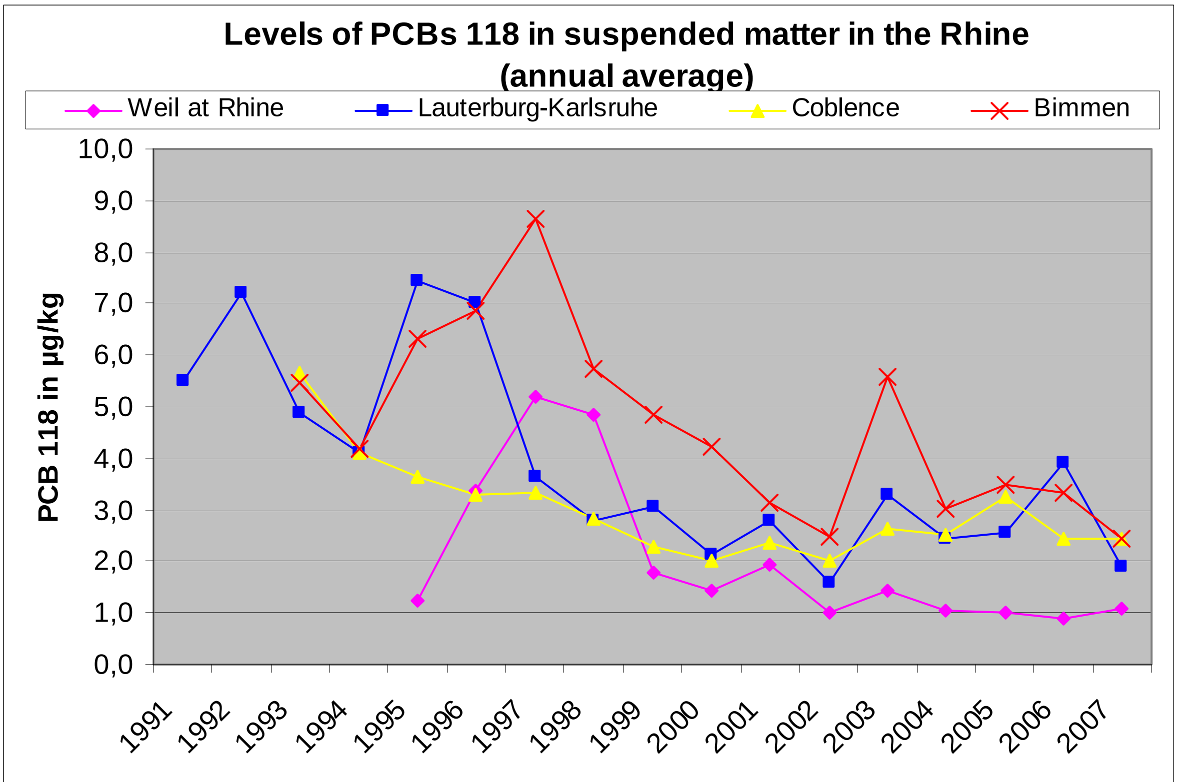

Figure 25: Levels of PCB 118 in suspended matter in the Rhine (annual average, levels in µg/kg). Source: ICPR suspended matter measurement programme 1991–2007

5. Summary of results for the Rhine catchment area

The following subsections provide a survey of the contamination of fish from the Rhine and its tributaries with dioxin-like PCBs and other pollutants on the basis of the combined data for the period from 2000 to 2010. Reference is generally to violation of the food legislation standards and in some cases the biota EQS according to Directive 2008/105/EC. Trends are noted when these are apparent.

Even if the data are not directly comparable, they still give a good overview of the contamination situation in the catchment area of the Rhine.

5.1 Dioxins, furans, DL-PCBs

Overall, significant fluctuations in the content of dioxins and PCBs were found in all the species of fish studied. These fluctuations are due, on the one hand, to the differing contamination situation in the particular water body and the sampling location and, on the other, to the nature and composition of the samples.

Reliable values for the sum TEQ for dioxins, furans, and dioxin-like PCBs are provided in Appendix 5. Unless otherwise indicated, raw data are listed without the measurement uncertainty being taken into account. Violations of the limits under food legislation are consequently not indicated here.

The values range from less than 1 pg/g FW in the case of individual chub, brown trout, roach, pike, pike-perch, perch and wels catfish to more than 70 pg/g FW in eel. The example of the asp (lowest value: 0.91 pg/g FW in an example from the Moselle; highest value: 73.32 pg/g FW in an example from the Middle Rhine) shows that the contamination is not species-specific but depends, for one thing, on the pollution situation of the water body concerned at the sampling site and, for another, on the age and fat content of the individual fish (see 1.2).

In the case of **eel**, a virtually blanket violation of the limit of 12 pg/g FW was determined along the Rhine and in many of its tributaries. An exception to this are eel from Lake Constance and from a former arm of the northern Upper Rhine that is connected only upstream and is affected by groundwater. Violations of the limits according to food legislation are normally due to DL-PCBs as a component of the total TEQ (see Figures 4, 6, 7, 8, 15).

The ICPR's suspended matter measurement programme for the period 1991–2007 makes possible a meaningful trend analysis for a dioxin-like PCB congener (PCB 118); this indicates a decreasing contamination.

5.2 Indicator PCBs

The limits for indicator PCBs under German and Dutch law (0.3 mg/kg) are sporadically exceeded in the Rhine itself (Upper Rhine to Delta Rhine) and in the Moselle and Main, namely in older, fat-rich eel and bream, but not in other species of fish. Investigation of the yellow eel from the Delta Rhine makes possible a meaningful trend analysis for indicator PCBs (see Figure 21). Since the 1980s, there has been a significant decrease in contamination here, from values greater than 3 mg/kg FW to values below 0.5 mg/kg FW; the same applies to the Moselle and to a lesser extent to the Saar.

5.3 Hexachlorobenzene

In the High and Upper Rhine, 2008 was the first time that no violation of the maximum levels permissible under the (German) ordinance on maximum quantities of residue was determined for hexachlorobenzene (HCB) (0.05 mg/kg FW or 0.5 mg/kg fat). These levels are still sporadically exceeded in eel in the Main area and in the Middle Rhine. In the Delta Rhine, a major decrease since the 1970s in HCB contamination of yellow eel was apparent, from more than 0.1 mg/kg FW to values of about 0.01 mg/kg FW. In Lake IJsselmeer, the Environmental Quality Standard (EQS) for biota according to Directive 2008/105/EC was achieved, namely 0.01 mg/kg FW.

5.4 Perfluorinated tensides

Clearly raised quantities of PFOS were identified, particularly in fish taken from the Rhine (Delta Rhine, Lower Rhine, Upper Rhine, High Rhine) (3 µg/kg to more than 70 µg/kg, with occasional extreme values of up to 126 µg/kg FW; BfR orientation value: 30 µg/kg; EQS proposed value: 9.1 µg/kg FW). The trend analysis in the Netherlands shows an increase since the 1970s to values greater than 100 µg/kg FW in the mid-1990s, followed by a decrease to values of between 7 to 58 µg/kg FW. For other PFTs, the values in the whole of the Rhine area were generally below the detection limit.

5.5 Mercury

The maximum levels of mercury permissible under EU foodstuffs legislation (1 mg/kg FW for eel and 0.5 mg/kg FW for other fish species) were only sporadically exceeded; values were generally between 0.7 and 0.35 mg/kg. The decrease in the concentration of mercury in fish from the Rhine itself between Weil and the Delta Rhine that was observed in the 1980s and 1990s has not continued. The biota standard of 0.02 mg/kg FW for mercury according to Directive 208/105/EC is exceeded comprehensively and systematically in all parts of the catchment area of the Rhine.

Table 10: Estimate of trend in contamination of fish from the Rhine
Estimate ➔stable, ➚ increasing, ➘ falling, ./. no statement possible because of lack of data, absence of previous surveys, or insufficient number of samples.

Country/federal state	Dioxins/furans	DL-PCBs*	Indicator PCBs	HCB	Hg
CH	➔➚	➔➚	➔➚	./.	./.
DE (UBA)	➔➚	➔➚	➔➚	➘	➔
DE-BW	./.	./.	./.	./.	./.
DE-RP	➔	➔	➔	➘	./.
DE-BAV	./.	./.	➔➘	➔➘	➔
DE-NW	./.	➔➚	➔➚	➘	./.
LU	➔	➔	➔	./.	./.
NL	➔	➔	➔	➘	➘

* Contamination with dioxin-like PCBs has only been measured since 2000, whereas contamination with indicator PCBs has in some cases been measured considerably longer.

6. Conclusion

Despite the extensive data available, it is extremely difficult to make statistically reliable statements about contamination of fish from the Rhine. Patterns of distribution and trends could be identified at no more than regional level. A standardised procedure for sampling through to analysis could make possible assessment of the contamination of fish **at the level of** the whole of the Rhine itself or the whole of the catchment area of the Rhine.

The results presented here – which come primarily from studies concerned with food legislation – can also not automatically be transferred to ecosystem questions. Well-founded conclusions in that regard would require data from specific studies, for example on the effects of pollutants on fish at different life stages, on fertility/reproduction in water bodies, associations with fish diseases, etc. Scientific studies of that kind are not currently foreseen in the Rhine States.

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Appendices

Appendix 1: Institutions involved and contacts in the Rhine States

Country	Authority	Location	Case worker	E-mail address	Phone	Remarks
Switzerland	Bundesamt für Umwelt (BAFU)	Bern	Erich Staub	erich.staub@bafu.admin.ch	0041-31-322 9377	
France	Office National de l'Eau et des Milieux Aquatiques (ONEMA)	Vincennes	Cendrine Dargnat	cendrine.dargnat@onema.fr	0033-1-45 14 4088	ONEMA carries out the practical work and distributes the data as part of the national action plan to combat PCBs in fish and sediments.
	Ministère du travail, de l'emploi et de la santé		Isabelle de Guido-Vincent-Genod	isabelle.deguido@santé.gouv.fr		
	Ministère de l'agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du territoire		Magali Naviner	magali.naviner@agriculture.gouv.fr		
	Ministère de l'écologie, du développement durable, des transports et du logement		Nathalie Tchilian	nathalie.tchilian@developpement-durable.gouv.fr		
DE Bavaria	Bayrisches Landesamt für Umwelt (LfU)	Wielenbach	Georgia Buchmeier	georgia.buchmeier@lfu.bayern.de	0049-881-185-144	
	Bayrisches Landesamt für Gesundheit und Lebensmittelsicherheit (LGL)	Oberschleißheim	Michael Albrecht	michael.albrecht@lgl.bayern.de	0049-89-31560500	
DE Baden-Württemberg	Regierungspräsidium Freiburg (RP FR)	Freiburg	Gerhard Bartl	gerhard.bartl@rpf.bwl.de	0049-761-208 1296	
	Chemisches und Veterinäruntersuchungsamt Freiburg (CVUA FR)	Freiburg	Karin Kypke	karin.kypke@cvuafr.bwl.de	0049-761-88 55-131	
DE Saarland	Ministerium für Umwelt	Saarbrücken	Adam Schmitt	A.Schmitt@Umwelt.Saarland.de	0049-681-5014793	

Country	Authority	Location	Case worker	E-mail address	Phone	Remarks
DE Rhineland-Palatinate	Landesamt für Umwelt, Wasserwirtschaft und Gewerbeaufsicht (LUWG)		Lothar Kroll	lothar.kroll@luwg.rlp.de	0049-6131-6033-1829	
DE Hesse	Regierungspräsidium Darmstadt (RP DA)	Darmstadt	Christian Köhler	christian.koehler@rpda.hessen.de	0049-6151-12 52 71	
	Landesbetrieb Hessisches Landeslabor (LHL)	Wiesbaden	Johannes Berger	johannes.berger@lhl.hessen.de	0049-611-7608-521	
DE North Rhine-Westphalia	Landesamt für Natur, Umwelt und Verbraucherschutz (LANUV)	Düsseldorf	Jens Rosenbaum-Mertens	jens.rosenbaum-mertens@lanuv.nrw.de	0049-211-1590-2250	
			Jaqueline Lowis	jaqueline.lowis@lanuv.nrw.de	0049-211-1590-2250	
DE Federal	Umweltbundesamt (UBA)	Dessau	Christa Schröter-Kermani	christa.schroeter-kermani@uba.de	0049-30-8903 1501	
Luxembourg	Ministère de l'Intérieur, Administration de la Gestion de l'Eau	Luxembourg	Max Lauff	max.lauff@eau.etat.lu	00352-26 0286-47	
	Ministère de la Santé, Service de la Sécurité Alimentaire		Patrick Hau	patrick.hau@ms.etat.lu	00352- 247-75620	
Luxembuorg, France, Germany	Internationale Kommissionen zum Schutz der Moselle und der Saar (IKSMS)	Trier	Daniel Assfeld	daniel.assfeld@iksms-cipms.org	0049-651-73147	
Netherlands	Rijkswaterstaat/waterdienst (RWS)	Lelystad	Charlotte Schmidt	charlotte.schmidt@rws.nl	0031-6-10012151	
	Wageningen UR - IMARES	IJmuiden	M. Kotterman, S. Glorius	info.imares@wur.nl	0031-317 - 480900	
	RIKILT - Instituut voor Voedselveiligheid	Wageningen	./.	info.rikilt@wur.nl	0031-317 - 480256	

Appendices 2 to 5 can be found at the end of the report.

Appendix 2: Pollutants investigated in fish from the catchment area of the Rhine

Appendix 3: Fish species investigated for pollutants in the catchment area of the Rhine

Appendix 4: Standards, regulations, and recommendations according to which the studies of contamination of the fish fauna in the Rhine catchment area were carried out

Appendix 5: Contamination of fish from the Rhine and its tributaries with dioxins, furans, and dioxin-like PCBs: results

Appendix 6: Terms and concepts from food legislation and eco-toxicology for estimating risks arising from contamination

Action levels
In addition to the maximum levels utilised in the report, action levels have been defined for a number of contaminants. These are a means for the responsible authorities and companies to identify those cases in which it is appropriate to determine a source of contamination and to take measures to reduce or eliminate it.

Target values
The target values determined by the EU indicate what level of contamination must be achieved in foods for humans and animals to reduce the exposure of the majority of the population to the TWI value for dioxins and dioxin-like PCBs determined by the EU's Scientific Committee on Food.

Tolerable intake levels
Tolerable intake levels are an estimate of the quantity of a substance in the air, food, or drinking water that can be consumed throughout a person's life without appreciable risk to health. The unit determined by the WHO is pg TEQ/kg bodyweight (BW) per day (TDI = *tolerable daily intake*) or per week (TWI = *tolerable weekly intake*).

The WHO's TWI value for dioxins, furans, and dioxin-like PCBs (as a sum parameter) is 14 pg TEQ/kg BW. For PFTs, EFSA[36] has determined a TDI of 0.15 µg/kg BW and for PFOA a TDI of 1.5 µg/kg BW.

Because the TWI/TDI is a limit for average lifelong contamination, assessment of exposure based on individual meals is not meaningful. When determining consumption recommendations – for example for river fish with a particular contamination – account must also be taken of the intake of contaminants via other foods and the rest of the environment (for example possible air contamination in housing space).

Calculation examples (worst-case scenarios):
- A consumer with a body weight of 60 kg should only consume a 200 g serving of eel with a **PCDD/F-PCB-TEQ** of 35.1 ng/kg (a level of contamination that has been measured in Germany/Hesse, for example) every 16.7 weeks, i.e. a

[36] Opinion of the Scientific Panel on Contaminants in the Food chain on Perfluorooctane sulphonate (PFOS), perfluorooctanoic acid (PFOA) and their salts. The EFSA Journal n° 653, adopted on 21 February 2008. http://www.efsa.europa.eu/de/scdocs/scdoc/653.htm

maximum of 3 times per year, so that – taking into account the intake of dioxins/DL-PCBs through the rest of his food – the TWI of 14 pg/kg BW is not exceeded.

- For a person weighing 65 kg, once-weekly consumption of 150 g of eel with a concentration of approx. 40 pg **PCDD/F-PCB-TEQ**/g (a concentration that has regularly been measured in eel from the Dutch section of the Rhine catchment area) will lead to an intake of 150 × 40 = 6000 pg TEQ, or 92 pg TEQ/kg BW/week. In addition, there is an average level of background contamination of approx. 6 pg TEQ/kg BW/week, meaning that the total contamination comes to 98 pg TEQ/kg BW/week, i.e. 7 times the TWI value.
- A person weighing 60 kg who consumed a serving of 200 g of fish contaminated with the highest level determined in Germany (Hesse) would use up his TDI for **PFOS** by 280% and his TDI for **PFOA** by less than 1%.
- If one assumes an average consumption quantity of freshwater fish of 14.98 g/day for an average consumer weighing 60 kg, the TDI for the most heavily contaminated samples in Hesse would be used up by 21% for PFOS and by less than 0.1% for PFOA. For heavy consumers eating an average of 36.79 g/day, the TDI use by the most heavily contaminated samples amounts to 50% for PFOS and approx. 0.1% for PFOA.

Because it is extremely difficult to estimate the risk of contaminants intake from various sources in individual cases, authorities often recommend entirely refraining from consuming highly contaminated fish species such as eel.

Bio-accumulation factors in fish

In order to determine species-specific bio-accumulation factors (BAF) for PFOS, the concentrations in the muscle tissue and in the water were determined for the species eel, orfe, brown trout, barbel, bream, chub, perch, pike, and roach at a minimum of 12 different catch locations for each species in North Rhine- Westphalia in 2006 to 2008. The bio-accumulation factor (BAF) is non-dimensional and represents the quotients from the concentration of PFOS in fish muscle tissue (µg/kg DM) and in water (µg/kg water).

The average species-nonspecific bio-accumulation factor for PFOS in fish muscle tissue derived from all the available data for all the catch locations and fish species considered is ~ 905 and varies species-specifically or due to other influences between 539 (for example in chub) and 2284 (for example in perch, see Table 11).

Table 11: Calculated average bio-accumulation factors for PFOS (in fish muscle tissue) for various species of fish

Species of fish	Number of catch locations	Number of samples	Bio-accumulation factor (average)
Perch	19	71	2284
Eel	19	65	1799
Bream	16	48	1731
Brown trout	43	200	862
Roach	15	58	812
Pike	13	27	797
Barbel	14	33	773
Orfe	12	31	616
Chub	46	152	539

The ranges of values found are also in line as regards their scale with the values given in the relevant literature. For the bluegill, for example, a PFOS factor of 2796 was determined.[37] For rainbow trout, values between 690 (skeleton) and 3100 (blood) were calculated.[38] These results were taken into account when the "Substances" expert group within the Working Group on Water Issues (LAWA) was working out a proposal for an Environmental Quality Standard for fish consumption ($EQS_{biota.Human}$).[39] When converted to the water concentration $EQS_{biota.Human}$, the value derived for PFOS (9 µg/kg in fish muscle tissue) on the basis of the TDI value (tolerable daily intake) is 0.002 – 0.020 µg/l.

Based on the available data, no reliable values for bio-accumulation (BAF values) in Rhine fish can be calculated because the PFOS concentration in the Rhine (water samples) is often below the detection limit (<0.01 mg/l) (see Table 12: 20–28% of the measured values for PFOS are below the detection limit). If one substitutes half the detection limit for these values, average BAF values of between 1050 and 1950 are derived for the measurement/catch locations in the North Rhine-Westphalia section of the Rhine. In the tributaries, the spread of BAF values is even greater. The values lie between 143 and 2923, on average, including the Rhine measurement locations (n=16), 1022.

[37] Environment Agency 2004: Environmental Risk Evaluation Report: Perfluoroctanesulphonate (PFOS). Bristol

[38] Umweltbundesamt Österreich: Fact Sheet on perfluorinated alkane sulphonic acids: Perfluoroctansulphonate; http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/gesundheit/fact_sheets/Fact_Sheet_Perfluorierte_Tenside.pdf

[39] LAWA "Substances" expert group (2010): PFOS data sheet. Drawn up by the Luhnstedt Analytical Laboratory; http://www.laenderfinanzierungsprogrammem.de/cms/WaBoAb_prod/WaBoAb/Vorhaben/LAWA/Vorhaben_des_Ausschusses_Oberflaechengewaesser_und_Kuestengewaesser_(AO)/O_5.07/L28_db_PFOS_Datenblatt_UQN-Vorschlag_1003158708448628300909157.pdf

Table 12: PFOS measurements at measurement locations in the North Rhine-Westphalia section of the Rhine in the period from 2007 to 02/2011. Water samples; in µg/l

Measurement location	River km	Number of samples	Proportion of values <DL*	Min.	Max.	Average	Standard deviation
Bad Honnef	640.0	54	25.9%	<0.01	0.078	0.013	0.010
Bad Godesberg	647.8	18	27.8%	<0.01	0.031	0.012	0.006
Dormagen-Stürzelberg	725.9	14	21.4%	<0.01	0.052	0.014	0.011
Düsseldorf-Flehe	732.3	30	23.3%	<0.01	0.032	0.012	0.006
Lobith	863.2	20	20.0%	<0.01	0.018	0.012	0.004
Kleve-Bimmen	865.0	53	22.6%	<0.01	0.029	0.012	0.005

**DL: Detection limit (0.01 µg/l)*
to calculate the average: 0.005 µg/l for values <DL

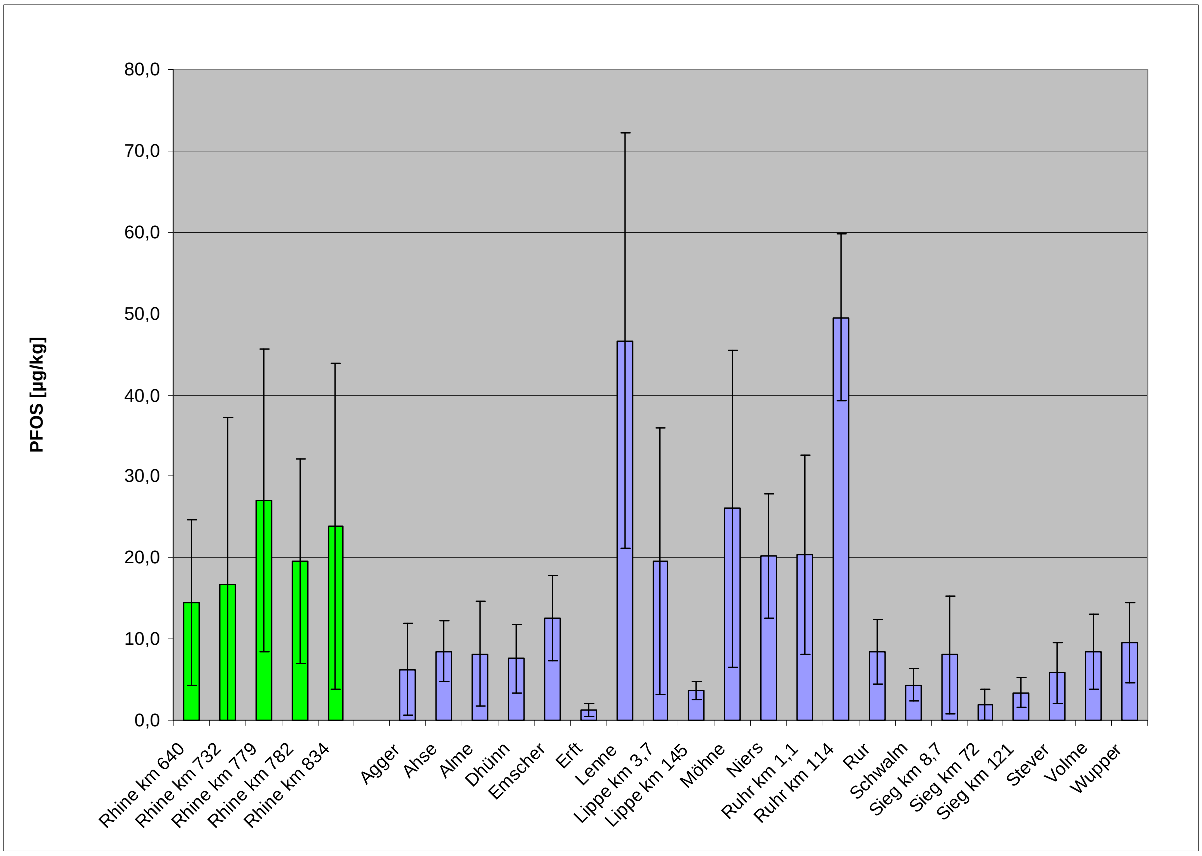

Figure 26: Investigations of PFOS concentrations (water samples) at selected survey measurement locations in the Rhine catchment area in North Rhine-Westphalia. Comparison of contents in the Rhine (green) and in tributaries (blue). The averages (n ≥ 6) for each measurement location for the period from 2007 to 02/2011 are shown, with the standard deviation.

Table 13: PFOS measurements at selected survey measurement locations in the North Rhine-Westphalia section of the Rhine in the period from 2007 to 02/2011 and calculated average bio-accumulation factors (BAF). (*Water samples; in µg/l*)

River and km	Measurement location	Number of samples	Min.	Max.	Average	Standard deviation	Average BAF (µg/kg)/(µg/l)
Rhine 640	Bad Honnef	66	0.005	0.078	0.014	0.012	1056.9
Rhine 732	Düsseldorf-Flehe	35	0.005	0.032	0.013	0.006	1321.0
Rhine 865	Kleve-Bimmen	66	0.005	0.029	0.012	0.005	1950.7
Agger	Troisdorf	6	0.005	0.011	0.007	0.003	916.1
Emscher	Emscher mouth	23	0.016	0.044	0.029	0.008	437.7
Erft	Neuss-Eppinghoven	20	0.005	0.032	0.009	0.009	142.9
Lenne	Hagen-Hohenlimburg	28	0.005	0.1	0.039	0.028	1196.9
Lippe 3.7	Wesel	21	0.005	0.03	0.013	0.007	1536.1
Lippe 145	Lippborg	105	0.005	0.056	0.012	0.011	315.1
Möhne	before enters the Ruhr	23	0.005	0.049	0.017	0.011	1542.6
Ruhr 2.65	Duisburg	49	0.005	0.055	0.027	0.015	751.2
Ruhr 114	Fröndenberg*	77	0.005	0.08	0.017	0.013	2922.9
Sieg 8.7	Menden	20	0.005	0.025	0.008	0.006	964.1
Stever	Haltern, below wastewater treatment plant	10	0.005	0.066	0.019	0.022	307.5
Volme	before enters the Ruhr	31	0.005	0.14	0.017	0.027	491.3
Wupper	Opladen	23	0.005	0.034	0.019	0.007	494.5

*The PFT concentrations in the Ruhr at Fröndenberg have decreased; fish data from previous period.

The differences in BAF values for the different rivers/measurement locations (Table 13) may be determined, for example, by different species of fish (see Table 11).

MTR and HC_5 levels

The **maximum tolerable risk** indicates the concentration of a substance at which 95% of the potentially present species in an ecosystem are protected. MTR values can be indicated as concentrations in water, soil, air, or organisms. The MTR values have never achieved official status.

The standard level derived from the MTR levels for protection of the ecosystem for the eel – converted on the basis of a "standard fish" with 10% dry matter or 5% fat – is 320 µg/kg for PCB 153 and 38 µg/kg for HCB. Because the quantity of PCB 153 is seen as an indicator for the whole group of substances, there are no MTR levels for the other PCB congeners. Levels for other substances are given in Table 14.

Table 14: MTR levels for eel in µg/kg for a standard fish with 10% dry matter or 5% fat. Because the quantity of PCB 153 is seen as an indicator for the whole group of substances, there are no MTR levels for the other PCB congeners listed here.

Substance	MTR level (µg/kg)
PCB153	320
QCB	160
HCB	38
α-HCH	1600
β-HCH	60
γ-HCH	370
Dieldrin	120
p,p'-DDE	22
p,p'-DDD	35
p,p'-DDT	23
∑DDT	26

Another value that indicates damage to the ecosystem by pollutants is the **HC_5 level**. This indicates the concentration of a pollutant in prey animals at which 5% of predators are no longer "protected". The HC_5 level is above the "no observed effect level concentration" (NOEC), i.e. the maximum pollutant concentration at which no damage to an organism can be observed.

Appendix 7: Glossary

BW	Bodyweight
DEHP	Bis(2-ethylhexyl) phthalate
EQS	Environmental Quality Standard
FW	Fresh weight
HCB	Hexachlorobenzene (fungicide, seed treatment substance)
HCBD	Hexachlorbutadiene
HC_5 value	Concentration in prey animals at which 5% of predators are no longer "protected"
HCH	gamma- hexachlorocyclohexane (= lindane)
MTR value	**m**aximum **t**olerable **r**isk
NOEC	**n**o **o**bserved **e**ffect level **c**oncentration
OCPs	(persistent) organochlorine pesticides, for example => HCH
PBDE	Polybrominated diphenyl ethers (flame retardants)
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCDD/F	Polychlorinated dibenzo-*p*-dioxins and dibenzofurans
PCDF	Polychlorinated dibenzofurans
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulphonate
QCB	Quintochlorobenzene = pentachlorobenzene (PeCB; intermediate product in the manufacture of disinfectants and plant protective agents)
TEQ	Toxicity equivalent quantity
TDI **TWI**	**t**olerable **d**aily **i**ntake, **t**olerable **w**eekly **i**ntake in pg WHO TEQ/kg BW
WHO	World Health Organisation

Appendix 8: Questionnaire regarding ongoing and completed studies of contamination of the fish fauna in the Rhine catchment area

The various sections of part 3 of this report were written on the basis of this questionnaire.

A. General information about the studies

1. **Authority** carrying out the study, contact (e-mail, phone, if not already known)

2. What **investigations** of contamination of fish have been carried out in the area for which you are responsible since 2000?

3. **List of sources** (published reports, Internet links to databases, consumption recommendations, etc.)

B. Objectives, materials, and methods of the particular investigation

1. What were the **objectives** of the investigation and what standards were applied?
   - EU Fish Consumption Regulation (No. 1881/2006 of 19 December 2006)
   - Biota standard according to Water Framework Directive
   - National consumer protection standards
   - Ecotoxicological "standards"

2. What **substances** (or congeners) were measured and in what units, and in what form are the results presented? Is reference made to fresh weight or to fat?

   - DL-PCBs, in particular indicator indicator-PCBs, as far as possible PCB 153
   - Dioxins
   - Sum of dioxins and dioxin-like PCBs (for better comparability, an indication in WHO-PCDD/F-PCB-TEQ upper limit### in pg TEQ/g is preferable)
   - Furans
   - HCB
   - Mercury
   - PFTs

3. At what **measurement locations** were the investigations carried out? (If possible exact location, with Rhine km indication)

4. Which **fish species** were studied? What length categories (cm) were applied? What were the criteria for selecting these species?

5. **How many fish** were sampled? Were composite or single samples utilised? Were averages calculated? Did the sample involve fillet, other parts of the fish, or the whole fish?

C. Results of investigations, assessments

1. If investigations have already been carried out in the past: is a **trend** in contamination apparent?

2. Are **standards exceeded**? If so, which standards and to what extent? Was a conversion to **WHO TEQ** carried out for the substances for which these values are available?

3. Did the investigations lead to **prohibitions on consumption or marketing**? If so, where were they published? (Internet links etc.)
   Please state briefly the limits/weekly intake amounts (preferably: TWI in g, for what bodyweight)

4. What **conclusions** have you drawn for future investigations?

Anlage 2: Untersuchte Schadstoffe in Fischen im Einzugsgebiet des Rheins

** Die Abkürzungen für die Institutionen sind Anlage 1 zu entnehmen.*

Schadstoff(gruppe)		Rheinanlie-gerstaaten	Schweiz	Frank-reich	Deutschland							Mosel-Saar-Gebiet	Luxem-burg	Nieder-lande
Staat / *Bundesland*					*Bund*	*BW*	*BY*	*RP*	*HE*	*NW*	*SL*			
Institution*		IKSR	BAFU	ONEMA	UBA	CVUA, RP	LfU, LGL	MUFV	LHL	LANUV	LUA	IKSMS	Min. Santé	RWS
Letzte Jahre der Untersuchung für PCB (und die meisten anderen Schadstoffe)		2000	2007 / 2008	2008 / 2009	2000 - 2009	2003 - 2008	2005 / 2006 / 2009	2009, 2010	2009	2000 - 2008	2009 / 2010	2004	2000, 2002, 2003	2009
laufende oder geplante Untersuchung / in Auswertung				*2010*	*2010*	*2010*		*Mosel + Rhein 2009 + 2010*						
Indikator-PCB (Kongenere)	***28***	x	x	x	x	x	x	x	x	x	x	x	x	x
	52	x	x	x	x	x	x	x	x	x	x	x	x	x
	101	x	x	x	x	x	x	x	x	x	x	x	x	x
	118	x	x	x	x	x	x	x	x	x	x	x	x	x
	138	x	x	x	x	x	x	x	x	x	x	x	x	x
	153	x	x	x	x	x	x	x	x	x	x	x	x	x
	180	x	x	x	x	x	x	x	x	x	x	x	x	x
non-ortho (= planare) dioxin-ähnliche PCB (dl-PCB-Kongenere)	***77***		x	x		x	x	x	x		x	x		x
	81		x	x		x	x	x	x		x	x		x
	126		x	x		x	x	x	x		x	x		x
	169		x	x		x	x	x	x		x	x		x
mono-ortho (= nicht planare) dioxinähnliche PCB (dl-PCB-Kongenere)	***105***		x	x		x	x	x	x		x	x		x
	114		x	x		x	x	x	x		x	x		x
	118		x	x		x	x	x	x		x	x		x
	123		x	x		x	x	x	x		x	x		x
	156	x	x	x		x	x	x	x	x	x	x		x
	157		x	x		x	x	x	x		x	x		x
	167		x	x		x	x	x	x		x	x		x
	189		x	x		x	x	x	x		x	x		x
PCB-Summen-parameter	**dl-PCB TEQ**		x	x	x	x	x	x	x	x	x			x
	ndl-PCB			x	x	x		x	x		x			x
Dioxine & Furane	**Dioxine**		x	x	x	x	x	x	x	x	x	x	x	x
	Furane		x	x	x	x	x	x	x		x	x		x
Summenparameter	**PCDD/F**			x	x	x	x	x	x	x			x	x
	PCDD/F + dl-PCB TEQ		x	x	x	x	x	x	x	x	x	x	x	x
weitere persistente organische Schadstoffe	**Alkylphenole**				x		x							
	DEHP						x							
	HCB	x		x	x	x	x	x		x				x
	HCBD	x		x		x	x							x
	HCH	x				x			x					
	HHCB						x							
	PAK				x									
	PBDE					x	x							
	PCA	x				x								
	PFOA					x	x		x		x			x
	PFOS					x	x		x	x	x			x
	PFT				x	x	x	x	x		x			(x)
	PeCB (QCB)	x				x	x							x
	TBT	x				x	x			x				
	weitere organ. Zinnverbindungen	x			x	x	x							
	Triclosan				x		x							
anorganische Schadstoffe (Schwermetalle)	**Hg**	x		x	x	x	x	x	x	x	x		x	x
	Cd	x			x	x	x		x	x			x	x
	Pb	x			x	x	x		x	x			x	x

<u>Ergänzende Bemerkungen:</u>

Im **IKSR-Messprogramm 2000** wurden außerdem Octachlorstyrol, Tri- und Tetrachlorbenzole, Nitromoschusverbindungen, Bromocyclen, Triphenylzinn und die Summe der 6 DDD-/DDT-Isomere bzw. Metabolite (Pestizide) gemessen.

In **Baden-Württemberg** wurden außerdem Nitromoschusverbindungen und Pyrethroide untersucht.

In **Rheinland-Pfalz** liegen ebenfalls Untersuchungen aus den Jahren 2001, 2003, 2006 und 2007 vor.

In **Nordrhein-Westfalen** liegen ebenfalls Untersuchungen für Moschusketon und -xylol, Mono-, Tetra-, Di-, Diphenyl- und Triphenylzinn sowie für DDE, DDD und DDT vor. Die Jahre der Messung sind Anlage 5 zu entnehmen.

In **Bayern** wurden auch folgende Metalle analysiert: B, Al, Cr, Ni, Co, Cu, Zn, As, Se, Sb, Ag; außerdem 1, 2, 4-Trichlorbenzol.

In den **Niederlanden** liegen für die meisten Substanzen ebenfalls Daten aus den Jahren 2006 bis 2008 vor.

Für einzelne PCB-Kongenere liegen lange Datenreihen (seit 1991) vor. HCB und Quecksilber werden seit 1977 gemessen.

Anlage 3: Auf Schadstoffe untersuchte Fischarten im Einzugsgebiet des Rheins

** Die Abkürzungen für die Institutionen sind Anlage 1 zu entnehmen.*

gelbe Markierung: im Rheineinzugsgebiet beliebte Speisefische

orangefarbene Markierung: von zahlreichen Staaten beprobte Fischart

Staat				Rheinan-liegerstaaten	**Schweiz**	**Frank-reich**	**Deutschland**							**Mosel-Saar-Gebiet**	**Luxem-burg**	**Nieder-lande**
Bundesland							*Bund*	*BW*	*BY*	*RP*	*HE*	*NW*	*SL*			
Institution*				IKSR	BAFU	ONEMA	UBA	CVUA RP	LfU, LGL	MUFV	LHL	LANUV	LUA	IKSMS	Min. Santé	RWS
Jahre der Untersuchung				2000	2007, 2008	2008, 2009	2000 - 2009	2005, 2006	2005, 2006	2009, 2010	2009	2000 - 2008	2009, 2010	2004	2000, 2003	2009
Mischprobe - M, Einzelprobe - E				E, M	E, M	M	M	M	E**	E, M	E, M	E, M	M	M	M	M
Länge, Aal (cm)				30 - 70 cm	55			40 - 60		58 - 62	58 - 66			50 - 82	55 - 60	30 - 40
Länge, sonstige Fische (cm)				15 - 24	17 - 230			15 - 25		20 - 55	9 - 120		34 - 52	11 - 37	7 - 26 cm***	40 - 50
(Mindest-)Gewicht des einzelnen Fischs (g)					48 - > 8000				> 250	> 90						
Anzahl Fische pro Messstelle							20	5 (Aale: 15)	3 - 6	20 - 25	1 - 50	> 10	1 - 11	10 - 25 (Aale: 3 - 5)	3	25
Fischart		Verwendete Teile		Filet	Filet, Leber	Muskel (Filet)	Muskel, Leber	Filet	Muskel, Leber, Milz, Niere	?	Filet****	Filet, Leber, Niere	Muskel	Filet	Filet	Filet
wissenschaftlicher Name	**deutscher Name**	**Kate-gorie*******	**Fettgehalt (%)**													
Abramis brama	**Brassen / Brachse**	**mittel**	**5,5**		**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**			
Alburnus alburnus	**Ukelei**	**mager**				**x**										
Anguilla anguilla	**Aal**	**fett**	**26,0**	**x**	**x**	**x**		**x**	**x**	**x**	**x**	**x**		**x**	**x**	**x**
Aspius aspius	**Rapfen**	**mager**										**x**				
Barbus barbus	**Barbe**	**mager**			**x**	**x**			**x**	**x**						
Blicca bjoerkna	**Güster / Blicke**	**mager**				**x**		**x**				**x**				
Carassius carassius	**Karausche**	**mager**				**x**										
Carassius gibelio	**Giebel**	**mager**											**x**			
Chondrostoma nasus	**Nase**	**mager**				**x**				**x**		**x**				
Coregonus ssp.	**Felchen**	**mittel**			**x**											
Cyprinus carpio	**Karpfen**	**mittel**	**7,0**		**x**	**x**		**x**		**x**		**x**	**x**			
Esox lucius	**Hecht**	**mager**	**0,9**		**x**	**x**		**x**	**x**	**x**		**x**				
Gobio gobio	**Gründling**	**mager**				**x**									**x**	
Leuciscus cephalus	**Döbel / Alet / Aitel**	**mager**			**x**	**x**		**x**	**x**	**x**		**x**	**x**	**x**	**x**	
Leuciscus idus	**Aland**	**mager**								**x**	**x**	**x**				
Leuciscus leuciscus	**Hasel**	**mager**			**x**	**x**										
Leuciscus souffia	**Strömer**	**mager**				**x**										
Lota lota	**Trüsche / Quappe**	**fett**	**16,0**		**x**											
Oncorhynchus mykiss	**Regenbogenforelle**	**mittel**	**2,0**		**x**	**x**										
Perca fluviatilis	**Flussbarsch**	**mager**	**0,8**		**x**	**x**		**x**	**x**	**x**	**x**	**x**				
Phoxinus phoxinus	**Elritze**	**mager**				**x**										
Platichthys flesus	**Flunder**	**mager**	**0,7**			**x**										
Rutilus rutilus	**Rotauge / Plötze**	**mager**		**x**	**x**	**x**		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Salmo trutta fario	**Bachforelle**	**mittel**	**2,0**		**x**	**x**			**x**						**x**	
Sander lucioperca	**Zander**	**mager**	**1,0**		**x**	**x**		**x**		**x**		**x**				**x**
Scardinius erythrophthalmus	**Rotfeder**	**mager**				**x**						**x**				
Silurus glanis	**Wels**	**fett**	**17,0**			**x**				**x**	**x**	**x**				
Thymallus thymallus	**Äsche**	**fett**			**x**	**x**										
Tinca tinca	**Schleie**	**mager**	**0,8**			**x**					**x**					

*** DE-BY: Mischproben nur bei Fischgewicht < ca. 200 g. Weitere Fischarten: diverse Cypriniden.*

**** LU: Größe je nach Fischart: Bachforelle 6,9 bis 12,5 cm, Groppe 9 - 18 cm (nur 2000), Rotauge 17 - 26 cm, Flussbarsch 19 - 23 cm, Döbel 22 - 24 cm, Aal 55 - 60 cm (nur 2000)*

***** DE-HE: Bei sehr kleinen Fischen wurden Kopf, Flossen und / oder Haut mit homogenisiert*

****** Kategorien nach durchschnittlichem Fettgehalt: Magerfische: ≤ 1% Fett, Mittelfette Fische: 1 bis 10% Fett, Fettfische: > 10% Fett.*

Insbesondere bei den Fettfischen hängt der Fettgehalt stark vom Lebensstadium (Alter) ab.

Prozentuale Angabe, sofern Wert bekannt.

Anlage 4: Normen, Verordnungen und Empfehlungen,
nach denen die Untersuchungen zur Kontamination der Fischfauna im Einzugsgebiet des Rheins durchgeführt wurden

** Die Abkürzungen für die Institutionen sind Anlage 1 zu entnehmen.*

Staat		**Schweiz**	**Frank-reich**	**Deutschland**							**Mosel-Saar-Gebiet**	**Luxem-burg**	**Nieder-lande**
Bundesland				*Bund*	*BW*	*BY*	*RP*	*HE*	*NW*	*SL*			
Institution*		BAFU	ONEMA	UBA	CVUA RP	LfU / LGL	MUFV	LHL	LANUV	LUA	IKSMS	Min. Santé	RWS
Norm, Verordnung	**Geltungs-bereich**												
Ökotoxikologische Grenzwerte der Weltgesundheitsorganisation (WHO)	weltweit	x	x	x	x	x	x	x	x	x	x	x	x
Verordnung (EG) Nr. 1881/2006 der Kommission vom 19. Dezember 2006 zur Festsetzung der Höchstgehalte für bestimmte Kontaminanten in Lebensmitteln, (Amtsblatt der Europäischen Union vom 20.12.2006, L364/5)	EG	(x)	x		x	x	x	x	x			x	x
Verordnung (EG) Nr. 1883/2006 der Kommission vom 19. Dezember 2006 zur Festlegung der Probenahmeverfahren und Analysemethoden für die amtliche Kontrolle der Gehalte von Dioxinen und dioxinähnlichen PCB in bestimmten Lebensmitteln (Amtsblatt der Europäischen Union vom 20.12.2006, L364/32)	EG		x					x					
Empfehlung der Kommission vom 6. Februar 2006 zur Reduzierung des Anteils von Dioxinen, Furanen und PCB in Futtermitteln und Lebensmitteln (2006/88/EG), (Amtsblatt der Europäischen Union vom 14.02.2006, L42/26)	EG				x	x							
Verordnung (EG) Nr. 629/2008 der Kommission vom 2. Juli 2008 zur Änderung der Verordnung (EG) Nr. 1881/2006 zur Festsetzung der Höchstgehalte für bestimmte Kontaminanten in Lebensmitteln (Amtsblatt der Europäischen Union vom 3.7.2008, L 173/6)	EG		x		x				x				
Richtlinie 2008/105/EG über Umweltqualitätsnormen im Bereich der Wasserpolitik ("Tochterrichtlinie Prioritäre Stoffe" / "Biota-Norm")	EG		x			x		x	x		x		x
DG SANCO-Vorschlag für eine Höchstgehalteregelung für nicht-dioxinähnliche PCB in Lebensmitteln	EG												
Verordnung (EG) Nr. 396/2005 über Höchstgehalte an Pestizidrückständen in oder auf Lebens- und Futtermitteln pflanzlichen und tierischen Ursprungs und zur Änderung der Richtlinie 91/414/EWG des Rates 396/2005 (23.02.2005)	EG							x	x				
Ökotoxikologische Normen der US-EPA (United States Environmental Pollution Agency)**	USA											x	
Rückstands-Höchstmengenverordnung (RHmV) vom 21.10.1999 (BGBl. I S. 2082, 2002 I S. 1004), Stand: letzte Änderungs-Verordnung vom 02.10.2009 (BGBl. I S.3230)	DE				x	x		x	x				
Verordnung zur Begrenzung von Kontaminanten in Lebensmitteln vom 19.03.2010 (BGBl. I S.286). Ersetzt die Schadstoffhöchstmengenverordnung (SHmV) vom 18.07.2007	DE				x	x	x	x	x				
BfR-Bewertung Nr. 041/2006 EU-Höchstgehalte für nichtdioxinähnliche PCB in Fisch	DE					x	x			x			
Fremd- und Inhaltsstoffverordnung für die Schweiz, 01.01.2009, entspricht Verordnung (EG) Nr. 466/2001	CH	x											
Warenwet, Regeling normen zware metalen, feb. 1992, nr DGVgz/VV/L92417, Stcrt 43; Regeling normen PCB's, nr. 141639, Ministerie VROM, 1984 ("Fischkonsumnorm")	NL												x
Dutch Maximum Residue Limits, http://www2.rikilt.dlo.nl/vws/index.html	NL												x

**Anmerkung: Im Jahr 2000, als eine der im Bericht zitierten Untersuchungen in Luxemburg durchgeführt wurden, existierten noch keine WHO- oder EU-Normen

Anlage 5: Kontamination von Fischen im Rhein und seinen Nebenflüssen mit Dioxinen, Furanen und dioxinähnlichen PCB: Ergebnisse

Stand: 26.10.2011

WHO-TEQ-Werte ohne Berücksichtigung der Messunsicherheit; vgl. Kap. 2.2 im Bericht

Die hier aufgeführten Werte können von den Werten, aufgrund derer über Verzehrsverbote entschieden wurde, erheblich abweichen.

Rhein-abschnitt	Lage der Messstelle	Rhein-km	Nation	Land, Kanton, Départ.	Institution	Jahr	Fischart	WHO-PCDD/F + dl-PCB TEQ (ng / kg = pg / g FG)	
Wert								min	max
VORDER- und HINTERRHEIN	Vorderrhein bei Valendas	VR	CH	GR	BAFU	2004	Bachforelle		0,40
	Hinterrhein bei Rothenbrunnen	HR	CH	GR	BAFU	2004	Bachforelle		1,00
ALPENRHEIN (km 0-93) Reichenau – Bodensee	Haldenstein	AR	CH	GR	BAFU	2004	Bachforelle		1,10
BODENSEE	Obersee	BS	CH		BAFU	?	Barsch u. a.		0,00
	Untersee	BS	CH	TG?	BAFU	?	Barsch, Aal, Hecht		0,00
	Untersee	BS	DE	BW	CVUA-FR	2008	Aal	3,50	7,10
	???	BS	CH	TG?	BAFU	2009	Trüsche		0,26
	???	BS	CH	TG?	BAFU	2009	Trüsche (Leber)		23,50
HOCHRHEIN (km 24-170)	Stein am Rhein	24	CH	BL?	BAFU	2008	Äsche		6,50
	Rheinfallbecken bei Neuhausen	48	CH	SH	BAFU	2008	Äsche		5,90
	oberhalb Rheinkraftwerk	78	DE	BW	CVUA-FR	2008	Aal	6,90	17,60
Bodensee – Basel	Augst, Fischpass	155	CH	BL	BAFU	2009	Barbe	10,50	14,90
	Augst, Fischpass	155	CH	BL	BAFU	2009	Rotauge	7,83	8,08
	Grenzach	160	DE	BW	CVUA-FR	2006	Aal	19,90	25,20
	Grenzach	160	DE	BW	CVUA-FR	2006	Rotauge		2,30
	Birsfelden, Stau / Fischpass	162	CH	BL	BAFU	2009	Aal	6,60	52,80
	Birsfelden, Stau / Fischpass	162	CH	BL	BAFU	2009	Barbe	15,00	32,30
	Birsfelden, Stau / Fischpass	162	CH	BL	BAFU	2009	Rotauge	6,16	14,10
	Kembs	174	CH	BS	BAFU	2009	Aal	2,85	26,00
	Weil	174	DE	Bund	UBA	2008	Brassen		7,00
OBERRHEIN (km 170-529)	Village-Neuf	174	FR	Haut-Rhin	ONEMA	2009	Aal	18,21	34,12
	Village-Neuf	174	FR	Haut-Rhin	ONEMA	2009	Barbe	3,63	9,60
	Village-Neuf	174	FR	Haut-Rhin	ONEMA	2009	Döbel	0,67	1,69
	Village-Neuf	174	FR	Haut-Rhin	ONEMA	2009	Nase		3,02
	Märkt	175	DE	BW	CVUA-FR	2006	Aal	17,60	27,90
Basel – Bingen	Chalampé	200	FR	Haut-Rhin	ONEMA	2009	Aal	9,48	16,11
	Chalampé	200	FR	Haut-Rhin	ONEMA	2009	Döbel	1,81	4,35
	Biesheim	227	FR	Haut-Rhin	ONEMA	2009	Aal	18,84	28,73
	Biesheim	227	FR	Haut-Rhin	ONEMA	2009	Döbel	3,79	7,17
	Taubergießen	255	DE	BW	CVUA-FR	2006	Aal		24,60
	Erstein	275	FR	Bas-Rhin	ONEMA	2009	Aal	18,52	30,22
	Erstein	275	FR	Bas-Rhin	ONEMA	2009	Nase	2,81	3,30
	Erstein	275	FR	Bas-Rhin	ONEMA	2009	Zander	0,82	2,39
	Auenheim	299	DE	BW	CVUA-FR	2008	Aal	29,10	68,70
	Iffezheim	334	DE	Bund	UBA	2008	Brassen		15,50
	Lauterbourg-Karlsruhe	350	FR	Bas-Rhin	ONEMA	2009	Aal	16,55	29,76
	Lauterbourg-Karlsruhe	350	FR	Bas-Rhin	ONEMA	2009	Barbe		2,20
	Karlsruhe-Knielingen	364	DE	BW	CVUA-FR	2008	Aal	12,00	28,20
	Wörth	366	DE	RP	MUFV	2005-2007	Rotauge		9,61
	Wörth	366	DE	RP	MUFV	2005-2007	Brassen		6,95
	Eggenstein / Leopoldshafen	370	DE	BW	CVUA-FR	2003	Brassen		19,50
	Eggenstein / Leopoldshafen	370	DE	BW	CVUA-FR	2003	Hecht		0,38
	Eggenstein / Leopoldshafen	370	DE	BW	CVUA-FR	2003	Zander		0,36
	Altrhein Lingenfeld	Altrh.	DE	RP	MUFV	2005-2007	Rotauge		9,81
	Altrhein Lingenfeld	Altrh.	DE	RP	MUFV	2005-2007	Brassen		1,99
	Berghausen	395	DE	RP	MUFV	2005-2007	Brassen		9,15
	Berghausen	394	DE	RP	MUFV	2005-2007	verschiedene		6,14
	Speyer	410	DE	RP	LUWG	2010	Aal	9,89	23,24
	Speyer	410	DE	RP	LUWG	2010	Flussbarsch		1,19
	Speyer	410	DE	RP	LUWG	2010	Rapfen		7,79
	Speyer	410	DE	RP	LUWG	2010	Rotauge		0,78
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Aal	3,73	20,66
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Flussbarsch		0,72
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Brassen		1,12
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Hecht	0,72	1,77
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Rotauge	0,90	3,36
	Otterstädter Altrhein	Altrh.	DE	RP	LUWG	2010	Zander	0,47	2,16
	Lampertheimer Altrhein	Altrh.	DE	HE	LHL	2009	Aal		16,60
	Lampertheimer Altrhein	Altrh.	DE	HE	LHL	2009	Wels		9,20
	Worms	450	DE	RP	LUWG	2010	Aal	8,36	25,17
	Worms	450	DE	RP	LUWG	2010	Flussbarsch		1,37
	Worms	450	DE	RP	LUWG	2010	Döbel		6,28
	Worms	450	DE	RP	LUWG	2010	Rapfen		4,46
	Worms	450	DE	RP	LUWG	2010	Rotauge		2,69
	Worms	450	DE	RP	LUWG	2010	Wels		1,13
	Ginsheimer Altrhein	Altrh.	DE	HE	LHL	2009	Aal		25,30
	Ginsheimer Altrhein	Altrh.	DE	HE	LHL	2009	Wels		2,00
	Mainz-Bodenheim	490	DE	RP	MUFV	2005-2007	Rotauge		10,20
	Mainz-Bodenheim	512	DE	RP	MUFV	2005-2007	Rotauge, Hecht		12,30
	Ingelheim	520	DE	RP	LUWG	2010	Aal	21,99	35,63
	Ingelheim	520	DE	RP	LUWG	2010	Barbe		22,00
	Ingelheim	520	DE	RP	LUWG	2010	Flussbarsch	1,27	1,45
	Ingelheim	520	DE	RP	LUWG	2010	Brassen		30,41
	Ingelheim	520	DE	RP	LUWG	2010	Brassen		1,75
	Ingelheim	520	DE	RP	LUWG	2010	Rotauge	5,91	6,92
	Rüdesheimer Hafen	528	DE	HE	LHL	2009	Aal		35,10

Rhein-abschnitt	Lage der Messstelle	Rhein-km	Nation	Land, Kanton, Départ.	Institution	Jahr	Fischart	WHO-PCDD/F + dl-PCB TEQ (ng / kg = pg / g FG)	
Wert								min	max
MITTELRHEIN (km 529-639)	Bingen	530	DE	RP	MUFV	2005-2007	Rotauge		17,00
	St. Goar	556	DE	RP	MUFV	2005-2007	Brassen		20,40
	St. Goar	556	DE	RP	MUFV	2005-2007	Barbe		45,00
Bingen	Boppard	570	DE	RP	LUWG	2010	Aal	10,66	35,02
– Bad-Honnef	Boppard	570	DE	RP	LUWG	2010	Barbe	17,06	24,18
	Boppard	570	DE	RP	LUWG	2010	Flussbarsch		1,51
	Boppard	570	DE	RP	LUWG	2010	Brassen		37,61
	Boppard	570	DE	RP	LUWG	2010	Rapfen	31,91	73,32
	Boppard	570	DE	RP	LUWG	2010	Rotauge	7,89	8,48
	Boppard	570	DE	RP	LUWG	2010	Zander		4,50
	Koblenz, oberhalb Moselmündung	590	DE	RP	MUFV	2005-2007	Rotauge		11,30
	Koblenz, Moselmündung	589	DE	RP	MUFV	2005-2007	Rotauge, Döbel		11,20
	Koblenz	590	DE	Bund	UBA	2008	Brassen		14,00
	Neuwied	608	DE	RP	MUFV	2005-2007	verschiedene		28,60
	Neuwied	608	DE	RP	MUFV	2005-2007	Brassen		27,50
	Andernach	610	DE	RP	LUWG	2010	Aal	15,21	29,57
	Andernach	610	DE	RP	LUWG	2010	Barbe		11,48
	Andernach	610	DE	RP	LUWG	2010	Flussbarsch		1,84
	Andernach	610	DE	RP	LUWG	2010	Brassen		11,39
	Andernach	610	DE	RP	LUWG	2010	Rotauge		2,14
	Linz	630	DE	RP	MUFV	2005-2007	Nase		7,50
NIEDERRHEIN (km 639-865,5)	Bad Honnef	640	DE	NW	LANUV	2008	Nase		5,4
	Bad Honnef	640	DE	NW	LANUV	2009	Döbel		1,5
	Bad Honnef	640	DE	NW	LANUV	2009	Brassen		6,9
Bad-Honnef –	Bad Honnef	640	DE	NW	LANUV	2009	Barbe		52,5
Kleve-Bimmen	Bad Honnef	640	DE	NW	LANUV	2010	Barbe		11,80
	Bad Honnef	640	DE	NW	LANUV	2010	Brassen		15,30
	Düsseldorf-Flehe	732,3	DE	NW	LANUV	2008	Aal		35,6
	Düsseldorf-Flehe	732,3	DE	NW	LANUV	2009	Barbe		40,4
	Düsseldorf-Flehe	732,3	DE	NW	LANUV	2009	Döbel		25,4
	Düsseldorf-Flehe	732,3	DE	NW	LANUV	2009	Brassen		28,20
	Rhein unterhalb Ruhrmündung	781,7	DE	NW	LANUV	2009	Brassen		31,0
	Rhein unterhalb Ruhrmündung	781,7	DE	NW	LANUV	2009	Aland		22,6
	Emmerich	848	DE	NW	LANUV	2009	Aal		28,8
	Emmerich	848	DE	NW	LANUV	2009	Aland		8,3
	Emmerich	848	DE	NW	LANUV	2010	Rapfen		2,43
	Emmerich	848	DE	NW	LANUV	2010	Brassen		4,22
	Emmerich	848	DE	NW	LANUV	2010	Barbe		23,00
	Kalkar (Beprobung durch das Heinrich-von-Thünen-Institut)	842	DE	NW	LANUV	2010	Aal	16,20	63,60
	Bimmen	865	DE	Bund	UBA	2008	Brassen		24,00
	Rhein bei Lobith	867	NL		RWS	2009	Aal		15,00
DELTARHEIN (km 865,5 -1032)	Waal bei Tiel	916	NL		RWS	2009	Aal		16,00
	Nieuwe Merwede	975	NL		RWS	2006	Aal		44,00
	IJssel bei Deventer	n. a.	NL		RWS	2009	Aal		13,00
Lobith - Küste	Ketelmeer bei IJsseloog	n. a.	NL		RWS	2009	Aal		25,00
inklusive IJsel und IJsselmeer	IJsselmeer bei Medemblik	n. a.	NL		RWS	2009	Aal		4,00
Nebenflüsse	**Lage der Messstelle**	**Rh-km**	**Nation**	**Land, Kanton, Départ.**	**Institution**			**WHO-PCDD/F + dl-PCB TEQ (ng / kg = pg / g FG)**	
Wert								min	max
Hochrhein-Zuflüsse	Birs bei Äsch	n.a.	CH	AG	BAFU	2009	Bachforelle		7,08
	Birs bei Laufen, oberhalb Wasserfall	n.a.	CH	BL	BAFU	2009	Äsche		11,40
	Birs bei Zwingen / Laufen	n.a.	CH	BL	BAFU	2009	Bachforelle		3,08
	Wiese oberhalb Schließe	n.a.	CH	BS	BAFU	2009	Aal		21,30
	Wiese oberhalb Schließe	n.a.	CH	BS	BAFU	2009	Barbe	7,93	9,83
ILL & Zuflüsse	Ill bei Ruelisheim	n. a.	FR	Haut-Rhin	ONEMA	2009	Barbe	4,54	18,52
	Ill bei Ruelisheim	n.a	FR	Haut-Rhin	ONEMA	2009	Döbel	1,42	4,30
	Ill bei Colmar	n. a.	FR	Haut-Rhin	ONEMA	2009	Aal	35,80	54,96
	Ill bei Colmar	n. a.	FR	Haut-Rhin	ONEMA	2009	Döbel	1,60	3,46
	Ill bei Offendorf	n. a.	FR	Bas-Rhin	ONEMA	2009	Aal	26,02	54,78
	Ill bei Offendorf	n. a.	FR	Bas-Rhin	ONEMA	2009	Döbel	2,23	4,66
	Ill bei Offendorf	n. a.	FR	Bas-Rhin	ONEMA	2009	Rotauge		1,70
	Ill bei Straßburg	n. a.	FR	Bas-Rhin	ONEMA	2009	Aal	29,66	53,01
	Ill bei Straßburg	n. a.	FR	Bas-Rhin	ONEMA	2009	Döbel	1,58	11,12
	Ill bei Ostwald	n. a.	FR	Bas-Rhin	ONEMA	2009	Aal	16,00	63,16
	Ill bei Ostwald	n. a.	FR	Bas-Rhin	ONEMA	2009	Döbel	2,26	12,30
	Ill bei Ostwald	n. a.	FR	Bas-Rhin	ONEMA	2009	Rotauge		2,56
	Andlau bei Andlau	n. a.	FR	Bas-Rhin	ONEMA	2009	Bachforelle	0,62	0,95
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Aal		24,01
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Barbe	10,79	20,34
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Döbel	4,56	7,15
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Rotauge	1,26	4,51
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Hecht		2,96
	Andlau bei Fegersheim	n. a.	FR	Bas-Rhin	ONEMA	2008	Bachforelle		0,64
	Bruche bei Bourg-Bruche	n. a.	FR	Bas-Rhin	ONEMA	2009	Bachforelle	0,64	0,85
	Bruche bei Holtzheim	n. a.	FR	Bas-Rhin	ONEMA	2009	Aal	13,52	22,97
	Bruche bei Holtzheim	n. a.	FR	Bas-Rhin	ONEMA	2009	Döbel	3,98	6,01
	Bruche bei Holtzheim	n. a.	FR	Bas-Rhin	ONEMA	2009	Flussbarsch	0,49	0,60
	Bruche bei Holtzheim	n. a.	FR	Bas-Rhin	ONEMA	2009	Rotauge		1,81
	Bruche bei Holtzheim	n. a.	FR	Bas-Rhin	ONEMA	2009	Nase		4,18
	Fecht bei Guemar	n. a.	FR	Haut-Rhin	ONEMA	2009	Nase		1,24
	Fecht bei Guemar	n. a.	FR	Haut-Rhin	ONEMA	2009	Döbel	1,58	24,00
	Fecht bei Guemar	n. a.	FR	Haut-Rhin	ONEMA	2009	Gründling	1,51	2,52
	Fecht bei Guemar	n. a.	FR	Haut-Rhin	ONEMA	2009	Barbe	3,27	7,35
	Fecht bei Metzeral	n. a.	FR	Haut-Rhin	ONEMA	2009	Bachforelle	1,15	1,71
	Muhlbach-de-Turckheim bei Wintzenheim	n. a.	FR	Haut-Rhin	ONEMA	2008	Döbel	1,86	3,15
	Muhlbach-de-Turckheim bei Wintzenheim	n. a.	FR	Haut-Rhin	ONEMA	2008	Gründling	3,15	3,17
	Muhlbach-de-Turckheim bei Wintzenheim	n. a.	FR	Haut-Rhin	ONEMA	2008	Rotauge		4,01
	Thur bei Staffelden	n. a.	FR	Haut-Rhin	ONEMA	2008	Hecht		12,10
	Thur bei Staffelden	n. a.	FR	Haut-Rhin	ONEMA	2008	Döbel	4,07	6,60
	Thur bei Staffelden	n. a.	FR	Haut-Rhin	ONEMA	2008	Gründling		4,26
	Thur bei Staffelden	n. a.	FR	Haut-Rhin	ONEMA	2008	Bachforelle	6,56	19,59
	Thur bei Tann	n. a.	FR	Haut-Rhin	ONEMA	2009	Äsche	1,35	1,38
	Thur bei Tann	n. a.	FR	Haut-Rhin	ONEMA	2009	Bachforelle	1,11	4,14

Nebenflüsse	Lage der Messstelle	Rh-km	Nation	Land, Kanton, Départ.	Institution			WHO-PCDD/F + dl-PCB TEQ (ng / kg = pg / g FG)	
Wert								min	max
MAIN	Main zwischen Michelau und Veitshöchheim	n. a.	DE	BY	LGL	2009	Aal	16,20	60,70
	Main bei Erlabrunn	n.a.	DE	BY	LfU	2002/03	Aal	34,80	61,10
& Zuflüsse	Main bei Hallstadt	n.a.	DE	BY	LfU	2002	Aal		31,20
	Main bei Kahl	n.a.	DE	BY	LfU	2002/03	Aal	26,30	43,20
	Main bei Kleinheubach	n.a.	DE	BY	LfU	2002/03	Aal	24,80	51,30
	Main bei Rothenfels	n.a.	DE	BY	LfU	2002/03	Aal	46,30	48,30
	Main bei Schweinfurt	n.a.	DE	BY	LfU	2002/03	Rotauge, Brassen	1,15	1,52
	Regnitz bei Hausen	n.a.	DE	BY	LfU	2002/03	Aal	35,80	77,70
	Regnitz bei Hausen	n.a.	DE	BY	LfU	2002/03	Rotauge		1,12
	Regnitz bei Hüttendorf, Pegel	n.a.	DE	BY	LfU	2002	Güster		8,27
	Pegnitz, Straßenbrücke Ottensoos	n.a.	DE	BY	LfU	2003	Nase		0,54
	Fränkische Saale bei Gemünden	n.a.	DE	BY	LfU	2002/03	Aal		36,00
	Fränkische Saale bei Gemünden	n.a.	DE	BY	LfU	2002/03	Bachforelle		1,60
	Brombach, Mandelsmühle	n.a.	DE	BY	LfU	2002/03	Aal		4,57
	Brombach, Mandelsmühle	n.a.	DE	BY	LfU	2002/03	Döbel	0,13	0,18
	Nahe bei Kirn	n.a.	DE	RP	MUFV		Döbel		2,00
NAHE	Nahe bei Bad Sobernheim	n.a.	DE	RP	MUFV		Brassen		16,60
	Nahe bei Bad Sobernheim	n.a.	DE	RP	MUFV		Rotauge		1,00
	Nahe bei Staudernheim	n.a.	DE	RP	MUFV		Brassen		11,20
	Nahe bei Staudernheim	n.a.	DE	RP	MUFV		Barbe		12,00
	Nahe bei Langenlonsheim	n.a.	DE	RP	MUFV		Barbe		20,60
	Lahnstein Staustufe	n.a.	DE	RP	MUFV		Rotauge		4,45
LAHN	Lahn bei Bad Ems	n.a.	DE	RP	MUFV		Döbel		5,72
	Lahn Nassau	n.a.	DE	RP	MUFV		Döbel		6,37
	Lahn Nassau	n.a.	DE	RP	MUFV		Rotauge		2,09
	Lahn Diez	n.a.	DE	RP	MUFV		Döbel		4,33
MOSEL-SAAR	Mosel bei Metz	n. a.	FR	Moselle	ONEMA	2009	Aal	9,99	45,40
& Zuflüsse	Mosel bei Metz	n. a.	FR	Moselle	ONEMA	2009	Döbel	1,96	3,52
	Mosel bei Metz	n. a.	FR	Moselle	ONEMA	2009	Rotauge		1,36
	Mosel bei Metz	n. a.	FR	Moselle	ONEMA	2009	Flussbarsch		1,53
	Mosel bei Sierck	n. a.	FR	Moselle	ONEMA	2008	Aal	26,72	32,37
	Mosel bei Sierck	n. a.	FR	Moselle	ONEMA	2008	Döbel	3,25	24,21
	Mosel bei Sierck	n. a.	FR	Moselle	ONEMA	2008	Sonnenbarsch		2,82
	Mosel bei Sierck	n. a.	FR	Moselle	ONEMA	2008	Wels	6,47	11,35
	Mosel bei Perl	n. a.	DE	SL	LUA	2010	Döbel		4,20
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2009	Aal	12,87	19,06
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2009	Flussbarsch		2,02
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2009	Rotauge		2,46
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2009	Wels		0,45
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2010	Döbel		1,02
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2010	Güster		4,05
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2010	Rotauge		1,93
	Mosel bei Palzem	n. a.	DE	RP	LUWG	2010	Zander		0,83
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2009	Aal	7,50	34,07
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2009	Flussbarsch		1,07
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2009	Rotauge		1,95
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2009	Wels		0,38
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2010	Döbel		0,78
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2010	Güster		1,62
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2010	Rapfen		1,20
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2010	Rotauge		1,42
	Mosel bei Detzem	n. a.	DE	RP	LUWG	2010	Zander		0,72
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2009	Aal	9,79	37,22
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2009	Flussbarsch		1,48
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2009	Rotauge		1,96
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2009	Wels	0,28	0,51
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2010	Brassen		4,72
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2010	Döbel		2,41
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2010	Rapfen		6,13
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2010	Rotauge		1,52
	Mosel bei Enkirch	n. a.	DE	RP	LUWG	2010	Zander		0,72
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2009	Aal	20,61	31,74
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2009	Rotauge		1,26
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2009	Wels	0,33	0,53
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2009	Flussbarsch		0,83
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2010	Güster		7,64
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2010	Rapfen	0,91	4,74
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2010	Rotauge	1,70	2,18
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2010	Zander		0,34
	Mosel bei Koblenz	n. a.	DE	RP	LUWG	2010	Döbel		3,92

Nebenflüsse	Lage der Messstelle	Rh-km	Nation	Land, Kanton, Départ.	Institution			WHO-PCDD/F + dl-PCB TEQ (ng / kg = pg / g FG)	
Wert								min	max
MOSEL-SAAR	Saar bei Güdingen	n. a.	DE	SL	LUA	2009	Döbel		9,40
& Zuflüsse	Saar bei Güdingen	n. a.	DE	BUND	UBA	2000-2008	Brassen	8,50	33,00
(Fortsetzung)	Saar bei Güdingen & Auersmacher	n. a.	DE	SL	LUA	2010	Döbel		4,40
	Saar bei Saarbrücken, Klarenthal	n. a.	DE	SL	LUA	2010	Döbel		4,40
	Saar bei Saarlouis, Lisdorf Schleuse	n. a.	DE	SL	LUA	2010	Brassen		29,60
	Saar bei Fremersdorf	n. a.	DE	SL	LUA	2009	Döbel		7,20
	Saar bei Rehlingen	n. a.	DE	BUND	UBA	2000-2008	Brassen	18,00	36,00
	Saar bei Mettlach & Merzig, Staustufe	n. a.	DE	SL	LUA	2010	Döbel		12,30
	Saar bei Serrig	n. a.	DE	RP	LUWG	2010	Brassen		4,62
	Saar bei Serrig	n. a.	DE	RP	LUWG	2010	Rotauge		2,08
	Saar bei Serrig	n. a.	DE	RP	LUWG	2010	Zander	0,48	0,50
	Saar bei Serrig	n. a.	DE	RP	LUWG	2010	Rapfen		2,45
	Saar bei Schoden	n. a.	DE	RP	LUWG	2009	Aal	28,14	51,25
	Saar bei Schoden	n. a.	DE	RP	LUWG	2009	Rotauge		1,11
	Saar bei Schoden	n. a.	DE	RP	LUWG	2009	Flussbarsch		1,21
	Saar bei Schoden	n. a.	DE	RP	LUWG	2009	Wels	0,56	1,23
	Saar bei Schoden	n. a.	DE	RP	LUWG	2010	Brassen		3,34
	Saar bei Schoden	n. a.	DE	RP	LUWG	2010	Rapfen		8,69
	Saar bei Schoden	n. a.	DE	RP	LUWG	2010	Rotauge		1,32
	Saar bei Schoden	n. a.	DE	RP	LUWG	2010	Döbel	1,56	2,05
	Blies bei Reinheim	n. a.	DE	SL	LUA	2009	Döbel		6,50
	Prims bei Dillingen, Mündung	n. a.	DE	SL	LUA	2009	Döbel		8,20
	Nied bei Niedaltorf	n. a.	DE	SL	LUA	2009	Döbel		1,00
	Sauer (oberer Oberlauf)	n.a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Sauer (Oberlauf)	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Sauer (Stausee Obersauer)	n. a.	LU		Adm.Gest.Eau	2002	Rotauge		
	Sauer (Mittellauf)	n. a.	LU		Adm.Gest.Eau	2002	Gründling		
	Sauer (Grenzsauer)	n. a.	LU		Adm.Gest.Eau	2002	Aal		
	Sauer (Grenzsauer)	n.a.	LU		Adm.Gest.Eau	2002	Rotauge		
	Our (Oberlauf)	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Our (Unterlauf)	n. a.	LU		IKSMS	2004	Bachforelle		
	Alzette (Oberlauf)	n. a.	LU		Adm.Gest.Eau	2002	Rotauge		
	Alzette (Unterlauf)	n. a.	LU		Adm.Gest.Eau	2002	Rotauge		
	Wiltz (Oberlauf)	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Wiltz (Unterlauf)	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Attert	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Bist bei Creutzwald	n. a.	FR	Moselle	ONEMA	2009	Döbel	0,33	3,29
	Bist bei Creutzwald	n. a.	FR	Moselle	ONEMA	2009	Rotauge	0,81	3,57
	Bist bei Creutzwald	n. a.	FR	Moselle	ONEMA	2009	Flussbarsch		3,81
	Clerve	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Eisch	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Horn bei Liederschiedt	n. a.	FR	Moselle	ONEMA	2009	Aal	7,17	25,87
	Horn bei Liederschiedt	n. a.	FR	Moselle	ONEMA	2009	Barbe	4,59	7,18
	Horn bei Liederschiedt	n. a.	FR	Moselle	ONEMA	2009	Döbel	0,98	5,67
	Mamer	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Syr	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Wark	n. a.	LU		Adm.Gest.Eau	2002	Bachforelle		
	Ahr bei Dümpelfeld	n. a.	DE	RP	MUFV	2005-2007	Döbel		1,98
AHR	Ahr bei Sinzig	n. a.	DE	RP	MUFV	2005-2007	Döbel		4,43
	Ahr bei Sinzig	n. a.	DE	RP	MUFV	2005-2007	Döbel		15,50
SIEG	Siegmündung	659	DE	NW	LANUV	2010	Nase		2,49
WUPPER	Wuppermündung	703,6	DE	NW	LANUV	2008	Barbe		46,5
ERFT	Erftmündung	736	DE	NW	LANUV	2010	Döbel (3 x)		1,50
LIPPE	Lippemündung	815	DE	NW	LANUV	2010	Döbel		5,04