are given in table 4.4. In some national surveys the percentage of mercury originating from fish is provided. It is assumed that in this foodstuff (fish) the percentage of methylmercury is from 60 to 90 percent. Therefore fish and fish products represent the major source of methylmercury. It may be concluded that in those areas where fish consumption represent a considerable part of diet, exposures could be considerably higher than the value of the US EPA RfD.

Table 4.4 *Selected estimates of the typical daily intake of mercury from dietary sources in a selection of countries (as presented by Pirrone* et al., *2001).*

Country	Intake (µg/day)	References
Belgium	All food: 13 of which 2.9 is from fish All foodstuff: 6.5	Fouassin and Fondu, 1978 Buchet *et al.*, 1983
Poland	5.08 (age group 1-6 years) 5.43 (age group 6-18 years) 15.8 in adults From fish: 7% of total dietary intake	Szprengier-Juszkiewicz, 1988 Nabrzyski and Gajewska, 1984
Germany	0.8 from fish 0.2 from food (except fish and vegetables)	LAI, 1996
Croatia	From fish: 27.7 (total Hg) 20.8 (MeHg form)	Buzina *et al.*, 1995
Spain	4-8 (60-90 % from seafood) in Valencia only 27% is from the seafood 18 of which about 10 is from fish (Basque country)	Moreiras *et al.*, 1996 Urieta *et al.*, 1996
Sweden	1.8 (market-basket)	Becker and Kumpulainen, 1991
United Kingdom	2	MAFF, 1994
Finland	2	Kumpulainen and Tahvonen, 1989
The Netherlands	0.7	Van Dokkum *et al.*, 1989
Czech Rep.	0.7	Ruprich, 1995
Brazil	315 – 448 (Amazon, Medeira river)	Boishio and Henshel, 2000
Japan	10 6.9 -11.0 24 (18 as MeHg)	Tsuda *et al.*, 1995 Ikarashi *et al.*, 1996 Nakagawa *et al.*, 1997

301. Pirrone *et al.* (2001) give the following conclusion regarding the general exposure pattern in Europe:

> "Mercury vapour is a risk of decreasing importance in Europe, as mercury-containing thermometers and other instruments are being phased-out, and the emissions from the chlor-alkali industry have decreased. In addition, only one mercury mine remains in operation in Europe today. New developments in dental technology have resulted in filling materials that can substitute amalgam for many purposes.
>
> The methylmercury risk will depend on the dietary habits and local sources of contaminated fish and seafood. The substantial exposures documented in the Faroe Islands, Greenland and other northern populations are mainly due to ingestion of marine mammals. The extent of this problem within Europe is therefore limited. However, a study from the island of Madeira showed that the consumption of local black scabbard resulted in average methylmercury exposures that were even higher than on the Faroe Islands. Similarly, evidence on mercury in seafood from the Tyrrhenian Sea have shown concentration levels which overlap with those present in pilot whale meat. Thus, excess exposures occur in Europe and may reach or even exceed levels observed in populations in which adverse effects on brain development have been documented. "

302. This conclusion may possibly apply to large parts of the western world.

4.4 Exposure through diets of fish and marine mammals

303. In the following sections, examples of data on methylmercury exposure from fish diets in different parts of the world are presented: Sweden, Finland, USA, the Arctic, Japan, China, Indonesia, Papua New Guinea, Thailand, Republic of Korea, the Amazonas and French Guyana. In some of these countries or areas mercury depositions have affected mercury contamination levels over years, and countermeasures have been set in during the last decades to reduce national emissions. Mercury emissions are, however, distributed over long distances in the atmosphere and by the oceans. This means that even countries with minimal local and national mercury emissions, and other areas situated remotely from dense human activity, may very well be similarly affected. For example, high mercury exposures have been observed in the Arctic, far distances from any significant sources of releases.

304. Data on mercury concentrations in fish have been submitted from a number of nations and international organisations. Additionally, many investigations of mercury levels in fish are reported in the literature. Submitted data giving examples of mercury concentrations in fish from various locations in the world are summarised in this chapter. The overview illustrates that mercury is present all over the globe in concentrations that may affect human beings and wildlife.

4.4.1 Exposure from fish diet in Sweden and Finland

305. According to von Rein and Hylander (2000), fish has traditionally been an important part of the diet in Sweden thanks to a long coastline and many lakes and rivers. Today, because of mercury contents in the fish, detailed recommendations for the consumption are given for fresh water fish such as pike, perch, pike-perch, burbot and eel. Women of childbearing age are recommended not to eat these fish from Swedish lakes at all, and the rest of the population should not eat them more than once a week. Based on comprehensive data sets, it has been estimated that in about 50 percent of the approximately 100,000 Swedish lakes, pike (1 kg size) contain mercury levels above the international WHO/FAO limit of 0.5 mg mercury/kg wet weight, and in 10 percent of the lakes pike contains over 1 mg/kg wet weight (Lindquist *et al.*, 1991). It has been calculated that the mercury deposition in Sweden must decrease by 80 percent from the level of the late 1980's in order to reduce the mercury content in Swedish fish to below 0.5 mg mercury/kg wet weight. The emissions to air from point sources in Sweden itself have decreased to about 1 metric ton/year from peak values in the 1960's of around 30 metric tons/year, and releases to water have been reduced similarly (Naturvårdsverket, 1991). Most of the present mercury deposition in Sweden originates from long-range atmospheric transport from other countries (Håkansson and Andersson, 1990; Iverfeldt *et al.*, 1995). This means that in order to meet the 80 percent reduction goal, emissions from Europe and other parts of the Northern hemisphere must also be reduced further. There are indications of recent reductions in deposition, and during the last few decades a general decrease of about 20 percent has been observed in mercury concentrations in fish in Sweden (Johansson *et al.*, 2001).

306. Also in Finland, the accumulation of mercury in fish has been studied during several decades (Louekari *et al.*, 1994). In the late 1960's about 10-15 percent of the lakes and coastal waters in Finland were affected by elevated mercury concentrations mainly caused by direct aqueous releases from pulp and paper industry and (related) mercury-based chlor-alkali production. Average concentrations of mercury in northern pike in these freshwaters and brackish coastal waters averaged as much as 1.52 mg/kg wet weight at that time. Since the abandonment of the use of mercury compounds for slimicides in paper production in Finland in 1968 and decreasing demand for chlorine in the same industry, releases of mercury have been reduced significantly. In 1990 average concentrations in pike in these waters had decreased to 0.60 mg mercury/kg wet weight (concentrations in pikes in freshwaters were generally higher than in brackish waters). Louekari *et al.* (1994) combined these findings with dietary surveys and calculated estimated daily intakes of mercury in different consumer segments, and the relative influence of pike/fish consumption. In 1967/68, mercury intakes of the farmer segment known to be most depending on locally caught fish were estimated at 22 μg mercury/day in the areas with elevated mercury contamination. Similar intakes in 1990 were estimated at 15 μg mercury/day. For office employees, who consume less locally caught fish, corresponding intakes were 13 and 8 μg mercury/day.

307. The mercury concentration limit of 0.5 mg/kg in fish, recommended by WHO/FAO, is exceeded for one-kilo pike (*Esox lucius*) in 85 per cent of the lakes in southern and central Finland (22,000 lakes), (Lindquist *et al.*, 1991; Verta 1990; all in Pirrone *et al.*, 2001).

4.4.2 Exposure from fish diet in the USA

308. In the mid-1990's the US EPA estimated from comprehensive national dietary surveys that up to 5 percent of women in the child bearing age (ages 15-44 years) in the USA consumed 100 grams of fish and shellfish per day or more. WHO recommends "special considerations" regarding mercury exposure for persons eating more than 100 g/day. Furthermore, the US EPA calculated from the same dietary surveys combined with average total mercury concentrations in the species of fish consumed, that 7 percent of US women in the child-bearing age may exceed the exposure of the US EPA RfD (see section 4.2.1). A recent study (by the US Centers for Disease Control and Prevention) of mercury concentrations measured in blood and hair in a representative group of women aged 16-49 in the USA (about 1700 women) confirmed these calculations, as approximately 8 percent of the women had hair and blood mercury levels exceeding the levels corresponding to the US EPA RfD (CDC, 2001; Schober *et al.*, 2003). The CDC also collected hair and blood samples for year 2002, but these results are not yet available. Moreover, the CDC plans to continue the blood measurements in future years, but the hair samples are not planned after year 2002.

309. The US EPA noted that the calculated results reflected the average choice of fish species, and that "consumption of fish with mercury levels higher than average may pose a significant source of methylmercury exposure to consumers of such fish" (elevated mercury concentrations have been measured in fish in quite a number of freshwater bodies in the USA). The US EPA concluded in their risk characterisation that "most USA consumers need not be concerned about their exposure to mercury", but the exposure of "those who regularly and frequently consume large amounts of fish" (especially species with high mercury concentrations), may be of concern (US EPA, 1997).

310. In the USA, fish advisories (consumption recommendations) have been issued for mercury in one or more freshwater bodies in 41 states, and 13 states have issued statewide mercury fish advisories. Mercury is the most frequent basis for fish advisories in the USA, representing 79 percent of all advisories (as of December 2000; US EPA, 2001a). The US EPA has presented a set of general recommendations for fish consumption. For example, fish with mercury concentrations ranging from 0.48 -0.97 mg methylmercury/kg wet weight should be eaten no more than once a month and with 0.97 - 1.9 mg/kg wet weight only every second month, whereas fish containing more than 1.9 mg/kg wet weight should not be eaten at all (US EPA, 2001a); see table 4.2 in section 4.2.1 above.

311. Fish sold in commerce in the USA are under the jurisdiction of the Food and Drug Administration (FDA), which issues action levels for concentration of mercury in fish and shellfish. The current FDA action level (as per 1998) is 1 ppm (1 mg/kg) total mercury based on a consideration of health impacts. As illustrated in table 4.5 in section 4.5, US freshwater fish can have mercury levels which exceed the FDA action limit of 1 ppm. The levels in some marine species such as shark, swordfish, and king mackeral are also typically this high. The concentration of methylmercury in commercially important marine species is on average close to ten times lower than the FDA action level in the USA. Mercury levels in marine fish have been monitored by the National Marine Fisheries Service for at least 20 years. The data in marine fish have shown mercury levels over this time to be relatively constant in various species. Comparable trends data for freshwater fish do not exist, although there are data for coastal and estuarine sites (US EPA, 1997).

312. See also the description of Canadian experiences related to mercury in aquatic ecosystems, including a map showing national fish mercury concentrations, in section 5.3.

4.4.3 Exposure from marine diet in the Arctic

313. The comprehensive AMAP (1998) assessment report on arctic pollution issues describes the high exposures of the Arctic population. AMAP and other Arctic Council activities relevant to mercury

cover the whole of the Arctic region, and mercury is a priority substance for assessment and abatement initiatives for the Council. Here, examples of mercury exposure in Greenland are given.

314. As for much of the population in the region, the diet in Greenland is to a high degree composed of marine mammals and also fish. The traditional Greenlandic diet is also a very important part of the Greenlandic culture and identity.

315. The concentration and distribution of mercury in humans in Greenland have been thoroughly studied in the last 15 years. Surveys have been performed in adults, pregnant women and newborn babies in most parts of Greenland including both hunting districts and more densely populated areas. In all regions studied, the determining factors for mercury exposure were the daily intake of meat from marine mammals. At a regional level, the blood mercury concentrations were directly proportional to the registered number of seals caught (and consumed), indicating that mercury concentration in meat is probably similar in all regions of Greenland (Hansen, 1990). In adults, whole blood concentrations of mercury are lowest in the Southwest and increasing towards the North where the intake of marine mammals is higher – see figure 4.1.

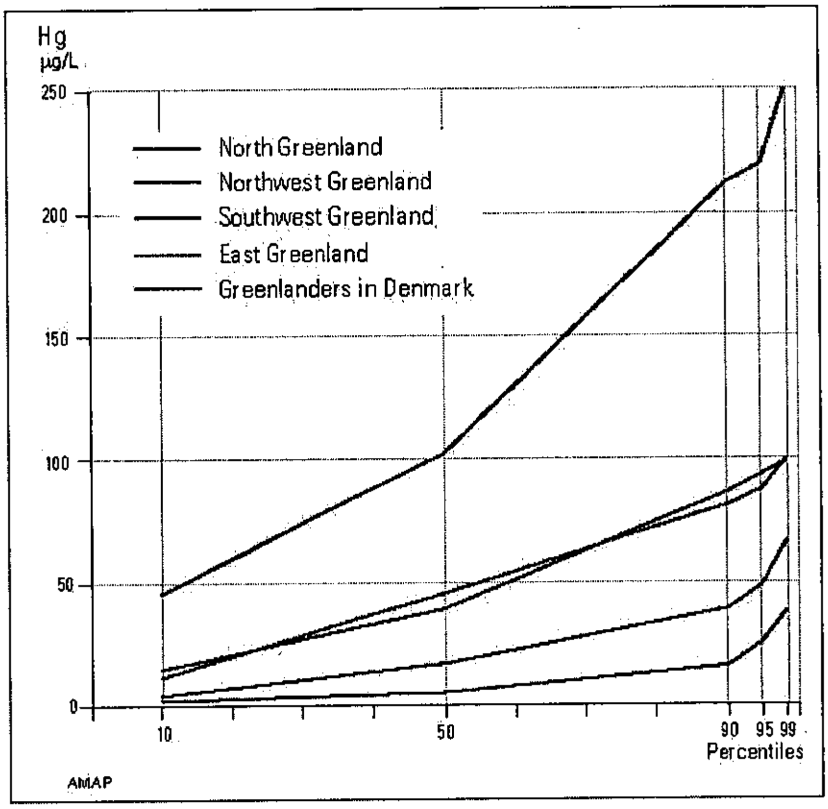


Figure 4.1 *Distribution (in percentiles) of whole blood mercury concentrations in four regions in Greenland and in Greenlanders living in Denmark (AMAP, 1998, based on 1988 measurements). Original figure presented courtesy of AMAP, Norway.*

316. In North Greenland, 16 percent of the adult population studied had blood mercury concentrations exceeding 200 µg/l, which is the level regarded by WHO as the minimum toxic blood concentration in non-pregnant adults (AMAP, 1998). More than 80 percent of the population in North Greenland exceeded 50 µg/l blood (Hansen and Pedersen, 1986), which almost corresponds to the benchmark dose level from the US NRC report (2000). Blood levels of 200 µg/l are approximately the level expected to occur following a daily average intake of about 4 µg methylmercury per kg body weight per day. Likewise, a daily intake of about 1 µg methylmercury per kg body weight per day is expected to result in blood mercury levels of about 50 µg/l and hair mercury levels of about 10 µg/g (US EPA, 1997; US ATSDR, 1999).

317. In a small set of 20 paired samples of maternal and umbilical cord blood taken under the AMAP programme, the mean concentrations were 24.2 and 53.8 µg/l, respectively. This level is very close to the NRC (2000) benchmark dose level (58 µg/l) based on the NRC evaluation of the Faroe Islands studies (see section 3.2.1).

318. As of 1997, no disease or symptoms had been registered which could be unequivocally related to environmental contaminant exposure in Greenland (AMAP, 1998). However, it should be noted that this can generally not be done for environmental contaminants because of its complexity, except in cases of extreme acute or sub-acute exposure. Furthermore, at that time measurements of more subtle neurological and reproductive effects had not yet taken place in Greenland. A recent study suggested exposure-related neurobehavioral deficits in Inuit children in Qaanaaq, Greenland, but the study was too small to provide solid statistical significance of the associations (Weihe *et al.*, 2002).

319. The traditional marine diet on Greenland and in parts of Arctic Canada has very positive nutritional qualities and is not readily replaced with other foods. Dietary advice from the Canadian Government states that the positive health benefits of a traditional northern marine diet outweigh the known risks associated with consumption of these foods. However, it is clear that the risks associated with this diet increase with increasing levels of methylmercury contamination. It is further important to note that, beyond the physical benefits associated with the traditional diet, it also plays an important role in the social and cultural life of indigenous communities in the North.

320. As mentioned above, the investigation of mercury exposure and effects on the Faroe Islands on the border of the Arctic area has been extensive, and subtle neurological effects have been shown on children at low prenatal exposure levels, see description in section 3.2.1 above.

321. The Arctic Council and the substantial coverage of mercury in its monitoring and assessment programme (AMAP) and its current action plan (ACAP) are described in section 9.5.1.

4.4.4 Examples from Asia

China, Japan and Indonesia

322. Feng *et al.* (1998) investigated total mercury and methylmercury concentrations in scalp hair of 243 male persons in three areas of the Tokushima Prefecture, Japan as well as in 64 males of the Chinese city Harbin and 55 males in the Indonesian city Medan (all subjects were randomly chosen males aged 40-49 years). They found the highest concentrations in subjects living in a seaside area reported to be without local direct anthropogenic contamination. Total mercury concentrations here ranged from 1.7-24 µg/g hair (mean 6.2 µg/g, 78 subjects), thus close to and exceeding the adverse effect benchmark level of about 10 µg/g maternal hair derived from the Faroe Islands studies (see section 3.2). The mean concentration for all three investigated areas in Japan was only slightly lower: 4.6 µg/g hair (243 subjects).

323. In Japan, where the diet is relatively high in fish and shellfish, methylmercury constituted large parts of the total mercury measured, and there was a high correlation between concentrations of methylmercury and total mercury, underlining that a marine diet was the major contributor to mercury exposure. Feng *et al.* (1998) quote the Japan General Affairs Department for 1996 dietary surveys estimating average national consumption of fish and shellfish at 107 g/day per person, being the third highest consumption rates among 23 countries investigated.

324. In the industrial cities of Harbin, China, and Medan, Indonesia, Feng *et al.* (1998) found lower mean total mercury concentrations (means 1.7 µg/g and 3.1 µg/g hair respectively). In both of these places methylmercury concentrations were lower – even for subjects with high total mercury concentrations - and correlation between methylmercury and total mercury concentrations was low, indicating that these subjects were mainly exposed to elemental or inorganic mercury from other sources.

Papua New Guinea

325. Feng *et al.* (1998) quotes Suzuki (1991) for mercury hair concentration levels found in residents of three villages in Papua New Guinea not influenced by local direct anthropogenic contamination. The highest concentrations were found in the seaside village Dorogi with means at 4.1 and 4.4 µg/g hair for males and females respectively, while concentrations were slightly lower in a riverside village 6 kilometres from the coast and lowest in a village 25 kilometres from the coast.

Thailand

326. For Thailand, the national submission (sub53gov) quotes Menasveta (1993) for an average national fish consumption rate of 61 g/day per person for Thai people (with average weight 60 kg). There is no study on hazards from methylmercury exposure of the Thai population.

Philippines

327. The average estimated national fish consumption rate is 75 g/person per day, and the average person weighs 60 kg. Also, the exposures described in the study by UNIDO (described in section 4.3 above) on mercury intoxication on the island of Mindanao (a gold-mining area) are probably partially due to exposures through the diet, especially for the non-occupationally burdened part of the population downstream from Mt. Divalwal, where approximately a third (55 of 163) are intoxicated (Global Mercury Assessment Working Group - Philippines delegation, 2002).

Republic of Korea

328. According to the national submission from the Republic of Korea, the supply of fish amounted to between 74 and 94 g fish/day per person in this country in the years 1996-1999 (Republic of Korea submission, sub76govatt2).

4.4.5 Exposure from fish diet in the Amazonas and French Guyana, South America

329. Several studies in the Amazonas have reported elevated exposures to methylmercury and total mercury in fish dependent populations in and around areas affected by mercury-based gold extraction.

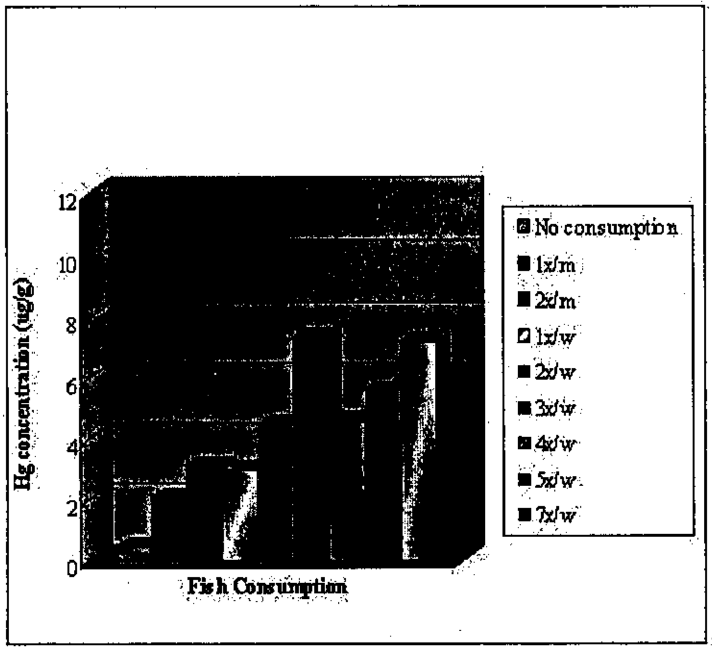
330. Some studies in the Amazonas have shown adverse effects from mercury exposure on humans. For example, in the Tapajós river community of Brazil, cognitive deficits have recently been reported in 7-year children who were exposed, in uterus, to mercury levels corresponding to maternal hair mercury levels below 10 µg/g hair (Malm *et al.*, 1999, as quoted the in Brazilian submission sub66govatt2A). Quite a number of studies have investigated exposures and toxic impacts from mercury in individual areas affected by gold mining activities in the Amazonas. The Ministry of Health, Brazil, reports to be in the process of reviewing the available exposure data from the Amazon area with fish consumption and mercury concentration in fish as focal points (sub66govatt2A). The Ministry has also submitted a list of a large number of references relevant to the impacts of mercury in the Amazon (sub66govatt2B).

331. Akagi and Naganuma (2000) used separate measurements of methylmercury and total mercury to distinguish between exposures through an aquatic diet and direct exposures of elemental mercury from gold extraction activities. They found methylmercury concentrations exceeding the adverse effects level for adults of 50 µg/g in hair in 3.2 percent of the 559 inhabitants surveyed, with the highest individual level being 132 µg/g. These values are substantially higher than the adverse effect benchmark level of 10 µg/g maternal hair derived from the Faroe Islands studies (see section 3.2.1).

332. Vasconcellos *et al.* (1998) determined total mercury concentrations in scalp hair in 13 of the 17 tribes of Indians inhabiting the Xingu Park in the Brazilian Amazon. In six of the investigated groups methylmercury concentrations in hair were also measured. Geometrical means for total mercury concentrations varied among the tribes in the range of 3.2-21 µg/g hair, but most group means were between 10 and 20 µg/g. In the tribes where methylmercury was also measured, methylmercury comprised nearly all of the mercury found in the hair samples. In the same study, three groups of inhabitants in the Brazilian State of Amapá were also investigated. Total mercury in hair versus numbers of fish

meals per week are shown in figure 4.2 - first for a region not affected directly by gold extraction (figure 4.2 a) and then for another region which is affected by gold extraction (figure 4.2 b).

a) Total mercury concentrations in hair versus fish consumption – region of Serra do Navio, State of Amapá, Brazil (not directly affected by gold extraction)



b) Total mercury concentrations in hair versus fish consumption – region of Vila Nova, State of Amapá, Brazil (directly affected by gold extraction)

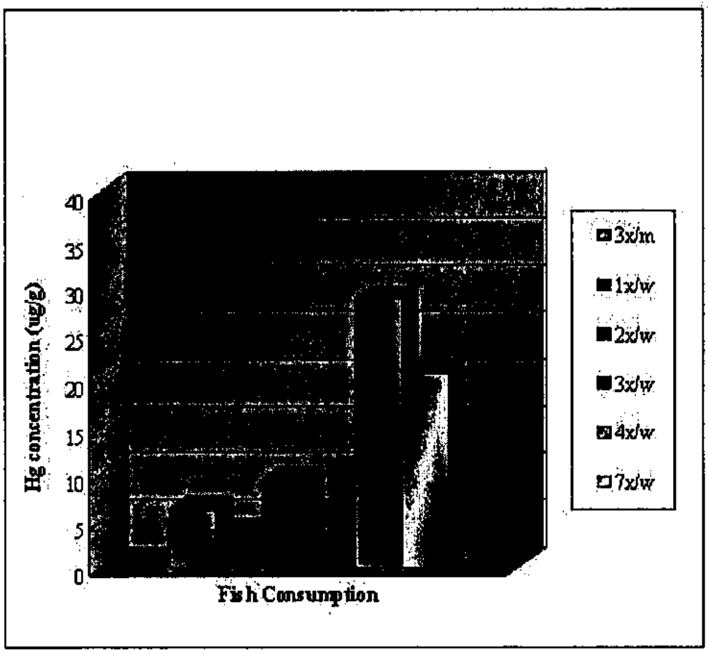


Figure 4.2 Total mercury concentrations in hair vs fish consumption in two regions of the State of Amapá, Brazil (from Vasconcellos et al.*, 1998, submitted by Brazil, sub68govatt1)*

333. Some researchers have considered if gold extraction alone could explain the observed mercury contamination levels in the Amazonas area. Other mercury sources mentioned are volcanic contributions and increased mobilisation due to deforestation and other sources of soil erosion (based on USA, comm-24-gov, 2002).

French Guyana

334. A study undertaken by Fréry *et al.* (1999) among the Wayana people in the higher area of the Maroni River, French Guyana, whose diet is based mainly on fish, confirmed mercury exposure due to consumption of river fish contaminated by mercury from gold extraction activities. Of 242 fish samples analysed, 14.5 percent had mercury levels over 0.5 mg/kg (with a high of 1.62 mg/kg). Based on the Wayana's fish consumption patterns, adults were found to consume between 40 and 60 µg total mercury per day, nursing infants approximately 3 µg per day, children between 1 and 3 years of age 7 µg per day, between 3 and 6 years approximately 15 µg per day and between 10 and 15 years between 28 and 40 µg per day. Over half of the population had hair mercury levels over the WHO recommended level of 10 µg total mercury/g, with an average of 11.4 µg/g. (Mercury levels in the population of Guyana are approximately 3 µg/g and 1.7 µg/g in people from urban areas.)

4.5 Submitted data on mercury concentrations in fish

335. Information on mercury concentrations in fish in different parts of the world has been chosen in this report as an indicator illustrating the presence of mercury in the global environment. Data on mercury concentrations in fish have been submitted from a number of nations and international organisations. Additionally, many investigations of mercury levels in fish are reported in the literature. Submitted data giving examples of mercury concentrations in fish from various locations in the world are summarised in table 4.5. The available data illustrate that mercury is present all over the globe in concentrations that may affect human beings and wildlife.

336. As an illustration of how the observed concentration levels are related to potential adverse effect levels, **concentrations at or exceeding 0.3 mg/kg wet weight** – the US EPA Tissue Residue Criterion (at 17.5 gram fish intake/day) and the Japanese guideline value (see section 4.2.1) – have been **marked in bold text in the table**. These values represent the most recent comprehensive risk assessments regarding mercury exposure from fish diets. As mentioned in table 4.1, FAO/WHO Codex Alimentarius guideline levels for fish are 0.5 mg/kg wet weight for non-predators and 1 mg/kg wet weight for predators (such as shark, swordfish, tuna, pike and others).

Table 4.5 Examples of mercury concentrations in fish/shellfish in different regions of the world, as reported in submissions to the Global Mercury Assessment. Sample collection, treatment, and analysis methodology may vary and may have affected results. Consult references for details.

Geographic location	Fish and shellfish species	Concentration (-level) *3 ww: Wet weight *4 dw: dry weight *5	Year of sampling	Trophic level *1	Contamination level in habitat *2	References
Arctic area	Marine fish	0.01 - 0.1 mg/kg ww Peaks: 0.1 - **0.9** mg/kg ww	Various			AMAP, 1998
	Marine mussels	<0.009 - 0.033 mg/kg ww	Various			
Australia (southwest Tasmania)	Australian eel (Lake Gordon)	**0.86 – 2.15** mg/kg (mean **1.40** mg/kg, 9 samples)	1994			Bowles, 1998, in National submission from Australia, sub63gov
	Brown trout (Lake Pedder)	0.06 – **0.3** mg/kg (mean 0.16 mg/kg, 20 samples)	1993			
	Brown trout (Lake Gordon)	0.1 – **1.4** mg/kg (mean **0.35** mg/kg, 20 samples)	1994			
	Brown trout (Gordon River)	**0.3 – 2.35** mg/kg (mean 1.09 mg/kg, 25 samples)	1993			
	Redfin perch (Lake Gordon)	0.12 – **1.3** mg/kg (mean **0.52** mg/kg, 20 samples)	1993			
Baltic Sea	Round fish	0.010-0.050 mg/kg ww	1994-1998		Back	ICES, 1997, in Helcom, 2001
	Marine fish	0.016 - 0.091 mg/kg ww (muscle, all investigated species).			Gen	
	Blue mussel	0.005 - 0.010 mg/kg ww		Non	Back	
	Blue mussel	Slightly exceeding 0.01 mg/kg ww			Gen	

Geographic location	Fish and shellfish species	Concentration (-level) *3 ww: Wet weight *4 dw: dry weight *5	Year of sampling	Trophic level *1	Contamination level in habitat *2	References
Brazil	46 species from six trophic levels: Herbivore/Denitrivore Planktophagus/Omnivore I Omnivore II/Piscuvore	 0.10/0.15 mg/kg (ww) 0.36/0.21 mg/kg (ww) 0.55/0.64 mg/kg (ww)	1991-1993			Boischio and Henshel, 2000
Brazil (Amazonas)	River fish from pristine areas Predatory fish from contaminated areas (main mined Amazonas river basin)	Lower than 0.2 mg/kg ww of Hg Can reach levels of 2 – 6 mg/kg or more, Average values above **0.5** mg/kg	1990's	 Pre	Back Con	Malm, as contained in NIMD Forum, 2001, in national submission from Japan (sub6govatt1)
Côte d'Ivoire	Tuna species, "Thon Albacore" (Thunnus Albacares) Large individuals (80-91 kg): Sole, "sole" Herring, "hareng"	**0.30 - 0,36** mg/kg ww **0.8** mg/kg ww (muscle) 0.064 - 0,090 mg/kg ww 0.037 - 0,047 mg/kg ww	1991	Pre Non Non	Gen Gen Gen	National submission from Côte d'Ivoire (sub72gov)
Cyprus	Sword fish Sea bream Red mullet Common dentex (dentex dentex)	0.20 - **2.00** mg/kg ww (mean **0.54** of 21 samples) 0.00 - **2.00** mg/kg ww (mean **0.38** of 42 samples) 0.00 - **0.70** mg/kg ww (mean 0.11 of 15 samples) 0.00 - **2.00** mg/kg ww (mean 0.51 of 20 samples)	1993-1997	Pre Non	Gen Gen Gen Gen	National submission from Cyprus (about 15 species reported in all)
Fiji	Shellfish (*Crassostrea mordax)* Shellfish (*Crassostrea mordax)* Shellfish (*Grafarium tumidum)* Shellfish (*Anadara spp.)* Canned tuna	<0.001-0.061 mg/kg ww **0.55-0.95** mg/kg dw 0.05-0.20 mg/kg dw 0.037-0.099 mg/kg dw 0.01-0.97 mg/kg ww	1987/88 1988 1985/86 1992/93 1990/92		Back Con Back Back ?	Naidu *et al.*, 1991 Naidu and Morrison, 1994 Gangaiya *et al.*, 1988 Morrison *et al.*, 2001 IAS, 1992
Finland	Northern pike in freshwater and brackish coastal waters	**1.52** mg/kg ww of Hg (average concentration) **0.60** mg/kg ww of Hg (average concentration)	1960's 1990			Submission from the Nordic Council of Ministers, sub84gov
France	Mussels (369 samples from 96 sampling stations along the coast of France	0.008 – 0.238 mg methylHg/kg dry weight (mean 0.064 mg/kg dry weight)	1996			Claisse *et al.*, 2001, in national submission from France, sub49gov
	Fish, Atlantic Sea: Conger Merlu Rousette	 1.2 +/- 0.3 mg/kg dw 0.4 +/- 0.1 mg/kg dw 2.0 +/- 0.6 mg/kg dw				Cossa, 1994 in national submission from France (sub49gov).
	Fish, Mediterranean Sea: Conger Merlu Rousette	 4.5 +/- 2.8 mg/kg dw 3.2 +/- 2.1 mg/kg dw 9.4 +/- 5.2 mg/kg dw				
	Fish caught in Baltic and North Sea, English Channel, Atlantic Ocean) Swordfish (*Xiphias gladius*) Shark (*Lamna sp.*) Red tuna (*Thunnus thynnus*)	 Mean **0.780** mg/kg ww (41 samples) Mean **0.692** mg/kg ww (497 samples) Mean **0.470** mg/kg ww (344 samples)	1971 – 1980			Thibaud, 1992 in national submission from France (sub49gov)

Geographic location	Fish and shellfish species	Concentration (-level) *3 ww: Wet weight *4 dw: dry weight *5	Year of sampling	Trophic level *1	Contami-nation level in habitat *2	References
Ghana	River species: Mostly "tilapia" (tilapia guineensis) and "catfish" (heterobranchus spp.)	General: 0,55 - 1,59 mg/kg ww Tilapia, mean: 1,17 mg/kg ww (of 8 fish)	2000		Con	National submission from Ghana and UNIDO report sub2igoatt6part2
Guam	Fish	0.009-0.045 mg/kg ww			Back	Denton *et al.*, 2001
Hong Kong	Mud carp (*Cirrhinus molitorella*) Freshwater grouper (*Micropterus sp.*) Golden thread (*Nemipterus virgatus*) Hair tail (*Trichiurus haumela*)	0.025 mg/kg ww 0.195 mg/kg ww 0.219 mg/kg ww 0.146 mg/kg ww	1995			Dickman and Leung, 1998
India	18 groups of fish and other seafood in the Bay of Bengal, Arabian Sea and Indian Ocean	0.005-0.065 mg total Hg/kg (mean average values)			Back	Ramamurthy, 1979, in comments from India (comm.-13-gov)
	Bombay, west coast Fish Bivalves Gastropods Crabs *Madras, southeast coast* Fish Fish *Sagar Island, east coast* Bivalves	 0.03-0.82 mg total Hg/kg dw 0.13-10.82 mg total Hg/kg dw 1.05-3.60 mg total Hg/kg dw 1.42-4.94 mg total Hg/kg dw Below detection limit (100 ng/g) 0.08-0.14 mg total Hg/kg ww 0.06-2.24 mg total Hg/kg dw				Bhattacharya and Sarkar, 1996
Italy	Bluefin tuna (Thunnusthynnus thynnus)	0-4 mg total Hg/kg ww		pre	gen	Renzoni *et al.*, 1998
Japan	Scorpionfish, inside Minamta Bay Scorpionfish, outside Minamata Bay	0.655 mg/kg ± 0.162 0.511 mg/kg ± 0.241 0.603 mg/kg ± 0.216 0.531 mg/kg ± 0.194 0.431 mg/kg ± 0.163	1978 1993 1983 1990 1999			Yasuda *et al*, in national submission from Japan, sub6gov
Kiribati	Shellfish (*Anadara spp.*)	<0.0001-0.006 mg/kg ww	1987		Back	Naidu *et al.*, 1991
Korea, Republic of	Unspecified freshwater fish species from 12 places each in Keum and Nakdong River Basins, respectively	Mean 0.126 mg/kg total Hg (10 species, 90 samples) Mean 0.196 mg/kg total Hg (6 species, 124 samples.	1989 1985			National submission from Korea (sub76govatt1)
	7 freshwater fish species(Givel, Carp, Grey mullet, Cat fish, Shake head, Eel, Mandarin fish) from Kangkyung area in Keum River	Mean 0.351 mg/kg (muscle, 7species, 57 samples)	1980			National submission from Korea (sub76govatt1)
	Freshwater fish species from 24 streams in South eastern area in Korea (Carassius auratus, Zacco temmincki, plecoglossus altivelis, Moroco lagowskii, Chaenogobius urotaenia urotaenia etc.)	0.02 – 0.12 mg/kg mean 0.07 mg/kg	1979			National submission from Korea (sub76govatt1)
Kuwait	Shrimp, various species	Not detected – 1.57 mg/kg (average less than 0.4 mg/kg)	1980's			Khordagui and Dhari, 1991, in UNESCWA submission, sub1igo

Geographic location	Fish and shellfish species	Concentration (-level) *3 ww: Wet weight *4 dw: dry weight *5	Year of sampling	Trophic level *1	Contamination level in habitat *2	References
Mauritius	Shark (unspecified) Marlin Tuna Swordfish	0.13 - 0.60 mg/kg of Hg (52 samples of fresh shark) 1.20 – 3.00 mg/kg of Hg (in 8 samples), 0.10-0.90 mg/kg of Hg (in 18 other samples) 0.10 – 0.70 mg/kg of Hg (16 samples of fresh tuna) 0.22 – 0.65 mg/kg of Hg (in 17 samples of swordfish)	?	Pre	Gen	National submission from Mauritius, sub56gov
North East Atlantic (OSPAR waters)	Marine fish	0.01-0.2 mg/kg ww (general) Up to 0.9 mg/kg ww (peak areas)	1993-1996		Gen	OSPAR, 2000b and 2000, in submission from the Nordic Council of Ministers, sub84gov)
	Marine mussels	0.01-0.1 mg/kg ww(general) Up to 0.9 mg/kg ww (peak areas)		Non	Gen	
Norway	Pike Perch	0.1 – 2.5 mg/kg 0.1 – 2.5 mg/kg	1988-1994			National submission from Norway, sub70gov
Philippines	Fish in river systems Taiwan clam Tilapia	0.00107 – 0.439 mg/kg totalHg 0.00071 – 0.377 mg/kg methylHg 0.233 -1.208 mg/kg total Hg 0.109-0.494 mg/kg total Hg	1996-1999 1997-1999 1996-1999	 Non	Con (artisinal gold mining area)	National submission from Philippines, sub1gov
Seycelles	Various ocean species	Mean of 0.2-0.3 mg/kg				Cernichiari *et al.*, 1995, as quoted by Pirrone *et al.*, 2001
Slovak Republic	Some river and lake species: Barbel (*Barbus barbus*) European perch (*Perca fluviazlis*) Grayling (*Thymallus thymallus*) Rainbow trout (*Salmo gairdnerii*) Eel (*Anguilla anguilla*)	 0.053-7.329 mg/kg ww (mean 0.728 mg/kg, 29 samples) 0.009-1.964 mg/kg ww (mean 0.212 mg/kg, 34 samples) 0.032-0.110 mg/kg ww (mean 0.064 mg/kg, 6 samples) 0.001-0.970 mg/kg ww (mean 0.038 mg/kg, 56 samples) 0.007-0.220 mg/kg ww (mean 0.093 mg/kg, 8 samples)	1995-2000 1995-2000 1995-1997 1995-2001 1995-1996			Comments from Slovak Republic (Comm-14-gov)
Solomon Islands	Fish flesh (spp. Unknown) Fish liver (spp. Unknown)	0.0002-0.0014 mg/kg ww 0.089-0.120 mg/kg ww			Back	Kannan *et al.*, 1995
Sweden	Northern pike of one kilogram in inland waters	0.1-2.0 mg/kg ww				Comments from Sweden (Comm-12-gov)
Taiwan	Blue marlin (*Makaira mazara*) Tuna (*Thunnus albacores*) Grass shrimp (*Penaeus mondon*) Oyster (*Crassostrea gigas*)	10.3 mg/kg dw 9.75 mg/kg dw 2.19 mg/kg dw 0.180 mg/kg dw	1995-1996			Han *et al.*, 1998
Thailand	Unspecified fish, shrimp and shellfish species at 15 different river mouths (caught with "artisanal gear")	0.041-0.32 mg/kg (dw) 0.01-0.6 mg/kg (dw)	1998 1999		Gen	National submissions from Thailand, sub53gov
	Snapper, Grouper, Threadfin bream, Lizard fish, Cobia	0.049 – 0.694 mg/kg (ww)	1997			Windom and Cranmer, 1998

Geographic location	Fish and shellfish species	Concentration (-level) *3 ww: Wet weight *4 dw: dry weight *5	Year of sampling	Trophic level *1	Contami-nation level in habitat *2	References
Tonga	Shellfish (*Grafarium tu-midum*)	0.022-0.191 mg/kg ww	1987		Back	Naidu *et al.*, 1991
United Kingdom (Irish Sea)	Flounder (*Platichthys flesus*) caught close to Ireland, Wales, Isle of Man Flounder caught close to Liverpool Bay Plaice (*Pleuronectes pla-tessa*) Dab (*Limanda limanda*) Lesser spotted dogfish (*Scyliorhinus caniculus*)	0.008 – **0.331** mg/kg ww Up to **1.96** mg/kg ww Less than **0.5** mg/kg ww Less than 1.1 mg/kg ww Less than **2.5** mg/kg ww	?			Leah *et al*, 1992 in national submission from United King-dom, sub39govatt1
United Kingdom	Eels (*Anguilla anguilla*) Caught in various East Anglia locations	0.001 – 0.082 µg/kg (mean 20) 0.014 – 0.788 µg/kg (mean 170) 0.022—0.168 µg/kg (mean 82)	?			Downs *et al.*, 1999 in national submission from United King-dom, sub39govatt1
United Kingdom	Survey of 336 fresh/frozen/processed sea fish and shellfish - Halibut Marlin Shark Swordfish Tuna	0.038-**0.617** mg/kg (mean 0.290, 2 samples) **0.409-2.204** mg/kg (mean **1.091**, 4 samples) **1.006-2.200** mg/kg (mean **1.521**, 5 samples) **0.153-2.706** mg/kg (mean **1.355**, 17 samples) **0.141-1.500** mg/kg (mean **0.401**, 34 samples)				University of Bristol Survey - Mercury in imported fish and shellfish and UK farmed fish and their products, unpub-lished, posted at www.food.gov.uk/multime-dia/pdfs/Mercury_in_Fish_table.pdf
United States of America	Bottom feeders – Carp Channel catfish White sucker Predators – Smallmouth bass Brown trout Largemouth bass Walleye Northern pike	 0.061 –0.250 mg/kg 0.010 - **0.890** mg/kg 0.042 - **0.456** mg/kg 0.094 - **0.766** mg/kg 0.037 - **0.418** mg/kg 0.101 - **1.369** mg/kg 0.040 - **1.383** mg/kg 0.084 - **0.531** mg/kg	1990-1995	Non Pre		US EPA, 1997
Vanuatu	Shellfish (*Anadara spp.)* Shellfish (*Crassostrea mordax*)	0.02-0.04 mg/kg ww 0.01-0.04 mg/kg ww	1987 1987		Back	Naidu *et al.*, 1991

Notes:

1 Indication of trophic level: **Pre** - predator/higher level; **Non** - non-predator/lower level;

2 Indication of contamination level in habitat: **Gen** - general/unspecified; **Back** - background level; **Con** – contaminated.

3 Unless otherwise mentioned, it is assumed that the results refer to measured content of total mercury (and not methylmercury).

4 Mercury concentration may be assumed to be wet weight (ww) unless otherwise indicated.

5 Dry weight results will by definition be higher than wet weight result (because of the water content in fish and seafood), and is therefore not directly comparable to wet weight results and guideline values based on wet weight.