Polychlorinated Biphenyls in Salmon (*Salmo salar*) from the Swedish East Coast

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Introduction

In spite of severe restriction and, in some cases, total ban in the use or application of certain organochlorine compounds (OCC) in agriculture and industry the residues are still widespread, though at low levels, in the Swedish environment. This study was primarily initiated as a result of demand to provide current OCC levels in fish from the Baltic environment, and check for possible correlation with specific environmental conditions.
Implementation of the study involved partially the determination of PCBs and some chlorinated pesticides in salmon (*Salmo salar*) caught along the Swedish east coast.
Results from this survey will be compared with previously obtained data and thus assess the implications for human exposure resulting from the consumption of salmon from this environment.

Material and Method

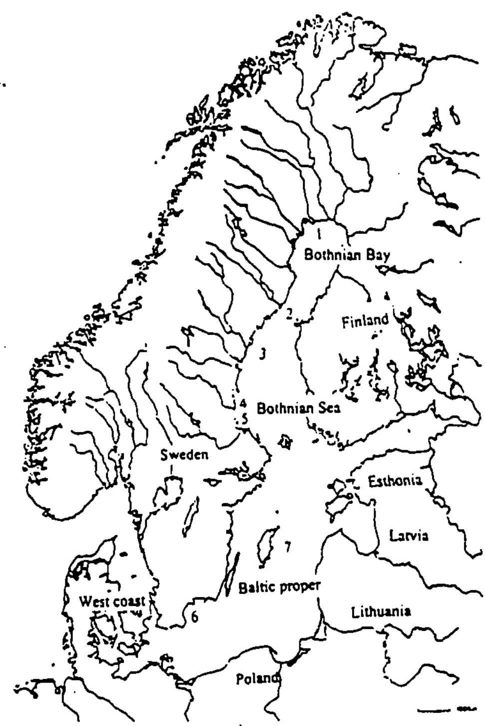
Samples comprising of eight sub-samples (or five in two cases) of salmon from seven different areas along the Swedish east coast in the Baltic (Fig. 1), representing mixed as well as river populations, were collected for analysis. Samples were obtained from the first six areas in July 1996 and from Gotland (site no 7) in November. Both individual tissues of the epaxial muscle and representative sub-samples of pooled homogenates from each site were analysed. Each fish weighed between 3-8 kg. The sample material was collected to show geographical differences along the coast depending upon, for example, differences in migratory patterns. In one of the sites (site no 4) two other sizes (2-4 and 10-12 kg) were also studied.

The sample extraction and clean-up were carried out in two ways. The first one was a modified standard procedure by Jensen *et al* (1). The other extraction procedure was by the supercritical fluid technique (SFE). This was followed by HPLC separation as described by Atuma and

Hansson (2) to isolate the mono- and non-ortho (planar) PCBs from the bulk of the other PCBs prior to GC/MS determination. Direct injection after SFE into the GC/MS is possible if the planar PCBs are the only substances of interest in a given sample. Comparison of the levels of the planar PCBs obtained with or without HPLC separation did not differ significantly. The GC/MS parameters have earlier been described (2). Samples were analysed for PCB congeners 77, 126, 169 (non-ortho); 28, 31, 105, 118, 156, 167 (mono-ortho); 52, 101, 138, 149, 153, 180 (di-ortho).

Figure 1. Sampling sites along the Swedish coast in the Baltic.

1) Lule älv
2) Ume älv
3) Ångermanälven
4) Gåsholma
5) Dalälven
6) Hanöbukten
7) Gotland



Results and Discussion

A total of seventeen PCB congeners covering the most environmentally persistent and toxicologically significant congeners were analysed. The levels from the various sites are summarised in Table 1 and Figures 2 and 3. Inspection of the analytical data reveals a considerable degree of agreement with the results published previously (3) concerning the comparative levels between the various sites. The spreads and even the median obtained in sites 2, 3 and 4 (Fig. 2A) are quite similar. There was a maximum of concentrations at the intermediate sites (Fig. 2A). This cannot easily be explained by environmental differences, e.g. water temperatures. The migration patterns may, however, differ between the stocks. Salmon from the northern rivers in the Bothnian Bay migrate to a large extent to the central Baltic Proper for feeding, while the Bothnian Sea populations tend to spend more time closer to the spawning rivers. The linear relationship between PCB 153 and the sum of the seventeen congeners analysed (Fig. 2B) further strengthens the possibility to use PCB 153 as an indicator or marker for PCB monitoring programmes (4).

Table 1. Mean levels of PCBs in salmon (*Salmo salar*) from seven areas along the east coast of Sweden. Numbers (1-7) refer to the sites in Fig. 1.

PCB IUPAC number	Mean levels (ng/g fat) n = 8							TEF	Mean TEQ (pg/g fat)
	1	**2**	**3**	**4**	**5**	**6**	**7**		
Di-*ortho*									
52	34.9	55.3	55.7	73.0	44.3	31.4	31.0		
101	170	249	267	253	202	145	147		
110	130	186	194	206	146	102	104		
138	328	525	513	519	422	219	249		
149	217	319	371	314	271	154	167		
153	467	780	815	764	641	306	370		
158	31.6	44.6	48.8	48.4	38.7	17.5	23.8		
180	178	259	316	275	222	84.1	105	0.000 01	2.06
Mono-*ortho*									
28	7.24	6.34	11.6	12.8	11.2	8.49	8.13		
31	5.55	8.64	8.87	10.1	7.34	6.23	5.49		
105	50.8	76.0	82.4	82.6	66.1	45.3	50.3	0.000 1	6.48
118	162	233	249	240	199	134	142	0.000 1	19.4
156	22.4	31.5	38.1	34.1	28.4	15.4	18.0	0.000 5	13.4
167	11.1	77.4	112	83.5	69.2	34.6	38.2	0.000 01	0.61
Non-*ortho*									
77	0.92	1.35	2.57	1.49	1.71	0.87	1.11	0.000 5	0.72
126	0.31	1.93	4.01	2.37	2.53	0.28	1.34	0.1	182
169	0.18	0.23	0.53	0.19	0.24	0.20	0.14	0.01	2.44
ΣPCBs	**1817**	**2854**	**3090**	**2920**	**2373**	**1304**	**1462**		
ΣTEQ*	**65.9**	**243**	**460**	**292**	**298**	**56.4**	**165**		

* Values in pg/g fat

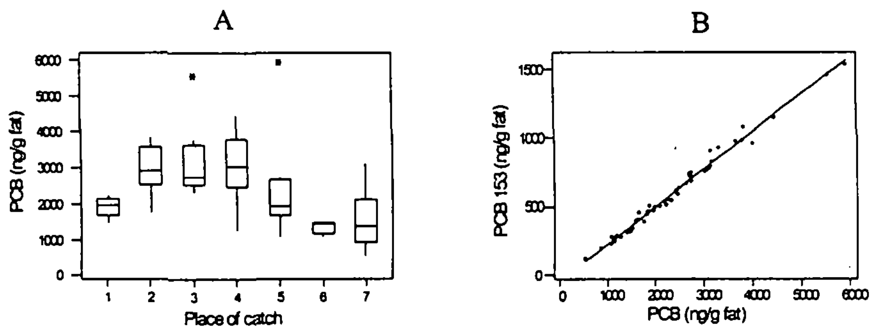


Figure 2. **(A)** A boxplot showing the median values and the corresponding first and third quartiles of ΣPCB (ng/g fat) in samples from different sites. **(B)** Correlation between the concentrations of PCB 153 and ΣPCB (r^2=0.988, n=56).

Fig. 3a indicates that while accumulation of PCBs may depend on the age or size of the fish species, other factors, particularly migration and variations in the intensity of pollution or length of time of exposure, can also influence the levels observed in the fish. This may explain the non-linear relationship between the PCB levels and the size of the fish samples from Gåsholma (site no 4 and Fig. 3a). The levels obtained at the west coast of Sweden (1992) and off Gotland in the central Baltic (1992, 1996; site no 7) are shown in Fig. 3b. A slight difference in levels (fat weight basis) is observed between years at the east coast but these levels still remain much higher than the values from the west coast. On fresh weight basis, however, the levels from 1992 were relatively higher than those from 1996 (not shown in the diagram), which could be explained by the high fat content (ca 23%) of the 1992 salmon compared to the 1996 salmon (ca 10%).

As for the non-ortho PCBs the TEQ values have followed essentially the same pattern distribution as the levels of the other PCB congeners, with the highest level found in site 3 followed by levels from sites 2, 4 and 5 (Table 1).

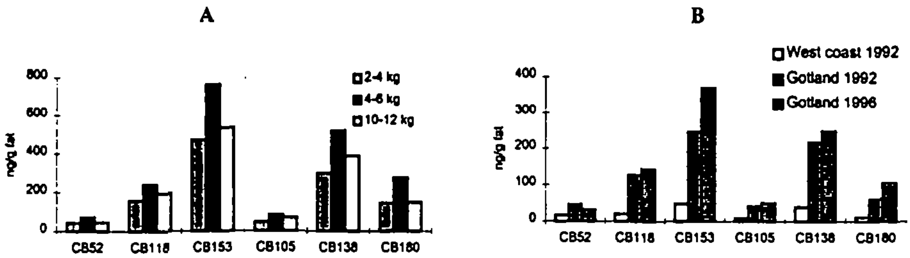


Figure 3. Mean levels (ng/g fat) of certain PCB congeners in (A) salmon of different sizes caught at site no 4 (Gåsholma) and (B) salmon samples from the west coast of Sweden (1992) and Gotland (1992 and 1996); for sample locations see Fig. 1.

References

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