Persistent Organochlorine Compounds in Arctic and Baltic Fish

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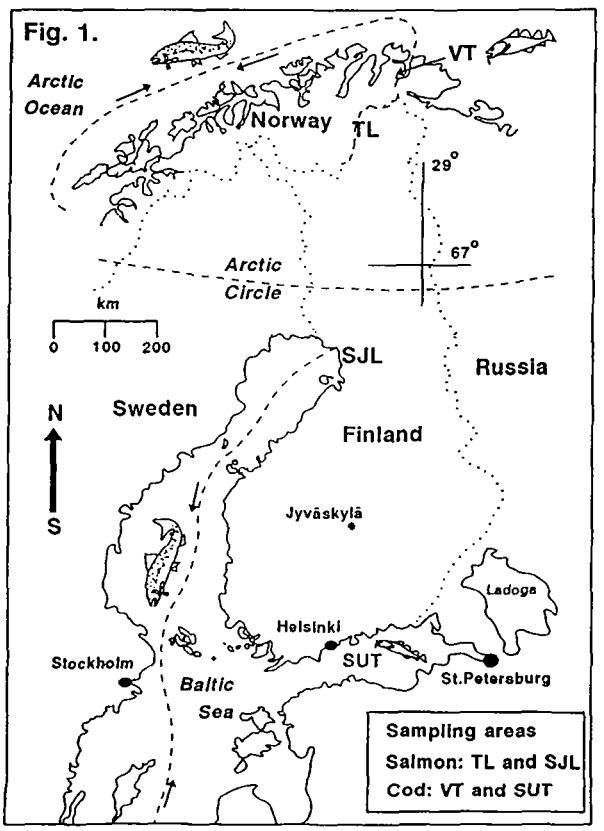
1. Introduction

Persistent Organochlorine Compounds (POCC's) have been analyzed by us since 1983 in fish (salmon and cod) from the Arctic coast of Scandinavia and in Baltic fish. In this study, the measured POCC levels in salmon and cod from areas shown in Fig. 1 are compared.



2. Materials and Methods

Salmon (*Salmo salar L.*) samples from Arctic were from Teno River (TL) sampled in 1988-90. Baltic salmons for comparison were mother salmons from Simo River (SJL) sampled in 1988-92. Broken lines in Fig. 1 show the main routes of salmons travelling during their feeding period in autumn, winter and spring. Arctic cod (*Cadus callarias*) liver samples were from Vestertana Fjord (VT) 1983-93 and the Baltic cod livers for comparison from the Gulf of Finland (SUT) 1988.

POCC's studied were toxaphene (PCC), lindane (γ-HCH) and its stable isomer α-HCH, hexachlorobenzene (HCBz), chlordane residues (SCHL = sum of stable congeners cis-, trans- and oxychlordane and trans-nonachlor), residues of DDT (SDDT = p,p'-DDT + p,p'-DDE + p,p'-DDD), PCB's including toxic congeners PCB 77, 105, 118, 126, 156 and 169, hexachloronaphthalenes (HxCN), and seventeen toxic PCDD's and PCDF's. Recently, also isomer-specific analyses of polychlorinated diphenyl ethers (PCDEs) were done in both Arctic and Baltic salmon[1]. Analytical procedures for these POCC's have been published earlier[1-6].

3. Results

The most abundant POCC's were chlorohydrocarbons (CHC's). Statistic of their contents in fresh eggs or muscles of salmons are presented in Table 1. Contents of CHC's in cod livers (lipid base) are presented in Table 2.

TABLE 1. Statistics of the contents ng/g fw in Arctic (TL) and in Baltic (SJL) salmons.

Area	Year		Lipid%	PCC	α-HCH	γ-HCH	HCBz	SCHL	SDDT	PCB
TL	89	x	9.91	88.8	0.8	0.8	3.8	8.8	18.7	27.7
Eggs		s	1.04	36.3	0.3	0.3	1.2	2.7	2.8	8.4
		N	6	6	6	6	6	6	6	6
TL	90	x	4.96	42.7	0.3	0.3	3.0	10.2	17.1	34.0
Muscles		s	2.16	28.5	0.2	0.2	1.3	4.5	8.4	15.3
		N	15	15	15	15	15	15	15	15
SJL	88-92	x	10.81	129.2	1.18	1.00	16.4	34.1	478.9	474.1
Muscles		s	6.00	81.4	0.98	0.78	7.83	17.0	299.2	241.1
		N	73	73	73	73	73	73	73	73

Time trends were analyzed from the CHC contents in lipid with linear regression. The only significant trend ($p < 0.01$) was obtained for p,p-DDT (but not for the DDT metabolites) in Arctic cod (VT; see Fig. 2). All other chlorohydrocarbon levels measured showed annual variations without any significant trend during the sampling period. Baltic/Arctic ratios of the contents were similar in salmon muscles and in cod livers: high for PCB and DDT residues but low for toxaphene (PCC) and HCH's and about one for HCBz and chlordanes (SCHL). Example of these ratios is illustrated in Fig. 3.

TABLE 2. Contents ng/g lw in cod liver (composites of five fish each) from Vestertana (VT) and from Gulf of Finland (SUT).

Area	Year	PCC	α-HCH	γ-HCH	HCBz	SCHL	SDDT	PCB
VT	1983				82	160	267	376
	1987				40	216	489	927
	1988				34	163	294	715
	1989	540			33	128	147	570
	1990		15	6	57	295	521	896
	1991		14	12	25	157	218	980
	1992		10	7	49	234	323	590
	1993		9	7	28	216	242	840
SUT	1988a		63	45	70	183	1681	6911
	1988b		40	28	51	153	1282	4284
Aver.1988 (SUT)		640	52	37	61	168	1482	5598

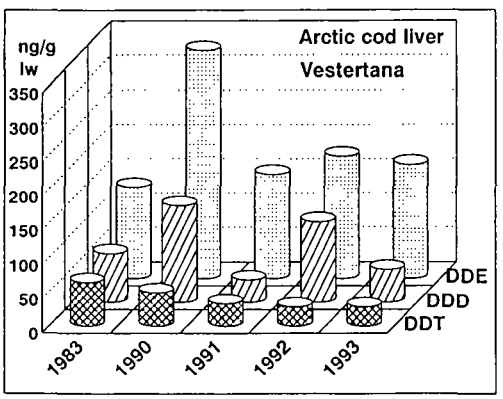


Fig. 2. Annual variation in the contents of DDT residues in Arctic (VT) cod liver composites (lipid basis).

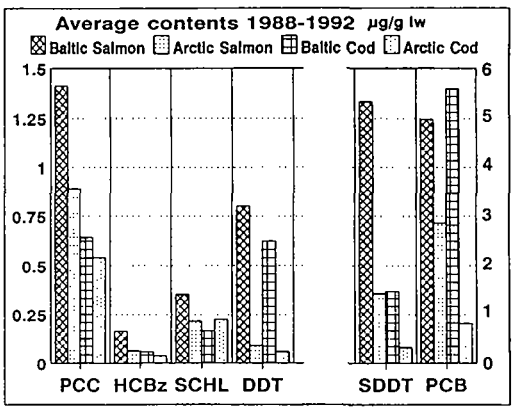


Fig. 3. Comparison of the average concentrations in fish lipid (see Baltic/Arctic ratios).

Contents of the dioxin-type toxic POCC's are collected in Tables 3 and 4. From toxic PCDD/Fs, 2,3,7,8-TeCDF was found in nearly all TL and SUT samples studied. The other congeners were in most Arctic samples non-detectable. Therefore, other toxic PCDD/F's analyzed in SJL and SUT samples were omitted from the present comparison. Five toxic PCB congeners and chloronaphthalenes (PCN's) were also measured. From the latter, hexachloronaphthalenes (HxCN) were included to the present comparison, because their dioxin-type of toxicity has been screened[7].

Relative toxic loads as TEQ's pg/g were calculated for average concentrations in salmon and cod lipids using TEF factors (see Table 3) suggested by Safe[8] and taking TEF 0.01 for HxCN's from the test data of Hanberg et al.[7]. The results are compared in Figures 4 and 5.

TABLE 3. Average contents pg/g fw of toxic POCC's in salmon muscles.

Area	Year	TeCDF	PCB77	PCB126	PCB105	PCB118	PCB169	HxCN
TL	1989	< 5	180	< 10	650		< 10	20
(Arctic)	1990	2.97	65.9	28.5	2400	4133	2.53	
SJL	1989	13.3	939	105	6413		32.5	199
(Baltic	1990	31.6	1140	555	32600	59100	20.5	376
TEF-factor[7,8)]		0.1	0.01	0.1	0.001	0.001	0.05	0.01

TABLE 4. Average contents pg/g lw of toxic POCC's in cod livers 1985-87.

Area		TeCDF	PCB77	PCB105	PCB126	PCB169	HxCN
VT	Arctic	26	1400	9500	310	60	170
SUT	Baltic	164	4600	34000	890	220	910

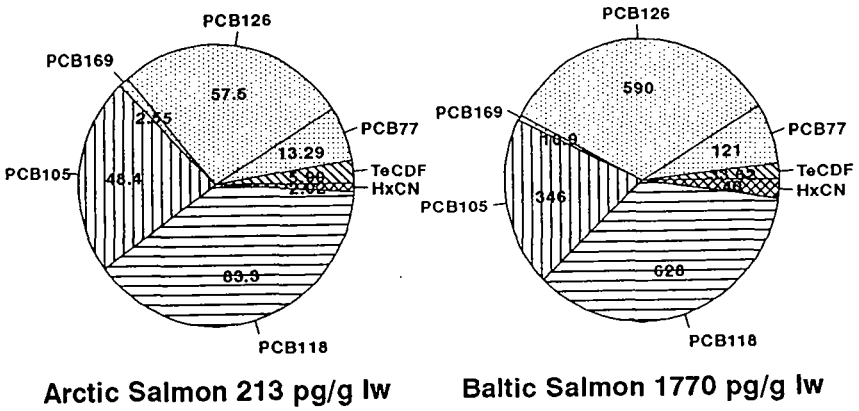


Fig. 4. Relative toxic loads (TEQ values) of POCC's in Arctic (TL) and Baltic (SJL) salmon.

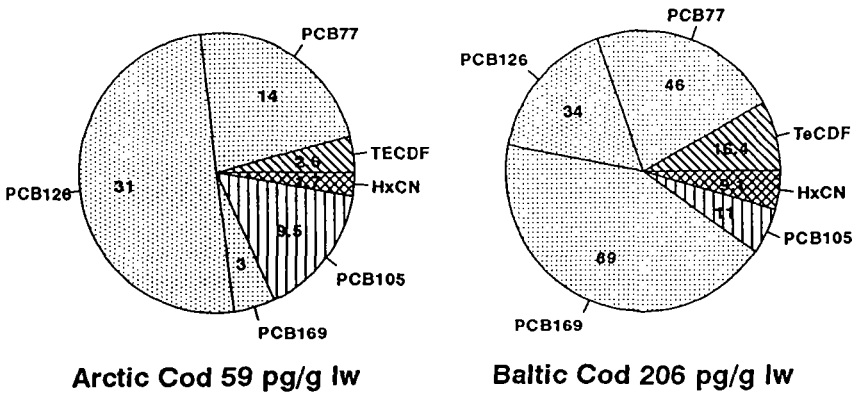


Fig. 5. Relative toxic loads (TEQ values) of POCC's in Arctic (VT) and Baltic (SUT) cod liver.

Some PCDE's were measured in in 1990 from Arctic (TL) and Baltic (SJL) salmon[1]. The results are shown in Fig. 6.

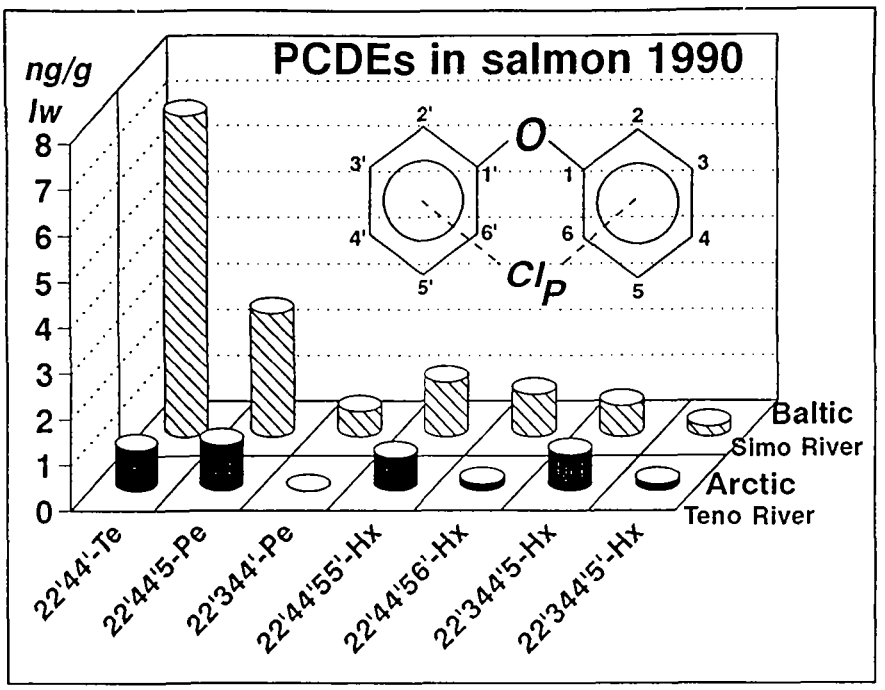


Fig. 6. Polychlorodiphenyl ethers in lipid of Arctic (TL) and Baltic (SJL) salmon muscles.

4. Discussion

The measured low concentration ratios Baltic/Arctic of PCC's, HCBz and chlordanes indicate that these rather volatile chlorohydrocarbons are dispersed in global long-range transport processes more rapidly than the other pollutants studied. This can be demonstrated by modeling.[9] Majority of the dioxin-type of toxic load from known substances in Arctic fish is due to PCB's.

Since 1990, Simojoki River Salmons (SJL) have suffered from increased mortality during the yolksac fry stage known as M74 syndrome, and the breeding loss did increase annually 1991-93. One hyphothesis to explain this syndrome is that the mother salmons collect POCC's while feeding in Southern Baltic Sea. Especially dioxin-type of toxicity could be factor in the M74. This has been demonstrated with 2,3,7,8-TeCDD[10]. In that sence the toxic POCC levels in SJL salmon could indicate danger to ecotoxic damage. While the levels in Arctic fish are order of magnitude lower, one could conclude that this risk is not very high for Arctic fish, thus far. However toxic PCDE's and other, still less known pollutants might contribute to possible increased risk in future. Consequently, more studies on POCC's and other contaminants in Arctic wildlife are urgently needed.

5. References

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