STUDY OF DIOXIN LEVELS IN FATTY FISH FROM SWEDEN 2001 – 2002 PART II

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Introduction

PCDD/DFs and PCBs are still an environmental problem in Sweden, although the use and production of PCBs have been banned for decades and the release of PCDD/DFs have decreased significantly. Because of this, the concentrations in food have declined since the 1970s. However, in fish from some parts of the Baltic Sea, the decline of PCDD/DFs appears to have ceased in the 1990s[1]. Thus, certain fatty fish species are suspected to contain levels of PCDD/DF that might exceed the maximum level for fish and fish products, 4 pg WHO-PCDD/DF-TEQ / g fresh weight, set by the European Council and into force from 1 July 2002[2]. Sweden and Finland currently have an exemption from the Council regulation that allows national marketing of fish that exceed the maximum level for PCDD/DF.

The Swedish National Food Administration (NFA) has undertaken a survey to analyse the concentrations of PCDD/DFs and dioxin like PCBs in fatty fish in the Baltic Sea area. This study reports the second part of the result from the PCDD/DF analyses. Most of the results are available on www.slv.se as interim reports.

Methods and materials

The study contains PCDD/DF results from analyses performed on salmon (*Salmo salar*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and whitefish (*Coregonus lavaretus*) from several locations in the Baltic Sea region as well as one location (herring) on Sweden's West Coast. For salmon and whitefish, analyses were carried out on muscle tissue and for herring and sprat, the muscle including fish skin was analysed (i.e. edible part). All fish were caught in 2001 and 2002. Analyses of salmon from Gotland were done on individual samples (n=10 and n=8 respectively) while analysis of the other samples were carried out on pooled samples (see Table for details). The

sampling design was intended to cover areas in Sweden were fatty fish are caught on commercial basis as well as in areas were the public perform sport fishing. From all individuals were taken equal amounts of tissue (in weight) from the area around the dorsal fin. The tissue was pooled and homogenised.

Extraction, clean-up and analysis were done according to validated methods at Environmental Chemistry, Umeå University, Sweden. The PCDD/DF are expressed in pg WHO-TEQ/g fresh weight according to the WHO TEFs for human risk assessment[3]. In calculating the WHO-TEQ values, the upper-bound level has been used for non-detects. The results presented refer to the 17 toxic PCDD/DF.

Results and Discussion

The results show (Table 1) that the concentration of PCDD/DF in ”all salmon” from the Baltic Sea region is positively correlated with age (Pearson correlation, $r=0.56$, $P<0.006$). For each year at sea, the concentration of PCDD/DF increase with 1.3 pg/g WHO-TEQ/g fresh weight (95% CI 0.4-2.2; $r^2=0.3$). The variation between different regions studied is relatively small, but significant (One-way ANOVA $P<0.01$). The age-adjusted means (General Linear Model) are for Bothnian Bay 5.4; Bothnian Sea 5.0 and Baltic Proper 3.6 pg WHO-TEQ/g fresh weight and the corresponding lipidweight-adjusted means are 5.5, 5.1 and 3.5, respectively. This indicates that the observed differences are not explained with age-or lipid weight differences in the analysed pooled samples, but can be due to environmental differences. Indeed, salmon in the Gulf of Bothnia are on their spawning migration and this may have contributed to an increased level of PCDD/DF. However, further statistical analysis of the data is needed to draw firm conclusions.

The herring result shows a bigger variation (see Table1). The concentration of PCDD/DF in “all herring” from the Baltic Sea region is positively correlated with age (Spearman correlation, $r=0.81$ $P<0.0001$). For each year, the concentration of PCDD/DF for “all herring” increase with 1.3 pg/g WHO-TEQ/g fresh weight (95% CI= 0.6-2.0; $r^2=0.3$). However, the differences between different herring stocks (i.e. Bothnian Bay, Bothnian Sea, Baltic Proper and W. Bornholm) of different ages and sizes are dramatic. The minimum value being 0.9 and the maximum as high as 23pg/g fw. Significant difference is revealed between “young” herring (3.5 – 5.5 years) from Bothnian Sea, Baltic Proper and West of Bornholm herring stocks (One-way ANOVA $P<0.05$) and also between “old” fish from the Bothnian Sea and Baltic Proper herring stocks (Mann Whitney U-test, $P<0.01$). The results indicate that the concentrations of PCDD/DF vary between different herring stocks in the Baltic Sea region. Earlier studies have also shown that PCDD/DF levels in fish from a single location can vary from year to year and season to season[4].

The notably and consistently low concentration found in the whitefish from the Gulf of Bothnia area illustrates well the large inter-species variation in the Baltic sea region. Further, in a partial least-square regression discriminant analysis (PLS-DA) sprat and herring from the same region of the Baltic proper showed significant different patterns regarding the PCDD/DF congeners.

The complexity regarding PCDD/DF levels in fish from the Baltic region is indeed plentiful, raising difficult questions to solve for European food and feed authorities and legislators.

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Table 1. The fish samples used in the analysis of WHO-TEQ PCDD/DFs from the Baltic Sea region. The "locations caught" are listed geographically from north to south for respective species. Italics represent previously reported data[5]. WC=West Coast; n.a. = not analysed; ind.=individuals

Species	Gender	Age* (years)	Mean weight (g)	Fat content (%)	Location caught	Year caught	No. of analyses (ind.)	PCDD/DF (pg/g fw)
Salmon	*female*	*1.8*	*6462*	*3.5*	*Bothnian Bay*[a]	*2001*	*1(5)*	*7.8*
Salmon	*male*	*1.2*	*3425*	*3.0*	*Bothnian Bay*[a]	*2001*	*1(5)*	*3.1*
Salmon	female	2.0	6907	6.09	*Bothnian Bay*[a]	2002	1(9)	4.9
Salmon	male	1.9	5796	7.21	*Bothnian Bay*[a]	2002	1(11)	5.2
Salmon	female	2.8	9558	7.31	*Bothnian Bay*[a]	2002	1(10)	5.9
Salmon	male	2.6	10450	7.62	*Bothnian Bay*[a]	2002	1(10)	5.6
Salmon	*female*	*1.4*	*4547*	*3.6*	*Bothnian Sea*[b]	*2001*	*1(5)*	*5.3*
Salmon	*male*	*1.8*	*6039*	*2.6*	*Bothnian Sea*[b]	*2001*	*1(5)*	*4.8*
Salmon	*female*	*1.2*	*3800*	*3.8*	*Bothnian Sea*[c]	*2001*	*1(5)*	*3.9*
Salmon	*female*	*1.6*	*4760*	*4.0*	*Bothnian Sea*[c]	*2001*	*1(5)*	*3.7*
Salmon	mixed	2.0	5278	8.09	*Bothnian Sea*[c]	2002	1(9)	4.9
Salmon	mixed	1.4	5176	8.17	*Bothnian Sea*[c]	2002	1(10)	5.7
Salmon	mixed	2.9	10804	6.96	*Bothnian Sea*[c]	2002	1(7)	5.8
Salmon	mixed	2.8	10583	7.29	*Bothnian Sea*[c]	2002	1(6)	5.7
Salmon	*male*	*1.0*	*3855*	*8.7*	*Baltic Proper*[d]	*2000*	*5(5)*	*3.2*
Salmon	*female*	*1.0*	*4367*	*8.7*	*Baltic Proper*[d]	*2000*	*5(5)*	*2.6*
Salmon	*female*	*1.0*	*3950*	*9.9*	*Baltic Proper*[d]	*2000*	*1(5)*	*3.1*
Salmon	mixed	1.9	2525	4.77	*Baltic Proper*[e]	2002	1(8)	2.3
Salmon	mixed	1.9	4010	6.08	*Baltic Proper*[e]	2002	1(10)	3.0
Salmon	mixed	2.0	3930	6.01	*Baltic Proper*[e]	2002	1(10)	3.0
Salmon	mixed	2.0	6389	9.03	*Baltic Proper*[e]	2002	1(9)	4.8
Salmon	mixed	2.0	6456	9.60	*Baltic Proper*[e]	2002	1(9)	5.1
Salmon	mixed	2.5	10083	9.28	*Baltic Proper*[e]	2002	1(6)	5.4
Salmon	*female*	*2.2*	*7417*	*2.8*	*Baltic Proper*[f]	*2001*	*1(5)*	*3.7*
Salmon	*male*	*2.0*	*7986*	*3.2*	*Baltic Proper*[f]	*2001*	*1(5)*	*3.8*
Herring	female	2.5(2-3)	23.9	5.6	Bothnian Bay[1]	2001	1(14)	1.1
Herring	male	2.5(2-3)	25.2	6.1	Bothnian Bay[1]	2001	1(14)	1.4
Herring	mixed	5.0(4-6)	31.6	5.1	Bothnian Bay[1]	2001	1(6)	3.8
Herring	mixed	1.0(1)	18.4	6.9	Bothnian Bay[1]	2001	1(7)	0.86
Herring	female	2.5(2-3)	25.5	5.1	Bothnian Sea[2]	2001	1(15)	2.0
Herring	male	2.5(2-3)	27.4	5.0	Bothnian Sea[2]	2001	1(15)	2.5
Herring	female	4.5(4-5)	34.8	4.1	Bothnian Sea[2]	2001	1(10)	3.5
Herring	male	4.5(4-5)	33.2	6.2	Bothnian Sea[2]	2001	1(10)	3.8
Herring	female	5.0(4-6)	62.0	11.4	Bothnian Sea[3]	2001	1(9)	10
Herring	male	5.0(4-6)	54.7	11.0	Bothnian Sea[3]	2001	1(6)	10
Herring	female	8.0(7-9)	98.0	15.0	Bothnian Sea[3]	2001	1(9)	17
Herring	male	8.0(7-9)	98.3	15.8	Bothnian Sea[3]	2001	1(6)	20
Herring	female	5.5(5-6)	85.5	11.3	Bothnian Sea[4]	2001	1(8)	19
Herring	male	5.5(5-6)	92.3	14.5	Bothnian Sea[4]	2001	1(10)	21
Herring	female	8.0(7-9)	86.8	11.8	Bothnian Sea[4]	2001	1(9)	17
Herring	male	8.0(7-9)	93.3	13.9	Bothnian Sea[4]	2001	1(9)	23
Herring	*male*	*5(4-6)*	*39.6*	*9.4*	*Baltic Proper*[5]	*2000*	*1(9)*	*6.8*
Herring	*female*	*5(4-6)*	*39.7*	*7.9*	*Baltic Proper*[5]	*2000*	*1(9)*	*4.6*
Herring	*male*	*7.9(7-9)*	*114.4*	*11.3*	*Baltic Proper*[5]	*2000*	*1(8)*	*6.7*

Herring	*female*	*7.8(7-9)*	*85.9*	*10.5*	*Baltic Proper[5]*	*2000*	*1(6)*	*5.3*
Herring	*male*	*5(4-6)*	*32.4*	*9.4*	*Baltic Proper[6]*	*2000*	*1(9)*	*4.7*
Herring	*female*	*5(4-6)*	*33.3*	*8.5*	*Baltic Proper[6]*	*2000*	*1(9)*	*4.5*
Herring	*male*	*7.9(7-9)*	*111.3*	*13.7*	*Baltic Proper[6]*	*2000*	*1(8)*	*9.9*
Herring	*female*	*7.9(7-9)*	*118.8*	*15.8*	*Baltic Proper[6]*	*2000*	*1(8)*	*10*
Herring	*male*	*12.2(12-13)*	*234.2*	*11.4*	*Baltic Proper[6]*	*2000*	*1(4)*	*11*
Herring	*female*	*12.2(12-13)*	*174.7*	*11.0*	*Baltic Proper[6]*	*2000*	*1(4)*	*7.2*
Herring	*male*	*5(4-6)*	*41.3*	*4.2*	*Baltic Proper[7]*	*2000*	*1(9)*	*1.7*
Herring	*female*	*5(4-6)*	*40.7*	*5.6*	*Baltic Proper[7]*	*2000*	*1(9)*	*1.9*
Herring	*male*	*7.3(7-9)*	*89.15*	*6.8*	*Baltic Proper[7]*	*2000*	*1(6)*	*2.9*
Herring	*female*	*7.6(7-9)*	*97.7*	*6.1*	*Baltic Proper[7]*	*2000*	*1(5)*	*2.6*
Herring	female	3.5(3-4)	87.9	10.2	W.Bornholm	2002	1(10)	1.9
Herring	male	3.5(3-4)	102.8	11.8	W.Bornholm	2002	1(10)	2.0
Herring	mixed	3.7(2-5)	90.3	10.4	W.Bornholm	2002	1(15)	5.1
Herring	mixed	3.1(2-5)	74.2	10.1	W.Bornholm	2002	1(15)	4.6
Herring	mixed	3.6(2-7)	62.7	3.9	W.Bornholm	2002	1(17)	3.0
Herring	mixed	2.4(1-5)	59.2	7.0	W.Bornholm	2002	1(18)	1.6
Herring	mixed	2.4(1-4)	54.2	2.4	W.Bornholm	2002	1(20)	1.5
Herring	mixed	2.8(2-4)	69.9	2.2	W.Bornholm	2002	1(15)	1.6
Herring	mixed	n.a.	49.6	7.2	W.Bornholm	2002	1(36)	1.8
Herring	mixed	n.a.	48.7	7.4	W.Bornholm	2002	1(30)	1.6
Herring	*male*	*3.2(3-4)*	*52.6*	*7.0*	*Fladen (WC)*	*2000*	*1(4)*	*0.95*
Herring	*female*	*3.5(3-4)*	*62.5*	*8.2*	*Fladen (WC)*	*2000*	*1(4)*	*0.99*
Sprat	mixed	n.a.	9.3	13.0	Baltic Proper[8]	2002	1(106)	3.5
Sprat	mixed	n.a.	9.6	10.6	Baltic Proper[8]	2002	1(105)	3.4
Sprat	mixed	n.a.	9.7	11.2	Baltic Proper[8]	2002	1(96)	3.8
Sprat	mixed	n.a.	9.4	11.2	Baltic Proper[8]	2002	1(104)	3.3
Sprat	mixed	n.a.	9.1	7.1	Baltic Proper[8]	2002	1(100)	3.1
Sprat	mixed	n.a.	8.9	7.9	Baltic Proper[8]	2002	1(102)	2.8
Sprat	mixed	5.0(2-8)	9.3	9.7	W.Bornholm	2002	1(22)	3.6
Sprat	mixed	2.5(2-3)	18.2	10.8	W.Bornholm	2002	1(16)	2.4
Sprat	mixed	4.9(4-7)	21.4	8.3	W.Bornholm	2002	1(14)	2.7
Whitefish	female	4.5(3-7)	509	1.6	Bothnian Bay[9]	2001	1(5)	1.1
Whitefish	male	5.2(4-6)	409	1.3	Bothnian Bay[9]	2001	1(5)	0.7
Whitefish	female	4.9(3-6)	379	1.0	Bothnian Sea[b]	2001	1(7)	1.9
Whitefish	male	4.5(3-6)	278	0.9	Bothnian Sea[b]	2001	1(10)	1.7
Whitefish	female	4.3(3-6)	358	1.0	Botnian Sea[10]	2001	1(10)	0.8
Whitefish	male	4.3(3-6)	314	1.2	Botnian Sea[10]	2001	1(7)	1.0

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[1]Piteå archipelago; [2]Omnefjärden; [3]Bålsön; [4]Västra Banken; [5] Landsort; [6]SE Gotland; [7]Utlängan; [8]Area West of Gotland and North of Öland; [9]Luleå archipelago; [10] Öregrunds-grepen;
* Number of years in the sea (after two-three years in the river)

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