7. Atmospheric Supply of PCDD/Fs to the Baltic Sea in 2007

In this chapter the results of model evaluation of dioxins and furans (PCDD/Fs) atmospheric input to the Baltic Sea and its sub-basins for 2007 is presented. Modelling of PCDD/F atmospheric transport and deposition was carried out using MSC-E Eulerian Persistent Organic Pollutant transport model MSCE-POP (*Gusev et al.*, 2005). Latest available official information on PCDD/F emission from HELCOM countries and other European countries was used in computations. Based on these data annual and monthly levels of PCDD/F deposition to the Baltic Sea region have been obtained and contributions of HELCOM countries emission sources to the deposition over the Baltic Sea are estimated.

7.1 PCDD/Fs emissions

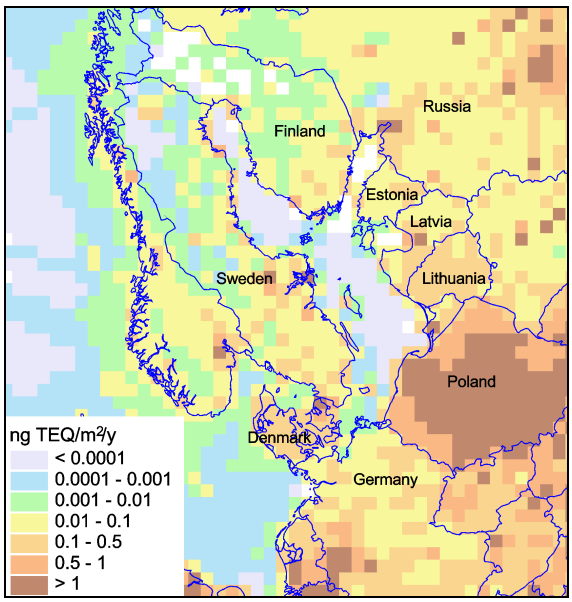


Figure 7.1. Annual total anthropogenic emissions of PCDD/F in the Baltic Sea region for 2007, ng TEQ/m^2/y.

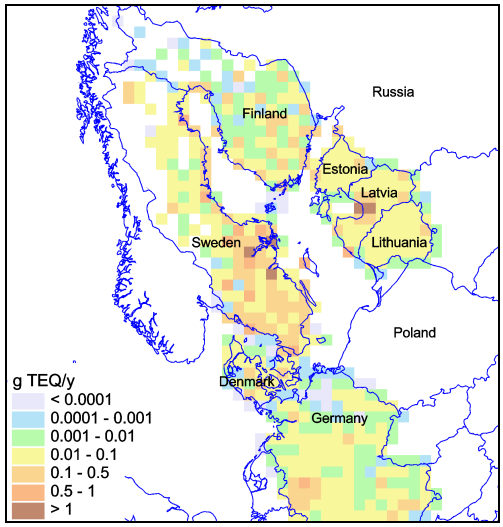


Figure 7.2. Annual PCDD/F emission of HELCOM countries from Combustion in Power Plants and Industry sector for 2007, g TEQ/y.

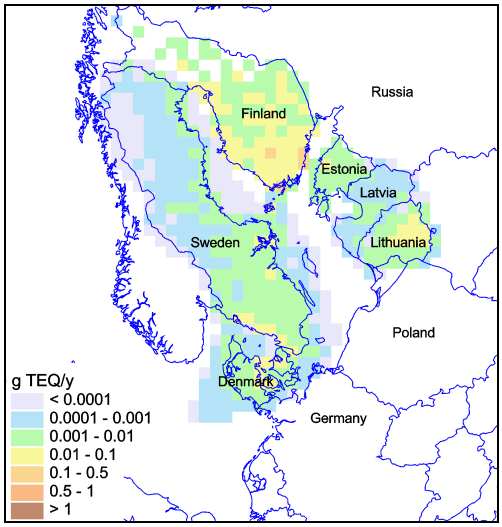


Figure 7.3. Annual PCDD/F emission of HELCOM countries from Transport sources below 1000 m sector for 2007, g TEQ/y.

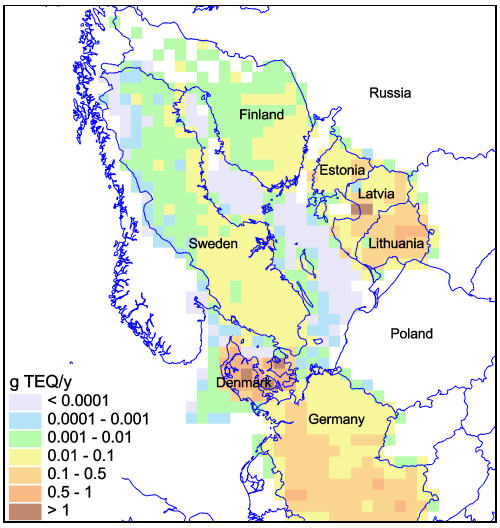


Figure 7.4. Annual PCDD/F emission of HELCOM countries from Commercial, Residential and Other Stationary Combustion sector for 2007, g TEQ/y.

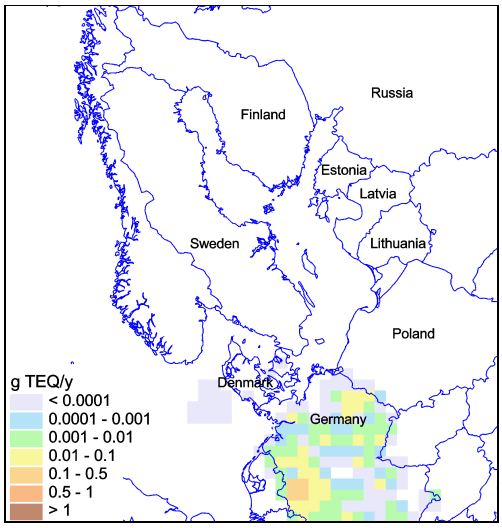


Figure 7.5. Annual PCDD/F emission of HELCOM countries from Fugitive Emissions From Fuels sector for 2007, g TEQ/y.

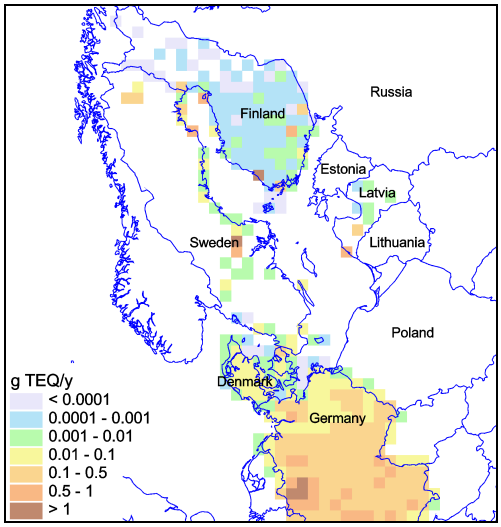


Figure 7.6. Annual PCDD/F emission of HELCOM countries from Industrial Processes sector for 2007, g TEQ/y.

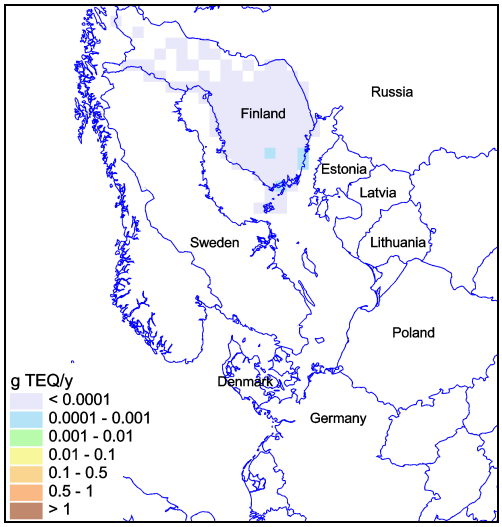


Figure 7.7. Annual PCDD/F emission of HELCOM countries from Solvent and Other Product Use sector for 2007, g TEQ/y.

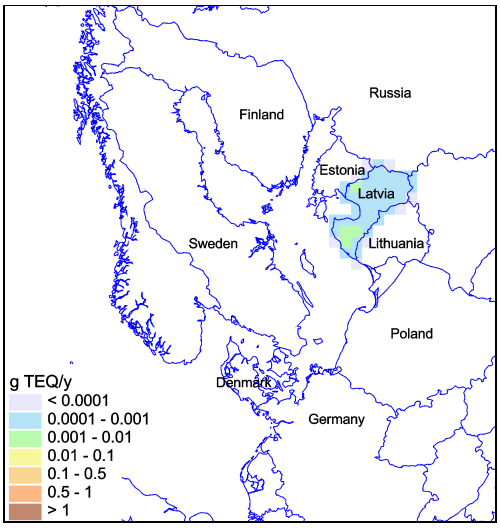


Figure 7.8. Annual PCDD/F emission of HELCOM countries from Agriculture sector for 2007, g TEQ/y.

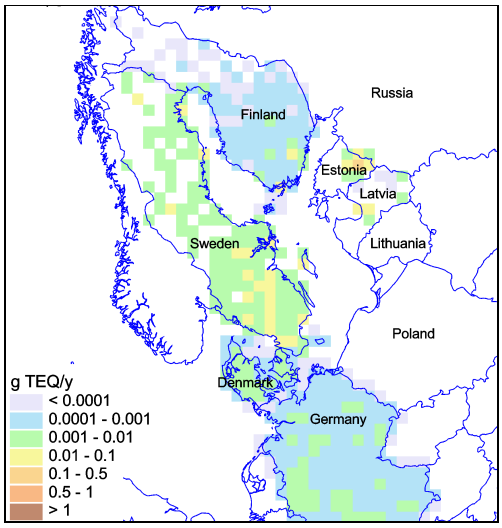


Figure 7.9. Annual PCDD/F emission of HELCOM countries from Waste sector for 2007, g TEQ/y.

Table 7.1. Annual total PCDD/F anthropogenic emissions of HELCOM countries from different sectors for 2007, in g TEQ/year

NFR emission sector	Sector name	DK	EE	FI	DE	LV	LT	PL	RU	SE
1	Combustion in Power Plants and Industry	1.5	2.8	4.8	7.1	5.35	1.5	50.6	808	26.9
2	Transport	0.2	0.05	2.8	3.16	0.02	0.3	0.7		0.6
3	Commercial, Residential and Other Stationary Combustion	20	1.6	1.1	21.04	6.7	9.1	188.4		4.01
4	Fugitive Emissions From Fuels	< 0.001	NA	0	1.72			3.1		0.19
5	Industrial Processes	6.1	0	3.0	50.206	1.2		15.5		3.8
6	Solvent and Other Product Use	0	0	0.002	NA			NA		NA
7	Agriculture	0		0	NA	0.02		0.3		NA
8	Waste	0.04	0.3	0.1	0.13	0.07		183.01		1
9	Other				NA					
Total		**27.8**	**4.8**	**11.8**	**83.4**	**13.3**	**10.9**	**441.6**	**808**	**36.5**

NA □not available
NO □not observed

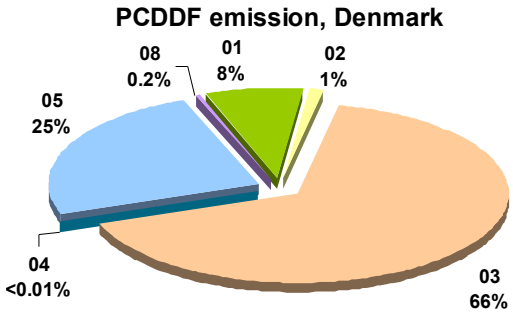


Figure 7.10. Contributions of different sector to total annual PCDD/F emission of Denmark in 2007

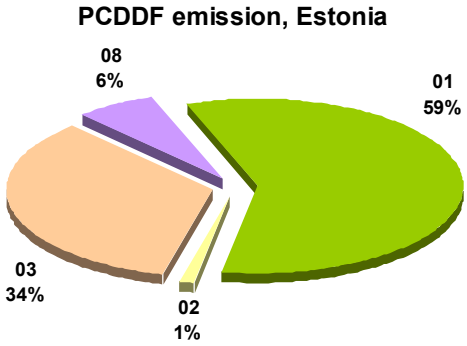


Figure 7.11. Contributions of different sector to total annual PCDD/F emission of Estonia in 2007

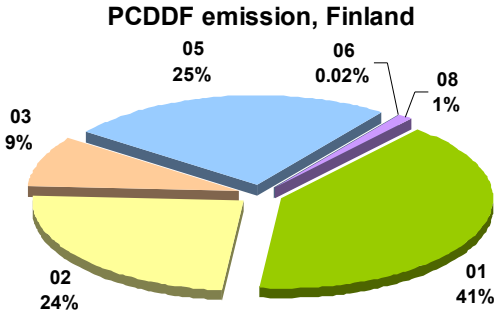


Figure 7.12. Contributions of different sector to total annual PCDD/F emission of Finland in 2007

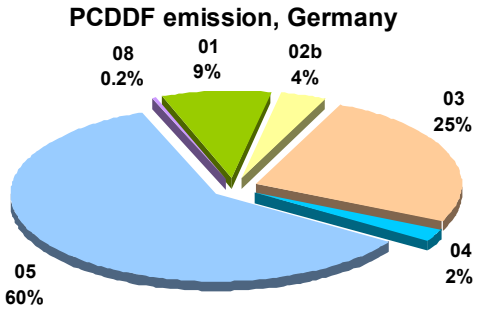


Figure 7.13. Contributions of different sector to total annual PCDD/F emission of Germany in 2007

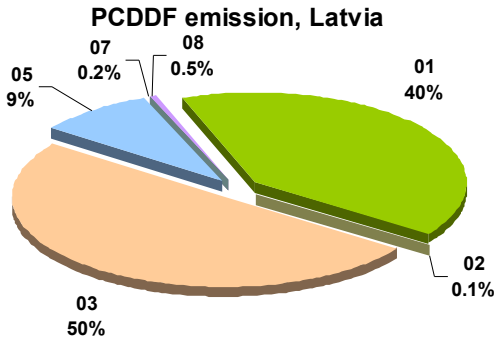


Figure 7.14. Contributions of different sector to total annual PCDD/F emission of Latvia in 2007

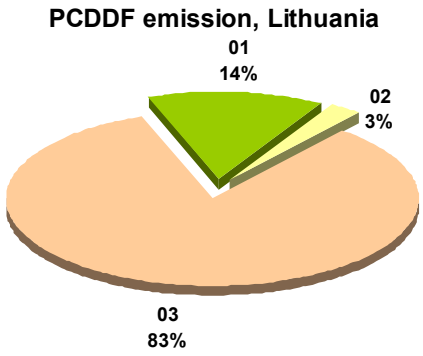


Figure 7.15. Contributions of different sector to total annual PCDD/F emission of Lithuania in 2007

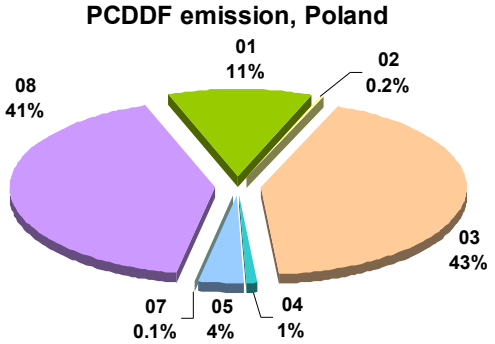


Figure 7.16. Contributions of different sector to total annual PCDD/F emission of Poland in 2007

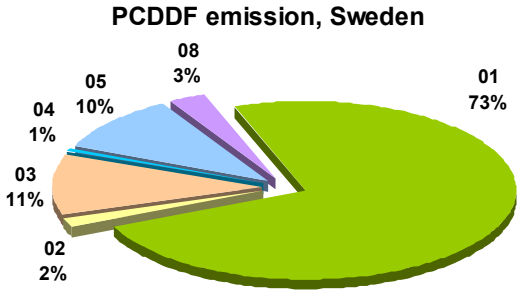
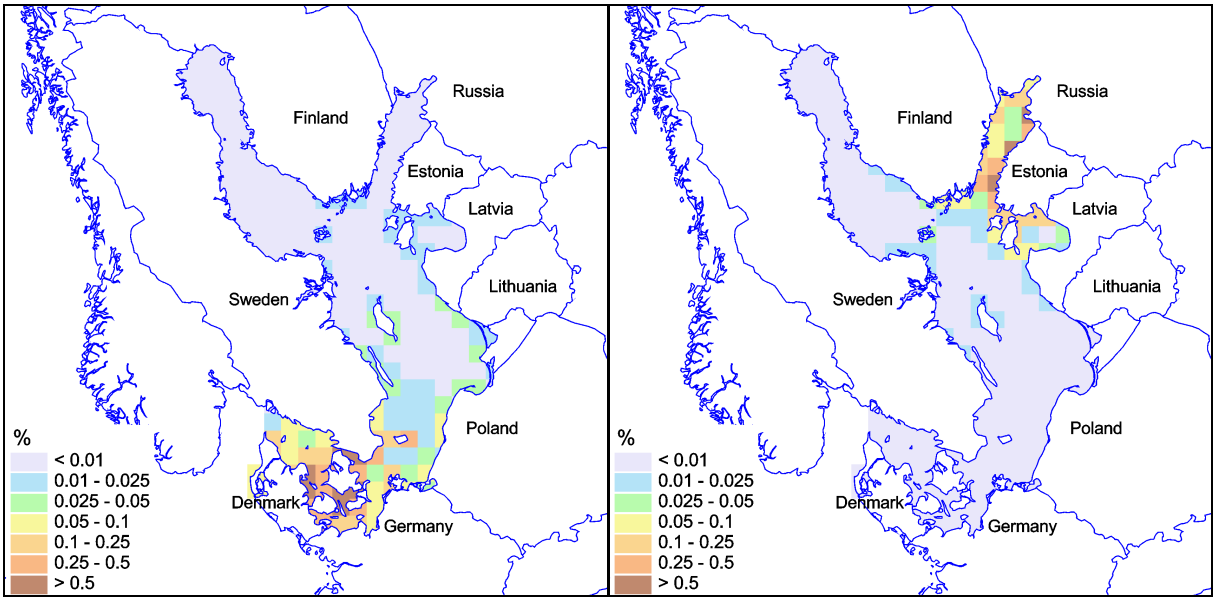
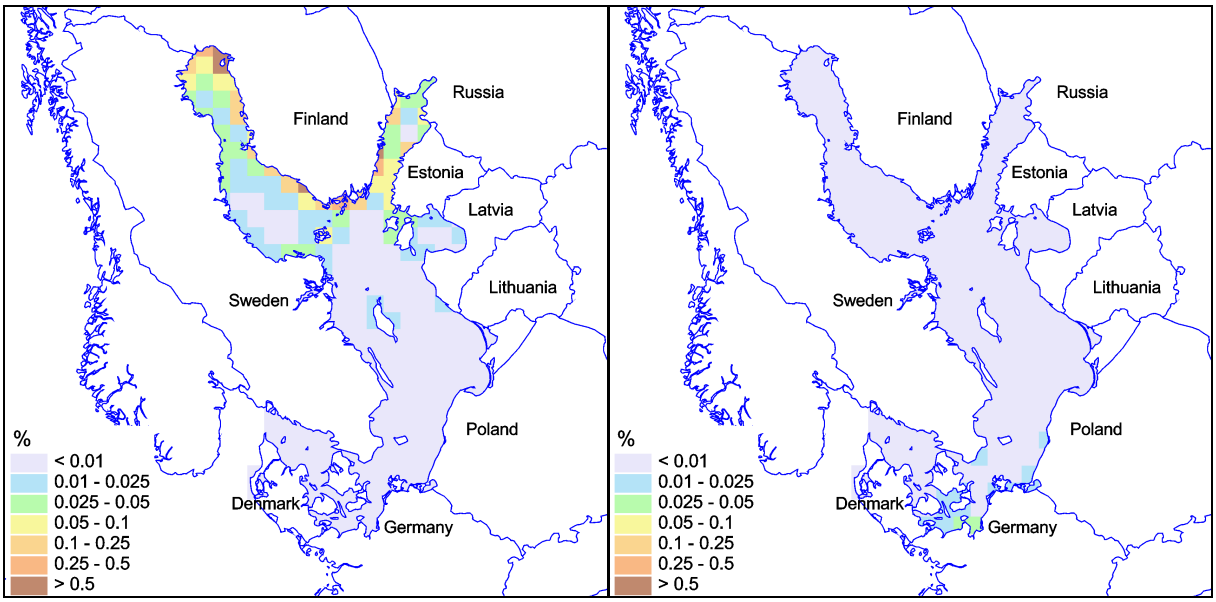


Figure 7.17. Contributions of different sector to total annual PCDD/F emission of Sweden in 2007

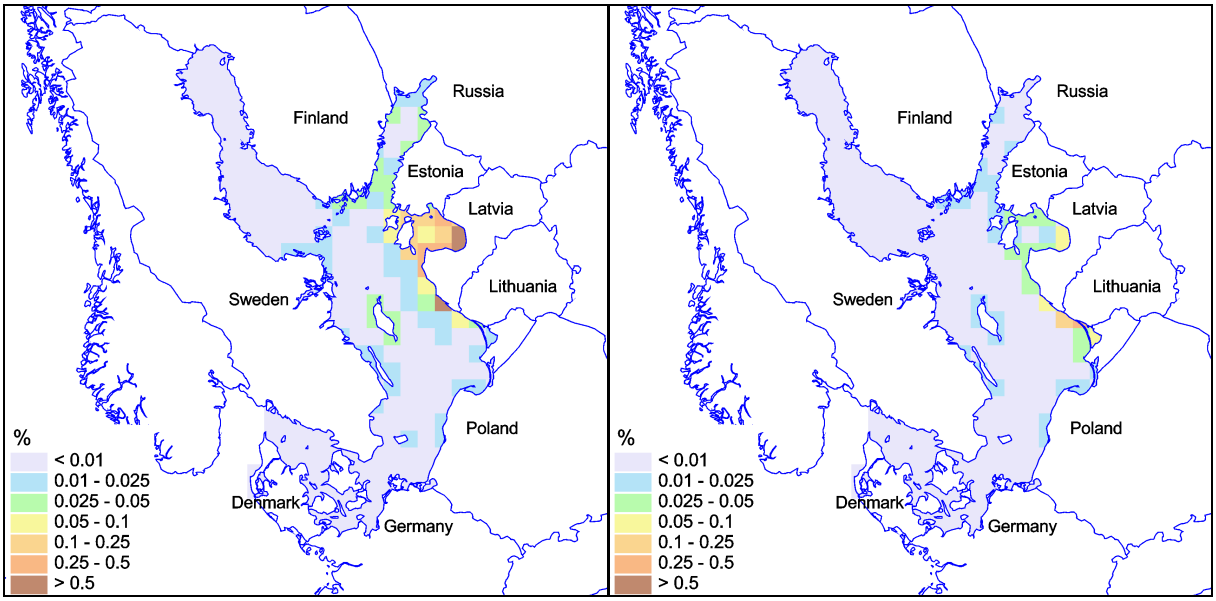


Denmark Estonia

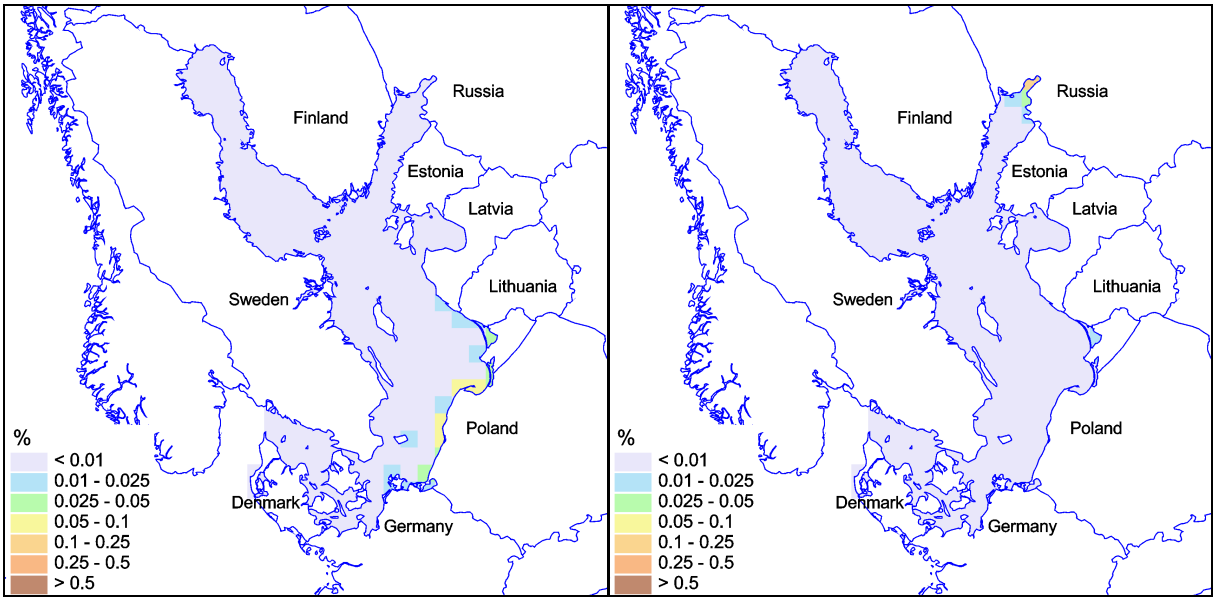


Finland Germany

Figure 7.18. Maps with the contributions of annual total anthropogenic PCDD/F emissions from HELCOM Parties to total PCDD/F deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).

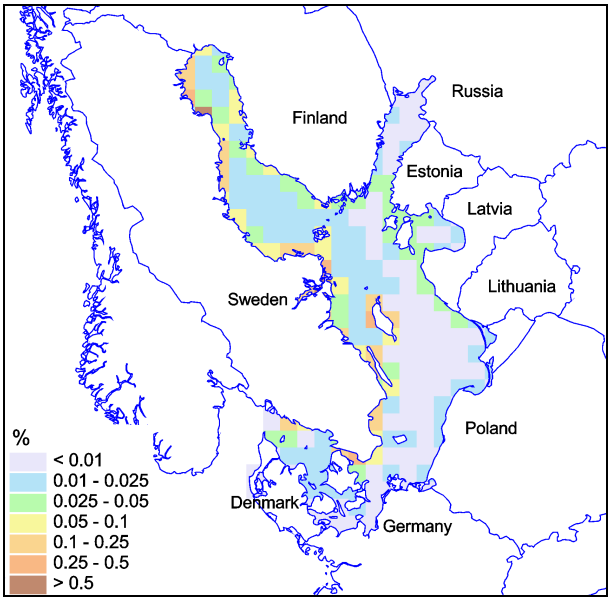


Latvia Lithuania



Poland Russia

Figure 7.18. (cont.) Maps with the contributions of annual total anthropogenic PCDD/F emissions from HELCOM Parties to total PCDD/F deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).



Sweden

Figure 7.18. (cont.) Maps with the contributions of annual total anthropogenic PCDD/F emissions from HELCOM Parties to total PCDD/F deposition over the Baltic Sea in 2007 (fraction of total deposition in % over the 50x50 km grid cell).

Table 7.2. Annual total anthropogenic emissions of PCDD/Fs of HELCOM countries and other EMEP countries in period 1990-2007, g TEQ/year (Unofficial emissions are shaded).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	67	64	59	54	51	49	47	44	37	31	32	30	27	29	24	25	26	28
Estonia	6	5	4	4	4	5	5	5	4	3	3	3	4	4	4	3	3	5
Finland	36	35	33	35	41	41	40	39	40	41	32	31	32	32	32	26	14	12
Germany	114	105	86	82	80	89	85	89	83	80	82	81	80	80	82	80	82	83
Latvia	7	8	7	8	9	10	11	12	11	12	10	11	11	12	13	13	14	13
Lithuania	20	18	16	14	12	10	8	6	6	5	4	13	12	12	11	11	11	11
Poland	529	535	517	592	520	515	484	440	381	381	333	447	433	482	387	416	449	442
Russia	991	947	901	878	825	769	637	614	606	625	631	643	655	686	716	747	778	808
Sweden	60	56	50	47	44	40	38	37	35	34	33	34	34	33	36	39	38	36
HELCOM	**1829**	**1773**	**1673**	**1713**	**1585**	**1527**	**1355**	**1284**	**1203**	**1212**	**1162**	**1293**	**1288**	**1371**	**1305**	**1361**	**1414**	**1438**
Albania	43	43	43	43	43	43	43	43	43	43	43	43	44	44	44	44	44	44
Armenia	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	48
Austria	160	135	77	67	56	58	60	59	56	54	52	57	48	51	52	53	53	48
Azerbaijan	98	98	98	98	98	98	98	98	98	98	98	99	100	101	102	102	103	104
Belarus	16	16	16	16	16	16	16	16	16	15	18	23	25	26	25	24	27	27
Belgium	592	552	520	455	481	445	359	374	245	135	116	80	58	60	62	61	57	58
Bosnia and Herzegovina	67	67	67	67	67	67	67	67	67	67	67	65	63	61	59	57	56	54
Bulgaria	554	535	515	495	476	456	341	310	288	245	233	201	219	255	239	230	247	58
Croatia	160	150	139	129	118	108	97	95	111	98	109	76	75	97	93	91	93	79
Cyprus	8	7	8	8	8	8	7	7	8	7	7	7	7	6	6	6	6	3
Czech Republic	1252	1220	1220	1140	1135	1135	922	830	767	643	744	620	177	114	187	179	175	148
France	1763	1814	1836	1893	1893	1694	1478	1043	938	611	520	384	357	235	315	194	121	117
Georgia	122	122	122	122	122	122	122	122	122	122	122	122	111	98	85	85	85	85
Greece	279	279	279	279	279	279	279	279	279	279	279	255	231	207	183	159	135	111
Hungary	196	175	132	129	124	116	113	109	98	99	97	98	98	99	97	95	92	85
Iceland	9	9	9	8	7	6	5	5	4	3	3	3	3	2	1	1	1	1
Ireland	27	27	26	26	25	25	25	24	21	21	22	22	30	34	26	22	22	15
Italy	472	495	475	451	441	460	419	426	413	388	369	293	283	282	289	294	302	318
Kazakhstan	40	40	40	40	40	40	40	40	40	40	40	40	41	41	41	42	42	42
Luxembourg	45	40	34	29	23	24	16	16	8	7	5	4	3	2	2	2	2	2
Malta	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Monaco	2	2	3	3	3	3	3	4	4	4	4	4	4	3	3	3	2	3
Netherlands	742	548	427	306	185	66	54	50	43	33	31	30	29	26	28	36	26	25
Norway	129	97	95	95	93	70	49	40	34	38	34	33	32	29	32	24	24	23
Portugal	18	18	18	18	18	18	19	21	18	17	15	11	11	11	10	9	9	9
Republic of Moldova	14	11	7	6	5	3	3	3	6	2	2	2	3	4	5	5	6	6
Romania	1537	1444	1352	1260	1168	1075	983	891	799	706	614	522	430	338	245	297	268	216
Serbia and Montenegro	172	172	172	172	172	172	172	172	172	172	172	170	169	167	166	164	162	161
Slovakia	136	132	128	124	120	116	106	96	109	98	90	87	91	70	65	86	67	66
Slovenia	16	17	15	14	13	12	12	12	11	11	11	10	10	10	9	9	8	8
Spain	181	187	195	192	186	161	160	133	134	140	147	141	142	147	150	149	157	160
Switzerland	175	159	148	135	122	105	96	88	81	63	54	42	29	17	16	16	16	15
The FYR of Macedonia	166	166	166	166	166	166	166	166	166	166	166	166	166	163	163	163	163	163
Turkey	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1018	1024	1029	1035	1041	1047	1053
Ukraine	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1024	1026	1027	1029	1030	1032	1033
United Kingdom	1143	1121	1093	886	686	733	470	374	280	254	226	216	199	197	227	198	197	190
EMEP, kg TEQ/ year	**14**	**14**	**13**	**13**	**12**	**12**	**10**	**9.4**	**8.8**	**8.0**	**7.8**	**7.3**	**6.7**	**6.5**	**6.4**	**6.4**	**6.3**	**6.0**

Expert estimates:

§ *Denier van der Gon, H.A.C., M. van het Bolscher A.J.H. Visschedijk P.Y.J. Zandveld [2006]*

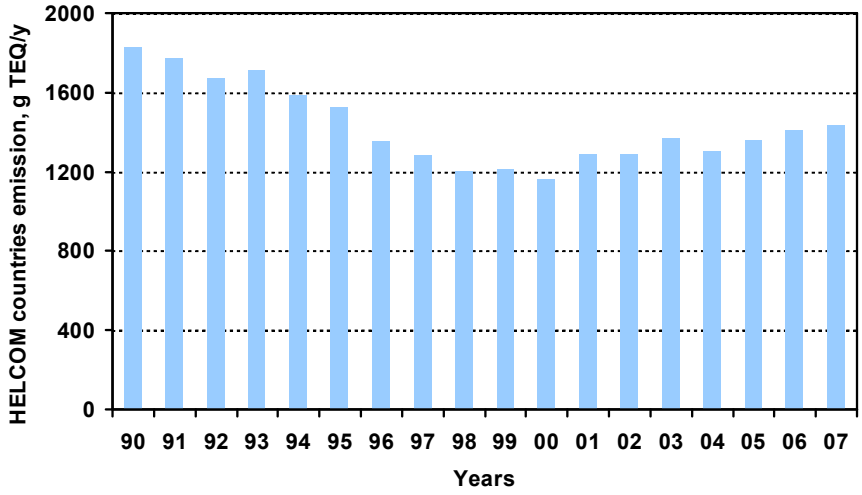


Figure 7.19. Time-series of total annual PCDD/F emissions of HELCOM countries in 1990-2007, g TEQ/year.

7.2 Annual total deposition of PCDD/F

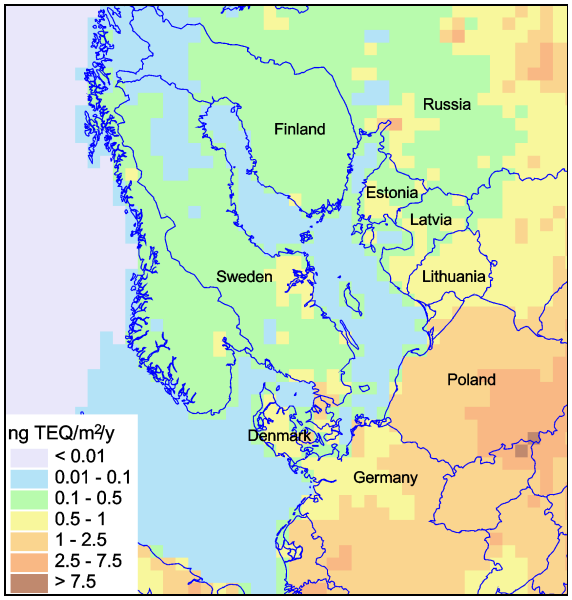


Figure 7.20. Annual total deposition fluxes of PCDD/Fs over the Baltic Sea region for 2007, ng TEQ/m^2/year.

7.3 Monthly total deposition of PCDD/F

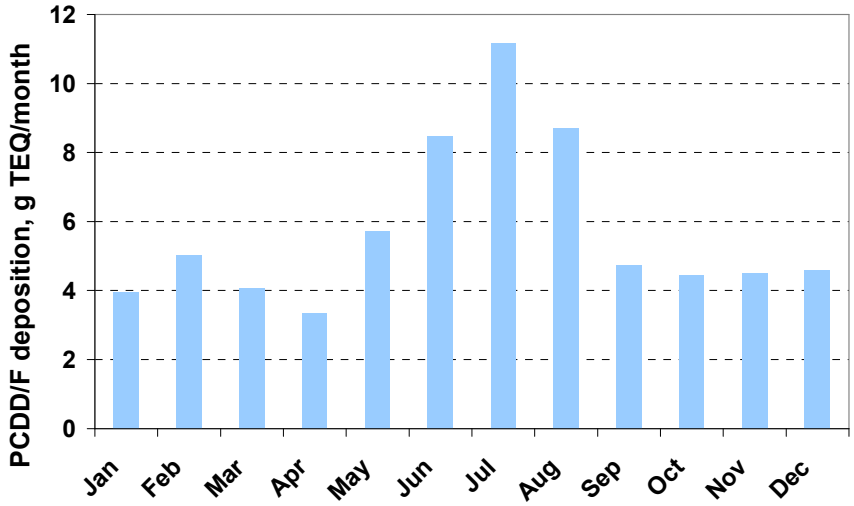


Figure 7.21. Monthly total deposition of PCDD/Fs over the Baltic Sea for 2007, g TEQ/month.

Table 7.3. Monthly total deposition of PCDD/Fs over the Baltic Sea for 2007, g TEQ/month.

Month	PCDD/Fs
Jan	3.19
Feb	4.05
Mar	3.29
Apr	2.71
May	4.62
Jun	6.83
Jul	9.00
Aug	7.02
Sep	3.81
Oct	3.58
Nov	3.63
Dec	3.71

7.4 Source allocation of PCDD/F deposition

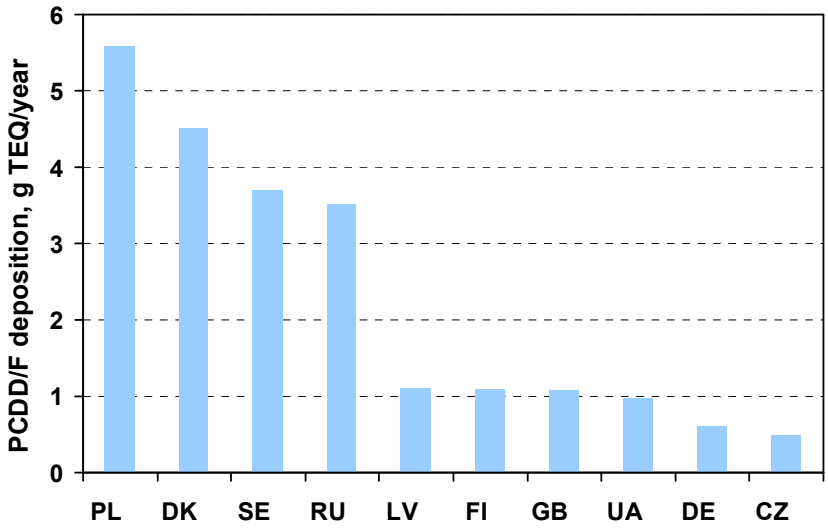


Figure 7.22. Top ten countries with the highest contribution to annual total deposition of PCDD/Fs over the Baltic Sea for 2007, g TEQ/y.

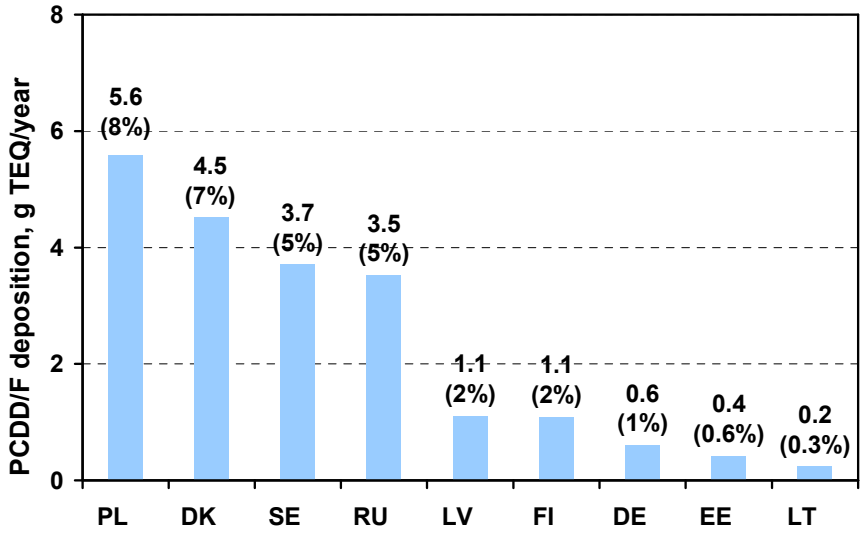


Figure 7.23. Contributions (in %) of HELCOM countries to annual total PCDD/F deposition to the Baltic Sea for 2007. HELCOM countries emissions of PCDD/Fs contributed 30% to total PCDD/F deposition over the Baltic Sea in 2007. Contribution of other EMEP countries accounted for 8%. Significant contribution was made by other emission sources, in particular, remote emissions sources and re-emission of PCDD/Fs (62%).

Table 7.4. Two most significant contributors to annual total deposition of PCDD/Fs to the six Baltic Sea sub-basins for 2007.

Sub-basin	Country (1)	%	Country (2)	%	*, %
GUB	Sweden	15	Finland	8	61
GUF	Russia	35	Estonia	4	47
GUR	Latvia	13	Poland	6	63
BAP	Poland	15	Sweden	6	62
BES	Denmark	19	Poland	3	70
KAT	Denmark	20	Sweden	4	64
BAS	Poland	8	Denmark	7	62

* - contribution of re-emission and remote sources.

7.5 Comparison of model results with measurements

PCDD/Fs are not currently included into the EMEP measurement programme. For this reason verification of the MSCE-POP model results for PCDD/Fs was based on the comparison with the data of various measurement campaigns. Due to the limited information on measured atmospheric levels of PCDD/Fs and their temporal variations the comparison with the model results for this contaminant is of a preliminary character.

The performance of MSCE-POP model for computation of PCDD/F pollution levels within the European region was evaluated during the model review carried out in the framework of EMEP Task Force on Monitoring and Measurements. In particular, MSCE-POP model results on long-range transport of one of the toxic PCDD/F congeners 2,3,4,7,8-PeCDF for the EMEP region and the period 1990-2003 were compared with measurements of EMEP monitoring network and observations of other studies within the European region (*Shatalov et al.*, 2005). One of the main conclusions of the TFMM Workshop on the Review of the EMEP Models on Heavy Metals and Persistent Organic Pollutants in Moscow in 2007 was that "the MSCE-POP model represents the state-of-the-science and fits to the purpose of evaluating the contributions of long-range transport to the environment impacts caused by POPs". It was recognized that the MSCE-POP model results demonstrated its ability to provide spatially and temporally resolved air concentrations and deposition of POPs across Europe. The model provided reasonable agreement with long-term

temporal trends of air pollution at most EMEP monitoring sites.

Additional comparison of PCDD/Fs modelling results obtained for 2004 was carried out with the measurement data of monitoring campaign carried out in Denmark. The results of the comparison are presented in the Joint report of EMEP Centres for HELCOM (*Bartnicki et al.*, 2006).

In this report no results of comparison of modeling results with measurement is presented since there was no available measurements of dioxins and furans within the European region for 2007 were found.

7.6 Conclusions for Chapter 7

- PCDD/F emissions from HELCOM countries have decreased from 1990 to 2007 by 21%. At the same time there is some increase of dioxins and furans emission from 2006 to 2007 amounted to approximately 2%.

- Annual PCDD/F deposition to the Baltic Sea has decreased from 1990 to 2007 by 62%. Level of PCDD/F deposition in 2007 has decreased comparing to 2006 by 9%.

- The contribution of anthropogenic sources of HELCOM countries to total PCDD/F deposition over the Baltic Sea was estimated to approximately 40%. Essential contribution belongs to the anthropogenic sources of other EMEP countries and global emission sources.

- The most significant contribution to dioxins and furans deposition over the Baltic Sea was made by Poland and Denmark.