PCDFs, PCDDs, Non-Ortho PCBs, and Mono-Ortho PCBs in Northern Fulmars from the Faroe Islands

Ingrid M Ericson[1], Jessika Hagberg[1], Maria Dam[2], Bert van Bavel[1], Jens-Kjeld Jensen[3], Jóannis Danielsen[3], Gunilla Lindström[1]

[1]Man-Technology-Environment (MTM) Research Centre, Örebro University
[2]Food and Environmental Agency, FO-100 Tórshavn, Faroe Islands
[3]The Faroese Museum of Natural History

Introduction

Since 1975, eggs and tissues of Northern Fulmars (*Fulmarusglacialis*) have been used to monitor contamination of the Canadian Arctic marine environment[1]. Levels of dioxins in Northern Fulmars from the Canadian Arctic are amongst the highest reported for birds, with PCDDs 5 500 pg/g, PCDFs 17 300 pg/g, and non-*ortho* PCBs 14 300 pg/g on a lipid weight basis[2]. High levels have also been reported in Black Guillemots and White-tailed Eagles from the Baltic Sea[3], in granivore, and piscivorous bird species from Japan[4], and in albatrosses from the North Pacific[5]. A 1998-1999 study on Northern Fulmars from the Faroe Islands comprising tissues of liver, intestinal, and subcutaneous fat as well as muscle on breeding, juvenile, and fledging individuals[6], revealed high concentrations of lipid soluble pollutants like PCBs, and chlorinated pesticides. In the present study we report on the results of analyses of PCDDs, PCDFs, and non-, and mono-*ortho* PCBs in liver tissue from juvenile Northern Fulmars (*Fulmarusglacialis*) from the Faroe Islands, sampled in 2003.

Materials and Methods

Liver samples of Northern Fulmars were collected during a traditional hunt in July 2003 in Nólsoy, Faroe Islands. Liver tissue was dissected within minutes after sacrifice, and the samples were put into glass jars with aluminum foil under the lid, and stored in
-20°C.

Liver samples were ground with anhydrous sodium sulfate. Sample extraction was performed using supercritical fluid extraction coupled to a solid phase liquid chromatography trap (SFE-LC). Standard SFE cells were filled with the homogenized sample containing approximately one gram of the original liver sample. During dynamic extraction at 40 °C and 280 atm with CO_2 for 45 minutes, the target compounds were collected on a solid phase trap containing AX-21 carbon on ODS silica.

After sample extraction the trap was eluted with 6 ml n-hexane/dichloromethane (1:1) for non-planar compounds and xylene for planar compounds. Prior to extraction the samples were spiked with a mixture of ^{13}C-labelled internal standards (Wellington) and ^{13}C-labelled recovery standards were added to the final extracts. Dioxin and planar PCB analysis was performed on a MicromassAutospecUltima HRGC/MS operating at 10 000 resolution using EI ionization at 35 eV. All measurements were performed in the selective ion recording mode (SIR), monitoring the two most abundant ions of the molecular chlorine cluster. The sample extracts were run on a 30 m DB5-MS (0,25mm id, 0,25µm), and on a 60 m Restek Dioxin-2column for confirmation. Splitless injection at 250 °C was used to inject 1 µl of the final extract on the GC column. Detection levels were calculated at a S/N ratio of 3, corrected for recovery of the internal standard.Toxic equivalents (TEQs) were calculated using World Health Organization avian toxic equivalency factors (TEFs) for PCDDs, PCDFs, and non-ortho PCBs[7].

Results and Discussion

Detectable concentrations of PCDFs, PCDDs, non-, and mono-*ortho* PCBs were found in all samples analyzed. Results on individual congeners are given in Table I. The highest levels were found in mono-*ortho* PCBs, followed by non-*ortho* PCBs, PCDFs, and PCDDs. 2,3,4,7,8-PnCDF was the predominant PCDD/F congener found in the liver

tissue. The dominating congener amongst the PCDDs were 1,2,3,6,7,8-HxCDD. PCB # 126 and # 169 were the dominating non-*ortho*PCBs. When calculating toxic equivalents (TEQs) the PCDF congeners are the biggest contributors to the total TEQ with 62 %. PCDDs, non-*ortho* PCBs, and mono-*ortho* PCBs contributes with 8, 29, and 0,6 % respectively. Dominating congeners contributing to total TEQ are 2,3,4,7,8-PeCDF with 60 %, 1,2,3,7,8-PeCDD and PCB # 126 with 7, and 29 % respectively.

Levels of PCDFs, PCDDs, and non-ortho PCBs were reported in northern fulmars (F*ulmarusglacialis*) from the Canadian Arctic by Braune & Simon, 2003. Levels and congener patterns in fulmars from the Faroe Islands and the Canadian Arctic are comparable, with slightly higher levels in the Faroe Islands samples, as seen in Figure 1. Differences in congener patterns amongst PCDFs are noticed between 2,3,4,6,7,8-HxCDF, seen only in the Faroe Island samples, and 1,2,3,7,8,9-HxCDF, seen only in the Canadian Arctic samples.

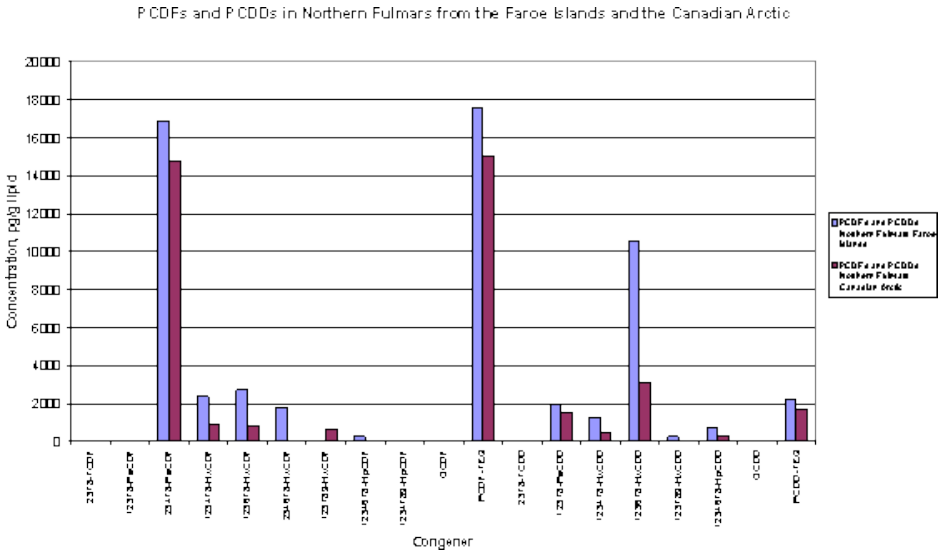

Figure 1. Comparison of PCDF and PCDD levels in liver tissue in Northern Fulmars (*Fulmarusglacialis*) from the Faroe Islands and the Canadian Arctic.

Table I. Concentrations and TEQs for PCDFs, PCDDs, Non-*Ortho* PCBs, and Mono-*Ortho* PCBs in liver tissue from 16 Northern Fulmars sampled in the Faroe Islands.

	Mean	Median	Min	Max	SD
PCDFs	(pg/g lipid)	(pg/g lipid)	(pg/g lipid)	(pg/g lipid)	(pg/g lipid)
2378-TCDF	17	14	3	48	12
12378-PeCDF	11	10	3	27	6
23478-PeCDF	16900	17300	5040	35800	9510
123478-HxCDF	2390	2030	808	4420	1100
123678-HxCDF	2720	2140	983	5710	1500
234678-HxCDF	1790	1630	481	4050	965
123789-HxCDF	10	9	4	17	4
1234678-HpCDF	265	267	65	511	127
1234789-HpCDF	40	35	20	68	18
OCDF	<4.0	<4.0	<0.7	<11	2
Sum PCDFs	24163	23800	8240	49700	12800
PCDF-TEQ*	17600	18100	5380	37200	9830
PCDDs					
2378-TCDD	77	63	30	214	46
12378-PeCDD	1940	1680	558	4390	1200
123478-HxCDD	1300	1150	168	3340	830
123678-HxCDD	10600	8920	4060	20600	4740
123789-HxCDD	255	234	78	510	133
1234678-HpCDD	773	680	200	1690	400
OCDD	<62	<60	<14	<126	31
Sum PCDDs	14900	12200	5470	28300	6780
PCDD-TEQ*	2210	1880	672	4900	1311
Non-*ortho* PCBs					
PCB#81	<0.38	<0.37	<0.27	<0.48	<0.05
PCB#77	152	125	72	419	89
PCB#126	80900	63400	27400	247000	56000
PCB#169	85900	74300	30700	181000	45200
Sum NO-PCBs	167000	135000	58100	428000	99000
NO-PCB-TEQ*	8190	6420	2770	24900	5640
Mono-*ortho* PCBs	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid	ng/g lipid
PCB#118	1700	1660	560	4130	810
PCB#114/122	33	27	12	64	14
PCB#105	518	484	150	954	223
PCB#156	450	418	130	1220	256
PCB#157	106	80	26	289	76
PCB#189	n.a	n.a	n.a	n.a	n.a
Sum MO-PCBs	2810	2690	877	6620	
TEQ* MO PCBs (pg/g lipid)	166	161	74	337	63

Total TEQ* (pg/g lipid wt)	**28200**	**26600**	**8900**	**67300**

* TEQ values calculated using World Health Organization avian toxic equivalency factors (TEFs) for PCDFs, PCDDs, non-*ortho* PCBs, and mono-*ortho* PCBs.

Differences in total TEQ between Northern Fulmars from the Faroe Islands and the Canadian Arctic is mainly due to different non-*ortho* PCBs TEQ contribution.

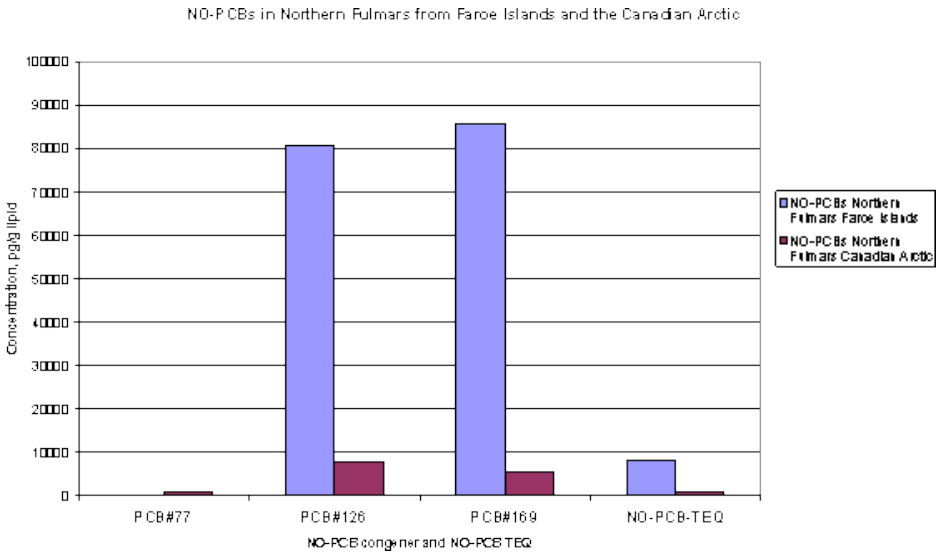

Figure 2. Comparison of non-*ortho* PCB levels in liver tissue in northern fulmars (*fulmarusglacialis*) from the Faroe Islands and the Canadian Arctic.

Conclusion

Reported levels of PCDDs, PCDFs, non- and mono-*ortho* PCBs are amongs the highest reported in birds, and 10 000 times over the limit for human consumption (EU standard 3 pg TEQ per g lipid[8]). Northern fulmars are part of the traditional food in the Faroe Islands[9], and hence a potential source of exposure to dioxins and dioxin-like compounds.

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