PCBs and PCDD/Fs Distribution in Tissues and Organs of Marine Animals in Russian Arctic

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Introduction

Studies of persistent organic pollutants (POPs) in the Russian Arctic were conducted recently by a Arctic Monitoring and Assessment Program (AMAP) project[1,2]. This project developed new data on the POPs pollution levels in the environment and biosphere, including PCBs and PCDD/Fs[3-6], in arctic regions of Russia.

Transboundary transport and biomagnification within food chains in arctic regions result in POPs accumulation in tissues of fish and marine animals. The aim of this study was to determine the concentration of indicator PCBs, co-planar PCBs and PCDD/Fs in different tissues and organs of seals, walruses and whales caught near the seashore of Chukotski Peninsula (settlement of Lavrenty), Russia, to determine the background level of arctic biota pollution and to study distribution of toxicants in organisms of marine animals.

Sampling was made in the course of the 1st and the 2nd stages of the 4th phase of Raipon/AMAP/GEF project "Persistent Toxic Substances (PTS), Food Security and Indigenous Peoples of the Russian North" in 2002 by researchers of the Regional Center for Monitoring of the Arctic (RCMA), St. Petersburg, Russia.

Methods and Materials

Individual samples of liver, muscle, kidney and subcutaneous fat of Grey whale (***Eschrichtius gibbosus***, female, 9 years) , Pacific walrus (***Odobenus rosmarus***, female, 6.5 years), and two species of seal: Ringed seal (***Phoca hispida***, male, 2.5 years) and Bearded seal (***Erignathus barbatus***, female, 2.5 years), were selected for this study. Tissue was homogenised immediately after sampling then frozen and stored at -20^0C up to the moment of analysis.

Fifteen PCBs congeners (IUPAC 28, 31, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, 187) were determined by the methods of GC and GC/LRMS at the laboratory of the RCMA. Determination of dioxin-like PCBs (DLPCBs; IUPAC 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and PCDD/Fs was carried out at the laboratory of BREC with the use of HRGC/HRMS by the methods of EPA 1613 and EPA 1668.

Conditions of extraction and measurement, standard substances used

Compounds	**Total PCBs (RCMA)**	**PCDDs, DLPCBs (BREC)**
Weight	20 g	20 g for tissues, 5 g for fat
Standards	DBOF, PCB # 198, PCBs standards (Ultra Scientific, ISO 9001)	^{13}C – PCDD/Fs (CIL, EDF 8999-4) and ^{13}C– PCBs (Wellington)
Extraction	acetone, hexane- acetone mixture, hexane	chloroform –hexane, diethyl ether
Extract purification	Gel-chromatography, Sephadex LH-20, Florisil	Envirogel TM GPC Cleanup, SiO_2-Al_2O_3-Carbopac C/Celite, Florisil
Rec. standard	TCN (tetrachloronaphthalene)	^{13}C– PCDD/Fs (CIL, EDF 5999-4)
Equipment	GC- Fisons Mega-2 (ECD 800), GC/MS – Fisons 8060/ MD 800	Carlo Erba 8035/Autospec-Ultima, DB-5MS, 60 m

Results and Discussion

Values of PCDD/Fs and PCBs found in liver, muscle, kidney and fat of marine animal species are given in Table 1.

Table 1. **PCDD/Fs and dioxin-like (DL) PCBs in tissues of different organs of marine animals**

Organs and tissues	% lipids	PCDD/Fs, pg/g		TEQ PCDD/Fs,pg/g		TEQ DLPCBs, pg/g	
		w.w.	lipids	w.w.	lipids	w.w.	lipids
Ringed seal (Phoca hispida)							
Liver (male)	3.32	1.94	58.5	0.19	5.71	0.56	16.86
muscle	0.49	0.83	170.9	0.06	12.41	0.13	26.09
kidney	2.51	1.72	68.33	0.19	7.43	0.11	4.5
fat	98.96	6.29	6.36	0.82	0.83	12.6	12.72
Ringed seal (Phoca hispida)							
Liver (female)	2.79	2.24	80.2	0.22	7.77	1.02	36.58
muscle	0.73	1.0	137.0	0.07	9.34	0.14	18.95
kidney	2.32	1.48	63.93	0.14	5.85	0.22	9.41
fat	95.1	8.28	8.71	0.83	0.87	23.6	24.87
Bearded seal (Erignathus barbatus)							
liver	4.2	1.39	33.05	0.06	1.52	0.69	16.4
muscle	0.36	1.07	280.3	0.07	20.29	0.11	30.27
kidney	1.9	0.09	45.39	0.09	4.54	0.14	7.21
fat	94.08	8.5	0.98	0.92	0.98	17.7	18.85
Gray whale (Eschrichtius gibbosus)							
liver	4.19	1.52	36.32	0.08	2.01	0.33	7.81
muscle	0.43	1.05	243.95	0.1	22.28	0.07	16.34
kidney	1.23	1.21	98.74	0.14	11.19	0.13	10.54
fat	34.9	7.0	20.07	0.43	1.23	8.2	23.49
Pacific walrus (Odobenus rosmarus)							
liver	2.8	1.17	41.68	0.1	3.43	0.15	5.48
muscle	1.52	1.3	85.76	0.07	4.64	0.09	6.32
kidney	2.2	0.88	10.07	0.08	3.76	0.05	2.14
fat	86.69	5.06	5.83	0.32	0.37	2.28	2.63

As it follows from the table the highest PCDD/Fs and PCBs concentrations calculated per sample weight have been found in fat, calculated per lipid concentration – in muscles. Accumulation of PCDD/Fs and PCBs in tissues of all animals was uneven: muscle ~ kidney < liver < fat, according to lipophilic properties of these groups of compounds (Figure 1). Data on PCDD/Fs ratio in fat and muscles of grey seal and other arctic animals have been reported earlier[5,6].

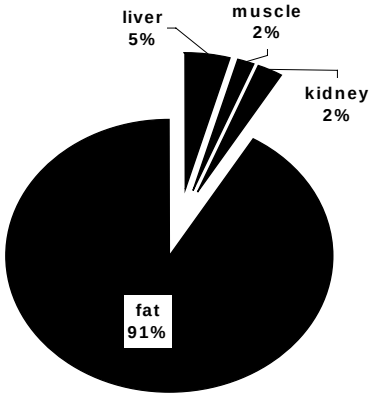

Figure 1. Distribution of DLPCBS in organs and tissues of grey whale

In this study the correlation of PCDD/Fs and DLPCBs (TEQ) concentrations in all tissues of examined species of marine animals has been found (Figure 2). However there is qualitative difference in bioaccumulation by different species. Thus for ringed seal and for bearded seal increased DLPCB TEQ concentration has been found, while the group is homogeneous both by lipid concentration and by PCDD/Fs and PCBs ratio.

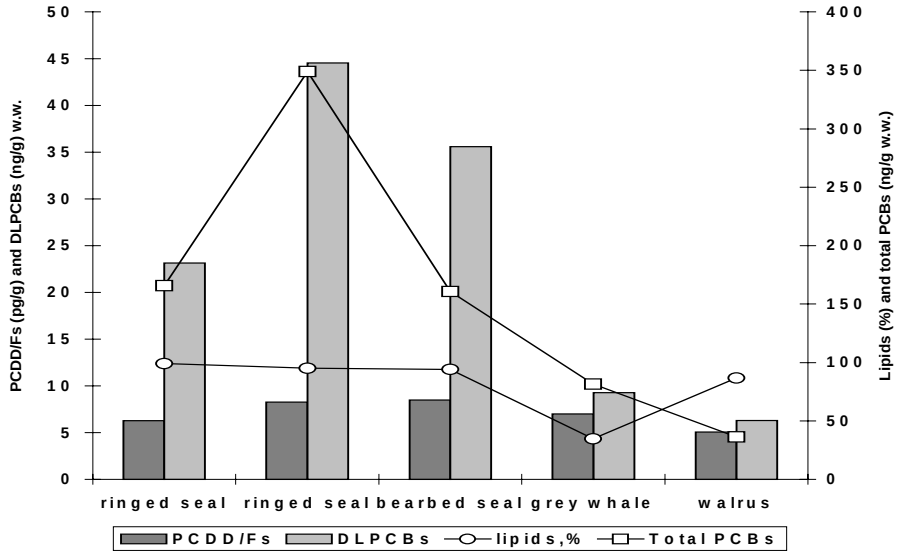

Figure 2. PCDD/Fs, DLPCBs, total PCBs and lipids in fat samples of marine animals

For grey whale and arctic walrus PCDD/Fs concentration is much higher, probably due to considerable age of species, difference in kinetics of excretion and metabolism of PCDD/Fs and PCBs, or food peculiarities connected with season migration. Thus, the ratio of $TEQ_{DLPCBs}/TEQ_{DLPCDD/Fs}$ in seal fat is on average 4.4, in fat of grey whale and arctic walrus – 1.3.

PCBs determination in tissues of arctic animals was carried out more extensively but data on different sets of PCB isomers not always allow to make comparison by regions of Arctic[2]. There is lack of data on separate species of animals, particularly on grey whale. Information on pollution of whales in the Bering Sea was enlarged in 2002[2,6] and in this study while estimating DLPCBs contribution into the total concentration of PCBs.
Table 2 gives data on different groups of PCB isomers: indicator, isomers predominant in the environment and most toxic isomers.

Table 2. **PCBs in marine animals, ng/g w.w.**

Tissue	non-ortho DLPCBs*	total DLPCBs	PCBs 105, 118, 156	indicators PCBs**	total PCBs
Ringed seal , male, 2,5 age					
Liver	0.009	0.64	0.6	6.83	7.47
muscle	0.004	0.31	0.29	1.87	2.18
kidney	0.005	0.51	0.24	2.57	3.08
fat	0.20	23.17	21.8	142.7	165.87
Ringed seal , female, 2,5 age					
Liver	0.013	1.3	1.23	13.2	14.5
muscle	0.003	0.36	0.34	2.16	2.52
kidney	0.004	0.52	0.49	3.54	3.86
fat	0.30	44.5	41.79	304.37	348.87
Bearded seal , male, 3,5 age					
liver	0.02	1.82	1.74	8.91	10.73
muscle	0.005	0.25	0.23	0.71	0.96
kidney	0.005	0.38	0.36	1.61	1.99
fat	0.43	35.6	32.9	125.18	160.78
Gray whale, female, 9 age					
liver	0.01	0.46	0.43	2.35	2.81
muscle	0.004	0.17	0.16	0.68	0.85
kidney	0.005	0.25	0.23	0.98	1.23
fat	0.20	9.29	8.28	72.22	81.51
Pacific walrus, female, 6,5 age					
liver	0.009	0.57	0.54	1.89	2.46
muscle	0.003	0.30	0.28	1.05	1.35
kidney	0.003	0.39	0.36	1.18	1.57
fat	0.065	6.3	5.97	29.92	36.22

*** - PCBs 77,81,126,169; ** - PCBs 28, 31, 52, 99, 101, 128, 138, 153, 170, 180, 183, 187;**

It follows from data comparison that DLPCBs share in different tissues of different marine animals of Arctic is approximately of one and the same value – about 15-17%.

Table 3. **Ratio of total PCBs/DLPCBs in tissues of seal, whale and walrus, ng/g w.w.**

Tissue	Mean value	Median
Fat	6.8±1.5	7.2
Liver	8.1±2.7	6.1
Muscle	5.5±1.3	5.0
kidney	6.7±2.7	5.2

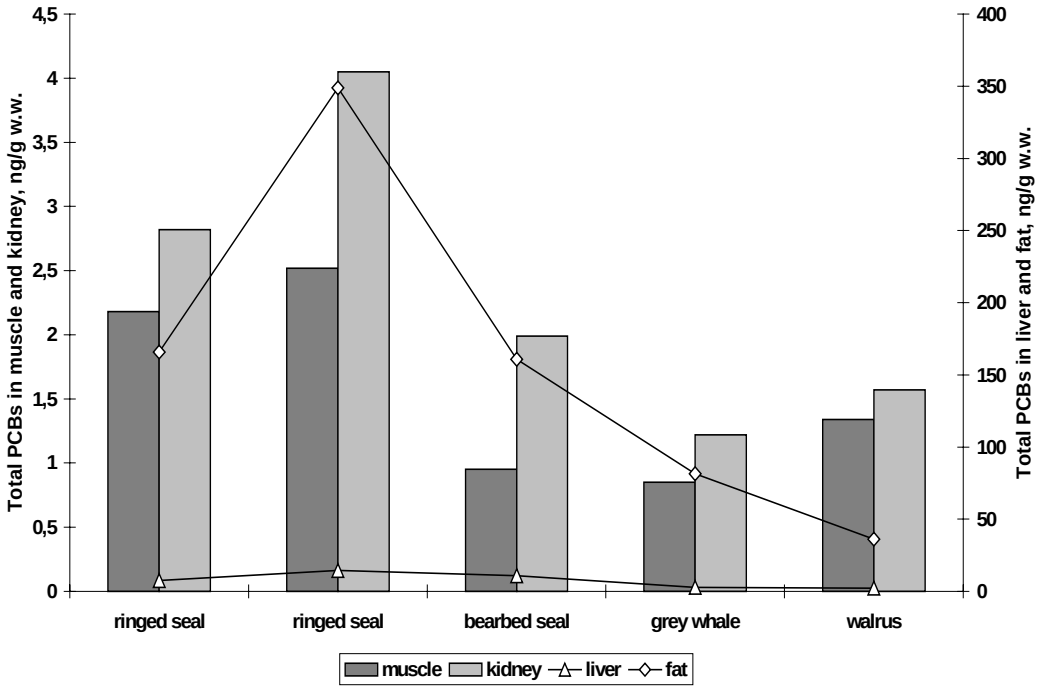

Figure 3. **Distribution of total PCBs by organs and tissues of marine animals of Arctic**

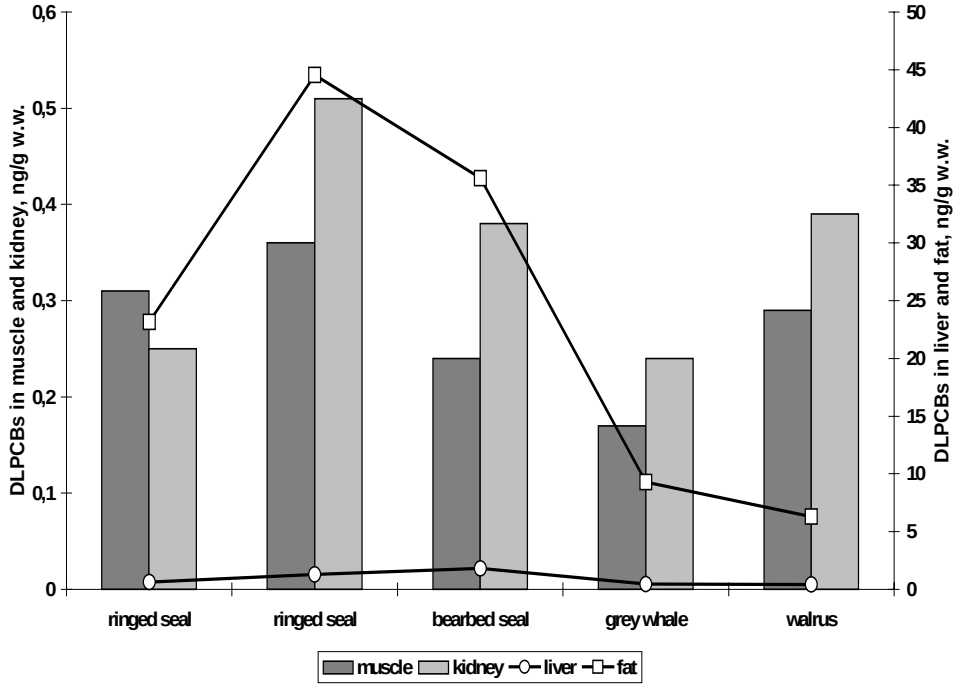

Figure 4**.** **Distribution of DLPCBs by tissue of marine animals of Arctic**

Acknowledgements

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