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Sammendrag / Summary

The report presents data on environmental contaminant concentrations in biota and bottom sediments from the White Sea, July-August 2009. Polycyclic aromatic hydrocarbons (PAHs) are the major contaminants of sediments. The highest PAH contamination levels, corresponding to "moderate contamination" (Class III) in the SFT classification system, were found in the inner part of Kandalaksha Bay. Concentrations of chlorinated hydrocarbons and polybrominated diphenyl ethers in all sediments analysed were at the Class I contamination except sediment ΣDDT concentration in Kandalaksha Bay (Class II contamination). Background trace element concentrations were typical for from the White Sea.
Contaminant levels in blue mussel and cod from the White Sea did not exceed Russian and EC requirements on contaminant concentrations in seafood and can, in accordance with the SFT system, be defined as "Insignificantly contaminated" (Class I).

Emneord:	Key words:
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Sedimenter	Sediments
Miljøgifter	Contaminants
Kvitsjøen	White Sea

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1 Introduction

The Coordinated Environmental Monitoring Programme (CEMP) was initiated in 2002 as a pilot study in Northwest Russia. This is part of the bi-lateral project between Russia and Norway on harmonisation with OSPAR's[1] CEMP guidelines of monitoring of hazardous substances in sediments and biota (http://www.ospar.org/v_publications/order.asp). The Norwegian Climate and Pollution Agency (earlier called the Norwegian Pollution Control Authority - *Statens forurensningstilsyn* – SFT) is the Norwegian project manager, and has engaged Akvaplan-niva to carry out the pilot study. In 2009, from the Russian side, four organisations belonging to different authorities have been involved in the project:

List of Russian institutes and organisations involved in the project

Name	Affiliation	Abbreviation used in the report
The Federal State Unitarian Research and Production Company for Geological Sea Survey "Sevmorgeo"	Ministry for Industry, Science and Technologies of the Russian Federation	Sevmorgeo
White Sea Biological Station Kartesh of Zoological Institute	Russian Academy of Sciences	WBS ZIN
Centre for Environmental Chemistry of Scientific Production Association "Typhoon" Obninsk	Federal Service for Hydrometeorology and Environment Monitoring	SPA Typhoon
North-Western Branch of S.P.A. Typhoon St-Petersbugr	Federal Service for Hydrometeorology and Environment Monitoring	NW Typhoon
Institute of biology of Karelian Scientific Centre	Russian Academy of Sciences	IB KarRC RAS

The overall aim of JAMP/CEMP project in Russia was to use the OSPAR guidelines in establishing suitable procedures for environmental monitoring activities in the coastal areas. It is the intention that these procedures can form the basis for future coastal monitoring programmes in the region.

In 2009 SEVMORGEO for the first time has planned to carry out the full monitoring program in the coastal areas of the White Sea using OSPAR/JAMP guidelines (OSPAR, 1999a; 1999b). It was planned that SEVMORGEO will carry out sediments sampling and analyses (basic POPs and PAHs) at NW Typhoon and Akvaplan-niva will contribute with analyses of new contaminants in sediments and will carry out monitoring of biota which is not included in the Russian monitoring

[1] The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention 1992)

program. Analyses of new compounds in sediments and the full range of contaminants were planned to carry out at SPA Typhoon.

However, due to unexpected difficulties with funding, monitoring program has changed and SEVMORGEO were not able to carry out full monitoring program for sediments as it was planned. Moreover, analytical laboratory NW Typhoon, where SEVMORGEO has planned to carry out basic POP and PAH analyses did not recently participate in the international inter-laboratory exercises. It was decided that all analyses of samples collected during the project will be conducted at SPA Typhoon and both laboratories will participate in the QUASIMEME. This is in a line with the aim of the project to assist the Russian analytical laboratories in analyses of environmental contaminants in sediments and biota.

Akvaplan-niva assisted in organising the implementation of the project, supplied necessary information on CEMP methods and procedures, and acted as coordinator for the laboratory analyses, intercalibration and the reporting.

2 Sampling area and sampling programme

The White Sea is a shelf water body situated in sub-polar physical-geographical zone in the northern European part of Russia. It is connected to the Arctic Ocean via the Barents Sea (*Figure 1*). The geographic position of the White Sea is enclosed by the following co-ordinates: the extreme northern point (Kanin Nos Cape) has latitude of 68°40´, the extreme southern point is the terminal part of the Onega Bay (63°47´). The extreme western point of the sea has a longitude of 32°00´, with the longitude of the extreme eastern point being 44°30´. The area of the White Sea is 89600 km^2 with an average depth of 60 m and a maximal depth of 340 m. The coastline is heterogeneous and complex. Most islands of the White Sea are situated in the Kandalaksha and Onega Bays where in the latter the largest is found among the Solovetsky Islands. (Berger and Naumov, 2001).

Figure 1. Map of the White Sea area

Relative shallowness, prolonged summer period, and abundance of nutrients, brought in with the inflow of numerous rivers, account for a sufficiently high biological productivity. Nevertheless, having rich and diverse plankton and benthic communities, the White Sea is nowadays characterized as relatively poor in stock and catch of fish and marine mammals of marked value.

However, this is not due to low biological productivity. Preliminary calculations of the sea energy balance (Berger *et al.*, 1995) show that, the number of fish in the White Sea is not limited by trophic conditions but could exceed 100 times the current mass. Indeed, the maximal annual catches of herring in the 19th century were about 30-35 thousand tons, about 100 times recent catched (300-400 tons) (Berger *et al.*, 2001). Thus, the current low catch of the sea is more likely due to other causes such as the anthropogenic impact such as barriers (e.g. hydroelectric dams, piles of logs, etc.) inhibiting spawning migrations of anadromous fish, or the fishing industry which can dramatically affect the size-age and sex structure of populations of commercial fish. Natural factors can have a significant impact as well, for example the massive loss (up to 97% of biomass) of sea grass *Zostera*, which provided the main spawning substrate of the White Sea herring, in 1960s (Alimov *et al.*, 2008), probably, as a result of catastrophic epiphytotic caused by protozoa *Labyrinthula* (Alim, 1962; Vekhov, 1992).

In general, the chemical contamination of the White Sea ecosystem is low. The only exceptions are the top regions of the Kandalaksha and Dvina Bays. Municipal and industrial activities in cities adjacent to the White Sea produce a variety of waste products, which are subsequently introduced into the marine environment by land-based discharges, runoff, and atmospheric deposition. Kandalaksha aluminium smelter SUAL and heat-and-power plants located in Kandalaksha, Arkhangelsk, Novodvinsk and Severodvinsk are the major potential sources of PAH contamination. Several large pulp- and paper mills in Arkhangelsk and Novodvinsk are additional potential sources of industrial contamination. The most problematic contamination for pulp and paper industry is dioxins and furans formed in the bleaching process (Thacker *et al.*, 2007). Assessment of dioxin contamination in Arkhangelsk area carried out in 1993 has shown that the main sources of emissions dioxins in the environment are the pulp and paper mills. (Bazhenova, 2007).

Another contamination source of the White Sea is the sewage from industrial enterprises, cities and smaller settlements. The White Sea is a region with potential risk to radioactive pollution. In Severodvinsk, there is a facility for equipping rockets with nuclear warheads, plants for repairing nuclear icebreakers, where industrial radioactive wastes are accumulated and submarines with non-operational nuclear power stations are stationed (Savinov *et al.*, 2001).

CEMP field work in the White Sea for 2009 was carried out onboard of RV *Ekolog* (July), onboard MSG *Priboy* (August) and along the littoral coastline of Kandalaksha Bay (August). The vessels belong to the Institute of Northern Water Problems of Karelian Research Centre of Russian Academy of Sciences (RV *Ecolog*) and Kandalaksha State Reserve (MSG *Priboy*). Kandalaksha, Dvina and Onega Bays were the study areas of the monitoring programme (*Figure 2*).

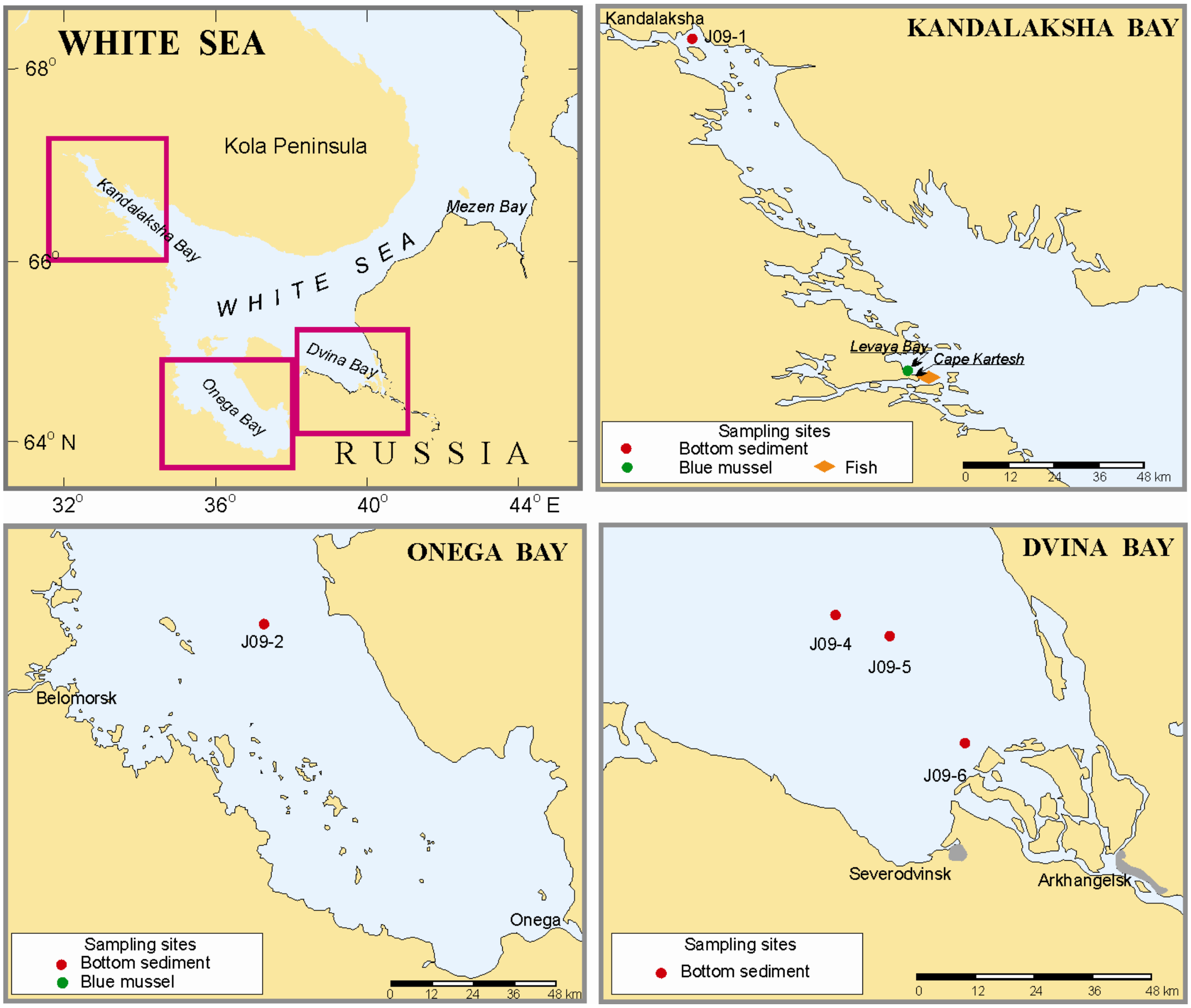

Figure 2. Sampling site locations, White Sea, July-August, 2009.

Surface sediments (0-1 cm), blue mussel and cod samples were collected from the three areas for determination of POPs and trace elements.

3 Materials and methods

3.1 Surface sediment sampling

Surface sediment (0-1 cm) samples were collected at the five stations located in Kandalaksha, Onega and Dvina Bays (*Figure 2*). The stations are also part of the Programme of Environmental Monitoring performed by Centre for Monitoring the Geological Environment of the Continental Shelf of Sevmorgeo. Coordinates for the sediment sampling sites are presented in *Table 1*.

Table 1. Locations of anchor stations of surface (0-1 cm) sediment sampling, White Sea, July-August, 2009.

Date	Station number	Depth, m	Latitude, N	Longitude, E	Area
06.07.09	J09-6	16.5	64°52.543'	39°42.84'	Dvina Bay
06.07.09	J09-5	54	64°57.97'	39°31.50'	Dvina Bay
06.07.09	J09-4	75	65°06.35'	39°17.17'	Dvina Bay
07.07.09	J09-2	64	64°40.97'	36°17.64'	Onega Bay
27.08.09	J09-1	43	67°08.15'	32°23.00'	Kandalaksha Bay

Sampling was carried out using Van-Veen grab according CEMP guidelines for sediment sampling (OSPAR, 1999a). We have collected sediment samples for persistent organic pollutants (POPs), heavy metals (HM) and total organic carbon (TOC) analyses in three replications at each of the five stations. Surface sediments (0-1 cm) sampled from three independent grabs were pooled and frozen immediately.

Pooled samples collected for trace element, granulometric and geochemical analyses were placed in plastic bags, while samples collected for analyses of organic contaminants were placed in pre-cleaned glassware in order to avoid the possible adsorption of contaminants onto the container material. Glassware was washed with detergents in the washing machine, and rinsed with distilled water. In addition, glassware was rinsed with an organic solvent (dichloromethane) and heated at 450 for 8 hours (OSPAR, 1999a).

3.2 Biota sampling

Biological samples were collected according CEMP guidelines (OSPAR, 1999a).

Blue mussel (*Mytilus edulis*) were collected on littoral of Guba Levaya (Kandalaksha Bay) (66°20.23'; 33°39.60'). Collected mussels were sorted by sizes; soft tissues of individuals with 45-50 mm sizes were pooled (3 replicates × 50 individuals) and placed into glass (for POPs analyses) or plastic containers (for HM analyses). All samples were stored frozen prior to analysis.

Cod *Gadus morhua marisalbi* (25 individuals) were caught with a fishing-rod in coastal water of Kartesh Cape (Kandalaksha Bay). Sex of the fish was noted and length measures were taken (*Appendix 1: Table 1.3*). Liver and muscle tissues were collected for POPs and heavy metal analyses, respectively. Hepatic samples were placed into glass containers and muscle samples were placed into plastic bags. All samples were stored frozen prior to analysis in the analytical laboratory (SPA "Typhoon").

3.3 Chemical analyses and methods

The following contaminants were analyzed in the surface sediments and biological samples by SPA Typhoon:

- chlorinated pesticides: DDT-group, HCHs, HCB, chlordanes (heptachlor, heptachlor epoxide, oxychlordane, trans-chlordane, cis-chlordane, trans-nonachlor, cis-nonachlor), mirex, endrin and dieldrin;
- polychlorinated biphenyls, (PCBs), 64 PCB congeners, included non- and mono-ortho substituted congeners (IUPAC # 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 180 and 189);
- polybrominated diphenyl ethers (PBDEs): PBDE-17, 28, 47, 49, 66, 71, 85, 99, 100, 138, 153, 154, 183, and 190.
- polychlorinated dibenzo-*p*-dioxins and furans (PCDD/Fs);
- polycyclic aromatic hydrocarbons (PAHs), 40 PAH compounds included 16 PAHs recommended by United States EPA (http://www.epa.gov/).
- trace elements(As, Zn, Cu, Cd, Pb and Hg).

Samples were analyzed in two analytical batches, which included laboratory procedural blank, spiked blank sample for biological samples and sample of certified reference material of sediment for sediment samples. To control recovery of analytes, surrogate isotope-labelled substances were used. There were introduced into the samples before extraction. Extracts were analyzed using GC/MS. SPA Typhoon has national accreditation within the framework of Russian Analytical Laboratories Accreditation System (ALAS) for POPs and mercury in abiotic and biotic environmental media (fresh- and seawater, air, soil, sediments, biological tissues) and participates in the International inter-laboratory study on POPs and heavy metals in sediments and biological samples: AMAP Ring Test for Persistent Organic Pollutants in Human Serum (POPs: 2001-2010), Cambridge Isotope Laboratories International Inter-laboratory Study on Fly Ash Reference Materials (POPs: 2007), MAPEP: Mixed Analyte Performance Evaluation Program (US DOE) – 1995-2005: semivolatile organics, HMs; QUASIMEME (POPs, HMs – 2000-2005), Inter-laboratory Study: Northern Contaminants Program (NCP) III – Canada, 2008-2010, Inter-laboratory Study For EMEP/AMAP/CAMP/Helcom in cooperation with the Northern Contaminants Program (NCP) – (POPs, 2010).

Detailed descriptions of analytical methods used for determination of environmental contaminants in the sediments and biota are present in *Appendix 2* and *Appendix 3*, respectively.

4 Results and discussion

4.1 Sediment characteristics

Due to the high hydrophobicity and thereby low water solubility, non-polar organic contaminants have a high affinity to organic particulate matter. These properties cause them to accumulate in the sediments. Concentrations of non-polar contaminants in sediments have been observed to correlate well with the organic total carbon content (TOC) of sediments (DiToro *et al.*, 1991; Lyman, 1982; Roy and Griffin, 1985; Johnsen *et al.*, 1986.)

The concentrations of organic contaminants usually reveal an inverse correlation with grain size (Grant and Middleton 1998). Numerous contaminants and nutrients are transported and stored in association with the silt and clay fractions and TOC (Horowitz *et al.* 1993; Foster and Charlesworth 1996; Owens *et al.* 2005; Förstner 2004; Nehyba *et al.*, 2009). However data from literature points to the fact that distribution of organic material in various grain size fractions and the concentration of both TOC and POPs are also important factors affecting the sorption capacity of the sediment. Wang *et al.* (2001) reported the highest PAHs concentration associated with the fraction above 200 µm and significant positive correlation between PAHs and TOC. Nehyba and Rez (2007) described the significant presence of TOC in the sand fraction of the modern fluvial deposits in this investigated area.

The samples from the White Sea show large variations in sediment type, from very coarse (4.7 % < 63 µm at station J09-6) to fine grained (75 % < 63µm at stations J09-4) (*Table 2*). Both of these stations are located in Dvina Bay. Coarse-grained sediments (23% < 63 µm) prevailed in samples from Onega Bay (station J09-2). More fine-grained sediments (41-54% < 63 µm) dominated in samples from stations J09-1 and J09-5 (*Table 2*).

Table 2. Total organic carbon content (TOC) (g/kg dw) and percentage of materials < 63 µm in surface (0-1 cm) sediments

Station number	Area	TOC g/kg dw	<63 µm %
J09-6	Dvina Bay	0.9	4.7
J09-5	Dvina Bay	9.4	54
J09-4	Dvina Bay	10.4	75
J09-2	Onega Bay	3.1	23
J09-1	Kandalaksha Bay	18.2	41

The SFT classification system is based on relatively fine-grained sediment (silt and clay, or the < 63µm fraction, (SFT, 2007). This criterion was fulfilled only for one sediment sample from Dvina Bay (station J09-4). This makes is difficult to classify POP concentrations found at the other stations. However, despite of more coarse-grained sediments at stations J09-1, J09-4 and J09-5, TOC contents in sediments from these stations (9.4 - 18.2 g/kg dw) were quite similar to those found in silt and clay sediments from the Barents and Kara Seas (Olsson *et al.*, 1997; Dahle *et al.*, 2003). Because POPs are primarily associated with the organic matter in sediments, differences in POP concentrations may be more easily studied when data are normalized against total organic carbon content (TOC-normalized) than when they are presented only on a dry weight basis (Michelsen, 1992). Therefore, to classify of contamination levels and to identify geographic differences, POP concentrations were TOC-normalized. POP concentrations in the table of the SFT classification system were also TOC-normalized assuming 10 g TOC/kg dw (Appendix 4, Table 4.2), which corresponds to those found in fine-grained sediments from station J9-04) (Table 2).

4.2 Contamination levels in sediments

4.2.1 Persistent organic pollutants (POPs) in sediments

Analytical results of POPs determinations in surface sediment samples are presented in *Appendix 2* (along with information on QA: Surrogate Internal Standards, % Recovery) and summarized in *Table 3*. Method detection limit (MDL) of sum of contaminants was taken as smallest MDL of the addendums.

Table 3. Persistent organic pollutants in surface sediments (0-1 cm) from the White Sea, 2009. Classification of contaminant concentrations found were according to the SFT system (2007), where the "background" (Class I) and Good (Class II) levels of contaminants are marked by blue and green, respectively. Note that because of the grain size characteristics found at each station the system could only be applied to J9-04 or when the system was normalized to TOC to JP-01, JP-02, JP-04 and JP-05 (see text).

Compounds	Unit	J9-01	J9-02	J9-04	J9-05	J9-06
HCB	ng/g dw	0.11	<0.03	0.14	0.07	0.06
	ng/gOC	6.0	0.5	13.5	7.5	66.7
[a]ΣHCH	ng/g dw	<0.05	<0.05	<0.05	<0.05	<0.05
	ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.
[b]ΣChlordanes	ng/g dw	<0.01	<0.01	<0.01	<0.01	<0.01
	ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.
[c]ΣDDT	ng/g dw	1.08	0.1	0.39	0.07	<0.03
	ng/gOC	59	33	38	7.0	n.d.
[d]Σ7PCB	ng/g dw	2.91	0.88	3.63	3.06	0.37
	ng/gOC	160	287	349	327	407
ΣPCDD	pg/g dw	19.4	5.72	38.0	29.5	<0.1
	ng/gOC	1066	1869	3654	3144	n.d.
ΣPCDF	pg/g dw	22.0	4.48	21.6	12.8	<0.1
	pg/gOC	1211	1462	2081	1368	n.d.
$TEQ_{PCDD/F}$	pgTEQ/g dw	1.57	0.327	0.930	0.606	<0.001
	pgTEQgOC	86	107	89	65	n.d.
ΣPBDE[e]	pg/g dw	11.6	1.92	15.5	2.30	2.46
	ng/gOC	0.64	0.63	1.49	0.25	2.73
BDE-99	pg/g dw	8.68	1.92	3.43	2.30	2.46
	ng/gOC	0.48	0.63	0.33	0.25	2.73
Endrin	ng/g dw	<0.10	<0.10	<0.10	<0.10	<0.10
	ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.
Deldrin	ng/g dw	<0.05	<0.05	<0.05	<0.05	<0.05
	ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.
Mirex	ng/g dw	<0.03	<0.03	<0.03	<0.03	<0.03
	ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.

[a]ΣHCH = sum of α-, β- and γ-HCH; [b]ΣChlordanes = sum of heptachlor, heptachlor epoxide, oxychlordane, *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, and *cis*-nonachlor; [c]ΣDDT = sum of *o,p'*-DDE, *p,p'*-DDE, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDT, and *p,p'*-DDT; [d]Σ7PCB = sum of PCB-28, 52, 101, 118, 138, 153, and 180;ΣPBDE=sum of BDE-17, 28, 49, 71, 47, 66, 100, 99, 85, 154, 153, 138, 183 and 190.

Among the pesticides determined, only HCB and DDT- concentrations found in surface sediment samples collected in 2009 were above detection limits *(Table 3, Appendix 1: Table 2.5)*. In sediment samples from the inner parts of Kandalaksha Bay (station J9-01, *Figure 3*), the ΣDDT concentration (1.08 ng/g dry weight or 59 ng/gOC) found corresponded to "good" status (Class

II, Appendix 4, Table 4.2). Concentrations of these pesticides in sediments samples from the other stations did not exceed the "background" level (Class I) (Appendix 4, Table 4.2).

Due to undetectable concentrations of most POPs, coarse materials and low TOC content, POP levels found at station J9-06 could not be classified.

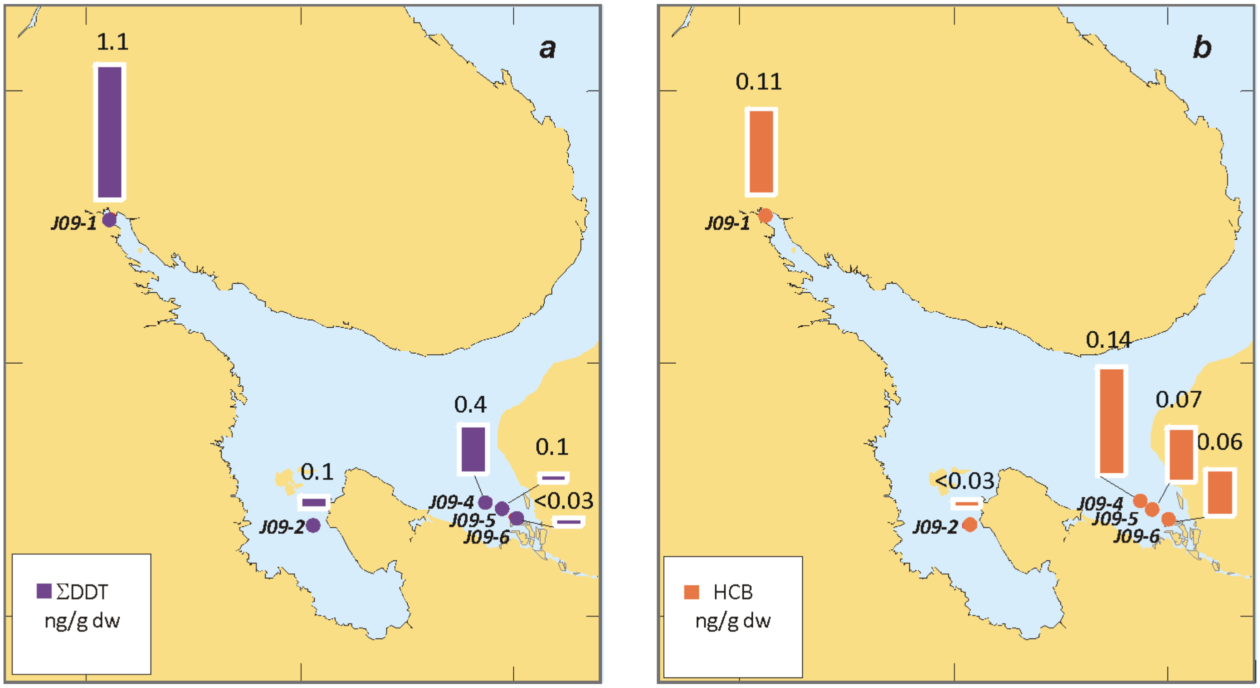

Figure 3. ΣDDT (a) and Σ7PCB (b) (ng/g dry weight) in sediments from the White Sea in 2009

PCB congeners were found in all five sediment samples analysed. Concentrations of "seven dutch" PCBs (Σ7PCB = sum of PCB-28, 52, 101, 118, 138, 153 and 180) ranged from 0.37 to 3.63 ng/g dw (160-349 ng/gOC) *(Table 3, Figure 4a)* (I Class contamination) (*Appendix 4, Table 4*.2.).

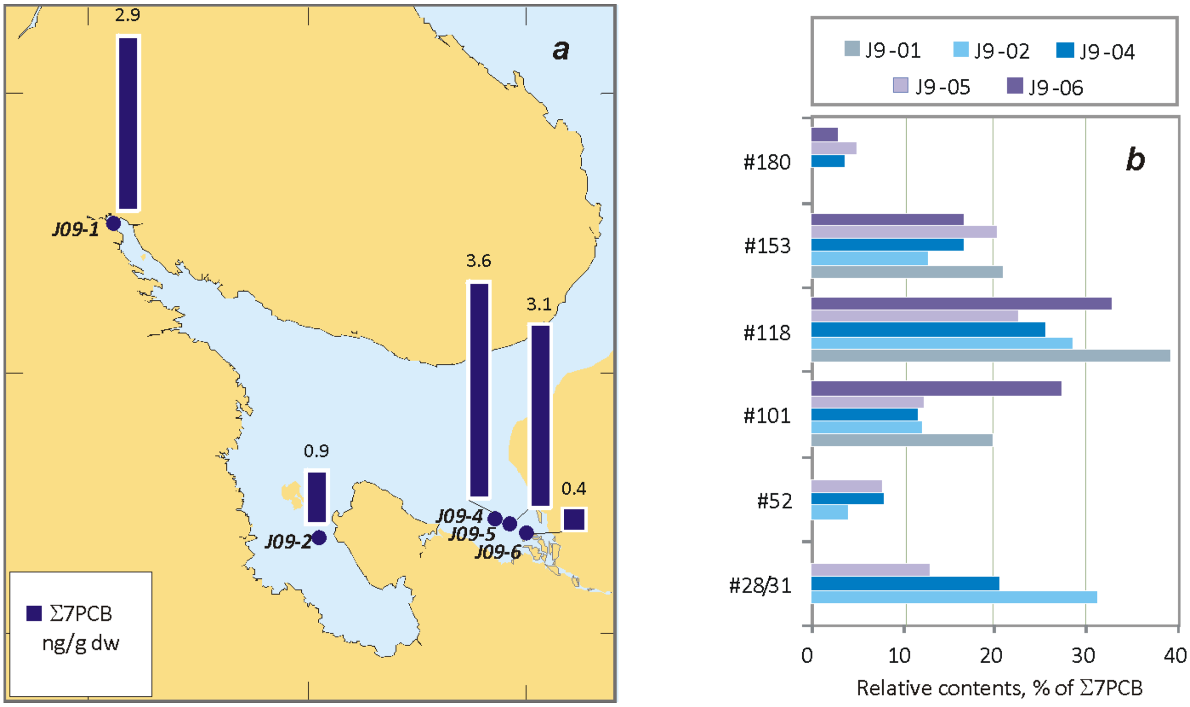

Figure 4. Σ7PCB concentration (a) and PCB patterns (b) in surface sediments from the White Sea in 2009.

PCB-118 and PCB-153 were the major PCB congeners in sediment samples from both Kandalaksha and Dvina Bays *(Figure 4b)*, however, in sediments from the Onega Bay (station J09-2) relative concentration of PCB-28/31 was the highest (*Figure 4b).*

Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were found in all sediment samples analysed with the exception of station J9-06, probably, due to low TOC content *(Table 3, Figure 5a).*

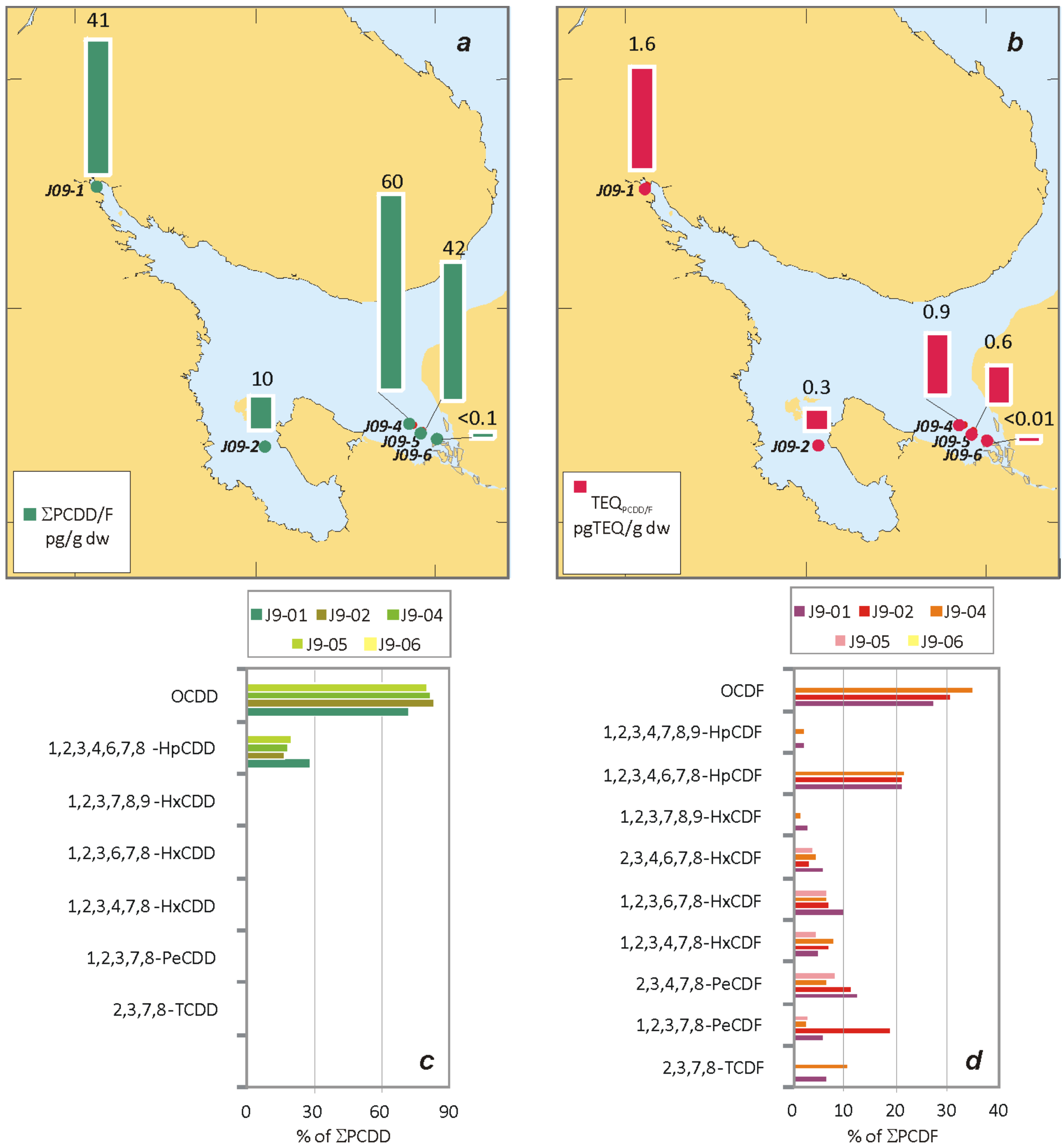

Figure 5. Concentrations of ΣPCDD/F (pg/g dry weight)(a) and $TEQ_{PCDD/F}$ (b) (pgTEQ/g dry weight) in 2009, and patterns of PCDD (c) and PCDF (d) in surface sediments from White Sea in 2009.

Total TEQ values calculated for TCDD/Fs ($TEQ_{TCDD/F}$) ranged from 65 to 107 pgTEQ/gOC. These values did not exceed the upper limit to "background" concentration (<1000 pgTEQ/gOC) (*Appendix 4, Table 4.2*).

PCDD/F patterns found in four sediment samples were quite similar. *Octa*-chlorinated dibenzo-*p*-dioxin and *octa*- and *hepta*-chlorinated dibenzo-*p*-furans prevailed in PCDD/F composition in all samples analysed *(Figure 5c,d).*

Polybrominated diphenyl ethers were found in all sediment samples analysed (*Figure 6*). Among 14 measured PBDE congeners (BDE-17, 28, 49, 71, 47, 66, 100, 99, 85, 154, 153, 138, 183 and 190) only concentrations of *penta*-BDE-99 were above the detection limit in all sediment samples analysed (*Appendix 2: Table 2.9*). This BDE congener was the only congener found in sediments from stations J9-02, J9-05 and J9-06. *Tetra*-BDE-47 was found only in sediments from station J9-04, while *tri*-BDE-28 and *penta*-BDE-100 were found only in samples from station J9-01.

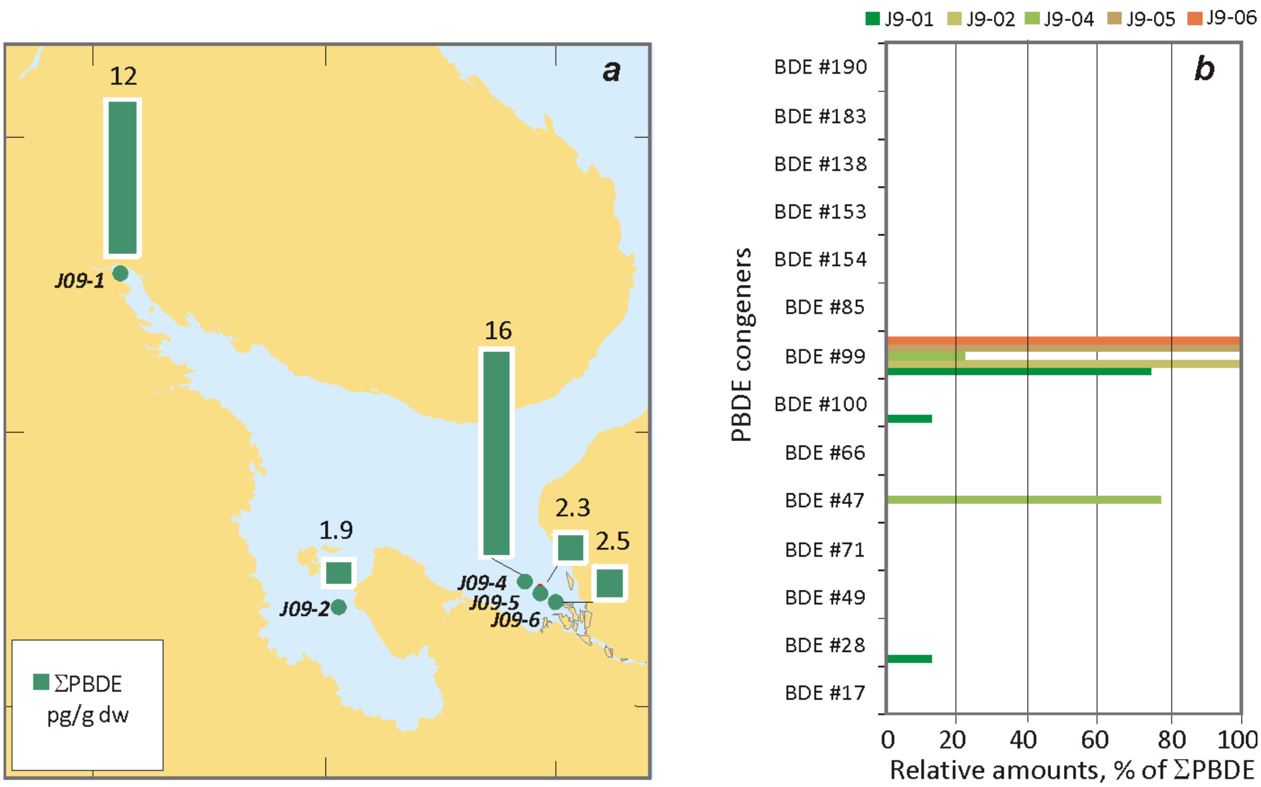

Figure 6. Total concentrations of polybrominated diphenyl ethers (ΣPBDE=sum of BDE-28, 47, 99, 100, 153, 154, and 183) (pg/g dry weight) (a) and PBDE patterns (b) in surface sediments from the White Sea in 2009. .

Penta-BDE-99 concentrations found in sediments from the White Sea ranged from 0.25 to 2.73 ng/gOC, corresponding to II Class contamination (Appendix 4, Table 4.2.).

4.2.2 Polycyclic aromatic hydrocarbons (PAHs) in sediments

Analytical results of PAHs measurements in surface sediment samples are presented in *Appendix 2 (Table 2.6)* along with information on QA (Surrogate Internal Standards, % Recovery) *(Table 2.7)* and summarised in *Table 4.*

Table 4. Polycyclic aromatic hydrocarbons in surface sediments (0-1 cm) from the White Sea, 2009. Classification of contaminant concentrations found were according to the SFT system (2007), Note that because of the grain size characteristics found at each station the system could only be applied to J9-04 or when the system was normalized to TOC to JP-01, JP-02, JP-04 and JP-05 (see text).

PAHs	Abbreviation	Units	KandalakshaBay	OnegaBay	Dvina Bay		
			J9-01	J9-02	J9-04	J9-05	J9-06
Naphthalene	NAP	ng/g d.w.	<10	<10	<10	<10	<10
		ng/gOC	n.d.	n.d.	n.d.	n.d.	n.d.
Acenaphthylene	ACL	ng/g d.w.	1.59	<0.3	<0.3	0.45	<0.3
		ng/gOC	87	n.d.	n.d.	48	n.d.
Acenaphthene	ACN	ng/g d.w.	3.34	<0.3	<0.3	<0.3	<0.3
		ng/gOC	184	n.d.	n.d.	n.d.	n.d.
Fluorene	FLN	ng/g d.w.	5.92	<0.3	0.6	0.84	<0.3
		ng/gOC	325	n.d.	58	89	n.d.
Phenanthrene	PHE	ng/g d.w.	61.6	<1.0	4.81	6.25	<1.0
		ng/gOC	3385	n.d.	463	665	n.d.
Anthracene	ANT	ng/g d.w.	11.5	<0.5	<0.5	1.06	<0.5
		ng/gOC	632	n.d.	n.d.	113	n.d.
Fluoranthene	FLT	ng/g d.w.	151	1.14	9.23	11	<0.5
		ng/gOC	8297	368	888	1170	n.d.
Pyrene	PYR	ng/g d.w.	88.4	2.08	14.4	14.4	<0.5
		ng/gOC	4857	671	1385	1532	n.d.
Benzo(*a*)anthracene	BAA	ng/g d.w.	88.5	1.1	8.94	11.2	<0.5
		ng/gOC	4863	355	860	1191	n.d.
Chrysene	CHR	ng/g d.w.	240	1.9	4.77	5.02	<0.5
		ng/gOC	13187	613	459	534	n.d.
Benzo(*b*+*j*)fluoranthene	BBF	ng/g d.w.	784	14.3	45.1	60	1.51
		ng/gOC	43077	4613	4337	6383	1678
Benzo(*k*)fluoranthene	BKF	ng/g d.w.	199	6.67	18.9	18.5	<1.0
		ng/gOC	10934	2152	1817	1968	n.d.
Benzo(*a*)pyrene	BAP	ng/g d.w.	165	4.06	16.2	20.3	1.2
		ng/gOC	9066	1310	1558	2160	1333
Indeno(1,2,3-*c*,*d*)pyrene	IND	ng/g d.w.	205	5.04	20.7	34.7	<1.5
		ng/gOC	11264	1626	1990	3691	n.d.
Benzo(*g*,*h*,*i*)perylene	BP	ng/g d.w.	246	8.24	35.4	43.7	<1.5
		ng/gOC	13516	2658	3404	4649	n.d.
Dibenzo(*a*,*h*)antracene	DBA	ng/g d.w.	76.5	<1.5	4.17	7.31	<1.5
		ng/gOC	4203	n.d.	401	778	n.d.
Sum of 16 EPA PAHs	Σ16 PAH	ng/g d.w.	2087	43	179	230	2.71
		ng/gOC	114670	13871	17212	24468	3011

I (Background) II (Good) III (Moderate) IV (Bad)

PAH concentrations, expressed as the sum of 16 EPA PAHs, ranged from 2.71 to 2087 ng/g dw (3011-114670 ng/gOC). (*Figure 7a*). The highest PAH contamination level was found in sediments from the inner parts of Kandalaksha Bay (station J09-1) (*Figure 7a*). According to the SFT environmental classification, this level can be attributed to Class III of contamination ('Moderate contamination"). Concentrations of benzo(*a)*pyrene found in sediment samples from this site appropriate to Class II of contamination, while levels of benzo(*b+j*)fluoranthene, indeno(1,2,3-*c,d*)pyrene and benzo(*g,h,i*)perylene can attributed to Class IV contamination ("Bad status"). Concentrations of the other PAHs in this sediment sample are appropriate to Class I or II of contamination (*Table 4, Appendix 4: Table 4.2*). Concentrations of both individual PAH analytes and Σ16 EPA PAH found in the other sediment samples analysed correspond to Class I or to Class II of contamination except benzo(*g,h,i*)perylene in sediments from two stations located in Dvina Bay, concentration of which can be attributed to Class IV *(Table 4).*

Due to undetectable concentrations of most PAH because of coarse materials and low TOC content, PAH levels found at station J9-06 were not classified.

PAH patterns characterizing PAH contamination in surface sediments (0-1 cm) from the different White Sea areas were quite similar. Benzo(*b,k*)fluoranthenes, benzo(*g,h,i*)perylene, benzo(*a*)pyrene and indeno(1,2,3-*c,d*)pyrene predominated (*Figure 7b*).

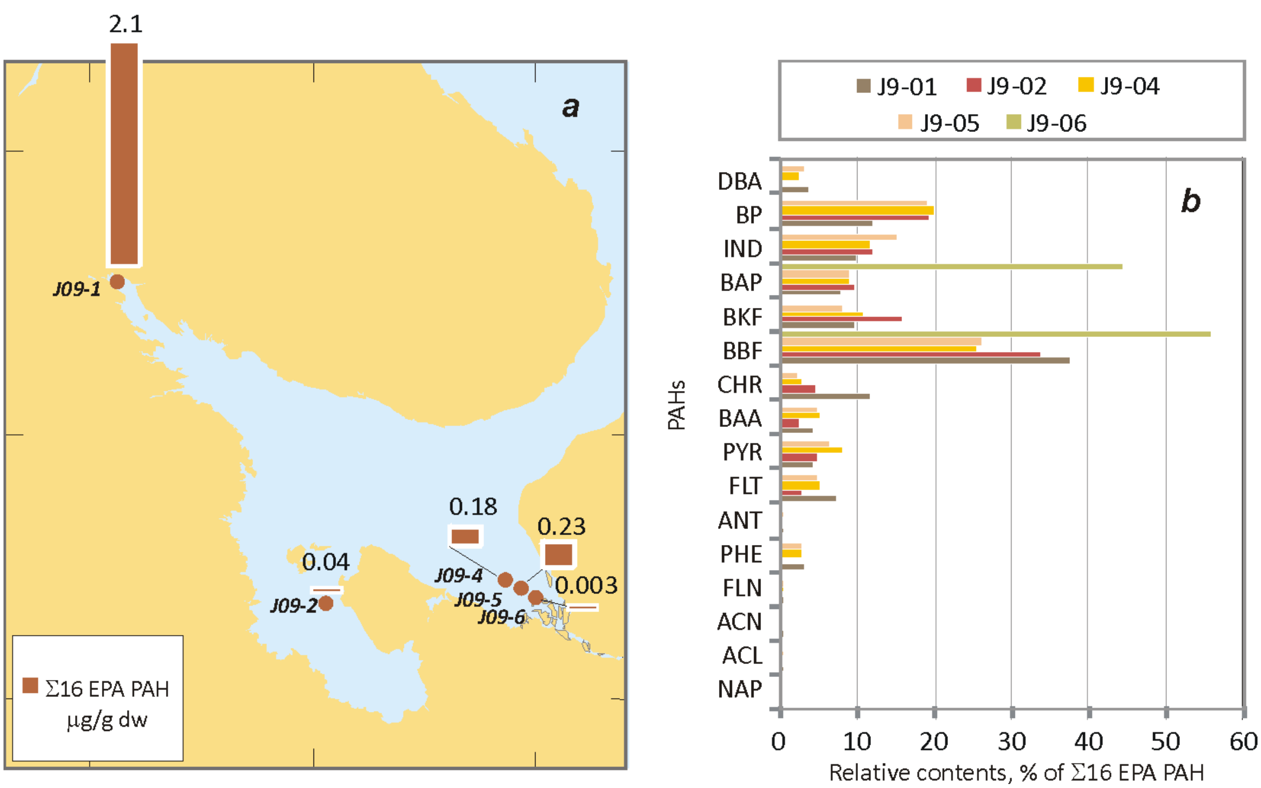

Figure 7. Total concentrations of 16 EPA PAH (ng/g dry weight)(a)) and PAH patterns (b) in sediments from the White Sea in 2009.

4.2.3 Geographic differences in POPs levels

Comparison of sediment POP concentrations expressed per unit of organic carbon has shown that the highest levels of Σ16 EPA PAH and ΣDDT were found at station located at the inner parts of Kandalaksha Bay while the highest levels of the other contaminants studied were found in sediments from Dvina Bay (*Figure 8*).

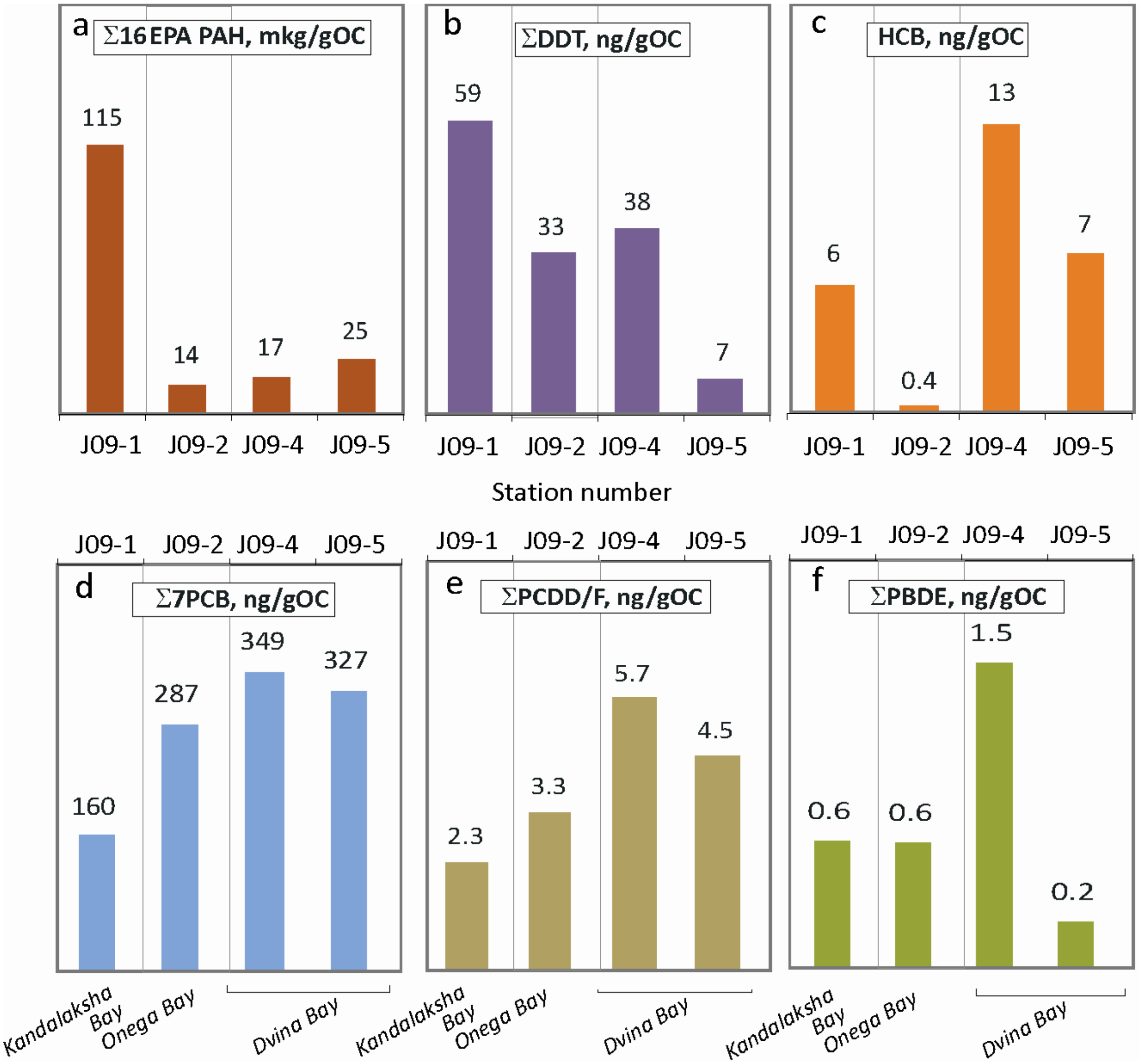

Figure 8. Concentrations of POPs (ng/gOC) in sediments from the White Sea, 2009.

4.2.4 Trace elements in sediments

Results of trace elements determinations in sediments from the White Sea are presented in *Table 5* and in *Appendix 2* along with QA/QC data *(Table 2.14, Table 2.15)*. Regional distribution of trace elements in sediments is presented in *Figure 9*.

Table 5. Trace elements (mg/kg dry weight) in surface sediment samples (0-1 cm) from the White Sea, 2009 and classification of contamination levels according to SFT, 2007.

Element	Kandalaksha Bay	Onega Bay	Dvina Bay		
	J9-01	J9-02	J9-04	J9-05	J 9-06
As	31.3	7.88	31.8	28.7	13.0
Zn	78.7	41.3	103	88.7	16.5
Cu	28.8	9.13	20.2	18.6	2.91
Cd	0.078	0.034	0.142	0.052	0.015
Pb	36.8	11.5	26.6	19.4	9.45
Hg	0.030	0.017	0.019	0.099	0.022

I (Background) II (Good)

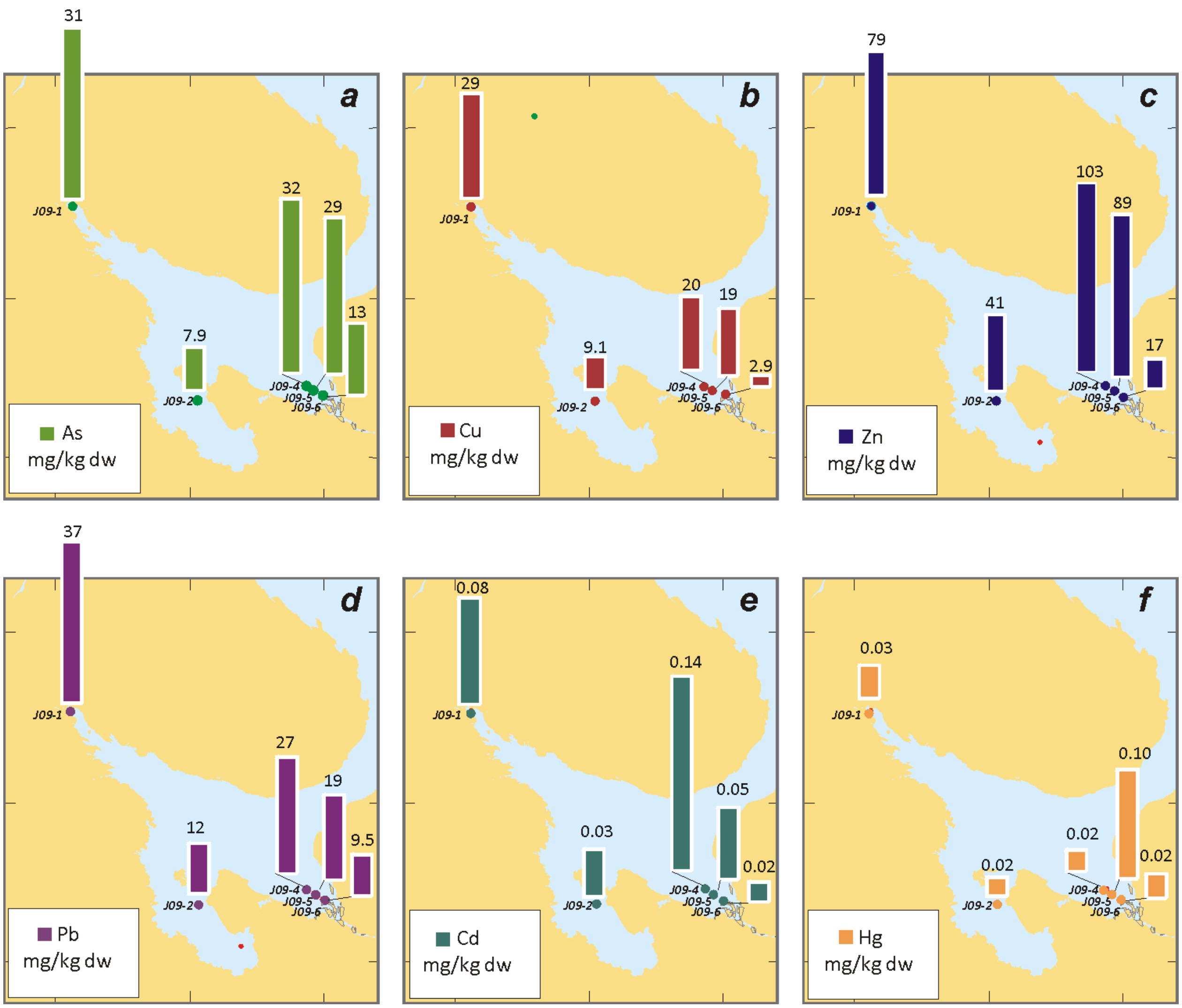

Figure 9. Trace elements (mg/kg dry weight) in surface sediments (0-1 cm) from the White Sea in 2006 and 2008.

Arsenic concentrations in sediments ranged from 7.88 to 31.8 mg/kg dry weight (*Table 5*). Highest concentrations of this element, corresponding to "good status" (Class II of contamination, 20-52 mg/kg) were found in sediments from the inner parts of Kandalaksha Bay and from Dvina Bay (stations J9-01, J9-04 and J9-05).

Copper (Cu) concentrations were at background levels in all five sediment samples analysed *(Table 5)*. The highest level of Cu (28.8 mg/kg dry weight) was detected in sediments from the inner parts of Kandalaksha Bay (station J9-01).

Lead (Pb) concentrations in sediments ranged from 9.45 mg/kg to 36.8 mg/kg dry weight. The highest Pb concentration, corresponding to Class II contamination, was detected in sediments from the inner parts of Kandalaksha Bay *(Figure 8d)*. Background Pb level was typical for all other samples analysed (*Table 5*).

Zinc (Zn) concentrations in all surface sediment samples analysed were at background levels (<150 mg/kg dry weight) (*Table 5*)

Cadmium (Cd) concentrations in 2009 ranged from 0.015 to 0.142 mg/kg dry weight (*Figure 8e*) remaining at the background level (*Table 5*).

Mercury (Hg) concentrations in sediments varied between 0.017 and 0.10 mg/kg dry weight and corresponded to the background level (*Table 5*).

4.3 Contamination levels in biota

4.3.1 POPs in biota

Results of POPs determinations in biological samples along with QA/QC data are presented in *Appendix 3* and summarized in *Table 6.*

Table 6. Persistent organic pollutants and TCDD toxic-equivalents (TEQ) in soft tissues of blue mussel and liver of cod from the White Sea, 2009. Classification of contaminant concentrations found were according to the SFT system (2007),

Contaminant	Units	Blue mussel, soft tissue			Cod, liver		
		Mean	±	S.D.	Mean	±	S.D.
HCB	ng/g ww	0.078	±	0.05	11.9	±	0.42
[a]ΣHCH	ng/g ww	<0.05			3.46	±	0.26
[b]ΣChlordanes	ng/g ww	0.053	±	0.08	96.2	±	7.65
[c]ΣDDT	ng/g ww	0.177	±	0.04	98.9	±	6.03
[d]Σ7PCB	ng/g ww	0.621	±	0.254	262	±	17.0
ΣPCDD	pg/g ww	<0.1			<0.1		
ΣPCDF	pg/g ww	<0.1			5.14		0.467
[e]ΣPBDE	ng/g ww	<5.0			2227	±	33.5
[f]Σ16PAH	ng/g ww	0.944	±	0.434	1.65	±	0.191
Benzo(*a*)pyrene	ng/g ww	<1.0			<1.0		
TEQ_{PCB}	pgTEQ/g ww	<0.0001			0.250	±	0.020
$TEQ_{PCDD/F}$	pgTEQ/g ww	<0.001			0.721	±	0.081
Total TEQ	pgTEQ/g ww	<0.0001			0.971	±	0.100

Class I - Insignificant contamination

[a]ΣHCH = sum of α-, β- and γ-HCH; [b]ΣChlordanes = sum of heptachlor, heptachlor epoxide, oxychlordane, *trans*-chlordane, *cis*-chlordane, *trans*-nonachlor, and *cis*-nonachlor; [c]ΣDDT = sum of *o,p'*-DDE, *p,p'*-DDE, *o,p'*-DDD, *p,p'*-DDD, *o,p'*-DDT, and *p,p'*-DDT; [d]Σ7PCB = sum of PCB-28, 52, 101, 118, 138, 153, and 180; [e]ΣPBDE= sum of BDE-17, 28, 49, 71, 47, 66, 100, 99, 85, 154, 153, 138, 183 and 190; [f]Σ16PAH = sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(*a*)anthracene, chrysene, benzo(*b+j*)fluoranthene, benzo(*k*)fluoranthene, benzo(*a*)pyrene, indeno(1,2,3-*c,d*)pyrene, benzo(*g,h,i*)perylene and, dibenzo(*a,h*)anthracene.

According to SFT classification (Molvær *et al.*, 1997), levels of all persistent organic pollutants measured in soft tissues of blue mussel and liver of cod from the White Sea in 2009 correspond to the Class I ("insignificant") contamination (*Table 6*) and meet the Russian (Anon., 2002) and EC hygienic requirements for foodstuff (Anon, 2006).

The results determinations of the POPs in blue mussels and cod liver obtained in 2009 have been compared with those found in the animals collected from the same sites in 2006 and 2008 (Savinova et al., 2006; 2008).

Blue mussel

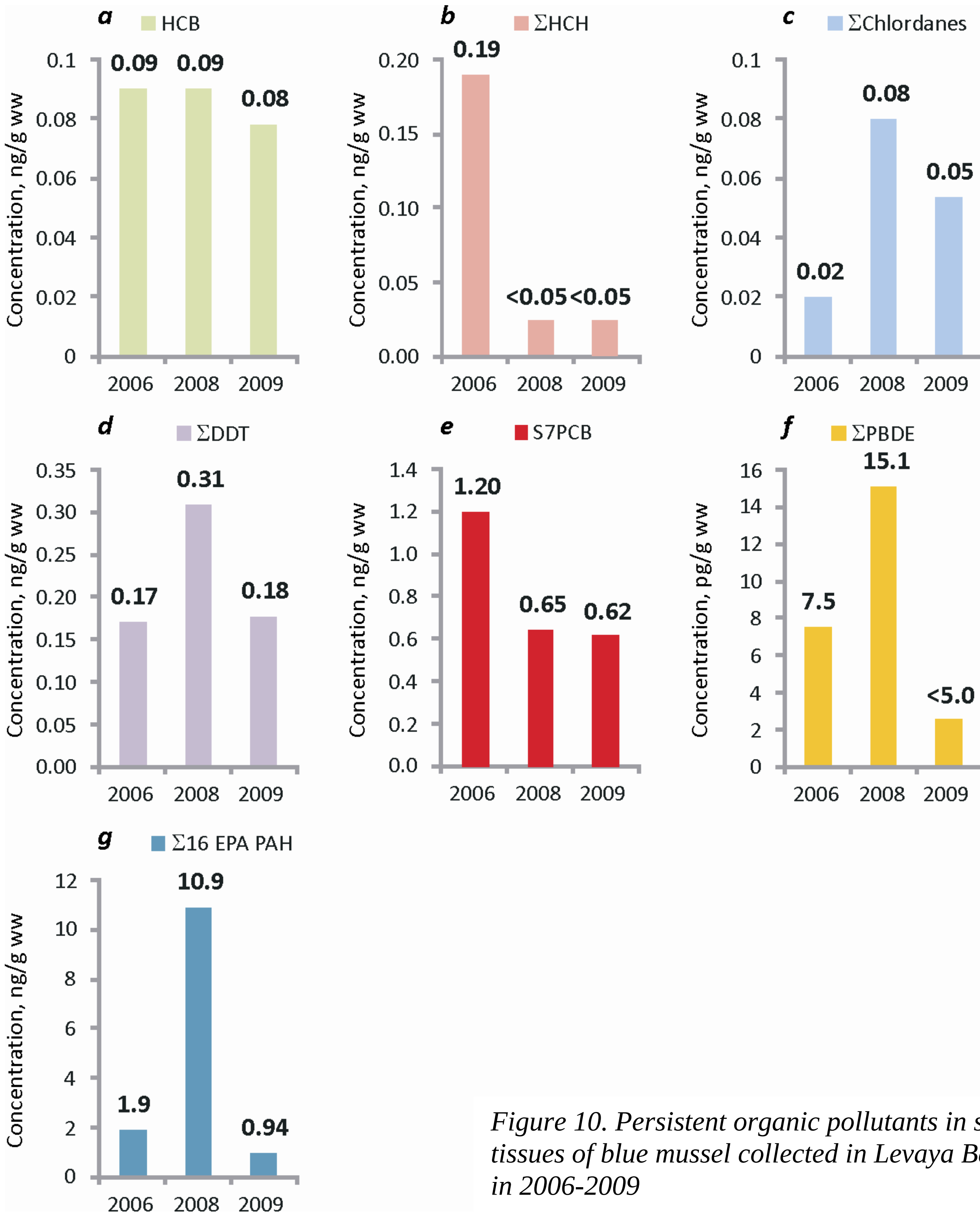

Figure 10. Persistent organic pollutants in soft tissues of blue mussel collected in Levaya Bay in 2006-2009

Like in 2006 and 2008, concentrations of polychlorinated dibenzo-p-dioxins and furans and hexachlorocyclohexanes in soft tissues of blue mussel collected in 2009 were below the MDL in all samples analysed (*Table 6*). HCB and Σ7PCB concentration measured in soft tissues of blue mussel collected in 2009 were quite similar to those found in 2008 (*Figure 10a,e*), while concentrations of all other studied persistent organic pollutants (ΣChlordanes, ΣDDT, Σ16 EPA

PAH and ΣPBDE) have decreased in two or more times as compared with levels found in 2008 (*Figure 10c,d,f,g*).

<u>*Cod*</u>

Comparison between concentrations of chlorinated pesticides in liver of cod collected in the 2008-2009 has shown that HCB and ΣHCH concentrations remained at the same level, while concentrations of ΣChlordanes and ΣDDT have increased (*Figure 11*) due to higher levels of oxychlordane and *p,p'*-DDT, respectively (*Figure 11c, d).*

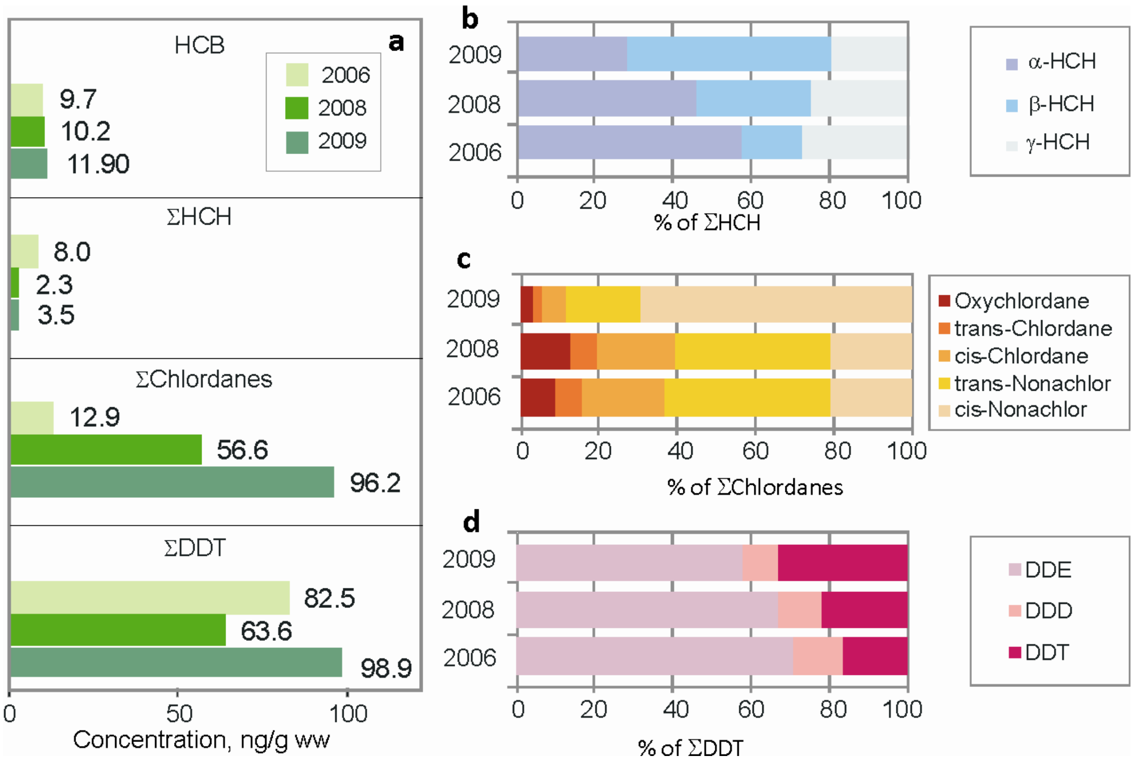

Figure 11. Concentrations of organochlorines (ng/g wet weight) (a) and patterns of HCH (b), chlordanes (c) and DDT family compounds (d) in liver of cod from the White Sea in 2006 - 2009.

Cod hepatic concentrations of Σ7PCB measured in 2009 and in 2008 as the PCB patterns found in liver of cod collected in these years were quite similar; PCB-153, 138 and 118 were the most abundant congeners (*Figure 12a,b*).

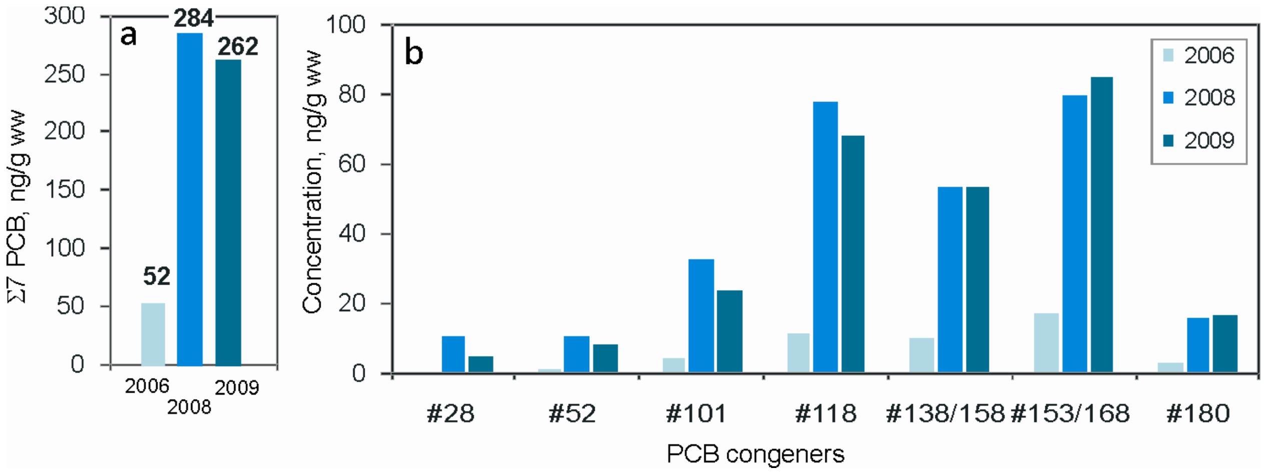

Figure 12. Concentrations of Σ7PCBs (a) and PCB congeners (b) (ng/g wet weight) in liver of cod from the White Sea in 2006 - 2009.

In 2009, cod hepatic ΣPBDE concentrations were half of those found in 2008 (*Figure 13a*). Concentrations of ten of the 14 measured PBDE congeners were above the method detection limit (MDL). However, relative contents of *tri*-BDEs #17, #28, *terta*BDE-66 and *penta*-BDEs #99 and #85 did not exceed 3% of ΣPBDE. In 2009, the major PBDE congeners were *terta*-BDEs #71 (9.5%), #49 (12.3%) and #47 (34.4%), *penta*-BDE-100 (16.4%) and *hexa*-BDE-154 (17.7%) (*Figure 13 b*).

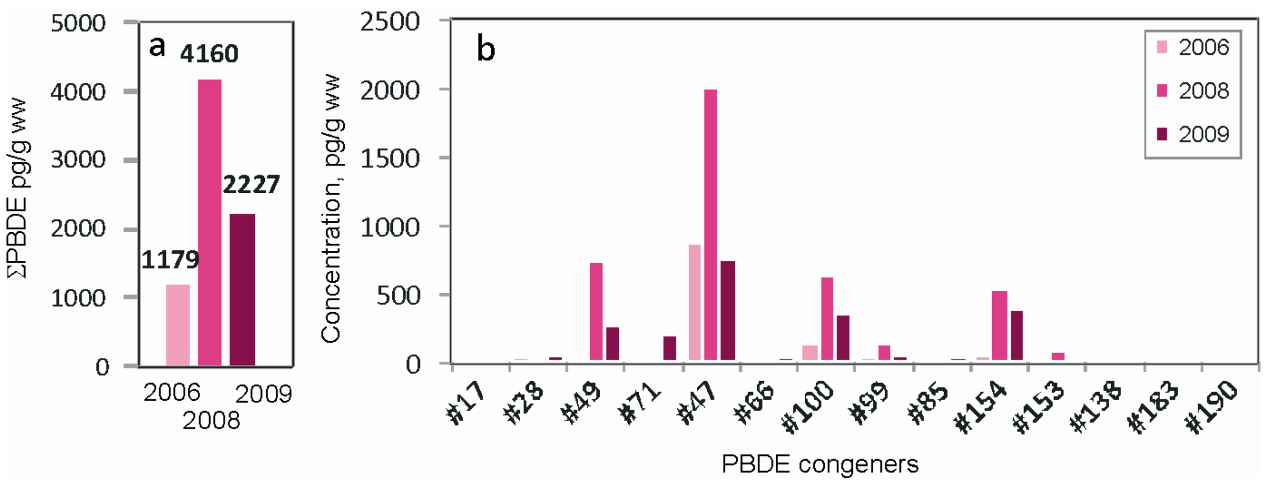

Figure 13. Concentrations of ΣPBDEs (a) and PBDE congeners (b) (pg/g wet weight) in liver of cod from the White Sea in 2006 - 2009.

In liver of cod collected in 2009, the concentrations of only two of the 16 measured PAH compounds (fluorene and anthracene) were found to be above the MDL (*Figure 14b*). Compared to 2008, Σ16 EPA PAH concentrations have been halved (*Figure 15a*).

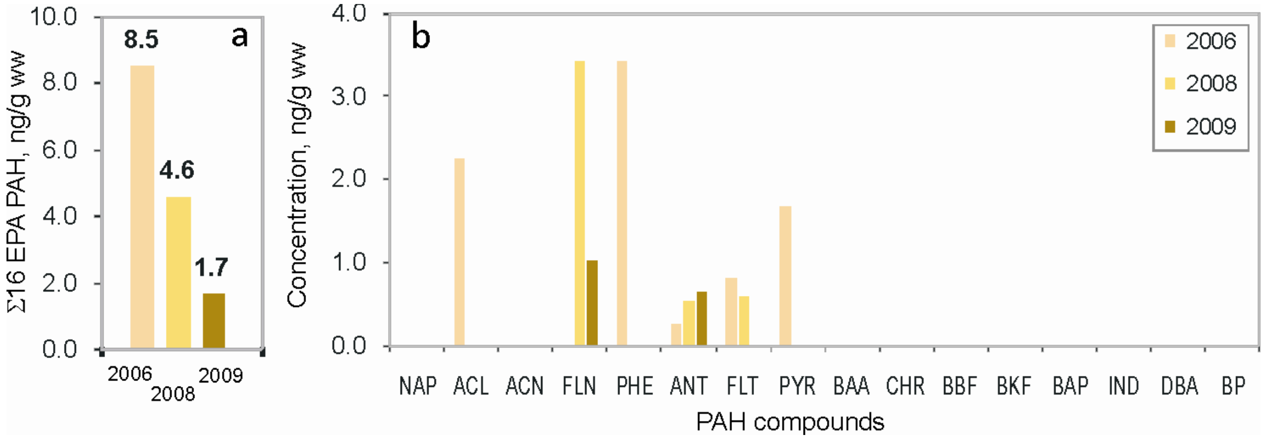

Figure 14. Concentrations of Σ16 EPA PAH (a) and PAH compounds (b)(ng/g ww) in hepatic tissues of cod from the White Sea collected in 2006 – 2009.

Concentrations of all polychlorinated dibenzo-p-dioxins measured in hepatic tissues of cod collected in 2009 were below the detection limit (*Figure 15b*). In 2009, cod hepatic concentrations of polychlorinated dibenzo-p-furans (ΣPCDF) were three times higher as compared to 2008 but lower than in 2006 (*Figure 15a*). Tetra- and penta-CDF were the most abundant PCDF congeners (*Figure 15b*).

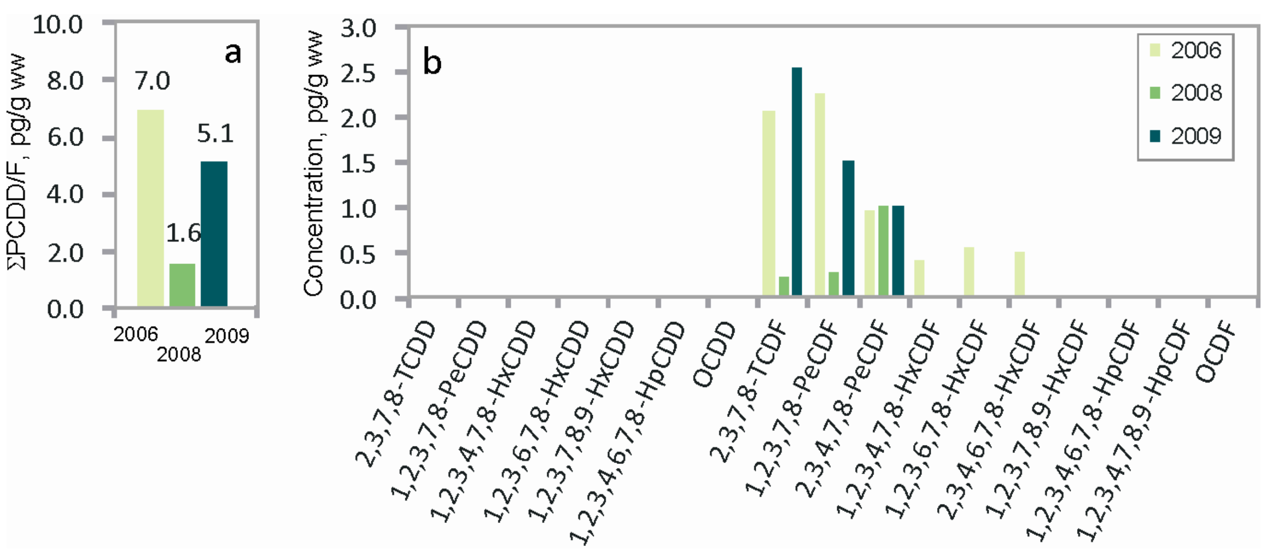

Figure 15. Concentrations of ΣPCDD/F (a) and PCDD/F congeners (b) (pg/g ww) in hepatic tissues of cod from the White Sea collected in 2006 – 2009.

Compared to 2008, toxic TCDD-equivalent of PCDD/Fs ($TEQ_{PCDD/F}$) calculated for hepatic tissues of cod collected in 2009 have increased, while TEQ levels of dioxin-like PCB congeners (TEQ_{PCB}) have noticeably decreased (*Figure 16*). In all, total TEQ has decreased from 2.19 pgTEQ/g wet weight (2008) to 0.97 pgTEQ/g wet weight (2008).

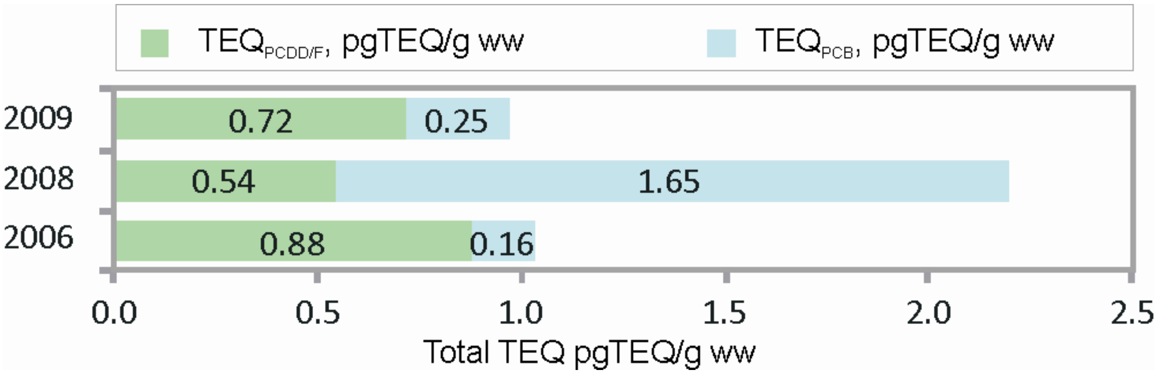

Figure 16. TCDD toxic equivalents (pgTEQ/g wet weight) calculated for hepatic tissues of cod from the White Sea in 2006 – 2009 according to (Van den Berg et al., 1998).

4.3.2 Trace elements in biota

Results of trace elements determinations in biological samples are presented *Table 7;* QA/QC data is presented in *Appendix 3.*

Table 7. Trace elements (mg/kg wet weight) in cod muscles and soft tissues of blue mussel from the White Sea, 2009.

Trace elements	Blue mussel, soft tissues			Cod, muscle
As	2.1	±	0.1	2.2
Zn	11.2	±	0.9	5.1
Cu	0.9	±	0.1	0.7
Cd	0.13	±	0.03	0.003
Pb	0.02	±	0.01	0.01
Hg	0.05	±	0.01	0.07

I Insignificant contamination

Concentrations of all heavy metals in both soft tissues of blue mussel and liver of cod collected in 2009 all showed insignificant levels of contamination (*Table 7*).

The results trace elements in soft tissues of blue mussels and cod muscles obtained in 2009 have been compared with those found in the animals collected from the same sites in 2006 and 2008 (Savinova et al., 2006; 2008).

Concentrations of trace elements in blue mussel found in 2009 were similar (mercury) or lower (all other studied elements) as compared with 2008 levels (*Figure 18*).

Comparison between heavy metal concentrations in cod muscles collected in 2008 and 2009 showed noticeable increase in concentration of zinc, copper, cadmium and mercury (*Figure 19a, b, c. e*), while arsenic concentrations remained at the same level and lead concentration slightly decreased (*Figure 19 d, f*).

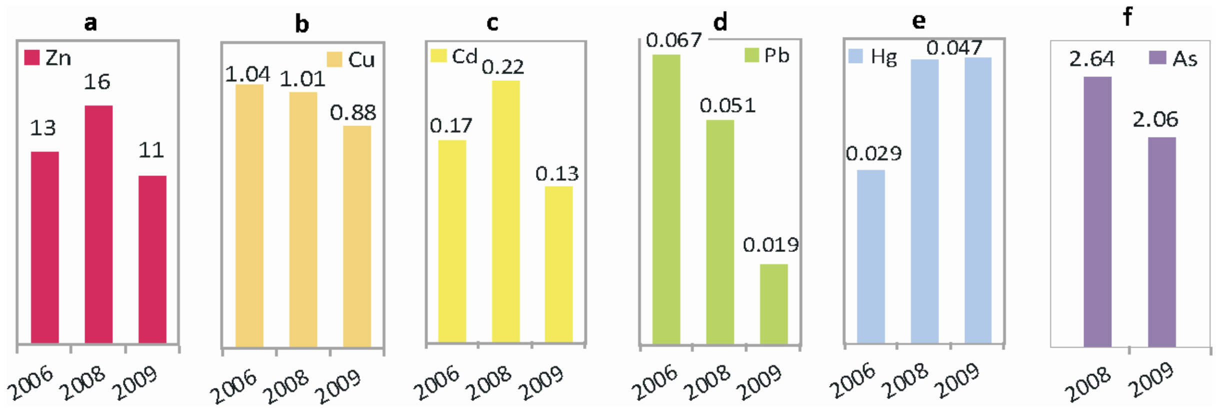

Figure 18. Trace elements (mg/kg wet weight) in blue mussel from the White Sea in 2006 - 2009.

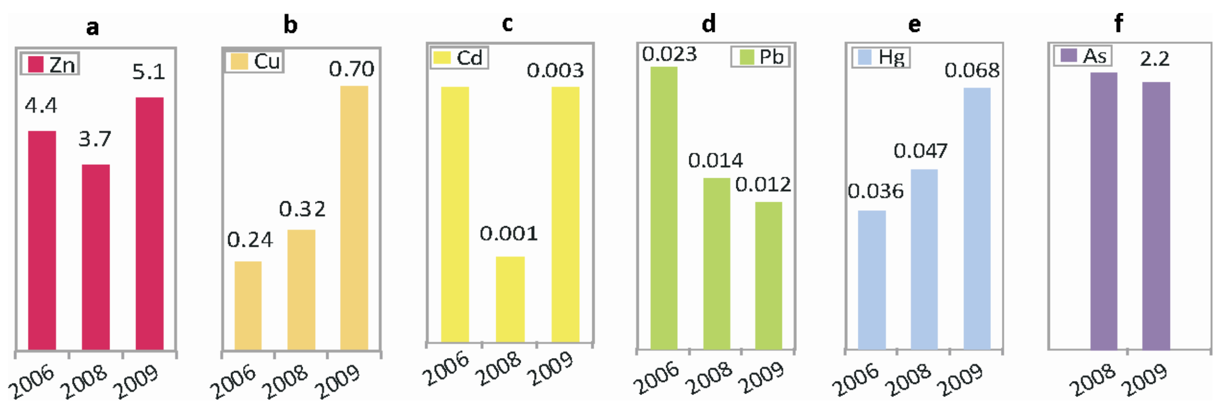

Figure 19. Trace elements (mg/kg wet weight) in cod muscles from the White Sea in 2006 - 2009.

5 Inter-calibration

Analytical laboratories of SPA Typhoon and NW Typhoon took part in 58 Round of QUASIMEME Laboratory Performance Studies (2009).

NW Typhoon participated in exercises on determination of trace elements, chlorinated hydrocarbons and PAHs in sediments. The results of Inter-calibrations are presented in Appendix 5 and available on QUASIMEME home page (http://www.quasimeme.org/nl/25222726-Home.html.)

Trace elements: 63% of concentrations were measured with satisfactory accuracy (including Cd, Cu, Cr, Pb, Ng, Zn, Fe), 12% of the results are questionable and 25% of the results are unsatisfactory. Erroneous values for Al and Cr were obtained as a result of insufficient extraction of the elements; errors in measuring the concentration of As associated with its losses. Errors in the determination of nickel associated with contamination of samples during processing. Currently identified causes of errors are eliminated.

Chlorinated hydrocarbons: Over 66% of concentrations were determined with satisfactory accuracy, 12% are questionable, and 22% of the results are unsatisfactory. Errors in the determination of *p,p'*-DDD and PCB # 105 due to an error of identification of these components in determining PCB # 180 there is insufficient extraction of this component.

PAH: Results for polycyclic aromatic hydrocarbons are generally unsatisfactory, the errors caused by a pump and dynamic mixer of liquid chromatograph, because of the uneven flow of the gradient of the time for the components were totally be reproduced.

After the necessary repairs, analyses will be repeated.

SPA Typhoon participated in exercises on determination of PCDD/Fs and planar PCBs in biotic samples. Because of the delays associated with delivery test materials, the results of determinations (Appendix 5) have been sent to QUASIMEME January, 29 (deadline is January, 31) and soon, they can be available on QUASIMEME home page.

The results of Inter-calibrations will be presented and discussed during the Project Workshop in April-May 2010.

6 Conclusions

- Polycyclic aromatic hydrocarbons are the major contaminants in the White Sea surface sediments (0-1 cm).
- Surface sediment samples from the inner parts of Kandalaksha Bay were the most contaminated by PAHs, corresponding to "moderate contamination" (Class III) for Σ16 EPA PAH. . Benzo(*b+j*)fluoranthene, indeno(1,2,3-*cd*)pyrene and benzo(*g,h,i*)perylene prevailed in PAH composition. Benzo(*a)*pyrene levels from the same site were in Class II of contamination ("good status").
- Σ16 EPA PAH and benzo(*a)*pyrene levels in surface sediments from the other sites studied were all at "background" level (Class I) and in "good status" (Class II), respectively.
- Concentrations of chlorinated pesticides, PCBs, PCDD/Fs ad PBDEs in all sediments analysed were at the I Class contamination except ΣDDT found in sample collected in the inner parts of Kandalaksha Bay where concentrations were in Class II ("good status").
- In general, background levels of trace element were found in all surface sediments from the White Sea. Concentrations of As and Pb found in sediments from the inner parts of Kandalaksha Bay slightly exceeded background levels. In Dvina Bay, levels of As were higher than background levels and can be classified as Class II contamination ("good status").
- According to SFT classification system (Molvær *et al.*, 1997), contamination levels of all persistent organic pollutants and trace elements measured in both blue mussel and cod were "insignificant" and can be classified as Class I contamination.
- HCB, ΣHCH and Σ7PCB concentrations measured in soft tissues of blue mussel collected in 2009 were quite similar to those found in 2008, while concentrations of all other studied persistent organic pollutants (ΣChlordanes, ΣDDT, Σ16 EPA PAH and ΣPBDE) have decreased in two or more times as compared with levels found in 2008.
- Comparison between heavy metal concentrations in cod muscles collected in 2008 and 2009 showed increase in concentrations of zinc, copper, cadmium and mercury, while arsenic concentrations remained at the same level and lead concentrations slightly decreased.
- Comparison between concentrations of chlorinated pesticides in liver of cod collected in the 2008 and 2009 has shown that HCB and ΣHCH concentrations remained at the same level, while concentrations of ΣChlordanes and ΣDDT have increased. In the same time, in 2009, ΣPBDE and Σ16 EPA PAH has been halved as compared with 2008.

- Compared to 2008, toxic TCDD-equivalent of PCDD/Fs calculated for hepatic tissues of cod collected in 2009 has increased while TEQ of dioxin-like PCBs has noticeably decreased to one half.
- Analytical laboratories of SPA Typhoon and NW Typhoon took part in 58 Round of QUASIMEME Laboratory Performance Studies (2009), results will be presented at Project Workshop in 2010.

7 Acknowledgements

The project participants thank the Joint Norwegian-Russian Commission on Environmental protection for initiation of this study and Norwegian Climate and Pollution Agency and Ministry of Nature Resources of Russian Federation for general support and coordination during project implementation.

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9 Appendices

9.1 Appendix 1. Information on samples collected

Table 1.1. Locations of anchor stations of sediment sampling, White Sea, July-August, 2009, and total organic content (TOC) (g/kg dw) and percentage of materials < 0.63 μ in surface (0-1 cm) sediments

Date	Station number	Depth, m	Latitude, N	Longitude, E	Area	TOC g/kg dw	<63 μ %
06.07.09	J09-6	16.5	64°52.543'	39°42.84'	Dvina Bay	0.9	4.7
06.07.09	J09-5	54	64°57.97'	39°31.50'	Dvina Bay	9.37	54.0
06.07.09	J09-4	75	65°06.35'	39°17.17'	Dvina Bay	10.4	75.2
07.07.09	J09-2	64	64°40.97'	36°17.64'	Onega Bay	3.06	23.0
27.08.09	J09-1	43	67°08.15'	32°23.00'	Kandalaksha Bay	18.2	40.6

Table 1.2. Sampling site location and size of blue mussel (Mytilus edulis), White Sea, August 2009

Date	Site	Latitude	Longitude	POPs		HM	
				Length, mm	Number individuals	Length, mm	Number individuals
23.08.09	Kandalaksha Bay, Levaya Bay	66°20.23'	33°39.60'	45-50	50 × 3	45-50	50 × 3

Table 1.3. Sampling site location and biological characteristics of cod (Gadus morhua marisalbi), White Sea, August, 2009.

Data	Area	Latitude N	Longitude E	Length, cm	Sex
22-25.08.09	Kandalaksha Bay, Guba Chupa, Cape Kartesh	66°20.2'	33°39.6'	39.0	M
				43.0	M
				40.0	F
				33.8	M
				39.9	F
				41.8	M
				32.1	F
				34.8	M
				37.8	F
				30.8	F
				38.6	F
				43.0	F
				42.5	M
				33.4	M
				41.6	M
				38.5	F
				28.5	F
				41.9	M
				32.1	F
				29.5	M
				34.3	M
				35.7	F
				40.9	F
				32.9	F
				34.4	F
				28.6	M

9.2 Appendix 2. Analytical data and quality assurance: sediments

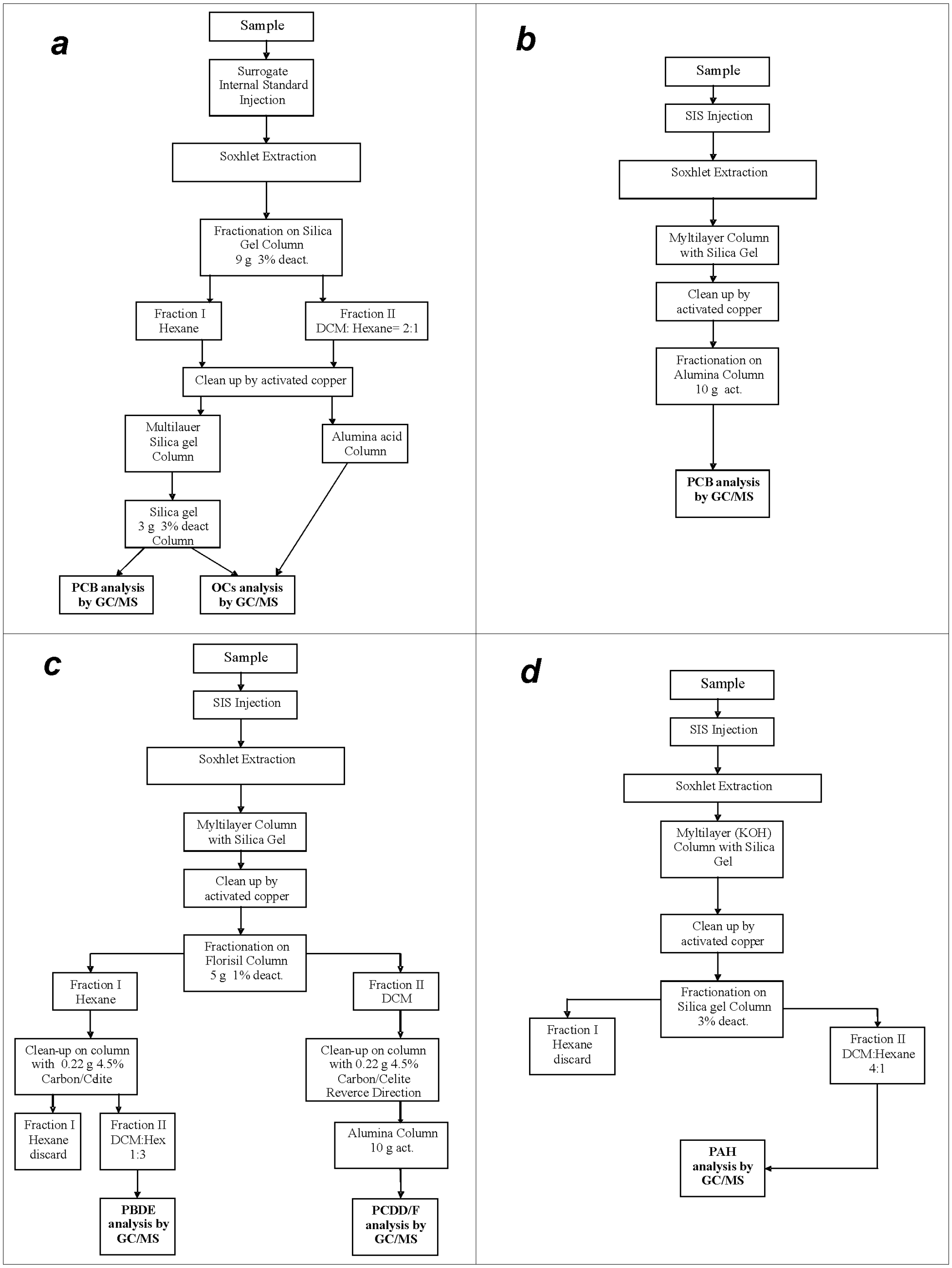

Figure 2.1. Analysis schemes for PCBs, OCs (a), planar PCBs (b), PCDD/PCDFs and PBDEs (c) and PAHs (d)

Table 2.1. QA/QC data report for PCB congeners in sediments

PCBs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Certified Reference Materials of NWRI EC-5	
			Detected, ng/g	Reference Value, ng/g
#1	n.d.	0.02	–	–
#3	n.d.	0.02	–	–
#4/10	n.d.	0.02	–	–
#8	n.d.	0.02	–	–
#19	n.d.	0.02	–	–
#17/18	n.d.	0.02	2.85	3.0 ± 1.1
#15	n.d.	0.02	–	–
#28/31	n.d.	0.04	5.21	5.3 ± 1.3
#54	n.d.	0.05	–	–
#33	n.d.	0.05	–	–
#22	n.d.	0.05	–	–
#52	n.d.	0.02	12.9	13.3 ± 4.1
#49	n.d.	0.02	–	–
#104	n.d.	0.02	–	–
#44	n.d.	0.02	7.55	7.3 ± 2.4
#37	n.d.	0.02	–	–
#74	n.d.	0.02	–	–
#70	n.d.	0.02	–	–
#95	n.d.	0.02	–	–
#155	n.d.	0.02	–	–
#101	n.d.	0.05	23.1	24.6 ± 6.0
#99	n.d.	0.02	–	–
#119	n.d.	0.02	–	–
#87	n.d.	0.02	8.64	9.6 ± 1.4
#110	n.d.	0.10	25.1	33.3 ± 11.9
#151	n.d.	0.02	–	–
#149	0.04	0.02	–	–
#188	n.d.	0.02	–	–
#153/168	n.d.	0.02	23.6	27.2 ± 5.5
#138/158	n.d.	0.05	25.1	28.6 ± 9.1
#178	n.d.	0.05	–	–
#187	n.d.	0.05	–	–
#183	n.d.	0.05	7.31	7.2 ± 2.8
#128	n.d.	0.05	6.93	5.5 ± 2.3
#177	n.d.	0.05	–	–
#202	n.d.	0.05	–	–
#171	n.d.	0.05	–	–
#201	n.d.	0.05	–	–
#191	n.d.	0.02	–	–
#199	n.d.	0.05	–	–
#208	n.d.	0.05	–	–
#194	n.d.	0.02	8.55	8.1 ± 10.1
#205	n.d.	0.05	–	–
#206	n.d.	0.05	2.12	2.2 ± 0.9
#209	n.d.	0.10	1.21	1.2 ± 0.9
Surrogate Internal Standards, % Recovery			*Surrogate Internal Standards, % Recovery*	
#28 [CL3] C^{13}	*83*	0.02	*81*	
#52 [CL4] C^{13}	*84*	0.02	*81*	
#101 [CL5] C^{13}	*75*	0.02	*80*	
#153 [CL6] C^{13}	*75*	0.02	*78*	
#138 [CL6] C^{13}	*76*	0.02	*77*	
#180 [CL7] C^{13}	*80*	0.02	*81*	
#209 [CL10] C^{13}	*91*	0.02	*84*	

Table 2.2. QA/QC data report for non- and mono-ortho-substituted congeners of PCBs in sediment

PCBs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Certified Reference Materials of NWRI EC-5	
			Detected, ng/g	Reference Value, ng/g
#CL4 81	n.d.	0.01	–	–
#CL4 77	n.d.	0.01	–	–
#CL5 123	n.d.	0.01	–	–
#CL5 118	0.04	0.02	13.6	17.0 ± 7.4
#CL5 114	n.d.	0.01	–	–
#CL5 105	n.d.	0.03	7.55	7.6 ± 2.7
#CL5 126	n.d.	0.01	–	–
#CL6 167	n.d.	0.02	–	–
#CL6 156	n.d.	0.01	–	–
#CL6 157	n.d.	0.02	–	–
#CL6 169	n.d.	0.01	–	–
#CL7 180	n.d.	0.01	21.6	22.3 ± 7.6
#CL7 170	n.d.	0.01	11.3	10.1 ± 1.6
#CL7 189	n.d.	0.01	–	–
Surrogate Internal Standards, % Recovery			*Surrogate Internal Standards, % Recovery*	
# 81[CL4] C^{13}	*111*	0.005	*75*	
# 77[CL4] C^{13}	*117*	0.005	*102*	
# 123[CL5] C^{13}	*107*	0.005	*82*	
# 118 [CL5]C^{13}	*102*	0.005	*80*	
# 114 [CL5]C^{13}	*75*	0.005	*79*	
# 105 [CL5]C^{13}	*106*	0.005	*84*	
# 126[CL5] C^{13}	*105*	0.005	*79*	
# 167[CL6] C^{13}	*111*	0.005	*81*	
# 156 [CL6]C^{13}	*116*	0.005	*85*	
# 157[CL6] C^{13}	*125*	0.005	*82*	
# 169[CL6] C^{13}	*110*	0.005	*80*	
# 180[CL7] C^{13}	*106*	0.005	*78*	
# 170[CL7] C^{13}	*117*	0.005	*85*	
# 189[CL7] C^{13}	*125*	0.005	*88*	

Table 2.3. Polychlorinated biphenyls (ng/g dry weight) in surface sediments from the White Sea, 2009. Non- and mono-ortho substituted congeners are marked by italic

PCBs	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
#1	<0.02	<0.02	<0.02	<0.02	<0.02
#3	<0.02	<0.02	<0.02	<0.02	<0.02
#4/10	<0.02	<0.02	<0.02	<0.02	<0.02
#8	<0.02	<0.02	<0.02	<0.02	<0.02
#15	<0.02	<0.02	<0.02	<0.02	<0.02
#17/18	<0.02	<0.02	<0.02	<0.02	<0.02
#19	<0.02	<0.02	<0.02	<0.02	<0.02
#22	<0.05	<0.05	<0.05	<0.05	<0.05
#28/31	<0.04	**0.27**	**0.74**	**0.39**	<0.04
#33	<0.05	<0.05	<0.05	<0.05	<0.05
#37	<0.02	<0.02	<0.02	<0.02	<0.02
#44	<0.02	<0.02	**0.15**	**0.17**	<0.02
#49	<0.02	<0.02	**0.23**	**0.20**	<0.02
#52	<0.02	**0.03**	**0.28**	**0.24**	<0.02

PCBs	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
#54	<0.05	<0.05	<0.05	<0.05	<0.05
#70	<0.02	**0.04**	**0.64**	**0.49**	**0.05**
#74	<0.02	**0.02**	**1.84**	**0.17**	**0.03**
#77	<0.01	<0.01	<0.01	<0.01	<0.01
#81	<0.01	<0.01	<0.01	<0.01	<0.01
#87	<0.02	<0.02	**0.28**	**0.23**	<0.02
#95	**0.25**	**0.10**	**0.35**	**0.30**	**0.05**
#99	**0.30**	**0.05**	**0.29**	**0.25**	**0.04**
#101	**0.57**	**0.10**	**0.42**	**0.37**	**0.10**
#104	<0.02	<0.02	<0.02	<0.02	<0.02
#105	**0.40**	**0.20**	**0.64**	**0.40**	**0.11**
#110	**0.84**	**0.17**	**0.68**	**0.61**	<0.10
#114	<0.01	<0.01	<0.01	<0.01	<0.01
#118	**1.14**	**0.25**	**0.92**	**0.69**	**0.12**
#119	<0.02	<0.02	<0.02	<0.02	<0.02
#123	**0.02**	<0.01	<0.01	**0.02**	<0.01
#126	<0.01	<0.01	<0.01	<0.01	<0.01
#128	<0.05	**0.08**	**0.32**	**0.35**	<0.05
#138/158	**0.59**	**0.10**	**0.53**	**0.60**	**0.08**
#149	<0.02	**0.07**	**0.33**	**0.49**	**0.02**
#151	<0.02	<0.02	<0.02	**0.25**	<0.02
#153/168	**0.61**	**0.11**	**0.60**	**0.62**	**0.06**
#155	<0.02	<0.02	<0.02	<0.02	<0.02
#156	**0.02**	<0.01	<0.01	**0.05**	<0.01
#157	<0.02	<0.02	<0.02	<0.02	<0.02
#167	**0.04**	<0.02	<0.02	**0.02**	<0.02
#169	<0.01	<0.01	<0.01	<0.01	<0.01
#170	<0.01	<0.01	<0.01	<0.01	<0.01
#171	<0.05	<0.05	<0.05	<0.05	<0.05
#177	<0.05	<0.05	<0.05	<0.05	<0.05
#178	<0.05	<0.05	<0.05	<0.05	<0.05
#180	<0.01	<0.01	**0.13**	**0.15**	**0.01**
#183	<0.05	<0.05	<0.05	<0.05	<0.05
#187	<0.05	<0.05	<0.05	**0.16**	<0.05
#188	<0.02	<0.02	<0.02	<0.02	<0.02
#189	<0.01	<0.01	<0.01	<0.01	<0.01
#191	<0.02	<0.02	<0.02	<0.02	<0.02
#194	<0.02	<0.02	<0.02	<0.02	<0.02
#199	<0.05	<0.05	<0.05	<0.05	<0.05
#201	<0.05	<0.05	<0.05	<0.05	<0.05
#202	<0.05	<0.05	<0.05	<0.05	<0.05
#205	<0.05	<0.05	<0.05	<0.05	<0.05
#206	<0.05	<0.05	<0.05	<0.05	<0.05
#208	<0.05	<0.05	<0.05	<0.05	<0.05
#209	<0.10	<0.10	<0.10	<0.10	<0.10
[a]Σ7PCB	**2.91**	**0.88**	**3.63**	**3.06**	**0.37**
[b]Σ10PCB	**3.33**	**1.08**	**4.26**	**3.51**	**0.47**
[c]Σ(n,m-o)PCB	**1.62**	**0.45**	**1.69**	**1.33**	**0.24**
ΣPCB	**4.77**	**1.61**	**9.39**	**7.22**	**0.66**

[a]Σ7PCB = sum of PCB-28, 52, 101, 118, 138, 153, and 180; [b]Σ10PCB = sum of PCB-28, 31, 52, 101, 105, 118, 138, 153, 156 and 180; [c]Σ(n,m-o)PCB = sum of PCB-77, 81, 105, 114, 118, 123, 126, 156, 157, 167, , 170 and 180

Table 2.4. QA/QC data t for chlorinated pesticides in sediment samples

Compound	Procedural Blank, ng/g	Method Detection Limit, ng/g	Quality Control Standards Lot No. 324, ng/g		
			Detected	Certified Value	Advisory
HCB	n.d.	0.03	–	–	–
α-HCH	n.d.	0.05	–	–	–
β-HCH	n.d.	0.05	158.0	145	25-213
γ-HCH	n.d.	0.05	121.0	119	70-178
Heptachlor	n.d.	0.05	234.0	297	101-330
Heptachlor epoxide	n.d.	0.10	–	–	–
Oxychlordane	n.d.	0.08	–	–	–
trans-Chlordane	n.d.	0.03	–	–	–
cis-Chlordane	n.d.	0.03	–	–	–
trans-Nonachlor	n.d.	0.01	–	–	–
cis-Nonachlor	n.d.	0.01	–	–	–
o,p\`-DDE	n.d.	0.03	–	–	–
p,p\`-DDE	n.d.	0.03	436.0	455	187-660
o,p\`-DDD	n.d.	0.03	–	–	–
p,p\`-DDD	n.d.	0.03	320.0	334	104-471
o,p\`-DDT	n.d.	0.08	–	–	–
p,p\`-DDT	n.d.	0.08	255.0	287	72-459
Endrin	n.d.	0.10	356.0	407	122-598
Dieldrin	n.d.	0.05	120.0	101	36-147
Mirex	n.d.	0.03	–	–	–
Surrogate Internal Standards, % Recovery			*Surrogate Internal Standards, % Recovery*		
HCB C^{13}	*78*	0.005		*82*	
β-HCH C13	*75*	0.005		*82*	
γ-HCH C^{13}	*78*	0.005		*75*	
Oxychlordane C^{13}	*87*	0.005		*78*	
p,p\`-DDE C^{13}	*83*	0.005		*79*	
p,p\`-DDT C^{13}	*125*	0.010		*88*	

Table 2.5. Organochlorines (ng/g dry weight) in surface sediments from the White Sea, 2009.

OCs	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
HCB	**0.11**	<0.03	**0.14**	**0.07**	**0.06**
α-HCH	<0.05	<0.05	<0.05	<0.05	<0.05
β-HCH	<0.05	<0.05	<0.05	<0.05	<0.05
γ-HCH	<0.05	<0.05	<0.05	<0.05	<0.05
ΣHCH	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide	<0.10	<0.10	<0.10	<0.10	<0.10
Oxychlordane	<0.08	<0.08	<0.08	<0.08	<0.08
trans-Chlordane	<0.03	<0.03	<0.03	<0.03	<0.03
cis-Chlordane	<0.03	<0.03	<0.03	<0.03	<0.03
trans-Nonachlor	<0.01	<0.01	<0.01	<0.01	<0.01
cis-Nonachlor	<0.01	<0.01	<0.01	<0.01	<0.01
ΣCHL	<0.01	<0.01	<0.01	<0.01	<0.01
o,p'-DDE	<0.03	<0.03	<0.03	<0.03	<0.03
p,p'-DDE	**0.48**	<0.03	**0.05**	**0.07**	<0.03
o,p'-DDD	**0.07**	<0.03	**0.04**	<0.03	<0.03
p,p'-DDD	**0.26**	<0.03	0.12	<0.03	<0.03
o,p'-DDT	<0.08	<0.08	<0.08	<0.08	<0.08
p,p'-DDT	**0.27**	**0.1**	**0.18**	<0.08	<0.08
ΣDDT	**1.08**	**0.1**	**0.39**	**0.07**	<0.03
Endrin	<0.10	<0.10	<0.10	<0.10	<0.10
Dieldrin	<0.05	<0.05	<0.05	<0.05	<0.05
Mirex	<0.03	<0.03	<0.03	<0.03	<0.03

Table 2.6. QA/QC data report for polycyclic aromatic hydrocarbons in sediments

PAHs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Certified Reference Materials of NWRI EC-5 Reference Value, ng/g	
			Detected	Reference Value
Naphthalene	n.d.	10.0	21.9	26±6
1-Methylnaphtalene	n.d.	5.00	–	–
2-Methylnaphtalene	n.d.	5.00	–	–
C2-Naphthalenes	n.d.	5.00	–	–
C3-Naphthalenes	n.d.	10.0	–	–
C4-Naphthalenes	n.d.	10.0	–	–
Acenaphthylene	n.d.	0.30	42.1	41±9
Acenaphthene	n.d.	0.30	23.8	29±9
Fluorene	n.d.	0.30	85.6	84±26
C1-Fluorenes	n.d.	0.50	–	–
C2-Fluorenes	n.d.	0.50	–	–
C3-Fluorenes	n.d.	0.70	–	–
Phenanthrene	n.d.	1.00	595	612±57
Anthracene	n.d.	0.50	105	113±17
C1-Phenans/Anths	n.d.	0.60	–	–
C2-Phenans/Anths	n.d.	0.60	–	–
C3-Phenans/Anths	n.d.	0.70	–	–
C4-Phenans/Anths	n.d.	0.70	–	–
Dibenzothiophene	n.d.	0.30	–	–
C1-Dibenzothiophenes	n.d.	0.50	–	–
C2-Dibenzothiophenes	n.d.	0.50	–	–
C3-Dibenzothiophenes	n.d.	0.70	–	–
Fluoranthene	n.d.	0.50	811	823±74
Pyrene	0.61	0.50	932	987±134
C1-Flanths/Pyrs	0.63	0.60	–	–
C2-Flanths/Pyrs	n.d.	0.60	–	–
C3-Flanths/Pyrs	n.d.	0.80	–	–
Benzo(a)anthracene	0.68	0.50	527	503±47
Chrysene	n.d.	0.50	653	619±60
C1-Chrysenes	n.d.	0.70	–	–
C2-Chrysenes	n.d.	0.70	–	–
C3-Chrysenes	n.d.	1.00	–	–
Benzo(b)fluoranthene	n.d.	1.00	426	480±88
Benzo(k)fluoranthene	n.d.	1.00	441	419±49
Benzo(e)pyrene	n.d.	1.00	420	440±76
Benzo(a)pyrene	n.d.	1.00	451	449±61
Perylene	n.d.	1.00	170	187±28
Indeno(1,2,3-c,d) pyrene	n.d.	1.50	379	386±66
Dibenzo(a,h)antracene	n.d.	1.50	194	195±44
Benzo(g,h,i)perylene	n.d.	1.50	322	333±53
Surrogate Internal Standards, % Recovery			*Surrogate Internal Standards, % Recovery*	
Naphthalene d_8	*80*	0.05	*79*	
Acenaphthene d_{10}	*77*	0.05	*79*	
Phenanthrene d_{10}	*78*	0.05	*83*	
Chrysene d_{12}	*82*	0.05	*78*	
Perylene d_{12}	*79*	0.10	*81*	

Table 2.7. Polycyclic aromatic hydrocarbons (ng/g dry weight) in surface sediments from the White Sea, 2009. 16 EPA PAHs are marked by italic.

PAHs	Abbreviation	Area and number of stations				
		Kandalaksha	Dvina Bay			Onega Bay
		J9-01	J9-02	J9-04	J9-05	J9-06
Naphthalene	*NAP*	<10	<10	<10	<10	<10
C1-Naphthalenes	C1N	**8.27**	<5.0	<5.0	<5.0	<5.0
C2-Naphtalenes	C2N	**16.6**	<5.0	<5.0	<5.0	<5.0
C3-Naphtalenes	C3N	**16.1**	<10	<10	<10	<10
C4-Naphtalenes	C4N	<10	<10	<10	<10	<10
Acenaphthylene	*ACL*	**1.59**	<0.3	<0.3	**0.45**	<0.3
Acenaphthene	*CAN*	**3.34**	<0.3	<0.3	<0.3	<0.3
Fluorene	*FLN*	**5.92**	<0.3	**0.60**	**0.84**	<0.3
C1-Fluorenes	C1F	<0.5	<0.5	<0.5	<0.5	<0.5
C2-Fluorenes	C2F	<0.5	<0.5	<0.5	<0.5	<0.5
C3-Fluorenes	C3F	<0.7	<0.7	<0.7	<0.7	<0.7
Phenanthrene	*PHE*	**61.6**	<1.0	**4.81**	**6.25**	<1.0
Anthracene	*ANT*	**11.5**	<0.5	<0.5	**1.06**	<0.5
C1-Phens/Anths	C1P	**33.6**	<0.6	**2.94**	**2.94**	<0.6
C2-Phens/Anths	C2P	**18.1**	<0.6	**0.98**	**1.12**	<0.6
C3-Phens/Anths	C3P	**15.9**	<0.7	1.02	**1.41**	<0.7
C4-Phens/Anths	C4P	**9.95**	<0.7	<0.7	**0.59**	<0.7
Dibenzothiophene	DBT	**2.40**	<0.3	<0.3	n.d.	<0.3
C1-Dibenzothiophenes	C1D	**4.78**	<0.5	<0.5	<0.5	<0.5
C2-Dibenzothiophenes	C2D	**6.17**	<0.5	<0.5	<0.5	<0.5
C3-Dibenzothiophenes	C3D	**2.04**	<0.7	<0.7	<0.7	<0.7
Fluoranthene	*FLT*	**151**	**1.14**	**9.23**	**11.0**	<0.5
Pyrene	*PYR*	**88.4**	**2.08**	**14.4**	**14.4**	<0.5
C1-Flanths/Pyrs	C1FP	**59.2**	**1.12**	**6.98**	**7.85**	<0.6
C2-Flanths/Pyrs	C2FP	**17.6**	<0.6	**1.40**	<0.6	<0.6
C3-Flanths/Pyrs	C3FP	**5.73**	<0.8	<0.8	<0.8	<0.8
Benzo(a)anthracene	*BAA*	**88.5**	**1.10**	**8.94**	**11.16**	<0.5
Chrysene	*CHR*	**240**	**1.90**	**4.77**	**5.02**	<0.5
C1-Chrysenes	C1C	**89.1**	<0.7	**2.90**	**7.81**	<0.7
C2-Chrysenes	C2C	**22.0**	<0.7	<0.7	<0.7	<0.7
C3-Chrysenes	C3C	**4.45**	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	*BBF*	**784**	**14.3**	**45.1**	**60.0**	**1.51**
Benzo(k)fluoranthene	*BKF*	**199**	**6.67**	**18.9**	**18.5**	<1.0
Benzo(e)pyrene	BEP	**444**	**9.90**	**34.7**	**38.1**	**1.05**
Benzo(a)pyrene	*BAP*	**165**	**4.06**	**16.2**	**20.3**	**1.20**
Perylene	PER	**43.0**	**1.94**	**43.2**	**70.7**	<1.0
Indeno(1,2,3-c,d)pyrene	*IND*	**205**	**5.04**	**20.7**	**34.7**	<1.5
Benzo(g,h,i)perylene	*DBA*	**246**	**8.24**	**35.4**	**43.7**	<1.5
Dibenzo(a,h)antracene	*BP*	**76.5**	<1.5	**4.17**	**7.31**	<1.5
Sum of 16 EPA PAHs	Σ16 EPA PAH	**2087**	**42.6**	**179**	**230**	**2.71**
Total PAH	ΣPAH	**3146**	**57.5**	**277**	**365**	**3.76**

Table 2.8. QA/QC data report for polybrominated diphenyl ethers in sediments

PBDEs	Method Detection Limit, pg/g	Procedural Blank, pg/g	Sludge Reference Material IIS-01-1		
			Median Value, pg/g	Detected, pg/g	% REC
TriBDE #17	1.00	n.d.	–	–	–
TriBDE #28	1.00	n.d.	1970	1891.2	*96*
TeBDE #49	1.00	n.d.	3370	2864.5	*85*
TeBDE #71	1.00	n.d.	761	631.6	*83*
TeBDE #47	8.00	n.d.	123200	103488.0	*84*
TeBDE #66	1.00	n.d.	–	–	–
PeBDE #100	1.00	n.d.	29000	28710.0	*99*
PeBDE #99	1.00	n.d.	150000	135000.0	*90*
PeBDE #85	3.00	n.d.	–	–	–
HexBDE #154	3.00	n.d.	12800	13056.0	*102*
HexBDE #153	3.00	n.d.	18400	15640.0	*85*
HexBDE #138	3.00	n.d.	–	–	–
HepBDE #183	5.00	n.d.	9430	9052.8	*96*
HepBDE #190	5.00	n.d.	–	–	–

Table 2.9. Polybrominated diphenyl ethers (pg/g dry weight) in surface sediments from the White Sea, 2009

PBDEs	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
TriBDE #17	<1.0	<1.0	<1.0	<1.0	<1.0
TriBDE #28	**1.43**	<1.0	<1.0	<1.0	<1.0
TeBDE #49	<1.0	<1.0	<1.0	<1.0	<1.0
TeBDE #71	<1.0	<1.0	<1.0	<1.0	<1.0
TeBDE #47	<8.0	<8.0	**12.0**	<8.0	<8.0
TeBDE #66	<1.0	<1.0	<1.0	<1.0	<1.0
PeBDE #100	**1.48**	<1.0	<1.0	<1.0	<1.0
PeBDE #99	**8.68**	**1.92**	**3.43**	**2.30**	**2.46**
PeBDE #85	<3.0	<3.0	<3.0	<3.0	<3.0
HexBDE #154	<3.0	<3.0	<3.0	<3.0	<3.0
HexBDE #153	<3.0	<3.0	<3.0	<3.0	<3.0
HexBDE #138	<3.0	<3.0	<3.0	<3.0	<3.0
HepBDE #183	<5.0	<5.0	<5.0	<5.0	<5.0
HepBDE #190	<5.0	<5.0	<5.0	<5.0	<5.0
ΣPBDE	**11.6**	**1.92**	**15.5**	**2.30**	**2.46**

Table 2.10. QA/QC data report for polychlorinated dibenzo-p-dioxins and furans in sediments

PCDD/Fs	Procedural Blank,	Method Detection Limit, ng/kg	Spiked Blank Sample		
			Detected, ng	Added, ng	%
2,3,7,8-TCDD	n.d.	1.00	0.038	0.04	*96*
1,2,3,7,8-PeCDD	n.d.	0.20	0.17	0.20	*85*
1,2,3,4,7,8-HxCDD	n.d.	0.10	0.16	0.20	*79*
1,2,3,6,7,8- HxCDD	n.d.	0.10	0.17	0.20	*85*
1,2,3,7,8,9- HxCDD	n.d.	0.10	0.16	0.20	*80*
1,2,3,4,6,7,8-HpCDD	n.d.	0.10	0.16	0.20	*79*
OCDD	n.d.	0.10	0.40	0.40	*100*
2,3,7,8-TCDF	n.d.	0.20	0.03	0.04	*85*
1,2,3,7,8-PeCDF	n.d.	0.10	0.19	0.20	*96*
2,3,4,7,8-PeCDF	n.d.	0.10	0.20	0.20	*102*
1,2,3,4,7,8-HxCDF	n.d.	0.10	0.23	0.20	*113*
1,2,3,6,7,8- HxCDF	n.d.	0.10	0.17	0.20	*85*
2,3,4,6,7,8-HxCDF	n.d.	0.10	0.19	0.20	*94*
1,2,3,7,8,9-HxCDF	n.d.	0.10	0.20	0.20	*99*
1,2,3,4,6,7,8-HpCDF	n.d.	0.10	0.18	0.20	*89*
1,2,3,4,7,8,9-HpCDF	n.d.	0.10	0.16	0.20	*80*
OCDF	n.d.	0.10	0.38	0.40	*96*
Surrogate Internal Standards, % Recovery			*Surrogate Internal Standards, % Recovery*		
($^{13}C_{12}$)2,3,7,8-TCDD	*92*	1.00		*99*	
($^{13}C_{12}$)2,3,7,8-TCDF	*87*	0.20		*115*	
($^{13}C_{12}$)1,2,3,7,8-PeCDD	*124*	0.20		*106*	
($^{13}C_{12}$)1,2,3,7,8-PeCDF	*109*	0.10		*98*	
($^{13}C_{12}$)1,2,3,6,7,8- HxCDD	*97*	0.10		*97*	
($^{13}C_{12}$)1,2,3,6,7,8- HxCDF	*101*	0.10		*89*	
($^{13}C_{12}$)1,2,3,4,6,7,8-HpCDD	*97*	0.10		*90*	
($^{13}C_{12}$)1,2,3,4,6,7,8-HpCDF	*105*	0.10		*96*	
($^{13}C_{12}$)OCDD	*116*	0.10		*103*	

Table 2.11. Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (pg/g dry weight) and TCDD toxic-equivalents ($TEQ_{PCDD/F}$) (pgTEQ/g dry weight) calculated according to (WHO, 1998) in surface sediments from the White Sea, 2009

PCDD/Fs	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
2,3,7,8-TCDD	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3,7,8-PeCDD	n.d.	n.d.	n.d.	n.d.	<0.2
1,2,3,4,7,8-HxCDD	<0.2	<0.2	<0.2	<0.2	<0.1
1,2,3,6,7,8-HxCDD	<1.0	<1.0	<1.0	<1.0	<0.1
1,2,3,7,8,9-HxCDD	<1.0	<1.0	<1.0	<1.0	<0.1
1,2,3,4,6,7,8-HpCDD	**5.40**	**0.94**	**7.00**	**5.76**	<0.1
OCDD	**14.0**	**4.78**	**31.0**	**23.7**	<0.1
2,3,7,8-TCDF	**1.46**	<0.2	**2.34**	**1.67**	<0.2
1,2,3,7,8-PeCDF	**1.30**	**0.85**	**0.59**	**0.40**	<0.1
2,3,4,7,8-PeCDF	**2.79**	**0.51**	**1.46**	**1.05**	<0.1
1,2,3,4,7,8-HxCDF	**1.12**	**0.31**	**1.70**	**0.61**	<0.1
1,2,3,6,7,8-HxCDF	**2.21**	**0.32**	**1.41**	**0.87**	<0.1
2,3,4,6,7,8-HxCDF	**1.30**	**0.16**	**1.04**	**0.52**	<0.1
1,2,3,7,8,9-HxCDF	**0.69**	<1.0	**0.36**	<1.0	<0.1
1,2,3,4,6,7,8-HpCDF	**4.68**	**0.96**	**4.67**	**3.02**	<0.1
1,2,3,4,7,8,9-HpCDF	**0.48**	<1.0	**0.47**	<1.0	<0.1
OCDF	**6.02**	**1.37**	**7.60**	**4.68**	<0.1
ΣPCDD	**19.4**	**5.72**	**38.0**	**29.5**	<0.1
ΣPCDF	**22.0**	**4.48**	**21.6**	**12.8**	<0.1
ΣPCDD/F	**41.4**	**10.2**	**59.6**	**42.3**	<0.1
$TEQ_{PCDD/F}$	**1.57**	**0.327**	**0.930**	**0.606**	<0.001

Table 2.12. QA/QC data report for trace elements in sediments

Elements	Procedural Blank, mg/kg	Duplicate Difference, % D	Matrix Spike Recovery, % R	Detection Limit, mg/kg	Marine sediment reference materials, Mess-3, mg/kg	
					Certified Value	Detected Value
As	<0.50	4.6	92.6	0.50	21.2±1.1	19.1
Cd	0.005	13.3	98.4	0.005	0.24±0.01	0.25
Cu	0.35	19.9	82.0	0.10	33.9±1.6	33.4
Pb	0.17	7.3	84.6	0.10	21.1± 0.7	20.2
Hg	<0.005	4.7	93.5	0.005	0.091±0.009	0.088
Li	<4.00	2.9	95.9	4.00	73.6±5.2	72.3
Zn	<0.80	9.7	87.9	0.80	159± 8	143

Table 2.13. Trace elements (mg/kg dry weight) in surface sediments from the White Sea, 2009

Trace elements	Area and number of stations				
	Kandalaksha Bay	Dvina Bay			Onega Bay
	J9-01	J9-02	J9-04	J9-05	J9-06
As	31.3	7.88	31.8	28.7	13.0
Zn	78.7	41.3	103	88.7	16.5
Cu	28.8	9.13	20.2	18.6	2.91
Cd	0.078	0.034	0.142	0.052	0.015
Pb	36.8	11.5	26.6	19.4	9.45
Hg	0.030	0.017	0.019	0.099	0.022
Li	24.9	14.9	39.4	35.4	4.09

9.3 Appendix 3. Analytical data and quality assurance: biota

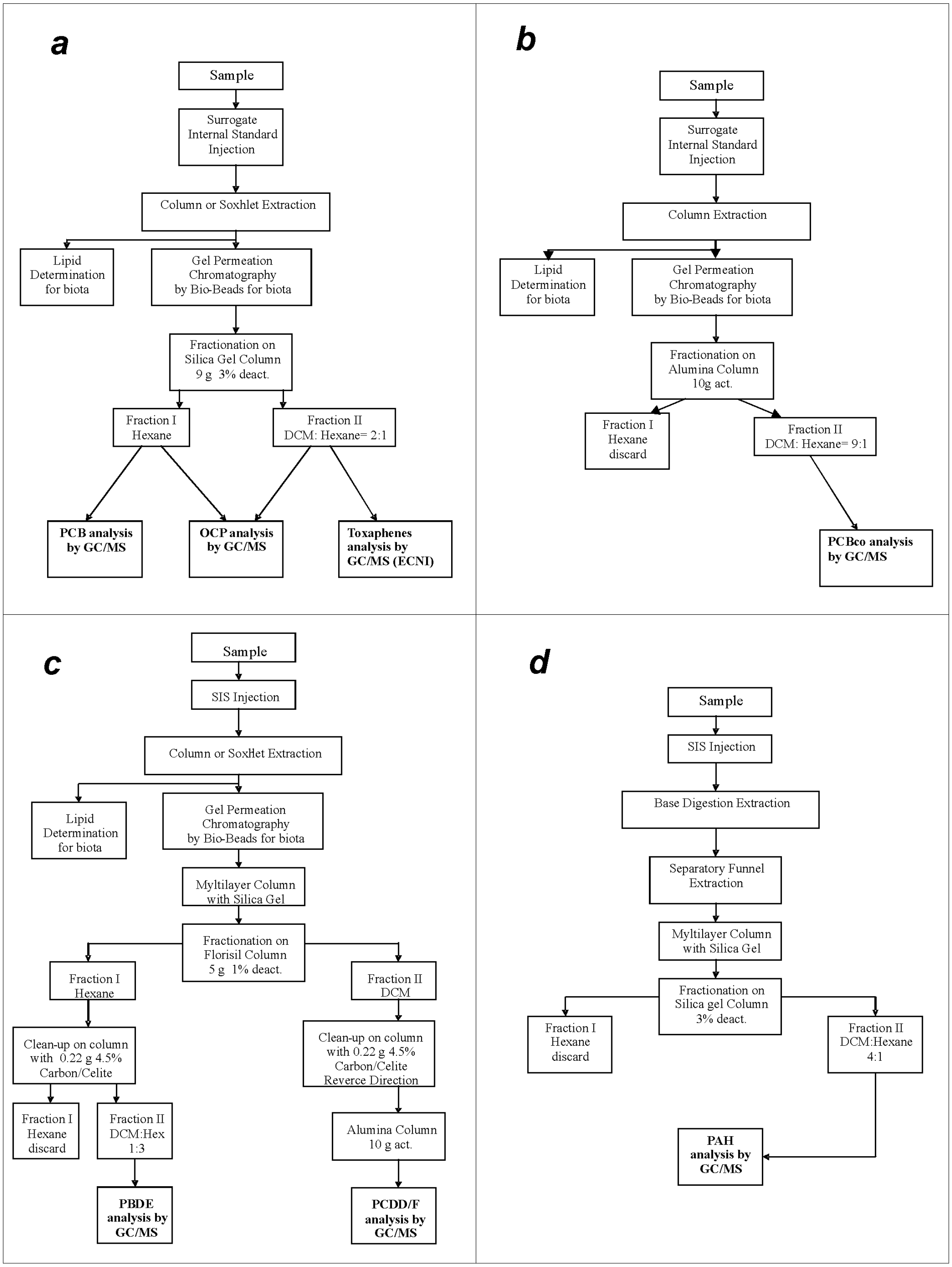

Figure 3.1. Analysis schemes for PCBs, OCs and toxaphenes(a),non- and mono-orthosubstituted PCBs (b) PCDD/PCDFs and PBDEs (c) and PAHs (d)

Table 3.1. QA/QC data report for PCB congeners in biota

PCBs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Duplicate Difference, % D	Standard Reference Material 2974, ng/g	
				Detected	Certified Concentration
#1	n.d.	0.10	–	–	–
#3	n.d.	0.10	–	–	–
#4/#10	n.d.	0.10	–	–	–
#8	n.d.	0.10	–	–	–
#19	n.d.	0.10	–	–	–
#17/#18	n.d.	0.10	–	28.8	26.8 ± 3.3
#15	n.d.	0.10	–	–	–
#28/#31	0.20	0.10	7	152.0	155 ± 15
#54	n.d.	0.10	–	–	–
#33	n.d.	0.10	–	–	–
#22	n.d.	0.10	–	–	–
#52	0.33	0.10	1	120.0	115 ± 12
#49	0.15	0.10	11	89.3	88.8 ± 5.7
#104	n.d.	0.10	–	–	–
#44	n.d.	0.10	13	73.1	72.7 ± 7.7
#37	n.d.	0.10	13	–	–
#74	0.19	0.10	4	–	–
#70	0.32	0.10	1	–	–
#95	0.26	0.10	5	85.6	83 ± 17
#155	n.d.	0.10	–	–	–
#101	0.38	0.10	16	115.0	128 ± 10
#99	0.30	0.10	4	73.9	70.9 ± 4.5
#119	n.d.	0.10	13	–	–
#87	0.27	0.10	4	55.9	54 ± 14
#110	0.32	0.10	7	132.0	127.3 ± 9.4
#151	n.d.	0.10	6	21.5	25.6 ± 3.6
#149	0.22	0.10	6	88.0	87.6 ± 3.5
#188	n.d.	0.10	–	–	–
#153 + #168	0.36	0.10	5	141.6	145.2 ± 8.8
#138 + #158	n.d.	0.10	16	141.0	134 ± 10
#178	n.d.	0.10	2	–	–
#187	n.d.	0.15	2	32.5	34.0 ± 2.5
#183	n.d.	0.15	9	15.3	16.0 ± 2.4
#128	n.d.	0.15	9	23.1	22.0 ± 3.5
#177	n.d.	0.15	11	–	–
#202	n.d.	0.15	22	–	–
#171	n.d.	0.15	15	–	–
#201	n.d.	0.15	25	–	–
#191	n.d.	0.15	12	–	–
#199	n.d.	0.15	19	–	–
#208	n.d.	0.15	–	–	–
#194	n.d.	0.15	–	–	–
#205	n.d.	0.15	–	–	–
#206	n.d.	0.15	–	–	–
#209	n.d.	0.15	–	–	–
Surrogate Internal Standards, % Recovery				*Surrogate Internal Standards, % Recovery*	
#28 [CL3] C^{13}	*84*	0.02	–	*79*	
#52 [CL4] C^{13}	*81*	0.02	–	*83*	
#101 [CL5] C^{13}	*78*	0.02	–	*78*	
#153 C^{13}	*84*	0.02	–	*81*	
#138 C^{13}	*83*	0.02	–	*82*	
#180 [CL7] C^{13}	*83*	0.02	–	*75*	
#209 [CL10 C^{13}	*85*	0.02		*82*	

Table 3.2. QA/QC data report for planar and mono- -substituted PCB congeners in biota

PCBs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Duplicate Difference, % D	Standard Reference Material 2974, ng/g	
				Detected	Certified Concentration
#81	n.d.	0.01	19	–	–
#77	n.d.	0.01	10	–	–
#123	n.d.	0.04	14	–	–
#118	0.40	0.20	10	132.6	130.8 ± 5.3
#114	n.d.	0.01	13	–	–
#105	0.22	0.10	12	55.0	53.0 ± 3.8
#126	n.d.	0.01	10	–	–
#167	n.d.	0.01	4	–	–
#156	n.d.	0.03	11	7.22	7.4 ± 1.0
#157	n.d.	0.01	12	–	–
#169	n.d.	0.01	18	–	–
#180	n.d.	0.05	1	16.2	17.1 ± 3.8
#170	n.d.	0.02	17	5.22	5.5 ± 1.1
#189	n.d.	0.01	18	–	–
Surrogate Internal Standards, % Recovery				*Surrogate Internal Standards, % Recovery*	
# 81[CL4] C^{13}	*92*	0.02	–	*104*	
# 77[CL4] C^{13}	*120*	0.02	–	*100*	
# 123[CL5] C^{13}	*94*	0.02	–	*103*	
# 118 [CL5]C^{13}	*95*	0.02	–	*103*	
# 114 [CL5]C^{13}	*83*	0.02	–	*88*	
# 105 [CL5]C^{13}	*103*	0.02	–	*110*	
# 126[CL5] C^{13}	*94*	0.02	–	*103*	
# 167[CL6] C^{13}	*97*	0.02	–	*109*	
# 156 [CL6]C^{13}	*102*	0.02	–	*116*	
# 157[CL6] C^{13}	*102*	0.02	–	*118*	
# 169[CL6] C^{13}	*96*	0.02	–	*105*	
# 180[CL7] C^{13}	*103*	0.02	–	*111*	
# 170[CL7] C^{13}	*109*	0.02	–	*125*	
# 189[CL7] C^{13}	*119*	0.02	–	*118*	

Table 3.3. Polychlorinated biphenyls (PCBs) (ng/g wet weight) and TCDD toxic-equivalents (TEQ_{PCB}) (pgTEQ/g wet weight) calculated for non- and mono-ortho substituted PCB congeners (italic) according to (WHO, 1998) in liver of cod and soft tissues of blue mussel from the White Sea, 2009

PCBs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	Cod 1	Cod 2	Mean ± S.D.
#1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#4/10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#8	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#15	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#17/18	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#19	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#22	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#28/31	<0.10	<0.10	<0.10	<0.10	**5.07**	**5.44**	**5.26 ± 0.26**
#33	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#37	<0.10	<0.10	<0.10	<0.10	**0.14**	**0.16**	**0.15 ± 0.01**
#44	**0.10**	<0.10	**0.13**	**0.09 ± 0.04**	**1.95**	**1.72**	**1.83 ± 0.17**
#49	<0.10	<0.10	<0.10	<0.10	**7.44**	**8.35**	**7.89 ± 0.64**
#52	<0.10	<0.10	<0.10	<0.10	**8.53**	**8.59**	**8.56 ± 0.04**
#54	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

PCBs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	Cod 1	Cod 2	Mean ± S.D.
#70	**0.40**	**0.29**	**0.30**	**0.33 ± 0.06**	**13.9**	**13.8**	**13.9 ± 0.06**
#74	**0.17**	**0.12**	**0.11**	**0.13 ± 0.03**	**8.31**	**8.65**	**8.48 ± 0.24**
#77	<0.01	<0.01	<0.01	<0.01	**0.19**	**0.21**	**0.20 ± 0.01**
#81	<0.01	<0.01	<0.01	<0.01	**0.05**	**0.06**	**0.05 ± 0.01**
#87	**0.12**	<0.10	**0.10**	**0.09 ± 0.03**	**10.3**	**10.7**	**10.5 ± 0.30**
#95	<0.10	<0.10	<0.10	<0.10	**5.79**	**6.11**	**5.95 ± 0.22**
#99	<0.10	<0.10	<0.10	<0.10	**27.2**	**28.3**	**27.8 ± 0.76**
#101	**0.15**	<0.10	**0.12**	**0.11 ± 0.05**	**22.3**	**26.0**	**24.1 ± 2.65**
#104	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#105	<0.10	<0.10	<0.10	<0.10	**25.1**	**28.4**	**26.7 ± 2.28**
#110	<0.10	<0.10	<0.10	<0.10	**13.7**	**14.7**	**14.2 ± 0.74**
#114	<0.01	<0.01	<0.01	<0.01	**0.88**	**1.01**	**0.94 ± 0.09**
#118	**0.35**	**0.11**	**0.20**	**0.22 ± 0.12**	**65.0**	**71.6**	**68.3 ± 4.72**
#119	<0.10	<0.10	<0.10	<0.10	**0.59**	**0.67**	**0.63 ± 0.06**
#123	**0.03**	<0.04	<0.04	<0.04	**5.81**	**5.04**	**5.42 ± 0.55**
#126	<0.01	<0.01	<0.01	<0.01	**0.04**	**0.04**	**0.04 ± 0.00**
#128	**0.17**	<0.15	0.08	**0.11 ± 0.05**	**16.9**	**18.5**	**17.7 ± 1.13**
#138/158	**0.13**	**0.11**	**0.14**	**0.13 ± 0.02**	**49.3**	**58.0**	**53.7 ± 6.11**
#149	<0.10	<0.10	<0.10	<0.10	**14.3**	**15.1**	**14.7 ± 0.59**
#151	<0.10	<0.10	<0.10	<0.10	**7.71**	**8.17**	**7.94 ± 0.32**
#153/168	**0.27**	**0.11**	**0.13**	**0.17 ± 0.08**	**83.2**	**87.9**	**85.5 ± 3.31**
#155	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#156	<0.03	<0.03	<0.03	<0.03	**6.41**	**7.12**	**6.77 ± 0.50**
#157	<0.01	<0.01	<0.01	<0.01	**2.11**	**1.87**	**1.99 ± 0.17**
#167	**0.02**	0.01	0.01	**0.01 ± 0.01**	**3.58**	**3.72**	**3.65 ± 0.10**
#169	<0.01	<0.01	<0.01	<0.01	**0.02**	**0.02**	**0.02 ± 0.00**
#170	<0.02	<0.02	<0.02	<0.02	**9.05**	**10.69**	**9.87 ± 1.16**
#171	<0.15	<0.15	<0.15	<0.15	**1.62**	**1.39**	**1.51 ± 0.16**
#177	<0.15	<0.15	<0.15	<0.15	**0.71**	**0.64**	**0.68 ± 0.05**
#178	<0.10	<0.10	<0.10	<0.10	**2.22**	**2.27**	**2.24 ± 0.03**
#180	<0.05	<0.05	<0.05	<0.05	**16.9**	**16.8**	**16.9 ± 0.12**
#183	<0.15	<0.15	<0.15	<0.15	**3.95**	**4.34**	**4.15 ± 0.27**
#187	<0.15	<0.15	<0.15	<0.15	**13.4**	**13.7**	**13.5 ± 0.19**
#188	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
#189	<0.01	<0.01	<0.01	<0.01	**0.12**	**0.10**	**0.11 ± 0.01**
#191	<0.15	<0.15	<0.15	<0.15	**0.28**	**0.32**	**0.30 ± 0.03**
#194	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
#199	<0.15	<0.15	<0.15	<0.15	**0.29**	**0.24**	**0.27 ± 0.04**
#201	<0.15	<0.15	<0.15	<0.15	**0.31**	**0.24**	**0.28 ± 0.05**
#202	<0.15	<0.15	<0.15	<0.15	**0.60**	**0.48**	**0.54 ± 0.08**
#205	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
#206	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
#208	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
#209	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
[a]Σ7PCB	0.89	0.38	0.59	**0.62 ± 0.25**	250	274	**262 ± 17.0**
[b]Σ10PCB	0.89	0.38	0.59	**0.62 ± 0.25**	282	310	**296 ± 19.7**
[c]Σ(n,m-o)PCB	0.40	0.12	0.20	**0.24 ± 0.14**	135	147	**141 ± 8.02**
ΣPCB	1.89	0.97	1.31	**1.39 ± 0.46**	455	491	**473 ± 25.3**
TEQ_{PCB}	<0.0001	<0.0001	<0.0001	<0.0001	0.236	0.263	**0.25 ± 0.02**

[a]Σ7PCB = sum of PCB-28, 52, 101, 118, 138, 153, and 180; [b]Σ10PCB = sum of PCB-28, 31, 52, 101, 105, 118, 138, 153, 156 and 180; [c]Σ(n,m-o)PCB = sum of PCB-77, 81, 105, 114, 118, 123, 126, 156, 157, 167, , 170 and 180

Table 3.4. QA/QC data report for chlorinated pesticides in biota

Compound	Procedural Blank,	Method Detection	Duplicate Difference,	Standard Reference Material 2974, ng/g	
				Detected	Certified Concentration
HCB	n.d.	0.03	5	–	–
α-HCH	n.d.	0.05	18	–	–
β-HCH	n.d.	0.05	1	–	–
γ-HCH	n.d.	0.05	25	–	–
Heptachlor	n.d.	0.05	25	–	–
Heptachlor epoxide	n.d.	0.10	–	–	–
Oxychlordane	n.d.	0.08	0	–	–
trans-Chlordane	n.d.	0.03	10	15.2	16.6 ± 1.8
cis-Chlordane	n.d.	0.03	17	16.0	17.2 ± 2.9
trans-Nonachlor	n.d.	0.01	12	19.3	18.0 ± 3.6
cis-Nonachlor	n.d.	0.01	14	6.52	6.84 ± 0.92
o,p'-DDE	n.d.	0.03	–	–	–
p,p'-DDE	n.d.	0.03	14	53.2	51.2 ± 5.7
o,p'-DDD	n.d.	0.03	7	–	–
p,p'-DDD	n.d.	0.03	4	41.0	43.0 ± 6.4
o,p'-DDT	n.d.	0.08	24	–	–
p,p'-DDT	n.d.	0.08	1	3.96	3.91 ± 0.60
Endrin	n.d.	0.10	–	–	–
Dieldrin	n.d.	0.05	–	–	–
Mirex	n.d.	0.03	–	–	–
Surrogate Internal Standards, % Recovery				*Surrogate Internal Standards, % Recovery*	
HCB C^{13}	*82*	0.005	–	*84*	
β-HCH C13	*84*	0.005	–	*75*	
γ-HCH C^{13}	*80*	0.005	–	*78*	
Oxychlordane C^{13}	*79*	0.005	–	*80*	
p,p'-DDE C^{13}	*79*	0.005	–	*101*	
p,p'-DDT C^{13}	*82*	0.005	–	*80*	

Table 3.5. Chlorinated pesticides (ng/g wet weight) in liver of cod and soft tissues of blue mussel from the White Sea, 2009

PCBs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	CL1	CL2	Mean ± S.D.
HCB	<0.03	**0.11**	**0.11**	**0.08 ± 0.05**	**11.6**	**12.2**	**11.90 ± 0.42**
α-HCH	<0.05	<0.05	<0.05	<0.05	**1.07**	**0.89**	**0.98 ± 0.13**
β-HCH	<0.05	<0.05	<0.05	<0.05	**1.8**	**1.78**	**1.79 ± 0.01**
γ-HCH	<0.05	<0.05	<0.05	<0.05	**0.77**	**0.6**	**0.69 ± 0.12**
ΣHCH	<0.05	<0.05	<0.05	<0.05	**3.64**	**3.27**	**3.46 ± 0.26**
Heptachlor	<0.05	<0.05	<0.05	<0.05	**0.09**	**0.07**	**0.08 ± 0.01**
Heptachlor epoxide	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Oxychlordane	<0.08	<0.08	<0.08	<0.08	**2.97**	**2.97**	**2.97 ± 0.00**
trans-Chlordane	<0.03	**0.06**	<0.03	**0.03 ± 0.03**	**2.23**	**2.46**	**2.35 ± 0.16**
cis-Chlordane	<0.03	<0.03	<0.03	<0.03	**6.41**	**5.4**	**5.91 ± 0.71**
trans-Nonachlor	<0.01	**0.09**	<0.01	**0.03 ± 0.05**	**17.5**	**19.7**	**18.6 ± 1.56**
cis-Nonachlor	<0.01	<0.01	<0.01	<0.01	**61.7**	**71.1**	**66.4 ± 6.65**
ΣCHL	<0.01	**0.15**	<0.01	**0.05 ± 0.08**	**90.8**	**102**	**96.2 ± 7.65**
o,p'-DDE	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
p,p'-DDE	**0.06**	**0.06**	**0.06**	**0.06 ± 0.00**	**53.6**	**61.6**	**57.6 ± 5.66**
o,p'-DDD	<0.03	<0.03	<0.03	<0.03	**0.83**	**0.77**	**0.80 ± 0.04**
p,p'-DDD	<0.03	<0.03	<0.03	<0.03	**7.52**	**7.8**	**7.66 ± 0.20**
o,p'-DDT	<0.08	<0.08	<0.08	<0.08	**1.83**	**2.34**	**2.09 ± 0.36**
p,p'-DDT	**0.15**	**0.08**	**0.12**	**0.12 ± 0.04**	**30.9**	**30.7**	**30.8 ± 0.14**
ΣDDT	**0.21**	**0.14**	**0.18**	**0.18 ± 0.04**	**94.7**	**103**	**98.9 ± 6.03**
Endrin	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Dieldrin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mirex	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03

Table 3.6. QA/QC data report for polycyclic aromatic hydrocarbons in biota

PAHs	Procedural Blank, ng/g	Method Detection Limit, ng/g	Duplicate Difference, % D	Standard Reference Material 2974, ng/g	
				Detected	Certified Concentration
Naphthalene	21.0	15.0	–	9.22	9.63 ± 0.61
1-Methylnaphtalene	12.2	6.00	–	4.28	3.47 ± 0.85
2-Methylnaphtalene	15.0	6.00	–	5.69	6.48 ± 0.85
C2-Naphthalenes	8.99	6.00	2	–	–
C3-Naphthalenes	13.9	10.0	–	–	–
C4-Naphthalenes	n.d.	10.0	–	–	–
Acenaphthylene	n.d.	0.70	–	–	–
Acenaphthene	n.d.	0.70	–	–	–
Fluorene	n.d.	0.70	12	–	–
C1-Fluorenes	n.d.	1.00	–	–	–
C2-Fluorenes	n.d.	1.00	–	–	–
C3-Fluorenes	n.d.	1.00	–	–	–
Phenanthrene	1.63	1.00	–	21.0	22.2 ± 2.5
Anthracene	0.77	0.50	23	6.55	6.1 ± 1.7
C1-Phenans/Anths	n.d.	0.60	–	–	–
C2-Phenans/Anths	n.d.	0.60	15	–	–
C3-Phenans/Anths	n.d.	0.70	22	–	–
C4-Phenans/Anths	n.d.	0.70	–	–	–
Dibenzothiophene	n.d.	0.30	–	–	–
C1-Dibenzothiophenes	n.d.	0.50	–	–	–
C2-Dibenzothiophenes	n.d.	0.50	–	–	–
C3-Dibenzothiophenes	n.d.	0.70	–	–	–
Fluoranthene	n.d.	0.50	–	165.0	163.7 ± 10.3
Pyrene	n.d.	0.50	–	153.0	151.6 ± 8.0
C1-Flanths/Pyrs	n.d.	0.60	–	–	–
C2-Flanths/Pyrs	n.d.	0.60	–	–	–
C3-Flanths/Pyrs	n.d.	0.80	–	–	–
Benzo(a)anthracene	n.d.	0.50	–	33.1	32.5 ± 4.8
Chrysene	n.d.	0.50	–	40.9	44.2 ± 2.7
C1-Chrysenes	n.d.	0.70	–	–	–
C2-Chrysenes	n.d.	0.70	–	–	–
C3-Chrysenes	n.d.	1.00	–	–	–
Benzo(b+j)fluoranthene	n.d.	1.00	–	45.0	46.4 ± 4.0
Benzo(k)fluoranthene	n.d.	1.00	–	20.9	20.2 ± 1.0
Benzo(e)pyrene	n.d.	1.00	–	85.1	84.0 ± 3.2
Benzo(a)pyrene	n.d.	1.00	–	15.3	15.63 ± 0.80
Perylene	n.d.	1.00	–	7.32	7.68 ± 0.35
Indeno(1,2,3-c,d) pyrene	n.d.	1.50	–	15.6	14.2 ± 2.8
Dibenzo(a,h)anthracene	n.d.	1.50	–	–	–
Benzo(g,h,i)perylene	n.d.	1.50	–	21.0	22.0 ± 2.3
Surrogate Internal Standards, % Recovery				*Surrogate Internal Standards, % Recovery*	
Naphthalene d_8	*79*	0.05	–	*83*	
Acenaphthene d_{10}	*80*	0.05	–	*78*	
Phenanthrene d_{10}	*78*	0.05	–	*78*	
Chrysene d_{12}	*79*	0.05	–	*76*	
Perylene d_{12}	*76*	0.10	–	*82*	

Table 3.7. Polycyclic aromatic hydrocarbons (ng/g wet weight) in liver of cod and soft tissues of blue mussel from the White Sea, 2008. 16 EPA PAHs are marked by italic.

PAHs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	Cod 1	Cod 2	Mean ± S.D.
Naphthalene	<15	<15	<15	<15	<15	<15	<15
C1-Naphthalenes	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
C2-Naphtalenes	<6.0	<6.0	<6.0	<6.0	**9.16**	**9.34**	**9.25 ± 0.12**
C3-Naphtalenes	<10	<10	<10	<10	<10	<10	<10
C4-Naphtalenes	<10	<10	<10	<10	<10	<10	<10
Acenaphthylene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Acenaphthene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Fluorene	<0.7	<0.7	<0.7	<0.7	**1.05**	**0.93**	**0.99 ± 0.08**
C1-Fluorenes	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
C2-Fluorenes	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
C3-Fluorenes	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	<0.5	<0.5	<0.5	<0.5	**0.73**	**0.58**	**0.66 ± 0.11**
C1-Phens/Anths	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
C2-Phens/Anths	**1.08**	<0.6	<0.6	**0.56 ± 0.45**	**1.31**	**1.52**	**1.42 ± 0.15**
C3-Phens/Anths	<0.7	<0.7	<0.7	<0.7	**1.71**	**1.37**	**1.54 ± 0.24**
C4-Phens/Anths	<0.7	**0.77**	<0.7	**0.49 ± 0.24**	<0.7	<0.7	<0.7
Dibenzothiophene	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
C1-Dibenzothiophenes	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C2-Dibenzothiophenes	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C3-Dibenzothiophenes	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Fluoranthene	**0.80**	**1.43**	**0.60**	**0.94 ± 0.43**	<0.5	<0.5	<0.5
Pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C1-Flanths/Pyrs	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
C2-Flanths/Pyrs	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
C3-Flanths/Pyrs	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Benzo(a)anthracene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chrysene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C1-Chrysenes	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
C2-Chrysenes	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
C3-Chrysenes	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(e)pyrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Perylene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Indeno(1,2,3-c,d)pyrene	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Benzo(g,h,i)perylene	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dibenzo(a,h)antracene	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Sum of 16 EPA PAHs	**0.80**	**1.43**	**0.60**	**0.94 ± 0.43**	**1.78**	**1.51**	**1.65 ± 0.19**
Total PAH	**3.03**	**3.93**	**1.85**	**2.94 ± 1.05**	**14.0**	**13.7**	**13.85 ± 0.16**

Table 3.8. QA/QC data report for polybrominated diphenyl ethers in biota

PBDEs	Procedural Blank, ng/kg	Method Detection Limit, ng/kg	Duplicate Difference, % D	Spiked Blank Sample		
				Detected, ng	Added, ng	% Recovery
TriBDE #17	n.d.	1.00	22	–	–	–
TriBDE #28	2.17	1.00	1	0.89	1.00	*89*
TeBDE #49	3.10	1.00	3	–	–	–
TeBDE #71	2.27	1.00	20	–	–	–
TeBDE #47	20.9	8.00	2	1.02	1.00	*102*
TeBDE #66	n.d.	1.00	8	–	–	–
PeBDE #100	6.60	1.00	2	–	–	–
PeBDE #99	6.85	1.00	2	0.99	1.00	*99*
PeBDE #85	n.d.	3.00	0	–	–	–
HexBDE #154	n.d.	3.00	1	–	–	–
HexBDE #153	n.d.	3.00	4	0.93	1.00	*93*
HexBDE #138	n.d.	3.00	–	–	–	–
HepBDE #183	n.d.	5.00	–	–	–	–
HepBDE #190	n.d.	5.00	–	–	–	–

Table 3.9. Polybrominated diphenyl ethers (PBDEs) (ng/g wet weight) in liver of cod and soft tissues of blue mussel from the White Sea, 2009

PBDEs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	CL1	CL2	Mean ± S.D.
TriBDE #17	<1.0	<1.0	<1.0	<1.0	**2.73**	**3.40**	**3.06 ± 0.48**
TriBDE #28	<1.0	<1.0	<1.0	<1.0	**59.6**	**58.8**	**59.20 ± 0.52**
TeBDE #49	<1.0	<1.0	<1.0	<1.0	**278**	**269**	**274 ± 6.36**
TeBDE #71	<1.0	<1.0	<1.0	<1.0	**190**	**233**	**212 ± 30.4**
TeBDE #47	<8.0	<8.0	<8.0	<8.0	**759**	**773**	**766 ± 9.90**
TeBDE #66	<1.0	<1.0	<1.0	<1.0	**43.1**	**46.9**	**45.0 ± 2.62**
PeBDE #100	<1.0	<1.0	<1.0	<1.0	**369**	**361**	**365 ± 5.66**
PeBDE #99	<1.0	<1.0	<1.0	<1.0	**52.6**	**51.6**	**52.1 ± 0.71**
PeBDE #85	<3.0	<3.0	<3.0	<3.0	**41.0**	**41.1**	**41.0 ± 0.11**
HexBDE #154	<3.0	<3.0	<3.0	<3.0	**392**	**396**	**394 ± 2.82**
HexBDE #153	<3.0	<3.0	<3.0	<3.0	**15.9**	**16.6**	**16.3 ± 0.46**
HexBDE #138	<3.0	<3.0	<3.0	<3.0	n.d.	n.d.	n.d.
HepBDE #183	<5.0	<5.0	<5.0	<5.0	n.d.	n.d.	n.d.
HepBDE #190	<5.0	<5.0	<5.0	<5.0	n.d.	n.d.	n.d.
ΣPBDE	<5.0	<5.0	<5.0	<5.0	**2203**	**2250**	**2227 ± 33.5**

Table 3.10. QA/QC data report for polychlorinated dibenzo-p-dioxins and furans in biota

PCDD/Fs	Procedural Blank,	Method Detection	Duplicate Difference,	Spiked Blank Sample		
				Detected,	Added, ng	%
2,3,7,8-TCDD	n.d.	1.00	–	0.041	0.040	*102*
1,2,3,7,8-PeCDD	n.d.	0.20	–	0.210	0.200	*105*
1,2,3,4,7,8-HxCDD	n.d.	0.10	–	0.170	0.200	*85*
1,2,3,6,7,8- HxCDD	n.d.	0.10	–	0.168	0.200	*84*
1,2,3,7,8,9- HxCDD	n.d.	0.10	–	0.176	0.200	*88*
1,2,3,4,6,7,8-HpCDD	n.d.	0.10	–	0.192	0.200	*96*
OCDD	n.d.	0.10	–	0.316	0.400	*79*
2,3,7,8-TCDF	n.d.	0.20	9	0.038	0.040	*96*
1,2,3,7,8-PeCDF	n.d.	0.10	16	0.204	0.200	*102*
2,3,4,7,8-PeCDF	n.d.	0.10	17	0.190	0.200	*95*
1,2,3,4,7,8-HxCDF	n.d.	0.10	–	0.206	0.200	*103*
1,2,3,6,7,8- HxCDF	n.d.	0.10	–	0.222	0.200	*111*
2,3,4,6,7,8-HxCDF	n.d.	0.10	–	0.170	0.200	*85*
1,2,3,7,8,9-HxCDF	n.d.	0.10	–	0.168	0.200	*84*
1,2,3,4,6,7,8-HpCDF	n.d.	0.10	–	0.174	0.200	*87*
1,2,3,4,7,8,9-HpCDF	n.d.	0.10	–	0.176	0.200	*88*
OCDF	n.d.	0.10	–	0.384	0.400	*96*
Surrogate Internal Standards, % Recovery				*Surrogate Internal Standards, %*		
($^{13}C_{12}$)2,3,7,8-TCDD	*85*	1.00	–		*83*	
($^{13}C_{12}$)2,3,7,8-TCDF	*89*	0.20	–		*81*	
($^{13}C_{12}$)1,2,3,7,8-PeCDD	*96*	0.20	–		*84*	
($^{13}C_{12}$)1,2,3,7,8-PeCDF	*102*	0.10	–		*81*	
($^{13}C_{12}$)1,2,3,6,7,8- HxCDD	*85*	0.10	–		*77*	
($^{13}C_{12}$)1,2,3,6,7,8- HxCDF	*84*	0.10	–		*85*	
($^{13}C_{12}$)1,2,3,4,6,7,8-HpCDD	*87*	0.10	–		*90*	
($^{13}C_{12}$)1,2,3,4,6,7,8-HpCDF	*96*	0.10	–		*105*	
($^{13}C_{12}$)OCDD	*102*	0.10	–		*88*	

Table 3.11. Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (pg/g wet weight) and TCDD toxic-equivalents ($TEQ_{PCDD/F}$) (pgTEQ/g wet weight) calculated according to (WHO, 1998)) in liver of cod and soft tissues of blue mussel from the White Sea, 2009

PCDD/Fs	Blue mussel				Cod liver		
	BM1	BM2	BM3	Mean ± S.D.	CL1	CL2	Mean ± S.D.
2,3,7,8-TCDD	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3,7,8-PeCDD	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1,2,3,4,7,8-HxCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,6,7,8-HxCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,7,8,9-HxCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,4,6,7,8-HpCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
OCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,3,7,8-TCDF	<0.2	<0.2	<0.2	<0.2	**2.45**	**2.68**	**2.57 ± 0.16**
1,2,3,7,8-PeCDF	<0.1	<0.1	<0.1	<0.1	**1.42**	**1.67**	**1.55 ± 0.18**
2,3,4,7,8-PeCDF	<0.1	<0.1	<0.1	<0.1	**0.94**	**1.12**	**1.03 ± 0.13**
1,2,3,4,7,8-HxCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,6,7,8-HxCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2,3,4,6,7,8-HxCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,7,8,9-HxCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,4,6,7,8-HpCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,3,4,7,8,9-HpCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
OCDF	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ΣPCDD	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ΣPCDF	<0.1	<0.1	<0.1	<0.1	**4.81**	**5.47**	**5.14**
ΣPCDD/F	<0.1	<0.1	<0.1	<0.1	**4.81**	**5.47**	**5.14**
$TEQ_{PCDD/F}$	<0.001	<0.001	<0.001	<0.001	**0.664**	**0.778**	**0.72 ± 0.08**

Table 3.12. QA/QC data report for trace elements in biota

Element	Procedural Blank, mg/kg	Matrix Spike Recovery, % R	Duplicate Difference, %D	Detection Limit, mg/kg
As	<0.20	89.6	5.5	0.20
Cd	<0.0004	80.9	20.0	0.0004
Cu	0.030	94.0	17.8	0.010
Hg	<0.003	88.3	0	0.003
Pb	<0.010	92.2	15.4	0.010
Zn	<0.10	102	14.3	0.10

Table 3. 13. Trace elements (mg/kg wet weight) in cod muscles and soft tissues of blue mussel from the White Sea, 2009

Trace elements	Blue mussel						Cod muscle
	BM4	BM5	BM6	Mean	±	S.D.	
As	2.16	2.01	2.01	2.06	±	0.09	2.18
Zn	12.1	11.1	10.4	11.19	±	0.88	5.05
Cu	0.87	0.75	1.01	0.88	±	0.13	0.70
Cd	0.160	0.130	0.100	0.13	±	0.03	0.003
Pb	0.025	0.018	0.013	0.02	±	0.01	0.012
Hg	0.041	0.060	0.040	0.05	±	0.01	0.068

9.4 Appendix 4. SFT classification system for POPs in sediments

Table 4.1. Classification organic compound contents in sediments (upper limit for Classes I-IV). SFT, 2007

Compounds	I	II	III	IV	V
	Background	Good	Moderate	Bad	Very bad
Naphthalene (µg/kg)	<2	290	1000	2000	>2000
Acenaphthylene (µg/kg)	<1.6	33	85	850	>850
Acenaphthene (µg/kg)	>4.8	160	360	3600	>3600
Fluorene (µg/kg)	>6.8	260	510	5100	>5100
Phenanthrene (µg/kg)	>6.8	500	1200	2300	>2300
Anthracene (µg/kg)	>1.2	31	100	1000	>1000
Fluoranthene (µg/kg)	>8	170	1300	2600	>2600
Pyrene (µg/kg)	<5.2	280	2800	5600	>5600
Benzo[a]anthracene (µg/kg)	<3.6	60	90	900	>900
Chrysene (µg/kg)	<4.4	280	280	560	>560
Benzo[b]fluoranthene (µg/kg)	<46	240	490	4900	>4900
Benzo[k]fluoranthene (µg/kg)		<210	480	4800	>4800
Benzo[a]pyrene (µg/kg)	<6	420	830	4200	>4200
Indeno[123cd]pyrene (µg/kg)	<20	47	70	700	>700
Dibenzo[ah]anthracene (µg/kg)	<12	590	1200	12000	>12000
Benzo[ghi]perylene (µg/kg)	<18	21	31	310	>310
S16 EPA PAH	<300	2000	6000	20000	>20000
S7PCB (µg/kg)	<5	17	190	1900	>1900
PCDD/F (TEQ) (µg/kg)	<0.01	0.03	0.1	0.5	>0.5
SDDT (µg/kg)	<0.5	20	490	4900	>4900
Lindane (µg/kg)		<1.1	2.2	11	>11
HCB (µg/kg)	<0.5	17	61	610	>610
BDE-99 (µg/kg)		62	7800	16000	>16000

Table 4.2. Classification organic compound contents in sediments (upper limit for Classes I-IV). Concentrations were recalculated per unit of organic carbon; TOC=10 g/kg.

Compounds	I	II	III	IV	V
	Background	Good	Moderate	Bad	Very bad
Naphthalene (µg/kgOC)	<200	29000	100000	200000	>200000
Acenaphthylene (µg/kgOC)	<160	3300	8500	85000	>85000
Acenaphthene (µg/kgOC)	<480	16000	36000	360000	>360000
Fluorene (µg/kgOC)	<680	26000	51000	510000	>510000
Phenanthrene (µg/kgOC)	<680	50000	120000	230000	>230000
Anthracene (µg/kgOC)	<120	3100	10000	100000	>100000
Fluoranthene (µg/kgOC)	<800	17000	130000	260000	>260000
Pyrene (µg/kgOC)	<520	28000	280000	560000	>560000
Benzo[a]anthracene (µg/kgOC)	<360	6000	9000	90000	>90000
Chrysene (µg/kgOC)	<440	28000	28000	56000	>56000
Benzo[b]fluoranthene (µg/kgOC)	<4600	24000	49000	490000	>490000
Benzo[k]fluoranthene (µg/kgOC)		<21000	48000	480000	>480000
Benzo[a]pyrene (µg/kgOC)	<600	42000	83000	420000	>420000
Indeno[123cd]pyrene (µg/kgOC)	<2000	4700	7000	70000	>70000
Dibenzo[ah]anthracene (µg/kgOC)	<1200	59000	120000	1200000	>1200000
Benzo[ghi]perylene (µg/kgOC)	<1800	2100	3100	31000	>31000

Compounds	I	II	III	IV	V
	Background	Good	Moderate	Bad	Very bad
S16 EPA PAH	<30000	200000	600000	2000000	>2000000
S7PCB (µg/kgOC)	<500	1700	19000	190000	>190000
PCDD/F (TEQ) (µg/kgOC)	<1	3	10	50	>50
SDDT (µg/kgOC)	<50	2000	49000	490000	>490000
Lindane (µg/kgOC)		<110	220	1100	>1100
HCB (µg/kgOC)	<50	1700	6100	61000	>61000
BDE-99 (µg/kgOC)		<6200	780000	1600000	>1600000

10 Appendix 5. The results of QUASIMEME Laboratory Performance Studies

NW Typhoon:

26 November 2009

Quasimeme Database

Q834A North-West Branch SPA Typhoon
Yulia Nikishechkina;Jeka Ishenko
Russia

Exercise 855 – R58 Trace metals in Sediment: Jul – Oct 2009

Matrix	*Determinand*	*Mean*	*Units*	*Assigned Value*	*Total Error*	*Z Score*	*z*	*Total Dupl.*
QTM088MS	Aluminium	2.010	%	5.517	0.740	-4.7	U	1
QTM088MS	Arsenic	8.600	mg/kg	17.75	2.719	-3.4	U	1
QTM088MS	Cadmium	1900	µg/kg	1978	257.3	-0.3	S	1
QTM088MS	Chromium	249.0	µg/kg	325.5	41.69	-1.8	S	1
QTM088MS	Copper	195.0	mg/kg	189.3	24.16	0.2	S	1
QTM088MS	Iron	4.150	%	4.786	0.648	-1.0	S	1
QTM088MS	Lead	213.0	mg/kg	242.3	31.29	-0.9	S	1
QTM088MS	Manganese	394.0	mg/kg	745.7	93.26	-3.8	U	1
QTM088MS	Mercury	607.0	µg/kg	676.2	89.53	-0.8	S	1
QTM088MS	Nickel	80.30	mg/kg	55.18	7.397	3.4	U	1
QTM088MS	Zinc	605.0	mg/kg	656.5	83.32	-0.6	S	1
QTM088MS	TOC	7.420	%	6.762	0.895	0.7	S	1
QTM089MS	Aluminium	1.590	%	3.786	0.523	-4.2	U	1
QTM089MS	Arsenic	9.800	mg/kg	17.27	2.659	-2.8	Q	1
QTM089MS	Cadmium	500.0	µg/kg	443.3	65.42	0.9	S	1
QTM089MS	Chromium	21.70	mg/kg	57.00	8.125	-4.3	U	1
QTM089MS	Copper	12.30	mg/kg	15.29	2.411	-1.2	S	1
QTM089MS	Iron	1.570	%	2.227	0.328	-2.0	Q	1
QTM089MS	Lead	36.60	mg/kg	41.60	6.200	-0.8	S	1
QTM089MS	Manganese	519.0	mg/kg	699.5	87.49	-2.1	Q	1
QTM089MS	Mercury	404.0	µg/kg	453.8	61.72	-0.8	S	1
QTM089MS	Nickel	23.60	mg/kg	19.93	2.991	1.2	S	1
QTM089MS	Zinc	120.0	mg/kg	143.0	19.13	-1.2	S	1
QTM089MS	TOC	2.050	%	1.701	0.263	1.3	S	1

The letters in the *z* column indicate: S – Satisfactory, Q – Questionable,

U – Unsatisfactory, C – Consistent, I – Inconsistent, B - Blanc.

If the analytical value looks like this, then the Assigned value is indicative only.

26 November 2009

Quasimeme Database

Q834A North-West Branch SPA Typhoon
Yulia Nikishechkina;Jeka Ishenko
Russia

Exercise 856 – R58 Chlorinated organics in Sediment: Jul – Oct 2009

Matrix	*Determinand*	*Mean*	*Units*	*Assigned Value*	*Total Error*	*Z Score*	*z*	*Total Dupl.*
QOR098MS	CB31	0.160	µg/kg	0.216	0.039	-1.4	S	1
QOR098MS	CB28	0.290	µg/kg	0.282	0.048	0.2	S	1
QOR098MS	CB52	0.400	µg/kg	0.456	0.070	-0.8	S	1
QOR098MS	CB101	0.550	µg/kg	0.768	0.109	-2.0	Q	1
QOR098MS	CB105	0.520	µg/kg	0.118	0.027	14.8	U	1
QOR098MS	CB118	0.610	µg/kg	0.549	0.081	0.8	S	1
QOR098MS	CB138+CB163	0.910	µg/kg	1.056	0.145	-1.0	S	1
QOR098MS	CB153	1.060	µg/kg	1.706	0.226	-2.9	Q	1
QOR098MS	CB156	0.120	µg/kg	0.095	0.024	1.0	S	1
QOR098MS	CB180	0.420	µg/kg	0.610	0.089	-2.1	Q	1
QOR098MS	pp'-DDD	0.650	µg/kg	1.949	0.256	-5.1	U	1
QOR098MS	pp'-DDE	0.480	µg/kg	0.844	0.118	-3.1	U	1
QOR098MS	op'-DDT	0.080	µg/kg	0.067	0.021	0.6	S	1
QOR098MS	pp'-DDT	0.170	µg/kg	0.178	0.035	-0.2	S	1
QOR098MS	HCB	0.620	µg/kg	0.478	0.072	2.0	S	1
QOR098MS	a-HCH	0.070	µg/kg	0.087	0.021	-0.8	S	1
QOR098MS	b-HCH	0.080	µg/kg	0.132	0.029	-1.8	S	1
QOR098MS	g-HCH	0.160	µg/kg	0.089	0.024	3.0	Q	1
QOR098MS	*Transnonachlor*	*0.040*	*µg/kg*				*B*	*1*
QOR098MS	TOC	1.970	%	1.670	0.219	1.4	S	1
QOR099MS	CB31	0.120	µg/kg	0.105	0.026	0.6	S	1
QOR099MS	CB28	0.170	µg/kg	0.120	0.028	1.8	S	1
QOR099MS	CB52	0.170	µg/kg	0.342	0.055	-3.1	U	1
QOR099MS	*CB101*	*0.500*	*µg/kg*				*B*	*1*
QOR099MS	CB105	0.890	µg/kg	0.134	0.029	25.9	U	1
QOR099MS	CB118	0.680	µg/kg	0.692	0.099	-0.1	S	1
QOR099MS	*CB138+CB163*	*1.350*	*µg/kg*				*B*	*1*
QOR099MS	*CB153*	*1.140*	*µg/kg*				*B*	*1*
QOR099MS	CB156	0.400	µg/kg	0.434	0.067	-0.5	S	1
QOR099MS	CB180	0.940	µg/kg	3.210	0.414	-5.5	U	1
QOR099MS	pp'-DDD	0.160	µg/kg	0.086	0.023	3.2	U	1
QOR099MS	pp'-DDE	0.130	µg/kg	0.097	0.025	1.4	S	1
QOR099MS	op'-DDT	0.040	µg/kg	0.052	0.019	-0.7	S	1
QOR099MS	pp'-DDT	0.130	µg/kg	0.131	0.029	0.0	S	1
QOR099MS	HCB	0.150	µg/kg	0.126	0.028	0.8	S	1
QOR099MS	*a-HCH*	*0.040*	*µg/kg*				*B*	*1*
QOR099MS	*b-HCH*	*0.070*	*µg/kg*				*B*	*1*

Matrix	*Determinand*	*Mean*	*Units*	*Assigned Value*	*Total Error*	*Z Score*	*z*	*Total Dupl.*
QOR099MS	*g-HCH*	*0.110*	*µg/kg*				*B*	*1*
QOR099MS	*Transnonachlor*	*0.030*	*µg/kg*				*B*	*1*
QOR099MS	TOC	0.220	%	0.204	0.035	0.5	S	1

The letters in the *z* column indicate: S – Satisfactory, Q – Questionable,

U – Unsatisfactory, C – Consistent, I – Inconsistent, B - Blanc.

If the analytical value looks like this, then the Assigned value is indicative only.

26 November 2009

Quasimeme Database

Q834A North-West Branch SPA Typhoon

Yulia Nikishechkina;Jeka Ishenko

Russia

Exercise 857 – R58 PAHs in Sediment: Jul – Oct 2009

Matrix	*Determinand*	*Mean*	*Units*	*Assigned Value*	*Total Error*	*Z Score*	*z*	*Total Dupl.*
QPH062MS	Benzo[g,h,i]perylene	113.0	µg/kg	112.6	14.18	0.0	S	1
QPH062MS	Acenaphthene	4.500	µg/kg	10.50	1.362	-4.4	U	1
QPH062MS	Acenaphthylene	5.500	µg/kg	5.857	0.832	-0.4	S	1
QPH062MS	Anthracene	6.900	µg/kg	29.64	3.755	-6.1	U	1
QPH062MS	Benzo[a]anthracene	12.60	µg/kg	78.47	9.859	-6.7	U	1
QPH062MS	*Benzo[a]pyrene*	*48.30*	*µg/kg*				*B*	*1*
QPH062MS	*Benzo[b]fluoranthene*	*235.0*	*µg/kg*				*B*	*1*
QPH062MS	Benzo[k]fluoranthene	97.00	µg/kg	72.79	9.149	2.6	Q	1
QPH062MS	Chrysene + triphenylene	155.0	µg/kg	125.6	15.80	1.9	S	1
QPH062MS	Dibenz[ah]anthracene	123.0	µg/kg	23.46	2.958	33.7	U	1
QPH062MS	Fluorene	3.500	µg/kg	27.50	3.487	-6.9	U	1
QPH062MS	Fluoranthene	330.0	µg/kg	201.1	25.24	5.1	U	1
QPH062MS	Indeno[1,2,3-cd]pyrene	52.00	µg/kg	133.4	16.78	-4.9	U	1
QPH062MS	Naphthalene	19.30	µg/kg	76.64	9.830	-5.8	U	1
QPH062MS	Phenanthrene	29.50	µg/kg	111.8	14.23	-5.8	U	1
QPH062MS	Pyrene	89.40	µg/kg	149.0	18.72	-3.2	U	1
QPH062MS	TOC	1.960	%	1.622	0.213	1.6	S	1
QPH063MS	Benzo[g,h,i]perylene	38.70	µg/kg	9.434	1.279	22.9	U	1
QPH063MS	Acenaphthene	3.800	µg/kg	2.449	0.356	3.8	U	1
QPH063MS	Acenaphthylene	43.00	µg/kg	0.786	0.198	212.9	U	1
QPH063MS	Anthracene	8.800	µg/kg	3.121	0.440	12.9	U	1
QPH063MS	Benzo[a]anthracene	15.60	µg/kg	13.38	1.723	1.3	S	1
QPH063MS	Benzo[a]pyrene	14.50	µg/kg	12.14	1.567	1.5	S	1
QPH063MS	Benzo[b]fluoranthene	42.30	µg/kg	16.47	2.309	11.2	U	1
QPH063MS	Benzo[k]fluoranthene	22.40	µg/kg	8.954	1.169	11.5	U	1

Matrix	*Determinand*	*Mean*	*Units*	*Assigned Value*	*Total Error*	*Z Score*	*z*	*Total Dupl.*
QPH063MS	Chrysene + triphenylene	30.50	µg/kg	14.36	1.896	8.5	U	1
QPH063MS	Dibenz[ah]anthracene	12.20	µg/kg	2.141	0.293	34.4	U	1
QPH063MS	Fluorene	3.100	µg/kg	3.169	0.446	-0.2	S	1
QPH063MS	Fluoranthene	53.50	µg/kg	31.29	4.011	5.5	U	1
QPH063MS	Indeno[1,2,3-cd]pyrene	19.40	µg/kg	12.22	1.627	4.4	U	1
QPH063MS	Naphthalene	23.00	µg/kg	4.953	0.869	20.8	U	1
QPH063MS	Phenanthrene	17.10	µg/kg	17.07	2.383	0.0	S	1
QPH063MS	Pyrene	29.70	µg/kg	23.58	3.047	2.0	Q	1
QPH063MS	TOC	0.230	%	0.201	0.035	0.8	S	1

The letters in the *z* column indicate: S – Satisfactory, Q – Questionable,

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SPA Typhoon:

SPA Typhoon, Obninsk
Content of Polychlorinated dibenzodioxines and dibenzofuranes in test materials

Compound	Units	QPL028BT	QPL029BT
2,3,7,8-TCDD	ng/kg	10.0	0.1
1,2,3,7,8-PeCDD	ng/kg	1.0	0.3
1,2,3,4,7,8-HxCDD	ng/kg	0.5	0.03
1,2,3,6,7,8-HxCDD	ng/kg	8.0	0.7
1,2,3,7,8,9-HxCDD	ng/kg	1.0	0.2
1,2,3,4,6,7,8-HpCDD	ng/kg	6.0	3.0
OCDD	ng/kg	6.0	3.0
2,3,7,8-TCDF	ng/kg	30.0	1.0
1,2,3,7,8-PeCDF	ng/kg	7.0	0.08
2,3,4,7,8-PeCDF	ng/kg	7.0	0.2
1,2,3,4,7,8-HxCDF	ng/kg	3.0	0.06
1,2,3,6,7,8-HxCDF	ng/kg	3.0	0.03
2,3,4,6,7,8-HxCDF	ng/kg	3.0	0.02
1,2,3,7,8,9-HxCDF	ng/kg	0.3	0.02
1,2,3,4,6,7,8-HpCDF	ng/kg	2.0	0.06
1,2,3,4,7,8,9-HpCDF	ng/kg	0.2	0.02
OCDF	ng/kg	0.4	0.05

SPA Typhoon, Obninsk
Content of PCB in test materials

Congener PCB (IUPAC)	Units	QPL028BT	QPL029BT
# Cl4 81	ng/kg	337	17.7
# Cl4 77	ng/kg	516	14.8
# Cl5 123	ng/kg	9044	29.6
# Cl5 118	ng/kg	53496	589
# Cl5 114	ng/kg	256	33.4
# Cl5 105	ng/kg	7055	194
# Cl5 126	ng/kg	164	2.36
# Cl6 167	ng/kg	9234	143
# Cl6 156	ng/kg	3345	58.8
# Cl6 157	ng/kg	1175	14.1
# Cl6 169	ng/kg	63.7	4.09
# Cl7 180	ng/kg	31534	425
# Cl7 170	ng/kg	12133	146
# Cl7 189	ng/kg	1004	4.79

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E-post: postmottak@klif.no
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Om Klima- og forurensningsdirektoratet

Klima- og forurensningsdirektoratet (Klif) er fra 2010 det nye navnet på Statens forurensningstilsyn. Vi er et direktorat under Miljøverndepartementet med 325 ansatte på Helsfyr i Oslo. Direktoratet arbeider for en forurensningsfri framtid. Vi iverksetter forurensningspolitikken og er veiviser, vokter og forvalter for et bedre miljø.

Våre hovedoppgaver er å:

- redusere klimagassutslippene
- redusere spredning av helse- og miljøfarlige stoffer
- oppnå en helhetlig og økosystembasert hav- og vannforvaltning
- øke gjenvinningen og redusere utslippene fra avfall
- redusere skadevirkningene av luftforurensning og støy

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