2024

Contamination Assessment and Reduction Project – Phase 2

(CARP II)

Appendix A-2. CARP II Sampling and Analysis Program and Database

Project Title:	NY/NJ Harbor Contamination Assessment and Reduction Project-CARP II
RFP NUMBER: 2016-10	NJDOT RESEARCH PROJECT MANAGER: Scott Douglas
Deliverable: Data Collection and Analysis Summary	Date Completed: June 1, 2022
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Appendix A-2. CARP II Sampling and Analysis Program and Database

Chapter 1. Overview

This document summarizes the data collected under CARP II including field sampling and data analysis for: 1) Ambient Water, Head of Tide and Stormwater; 2) Harbor Wide Sediment Characterization; and 3) Navigation Channel and Off-Channel Characterization. Each of media were analyzed for congener PCBs (Method 1668) and the 17 toxic polychlorinated-dibenzo dioxins and furans (PCDD/Fs) by Method 1613. The PAHs, pesticides, and metals that were targets in CARP I were not sought in CARP II. The report also provides a data quality review of the PCDD/F and PCB data and information on how to access the data.

Water samples were collected with the TOPS device which produced filtered water (1 micron nominal pore size wound glass fiber cartridge filter), and suspended solids collected on the cartridge filter. The two phases were analyzed separately.

Sediment cores were divided into upper and lower portions which were analyzed separately. All of the grab sediment samples were analyzed for sediment characteristics. Worms (*Neanthes virens*) were exposed to sediments from all the core samples. All of these samples were tested for PCDD/Fs and congener PCBs. Also, accessory parameters were measured. All of the 42 grab samples were analyzed for sediment characteristics. Eight of them were also analyzed for PCDD/Fs and seven for congener PCBs.

A major focus of CARP II field work was to determine if there were differences in contaminant concentrations between navigational and non-navigational sediments. This is addressed in section 4.7. In summary, there were some differences but they were inconsistent and not very large.

Chapter 2. Water

Water samples were collected using Trace Organics Platform Samplers (TOPS, Figure 1)). In total, 34 events were sampled with TOPS; seven Harbor ambient sites, five Head-of-Tide sites each visited twice; five storm water sites each visited twice, and seven Poughkeepsie sampling events (Figure 2). The TOPS samples were analyzed for dissolved and particle bound PCBs and PCDD/Fs, suspended solids, particulate organic carbon, and dissolved organic carbon.

Figure 1. Trace Organics Platform Sampler (TOPS). Here two units are collecting duplicate samples of suspended solids and filtered water. The carboy in the upper right is collecting filtered water to determine the volume of water passed through the glass fiber cartridge. Aqueous samples for chemical analysis are pumped directly into laboratory cleaned glass jugs. Power is being supplied by portable generator.

CARP II largely followed the procedures developed in CARP I for obtaining PCB and PCDD/F data from water samples by using TOPS (Trace Organics Platform Sampler). TOPS is a sampling platform designed to process large volumes of water on site to capture a sufficient mass of analyte for reliable detections of trace hydrophobic contaminants. TOPS was used in CARP I for both the dissolved phase (contaminants captured on the synthetic resin XAD) and the particulate phase. In CARP II the XAD resin was not used. Aqueous samples of filtered water were sent to the laboratory. Particles are captured on a 4-inch long wound glass cartridge filter having a nominal porosity of 1 micron. Volumes of water filtered ranged from 17 to 1,800 liters depending on particle concentrations. TOPS automatically shuts off when back-pressure from the filter reaches 10 psi.

Operation of the TOPS requires two considerations. Estuary ambient waters may contain appreciable concentrations of large zooplankton that may complicate interpretation of the data. Therefore a Nytex 110 micron porosity plankton net was used to exclude large zooplankton. The second consideration is that the 1 micron glass cartridge filter permits some blow-by of small particles. This is corrected by calculating the trapping efficiency through measuring pre- and post-filtration with particulate organic carbon (POC) captured on 0.7 micron flat glass filters from influent (inf) and effluent (eff) water from the glass fiber cartridge filter. Raw concentrations were divided by a POC efficiency calculated as (1-eff/inf).

PCBs were calculated as the sum of the aqueous and particulate phases. PCDD/Fs were assumed to be non-detectable in the aqueous phase and only analyzed from the particulate phase.

Site name abbreviations used in the graphs and tables of this report are shown in Table 1.

Table 1 Site name abbreviations used in the graphs and tables of this report

site_type	Site name	Abbr.
Ambient	Arthur Kill	AK
Ambient	Hackensack River, ambient	Hra
Ambient	Kill van Kull	KVK
Ambient	Lower Bay	LB
Ambient	Newark Bay	NB
Ambient	Raritan Bay	RB
Ambient	Upper Bay	UB
Head_of_Tide	Dundee Dam, Passaic River	Dun
Head_of_Tide	Elizabeth River	ER
Head_of_Tide	Hackensack River	HR
Head_of_Tide	Passaic River	PR
Head_of_Tide	Raritan River	RR
Head_of_Tide	Saddle River	SR
Poughkeepsie	HRECOS pump station	Pough
Poughkeepsie	Poughkeepsie Drinking Water	Pough
Storm_Water	Bayonne	Bay
Storm_Water	Belleville	Bell
Storm_Water	Kearny	Kea
Storm_Water	Keyport Waterfront	Key
Storm_Water	New Milford	NM

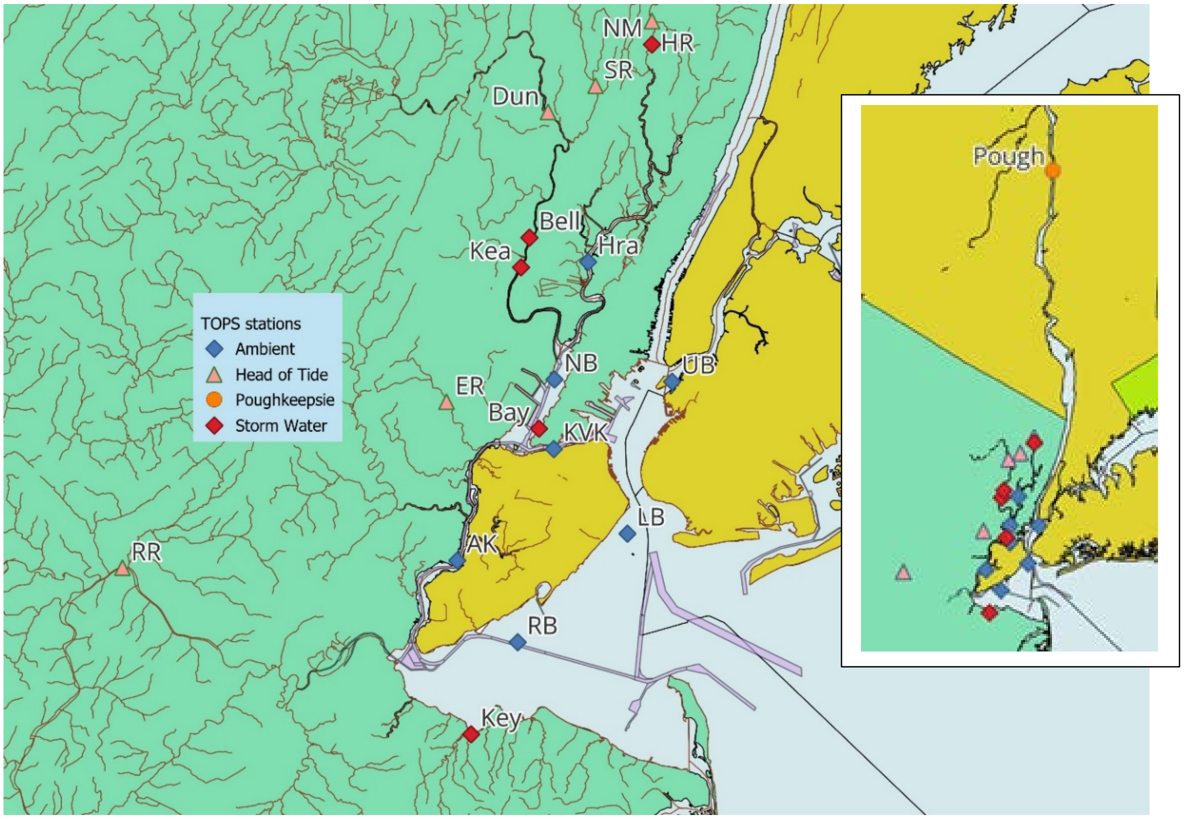


Figure 2. TOPS sampling sites for water.

2.1. Accessory Parameters

Accessory parameters particulate organic carbon (POC) and total suspended solids (TSS) were measured at the TOPS sites (Table 1).

Table 2 Accessory Parameters measured at TOPS sites.

	POC	TSS		POC	TSS
Ambient			**Poughkeepsie**		
AK-07/26/19	0.389	5.5	Pough-01/09/19	1.4	17.9
Hra-07/16/19	1.14	19	Pough-01/14/19	1.12	16.4
KVK-07/26/19	0.31	8.3	Pough-03/13/19	0.373	41.3
LB-08/07/19	0.588	16.7	Pough-03/18/19	0.971	70
NB-07/16/19	0.837	11.3	Pough-04/22/19		12.9
RB-08/22/19	1.22	8	Pough-06/05/19	2.17	43.8
UB-08/07/19	0.513	16.7	Pough-12/11/18	1.84	31.6
Head_of_Tide			**Storm_Water**		

Dun-01/15/19	0.641	ND	Bay-06/10/19	1.44	ND
Dun-09/20/19	0.357	ND	Bay-10/16/19	2.6	4.4
ER-02/08/19	3.28	14.8	Bell-07/23/19	40.1	114
ER-12/25/19	1.05	ND	Bell-10/03/19	41.3	154
HR-02/26/19	1.25	4.2	Kea-07/23/19	2.94	12.1
HR-12/13/19	0.723	ND	Kea-12/02/19	7.75	20
RR-01/09/19	0.895	9.3	Key-05/28/19	3.21	15.6
RR-12/27/19	0.621	ND	Key-12/09/19	6.14	9.3
SR-01/15/19	0.669	ND	NM-06/10/19	10.5	57.7
SR-09/26/19	0.425	ND	NM-12/02/19	7.17	23.3

2.2. Ambient Water - PCDD/Fs and PCBs

For ease of presentation the PCDD/F congeners were assigned an Order. The order value (from 1-17) will be used in the subsequent tables and graphs instead of an unwieldy chemical name. Toxic Equivalency Factors (TEFs) relate the toxicity of each PCDD/F congener to that of 2,3,7,8-TCDD. By multiplying the concentrations of each congener by its TEF a Toxic Equivalency (TEQ) is obtains. TEQs can meaningfully be summed.

Table 3. World Health Organization Toxic Equivalency Factors (TEFs) for PCDD/Fs.

Analyte Name	TEF WHO 2005	Order
2,3,7,8-TCDD	1	1
1,2,3,7,8-PECDD	1	2
1,2,3,4,7,8-HXCDD	0.1	3
1,2,3,6,7,8-HXCDD	0.1	4
1,2,3,7,8,9-HXCDD	0.1	5
1,2,3,4,6,7,8-HPCDD	0.01	6
OCDD	0.0003	7
2,3,7,8-TCDF	0.1	8
1,2,3,7,8-PECDF	0.03	9
2,3,4,7,8-PECDF	0.3	10
1,2,3,6,7,8-HXCDF	0.1	11
1,2,3,4,7,8-HXCDF	0.1	12
1,2,3,7,8,9-HXCDF	0.1	13
2,3,4,6,7,8-HXCDF	0.1	14
1,2,3,4,6,7,8-HPCDF	0.01	15
1,2,3,4,7,8,9-HPCDF	0.01	16
OCDF	0.0003	17

Similarly, PCBs are displayed as homologs. The ten homologs (1-10) encompass congeners of the same molecular weight. Homolog #1 has one chlorine whereas homolog #10 has ten chlorines. State and Federal regulations assume that all PCBs have the same toxicity so they can be summed without needing toxicity factors. This subject is discussed in Section 5.

Total TEQ in all the CARP II ambient samples were dominated by 2,3,7,8-TCDD (congener #1) but the magnitude of the dominance decreased with increasing distance from the Passaic River. 2,3,7,8-TCDD dominance was greatest, and virtually identical, in samples from Newark Bay (NB), Kill van Kull (KVK), and the Hackensack River (HR). The relative contribution of 1,2,3,4,6,7,8-HPCDD (congener # 6), was relatively minor despite its prominence in the Hudson River samples taken at Poughkeepsie. 1,2,3,7,8-PECDD (#2) was, unusually, more abundant than 2,3,7,8-TCDD at Raritan Bay (RB). 1,2,3,7,8-PECDD was also abundant in the Keyport storm water samples. Table 3 and Figure 3 show the PCDD/F congener concentrations (as fg/L TEQ).

Table 4. PCDD/Fs in TOPS samples, TEQ in fg/L. See Table 3 for chemical names of the orders.

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	sum
Ambient																		
AK-07/26/19	188	43	6	19	24	46	20	50	3	44	19	40	2	11	28	2	1	549
Hra-07/16/19	1254	84	8	32	26	60	25	111	5	92	60	240	1	25	115	3	5	2,146
KVK-07/26/19	209	0	2	12	14	23	8	31	2	22	9	22	1	6	16	1	1	376
LB-08/07/19	83	32	5	18	16	28	9	33	2	26	7	13	0	5	9	0	0	288
NB-07/16/19	448	34	5	15	11	28	9	53	3	26	17	59	0	9	32	1	1	753
RB-08/22/19	8	14	1	4	4	7	3	9	0	5	2	3	1	2	3	0	0	67
UB-08/07/19	50	32	4	15	17	30	9	38	2	29	7	13	0	5	10	1	0	263
Head_of_Tide																		
Dun-01/15/19	15	18	3	7	8	21	8	4	0	4	4	5	0	3	9	0	0	110
Dun-09/20/19	10	18	8	22	21	75	25	16	1	22	15	16	0	11	29	1	2	291
ER-02/08/19	23	88	15	41	32	116	44	17	2	26	24	29	1	18	51	3	4	532
ER-12/25/19	0	0	2	4	5	13	6	3	0	5	4	6	0	3	6	0	0	58
HR-12/13/19	5	18	2	5	7	14	5	4	0	4	4	4	0	3	6	0	0	82
RR-01/09/19	2	7	2	5	5	20	27	2	0	3	2	3	0	1	4	0	0	85
RR-12/27/19	0	9	3	7	8	29	39	3	0	5	3	3	0	3	4	0	0	116
SR-01/15/19	7	10	3	7	7	19	6	3	0	4	4	4	0	3	8	0	1	85
SR-09/26/19	46	247	29	76	87	117	19	14	1	23	22	19	0	11	31	3	1	747
Poughkeepsie																		
1/9/2019	6	19	3	13	11	33	12	16	1	13	4	5	0	2	7	0	0	145
1/14/2019	3	4	1	3	3	9	3	4	0	3	1	1	0	1	2	0	0	38
3/13/2019	12	23	8	26	13	80	24	28	1	19	7	7	1	4	11	1	1	265
3/18/2019	9	28	6	21	16	55	17	30	1	15	5	6	0	3	9	0	0	222
4/22/2019	3	5	1	3	2	7	3	3	0	3	1	1	0	1	2	0	0	36
6/5/2019	23	60	14	44	35	133	42	54	2	39	12	14	1	7	20	1	1	502
12/11/2018	7	20	3	11	9	26	9	13	1	13	3	4	1	3	6	0	0	131
Storm_Water																		

Bay-06/10/19	0	546	88	253	250	476	116	144	16	154	68	108	19	55	81	6	2	2,382
Bay-10/16/19	85	223	33	74	88	229	55	47	3	54	25	41	1	21	34	2	2	1,017
Bell-07/23/19	75	102	25	150	77	537	129	27	3	40	27	45	2	19	40	2	2	1,305
Bell-10/03/19	281	569	52	252	182	690	256	149	10	168	88	139	1	67	98	6	5	3,013
Kea-07/23/19	41	141	40	151	116	501	87	18	2	37	47	66	1	34	96	4	4	1,385
Key-05/28/19	153	1082	187	510	456	1473	298	50	6	81	140	102	2	107	236	12	11	4,907
Key-12/09/19	332	4163	921	2901	2245	7720	1870	76	23	225	787	477	13	545	1426	70	69	23,864
NM-06/10/19	391	759	207	830	515	4011	747	35	8	97	381	294	6	254	977	55	69	9,636
NM-12/02/19	97	1087	327	1468	836	7899	1336	28	10	101	474	415	9	249	1199	73	109	15,717

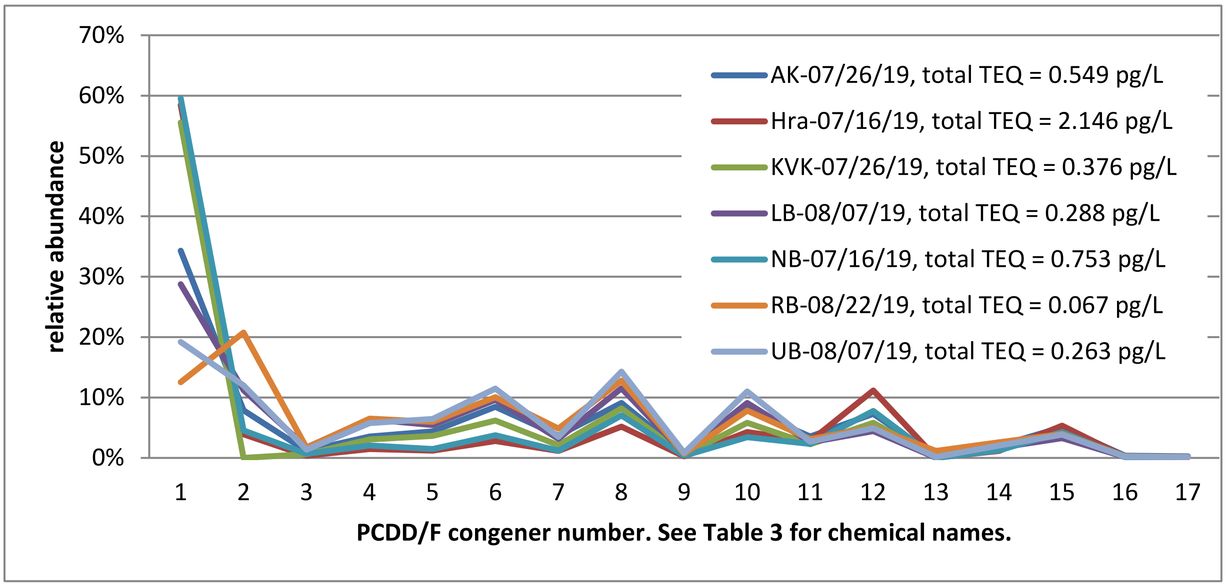


Figure 5. Relative Abundance of PCDD/F TEQ in ambient suspended sediment.

Water data for PCBs are shown below summed by homologs (1-10) and as totals.

Table 5 PCBs in TOPS samples, pg/L.

Homologs	1	2	3	4	5	6	7	8	9	10	sum
Ambient											
AK-07/26/19	0.019	0.57	2.033	2.774	1.677	1.067	0.549	0.181	0.051	0.035	8.95
Hra-07/16/19	0.039	0.745	2.74	4.719	2.507	1.309	0.621	0.227	0.075	0.053	13.03
KVK-07/26/19	0.032	0.597	1.397	1.544	0.803	0.479	0.211	0.086	0.04	0.019	5.21
LB-08/07/19	0.074	0.717	1.567	1.58	0.756	0.465	0.21	0.084	0.037	0.024	5.51
NB-07/16/19	0.031	0.59	1.561	1.961	1.093	0.616	0.277	0.101	0.036	0.023	6.29
RB-08/22/19	0.018	0.22	0.518	0.63	0.354	0.191	0.078	0.024	0.011	0.008	2.05
UB-08/07/19	0.066	0.72	1.669	1.777	0.98	0.652	0.307	0.116	0.05	0.034	6.37
Head of Tide											

Dun-01/15/19	0	0.069	0.071	0.104	0.098	0.076	0.031	0.011	0.004	0.002	0.47
Dun-09/20/19	0.004	0.1	0.312	0.598	0.628	0.567	0.254	0.117	0.052	0.031	2.66
ER-02/08/19	0.006	0.197	0.325	0.579	1.102	1.734	1.196	0.341	0.075	0.029	5.58
ER-12/25/19	0.027	0.365	0.458	0.375	0.358	0.612	0.389	0.107	0.013	0.005	2.71
HR-02/26/19	0.006	0.051	0.035	0.037	0.057	0.054	0.022	0.006	0.001	0.001	0.27
HR-12/13/19	0.002	0.067	0.047	0.084	0.138	0.11	0.046	0.015	0.003	0.002	0.51
RR-01/09/19	0	0.017	0.033	0.055	0.091	0.109	0.063	0.019	0.006	0.002	0.4
RR-12/27/19	0.005	0.038	0.04	0.067	0.116	0.13	0.066	0.024	0.006	0.003	0.49
SR-01/15/19	0.005	0.073	0.1	0.089	0.083	0.063	0.024	0.006	0.002	0.001	0.45
SR-09/26/19	0.217	0.17	0.362	0.441	0.514	0.514	0.159	0.062	0.013	0.005	2.46
Poughkeepsie											
Pough-01/09/19	0.185	1.602	3.288	2.757	0.74	0.328	0.09	0.026	0.013	0.007	9.03
Pough-01/14/19	0.116	1.034	1.886	1.421	0.511	0.227	0.064	0.019	0.009	0.004	5.29
Pough-03/13/19	0.774	4.962	9.15	6.217	2.259	1.119	0.335	0.133	0.065	0.029	25.04
Pough-03/18/19	0.832	5.596	10.252	6.359	2.239	1.041	0.311	0.161	0.132	0.039	26.96
Pough-04/22/19	0.196	2.245	3.27	2.26	0.732	0.352	0.093	0.031	0.015	0.007	9.2
Pough-06/05/19	1.472	9.036	17.51	12.977	4.798	2.136	0.641	0.233	0.114	0.055	48.97
Pough-12/11/18	0.21	1.993	3.458	2.686	0.928	0.388	0.099	0.029	0.014	0.007	9.81
Storm Water											
Bay-06/10/19	0.068	1.436	1.763	2.485	4.431	4.325	1.885	0.715	0.179	0.065	17.35
Bay-10/16/19	0.014	0.445	0.393	1.096	3.177	2.477	1.025	0.381	0.092	0.035	9.14
Bell-07/23/19	0.064	0.622	1.15	3.415	8.973	6.792	2.351	0.769	0.249	0.259	24.64
Bell-10/03/19	0.135	1.548	1.976	5.665	15.71	22.144	21.87	8.342	0.94	0.401	78.73
Kea-07/23/19	0.001	0.083	0.097	0.409	1.001	1.121	0.523	0.193	0.073	0.065	3.57
Kea-12/02/19	0.016	0.909	0.451	0.924	1.578	1.787	0.896	0.328	0.097	0.053	7.04
Key-05/28/19	0.013	1.162	0.216	0.388	1.009	1.242	0.49	0.157	0.044	0.023	4.74
Key-12/09/19	0.012	1.546	0.461	0.9	1.898	1.758	0.779	0.274	0.082	0.034	7.75
NM-06/10/19	0.032	3.045	1.912	1.394	1.047	0.921	0.308	0.095	0.035	0.018	8.81
NM-12/02/19	0.102	4.274	1.095	0.62	0.801	0.796	0.335	0.106	0.028	0.012	8.17

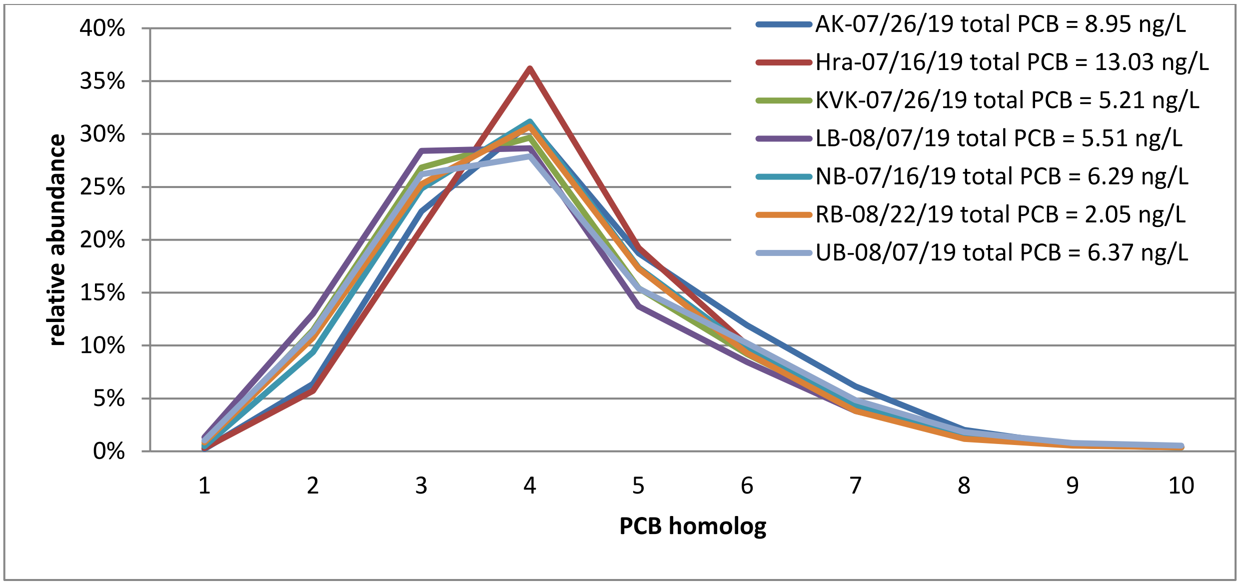


Figure 6. Total PCB homolog concentrations in water, suspended sediment and filtered water.

2.4. Head of Tide PCDD/Fs and PCBs

2,3,7,8-TCDD was never dominant in any of the HOT or storm water samples. Total TEQ at the HOT Passaic River site, the Dundee Dam, were both low. Discharges were 1845 CFS on 1.15/19 and 231 on 9/20/19.

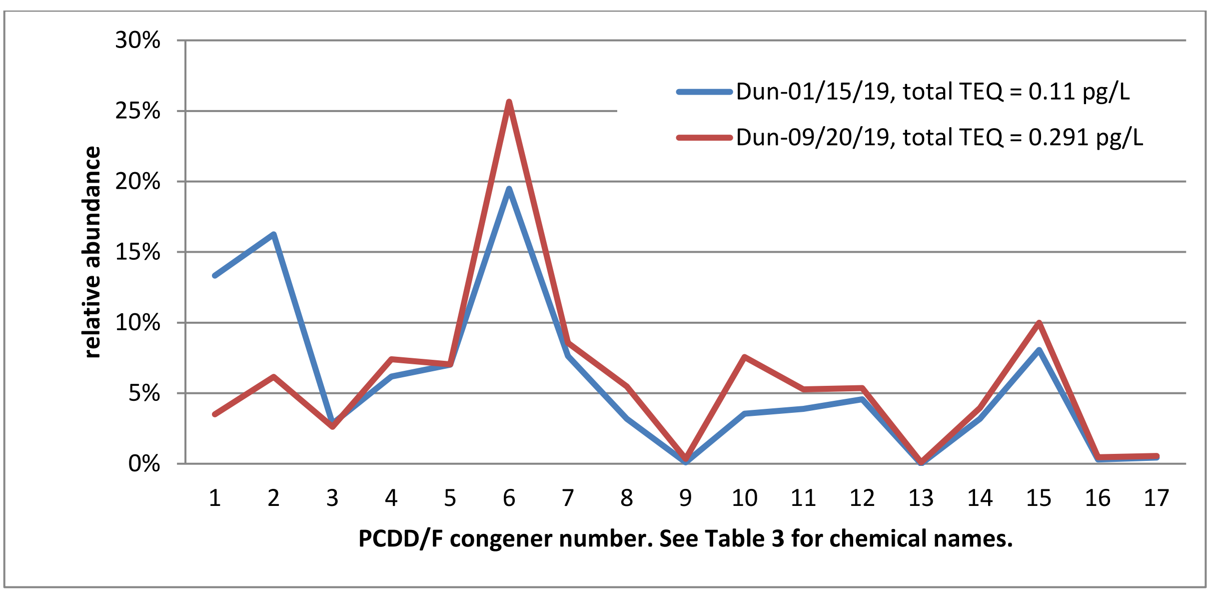


Figure 7. Relative Abundance of PCDD/F TEQ at Dundee Dam in suspended sediment.

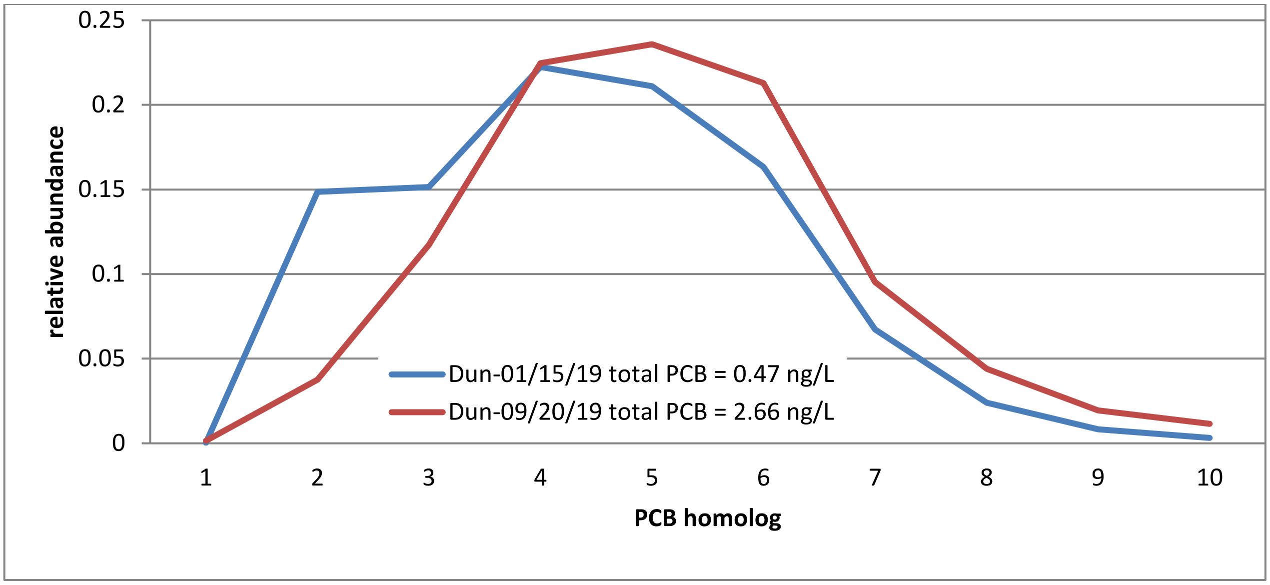


Figure 8. Relative Abundance of PCB homologs at Dundee Dam, suspended sediment and filtered water.

The Elizabeth River showed one of the higher TEQs (average 0.532 pg/L) on 2/8/19 (57 CFS) and one of the lowest TEQs (0.06 pg/L) on 12/25/19 (15 CFS).

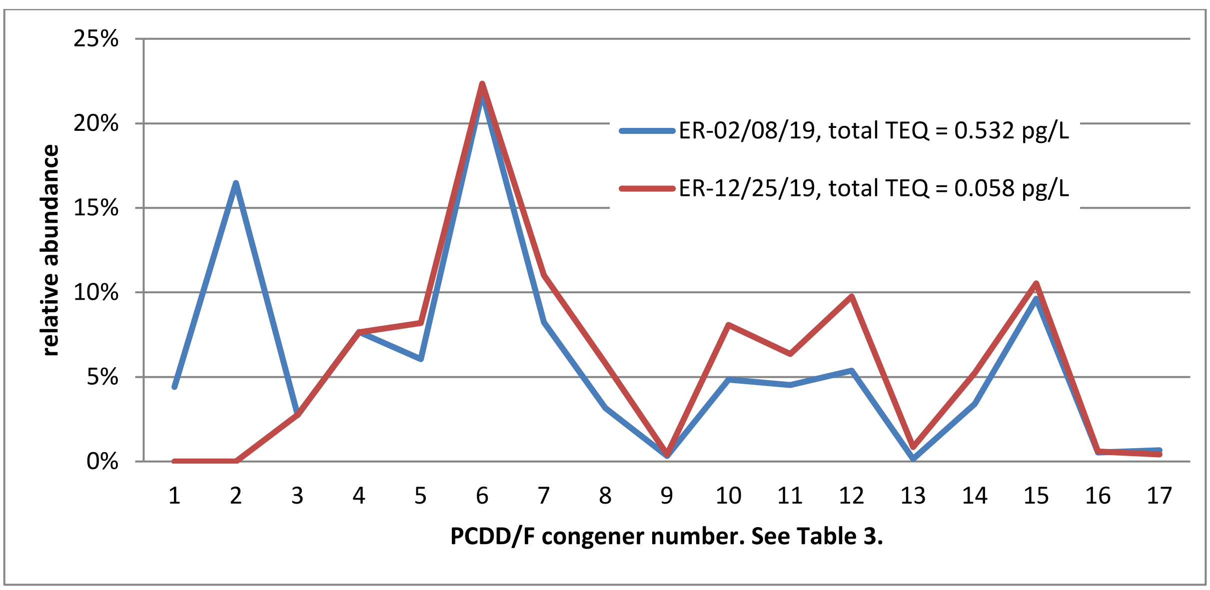


Figure 9. Relative Abundance of PCDD/F TEQ at Elizabeth River Site, suspended sediment.

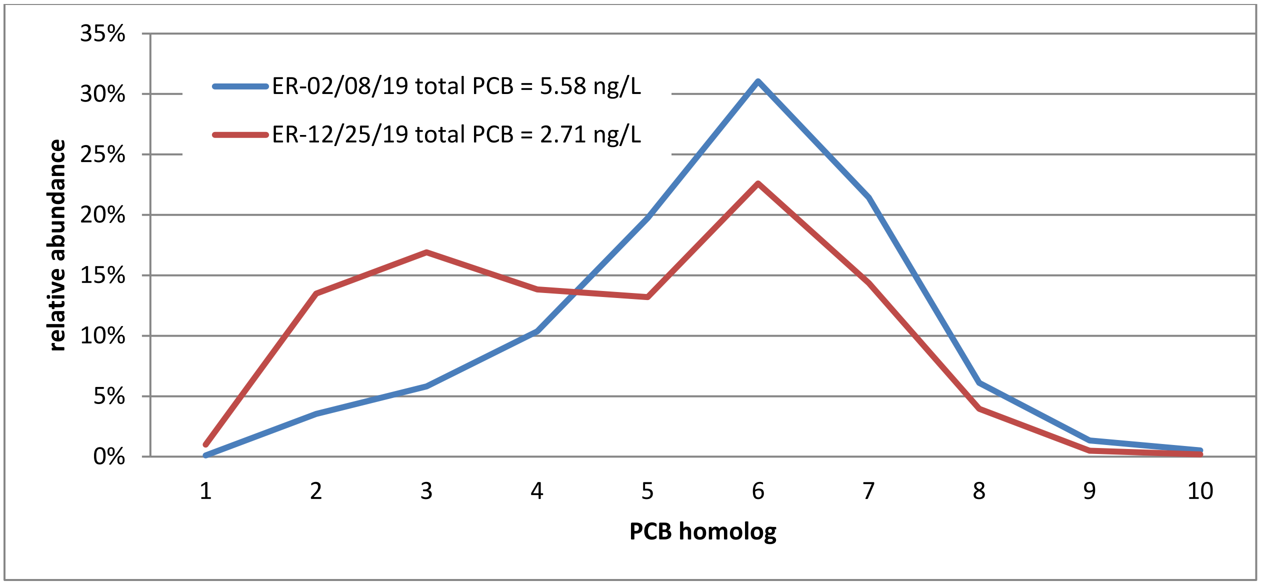


Figure 10. Relative Abundance of PCB homologs at Elizbeth River Site, suspended sediment and filtered water.

The HOT Hackensack was sampled on 2/26/19 and on 12/13/19 but the PCDD/F sample from 2/26/19 was lost in a lab accident. Discharge on 2/26/19 was 213 CFS but only 2.15 CFS on 12/13/19.

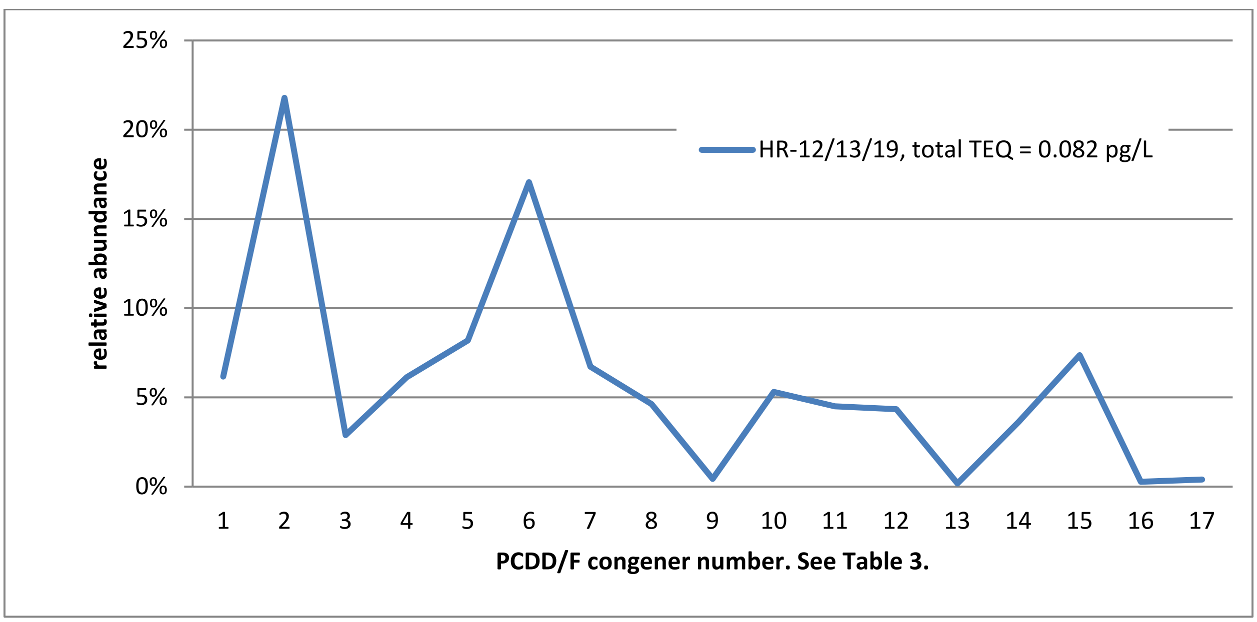


Figure 11. Relative Abundance of PCDD/F TEQ at Hackensack River Site, suspended sediment.

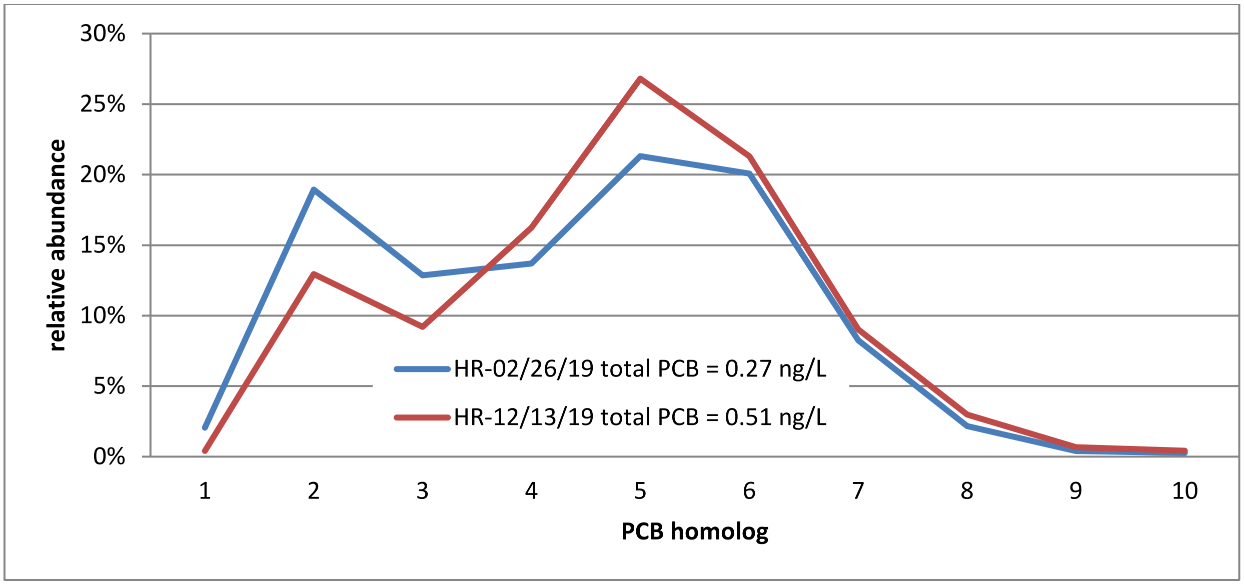


Figure 12. Relative Abundance of PCB homologs at Hackensack River Site, suspended sediment and filtered water.

HOT Raritan River (at Bound Brook, NJ) was sampled on 1/9/19 (2487 CFS) and on 12/27/19 (722 CFS). This was only site where OCDD (# 7) was the dominant contributor to total TEQ. The NOAA historical sediment database compiled under CARP II project has a similar pattern of OCDD dominance at the Tremley Point on the Arthur Kill.

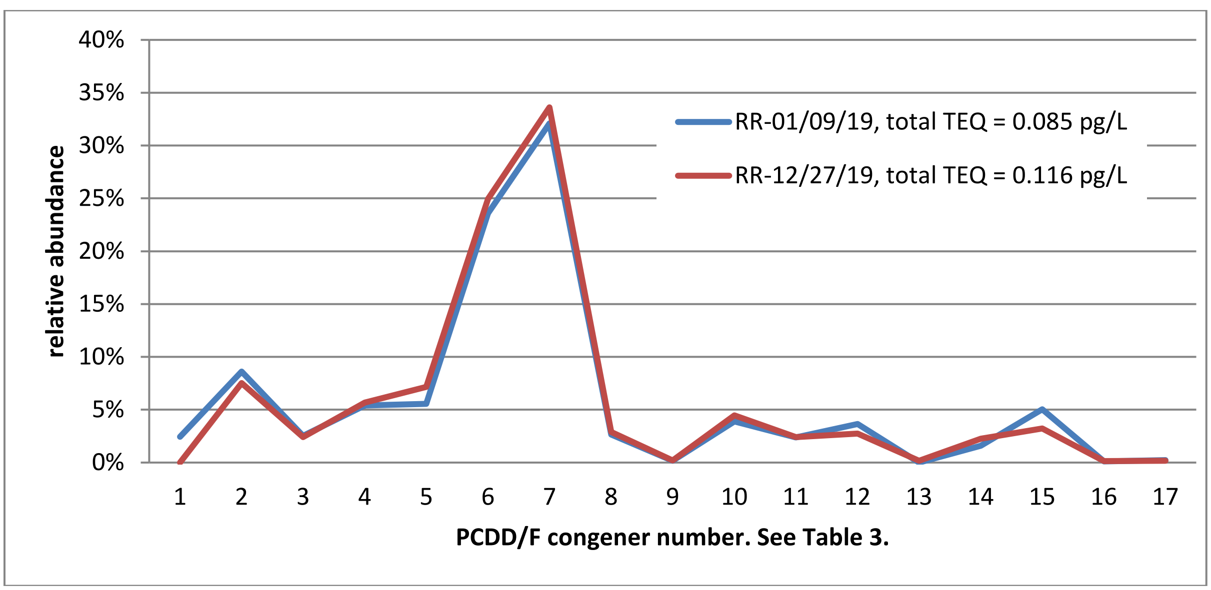


Figure 13. Relative Abundance of PCDD/F TEQ at Raritan River Site, suspended sediment.

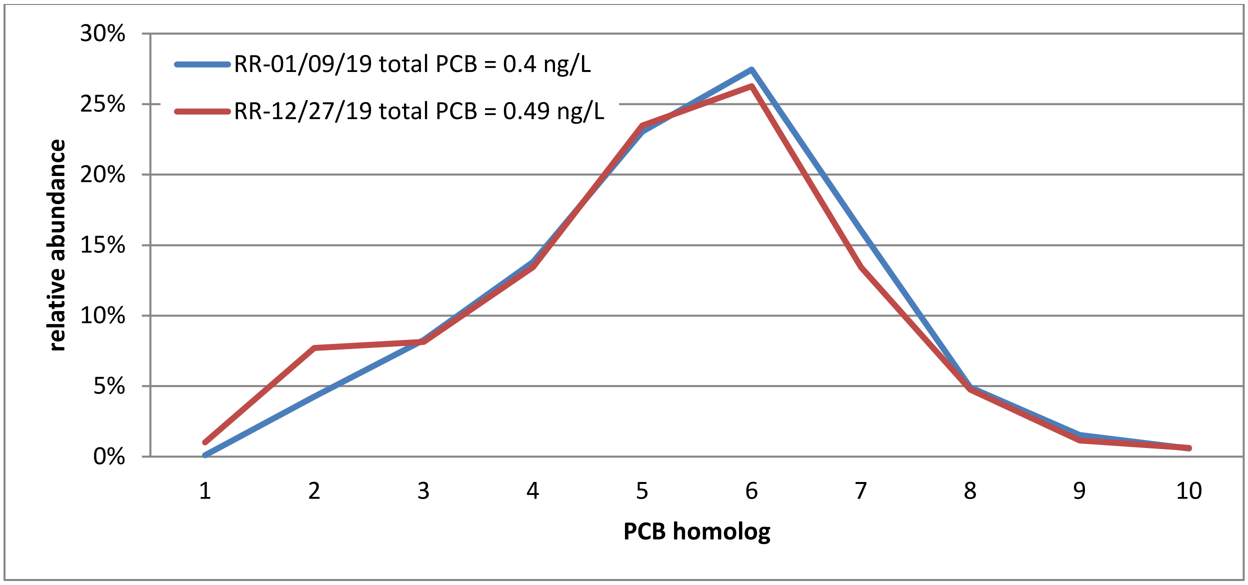


Figure 14. Relative Abundance of PCB homologs at Raritan River, suspended sediment and filtered water.

The Saddle River HOT samples (1/15/19; 123 CFS and 9/26/19; 25.9 CFS) is another example, like the Passaic at the Dundee, of apparent dilution where concentrations were higher at lower discharges. The patterns of the congener abundances were, like the Elizabeth River, distinctive.

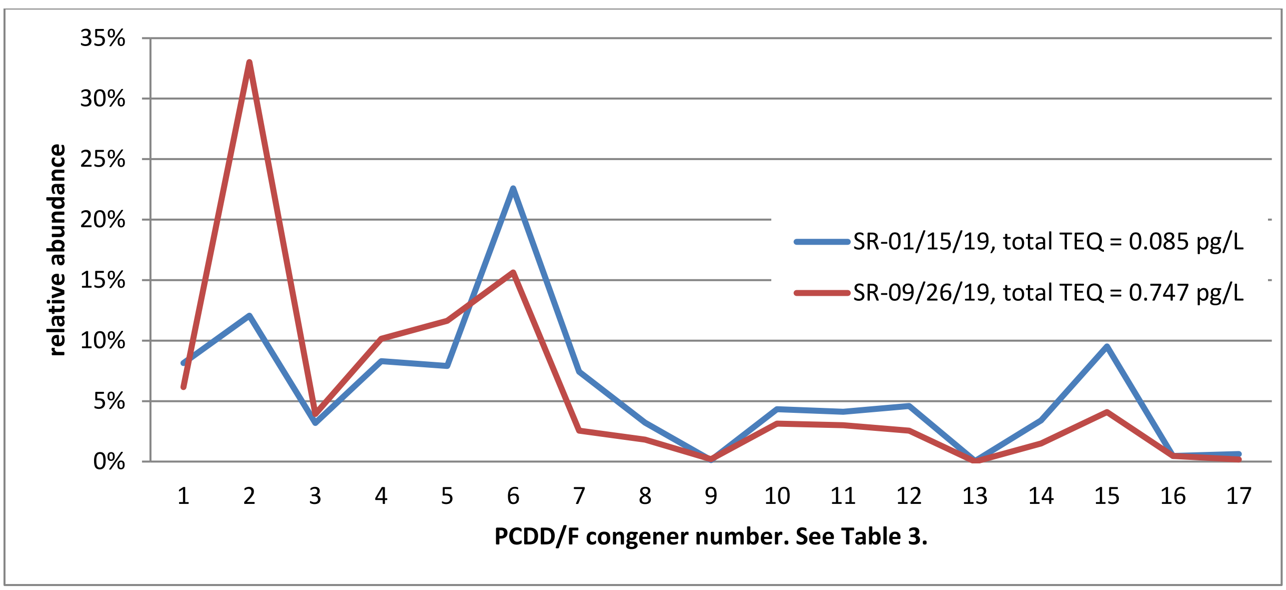


Figure 25. Relative Abundance of PCDD/F TEQ at Saddle River Site, suspended sediment.

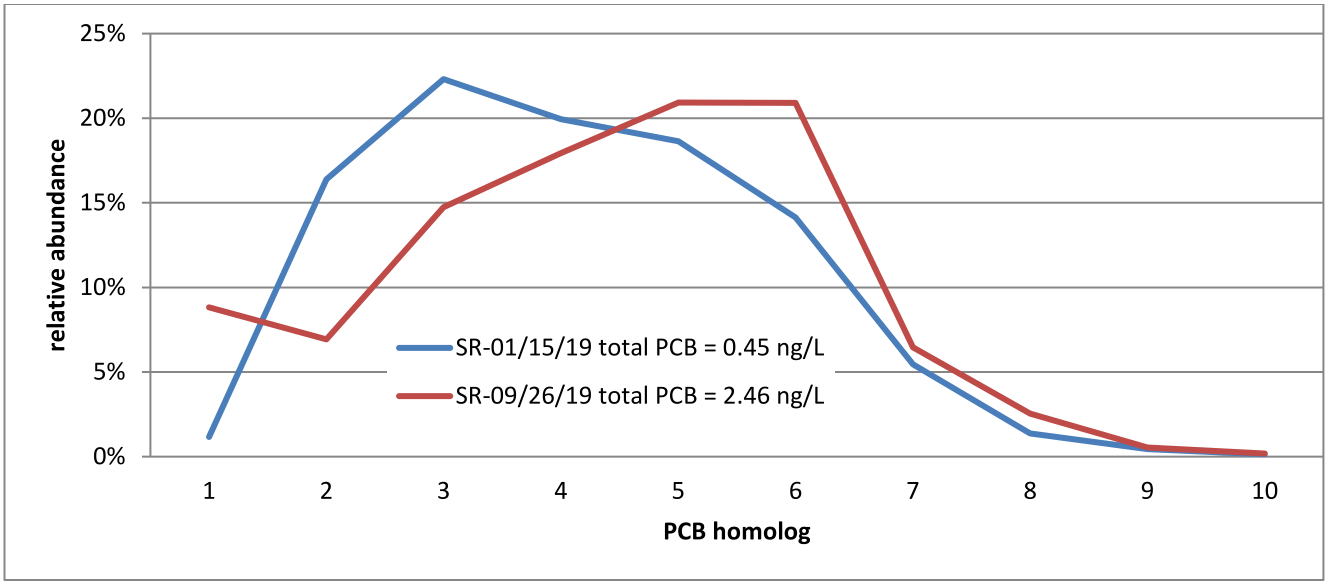


Figure 16. Relative Abundance of PCB homologs at Saddle River Site, suspended sediment and filtered water.

2.4. Poughkeepsie PCDD/Fs and PCBs

2,3,7,8-TCDD, so prominent in the harbor, was a minor component of the total TEQ in the Poughkeepsie samples (Figure 15). The patterns of relative abundances at all Poughkeepsie events were very similar. The hydrological regime of the Hudson River at Poughkeepsie is dominated by the tidal cycles. The graphs in Figure 16 indicate the times of sampling (in red) in the tidal cycle at Poughkeepsie.

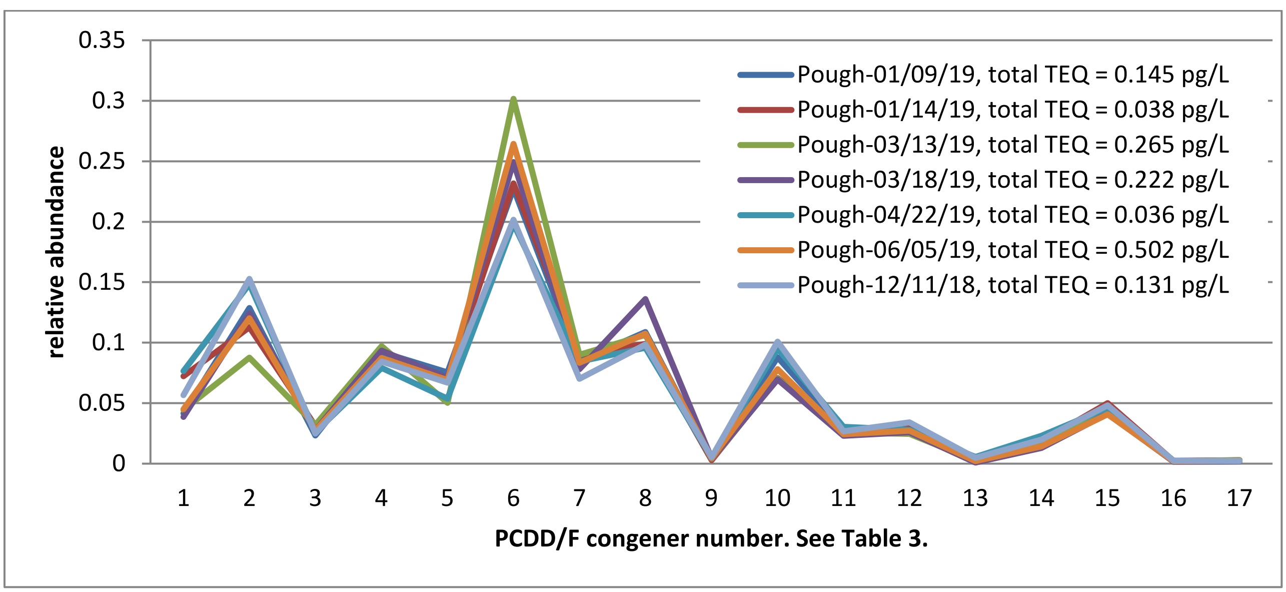


Figure 17. Relative abundances of PCDD/F TEQ at Poughkeepsie, suspended sediment.

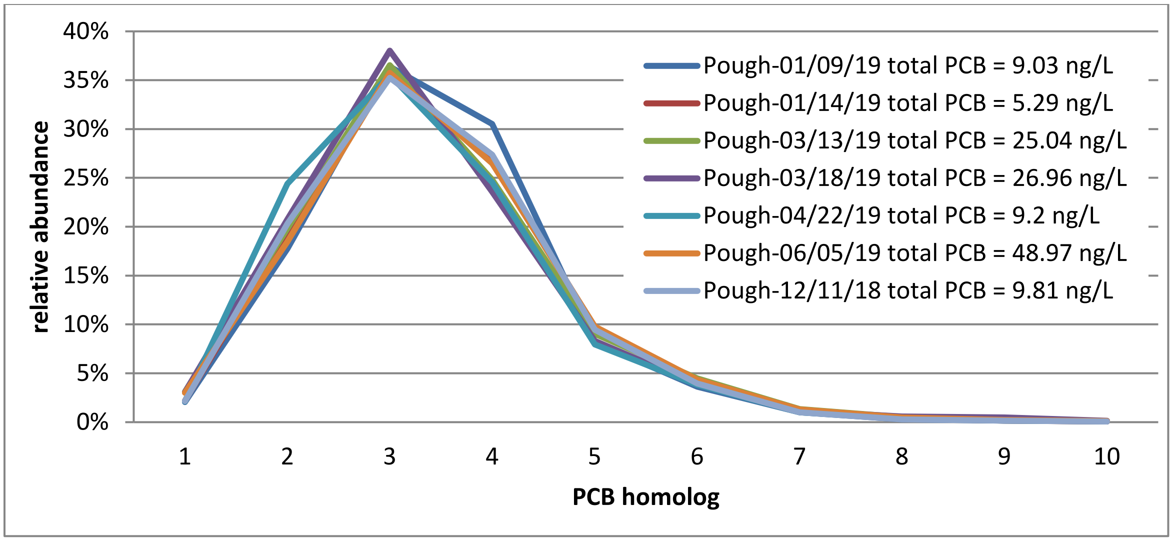


Figure 38. Relative Abundance of PCB homologs at Poughkeepsie, suspended sediment and filtered water.

Hudson Estuary suspended sediment concentrations are strongly affected by tides. A plot of river elevation and NTU, a surrogate for suspended sediment concentration, shows concentrations dramatically rising on the rising limb of the tidal cycle.

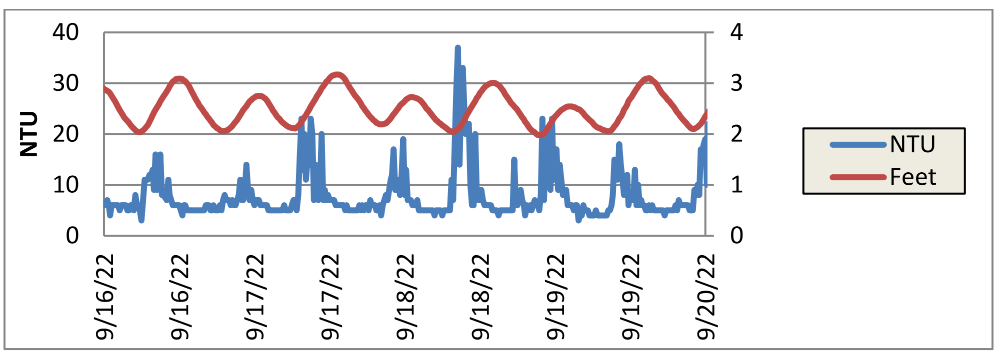


Figure 19. Hudson River turbidity (NTU) and surface elevation at Norrie Point. HRECOS data.

TOPS sampling occurs over several hours. None of the Poughkeepsie sampling events occurred during the rising limb of the hydrograph so we could expect to have seen much higher contaminant concentrations had the samples been taken at different times.

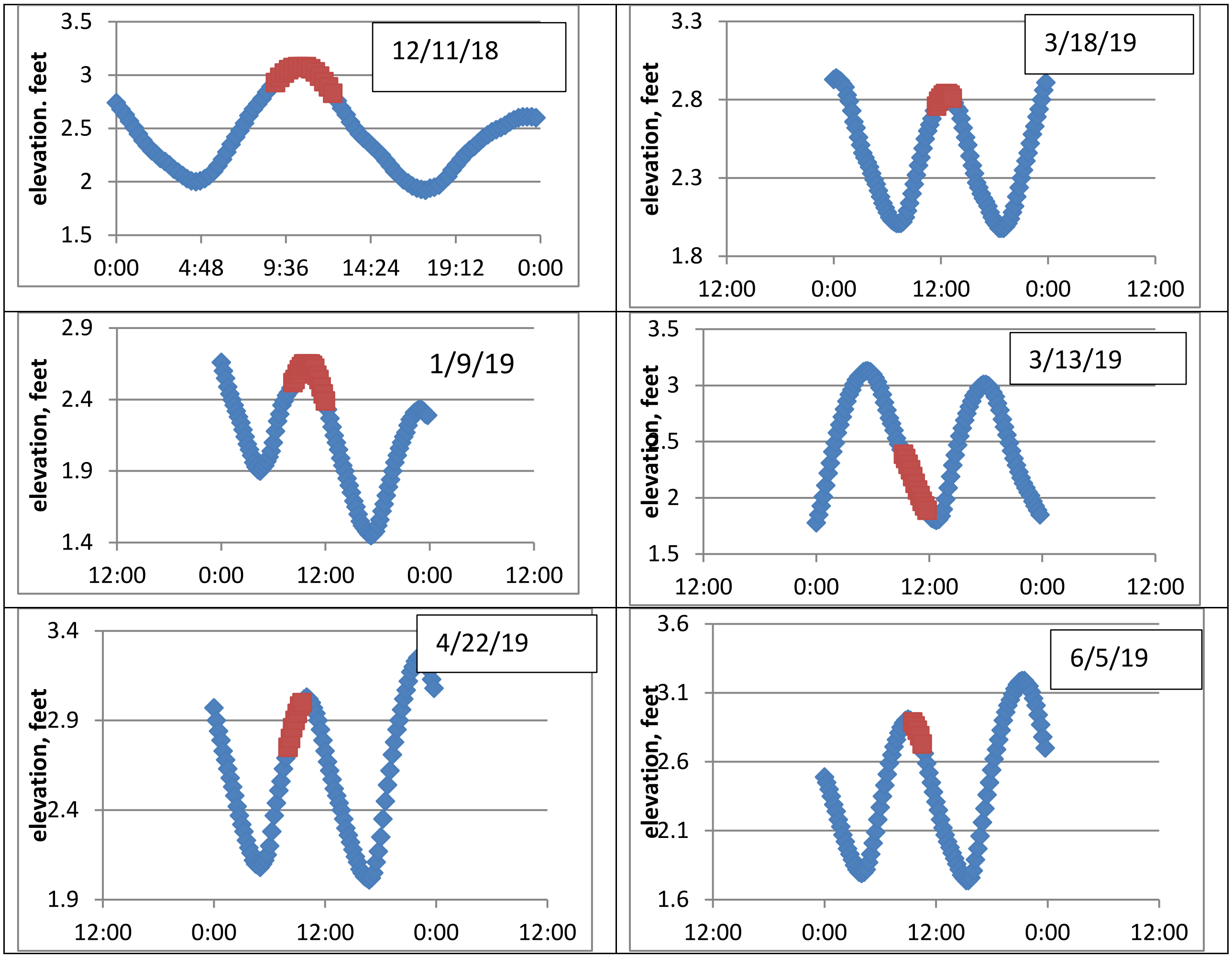


Figure 4. Time of sampling (in red) in the tidal cycle at Poughkeepsie.

2.5. Storm Water PCDD/Fs and PCBs.

Storm water samples were taken at Bayonne of 6/10/19 and 10/16/19. It was starting to rain at Newark Airport when the 6/10 sample was taken and raining rather hard when the 10/16 sampling was being done.

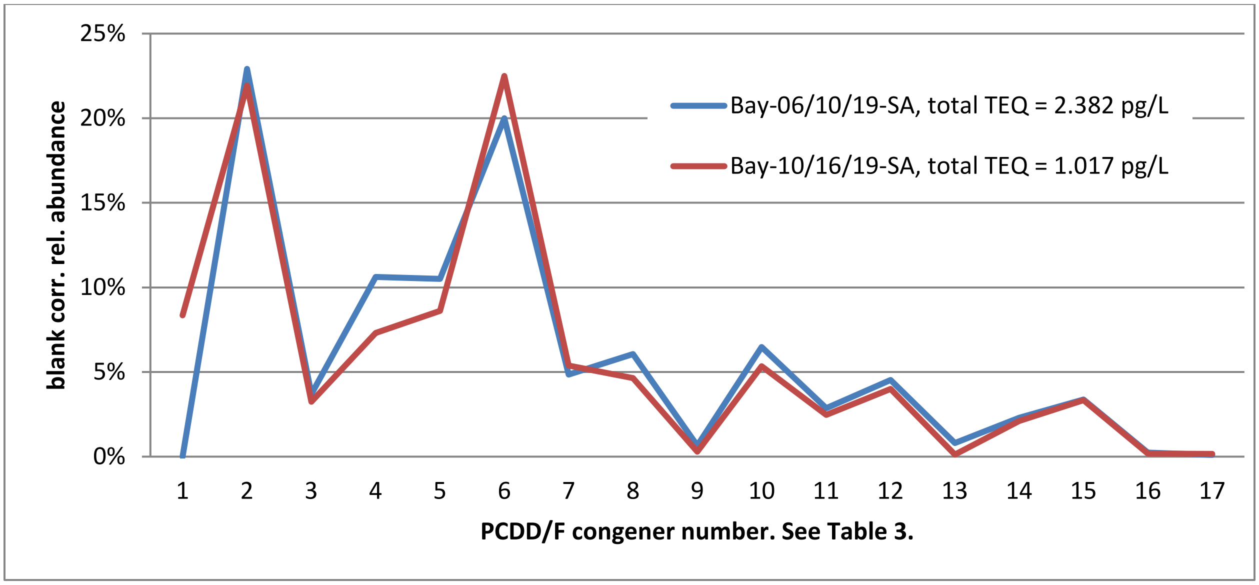


Figure 21. Relative abundances of total PCDD/F TEQ at Bayonne storm water.

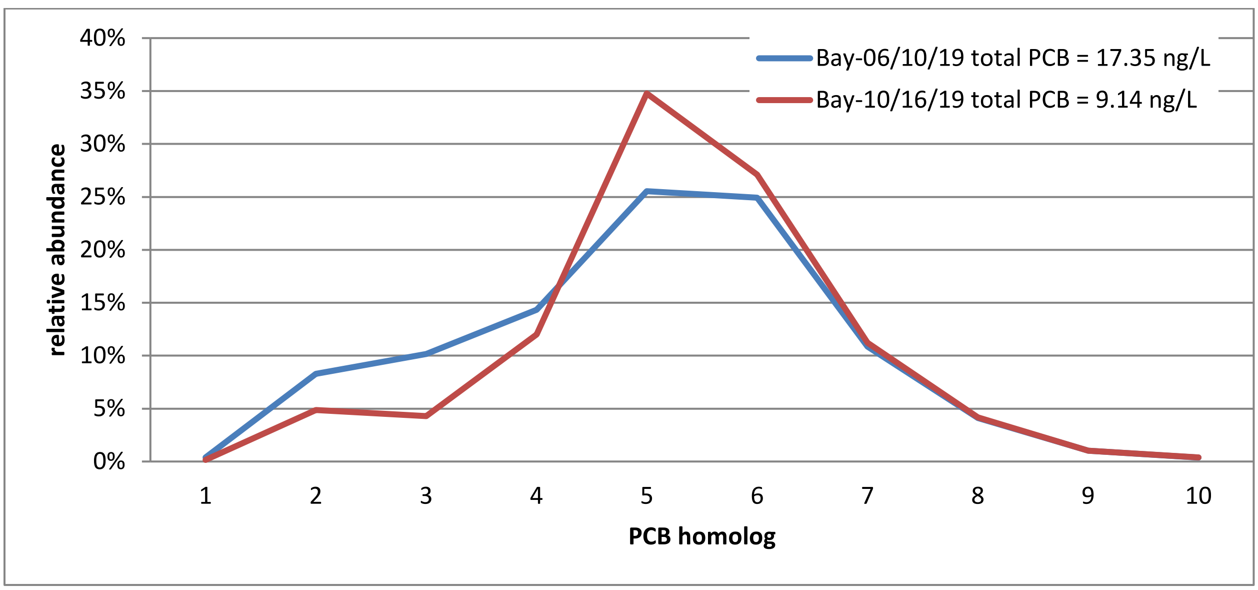


Figure 22. Relative abundances of PCB homologs at Bayonne storm water.

The 7/23/19 Belleville storm water sample (Bell) was taken as an earlier rain storm was ending. The sample taken on 10/3/19 was during a rain storm at the Newark Airport.

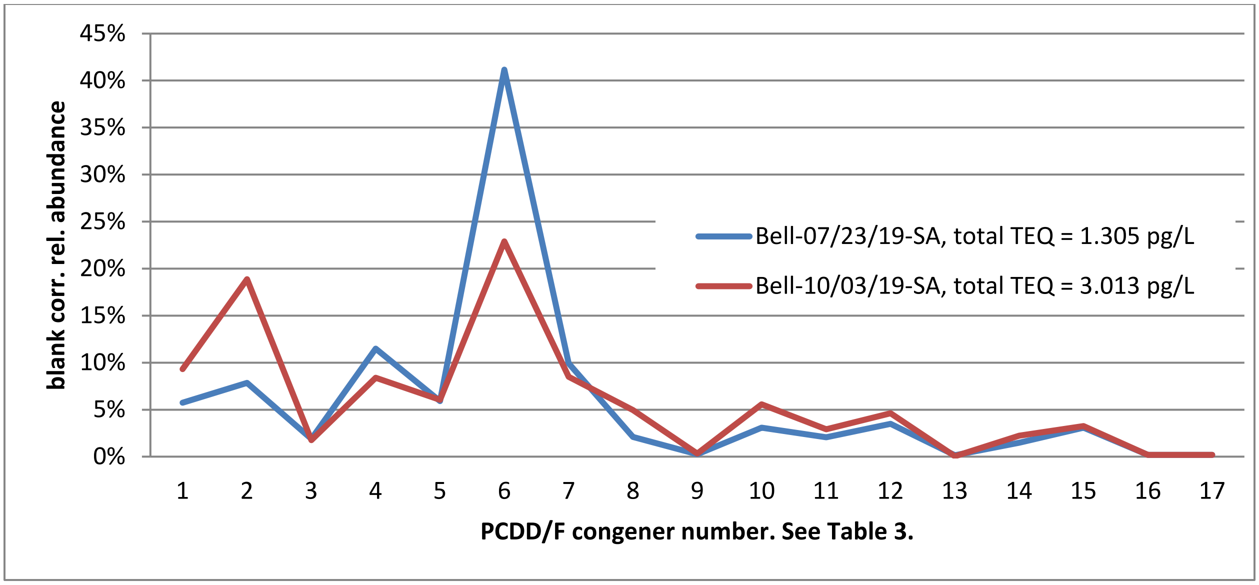


Figure 23. Relative abundances of PCDD/F TEQ at Belleville storm water.

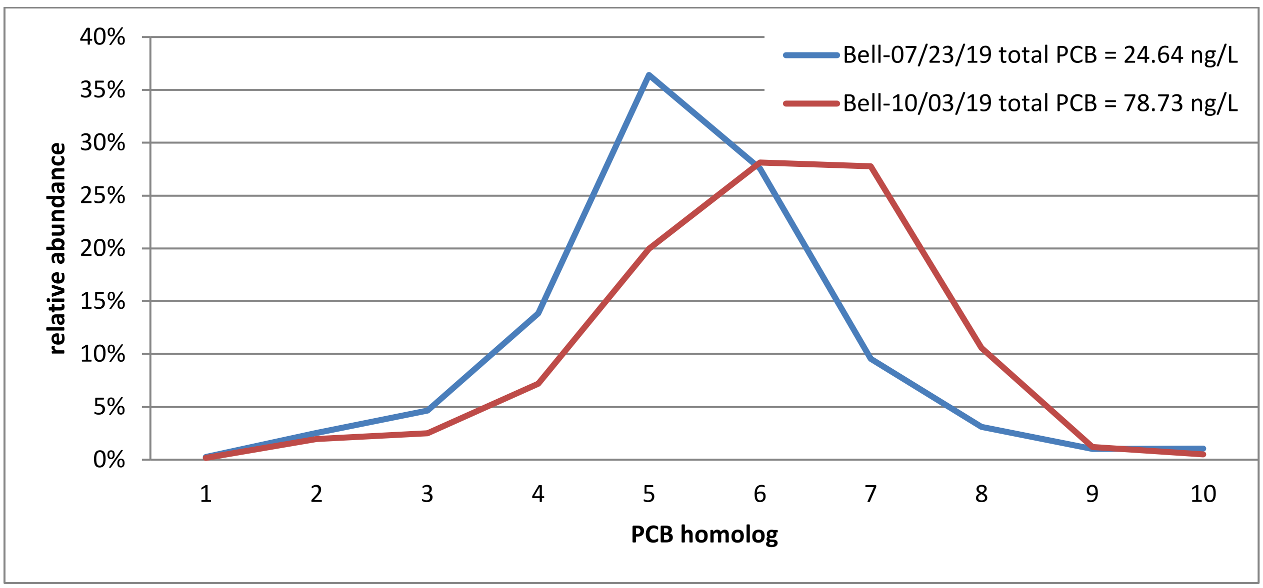


Figure 54. Relative abundances of PCB homologs at Belleville storm water.

Sampling at the Kearny storm water site (Kea) occurred during an early morning rain shower. A sample was also taken on 12/2/19 but lost in a lab accident.

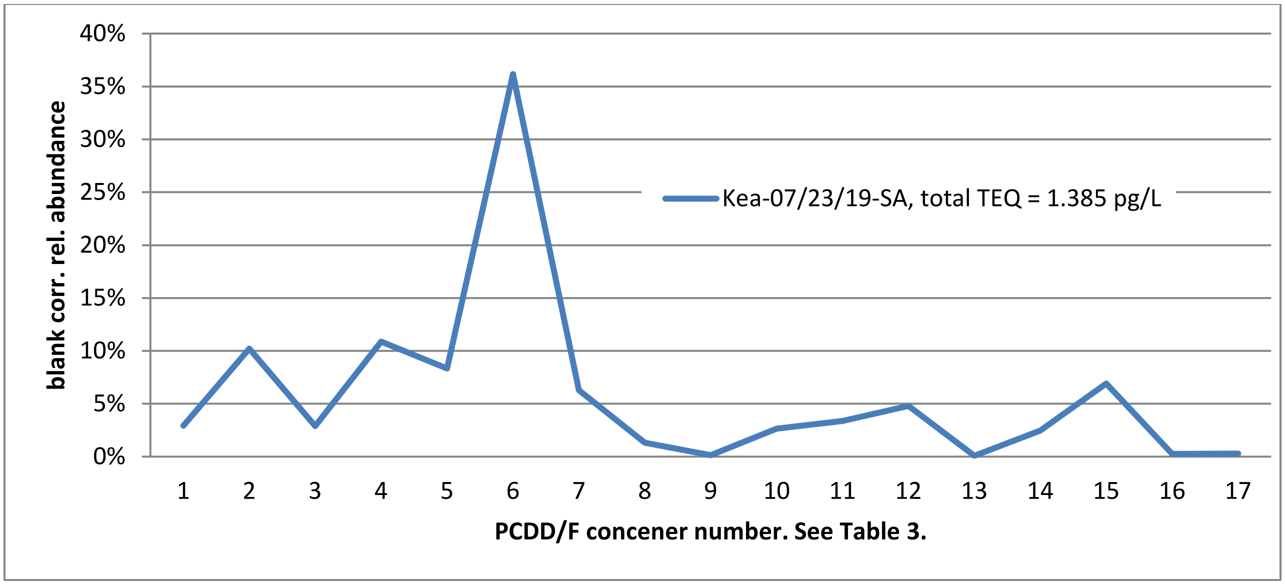


Figure 25. Relative abundances of PCDD/F TEQ at Kearny Point storm water.

A lab accident lost any possibility of detecting the mono-chlorobiphenyls in Kea-07/23/19.

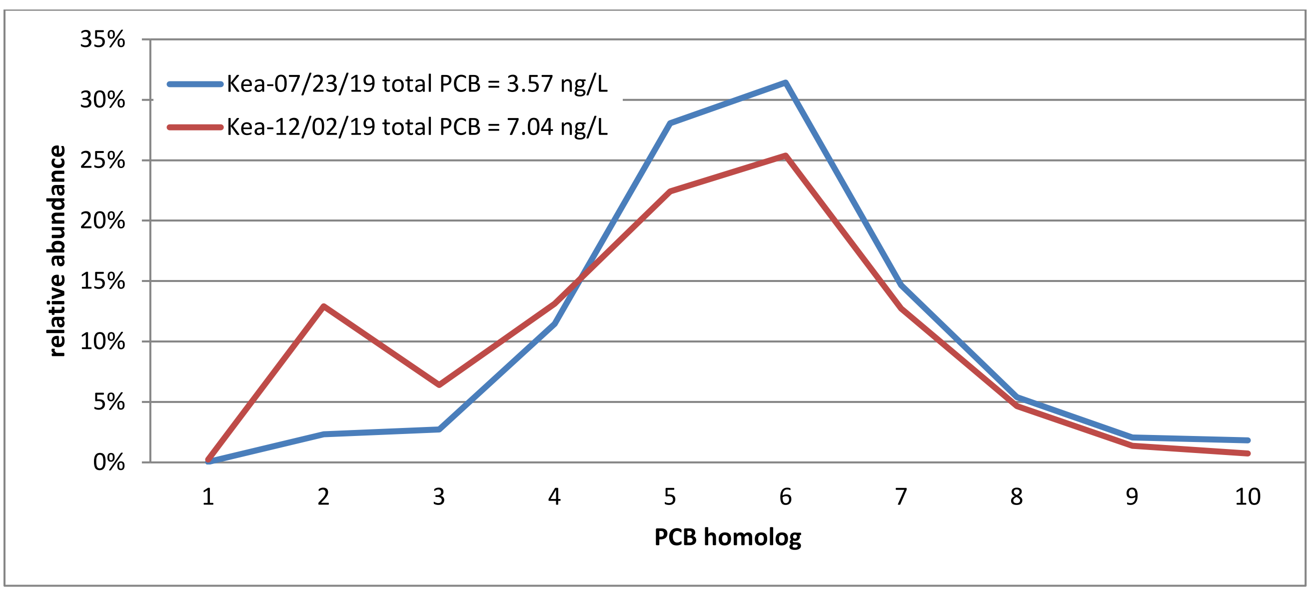


Figure 26. Relative abundances of PCB homologs at Kearny Point storm water.

The highest total TEQ seen in water samples occurred in one of the Keyport storm water samples. Weather data from Newark International Airport indicates that it was dry on 5/28/19 but rainy on 12/9/19. Congener patterns on the two occasions were very similar but total TEQs were different.

The suspended sediment particles trapped by the filter differed in abundance but had the same source.

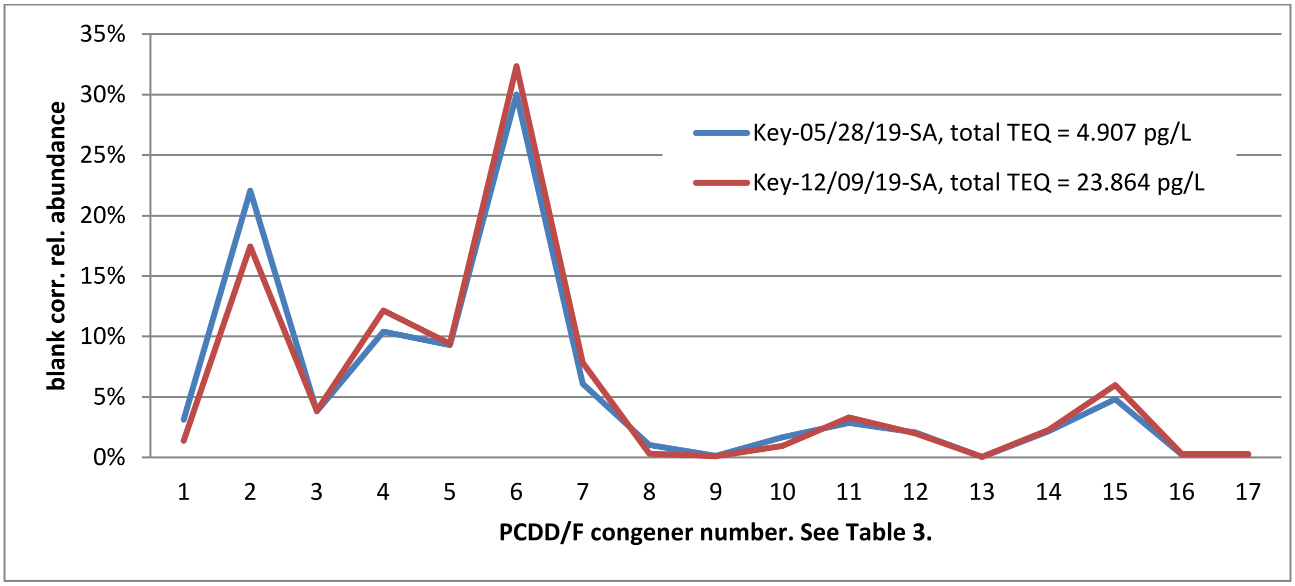


Figure 27. Relative abundances of PCDD/F TEQ in Keyport storm water.

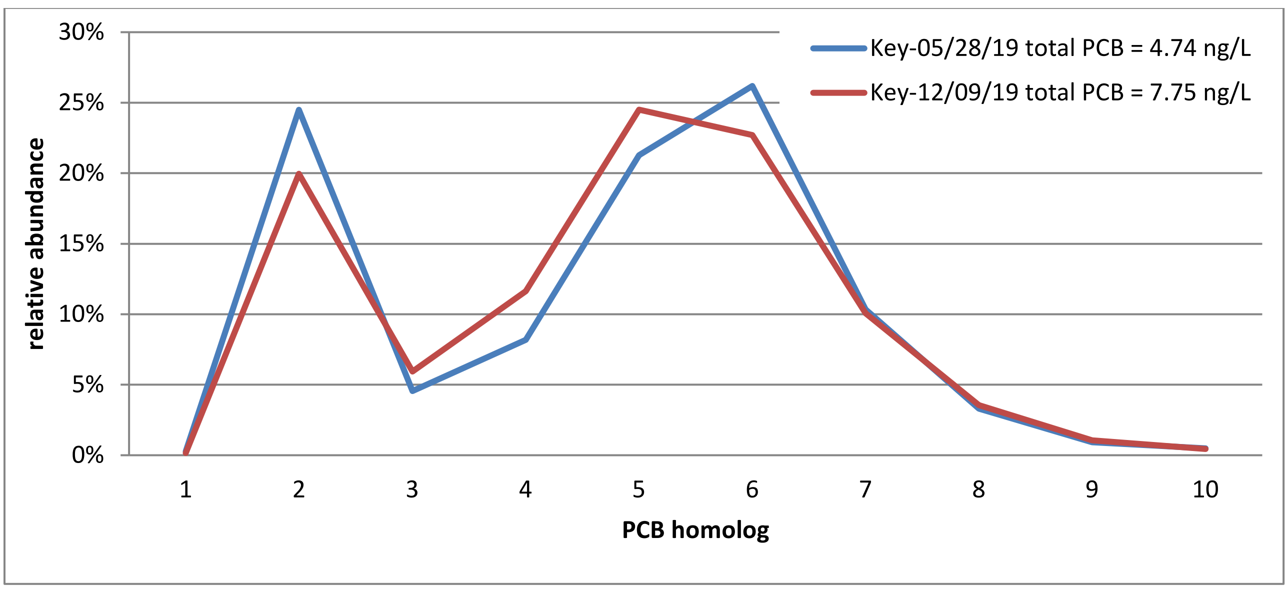


Figure 28. Relative abundances of PCB homologs in Keyport storm water.

Light rain was falling at Newark Airport on both sampling occasions at New Milford (NM). Total TEQ was high, particularly from the 12/2/19 event. Congener patterns on the two occasions were very similar.

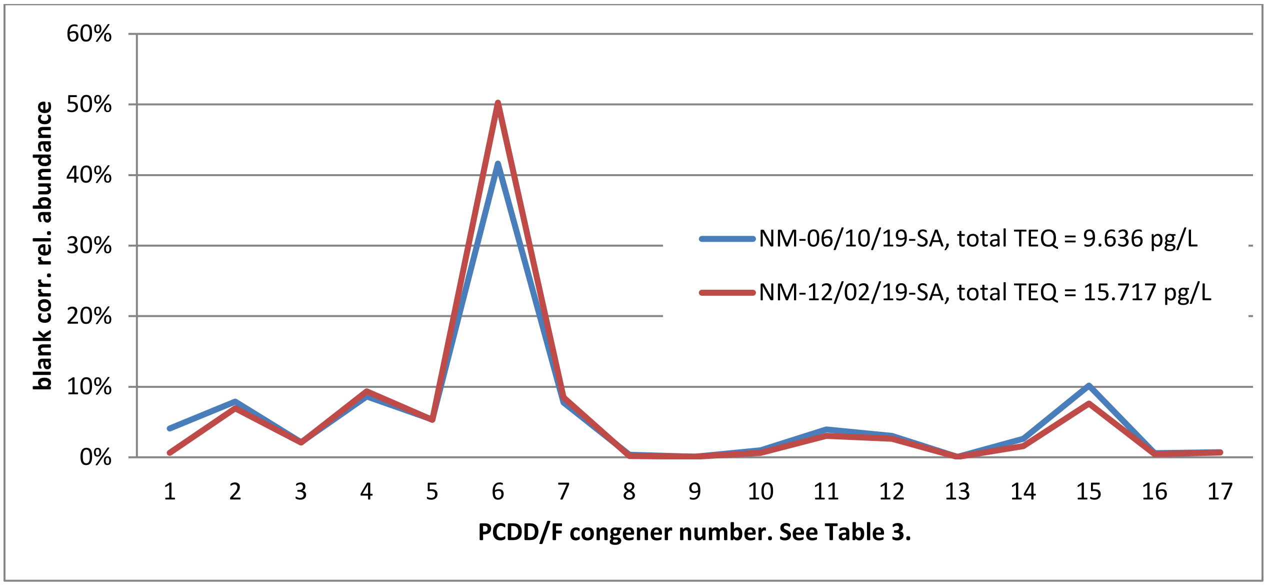


Figure 29. Relative abundances of PCDD/F TEQ at New Milford storm water.

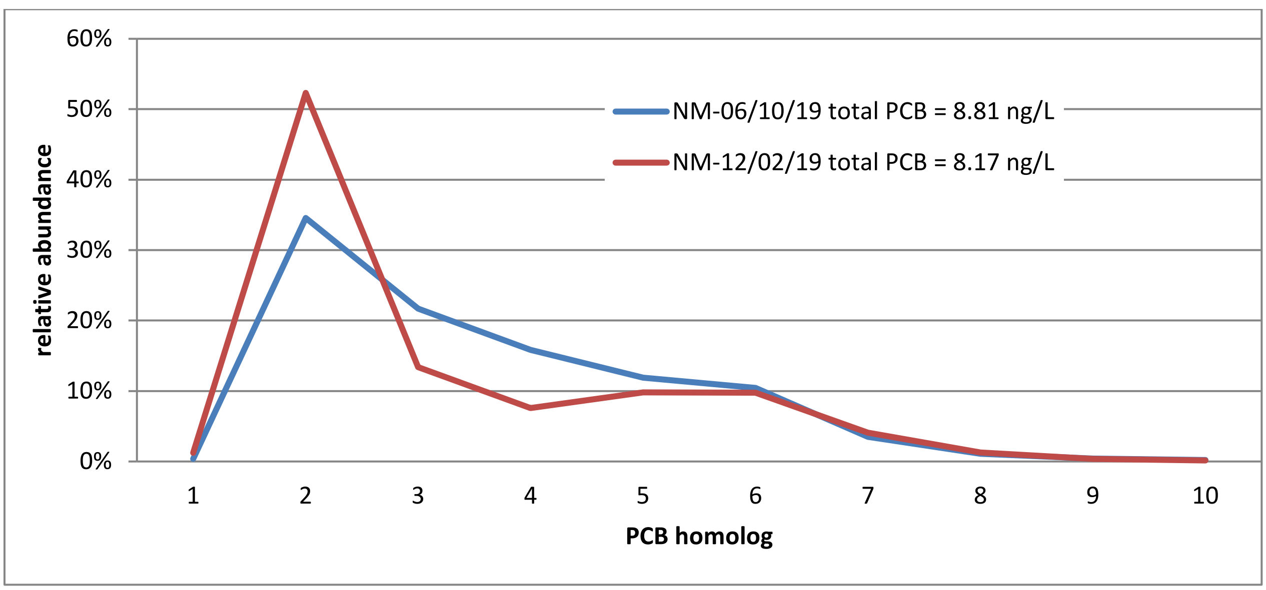


Figure 30. Relative abundances of PCB homologs at New Milford storm water.6

Total TEQs of most of the water column samples shown above were dominated by congener # 6, (1,2,3,4,6,7,8-HPCDD). This congener could be produced by dechlorination of OCDD, which is always the most abundant dioxin congener, in terms of raw concentration instead of TEF adjusted values, of the seven that are measured.

Dichlorobiphenyl (PCB homolog # 2) was the dominant PCB homolog group only in the two New Milford storm water samples (NM). In 16 of the TOPS sampling events the major congener of the dichlorobiphenls was 3,3'-dichlorobiphenyl (IUPAC 11). Prior to the use of method 1668 for PCBs this congener was unknown in environmental work. Printing shops, which may have been using diarylide pigments (often contaminated with 3,3'-DiCB) were found immediately upstream from one of the storm sewer sampling points. A partial exception to the 1979 PCB ban for inadvertently manufactured mono- and dichlorobiphenyls was made to the Federal Toxic Substances Control Act in 1986. State regulations may differ.

Chapter 3. Sediments

For the evaluation of sediments in navigation channels and off-channel areas, sediment core samples were collected from six locations in NY-NJ Harbor: Buttermilk Channel, Elizabeth Channel, Port Jersey, Port Newark, South Brother Island Channel and Ward Point Bend near the mouth of the Raritan River (Figure 2). Generally, for each station, three samples were collected in the navigation channel and three samples were collected from the adjacent off-channel sediments. To represent sediments that are typically considered in dredged material testing, navigation channel sediment core samples were sub-sampled from a surface layer (0 -10 cm) and a deeper layer (20 - 30 cm). Since off-channel sediments were expected to accumulate at slower rates, off-channel sediment samples were sub-sampled from a surface layer (0 -4 cm) and a deeper layer (6 - 10 cm). In total 68 sediment samples were collected from in-channel and off-channel areas across the harbor.

Each of the 68 sediment samples were analyzed for PCB congeners and 2,3,7,8-chlorine substituted PCDD/Fs. Additional sediment parameters of total organic carbon, soot (black carbon), dissolved organic carbon and Berylium-7 concentrations were also measured. A subset of 20 sediment samples were analyzed using polyethylene passive samplers to determine porewater concentrations for PCBs, PCDD/Fs, and black carbon. 28-day bioaccumulation tests were performed on all 68 of the samples following the protocols[1] outlined in the Region 2 Testing Manual (USACE/USEPA 2016). These data were used to assess the accuracy of the CARP I models projections, and as discussed below, in the refinement of the CARP II models.

3.1. Sediment Core Samples and Map

Sediment cores were taken from six sediment groups. In each group three sediment cores were taken from the in the navigational channel (IC) and three were from adjacent off channel (OC) locations (except Port Newark when only one OC core was taken). Cores were taken using a HAPS gravity corer. The cores were sectioned into an upper (Over) "active" layer and a lower (Under) "deep" layer. The active layer or Over core sections were 0-10 cm in IC samples and 0-4 cm in OC samples. The deep layer or Under samples were usually from 20-30 cm in the IC cores and usually 6-10 cm from the OC or off channel cores.

[1] Dredged material testing methods for were modified to use less sediment, keeping the sediment to water ratio consistent with the standard protocols.

After each deployment the HAPS corer and associated sampling equipment were thoroughly brushed and rinsed with site water. Sediment samples were analyzed for PCBs, PCDD/Fs, TOC, black carbon, particle size and Be-7. Sediment wet weight, bulk density/dry weight and grain size distribution was also measured. Each sample was also be used for the 28-day bioaccumulation (Tissue) tests.

Table 6. Sediment core samples.

Sample group and date	Abbr.	Nav. Status	Latitude	Longitude
Buttermilk_Channel_2-4/16/2019	BMC	in channel	40.67351	-74.02555
Buttermilk_Channel_3-4/16/2019	BMC	in channel	40.67703	-74.03010
Buttermilk_Channel_6-4/16/2019	BMC	in channel	40.67951	-74.03024
Buttermilk_Channel_3-4/16/2019	BMC	off channel	40.68249	-74.02851
Buttermilk_Channel_5-4/16/2019	BMC	off channel	40.68724	-74.00736
Buttermilk_Channel_6-4/16/2019	BMC	off channel	40.68559	-74.01854
Elizabeth Channel_1-5/16/2019	EC	in channel	40.68508	-74.15281
Elizabeth Channel_2-5/16/2019	EC	in channel	40.67494	-74.14019
Elizabeth Channel_3-5/16/2019	EC	in channel	40.66175	-74.14715
Elizabeth Channel_4-5/16/2019	EC	off channel	40.66545	-74.13439
Elizabeth Channel_5-5/16/2019	EC	off channel	40.65767	-74.14086
Elizabeth Channel_6-5/16/2019	EC	off channel	40.67912	-74.12786
Port Jersey 1-5/7/2019	PJ	in channel	40.66730	-74.07487
Port Jersey 2-5/7/2019	PJ	in channel	40.66711	-74.07180
Port Jersey 3-5/7/2019	PJ	in channel	40.66508	-74.06992
Port Jersey 4-5/7/2019	PJ	off channel	40.66327	-74.06791
Port Jersey 5-5/7/2019	PJ	off channel	40.66567	-74.06331
Port Jersey 6-5/7/2019	PJ	off channel	40.66957	-74.08132
Port_Newark_7-6/13/2019	PN	in channel	40.69254	-74.13662
Port_Newark_8-6/13/2019	PN	in channel	40.69505	-74.13930
Port_Newark_9-6/13/2019	PN	in channel	40.69798	-74.15093
Port_Newark_10-6/13/2019	PN	off channel	40.68388	-74.12646
Wards_Point_Bend_1-3/26/2019	RB	in channel	40.48556	-74.24775
Wards_Point_Bend_2-3/26/2019	RB	in channel	40.48433	-74.25554
Wards_Point_Bend_3-3/26/2019	RB	in channel	40.48445	-74.26086
Wards_Point_Bend_4-3/26/2019	RB	off channel	40.48604	-74.24858
Wards_Point_Bend_5-3/25/2019	RB	off channel	40.48412	-74.24726
Wards_Point_Bend_6-3/25/2019	RB	off channel	40.48539	-74.25251
South Brother_1-4/23/2019	SB	in channel	40.79239	-73.89477
South Brother_2-4/23/2019	SB	in channel	40.79407	-73.89387
South Brother_3-4/23/2019	SB	in channel	40.79667	-73.89339
South Brother_4-4/23/2019	SB	off channel	40.78859	-73.89238
South Brother_5-4/23/2019	SB	off channel	40.78645	-73.89052
South Brother_6-4/23/2019	SB	off channel	40.78979	-73.89582

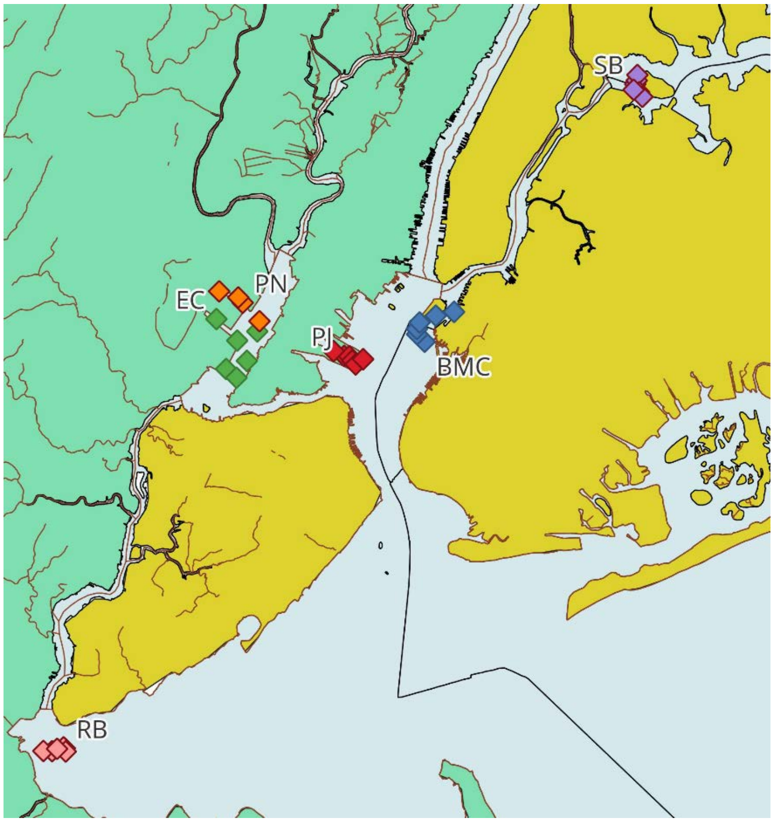


Figure 31. Sediment core sampling locations.

3.2. Sediment Grab Samples and Map.

Surficial sediment samples were collected throughout the harbor to evaluate how contaminant concentrations and sediment properties vary across spatial gradients. At 42 locations, surficial sediment samples were collected and analyzed for grain size, total organic carbon (TOC) and soot (black) carbon. Eight of these were to be analyzed for PCBs and PCDD/Fs but one the PCB extracts was lost in a laboratory accident.

Table 7. Sediment grab samples.

Sample name	date	Abbr.	Nav. Status	Latitude	Longitude
Arthur Kill_1	9/20/2021	AK1	in channel	40.64151	-74.19033
Arthur Kill_3	10/21/2021	AK3	in channel	40.60400	-74.20240
Arthur Kill_4	10/21/2021	AK4	in channel	40.57830	-74.20950
Arthur Kill_5	10/21/2021	AK5	in channel	40.53040	-74.24880
East River_1	10/25/2021	ER1	off channel	40.79520	-73.90290
East River_2	10/25/2021	ER2	off channel	40.73340	-73.96290
East River_3	10/25/2021	ER3	off channel	40.69880	-73.99940
Harlem River_1	9/16/2021	HAR1	off channel	40.83899	-73.93155

Harlem River_2	9/16/2021	HAR2	off channel	40.79116	-73.93196
Hudson River_1	9/16/2021	HR1	off channel	40.94351	-73.90973
Hudson River_2	9/16/2021	HR2	off channel	41.19372	-73.92225
Hudson River_3	9/16/2021	HR3	off channel	41.05609	-73.88911
Hudson River_4	9/16/2021	HR4	off channel	40.99806	-73.88597
Hudson River_5	9/22/2021	HR5	off channel	40.82116	-73.96830
Hudson River_6	9/22/2021	HR6	off channel	40.76615	-74.00509
Hudson River_7	9/22/2021	HR7	off channel	40.71045	-74.02617
Jamaica Bay _1	10/21/2021	JB1	off channel	40.57160	-73.94510
Jamaica Bay _2	10/21/2021	JB2	off channel	40.62118	-73.77878
Jamaica Bay _3	10/21/2021	JB3	off channel	40.62650	-73.86030
Jamaica Bay _4	10/21/2021	JB4	off channel	40.59260	-73.86330
Kill Van Kull_1	9/20/2021	KVK1	in channel	40.64405	-74.13007
Kill Van Kull_2	9/20/2021	KVK2	in channel	40.65010	-74.08208
Long Island Sound_1	10/25/2021	LIS1	off channel	40.88944	-73.72111
Long Island Sound_2	10/25/2021	LIS2	off channel	40.80399	-73.78640
Long Island Sound_3	10/25/2021	LIS3	off channel	40.79620	-73.85020
Lower_Bay_1	10/21/2021	LB1	off channel	40.59310	-74.02110
Lower_Bay_2	10/21/2021	LB2	off channel	40.58570	-74.05760
Newark Bay_1	9/20/2021	NB1	in channel	40.71319	-74.11184
Newark Bay_2	9/20/2021	NB2	off channel	40.65538	-74.15426
Newark Bay_3	9/20/2021	NB3	off channel	40.68920	-74.12087
Upper Bay_1	9/20/2021	UB1	off channel	40.66169	-74.02973
Upper Bay_2	9/20/2021	UB2	off channel	40.65369	-74.03019
Upper Bay_3	9/22/2021	UB3	off channel	40.69438	-74.03762
Upper Bay_4	9/22/2021	UB4	in channel	40.67620	-74.05347
Upper Bay_5	9/22/2021	UB5	off channel	40.63107	-74.06226
Upper Bay_6	9/22/2021	UB6	off channel	40.61381	-74.04735

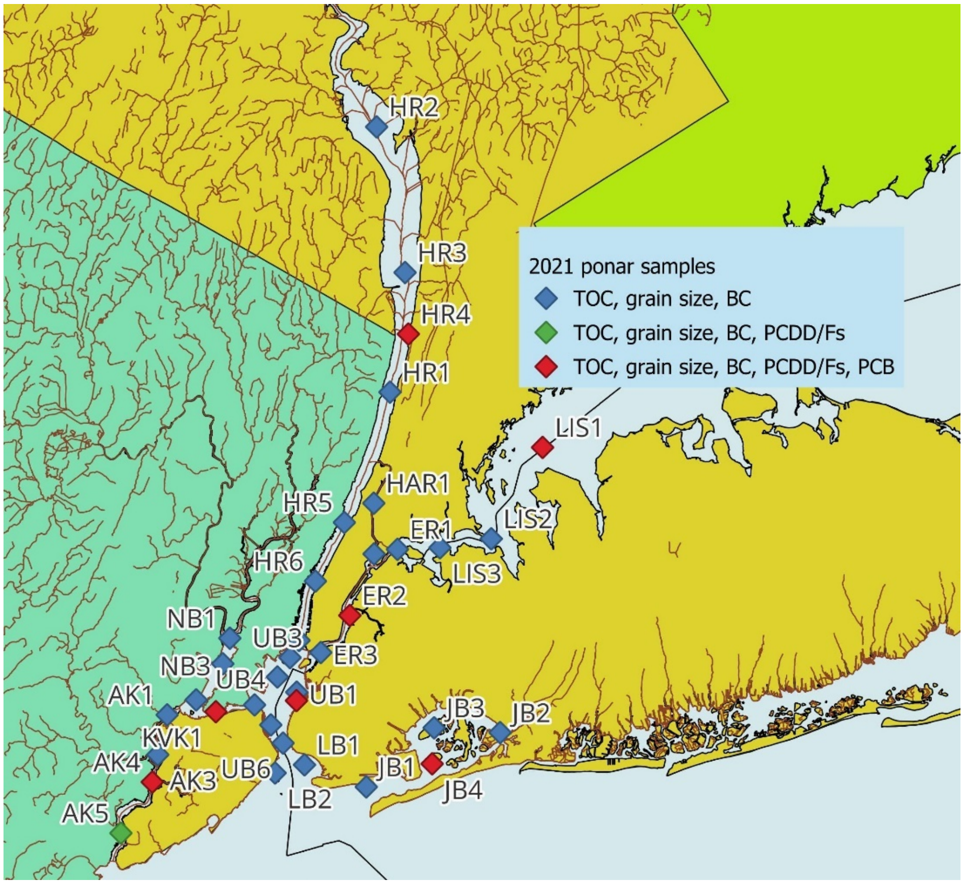


Figure 32. Sediment grab samples.

3.3. Sediment Characterization

Sediment cores were characterized by grain size analysis, soot carbon (or black carbon), solids, and total organic carbon (TOC).

Table 8. Sediment characterization.

	Grain Size Total Fines	Fine Sand	Medium Sand	Coarse Sand	Total Gravel	Soot	Solids	TOC
BMC	36.2	33.5	21.3	5.8	5.2	0.5	48.8	2.4
BMC-IC-Over	40.6	27.6	26.9	3.9	7	0.4	47.3	2.3
BMC-IC-Under	37.1	31.2	25.1	3.7	4.4	0.3	50.2	2.4
BMC-OC-Over	37.7	38.8	14.4	6.3	2.9	0.6	48.5	2.6
BMC-OC-Under	29.2	36.5	18.7	9.1	6.5	0.5	49.2	2.3
EC	49.8	15.2	29.0	6.2	1.1	0.1	40.6	2.5
EC-IC-Over	44.9	14.9	31.2	8	1.5	0.1	33.2	2.9

EC-IC-Under	48.1	14.9	31.4	6.2	1.4	0.1	42	2.6
EC-OC-Over	53.4	15.7	26.7	4.1	0.8	0.1	43	2.3
EC-OC-Under	52.9	15.2	26.6	6.5	0.6	0.2	44.3	2.2
PJ	27.3	12.7	21.5	26.7	11.8	0.2	39.6	2.7
PJ-IC-Over	29.6	7.1	23.4	29.9	9.9	0.1	31.9	3.1
PJ-IC-Under	21.7	4.9	17.3	32.8	23.3	0.1	35.6	3.1
PJ-OC-Over	30.2	21.6	23.3	17.9	7.1	0.4	46.4	2.2
PJ-OC-Under	27.6	17.3	21.8	26.3	7	0.1	44.5	2.4
PN	45.8	25.1	21.4	7.6	0.5	0.2	45.5	2.5
PN-IC-Over	52.3	9.9	27.8	9.9	0.3	0.1	30.7	3.5
PN-IC-Under	46.9	11.6	28.6	12.5	0.7	0.1	36.2	3.1
PN-OC-Over	40.9	35.8	19.2	4.1	ND	0.3	54.4	1.7
PN-OC-Under	43.2	42.9	9.9	4	ND	0.3	60.8	1.5
RB	55.5	13.0	14.5	8.5	9.8	0.1	36.7	3.4
RB-IC-Over	73.1	5.3	8.3	8	5.4	0.1	30.9	4
RB-IC-Under	46.5	6	13.6	14.6	19.2	0.1	34.2	3.8
RB-OC-Over	47.4	23.9	19.8	5.1	5.8	ND	41.7	2.7
RB-OC-Under	55.1	16.7	16.4	6.1	8.6	0.1	39.8	3
SB	32.8	32.0	30.3	4.3	1.3	0.8	40.4	3.8
SB-IC-Over	41.8	14.2	37.1	4.8	2.1	0.1	24	4.5
SB-IC-Under	38.4	15.2	39.2	6.8	1	0.1	31.3	4
SB-OC-Over	26.1	48.5	22.7	2.3	1.4	1.2	51.8	3.2
SB-OC-Under	24.8	50.2	22	3.3	0.6	1.6	54.5	3.5

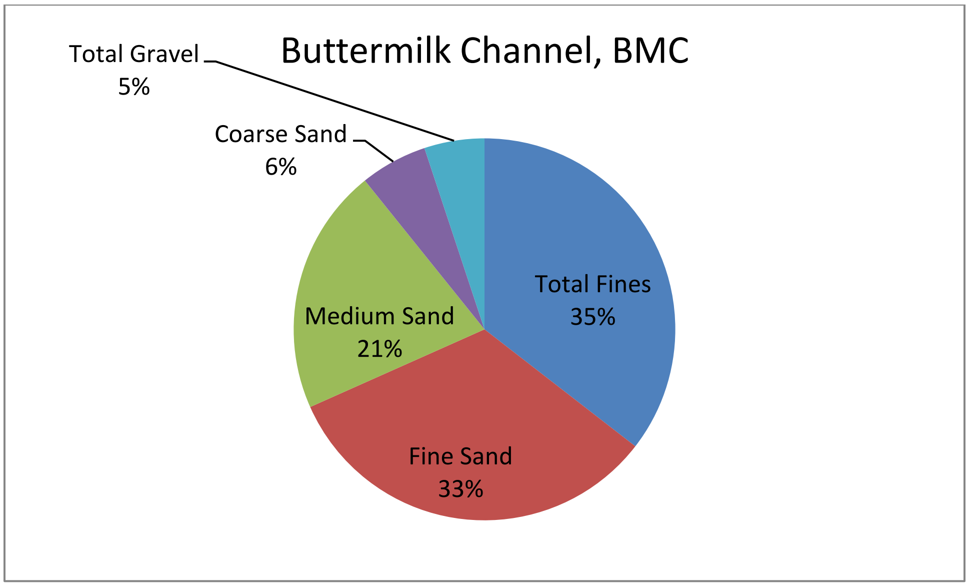
Beryllium-7 (in pCi/g) assesses the integrity of the cores. This short-lived isotope should have higher concentrations in the Over segment than in the Under ones. This condition was met, on average, for all samples except for the Raritan Bay (RB) Off-Channel samples where two of the three cores showed higher Be-7 in the Under segments. Be-7 error bars are very broad relative to the observed concentrations so this parameter should be regarded cautiously.

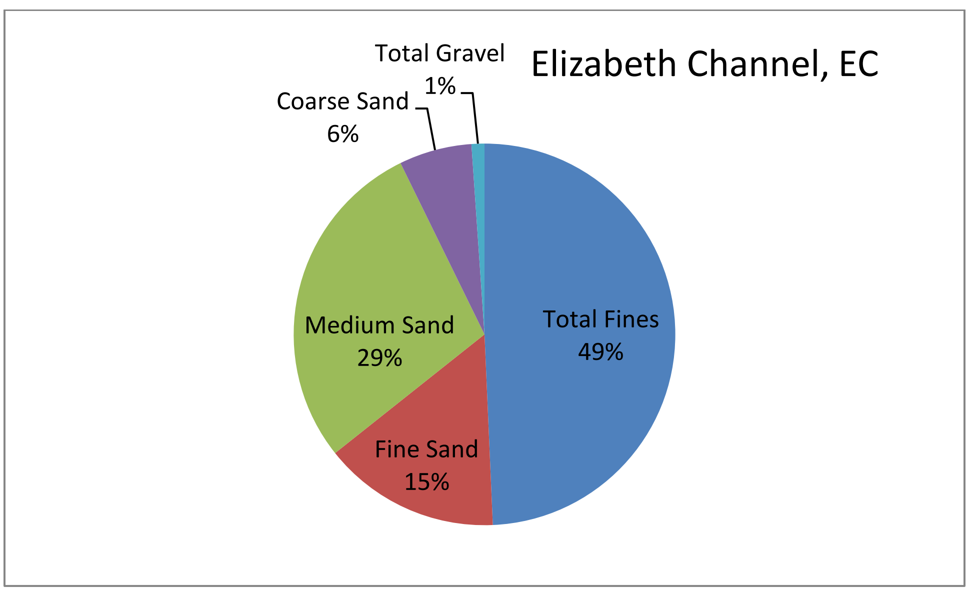
Table 9. Beryllium-7.

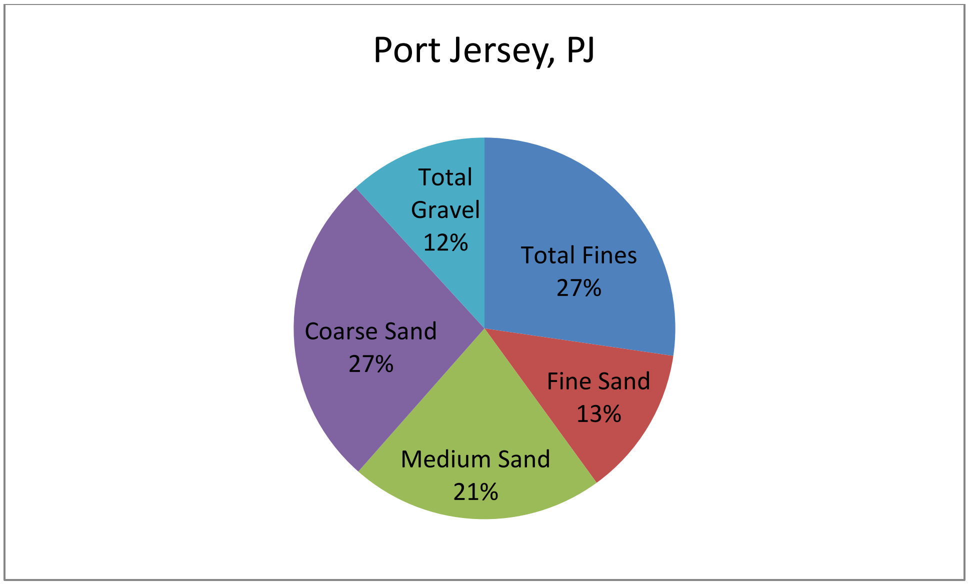
	Be-7	+/-		Be-7	+/-
BMC			**PN**		
BMC-IC-Over	1.907	0.977	PN-IC-Over	2.929	1.477
BMC-IC-Under	0.298	1.05	PN-IC-Under	0.128	1.086
BMC-OC-Over	1.784	1.232	PN-OC-Over	0.548	0.845
BMC-OC-Under	0	1.078	PN-OC-Under	0	0.326
EC			**RB**		
EC-IC-Over	2.226	1.544	RB-IC-Over	5.342	1.791
EC-IC-Under	0.811	1.14	RB-IC-Under	0.345	1.578
EC-OC-Over	2.433	1.479	RB-OC-Over	0.238	1.183

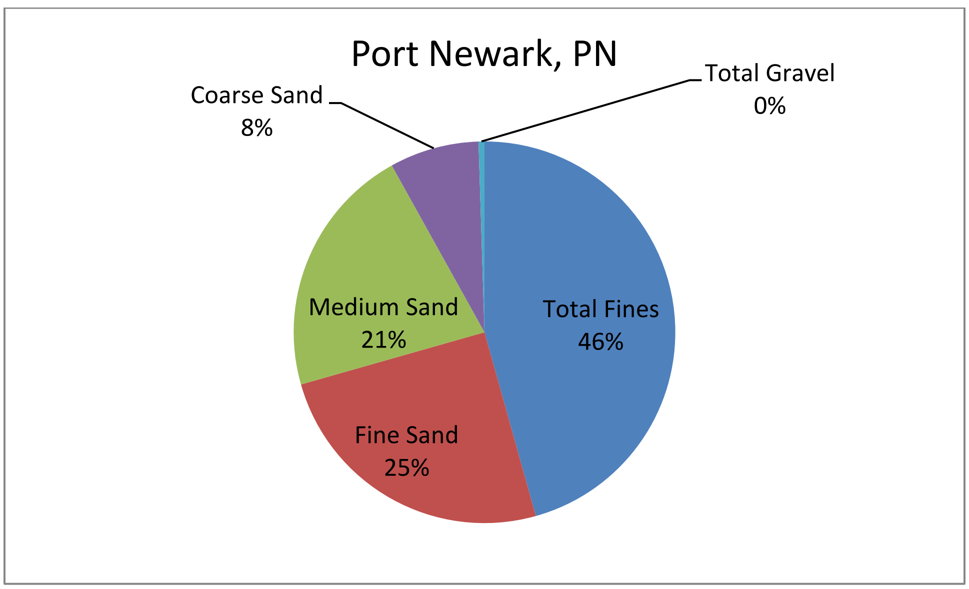
EC-OC-Under	0.336	0.828	RB-OC-Under	0.289	1.551
PJ			**SB**		
PJ-IC-Over	5.033	1.554	SB-IC-Over	7.991	2.369
PJ-IC-Under	1.393	1.206	SB-IC-Under	1.158	1.643
PJ-OC-Over	1.736	0.871	SB-OC-Over	1.32	1.184
PJ-OC-Under	0.81	0.831	SB-OC-Under	0.405	1.352

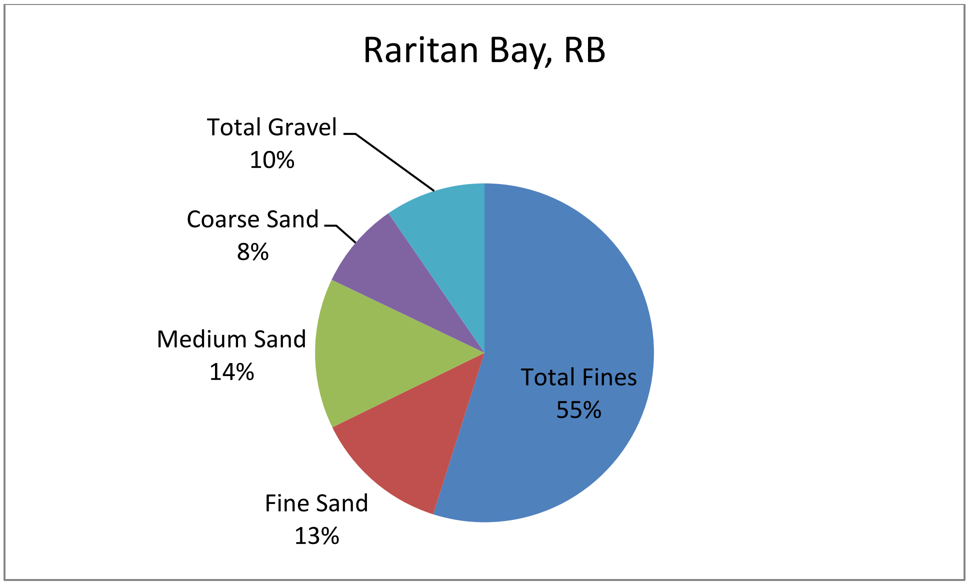
Sample group grain size proportions, averages of 2019 samples by sediment group.






Port Jersey, PJ
Total Gravel 12%
Total Fines 27%
Coarse Sand 27%
Fine Sand 13%
Medium Sand 21%


Port Newark, PN
Coarse Sand 8%
Total Gravel 0%
Medium Sand 21%
Total Fines 46%
Fine Sand 25%



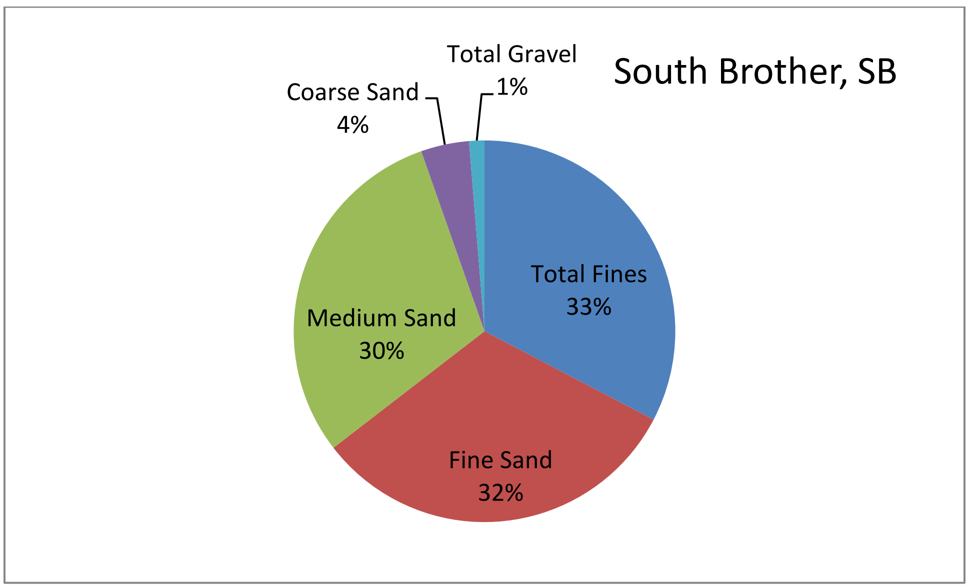


Figure 33. Average grain size characteristics from the six clusters of sediment core.

Sediment characteristics of the 42 grab samples taken in 2021 are shown in Table 10.

Table 10. Grab sample sediment characteristics.

		Grain size, %					%		
Abbr	harbor_region	Fines	Fine Sand	Medium Sand	Coarse Sand	Gravel	Soot	Solids	TOC
AK1	Upper Bay	48.8	15.9	10.4	9	15.9	0.23	31.3	3.2
AK3	Arthur Kill	6.5	4.1	27.9	20.4	41.1	0.15	76	0.7

AK4	Arthur Kill	17.1	28.6	38.2	6.6	9.5	0.07	71.1	1.8
AK5	Arthur Kill	53.4	9.5	23.9	13.2		0.13	36.1	3.9
ER1	East River	12.1	14.2	35.9	11.1	26.7		75.2	1.9
ER2	East River	56.4	13.1	21.2	9.1	0.2	2.21	38.9	6
ER3	East River	49.3	4.5	20.8	21.9	3.5	0.1	31.2	3.5
HAR1	Hudson River	2.3	12.2	84.4	1.1		0.02	75.4	0.2
HAR2	Harlem River	43	12	17.3	21.5	6.2	1.76	43.2	5.6
HR1	Hudson River	22.2	50.9	24	1.2	1.7	0.04	68.2	0.6
HR2	Hudson River	44	13.6	11.6	7.4	23.4	0.16	56.2	1.9
HR3	Hudson River	66.6	8	17.3	7.9	0.2	0.17	42.1	2.2
HR4	Hudson River	74.2	12	9	3.5	1.3	0.18	51	2
HR5	Hudson River	47.9	4.5	13.5	26.3	7.8	0.12	36.6	2.4
HR6	Hudson River	52.2	5.6	16.5	21.4	4.3	0.08	41.9	2.6
HR7	Hudson River	33.8	32.6	18	14.6	1	0.11	34	2.5
JB1	Jamaica Bay	26	58.9	5.2	3.1	6.8	0.02	59.9	1.4
JB2	Jamaica Bay	45.1	5.1	16	23.3	10.5	0.1	20.2	5.9
JB3	Jamaica Bay	15.1	83.8	0.3	0.4	0.4	0.03	72.8	0.3
JB4	Jamaica Bay	53.7	29.3	12.5	4.5		0.1	42.6	2.8
KVK1	Kill Van Kull	14.1	48.1	34.3	2.8	0.7	0.03	58.8	0.9
KVK2	Kill Van Kull	44.75	47.95	5.65	1.65		0.07	54.5	1
LB1	Lower Bay	58.6	35.9	4.9	0.6		0.07	52.5	1.5
LB2	Lower Bay	24.5	63.6	7.2	4.1	0.6	0.02	64.8	0.8
LIS1	Long Island Sound	57.7	6.5	21.7	13.2	0.9	0.16	34.7	3.2
LIS2	Long Island Sound	19.1	53.5	16.2	5.4	5.8	0.22	71.1	1.2
LIS3	Long Island Sound	15	46.6	24.7	7.2	6.5	0.03	80.4	0.4
NB1	Arthur Kill	21.4	66.5	9	1.6	1.5	0.31	60.2	2.2
NB2	Newark Bay	32.9	62.6	3.7	0.8		0.47	62.8	0.8
NB3	Newark Bay	39	23.8	22.7	10.6	3.9	0.18	42.4	2.5
RB1	Raritan Bay	30.5	21.7	32.4	14.7	0.7	0.1	41	3.4
RB2	Raritan Bay	46.6	13.9	21.6	15.2	2.7	0.14	45.3	2.5
RB3	Raritan Bay	0.8	90.8	8	0.4		0.03	76.7	0.1
RB4	Raritan Bay	8.2	89.6	0.5	0.7	1		71.6	0.2
RB5	Raritan Bay	43.45	53.45	2.5	0.6		0.07	64.1	0.8
RR1	Raritan River	30.1	4.9	41.4	22.7	0.9	0.14	31.3	4.2
UB1	Upper Bay	29.9	43.5	16.2	8.6	1.8	1.14	51.5	3.2
UB2	Newark Bay	75.1	12	9.4	3.5		0.22	46.9	2
UB3	Upper Bay	16.6	11.2	44.6	13.6	14	0.09	49	1.7
UB4	Upper Bay	75	10.1	12.4	2.5		0.1	38	2.6
UB5	Upper Bay	6.9	89.1	3.2	0.5	0.3		73.8	0.2
UB6	Harlem River	10.6	61.3	13.9	5.5	8.7	0.19	74	0.2

The question of whether navigational versus non-navigational channels (In Channel v Off Channel) sites can be seen in sediment characteristic data was addressed by use of principal component analysis calculated in the R statistics package. Data from 2019 and 2021 samples are used.

Eight principal components were calculated. The first four accounted for 90% of the total variance. The primary axis, accounting for 39.5% of the total variability, represents TOC, fines, coarse sand and the absence of solids. The second principal component (21% of the total variance) represents gravel, coarse sand, and the absence of fines. Red values are negative.

Table 11. Principal components of sediment characteristics, from grab and core samples.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Standard deviation	1.7777	1.2964	1.1015	1.0869	0.6520	0.5258	0.2502	0.0020
Proportion of Variance	0.3951	0.2101	0.1517	0.1477	0.0531	0.0346	0.0078	0
Cumulative Proportion	0.3951	0.6051	0.7568	0.9045	0.9576	0.9922	1	1

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
coarse sand	0.3175	0.5087	0.2158	0.0362	0.5611	0.4398	0.1282	0.2604
fine sand	0.5166	0.1355	0.1720	0.0715	0.3315	0.3654	0.0309	0.6601
fines	0.3657	0.4206	0.1849	0.3758	0.3101	0.3322	0.0682	0.5503
gravel	0.1321	0.6268	0.2207	0.2351	0.5441	0.3458	0.1404	0.2244
medium sand	0.0721	0.1262	0.3105	0.8348	0.1909	0.0569	0.0502	0.3787
solids	0.5171	0.1673	0.0420	0.0183	0.3106	0.3515	0.6946	0.0001
soot	0.0679	0.2457	0.7891	0.2449	0.2209	0.3358	0.3013	0.0000
TOC	0.4515	0.2210	0.3465	0.1996	0.0366	0.4512	0.6184	0.0002

The shaded circles represent 95% confidence intervals for In Channel (blue) and Off Channel (gold) observations. The extent of overlap suggests that the two kinds of samples are not statistically different with respect to sediment quality.

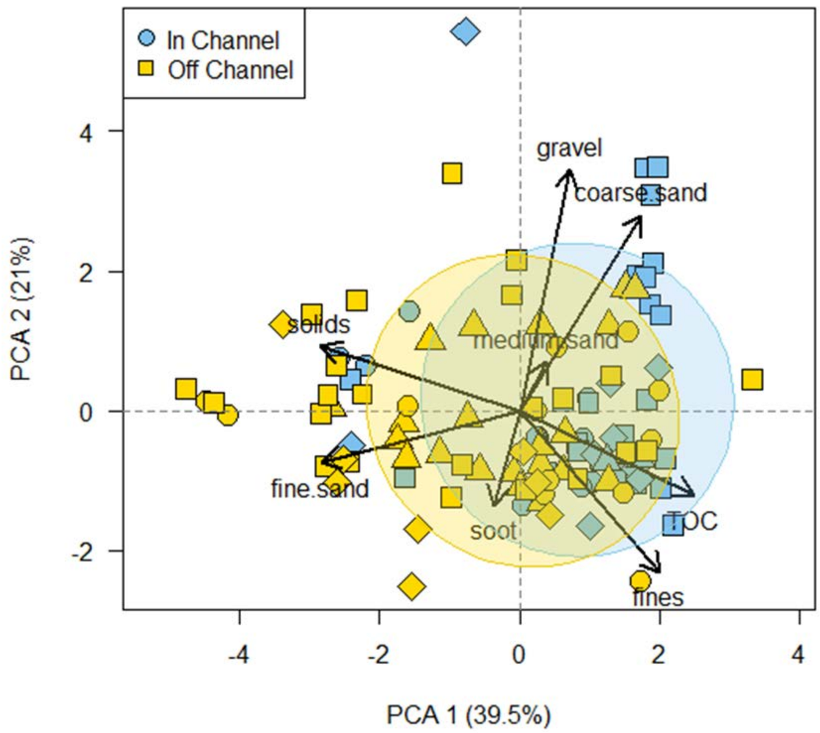


Figure 34. Principal component analysis of sediment characteristics from In- and Off-Channel samples.

3.4. PCDD/Fs and PCBs in Sediment Cores.

Sediment cores were collected from six areas around the harbor. Sampling cores were usually taken at three sites within navigational channels (IC, In-Channel) and three taken out of navigational channels (OC, Off-Channel). Each of the cores was divided into in an upper (Over) portion and a lower (Under) portion.

Since there was one primary source of most of the PCDD/F TEQ, the former Diamond Alkali plant on the Passaic River, there was more of a spatial gradient in total TEQ across the sediment groups than there was for total PCBs where there were multiple sources.

Average and median concentrations of PCDD/Fs in sediment and tissue were higher in Off-Channel samples than from the In-Channel ones. PCBs were higher in Off-Channel tissues but not in Off-Channel sediment. Under samples were higher in PCDD/Fs and PCBs for sediment and for tissue.

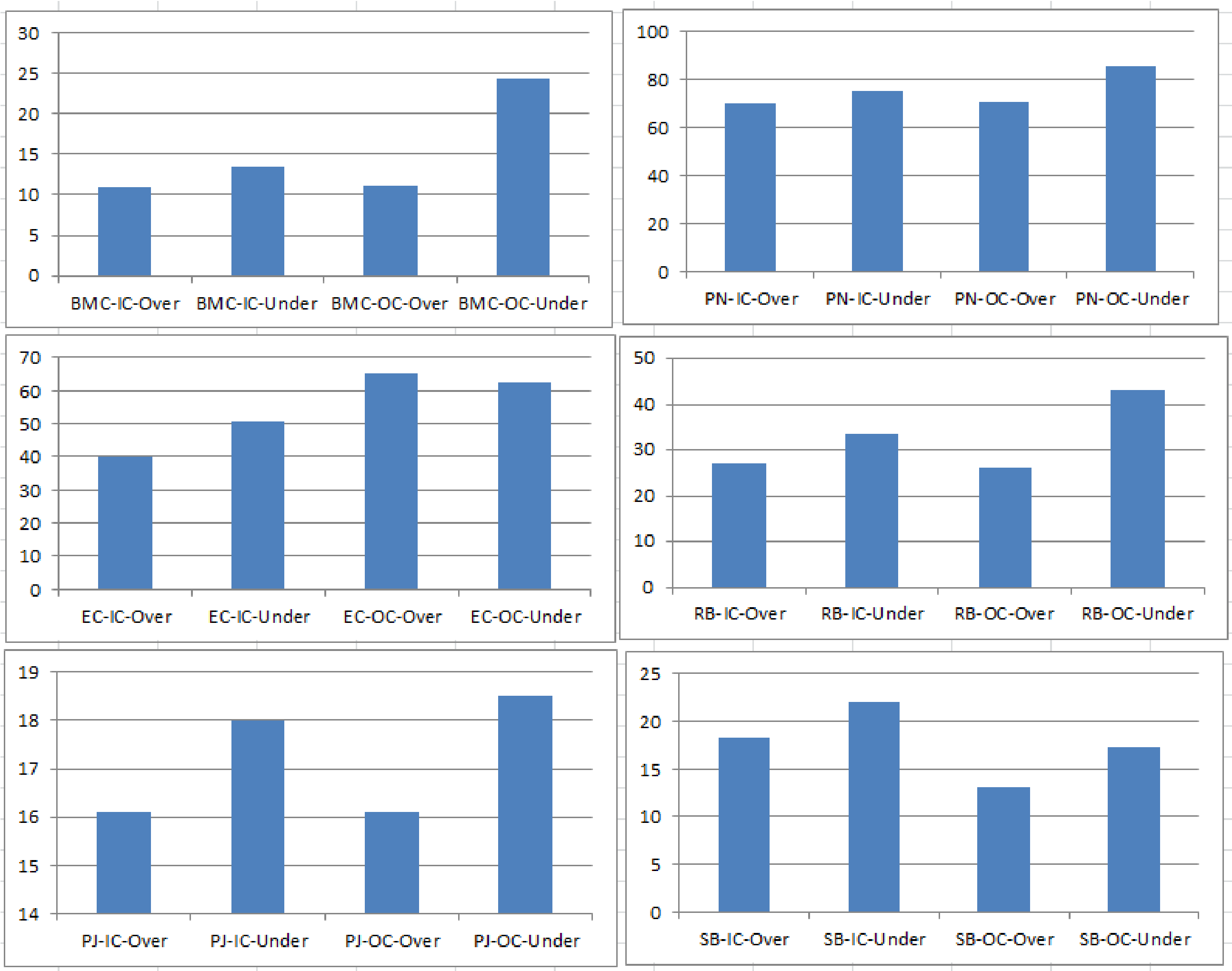


Figure 35. Graphical representation of PCDD/Fs in sediments, pg/g total TEQ. Values are averages of the triplicate replicates from each site.

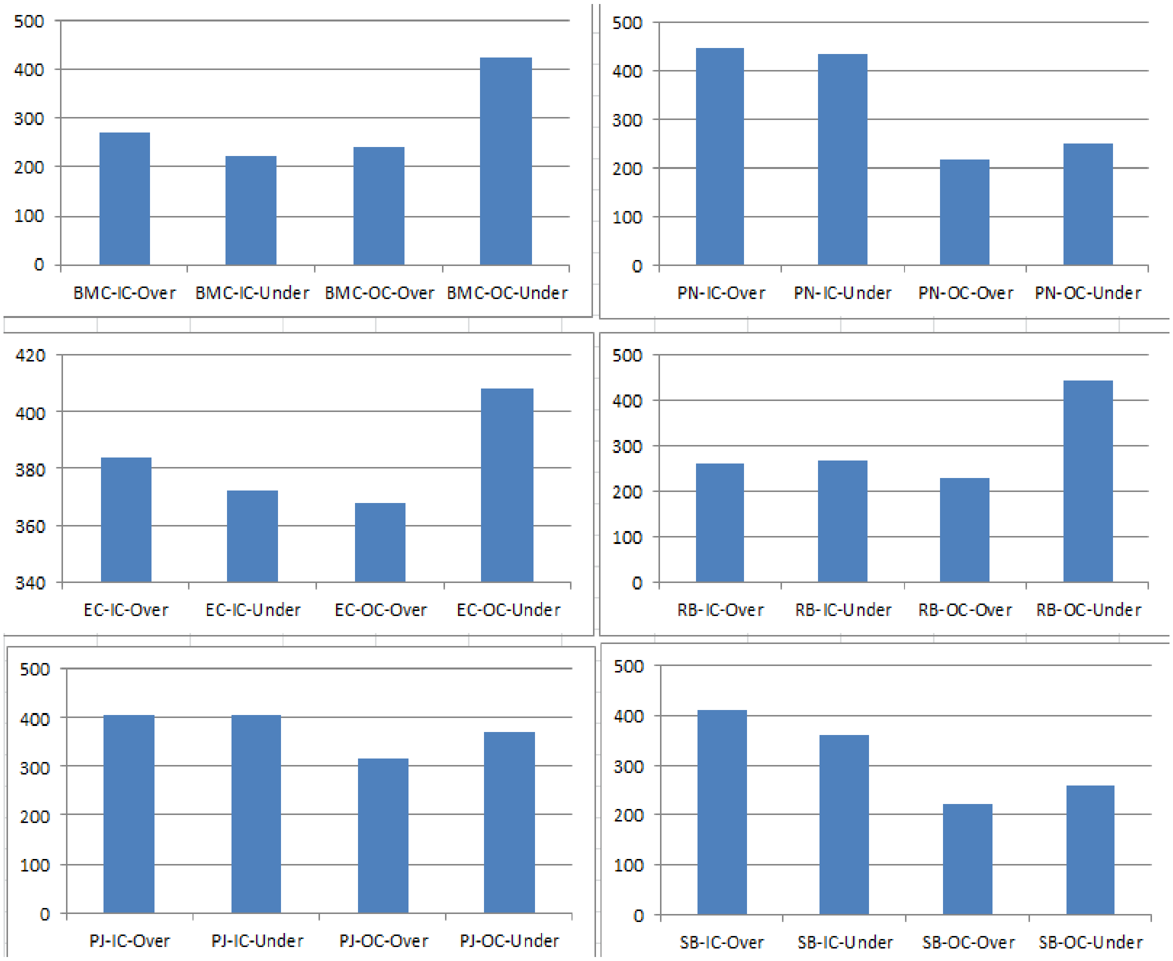


Figure 36. Graphical representation of PCBs in sediments, pg/g. Values are averages of the triplicate replicates from each site.

3.5. PCDD/Fs in Sediment Cores

The following figures show relative abundances of TEQ PCDD/Fs (in pg/g dry weight) from the six sediment groups; Buttermilk Channel (BMC), Elizabeth Channel (EC), Port Jersey (PJ), Port Newark (PN), Raritan River (RR), and South Brother (SB). Sampling at each sediment group consisted of three cores taken in a dredged area (IC or In Channel), and three taken off channel (OC). The cores were sectioned into upper (Over) and a lower (Under) portions. In the figures the TEQs were averaged.

As expected, the Newark Bay sediment groups (EC and PN) had the highest concentrations and the highest proportional contribution by 2,3,7,8-TCDD. The relative abundances of all the congeners in the two Newark Bay groups were virtually identical. Port Newark and South Brother had higher average total TEQs in the in channel (IC) samples but off channel averages (OC) were higher in the others. In every case the average total TEQs were higher in the lower portions

(Under) of the cores than in the upper parts (Over). In every sediment group 2,3,7,8-TCDD (# 1) and 2,3,7,8-TCDF (#8) were the greatest contributors to TEQ. Congener #6 (1,2,3,4,6,7,8-HPCDD) which was usually the single greatest contributor to TEQ in the water samples was usually the third greatest contributor in the sediment samples.

Table 12. PDCC/Fs in sediment. Blank corrected TEQ, pg/g. Values are averages of the replicates from each site. See Table 3 for Order numbers 1-17.

Sed. Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	sum
BMC	4.23	1.62	0.21	0.85	0.70	1.67	0.51	2.21	0.10	1.23	0.35	0.56	0.03	0.25	0.48	0.03	0.02	15.0
BMC-IC-Over	2.26	1.34	0.19	0.71	0.57	1.41	0.46	1.51	0.07	1.09	0.27	0.42	0.02	0.20	0.39	0.02	0.01	11.0
BMC-IC-Under	2.97	1.49	0.19	0.80	0.69	2.07	0.60	1.78	0.09	1.16	0.32	0.56	0.02	0.23	0.45	0.03	0.02	13.5
BMC-OC-Over	2.51	1.33	0.15	0.71	0.57	1.30	0.41	1.75	0.09	1.08	0.28	0.45	0.03	0.20	0.40	0.02	0.02	11.3
BMC-OC-Under	9.16	2.32	0.29	1.18	0.97	1.90	0.55	3.78	0.14	1.59	0.51	0.81	0.04	0.38	0.69	0.04	0.03	24.4
EC	30.75	2.84	0.36	1.31	1.09	2.62	0.85	4.32	0.17	2.61	1.02	3.43	0.04	0.56	1.79	0.07	0.08	53.9
EC-IC-Over	19.80	2.58	0.34	1.32	1.09	2.69	0.89	3.51	0.15	2.24	0.83	2.24	0.03	0.48	1.43	0.06	0.06	39.7
EC-IC-Under	28.12	2.75	0.37	1.32	1.12	2.83	0.86	4.02	0.16	2.48	0.97	3.23	0.05	0.55	1.68	0.07	0.07	50.7
EC-OC-Over	39.83	3.25	0.37	1.31	1.06	2.45	0.87	4.98	0.19	2.93	1.15	4.14	0.05	0.59	1.95	0.08	0.08	65.3
EC-OC-Under	37.00	2.86	0.34	1.29	1.08	2.35	0.78	4.97	0.18	2.87	1.17	4.26	0.05	0.62	2.18	0.08	0.09	62.2
PJ	4.41	2.02	0.26	1.06	0.85	1.95	0.60	2.44	0.11	1.58	0.39	0.64	0.03	0.29	0.57	0.03	0.03	17.3
PJ-IC-Over	3.05	1.98	0.29	1.13	0.87	2.15	0.66	2.17	0.10	1.77	0.39	0.56	0.02	0.29	0.57	0.03	0.04	16.1
PJ-IC-Under	3.86	2.33	0.29	1.19	0.98	2.21	0.71	2.46	0.11	1.66	0.44	0.69	0.03	0.31	0.64	0.03	0.03	18.0
PJ-OC-Over	4.81	1.74	0.24	0.90	0.76	1.59	0.48	2.39	0.09	1.38	0.35	0.57	0.02	0.25	0.49	0.03	0.02	16.1
PJ-OC-Under	5.55	2.03	0.25	1.05	0.82	1.87	0.57	2.66	0.11	1.52	0.40	0.71	0.03	0.31	0.57	0.03	0.03	18.5
PN	48.12	2.99	0.35	1.37	1.10	2.52	0.83	5.44	0.18	2.98	1.32	4.81	0.05	0.67	2.41	0.08	0.13	75.4
PN-IC-Over	41.57	3.43	0.45	1.61	1.40	3.19	1.04	4.93	0.19	3.04	1.38	4.37	0.06	0.74	2.55	0.09	0.10	70.1
PN-IC-Under	45.03	3.40	0.42	1.66	1.32	3.07	1.01	5.66	0.22	3.36	1.44	5.14	0.06	0.77	2.56	0.09	0.18	75.4
PN-OC-Over	49.30	2.18	0.22	0.82	0.68	1.41	0.49	4.94	0.14	2.35	1.06	4.35	0.04	0.47	2.00	0.07	0.10	70.6
PN-OC-Under	62.00	2.12	0.18	0.82	0.55	1.25	0.42	6.13	0.14	2.63	1.18	5.20	0.04	0.51	2.18	0.07	0.13	85.5
RB	9.06	3.72	0.43	2.06	1.62	2.89	1.70	3.83	0.25	2.60	0.87	1.65	0.07	0.65	1.13	0.07	0.05	32.6
RB-IC-Over	7.17	3.28	0.41	1.52	1.35	2.70	1.67	3.04	0.21	2.27	0.70	1.32	0.06	0.54	0.97	0.06	0.04	27.3
RB-IC-Under	10.06	3.67	0.46	1.83	1.56	3.12	1.91	3.61	0.27	2.68	0.86	1.59	0.06	0.64	1.11	0.07	0.05	33.5
RB-OC-Over	6.96	3.07	0.35	1.55	1.29	2.42	1.40	2.98	0.21	2.27	0.74	1.39	0.06	0.54	0.93	0.06	0.04	26.2
RB-OC-Under	11.71	4.88	0.49	3.42	2.31	3.26	1.76	5.74	0.31	3.17	1.17	2.31	0.10	0.90	1.51	0.10	0.07	43.2
SB	3.00	2.51	0.29	1.02	0.95	1.84	0.60	2.72	0.16	1.89	0.56	0.78	0.03	0.44	0.76	0.03	0.03	17.6
SB-IC-Over	2.73	2.55	0.35	1.25	1.13	2.41	0.78	2.51	0.14	1.80	0.53	0.72	0.03	0.40	0.75	0.04	0.03	18.2
SB-IC-Under	3.67	3.14	0.36	1.33	1.20	2.60	0.87	3.15	0.20	2.29	0.68	0.94	0.04	0.55	0.93	0.04	0.04	22.0
SB-OC-Over	2.26	1.87	0.20	0.69	0.63	1.26	0.41	2.19	0.14	1.48	0.41	0.63	0.03	0.32	0.53	0.03	0.02	13.1
SB-OC-Under	3.25	2.50	0.27	0.87	0.87	1.29	0.40	2.95	0.16	1.96	0.61	0.80	0.03	0.47	0.81	0.03	0.02	17.3

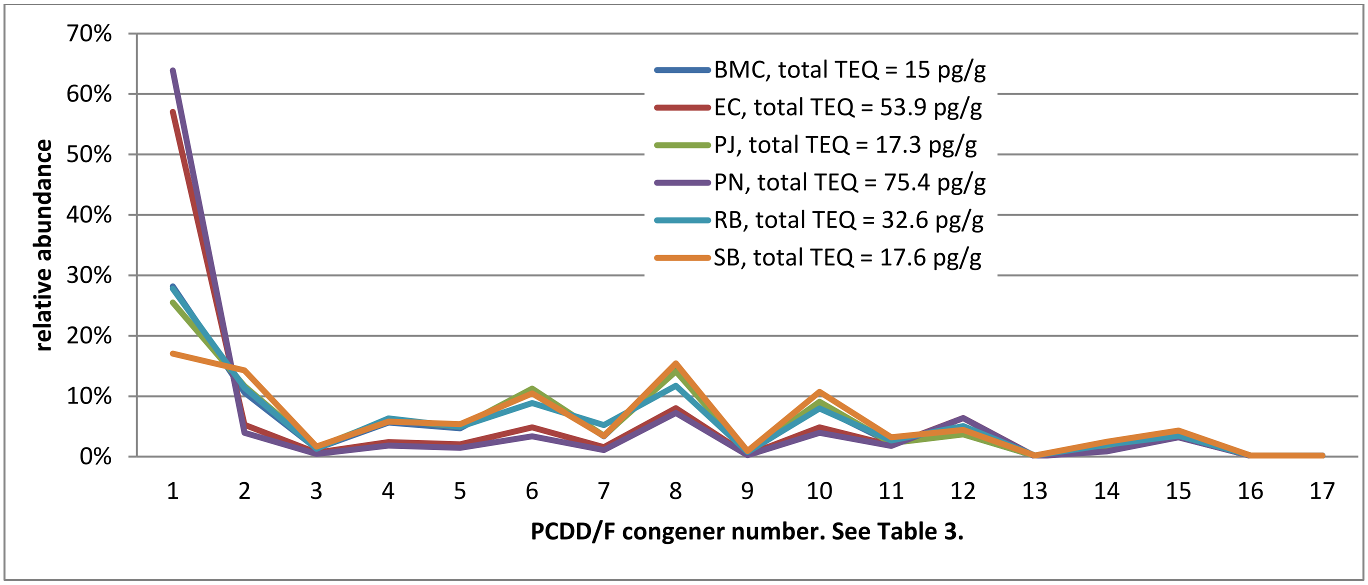


Figure 37. Average PCDD/F TEQ relative abundances from six sediment group.

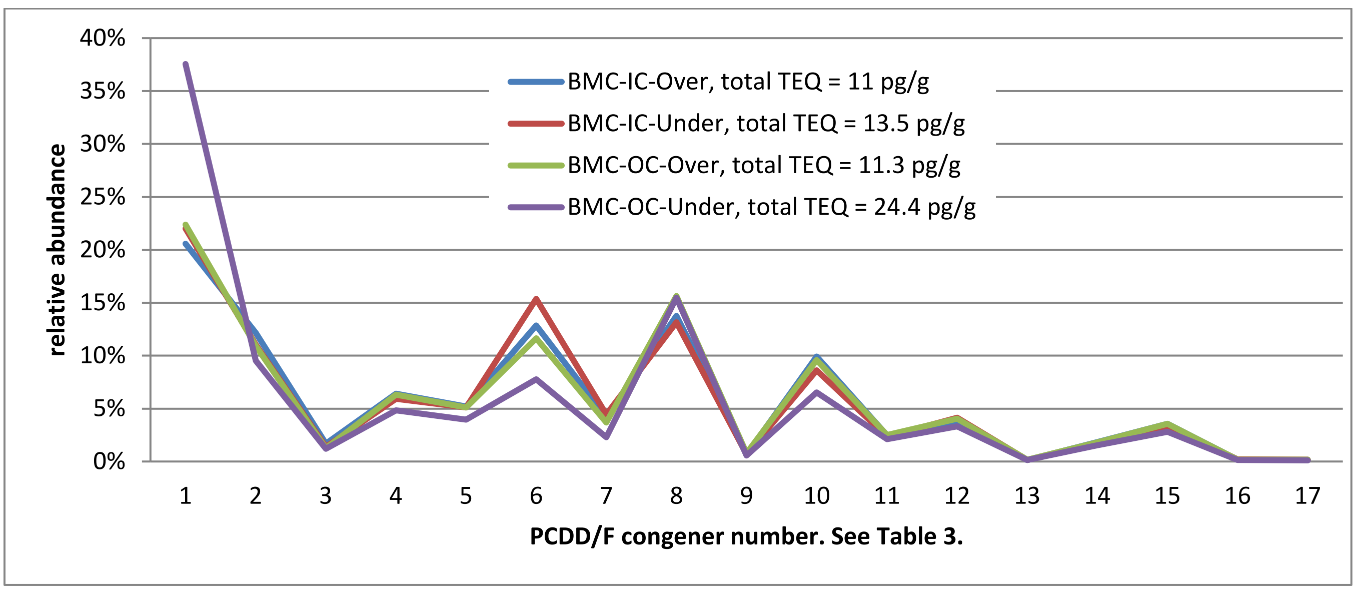


Figure 38. Sediment BMC PCDD/F TEQ relative abundances.

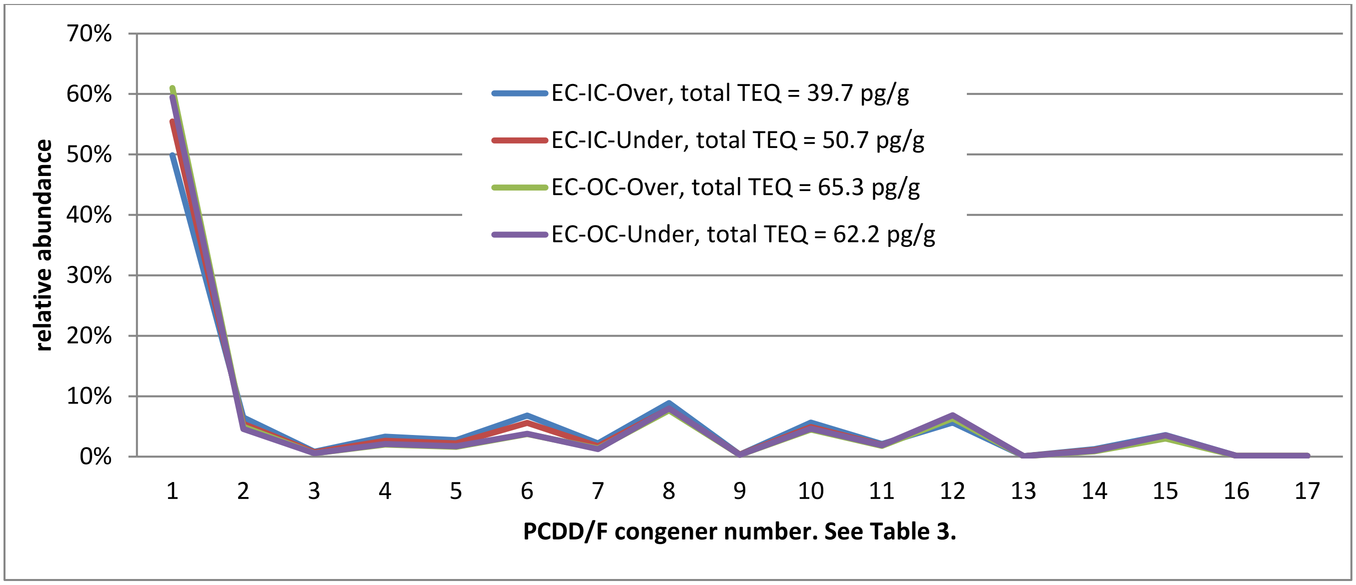


Figure 39. Sediment EC PCDD/F TEQ relative abundances.

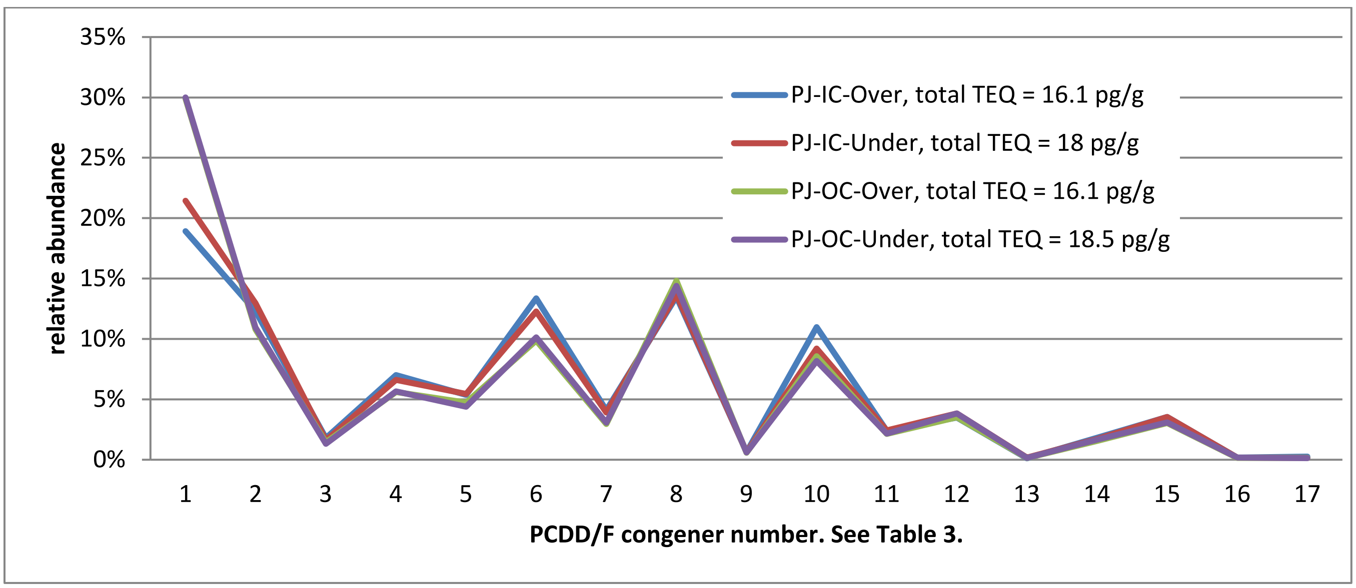


Figure 40. Sediment PJ PCDD/F TEQ relative abundances.

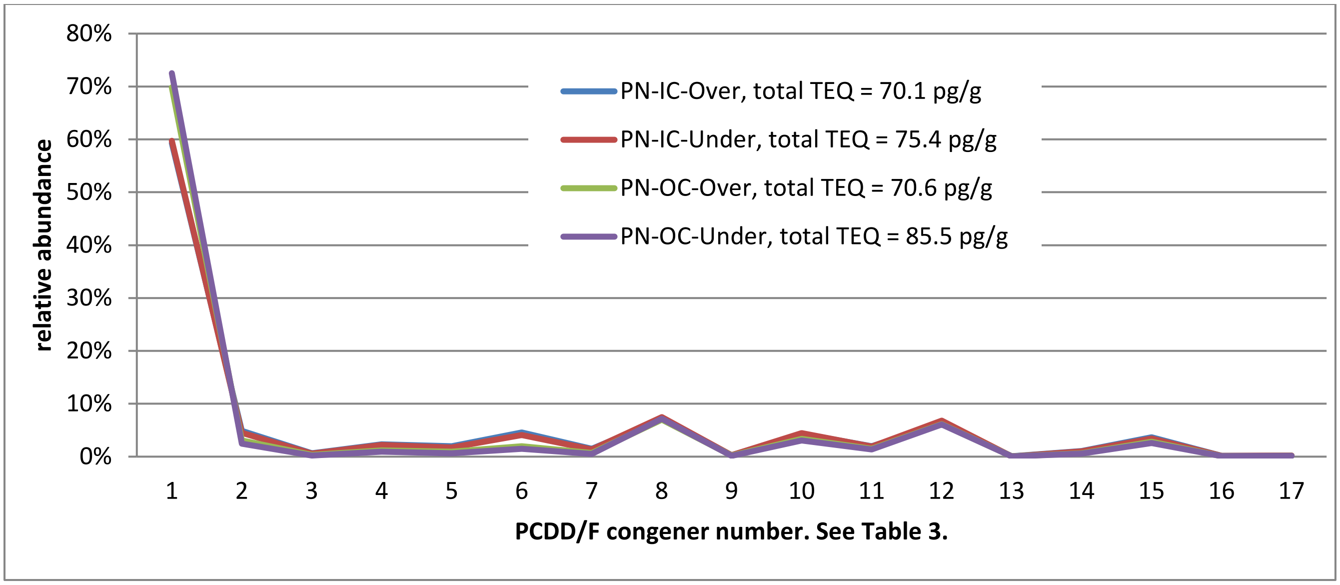


Figure 41. Sediment PN PCDD/F TEQ relative abundances.

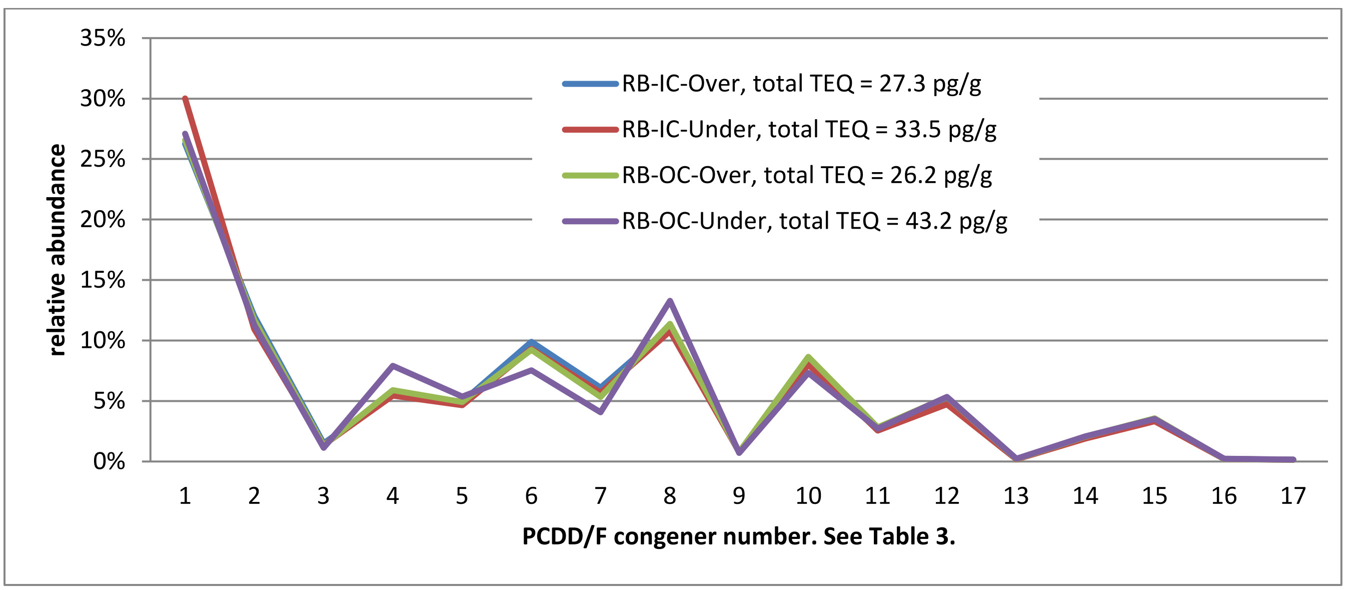


Figure 42. Sediment RB PCDD/F TEQ relative abundances.

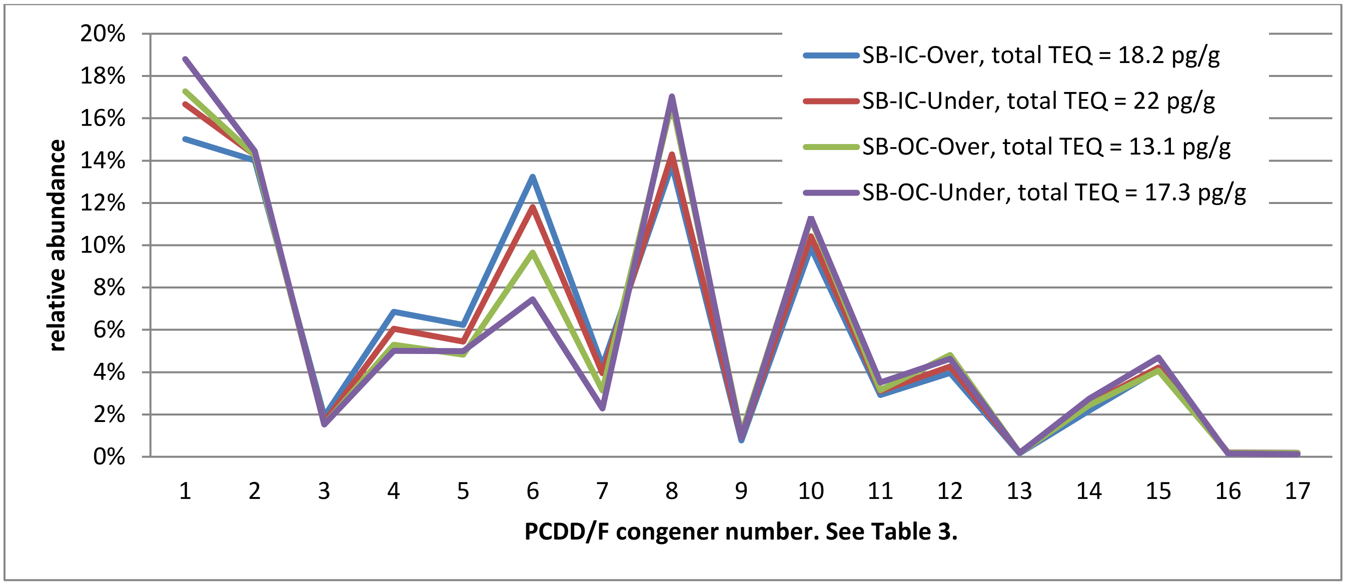


Figure 43. Sediment SB PCDD/F TEQ relative abundances.

3.6. PCBs in Sediment Cores.

Table 13. PCBs in Sediments, ng/g averages. Values are averages of the triplicate) replicates from each site.

Sed. Group	1	2	3	4	5	6	7	8	9	10	sum
BMC	4.0	33.1	79.2	78.9	43.5	28.5	13.3	5.1	2.2	1.3	289.2
BMC-IC-Over	5.2	37.6	79.8	72.7	36.2	22.2	10.2	4.2	1.9	1.1	271.0
BMC-IC-Under	3.8	28.6	62.0	58.0	32.4	22.0	10.9	4.2	1.9	1.1	224.7
BMC-OC-Over	3.8	29.5	65.8	65.2	36.5	23.6	11.1	4.0	1.7	1.1	242.2
BMC-OC-Under	3.1	35.5	109.0	121.9	71.6	48.5	22.2	8.2	3.4	2.0	425.2
EC	4.2	35.1	81.1	98.4	71.2	52.9	23.0	10.0	4.7	2.3	382.9
EC-IC-Over	5.8	45.2	96.5	102.7	60.6	41.6	19.4	7.7	3.6	2.2	385.2
EC-IC-Under	4.0	35.4	83.9	99.8	66.0	46.8	22.4	8.5	3.3	2.3	372.4
EC-OC-Over	3.4	29.6	71.2	95.1	68.8	50.2	23.9	15.5	8.5	2.3	368.5
EC-OC-Under	3.4	30.2	71.9	95.5	90.9	75.1	26.8	8.8	3.8	2.4	408.9
PJ	6.9	53.4	109.8	99.0	49.3	31.9	14.9	5.9	2.4	1.5	375.0
PJ-IC-Over	9.0	65.6	127.8	105.3	48.4	28.1	12.3	5.8	2.6	1.5	406.3
PJ-IC-Under	8.3	61.9	122.2	105.7	50.8	32.5	14.7	6.4	2.9	1.7	407.1
PJ-OC-Over	5.0	41.1	87.8	84.9	44.2	30.6	14.5	5.0	1.9	1.2	316.3
PJ-OC-Under	6.0	48.5	104.7	99.8	51.9	34.5	16.7	6.3	2.4	1.5	372.3
PN	3.5	31.8	76.2	102.6	71.9	51.7	26.3	11.2	3.9	2.0	381.0
PN-IC-Over	4.9	42.2	99.0	122.0	79.0	56.1	27.9	10.5	3.7	2.3	447.8

PN-IC-Under	4.1	36.4	84.4	113.8	81.5	61.0	32.4	15.2	5.5	2.6	436.8
PN-OC-Over	1.6	16.2	41.2	59.8	44.5	30.6	15.5	6.3	2.1	1.2	218.9
PN-OC-Under	1.3	14.5	42.8	72.6	55.7	36.9	16.8	6.7	1.9	1.1	250.4
RB	2.7	22.8	58.6	80.8	60.7	40.4	18.5	7.4	3.8	2.8	298.5
RB-IC-Over	3.1	25.9	58.9	69.1	46.7	32.8	15.2	5.6	2.6	1.6	261.4
RB-IC-Under	2.9	23.1	55.4	69.5	53.0	37.0	17.1	6.2	2.8	1.8	268.9
RB-OC-Over	2.1	18.3	43.9	58.1	46.6	31.9	15.7	6.4	3.5	2.6	229.1
RB-OC-Under	2.5	23.9	77.4	130.2	99.0	61.1	26.6	11.7	6.6	5.6	444.7
SB	3.8	29.8	68.9	73.1	53.0	45.9	22.0	7.6	3.3	2.2	309.6
SB-IC-Over	6.9	52.1	113.5	103.5	51.6	48.1	24.1	7.3	3.0	1.9	412.1
SB-IC-Under	5.4	40.1	88.2	86.7	56.2	47.4	22.6	8.6	4.0	2.8	362.0
SB-OC-Over	2.1	16.7	39.3	46.7	47.9	41.1	16.8	5.9	2.6	1.9	220.9
SB-OC-Under	1.6	15.1	43.2	59.9	55.6	46.9	23.8	8.4	3.4	2.2	260.1

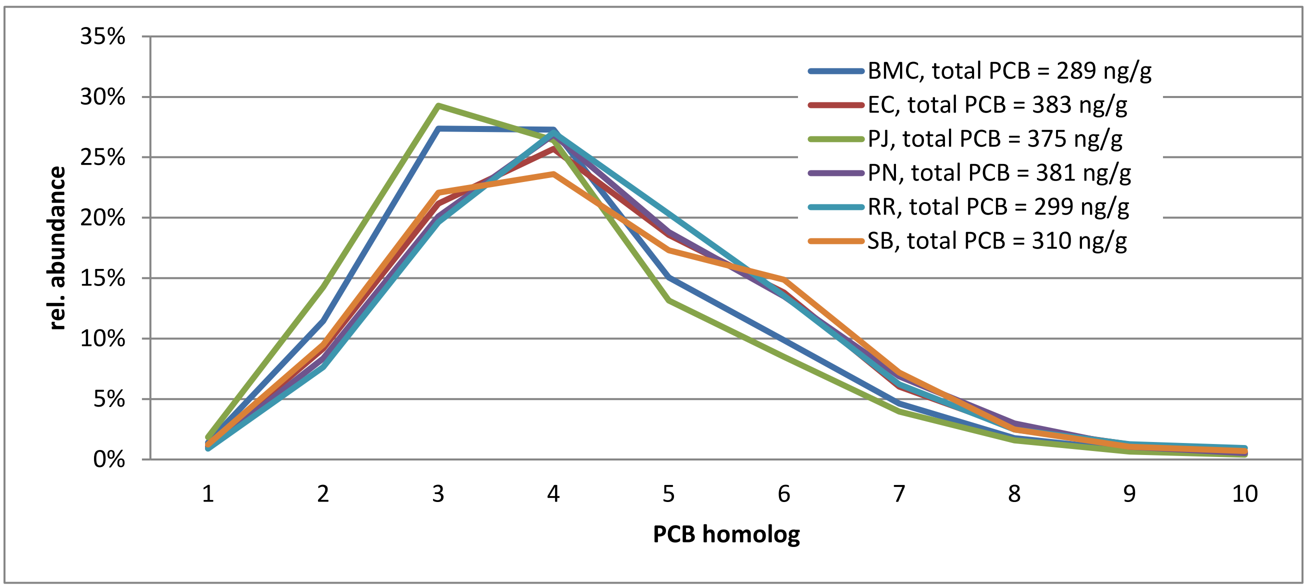


Figure 44. Average sediment PCB homolog relative abundances from six sediment groups.

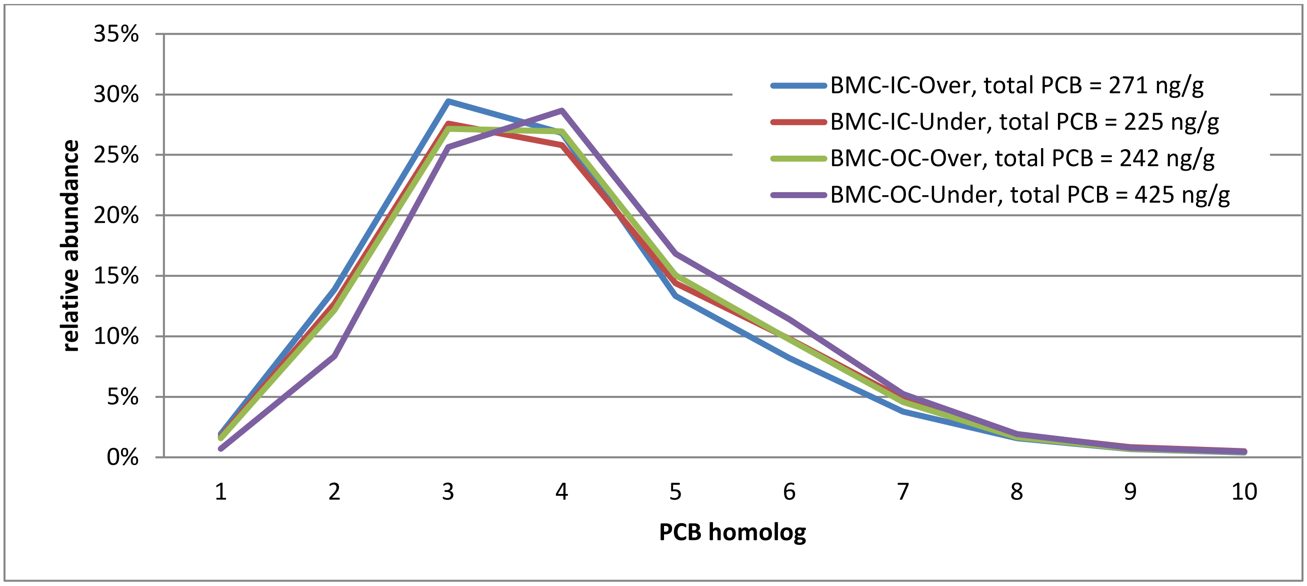


Figure 45. Sediment BMC PCB homolog relative abundances.

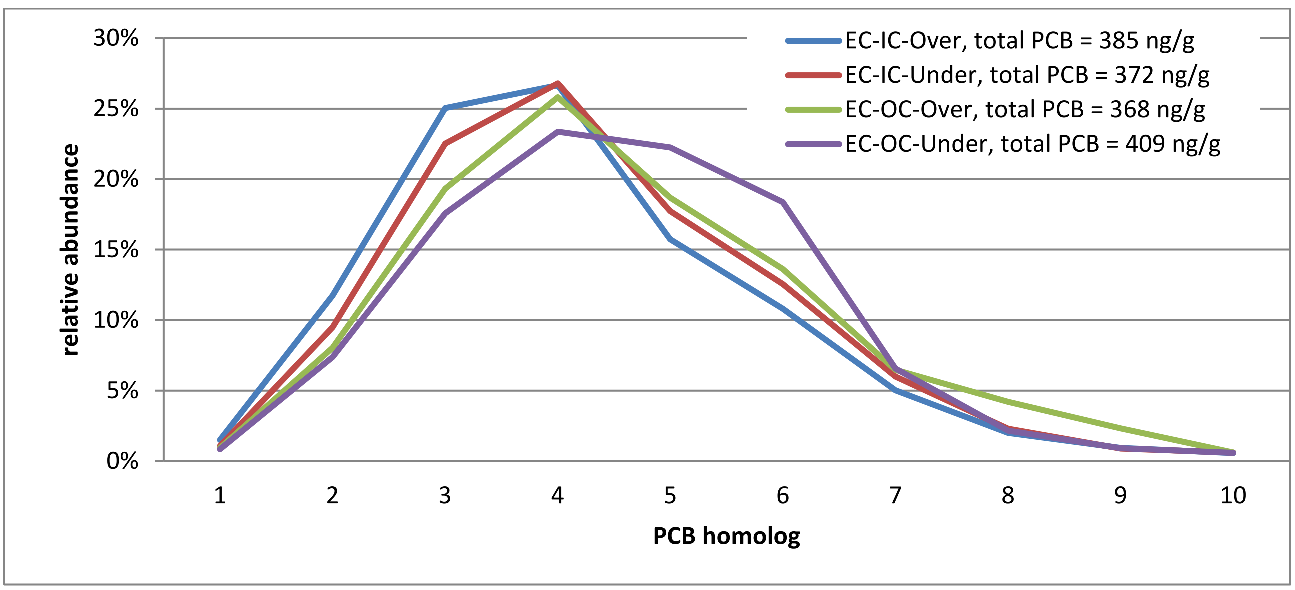


Figure 46. Sediment EC PCB homolog relative abundances.

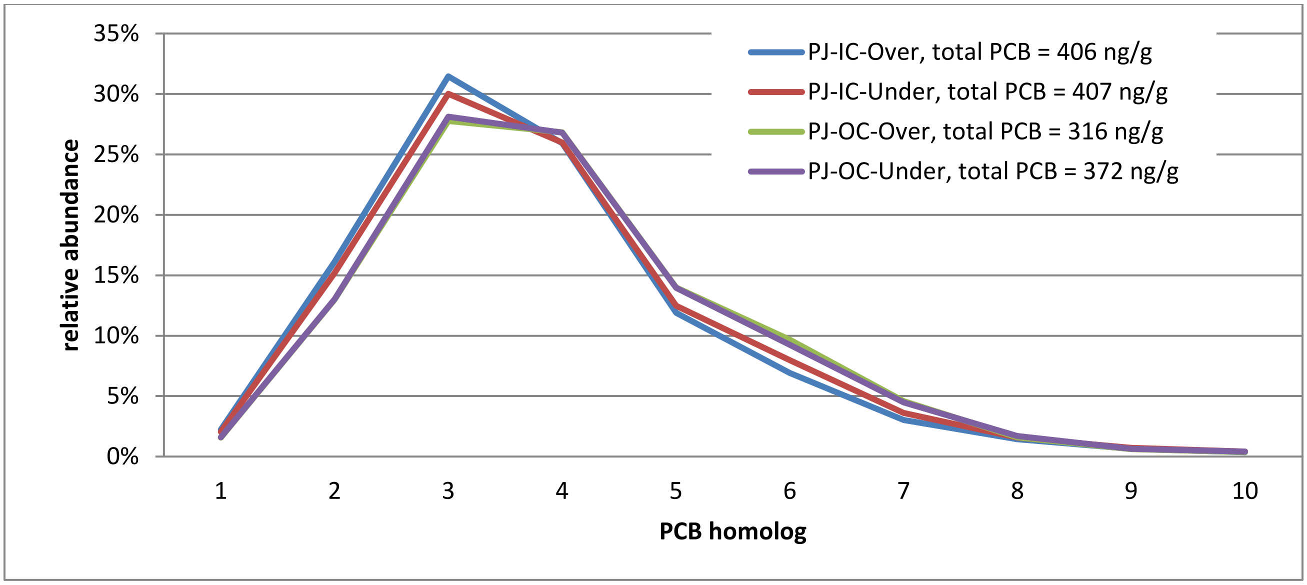


Figure 47. Sediment PJ PCB homolog relative abundances.

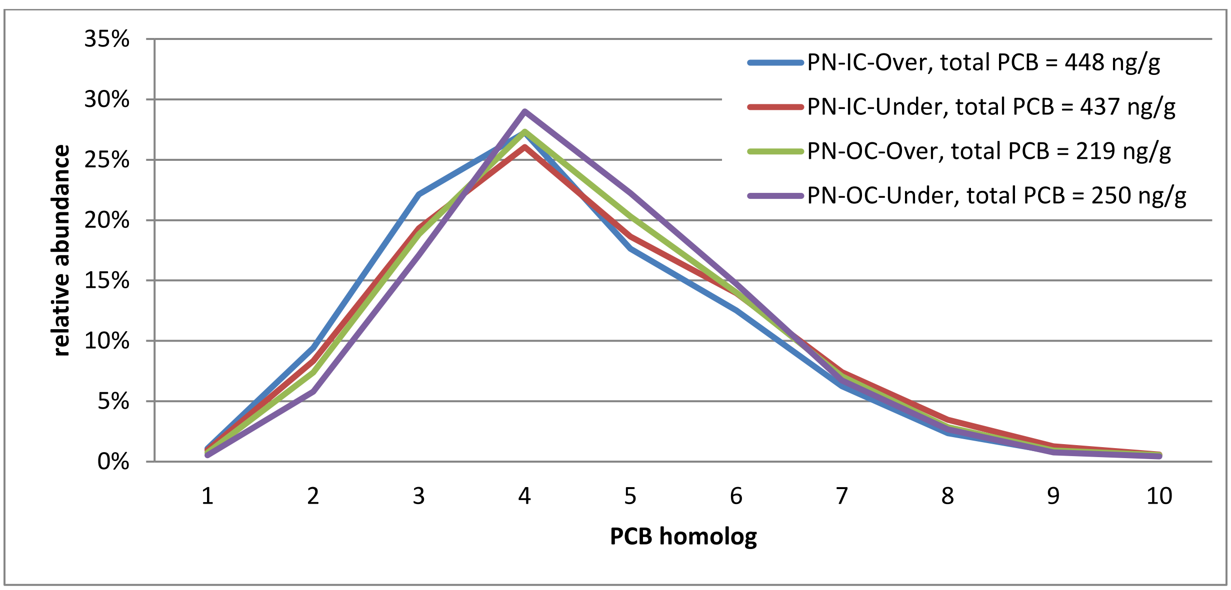


Figure 48. Sediment PN PCB homolog relative abundances.

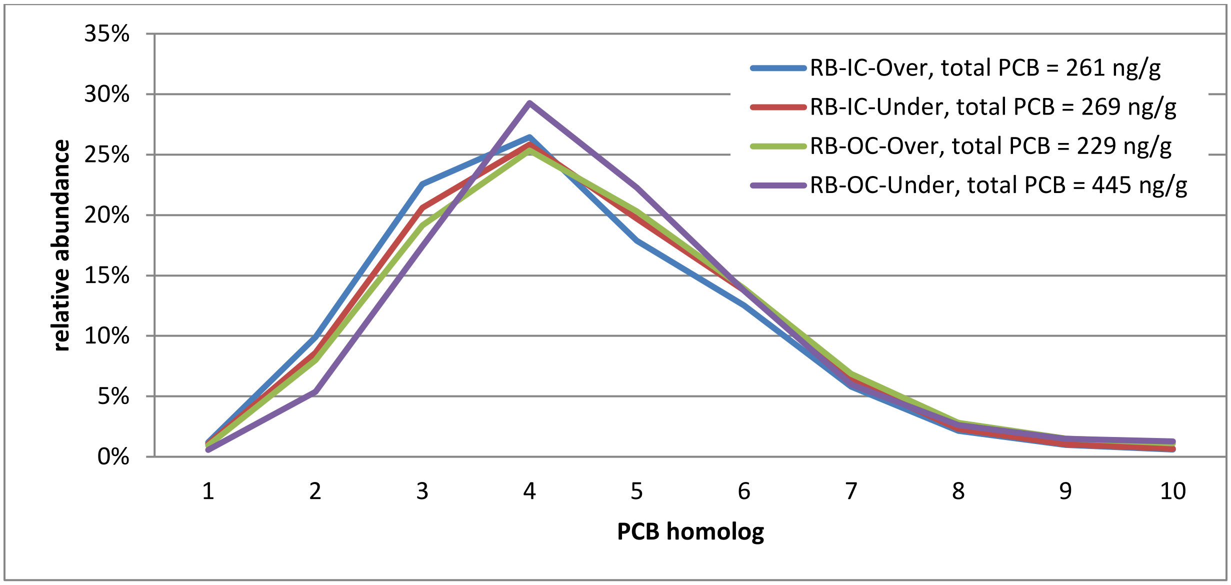


Figure 49. Sediment RB PCB homolog relative abundances.

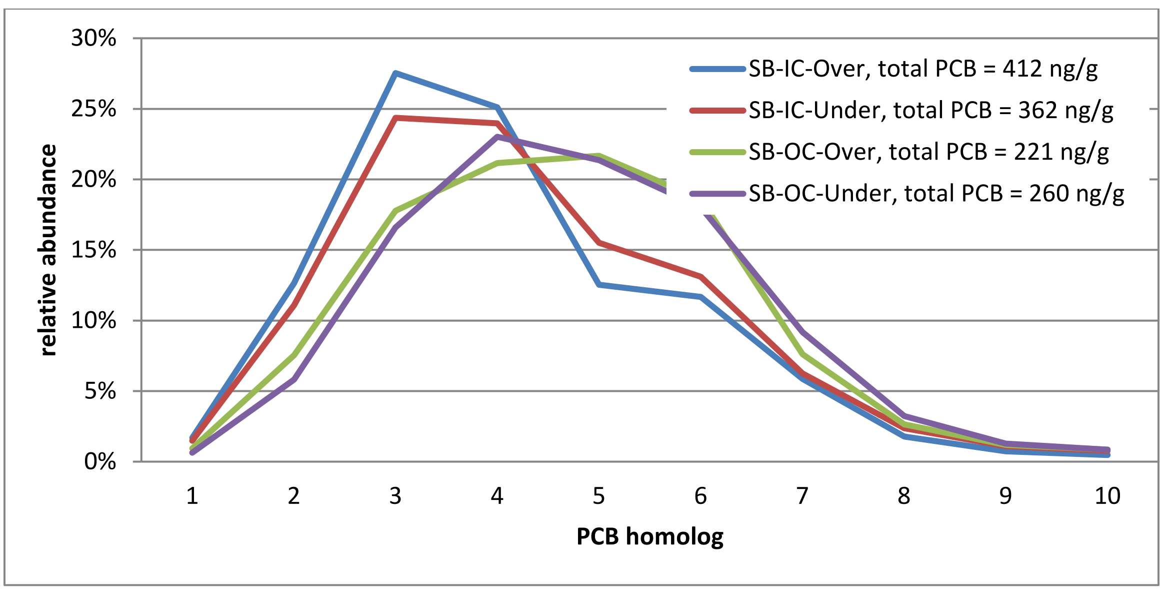


Figure 50. Sediment SB PCB homolog relative abundances.

Chapter 4. Tissue

Sediment samples at the six harbor locations were collected for use in 28-day bioaccumulation tests using the dredged material test organism, *Neanthes virens*. At each site, three in-channel and three off-channel samples at each of four depth intervals were analyzed. In addition to measuring contaminant concentrations and lipid content of the worms at the end of the 28-day exposure period, the weights of the worms were measured at the beginning and end of the 28-day exposure period (to evaluate average growth rates). Sediment TOC at the beginning and end of the 28-day period were also be measured and used in estimating the digestible organic carbon content of the sediment.

The bioaccumulation tests were comprised of the individual 84 test samples and 3 replicates of a control sediment. The methods for the bioaccumulation tests are a modification of the testing procedures outlined in the USACE/EPA Regional Testing Manual (USACE, 2017). Two important adaptions were made: 1) The volume of sediment per test organism was similar but the tests used 2.5-gallon tanks instead of the standard 10 gallon tanks. This is needed to reduce the number of sediment samples needed to achieve the per sample volume of sediment required. Here we are analyzing small discrete sediment intervals of only a few centimeters instead of the typically large composite samples analyzed for HARS suitability testing. 2) There could be no replicates of the field samples.

The lab performing the bioassays, AquaSurvey, depurated and froze the specimens prior to shipping them to Axys for chemical analysis. The chemical lab, Axys, homogenized the samples prior to completing their analysis.

The potential for bioaccumulation of PCDD/Fs and PCBs from sediments was assessed by exposing *Neanthes virens* to sediments. Toxicity of sediments was assessed by recording survival and weight of *Neanthes*.

4.1. Lipids

Table 14. Evaluations of the body burden of aquatic organisms may be assisted by knowing their lipid composition.

	% lipid		% lipid
BMC	1.41	**PN**	1.65
BMC-IC-Over	1.7	PN-IC-Over	1.73

BMC-IC-Under	1.2	PN-IC-Under	1.54
BMC-OC-Over	1.4	PN-OC-Over	1.66
BMC-OC-Under	1.35	PN-OC-Under	1.67
EC	2.16	**RB**	1.26
EC-IC-Over	2.47	RB-IC-Over	1.46
EC-IC-Under	1.6	RB-IC-Under	1.21
EC-OC-Over	2.11	RB-OC-Over	1.17
EC-OC-Under	2.44	RB-OC-Under	1.2
PJ	1.59	**SB**	1.74
PJ-IC-Over	1.48	SB-IC-Over	1.87
PJ-IC-Under	1.43	SB-IC-Under	1.2
PJ-OC-Over	2.04	SB-OC-Over	1.78
PJ-OC-Under	1.43	SB-OC-Under	2.12

4.2. Toxicity

The Newark Bay sites (PJ and EC) were perhaps a little less toxic than the samples from Raritan Bay (RB), South Brother Island (SB), and the Buttermilk Channel (BMC). Only one sample from the Elizabeth Channel (EC) was reported for toxicity.

Table 15. Toxicity.

sample	% Survival	Tissue Mass (wet wt in g)
BMC-IC-Over	92	31
BMC-IC-Under	92	33
BMC-OC-Over	79	31
BMC-OC-Under	92	28
EC-IC-Under	100	37
PJ-IC-Over	100	40
PJ-IC-Under	96	32
PJ-OC-Over	100	35
PJ-OC-Under	96	32
PN-IC-Over	100	38
PN-IC-Under	83	31
PN-OC-Over	100	35
PN-OC-Under	100	41
RB-IC-Over	96	39
RB-IC-Under	79	30
RB-OC-Over	79	26
RB-OC-Under	79	27
SB-IC-Over	90	36

SB-IC-Under	88	30
SB-OC-Over	90	33
SB-OC-Under	81	30

4.3 PCDD/Fs in Tissue

Data quality for PCDD/Fs in tissues was weaker than for PCDD/Fs in sediments.

Table 16. Averages of the triplicate replicates from each site, fg/g TEQ wet wt. Table 3 has the chemical names of the 1-17 congeners indicated.

Sed. Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	sum
BMC	146	122	3.2	17.2	9.0	10.9	1.5	104	4.6	54	6.5	9.8	2.5	5.6	4.5	0.1	0.1	502
BMC-IC-Over	95	123	5.7	16.5	8.2	12.2	1.8	86	3.8	52	5.9	9.1	2.2	4.0	5.1	0.2	0.1	430
BMC-IC-Under	98	80	0.0	13.7	7.6	8.1	1.2	86	4.1	44	5.4	8.6	6.1	3.3	3.3	0.0	0.1	369
BMC-OC-Over	127	152	5.4	21.4	9.2	13.5	1.6	110	4.8	62	6.5	9.7	0.0	9.4	6.0	0.2	0.2	539
BMC-OC-Under	263	133	1.8	17.1	10.8	9.8	1.5	135	5.8	59	8.3	12.0	1.8	5.7	3.7	0.0	0.1	668
EC	989	156	5.1	23.8	13.3	11.0	1.6	185	7.8	108	15.8	33.5	3.2	8.7	6.8	0.3	0.2	1569
EC-IC-Over	828	136	3.3	23.2	11.7	11.7	1.8	191	6.7	104	11.6	25.4	0.0	6.7	6.2	0.0	0.2	1368
EC-IC-Under	791	140	2.7	22.3	10.5	10.4	1.6	161	6.6	87	12.2	25.7	2.3	4.4	5.7	0.0	0.2	1283
EC-OC-Over	993	161	4.1	23.9	14.6	11.2	1.6	194	8.9	117	16.9	33.4	3.5	11.1	7.1	0.4	0.2	1602
EC-OC-Under	1343	186	10.3	25.8	16.3	10.6	1.6	194	9.2	126	22.4	49.5	7.2	12.7	8.4	0.8	0.2	2024
PJ	254	196	15.4	29.7	21.6	11.7	1.7	138	7.9	100	16.2	19.2	12.8	13.9	4.9	0.8	0.1	845
PJ-IC-Over	151	105	7.1	23.7	14.9	10.5	1.7	118	6.0	81	9.4	12.9	8.5	7.7	3.8	0.3	0.1	561
PJ-IC-Under	169	124	8.7	19.6	15.3	12.4	2.1	110	5.1	64	7.5	10.1	7.7	6.5	4.6	0.0	0.1	567
PJ-OC-Over	268	176	13.7	27.5	18.4	11.2	1.5	150	7.9	96	14.8	18.2	9.3	12.8	4.6	0.7	0.1	831
PJ-OC-Under	428	380	32.1	47.9	37.9	12.7	1.7	175	12.6	160	33.1	35.5	25.8	28.7	6.5	2.2	0.2	1419
PN	2126	167	5.6	20.2	11.8	11.5	1.7	256	9.1	118	18.7	50.5	1.0	7.7	9.6	0.3	0.3	2814
PN-IC-Over	1393	148	3.0	25.6	12.2	12.2	1.7	207	7.8	104	13.1	31.1	0.0	8.8	7.3	0.4	0.2	1977
PN-IC-Under	1430	138	0.0	16.4	10.7	9.1	1.4	208	8.4	99	15.6	37.3	4.0	8.7	6.3	0.2	0.2	1993
PN-OC-Over	1720	201	9.4	19.1	11.7	12.0	1.7	235	8.0	99	16.4	47.5	0.0	8.5	10.6	0.0	0.3	2401
PN-OC-Under	3960	180	10.2	19.6	12.4	12.6	2.1	372	12.0	168	29.8	86.2	0.0	4.8	14.2	0.7	0.4	4885
RB	233	116	3.1	19.6	12.1	15.1	3.9	129	6.3	68	8.7	15.1	5.1	5.5	5.6	0.3	0.3	646
RB-IC-Over	173	104	2.2	15.5	11.7	11.3	2.7	113	5.8	69	7.9	11.3	2.7	5.3	4.1	0.0	0.1	539
RB-IC-Under	151	116	5.6	19.0	11.5	20.7	6.7	104	6.6	61	7.8	20.2	5.6	5.6	7.0	0.7	0.4	549
RB-OC-Over	226	100	0.0	13.4	9.6	9.9	2.6	113	5.5	60	7.4	8.9	7.4	4.2	3.8	0.0	0.1	571
RB-OC-Under	384	144	4.7	30.5	15.5	18.6	3.5	184	7.3	81	11.6	19.9	4.7	7.1	7.3	0.4	0.5	925
SB	120	141	4.8	20.2	11.2	11.8	1.6	137	6.2	73	9.0	11.6	0.7	6.4	4.8	0.2	0.1	558
SB-IC-Over	113	166	7.9	22.6	12.6	14.2	1.7	130	5.3	76	8.4	11.3	0.0	7.5	6.7	0.2	0.1	583
SB-IC-Under	124	139	0.0	16.9	7.7	9.6	1.5	136	5.6	74	7.7	7.7	2.9	7.1	3.4	0.0	0.1	543
SB-OC-Over	117	138	6.9	22.7	11.7	14.6	1.8	141	7.0	63	9.6	14.1	0.0	4.6	5.1	0.3	0.1	558
SB-OC-Under	124	120	4.5	18.5	13.0	9.0	1.3	140	6.9	78	10.5	13.5	0.0	6.6	3.9	0.2	0.1	550

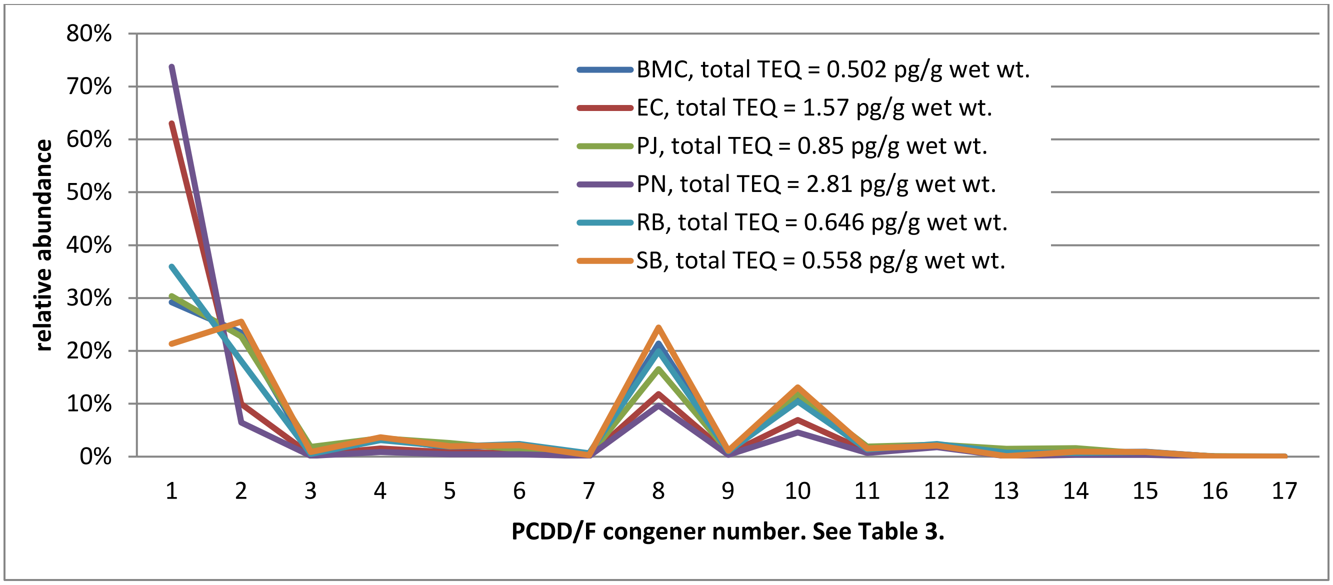


Figure 51. Average tissue PCDD/F TEQ in six sediment groups.

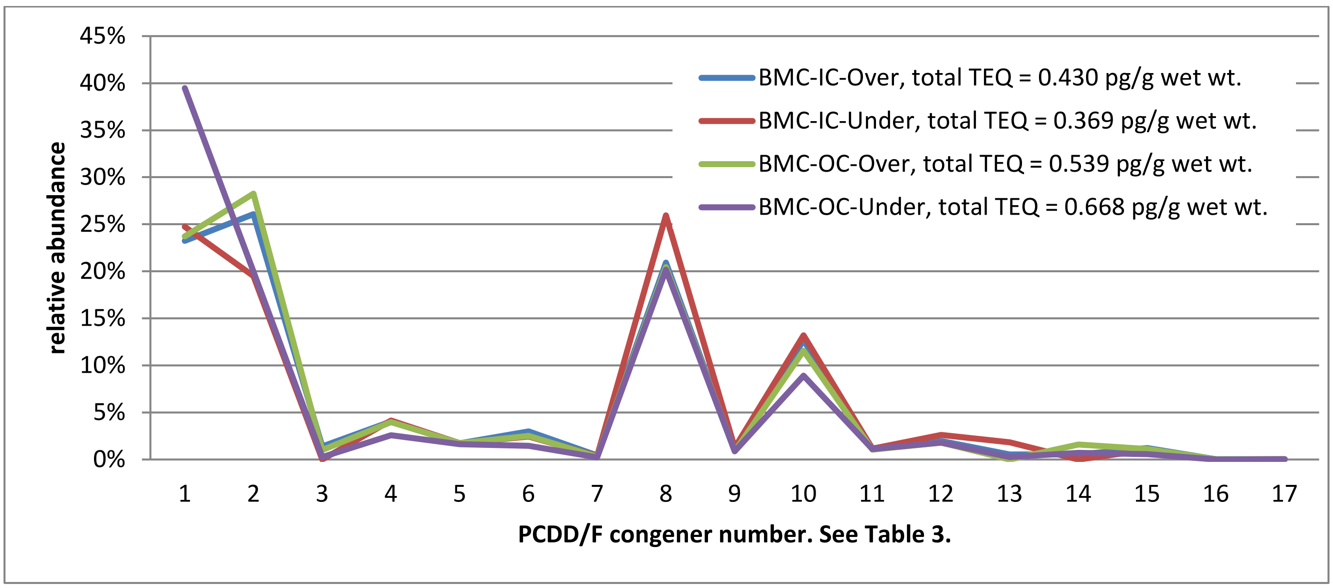


Figure 52. Tissue BMC PCDD/F TEQ relative abundances.

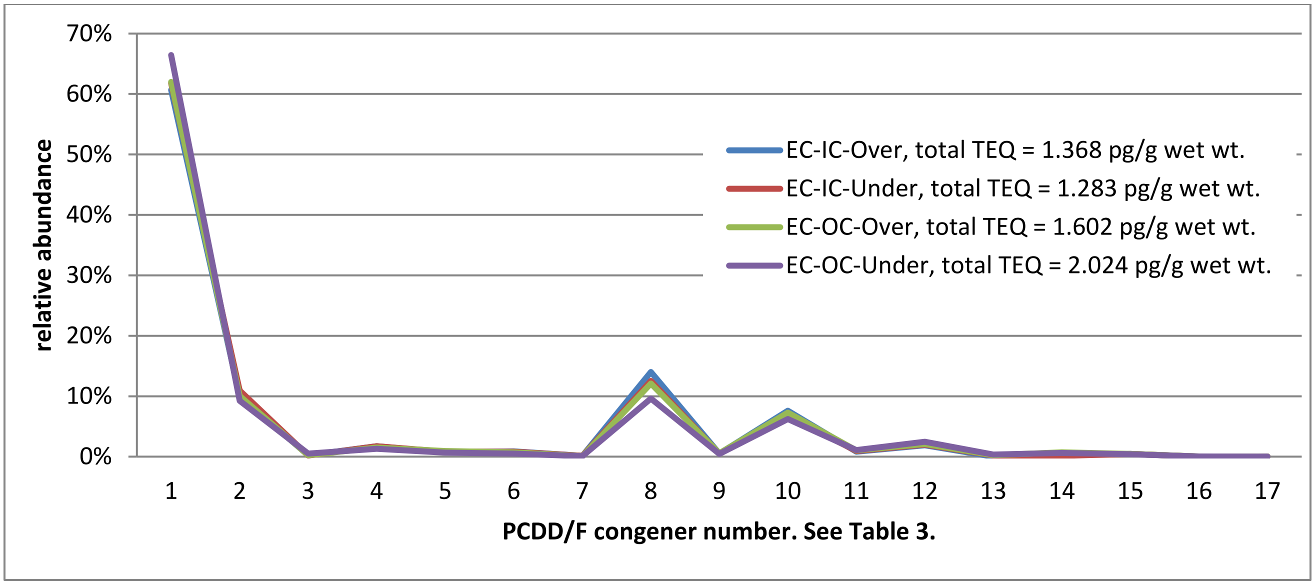


Figure 53. Tissue EC PCDD/F TEQ relative abundances.

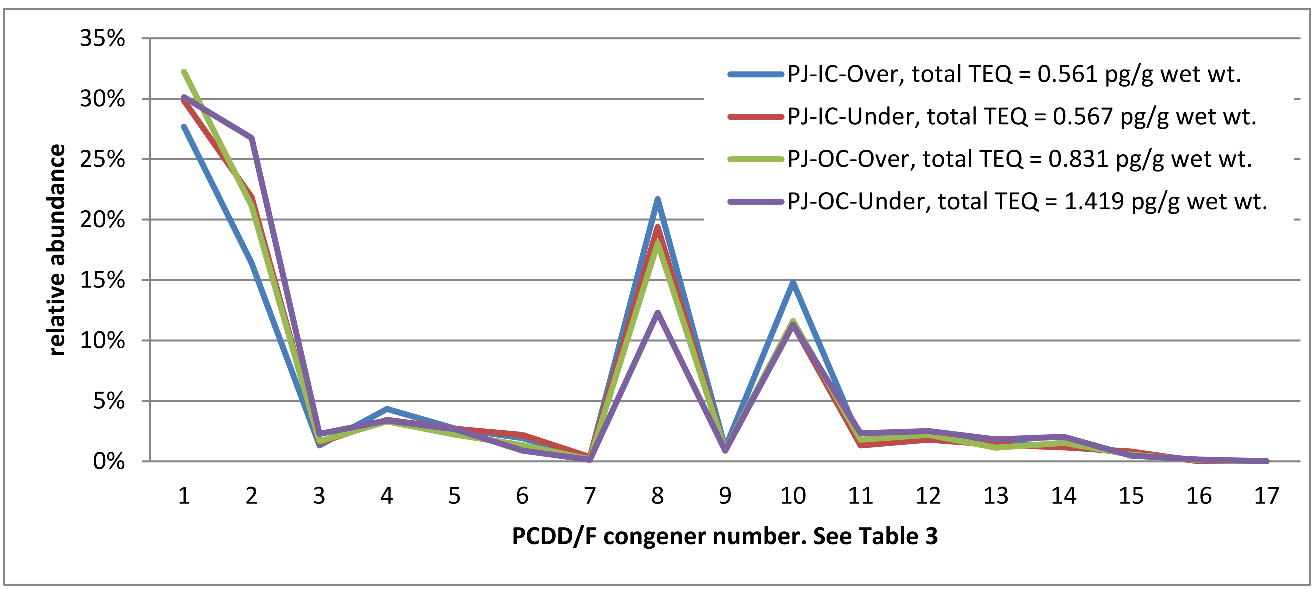


Figure 54. Tissue PJ PCDD/F TEQ relative abundances.

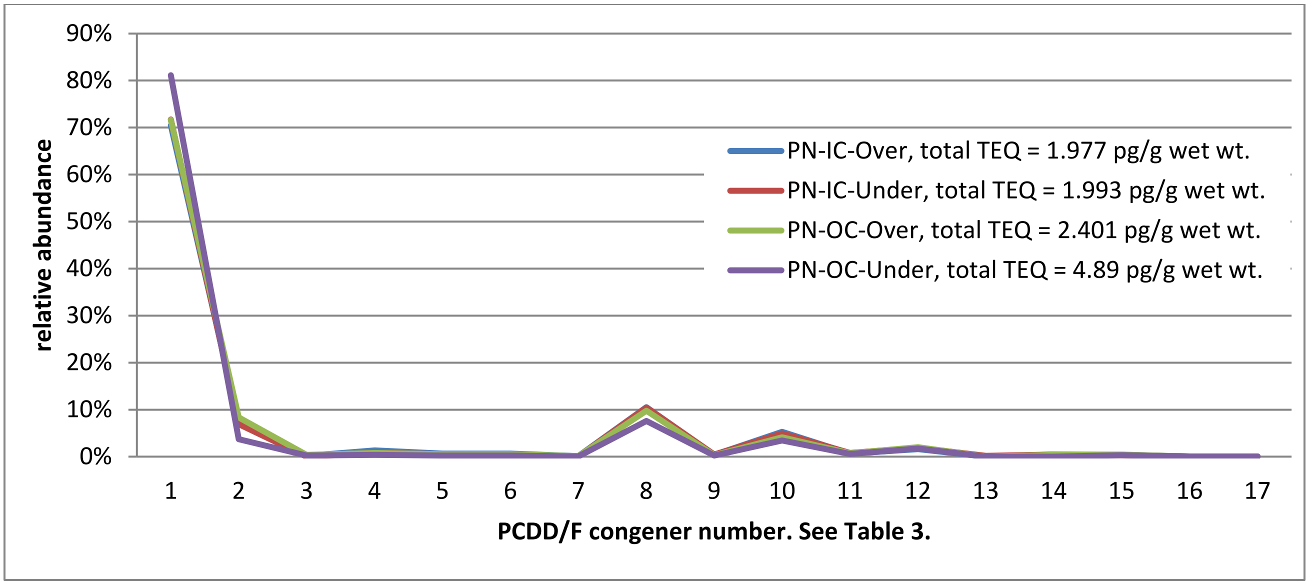


Figure 55. Tissue PN PCDD/F TEQ relative abundances.

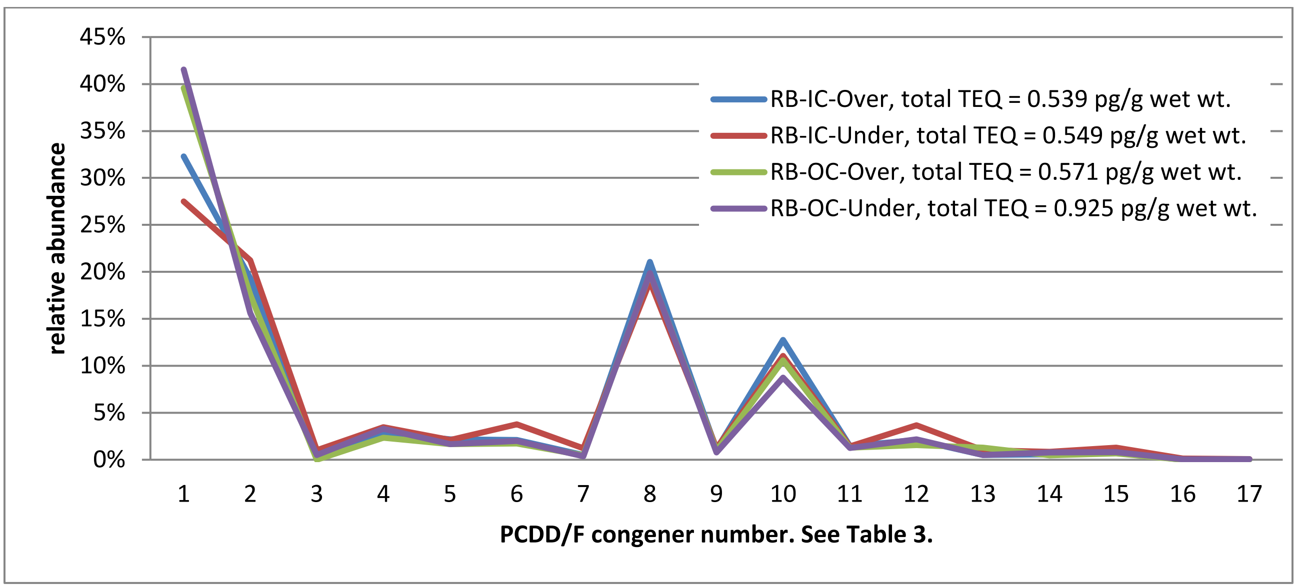


Figure 56. Tissue RB PCDD/F TEQ relative abundances.

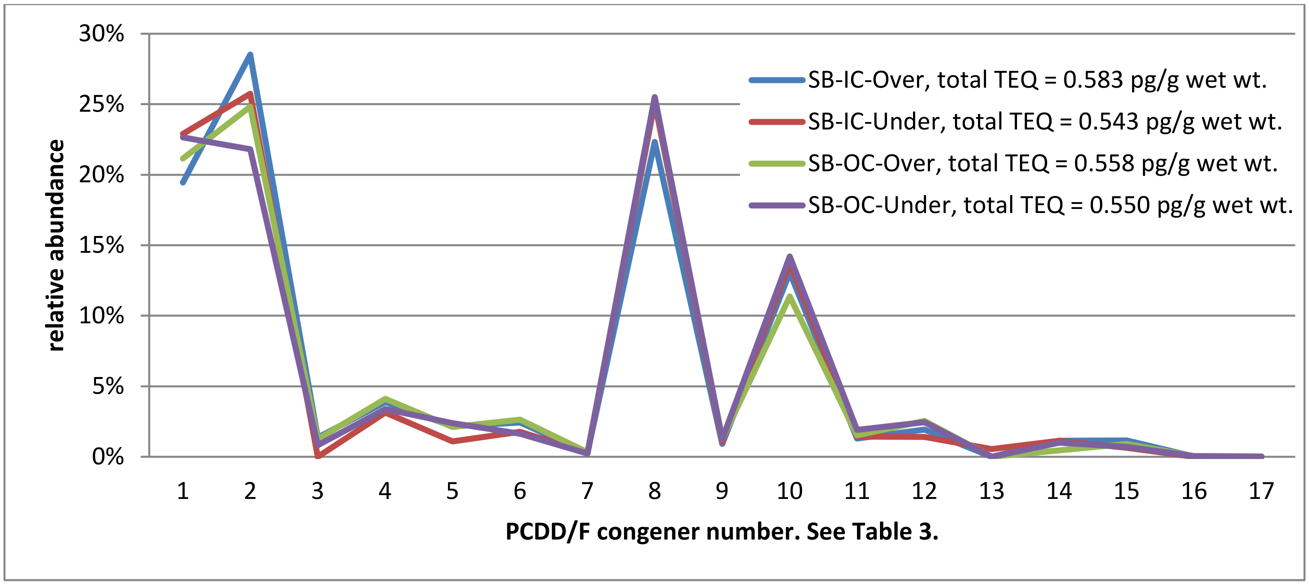


Figure 57. Tissue SB PCDD/F TEQ relative abundances.

4.4. Comparison of PCDD/Fs in Tissue and Sediment.

There is a fairly strong relationship between sediment and tissue concentrations of PCDD/F TEQ for samples from Elizabeth Channel and Port Newark but the relationship is much weaker for samples from the Buttermilk Channel, Port Jersey, Raritan River, and South Brother samples where PCDD/F TEQ concentrations were lower.

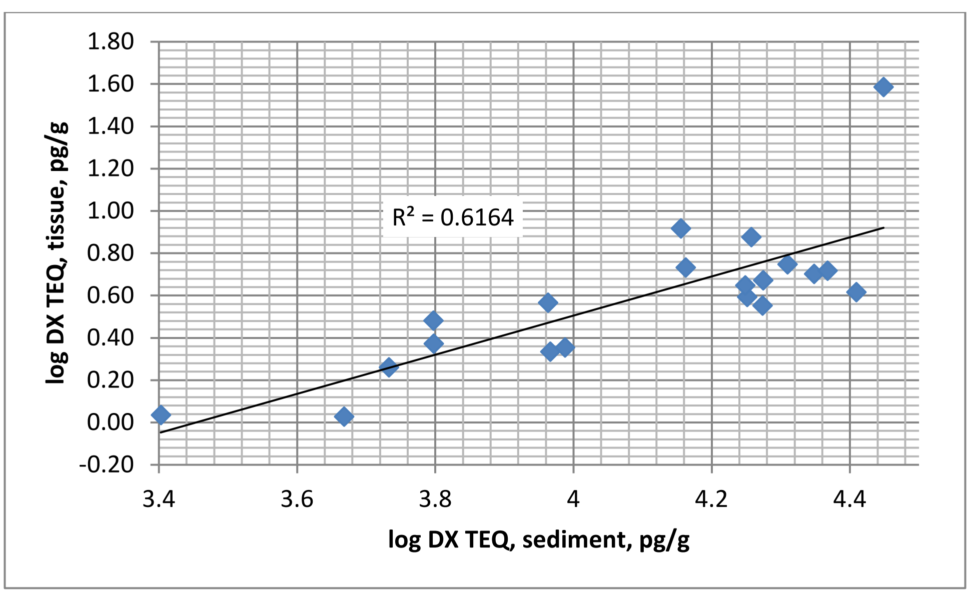


Figure 58. Elizabeth Channel and Port Newark PCDD/F TEQ in sediment

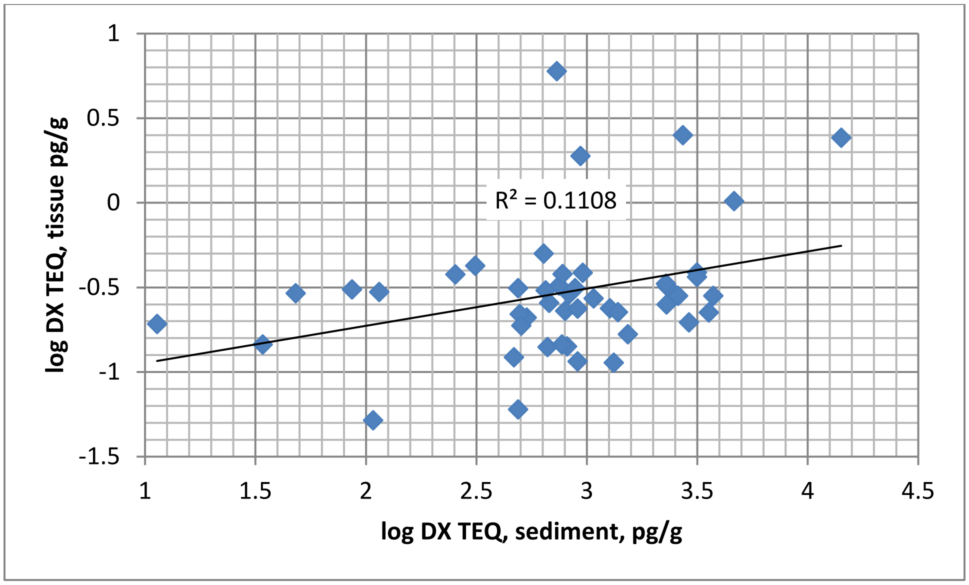


Figure 59. BMC, PN, RR, and SB PCDD/F TEQ in sediment and tissue.

4.5 PCBs in Tissue

Table 17. Averages of the triplicate replicates from each site, ng/g wet wt.

Sed. Group	1	2	3	4	5	6	7	8	9	10	sum
BMC	0.006	0.250	2.042	5.392	5.408	6.396	3.191	1.102	0.413	0.211	24.41
BMC-IC-Over	0.005	0.256	1.066	3.389	4.145	5.249	2.331	0.726	0.352	0.191	17.71
BMC-IC-Under	0.004	0.197	1.055	3.244	4.086	5.041	2.313	0.713	0.357	0.195	17.21
BMC-OC-Over	0.007	0.240	1.719	4.558	4.895	5.927	2.808	0.971	0.375	0.203	21.70
BMC-OC-Under	0.009	0.307	4.330	10.376	8.505	9.368	5.312	1.998	0.567	0.256	41.03
EC	0.009	0.360	2.000	6.836	7.316	7.725	3.522	1.100	0.416	0.198	29.48
EC-IC-Over	0.009	0.486	2.268	7.281	8.159	8.430	3.790	1.122	0.422	0.199	32.17
EC-IC-Under	0.007	0.372	1.928	6.233	6.859	7.401	3.378	1.074	0.424	0.200	27.88
EC-OC-Over	0.005	0.304	1.655	5.923	6.250	7.097	3.173	0.990	0.404	0.202	26.00
EC-OC-Under	0.015	0.298	2.263	8.211	8.352	8.180	3.863	1.249	0.420	0.192	33.04
PJ	0.012	0.533	2.781	7.798	8.047	8.817	3.971	1.171	0.432	0.201	33.76
PJ-IC-Over	0.016	0.549	1.815	5.682	6.415	7.253	3.442	1.078	0.418	0.187	26.85
PJ-IC-Under	0.011	0.502	1.580	4.560	5.079	6.311	3.158	1.014	0.411	0.199	22.82
PJ-OC-Over	0.010	0.456	2.859	8.605	9.352	10.275	4.520	1.276	0.456	0.217	38.03
PJ-OC-Under	0.011	0.650	4.845	12.075	10.906	10.944	4.580	1.280	0.436	0.195	45.92
PN	0.007	0.478	2.790	9.199	8.736	8.482	3.771	1.132	0.411	0.199	35.21
PN-IC-Over	0.007	0.596	3.309	10.867	9.676	9.137	4.054	1.212	0.445	0.214	39.52
PN-IC-Under	0.004	0.371	2.292	7.791	7.776	7.664	3.398	1.040	0.390	0.189	30.91
PN-OC-Over	0.012	0.490	3.141	9.562	8.946	9.404	4.183	1.243	0.422	0.201	37.60
PN-OC-Under	0.008	0.434	2.377	8.059	8.584	8.055	3.632	1.057	0.363	0.177	32.75
RB	0.004	0.207	1.638	5.505	6.315	6.581	2.812	0.896	0.439	0.276	24.67

RB-IC-Over	0.004	0.288	0.865	3.188	4.204	6.208	2.897	0.886	0.393	0.210	19.14
RB-IC-Under	0.005	0.149	0.696	2.829	3.711	4.788	2.314	0.699	0.315	0.169	15.68
RB-OC-Over	0.002	0.097	1.346	4.932	6.458	6.374	2.719	0.933	0.494	0.286	23.64
RB-OC-Under	0.004	0.294	3.644	11.069	10.887	8.954	3.318	1.067	0.557	0.439	40.23
SB	0.006	0.212	1.154	3.981	5.787	7.152	3.482	0.942	0.408	0.222	23.35
SB-IC-Over	0.010	0.266	1.083	3.331	4.538	6.158	3.111	0.825	0.333	0.177	19.83
SB-IC-Under	0.006	0.215	1.302	4.091	6.077	7.054	3.682	0.922	0.416	0.217	23.98
SB-OC-Over	0.003	0.161	0.907	3.918	6.446	8.114	3.485	0.980	0.453	0.257	24.72
SB-OC-Under	0.004	0.188	1.347	4.802	6.505	7.613	3.771	1.082	0.453	0.253	26.02

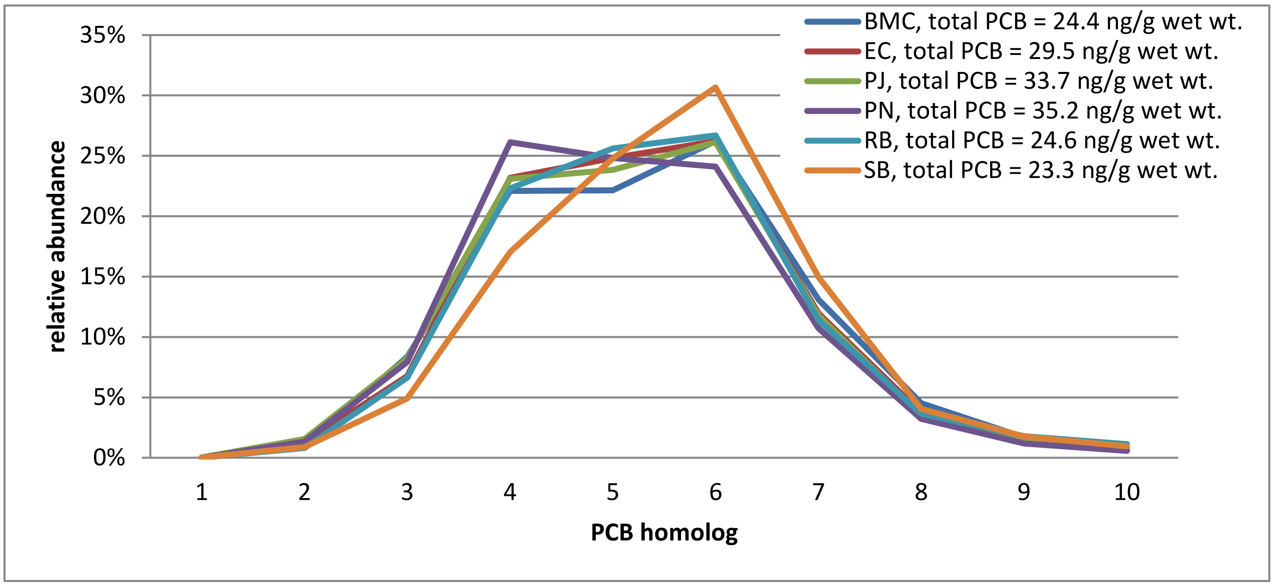


Figure 60. Average tissue PCB homolog relative abundances from the six sediment groups.

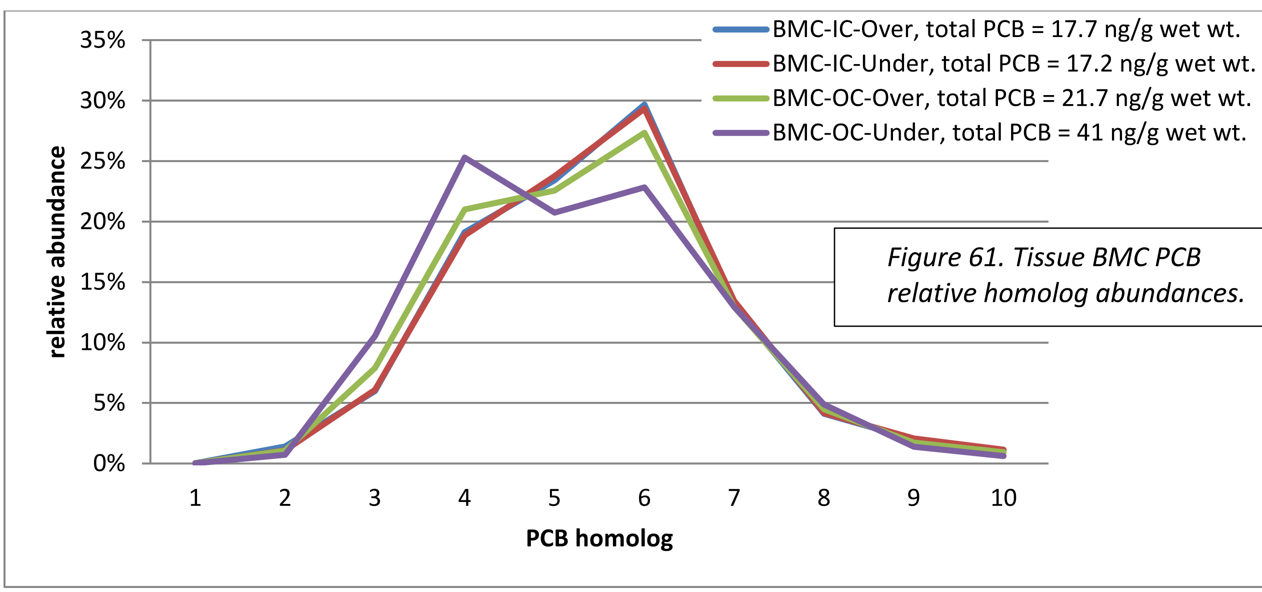


Figure 61. Tissue BMC PCB relative homolog abundances.

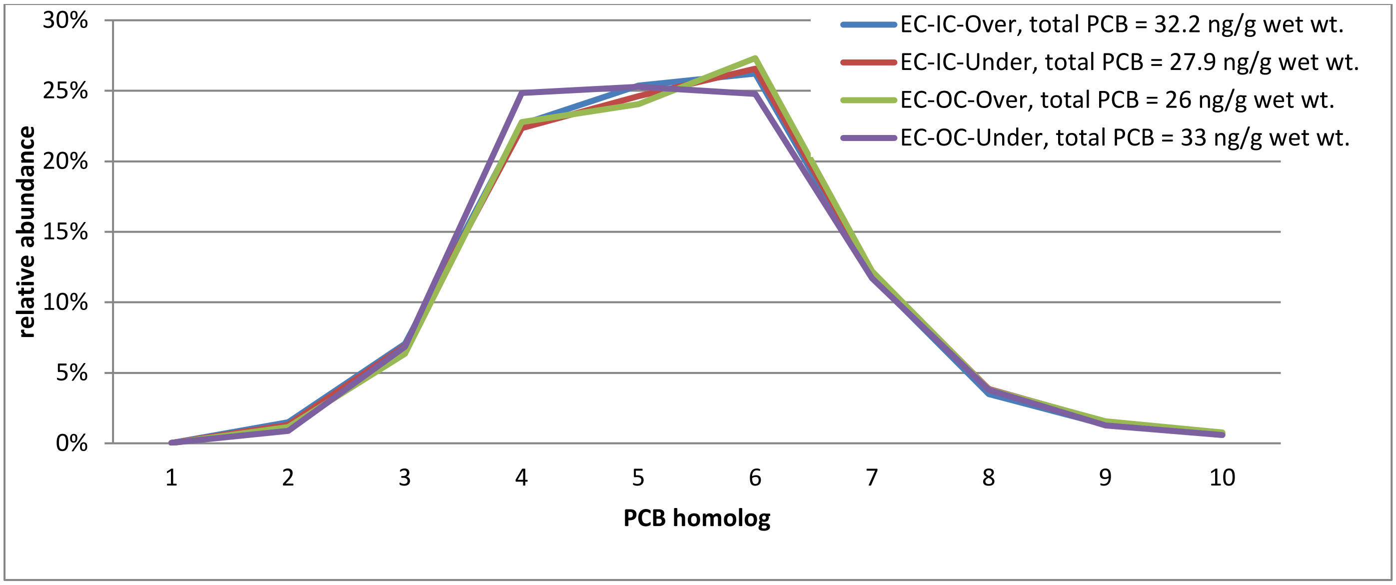


Figure 62. Tissue EC PCB relative homolog abundances. A lab accident lost any possibility of detecting all three monochlorobiphenyls in one of the three EC-OC-Over samples.

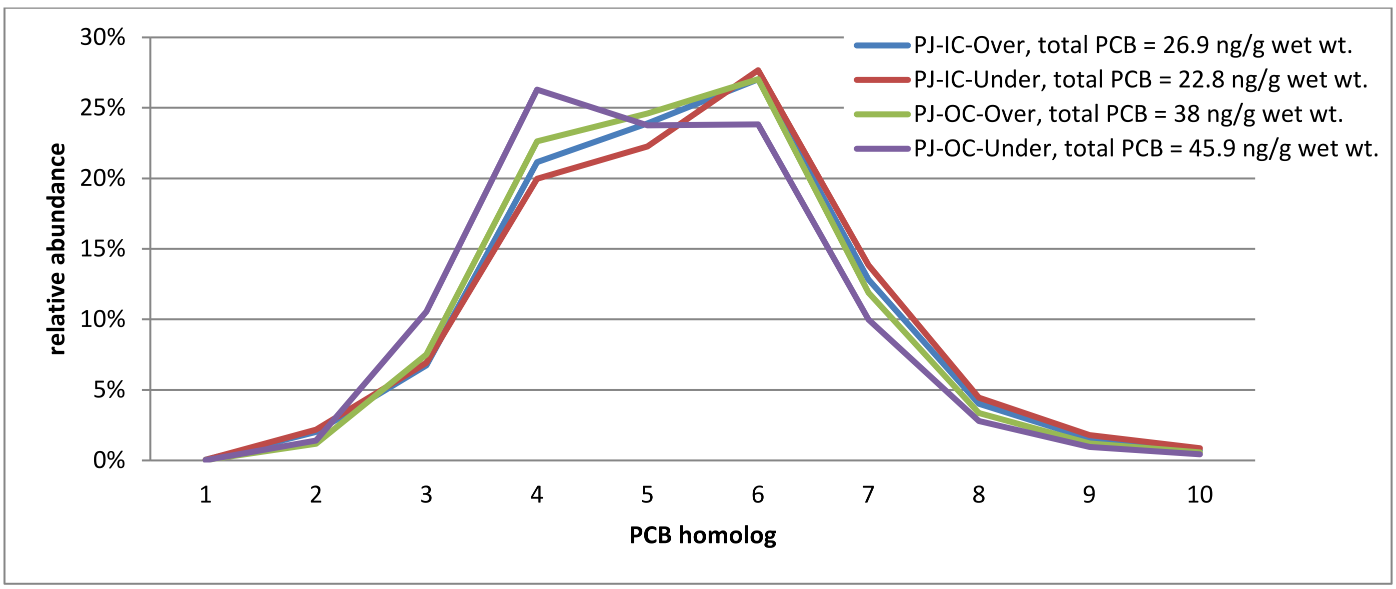


Figure 63. Tissue PJ PCB relative homolog abundances.

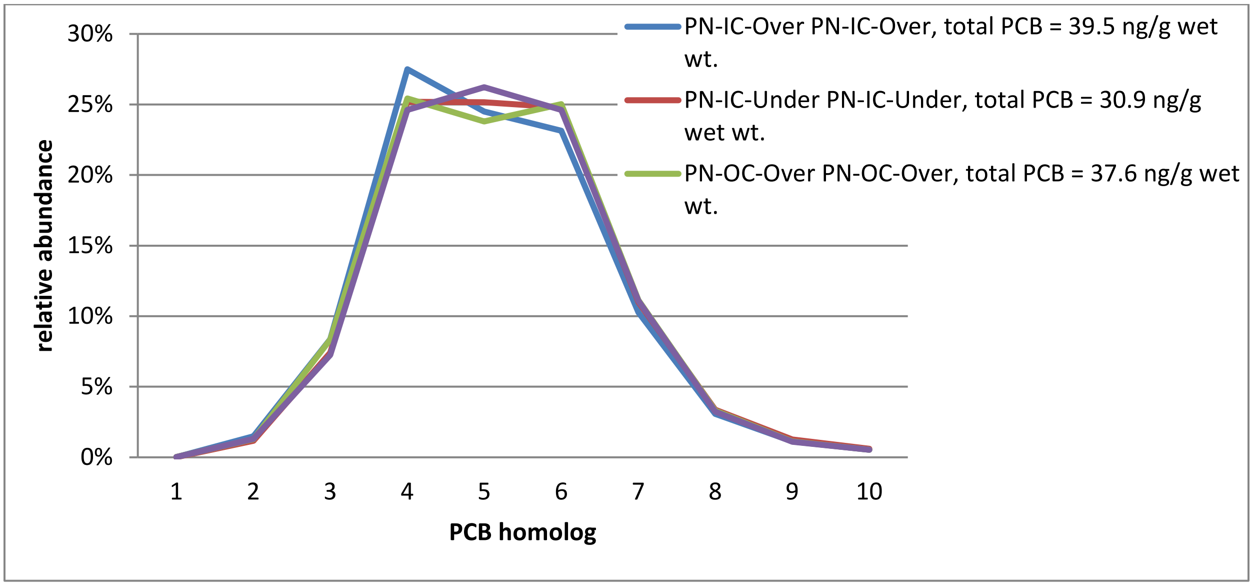


Figure 64. Tissue PN PCB relative homolog abundances. Lab accidents lost 2- and 3-MoCB from one of the three PN-IC-Under samples and 2-, 3, and 4-MoCB from another of the PN-IC-Under samples.

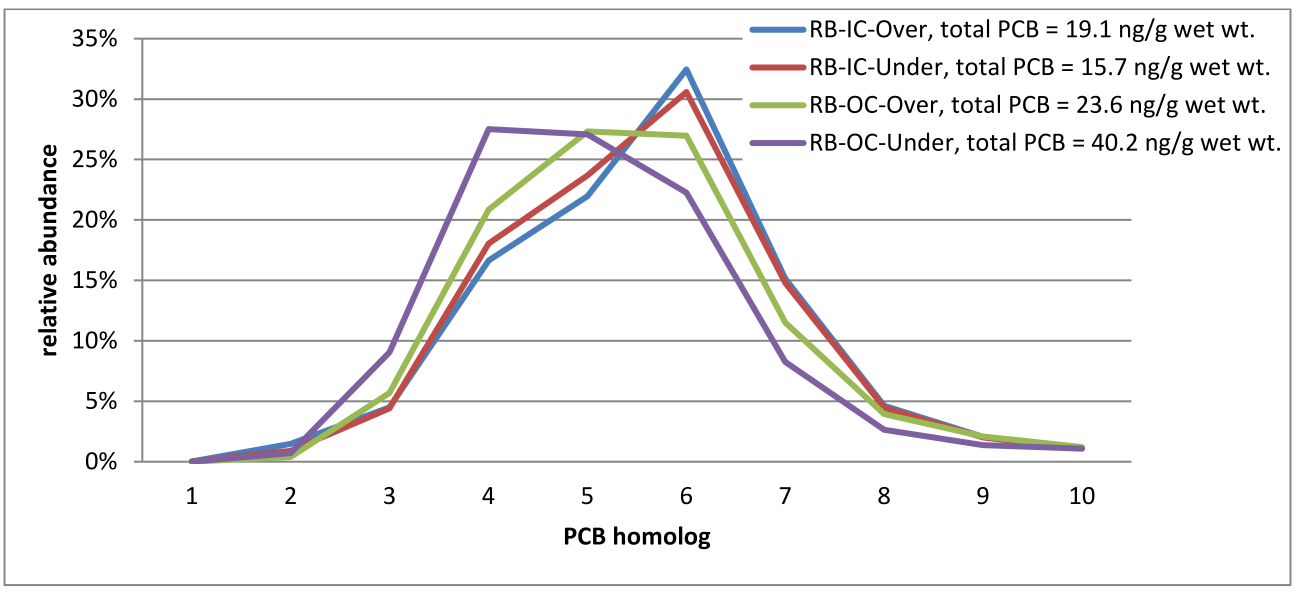


Figure 65. Tissue RB PCB relative homolog abundances. A lab accident lost 9 of the 12 dichlorobiphenyls from one of the three RR-0C-Upper samples.

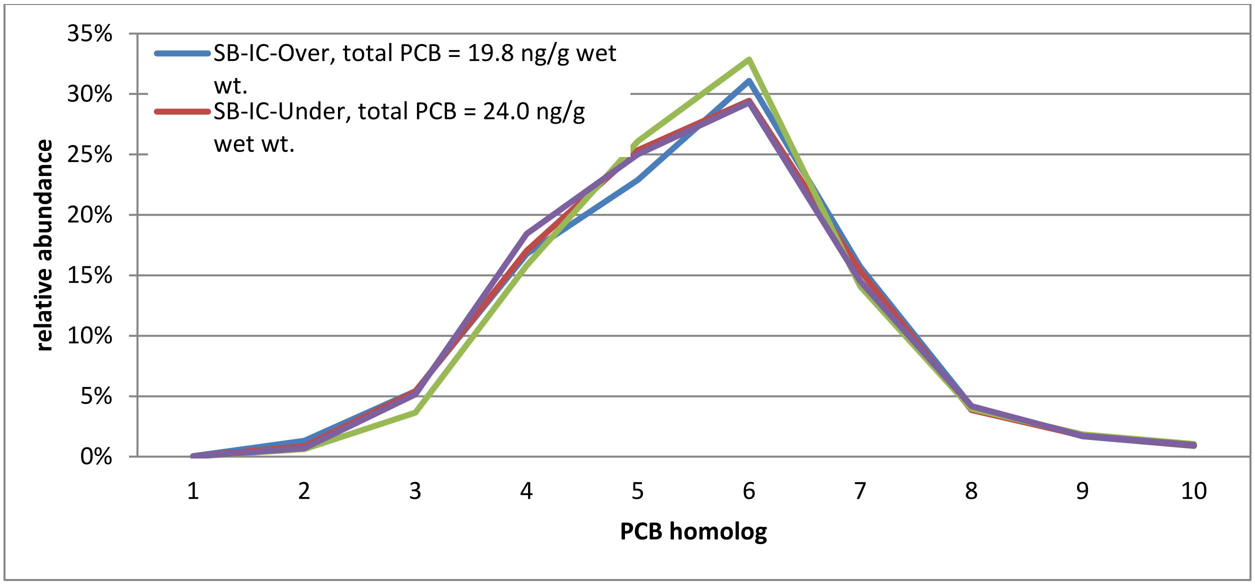


Figure 66. Tissue SB PCB relative homolog abundances.

Four of the sediment group averages show a similar pattern of enhanced uptake of the heavier homologs by the worms, particularly hexa- and hepta chlorobiphenyls. However, the enhancement appears to be much increased in the PJ (Port Jersey) and BMC (Buttermilk Channel) samples. At PJ the excessive uptake of the hexa- and hepta-PCBs was most pronounced in the Off-Channel samples. At BMC all four kinds of samples were about equal.

4.6. Comparison between PCBs in Sediment and Tissue.

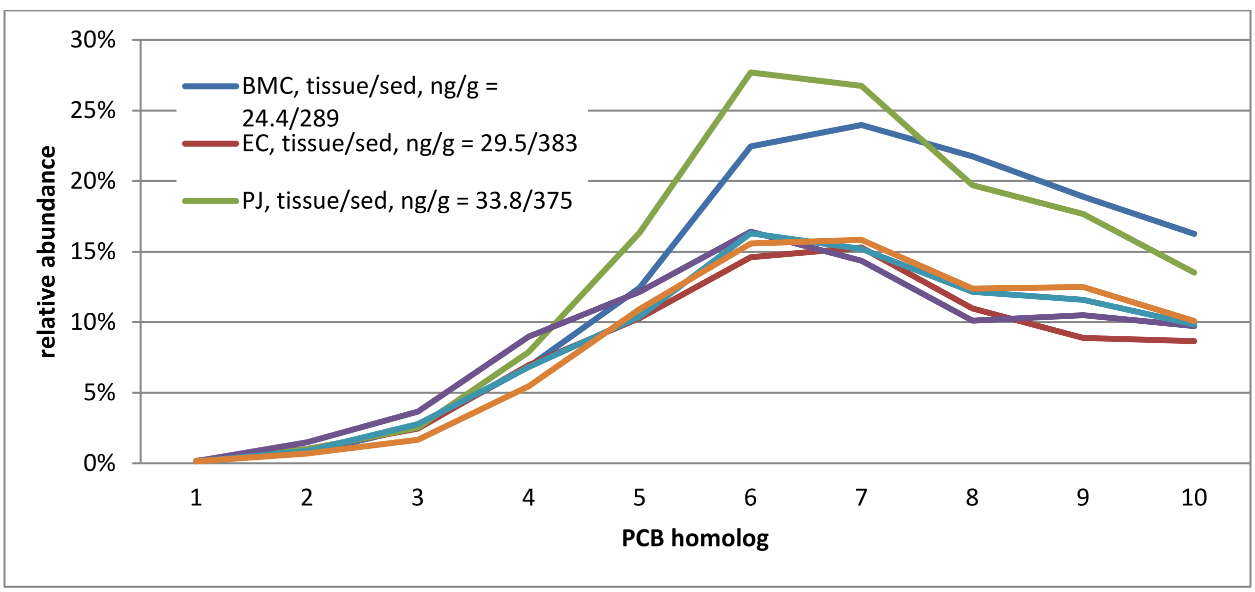


Figure 67. Average tissue/sediment ratios, PCB homologs.

Table 18. PCDD/F (pg/g) and PCB (ng/g) concentrations in sediment and tissue.

		PCDD/F		PCB	
		Sed	Tissue	Sed	Tissue
IC	avg	33.0	0.889	354	24.4
	median	24.7	0.558	378	23.4
OC	avg	37.8	1.413	312	32.5
	median	25.3	0.878	288	32.9
Over	avg	32.1	0.992	314	27.2
	median	22.2	0.576	293	25.4
Under	avg	38.7	1.310	352	29.8
	median	29.0	0.796	372	29.4

Table 19. Values are averages of the triplicate replicates from each site.

	PCDD/F TEQ, pg/g			PCB, ng/g		
	Sed	Tissue	Tissue/Sed	Sed	Tissue	Tissue/Sed
BMC	15.03	0.50	3.34%	291	2.44	0.84%
BMC-IC-Over	10.96	0.43	3.92%	271	1.77	0.65%
BMC-IC-Under	13.47	0.37	2.75%	225	1.72	0.77%
BMC-OC-Over	11.30	0.54	4.78%	242	2.17	0.90%
BMC-OC-Under	24.37	0.67	2.75%	425	4.10	0.96%
EC	54.47	1.57	2.88%	384	2.98	0.78%
EC-IC-Over	39.73	1.37	3.45%	385	3.22	0.84%
EC-IC-Under	50.67	1.28	2.53%	372	2.79	0.75%
EC-OC-Over	65.28	1.60	2.45%	368	2.60	0.71%
EC-OC-Under	62.18	2.02	3.25%	409	3.30	0.81%
PJ	17.15	0.85	4.93%	375	3.34	0.89%
PJ-IC-Over	16.05	0.56	3.49%	406	2.69	0.66%
PJ-IC-Under	17.97	0.57	3.17%	407	2.28	0.56%
PJ-OC-Over	16.10	0.83	5.16%	316	3.80	1.20%
PJ-OC-Under	18.48	1.42	7.68%	372	4.59	1.23%
PN	75.41	2.81	3.73%	338	3.52	1.04%
PN-IC-Over	70.14	1.98	2.82%	448	3.95	0.88%
PN-IC-Under	75.38	1.99	2.64%	437	3.09	0.71%
PN-OC-Over	70.61	2.40	3.40%	219	3.76	1.72%
PN-OC-Under	85.52	4.88	5.71%	250	3.27	1.31%
RB	32.56	0.65	1.99%	301	2.47	0.82%
RB-IC-Over	27.29	0.54	1.98%	261	1.91	0.73%
RB-IC-Under	33.52	0.55	1.64%	269	1.57	0.58%
RB-OC-Over	26.23	0.57	2.17%	229	2.36	1.03%

RB-OC-Under	43.21	0.93	2.15%	445	4.02	0.90%
SB	17.64	0.56	3.16%	314	2.36	0.75%
SB-IC-Over	18.16	0.58	3.19%	412	1.98	0.48%
SB-IC-Under	22.03	0.54	2.45%	362	2.40	0.66%
SB-OC-Over	13.11	0.56	4.27%	221	2.47	1.12%
SB-OC-Under	17.27	0.55	3.18%	260	2.60	1.00%

The relationship between PCB concentrations in sediments and tissue is shown below.

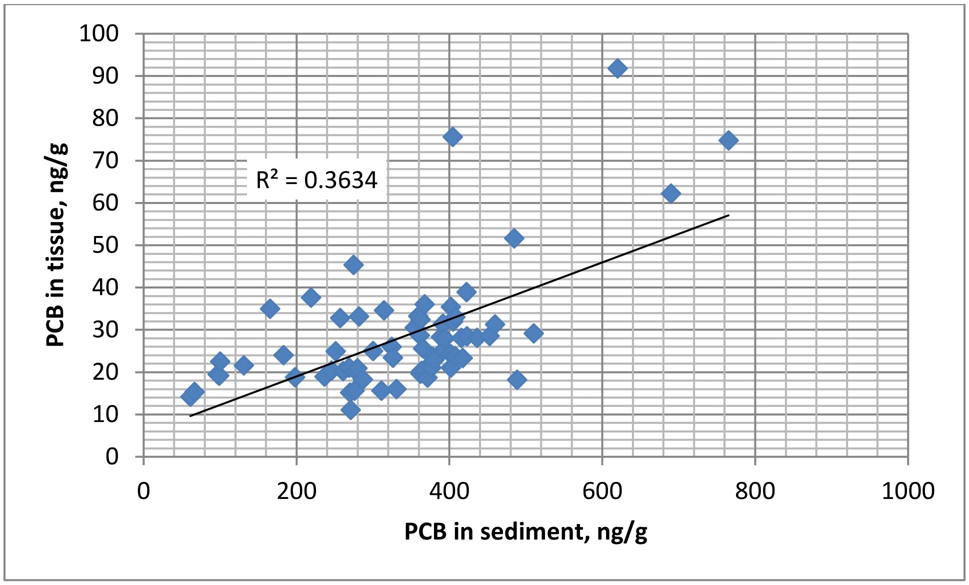


Figure 68. Plot of total PCBs in tissue and sediment.

4.7. Ratios IC/OC and Over/Under for Sediment and Tissue

CARP II was designed to look for differences in PCB and PCDD/F concentrations between surface and deeper layers in sediment cores and between in-channel and off-channel sites. By looking at ratios of 2378-TCDD, total TEQ, and total PCBs we can say that generally, in-channel 2378-TCDD concentrations were lower than off-channel levels and that surface concentrations were lower than those from deeper layers.

Table 20. PCDD/F TEQ and 2378-TCDD concentration ratios in sediment and tissue.

IC/OC	Sed. TEQ	Sed. 2378-TCDD	Tissue TEQ	Tissue 2378-TCDD	**Over/Under**	Sed. TEQ	Sed. 2378-TCDD	Tissue TEQ	Tissue 2378-TCDD
BMC	68%	45%	66%	49%	**BMC**	59%	67%	93%	94%
BMC-Over	97%	90%	80%	75%	BMC-IC	75%	76%	124%	117%
BMC-Under	55%	32%	55%	37%	BMC-OC	61%	58%	95%	72%

EC	73%	65%	74%	71%	**EC**	95%	89%	91%	93%
EC-Over	61%	50%	85%	83%	EC-IC	81%	74%	106%	103%
EC-Under	81%	76%	63%	59%	EC-OC	103%	105%	85%	83%
PJ	97%	66%	52%	48%	**PJ**	88%	83%	72%	84%
PJ-Over	100%	63%	68%	56%	PJ-IC	89%	79%	98%	89%
PJ-Under	97%	70%	40%	40%	PJ-OC	104%	87%	78%	79%
PN	90%	75%	54%	50%	**PN**	88%	90%	77%	84%
PN-Over	99%	84%	82%	81%	PN-IC	93%	93%	99%	98%
PN-Under	88%	73%	41%	36%	PN-OC	83%	80%	49%	43%
RB	89%	94%	69%	50%	**RB**	71%	83%	75%	92%
RB-Over	104%	103%	94%	77%	RB-IC	84%	87%	99%	113%
RB-Under	78%	86%	59%	39%	RB-OC	72%	79%	87%	105%
SB	130%	113%	102%	97%	**SB**	81%	79%	105%	101%
SB-Over	138%	121%	104%	96%	SB-IC	83%	75%	103%	93%
SB-Under	128%	113%	99%	99%	SB-OC	79%	82%	109%	109%

Figure 69 illustrates these data with the example of IC/OC ratios for 2378-TCDD in sediment (the second data column in the above table). The second data row (90%) is the ratio from Sediment Group BMC of the mean 2378-TCDD concentrations in the upper layer of the IC cores divided by the mean concentration of 2378-TCDD in the upper layer of the OC cores.

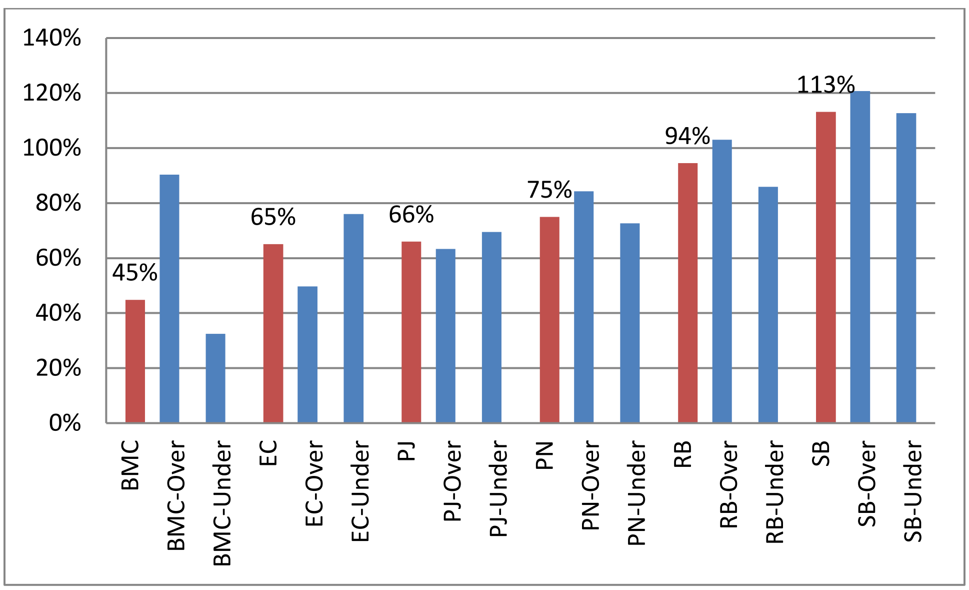


Figure 69. 2378-TCDD concentrations from sediment samples in navigational channels divided by concentrations in matched off channel areas. Bars less than 100% occur when concentrations are lower in IC samples.

Table 21. PCB concentration ratios, In-Channel/Off-Channel.

IC/OC	Sed	Tissue	Over/Under	Sed	Tissue
BMC	68%	66%	**BMC**	80%	68%
BMC-Over	97%	80%	BMC-IC	169%	103%
BMC-Under	55%	55%	BMC-OC	76%	73%
EC	73%	74%	**EC**	97%	94%
EC-Over	61%	85%	EC-IC	102%	116%
EC-Under	81%	63%	EC-OC	93%	80%
PJ	97%	52%	**PJ**	94%	97%
PJ-Over	100%	68%	PJ-IC	100%	118%
PJ-Under	97%	40%	PJ-OC	114%	104%
PN	90%	54%	**PN**	104%	124%
PN-Over	99%	82%	PN-IC	103%	130%
PN-Under	88%	41%	PN-OC	87%	115%
RB	89%	69%	**RB**	71%	77%
RB-Over	104%	94%	RB-IC	97%	130%
RB-Under	78%	59%	RB-OC	69%	68%
SB	130%	102%	**SB**	104%	88%
SB-Over	138%	104%	SB-IC	114%	90%
SB-Under	128%	99%	SB-OC	85%	100%

Generally, 2378-TCDD and to a lesser extent, total TEQ, is lower in surficial sediment and in navigational channel sediments than in deeper sediments and sediments from the off-channel cores. If we assume that surficial sediments and navigational channel sediments are younger, we may conclude that the rate of PCDD/F deposition is decreasing in some regions. The effect is stronger for IC/OC comparisons than for Over/Under comparisons. This effect is also seen in IC/OC comparisons for PCBs but less for Over/Under PCB comparisons.

It is reasonable to expect environmental 2378-TCDD concentrations to fall off faster than PCBs because there is less of it in the urban fabric.

Chapter 5. Contribution of PCBs to total TEQ in Sediment and Tissue

The 2005 WHO list of dioxin-like toxic equivalency factors (TEFs) includes 12 PCB congeners. PCB TEFs are usually lower than those for the PCDD/Fs but PCBs are more abundant. While they are not currently considered as part of the regulatory definition of dioxin TEQ, they can contribute a significant proportion of the total TEQ in some harbor environments.

Table 22. WHO TEFs for the Co-Planar "Toxic" PCBs.

PCB congener	TEF WHO 2005
3,3',4,4'-TeCB	0.0001
3,4,4',5-TeCB	0.0003
2,3,3',4,4'-PeCB	0.00003
2,3,4,4',5-PeCB	0.00003
2,3',4,4',5-PeCB	0.00003
2',3,4,4',5-PeCB	0.00003
3,3',4,4',5-PeCB	0.1
2,3,3',4,4',5-HxCB	0.00003
2,3,3',4,4',5'-HxCB	0.00003
2,3',4,4',5,5'-HxCB	0.00003
3,3',4,4',5,5'-HxCB	0.03
2,3,3',4,4',5,5'-HpCB	0.00003

Table 23. PCDD/F and PCB TEQs in sediment and tissue, pg/g.

	Sediment			TISSUE		
Row Labels	PCDD/F	PCB	PCB contribution to total TEQ	OCDD/F	PCB	PCB contribution to total TEQ
BMC	15.0	3.9	21%	0.5	0.3	35%
BMC-IC-Over	11.0	4.0	26%	0.4	0.3	37%
BMC-IC-Under	13.5	3.3	20%	0.4	0.2	39%
BMC-OC-Over	11.3	3.4	23%	0.5	0.3	34%
BMC-OC-Under	24.4	5.1	17%	0.7	0.3	33%
EC	53.9	5.8	10%	1.6	0.3	17%
EC-IC-Over	39.7	5.5	12%	1.4	0.4	23%
EC-IC-Under	50.7	5.6	10%	1.3	0.4	24%
EC-OC-Over	65.3	6.1	9%	1.6	0.3	14%
EC-OC-Under	62.2	6.0	9%	2.0	0.3	12%
PJ	17.3	4.7	21%	0.8	0.5	37%
PJ-IC-Over	16.1	4.3	21%	0.6	0.6	50%
PJ-IC-Under	18.0	4.5	20%	0.6	0.5	46%
PJ-OC-Over	16.1	3.8	19%	0.8	0.5	36%
PJ-OC-Under	18.5	5.4	23%	1.4	0.5	25%
PN	75.4	4.9	6%	2.4	0.3	12%
PN-IC-Over	70.1	5.9	8%	2.0	0.4	17%
PN-IC-Under	75.4	5.6	7%	2.0	0.3	12%
PN-OC-Over	70.6	2.5	3%	2.4	0.3	11%
PN-OC-Under	85.5	3.2	4%	4.9	0.3	6%
RB	32.6	4.9	13%	0.7	0.4	37%

RB-IC-Over	27.3	4.7	15%	0.5	0.4	45%
RB-IC-Under	33.5	4.8	12%	0.6	0.3	38%
RB-OC-Over	26.2	3.9	13%	0.6	0.3	36%
RB-OC-Under	43.2	6.3	13%	0.9	0.4	32%
SB	17.6	5.7	25%	0.6	0.4	39%
SB-IC-Over	18.2	5.1	22%	0.6	0.4	38%
SB-IC-Under	22.0	6.4	22%	0.5	0.3	35%
SB-OC-Over	13.1	4.1	24%	0.6	0.4	42%
SB-OC-Under	17.3	7.0	29%	0.6	0.4	42%

Chapter 6. PCDD/F and PCB Data Quality Review

6.1. Completeness

The completeness of the principal study components is shown below.

Table 24. Sampling completeness for water and sediment cores for PCDD/Fs and PCBs.

study	analyte	expected	achieved	% completeness
water	PCDD/Fs	34	32	94%
water	PCBs	68	66	97%
sediment core	PCDD/Fs	72	68	94%
Sediment core	PCBs	72	68	94%

In five samples some of the mono- or dichlorobiphenyls were lost due to lab accidents, flagged “NQ”. These are noted in the discussion below. They do not materially impact total PCB concentrations from the samples.

6.2. Non-detections

The CARP Management team developed a procedure for handling non-detections:

[conc_found] = concentration found

[DL] = sample specific detection limit

[ratio_conc] = the frequency of detection of an analyte divided by the number of analyses for that analyte by medium (sediment, TOPS cartridge, tissue, water) and by site type (sediment, ambient, HOT, Poughkeepsie, storm water)

If [conc_found]>[DL], [conc_found], then use [conc_found] otherwise,

If [ratio_conc]>0.7, then use [DL]/2 other wise, 0.

6.3. Flagged data

Contaminant analysis for PCDD/F and PCBs was performed by the contract lab AXYS. Axys reported seven distinct data quality flags, other than blanks (null) indicating no quality issues. The database contains the following data quality flags:

B – analyte found in lab blank.
C – coelution, applies only to PCB samples.
D – sample required dilution.
J – reported value is less than the method detection level but above the sample detection level.
U – analyte less than sample detection level and reported as null.
K – all method criteria were not satisfied, reported value is an estimated maximum.
G – lock mass disturbances[2]

The percent frequency of data quality flags by medium and sample type are shown in Table 24. Samples may have multiple flags so these percents add up to more than 100%.

Table 24. Frequency of flagged analyses.

		null, C or D	*U*	*B*	*J*	*K* or *G*
Cartridge Water	DIOX/F	0%	43%	27%	49%	16%
Sediment	DIOX/F	41%	1%	45%	18%	2%
Susp_Sed	DIOX/F	25%	10%	39%	39%	14%
Tissue	DIOX/F	12%	12%	18%	68%	20%
Sediment	PCB	45%	9%	39%	5%	5%
Susp_Sed	PCB	22%	17%	43%	26%	13%
Tissue	PCB	48%	10%	37%	2%	6%
Water	PCB	10%	25%	37%	40%	17%

The significance of the lab blanks (B) can be assessed by looking at how much the reported concentration exceeds the blank. In the following table we see that 94% of the tissue samples for PCDD/Fs exceeded their associated blanks by 10 times and 98% were twice the blank. Cartridge water samples were more problematic.

[2] The "lock mass" is a compound that is monitored to demonstrate that the instrument sees the ions that are being monitored accurately. Things that interfere with the instrument's ability to see this ion show a deflection in the lock mass channel. When the instrument can see the lock mass target it shows a straight-ish line in the chromatogram of the lockmass channel. But when the instrument's ability to see the compound is interfered with (usually caused by matrix interferences) you see a defection in that straight-ish line. If the deflection is at the same retention time as a target but <20% it's considered tolerable but when it is deflected greater than 20%, but not horrible we report the result and flag it with a "G". Lockmass interference can be so severe that the result is not reportable- then we have to flag as NQ (not quantifiable).

In the subsequent data tables all PCDD/F and PCB data are blank corrected where the lab blank for each work group is subtracted from the reported value. Where the blank was reported as non-detect, the subtracted value was 0.

Table 25. Frequency of data values exceeding the associated blanks by 10 and 2 times.

		%>10X	%>2X
Cartridge Water	DIOX/F	22%	59%
Sediment	DIOX/F	94%	98%
Susp_Sed	DIOX/F	67%	86%
Tissue	DIOX/F	50%	74%
Sediment	PCB	100%	100%
Susp_Sed	PCB	77%	89%
Tissue	PCB	93%	99%
Water	PCB	66%	90%

Four PCDD/F congeners accounted for 66% of total TEQ across all media. The data quality flags for these compounds are shown below by medium.

Table 26. Frequency of data flags on the PCB and PCDD/F congeners most critical to total TEQ.

medium	Order	analyte	null or D	*U*	*B*	*J*	*K* or *G*	# samples
Cart. Water	1	2,3,7,8-TCDD		4		4	4	8
Cart. Water	2	1,2,3,7,8-PECDD		5		3		8
Cart. Water	8	2,3,7,8-TCDF		4		4	3	8
Cart Water	10	2,3,4,7,8-PECDF		5		3	2	8
Sediment	1	2,3,7,8-TCDD	39		35		1	74
Sediment	2	1,2,3,7,8-PECDD	29	1		43	3	74
Sediment	8	2,3,7,8-TCDF	73		1			74
Sediment	10	2,3,4,7,8-PECDF	22		51	6		74
Susp_Sed	1	2,3,7,8-TCDD	9	6	20	10	16	42
Susp_Sed	2	1,2,3,7,8-PECDD	9	9	2	23	14	42
Susp_Sed	8	2,3,7,8-TCDF	36	5			2	42
Susp_Sed	10	2,3,4,7,8-PECDF	9	4	2	27	6	42
Tissue	1	2,3,7,8-TCDD	32	1		31	14	70
Tissue	2	1,2,3,7,8-PECDD		3	16	66	30	70
Tissue	8	2,3,7,8-TCDF	61				9	70
Tissue	10	2,3,4,7,8-PECDF	1			69	8	70

The impact of K-flagging on total TEQ was evaluated by calculating the ratio of samples with K and G flagged instances over uncensored samples.

Table 27. Impact of k-flagging on total TEQ, by medium.

	Susp_Sed	Sediment	Tissue
TOPS Samples			
Ambient	92%		
HOT	83%		
Poughkeepsie	93%		
Storm Water	91%		
Sediment			
BMC		95%	82%
EC		100%	86%
PJ		99%	63%
PN		100%	97%
RR		100%	72%
SB		98%	80%

Generally, the significance of K-flagged instances in calculating TEQ was greatest in tissue samples. Some areas were more problematic than others. The magnitude of error from K and G flagging was assessed for the PCBs in a similar manner. For example, the average PCB concentration from ambient water samples would be reduced by 15% if all the observations with K or G flags were set to zero due to their uncertainty.

Table 28. Impact of k-flagging on PCB concentrations by medium.6

	Susp_Sed	Water	Sediment	Tissue
TOPS Samples				
Ambient	91%	85%		
HOT	97%	98%		
Poughkeepsie	95%	91%		
Storm Water	96%	92%		
Sediment				
BMC			94%	88%
EC			95%	92%
PJ			91%	87%
PN			87%	91%
RB			92%	87%
SB			91%	87%

6.4. A measure of quantitative reliability

Quantitation of chemical targets are more certain when they are well above the detection limits. As a rule of thumb, good quantitations are ten or more times greater than the detection level. To simplify an examination of the adequacy of the project's sensitivity, we look at the average ratios of observed/DL for the four homologs. Detection of these key congeners was uniformly strong in sediment samples and of variable quality among the TOPS and Tissue samples.

Table 29. Average ratios, reported analyte concentrations/sample specific detection limits of four PCB homologs.

	Susp_Sed				Sediment				TISSUE			
Homologs	1	2	8	10	1	2	8	10	1	2	8	10
TOPS Samples												
Ambient	18.5	2.1	35.4	6.3								
Head_of_Tide	3.4	7.9	17.7	5.4								
Poughkeepsie	4.1	6.4	53.0	17.9								
Storm_Water	8.7	26.3	32.0	6.6								
Sediment												
BMC					28.4	11.5	147.7	25.9	2.6	2.3	16.0	3.0
EC					175.2	14.3	255.8	37.6	16.3	2.3	19.5	4.9
PJ					26.7	10.2	125.6	26.5	4.9	3.1	22.0	5.6
PNC					222.9	16.4	257.7	30.9	23.5	2.2	28.6	4.1
RR					55.0	22.6	251.3	51.5	4.6	2.0	21.5	3.6
SB					22.1	18.9	194.1	47.3	1.9	2.1	20.8	3.5

For the PCBs the average ratios of observed/detection limits less than 10X show relatively poor quantitations for mono, nona- and octa-CBs in 15% of water samples. Six percent of suspended sediment samples, mostly from HOT sites, had ratios less than 10X. One percent of tissue sample mono and diCBs had conc/DL ratios less than 10X. Detection limits were never a problem with sediments.

No field blank samples were taken for sediments or tissues. Four were made for the TOPS samples. Field blanks are compared against samples by pg/recovered, not calculated concentrations. The highest field blank (total TEQ of 0.8116) was 7 times lower than the lowest sample (5.466 pg/sample, from the Lower Bay). Contamination of the TOPS or the cartridge filters do not appear to have been significant. The field blanks were not significantly greater than the lab blanks.

Chapter 7. Data Management and Data Sharing

The data collected under CARP II are freely and publicly available through the NOAA Data portal. The CARP II researcher teams strove to ensure that the data developed under the project was complete, accurate and useful. However, given the complexity of the data collection and analysis processes, users should make the own determination of the quality, accuracy or completeness of the data and the fitness of use for a particular purpose.

NOAA DIVER Data Portal

The Data collected under CARP II are available through the NOAA data portal.
https://www.diver.orr.noaa.gov/

1. Choose Hudson River, Keyword Search: CARP II (Figure 1)