2024

Contamination Assessment and Reduction Project – Phase 2 (CARP II)

Appendix A-1. Historical Data Compilation and Analysis

Project Title:	NY/NJ Harbor Contamination Assessment and Reduction Project-CARPII
RFP NUMBER: 2016-10	NJDOT RESEARCH PROJECT MANAGER: Scott Douglas
Deliverable: Historical Data Review of Contaminants of Concern in New York Harbor	Date Completed: 6-8-2018

Appendix A-1 Historical Data Compilation and Analysis

Contents

1. Background

The majority of the data collection efforts for CARP I were completed by 2002. Additional monitoring has subsequently occurred throughout the Harbor. A primary objective of this task was gathering available information on post-2002 sediment contamination concentrations including dredged material testing data is to assess the adequacy and accuracy of previous CARP model projections for future contaminant levels in Harbor sediments. The data were used to evaluate the need for the CARP II models to distinguish navigational from non-navigational reaches and to gain insights in designing CARP II sampling efforts. The parameters of interest are: total PCBs determined by congener-specific methods; 2,3,7,8-tetrachlorodibenzo-p-dioxin (2378-TCDD); percent clay and silt; and black carbon and total organic carbon.

2. Databases Used in the CARP II Historical Data Review:

Historical data on contaminants in New York Harbor were harvested from three sources and compiled into a Microsoft Access database management system. Three Access databases were assembled and reside at the Hudson River Foundation: 1) NOAA_QM_Historical_Sediments; 2) Our Passaic; and 3) USACE_Dredging_Records. Each of these three are compilations of data from separate projects that were not intended to be combined. Sample identifications, analyte names, and location coordinates were inconsistent. Metadata such as sample methods are often absent. Persons interested in using the databases should examine the tables, queries, and relationships to see how to manipulate them.

2.1. NOAA_QM_Historical_Sediments

This compiled database contains 1,279,849 records from 12,099 samples taken between 1972 and September, 2015. **tblNOAA_DATA_All** is a concatenation of the 228 individual project databases rearranged for consistency of the fields. Samples from navigational channels are indicated in **tblNav_samples**.

Generally the fields should be intelligible with the possible exception of [factor_DIVIDE_BY] in **tblChems_classified. This field** contains two kinds of factors. These are the 2010 Human Health Risk toxic equivalency factors for polychlorinated dioxins/furans ([Class]=DIOX/F) taken from *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8- Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds* (https://rais.ornl.gov/documents/dioxin_tef.pdf). A sample's total toxic equivalency (TEQ) is the sum of the products of the TEF and the concentrations. Multiply [factor_DIVIDE_BY] and [conc]. The other kind is factors that divide concentrations of PCB coelutions by the number of congeners in the group. This is necessary when congeners in a coelution group span different homologs. For example, [chemcode]="PCB020033_" includes PCB congeners 20, 33, and 53. Congeners 20 and 33 are trichlorobiphenyls while 53 is a tetrachlorobiphenyl. Divide [conc] by [factor_DIVIDE_BY] under the assumption that total concentration of a coelution is equally distributed among the constituent congeners. The table **tblUSACOE_Cong** lists the PCB congeners used in the Army Corps sediment projects. This allows comparisons with the large data set in NOAA.

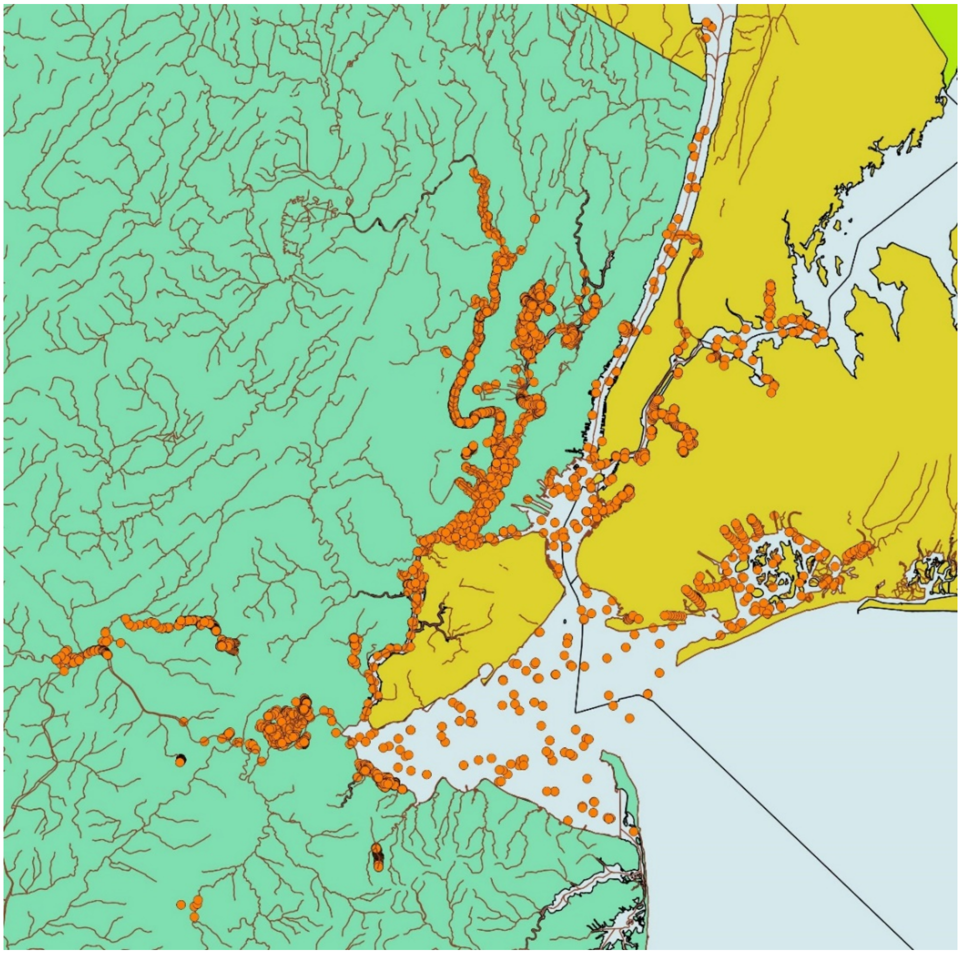
set. 

Figure 1. Sampling locations in the NOAA database.

2.2 Our_Passaic_Water

The Our_Passaic database contains 578,596 records and 3,011 samples taken between 9/14/2005 and 11/1/2013. However, only 128 samples are not already included in the larger NOAA database. The 128 sites are shown in Figure 2. The qry examples include a table restricting the outputs to the stations unique to Our Passaic.

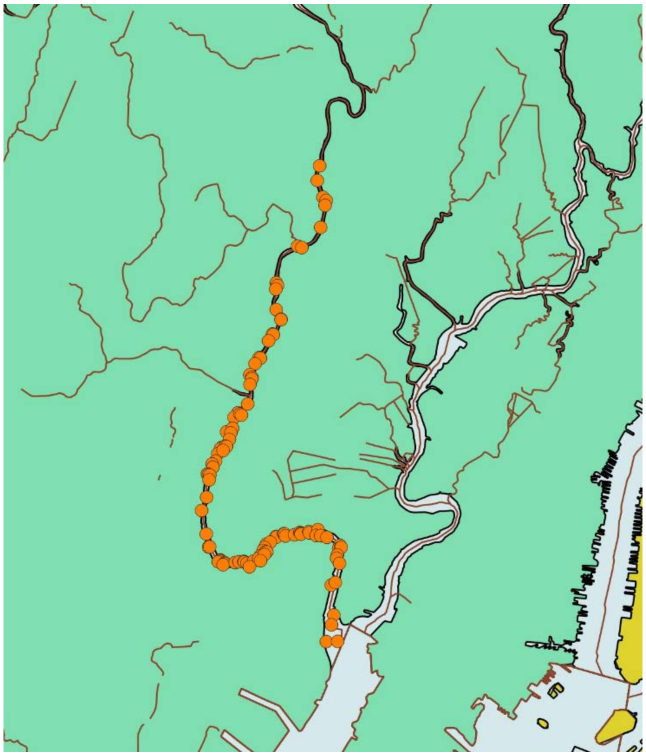


Figure 2. Unique Our Passaic sampling sites.

Table 1 Sources of Historical PCB and dioxin sediment data newer than 2004, NOAA and Our Passaic databases.

2005 USEPA-MPI High Res Sediment Core	Newtown Creek Phase 2 Subsurface Sed Chem 2014
2006 USEPA-MPI Low Resolution Core	Newtown Creek Phase 2 Surface Sed Chem 2014
2010 CPG Benthic Sediment Sampling	Newtown Creek Sediment Cores 2014
2012 CPG Low Res Coring Supplemental	Newtown Creek Surface Sediment Spring 2012 (DSR-1)
2013 EPA-DESA Post Hurricane Sandy Grab	Passaic CPG Background Sed & Tox 2012
Berry's Creek RI Phase 1 Sed/Tiss 2009	Passaic CPG Benthic Sediment 2009
Bound Brook Raritan 2011 Remedial Investigation	Passaic CPG Benthic Sediment 2009 MPI Oversight
Gowanus Canal EPA Ph3 Remed Invest 2005-06 2010	Passaic CPG Benthic Sediment 2010
Hackensack HRWC Apr-May 2008	Passaic CPG Benthic Sediment 2010 EPA Oversight
Hackensack River RI 2006	Passaic CPG Low Res Core 2008
Hackensack River Sampling January 2008	Passaic CPG Low Res Core Supplemental 2 2013
LCP Chemicals Phase II RI 2006-07	Passaic CPG Low Res Core Supplemental 2012
LCP Chemicals RI 2001 2006 2008	Passaic CPG River Mile 10.9 Sediment 2011
NCA Program Hudson River 2005	Passaic CPG River Mile 10.9 Sediment 2012
NCA Program Hudson River 2006	Passaic EPA-MPI Dundee High Res Core 2007
NCA Program Long Island Sound 2005	Passaic EPA-MPI EMBM 2007-08
NCA Program New York/New Jersey Harbor 2005	Passaic EPA-MPI High Res Core 2005

NCA Program New York/New Jersey Harbor 2006	Passaic Newark Bay RI Phase 1 2005
Newark Bay Sediment Chemistry 2014	Passaic Newark Bay RI Phase 1 2005 MPI Oversight
Newark Bay Toxicity and Bioaccumulation Sept 2015	Passaic Newark Bay RI Phase 2 2007
Newtown Creek National Grid 2010	UOP OU2 Focused Sediment Study 2006
Newtown Creek NYC 2014-15 Chem & Tox	UOP UO2 Sediment Sampling 2007
Newtown Creek Phase 2 Sed Chem & Tox 2014	Woodbrook Road 2009 RI/FS Sediment Data

Table 2 shows all 14,271 samples from NOAA and OurPassaic in the NY/NJ Harbor area. The table includes coordinates, year, Region, and navigational channel status.

Table 2. Summary of numbers of samples by harbor region and navigational status from NOAA and Our Passaic.

	<2000	2000-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	total
Arthur_Kill	58	242	53	159	28	2	9	11	2	87	12	4	2	669
NAV_CHANNEL	0	0								87				87
OFF_CHANNEL	58	242	53	159	28	2	9	11	2		12	4	2	582
East_River	23	17	1		1	42	1			38	19	14	2	158
NAV_CHANNEL	0	0									18			18
OFF_CHANNEL	23	17	1		1	42	1			38	1	14	2	140
Gowanus_Cannal	1	2	8	6				56			1			74
OFF_CHANNEL	1	2	8	6				56			1			74
Hackensack_R.	260	133	23	101	21	33	295	275	117	289	126	176	62	1,911
NAV_CHANNEL	0	0		8					6	60				74
OFF_CHANNEL	260	133	23	93	21	33	295	275	111	229	126	176	62	1,837
Hudson_R.	140	18	1	2						1	15			177
NAV_CHANNEL	0	0								1				1
OFF_CHANNEL	140	18	1	2							15			176
Jamaica_Bay	58	10	2							58	23	70	4	225
NAV_CHANNEL	0	0									6			6
OFF_CHANNEL	58	10	2							58	17	70	4	219
KVK	6	1			21				14	33	8			83
NAV_CHANNEL	0	0								1				1
OFF_CHANNEL	6	1			21				14	32	8			82
Lower_Bay	67	24	7	6						9	22			135
NAV_CHANNEL	0	0		3						1				4
OFF_CHANNEL	67	24	7	3						8	22			131
Newark_Bay	74	10	146	8	110	26	1	1	45	309	87	13	48	878
NAV_CHANNEL	0	0		8					17	179	13			217
OFF_CHANNEL	74	10	146		110	26	1	1	28	130	74	13	48	661
Newtown_Ck.	0	43	209	11		21		24		130	50	233	27	748
NAV_CHANNEL	0	0	187	11		21				6	30			255
OFF_CHANNEL	0	43	22					24		124	20	233	27	493
Passaic_R.	458	75	361	104	112	677	132	61	216	1,724	343	132	18	4,413
NAV_CHANNEL	200	44	124	38	61	205	39	11	115	855	141	132	18	1,983

OFF_CHANNEL	258	31	237	66	51	472	93	50	101	869	202			2,430
Raritan_Bay	90	12	3	1	102	191	968	703	3	6	9	55		2,143
NAV_CHANNEL	0	0								6	3			9
OFF_CHANNEL	90	12	3	1	102	191	968	703	3		6	55		2,134
Raritan_R.	1,296	167	200	46	455	188	177		42	3		2		2,576
NAV_CHANNEL	0	0		3										3
OFF_CHANNEL	1,296	167	200	43	455	188	177		42	3		2		2,573
Upper_Bay	45	10	1	1		2		9			13			81
NAV_CHANNEL	0	0									1			1
OFF_CHANNEL	45	10	1	1		2		9			12			80
Grand Total	2,576	764	1,015	445	850	1,182	1,583	1,140	439	2,687	728	699	163	14,271

2.3. USACOE Database

The Hudson River Foundation digitized 37 ACOE project reports from PDFs. The ACOE Database contains tables derived from the ACOE dredging PDFs. All samples were from navigational channels. Each of the projects consists of numerous individual cores. Sediment characteristics, such as grain size and TOC, were measured in each core. Chemical analyses in bulk sediment or bioaccumulation assays were determined on composites of the cores. Locations of the composites can be mapped as the averages of the latitudes and longitudes of the individual cores. In some cases, in relatively narrow and winding channels, Arthur Kill 2012, Arthur Kill Upland 2012, and Flushing Bay 2009, the centroid occurs on land. Only 22 PCB congeners were measured on the theory that the sum of these 22 will be approximately equal to the total of all 209 PCB congeners.

Table 3. ACOE Projects.

Project	ACOE Region
Arthur Kill_N 2012	Arthur Kill, Northern
Arthur_Kill_Upland_2014	Arthur Kill, Northern
Arthur Kill_S 2012	Arthur Kill, Southern
Anchorage Channel 2015	Bight
Buttermilk Channel 2009	Bight
Buttermilk Channel 2014	Bight
East River SBI 2009	East River
East River South Brother Island 2015	East River
Eastchester - 2009	East River, East
East Rockaway Inlet 2016	East Rockaway
Flushing Bay, 2009	Flushing Bay
Flushing Bay-Creek Upland 2014	Flushing Bay
American Sugar 2014	Hudson River
Main Channel 2010	Lower Bay
Newark Bay 2012	Newark Bay
Seguine Point 2007	Raritan Bay
Seguine Point 2011	Raritan Bay
Seguine Point 2012	Raritan Bay
Perth Amboy 2014	Raritan R./Lower Arthur Kill
Raritan River 2007	Raritan R./Lower Arthur Kill

Raritan River HARS 2013	Raritan R./Lower Arthur Kill
Raritan River to Arthur Kill 2013	Raritan R./Lower Arthur Kill
Wards Point Bend 2007	Raritan R./Lower Arthur Kill
Wards Point Bend 2011	Raritan R./Lower Arthur Kill
Bay Ridge/Red Hook Channels 2013	Upper Bay
Red Hook Flats 2010	Upper Bay
SRUC Anchorage Channel 2012 (August Sampling)	Upper Bay
SRUC Kill van Kull Eastern End 2012	Upper Bay
Upper Hudson River, Staats Point (RCH 9) and Albany Turning Basin 2015	Upper Hudson River
Manhattan Cruise Terminal 2015	West Side of Manhattan

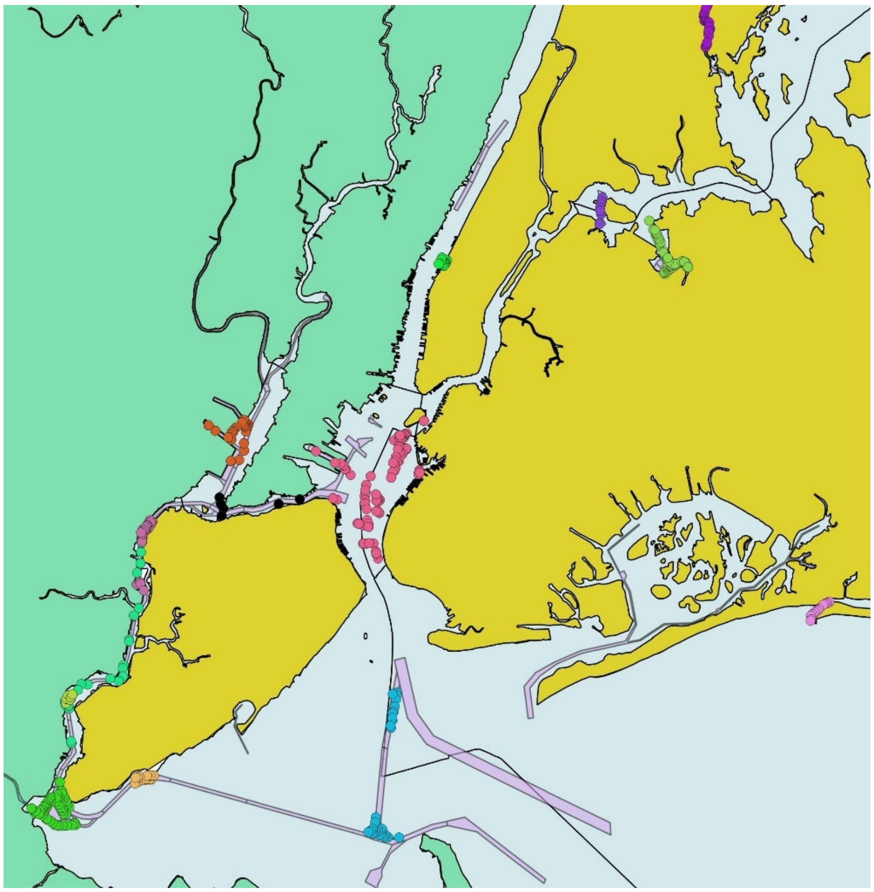


Figure 3. Army Corps of Engineers sampling sites.

3.0 Historical Data Summaries

For the analysis presented in this report, samples with non-detection were censored instead of assigning a value such as 0, or half the detection limit (often unavailable). Surficial sediment data were taken from three sources described previously. The review was restricted to observations made after 2005.

3.1 Total Organic Carbon, Black Carbon and Sediment Characteristic Measurements

Total organic carbon was reported from 2,338 sites harbor-wide since the beginning of 2006 in the NOAA and Our Passaic, and USACE databases. The NOAA data contain 183 instances where multiple samples or analyses were conducted on material with the same geographic coordinates. These replicates have a mean relative percent difference of 20%, the upper limit for data quality acceptability.

The average percent TOC from the regions and channels are indicated in Table 1. Statistical significance was assessed from regions where there was a minimum of five samples in each of the two navigational statuses with a two-tailed t-test at p=0.05. In cases where there were statistically different concentrations, yellow highlights indicate which channel type had the higher concentration. The analysis shows mixed results; TOC was higher in the navigational channels in the Passaic River and Raritan R./Lower Arthur Kill but the off-channel areas had higher TOCs in Newtown Creek, the Lower Bay, and the Upper Harbor.

Table 4. Average percent TOC concentrations in Harbor regions.

Regions	**NAV_CHANNEL**			**OFF_CHANNEL**			**Totals**			**t-test**
	Avg	**count**	**StDev**	**Avg**	**count**	**StDev**	**Avg**	**count**	**StDev**	**2-tail**
Arthur_Kill	4.87	4	0.99	6.10	128	5.43	6.07	132	5.36	
East_River	4.07	12	1.28	3.77	85	2.30	3.81	97	2.21	NS p=0 .6627
Gowanus_Canal				6.12	40	3.63	6.12	40	3.63	
Hudson_R._south	0.8	3	0.14	2.31	1	0	1.18	4	0.67	
Jamaica_Bay				3.70	89	2.29	3.70	89	2.29	
KVK				3.20	3	0.64	3.20	3	0.64	
Lower_Bay	0.60	18	0.87	6.04	11	5.03	2.66	29	4.13	Sig p= 0.0002
Newark_Bay	3.14	19	0.99	3.13	76	2.16	3.13	95	1.98	NS p=0.9770
Newtown_Ck	6.84	157	3.34	8.12	337	4.36	7.71	494	4.10	Sig p=0.0012
North_River	3.12	1	0	2.41	1	0	2.77	2	0.35	
Passaic_above_Dundee				3.26	55	2.30	3.26	55	2.30	
Passaic_River	5.49	193	4.00	4.40	344	2.28	4.79	537	3.06	Sig p=0.0001
Raritan R./Lower Arthur Kill	3.48	6	0.19	0.90	11	1.15	1.81	17	1.54	Sig p=0.0001
Raritan_Bay				3.15	55	3.68	3.15	55	3.68	
Upper_Bay	0.76	17	0.74	2.30	11	1.16	1.39	28	1.20	Sig p=.0001

Strong difference in percent silt and clay are seen between navigational and off channel areas in the Arthur Kill, Newark Bay and Raritan Bay. When significant, the percent silt and clay was about twice that seen in off channels from the same region.

Table 5. Silt and clay, percent.

Region	**NAV_CHANNEL**			**OFF_CHANNEL**			**Totals**			**t-test**
	Avg	count	StDev	Avg	count	StDev	Avg	count	StDev	2-tail
Arthur_Kill	62.2	83	22.9	30.3	17	21.8	56.8	100	25.7	Sig p=0.00001
East River	76.5	35	24.7				76.5	35	24.7	
Flushing Bay	79.0	92	9.6				79.0	92	9.6	

Gowanus_Canal				58.9	36	16.0	58.9	36	16.0	
KVK				11.6	3	2.6	11.6	3	2.6	
Lower Bay	45.5	37	31.4				45.5	37	31.4	
Newark Bay	58.4	44	33.9	29.3	81	19.3	39.6	125	29.0	Sig p=0.0001
Passaic_above_Dundee				30.9	14	19.8	30.9	14	19.8	
Passaic_River	35.2	145	28.5	40.7	243	27.0	38.7	388	27.7	NS p=0.1084
Raritan Bay	50.3	44	16.7	14.3	5	7.5	46.6	49	19.3	Sig p=0.00003
Raritan R./Lower Arthur Kill	70.3	111	26.2				70.3	111	26.2	
Upper Bay	63.1	77	29.8	67.7	8	7.0	63.6	85	28.5	NS p=0.3354
Upper Hudson	60.3	12	24.6				60.3	12	24.6	
West Side of Manhattan	76.8	21	29.0				76.8	21	29.0	

Black carbon was analyzed in 507 samples but detected in only 421. BC observations below the detection limit were censored. The overall average concentration was 4,539 ppm.

Table 6. Black carbon in ppm.

Region	**NAV_CHANNEL**			**OFF_CHANNEL**		
	Avg	count	StDev	Avg	count	StDev
East_River				4,111	42	3,605
Jamaica_Bay				1,973	65	1,778
Lower_Bay				7,935	8	13,403
Newtown_Ck.				5,453	211	5,556
Passaic_R.	4,165	95	3,874			

The ratios of BC/TOC are shown below in Table 4. Data are lacking to compare black carbon in and out of navigational channels.

Table 7. Ratio of black carbon/total organic carbon. Percent.

Regions	**NAV_CHANNEL**			**OFF_CHANNEL**		
	Avg	count	StDev	Avg	count	StDev
East_River				18.71	42	26.06
Jamaica_Bay				5.94	65	5.11
Lower_Bay				10.11	8	13.74
Newtown_Ck.				7.50	211	7.53
Passaic_R.	8.72	95	16.95			

3.2. Bioaccumulation Measurements

Twenty USACE projects included bioaccumulation testing on *Macoma nasuta* and *Nereis virens*. Comparisons between channel types were not possible. The USACE reports lack data on lipid so lipid content normalization could not be performed.

Table 8. Geometric mean total PCB and total PAH concentrations in two worms by region. PPB.

	PAH			PCB		
Region	M. nasuta	N. virens		M. nasuta	N. virens	
	GeoMean		count	GeoMean		count
Arthur_Kill	199.8	92.4	2	34.8	82.3	2
East_River	475.5	155.9	2	6.7	9.0	6
Hudson_R._south	121.6	15.1	1	11.5	15.0	1
Lower_Bay	126.7	27.0	4	5.8	10.6	4
Newark_Bay	256.0	99.9	2	16.7	31.7	2
North_River	142.0	1.6	1	11.5	19.9	1
Raritan R./Lower AK	81.4	31.7	6	9.7	20.9	6
Raritan_Bay	81.8	41.0	2	14.9	43.4	2
Upper_Bay	217.1	45.7	5	15.6	28.1	5

Table 9. USACE Bioaccumulation. Dioxins and Furans, ng/kg.

Regions	***Macoma nasuta***			***Nereis virens***		
	ΣTEQ	2378-TCDD	count TEQ/2378-TCDD	ΣTEQ	2378-TCDD	count TEQ/2378-TCDD
Arthur_Kill	4.82	3.76	2/1	22.51	13.94	2/1
East_River	5.12		6/0	11.36	2.85	6/1
Hudson_R._south	2.34	0.40	1/1	6.22	1.40	1/1
Lower_Bay	52.26	50.40	4/1	107.10	85.60	4/1
Newark_Bay	61.94	55.86	2/1	108.80	92.82	2/1
North_River	1.26		1/0	2.98		1/0
Raritan R./Lower AK	4.15	1.13	6/1	11.42	4.48	6/1
Raritan_Bay	7.44	1.40	2/1	19.89	7.26	2/1
Upper_Bay	40.46	1.08	4/1	154.33	58.30	4/1

Table 10. Average USACE Bioaccumulation, metals, mg/kg.

metals	**AK**	**ER**	**HR**	**LB**	**NB**	**NR**	**RRLAK**	**RB**	**UB**	
	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg	count
Count	2	2	1	4	2	1	6	2		
Macoma nasuta										
Ag	0.03	0.03	0.05	0.03	0.03	0.02	0.04	0.04	0.04	5
As	2.42	2.53	3.93	2.55	2.81	1.68	2.67	2.32	2.71	7
Cd	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03	0.04	6
Cr	0.42	0.30	0.39	0.44	0.46	0.79	0.34	0.33	0.38	7
Cu	1.88	1.48	4.14	1.48	1.66	1.26	2.00	2.63	1.58	7
Hg	0.03	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.02	7

Ni	0.51	0.36	0.55	0.41	0.64	0.54	0.42	0.34	0.46	7
Pb	0.43	0.41	0.67	0.50	0.56	0.29	0.53	0.52	0.54	7
Zn	13.78	12.08	21.36	12.98	14.64	9.82	12.01	10.65	13.87	7
Nereis virens										
Ag	0.02	0.02	0.02	0.04	0.02	0.04	0.02	0.03	0.03	5
As	2.40	2.51	2.33	2.33	2.48	2.67	1.81	1.54	2.22	7
Cd	0.08	0.05	0.04	0.04	0.07	0.05	0.03	0.03	0.04	6
Cr	0.10	0.09	0.12	0.13	0.11	0.40	0.09	0.08	0.12	6
Cu	1.45	1.18	6.01	1.46	1.41	1.47	1.64	1.94	1.39	7
Hg	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.01	0.03	7
Ni	0.42	0.15	0.13	0.24	0.42	0.48	0.20	0.22	0.26	6
Pb	0.27	0.15	0.13	0.15	0.30	0.11	0.16	0.15	0.13	6
Zn	21.50	19.83	24.92	30.16	19.25	30.47	20.13	19.98	23.02	7

Table 11. USACE Bioaccumulation. Ratio of metals concentrations in worms and sediments.

metal	**Macoma nasuta**					
	ER	LB	NR	RRLAK	RB	UB	average
Ag	0.8%	22.4%	1.2%	2.6%	3.6%	3.5%	7.0%
As	19.2%	109.1%	12.3%	23.8%	41.5%	39.3%	46.6%
Cd	2.6%	34.4%	5.9%	5.9%	8.0%	9.0%	12.8%
Cr	0.2%	4.7%	1.4%	0.7%	0.6%	0.8%	1.6%
Cu	0.8%	30.2%	1.7%	2.9%	3.4%	4.4%	9.0%
Hg	0.8%	16.0%	1.1%	1.8%	1.8%	4.0%	5.3%
Ni	0.9%	8.2%	1.7%	2.2%	2.2%	2.3%	3.4%
Pb	0.4%	6.3%	0.4%	0.8%	1.0%	1.2%	2.0%
Zn	4.4%	58.2%	5.3%	8.4%	9.7%	15.1%	20.6%
	Nereis virens						
Ag	0.8%	29.4%	2.5%	1.3%		2.8%	8.3%
As	14.8%	119.5%	19.6%	10.6%		37.5%	45.0%
Cd	3.4%	45.9%	9.8%	4.2%		11.9%	16.6%
Cr	0.1%	1.2%	0.7%	0.1%		0.3%	0.5%
Cu	1.0%	29.0%	2.0%	2.4%		4.0%	8.9%
Hg	1.9%	37.0%	4.1%	2.6%		7.7%	12.2%
Ni	0.5%	4.8%	1.5%	0.9%		1.1%	1.9%
Pb	0.1%	2.0%	0.1%	0.2%		0.3%	0.6%
Zn	8.6%	142.9%	16.5%	10.6%		27.9%	46.8%

3.3. PCBS in Sediment

Congener data collected after 2005 by regions and navigational channel status. Multiple concentration values from the same geographic coordinates and dates were averaged. Statistical significance between concentrations in and out of navigational channels was evaluated by t-tests on log data. Significant differences occurred only in Newark Bay. On 48 occasions multiple samples were taken at the same geographic coordinates. From the relative percent difference (range/average) can be calculated. The average RPD was 29% and median was 18%. Conventional data quality upper limit for RDP is 20%.

Table 12. PCB by 1668, ng/g.

Region	NAV_CHANNEL		OFF_CHANNEL		totals		t-test
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tail
Arthur_Kill	933	2	537	9	594	11	
East_River	535	6	420	10	460	16	NS, P=0.2721
Gowanus_Canal			3,269	24	3,269	24	
Jamaica_Bay			107	38	107	38	
KVK			789	3	789	3	
Newark_Bay	513	17	105	80	138	97	Sig, p=0.0005
Newtown_Ck	3,842	91	3,693	199	3,739	290	NS, p=0.8099
Passaic_above_Dundee			179	54	179	54	
Passaic_River	1,118	195	1,166	342	1,149	537	NS, p=0.7734
Upper_Bay			847	2	847	2	

Table 13. PCB congeners normalized to TOC, ppm PCB /percent TOC.

Region	NAV_CHANNEL		OFF_CHANNEL		totals		t-test
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tail
Arthur_Kill	50	2	29	9	32	11	
East_River	23	6	18	10	20	16	NS, p=0.1544
Gowanus_Canal			93	20	93	20	
Jamaica_Bay			14	36	14	36	
KVK			59	3	59	3	
Newark_Bay	34	16	5	76	8	92	Sig, p=0.0026
Newtown_Ck	122	91	100	199	106	290	NS, p=0.1168
Passaic_above_Dundee			14	48	14	48	
Passaic_River	57	92	68	203	65	295	NS, p=0.1181
Upper_Bay			56	2	56	2	

Table 14. Twenty-two PCB congeners reported by USACE from bulk sediment samples in the navigational channels.

Chem	homolog		Chem	homolog
PCB 8	2		PCB 128	6
PCB 18	3		PCB 138	6
PCB 28	3		PCB 153	6
PCB 44	4		PCB 170	7
PCB 49	4		PCB 180	7
PCB 52	4		PCB 183	7
PCB 66	4		PCB 184	7
PCB 87	5		PCB 187	7
PCB 101	5		PCB 195	8
PCB 105	5		PCB 206	9
PCB 118	5		PCB 209	10

Table 15. Twenty-two PCB congeners, ng/g. NOAA and USACE data.

Regions	NAV_CHANNEL		OFF_CHANNEL		Totals		t-test
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tail
Arthur_Kill	253	2	137	9	153	11	
East_River	375	9	101	10	188	19	Sig, p=0.0351
Gowanus_Canal			716	24	716	24	
Jamaica_Bay			28	38	28	38	
KVK			211	3	211	3	
Lower_Bay	343	7			343	7	
Newark_Bay	123	17	19	80	26	97	Sig, p=0.0003
Newtown_Ck	911	91	894	199	899	290	NS, p=0.9055
North_River	2,112	3			2,112	3	
Passaic_above_Dundee	1		44	54	44	54	
Passaic_River	272	195	288	342	283	537	NS, p=0.6951
Raritan R./Lower AK	2,082	9			2,082	9	
Raritan_Bay	1,375	1			1,375	1	
Upper_Bay	1,721	19	185	2	1,391	21	

3.4 Dioxins in Sediment

2378-TCDD data were available from the NOAA, Our Passaic and USACE databases. Log transformed concentrations were significantly higher in navigational channel samples from the Arthur Kill and Newtown Creek. In the Passaic River and Upper Bay concentrations were higher in the off-channel samples.

Table 16. 2378-TCDD, ppb.

Regions	NAV_CHANNEL		OFF_CHANNEL		Totals		t-test
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tail
Arthur_Kill	29.2	10	6.00	48	7.88	58	Sig, p=0.0012
East_River	2.97	13	2.23	11	2.60	24	NS, p=0.3743
Gowanus_Canal			9.40	1	9.40	1	
Hudson_R._south	1.004	3	2.90	1	1.31	4	
Jamaica_Bay			2.37	33	2.37	33	
KVK			7.93	5	7.93	5	
Lower_Bay	3.03	5	2.90	8	2.95	13	NS, p=0.2633
Newark_Bay	55.9	29	43.1	89	45.9	118	NS, p=0.3839
Newtown_Ck	6.86	84	5.20	188	5.66	272	Sig, p=0.0155
North_River	2.53	3	2.51	12	2.52	15	
Passaic_above_Dundee			0.60	39	0.60	39	
Passaic_River	128.3	196	198.1	321	168.0	517	Sig, p=0.0362
Raritan R._Lower AK	6.11	13	8.70	1	6.26	14	
Raritan_Bay	5.16	2	4.39	4	4.64	6	
Upper_Bay	2.08	14	3.08	11	2.47	25	Sig, p=0.0491

Measurement of 2378-TCDD only captures part of the dioxin-type toxicity. Dioxin-type chemicals include other 2378-substituted dioxins and furans as well as 12 coplanar PCB congeners. Other chemicals, such as brominated dioxin and furan analogs, polychlorinated biphenylenes, and many other substances probably contribute to dioxin-type toxicity but they are either absent or very under-sampled in the NOAA data. Table 14 shows the total toxic equivalence (TEQ) contributed by 2378-TCDD, all the 2378-substituted dioxins and furans, and the sum of TEQs from all the dioxins and furans and the "toxic" PCBs. Only samples where 2378-TCDD and congener PCBs were detected were used in this comparison. Geometric means are shown. The sample size is the same for each cell in a row.

The relative contribution by 2378-TCDD to total TEQ varies widely between harbor regions. 2378-TCDD contributed the greatest proportion of total TEQ in Newark Bay and the Passaic River. It was the least significant contributor in Newtown Creek.

Table 17. Geometric means of TEQ for 2378-TCDD, total dioxins and furans, and total TEQ including dioxins, furans, and PCBs. ng/kg.

Region/channel	2378TCDD	Total Diox/F	Total Diox/F+PCB	count	% 2378TCDD/Total TEQ
Arthur_Kill	**17.45**	**42.81**	**50.20**	**11**	**35%**
NAV_CHANNEL	48.81	94.79	108.15	2	45%
OFF_CHANNEL	13.88	35.88	42.33	9	33%
East_River	**2.80**	**30.32**	**34.85**	**16**	**8%**
NAV_CHANNEL	3.94	28.01	33.27	6	12%
OFF_CHANNEL	2.28	31.79	35.84	10	6%
Hackensack_River	**13.39**	**44.62**	**47.99**	**66**	**28%**
NAV_CHANNEL	6.65	21.95	22.77	4	29%
OFF_CHANNEL	14.01	46.71	50.35	62	28%

Jamaica_Bay	**2.46**	**15.06**	**17.53**	**28**	**14%**
OFF_CHANNEL	2.46	15.06	17.53	28	14%
KVK	**13.07**	**33.27**	**44.22**	**3**	**30%**
OFF_CHANNEL	13.07	33.27	44.22	3	30%
Newark_Bay	**46.87**	**73.38**	**79.90**	**91**	**59%**
NAV_CHANNEL	58.21	93.89	104.30	17	56%
OFF_CHANNEL	44.59	69.34	75.15	74	59%
Newtown_Ck	**5.57**	**98.53**	**137.40**	**269**	**4%**
NAV_CHANNEL	6.66	111.41	152.03	82	4%
OFF_CHANNEL	5.15	93.37	131.44	187	4%
Passaic_above_Dundee	**0.61**	**8.48**	**11.04**	**39**	**5%**
OFF_CHANNEL	0.61	8.48	11.04	39	5%
Passaic_River	**158.35**	**276.69**	**295.26**	**487**	**54%**
NAV_CHANNEL	121.80	210.77	223.89	187	54%
OFF_CHANNEL	186.48	327.85	350.84	300	53%

When 2378-TCDD concentrations are normalized with total organic carbon. Only Newtown Creek remains having a significant difference between navigational and off channel samples but the difference is small. Significance was very narrowly missed (p=0.0502) in the East River. If the rule of a minimum of five samples had been relaxed, the Arthur Kill would also have been significant, p=0.0060. Data from the NOAA, Our Passaic, and USACE databases.

Table 18. 2378-TCDD as ppb/% TOC.

Region	**NAV_CHANNEL**		**OFF_CHANNEL**		**Totals**		**t-test**
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tail
Arthur_Kill	9.18	4	1.50	31	1.84	35	
East_River	0.86	6	0.48	10	0.60	16	NS, p=0.0502
Jamaica_Bay			0.80	27	0.80	27	
KVK			4.16	3	4.16	3	
Lower_Bay	2.84	3	1.00		2.84	3	
Newark_Bay	19.32	19	18.88	73	18.97	92	NS, p=0.9224
Newtown_Ck	1.05	84	0.70	188	0.79	272	Sig, p=0.0015
North_River	0.87	1	1.00		0.87	1	
Passaic_above_Dundee			0.22	38	0.22	38	
Passaic_River	27.73	91	44.20	188	37.97	279	NS, p=0.0660
Raritan R./Lower AK	1.73	4			1.73	4	
Raritan_Bay	1.50	1			1.50	1	
Upper_Bay	1.20	2			1.20	2	

3.5. Non-Conventional PCDD/Fs

The NOAA database includes 171 analyses for non-conventional dioxins and furans. These compounds lacking 2,3,7,8-substitutions are regarded as having no dioxin-type toxicity and are rarely reported. Table 16 shows geometric means and counts of the non-conventional dioxins and furans from the Passaic River in samples taken after 2005. Non-detections were censored.

Table 19. Non-conventional PCDD/Fs. ng/kg.

homo.	**cong.**	**dioxins**		**furans**		**homo.**	**cong.**	**dioxins**		**furans**	
		GeoMean	count	GeoMean	count			GeoMean	count	GeoMean	count
Tetra	1234	1.55	48			Hexa	123467	3.91	66	8.20	75
Tetra	1246			8.30	75	Hexa	123468			26.54	76
Tetra	1247	3.60	67			Hexa	123469	3.60	67		
Tetra	1267	446.53	85	3.86	74	Hexa	123489			3.25	64
Tetra	1268	1.74	50			Hexa	123679	48.92	76	1.64	55
Tetra	1269	1.55	48	2.39	65	Hexa	124678			89.72	76
Tetra	1346			8.30	75	Hexa	124679			6.07	74
Tetra	1347			14.12	76	Hexa	124689			58.46	75
Tetra	1348			1.81	25	Hexa	134678			89.72	76
Tetra	1368	29.30	76	4.85	73	Hepta	1234679	322	76	8.64	72
Tetra	1378	13.88	74			Hepta	1234689			143	76
Tetra	1379	7.95	73								
Tetra	1468			7.88	76						
Tetra	1469			41.86	75						
Tetra	1478	2.52	56								
Tetra	2346			10.36	75						
Tetra	2348			67.87	76						
Tetra	2367			11.01	75						
Tetra	2467			5.12	72						
Tetra	3467			11.01	75						
Penta	12346	2.89	60								
Penta	12349			1.28	25						
Penta	12367	1.80	48	10.92	76						
Penta	12368	8.20	75								
Penta	12369	4.50	69	4.86	75						
Penta	12379	4.19	71								
Penta	12389	1.97	57	1.24	14						
Penta	12467			13.86	76						
Penta	12468			87.72	76						
Penta	12478	6.19	83	54.23	76						
Penta	13468			87.72	76						

Penta	13469			2.30	57						
Penta	13478			54.23	76						
Penta	23467			4.86	75						

A similar listing of the conventional dioxins are furans (Passaic River since 2005, non-detections censored) is shown below.

Table 20. Geometric means and counts of conventional PCDD/F congeners in Passaic River samples. ng/kg.

		dioxin		furan	
homologue	congener	GeoMean	count	GeoMean	count
Tetra	2378	173	501	16.0	489
Penta	12378	4.8	479	6.8	492
Penta	23478			18.7	504
Hexa	123478	4.6	484	54.0	508
Hexa	123678	17.0	502	18.3	499
Hexa	123789	11.1	493	1.1	166
Hexa	234678			13.7	501
Hepta	1234678	299	511	257	511
hepta	1234789			12.1	483
octa	12346789	3,387	511	479	507

3.6. Other Chemical of Concern

While PCBs and PCDD/Fs are the principal analytes of interest, the databases contain information on many other chemicals. Some of them would be expected to behave somewhat similarly with regard to attachment to fines or organic particles. Their occurrences and sediment concentrations would reflect different histories. Here we look at p,p'-DDT (DDT) and 16 Priority Pollutant PAHs (PAHs).

DDT showed significant differences in concentrations between navigational and off channel sites in Newark Bay.

Table 21. p,p'-DDT, ng/g.

Regions	**NAV_CHANNEL**		**OFF_CHANNEL**		**Totals**		**t-test**
	GeoMean	count	GeoMean	count	GeoMean	count	2-tail, logs
Arthur_Kill	440.26	4	23.58	86	26.85	90	
East_River	2.46	12	2.06	42	2.14	54	NS p=0.06937
Gowanus_Canal			24.02	8	24.02	8	
Jamaica_Bay			1.53	69	1.53	69	
KVK			25.10	2	25.10	2	
Lower_Bay	5.82	2	5.08	8	5.22	10	
Newark_Bay	6.94	9	1.91	64	2.24	73	Sig p=0.0354
Newtown_Ck	7.82	93	8.63	195	8.36	288	NS p=0.5258
North_River	0.75	1			0.75	1	

Passaic_above_Dundee			1.81	41	1.81	41	
Passaic_River	5.82	184	6.90	318	6.48	502	NS p=0.1885
Raritan R._Lower AK	13.17	6	3.02	5	6.75	11	NS p=0.2329
Raritan_Bay			3.08	13	3.08	13	
Upper Bay	1.16	3			1.16	3	

Samples of other Priority Pollutant pesticides collected after 2005 are summarized in Table 19. With the exceptions of total chlordanes and the DDTs (DDE, DDD, and DDT), the highest geometric mean concentrations were from the Gowanus Canal. However, sample sizes in the Gowanus Canal were small. Non-detections are omitted. The highest sum DDT concentration came from Piles Creek in the Arthur Kill.

Table 22. Priority Pollutant pesticides. NOAA and USACE databases. Geometric means (GM) in ng/g and count (n).

Region		**AK**	**ER**	**GC**	**JB**	**LB**	**NB**	**NC**	**PaD**	**PR**	**RRLAK**	**RB**	**UB**
Aldrin	GM	2.1	0.37	11.21	0.32	0.68	0.24	0.38	0.35	0.65			
	n	3	36	6	52	8	34	219	36	428			
Chlordanes	GM	11.7	14.3	26.9	10.5	87.3	6.71	43.9	16.5	37.8	3	5.76	3.4
	n	16	48	13	74	9	78	372	52	510	2	34	2
Dieldrin	GM	7.01	1.82	28.52	1.17	4.51	1.38	8.49	1.99	3.5	2.43	3.52	0.2
	n	29	37	10	50	6	76	341	48	501	10	10	4
Endo. sulfate	GM	1.3	0.06	21.06	0.17	0.17	2.43	0.66	0.19	0.16		18.9	
	n	1	8	8	3	1	14	91	8	274	1	4	
Endosulfan-alpha	GM			9.71	1		0.23	3.76	0.37	0.36	0.07	0.17	0.4
	n			2	3		2	36	1	21	2	91	2
Endosulfan-beta	GM		1.26	35.82	1.08	1.41	0.34	1.13	0.71	0.71	0.77	11.3	
	n		9	3	11	7	4	89	3	215	2	7	
Endrin	GM	2.04	0.64	40.99	1.41	1.75	1.34	1.7	0.03	0.17	0.12	0.53	
	n	2	5	2	5	2	2	116	1	48	2	30	
Endrin aldehyde	GM	2.71	1.23	20.94	2.1		1.56	0.56	0.06	0.09		11	
	n	2	2	6	1		18	86	4	35		1	
Endrin ketone	GM	2.88	0.25	14.6			0.46	1.56	0.14	0.09		0.2	
	n	3	1	8			12	87	10	126		12	
HCH-a	GM	0.96	0.1	8.08	0.12		0.08	0.2	0.09	0.13		1.61	
	n	5	14	3	23		56	156	12	317		4	
HCH-b	GM	0.6	0.26	13.61	0.14	0.11	0.13	0.27	0.16	0.18	0.1	0.16	
	n	2	11	4	7	1	46	141	14	363		3	
HCH-d	GM	2.68	0.31	6.56	1.15		0.36	0.36	0.08	0.08		0.51	

	n	2	6	5	2		20	112	5	214		2	
HCH-g	GM	3.26	0.29	7.38	0.16	1.01	0.05	0.29	0.1	0.11			
	n	3	14	3	15	2	27	52	9	222			
Heptachlor	GM	2.9	0.2	5.05	0.21	0.91	0.28	0.42	0.13	0.12		0.74	0.1
	n	1	21	3	33	9	20	86	16	392		4	2
Hept. Epox	GM	4.93	0.21	19.52	0.14	0.71	0.47	0.77	0.37	0.6	0.74	1.61	
	n	8	21	10	27	1	54	266	48	474	3	13	
Methoxychlor	GM	23.4	3.42	102.4	2.48	6.54	0.22	7.57	7.39	2.89		12.8	
	n	4	15	11	9	2	18	159	38	167		4	
p,p'-DDD	GM	52.2	4.8	34.38	3.88	4.3	11	31.5	5.79	22.7	6.92	0.52	3.2
	n	119	61	18	80	15	93	374	52	506	16	107	19
p,p'-DDE	GM	29	4.75	28.68	4.39	2.97	16.7	27.3	3.42	24.4	7.14	1.28	4.4
	n	100	61	12	90	17	93	389	52	505	15	57	20

3.7. PAHs in Sediment

Table 23 shows the averages of the sums of 16 PAHs reported in each of the databases. Sum PAH differences between channel types occurred at Passaic River, Raritan R./Lower AK, and the Upper Bay. In the latter two region all or most of the navigational channel observations were from USACE data thus the comparison is between programs as well as channel types.

Table 23. Sum of 16 PAHs (ng/g).

Regions	**NAV_CHANNEL**		**OFF_CHANNEL**		**Totals**		**t-test**
	GeoMean	count	GeoMean	count	GeoMean	count	logs, 2-tailed
Arthur_Kill	18,888	2	2,733	147	2,805	149	
East_River	30,069	12	24,798	83	25,409	95	NS, p=0.4980
Gowanus_Canal			96,403	52	96,403	52	
Jamaica_Bay			3,421	90	3,421	90	
Lower_Bay	15,257	8	8,909	11	11,174	19	NS, p=0.6485
Newark_Bay	5,836	17	2,905	77	3,296	94	NS, p=0.0801
Newtown_Ck	44,850	132	51,595	284	49,352	416	NS, p=0.1288
Passaic_above_Dundee			61,556	55	61,556	55	
Passaic_River	45,960	231	35,523	366	39,246	597	Sig, p=0.0135
Raritan R./Lower AK	90,340	5	573	6	5,715	11	Sig, p=0.0021
Raritan_Bay	49,649	1	118	103	125	104	
Raritan_River			13,807	16	13,807	16	
Upper_Bay	173,980	14	5,332	11	37,541	25	Sig, p=0.00001

An examination of post-2005 individual PAHs shows that the highest concentrations occurred, in every case, in the Gowanus Canal.

Table 24. Priority Pollutant PAHs (ng/g). NOAA and USACE databases.

Region		Acenaphthene	Acenaphthylene	Anthra.	B(a)A	B(a)P	B(b)F	B(g,h,i)P	B(k)F	Chry
AK	GeoMean	156	97	138	282	276	363	208	324	329
	count	32	68	111	137	137	132	116	115	145
ER	GeoMean	143	346	706	1,650	2,242	1,470	1,023	712	1,764
	count	63	63	78	88	89	70	70	66	89
GC	GeoMean	3,491	3,185	4,095	4,301	5,169	3,684	2,373	3,002	4,356
	count	40	32	42	52	48	50	51	48	51
JB	GeoMean	20	42	76	194	218	218	181	135	234
	count	81	82	90	89	89	71	89	52	89
LB	GeoMean	38	40	128	399	436	520	339	212	516
	count	12	12	12	12	12	12	12	12	12
NB	GeoMean	26	43	94	278	347	321	161	1,055	325
	count	90	94	93	93	93	93	93	38	93
NC	GeoMean	467	501	1,219	2,925	3,032	3,198	2,045	992	3,300
	count	408	416	412	409	409	374	409	182	409
PaD	GeoMean	646	905	1,255	2,877	3,246	2,306	1,748	1,578	3,470
	count	55	53	55	55	55	49	55	55	55
PR	GeoMean	241	265	610	2,000	2,209	2,390	1,461	1,408	2,606
	count	565	581	585	592	594	550	591	591	595
RR/LAK	GeoMean	30	19	89	56	65	262	156	245	65
	count	2	4	3	6	6	4	4	3	6
RB	GeoMean	8	12	37	28	33	72	67	50	31
	count	13	35	12	82	72	46	22	25	84
UB	GeoMean	186	105	336	638	606	584	331	367	524
	count	4	3	8	10	11	10	10	10	11

Region		DiB(a,h)A	Fluoranth	Fluorene	I(1,2,3)P	Naphth	Phenanth	Pyrene
AK	GeoMean	139	491	165	203	91	210	498
	count	59	146	33	110	37	131	148
ER	GeoMean	187	2,487	161	1,023	363	1,235	2,924
	count	55	91	58	70	69	84	94
GC	GeoMean	832	6,731	1,954	2,831	1,985	5,050	9,934
	count	44	52	34	51	37	49	50
JB	GeoMean	56	359	27	172	35	150	369
	count	66	89	82	89	84	85	89
LB	GeoMean	65	914	50	329	57	1,398	767
	count	12	12	12	12	12	8	12
NB	GeoMean	40	474	25	151	47	175	484
	count	82	93	90	93	94	93	93
NC	GeoMean	498	5,916	352	1,981	830	2,265	6,761
	count	224	416	391	409	403	396	416

PaD	GeoMean	447	4,462	570	1,599	610	3,004	5,404
	count	55	55	55	55	51	55	55
PR	GeoMean	367	3,593	262	1,312	329	1,897	3,642
	count	581	597	568	590	519	590	597
RR/LAK	GeoMean	38	329	18	171	40	85	358
	count	4	4	4	4	3	1	4
RB	GeoMean	15	84	10	68	19	35	68
	count	40	56	20	24	17	33	59
UB	GeoMean	79	630	200	350	368	458	935
	count	2	12	4	10	5	8	7

3.8. Oil Spill Tracers

The NOAA database has three classes of oil spill tracers; alkanes, terpanes, and hopanes. Full utilization of these data would require a much high level of analysis than depicted here.

Thirty-three higher alkanes were reported from 696 samples taken after 2006. The chemicals are:

Table 25. Petroleum tracers.

Decane (C10)	**Hexadecane (C16)**	**Pentadecane (C15)**
Docosane (C22)	Hexatriacontane (C36)	Pentatriacontane (C35)
Dodecane (C12)	Nonacosane (C29)	Tetracontane (C40)
Dotriacontane (C32)	Nonadecane (C19)	Tetracosane (C24)
Eicosane (C20)	Nonane (C9)	Tetradecane (C14)
Heneicosane (C21)	Nonatriacontane (C39)	Tetratriacontane (C34)
Hentriacontane (C31)	Octacosane (C28)	Triacontane (C30)
Heptacosane (C27)	Octadecane (C18)	Tricosane (C23)
Heptadecane (C17)	Octane (C8)	Tridecane (C13)
Heptatriacontane (C37)	Octatriacontane (C38)	Tritriacontane (C33)
Hexacosane (C26)	Pentacosane (C25)	Undecane (C11)

Table 26 gives the geometric means of the sum of the 33 alkanes by region. The highest concentration, from a small sample size, came from the Lower Bay. Lower Bay also had the highest black carbon concentration. The most abundant alkanes in the Lower Bay were nonacosane and pentatricontane.

Table 26. Alkanes. NOAA database. ng/g.

Region	**GeoMean**	**count**
Arthur_Kill	2,131	2
East_River	19,970	72
Hackensack_River	3,470	4
Jamaica_Bay	12,024	144

Lower_Bay	92,665	8
Newark_Bay	1,982	55
Newtown_Ck	66,121	696
Passaic_above_Dundee	17,157	41
Passaic_River	26,599	130

The analyzed hopanes (HOP) and terpanes (TER) are listed below.

Table 27 Hopanes and terpanes.

CLASS	chem_name	CLASS	chem_name
HOP	17A(H),21B(H)-25-Norhopane	HOP	T35-Pentakishomohopane (R)
HOP	17a(H),21b(H)-Hopane (Hopane)	HOP	Tetrakishomohopane-22R
HOP	17A(H)-22,29,30-TRISNorhopane-TM	HOP	Tetrakishomohopane-22S
HOP	17A(H)-Diahopane	TER	C23 Tricyclic Terpane
HOP	17A/B,21B/A 28,30-Bisnorhopane	TER	C24 Tetracyclic Terpane
HOP	18A(H)-30-Norneohopane-C29TS	TER	C24 Tricyclic Terpane
HOP	18A-22,29,30-Trisnorneohopane-TS	TER	C25 Tricyclic Terpane
HOP	30,31-Bishomohopane-22R	TER	C26 Tricyclic Terpane-22R
HOP	30,31-Bishomohopane-22S	TER	C26 Tricyclic Terpane-22S
HOP	30,31-Trishomohopane-22R	TER	C28 Tricyclic Terpane-22R
HOP	30,31-Trishomohopane-22S	TER	C28 Tricyclic Terpane-22S
HOP	30-Homohopane-22S	TER	C29 Tricyclic Terpane-22R
HOP	30-Norhopane	TER	C29 Tricyclic Terpane-22S
HOP	C29-Hopane	TER	C30 Tricyclic Terpane-22R
HOP	T22-C31-Homohopane (R)	TER	C30 Tricyclic Terpane-22S
HOP	T34-Pentakishomohopane (S)		

The highest geometric mean concentrations of total terpanes and hopanes were in Newtown Creek. The highest concentration of total alkanes came from the Lower Bay but terpanes and hopanes were only reported from the East River, Jamaica Bay, and Newtown Creek.

Table 28. Terpanes and Hopanes. ng/g.

Regions	Alkanes		Hopanes		Terpanes	
	GeoMean	count	GeoMean	count	GeoMean	count
East_River	19,970	52	4,894	10	746	10
Jamaica_Bay	12,024	84	1,171	30	164	30
Newtown_Ck	66,121	320	24,191	188	4,042	188

3.9. Metals and Organotin

Organotins are toxic metal compounds. Tributyl tin (TBT) is a biocide formerly incorporated in hull paint to reduce biofouling on recreational and commercial vessels. Due to its toxicity to marine life its use was banned on all classes of vessels in 2008. However, it was used for other applications including in chlorinated rubber concrete sealer. The NOAA database records 881 TBT samples since 1992. The highest concentrations, 1220 ppm occurred in Port Newark. Elevated levels were also found in the Passaic River. The highest levels seen in samples taken since 2005, 470 ppb, were from the Passaic River off Riverside Park in Lyndhurst just below Third River. Interestingly, the database does contain 880 records and 184 detections for tetrabutyl tin, (also called stannane-tetrabutyl, CAS 1461-25-2). Locations of the highest concentrations roughly mirrored those from tributyl tin. Tetrabutyl tin was used as an intermediate in polyvinyl chloride manufacture and as a starting chemical to make tributyl tin. Its use is now restricted by the Toxic Substances Control Act. The database also contains findings on mono- and dibutyl tin. Geometric means and counts of detected analytes are shown for samples taken before2006 (Old) and for years after 2005 (New). Tetraphenyl tin had been used by General Electric as a chloride scavenger in some Pyranol (PCB-based transformer fluids) formulations. Monsanto patented use of dibutyl diphenyl tin as a scavenger in PCBs. Neither were reported in the NOAA records.

Table 29. Organotins. ng/g.

Regions	**Monobutyl tin**				**Dibutyl tin**			
	New		Old		New		Old	
	GeoMean	count	GeoMean	count	GeoMean	count	GeoMean	count
Arthur_Kill			17.0	6	4.9	1	37.3	10
Bight			1.4	20			3.3	21
East_River			3.2	6			8.5	7
Hackensack_River				2			8.6	4
Hudson_R._south			4.0	1			14.4	1
Jamaica_Bay			2.6	26			3.6	28
KVK			11.3	1			80.7	1
Lower_Bay			1.3	19			3.0	19
Newark_Bay	4.4	2	11.6	16	5.9	14	8.8	79
North_River			3.9	7			12.9	7
Passaic_above_Dundee	2.7	30			4.4	34		
Passaic_River	11.9	416	4.8	54	22.2	438	12.2	85
Raritan R./Lower AK			13.1	1			66.3	1
Raritan_Bay			6.6	5			18.8	5
Raritan_River			9.5	1			3.2	1
Upper_Bay			2.9	11			7.2	13
Regions	Tributyl tin				Tetrabutyl tin			
	New		Old		New		Old	
	GeoMean	count	GeoMean	count	GeoMean	count	GeoMean	count
Arthur_Kill			24.33	8			2.71	3
Bight			14.65	21			1.15	2
East_River			20.92	7			4.25	2

Hackensack_River	16	1	3.23	3				
Hudson_R._south			32.00	1				
Jamaica_Bay			11.50	28			1.57	16
KVK			156.00	1			5.50	1
Lower_Bay			5.93	21			1.32	3
Newark_Bay	4.67	12	11.10	73	2.6	1	2.26	11
North_River			18.36	7				
Passaic_above_Dundee	2.51	3			17	1		
Passaic_River	12.47	393	34.05	78	8.12	79	1.23	19
Raritan R./Lower AK			70.90	1			2.20	1
Raritan_Bay			19.20	5			2.13	2
Raritan_River								
Upper_Bay			13.07	15			0.20	1

Table 30 shows results from post 2005 metals analyses. High concentrations of arsenic mercury from the Arthur Kill were taken from the Bayway Refinery site on Morses Creek.

Table 30. As, Cr, Cu, Pb, Hg, and Ag. ng/g.

Regions	**ARSENIC**		**CHROMIUM_6**		**COPPER**	
	GeoMean	count	GeoMean	count	GeoMean	count
Arthur_Kill	4,368	162	4.10	114	251,089	162
East_River	150	58	0.41	10	46,502	58
Gowanus_Canal	141	57			223,116	57
Hackensack_River	244	340	2.10	91	18,265	345
Hudson_R._south	294	1			29,546	1
Jamaica_Bay	60	91	0.10	30	13,760	91
KVK	403	3			119,921	3
Lower_Bay	114	12			53,215	12
Newark_Bay	312	97	0.95	60	53,483	100
Newtown_Ck	641	420	0.42	177	1,502,876	420
North_River	215	1			12,908	1
Passaic_above_Dundee	3	51	0.82	1	8,159	62
Passaic_River	43	500	13.99	9	48,114	664
Raritan R./Lower AK	67	89	0.14	20	310	89
Raritan_Bay	65	1591	0.15	276	285	1587
Upper_Bay	214	10			13,393	10
Regions	LEAD		MERCURY		SILVER	
	GeoMean	count	GeoMean	count	GeoMean	count
Arthur_Kill	297,791	162	994	173	2.82	160
East_River	55,298	58	0.45	58	4.89	58

Gowanus_Canal	680,651	57	1.10	57	10.69	57
Hudson_R._south	33,751	1	1.02	1	46.53	1
Jamaica_Bay	17,965	91	0.07	91	0.75	91
KVK	196,639	3	10.25	3	15.17	3
Lower_Bay	165,504	12	0.39	12	5.59	12
Newark_Bay	66,391	98	3.18	99	2.35	91
Newtown_Ck	645,465	420	1.87	407	56.23	420
North_River	19,953	1	0.59	1	9.27	1
Passaic_above_Dundee	49,878	56	0.15	51	0.24	56
Passaic_River	143,189	582	1.47	519	2.46	582
Raritan R./Lower AK	1,251	89	0.00	82	0.08	82
Raritan_Bay	5,273	1881	0.00	989	0.09	1460
Upper_Bay	21,132	10	0.61	10	7.04	10

3.10. Comparison of Navigation Channels to Off-Channel Areas

The results of the significance tests for ten comparisons of in and out of navigational channels are summarized below. The channel type with the statistically greater ($p<0.05$) concentration is indicated. The result is underlined when the difference is a doubling or greater.

Table 31. Summary of significance tests.

Region	TOC	Silt & Clay	T_PCB	PCB/TOC	22_PCB	TCDD	TCDD/TOC	DDT	T_PAH
Arthur_Kill		**Nav**			**Nav**	**Nav**			
East_River									
Lower_Bay	**Off**								
Newark_Bay		Nav	**Nav**	**Nav**	**Nav**			**Nav**	
Newtown_Ck	Off					Nav	Nav		
Passaic_River	Nav					Off			Nav
Raritan R./Lower AKl	**Nav**								**Nav**
Raritan_Bay		**Nav**							-
Upper_Bay	**Off**	-				Off			**Nav**

In 16 out of 21 cases of significant differences, the examined analyte was greater in the navigational channel. The two analytes showing higher concentrations in the off-channel samples occurred in the Lower Bay, Upper Bay, Passaic River, and Newtown Creek regions. Of these only TOC in the Lower and Upper Bays had a two-fold difference. The fewest total number of samples in a statistically significant comparison, Raritan R./Lower AK for total PAHs, was 11.