Contaminant Assessment and Reduction Project:

NY/NJ Harbor Sediment Report 1998-2001

NYS Department of Environmental Conservation
Division of Water

June 2003

Table of Contents

List of Figures

List of Tables

Acknowledgment

Our friend and co-worker, Bruce Garabedian, passed away this June. He was one of the original gang of four in the Sediment Assessment and Management Section in the Division of Water. His engineering expertise was a great asset to this Section and his friendly manner was inspiration to all. He will be missed by all his friends at DEC.

We would like to thank New Jersey Marine Science Consortium and the State University of New York at Stony Brook for their ships, staff and equipment in assisting DEC in the sediment collection process. We appreciate Alan Dorfman and the US Army Corps of Engineers for providing DEC with dock space and processing facilities at their office at Caven Point Marine Terminal in Jersey City, NJ while sampling.

We would like to thank those assisting in the sediment collection and processing including Bernadette Anderson, Diane English, Bruce Garabedian, Tracy Tomajer, and Karen Woodfield.

Finally, a special thanks to Bernadette Anderson for preparing the maps used in this report and editing the draft document.

EXECUTIVE SUMMARY

Report Summary

The Port of New York/New Jersey is an important link in the economic well being of the Northeast. It is also a substantial environmental resource, home to an abundant array of fish and wildlife. Because of this, it is vital that dredging operations, the disposal of dredge material and the management of contaminants be conducted in an efficient, environmentally sound manner.

In 1998, the NYSDEC and the NJDEP entered into an agreement with the NY/NJ Port Authority to assess the environmental quality of the Harbor. This assessment program became part of the Contaminant Assessment and Reduction Program (CARP) under the auspices of the Harbor Estuary Program (HEP). This monitoring program included the environmental sampling matrices of the water column, sediments and biota.

In September of 1998, staff from the NYSDEC's Division of Water began collecting core and surficial sediment samples in the harbor complex. The intent of this sampling effort was to support the harbor modeling work, validate previously identified contaminants of concern and help trackdown active sources of contamination. Laboratory analyses included: heavy metals, organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), dioxins/furans and toxicity testing.

The initial sampling work in 1998 tested sampling equipment and analytical methods (high resolution GC/MS isotope dilution) and provided the sampling staff an opportunity to become familiar with the harbor environment and its sediments. Along with the 26 samples collected through this effort, almost 150 archived samples from sediment cores previously collected in the lower Hudson River and in the Harbor were submitted for chemical analysis.

In 1999, surficial samples (0-10cm) were collected at 18 locations to characterize the sediment quality conditions for the harbor modeling work.

Subsequent sample collection (2000-2001) was designed to fill in data gaps and/or provide additional information on areas/analytes of interest. To date, 42 cores (sub-sectioned to 160 samples) and 91 surficial sediment samples have been submitted to analytical laboratories for chemical, physical (grain size) and/or biological (toxicity testing) analyses.

Findings

Scientists from the Rensselaer Polytechnic Institute (RPI) and NYSDEC technical staff have reviewed much of the analytical results (in combination with historical data) and have formulated these observations:

- The sediments in the western harbor are generally more contaminated than the rest of the harbor.

- Historical sediments (1940-1980) are more contaminated than recent depositions. (i.e., the concentration of PCBs in the harbor sediments seems to have decreased by about 90% since the mid-1970s.)

- Historically, about two-thirds of the PCBs in the harbor sediments appear to have originated from the Upper Hudson River. Currently, the percentage is estimated to be around 25.

- The Passaic River has been and is a likely source of mercury, PCBs and chlordane to the western harbor.

- The Newtown Creek has been and is a potential source of contamination to the Upper Bay and East River.

- Mercury, silver, lead and copper are likely the most environmentally important inorganic contaminants in the harbor complex. Cadmium and chromium appear to be of minimal concern.

Recommendations (future work)

- Make the full database available to academia and other environmental specialists. Provide funds to initiate a thorough evaluation/assessment of the data under guidance of the regulators to ensure the practicality of outputs (i.e., investigate the role that inplace sediments play as a source of contaminants to the water column and biota).

- Participate in impact evaluation and source trackdown activities as identified by the above assessment (particularly in the Passaic River and Newtown Creek water bodies).

- Develop a long term monitoring strategy and program to identify contaminant trends and impacts.

- Collect additional sediment samples in support of new modeling needs.

- Identify and measure sediment depositional areas, rates and sources.

BACKGROUND

The Port of New York/New Jersey is a vital link to the economic wellbeing of the Northeast. It is the largest seaport on the east coast and the third busiest in the United States. In 2002, the Port handled over 73,000,000 metric tons of cargo, over 3,000,000 TEU (twenty-foot equivalent) containers, and nearly 550,000 motor vehicles with a total value of $90 billion. There are 87,000 full-time equivalent jobs in NYS (69,000 in NYC) and 137,000 full-time equivalent jobs in NJ from the Port with a personal income of nearly $17 billion. The tax revenue from the Port is nearly $2 billion, $1.5 in NJ and $916 million in NY State.

In order to allow the Port to compete now and in the future, it is essential that dredging and the management of dredge materials take place in a timely, cost-effective, and environmentally sound manner. The Harbor is also a vital natural resource and the proper management of dredge material will provide for the preservation and improvement of the harbor ecology.

The NY/NJ Harbor supports an abundant and varied fish and wildlife population that rely on the remaining wetland and estuary habitat. The Harbor has over 100 species of fish that have been recorded. The Harbor area lies on the Atlantic Flyway, a major pathway for migratory birds, and is an important area for waterfowl and shorebirds. Brant, scaup, American black duck and bufflehead are some of the overwintering species. The Harbor is an important nesting area for sandpipers, plovers, herons, and terns.

Until 1992, most of the dredged material (95%) from New York/New Jersey Harbor was found to be acceptable for ocean disposal (Category 1). A large amount of remaining material (nearly 5%) was Category 2, requiring capping with a layer of clean material, leaving only a very small portion of material (1% or less) which was considered unacceptable for ocean disposal (Category 3).

The US Environmental Protection Agency (EPA) revised its testing protocols in 1992, increasing the analytical sensitivity of detection limits, increasing the number of chemicals of concern for testing, and adding other biological assay requirements. The net result of these changes was a dramatic increase in material classified as Category 3. It is now estimated that 66% of the material to be dredged over the coming years is Category 3, 20% is Category 2 and only 14% is Category 1.

On July 24, 1996, the United States government mandated the closure of the Mud Dump Site (MDS), the long-term ocean disposal site for harbor-dredged material, by September 1997. Presently, only Category 1 dredge material can be disposed of the MDS, and then only for specific remedial purposes. This disposal area is now known as the Harbor Area Remediation Site (HARS).

In 1998, the New York State Department of Environmental Conservation (NYSDEC) and the New Jersey Department of Environmental Protection (NJDEP) entered into an agreement with the NY/NJ Port Authority to assess the environmental

quality of the Harbor. The program was called the Contaminant Assessment and Reduction Program (CARP) and was placed under the auspices of the Harbor Estuary Program (HEP). This assessment included water quality, sediments, and biota (including birds, fish and benthic organisms).

CARP is funded by a $20 million grant from the Port Authority of NY/NJ to New York State DEC and a $13 million grant to the New Jersey Department of Environmental Protection, where it is administered as the New Jersey Toxics Reduction Plan. Additional funding for these studies comes from the Hudson River Foundation (HRF).

OBJECTIVES

The primary goal of the CARP program is to identify and track the movement of toxic chemicals in the water, sediments and biota of the New York/New Jersey Harbor and tributaries to it. Another goal of the program is to reduce the input of additional contaminants into the Harbor. Some of the toxic chemicals of concern to the CARP program include organochlorine pesticides, PAHs (polynuclear aromatic hydrocarbons), mercury, cadmium, PCBs (polychlorinated biphenyls), and dioxin. A list of the contaminants of concern was developed at the beginning of this project, Table 1, and served as NYSDEC's initial guidance in toxics monitoring.

Table 1: CARP List of Contaminants of Concern

PCBs (EPA list of congeners)
Dioxins/furans (17 congeners)
PAHs (approximately 20)
Total and methyl mercury
Cadmium
Total DDT
Total Chlordane
Dieldrin

The CARP program monitored three media: water, sediment and biota. The water quality monitoring consisted of ambient monitoring and loadings, the later used to delineate the regions where contaminants enter. Sediment sampling consisted of surficial samples and cores (some of which were radio-dated). The biota samples included birds, fish, crustacean, zooplankton, and benthic invertebrates.

The sediment program identified four objectives for the collection and analysis of sediments: to augment/complement existing data for contaminant of concern identification, track and identify sources, identify suitable dredge disposal options, and provide baseline data for future monitoring.

One of the first steps in identifying where to sample was to review previous data sources. Therefore, an historical sediment chemistry data compilation was conducted.

HISTORICIAL SEDIMENT DATA COMPILATION

In 1998, DEC contracted with IT Corporation to conduct a historical sediment chemistry data compilation for the NY/NJ Harbor. IT compiled, evaluated and provided electronic copies of the database that was to be used to assess data gaps, locate areas of contamination and identify additional contaminants of concern to aid in source identification. This information was intended to be used to plan further sediment sampling efforts.

The final dataset compiled by IT had over 240,000 analytical chemic results for over 800 sites. Table 2 gives further detail on the database that IT prepared. The four sources of data were the Army Corp of Engineers, US Environmental Protection Agency, National Atmospheric and Oceanic Administration and NYS Department of Environmental Conservation. Over half the results from the database are from the Newark Bay basin, (54.8%), while Jamaica Bay comprises 24% and the Upper Harbor 11.6%.

Table 2: IT Historical Data Summary

Number	Sites	Samples		Results
		Cores	Surficials	
Total	1,439	2,287	2,439	266,572
With Coordinates	1,314	2,246	1,385	258,225
With Coordinates and Chemical Results	839	1,830	1,273	258,225
Acceptable Results				240,573

Figures 1 to 7 show the sampling locations from the historical database used in this study by basins. Figures 8 through _ show the min, max and mean summary for the final database.

Figure 1: Historic Sampling Sites - Hudson River

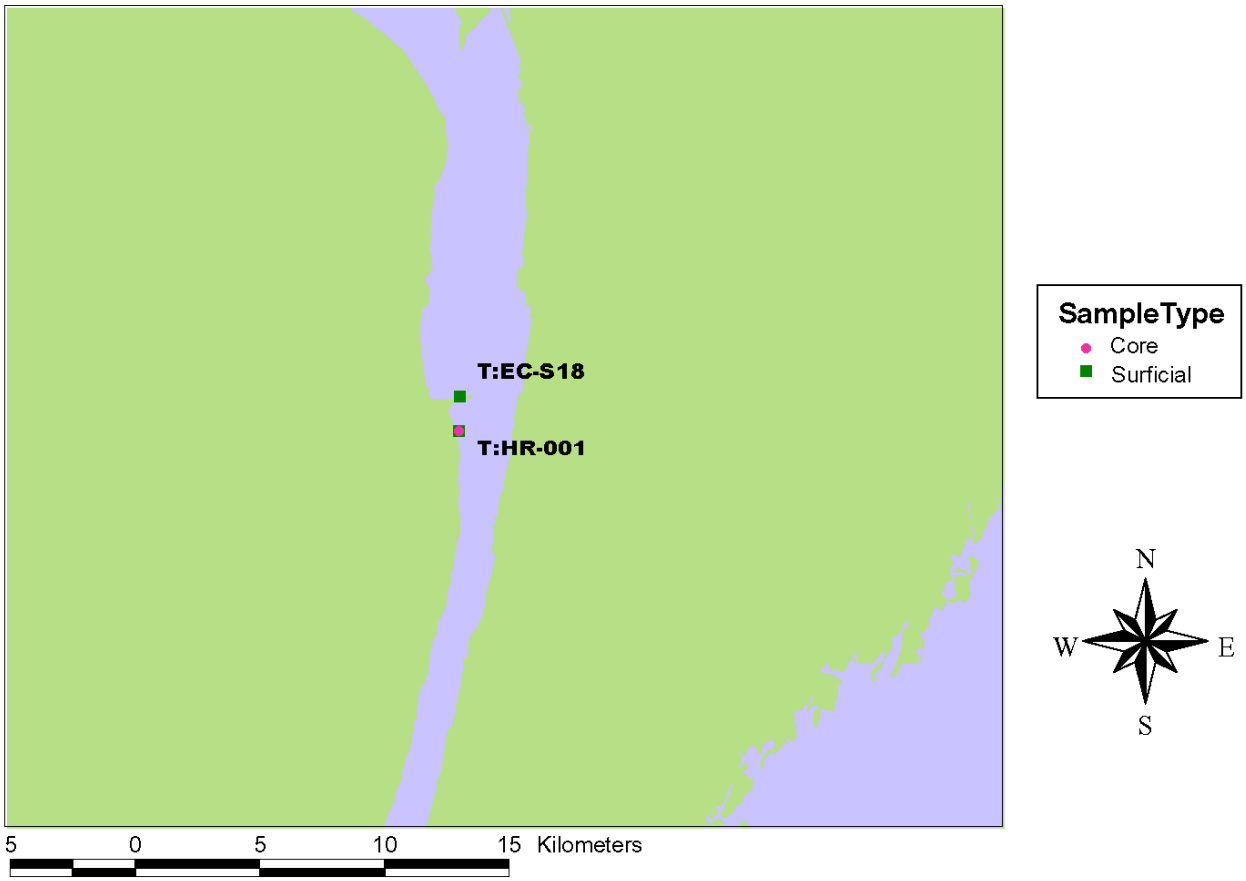


Figure 2: Historic Sampling Sites - Jamaica Bay

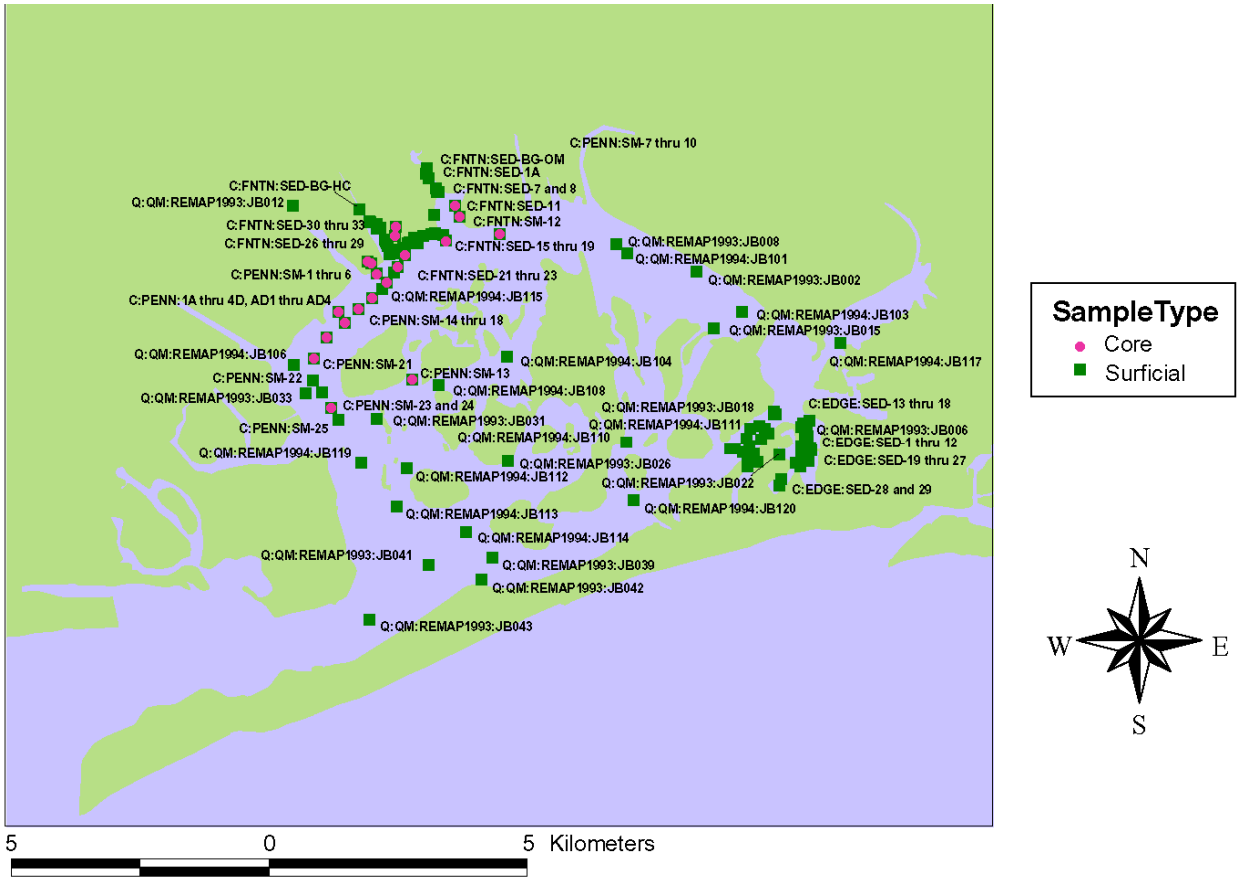


Figure 3: Historic Sampling Sites - Lower Harbor

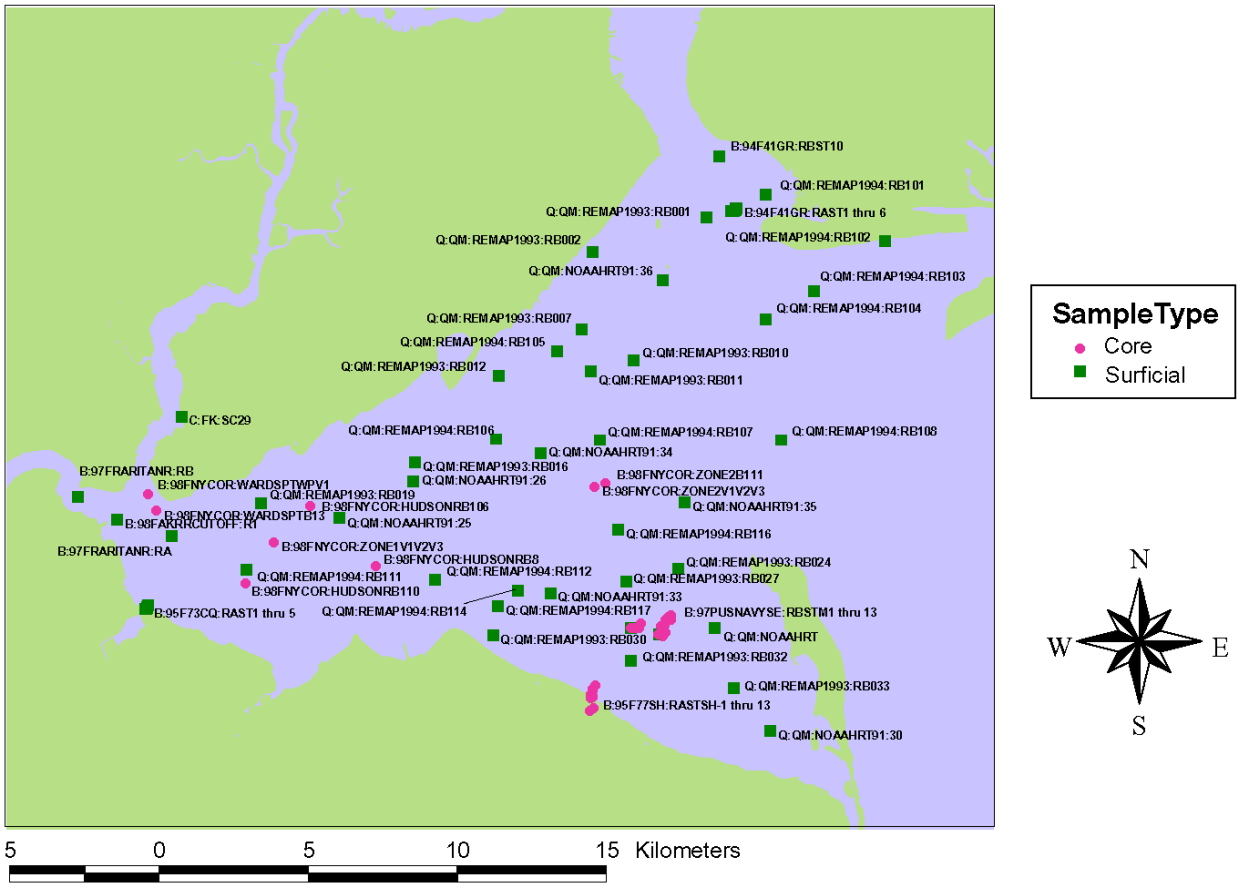


Figure 4: Historic Sampling Sites - Long Island Sound

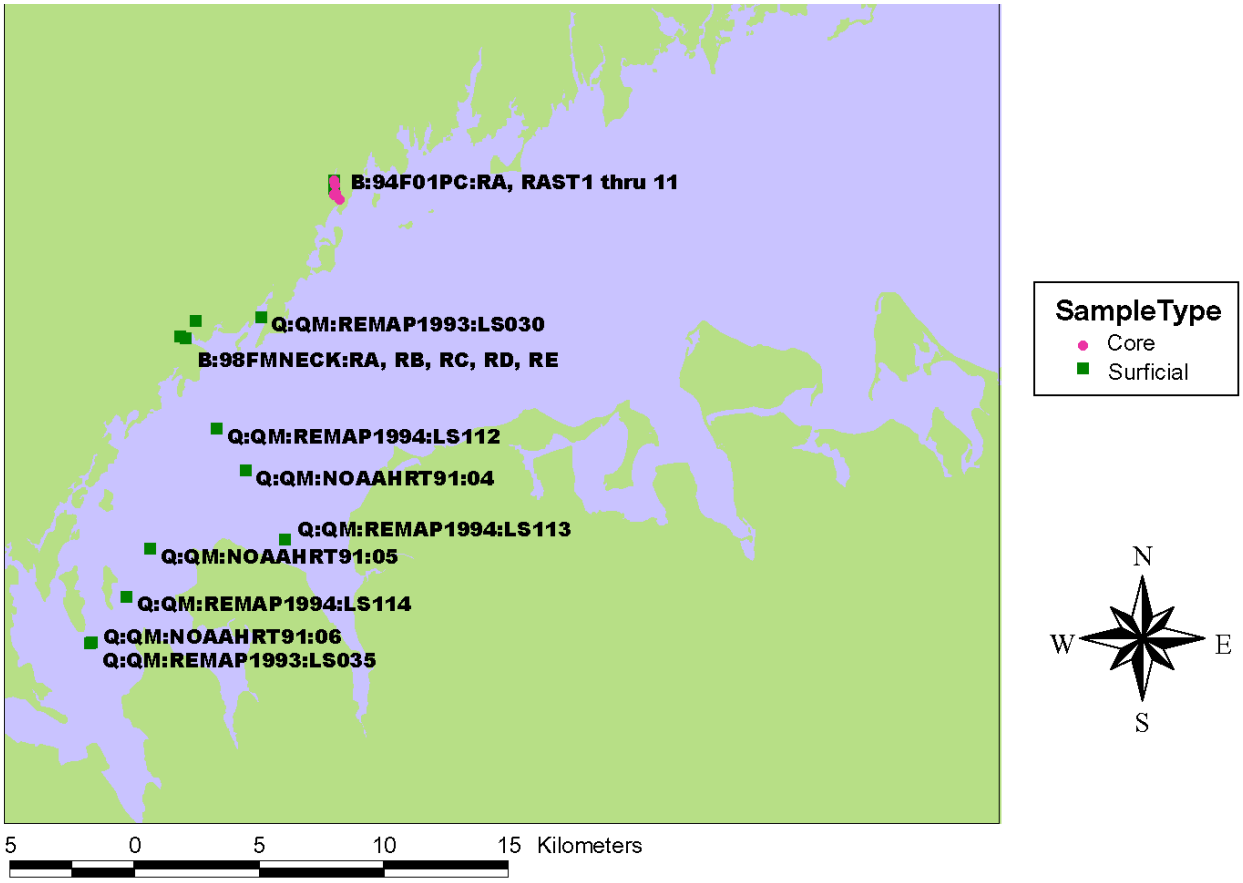


Figure 5: Historic Sampling Sites - Newark Bay

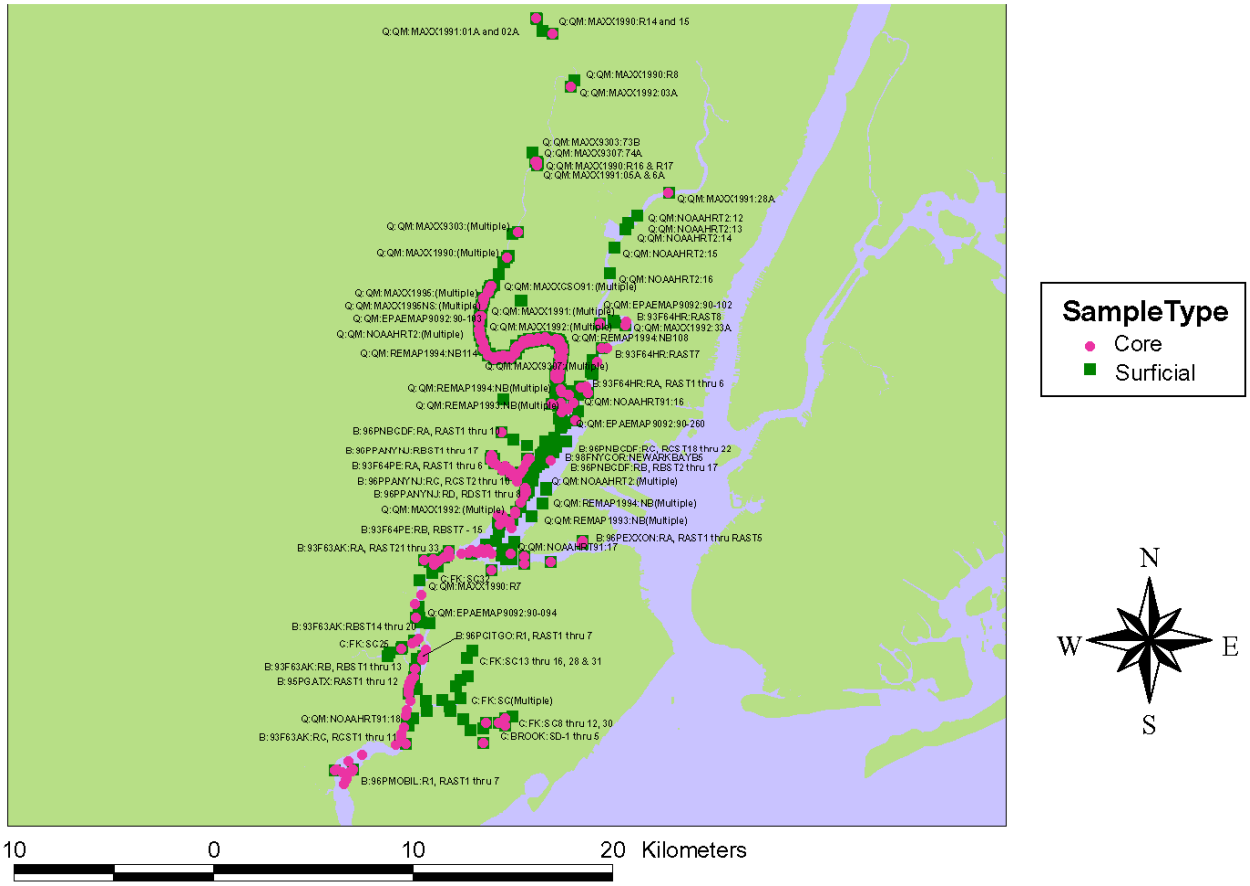


Figure 6: Historic Sampling Sites - New York Bight and Atlantic Ocean

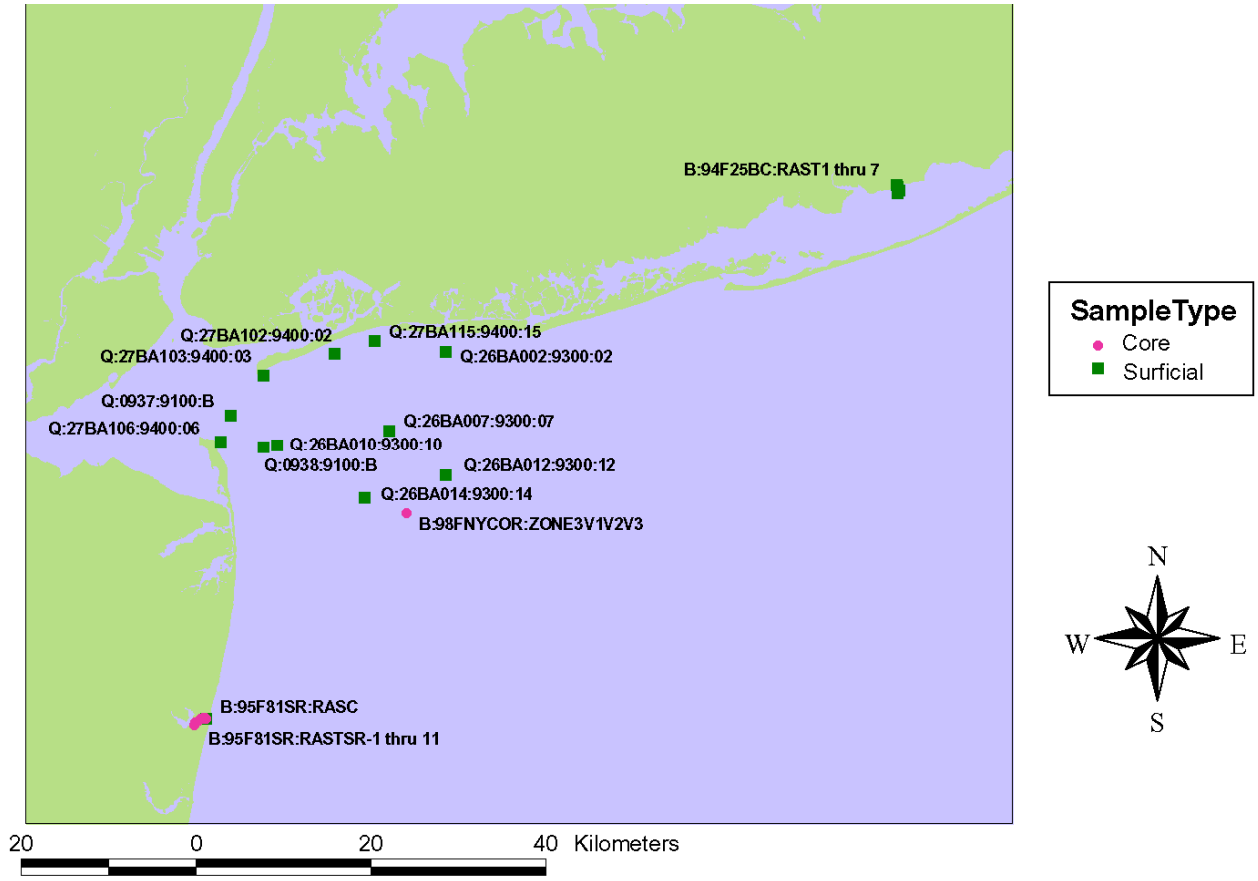
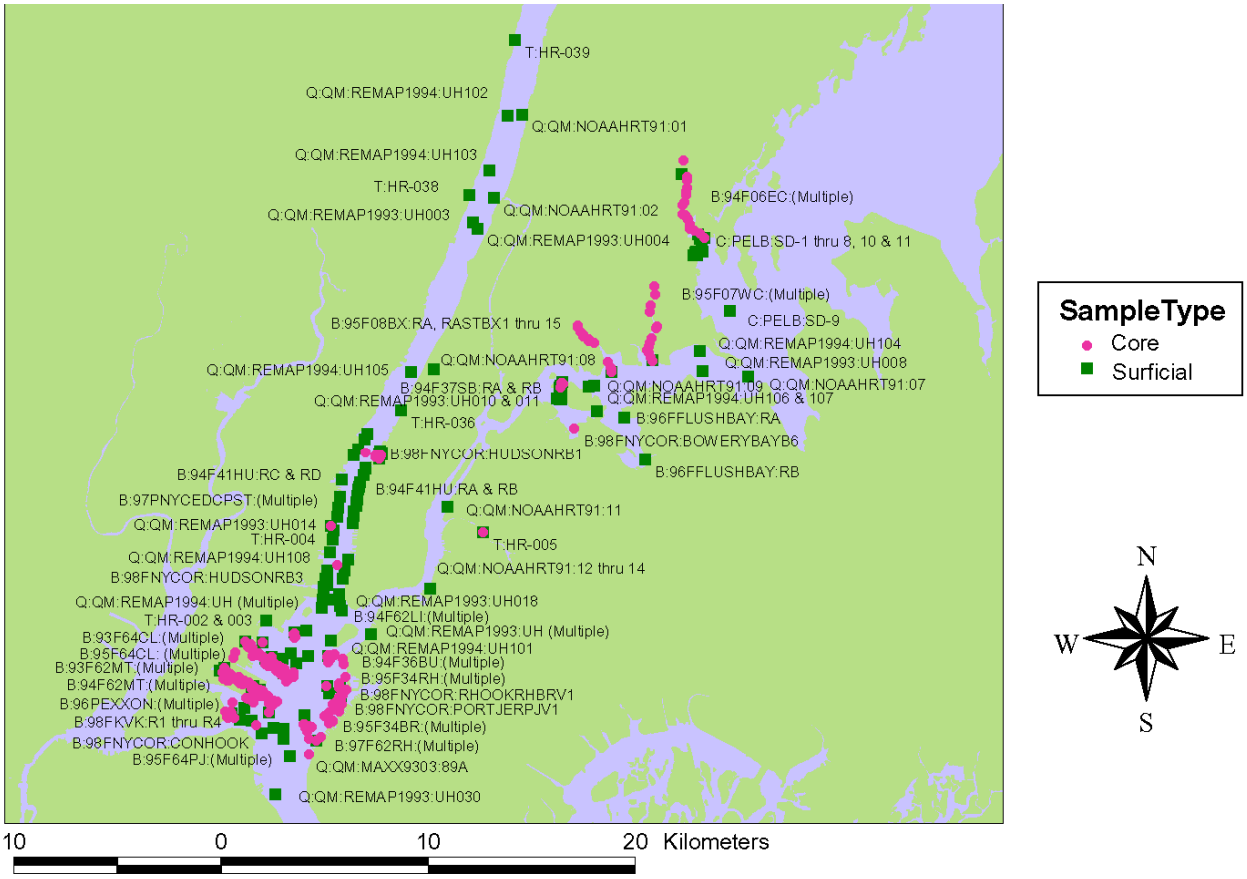


Figure 7: Historic Sampling Sites - Upper Harbor



CARP ANALYTICAL CHEMISTRY METHODS

Four analytical laboratories performed the trace organic analyses. Method 1613B was used for chlorinated dioxins and furans, NYSDEC HRMS-1 for the 209 PCB congeners, NYSDEC HRMS-2 for chlorinated pesticides, and NYSDEC LRMS-3 for PAHs. Low-level mercury and cadmium were performed by two contract laboratories using Method 1631 for total mercury, 1630 for methyl mercury and a modified Method 1638 for total cadmium. One contract lab analyzed samples for twenty-three metals using Method CLP/LIM04.0. The analytical methods, detection limits, reporting limits and other QA/QC information can be found in Table 3. Further information on the quality assurance of the project can be found in the QAPP, Sediment Sample Collection and Analysis New York Harbor And Hudson River Technical Program (NYSDEC, 1998)[i].

Table 3: Analytical Methods and QAQC Information

PARAMETER	RESPONSIBLE PARTY	STANDARD METHOD	PRECISION	ACCURACY	CALIBRATION			INSTRUMENT DETECTION LIMIT (mg/kg)	REPORTING LIMIT (µg/g)
					INITIAL	ONGOING	BLANKS		
RASIOISOTOPE DATING 7-BERYILLUM,137-CESIUM, 210-LEAD	Contract Laboratory	GAMMA SPECTROSCOPY	± 10%	± 5%	ANNUAL	WEEKLY	BIWEEKLY	---	MDA=0.l pCi/g
DIOXIN/FURAN 2,3,7,8-SUBSTITUTED CONGENERS AND TETRA THRU OCTA HOMOLOG TOTALS	Contract Laboratory	EPA-1613B	± 40% ** ** (BASED ON EPA-8290; STUDY NOT DONE FOR EPA-1613A)	± 40%*	when necessary	DAILY	PER METHOD	---	1-10 pg/g
PCB CONGENERS (MS)	Contract Laboratory	HRMS-1	± 60%	± 40%	when necessary	DAILY	1/ batch or 20(max.)	0.4-46 ng/kg	25-100 ng/kg
ORGANOCHLORINE PESTICIDES, PCB AROCLORS	Contract Laboratory	HRMS-2	± 60%	± 40%	when necessary	DAILY	1/ batch or 20(max.)		1.7- 17
--METALS--									
Pb	Contract Laboratory	EPA-239.2 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.4	0.6
Al	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	3	4.5
Ni	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	2.4	8
Zn	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	2	4
Cu	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1.4	5
Cd	Contract Laboratory	EPA-1638 MOD	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1	1
Cr	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1.2	2
Fe	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1.4	20
Ag	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1	2
K	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Hg	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Mn	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Mg	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
As	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Ca	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Sb	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Ba	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Be	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Co	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Na	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Se	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Tl	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
V	Contract Laboratory	EPA-200.7 CLP-M	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.		
Hg - Total/Methyl	Contract Laboratory	EPA 1631/1630	± 20%RPD	± 20%	DAILY	EVERY 10 SAMP.	2 per batch	2/0.005 pg/kg	5/0.01 pg/kg
TOC	Contract Laboratory	9060 W/LLOYD KAHN (SEE APPENDIX A)	± 20%RPD	± 20%	ICV/CCV 15%			20	20
TVS	Contract Laboratory	ASTM D2974		PER METHOD		NA		0.1%	0.01 %
GRAIN SIZE	Contract Laboratory	ASTM D421/D422		PER METHOD		NA			
TOXICITY TESTING									
SOLID PHASE TEST	Contract Laboratory	EPA DRAFT METHODS FOR MEASURING TOXICITY AND BIOACCUMULATION OF SEDIMENT ASSOCIATED CONTAMINANTS WITH FRESHWATER INVERTEBRATES; EPA 100.1(HYALELLA), EPA 100.2(CHIRONOMUS), AND ASTM E1383-93, AND E1525-93							
MICROTOX ANALYSIS	NYSDEC/ KUZIA	MICROBICS CORPORATION;METHOD DETALED IN MICROTOX MANUAL ,VOL. 2,DETAILED PROTOCALS,1992							

Toxicity testing was performed on surficial sediment samples. All surficial samples in 1998 and 1999 were submitted for toxicity testing with the exception of site HRA19 in 1999. In 2001 and 2002, random surficial samples were collected on each of the surveys. These samples were placed in 5-gallon plastic buckets and chilled to 4° C, prior to shipment to the laboratory. Toxicity testing was done using *Ampelisca abdita* or *Neanthes arenaceodentata*. The 10-day test on the amphipod *Ampelisca a.* used the 1994

USEPA[ii] method. The 20-day test on the polychaete *Neanthes a.* used ASTM method E 1611-94[iii]. The endpoint was survival and growth.

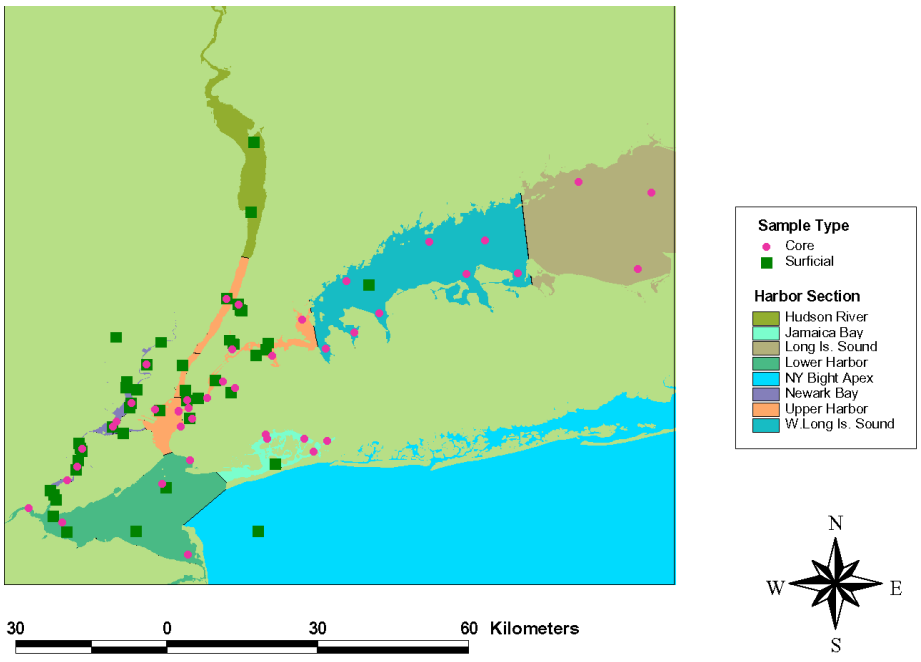
Grain size fractions were determined on most surficial sediments using ASTM D421/D422 method. These samples were placed in 500 ml glass jars and submitted for analysis. The analytical laboratories reported the results with different class size represented, therefore the results were grouped into three similar particle size categories; gravel (greater than #4 sieve), sand (less than #4 and greater than #200 sieve), and fines (less than #200 sieve).

CARP SAMPLING METHODS

Surficial sediment samples were collected using several different sampling devices, depending upon the sampling vessel being used. The DEC pontoon boat used a standard stainless steel ponar or stainless steel box corer. The box corer was used to collect both surficial and short cores (generally less than 40 cm). A Smith-McIntyre was used on the New Jersey Marine Sciences Consortium's (NJMSC) *Walford* or a modified Van-Veen sampler, which was used on SUNY Stony Brook's *Seawolf,* was also utilized for surficial sampling.

Sediment cores were collected using an electric vibrocore or the box corer. Two different vibrocores were used during the project period. Over 90 percent of the electric vibrocore were collected with a PVL PC-3.5 that DEC owns and operates from its pontoon boat. The other coring device used in the project was the Rossfelder VT-6, which was owned by the NJMSC and operated aboard the *Walford*. Figure 8 shows the location of the core and surficial sediment collected from 1998 to 2001.

Figure 8: NY/NJ Harbor Sediment Sampling Locations



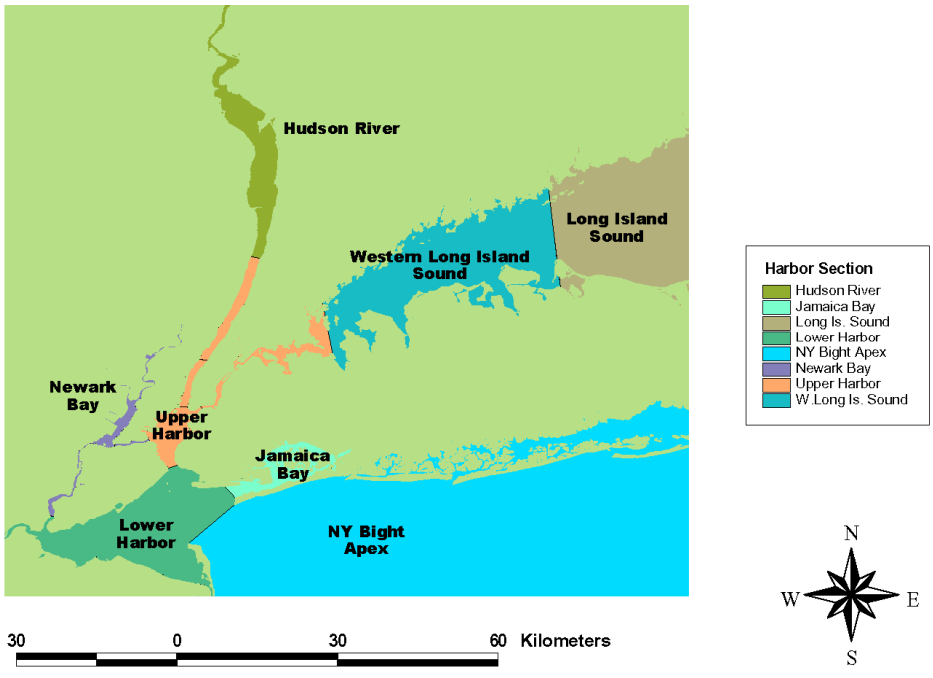
Sediment samples were collected, processed and preserved according the QAPP. Radio dating samples were collected from extruded cores and placed in zip-lock baggies marked with the site ID and depth. These samples were submitted to Rensselaer Polytechnic Institute (RPI) for analysis.

The data management system was handled through a contract with Battelle's Environmental Management Information System. Part of this system included the ability to prepare sample IDs and labels prior to sample collection. After sample collection, the data management system prepared the request for chemical analyses and a chain of custody, which accompanied samples. The analytical laboratory submitted the chemical results in a predefined format to Battelle. This database would eventually be accessible to all the scientific investigators.

Data validation was performed by Booze, Allen and Hamilton (BAH) under contract with the HRF. BAH was responsible for checking sampling SOPs and laboratory methods and outputs. The data were initially screened to make sure they met the data reporting requirements of the CARP program. The final process involved a check of the accuracy and precision of the labs, a review of the chromatograms, and manually checking the QA/QC of the laboratories. Once the data was approved by BAH, the results in the Battelle database were flagged as validated.

For comparative purposes with past studies, we broke down the NY/NJ Harbor into the seven basins used in the EPA R-EMAP studies (USEPA, 1996). These were the Hudson River (HR), Jamaica Bay (JB), Lower Harbor (LH), Newark Bay (NB), NY Bight Apex (NYBA), Upper Harbor (UH), and Western Long Island Sound (WLIS). An additional sub basin was included, Long Island Sound (LIS), which extended beyond the 73 24' W longitude western boundary of the WLIS (see Figure 9).

Figure 9: Harbor Sub Basins



Figures 10 through 17 show the sampling locations by basin and give the sampling station IDs used throughout this study. The station ID was provided rather than the sample ID due to the number of locations where cores were collected.

Figure 10: Harbor Sampling Sites - Hudson River Basin

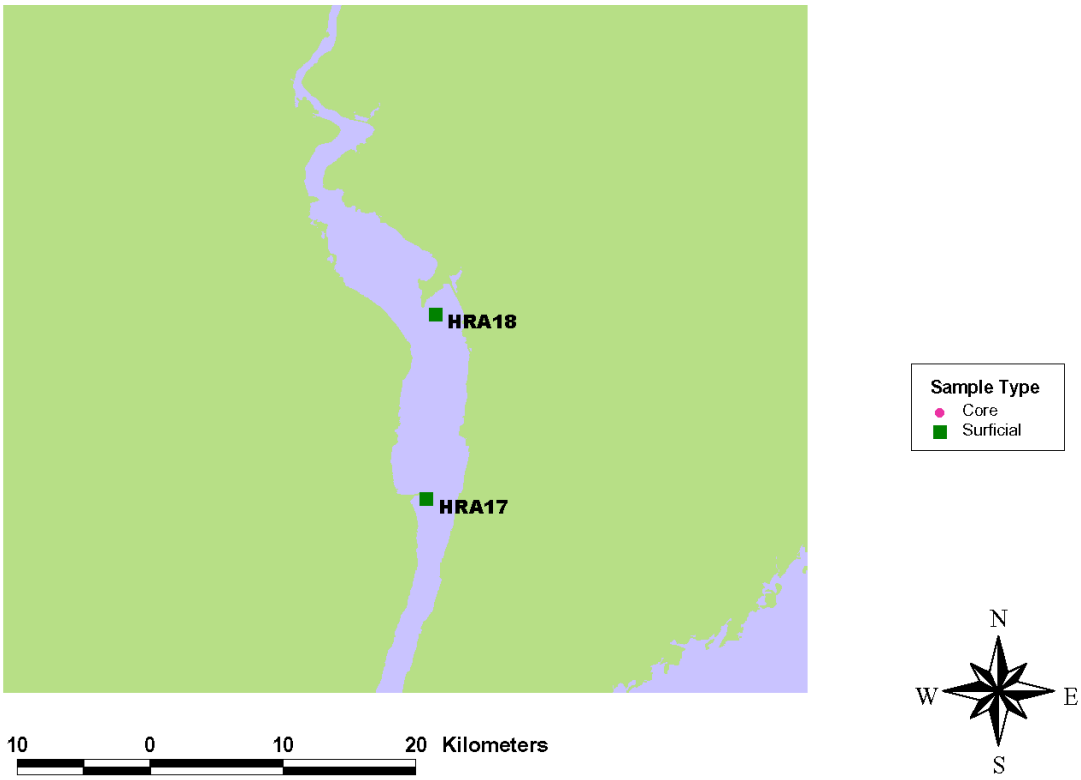


Figure 11: Harbor Sampling Sites - Jamaica Bay

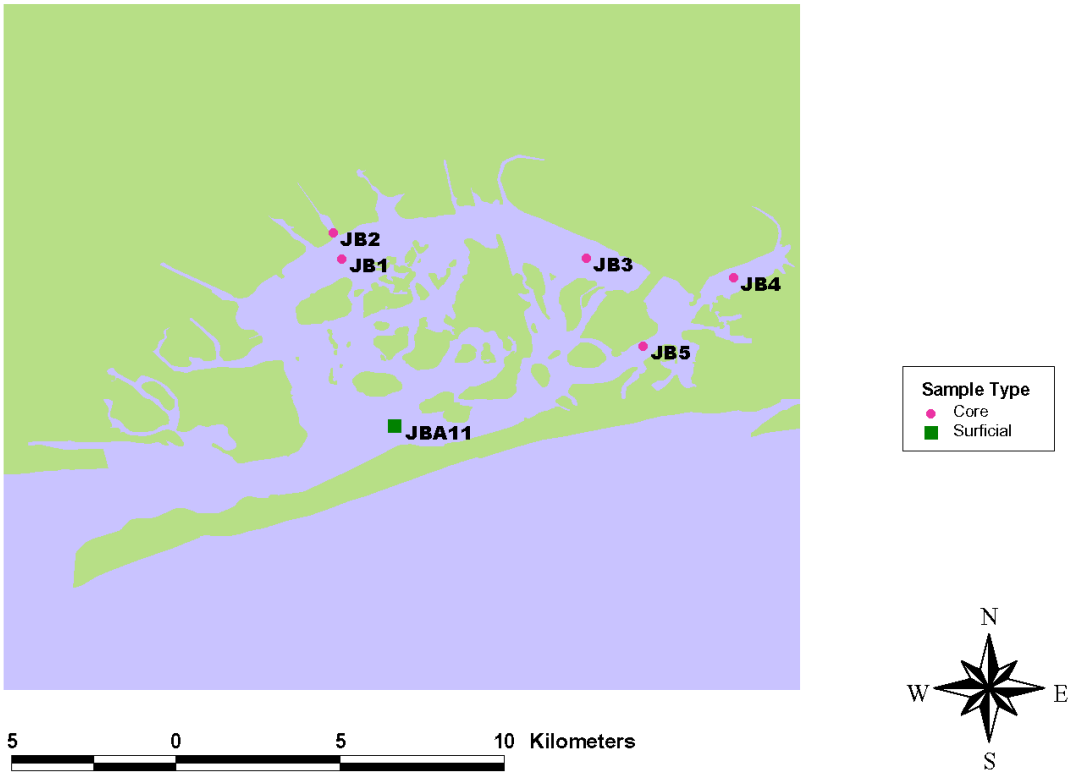


Figure 12: Harbor Sampling Sites - Lower Harbor

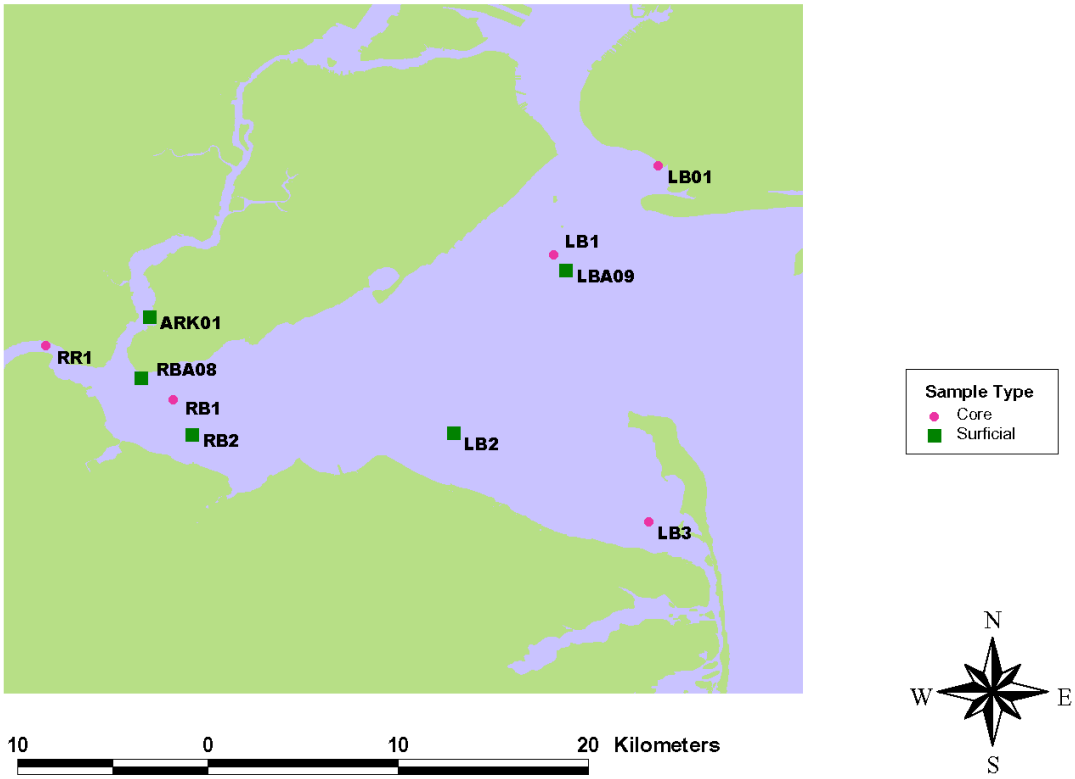


Figure 13: Harbor Sampling Sites - Long Island Sound

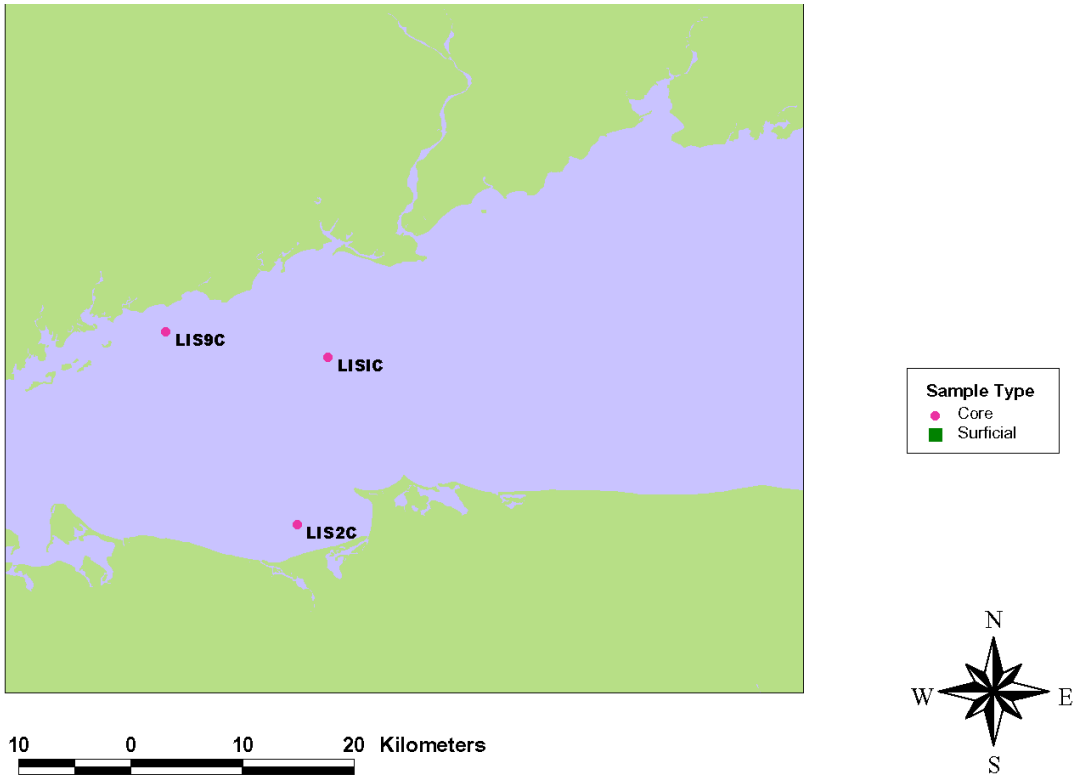


Figure 14: Harbor Sampling Sites - Newark Bay

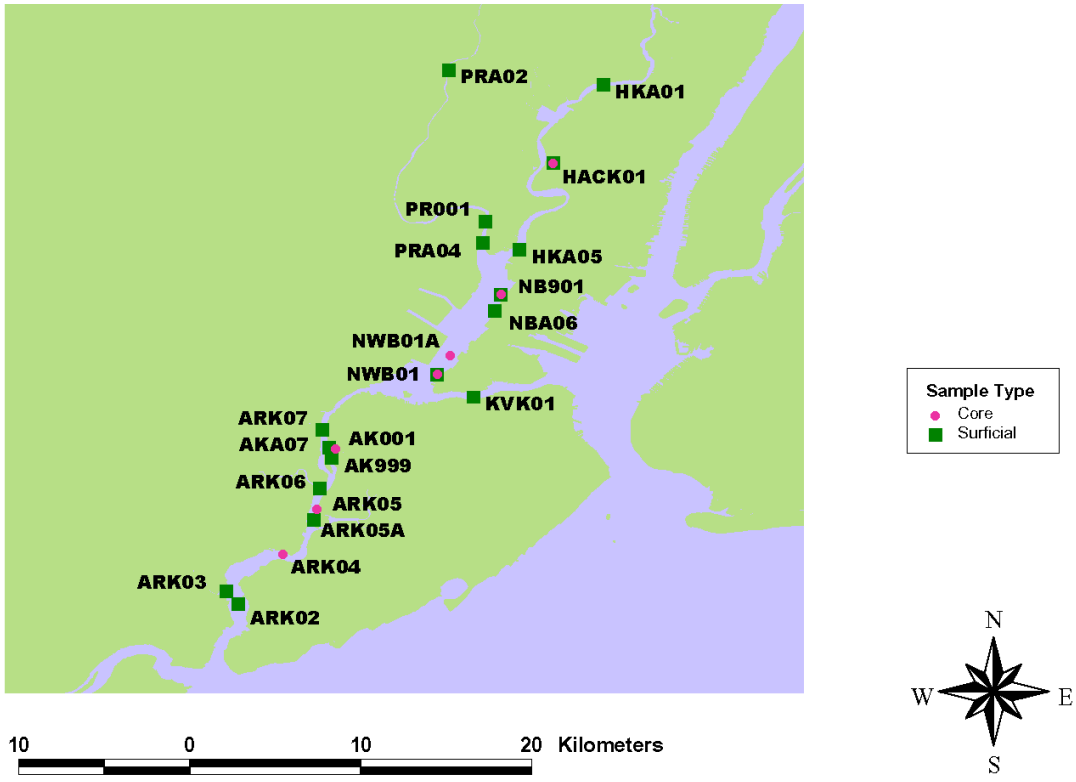


Figure 15: Harbor Sampling Sites - NY Bight and Atlantic Ocean

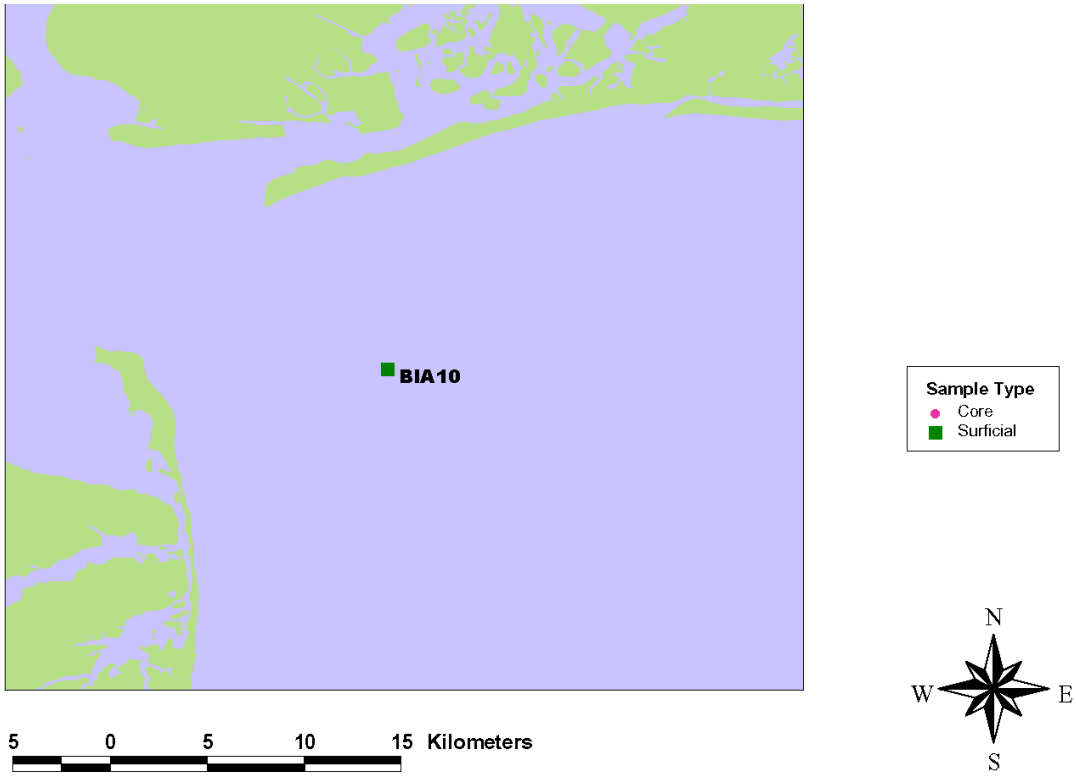


Figure 16: Harbor Sampling Sites - Upper Hudson

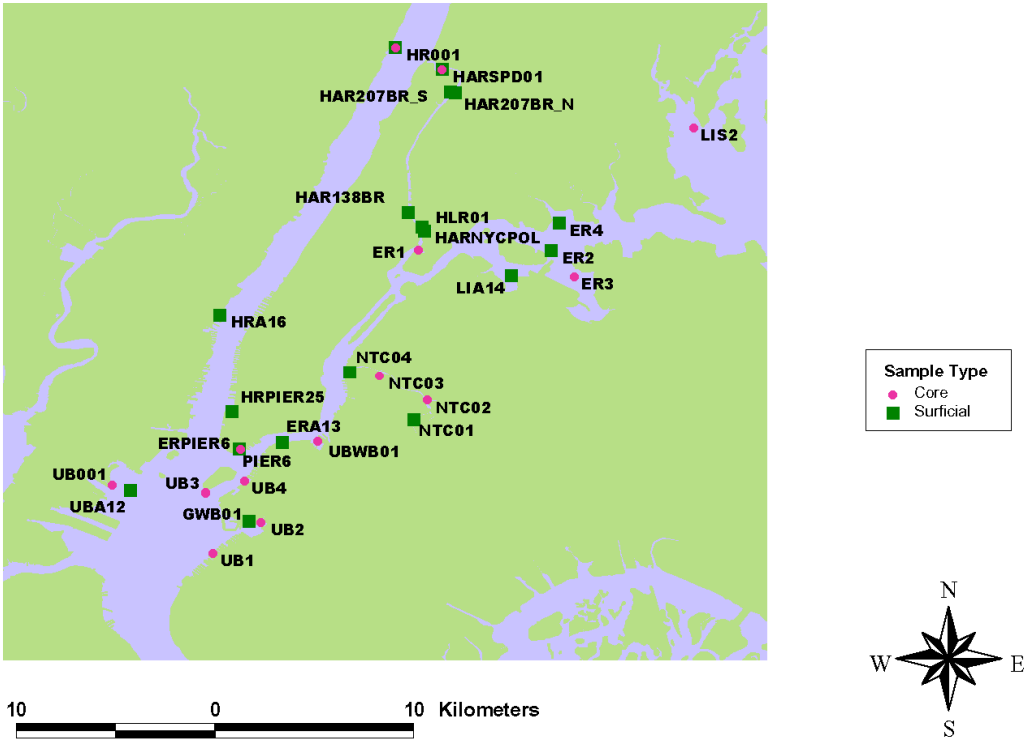
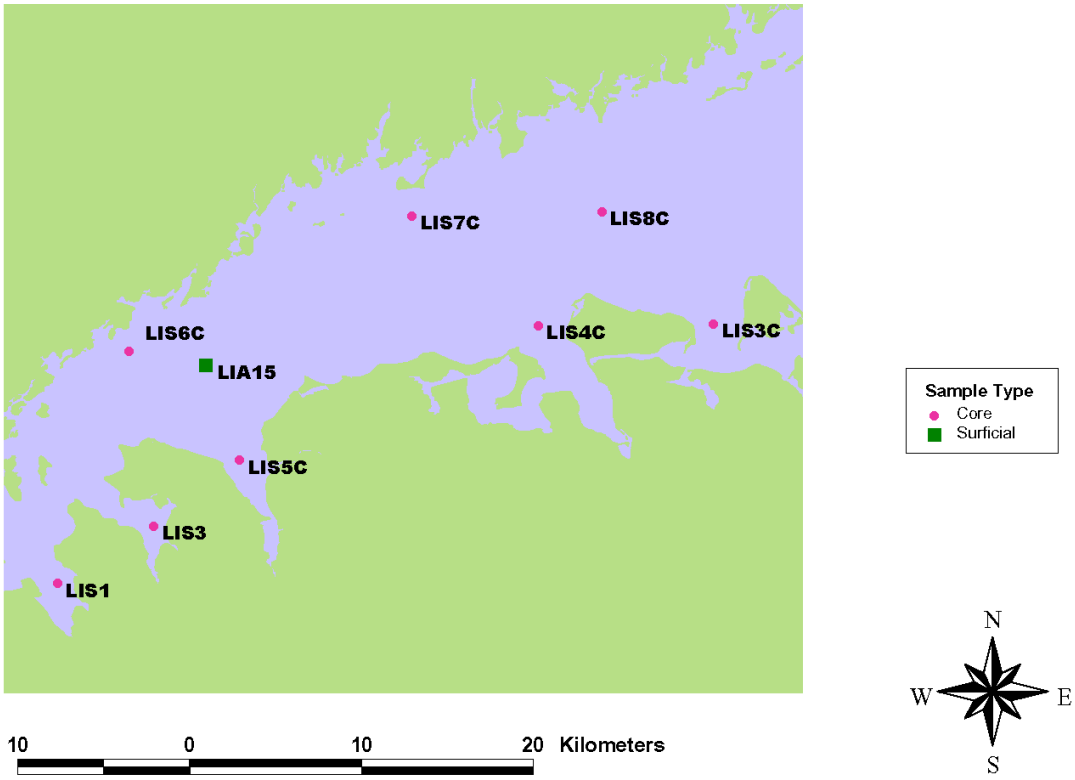


Figure 17: Harbor Sampling Sites - Western Long Island Sound



In summarizing the data, metals non-detects from the analytical laboratory were replaced with one-half the reporting level, while PCB, pesticides, PAHs and dioxin/furan non-detects were replaced with one-half the detection limit. Total PCB was calculated by summing the concentrations of the 209 individual congeners.

Dioxin/furan results are reported in Toxic Equivalent Quotient (TEQ) concentrations. The TEQ represents the sum of the seventeen-dioxin and furan 2,3,7,8-substitued congeners times a Toxic Equivalent Factor (TEF). TEFs are used to relate the relative toxicity of each of the dioxin/furan congeners to the 2,3,7,8-TCDD congener. The TEQ used in this summary was obtained from the 1998 United Nation World Health Organization's (WHO) TEF numbers[iv]. These TEQ values are slightly different from those used by NYSDEC in their ambient water quality standards, which rely on the 1994 WHO values. In most cases, this difference between the two TEQ numbers is negligible. Both numbers are given in Appendix _.

For biological comparisons, the results were compared to the Long, et al., effects range low (ERL) and effects range moderate (ERM) for marine sediments.[v] These guidance values represent an evaluation of chemistry and toxicity testing from marine waters from National Oceanic and Atmospheric Administration's (NOAA) Status and Trends studies. The ERL and ERM represent the 10^{th} and 50^{th} percentile, respectively, of the effects database for each substance. The 10^{th} percentile is indicative of concentrations below which adverse effects are rarely observed. The 50^{th} percentile, or

ERM, represents concentrations above which adverse effects are frequently expected to occur. Since the data were not derived as toxicity thresholds, these guidance values will not guarantee toxicity or lack thereof, at any given concentration. These are simply guidance numbers for assessment purposes.

The data was also examined for values greater than five times the ERM. Such concentrations would be considered to have significant impacts on benthic organisms. Samples having levels that exceeded this threshold may be considered "hotspots." This information can be important from a dredging disposal option and as possible contaminant sources.

Dioxins do not have an ERL or ERM guidance values. For this study, we used a TEQ of 300 ppt to represent the 5x-ERM or "hotspot" level. This value of 300 ppt for Dioxins represent five times the HARS value for likely to fail (see Table 5). The ERL, ERM, dioxin and "hotspot" guidance values are presented in Table 4 for the metals and organics.

Table 4: ERL, ERM, and "hotspot" guidance values

	ERL	ERM	5X ERM	Units
Arsenic	8.2	70.	350.	ppm
Cadmium	1.2	9.6	48.	ppm
Chromium	81.	370.	1,850.	ppm
Copper, Total	34.	270.	1,350.	ppm
Lead, Total	46.7	218.	1,090.	ppm
Mercury, Total	0.15	0.71	3.55	ppm
Nickel	20.9	51.6	258.	ppm
Silver	1.	3.7	18.5	ppm
Zinc	150.	410.	2,050.	ppm
Total PCB	22.7	180.	900.	ppb
Total DDT	1.58	46.1	230.5	ppb
Dieldrin	0.02	8.	40.	ppb
Total Chlordane	0.5	6.	30.	ppb
Total PAH	4,022.	44,792.	223,960.	ppb
Dioxin TEQ *			300.	ppt

* Dioxin TEQ is representative of "hotspot" and not from Long, et al.

The results were also compared to sediment concentrations that might prohibit disposal in the HARS dredge disposal site. These "disposal values" are based on anecdotal information from various discussions with individuals possessing considerable expertise in Harbor dredging/disposal issues. These "disposal values" used are for total PCB, total DDT and dioxin/furan TEQ because these are the analytes that have been found to be problematic to HARS acceptability. Unlike the ERL, ERM and hotspot TEQ, the HARS disposal TEQ is based only on the sum of 2,3,7,8 – TCDD and 2,3,7,8 – TCDF times the respective TEF. The lower numbers are classified as likely to "pass" while the upper number would be likely to "fail". The HARS dredge disposal numbers are listed in Table 5.

Table 5: HARS Disposal Guidelines

	Pass	Fail	Units
Total PCB	100.	200.	ppb
Dioxin TEQ	10.	60.	ppt
Total DDT	100.	250.	ppb

QUALITY ASSURANCE/QUALITY CONTROL

Before we began to collect sediment samples, several QA/QC samples were collected and submitted to four labs used for organic analysis. The labs were all under DEC contract for high-resolution analysis of PCBs, dioxin/furans and pesticides. PAHs were analyzed using low-resolution method, DEC LRMS-3. The first set of QA/QC samples were a set of six dry sediment samples that had been collected by RPI and submitted to the labs in 1998. Five of the six samples were Harbor and Hudson River sediments of varying concentrations of contaminants. The sixth sample was a duplicate of one of the five that was randomly selected for each lab.

A second round of inter-laboratory QA/QC was done in 1999, when a NIST SRM-1944 reference sediment sample was submitted to five DEC contract labs. The PCB analytical results of this round of samples are presented in Figure 18. Twenty-nine congeners were used for this comparison.

Figure 18: PCB Average Percent Deviation from NIST SRM 1944

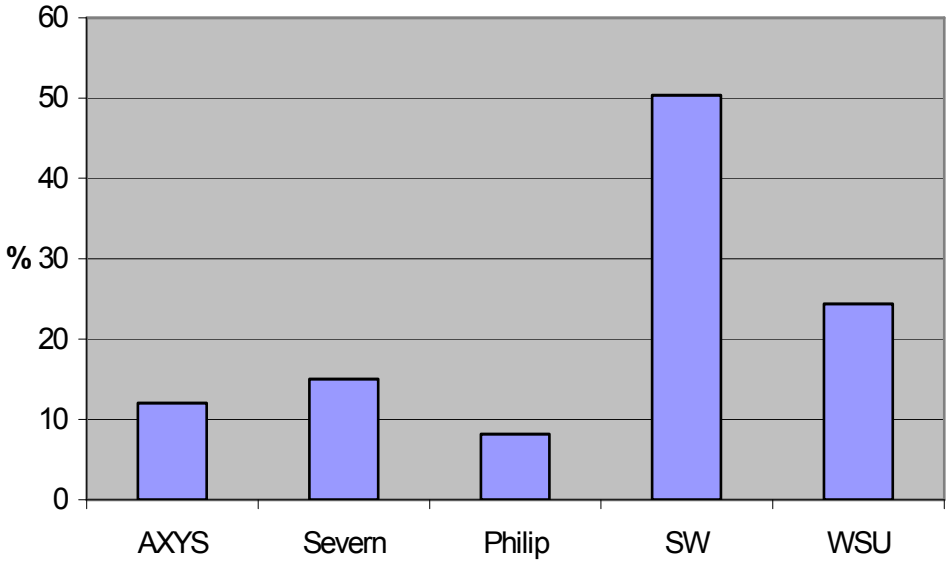
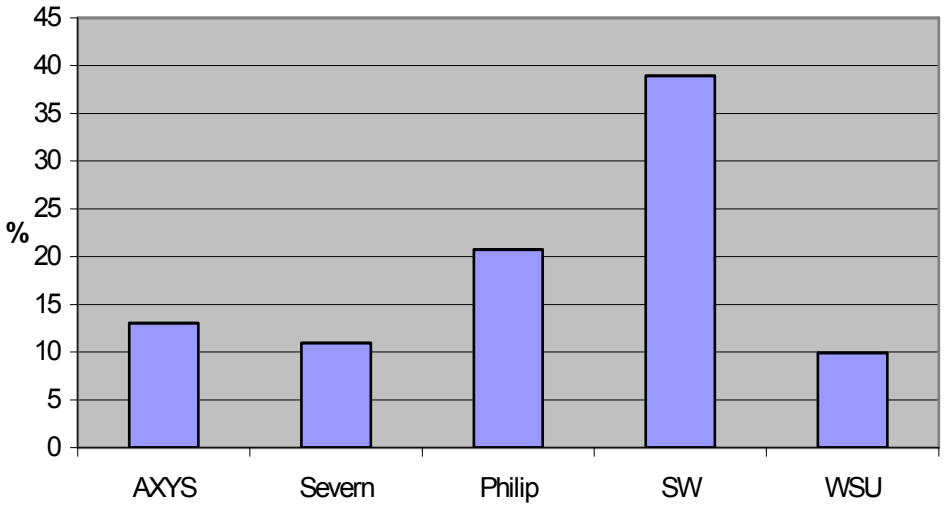


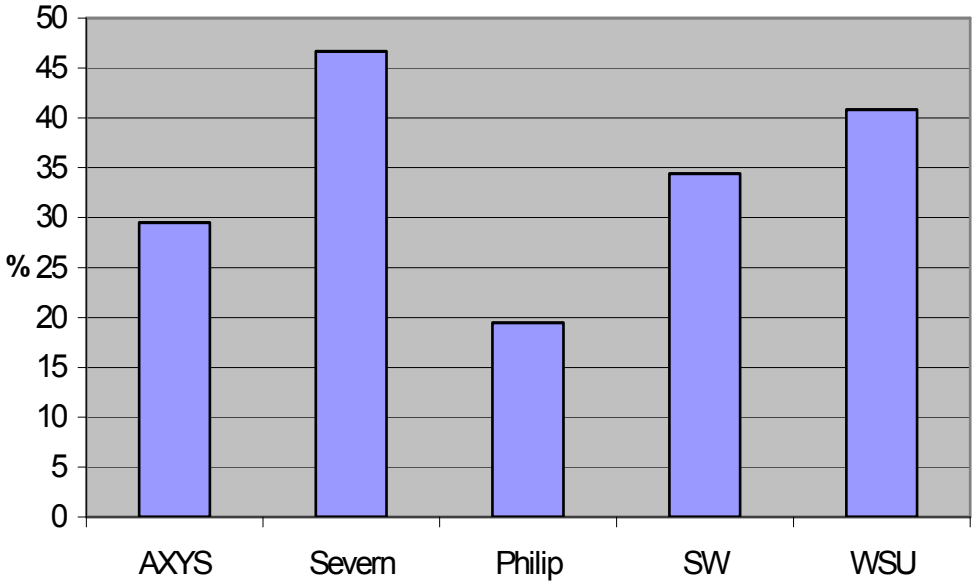
Figure 19 shows the percent deviation for dioxin/furans for the NIST reference standard. Seven dioxin and ten furan congeners were compared.

Figure 19: Dioxin/Furan Percent Deviation from NIST SRM 1944



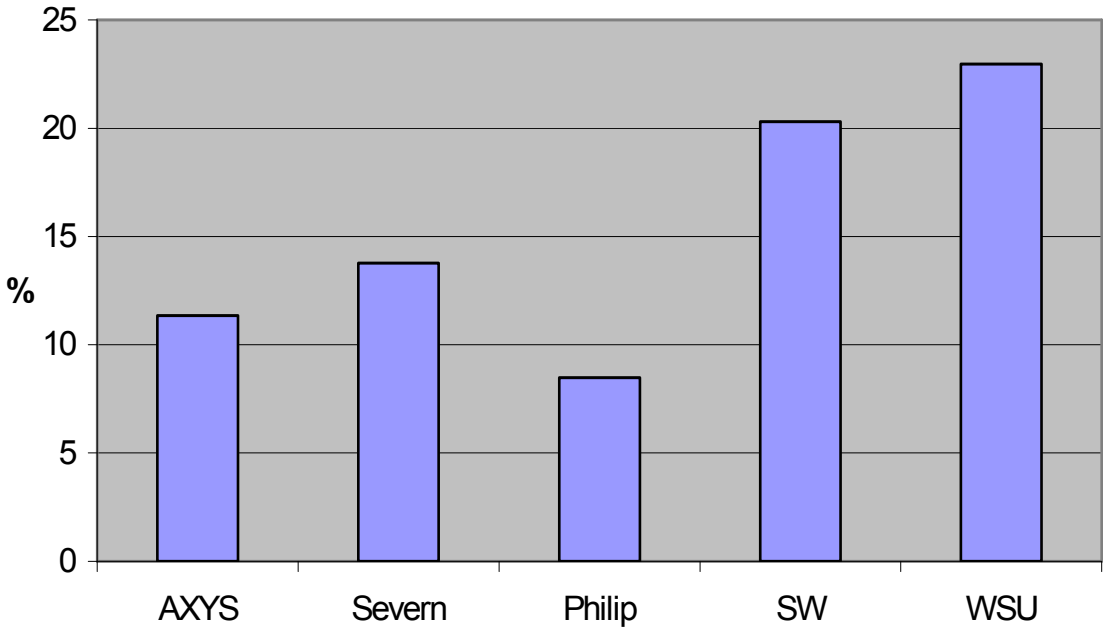
The pesticide data are shown in Figure 20 for eleven compounds that were measured in the NIST reference samples.

Figure 20: Pesticide Percent Deviation from NIST SRM 1944



The PAH data is shown in Figure 21 for eight compounds.

Figure 21: PAH Percent Deviation from NIST SRM 1944



An ongoing precision and recovery study was evaluated using a homogenized sediment sample that was collected on the east side of Prall's Island in the Arthur Kill. Approximately 38 liters of surficial sediments were homogenized for 15 minutes in a plastic cement mixer and transferred to precleaned 40-ml vials. These samples were submitted to each of the labs at the beginning of the project and during the water and sediment sampling project.

The results for the PCB were presented by DEC staff at EPA's 22nd Annual National Conference on Managing Environmental Quality Systems in 2003 entitled "How to Get Good Science from a Cement Mixer: Measuring the Precision and Accuracy of Method 1668A[vi]".

An equipment blank was run during sediment sampling project. Two blanks were submitted and analyzed for all metals and organics in 2000. The results are presented below.

RESULTS

GRAIN SIZE

Only surficial sediment samples were analyzed for grain size. Sixty-two samples were collected and analyzed for grain size at two laboratories over the project period. The results were adjusted to reflect the differences in reporting values. Total organic carbon (TOC) is shown on the graphs to assist in sediment characterization. The results are reported by *sampleID* for each basin and are found in figures 18 through 25.

In general, the more fine grained material, the higher the organic carbon and the greater the ability of contaminants to adhere to them.

Figure 22: Grain Size - Hudson River

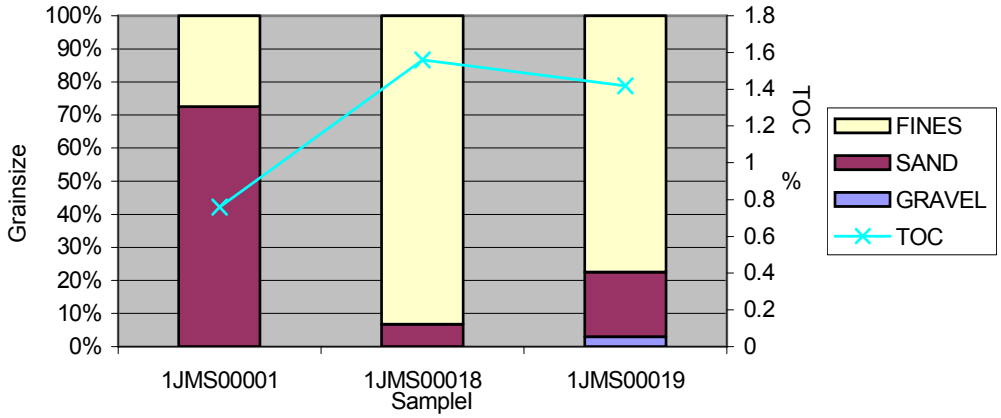


Figure 23: Grain Size - Jamaica Bay

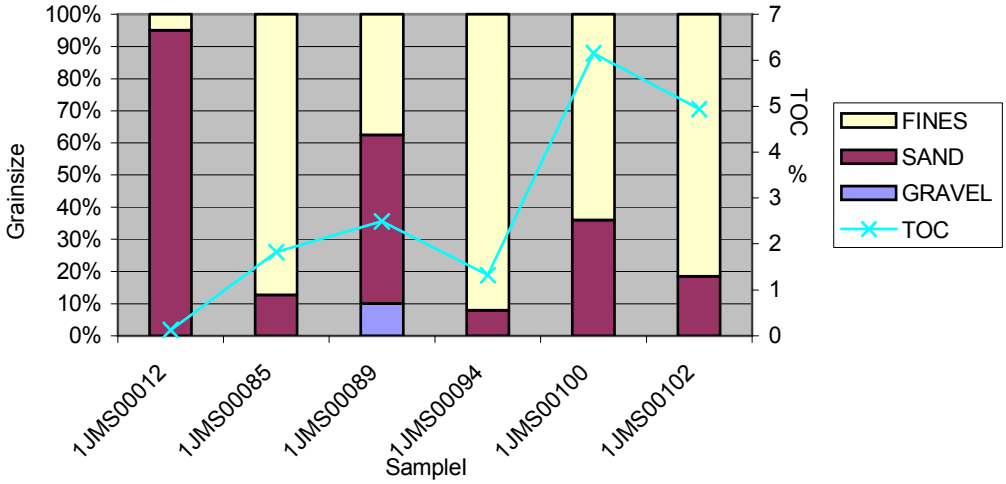


Figure 24: Grain Size - Lower Harbor

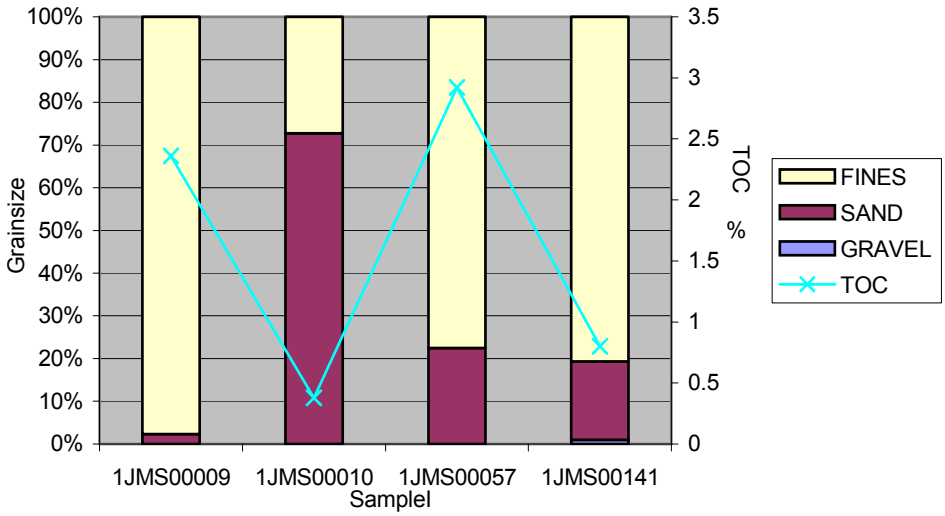


Figure 25: Grain Size - Long Island Sound

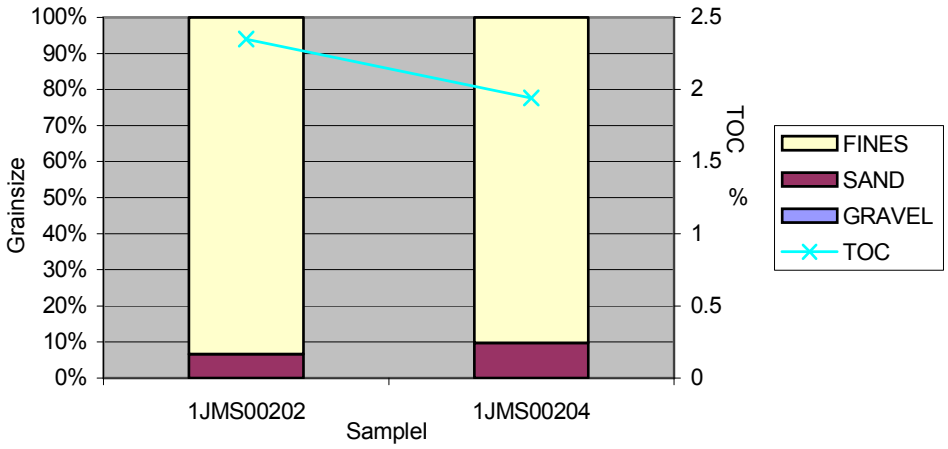


Figure 26: Grain Size - Newark Bay

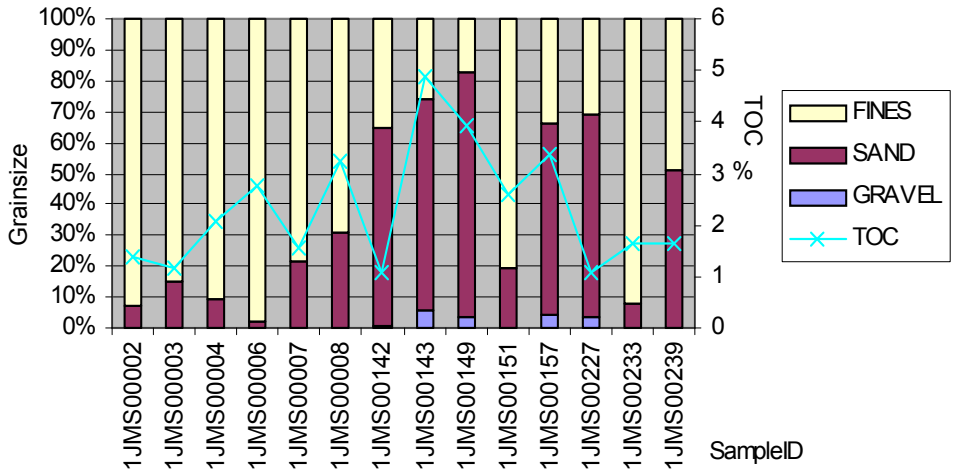


Figure 27: Grain Size - NY Bight

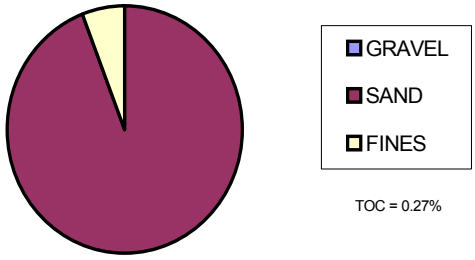


Figure 28: Grain Size - Upper Harbor

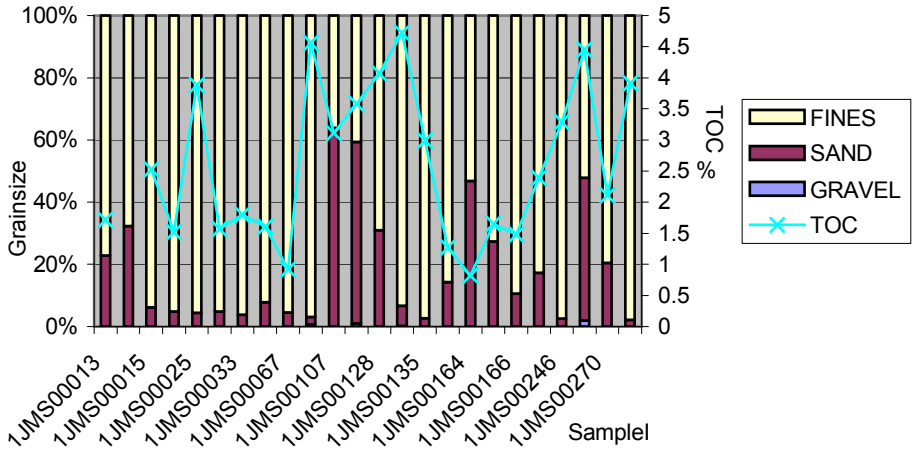
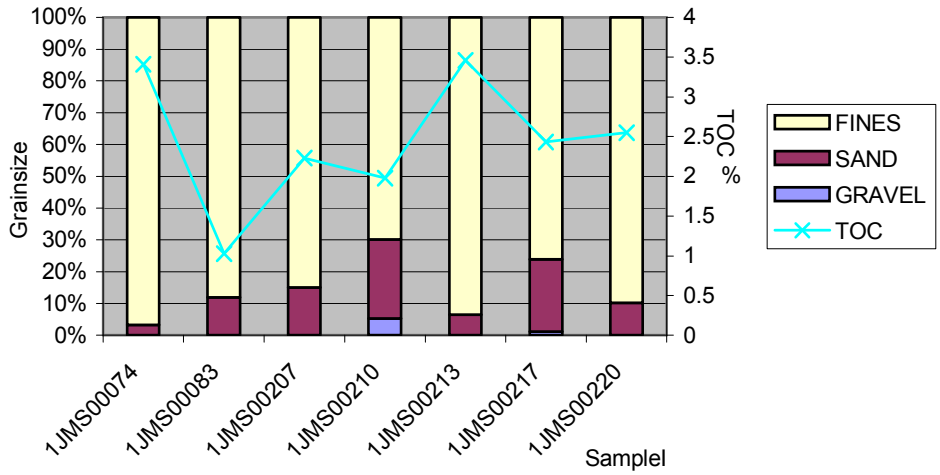


Figure 29: Grain Size - Western Long Island



Total organic carbon varies from a high of six percent in Jamaica Bay to less than 0.3 percent in the Bight Apex. The average TOC for all samples was 2.4 percent. Average grain size and TOC by basin are presented in Table 6 (the number in parenthesis is the number of samples). Excluding the Bight Apex, the Hudson River basin had the lowest mean TOC value (1.2 %), while Jamaica Bay, Long Island Sound, Newark Bay, Upper Harbor and Western Long Island Sound each had a mean TOC greater than 2%.

Table 6: Mean Grain Size and TOC Data by Basin

Basin	AVERAGE (%)			
	GRAVEL	SAND	FINES	TOC
HR (3)	1.	32.9	66.1	1.2
JB (6)	1.7	37.4	60.9	2.8
LH (5)	0.2	27.2	72.5	1.7
LIS (2)	0.	8.2	91.8	2.1
NB (14)	1.2	35.	63.7	2.3
NYBA (1)	0.	93.7	5.8	0.3
UH (23)	0.2	18.4	81.4	2.6
WLIS (8)	0.8	12.4	86.8	2.5

TOXICITY

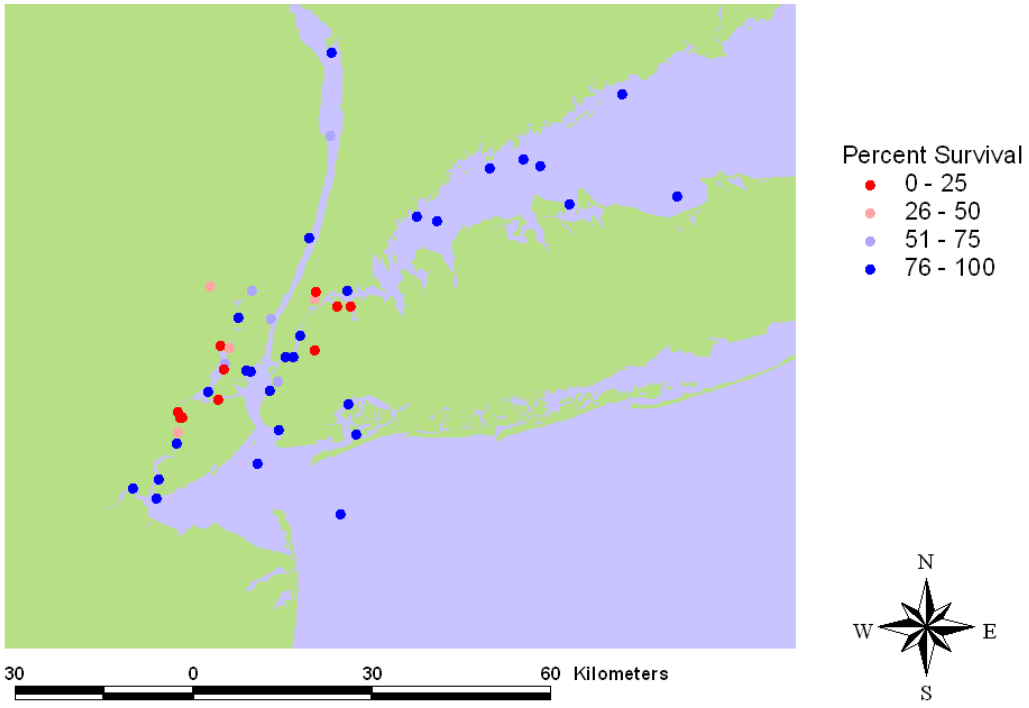
Fifty-two sediment samples were collected for toxicity testing for this project. The sites were selected to represent each of the basins and varied habitats within the basins. In the first year, two marine test species (amphipod and polychaete) were used for chronic whole sediment toxicity testing. In the following three years, only the amphipod test was used as it was judged more sensitive than the polychaete test.

The results by sub-basin (Table 7) show that Newark Bay had the lowest mean survival percentage, followed by the Upper Harbor. Within the Upper Harbor basin, the lowest survival was found in Newtown Creek, Harlem River, Bowery Bay and Flushing Bay. The results show little toxicity in the Lower Harbor, Jamaica Bay, or Long Island Sound basins. Figure 26 illustrates the survival rates for the harbor.

Table 7: Toxicity Results Summarized by Basin

Basin	Number Samples	Number < 50% Survival	Avg. Percent Survival
HR	2.	0.	75.5
JB	2.	0.	94.
LH	5.	0.	91.6
LIS	2.	0.	96.
NB	14.	9.	36.6
NYBA	1.	0.	97.
UH	15.	5.	60.
WLIS	6.	0.	95.3

Figure 30: Harbor Toxicity



The results for all tests are shown in Table 8. The polychaete test results in 1998 showed 100 percent survival in the 20-day test at all three sampling sites, while the 10-day amphipod indicated severe toxicity at the Arthur Kill site (AK001). The results also show that for the samples analyzed on August 3, 1999 and October 26, 2000, the laboratory control sediment had an 86 and 89 percent survival rate, respectively. Although these are below the 90 percent sediment control that the methods require for test acceptability, the results are still provided below and highlighted.

Table 8: Toxicity Test Results

Samp_ID	Basin	Station_ID	Latitude	Longitude	Mean Survival		Analysis Date	Species	Collection Date
6JMS00001	NB	AK001	40.6145	-74.1971	100		10/22/1998	Neanthes a.	9/22/1998
6JMS00001	NB	AK001	40.6145	-74.1971	1	*	10/12/1998	Ampelisca a.	9/22/1998
6JMS00021	NB	NB901	40.6962	-74.1103	100		10/22/1998	Neanthes a.	9/24/1998
6JMS00021	NB	NB901	40.6962	-74.1103	73	*	10/12/1998	Ampelisca a.	9/24/1998
6JMS00031	UH	UB001	40.6855	-74.0679	100		10/22/1998	Neanthes a.	9/23/1998
6JMS00031	UH	UB001	40.6855	-74.0679	95	*	10/12/1998	Ampelisca a.	9/23/1998
		Sediment Control			99		10/12/1998	Ampelisca a.	
		Sediment Control			100		10/22/1998	Neanthes a.	
1JMS00002	NB	HKA01	40.8062	-74.0563	66		8/31/1999	Ampelisca a.	7/19/1999
1JMS00003	NB	HKA05	40.7194	-74.1003	26	*	8/31/1999	Ampelisca a.	7/19/1999
1JMS00006	NB	PRA04	40.7231	-74.1197	11	*	8/3/1999	Ampelisca a.	7/13/1999
1JMS00007	NB	NBA06	40.6875	-74.1136	0	*	8/3/1999	Ampelisca a.	7/13/1999
1JMS00008	NB	AKA07	40.6150	-74.2008	0	*	8/3/1999	Ampelisca a.	7/13/1999
1JMS00009	LH	RBA08	40.4939	-74.2492	81		8/3/1999	Ampelisca a.	7/13/1999
1JMS00015	UH	LIA14	40.7808	-73.8872	1	*	8/3/1999	Ampelisca a.	7/14/1999
1JMS00017	UH	HRA16	40.7628	-74.0192	64		8/3/1999	Ampelisca a.	7/14/1999
1JMS00018	HR	HRA17	41.0389	-73.8964	64		8/31/1999	Ampelisca a.	7/20/1999
1JMS00019	HR	HRA18	41.1636	-73.8906	87		8/31/1999	Ampelisca a.	7/20/1999
		Sediment Control			86		8/3/1999	Ampelisca a.	
1JMS00004	NB	PRA02	40.8141	-74.1375	27	*	9/13/1999	Ampelisca a.	8/23/1999
1JMS00012	JB	JBA11	40.5871	-73.8526	96		9/13/1999	Ampelisca a.	8/24/1999
1JMS00010	LH	LBA09	40.5450	-74.0486	100		9/13/1999	Ampelisca a.	8/24/1999
1JMS00011	NYBA	BIA10	40.4670	-73.8839	97		9/13/1999	Ampelisca a.	8/24/1999
1JMS00013	UH	UBA12	40.6831	-74.0597	82	*	9/13/1999	Ampelisca a.	8/24/1999
1JMS00014	UH	ERA13	40.7047	-73.9911	95		9/13/1999	Ampelisca a.	8/25/1999
1JMS00016	WLIS	LIA15	40.9084	-73.6852	98		9/13/1999	Ampelisca a.	8/25/1999
		Sediment Control			98		9/13/1999	Ampelisca a.	
1JMS00033	UH	ER1	40.7924	-73.9296	31	*	7/10/2000	Ampelisca a.	6/19/2000
1JMS00025	UH	ER3	40.7800	-73.8589	1	*	7/10/2000	Ampelisca a.	6/19/2000
1JMS00030	UH	ER4	40.8044	-73.8658	88		7/10/2000	Ampelisca a.	6/19/2000
1JMS00057	LH	RR1	40.5096	-74.2944	92		7/10/2000	Ampelisca a.	6/20/2000
1JMS00067	UH	UB1	40.6544	-74.0223	94		7/10/2000	Ampelisca a.	6/21/2000
1JMS00089	JB	JB1	40.6330	-73.8670	92		7/10/2000	Ampelisca a.	6/22/2000
		Sediment Control			96		7/10/2000	Ampelisca a.	
1JMS00127	UH	HLR01	40.8029	-73.9280	1	*	10/26/2000	Ampelisca a.	8/29/2000
1JMS00128	UH	NTC01	40.7150	-73.9316	0	*	10/26/2000	Ampelisca a.	8/29/2000
1JMS00134	UH	NTC04	40.7365	-73.9605	79	*	10/26/2000	Ampelisca a.	8/29/2000
1JMS00135	UH	GWB01	40.6689	-74.0059	74	*	10/26/2000	Ampelisca a.	8/29/2000
1JMS00141	LH	ARK01	40.5227	-74.2452	91		10/26/2000	Ampelisca a.	8/30/2000
1JMS00149	NB	ARK05A	40.5769	-74.2085	82		10/26/2000	Ampelisca a.	8/30/2000
1JMS00150	NB	ARK06	40.5937	-74.2055	40	*	10/26/2000	Ampelisca a.	8/30/2000
1JMS00151	NB	ARK07	40.6242	-74.2042	12	*	10/26/2000	Ampelisca a.	8/30/2000
1JMS00157	NB	KVK01	40.6419	-74.1247	0	*	10/26/2000	Ampelisca a.	8/30/2000
		Sediment Control			89		10/26/2000	Ampelisca a.	
1JMS00204	LIS	LIS2C	40.9380	-73.2055	98		11/9/2001	Ampelisca a.	10/30/2001
1JMS00207	WLIS	LIS3C	40.9301	-73.4195	99		11/9/2001	Ampelisca a.	10/30/2001
1JMS00210	WLIS	LIS4C	40.9992	-73.5111	95		11/9/2001	Ampelisca a.	10/30/2001
1JMS00217	WLIS	LIS6C	40.9156	-73.7252	90		11/9/2001	Ampelisca a.	10/30/2001
1JMS00220	WLIS	LIS7C	40.9866	-73.5772	92		11/9/2001	Ampelisca a.	10/30/2001
1JMS00223	WLIS	LIS8C	40.9887	-73.4778	98		11/9/2001	Ampelisca a.	10/30/2001
1JMS00225	LIS	LIS9C	41.0939	-73.3109	94		11/9/2001	Ampelisca a.	10/30/2001
		Sediment Control			96		11/9/2001	Ampelisca a.	
1JMS00244	NB	HACK01	40.7650	-74.0828	91		11/23/2001	Ampelisca a.	11/13/2001
1JMS00245	NB	NWB01	40.6542	-74.1438	83	*	11/23/2001	Ampelisca a.	11/13/2001
1JMS00270	LH	LB01	40.5945	-74.0051	94		11/23/2001	Ampelisca a.	11/14/2001
1JMS00246	UH	HR001	40.8841	-73.9398	97		11/23/2001	Ampelisca a.	11/14/2001
1JMS00275	UH	UBWB01	40.7053	-73.9749	97		11/23/2001	Ampelisca a.	11/14/2001
		Sediment Control			100		11/23/2001	Ampelisca a.	

RADIO DATING RESULTS

Twenty-two sediment cores were collected over the four-year period for radio dating. Sediment samples were analyzed for beryllium^{7} and cesium^{137}. Beryllium^{7} is a

naturally occurring nuclide that decays quickly. Ideally, the beryllium would be high in the top couple of centimeters on newly deposited sediments and will not be detected in older (> 6 months) sediments. The cesium^{137} isotope is an historical tracer of atmospheric fallout from aboveground nuclear testing in the 50s and early 60s. The first date that cesium^{137} is detectable in layered sediments is 1954 and the peak concentration is found in 1963. The radioisotope is useful in determining if a site has chronological deposition and therefore is capable of presenting a historical contamination timeline.

Some of the radio dating results are shown in figures 27 to 30. What is apparent from the data is that there are many disruptions to the depositional record at most of the sites sampled, such as UB001(fig. 30). The cores at AK001 and ER3, which showed reasonably good depositional records, were the exception. The lack of good chronological or undisturbed depositional records at many of the sites may be associated with nearby dredging activities, storm events, and/or boat traffic.

Only ten of the twenty-eight sediment cores submitted for radio dating have been completed. The remaining eighteen have had only one or two of the top segments dated.

Figure 31: Cesium Radio Dating Profile - Arthur Kill (AK001)

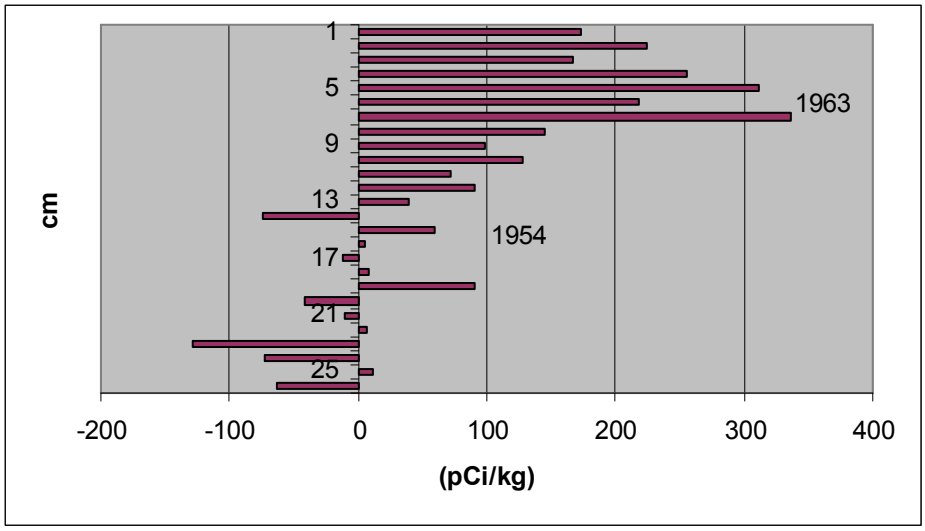


Figure 32: Cesium Radio Dating Profile - Newark Bay (NB901)

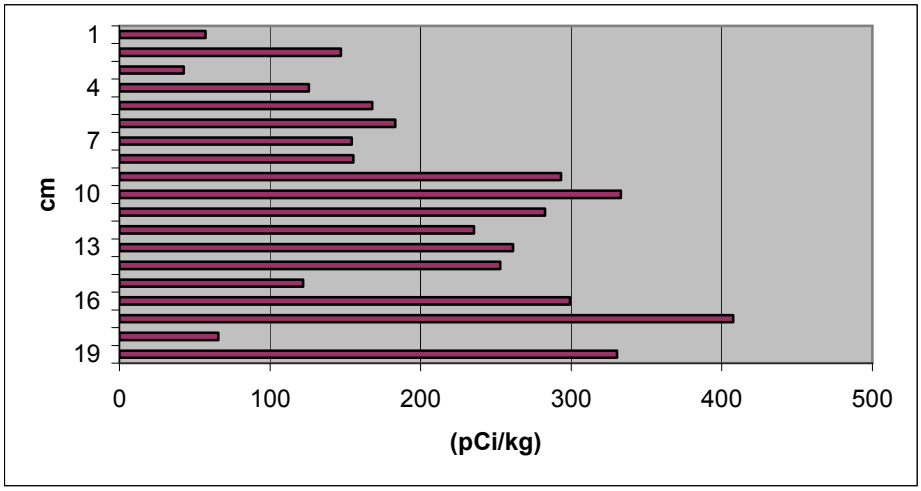


Figure 33: Cesium Radio Dating Profile - East River near Flushing Bay (ER3)

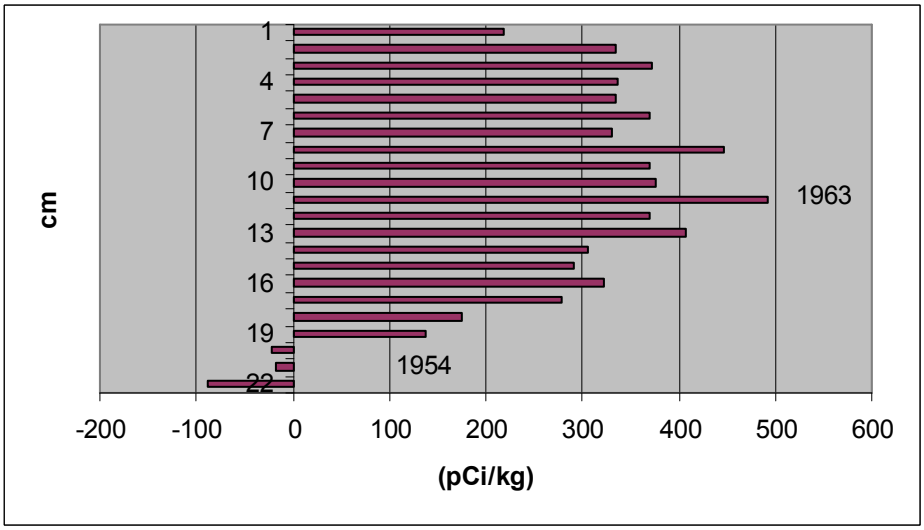
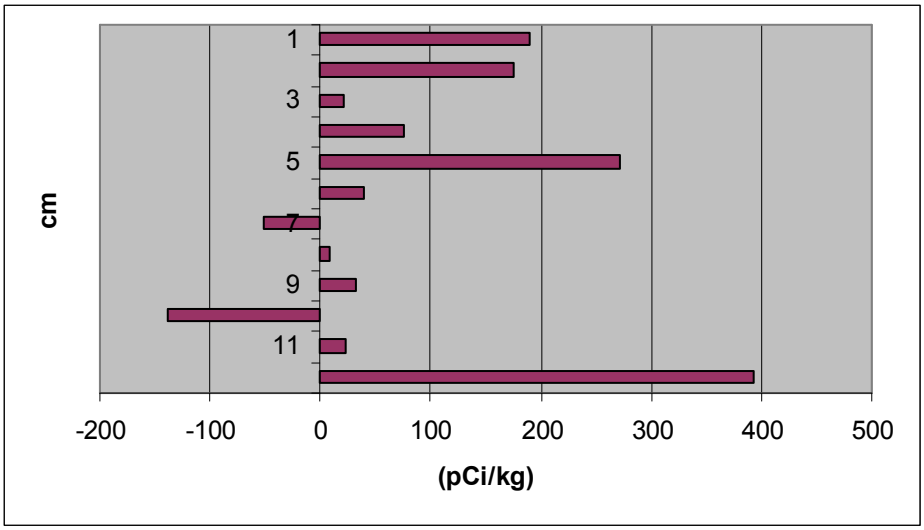


Figure 34: Cesium Radio Dating Profile - Upper Harbor (UB001)



METALS

The following ten metals have associated ERL and ERM marine/estuary guidance numbers: antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc. For this study, antimony was not evaluated since it was not detected in most samples. Mean and maximum metals results were calculated for the surficial samples and are presented in Table 9 (the highest mean and maximum data are shown in bold for each metal).

Table 9: Metals: Mean and Maximum by Basin for Surficial Samples (ppm)

Basin		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
HR (3)	Mean	6.77	0.91	45.47	51.7	51.77	0.45	22.9	2.25	134.5
	Max	10.2	1.3	71.3	89.6	84.	0.83	27.9	3.4	167.
JB (6)	Mean	8.72	1.27	43.13	65.63	72.05	0.56	18.47	2.13	153.17
	Max	16.9	1.8	74.4	117.	128.	0.84	28.	3.	238.
LH (10)	Mean	18.7	1.11	74.87	109.1	106.69	1.33	28.22	2.74	237.36
	Max	35.3	2.2	155.	208.	196.	2.7	37.8	5.1	427.
LIS (3)	Mean	9.2	0.39	66.27	79.27	39.97	0.26	25.	0.47	153.
	Max	9.6	0.43	73.1	88.1	48.7	0.3	29.8	0.65	195.
NB(23)	Mean	**23.15**	2.78	**120.64**	236.29	**223.83**	**3.94**	42.09	3.09	388.13
	Max	**117.**	14.8	349.	959.	**1,100.**	**28.2**	119.	8.7	2,490.
NYBA (1)	Mean	5.3	0.65	9.2	4.	11.9	0.04	6.4	0.12	25.3
	Max									
UH (33)	Mean	16.24	**5.33**	113.42	**294.09**	221.34	1.87	**59.72**	**6.09**	**433.06**
	Max	51.1	**81.4**	**497.**	**2,850.**	898.	7.	**368.**	**19.6**	**3,160.**
WLIS (9)	Mean	9.37	1.01	70.94	104.47	72.54	0.58	27.	1.91	202.44
	Max	13.3	1.9	95.1	183.	133.	1.7	33.3	5.4	273.

The numbers of surficial samples with levels exceeding the ERL, ERM and 5x ERM, ("hotspot"), are listed in Table 10. The number in parenthesis is the number of

samples per basin. Table 11 shows the number of exceedances for all samples (cores and surficials).

Table 10: Metals exceeding ERL, ERM and 5 times ERM for Surficial Samples

		HR (3)	JB (6)	LH (10)	LIS (3)	NB (24)	NYBA (1)	UH (33)	WLIS (9)
Arsenci	ERL	1	4	9	3	19	0	26	6
	ERM	0	0	0	0	2	0	0	0
	5X ERM	0	0	0	0	0	0	0	0
Cadmium	ERL	1	3	2	0	14	0	14	3
	ERM	0	0	0	0	1	0	3	0
	5X ERM	0	0	0	0	0	0	1	0
Chromium	ERL	0	0	3	0	18	0	18	2
	ERM	0	0	0	0	0	0	1	0
	5X ERM	0	0	0	0	0	0	0	0
Copper	ERL	2	4	9	3	17	0	27	9
	ERM	0	0	0	0	6	0	6	0
	5X ERM	0	0	0	0	0	0	2	0
Lead	ERL	2	4	9	1	16	0	24	7
	ERM	0	0	0	0	5	0	9	0
	5X ERM	0	0	0	0	1	0	0	0
Mercury	ERL	1	4	1	3	1	0	1	6
	ERM	1	1	8	0	22	0	32	2
	5X ERM	0	0	0	0	9	0	4	0
Nickel	ERL	2	4	9	3	19	0	28	8
	ERM	0	0	0	0	5	0	5	0
	5X ERM	0	0	0	0	0	0	2	0
Silver	ERL	2	4	8	0	14	0	12	1
	ERM	0	0	1	0	7	0	21	2
	5X ERM	0	0	0	0	0	0	1	0
Zinc	ERL	1	4	7	1	16	0	25	8
	ERM	0	0	1	0	4	0	6	0
	5X ERM	0	0	0	0	1	0	1	0

Table 11: Metals exceeding ERL, ERM and 5 times the ERM for all Samples (Surficial and Cores)

		HR (3)	JB (23)	LH (32)	LIS (7)	NB (60)	NYBA (1)	UH (100)	WLIS (24)
Arsenic	ERL	1	20	27	6	33	0	85	17
	ERM	0	0	3	0	10	0	4	0
	5X ERM	0	0	0	0	0	0	0	0
Cadmium	ERL	1	15	12	0	33	0	53	10
	ERM	0	1	0	0	2	0	12	0
	5X ERM	0	0	0	0	0	0	4	0
Chromium	ERL	0	9	15	0	38	0	63	6
	ERM	0	0	0	0	2	0	7	0
	5X ERM	0	0	0	0	0	0	0	0
Copper	ERL	2	17	24	7	29	0	65	21
	ERM	0	2	4	0	16	0	27	1
	5X ERM	0	0	0	0	0	0	6	0
Lead	ERL	2	17	24	2	24	0	46	16
	ERM	0	2	5	0	19	0	46	1
	5X ERM	0	0	0	0	1	0	1	0
Mercury	ERL	1	8	5	7	1	0	5	15
	ERM	1	12	25	0	45	0	90	5
	5X ERM	0	0	5	0	25	0	24	0
Nickel	ERL	2	19	28	7	36	0	77	21
	ERM	0	2	0	0	8	0	22	0
	5X ERM	0	0	0	0	0	0	8	0
Silver	ERL	2	12	14	0	24	0	19	4
	ERM	0	7	12	0	18	0	73	6
	5X ERM	0	0	0	0	0	0	8	0
Zinc	ERL	1	17	25	4	25	0	63	19
	ERM	0	2	3	0	17	0	26	0
	5X ERM	0	0	0	0	1	0	6	0

From these summaries, it is apparent that sediments often exceed the metals ERL values, even in recently deposited sediments. The surficial sediments rarely exceed the ERM guideline values, except in Newark Bay and the Upper Harbor. In these two basins, sediments exceed the ERM for copper, lead, mercury, nickel, silver and zinc. Surficial metals concentrations greater than 5x the ERM were only found in Newark Bay and the Upper Harbor basins, with mercury being the most numerous. The maximum total mercury concentration (28.2 ppm) was found at AK001, a site north of Prall's Island in the Arthur Kill. In the Upper Harbor, the highest concentration of mercury (7.0 ppm) was found off Pier 25, which was sampled shortly after the 9/11 tragedy. Newtown Creek accounted for the highest concentrations of the remaining eight metals in surficial and core samples from the Upper Harbor.

One of the interesting findings from the sediment sampling was the concentration of silver in NY/NJ Harbor. Silver was found in all but two basins, the Bight and LIS, at concentrations greater than the ERL. In the JB, UH and LH basins, silver was the next most prevalent metal, after mercury, to exceed the ERM.

Cadmium, considered previously to be a contaminant of concern in the Harbor, was rarely found in concentrations greater than the ERM. Only two basins, NB and UH, contained levels of cadmium that exceeded the ERM.

Figures 31 to 39 show the spatial surficial sediment patterns of nine metals with respect to the ERL, ERM and 5 times the ERM. These are spatial representations of the surficial data points created using the Spatial Analyst extension in ESRI's ArcView ® mapping software. The metals data is found in Appendix A.

Figure 35: Arsenic Surficial Spatial Pattern

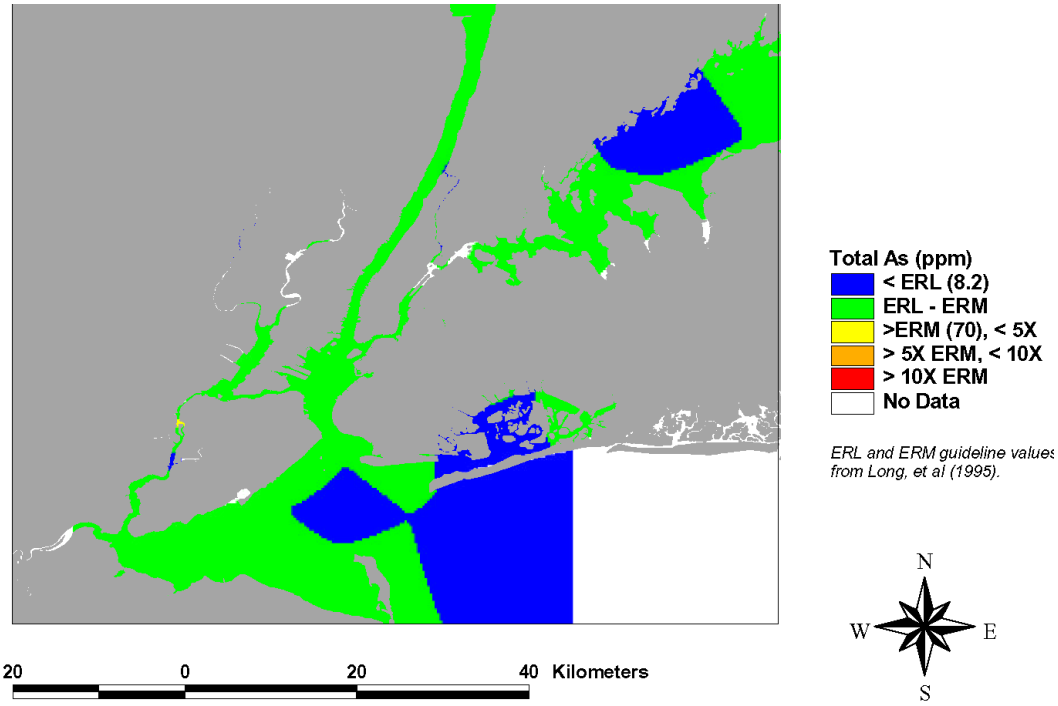


Figure 36: Cadmium Surficial Spatial Pattern

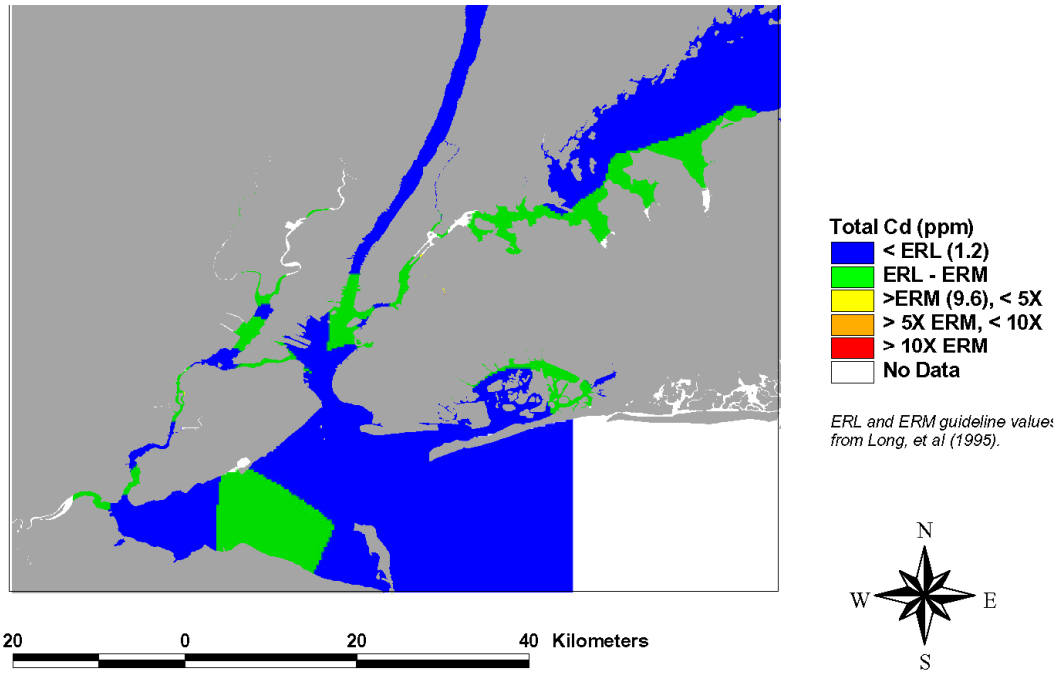


Figure 37: Chromium Surficial Spatial Pattern

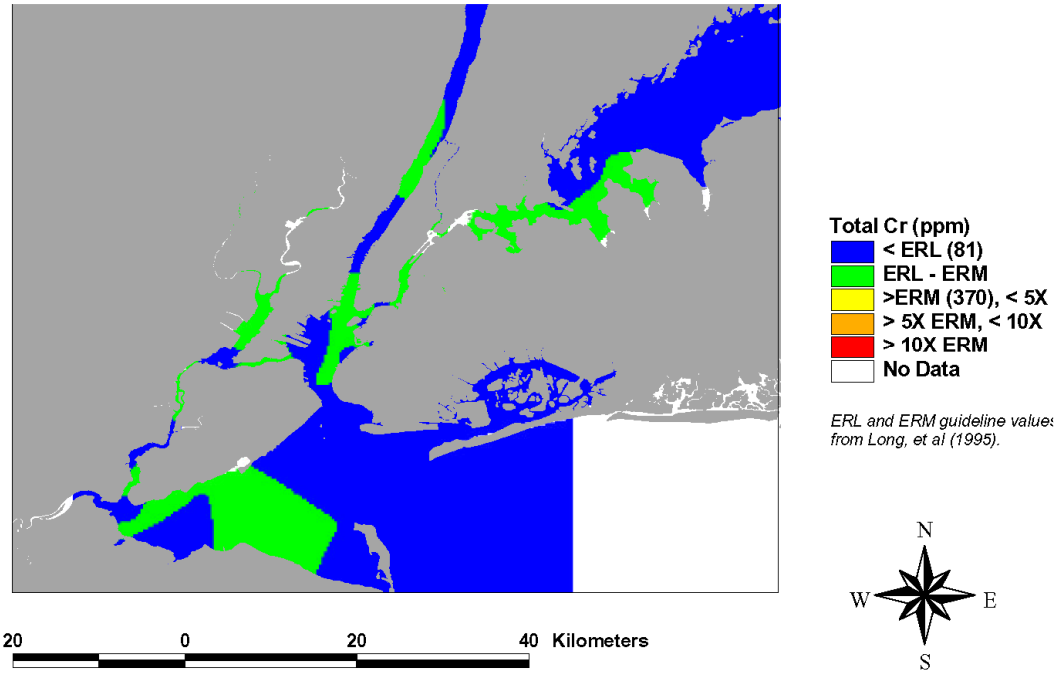


Figure 38: Copper Surficial Spatial Pattern

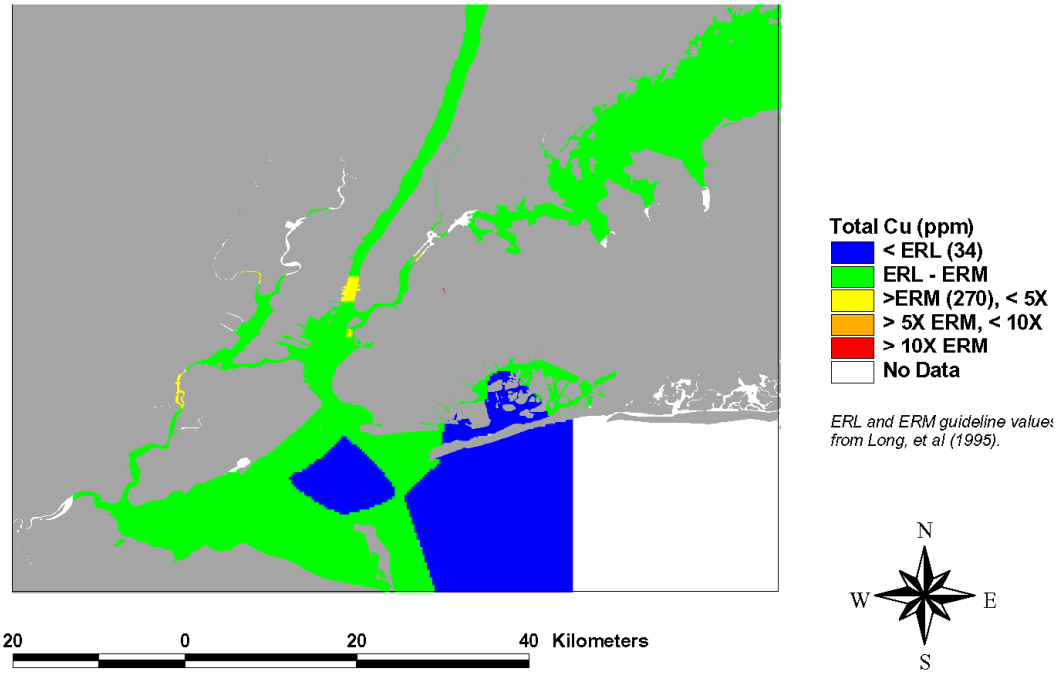


Figure 39: Lead Surficial Spatial Pattern

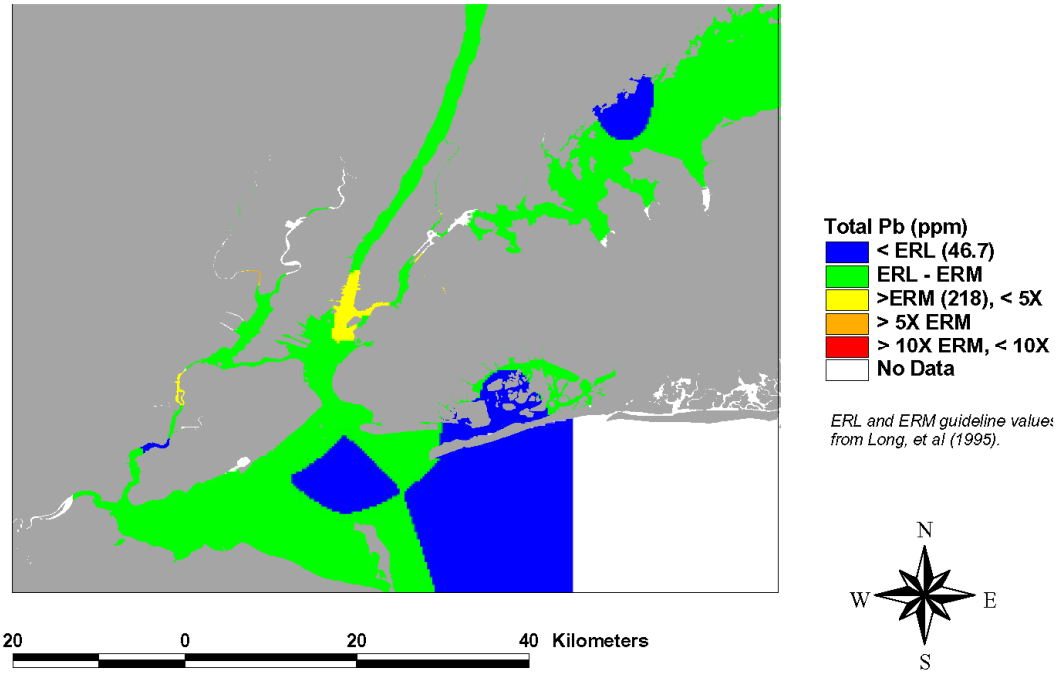


Figure 40: Total Mercury Surficial Spatial Pattern

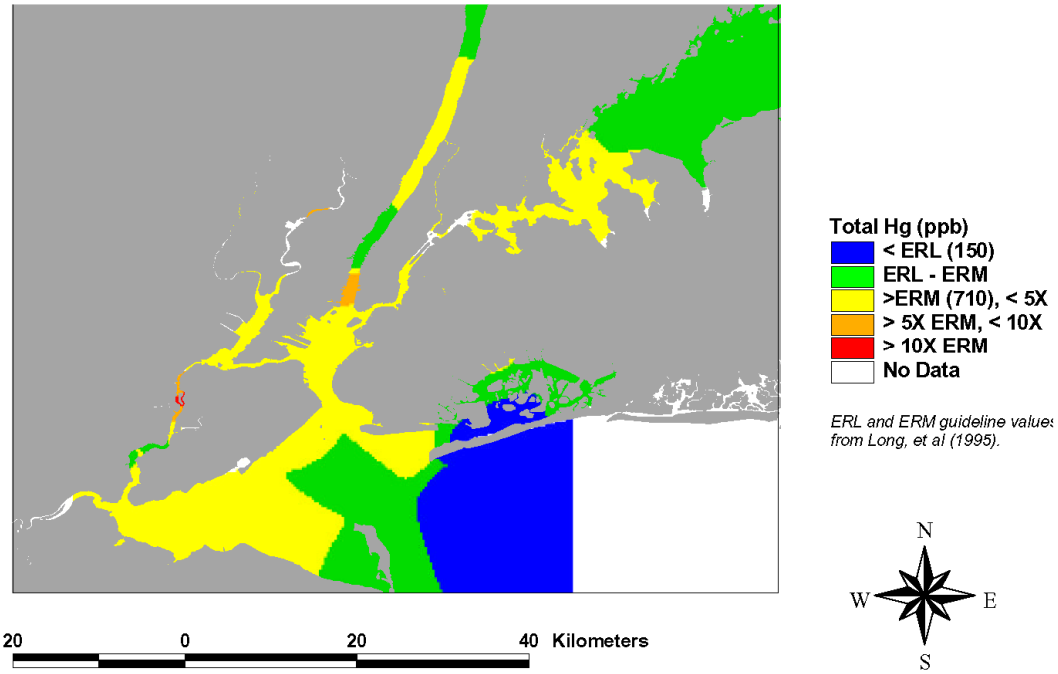


Figure 41: Nickel Surficial Spatial Pattern

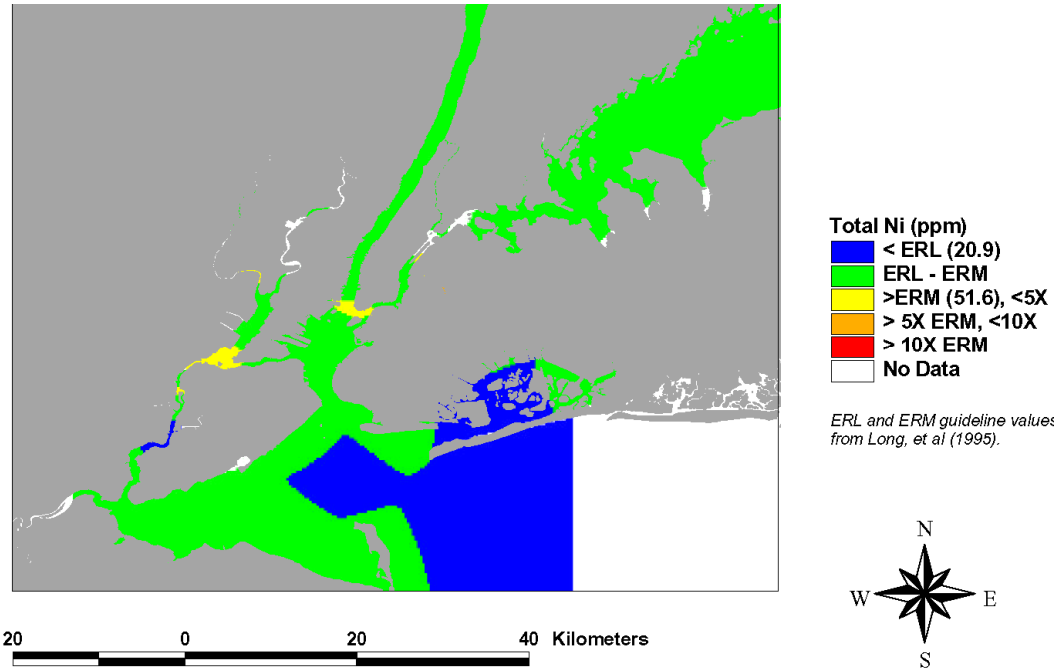


Figure 42: Silver Surficial Spatial Pattern

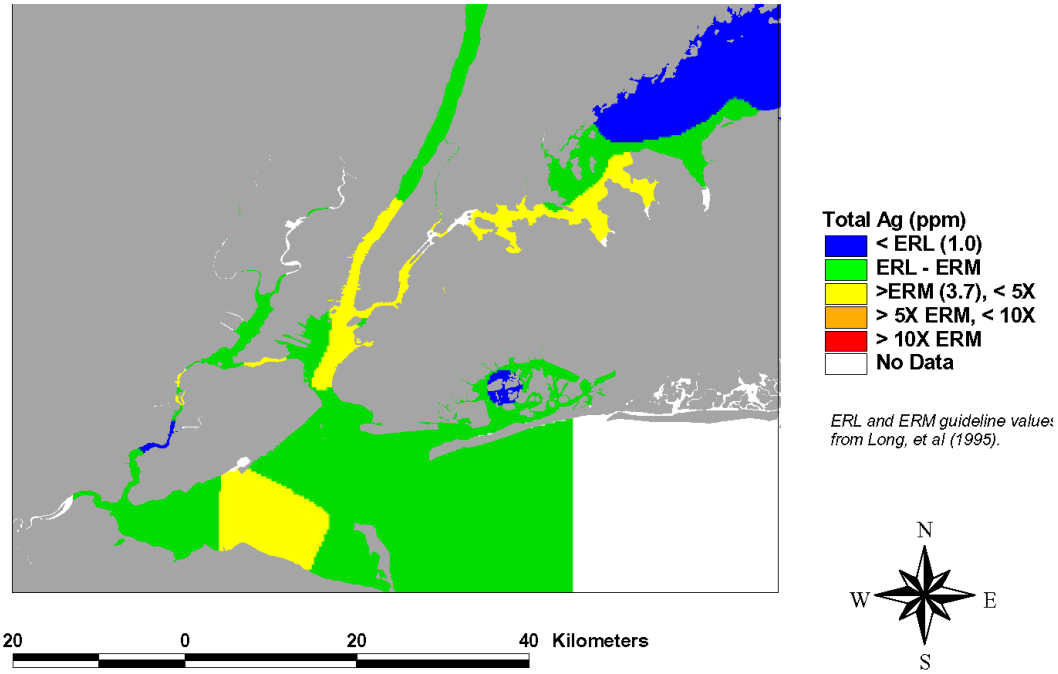
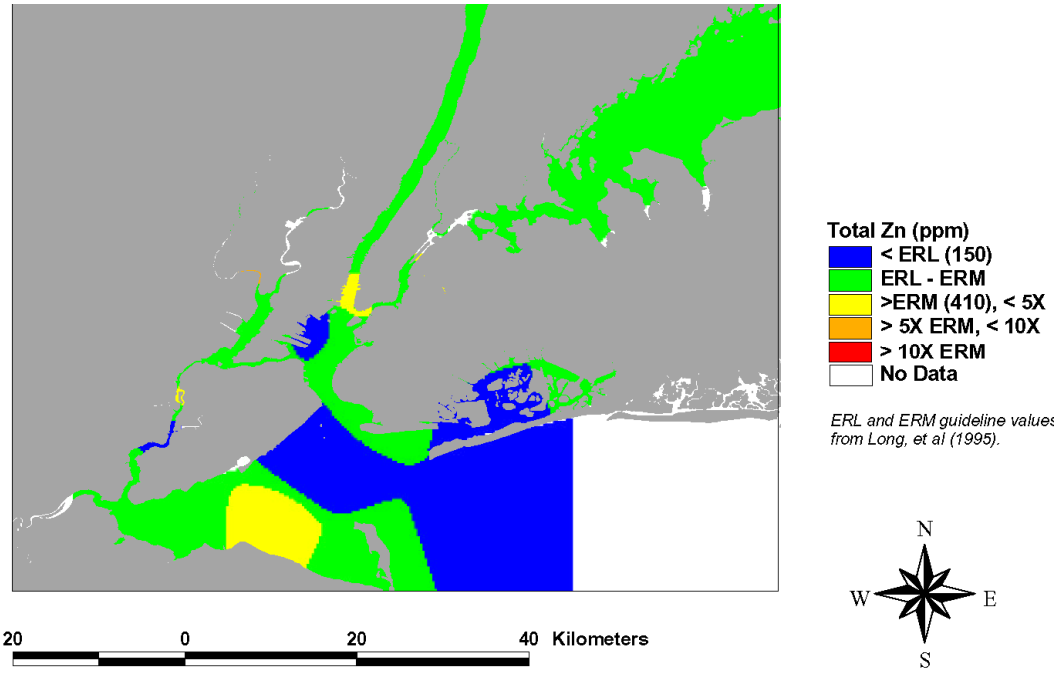


Figure 43: Zinc Surficial Spatial Pattern



Mercury and cadmium were analyzed using two methods, standard (EPA 200.7) and high-resolution (EPA 1630, 1631 and modified 1638). In the standard method, total mercury and cadmium were part of a suite of ten metals. The high-resolution methods for total mercury, methyl mercury, and cadmium were analyzed on most of the samples collected to provide low-level detection limits and the methyl fraction of mercury not found in the standard method. Table 12 gives a comparison of the results of the two methods. The comparison is for only those samples that had results greater than the detection limits. The results for the two methods correlated well to one another. One exception was a single sample where the standard method reported a concentration of 43.6 ppm while the high-resolution method reported 24 ppm.

Table 12: Comparison of Analytical Methods for Mercury and Cadmium (ppb)

Parameter	Count	Method	Mean	Std. Dev.	Min.	Max.	RPD (%)
Total Mercury	190	200.7	2,940.95	4,773.45	30.	43,600.	5.85
	190	1630	2,617.9	3,402.68	29.4	24,093.	
Total Cadmium	166	200.7	5.1	14.04	0.12	116.	7.02
	166	Modified1668	6.46	18.06	0.09	132.94	

Methyl mercury was found in highest concentrations on the surficial layer of sediments. Table 13 summarizes the data for each of the basins. No samples were analyzed from the Bight Apex. Newark Bay's average surficial concentration was twice that of the Upper Harbor. The high-resolution mercury and cadmium data are presented in Appendix B.

Table 13: Methyl Mercury Summary by Basin (ppb)

	Surf # Exceeding			All Depths # Exceeding		
Basin	Count	Mean	Max	Count	Mean	Max
HR	3	0.51	0.9	3	0.51	0.9
JB	1	1.6	1.6	2	0.92	1.6
LH	10	2.3	7.93	27	1.3	7.93
LIS	3	0.42	0.64	7	0.33	0.64
NB	20	6.49	23.2	42	4.58	23.2
NYBA	0	NA	NA	0	NA	NA
UH	29	2.67	10.93	87	1.69	10.93
WLIS	8	1.34	3.13	19	0.74	3.13

ORGANICS

The results for organics are summarized for total PCB, dioxins, pesticides, and total PAH. Individual PCB congeners, dioxin and furan congeners, PAH and pesticide values are presented in Appendix C.

PCBs

Total PCBs were found throughout the harbor in concentrations ranging from 0.001 to 39 ppm. The highest concentration found was in a surficial sample (NTC01) from Newtown Creek. The Upper Harbor had the highest average total PCB concentration due to the contributions from Newtown Creek. When four Newtown Ck. Sample results are removed from the Upper Harbor evaluation, mean total PCB concentration falls from 2,360 ppb to 930 ppb. The lowest average total PCB was in the Bight, followed by Western Long Island Sound and Jamaica Bay. Table 14 shows the mean and maximum concentrations of PCBs in each of the basins. Table 15 shows the number of samples that exceeded the ERL, ERM, and 5x ERM in each basin. Figure 40 shows the spatial distribution of surficial total PCBs.

It should be noted that only surficial samples were collected from the HR basin thus the mean and maximum data for PCBs and all subsequent organic results are the same for surficials and all depth samples for that basin.

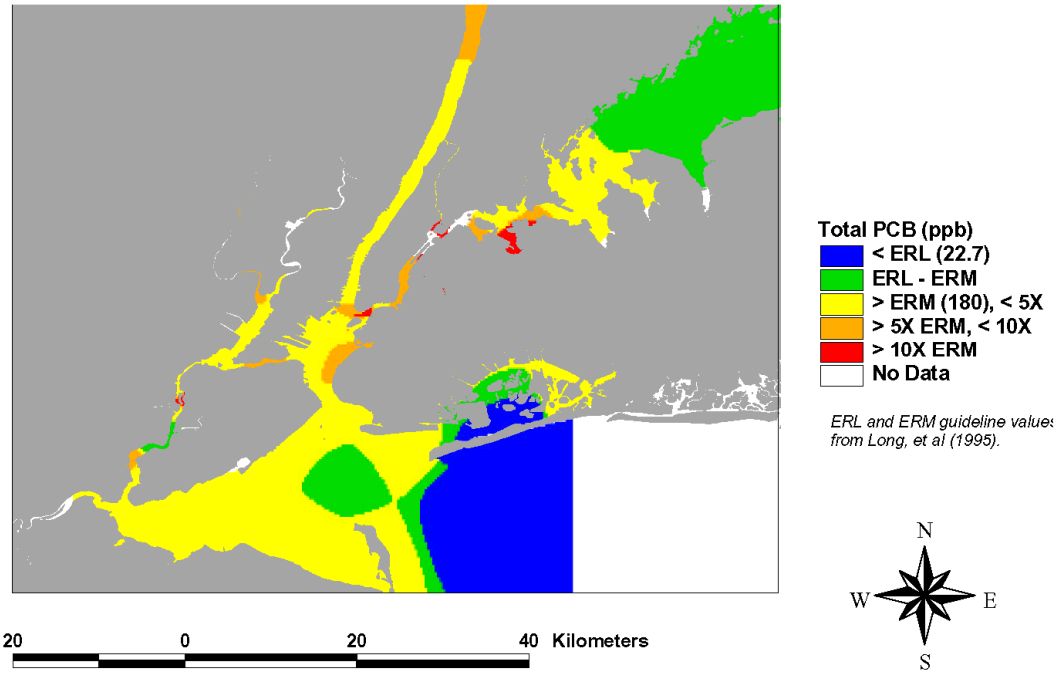
Table 14: Total PCB Summary by Basin (ppb)

	Surficial			All Depths		
Basin	Count	Mean	Max	Count	Mean	Max
HR	3	844.	1,069.5	3	844.	1,069.5
JB	6	274.3	608.1	23	512.	3,920.6
LH	10	389.7	571.8	32	490.	2,067.1
LIS	3	48.8	56.2	7	52.4	84.4
NB	25	1,193.7	3,631.6	60	1,685.5	8,450.
NYBA	1	4.5	4.5	1	4.5	4.5
UH	33	2,360.	39,908.3	100	2,388.	39,908.3
WLIS	9	147.8	466.	24	170.4	170.4

Table 15: Total PCB Exceedances of ERL, ERM and 5x ERM

Basin	Surficial # Exceeding				All Depths # Exceeding			
	Count	ERL	ERM	5X ERM	Count	ERL	ERM	5X ERM
HR	3	0	3	1	3	0	3	1
JB	6	3	1	0	23	5	17	2
LH	10	5	1	0	32	3	25	3
LIS	3	0	0	0	7	6	0	0
NB	25	12	11	6	60	4	44	24
NYBA	1	0	0	0	1	0	0	0
UH	33	22	5	1	100	3	88	51
WLIS	9	2	0	0	24	15	7	0

Figure 44: Total PCB Surficial Spatial Pattern



The comparison to ERL and ERM guidelines for the surficial data show that only two basins, LIS and NYBA, had no exceedances for PCBs. Three basins, HR, NB and UH, each had exceedances greater than 5 times the ERM on the surficial samples. Over half the results on all samples collected in the UH were greater than the PCB "hotspot" value.

The PCB homolog patterns indicate two different patterns for the dominant depositional sites. The HR showed a peak in the tri's (indicative of Aroclor 1016/1242), while the UH and NB both showed peaks in the tetra's (indicative of Aroclor 1248). Figure 41 shows the average surficial total PCB homolog pattern for each of the basins. Figure 42 shows the homolog pattern as a percent of the total, which provides more detail for the lower concentrations basins. The number in parentheses indicates the number of

samples for each basin. The patterns were similar between the surficial data and the entire dataset for each of the basins.

Figure 45: Average Surficial PCB Homolog Patterns by Basins

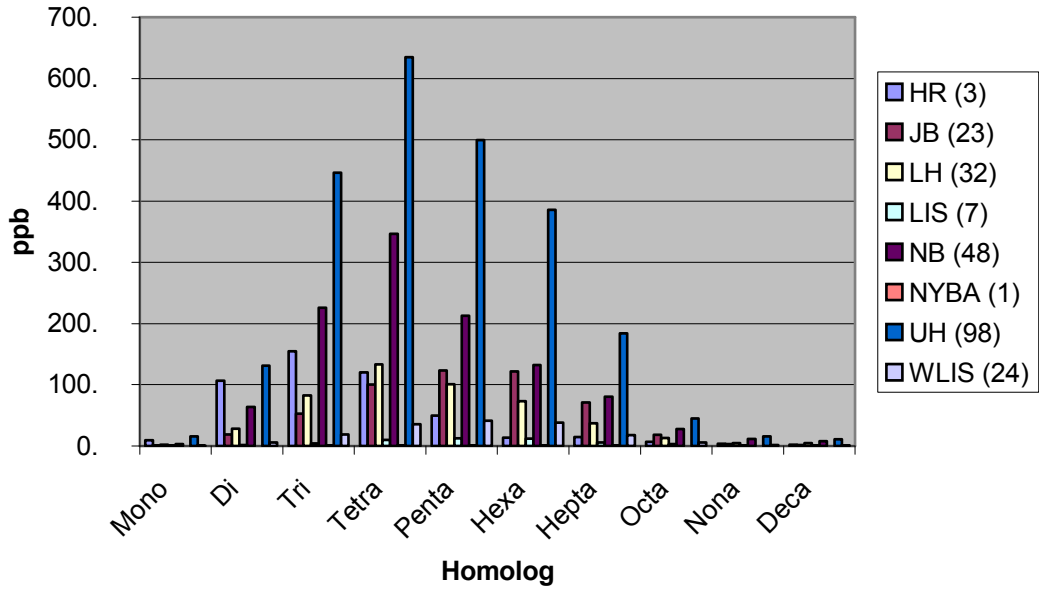
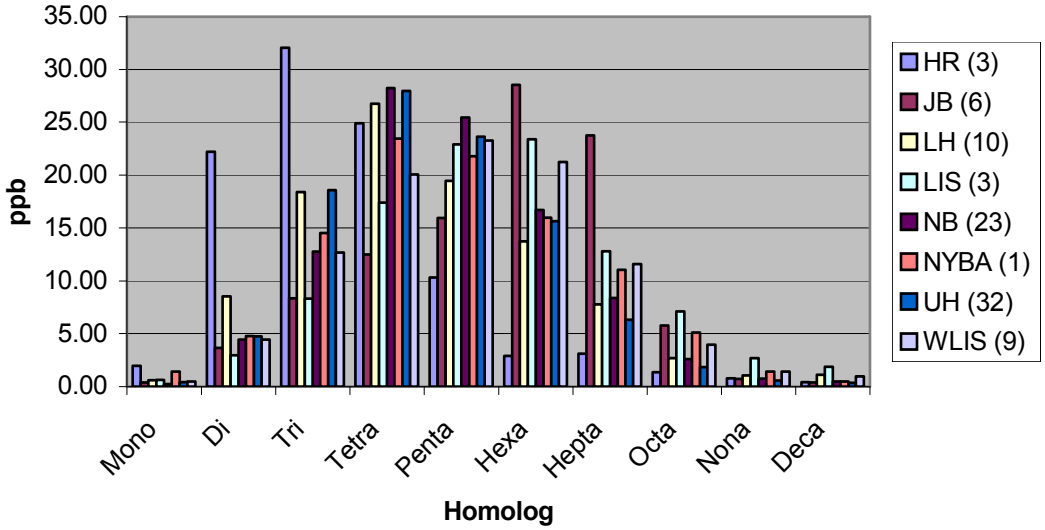


Figure 46: Average Surficial Percent PCB Homolog Patterns by Basins



The following two figures (43 and 44) show the total PCB concentrations relative to the HARS disposal guidelines (refer to Table 3). There is little difference between the surficial results and the average core values. The data show that for total PCB, most sediments sampled would likely fail to be suitable for HARS disposal.

Figure 47: Surficial Total PCB Relative to HARS Suitability Criteria

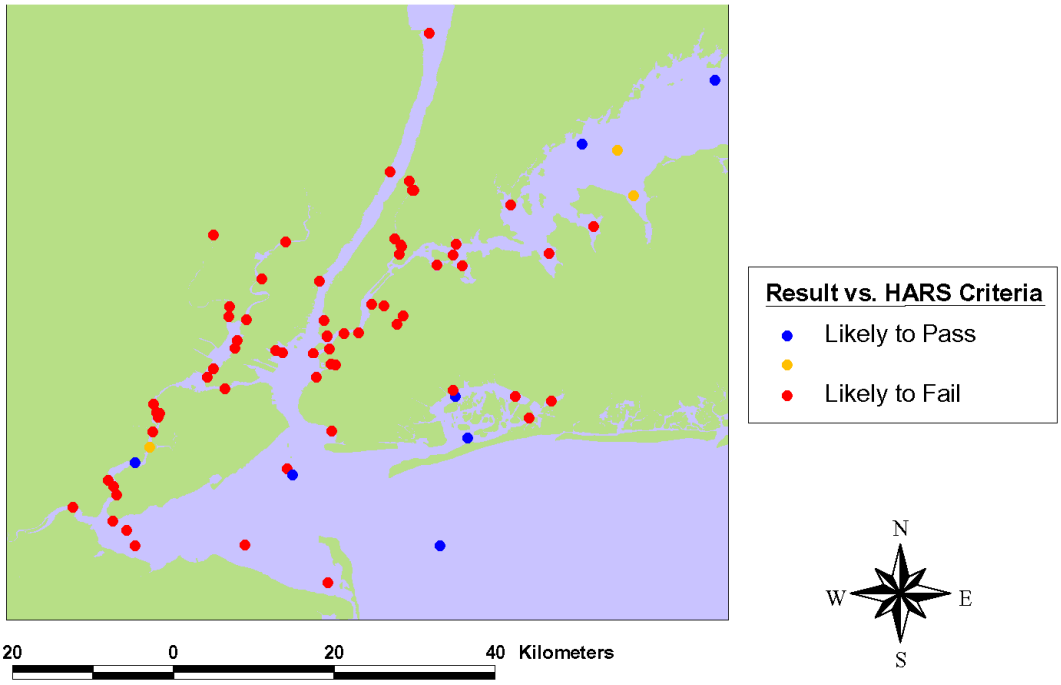
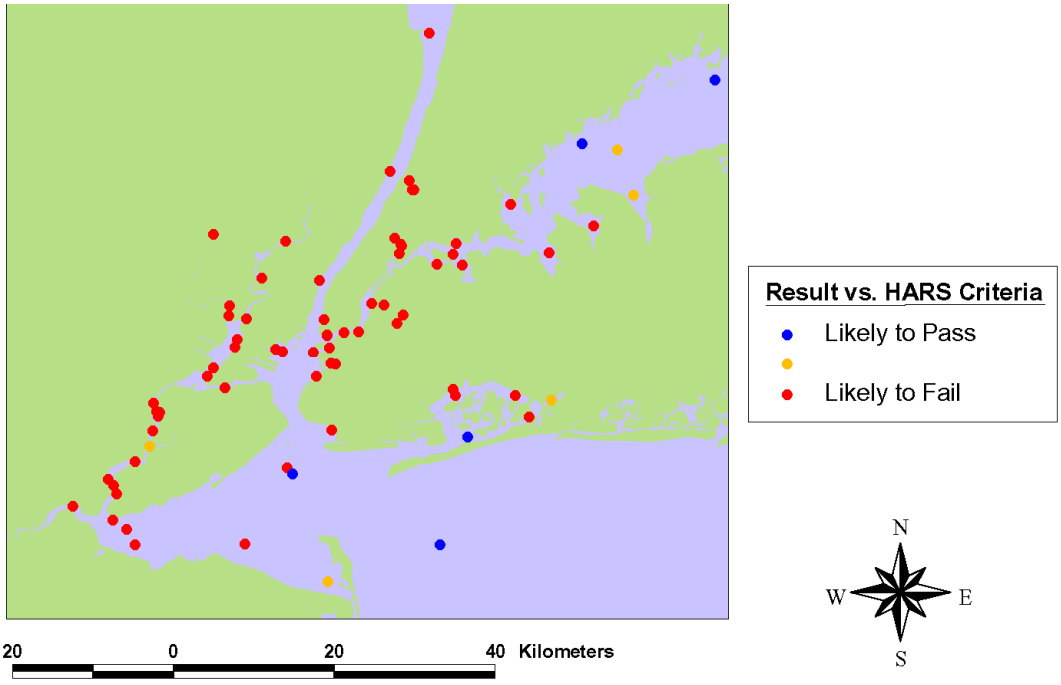


Figure 48: Average Core Total PCB Relative to HARS Suitability Criteria



DIOXIN/FURAN

The surficial sediment dioxin/furan data (Table 16) show that the Newark Bay basin had the highest average TEQ of any of the Harbor basins, followed by the Upper Harbor. The maximum TEQ value of surficial sediments found in this study was 747 ppt at Newtown Creek in the Upper Harbor. As with the PCB data, if we were to exclude the Newtown Creek samples (four), the maximum TEQ in the UH would be 92 ppt.

Table 16: Dioxin TEQ Summary by Basin (ppt)

	Surficial			All Depths		
Basin	Count	Mean TEQ	Max TEQ	Count	Mean TEQ	Max TEQ
HR	3	19.3	34.8	3	19.3	34.8
JB	6	18.2	30.7	23	44.3	250.
LH	10	33.8	57.4	32	41.4	141.1
LIS	3	10.2	13.7	7	10.1	14.1
NB	25	169.1	532.9	60	249.2	1,713.7
NYBA	1	0.7	0.7	1	0.7	0.7
UH	33	76.1	747.4	100	126.	1,752.4
WLIS	9	17.7	28.3	24	18.4	18.4

The Newark Bay Basin is the Harbor area with the highest average TEQ in the surficial and cores. A known source of dioxin to the harbor is the Diamond Alkali Superfund site, also known as 80 Lister Avenue. The plant manufactured pesticides from 1951 to 1969, including the production of DDT and phenoxy herbicides. This site is located on the Passaic River in New Jersey and is currently under EPA remediation. A six-mile stretch of the river is being evaluated under a Remedial Investigation and Feasibility Study for long-term remedies.

The maximum TEQ found in all sediment samples (core and surficial) was in Newtown Creek (NTC03) and Newark Bay (NB901). The data suggest that there was also a source of dioxin in the Newtown Creek area. The core data from both basins indicate that these are historical sources; i.e. the concentrations are lower at the surface and increase further down the core.

The Newtown Creek area, which borders the Brooklyn/Queens area of the Upper Harbor, was historically one of the world's most industrialized sites in the early 1900's. Chemical and metals refining were typical in this area. Metals refining operations at the Dodge-Phelps site from 1920 to 1983 contributed many contaminants to this site including cadmium, lead, PCB and asbestos. Quanta Resources operated a waste oil storage and processing facility from 1960 to 1981 and is located 500 feet from the channel. This site was abandoned by Quanta, leaving leaking drums and tanks. This site is contaminated with PCBs, heavy metals, PAHs and chlorinated solvents.

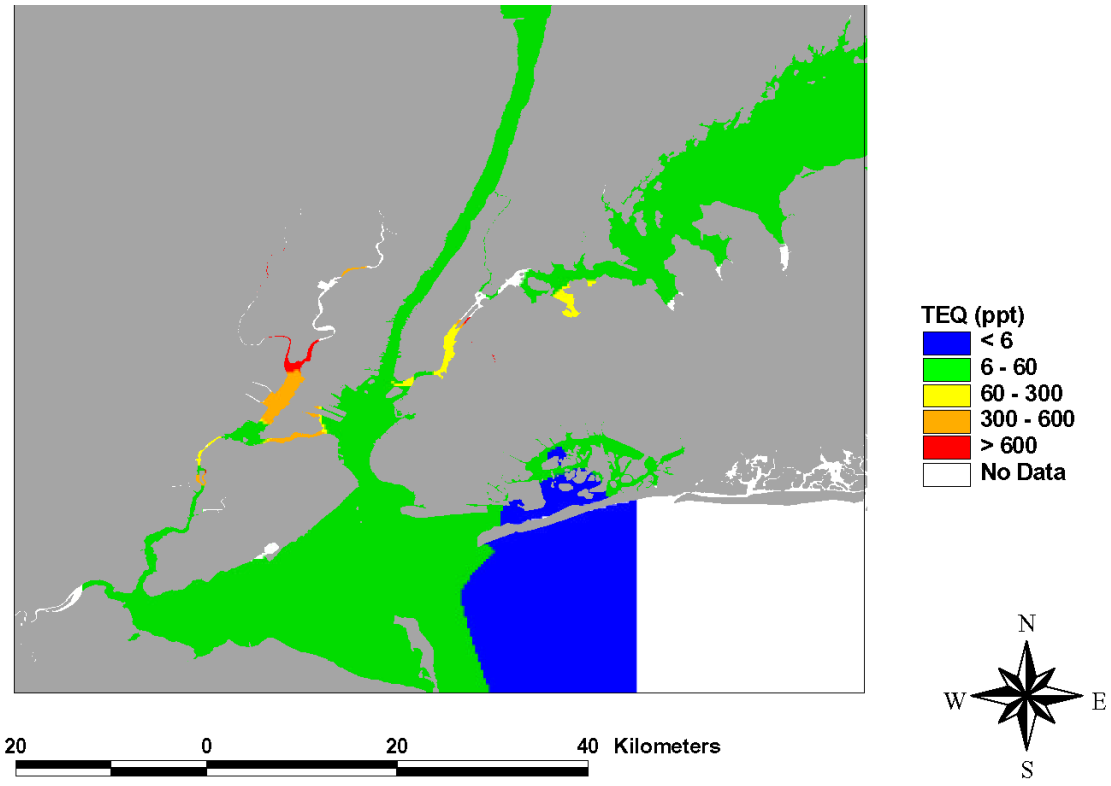
Table 17 show the number of samples exceeding the dioxin TEQ "hotspot" value of 300 ppt in each of the basins. Three basins, HR, NB and UH all had surficial samples

that exceeded this threshold. For all samples (cores and surficials) the UH had just over 50 percent of the results exceed the "hotspot" value. Figure 45 show the surficial sediment dioxin TEQ spatial pattern for the NY/NJ Harbor.

Table 17: Dioxin TEQ "Hotspot" Exceedances by Basin

Basin	Surficial # Exceedances		All Depths # Exceedances	
	Count	5X ERM	Count	5X ERM
HR	3	1	3	1
JB	6	0	23	2
LH	10	0	32	3
LIS	3	0	7	0
NB	25	6	60	24
NYBA	1	0	1	0
UH	33	1	100	51
WLIS	9	0	24	0

Figure 49: Dioxin TEQ Surficial Spatial Pattern



Figures 46 and 47 show the likely suitability of the sediments for HARS disposal with respect to dioxins. The HARS dioxin TEQ for likely to pass was 10 ppt or less,

while those higher than 60 ppt were likely to fail. Over half the sites sampled would likely fail these HARS guidelines for dioxins.

Figure 50: Surficial Dioxin TEQs Relative to HARS Suitability Criteria

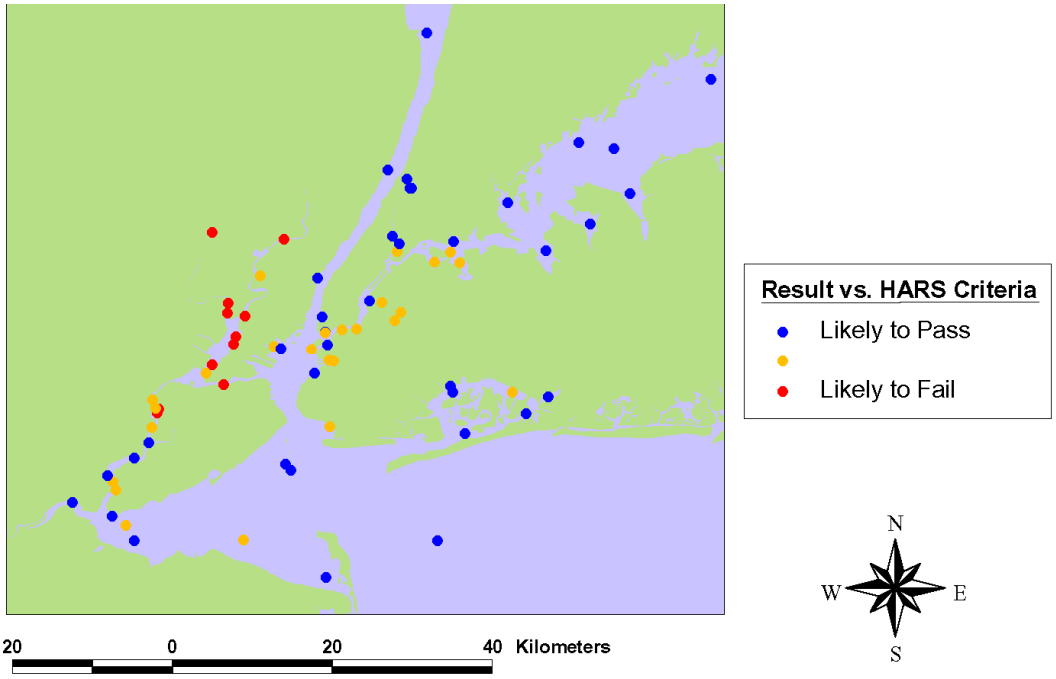
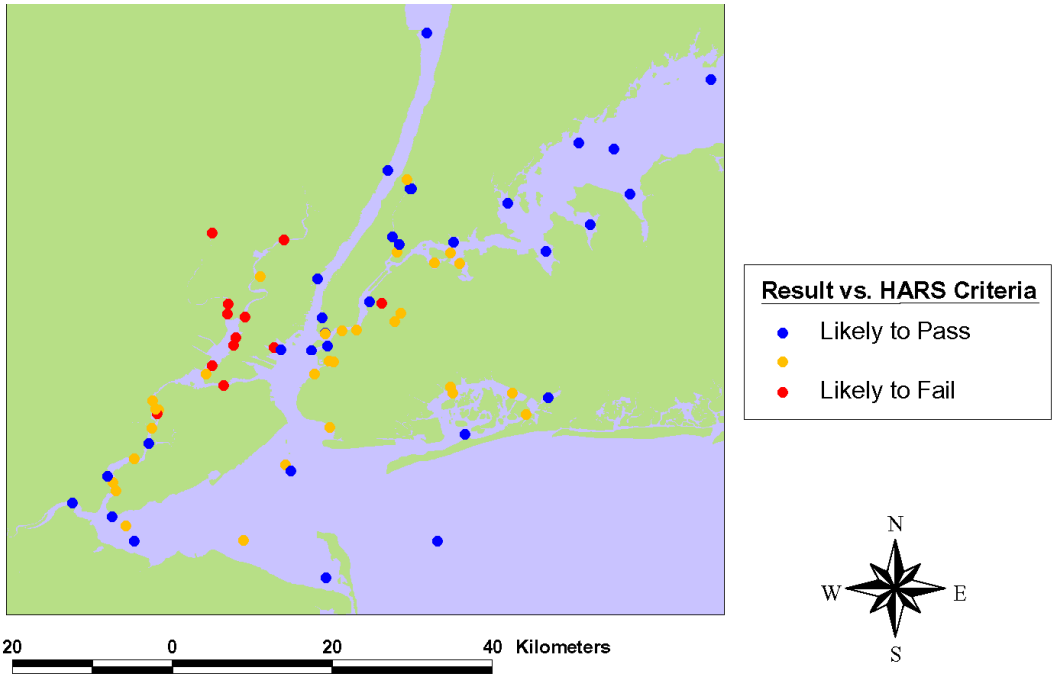


Figure 51: Average Core Dioxin TEQ Relative to HARS Suitability Criteria



ORGANCHLORINE PESTICIDES

The pesticide data was summarized for four pesticides: total DDT, dieldrin, total chlordane and mirex. The first three pesticides have ERL and ERM values that are shown in Table 4. The summary data include the mean and maximum concentration for each of the five pesticides for each basin and then the number of exceedances of the ERL, ERM and 5 times the ERM for the surficial and core samples. Endrin was not included in this summary because it was seldom detected. Over 96 percent of the samples for endrin had non-detect results.

The greatest surficial concentration of total DDT is found in the Arthur Kill (Newark Bay basin). Table 18 presents the total DDT summary for surficial and all samples (surficials plus cores). In the Upper Harbor, Newtown Creek, around Pier 6 and south of Governor's Island were found to have the highest concentrations in the surficial sediments. These last two sites had the highest levels of total DDT on the top or surface layer of the core and were considerably lower in subsurface depths. The maximum concentration of total DDT for all depths were found in the UH. Figure 48 gives the surficial sediments spatial pattern of total DDT for the Harbor.

Table 18: Total DDT Summary by Basin (ppb)

	Surficial			All Depths		
Basin	Count	Mean	Max	Count	Mean	Max
HR	3	16.5	28.	3	16.5	28.
JB	6	44.	180.9	23	39.7	274.4
LH	9	53.5	183.7	22	38.1	183.7
LIS	3	2.9	3.7	7	4.7	10.3
NB	24	507.3	2,315.	49	816.6	5,480.
NYBA	1	0.4	0.4	1	0.4	0.4
UH	33	124.	1,246.	100	292.	17,307.
WLIS	9	14.7	42.8	24	13.2	13.2

Figure 52: Total DDT Surficial Spatial Pattern

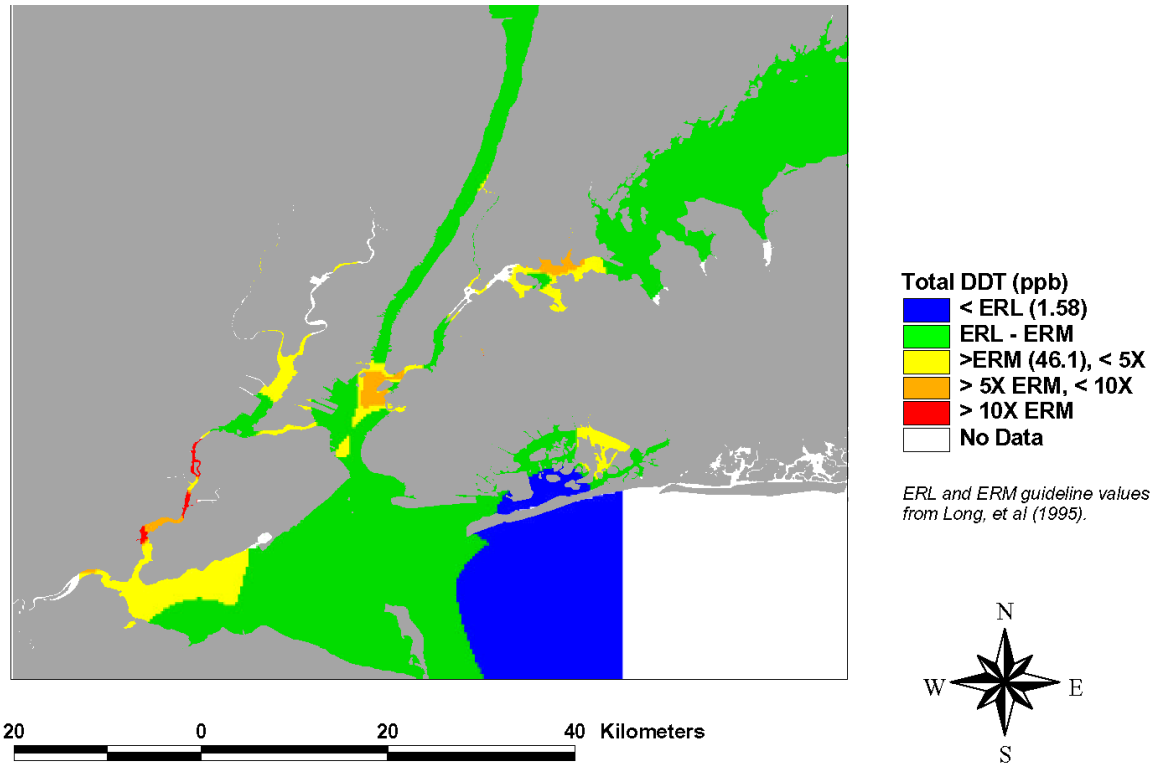


Table 19 shows the number of samples exceeding the ERL, ERM and 5x ERM for total DDT in each of the basins.

Table 19: Total DDT Exceedances of ERL, ERM and 5x ERM

Basin	Surficial # Exceedances				All Depths # Exceedances			
	Count	ERL	ERM	5X ERM	Count	ERL	ERM	5X ERM
HR	3	3	0	0	3	3	0	0
JB	6	4	1	0	23	19	3	1
LH	10	6	3	0	32	13	7	0
LIS	3	3	0	0	7	7	0	0
NB	24	2	22	9	49	8	40	20
NYBA	1	0	0	0	1	0	0	0
UH	33	19	14	5	100	41	45	15
WLIS	9	9	0	0	24	22	0	0

Figures 49 and 50 illustrate total DDT levels relative to HARS suitability criteria. The core data show that for total DDT, most of the samples would likely pass. The Arthur Kill and a few sites in the Upper Harbor would likely fail.

Figure 53: Surficial Total DDT Relative to HARS Suitability Criteria

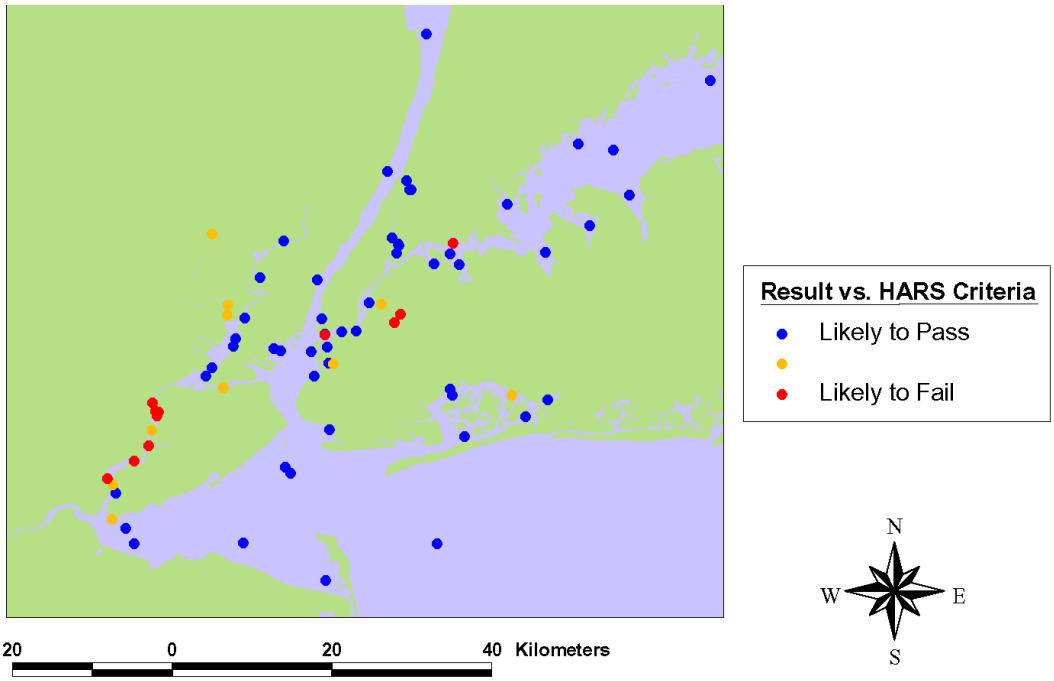
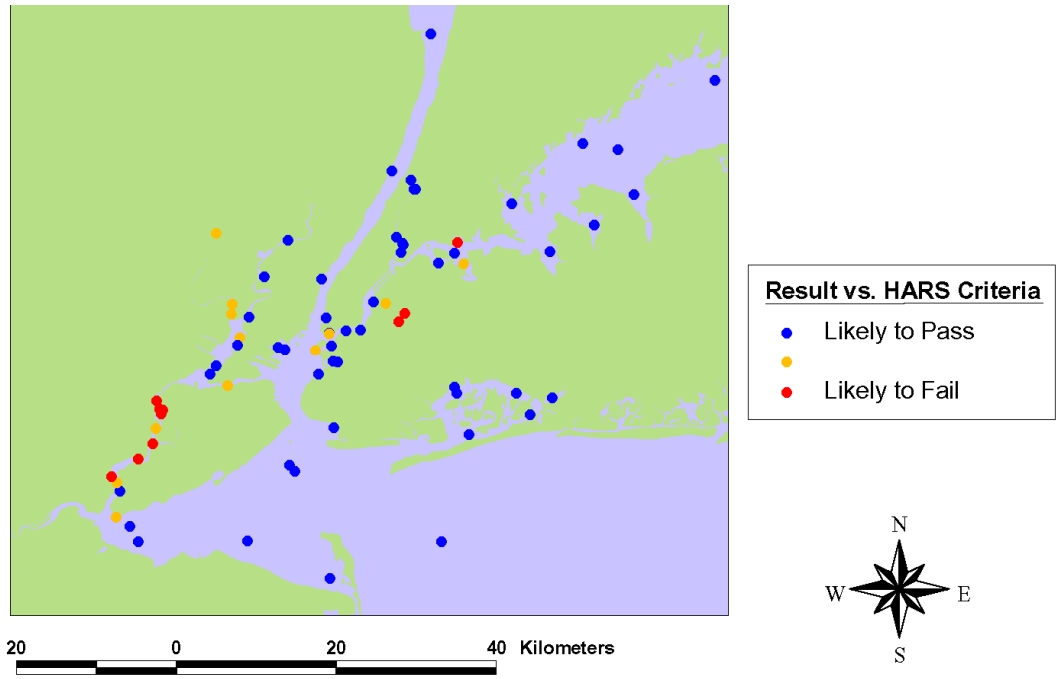


Figure 54: Average Core Total DDT Relative to HARS Suitability Criteria



Dieldrin is found in Newtown Creek on the surficial sediments at over the 5x ERM in three of the four samples collected. These concentrations make the Upper

Harbor the basin with the highest mean levels of dieldrin. Tables 20 and 21 summarize the dieldrin data for the harbor.

Table 20: Dieldrin Summary by Basin (ppb)

Basin	Surficial			All Depths		
	Count	Mean	Max	Count	Mean	Max
HR	3	0.79	1.8	3	0.79	1.8
JB	6	2.73	9.9	23	4.49	53.
LH	9	0.94	2.9	22	0.86	2.9
LIS	3	0.13	0.18	7	0.12	0.18
NB	24	4.24	14.	49	6.29	62.
NYBA	1	0.02	0.02	1	0.02	0.02
UH	33	11.68	210.	100	16.87	340.
WLIS	9	0.75	1.9	24	1.08	11.

Table 21: Dieldrin Exceedances of ERL, ERM and 5x ERM

Basin	Surficial # Exceedances				All Depths # Exceedances			
	Count	ERL	ERM	5X ERM	Count	ERL	ERM	5X ERM
HR	3	3	0	0	3	3	0	0
JB	6	4	1	0	23	20	2	1
LH	9	9	0	0	22	22	0	0
LIS	3	3	0	0	7	7	0	0
NB	24	20	4	0	49	38	11	1
NYBA	1	1	0	0	1	1	0	0
UH	33	27	6	3	100	80	20	10
WLIS	9	1	0	0	24	24	0	0

Total chlordane is calculated by summing alpha-chlordane, gamma-chlordane, oxy-chlordane, cis-nonachlor and trans-nonachlor. The highest concentrations of chlordane were found in the Newtown Creek area of the Upper Harbor. The surficial sample collected at NTC01 had over 1700 ppb and the sample at site NTC02 had over 1200 ppb total chlordane. The next highest levels outside Newtown Creek in the Upper Harbor were at ER3, near Flushing Meadows, where total chlordane was 84 ppb in the surficial layer of sediments. Tables 22 and 23 present a summary of the chlordane data by basin.

Table 22: Total Chlordane Summary by Basin (ppb)

Basin	Surficial			All Depths		
	Count	Mean	Max	Count	Mean	Max
HR	3	2.	4.7	3	1.	4.7
JB	6	12.2	31.8	23	19.9	171.
LH	9	5.	12.4	22	4.7	14.9
LIS	3	0.5	0.8	7	0.5	0.8
NB	24	29.4	104.9	49	20.3	104.9
NYBA	1	0.1	0.1	1	0.1	0.1
UH	33	78.	1,728.2	100	71.	1,728.2
WLIS	9	3.6	13.	24	5.7	55.5

Table 23: Total Chlordane Exceedances of ERL, ERM and 5x ERM

Basin	Surficial # Excceedances				All Depths # Exceedances			
	Count	ERL	ERM	5X ERM	Count	ERL	ERM	5X ERM
HR	3	2	0	0	3	2	0	0
JB	6	1	4	1	23	3	18	3
LH	9	6	3	0	22	11	7	0
LIS	3	1	0	0	7	4	0	0
NB	24	4	19	7	49	12	26	9
NYBA	1	0	0	0	1	0	0	0
UH	33	13	20	7	100	38	55	21
WLIS	9	0	0	0	24	13	6	0

Mirex is included in the summary of pesticide data even though no ERL or ERM guidance values are published for this chemical. Mirex was found in about 63 percent of the samples analyzed. The concentrations found were low, especially on the surficial samples as shown in Table 24. The highest concentration of mirex found was at the bottom of a core from ER3 in the Upper Harbor.

Table 24: Mirex Summary by Basin (ppb)

Basin	Surficial			All Depths		
	Count	Mean	Max	Count	Mean	Max
HR	3	0.03	0.03	3	0.03	0.03
JB	6	0.31	0.76	23	0.48	2.6
LH	9	0.1	0.21	22	0.14	0.53
LIS	3	0.01	0.02	7	0.01	0.02
NB	24	0.23	1.9	49	0.14	1.9
NYBA	1	0.04	0.04	1	0.04	0.04
UH	33	0.31	1.9	100	0.65	11.
WLIS	9	0.3	0.83	24	0.48	4.6

PAHs

Typically, the number of PAH compounds analyzed was twenty-four. There were as many as twenty-eight and as few as twenty-two PAH compounds in the results. For this report we calculated total PAH as the sum of all PAH compounds reported. Refer to Table 5 for the ERL and ERM guidance values used for the summary.

The Upper Harbor had the highest concentrations of PAHs of any of the basins in the surface and subsurface samples. Only two basins, the UH and NB, had surficial concentrations that exceed the ERM and none that were considered hotspots. Sites in the UH that had high concentrations in the surface sediments were Newtown Creek site NTC01 (223 ppm), UB4 near Pier 9B (198 ppm), HRPIER25 near Pier 25 (177 ppm) and

HRPIER6 near Pier 6 (163 ppm). Table 25 gives a summary of the total PAHs for each of the basins. Table 26 gives the number of samples that exceeded the ERL, ERM and five times the ERM. Figure 51 show the surficial sediment total PAH spatial pattern for the Harbor.

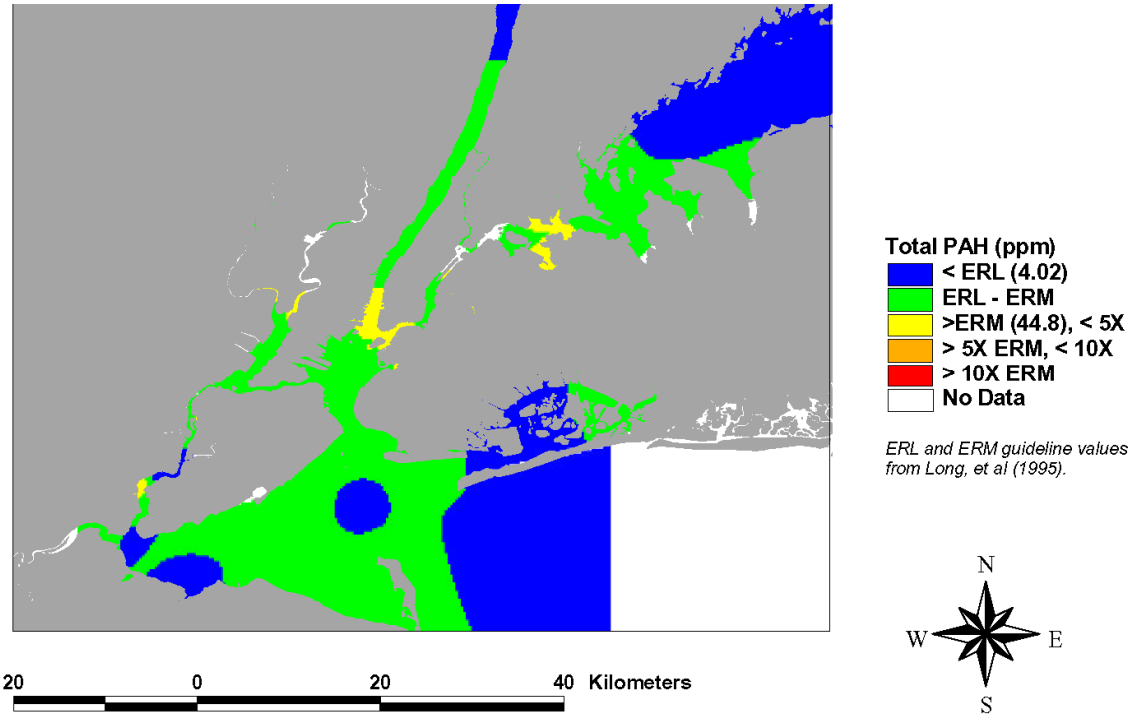
Table 25: Total PAH Summary by Basin (ppm)

Basin	Surficial			All Depths		
	Count	Mean	Max	Count	Mean	Max
HR	3	1.9	2.9	3	1.9	2.9
JB	6	3.9	6.1	23	6.	33.6
LH	10	8.7	22.8	32	9.3	24.2
LIS	3	2.4	3.2	7	2.1	3.2
NB	25	19.6	82.3	60	27.2	107.7
NYBA	1	0.1	0.1	1	0.1	0.1
UH	33	51.3	223.6	100	65.7	529.2
WLIS	9	5.2	20.7	24	5.	5.

Table 26: Total PAH Exceedances of ERL, ERM and 5x ERM

Basin	Surficial # Exceedances				All Depths # Exceedances			
	Count	ERL	ERM	5X ERM	Count	ERL	ERM	5X ERM
HR	3	0	0	0	3	0	0	0
JB	6	3	0	0	23	14	0	0
LH	10	7	0	0	32	25	0	0
LIS	3	0	0	0	7	0	0	0
NB	25	19	4	0	60	35	10	0
NYBA	1	0	0	0	1	0	0	0
UH	33	24	13	0	100	57	36	8
WLIS	9	5	0	0	24	12	0	0

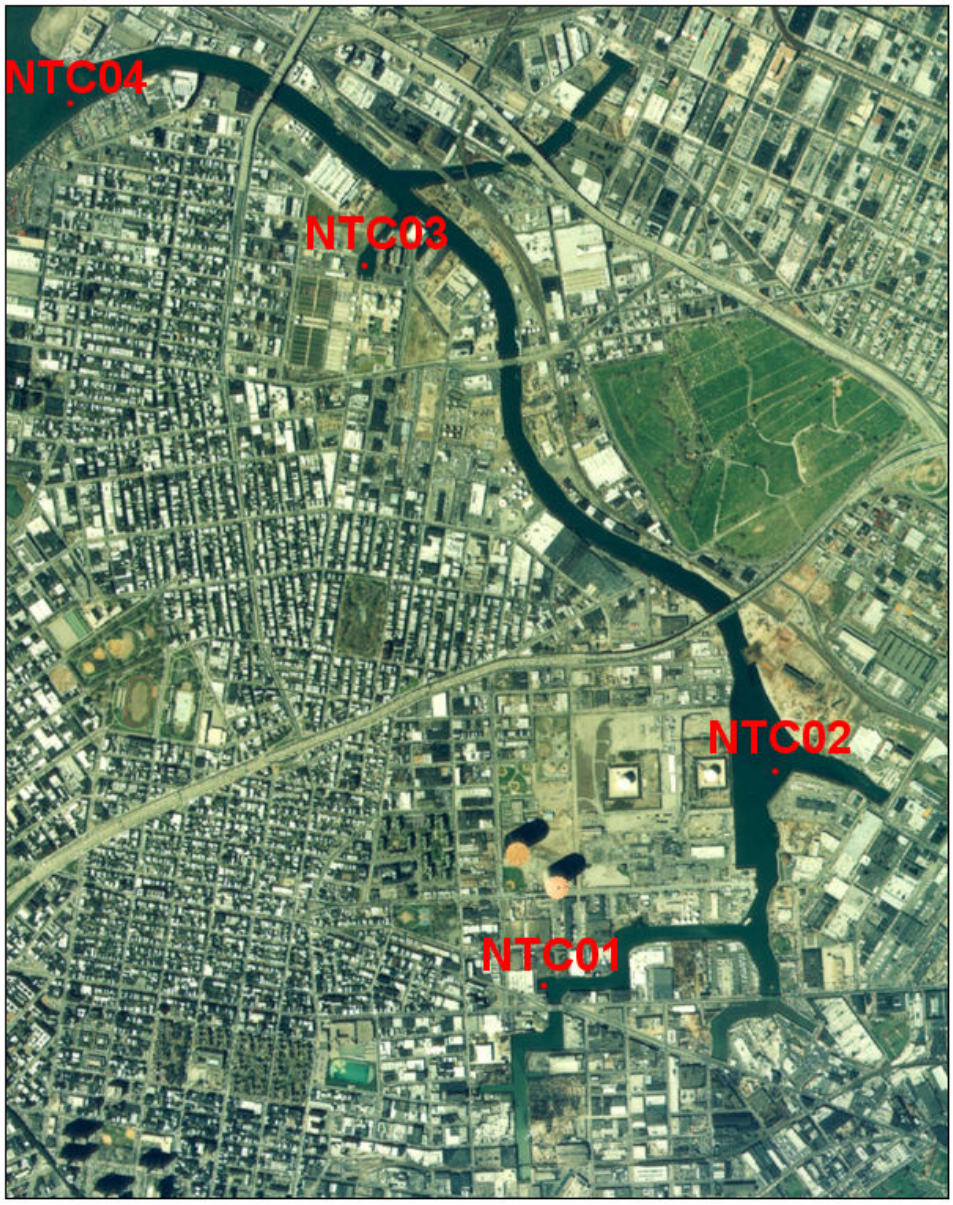
Figure 55: Total PAH Surficial Spatial Pattern



NEWTOWN CREEK

Of all the sites that were sampled by the sediment team, the one area that stands out for the degree of contamination is Newtown Creek (NC). Due to a number of historical and morphological conditions, this area is one of the major sinks and potential sources of contaminants to the harbor. The following section provides some of the potential sources of contaminants. Figure 52 shows the four sampling sites in more detail. This photo shows the area is highly developed, predominantly with commercial business and industry along the creek.

Figure 56: Sampling Locations within Newtown Creek



EPA has a listing of six inactive hazardous waste sites and three Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) hazardous waste sites within NC. These are shown in figures 53 and 54 along with EPA's Industrial Facilities Discharge (IFD) permitees. We have already mentioned BCF Oil Refining, Phelps Dodge and Quanta as potential sources of contaminants to NC, but there may be others. In addition to the hazardous waste and IFD sites, there are nearly 100 Resource Conservation and Recovery Act (RCRA) Hazardous Waste Handlers along NC. Figures 55 and 56 show the information that is listed by EPA.

Figure 57: Newtown Creek Potential Contaminant Sources

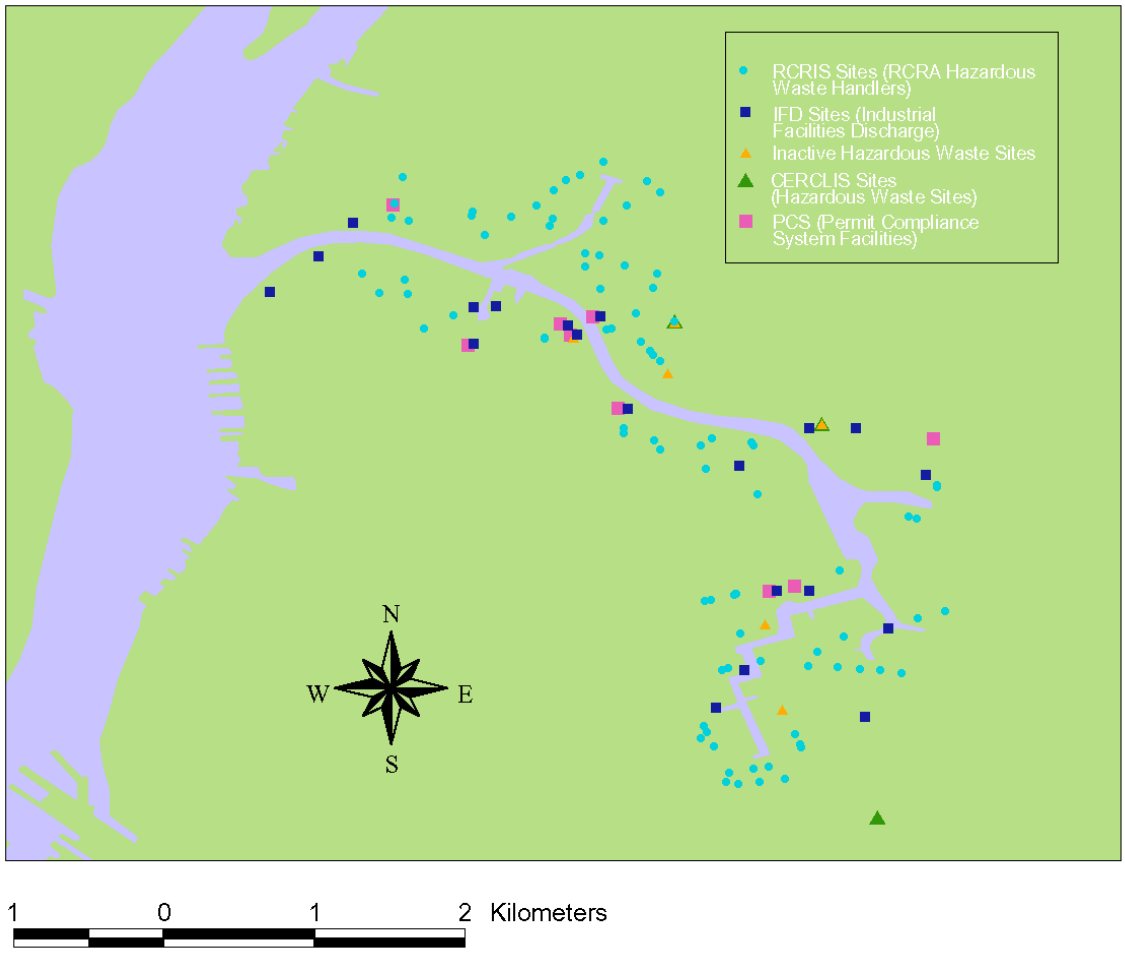


Figure 58: Newtown Creek Hazardous Waste and IFD Sites

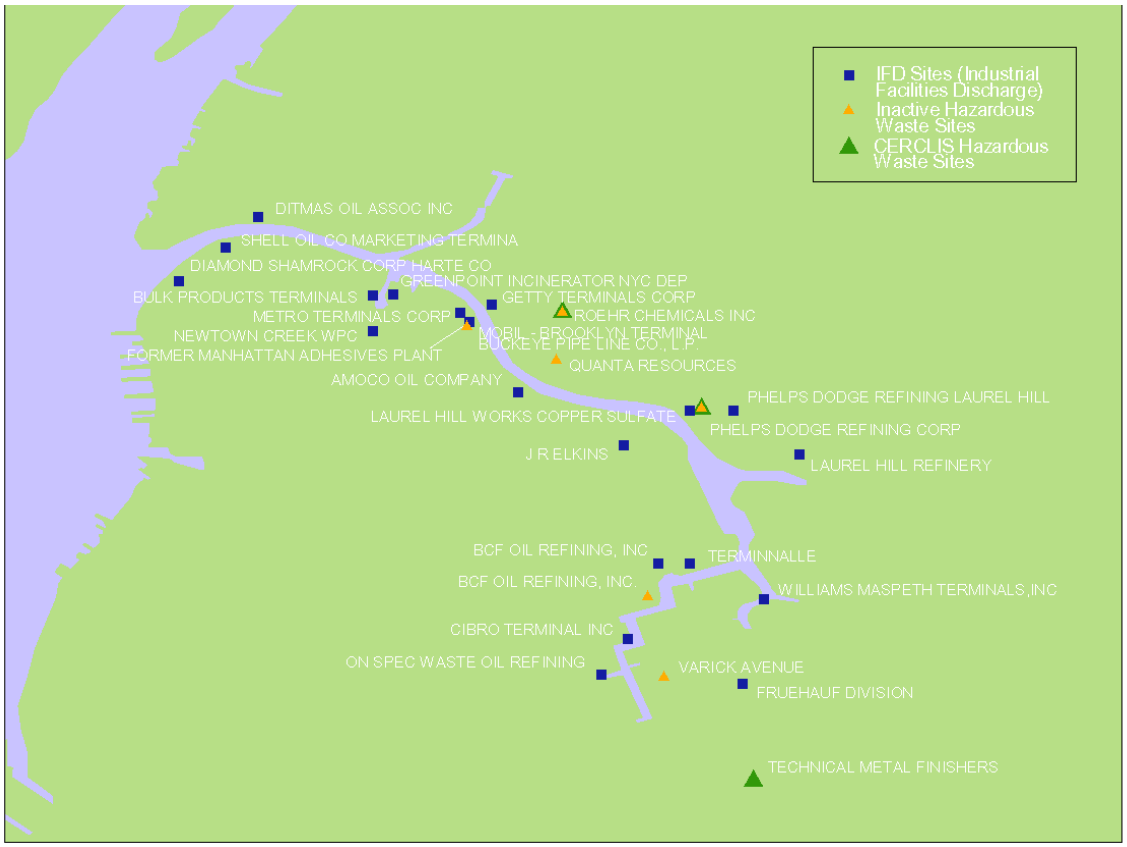


Figure 59: Newtown Creek RCRA Hazardous Waste Handlers Sites

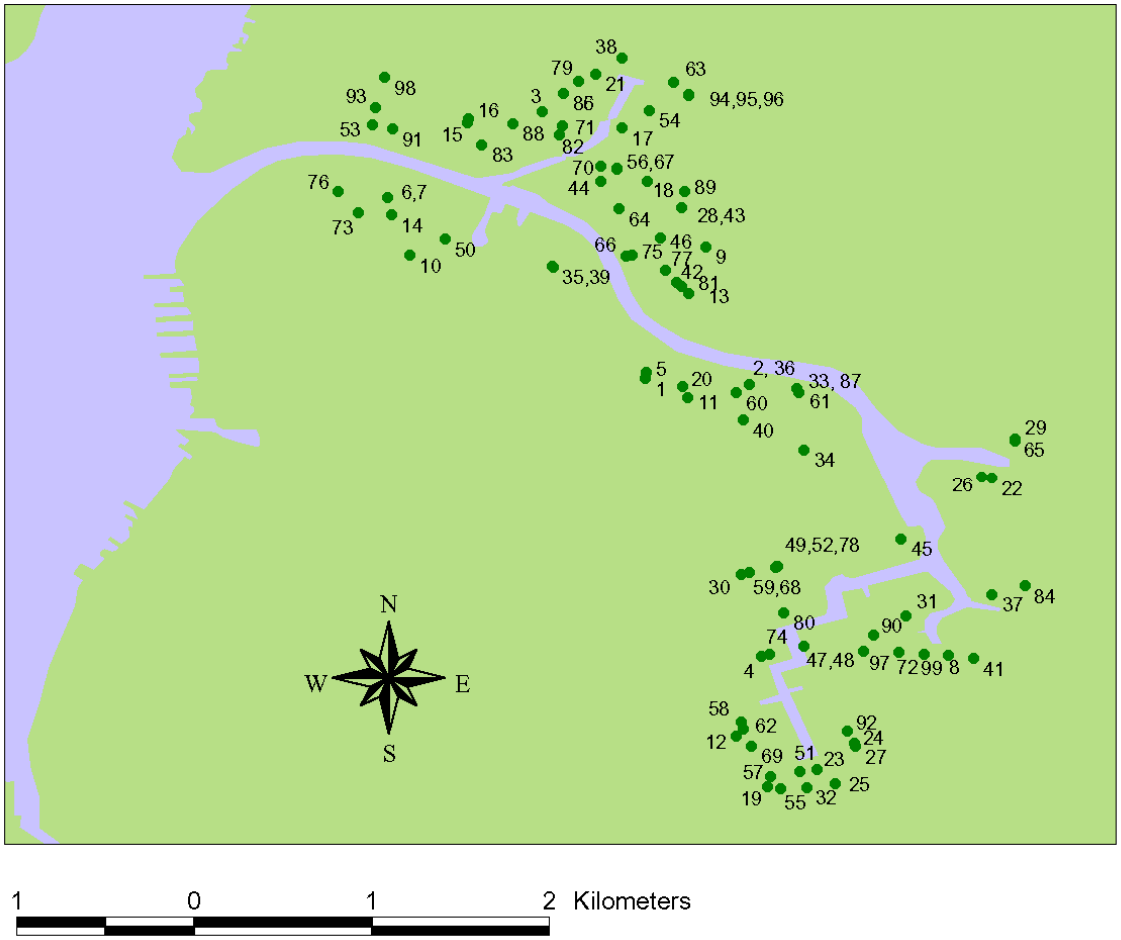


Figure 60: Newtown Creek RCRA Hazardous Waste Handlers List

Map Number	Facility ID	Facility Name	Map Number	Facility ID	Facility Name
1		MCKESSON CORP	51	NYD987006996	ENVELOPE MANUFACTURERS CORP
2		ENVIRO-SHRED CORP	52	NYD068273044	TANKS-A-LOT INC.
3		PUBLIC SERVICE TRUCK RENTING	53	NYD987013927	QUEENS TUNNEL SERVICE STATION
4	NYD000390716	ACME ALBERT STEEL DRUM INC	54	NYD072731730	HUNT PHILIP A CHEMICAL CORP
5	NYD000632018	AMOCO OIL CO	55	NYD072749104	BASIC ADHESIVES INC.
6	NYD000632141	BROOKLYN PLANT SHELL OIL COMPANY	56	NYD072756414	WARNER LAMBERT CO
7	NYD000632141	EXXON BROOKLYN TERMINAL	57	NYD987016219	ROBINWOOD MFG CO
8	NYD000705970	EXXON CO USA-MASPETH TERMINAL	58	NYD074359472	MORGAN OIL TERMINALS CORP
9	NYD000764936	ROEHR CHEMICALS INC	59	NYD987020591	BUTLER FLEET
10	NYD001213156	REPUBLIC METALS CO INC	60	NYD078162856	DEKOTA LEASING
11	NYD001233113	EMPIRE STATE VARNISH CO INC	61	NYD080447469	SPIRAL METAL CO INC
12	NYD001255637	RAVENWARE CO INC	62	NYD084090414	RAINBOW POLY BAG CO. INC.
13	NYD001284645	GULF & WESTERN MFG CO#	63	NYD085203198	SIMOS INC.
14	NYD001289131	HARCO CHEMICAL COATING INC	64	NYD987029527	EXHIBIT CO INC THE
15	NYD001311455	METRO GROUP INC	65	NYD089724975	ELM COATED FABRICS DIVISION
16	NYD001341726	ABLE STEEL EQUIPMENT CO INC	66	NYD089802995	POWER TEST CORP
17	NYD001344886	NEW YORK ENVELOPE CORPORATION	67	NYD987033982	NYSDOT CONTRACT 253037
18	NYD001356500	WALTER P SAUER & SONS INC	68	NY0000092858	ROADWAY PACKAGE SYSTEM INC
19	NYD001360635	ENVELOPE CONVERTORS INC.	69	NYD115218257	FOROX TECHNICAL CORPORATION
20	NYD001383538	GKM MFG CORP	70	NY0000100735	GREAT EASTERN INDUSTRIES INC
21	NYD001504695	STALEY ELEVATOR CO INC	71	NYD136092939	UNITED PARCEL SERVICE
22	NYD001512847	LARSTAN PROCESSING CO. INC.	72	NYD157709486	MIONE TRANSIT MIX
23	NYD001532126	TWENTIETH CENTURY COSMETICS INC.	73	NY0000441139	INTERFLO TECHNOLOGIES
24	NYD001641489	WOOD-TEX PANELS INC	74	NYD980526420	CIBRO GRANT ST
25	NYD001683457	CORNISH KNITGOODS MANUFACTORING CORP	75	NYD980530455	PROLERIZED SCHIABO NEU CO
26	NYD001903475	CANOVER INDUSTRIES INC	76	NY0000693820	GREEN ROUND EPS OF NY CORP
27	NYD002028827	ENEQUIST CHEMICAL CO INC	77	NYD980592562	QUANTA RESOURCES CORP
28	NYD003933355	ACTIVE STEEL DRUM CO. INC.	78	NYD980647283	CALLEIA BROS. INC.
29	NYD005907621	DAVIS & WARSHOW	79	NY0000990861	CONFORT & CO
30	NYD006978795	BROOKLYN UNION GAS GREENPOINT FACILITY	80	NYD980755680	NEW YORK TELEPHONE
31	NYD012573648	CHARLES J KING INC	81	NY0001039759	PENN GROVER ENVELOPE CORP
32	NYD020592838	POPULAR UNIFORM RENTAL	82	NYD980772487	IKG INDUSTRIES
33	NYD986973675	JOHN KNICK REALTY CORP	83	NY0001168392	CASE PAPER CO INC
34	NYD986973683	MORGAN REALTY CORP	84	NY0001169861	RADIO STATION WQXR THE
35	NYD040796211	PITTSTON PETROLEUM INC	85	NYD980781322	J MANHEIMER
36	NYD986974376	GREYMART METAL-A 21ST CENTURY ENVIRON CO	86	NYD980781322	J MANHEIMER INC
37	NYD986976058	AVIS RENT A CAR SYSTEM INC	87	NYD980787501	PRESTON TRUCKING CO
38	NYD045440997	SUBACCHI FURNITURE	88	NYD981180508	GALASSO TRUCKING INC.
39	NYD986984789	METRO FUEL CO	89	NYD981557564	SPORTCAR PAINTING
40	NYD048357453	NON FERROUS PROCESSING CORP	90	NYD982183444	KALEX CHEMICAL PRODUCTS INC
41	NYD050472786	SUPERIOR METAL LITHOGRAPHY	91	NYD982740946	DENTSPLY EQUIPMENT DIVISION
42	NYD053175667	DYNAMIC DISPLAY INCORPORATED	92	NYD982744815	ALLIED SANITATION CORP
43	NYD986993699	UNITED AIR CONDITIONING CORP	93	NYD982796427	TBTA - QUEENS MIDTOWN TUNNEL
44	NYD056410178	BIG KEY SELF STORAGE INC	94	NYD986873586	HELMSLEY SPEAR INC.
45	NYD986995512	TRANSCON LINES TERMINAL	95	NYD986873586	SMITH & WATSON INC
46	NYD057435570	DOUBLE CHECK AUTO ELECTRIC CORP	96	NYD986873586	OFFICE FURNITURE SVCS
47	NYD058581497	AID AUTO STORES INC.	97	NYD986892412	RELIABLE POLY PACKAGING CO INC
48	NYD058581497	MANHATTAN POLY BAG CORP	98	NYD986899698	NYCTA - 48TH STREET SUBSTATION
49	NYD059358234	GULF OIL CORPORATION	99	NYD986931533	GREENWALD INDUSTRIES INC
50	NYD063855746	EXXON CO USA-BROOKLYN TERMINAL			

It is recommended that additional sampling be conducted in and around NC to determine what impact this area may have on the East River and the Harbor.

---

[i] NYSDEC. Quality Assurance Project Plan: Sediment Sample Collection and Analysis New York Harbor and Hudson River Technical Program. 1998.

[ii] USEPA. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Estuarine and Marine Amphipods. EPA/600/R-94/025. 1994.

[iii] ASTM. Standard Guide for Conducting Sediment Toxicity Tests with Marine and Estuarine Polychaetous Annelids. ASTM E-1611-94. 1994.

[iv] Van den Berg, M. et al. Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife. Environmental Health Perspective, 106 (12), p 775-792. 1998.

[v] Long, Edward L., Donald D. MacDonald, Sherri L. Smith, Fred D. Calder. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management. Vol. 19, No. 1. Pp 81 – 97. 1995.

[vi] Pretti, V.A. How to Get Good Science from a Cement Mixer: Measuring the Precision and Accuracy of EPA Method 1668A. NYSDEC. From proceedings of EPA 22nd Annual National Conference on Managing Environmental Quality Systems. 2003.