CLH 302
Pollution/Contaminated

DATA REPORT

EVALUATION OF TRACE-METAL LEVELS IN AMBIENT WATERS AND TRIBUTARIES TO NEW YORK/NEW JERSEY HARBOR FOR WASTE LOAD ALLOCATION

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and
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1.0 INTRODUCTION

The Environmental Protection Agency (EPA) Region II and the States of New York and New Jersey have declared that the waters of New York/New Jersey Harbor (NY/NJ Harbor) are impaired under the provisions of Section 304(l) of the Federal Water Pollution Control Act. This determination was based on exceedances of EPA water quality criteria (WQC) and State standards for the metals copper and mercury. These WQC exceedances were attributed to point-source discharges, prompting the development of a pollution-control strategy that included an Intensive Master Station Survey (IMSS) to determine the concentrations of metals over a tidal cycle in surface and bottom layers of the water column and in the ambient waters of NY/NJ Harbor, and its major tributaries. The results of this survey are presented and briefly discussed in this report.

The objectives of this study were to provide data that could be used by EPA and others to

- Determine the tidal distribution and identify any patterns of metal concentrations in NY/NJ Harbor
- Determine the metals that exceed Federal or State water-quality criteria or standards and the locations of exceedances within NY/NJ Harbor
- Estimate the spatial distribution and identify any patterns of metal concentrations in NY/NJ Harbor
- Develop a water-quality based waste-load allocation model as part of the point-source discharge control strategy
- Determine metal concentration in particulate sample collected from approximately one meter above the sediment (surface floc).

To meet these objectives, a field survey was conducted in May 1991 to collect ambient water samples at six stations in the NY/NJ Harbor over a tidal cycle (see Figure 1 and Table 1. *Note*: All figures and tables are in the Appendix) and tributary samples at three New Jersey Tributaries: Hackensack, Passaic, and Raritan rivers (see Table 2). All samples were analyzed for trace metals (Ag, As, Cd, Cu, Hg, Ni, Pb, Zn), total suspended solids (TSS), particulate carbon (PC), dissolved organic carbon (DOC), and salinity. Metal concentrations were determined in two phases, total recoverable and dissolved, for all metals. In addition, mercury was analyzed in the particulate phase.

Sample collection was a joint effort among personnel from the New Jersey Department of Environmental Protection and Engineering (NJDEP&E), EPA, and Battelle.

Additional background information on this project is given in the Work/Quality Assurance Project Plans (W/QAPjPs; Battelle, 1990a) and Survey Plan (Battelle, 1990b). Activities that were conducted during the IMSS are summarized in a Survey Report Letter (Battelle, 1991c).

2.0 METHODS

2.1 SAMPLE COLLECTION PROCEDURES

2.1.1 Ambient Water Samples

All ambient water samples were collected by using the Battelle Ocean Sampling System (BOSS) on board the OSV *Anderson*. Details of the sample-collection procedures, including decontamination of the BOSS tubing, have been given in the Survey Plan (Battelle, 1990b). Sample aliquots were placed in polyethylene bottles for trace metals (two bottles), PC/DOC, and TSS measurements. Two Teflon® bottles were filled for Hg analysis. The bottles used for Hg and the other trace metals were cleaned by using the multistep process described by Patterson and Settle (1976). In addition, *in situ* measurements of (1) salinity, (2) temperature, (3) depth, and (4) transmissometry were obtained at each sampling event. Only salinity and depth are presented in this report.

2.1.2 Tributary Water Samples

All of the sample bottles required for a tributary were placed capless in an alconox-washed, deionized water-rinsed weighted, polypropylene-mesh bag. The bottles and mesh bags for each tributary were stored in clean plastic bags prior to and after use. For sampling, each mesh bag was secured with nylon rope and lowered down into the water. All bottle caps were kept in a clean plastic bag while the sample was being collected. The weighted bag was heavy enough to submerge all bottles at the same time to a depth of about 1 to 2 ft under the surface. At each sample site, the mesh bag and rope were replaced with clean, previously unused equipment.

2.2 SAMPLE PREPARATION

Laboratory procedures used to process and analyze the samples are discussed in detail in the QAPjP (Battelle, 1990b) and are summarized in this section. Detailed descriptions of the EPA methods used during this study are given in *Methods for Chemical Analysis of Water and Wastes* (EPA-600-1-79-020, March 1983). The procedures for processing the metals samples were the following.

- **Total recoverable metals.** The concentration of metals in an unfiltered sample following treatment with hot dilute mineral acid; described in Section 4.1.4 of EPA-600-1-79-020 (March 1983).

- **Dissolved metals.** Metals that will pass through a 0.45-μm-membrane filter in an unacidified sample; described in Section 4.1.1 of EPA-600-1-79-020 (March 1983).

- **Particulate metals** (also referred to as suspended metals). Metals that are retained by a 0.45-μm-membrane filter in an unacidified sample described in Section 4.1.2 of EPA-600-1-79-020 (March 1983).

Flow charts showing the processing steps that Battelle used for each of the metal phases measured in the this study are given in Battelle (1990b). Deviations from these EPA methods are given below.

2.2.1 Ambient Water Samples

Dissolved and particulate metals samples were processed in a Class 100 clean bench located within the wet laboratory of the OSV *Anderson*. Vacuum filtration at 5-10 psi was used to separate particulate from dissolved metals within about 2 h after sample collection. After the remaining sample had been discarded and the bottle rinsed with about 15 mL of filtrate, the metal-sample filtrate (dissolved phase) was placed back into its original sample container. Precombusted (350 °C) glass-fiber filters, with a 0.7-μm nominal pore size, were used for Hg filtrations, and Nuclepore membranes (0.4 μm) were used to filter samples for the other metals.

The same filter types were used to filter the acid-soluble phase approximately 2 days after acidification of the sample. Acid-soluble samples were processed in a Class 100 clean bench located within the wet laboratory of the OSV *Anderson*.

Particulate samples were stored frozen in acid-rinsed, airtight plastic petri dishes. Total-recoverable, acid-soluble, and dissolved-phase samples were acidified to pH 1.0 for mercury and at pH <2.0 for the other metals by using an ultrapure-grade nitric acid, and were stored at room temperature.

Samples for TSS were vacuum-filtered at 10 psi through preweighed 0.4-μm Nuclepore membrane filters. The total volume of water filtered was determined by using a graduated cylinder. Each filter was washed with three successive 10-mL rinses of deionized water (adjusted to pH 8 with ammonium hydroxide) to remove sea salt. Samples were stored in acid-rinsed, airtight, plastic petri dishes and air-dried in a Class 100 clean room prior to determination of the total mass of particles retained on the filter.

Duplicate PC and DOC sample aliquots from each sampling event were processed within about 2 h of sample collection. PC was collected on precombusted 25-mm glass-fiber filters, stored in an aluminum-foil pouch, and frozen until analysis. The DOC sample (filtrate) was sealed in a glass vial and also frozen until analysis. DOC and PC samples were shipped to Battelle's subcontractor, Chesapeake Bay Laboratory (CBL) in Solomons, Maryland, for analysis.

Samples for surface floc were processed in a Class 100 clean bench located within the wet laboratory of the OSV *Anderson*. Vacuum filtration at 5-10 psi was used to separate particulate from dissolved metals within about 6 h after sample collection. The particulate fraction was stored frozen in acid-rinsed, airtight, plastic petri dishes.

2.2.2 Tributary Samples

Dissolved and particulate metals samples were processed in a Class 100 clean room at Battelle in Duxbury, Massachusetts. Vacuum filtration at 5-10 psi was used to separate particulate from dissolved metals within about 1 day after sample collection. Precombusted (350 °C) glass-fiber filters (Whatman, GF/F), with a 0.7-μm nominal pore size, were used for Hg filtrations, and Nuclepore membranes (0.4 μm) were used to filter samples for the other metals.

Particulate samples were stored frozen in acid-rinsed, air-tight plastic petri dishes. Total-recoverable and dissolved phase samples were acidified to pH 1.0 for mercury and at pH <2.0 for the other metals by using an ultrapure-grade nitric acid.

Samples for TSS were vacuum-filtered at 10 psi through preweighed 0.4-μm Nuclepore membrane filters. The total volume of water filtered was determined by using a graduated cylinder. Each filter was washed with three successive 10-mL rinses of deionized water (adjusted to pH 8 with ammonium hydroxide) to remove sea salt. Samples were stored in acid-rinsed, airtight, plastic petri dishes and air-dried in a Class 100 clean room prior to determination of the total mass of particles retained on the filter.

Duplicate PC and DOC sample aliquots were processed from each municipal effluent within about 1 day of sample collection. PC was collected on precombusted, 25-mm glass-fibre filters stored in aluminum foil pouch, and frozen until analysis. The DOC sample (filtrate) was sealed in a glass vial and also frozen until analysis. Both DOC and PC samples were shipped to CBL for analysis.

2.2.3 Sample Digestion and Preconcentration

Both the IMSS samples and the tributary samples were prepared and analyzed using the same methods.

Total-recoverable metal analysis required additional sample preparation prior to analysis for all metals except Hg. A 100-mL aliquot of the sample was spiked with 500 μl HNO_3 and the sample was reduced in volume to about 20 mL by evaporation. Samples were diluted back to 100 mL and metals isolated by chelation/extraction (except As) before analysis. Arsenic samples were analyzed directly without preconcentration.

Ambient samples were concentrated by chelation and extraction at pH < 1 for Ag and at pH 4.5 for Cd, Cu, Ni, Pb, and Zn. Metals were chelated with ammonium-1-pyrrolidine dithiocarbamate/ diethylammonium diethyldithiocarbamate (APDC/DDDC) and extracted from the water with Freon (Danielson *et al.*, 1978). Prior to analysis, the solvent was acidified and the metals were backextracted into 2 mL of 10% nitric acid.

The particulate filter samples were digested in nitric acid (pH 1) at room temperature for about 2 days prior to analysis.

2.3 INSTRUMENTAL ANALYSIS

Instrumental analysis included either graphite furnace atomic absorption spectrometry (GFAAS), cold vapor atomic absorption spectrometry (CVAAS), or hydride atomic absorption spectrometry (HAAS). Samples were analyzed for Ag, Cd, Cu, Ni, Pb, and Zn by GFAAS after the chelation/extraction step for total-recoverable and dissolved metals.

For As analysis, a 5- to 10-mL sample aliquot was reacted with $NaBH_4$ to form a hydride prior to analysis by AAS.

For mercury analysis of ambient samples, about 250 mL of the acidified sample (total recoverable and dissolved) was processed by using a two-step analytical scheme described by Gill and Fitzgerald (1987) and Gill and Bruland (1990). The samples were reacted with $NaBH_4$ to cleave the C-Hg bonds, and the liberated Hg(II) was collected on a gilded-sand column and subsequently heated from the gold column for detection by CVAAS. Particulate sample digestates were analyzed directly by CVAAS without preconcentration.

2.4 SAMPLE CUSTODY

Field documentation consisted of log forms containing the project name, site number, sample-type designation, and an alphanumeric code. During field collection, log forms were completed and labels were affixed to the sample containers, thereby creating a link between the sample and data recorded on the log form. The log forms also contained the same alphanumeric code as their corresponding labels, ensuring the tracking of sample location and status.

The Chief Scientist recorded each sample on the Sample Transfer Record. Responsibility was relinquished by the Chief Scientist via signature at the time of receipt by laboratory personnel at Battelle. Transfer of samples to other laboratories took place at Battelle in Duxbury, Massachusetts.

Upon receipt of samples at Battelle, the Laboratory Sample Custodian examined the samples received, verified that the information recorded on the Sample Transfer Record was accurate, and logged the samples into the laboratory by signing the Sample Transfer Record. Date and time of receipt were also recorded. The sample identification numbers were used to track the samples through the laboratory.

Samples for PC/DOC analysis were shipped to CBL. The Battelle laboratory identification numbers were used to track the samples.

2.5 DATA QUALITY OBJECTIVES

A summary of the data-quality objectives for the analytical measurements is presented in Table 2. The reporting-limit goals (RLG) for metal analyses (Table 2) are one-fifth the most stringent WQC. Actual method detection limits (MDL) for metals analysis were determined from the instrument detection limits and the volume extracted. For all other analyses, historical MDLs are reported in Table 2 and were not redetermined for this project.

For metals analysis, accuracy was determined by using a standard reference material (SRM), and was also monitored via procedural blanks, equipment blanks, and matrix spike (MS) analysis. Precision was determined for metals via repeated analysis of an SRM and from analysis of laboratory duplicates of a sample and also field duplicates of a sample (samples were collected by splitting the sample stream so that the duplicate samples were collected simultaneously). For all other analyses, accuracy was determined from instrument calibration (salinity, TSS, PC) or analysis of matrix spikes (DOC only).

The quality-control results, which include procedural blanks, SRM recoveries, matrix spike recoveries, and analytical duplicate are listed by metal in Table 3. For this project, low-level procedural blanks were experienced for most of the analyses. Because the procedural blanks were low and consistent (see Appendix tables for procedural blanks), blank-corrected values are reported where appropriate for all metals except mercury. Blank corrections were determined and applied to each sample batch. All of the cadmium, copper, nickel, silver, and zinc and approximately 80% of the lead total recoverable results were blank-corrected. All of the silver, approximately 50% of the cadmium, copper, and lead, and 90% of the nickel and zinc dissolved results were blank-corrected. These corrections were generally less than 25% of the reported concentrations, except for total recoverable samples with extremely low concentrations (e.g., silver at station H8). Generally, the value of the Cd, Cu, Pb, and Zn blanks were <20%, <5%, <10%, and <30% of the lowest reported concentration, respectively. Blank corrections for Ni were higher, being approximately 50% of the reported concentration in the sample with the lowest Ni concentration.

The accuracy of the analytical results, as measured by the recovery of metals from standard reference materials and matrix spike recovery samples, was generally good, with most recoveries lying within ±15% of the expected values. Similarly, measures of analytical precision generally were within the data quality objectives of the program. Precision results of the IMSS field duplicates are listed in Table 4.

In a separate experiment, mercury was found to be stable for longer than the 30-day limit prescribed by EPA Methods for Chemical Analysis of Water and Wastes (EPA-600-1-79-020, March 1983). A mercury sample (station O4) collected in January 1991 under WA2-202 was reanalyzed in June 1991. The results differed by only 4% from the results of the first analysis conducted in February 1991.

3.0 RESULTS

The IMSS and the tributary sample analyses results for salinity, TSS, PC/DOC, and metals concentrations are listed in Table 3. Results from the IMSS sample analyses are plotted in Figure 2. Analyses of all dissolved As and acid-soluble Hg samples were not completed due to a programmatic decision to not apply the acid-soluble phase to the criteria being used in the TMDL/WLA and the need to complete the analysis of the hydrographic and turbidity data collected during the May IMSS survey (Battelle, 1991c).

Results from the surface floc samples collected during the IMSS are listed in Table 4.

4.0 CONCLUSIONS

This report presents a data set for the waters of NY/NJ Harbor that is of comparable quality to that reported for the January 1991 Ambient Evaluation Survey (Battelle, 1991b). Interpretation of the data presented in this report is beyond the scope of this project. However, the following are some observations and preliminary conclusions readily apparent from a cursory examination of the data.

- Surface and the bottom water total-recoverable mercury concentrations exceeded the EPA water quality criterion (0.025 μg/L) at stations H3, A3, and A7.

- Total-recoverable copper concentrations exceeded the EPA water quality criterion (2.0 μg/L) at all stations, times, and depths, with the exception of the surface sample from the station H8 (Hudson River). Because this is a freshwater station, the marine water quality criterion do not apply at this station.

- Dissolved copper concentrations do not exceed the EPA criterion, except at the stations located in the Arthur Kills region (A3 and A7)

- Bottom waters of station H3 exceeded the EPA WQC for lead and zinc in the total recoverable phase. All other lead and zinc values were below the EPA WQC.

- No exceedances of EPA WQC were observed for arsenic, cadmium, nickel, or silver.

- Bottom waters tended to have higher concentrations of metals than did surface waters.

- Except at station H3, variations in the total metals concentrations over the tidal cycle are small.

- Surface waters generally have lower TSS concentrations; the differences between surface and bottom waters are generally within a factor of 2 to 3.

- Variations in total suspended solids concentrations over the tidal cycle are small except at station H3.

- Changes in the total-recoverable metals concentrations over tidal cycles correspond closely with the changes in total suspended solids.

- Dissolved metals concentrations do not vary greatly over the tidal cycle. Changes are most likely related to variations in salinity (water type) than to remobilization of the metals from particulate matter.

- Particulate metal concentrations in the samples collected from near the sediment/water interface vary. The As, Hg, Cu, and Pb concentrations in the particulate samples from the Station H3 and H8 in the Hudson River are lower than at the other stations; Ni concentrations do not vary significantly.

- The particulate Hg results determined using room temperature pH 1 digestion are less than the difference between the total recoverable and dissolved measurement. This indicates particulate Hg is strongly bound to particles and released only with rigorous digestion techniques.

- The total-recoverable mercury concentration in the tributaries were less then the WQC. This implicates other sources as causes for high Hg in the Kills and at Hudson River station #3.

5.0 REFERENCES

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Battelle. 1990b. Survey Plan for evaluation of trace-metal levels in ambient waters and discharges to New York/New Jersey Harbor for waste load allocation. Final report submitted to the Environmental Protection Agency under Work Assignment 2-202, Contract No. 68-C3-0105.

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Battelle. 1991c. Hydrographic results from the May 1992 Intensive Master Station Survey in New York/New Jersey Harbor. Letter report submitted to the Environmental Protection Agency under Work Assignment 2-213, Contract No. 68-C3-0105.

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Appendix

FIGURES AND TABLES

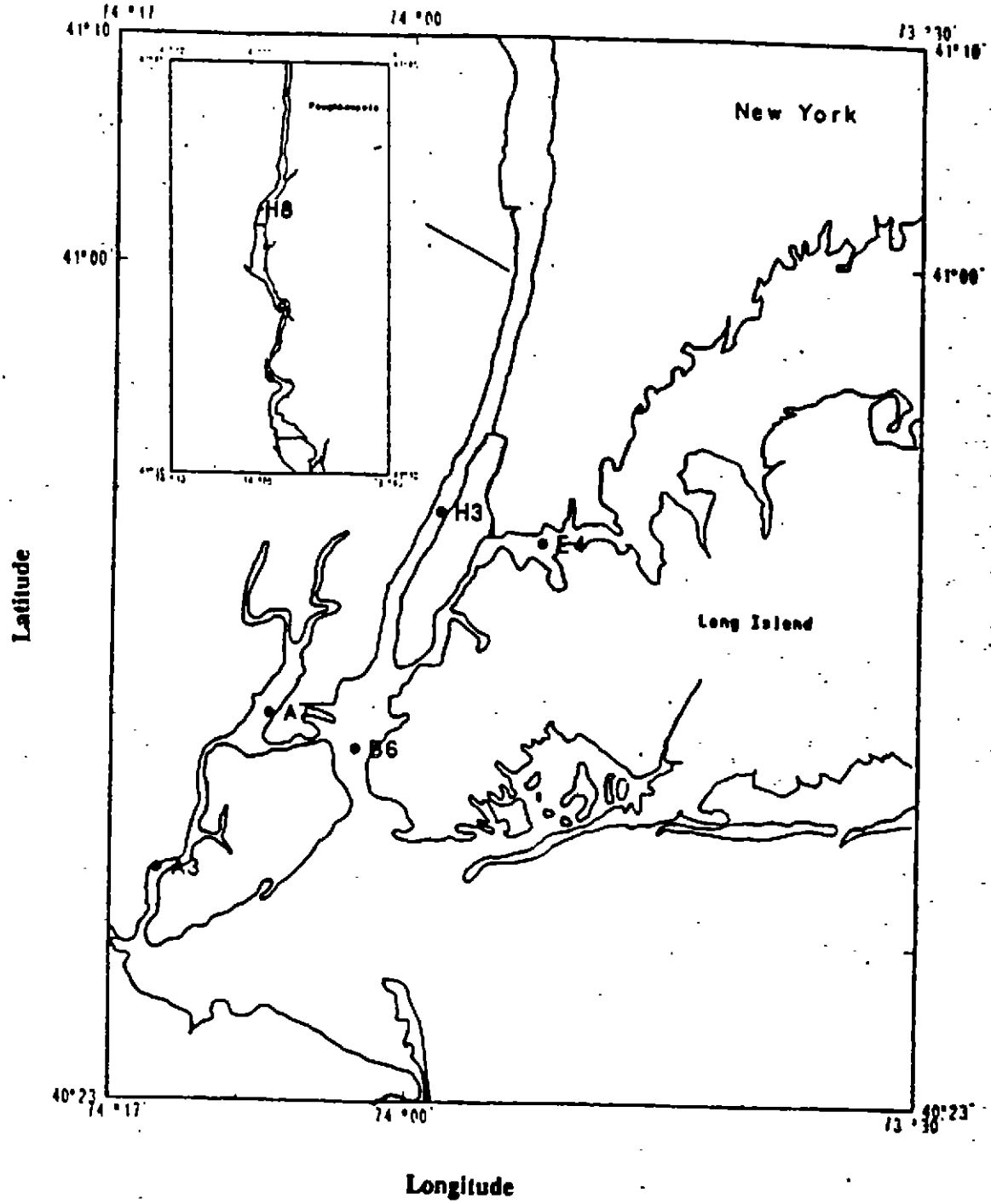

Figure 1. Station Locations for May 1991 Intensive Master Station Survey.

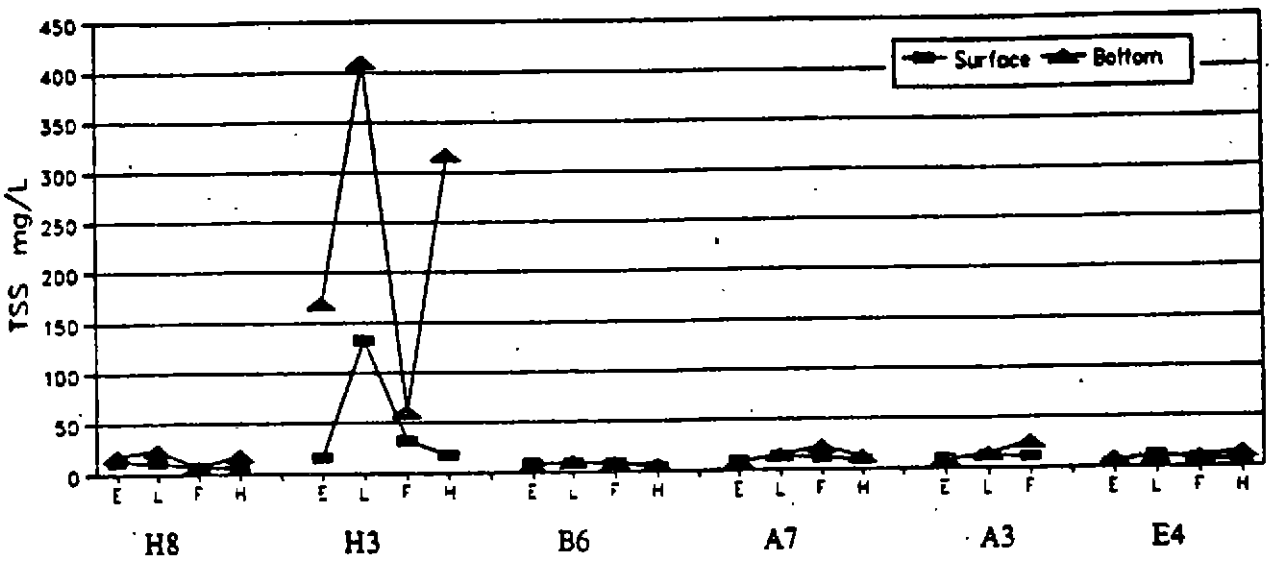

Figure 2(a). Total Suspended Solids in New York/New Jersey Harbor Waters. .

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.

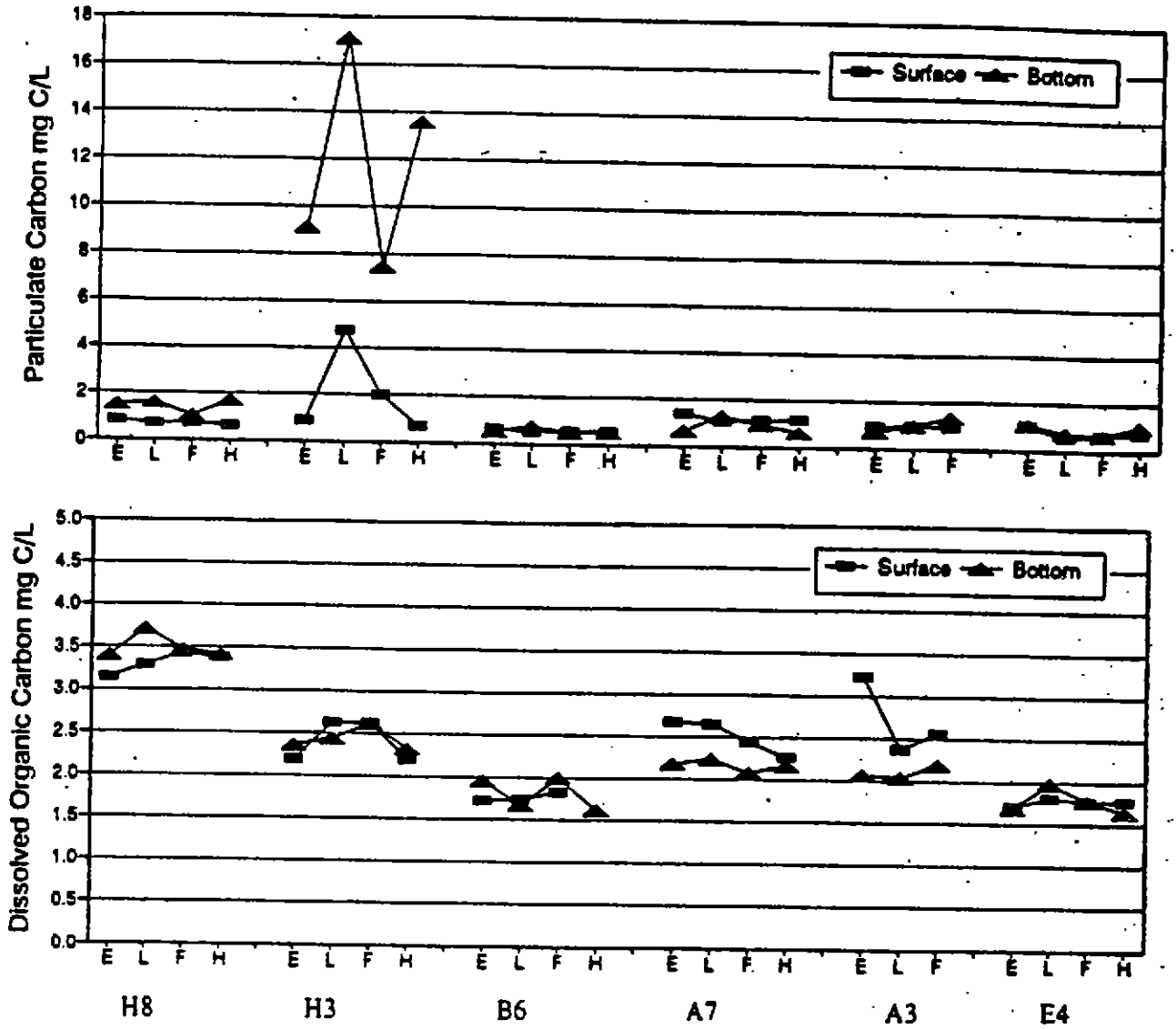

Figure 2(b). Particulate Carbon and Dissolved Organic Carbon in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.

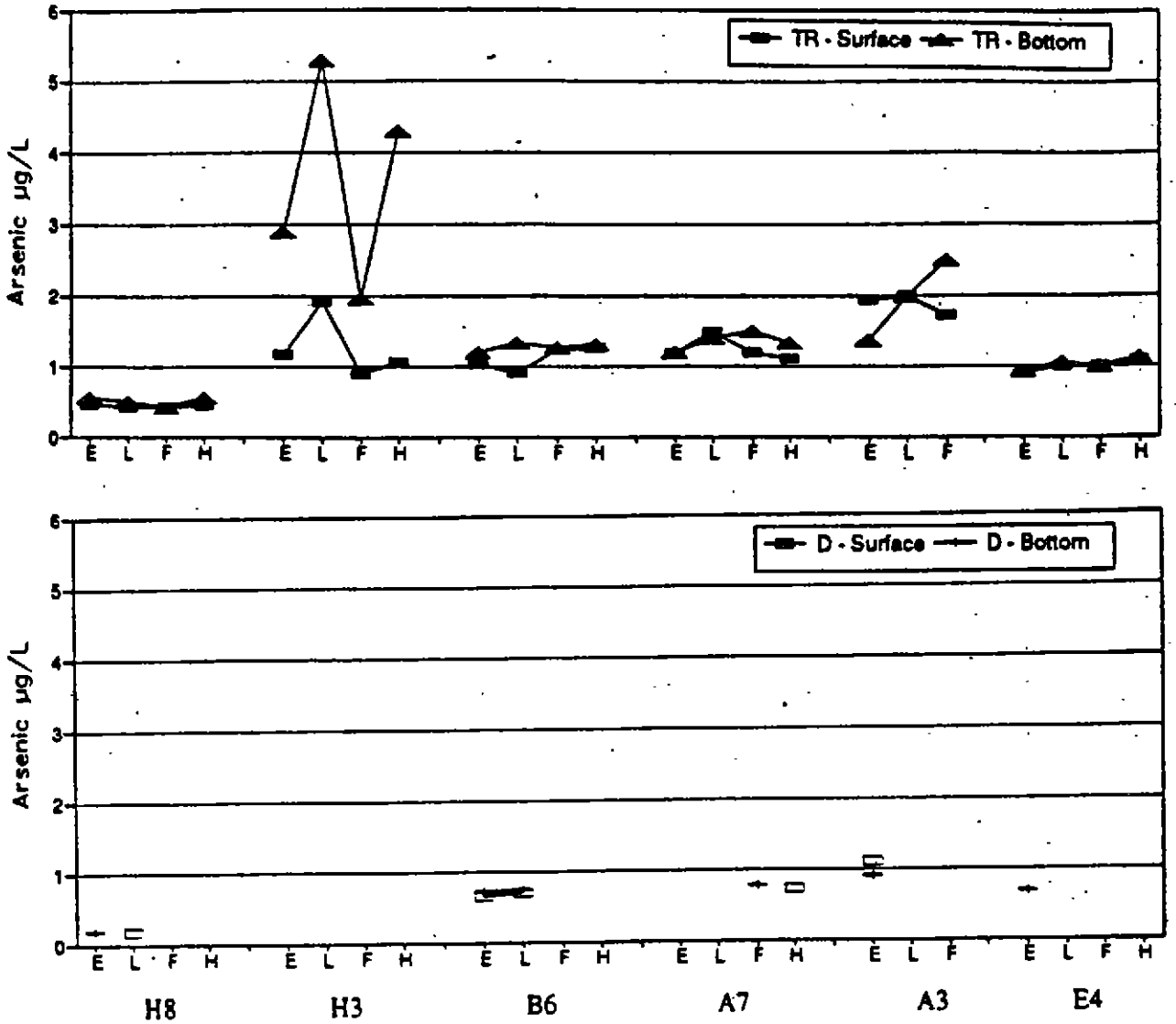

Figure 2(c). **Arsenic Concentrations in New York/New Jersey Harbor Waters.**

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

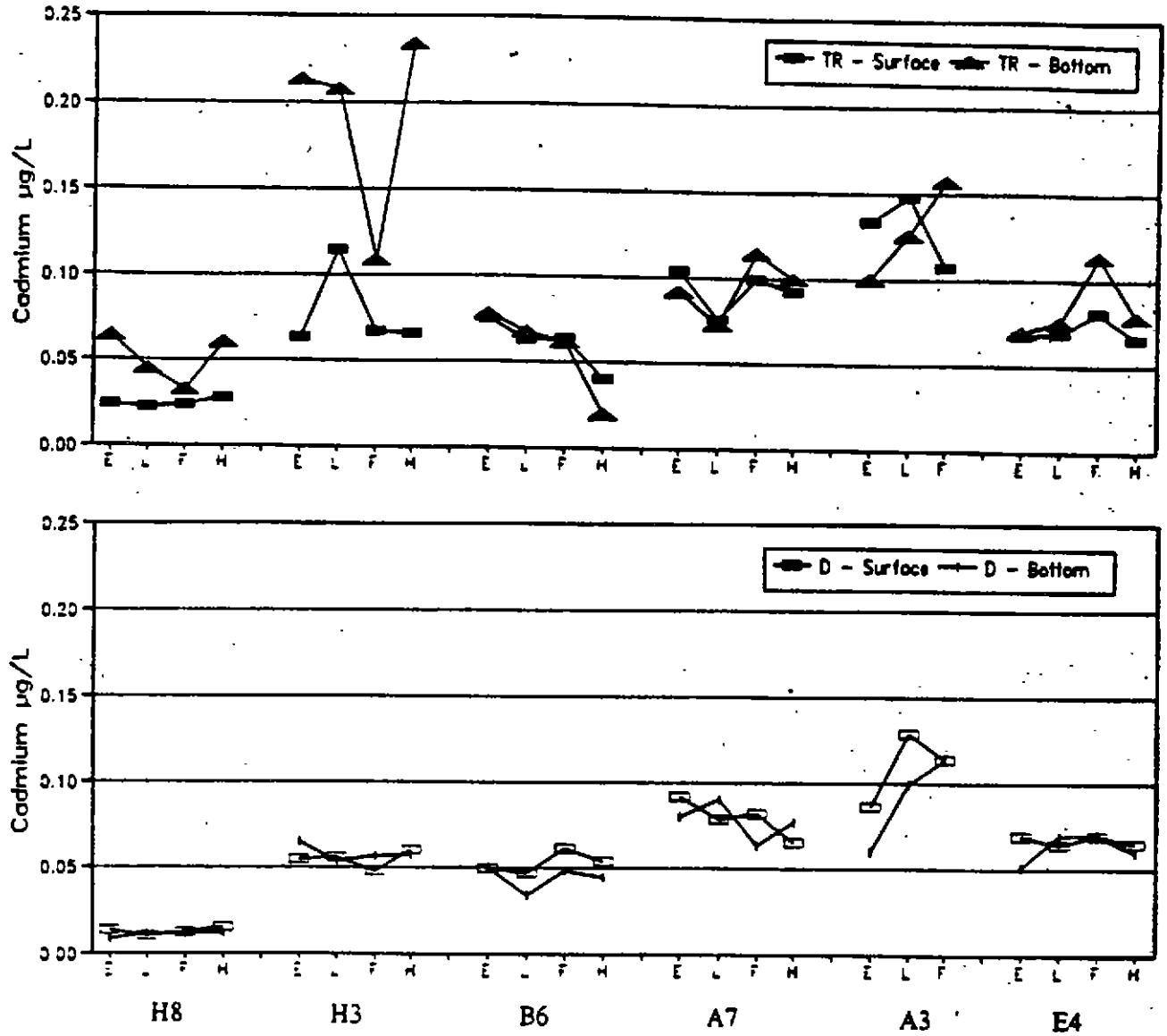

Figure 2(d). Cadmium Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

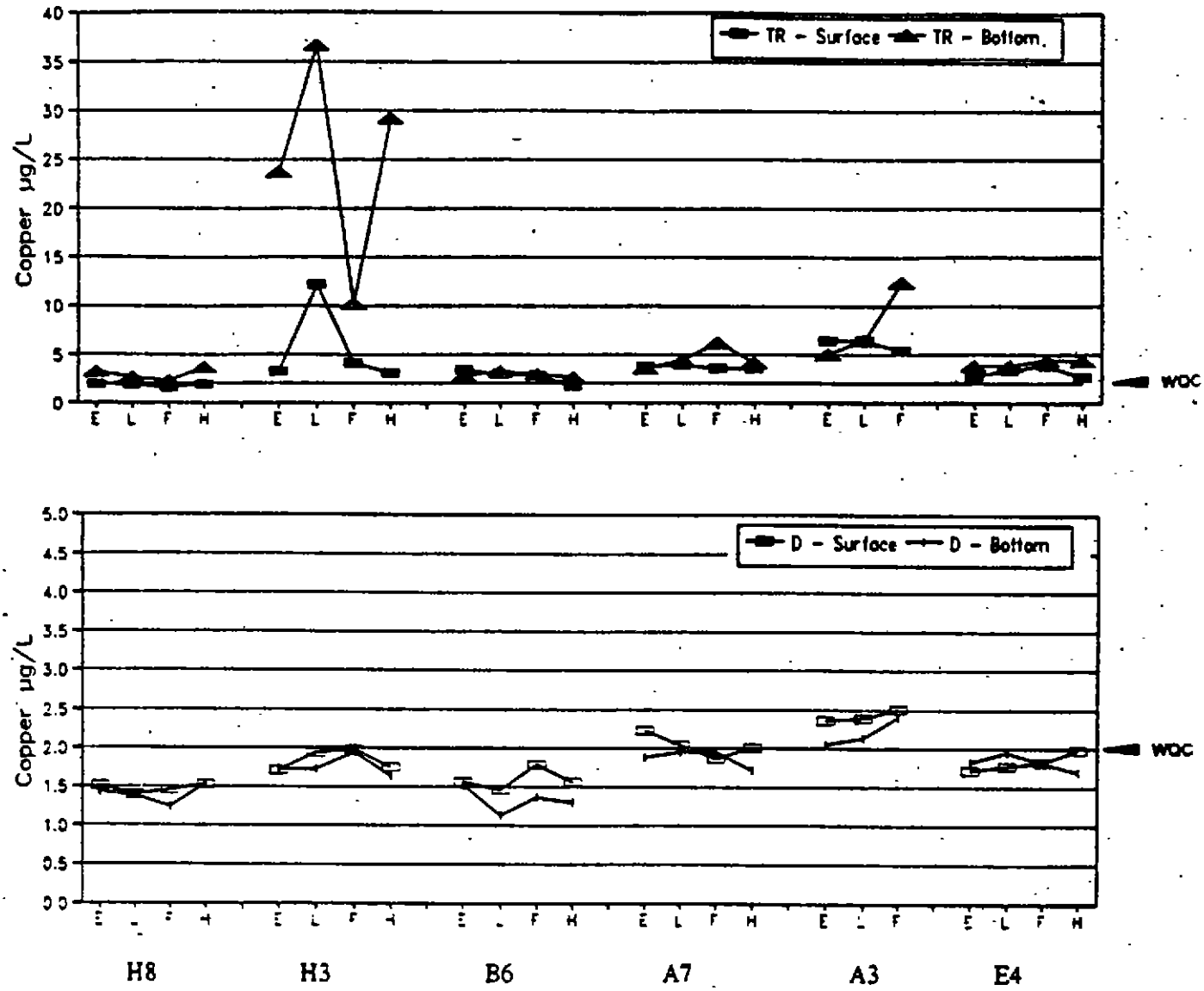

Figure 2(e). Copper Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

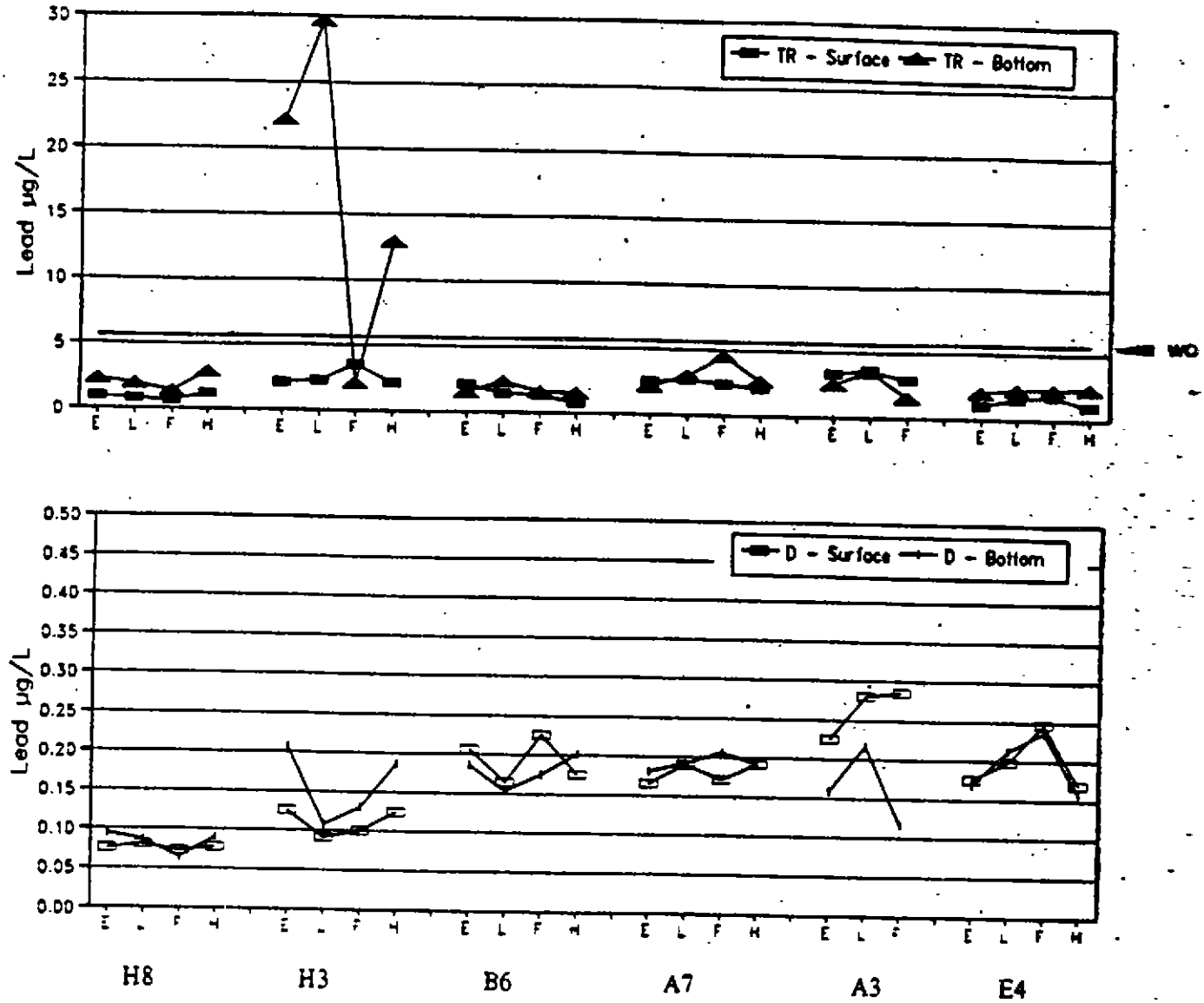

Figure 2(f). Lead Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

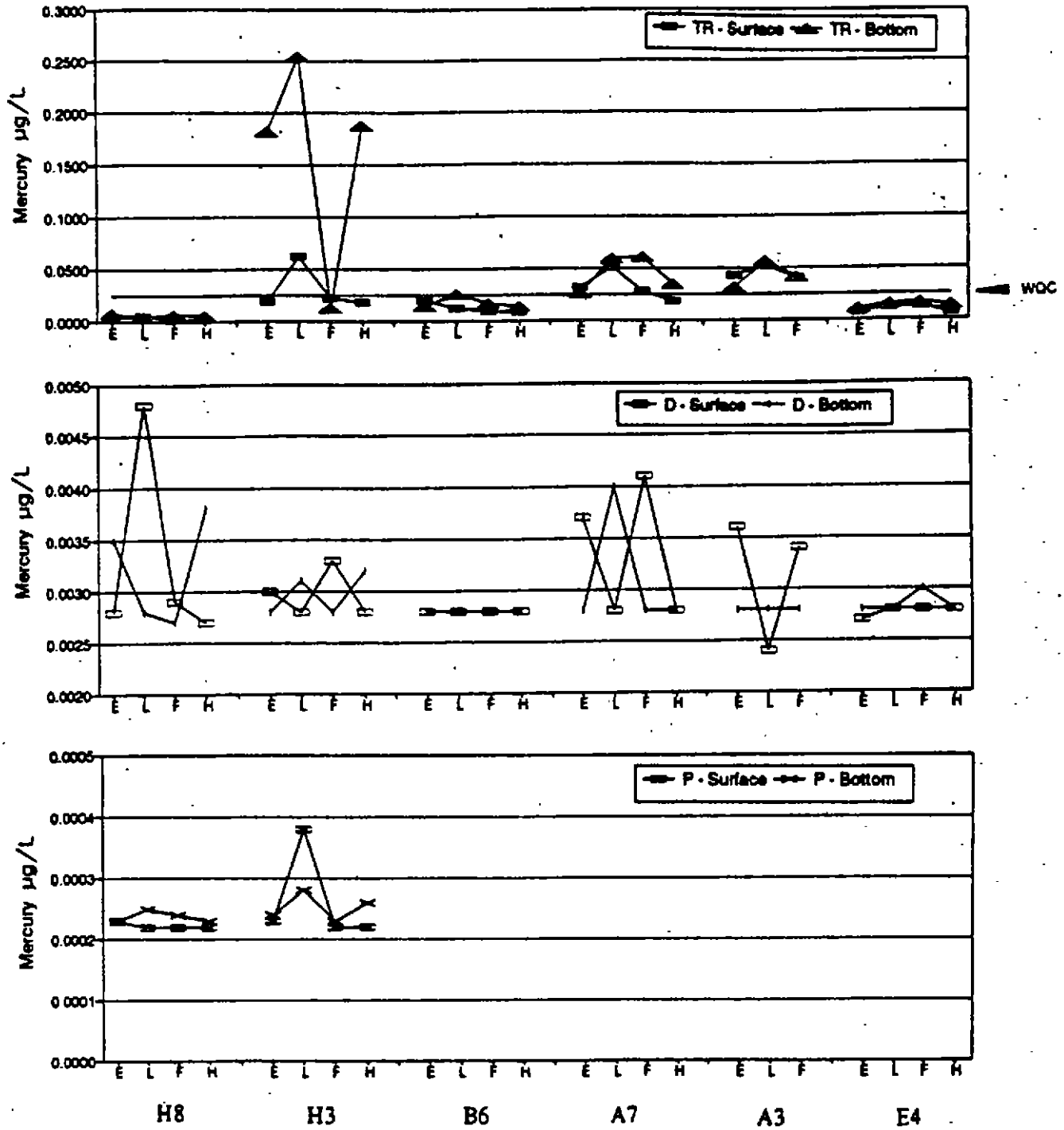

Figure 2(g). Mercury Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved. P: Particulate.

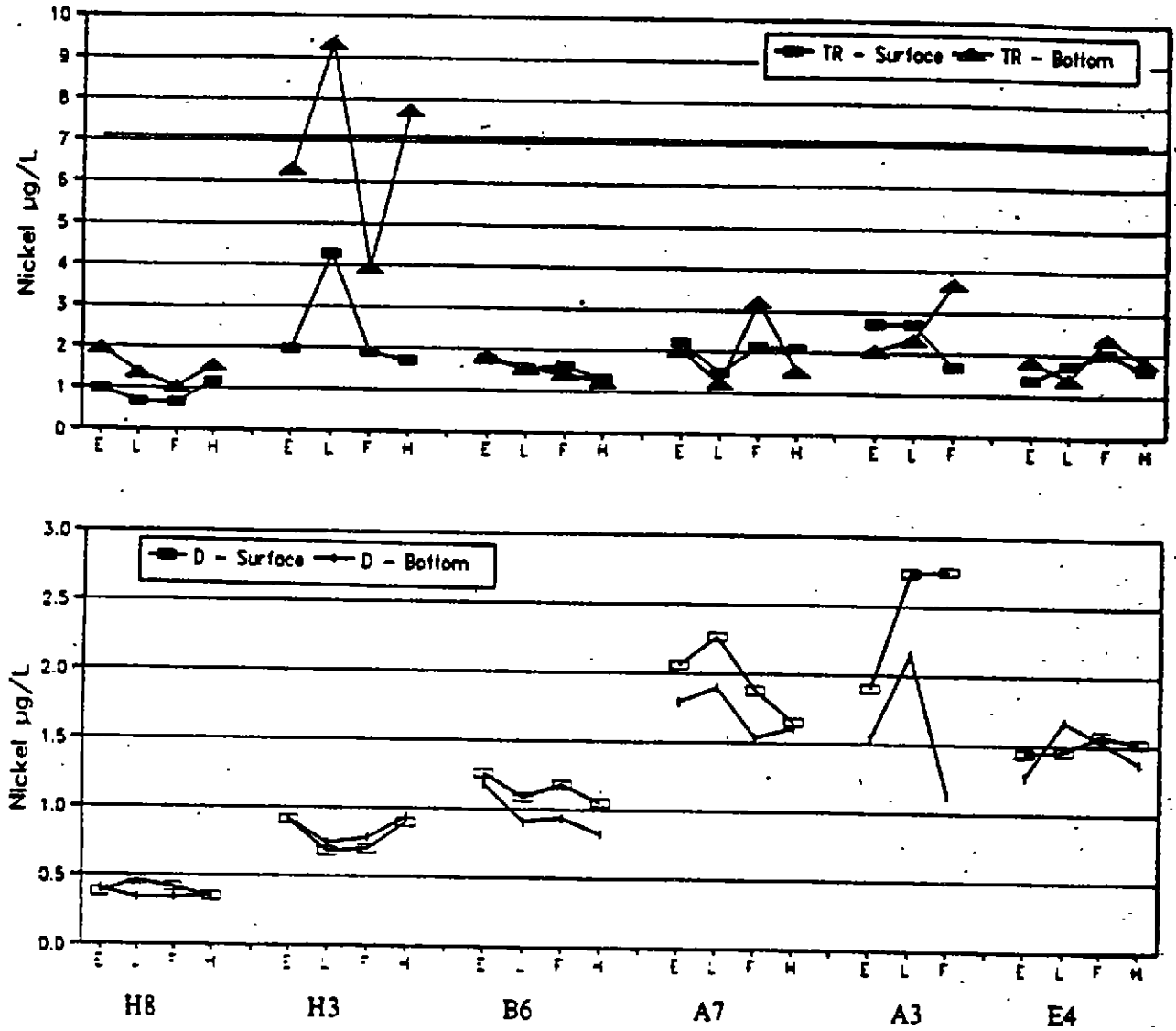

Figure 2(h). Nickel Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

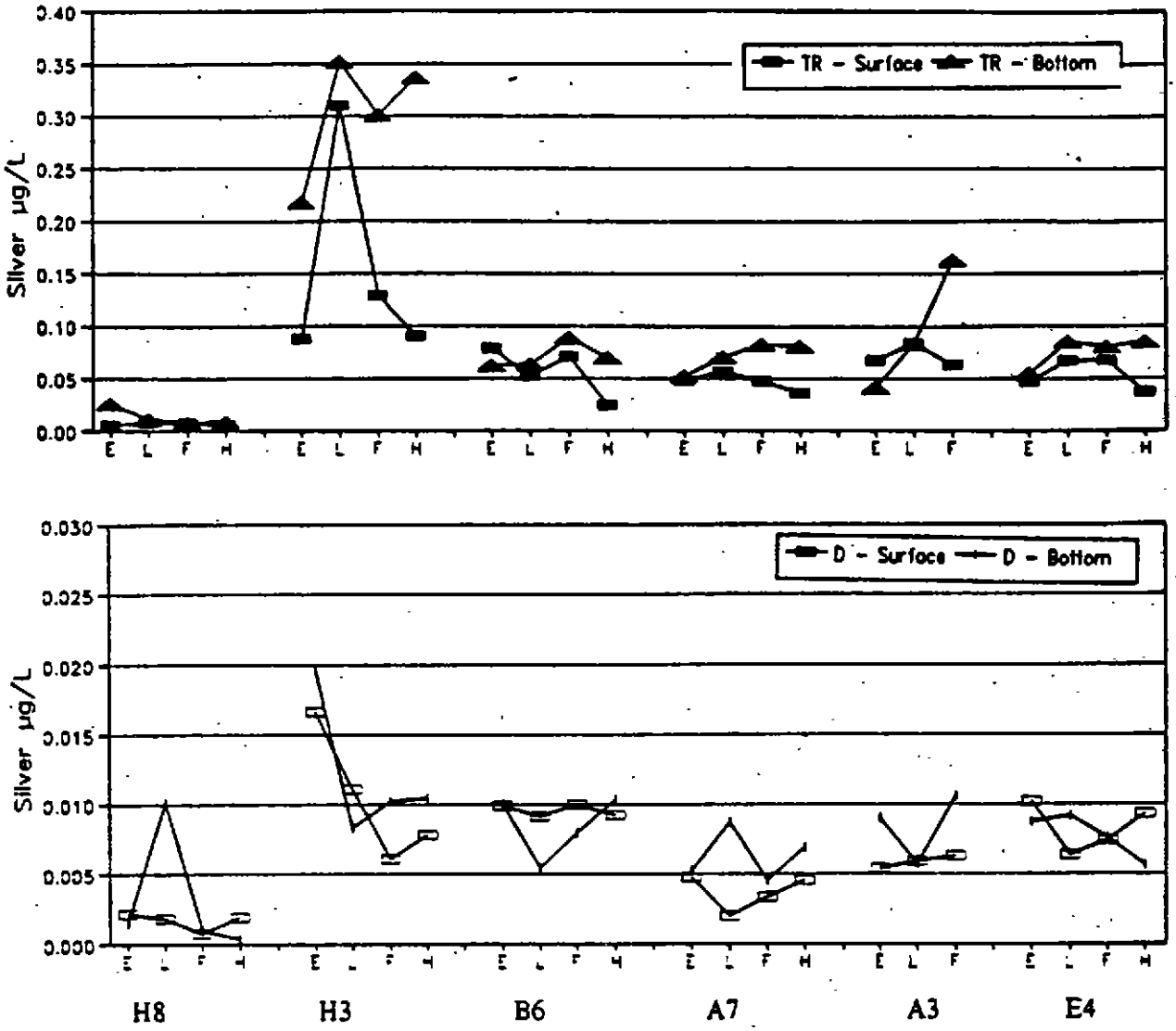

Figure 2(i). Silver Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

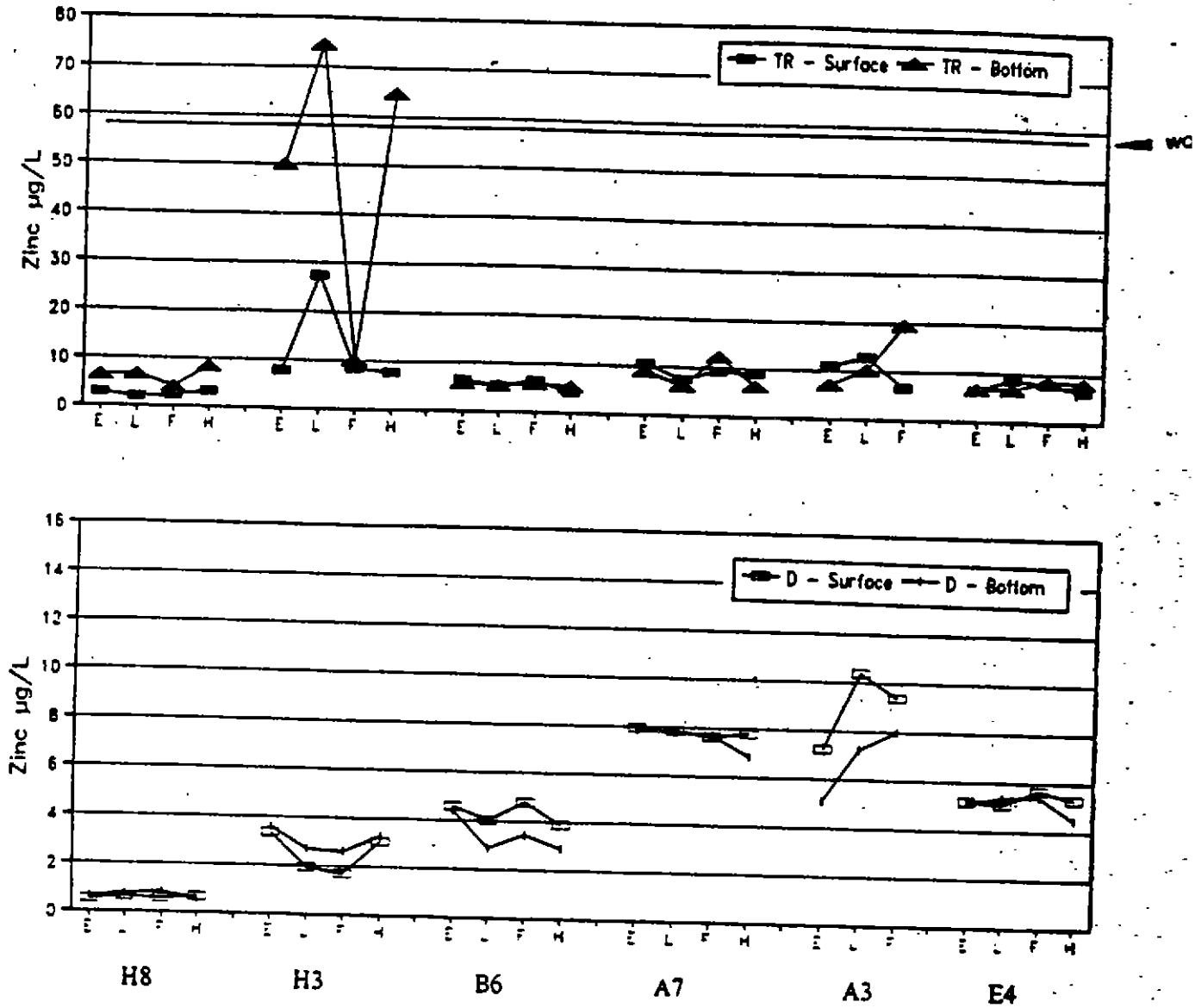

Figure 2(j). Zinc Concentrations in New York/New Jersey Harbor Waters.

Data Are from May 1991 Intensive Master Station Survey.
E: Ebb. L: Low. F: Flood. H: High.
TR: Total Recoverable. D: Dissolved.

Table 1. List of samples collected during the May 1991 Intensive Master Station Survey.[a]

Time & Tidal Stage	Sample ID	Location		Depth[b] (m)	Metals		Mercury				Split	Organic Part[c]	Surface Floc
		Lat. (N)	Long. (W)		TR	D	TR	D	AS	P			
May 15	**Station 113**												
1055 H	NYJ00082	40°49.14′	73°58.17′	8.72	1	1	1	1	1	1	0	0	—
1102 H	NYJ00083	40°49.14′	73°58.18′	2.87	1	1	1	1	1	1	0	1	—
1348 E	NYJ00084	40°49.05′	73°58.23′	8.79	1	1	1	1	1	1	0	1	—
1358 E	NYJ00085	40°49.05′	73°58.23′	2.70	1	1	1	1	1	1	0	0	—
1406 E	NYJ00084SF	40°49.05′	73°58.23′	9.30	—	—	—	—	—	—	—	—	1[d]
1645 L	NYJ00086	40°49.03′	73°58.24′	7.35	1	1	1	1	1	1	0	0	—
1652 L	NYJ00087	40°49.03′	73°58.24′	2.69	1	1	1	1	1	1	0	0	—
1957 F	NYJ00088	40°49.09′	73°58.20′	8.17	1	1	1	1	1	1	0	0	—
2005 F	NYJ00089	40°49.09′	73°58.20′	3.09	1	1	1	1	1	1	0	0	—
2013 F	NYJ00088SF	40°49.09′	73°58.20′	10.75	—	—	—	—	—	—	—	—	1
May 16	**Station 118**												
1214 F	NYJ00090	41°32.33′	73°59.35′	10.18	1	1	1	1	1	1	0	0	—
1220 F	NYJ00091	41°32.33′	73°59.35′	3.19	1	1	1	1	1	1	0	0	—
1226 F	NYJ00090SF	41°32.33′	73°59.34′	12.06	—	—	—	—	—	—	—	—	1[d]
1507 H	NYJ00092	41°32.32′	73°59.33′	9.81	1	1	1	1	1	1	0	0	—
1514 H	NYJ00093	41°32.32′	73°59.32′	3.19	1	1	1	1	1	1	0	0	—
1819 E	NYJ00094	41°32.28′	73°59.30′	8.62	1	1	1	1	1	1	1	1	—
1819 E	NYJ00098	41°32.28′	73°59.30′	8.62	1	1	1	1	1	1	0	0	—

[a]Single samples for salinity and dissolved organic carbon as well as duplicate samples for particulate carbon and total suspended solids were collected whenever a metals total-recoverable sample was collected.
[b]Noncalibrated depth.
[c]Organic particulate.
[d]Sample collected but not filtered.
H: High; E: Ebb; L: Low; F: Flood.
TR: Total Recoverable; D: Dissolved; AS: Acid-soluble; P: Particulate.

Table 1. List of samples collected during the May 1991 Intensive Master Station Survey.[a] (continued)

Time & Tidal Stage	Sample ID	Location		Depth[b] (m)	Metals		Mercury				Split	Organic Part[c]	Surface Floc
		Lat. (N)	Long. (W)		TR	D	TR	D	AS	P			
1832 E	NYJ00095	41°32.24′	73°59.33′	2.94	1	1	1	1	1	1	0	0	—
1842 E	NYJ00094SF	41°32.25′	73°59.38′	11.14	—	—	—	—	—	—	—	—	1
2125 L	NYJ00096	41°32.24′	73°59.39′	9.58	1	1	1	1	1	1	0	1	—
2136 L	NYJ00097	41°32.24′	73°59.38′	3.08	1	1	1	1	1	1	1	0	—
May 17	Station B6												
1155 H	NYJ00099	40°39.08′	74°03.45′	11.27	1	1	1	1	0	0	0	0	—
1200 H	NYJ00100	40°39.20′	74°03.42′	4.06	1	1	1	1	0	0	0	0	—
1449 E	NYJ00101	40°38.62′	74°03.08′	10.35	1	1	1	1	0	0	1	1	—
1449 E	NYJ00103	40°38.62′	74°03.08′	10.35	1	1	1	1	0	0	0	0	—
1500 E	NYJ00102	40°38.62′	74°03.08′	3.51	1	1	1	1	0	0	1	0	—
1512 E	NYJ00101SF	40°38.62′	74°03.06′	13.71	—	—	—	—	—	—	—	—	1[d]
1739 L	NYJ00104	40°38.59′	74°03.13′	10.48	1	1	1	1	0	0	1	0	—
1746 L	NYJ00105	40°38.57′	74°03.13′	3.98	1	1	1	1	0	0	1	1	—
2049 F	NYJ00106	40°38.65′	74°03.07′	11.72	1	1	1	1	0	0	0	0	—
2056 F	NYJ00107	40°38.65′	74°03.07′	3.84	1	1	1	1	0	0	0	0	—
2104 F	NYJ00106SF	40°38.64′	74°03.08′	13.94	—	—	—	—	—	—	—	—	1
May 18	Station A3												
1016 F	NYJ00108	40°33.26′	74°14.68′	10.36	1	1	1	1	0	0	0	0	—
1022 F	NYJ00109	40°33.30′	74°14.66′	3.20	1	1	1	1	0	0	0	0	—
1030 F	NYJ00108SF	40°33.27′	74°14.69′	11.64	—	—	—	—	—	—	—	—	1

[a]Single samples for salinity and dissolved organic carbon as well as duplicate samples for particulate carbon and total suspended solids were collected whenever a metals total-recoverable sample was collected.
[b]Noncalibrated depth.
[c]Organic particulate.
[d]Sample collected but not filtered.
H: High; E: Ebb; L: Low; F: Flood.
TR: Total Recoverable; D: Dissolved; AS: Acid-soluble; P: Particulate

Table 1. List of samples collected during the May 1991 Intensive Master Station Survey.[a] (continued)

Time & Tidal Stage	Sample ID	Location		Depth[b] (m)	Metals		Mercury				Split	Organic Part[c]	Surface Floc
		Lat. (N)	Long. (W)		TR	D	TR	D	AS	P			
1609 E	NYJ00112	40°33.29′	74°14.66′	8.70	1	1	1	1	0	0	1	1	—
1620 E	NYJ00113	40°33.28′	74°14.69′	2.32	1	1	1	1	0	0	1	0	—
1627 E	NYJ00112SF	40°33.29′	74°14.69′	9.95	—	—	—	—	—	—	—	—	1[d]
1845 L	NYJ00114	40°33.28′	74°14.68′	8.80	1	1	1	1	0	0	0	0	—
1851 L	NYJ00115	40°33.28′	74°14.67′	3.18	1	1	1	1	0	0	0	1	—
1851 L	NYJ00116	40°33.28′	74°14.67′	3.18	1	1	1	1	0	0	0	0	—
May 19	Station A7												
0812 L	NYJ00117	40°40.21′	74°08.19′	9.59	1	1	1	1	0	0	0	0	—
0818 L	NYJ00118	40°40.22′	74°08.20′	3.11	1	1	1	1	0	0	0	1	—
1033 F	NYJ00119	40°40.25′	74°08.19′	12.03	1	1	1	1	0	0	1	0	—
1040 F	NYJ00120	40°40.26′	74°08.17′	3.55	1	1	1	1	0	0	0	0	—
1046 F	NYJ00119SF	40°40.26′	74°08.17′	12.68	—	—	—	—	—	—	—	—	1
1408 H	NYJ00121	40°40.36′	74°08.08′	11.32	1	1	1	1	0	0	0	0	—
1414 H	NYJ00122	40°40.37′	74°08.06′	3.80	1	1	1	1	0	0	1	0	—
1710 E	NYJ00123	40°40.35′	74°08.07′	10.35	1	1	1	1	0	0	0	1	—
1710 E	NYJ00125	40°40.35′	74°08.07′	10.35	1	1	1	1	0	0	0	0	—
1720 E	NYJ00124	40°40.37′	74°08.07′	3.53	1	1	1	1	0	0	0	0	—
1727 E	NYJ00123SF	40°40.37′	74°08.08′	12.96	—	—	—	—	—	—	—	—	1[d]

[a]Single samples for salinity and dissolved organic carbon as well as duplicate samples for particulate carbon and total suspended solids were collected whenever a metals total-recoverable sample was collected.
[b]Noncalibrated depth.
[c]Organic particulate.
[d]Sample collected but not filtered.
H: High; E: Ebb; L: Low; F: Flood.
TR: Total Recoverable; D: Dissolved; AS: Acid-soluble; P: Particulate;

Table 1. List of samples collected during the May 1991 Intensive Master Station Survey.[a] (continued)

Time & Tidal Stage	Sample ID	Location		Depth[b] (m)	Metals		Mercury				Split	Organic Part[c]	Surface Floc
		Lat. (N)	Long. (W)		TR	D	TR	D	AS	P			
May 20	Station E4												
0641 E	NYJ00126	40°47.79′	73°52.16′	10.49	1	1	1	1	0	0	1	0	—
0649 E	NYJ00127	40°47.78′	73°52.16′	2.79	1	1	1	1	0	0	0	0	—
0655 E	NYJ00126SF	40°47.79′	73°52.16′	13.40	—	—	—	—	—	—	—	—	1[d]
1250 L	NYJ00128	40°47.79′	73°52.06′	8.86	1	1	1	1	0	0	0	0	—
1256 L	NYJ00129	40°47.79′	73°52.06′	3.30	1	1	1	1	0	0	0	1	—
1327 F	NYJ00130	40°47.79′	73°52.06′	9.63	1	1	1	1	0	0	0	1	—
1327 F	NYJ00132	40°47.79′	73°52.06′	9.63	1	1	1	1	0	0	0	0	—
1340 F	NYJ00131	40°47.79′	73°52.06′	3.13	1	1	1	1	0	0	0	0	—
1346 F	NYJ00130SF	40°47.80′	73°52.06′	11.98	—	—	—	—	—	—	—	—	2
1934 H	NYJ00133	40°47.79′	73°52.17′	10.91	1	1	1	1	0	0	0	0	—
1948 H	NYJ00134	40°47.79′	73°52.18′	2.77	1	1	1	1	0	0	0	0	—

[a]Single samples for salinity and dissolved organic carbon as well as duplicate samples for particulate carbon and total suspended solids were collected whenever a metals total-recoverable sample was collected.
[b]Noncalibrated depth.
[c]Organic particulate.
[d]Sample collected but not filtered.
H: High; E: Ebb; L: Low; F: Flood.
TR: Total Recoverable; D: Dissolved; AS: Acid-soluble; P: Particulate

Table 2. Data-Quality Objectives for Analytical Measurements.

Parameter	Units	WQC[a]	RLG[b]	Accuracy[c]	Precision[d]	Method[e]
Ag	µg/L	2.3	0.46	±20%	±20%	Extraction/GFAAS
As	µg/L	13	2.6	±20%	±20%	HAAS
Cd	µg/L	2.7	0.54	±20%	±20%	Extraction/GFAAS
Cu	µg/L	2.0	0.40	±20%	±20%	Extraction/GFAAS
Hg	µg/L	0.025	0.005	±20%	±20%	Extraction/CVAAS
Ni	µg/L	7.1	1.42	±20%	±20%	Extraction/GFAAS
Pb	µg/L	5.6	1.12	±20%	±20%	Extraction/GFAAS
Zn	µg/L	58	11.6	±20%	±20%	Extraction/GFAAS
TSS	mg/L	NP[f]	0.1	±10%	±5%	Mass measurement
DOC	mg/L	NP	0.24	±10%	±5%	Digestion/infrared
PC	mg/L	NP	0.063	±10%	±10%	Elemental analyzer

[a]Water quality criteria. Minimum marine chronic values are listed (from EPA or NYSDEC); except for Ag (acute value is listed. no chronic value is available).
[b]Reporting limit goals. The metal RLGs are one-fifth the corresponding minimum WQC as required for this program. Actual method detection limits (MDL) for the extraction/AAS methods are expected to be significantly lower than the RLGs. except for Ag. MDLs for direct-injection AAS methods are expected to be near or above the RLGs. Actual MDLs are given for the RLGs for total suspended solids (TSS), particulate carbon (PC), and dissolved organic carbon (DOC).
[c]Accuracy is determined as percent difference from true value (e.g., SRM, matrix spikes).
[d]Precision is determined as percent difference between replicate analysis.
[e]GFAAS: Graphite furnace atomic absorption spectrometry. HAAS: Hydride atomic absorption spectrometry. CVAAS: Cold vapor atomic absorption.
spectrometry.
[f]Not applicable.

Table 3(a). Results from the New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Salinity (‰). [a]

Station	Tide	Surface[b]	Bottom[b]
E4	Ebb	23.83	24.18
	Low	23.75	23.89
	Flood	23.35	23.49
	High	23.98	24.46
H3	Ebb	15.59	17.90
	Low	10.79	13.46
	Flood	9.93	11.43
	High	14.96	18.19
H8	Ebb	0.10	0.10
	Low	0.09	0.10
	Flood	0.10	0.11
	High	0.10	0.11
A7	Ebb	17.83	19.44
	Low	17.32	18.85
	Flood	17.98	19.58
	High	18.96	20.49
A3	Ebb	21.61	22.86
	Low	20.08	21.61
	Flood	20.40	21.18
B6	Ebb	22.87	23.13
	Low	22.42	25.76
	Flood	22.28	23.37
	High	24.22	26.17

[a]Salinity values not available for tributary stations.
[b]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively.

Table 3(b). Results from the New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Total Suspended Solids (mg/L).

Station	Tide	Surface[a]	Bottom[a]
E4	Ebb	4.40	8.65
	Low	12.1	9.17
	Flood	7.97	9.88
	High	5.17	14.0
H3	Ebb	15.9	169
	Low	132	409
	Flood	32.4	60.5
	High	17.9	317
H8	Ebb	11.4	18.0
	Low	11.2	24.5
	Flood	6.79	7.27
	High	6.87	18.1
A7	Ebb	9.50	7.58
	Low	13.8	14.1
	Flood	10.8	22.4
	High	8.99	12.5
A3	Ebb	9.15	8.11
	Low	12.2	13.5
	Flood	10.7	25.5
B6	Ebb	8.81	6.07
	Low	8.38	10.0
	Flood	8.78	8.75
	High	4.50	6.10

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]Not collected.
[c]Filter blank is based on 500-mL sample volume.

Table 3(b). Results from the New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Total Suspended Solids (mg/L). (continued)

Station	Date	Surface[a]	Bottom[a]
H8	06/19/91	33.16	28.57
	06/23/91	16.20	14.31
Hackensack	06/04/91	13.96	NC[b]
	06/18/91	6.91	NC
	08/13/91	6.83	NC
	10/30/91	9.36	NC
Passaic	06/04/91	14.55	NC
	06/18/91	22.72	NC
	08/13/91	17.17	NC
	10/30/91	8.78	NC
Raritan	06/04/91	6.50	NC
	06/18/91	7.37	NC
	08/13/91	10.2	NC
	10/30/91	3.72	NC
Quality Control Results			
Filter blank[c]			0.33

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples which were collected <1 m below the surface.
[b]Not collected.
[c]Filter blank is based on 500-mL sample volume.

Table 3(c). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Particulate Carbon and Dissolved Organic Carbon (mg C/L).

Station	Tide	Surface[a]		Bottom[a]	
		PC[b]	DOC[b]	PC	DOC
E4	Ebb	1.060	1.71	1.100	1.69
	Low	0.563	1.81	0.757	1.98
	Flood	0.657	1.77	0.666	1.78
	High	0.740	1.77	1.020	1.65
H3	Ebb	0.906	2.19	9.120	2.36
	Low	4.760	2.63	17.100	2.44
	Flood	2.000	2.63	7.460	2.62
	High	0.696	2.20	13.600	2.33
H8	Ebb	0.843	3.14	1.525	3.40
	Low	0.697	3.29	1.620	3.72
	Flood	0.747	3.43	1.060	3.47
	High	0.646	3.38	1.725	3.42
A7	Ebb	1.420	2.67	0.666	2.18
	Low	1.090	2.65	1.310	2.24
	Flood	1.140	2.45	0.975	2.08
	High	1.160	2.26	0.639	2.16
A3	Ebb	0.980	3.23	0.695	2.06
	Low	0.990	2.37	1.010	2.04
	Flood	0.945	2.56	1.350	2.19
B6	Ebb	0.623	1.73	0.528	1.96
	Low	0.494	1.74	0.778	1.67
	Flood	0.557	1.83	0.499	2.00
	High	0.568	17.10	0.518	1.62

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected 1 m below the surface.
[b]PC: Particulate carbon. DOC: Dissolved organic carbon.
[c]Not collected.
[d]Not analyzed.

Table 3(c). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Particulate Carbon and Dissolved Organic Carbon (mg C/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		PC[b]	DOC[b]	PC	DOC
H8	06/19/91	0.924	3.17	0.360	4.11
	06/23/91	0.364	3.13	0.362	3.07
Hackensack	06/04/91	2.24	4.95	NC[c]	NC
	06/18/91	1.36	4.00	NC	NC
	08/13/91	NA[d]	NA	NC	NC
	10/30/91	NA	NA	NC	NC
Passaic	06/04/91	2.58	9.99	NC	NC
	06/18/91	2.93	6.61	NC	NC
	08/13/91	NA	NA	NC	NC
	10/30/91	NA	NA	NC	NC
Raritan	06/04/91	0.345	8.52	NC	NC
	06/18/91	0.735	51	NC	NC
	08/13/91	NA	NA	NC	NC
	10/30/91	NA	NA	NC	NC

Quality Control Results	Particulate Carbon	Dissolved Organic Carbon
Matrix spike recovery (%)[e]	NP[f]	104 ± 4
Duplicates (RPD)[e]	36 ±34	2 ± 1

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected 1 m below the surface.
[b]PC: Particulate carbon. DOC: Dissolved organic carbon.
[c]Not collected.
[d]Not analyzed.
[e]Mean ± standard deviation.
[f]Not applicable.

Table 3(d). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Arsenic (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	0.90	NA[c]	0.9	0.68
	Low	1.0	NA	1.1	NA
	Flood	1.0	NA	1.0	NA
	High	1.1	NA	1.1	NA
H3	Ebb	1.2	NA	2.9	NA
	Low	1.9	NA	5.3	NA
	Flood	0.90	NA	2.0	NA
	High	1.1	NA	4.3	NA
H8	Ebb	0.46	NA	0.56	<0.19
	Low	0.43	0.18	0.51	NA
	Flood	0.43	NA	0.41	NA
	High	0.45	NA	0.56	NA
A7	Ebb	1.2	NA	1.2	NA
	Low	1.5	NA	1.4	NA
	Flood	1.2	NA	1.5	0.78
	High	1.1	0.73	1.3	NA
A3	Ebb	1.9	1.1	1.4	0.91
	Low	2.0	NA	2.0	NA
	Flood	1.7	NA	2.5	NA
B6	Ebb	1.0	0.66	1.2	0.72
	Low	0.91	0.70	1.3	0.75
	Flood	1.2	NA	1.3	NA
	High	1.3	NA	1.3	NA

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not analyzed.
[d]Not collected.
[e]Mean ± standard deviation or (range).
[f]Not applicable.

Table 3(d). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Arsenic (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	0.93	NA[c]	0.83	NA
	06/23/91	0.73	NA	0.73	NA
Hackensack	06/04/91	1.1	NA	NC[d]	NC
	06/18/91	0.68	NA	NC	NC
	08/13/91	NA	NA	NC	NC
	10/30/91	NA	NA	NC	NC
Passaic	06/04/91	1.0	NA	NC	NC
	06/18/91	1.5	NA	NC	NC
	08/13/91	NA	NA	NC	NC
	10/30/91	NA	NA	NC	NC
Raritan	06/04/91	1.4	NA	NC	NC
	06/18/91	1.2	NA	NC	NC
	08/13/91	NA	NA	NC	NC
	10/30/91	NA	NA	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[e]	<0.03 (<0.03-0.05)	NP[f]
SRM recovery (%)[e]	105 ± 3	70 (66-73)
Matrix spike recovery (%)[e]	104 ± 13	116
Duplicates (RPD)[e]	2 ± 2	NP

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected <1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not analyzed.
[d]Not collected.
[e]Mean ± standard deviation or (range).
[f]Not applicable.

Table 3(e). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Cadmium (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	0.068	0.070	0.070	0.051
	Low	0.069	0.064	0.076	0.070
	Flood	0.081	0.070	0.114	0.070
	High	0.066	0.065	0.079	0.060
H3	Ebb	0.064	0.055	0.214	0.065
	Low	0.114	0.056	0.208	0.054
	Flood	0.067	0.048	0.109	0.057
	High	0.066	0.060	0.234	0.057
H8	Ebb	0.024	0.013	0.064	0.008
	Low	0.022	0.010	0.045	0.011
	Flood	0.024	0.012	0.032	0.011
	High	0.028	0.015	0.061	0.011
A7	Ebb	0.104	0.092	0.092	0.080
	Low	0.076	0.079	0.073	0.090
	Flood	0.100	0.082	0.115	0.063
	High	0.093	0.066	0.100	0.077
A3	Ebb	0.134	0.086	0.100	0.060
	Low	0.148	0.129	0.126	0.099
	Flood	0.107	0.114	0.157	0.114
B6	Ebb	0.075	0.050	0.078	0.050
	Low	0.063	0.047	0.068	0.034
	Flood	0.064	0.061	0.062	0.048
	High	0.040	0.054	0.020	0.044

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected <1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(e). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Cadmium (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	0.076	0.032	0.052	0.027
	06/23/91	0.036	0.038	0.032	0.027
Hackensack	06/04/91	0.039	0.012	NC[c]	NC
	06/18/91	0.028	0.022	NC	NC
	08/13/91	0.012	0.009	NC	NC
	10/30/91	0.016	0.014	NC	NC
Passaic	06/04/91	0.110	0.066	NC	NC
	06/18/91	0.212	0.090	NC	NC
	08/13/91	0.048	0.026	NC	NC
	10/30/91	0.149	0.153	NC	NC
Raritan	06/04/91	0.030	0.079	NC	NC
	06/18/91	0.054	0.043	NC	NC
	08/13/91	0.014	0.020	NC	NC
	10/30/91	0.035	0.034	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[d,e]	0.004 ± 0.003	0.002 ± 0.002
SRM recovery (%)[e]	92 ± 14	86 ± 22
Matrix spike recovery (%)[e]	83 ± 7	81 ± 7
Duplicates (RPD)[e]	4 ± 5	14 ± 11

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(f). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Copper (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	2.7	1.72	3.8	1.83
	Low	3.4	1.77	3.8	1.95
	Flood	3.8	1.83	4.4	1.82
	High	2.7	1.98	4.3	1.70
H3	Ebb	3.2	1.71	23.8	1.72
	Low	12.2	1.94	36.6	1.72
	Flood	4.1	1.98	10.2	1.95
	High	3.1	1.75	29.2	1.63
H8	Ebb	1.9	1.50	3.2	1.44
	Low	1.8	1.40	2.6	1.38
	Flood	1.6	1.46	2.3	1.25
	High	1.9	1.53	3.7	1.53
A7	Ebb	3.8	2.22	3.5	1.88
	Low	3.9	2.04	4.3	1.96
	Flood	3.5	1.86	6.2	1.96
	High	3.5	2.01	4.1	1.72
A3	Ebb	6.4	2.36	5.0	2.05
	Low	6.4	2.39	6.5	2.13
	Flood	5.3	2.50	12.4	2.41
B6	Ebb	3.3	1.56	2.7	1.53
	Low	2.9	1.47	3.2	1.13
	Flood	2.8	1.79	2.9	1.37
	High	1.7	1.56	2.6	1.30

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(f). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Copper (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	4.72	2.03	3.59	1.90
	06/23/91	3.16	2.13	3.39	2.64
Hackensack	06/04/91	18.09	9.85	NC[c]	NC
	06/18/91	16.32	10.97	NC	NC
	08/13/91	5.44	3.68	NC	NC
	10/30/91	6.16	6.21	NC	NC
Passaic	06/04/91	6.56	3.94	NC	NC
	06/18/91	12.58	6.96	NC	NC
	08/13/91	5.55	3.06	NC	NC
	10/30/91	4.97	4.59	NC	NC
Raritan	06/04/91	3.03	2.61	NC	NC
	06/18/91	4.04	2.98	NC	NC
	08/13/91	3.65	2.73	NC	NC
	10/30/91	4.24	4.00	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[d,e]	0.09 ± 0.06	0.03 ± 0.05
SRM recovery (%)[e]	99 ± 8	100 ± 7
Matrix spike recovery (%)[e]	96 ± 7	100 ± 2
Duplicates (RPD)[e]	3 ± 3	5 ± 8

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(g). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Lead (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	1.04	0.176	2.02	0.169
	Low	1.57	0.198	2.27	0.213
	Flood	1.80	0.247	2.32	0.237
	High	1.01	0.170	2.39	0.158
H3	Ebb	2.09	0.126	22.2	0.206
	Low	2.27	0.092	29.6	0.108
	Flood	3.49	0.100	2.07	0.130
	High	2.15	0.125	12.9	0.186
H8	Ebb	0.91	0.075	2.25	0.095
	Low	0.81	0.080	1.94	0.087
	Flood	0.61	0.073	1.36	0.064
	High	1.15	0.077	2.86	0.090
A7	Ebb	2.54	0.165	2.14	0.181
	Low	2.72	0.190	3.00	0.192
	Flood	2.43	0.172	4.54	0.206
	High	2.10	0.192	2.64	0.192
A3	Ebb	3.33	0.225	2.52	0.159
	Low	3.61	0.280	3.55	0.217
	Flood	2.92	0.286	1.54	0.117
B6	Ebb	2.07	0.206	1.52	0.186
	Low	1.44	0.165	2.34	0.154
	Flood	1.36	0.225	1.60	0.175
	High	0.74	0.175	1.49	0.202

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(g). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Lead (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	3.14	0.147	2.17	0.151
	06/23/91	1.45	0.091	1.33	0.094
Hackensack	06/04/91	1.37	0.068	NC[c]	NC
	06/18/91	3.58	1.311	NC	NC
	08/13/91	0.28	0.038	NC	NC
	10/30/91	0.92	0.87	NC	NC
Passaic	06/04/91	4.63	0.474	NC	NC
	06/18/91	14.72	1.931	NC	NC
	08/13/91	4.68	0.523	NC	NC
	10/30/91	3.08	3.10	NC	NC
Raritan	06/04/91	0.55	0.256	NC	NC
	06/18/91	0.66	0.181	NC	NC
	08/13/91	0.77	0.212	NC	NC
	10/30/91	0.60	0.28	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[d,e]	0.01 ± 0.02	0.007 ± 0.007
SRM recovery (%)[e]	89 ± 37	70 ± 21
Matrix spike recovery (%)[e]	97 ± 8	96 ± 4
Duplicates (RPD)[e]	4 ± 2	5 ± 5

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(h). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Mercury (μg/L).

Station	Tide	Surface[a]			Bottom[a]		
		TR[b]	D[b]	P[b]	TR	D	P
E4	Ebb	0.0072	0.0027	NC[c]	0.0109	<0.0028	NC
	Low	0.0118	<0.0028	NC	0.0150	<0.0028	NC
	Flood	0.0131	<0.0028	NC	0.0161	0.0030	NC
	High	0.0063	<0.0028	NC	0.0138	<0.0028	NC
H3	Ebb	0.0195	0.0030	<0.00023	0.1818	<0.0028	<0.00024
	Low	0.0621	<0.0028	0.00038	0.2539	0.0031	<0.00028
	Flood	0.0221	0.0033	<0.00022	0.0127	<0.0028	<0.00023
	High	0.0186	<0.0028	<0.00022	0.1873	0.0032	<0.00026
H8	Ebb	0.0032	<0.0028	<0.00023	0.0077	0.0035	<0.00023
	Low	0.0051	0.0048	<0.00022	0.0048	<0.0028	<0.00025
	Flood	<0.0020	0.0029	<0.00022	0.0071	0.0027	<0.00024
	High	0.0021	0.0027	<0.00022	0.0060	0.0038	<0.00023
A7	Ebb	0.0321	0.0037	NC	0.0266	<0.0028	NC
	Low	0.0513	<0.0028	NC	0.0598	0.0040	NC
	Flood	0.0282	0.0041	NC	0.0609	<0.0028	NC
	High	0.0190	<0.0028	NC	0.0351	<0.0028	NC
A3	Ebb	0.0433	0.0036	NC	0.0315	<0.0028	NC
	Low	0.0527	0.0024	NC	0.0562	<0.0028	NC
	Flood	0.0409	0.0034	NC	0.0416	<0.0028	NC
B6	Ebb	0.0202	<0.0028	NC	0.0143	<0.0028	NC
	Low	0.0125	<0.0028	NC	0.0263	<0.0028	NC
	Flood	0.0098	<0.0028	NC	0.0166	<0.0028	NC
	High	0.0085	<0.0028	NC	0.0140	<0.0028	NC

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved. P: Particulate.
[c]Not collected.
[d]Procedural blank is based on 250-mL sample volume.
[e]Mean ± standard deviation.

Table 3(h). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Mercury (µg/L). (continued)

Station	Date	Surface[a]			Bottom[a]		
		TR[b]	D[b]	P[b]	TR	D	P
H8	06/19/91	0.0044	0.0045	0.00033	0.0060	0.0048	0.00029
	06/23/91	0.0042	0.0081	0.00017	0.0074	0.0038	<0.00018
Hackensack	06/04/91	0.0065	0.0086	0.00055	NC[c]	NC	NC
	06/18/91	0.0028	0.0062	0.00038	NC	NC	NC
	08/13/91	0.0039	0.0054	NR[d]	NC	NC	NC
	10/30/91	0.0024	0.0968	NR	NC	NC	NC
Passaic	06/04/91	0.0138	0.0063	0.00038	NC	NC	NC
	06/18/91	0.0183	0.0103	<0.00017	NC	NC	NC
	08/13/91	0.0085	0.0052	NR	NC	NC	NC
	10/30/91	0.0043	0.0080	NR	NC	NC	NC
Raritan	06/04/91	0.0054	0.0042	<0.00018	NC	NC	NC
	06/18/91	0.0049	0.0115	<0.00017	NC	NC	NC
	08/13/91	0.0032	0.0056	NR	NC	NC	NC
	10/30/91	0.0043	0.0140	NR	NC	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural Blank (µg/L)[e,f]	0.002 ± 0.002	0.002 ± 0.001
Blank Spike Recovery (%)[f]	99 ± 13	95 ± 8
Matrix Spike Recovery (%)[f]	78 ± 25	90 ± 11
Duplicates (%RPD)[f]	20 ± 9	6 ± 8

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved. P: Particulate.
[c]Not collected.
[d]Not reported.
[e]Procedural blank is based on 250-mL sample volume.
[f]Mean ± standard deviation.

Table 3(i). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Nickel (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	1.4	1.44	1.8	1.27
	Low	1.7	1.46	1.4	1.67
	Flood	2.0	1.57	2.4	1.53
	High	1.6	1.52	1.8	1.37
H3	Ebb	2.0	0.91	6.3	0.91
	Low	4.3	0.68	9.3	0.74
	Flood	1.9	0.70	3.9	0.78
	High	1.7	0.89	7.8	0.93
H8	Ebb	1.0	0.38	1.9	0.40
	Low	0.7	0.46	1.4	0.34
	Flood	0.7	0.42	1.0	0.34
	High	1.2	0.35	1.6	0.36
A7	Ebb	2.2	2.06	2.0	1.79
	Low	1.5	2.26	1.2	1.89
	Flood	2.1	1.88	3.2	1.54
	High	2.1	1.65	1.5	1.61
A3	Ebb	2.7	1.90	2.1	1.53
	Low	2.7	2.74	2.4	2.14
	Flood	1.7	2.75	3.7	1.13
B6	Ebb	1.8	1.26	1.8	1.18
	Low	1.5	1.08	1.6	0.90
	Flood	1.6	1.18	1.4	0.94
	High	1.3	1.04	1.2	0.83

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(i). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Nickel (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	1.58	0.55	1.17	0.50
	06/23/91	0.92	0.71	1.31	0.60
Hackensack	06/04/91	0.91	0.85	NC[c]	NC
	06/18/91	0.59	0.83	NC	NC
	08/13/91	0.39	0.43	NC	NC
	10/30/91	0.72	0.69	NC	NC
Passaic	06/04/91	3.12	3.06	NC	NC
	06/18/91	4.20	3.17	NC	NC
	08/13/91	1.92	1.39	NC	NC
	10/30/91	3.80	3.42	NC	NC
Raritan	06/04/91	1.14	1.74	NC	NC
	06/18/91	1.28	1.75	NC	NC
	08/13/91	1.30	1.03	NC	NC
	10/30/91	1.56	1.57	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[d,e]	0.4 ± 0.2	0.2 ± 0.1
SRM recovery (%)[f]	97 ± 22	92 ± 7
Matrix spike recovery (%)[g]	100 ± 11	94 ± 7
Duplicates (RPD)[g]	9 ± 5	5 ± 7

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected <1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(j). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Silver (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	0.047	0.0102	0.054	0.0087
	Low	0.067	0.0063	0.085	0.0091
	Flood	0.067	0.0074	0.080	0.0076
	High	0.037	0.0093	0.084	0.0056
H3	Ebb	0.087	0.0166	0.218	0.0197
	Low	0.310	0.0111	0.352	0.0083
	Flood	0.129	0.0060	0.301	0.0102
	High	0.090	0.0078	0.337	0.0104
H8	Ebb	0.006	0.0021	0.026	0.0015
	Low	0.008	0.0018	0.011	0.0101
	Flood	0.007	0.0008	0.008	0.0010
	High	0.005	0.0019	0.009	0.0004
A7	Ebb	0.048	0.0048	0.052	0.0052
	Low	0.056	0.0020	0.070	0.0087
	Flood	0.048	0.0034	0.083	0.0045
	High	0.036	0.0046	0.081	0.0069
A3	Ebb	0.067	0.0053	0.041	0.0090
	Low	0.084	0.0059	0.083	0.0057
	Flood	0.064	0.0063	0.163	0.0106
B6	Ebb	0.079	0.0098	0.062	0.0100
	Low	0.052	0.0091	0.064	0.0054
	Flood	0.070	0.0100	0.088	0.0079
	High	0.025	0.0092	0.069	0.0103

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not detected above the blank.
[d]Not collected.
[e]Procedural blank is based on 100-mL sample volume.
[f]Mean ± standard deviation.
[g]Not applicable.

Table 3(j). Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Silver (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	0.023	0.005	0.017	0.008
	06/23/91	0.006	0.007	0.005	0.002
Hackensack	06/04/91	ND[c]	0.005	NC[d]	NC
	06/18/91	ND	0.001	NC	NC
	08/13/91	0.004	ND	NC	NC
	10/30/91	ND[e]	0.004[e]	NC	NC
Passaic	06/04/91	0.089	0.018	NC	NC
	06/18/91	0.180	0.090	NC	NC
	08/13/91	0.060	ND	NC	NC
	10/30/91	0.054[e]	0.014[e]	NC	NC
Raritan	06/04/91	ND	0.010	NC	NC
	06/18/91	ND	0.010	NC	NC
	08/13/91	0.021	ND	NC	NC
	10/30/91	0.010[e]	0.007[e]	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[f,g]	0.01 ± 0.007	0.01 ± 0.006
SRM recovery (%)[g]	NP[h]	NP
Matrix spike recovery (%)[g]	105 ± 48	64 ± 28
Duplicates (RPD)[g]	32 ± 49	30 ± 25

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not detected above the blank.
[d]Not collected.
[e]Inefficient silver extraction.
[f]Procedural blank is based on 100-mL sample volume.
[g]Mean ± standard deviation.
[h]Not applicable.

Table 3(k). Results from the New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Zinc (μg/L).

Station	Tide	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
E4	Ebb	6.3	5.20	6.6	5.16
	Low	8.6	5.09	6.8	5.35
	Flood	7.9	5.68	8.5	5.44
	High	6.5	5.32	8.2	4.49
H3	Ebb	7.7	3.35	50.1	3.57
	Low	27.3	1.93	74.4	2.69
	Flood	8.5	1.70	10.0	2.58
	High	7.6	3.03	64.8	3.27
H8	Ebb	2.8	0.52	6.4	0.66
	Low	1.9	0.63	6.6	0.73
	Flood	2.3	0.56	4.2	0.84
	High	3.3	0.66	8.5	0.57
A7	Ebb	10.5	7.92	9.0	7.86
	Low	7.4	7.86	6.2	7.81
	Flood	9.3	7.60	12.2	7.68
	High	8.9	7.78	6.5	6.84
A3	Ebb	11.0	7.22	7.1	5.08
	Low	12.8	10.40	10.2	7.23
	Flood	6.6	9.38	19.6	7.95
B6	Ebb	6.4	4.57	5.7	4.38
	Low	5.2	4.00	5.5	2.85
	Flood	6.5	4.75	5.9	3.43
	High	4.3	3.88	5.5	2.89

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 3(k). Results from the New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Zinc (μg/L). (continued)

Station	Date	Surface[a]		Bottom[a]	
		TR[b]	D[b]	TR	D
H8	06/19/91	8.50	3.20	6.25	2.52
	06/23/91	3.57	2.48	4.11	3.46
Hackensack	06/04/91	7.84	1.59	NC[c]	NC
	06/18/91	4.05	1.85	NC	NC
	08/13/91	1.54	2.26	NC	NC
	10/30/91	2.42	2.09	NC	NC
Passaic	06/04/91	14.78	6.49	NC	NC
	06/18/91	32.06	16.96	NC	NC
	08/13/91	8.05	3.81	NC	NC
	10/30/91	10.09	10.10	NC	NC
Raritan	06/04/91	3.91	3.73	NC	NC
	06/18/91	7.03	6.44	NC	NC
	08/13/91	4.15	4.83	NC	NC
	10/30/91	7.30	7.76	NC	NC

Quality Control Results	Total Recoverable	Dissolved
Procedural blank (μg/L)[d,e]	0.4 ± 0.2	0.2 ± 0.1
SRM recovery (%)[e]	105 ± 25	109 ± 13
Matrix spike recovery (%)[e]	95 ± 23	101 ± 7
Duplicates (RPD)[e]	16 ± 14	6 ± 4

[a]Samples were collected at the surface and bottom, at 1/4 and 3/4 depth in the water column, respectively, except for the New Jersey Tributary samples, which were collected < 1 m below the surface.
[b]TR: Total recoverable. D: Dissolved.
[c]Not collected.
[d]Procedural blank is based on 100-mL sample volume.
[e]Mean ± standard deviation.

Table 4. Precision Results of the Field-duplicate Samples Collected for the New York/New Jersey Harbor Intensive Master Station Survey — Relative Percent Difference.

Station	As	Cd	Cu	Pb	Hg	Ni	Ag	Zn
Total Recoverable								
E4	10	64	2	<1	14	33	9	12
H8	21	9	16	14	54	8	65	35
A7	8	2	6	2	12	<1	2	33
A3	15	12	6	6	4	15	16	38
B6	9	25	2	3	5	20	44	18
Dissolved								
E4	NA[a]	7	3	3	ND[b]	7	11	2
H8	ND	25	7	23	5	2	120	21
A7	NA	10	2	3	ND	2	29	4
A3	NA	2	11	8	ND	3	17	1
B6	1	38	1	2	ND	1	12	8

[a]Not analyzed.
[b]Not detected. At least one of the field duplicates was below the detection limit.

Table 5. Results from New York/New Jersey Harbor Intensive Master Station and Tributary Surveys — Surface Floc (μg/g particulate matter).

Station	Ag	As	Cd	Cu	Hg	Ni	Pb	Zn
E4	<0.162	11.54	1.18	185.2	<0.0651	12.5	184.0	188
H3	<0.006	0.76	0.90	91.8	<0.0025	15.6	77.3	205
H8	<0.012	0.72	1.56	39.2	<0.0048	12.7	50.4	129
A7	<0.049	11.18	1.76	141.9	<0.0197	12.3	179.2	237
A3	<0.092	24.69	2.38	276.1	<0.0366	18.4	238.9	386
B6	<0.065	11.47	1.17	122.5	<0.0258	12.8	131.2	195
Quality Control								
Filter blank[a]	<0.024	<0.39	0.012	<0.53	NR[b]	<0.38	<0.08	0.26

[a]Filter blanks based on a 0.017-g mean particulate mass.
[b]Not reported; contamination suspected.

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January 20, 1992

Mr. Seth Ausubel
EPA Region II
26 Federal Plaza
New York, NY 10278

Dear Mr. Ausubel:

Enclosed are corrections and additions to the final data report *Evaluation of Trace-Metal Levels in Ambient Waters and Tributaries to New York/New Jersey Harbor for Waste Load Allocation*. Please replace page 8 you currently have with the one accompanying this letter. We have not changed the water quality criteria for Cu, Pb, and Zn elsewhere in the document because these must remain consistent with the approved Quality Assurance Project Plan.

If you have questions regarding this report please call Dr. Carlton Hunt or Dr. Damian Shea at (617) 934-0571.

Sincerely,

Damian Shea

Damian Shea, Ph.D.

Enclosure

4.0 CONCLUSIONS

This report presents a data set for the waters of NY/NJ Harbor that is of comparable quality to that reported for the January 1991 Ambient Evaluation Survey (Battelle, 1991b). Interpretation of the data presented in this report is beyond the scope of this project. However, the following are some observations and preliminary conclusions readily apparent from a cursory examination of the data.

- Surface and the bottom water total-recoverable mercury concentrations exceeded the EPA water quality criterion (0.025 µg/L) at stations H3, A3, and A7.

- Total-recoverable copper concentrations exceed the EPA water quality criterion (2.9 µg/L) at stations A3, A7, E4, and H3 at all times and depths, with the exception of the surface ebb and high tide from station E4. There were two exceedences for both stations H8 and B6. Station H8 exceeded WQC during ebb and high tide at the bottom and station B6 during ebb tide at the surface and during low tide at the bottom. Because station H8 is a freshwater station, the marine water quality criterion do not apply at this station.

- Dissolved copper concentrations do not exceed the EPA criterion.

- Bottom waters of station H3 exceeded EPA WQC for lead, nickel, and zinc during low tide, lead and nickel during high tide, and lead during ebb tide. All other lead, nickel, and zinc values were below EPA WQC.

- No exceedances of EPA WQC were observed for arsenic, cadmium, or silver.

- Bottom waters tended to have higher concentrations of metals than did surface waters.

- Except at station H3, variations in the total metals concentrations over the tidal cycle are small.

- Surface waters generally have lower TSS concentrations; the differences between surface and bottom waters are generally within a factor of 2 to 3.

- Variations in total suspended solids concentrations over the tidal cycle are small except at station H3.

- Changes in the total-recoverable metals concentrations over tidal cycles correspond closely with the changes in total suspended solids.

- Dissolved metals concentrations do not vary greatly over the tidal cycle. Changes are most likely related to variations in salinity (water type) than to remobilization of the metals from particulate matter.

- Particulate metal concentrations in the samples collected from near the sediment/water interface vary. The As, Hg, Cu, and Pb concentrations in the particulate samples from the Station H3 and H8 in the Hudson River are lower than at the other stations; Ni concentrations do not vary significantly.

- The particulate Hg results determined using room temperature pH 1 digestion are less than the difference between the total recoverable and dissolved measurement. This indicates particulate Hg is strongly bound to particles and released only with rigorous digestion techniques.

- The total-recoverable mercury concentration in the tributaries were less then the WQC. This implicates other sources as causes for high Hg in the Kills and at Hudson River station #3.

5.0 REFERENCES

Battelle. 1990a. Evaluation of trace-metal levels in ambient waters and discharges to New York/New Jersey Harbor for waste load allocation. Work/quality assurance project plan submitted to the Environmental Protection Agency under Work Assignment 2-202, Contract No. 68-C3-0105.

Battelle. 1990b. Survey Plan for evaluation of trace-metal levels in ambient waters and discharges to New York/New Jersey Harbor for waste load allocation. Final report submitted to the Environmental Protection Agency under Work Assignment 2-202, Contract No. 68-C3-0105.

Battelle. 1991a. Initial Survey Report: Evaluation of trace-metal levels in ambient waters and discharges to New York/New Jersey Harbor for waste load allocation. Final report submitted to the Environmental Protection Agency under Work Assignment 2-202, Contract No. 68-C3-0105.

Battelle. 1991b. Results of the ambient and municipal sample interlaboratory comparison study in ambient waters and discharges to New York/New Jersey Harbor. Working draft report submitted to the Environmental Protection Agency under Work Assignment 2-202, Contract No. 68-C3-0105.