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Statistical Summary
EMAP-Estuaries
Virginian Province - 1992

by

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APPENDIX A

SUB-POPULATION ESTIMATES FOR CHESAPEAKE BAY AND LONG ISLAND SOUND

The two largest systems within the Virginian Province are Chesapeake Bay (11,469 km^2) and Long Island Sound (3,344 km^2). Combined, these two systems represent 63% of the surface area of the entire Province. Because of their size, and therefore the number of sampling locations in each, estimates of ecological condition of these systems are possible using the EMAP design. However, the level of uncertainty will remain higher than for estimates for the Province as a whole or individual classes.

This appendix provides the tools for generating these estimates, *i.e.*, data for these two systems are summarized using CDFs and bar charts. Each system is defined as including all adjacent tributaries and small systems. For example, the data set for Chesapeake Bay includes the Potomac, James, and Rappahannock Rivers, and all the small systems connecting to the mainstem of the Bay. Since the Long Island Sound data set contains no large tidal rivers and fewer small systems than Chesapeake Bay, this may account for some of the differences observed between these two systems. Fifty three stations are included in the Chesapeake Bay data set and 14 in the Long Island Sound data set.

A.1 Biotic Condition Indicators

A.1.1 Benthic Index

A benthic index value below zero is indicative of a degraded benthic community. Approximately 20 ± 13% of the sampled area of Chesapeake Bay produced a benthic index value below zero, and the corresponding area of Long Island Sound was 3 ± 4% (Figure A-1).

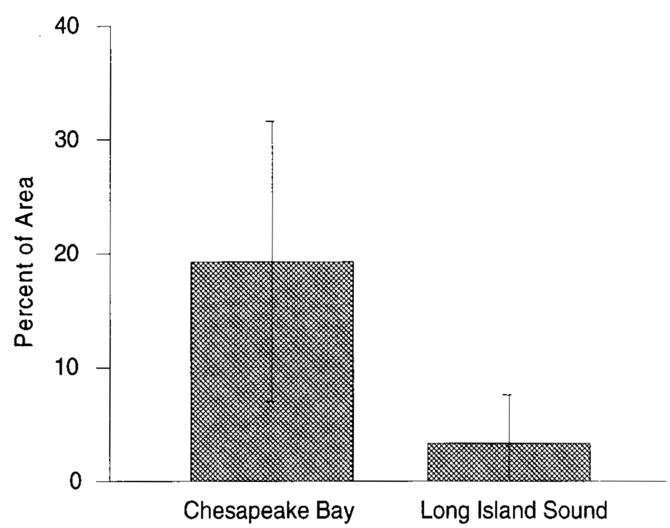


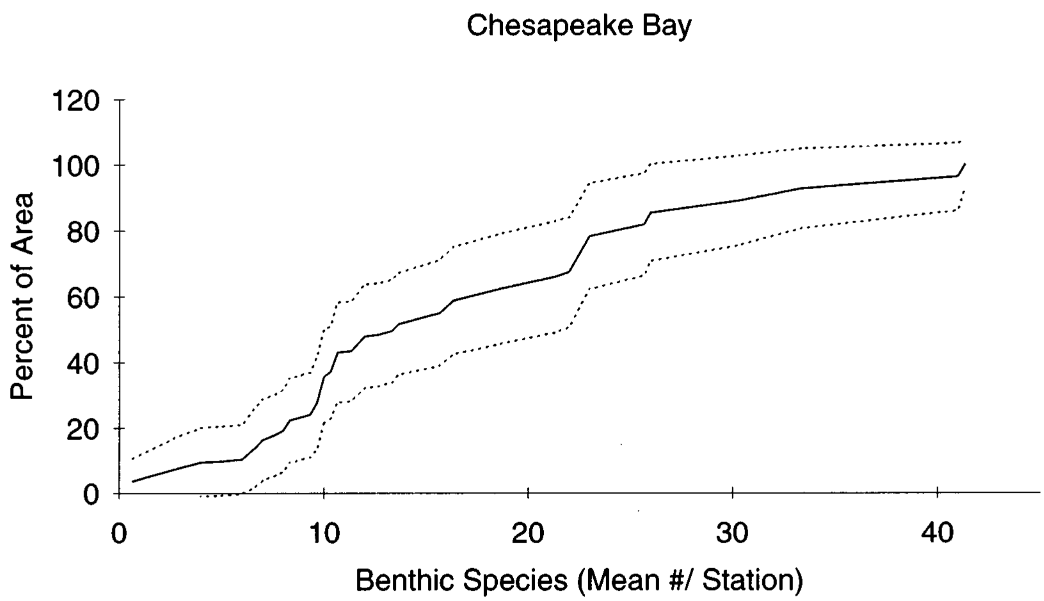
Figure A-1. Percent area of Chesapeake Bay and Long Island Sound in 1992 with a benthic index below 0. (Error bars are the 95% confidence intervals).

A.1.2 Number of Benthic Species

The total number of species collected at each station, as percent area in these systems, is illustrated in Figure A-2. The distribution and maximum (41 and 36 species) values are similar for Chesapeake Bay and Long Island Sound, respectively.

A.1.3 Total Benthic Infauna Abundance

Figure A-3 shows the distribution of total number of benthic individuals per m^2 measured in Chesapeake Bay and Long Island Sound. The maximum number of individuals collected at a station was higher in the Sound than in the Bay (21,265 and 16,712, respectively).



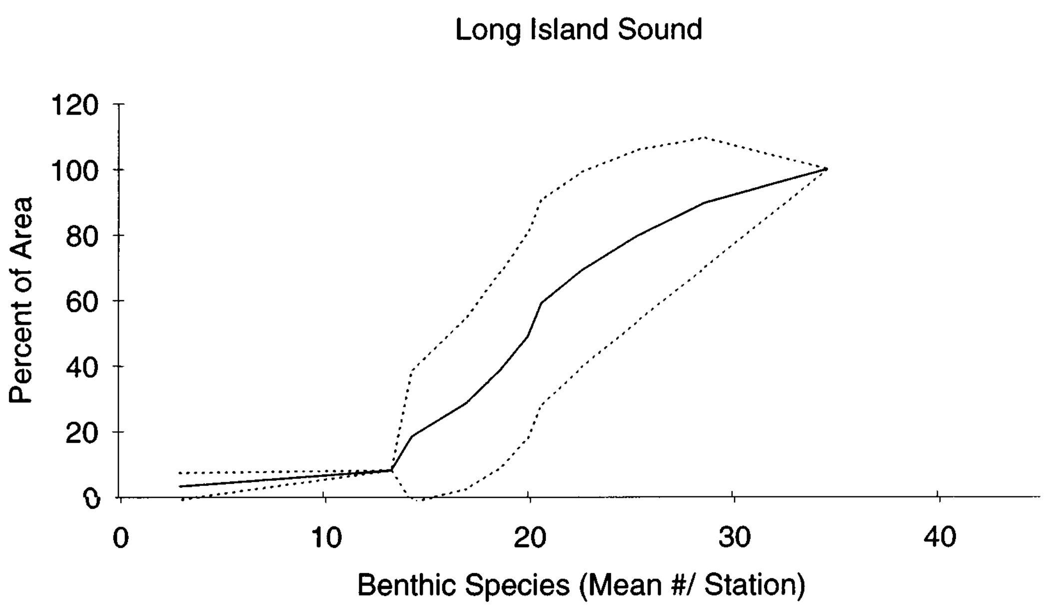
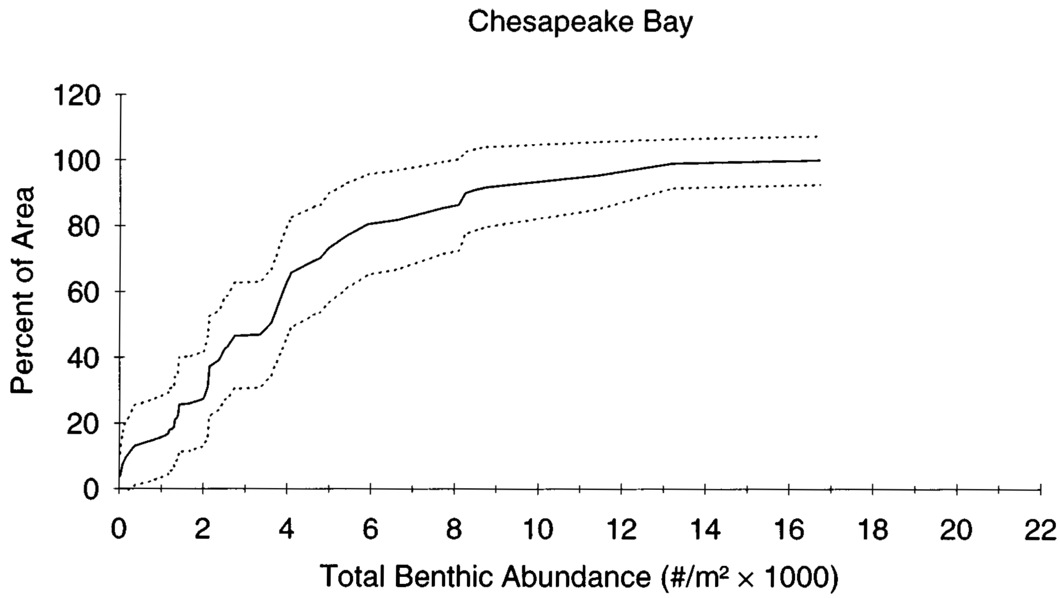


Figure A-2. Cumulative distributions of the mean number of benthic invertebrate species per station as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



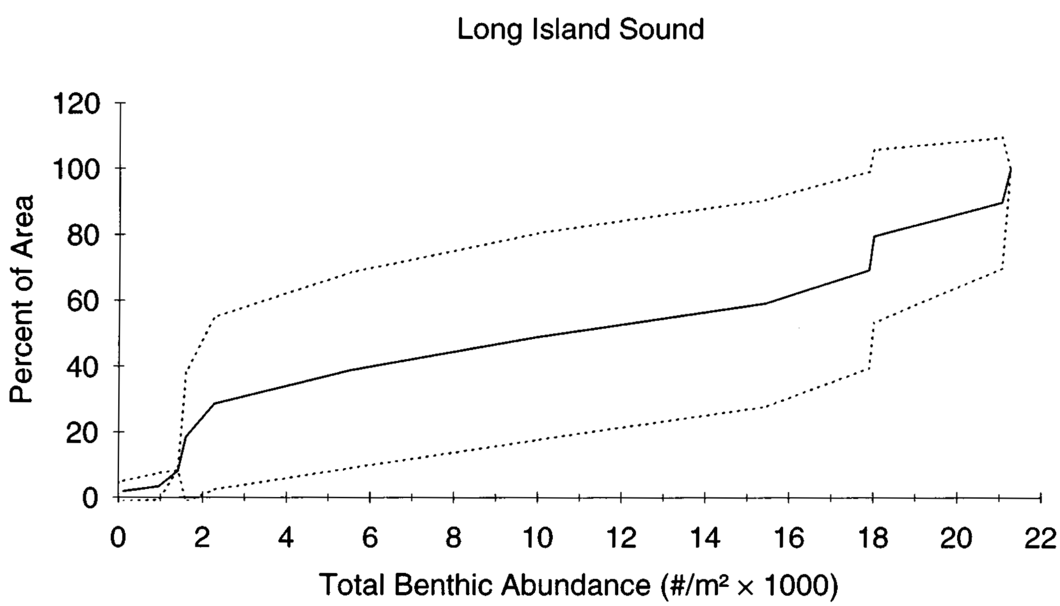


Figure A-3. Cumulative distributions of the number of benthic invertebrates collected per m^2 as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).

A.1.4 Number of Fish Species

The number of fish species collected per standard trawl is shown in Figure A-4. Between 0 and 7 species the distributions are similar; however the maximum number of individuals caught at a station in Chesapeake Bay was approximately double that in Long Island Sound (17 and 9, respectively).

A.1.5 Total Finfish Abundance

The total number of fish captured per standard trawl (catch per unit effort) was greater at Chesapeake Bay stations than Long Island Sound stations (Figure A-5). The maximum catch in the Bay was 424 individuals; whereas, no more than 212 were collected at any station in Long Island Sound. This is presumably due to habitat and cannot be related to man's impact.

A.1.6 Fish Gross External Pathology

All fish species were examined for evidence of gross external pathologies. Only two pathologies were observed in Chesapeake Bay and none in Long Island Sound; however, only 314 fish were collected and examined in Long Island Sound compared to 1,756 in Chesapeake Bay (Table A-1).

A.2 Abiotic Condition Indicators

A.2.1 Dissolved Oxygen Concentration

CDFs for bottom dissolved oxygen concentration in Chesapeake Bay and Long Island Sound are shown in Figure A-6. Approximately 11 ± 11% of sampled area of Chesapeake Bay contained severely hypoxic water (DO ≤2 mg/l). A DO of less than 2 mg/L was not measured at any station in Long Island Sound in 1992. Approximately 55 ± 29% of the Sound was marginal, with DO values less than 5 mg/L (compared to 40 ± 15% for the Bay).

A.2.2 Dissolved Oxygen Stratification

The difference in measured DO concentrations at the bottom compared with surface measurements taken at those same stations are illustrated in Figure A-7. The stations with the greatest Δ DO were found in Chesapeake Bay.

A.2.3 Sediment Toxicity

Sediments were classified as toxic if amphipod survival in the test sediment was less than 80% of that in the control sediment, and significantly different from the control. Sediments sampled from Chesapeake Bay in 1992 representing 0.6 ± 1% of the Bay's area exhibited toxicity. Approximately 10 ± 20% of the area sampled in Long Island Sound contained toxic sediments (Figure A-8).

A.2.4 Sediment Contaminants - Organics

Draft EPA Sediment Quality Criteria (SQC) exist for four compounds for which EMAP is monitoring: acenaphthene, phenanthrene, fluoranthene, and dieldrin. No station in Chesapeake Bay or Long Island Sound exceeded any of the SQCs.

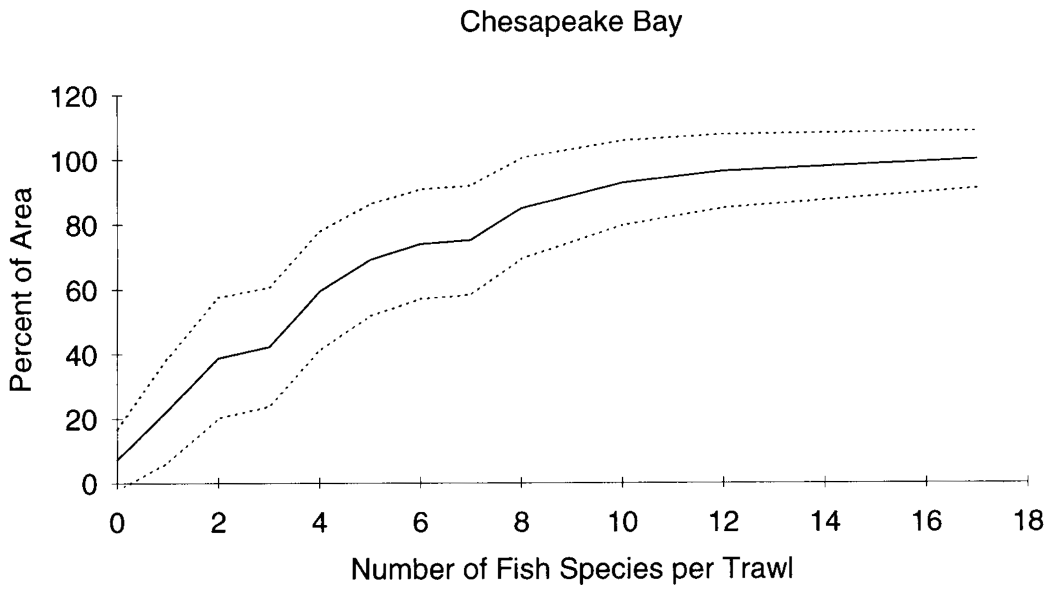
CDFs for combined PAHs are presented in Figure A-9. Although the maximum concentration measured was higher in Chesapeake Bay than Long Island Sound (13,219 and 8,235 ng/g dry weight, respectively), the distributions are similar with 97 ± 3% of the sampled area of Long Island Sound containing concentrations less than 4,000 ng/g compared to 87 ± 12% for Chesapeake Bay.

A.2.5 Sediment Contaminants - Metals

Table A-2 lists minimum, maximum, and median bulk sediment concentrations of metals measured in Chesapeake Bay and Long Island Sound in 1992. Median values for most metals were higher in Long Island Sound than in Chesapeake Bay.

A.2.6 Marine Debris

The incidence of trash collected in trawls is illustrated in Figure A-10. Trash was found in 27 ± 17% of the area of Chesapeake Bay and 18 ± 22% of the area of Long Island Sound.



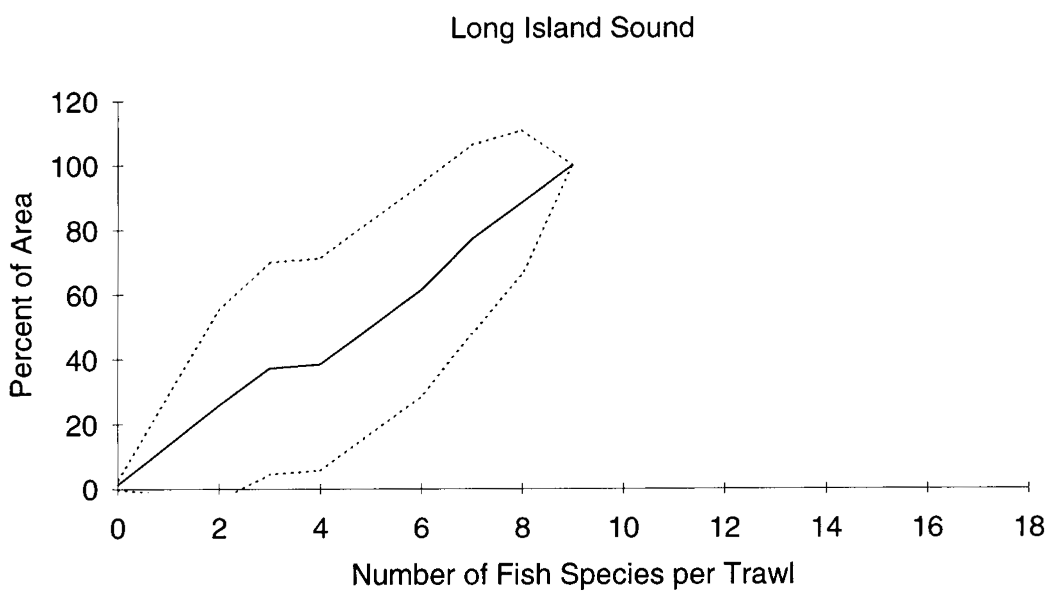


Figure A-4. Cumulative distributions of the number of fish species collected in standard trawls as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).

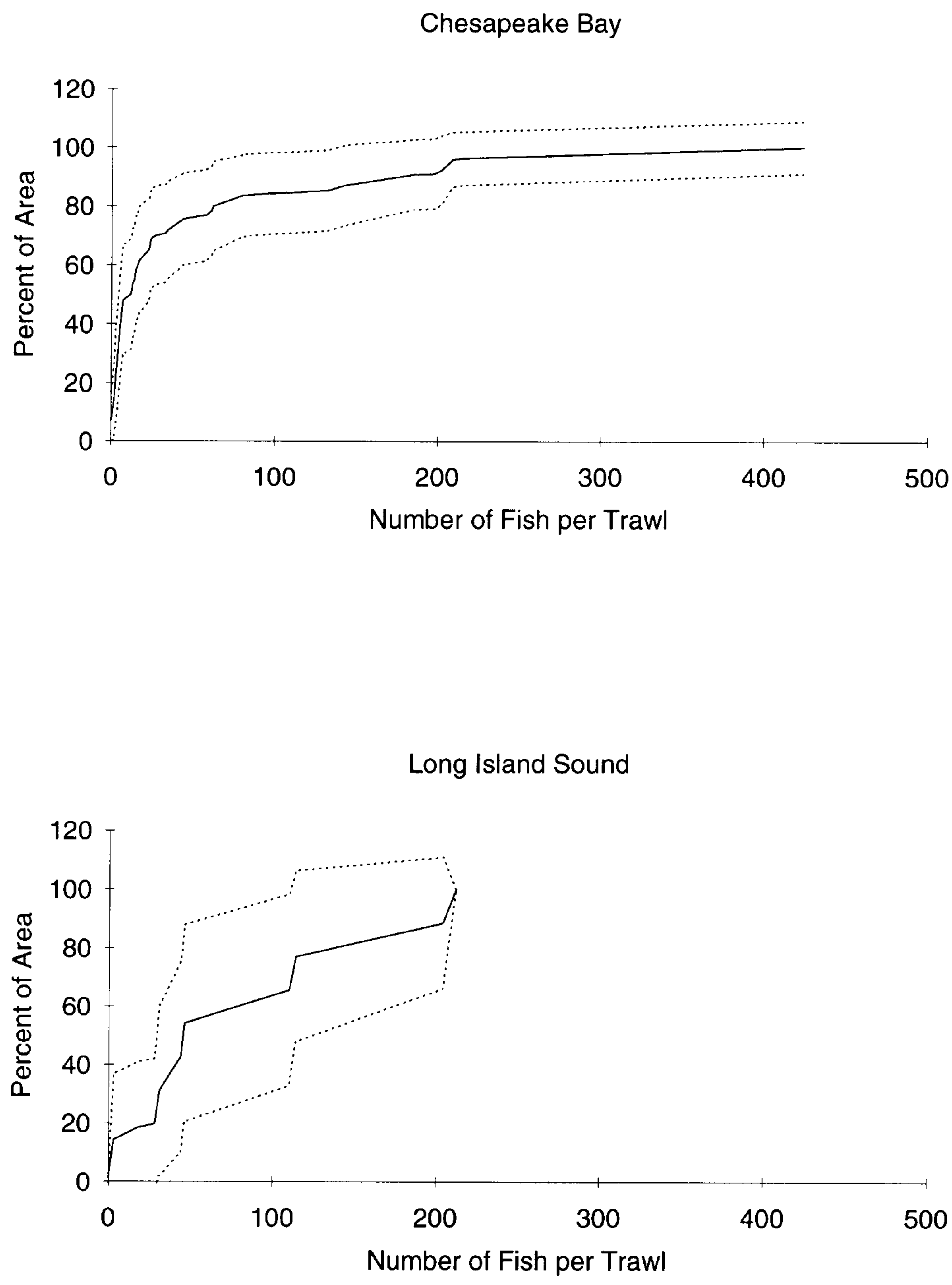
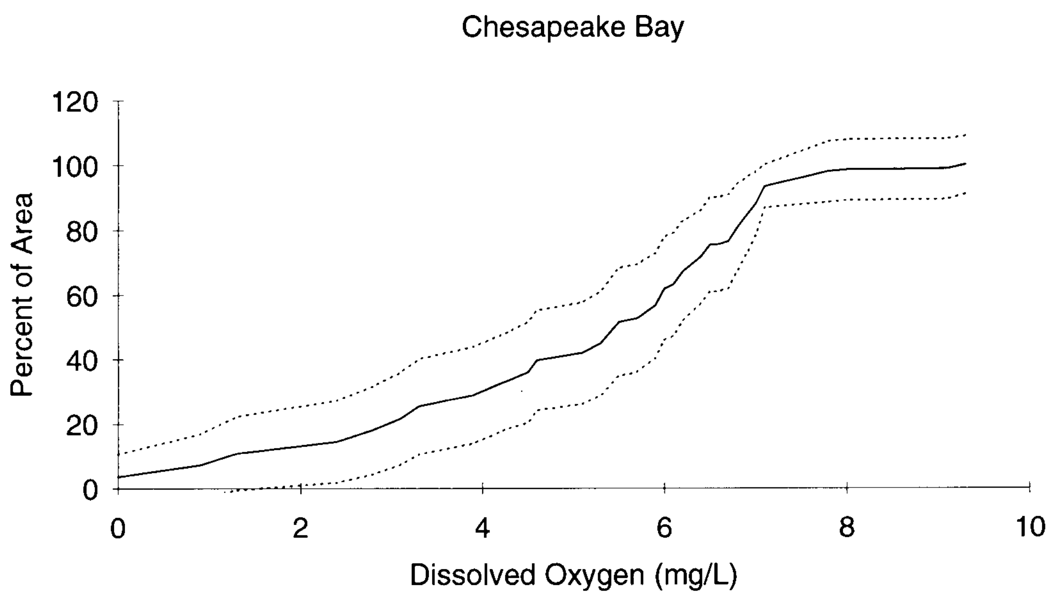


Figure A-5. Cumulative distributions of the number of fish collected in standard trawls as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).

Table A-1. Incidence of gross external pathology for Chesapeake Bay and Long Island Sound observed by field crews in 1992.

	Lumps	Growths	Ulcers	Fin Rot	Total
Chesapeake Bay					
Frequency	0	0	2	0	2
Total # Fish Examined	1,756	1,756	1,756	1,756	1,756
Percent Incidence	0%	0%	0.11%	0%	0.11%
Number Stations Represented					2
Long Island Sound					
Frequency	0	0	0	0	0
Total # Fish Examined	314	314	314	314	314
Percent Incidence	0%	0%	0%	0%	0%
Number Stations Represented					0



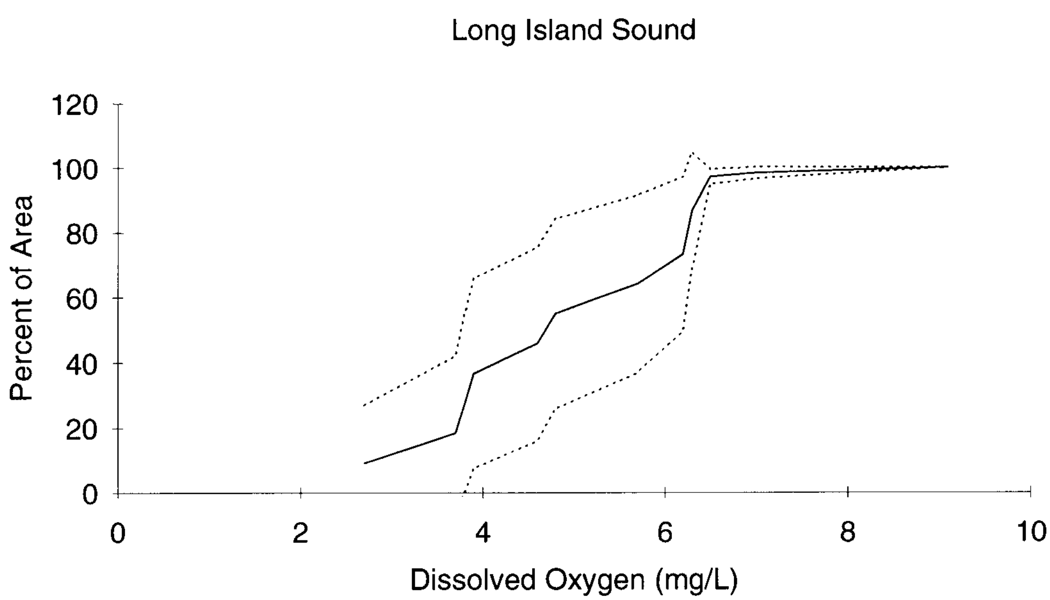
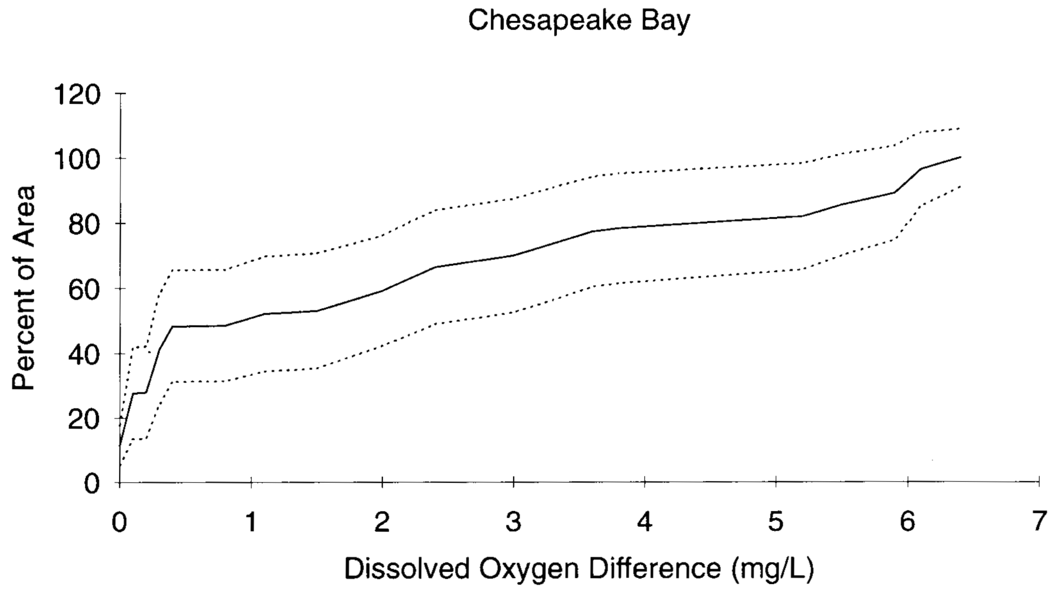


Figure A-6. Cumulative distributions of dissolved oxygen in the bottom waters as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



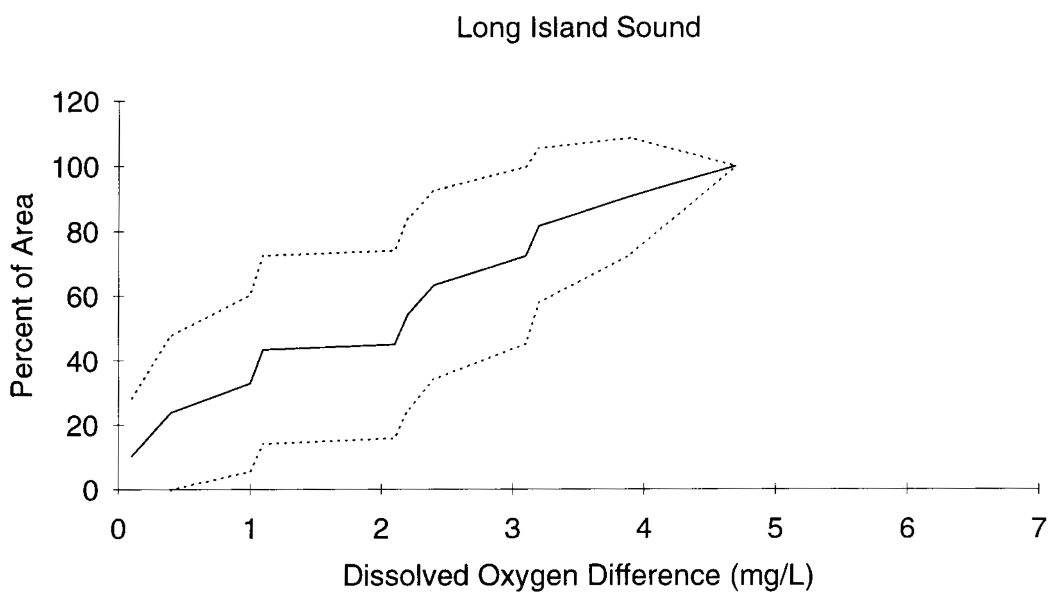
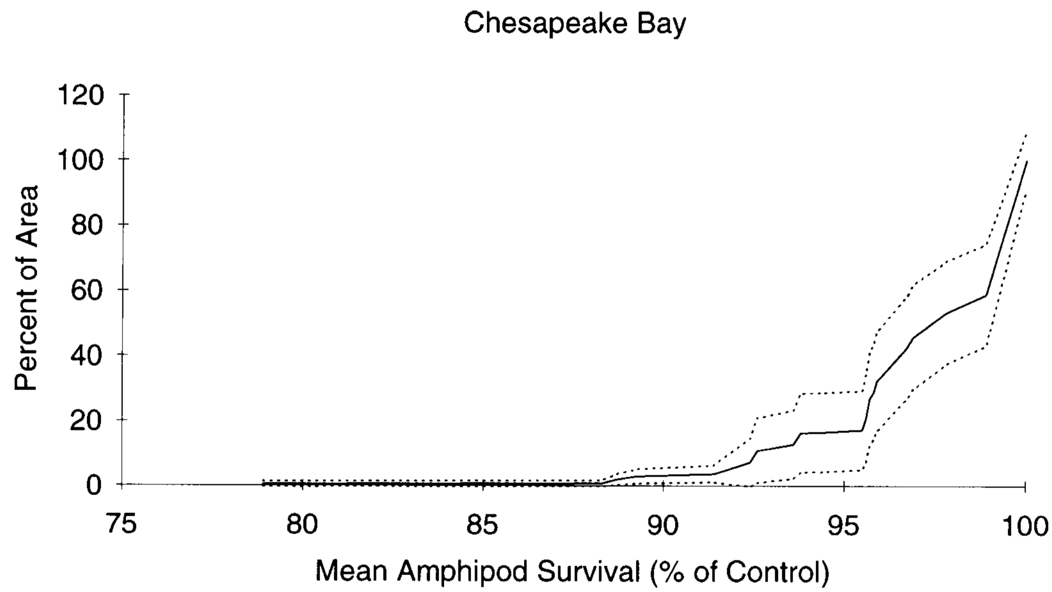


Figure A-7. Cumulative distributions of the DO difference between surface and bottom waters as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



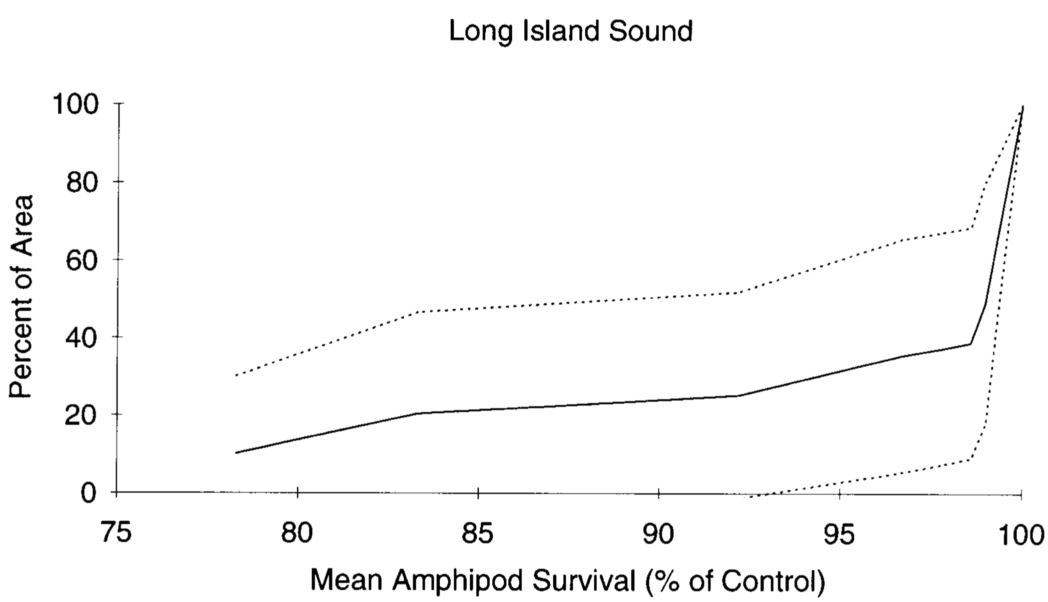
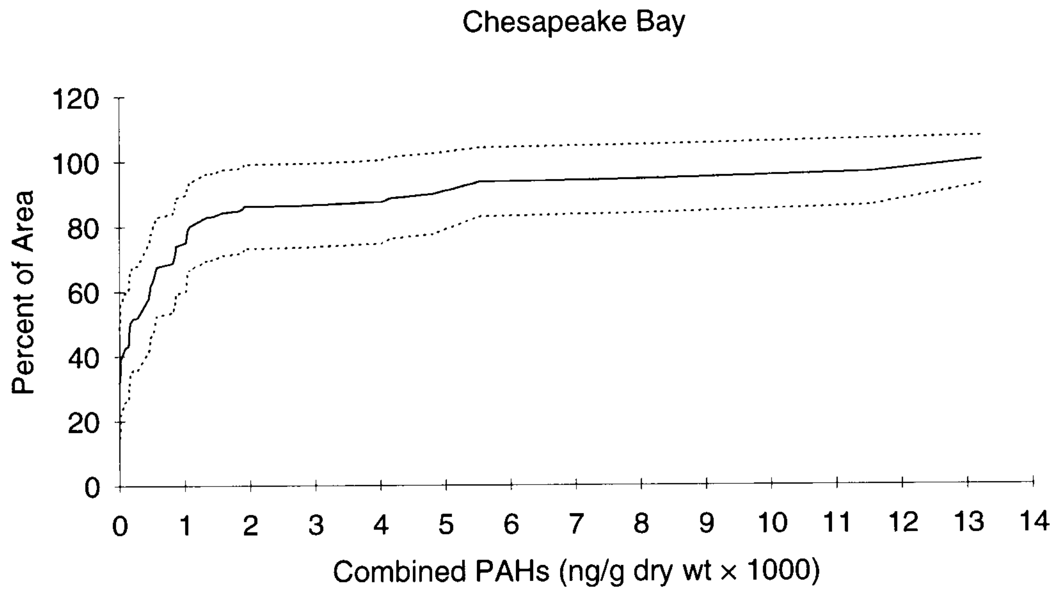


Figure A-8. Cumulative distributions of amphipod survival (% of control) in 10-day toxicity tests as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



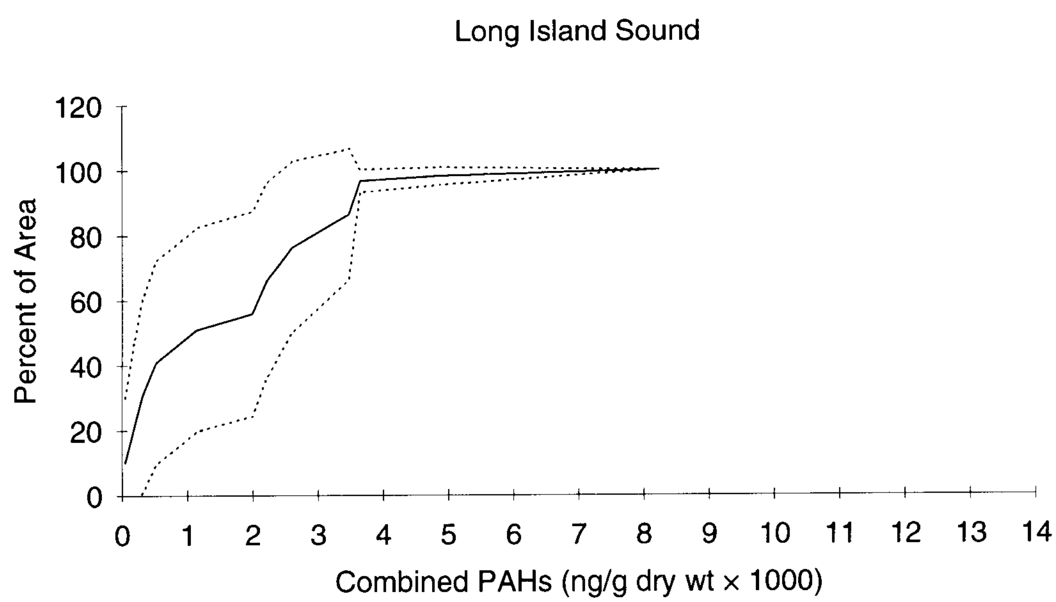


Figure A-9. Cumulative distributions of combined PAH concentrations as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).

Table A-2. Range and median metal concentrations in Chesapeake Bay and Long Island Sound sediments, 1992. Concentrations are as µg/g dry weight.

Analyte	MIN	MAX	Median
		Chesapeake Bay	
Major			
Aluminum	3,100	83,000	44,500
Iron	2,700	64,700	27,700
Manganese	52.1	5,850	447
Trace			
Antimony	ND	152[a]	0.451
Arsenic	0.423	30.8	7.93
Cadmium	ND	2.39	0.206
Chromium	6.19	147	50.3
Copper	1.91	118	22.5
Lead	ND	13,600[a]	24.3
Mercury	ND	0.21	0.054
Nickel	ND	66.7	19.8
Selenium	ND	0.86	0.314
Silver	ND	8.77	0.112
Tin	ND	11.6	2.15
Zinc	9.05	402	91.5
		Long Island Sound	
Major			
Aluminum	25,800	59,300	43,950
Iron	15,000	34,600	26,700
Manganese	464	1,230	605
Trace			
Antimony	0.228	0.820	0.445
Arsenic	3.48	17.7	6.83
Cadmium	0.063	2.23	0.168
Chromium	22.9	136	66.8
Copper	4.85	201	43.3
Lead	5.34	147	44.2
Mercury	ND	1.26	0.088
Nickel	9.7	37.1	22.9
Selenium	ND	0.760	0.336
Silver	0.017	6.44	0.541
Tin	1.05	16.3	4.47
Zinc	32.0	309	125

ND = Not Detected

[a] Lead and antimony were elevated by several orders of magnitude in sediments from one station in Chesapeake Bay. Lead shot is suspected as the cause.

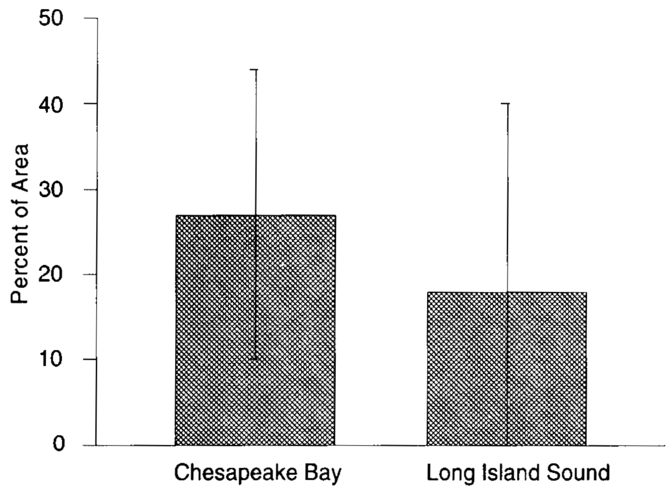


Figure A-10. The incidence of anthropogenic debris in fish trawls as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Error bars represent the 95% confidence intervals).

A.3 Habitat Indicators

A.3.1 Water Depth

Cumulative distribution functions for water depth in Chesapeake Bay and Long Island Sound are presented in Figure A-11. The Bay is generally much shallower than Long Island Sound. The maximum depths measured in the two systems in 1992 were 22 and 46 m, respectively.

The area shallower than 2 m is underestimated because this is the minimum depth sampled, and, because of the statistical design, unsampleable areas were distributed across the CDF as missing values.

A.3.2 Temperature

The CDFs for bottom water temperature in Chesapeake Bay and Long Island Sound show the Sound to generally contain lower temperature bottom waters than Chesapeake Bay (Figure A-12). This is most likely a function of both water depth and latitude.

A.3.3 Salinity

The CDFs for Chesapeake Bay and Long Island Sound (Figure A-13) illustrate their different salinity patterns, with Long Island Sound generally containing higher salinity water than the Bay.

Long Island Sound contains only polyhaline waters with a minimum bottom salinity measured in 1992 of 25‰. Chesapeake Bay, because of the inclusion of three major tidal rivers as well as the Susquehanna River, contains a significant area of oligohaline and mesohaline water (49 ± 16% of the area sampled).

A.3.4 Stratification

Stratification is shown as CDFs of $\Delta\sigma_t$, which is the σ_t (sigma-t) difference between surface and bottom waters (Figure A-14).

The greatest stratification in the Province occurred in the lower portion of the Chesapeake Bay. Chesapeake Bay and Long Island Sound were similar in the percent area with well-mixed water (64 ± 16% and 54 ± 30% respectivly, with a $\Delta\sigma_t < 1$). Chesapeake Bay had the highest percent area with significantly stratified water ($\Delta\sigma_t > 2$). All of Long Island Sound fell between $\Delta\sigma_t$'s of 0 and 1.5.

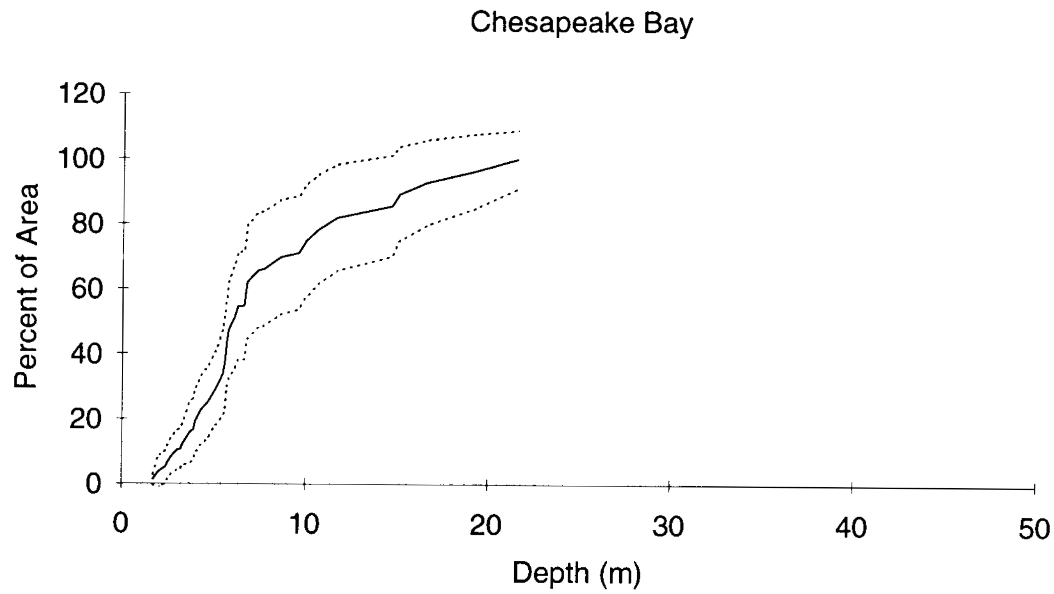
A.3.6 Percent Silt-Clay Content

The CDFs of silt-clay content for Chesapeake Bay and Long Island Sound are similar, with approximately the same percent area of mud and sand in each system (Figure A-15).

The large area of sandy sediments found in the mouth of Chesapeake Bay is likely due to sands being carried in from the ocean (Hobbs *et al.*, 1992). In Long Island Sound coarser sediments at the mouth are mainly a result of strong tidal currents transporting away the fine fraction (winnowing), leaving behind the coarser sands and gravel (Akapati, 1974; Gordon, 1980).

A.3.5 Light Extinction (water clarity)

Water clarity showed definite differences between Chesapeake Bay and Long Island Sound. Approximately 19 ± 13% of the water of Chesapeake Bay was classified as poor or marginal (light extinction coefficient ≥1.387), meaning that a wader could not see his/her toes in waste deep water, compared to 2 ± 2% of the area of Long Island Sound (Figure A-16).



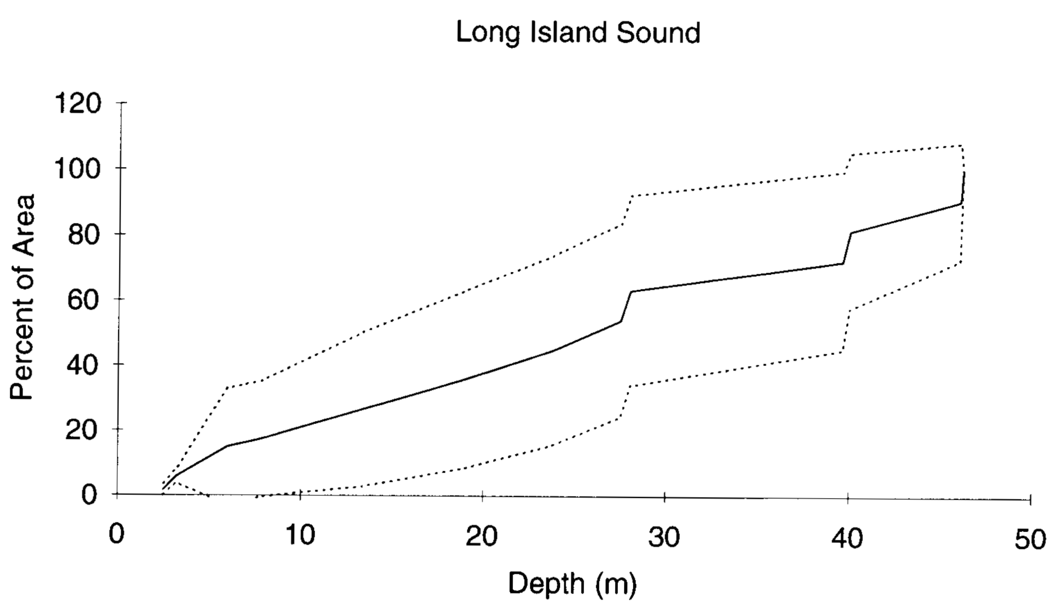
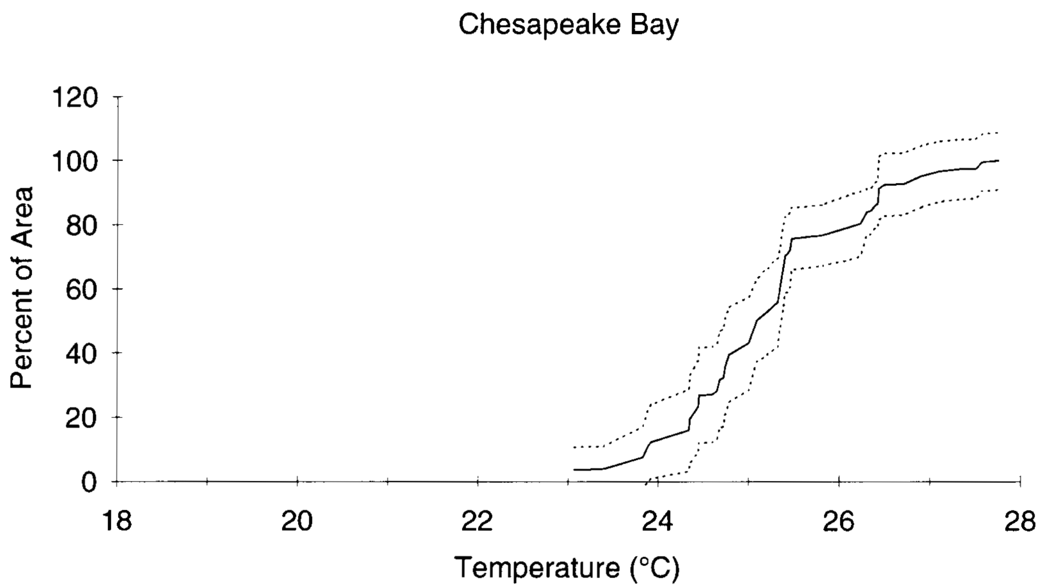


Figure A-11. Cumulative distributions of water depth as a percent of area aof Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



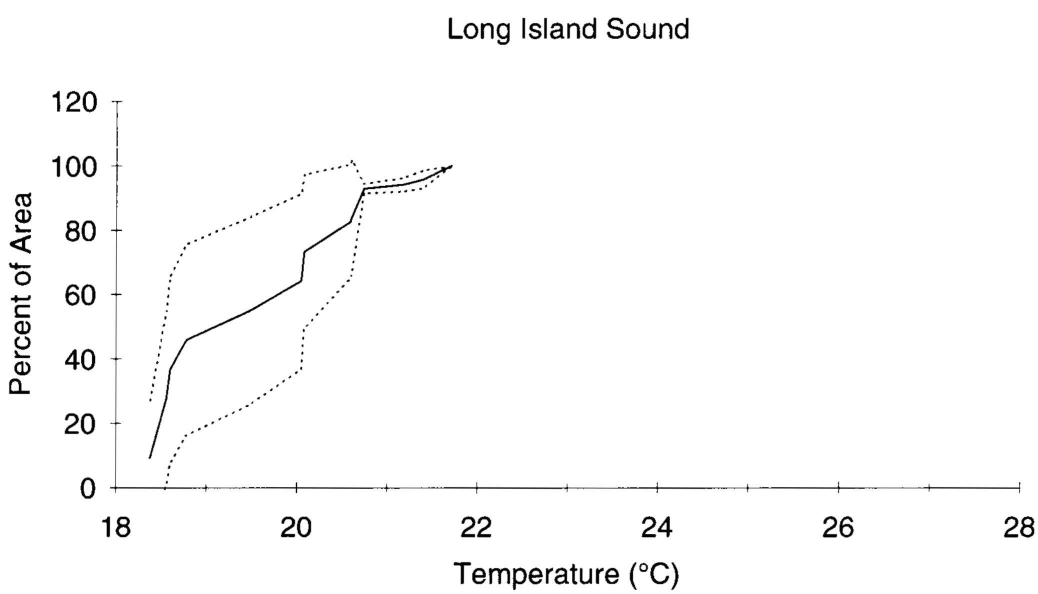
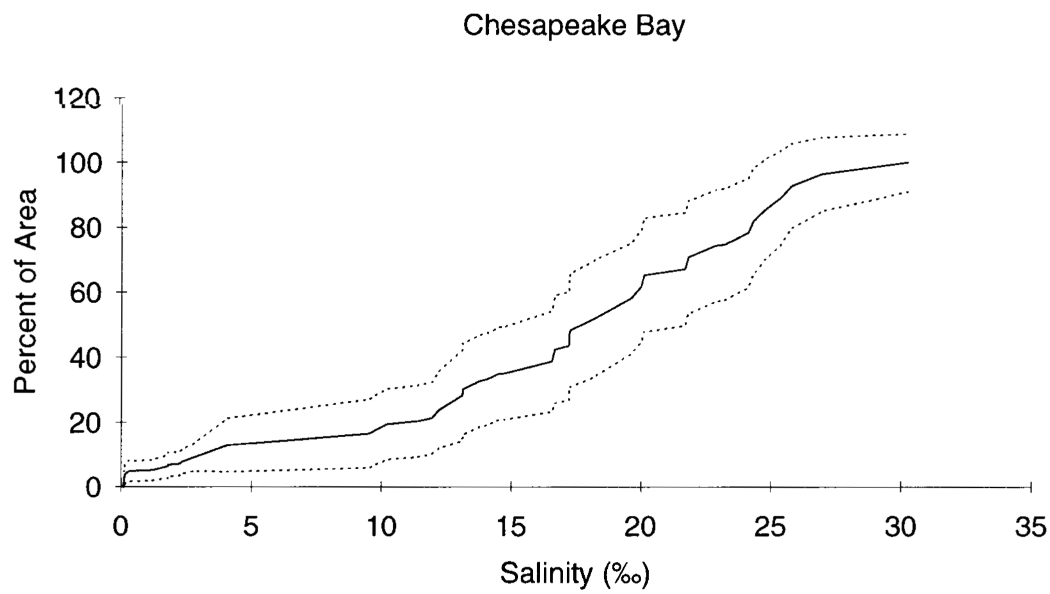


Figure A-12. Cumulative distributions of bottom water temperature as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



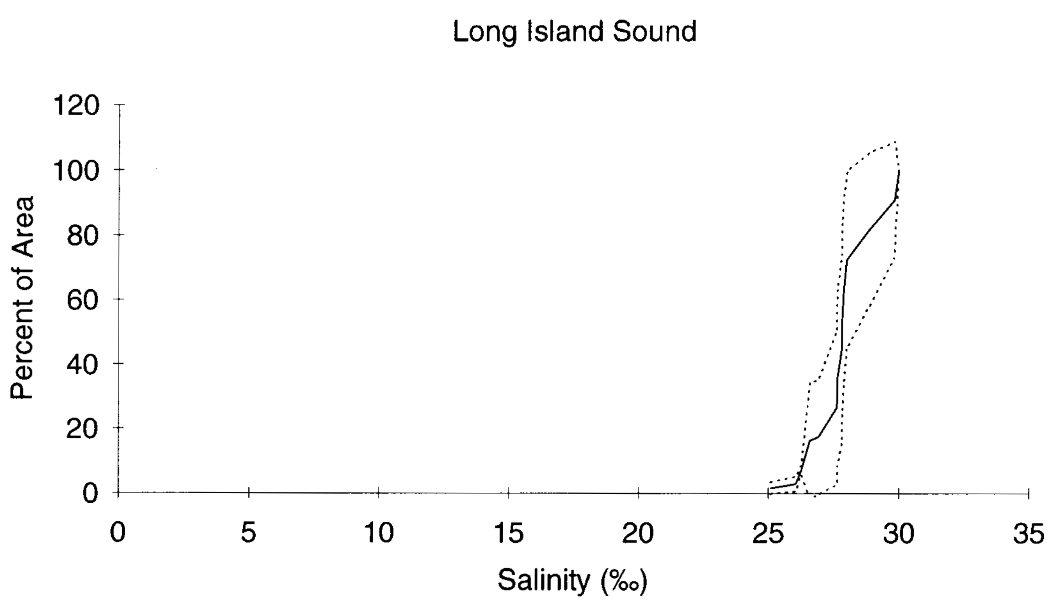
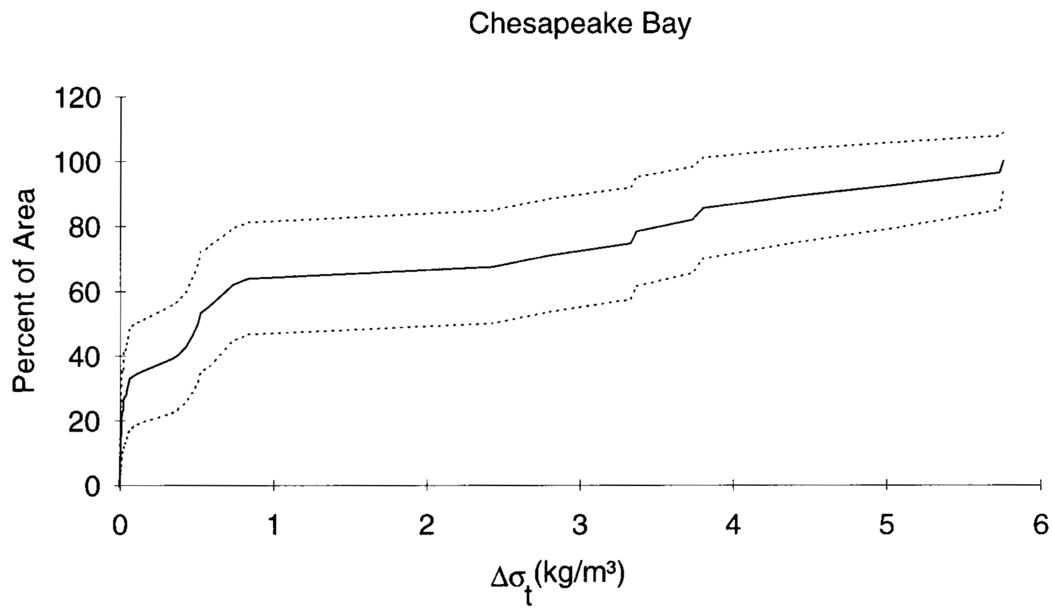


Figure A-13. Cumulative distributions of bottom water salinity as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



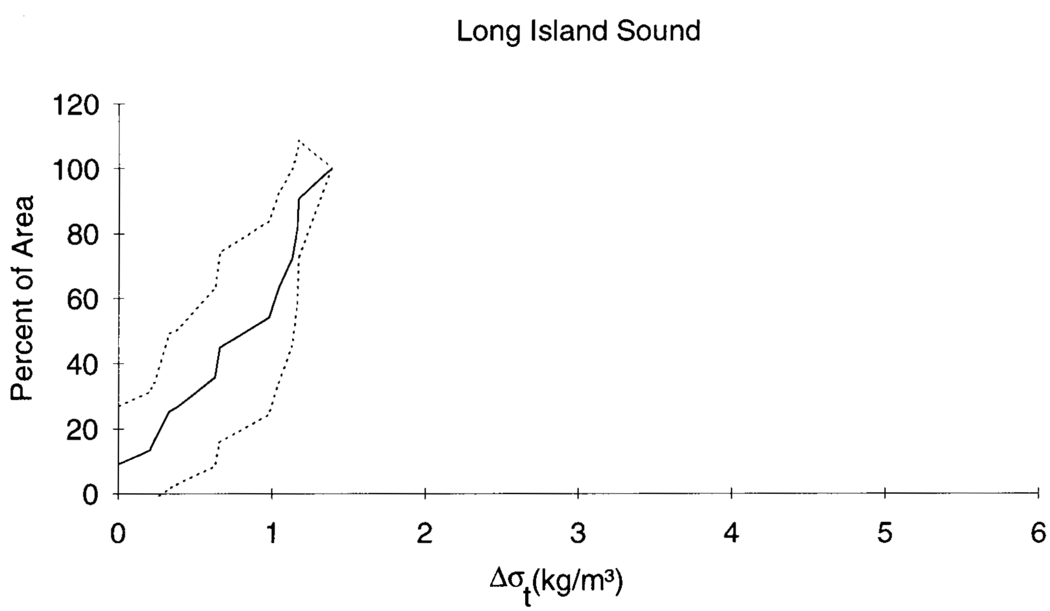
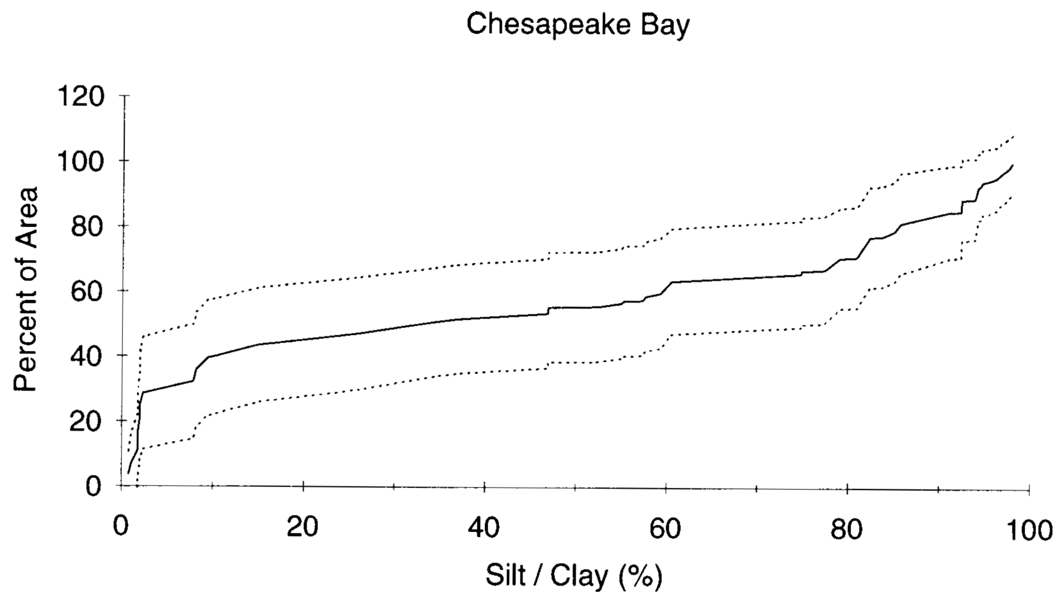


Figure A-14. Cumulative distributions of surface to bottom sigma-t difference as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence intervals).



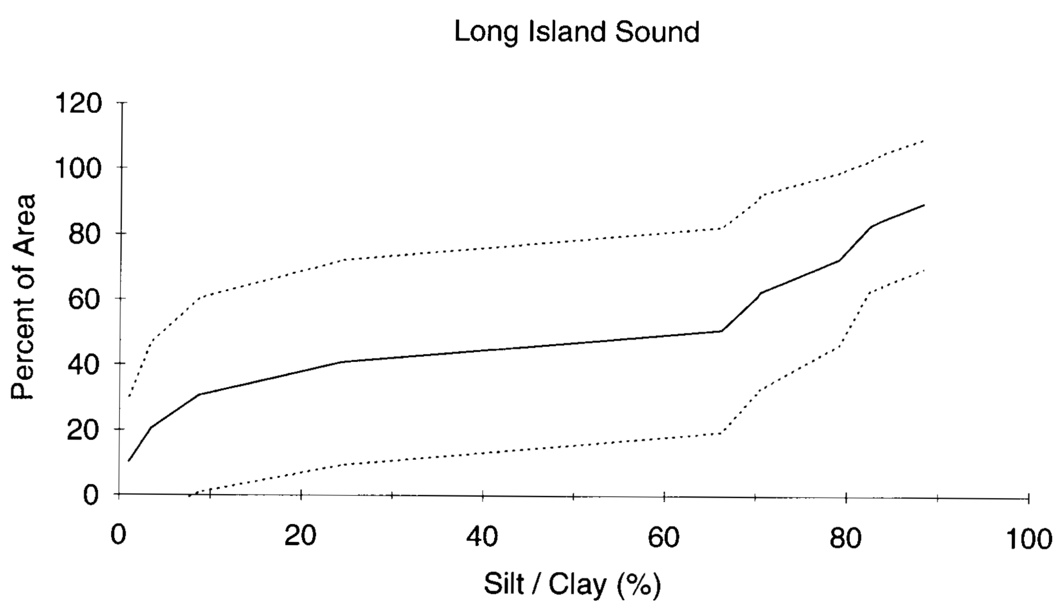


Figure A-15. Cumulative distributions of sediment silt/clay content as a percent of area of Chesapeake Bay and Long Island Sound, 1992. (Dashed lines are the 95% confidence interval).

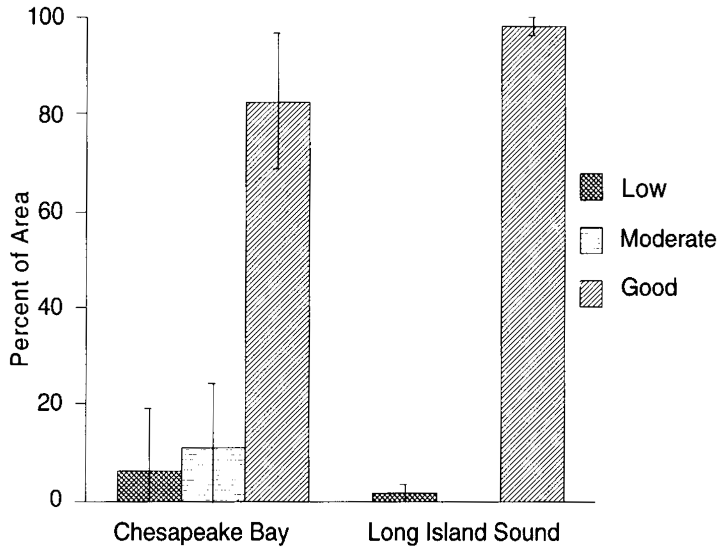


Figure A-16. Percent area of Chesapeake Bay and Long Island Sound with water clarity classified as low, moderate, or good based on light extinction coefficients. (Error bars represent 95% confidence intervals).

APPENDIX B

LINEAR REGRESSIONS OF INDIVIDUAL METALS AGAINST ALUMINUM USED IN THE DETERMINATION OF METALS ENRICHMENT OF SEDIMENTS OF THE VIRGINIAN PROVINCE

As discussed in Section 3.2.3.7, concentrations of individual metals were normalized against the crustal element aluminum in an attempt to provide a basis for estimating the areal extent of enrichment of these metals in Virginian Province sediments. The method utilized is described in Appendix A (Section A.8.2.3) of the 1991 Virginian Province Statistical Summary (Schimmel *et al.*, 1994). For each metal, a regression and an upper 95% confidence interval was determined and plotted (Figures B-1 to B-14). Stations with concentrations falling above the upper 95% confidence interval were classified as enriched for that metal. Regression parameters (slope, intercept, and correlation coefficient) are listed in Table B-1.

As described in Appendix D of the 1991 Virginian Province Statistical Summary (Schimmel *et al.*, 1994), results of this method compare well with those obtained by other researchers.

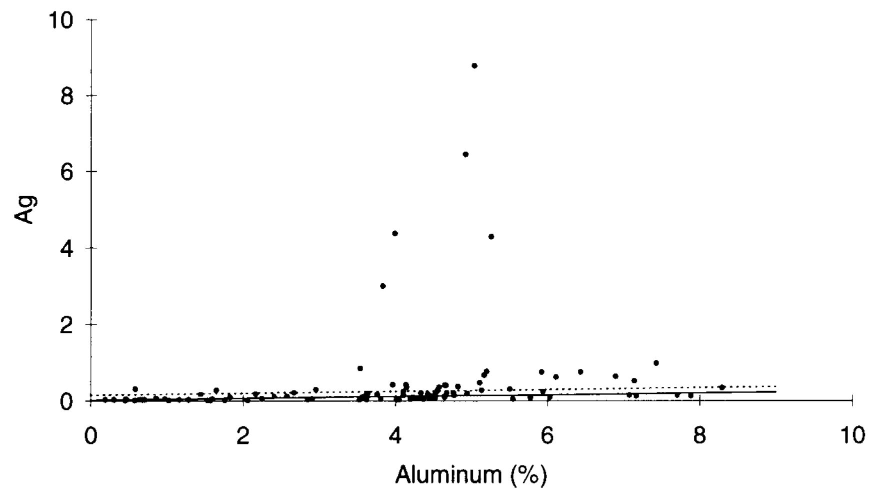


Figure B-1. Linear regression of silver against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

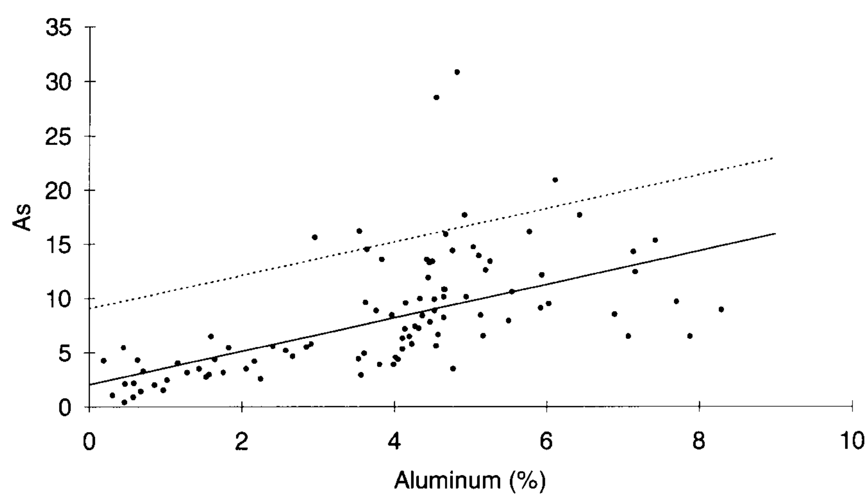


Figure B-2. Linear regression of arsenic against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

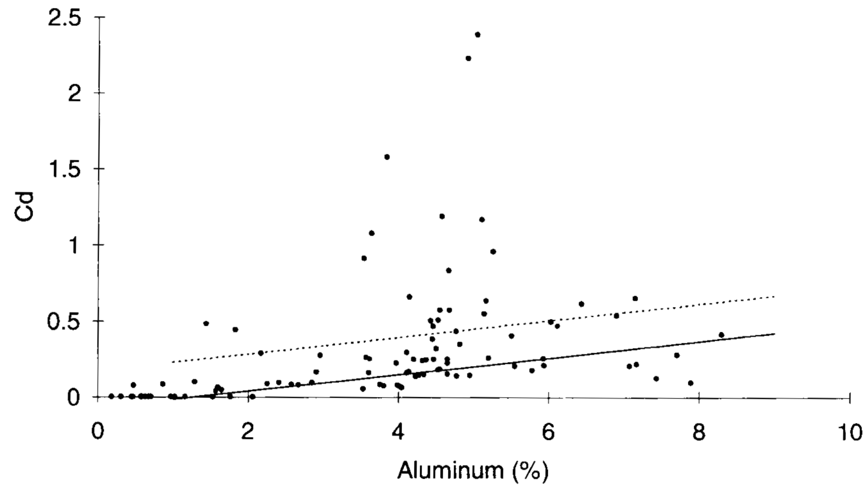


Figure B-3. Linear regression of cadmium against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

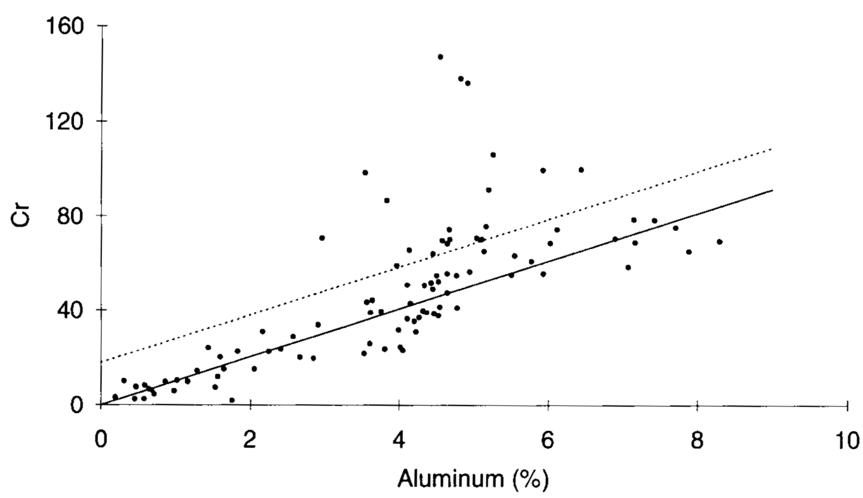


Figure B-4. Linear regression of chromium against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

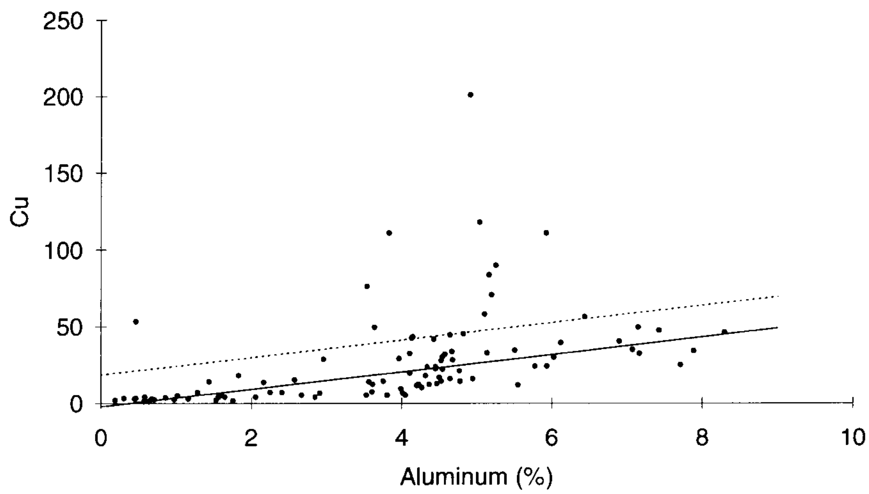


Figure B-5. Linear regression of copper against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

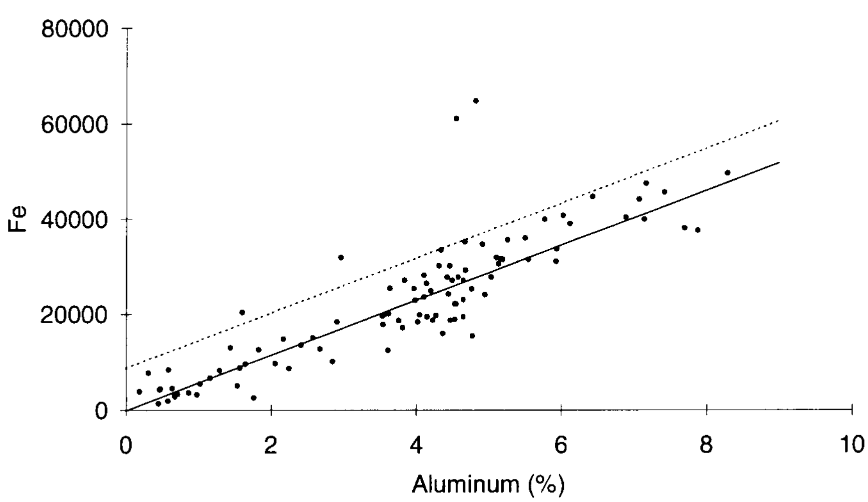


Figure B-6. Linear regression of iron against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

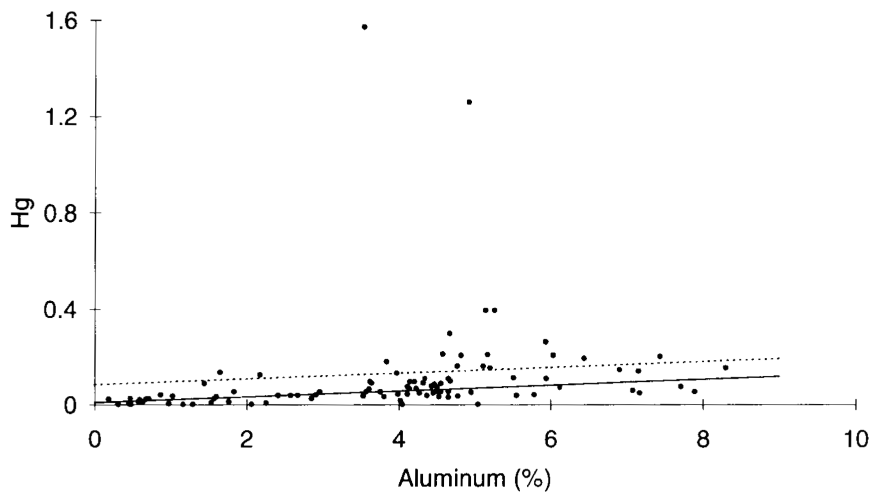


Figure B-7. Linear regression of mercury against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

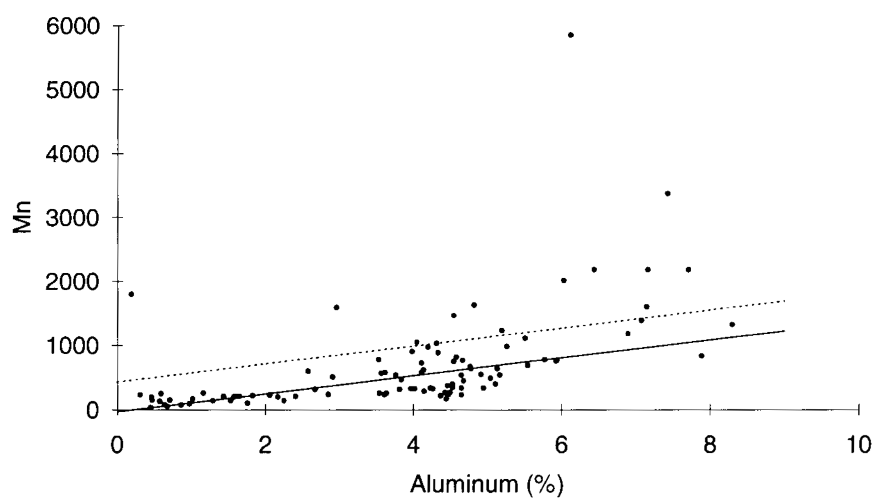


Figure B-8. Linear regression of manganese against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

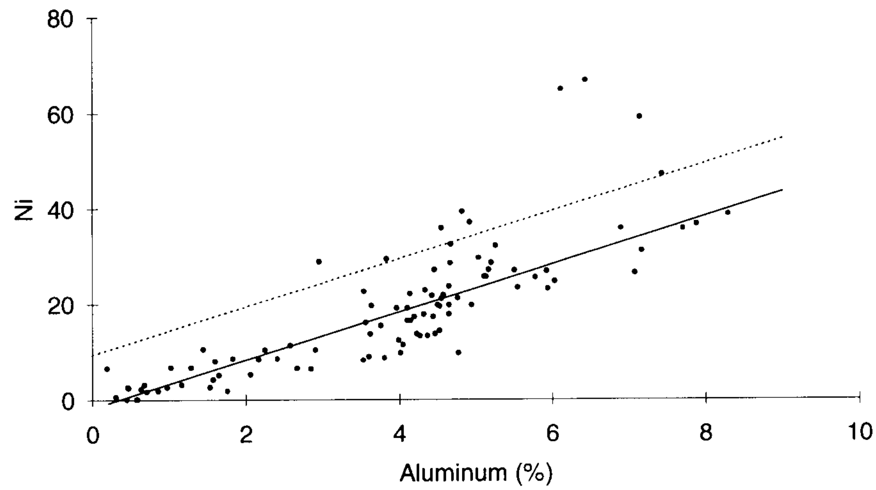


Figure B-9. Linear regression of nickel against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

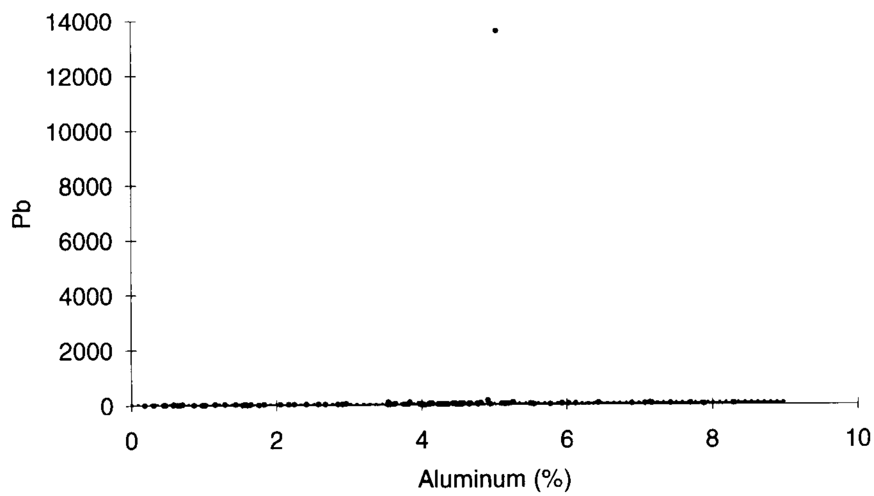


Figure B-10. Linear regression of lead against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

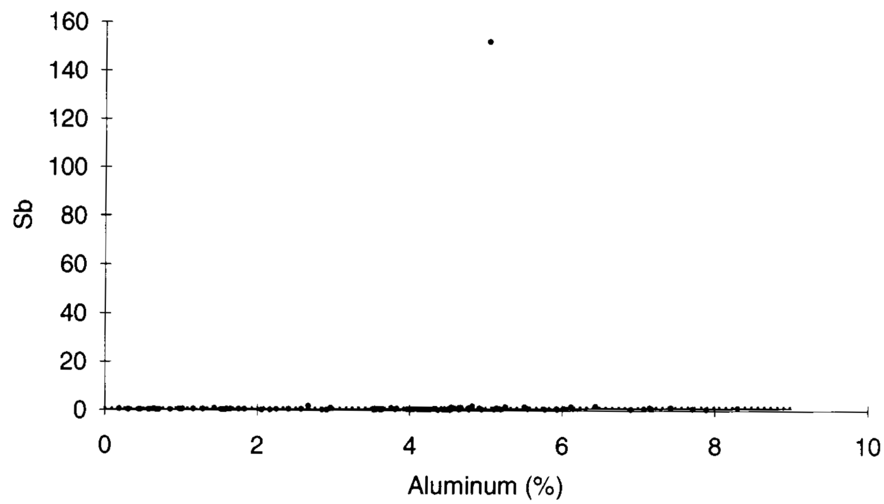


Figure B-11. Linear regression of antimony against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

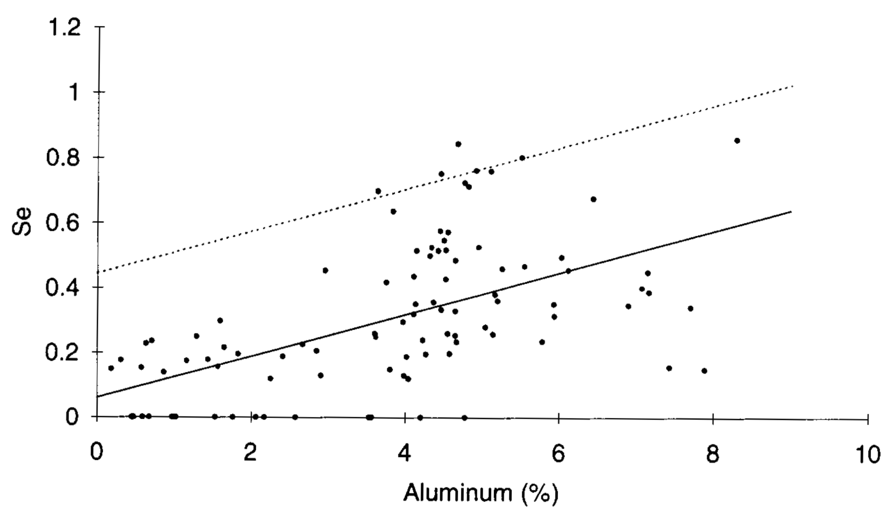


Figure B-12. Linear regression of selenium against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

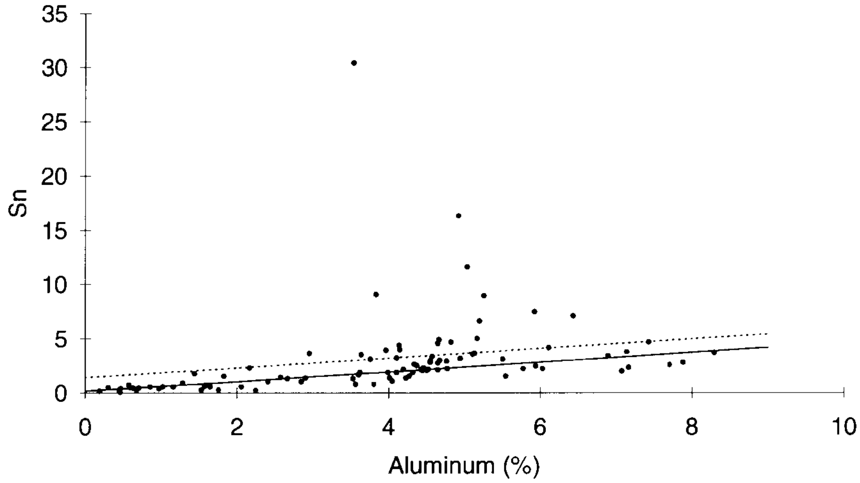


Figure B-13. Linear regression of tin against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

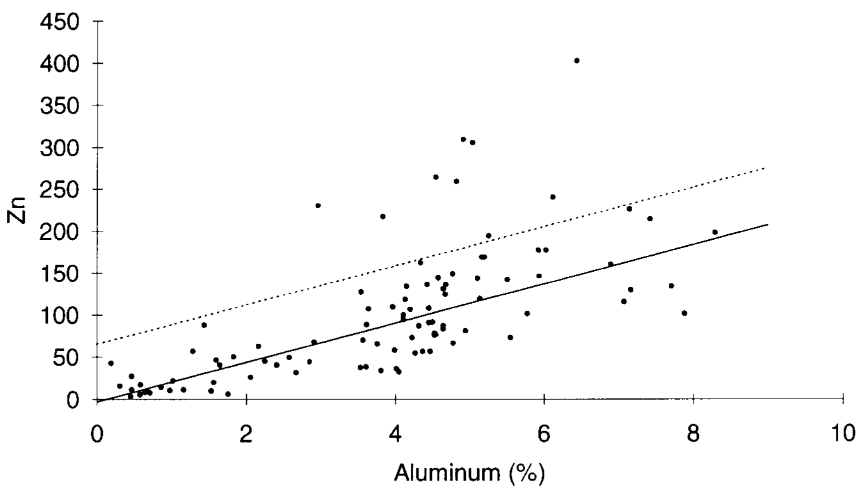


Figure B-14. Linear regression of zinc against aluminum (dashed line is the upper 95% confidence interval). Metal concentrations are as µg/g dry weight.

Table B-1. Metal-aluminum regression parameters obtained from 1992 Virginian Province sediment data (m = slope, b = intercept, r^2 = correlation coefficient).

Element	Regression parameters		
	m	b	r^2
Ag	0.0243	0.0128	0.35
As	1.5462	2.0021	0.44
Cd	0.0549	-0.0149	0.47
Cr	10.1341	0.0220	0.85
Cu	5.6758	-2.2951	0.55
Fe	5,763	-133.14	0.87
Hg	0.0122	0.0087	0.39
Mn	139.67	-32.1638	0.56
Ni	5.0110	-1.7338	0.75
Pb	6.6833	2.5058	0.32
Sb	0.1067	0.0895	0.28
Se	0.0646	0.0597	0.31
Sn	0.4453	0.1523	0.69
Zn	23.3211	-3.1249	0.66

APPENDIX C

QUALITY ASSURANCE

The 1992 Virginian Province monitoring effort was implemented using a quality assurance program to ensure comparability of data with those collected in other EMAP-E provinces, and to assure data quality consistent with the goals of the Program. As described in the Quality Assurance Project Plan (Valente *et al.*, 1992), Measurement Quality Objectives (MQOs) were established for data quality. Quality control steps taken to assure that MQOs were met included intensive training of field and laboratory personnel, field performance reviews of sampling crews, laboratory certification and audits. This document provides only a brief summary of QA results for 1992. A more comprehensive QA document is currently being prepared.

C.1 CREW TRAINING

One of the most critical components of the EMAP-VP QA Program was the thorough training of field personnel. Training was divided into two distinct courses: crew chief training and crew training.

Crew chiefs, who were all returnees from previous years, underwent a refresher training course during the last week of May, 1992. This training was conducted at the U.S. EPA Environmental Research Laboratory-Narragansett, RI (ERL-N) and focused mainly on the sampling methods, with emphasis placed on the electronic measurements and the computer system. Crew chief training was conducted by SAIC and CSC (Computer Sciences Corporation) personnel with oversight by EPA ERL-N staff.

Crew training was held from 15 June to 17 July 1992. Both safety and sampling methods were important components of training. Crew training was broken into two phases: formal training which lasted for approximately 3 weeks, and one week (per crew) of dry runs.

Dry runs consisted of five days in the field during which crews operated as they would during the sampling season, monitoring practice stations for all parameters. Crew members stayed in motels, prepared samples for shipment, entered data into the field computer, and electronically transmitted all data to the Field Operations Center (FOC) just as they would during actual field operations. In addition, the Field Coordinator or the QA Coordinator visited each crew during dry runs, completing a performance review sheet to determine the crew's readiness. All crews were deemed properly prepared to begin sampling activities on 27 July, 1992.

Certification examinations for crew chiefs and field crew members were administered at the end of each course and proved to be very useful. Unlike previous years, no crew chiefs were found to need additional training, and all subjects covered during training appeared to have been adequately covered.

C.2 FIELD DATA AND SAMPLE COLLECTION - QUALITY CONTROL CHECKS

Several measures were taken during the 1992 field season to assure the quality of the data collected. These consisted of QC checks, the collection of QC samples, and performance reviews by senior Program personnel (QA Coordinator or Field Coordinator).

C.2.1 Water Quality Measurements

Generally the first activity performed at each station was to obtain a vertical profile of the water column for key parameters. The instrument chosen for this operation was the SeaBird SBE 25 SeaLogger CTD. This instrument is generally regarded as a very sensitive, accurate and reliable device. All CTDs were calibrated according to manufacturers instructions at the EMAP-VP calibration facility just before the field season began. The procedures for calibration and checks are described in the 1992 Quality Assurance Project Plan (Valente *et al.*, 1992).

Field QC checks on the performance of the CTD fell into two categories: daily and weekly. The daily check consisted of taking duplicate surface and bottom measurements with a YSI Model 58 dissolved oxygen meter (instrument air calibrated at each station), a refractometer (salinity), and a thermometer (temperature) at every station. Acceptable differences are listed in the QA Plan. It is worth noting that the salinity values produced by the CTD are expected to be much more accurate than those from the refractometer, and are more accurate than is required by EMAP. The refractometer only provided a "gross" check to determine if there was an electrical problem with the CTD's conductivity sensor; it provided no information about gradual drift. If the instrument failed QC, the cast was repeated. If it failed on the second attempt, the cast was saved but flagged. Of the 143 casts for which separate dissolved oxygen measurements were successfully obtained with the YSI meter, 91.6% passed QC, showing differences of ≤ 0.5 mg/L. Values obtained using the YSI meter were used in this assessment for those stations where the CTD failed QC. All temperatures and salinities passed QC.

In addition to the daily checks, a more thorough weekly (once per 6-day shift) check was also performed. First, a bucket of water was bubbled with air for at least two hours to reach saturation for dissolved oxygen. The YSI meter was air-calibrated according to manufacturer's instructions, and the dissolved oxygen concentration of the water determined. At the same time multiple water samples were drawn off for Winkler titration using a Hach digital titrator. The YSI value was compared to the concentration determined by titration. Since the YSI meter was calibrated prior to each use, this served as a check on the validity of the air calibration method.

Following this check of the YSI meter, the CTD was immersed in water and the DO, temperature, and salinity compared with values obtained from the YSI, thermometer, and refractometer respectively. The unit was brought back on the deck and the pH probe immersed in a pH 10 standard for comparison (pH 10 was used instead of pH 7 because the instrument defaults to a reading of 7 when malfunctioning). If the unit failed for any variable it was returned to the Field Operations Center for recalibration. A total of 17 checks were performed during the field season, with all meeting the criteria for acceptance.

C.2.2 Benthic Indicators

As described in Section 3, several different benthic samples were obtained at each station. Three of the samples were processed for benthic community structure and biomass determination.

Crews were observed closely during field performance reviews to ensure that standard protocols were being followed for all benthic sampling. Laboratory QA measures are described below in Section C.3.

In addition to the infaunal samples, sediment was collected for chemical analysis, toxicity testing, and grain size determination. Additional QC samples were collected for chemistry at one station per crew. A second duplicate sample was removed from the homogenate, and a "blank" bottle was left open whenever the sample was exposed to the atmosphere. The purpose of the blank was to determine if atmospheric contamination was a significant problem. Additional analytical measures are described in Section C.4. Grain size and toxicity QA results are discussed in Section C.3.

C.2.3 Fish Indicators

The two fish indicators for which field data, as opposed to samples, were collected were fish community structure and gross external pathology. The QA Project Plan (Valente *et al.*, 1992) called for QA samples to be collected for both of these indicators.

To verify each crew's ability to correctly identify fish species for the community structure indicator, the first individual of each species collected by each crew was shipped to ERL-N or Versar for verification by an expert taxonomist.

Three types of errors were detected: misspelled or incomplete species names (in the database), misidentifications, and fish that could not be identified in the field. Errors falling into the first category were easily detected, corrected in the database, and documented.

The second type of error was mis-identifications. Of the 397 fish sent in for taxonomic verification, 36 were misidentified. In all cases the crew identified a closely-related species, such as longspine porgy instead of scup, or brown bullhead catfish instead of the yellow bullhead. An additional eight individuals were sent in as unknowns or partial unknowns (*e.g.*, herring uncl.). Most mis-identified or partially identified individuals were juveniles.

The total of 44 incomplete identifications or misidentifications represent 116 fish records in the database (including other fish of the same species caught in the same trawl). A total of 14,704 fish were collected in all trawls (both standard and non-standard) from all station types during the 1992 field season representing 78 species. The percentage of errors detected was therefore less than one percent.

C.2.4 Field Performance Reviews

In addition to the crew certification visits performed during dry runs, each crew was visited by a senior EMAP staff member during field operations. All aspects of sampling, from boat operations to shipping, were observed by the reviewer. Some of the activities included confirming the presence/absence of external pathologies, re-measuring fish, assuring that all precautions were taken to avoid contamination of the chemistry samples, assuring proper processing of benthic infauna samples, observing data entry, and assuring that all necessary safety precautions were observed. The reviewer used a "field review check-off sheet" to provide guidance during the review, and to document the crew's performance. Both reviewers concluded that the crews were sufficiently concerned with all QA issues, and that the data generated were representative of ambient conditions.

C.3 LABORATORY TESTING AND ANALYSIS

Quality control requirements for laboratory testing and sample analysis are covered in detail in the 1992 EMAP-VP QA Project Plan (Valente *et al.*, 1992) and the EMAP-E Laboratory Methods Manual (U.S. EPA, 1991) and will not be reiterated here. All laboratories were required to perform QA activities, and the results of those activities will be discussed in this report. Because of the complexity of chemical analyses, QA results for those analyses are listed separately in Section C.4.

C.3.1 Sediment Toxicity Testing

All sediment toxicity testing was performed at the SAIC Environmental Testing Center (ETC) in Narragansett, RI. Certification of the ETC occurred in 1990 and those results will not be discussed here, with the exception of stating that the laboratory successfully met EMAP requirements.

As per the QA Project Plan, the laboratory was required to maintain a control chart for toxicity testing using a reference toxicant. The ETC used SDS (sodium dodecyl sulfate) as their reference material, running a standard 48-hour water-only toxicity test with SDS whenever EMAP samples were run. The control chart shows that the LC50 for SDS ranged from < 2.57 to 11.2 mg/L, with all but the lowest value falling within two standard deviations of the mean as required in the QA Plan. Results of the one reference toxicity test falling outside two standard deviations of the mean were examined, as were all testing performed during the same time period. No anomalies in the tests were apparent and no re-testing was performed.

C.3.2 Grain Size Analysis

All "sediment grain size" and "benthic grain size" samples were analyzed for the determination of percent silt/clay. Approximately 10% of these analyses were performed in duplicate and the Relative Percent Difference (RPD) determined as per the EMAP-E Laboratory Methods Manual (U.S. EPA, 1991). The maximum allowable percent difference for the predominant fraction (silt/clay or sand) is 10%. The mean difference for the samples analyzed was less than 1%, with none exceeding 10% so no remedial action or retesting was required.

C.3.3 Benthic Infauna Analysis

Two QA steps were required by the EMAP-VP 1992 QA Project Plan: 10% recounts and independent verification of species identification. The recounts (multiple types - see Table C-1) and preliminary species verification were performed by the laboratory performing the analyses. All of these met the requirements established in the QA Plan. Definitive verification of species identification was performed by an independent laboratory and the results are described below.

C.3.4 Total Suspended Solids Analysis

The QA Plan requires that at least 10% of all samples analyzed for Total Suspended Solids (TSS) concentration be analyzed in duplicate. The RPD between the duplicates is then calculated. To pass QA, this value must be less than 10%. If it exceeds 10%, all samples analyzed since the last successful QC check must be repeated.

Due to an apparent mis-communication at the analytical laboratory, the first group of samples did not have the appropriate QA samples run. Therefore, the quality of the resultant data cannot be evaluated and are "flagged" in the EMAP database. A sufficient number of duplicate analyses were performed with the remainder of the samples; however, several failed QA, with the RPD exceeding 10%. Unfortunately this was not discovered until several months after the analyses were completed, and the original samples (degradable) had been discarded. As a result, approximately 44.4% of the data have been flagged as being of questionable quality.

C.4 LABORATORY CERTIFICATION AND CHEMICAL ANALYSIS

EMAP-E requires that analytical laboratories participate in an extensive certification process prior to the analysis of any EMAP-E chemistry samples. This certification is in addition to normal quality control measures that are required during analysis to ensure quality data (*e.g.*, blanks, spikes, controls, duplicates, etc.). Standard Reference Materials (SRMs) with known or certified values for metals and organic compounds were used by the Virginian Province laboratories conducting analyses to confirm the accuracy and precision of their analyses. Many of the SRMs used extensively in the EMAP-E program are naturally-occurring materials (*e.g.*, marine sediments or oyster tissue) in which the analytes of interest are present at levels that are environmentally realistic, and for which analyte concentrations are known with reasonable certainty. The certification results for the laboratory conducting the sediment analyses can be found in Table C-2.

The 1992 Virginian Province QA Project Plan (Valente *et al.*, 1992) lists warning and control limit criteria for the analysis of Certified (or Standard) Reference Materials. The more conservative warning limit for all organics is stated to be "Lab's value should be within ± 25% of true value on average for all analytes; not to exceed ± 30% of true value for more than 30% of individual analytes for each batch". The laboratory's performance during certification resulted in permission being granted for the analysis of samples to begin.

Table C-1. Results of recounts performed by the laboratory processing benthic infauna samples. Approximately 10% of all samples were processed in duplicate.

Measurement	Mean Error	Range of Error
Benthic sorting	1.7%	0 - 18%
Species identification and enumeration	1.8%	0 - 12%
Biomass	1.2%	0 - 1.4%
Weighing blanks for biomass	7×10^{-5} g	$0 - 7 \times 10^{-4}$ g

Table C-2. Results of certification analysis for sediment contaminants performed by EMSL-Cinn. The Reference Material for the organics certification was NIST SRM 1941. The SRM for inorganics was the National Research Council of Canada BCSS-1 CRM. For organic analyses, only those analytes with certified values at least 10x the detection limit are included.

Analyte	Certified Concentration	Measured Concentration
Inorganics (µg/g dry weight)		
Al	62700 ± 2173	58,600
As	11.1 ± 1.4	11.0
Cd	0.25 ± 0.04	0.20
Cr	123 ± 14	81.3
Cu	18.5 ± 2.7	18.4
Fe	32900 ± 980	29,800
Mn	229 ± 15	199
Ni	55.3 ± 3.6	47.0
Pb	22.7 ± 3.4	27.8
Sb	0.59 ± 0.06	0.56
Se	0.43 ± 0.06	0.42
Sn	1.85 ± 0.20	2.24
Zn	119 ± 12	96.4
Organics (PCBs/pesticides - ng/g dry weight)		
PCB 18	9.90 ± 0.25[1]	2.82
PCB 28	16.1 ± 0.4[1]	12.8
PCB 52	10.4 ± 0.4[1]	11.6
PCB 66	22.4 ± 0.7[1]	20.4
PCB 101	22.0 ± 0.7[1]	15.1
PCB 118	15.2 ± 0.7[1]	16.2
PCB 153	22.0 ± 1.4[1]	14.5
PCB 187	12.5 ± 0.6[1]	7.50
PCB 180	14.3 ± 0.3[1]	13.2
PCB 170	7.29 ± 0.26[1]	4.95
PCB 206	4.81 ± 0.15[1]	3.11
PCB 209	8.35 ± 0.21[1]	6.49
4,4' DDE	9.71 ± 0.17[1]	8.43
4,4' DDD	10.3 ± 0.1[1]	8.24
4,4' DDT	1.11 ± 0.05[1]	1.47

(continued)

Table C-2 continued.

Analyte	Certified Concentration	Measured Concentration
Organics (PAHs - ng/g dry weight)		
Phenanthrene	577 ± 59	535
Anthracene	202 ± 42	170
Fluoranthene	1220 ± 240	1100
Pyrene	1080 ± 200	1020
Benz(a)anthracene	550 ± 79	572
Benzo (b & k) fluoranthene	1224 ± 239	983
Benzo(a)pyrene	670 ± 130	494
Perylene	422 ± 33	252
Ideno(1,2,3-cd)pyrene	569 ± 40	609
Benzo(g,h,i)perylene	516 ± 83	526
Naphthalene	1322 ±14[1]	722
2-Methylnaphthalene	406 ± 36[1]	355
1-Methylnaphthalene	229 ± 19[1]	191
Biphenyl	115 ± 15[1]	94
2,6-Dimethylnaphthalene	198 ± 23[1]	203
Fluorene	104 ± 5[1]	101
Benzo(e)pyrene	573[1]	579
Chrysene	449[1]	709

[1] Value provided by NIST but not considered a "certified" value, meaning the values were determined via a single method. Despite not being certified, these values are still considered accurate.

During sample analysis, the laboratory was required to analyze a Laboratory Control Material (LCM) with each batch of samples being analyzed. An LCM is identical to an SRM with the exception that the true values need not be certified by an external agency (however, in these cases the same SRMs used during certification were used as the LCM). In addition to the LCM, duplicate "matrix-spiked" samples were required for each batch.

In addition to the analysis of the required QA data, summary data have been reviewed by an environmental chemist to verify that they are "reasonable" based on past studies and known distributions of contaminants in East Coast estuaries. This included examining the ratios of individual congeners (*e.g.*, PCBs); and PAH and DDT analytes. Any data that were deemed "questionable" were flagged for further study.

As stated earlier, at each sediment chemistry QA station crews opened a blank bottle whenever the sample was exposed to the atmosphere. The analytical laboratory solvent rinsed this bottle and then analyzed the solvent for contamination. Results showed no evidence of contamination, which if present, could have come from either the field or the laboratory.

C.5 DATA MANAGEMENT

To expedite the process of data reporting, all field data were entered into field computers and transmitted electronically to the Information Management Center. Upon receipt of the "hard copy" data sheets, a 100% check was performed by the EMAP data librarian (*i.e.*, every record in the computer was manually compared to the data sheet). Following corrections, a different individual then performed a second 100% check. A third check (20%) was then performed by a third person. By the completion of this exercise we were confident that the computer data base accurately reflected what the crew reported.

The number of data errors detected can be classified as "record" errors or "value" errors. A value refers to a single observation recorded as part of a record. A record refers to an entire set composed of "n" values, such as a data sheet. Record errors generally refer to duplicate or missing data sheets. Duplicate electronic data sheets can result from the crew accidentally saving the same page twice, but with different page numbers. Value errors refer to missing or incorrect values recorded on a data sheet.

Results of the checks described above showed a value error rate of 0.3%. The rate of record errors was approximately 1.35%.

The next step in data QA was data verification and validation. Verification was another step in assuring that the data were correct (*e.g.*, assuring that each CTD cast was associated with the correct station). Validation was the process of checking to make sure all data were reasonable (*e.g.*, making sure that fish lengths were all entered in mm, not cm). These processes were extensive; therefore, only a few examples will be provided here.

Part of the process of verifying CTD dissolved oxygen profiles was to compare cast depth to water depth. If they were significantly different, the cast was flagged for additional investigation. Validation then consisted of an expert examining every cast to assure the DO values were realistic and that the profile appeared reasonable.

One of the steps in validation of the fish community data set was to compare each fish length to the reported size range for that species. Geographic distributions were also examined to determine if the species had previously been reported where EMAP crews found them.

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