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Ambient Toxicity Testing in Chesapeake Bay:

Year 9-An Assessment of the Chester and Rappahannock Rivers

Chesapeake Bay Program

A Watershed Partnership

Ambient Toxicity Testing in Chesapeake Bay: Year 9
An Assessment of the Chester and Rappahannock Rivers

Prepared by:

Lenwood W. Hall, Jr. & Ronald D. Anderson
University of Maryland System
Agricultural Experiment Station
Wye Research and Education Center
Box 169
Queenstown, Maryland 21658

Alan Messing, Joe Winfield, A. Keith Jenkins & Irene J. Weber
Old Dominion University
College of Sciences
Applied Marine Research Laboratory
Norfolk, Virginia 23529-0456

Raymond W. Alden III
University of Nevada Las Vegas
College if Sciences
4505 Maryland Parkway
Las Vegas, Nevada 89154

David Goshorn, Margaret McGinty
Maryland department of Natural Resources
Tidewater Ecosystem Assessment Division
Tawes State Office Building
Annapolis, Maryland 21401

Chesapeake Bay Program
A Watershed Partnership

Chesapeake Bay Program
410 Severn Avenue, Suite 109
Annapolis, Maryland 21403
1-800-YOUR-BAY

www.chesapeakebay.net

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FOREWORD

This study was designed to evaluate ambient toxicity in the Chesapeake Bay watershed by using a battery of water column and sediment toxicity tests in concert with both fish and benthic community assessments. A team of scientists from two Chesapeake Bay research laboratories, Maryland Department of Natural Resources and Versar Inc. worked jointly to complete this goal. Water column toxicity studies and overall project management were directed by Lenwood W. Hall, Jr. of the University of Maryland's Wye Research and Education Center. Sediment toxicity tests and water/sediment chemical analysis were managed by Joe Winfield of Old Dominion Universities' Applied Marine Research Laboratory. Margaret McGinty of Maryland Department of Natural Resources was responsible for the fish community assessments and Roberto Llanso of Versar Inc. conducted the benthic community assessments. Raymond Alden was responsible for the water and sediment index calculations. This report summarizes data from the ninth year of a nine-year ambient toxicity testing program. The U. S. Environmental Protection Agencies Chesapeake Bay Program Office supported this study.

ABSTRACT

This report summarizes data collected during the ninth year of a research program designed to assess ambient toxicity of living resource habitats in Chesapeake Bay. The goals of this study were to identify toxic ambient areas in the Chesapeake Bay watershed by using a battery of standardized water column and sediment toxicity tests concurrently with fish and benthic community assessments (index of biotic integrity approaches). The toxicity of ambient estuarine water and sediment was evaluated during the late summer/early fall of 1999 at ten stations in the Rappahannock River and ten stations in the Chester River. The toxicity of ambient estuarine water was assessed at all stations by using the 8-d larval sheepshead minnow, *Cyprinodon variegatus*, survival and growth test and three 48-h coot clam, *Mulinia lateralis* embryo/larval tests. Toxicity of ambient estuarine sediment was determined by using the 20-d survival, growth and reburial test with the amphipod *Leptocheirus plumulosus* and 20-d survival and growth test with the polychaete worm, *Streblospio benedicti.* Both inorganic and organic contaminants were assessed in ambient sediment and inorganic contaminants were measured in ambient water concurrently with toxicity testing to assess "possible" causes of toxicity. Fish and benthic communities were also assessed at the 20 stations. An index of biotic integrity (IBI) was determined for each trophic group.

Both univariate and multivariate (using all endpoints) statistical techniques were used to analyze the water column and sediment toxicity data. Results from univariate analysis of water column data showed that survival of sheepshead minnows was not significantly reduced at any site when compared with the controls. However, significant effects on growth were reported for this species at two Chester River sites. Percent normal shell development with the coot clam from test 1 was significantly different than the controls for four sites in each river. Effects were reported at the three downstream sites and the most upstream site in the Chester River. For the Rappahannock River, effects from coot clam test 1 did not follow any type of spatial pattern. Results from coot clam tests 2 and 3 generally did not show any significant biological effects (except the upstream Rappahannock River site). The combined test results from coot clam tests 1-3 did not show significant effects at any of the 20 sites. Results from multivariate of water column data only showed significant effects at one of the Chester River sites. Metals concentrations from the 20 stations in both the Chester and Rappahannock Rivers showed that chronic water quality criteria were exceeded at two Chester River sites and one Rappahannock River site for copper, at two Chester River sites and one Rappahannock River site for lead, at two Rappahannock River sites for nickel, and at one Rappahannock River site for zinc. However, only one site in each river showed any degree of positive correlation between metals concentrations exceeding criteria and biological effects (coot clam test 1). The site with highest number of metals exceedances (copper, lead and zinc) in the Rappahannock River showed no significant effects from either of the tests species.

Univariate results from the 20 day sediment amphipod (*Leptocheirus plumulosus*) test showed that survival was significantly different from the reference site (Carters Creek, Virginia) at one site in the Rappahannock river and three sites in the Chester River. Survival results from sediment toxicity tests with the polychaete worm *Streblospio benedicti* showed that this species was more sensitive than the amphipod. Six sites in the Chester River and four sites in the Rappahannock River were significantly different from the reference site based on the polychaete worm survival. Growth of the amphipod, expressed as a change of length, was significantly different from the reference site at two Chester River sites and one Rappahannock River site. The polychaete worm toxicity test showed that two sites in the Chester River were significantly different for increase in length over the initial size. There was no significant

differences in change of weight for either test species when comparing test sites and the reference sites. Results from the multivariate analysis showed significant effects at eight Chester River sites and five Rappahannock River sites. At the methods detection limit used in this study, no pesticides, PAHs, or PCBs were detected in sediment from any site including the reference and control sites. Nickel was found throughout the Rappahannock River (8 of 10 sites) at concentrations above the NOAA benchmark for Effects Range-Low (ERL) but no other metals exceeded the respective ERLs or the Effects Range-Median (ERM) benchmarks in this river. The ERL predicts a low probability of toxicity due to nickel when ambient concentrations are below that value and the ERM predicts a high probability of effects to benthic populations when exceeded. In the case of nickel, the reliability of the ERM is suspect and the probability of effects at values greater than the ERL and less than the ERM are difficult to predict. The sites sampled in the Chester River had similar instances where nickel was greater than the ERL (7 of 10 sites), but there were 4 sites where nickel, lead and zinc concurrently exceeded the ERL. Zinc exceeded the ERL at one Chester River site in addition to nickel. The analysis for simultaneously extractable metals (SEM) and acid volatile sulfides (AVS) SEM/AVS is considered a reliable approach for determining the bioavailability of metals to benthic organisms. The AVS/SEM results generally suggest that metals are unlikely responsible for sediment toxicity at any of the sites.

Results from the Fish IBI assessments showed that most of the stations (8 out of 10) in the Chester River had degraded fish communities based on either seining or trawling methods. In contrast , fish communities at all Rappahannock River sites appeared relatively healthy. The Benthic Index of Biotic Integrity (B-IBI) scores for the Chester River River showed that seven sites met the benthic restoration goal, one site was marginal, one site was degraded and one site was highly degraded. The degraded and severely degraded sites were upstream. For the Rappahannock River, three sites met the restoration goal, one site was marginal, three sites were degraded and three sites were severely degraded. All three sites that met the goal were barely above the cut off between meeting the goal and degraded. The B-IBI results were more variable in the Rappahannock River when compared to the Chester River. Although there was no clear spatial trend, the benthic communities in the Rappahannock River generally appeared more impaired than in the Chester River.

In summary, sediment toxicity data and impaired fish communities suggested some degree of stress at most of the Chester River stations. In contrast, water column toxicity and benthic community impairment were generally not reported at the various sites in this eastern shore river. At three sites, either toxicity or biological community impairment were reported from three of the four measures; three of the four measures failed to report either toxicity or biological impairment at two of the sites. The other five sites provided mixed results as two measures showed effects and two measures showed no effects.

A final analysis of water column toxicity data, sediment toxicity data, fish community data and benthic community data for the Rappahannock River demonstrated effects from two of the four measures at four of the sites. Effects were reported for only one measure at four of the sites and no effects were reported for any of the measures at two sites. A lower degree of toxicity and biological impairment was reported in the Rappahannock River than in the Chester River.

ACKNOWLEDGMENTS

We acknowledge the U. S. Environmental Protection Agency's Chesapeake Bay Program Office for supporting this study. We would like to acknowledge various individuals from the University of Maryland and Old Dominion University for technical assistance and the U. S. EPA's Chesapeake Bay Program Office and Maryland Department of the Environment for their comments on the study design.

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SECTION 1
INTRODUCTION

The potential relationship between contaminants and adverse effects on Chesapeake Bay living resources is of concern due to increasing population growth and associated anthropogenic activities in the watershed. Traditional approaches such as calculation of loading rates of toxic chemicals and/or chemical monitoring studies provide useful data for exposure characterizations but these approaches are not totally adequate for assessing the ecological effects resulting from numerous sources such as multiple point source effluents, nonpoint source runoff from agriculture, silviculture and urban sites, atmospheric deposition, groundwater contamination, and release of toxic chemicals from sediments. The direct measure of biological responses in the ambient environment is the most realistic and ecologically relevant approach for evaluating the adverse effects of toxic conditions on living resources. For the purposes of this report, the ambient environment is defined as aquatic areas located outside of mixing zones of point source discharges in the Chesapeake Bay.

In recent years various studies have been conducted to address the link between contaminants and adverse effects on living aquatic resources in the ambient environment of the Chesapeake Bay watershed. These ambient toxicity tests are designed to detect toxic conditions on a much broader scale than traditional effluent toxicity tests. These tests are considered a first tier type approach used as a screening tool to identify areas where ambient toxicity exists and future assessment efforts are warranted. Biological responses such as survival, growth, and reproduction of resident species are used to identify stressful conditions in the ambient environment resulting from point and non-point sources.

The ambient toxicity testing approach is consistent with the Chesapeake Bay Basinwide Toxics Reduction Strategy which has a commitment to develop and implement a plan for Baywide assessment and monitoring of the effects of toxic substances, within natural habitats, on selected commercially, recreationally and ecologically important species of living resources (CEC, 1989). This commitment is also consistent with the recommendations of the Chesapeake Bay Living Resource Monitoring Plan (CEC, 1988).

Previous ambient toxicity assessments in the Chesapeake Bay (1990-1998) have been completed and reports have been published (Hall et al., 1991; Hall et al., 1992; Hall et al., 1994; Hall et al., 1996; Hall et al. 1997; Hall et al., 1998; Hall et al., 2000a; Hall et al. 2000b). General conclusions to date have shown that 62% of the time water column tests conducted at 64 stations (19 rivers and harbors with multiple years of testing at some sites) have suggested some degree of toxicity. The most toxic sites were located in urbanized areas such as the Anacostia, Elizabeth and Middle Rivers. Water quality criteria for copper, lead, mercury, nickel and zinc were exceeded at various sites in these rivers. Water column toxicity was also reported in localized areas of the South and Chester Rivers. Some degree of sediment toxicity was reported from 58% of the ambient tests at 64 stations conducted during the nine year period (1990 - 1998). The Elizabeth River and Baltimore Harbor stations were reported as the most toxic areas based on sediment results. Sediment toxicity guidelines (Long and Morgan, 1990; Long et al., 1995) were exceeded for one or more of the following metals at these two locations: arsenic, cadmium, chromium, copper, lead, nickel and zinc. At the Elizabeth River station tested in 1990, nine of sixteen semi-volatile organics and two of seven pesticides measured exceeded the Effects Range - Median as defined by Long et al., 1995 (ER-M values). Various semi-volatile organics exceeded the ER-M values at a number of Baltimore Harbor sites; pyrene and dibenzo (a, h) anthracene were particularly high at one of the stations

(Northwest Harbor). Sediment toxicity was also reported from localized areas in the Chester, Magothy, and Potomac Rivers.

The goals of this study were to conduct a suite of water column and sediment toxicity tests in concert with fish and benthic community assessments (IBI type approach) at ten stations in the Rappahannock River and ten stations in the Chester River. The fish and benthic community assessments were new components added to the ambient toxicity testing program in 1996 and continued annually through 1999 to provide field data for assessing the status of biological communities at the study sites. In order to provide limited exposure data for correlation with the toxicity data and biological assessments, inorganic contaminants were evaluated in water and both organic and inorganic contaminants were evaluated in sediment during these experiments.

SECTION 2
OBJECTIVES

This ambient toxicity study was a continuation of an assessment effort previously conducted from 1990-1998 in the Chesapeake Bay watershed. The major goal of this program was to assess the toxicity of ambient water and sediment in selected areas of the Chesapeake Bay watershed by using a battery of standardized water column and sediment toxicity tests in concert with limited chemical characterizations. Biological communities (fish and benthos) were also evaluated at the study sites.

The specific objectives of the nineth year of this study were to:

- assess the toxicity of ambient estuarine water and sediment during the late summer/early fall of 1999 at the ten stations in the Rappahannock River and ten stations in the Chester River;
- determine the toxicity of ambient estuarine water described in the first objective by using the following estuarine tests: 8-d larval sheepshead minnow, *Cyprinodon variegatus* survival and growth test and 48-h coot clam, *Mulinia lateralis* embryo-larval tests;
- evaluate the toxicity of ambient sediment described in the first objective by using the following estuarine tests: 20-d amphipod *Leptocheirus plumulosus* survival, growth and reburial test and 20-d polychaete worm, *Streblospio benedicti* survival and growth test;
- measure inorganic contaminants in ambient water and organic and inorganic contaminants in sediment concurrently with toxicity tests to determine "possible" causes of toxicity;
- determine the relative sensitivity of test species for each type of test and compare between test methods to identify regions where ambient toxicity exists;
- assess the status of fish and benthic communities at the ten stations in each river using an Index of Biotic Integrity approach; and
- summarize water column and sediment toxicity data from 1990 to 1999 using a composite index approach for each site

SECTION 3
METHODS

3.1 Study Areas

The rationale for selecting study sites in the Rappahannock and Chester Rivers is presented below. The Rappahannock River was selected for ambient toxicity testing because it is an ecologically important western shore river in Virginia that has not been tested previously in the ambient toxicity program (Figure 3.1). Historical contaminants data and aquatic toxicity data are limited for this river. Coordinates for the ten Rappahannock River stations were as follows:

RP1 - 37 47 34 x 76 38 40
RP2 - 37 47 59 x 76 42 24
RP3 - 37 48 24 x 76 40 52
RP4 - 37 48 33 x 76 41 33
RP5 - 37 49 54 x 76 44 57
RP6 - 37 50 57 x 76 44 39
RP7 - 37 54 08 x 76 47 30
RP8 - 37 54 58 x 76 49 25
RP9 - 37 57 55 x 76 51 58
RP10 - 37 59 00 x 76 54 17

The Chester River was selected for ambient toxicity testing because previous ambient toxicity data collected from this river at a limited number of stations in 1996 suggested potential toxicity (Hall et al., 1998). Ambient toxicity testing was therefore conducted on a broader spatial scale to assess potential toxicity in 1999 (Figure 3.2). Coordinates for the ten Chester River sites were as follows:

CH1 - 39 00 18 x 76 10 27
CH2 - 39 04 47 x 76 11 33
CH3 - 39 06 20 x 76 08 20
CH4 - 39 09 35 x 76 03 05
CH5 - 39 10 41 x 76 02 40
CH6 - 39 11 52 x 76 03 56
CH7 - 39 13 04 x 76 02 31
CH8 - 39 14 14 x 76 00 50
CH9 - 39 14 44 x 75 55 03
CH10 - 39 14 43 x 75 55 26

3.2 Water Column Toxicity Tests

The objectives of the water column toxicity tests were to determine the toxicity of ambient water at the 20 stations described above. The following tests were conducted at these stations during the late summer/early fall of 1999: 8-d larval sheepshead minnow *C. variegatus* survival and growth test and 48-h coot clam *M. lateralis* embryo/larval tests. Water from all sites was adjusted to a salinity of 15 ppt to provide data comparable to the 1990 through 1998 ambient toxicity data sets. A suite of metals was measured in ambient water used for these tests.

3.2.1 Test species

Larval sheepshead minnows, a previously used species for the past eight years of ambient toxicity testing, was used for the 1999 testing. This test species were selected because it meets the following criteria: (1) resident Chesapeake Bay species, (2) sensitive to contaminants in short time period (less than 10 d) and (3) standard test organism that does not require additional research. Larval sheepshead minnows are highly abundant, resident Chesapeake Bay organisms used extensively in standard tests. Sheepshead minnows have demonstrated moderate sensitivity in subchronic tests and are commonly used in EPA's and MDE's Whole Effluent Toxicity Testing Program.

The coot clam, *M. lateralis*, was added to the suite of test organisms during the third year of ambient toxicity testing. This clam is a small (< 2 cm length) euryhaline bivalve. It is a numerically dominant species in the mesohaline areas of the Chesapeake Bay as well as numerous tributaries (Shaughnessy et al., 1990). Embryo/larval development occurs in the water column in approximately 6-8 days. This clam is suitable for water column testing because the sensitive life stage occurs in the water column. The coot clam is not a standard test organism, however, the U.S. EPA has written a draft test method for estimating toxicity of effluents using *Mulinia* (Morrison and Petrocelli, 1990a; 1990b). We also developed a Standard Operating Procedure for testing *Mulinia* (Hall and Ziegenfuss, 1993).

3.2.2 Test Procedures

Test procedures and culture methods have been previously described in the year 1 ambient toxicity report for the 8-d larval sheepshead minnow survival and growth test (Hall et al., 1991). The test procedures for the coot clam described in the year 3 report were used for these experiments (Hall et al. 1994). The sources for the species were as follows: sheepshead minnows, Aquatic Biosystems, Denver, Colorado and and coot clams (U. S. EPA Laboratory in Narragansett, Rhode Island).

3.2.3 Statistical Analysis

Univariate statistical tests described in Fisher et al. (1988) were used for each test species when appropriate. The goal of this study was not to generate typical LC50 data with various dilutions of ambient water. For each test species response, control and test conditions (100 percent ambient water) were compared using a one-way Analysis of Variance (ANOVA). A statistical difference between the response of a species exposed to a control condition and an ambient condition was used to determine toxicity. Dunnett's (parametric) or Dunn's (non-parametric) mean testing procedures were used in cases where comparisons of a species response on a spatial scale was necessary.

3.2.4 Sample Collection, Handling and Storage

Sample collection, handling and storage procedures used in the previous studies were implemented (Hall et al., 1991). Ambient water was collected from all study areas and taken to our toxicity testing facility at the Wye Research and Education Center, Queenstown, Maryland for testing.

Grab samples were used because they are easier to collect, require minimum equipment (no composite samplers), instantaneous toxicity is evaluated, and toxicity spikes are not masked by dilution. Grab samples collected from each station represented a composite of the water column (top, mid-depth and bottom). A metering pump with teflon line was used to collect samples in 13.25 L glass containers.

The time lapsed from the collection of a grab sample and the initiation of the test or renewal did not exceed 72 hours. Water column samples were collected on days 0, 3 and 6 during the 8 day tests. All samples were chilled after collection and maintained at 4C until used. Water from each ambient site and control was renewed in test containers every 24 hours. The temperature of the ambient water used for testing was 25C. Salinity adjustments (increase) were performed on samples collected from less saline sites to obtain a standard test salinity of approximately 15 ppt.

3.2.5 Quality Assurance

A copy of our general Standard Operating Procedures (SOP) Manual (including the sheepshead minnow SOP) was submitted and approved by the sponsor prior to the study (Fisher et al., 1988). Standard Quality Assurance (QA) procedures used in our laboratory for The State of Maryland's Whole Effluent Toxicity Testing Program were followed (Fisher et al., 1988). These QA procedures were also used during the previous eight years of ambient toxicity testing study. A specific SOP for *M. lateralis* was followed (Hall and Ziegenfuss, 1993). The control water used for these experiments was obtained from a pristine area of the Choptank River. The water was autoclaved and filtered with a 1 um filter. Hawaiian (HW) Marine sea salts were used to salinity adjust samples to 15 ppt. The pH was also adjusted to 7.5 to 8.0 after salinity adjustment.

Acute reference toxicant tests with cadmium chloride were conducted with the same stocks of species used for ambient toxicity tests. Cadmium chloride was selected as the reference toxicant because there is an established data base with this chemical for all of the proposed tests. Reference toxicity tests were used to establish the validity of ambient toxicity data generated from toxicity tests by ensuring that the test species showed the expected toxic response to cadmium chloride (Fisher et al., 1988). The reference toxicant tests were conducted on each saltwater test species and source (of species) once during this study using procedures described in Hall et al. (1991).

3.2.6 Contaminant Analysis and Water Quality Evaluations

The contaminant analyses used for these studies provided limited information on selected contaminants that may be present in the study areas. It was not our intention to suggest that the proposed analysis for inorganic contaminants would provide an absolute "cause and effect relationship" between contaminants and biological effects if effects were reported. Information on suspected contaminants in the study areas may, however, provide valuable insights if high potentially toxic concentrations of inorganic contaminants were reported in conjunction with biological effects.

Aqueous samples for analysis of inorganic contaminants listed in Table 3.1 were collected during the ambient toxicity tests. These contaminants and methods for their measurement have been used in our previous ambient toxicity testing study (Hall et al., 1991). Analytical procedures and references for analysis of these samples are presented in Table 3.1. Total inorganic contaminant analysis (dissolved metals) were conducted on filtered samples using 0.40 um polycarbonate membranes. All samples were preserved with ultrex grade nitric acid. The Applied Marine Research Laboratory of Old Dominion University conducted the inorganic analysis.

Standard water quality conditions of temperature, salinity, dissolved oxygen, pH and conductivity were evaluated at each site after sample collection. These conditions were evaluated every 24 hours at all test conditions during the tests.

3.3 Sediment Toxicity Tests

All tests and analyses were conducted according to the SOPs and QA plans previously submitted to the sponsor. All sediment toxicity tests were conducted by the Applied Marine Research Laboratory (AMRL). The toxicity tests were performed in compliance with the AMRL Quality Assurance Project Plan (QAPjP) 1999 used for characterizing ambient toxicity in Chesapeake Bay. The Chesapeake Bay Program Office of the U.S. Environmental Protection Agency has approved the protocols contained within the QAPjP for conducting the 20 day amphipod (*Leptocheirus plumulosus*) survival and growth bioassay and the 20 day polychaete worm (*Streblospio benedicti*) survival and growth bioassay (Messing et al., 1999). The details of the test methods were provided in the QAPjP and summarized below.

3.3.1 Test Species

Two native benthic organisms were used to assess the potential toxicity of estuarine sediments: the estuarine amphipod *Leptocheirus plumulosus* and the polychaete worm *Streblospio benedicti.*

3.3.2 Test Procedures

All tests were conducted for 20 days at 25±1°C and monitored daily. Monitoring of test conditions included measurement of water quality parameters (Hall et al., 1991). The monitoring continued daily until the test was terminated. On day 10 of the tests, all replicate vessels were sieved to remove test animals from the sediment. Surviving animals were counted, returned to the original test containers, and monitored for an additional 10 days. Due to the potential for damaging *S. benedicti* and miscounting of both species at this stage in the bioassays, the sieving after 10 days of exposure was not applied as aggressively as required to develop reliable counts of survivors. These data were not used in the statistical assessment of potential biological effects. At day 20, all site replicates were sieved once more to obtain final counts of surviving animals. Survivors were preserved to facilitate collection of length and weight measurements.

Treatment sediments were collected from ten sites in the Rappahannock River, Virginia (RP1 through RP10) and from ten sites in the Chester River, Maryland (CH1 through CH10). The exact locations of all sites were previously presented in Section 3.1. Reference sediments were chosen as the basis for assessing differences in survival of the test species against survival in sediment from the study area and the response of the test organisms in control sediments was used as a measure of acceptable performance of the bioassays. Control sediment was collected from a location within the Ware River, Virginia and reference sediment was collected from within a 100m x 100m area inside Carter Creek, Virginia. Particle size analyses were performed on each of the five field replicates from all test sites and sediment from the reference and control sites to determine similarities in sand, silt, and clay content.

Culture, maintenance, and test procedures used for *S. benedicti* and *L. plumulosus* are described in Hall et al. (1991) and Hall et al. (1993), respectively.

3.3.3 Statistical Analysis of Sediment Data

The objective of the study was to evaluate the potential toxicity of ambient sediments by comparing all test endpoints of each species to the endpoints observed in reference sediments. Survival and weight data were tested for assumptions of normality and equality of variances using Shapiro-Wilk's and Bartlett's tests, respectively. Parameters violating these assumptions were transformed to arc-sine values, ranks and normalized rankits and then retested for these assumptions. If the original or transformed data met the assumptions, an ANOVA was used to test for significant differences in mean survival and weight between stations. *A posteriori* pairwise comparisons of survival and weights between the test and reference sites were made using Fisher's LSD test. *A posteriori* pairwise comparisons of length data were conducted using the Bonferroni T-test for unequal sample sizes. If transformed data did not meet the assumptions of the parametric tests, a Kruskal-Wallis test was used to test for significant differences in median ranks between stations and *a posteriori* pairwise comparisons between the test and reference sites were made using Wilcoxon's Rank-Sum test.

Length was expressed as change in size from the mean initial length and weight was evaluated as the mean individual weight gain for each site. In order to eliminate any potential bias due to differential survival, only those test sites not exhibiting significantly lower survival at the end of the 20 day tests were analyzed for sublethal effects. Toxicity was inferred in test sediments with endpoints that were significantly lower than those observed for the test-specific reference sediments.

3.3.4 Sample Collection, Handling and Storage

Sediment collection, preservation, storage and preparation procedures for this study are described in Hall et al. (1991). Samples were collected at each site by The University of Maryland and the Applied Marine Research Laboratory (AMRL) personnel and returned to the laboratory for testing. Sediments were collected using a petite ponar grab at sites in the Rappahannock River from September 22-23, 1999 and in the Chester River on September 20, 1999 . True field replicates were maintained separately and transported to the laboratory. Sediment was collected at each station by first randomly identifying 5 grab sample locations within a 100 meter square grid. At each location a discrete field replicate was collected for bioassays and stored on ice, while a separate subset from the same ponar grab was placed into a handling container. Subsamples from all 5 random grab locations within the station were placed into the handling container, homogenized, and distributed into sample containers designated for chemical analyses. All samples were transported on ice in coolers, out of direct sunlight. Bioassay samples were held in refrigerators at $4^{o}C$ until initiation of the toxicity tests. Samples for chemical analysis were stored as required for all analyses.

3.3.5 Quality Assurance

All quality assurance procedures were submitted previously to the sponsoring agency and were implemented during sediment collection and analysis. Toxicity test control and reference sediments were used as described in Section 3.3.2. Laboratory quality assurance procedures for organic and inorganic chemical analyses, and for sediment pore water analyses, followed the AMRL QAPjP.

Static acute non-renewal, water-only reference toxicant tests were performed for each species used for sediment toxicity testing. Cadmium chloride was used as a reference toxicant because there is an established data base for this chemical for both species used. Reference toxicant information was used to verify the health and sensitivity of the test animals.

3.3.6 Contaminant and Sediment Quality Evaluations

Sediment bioassays were performed on each replicate sample (n=5) from a study site, but contaminants were analyzed in composite samples of sediment from each site. It is assumed that if the contaminants were present in sufficiently high concentration to cause significant effects in the sediment bioassays, the contaminants would be present in detectable concentrations in the composite samples.

Sediment sample collection was described in Section 3.3.4. Inorganic contaminant analytical methods are provided in Table 3.2. Polycyclic aromatic hydrocarbons (PAHs) were extracted and analyzed in accordance with SW-846 Methods 3550, 3640, and 8270 (USEPA, 1994). Pesticides and Aroclors were extracted and analyzed in accordance with SW-846 Methods 3350, 3640, and 8081 (USEPA, 1994).

Whole or bulk sediment was analyzed for acid volatile sulfides (AVS) and total organic carbon (TOC). Sediment samples were analyzed for AVS using USEPA (1991) draft methods. Details of the analytical procedures for both AVS and TOC are described in Hall et al. (1991). Sediment pore water was analyzed for ammonia, nitrite, and sulfides. Samples analyzed for TOC were frozen until analysis, at which time they were thawed, then homogenized by gently stirring. Pore water samples were extracted from sediment using a nitrogen press. All pore water samples were filtered and frozen until analyses were conducted. Details of the methods are described in Hall et al. (1991).

Sediments were also analyzed for Simultaneously Extractable Metals (SEM). The sample for the SEM analysis was obtained from the AVS procedure mentioned above. The SEM sample was the sediment suspension remaining in the generation flask after the cold acid extraction had been completed. The sediment suspension was filtered through a 0.2 micron membrane filter into a 250 ml volumetric flask, and was then diluted to volume with deionized water. The concentrations of the SEMs were determined by the same analytical methods as bulk metals. The concentrations were then converted to micromoles per gram (: M/g) dry sediment and summed to yield total SEM. SEM results were used in conjunction with the AVS data to estimate the potential toxicity of the sediment due to metals.

3.4 Analysis of Ten Year Data Base

A series of summary multivariate statistical analyses were conducted in order to provide environmental managers with summary information concerning the relative toxicity of water and sediments from the collection areas (see Section 6). These analyses also provide quantitative indicators of the degree of confidence which may be given to differences between responses observed for "clean" ("reference") conditions and those seen for test media (water or sediments) of unknown quality. These analyses are based upon the summary composite indices first developed for the toxicity axis of the “sediment quality triad” (Long and Chapman, 1985; Chapman, 1986; Chapman et al. 1987 and Chapman 1990). This approach has been modified to provide confidence limits on composite indices designated as “ratio-to-reference mean” (RTRM) indices (Alden, 1992). Details of the calculation of the RTRM indices for the Ambient Toxicity Program are presented in the Year 3 report (Hall et al., 1994).

In order to make the RTRM indices more meaningful to managers, a method was developed to scale the values, so that they range between a “best case” (uncontaminated) condition, represented by a score of 0 and a “worst case” (highly contaminated and toxic) condition, represented by a score of 100. A value of 0 would represent the median response of a reference test of uncontaminated water or sediment, while a value of 100 would represent a condition producing the maximum detrimental responses in all of the endpoints (e.g. no growth, reproduction, or survival of all test populations). Not only does this sort of scaling provide a “frame of reference” to address the question of “how bad is this site?”, but it allows scores of RTRM indices from different years (which may have had different numbers of endpoints) to be evaluated on the same scale. This well-defined scaling system is much more readily interpreted than the sediment quality triad RTR values or the RTRM indices, which have a reference value of 1, but have an open-ended scale for toxic conditions, the maximum value of which depends upon the number of endpoints, the magnitude of the test responses, and the reference response values used in the calculations.

The scaled RTRM index, hereafter designated as “toxicity index” or TOX-INDEX, was calculated as follows. The RTRM values and confidence limits were calculated as in previous years (Hall et al., 1994). The reference median for any given site was subtracted from all reference and test values (medians, lower and upper confidence limits). This step scales the reference median to 0. The values are then divided by a "worst case" constant for each test data set. This "worst case" constant is calculated by taking the test data set and setting the values to the maximum detrimental responses for each endpoint (e.g., no survival, growth, reproduction, hatching of eggs, etc.), calculating the RTRM values for these "worst case" conditions by dividing by the appropriate reference means (i.e., for the sediment data set, each sample was matched to the reference data set that most closely matched the sediment characteristics) and calculating the "worst case" constant as the mean of RTRM values for all endpoints. The division by the "worst case" constant makes all values (medians and confidence limits) a fraction of the "worst case" condition. The TOX-INDEX values are converted to a percentage scale by multiplying by 100. The TOX-INDEX medians and confidence limits for test and reference conditions of each site are plotted on maps of the Bay to indicate the relative toxicity of various geographic locations. For graphical purposes, the lower confidence limits of the reference data are not shown, unless the test confidence limits overlap those of the reference conditions (i.e. a portion of the confidence limits for both the test and reference conditions are less than zero).

In order to provide more information to the TOX-INDEX maps, pie charts are included to indicate the relative percentage of endpoints that were shown to be different between the test and reference data sets in the RTRM simulations. Therefore, a highly toxic site would not only be shown to have high TOX-INDEX values which display a low degree of uncertainty (i.e., to have narrow confidence bands that are well separated from reference conditions), but it would also be shown to have a high percentage of endpoints that were adversely affected by the toxic conditions.

This type of presentation should provide managers with a tool to evaluate the relative ecological risk of the sites in comparison to each other and aid in targeting mitigation efforts on a spatial scale. A site with TOX-INDEX confidence limits that overlap those of a reference site, and which displays few statistically significant endpoints, would be expected to pose little ecological risk with respect to ambient toxicity. On the other hand, a site displaying a large TOX-INDEX value, with confidence limits that are well separated for the reference condition and with many significantly impacted endpoints would be expected to pose a much greater ecological risk. The ecological significance of toxicity at sites with intermediate TOX-INDEX scores would have to be interpreted through the best professional judgement of scientists and managers, although the relative magnitude of the values does provide information on the relative degree of toxicity with respect to other sites. Although absolute ecological risk assessments would require much more intensive biological evaluations of long-term population and community level effects, TOX-INDEX provides a screening system that indicates the relative ranking by which regions can be prioritized for management actions related to toxicity. Thus, the maps provide quantitative indications of the magnitude, certainty and consistency of toxic effects.

The site location symbols in the TOX-INDEX maps indicate the degree to which water or sediment benchmarks (water quality criteria or ER-M values, respectively) were exceeded. Thus, the maps also display the qualitative degree of chemical contamination.

During the 1998 studies, the water column toxicity data sets were re-scaled (Hall et al., 2000b). The re-scaling effort was designed to make the scaled water column data sets more comparable to the scaled sediment toxicity data sets. The issue to be resolved was the definition of the "worst case" for growth endpoints (e.g., growth of sheepshead minnows, and in the earlier years of the study, grass shrimp).

Traditionally, the growth endpoints for the water column tests were measured as the absolute weight of the larval organisms at the end of the test compared to the weight of controls. Conversely, the sediment tests measure growth as the relative change in size of organisms as a percentage of the starting size (i.e., growth rates) in test treatments compared to controls. Either of these approaches provides a valid test of sublethal effects on growth. However, a "worst case" for the former case is zero weight, while it is a zero growth rate for the latter. Our consensus was that the zero growth rate represented a more realistic "worst case" scaling factor, so the water column growth data from 1990 to 1999 were converted to growth rates and re-scaled.

Since the "worst cases" for the growth endpoints were more in line with what could possibly be achieved in the tests, the re-scaled Toxicity Index values tended to be greater by a factor of approximately 2. However, the re-scaling process did not scale equally across all sites for all years. The performance of controls, the number of endpoints, and the number of replicates all influence the scaling factor produced for each data set. In addition, RTRM values had to be calculated for growth rates instead of absolute growth. Thus, the relative toxicity rankings of sites changed somewhat during the re-scaling process. However, the major patterns of toxicity among sites remained (i.e. toxic sites remained toxic) and made environmental sense from a "best professional judgement" perspective. The re-scaled water column Toxicity Index values and rankings are discussed in Section 6.

3.5 Fish Index of Biotic Integrity

3.5.1 Data Collection

All sites were sampled monthly for fish assemblages during the summer index period (July, August, and September, 1999). This period reflects the time of greatest fish species diversity and abundance in the Chesapeake Bay due to the function of the estuary as a spawning and nursery habitat for anadromous, marine, and estuarine resident species.

Sites in both rivers were sampled inshore using a 30.5 m X 1.2 m beach seine with 6.4 mm mesh. The seine was pulled with the tide employing the quarter sweep method. Two seine hauls were conducted per site with a 30 minute interval between each haul to allow for repopulation of the seine area. Fish from the first seine haul were held and released after completion of the second seine haul.

In the channel adjacent to the seining area, fish were sampled using a 3.1 m otter or box trawl with 12.8 mm stretch mesh and 50.8 cm by 25.4 cm doors. All sites in both rivers were sampled with a single trawl tow pulled with the tide at two knots for five minutes.

All fish captured in the seine and trawl were identified to species, counted, and minimum and maximum length recorded for each species. Age of game and commercial species was also recorded. Scales were collected for fish when age determination could not be made in the field. When field identification was not possible, specimens were retained for later laboratory evaluation.

Water quality parameters were sampled using a Hydrolab. Water temperature, pH, dissolved oxygen, conductivity, and salinity were measured at bottom, mid-water and surface depth profiles near the trawl area for each site. Water clarity was measured with a Secchi disc. Detailed sampling methods are described in Carmichael et al., 1992a.

Fish catch data and water quality data were recorded in the field on standardized data sheets. All data sheets were verified prior to leaving the sampling site. Data sheets were again proofed in the laboratory for errors and omissions. Data were keypunched into ASCII files, then compared to the original field sheets to locate any data entry errors. Corrected data files were then converted to PC-SAS data sets. Data were proofed again using a computerized quality control program designed for the project. Finalized data sets were created for analysis and computation of IBI metrics.

3.5.2 Index of Biotic Integrity Calculations

Data for each site were summed for the entire summer season. Data were prepared using a program which assigns spawning location, feeding strategy, and area of residence (freshwater, estuarine or marine species) for each species (Table 3.3). These assignments were made based on the adult life stages of each species.

Nine metrics were used to calculate the provisional IBI score by site. The metrics were divided into three categories: *Richness Measures* - total number of species, number of species caught in bottom trawl, and number of species comprising 90% of the catch; *Abundance Measures* - number of anadromous fish, number of estuarine fish, and total number of fish with menhaden removed; *Trophic Measures* - proportion of planktivores, proportion of carnivores, and proportion of benthivores. Abundance and proportion metrics were then normally transformed and ranked into thirds and assigned a value of 5, 3, or 1. All metrics in the upper third were given a five; middle third a three; and lower third a 1. Planktivores were ranked in reverse because increasing trends in abundance are quantitatively associated with increases in pollutant loadings (Vaas and Jordan, 1990). The individual ranks were then summed to give a total for each site. This total represents the provisional IBI score. A more detailed description is presented in Carmichael et al., 1992b.

3.5.3 Establishing Reference Conditions

Reference IBI conditions were established based on examining numerous years of existing data for the Wicomico River. The 95% confidence intervals about the mean IBI score for the Wicomico River were calculated. The lower limit of the 95% confidence interval (IBI score of 31) was identified as the cut off point for reference systems (any value below this is not meeting the reference standard).

3.5.4 Trawl Index

A trawl index was calculated for each station. The index was derived by calculating the mean rank of the monthly bottom trawl richness measures for each station. The mean ranks were then assigned a narrative rating of good (mean rank greater than 1.33), fair (mean rank between 0.67 and 1.33), and poor (mean rank less than 0.67).

3.6 Benthic Index of Biotic Integrity

3.6.1 Sample Collection

Benthic samples for the Ambient Toxicity study were collected at the twenty sites described in Section 3.1 during the summer of 1999. The ten sites in the Chester River were sampled between September 7 and September 15, while the ten sites in the Rappahannock River were sampled between August 10 and 11. A Global Positioning System (GPS) with differential correction was used to locate study sites. All sites were sampled in the summer window for application of the Benthic Index of Biotic Integrity (Weisberg et al. 1997). Bottom water temperature, conductivity, salinity, dissolved oxygen concentration (DO), and pH were measured at each site.

3.6.2 Benthic Samples

In the Rappahannock River, three replicate samples were collected at each site. Due to funding limitations, one sample was collected at each site in the Chester River. Benthic samples were collected at each site using a Young Grab which samples an area of 440 cm^2 to a depth of 10 cm. The samples were seived through a 0.5 mm screen using an elutriative process. Organisms retained on the screen were transferred to labeled jars and preserved in 10% buffered formalin stained with rose bengal (a vital stain used to aid separation of organisms from sediment and detritus). An additional grab sample was collected from each site for sediment silt/clay analysis. Samples were frozen until processed in the laboratory.

3.6.3 Laboratory Processing

Organisms were sorted from detritus under dissecting microscopes, identified to the lowest practical taxonomic level, and counted. Oligochaetes and chironomids were mounted on slides, examined under a compound microscope, and identified to genus and species. Ash-free dry weight biomass was measured for each species by drying the organisms to a constant weight at 60C followed by ashing in a muffle furnace at 500C for four hours.

Silt-clay composition was determined by wet-sieving through a 63µ stainless steel sieve and weighed using the procedures described by Plumb (1981) and Buchanan (1984).

3.6.4 Data Analysis and Benthic IBI Calculations

Analyses were performed in the context of the Chesapeake Bay Program's Benthic Community Restoration Goals which use the Benthic Index of Biotic Integrity (B-IBI) to measure goal attainment. The newly developed Tidal Freshwater Benthic Community Restoration Goals were applied to one oligohaline site in the Chester River (Alden et al., 2000).

The B-IBI is a multiple-attribute index developed to identify the degree to which a benthic assemblage meets the Chesapeake Bay Program's Benthic Community Restoration Goals (Ranasinghe et al., 1994, updated by Weisberg et al., 1997). The B-IBI provides a means for comparing the relative condition of benthic invertebrate assemblages across different habitats. It also provides a validated mechanism for integrating several benthic community attributes indicative of "health" into a single number that measures overall benthic community condition.

The B-IBI is scaled from 1 to 5, and sites with values of 3 or more are considered to meet the Restoration Goals. The index is calculated by scoring each of several attributes as either 5, 3, or 1 depending on whether the value of the attribute approximates, deviates slightly from, or deviates strongly from values at the best reference sites in similar habitats, and then averaging these scores across attributes. The criteria for assigning these scores are numeric and habitat-dependent.

Benthic community condition was classified into three levels based on the B-IBI. Values less than or equal to 2 were classified as severely degraded; values from 2 to less than 3.0 were classified as degraded; and values of 3.0 or more were classified as meeting the goal. A marginal category of values between 2.6 and 3.0 was also applied to this study.

SECTION 4
RESULTS

4.1 Water Column Toxicity Tests

The following results from water toxicity column tests are presented below: toxicity data, contaminants data, water quality data and toxicity data from reference toxicant tests.

4.1.1 Toxicity Data

Survival, growth, and percent normal shell development from the two estuarine tests conducted from 9/28/99 to 10/6/99 are presented in Tables 4.1 and 4.2. Based on univariate analysis, survival of sheepshead minnows was not significantly reduced at any of the 20 sites when compared with the controls (Table 4.1). However, significant effects on growth were reported for this fish species at two sites in the Chester River (CH2 and CH5). Percent normal shell development with the coot clam from test 1 was significantly different than the controls for four sites in each river (Table 4.2). Specifically, effects were reported at the three downstream sites in the Chester River (CH1, CH2 and CH3) and the most upstream site (CH10). For the Rappahannock River, effects from clam test 1 did not follow any type of spatial pattern (RP1, RP5, RP6 and RP8). Results from coot clam tests 2 and 3 generally did not show any significant biological effects (except RP10). The combined test results from coot clam tests 1-3 did not show significant effects at any of the 20 sites.

4.1.2 Contaminants Data

Inorganic contaminant concentrations from the 20 stations in both the Chester and Rappahannock Rivers showed that chronic water quality criteria were exceeded for copper (CH7, CH10 and RP3), lead (CH8, CH10 and RP3) nickel (RP6 and RP7), and zinc (RP3) (Table 4.3). However, only CH10 and RP6 showed any degree of positive correlation between metals concentrations exceeding criteria and biological effects (coot clam test 1). The site with highest number of metals exceedances (copper, lead and zinc for RP3) showed no significant effects from either of the tests species.

4.1.3 Water Quality Data

Water quality parameters reported from grab samples collected three times at all stations are presented in Table 4.4. Most of these ambient water quality conditions appeared adequate for survival of test species except occasional dissolved oxygen concentrations below 5.0 mg/L at three sites in the Chester River. Water quality conditions reported in test containers during testing are reported in Appendix A. All of these parameters appeared adequate for survival of test species.

4.1.4 Reference Toxicant Data

Forty-eight hour LC or EC50 values for the two test species exposed to cadmium chloride during reference toxicant tests are presented in Table 4.5. These toxicity values were compared with the values from the previous eight years for all species except the coot clam, where six years of data were available.

The sheepshead minnow LC50 of 11.0 mg/L is similar to the value of 10.4 mg/L reported in year 8 but both of these values are higher than reported during the first seven years of the study (0.51 to 2.3 mg/L). The EC50 for the coot clam (0.094 mg/L) is similar to the value of 0.082 mg/L reported the year 7 study. The reference toxicant data in Table 4.5 demonstrates that the test species from the various sources are healthy and the ambient toxicity data were valid.

4.2 Sediment Tests

4.2.1 Toxicity Data

The results of the 20 day exposure of the amphipods (*Leptocheirus plumulosus*) to sediments showed that survival was significantly different from the reference site (Carters Creek, Virginia) at several sites in the Rappahannock and Chester Rivers (Table 4.6). One site in the Rappahannock River (RP-10) and three sites in the Chester River (CH5, CH7 and CH8) were significantly different from the reference site. Results from sediment toxicity tests with the polychaete worm *Streblospio benedicti* in Table 4.7 showed that this species was more sensitive than the amphipod. The sites in the Chester River that were significantly different from the reference site based on the polychaete worm bioassay included: CH4; CH5; CH6; CH8; CH9; and CH10. The sites in the Rappahannock River that were significantly different from the reference site were: RP1; RP5; RP9; and RP10. The agreement between the two toxicity tests for the reduced survival endpoint at CH
5, CH8, and RP10 indicates an increased probability of an adverse impact to benthic resources at these sites.

Growth of the amphipod, expressed as a change of length, was significantly different from the reference site at CH3 and CH10 in the Chester River, and RP5 in the Rappahannock River (Table 4.8). The polychaete worm toxicity test (Table 4.9) revealed that two sites in the Chester River (CH2 and CH3) were significantly different for increase in length over the initial size. There was no significant differences in change of weight for either test species when comparing test sites and the reference sites (Tables 4.8 and 4.9). The basis for statistically analyzing only growth results from sites not already shown to be significantly different from the reference site for survival was that if the sediment was acutely toxic, it would most certainly be significantly different for the sub-acute measurements (e.g., length and weight measurements).

4.2.2 Sediment Chemistry Data

4.2.2.1 Organic Contaminants

At the method detection limit for the analytical methods used in this study, no pesticides, PAHs, or PCBs were detected in sediment from any site including the reference and control sites. This would initially appear to be an indication that these classes of compounds are not present in the study area. If the detection limit was below benchmark concentrations traditionally associated with rarely observing adverse effects to benthic populations or communities (e.g., effects range-low values, Long, et al., 1995), then there is a high degree of confidence that no impairment was occurring at the study sites. If the detection limit for a compound was higher than the benchmark value associated with frequently observing adverse effects (e.g., effects range-median value, Long, et al., 1995), then there is a low degree of confidence that the condition at the site could be characterized. Although the detection limit is a statistically driven estimate of the sensitivity of the measurement process, guidance exists for substituting the detection limit or one-half the detection limit into the exposure assessment (USEPA, 1992) when compounds are not detected in environmental media. Advantages and limitations to this approach and other means of assigning values to contaminants at concentrations below the detection limits have been discussed by Newman (1994). The assumption of compounds being present at one-half the detection limit was used in the following discussion in cases where the detection limit was greater than the effects range-low (ERL) benchmark values.

4.2.2.2 Polycyclic Aromatic Hydrocarbons (PAHs) in Bulk Sediment

Since no PAHs were detected in the sediments from the Rappahannock or Chester Rivers, Tables 4.10 and 4.11 (respectively) show only the detection limits unique to each compound for each site concurrent with the ERL and ERM benchmarks. At the reported detection limit, dibenz(a,h)anthracene is the only PAH than cannot consistently be declared less than the ERM. If it is assumed that this PAH is present at one-half the detection limit, then no site in either river has an individual PAH in excess of the ERM benchmark for that PAH. That is, there is no strong evidence for impairment to the benthos due to the presence of individual PAHs in either river. However, it is impossible to declare any site free of the potential for impairment since the majority of the detection limits are greater than the ERL, even when the assumption of one-half the detection limit is employed. The same conclusions can be drawn when comparing the ERL and ERM for low molecular weight PAHs, but all sites can be assessed as unlikely to be impaired based on high molecular weight PAHs and total PAHs with the assumption of one-half the detection limit.

Although the assessment remains essentially the same as above, the PAHs detection limits for the Rappahannock and Chester Rivers sediment samples and the ERL and ERM (assuming 1% TOC) have been converted in Tables 4.12 and 4.13, respectively, to organic carbon normalized concentrations. The only important change is that when evaluating the data in this fashion, the organic carbon normalized detection limits are less than the organic carbon normalized ERL. Additionally, when compared to the draft sediment quality criteria (USEPA, 1993 a-c) for acenanthrene (Table 4.14), fluoranthene (Table 4.15), and phenanthrene (Table 4.16), there appears to be no site with site-specific organic carbon normalized detection limits that are greater than the draft criteria.

4.2.2.3 Pesticides in Bulk Sediment

The analysis of sediments for pesticides revealed no detectable concentrations in any of the study sites. The sample-specific method detection limits are provided in Table 4.17 for the Rappahannock River and in Table 4.18 for the Chester River. For the limited compounds with effects-based benchmark values, the detection limits were less than the ERM in all cases, but greater than the ERL in all cases. Thus, it can be said that there is no evidence for the potential for adverse impacts to the benthos for dieldrin, DDD, DDE and DDT, but these pesticides cannot be eliminated as potential toxicants in the rivers since it cannot be shown that they are not present above the ERL benchmark value.

Previous pesticide measurements conducted by Hall et al. (1998) in the Chester River in 1996 at four sites in the same study area used in 1999 showed the following ranges of pesticide concentrations: Dieldrin - 1.5 to 3.4 ug/kg; DDT - 4.3 to 63 ug/kg; DDD - BDL to 6.8 ug/kg and DDE - 1.4 to 5.1 ug/kg. Our 1999 results with higher detection limits for these four pesticides (or pesticide breakdown products) showed that all concentrations were less than 7.6 ug/kg. For Dieldrin, DDD and DDE, the evaluated detection limits used for the 1999 study preclude exact comparisons since all the 1996 concentrations were less than 7.6 ug/kg. However, two DDT concentrations (8.4 and 63 ug/kg) reported at two different stations in the Chester River in 1996 were not confirmed with the more recent measurements of < 7.6 ug/kg conducted in 1999. These limited data suggest that DDT concentrations may have declined in sediment from 1996 to 1999.

4.2.2.4 Polychlorinated Biphenyls (PCBs) in Bulk Sediment

The absence of polychlorinated biphenyls measured as Aroclors cannot be assumed to be evidence that sites sampled in this study are free of PCBs at the stated detection limits (Table 4.19). It is possible that the mixture of congeners, in the concentrations required to meet the characterization requirements of the specific Aroclors was not sufficient for the analyst to confirm the presence at the stated detection limits. Because individual congeners degrade differentially under physical and biogeochemical processes based on chemical structure, it is possible, and even likely, that identification and quantification of Aroclors can be missed even in the presence of high concentrations of PCB congeners (USEPA, 1996). Thus, since the differential degradation of congeners is a plausible explanation for the absence of PCBs as Aroclors, it cannot be assumed that PCB congeners are absent from these rivers.

4.2.2.5 Metals in Bulk Sediment

Nickel was found throughout the Rappahannock River (8 of 10 sites) (Table 4.20) in concentrations above the NOAA benchmark for Effects Range-Low (Long et al., 1995), but no other metals exceeded the respective ERLs or the Effects Range-Median benchmarks. The ERL predicts a low probability of toxicity due to nickel when ambient concentrations are below that value and the ERM predicts a high probability of effects to benthic populations when exceeded. In the case of nickel, the reliability of the ERM is suspect and the probability of effects at values greater than the ERL and less than the ERM are difficult to predict. The sites sampled in the Chester River (Table 4.21) had similar instances where nickel was greater than the ERL (7 of 10 sites), but there were 4 sites where nickel, lead and zinc exceeded the ERL (CH4, CH5, CH6 and CH7). Zinc exceeded the ERL at CH2 in addition to nickel. For most metals with ERL and ERM values, when an ambient concentration falls between the two benchmarks, it is expected that toxicity due to the metal(s) is "occasionally" observed. Based on bulk metal concentrations, there are at least 4 and possibly 5 sites in the Chester River with the potential for toxicity due to zinc and lead, but there is no substantial evidence for metals toxicity at the Rappahannock River sites.

Another method of evaluating the metals residues is to consider the contribution each metal may have to any observed toxicity assuming that the toxicity of the individual metals is additive. If the ambient concentration is divided by the ERL benchmark value, the quotient or toxicity unit (TU) may express the relative contribution of the individual metal to the overall potential toxicity of the sediment. In Table 4.22, the concentrations of the metals are expressed as toxic units (TU) relative to the respective ERL benchmarks defined by Long et al., 1995. The TU is defined as the observed concentration divided by the ERL such that TU values less than "1" express a low probability that the specific metal is likely to be responsible for any observed toxicity. TUs greater than "1" for ERL benchmark values indicates when toxicity is "occasionally" observed. If the toxicity of metals can be assumed to be additive in nature, when the total of all TU ERLs for a given site (SUM TU ERL) is less than one, toxicity is not expected to be due to the metals. The SUM TU ERL for the study sites does not allow for ruling out metals as potentially responsible for any observed sediment toxicity.

4.2.2.6 Simultaneously Extracted Metals and Acid Volatile Sulfides (SEM/AVS)

The results of the SEM analysis for the 6 divalent metals is presented in Table 4.23. At all sites in the Rappahannock and Chester Rivers neither cadmium or mercury were detected and nickel was not detected anywhere in the Rappahannock River as a simultaneously extracted metal. Copper, lead and zinc appeared to be similar throughout both study areas, the reference area and the control sites.

The sum of the SEM, the acid volatile sulfides and the ratio (SEM/AVS) for the study sites are presented in Table 4.24. The largest ratio of 1.4 occurred at RP8 in the Rappahannock River. The largest ratio (1.7) for the Chester River was reported in sediments from CH3. The value of these ratios are not sufficiently large to warrant concern for any toxicity being due to the presence of these 6 metals. The amount of AVS was much more variable than the SEM, not between Rivers but between sites in each waterbody. In the Rappahannock River, the highest AVS was at RP10 (15.2 uM/g) with the next highest concentration at RP3 (7.9 uM/g). At three sites in the Chester River (CH8, CH5 and CH7) the concentration of AVS was elevated as well (21.8 uM/g, 18.9 uM/g, and 10.7 uM/g, respectively). The Chester River appears to have a greater overall concentration of SEM (mean = 1.4 uM/g) but an even greater amount of AVS (mean = 6.6 uM/g) than the Rappahannock River (mean SEM = 1.1 uM/g and mean AVS = 5.5 uM/g). With respect to these metals in sediment, the amount of AVS in the Chester River has a slightly greater capacity for binding with the metals than the sites sampled in the Rappahannock River.

4.2.2.7 Pore Water Characteristics

Sediment pore water was analyzed for several naturally occurring substances (*i.e.*, nitrate, ammonia, and sulfide) that can affect survival and growth of the test organisms (Table 4.25). Nitrate concentrations ranged from 0.0001 to 0.0018 mg/L in the Rappahannock River; the range in the Chester River was 0.0006 to 0.0025 mg/L. Ammonia concentrations ranged from 4.9 to 11.9 mg/L in the Rappahannock River while these values ranged from 2.6 to 10.6 mg/L in the Chester River. Sulfide concentrations ranged from < 0.005 to 0.015 mg/L in the Rappahannock River; the range of this porewater parameter in the Chester River was < 0.005 to 0.011 mg/L.

4.2.2.8 Total Organic Carbon in Sediments

The results of the analysis of sediment for organic carbon content is provided in Table 4.25. Organic carbon (expressed as percent TOC dry weight basis) in the Rappahannock River ranged from 0.82% to 2.44% with a mean value of 1.87%. There were 5 sites in this River with organic carbon greater than 2% (RP2, RP5, RP7, RP9 and RP10). The Chester River sites were more enriched with organic carbon than the Rappahannock River. In the Chester River there was one site with more than 5% TOC (CH9), 5 sites with more than 3% TOC (CH4, CH6, CH7, CH8 and CH10) and 2 sites with more than 2 % TOC (CH2 and CH5). The minimum organic carbon concentration in the Chester River was 0.64 % (CH1), a value similar to the lowest value from the Rappahannock River (0.82% at RP6). The mean organic carbon content in the Chester River was 2.88% as compared to the Rappahannock River at 1.88%. The organic carbon content in sediment from the reference site in Carters Creek (4.91%) was similar to the mean TOC for the Chester River sites and the control site in the Ware River (2.53%) was similar to the mean TOC for the Rappahannock River sites.

Organic matter, including organic carbon, in and on the sediment is used by the test organisms as a source of food. Concurrently, organic carbon may bind with organic compounds and render them non-bioavailable which reduces toxicity to benthic organisms exposed to interstitial or pore water in the sediment. The organic carbon data are used elsewhere in this report to normalize PAH and pesticide residues for comparison against sediment quality benchmarks and guidelines. It should be noted however that if there were similar concentrations in both Rivers, the amount of organic carbon throughout the Chester River would produce lower organic carbon normalized organic contaminant concentrations than the Rappahannock River.

4.2.2.9 Particle Size Characteristics of Sediments

Field surveys were performed in advance of the sediment sampling events in an effort to select areas with sediment deposition greater than erosion. The results of characterization for particle size is presented in Table 4.26. The reference and control sites for this study were composed of sediment that was more than 90% fines (silt plus clay) and sediment from 12 of the 20 sites were similar in particle size characteristics. Sediment from several sites was more than 80% fines, and only 4 sites had sediment with more sand than either silt or clay. Only three of the sites that had markedly different sediment types among the randomly located samples within the 100 x 100 m grid (RP8, CH9 and CH10).

4.2.3 Reference Toxicant Data

The relative sensitivities of each set of test organisms were evaluated by reference toxicant tests. The results of each test are shown in Table 4.27. All animals were tested using cadmium chloride ($CdCl_2$). The response of the amphipod to the reference toxicant fell within the expected range for this toxicant, however, the polychaete worm response fell outside of the expected range.
These data suggest that both species are healthy but the polychaetes used for these tests may be more tolerant than polychaetes used in previous experiments. Despite the increased tolerance of this species, it was still more sensitive than the amphipods when detecting toxicity at the various sites (Tables 4.6 and 4.7).

4.3 Fish Index of Biotic Integrity

4.3.1 Fish Community

A summary of the fish data for all sites on the Chester River showed that 6,144 individuals representing 32 species were captured (Appendix B). White perch were the most dominant species, followed by Atlantic silverside and bay anchovy. These three species combined composed 73% of the overall catch. Rappahannock River data showed that 4,606 individual were captured representing 39 species. Bay anchovy, white perch and Atlantic silversides were the most dominant species, representing 78% of the catch.

Individual metrics for each station in the Chester River are presented in Table 4.28. Station CH-3 showed the highest overall abundance and station CH-9, the lowest. Total estuarine individuals declined steadily from station CH-1 (mouth of the river) where the count was highest at 415 individuals to Station CH-10 (most upstream site) where the count was a low 26 individuals. Anadromous fish abundance varied among the stations , with station CH-3 representing the largest total catch for the season of 565 individuals. Both stations CH-5 and CH-9 showed low anadromous counts of 192 and 159, respectively. In the Chester River, carnivores comprised the largest proportion of the catch at station CH-8. Planktivorous fish dominated the catch at station CH-1. Benthic feeders were observed in low numbers, however, the largest proportion of benthivores was observed at station CH-10. Station CH-10 had the highest species richness with 23 species observed in total. This station also had the largest number of species observed in the trawl, and showed the greatest richness, with nine species representing 90% of the overall catch. Stations CH-4 and CH-5 showed the poorest measures of richness and diversity.

Table 4.29 shows the individual metrics for each of the Rappahannock River stations. The largest catch was recorded at station RP-4, with 1011 individuals and the lowest at sation RP-7 showing only 127 individuals. Estuarine fish abundance seemed to follow this trend with the largest anadromous catch found at station RP-4 and the lowest at station RP-7. Anadromous fish were observed at all stations; however, station RP-1 had only one individual recorded. The greatest anadromous fish count was observed at station RP-10 (the most upstream station). The largest proportion of carnivorous fish was observed at station RP-10, and the lowest at station RP-4 where planktivores dominated. The largest proportion of benthic feeders was observed at station RP-7. The total number of species ranged from a low of 12, recorded at station RP-3, to a high of 20 which was observed at three stations, RP-8, RP-9, and RP-10. Stations RP-8 and RP-10, both yielded 10 species in the bottom trawl. Station RP-4 showed the lowest value for species richness with only 2 individuals representing 90% of the catch.

IBI scores for the Chester River ranged from a low of 21 at station CH-4 and CH-5 to a high of 35 at station CH-7 (Table 4.30). Only three stations, CH-1, CH-7 and CH-10 scored at or above the reference criteria of 31. Scores for the Rappahannock River ranged from 31 to 35; all stations met or exceeded the reference criteria of 31.

The trawl index for the Chester River (Table 4.31) showed a poor ratings for all lower river stations (CH-1 to CH-6). Station CH-7 and CH-10 rated good and CH-8 and CH-9 were rated fair. For the Rappahannock River, the trawl index rated good at all stations except RP-6 and RP-7 where a fair rating was reported (Table 4.31).

4.3.2 Water Quality

Summer mean dissolved oxygen levels at all stations on both river systems met the requirements recommended by the U.S. Environmental Protection Agency's Chesapeake Bay Program Office. Mean dissolved oxygen values were greater than 5.0 mg/L at the surface and greater than 3.0 mg/L at the bottom at all stations (Table 4.32). Summer mean Secchi depth measurements were below the criteria for SAV recovery (0.97m) at all sites in the Rappahannock River. Secchi depth measurements failed to meet criteria at all Chester River stations except for CH-5 and CH-3 (Table 4.33).

4.4 Benthic Index of Biotic Integrity

Water quality measurements, sediment composition, species abundances, species biomass and benthic IBI scores for each site are presented in Appendix C. The number of benthic taxa in the Chester River (6-15) was generally more variable by site than in the Rappahannock River (9-14).
Abundance measurements ranged from 1,068 to 4,545 per sq. meter in the Chester River. In the Rappahannock River, abundance measurements were more variable as they ranged from 879 to 20,917 per sq. meter.

The B-IBI scores for the Chester River River in Table 4.34 showed that seven sites met the benthic restoration goal, one site was marginal, one site was degraded and one site was severely degraded. The degraded (CH10) and severely degraded (CH9) sites were upstream. The benthic communities at these sites had low diversity, low biomass and a high number of pollution-indicative species. For the

Rappahannock River, three sites met the restoration goal, one site was marginal, three sites were degraded and three sites were severely degraded (Table 4.34). All three sites that met the goal (RP3, RP7, and RP10) did so barely with a B-IBI of 3.0 which is at the cut off between meeting the goal and degraded. Three of the sites that failed to meet the goal (RP6, RP8 and RP9) had low diversity and were dominated by the oligochaete *Tubificoides heterochaetus*. This oligochaete is often an indicator of eutrophic conditions. The B-IBI results were more variable in the Rappahannock River when compared to the Chester River. Although there was no clear spatial trend, the benthic communities in the Rappahannock River were generally more impaired than in the Chester River.

SECTION 5
DISCUSSION

5.1 Chester River

The water column/sediment toxicity data, water column/sediment contaminants data and the biological community metric data for fish and benthos presented in this report allows a cumulative "weight of evidence approach" for assessing the condition of each respective river (Table 5.1). Univariate analysis of water column toxicity data from the Chester River showed sporadic toxicity at a few sites based on sheepshead minnow growth and normal shell development in the coot clam (from only one of three tests). Four of the Chester River stations (CH2, CH4, CH5 and CH6) tested for water column toxicity in 1999 were also tested in 1996 (Hall et al., 1998). The 1996 results from both the sheepshead minnow (growth endpoint) and coot clam development (two tests) showed toxicity at three of the four sites for sheepshead growth and toxicity at all sites for clam development. Multivariate analysis showed water column toxicity at all four sites tested in 1996. The 1999 results showed much less toxicity in the water column as significant effects were only reported at CH4 based on multivariate analysis (Table 6.1). The association between inorganic contaminants in the water column and biological effects at station CH4 is weak because concentrations of metals in the water column are below established biological thresholds. In general metals in the water column at all 10 Chester River sites are generally low (except for lead at two sites) and other contaminants such as pesticides or other organics were not measured.

Sediment toxicity data based on univariate analysis of survival and growth of the amphipod and polychaete showed significant effects from two of the four endpoints at four of the Chester River sites. Sediment toxicity was reported from at least one endpoint at nine of the ten sites. Multivariate analysis showed significant effects at eight of the ten sites (Table 6.2). In contrast to the water column data discussed above, sediment toxicity from four sites tested in both 1999 and 1996 was reasonably consistent (Hall et al., 1998). In 1996, sediment toxicity based on multivariate analysis was reported at CH2, CH4, CH5 and CH6; toxicity was reported at all sites except CH2 in 1999. Linkage of biological effects in sediment and contaminants was weak as organics were not reported above detection limits and all metals concentrations were below ERL values except lead, nickel and zinc at various sites. The generally low SEM/AVS ratios suggested that toxicity due to metals was unlikely.

Fish community data suggested disturbance at eight of the ten stations. These data were consistent with the fish community assessments conducted at CH2, CH4, CH5 and CH6 in 1996 as impairment was also previously reported for fish communities at these sites (Hall et al., 1998). In contrast to the fish community data, the benthic community data showed no significant effects at seven of the ten sites. These results are in agreement with benthic assessments conducted in 1996 at four sites also sampled in 1999 (Hall et al., 1998). The consistent lack of agreement for fish and benthic assemblage status is not surprising and has been reported in previous Chesapeake Bay ambient toxicity studies (Hall et al., 1999) and other studies (Yoder and Rankin, 1994). Testing both biological assemblages increases the discriminatory of detecting impairment and reduces the possibility of reporting "false negatives".

In summary, sediment toxicity data and impaired fish communities suggested some degree of stress at most of the Chester River stations. In contrast, water column toxicity and benthic community impairment were generally not reported at the various Chester River sites. At three sites, either toxicity or biological community impairment were reported from three of the four measures; three of the four measures also failed to report either toxicity or biological impairment at two of the sites. The other five sites provided mixed results as two measures showed effects and two measures showed no effects. These data suggested that the contaminants measured in the water column and sediment during this study are unlikely responsible for the toxicity or biological impairment reported at the Chester River sites.

5.2 Rappahannock River

A discussion of the Rappahannock River "weight of evidence" for assessing water column/sediment toxicity data, water column/sediment contaminants data, and community metric data for fish and benthos is presented below (see Table 5.1). Results from water column toxicity tests in the Rappahannock River showed no effects at any of the 10 sites from sheepshead minnow toxicity tests using survival and growth endpoints. Coot clam development was reduced at four of the sites during the first 48 h test but on effects were reported at any of the sites during two other tests. Multivariate results presented in Table 6.1 showed no significant effects based on water column tests at any of the ten sites. With the exception of lead and zinc at station RP3, metals concentrations were generally low in this river.

Sediment toxicity data for the Rappahannock River showed effects at five of ten sites based on multivariate analysis presented in Table 6.2. A higher degree of toxicity was reported at the upstream stations (RP10) and mid-stream station (RP5). The association between toxicity and presence of contaminants in sediment is weak since toxic metals were unlikely bioavailable due to low SEM/AVS ratios and organic contaminants were not detected at the reported detection limits.

Fish communities at the 10 Rappahannock River sites appeared to be reasonably healthy. In contrast, the benthic communities were somewhat impaired at seven of the ten sites. As discussed above, it is not surprising that the fish and benthic community data provide contrasting results (Hall et al., 2000b; Yoder and Rankin, 1994). These data support the need to evaluate both biological assemblages for a complete ecological assessment in lotic systems.

A final analysis of water column toxicity data, sediment toxicity data, fish community data and benthic community data for the Rappahannock River demonstrated effects from two of the four measures at four of the sites (Table 5.1). The contaminants measured during this study were unlikely responsible for the reported toxicity or biological impairment. Effects were reported for only one measure at four of the sites and no effects were reported for any of the measures at two sites. A lower degree of toxicity and biological impairment was reported in the Rappahannock River than in the Chester River.

SECTION 6
ANALYSIS OF TEN YEAR DATA BASE

6.1 Water Column Toxicity

The results of Toxicity Index calculations for water column toxicity for the 1990, 1991, 1992-93, 1994, 1995, 1996, 1997, 1998, and 1999 experiments are summarized in Figures 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, and 6.9 respectively. The species tested and the number of endpoints used varied slightly from year to year. Therefore, comparisons of index values within the figures for the same year are more comparable to each other than to those of different years. The Toxicity Index calculations generated for each station and year from concurrent reference (control value) and test conditions, therefore, provide interpretation on the relative magnitude of the toxic response of the various sites. This analysis also provided a degree of confidence that could be given to differences between reference and test values. A summary of comparison of Toxicity Index values for reference (control) and test sites is presented in Table 6.1.

The Toxicity Index analysis for the 1990 data in Figure 6.1 showed that the Elizabeth River was clearly the most toxic site tested. The confidence limits for the reference and test condition did not overlap at this location. Nearly half of the endpoints displayed significant differences between the reference and test conditions. The results from the Elizabeth River are not surprising since significant mortality was observed in two of the three tests that were conducted. The Patapsco River displayed significant mortality in one out of three tests. However, the confidence interval was fairly wide (indicating variability) for this station and there was no difference in the median values for the reference and test site. Morgantown and Dahlgren stations on the Potomac River displayed significantly elevated Toxicity Index values, largely driven by significant mortality with the sheepshead minnow test. However, the results from the Indian Head, Freestone Point and Possum Point sites were not significantly different from the reference conditions. The Wye River site did not produce significant water column toxicity.

The Toxicity Index calculations for the 1991 experiments are presented in Figure 6.2. Four water column tests with two endpoints for each test were used to determine the final values for two testing periods (summer and fall). The Wye River site showed the most significant effects as significant mortality was reported for two different test species during different testing periods. Although the median values from the reference and test sites were different, there was overlap of confidence limits with these two conditions. A comparison of reference and test index values for the Patapsco River, Morgantown and Dahlgren sites showed no significant differences. However, reduced growth of the sheepshead minnow was reported at both the Morgantown and Dahlgren sites during the summer experiments.

The results from the 1992-93 experiments presented in Figure 6.3 include experiments conducted during the fall (1992) and spring (1993) at each of the 6 sites (2 sites per river). The most toxic sites were reported at both Middle River stations (Wilson Point and Frog Mortar Creek). Results from the coot clam toxicity tests (2 tests per experiment conducted in the fall and spring) showed consistent toxicity at both sites. Median toxicity values were similar for these two Middle River sites, both falling within the top quartile of all sites tested. Water quality criteria for selected metals were exceeded at both sites. The results from Toxicity Index analysis at the other 4 sites showed no difference between the reference and the test condition. The only other biological effect reported at any of these 4 sites was significant mortality of *E. affinis* at the Quarter Creek site during the spring experiments.

The results of the 1994 experiments are presented in Figure 6.4a and 6.4b. Except for the South Ferry site, which was shown to be non-toxic, all sites sampled in the Severn, Magothy and Sassafras Rivers displayed moderately low, but significant toxicity (Figure 6.4a). On the other hand, Sparrow Point in Baltimore Harbor displayed significant toxicity, with Toxicity Index values falling within the top quartile of those observed from all sites tested (Figure 6.4b). The Bear Creek site in Baltimore Harbor displayed significant but low toxicity. The other Baltimore Harbor sites displayed no statistically significant toxicity.

The results of the 1995 studies are presented in Figure 6.5. The Toxicity Index values for the Lynnhaven River were not significantly different from the reference. In the James River basin, the James River "Above" and the Willoughby Bay sites displayed Toxicity Index values that were statistically significant. In contrast, the James River "Below" did not display significant toxicity. The York River sites also displayed insignificant to moderate water column toxicity: the Pamunkey "Above" and York River "Below" sites had Toxicity Index values that were not significantly different from the references; the York River "Above" had only a very slight elevation of toxicity above controls; and the Pamunkey "Below" displayed a moderate level of toxicity.

Figure 6.6 presents the results of the 1996 studies on the Chester and the Patuxent Rivers. The water from all of the sites except Jack Bay in the Patuxent River exhibited significant differences in Toxicity Index values compared to the reference conditions. The CH5 and CH6 sites in the Chester River had the highest values. The values from the remaining sites were indicative of low to moderate toxicity.

The results of the 1997 studies in the South River and the Elizabeth River are presented in Figure 6.7. The water from all of the sites displayed significant differences in Toxicity Index values compared to the reference conditions. Three of the sites on the South River (SR1, SR3 and SR4) exhibited a moderately high degree of toxicity, with Toxicity Index values ranking in the top 10% of all values through 1997. *Eurytemora affinis* survival and reproduction were significantly affected at all three of these sites. Site SR2 was somewhat lower in toxicity. The Toxicity Index values from the sites in the Elizabeth River were quite high, ranking in the top quartile of the data sets evaluated to date. However, the relative toxicities of the sites in 1997 were lower than the level observed at the Elizabeth River site in 1990 (see discussion of sediment data below).

The results of the 1998 studies in the Choptank and Anacostia Rivers are presented in Figures 6.8a and 6.8b, respectively. Water column toxicities in the Anacostia River were quite heterogeneous: running from nonsignificant at Sites AR2 and AR6; through significant but relatively low at Site AR4; to moderately toxic at Site AR1; and to quite toxic at Sites AR3 and AR5. In fact, the toxicities at the latter two sites were the highest (AR3) and the third highest (AR5) observed during the first eight years of AMTOX studies (see below). Coot clam larval survival was the most impacted endpoint, with significant effects observed at Sites AR1, AR3, AR4, and AR5. Sheepshead minnow growth was significantly affected at Sites AR1, AR4, and AR5, while *Eurytemora affinis* reproduction was impacted at AR3. In contrast to the heterogeneity in toxicity observed for the Anacostia River, the water column toxicity was very homogeneous among the Choptank River sites. All four sites displayed significant, moderate toxicities. For these sites, *Eurytemora affinis* survival and reproduction were the endpoints that were impacted.

The results of the 1999 studies in the Chester and Rappahannock Rivers are presented in Figures 6.9a - 6.9d. Four of the sites in the Chester River had been previously sampled in 1996: CH2; CH4; CH5; and CH6. The degree of toxicity observed for the water column samples taken from both rivers was minimal. While the bootstrap evaluations indicated that sheepshead minnow growth was depressed for some of the sites in both rivers, the effect was slight and the Toxicity Index was not significantly different for 19 of the 20 sites. Chester River site CH4 was the only site for which the Toxicity Index was statistically significant and this difference was negligible.

A summary of the ten year water column data base using the Toxicity Index analysis (Figures 6.10 a-c) indicated the following ranking of toxicity for the various sites:

! the sites (and dates tested) displaying the greatest water column toxicity (15% to >30%) were as follows:

Anacostia River: Site AR3 and Site AR5 (1998)
Elizabeth River: Elizabeth River Site (1990); Southern Branch, Site SB (1997); Main Stem, Site EL (1997); Western Branch, Site WB (1997); & Eastern Branch, Site EB (1997)
South River: Site SR1, Site SR3 & Site SR4 (1997)
Middle River: Wilson Point Site & Frog Mortar Creek Site (1994)
Chester River: Site CH6 and CH5 (1996)

! the sites that displayed a low to moderate degree of water column toxicity (5% to 14%) were:

South River, Site S2 (1997)
Baltimore Harbor: Sparrows Point Site (1994) & Patapsco River Site(1990)
Potomac River: Morgantown and Dahlgren Sites (1990)
Wye River, Manor House Site (1991)
Anacostia River, Site AR1 (1998)
Choptank River: Sites CR59, CR61, CR62 & CR63 (1998)
Chester River, Site CH4 (1996 & 1999)
Pamunkey River, site below West Point in the York River basin (1995)
James River, site above Newport News (1995)
Severn River sites at Annapolis and Junction with Route 50 (1994)
Patuxent River: Broomes Island & Chalk Point Sites (1996)
Chester River, Site CH2 (1996)

! the sites (listed geographically, from north to south) that displayed water column toxicity that was low in magnitude (<5%), but significantly different from reference (control) responses were:

Sassafras River: Betterton and Turner Creek Sites (1994)
Baltimore Harbor, Bear Creek Site (1994)
Magothy River, Gibson Island site (1994)

- # Anacostia River, Site AR4 (1998)
- # Patuxent River, Buzzard Island Site(1996)
- # York River, site above Cheatham Annex (1995)
- # James River Basin: Willoughby Bay Site (1995)

! the sites (listed geographically, from north to south) that displayed no significant water column toxicity were:

- # Baltimore Harbor: Patapsco River Site (1991); Curtis Bay, Middle Branch, Northwest Harbor and Outer Harbor Sites (1994)
- # Chester River: Site CH1, CH2, CH3, CH5, CH6, CH7, CH8, CH9, CH10 (1999)
- # Magothy River, South Ferry Site (1994)
- # Wye River: Manor House Site (1990, 1992-3); & Quarter Creek Site (1992-3)
- # Anacostia River, Sites AR2 and AR6 (1998)
- # Patuxent River, Jack Bay Site (1996)
- # Nanticoke River: Bivalve Site & Sandy Hill Beach Site (1992-3)
- # Potomac River: Dahlgren (1991), Freestone Point (1990), Indian Head (1990), Morgantown (1991), and Possum Point (1990) Sites
- # Rappahannock River: Sites RP1, RP2, RP3, RP4, RP5, RP6, RP7, RP8, RP9, RP10 (1999)
- # Pamunkey River, site above West Point in the York River basin (1995)
- # York River, site below Cheatham Annex, (1995)
- # James River, site below Newport News (1995)
- # Lynnhaven River Site(1995)

6.2 Sediment Toxicity

The results of the Toxicity Index calculations for sediment toxicity for the 1990, 1991, 1992-93, 1994, 1995, 1996, 1997, 1998, and 1999 studies are summarized in Figures 6.11, 6.12, 6.13, 6.14, 6.15 6.16, 6.17, 6.18, and 6.19, respectively. It should be noted that the species and the number of endpoints tested varied slightly from year to year, so index values within the figures (within the same year) are more comparable than are those between figures. Nonetheless, the comparisons of concurrent reference and test experiments provide insight into the relative magnitude of the toxic responses of the various sites. Table 6.2 summarizes the comparisons presented in Figures 6.11 - 6.19.

During the 1990 study, the Elizabeth River was clearly the most toxic of the sites, since all species displayed nearly complete mortality during the first 10 days of the experiment (i.e., the median for the index for the test data was greatly separated from the median for the reference data with little variation; Figure 6.11). The Elizabeth River provides an example of the worst case Toxicity Index values. The confidence limits of the test data index values were well separated from those of the corresponding reference sites for a number of other sites: Patapsco River; Wye River; and the Freestone Point, Possum Point and Dahlgren sites on the Potomac River (although the latter two sites displayed a considerable degree of variation in index values). The Indian Head and Morgantown sites on the Potomac River displayed only slight separation between the median index values for the test and reference conditions. Thus, the magnitude of potential toxicity appears to be less for the Indian Head and Morgantown sites than for the others. It should be noted, however, that all sites selected for the first year of the study were those considered potentially toxic due to the results of previous studies, so it is not surprising that most displayed significant deviations from the reference conditions.

The 1991 study involved an assessment of the effects of short-term temporal variability (a summer versus a fall collection) on the apparent toxicity of sediments from four sites. The separation between test and reference treatments was greatest for the Patapsco River site, with less separation being displayed for Dahlgren, Morgantown, and the Wye (Figure 6.12). The results of the Patapsco River index comparison were remarkably similar to those observed for the 1990 study. The Dahlgren site index values, which were quite variable in the 1990 study, were still separated from the reference values in the 1991 study. The small degree of separation observed between the Morgantown index limits and reference limits in 1990 was also observed for 1991. The Wye River index limits were only slightly separated from the reference limits due to the fact that only one of the two sets of experiments displayed significant differences between test and control treatments. This slight variability in responses could be due to temporal variation in toxicity, but is more likely due to small scale spatial heterogeneity (i.e., sediments were taken from the same general station, but there may have been patchiness in sediment quality in the grabs composited for the two sets of tests). Overall, the degree of variability observed in the Toxicity Index limits for the combination of the two sampling events was quite small for all four sites. The patterns were remarkably consistent with those observed at these same sites during the previous year.

The 1992-93 study also involved two sampling periods during the Fall and Spring. The test and reference Toxicity Index limits overlapped for all of the sites selected for testing (Figure 6.13). Thus, the sites in the Middle River (Frog Mortar and Wilson Point), the Wye River (Quarter Creek and Manor House), and the Nanticoke River (Sandy Hill Beach and Bivalve) appeared to contain sediment displaying little or no overall toxicity compared to reference conditions. It should be noted, however, that the Frog Mortar sediments were quite heterogeneous in character and they displayed somewhat elevated metals in the composite samples (see Hall *et al.*, 1993). Therefore, there may be patches of contaminated sediments at this site, which may have produced responses in a few of the field replicates. The purpose of taking true field replicates at two different times during the 1992-93 study was to produce confidence limits to indicate the probability of observing the same sort of response if the site were sampled again, so the observed variability provides insight into the variation in sediment quality expected for this site.

The results of the 1992-3 studies on the two Wye River sites (Quarter Creek and Manor House) displayed little difference from the reference conditions, which is in contrast to the apparent toxicity observed in 1990 and one of the sampling period of the 1991 study. The Wye River Manor House Site was sampled three times during the first four years of testing.

The 1994 studies focused on the Sassafras River, the Severn River, and the Baltimore Harbor/Patapsco River (Figures 6.14a and 6.14b). The Sassafras River sites displayed no sediment toxicity (Figure 6.14a). The Magothy River sites exhibited slight to moderate toxicity, particularly the South Ferry site, which was highly variable (Figure 6.14a). The Annapolis site on the Severn River also displayed significant but moderately low toxicity. In contrast, the Toxicity Index limits from the Severn River site at the Route 50 bridge overlapped those of the reference site. The Baltimore Harbor sites showed various degrees of toxicity from slight (Outer Harbor) to quite high (Bear Creek and Northwest Harbor), with most displaying moderate toxicity (Sparrow Point, Middle Branch and Curtis Bay; Figure 6.14b). All Baltimore Harbor sites contained sediments that exceeded ER-M values for 3 or more contaminants.

The 1995 studies involved sites in the James and York River basins and a site in the Lynnhaven River (Figure 6.15). The Toxicity Index was elevated for the Willoughby Bay site, which is located near the mouth of the James River and in the vicinity of heavy military, residential, and marina activities. The James River site below Newport News displayed Toxicity Index values that were also significantly elevated relative to the reference, but the degree of toxicity was lower than for the Willoughby site. None of the other sites displayed overall significance in the Toxicity Index comparisons to references, although the Lynnhaven site was the only one to display no significant endpoints in the univariate comparison of confidence limits.

The 1996 studies focused on the Chester and the Patuxent Rivers (Figure 6.16). All sites in the Chester River displayed some degree of toxicity. The CH2 and CH4 sites in the Chester River had sediments that produced a low to moderate level of toxicity, while sediments from sites CH5 and CH6 were associated with a higher degree of toxicity. The magnitude of toxicity displayed by sediments from the latter two sites was of the same overall magnitude as that observed during earlier studies for the South Ferry site in the Magothy River and two of the sites (Possum Point and Dahlgren) in the Potomac River (see below). In contrast, sediments from the Patuxent River were, for the most part, not significantly toxic. While the median toxicity index values (5-10 on the toxicity index scale) for the Patuxent River sites were somewhat higher than for the reference condition, variation in results made these differences not statistically significant except for the Buzzard Island site. The Buzzard Island site displayed a moderately low level of toxicity that was statistically greater than the reference condition.

The 1997 studies involved four sites in the South River and four sites in the Elizabeth River (Figure 6.17). While there was significant sediment toxicity detected at six of the eight sites, the degree of toxicity was moderately low. South River Sites 1 and 2 displayed the highest level of toxicity, but Toxicity Index values only ranged between 7% and 12%. *Streblospio benedicti* survival and growth, *Leptocheirus plumulosus* growth, and fish egg hatching success were the endpoints that were the most affected in the experiments for these sites. In contrast, Sites SR3 and SR4 displayed no significant toxicity. The sediments from all the Elizabeth River sites displayed significant but low levels of toxicity. Obviously, the toxicity of the Elizabeth River sediments studied during 1997 was considerably less than the degree of toxicity detected in 1990. Possible explanations were that the toxicity of the sediments has decreased during the intervening seven years and/or the toxicity of the sediments is highly patchy. There has been a considerable degree of management efforts focused on the Elizabeth River during the 1990s (e.g. the Elizabeth River Project; pollution control actions of the Virginia Department of Environmental Quality; activities associated with the Region of Concern status of the River in the Chesapeake Bay Program), so it is entirely possible that the degree of contamination/toxicity has significantly decreased. However, it should be noted that the Elizabeth River site studied in 1990 was selected to be extremely contaminated to serve as a sort of "positive control" during the development phase of the ambient toxicity tests. The 1990 samples were taken in proximity to a Superfund site that was highly contaminated with creosote (polynuclear aromatic hydrocarbons). The 1997 samples were taken to be more representative of the Elizabeth River main stem and its three major branches. Thus, the apparent decrease of toxicity may have been due to site selection in a patchy system. Nonetheless, the more representative 1997 samples indicate that the overall toxicity of the sediments is relatively modest.

The 1998 studies focused on sediments collected from the Anacostia and Choptank Rivers (Figures 6.18a and b). Except for AR6, all of the Anacostia River sites displayed significant toxicity, ranging from low (5% for AR1) to moderate (13% for AR4). While a number of endpoints were impacted, *Leptocheirus plumulosus* survival was the most significantly affected for all of these sites. In contrast, none of the sites from the Choptank River displayed significant toxicity.

The 1999 studies involved studies taken from the Chester and Rappahannock Rivers (Figures 6.19 a-d). As previously indicated, four of the sites in the Chester River had been previously sampled in 1996: CH2; CH4; CH5; and CH6. While the lower reaches of the Chester River (sites CH1 and CH2) had sediments that produced Toxicity Index values that were not significantly different from those of the reference, the remaining sites (CH3 to CH10) had toxic sediments. Toxicity for these sites tended to increase to a maximum at CH8, where the Toxicity Index was approximately 40% of the worst case value. This site was upstream from Chestertown (CH6) that had a median Toxcity Index of 31%. Sediment toxicity in the Rappahannock River was somewhat more variable; significant Toxicity Index values were observed at sites RP1, RP4, RP5, RP9 and RP10. Maximum toxicity (27%) was observed at RP10. Variable toxicities were observed at RP9, where the Toxicity Index was significant, and at RP6 and RP3, where they the Toxicity Index values were not significant. Moderately high sediment toxicity (21%) was also observed for RP1 near the mouth of the Rappahannock River.

A summary of the ten year sediment data base using the Toxicity Index analysis in Figures 6.20 a-c indicated the following ranking of toxicity for the various sites:

- ! the sites (and dates tested) displaying the greatest sediment toxicity (15% to 100%) were as follows:

  - # Elizabeth River Site (1990)
  - # Baltimore Harbor: Northwest Harbor, Bear Creek, Sparrows Point, Curtis Bay, and Middle Branch Sites (1994)
  - # Chester River: Site CH5 (1996); and Site CH6 (1996); Sites CH4, CH5, CH6, CH7, CH8, CH9, and CH10 (1999)
  - # James River basin: Willoughby Bay Site(1995)
  - # Magothy River, South Ferry Site (1994)
  - # Rappahannock River: Sites RP1, RP9, RP10 (1999)
  - # Potomac River: Possum Point Site; and Dahlgren Site (1990)

- ! the sites that displayed a low to moderate degree (5% to 14%) of sediment toxicity were:

  - # Patapsco River Site (1990, 1991)
  - # Potomac River: Freestone Point Site (1990) and Dahlgren Site(1991)
  - # Chester River, Site CH2, Tams Point (1996)
  - # South River, Site S1 (1997)
  - # Severn River, Annapolis site (1994)
  - # Anacostia River: Sites AR4, AR3, AR2, AR5 & AR1

(1998)

Wye River, Manor House Site (1991)
Chester River, Site CH4 (1996); Site CH3 (1999)
James River, site below Newport News (1995)
Rappahannock River: Site RP4 and RP5 (1999)
Patuxent River, Buzzard Island Site (1996)
Baltimore Harbor, Outer Harbor Site (1994)

! the sites (listed geographically, from north to south) that displayed sediment toxicity that was low in magnitude (<5%), but significantly different from reference responses were:

Magothy River, Gibson Island Site (1994)
Wye River, Manor House Site (1990)
South River, Site SR2 (1997)
Potomac River: Morgantown Site (1990, 1991) and Indian Head Site(1990)
Elizabeth River: Main stem, Site EL; Western Branch, Site WB; Eastern Branch, Site EB; and Southern Branch, Site SB (1997)

! the sites (listed geographically, from north to south) that displayed no significant sediment toxicity were:

Middle River: Frog Mortar Site & Wilson Point Site (1992-3)
Sassafras River: Betterton Site & Turner Creek Site (1994)
Chester River: Sites CH1 and CH2 (1999)
Wye River: Quarter Creek Site & Manor House Site (1992-3)
South River: Site SR3 and Site SR4 (1997)
Anacostia River, Site AR6 (1998)
Choptank River: Sites CR59, CR61, CR62, CR63 (1998)
Patuxent River: Broomes Island Site, Jack Bay Site, and Chalk Point Site(1996)
Nanticoke River: Bivalve Site & Sandy Hill Beach Site (1992-3)
Rappahannock River: Sites RP2, RP3, RP6, RP7, and RP8 (1999)
Pamunkey and York River sites (all sites) (1995)
James River, site above Newport News (1995)
Lynnhaven River Site (1995)

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SECTION 8
TABLES AND FIGURES

Table 3.1 Analytical methods used for inorganic analysis in water samples. The following abbreviations are used: AA-H (Atomic Absorption - Hydride), AA-F (Atomic Absorption-Furnace), AA-DA (Atomic Absorption - Direct Aspiration) and AA-CV (Atomic Absorption-Cold Vapor).

Contaminant	Method	Method #	Reference
Arsenic	AA-H	206.3	U.S. EPA, 1979
Cadmium	AA-F	213.2	U. S. EPA, 1979
Chromium, Total	AA-F	218.2	U. S. EPA, 1979
Copper	AA-F	220.2	U. S. EPA, 1979
Lead	AA-F	239.2	U. S. EPA, 1979
Mercury	AA-CV	245.1	U. S. EPA, 1979
Nickel	AA-F	249.2	U. S. EPA, 1979
Selenium	AA-H	270.3	U. S. EPA, 1979
Zinc	AA-DA	200.7	U. S. EPA, 1979

Table 3.2 Analytical methods for inorganic analysis of sediment samples. The detection limits (DL) for the target analytes vary with the amount of sample digested and are typically lower than shown.

ELEMENT		**METHOD**	**REF**	**DATE**	**INSTRUMENT**	**DL (ug/g)**
Aluminum	Al	7020	1	Sep-86	FAA	100
Arsenic	As	3114 B	2	1995	AA/Hydride	0.025
Cadmium	Cd	7131 A	1	Sep-94	GFAA	0.01
Chromium	Cr	7190	1	Sep-86	FAA	1.00
Copper	Cu	7210	1	Sep-86	FAA	5.00
Lead	Pb	7420	1	Sep-86	FAA	10
Mercury	Hg	7470A	1	Sep-94	CVAA	0.025
Nickel	Ni	7520	1	Sep-86	FAA	5.00
Selenium	Se	3114B	2	1995	AA/Hydride	0.025
Tin	Sn	282.2	3	Mar-83	GFAA	0.50
Zinc	Zn	7950	1	Sep-86	FAA	1.00

NOTE:

1 - Test Methods for Evaluating Solid Waste Physical/Chemical Methods (EPA SW-846)
2 - Standard Methods for the Examination of Water and Wastewater, 19th Ed., 1995
3 - Methods for the Chemical Analysis of Water and Wastes (EPA-600/4-79-020)

Digestion Method is Method 3050B from SW-846 (December 1996)

AA/Hydride = Atomic Absorption - Hydride
CVAA = Atomic Absorption - Cold Vapor
FAA = Atomic Absorption - Flame
GFAA = Atomic Absorption - Graphite Furnace

Table 3.3 Trophic classification, spawning location and residency of fish captured at the twenty sampling locations.

SPECIES NAME	TROPHIC	FAMILY	SPAWN LOCATION	RESIDENCY
Alewife *Alosa pseudoharengus*	Planktivore	Clupeidae	Freshwater Anadromous	Non-resident
American eel *Anguilla rostrata*	Benthic	Anguillidae	Marine Catadromous	Resident
Atlantic croaker *Micropogonias undulatus*	Benthic	Sciaenidae	Marine	Non-resident
Atlantic menhaden *Brevoortia tyrannus*	Planktivore	Clupeidae	Marine	Non-resident
Atlantic needlefish *Strongylura marina*	Carnivore	Belonidae	Marine	Non-resident
Atlantic silverside *Menidia menidia*	Planktivore	Atherinidae	Estuarine	Resident
Atlantic stingray *Dasyatis sabina*	Benthic	Dasyatidae	Marine	Non-resident
Banded killifish *Fundulus diaphanus*	Planktivore	Cyprinodontidae	Freshwater	Resident
Bay anchovy *Anchoa mitchelli*	Planktivore	Engraulidae	Estuarine	Resident
Blackcheek tonugefish *Symphurus plagiusa*	Benthic	Soleidae	Marine	Non-resident
Blue catfish *Ictaluris furcatus*	Benthic	Ictaluridae	Estuarine	Resident
Blueback herring *Alosa aestivalis*	Planktivore	Clupeidae	Freshwater Anadromous	Non-resident
Bluefish *Pomatomus saltatrix*	Carnivore	Pamatomidae	Marine	Non-resident
Bluegill *Lepomis macrochirus*	Planktivore	Centrarchidae	Freshwater	Resident
Brown bullhead *Ameiurus nebulosus*	Benthic	Ictaluridae	Freshwater	Resident
Channel catfish *Ictalurus punctatus*	Benthic	Ictaluridae	Freshwater	Resident
Gizzard shad *Dorosoma cepedianum*	Planktivore	Clupeidae	Freshwater	Resident
Golden shiner *Notemigonus crysoleucas*	Planktivore	Cyprinidae	Freshwater	Resident

SPECIES NAME	TROPHIC	FAMILY	SPAWN LOCATION	RESIDENCY
Harvestfish *Peprilus alepidotus*	Carnivore	Stromateidae	Marine	Non-resident
Hogchoker *Trinectes maculatis*	Benthic	S oleidae	Estuarine	Resident
Horse-eye jack *Caranx latus*	Carnivore	Carangidae	Marine	Non-resident
Inland silverside *Menidia beryllina*	Planktivore	Atherinidae	Estuarine	Resident
Inshore lizardfish *Synodus foetens*	Carnivore	Synodontidae	Marine	Non-resident
Mummichog *Fundulus heteroclitus*	Planktivore	Cyprinodontidae	Estuarine	Resident
Naked goby *Gobiosoma bosc*	Benthic	Gobiidae	Estuarine	Resident
Northern kingfish *Menticirrhus saxatilis*	Benthic	Sciaenidae	Marine	Non-resident
Northern pipefish *Syngnathus fuscus*	Planktiovre	Syngnathidae	Estuarine	Resident
Pigfish *Orthopristis chrysoptera*	Benthic	Haemulidae	Marine	Non-resident
Pumpkinseed *Lepomis gibbosus*	Planktivore	Centrarchidae	Freshwater	Resident
Rough silverside *Membras martinica*	Planktivore	Atherinidae	Estuarine	Resident
Sheepshead minnow *Cyprinodon variegatus*	Planktivore	Cyprinodontidae	Estuarine	Resident
Silver perch *Bairdiella chrysoura*	Benthic	Sciaenidae	Estuarine	Resident
Eastern silvery minnow *Hybognathus regius*	Planktivore	Cyprinidae	Freshwater	Resident
Skillet fish *Gobiesox strumosus*	Benthic	Gobiesocidae	Estuarine	Resident
Spanish mackerel *Scomberomorus maculatus*	Carnivore	Scombridae	Marine	Non-resident
Spot *Leiostomus xanthurus*	Benthic	Sciaenidae	Marine	Non-resident

SPECIES NAME	TROPHIC	FAMILY	SPAWN LOCATION	RESIDENCY
Spottail shiner *Notropis hudsonius*	Planktivore	Cyprinidae	Freshwater	Resident
Spotted sea trout *Cynoscion nebulosus*	Carnivore	Sciaenidae	Marine	Non-resident
Striped anchovy *Anchoa hepsetus*	Planktivore	Engraulidae	Marine	Non-resident
Striped bass *Morone saxatilis*	Carnivore	Moronidae	Freshwater Anadromous	Non-resident
Striped killifish *Fundulus majalis*	Planktivore	Cyprinodontidae	Estuarine	Resident
Summer flounder *Paralichthys dentatus*	Benthic	Bothidae	Marine	Non-resident
Tessellated darter *Etheostoma olmstedi*	Benthic	Percidae	Freshwater	Resident
Unidentified scianidae *Cynoscion sp.*	Carnivore	Sciaenidae	Marine	Non-resident
Weakfish *Cynoscion regalis*	Carnivore	Sciaenidae	Marine	Non-resident
White catfish Ameiurus catus	Benthic	Ictaluridae	Freshwater	Resident
White perch *Morone americana*	Carnivore	Moronidae	Freshwater Anadromous	Non-resident
Yellow perch *Perca flavescens*	Carnivore	Percidae	Freshwater Anadromous	Resident

Table 4.1. Survival and growth data for sheepshead minnow larvae after 8 day toxicity tests conducted from 9/28/99 to 10/6/99.

	Cumulative % Survival			Dry Weight Per Individual[a]	
Station	Survival	± S.E.	n (day 8)	Weight (mg)	± S.E.
Control	95.8	4.17	42	1.31	0.069
CH1	100	0.0	45	1.39	0.025
CH2	95.8	4.17	44	0.96*	0.134
CH3	100	0.0	46	1.12	0.090
CH4	79.2	9.46	34	1.26	0.071
CH5	93.8	4.00	45	0.84*	0.106
CH6	97.9	2.08	42	1.54	0.044
CH7	97.7	2.28	44	1.09	0.074
CH8	97.5	2.50	41	1.53	0.059
CH9	100	0.0	44	1.23	0.132
CH10	97.9	2.08	43	1.12	0.113
RP1	97.7	2.28	45	1.28	0.074
RP2	95.7	2.52	43	1.34	0.029
RP3	100	0.0	46	1.37	0.043
RP4	95.2	2.76	42	1.01	0.088
RP5	97.9	2.08	44	1.36	0.058
RP6	95.8	4.17	41	1.31	0.103
RP7	97.9	2.08	42	1.27	0.111
RP8	95.5	2.63	42	1.37	0.134
RP9	95.8	4.17	45	1.06	0.077
RP10	97.5	2.50	42	1.16	0.158

[a] Initial weight per individual (day 0) 0.22 mg.

* Indicates significant difference from control value ($P<0.05$).

Table 4.2. Percent normal shell development from 48 hour coot clam embryo/larval toxicity tests conducted from 9/28/99 to 10/6/99.

	Test #1		Test #2		Test #3		Combined Results Tests 1-3	
Station	Percent Normal	± S.E.	Percent Normal	± S.E.	Percent Normal	± S.E.	Percent Normal	± S.E.
Control	96.5	0.76	97.9	0.63	99.2	0.80	97.9	0.53
CH1	84.0*	4.83	96.9	1.40	96.5	0.97	92.5	2.58
CH2	79.3**	4.70	97.0	1.79	97.4	0.36	91.2	3.32
CH3	83.6*	1.10	96.6	0.88	96.9	1.10	92.4	2.25
CH4	95.0	1.72	98.5	0.78	97.5	0.96	97.0	0.80
CH5	89.8	2.87	97.7	0.67	98.4	0.55	95.3	1.63
CH6	95.4	0.73	97.5	0.47	97.9	0.75	96.9	0.50
CH7	93.7	1.92	98.4	0.78	98.5	0.12	96.9	0.98
CH8	96.5	0.60	99.2	0.10	98.7	0.15	98.1	0.45
CH9	95.3	1.56	98.6	0.95	99.0	0.46	97.6	0.79
CH10	84.7*	2.90	97.8	0.80	98.9	0.47	93.8	2.45
RP1	86.7*	1.01	98.4	0.29	98.8	0.91	94.6	2.03
RP2	88.8	1.95	95.7	0.79	99.1	0.28	94.6	1.63
RP3	92.2	3.45	99.1	0.47	99.1	0.21	96.8	1.53
RP4	91.7	2.20	95.3	1.79	98.8	0.17	95.2	1.31
RP5	82.5*	4.19	98.0	0.55	99.0	0.08	93.2	2.94
RP6	86.1*	3.24	98.5	0.47	97.0	0.58	93.9	2.18
RP7	89.1	1.82	96.3	1.02	96.8	0.85	94.0	1.41
RP8	83.7*	3.09	97.2	1.16	97.8	0.98	92.9	2.51
RP9	88.4	3.76	95.3	2.54	98.7	0.44	94.1	2.01
RP10	90.1	2.88	91.6*	1.20	95.9	1.99	92.5	1.38

* Indicates significant difference from control value (P<0.05).

** Indicates significant difference from control value (P<0.01).

Table 4.3. Inorganic contaminants data from the 20 stations sampled in the Chester and Rappahannock rivers during the fall of 1999 (9/28 - 10/06/99). Marine U.S. EPA chronic water quality criteria (WQC) are listed below each metal. Metals exceeding the criteria are underlined.

	Metal Concentration (WQC μg/L)								
Stations	As (-)	Cd (9.3)	Cr (50)	Cu (2.9)	Pb (8.5)	Hg (.025)	Ni (8.3)	Se (71)	Zn (86)
CH1	<0.25	<0.125	<1.00	1.63	<1.00	<0.50	2.550	<0.25	<10.0
CH2	0.566	<0.125	<1.00	1.36	<1.00	<0.25	<2.00	<0.25	<10.0
CH3	0.467	<0.125	<1.00	1.60	6.20	<0.25	<2.00	<0.25	<10.0
CH4	0.665	<0.125	<1.00	1.65	<1.00	<0.25	<2.00	<0.25	<10.0
CH5	0.517	<0.125	<1.00	1.98	<1.00	<0.25	<2.00	<0.25	<10.0
CH6	0.616	<0.125	<1.00	1.87	<1.00	<0.25	<2.00	<0.25	<10.0
CH7	0.418	<0.125	<1.00	3.62	3.07	<0.25	3.83	<0.25	<10.0
CH8	0.270	<0.125	<1.00	2.68	20.5	<0.25	<2.00	<0.25	<10.0
CH9	0.220	<0.125	<1.00	2.37	<1.00	<0.25	<2.00	<0.25	<10.0
CH10	<0.25	0.082	20.3	6.4	12.5	<0.25	<2.00	<0.25	<10.0
RP1	<0.25	0.347	1.01	1.16	<1.00	<0.25	<2.00	<0.25	<10.0
RP2	<0.25	<0.125	<1.00	1.68	<1.00	<0.25	<2.00	<0.25	<10.0
RP3	<0.25	0.424	2.97	3.61	18.5	<0.25	<2.00	<0.25	144
RP4	<0.25	<0.125	<1.00	<1.00	<1.00	<0.25	<2.00	<0.25	<10.0
RP5	0.122	0.243	4.75	<1.00	<1.00	<0.25	<2.00	<0.25	<10.0
RP6	<0.25	<0.125	<1.00	1.04	<1.00	<0.25	13.3	<0.25	<10.0
RP7	<0.25	<0.125	<1.00	<1.00	<1.00	<0.25	32.1	<0.25	<10.0
RP8	<0.25	0.128	<1.00	<1.00	<1.00	<0.25	<2.00	<0.25	<10.0
RP9	<0.25	<0.125	<1.00	<1.00	<1.00	<0.25	<2.00	<0.25	<10.0
RP10	<0.25	<0.125	<1.00	<1.00	<1.00	<0.25	<2.00	<0.25	<10.0

Table 4.4. Water quality parameters from field collections in the Chester and Rappahannock rivers in the fall of 1999.

Date	Station	Temp (C)	Salinity (ppt)	Conductivity (umhos/cm)	DO (mg/L)	pH
9/20/99	CH-1	21.5	8.5	14000	8.5	7.98
	CH-2	21.2	6.0	10000	8.1	7.73
	CH-3	21.7	3.3	5000	7.4	7.20
	CH-4	22.7	2.5	4500	5.4	6.69
	CH-5	21.6	2.5	4500	5.2	6.65
	CH-6	20.8	1.5	2600	4.5	6.45
	CH-7	20.3	0.5	300	4.4	6.30
	CH-8	19.6	0.0	130	4.4	6.23
	CH-9	19.3	0.0	125	5.2	6.19
	CH-10	18.9	0.0	110	6.1	6.16
9/22/99	RP-1	20.0	14.2	21500	8.4	7.93
	RP-2	20.1	13.0	20000	8.4	7.96
	RP-3	19.6	12.7	19000	8.7	7.86
	RP-4	19.6	12.0	19000	8.5	7.82
	RP-5	20.0	11.7	18000	8.8	8.02
	RP-6	18.2	9.5	14200	8.4	7.74
	RP-7	18.7	8.5	13000	8.1	7.73
	RP-8	19.9	7.0	10000	9.0	8.09
	RP-9	19.5	5.5	8000	8.1	7.53
	RP-10	19.5	4.0	6800	8.0	7.55
9/27/99	RP-1	21.4	13.5	21000	8.4	8.26
	RP-2	21.2	12.0	20000	8.2	8.16
	RP-3	21.4	13.5	21000	8.2	8.10
	RP-4	21.2	13.0	21000	8.4	8.10

Date	Station	Temp (C)	Salinity (ppt)	Conductivity (umhos/cm)	DO (mg/L)	pH
	RP-5	21.3	11.5	18000	8.7	8.18
	RP-6	21.0	11.0	18000	8.4	8.09
	RP-7	20.9	9.0	14000	8.3	8.00
	RP-8	21.5	8.0	12500	8.1	7.85
	RP-9	21.0	7.0	11000	8.2	7.84
	RP-10	21.2	5.5	9000	8.2	7.82
9/28/99	CH-1	20.2	10.4	17500	7.6	7.97
	CH-2	20.7	8.0	14000	7.6	7.80
	CH-3	20.6	9.0	15000	6.6	7.53
	CH-4	21.0	7.5	12000	5.0	6.99
	CH-5	21.1	6.7	10500	5.4	7.09
	CH-6	21.2	4.0	6500	5.2	6.97
	CH-7	21.1	3.0	4600	5.3	6.91
	CH-8	21.1	1.2	2500	5.2	6.77
	CH-9	21.1	0.6	1450	5.2	6.72
	CH-10	21.3	0.0	315	8.6	7.15
10/1/99	RP-1	20.0	14.0	21500	--	8.18
	RP-2	20.0	12.0	17500	--	8.18
	RP-3	20.6	14.0	21500	--	7.70
	RP-4	20.4	13.0	19500	--	8.18
	RP-5	19.9	11.0	16500	--	8.05
	RP-6	20.3	10.0	15000	--	8.05
	RP-7	20.3	8.2	13000	--	7.98
	RP-8	19.3	6.0	9500	--	7.81
	RP-9	20.2	4.5	7000	--	7.76

Date	Station	Temp (C)	Salinity (ppt)	Conductivity (umhos/cm)	DO (mg/L)	pH
	RP-10	20.0	3.5	5000	--	8.01
	CH-1	19.4	11.0	14000	7.4	8.04
	CH-2	20.1	9.6	14000	7.4	7.92
	CH-3	20.5	9.0	13500	7.0	7.74
	CH-4	20.3	5.5	8000	6.8	7.42
	CH-5	20.1	4.3	6500	6.0	7.39
	CH-6	20.6	2.7	4000	6.4	7.33
	CH-7	20.4	1.6	3500	6.0	7.23
	CH-8	20.3	1.0	1500	6.2	7.24
	CH-9	20.3	0.0	700	7.0	7.48
	CH-10	19.2	0.0	275	8.6	8.09
10/3/99	RP-1	20.6	10.0	20000	--	7.74
	RP-2	20.2	9.5	15000	--	7.87
	RP-3	20.4	10.5	15500	--	7.97
	RP-4	20.5	10.5	17000	--	7.80
	RP-5	20.3	8.0	12500	--	7.70
	RP-6	20.5	8.0	13000	--	7.85
	RP-7	20.6	6.0	9000	--	7.53
	RP-8	20.7	3.0	4700	--	7.87
	RP-9	20.9	2.0	2650	--	7.79
	RP-10	20.9	1.5	1900	--	7.87
10/4/99	CH-1	19.9	11.8	18000	8.4	8.26
	CH-2	20.6	9.7	15000	8.7	8.43
	CH-3	20.5	9.2	14000	8.2	7.62
	CH-4	20.8	6.7	10000	6.6	7.18

Date	Station	Temp (C)	Salinity (ppt)	Conductivity (umhos/cm)	DO (mg/L)	pH
	CH-5	20.8	5.7	9000	6.7	6.98
	CH-6	20.7	3.6	5050	6.2	6.98
	CH-7	20.8	2.7	4000	6.6	6.90
	CH-8	20.7	1.7	2000	7.0	6.87
	CH-9	20.6	1.0	1100	9.2	7.06
	CH-10	20.1	0.0	260	9.8	7.78

Table 4.5. Toxicity data (48h LC50s or EC50s) from 1999 reference toxicant tests conducted with cadmium chloride for the two test species. Previous values from years 1 thru 8 are reported.

			Previous 48h LC50 values (mg/L)							
Date	Species	LC50 (mg/L)	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8
11/3/99	Sheepshead minnow	11.0	0.51	1.54	1.18	0.71	1.03	2.30	1.34	10.4
10/26/99	Coot clam	.094[a]	-----	-----	.005[a]	.008[a]	.069[a]	.040[a]	.082[a]	.049[a]

[a] Value is an EC50 (percent normal shell development is the endpoint).

Table 4.6 Survival of the amphipod *Leptocheirus plumulosus* in sediment bioassays. The survivors were scored on day 20 (termination) of the bioassay. The reference site chosen for this amphipod was mostly silt and clay (Carters Creek). An asterisk marks site results significantly different from the test organism response to reference site sediment. The means and standard errors (SE) are based on sediment bioassays using amphipods (n = 20) exposed to five randomly located grab samples from each site.

SITE NAME	SITE	MEAN % SURVIVAL	SE
Rappahannock River, Virginia			
Lancaster Creek	RP-1	81	5.3
Wildwood Beach	RP-2	89	3.7
Farnham Creek	RP-3	77	6.0
Sharps	RP-4	61	8.0
Bowlers Wharf	RP-5	80	3.5
Neals Point	RP-6	76	3.7
Lowery Point	RP-7	62	8.0
Jones Point	RP-8	69	3.7
Mallorys Point	RP-9	66	4.3
Mulberry Point	RP-10	53*	6.0
Chester River, Maryland			
QACC	CH-1	73	11
Grays Inn Creek	CH-2	74	3.3
Cliffs Wharf	CH-3	81	4.0
Southeast Creek	CH-4	76	4.3
Duck Blind	CH-5	44*	9.9
Chestertown	CH-6	76	4.3
Peach Tree Point	CH-7	57*	9.4
Buckingham Wharf	CH-8	59*	6.2
Cow Pasture	CH-9	62	4.6
Crumpton	CH-10	61	9.5
Control and Reference Sites			
Ware River Mud	WRM	77	6.4
Carters Creek Mud	CCM	78	2.0

* Significantly different from the reference sediment ($p<0.05$).

Table 4.7 Survival of the polychaete worm *Streblospio benedicti* in sediment bioassays. The survivors were scored on day 20 (termination) of the bioassay. The reference site chosen for the polychaete worm was mostly silt and clay (Carters Creek). An asterisk marks site results significantly different from the test organism response to reference site sediment. The means and standard errors (SE) are based on sediment bioassays using *S. benedicti* (n = 12) exposed to five randomly located grab samples from each site.

SITE NAME	SITE	MEAN % SURVIVAL	SE
Rappahannock River, Virginia			
Lancaster Creek	RP-1	72*	2.0
Wildwood Beach	RP-2	90	3.1
Farnham Creek	RP-3	80	18.7
Sharps	RP-4	87	4.2
Bowlers Wharf	RP-5	82*	4.9
Neals Point	RP-6	75	20.2
Lowery Point	RP-7	88	3.3
Jones Point	RP-8	92	2.6
Mallorys Point	RP-9	70*	16.2
Mulberry Point	RP-10	72*	5.7
Chester River, Maryland			
QACC	CH-1	87	5.0
Grays Inn Creek	CH-2	87	7.7
Cliffs Wharf	CH-3	83	5.3
Southeast Creek	CH-4	75*	3.7
Duck Blind	CH-5	77*	7.6
Chestertown	CH-6	62*	10.1
Peach Tree Point	CH-7	80	8.6
Buckingham Wharf	CH-8	55*	8.2
Cow Pasture	CH-9	80*	2.0
Crumpton	CH-10	67*	16.9
Control and Reference Sites			
Ware River Mud	WRM	98	5.5
Carters Creek Mud	CCM	97	3.3

* Significantly different from the reference sediment ($p<0.05$).

Table 4.8 Growth of the amphipod *Leptocheirus plumulosus* in sediment bioassays. Length (mm) and weight (mg) increase over the initial size and standard error (SE) of 5 replicates of the mean of the surviving animals for each replicate. An asterisk marks site results significantly different from the test organism response to reference site sediment for sites not already determined to be significantly based on percent survival. "N1" is the number of survivors that remained intact after the 20 day breakdown of the test. "N2" is the number of locations within a site that had survivors in the sediment bioassay at the end of 20 days.

SITE NAME	SITE	N1	MEAN LENGTH	SE	N2	MEAN WEIGHT	SE
Rappahannock River, Virginia							
Lancaster Creek	RP-1	79	1.574	10.38	5	0.110	0.011
Wildwood Beach	RP-2	88	1.275	9.83	5	0.104	0.008
Farnham Creek	RP-3	76	1.379	11.17	5	0.098	0.019
Sharps	RP-4	60	1.031	11.51	5	0.088	0.021
Bowlers Wharf	RP-5	74	0.883*	10.52	5	0.076	0.008
Neals Point	RP-6	75	1.321	10.37	5	0.106	0.020
Lowery Point	RP-7	60	1.303	11.48	5	0.114	0.022
Jones Point	RP-8	65	0.967	11.18	5	0.076	0.013
Mallorys Point	RP-9	66	1.113	10.33	5	0.124	0.018
Mulberry Point	RP-10	52	0.377	10.43	5	0.066	0.013
Chester River, Maryland							
QACC	CH-1	73	1.502	9.08	5	0.148	0.017
Grays Inn Creek	CH-2	72	1.006	9.34	5	0.078	0.020
Cliffs Wharf	CH-3	79	0.670*	8.51	5	0.066	0.016
Southeast Creek	CH-4	76	1.305	10.71	5	0.148	0.017
Duck Blind	CH-5	43	1.673	16.75	5	0.132	0.028
Chestertown	CH-6	72	1.090	10.71	5	0.074	0.011
Peach Tree Point	CH-7	57	1.164	10.29	5	0.126	0.016
Buckingham Wharf	CH-8	58	0.835	9.71	5	0.072	0.020
Cow Pasture	CH-9	57	0.998	11.33	5	0.100	0.038
Crumpton	CH-10	59	0.790*	12.40	5	0.096	0.020
Control and Reference Sites							
Ware River Mud	WRM	76	1.630	10.56	5	0.128	0.025
Carters Creek Mud	CCM	78	1.404	9.31	5	0.102	0.015

* Significantly different from the reference sediment (p<0.05).

Table 4.9 Growth of the polychaete worm *Streblospio benedicti* in sediment bioassays. Length (mm) and weight (mg) increase over the initial size and standard error (SE) of 5 replicates of the mean of the surviving animals for each replicate. An asterisk marks site results significantly different from the test organism response to reference site sediment for sites not already determined to be significantly based on percent survival. "N1" is the number of survivors that remained intact after the 20 day breakdown of the test. "N2" is the number of locations within a site that had survivors in the sediment bioassay at the end of 20 days.

SITE NAME	SITE	N	MEAN LENGTH	SE	N	MEAN WEIGHT	SE
			Rappahannock River, Virginia				
Lancaster Creek	RP-1	43	1.849	22.20	5	0.028	0.007
Wildwood Beach	RP-2	48	2.397	17.51	5	0.036	0.007
Farnham Creek	RP-3	46	2.406	14.77	5	0.074	0.035
Sharps	RP-4	48	2.371	21.22	5	0.084	0.026
Bowlers Wharf	RP-5	46	2.093	18.62	5	0.032	0.020
Neals Point	RP-6	45	1.828	20.38	4	0.044	0.004
Lowery Point	RP-7	46	1.463	17.73	5	0.040	0.009
Jones Point	RP-8	50	1.849	19.29	5	0.036	0.008
Mallorys Point	RP-9	42	2.009	25.38	5	0.044	0.008
Mulberry Point	RP-10	38	1.540	17.59	5	0.032	0.009
			Chester River, Maryland				
QACC	CH-1	44	1.920	18.84	5	0.052	0.006
Grays Inn Creek	CH-2	49	1.107*	19.54	5	0.042	0.006
Cliffs Wharf	CH-3	48	0.555*	16.18	5	0.010	0.015
Southeast Creek	CH-4	40	1.774	21.25	5	0.016	0.016
Duck Blind	CH-5	39	0.947	22.55	5	0.028	0.014
Chestertown	CH-6	36	1.395	21.89	5	0.016	0.012
Peach Tree Point	CH-7	46	1.738	13.21	5	0.048	0.013
Buckingham Wharf	CH-8	33	1.357	22.52	5	0.038	0.007
Cow Pasture	CH-9	47	2.075	16.31	5	0.038	0.006
Crumpton	CH-10	34	1.849	28.09	4	0.044	0.009
			Control and Reference Sites				
Ware River Mud	WRM	49	1.708	18.51	5	0.038	0.010
Carters Creek Mud	CCM	54	2.265	17.84	5	0.040	0.006

* Significantly different from the reference sediment ($p<0.05$).

Table 4.10 Results of the analysis of composite sediment samples for polycyclic aromatic hydrocarbons (PAHs) for sites in the Rappahannock River, Virginia. The values reported are the method detection limits (as ppb dry weight) since no compounds were observed above the detection limits.

				Method Detection Limit (ng/g or ug/kg or ppb sediment dry weight)											
Compound	**CASRN**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRM**	**CCM**
Acenaphthene	83-32-9	16	500	260	280	250	260	300	150	240	190	300	290	200	200
Acenaphthylene	208-96-8	44	640	260	280	250	260	300	150	240	190	300	290	200	200
Anthracene	120-12-7	85.3	1100	260	280	250	260	300	150	240	190	300	290	200	200
Fluorene	86-73-7	19	540	260	280	250	260	300	150	240	190	300	290	200	200
Naphthalene	91-20-3	160	2100	260	280	250	260	300	150	240	190	300	290	200	200
Phenanthrene	85-01-8	240	1500	260	280	250	260	300	150	240	190	300	290	200	200
2-Methylnaphthalene*		70	670	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low Molecular Weight PAHs		552	3160	1560	1680	1500	1560	1800	900	1440	1140	1800	1740	1200	1200

Compound	**CASRN**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRM**	**CCM**
Benzo(a)anthracene	56-55-3	261	1600	260	280	250	260	300	150	240	190	300	290	200	200
Benzo(a)pyrene	50-32-8	430	1600	260	280	250	260	300	150	240	190	300	290	200	200
Benzo(b)fluoranthene	205-99-2			260	280	250	260	300	150	240	190	300	290	200	200
Benzo(g,h,i)perylene	191-24-2			260	280	250	260	300	150	240	190	300	290	200	200
Benzo(k)fluoranthene	207-08-9			260	280	250	260	300	150	240	190	300	290	200	200
Chrysene	218-01-9	384	2800	260	280	250	260	300	150	240	190	300	290	200	200
Dibenz(a,h)anthracene	53-70-3	63.4	260	260	280	250	260	300	150	240	190	300	290	200	200
Fluoranthene	206-44-0	600	5100	260	280	250	260	300	150	240	190	300	290	200	200
Indeno(1,2,3-cd)pyrene	193-39-5			260	280	250	260	300	150	240	190	300	290	200	200
Pyrene	129-00-0	665	2600	260	280	250	260	300	150	240	190	300	290	200	200
High Molecular Weight PAHs		1700	9600	1560	1680	1500	1560	1800	900	1440	1140	1800	1740	1200	1200
Total PAHs		4022	44792	3120	3360	3000	3120	3600	1800	2880	2280	3600	3480	2400	2400

Table 4.11 Results of the analysis of composite sediment samples for polycyclic aromatic hydrocarbons (PAHs) for sites in the Chester River, Maryland. The values reported are the method detection limits (as ppb dry weight) since no compounds were observed above the detection limits.

				Method Detection Limit (ng/g or ug/kg or ppb sediment dry weight)											
Compound	**CASRN**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRM**	**CCM**
Acenaphthene	83-32-9	16	500	130	240	210	300	290	290	300	290	200	190	200	200
Acenaphthylene	208-96-8	44	640	130	240	210	300	290	290	300	290	200	190	200	200
Anthracene	120-12-7	85.3	1100	130	240	210	300	290	290	300	290	200	190	200	200
Fluorene	86-73-7	19	540	130	240	210	300	290	290	300	290	200	190	200	200
Naphthalene	91-20-3	160	2100	130	240	210	300	290	290	300	290	200	190	200	200
Phenanthrene	85-01-8	240	1500	130	240	210	300	290	290	300	290	200	190	200	200
2-Methylnaphthalene*		70	670	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low Molecular Weight PAHs		552	3160	780	1440	1260	1800	1740	1740	1800	1740	1200	1140	1200	1200
Compound	**CASRN**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRM**	**CCM**
Benzo(a)anthracene	56-55-3	261	1600	130	240	210	300	290	290	300	290	200	190	200	200
Benzo(a)pyrene	50-32-8	430	1600	130	240	210	300	290	290	300	290	200	190	200	200
Benzo(b)fluoranthene	205-99-2			130	240	210	300	290	290	300	290	200	190	200	200
Benzo(g,h,i)perylene	191-24-2			130	240	210	300	290	290	300	290	200	190	200	200
Benzo(k)fluoranthene	207-08-9			130	240	210	300	290	290	300	290	200	190	200	200
Chrysene	218-01-9	384	2800	130	240	210	300	290	290	300	290	200	190	200	200
Dibenz(a,h)anthracene	53-70-3	63.4	260	130	240	210	300	290	290	300	290	200	190	200	200
Fluoranthene	206-44-0	600	5100	130	240	210	300	290	290	300	290	200	190	200	200
Indeno(1,2,3-cd)pyrene	193-39-5			130	240	210	300	290	290	300	290	200	190	200	200
Pyrene	129-00-0	665	2600	130	240	210	300	290	290	300	290	200	190	200	200
High Molecular Weight PAHs		1700	9600	780	1440	1260	1800	1740	1740	1800	1740	1200	1140	1200	1200
Total PAHs		4022	44792	1560	2880	2520	3600	3480	3480	3600	3480	2400	2280	2400	2400

Table 4.12 Results of the analysis of composite sediment samples for polycyclic aromatic hydrocarbons (PAHs) for sites in the Rappahannock River, Virginia. The values reported are the method detection limits reported as ug/g organic carbon normalized concentrations (note: no compounds were observed above the detection limits). Benchmark values (ERL and ERM) have been converted to the same units.

				Method Detection Limit (expressed as ug/g oc normalized concentrations)											
Compound	**CASRN**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRM**	**CCM**
Acenaphthene	83-32-9	2	50	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Acenaphthylene	208-96-8	4	64	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Anthracene	120-12-7	9	110	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Fluorene	86-73-7	2	54	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Naphthalene	91-20-3	16	210	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Phenanthrene	85-01-8	24	150	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Low Molecular Weight PAHs		57	638	85.0	75.1	75.9	90.5	89.9	109.5	66.9	79.4	73.7	84.0	24.5	47.4
Compound	**CASRN**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRM**	**CCM**
Benzo(a)anthracene	56-55-3	26	160	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Benzo(a)pyrene	50-32-8	43	160	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Benzo(b)fluoranthene*	205-99-2	32	188	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Benzo(g,h,i)perylene	191-24-2			14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Benzo(k)fluoranthene*	207-08-9	28	162	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Chrysene	218-01-9	38	280	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Dibenz(a,h)anthracene	53-70-3			14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Fluoranthene	206-44-0	60	510	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Indeno(1,2,3-cd)pyrene	193-39-5			14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
Pyrene	129-00-0	66	260	14.2	12.5	12.7	15.1	15.0	18.2	11.1	13.2	12.3	14.0	4.1	7.9
High Molecular Weight PAHs		293	1720	99.1	87.7	88.6	105.6	104.8	127.7	78.0	92.7	86.0	98.0	28.5	55.3
Total PAHs		350	2358	184.1	162.8	164.6	196.1	194.7	237.2	144.8	172.1	159.6	181.9	53.0	102.7

Table 4.13 Results of the analysis of composite sediment samples for polycyclic aromatic hydrocarbons (PAHs) for sites in the Chester River, Maryland. The values reported are the method detection limits reported as ug/g organic carbon normalized concentrations (note: no compounds were observed above the detection limits). Benchmark values (ERL and ERM) have been converted to the same units.

				Method Detection Limit (expressed as ug/g oc normalized concentrations)											
Compound	**CASRN**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRM**	**CCM**
Acenaphthene	83-32-9	2	50	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Acenaphthylene	208-96-8	4	64	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Anthracene	120-12-7	9	110	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Fluorene	86-73-7	2	54	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Naphthalene	91-20-3	16	210	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Phenanthrene	85-01-8	24	150	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Low Molecular Weight PAHs		57	638	122.4	71.9	79.4	59.0	64.7	51.6	59.4	49.2	22.6	32.3	24.5	47.4
Compound	**CASRN**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRM**	**CCM**
Benzo(a)anthracene	56-55-3	26	160	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Benzo(a)pyrene	50-32-8	43	160	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Benzo(b)fluoranthene*	205-99-2	32	188	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Benzo(g,h,i)perylene	191-24-2			20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Benzo(k)fluoranthene*	207-08-9	28	162	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Chrysene	218-01-9	38	280	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Dibenz(a,h)anthracene	53-70-3			20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Fluoranthene	206-44-0	60	510	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Indeno(1,2,3-cd)pyrene	193-39-5			20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
Pyrene	129-00-0	66	260	20.4	12.0	13.2	9.8	10.8	8.6	9.9	8.2	3.8	5.4	4.1	7.9
High Molecular Weight PAHs		293	1720	142.9	83.8	92.6	68.8	75.5	60.2	69.3	57.4	26.4	37.7	28.5	55.3
Total PAHs		350	2358	265.3	155.7	172.0	127.8	140.2	111.8	128.6	106.6	48.9	70.0	53.0	102.7

Table 4.14 An evaluation of the method detection limit as compared to the USEPA (draft) sediment quality criterion for the PAH acenaphthene. MDL is the weight adjusted method detection limit for each sediment sample, PAHb is the concentration of acenaphthene detected (all below the detection limit or BDL), the fraction of organic carbon (foc), and the Effective PAHb concentration is the minimum concentration that could be detected at the MDL expressed as ug/g oc. "RP" sites are from locations in the Rappahannock River, Virginia, "CH" sites are from the Chester River, Maryland, "WRM" is the control site in the Ware River, Virginia and "CCM" is the reference site in Carters Creek, Virginia.

SITE	MDL ug/kg dry wt	PAHb ug/kg dry wt	foc = % oc dry wt	Effective PAHb ug/g oc	ACENAPHTHENE USEPA SQC DRAFT 95% CL Lower	SQC	95% CL Upper
RP-1	260	BDL	1.836	14	110	240	500
RP-2	280	BDL	2.236	13	110	240	500
RP-3	250	BDL	1.975	13	110	240	500
RP-4	260	BDL	1.724	15	110	240	500
RP-5	300	BDL	2.003	15	110	240	500
RP-6	150	BDL	0.822	18	110	240	500
RP-7	240	BDL	2.154	11	110	240	500
RP-8	190	BDL	1.435	13	110	240	500
RP-9	300	BDL	2.443	12	110	240	500
RP-10	290	BDL	2.072	14	110	240	500
CH-1	130	BDL	0.637	20	110	240	500
CH-2	240	BDL	2.004	12	110	240	500
CH-3	210	BDL	1.587	13	110	240	500
CH-4	300	BDL	3.051	10	110	240	500
CH-5	290	BDL	2.689	11	110	240	500
CH-6	290	BDL	3.373	9	110	240	500
CH-7	300	BDL	3.032	10	110	240	500
CH-8	290	BDL	3.535	8	110	240	500
CH-9	200	BDL	5.313	4	110	240	500
CH-10	190	BDL	3.529	5	110	240	500
WRM	990	BDL	4.905	20	110	240	500
CCM	870	BDL	2.531	34	110	240	500

Table 4.15 An evaluation of the method detection limit as compared to the USEPA (draft) sediment quality criterion for the PAH fluoranthene. MDL is the weight adjusted method detection limit for each sediment sample, PAHb is the concentration of fluoranthene detected (all below the detection limit or BDL), the fraction of organic carbon (foc), and the Effective PAHb concentration is the minimum concentration that could be detected at the MDL expressed as ug/g oc. "RP" sites are from locations in the Rappahannock River, Virginia, "CH" sites are from the Chester River, Maryland, "WRM" is the control site in the Ware River, Virginia and "CCM" is the reference site in Carters Creek, Virginia.

SITE	MDL ug/kg dry wt	PAHb ug/kg dry wt	foc = % oc dry wt	Effective PAHb ug/g oc	FLUORANTHENE USEPA SQC DRAFT 95% CL Lower	SQC	95% CL Upper
RP-1	260	BDL	1.836	14	140	300	640
RP-2	280	BDL	2.236	13	140	300	640
RP-3	250	BDL	1.975	13	140	300	640
RP-4	260	BDL	1.724	15	140	300	640
RP-5	300	BDL	2.003	15	140	300	640
RP-6	150	BDL	0.822	18	140	300	640
RP-7	240	BDL	2.154	11	140	300	640
RP-8	190	BDL	1.435	13	140	300	640
RP-9	300	BDL	2.443	12	140	300	640
RP-10	290	BDL	2.072	14	140	300	640
CH-1	130	BDL	0.637	20	140	300	640
CH-2	240	BDL	2.004	12	140	300	640
CH-3	210	BDL	1.587	13	140	300	640
CH-4	300	BDL	3.051	10	140	300	640
CH-5	290	BDL	2.689	11	140	300	640
CH-6	290	BDL	3.373	9	140	300	640
CH-7	300	BDL	3.032	10	140	300	640
CH-8	290	BDL	3.535	8	140	300	640
CH-9	200	BDL	5.313	4	140	300	640
CH-10	190	BDL	3.529	5	140	300	640
WRM	200	BDL	4.905	4	140	300	640
CCM	200	BDL	2.531	8	140	300	640

Table 4.16 An evaluation of the method detection limit as compared to the USEPA (draft) sediment quality criterion for the PAH phenanthrene. MDL is the weight adjusted method detection limit for each sediment sample, PAHb is the concentration of phenanthrene detected (all below the detection limit or BDL), the fraction of organic carbon (foc), and the Effective PAHb concentration is the minimum concentration that could be detected at the MDL expressed as ug/g oc. "RP" sites are from locations in the Rappahannock River, Virginia, "CH" sites are from the Chester River, Maryland, "WRM" is the control site in the Ware River, Virginia and "CCM" is the reference site in Carters Creek, Virginia.

					PHENANTHRENE USEPA SQC DRAFT		
SITE	**MDL ug/kg dry wt**	**PAHb ug/kg dry wt**	**foc = % oc dry wt**	**Effective PAHb ug/g oc**	**95% CL Lower**	**SQC**	**95% CL Upper**
RP-1	260	BDL	1.836	14	110	240	510
RP-2	280	BDL	2.236	13	110	240	510
RP-3	250	BDL	1.975	13	110	240	510
RP-4	260	BDL	1.724	15	110	240	510
RP-5	300	BDL	2.003	15	110	240	510
RP-6	150	BDL	0.822	18	110	240	510
RP-7	240	BDL	2.154	11	110	240	510
RP-8	190	BDL	1.435	13	110	240	510
RP-9	300	BDL	2.443	12	110	240	510
RP-10	290	BDL	2.072	14	110	240	510
CH-1	130	BDL	0.637	20	110	240	510
CH-2	240	BDL	2.004	12	110	240	510
CH-3	210	BDL	1.587	13	110	240	510
CH-4	300	BDL	3.051	10	110	240	510
CH-5	290	BDL	2.689	11	110	240	510
CH-6	290	BDL	3.373	9	110	240	510
CH-7	300	BDL	3.032	10	110	240	510
CH-8	290	BDL	3.535	8	110	240	510
CH-9	200	BDL	5.313	4	110	240	510
CH-10	190	BDL	3.529	5	110	240	510
WRM	200	BDL	4.905	4	110	240	510
CCM	200	BDL	2.531	8	110	240	510

Table 4.17 Results of the analysis of composite sediment samples for pesticides for sites in the Rappahannock River, Virginia. The values reported are the method detection limits (as ppb dry weight) since no compounds were observed above the detection limits.

				Method Detection Limits as ug/kg or ng/g or ppb dry weight											
Compound	**CAS**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRM**	**CCM**
Aldrin	309-00-2			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
Dieldrin	60-57-1	0.02	8	6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
Endosulfan I	959-98-8			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
Endosulfan II	33213-65-9			6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
Endosulfan sulfate	1031-07-8			6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
Endrin	72-20-8			6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
Endrin aldehyde	7421-93-4			13	14	13	14	15	7.6	12	9.6	16	15	12	11
Endrin ketone	53494-70-5			13	14	13	14	15	7.6	12	9.6	16	15	12	11
Heptachlor	76-44-8			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
Heptachlor epoxide	1024-57-3			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
Methoxychlor	72-43-5			33	35	33	34	38	19	31	24	39	37	29	28
alpha-BHC	319-84-6			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
beta-BHC	319-85-7			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
delta-BHC	319-86-8			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
gamma-BHC (Lindane)	58-89-9			3.3	3.5	3.3	3.4	3.8	1.9	3.1	2.4	3.9	3.7	2.9	2.8
4,4'-DDD	72-54-8	2	20	6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
4,4'-DDE	72-55-9	2.2	27	6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
4,4'-DDT	50-29-3	1	7	6.6	7	6.6	6.8	7.6	3.8	6.2	4.8	7.8	7.4	5.8	5.6
DDT Total		1.58	46.1												

Table 4.18 Results of the analysis of composite sediment samples for pesticides for sites in the Chester River, Maryland. The values reported are the method detection limits (as ppb dry weight) since no compounds were observed above the detection limits.

				Method Detection Limits as ug/kg or ng/g or ppb dry weight											
Compound	**CAS**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRM**	**CCM**
Aldrin	309-00-2			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
Dieldrin	60-57-1	0.02	8	3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
Endosulfan I	959-98-8			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
Endosulfan II	33213-65-9			3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
Endosulfan sulfate	1031-07-8			3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
Endrin	72-20-8			3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
Endrin aldehyde	7421-93-4			6.6	12	10	15	14	14	15	14	10	9.6	12	11
Endrin ketone	53494-70-5			6.6	12	10	15	14	14	15	14	10	9.6	12	11
Heptachlor	76-44-8			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
Heptachlor epoxide	1024-57-3			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
Methoxychlor	72-43-5			17	29	26	38	36	36	38	36	25	24	29	28
alpha-BHC	319-84-6			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
beta-BHC	319-85-7			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
delta-BHC	319-86-8			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
gamma-BHC (Lindane)	58-89-9			1.7	2.9	2.6	3.8	3.6	3.6	3.8	3.6	2.5	2.4	2.9	2.8
4,4'-DDD	72-54-8	2	20	3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
4,4'-DDE	72-55-9	2.2	27	3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
4,4'-DDT	50-29-3	1	7	3.3	5.8	5.2	7.6	7.2	7.2	7.6	7.2	5	4.8	5.8	5.6
DDT Total		1.58	46.1												

Table 4.19 Results of the analysis of composite sediment samples for polychlorinated biphenyls (PCBs) as Aroclor (ppb dry weight) for sites in the Rappahannock River, Virginia and Chester River, Maryland. The values reported are the method detection limits (as ppb dry weight) since no compounds were observed above the detection limits.

Rappahannock River, Virginia

				Method Detection Limits as ug/kg or ng/g or ppb dry weight											
Compound	**CAS**	**ERL**	**ERM**	**RP-1**	**RP-2**	**RP-3**	**RP-4**	**RP-5**	**RP-6**	**RP-7**	**RP-8**	**RP-9**	**RP-10**	**WRMC**	**CM**
Aroclor 1016	12674-11-2			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1221	11104-28-2			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1232	11141-16-5			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1242	53469-21-9			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1248	12672-29-6			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1254	11097-69-1			66	70	66	68	76	38	62	48	78	74	58	56
Aroclor 1260	11096-82-5			66	70	66	68	76	38	62	48	78	74	58	56
PCBs		22.7	180												

Chester River, Maryland

				Method Detection Limits as ug/kg or ng/g or ppb dry weight											
Compound	**CAS**	**ERL**	**ERM**	**CH-1**	**CH-2**	**CH-3**	**CH-4**	**CH-5**	**CH-6**	**CH-7**	**CH-8**	**CH-9**	**CH-10**	**WRMC**	**CM**
Aroclor 1016	12674-11-2			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1221	11104-28-2			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1232	11141-16-5			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1242	53469-21-9			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1248	12672-29-6			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1254	11097-69-1			33	58	52	76	72	72	76	72	50	48	58	56
Aroclor 1260	11096-82-5			33	58	52	76	72	72	76	72	50	48	58	56
PCBs		22.7	180												

Table 4.20 Inorganic contaminants in sediment from 10 sites in the Rapphannock River, Virginia (RP) as well as control (Ware River) and reference (Carters Creek) sites. Single underlined values indicate when concentrations of specific metals exceed the Effects Range Low benchmarks defined by Long et al., 1995. There were no instances where the Effects Range Median benchmarks were exceeded.

		TOTAL METAL IN BULK SEDIMENT (ug/g dry weight)										
SITE NAME	**SITE**	**Al**	**As**	**Cd**	**Cr**	**Cu**	**Pb**	**Hg**	**Ni**	**Se**	**Sn**	**Zn**
Rappahannock River, Virginia												
Lancaster Creek	RP1	33762	6.16	0.505	46.5	24.1	27.9	0.060	22.2	0.537	0.677	119.0
Wildwood Beach	RP2	51670	7.58	0.604	53.6	27.7	27.9	0.071	26.3	0.665	0.606	124.0
Farnham Creek	RP3	52490	5.63	0.475	49.5	25.3	26.3	0.071	24.3	0.569	0.499	119.0
Sharps	RP4	41140	4.48	0.411	52.7	23.7	27.4	0.056	24.6	0.539	0.926	107.0
Bowlers Wharf	RP5	45990	4.27	0.566	46.5	25.5	26.7	0.064	24.1	0.576	0.815	113.0
Neals Point	RP6	10092	3.09	0.213	16.4	7.4	11.8	0.026	8.0	0.177	1.360	27.7
Lowery Point	RP7	47100	3.78	0.483	58.8	21.0	22.0	0.030	26.2	0.503	0.358	91.0
Jones Point	RP8	37992	2.45	0.426	34.0	18.6	20.6	0.035	17.4	0.366	0.679	79.7
Mallorys Point	RP9	43780	6.70	0.750	53.1	30.6	29.1	0.063	26.9	0.650	1.870	129.0
Mulberry Point	RP10	63101	4.39	0.523	52.2	33.3	35.8	0.066	29.5	0.752	0.953	118.0
Control (WRM) and Reference (CCM)Sites												
Carters Creek Mud	CCM	21820	6.30	0.204	49.1	18.6	27.2	0.055	18.8	0.509	0.284	132.0
Ware River Mud	WRM	25156	5.69	0.475	37.4	18.6	37.1	0.077	19.2	0.696	0.545	127.0
Sediment Quality Benchmarks (Long et al., 1995)												
Effects Range Low	ERL		8.2	1.2	81	34	46.7	0.15	20.9			150
Effects Range Median	ERM		70	9.6	370	270	218	0.71	51.6			410
Method Detection Limit	MDL	122	0.012	0.006	2.44	1.22	4.88	0.027	2.44	0.012	0.20	0.488

Table 4.21 Inorganic contaminants in sediment from 10 sites in the Chester River, Maryland (CH) as well as control (Ware River) and reference (Carters Creek) sites. Single underlined values indicate when concentrations of specific metals exceed the Effects Range Low benchmarks defined by Long et al., 1995. There were no instances where the Effects Range Median benchmarks were exceeded.

		TOTAL METAL IN BULK SEDIMENT (ug/g dry weight)										
SITE NAME	**SITE**	**Al**	**As**	**Cd**	**Cr**	**Cu**	**Pb**	**Hg**	**Ni**	**Se**	**Sn**	**Zn**
Chester River, Maryland												
QACC	CH1	5792	1.76	0.380	13.1	7.8	19.5	0.019	11.0	0.255	0.551	55.5
Grays Inn Creek	CH2	22181	7.95	0.908	38.1	24.4	42.3	0.060	33.9	0.864	0.472	159.0
Cliffs Wharf	CH3	17931	7.10	0.979	44.0	18.5	37.0	0.068	28.5	0.646	0.472	137.0
Southeast Creek	CH4	31670	6.10	0.987	53.8	23.3	48.6	0.068	32.5	0.787	0.755	151.0
Duck Blind	CH5	36752	7.65	0.941	64.6	24.3	49.5	0.090	34.4	0.778	1.050	174.0
Chestertown	CH6	32850	3.88	0.920	51.9	22.2	46.7	0.086	28.2	0.773	1.230	155.0
Peach Tree Point	CH7	31304	6.44	0.992	55.0	21.4	49.7	0.087	27.6	0.766	0.899	155.0
Buckingham Wharf	CH8	33272	4.70	1.034	58.3	20.9	46.2	0.080	28.1	0.719	0.434	144.0
Cow Pasture	CH9	15582	3.22	0.576	29.8	9.2	27.4	0.029	11.8	0.395	0.744	54.8
Crumpton	CH10	13160	2.34	0.007	31.8	7.2	25.8	0.027	12.7	0.221	0.514	59.3
Control (WRM) and Reference (CCM)Sites												
Carters Creek Mud	CCM	21820	6.30	0.204	49.1	18.6	27.2	0.055	18.8	0.509	0.284	132.0
Ware River Mud	WRM	25156	5.69	0.475	37.4	18.6	37.1	0.077	19.2	0.696	0.545	127.0
Sediment Quality Benchmarks (Long et al., 1995)												
Effects Range Low	ERL		8.2	1.2	81	34	46.7	0.15	20.9			150
Effects Range Median	ERM		70	9.6	370	270	218	0.71	51.6			410
Method Detection Limit	MDL	122	0.012	0.006	2.44	1.22	4.88	0.027	2.44	0.012	0.20	0.488

Table 4.22 Concentrations of inorganic contaminants in sediment expressed as toxic units (TU) relative to the Effects Range Low (ERL) benchmarks defined by Long et al., 1995. TU is defined as the observed concentration divided by the ERL value such that TU values less than “1" express a low probability that the specific metal is likely to be responsible for any observed toxicity. TU greater than “1" indicate when toxicity is occasionally seen when the metal concentration is greater than the ERL. If the toxicity of metals can be assumed to be additive in nature, when the total of all TU ERLs for a given site (SUM TU ERL) is less than one, toxicity is not expected to be due to the metals.

		TOTAL METAL IN BULK SEDIMENT (ug/g dry weight) as TU ERL								SUM
SITE NAME	**SITE**	**As**	**Cd**	**Cr**	**Cu**	**Pb**	**Hg**	**Ni**	**Zn**	**TU ERL**
Rappahannock River, Virginia										
Lancaster Creek	RP1	0.75	0.42	0.57	0.71	0.60	0.40	1.06	0.79	5.3
Wildwood Beach	RP2	0.92	0.50	0.66	0.81	0.60	0.47	1.26	0.83	6.1
Farnham Creek	RP3	0.69	0.40	0.61	0.74	0.56	0.47	1.16	0.79	5.4
Sharps	RP4	0.55	0.34	0.65	0.70	0.59	0.37	1.18	0.71	5.1
Bowlers Wharf	RP5	0.52	0.47	0.57	0.75	0.57	0.43	1.15	0.75	5.2
Neals Point	RP6	0.38	0.18	0.20	0.22	0.25	0.17	0.38	0.18	2.0
Lowery Point	RP7	0.46	0.40	0.73	0.62	0.47	0.20	1.25	0.61	4.7
Jones Point	RP8	0.30	0.36	0.42	0.55	0.44	0.23	0.83	0.53	3.7
Mallorys Point	RP9	0.82	0.63	0.66	0.90	0.62	0.42	1.29	0.86	6.2
Mulberry Point	RP10	0.54	0.44	0.64	0.98	0.77	0.44	1.41	0.79	6.0
Chester River, Maryland										
QACC	CH1	0.21	0.32	0.16	0.23	0.42	0.13	0.53	0.37	2.4
Grays Inn Creek	CH2	0.97	0.76	0.47	0.72	0.91	0.40	1.62	1.06	6.9
Cliffs Wharf	CH3	0.87	0.82	0.54	0.54	0.79	0.45	1.36	0.91	6.3
Southeast Creek	CH4	0.74	0.82	0.66	0.69	1.04	0.45	1.56	1.01	7.0
Duck Blind	CH5	0.93	0.78	0.80	0.71	1.06	0.60	1.65	1.16	7.7
Chestertown	CH6	0.47	0.77	0.64	0.65	1.00	0.57	1.35	1.03	6.5
Peach Tree Point	CH7	0.79	0.83	0.68	0.63	1.06	0.58	1.32	1.03	6.9
Buckingham Wharf	CH8	0.57	0.86	0.72	0.61	0.99	0.53	1.34	0.96	6.6
Cow Pasture	CH9	0.39	0.48	0.37	0.27	0.59	0.19	0.56	0.37	3.2
Crumpton	CH10	0.29	0.01	0.39	0.21	0.55	0.18	0.61	0.40	2.6
Control (WRM) and Reference (CCM)Sites										
Carters Creek Mud	CCM	0.77	0.17	0.61	0.55	0.58	0.37	0.90	0.88	4.8
Ware River Mud	WRM	0.69	0.40	0.46	0.55	0.79	0.51	0.92	0.85	5.2

Table 4.23 The concentration of simultaneously extracted metals obtained following the determination of acid volatile sulfides in bulk sediment samples from 10 sites in the Chester River, Maryland (CH) and 10 sites in the Rapphannock River, Virginia (RP) as well as control (Ware River) and reference (Carters Creek) sites. The results are expressed as umoles per gram dry weight sediment.

		SEM (uM/g dry weight)					
SITE NAME	**SITE**	**Cd**	**Cu**	**Pb**	**Hg**	**Ni**	**Zn**
				Rappahannock River, Virginia			
Lancaster Creek	RP1	0.000	0.109	0.083	0.000	0.000	1.094
Wildwood Beach	RP2	0.000	0.126	0.094	0.000	0.000	0.947
Farnham Creek	RP3	0.000	0.120	0.091	0.000	0.000	0.857
Sharps	RP4	0.000	0.130	0.079	0.000	0.000	1.062
Bowlers Wharf	RP5	0.000	0.139	0.099	0.000	0.000	0.885
Neals Point	RP6	0.000	0.041	0.015	0.000	0.000	0.311
Lowery Point	RP7	0.000	0.086	0.057	0.000	0.000	0.733
Jones Point	RP8	0.000	0.096	0.061	0.000	0.000	0.547
Mallorys Point	RP9	0.000	0.159	0.094	0.000	0.000	1.231
Mulberry Point	RP10	0.000	0.089	0.118	0.000	0.000	0.924
				Chester River, Maryland			
QACC	CH1	0.000	0.051	0.044	0.000	0.052	0.549
Grays Inn Creek	CH2	0.000	0.151	0.171	0.000	0.213	1.273
Cliffs Wharf	CH3	0.000	0.128	0.130	0.000	0.170	1.195
Southeast Creek	CH4	0.000	0.134	0.146	0.000	0.134	1.844
Duck Blind	CH5	0.000	0.088	0.156	0.000	0.126	1.584
Chestertown	CH6	0.000	0.093	0.157	0.000	0.118	1.478
Peach Tree Point	CH7	0.000	0.060	0.146	0.000	0.076	1.386
Buckingham Wharf	CH8	0.000	0.039	0.125	0.000	0.078	1.167
Cow Pasture	CH9	0.000	0.017	0.052	0.000	0.035	0.597
Crumpton	CH10	0.000	0.018	0.037	0.000	0.037	0.482
				Control (WRM) and Reference (CCM)Sites			
Carters Creek Mud	CCM	0.002	0.127	0.106	0.000	0.099	1.013
Ware River Mud	WRM	0.000	0.088	0.137	0.000	0.100	0.793

Table 4.24 Comparison of simultaneously extracted metals (SEM) to the acid volatile sulfides (AVS) available to potentially bind with the divalent metals such that they are no longer bioavailable. A ratio of less than “1" suggests that toxicity due to the divalent metals is unlikely.

RATIO OF SEM TO AVS

SITE NAME	SITE	SEM (uM/g)	AVS (uM/g)	SEM/AVS RATIO
Rappahannock River, Virginia				
Lancaster Creek	RP1	1.285	7.106	0.2
Wildwood Beach	RP2	1.167	5.439	0.2
Farnham Creek	RP3	1.068	7.908	0.1
Sharps	RP4	1.272	6.005	0.2
Bowlers Wharf	RP5	1.124	3.450	0.3
Neals Point	RP6	0.366	0.304	1.2
Lowery Point	RP7	0.876	6.068	0.1
Jones Point	RP8	0.704	0.496	1.4
Mallorys Point	RP9	1.485	1.556	1.0
Mulberry Point	RP10	1.131	15.205	0.1
Control (WRM) and Reference (CCM)Sites				
QACC	CH1	0.696	0.745	0.9
Grays Inn Creek	CH2	1.809	4.215	0.4
Cliffs Wharf	CH3	1.622	0.929	1.7
Southeast Creek	CH4	2.258	4.036	0.6
Duck Blind	CH5	1.954	18.864	0.1
Chestertown	CH6	1.847	7.621	0.2
Peach Tree Point	CH7	1.667	10.702	0.2
Buckingham Wharf	CH8	1.409	21.750	0.1
Cow Pasture	CH9	0.701	3.917	0.2
Crumpton	CH10	0.575	1.369	0.4
Control (WRM) and Reference (CCM)Sites				
Carters Creek	CC	1.347	1.392	1.0
Ware River	WR	1.117	3.956	0.3

Table 4.25 Results of the analysis of composite sediment samples for organic carbon (% total organic carbon or TOC) and pore water extracted from the same samples that was analyzed for nitrite (NO_2 mg/L), ammonia (NH_3) and sulfide (mg/L).

SITE NAME	SITE ID	SAMPLE DATE	% TOC	NO2 mg/L	NH3 mg/L	Sulfide mg/L
Rappahannock River, Virginia						
Lancaster Creek	RP-1	09/23/1999	1.836	0.0006	6.649	<.005
Wildwood Beach	RP-2	09/23/1999	2.236	0.0005	9.919	<.005
Farnham Creek	RP-3	09/23/1999	1.975	0.0009	8.481	<.005
Sharps	RP-4	09/23/1999	1.724	0.0006	5.313	<.005
Bowlers Wharf	RP-5	09/23/1999	2.003	0.0008	11.089	<.005
Neals Point	RP-6	09/23/1999	0.822	0.0006	7.260	0.005
Lowery Point	RP-7	09/23/1999	2.154	0.0004	5.637	<.005
Jones Point	RP-8	09/22/1999	1.435	0.0009	5.396	0.006
Mallorys Point	RP-9	09/22/1999	2.443	0.0018	11.894	0.005
Mulberry Point	RP-10	09/22/1999	2.072	0.0001	4.864	0.015
Chester River, Maryland						
QACC	CH-1	09/20/1999	0.637	0.0025	5.396	<.005
Grays Inn Creek	CH-2	09/20/1999	2.004	0.0010	4.758	<.005
Cliffs Wharf	CH-3	09/20/1999	1.587	0.0015	2.645	<.005
Southeast Creek	CH-4	09/20/1999	3.051	0.0009	4.994	<.005
Duck Blind	CH-5	09/20/1999	2.689	0.0006	5.336	<.005
Chestertown	CH-6	09/20/1999	3.373	0.0015	6.460	0.013
Peach Tree Point	CH-7	09/20/1999	3.032	0.0009	4.777	0.009
Buckingham Wharf	CH-8	09/20/1999	3.535	0.0011	5.683	0.008
Cow Pasture	CH-9	09/20/1999	5.313	0.0014	5.567	0.011
Crumpton	CH-10	09/20/1999	3.529	0.0010	10.603	0.008
Control (WRM) and Reference (CCM)Sites						
Ware River Mud	WRM	10/13/1999	4.905	0.0007	14.049	0.010
Carters Creek Mud	CCM	10/13/1999	2.531	0.0005	10.474	0.006

Table 4.26 Sediment particle size characteristics from the 20 sites. Results of particle size analysis for grab samples that were collected from 5 randomly located positions (REP 1-5) at each SITE in the Rappahannock River, Virginia (RP) and Chester River, Maryland (CH). The particle size description for percent (%) gravel is the total weight of particles greater than 2.0mm (usually shell hash and debris, rarely "gravel"). The percentage reported for sand, silt, and clay is the percent of the whole sediment sample *minus the gravel fraction*. The assignment of a TYPE to each replicate follows the physical/geological characterization described in Folk (1980) and is used to evaluate the similarity of sediment characteristics within a SITE.

SITE NAME	SITE	REP	% GRAVEL	% SAND	% SILT	% CLAY	TYPE
Lancaster Creek	RP-1	R1	1.0	15.2	29.1	55.8	sandy mud
Lancaster Creek	RP-1	R2	0.0	14.3	29.5	56.2	sandy mud
Lancaster Creek	RP-1	R3	0.2	11.8	32.5	55.7	sandy mud
Lancaster Creek	RP-1	R4	0.0	13.9	30.6	55.5	sandy mud
Lancaster Creek	RP-1	R5	0.0	13.0	29.8	57.2	sandy mud
Wildwood Beach	RP-2	R1	0.0	2.3	31.3	66.4	clay
Wildwood Beach	RP-2	R2	0.0	1.5	35.9	62.6	mud
Wildwood Beach	RP-2	R3	0.0	1.5	37.6	60.9	mud
Wildwood Beach	RP-2	R4	0.0	1.2	32.9	65.9	clay
Wildwood Beach	RP-2	R5	0.0	1.9	32.4	65.7	clay
Farnham Creek	RP-3	R1	0.0	4.5	33.0	62.5	mud
Farnham Creek	RP-3	R2	0.0	5.0	33.0	62.0	mud
Farnham Creek	RP-3	R3	0.0	3.8	34.3	61.9	mud
Farnham Creek	RP-3	R4	2.9	4.6	32.3	63.0	mud
Farnham Creek	RP-3	R5	0.0	4.6	31.5	63.9	mud
Sharps	RP-4	R1	0.3	8.6	32.7	58.7	mud
Sharps	RP-4	R2	0.0	8.5	31.8	59.7	mud
Sharps	RP-4	R3	0.0	8.7	32.1	59.2	mud
Sharps	RP-4	R4	0.7	9.0	31.2	59.8	mud
Sharps	RP-4	R5	0.0	8.3	32.8	58.9	mud
Bowlers Wharf	RP-5	R1	1.2	6.3	29.3	64.4	clay
Bowlers Wharf	RP-5	R2	0.0	7.0	29.4	63.6	clay
Bowlers Wharf	RP-5	R3	4.5	8.8	28.7	62.5	clay
Bowlers Wharf	RP-5	R4	2.0	7.2	29.9	62.9	clay
Bowlers Wharf	RP-5	R5	0.4	6.9	31.3	61.7	clay

Table 4.26 - continued

SITE NAME	SITE	REP	% GRAVEL	% SAND	% SILT	% CLAY	TYPE
Neals Point	RP-6	R1	0.0	68.7	12.5	18.8	muddy sand
Neals Point	RP-6	R2	0.0	15.6	31.4	53.0	sandy mud
Neals Point	RP-6	R3	0.0	81.8	6.4	11.8	muddy sand
Neals Point	RP-6	R4	0.0	83.7	5.6	10.7	clayey sand
Neals Point	RP-6	R5	0.0	89.6	3.7	6.7	sand
Lowery Point	RP-7	R1	0.0	3.8	41.6	54.6	mud
Lowery Point	RP-7	R2	0.0	1.7	29.1	69.2	clay
Lowery Point	RP-7	R3	0.3	4.1	35.9	60.0	mud
Lowery Point	RP-7	R4	0.0	6.5	30.5	63.0	clay
Lowery Point	RP-7	R5	0.0	7.1	34.8	58.1	mud
Jones Point	RP-8	R1	0.0	40.6	19.5	39.9	sandy clay
Jones Point	RP-8	R2	0.0	1.4	30.2	68.4	clay
Jones Point	RP-8	R3	1.4	34.2	20.4	45.4	sandy clay
Jones Point	RP-8	R4	0.5	46.2	17.8	36.0	sandy clay
Jones Point	RP-8	R5	0.0	45.7	17.0	37.3	sandy clay
Mallorys Point	RP-9	R1	0.0	0.3	33.6	66.1	clay
Mallorys Point	RP-9	R2	0.0	0.9	29.8	69.3	clay
Mallorys Point	RP-9	R3	0.0	0.1	33.8	66.1	clay
Mallorys Point	RP-9	R4	0.0	0.3	30.9	68.8	clay
Mallorys Point	RP-9	R5	0.0	0.4	31.5	68.1	clay
Mulberry Point	RP-10	R1	39.9	1.3	25.3	73.4	clay
Mulberry Point	RP-10	R2	0.0	1.5	25.8	72.7	clay
Mulberry Point	RP-10	R3	0.0	1.6	27.3	71.1	clay
Mulberry Point	RP-10	R4	0.2	1.4	26.2	72.4	clay
Mulberry Point	RP-10	R5	3.3	2.2	26.7	71.1	clay
QACC	CH-1	R1	0.0	62.9	27.7	9.4	silty sand
QACC	CH-1	R2	0.0	62.3	27.7	10.0	silty sand
QACC	CH-1	R3	0.2	51.8	34.1	14.1	silty sand
QACC	CH-1	R4	0.0	53.1	33.9	13.0	silty sand
QACC	CH-1	R5	0.7	63.2	26.2	10.6	silty sand
Grays Inn Creek	CH-2	R1	0.0	10.0	44.2	45.8	mud
Grays Inn Creek	CH-2	R2	0.0	13.3	44.1	42.6	sandy mud
Grays Inn Creek	CH-2	R3	1.5	12.9	42.1	45.0	sandy mud
Grays Inn Creek	CH-2	R4	0.0	12.1	43.6	44.3	sandy mud
Grays Inn Creek	CH-2	R5	0.0	13.3	44.1	42.6	sandy mud

Table 4.26 - continued

SITE NAME	SITE	REP	% GRAVEL	% SAND	% SILT	% CLAY	TYPE
Cliffs Wharf	CH-3	R1	13.4	29.3	28.3	42.4	sandy mud
Cliffs Wharf	CH-3	R2	0.0	33.6	28.4	38.0	sandy mud
Cliffs Wharf	CH-3	R3	29.7	29.9	29.7	40.4	sandy mud
Cliffs Wharf	CH-3	R4	9.8	21.5	27.8	50.7	sandy mud
Cliffs Wharf	CH-3	R5	3.0	28.1	30.2	41.6	sandy mud
Southeast Creek	CH-4	R1	0.4	6.1	26.7	67.2	clay
Southeast Creek	CH-4	R2	0.0	9.3	40.2	50.5	mud
Southeast Creek	CH-4	R3	0.0	3.9	26.5	69.6	clay
Southeast Creek	CH-4	R4	0.0	2.8	29.2	68.0	clay
Southeast Creek	CH-4	R5	0.0	4.6	26.7	68.7	clay
Duck Blind	CH-5	R1	0.0	1.6	26.8	71.6	clay
Duck Blind	CH-5	R2	0.0	4.0	29.0	67.0	clay
Duck Blind	CH-5	R3	4.1	5.5	28.7	65.8	clay
Duck Blind	CH-5	R4	0.0	4.2	29.0	66.8	clay
Duck Blind	CH-5	R5	0.0	4.0	43.5	52.5	mud
Chestertown	CH-6	R1	0.0	1.5	27.6	70.9	clay
Chestertown	CH-6	R2	2.7	1.8	35.5	62.7	mud
Chestertown	CH-6	R3	18.7	2.7	33.5	63.8	mud
Chestertown	CH-6	R4	0.3	1.9	32.3	65.8	mud
Chestertown	CH-6	R5	28.9	1.1	34.5	64.4	mud
Peach Tree Point	CH-7	R1	37.5	2.9	27.5	69.6	clay
Peach Tree Point	CH-7	R2	0.4	5.6	34.7	59.6	mud
Peach Tree Point	CH-7	R3	0.0	3.0	26.0	71.0	clay
Peach Tree Point	CH-7	R4	0.0	2.5	29.0	68.5	clay
Peach Tree Point	CH-7	R5	0.0	2.6	31.7	65.7	clay
Buckingham Wharf	CH-8	R1	0.0	3.5	32.7	63.8	clay
Buckingham Wharf	CH-8	R2	36.7	10.4	33.2	56.4	mud
Buckingham Wharf	CH-8	R3	51.4	6.2	32.1	61.7	mud
Buckingham Wharf	CH-8	R4	1.5	4.5	32.8	62.7	mud
Buckingham Wharf	CH-8	R5	55.2	11.6	32.1	56.3	mud

Table 4.26 - continued

SITE NAME	SITE	REP	% GRAVEL	% SAND	% SILT	% CLAY	TYPE
Cow Pasture	CH-9	R1	0.0	45.4	17.2	37.4	sandy clay
Cow Pasture	CH-9	R2	0.0	38.6	24.0	37.4	sandy mud
Cow Pasture	CH-9	R3	1.1	38.3	25.0	36.7	sandy mud
Cow Pasture	CH-9	R4	2.5	36.0	25.5	38.5	sandy mud
Cow Pasture	CH-9	R5	6.8	80.3	7.9	11.8	muddy sand
Crumpton	CH-10	R1	1.6	73.8	12.9	13.3	muddy sand
Crumpton	CH-10	R2	1.8	90.6	5.6	3.8	sand
Crumpton	CH-10	R3	0.0	4.3	44.5	51.2	mud
Crumpton	CH-10	R4	0.9	83.5	8.0	8.6	muddy sand
Crumpton	CH-10	R5	0.0	2.1	44.1	53.8	mud
Ware River Mud	WRM		0.0	4.0	40.9	55.1	mud
Carters Creek Mud	CCM		0.0	2.5	53.8	43.7	mud

Table 4.27 Sediment bioassay reference toxicant data. The reference toxicant bioassays were water-only exposures. Test duration was for 96 hours. The LC_{50} for the polychaete worm falls outside of the 95% confidence limits for the historical response of this species to $CdCl_2$.

Species	**Toxicant**	**LC_{50} (mg/L)**	**95% CL (mg/L)**	**Historic Mean LC_{50} (mg/L)**
Polychaete worm (*Streblospio benedicti*)	$CdCl_2$	3.23	1.34-2.55	1.892
Amphipod (*Leptocheirus plumulosus*)	$CdCl_2$	1.98	1.36-3.30	0.971

Table 4.28. Individual fish metric values for each station on the Chester River.

	Chester River Stations									
Metric	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total abundance with menhaden removed	785	698	893	705	508	558	530	473	267	500
Abundance estuarine individuals	415	371	289	330	302	167	92	64	30	26
Abundance anadromous individuals	239	296	565	359	192	223	371	316	159	321
Proportion of carnivores	0.22	0.38	0.62	0.50	0.38	0.42	0.64	0.67	0.60	0.65
Proportion of planktivores	0.77	0.62	0.36	0.50	0.62	0.56	0.34	0.31	0.33	0.26
Proportion of benthivores	0.01	0.00	0.02	0.00	0.00	0.03	0.02	0.02	0.07	0.09
Total number of species	17	16	15	12	10	15	17	13	13	23
Number of species captured in bottom trawl	1	2	2	0	2	3	6	4	4	8
Number of species comprising 90% of catch	7	5	4	4	4	5	5	4	7	9

Table 4.29. Individual fish metric values for each station on the Rappahanock River.

	Rappahannock River Stations									
Metric	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Total abundance with menhaden removed	422	382	150	1011	198	348	127	473	993	493
Abundance estuarine individuals	388	241	89	959	136	284	45	383	683	272
Abundance anadromous individuals	1	52	30	4	35	12	26	15	139	145
Proportion of carnivores	0.03	0.19	0.23	0.01	0.20	0.06	0.26	0.06	0.13	0.32
Proportion of planktivores	0.92	0.59	0.57	0.95	0.61	0.83	0.39	0.83	0.78	0.45
Proportion of benthivores	0.05	0.21	0.21	0.04	0.19	0.11	0.35	0.11	0.09	0.23
Total number of species	16	18	12	15	15	17	17	20	20	20
Number of species captured in bottom trawl	6	5	5	5	7	4	6	10	6	10
Number of species comprising 90% of catch	3	8	5	2	6	4	8	5	6	8

Table 4.30. Fish IBI scores for stations sampled in 1999.

River	Station	IBI Score
Chester	CH-1	31
	CH-2	29
	CH-3	27
	CH-4	21
	CH-5	21
	CH-6	25
	CH-7	35
	CH-8	23
	CH-9	27
	CH-10	33
Rappahannock	RP-1	31
	RP-2	33
	RP-3	31
	RP-4	33
	RP-5	33
	RP-6	33
	RP-7	33
	RP-8	31
	RP-9	35
	RP-10	35

Table 4.31. Trawl Index score and rating for each station sampled in the Chester and Rappahannock Rivers 1999.

River	Station	Trawl Index Score	Rating
Chester	CH-1	0.00	Poor
	CH-2	0.33	Poor
	CH-3	0.67	Poor
	CH-4	0.00	Poor
	CH-5	0.67	Poor
	CH-6	0.00	Poor
	CH-7	1.33	Good
	CH-8	1.00	Fair
	CH-9	1.00	Fair
	CH-10	2.00	Good
Rappahannock	RP-1	1.33	Good
	RP-2	1.33	Good
	RP-3	1.67	Good
	RP-4	1.33	Good
	RP-5	1.67	Good
	RP-6	1.00	Fair
	RP-7	1.00	Fair
	RP-8	2.00	Good
	RP-9	2.00	Good
	RP-10	1.33	Good

Table 4.32. Surface and bottom dissolved oxygen (DO) concentrations for study sites.

River	Station	Surface DO (mg/L)	Bottom DO (mg/L)
Chester	CH-1	6.73	5.18
	CH-2	7.19	5.11
	CH-3	6.82	5.84
	CH-4	6.58	5.36
	CH-5	5.88	5.44
	CH-6	6.03	5.84
	CH-7	6.23	6.16
	CH-8	5.69	5.62
	CH-9	5.04	5.02
	CH-10	6.37	6.26
Rappahannock	RP-1	6.65	7.09
	RP-2	7.56	6.71
	RP-3	7.37	6.92
	RP-4	7.23	6.47
	RP-5	7.95	7.45
	RP-6	7.83	6.83
	RP-7	7.27	7.33
	RP-8	7.28	6.96
	RP-9	7.29	7.24
	RP-10	7.38	7.10

Table 4.33. Secchi depth by station. The habitat requirement for one meter restoration of SAV in the Chesapeake Bay for mesohaline habitat is 0.97m; 0.75m is used for oligohaline and tidal fresh habitats.

River	Station	Mean Secchi Depth (m)
Chester	CH-1	0.89
	CH-2	0.96
	CH-3	0.98
	CH-4	0.90
	CH-5	1.12
	CH-6	0.94
	CH-7	0.64
	CH-8	0.61
	CH-9	0.44
	CH-10	0.34
Rappahannock	RP-1	0.82
	RP-2	0.74
	RP-3	0.84
	RP-4	0.71
	RP-5	0.78
	RP-6	0.83
	RP-7	0.71
	RP-8	0.66
	RP-9	0.60
	RP-10	0.53

Table 4.34. B-IBI values and benthic community condition for the Chester (CH) and Rappahannock River (RP) sites sampled in 1999.

Station	B-IBI Value	Benthic Community Condition
CH1	3.7	Meets Goal
CH2	2.7	Marginal
CH3	5.0	Meets Goal
CH4	3.8	Meets Goal
CH5	3.0	Meets Goal
CH6	3.4	Meets Goal
CH7	3.4	Meets Goal
CH8	3.0	Meets Goal
CH9	1.8	Severely Degraded
CH10	2.6	Degraded
RP1	2.7	Marginal
RP2	2.3	Degraded
RP3	3.0	Meets Goal
RP4	2.0	Severely Degraded
RP5	2.3	Degraded
RP6	1.7	Severely Degraded
RP7	3.0	Meets Goal
RP8	1.7	Severely Degraded
RP9	2.2	Degraded
RP10	3.0	Meets Goal

Table 5.1 Comparison of toxicity results from water column and sediment toxicity tests (multivariate analysis), along with fish and benthic IBI data for ambient stations tested in 1999. A yes (Y) means some significant level of toxicity or impaired biological response was reported. A no (N) means it was not.

Station	Water	Sediment	Fish[a]	Benthos
CH1	N	N	Y	N
CH2	N	N	Y	Y
CH3	N	Y	Y	N
CH4	Y	Y	Y	N
CH5	N	Y	Y	N
CH6	N	Y	Y	N
CH7	N	Y	N	N
CH8	N	Y	Y	N
CH9	N	Y	Y	Y
CH10	N	Y	N	Y
RP1	N	Y	N	Y
RP2	N	N	N	Y
RP3	N	N	N	N
RP4	N	Y	N	Y
RP5	N	Y	N	Y
RP6	N	N	N	Y
RP7	N	N	N	N
RP8	N	N	N	Y
RP9	N	Y	N	Y
RP10	N	Y	N	N

[a] If either fish seining or trawling suggested impairment “yes” was included.

Table 6.1 Summary of comparisons of water column RTRM indices for references and test sites presented in Figure 6.1-6.9. Comparisons for which confidence limits overlap are indicated by "O", those for which the confidence limits do not overlap are indicated by "X", while "--" indicates no data taken for the period.

STATION	1990	1991	1992-3	1994
BALTIMORE HARBOR BEAR CREEK (1)	-	-	-	X
CURTIS BAY (2)	-	-	-	O
MIDDLE BRANCH (3)	-	-	-	O
NORTHWEST HARBOR (4)	-	-	-	O
OUTER HARBOR (5)	-	-	-	O
PATAPSCO RIVER (6a, b)	O	O	-	-
SPARROWS POINT (7)	-	-	-	X
ELIZABETH RIVER (8)	X	-	-	-
MAGOTHY GIBSON ISLAND (9)	-	-	-	X
SOUTH FERRY (10)	-	-	-	O
MIDDLE RIVER FROG MORTAR (11)	-	-	X	-
WILSON POINT (12)	-	-	X	-
NANTICOKE RIVER BIVALVE (13)	-	-	O	-
SANDY HILL BEACH (14)	-	-	O	-
POTOMAC RIVER DAHLGREN (15a, b)	X	O	-	-
FREESTONE POINT (16)	O	-	-	-
INDIAN HEAD (17)	O	-	-	-
MORGANTOWN (18a, b)	X	O	-	-
POSSUM POINT (19)	O	-	-	-
SASSAFRAS BETTERTON (20)	-	-	-	X
TURNER CREEK (21)	-	-	-	X
SEVERN ANNAPOLIS (22)	-	-	-	X
JUNCTION ROUTE 50 (23)	-	-	-	X

WYE RIVER MANOR HOUSE (24a, b, c)	O	X	O	-
QUARTER CREEK (25)	-	-	O	

Table 6.1 (cont.)

STATION	1995	1996	1997	1998	1999
PAMUNKEY RIVER PAMUNKEY RIVER ABOVE WEST POINT (26)	O	-	-	-	-
PAMUNKEY RIVER BELOW WEST POINT (27)	X	-	-	-	-
YORK RIVER YORK RIVER ABOVE CHEATHAM ANNEX (28)	X	-	-	-	-
YORK RIVER BELOW CHEATHAM ANNEX (29)	O	-	-	-	-
JAMES RIVER JAMES RIVER ABOVE NEWPORT NEW SHIPBUILDING (30)	X	-	-	-	-
JAMES RIVER BELOW NEWPORT NEW SHIPBUILDING (31)	O	-	-	-	-
WILLOUGHBY BAY (32)	X	-	-	-	-
LYNNHAVEN RIVER (33)	O	-	-	-	-
CHESTER RIVER CH1 (60)	-	-	-	-	O
CHESTER RIVER CH2 (34a, b)	-	X	-	-	O
CHESTER RIVER CH3 (61)	-	-	-	-	O
CHESTER RIVER CH4 (35a, b)	-	X	-	-	X
CHESTER RIVER CH5 (36a, b)	-	X	-	-	O
CHESTER RIVER CH6 (37a, b)	-	X	-	-	O
CHESTER RIVER CH7 (62)	-	-	-	-	O
CHESTER RIVER CH8 (63)	-	-	-	-	O
CHESTER RIVER CH9 (64)	-	-	-	-	O
CHESTER RIVER CH10 (65)	-	-	-	-	O
PATUXENT RIVER BROOMES ISLAND (38)	-	X	-	-	-
PATUXENT RIVER JACK BAY (39)	-	O	-	-	-
PATUXENT RIVER BUZZARD ISLAND (40)	-	X	-	-	-
PATUXENT RIVER CHALK POINT (41)	-	X	-	-	-

SOUTH RIVER-1 (42)	-	-	X	-	-
SOUTH RIVER-2 (43)	-	-	X	-	-
SOUTH RIVER-3 (44)	-	-	X	-	-
SOUTH RIVER-4 (45)	-	-	X	-	-

Table 6.1 (cont.)

STATION	1995	1996	1997	1998	1999
SOUTH RIVER-1 (42)	-	-	X	-	-
SOUTH RIVER-2 (43)	-	-	X	-	-
SOUTH RIVER-3 (44)	-	-	X	-	-
SOUTH RIVER-4 (45)	-	-	X	-	-
ELIZABETH RIVER-EL (46)	-	-	X	-	-
ELIZABETH RIVER-EB (47)	-	-	X	-	-
ELIZABETH RIVER-WB (48)	-	-	X	-	-
ELIZABETH RIVER-SB (49)	-	-	X	-	-
ANACOSTIA RIVER - AR1 (50)	-	-	-	X	-
ANACOSTIA RIVER - AR2 (51)	-	-	-	O	-
ANACOSTIA RIVER - AR3 (52)	-	-	-	X	-
ANACOSTIA RIVER - AR4 (53)	-	-	-	X	-
ANACOSTIA RIVER - AR5 (54)	-	-	-	X	-
ANACOSTIA RIVER - AR6 (55)	-	-	-	O	-
CHOPTANK RIVER - CR59 (56)	-	-	-	X	-
CHOPTANK RIVER - CR61 (57)	-	-	-	X	-
CHOPTANK RIVER - CR62 (58)	-	-	-	X	-
CHOPTANK RIVER - CR63 (59)	-	-	-	X	-

RAPPAHANNOCK RIVER - RP1 (66)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP2 (67)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP3 (68)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP4 (69)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP5 (70)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP6 (71)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP7 (72)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP8 (73)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP9 (74)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP10 (75)	-	-	-	-	O

Table 6.2 Summary of comparisons of sediment RTRM indices for reference and test sites presented in Figures 6.11- 6.19. Comparisons for which confidence limits overlap are indicated by "O", those for which the confidence limits do not overlap are indicated by "X", while "--" indicates no data taken for the period.

STATION	1990	1991	1992-3	1994
BALTIMORE HARBOR BEAR CREEK (1)	-	-	-	X
CURTIS BAY (2)	-	-	-	X
MIDDLE BRANCH (3)	-	-	-	X
NORTHWEST HARBOR (4)	-	-	-	X
OUTER HARBOR (5)	-	-	-	X
PATAPSCO RIVER (6a, b)	X	X	-	-
SPARROWS POINT (7)	-	-	-	X
ELIZABETH RIVER (8)	X	-	-	-
MAGOTHY GIBSON ISLAND (9)	-	-	-	X
SOUTH FERRY (10)	-	-	-	X
MIDDLE RIVER FROG MORTAR (11)	-	-	O	-
WILSON POINT (12)	-	-	O	-
NANTICOKE RIVER BIVALVE (13)	-	-	O	-
SANDY HILL BEACH (14)	-	-	O	-
POTOMAC RIVER DAHLGREN (15a, b)	X	X	-	-
FREESTONE POINT (16)	X	-	-	-
INDIAN HEAD (17)	X	-	-	-
MORGANTOWN (18a, b)	X	X	-	-
POSSUM POINT (19)	X	-	-	-
SASSAFRAS BETTERTON (20)	-	-	-	O
TURNER CREEK (21)	-	-	-	O
SEVERN ANNAPOLIS (22)	-	-	-	X
JUNCTION ROUTE 50 (23)	-	-	-	O
WYE RIVER MANOR HOUSE (24a, b, c)	X	X	O	-
QUARTER CREEK (25)	-	-	O	-

Table 6.2 (cont.)

STATION	1995	1996	1997	1998	1999
PAMUNKEY RIVER PAMUNKEY RIVER ABOVE WEST POINT (26)	O	-	-	-	-
PAMUNKEY RIVER BELOW WEST POINT (27)	O	-	-	-	-
YORK RIVER YORK RIVER ABOVE CHEATHAM ANNEX (28)	O	-	-	-	-
YORK RIVER BELOW CHEATHAM ANNEX (29)	O	-	-	-	-
JAMES RIVER JAMES RIVER ABOVE NEWPORT NEW SHIPBUILDING (30)	O	-	-	-	-
JAMES RIVER BELOW NEWPORT NEW SHIPBUILDING (31)	X	-	-	-	-
WILLOUGHBY BAY (32)	X	-	-	-	-
LYNNHAVEN RIVER (33)	O	-	-	-	-
CHESTER RIVER CH1 (60)	-	-	-	-	O
CHESTER RIVER CH2 (34a, b)	-	X	-	-	O
CHESTER RIVER CH3 (61)	-	-	-	-	X
CHESTER RIVER CH4 (35a, b)	-	X	-	-	X
CHESTER RIVER CH5 (36a, b)	-	X	-	-	X
CHESTER RIVER CH6 (37a, b)	-	X	-	-	X
CHESTER RIVER CH7 (62)	-	-	-	-	X
CHESTER RIVER CH8 (63)	-	-	-	-	X
CHESTER RIVER CH9 (64)	-	-	-	-	X
CHESTER RIVER CH10 (65)	-	-	-	-	X
PATUXENT RIVER BROOMES ISLAND (38)	-	O	-	-	-
PATUXENT RIVER JACK BAY (39)	-	O	-	-	-
PATUXENT RIVER BUZZARD ISLAND (40)	-	X	-	-	-
PATUXENT RIVER CHALK POINT (41)	-	O	-	-	-

SOUTH RIVER-1(42)	-	-	X	-	-
SOUTH RIVER-2 (43)	-	-	X	-	-
SOUTH RIVER-3 (44)	-	-	O	-	-
SOUTH RIVER-4 (45)	-	-	O	-	-

Table 6.2 (cont.)

STATION	1995	1996	1997	1998	1999
ELIZABETH RIVER-EL (46)	-	-	X	-	-
ELIZABETH RIVER-EB (47)	-	-	X	-	-
ELIZABETH RIVER-WB (48)	-	-	X	-	-
ELIZABETH RIVER-SB (49)	-	-	X	-	--
ANACOSTIA RIVER - AR1 (50)	-	-	X	-	-
ANACOSTIA RIVER - AR2 (51)	-	-	X	-	-
ANACOSTIA RIVER - AR3 (52)	-	-	X	-	-
ANACOSTIA RIVER - AR4 (53)	-	-	X	-	-
ANACOSTIA RIVER - AR5 (54)	-	-	X	-	-
ANACOSTIA RIVER - AR6 (55)	-	-	O	-	-
CHOPTANK RIVER - CR59 (56)	-	-	O	-	-
CHOPTANK RIVER - CR61 (57)	-	-	O	-	-
CHOPTANK RIVER - CR62 (58)	-	-	O	-	-
CHOPTANK RIVER - CR63 (59)	-	-	O	-	-
RAPPAHANNOCK RIVER - RP1 (66)	-	-	-	-	X
RAPPAHANNOCK RIVER - RP2 (67)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP3 (68)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP4 (69)	-	-	-	-	X
RAPPAHANNOCK RIVER - RP5 (70)	-	-	-	-	X
RAPPAHANNOCK RIVER - RP6 (71)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP7 (72)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP8 (73)	-	-	-	-	O
RAPPAHANNOCK RIVER - RP9 (74)	-	-	-	-	X
RAPPAHANNOCK RIVER - RP10 (75)	-	-	-	-	X

Figure 3.1. Rappahannock River sample stations from the 1999 Ambient Toxicity Study.

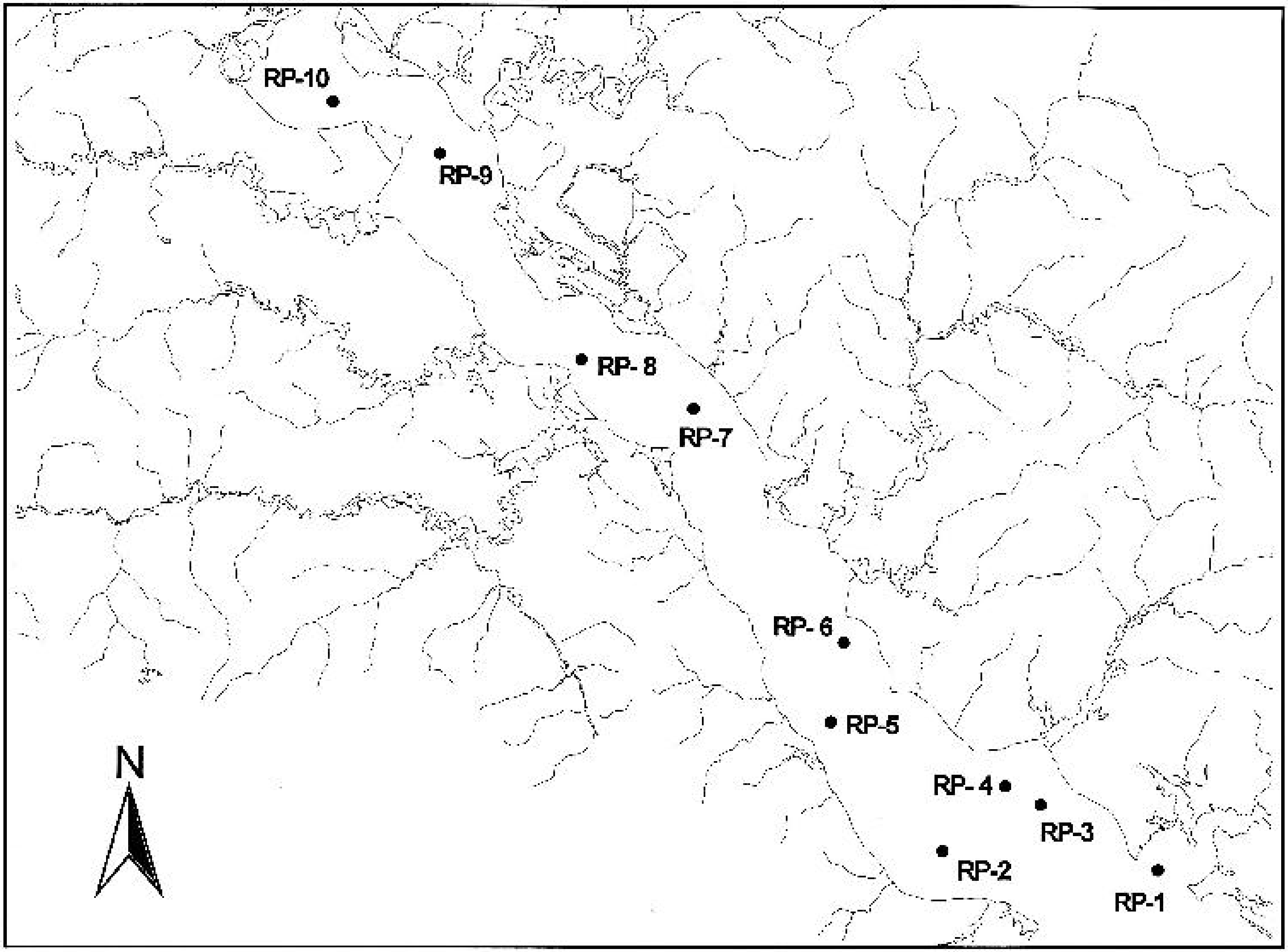

Figure 3.2. Chester River sample stations from the 1999 Ambient Toxicity Study.

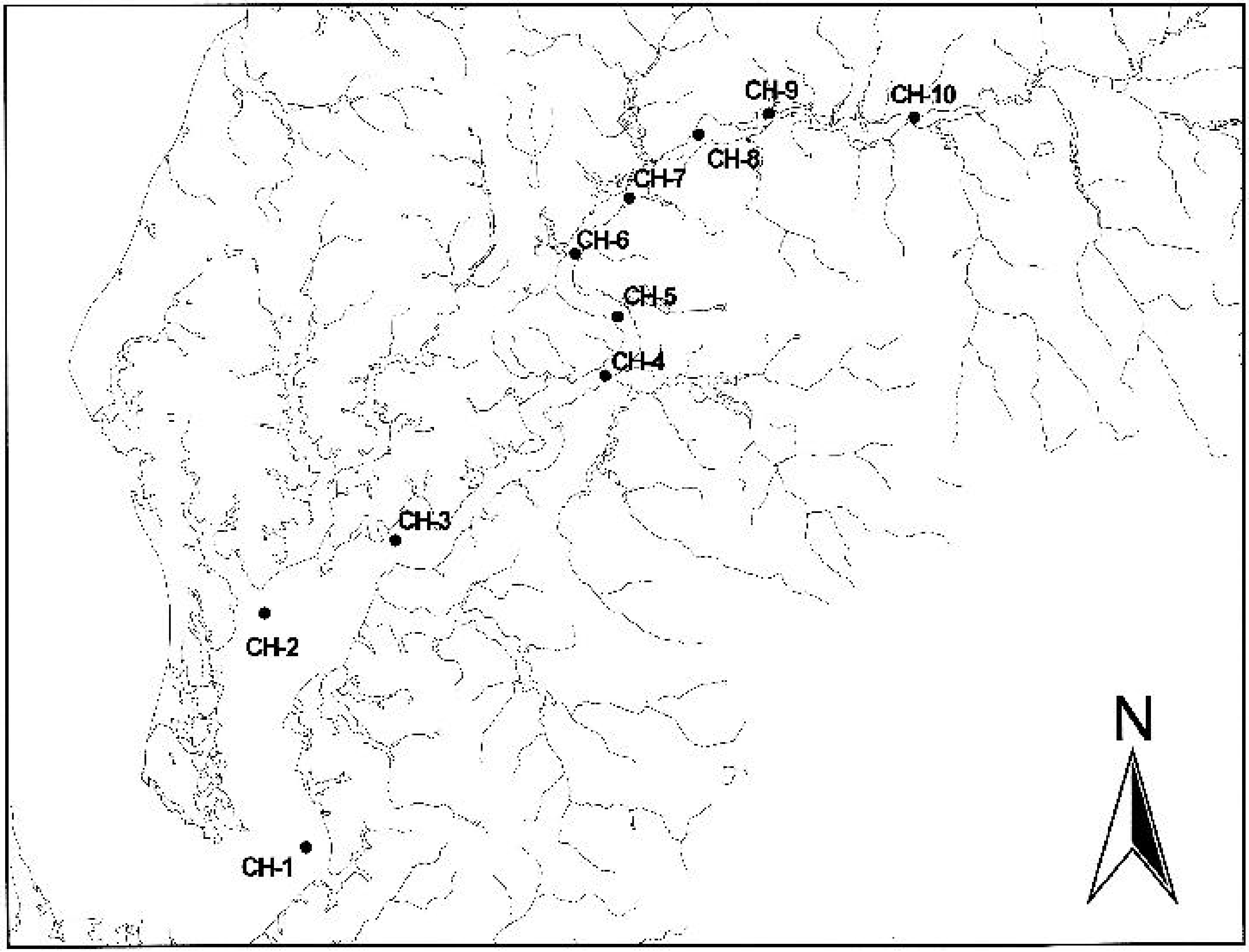

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Figure 6.1 Toxicity Index results for the 1990 water column data. (See Section 3.4 for a detailed description of presentation).

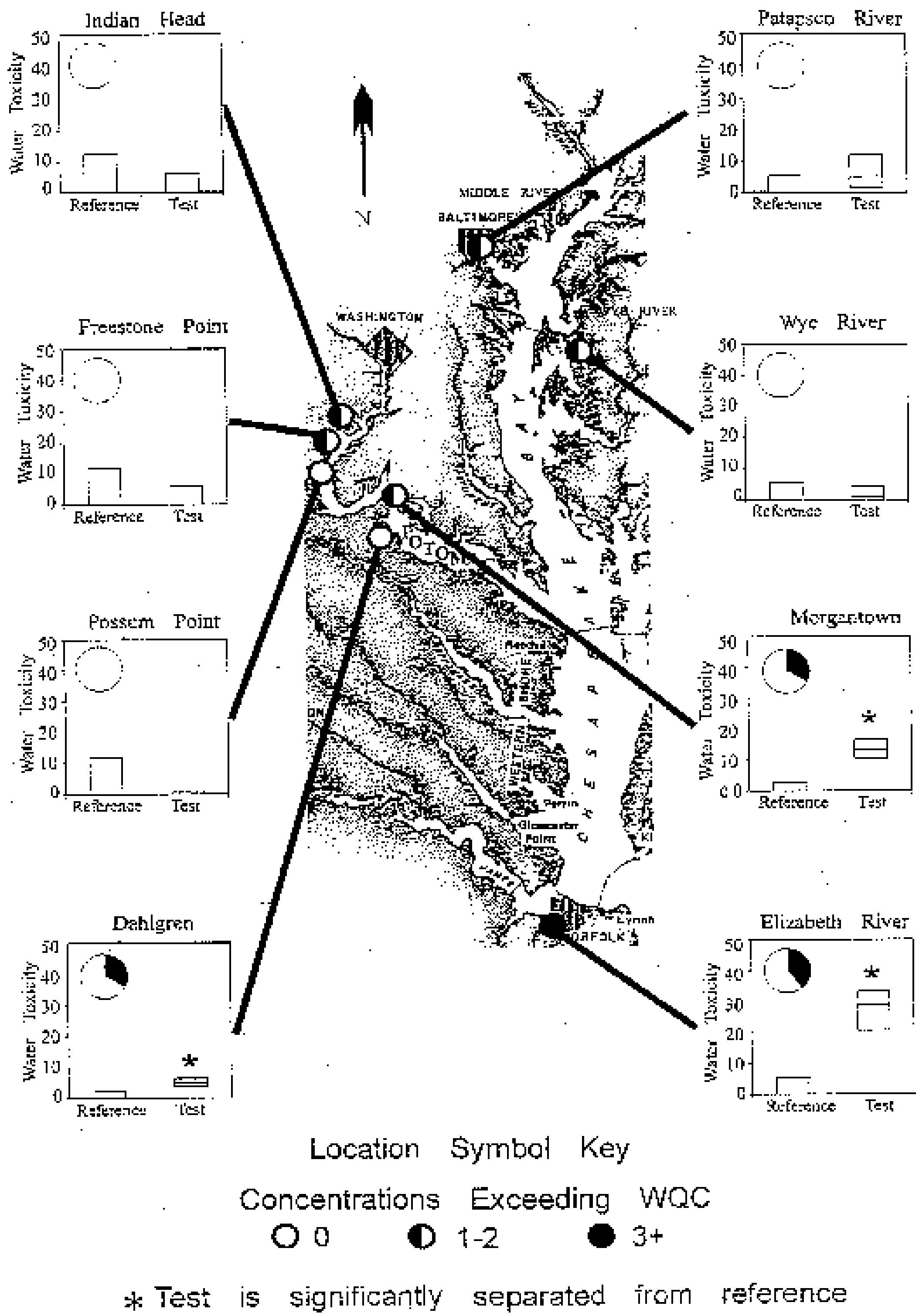


Figure 6.2 Toxicity Index results for the 1991 water column data. (See Section 3.4 for a detailed description of presentation).

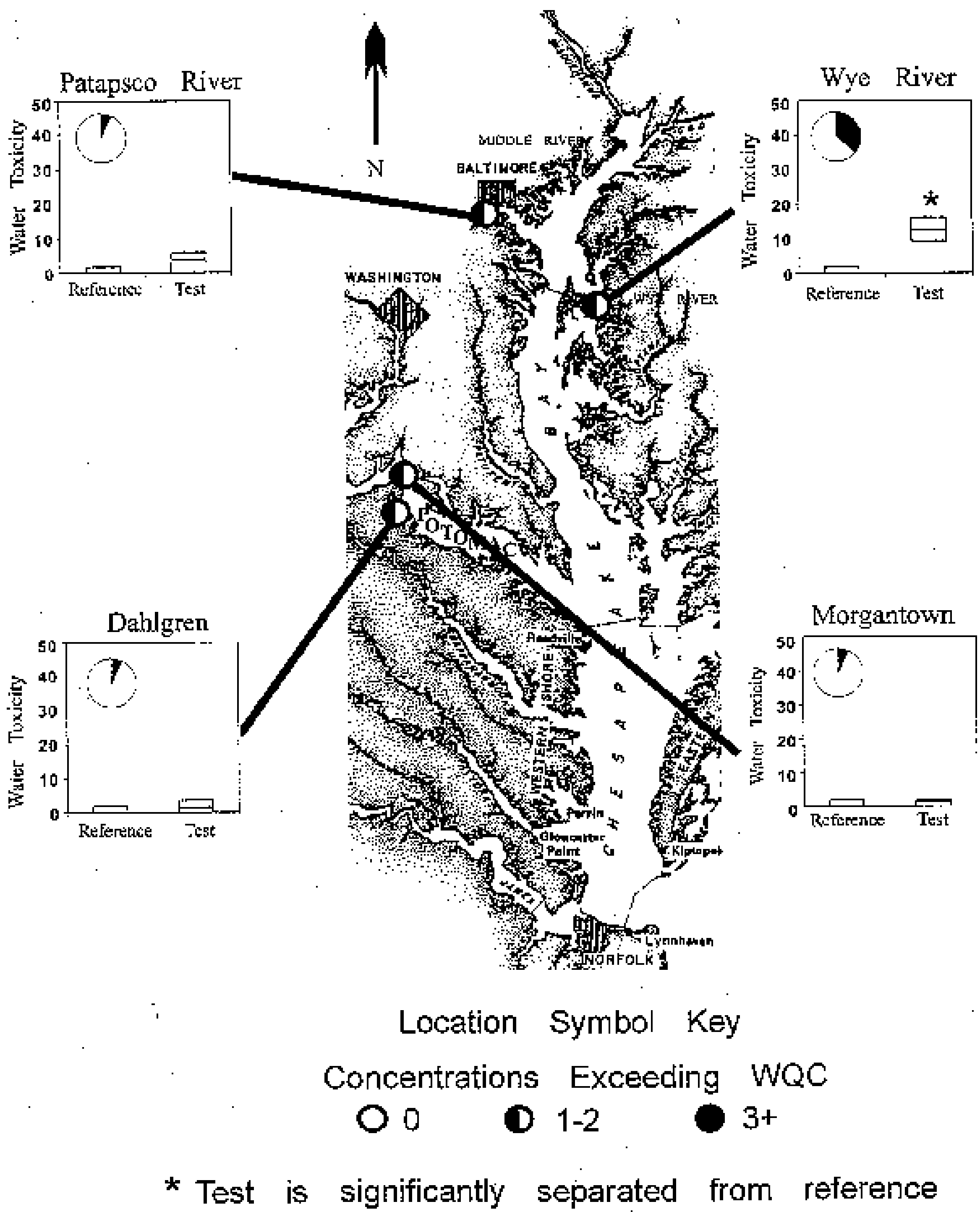
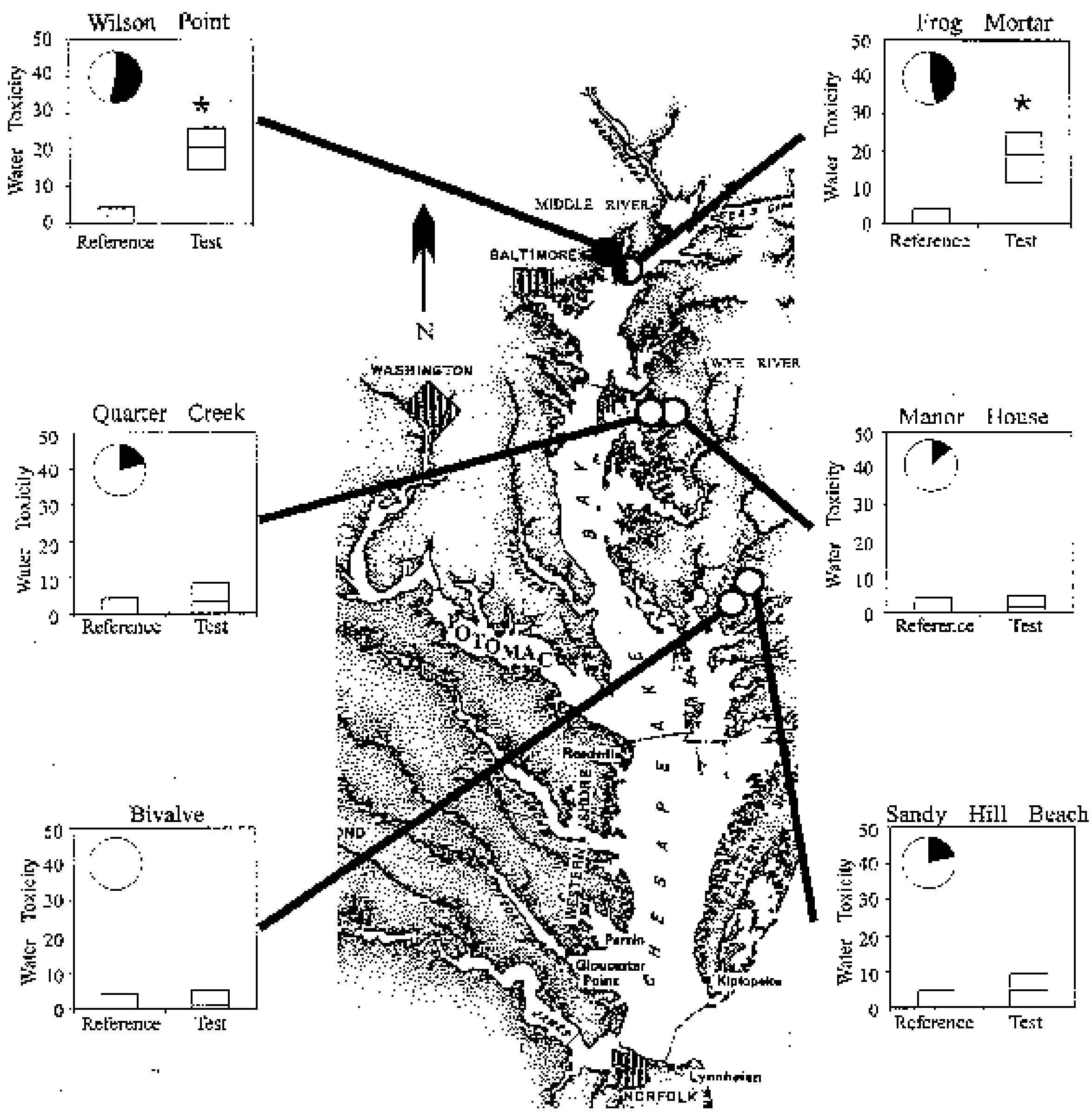


Figure 6.3 Toxicity Index results for the 1992-3 water column data.(See Section 3.4 for a detailed description of presentation).



Location Symbol Key

Concentrations Exceeding WQC

O 0 ◐ 1-2 ● 3+

* Test is significantly separated from reference

Figure 6.4a Toxicity Index results for the 1994 water column data for the Severn, Magothy and Sassafras Rivers. (See Section 3.4 for a detailed description of presentation).

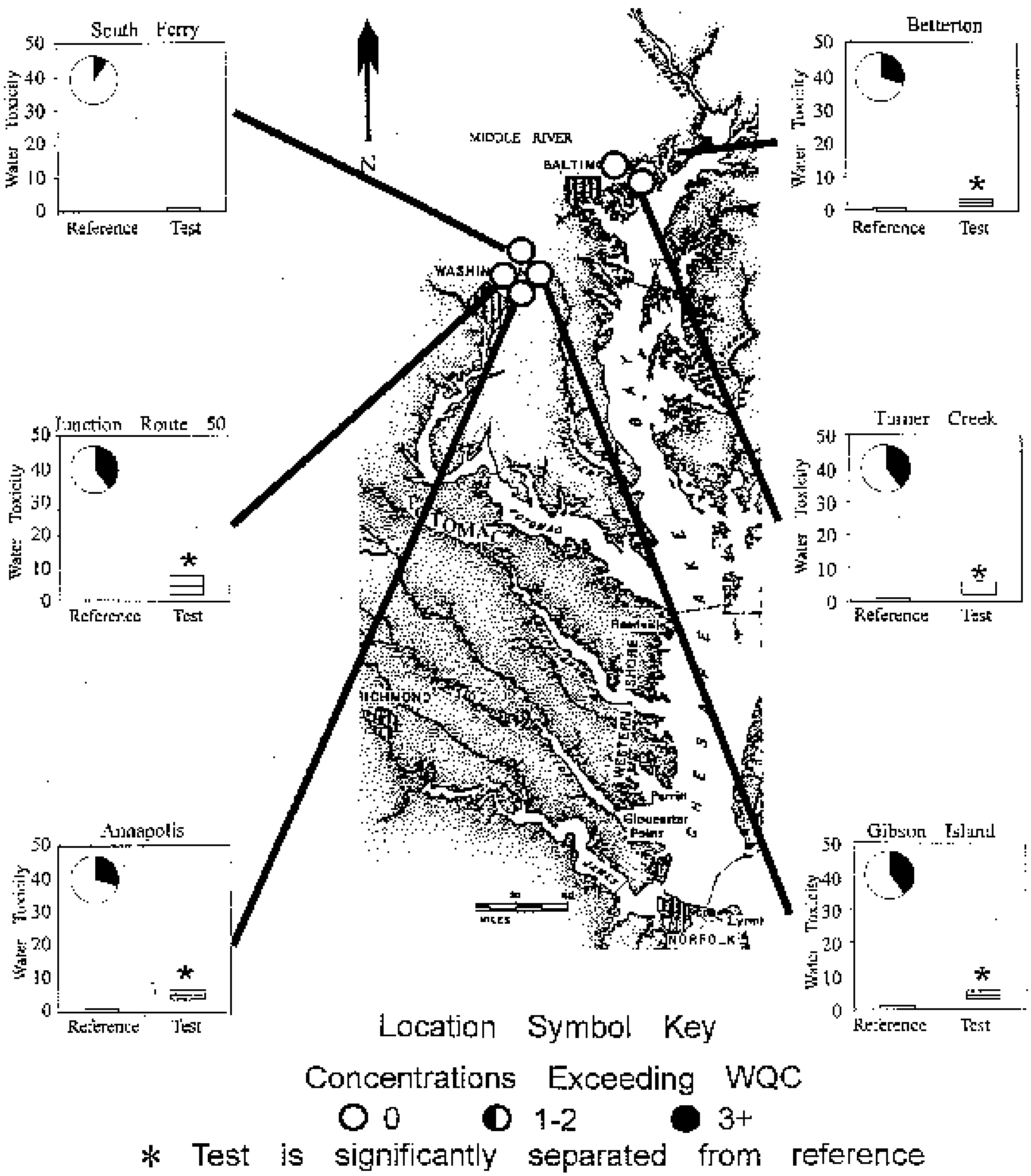


Figure 6.4b Toxicity Index results for the 1994 water column data for Baltimore Harbor sites. (See Section 3.4 for a detailed description of presentation).

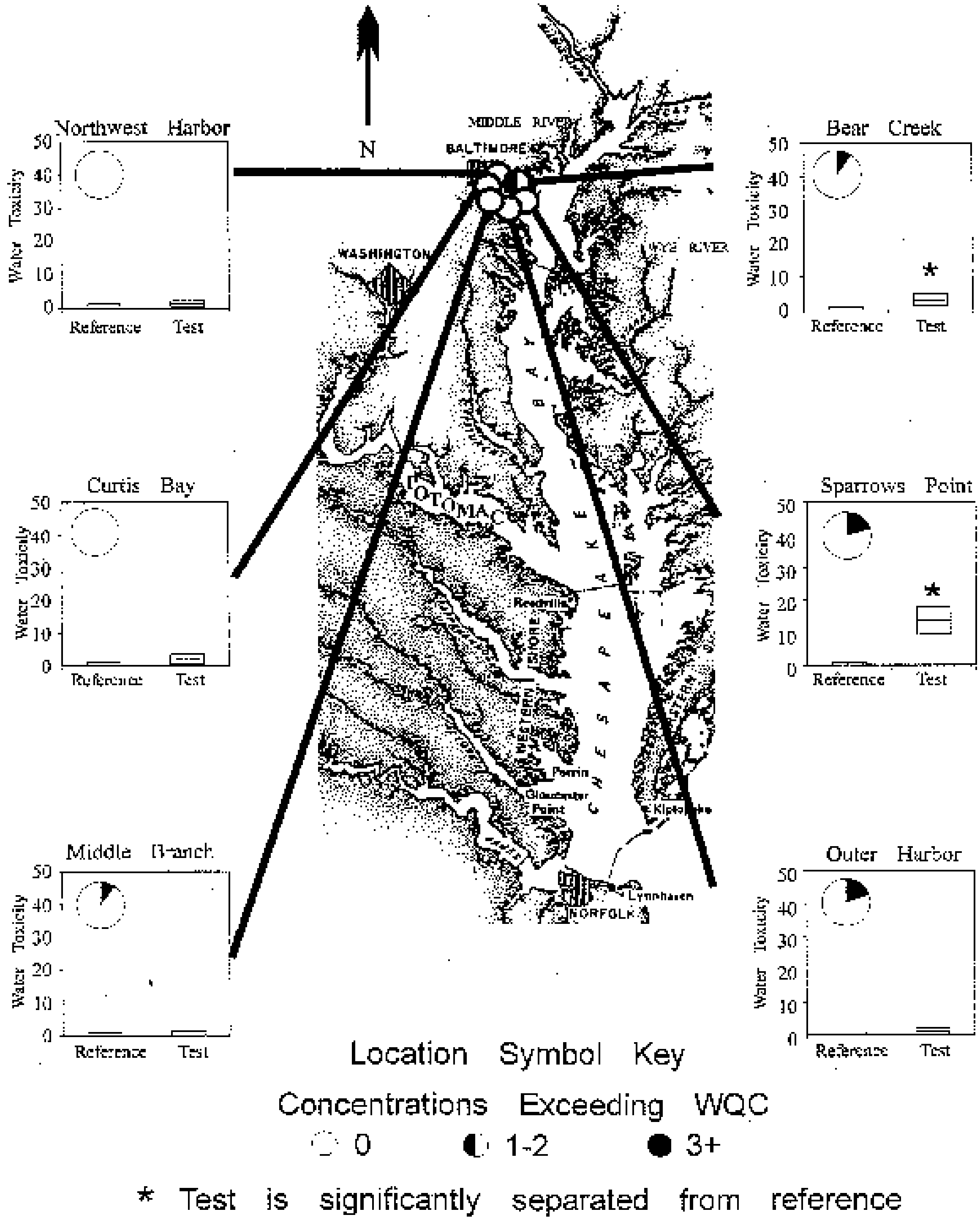


Figure 6.5 Toxicity Index results for the 1995 water column data.(See Section 3.4 for a detailed description of presentation).

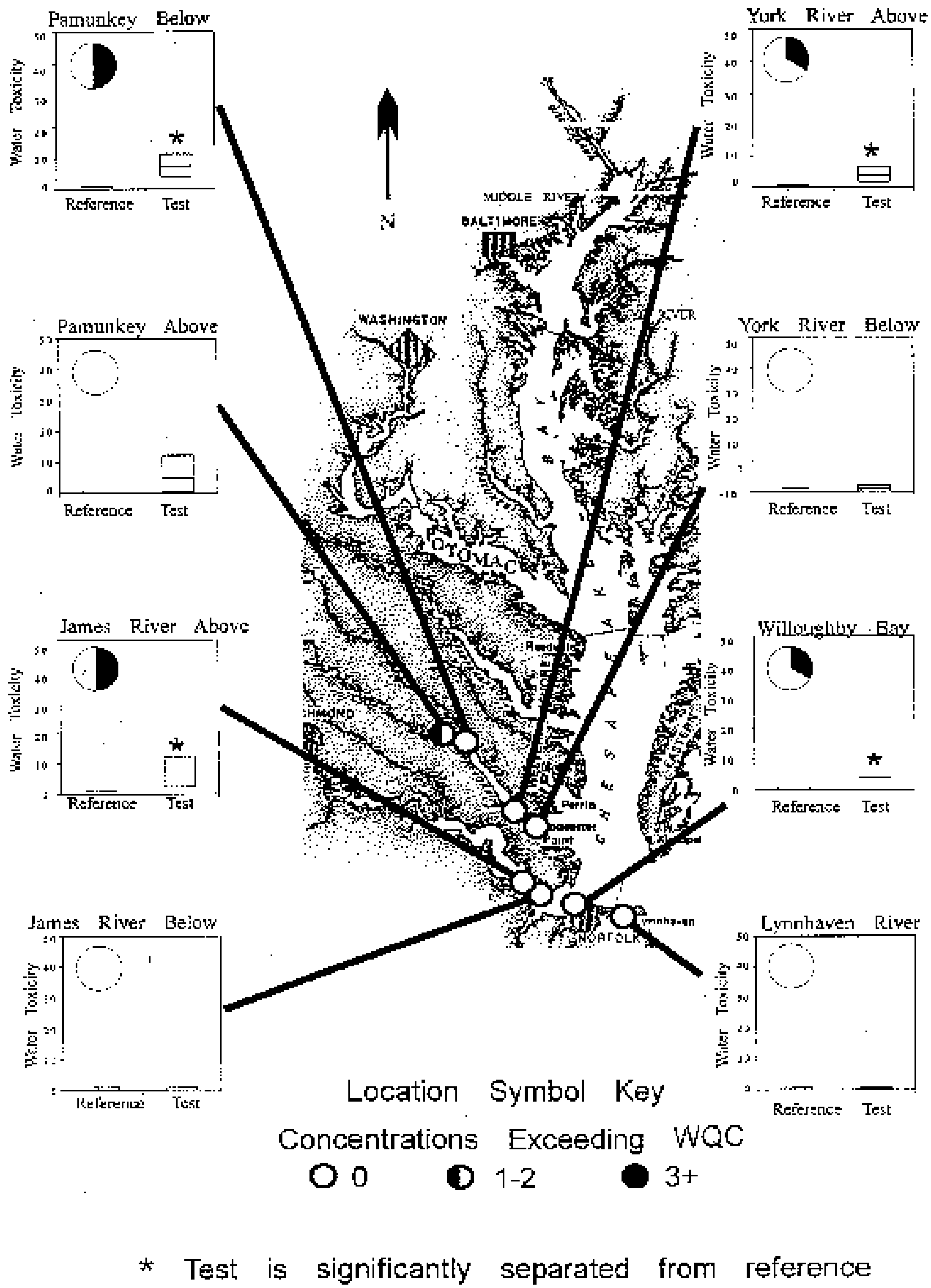
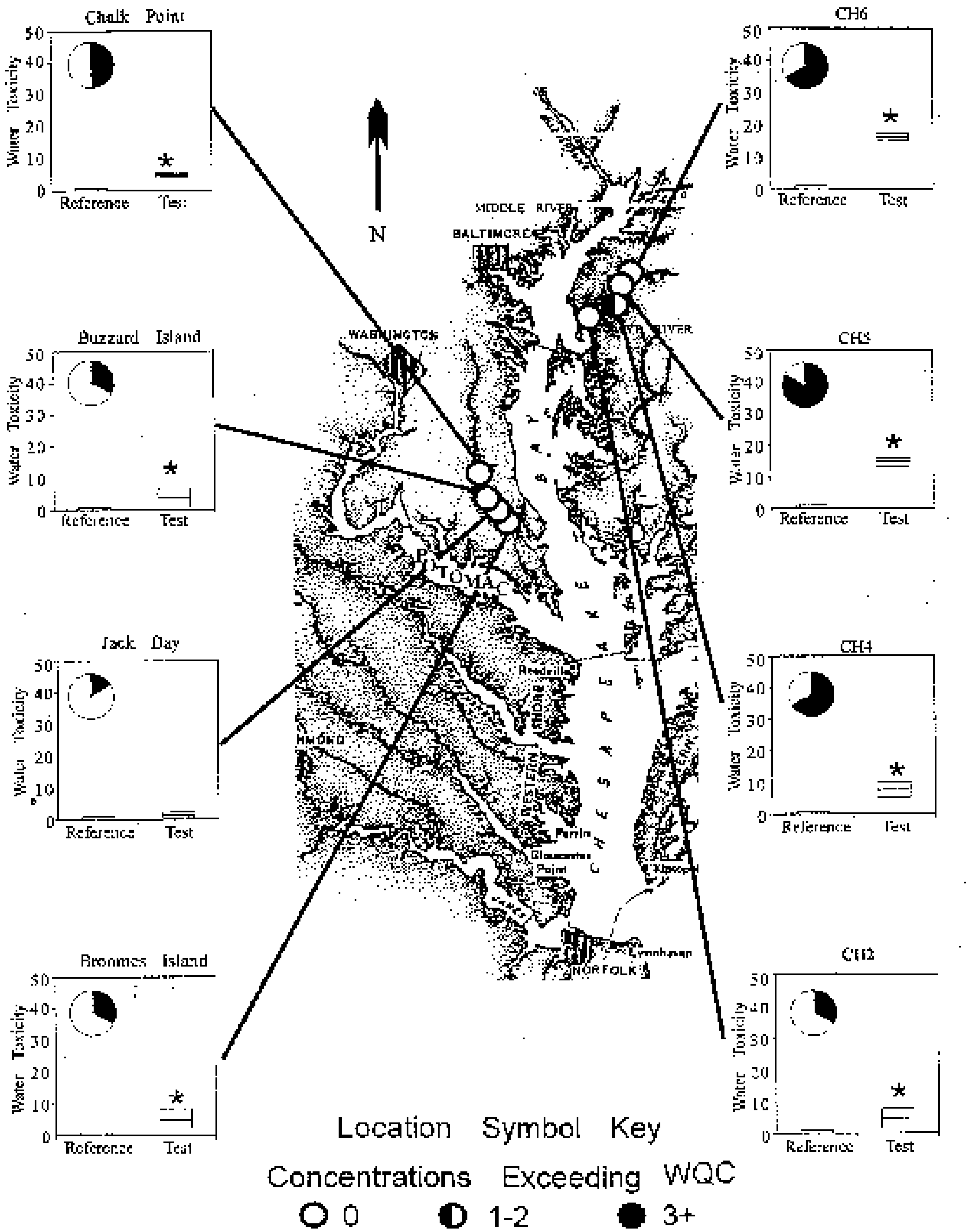


Figure 6.6 Toxicity Index results for the 1996 water column data.(See Section 3.4 for a detailed description of presentation).



* Test is significantly separated from reference

Figure 6.7 Toxicity Index results for the 1997 water column data.(See Section 3.4 for a detailed description of presentation).

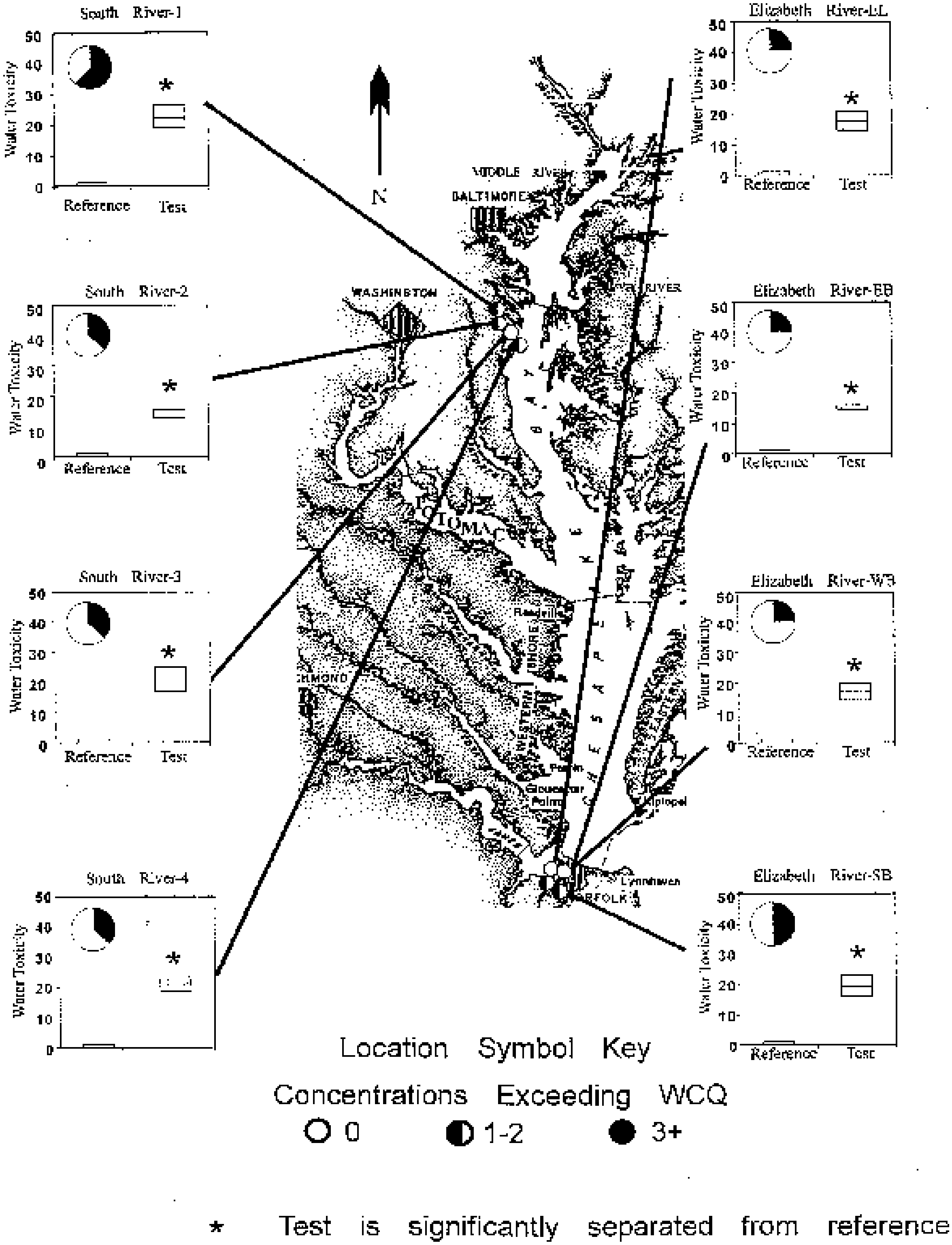


Figure 6.8a Toxicity Index results for the 1998 water column data from the Choptank River.(See Section 3.4 for a detailed description of presentation).

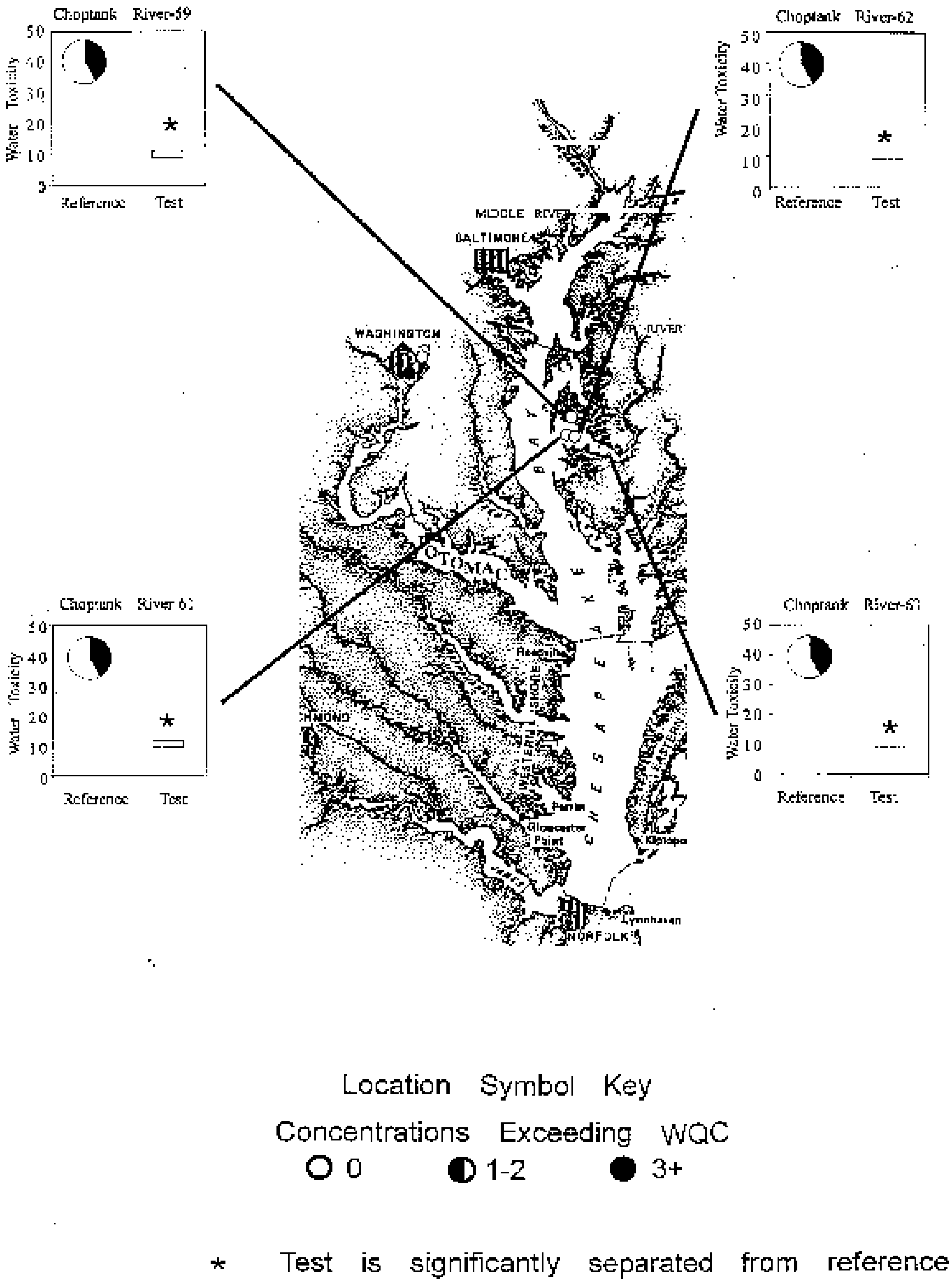
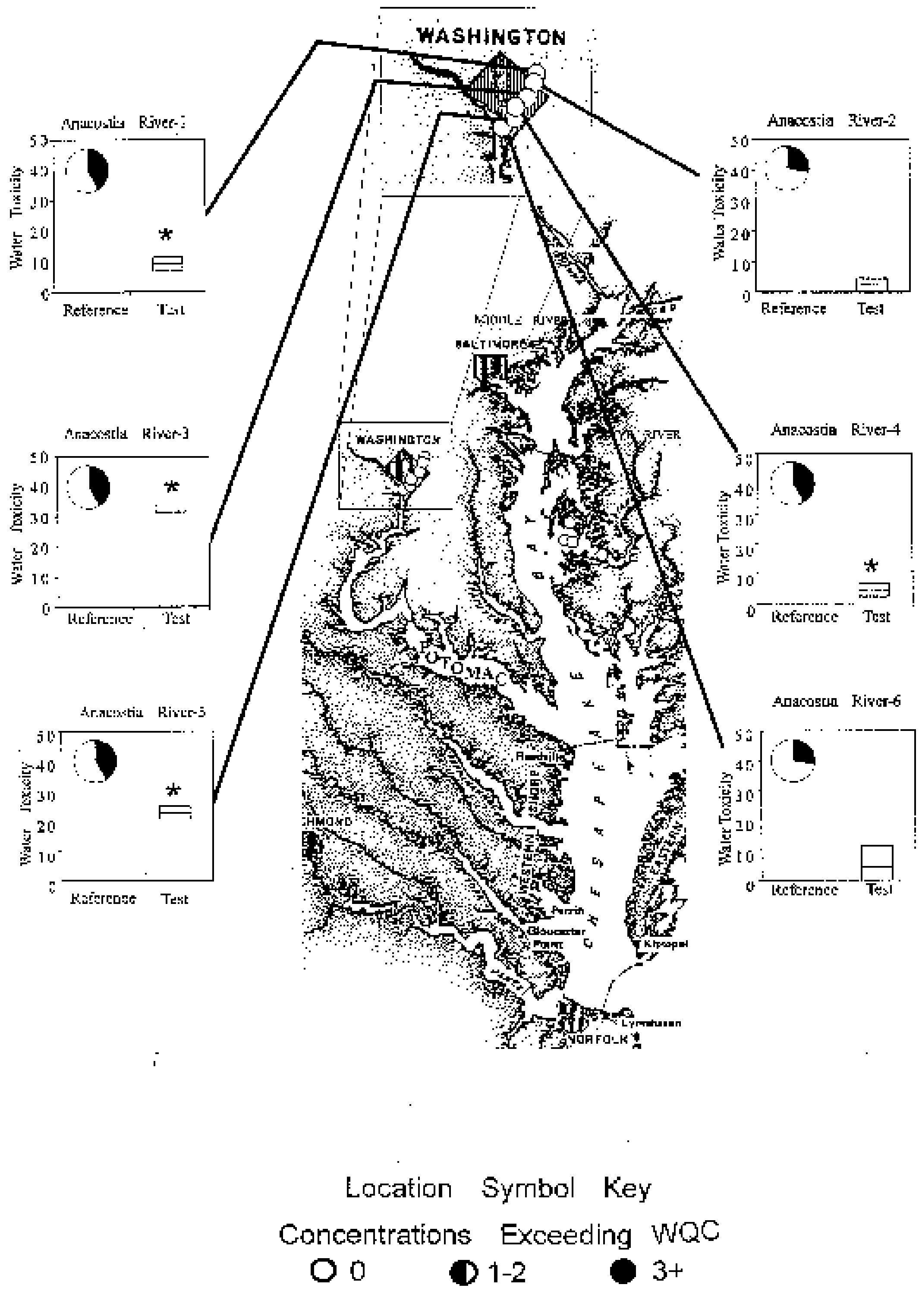


Figure 6.86 Toxicity Index results for the 1998 water column data from the Anacostia River.(See Section 3.4 for a detailed description of presentation).



* Test is significantly separated from reference

Figure 6.9a Toxicity Index results for the 1999 water column data from the Chester River (see Section 3.4 for a detailed description of presentation).

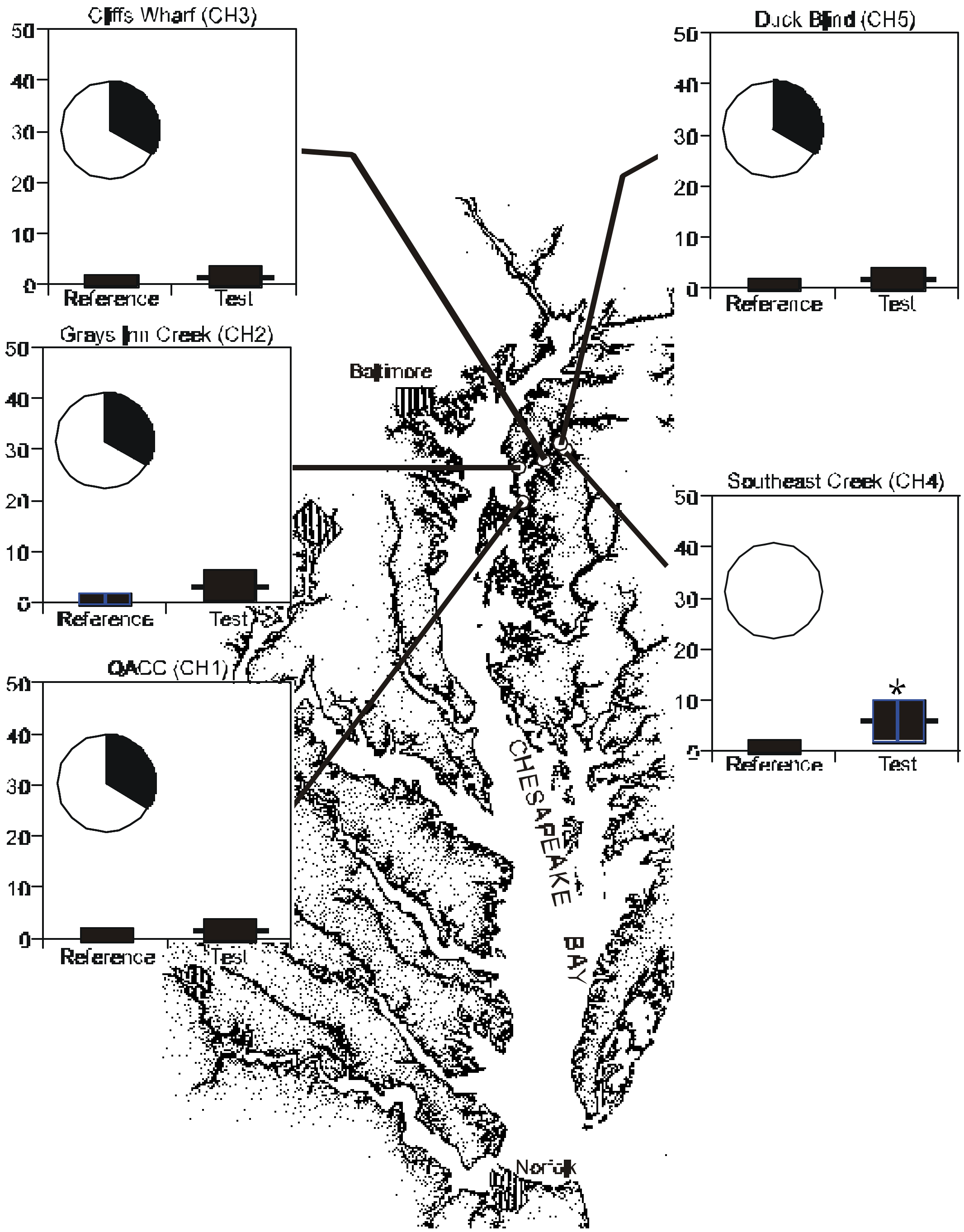


Figure 6.9b Toxicity Index results for the 1999 water column data from the Chester River (continued).

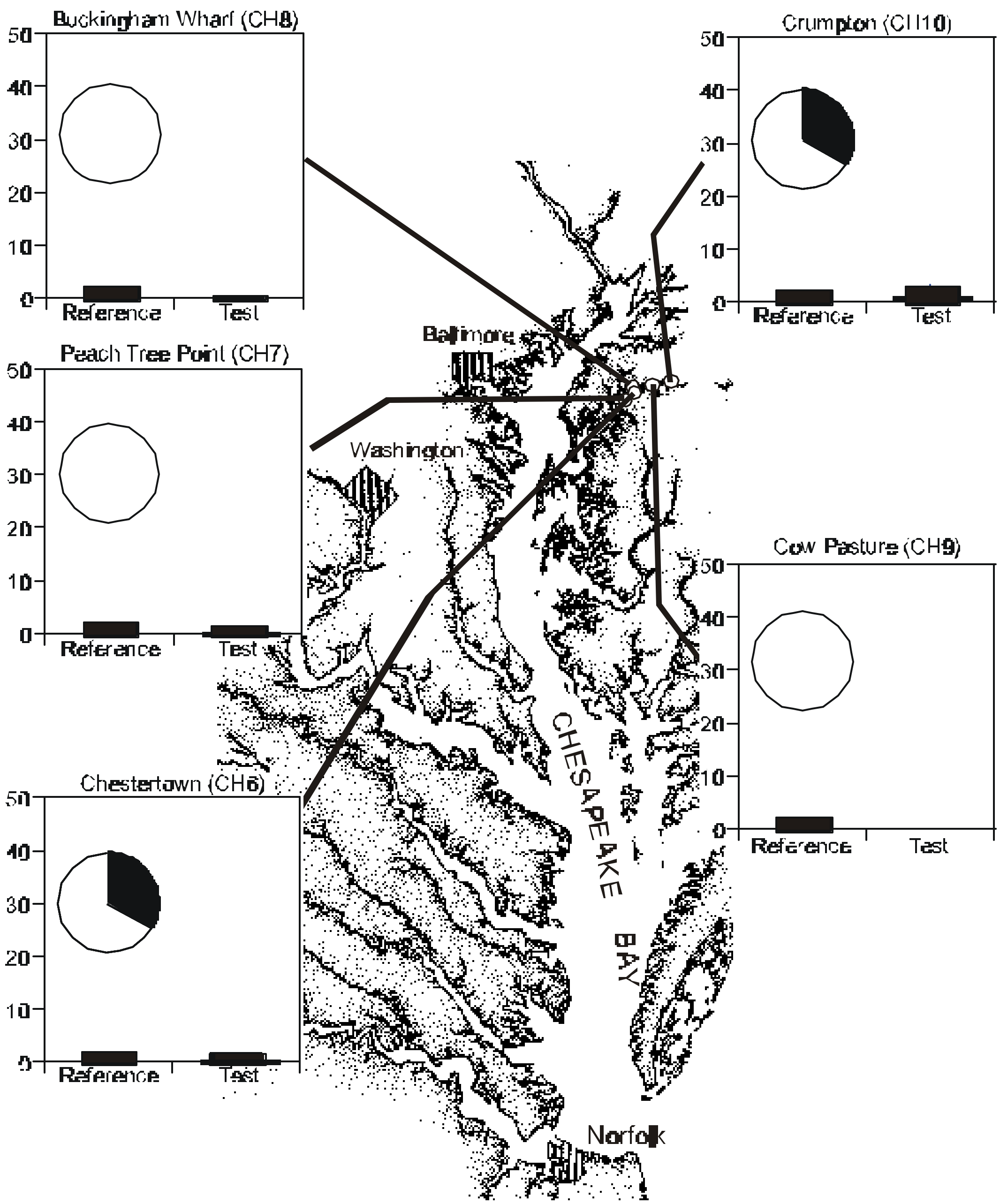


Figure 6.9c Toxicity Index results for the 1999 water column data from the Rappahannock River (see Section 3.4 for a detailed description of presentation).

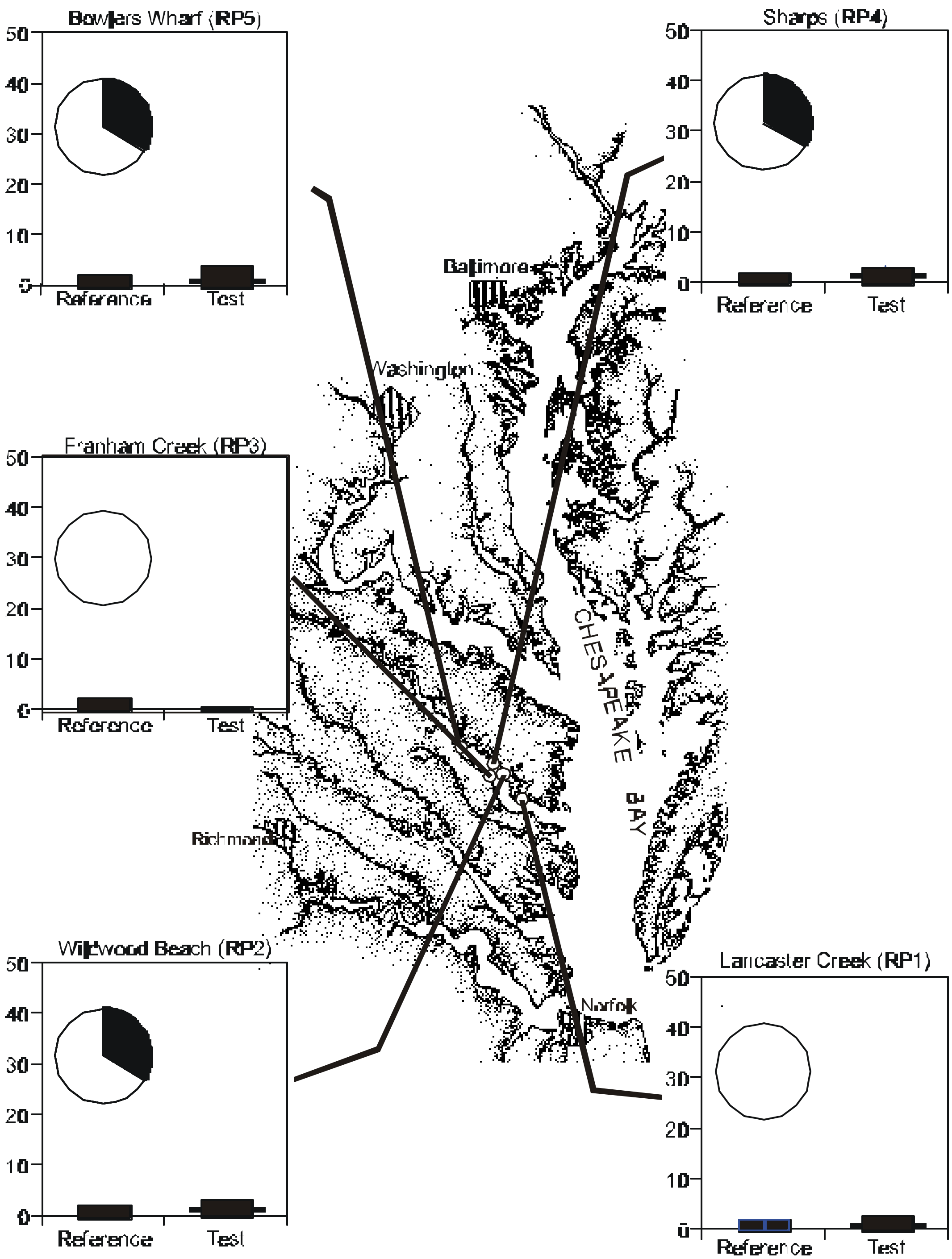
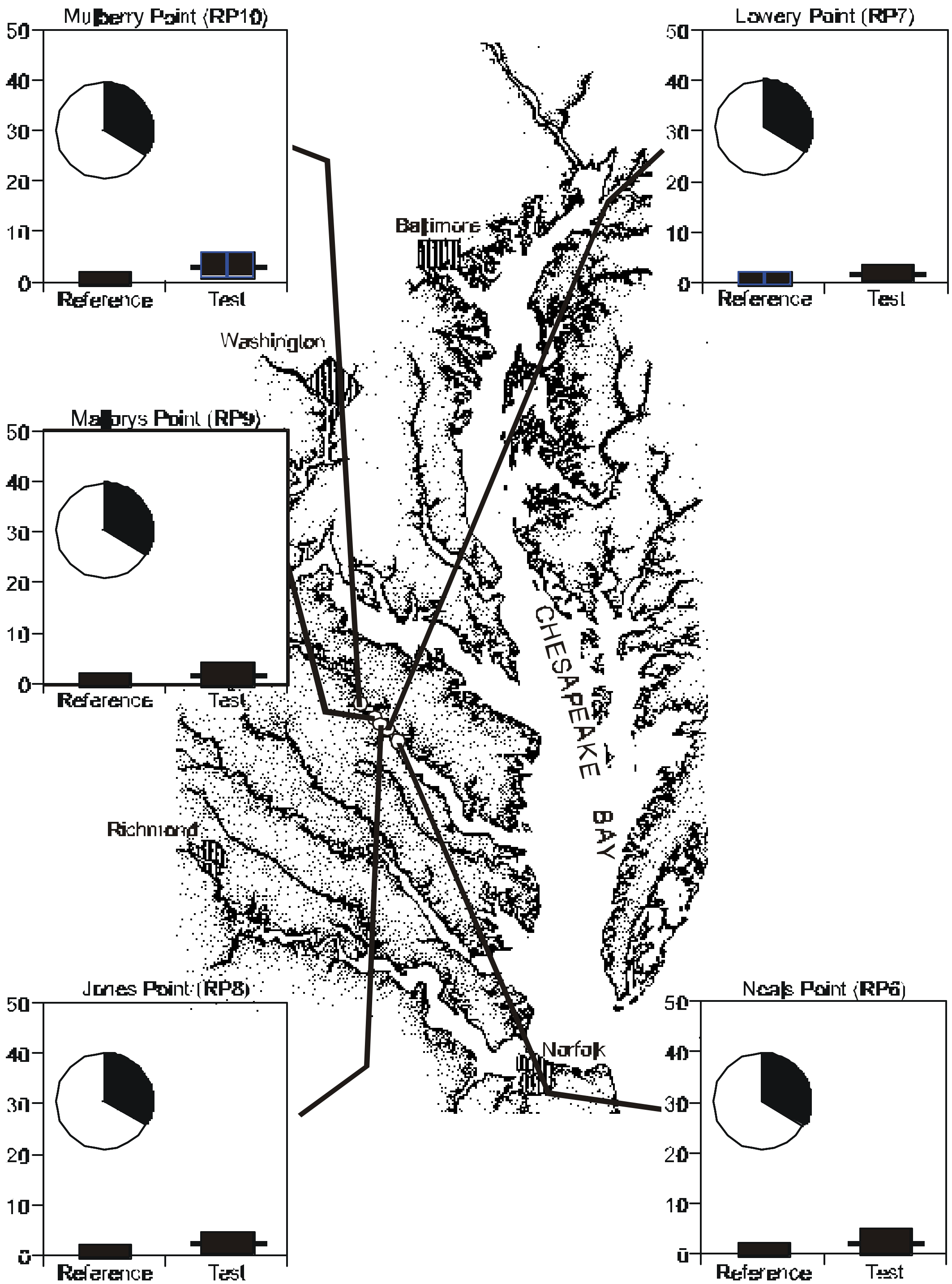


Figure 6.9d Toxicity Index results for the 1999 water column data from the Rappahannock River (continued).



8-69

Figure 6.10a Summary of water column Toxicity Index results for 1990-1999. The sites are ranked according to median Toxicity Index values (closed circles). The results are for the least toxic third of the sites in the data set (see Figure 6.10b and 6.10c for remainder of ranked data). Also shown are the 95% confidence limits for the Toxicity Index values (vertical bars) and the percentage of endpoints displaying significant differences from the references (open squares). The dashed horizontal line is the average upper confidence limit observed for reference conditions during the study and is included as a general benchmark. The identities of the site numbers are provided in Table 6.1.

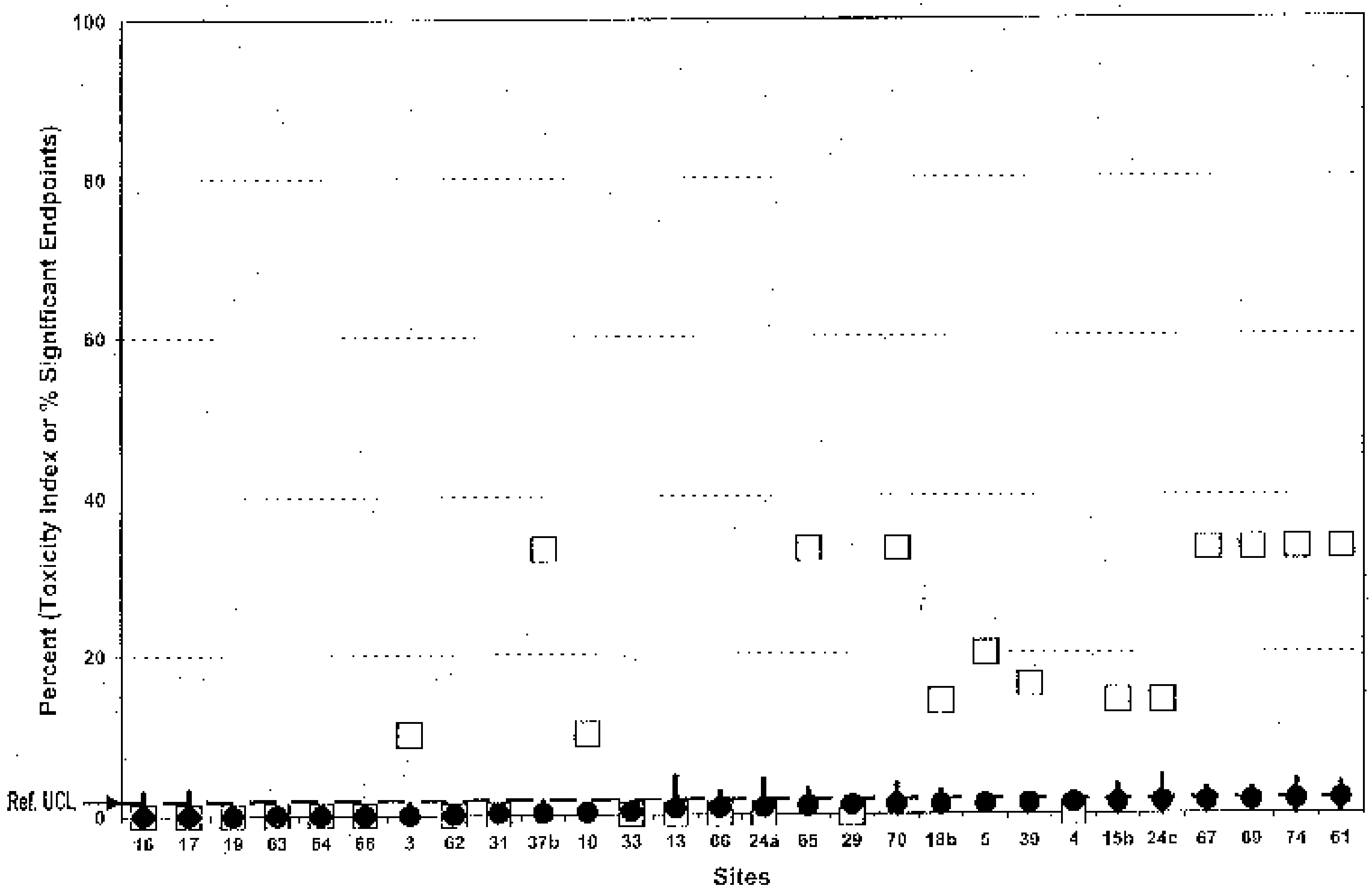
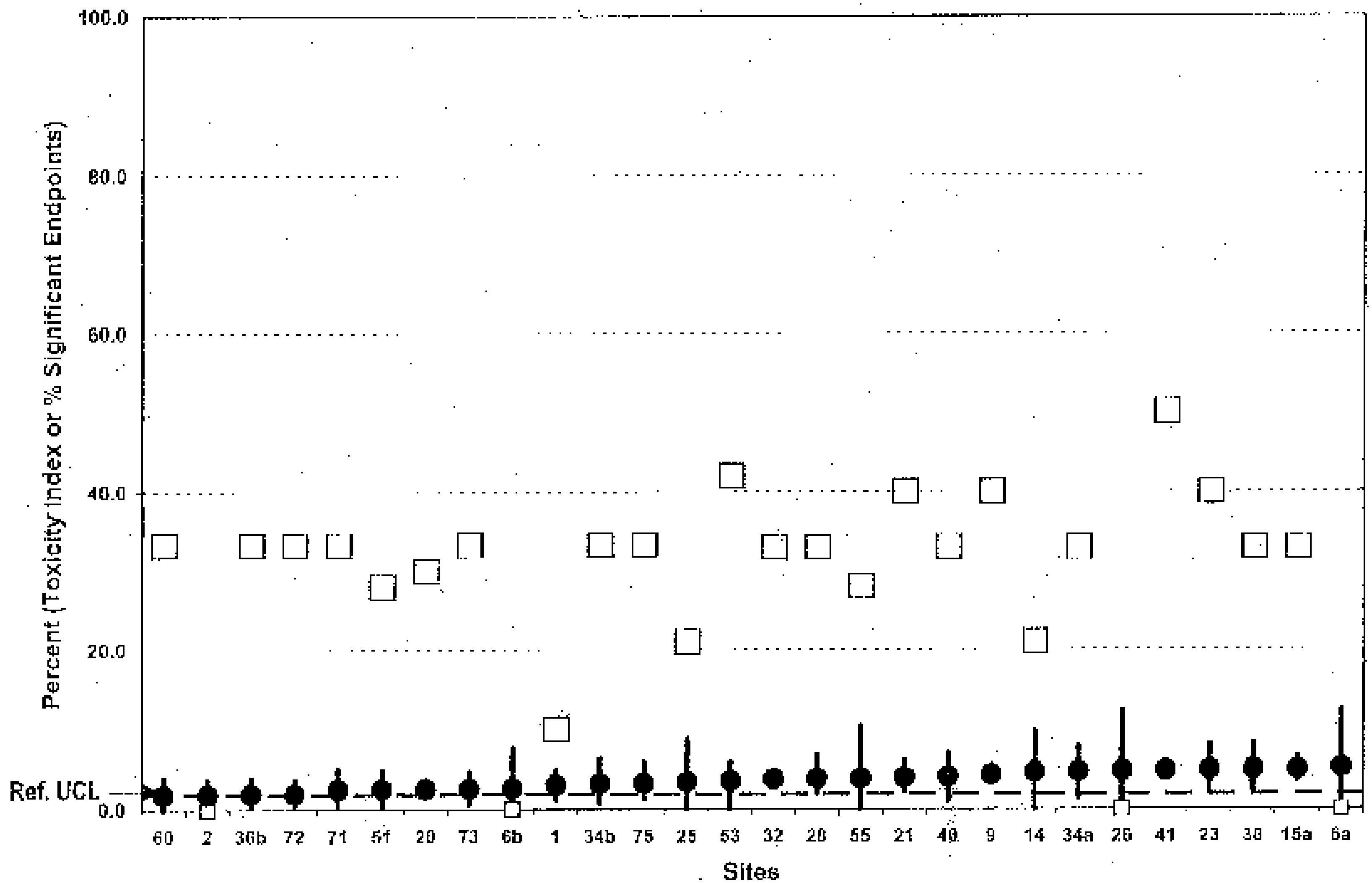
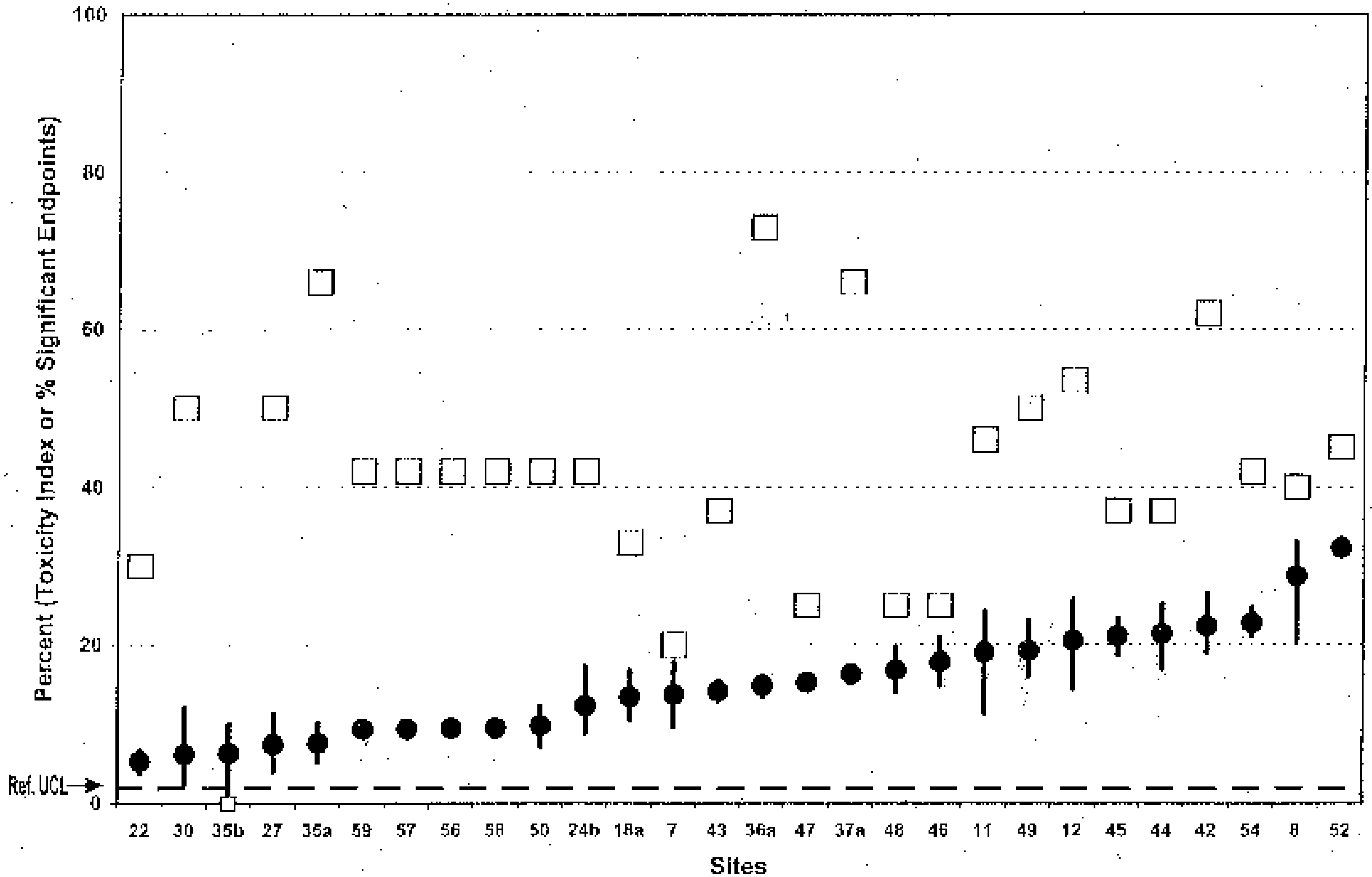


Figure 6.10b Summary of water column Toxicity Index results for 1990-1999 (continued). The results are for the middle third of the sites in the data set. The identities of the site numbers are provided in Table 6.1.



8-70

Figure 6.10c Summary of water column Toxicity Index results for 1990-1999 (continued). The results are for the most toxic third of the sites in the data set. The identities of the site numbers are provided in Table 6.1.



8-71

Figure 6.11 Toxicity Index results for the 1990 sediment data. (See Section 3.4 for a detailed description of presentation).

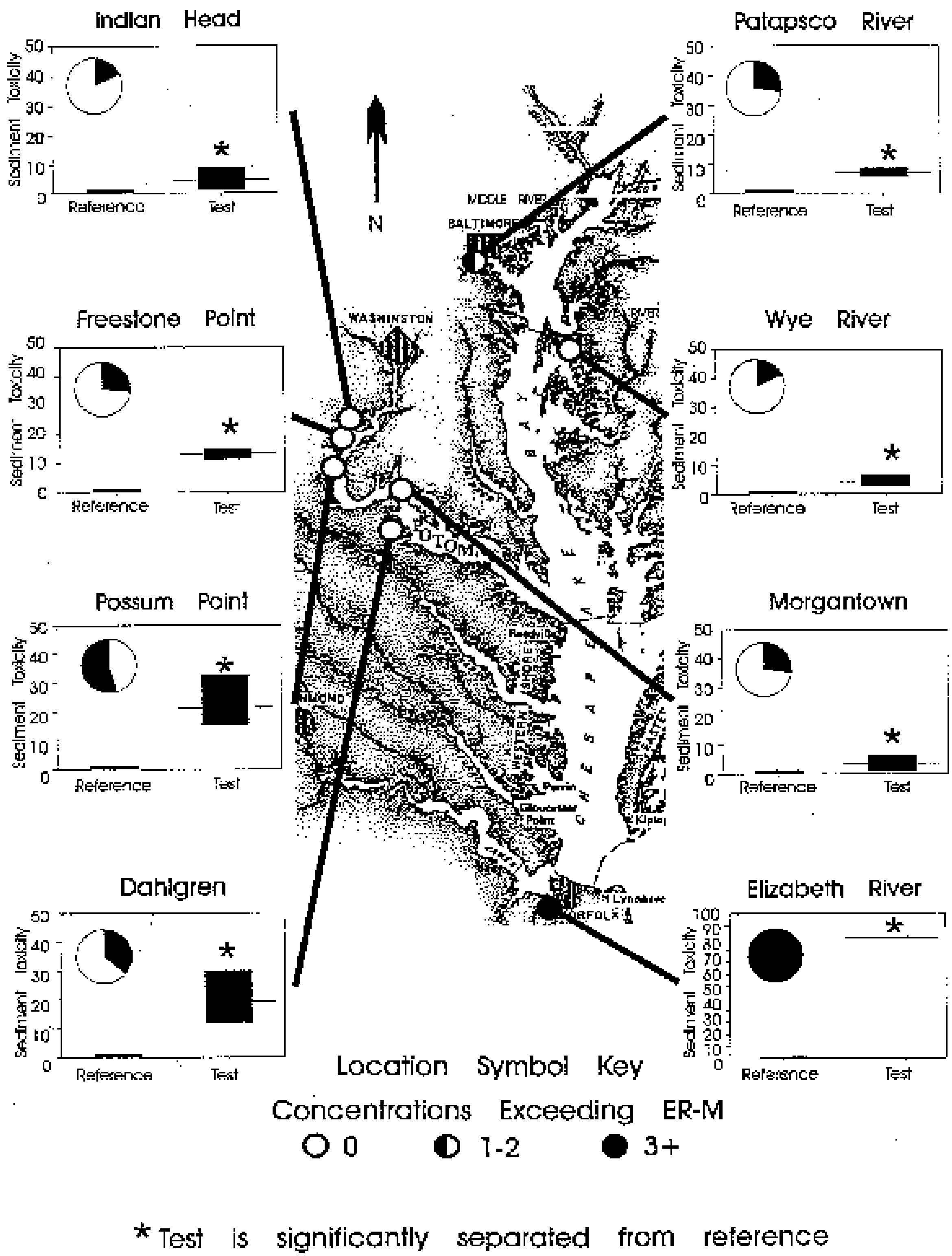


Figure 6.12 Toxicity Index results for the 1991 sediment data. (See Section 3.4 for a detailed description of presentation).

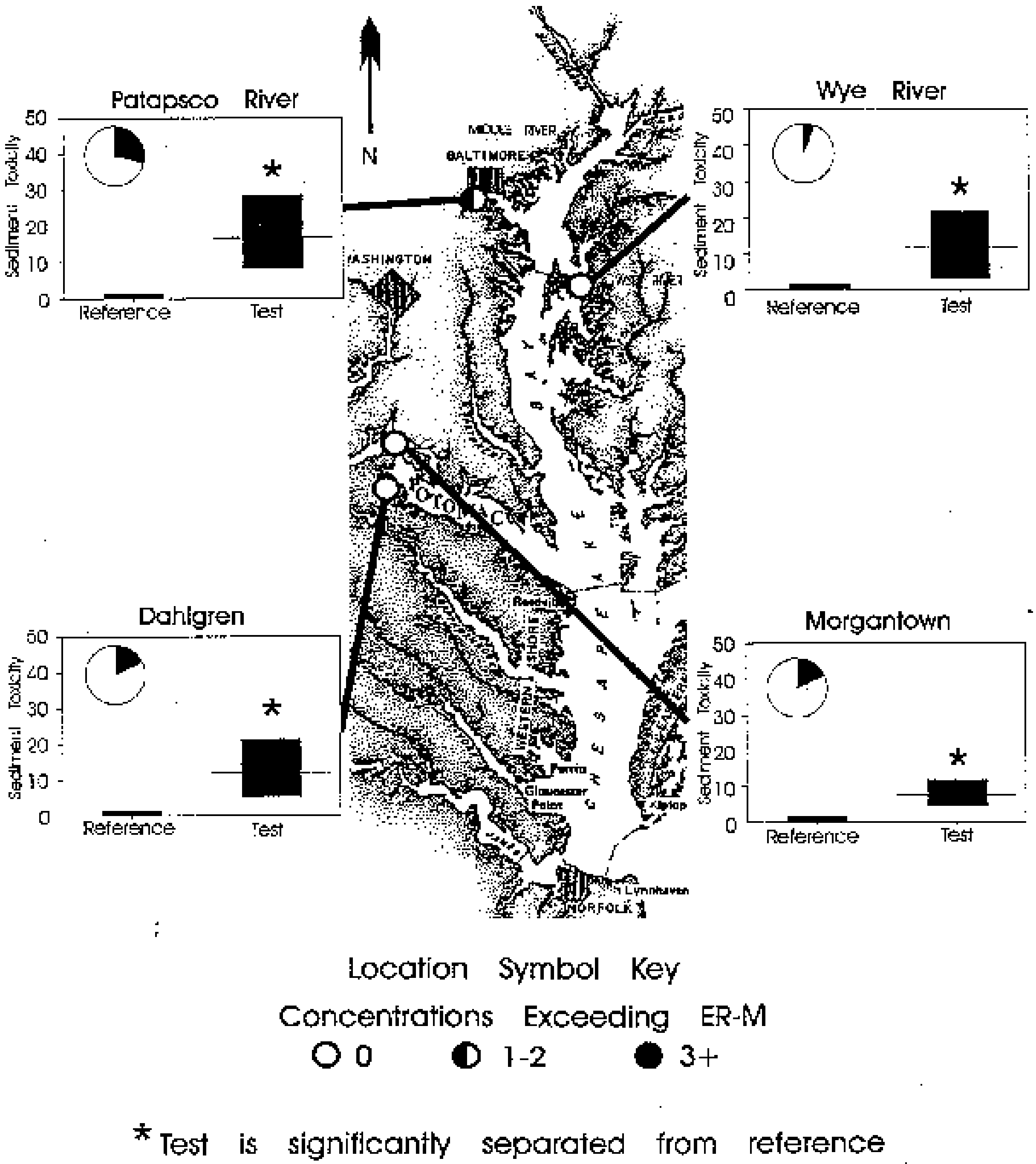


Figure 6.13 Toxicity Index results for the 1992-3 sediment data. (See Section 3.4 for a detailed description of presentation).

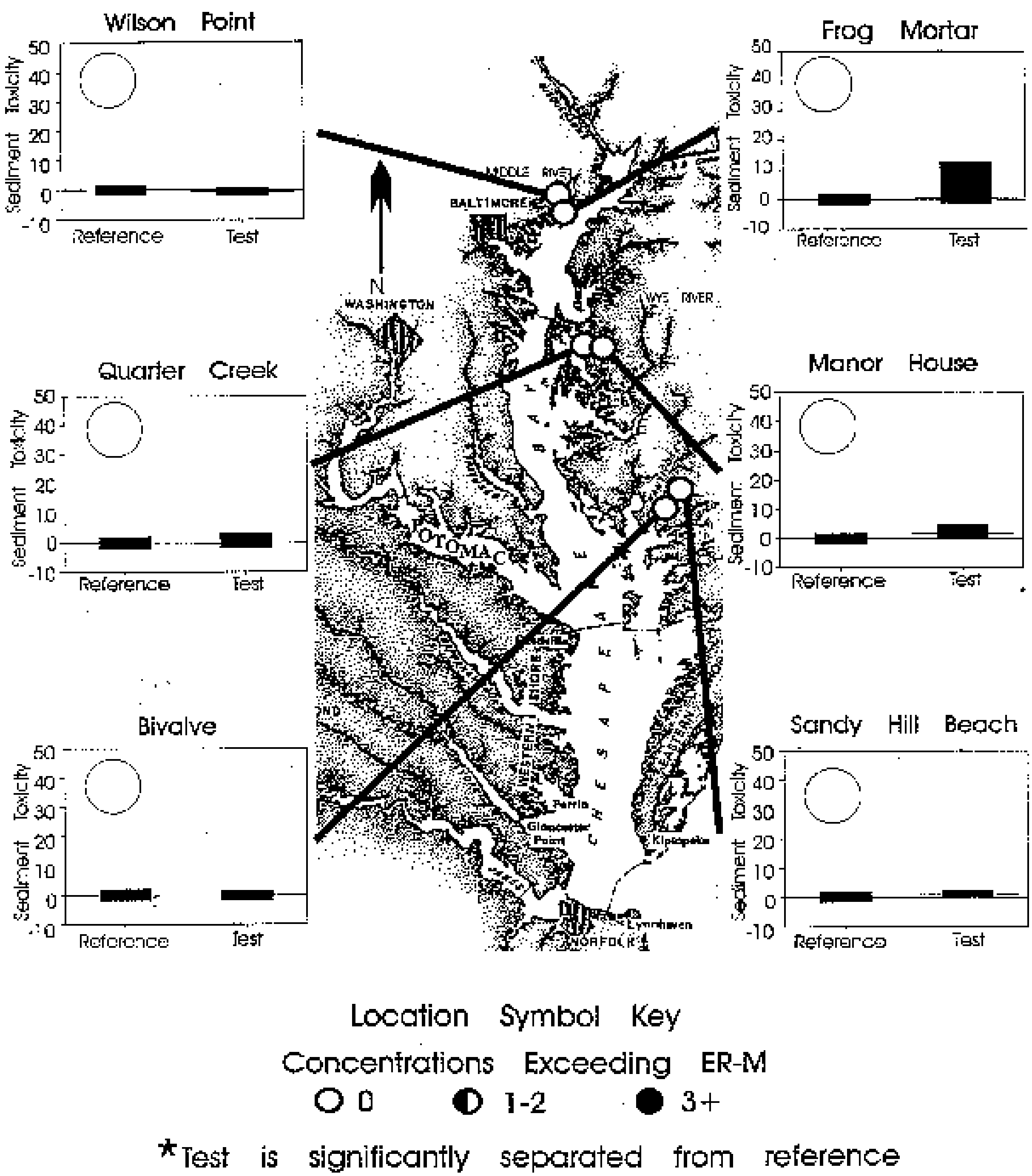


Figure 6.14a Toxicity Index results for the 1994 sediment data from the Severn, Magothy and Sassafras Rivers. (See Section 3.4 for a detailed description of presentation).

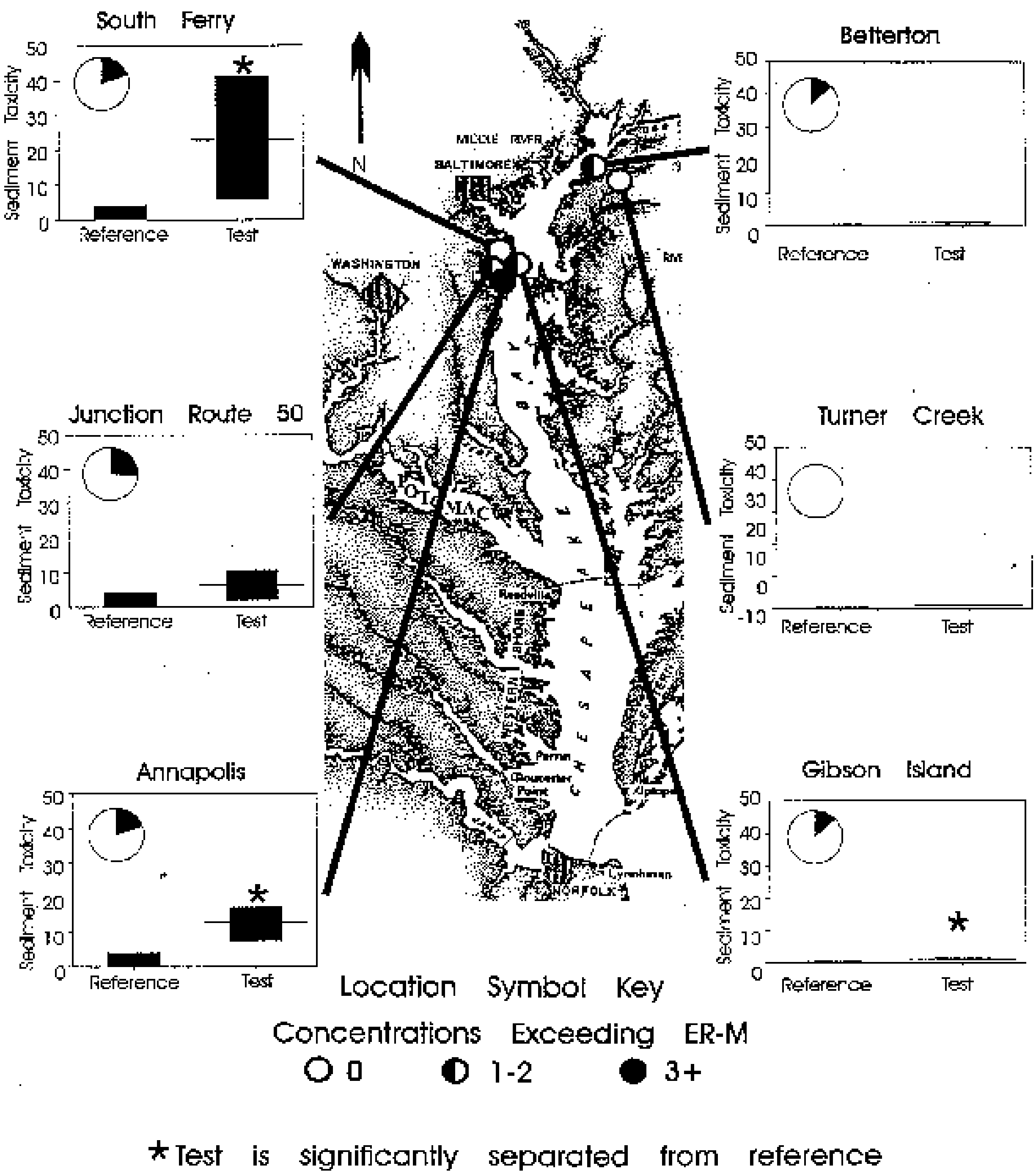


Figure 6.14b Toxicity Index results for the 1994 sediment data from Baltimore Harbor sites. (See Section 3.4 for a detailed description of presentation).

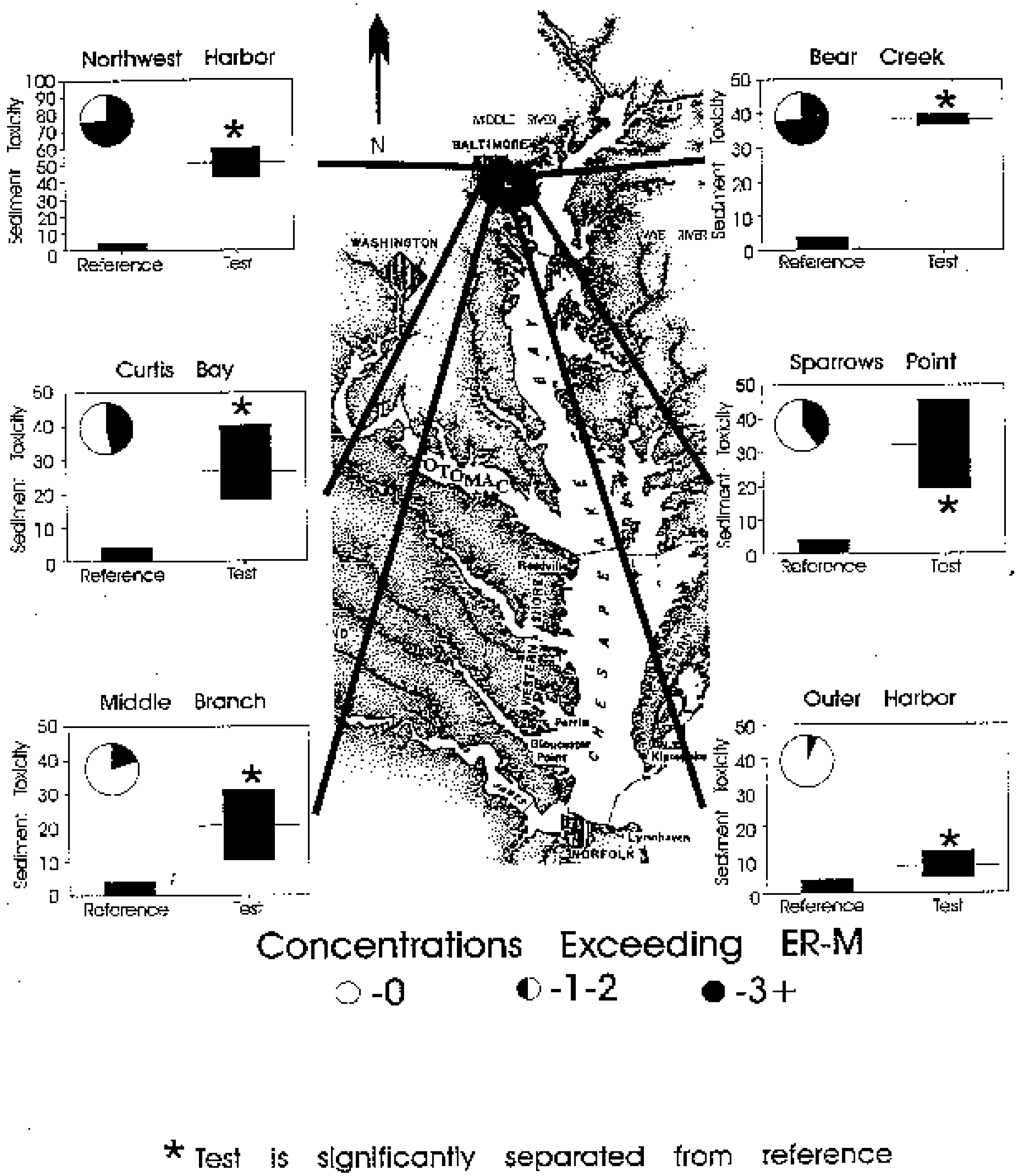


Figure 6.15 Toxicity Index results for the 1995 sediment data. (See Section 3.4 for a detailed description of presentation).

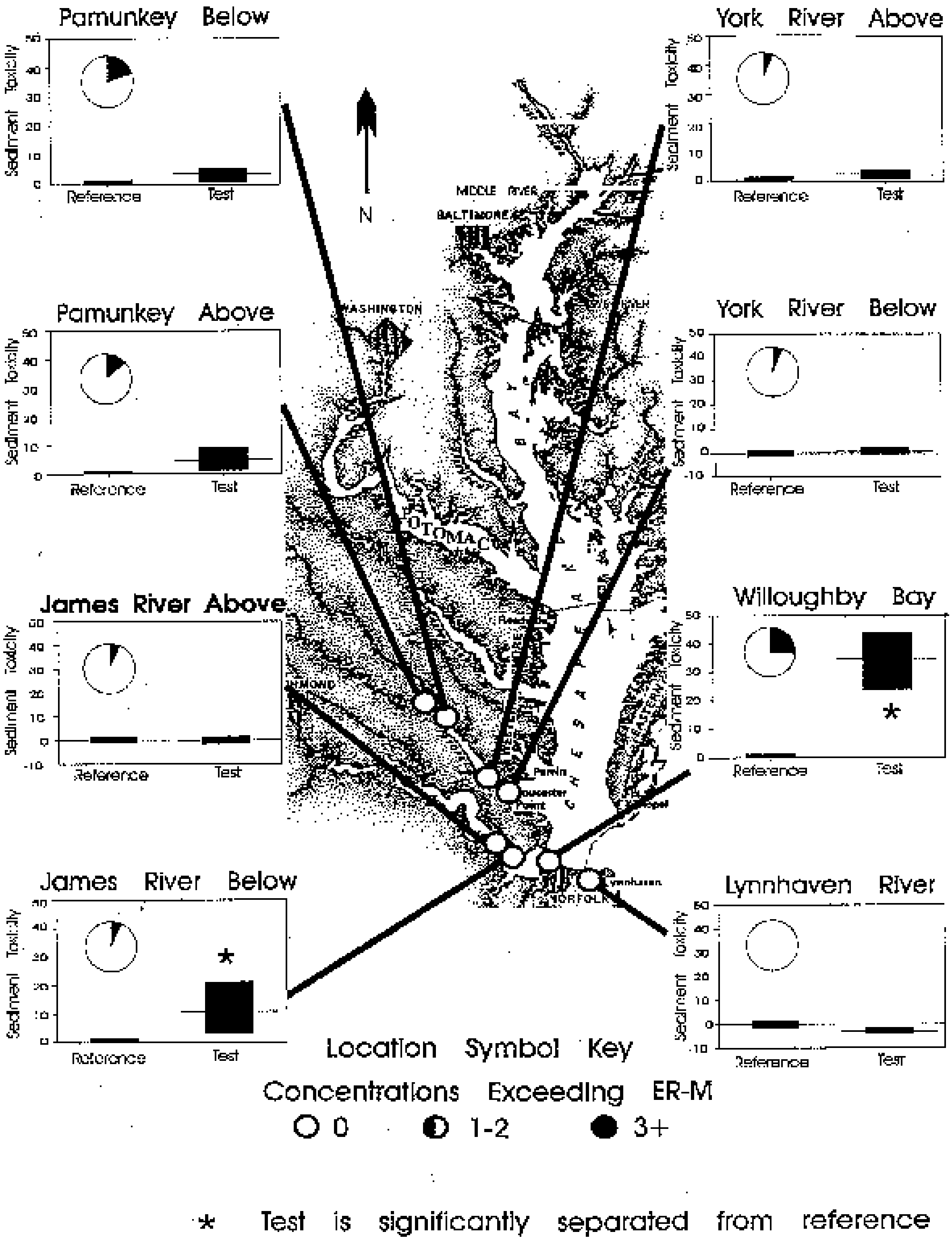


Figure 6.16 Toxicity Index results for the 1996 sediment data. (See Section 3.4 for a detailed description of presentation).

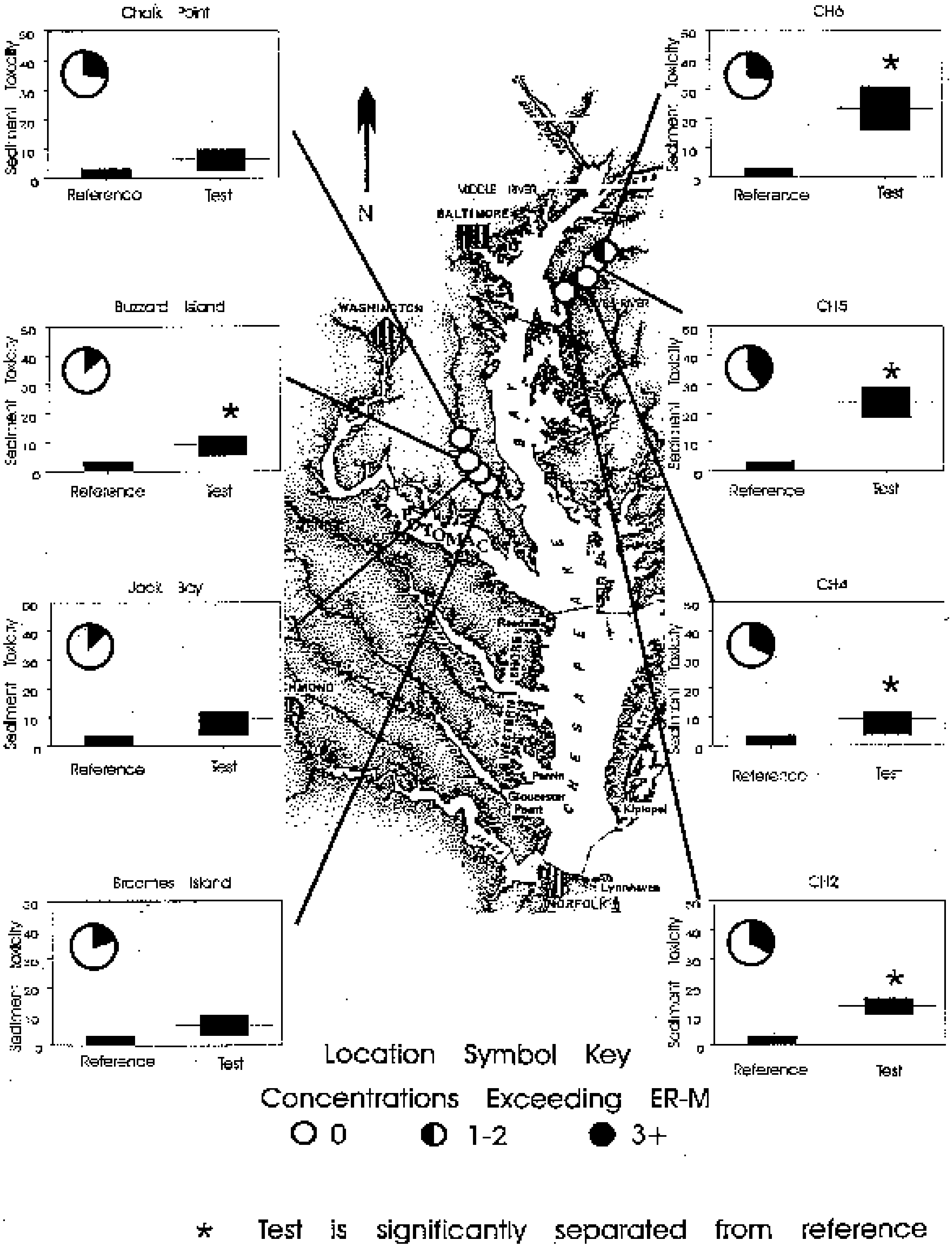


Figure 6.17 Toxicity Index results for the 1997 sediment data. (See Section 3.4 for a detailed description of presentation).

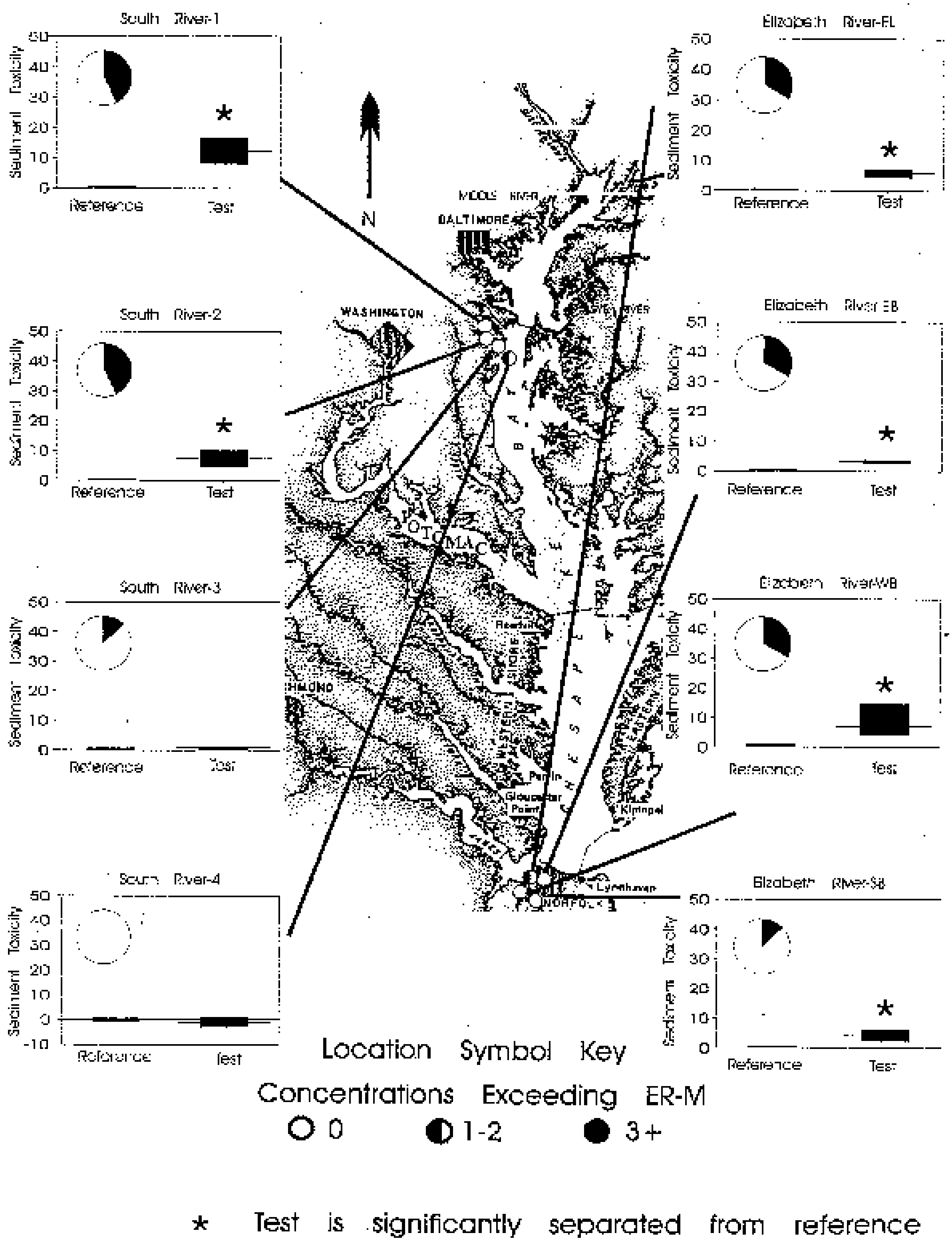
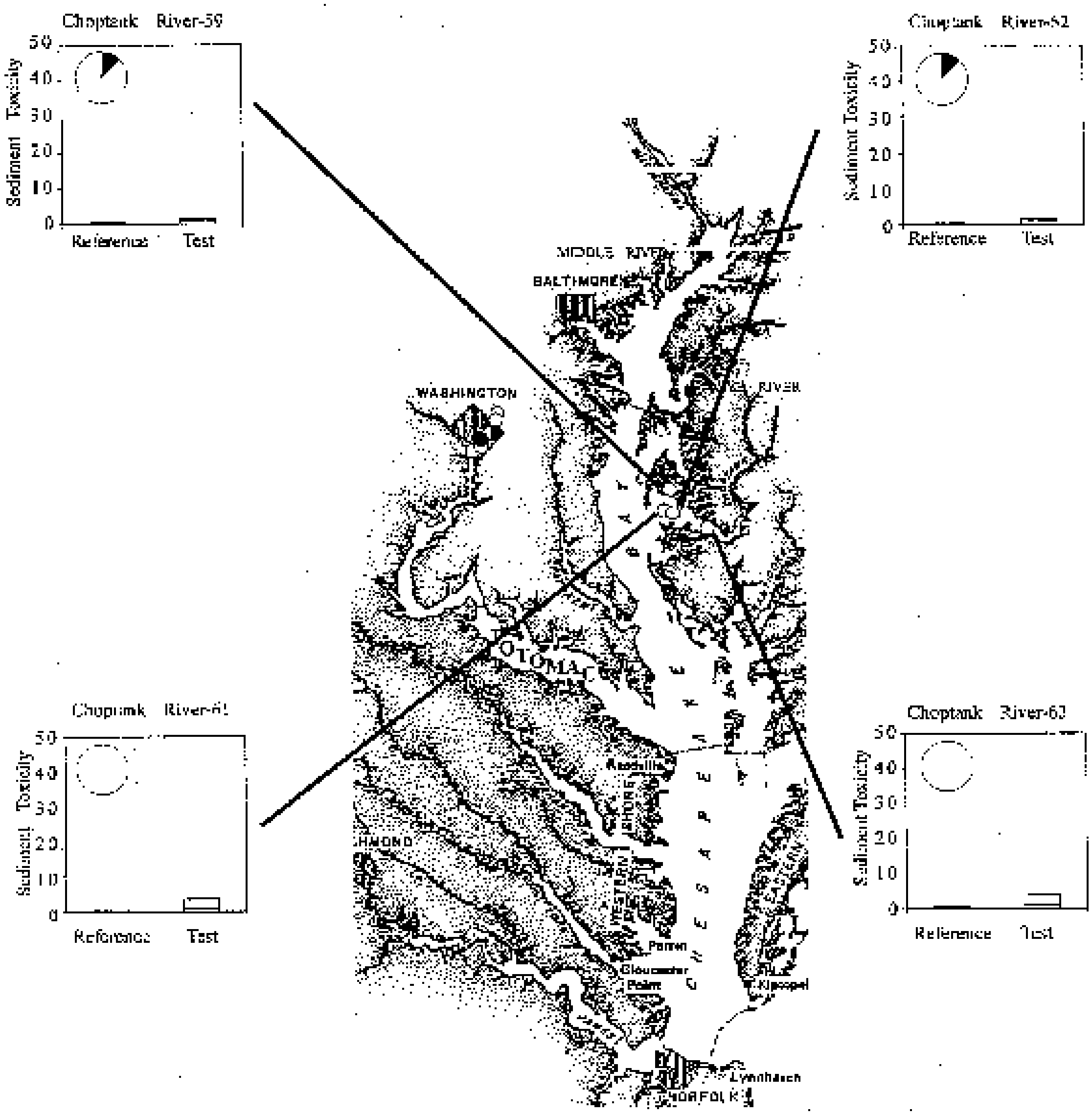


Figure 6.18a Toxicity Index results for the 1998 sediment data from the Choptank River. (See Section 3.4 for a detailed description of presentation).



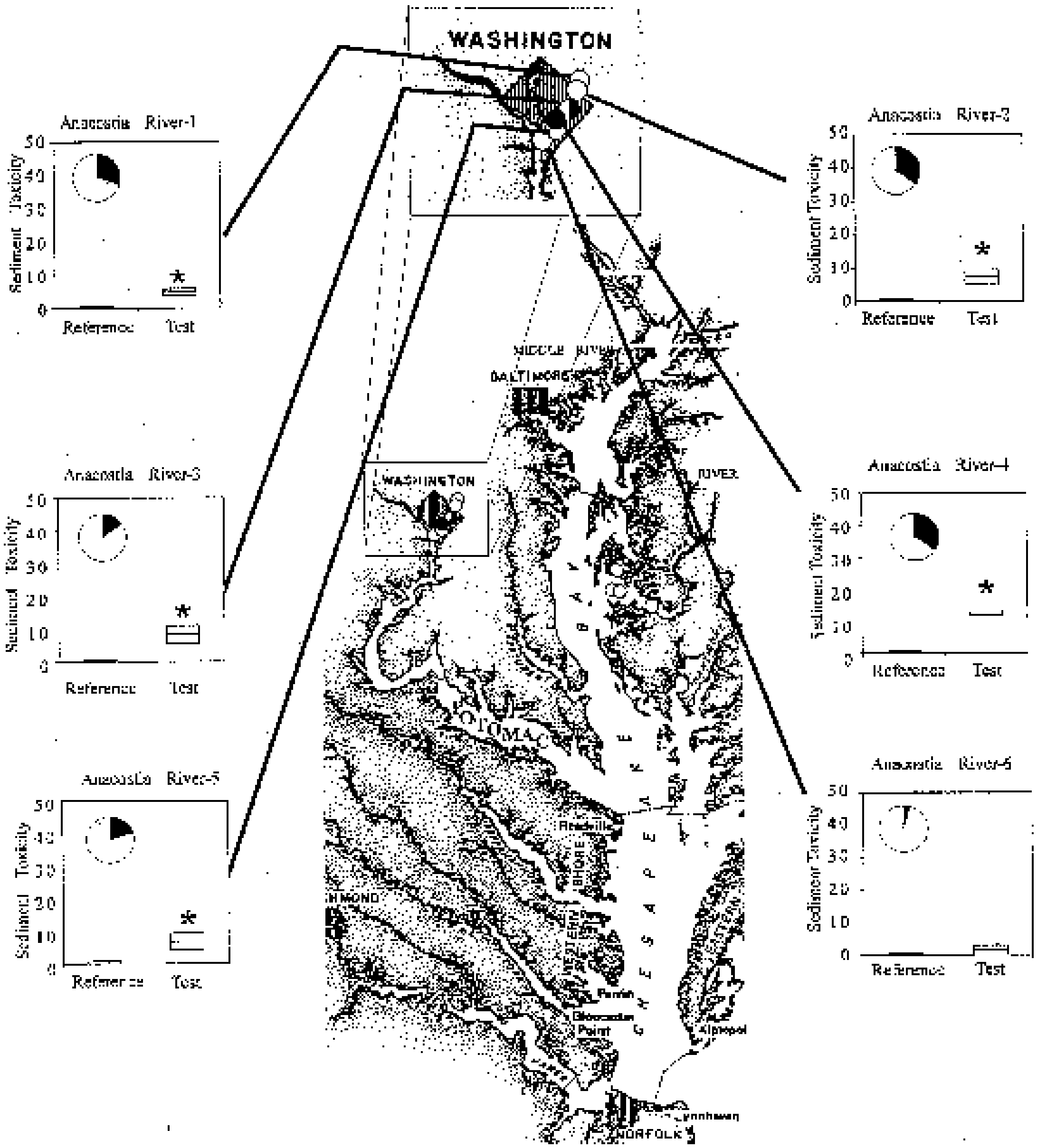
Location Symbol Key

Concentrations Exceeding ER-M

O 0 ◐ 1-2 ● 3+

* Test is significantly separated from reference

Figure 6.18b Toxicity Index results for the 1998 sediment data from the Anacostia River. (See Section 3.4 for a detailed description of presentation).



Location Symbol Key

Concentrations Exceeding ER-M

0 1-2 3+

* Test is significantly separated from reference

Figure 6.19a Toxicity Index results for the 1999 sediment data from the Chester River (see Section 3.4 for a detailed description of presentation).

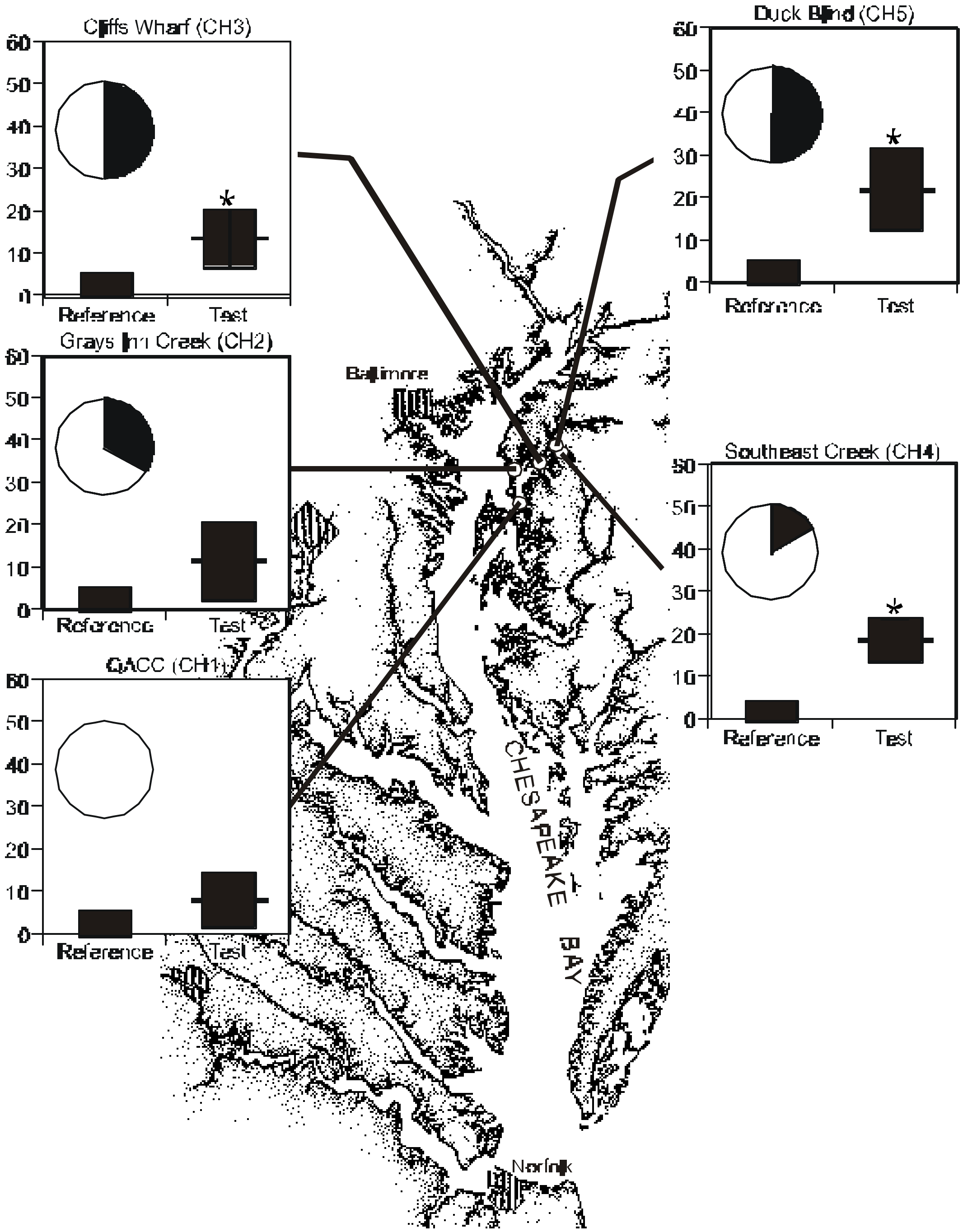


Figure 6.19b Toxicity Index results for the 1999 sediment data from the Chester River (continued).

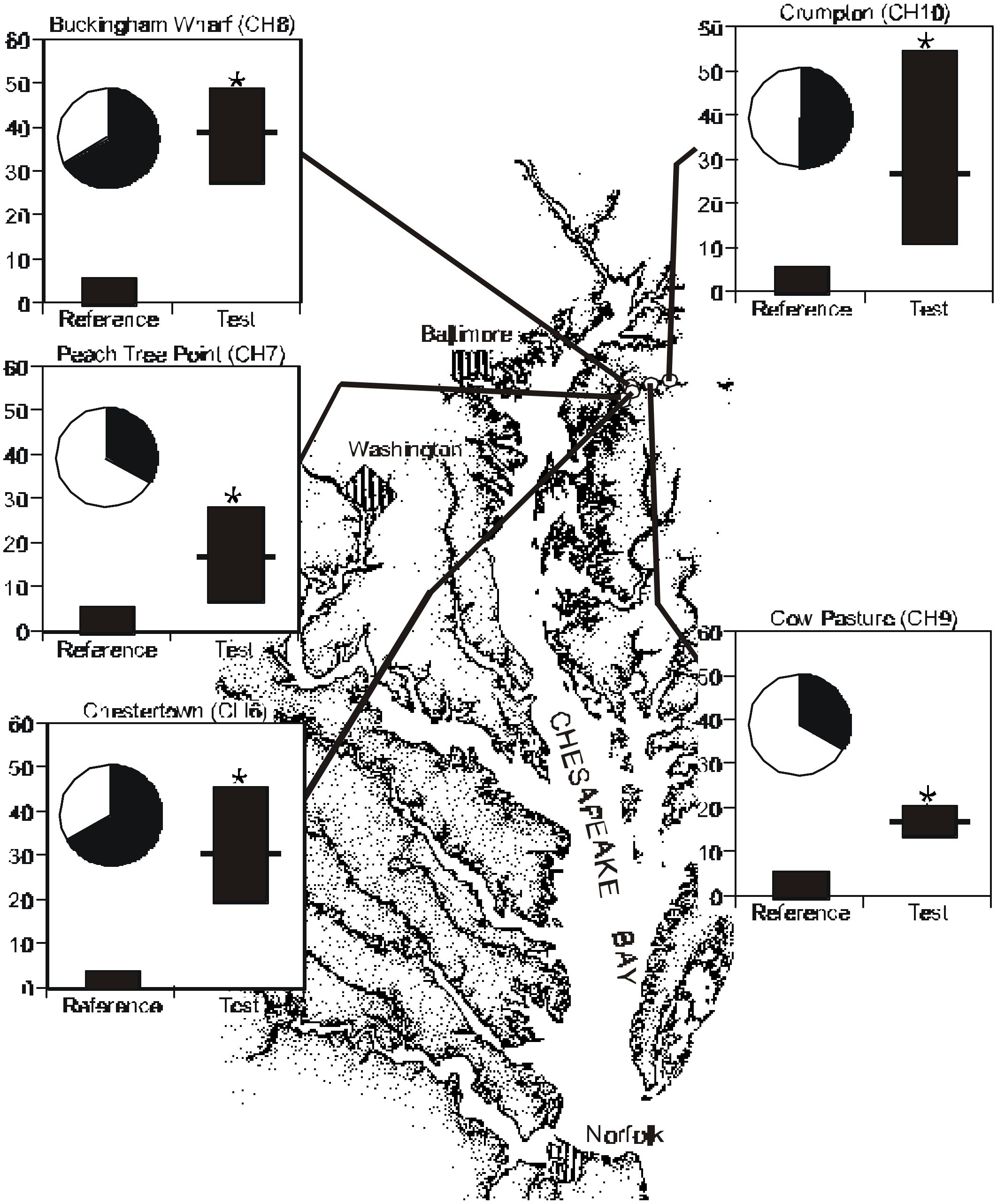


Figure 6.19c Toxicity Index results for the 1999 sediment data from the Rappahannock River (see Section 3.4 for a detailed description of presentation).

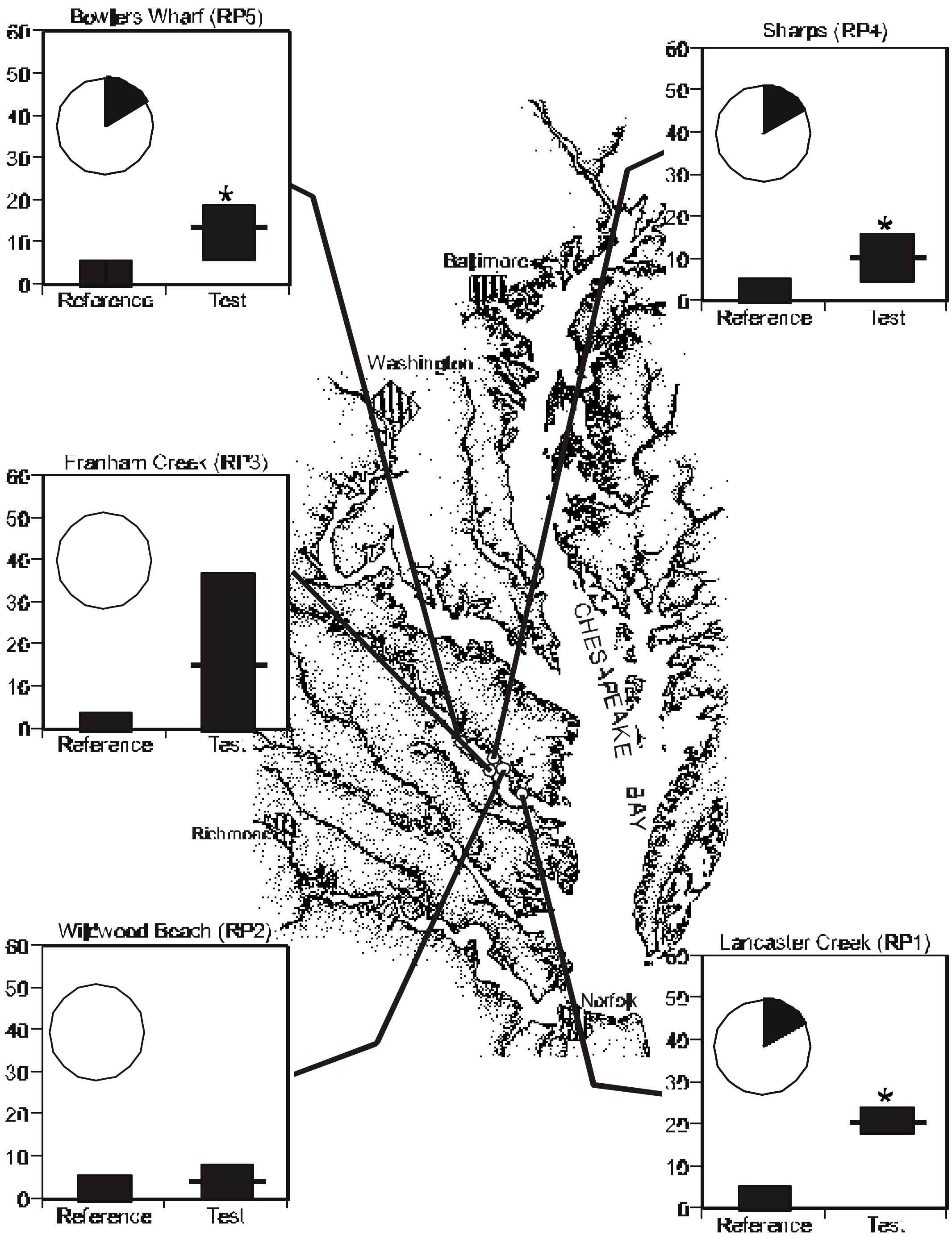


Figure 6.19d Toxicity Index results for the 1999 sediment data from the Rappahannock River (continued).

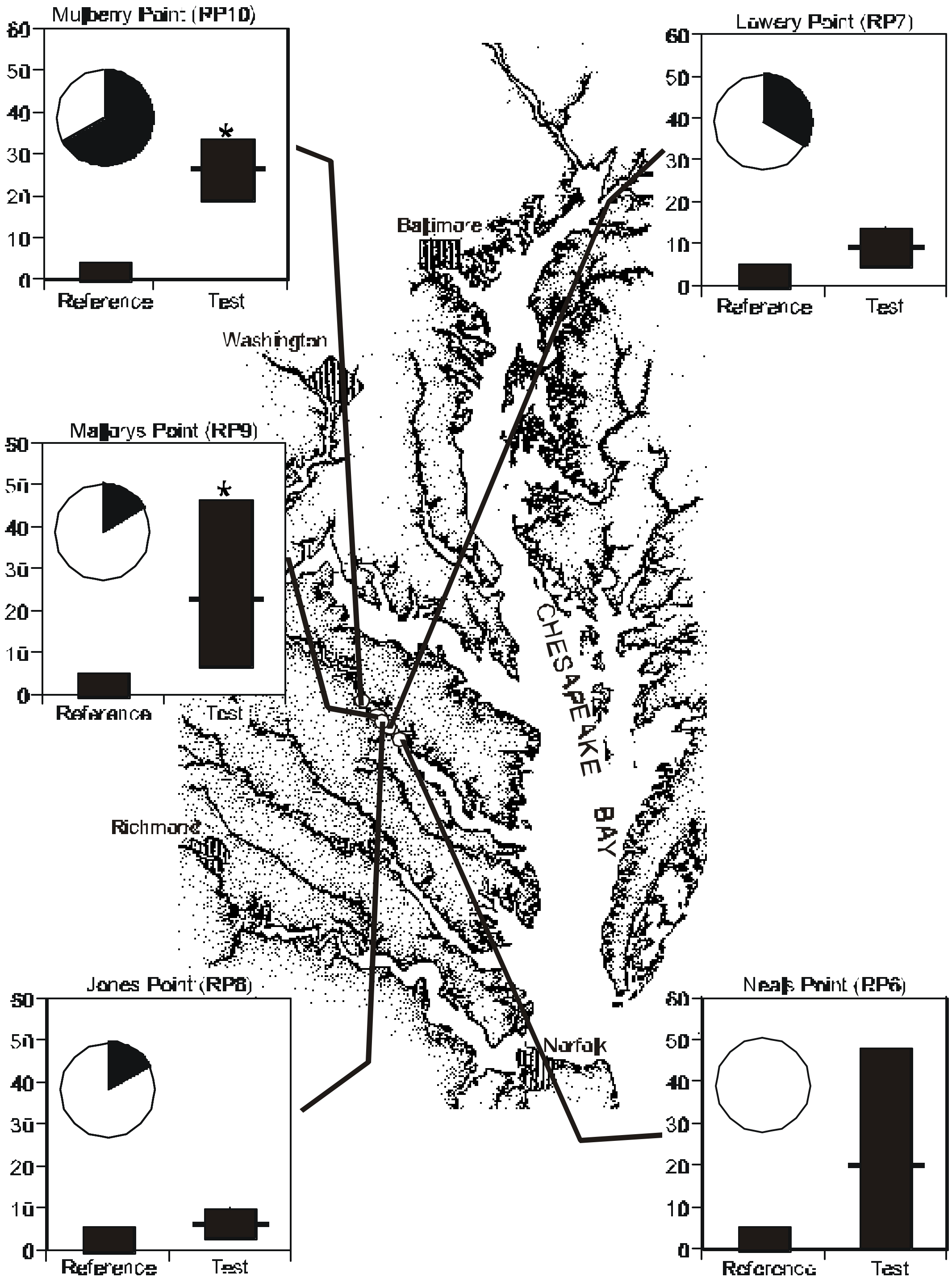
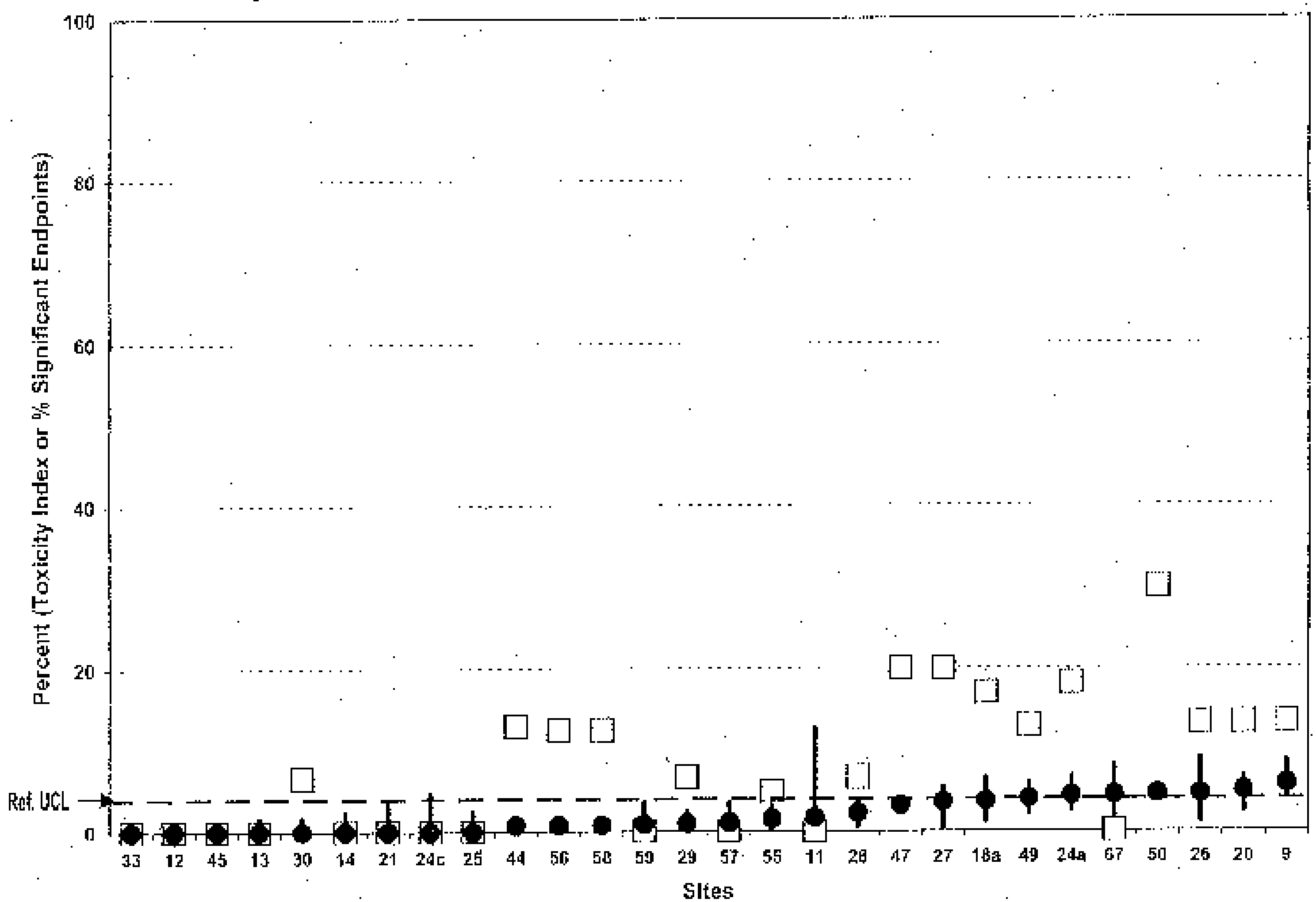
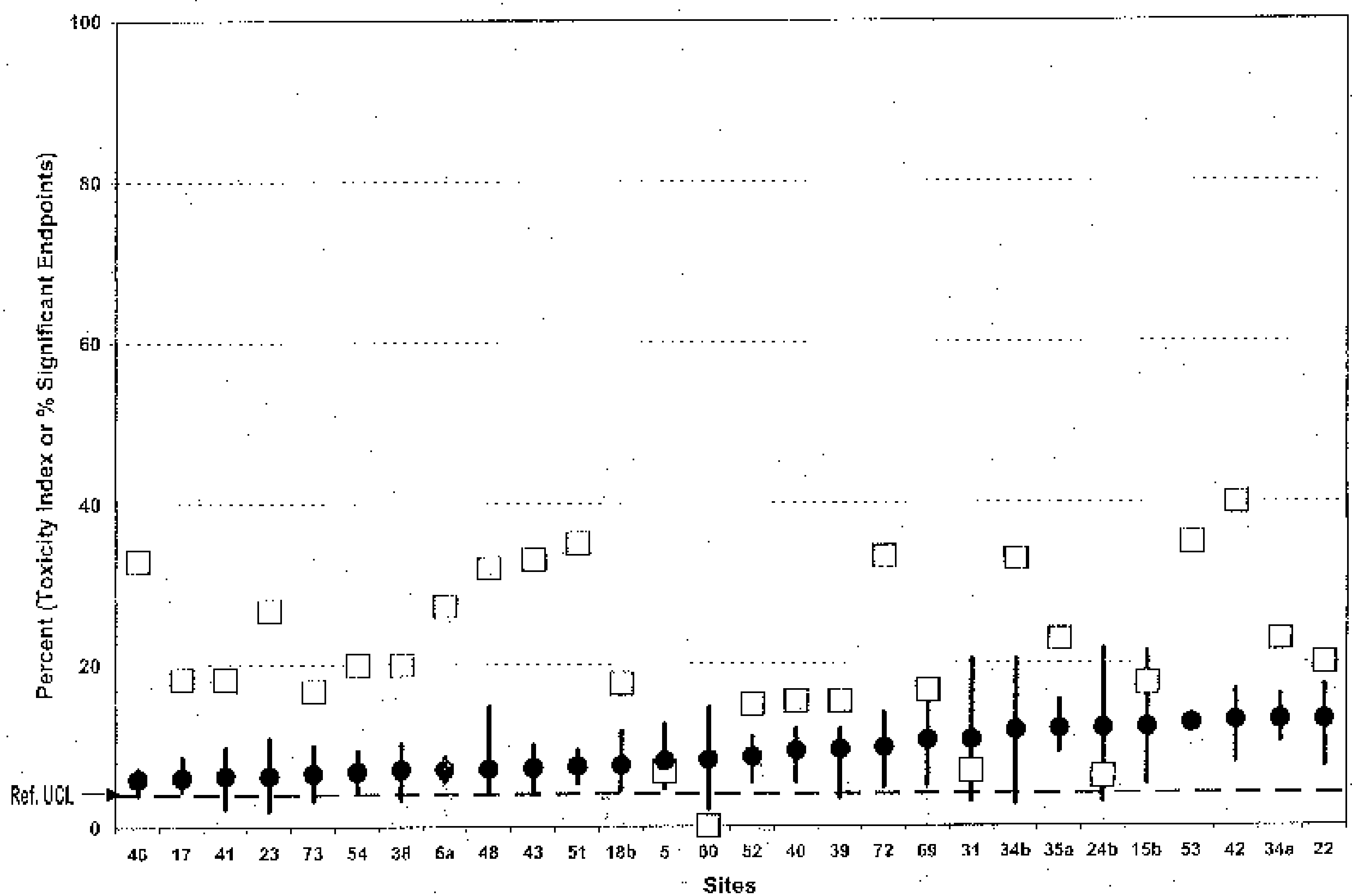


Figure 6.20a Summary of sediment Toxicity Index results for 1990-1999. The sites are ranked according to median Toxicity Index values (closed circles). The results are for the least toxic third of the sites in the data set (see Figure 6.20b and 6.20c for remainder of ranked data). Also shown are the 95% confidence limits for the Toxicity Index values (vertical bars) and the percentage of endpoints displaying significant differences from the references (open squares). The dashed horizontal line is the average upper confidence limit observed for reference conditions during the study and is included as a general benchmark. The identities of the site numbers are provided in Table 6.2.



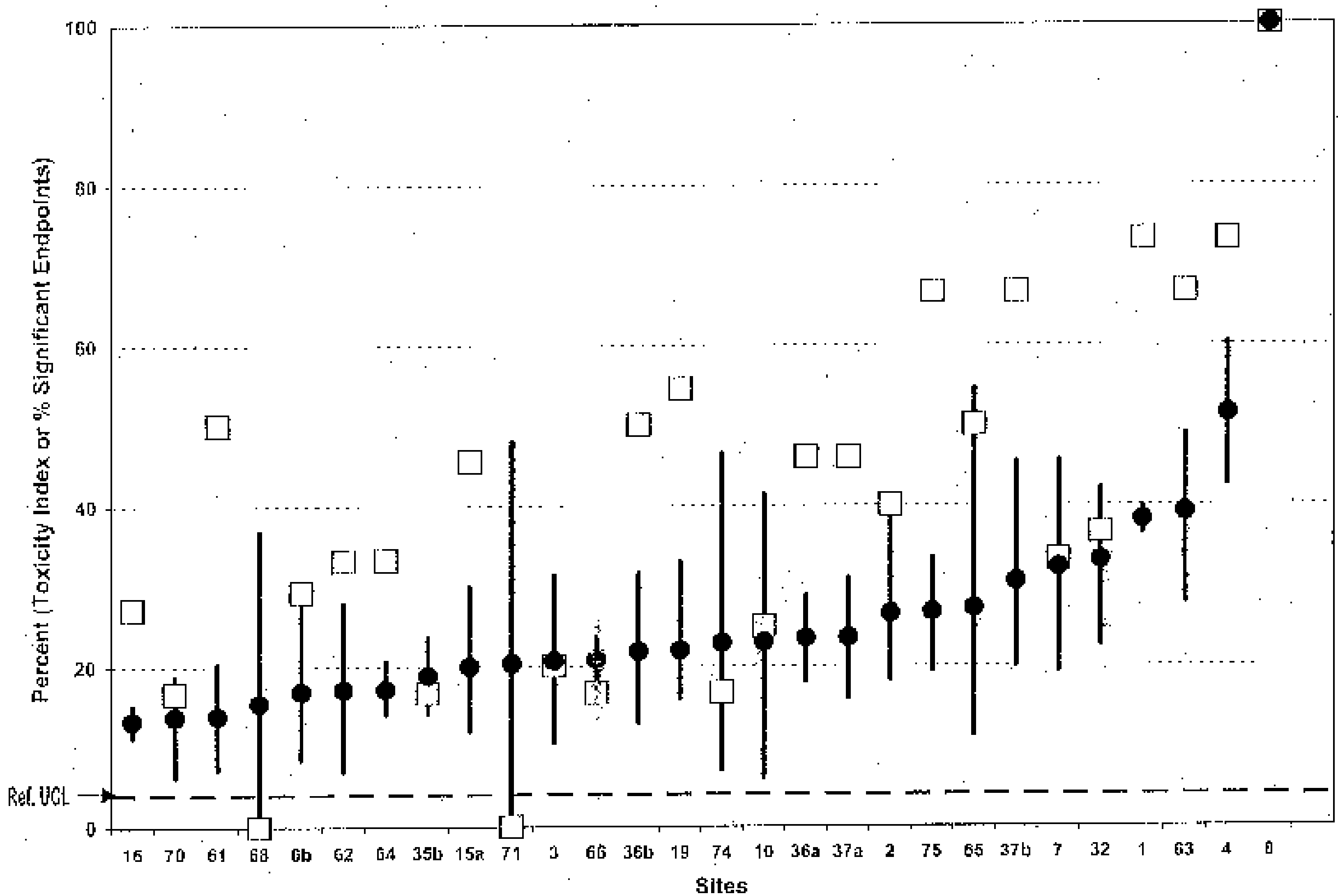
8-87

Figure 6.20b Summary of sediment Toxicity Index results for 1990-1999 (continued). The results are for the middle third of the sites in the data set. The identities of the site numbers are provided in Table 6.2.



8-87

Figure 6.20c Summary of sediment Toxicity Index results for 1990-1999 (continued). The results are for the most toxic third of the sites in the data set. The identities of the site numbers are provided in Table 6.2.



APPENDIX A

Water quality conditions reported in test chambers during all water column tests. Test species were *Cyprinodon variegatus* (Cv) and *Mulinia lateralis* (Ml).

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
9/28/99	Cv	Control	8.1	15	7.90	23.8
		CH-1	7.2	15	7.94	23.8
		CH-2	7.2	15	8.00	23.8
		CH-3	7.6	15	7.80	23.8
		CH-4	7.8	15	7.84	23.8
		CH-5	7.4	15	7.87	23.8
		CH-6	7.2	15	7.82	23.8
		CH-7	7.4	15	7.95	23.8
		CH-8	7.4	15	7.96	23.8
		CH-9	7.4	15	7.80	23.8
		CH-10	7.4	15	7.89	23.8
		RP-1	7.1	15	8.00	23.8
		RP-2	7.8	15	8.00	23.8
		RP-3	7.2	15	7.94	23.8
		RP-4	7.1	15	7.99	23.8
		RP-5	7.4	15	7.98	23.8
		RP-6	7.4	15	7.96	23.8
		RP-7	6.8	15	7.88	23.8
		RP-8	6.8	15	7.99	23.8
		RP-9	7.0	15	7.98	23.8
		RP-10	7.2	15	7.93	23.8
9/29/99	Cv	Control	6.6	15	7.90	24.6
		CH-1	6.8	15	7.98	24.5
		CH-2	6.8	15	7.71	24.4
		CH-3	6.9	15	7.99	24.2
		CH-4	6.8	15	7.59	24.5

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-5	7.0	15	7.99	23.7
		CH-6	6.9	14	7.67	24.6
		CH-7	6.9	15	7.57	24.4
		CH-8	7.1	15	7.58	24.1
		CH-9	7.1	14	7.60	24.1
		CH-10	7.7	14	7.84	24.3
		RP-1	7.2	15	7.87	24.4
		RP-2	7.0	15	8.00	24.2
		RP-3	7.2	15	8.02	24.4
		RP-4	7.3	15	7.80	24.4
		RP-5	7.1	15	8.02	24.3
		RP-6	7.1	15	7.97	24.4
		RP-7	7.2	15	7.84	24.4
		RP-8	7.5	16	7.74	24.2
		RP-9	7.3	15	7.83	24.1
		RP-10	7.1	14	8.01	24.4
9/29/99	Ml	Control	7.2	15	7.98	24.7
		CH-1	7.8	15	7.99	24.1
		CH-2	7.4	15	7.85	24.0
		CH-3	7.4	15	7.84	23.8
		CH-4	7.7	15	7.85	23.8
		CH-5	7.5	15	7.85	23.7
		CH-6	7.4	15	7.86	23.9
		CH-7	7.6	15	7.85	23.8
		CH-8	7.4	15	7.82	24.1
		CH-9	7.7	15	7.82	23.9

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-10	7.6	15	7.90	23.9
		RP-1	7.5	15	7.90	24.4
		RP-2	7.4	15	7.93	24.2
		RP-3	7.3	15	7.94	24.5
		RP-4	7.3	15	7.95	23.8
		RP-5	7.4	15	7.92	24.1
		RP-6	7.4	15	7.91	24.3
		RP-7	7.3	15	7.93	24.0
		RP-8	7.3	16	7.85	24.7
		RP-9	7.6	15	7.83	24.5
		RP-10	7.5	15	7.85	24.2
9/30/99	Cv	Control	6.8	15	7.71	24.2
		CH-1	7.1	15	7.71	24.4
		CH-2	7.0	15	7.65	24.5
		CH-3	6.9	16	7.59	24.4
		CH-4	6.8	15	7.55	24.6
		CH-5	7.1	15	7.63	24.3
		CH-6	6.8	14	7.78	24.6
		CH-7	6.8	14	7.57	24.8
		CH-8	7.1	14	7.59	24.6
		CH-9	7.6	14	7.64	24.8
		CH-10	7.8	14	7.89	24.4
		RP-1	7.5	15	7.89	24.6
		RP-2	7.1	15	7.88	24.4
		RP-3	7.5	15	7.87	24.7
		RP-4	7.6	15	7.85	24.3

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-5	7.4	15	7.83	24.6
		RP-6	7.3	15	7.82	24.6
		RP-7	7.3	15	7.81	24.4
		RP-8	7.7	16	7.85	24.0
		RP-9	7.4	15	7.74	24.3
		RP-10	7.4	15	7.79	24.3
10/1/99	Cv	Control	7.1	15	7.80	-
		CH-1	7.5	15	7.87	-
		CH-2	7.1	15	7.72	-
		CH-3	7.1	16	7.70	-
		CH-4	7.0	15	7.66	-
		CH-5	7.2	15	7.67	-
		CH-6	7.1	15	7.67	-
		CH-7	7.5	15	7.75	-
		CH-8	7.6	15	7.82	-
		CH-9	7.6	15	7.84	-
		CH-10	7.7	15	8.13	-
		RP-1	7.7	16	8.04	-
		RP-2	7.6	15	8.02	-
		RP-3	7.5	16	7.97	-
		RP-4	7.6	15	7.97	-
		RP-5	7.4	15	8.02	-
		RP-6	7.8	15	8.06	-
		RP-7	7.8	15	8.02	-
		RP-8	7.9	16	8.06	-
		RP-9	7.7	16	7.92	-

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-10	7.9	15	8.04	-
10/1/99	Ml	Control	7.0	15	7.89	24.9
		CH-1	7.1	15	7.79	24.5
		CH-2	7.0	15	7.77	24.5
		CH-3	7.4	15	7.76	24.5
		CH-4	7.1	15	7.79	24.5
		CH-5	7.3	14	7.73	24.4
		CH-6	7.1	14	7.74	24.5
		CH-7	7.2	14	7.76	24.5
		CH-8	7.2	14	7.77	24.5
		CH-9	7.2	14	7.81	24.5
		CH-10	7.1	14	7.78	24.4
		RP-1	7.1	15	7.90	24.5
		RP-2	7.1	15	7.95	24.6
		RP-3	7.3	15	7.97	24.7
		RP-4	7.2	14	8.08	24.3
		RP-5	7.2	15	7.93	24.9
		RP-6	7.0	14	7.90	24.8
		RP-7	7.4	15	7.94	24.7
		RP-8	7.4	15	7.90	24.7
		RP-9	7.3	15	7.86	24.8
		RP-10	7.0	15	7.83	24.7
10/2/99	Cv	Control	6.7	15	7.70	25.0
		CH-1	6.9	15	7.74	24.5
		CH-2	6.5	15	7.57	24.5
		CH-3	6.9	15	7.61	24.5

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-4	6.8	15	7.66	24.5
		CH-5	6.7	15	7.72	24.0
		CH-6	6.5	14	7.58	25.0
		CH-7	6.9	15	7.63	24.5
		CH-8	7.2	15	7.75	24.2
		CH-9	7.6	15	7.75	25.0
		CH-10	8.4	15	7.97	24.9
		RP-1	7.0	15	7.77	24.8
		RP-2	7.4	15	7.84	25.0
		RP-3	7.3	15	7.77	24.5
		RP-4	7.1	14	7.74	24.5
		RP-5	7.2	15	7.88	25.0
		RP-6	7.1	15	7.84	24.7
		RP-7	6.9	15	7.83	25.0
		RP-8	7.5	16	7.89	24.5
		RP-9	7.4	15	7.74	24.2
		RP-10	7.3	16	7.84	25.0
10/2/99	Ml	Control	7.4	15	7.81	22.2
		CH-1	7.4	16	7.91	22.8
		CH-2	7.7	15	7.88	22.6
		CH-3	7.6	15	7.80	22.3
		CH-4	7.8	14	7.89	22.7
		CH-5	7.2	15	7.85	22.4
		CH-6	7.6	15	7.86	22.3
		CH-7	7.8	15	7.84	22.5
		CH-8	7.6	16	7.91	22.1

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-9	7.0	15	7.79	22.6
		CH-10	7.2	15	7.86	22.3
		RP-1	7.7	15	7.92	22.6
		RP-2	7.7	15	7.93	22.3
		RP-3	7.9	14	7.85	23.2
		RP-4	7.8	15	7.87	22.6
		RP-5	7.4	15	7.83	22.0
		RP-6	7.6	15	7.91	22.2
		RP-7	7.8	15	7.95	22.4
		RP-8	7.8	16	7.92	22.7
		RP-9	7.7	14	7.86	22.8
		RP-10	7.5	16	7.83	22.8
10/3/99	Cv	Control	6.6	15	7.66	25.3
		CH-1	7.3	15	7.90	25.2
		CH-2	7.1	15	7.67	25.8
		CH-3	6.5	16	7.57	25.0
		CH-4	6.5	15	7.53	25.4
		CH-5	6.6	15	7.66	25.3
		CH-6	6.9	15	7.60	25.4
		CH-7	7.7	15	7.78	25.0
		CH-8	9.7	16	8.30	25.2
		CH-9	9.6	15	8.37	25.6
		CH-10	9.3	15	8.36	25.2
		RP-1	7.4	14	7.78	25.0
		RP-2	7.2	16	7.90	25.3
		RP-3	7.5	16	7.89	25.0

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-4	7.5	15	7.81	-
		RP-5	7.4	15	7.87	25.4
		RP-6	7.3	14	7.86	25.0
		RP-7	7.6	15	7.95	25.7
		RP-8	8.5	16	8.12	25.2
		RP-9	7.6	15	7.84	25.1
		RP-10	7.6	15	7.92	25.3
10/4/99	Cv	Control	6.2	15	7.45	25.0
		CH-1	7.2	15	7.87	25.0
		CH-2	7.0	15	7.67	25.2
		CH-3	6.8	15	7.54	25.0
		CH-4	7.2	15	7.72	25.1
		CH-5	7.3	15	7.64	25.5
		CH-6	-	-	-	-
		CH-7	7.4	15	7.95	25.0
		CH-8	8.0	16	8.30	25.0
		CH-9	8.6	15	8.54	25.0
		CH-10	8.6	15	8.47	25.0
		RP-1	7.1	15	7.81	25.0
		RP-2	7.0	15	7.75	25.1
		RP-3	7.0	15	7.81	25.0
		RP-4	7.1	14	7.73	25.2
		RP-5	7.0	14	7.80	25.0
		RP-6	7.5	15	7.87	25.2
		RP-7	7.5	15	7.90	25.0
		RP-8	8.0	17	8.14	25.1

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-9	7.6	14	7.87	25.0
		RP-10	7.7	16	7.93	25.5
10/4/99	Ml	Control	7.2	14	7.84	24.4
		CH-1	7.4	15	7.95	24.3
		CH-2	7.4	14	7.81	24.3
		CH-3	7.2	15	7.80	24.5
		CH-4	7.2	14	7.90	24.3
		CH-5	7.0	14	7.75	24.6
		CH-6	7.6	14	7.81	24.5
		CH-7	7.1	14	7.80	24.4
		CH-8	7.3	16	7.83	24.4
		CH-9	7.3	15	7.96	24.4
		CH-10	7.3	15	8.14	24.5
		RP-1	7.4	14	8.00	24.3
		RP-2	7.3	15	7.95	24.4
		RP-3	7.1	14	7.90	24.3
		RP-4	7.3	14	8.02	24.4
		RP-5	7.1	14	7.88	24.4
		RP-6	7.3	15	8.02	24.5
		RP-7	7.3	15	8.02	24.1
		RP-8	7.1	14	8.06	24.4
		RP-9	7.2	14	7.91	24.5
		RP-10	7.3	16	8.05	24.2
10/5/99	Cv	Control	6.3	15	7.63	25.7
		CH-1	5.2	15	7.59	25.5
		CH-2	5.2	15	7.49	25.0

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-3	6.1	15	7.53	24.5
		CH-4	7.4	15	7.76	25.3
		CH-5	5.0	15	7.42	25.0
		CH-6	6.8	14	7.75	25.1
		CH-7	8.03	15	8.04	25.0
		CH-8	10.5	15	8.48	25.1
		CH-9	10.2	15	8.58	25.0
		CH-10	9.6	15	8.49	25.0
		RP-1	6.1	15	7.83	25.0
		RP-2	6.5	15	7.72	25.3
		RP-3	5.9	15	7.66	25.0
		RP-4	6.2	14	7.57	25.0
		RP-5	6.1	14	7.73	25.0
		RP-6	6.4	15	7.78	25.6
		RP-7	6.2	15	7.79	25.0
		RP-8	7.1	16	7.86	25.0
		RP-9	6.7	15	7.63	25.0
		RP-10	6.7	15	7.85	26.5
10/5/99	Ml	Control	8.2	15	7.92	25.6
		CH-1	7.7	15	7.78	25.6
		CH-2	7.3	15	7.83	25.6
		CH-3	7.5	15	7.78	25.6
		CH-4	7.7	15	7.90	25.6
		CH-5	7.2	15	7.82	25.6
		CH-6	7.3	15	7.83	25.6
		CH-7	7.7	15	7.74	25.6

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		CH-8	7.2	15	7.85	25.6
		CH-9	7.2	15	7.89	25.6
		CH-10	7.7	15	7.83	25.6
		RP-1	7.2	15	7.94	25.6
		RP-2	7.2	15	7.94	25.6
		RP-3	7.9	15	7.88	25.6
		RP-4	7.8	15	7.86	25.6
		RP-5	7.8	14	7.92	25.6
		RP-6	7.8	15	7.89	25.6
		RP-7	7.2	15	7.90	25.6
		RP-8	7.9	15	7.91	25.6
		RP-9	7.9	15	7.79	25.6
		RP-10	7.8	15	7.79	25.6
10/6/99	Cv	Control	6.4	15	7.57	25.0
		CH-1	7.1	15	7.57	24.8
		CH-2	7.7	15	7.65	24.9
		CH-3	6.8	15	7.67	24.3
		CH-4	8.4	15	8.18	24.9
		CH-5	6.4	15	7.57	25.0
		CH-6	7.6	15	7.86	24.5
		CH-7	7.9	15	7.94	25.0
		CH-8	8.8	15	8.45	24.0
		CH-9	8.5	15	8.35	24.9
		CH-10	8.5	15	8.38	24.5
		RP-1	6.7	15	7.01	25.0
		RP-2	6.6	15	7.66	25.0

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-3	6.6	15	7.63	25.0
		RP-4	7.0	15	7.73	25.2
		RP-5	6.8	15	7.71	24.5
		RP-6	6.6	15	7.70	24.9
		RP-7	7.1	15	7.79	24.5
		RP-8	7.0	15	7.77	25.0
		RP-9	7.2	15	7.75	25.1
		RP-10	7.2	15	7.94	24.9
10/7/99	Ml	Control	7.3	15	8.02	24.0
		CH-1	7.1	15	7.78	24.1
		CH-2	7.1	15	7.78	24.5
		CH-3	7.3	15	7.83	23.8
		CH-4	7.4	15	7.80	24.0
		CH-5	7.2	15	7.86	24.0
		CH-6	7.6	14	7.95	24.6
		CH-7	7.2	15	7.77	24.2
		CH-8	7.5	15	7.89	24.9
		CH-9	7.5	15	7.97	24.9
		CH-10	7.6	14	8.35	24.0
		RP-1	7.1	15	8.02	24.0
		RP-2	7.3	15	7.95	23.9
		RP-3	7.2	15	7.97	23.8
		RP-4	7.5	14	7.96	24.1
		RP-5	7.2	15	7.83	24.3
		RP-6	7.2	14	8.01	23.8
		RP-7	7.2	15	7.86	24.2

Date	Test Species	Station	DO (mg/L)	Salinity (ppt)	pH	Temp. (C)
		RP-8	7.1	14	8.02	23.9
		RP-9	7.4	15	7.94	24.1
		RP-10	7.2	14	7.93	23.8

APPENDIX B

Summary of fish species by station and gear type.
Total abundance for each species at all stations is also presented.

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-1	Alewife	47	
	American eel	1	
	Atlantic menhaden	108	
	Atlantic silverside	215	
	Banded killifish	108	
	Bay anchovy	3	90
	Bluefish	3	
	Gizzard shad	3	
	Mummichog	9	
	Northern pipefish	2	
	Pumpkinseed	4	
	Skillet fish	5	
	Spot	5	
	Striped anchovy	7	
	Striped bass	56	
	Striped killifish	91	
	White perch	136	
CH-2	Atlantic menhaden	52	
	Atlantic silverside	171	
	Banded killifish	13	
	Bay anchovy		172
	Blueback herring		14
	Gizzard shad	4	
	Hickory shad	4	
	Inland silverside	1	
	Mummichog	16	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-2	Pumpkinseed	1	
	Spot	1	
	Striped anchovy	9	
	Striped bass	17	
	Striped killifish	8	
	White perch	264	
	Yellow perch	2	
CH-3	Atlantic menhaden	16	
	Atlantic silverside	158	
	Banded killifish	7	
	Bay anchovy		59
	Bluefish	1	
	Gizzard shad	10	
	Inland silverside	2	
	Mummichog	67	
	Pumpkinseed	1	
	Spot	14	
	Striped anchovy	2	
	Striped bass	22	
	Striped killifish	5	
	White perch	542	1
	Yellow perch	2	
CH-4	Atlantic silverside	237	
	Bay anchovy	1	
	Blueback herring	10	
	Inland silverside	1	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-4	Mummichog	6	
	Spot	2	
	Spottail shiner	3	
	Striped anchovy	5	
	Striped bass	45	
	Striped killifish	86	
	White perch	304	
	Yellow perch	5	
CH-5	Atlantic silverside	106	
	Banded killifish	11	
	Bay anchovy	1	
	Bluefish	1	
	Mummichog	12	
	Sheepshead minnow	1	
	Spot	1	1
	Striped bass	57	
	Striped killifish	182	
	White perch	130	5
CH-6	Atlantic silverside	7	4
	Banded killifish	8	
	Bay anchovy	12	2
	Blueback herring	3	
	Channel catfish	2	
	Hogchoker	2	
	Inland silverside	1	
	Mummichog	133	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-6	Spot	2	
	Spottail shiner	133	
	Striped bass	7	
	Striped killifish	7	
	Tessellated darter	10	
	White perch	212	1
	Yellow perch	12	
CH-7	Alewife	1	
	Atlantic croaker		1
	Atlantic menhaden	42	
	Atlantic silverside	2	
	Banded killifish	11	
	Bay anchovy	1	67
	Blueback herring	6	
	Channel catfish		2
	Gizzard shad	6	
	Hogchoker	1	4
	Mummichog	17	
	Spot	1	
	Spottail shiner	40	
	Striped bass	3	1
	Tessellated darter	2	
	White perch	323	37
	Yellow perch	4	
CH-8	Atlantic silverside	12	
	Banded killifish	13	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-8	Bay anchovy	1	33
	Blueback herring	1	
	Channel catfish	1	
	Hogchoker	3	
	Mummichog	15	
	Spot	4	
	Spottail shiner	70	1
	Striped bass	1	
	Tessellated darter		2
	White perch	279	35
	Yellow perch	2	
CH-9	Atlantic silverside	6	
	Banded killifish	14	
	Bay anchovy	2	13
	Bluegill		1
	Channel catfish	1	1
	Gizzard shad	4	
	Mummichog	9	
	Spot	2	
	Spottail shiner	35	
	Striped anchovy	3	
	Striped bass	14	
	Tessellated darter	17	
	White perch	138	7
CH-10	Alewife	1	
	American eel	4	4

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
CH-10	Atlantic menhaden	9	
	Banded killifish	3	
	Bay anchovy	4	16
	Blueback herring	10	
	Bluegill	5	
	Brown bullhead	1	
	Channel catfish	1	19
	Gizzard shad	10	
	Golden shiner	1	
	Hickory shad	1	
	Hogchoker		3
	Mummichog	2	
	Naked goby		1
	Pumpkinseed	9	
	Spot	10	1
	Spottail shiner	63	
	Striped bass		1
	Tessellated darter	1	
	White catfish	1	
	White perch	273	24
	Yellow perch	20	
RP-1	Atlantic needlefish	1	
	Atlantic silverside	99	
	Bay anchovy	15	270
	Gizzard shad	2	
	Harvestfish		1

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
	Hogchoker		1
	Inshore lizardfish	5	
	Mummichog	1	
	Northern kingfish	1	
	Silver perch		3
	Spot	15	1
	Striped anchovy	5	
	Striped bass	1	
	Striped killifish	2	
	Unidentified Sciaenidae		2
	Weakfish		3
RP-2	American eel	1	
	Atlantic croaker		6
	Atlantic silverside	8	
	Bay anchovy	8	184
	Gizzard shad	3	
	Hogchoker	15	7
	Inshore lizardfish	10	
	Mummichog	4	
	Northern kingfish	1	
	Silver perch	1	
	Skilletfish	45	
	Spot	2	1
	Spotted seatrout	6	
	Striped anchovy	11	
	Striped bass	4	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
RP-2	Striped killifish	41	
	Weakfish		10
	White perch	76	
RP-3	American eel	1	
	Atlantic silverside	6	
	Bay anchovy		76
	Hogchoker	1	4
	Inshore lizardfish	1	
	Pigfish	1	
	Silver perch	2	
	Skillet fish	2	
	Spot	19	1
	Striped anchovy	2	1
	Weakfish		3
	White perch	30	
RP-4	Atlantic croaker	1	
	Atlantic menhaden	4	
	Atlantic silverside	70	
	Bay anchovy	11	854
	Gizzard shad	4	
	Harvestfish		1
	Hogchoker	1	3
	Inshore lizardfish	2	
	Mummichog	12	
	Spot	34	
	Spotted seatrout	1	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
RP-4	Striped anchovy	1	
	Striped bass	1	
	Striped killifish	8	
	Unidentified Sciaenidae		1
	Weakfish		4
	White perch	4	
RP-5	American eel	4	
	Atlantic silverside	16	
	Bay anchovy	38	58
	Blueback herring	1	
	Bluefish	1	
	Gizzard shad	3	
	Hickory shad	1	
	Hogchoker		18
	Naked goby		1
	Mummichog	4	
	Skillet fish	1	
	Spot	10	4
	Unidentified Sciaenidae		3
	Weakfish		2
	White perch	30	3
RP-6	Atlantic croaker	13	
	Atlantic silverside	21	
	Atlantic stingray	1	
	Bay anchovy	124	133
	Bluefish	2	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
Ch-6	Hogchoker		1
	Gizzard shad	1	
	Mummichog	2	
	Rough silverside	3	
	Spanish mackerel	1	
	Spot	25	
	Striped anchovy	3	
	Striped bass	2	
	Summer flounder	1	
	Unidentified Sciaenidae	3	
	Weakfish	2	
	White perch	10	
Ch-7	Atlantic croaker	10	
	Atlantic needlefish	4	
	Atlantic silverside	8	
	Bay anchovy	16	17
	Blackcheek tonguefish		1
	Gizzard shad	2	1
	Harvestfish	1	
	Hogchoker		1
	Inshore lizardfish	1	
	Rough silverside	2	
	Skillet fish		1
	Spanish mackerel	1	
	Spot	31	
	Striped anchovy	3	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
RP-7	Striped bass	15	
	Summer flounder	1	
	White perch	10	1
RP-8	Alewife		1
	Atlantic croaker	7	2
	Atlantic menhaden	1	1
	Atlantic silverside	25	
	Bay anchovy	23	326
	Blue catfish	1	
	Channel catfish	1	
	Gizzard shad	4	
	Harvestfish	2	3
	Hickory shad	1	
	Horse-eye jack	1	
	Mummichog	1	
	Rough silverside	2	
	Spot	33	2
	Spotted seatrout	1	
	Striped anchovy	5	2
	Striped bass	13	
	Unidentified Sciaenidae	1	2
	Weakfish		6
	White perch	1	
RP-9	American eel	2	
	Atlantic croaker	17	1
	Atlantic menhaden	97	

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
RP-9	Atlantic silverside	31	
	Bay anchovy	21	598
	Blue catfish	23	
	Blueback herring	12	
	Channel catfish	4	
	Gizzard shad	5	
	Harvestfish	2	
	Hickory shad	1	
	Hogchoker	1	4
	Mummichog	5	
	Silver perch	4	
	Spot	30	
	Striped anchovy	2	2
	Striped bass	24	
	Unidentified Sciaenidae	3	
	Weakfish		2
	White perch	100	2
RP-10	Atlantic croaker	7	4
	Atlantic menhaden	6	
	Atlantic silverside	34	
	Bay anchovy	12	140
	Blue catfish	16	6
	Channel catfish	5	
	Gizzard shad	7	
	Hogchoker	1	63
	Naked goby		1

STATION	SPECIES	SEINE CATCH	TRAWL CATCH
RP-10	Pumpkinseed	1	
	Silver perch	3	
	Silvery minnow	1	
	Spot	5	2
	Spottail shiner	12	
	Spotted seatrout	1	
	Striped anchovy	2	6
	Striped bass	2	
	Unidentified Sciaenidae	3	10
	Weakfish		1
	White perch	100	43

APPENDIX C

Water quality measurements, sediment composition, species abundances, species biomass, and B-IBI metric values and scores for each site.

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: CH01

Watershed: Chester River	Habitat: High Mesohaline Sand	Date: September 7, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 15:13

BOTTOM ENVIRONMENT

Depth (m): 5.5	Salinity (ppt): 15.28	Temperature (C): 23.66
Dissolved Oxygen (mg/l): 5.35	Sediment Silt-Clay (%): 25.47	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.67   Condition: Meets Goal   # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.42	1	Pollution Indicative Species Abundance (%)	6.00	5
Abundance (#/m2)	3409	3	Pollution Indicative Species Biomass (%)	0.73	
Biomass (g/m2)	3.47	5	Pollution Sensitive Species Abundance (%)	18.67	3
Carnivore-Omnivore Abundance (%)	37.33	5	Pollution Sensitive Species Biomass (%)	23.20	
Deep Deposit Feeder Abundance (%)	50.67				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Heteromastus filiformis	1659	1659.1		1659	1659	48.0
Neanthes succinea	614	613.6		614	614	65.8
Glycinde solitaria	477	477.3		477	477	79.6
Carinoma tremaphoros	114	113.6		114	114	82.9
Macoma mitchelli	114	113.6		114	114	86.2
Mulinia lateralis	114	113.6		114	114	89.5
Macoma balthica	91	90.9		91	91	92.1
Cyathura polita	45	45.5		45	45	93.4
Imm. Tubificid w/o Cap. Chaete	45	45.5		45	45	94.7
Mysidae (Epi)	45	45.5		45	45	96.1

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	45	45.5		45	45	97.4
Gemma gemma	23	22.7		23	23	98.0
Marenzelleria viridis	23	22.7		23	23	98.7
Parahesione luteola	23	22.7		23	23	99.3
Tubificoides spp.	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	3455	3454.5		3455	3455	
Total Abundance w/o Epifauna	3409	3409.1		3409	3409	
Number of Taxa w/ Epifauna	15	15.0		15	15	
Number of Taxa w/o Epifauna	14	14.0		14	14	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Carinoma tremaphoros	1.4007	1.4007		1.4007	1.4007	39.3
Neanthes succinea	1.2236	1.2236		1.2236	1.2236	73.7
Marenzelleria viridis	0.4945	0.4945		0.4945	0.4945	87.6
Glycinde solitaria	0.1311	0.1311		0.1311	0.1311	91.2
Macoma balthica	0.1035	0.1035		0.1035	0.1035	94.2
Mysidae (Epi)	0.0874	0.0871		0.0874	0.0874	96.6
Cyathura polita	0.0759	0.0759		0.0759	0.0759	98.7
Mulinia lateralis	0.0230	0.0230		0.0230	0.0230	99.4
Heteromastus filiformis	0.0092	0.0092		0.0092	0.0092	99.6
Parahesione luteola	0.0046	0.0046		0.0046	0.0046	99.7
Macoma mitchelli	0.0023	0.0023		0.0023	0.0023	99.8
Streblospio benedicti	0.0023	0.0023		0.0023	0.0023	99.8
Gemma gemma	0.0012	0.0012		0.0012	0.0012	99.9
Oligochaeta	0.0012	0.0012		0.0012	0.0012	99.9

Continued . .

BENTHIC BIOMASS (Grams per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Tubificoides spp.	0.0012	0.0012		0.0012	0.0012	100.0
Total Biomass w/ Epifauna	3.5616	3.5616		3.5616	3.5616	
Total Biomass w/o Epifauna	3.4742	3.4742		3.4742	3.4742	

* Indicates species is skipped in species counts

Station: CH02

Watershed: Chester River	Habitat: High Mesohaline Sand	Date: September 7, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 15:36

BOTTOM ENVIRONMENT

Depth (m): 5.0	Salinity (ppt): 13.53	Temperature (C): 24.02
Dissolved Oxygen (mg/l): 6.59	Sediment Silt-Clay (%): 32.60	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.67 — Condition: Degraded — # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	3.17	3	Pollution Indicative Species Abundance (%)	27.66	1
Abundance (#/m2)	1068	3	Pollution Indicative Species Biomass (%)	5.53	
Biomass (g/m2)	0.70	1	Pollution Sensitive Species Abundance (%)	23.40	3
Carnivore-Omnivore Abundance (%)	40.43	5	Pollution Sensitive Species Biomass (%)	61.14	
Deep Deposit Feeder Abundance (%)	29.79				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Tubificoides spp.	227	227.3		227	227	21.3
Cyathura polita	182	181.8		182	182	38.3
Streblospio benedicti	182	181.8		182	182	55.3
Carinoma tremaphoros	114	113.6		114	114	66.0
Glycinde solitaria	68	68.2		68	68	72.3
Macoma mitchelli	68	68.2		68	68	78.7
Heteromastus filiformis	45	45.5		45	45	83.0
Imm. Tubificid w/o Cap. Chaete	45	45.5		45	45	87.2
Mulinia lateralis	45	45.5		45	45	91.5
Amphiporus bioculatus	23	22.7		23	23	93.6

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	23	22.7		23	23	95.7
Parahesione luteola	23	22.7		23	23	97.9
Paraprionospio pinnata	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	1068	1068.2		1068	1068	
Total Abundance w/o Epifauna	1068	1068.2		1068	1068	
Number of Taxa w/ Epifauna	13	13.0		13	13	
Number of Taxa w/o Epifauna	13	13.0		13	13	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Cyathura polita	0.4136	0.4136		0.4136	0.4136	59.2
Carinoma tremaphoros	0.0818	0.0818		0.0818	0.0818	70.9
Neanthes succinea	0.0545	0.0545		0.0545	0.0545	78.7
Macoma mitchelli	0.0500	0.0500		0.0500	0.0500	85.9
Heteromastus filiformis	0.0250	0.0250		0.0250	0.0250	89.4
Paraprionospio pinnata	0.0182	0.0182		0.0182	0.0182	92.0
Glycinde solitaria	0.0136	0.0136		0.0136	0.0136	94.0
Streblospio benedicti	0.0114	0.0114		0.0114	0.0114	95.6
Mulinia lateralis	0.0091	0.0091		0.0091	0.0091	96.9
Tubificoides spp.	0.0091	0.0091		0.0091	0.0091	98.2
Parahesione luteola	0.0068	0.0068		0.0068	0.0068	99.2
Amphiporus bioculatus	0.0045	0.0045		0.0045	0.0045	99.8
Oligochaeta	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	0.6989	0.6989		0.6989	0.6989	
Total Biomass w/o Epifauna	0.6989	0.6989		0.6989	0.6989	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)

AMBIENT TOXICITY SITES

Station: CH03

Watershed: Chester River	Habitat: High Mesohaline Mud	Date: September 7, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 16:09

BOTTOM ENVIRONMENT

Depth (m): 4.0	Salinity (ppt): 13.32	Temperature (C): 24.78
Dissolved Oxygen (mg/l): 7.41	Sediment Silt-Clay (%): 87.04	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 5.00 | Condition: Meets Goal | # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	3.26	5	Pollution Indicative Species Abundance (%)	24.72	
Abundance (#/m2)	2023	5	Pollution Indicative Species Biomass (%)	0.40	5
Biomass (g/m2)	7.96	5	Pollution Sensitive Species Abundance (%)	16.85	
Carnivore-Omnivore Abundance (%)	40.45	5	Pollution Sensitive Species Biomass (%)	89.18	5
Deep Deposit Feeder Abundance (%)	14.61				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	455	454.5		455	455	21.5
Macoma mitchelli	295	295.5		295	295	35.5
Streblospio benedicti	250	250.0		250	250	47.3
Tubificoides spp.	205	204.5		205	205	57.0
Mulinia lateralis	182	181.8		182	182	65.6
Cyathura polita	159	159.1		159	159	73.1
Carinoma tremaphoros	136	136.4		136	136	79.6
Edotea triloba (Epi)	91	90.9		91	91	83.9
Heteromastus filiformis	91	90.9		91	91	88.2
Macoma balthica	91	90.9		91	91	92.5

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Hypereteone heteropoda	68	68.2		68	68	95.7
Marenzelleria viridis	68	68.2		68	68	98.9
Rangia cuneata	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	2114	2113.6		2114	2114	
Total Abundance w/o Epifauna	2023	2022.7		2023	2023	
Number of Taxa w/ Epifauna	13	13.0		13	13	
Number of Taxa w/o Epifauna	12	12.0		12	12	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	5.2204	5.2204		5.2204	5.2204	65.5
Macoma balthica	1.4477	1.4477		1.4477	1.4477	83.6
Neanthes succinea	0.6636	0.6636		0.6636	0.6636	92.0
Cyathura polita	0.3000	0.3000		0.3000	0.3000	95.7
Marenzelleria viridis	0.1341	0.1341		0.1341	0.1341	97.4
Heteromastus filiformis	0.0614	0.0614		0.0614	0.0614	98.2
Macoma mitchelli	0.0568	0.0568		0.0568	0.0568	98.9
Carinoma tremaphoros	0.0432	0.0432		0.0432	0.0432	99.4
Mulinia lateralis	0.0159	0.0159		0.0159	0.0159	99.6
Streblospio benedicti	0.0114	0.0114		0.0114	0.0114	99.8
Edotea triloba (Epi)	0.0091	0.0091		0.0091	0.0091	99.9
Tubificoides spp.	0.0045	0.0045		0.0045	0.0045	99.9
Hypereteone heteropoda	0.0045	0.0045		0.0045	0.0045	100.0
Total Biomass w/ Epifauna	7.9727	7.9727		7.9727	7.9727	
Total Biomass w/o Epifauna	7.9636	7.9636		7.9636	7.9636	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: CH04

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 9:48

BOTTOM ENVIRONMENT

Depth (m): 3.5	Salinity (ppt): 11.09	Temperature (C): 25.19
Dissolved Oxygen (mg/l): 5.74	Sediment Silt-Clay (%): 70.22	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.80 | Condition: Meets Goal | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	2.38	3	Pollution Indicative Species Abundance (%)	25.61	1
Abundance (#/m2)	1864	5	Pollution Indicative Species Biomass (%)	0.53	
Biomass (g/m2)	7.26	5	Pollution Sensitive Species Abundance (%)	8.54	
Carnivore-Omnivore Abundance (%)	21.95		Pollution Sensitive Species Biomass (%)	98.53	5
Deep Deposit Feeder Abundance (%)	31.71				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Tubificoides spp.	591	590.9		591	591	29.9
Leptocheirus plumulosus	568	568.2		568	568	58.6
Streblospio benedicti	250	250.0		250	250	71.3
Coelotanypus spp.	227	227.3		227	227	82.8
Cyathura polita	114	113.6		114	114	88.5
Edotea triloba (Epi)	91	90.9		91	91	93.1
Neanthes succinea	68	68.2		68	68	96.6
Macoma balthica	23	22.7		23	23	97.7
Melita nitida (Epi)	23	22.7		23	23	98.9

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	1977	1977.3		1977	1977	
Total Abundance w/o Epifauna	1864	1863.6		1864	1864	
Number of Taxa w/ Epifauna	10	10.0		10	10	
Number of Taxa w/o Epifauna	8	8.0		8	8	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	6.9273	6.9273		6.9273	6.9273	95.4
Cyathura polita	0.1818	0.1818		0.1818	0.1818	97.9
Leptocheirus plumulosus	0.0591	0.0591		0.0591	0.0591	98.7
Macoma balthica	0.0432	0.0432		0.0432	0.0432	99.3
Coelotanypus spp.	0.0273	0.0273		0.0273	0.0273	99.6
Streblospio benedicti	0.0114	0.0114		0.0114	0.0114	99.8
Edotea triloba (Epi)	0.0045	0.0045		0.0045	0.0045	99.9
Neanthes succinea	0.0045	0.0045		0.0045	0.0045	99.9
Tubificoides spp.	0.0045	0.0045		0.0045	0.0045	100.0
Melita nitida (Epi)	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	7.2647	7.2647		7.2647	7.2647	
Total Biomass w/o Epifauna	7.2591	7.2591		7.2591	7.2591	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: CH05

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 10:00

BOTTOM ENVIRONMENT

Depth (m): 2.9	Salinity (ppt): 10.60	Temperature (C): 25.37
Dissolved Oxygen (mg/l): 5.73	Sediment Silt-Clay (%): 95.66	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.00 Condition: Meets Goal # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	2.63	5	Pollution Indicative Species Abundance (%)	21.82	1
Abundance (#/m2)	1250	3	Pollution Indicative Species Biomass (%)	0.00	
Biomass (g/m2)	33.70	1	Pollution Sensitive Species Abundance (%)	41.82	
Carnivore-Omnivore Abundance (%)	23.64		Pollution Sensitive Species Biomass (%)	99.91	5
Deep Deposit Feeder Abundance (%)	21.82				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	318	318.2		318	318	25.5
Streblospio benedicti	273	272.7		273	273	47.3
Tubificoides spp.	273	272.7		273	273	69.1
Cyathura polita	182	181.8		182	182	83.6
Neanthes succinea	91	90.9		91	91	90.9
Ameroculodes species complex	45	45.5		45	45	94.5
Amphiporus bioculatus	23	22.7		23	23	96.4
Leptocheirus plumulosus	23	22.7		23	23	98.2

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Marenzelleria viridis	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	1250	1250.0		1250	1250	
Total Abundance w/o Epifauna	1250	1250.0		1250	1250	
Number of Taxa w/ Epifauna	9	9.0		9	9	
Number of Taxa w/o Epifauna	9	9.0		9	9	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	33.5044	33.5044		33.5044	33.5044	99.4
Marenzelleria viridis	0.1659	0.1659		0.1659	0.1659	99.9
Neanthes succinea	0.0250	0.0250		0.0250	0.0250	100.0
Ameroculodes species complex	0.0011	0.0011		0.0011	0.0011	100.0
Amphiporus bioculatus	0.0011	0.0011		0.0011	0.0011	100.0
Cyathura polita	0.0011	0.0011		0.0011	0.0011	100.0
Leptocheirus plumulosus	0.0011	0.0011		0.0011	0.0011	100.0
Streblospio benedicti	0.0011	0.0011		0.0011	0.0011	100.0
Tubificoides spp.	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	33.7022	33.7022		33.7022	33.7022	
Total Biomass w/o Epifauna	33.7022	33.7022		33.7022	33.7022	

* Indicates species is skipped in species counts

Station: CH06

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 10:13

BOTTOM ENVIRONMENT

Depth (m): 2.0	Salinity (ppt): 8.90	Temperature (C): 25.55
Dissolved Oxygen (mg/l): 5.35	Sediment Silt-Clay (%): 92.95	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.40 | Condition: Meets Goal | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	2.07	3	Pollution Indicative Species Abundance (%)	17.27	3
Abundance (#/m2)	2500	5	Pollution Indicative Species Biomass (%)	0.03	
Biomass (g/m2)	62.54	1	Pollution Sensitive Species Abundance (%)	64.55	
Carnivore-Omnivore Abundance (%)	25.45		Pollution Sensitive Species Biomass (%)	99.91	5
Deep Deposit Feeder Abundance (%)	3.64				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	1545	1545.4		1545	1545	59.1
Coelotanypus spp.	273	272.7		273	273	69.6
Carinoma tremaphoros	182	181.8		182	182	76.5
Streblospio benedicti	159	159.1		159	159	82.6
Edotea triloba (Epi)	114	113.6		114	114	87.0
Neanthes succinea	91	90.9		91	91	90.4
Tubificoides spp.	91	90.9		91	91	93.9
Cyathura polita	45	45.5		45	45	95.7
Ameroculodes species complex	23	22.7		23	23	96.5
Chiridotea almyra	23	22.7		23	23	97.4

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Laeonereis culveri	23	22.7		23	23	98.3
Marenzelleria viridis	23	22.7		23	23	99.1
Polydora cornuta	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	2614	2613.6		2614	2614	
Total Abundance w/o Epifauna	2500	2500.0		2500	2500	
Number of Taxa w/ Epifauna	13	13.0		13	13	
Number of Taxa w/o Epifauna	12	12.0		12	12	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	62.4816	62.4816		62.4816	62.4816	99.9
Carinoma tremaphoros	0.0227	0.0227		0.0227	0.0227	99.9
Coelotanypus spp.	0.0205	0.0205		0.0205	0.0205	100.0
Polydora cornuta	0.0068	0.0068		0.0068	0.0068	100.0
Ameroculodes species complex	0.0011	0.0011		0.0011	0.0011	100.0
Chiridotea almyra	0.0011	0.0011		0.0011	0.0011	100.0
Cyathura polita	0.0011	0.0011		0.0011	0.0011	100.0
Edotea triloba (Epi)	0.0011	0.0011		0.0011	0.0011	100.0
Laeonereis culveri	0.0011	0.0011		0.0011	0.0011	100.0
Marenzelleria viridis	0.0011	0.0011		0.0011	0.0011	100.0
Neanthes succinea	0.0011	0.0011		0.0011	0.0011	100.0
Streblospio benedicti	0.0011	0.0011		0.0011	0.0011	100.0
Tubificoides spp.	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	62.5418	62.5418		62.5418	62.5418	
Total Biomass w/o Epifauna	62.5407	62.5407		62.5407	62.5407	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: CH07

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 10:30

BOTTOM ENVIRONMENT

Depth (m): 2.3	Salinity (ppt): 7.67	Temperature (C): 25.37
Dissolved Oxygen (mg/l): 5.75	Sediment Silt-Clay (%): 92.68	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.40 | Condition: Meets Goal | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	2.73	5	Pollution Indicative Species Abundance (%)	24.56	1
Abundance (#/m2)	1295	3	Pollution Indicative Species Biomass (%)	0.07	
Biomass (g/m2)	12.90	3	Pollution Sensitive Species Abundance (%)	8.77	
Carnivore-Omnivore Abundance (%)	12.28		Pollution Sensitive Species Biomass (%)	99.17	5
Deep Deposit Feeder Abundance (%)	21.05				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus	364	363.6		364	364	27.6
Streblospio benedicti	318	318.2		318	318	51.7
Tubificoides spp.	273	272.7		273	273	72.4
Carinoma tremaphoros	91	90.9		91	91	79.3
Polydora cornuta	68	68.2		68	68	84.5
Cyathura polita	45	45.5		45	45	87.9
Hobsonia florida	45	45.5		45	45	91.4
Chiridotea almyra	23	22.7		23	23	93.1
Gammarus daiberi (Epi)	23	22.7		23	23	94.8
Macoma balthica	23	22.7		23	23	96.6

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Marenzelleria viridis	23	22.7		23	23	98.3
Rangia cuneata	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	1318	1318.2		1318	1318	
Total Abundance w/o Epifauna	1295	1295.5		1295	1295	
Number of Taxa w/ Epifauna	12	12.0		12	12	
Number of Taxa w/o Epifauna	11	11.0		11	11	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	12.6091	12.6091		12.6091	12.6091	97.7
Macoma balthica	0.0864	0.0864		0.0864	0.0864	98.4
Marenzelleria viridis	0.0705	0.0705		0.0705	0.0705	98.9
Leptocheirus plumulosus	0.0409	0.0409		0.0409	0.0409	99.3
Carinoma tremaphoros	0.0364	0.0364		0.0364	0.0364	99.5
Cyathura polita	0.0250	0.0250		0.0250	0.0250	99.7
Hobsonia florida	0.0091	0.0091		0.0091	0.0091	99.8
Streblospio benedicti	0.0091	0.0091		0.0091	0.0091	99.9
Tubificoides spp.	0.0068	0.0068		0.0068	0.0068	99.9
Gammarus spp. (Epi)	0.0045	0.0045		0.0045	0.0045	100.0
Chiridotea almyra	0.0023	0.0023		0.0023	0.0023	100.0
Polydora cornuta	0.0023	0.0023		0.0023	0.0023	100.0
Total Biomass w/ Epifauna	12.9022	12.9022		12.9022	12.9022	
Total Biomass w/o Epifauna	12.8977	12.8977		12.8977	12.8977	

* Indicates species is skipped in species counts

Station: CH08

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 10:43

BOTTOM ENVIRONMENT

Depth (m): 2.6	Salinity (ppt): 6.57	Temperature (C): 25.26
Dissolved Oxygen (mg/l): 5.42	Sediment Silt-Clay (%): 95.28	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.00 Condition: Meets Goal # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	1.92	3	Pollution Indicative Species Abundance (%)	44.58	1
Abundance (#/m2)	3773	3	Pollution Indicative Species Biomass (%)	0.22	
Biomass (g/m2)	19.85	3	Pollution Sensitive Species Abundance (%)	2.41	
Carnivore-Omnivore Abundance (%)	2.41		Pollution Sensitive Species Biomass (%)	99.30	5
Deep Deposit Feeder Abundance (%)	38.55				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	1545	1545.4		1545	1545	41.0
Tubificoides spp.	1364	1363.6		1364	1364	77.1
Leptocheirus plumulosus	591	590.9		591	591	92.8
Imm. Tubificid w/ Cap. Chaete	91	90.9		91	91	95.2
Rangia cuneata	68	68.2		68	68	97.0
Coelotanypus spp.	45	45.5		45	45	98.2
Carinoma tremaphoros	23	22.7		23	23	98.8
Cyathura polita	23	22.7		23	23	99.4

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Polydora cornuta	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	3773	3772.7		3773	3773	
Total Abundance w/o Epifauna	3773	3772.7		3773	3773	
Number of Taxa w/ Epifauna	9	9.0		9	9	
Number of Taxa w/o Epifauna	9	9.0		9	9	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	19.7068	19.7068		19.7068	19.7068	99.3
Leptocheirus plumulosus	0.0750	0.0750		0.0750	0.0750	99.6
Streblospio benedicti	0.0341	0.0341		0.0341	0.0341	99.8
Tubificoides spp.	0.0114	0.0114		0.0114	0.0114	99.9
Coelotanypus spp.	0.0091	0.0091		0.0091	0.0091	99.9
Cyathura polita	0.0091	0.0091		0.0091	0.0091	100.0
Carinoma tremaphoros	0.0068	0.0068		0.0068	0.0068	100.0
Oligochaeta	0.0011	0.0011		0.0011	0.0011	100.0
Polydora cornuta	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	19.8545	19.8545		19.8545	19.8545	
Total Biomass w/o Epifauna	19.8545	19.8545		19.8545	19.8545	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: CH09

Watershed: Chester River	Habitat: Low Mesohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 11:51

BOTTOM ENVIRONMENT

Depth (m): 2.6	Salinity (ppt): 5.85	Temperature (C): 25.11
Dissolved Oxygen (mg/l): 5.07	Sediment Silt-Clay (%): 95.76	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 1.80 | Condition: Severely Degraded | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	0.97	1	Pollution Indicative Species Abundance (%)	89.62	1
Abundance (#/m2)	2409	5	Pollution Indicative Species Biomass (%)	70.80	
Biomass (g/m2)	0.13	1	Pollution Sensitive Species Abundance (%)	0.00	
Carnivore-Omnivore Abundance (%)	0.94		Pollution Sensitive Species Biomass (%)	0.00	1
Deep Deposit Feeder Abundance (%)	9.43				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	1977	1977.3		1977	1977	81.3
Imm. Tubificid w/ Cap. Chaete	182	181.8		182	182	88.8
Leptocheirus plumulosus	182	181.8		182	182	96.3
Tubificoides spp.	45	45.5		45	45	98.1
Carinoma tremaphoros	23	22.7		23	23	99.1
Gammarus daiberi (Epi)	23	22.7		23	23	100.0
Total Abundance w/ Epifauna	2432	2431.8		2432	2432	
Total Abundance w/o Epifauna	2409	2409.1		2409	2409	
Number of Taxa w/ Epifauna	6	6.0		6	6	
Number of Taxa w/o Epifauna	5	5.0		5	5	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	0.0909	0.0909		0.0909	0.0909	70.2
Leptocheirus plumulosus	0.0341	0.0341		0.0341	0.0341	96.5
Carinoma tremaphoros	0.0011	0.0011		0.0011	0.0011	97.4
Gammarus daiberi (Epi)	0.0011	0.0011		0.0011	0.0011	98.2
Oligochaeta	0.0011	0.0011		0.0011	0.0011	99.1
Tubificoides spp.	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	0.1295	0.1295		0.1295	0.1295	
Total Biomass w/o Epifauna	0.1284	0.1284		0.1284	0.1284	

* Indicates species is skipped in species counts

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (CRUISE 1: 1999/2000)
FIXED SITES

Station: CH10

Watershed: Chester River	Habitat: Oligohaline	Date: September 15, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 11:28

BOTTOM ENVIRONMENT

Depth (m): 3.2	Salinity (ppt): 4.07	Temperature (C): 24.41
Dissolved Oxygen (mg/l): 6.46	Sediment Silt-Clay (%): 85.83	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.60 | Condition: Degraded | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	0.45		Oligohaline Pollution Indicative Spp. Abund.	95.85	1
Abundance (#/m2)	4386		Tolerance Score	9.40	3
Deep Deposit Feeder Abundance (%)	1.04		Oligohaline Pollution Sensitive Spp. Abund.	1.55	3
Carnivore-Omnivore Abundance (%)	0.00	1	Tanypodinae/Chironomidae Abundance Ratio	0.00	5

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	4114	4113.6		4114	4114	90.5
Apocorophium lacustre (Epi)	159	159.1		159	159	94.0
Hobsonia florida	114	113.6		114	114	96.5
Marenzelleria viridis	68	68.2		68	68	98.0
Imm. Tubificid w/ Cap. Chaete	45	45.5		45	45	99.0
Polydora cornuta	45	45.5		45	45	100.0
Total Abundance w/ Epifauna	4545	4545.4		4545	4545	
Total Abundance w/o Epifauna	4386	4386.3		4386	4386	
Number of Taxa w/ Epifauna	6	6.0		6	6	
Number of Taxa w/o Epifauna	5	5.0		5	5	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (CRUISE 1: 1999/2000)

FIXED SITES (Station: CH10 Contd.)

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	0.1591	0.1591		0.1591	0.1591	52.0
Marenzelleria viridis	0.1409	0.1409		0.1409	0.1409	98.1
Hobsonia florida	0.0023	0.0023		0.0023	0.0023	98.9
Apocorophium lacustre (Epi)	0.0011	0.0011		0.0011	0.0011	99.3
Oligochaeta	0.0011	0.0011		0.0011	0.0011	99.6
Polydora cornuta	0.0011	0.0011		0.0011	0.0011	100.0
Total Biomass w/ Epifauna	0.3057	0.3057		0.3057	0.3057	
Total Biomass w/o Epifauna	0.3045	0.3045		0.3045	0.3045	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA01

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 11, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 14:42

BOTTOM ENVIRONMENT

Depth (m): 2.0	Salinity (ppt): 16.9	Temperature (C): 30.4
Dissolved Oxygen (mg/l): 6.4	Sediment Silt-Clay (%): 92.4	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.67	Condition: Degraded	# Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.88	3	Pollution Indicative Species Abundance (%)	40.55	
Abundance (#/m2)	1159	3	Pollution Indicative Species Biomass (%)	43.33	1
Biomass (g/m2)	0.52	3	Pollution Sensitive Species Abundance (%)	8.07	
Carnivore-Omnivore Abundance (%)	35.56	5	Pollution Sensitive Species Biomass (%)	8.77	1
Deep Deposit Feeder Abundance (%)	17.41				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Mulinia lateralis	364	68	295	242.4	154.70	68	364	20.9
Rictaxis punctostriatus	386	23	295	234.8	189.24	23	386	41.2
Paraprionospio pinnata	159	182	250	197.0	47.31	159	250	58.2
Tubificoides heterochaetus	250	159	136	181.8	60.13	136	250	73.9
Leucon americanus	91	45	68	68.2	22.73	45	91	79.7
Neanthes succinea	45	114	45	68.2	39.36	45	114	85.6
Glycinde solitaria	23	68	68	53.0	26.24	23	68	90.2
Acteocina canaliculata	68		45	37.9	34.72	0	68	93.5
Streblospio benedicti	45	23	45	37.9	13.12	23	45	96.7
Podarkeopsis levifuscina		23	23	15.2	13.12	0	23	98.0
Leitoscoloplos spp.		23		7.6	13.12	0	23	98.7
Macoma mitchelli			23	7.6	13.12	0	23	99.3

BENTHIC ABUNDANCE (Grams per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Parahesione luteola		23		7.6	13.12	0		
Total Abundance w/ Epifauna	1432	750	1295	1159.1	360.78	750	1432	
Total Abundance w/o Epifauna	1432	750	1295	1159.1	360.78	750	1432	
Number of Taxa w/ Epifauna	9	11	11	10.3	1.15	9	11	
Number of Taxa w/o Epifauna	9	11	11	10.3	1.15	9	11	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	0.1136	0.2727	0.0227	0.1364	0.1265	0.0227	0.2727	26.1
Paraprionospio pinnata	0.0909	0.0909	0.2045	0.1288	0.0656	0.0909	0.2045	50.7
Mulinia lateralis	0.1591	0.0227	0.0227	0.0682	0.0787	0.0227	0.1591	63.8
Glycinde solitaria	0.0227	0.0455	0.0227	0.0303	0.0131	0.0227	0.0455	69.6
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	73.9
Rictaxis punctostriatus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	78.3
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	82.6
Tubificoides heterochaetus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	87.0
Macoma mitchelli			0.0682	0.0227	0.0394	0.0000	0.0682	91.3
Acteocina canaliculata	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	94.2
Podarkeopsis levifuscina		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	97.1
Leitoscoloplos spp.		0.0227		0.0076	0.0131	0.0000	0.0227	98.6
Parahesione luteola		0.0227		0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.5000	0.5909	0.4773	0.5227	0.0601	0.4773	0.5909	
Total Biomass w/o Epifauna	0.5000	0.5909	0.4773	0.5227	0.0601	0.4773	0.5909	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA02

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 11, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 12:18

BOTTOM ENVIRONMENT

Depth (m): 3.0	Salinity (ppt): 16.9	Temperature (C): 29.0
Dissolved Oxygen (mg/l): 6.3	Sediment Silt-Clay (%): 96.8	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.33 | Condition: Degraded | # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.14	3	Pollution Indicative Species Abundance (%)	20.20	
Abundance (#/m2)	2545	3	Pollution Indicative Species Biomass (%)	21.55	3
Biomass (g/m2)	0.45	1	Pollution Sensitive Species Abundance (%)	2.25	
Carnivore-Omnivore Abundance (%)	11.22	3	Pollution Sensitive Species Biomass (%)	5.57	1
Deep Deposit Feeder Abundance (%)	62.21				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	773	1795	2023	1530.3	665.85	773	2023	60.1
Streblospio benedicti	205	295	477	325.8	138.87	205	477	72.9
Neanthes succinea	68	205	182	151.5	73.06	68	205	78.9
Leucon americanus	114	182	136	143.9	34.72	114	182	84.5
Mulinia lateralis	68	91	136	98.5	34.72	68	136	88.4
Paraprionospio pinnata	91	45	68	68.2	22.73	45	91	91.1
Heteromastus filiformis		114	68	60.6	57.20	0	114	93.5
Glycinde solitaria	45	45	68	53.0	13.12	45	68	95.5
Nemertinea	23		68	30.3	34.72	0	68	96.7
Rictaxis punctostriatus	45	23	23	30.3	13.12	23	45	97.9
Tubificoides spp.			68	22.7	39.36	0	68	98.8
Podarkeopsis levifuscina			45	15.2	26.24	0	45	99.4
Leitoscoloplos spp.	23			7.6	13.12	0	23	99.7

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Macoma mitchelli		23		7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	1455	2818	3364	2545.5	983.33	1455	3364	
Total Abundance w/o Epifauna	1455	2818	3364	2545.5	983.33	1455	3364	
Number of Taxa w/ Epifauna	10	10	12	10.7	1.15	10	12	
Number of Taxa w/o Epifauna	10	10	12	10.7	1.15	10	12	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	0.0909	0.2955	0.0909	0.1591	0.1181	0.0909	0.2955	35.0
Mulinia lateralis	0.0227	0.0455	0.0682	0.0455	0.0227	0.0227	0.0682	45.0
Tubificoides heterochaetus	0.0227	0.0682	0.0455	0.0455	0.0227	0.0227	0.0682	55.0
Macoma mitchelli		0.1136		0.0379	0.0656	0.0000	0.1136	63.3
Glycinde solitaria	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	68.3
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	73.3
Paraprionospio pinnata	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	78.3
Rictaxis punctostriatus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	83.3
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	88.3
Heteromastus filiformis		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	91.7
Nemertinea	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	95.0
Leitoscoloplos spp.	0.0227			0.0076	0.0131	0.0000	0.0227	96.7
Podarkeopsis levifuscina			0.0227	0.0076	0.0131	0.0000	0.0227	98.3
Tubificoides spp.			0.0227	0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.2955	0.6591	0.4091	0.4545	0.1860	0.2955	0.6591	
Total Biomass w/o Epifauna	0.2955	0.6591	0.4091	0.4545	0.1860	0.2955	0.6591	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA03

Watershed: Rappahannock River | Habitat: High Mesohaline Mud | Date: August 11, 1999
Gear: Young Grab | Sampled Area: 0.044 sq.m | Time: 13:46

BOTTOM ENVIRONMENT

Depth (m): 3.0 | Salinity (ppt): 16.8 | Temperature (C): 30.1
Dissolved Oxygen (mg/l): 6.3 | Sediment Silt-Clay (%): 93.3

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.00 | Condition: Meets Goal | # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	3.04	5	Pollution Indicative Species Abundance (%)	40.44	
Abundance (#/m2)	1121	3	Pollution Indicative Species Biomass (%)	27.50	3
Biomass (g/m2)	0.53	3	Pollution Sensitive Species Abundance (%)	4.36	
Carnivore-Omnivore Abundance (%)	20.40	3	Pollution Sensitive Species Biomass (%)	5.83	1
Deep Deposit Feeder Abundance (%)	34.80				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	341	227	159	242.4	91.85	159	341	21.6
Mulinia lateralis	136	318	136	197.0	104.97	136	318	39.2
Paraprionospio pinnata	182	159	68	136.4	60.13	68	182	51.4
Streblospio benedicti	68	136	91	98.5	34.72	68	136	60.1
Neanthes succinea	114	68	91	90.9	22.73	68	114	68.2
Tubificoides spp.	136	45	23	68.2	60.13	23	136	74.3
Heteromastus filiformis	114	45	45	68.2	39.36	45	114	80.4
Rictaxis punctostriatus		205		68.2	118.09	0	205	86.5
Glycinde solitaria	114	23		45.5	60.13	0	114	90.5
Leucon americanus	68	45		37.9	34.72	0	68	93.9
Macoma mitchelli	45			15.2	26.24	0	45	95.3

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Nemertinea	23	23		15.2	13.12	0	23	96.6
Podarkeopsis levifuscina	45			15.2	26.24	0	45	98.0
Acteocina canaliculata		23		7.6	13.12	0	23	98.6
Leitoscoloplos spp.		23		7.6	13.12	0	23	99.3
Loimia medusa	23			7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	1409	1341	614	1121.2	440.89	614	1409	
Total Abundance w/o Epifauna	1409	1341	614	1121.2	440.89	614	1409	
Number of Taxa w/ Epifauna	13	13	7	11.0	3.46	7	13	
Number of Taxa w/o Epifauna	13	13	7	11.0	3.46	7	13	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	0.4545	0.0682	0.0909	0.2045	0.2168	0.0682	0.4545	38.6
Mulinia lateralis	0.0909	0.0909	0.0227	0.0682	0.0394	0.0227	0.0909	51.4
Heteromastus filiformis	0.0682	0.0227	0.0227	0.0379	0.0262	0.0227	0.0682	58.6
Paraprionospio pinnata	0.0455	0.0455	0.0227	0.0379	0.0131	0.0227	0.0455	65.7
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	70.0
Tubificoides heterochaetus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	74.3
Tubificoides spp.	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	78.6
Glycinde solitaria	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	81.4
Leitoscoloplos spp.		0.0455		0.0152	0.0262	0.0000	0.0455	84.3
Leucon americanus	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	87.1
Loimia medusa	0.0455			0.0152	0.0262	0.0000	0.0455	90.0
Macoma mitchelli	0.0455			0.0152	0.0262	0.0000	0.0455	92.9
Nemertinea	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	95.7
Acteocina canaliculata		0.0227		0.0076	0.0131	0.0000	0.0227	97.1
Podarkeopsis levifuscina	0.0227			0.0076	0.0131	0.0000	0.0227	98.6
Rictaxis punctostriatus		0.0227		0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.9091	0.4545	0.2273	0.5303	0.3472	0.2273	0.9091	

Total Biomass w/o Epifauna	0.9091	0.4545	0.2273	0.5303	0.3472	0.2273	0.9091

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA04

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 11, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 13:02

BOTTOM ENVIRONMENT

Depth (m): 4.0	Salinity (ppt): 16.7	Temperature (C): 29
Dissolved Oxygen (mg/l): 6.1	Sediment Silt-Clay (%): 88.4	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.00 | Condition: Severely Degraded | # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.72	3	Pollution Indicative Species Abundance (%)	50.99	
Abundance (#/m2)	1455	3	Pollution Indicative Species Biomass (%)	35.57	1
Biomass (g/m2)	0.49	1	Pollution Sensitive Species Abundance (%)	4.87	
Carnivore-Omnivore Abundance (%)	24.28	3	Pollution Sensitive Species Biomass (%)	6.13	1
Deep Deposit Feeder Abundance (%)	21.49				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Paraprionospio pinnata	318	318	364	333.3	26.24	318	364	22.9
Mulinia lateralis	364	273	227	287.9	69.43	227	364	42.7
Tubificoides heterochaetus	500		364	287.9	258.47	0	500	62.5
Neanthes succinea	136	250	136	174.2	65.61	136	250	74.5
Streblospio benedicti	45	91	159	98.5	57.20	45	159	81.2
Glycinde solitaria	136	23	68	75.8	57.20	23	136	86.5
Rictaxis punctostriatus		91	114	68.2	60.13	0	114	91.1
Heteromastus filiformis	23	45	68	45.5	22.73	23	68	94.3

Leucon americanus		45	91	45.5	45.45	0	91	97.4
Nemertinea	45			15.2	26.24	0	45	98.4
Eteone heteropoda	23			7.6	13.12	0	23	99.0
Macoma mitchelli	23			7.6	13.12	0	23	99.5
Tubificoides spp.	23			7.6	13.12	0	23	100.0

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Total Abundance w/ Epifauna	1636	1136	1591	1454.5	276.49	1136	1636
Total Abundance w/o Epifauna	1636	1136	1591	1454.5	276.49	1136	1636
Number of Taxa w/ Epifauna	11	8	9	9.3	1.53	8	11
Number of Taxa w/o Epifauna	11	8	9	9.3	1.53	8	11

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Neanthes succinea	0.0682	0.2273	0.1591	0.1515	0.0798	0.0682	0.2273	30.8
Paraprionospio pinnata	0.0682	0.1364	0.0682	0.0909	0.0394	0.0682	0.1364	49.2
Heteromastus filiformis	0.0455	0.0227	0.1136	0.0606	0.0473	0.0227	0.1136	61.5
Mulinia lateralis	0.1136	0.0227	0.0227	0.0530	0.0525	0.0227	0.1136	72.3
Glycinde solitaria	0.0227	0.0227	0.0455	0.0303	0.0131	0.0227	0.0455	78.5
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	83.1
Leucon americanus		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	86.2
Nemertinea	0.0455			0.0152	0.0262	0.0000	0.0455	89.2
Rictaxis punctostriatus		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	92.3
Tubificoides heterochaetus	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	95.4
Eteone heteropoda	0.0227			0.0076	0.0131	0.0000	0.0227	96.9
Macoma mitchelli	0.0227			0.0076	0.0131	0.0000	0.0227	98.5
Tubificoides spp.	0.0227			0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.4773	0.5000	0.5000	0.4924	0.0131	0.4773	0.5000	
Total Biomass w/o Epifauna	0.4773	0.5000	0.5000	0.4924	0.0131	0.4773	0.5000	

Station: RA05

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 11, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 10:05

BOTTOM ENVIRONMENT

Depth (m): 3.0	Salinity (ppt): 15.4	Temperature (C): 26.9
Dissolved Oxygen (mg/l): 6.0	Sediment Silt-Clay (%): 91.7	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.33 — Condition: Degraded — # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.12	3	Pollution Indicative Species Abundance (%)	13.29	
Abundance (#/m2)	2871	3	Pollution Indicative Species Biomass (%)	17.17	3
Biomass (g/m2)	0.36	1	Pollution Sensitive Species Abundance (%)	4.67	
Carnivore-Omnivore Abundance (%)	18.42	3	Pollution Sensitive Species Biomass (%)	8.59	1
Deep Deposit Feeder Abundance (%)	61.66				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	3477	886	1136	1833.3	1429.17	886	3477	63.9
Neanthes succinea	136	205	318	219.7	91.85	136	318	71.5
Mulinia lateralis	205	136	182	174.2	34.72	136	205	77.6
Leucon americanus	250	91	136	159.1	81.94	91	250	83.1
Streblospio benedicti	250	136	91	159.1	81.94	91	250	88.7
Glycinde solitaria	136	91	114	113.6	22.73	91	136	92.6
Nemertinea	23	114	23	53.0	52.49	23	114	94.5
Heteromastus filiformis	68		23	30.3	34.72	0	68	95.5
Rictaxis punctostriatus	68	23		30.3	34.72	0	68	96.6
Tubificoides spp.	91			30.3	52.49	0	91	97.6
Leitoscoloplos spp.		23	23	15.2	13.12	0	23	98.2
Macoma mitchelli	23		23	15.2	13.12	0	23	98.7
Paraprionospio pinnata	23		23	15.2	13.12	0	23	99.2
Cyathura polita	23			7.6	13.12	0	23	99.5

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus		23		7.6	13.12	0	23	99.7
Parahesione luteola	23			7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	4795	1727	2091	2871.2	1676.33	1727	4795	
Total Abundance w/o Epifauna	4795	1727	2091	2871.2	1676.33	1727	4795	
Number of Taxa w/ Epifauna	14	10	11	11.7	2.08	10	14	
Number of Taxa w/o Epifauna	14	10	11	11.7	2.08	10	14	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Macoma mitchelli	0.0909		0.1364	0.0758	0.0694	0.0000	0.1364	21.3
Tubificoides heterochaetus	0.0455	0.0227	0.0455	0.0379	0.0131	0.0227	0.0455	31.9
Neanthes succinea	0.0227	0.0227	0.0455	0.0303	0.0131	0.0227	0.0455	40.4
Nemertinea	0.0227	0.0455	0.0227	0.0303	0.0131	0.0227	0.0455	48.9
Glycinde solitaria	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	55.3
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	61.7
Mulinia lateralis	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	68.1
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	74.5
Heteromastus filiformis	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	78.7
Leitoscoloplos spp.		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	83.0
Paraprionospio pinnata	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	87.2
Rictaxis punctostriatus	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	91.5
Cyathura polita	0.0227			0.0076	0.0131	0.0000	0.0227	93.6
Leptocheirus plumulosus		0.0227		0.0076	0.0131	0.0000	0.0227	95.7
Parahesione luteola	0.0227			0.0076	0.0131	0.0000	0.0227	97.9
Tubificoides spp.	0.0227			0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.4091	0.2500	0.4091	0.3561	0.0919	0.2500	0.4091	
Total Biomass w/o Epifauna	0.4091	0.2500	0.4091	0.3561	0.0919	0.2500	0.4091	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA06

Watershed: Rappahannock River | Habitat: High Mesohaline Mud | Date: August 11, 1999

Gear: Young Grab | Sampled Area: 0.044 sq.m | Time: 9:09

BOTTOM ENVIRONMENT

Depth (m): 3.0 | Salinity (ppt): 15.3 | Temperature (C): 26.5

Dissolved Oxygen (mg/l): 6.0 | Sediment Silt-Clay (%): 87.9

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 1.67 | Condition: Severely Degraded | # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	1.41	1	Pollution Indicative Species Abundance (%)	11.77	
Abundance (#/m2)	5674	1	Pollution Indicative Species Biomass (%)	16.16	3
Biomass (g/m2)	0.52	3	Pollution Sensitive Species Abundance (%)	2.48	
Carnivore-Omnivore Abundance (%)	7.38	1	Pollution Sensitive Species Biomass (%)	8.79	1
Deep Deposit Feeder Abundance (%)	76.69				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	8455	4000	1523	4659.1	3512.60	1523	8455	82.1
Mulinia lateralis	364	273	409	348.5	69.43	273	409	88.3
Leucon americanus	205	159	114	159.1	45.45	114	205	91.1
Neanthes succinea	68	136	114	106.1	34.72	68	136	92.9
Glycinde solitaria	68	114	114	98.5	26.24	68	114	94.7
Streblospio benedicti	91	91	45	75.8	26.24	45	91	96.0
Paraprionospio pinnata	45	114	45	68.2	39.36	45	114	97.2
Nemertinea	91	23	23	45.5	39.36	23	91	98.0
Macoma mitchelli		68	45	37.9	34.72	0	68	98.7
Rictaxis punctostriatus	45		45	30.3	26.24	0	45	99.2
Clinotanypus pinguis		23	23	15.2	13.12	0	23	99.5
Heteromastus filiformis		23	23	15.2	13.12	0	23	99.7
Eteone heteropoda			23	7.6	13.12	0	23	99.9

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus		23		7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	9432	5045	2545	5674.2	3485.98	2545	9432	
Total Abundance w/o Epifauna	9432	5045	2545	5674.2	3485.98	2545	9432	
Number of Taxa w/ Epifauna	9	12	13	11.3	2.08	9	13	
Number of Taxa w/o Epifauna	9	12	13	11.3	2.08	9	13	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Macoma mitchelli		0.0909	0.2727	0.1212	0.1389	0.0000	0.2727	23.2
Neanthes succinea	0.0909	0.1136	0.0909	0.0985	0.0131	0.0909	0.1136	42.0
Tubificoides heterochaetus	0.1136	0.0682	0.0227	0.0682	0.0455	0.0227	0.1136	55.1
Glycinde solitaria	0.0227	0.0909	0.0227	0.0455	0.0394	0.0227	0.0909	63.8
Mulinia lateralis	0.0227	0.0227	0.0455	0.0303	0.0131	0.0227	0.0455	69.6
Heteromastus filiformis		0.0227	0.0455	0.0227	0.0227	0.0000	0.0455	73.9
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	78.3
Nemertinea	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	82.6
Paraprionospio pinnata	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	87.0
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	91.3
Clinotanypus pinguis		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	94.2
Rictaxis punctostriatus	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	97.1
Eteone heteropoda			0.0227	0.0076	0.0131	0.0000	0.0227	98.6
Leptocheirus plumulosus		0.0227		0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.3636	0.5455	0.6591	0.5227	0.1490	0.3636	0.6591	

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Total Biomass w/o Epifauna	0.3636	0.5455	0.6591	0.5227	0.1490	0.3636	0.6591	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA07

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 10, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 18:53

BOTTOM ENVIRONMENT

Depth (m): 3.0	Salinity (ppt): 13.4	Temperature (C): 27.5
Dissolved Oxygen (mg/l): 6.5	Sediment Silt-Clay (%): 92.3	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.00 Condition: Meets Goal # Attributes Scored: 6

	Value	Score		Value	Score
Shannon-Weiner Index	2.83	3	Pollution Indicative Species Abundance (%)	21.06	
Abundance (#/m2)	871	1	Pollution Indicative Species Biomass (%)	10.47	3
Biomass (g/m2)	0.52	3	Pollution Sensitive Species Abundance (%)	36.91	
Carnivore-Omnivore Abundance (%)	38.70	5	Pollution Sensitive Species Biomass (%)	47.45	3
Deep Deposit Feeder Abundance (%)	9.06				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %

Cyathura polita	182	159	273	204.5	60.13	159	273	23.3
Leucon americanus	159	23	136	106.1	73.06	23	159	35.3
Mulinia lateralis	45	159	91	98.5	57.20	45	159	46.6
Streblospio benedicti	68	227		98.5	116.63	0	227	57.8
Glycinde solitaria	45	159	68	90.9	60.13	45	159	68.1
Macoma mitchelli	68	114	91	90.9	22.73	68	114	78.4
Tubificoides heterochaetus		182	91	90.9	90.91	0	182	88.8
Leptocheirus plumulosus		23	91	37.9	47.31	0	91	93.1
Marenzelleria viridis	23	23		15.2	13.12	0	23	94.8
Neanthes succinea	45			15.2	26.24	0	45	96.6
Nemertinea	23		23	15.2	13.12	0	23	98.3
Macoma balthica		23		7.6	13.12	0	23	99.1
Melita nitida (Epi)		23		7.6	13.12	0	23	100.0

Total Abundance w/ Epifauna	659	1114	864	878.8	227.65	659	1114
Total Abundance w/o Epifauna	659	1091	864	871.2	216.01	659	1091
Number of Taxa w/ Epifauna	9	11	8	9.3	1.53	8	11
Number of Taxa w/o Epifauna	9	10	8	9.0	1.00	8	10

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Cyathura polita	0.1591	0.1591	0.2045	0.1742	0.0262	0.1591	0.2045	32.9
Macoma mitchelli	0.0909	0.1364	0.1818	0.1364	0.0455	0.0909	0.1818	58.6
Mulinia lateralis	0.0682	0.0227	0.0227	0.0379	0.0262	0.0227	0.0682	65.7
Glycinde solitaria	0.0227	0.0455	0.0227	0.0303	0.0131	0.0227	0.0455	71.4

Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	75.7
Marenzelleria viridis	0.0227	0.0455		0.0227	0.0227	0.0000	0.0455	80.0
Macoma balthica		0.0682		0.0227	0.0394	0.0000	0.0682	84.3
Leptocheirus plumulosus		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	87.1
Neanthes succinea	0.0455			0.0152	0.0262	0.0000	0.0455	90.0
Nemertinea	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	92.9
Streblospio benedicti	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	95.7
Tubificoides heterochaetus		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	98.6
Melita nitida (Epi)		0.0227		0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.4773	0.5909	0.5227	0.5303	0.0572	0.4773	0.5909	
Total Biomass w/o Epifauna	0.4773	0.5682	0.5227	0.5227	0.0455	0.4773	0.5682	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA08

Watershed: Rappahannock River	Habitat: High Mesohaline Mud	Date: August 10, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 19:29

BOTTOM ENVIRONMENT

Depth (m): 1.0	Salinity (ppt): 13.0	Temperature (C): 27.4
Dissolved Oxygen (mg/l): 6.2	Sediment Silt-Clay (%): 68.3	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 1.67	Condition: Severely Degraded	# Attributes Scored: 6			
	Value	Score		Value	Score
Shannon-Weiner Index	1.43	1	Pollution Indicative Species Abundance (%)	4.78	
Abundance (#/m2)	13106	1	Pollution Indicative Species Biomass (%)	5.81	3
Biomass (g/m2)	0.93	3	Pollution Sensitive Species Abundance (%)	0.90	
Carnivore-Omnivore Abundance (%)	3.39	1	Pollution Sensitive Species Biomass (%)	11.44	1
Deep Deposit Feeder Abundance (%)	74.63				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	8432	10227	10432	9697.0	1100.42	8432	10432	73.0
Leucon americanus	2045	455	1864	1454.5	870.78	455	2045	83.9
Leptocheirus plumulosus	955	636	409	666.7	273.99	409	955	88.9
Streblospio benedicti	455	636	727	606.1	138.87	455	727	93.5
Neanthes succinea	205	182	227	204.5	22.73	182	227	95.0
Melita nitida (Epi)	273	227	23	174.2	133.17	23	273	96.4
Macoma mitchelli	68	91	182	113.6	60.13	68	182	97.2
Nemertinea	45	91	114	83.3	34.72	45	114	97.8
Heteromastus filiformis	91	23	114	75.8	47.31	23	114	98.4
Clinotanypus pinguis	91		68	53.0	47.31	0	91	98.8
Cyathura polita	45	45	68	53.0	13.12	45	68	99.2
Rangia cuneata	23	23	68	37.9	26.24	23	68	99.5
Eteone heteropoda	23	23	23	22.7	0.00	23	23	99.7

Continued . .

BENTHIC ABUNDANCE (per sq. meter) - Contd.

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Glycinde solitaria		23	45	22.7	22.73	0	45	99.8
Ceratopogonidae	23			7.6	13.12	0	23	99.9
Macoma balthica			23	7.6	13.12	0	23	99.9
Turbellaria (Epi)	23			7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	12795	12682	14386	13287.9	953.01	12682	14386	
Total Abundance w/o Epifauna	12500	12455	14364	13106.1	1089.33	12455	14364	
Number of Taxa w/ Epifauna	15	13	15	14.3	1.15	13	15	
Number of Taxa w/o Epifauna	13	12	14	13.0	1.00	12	14	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Macoma mitchelli	0.2045	0.2045	0.5000	0.3030	0.1706	0.2045	0.5000	31.5
Neanthes succinea	0.0909	0.1364	0.1364	0.1212	0.0262	0.0909	0.1364	44.1
Leptocheirus plumulosus	0.1136	0.1136	0.0909	0.1061	0.0131	0.0909	0.1136	55.1
Tubificoides heterochaetus	0.0455	0.1591	0.1136	0.1061	0.0572	0.0455	0.1591	66.1
Cyathura polita	0.0227	0.0227	0.0909	0.0455	0.0394	0.0227	0.0909	70.9
Leucon americanus	0.0455	0.0227	0.0682	0.0455	0.0227	0.0227	0.0682	75.6
Heteromastus filiformis	0.0455	0.0227	0.0227	0.0303	0.0131	0.0227	0.0455	78.7
Macoma balthica			0.0909	0.0303	0.0525	0.0000	0.0909	81.9
Rangia cuneata	0.0227	0.0227	0.0455	0.0303	0.0131	0.0227	0.0455	85.0
Streblospio benedicti	0.0227	0.0227	0.0455	0.0303	0.0131	0.0227	0.0455	88.2
Eteone heteropoda	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	90.6
Melita nitida (Epi)	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	92.9
Nemertinea	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	95.3
Clinotanypus pinguis	0.0227		0.0227	0.0152	0.0131	0.0000	0.0227	96.9
Glycinde solitaria		0.0227	0.0227	0.0152	0.0131	0.0000	0.0227	98.4
Ceratopogonidae	0.0227			0.0076	0.0131	0.0000	0.0227	99.2
Turbellaria (Epi)	0.0227			0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.7500	0.8182	1.3182	0.9621	0.3102	0.7500	1.3182	
Total Biomass w/o Epifauna	0.7045	0.7955	1.2955	0.9318	0.3182	0.7045	1.2955	

Station: RA09

Watershed: Rappahannock River	Habitat: Low Mesohaline	Date: August 10, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 16:41

BOTTOM ENVIRONMENT

Depth (m): 2.0	Salinity (ppt): 11.8	Temperature (C): 27.6
Dissolved Oxygen (mg/l): 6.5	Sediment Silt-Clay (%): 97.1	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 2.20 | Condition: Degraded | # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	1.08	1	Pollution Indicative Species Abundance (%)	0.29	5
Abundance (#/m2)	20788	1	Pollution Indicative Species Biomass (%)	2.15	
Biomass (g/m2)	1.38	3	Pollution Sensitive Species Abundance (%)	0.15	
Carnivore-Omnivore Abundance (%)	0.51		Pollution Sensitive Species Biomass (%)	1.68	1
Deep Deposit Feeder Abundance (%)	70.41				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides heterochaetus	17568	12818	13682	14689.4	2530.22	12818	17568	70.2
Leptocheirus plumulosus	5205	5545	5614	5454.5	219.17	5205	5614	96.3
Leucon americanus	114	341	568	340.9	227.27	114	568	97.9
Melita nitida (Epi)	91	68	227	128.8	86.04	68	227	98.6
Macoma mitchelli	136	114	45	98.5	47.31	45	136	99.0
Neanthes succinea	91	114	68	90.9	22.73	68	114	99.5
Streblospio benedicti	68	45	45	53.0	13.12	45	68	99.7
Rangia cuneata	23	45	23	30.3	13.12	23	45	99.9
Heteromastus filiformis	45			15.2	26.24	0	45	99.9
Clinotanypus pinguis			23	7.6	13.12	0	23	100.0
Eteone heteropoda	23			7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	23364	19091	20295	20916.7	2203.06	19091	23364	
Total Abundance w/o Epifauna	23273	19023	20068	20787.9	2214.52	19023	23273	
Number of Taxa w/ Epifauna	10	8	9	9.0	1.00	8	10	
Number of Taxa w/o Epifauna	9	7	8	8.0	1.00	7	9	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus	0.6136	0.5682	0.6364	0.6061	0.0347	0.5682	0.6364	43.2
Macoma mitchelli	0.5227	0.2727	0.3636	0.3864	0.1265	0.2727	0.5227	70.8
Tubificoides heterochaetus	0.3182	0.1818	0.2727	0.2576	0.0694	0.1818	0.3182	89.2
Neanthes succinea	0.0455	0.0455	0.0227	0.0379	0.0131	0.0227	0.0455	91.9
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	93.5
Melita nitida (Epi)	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	95.1
Rangia cuneata	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	96.8
Streblospio benedicti	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	98.4
Clinotanypus pinguis			0.0227	0.0076	0.0131	0.0000	0.0227	98.9
Eteone heteropoda	0.0227			0.0076	0.0131	0.0000	0.0227	99.5
Heteromastus filiformis	0.0227			0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	1.6364	1.1591	1.4091	1.4015	0.2387	1.1591	1.6364	
Total Biomass w/o Epifauna	1.6136	1.1364	1.3864	1.3788	0.2387	1.1364	1.6136	

BOTTOM ENVIRONMENT AND BENTHOS, SUMMER 1999 (1999/2000)
AMBIENT TOXICITY SITES

Station: RA10

Watershed: Rappahannock River	Habitat: Low Mesohaline	Date: August 10, 1999
Gear: Young Grab	Sampled Area: 0.044 sq.m	Time: 15:36

BOTTOM ENVIRONMENT

Depth (m): 3.0	Salinity (ppt): 10.6	Temperature (C): 29.3
Dissolved Oxygen (mg/l): 5.9	Sediment Silt-Clay (%): 95.6	

BENTHIC INDEX OF BIOTIC INTEGRITY

B-IBI Score: 3.00 — Condition: Meets Goal — # Attributes Scored: 5

	Value	Score		Value	Score
Shannon-Weiner Index	1.72	3	Pollution Indicative Species Abundance (%)	0.00	5
Abundance (#/m2)	3530	3	Pollution Indicative Species Biomass (%)	0.00	
Biomass (g/m2)	39.63	1	Pollution Sensitive Species Abundance (%)	9.44	
Carnivore-Omnivore Abundance (%)	5.90		Pollution Sensitive Species Biomass (%)	79.25	3
Deep Deposit Feeder Abundance (%)	8.41				

BENTHIC ABUNDANCE (per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus	3045	2159	1795	2333.3	642.96	1795	3045	63.5
Leucon americanus	591	341	159	363.6	216.80	159	591	73.4
Tubificoides heterochaetus	773	114	136	340.9	374.14	114	773	82.7
Melita nitida (Epi)	227	91	114	143.9	73.06	91	227	86.6
Marenzelleria viridis	205	91	68	121.2	73.06	68	205	89.9
Rangia cuneata	91	68	159	106.1	47.31	68	159	92.8
Clinotanypus pinguis	68	114	91	90.9	22.73	68	114	95.3
Cyathura polita	68	159	45	90.9	60.13	45	159	97.7
Boccardiella ligerica	23	136		53.0	73.06	0	136	99.2
Macoma mitchelli	23		23	15.2	13.12	0	23	99.6
Limnodrilus spp.	23			7.6	13.12	0	23	99.8
Neanthes succinea			23	7.6	13.12	0	23	100.0
Total Abundance w/ Epifauna	5136	3273	2614	3674.2	1308.41	2614	5136	
Total Abundance w/o Epifauna	4909	3182	2500	3530.3	1241.78	2500	4909	
Number of Taxa w/ Epifauna	11	9	10	10.0	1.00	9	11	
Number of Taxa w/o Epifauna	10	8	9	9.0	1.00	8	10	

BENTHIC BIOMASS (Grams per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Rangia cuneata	0.0227	41.0909	75.6364	38.9167	37.8537	0.0227	75.6364	98.1
Leptocheirus plumulosus	0.3636	0.3182	0.2045	0.2955	0.0819	0.2045	0.3636	98.9
Marenzelleria viridis	0.1591	0.1591	0.0455	0.1212	0.0656	0.0455	0.1591	99.2
Macoma mitchelli	0.0455		0.2727	0.1061	0.1461	0.0000	0.2727	99.5
Cyathura polita	0.1591	0.0909	0.0227	0.0909	0.0682	0.0227	0.1591	99.7
Clinotanypus pinguis	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	99.8
Leucon americanus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	99.8
Melita nitida (Epi)	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	99.9
Tubificoides heterochaetus	0.0227	0.0227	0.0227	0.0227	0.0000	0.0227	0.0227	99.9
Boccardiella ligerica	0.0227	0.0227		0.0152	0.0131	0.0000	0.0227	100.0
Limnodrilus spp.	0.0227			0.0076	0.0131	0.0000	0.0227	100.0
Neanthes succinea			0.0227	0.0076	0.0131	0.0000	0.0227	100.0
Total Biomass w/ Epifauna	0.8864	41.7727	76.2955	39.6515	37.7493	0.8864	76.2955	
Total Biomass w/o Epifauna	0.8636	41.7500	76.2727	39.6288	37.7493	0.8636	76.2727	