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A Pilot Study for Ambient Toxicity Testing in Chesapeake Bay

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FOREWORD

This pilot study was designed to evaluate ambient toxicity in the Chesapeake Bay watershed by using a battery of water column, sediment and suborganismal tests. To complete this ambitious goal, a team of scientists from three Chesapeake Bay Research Laboratories were involved. Water column toxicity studies were directed by Lenwood W. Hall, Jr. of the University of Maryland's Agricultural Experiment Station, sediment toxicity tests were managed by Raymond W. Alden, III of Old Dominion University Applied Marine Research Laboratory, and suborganismal tests were directed by Jay Gooch of the University of Maryland's Chesapeake Biological Laboratory. This report summarizes data from the first year of this two-year study. The following government agencies were responsible for supporting and/or managing this research: Maryland Department of Natural Resources (CB-90-001-005), Maryland Department of Environment (182-C-MDE-91) and the U.S. Environmental Protection Agency (X-003554-01).

ABSTRACT

The link between toxic contaminants and biological effects in the ambient environment of the Chesapeake Bay watershed has become a major environmental issue in recent years. Evaluating potentially toxic conditions in natural habitats can only be accomplished by direct measurement of biological responses in the ambient environment. The primary goal of this ambient toxicity pilot study was to identify toxic areas in the Chesapeake Bay watershed by using a battery of concurrent water column, sediment and suborganismal toxicity tests. Ambient areas evaluated in the first year of this two-year pilot study were: suspected toxic locations in the Elizabeth River (one station) and Patapsco River (one station); a suspected contaminant-free area in the Wye River (one station) and critical habitat areas in the Potomac River (three freshwater and two saltwater stations). The Potomac River stations were located at Indian Head, Freestone Point, Possum Point, Morgantown and Dahlgren. A suite of inorganic and organic contaminants was evaluated in the water column and sediment from at least one grab sample collected from selected stations during water column and sediment tests. Standard water quality conditions were also evaluated in water and sediment from all stations.

The following water column tests were conducted in saltwater: 8-d sheepshead minnow, Cyprinodon variegatus, survival and growth tests; 8-d grass shrimp, Palaemonetes pugio, survival and growth

tests and 8-d *Eurytemora affinis* life cycle test. In freshwater habitats of the Potomac River, 8-d fathead minnow, *Pimephales promelas*, larval survival and growth tests and 8-d *Ceriodaphnia dubia* survival and reproduction tests were conducted. Concurrent tests with salinity adjusted freshwater were conducted at the freshwater stations with *E. affinis* and *P. pugio* to compare these results with those from the two freshwater tests. The following sediment tests were conducted: 20-d juvenile and adult polychaete worm, *Streblospio benedicti*, survival and growth test; 20-d juvenile grass shrimp ,*P. pugio*, survival and growth test and 20-d amphipod, *Lepidactylus dytiscus*, survival, growth and reburial test. Concurrent tests with salinity adjusted freshwater were conducted with the above three species to compare these results with those from the freshwater tests. Suborganismal tests were conducted to evaluate hepatic monooxygenase (EROD) activity in *Fundulus heteroclitus* exposed to test water and sediment from the saltwater stations. Livers were collected from *Fundulus* exposed to water and sediment and analyzed for induction of cytochrome P450 monooxygenase activity indicative of aromatic hydrocarbon exposure. In addition, feral *Fundulus* were collected where possible from near the test stations and analyzed for induced monooxygenase activity. White perch, *Morone americana*, and/or spot, *Leiostomus xanthurus*, were collected by trawling or hook and line in areas where *Fundulus* were not found. Livers from these fish species were also analyzed for induced monooxygenase activity.

The Elizabeth River was the most toxic area tested based on the various biological indicators. The water column and sediment tests demonstrated the presence of toxic conditions at this station and the suborganismal tests suggested toxic conditions. The Patapsco River station was also reported toxic as water column and sediment tests indicated adverse conditions to be present. Feral spot collected at this station had EROD hepatic activities that were similar to spot collected from the highly PAH-contaminated Elizabeth River station. The Wye River station was selected as a putative toxic-free control area. Water column tests did not suggest the presence of toxic conditions in this area but sediment tests demonstrated significant effects. Feral _Fundulus_ from the Wye River had hepatic EROD activities which suggested possible planar aromatic hydrocarbon exposures. Both water column and sediment tests demonstrated toxic conditions at the Indian Head, Morgantown and Dahlgren stations. Sediment tests showed significant effects at the Freestone Point and Possum Point stations while no effects were reported at these stations from water column or suborganismal tests. The results discussed above clearly demonstrate the need for integrated water column, sediment and suborganismal testing because one type of test was not sufficient to maximize our ability to identify toxic conditions in the ambient environment of the Chesapeake Bay watershed.

A general ranking of sensitivity among tests within each test type (water column, sediment and suborganismal) showed the following results after one year of testing. Results from the water column tests demonstrated no significant ranking of sensitivity among the three saltwater tests but rather supported the need for multispecies tests because different species displayed varying sensitivity to different types of contaminants. Both grass shrimp and sheepshead minnow tests demonstrated effects at two of the eight stations while *E. affinis* showed effects at only one station. A comparison of the two freshwater water column tests at three stations showed that the *Ceriodaphnia* test was more sensitive than the fathead minnow test. Results from the sediment tests clearly showed that the amphipod test was most sensitive as effects were reported at all stations. The polychaete worm test was the second most sensitive test and the grass shrimp test was least sensitive. A ranking of sensitivity among the various suborganismal tests is not appropriate until further research has been completed.

Organic and inorganic contaminants data from the water column and sediment of the various stations provided supportive but not conclusive evidence to explain biological effects. The greatest number of contaminants at possibly toxic concentrations (three for water and fourteen for sediment) were reported at the Elizabeth River station, where all three types of tests demonstrated toxic conditions. Three to four metals at possibly toxic concentrations were found in the sediment at the Patapsco River, Indian Head, Freestone Point and Possum Point stations. Sediment toxicity was demonstrated at all of the stations with the most sensitive sediment toxicity test (amphipod test). This sediment test also showed toxicity at the Morgantown and Dahlgren stations where metals at possibly toxic concentrations were not reported in the sediment. One or two metals at possibly toxic concentrations were reported in the water column at the following stations: Patapsco River, Wye River, Indian Head, Freestone Point and Morgantown. Significant effects from water column tests were reported at the Patapsco River, Indian Head, Morgantown and Dahlgren stations; effects were not reported at the Wye River, Possum Point or Freestone Point stations. Suborganismal tests suggested planar aromatic hydrocarbon exposure at the Patapsco River and Wye River stations but effects were not implicated at any of the five Potomac River stations.

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SECTION 1

INTRODUCTION

In recent years there has been concern about the link between adverse biological effects and the presence of toxic contaminants and adverse water quality conditions in critical Chesapeake Bay habitat areas. Information on the loading of toxic contaminants is not sufficient to determine the biological effects of complex mixtures of contaminants derived from sources such as atmospheric deposition, groundwater contamination, multiple point source effluents, non-point source runoff from agricultural and urban land and release of toxic contaminants from sediments. Evaluating potentially toxic conditions in natural habitats can only be accomplished by direct measurement of biological responses in the ambient aquatic environment. Numerous investigators have reported toxic conditions in ambient waters of the Chesapeake Bay watershed (Alden et. al., 1988; Bender and Huggett, 1987; Hall et al., 1985; Hall et al., 1989; Klauda et al., 1988; Wright et al., 1988).

Ambient toxicity tests are designed to evaluate toxicity in the ambient aquatic environments (areas outside of any mixing zones) by using biological responses (survival, growth, reproduction, etc.) of test species. Ambient toxicity tests are conducted less frequently when compared with the more traditional effluent toxicity tests. Effluent toxicity tests are used to establish effluent discharge rates that minimize effects on organisms in the receiving system (U.S. EPA., 1983; U.S. EPA., 1985a). Ambient toxicity tests are designed to detect toxic conditions in the ambient environment (areas outside of mixing zones) by using responses of aquatic biota. Toxic conditions in the ambient environment may result from point or non-point sources or by combinations of effluents that are not toxic individually.

Toxicity can be defined in a number of ways. Standard toxicity testing protocols used for regulatory purposes focus primarily on toxicity as defined by effects on survival, reproduction and growth of test species. In recent years, increases in our knowledge of how chemicals affect biochemical systems (i.e., mechanisms of toxicity) has lead to the development of tests, or more appropriately, to the use of biochemical effects measurements (suborganismal tests) to detect sublethal levels of exposure in laboratory and field experiments. In this study, we have addressed ambient toxicity testing in a comprehensive manner by using concurrent water column, sediment and suborganismal tests in conjunction with water quality and contaminant analysis in both water and sediment. Both ambient water and sediment were collected and transported back to the laboratory for testing. This battery of tests will maximize our ability to detect "ambient toxicity" in Chesapeake Bay waters during this pilot study.

The **Chesapeake Bay Basinwide Toxics Reduction Strategy** 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, 1988a). This commitment is consistent with recommendations of the **Chesapeake Bay Living Resource Monitoring Plan** (CEC, 1988b). In July of 1989 an Ambient Toxicity Assessment Workshop was held in Annapolis, Maryland, to provide a forum on how to use biological indicators to monitor the effects of toxic contaminants in Chesapeake Bay habitats to living resources. This pilot study was designed by using various recommendations of the workshop.

SECTION 2

OBJECTIVES

The objectives of year one of this two-year pilot study were to: (1) develop a survey program to broadly assess ambient toxicity of living resource habitats for the purpose of identifying defined regions where ambient toxicity levels warrant further investigation of effects on living resources; (2) assess the feasibility and utility of such a survey through a pilot study; (3) field test existing standardized, directly modified or recently developed water column, sediment and suborganismal toxicity test methods for use in ambient toxicity testing and determine the relative sensitivity of these three test methods and (4) identify long term test methods development or follow up survey design testing needs (if any) to support Baywide assessment of ambient toxicity. Toxicity in natural habitat areas was evaluated by using water column toxicity tests (Lenwood Hall), sediment toxicity tests (Ray Alden) and suborganismal evaluations (Jay Gooch).

Test areas included polluted areas (Elizabeth River and Patapsco River), critical habitat areas with potentially toxic conditions (Potomac River), and a presumed contaminant-free area (Wye River). One station was located in the Elizabeth River, Patapsco River and Wye River, and five stations were located in the Potomac River (3 freshwater and 2 saltwater). All eight stations were evaluated once in 1990 (August 13 - October 2). A suite of inorganic and organic contaminants was evaluated in the water column and sediment for selected station during testing.

Water column, sediment and suborganismal tests were conducted concurrently. The following saltwater water column tests were conducted: 8-d sheepshead minnow, *Cyrinodon variegatus*, survival and growth test; 8-d grass shrimp, *Palaemonetes pugio*, survival and growth test and 8-d copepod, *Eurytemora affinis*, life cycle test. In freshwater habitats, 8-d fathead minnow, *Pimephales promelas*, larval survival and growth test and 8-d *Ceriodaphnia dubia* survival and reproduction tests were conducted. Concurrent tests with salinity adjusted freshwater were conducted at the freshwater stations with *E. affinis* and *P. pugio* to compare these results with those from the two freshwater tests.

The following saltwater sediment toxicity tests were conducted: 20-d juvenile *Streblospio benedicti* (polychaete worm) survival and growth test; 20-d juvenile grass shrimp (*P. pugio*) survival and growth test and 20-d amphipod (*Lepidactylus dytiscus*) survival, growth and reburial test.

Several types of samples were collected for suborganismal testing and many of the analyses are still ongoing. Our efforts to date have been focused on evaluating hepatic monooxygenase activity in feral and laboratory-exposed fishes. Livers were collected from *Fundulus heteroclitus* exposed to test sediment and water and analyzed for induction of cytochrome P450 monooxygenase activity indicative of aromatic hydrocarbon exposure. In addition, feral *Fundulus* were collected, where possible, from near the test sites and analyzed for induced monooxygenase activity. For stations where we were unable to collect resident Fundulus (inappropriate habitat or salinity), we collected white perch (Morone americana) and/or spot (Leiostomus xanthurus) by trawling or hook and line. Livers from these fish species were also analyzed for induced monooxygenase activity.

Samples of animals were also collected from various water and sediment toxicity tests and preserved in liquid nitrogen. These samples will be analyzed in a logical progression. We collected samples from the grass shrimp (P. pugio) and amphipod (L. dytiscus) sediment tests for analysis of stress protein responses. We also collected samples from the invertebrate water column tests (grass shrimp and Eurytemora) and samples of surviving sheepshead and fathead minnow larvae for stress protein evaluations. We will also be evaluating monooxygenase induction in the larval fish samples.

An important goal of this integrated water column, sediment and suborganismal testing was to use this battery of tests as a screening tool to identify toxic areas in ambient waters of the Chesapeake Bay watershed. Results from this study will be used to determine if toxicity exists in ambient areas. Inorganic contaminants, organic contaminants and water quality conditions (temperature, dissolved oxygen, pH, salinity and conductivity) were evaluated during these tests. However, the limited analysis of these contaminants and water quality conditions was not intended to provide conclusive evidence on what factors caused toxicity (if reported). In addition, this study was not designed to identify sources of contaminants if they were reported. The use of these data for regulatory processes would only be warranted after more comprehensive studies were designed to evaluate causes and sources of toxicity. Data collected during this study would, however, be useful for identifying potentially toxic areas that would be of interest to regulatory agencies.

SECTION 3

METHODS

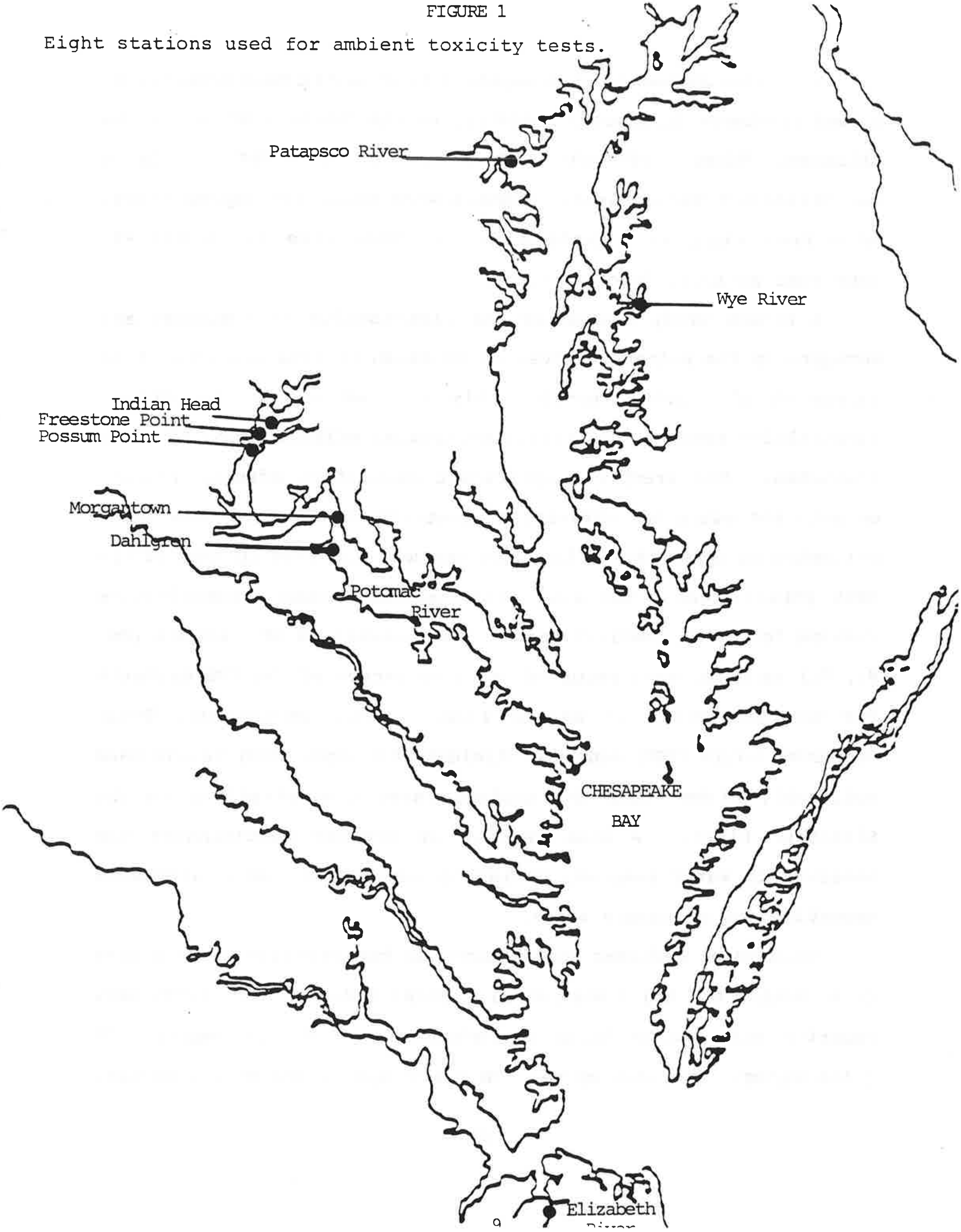
3.1 Study Areas

Three types of areas were selected for pilot ambient toxicity tests: polluted areas in the Elizabeth River and Patapsco River; a relatively toxic-free area in the Wye River; critical habitat areas in the Potomac River with potentially toxic conditions (Figure 1). The polluted sites in the Elizabeth River and Patapsco River were selected to allow field testing of existing test methods for ambient toxicity testing. Reduced survival and other sublethal effects would be likely with some of the test species. The Wye River was selected because it is a relatively clean area that should not have toxic conditions. Conducting ambient toxicity tests in the Wye River will provide data to demonstrate that the proposed test methods will demonstrate adequate survival or no sublethal effects by test species in toxic-free water. The Potomac River was selected for testing because it offers gradients of salinity, contamination and habitat similar to those of the whole Bay. Another reason for selecting the Potomac River is that the geography and numerous resources of the river are shared by three states. A brief description of each study site and rationale for selection are presented below.

3.1.1 Elizabeth River Station

FIGURE 1

Eight stations used for ambient toxicity tests.



This station was located adjacent to Atlantic Wood Industries, a wood treatment (creosote) industry, on the Southern Branch of the Elizabeth River (36° 48' 29" N x 76° 17' 36" W) in a mesohaline/polyhaline area. Samples were collected approximately 30 m from shore at a depth of 6 m. This site is on the EPA Superfund National Priority List.

A recent study evaluating the distribution of toxicants and mutagens in the Elizabeth River in relation to land use activities (Alden et al., 1988) reported this site as having the highest quantitative ranking for overall biological effects among 27 sites evaluated. For example, significant cumulative effects (acute, chronic and sublethal effects) of contaminant extracts from water collected at this site on fish embryos were observed in >50% of the test populations. The site also had the highest quantitative ranking for water chemistry data. Concentrations of 3 metals (Cu, Ni, Zn) in water were reported to be in excess of the EPA criteria for the protection of marine life. Total phosphorus, Total Suspended Solid (TSS) and Total Kjeldahl Nitrogen (TKN) levels were noticeably higher than the ambient water concentrations in the Elizabeth River. A wide variety of organic contaminants was observed in water samples, including numerous alkanes, alkylated aromatics and propanoic acids.

Studies of sediment contaminants in the vicinity of this site (i.e. within 0.5 km) (Ewing et al., 1989; Alden et al., 1990) have reported potentially toxic concentrations of Cd (>3 mg/kg), Cr (>100 mg/kg), Cu (>300 mg/kg), Pb (>400 mg/kg) and Hg (>3 mg/kg).

Concentrations of organic contaminants in sediments were generally high in this portion of the Elizabeth River (e.g. total PNAHs approximately 150 mg/kg).

A study conducted by the Virginia Institute of Marine Sciences (VIMS) reported high concentrations (i.e. highest in the Southern Branch) of total aromatic organic compounds in the tissues of Callinectus (3,200 ppb in muscle, 13,000 ppb in hepatopancreas) collected from this site (Greeves, 1990). Other VIMS researchers have observed an exceptionally high incidence of neoplastic liver lesions in Fundulus from this site (Vogelbein et al., 1990).

Bioassessments conducted by Old Dominion University Applied Marine Research Laboratory in early summer, 1990, showed significant toxic effects in tests of sediment pore water (Microtox and sea urchin fertilization tests) and whole sediments (amphipod tests) from this site (Emily Deaver, personal observation). This station, located in a documented toxic area of the Elizabeth River, was selected to allow field testing of our tests in an area where effects were likely.

3.1.2 Patapsco River Station

This station was located adjacent to the Bethlehem Steel Corporation at Sparrows Point on the Patapsco River near Bear Creek (39° 14' N x 76° 29.7' W). Samples were collected approximately 75 m from shore at a depth of 2 m. This site was located in a mesohaline area outside the mixing zone of Bethlehem Steel's largest discharge. Effluent toxicity tests conducted by the

University of Maryland's Agricultural Experiment Station have reported chronic effects on Bethlehem Steel's effluent from both Ceriodaphnia and fathead minnow tests (Mel Knott, personal communication). Various potentially toxic contaminants such as zinc, chromium, lead-free cyanide and tetrachloroethane have been reported in effluents from the Bethlehem Steel facility.

This station was selected to allow field testing of our methods in an area where toxic conditions may be found. Based on our limited background data, the ambient environment at this station should be less toxic than the Elizabeth River station.

3.1.3 Wye River Station

This station was located in a mesohaline area on the Wye River at Wye Narrows above the Manor House (38° 53.2' N x 76° 1.9' W). Samples were collected approximately 75 m from shore at a depth of 2 m. There are no known point sources of contaminants in this area and non-point runoff is minimal due to the vegetation cover and hardwoods in the area. This area supports healthy populations of various Chesapeake Bay species. A preliminary sample of water from this area did not indicate any potentially toxic contaminants. This station was selected as a control area where toxic conditions were not suspected.

3.1.4 Potomac River - Indian Head Station

This station was located in a freshwater area on the Maryland side of the Potomac River near the Naval Ordnance Station (NOS) at

Indian Head, Maryland (38° 36' N x 77° 11' W). Samples were collected approximately 125 m from shore at a depth of 4 m. The NOS facility has 51 industrial outfalls and one municipal outfall discharging into the Potomac River. In recent screening toxicity tests with freshwater species, several of the outfalls were toxic. We have no documented evidence to demonstrate that the NOS facility is causing adverse effects to aquatic life in the ambient areas of the Potomac River. However, the station near this facility is a representative ambient area of the Potomac River and provides a good location for the security of our equipment during testing (datasonde units).

3.1.5 Potomac River - Freestone Point

This station was located in a freshwater area on the Virginia side of the Potomac River near the mouth of Nebesco Creek (38° 35.2' N x 77° 14.7' W). Samples were collected approximately 100 m from shore at a depth of 4 m. This station was near a station previously used for in-situ striped bass studies in 1986 (Hall et al., 1987a). The following metals were reported at this station in 1986: Cd (15 ug/L); Cr (110 ug/L) and Cu (47 ug/L). All of these concentrations exceed the U.S. EPA acute freshwater water quality criteria for these metals (U.S. EPA, 1987a). Higher than ambient pH conditions (> 9) were also reported at this station during the previously mentioned study. Survival of both striped bass prolarvae and yearlings was also low at this station during the in-situ studies in 1986. This station was selected as a representative area of the Potomac River where biological effects were possible.

3.1.6 Potomac River - Possum Point

This station was located in a freshwater area on the Virginia side of the Potomac River near Possum Point (38° 32' N x 77° 16.5' W). Samples were collected approximately 300 m from shore at a depth of 4 m. We conducted contaminant monitoring at this station during previous in-situ striped bass studies and reported the following concentrations of metals from one grab sample in 1990: Cd (4.7 ug/L), Cr (150 ug/L), Cu (37 ug/L), Ni (281 ug/L), Pb (14 ug/L) and Zn (270 ug/L) (Hall, personal communication). All of these metal concentrations exceed the U.S. EPA water quality criteria for freshwater (U.S. EPA, 1987a). Mortality of striped bass prolarvae was also high at this station during in-situ studies in 1990. In 1989, above-ambient concentrations of arsenic (12 ug/L) and chromium (29 ug/L) were reported at this station (Hall et al., 1990). Significant mortality of striped bass prolarvae and yearlings was also reported during in-situ tests at this station. Previous potentially toxic contaminant conditions reported at this station during the spring of 1989 and 1990 were reasons for selecting this station.

3.1.7 Potomac River - Morgantown Station

This station was located in a typical ambient mesohaline area on the Maryland side of the Potomac River near the Harry Nice

Memorial Bridge (38° 21.8' N x 77° 59.5' W). Samples were collected approximately 200 m from shore at a depth of 3 m. TBT concentrations of 20 and 24 ug/L were detected at this station during a tributyltin (TBT) monitoring study in 1985 and 1986 (Hall et al., 1987b). These TBT concentrations exceed the U.S. EPA provisional water quality criteria of 10 ng/L (U.S. EPA, 1987b). There are no other background contaminants data for this station.

3.1.8 Potomac River - Dahlgren Station

This station was located in a typical ambient mesohaline area on the Virginia side of the Potomac River at the mouth of Machodoc Creek near the Naval Surface Warfare Center at Dahlgren, Virginia (38° 19' N x 77° 2' W). Samples were collected approximately 300 m from shore at a depth of 2 m. The Dahlgren facility has six discharge points in this area. This is a typical ambient mesohaline area of the Potomac River. Water quality and contaminant problems have not been reported in this area.

3.2 Water Column Toxicity Tests

3.2.1 General Description

The following estuarine tests were conducted with water collected at the Elizabeth River, Patapsco River, Wye River and Potomac River (Morgantown and Dahlgren stations): 8-d sheepshead minnow, *Cyprindodon variegatus*, survival and growth test; 8-d grass shrimp, *Palaemonetes pugio*, survival and growth test and 8-d *Eurytemora affinis* life cycle test. Three stations in the Potomac

River (Indian Head, Freestone Point and Possum Point) were located in freshwater areas. For these stations, 8-d fathead minnow, Pimephales promelas, larval survival and growth tests and 8-d Ceriodaphnia dubia survival and reproduction tests were performed. In addition to the two freshwater tests, estuarine tests with E. affinis and grass shrimp were conducted with salinity adjusted freshwater at these three sites. These estuarine tests were conducted concurrently with the two freshwater tests so results could be compared (i.e., significant biological effects or no significant biological effects). Control water used for freshwater tests was deep-well groundwater from our laboratory. Artificial seawater made with HW-MARINEMIX and deep-well groundwater was used as the control water for saltwater tests (15 °/oo).

Each of the eight stations were tested one time during 1990 (August - October) with the various test species described above. Reference toxicant tests described later in this methods section were conducted at least once with each test species in 1990. The total number, type and location of tests conducted in 1990 are presented in Table 1. The Elizabeth River, Patapsco River and Wye River tests were conducted on 8/14/90 - 8/21/90. The Potomac River tests were performed on 9/24/90 - 10/2/90. A second test of Ceriodaphnia tests were conducted at the three freshwater Potomac River stations on 10/26/90 - 11/3/90.

3.2.2 Culture or Maintenance Procedures for Test Species The following subsections provide a brief description of culture or

Table 1. Water column toxicity tests conducted in 1990. The following abbreviations are used for test species: C.v. (*Cyprinodon variegatus*) P.p. (*Palaemonetes pugio*), E.a. (*Eurytemora affinis*), P.pr. (*Pimephales promelas*), C.d. (*Ceriodaphnia dubia*).

Stations or Test Conditions (Number of Each)	Species						
	C.v.	P.p.	E.a.	P.pr.	C.d.	P.p[1]	E.a.[1]
Patapsco River (1)	X	X	X				
Elizabeth River (1)	X	X	X				
Potomac River Freshwater(3)				XXX	XXX	XXX	XXX
Potomac River Estuarine(2)	XX	XX	XX				
Wye River (1)	X	X	X				
Control Water Column (1)	X^2	X^2	X^2	X^2	X^2	X^2	X^2
Water Column Ref. Tox. (1)	X	X	X	X	X		

[1] Salinity adjusted freshwater

[2] Controls were used for each test

maintenance procedures for the five test species. Culture procedures for all test species except grass shrimp and *E. affinis* are described in detail in Fisher et al. (1988).

3.2.2.1 Grass Shrimp

All grass shrimp used for reference toxicant or ambient toxicity tests were obtained from laboratory brood stock cultures at SP Engineering and Technology (Salem, MA). Larvae (< 7-d old) were held for ~ 1 week in a 150 L fiberglass trough or 75 L aquaria at 15 ppt salinity and 25 C. A single airstone (medium trickle) was placed in the middle of the trough or aquaria to provide aeration and circulation. Temperature, salinity, dissolved oxygen, pH and ammonia were monitored daily prior to water renewal. Artificial seawater made with HW-MARINEMIX was used to exchange one-third of the water volume daily (HW-MARINEMIX, Wiegandt GMBH & Co., W. Germany). The bottom of the holding tank was siphoned daily to remove decaying organic matter. Larval grass shrimp were fed *Artemia* nauplii ad libitum one time per day following the water exchange. A 12-h L:12-h D cycle was maintained during the holding period.

3.2.2.2 Copepod (*E. affinis*)

Initial cultures of *E. affinis* were obtained from established cultures at University of Maryland Chesapeake Biological Laboratory at Solomons Island, MD. Cultures were then maintained in our laboratory. Cultures were held in 10 L glass aquaria containing synthetic seawater (HW-MARINEMIX) adjusted to 15 ppt salinity and 25 C. Stocking density was approximately 10^3 organisms /L. Photoperiod was maintained at 12-h L:12-h D using indirect lighting. E. affinis were fed a phytoplankton diet consisting of Thalassiosira fluviatilis and Isochrysis galbana. Copepods were fed equal volumes of phytoplankton, in log-phase of growth, three times a week, to maintain a density of 10^4 T. fluviatilis cells/ml and 10^5 I. galbana cells/ml within the culture aquaria. The algal stocks were grown in 0.2um filtered well water adjusted to 15 ppt with synthetic sea salts using a standard culture procedure for marine algae (Guillard, 1975).

3.2.2.3 Sheepshead Minnows

Adult sheepshead minnows cultured in our laboratory were fed Tetramin® flake food ad libitum daily. Eggs obtained from these established cultures were used for the first set of experiments. Eggs were aerated vigorously in one liter glass beakers (150 eggs/L) containing synthetic seawater (HW-MARINEMIX) adjusted to 10 ppt salinity and 25C. Culture temperature and photoperiod (12-h L:12-h D) were controlled in biological incubators (Percival Manufacturing Co.). Dead eggs were removed from the beakers daily prior to 50 % culture water changes. Salinity was gradually adjusted to 15 ppt over two days to facilitate a uniform hatching rate. Twenty-four hours prior to starting a test, all previously hatched sheepshead larvae were separated from unhatched eggs and placed in a separate beaker. Only those larvae which hatched within the twenty-four hours prior to starting the test were used to conduct the reference toxicant or ambient toxicity tests. Due to low hatching rate in our cultures, eggs were obtained from the Aquatic Bioassay Lab in Baton Rouge, LA, for the second set of experiments. The same procedures described above were used.

3.2.2.4 Fathead Minnows

Adult fathead minnows cultured in our laboratory were fed Tetramin® flake food ad libitum daily. Eggs obtained from these established cultures were used for our experiments. Eggs attached to a PVC substrate were placed in a five liter polyethylene container filled with 0.2 um filtered deep well water. The eggs were held at 25 C with moderate aeration. Twenty-four hours prior to tests, all previously hatched larvae were separated from unhatched eggs and collected in a separate beaker. Only those larvae which hatched within the 24 hours prior to starting the test were used to conduct the test.

3.2.2.5 Ceriodaphnia

Adult *Ceriodaphnia* were obtained from stock cultures at our laboratory. Organisms were cultured in one liter glass beakers containing 900 mL of 0.2 um filtered well water. The cultures were covered with clear plastic panels and gently aerated. The organisms were maintained at 25 C and 16-h L:8-h D photoperiod. *Ceriodaphnia* were fed a mixture of CEROPHYL (Sigma Chemical Co.) and *Selenastrum capricornutum*. The CEROPHYL was prepared as previously described (Fisher et al., 1988) and fed at a rate providing approximately 60 ug/mL final concentration. Selenastrum capricornutum was cultured according to the methods described by the U.S. Environmental Protection Agency (U.S. EPA, 1985b) and fed at a rate to provide approximately 7 x 10^5 cells/mL final concentration. Cultures were fed daily to maintain the organisms in optimum condition so as to provide maximum reproduction in the toxicity tests.

Four hours prior to starting the reference toxicant test, adult Ceriodaphnia were isolated in 250 ml glass beakers containing 60 mL of culture water (approximately 20 adults per beaker). After 4 h, neonates were collected by removing adults with a 500 um mesh Nitex screen. Reference toxicant and ambient toxicity tests were conducted on neonates that had hatched within 4 h prior to starting the tests.

3.2.3 Reference Toxicant Tests

A 48-h static cadmium chloride reference toxicant test was conducted with each test species in 1990. A reference toxicant is used to establish the relative health and sensitivity of the test organisms. Cadmium chloride was selected as the reference toxicant because we have a two-year data base with this chemical for all of the proposed test species except E. affinis. A complete description of rationale and use of reference toxicant tests is described in Fisher et al., 1988.

Cadmium concentrations were made from a common stock solution of cadmium chloride (Sigma Chemical Co.). A 1 mg/mL (1.6308 mg/mL $CdCl_2$) cadmium stock solution was created by dissolving 407.7 mg $CdCl_2$ in 250 mLs deionized water. The stock solution was diluted to final concentrations by pipetting stock solutions into 2 L glass beakers containing filtered artificial seawater (15 ppt) diluent for saltwater tests. Deep well water was used for freshwater tests. Approximately 20 mL of each final test concentration was acidified with 100 ul ultrex nitric acid for future Atomic Absorption analysis.

Survival of test organisms was monitored at each test condition at both 24 and 48 hours (except _E_. _affinis_ at 24 h). An LC50 value and 95 % confidence interval were calculated at 24 and 48 h using the moving-average and probit methods (Stephan, 1978). Temperature, salinity, dissolved oxygen, and pH were measured in each beaker at both 24 and 48 hours (except _E_. _affinis_). Specific details on methods used for each species are presented below.

3.2.3.1 _Grass Shrimp_

A 48-h cadmium chloride reference toxicant test was conducted with 18-d old larvae at the following nominal test concentrations (0, 0.18, 0.32, 0.56, 1.0, 1.8, 3.2 and 5.6 mg/L Cd). One replicate consisted of four larvae per 600 ml glass beaker containing 300 ml of test solution. Four replicates were conducted per test condition. Larvae were placed in individual Nitex chambers (0.202 mm mesh) in each beaker. We also exposed groups of 5 larvae per beaker in two additional beakers at 0.56 mg/L cadmium to examine possible cannibalistic behavior.

3.2.3.2 Copepod (*E. affinis*)

A 48-h cadmium chloride reference toxicity test was conducted at the following nominal cadmium concentrations: 0, 0.032, 0.100, 0.180, 0.320, 0.560, and 1.000 mg/L. Ten to fifteen nauplii (< 24-h old) were placed in replicate 150 ml glass beakers for each test condition. One hundred mls of test solution was used for each condition. A testing chamber was suspended within each beaker to hold the organisms. The chambers were constructed from 3.8 cm diameter polycarbonate rigid tubing cut to a length of 5.0 cm which provided a 40 ml volume when suspended in the beaker. The bottom of the chamber was covered with 53 um mesh Nitex screen. Nauplii were counted by drawing small aliquots of nauplii (<24-h old) and culture water into a wide-bore, fire-polished glass pipette and examined under a dissecting microscope (15x magnification). The number of nauplii introduced and the corresponding test chamber were recorded. Test beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod (12-h L:12-h D). Mortality was recorded at 48 h. All final counts were made with a wide-bore pipette under a dissecting microscope (15x magnification) after first lowering the test solution level in the chambers.

3.2.3.3 Sheepshead Minnow

A 48-h cadmium chloride reference toxicant test was conducted at the following nominal cadmium concentrations: 0, 0.32, 0.56, 1.0, 1.8, 3.2, 5.6, and 10.0 mg/L. Ten fish larvae (< 24-h old) were placed in replicate 600 ml glass beakers containing 400 ml of test solution. The larvae were transferred to each beaker with a wide-bore, fire-polished glass pipette. Test beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod (12-h L:12-h D). Two reference toxicant tests were conducted with sheepshead minnow larvae because the source of these larvae was different. One group of larvae was obtained from established cultures in our laboratory. The other source was Aquatic Bioassay Laboratory in Baton Rouge, LA.

3.2.3.4. Fathead Minnow

A 48-h cadmium chloride reference toxicity test was conducted at the following nominal cadmium concentrations: 0, 0.032, 0.056, 0.1, 0.18, 0.56 and 1.0 mg/L. Ten fish larvae (< 24-h old) were placed in replicate 600 ml glass beakers containing 400 ml of test solution. The larvae were transferred to each beaker with a wide-bore glass pipette. Test beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod 16-h L: 8-h D.

3.2.3.5 Ceriodaphnia

A 48-h cadmium chloride reference toxicity test was conducted at the following nominal cadmium concentrations: 0, 0.018, 0.032, 0.056, 0.10, 0.180, 0.320 and 0.560 mg/L. Five Ceriodaphnia neonates (< 4-h old) were pipetted into replicate 30 mL glass beakers containing 15 mL test solution (10 neonates per condition). Neonates were counted by drawing them into a narrow-bore glass pipette and examined under a dissecting microscope (15x magnification). Test beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod 16-h L: 8-h D. The organisms in each test beaker received 0.1 mL Selenastrum and 0.24 mL CEROPHYL initially and at 24 h.

3.2.4 Sample Collection, Handling and Storage

Ambient water was collected from all eight stations and transported to a toxicity testing facility at the Wye Research and Education Center. Grab samples collected from each station were a composite of the water column (˜ 1m from the top and ˜ 1m from the bottom). A metering pump (12 V DC Little Giant Utility Pump, Model PPS-12) with polyethylene line was used to collect samples in 11.25 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 h. Samples were collected on day 0, day 3 and day 6 during the 8-day tests. All samples were chilled after collection and maintained at 4 C until used. The temperature of the ambient water used for testing was 25 C. Salinity adjustments (increase) were performed on samples collected from saline sites to obtain a standard test salinity of ˜ 15 ppt. Slightly higher ambient salinity conditions of 19-20 ppt were reported at the Elizabeth River station;

therefore, salinity was not changed.

3.2.5 Test Procedures

3.2.5.1 Grass Shrimp

Eight to 9-d old larvae were exposed to each ambient water condition from all eight stations and a 15 ppt salinity control. Salinity adjusted freshwater (15 ppt) from the Indian Head, Freestone Point and Possum Point stations (Potomac River) was used. During the first set of experiments (Elizabeth River, Patapsco River and Wye River), larvae were tested individually in Nitex chambers (0.202 mm mesh) to prevent cannibalism. Each test condition consisted of 4 larvae per 600 ml beaker with 12 beakers (total of 48 larvae per condition). Each beaker contained 200 ml of sample water; no aeration was supplied to the beakers. Larvae were also tested in groups of 5 at two test conditions during these initial tests to determine if cannibalism occurred. Cannibalism did not occur, therefore, all future tests (Potomac River experiments) were conducted with groups of 5 larvae per 600 ml beaker. Eight beakers were used for each test condition for a total of 40 larvae per condition.

Temperature, salinity, dissolved oxygen and pH were measured daily in randomly-selected beakers at each test condition prior to water exchange. One beaker was randomly selected per treatment condition daily to monitor ammonia. One-half of the water (100 ml) was siphoned out daily from each beaker and then renewed with a fresh sample held at 4 C and warmed to 25 C. Larvae were fed concentrated volumes of *Artemia* nauplii daily after water renewal. For larvae tested individually, 75 ul of concentrated *Artemia* was used daily. Approximately 375 ul of concentrated *Artemia* was fed to larvae tested in groups of five. At the completion of the 8-d experiments, all larvae were preserved in 10% formalin prior to wet weight analyses. Dry weights for each larvae were recorded following 72-h drying at 70 C.

Survival proportions were compared using the Kruskal-Wallis test. A nonparametric test was chosen in lieu of ANOVA because the homogeneity of variance assumption was not satisfied in the data set. Growth parameters were compared using ANOVA and the Bonferroni T-test. This t-test was chosen because of the unequal replicate numbers (Weber et al., 1989). Differences between means were considered significant at the p< 0.05 level.

3.2.5.2 Copepod (*E. affinis*)

The methods used for testing *E. affinis* were modified from Hall et al., 1988b. Experiments were started with *E. affinis* nauplii <24-h old. Nauplii were exposed to all eight test conditions and an artificial seawater control (15 ppt). Salinity adjusted freshwater 15 ppt from the Indian Head, Freestone Point and Possum Point stations (Potomac River) was used. Four replicate 150 ml beakers containing 100 ml of test water were used for each condition. Ten to fifteen nauplii were placed in a chamber suspended within each test beaker. The initial number of nauplii were recorded. The chamber design was the same as that used in the reference toxicant tests described previously (Section 3.2.3.2). Nauplii were counted using a wide-bore, glass pipette under a dissecting microscope (15x magnification). Test beakers were held in a biological incubator to control temperature (25 C) and photoperiod (12-h L:12-h D). Temperature, dissolved oxygen, and salinity were measured daily in selected beakers. On alternate days, pH values were recorded. A one liter sample was taken daily from each of the ambient test conditions, stored at 4 C, and warmed to 25 C. One-half of the water volume per beaker was siphoned out daily and renewed with the fresh sample. Following the daily water renewals, copepods were fed an equal volume mixture of _T. fluviatilis_ and _I. galbana_. Four mL of the two-species algal mix, each in log-phase, was pipetted into each test chamber. Algal cell densities within the chambers were generally 2 - 5 x 10^5 cells/ml. All cell counts were done with Spencer improved Neubauer corpuscle counting chamber (hemacytometer).

On day four of exposure to ambient water, two test beakers from each condition were selected to evaluate nauplii survival. Counts were made by first lowering the volume of water in the chambers, then removing the remaining water and nauplii in small aliquots with a wide-bore glass pipette. The nauplii were counted under a dissecting microscope (15x magnification) then discarded. Survival was evaluated again on day eight using the two remaining beakers at each test condition. Surviving egg-carrying adult female copepods were isolated in 20 ml glass vials (1 adult/vial) from each test condition. Within 24-48 h, egg-sacs had been released by the females and the resulting brood size was determined for each female.

Percent survival of copepods was compared using the Kruskal-Wallis test. A nonparametric test was used in lieu of ANOVA because the homogeneity of variance assumption was not satisfied in the data set. Analysis of variance (ANOVA) and the Bonferroni T-test were used to compare brood sizes. Differences between means were considered significant at the $p< 0.05$ level.

3.2.5.3 Sheepshead Minnow

Experiments were initiated with sheepshead minnow larvae < 24-h old. Larvae were exposed to all test conditions and an artificial seawater control (15 ppt). Four replicates of 10 larvae per replicate (600 ml beaker) were used for the Potomac River tests. However, due to poor hatching success prior to the first set of experiments, the number of larvae per test condition was reduced. Three replicate 600 ml glass beakers, per condition, containing 400 ml of test water were used for the control and Elizabeth River conditions. Four replicate beakers per condition were used for Patapsco River and Wye River conditions. Each of the beakers contained eight larvae with the exception of one replicate from the Elizabeth River condition which had only seven larvae. Larvae were transferred to the beakers with a wide-bore, fire-polished glass pipette.

Temperature, salinity, and dissolved oxygen were measured daily in selected beakers prior to water exchange. On alternate days, pH measurements were recorded. Test beakers were held in a biological incubator to maintain constant temperature (25 C) and photoperiod (12-h L:12-h D). A one liter sample was taken daily from each of the three field samples, stored at 4 C, and warmed to 25 C. One-half of the water volume per beaker was siphoned out daily and renewed with the fresh sample. Following the daily water renewals, larvae were fed <24-h old Artemia nauplii. Artemia nauplii were concentrated on a Nitex mesh and rinsed briefly with culture water (15 ppt artificial seawater). Four mL of the concentrate was diluted to 100 mL with culture water. One-half mL of the diluted nauplii was pipetted into each beaker.

Larval survival was recorded daily for eight days. At the end of 8-d exposure to ambient water, one-half of the surviving larvae from each beaker were preserved in 10 % formalin. The remaining larvae were rapidly frozen in liquid nitrogen for protein analysis (see Suborganismal Section). Larvae were removed from the formalin and rinsed with deionized water prior to measuring wet weight and length. Dry weights for pooled larvae samples were recorded following 31-h drying at 78 C. Mean individual larval weights were calculated from the pooled weights.

The average dry weight of control larvae must exceed 0.25 mg/L for an acceptable growth test. Our SOP's state that an average dry weight of 0.50 mg is required for an acceptable test. This value is based on culture and testing salinities of 20 - 30 °/oo. The salinity used in these tests (15 °/oo) is much lower and results in lower growth rates.

Survival proportions were compared using the Kruskal-Wallis test. A nonparametric test was used because the homogeneity of variance assumption was not satisfied in this data set. Some conditions had zero variance. Growth parameters were compared using ANOVA and the Bonferroni T-test. Differences between means were considered significant at the $p<0.05$ level.

3.2.5.4. Fathead Minnow

Experiments were initiated with fathead minnow larvae less than 24-h old. Larvae were exposed to the following test conditions: Control water, and Potomac River water collected from Indian Head, Freestone Point and Possum Point. Four replicate 600 ml glass beakers containing 400 mls of test water were used for each condition. Ten larvae were transferred to each beaker with a fire-polished, wide-bore glass pipette. Beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod (16-h L: 8-h D). The larvae in each test beaker were fed 0.1 mL of a concentrated suspension of newly hatched brine shrimp nauplii twice daily. Nauplii were rinsed with fresh water prior to feeding larvae.

Temperature, dissolved oxygen, and pH were measured daily in selected beakers from each condition. Hardness was measured three times corresponding to each new sample collected from the Potomac River. Larval mortality was recorded daily and dead larvae were discarded. A one-liter sample was taken daily from each of the three field samples, stored at 4 C, and warmed to 25 C. Before the renewal of test solutions, uneaten and dead brine shrimp were removed from the bottom of each test beaker. The test solutions were renewed daily immediately after cleaning each beaker. One-half the water volume per beaker was siphoned out and renewed with the fresh, warmed sample.

At the end of 8-d exposure to ambient water, one-half of the surviving larvae from each beaker were preserved in 10% formalin. The remaining larvae were rapidly frozen in liquid nitrogen for subsequent protein analysis. Larvae were removed from the formalin and rinsed with deionized water prior to measuring wet weight and length. Dry weights for pooled larvae samples were recorded following 31-h drying at 78 C. Mean individual larval weight was calculated from the pooled weight.

Survival proportions were transformed using the arc sine (square root (Y)) transformation. Analysis of variance (ANOVA) and Dunnetts Test were used to compare survival in the river conditions to the control. Growth parameters were compared using ANOVA followed by Dunnetts Test or Bonferroni T-Test. Differences between means were considered significant at the $p<0.05$ level.

3.2.5.5 _Ceriodaphnia_

Experiments were initiated with _Ceriodaphnia_ neonates less than 24-h old and released during the same 4-h period. Neonates were exposed to the following test conditions: Control water, and Potomac River water collected from Indian Head, Freestone Point and Possum Point. Ten replicate 30 mL glass beakers containing 15 mLs of test water were used for each of the four conditions. One neonate was placed in each beaker with a narrow-bore glass pipette. Beakers were placed in a biological incubator to maintain constant temperature (25 C) and photoperiod (16-h L: 8-h D). During the test, the Ceriodaphnia were fed the same diet as used for the cultures. The organisms in the test beakers were fed 0.1 mL Selenastrum and 0.24 mL CEROPHYL daily.

Two Ceriodaphnia tests were conducted because the mean number of neonates produced per adult in the control during the first experiment was less than 15. A minimum number of 15 is needed for a valid test using reproduction as an endpoint. However, survival data from the first experiment was valid.

Temperature, dissolved oxygen, and pH were recorded daily in selected beakers from each test condition. Hardness was measured three times corresponding to each new sample collected from the Potomac River. A glass pipette was used to transfer each test organism daily to a new beaker containing 15 mL of fresh sample to which food had already been added. Prior to transferring each organism, adult mortality and neonate production was recorded daily. The young were counted with the aid of a dissecting microscope (15x magnification). Fishers Exact Test and/or a T-test were used to analyze survival (Weber et al., 1989). Analysis of variance (ANOVA) and the Bonferroni T-Test were used to compare reproduction. Differences between means were considered significant at the $p<0.05$ level.

3.2.5.6 *Fundulus heteroclitus*

F. heteroclitus exposed to ambient water from all saline sites were used for suborganismal testing (protein analysis). These fish were collected near the Chesapeake Biological Laboratory and transported to our laboratory by Dr. Jay Gooch. Test organisms were exposed to all 5 ambient saline conditions and an artificial seawater control (15°/oo) at 25 C. Replicate 18 L glass aquaria with 14 L of water contained six fish per aquaria. One-half of the water volume in each test aquaria was siphoned out daily and renewed with fresh sample. Aeration was supplied if dissolved oxygen fell below 5.0 mg/L. Temperature, salinity and dissolved oxygen were measured daily and on alternate days pH values were recorded. Fish were fed once daily to satiation with flake food (Tetramin®). Experiments were terminated after 8 days and surviving fish were given to Dr. Gooch for protein analysis.

3.2.6 Contaminant and Water Quality Evaluations

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

Aqueous samples for analysis of organic and inorganic contaminants listed in Table 2 were collected during the ambient toxicity tests. Analytical procedures and references for analysis of these samples are presented in Table 3. Total inorganic contaminant analysis was conducted on filtered samples using 0.40 um polycarbonate filters.

Four liter whole water samples were collected for organic contaminants analysis (Table 2). Organic contaminants other than those identified in Table 2 (non-target organics) were measured if GC/MS peaks were identified. Detailed procedures for preparing samples for inorganic and organic analysis are described in detail in Hall et al. (1988a). These contaminants have been evaluated during our previous striped bass contaminant studies on the Potomac River. Various metals (cadmium, lead and zinc) and organics (chlordane) have been reported at potentially toxic concentrations in the Potomac River (Hall et al., 1988a). Analysis for both organic and inorganic contaminants was conducted at least one time on aqueous samples collected from each station. If toxicity was reported during the experiments then the suite of contaminants was analyzed on at least 2 separate samples taken during these tests. VERSAR Inc. was responsible for all organic and inorganic analyses.

Standard water quality conditions of temperature, salinity, dissolved oxygen, pH, conductivity and hardness (freshwater stations) were evaluated at each site after sample collection. These conditions were evaluated every 24 h at all test conditions during the tests. Datasonde units (continuous water quality

Table 2. Concentrations of the following organic and inorganic contaminants were evaluated.

Contaminant	Detection Limit (ug/L)
Aroclor 1248	0.050
Aroclor 1254	0.050
Aroclor 1260	0.050
DDE	0.02
Toxaphene	0.2
Chlordane	0.02
Perylene	0.70
Fluorene	0.90
Phenanthene	0.70
Anthracene	0.70
Fluoranthrene	1.1
Pyrene	1.0
Benz(a)anthracene	1.7
Chrysene	0.7
Aluminum	3.0
Arsenic	3.0
Cadmium	2.0
Chromium, total	3.0
Copper	2.0
Lead	2.0
Mercury	0.2
Nickel	5.0
Selenium	3.0
Tin	5.0
Zinc	5.0

Table 3. Analytical methods used for organic and inorganic analysis. The following abbreviations were used: GC-EC (Gas Chromatography - Electron Capture), GC -MS (Gas Chromatography - Mass Spectrometry), Atomic Emission - ICP (AE-ICP), AA-H (Atomic Absorption - Hydride), AA- F (Atomic Absorption - Furnace) and AA-DA (Atomic Absorption - Direct Aspiration) and AA-CV (Atomic Absorption - Cold Vapor).

Contaminant	Method	Method #	Reference
Halogenated Hydrocarbon Pesticides	GC-EC	608	U. S. EPA, 1984
Polychlorinated Biphenyls	GC-EC	608	U. S. EPA, 1984
Base-Neutral Extractable Organic Compounds	GC-MS	625	U. S. EPA, 1984
Aluminum	AE-ICP	200.7	U. S. EPA, 1984
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
Tin	AA-F	282.2	U. S. EPA, 1979
Zinc	AA-DA	289.1	U. S. EPA, 1979

monitors) were used to continuously record the above water quality conditions at the various stations during the Potomac River experiments. (Appendix B)

3.3 Sediment Tests

3.3.1 General Description

All tests and analyses were conducted according to the SOPs and QA plans previously submitted to the sponsor. The methods described in this report are general summaries of those protocols. Sediment samples (100% ambient sediment samples) from eight stations were tested using 3 organisms: the grass shrimp, *Palaemonetes pugio*, the amphipod, *Lepidactylus dytiscus*, and the polychaete worm, *Streblospio benedicti*. All tests were conducted for 10 d at 25C and monitored daily. At the end of 10 d, mortalities were recorded, and the animals were returned to the original test containers. The organisms were then monitored daily for an additional 10 d. Numbers of live animals were recorded on day 20, and any living organisms were preserved for length/weight measurements. The sediment samples were collected from the Elizabeth River, Patapsco River, Potomac River, and the Wye River. Three of the Potomac sites were located in freshwater areas. Two other sites in the Potomac River, the Wye River and Patapsco River had low salinities (between 7 and 9 ppt). All of these samples were adjusted to 15 ppt by sieving with 15 ppt control water prior to testing. The eighth station, in the Elizabeth River, was 20 ppt without adjustment, and was tested at 20 ppt. Control sediments for each species consisted of the native sediments from the area in which the test organisms were collected. A control was tested with each set of samples. In addition, a reference sediment (see below) was tested with each set of test samples.

Sediment was collected for particle size analysis from each of the test stations several weeks prior to the toxicity tests. A reference sediment was then chosen for each set of samples. From the initial sediment collection, the Wye River sample matched the sediment particle size needed for a reference sediment for the first set of test samples. The Patapsco River site initially sampled was less than 1% sand (99% silt/clay) and the Elizabeth River site was 5% sand (95% silt/clay). The Wye River sample was about 4.5% sand, and therefore, was suitable as a reference sediment to be used for these two sites (Table 4). However, when the actual test sediments were collected, the particle size/composition of the Patapsco River site was drastically different from the initial sample. The test sediment was approximately 94% sand (Table 5). However, the amphipod control sediment tested was also a very sandy sediment (approx. 99% sand), so an additional reference sample was not needed. The second set of test samples fit into two categories: greater than 85% sand and greater than 85% silt/clay. A reference sediment from the Nansemond River, Virginia, was chosen for the greater than 85% silt/clay samples, and the amphipod control sediment was used for comparison to the sandy samples.

Table 4. Particle size analysis of sediments collected for pilot survey from the eight stations. The five Potomac River sites are Indian Head, Freestone Point, Possum Point, Morgantown, and Dahlgren.

Station	% Sand	% Silt	% Clay
Set #1:			
Elizabeth River (Atlantic Wood)	5.14	68.03	26.84
Patapsco River	0.16	92.71	7.13
Wye River	4.47	86.86	8.67
Set #2:			
Indian Head	14.43	69.23	16.34
Freestone Point	10.19	78.58	11.23
Possum Point	3.90	74.95	21.15
Morgantown	95.98	1.40	2.62
Dahlgren	89.82	4.93	5.25

Table 5. Particle size analysis of sediments from eight stations and controls used in toxicity tests. The five Potomac River sites are Indian Head, Freestone Point, Possum Point, Morgantown, and Dahlgren.

Station	% Sand	% Silt	% Clay
Set #1:			
Elizabeth River (Atlantic Wood)	13.84	37.24	48.93
Patapsco River	94.32	2.84	2.84
Wye River	20.20	48.85	30.95
Worm Control	84.05	9.50	6.45
Amphipod Control	100.00	0.00	0.00
Grass Shrimp Control	100.00	0.00	0.00
Set #2:			
Indian Head	11.18	56.85	31.97
Freestone Point	17.08	60.48	22.44
Possum Point	1.22	69.34	29.44
Morgantown	92.03	2.87	5.10
Dahlgren	85.43	7.73	6.85
Nansemond Reference	19.80	42.80	37.40
Amphipod Control	100.00	0.00	0.00

3.3.2 Collection, Handling, Maintenance and Culture of Test Species

3.3.2.1 Grass shrimp - *Palaemonetes pugio*

Grass shrimp were collected from the Lynnhaven Inlet, Virginia, quarantined, and identified with identifications of the species verified by a local crustacean specialist. Gravid adult females were then selected and moved to breeding tanks. As larvae were released, the adults were removed to prevent predation. Larvae were reared in 10 gallon tanks to the post-larval stage. Grass shrimp post-larvae approximately 30-d old were used in the first set of tests. Half of the animals were acclimated to 20 ppt salinity and half acclimated to 15 ppt prior to the tests.

Grass shrimp were purchased from a supplier (Multi Aquaculture Systems, New York) for the second set of tests. The shrimp were handled in the same fashion as mentioned above. We received post larvae 9-12 d old on September 25, 1990. These animals were held at 25 C and 15 ppt salinity, fed 24 hr old artemia nauplii daily *ad libitum*, and acclimated to laboratory conditions. The shrimp were held for observation for 4-d prior to initiation of the tests. Animals 12 to 15-d old were used in the second set of tests. Less than 10% mortality was observed during the holding and acclimation period.

3.3.2.2. Amphipod - *Lepidactylus dytiscus*

Animals were collected from an estuarine site at Virginia Beach, Virginia, transported in buckets to the AMRL and acclimated to laboratory conditions. Amphipods were collected at 20 ppt salinity. Half of the population were acclimated to 15 ppt over a 4-d period, and the remaining half were maintained at 20 ppt. Animals were held in their native sediment (sand) in 20 gallon tanks for approximately 7 d prior to initiation of the tests. Less than 10% mortality was observed during the holding period. For the second set of tests, the animals were again collected from the field and brought to the laboratory approximately one week prior to initiation of the toxicity tests. These animals were acclimated to 15 ppt over a 4-d period. Again, mortality during the holding period was less than 10%.

3.3.2.3 Polychaete worm - Streblospio benedicti

Worms were collected from a tidal creek entering the Lafayette River (Norfolk, VA), brought to the laboratory, and held in 10 gallon tanks of native mud with 15 ppt overlying water approximately one week before testing. A subset of animals was acclimated to 20 ppt over a 4-d period for the first set of tests. Animals were sieved out of the holding tank and placed into 4" culture dishes 24 h prior to addition to the test containers. Both sets of organisms had less than 10% mortality during the holding period.

3.3.3 Reference Toxicant Tests

The relative sensitivities of each set of test organisms was evaluated by a reference toxicant test designed to assess changes in tolerances of the organisms that may have been due to disease, or stress developed from handling and acclimation. The grass shrimp, *Palaemonetes pugio*, was tested in a 96-h, water only, acute test using SDS (sodium dodecyl sulfate) in 1 liter containers with 800 mL of test solution. SDS was selected as the reference toxicant to be used with the grass shrimp because it is a standard EPA reference toxicant with a large historical data base. Literature exists for grass shrimp tested with SDS, and there is minimal human health risk from this toxicant. Ten animals were placed into each test container, with two replicates per concentration. Each batch of organisms used for each set of bioassays was tested with a reference toxicant.

The amphipod, *Lepidactylus dytiscus*, was tested in a 96-h, water only, cadmium chloride reference toxicant test using 400 mL of solution with 10 animals per container. Five concentrations and a control (seawater only) were prepared by serial dilution. Tests were conducted at 20 ppt salinity with two replicates for each concentration.

The polychaete worm, *Streblospio benedicti*, was tested in a 96-h, water only, cadmium chloride ($CdCl_2$) reference toxicant test. Animals were tested in 250 mL crystallizing dishes with 200 mL of test solution, 10 animals per dish and two replicates per concentration.

3.3.4 Sample Collection, Handling and Storage

Sediment samples were collected at each site by AMRL personnel and returned to the laboratory for testing. The first set of sediments was collected at the following sites: Elizabeth River (Atlantic Wood), Patapsco River (Bethlehem Steel), and the Wye River. All samples were collected on Thursday, August 16, 1990, by petite ponar grab. Grab samples were collected and emptied into a large stainless steel pan. The top 2 cm of sediment was then removed from each grab and placed into a tub. Enough grabs were taken at each site to fill a tub with approximately 8 gallons of sediment. Each composite sediment sample was then homogenized by stirring (using an analytically cleaned stainless steel paddle). Aliquots were taken from the tub and distributed to individual sample containers for toxicity tests, chemical analysis and particle size analysis. All samples were transported to the AMRL in coolers, on ice, and out of direct sunlight. Samples were logged into AMRL refrigerators and held at 4 C until toxicity tests were initiated. All sediment samples used for bioassays were tested within the recommended two week holding period (USEPA/ACOE, 1977). Samples for chemical analysis were frozen until ready for testing.

The second set of sediment samples was collected on September 26, 1990, at the following Potomac River sites: Dahlgren, Indian Head, Possum Point, Morgantown and Freestone Point. A sample was also collected at a Nansemond River reference site in Suffolk, VA. All samples were collected and handled the same as the first set. Approximately 8 gallons of sediments were collected by petite ponar grab, homogenized and distributed to sample containers. All samples were transported on ice, out of direct sunlight. Samples were held in refrigerators at 4 C until used in toxicity tests. Samples for chemical analysis were stored frozen until tested. All samples were analyzed within EPA recommended holding times.

3.3.5 Test Procedures

Sediments were removed from the refrigerator and homogenized by stirring. Large sticks or debris and macrofauna were removed by sieving the sediments through a 0.5 mm mesh screen prior to placing them into test containers. A two centimeter layer of sediment was placed into each test dish with overlying water made from artificial sea salts and deionized water. The test containers were placed into water baths and allowed to equilibrate 24-h before animals were added. The first set of test sediment was placed into the test containers on August 27, 1990. All test animals were added the next day (August 28, 1990). Seven replicates were set up for each test sediment and a control. A subset of each test population of organisms was set aside for initial growth measurements. All containers were gently aerated throughout the test (no more than 100 bubbles/minute). All tests were conducted at 25 C. The test was monitored daily for 10 d for oxygen, temperature, pH, mortality and behavior (i.e., amphipod emergence from sediment). At day ten (September 7, 1990), the animals were counted, mortality assessed, overlying water changed, and living animals returned to test containers for an additional 10 d. Organisms from replicates 6 and 7 were removed and given to Dr. Jay

Gooch, CBL, for stress protein analysis (see Section 3.4). On day 20 of the test (September 17, 1990) mortality was recorded and surviving organisms were measured for growth. The second set of sediment samples (Potomac sediment) was treated the same as the first set. The test material was placed into the test containers on September 27, 1990, and allowed to equilibrate overnight. Test organisms were added on September 28, 1990, and monitored for 10 d. On October 8, 1990, day 10 of the test, mortality was assessed and animals from replicates 6 and 7 were collected and processed for stress protein analysis. All surviving organisms in replicates 1 through 5 were returned to the test containers for an additional 10-d. On October 18, 1990 (day 20), the test was terminated, mortality recorded and growth measurements made on surviving organisms.

In addition to the three species used for toxicity tests (i.e., the shrimp, amphipod and worm) populations of mummichogs, Fundulus heteroclitis, were exposed to test solutions in five gallon aquaria with 2 cm of sediment and four gallons of overlying water. These fish were used for protein analysis by Dr. Jay Gooch of CBL. The animals were provided by Dr. Gooch and stocked six per tank. Two replicates were set up for each test sediment and the control. Tanks were monitored daily and 75% of the overlying water was changed every 48 hours for ten days. The animals were fed flake food daily. On day ten, all fish were removed and given to Dr. Gooch for analysis (see Section 3.4).

3.3.5.1 Grass Shrimp - *Palaemonetes pugio*

The test methods for the grass shrimp, *Palaemonetes pugio*, followed the methods described in the EPA/ACOE *Implementation manual* (1977) for sediment bioassays. Twenty juvenile grass shrimp were placed into a one gallon glass aquarium containing a 2 cm layer of sediment and 3000 mL of overlying water. All animals were fed live artemia twice a day, and 75% of the overlying water was changed every 48 h. The shrimp control sediment was clean sand from their native habitat and was tested at 20 ppt salinity. Oxygen, temperature, pH and mortality were recorded daily for 10 d. Animals were removed from the tanks and survival recorded on day ten. Replicate 6 and 7 animals were given to Dr. Gooch for protein analysis. The remaining five replicates of animals were returned to the test chambers and monitored for an additional 10 d. On day twenty, all animals were removed and mortality recorded. Any surviving animals were measured for length and dry weight.

3.3.5.2 Amphipod - *Lepidactylus dytiscus*

A series of test containers was set up according to the methods outlined in the ASTM "Guide for Conducting Solid Phase 10-Day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods" (ASTM, 1990). Two centimeters of sediment were placed into each 1 liter jar with 700 mL of overlying water. Twenty animals were placed into each test jar and monitored for 10 d. Control sediment was native sand from the amphipod collection site and was tested at 20 ppt salinity. A subset of the population of test animals was selected for initial length/weight measurements. Test containers were monitored daily for oxygen, temperature, and pH. Observations relative to the number of animals emerged from the sediment were also recorded. The amphipods were not fed during the test. At the end of 10 d, animals were sieved from test containers, mortality recorded, and surviving animals returned to the test containers for an additional 10-d period. On day twenty, animals were again sieved from the containers and mortality recorded. Live animals were preserved for growth measurements.

3.3.5.3 Polychaete worm - Streblospio benedicti

Test methods for the polychaete, Streblospio benedicti are similar to those applied to the amphipod test. Ten organisms were placed into each 750 mL test jar containing 2 cm of sediment and 500 mL of overlying water. Test containers were monitored daily for oxygen, temperature and pH. The worms were not fed during the test. After 10 d, the worms were sieved from the sediment and mortality recorded. Surviving organisms were returned to the test dishes and monitored for an additional 10 d. On day twenty, the worms were sieved from the test jars, counted and preserved for growth measurements.

3.3.6 Contaminant and Sediment Quality Evaluations

3.3.6.1 Semi-Volatile Organic Analysis: Sediment

The sediment sample and corresponding QA/QC spikes and blank were analyzed for semi-volatile (base/neutral and acid extractables) organic compounds (Table 6) in accordance with USEPA methods 3550 and 8270 (USEPA, 1986). In summary, the method requires an ultra-sonication extraction of approximately thirty grams of sample with a methylene chloride:acetone solvent system. Each sample was sonicated three times and the filtrates pooled as the final extract. Each extract was then concentrated using Kuderna-Danish and rotary evaporation techniques to a final volume of 1 ml. Each sample received six USEPA-approved surrogates and, after concentration, each 1 ml extract was spiked with six USEPA-approved internal standards.

Sample extracts were analyzed using a Finnigan INCOS-50 GC/MS/DS. The MS was tuned to USEPA criteria by injecting 50 ng of decafluorotriphenylphosphine (DFTPP) into the GC inlet for tune criteria.

A calibration curve for all analytes was established using a five-point calibration. All analytes were calibrated at 12.5, 25, 50, 100, and 200 ng/uL using the internal standard method. The calibration curve was checked and corrected regularly using the 100 ng calibration point.

Tentative identifications were made based on the USEPA accepted National Bureau of Standards (NBS) compound library. The substances of greatest apparent concentration (to a maximum of 20) are reported for each semi-volatile organic sample.

The GC was equipped with a J&W DB-5 (30m x .32mm ID x .25μm film) capillary column and sample introduction was via a grab type split/splitless injection system. The MS scanned from 35 to 450

Table 6. Semi-volatile organic compounds analyzed for utilizing a user-created calibration library. Sediment method detection limits (MDL) are reported in µg/kg dry weight.

CAS NO.	COMPOUND	SEDIMENT MDL
65-53-3	Aniline	14.5
95-57-8	2-chlorophenol	13.2
111-44-4	Bis(2-chloroethyl)ether	11.2
108-95-2	Phenol	11.9
541-73-1	1,3-dichlorobenzene	11.9
106-46-7	1,4-dichlorobenzene	12.5
95-50-1	1,2-dichlorobenzene	11.9
100-51-6	Benzyl alcohol	27.1
39638-32-9	Bis(2-chloroisopropyl)ether	5.9
95-48-7	2-methylphenol	15.8
91-57-6	2-methylnaphthalene	9.2
67-72-1	Hexachloroethane	21.8
621-64-7	n-nitroso-di-n-propylamine	13.2
106-44-5	4-methylphenol	13.9
98-95-3	Nitrobenzene	11.2
78-59-1	Isophorone	6.6
88-75-7	2-nitrophenol	27.1
65-85-0	Benzoic acid	18.5
105-67-9	2,4-dimethylphenol	15.8
111-91-1	Bis(2-chloroethoxy)methane	9.9
120-83-2	2,4-dichlorophenol	21.8
120-82-1	1,2,4-trichlorobenzene	15.2
91-20-3	Naphthalene	4.6
106-47-8	4-chloroaniline	26.4
87-68-3	Hexachlorobutadiene	22.4
59-50-7	4-chloro-3-methylphenol	20.5
77-47-4	Hexachlorocyclopentadiene	25.7
88-06-2	2,4,6-trichlorophenol	37.0
95-95-4	2,4,5-trichlorophenol	44.9
88-74-4	2-nitroaniline	37.6
91-58-7	2-chloronaphthalene	9.9
208-96-8	Acenaphthalene	5.9
84-66-2	Dimethylphthalate	9.9
606-20-2	2,6-dinitrotoluene	48.2
99-09-2	3-nitroaniline	247
83-32-9	Acenaphthene	9.9
51-28-5	2,4-dinitrophenol	262
132-64-5	Dibenzofuran	7.9
100-02-7	4-nitrophenol	268
121-14-2	2,4-dinitrophenol	43.6
86-73-7	Fluorene	9.9
7005-72-3	4-chlorophenylphenylether	20.5
84-66-2	Diethylphthalate	9.9
100-01-6	4-nitroaniline	279
534-52-1	4,6,-dinitro-2-methylphenol	122
86-30-6	n-nitrosodiphenylamine	19.1

Table 6. (Continued)

CAS NO.	COMPOUND	SEDIMENT MDL
101-55-3	4-bromophenylphenylether	41.6
85-01-8	Phenanthrene	9.2
118-74-1	Hexachlorobenzene	37.6
87-86-5	Pentachlorophenol	136
120-12-7	Anthracene	9.9
84-74-2	Di-n-butylphthalate	5.9
206-44-0	Fluoranthene	10.6
129-00-0	Pyrene	10.6
85-68-7	Butylbenzylphthalate	17.8
56-55-3	Benzo(a)anthracene	17.8
218-01-9	Chrysene	14.5
91-94-1	3,3'-dichlorobenzidine	101
117-81-7	Bis(2-ethylhexyl)phthalate	12.5
117-84-0	Di-n-octylphthalate	7.3
205-99-2	Benzo(b)fluoranthene	13.9
207-08-9	Benzo(k)fluoranthene	13.9
50-32-8	Benzo(a)pyrene	15.2
193-39-5	Indeno(1,2,3-cd)pyrene	16.5
53-70-3	Dibenz(a,h)anthracene	17.8
191-24-2	Benzo(ghi)perylene	16.5
103-33-3	Azobenzene	7.3
92-87-5	Benzidine	24.4

amu. The GC was temperature programmed, starting at 35C then to 300C at 7C/min and held until all compounds eluted. The detection limits for calibrated priority pollutants are presented in Table 6. The detection limit for tentatively identified non-priority pollutants was determined to be 10 ug/L.

3.3.6.2 Pesticide Analysis: Sediment

The sediment sample was analyzed for organochlorine pesticides (OCP) as well as polychlorinated biphenyls (PCBs) in accordance with USEPA Methods 3550 and 8080 (Table 7). In summary, the method requires an ultra-sonication extraction of approximately thirty grams of sample with a methylene chloride:acetone solvent system. Each sample was sonicated three times and the filtrates pooled as the final extract. Each extract was then exchanged to hexane and concentrated using Kuderna-Danish and rotary evaporation techniques to a final volume of 1 mL. The extracts were fractionated using florisil column chromatography and treated with activated copper to reduce sulfur contamination. One microliter of each extract was analyzed for organochlorine pesticides and PCBs by gas chromatography/electron capture (GC/ECD) detection. The GC was equipped with a DB-17 capillary column (.32mm x 30m x .25μm film), and analyses were carried out isothermally at 220° C. Quantitation was based on the external standard technique ($r>0.995$ for all analytes of interest).

3.3.6.3 Acid Volatile Sulfides

Table 7. Method detection limits for organochlorine pesticides and PCBs. Detection limits for sediment are reported in µg/kg dry weight.

CAS NO.	COMPOUND	SEDIMENT MDL
391-84-6	α-BHC	0.714
301-85-7	β-BHC	0.559
391-86-8	δ-BHC	1.062
58-89-9	Lindane	0.616
76-44-8	Heptachlor	0.819
309-00-2	Aldrin	0.608
1024-57-3	Heptachlor epoxide	0.570
959-98-8	Endosulfan I	0.859
60-57-1	Dieldrin	0.898
72-55-9	4,4'-DDE	0.528
33213-65-9	Endosulfan II	0.745
72-20-8	Endrin	1.240
72-54-8	4,4'-DDD	0.469
1031-07-8	Endosulfan sulfate	1.500
50-29-3	4,4'-DDT	3.420
72-43-5	Methoxychlor	5.0
57-74-5	Chlordane	5.0
80001-35-2	Toxaphene	10.0
2385-85-5	Mirex	1.000
7421-93-4	Endrin aldehyde	2.410
12574-11-2	Aroclor 1016	16.6
11104-28-2	Aroclor 1221	16.6
11141-16-5	Aroclor 1232	16.6
53469-21-9	Aroclor 1242	16.6
12672-29-6	Aroclor 1248	16.6
11097-69-1	Aroclor 1254	16.6
11096-82-5	Aroclor 1260	16.6

Sediment samples were frozen until analysis for acid volatile sulfides (AVS). Samples were thawed, then re-homogenized by gently stirring. Sediment samples were analyzed for AVS using the method of DiToro et al. (1990). Samples were analyzed at least in duplicate.

The analytical apparatus was a one-way flow-through system which consisted of a nitrogen purifier (deoxygenator) followed by a series of four flasks connected by glass and tygon tubing. The first flask for placement of the sample or standard was followed by a flask containing 175-200 mL of 0.05M potassium hydrogen phthalate. The last two flasks in the series each contained 175-200 mL of 0.1M silver nitrate.

Prior to analysis, the system was deoxygenated by purging with nitrogen for one hour. After purging, 10-15 grams (by weight) of sediment samples were weighed then placed into the first flask. The sample was quantitatively transferred using deoxygenated purified water. The system was then purged with nitrogen for an additional ten minutes. The AVS extraction was initiated by the addition of 6M hydrochloric acid to the sample to achieve a final hydrochloric acid molarity of 0.5M. The system was then purged with nitrogen for one hour. Sample flasks were swirled every five to ten minutes throughout the extraction. After one hour, the flow of nitrogen was stopped. The silver sulfide precipitate in the third flask (first flask originally containing silver nitrate) was filtered onto a Whatman GF/C glass fiber filter which was pre-rinsed, dried at 104C, cooled, and pre-weighed. After the silver sulfide precipitate was concentrated onto the filter, the filter was dried at 104C, cooled then re-weighed. Sample blanks were analyzed in the same manner as samples except acid was not added to the sample flask.

Sediment dry weight:wet weight ratios were calculated using separate aliquots of each sample. AVS was calculated on a micromolar basis, based upon uM of silver sulfide residue and normalized to a sediment dry weight basis.

3.3.6.4 Total Organic Carbon

Sediment subsamples were dried at approximately 50C for Total Organic Carbon (TOC) analysis. Sample homogeneity was achieved by grinding with an acid-cleaned mortar and pestle. After drying and homogenization, approximately 5 mg subsamples were placed onto pre-cleaned sample cups and weighed using a micro-balance. Inorganic carbon was removed using 0.5M hydrochloric acid. Samples were analyzed by high temperature combustion using a Carlo-Erba NA1500 isothermal gas chromatograph in accordance with the manufacturer's instructions.

3.3.6.5 Ammonia and Nitrite

Pore water samples were removed from the sediment samples by squeezing with a nitrogen press. Water samples were filtered then frozen until analysis for ammonia-N and nitrite-N. Samples were analyzed for ammonia-N using the automated phenate method (SIC, 1981). Nitrite-N analyses were preformed using the Diazotization

Method (APHA, 1985).

3.3.6.6. Metals

All sediment samples were analyzed for Al, Cd, Cr, Cu, Pb, Ni, Sn, and Zn using an ICP following USEPA/SW-846, Method 6010. The elements were extracted from a thoroughly homogenized sample using 1:1 redistilled nitric acid, 30% peroxide, and concentrated hydrochloric acid as prescribed in USEPA/SW-846, Method 3050. An aliquot of the digestate was further prepared for the analysis of As and Se using a continuous hydride generation system as described in Standard Methods for the Determination of Water and Wastewater, Method 3114C. Mercury was analyzed using the cold vapor technique as described in USEPA 245.5, modified for the Contract Laboratory Program.

3.4 Suborganismal Tests

3.4.1 Fundulus-Water and Sediment Exposures

Fundulus heteroclitus used in water and sediment exposures were collected from St. John's Creek, a tidal tributary of the Patuxent River approximately one mile from the Chesapeake Biological Laboratory (CBL). Fish were collected using baited minnow traps and held in flowing, filtered, ambient Patuxent River water in tanks at CBL. In order to remove any potential influence of aromatic hydrocarbon exposure from the collection site on monooxygenase activity (unknown, though not believed to be substantial), fish were held for a minimum of 2-3 months before use.

Detailed studies by Kloepper-Sams and Stegeman (1989) have shown that induced EROD activity in *Fundulus* readily declines following the removal of a model PAH inducer. Numerous other studies with fish species have shown this as well (for review see Payne et al., 1987). Thus, though we did not measure EROD activity in *Fundulus* prior to the start of tests, we feel confident that the holding time was sufficient to remove the influence of any potential prior exposure in St. John's Creek. For year two studies, we will test this hypothesis by evaluating EROD activity in freshly collected, versus laboratory held, *Fundulus* from this location.

At the initiation of water and sediment exposures, fish from the laboratory stock were transported in aerated containers to the laboratories at WREC and ODU, respectively. Methods for exposing *Fundulus* to water (Section 3.2.5.6) and sediment (Section 3.3.5) were previously described.

3.4.2 Collection of Feral Fishes

Various species of fish were collected from the sampling locations using a combination of seining, minnow traps, hook and line and trawling. We had originally intended to collect *Fundulus heteroclitus* from all estuarine sampling stations using minnow traps and seining, but were unable to do so, primarily due to unsuitable habitat proximate to some of the locations (i.e., the Patapsco River and the Morgantown and Dahlgren stations). At stations where Fundulus were not available, and at the freshwater stations in the Potomac, we collected spot (Leiostomus xanthurus) and/or white perch (Morone americana) using a combination of hook and line and trawling with a 16 foot otter trawl. A complete list of all fish collected is contained within Appendix A. We collected approximately 125 fish of various species, from which liver samples were taken for cytochrome P-450 dependent monooxygenase activity analyses.

As fish were collected, they were brought on-board the boat, dissected, and livers from individual fish were removed and immediately frozen in liquid nitrogen. Previous studies have shown that these storage conditions are adequate to preserve monooxygenase activity for greater than one year (J. Stegeman, personal communication). The remainder of the fish were packaged in whirl-pak bags and transported to the laboratory on ice for measurements of body size (wt), sex determination and evaluation of gonadosomatic indices (gonad wt./body weight).

3.4.3 Sampling of Organisms from Water and Sediment Toxicity Tests

3.4.3.1 Fundulus

On the day toxicity tests were being terminated, Fundulus from the replicate test chambers were pooled, tissues dissected and frozen in liquid nitrogen as described for the feral fish samples. In general, samples from individual fish were kept separate at this point in order to be able to generate individual hepato-somatic and gonado-somatic indices. However, due to limitations in our ability to process tissue samples with weights below approximately 200 mg, samples within treatments were generally pooled for the biochemical preparations. We processed approximately 67 samples (including pooled samples) from these tests.

3.4.3.2 Larval Fish and Invertebrates

Samples of surviving larval fish and invertebrates from water column tests were sampled from individual test chambers, pooled and frozen and stored in liquid nitrogen. We obtained samples of larval sheepshead and fathead minnows as well as grass shrimp and *E. affinis*. These samples are currently being processed.

3.4.3.3 Biochemical Methods

Microsomes were prepared for monooxygenase system measurements from tissue samples using methods described by Stegeman et al. (1987). Ethoxyresorufin-0-deethylase assays were conducted using the fluorometric technique described by Burke and Mayer (1974). This enzymatic activity is catalyzed by the cytochrome P450IA isoform in fishes (Stegeman, 1989) which is induced by planar aromatic hydrocarbon exposure. EROD activity has been widely used in field studies of fish responses to aromatic contaminants in ambient settings (Kleinow et al., 1987; Jimenez and Stegeman, 1990) and its induction is widely accepted as an indication of biologically significant aromatic hydrocarbon exposure.

Quantitation of the cytochrome P450IA1 isozyme will be done using "Western" blots (Towbin et al. 1989) using a monoclonal antibody (1-12-3) against the P450IA1 (cytochrome P450E) of scup, a marine teleost. Kloepper-Sams et al. (1987) and Stegeman (1989) have shown that this antibody is highly specific for this P450 form in all teleosts examined to date. Relative concentrations of P450E equivalents will be determined using purified P450E from scup as a standard (Kloepper-Sams et al., 1987).

3.4.3.4 Stress Proteins

Currently, two major approaches to evaluating stress protein production (induction) exists. The most widely applied method reflects active synthesis as measured by the uptake and incorporation of a radiolabeled amino acid (e.g. [^{35}S]methionine) into protein (see for example, Bradley et al., 1988, Roccheri et al., 1981, Heikkila et al., 1982, Sanders, 1988). We quickly realized this methodology was inappropriate for our study due to cost and logistical constraints on isotope use among institutions. For example, in order to conduct isotopes based assays, each facility and P.I. would be required to be licensed for isotope use and provide the appropriate isolated work and containment areas. As Dr. Alden and Mr. Hall do not currently use isotope methodologies for their work, they do not meet these requirements. The costs and time required to do so were prohibitive relative to the time and needs of the other tests. We, therefore, did not pursue this option further and suggest that it is not a workable design for a study of this type (i.e., varying locations for tests, etc.). We also found significant problems with movement of isotopes among locations. Finally, current guidelines for tracking isotope use and disposal would have required a personnel effort we could not meet. Since this portion of the study was only a small portion of the overall study plan and its requirements would have been disruptive to the primary tests, we chose to delete it in favor of attempting antibody based approaches which do not have these overwhelming logistical problems. We suggested that this may be a better option in the original proposal. Our current plans are to evaluate stress protein production in collected samples collected using commercially available reagent antibodies for specific stress proteins (hsp70 and hsp90).

SECTION 4

RESULTS

4.1 Water Column Tests

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

4.4.1 Toxicity Data

Survival, growth and reproduction data from the three estuarine tests conducted from 8/14/90 - 8/21/90 in the Elizabeth River, Patapsco River, Wye River stations and controls are presented in Tables 8 and 9. Survival of E. affinis was significantly lower (55%) in the Elizabeth River after 8 d when compared with the controls or other stations. However, mean brood size of the remaining E. affinis at this station was not significantly lower than the other two ambient stations or the controls. Mean brood size from the controls was significantly lower than the three ambient stations. The reason for lower reproduction in the controls may be related to the available phytoplankton and nutrients in the various conditions. Ambient water contained phytoplankton and nutrients in addition to the concentrations applied during feeding. The controls only contained phytoplankton and nutrients introduced during feeding. Since quantity and quality of food is important in reproduction of E.

Table 8. Survival data from *E. affinis*, sheepshead minnow larvae and grass shrimp larvae tests conducted in the Elizabeth River, Patapsco River, Wye River and control. Tests were conducted from 8/14/90 - 8/21/90.

Species	Station	% Survival Per Day 1	2	3	4	5	6	7	8
E. affinis	Eliz. R.				82				55*
	Pat. R.				87				95
	Wye R.				100				[a]
	Control				93				100
Sheepshead minnow	Eliz. R.	100	96	91	91	91	91	91	91
	Pat. R.	100	100	100	100	100	100	100	100
	Wye R.	97	97	90	90	90	90	90	90
	Control	100	100	100	100	100	100	100	100
Grass shrimp	Eliz. R.	100	42	23	17	15	13	13	13*
	Pat. R.	100	98	86	64	61	61	61	61*
	Wye R.	100	100	98	96	94	94	92	92
	Control	100	100	100	100	100	100	100	98

* Indicates value is significantly different than the control $p < 0.05$.

[a] Copepods from ambient water were inadvertently introduced into test chambers.

Table 9. Reproduction (brood size) and growth data from E. affinis, sheepshead minnow larvae, and grass shrimp larvae tests conducted in the Elizabeth River, Patapsco River, Wye River and control. Tests were conducted 8/14/90 - 8/21/90.

E. affinis Brood Size Comparisons Following 8-d Exposures

Station	n	Mean Brood Size	S. E.
Eliz. R.	5	64.6*	15.2
Pat. R.	10	66.1*	10.2
Wye R.	5	47.8*	7.4
Control	6	10.7	3.7

Sheepshead Minnow and Grass Shrimp Growth Comparisons

Sheepshead minnow length

Station	n	Mean (mm)	S. E.
Eliz. R.	11	5.73	0.16
Pat. R.	16	6.13	0.22
Wye R.	14	5.61	0.23
Control	12	6.08	0.21

Sheepshead minnow dry weight

Station	n(pooled samples)	Mean (mg)	S. E.
Eliz. R.	3 (3 groups of 3)	0.44	0.06
Pat. R.	4 (4 groups of 4)	0.46	0.04
Wye R.	4 (4 groups of 3)	0.34	0.07
Control	3 (3 groups of 4)	0.30	0.13

Grass shrimp dry weight

Station	n	Mean (mg)	S. E.
Eliz. R.	5	0.34	0.08
Pat. R.	11	0.40	0.02
Wye R.	12	0.48*	0.03
Control	12	0.41	0.02

* Indicates value is significantly different than control, ($p < 0.05$).

affinis, food in ambient conditions may account for the increased reproduction. Masters et al. (1991) have suggested a similar explanation for a freshwater zooplankton species (C. dubia) experiencing lower reproduction in control water than ambient water.

Survival, length and dry weight of sheepshead minnow larvae was not significantly reduced in ambient water from any station when compared with the controls. In contrast, survival of grass shrimp was significantly reduced at the Elizabeth River (13%) and Patapsco River (61%) stations after 8-d exposure. Survival of grass shrimp in the Wye River and control conditions was ≥ 92%. Dry weight of grass shrimp was not significantly lower at any ambient station when compared with the controls. The mean dry weight at the Wye River station (0.48 mg) was, however, significantly greater than the other stations.

Survival, growth and reproduction data from estuarine and freshwater tests conducted at the five Potomac River stations and controls from 9/24/90 -10/2/90 are presented in Tables 10 - 12. There was no significant difference among survival of E. affinis after 8 d at all stations, including controls. Number of E. affinis produced at all five Potomac River stations was significantly greater than the controls (Table 11). The reason for lower reproduction in the controls was likely related to the quality and quantity of food as previously discussed. Survival of sheepshead minnow larvae was significantly reduced at the Morgantown and Dahlgren stations when compared to the controls.

Table 10. Survival data from _E_. _affinis_, sheepshead minnow, grass shrimp, fathead minnow and _Ceriodaphnia_ tests conducted at the 5 Potomac River stations. Tests were conducted from 9/24/90 - 10/2/90. Salinity adjusted tests were conducted with _E_. _affinis_ and grass shrimp at the 3 freshwater stations (Possum Point, Freestone Point and Indian Head).

		Cumulative % Survival Per Day							
Species	Station	1	2	3	4	5	6	7	8
_E_. _affinis_	Control				100				92
	Morgantown				100				96
	Dahlgren				100				96
	Possum Pt.*				79				100
	Freestone Pt.				81				80
	Indian Hd.				89				77
Sheepshead minnow	Control	95	90	88	88	88	88	88	88
	Morgantown	98	83	83	70	53	45	40	40*
	Dahlgren	100	95	93	90	78	60	60	50*
Grass shrimp	Control	100	100	90	88	80	80	75	75
	Morgantown	100	95	95	93	93	93	85	78
	Dahlgren	100	100	100	100	98	98	98	98*
	Possum Pt.	100	100	100	100	100	98	98	98*
	Freestone Pt.	98	95	95	93	93	93	93	88
	Indian Hd.	100	98	98	98	93	93	93	88
Fathead minnows	Control	100	100	90	90	90	90	88	83
	Possum Pt.	100	98	90	90	90	90	90	90
	Freestone Pt.	100	98	88	88	88	88	88	88
	Indian Hd.	100	93	75	73	73	73	73	73

*Survival increased from day 4 to day 8 as this parameter was evaluated in 2 test chambers on day 4 and different 2 test chambers on day 8 (see Methods Section for _E_. _affinis_).

Table 10 - continued

Species	Station	Cumulative % Survival Per Day							
		1	2	3	4	5	6	7	8
Ceriodaphnia	Control	100	100	100	100	100	100	89	89
	Possum Pt.	100	100	100	100	90	90	80	70
	Freestone Pt.	100	100	100	100	100	100	89	78
	Indian Hd.	100	100	100	90	90	90	50	50**
Ceriodaphnia[1]	Control	100	100	100	100	100	100	100	100
	Possum Pt.	100	100	100	100	100	100	100	100
	Freestone Pt.	100	100	100	100	100	100	100	100
	Indian Hd.	100	100	100	100	100	100	100	100

[1] Test conducted 10/26/90 - 11/3/90

* Indicates value is significantly different than control value ($p < 0.05$).

** Significantly different than control ($p = 0.037$) using a T-test.

Table 11. Reproduction of E. affinis and Ceriodaphnia after 8-d exposures to Potomac River water from 5 stations and the controls.

E. affinis Brood Size

Station	n	Mean Number of Nauplii	S. E.
Control	5	2.2	1.3
Morgantown	4	24*	4.4
Dahlgren	3	23.3*	5.5
Possum Pt.	8	25.4*	4.2
Freestone Pt.	6	20.8*	4.6
Indian Hd.	5	19.2*	4.0

Ceriodaphnia Neonate Production

Station	n	Mean Number of Neonates 3 Broods	S. E.
Control[1]	9	1.6	0.9
Possum Pt.[1]	10	5.0	0.9
Freestone Pt.[1]	9	14*	1.7
Indian Hd.[1]	10	2.0	0.7
Control[2]	10	15.9	1.6
Possum Pt.[2]	9	16.1	1.4
Freestone Pt.[2]	10	17.1	1.2
Indian Hd.[2]	10	22.2*	1.0

* Indicates value is significantly different than control value ($p < 0.05$).

[1] Test conducted 9/24/90 - 10/2/90.

[2] Test conducted 10/26/90 - 11/3/90.

Table 12. Growth data for grass shrimp (dry weight), sheepshead minnow (dry weight and length and fathead minnow (dry weight and length) after 8-d exposures to Potomac River water from the 5 stations.

Grass Shrimp Dry Weight

Site	n	Mean Weight (mg)	S. E.
Control	8	0.59	0.03
Indian Hd.	8	0.52	0.03
Possum Pt.	8	0.53	0.02
Freestone Pt.	8	0.52	0.03
Morgantown	8	0.57	0.02
Dahlgren	8	0.58	0.02

No significant differences ($p < 0.05$) were detected with Dunnetts Test.

Sheepshead Minnow Dry Weight and Length

Site	n	Mean Weight (mg)	S. E.	Length (mm)	S. E.
Control	9	0.25	0.02	5.8	0.3
Morgantown	8	0.29	0.10	5.9	0.4
Dahlgren	10	0.28	0.03	5.6	0.3

No significant differences ($p < 0.05$) were detected with Bonferroni T-Test.

Fathead Minnow Dry Weight and Length

Site	n	Mean Weight (mg)	S. E.	Length (mm)	S. E.
Control	17	0.29	0.03	7.6	0.2
Possum Pt.	18	0.30	0.02	7.6	0.1
Freestone Pt.	19	0.25	0.07	7.6	0.2
Indian Hd.	15	0.36	0.04	7.8	0.1

No significant differences ($p < 0.05$) were detected with Bonferroni T-Test.

There was no significant difference in dry weight or length among the test conditions for this species (Table 12). Survival of grass shrimp at all ambient stations was not significantly lower than the controls; survival at Possum Point and Dahlgren was significantly higher than the controls. There was no significant difference in dry weight for grass shrimp among stations.

There was no significant decrease in survival, dry weight or length of fathead minnows at the three freshwater stations when compared with the control. Survival data for Ceriodaphnia in two separate tests was different. Survival of Ceriodaphnia was significantly lower at the Indian Head Station than the control in the first experiment. In experiment 2, there was no statistical difference in survival among the 4 test conditions. The low mean number of neonates (1.6) produced in the controls for the first experiment was unacceptable for using reproduction as an endpoint; therefore, a second experiment was conducted. Reproduction data (mean number of neonates from 3 broods) for Ceriodaphnia showed no significant reductions at the three ambient stations in the second experiment when compared with the controls.

4.1.2 Contaminants Data

Inorganic contaminants data from the eight stations are presented in Table 13. Aluminum concentrations were reported above detection limits at all stations. Arsenic, tin and selenium were not reported above detection limits at any station. Concentrations of cadmium above detection limits were reported at Indian Head

Table 13. Inorganic contaminants reports by date for the eight stations. The five Potomac River stations are Indian Head, Freestone Point, Possum Point, Morgantown and Dahlgren. Indian Head, Freestone Point and Possum Point were freshwater stations; the other 5 stations were in saltwater. All underlined values exceed U.S. EPA chronic water quality criteria for either freshwater or saltwater (U.S. EPA, 1987a).

		Contaminant (ug/L)										
Station	Date	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Sn	Se	Zn
Elizabeth R.	8/13/90	15.3	<6.0	<2.0	<3.0	3.2	<.2	<5.0	<2.0	<50	<30	14
	8/16/90	8.7	<6.0	<2.0	<3.0	3.7	0.22	<5.0	<2.0	<50	<30	15
Patapsco R.	8/13/90	20.3	<3.0	<2.0	<3.0	<2.0	<.2	10.8	<2.0	<50	<30	<5
	8/16/90	5.4	<3.0	<2.0	<3.0	<2.0	<.2	6.5	<2.0	<50	<30	<5
Wye R.	8/13/90	10.9	<3.0	<2.0	<3.0	5.4	<.2	18	2.14	<50	<30	12.6
Indian Hd.	9/30/90	46.5	<3.0	1.32	<3.0	5.9	<.2	7.5	2.6	<5.0	<3.0	22.2
Freestone Pt.	9/27/90	49.8	<3.0	1.48	<3.0	6.7	<.2	12.0	2.6	<5.0	<3.0	26.5
Possum Pt.	9/27/90	48.6	<3.0	<1.0	<3.0	3.9	<.2	19.9	<2.0	<5.0	<3.0	19.6
Morgantown	9/24/90	10.3	<3.0	<1.0	<3.0	<2.0	.29	8.4	2.8	<5.0	<3.0	<5.0
	9/27/90	16.8	<3.0	<1.0	<3.0	<2.0	<.2	5.5	3.9	<5.0	<3.0	<5.0
Dahlgren	9/24/90	6.9	<3.0	<1.0	<3.0	<2.0	<.2	<5.0	5.2	<5.0	<3.0	<5.0
	9/27/90	15.2	<3.0	<1.0	<3.0	<2.0	<.2	5.5	3.6	<5.0	<3.0	7.4

(1.32 ug/L) and Freestone Point (1.48 ug/L). Copper concentrations above detection limits were reported from two Elizabeth River samples (3.2 and 3.7 ug/L), Wye River (5.4 ug/L), Indian Head (5.9 ug/L), Freestone Point (6.7 ug/L) and Possum Point (3.9 ug/L). Mercury was reported above detection limits from the Elizabeth River (0.22 ug/L) and Morgantown (0.29 ug/L) stations. Concentrations of nickel above detection limits were reported at all stations except the Elizabeth River and Dahlgren (9/24/90). Lead was reported above detection limits at the following stations: Wye River (2.14 ug/L), Indian Head (2.6 ug/L), Freestone Point (2.6 ug/L), Morgantown (2.8 and 3.9 ug/L) and Dahlgren (5.2 and 3.6 ug/L). Concentrations of zinc were reported above detection limits for all stations except the Patapsco River, Morgantown and one Dahlgren Sample.

Metal concentrations that exceeded EPA chronic water quality criteria for either freshwater (Indian Head, Freestone Point and Possum Point) or saltwater (all other stations) were: 1.32 and 1.48 ug/L cadmium at Indian Head and Freestone Point, respectively; 3.2 and 3.7 ug/L copper at the Elizabeth River station; 5.4 ug/L copper at the Wye River station; 0.22 and 0.29 ug/L mercury at the Elizabeth River and Morgantown stations, respectively, and 10.8, 18 and 8.4 ug/L nickel at the Patapsco River, Wye River and Morgantown stations, respectively (U.S. EPA, 1987a).

None of the organic contaminants listed in Table 2 were confirmed present above detection limits in any samples collected from the 8 stations. A minimum of one sample was analyzed from all

8 stations during testing. Two samples were analyzed from the Elizabeth River, Patapsco River, Potomac River - Morgantown and Potomac River - Dahlgren stations.

4.1.3 Water Quality Data

Water quality parameters reported from grab samples collected for all tests are presented in Table 14. The temperature and salinity (estuarine areas) were adjusted to 25 C and 15 ppt before exposing test species (except the ambient Elizabeth River salinity of 19-20 ppt). Most of these ambient water quality conditions appeared adequate for survival of test species with the possible exception of dissolved oxygen of 3.0 mg/L in the Elizabeth River.

Temperature, salinity, dissolved oxygen, pH and conductivity were measured at 1-h intervals at all Potomac River stations using datasonde units (Appendix B). All parameters appeared adequate for the various test species. Water quality parameters reported in test containers during tests are reported in Appendix C. Most of these parameters appeared adequate for test species except for occasional low D.O. values in the Elizabeth River test conditions.

4.1.4 Reference Toxicant Data

Twenty-four and 48-h LC50 values for the test species exposed to cadmium chloride during reference toxicant tests are presented in Table 15. Values obtained in these tests were compared with mean 48-h LC50 values for cadmium chloride collected over 2 years in our laboratory (except *E. affinis*). Forty-eight h LC50s for

Table 14. Water quality parameters reported in the field during collection of water samples. The following eight stations were sampled: Wye River (WR), Elizabeth River (ER), Patapsco River (PR), Morgantown (MT), Dahlgren (DG), Indian Head (IH), Possum Point (PP), Freestone Point (FP). Water quality parameters measured from the field samples collected from the Potomac River during the second <u>Ceriodaphnia</u> test are included.

Date 1990	Station	Temp (C)	Sal (ppt)	DO (mg/L)	pH	Cond (umhos/cm)	Hardness (mg/L $CaCo_3$)
08/13	PR	24.0	7.5	8.8	8.58	12200	NA
	WR	27.0	9.0	7.4	8.13	15000	NA
	ER	28.7	20.1	3.3	7.22	32500	NA
08/16	PR	28.0	6.8	9.3	8.47	11600	NA
	WR	28.0	8.7	7.6	8.29	15200	NA
	ER	28.5	20.1	3.3	7.14	32300	NA
08/19	PR	27.8	6.3	7.2	8.52	11200	NA
	WR	27.0	9.5	5.0	8.28	16000	NA
	ER	28.2	19.4	3.0	7.24	31100	NA
09/24	DG	18.5	8.2	8.4	7.72	12000	NA
	MT	19.0	8.0	8.6	7.70	11800	NA
	PP	19.5	0	8.0	8.31	270	88
	IH	19.0	0	8.5	7.33	278	120
	FP	18.0	0	8.7	7.42	240	112
09/27	DG	18.0	8.0	8.2	-	12500	NA
	MT	19.0	7.5	7.4	7.46	11000	NA
	PP	19.5	0	8.0	-	268	100
	IH	20.5	0	7.8	-	283	108
	FP	19.0	0	9.3	-	255	92
09/30	DG	21.0	8.0	8.8	-	13000	NA
	MT	21.0	8.5	7.4	-	13500	NA
	PP	20.0	0	7.0	-	285	112
	IH	20.2	0	6.6	-	203	124
	FP	20.0	0	8.0	-	305	100
10/26	PP	14.5	0	10.5	7.75	200	92
	IH	14.0	0	10.0	7.60	150	92
	FP	14.0	0	10.8	7.77	200	84
10/28	PP	13.0	0	8.8	7.80	173	92
	IH	12.5	0	10.0	7.69	140	76
	FP	13.0	0	9.0	7.69	160	84
10/31	PP	12.0	0	9.8	7.55	160	80
	IH	12.5	0	9.4	7.57	140	84
	FP	11.0	0	10.0	7.69	173	90

NA = Not appropriate

Table 15. LC50's (mg/L) from reference toxicant tests conducted with cadmium chloride for the five species. Two reference toxicant tests were conducted with sheepshead minnow larvae because the source was different for the Potomac River experiments. The two-year mean 48-h value is based on numerous tests previously conducted in our laboratory.

Date 1990	Species	24-h	48-h	Two-year Mean 48 h	96-h*
07/18	Grass Shrimp	1.080	0.502	0.87	-
07/30	Sheepshead Larvae	1.049	0.510	0.9	-
08/01	*Eurytemora affinis*	-	0.021		0.06
09/11	Fathead Larvae	0.123	0.117	0.09	-
09/17	*Ceriodaphnia*	0.449	0.134	0.076	-
10/20	Sheepshead Larvae	0.560	0.496	0.9	-

* 96-h value from Roberts et. al, 1982

grass shrimp, fathead minnows, *Ceriodaphnia* and sheepshead minnows in the present study were similar to previous values. These data demonstrated that these species were healthy and test results from ambient toxicity tests were valid.

A 96-h LC50 value obtained for *E. affinis* nauplii from the literature was used for comparing our 48-h LC50 (Roberts et al., 1982). The 96-h LC value of 0.06 mg/L (95% confidence limits < .001 - .20 mg/L) reported by Roberts et al. (1982) was approximately one-third of our 48-h value (0.21 mg/L). The upper confidence limit of .20 mg/L reported by Roberts et al. (1982) was approximately equal to our 48-h values of .21 mg/L. Based on the 48-h difference in LC50 values, both of these concentrations are within the same range (i.e., the 96-h LC reported by Roberts et al. [1982] would likely be much higher after only 48 h). *E. affinis* cultures were therefore healthy, and test results from ambient tests were valid.

Two reference toxicant tests were conducted with sheepshead larvae because the sources of these fish were different. Both 48-h values were similar (0.510 mg/L and 0.496 mg/L).

4.2 Sediment Tests

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

4.2.1 Toxicity Data

Survival and growth data from toxicity tests at the three estuarine stations conducted on 8/28/90-9/17/90 in the Elizabeth River, Patapsco River, Wye River stations and controls are presented in Tables 16 and 17. Survival of all test organisms was statistically lower (0% survival) at the Elizabeth River station compared to the other stations and the controls. Survival of the grass shrimp was ≥99% at the other estuarine stations in this set. None of the grass shrimp growth measures were statistically different from the controls.

The amphipod showed statistically lower survival in all three test sites compared to the controls (0% at the Elizabeth River, 54% survival at the Patapsco River, and 57% survival at the Wye River) after a 10 day exposure to test sediments. After 20 days exposure, the same trend was evident; significantly reduced survival in the Patapsco River (13% survival) and the Wye River (24% survival) stations as compared to the controls. Amphipod reburial data are presented in Table 18. The amphipod showed a significantly reduced ability to rebury in clean sediments after a 10 day exposure to the Patapsco River sediments. The amphipod also showed a reduced growth (in mean length) at the Wye River site as compared to the controls. The Wye River station was initially chosen as a "clean" reference site. The sediment sample from the Wye contained a large percentage of plant detrital material that may have interfered with the amphipods' ability to move within the sediments and feed, and therefore resulted in reduced survival and growth. In addition, the large detrital particles found in this sample may have

Table 16. Survival data from grass shrimp, amphipod and worm tests conducted at the Patapsco River, Elizabeth River and Wye River stations. Tests were conducted August 28, 1990 to September 17, 1990.

Species	Station	% Survival Day 10	% Survival Day 20
Grass shrimp	Control	99	95
	Patapsco River	100	95
	Elizabeth River	0*	-
	Wye River	99	99
Amphipod	Control	98	83
	Patapsco River	54*	13*
	Elizabeth River	0*	-
	Wye River	57*	24*
Worm	Control	100	100
	Patapsco River	58*	52*
	Elizabeth River	0*	-
	Wye River	46*	46*

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

Table 17. Growth data (dry weight and length) for grass shrimp, amphipod and worm after 20-day exposure to sediments from the Patapsco River, Elizabeth River, and Wye River stations.

Site	Number of True Replicates*	Weight (mg)	S.E.	Length (mm)	S.E.
Grass shrimp:					
Initial Measurements	-	18.13	-	19.54	-
Control	5	32.56	2.20	23.74	0.65
Patapsco River	5	28.35	0.89	22.34	0.30
Wye River	5	27.37	1.12	22.73	0.45
Amphipod:					
Initial Measurements	-	1.07	-	3.32	-
Control	5	1.10	0.08	4.44	0.17
Patapsco River	5	1.59	0.10	4.56	0.10
Wye River	5	1.13	0.14	4.05**	0.10
Worm:					
Initial Measurements	-	0.54	-	6.25	-
Control	5	0.11	0.04	4.92	0.61
Patapsco River	4	0.10	0.82	4.24	0.23
Wye River	3	0.14	0.02	5.08	0.70

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* Data for each replicate is the mean of the surviving animals from each.

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

Table 18. Amphipod reburial data after 10 day exposure to sediments. Table shows percent of surviving animals able to rebury within one hour.

Station	% Reburial	S.E.
Patapsco River	75*	6.3
Wye River	95	3.6
Control	99	0.6
Dahlgren	100	0.0
Indian Head	100	0.0
Freestone Point	90	6.6
Possum Point	88	12.5
Morgantown	100	0.0
Nansemond Reference	98	15.3
Control	100	0.0

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* Significantly different from control ($p<0.05$).

interfered with retrieval of the animals at the end of the test period, resulting in seemingly high mortalities that may not have been totally due to toxicity.

The worms and amphipods showed similar results; statistically lower survival in the Patapsco River and the Wye River after 10 and 20 day exposures to test sediments, as compared to control survival. Survival in the Wye River sediments after 10 and 20 days of exposure was 46%. Survival of the worms in the Patapsco River sediments was 58% and 52% after 10 and 20 days, respectively. The worms showed no significant differences in growth, as compared to the controls.

Survival and growth data from estuarine and freshwater tests conducted at the five Potomac River stations and controls from 9/28/90-10/18/90 are presented in Tables 19 and 20. There was no significant difference in survival of the grass shrimp at any of the sites; all animals survived at all stations. There was a statistically significant reduction in growth (mean length) of the grass shrimp at the Possum Point site (19.90 mm) as compared to the controls (20.52 mm). None of the other shrimp measurements were statistically significant. The amphipod showed statistically reduced survival at all Potomac tests sites as compared to controls at both 10 and 20 day exposures, with only 6% survival at the Possum Point site after 10 days, and 0% survival after 20 days. No statistical differences were evident in the reburial data.

Worm survival was not statistically different at any of the Potomac River stations after 10 or 20-day exposures. Two

Table 19. Survival data from grass shrimp, amphipod and worm tests conducted at the five Potomac River stations. Tests were conducted September 28, 1990 to October 18, 1990.

Species	Station	% Survival Day 10	 Day 20
Grass shrimp	Control	100	100
	Morgantown	100	100
	Dahlgren	100	100
	Possum Point	100	100
	Freestone Point	100	100
	Indian Head	100	100
	Nansemond Reference	100	100
Amphipod	Control	91	91
	Morgantown	70*	20*
	Dahlgren	22*	6*
	Possum Point	6*	0*
	Freestone Point	24*	4*
	Indian Head	41*	14*
	Nansemond Reference	47*	12*
Worm	Control	74	57**
	Morgantown	61	55
	Dahlgren	61	62
	Possum Point	49	41
	Freestone Point	50	51
	Indian Head	67	53
	Nansemond Reference	51	40

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* Significantly different from the controls ($p<0.05$).
** Replicates with 0% survival due to predation were omitted from this calculation.

Table 20. Growth data (dry weight and length) for grass shrimp and amphipods after 20-day exposure to sediments from the five Potomac River stations.

Site	Number of True Replicates*	Weight (mg)	S.E.	Length (mm)	S.E.
Grass shrimp:					
Initial Measures	-	6.50	-	12.19	-
Dahlgren	5	24.86	1.43	20.71	0.16
Indian Head	5	23.09	1.47	20.56	0.37
Freestone Point	5	22.27	0.97	20.91	0.32
Possum Point	5	20.81	2.35	19.90**	0.38
Morgantown	5	21.13	1.48	21.21	0.25
Control	5	17.08	2.13	20.52	0.32
Nansemond Reference	5	20.17	2.45	20.84	0.26
Amphipod:					
Initial Measures	-	1.07	-	2.07	-
Dahlgren	2***	0.60	0.16	3.11	0.31
Indian Head	4	1.03	0.38	4.15	0.65
Freestone Point	3***	1.19	0.52	4.25	0.68
Possum Point	-	-	-	-	-
Morgantown	4	0.90	0.10	4.08	0.14
Control	5	1.17	0.02	3.89	0.11
Nansemond Reference	3	0.98	0.30	4.40	0.58

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* Data for each replicate is the mean of the surviving animals from each.

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

*** Low survival (4-6%) may have reduced statistical sensitivity in detecting growth effects.

Note: Worm growth data were not collected due to sample preservation problems.

replicates of the worm control sediments had no surviving Streblospio benedicti at day 20. Several large predators (nereid worms) were also found in both test dishes. Control percent mortality was calculated omitting the two replicates with 0% survival. For future worm tests, all control sediments will be frozen ≥ 48 hours prior to testing. No worm growth data were obtained for the Potomac stations because of a problem with the preservation technique used. All worms began to disintegrate before they could be measured.

4.2.2 Contaminants Data

Sediment samples from the eight stations were analyzed for Total Organic Carbon (TOC) and Acid Volatile Sulfides (AVS). The results are shown in Table 21. The AVS approach to sediment contaminants evaluation is still developmental and only recently published (DiToro, 1990). To appropriately interpret the AVS data, selectively extractable metals (SEM) must be analyzed; a procedure that will be proposed for year two of this project. The AVS analysis of these samples will be used to help build a data base for future comparisons. TOC analysis was also included to allow for future comparisons. At present there is no readily accessible data base for comparison of TOC normalized data. Inorganic contaminants data from the eight stations are presented in Table 22. All test sites, the Nansemond Reference, and the worm control sediments had concentrations of the eleven metals above detection limits. At the Wye River station arsenic, cadmium and lead were

Table 21. Chemical data for sediment samples from the eight stations and the controls. The five Potomac River stations are Indian Head, Freestone Point, Possum Point, Morgantown, and Dahlgren. All data is on a dry weight basis.

Station	Total Organic Carbon (%)	AVS (μ mol/g)
Elizabeth River (Atlantic Wood)	6.14	5.90
Patapsco River	<0.37	4.60
Wye River	7.38	10.91
Amphipod Control, Set #1	<0.37	<1.00
Worm Control, Set #1	1.54	5.02
Indian Head	2.77	5.32
Freestone Point	2.30	8.89
Possum Point	2.44	1.82
Morgantown	<0.37	<1.00
Dahlgren	0.39	3.15
Nansemond Reference	1.42	4.03
Amphipod Control, Set #2	<0.37	<1.00
Worm Control, Set #2	4.91	10.79

Table 22. Inorganic contaminants for sediment samples from the eight stations and the controls. The five Potomac River stations are Indian Head, Freestone Point, Possum Point, Morgantown and Dahlgren. (Note: Single underlined values represent concentrations exceeding "Effects Range-Low", and double underlined value represent concentrations exceeding "Effects Range-Medium" levels as defined in Long and Morgan, 1990).

	Contaminant (ug/g)									
Station	Al	Cd	As	Cr	Cu	Hg	Ni	Pb	Se	Sn	Zn
Elizabeth River	12914.0	23.28	1.1	30.0	54.2	3.226	14.0	118.8	0.94	15.0	275.7
Patapsco River	575.0	4.89	3.2	157.0	20.6	0.022	7.0	55.8	0.55	83.0	603.1
Wye River	1100.0	<0.02	<0.3	2.0	0.5	0.075	1.0	<3.8	0.50	3.0	6.8
Amphipod Ctl*	7134.0	4.31	0.4	11.0	7.1	<0.006	8.0	14.5	0.06	7.0	29.9
Worm Ctl*	1005.0	2.60	1.0	29.0	87.2	0.147	12.0	118.2	0.24	8.0	207.7
Indian Head	19696.0	5.10	1.0	45.0	43.3	0.169	38.0	47.3	0.32	18.0	211.9
Freestone Point	19409.0	3.77	0.7	47.0	41.9	0.149	34.0	40.2	0.22	14.0	171.1
Possum Point	23780.0	7.30	0.7	48.0	61.8	0.176	40.0	47.8	0.30	19.0	223.6
Morgantown	4593.0	2.09	0.6	22.0	6.8	0.018	4.0	9.9	0.06	5.0	31.0
Dahlgren	3656.0	1.46	0.3	11.0	4.5	0.019	6.0	10.5	0.09	5.0	40.8
Amphipod Ctl**	376.0	0.33	<0.3	12.0	0.6	<0.006	21.0	<3.8	<0.02	<2.0	2.0
Worm Ctl**	10954.0	3.33	1.1	29.0	44.2	0.099	12.0	95.4	0.26	9.0	246.7
Nansemond Ref.	19763.0	11.26	0.5	39.0	22.2	0.094	19.0	34.2	0.39	15.0	149.4
Detection Limit	**25.0**	**0.02**	**0.3**	**1.0**	**0.3**	**0.006**	**1.0**	**3.8**	**0.02**	**2.0**	**0.1**
ER - L	-	5.0	33.0	80.0	70.0	0.15	30	35.0	-	-	120
ER - M	-	9.0	85.0	145.0	390.0	0.96	50	110.0	-	-	270

* = Set #1; ** = Set #2

all reported at concentrations below the detection limit. The amphipod control sediment used with the Potomac River test sediments had concentrations of cadmium, mercury, lead, selenium, and tin below detection limits.

Sediment-sorbed contaminants have been extensively studied by Long and Morgan (1990). They have established a table of concentrations at which biological effects would be expected if these contaminants were present in the sediment. The lower ten percentile of their data was established as the "Effects Range-Low" (ER-L) and median concentrations were identified as the" Effects Range-Median" (ER-M). Comparisons can be made between sites with respect to the potential for adverse biological effects by comparing the level of toxicants observed through chemical analysis with the ER-L or ER-M values. Those contaminants with levels exceeding the ER-L are in the "possible" effects range for toxic effects. The contaminant levels above the ER-M fall in the range of "probable" toxic effects.

The Elizabeth River station had concentrations of mercury, lead and zinc that all exceeded the ER-M as defined by Long and Morgan (1990). The Patapsco River site had concentrations of chromium (157.0 ug/g) and zinc (603.1 ug/g) that exceeded the ER-M (which is 145 ppm for chromium, and 270 ppm for zinc) and a concentration of lead (55.8 ug/g) that exceeds the ER-L of 35 ppm. Indian Head, Freestone Point, and Possum Point all had concentrations of mercury, nickel, lead and zinc that exceeded the ER-L for those contaminants (Table 22). The worm control used with the first set

(Elizabeth River, Patapsco River and Wye River) of tests had concentrations of copper, mercury, and zinc all above the ER-L and concentrations of lead above the ER-M. The worm control used with the Potomac stations also had concentrations of lead and zinc above the ER-L. The Nansemond Reference site had concentrations of zinc (149.4 ug/g) above the ER-L.

The sediment samples analyzed for semi-volatile organic compound and pesticides are presented in Appendix D and E. Only the Elizabeth River sediments had compounds listed in the Long and Morgan (1990) reference that exceeded the possible effects ranges. Nine of the sixteen semi-volatiles detected in the Elizabeth River sediments were above the ER-M values. In addition, two of the seven pesticides detected were above the ER-M values.

4.2.3 Pore Water Data

Sediment pore water was analyzed for sulfide, ammonia and nitrite for all eight stations and the controls and is presented in Table 23. Sediment samples used in toxicity tests were sieved with laboratory control water prior to conducting toxicity tests. The pore water analysis, however, was conducted on sediment samples collected from the field with no manipulation. The data from these analyses are included to provide relative numbers for comparison of test sites, rather than to suggest cause and effect relationships. It is assumed that the test pore water would reach a rough "steady state" with the sediments during the course of the experiments, so the pore water chemistry provides a relative indication of

Table 23. Chemical data for pore water samples from the eight stations and the controls. The five Potomac River stations are Indian Head, Freestone Point, Possum Point, Morgantown, and Dahlgren. All data is on a dry weight basis.

Station	Sulfide (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)
Elizabeth River (Atlantic Wood)	.011	3.835	.0012
Patapsco River	.013	2.099	.0049
Wye River Reference	.007	1.342	.0037
Amphipod Control, Set #1	<.006	0.826	.0040
Worm Control, Set #1	.032	1.289	.0151
Indian Head	.035	6.477	.0070
Freestone Point	.010	6.663	.0110
Possum Point	.012	15.790	.0205
Morgantown	.012	0.905	.0042
Dahlgren	.017	1.712	.0118
Nansemond Reference	.010	2.442	.0065
Amphipod Control, Set #2	.042	2.489	.0028
Worm Control, Set #2	.023	3.176	.0034

potential stresses. Concentrations of ammonia greater than 6.0 mg/L were reported at Indian Head (6.5 mg/L), Freestone Point (6.7 mg/L) and Possum Point (15.8 mg/L). Levels of ammonia between 1.0 mg/L and 4.0 mg/L were reported at the Elizabeth River, Patapsco River, Dahlgren, Wye River, Nansemond Reference, the worm controls and amphipod control (set 2) sediments. The Morgantown sediments and the amphipod controls (set 1) had concentrations of $NH3 < 1.0$ mg/L. Sulfide concentrations at all test sites except Indian Head were below 0.02 mg/L. The Indian Head sediment pore water had a sulfide concentration of 0.035 mg/L. Control sediment sulfide concentrations ranged from <0.006 in the amphipod control (set 1) to 0.042 mg/L in the amphipod control, set 2.

4.2.4 Reference Toxicant Data

The relative sensitivities of each set of test organisms was evaluated by a reference toxicant test. The results of 96-hour static acute tests for grass shrimp exposed to sodium dodecyl sulfate (SDS) are presented in Table 24. Results of reference toxicant tests conducted with amphipods and worms exposed to cadmium chloride are also presented in Table 24. Although the grass shrimp tested were from two separate populations (one set reared at the AMRL and one set purchased), both sets of test animals showed similar sensitivities to the reference toxicant. Therefore, it is reasonable to consider toxicity data from the two sets of organisms valid and comparable. In addition, both tests gave results similar to those published in the literature. Tatem

Table 24. Reference toxicant data results from the ambient toxicity project.

Organism	Test Set #	Chemical	LC50 and CIs* (mg/l)
P. pugio	1	SDS**	56.7 (45.5 to 71.1)
	2	SDS	67.7 (54.6 to 83.9)
L. dytiscus	1	$CdCl_2$	6.93 (5.25 to 9.26)
	2	$CdCl_2$	5.58 (4.23 to 7.20)
S. benedicti	1	$CdCl_2$	6.51 (5.12 to 8.21)
	2	$CdCl_2$	5.69 (3.28 to 8.88)

* CI = Confidence intervals
**SDS = Sodium dodecyl sulfate

et al (1976) found median lethal toxicity values of 72.0, 90.0, 52.5, 98, and 55.0 mg/L SDS for grass shrimp held in the laboratory for less than a month. Values obtained in the amphipod test were comparable with 96-hr LC50 values for cadmium chloride collected over the last nine months in our laboratory. Amphipod reference toxicant tests conducted at the AMRL over a nine month period ranged from 6.13 mg/L $CdCl_2$ (95% CI 5.3 and 7.25) to 4.68 mg/L $CdCl_2$ (CI 3.70 and 6.09). The worm reference toxicant data represent the first set of tests done with this organism and are the beginning of a data base for future comparisons.

4.3 Suborganismal Tests

4.3.1 Cytochrome P-450 Induction

4.3.1.1. Fundulus Water and Sediment Exposures

Hepatic microsomal ethoxyresorufin-O-deethylase (EROD) activity in *Fundulus* exposed to test water and sediment is presented in Tables 25 and 26. Induction, or elevation, of EROD activity relative to controls or reference stations, suggests significant exposure to planar aromatic hydrocarbon inducing substances such as PAH and planar PCBs. Depression of activity is much less understood. High trace metal exposure can inhibit P-450 dependent activity via stimulation of heme degradation (cytochrome P-450 is a heme-protein). Alternatively, some organic substances can interfere with cytochrome P-450 metabolism through binding and inactivation of the catalyst (for example, insecticide synergists such as piperonyl butoxide) or through substrate competition at the

Table 25. Ethoxyresorufin-O-deethylase activity in <u>Fundulus heteroclitus</u> exposed to sediment and water from tests conducted 8/14/90 - 8/21/90.

Station	(n)	EROD Activity (pmol/min/mg protein)
Water Exposures		
Control	4	676.1 (327.3, 1396.4)
Wye River	5	379.3 (310.4, 463.4)
Patapsco R.	4	184.9 (105.9, 322.8)[A]
Elizabeth R.	2*	748.2 (140.0, 3999.4)
Sediment Exposures		
Control	5	323.8 ± 135.8[B]
Wye River	5	695.3 ± 442.3
Patapsco R.	6	404.4 ± 73.9
Elizabeth R.		Nearly Complete Mortality-No Samples.

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* Forty percent mortality. Mortality in other tests was less than 20%, except as noted for the Elizabeth River sediment exposure.

[A] Significantly different from the Control (p=0.05). To establish homogenous variance, an ANOVA was done on log transformed data and hence activities are reported as the back-transformed means with 95% confidence limits. Differences were tested with the Scheffe F Test (alpha=0.05).

[B] Mean ± SD.

Table 26. Ethoxyresorufin-O-deethylase activity in *Fundulus heteroclitus* exposed to sediment and water from tests conducted 9/24/90 - 10/2/90 (Potomac River).

Station	(n)	EROD Activity (pmol/min/mg protein)
Water Exposures		
Control	5	452.5 ± 164.2
Dahlgren	5	571.2 ± 137.8
Morgantown	6	411.8 ± 148.9
Sediment Exposures		
Nansemond R. (Ref. Site)	8	401.3 ± 181.3
Dahlgren	5	555.5 ± 147.1
Morgantown	6	471.9 ± 264.1
Freestone Pt.	8	727.5 ± 518.4
Possum Pt.	8	617.6 ± 382.5
Indian Head	6	695.2 ± 278.1

Mortalities in all exposures were sporadic and less than 20%.

All data as mean ± s.d.

active site. This study is not designed to understand depression if it occurs, though the observation will be noted where appropriate. The appropriate comparisons for these data are within the exposure groups.

For water exposures, there were no significant differences detected between the controls and the stations tested (Dahlgren and Morgantown) in the estuarine portion of the Potomac River. There were, however, significant differences in EROD activity detected between animals from tests conducted with Wye, Patapsco and Elizabeth River waters. The most striking observation is the nearly 4-fold <u>depression</u> in activity in animals exposed to Patapsco River water. We did not detect any significant <u>induction</u> in activity between controls and test stations. It is important to note, however, that there was 40% mortality for <u>Fundulus</u> exposed to Elizabeth River water.

Mean values for EROD activity in sediment exposed <u>Fundulus</u> ranged approximately 2-fold and no significant differences were detected among stations from the two experiments. The variation encountered between the groups obscures any subtle differences between groups.

4.3.1.2 <u>Larval Sheepshead and Fathead Minnows from Water Exposures</u>

Samples of larval sheepshead and fathead minnows were collected for evaluation of monooxygenase induction. These samples are currently being held at -80C until further processing.

4.3.1.3 Feral Fish

EROD activities were measured in samples of *Fundulus*, white perch and spot from various sampling locations (Table 27). Activities varied between species and the appropriate comparisons were made within a species among sites. Activities were highest in the spot samples, followed by *Fundulus* and white perch, respectively.

The *Fundulus* collected from the Wye River reference site and the Elizabeth River both contained high EROD activities. The activities were 2-5 fold higher than the mean activities detected in *Fundulus* from the water and sediment exposures (Tables 25 and 26).

White perch collected from four stations in the Potomac River had relatively low EROD activities and no significant differences were detected among stations. While we obtained samples from the Morgantown station, these samples have not been processed. We did note, however, that the liver samples from the largest white perch collected at this station were very dark brown in color. We will be processing these samples for histological evaluation and will attempt to resolve the cause of this phenomenon. From a consultation with Dr. Mike Lipsky of UMAB, we are hypothesizing that this "anomaly" may be due to high metal content. We recently discussed this observation with Dr. Tracie Bunton of Johns Hopkins University. She has been studying a copper storage disease in livers of white perch for the last several years. Her description of the color of livers of affected white perch ("looks like an old

Table 27. EROD activity in fish collected from various sampling locations

Species	(n)	EROD Activity (pmol/min/mg protein)
Fundulus heteroclitus		
Wye River	9	1584.8 ± 762.7
Elizabeth River	15	2120.4 ± 1614.5
White Perch		
Dahlgren	5	234.2 ± 133.0
Possum Point	9	328.3 ± 110.0
Indian Head	8	280.8 ± 102.5
Freestone Pt.	9	233.9 ± 87.8
Spot		
Wye River	3	2751.9 ± 634.3
Patapsco River.	8	6315.2 ± 2683.3
Elizabeth River	6	5167.8 ± 1685.1
Freestone Pt.	3	2303.1 ± 262.7

All data as mean ± s.d.

penny") agrees closely with our observations.

Spot were collected from four locations. EROD activity was high in all samples relative to the other species and the highest values were found in fish from the Elizabeth and Patapsco Rivers.

4.3.1.4 Ongoing Activities

We currently have many samples yet to process for the suborganismal component of year 1 studies. We have been processing samples in a logical fashion for six months and consider the results presented here as only preliminary. We will be conducting immunologic evaluations of the cytochrome P450IA protein concentration as the complement to the catalytic measurements. These studies will enable us to better resolve the extent of induction or repression of catalytic activities detected in the samples (see for example Gooch et al., 1989). We will also be evaluating the cytochrome P450 response in the larval fish samples collected from water exposures. In addition, we will also be carrying out laboratory studies with *Fundulus* using a model PAH inducer in order to calibrate the induction response in our local population of *Fundulus*.

In addition to completing cytochrome P-450 studies, we will be analyzing invertebrate samples for stress protein induction using immunoassay techniques with commercially available antibodies. As previously stated, it was apparent from the initiation of these studies, that the protocols found in the literature (i.e., the use of S-35 amino acids) would be logistically impossible for a study of this size and design. We are, therefore, refocusing our efforts to determine the utility of this technique for year 2 studies and for ambient protocols in general.

SECTION 5

DISCUSSION

5.1 Elizabeth River Station

The Elizabeth River station located near the Atlantic Wood Industries (a wood treatment creosote facility) and in the vicinity of major military installations and industrial activities was known to be a toxic area based on previous data (Alden et al., 1988). Our water column toxicity tests confirmed the presence of toxic conditions. Significant reductions in survival were reported for *E. affinis* and grass shrimp after 8-d exposures to Elizabeth River water. Significant reductions in reproduction were not reported for surviving *E. affinis* and significant reductions in growth were not reported for surviving grass shrimp larvae. Survival and growth of sheepshead minnow larvae was not significantly reduced after 8-d exposures to water from this location.

This study was not designed to identify an absolute cause and effect relationship between biological effects and contaminant and/or water quality measurements (if present), due to the limited number and scope of these evaluations. Comparisons of field contaminant concentrations with specific water quality criteria (fresh or marine, acute or chronic) will be used throughout this discussion section to provide a basis for discussing the relationship between contaminant concentrations and biological effects. These water quality criteria are based on toxicity data from numerous species (rather than a single species). It should be noted, however, that EPA water quality criterion were developed as values which are protective of most organisms and not necessarily concentrations at which stress or toxicity may occur. However, specific water quality criteria do provide a general "benchmark" for discussing possible effects if protective concentrations are exceeded.

At this particular station possibly stressful contaminant and water quality conditions were reported in the water column concurrently with significant reductions in survival of two test species. Copper concentrations of 3.2 and 3.7 ug/L in the Elizabeth River exceeded the U.S. EPA marine acute water quality criteria (2.9 ug/L) for this metal in saltwater (U.S. EPA, 1987a). In previous toxicity studies, concentrations of copper as low as 1 ug/L have been reported to inhibit the growth of phytoplankton Thalassiosira pseudonana (Davey et al., 1973). Copper concentrations at this station were higher than ambient concentrations of 0.08 - 2.3 ug/L reported in the main body of Chesapeake Bay waters (Kingston et al., 1983).

Mercury concentrations of 0.22 ug/L at this station also exceeded the U. S. EPA marine chronic water quality criteria (0.025 ug/L) for saltwater. It should be noted, however, that this mercury chronic criteria is based on human health data (e.g., FDA action levels and bioaccumulation data) and not aquatic toxicity data. Concentrations of total mercury lethal to sensitive aquatic species range from 0.1 to 2.0 ug/L (Eisler, 1987). This extremely toxic heavy metal would not be expected in detectable concentrations in the ambient environment of Chesapeake Bay. Mercury is a particularly hazardous metal because non-toxic forms can be readily transformed into toxic forms (i.e., methylmercury) through biological processes. This metal can also be easily bioconcentrated in organisms and biomagnified through the food chain.

The above discussion of potentially toxic effects of copper and mercury at the Elizabeth River station should be interpreted with certain caveats. It is difficult to relate laboratory toxicity data with a field concentration of a specific metal without knowing the precise concentration of the toxic component of the metal that is bioavailable to the organism. Numerous physical (adsorption, flocculation sedimentation and remobilization), chemical (ionic strength, inorganic complexation, pH, redox reactions and equilibria and organic-metallic compounds) and biological (uptake and incorporation, transformation and environmental modification) factors influence the bioavailability of these toxic metals. Although the above metals data were generated from .40 um filtered samples (dissolved fraction), we do not know the exact concentration of the toxic component of the bioavailable fraction.

Dissolved oxygen (~ 3.0 mg/L) was the only potentially stressful water quality condition reported from ambient water collected at this station. In laboratory studies, sensitive species such as larval stages of the American lobster (*Homarus* *americanus*) were adversely affected by dissolved oxygen concentrations of ~ 3.0 mg/L (Don Miller, personal communication, U.S. Environmental Protection Agency). Jordan et al. (1990) have reported that dissolved oxygen concentrations of less than or equal to 3.0 mg/L can severely affect reproduction of Chesapeake Bay fish eggs and larvae. It is doubtful that the dissolved oxygen concentrations reported in the Elizabeth River were entirely responsible for the mortality of test species, but these conditions may have acted synergistically with other adverse contaminants.

The Elizabeth River station was located in a region with sediments previously demonstrated to be toxic (Alden and Young, 1982; Hargis *et al*., 1984; Alden and Butt, 1988; Alden *et al*., 1988) and highly contaminated with metals (Johnson and Villa, 1976; Alden *et al*., 1981; Rule, 1986; Alden *et al*., 1991) and organic pollutants (Alden and Hall, 1984; Bieri *et al*., 1986; Alden and Butt, 1988; Greaves, 1990; Alden *et al*., 1991). The *in situ* biological communities are clearly impacted by the contaminants in the sediments (Weeks and Warinner, 1986; Weeks *et al*., 1986; Ewing *et al*., 1989; Dauer *et al*., 1989; Alden *et al*., 1991). This station was selected to act as a "positive reference site", for which sediment toxicity tests should demonstrate significant effects.

All of the sediment test species (shrimp, worms and amphipods) exhibited complete mortality within the first 10 days of exposure to the sediments. The Elizabeth River sediment sample was 86.16% silt/clay by analysis. The amphipod *Lepidactylus dytiscus* will exhibit approximately a 15% increase in mortality in clean sediments with greater than 85% silt/clay (Deaver and Adolphson, 1991). However, it was observed that all amphipods died in all replicates within the first few days of the test. Therefore, it is likely that the mortalities observed during the tests of sediments from this site are due to contaminants rather than particle size. The extremely high levels of contaminants in the sediments of the Elizabeth River station also indicated that this area is highly impacted. Mercury (3.23 ug/kg), lead (118.8 ug/g) and zinc (275.7 ug/kg) concentrations exceeded the ER-M levels employed by NOAA (Long and Morgan, 1990) to delineate sediments which are potentially toxic (Table 22). Each of these metals is potentially toxic to estuarine organisms (Waldichulk, 1974; Neff et al., 1978; Gilfillan et al., 1985; Long and Morgan, 1990) and could have been responsible for the observed toxicity. Unionized ammonia in pore water was also potentially toxic, with concentrations (0.36 mg/L) exceeding USEPA criteria for one-hour exposure (0.233 mg/L). However, potential organic toxicants, particularly polynuclear aromatic hydrocarbons (PNAHs), dominate the sediment contaminants at this site.

The sediments contained concentrations of PNAHs (Appendix D-7) that greatly exceeded almost all of ER-M values (9 out of 12) established for these contaminants by NOAA (Long and Morgan, 1990). Three additional semi-volatile organic contaminants (Appendix D-7) and over 20 tentatively identified semi-volatile contaminants (Appendix D-8) were detected in concentrations of thousands to tens of thousands of parts per billion (ug/kg). In addition, seven pesticides were also detected, two of which exceeded the ER-M values (Appendix E-4). Previous studies have suggested that toxicity in the sediments from this region can be correlated with certain groups of PNAHs (Alden and Butt, 1987, 1988). In fact, reference toxicity tests suggest that fluoranthene in sediment alone is toxic to amphipods at concentrations below those observed for the Elizabeth River site (DeWitt et al., 1989; Deaver and Adolphson, 1991). Since fluoranthene is only one of numerous similar contaminants found at high concentrations at this station, the observed toxicity was not surprising. In fact, the magnitude of inorganic and organic contaminants found at highly elevated levels at this station would make sediment toxicity expected, but would confound speculations concerning specific "cause and effect" relationships.

The limited results from the suborganismal tests with Fundulus exposed to ambient water and sediment also suggested the presence of toxic conditions at this station. Forty percent mortality was reported in water exposures (at least double that of any other exposure) and Fundulus could not be maintained in the presence of Elizabeth River sediments. EROD activities in samples from surviving Fundulus from water exposure were not significantly elevated relative to the controls. However, native Fundulus collected from the Elizabeth River contained relatively high levels of EROD activity compared to other field studies with Fundulus (Elskus and Stegeman, 1989). Also, grossly visible nodules (putatively tumors) were also noted in approximately 30% of the animals sampled from this site as has been seen by Vogelbein et al. (1990). This is not surprising in light of the high levels of PAH at this site.

The lack of apparent induction of EROD activity in Fundulus from water exposures indicates that either biologically available concentrations of PAH in the water were too low to cause induction (non-detectable in water samples at concentrations reported in Table 2) or that some other factor, chemical or biochemical, interfered with any induction response (note: we encountered 40% mortality in this group).

We also analyzed hepatic EROD activity in spot collected from this location. The values were approximately 2-fold higher than spot collected by Van Veld et al. (1990) from this location. It is also important to note that spot collected along a PAH contamination gradient in the Elizabeth River, did not show uniformly high values. Rather, hepatic EROD activity mirrored the gradient quite well. Thus, high EROD values in spot from this location were expected.

5.2 Patapsco River Station

Potentially toxic conditions were suspected at the Patapsco River station based on effluent toxicity data from a nearby industrial facility. However, actual toxicity data had not been previously collected at this specific study site. Results from our water column tests showed that survival of one of our three test species (grass shrimp) was significantly reduced after 8 days of exposure to habitat water. Survival of E. affinis and sheepshead minnows was not significantly reduced in concurrent experiments. In addition, growth (sheepshead minnows) and reproduction (E. affinis) were not significantly reduced after exposure to Patapsco River water.

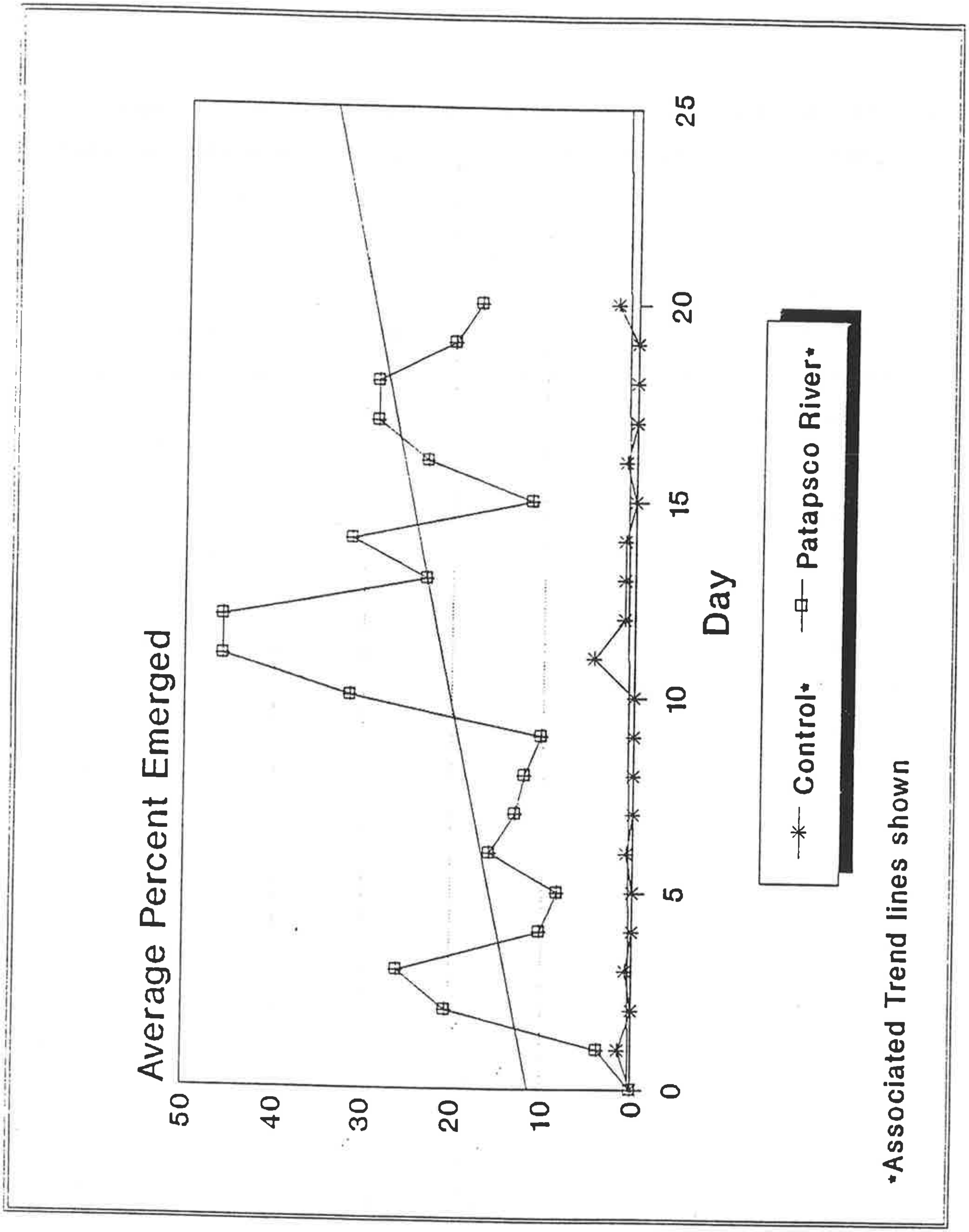
Contaminant and water quality data provided minimal information on potentially toxic conditions at the study site. Nickel concentrations of 10.8 ug/L at this station exceeded the U.S. EPA marine chronic water quality criteria for this metal in saltwater (U.S. EPA, 1987a). Therefore, concentrations of this metal may be stressful. All water quality conditions that were measured appeared adequate for the test species in water column tests.

Sediment toxicity tests demonstrated toxic conditions at this site. Survival of two of the sediment test species, the amphipod and the worm, was significantly reduced after 10 and 20-d exposures to sediments collected from this site. Survival of the grass shrimp was not significantly reduced when compared to the controls. No significant growth effects were seen with any of the test organisms exposed to Patapsco River sediments. Although the amphipods showed no significant difference in growth at this station, they did show a significant difference in ability to rebury in clean sediments at the end of the 20-d test. Ninety-nine percent of the control animals were able to rebury, while only 75% of the surviving amphipods from the Patapsco River sediments were able to rebury when placed into clean sediment, indicating a chronic level of toxicity (Table 18). In addition, observations during the test indicated that a high percentage of the organisms were emerged from the sediments or swimming in the overlying water throughout the test period. Figure 2 illustrates the average number of amphipods emerged per day throughout the 20-d test period as compared to the controls. This high percentage of emergence is abnormal for the amphipod Lepidactylus dytiscus, and indicates an avoidance response. In addition, it is possible that fewer mortalities may have occurred because the animals were swimming in the water column and not actually in contact with the sediment.

Very high levels of chromium, zinc, and lead were observed in the Patapsco River sediments. Chromium (157.0 ug/g) and zinc (603.1 ug/g) were found in levels exceeding the ER-M, and lead (55.8 ug/g) concentrations exceeded the ER-L level. The high levels of these metals is consistent with the various toxic responses exhibited at this site.

Suborganismal test results were similar to those reported for water column and sediment tests. Fundulus exposed to water samples from this location showed a significant depression in hepatic EROD activity as compared to controls. There are several possible explanations for this, though the results of catalytic protein measurements will be required for additional interpretation. Two logical hypotheses based on literature information are plausible. Previous studies have shown that high concentrations of PCBs can inhibit EROD activity in some teleosts (Gooch et al., 1989). It is possible, though unlikely, that this type of phenomenon could be

Figure 2. Amphipod emergence in Patapsco River and control sediments.



occurring here. An alternate possibility, is that high concentrations of trace metals could cause inhibition of activity, as has been seen with cadmium exposed flounder (George, 1989). Unfortunately, the contaminants data obtained do not support either of these hypotheses. Currently, we have no obvious explanation for these results.

In contrast, we measured high hepatic EROD activities in spot samples from this location. In fact, the values were similar to those found in spot collected from the Elizabeth River. These data are highly suggestive of biologically significant aromatic hydrocarbon exposure, putatively from somewhere near this location. This result is consistent with reported data on PNAH concentrations in sediments from in and around the Baltimore Harbor area (Helz and Huggett, 1987). Further analysis of the EROD catalyst content from this station, and others, will be required for a more detailed analysis of this observation.

5.3 Wye River Station

The Wye River station was selected for this study because it is located in a relatively pristine saltwater area where toxic conditions were not suspected. Survival, growth and reproduction data from our three test species suggested that habitat water from this station was non-toxic. It was interesting to note, however, that copper (5.4 ug/L) and nickel (18 ug/L) concentrations that exceeded the U.S. EPA water marine chronic quality criteria were reported at this station (U.S. EPA, 1987a). Toxic forms of these metals (i.e., free cupric ion for copper) were likely not present, duration of exposure was too short to create toxic conditions, or reported concentrations were too low to cause effects with test species. All water quality conditions measured in the Wye River samples were adequate for survival, reproduction and growth of the test species.

In contrast to the water tests, sediment tests indicated potentially adverse conditions at the Wye River station. Significantly lower survival was reported in the amphipod and worm test. The amphipod had only 57% survival at the Wye station after 10 d of exposure and 24% survival after 20 d. Amphipod growth (mean length) was significantly lower than the controls. The sediment collected at the Wye River station was 80% silt-clay and had a large percentage of organic plant matter (7.38% TOC). The combination of particle size and high organic matter may account, at least in part, for the reduced survival of the amphipod. DeWitt (1988) found that in fine, uncontaminated sediments ($\geq$ 80% silt-clay) mean survival of the amphipod Rhepoxynius abronius was approximately 15% lower than in native sediment. Deaver and Adolphson (1991) found similar results in tests done at the AMRL with the amphipod Lepidactylus dytiscus. In addition, the sediment sample from the Wye River site contained a high percentage of large detrital particles that may have interfered with the animals' ability to move and feed within the sediments and, therefore, may have resulted in reduced survival and growth.

The results of the worm bioassays were similar to those of the amphipod tests. There was statistically reduced survival of the worms in the Wye River sediments after 10 and 20-day exposures. The worm showed no significant growth effects. The worm, Streblospio benedicti can occur naturally in areas of high organic matter and muddy sediments (Levin, 1981), therefore the sediment physical characteristics alone would not be expected to be the cause of the worm mortalities. The grass shrimp test did not suggest toxic conditions in Wye River sediment. Survival of grass shrimp was > 99% for both 10- and 20-d tests and no significant differences in growth were reported when compared with controls. Since two of the three species tested (the amphipod and the worm) showed significant reduction in survival at the Wye River station, it is possible that there was some unknown contaminant present that contributed to the toxic response. Very low concentrations of inorganic contaminants were reported in the sediment at this site. Unfortunately, organic contaminants were not analyzed due to funding limitations.

Suborganismal tests conducted at the Wye River site provided contrasting results for Fundulus tested in the laboratory versus feral fish. Hepatic EROD activity was not elevated relative to controls in Fundulus exposed to water and sediment from the Wye River. This potentially indicates no significant exposure to aromatic hydrocarbons through these routes or that other chemical or biological factors precluded induction (see discussion in Section 5.1). However, elevated EROD activities (relative to activities in sediment and water exposed animals) was reported in feral _Fundulus_ collected by seine from this station. Interestingly, the activities in the feral fish were near those detected in the fish collected from the Elizabeth River, a highly PNAH contaminated site. Since no information exists on possible genetic differences in P450 expression among _Fundulus_ populations, a plausible hypothesis is that _Fundulus_ from the Wye River are exposed to planar aromatic hydrocarbons, presumably through a dietary source. As previously discussed, organic contaminants (i.e., sediment concentrations of PNAHs or PCBs) were not measured, thus this suggestion cannot be corroborated. Spot collected from this site had mean hepatic EROD activities that were substantially lower than those collected from the Elizabeth River station, though unequal samples sizes and heterogeneous variance precludes a more thorough statistical evaluation of the feral spot data.

5.4 Potomac River - Indian Head Station

This station was selected because it is a representative freshwater area of the Potomac River near a major military facility with numerous outfalls. Although toxic conditions have not been previously documented at this station, results from our first _Ceriodaphnia_ test demonstrated reduced survival. Contaminant and water quality data provide little insight on causes for reduced survival of _Ceriodaphnia_ during experiment 1. Cadmium (1.32 ug/L) was the only metal measured at this station that was possibly toxic based on the U.S. EPA freshwater chronic water quality criterion of 1.1 ug/L (U.S. EPA, 1987a). All water quality conditions appeared adequate for the test species. Results from one other freshwater test and three salinity adjusted tests showed no significant statistical reductions in survival, growth or reproduction for test species after exposure to ambient water from this station.

Sediment toxicity tests conducted at this station suggested toxic conditions. Results of the amphipod sediment tests indicated a significant reduction in survival at 10 and 20 days. This site was 88.82% silt/clay by analysis, which could account for approximately 15% mortality (Deaver and Adolphson, 1991). However, only 41% of the amphipods survived the initial 10-day test, and by day 20, only 14% of the test organisms remained alive. There were no significant effects seen in survival or growth with either the grass shrimp or the worms, or with growth of the amphipods. Inorganic contaminant analysis of the sediment indicated levels of mercury, nickel, lead and zinc that all exceeded the ER-L (see Table 22). Pore water analysis also showed high levels of ammonia (6.5 mg/L). By calculation, the level of unionized ammonia present at test conditions was 0.163 mg/L, which is near the EPA acute criteria level of 0.233 mg/L for a one hour average. The Indian Head sediments were not analyzed for organic contaminants.

Suborganismal tests (hepatic EROD activity) conducted to date at this station did not provide any data to suggest toxic conditions. Feral fish (white perch) collected at Indian Head had lower mean hepatic EROD values than spot from the Elizabeth and Patapsco Rivers.

5.5. Potomac River - Freestone Point

The Freestone Point station was located near an area where potentially toxic concentrations of trace metals (cadmium, chromium and copper) have been previously reported (Hall et al., 1987a). Survival, growth and reproduction data from our water column tests did not implicate the presence of toxic conditions at this site. Contaminant and water quality conditions from this station were generally non-toxic with the possible exception of cadmium. Cadmium concentrations of 1.48 ug/L at Freestone Point exceeded the U.S. EPA freshwater chronic water quality criteria of 1.1 ug/L for this trace metal in freshwater (U.S. EPA, 1987a). It is likely that the toxic form of cadmium was not present, duration of exposure was too short to create toxic conditions, or the reported concentration was too low to affect the test species.

One sediment toxicity test suggested toxic conditions at this station. Amphipods showed a significant decrease in survival (24% at day 10, 4% at day 20), but no growth effects. Again, the amphipod may have been somewhat affected by particle size (82.9% silt/clay) but only 15% of the deaths would be expected to be particle size preference (Deaver and Adolphson, 1991). The grass shrimp and worms showed no significant effects. Inorganic contaminants analysis indicated levels of mercury, nickel, lead and zinc that exceeded the ER-L (see Table 22). Pore water analysis showed ammonia levels of 6.663 mg/L and organic analysis identified two semi-volatile compounds (Appendix D-3), twenty tentatively identified semi-volatiles (Appendix D-4) and two pesticides (Appendix E-2) present.

Suborganismal tests conducted to date suggest no significant toxic conditions based on laboratory exposures of <u>Fundulus</u> to sediment and evaluation of EROD activity in feral fish (white perch and spot).

5.6 Potomac River - Possum Point

This station was located in an area where potentially toxic concentrations of trace metals have been reported in previous striped bass contaminant studies (Hall et al., 1990; Hall, unpublished data). Survival, growth and reproduction data from our water column tests did not show toxic conditions at this station. Water quality and contaminants data from this station also suggested that the ambient water from this station was non-toxic.

Results from sediment toxicity tests indicated a significant decrease in survival of the amphipod at day 10 and day 20. Only 6% of the test animals were alive after 10 days of exposure to Possum Point sediments, and none were alive after 20 days of exposure. The Possum Point sediments were 98% silt/clay by analysis, which could account for up to 15% of the amphipod mortalities at this site. The grass shrimp and the worm showed no significant differences in survival, but there was a significant difference in grass shrimp mean length, as compared to the controls. Inorganic analysis indicated high concentration of mercury, nickel, lead and zinc. Concentrations of these metals exceeded the ER-L. In addition, pore water analysis indicated very high levels of ammonia. By calculation, the level of unionized ammonia present

(0.316 mg/L) under test conditions would have exceeded the EPA acute criteria level of 0.233 mg/L for a one hour average. Organic analysis identified five semi-volatiles (Appendix D-1), 20 tentatively identified semi-volatiles (Appendix D-2) and the pesticide DDE present in the sediment sample (Appendix E-1). Any of these toxicants, or a combination of effects from all of them, may be the source of the toxicity in this sediment sample. The response of the amphipod illustrates the varying sensitivities of different organisms, and serves to underscore the need for multi-species toxicity testing.

Suborganismal tests (hepatic EROD activity) conducted to date at this station did not suggest the presence of toxic conditions. Feral fish (white perch) collected at Possum Point did not demonstrate any significant induction of hepatic EROD activities.

5.7 Potomac River - Morgantown

The Morgantown station was located in a typical mesohaline area of the Potomac River. Toxic conditions have not been previously reported at this station with the exception of tributyltin concentrations of 20 - 24 ng/L in 1985 and 1986 (Hall et al., 1987b). Results from one of our water column tests suggested toxic conditions were present. Survival of sheepshead minnow larvae was significantly reduced (40%) at this station after 8 days of exposure when compared with control survival (88%). Survival and reproduction of *E. affinis* and survival and growth of grass shrimp was not significantly reduced at this station. The sheepshead minnow is generally considered to be a moderately resistent species; therefore, reduced survival reported at this station is noteworthy. Survival of test species in our most toxic area (the Elizabeth River) showed no reduction in survival of sheepshead minnow larvae but reduced survival was reported for our other two test species (E. affinis and grass shrimp). These data support the use of water column tests with several species when attempting to evaluate toxic conditions in ambient areas.

Contaminants data from this station showed that concentrations of mercury (0.29 ug/L) and nickel (8.4 ug/L) exceeded the U.S. EPA marine chronic water quality criteria for these metals in saltwater (U.S. EPA, 1987a). Mercury is an extremely toxic heavy metal as concentrations of 0.1 ug/L have been reported toxic to sensitive aquatic biota (Eisler, 1987). Nickel is much less toxic than mercury but the 8.4 ug/L still exceeds environmentally safe concentrations as determined by the U.S. Environmental Protection Agency. All water quality conditions measured in the water column appeared non-toxic.

Results from the amphipod sediment toxicity test showed a statistically significant reduction in survival (70% survival at day 10 and 20% survival at day 20). The Morgantown sediment was approximately 92% sand, very similar to the native amphipod sediment, so the differences in mortality cannot be attributed to sand-silt/clay ratios. No toxic levels of inorganic contaminants or unionized ammonia were found in this sediment. Since organic analysis was not conducted on this sample due to funding limitations, it is possible that the amphipod mortalities are due to an unknown organic contaminant. The shrimp and the worm showed no significant difference in survival or growth.

Suborganismal tests conducted to date at this station did not suggest the presence of toxic conditions based on exposures of Fundulus to water and sediment. Feral white perch collected from the Morgantown station did provide interesting anecdotal information as their livers were dark brown (see Section 4.3.1.3).

5.8 Potomac River - Dahlgren Station

This station was located in a typical mesohaline area of the Potomac River near a major military facility. Toxic conditions have not been previously evaluated in this area. Results from our sheepshead minnow larvae tests showed reduced survival of larvae after 8 days of exposure. Survival, growth and reproduction data from the E. affinis and grass shrimp tests showed no significant effects at this station. Contaminant and water quality data showed no obvious conditions that were potentially toxic based on U.S. EPA water quality criteria data or toxicity data with sheepshead minnow larvae. It is interesting to note, however, that detectable concentrations of lead (3.6 and 5.2 ug/L) were reported at this station.

Results from sediment toxicity tests indicated a significant reduction in amphipod survival (22% survival), but no significant differences in shrimp and worm survival or shrimp growth. Contaminant analysis showed no evidence of toxic inorganic contaminants. The sediments from this site were > 85% sand by analysis, similar to native amphipod sediment. Therefore, the mortalities seen at this site would not be due to particle size preference of the amphipods. Pore water analysis did show relatively high levels of unionized ammonia (0.159 mg/L), just below the EPA acute criteria of 0.233 mg/L for a one hour average of unionized ammonia. The amphipod appears to be more sensitive to ammonia stress than the other sediment species tested. Organic analysis identified two semi-volatiles (Appendix D-5), 11 tentatively identified semi-volatile compounds (Appendix D-6), and one pesticide (Appendix E-3) present in the sample.

Suborganismal tests conducted to date do not suggest any significant induction of hepatic EROD activity in fish from this site. The results for feral fish (white perch) were similar.

SECTION 6

CONCLUSIONS

The primary goal of this pilot study was to use a suite of water column, sediment and suborganismal tests to identify toxic areas in the Chesapeake Bay watershed. This battery of tests demonstrated the presence of toxic conditions in various environmental media in suspected contaminated areas such as the Elizabeth River and the Patapsco River (Table 28). More importantly however, some of these tests suggested the presence of toxic conditions in a suspected toxic-free habitat in the Wye River and in critical habitat areas of the Potomac River (Table 28). Results from this study clearly demonstrate the need for multispecies testing within each type of test when attempting to identify toxic ambient areas. Two water column tests (E. affinis and sheepshead minnows) conducted at the Patapsco River station showed no significant effects. However, the third test species (larval grass shrimp) demonstrated reduced survival at this station. The same scenario existed for sediment tests conducted at all Potomac River sites. The worm tests showed no effects at all 5 stations and the grass shrimp demonstrated no effects at 4 of the stations. In contrast, reduced survival of amphipods was reported at all 5 stations.

The need for integrated water column, sediment and suborganismal testing was also demonstrated because one type of

Table 28. Toxicity data from water column, sediment and suborganismal tests. Effects were noted if significantly different than controls for water column and sediment tests. The following abbreviations were used for various effects: NE = No Effect; M = Mortality; RG = Reduced Growth; RR = Reduced Reproduction; RB = Reduced Reburial; IE = Induced EROD Activity; RE = Reduced EROD Activity and LA = Liver Abnormality. Station abbreviations were as follows: ER = Elizabeth River; PR = Patapsco River; WR = Wye River; IH = Indian Head: FP = Freestone Pt; PP = Possum Pt; MT = Morgantown and DA = Dahlgren.

	Station							
	ER	PR	WR	IH	FP	PP	MT	DA
Test Type								
Water Column								
E. affinis	M	NE*	NE*	NE*	NE*	NE*	NE*	NE*
P. pugio	M	M	NE	NE	NE	NE	NE	NE
C. variegatus	NE	NE	NE	NE	NE	NE	M	M
Ceriodaphnia sp.	-	-	-	M,NE	NE	NE	-	-
P. promelas	-	-	-	NE	NE	NE	-	-
Sediment								
Amphipod	M	M,RB	M,RG	M	M	M	M	M
Worm	M	M	M	NE	NE	NE	NE	NE
Grass Shrimp	M	NE	NE	NE	NE	RG	NE	NE
Suborganismal**								
Fundulus - water	M	RE	NE	-	-	-	NE	NE
Fundulus - sediment	M	NE	NE	NE	NE	NE	NE	NE
Feral Fish	IE	IE	IE	NE	NE	NE	LA	NE

*Low control reproduction limits the use of this endpoint; therefore, NE is based on survival.

**Qualitative determinations.

test was not sufficient to maximize our ability to identify toxic conditions in the ambient environment of the Chesapeake Bay watershed. For example, the three water column tests conducted at the Wye River station did not suggest the presence of toxic conditions but the sediment and suborganismal tests did implicate potential contaminant problems. Sediment tests with amphipods also identified toxic conditions at two Potomac River stations (Freestone Point and Possum Point) where five water column tests did not. This integrated multi-test approach also demonstrated supportive data for the various stations. The water column and sediment tests demonstrated significant effects at the Elizabeth River and Patapsco River stations; suborganismal tests suggested significant effects at these stations. Both the water column and sediment tests also showed significant effects at the Indian Head, Morgantown and Dahlgren stations in the Potomac River.

Ranking of sensitivity among tests within each test type (water column, sediment and suborganismal) showed the following results after one year of testing. Results from the water column tests demonstrated no significant ranking of sensitivity among the three saltwater tests but rather supported the need for multispecies tests because different species display varying sensitivity to different types of contaminants. Both grass shrimp and sheepshead minnow tests demonstrated effects at two of the eight stations, while _E. affinis_ showed effects at only one station. A comparison of the two freshwater water column tests at three stations showed that the _Ceriodaphnia_ test was more sensitive than the fathead minnow test. Results from the sediment tests clearly showed that the amphipod test was most sensitive as effects were reported at all stations. The polychaete worm test was the second most sensitive test and the grass shrimp test was least sensitive. A ranking of sensitivity among the various suborganismal tests is not appropriate until further research has been completed.

Water quality and contaminant evaluations conducted in water and sediment during this pilot study provided supportive information on possible causes of biological effects but these evaluations were not intended to provide conclusive data on specific cause and effect relationships if reported. The number of potentially toxic inorganic contaminants in water and inorganic and organic contaminants in sediment was higher at the station where the greatest number of toxic effects were reported by biological indicators (Elizabeth River). The second most toxic area based on biological data, the Patapsco River, also contained potentially toxic concentrations of inorganic contaminants in both water and sediment. The Wye River station provided an interesting comparison between biological and contaminants data. Both sediment and suborganismal tests suggested toxic conditions while water column tests did not. Toxic inorganics were not detected in Wye River sediment and organic evaluations were not conducted in this media. In contrast, two potentially toxic metals were reported in the water column at the Wye River station.

The Potomac River was perhaps the most important habitat evaluated in this pilot study. It provided various examples where toxic effects demonstrated in our tests were reported concurrently with potentially toxic contaminants. There are also examples of biological effects without supportive contaminants data. One potentially toxic metal was reported in the water column at the Indian Head and Freestone Point station and four potentially toxic metals were measured in the sediment at each of these stations. Results from one water column test and one sediment test demonstrated toxic conditions at Indian Head. However, only one sediment test showed toxic conditions at Freestone Point. Potentially toxic metals were not found in the water column at Possum Point but four potentially toxic metals were found in the sediment. The amphipod test (sediment exposure) demonstrated reduced survival while no significant effects were reported during water column or suborganismal tests. Potentially toxic contaminants were not reported in sediment from the Morgantown or Dahlgren station. Two metals exceeded U.S. EPA water quality criteria at Morgantown and no potentially toxic contaminants were reported in the water column at Dahlgren. Significant effects were reported from water column and sediment tests at both Morgantown and Dahlgren.

SECTION 7

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Appendix A

Suborganismal sampling for various fish species

SAMPLING RECORD FOR AMBIENT TOX. STUDY- FISH

SPECIES	TEST TYPE	SITE	DATE	VIAL NO.	NO. POOLED	TISSUES: LIV	GUT	BODY WEIGHT	GONAD WEIGHT	SEX
SPOT	Feral	BEAR CR.	8/12/90	1	1	X	X	32.3	<.01	
SPOT	Feral	BEAR CR.	8/12/90	2	1	X	X	13.7	<.01	
SPOT	Feral	BEAR CR.	8/12/90	3	1	X	X	25.7	0.02	
SPOT	Feral	BEAR CR.	8/12/90	4	1	X	X	18.3	0.01	
SPOT	Feral	BEAR CR.	8/12/90	5	1	X	X	48.8	<.01	
SPOT	Feral	BEAR CR.	8/12/90	6	1	X	X	39	<.01	
SPOT	Feral	BEAR CR.	8/12/90	7	1	X	X	15.2	<.01	
SPOT	Feral	BEAR CR.	8/12/90	8	1	X	X	49.3	0.04	
SPOT	Feral	BEAR CR.	8/12/90	9	1	X	X	26.1	0.02	
SPOT	Feral	BEAR CR.	8/12/90	10	1	X	X	36.9	0.01	
SPOT	Feral	BEAR CR.	8/12/90	11	1	X	X	30.7	<.01	
SPOT	Feral	BEAR CR.	8/12/90	12	1	X	X	23.6	0.03	
SPOT	Feral	ELIZABETH	8/27/90	1	1	X	X	32.7	0.06	
SPOT	Feral	ELIZABETH	8/27/90	2	1	X	X	15.2	<.01	
SPOT	Feral	ELIZABETH	8/27/90	3	1	X	X	17.4	0.02	
SPOT	Feral	ELIZABETH	8/27/90	4	1	X	X	25.6	0.05	
SPOT	Feral	ELIZABETH	8/27/90	5	1	X	X	22.2	<.01	
SPOT	Feral	ELIZABETH	8/27/90	6	1	X	X	33.8	<.01	
SPOT	Feral	ELIZABETH	8/27/90	7	1	X	X	15.3	0.02	
SPOT	Feral	ELIZABETH	8/27/90	8	2	X	X	26.5	0.02	
SPOT	Feral	ELIZABETH	8/27/90	10	1	X	X	18.1	<.01	
FUNDULUS	Feral	ELIZABETH	8/16/90	1	1	X	X	14	0.34	F
FUNDULUS	Feral	ELIZABETH	8/16/90	2	1	X	X	11.1	0.63	F
FUNDULUS	Feral	ELIZABETH	8/16/90	3	1	X	X	6.9	0.16	F
FUNDULUS	Feral	ELIZABETH	8/16/90	4	1	X	X	12.7	0.28	M
FUNDULUS	Feral	ELIZABETH	8/16/90	5	1	X	X	8.4	0.26	M
FUNDULUS	Feral	ELIZABETH	8/16/90	6	1	X	X	6.2	0.06	M
FUNDULUS	Feral	ELIZABETH	8/16/90	7	1	X	X	7		F
FUNDULUS	Feral	ELIZABETH	8/16/90	8	1	X	X	6.4	0.14	M
FUNDULUS	Feral	ELIZABETH	8/16/90	9	1	X	X	11.8	0.21	M
FUNDULUS	Feral	ELIZABETH	8/16/90	10	1	X	X	5.5	0.32	F
FUNDULUS	Feral	ELIZABETH	8/16/90	11	1	X	X	6	0.04	M
FUNDULUS	Feral	ELIZABETH	8/16/90	12	1	X	X	8.9	0.34	F
FUNDULUS	Feral	ELIZABETH	8/16/90	13	1	X	X	6.7	0.17	F
FUNDULUS	Feral	ELIZABETH	8/16/90	14	1	X		7.1	0.22	F
FUNDULUS	Feral	ELIZABETH	8/16/90	15	1	X		9	<.01	M
FUNDULUS	Feral	ELIZABETH	8/16/90	16	1	X		6.5	0.05	M
FUNDULUS	Feral	ELIZABETH	8/16/90	17	1	X		10.9	0.14	M
FUNDULUS	Feral	ELIZABETH	8/16/90	18	1	X		8.6	0.11	M
FUNDULUS	Feral	ELIZABETH	8/16/90	19	1	X		6.2	0.07	M
FUNDULUS	Feral	ELIZABETH	8/16/90	20	1	X		6.7	0.08	M
FUNDULUS	Feral	WYE R	8/15/90	1	1	X	X	15.9	0.27	F
FUNDULUS	Feral	WYE R	8/15/90	2	1	X	X	12.3		M
FUNDULUS	Feral	WYE R	8/15/90	3	1	X	X	16	0.33	F
FUNDULUS	Feral	WYE R	8/15/90	4	1	X	X	10.2	0.05	F
FUNDULUS	Feral	WYE R	8/15/90	5	1	X	X	10	0.06	F

FUNDULUS	Feral	WYER	8/15/90	6	1	X	X	11.9	0.07	M
FUNDULUS	Feral	WYER	8/15/90	7	1	X	X	14.2		F
FUNDULUS	Feral	WYER	8/15/90	8	1	X	X	6.4	0.01	M
FUNDULUS	Feral	WYER	8/15/90	9	1	X	X	24.1	0.91	F
FUNDULUS	Feral	WYER	8/15/90	10	1	X	X	11.4		F
FUNDULUS	Feral	WYER	8/15/90	11	1	X	X	16.1	0.08	M
FUNDULUS	Feral	WYER	8/15/90	12	1	X	X	10.9	0.01	M
FUNDULUS	Feral	WYER	8/15/90	13	1	X	X	5.5	<.01	M
FUNDULUS	Feral	WYER	8/15/90	14	1	X	X	5.3	0.01	M
FUNDULUS	Feral	WYER	8/15/90	15	1	X	X	9.1	0.05	M
FUNDULUS	Feral	WYER	8/15/90	16	1	X	X	6.9	0.3	F
FUNDULUS	Feral	WYER	8/15/90	17	1	X	X	5.8	0.03	F
FUNDULUS	Feral	WYER	8/15/90	18	1	X	X	5.4		F
FUNDULUS	Feral	WYER	8/15/90	19	1	X		9.3	0.04	F
FUNDULUS	Feral	WYER	8/15/90	20	1	X		5.3	0.02	F
F.MAJELIS	Feral	WYER	8/15/90	1	1	X		22.4	0.11	F
F.MAJELIS	Feral	WYER	8/15/90	2	1	X		23.2	0.15	F
F.MAJELIS	Feral	WYER	8/15/90	3	1	X		17.5	0.08	F
F.MAJELIS	Feral	WYER	8/15/90	4	1	X		14.9	0.07	F
SPOT	Feral	WYER	8/15/90	1	1	X	X	32.8		
SPOT	Feral	WYER	8/15/90	2	1	X	X	52.6	0.05	
SPOT	Feral	WYER	8/15/90	3	1	X	X	23.7	<.01	
SPOT	Feral	WYER	8/15/90	4	1	X		40	<.01	
S.BASS	Feral	WYER	8/15/90	1	1	X		55.2	0.02	
S.BASS	Feral	WYER	8/15/90	2	1	X		67.8	0.13	
S.BASS	Feral	WYER	8/15/90	3	1	X		59.6	<.01	
W.PERCH	Feral	DAHLGREN	9/26/90	1	1	X	X	28.2	0.31	
W.PERCH	Feral	DAHLGREN	9/26/90	2	1	X	X	26.2	0.03	
W.PERCH	Feral	DAHLGREN	9/26/90	3	1	X	X	30.3	0.05	
W.PERCH	Feral	DAHLGREN	9/26/90	4	1	X	X	23.9	0.16	
W.PERCH	Feral	DAHLGREN	9/26/90	5	1	X	X	16.6	0.11	
W.PERCH	Feral	DAHLGREN	9/26/90	6	1	X	X	15.4	0.1	
W.PERCH	Feral	DAHLGREN	9/26/90	7	2	X		25.4	0.14	
W.PERCH	Feral	DAHLGREN	9/26/90	8	2	X		27.9	0.07	
W.PERCH	Feral	DAHLGREN	9/26/90	9	2	X		29	0.1	
W.PERCH	Feral	DAHLGREN	9/26/90	10	3	X		38.2	0.07	
W.PERCH	Feral	MORGANTN	9/26/90	1	1	X	X	44.4	0.29	
W.PERCH	Feral	MORGANTN	9/26/90	2	1	X	X	51.1	0.22	
W.PERCH	Feral	MORGANTN	9/26/90	3	1	X	X	41.2	0.24	
W.PERCH	Feral	MORGANTN	9/26/90	4	1	X	X	38.6	0.33	
W.PERCH	Feral	MORGANTN	9/26/90	5	1	X	X	48.2	0.08	
W.PERCH	Feral	MORGANTN	9/26/90	6	1	X	X	52.1	0.46	
W.PERCH	Feral	MORGANTN	9/26/90	7	1	X		37.5	0.22	
W.PERCH	Feral	MORGANTN	9/26/90	8	3	X		55.2	0.05	
W.PERCH	Feral	POSSUM PT	9/26/90	1	1	X	X	34.9	0.26	
W.PERCH	Feral	POSSUM PT	9/26/90	2	1	X	X	37.5	0.32	
W.PERCH	Feral	POSSUM PT	9/26/90	3	1	X	X	37	0.29	
W.PERCH	Feral	POSSUM PT	9/26/90	4	1	X	X	28.2	0.12	
W.PERCH	Feral	POSSUM PT	9/26/90	5	1	X	X	25.5	0.04	
W.PERCH	Feral	POSSUM PT	9/26/90	6	1	X	X	34.9	0.26	
W.PERCH	Feral	POSSUM PT	9/26/90	7	2	X		58.2	0.28	
W.PERCH	Feral	POSSUM PT	9/26/90	8	3	X		95.3	0.35	
W.PERCH	Feral	POSSUM PT	9/26/90	9	2	X		69.9	0.48	

W. PERCH	Feral	POSSUM PT	9/26/90	10	2	X		56.5	0.12	
W. PERCH	Feral	FREESTONE	9/26/90	1	1	X	X	24	0.15	
W. PERCH	Feral	FREESTONE	9/26/90	2	3	X	X	40.4	0.26	
W. PERCH	Feral	FREESTONE	9/27/90	1	1	X	X	223	2.11	
W. PERCH	Feral	FREESTONE	9/27/90	2	1	X	X	66.4	0.46	
W. PERCH	Feral	FREESTONE	9/27/90	3	1	X	X	34.6	0.2	
W. PERCH	Feral	FREESTONE	9/27/90	4	1	X	X	31.9	0.1	
W. PERCH	Feral	FREESTONE	9/27/90	5	1	X	X	34.7	0.12	
W. PERCH	Feral	FREESTONE	9/27/90	6	1	X	X	22.4	0.01	
W. PERCH	Feral	FREESTONE	9/27/90	7	2	X		46.4	0.2	
W. PERCH	Feral	FREESTONE	9/27/90	8	2	X		40.9	0.22	
W. PERCH	Feral	INDIAN HD	9/27/90	1	1	X	X	41.9	0.11	
W. PERCH	Feral	INDIAN HD	9/27/90	2	1	X	X	37.2	0.23	
W. PERCH	Feral	INDIAN HD	9/27/90	3	1	X	X	43.2	0.34	
W. PERCH	Feral	INDIAN HD	9/27/90	4	1	X	X	33.2	0.24	
W. PERCH	Feral	INDIAN HD	9/27/90	5	1	X	X	33.3	0.23	
W. PERCH	Feral	INDIAN HD	9/27/90	6	1	X	X	31.8	0.03	
W. PERCH	Feral	INDIAN HD	9/27/90	7	1	X		48.4	0.48	
W. PERCH	Feral	INDIAN HD	9/27/90	8	1	X		40.2	0.12	
W. PERCH	Feral	INDIAN HD	9/27/90	9	2	X		62.2	0.28	
W. PERCH	Feral	INDIAN HD	9/27/90	10	2	X		62.9	0.42	
SPOT	Feral	INDIAN HD	9/27/90	1	3	X		56.5	0.03	
SPOT	Feral	FREESTONE	9/27/90	1	2	X		41.4	0.05	
SPOT	Feral	FREESTONE	9/27/90	2	2	X		46.6	0.02	
SPOT	Feral	FREESTONE	9/27/90	3	2	X		32	0.01	
FUNDULUS	WATER	CONTROL	10/2/90	1	1	X		7.5	0.04	M
FUNDULUS	WATER	CONTROL	10/2/90	2	1	X		6.3	0.05	F
FUNDULUS	WATER	CONTROL	10/2/90	3	1	X		5	0.12	F
FUNDULUS	WATER	CONTROL	10/2/90	4	1	X		6.6	0.1	F
FUNDULUS	WATER	CONTROL	10/2/90	5	1	X		5.4	0.08	M
FUNDULUS	WATER	CONTROL	10/2/90	6	1	X		5.9	0.04	F
FUNDULUS	WATER	CONTROL	10/2/90	7	1	X		4.7	0.03	M
FUNDULUS	WATER	CONTROL	10/2/90	8	1	X		3.9	0.03	F
FUNDULUS	WATER	CONTROL	10/2/90	9	1	X		5.4	0.03	F
FUNDULUS	WATER	CONTROL	10/2/90	10	1	X		3.5	0.01	M
FUNDULUS	WATER	CONTROL	10/2/90	11	1	X		3.5	0.02	F
FUNDULUS	WATER	CONTROL	10/2/90	12	1	X		4.8	0.05	F
FUNDULUS	WATER	CONTROL	10/2/90	13	4			16.8		
FUNDULUS	WATER	MORGANTN	10/2/90	1	1	X		9.4	0.13	M
FUNDULUS	WATER	MORGANTN	10/2/90	2	1	X		7.4	0.38	F
FUNDULUS	WATER	MORGANTN	10/2/90	3	1	X		7.2	0.04	F
FUNDULUS	WATER	MORGANTN	10/2/90	4	1	X		5.7	0.02	M
FUNDULUS	WATER	MORGANTN	10/2/90	5	1	X		9.5	0.24	F
FUNDULUS	WATER	MORGANTN	10/2/90	6	1	X		6	0.02	M
FUNDULUS	WATER	MORGANTN	10/2/90	7	1	X		7.2	0.05	F
FUNDULUS	WATER	MORGANTN	10/2/90	8	1	X		5.5	0.05	F
FUNDULUS	WATER	MORGANTN	10/2/90	9	1	X		7.1	0.05	M
FUNDULUS	WATER	MORGANTN	10/2/90	10	1	X		4.9	0.02	M
FUNDULUS	WATER	MORGANTN	10/2/90	11	1	X		4.6	0.03	M
FUNDULUS	WATER	MORGANTN	10/2/90	12	1	X		4.8	0.01	M
FUNDULUS	WATER	MORGANTN	10/2/90	13	4			17.5		
FUNDULUS	WATER	DAHLGREN	10/2/90	1	1	X		11.4	0.11	M
FUNDULUS	WATER	DAHLGREN	10/2/90	2	1	X		11.6	0.04	M

FUNDULUS	WATER	DAHLGREN	10/2/90	3	1	X	6.1	0.01	
FUNDULUS	WATER	DAHLGREN	10/2/90	4	1	X	7.4	0.08	F
FUNDULUS	WATER	DAHLGREN	10/2/90	5	1	X	5.3	0.05	F
FUNDULUS	WATER	DAHLGREN	10/2/90	6	1	X	5.4	0.01	M
FUNDULUS	WATER	DAHLGREN	10/2/90	7	1	X	5.1	0.01	M
FUNDULUS	WATER	DAHLGREN	10/2/90	8	1	X	5	0.04	F
FUNDULUS	WATER	DAHLGREN	10/2/90	9	1	X	6.1	0.04	F
FUNDULUS	WATER	DAHLGREN	10/2/90	10	1	X	3.4	0.05	F
FUNDULUS	WATER	DAHLGREN	10/2/90	11	1	X	4.2	0.04	F
FUNDULUS	WATER	DAHLGREN	10/2/90	12	1	X	5.9	0.06	F
FUNDULUS	WATER	DAHLGREN	10/2/90	13	3	X	11.7		
FUNDULUS	WATER	CONTROL	8/21/90	1	1	X	4.5	0.08	F
FUNDULUS	WATER	CONTROL	8/21/90	2	1	X	12.5	0.19	F
FUNDULUS	WATER	CONTROL	8/21/90	3	1	X	2.9	0.02	F
FUNDULUS	WATER	CONTROL	8/21/90	4	1	X	2.1	<.01	M
FUNDULUS	WATER	CONTROL	8/21/90	5	1	X	7.4	0.06	F
FUNDULUS	WATER	CONTROL	8/21/90	6	1	X	4.3	<.01	M
FUNDULUS	WATER	CONTROL	8/21/90	7	1	X	5.9	0.21	F
FUNDULUS	WATER	CONTROL	8/21/90	8	1	X	7	0.02	M
FUNDULUS	WATER	CONTROL	8/21/90	9	1	X	7	0.05	F
FUNDULUS	WATER	CONTROL	8/21/90	10	1	X	4.4	0.02	F
FUNDULUS	WATER	WYE R	8/21/90	1	1	X	5.1	0.07	F
FUNDULUS	WATER	WYE R	8/21/90	2	1	X	9.3	0.06	F
FUNDULUS	WATER	WYE R	8/21/90	3	1	X	2.9	<.01	M
FUNDULUS	WATER	WYE R	8/21/90	4	1	X	10.9	0.05	M
FUNDULUS	WATER	WYE R	8/21/90	5	1	X	10.5	0.08	F
FUNDULUS	WATER	WYE R	8/21/90	6	1	X	6.3	0.09	F
FUNDULUS	WATER	WYE R	8/21/90	7	1	X	4.3	0.01	M
FUNDULUS	WATER	WYE R	8/21/90	8	1	X	6.2	0.05	F
FUNDULUS	WATER	WYE R	8/21/90	9	2	X	4.6	0.01	M
FUNDULUS	WATER	BALTIMORE	8/21/90	1	1	X	4.6	0.04	F
FUNDULUS	WATER	BALTIMORE	8/21/90	2	1	X	9	0.09	F
FUNDULUS	WATER	BALTIMORE	8/21/90	3	1	X	6.8	0.02	M
FUNDULUS	WATER	BALTIMORE	8/21/90	4	1	X	4.6	0.04	M
FUNDULUS	WATER	BALTIMORE	8/21/90	5	1	X	5.9	0.05	F
FUNDULUS	WATER	BALTIMORE	8/21/90	6	2	X	6.9	0.02	M
FUNDULUS	WATER	BALTIMORE	8/21/90	7	2	X	6.1	0.04	F
FUNDULUS	WATER	BALTIMORE	8/21/90	8	2	X	6.8	0.06	F
FUNDULUS	WATER	ELIZABETH	8/21/90	1	1	X	5.1	0.02	M
FUNDULUS	WATER	ELIZABETH	8/21/90	2	1	X	5.8	0.01	F
FUNDULUS	WATER	ELIZABETH	8/21/90	3	1	X	6.7	0.05	F
FUNDULUS	WATER	ELIZABETH	8/21/90	4	2	X	6.6	0.02	F
FUNDULUS	WATER	ELIZABETH	8/21/90	5	2	X	8.5	0.04	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	1	1	X	5.2	0.02	M
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	2	1	X	5.7	0.04	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	3	1	X	5.8	0.05	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	4	1	X	6.5	0.04	M
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	5	1	X	8.2	0.06	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	6	1	X	4.2	0.01	M
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	7	1	X	4.6	0.04	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	8	1	X	3.8	0.02	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	9	1	X	4.3	0.04	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	10	1	X	4.2	0.01	F

FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	11	1	X	3.9	0.04	F
FUNDULUS	SEDIMENT	NANSEMOND	10/8/90	12	1	X	4.2	0.03	M
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	1	1	X	9	0.08	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	2	1	X	5.1	0.03	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	3	1	X	4.6	0.01	M
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	4	1	X	10	0.06	M
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	5	1	X	6.7	0.05	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	6	1	X	5.3	0.04	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	7	1	X	4.7	0.02	M
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	8	1	X	5	0.03	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	9	1	X	4.9	0.04	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	10	1	X	6.3	0.03	M
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	11	1	X	4.3	0.02	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	12	1	X	4.4	0.02	F
FUNDULUS	SEDIMENT	DAHLGREN	10/8/90	13			22.5		
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	1	1	X	8.7	0.07	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	2	1	X	5.1	0.02	M
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	3	1	X	5.5	0.01	M
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	4	1	X	5.8	0.01	M
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	5	1	X	7.7	0.06	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	6	1	X	6.8	0.03	M
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	7	1	X	5.9	0.04	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	8	1	X	5.2	0.06	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	9	1	X	7.3	0.06	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	10	1	X	10	0.08	F
FUNDULUS	SEDIMENT	INDIAN HD	10/8/90	11	1	X	4.6	<.01	M
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	1	1	X	5.7	0.04	M
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	2	1	X	6.4	0.08	F
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	3	1	X	5.1	0.03	M
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	4	1	X	5	0.04	F
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	5	1	X	9.5	0.08	F
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	6	1	X	7.6	0.04	M
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	7	1	X	3.1	0.02	
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	8	1	X	6.5	0.02	M
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	9	1	X	3.3	0.02	F
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	10	1	X	4.6	0.03	F
FUNDULUS	SEDIMENT	POSSUM PT	10/8/90	11	1	X	4.5	0.01	M
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	1	1	X	8	0.08	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	2	1	X	8.1	0.08	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	3	1	X	13.3	0.13	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	4	1	X	7.3	0.02	M
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	5	1	X	4.8	0.03	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	6	1	X	4.4	0.03	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	7	1	X	7.8		M
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	8	1	X	4.7	0.01	M
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	9	1	X	6.8	0.04	F
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	10	2	X	6.2	0.03	
FUNDULUS	SEDIMENT	FREESTONE	10/8/90	11	1	X	8.4	0.05	M
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	1	1	X	12.2	0.28	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	2	1	X	5.3	0.02	M
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	3	1	X	5	0.05	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	4	1	X	7.9	0.17	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	5	1	X	6.4	0.06	F

FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	6	1	X	5.3	0.01	M
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	7	1	X	6.5	0.11	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	8	1	X	5.8	0.06	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	9	1	X	5.5	0.17	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	10	1	X	3.2	0.03	F
FUNDULUS	SEDIMENT	MORGANTOW	10/8/90	11	2	X	6.7	0.04	M
FUNDULUS	SEDIMENT	CONTROL	9/6/90	1	1	X	5.5	0.04	M
FUNDULUS	SEDIMENT	CONTROL	9/6/90	2	1	X	6.9	0.07	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	3	1	X	6.3	0.03	M
FUNDULUS	SEDIMENT	CONTROL	9/6/90	4	1	X	8.1	0.08	M
FUNDULUS	SEDIMENT	CONTROL	9/6/90	5	1	X	7.6	0.07	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	6	1	X	7.2	0.03	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	7	1	X	7.5	0.06	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	8	1	X	8.1	0.07	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	9	1	X	4.7	0.03	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	10	1	X	6.9	0.44	F
FUNDULUS	SEDIMENT	CONTROL	9/6/90	11	2	X	6	0.04	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	1	1	X	4.6	0.05	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	2	1	X	9.4	0.15	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	3	1	X	8.9	0.15	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	4	1	X	7.8	0.05	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	5	1	X	6.9	0.09	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	6	1	X	9	0.14	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	7	1	X	7.1	0.16	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	8	1	X	3.6	0.01	M
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	9	1	X	4.6	0.04	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	10	1	X	3.8	0.03	F
FUNDULUS	SEDIMENT	BALTIMORE	9/6/90	11	1	X	4	0.03	M
FUNDULUS	SEDIMENT	WYE R	9/6/90	1	1	X	6.6	0.09	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	2	1	X	8.8	0.03	M
FUNDULUS	SEDIMENT	WYE R	9/6/90	3	1	X	5.8	0.07	M
FUNDULUS	SEDIMENT	WYE R	9/6/90	4	1	X	5.2	0.09	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	5	1	X	7.4	0.03	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	6	1	X	5	0.07	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	7	1	X	5.7	0.1	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	8	1	X	6	0.04	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	9	1	X	5.7	0.05	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	10	1	X	4	0.01	M
FUNDULUS	SEDIMENT	WYE R	9/6/90	11	1	X	6.1	0.04	F
FUNDULUS	SEDIMENT	WYE R	9/6/90	12	1	X	5.9	0.13	M
FUNDULUS	SEDIMENT	ELIZABETH	9/6/90	1	2	X	6.5	0.01	M,F

Appendix B

Water quality data collected at 1-h intervals with datasonde units during the Potomac River experiments (9/23/90 - 10/2/90). Stations were Dahlgren (DG), Morgantown (MT), Possum Point (PP), Freestone Point (FP) and Indian Head (IH)

STATION ID : DG

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092390						
1400	+21.42	+07.72	+14.74	+08.33	+09.08	+05.76
1500	+21.46	+07.73	+14.86	+08.40	+08.94	+05.75
1600	+21.46	+07.74	+14.95	+08.46	+08.96	+05.75
1700	+21.37	+07.73	+14.65	+08.27	+08.84	+05.75
1800	+21.20	+07.91	+14.26	+08.02	+09.22	+05.74
1900	+20.95	+07.89	+14.12	+07.93	+09.30	+05.74
2000	+20.91	+07.93	+14.35	+08.08	+09.34	+05.73
2100	+20.78	+07.84	+14.33	+08.06	+08.94	+05.73
2200	+20.70	+07.67	+14.60	+08.24	+08.43	+05.73
2300	+20.57	+07.66	+14.43	+08.16	+08.23	+05.73
092490						
0000	+20.40	+07.67	+14.38	+08.10	+08.21	+05.73
0100	+20.44	+07.63	+14.63	+08.26	+07.95	+05.73
0200	+20.23	+07.64	+14.45	+08.14	+07.98	+05.73
0300	+20.61	+07.41	+>>.<<	+08.61	+06.93	+05.73
0400	+20.44	+07.46	+14.99	+08.49	+07.07	+05.73
0500	+20.32	+07.42	+14.94	+08.46	+07.10	+05.73
0600	+20.06	+07.39	+14.82	+08.38	+06.79	+05.72
0700	+19.77	+07.41	+14.31	+08.37	+06.89	+05.72
0800	+19.39	+07.48	+14.40	+08.11	+07.81	+05.72
0900	+19.68	+07.42	+14.56	+08.21	+07.15	+05.72
1000	+19.73	+07.61	+14.48	+08.16	+07.52	+05.72
1100	+19.98	+07.74	+14.65	+08.27	+08.45	+05.72
1200	+20.11	+07.68	+14.79	+08.36	+08.20	+05.72
1300	+20.19	+07.76	+14.69	+08.30	+08.82	+05.72
1400	+20.44	+07.76	+14.77	+08.34	+08.59	+05.72
1500	+20.27	+07.56	+14.87	+08.41	+07.89	+05.72
1600	+20.32	+07.66	+14.81	+08.37	+08.25	+05.72
1700	+20.36	+07.61	+14.79	+08.36	+08.11	+05.72
1800	+20.32	+07.64	+14.79	+08.36	+08.12	+05.71
1900	+20.23	+07.68	+14.81	+08.37	+08.27	+05.71
2000	+20.19	+07.68	+14.76	+08.34	+08.18	+05.71
2100	+20.15	+07.68	+14.77	+08.35	+08.30	+05.71
2200	+20.19	+07.74	+14.62	+08.25	+08.32	+05.71
2300	+20.23	+07.64	+14.86	+08.40	+08.00	+05.71

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092590						
0000	+19.94	+07.75	+14.68	+08.29	+08.42	+05.71
0100	+19.73	+07.74	+14.68	+08.29	+08.35	+05.71
0200	+19.68	+07.79	+14.56	+08.21	+08.60	+05.71
0300	+19.56	+07.82	+14.53	+08.19	+08.80	+05.71
0400	+19.73	+07.69	+14.68	+08.29	+08.44	+05.71
0500	+19.73	+07.58	+14.82	+08.38	+07.96	+05.70
0600	+19.68	+07.57	+14.79	+08.36	+07.83	+05.70
0700	+19.30	+07.53	+14.73	+08.32	+07.65	+05.70
0800	+19.22	+07.47	+14.80	+08.37	+07.39	+05.69
0900	+18.67	+07.60	+14.61	+08.25	+07.67	+05.69
1000	+18.84	+07.52	+14.72	+08.31	+07.52	+05.69
1100	+19.22	+07.52	+14.78	+08.35	+07.60	+05.69
1200	+19.60	+07.61	+14.72	+08.32	+07.59	+05.69
1300	+19.73	+07.60	+14.77	+08.35	+07.32	+05.70
1400	+19.77	+07.52	+14.74	+08.33	+07.33	+05.70
1500	+20.11	+07.66	+14.79	+08.36	+08.[illegible]	+05.70
1600	+20.15	+07.73	+14.80	+08.36	+08.33	+05.70
1700	+20.11	+07.79	+14.83	+08.39	+08.81	+05.70
1800	+20.23	+07.83	+14.88	+08.42	+08.94	+05.70
1900	+20.15	+07.79	+14.86	+08.41	+08.83	+05.70
2000	+20.15	+07.81	+14.86	+08.41	+08.90	+05.70
2100	+20.23	+07.75	+14.81	+08.37	+08.81	+05.70
2200	+20.15	+07.75	+14.80	+08.36	+08.53	+05.70
2300	+20.06	+07.68	+14.80	+08.37	+08.45	+05.70
092690						
0000	+20.06	+07.73	+14.85	+08.39	+08.48	+05.70
0100	+19.95	+07.71	+14.85	+08.40	+08.61	+05.[illegible]
0200	+19.89	+07.71	+14.83	+08.39	+08.53	+05.69
0300	+19.98	+07.81	+14.83	+08.38	+08.92	+05.69
0400	+19.98	+07.89	+14.85	+08.40	+09.19	+05.69
0500	+19.73	+07.84	+14.91	+08.44	+09.22	+05.69
0600	+19.30	+07.60	+14.84	+08.39	+08.07	+05.69
0700	+19.22	+07.61	+14.80	+08.37	+08.02	+05.68
0800	+19.18	+07.59	+14.77	+08.35	+07.96	+05.68
0900	+18.88	+07.57	+14.80	+08.36	+07.82	+05.67
1000	+19.13	+07.66	+14.81	+08.37	+08.60	+05.67
1100	+19.30	+07.69	+14.84	+08.39	+08.34	+05.67
1200	+19.43	+07.70	+14.83	+08.38	+08.31	+05.68
1300	+19.51	+07.70	+14.34	+08.39	+08.29	+05.68
1400	+20.15	+07.91	+14.82	+08.38	+09.04	+05.69
1500	+20.15	+07.93	+14.34	+08.39	+09.11	+05.69
1600	+20.15	+08.10	+14.82	+08.38	+10.02	+05.69
1700	+20.19	+08.07	+14.87	+08.41	+10.00	+05.69
1800	+20.23	+07.91	+14.88	+08.42	+09.65	+05.69
1900	+20.23	+07.98	+14.90	+08.43	+09.82	+05.69
2000	+20.19	+07.98	+14.87	+08.41	+10.00	+05.69
2100	+20.23	+07.73	+14.86	+08.40	+09.08	+05.69
2200	+20.06	+07.91	+14.37	+08.41	+09.43	+05.69
2300	+20.02	+07.37	+14.79	+08.36	+09.11	+05.69

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092790						
0000	+19.94	+07.91	+14.84	+08.37	+09.44	+05.69
0100	+19.73	+07.90	+14.75	+08.33	+09.47	+05.68
0200	+19.68	+07.92	+14.63	+08.26	+09.56	+05.68
0300	+19.64	+08.02	+14.55	+08.21	+09.85	+05.68
0400	+19.47	+08.07	+14.51	+08.18	+10.04	+05.67
0500	+19.43	+08.06	+14.53	+08.19	+09.95	+05.67
0600	+19.35	+08.05	+14.53	+08.19	+09.91	+05.67
0700	+19.09	+07.85	+14.57	+08.22	+09.39	+05.67
0800	+19.18	+07.58	+14.89	+08.42	+07.96	+05.67
0900	+18.67	+07.59	+14.73	+08.35	+07.81	+05.66
1000	+18.97	+07.84	+14.61	+08.24	+08.51	+05.66
1100	+19.30	+07.87	+14.71	+08.31	+08.87	+05.66
1200	+19.36	+07.94	+14.69	+08.30	+09.42	+05.67
1300	+19.68	+07.81	+14.74	+08.33	+08.97	+05.66
1400	+19.64	+07.75	+14.73	+08.32	+08.60	+05.68
1500	+19.43	+07.62	+14.76	+08.34	+07.93	+05.67
1600	+19.60	+07.73	+14.79	+08.36	+07.89	+05.67
1700	+19.94	+07.93	+14.77	+08.35	+08.73	+05.67
1800	+21.54	+07.94	+14.48	+08.16	+09.93	+05.68
1900	+21.33	+07.93	+14.73	+08.32	+09.76	+05.68
2000	+21.20	+07.94	+14.75	+08.33	+09.80	+05.68
2100	+21.25	+07.94	+14.56	+08.21	+09.73	+05.68
2200	+21.25	+07.90	+14.45	+08.14	+09.57	+05.68
2300	+21.25	+07.81	+14.60	+08.24	+09.00	+05.68
092890						
0000	+21.25	+07.81	+14.64	+08.27	+09.10	+05.68
0100	+20.75	+08.12	+14.32	+08.18	+10.34	+05.68
0200	+20.74	+07.95	+14.69	+08.30	+09.61	+05.67
0300	+20.74	+07.79	+14.78	+08.35	+08.77	+05.67
0400	+20.65	+07.89	+14.72	+08.31	+09.43	+05.67
0500	+20.53	+08.15	+14.63	+08.26	+09.91	+05.67
0600	+20.44	+08.14	+14.52	+08.19	+10.51	+05.67
0700	+20.53	+07.86	+14.47	+08.16	+09.24	+05.67
0800	+20.57	+07.76	+14.55	+08.20	+08.73	+05.67
0900	+20.61	+07.89	+14.65	+08.27	+09.15	+05.67
1000	+20.65	+07.92	+14.63	+08.26	+09.34	+05.67
1100	+20.61	+08.15	+14.74	+08.32	+10.05	+05.67
1200	+20.78	+07.97	+14.53	+08.17	+09.83	+05.67
1300	+20.44	+07.98	+14.52	+08.19	+09.67	+05.67
1400	+20.61	+07.98	+14.58	+08.22	+09.65	+05.67
1500	+21.42	+08.18	+14.52	+08.19	+10.16	+05.67
1600	+21.33	+08.13	+14.55	+08.21	+10.16	+05.67
1700	+20.61	+07.91	+14.53	+08.20	+09.25	+05.67
1800	+21.54	+08.24	+14.55	+08.21	+10.93	+05.67
1900	+21.46	+08.20	+14.58	+08.22	+10.77	+05.67
2000	+21.50	+08.23	+14.59	+08.23	+11.14	+05.67
2100	+21.37	+08.17	+14.60	+08.24	+10.70	+05.67
2200	+21.37	+08.23	+14.60	+08.24	+10.92	+05.67
2300	+21.37	+08.17	+14.60	+08.24	+10.70	+05.67

```
TIME      TEMP      PH       COND      SALIN      DO      BATTERY
HHMM     DEG C     UNITS     MS/CM      PPT    MG/L(PPM)   VOLTS
-------------------------------------------------------------------
092990
0000     +21.42    +08.17    +14.61    +08.25    +10.71    +05.67
0100     +20.95    +08.12    +14.56    +08.21    +10.24    +05.67
0200     +20.99    +07.98    +14.59    +08.23    +09.44    +05.67
0300     +20.91    +08.07    +14.57    +08.22    +10.03    +05.67
0400     +21.03    +07.95    +14.58    +08.22    +09.36    +05.67
0500     +21.08    +07.90    +14.54    +08.20    +09.32    +05.67
0600     +21.08    +07.80    +14.56    +08.21    +08.76    +05.67
0700     +21.08    +07.75    +14.56    +08.21    +08.49    +05.67
0800     +20.95    +07.74    +14.61    +08.24    +08.46    +05.66
0900     +20.91    +07.86    +14.51    +08.18    +08.70    +05.66
1000     +20.91    +07.86    +14.62    +08.25    +08.54    +05.66
1100     +21.07    +07.99    +14.60    +08.24    +09.16    +05.66
1200     +21.16    +07.88    +14.63    +08.25    +08.86    +05.66
1300     +21.16    +07.96    +14.56    +08.21    +08.70    +05.66
1400     +21.12    +07.96    +14.53    +08.19    +09.14    +05.66
1500     +20.91    +07.97    +14.44    +08.14    +09.10    +05.66
1600     +21.71    +08.20    +14.54    +08.20    +09.39    +05.66
1700     +21.16    +07.94    +14.47    +08.16    +08.77    +05.67
1800     +21.37    +08.13    +14.45    +08.14    +09.53    +05.67
1900     +21.63    +08.27    +14.52    +08.19    +10.97    +05.67
2000     +21.54    +08.09    +14.55    +08.21    +10.29    +05.67
2100     +21.58    +08.01    +14.56    +08.21    +09.69    +05.67
2200     +21.67    +08.16    +14.55    +08.21    +10.28    +05.67
2300     +21.50    +08.03    +14.56    +08.21    +09.84    +05.67

093090
0000     +21.54    +08.14    +14.57    +08.22    +09.93    +05.66
0100     +21.34    +07.63    +>>.<<    +08.33    +08.66    +05.67
0200     +21.54    +07.79    +14.92    +08.44    +08.39    +05.67
0300     +21.67    +07.94    +14.84    +08.39    +09.07    +05.67
0400     +21.54    +08.02    +14.70    +08.30    +09.83    +05.66
0500     +21.50    +07.66    +>>.<<    +08.61    +07.84    +05.66
0600     +21.46    +07.81    +>>.<<    +08.54    +08.05    +05.66
0700     +21.50    +07.59    +>>.<<    +08.51    +07.46    +05.66
0800     +21.50    +07.39    +>>.<<    +08.69    +06.84    +05.66
0900     +21.54    +07.46    +>>.<<    +08.79    +06.82    +05.66
1000     +21.54    +07.62    +>>.<<    +08.67    +07.41    +05.65
1100     +21.54    +07.56    +>>.<<    +08.81    +07.37    +05.65
1200     +21.58    +07.56    +>>.<<    +08.81    +07.36    +05.65
1300     +21.63    +07.52    +>>.<<    +08.83    +07.19    +05.66
1400     +21.63    +07.58    +>>.<<    +08.65    +07.39    +05.66
1500     +21.54    +07.61    +>>.<<    +08.65    +07.05    +05.63
1600     +21.63    +07.63    +>>.<<    +08.65    +07.39    +05.63
1700     +21.58    +07.52    +>>.<<    +08.78    +06.88    +05.63
1800     +21.54    +07.56    +>>.<<    +08.89    +07.04    +05.63
1900     +21.63    +07.62    +>>.<<    +08.77    +06.97    +05.63
2000     +21.71    +07.71    +>>.<<    +08.76    +06.92    +05.63
2100     +21.75    +07.79    +>>.<<    +08.64    +07.11    +05.65
2200     +21.84    +08.02    +>>.<<    +08.62    +08.72    +05.63
2300     +21.67    +07.90    +>>.<<    +08.63    +08.64    +05.65
```

	TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
	100190						
	0000	+21.50	+07.74	+>>.<<	+08.66	-08.07	+05.63
	0100	+21.42	+07.84	+>>.<<	+06.57	+07.90	-05.63
	0200	+21.37	+07.91	+14.91	+09.44	+08.01	+05.63
	0300	+21.50	+07.93	+>>.<<	+08.56	+08.33	+05.63
	0400	+21.54	-07.83	+>>.<<	+08.67	+08.15	+05.63
	0500	+21.54	+07.79	+>>.<<	+08.67	+07.83	+05.63
	0600	+21.63	+07.70	+>>.<<	+08.65	+07.58	+05.63
	0700	+21.46	+07.84	+>>.<<	+08.57	+07.73	+05.63
	0800	+21.25	+07.92	+15.00	+08.49	+08.04	+05.63
	0900	+21.12	+08.00	+14.93	+08.45	+08.37	+05.62
	1000	+21.16	+07.95	+>>.<<	+08.52	-08.45	+05.63
	1100	+21.20	+07.81	+>>.<<	+08.61	+07.92	+05.63
	1200	+21.12	-07.73	->>.<<	-08.69	-07.67	+05.62
	1300	+21.08	+07.70	+>>.<<	+08.73	+07.61	+05.62
	1400	+21.08	+07.68	+>>.<<	+08.69	+07.48	+05.62
	1500	+21.12	+07.68	+>>.<<	+08.70	+07.28	+05.63
	1600	+21.29	+07.77	+>>.<<	+08.65	+08.22	+05.63
	1700	+21.42	+07.90	+>>.<<	+08.69	+07.99	+05.63
	1800	+21.20	+07.71	+>>.<<	+08.74	+07.62	+05.63
	1900	+21.25	+07.76	+>>.<<	+08.73	+07.74	+05.63
	2000	+21.33	+07.77	+>>.<<	+08.71	+07.78	+05.63
	2100	+21.33	+07.71	+>>.<<	+08.71	+07.55	+05.63
	2200	+21.20	+07.87	+>>.<<	+08.70	+08.30	+05.63
	2300	+21.16	+07.96	+>>.<<	+08.68	+08.64	+05.63
	100290						
	0000	+21.12	+07.84	+>>.<<	+08.71	+08.29	+05.63
	0100	-20.91	+07.36	->>.<<	-08.72	-08.38	+05.62
	0200	+20.70	+07.73	+>>.<<	+08.65	-07.21	+05.62
	0300	+20.78	+07.62	+>>.<<	+06.60	+07.29	+05.62
	0400	+20.74	+07.80	+>>.<<	+08.57	+07.60	+05.62
	0500	+20.82	+07.87	->>.<<	+08.51	+08.05	+05.62
	0600	+20.78	+07.90	+>>.<<	+08.60	-08.19	+05.62
	0700	+20.74	+07.84	+>>.<<	+08.61	+08.20	+05.62
pH 7 post-cal	0800	+15.25	+06.98	+07.23	+03.67	+08.46	+05.60
pH 10 post-cal	0900	+16.30	+09.95	+>>.<<	+09.71	+08.93	-05.59
	1000	+18.71	+09.90	->>.<<	+09.71	+08.33	+05.61
	1100	+20.11	+09.74	+>>.<<	+09.79	+08.07	-05.62
	1200	+20.70	+08.89	+00.40	+00.00	+08.85	+05.62
	1300	+22.94	+09.14	+00.34	+00.00	+08.55	+05.63
	1400	+25.13	+09.23	+00.47	+00.00	+08.55	+05.65
	1500	+25.47	+09.22	+00.44	+00.00	+07.89	+05.66
	1600	+25.64	+09.23	+00.48	+00.00	+07.61	+05.67
	1700	+25.47	+09.23	+00.44	+00.00	+07.47	-05.67
	1800	+25.05	+09.22	+00.47	-00.00	+07.50	+05.66
	1900	+24.67	+09.21	+00.47	+00.00	+07.31	+05.66

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STATION ID : MT

TIME       TEMP        PH         COND       SALIN       DO         BATTERY
HHMM       DEG C      UNITS      MS/CM       PPT     MG/L(PPM)     VOLTS
------------------------------------------------------------------------------

092390
1430      +22.34     +07.49     +13.14     +07.31     +07.04     +05.60
1530      +22.18     +07.51     +13.27     +07.39     +07.23     +05.59
1630      +23.06     +07.45     +13.54     +07.57     +06.88     +05.59
1730      +22.26     +07.49     +13.13     +07.30     +07.11     +05.58
1830      +22.51     +07.45     +13.55     +07.57     +06.74     +05.58
1930      +23.57     +07.30     +>>.<<     +08.65     +05.50     +05.58
2030      +23.44     +07.30     +>>.<<     +08.82     +05.51     +05.58
2130      +22.89     +07.40     +14.39     +08.10     +06.56     +05.58
2230      +21.37     +07.53     +13.16     +07.33     +07.36     +05.58
2330      +22.09     +07.40     +14.20     +07.99     +06.60     +05.57

092490
0030      +21.73     +07.40     +13.73     +07.68     +06.45     +05.57
0130      +21.29     +07.43     +13.12     +07.30     +06.88     +05.57
0230      +21.20     +07.46     +13.03     +07.24     +06.84     +05.57
0330      +20.95     +07.49     +12.88     +07.15     +07.06     +05.56
0430      +21.12     +07.48     +12.57     +06.95     +07.11     +05.56
0530      +20.99     +07.47     +12.50     +06.91     +07.01     +05.56
0630      +20.91     +07.46     +12.62     +06.99     +07.00     +05.56
0730      +21.50     +07.41     +13.08     +07.28     +06.78     +05.56
0830      +20.87     +07.45     +12.59     +06.97     +07.41     +05.56
0930      +22.81     +07.34     +14.24     +08.01     +06.36     +05.56
1030      +21.16     +07.43     +12.72     +07.05     +06.33     +05.56
1130      +20.78     +07.52     +12.31     +06.79     +07.44     +05.56
1230      +20.70     +07.55     +12.40     +06.85     +07.59     +05.55
1330      +20.44     +07.66     +12.24     +06.81     +07.79     +05.55
1430      +20.70     +07.69     +12.03     +06.62     +08.12     +05.55
1530      +20.70     +07.73     +11.93     +06.55     +08.32     +05.55
1630      +21.12     +07.69     +11.82     +06.48     +08.13     +05.55
1730      +21.29     +07.59     +11.37     +06.21     +07.81     +05.55
1830      +22.01     +07.52     +12.15     +06.69     +07.38     +05.55
1930      +24.58     +07.30     +14.22     +08.00     +05.95     +05.56
2030      +23.74     +07.28     +14.92     +08.44     +05.75     +05.56
2130      +23.91     +07.30     +14.85     +08.39     +05.84     +05.56
2230      +23.36     +07.27     +>>.<<     +08.89     +05.40     +05.56
2330      +23.27     +07.28     +>>.<<     +08.92     +05.34     +05.55
```

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TIME      TEMP      PH       COND      SALIN      DO        BATTERY
HHMM      DEG C     UNITS    MS/CM     PPT      MG/L(PPM)   VOLTS
-----------------------------------------------------------------------
092590
0030     +22.94    +07.31    +>>.<<    +08.63    +05.32    +05.56
0130     +22.18    +07.34    +14.61    +08.25    +05.38    +05.55
0230     +21.71    +07.36    +14.46    +08.15    +06.02    +05.54
0330     +21.50    +07.38    +13.78    +07.72    +06.29    +05.54
0430     +21.08    +07.40    +13.19    +07.34    +06.49    +05.54
0530     +21.12    +07.39    +13.29    +07.41    +06.40    +05.54
0630     +21.25    +07.38    +13.28    +07.40    +06.29    +05.54
0730     +23.40    +07.24    +>>.<<    +08.80    +05.15    +05.54
0830     +23.02    +07.26    +>>.<<    +08.61    +05.24    +05.54
0930     +22.60    +07.25    +>>.<<    +08.85    +05.22    +05.54
1030     +22.91    +07.27    +>>.<<    +08.63    +05.30    +05.54
1130     +22.05    +07.26    +>>.<<    +08.94    +05.28    +05.54
1230     +22.22    +07.30    +>>.<<    +08.63    +05.67    +05.54
1330     +22.30    +07.31    +14.99    +08.48    +05.67    +05.54
1430     +22.22    +07.37    +14.50    +08.17    +06.08    +05.54
1530     +22.26    +07.56    +13.76    +07.70    +07.26    +05.54
1630     +21.75    +07.68    +12.87    +07.14    +07.36    +05.54
1730     +21.50    +07.77    +12.28    +06.77    +08.31    +05.54
1830     +23.61    +07.45    +14.73    +08.32    +07.25    +05.54
1930     +22.72    +07.36    +>>.<<    +08.53    +06.15    +05.54
2030     +23.23    +07.40    +14.58    +08.22    +06.34    +05.54
2130     +22.77    +07.41    +14.84    +08.39    +06.63    +05.54
2230     +22.30    +07.37    +>>.<<    +08.72    +06.04    +05.54
2330     +22.98    +07.33    +>>.<<    +08.87    +05.81    +05.54

092690
0030     +21.96    +07.36    +>>.<<    +08.86    +06.02    +05.54
0130     +22.29    +07.37    +>>.<<    +08.63    +06.17    +05.53
0230     +21.80    +07.43    +>>.<<    +08.63    +06.58    +05.53
0330     +21.46    +07.47    +14.28    +08.03    +06.76    +05.53
0430     +21.42    +07.46    +14.29    +08.04    +06.82    +05.53
0530     +22.00    +07.36    +14.95    +08.46    +06.26    +05.53
0630     +21.50    +07.44    +14.37    +08.10    +07.01    +05.53
0730     +22.51    +07.39    +14.72    +08.32    +06.58    +05.53
0830     +22.43    +07.35    +>>.<<    +08.55    +06.15    +05.53
0930     +22.56    +07.37    +>>.<<    +08.58    +06.36    +05.53
1030     +22.47    +07.37    +>>.<<    +08.61    +06.35    +05.53
1130     +21.54    +07.40    +>>.<<    +08.50    +06.41    +05.53
1230     +21.75    +07.41    +>>.<<    +08.52    +06.62    +05.52
1330     +21.80    +07.41    +>>.<<    +08.51    +06.72    +05.52
1430     +21.96    +07.44    +14.72    +08.31    +06.85    +05.52
1530     +22.30    +07.50    +14.59    +08.27    +07.11    +05.52
1630     +21.63    +07.58    +13.57    +07.58    +07.61    +05.52
1730     +21.54    +07.69    +13.11    +07.29    +08.04    +05.52
1830     +21.54    +07.72    +12.85    +07.13    +08.28    +05.52
1930     +23.15    +07.39    +14.82    +08.37    +06.80    +05.52
2030     +22.81    +07.29    +>>.<<    +08.70    +05.70    +05.52
2130     +23.15    +07.31    +>>.<<    +08.63    +05.97    +05.52
2230     +22.82    +07.34    +14.64    +08.27    +05.79    +05.52
2330     +22.30    +07.31    +>>.<<    +08.75    +05.70    +05.52
```

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TIME      TEMP       PH        COND       SALIN       DO        BATTERY
HHMM      DEG C      UNITS     MS/CM       PPT     MG/L(PPM)    VOLTS
-------------------------------------------------------------------------
092790
0030      +22.09     +07.34    +>>.<<     +08.69    +05.90     +05.52
0130      +22.01     +07.37    +14.80     +08.37    +06.29     +05.52
0230      +21.92     +07.38    +14.49     +08.17    +06.50     +05.52
0330      +21.33     +07.42    +13.82     +07.74    +06.82     +05.52
0430      +20.95     +07.46    +13.34     +07.44    +07.02     +05.51
0530      +20.78     +07.45    +13.41     +07.48    +07.09     +05.51
0630      +20.44     +07.48    +12.61     +06.98    +07.32     +05.51
0730      +20.44     +07.45    +12.46     +06.89    +07.02     +05.51
0830      +20.44     +07.44    +12.28     +06.77    +07.08     +05.51
0930      +21.12     +07.39    +12.61     +06.78    +06.89     +05.51
1030      +22.22     +07.32    +13.38     +07.46    +06.13     +05.51
1130      +23.06     +07.27    +14.13     +07.94    +05.83     +05.51
1230      +23.40     +07.25    +14.52     +08.19    +05.54     +05.52
1330      +23.65     +07.27    +14.45     +08.14    +05.87     +05.52
1430      +23.10     +07.34    +14.07     +07.90    +06.13     +05.52
1530      +22.60     +07.46    +13.13     +07.31    +06.81     +05.52
1630      +22.60     +07.36    +13.95     +07.83    +06.33     +05.51
1730      +22.30     +07.35    +13.78     +07.72    +06.16     +05.51
1830      +22.01     +07.35    +13.63     +07.63    +06.14     +05.51
1930      +22.51     +07.33    +14.02     +07.87    +06.06     +05.51
2030      +22.60     +07.30    +>>.<<     +08.92    +05.70     +05.51
2130      +22.94     +07.27    +>>.<<     +08.84    +05.35     +05.51
2230      +23.44     +07.28    +>>.<<     +08.73    +05.47     +05.51
2330      +23.27     +07.29    +>>.<<     +08.68    +05.72     +05.51

092890
0030      +22.77     +07.29    +>>.<<     +08.80    +05.58     +05.51
0130      +22.68     +07.30    +>>.<<     +08.96    +05.26     +05.51
0230      +22.94     +07.32    +>>.<<     +08.53    +05.72     +05.51
0330      +21.96     +07.36    +>>.<<     +08.59    +05.93     +05.51
0430      +21.92     +07.35    +14.77     +08.35    +06.05     +05.51
0530      +21.63     +07.36    +14.51     +08.18    +06.24     +05.51
0630      +21.42     +07.32    +14.43     +08.13    +06.00     +05.50
0730      +20.99     +07.35    +13.55     +07.57    +06.28     +05.50
0830      +20.87     +07.35    +13.63     +07.62    +06.25     +05.50
0930      +21.50     +07.30    +14.71     +08.30    +05.63     +05.50
1030      +23.23     +07.23    +>>.<<     +08.93    +04.87     +05.51
1130      +22.72     +07.26    +>>.<<     +08.95    +05.30     +05.51
1230      +23.36     +07.27    +>>.<<     +08.84    +05.43     +05.51
1330      +22.68     +07.26    +>>.<<     +09.08    +05.20     +05.51
1430      +23.23     +07.33    +>>.<<     +08.84    +05.72     +05.51
1530      +22.60     +07.38    +14.79     +08.36    +06.18     +05.51
1630      +22.81     +07.61    +14.26     +08.02    +07.14     +05.51
1730      +22.85     +07.71    +14.44     +08.14    +07.66     +05.50
1830      +22.68     +07.78    +14.28     +08.03    +08.16     +05.50
1930      +22.64     +07.79    +14.08     +07.90    +08.02     +05.50
2030      +22.13     +07.72    +13.66     +07.64    +07.93     +05.50
2130      +23.70     +07.33    +>>.<<     +09.13    +05.83     +05.50
2230      +24.33     +07.71    +>>.<<     +08.76    +05.53     +05.50
2330      +24.41     +07.35    +>>.<<     +08.97    +05.71     +05.51
```

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092990						
0030	+22.89	+07.54	+>>.<<	+08.74	-06.88	+05.51
0130	+22.35	-07.58	+>>.<<	+08.91	+06.89	-05.51
0230	+22.72	+07.47	+>>.<<	+09.12	+06.51	+05.50
0330	+23.02	+07.55	+>>.<<	+08.81	+06.99	+05.50
0430	+22.13	+07.35	+14.88	+08.42	+06.09	+05.50
0530	+22.05	+07.37	+14.83	+08.38	+06.05	+05.50
0630	+21.68	+07.34	+14.55	+08.20	+06.04	+05.50
0730	+21.71	+07.36	+14.34	+08.07	+06.26	+05.50
0830	+21.29	+07.40	+13.65	+07.63	+06.60	+05.49
0930	+21.29	+07.43	+13.34	+07.44	+06.90	+05.49
1030	+21.54	-07.42	+13.43	+07.50	-06.76	-05.49
1130	+23.44	+07.30	+>>.<<	+08.51	+05.97	-05.50
1230	+23.36	-07.35	+>>.<<	-08.72	-05.67	+05.50
1330	+22.47	+07.52	+>>.<<	+08.66	-06.75	-05.50
1430	+22.85	+07.46	+>>.<<	+08.84	+06.47	-05.50
1530	+22.81	+07.59	+>>.<<	+08.63	+07.14	+05.50
1630	+22.43	+07.55	+14.93	+08.45	+07.21	+05.49
1730	+22.26	+07.50	-14.57	+08.22	+06.64	+05.49
1830	+22.30	+07.59	+13.84	+07.76	+07.34	+05.49
1930	+22.22	+07.60	+13.71	+07.67	+07.44	+05.49
2030	+22.01	+07.62	+13.44	+07.50	+07.65	+05.49
2130	+22.01	+07.73	+12.82	+07.11	+08.06	+05.49
2230	+23.36	+07.46	+14.60	+08.23	+07.16	+05.49
2330	+23.65	+07.37	+14.71	+08.31	+06.13	+05.49
093090						
0030	+23.61	+07.37	+>>.<<	+08.61	+05.93	+05.50
0130	-22.72	-07.53	+>>.<<	+08.92	-06.67	+05.49
0230	+22.47	+07.52	+>>.<<	+09.34	+06.45	+05.49
0330	+22.72	+07.51	+>>.<<	+09.39	+06.29	+05.49
0430	+22.47	-07.57	+>>.<<	+09.16	+06.56	+05.49
0530	+22.13	-07.60	+>>.<<	+08.73	-06.92	+05.49
0630	+22.05	+07.56	->>.<<	+08.52	+06.98	+05.49
0730	+21.88	+07.46	+14.49	+08.17	+06.72	+05.49
0830	+21.75	+07.49	+14.49	+08.17	+06.69	+05.49
0930	+21.67	+07.45	+13.71	+07.68	+06.78	+05.49
1030	+21.58	+07.53	+13.04	+07.25	+07.34	+05.49
1130	+21.84	+07.45	-13.47	+07.52	-06.86	+05.48
1230	+22.94	+07.41	+>>.<<	+08.81	+06.28	+05.49
1330	+23.78	+07.44	+>>.<<	+08.66	+06.37	+05.49
1430	+22.39	+07.56	+>>.<<	+09.01	+06.66	+05.49
1530	+22.47	+07.54	+>>.<<	+09.35	+06.57	-05.49
1630	+22.51	+07.59	+>>.<<	+09.16	+06.67	+05.49
1730	+22.34	+07.59	+>>.<<	+08.75	+06.98	-05.48
1830	+22.51	+07.61	+14.92	+08.44	+07.24	+05.49
1930	+22.26	+07.81	+13.96	+07.83	+07.99	+05.49
2030	+22.01	+07.67	+13.67	+07.65	+07.83	+05.48
2130	+21.88	+07.67	-13.02	+07.23	+07.88	-05.48
2230	-21.75	-07.60	-12.53	+06.73	+07.69	+05.48
2330	+21.84	+07.58	-12.79	+07.09	-07.58	-05.48

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
100190						
0030	+22.30	+07.52	+13.31	+07.42	+07.30	+05.48
0130	+24.84	+07.26	+>>.<<	+09.32	+05.20	+05.48
0230	+24.16	+07.23	+>>.<<	+08.84	+05.35	+05.47
0330	+23.61	+07.32	+>>.<<	+08.59	+05.71	+05.49
0430	+23.10	+07.31	+>>.<<	+08.80	+05.52	+05.47
0530	+22.72	+07.36	+14.89	+08.42	+05.73	+05.48
0630	+21.63	+07.41	+13.65	+07.63	+06.47	+05.48
0730	+21.52	+07.43	+13.84	+07.75	+06.58	+05.48
0830	+21.54	+07.40	+13.69	+07.66	+06.54	+05.48
0930	+21.25	+07.34	+13.92	+07.81	+06.15	+05.47
1030	+21.20	+07.42	+13.11	+07.29	+06.17	+05.47
1130	+21.29	+07.57	+12.88	+07.15	+07.23	+05.47
1230	+21.71	+07.52	+13.32	+07.43	+07.[illegible]8	+05.47
1330	+23.53	+07.28	+>>.<<	+08.95	+05.49	+05.48
1430	+25.34	+07.26	+>>.<<	+09.24	+05.36	+05.48
1530	+24.25	+07.31	+>>.<<	+09.12	+05.71	+05.49
1630	+24.63	+07.37	+>>.<<	+08.92	+05.94	+05.49
1730	+24.46	+07.36	+>>.<<	+09.09	+05.72	+05.49
1830	+23.78	+07.33	+>>.<<	+09.19	+05.66	+05.48
1930	+22.18	+07.80	+13.66	+07.64	+08.15	+05.48
2030	+22.09	+07.99	+13.45	+07.51	+08.80	+05.48
2130	+21.71	+07.84	+13.14	+07.32	+08.44	+05.48
2230	+21.50	+07.69	+12.90	+07.16	+07.90	+05.47
2330	+23.95	+07.41	+>>.<<	+08.59	+06.75	+05.47
100290						
0030	+24.75	+07.31	+>>.<<	+09.16	+05.91	+05.48
0130	+24.41	+07.3[illegible]	+>>.<<	+08.99	+05.72	+05.48
0230	+23.40	+07.26	+>>.<<	+09.35	+05.28	+05.48
0330	+23.48	+07.20	+>>.<<	+10.17	+04.51	+05.48
0430	+22.26	+07.25	+>>.<<	+10.50	+04.39	+05.48
0530	+22.85	+07.19	+>>.<<	+10.34	+04.07	+05.47
0630	+22.22	+07.27	+>>.<<	+09.79	+04.75	+05.47
0730	+21.71	+07.33	+>>.<<	+09.10	+05.46	+05.47
0830	+16.73	+06.87	+07.04	+03.56	+07.86	+05.46
0930	+19.30	+06.86	+00.46	+00.00	+08.74	+05.46
1030	+20.44	+07.20	+00.37	+00.00	+07.78	+05.47
1130	+20.49	+07.21	+00.37	+00.00	+07.54	+05.47
1230	+21.50	+07.23	+00.40	+00.00	+07.80	+05.47
1330	+24.71	+07.21	+00.41	+00.00	+07.42	+05.48
1430	+25.39	+07.20	+00.41	+00.00	+07.00	+05.48
1530	+25.34	+07.17	+00.41	+00.00	+05.90	+05.48
1630	+25.26	+07.15	+00.41	+00.00	+04.51	+05.48

STATION ID : PP

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092390						
~~1100~~	~~+23.32~~	~~+07.71~~	~~+00.62~~	~~+00.00~~	~~+04.40~~	~~+05.67~~
1200	+21.58	+07.57	+00.33	+00.00	+07.97	+05.69
1300	+21.63	+07.48	+00.31	+00.00	+07.78	+05.68
1400	+21.54	+07.45	+00.31	+00.00	+07.70	+05.68
1500	+21.63	+07.44	+00.31	+00.00	+07.64	+05.68
1600	+21.67	+07.47	+00.31	+00.00	+07.74	+05.67
1700	+21.63	+07.45	+00.31	+00.00	+07.68	+05.67
1800	+21.46	+07.39	+00.31	+00.00	+07.47	+05.67
1900	+21.37	+07.37	+00.29	+00.00	+07.42	+05.67
2000	+21.37	+07.33	+00.33	+00.00	+08.03	+05.[illegible]
2100	+21.37	+07.42	+00.31	+00.00	+07.58	+05.66
2200	+21.37	+07.42	+00.36	+00.00	+07.60	+05.66
2300	+21.29	+07.44	+00.36	+00.00	+07.65	+05.66
092490						
0000	+21.12	+07.37	+00.32	+00.00	+07.52	+05.66
0100	+20.95	+07.41	+00.32	+00.00	+07.78	+05.65
0200	+20.78	+07.38	+00.30	+00.00	+07.44	+05.65
0300	+20.65	+07.36	+00.30	+00.00	+07.32	+05.65
0400	+20.49	+07.36	+00.30	+00.00	+07.31	+05.65
0500	+20.36	+07.35	+00.32	+00.00	+07.32	+05.65
0600	+20.40	+07.34	+00.30	+00.00	+07.33	+05.65
0700	+20.57	+07.31	+00.30	+00.00	+07.27	+05.64
0800	+20.70	+07.33	+00.32	+00.00	+07.43	+05.64
0900	+20.74	+07.33	+00.32	+00.00	+07.35	+05.64
1000	+20.74	+07.35	+00.32	+00.00	+07.42	+05.64
1100	+20.82	+07.36	+00.30	+00.00	+07.36	+05.64
1200	+20.91	+07.36	+00.32	+00.00	+07.50	+05.64
1300	+20.95	+07.35	+00.32	+00.00	+07.56	+05.64
1400	+20.75	+07.36	+00.32	+00.00	+07.36	+05.64
1500	+20.87	+07.37	+00.30	+00.00	+07.58	+05.64
1600	+20.95	+07.36	+00.32	+00.00	+07.42	+05.64
1700	+20.91	+07.37	+00.32	+00.00	+07.29	+05.64
1800	+20.87	+07.38	+00.32	+00.00	+07.44	+05.63
1900	+20.91	+07.35	+00.30	+00.00	+07.38	+05.63
2000	+20.87	+07.32	+00.32	+00.00	+07.35	+05.63
2100	+20.82	+07.37	+00.32	+00.00	+07.69	+05.63
2200	+20.78	+07.45	+00.34	+00.00	+07.94	+05.63
2300	+20.82	+07.44	+00.34	+00.00	+07.69	+05.63

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092590						
0000	+20.74	+07.46	+00.34	+00.00	+07.73	+05.63
0100	+20.70	+07.45	+00.34	+00.00	+07.77	+05.63
0200	+20.53	+07.43	+00.34	+00.00	+07.61	+05.63
0300	+20.32	+07.38	+00.32	+00.00	+07.55	+05.62
0400	+20.32	+07.33	+00.32	+00.00	+07.26	+05.62
0500	+20.19	+07.33	+00.30	+00.00	+07.14	+05.62
0600	+20.19	+07.31	+00.30	+00.00	+06.97	+05.62
0700	+20.19	+07.31	+00.30	+00.00	+07.21	+05.62
0800	+20.27	+07.32	+00.30	+00.00	+07.31	+05.62
0900	+20.40	+07.33	+00.32	+00.00	+07.45	+05.62
1000	+20.44	+07.35	+00.32	+00.00	+07.47	+05.62
1100	+20.57	+07.35	+00.30	+00.00	+07.41	+05.62
1200	+20.61	+07.36	+00.32	+00.00	+07.50	+05.62
1300	+20.70	+07.36	+00.32	+00.00	+07.60	+05.62
1400	+20.82	+07.36	+00.32	+00.00	+07.59	+05.62
1500	+20.95	+07.39	+00.32	+00.00	+07.82	+05.62
1600	+21.03	+07.42	+00.32	+00.00	+07.95	+05.62
1700	+20.99	+07.42	+00.32	+00.00	+07.93	+05.62
1800	+20.95	+07.43	+00.32	+00.00	+07.97	+05.62
1900	+20.95	+07.42	+00.34	+00.00	+07.92	+05.62
2000	+20.82	+07.37	+00.32	+00.00	+07.62	+05.61
2100	+20.78	+07.36	+00.32	+00.00	+07.65	+05.61
2200	+20.78	+07.41	+00.32	+00.00	+08.01	+05.61
2300	+20.82	+07.43	+00.34	+00.00	+08.00	+05.61
092690						
0000	+20.78	+07.44	+00.34	+00.00	+08.01	+05.61
0100	+20.63	+07.45	+00.34	+00.00	+08.09	+05.61
0200	+20.61	+07.44	+00.34	+00.00	+08.05	+05.61
0300	+20.49	+07.43	+00.34	+00.00	+08.01	+05.61
0400	+20.36	+07.43	+00.32	+00.00	+08.04	+05.61
0500	+20.23	+07.43	+00.32	+00.00	+08.05	+05.61
0600	+20.15	+07.43	+00.32	+00.00	+08.05	+05.60
0700	+20.06	+07.42	+00.32	+00.00	+07.90	+05.60
0800	+20.15	+07.42	+00.32	+00.00	+07.95	+05.60
0900	+20.27	+07.40	+00.32	+00.00	+07.90	+05.60
1000	+20.32	+07.40	+00.32	+00.00	+07.98	+05.60
1100	+20.40	+07.41	+00.32	+00.00	+08.01	+05.60
1200	+20.49	+07.42	+00.32	+00.00	+08.01	+05.60
1300	+20.53	+07.42	+00.32	+00.00	+07.95	+05.60
1400	+20.40	+07.43	+00.32	+00.00	+08.01	+05.60
1500	+20.57	+07.45	+00.34	+00.00	+08.09	+05.60
1600	+20.44	+07.46	+00.32	+00.00	+08.17	+05.60
1700	+20.49	+07.45	+00.32	+00.00	+08.13	+05.60
1800	+20.44	+07.47	+00.32	+00.00	+08.26	+05.60
1900	+20.36	+07.47	+00.32	+00.00	+08.02	+05.60
2000	+20.40	+07.44	+00.32	+00.00	+07.96	+05.60
2100	+20.44	+07.41	+00.32	+00.00	+07.71	+05.60
2200	+20.44	+07.38	+00.32	+00.00	+07.71	+05.60
2300	+20.36	+07.48	+00.32	+00.00	+08.17	+05.60

```
TIME      TEMP       PH        COND       SALIN       DO        BATTERY
HHMM      DEG C      UNITS     MS/CM      PPT      MG/L(PPM)    VOLTS
-----------------------------------------------------------------------
092790
0000     +20.40     +07.43    +00.34     +00.00     +07.86     +05.59
0100     +20.36     +07.43    +00.34     +00.00     +07.87     +05.59
0200     +20.32     +07.41    +00.32     +00.00     +07.76     +05.59
0300     +20.19     +07.44    +00.34     +00.00     +08.01     +05.59
0400     +20.06     +07.42    +00.32     +00.00     +07.73     +05.59
0500     +20.02     +07.40    +00.32     +00.00     +07.76     +05.59
0600     +19.89     +07.39    +00.32     +00.00     +07.62     +05.59
0700     +19.77     +07.39    +00.32     +00.00     +07.43     +05.59
0800     +19.73     +07.42    +00.32     +00.00     +07.47     +05.59
0900     +19.68     +07.43    +00.30     +00.00     +07.48     +05.59
1000     +19.98     +07.36    +00.32     +00.00     +07.43     +05.59
1100     +20.23     +07.32    +00.32     +00.00     +07.52     +05.59
1200     +20.40     +07.31    +00.32     +00.00     +07.33     +05.59
1300     +20.53     +07.32    +00.32     +00.00     +07.57     +05.59
1400     +20.19     +07.33    +00.32     +00.00     +07.48     +05.59
1500     +20.19     +07.33    +00.32     +00.00     +07.50     +05.59
1600     +20.65     +07.32    +00.32     +00.00     +07.39     +05.59
1700     +21.29     +07.46    +00.31     +00.00     +08.00     +05.59
1800     +21.75     +07.49    +00.31     +00.00     +08.12     +05.59
1900     +21.58     +07.48    +00.31     +00.00     +08.02     +05.59
2000     +21.46     +07.44    +00.31     +00.00     +07.87     +05.59
2100     +20.78     +07.36    +00.32     +00.00     +07.48     +05.59
2200     +20.44     +07.33    +00.32     +00.00     +07.37     +05.58
2300     +20.40     +07.35    +00.32     +00.00     +07.55     +05.58

092890
0000     +20.40     +07.38    +00.32     +00.00     +07.55     +05.58
0100     +20.44     +07.41    +00.34     +00.00     +07.66     +05.58
0200     +20.49     +07.41    +00.34     +00.00     +07.84     +05.58
0300     +20.44     +07.41    +00.34     +00.00     +07.71     +05.58
0400     +20.36     +07.40    +00.32     +00.00     +07.73     +05.58
0500     +20.40     +07.35    +00.32     +00.00     +07.48     +05.58
0600     +20.36     +07.33    +00.32     +00.00     +07.37     +05.58
0700     +20.23     +07.30    +00.32     +00.00     +07.08     +05.58
0800     +20.15     +07.29    +00.32     +00.00     +07.00     +05.58
0900     +20.23     +07.27    +00.32     +00.00     +07.08     +05.58
1000     +20.23     +07.26    +00.32     +00.00     +07.03     +05.58
1100     +20.40     +07.27    +00.32     +00.00     +07.21     +05.58
1200     +20.49     +07.31    +00.34     +00.00     +07.46     +05.58
1300     +20.40     +07.34    +00.34     +00.00     +07.53     +05.58
1400     +20.44     +07.35    +00.36     +00.00     +07.61     +05.57
1500     +20.49     +07.36    +00.43     +00.00     +07.67     +05.57
1600     +20.57     +07.35    +00.34     +00.00     +07.61     +05.57
1700     +21.03     +07.34    +00.34     +00.00     +07.73     +05.57
1800     +20.74     +07.32    +00.32     +00.00     +07.57     +05.57
1900     +20.61     +07.32    +00.32     +00.00     +07.48     +05.57
2000     +20.57     +07.31    +00.32     +00.00     +07.51     +05.57
2100     +20.53     +07.30    +00.32     +00.00     +07.45     +05.57
2200     +20.57     +07.30    +00.32     +00.00     +07.44     +05.57
2300     +20.74     +07.30    +00.32     +00.00     +07.54     +05.57
```

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092990						
0000	+20.61	+07.31	+00.38	+00.00	+07.59	+05.57
0100	+20.65	+07.37	+00.33	+00.00	+07.72	+05.57
0200	+20.65	+07.37	+00.45	+00.00	+07.85	+05.57
0300	+20.61	+07.38	+00.47	+00.00	+07.90	+05.57
0400	+20.61	+07.40	+00.45	+00.00	+07.90	+05.57
0500	+20.49	+07.36	+00.38	+00.00	+07.77	+05.57
0600	+20.40	+07.35	+00.34	+00.00	+07.74	+05.57
0700	+20.40	+07.33	+00.34	+00.00	+07.65	+05.57
0800	+20.32	+07.33	+00.32	+00.00	+07.62	+05.57
0900	+20.32	+07.33	+00.32	+00.00	+07.55	+05.56
1000	+20.36	+07.32	+00.32	+00.00	+07.44	+05.56
1100	+20.61	+07.31	+00.32	+00.00	+07.52	+05.56
1200	+20.82	+07.30	+00.34	+00.00	+07.52	+05.56
1300	+20.78	+07.31	+00.36	+00.00	+07.58	+05.56
1400	+20.74	+07.33	+00.38	+00.00	+07.68	+05.56
1500	+20.57	+07.33	+00.43	+00.00	+07.60	+05.56
1600	+20.61	+07.32	+00.42	+00.00	+07.59	+05.56
1700	+20.74	+07.31	+00.40	+00.00	+07.36	+05.56
1800	+20.99	+07.33	+00.36	+00.00	+07.72	+05.56
1900	+20.82	+07.33	+00.38	+00.00	+07.59	+05.56
2000	+20.74	+07.32	+00.38	+00.00	+07.56	+05.56
2100	+20.70	+07.32	+00.34	+00.00	+07.53	+05.56
2200	+20.74	+07.31	+00.38	+00.00	+07.45	+05.56
2300	+20.65	+07.30	+00.34	+00.00	+07.44	+05.56
093090						
0000	+20.61	+07.27	+00.32	+00.00	+07.31	+05.56
0100	+20.51	+07.27	+00.38	+00.00	+07.65	+05.56
0200	+20.65	+07.34	+00.45	+00.00	+07.77	+05.56
0300	+20.70	+07.36	+00.49	+00.00	+07.83	+05.56
0400	+20.65	+07.36	+00.59	+00.00	+07.79	+05.56
0500	+20.61	+07.36	+00.57	+00.00	+07.80	+05.56
0600	+20.61	+07.35	+00.49	+00.00	+07.81	+05.56
0700	+20.49	+07.35	+00.43	+00.00	+07.74	+05.56
0800	+20.44	+07.30	+00.34	+00.00	+07.47	+05.56
0900	+20.36	+07.29	+00.32	+00.00	+07.37	+05.55
1000	+20.44	+07.27	+00.34	+00.00	+07.35	+05.55
1100	+20.57	+07.27	+00.34	+00.00	+07.32	+05.55
1200	+20.82	+07.27	+00.32	+00.00	+07.30	+05.55
1300	+20.99	+07.30	+00.34	+00.00	+07.60	+05.55
1400	+20.95	+07.30	+00.40	+00.00	+07.66	+05.55
1500	+20.95	+07.35	+00.55	+00.00	+07.77	+05.55
1600	+20.99	+07.36	+00.63	+00.00	+07.90	+05.35
1700	+20.91	+07.37	+00.65	+00.00	+07.65	+05.55
1800	+21.03	+07.36	+00.63	+00.00	+07.87	+05.55
1900	+21.08	+07.35	+00.48	+00.00	+07.77	+05.55
2000	+20.99	+07.35	+00.44	+00.00	+07.72	+05.55
2100	+20.99	+07.36	+00.40	+00.00	+07.79	+05.55
2200	+20.99	+07.41	+00.36	+00.00	[illegible]	+05.55
2300	+20.95	+07.46	+00.36	+00.00	+08.13	+05.55

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
100190						
0000	+20.87	+07.37	+00.36	+00.00	+07.65	+05.55
0100	+20.82	+07.32	+00.36	+00.00	+07.52	+05.55
0200	+20.74	+07.30	+00.40	+00.00	+07.49	+05.55
0300	+20.79	+07.36	+00.49	+00.00	+07.77	+05.55
0400	+20.74	+07.36	+00.53	+00.00	+07.68	+05.55
0500	+20.70	+07.36	+00.76	+00.00	+07.73	+05.55
0600	+20.65	+07.37	+00.74	+00.00	+07.79	+05.55
0700	+20.57	+07.36	+00.49	+00.00	+07.63	+05.55
0800	+20.40	+07.35	+00.41	+00.00	+07.50	+05.55
0900	+20.36	+07.31	+00.36	+00.00	+07.41	+05.54
1000	+20.32	+07.30	+00.34	+00.00	+07.47	+05.54
1100	[illegible]	[illegible]	+00.34	+00.00	+07.48	+05.54
1200	[illegible]	[illegible]	[illegible]	+00.00	+07.44	[illegible]
1300	+20.91	+07.35	+00.34	+00.00	+07.36	+05.54
1400	+21.20	+07.32	+00.34	+00.00	+07.37	+05.54
1500	+21.42	+07.33	+00.35	+00.00	+07.74	+05.54
1600	+21.25	+07.39	+00.42	+00.00	+08.05	+05.55
1700	+20.99	+07.36	+00.40	+00.00	+07.69	+05.54
1800	+21.08	+07.33	+00.48	+00.00	+07.77	+05.54
1900	+21.03	+07.35	+00.44	+00.00	+07.85	+05.54
2000	+21.03	+07.36	+00.42	+00.00	+07.92	+05.54
2100	+21.16	+07.37	+00.38	+00.00	+07.96	+05.54
2200	+20.91	+07.33	+00.36	+00.00	+07.71	+05.54
2300	+20.74	+07.32	+00.36	+00.00	+07.66	+05.54
100290						
0000	+20.57	+07.33	[illegible]	[illegible]	[illegible]	+05.54
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+05.54
0200	+20.70	+07.32	+00.49	+00.00	+07.67	+05.54
0300	+20.78	+07.36	+00.55	+00.00	+07.79	+05.54
0400	+20.78	+07.36	+00.78	+00.00	+07.81	+05.54
0500	+20.74	+07.38	+00.95	+00.00	+07.83	+05.54
0600	+20.78	+07.36	+01.10	+00.09	+07.82	+05.54
0700	+20.61	+07.36	+00.89	+00.00	+07.77	+05.54
0800	+20.44	+07.35	+00.55	+00.00	+07.73	+05.54
0900	+20.23	+07.34	+00.47	+00.00	+07.61	+05.53
1000	+20.11	+07.37	+00.39	+00.00	[illegible]	[illegible]
1100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

pH10 post-cal.

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STATION ID : [illegible]

TIME      TEMP      PH        COND      SALIN        DO        BATTERY
HHMM      DEG C     UNITS     MS/CM     PPT      MG/L(PPM)    VOLTS
------------------------------------------------------------------------
092390
1030     +20.44    +07.40    +00.29    +00.00    +08.13      +05.84
1130     +20.57    +07.26    +00.29    +00.00    +07.98      +05.83
1230     +20.74    +07.34    +00.29    +00.00    +08.28      +05.83
1330     +20.87    +07.66    +00.29    +00.00    +09.14      +05.82
1430     +20.99    +07.79    +00.31    +00.00    +09.74      +05.82
1530     +20.99    +07.76    +00.31    +00.00    +09.77      +05.82
1630     +21.08    +07.88    +00.31    +00.00    +09.68      +05.82
1730     +21.20    +08.01    +00.28    +00.00    +10.06      +05.82
1830     +21.08    +07.86    +00.28    +00.00    +09.85      +05.82
1930     +20.87    +07.69    +00.29    +00.00    +09.53      +05.81
2030     +20.74    +07.41    +00.29    +00.00    [illegible] +05.81
2130     +20.57    +07.47    +00.29    +00.00    +08.60      +05.81
2230     +20.49    +07.37    +00.27    +00.00    +08.43      +05.80
2330     +20.36    +07.73    +00.29    +00.00    +08.78      +05.80

092490
0030     +20.19    +07.63    +00.29    +00.00    +09.16      +05.80
0130     +19.98    +07.30    +00.29    +00.00    +08.39      +05.80
0230     +19.77    +07.34    +00.29    +00.00    +08.39      +05.80
0330     +19.56    +07.36    +00.29    +00.00    +08.36      +05.79
0430     +19.18    +07.34    +00.30    +00.00    +08.46      +05.79
0530     +19.13    +07.35    +00.30    +00.00    +08.32      +05.79
0630     +19.18    +07.44    +00.30    +00.00    +08.49      +05.78
0730     +18.92    +07.30    +00.30    +00.00    +08.35      +05.78
0830     +18.88    +07.62    +00.28    +00.00    +08.42      +05.78
0930     +18.84    +08.16    +00.28    +00.00    [illegible] +05.78
1030     +18.88    +08.23    +00.28    +00.00    +08.51      +05.78
1130     +18.97    +08.10    +00.28    +00.00    +08.67      +05.78
1230     +19.22    +07.93    +00.30    +00.00    +09.15      +05.77
1330     +19.68    +07.61    +00.29    +00.00    +09.22      +05.77
1430     +20.02    +07.38    +00.29    +00.00    +09.70      +05.77
1530     +20.19    +07.88    +00.31    +00.00    +09.96      +05.78
1630     +20.23    +08.03    +00.29    +00.00    +10.06      +05.77
1730     +20.49    +07.76    +00.29    +00.00    +09.98      +05.77
1830     +20.23    +08.03    +00.29    +00.00    +09.69      +05.77
1930     +20.06    +07.72    +00.29    +00.00    +09.31      +05.77
2030     +20.02    +08.77    +00.27    +00.00    +09.33      +05.77
2130     +19.56    +08.97    +00.27    +00.00    +10.45      +05.77
2230     +19.56    +08.73    +00.27    +00.00    +09.38      +05.76
2330     +19.47    +08.68    +00.27    +00.00    +09.32      +05.76
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TIME      TEMP       PH        COND       SALIN       DO        BATTERY
HHMM      DEG C      UNITS     MS/CM      PPT      MG/L(PPM)    VOLTS
-----------------------------------------------------------------------
092590
0030     +19.60     +08.39     +00.27     +00.00     +09.36     +05.75
0130     +19.43     +08.32     +00.27     +00.00     +09.59     +05.76
0230     +19.35     +07.40     +00.30     +00.00     +08.41     +05.76
0330     +18.97     +07.40     +00.28     +00.00     +08.58     +05.76
0430     +18.75     +07.40     +00.28     +00.00     +08.69     +05.75
0530     +18.59     +07.46     +00.30     +00.00     +08.63     +05.75
0630     +18.50     +07.53     +00.28     +00.00     +08.58     +05.75
0730     +18.75     +08.13     +00.28     +00.00     +08.96     +05.75
0830     +18.59     +07.27     +00.28     +00.00     +08.20     +05.75
0930     +18.63     +07.20     +00.28     +00.00     +07.98     +05.75
1030     +18.75     +07.66     +00.28     +00.00     +08.01     +05.75
1130     +19.75     +08.22     +00.28     +00.00     +08.67     +05.75
1230     +19.42     +08.[illegible]  +00.28     +00.00     +09.12     [illegible]
1330     +19.43     +07.71     +00.27     +00.00     +09.12     +05.75
1430     +19.77     +07.50     +00.29     +00.00     +08.94     +05.75
1530     +20.15     +07.52     +00.29     +00.00     +09.06     +05.75
1630     +20.49     +07.70     +00.29     +00.00     +09.47     +05.75
1730     +20.65     +07.73     +00.29     +00.00     +09.34     +05.75
1830     +20.44     +07.54     +00.29     +00.00     +09.17     +05.75
1930     +20.36     +07.57     +00.29     +00.00     +08.29     +05.75
2030     +20.44     +07.34     +00.29     +00.00     +08.10     +05.75
2130     +20.49     +08.49     +00.29     +00.00     +10.63     +05.75
2230     +20.49     +07.42     +00.29     +00.00     +08.71     +05.75
2330     +20.19     +08.43     +00.29     +00.00     +09.79     +05.75

092690
0030     +20.11     +07.74     +00.29     +00.00     +08.93     +05.74
0130     +19.81     +07.34     +00.27     +00.00     +08.33     +05.74
0230     +19.77     +07.29     +00.29     +00.00     +08.16     +05.74
0330     +19.51     +07.27     +00.29     +00.00     +08.08     +05.74
0430     +19.35     +07.34     +00.27     +00.00     +08.06     +05.74
0530     +19.22     +07.26     +00.28     +00.00     +08.10     +05.74
0630     +19.13     +07.35     +00.30     +00.00     +08.32     +05.73
0730     +19.26     +07.26     +00.30     +00.00     +08.02     +05.73
0830     +19.26     +07.17     +00.32     +00.00     +07.76     +05.73
0930     +19.05     +07.25     +00.30     +00.00     +07.61     +05.73
1030     +19.01     +07.27     +00.30     +00.00     +07.65     +05.73
1130     +19.13     +07.49     +00.30     +00.00     +07.94     +05.73
1230     +19.26     +07.46     +00.30     +00.00     +08.38     +05.73
1330     +19.47     +07.26     +00.29     +00.00     +08.09     +05.73
1430     +19.77     +07.31     +00.31     +00.00     +08.42     +05.73
1530     +20.06     +07.35     +00.31     +00.00     +09.03     +05.73
1630     +19.94     +07.59     +00.31     +00.00     +09.32     +05.73
1730     +20.02     +07.79     +00.31     +00.00     +09.37     +05.73
1830     +19.94     +07.91     +00.31     +00.00     +09.93     +05.73
1930     +19.73     +08.15     +00.31     +00.00     +10.46     +05.73
2030     +19.74     +07.44     +00.31     +00.00     +08.92     +05.73
[illegible]  [illegible]  [illegible]  [illegible]  [illegible]  +08.65     +05.73
[illegible]  [illegible]  [illegible]  +00.29     +00.00     +08.34     +05.73
[illegible]  +19.64     +07.34     +00.29     +00.00     +08.22     +05.73
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TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092790						
0030	+19.60	+07.38	+00.27	+00.00	-08.40	+05.72
0130	+19.51	-07.50	+00.32	+00.00	-08.63	+05.73
0230	+19.51	+07.21	+00.29	+00.00	+08.25	+05.72
0330	+19.22	+07.29	+00.30	+00.00	+08.39	+05.72
0430	+18.97	+07.47	+00.30	+00.00	+08.93	+05.72
0530	+18.88	+07.48	+00.32	+00.00	-09.04	+05.72
0630	+18.71	+07.23	+00.32	+00.00	+08.56	+05.72
0730	+18.59	+07.22	+00.34	+00.00	+08.44	+05.72
0830	+18.63	-07.25	+00.32	+00.00	+08.31	+05.72
0930	+18.71	+07.36	+00.32	+00.00	+08.64	+05.71
1030	+19.01	+07.39	+00.30	+00.00	+08.62	+05.71
1130	+19.22	-07.58	+00.30	+00.00	+08.86	+05.71
1230	-19.43	+08.00	+00.30	+00.00	-08.83	+05.71
1330	+19.43	+07.83	+00.30	+00.00	+08.87	+05.71
1430	+19.39	-07.77	+00.32	+00.00	+09.15	+05.71
1530	+19.56	+07.35	+00.32	+00.00	-10.02	-05.71
1630	+19.77	+07.95	+00.31	+00.00	+10.12	-05.71
1730	+20.53	+08.10	+00.31	+00.00	+10.84	+05.71
1830	+21.03	+08.13	+00.33	+00.00	+10.95	+05.72
1930	+21.12	+08.11	+00.33	+00.00	+10.87	+05.72
2030	+21.12	+08.01	+00.33	+00.00	+10.59	+05.72
2130	+20.32	+07.90	+00.31	+00.00	+09.78	+05.72
2230	+20.27	+07.43	+00.31	+00.00	+08.65	+05.71
2330	+20.27	+07.35	+00.29	+00.00	+08.14	+05.71
092890						
0030	+20.36	+07.31	+00.29	+00.00	+07.84	+05.71
0130	+20.27	+07.25	+00.29	-00.00	+07.74	-05.71
0230	+20.33	+07.60	+00.31	+00.00	+08.58	+05.71
0330	+19.98	+07.41	+00.31	+00.00	+08.53	+05.71
0430	+19.98	+07.41	+00.31	+00.00	+08.56	+05.71
0530	+19.98	+07.56	+00.31	+00.00	-09.02	+05.71
0630	+20.15	-07.55	+00.31	+00.00	+09.14	+05.71
0730	+20.11	+07.58	+00.33	+00.00	+09.44	+05.71
0830	+20.02	+07.53	+00.31	+00.00	+08.95	+05.71
0930	+20.02	+07.69	+00.31	+00.00	+09.21	+05.71
1030	+19.94	+07.41	+00.31	+00.00	-08.60	+05.71
1130	+20.15	+07.37	+00.31	+00.00	-08.49	+05.71
1230	+20.36	+07.27	+00.31	+00.00	-08.12	+05.70
1330	+20.49	+07.24	+00.31	+00.00	-07.86	-05.70
1430	+20.40	+07.27	+00.31	+00.00	+07.77	-05.70
1530	+20.57	+07.63	+00.31	+00.00	-09.14	+05.71
1630	+20.87	+07.65	+00.31	+00.00	+09.22	+05.71
1730	+21.12	-07.91	+00.30	+00.00	+10.03	+05.70
1830	+21.33	+08.04	+00.30	+00.00	+10.52	+05.71
1930	+21.46	+08.12	+00.30	+00.00	+10.67	+05.71
2030	+21.46	+08.04	+00.30	+00.00	+10.42	+05.71
2130	-21.42	+08.13	+00.30	+00.00	+10.60	+05.71
2230	+20.95	-07.79	+00.31	+00.00	-09.53	+05.71
2330	+20.95	-07.71	+00.31	-00.00	+09.53	+05.70

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092990						
0030	+20.87	+07.86	+00.31	+00.00	+09.58	+05.70
0130	+20.78	+07.43	+00.31	+00.00	+08.71	+05.70
0230	+20.61	+07.24	+00.31	+00.00	+07.91	+05.70
0330	+20.70	+07.33	+00.31	+00.00	+08.09	+05.70
0430	+20.70	+07.61	+00.31	+00.00	+09.16	+05.70
0530	+20.70	+07.34	+00.31	+00.00	+08.60	+05.70
0630	+20.65	+07.39	+00.31	+00.00	+08.69	+05.70
0730	+20.61	+07.62	+00.31	+00.00	+09.10	+05.70
0830	+20.65	+07.61	+00.31	+00.00	+09.28	+05.70
0930	+20.57	+07.61	+00.31	+00.00	+09.17	+05.69
1030	+20.40	+07.38	+00.31	+00.00	+08.85	+05.70
1130	+20.70	+07.37	+00.31	+00.00	+08.68	+05.69
1230	+20.78	[illegible]	+00.31	+00.00	[illegible]	[illegible]
1330	+20.91	+07.51	+00.31	+00.00	+07.95	+05.69
1430	+20.99	+07.36	+00.31	+00.00	+07.82	+05.70
1530	+21.03	+07.29	+00.31	+00.00	+07.75	+05.69
1630	+21.12	+07.55	+00.30	+00.00	+08.48	+05.70
1730	+21.25	+07.40	+00.30	+00.00	+08.45	+05.70
1830	+21.42	+07.36	+00.30	+00.00	+08.60	+05.69
1930	+21.46	+07.44	+00.30	+00.00	+09.11	+05.69
2030	+21.58	+07.73	+00.32	+00.00	+09.75	+05.69
2130	+21.58	+07.45	+00.32	+00.00	+09.48	+05.69
2230	+21.50	+07.60	+00.32	+00.00	+09.56	+05.70
2330	+21.20	+07.34	+00.30	+00.00	+08.57	+05.69
093090						
0030	+20.99	+07.28	+00.31	+00.00	+08.13	+05.69
0130	+20.91	+07.76	+00.31	+00.00	+08.43	+05.69
0230	+20.87	+07.71	+00.31	+00.00	+08.32	+05.69
0330	+20.74	+07.94	+00.31	+00.00	+08.58	+05.69
0430	+20.82	+07.52	+00.31	+00.00	+08.31	+05.69
0530	+20.87	+07.57	+00.31	+00.00	+08.61	+05.69
0630	+20.87	+07.19	+00.31	+00.00	+07.93	+05.69
0730	+20.78	+07.19	+00.29	+00.00	+07.90	+05.69
0830	+20.87	+07.28	+00.31	+00.00	+08.21	+05.69
0930	+20.95	+07.22	+00.33	+00.00	+08.28	+05.69
1030	+20.93	+07.26	+00.33	+00.00	+08.42	+05.69
1130	+20.95	+07.46	+00.31	+00.00	+08.33	+05.69
1230	+21.20	+07.25	+00.30	+00.00	+08.10	+05.69
1330	+21.25	+07.44	+00.30	+00.00	+07.65	+05.69
1430	+21.42	+07.30	+00.30	+00.00	+07.53	+05.69
1530	+21.42	+07.45	+00.30	+00.00	+07.55	+05.69
1630	+21.46	+07.37	+00.30	+00.00	+07.79	+05.69
1730	+21.75	+07.52	+00.32	+00.00	+08.04	+05.69
1830	+21.67	+07.35	+00.30	+00.00	+08.09	+05.69
1930	+21.63	+07.22	+00.30	+00.00	+08.02	+05.69
2030	+21.71	+07.34	+00.30	+00.00	+08.44	+05.69
2130	+21.63	+07.32	+00.32	+00.00	+08.57	+05.69
2230	+21.63	+07.30	+00.32	+00.00	+08.38	+05.69
2330	+21.42	+07.35	+00.32	+00.00	+08.38	+05.68

	TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
	100190						
	0030	+21.25	+07.42	-00.30	-00.00	+07.81	+05.68
	0130	+21.16	+07.13	-00.30	+00.00	+07.64	+05.68
	0230	+20.99	+07.15	+00.31	+00.00	+07.43	+05.68
	0330	+20.78	+07.59	+00.31	+00.00	+07.79	+05.68
	0430	+20.82	+07.21	+00.31	+00.00	+07.39	-05.68
	0530	+20.70	+07.26	+00.31	+00.00	+07.53	+05.68
	0630	+20.53	+07.35	+00.31	+00.00	+07.77	+05.68
	0730	+20.32	+07.12	+00.31	+00.00	+07.50	+05.68
	0830	+20.15	+07.17	+00.31	+00.00	+07.72	+05.67
	0930	+20.19	+07.22	+00.31	+00.00	+07.85	+05.67
	1030	+20.49	+07.01	+00.39	+00.00	+07.60	+05.67
	1130	+20.57	-07.09	-00.37	+00.00	+07.38	+05.67
	1230	+20.57	+07.16	+00.37	+00.00	+07.[illegible]	+05.67
	1330	+21.03	+07.34	-00.31	+00.00	+07.78	+05.66
	1430	+21.33	+07.27	+00.30	+00.00	+07.99	+05.67
	1530	+21.42	+07.38	+00.30	+00.00	+07.77	+05.68
	1630	+21.29	+07.83	+00.30	+00.00	+07.72	+05.68
	1730	+21.16	+07.60	+00.30	+00.00	+07.71	+05.67
	1830	+21.20	+07.51	+00.30	+00.00	+07.63	+05.67
	1930	+21.33	+07.37	+00.30	+00.00	+08.10	+05.67
	2030	+21.25	+07.49	+00.30	+00.00	+08.48	+05.67
	2130	+21.03	+07.42	+00.31	+00.00	+08.62	+05.67
	2230	+21.03	+07.43	+00.33	+00.00	+08.81	+05.67
	2330	+20.99	+07.41	+00.33	+00.00	+08.63	+05.67
	100290						
	0030	+20.74	+07.37	+00.31	+00.00	+08.12	+05.67
	0130	-20.49	-07.33	+00.31	-00.00	-07.30	-05.67
	0230	+20.19	+07.34	+00.31	+00.00	+07.48	+05.67
	0330	+20.06	+07.32	+00.31	+00.00	-07.31	+05.67
	0430	+19.89	+07.53	+00.29	+00.00	+07.52	+05.67
	0530	+20.11	+07.32	+00.29	+00.00	+07.36	+05.66
	0630	+19.87	+07.23	+00.29	+00.00	+07.40	+05.66
	0730	+19.85	+07.26	+00.29	+00.00	+07.70	+05.66
	0830	+19.77	+07.28	+00.31	+00.00	+07.95	+05.66
	0930	+19.81	+07.35	+00.31	+00.00	+08.26	+05.66
	~~1030~~	~~+17.96~~	~~+07.41~~	~~+00.32~~	~~+00.00~~	[illegible]	~~+05.66~~
+7 post-cal	1130	+20.32	+07.07	+07.40	-03.77	+08.39	+05.66
+10 post-cal	1230	-20.44	-10.05	[illegible]	+08.67	+08.47	+05.67

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STATION ID : I4

TIME      TEMP      PH        COND      SALIN       DO         BATTERY
HHMM      DEG C     UNITS     MS/CM     PPT     MG/L(PPM)     VOLTS
------------------------------------------------------------------------
092390
1000      +21.29    +07.04    +00.31    +00.00    +07.68    +05.73
1100      +21.33    +07.09    +00.31    +00.00    +06.76    +05.72
1200      +21.54    +07.09    +00.31    +00.00    +06.97    +05.71
1300      +21.37    +07.10    +00.31    +00.00    +07.04    +05.71
1400      +21.42    +07.08    +00.31    +00.00    +06.89    +05.71
1500      +21.46    +07.08    +00.31    +00.00    +06.95    +05.71
1600      +21.50    +07.10    +00.31    +00.00    +07.09    +05.71
1700      +21.54    +07.13    +00.33    +00.00    +07.37    +05.71
1800      +21.43    +07.12    +00.31    +00.00    +07.25    +05.71
1900      +21.35    +07.12    +00.33    +00.00    +07.13    +05.70
2000      +21.22    +07.13    +00.31    +00.00    +07.27    +05.70
2100      +21.15    +07.13    +00.31    +00.00    +07.27    +05.70
2200      +21.03    +07.14    +00.31    +00.00    +07.34    +05.70
2300      +21.03    +07.13    +00.31    +00.00    +07.37    +05.70

092490
0000      +20.91    +07.15    +00.31    +00.00    +07.40    +05.70
0100      +20.65    +07.16    +00.31    +00.00    +07.50    +05.69
0200      +20.82    +07.12    +00.31    +00.00    +07.31    +05.69
0300      +20.65    +07.11    +00.31    +00.00    +07.28    +05.69
0400      +20.61    +07.10    +00.31    +00.00    +07.25    +05.69
0500      +20.61    +07.10    +00.31    +00.00    +07.25    +05.69
0600      +20.32    +07.12    +00.31    +00.00    +07.39    +05.69
0700      +20.15    +07.12    +00.32    +00.00    +07.32    +05.69
0800      +20.27    +07.10    +00.31    +00.00    +07.25    +05.69
0900      +20.27    +07.11    +00.31    +00.00    +07.29    +05.69
1000      +20.27    +07.12    +00.31    +00.00    +07.36    +05.69
1100      +20.36    +07.13    +00.31    +00.00    +07.42    +05.69
1200      +20.53    +07.13    +00.31    +00.00    +07.53    +05.68
1300      +20.70    +07.13    +00.33    +00.00    +07.53    +05.68
1400      +20.82    +07.14    +00.31    +00.00    +07.65    +05.68
1500      +20.91    +07.13    +00.31    +00.00    +07.44    +05.68
1600      +20.70    +07.10    +00.31    +00.00    +07.38    +05.68
1700      +20.70    +07.09    +00.31    +00.00    +07.27    +05.67
1800      +20.82    +07.10    +00.31    +00.00    +07.39    +05.67
1900      +20.91    +07.14    +00.33    +00.00    +07.55    +05.67
2000      +20.78    +07.10    +00.31    +00.00    +07.47    +05.67
2100      +20.70    +07.12    +00.31    +00.00    +07.49    +05.67
2200      +20.65    +07.11    +00.31    +00.00    +07.43    +05.67
2300      +20.61    +07.13    +00.31    +00.00    +07.51    +05.67
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TIME    TEMP        PH        COND       SALIN       DO        BATTERY
HHMM     DEG C     UNITS      MS/CM        PPT    MG/L(PPM)    VOLTS
-----------------------------------------------------------------------
092590
0000     +20.36    +07.16    +00.31     +00.00    +07.61     +05.67
0100     +20.36    +07.15    +00.31     +00.00    +07.57     +05.67
0200     +20.40    +07.14    +00.31     +00.00    +07.56     +05.67
0300     +20.53    +07.09    +00.33     +00.00    +07.30     +05.67
0400     +20.44    +07.09    +00.33     +00.00    +07.21     +05.67
0500     +20.36    +07.10    +00.31     +00.00    +07.23     +05.67
0600     +20.23    +07.10    +00.32     +00.00    +07.18     +05.67
0700     +20.15    +07.10    +00.32     +00.00    +07.20     +05.67
0800     +20.15    +07.09    +00.32     +00.00    +07.20     +05.67
0900     +20.15    +07.08    +00.32     +00.00    +07.17     +05.67
1000     +20.15    +07.10    +00.32     +00.00    +07.24     +05.67
1100     +20.23    +07.09    +00.32     +00.00    +07.22     +05.66
1200     +20.27    +07.14    +00.32     +00.00    +07.19     +05.66
1300     +20.27    +07.14    +00.31     +00.00    +07.55     +05.66
1400     +20.53    +07.14    +00.33     +00.00    +07.60     +05.66
1500     +20.70    +07.12    +00.31     +00.00    +07.53     +05.66
1600     +20.44    +07.08    +00.31     +00.00    +07.25     +05.66
1700     +20.44    +07.08    +00.33     +00.00    +07.25     +05.66
1800     +20.44    +07.07    +00.33     +00.00    +07.25     +05.66
1900     +20.53    +07.10    +00.31     +00.00    +07.38     +05.66
2000     +20.44    +07.10    +00.33     +00.00    +07.29     +05.66
2100     +20.44    +07.10    +00.33     +00.00    +07.40     +05.66
2200     +20.40    +07.09    +00.31     +00.00    +07.33     +05.65
2300     +20.44    +07.10    +00.33     +00.00    +07.40     +05.65

092690
0000     +20.36    +07.10    +00.31     +00.00    +07.34     +05.65
0100     +20.27    [illegible] +00.31   +00.00    +07.36     +05.65
0200     +20.27    +07.12    +00.31     +00.00    +07.44     +05.65
0300     +20.23    +07.09    +00.32     +00.00    +07.37     +05.65
0400     +20.23    +07.08    +00.32     +00.00    +07.34     +05.65
0500     +20.19    +07.09    +00.32     +00.00    +07.35     +05.65
0600     +20.06    +07.08    +00.32     +00.00    +07.26     +05.65
0700     +20.02    +07.08    +00.32     +00.00    +07.23     +05.65
0800     +20.06    +07.07    +00.32     +00.00    +07.18     +05.65
0900     +20.02    +07.08    +00.32     +00.00    +07.27     +05.65
1000     +20.02    +07.09    +00.32     +00.00    +07.31     +05.65
1100     +20.02    +07.09    +00.32     +00.00    +07.35     +05.65
1200     +20.06    +07.08    +00.34     +00.00    +07.30     +05.65
1300     +20.19    +07.10    +00.32     +00.00    +07.46     +05.65
1400     +20.23    +07.11    +00.33     +00.00    +07.45     +05.64
1500     +20.19    +07.14    +00.32     +00.00    +07.69     +05.65
1600     +20.36    +07.12    +00.33     +00.00    +07.64     +05.64
1700     +20.27    +07.08    +00.33     +00.00    +07.36     +05.64
1800     +20.23    +07.07    +00.33     +00.00    +07.34     +05.64
1900     +20.23    +07.03    +00.33     +00.00    +07.22     +05.64
2000     +20.27    +07.04    +00.31     +00.00    +07.33     +05.64
2100     +20.27    +07.12    +00.31     +00.00    +07.31     +05.64
2200     +20.19    +07.12    +00.32     +00.00    +07.53     +05.64
2300     +20.23    +07.12    +00.33     +00.00    +07.52     +05.64
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TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092790						
0000	+20.15	+07.12	+00.32	+00.00	+07.47	+05.64
0100	+20.19	+07.09	+00.32	+00.00	+07.42	+05.64
0200	+20.15	+07.12	+00.34	+00.00	+07.43	+05.64
0300	+20.06	+07.12	+00.32	+00.00	+07.56	+05.63
0400	+20.02	+07.12	+00.32	+00.00	+07.61	+05.64
0500	+20.02	+07.06	+00.32	+00.00	+07.46	+05.64
0600	+20.02	+07.06	+00.32	+00.00	+07.35	+05.63
0700	+19.94	+07.06	+00.32	+00.00	+07.25	+05.63
0800	+19.89	+07.06	+00.32	+00.00	+07.26	+05.63
0900	+19.81	+07.07	+00.32	+00.00	+07.32	+05.63
1000	+19.39	+07.10	+00.32	+00.00	+07.45	+05.62
1100	+20.02	+07.11	+00.32	+00.00	+07.47	+05.62
1200	+20.36	+07.11	+00.33	+00.00	[illegible]	+05.62
1300	+20.49	+07.13	+00.31	+00.00	+07.88	+05.62
1400	+21.19	+07.20	+00.31	+00.00	+08.01	+05.63
1500	+21.57	+07.24	+00.32	+00.00	+08.13	+05.63
1600	+20.70	+07.12	+00.33	+00.00	+07.79	+05.63
1700	+20.23	+07.11	+00.32	+00.00	+07.52	+05.62
1800	+20.15	+07.08	+00.32	+00.00	+07.36	+05.62
1900	+20.06	+07.09	+00.32	+00.00	+07.41	+05.62
2000	+20.11	+07.08	+00.32	+00.00	+07.40	+05.62
2100	+20.06	+07.07	+00.32	+00.00	+07.22	+05.62
2200	+20.27	+07.08	+00.31	+00.00	+07.17	+05.62
2300	+20.44	+07.11	+00.31	+00.00	+07.51	+05.62
092890						
0000	+20.27	+07.13	+00.31	+00.00	+07.55	+05.62
0100	+20.11	+07.11	+00.32	+00.00	+07.33	+05.62
0200	+20.32	+07.22	+00.32	+00.00	+08.03	+05.62
0300	+20.02	+07.20	+00.32	+00.00	+07.92	+05.62
0400	+20.19	+07.11	+00.32	+00.00	+07.65	+05.62
0500	+20.36	+07.17	+00.31	+00.00	+07.95	+05.62
0600	+20.19	+07.10	+00.32	+00.00	+07.72	+05.62
0700	+20.23	+07.10	+00.32	+00.00	+07.68	+05.62
0800	+20.11	+07.10	+00.32	+00.00	+07.40	+05.62
0900	+20.06	+07.09	+00.34	+00.00	+07.41	+05.62
1000	+20.11	+07.08	+00.32	+00.00	+07.25	+05.62
1100	+20.19	+07.11	+00.32	+00.00	+07.42	+05.62
1200	+20.27	+07.12	+00.31	+00.00	+07.59	+05.62
1300	+20.53	+07.13	+00.31	+00.00	+07.90	+05.62
1400	+20.74	+07.23	+00.33	+00.00	+08.34	+05.62
1500	+22.05	+07.32	+00.30	+00.00	+08.75	+05.62
1600	+21.75	+07.33	+00.30	+00.00	+08.87	+05.62
1700	+20.70	+07.13	+00.29	+00.00	+08.15	+05.62
1800	+20.27	+07.08	+00.31	+00.00	+07.51	+05.62
1900	+20.32	+07.11	+00.33	+00.00	+07.66	+05.62
2000	+20.23	+07.07	+00.32	+00.00	+07.41	+05.61
2100	+20.15	+07.06	+00.32	+00.00	+07.32	+05.61
2200	+20.36	+07.08	+00.31	+00.00	+07.46	+05.61
2300	+20.27	+07.08	+00.31	+00.00	+07.48	+05.61

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS
092990						
0000	+20.49	+07.13	+00.31	+00.00	+07.53	+05.61
0100	+20.49	+07.11	+00.31	+00.00	+07.65	+05.61
0200	+20.57	+07.14	+00.31	+00.00	+07.74	+05.61
0300	+20.49	+07.16	+00.31	+00.00	+07.88	+05.61
0400	+20.49	+07.15	+00.31	+00.00	+07.84	+05.61
0500	+20.44	+07.12	+00.31	+00.00	+07.70	+05.61
0600	+20.32	+07.11	+00.33	+00.00	+07.62	+05.61
0700	+20.32	+07.09	+00.33	+00.00	+07.69	+05.61
0800	+20.32	+07.08	+00.31	+00.00	+07.54	+05.61
0900	+20.27	+07.08	+00.33	+00.00	+07.59	+05.61
1000	+20.23	+07.08	+00.32	+00.00	+07.52	+05.61
1100	+20.32	+07.08	+00.31	+00.00	+07.43	+05.61
1200	+20.40	+07.17	+00.31	+00.00	+07.43	+05.61
1300	+20.91	+07.18	+00.31	+00.00	+08.14	+05.60
1400	+20.91	+07.17	+00.33	+00.00	+08.23	+05.61
1500	+20.95	+07.17	+00.31	+00.00	+08.13	+05.61
1600	+20.82	+07.16	+00.33	+00.00	+08.05	+05.61
1700	+20.99	+07.19	+00.33	+00.00	+08.34	+05.61
1800	+21.12	+07.20	+00.33	+00.00	+08.42	+05.61
1900	+20.78	+07.13	+00.31	+00.00	+07.84	+05.61
2000	+20.53	+07.09	+00.31	+00.00	+07.72	+05.60
2100	+20.44	+07.07	+00.31	+00.00	+07.55	+05.60
2200	+20.53	+07.08	+00.31	+00.00	+07.57	+05.60
2300	+20.49	+07.07	+00.31	+00.00	+07.58	+05.60
093090						
0000	+20.53	+07.09	+00.31	+00.00	+07.60	+05.60
0100	+20.57	+07.09	+00.31	+00.00	+07.73	+05.60
0200	+20.65	+07.11	+00.31	+00.00	+07.76	+05.60
0300	+20.73	+07.15	+00.29	+00.00	+07.95	+05.60
0400	+20.78	+07.17	+00.31	+00.00	+07.99	+05.60
0500	+20.74	+07.22	+00.31	+00.00	+08.26	+05.60
0600	+20.74	+07.14	+00.31	+00.00	+07.89	+05.60
0700	+20.49	+07.08	+00.29	+00.00	+07.65	+05.60
0800	+20.49	+07.09	+00.31	+00.00	+07.69	+05.60
0900	+20.44	+07.09	+00.31	+00.00	+07.70	+05.60
1000	+20.36	+07.08	+00.31	+00.00	+07.65	+05.60
1100	+20.49	+07.07	+00.31	+00.00	+07.62	+05.60
1200	+20.61	+07.10	+00.31	+00.00	+07.73	+05.60
1300	+20.95	+07.15	+00.33	+00.00	+08.17	+05.60
1400	+21.16	+07.18	+00.33	+00.00	+08.34	+05.60
1500	+21.08	+07.17	+00.31	+00.00	+08.25	+05.60
1600	+21.03	+07.17	+00.31	+00.00	+08.11	+05.60
1700	+21.08	+07.19	+00.29	+00.00	+08.25	+05.60
1800	+21.08	+07.17	+00.31	+00.00	+08.17	+05.60
1900	+20.82	+07.12	+00.33	+00.00	+08.05	+05.60
2000	+20.82	+07.13	+00.33	+00.00	+08.02	+05.60
2100	+20.78	+07.14	+00.33	+00.00	+08.06	+05.59
2200	+20.78	+07.12	+00.33	+00.00	+08.03	+05.59
2300	+20.79	+07.14	+00.33	+00.00	+08.06	+05.59

TIME HHMM	TEMP DEG C	PH UNITS	COND MS/CM	SALIN PPT	DO MG/L(PPM)	BATTERY VOLTS	
100190							
0000	+20.74	+07.14	+00.33	+00.00	+08.08	+05.59	
0100	+20.61	+07.13	+00.31	+00.00	+08.03	+05.59	
0200	+20.61	+07.10	+00.33	+00.00	+08.00	+05.59	
0300	+20.53	+07.12	+00.31	+00.00	+07.98	+05.59	
0400	+20.49	+07.12	+00.29	+00.00	+08.03	+05.59	
0500	+20.36	+07.11	+00.29	+00.00	+07.95	+05.59	
0600	+20.32	+07.12	+00.31	+00.00	+07.96	+05.59	
0700	+20.27	+07.13	+00.31	+00.00	+07.97	+05.59	
0800	+20.36	+07.10	+00.31	+00.00	+07.95	+05.59	
0900	+20.36	+07.09	+00.31	+00.00	+07.83	+05.59	
1000	+20.53	+07.06	+00.31	+00.00	+07.75	+05.59	
1100	+20.57	+07.06	+00.33	+00.00	+07.71	+05.59	
1200	+20.53	+07.13	+00.33	+00.00	+07.81	+05.57	
1300	+20.53	+07.18	+00.31	+00.00	+07.87	+05.59	
1400	+20.61	+07.17	+00.33	+00.00	+07.77	+05.59	
1500	+20.78	+07.11	+00.33	+00.00	+07.99	+05.59	
1600	+21.29	+07.17	+00.31	+00.00	+08.38	+05.59	
1700	+21.20	+07.34	+00.29	+00.00	+08.84	+05.59	
1800	+21.08	+07.28	+00.31	+00.00	+08.87	+05.59	
1900	+20.78	+07.18	+00.31	+00.00	+08.40	+05.59	
2000	+20.91	+07.19	+00.31	+00.00	+08.33	+05.58	
2100	+20.57	+07.06	+00.33	+00.00	+07.74	+05.58	
2200	+20.65	+07.07	+00.33	+00.00	+07.72	+05.58	
2300	+20.70	+07.09	+00.33	+00.00	+08.01	+05.58	
100290							
0000	+20.53	+07.09	+00.33	+00.00	+08.02	+05.58	
0100	+20.33	+07.09	+00.33	+00.00	+08.02	+05.58	
0200	+20.36	+07.09	+00.31	+00.00	+07.91	+05.58	
0300	+20.23	+07.07	+00.32	+00.00	+07.75	+05.58	
0400	+20.36	+07.17	+00.31	+00.00	+08.21	+05.58	
0500	+20.27	+07.18	+00.30	+00.00	+08.27	+05.58	
0600	+20.19	+07.17	+00.30	+00.00	+08.25	+05.57	
0700	+20.11	+07.18	+00.30	+00.00	+08.23	+05.57	
0800	+20.23	+07.11	+00.32	+00.00	+08.05	+05.57	
0900	+20.27	+07.10	+00.31	+00.00	+08.01	+05.57	
1000	+15.84	+07.00	+02.41	+00.84	+10.08	+05.58	pH 7 post-cal
1100	+19.09	+06.91	+03.25	+01.32	+09.46	+05.58	
1200	+22.98	+10.02	+>>.<<	+08.89	+08.57	+05.59	pH 10 post-cal
1300	+25.47	+09.99	+>>.<<	+09.05	+08.63	+05.60	

Appendix C

Water quality conditions reported in test containers during all water column tests

Table C-1: Experiments conducted with Fundulus spp. (Fs), *Palaemonetes pugio* (Pp), *Cyprinodon variegatus* (Cv) and *Eurytemora affinis* (Ea) using water samples collected from the Wye R. (WR), Patapsco R. (PR), and the Elizabeth R. (ER) from 8/14/90 to 8/21/90

Date	Test Species	Station	Temp (C)	Sal (ppt)	DO (mg/L)	pH
8/14/90						
	Fs	WR	26.60	15.5	7.3	7.75
			26.20	16.0	7.2	7.79
		PR	25.30	14.5	7.3	7.77
			25.50	15.5	7.5	7.74
		ER	25.30	20.0	7.3	7.61
			25.30	20.0	7.2	7.61
		CONTROL	25.60	15.5	7.1	7.94
			26.30	15.5	7.4	7.95
	Pp	WR	24.60	15.5	4.3	7.51
			24.60	15.5	5.3	7.59
		PR	25.40	16.0	6.5	7.68
			24.20	16.0	5.1	7.46
		ER	24.50	20.0	2.7	7.08
			24.80	20.0	2.6	7.12
		CONTROL	24.70	15.5	5.7	8.10
			24.50	16.0	5.8	8.01
	Cv	WR	25.20	15.5	3.8	7.85
			24.90	15.0	3.7	7.86
		PR	25.10	16.0	7.2	7.74
			25.00	16.0	7.4	7.78
		ER	25.20	20.0	6.4	7.48
			25.20	20.0	6.5	7.50
		CONTROL	25.20	15.5	3.8	7.85
			25.10	15.5	3.7	7.86
	Ea	WR	25.30	16.0	5.2	7.80
			25.50	16.5	5.0	7.75
		PR	25.20	16.5	5.3	7.70
			25.20	16.5	5.5	7.74
		ER	25.50	*	5.0	7.56
			25.70	20.0	4.9	7.50
		CONTROL	25.30	16.0	4.5	7.96
			25.20	16.0	4.4	7.95
8/15/90						
	Fs	WR	27.00	15.0	6.6	*
		PR	26.20	15.0	6.8	*
		ER	26.00	20.0	7.4	*
		CONTROL	27.00	15.0	6.9	*
	Pp	WR	25.20	15.0	2.6	*
			24.60	15.0	3.9	*
		PR	26.00	15.0	5.0	*
			25.00	15.0	3.2	*
		ER	25.20	20.0	*	*
			25.20	20.0	*	*
		CONTROL	25.30	15.0	6.6	*
			25.10	15.0	6.1	*

	Cv	WR	25.20	15.0	6.50	*
		PR	25.50	15.0	6.1	*
		ER	25.30	20.0	6.5	*
			25.30	20.0	5.6	*
		CONTROL	25.30	15.0	2.1	*
	Ea	WR	25.20	15.0	-	*
		PR	25.80	15.0	6.5	*
		ER	25.50	20.0	4.3	*
		CONTROL	26.00	16.0	5.0	*
8/16/90						
	Fs	WR	24.00	15.0	5.6	*
		PR	25.50	15.0	6.8	*
		ER	25.30	20.0	6.6	*
		CONTROL	25.20	15.0	6.2	*
	Pp	WR	25.50	15.5	4.2	*
			25.00	16.0	4.2	*
		PR	25.20	15.0	*	*
			25.00	15.5	*	*
		ER	26.00	21.0	*	*
			25.20	20.5	*	*
		CONTROL	25.20	16.0	5.3	*
			25.70	15.5	5.8	*
	Cv	WR	25.50	15.5	4.8	*
		PR	25.50	15.0	6.0	*
		ER	25.50	20.0	2.7	*
		CONTROL	25.20	15.0	3.4	*
	Ea	WR	25.00	15.0	6.2	*
		PR	25.70	15.0	7.7	*
		ER	25.50	20.0	4.3	*
		CONTROL	25.20	15.0	5.4	*
8/17/90						
	Fs	WR	26.80	14.5	3.7	7.30
		PR	25.90	13.5	7.0	7.68
		ER	26.00	20.0	6.9	7.60
		CONTROL	26.40	15.0	7.0	8.11
	Pp	WR	25.70	15.0	6.0	7.76
			25.30	15.0	6.3	7.78
		PR	25.00	13.5	4.5	7.51
			25.20	13.5	*	7.29
		ER	24.90	21.0	5.7	7.55
			25.10	20.5	5.1	7.45
		CONTROL	24.90	14.5	6.5	8.20
			25.50	15.0	6.5	8.14
	Cv	WR	25.30	15.0	3.0	7.47
		PR	25.70	14.5	6.4	7.86
		ER	25.50	20.5	2.2	7.17
		CONTROL	25.20	15.0	4.4	7.91
	Ea	WR	25.50	15.5	6.5	7.86
		PR	25.50	15.0	4.0	7.53
		ER	25.00	20.5	4.8	7.30
		CONTROL	25.00	15.0	5.4	7.99
8/18/90						
	Fs	WR	26.10	15.0	6.3	*
		PR	25.90	14.0	6.6	*

		ER	26.00	20.0	6.5	*
		CONTROL	26.10	15.0	7.2	*
	Pp	WR	25.20	15.5	5.8	*
			25.10	16.0	5.2	*
		PR	25.70	13.5	5.4	*
			25.20	13.5	4.9	*
		ER	24.90	20.0	6.3	*
			25.00	20.0	6.1	*
		CONTROL	25.50	15.0	6.9	*
			25.20	15.0	6.9	*
	Cv	WR	25.20	15.0	6.2	*
		PR	25.20	13.5	5.8	*
		ER	25.40	20.0	6.0	*
		CONTROL	25.20	15.0	5.3	*
	Ea	WR	25.50	15.5	6.7	*
		PR	25.50	13.5	6.4	*
		ER	25.80	20.0	6.2	*
		CONTROL	25.80	16.0	6.6	*
8/19/90						
	Fs	WR	26.00	16.0	6.6	*
		PR	25.50	14.0	6.9	*
		ER	25.50	20.0	6.8	*
		CONTROL	26.00	15.0	6.6	*
	Pp	WR	25.00	15.0	6.6	*
			25.00	14.0	5.8	*
		PR	24.70	14.0	5.9	*
			24.70	14.0	6.0	*
		ER	25.20	20.0	6.8	*
			24.70	20.0	6.4	*
		CONTROL	25.00	15.5	6.8	*
			25.00	16.0	6.5	*
	Cv	WR	25.00	15.0	7.7	*
		PR	25.10	14.5	6.5	*
		ER	25.50	20.0	6.7	*
		CONTROL	25.00	15.5	6.2	*
	Ea	WR	25.00	15.0	7.6	*
		PR	25.50	14.5	8.2	*
		ER	25.70	19.5	7.8	*
		CONTROL	25.00	15.0	7.6	*
8/20/90						
	Fs	WR	26.00	15.5	3.4	*
			26.00	15.5	7.5	*
		PR	25.70	14.5	6.8	*
			25.50	14.5	7.7	*
		ER	25.50	20.0	7.7	*
			25.50	20.0	7.6	*
		CONTROL	26.00	15.0	6.6	*
			26.00	15.0	6.6	*
	Pp	WR	25.00	15.0	6.7	*
			25.20	15.5	6.4	*
		PR	25.00	15.0	7.0	*
			25.00	15.0	6.5	*
		ER	26.00	20.5	7.2	*

			25.00	20.5	7.6	*
		CONTROL	26.00	15.0	7.0	*
			25.50	15.0	7.2	*
	Cv	WR	25.20	15.0	8.5	*
		PR	25.20	15.0	8.3	*
		ER	25.20	20.0	7.9	*
		CONTROL	25.20	15.5	7.0	*
	Ea	WR	25.70	15.0	6.7	*
		PR	25.50	14.5	6.4	*
		ER	26.00	20.0	6.7	*
		CONTROL	25.70	15.5	7.2	*
8/21/90						
	Fs	WR	26.30	15.5	4.9	7.46
		PR	26.00	15.0	7.2	7.80
		ER	26.00	19.0	7.4	7.87
		CONTROL	26.30	15.0	7.3	8.19
	Pp	WR	25.80	14.5	6.4	7.98
			25.10	15.5	6.6	7.99
		PR	25.30	14.5	6.2	7.88
			25.10	15.0	6.0	7.88
		ER	26.20	20.5	6.8	7.93
			25.50	20.0	6.5	7.84
		CONTROL	26.30	15.0	6.6	8.31
			25.80	15.0	6.3	8.34
	Cv	WR	25.20	15.0	8.3	8.27
		PR	25.40	15.0	8.3	8.27
		ER	25.50	18.0	6.7	7.90
		CONTROL	25.30	16.0	6.4	8.25
	Ea	WR	25.50	15.5	6.5	7.94
		PR	25.80	15.0	6.9	8.01
		ER	25.60	19.5	6.3	7.70
		CONTROL	25.80	16.0	7.5	8.31

* = parameter not measured

Table C-2: Experiments conducted with water samples collected from five Potomac River stations from 9/25/90 to 10/2/90. Station abbreviations are as follows: MT= Morgantown, DG= Dahlgren, PP= Possum Point, IH= Indian Head, FP= Freestone Point. Freshwater test species included: <u>Pimephales promelas</u> (Pl), and <u>Ceriodaphnia dubia</u> (Cd). Saltwater test species included:Fundulus spp., <u>Eurytemora affinis</u>, <u>Palaemonetes pugio</u>, and <u>Cyprinodon variegatus</u>. Salinity adjusted test species included: <u>Eurytemora affinis</u> and <u>Palaemonetes pugio</u>.

Date	Test Species	Station	Temp (C)	Sal (ppt)	DO (mg/L)	pH
9/25/90						
	Fs	MT	25.10	16.5	6.7	7.81
		DG	26.30	19.0	7.2	7.86
		CONTROL	25.50	17.5	6.7	8.04
	Pp	MT	24.20	15.0	6.4	7.82
		DG	25.10	19.0	6.1	7.98
		PP	24.10	16.0	6.4	7.97
		IH	23.80	13.0	6.8	7.88
		FP	23.70	15.0	6.4	7.77
		CONTROL	22.70	17.0	7.0	8.00
	Ea	MT	25.20	16.5	6.0	7.75
		DG	25.10	18.0	6.7	7.81
		PP	25.50	15.5	6.8	7.58
		IH	25.30	14.5	6.5	7.52
		FP	24.90	14.5	6.5	7.52
		CONTROL	25.40	16.0	6.2	7.99
	Pl	PP	25.20	0	6.1	7.08
		IH	25.20	0	6.2	7.19
		FP	25.10	0	6.0	7.19
		CONTROL	25.20	0	6.0	7.53
	Cd	PP	25.10	0	8.5	7.08
		IH	25.20	0	8.0	6.38
		FP	25.20	0	7.2	6.03
		CONTROL	24.90	0	6.9	7.18
9/26/90						
	Fs	MT	25.90	16.5	7.2	7.98
		DG	25.10	18.0	7.4	7.97
		CONTROL	25.70	16.0	7.4	8.23
	Cv	MT	24.70	21.0	6.8	8.37
		DG	24.90	20.0	7.0	8.19
		CONTROL	25.20	20.0	6.3	8.18
	Pp	MT	25.00	17.0	6.3	8.08
		DG	25.80	19.0	6.0	8.04
		PP	24.70	16.0	6.2	8.05
		IH	24.40	15.0	6.2	8.02
		FP	24.80	14.5	6.0	8.05
		CONTROL	24.60	17.0	5.8	8.18
	Ea	MT	24.40	17.5	7.7	7.87

		DG	25.00	19.0	7.0	7.79
		PP	24.50	16.0	6.8	7.73
		IH	24.70	14.5	6.2	7.82
		FP	24.40	14.5	7.2	7.71
		CONTROL	25.20	17.0	7.4	7.86
	Pl	PP	25.10	0	6.2	7.08
		IH	25.20	0	6.3	7.08
		FP	25.20	0	6.0	7.07
		CONTROL	25.20	0	6.1	7.04
	Cd	PP	24.90	0	8.2	7.52
		IH	24.80	0	8.0	7.30
		FP	24.80	0	7.9	6.68
		CONTROL	24.40	0	6.7	7.06
9/27/90						
	Fs	MT	26.50	17.0	6.7	7.90
		DG	25.70	18.0	7.2	8.08
		CONTROL	26.70	15.0	7.3	8.32
	Cv	MT	25.00	20.0	7.9	8.26
		DG	25.10	18.0	7.8	8.25
		CONTROL	25.10	16.0	7.0	7.97
	Pp	MT	25.00	17.5	6.0	7.97
		DG	26.20	18.0	6.2	7.95
		PP	25.00	16.0	6.0	7.94
		IH	24.60	15.0	5.8	7.97
		FP	25.00	14.5	5.3	7.92
		CONTROL	25.00	14.0	7.7	8.21
	Ea	MT	25.00	18.0	6.3	7.98
		DG	25.80	19.0	6.2	7.84
		PP	24.60	16.0	6.0	8.03
		IH	25.10	15.0	5.8	7.88
		FP	24.80	15.0	5.6	7.94
		CONTROL	25.00	15.0	6.6	8.15
	Pl	PP	25.10	0	4.2	7.52
		IH	25.30	0	4.8	7.63
		FP	25.20	0	4.5	7.55
		CONTROL	25.20	0	5.6	7.56
	Cd	PP	24.70	0	9.3	7.19
		IH	24.60	0	8.2	6.94
		FP	25.00	0	9.0	7.08
		CONTROL	25.60	0	7.9	7.11
9/28/90						
	Fs	MT	26.40	16.0	4.8	7.73
		DG	24.80	18.0	4.9	7.65
		CONTROL	26.10	15.0	4.8	8.06
	Cv	MT	25.10	18.0	6.9	8.04
		DG	24.70	19.0	7.0	7.98
		CONTROL	25.30	16.0	7.1	8.20
	Pp	MT	25.00	16.0	6.5	7.90
		DG	25.50	19.0	6.6	7.93
		PP	24.90	16.0	6.9	7.91
		IH	25.30	14.5	7.1	7.91
		FP	25.50	15.0	7.1	7.93
		CONTROL	25.40	14.6	7.6	8.17
	Ea	MT	26.10	16.0	8.3	8.23

		DG	26.00	17.5	7.6	8.16
		PP	26.60	15.5	8.0	8.15
		IH	25.90	15.0	7.5	8.11
		FP	26.10	15.0	7.7	8.18
		CONTROL	25.50	14.5	7.8	8.29
	Pl	PP	25.00	0	6.7	7.48
		IH	25.20	0	6.9	7.37
		FP	25.10	0	7.0	7.43
		CONTROL	25.10	0	7.0	7.43
	Cd	PP	25.10	0	8.6	8.21
		IH	25.20	0	8.5	7.41
		FP	24.40	0	8.4	6.78
		CONTROL	25.30	0	8.0	7.25
9/29/90						
	Fs	MT	26.50	15.5	5.4	7.89
		DG	25.40	17.0	5.9	7.80
		CONTROL	26.30	15.0	5.9	8.22
	Cv	MT	24.90	16.0	7.1	8.05
		DG	25.30	18.0	7.5	8.09
		CONTROL	25.00	15.5	7.5	8.31
	Pp	MT	25.40	16.0	6.9	8.00
		DG	25.10	18.0	6.7	7.99
		PP	24.80	16.0	6.7	8.10
		IH	24.60	15.5	6.5	8.07
		FP	24.70	15.5	7.0	8.14
		CONTROL	24.70	15.0	6.7	8.25
	Ea	MT	25.50	17.0	7.5	8.24
		DG	25.80	16.0	7.7	8.19
		PP	25.00	15.5	7.7	8.18
		IH	25.00	15.0	7.2	8.19
		FP	25.40	15.0	7.0	8.38
		CONTROL	25.60	15.0	7.5	8.31
	Pl	PP	25.00	0	7.9	7.65
		IH	25.20	0	8.4	7.50
		FP	25.20	0	7.9	7.58
		CONTROL	25.00	0	8.0	7.95
	Cd	PP	25.30	0	9.4	8.36
		IH	25.80	0	8.2	7.81
		FP	25.80	0	8.4	6.67
		CONTROL	25.10	0	8.2	7.93
9/30/90						
	Fs	MT	26.30	16.0	6.3	7.95
		DG	25.80	16.0	6.4	7.93
		CONTROL	26.00	15.0	6.6	8.27
	Cv	MT	25.40	16.0	7.2	8.05
		DG	25.10	16.0	7.2	8.04
		CONTROL	24.60	15.0	7.2	8.33
	Pp	MT	24.50	16.0	7.1	7.99
		DG	25.50	17.5	7.0	7.99
		PP	24.50	16.0	7.1	8.11
		IH	24.60	15.5	7.0	8.08
		FP	24.60	15.5	7.1	8.06
		CONTROL	23.60	15.0	7.2	8.30
	Ea	MT	27.10	16.5	8.0	8.11

		DG	27.30	16.0	7.7	8.00
		PP	26.80	15.5	8.0	8.10
		IH	27.10	8.0	7.8	7.80
		FP	27.20	15.5	7.5	8.10
		CONTROL	26.50	15.0	7.6	8.31
	Pl	PP	25.00	0	8.9	7.64
		IH	25.70	0	8.1	7.91
		FP	25.20	0	8.2	7.85
		CONTROL	24.90	0	7.1	7.76
	Cd	PP	25.10	0	8.9	8.20
		IH	25.20	0	9.1	8.09
		FP	25.70	0	8.7	8.09
		CONTROL	25.10	0	8.2	7.81
10/1/9						
	Fs	MT	25.80	12.0	1.7	7.47
			26.10	12.0	6.2	7.93
		DG	25.50	15.5	6.5	7.91
		CONTROL	26.10	15.0	6.7	8.31
	Cv	MT	24.90	17.0	7.5	8.14
		DG	25.20	17.0	7.5	8.12
		CONTROL	25.10	15.5	7.5	8.40
	Pp	MT	24.50	17.0	7.5	8.14
		DG	24.60	17.0	7.4	8.12
		PP	24.80	15.5	7.3	8.27
		IH	24.40	15.0	7.3	8.24
		FP	24.30	15.0	7.5	8.29
		CONTROL	24.60	16.0	7.5	8.42
	Ea	MT		DATA	LOST	
		DG	25.80	17.0	7.7	8.26
		PP	25.80	15.0	8.0	8.39
		IH	25.80	11.0	7.8	8.43
		FP	25.90	15.0	8.3	8.35
		CONTROL	26.30	16.0	7.6	8.42
	Pl	PP	25.00	0	8.2	7.95
		IH	25.30	0	8.3	7.96
		FP	25.10	0	7.8	7.91
		CONTROL	25.10	0	7.4	7.45
	Cd	PP	25.10	0	7.0	7.83
		IH	25.50	0	7.8	8.03
		FP	26.20	0	7.1	7.96
		CONTROL	26.20	0	6.5	7.81
10/2/90						
	Fs	MT	26.10	14.0	7.1	7.92
		DG	25.50	15.5	7.1	7.91
		CONTROL	26.10	15.0	7.3	8.23
	Cv	MT	24.70	17.0	7.2	7.93
		DG	25.20	16.0	6.9	7.90
		CONTROL	24.90	16.0	7.0	8.28
	Pp	MT	24.20	17.0	6.9	8.03
		DG	24.60	17.0	7.0	8.04
		PP	24.40	15.0	7.3	8.15
		IH	24.70	15.0	7.2	8.16
		FP	24.20	15.0	7.1	8.08
		CONTROL	24.70	16.0	7.3	8.35

	Ea	MT	25.50	17.0	<10.0	8.68
		DG	25.40	16.0	<10.0	8.56
		PP	22.90	15.0	<10.0	8.77
		IH	24.40	14.0	<10.0	8.83
			24.30	14.0	<10.0	8.93
		FP	25.20	15.0	<10.0	8.75
		CONTROL	25.70	14.0	<10.0	8.68
	Pl	PP	25.50	0	9.7	8.22
		IH	25.70	0	10.2	8.41
		FP	25.30	0	9.6	8.21
		CONTROL	25.30	0	6.8	8.01
	Cd	PP	25.00	0	7.9	8.16
		IH	25.30	0	7.7	8.03
		FP	25.20	0	8.4	8.36
		CONTROL	25.20	0	7.8	8.19
10/3/90						
	Cv	MT	25.00	17.0	7.8	8.12
		DG	25.30	16.0	7.4	7.99
		CONTROL	25.50	16.5	7.4	8.32

Table C-3: Laboratory water quality conditions during the second *Ceriodaphnia* test conducted from 10/27/90 to 11/3/90 using fresh water from the three Potomac River sites.

Date	Station	Temp (C)	DO (mg/L)	pH	Hardness (mg/L $CaCO_3$)
10/27/90					
	PP	23.60	6.5	7.87	92
	IH	23.10	7.0	7.87	92
	FP	22.80	6.9	7.82	84
	CONTROL	22.80	7.2	8.40	136
10/28/90					
	PP	24.20	7.5	8.15	92
	IH	23.70	7.4	7.95	76
	FP	23.80	7.5	7.98	84
	CONTROL	24.00	7.7	8.48	184
10/29/90					
	PP	25.20	7.0	7.97	*
	IH	24.70	7.6	7.93	*
	FP	24.80	7.6	7.89	*
	CONTROL	25.60	7.2	8.30	*
10/30/90					
	PP	25.30	7.7	7.82	*
	IH	25.10	7.9	7.95	*
	FP	25.50	7.7	7.85	*
	CONTROL	25.10	7.6	8.29	*
10/31/90					
	PP	25.10	7.2	7.95	*
	IH	25.00	7.2	8.15	*
	FP	25.20	7.3	8.07	*
	CONTROL	24.70	7.5	8.36	*
11/1/90					
	PP	26.60	7.4	7.97	*
	IH	26.50	7.7	7.90	*
	FP	26.00	7.9	7.87	*
	CONTROL	26.00	7.6	8.30	*
11/2/90					
	PP	24.50	7.3	7.90	*
	IH	25.20	7.2	7.88	*
	FP	25.00	7.7	7.91	*
	CONTROL	24.60	7.7	8.26	*
11/3/90					
	PP	24.80	7.4	7.97	*
	IH	24.80	7.6	7.98	*
	FP	24.80	7.4	7.97	*
	CONTROL	24.80	7.5	8.40	*

* = parameter not measured

Appendix D

Organic analysis data are presented for
Possum Point, Freestone Point, Dahlgren,
Elizabeth River and the Nansemond River sediments.
The semi-volatile organic compounds were identified and
quantitated against a user-created "priority pollutants"
library which matches both retention times and spectral fit.
The quantitations were based upon 5-7 point calibration curves.
The tentatively identified compounds were identified
by spectral fit against the NBS library and quantitated against
an internal standard, assuming a 1:1 response factor.

Table D-1 Organics analysis data sheet for semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Possum Point

Contractor: MD DNR
Sample #: 35363

Dates: Received - 9/26/90
Analyzed - 11/30/90

Extracted - 11/21/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.04

Units: µg/kg dry
% Moisture: 49.52

CAS #	Compound	Concentration	Detection Limit
84-74-2	Di-n-butylphthalate	77 *	5.9
129-00-0	Pyrene	65	10.6
218-01-9	Chrysene	186	14.5
117-81-7	Bis(2-ethylhexyl)phthalate	670	12.5
50-32-8	Benzo(a)pyrene	155	15.2

* Compound detected in QC blank.

Table D-2 Organics analysis data sheet for tentatively identified semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Possum Point

Contractor: MD DNR
Sample #: 35363

Dates: Received - 9/26/90
Analyzed - 11/30/90

Extracted - 11/21/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.04

Units: μg/kg dry
% Moisture: 49.52

CAS #	Compound	Scan #	Estimated Concentration*
	Unknown	511	4310 **
75-91-2	Hydroperoxide, 1,1-dimethylethyl	516	675 **
	Unknown	529	635 **
4160-75-2	2-propanone, 1-cyclopropyl-	535	369 **
75-91-2	Hydroperoxide, 1,1-dimethylethyl	582	11200 **
	Unknown	592	16300 **
	Unknown	635	223000
4305-26-4	2-hexanone, 6-(acetyloxy)-	756	10800
17257-81-7	Ethanone, 1-(3-ethyloixeahyl)-	786	937
3240-09-3	5-hexen-2-one, 5-methyl	843	5780
	Unknown	867	1830
26118-38-7	2-hexanone, 3,3-dimethyl-	931	2900
56052-85-8	2-pentene, 5-(pentyloxy)-, (E)-	954	12800
5343-96-4	2-butanol, 3-methyl-, acetate	999	3750
542-59-6	1,2-ethanediol, monoacetate	1114	6360
10544-50-0	Sulfur, mol (S8)	2896	6690
3891-98-3	Dodecane, 2,6,10-trimethyl-	4139	1400
3891-98-3	Dodecane, 2,6,10-trimethyl-	3938	842
6971-40-0	17-pentatriacontene	3949	871
107-41-5	2.4-pentanediol, 2-methyl	1420	780

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* Estimated concentration is based on a 1:1 response with the internal standard.

** Compound detected in QC blank.

Table D-3 Organics analysis data sheet for semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Freestone Point

Contractor: MD DNR
Sample #: 35362

Dates: Received - 9/26/90
Analyzed - 11/30/90

Extracted - 11/21/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.08

Units: µg/kg dry
% Moisture: 49.09

CAS #	Compound	Concentration	Detection Limit
218-01-9	Chrysene	210	14.5
117-81-7	Bis(2-ethylhexyl)phthalate	490 *	12.5

* Compound detected in QC blank.

Table D-4 Organics analysis data sheet for tentatively identified semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Freestone Point

Contractor: MD DNR
Sample #: 35362

Dates: Received - 9/26/90
Analyzed - 11/30/90

Extracted - 11/21/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.08

Units: µg/kg dry
% Moisture: 49.09

CAS #	Compound	Scan #	Estimated Concentration*
	Unknown	451	3060
627-09-8	2-propyn-1-01, acetate	505	1120 **
	Unknown	543	1020 **
75-91-2	Hydroperoxide, 1,1-dimethylethyl	563	22000
627-09-8	2-propyn-1-01, acetate	613	162000 **
4305-26-4	2-hexanone, 6-(acetyloxy)-	744	7460
3377-86-4	Hexane, 2-bromo-	777	723
3240-09-3	5-hexen-2-one, 5-methyl-	836	4880
627-09-8	2-propyn-1-01, acetate	860	1820
	Unknown	924	2100
56052-85-8	2-pentene, 5-(pentyloxy)-, (E)-	949	13200
18641-71-9	3-heptanone, 2,4-dimethyl	962	8000
18641-71-9	3-heptanone, 2,4-dimethyl	994	3500
431-03-8	2,3-butanedione	1116	4890
	Unknown	1005	621
10544-50-0	Sulfur, mol. (S8)	2890	4020
17301-30-3	Undecane, 3,8-dimethyl	3938	804
6971-40-0	17-pentatriacontene	3951	657
2432-89-5	Decanedioic acid, didecyl ether	4138	1030
625-06-9	2-pentanol, 2,4-dimethyl	1419	647

---

* Estimated concentration is based on a 1:1 response with the internal standard.

** Compound detected in QC blank.

Table D-5 Organics analysis data sheet for semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Dahlgren

Contractor: MD DNR
Sample #: 35360

Dates: Received - 9/26/90
Analyzed - 11/30/90

Extracted - 11/21/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.00

Units: µg/kg dry
% Moisture: 27.06

CAS #	Compound	Concentration	Detection Limit
56-55-3	Benzo(a)anthracene	99.8	17.8
117-81-7	Bis(2-ethylhexyl)phthalate	691 *	12.5

* Compound detected in QC blank.

Table D-6 Organics analysis data sheet for tentatively identified semi-volatile compounds.

Laboratory:	Organics	Contractor:	MD DNR
Project ID:	Ambient Toxicity	Sample #:	35360
Sample ID:	Dahlgren		
Dates:	Received - 9/26/90 Analyzed - 11/30/90	Extracted - 11/21/90	
Method:	EPA 3550/8270	Instrument:	INCOS50
Analyst:	TLP	Data Released By:	M. Helmstetter
Matrix:	Sediment	Units:	µg/kg dry
Sample w/v:	30.00	% Moisture:	27.06

CAS #	Compound	Scan #	Estimated Concentration*
563-80-4	2-butanone, 3-methyl-	790	2230
20019-64-1	2(5H)-furanone, 5,5-dimethyl	839	620
	Unknown	865	341
	Unknown	930	1660
18641-71-9	3-heptanone, 2,4-dimethyl-	966	5660
18641-71-9	3-heptanone, 2,4-dimethyl-	1001	8060
	Unknown	1012	553
	Unknown	1094	955
431-03-8	2,3-butanedione	1111	230
10544-50-0	Sulfur, mol. (S8)	2886	1270
74630-61-8	2-undecene, 6-methyl-, (E)-	3106	1270

---

* Estimated concentration is based on a 1:1 response with the internal standard.

Table D-7 Organics analysis data sheet for semi-volatile compounds. (Note: Double underlined values represent concentrations exceeding "Effects Range-Medium" levels for selected polynuclear aromatic hydrocarbons, as defined in Long and Morgan, 1990).

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Atlantic Wood

Contractor: MD DNR
Sample #: 34927

Dates: Received - 8/16/90
Analyzed - 12/14/90

Extracted - 12/14/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.00

Units: μg/kg dry
% Moisture: 62.7

CAS #	Compound	Concentration	Detection Limit
91-20-3	Naphthalene	43.7	4.6
208-96-8	Acenaphthalene	486	5.9
83-32-9	Acenaphthene	$3.11x10^{3}$	9.9
132-64-5	Dibenzofuran	486	7.9
86-73-7	Fluorene	690	9.9
85-01-8	Phenanthrene	$5.31x10^{3}$	9.2
120-12-7	Anthracene	$7.10x10^{3}$	9.9
206-44-0	Fluoranthene	$1.07x10^{4}$	10.6
129-00-0	Pyrene	$1.18x10^{4}$	10.6
218-01-9	Chrysene	$9.18x10^{3}$	14.5
117-81-7	Bis(2-ethylhexyl)phthalate	146 *	12.5
205-99-2	Benzo(b)fluoranthene	$6.29x10^{3}$	13.9
50-32-8	Benzo(a)pyrene	$6.23x10^{3}$	15.2
53-70-3	Dibenzo(a,h)anthracene	$2.16x10^{3}$	17.8
193-39-5	Indeno(1,2,3-cd)pyrene	$3.42x10^{3}$	16.5
191-24-2	Benzo(g,h,i)perylene	$3.89x10^{3}$	16.5

* Compound detected in QC blank.

Table D-8 Organics analysis data sheet for tentatively identified semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Atlantic Wood

Contractor: MD DNR
Sample #: 34927

Dates: Received - 8/16/90
Analyzed - 12/14/90

Extracted - 12/14/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.00

Units: µg/kg dry
% Moisture: 62.7

CAS #	Compound	Scan #	Estimated Concentration*
613-12-7	Anthracene, 2-methyl-	2690	4750
	Unknown	2714	2960
203-64-5	4H-cyclopenta(def)phenanthrene	2722	11200
13141-45-2	Benzene, 1,1'-(1-buten-3-yne-1,4-diyl)bis-	2803	3130
129-00-0	Pyrene **	2942	24800
129-00-0	Pyrene **	3013	21900
243-42-5	Benzo(b)naphthol[2,3-D]furan	3020	5730
238-84-6	11H-benzo(a)fluorene	3143	12300
2381-21-7	Pyrene, 1-methyl	3166	9200
205-43-6	Benzo(b)naphthol[1,2-D]thiophene	3354	2890
195-19-7	Benzo(c)phenanthrene	3368	4890
217-59-4	Triphenylene	3464	11900
	Unknown	3482	4910
2871-91-2	Triphenylene, 1-methyl	3595	2980
	Unknown	3639	4590
	Unknown	3842	2840
886-38-4	2-cyclopropen-1-one, 2,3-diphenyl	3880	4390
205-82-3	Benzo(j)fluoranthene	3911	10700
192-97-2	Benzo(e)pyrene	3936	2800
	Unknown	3987	3850

* Estimated concentration is based on a 1:1 response with the internal standard.

** Compound name based on NBS library match. These compounds do not have the correct retention time for Pyrene which is found in this sample at its correct retention time.

Table D-9 Organics analysis data sheet for semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Nansemond Reference

Contractor: MD DNR
Sample #: 35378

Dates: Collected - 9/25/90
Extracted - 11/21/90

Received - 9/27/90
Analyzed - 11/30/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.01

Units: μg/kg dry
% Moisture: 51.95

CAS #	Compound	Concentration	Detection Limit
117-81-7	Bis(2-ethylhexyl)phthalate	32 *	12.5
56-55-3	Benzo(a)anthracene	193	17.8

* Compound detected in QC blank.

Table D-10 Organics analysis data sheet for tentatively identified semi-volatile compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Nansemond Reference

Contractor: MD DNR
Sample #: 35378

Dates: Collected - 9/25/90
Extracted - 11/21/90

Received - 9/27/90
Analyzed - 11/30/90

Method: EPA 3550/8270
Analyst: TLP

Instrument: INCOS50
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.01

Units: μg/kg dry
% Moisture: 51.95

CAS #	Compound	Scan #	Estimated Concentration*
	Unknown	451	2200
75-91-2	Hydroperoxide, 1,1-dimethylethyl	516	15600
	Unknown	555	848
75-91-2	Hydroperoxide, 1,1-dimethylethyl	585	24600
	Unknown	629	298000
	Unknown	752	8910
	Unknown	784	1700
758-87-2	4-penten-2-one, 3-methyl	838	3050
	Unknown	862	1680
18641-71-9	3-heptanone, 2,4-dimethyl	962	7420
18641-71-9	3-heptanone, 2,4-dimethyl	996	5600
	Unknown	1007	762
542-59-6	1,2-ethenediol, monoacetate	1102	1290
	Unknown	1417	425
10544-50-0	Sulfur, mol. (S8)	2881	920

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* Estimated concentration is based on a 1:1 response with the internal standard.

Appendix E

Pesticide analysis data for Possum Point, Freestone Point, Dahlgren, Elizabeth River and Nansemond River sediments

Table E-1 Organics analysis data sheet for tentatively identified pesticide compounds.

Laboratory:	Organics	Contractor:	MD DNR
Project ID:	Ambient Toxicity	Sample #:	35363
Sample ID:	Possum Point		
Dates:	Received - 9/26/90 Analyzed - 1/14/91	Extracted - 12/14/90	
Method:	EPA 3550/8080	Instrument:	GC-6
Analyst:	RJM	Data Released By:	M. Helmstetter
Matrix:	Sediment	Units:	μg/kg dry
Sample w/v:	30.02	% Moisture:	49.52

CAS #	Compound	Concentration	Detection Limit
72-55-9	4,4'-DDE	1.05	0.528

Table E-2 Organics analysis data sheet for tentatively identified pesticide compounds.

Laboratory:	Organics	Contractor:	MD DNR
Project ID:	Ambient Toxicity	Sample #:	35362
Sample ID:	Freestone Point		
Dates:	Received - 9/26/90 Analyzed - 1/14/91	Extracted - 12/14/90	
Method:	EPA 3550/8080	Instrument:	GC-6
Analyst:	RJM	Data Released By:	M. Helmstetter
Matrix:	Sediment	Units:	µg/kg dry
Sample w/v:	30.06	% Moisture:	49.09

CAS #	Compound	Concentration	Detection Limit
391-84-6	α-BHC	0.574 *	0.714
72-55-9	4,4'-DDE	0.353 *	0.528

* Compound detected below calculated method limit.

Table E-3 Organics analysis data sheet for tentatively identified pesticide compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Dahlgren

Contractor: MD DNR
Sample #: 35360

Dates: Received - 9/26/90
Analyzed - 1/14/91

Extracted - 12/14/90

Method: EPA 3550/8080
Analyst: RJM

Instrument: GC-6
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.03

Units: µg/kg dry
% Moisture: 27.06

CAS #	Compound	Concentration	Detection Limit
1024-57-3	Heptachlor epoxide	2.06	0.570

Table E-4 Organics analysis data sheet for tentatively identified pesticide compounds. (Note: Single underlined values represent concentrations exceeding the "Effects-Range Low"; double underlined values represent concentrations exceeding "Effects Range-Medium" levels for selected chlorinated pesticides, as defined in Long and Morgan, 1990.)

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Atlantic Wood

Contractor: MD DNR
Sample #: 34927

Dates: Received - 8/16/90
Analyzed - 1/14/91

Extracted - 12/14/90

Method: EPA 3550/8080
Analyst: RJM

Instrument: GC-6
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.06

Units: μg/kg dry
% Moisture: 62.7

CAS #	Compound	Concentration	Detection Limit
391-84-6	α-BHC	3.67	0.714
391-86-8	δ-BHC	6.59	1.05
1024-57-3	Heptachlor epoxide	5.57	0.570
959-98-8	Endosulfan I	1.88	0.859
72-55-9	4,4'-DDE	11.8	0.528
60-57-1	Dieldrin	$\underline{\underline{29.7}}$	0.898
7421-93-4	Endrin aldehyde	$\underline{\underline{2.16}}$	2.41

Table E-5 Organics analysis data sheet for tentatively identified pesticide compounds.

Laboratory: Organics
Project ID: Ambient Toxicity
Sample ID: Nansemond Reference

Contractor: MD DNR
Sample #: 35378

Dates: Received - 9/25/90
Analyzed - 1/14/91

Extracted - 12/14/90

Method: EPA 3550/8080
Analyst: RJM

Instrument: GC-6
Data Released By: M. Helmstetter

Matrix: Sediment
Sample w/v: 30.09

Units: μg/kg dry
% Moisture: 51.95

CAS #	Compound	Concentration	Detection Limit
	No compounds detected		