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FINAL THAMES RIVER VALIDATION STUDY REPORT NSB NEW LONDON CT
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BATTELLE

Final

THAMES RIVER VALIDATION STUDY REPORT

NAVAL SUBMARINE BASE - NEW LONDON GROTON, CONNECTICUT

Prepared for:

NAVFAC MIDLANT OPNEEV
Environmental Restoration
Building N-26, Rm 3208
9742 Maryland Avenue
Norfolk, VA 23511-3095

Prepared by:

Battelle
397 Washington St.
Duxbury, MA 02332

Neptune and Company
1505 15th St. Suite B
Los Alamos, NM 87544

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EXECUTIVE SUMMARY

The purpose of the Thames River Validation Study Report is to supplement historical data collected along the shoreline of the Naval Submarine Base in New London, Connecticut (NSB-NLON) and to determine if there are potential unacceptable risks to ecological receptors from contaminants of potential concern (COPCs) in three areas (Zone 4, Zone 7, and Outer Pier 1) of the Thames River. This report presents a summary of the field sampling efforts, results of the sediment and tissue chemistry analyses, an updated conceptual site model (CSM), and the results of the baseline ecological risk assessment (BERA) using data collected in 2004 and 2007. The results of this study will determine if the current level of risk along the Thames River NSB-NLON is different from regional risk within the river and whether further evaluation is necessary in a Feasibility Study (FS).

The results of this Validation Study will be used to supplement prior data that have been collected within Zone 4, Zone 7, and Pier 1 at NSB-NLON. These previous investigations include Phases I and II of a Lower Subase Remedial Investigation (RI), which occurred in all three study areas; an Environmental Assessment (EA) along Pier 15 and Pier 17 (Zone 7) and Pier 6 (Zone 4); and the Rapid Sediment Characterization (RSC) Pilot Study and Screening-level Ecological Risk Assessment (SLERA) that occurred in Zone 4 and Zone 7. Furthermore, Pier 1 has been divided into two subareas (Inner and Outer) based on the elevated concentrations of chemicals in the Inner Area. The evaluation of Outer Pier 1 is included in this report, and Inner Pier 1 is evaluated in an Engineering Evaluation/Cost Analysis (EE/CA) (Battelle, 2007a [in press]).

A number of onshore and upstream historical sources of chemical constituents have impacted the Study Areas including fuel spills, surface runoff, incinerators, septic system leaching fields, several storage buildings, fuel distribution lines, underground storage tanks, a golf course, submarine maintenance activities, transformers, and storm-sewer outfalls. The primary contaminated medium in Zones 4, 7, and Outer Pier 1 is surface sediment. Data collected during the Lower Subase RI determined that sediments in these areas contained elevated levels of metals, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). Although surface water is a transport mechanism for suspended particulates, it is not a media of concern in the Study Areas. Because of the relatively insoluble nature of the COPCs and the constant flushing of water due to downstream flow of the river, the dissolved fraction available to water column-feeding organisms is limited.

Ten metals, PAHs, PCBs, and pesticides were identified and analyzed as COPCs in sediments from the Thames River Study Areas. In addition, all samples were analyzed for conventional parameters (grain size, total organic carbon [TOC], and acid volatile sulfides/simultaneously extracted metals [AVS/SEM]). Fish tissue samples were collected from the Pier 1 area and the upstream Reference Area (no fish were caught in Zones 4 and 7). The data were paired with available sediment chemistry from the areas of collection to calculate bioaccumulation factors (BAFs) that were then extrapolated to Zones 4 and 7 to determine potential ecological risk.

Risk to ecological receptors, including benthic invertebrates and upper-trophic level piscivorous birds (represented by the double-crested cormorant), were evaluated in the BERA as part of this Validation Study. To assess potential risk to benthic invertebrates, a 28-day laboratory bioassay was conducted using the amphipod *Leptocheirus plumulosus* as a surrogate for all benthic invertebrates. Results were evaluated for survival, growth, and reproduction using sediment data collected in 2007. Concentrations of COPCs in whole body forage fish tissue collected in 2004 were used to estimate a range of site-specific BAFs to calculate dose inputs to the cormorant food chain model. Exposure point concentrations (EPCs) for estimating an ingestion dose to the cormorant in each area were calculated using the 95% upper confidence limit (UCL) of the mean sediment COPC concentrations.

Dose modeling to piscivorous birds showed potential low-level risk from zinc in Zone 7, lead and zinc in Zone 4, and mercury in Outer Pier 1 because hazard quotients (HQs) exceeded no observed adverse effect level (NOAEL) toxicity reference values (TRVs). Doses did not exceed lowest observed adverse effects level (LOAEL) TRVs for any constituent in any area. Evaluation of the uncertainties associated with site-specific BAFs and cormorant site use factors (SUFs) combined with the low HQs for zinc in Zone 7, lead in Zone 4, and mercury in Outer Pier 1 suggest that these COPCs do not pose unacceptable risk to piscivorous birds in these areas. Zinc in Zone 4 was determined to pose potential unacceptable risk from sediments along the quay wall, which generally exceeded the zinc LOAEL preliminary remediation goal (PRG) of 2,150 mg/kg and is recommended for further evaluation in the Feasibility Study (FS).

Statistical comparisons of the bioassay data showed that survival in Zone 7 was statistically different than Reference Area mean survival at two of the six sampling locations; and Zone 4 survival was statistically different than Reference Area survival in three of the six sampling locations. Growth was statistically different in four Zone 7 locations when compared to the Reference Area. In Zone 4, amphipods were approximately 25% smaller than those from the Reference Area, with statistically significant differences observed at five of the six Zone 4 sampling locations. Reproduction in Zone 7 resulted in approximately 20% fewer offspring compared to average Reference Area reproduction, with statistically significant differences observed at two of the six bioassay locations. Reproduction in Zone 4 was slightly greater than 50% of Reference Area reproduction (1.87 offspring/adult vs. 3.66 offspring/adult).

Bioassay results for all three lines of evidence were compared to chemistry results, including Effects Range Median – Quotients (ERM-Q), Metals ERM-Q, and Total PCB concentrations. From these correlations, the following PRGs were identified:

- ERM-Qs associated with a 30% reduction in survival (1.43), a 30% reduction in growth (1.54), a 50% reduction in growth (2.34), a 25% reduction in offspring (0.53), and a 50% reduction in offspring (1.17);
- Metals ERM-Q associated with a 30% reduction in survival (1.64); and,
- Total PCBs associated with a 30% reduction in growth (270 µg/kg), a 50% reduction in growth (387 µg/kg), a 25% reduction in offspring (121 µg/kg), and a 50% reduction in offspring (208 µg/kg).

In selecting areas to evaluate in the FS, two footprints were initially identified for each Study Area: a multiple endpoint risk footprint defined by sediments that pose moderate or high risk for **two or more lines** of evidence; and a single endpoint risk footprint based on sediments where any **single** bioassay line of evidence (survival, growth, or reproduction) is reduced by 50% or more, or has food chain doses that are greater than the LOAEL TRV. Multiple endpoint and single endpoint footprints in each area are summarized in Table ES-1 below.

This Validation Study identifies footprints in each area to be evaluated in the FS to reduce ecological risk with consideration of CERCLA criteria. The study proposes that the larger of the two footprints defined above and identified in each area be carried forward to the FS for evaluation of remedial actions to ameliorate ecological risk, with the smaller footprints serving as a minimum bounding condition. Zone 7 and Outer Pier 1 did not pose risk to multiple endpoints as defined by the PRGs. Zone 7 also did not pose risk based upon a 50% reduction for any individual line of evidence. Therefore no area of Zone 7 is proposed for evaluation in the FS. Outer Pier 1 contained 0.17 acres that exceeded the Total PCB PRG for greater than 50% reduction in reproduction; this 0.17-acre area will be evaluated in the FS. Additional sampling is proposed to further refine the southern and western boundaries of this footprint conducted either during the FS or as part of the EE/CA for Inner Pier 1.

Table ES -1. Footprints for Consideration in the NSB-NLON Feasibility Study

Area	Multiple Endpoint Footprint		Single Endpoint Footprint	
	Footprint Size (acres)	Basis	Footprint Size (acres)	Basis
Zone 7	0	No unacceptable risk to more than one line of evidence	0	No 50% impact to any line of evidence based on ERM-Q, Metals ERM-Q, or Total PCB PRG
Zone 4	0.29	Unacceptable risk based on invertebrate reproduction and growth for Total PCBs > 270 µg/kg and/or ERM-Q > 1.43[a]	0.39	Greater than 50% reduction in benthic invertebrate reproduction based on ERM-Q > 1.17 and/or Total PCBs > 208 µg/kg[a]
Outer Pier 1	0	No unacceptable risk to more than one line of evidence	0.17	Greater than 50% reduction in benthic invertebrate reproduction based on Total PCB > 208 µg/kg.

a. Footprints similar in size and shape

Zone 4 poses risk to invertebrate survival, growth, and reproduction, and low-level risk to piscivorous birds in an area defined by the undredged sediment shelf extending approximately 50 feet offshore of the quay wall. The actual footprints in Zone 4 encompass 0.39 acres (risk to single endpoint) and 0.29 acres (risk to multiple endpoints) but the northern boundaries of those footprints were influenced by the lack of data north of the former Pier 4. Therefore, the Zone 4 footprint for evaluation in the FS represents the entire area of the undredged sediment shelf extending approximately 50 feet out from the quay wall and running the entire length of Zone 4.

Ultimately, it is recommended that the entire sediment shelf adjacent to the quay wall in Zone 4, including the 0.39 acres identified above, and a small portion (0.17 acres) of Outer Pier 1 be further evaluated in the FS for the Lower Subase (Figures ES-1 and ES-2, respectively).

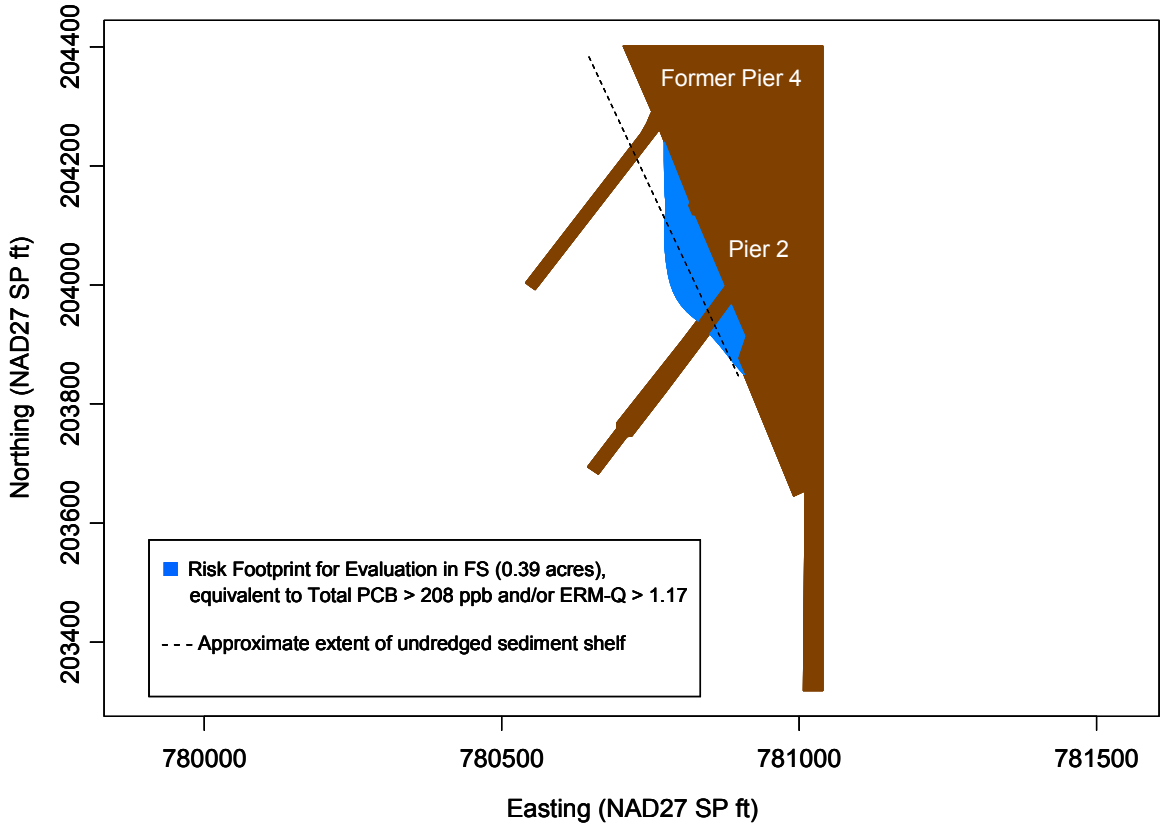

Figure ES-1. Zone 4 Footprint Associated with Exceedance of PRGs

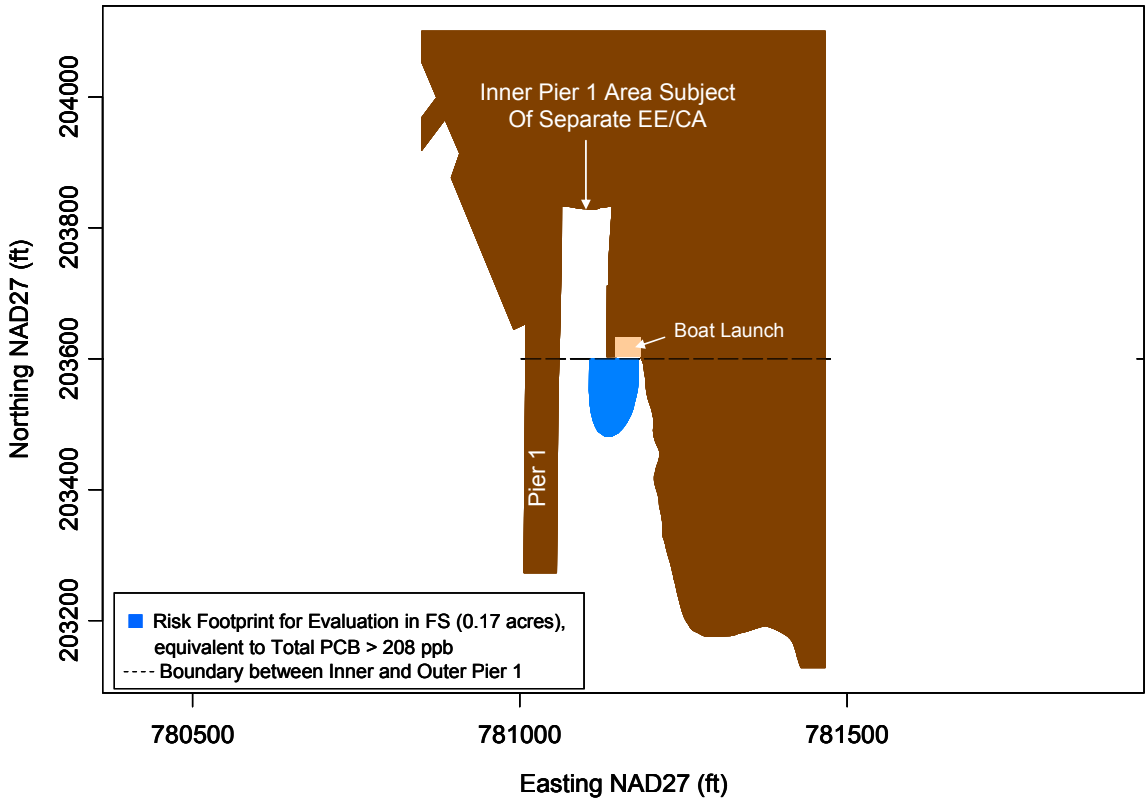

Figure ES-2. Outer Pier 1 Footprint Associated with Exceedance of PRGs

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
As	arsenic
ASA	Applied Science Associates
ATSDR	Agency for Toxic Substances and Disease Registry
AVS	acid volatile sulfides
Ba	barium
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
BW	body weight
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIF	Controlled Industrial Facility
COPC	contaminants of potential concern
Cr	chromium
CSM	conceptual site model
CTDEP	Connecticut Department of Environmental Protection
Cu	copper
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDx	DDT and associated compounds (DDD and DDE)
DI	daily ingestion
DON	Department of Navy
DQO	data quality objectives
EA	Environmental Assessment
Eco-SSL	Ecological soil screening level
EE/CA	Engineering Evaluation/Cost Assessment
EFANE	Engineering Field Activity Northeast
EIS	Environmental Impact Statement
EPC	exposure point concentrations
ERM-Q	effects range median quotient
FFA	Federal Facilities Agreement
FS	Feasibility Study
Hg	mercury
HMW	high molecular weight
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendment
IR	Installation Restoration
IRP	Installation Restoration Program
LMW	low molecular weight

LOAEL	lowest observed adverse effects level
msl	mean sea level
NAVFAC	Naval Facilities
NCP	National Contingency Plan
Ni	nickel
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
NPL	National Priorities List
NSB-NLON	Naval Submarine Base – New London
OEHHA	(California) Office of Environmental Health Hazard Assessment
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PRG	preliminary remediation goal
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSC	Rapid Sediment Characterization
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
Se	selenium
SEM	simultaneously extractable metals
SLERA	Screening-level Ecological Risk Assessment
SUF	site use factor
SVOC	semi-volatile organic compound
TOC	total organic carbon
TPH-DRO	total petroleum hydrocarbons – diesel range organics
TPH-MRO	Total petroleum hydrocarbons – motor oil range organics
TRV	toxicity reference value
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
Zn	zinc

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1.0 INTRODUCTION

The Naval Submarine Base – New London (NSB-NLON) Lower Subase Validation Study Report is prepared for the Engineering Field Activity Northeast (EFANE) (now referred to as NAVFAC Midlant) under Contract No. N62472-00-D-1300. The objective of the Thames River Validation Study is to supplement historical data collected along the NSB-NLON shoreline and determine if there are potential unacceptable risks to ecological receptors from contaminants of potential concern (COPCs). The purpose of this report is to provide an assessment of the potential ecological risks in three areas (Zone 4, Zone 7, and Outer Pier 1) of the Thames River located adjacent to the Naval Submarine Base in New London, Connecticut (Figure 1-1). This report presents a summary of the field sampling effort, results of the sediment and tissue chemistry analyses, an updated conceptual site model (CSM), and the results of the baseline ecological risk assessment (BERA) using data collected in 2004 and 2007. The results of this study will determine if the current level of risk along the Thames River NSB-NLON is different from regional risk within the river and whether further evaluation is necessary in a Feasibility Study (FS).

The approach for the Thames River Validation Study was developed through meetings between the Navy and technical representatives of the U.S. Environmental Protection Agency (USEPA) Region 1, National Oceanic and Atmospheric Administration (NOAA), and the State of Connecticut Department of Environmental Protection (CTDEP). The primary goals of the Navy and the regulatory agency technical group were to reach agreement on the type, quality, and quantity of data to be collected, and to address data evaluation and interpretation for the BERA at Zone 4, Zone 7, and the outer area of Pier 1. The inner area of Pier 1 is evaluated separately in an Engineering Evaluation/Cost Analysis (EE/CA) (Battelle, 2007a [in press]) due to the high levels of contamination.

1.1 Goals and Objectives

The primary objective of the Validation Study is to evaluate specific areas of the Thames River adjacent to the Lower Subase for potential impacts of COPCs that have migrated from onshore source areas or have been deposited due to activities associated with the berthing of submarines and ships in the pier areas. The three areas that are the subject of this study (Zone 7, Zone 4, and Outer Pier 1) were the subject of a Rapid Sediment Characterization (RSC) Pilot Study and a screening-level ecological risk assessment (SLERA) was performed using the RSC data to identify and refine the list of COPCs to be further evaluated in the BERA. Specific objectives of the BERA are as follows:

- Evaluate concentrations of COPCs in the sediments in Zone 4, Zone 7, and Outer Pier 1 by collecting surface and subsurface sediment samples for physical and chemical analyses from these three areas, and from an upstream Reference Area.
- Evaluate potential toxicity to benthic macroinvertebrates by conducting a 28-day laboratory bioassay with the amphipod *Leptocheirus plumulosus* and surface sediment samples collected from Zone 4, Zone 7, and the upstream Reference Area.
- Evaluate potential risk to upper-trophic level receptors (i.e., piscivorous birds) using whole body forage fish tissue samples in a dose model.

Although only Outer Pier 1 (not the entire area of Pier 1) is the subject of the BERA, additional sediment samples were taken in 2004 from the inner area of Pier 1 to further assess the extent of contamination and better define the boundary between the inner and outer areas of Pier 1, which are being used to support the EE/CA (Battelle, 2007a).

1.2 Regulatory Context

Due to the identification of uncontrolled hazardous waste sites located at the Subase, NSB-NLON was placed on the National Priorities List (NPL) on August 28, 1991 by the USEPA, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, and the Superfund Amendments and Reauthorization Act (SARA) of 1986. In January 1995, the Navy, USEPA, and the State of Connecticut signed the USEPA Federal Facilities Agreement (FFA) for NSB-NLON. The FFA established a procedural framework and timetable for developing, implementing, and monitoring appropriate responses at NSB-NLON, in accordance with CERCLA (and SARA amendment of 1986), the National Contingency Plan (NCP), the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendment (HSWA) of 1984, Executive Order 12580, and applicable Connecticut State laws.

The Thames River Validation Study was conducted, as part of the Navy Installation Restoration Program (IRP), to determine the current nature and extent of contamination along the Lower Subase New London, to assess the current ecological risks posed by the site, and to determine the need for future remedial action. A BERA was performed at the Lower Subase following guidance established by the Navy (DON, 1999). The Navy guidelines were adapted from the United States Environmental Protection Agency (USEPA, 1997) under CERCLA, also known as "Superfund." Steps 1 and 2 of the 8-step USEPA Superfund guidance encompass the screening portion of the ecological risk assessment (Battelle and Neptune & Company, 2004). During the SLERA, conservative exposure assumptions were used to determine which site chemicals posed potential risk and warranted further evaluation in the BERA.

1.3 Site Description and History

Currently, NSB-NLON consists of more than 300 buildings on 687 acres of land; however, the origins of this facility date back to the 1868. Approximately 112 acres of land on the east bank of the Thames River were obtained by the United States Navy (Navy) in 1867, and the parcel was officially designated a Navy Yard in 1868. The site was originally used to moor small craft and obsolete warships and served as a coaling station for the Navy's Atlantic fleet. In 1916, the Navy designated the facility as a Submarine Base. During World War I, infrastructure at the facility was extensively expanded, adding six piers and 81 buildings. In 1917, a Submarine School was established, and in 1918 the Submarine Medical Center was founded. Between 1935 and 1945, the Navy constructed more than 180 buildings and acquired land adjacent to NSB-NLON, expanding the facility from 112 acres to 497 acres. The growth of NSB-NLON continued after World War II. In 1946, the Medical Research Laboratory was established. In 1968, the status of the Submarine School was changed from an Activity to a Command, and the school became the largest tenant on the base. The Naval Submarine Support Facility was established in 1974, and the Naval Undersea Medical Institute was established the following year.

Most of the construction at the Lower Subase south of Pier 15 took place in the early 1900s, with a major expansion from 1935 to 1940. In 1946, the waterfront area to the north of Pier 15 was developed extensively to accommodate berthing of the reserve fleet. The area was dredged and filled, and bulkheads, piers, support buildings, and utilities were constructed. Recently, dredging activities have occurred in the Thames River adjacent to the Lower Subase. Activities were conducted during 1995 and 1996 as part of the Pier 17 Replacement and Seawolf Class Submarine Homeporting projects. In 2006 dredging activities occurred as part of the Pier 6 replacement project and additional maintenance dredging occurred along Piers 10, 12, and 31. Dredged material was disposed at a designated open-water disposal site in Long Island Sound.

Piers 4 and 6 (Zone 4) were removed in 2006 because they lacked sufficient load capacity and were too small to provide adequate berthing for new submarines. A new, larger Pier 6 is under construction several meters upstream of the former Pier 6.

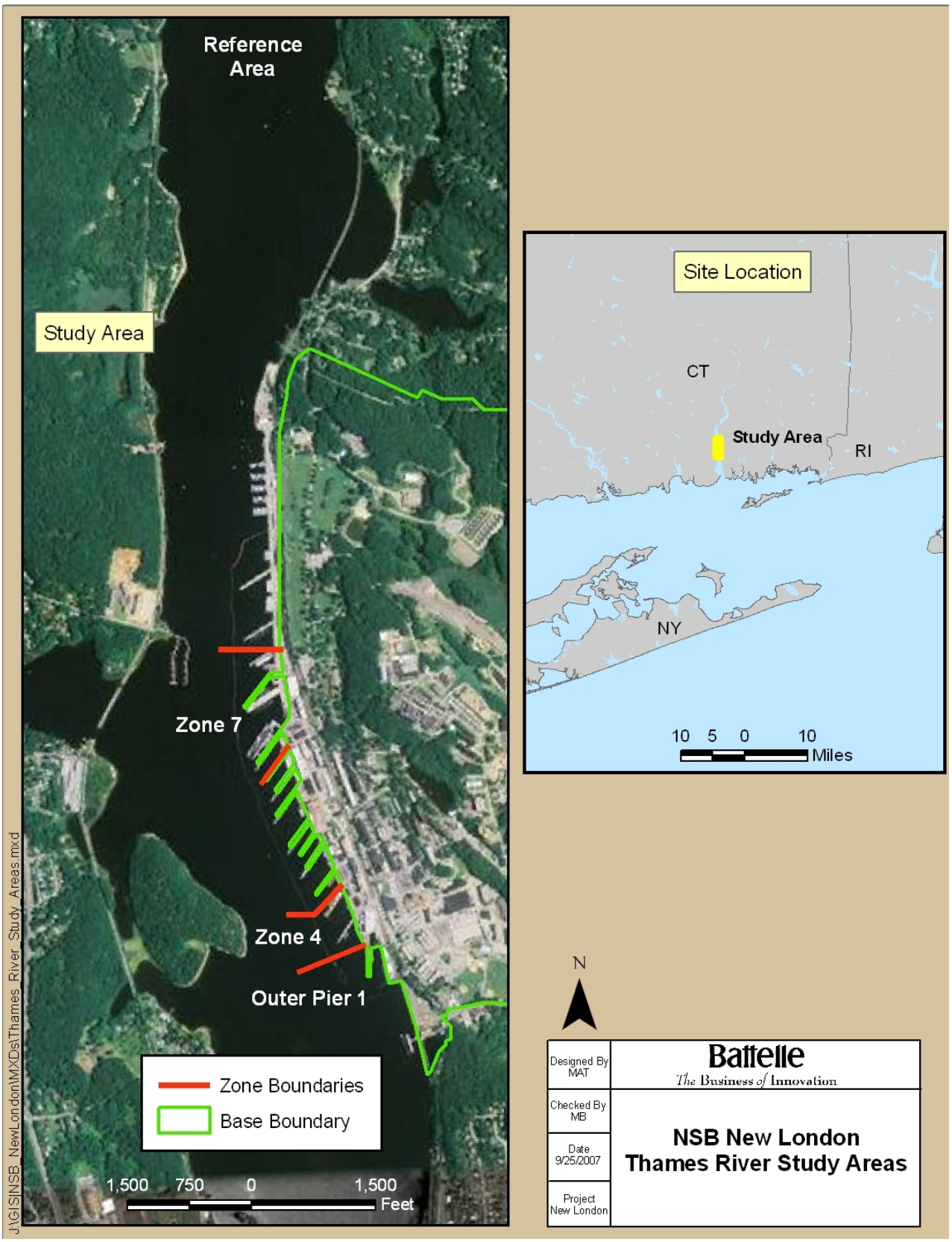

Figure 1-1. NSB-NLON Thames River Validation Study Areas

1.4 Previous Investigations

The results of this Validation Study will be used to supplement prior data that have been collected within Zone 4, Zone 7, and Pier 1 at NSB-NLON. These previous investigations include Phases I and II of a Lower Subase Remedial Investigation (RI), which occurred in all three study areas; an Environmental Assessment (EA) along Pier 15 and Pier 17 (Zone 7) and Pier 6 (Zone 4); and the RSC Pilot Study that took place in Zone 4 and Zone 7. These investigations are described below.

1.4.1 Lower Subase Remedial Investigations

A base-wide RI was completed in two phases (Phases I and II) by Atlantic Environmental (Phase I) and Brown and Root (Phase II). The results of the two RI phases were presented in a Data Summary Report (Brown and Root, 1997). Seven zones were identified by grouping Installation Restoration (IR) sites in close proximity to each other. The areas in the Thames River adjacent to these seven zones were investigated for potential contamination from site-related activities as part of the Phase II RI. Two of these seven offshore zones (Zones 4 and 7) were identified in the Lower Subase RI as posing potential ecological risk based on chemical constituents present in sediment. The data collected during the Phase II RI determined that several metals (chromium, lead, zinc) and organic compounds (e.g., polycyclic aromatic hydrocarbons [PAHs]) were present at concentrations in excess of screening benchmark values based on the protection of aquatic biota. The Phase II RI recommended additional investigation of Lower Subase sites and the adjacent Thames River. Portions of Zones 4 and 7 were subsequently dredged in connection with the homeporting of a new class of submarines.

An additional RI of the Lower Subase was conducted by Brown and Root (1999) to further characterize subsurface soil and groundwater contamination in onshore areas of the Lower Subase, and sediment contamination in adjacent areas of the Thames River. This RI identified the potential for ecological risk in areas of Zones 4 and 7, and recommended further ecological evaluations in these areas.

The Pier 1 Marine Railway area, although not part of the Lower Subase RI, was sampled by Science Applications International Corporation (SAIC) in October 1999 after remnants of marine vessel overhaul activities were discovered during the draining of the railway for a building construction project. The purpose of the investigation was to evaluate whether chemicals from these activities had been released and transported to sediments in the Thames River. Results of this small-scale study indicated that concentrations of metals, PAHs, and polychlorinated biphenyls (PCBs) in sediment exceeded benchmark values, and that chemical concentrations in the Pier 1 area decreased from north to south away from the new building location (SAIC, 2000).

1.4.2 Environmental Assessment

In September 1994, the Maguire Group prepared an EA for the proposed replacement of Pier 17 and dredging alongside Pier 15 in Zone 7. The EA was conducted to determine whether the proposed pier replacement would affect the offshore environment. As part of the EA, surface water, sediment, fish, and benthic tissue samples were collected at, and in the vicinity of, Piers 15 and 17 (Maguire Group, Inc, 1994).

Sediment sampling was performed to characterize the physical and chemical nature of sediments to be dredged around Piers 15 and 17. Sediment samples were collected from the proposed dredging area and analyzed for total organic carbon (TOC), metals, semi-volatile organic compounds (SVOCs), pesticides, and PCBs. Surface sediments (0 to 3 feet) contained higher concentrations of metals and PAHs than deeper sediment layers. Pesticides and PCBs were also detected at low levels in the upper sediment layer. Maximum concentrations were generally detected in the samples collected on the southern side of Pier 17. However, results of a 10-day benthic toxicity test with the amphipod *Ampelisca abdita* showed that

amphipod mortality from exposure to site-specific sediment was not statistically greater than mortality associated with reference sediment. Samples collected adjacent to Pier 17 to assess benthic communities contained a relatively low number of species and individuals. The EA suggested that the results are indicative of an area that was highly disturbed and/or is subjected to stressful environmental conditions. The sample collected from Pier 15 contained a high number of species and individuals, and was more characteristic of organisms (both numerically and in terms of species richness) associated with many areas in the Thames River estuary.

The EA for Pier 6 found that in the vicinity of Piers 4 and 6, chemical constituents in the sediments in the berth areas and under the pier are elevated and potentially impact the benthic invertebrate community and the predators that feed on them, especially in the sediments beneath the pier where localized areas of elevated chemical constituent concentrations occur (Maguire Group, 2004).

1.4.3 Rapid Sediment Characterization Pilot Study

In June 2003, an RSC Pilot Study was conducted by Battelle (2003) to support the SLERA and Step 3a COPC refinement for Zones 4 and 7 (Battelle and Neptune & Company, 2004). The objectives of the RSC Pilot Study were as follows:

- Define the nature and extent of contamination in Zone 4 and Zone 7 surface sediments using both RSC results and fixed laboratory data for a subset of samples;
- Determine if the dredging in Zone 7 effectively removed some or all of the sediments that previously posed a potential ecological concern; and
- Conduct a SLERA and Step 3a COPC refinement for Zones 4 and 7 using the fixed laboratory data.

Results of the RSC Pilot Study revealed that elevated levels of chemical constituents remained in the dredged area footprint within Zone 7. The SLERA and Step 3a refinement identified COPCs for further evaluation in the BERA and was first presented to the regulatory agencies in February 2004 and supplemented the Validation Study Work Plan as Appendix D (Battelle and Neptune & Company, 2004).

1.5 Report Organization

The Thames River Validation Study report is organized as follows:

Section 1.0: **Introduction.** This section presents the site's background and historical information and describes previous investigations that have occurred in the three study areas.

Section 2.0: **Conceptual Site Model.** The results from the Validation Study were used to update and refine the conceptual site model (CSM).

Section 3.0: **Validation Study Data Results**. This section presents a summary of the analytical chemistry results for sediment, tissue, and bioassay samples.

Section 4.0: **Baseline Ecological Risk Assessment**. This section presents the results of the BERA and includes toxicity test results; food-chain modeling results; and comparison of the potential risks in the Thames River Study Areas to background conditions at the upstream Reference Area.

Section 5.0: **Summary and Conclusions**. This section summarizes the results of the Lower Subase Thames River Validation Study.

Section 6.0: **References.** This section presents a bibliography of references.

Supporting information for data analysis is provided in Appendices A through E:

Appendix A: Statistical Approach
Appendix B: Sediment Data
Appendix C: Fish Tissue Data
Appendix D: Bioassay Data
Appendix E: Responses to Comments

2.0 CONCEPTUAL SITE MODEL

This section provides information on and updates the CSM for the Thames River NSB-NLON that serves as the basis for the BERA (Section 4.0). The original CSM that was presented in the Work Plan (Battelle and Neptune & Company, 2004) was based on the results of previous investigations, including the RSC Pilot Study. The CSM has been updated, based on the results of this Validation Study, to represent the current conditions and assumptions for the Lower Subase Study Areas.

2.1 Historical and Potentially Continuing Sources of Contaminants

This section defines the CSM for the Thames River NSB-NLON through the evaluation of historical and continuing sources of chemical constituents, media impacted by those sources, and biotic and abiotic transport mechanisms of the chemicals present at the site. A number of onshore and upstream historical sources of chemical constituents have impacted the Study Areas. Each of these sources is summarized in the following subsections and graphically displayed in Figure 2-1.

2.1.1 Zone 4

Zone 4 extends from the south side of Bullhead Road to the southern boundary of the Lower Subase and includes the following IRP sites: Site 13 - Building 79 Waste Oil Pit; Site 17- Hazardous Material/Solvent Storage Area (Building 31); Site 19 - Solvent Storage Area (Building 316); and the Quay Wall Study Area. Zone 4 was also the location of the coaling station, which operated from the 1870s through the early part of the twentieth century. A severe fire that burned for several days in January 1916 set the coal dump on fire and destroyed the coaling wharfs.

Two areas of significant petroleum accumulation were observed during the manhole inspection of the storm sewers in Zone 4 during the Phase I RI. Thick black oil was identified in an area west of Building 80, on the boundary of Zones 3 and 4. The accumulation appeared to be from product release. There was no evidence of ongoing releases. In the other area, a brown milky oil was identified west of Building 79. The report indicated this oil potentially originated from the former waste pit in Building 79, which serviced diesel train engines in the 1950s. An old drawing shows the outlet from the waste oil pit located 29 feet south of the north side of Building 79. The Phase II RI found relatively high concentrations of total petroleum hydrocarbons (TPH) (maximum - 11,800 mg/kg) in Zone 4 subsurface soil west and adjacent to Building 79, particularly near the waste oil pit at Building 79 (Site 13). It was determined that this soil contained a mixture of No. 6 fuel oil and waste oil. This mixture was also identified in groundwater during the RI investigation. The Building 79 waste oil pit has been filled with concrete, but no remediation of soils in the area has occurred.

Petroleum seeps or sheens have historically been observed at the waterfront near Pier 4, apparently coming out of the Quay Wall. Removal actions were performed in November and December 1994 to remedy petroleum product releases that occurred along the quay wall. A spill response and cleanup contractor retained by the Navy completed cleanup activities along the quay wall. Approximately 2,300 gallons of oily waste water and an equal amount of absorbent pads contaminated with product were generated during cleanup activities. Five product recovery wells (QW-1 through QW-5) were subsequently installed. Oil/water was pumped from the recovery wells four times between December 5 and 21, 1994. A total of approximately 16,000 gallons of oil/water was pumped and containerized. Very little of the liquid was petroleum product, indicating that the cleanup efforts were effective. In addition, five subsurface soil samples were collected from soil borings in the area. Lead was identified as the only chemical of concern in the soil samples. Based on current and anticipated land use of the area, direct

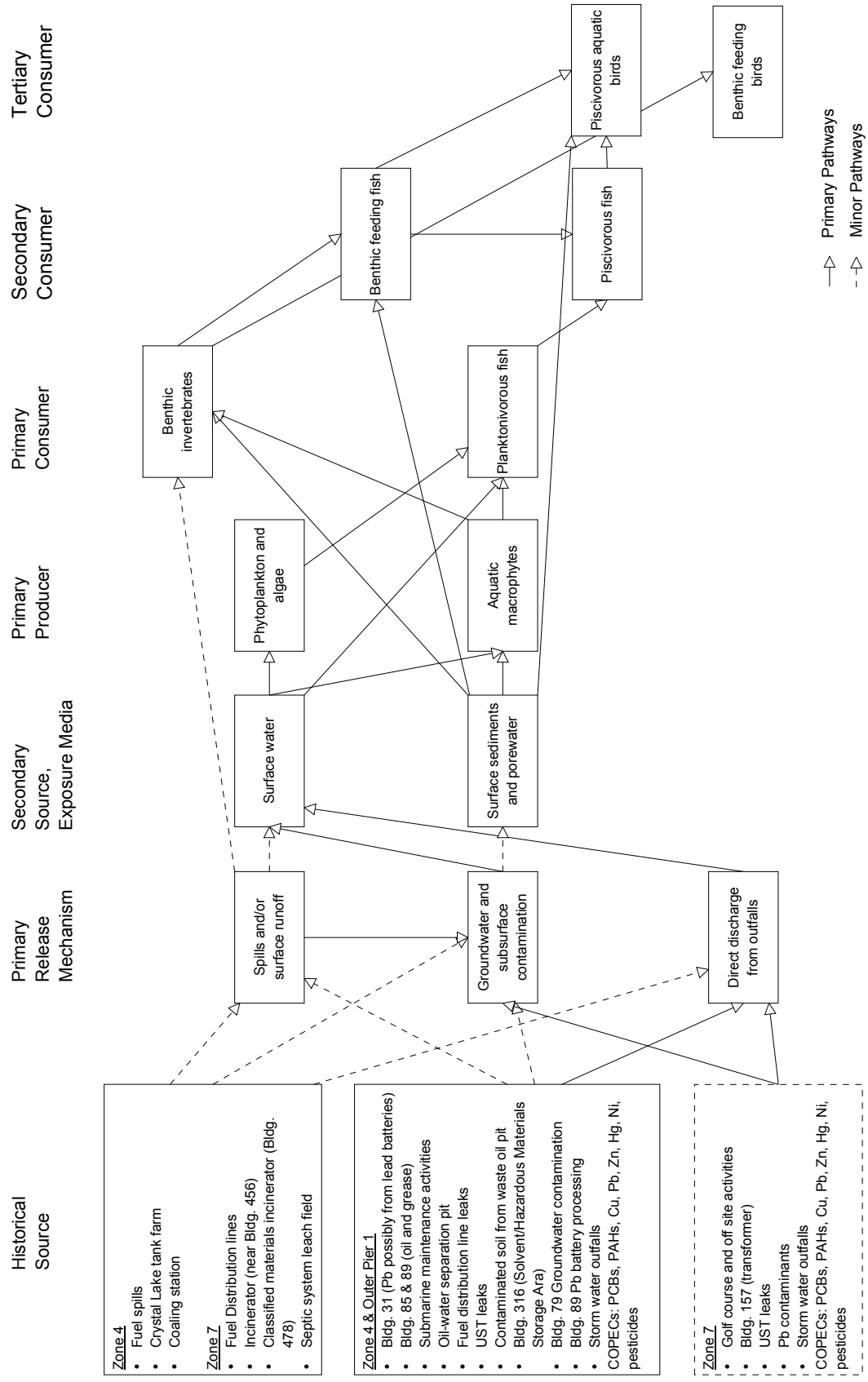

Figure 2-1. Conceptual Site Model for the Thames River Validation Study

exposures to lead were not considered likely to occur except during construction activities. Therefore, the Removal Site Evaluation recommended that no further removal action be performed at that time, but that further site investigations need to focus on lead concentrations. It was estimated that no more than 800 gallons of petroleum were pumped from the void spaces in the quay wall.

With the demolition of Pier 6, approximately 54,000 cubic meters (m^3) of sediments were dredged on the north and south sides of the existing Piers 4 and 6, respectively. Sampling of the sediment and water media at the pier waterfront to determine bulk sediment quality was conducted. Elevated concentrations of heavy metals and PAHs were detected in unconsolidated recently deposited sediments adjacent to the pier and quay wall (Maguire Group, Inc., 2004).

2.1.2 Zone 7

Zone 7 extends from just north of Building 478 to the southern side of Dorado Road and includes the following IRP sites: Site 21 - Berth 16, and transformers at Building 157 Vault 31; and Site 25 - Classified Materials Incinerator. Fuel oil distribution lines were historically located in Zone 7, but they are not currently in use. Steam, condensate, and electrical ducts are also located within Zone 7. Berth 16 formerly included a 250-gallon underground diesel-fuel storage tank located adjacent to the northern wall of Building 157. The storage tank was connected to the diesel-fuel transfer lines and was used to power the emergency generator for the sewage-lift station.

Also included within Site 21 were an electrical substation (Building 173), a periscope shop (Building 157), a photo and electronics lab (Building 106), and two maintenance shops (Buildings 456 and 478). Building 173 formerly had a septic tank and associated leach field, whose locations are not currently known. Site 25 was a classified materials incinerator that operated within Building 97 from 1944 to 1963. The incinerator was used to burn classified materials and other wastes generated at NSB-NLON. The incinerator was demolished in 1979, and Buildings 456 and 478 were constructed on the site. All materials generated by base operations that were not salvageable were incinerated at Site 25. Residual ash produced by incineration was disposed in the Goss Cove Landfill (USEPA et al., 1995).

Adjacent to the incinerator was a dumpster-cleaning operation. The incinerator became inoperable in 1963. Transformers, which formerly contained PCB-based oils, were located in an outdoor electrical vault (Vault 31) at Building 157. The transformers reportedly contained approximately 140 gallons of PCB-containing dielectric fluid. These transformers were replaced by non-PCB transformers, and there are no records indicating that releases of dielectric oil occurred from the PCB-laden transformers before they were replaced. As late as 1954, underground diesel-fuel lines serviced Berth 16. The underground diesel lines currently do not go farther north than Pier 13. The method of abandonment of these lines is unknown. Three storm sewers discharge to the Thames River from Zone 7. Elevations for the storm sewer outfalls to the Thames River and up-gradient catch basins were not readily available, with the exception of Catch Basin No. 899 which is located on the southwest side of Building 478. The invert elevation for Catch Basin 899 was -1.42 feet mean sea level (msl) (*Utility Map, Storm Drainage*, Drawing Number 1142295, Sheet 2 of 19, July 27, 1967). The elevation of the Thames River fluctuates daily and seasonally, but the elevation of the river typically ranges between approximately 0 to 4 feet msl. Therefore, the storm sewer system will be submerged to varying degrees depending on the time of day and time of year (Connecticut Geological and Natural History Survey, 1974).

2.1.3 Pier 1

Pier 1 was the location of a former marine railway that operated from approximately 1930 to 1960. This railway was used to pull ships and submarines out of the water for sandblasting/paint scraping and maintenance. Paint scraping activities often took place on the apron of the pull-out area. PCB transformers were located adjacent to Pier 1. When these transformers were removed, there was no

evidence of staining. The controlled industrial facility (CIF) was constructed across the northern end of Pier 1 in 1998. Preconstruction surveys for the CIF found elevated PAH concentrations in subsurface soil near groundwater, and high concentrations of lead extending down to bedrock. Sediments in the inner area of Pier 1 contain high levels of PAHs and PCBs (SAIC, 2000; Battelle and Neptune & Company, 2004).

Pier 1 has been divided into two subareas (Inner and Outer) based on the extremely elevated concentrations of chemicals in the Inner Area. The evaluation of Outer Pier 1 is included in this report, and Inner Pier 1 is proceeding directly to an EE/CA sediment removal action (Battelle, 2007a [in press]). The boundary between Inner and Outer Pier 1 was identified through an analysis of sediment data collected by SAIC (2000) and Battelle (2003; 2004) (Figure 2-2). The data show that the highest concentrations of chemical constituents are in the Inner Area of Pier 1 between the end of the boat ramp wall in the south, and the CIF building in the north. Based on the chemical constituent analysis and the chemical concentration gradients observed, the boundary separating the Inner and Outer Areas of Pier 1 was set at the end of the boat ramp wall, between sampling locations P1-C2 and P1-C4 (Figure 2-2).

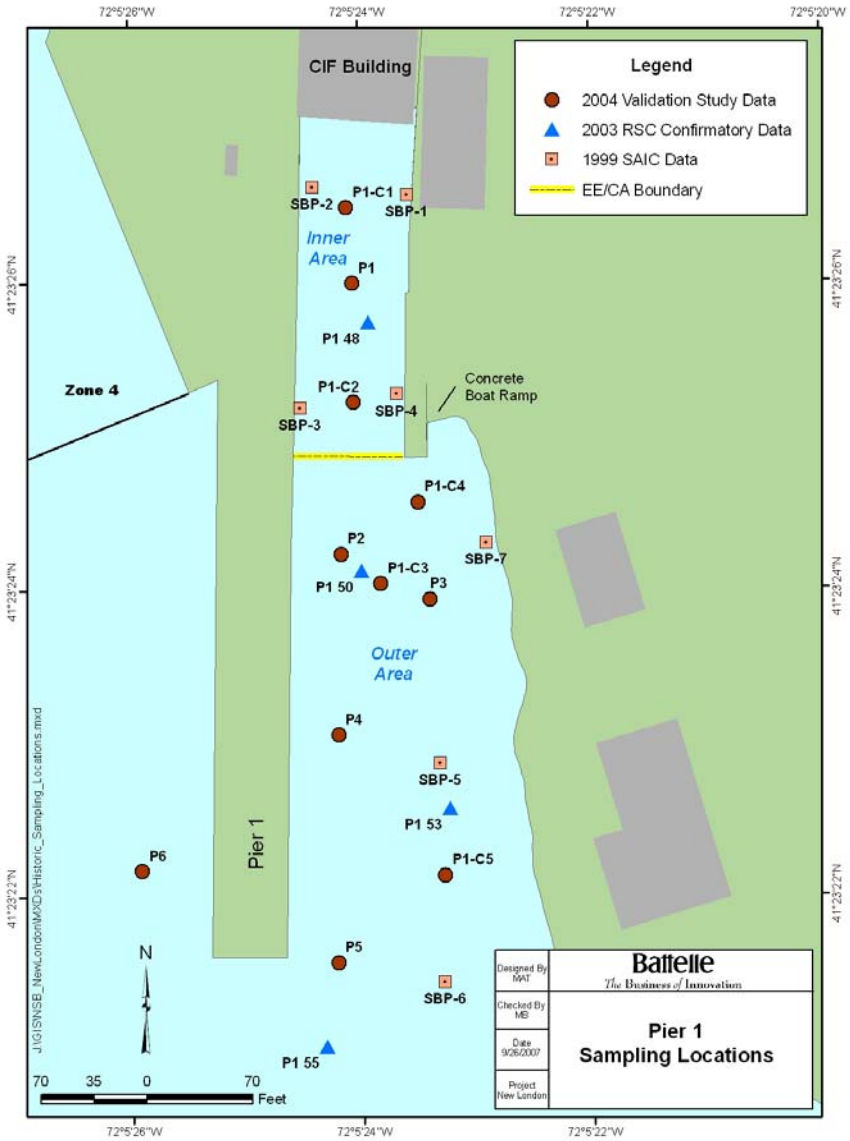

Figure 2-2. Pier 1 Sampling Locations

2.2 Contaminant Transport Mechanisms

A CSM has been developed for the Thames River Validation Study to determine how chemical constituents are physically transported to and within each of the Study Areas, and how they biologically move through the food chain (Figure 2-3).

Surface water transport is considered the primary transport and redistribution mechanism for COPCs in the Thames River Study Areas. Potential primary release mechanisms from NSB-NLON to the Thames River include surface water runoff from potentially contaminated onshore soils, direct discharge from storm and industrial outfalls, and groundwater discharge. Surface water transport occurs from both direct discharges to the river from onshore industrial areas and piers, and from indirect discharge from the storm sewer system at outfalls located in Zone 4 and Zone 7. Deposition of airborne particles may have been an

important historical transport pathway for discharges from the former incinerator located in Zone 7, and the coaling dock fire in Zone 4.

Food-chain transport is also considered a complete transport and exposure pathway for ecological receptors in the Thames River Study Areas. The lipophilic nature of PCBs and chlorinated pesticides can result in transfer of these chemicals through the food chain, making bioaccumulation a pathway of concern for upper-trophic receptors in the area. A generalized food web is presented in Figure 2-3, and the role of the proposed measurement endpoints in the food-web are discussed in the BERA (Section 4.0).

2.3 Contaminated Media

The primary contaminated medium in Zones 4, 7, and Outer Pier 1 is surface sediment. Data collected during the Lower Subase RI determined that sediments in these areas contained elevated levels of some metals, PAHs, and PCBs. It should be noted, however, that the results of the SLERA indicate that PAHs and PCBs are not bioaccumulating to levels that would cause harm in these areas. Surface water, although a transport mechanism for suspended particulates, is not a media of concern. The relatively insoluble nature of the COPCs and the constant flushing of water due to downstream flow of the river limits the dissolved fraction available to water column feeding organisms.

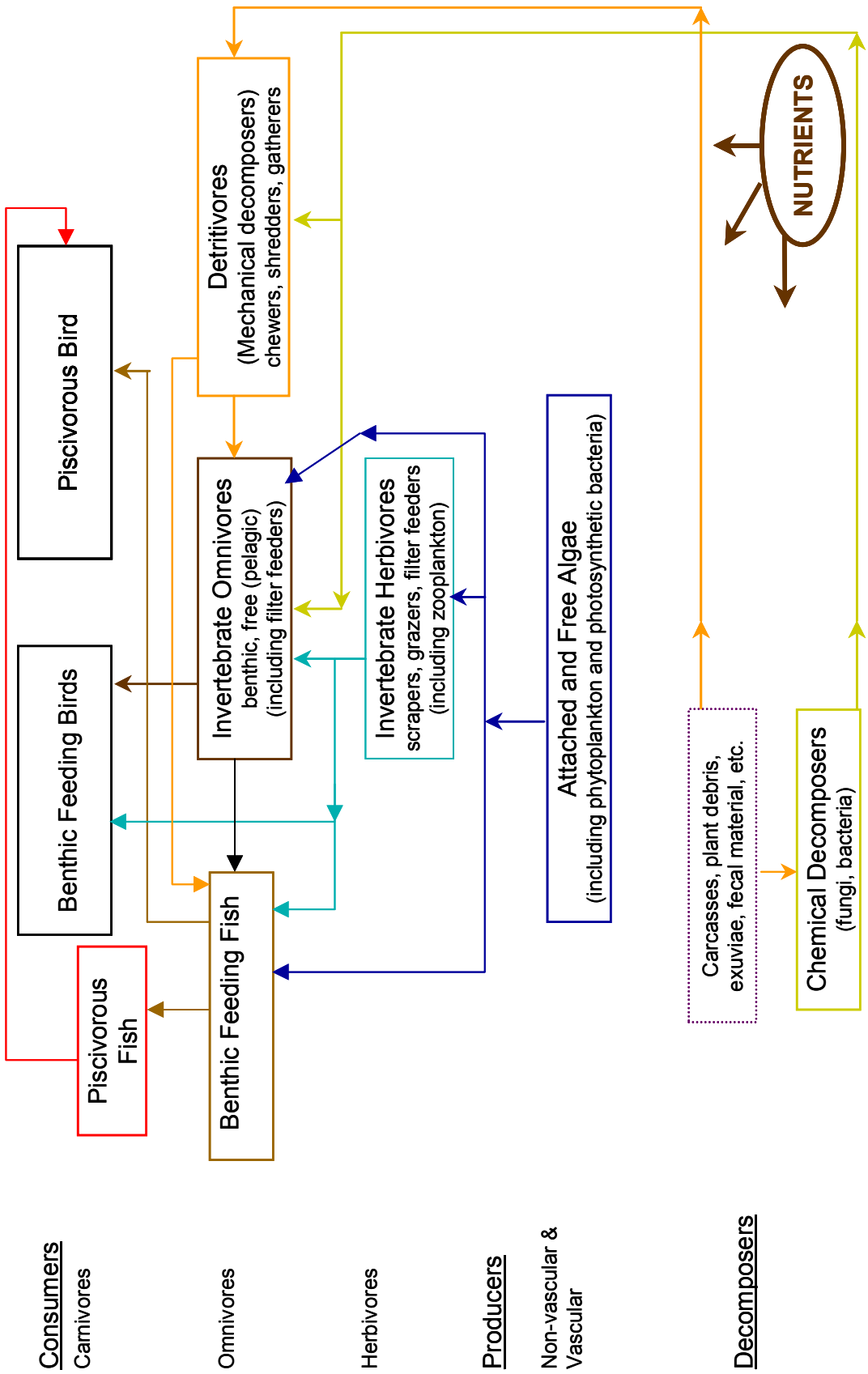

Figure 2-3. General Food Web for the Thames River Validation Study

2.4 Ecological Setting and Exposure Pathways

The Thames River is a salt wedge estuary that is highly stratified, with fresher water on the surface and denser saline water on the bottom. Along the Lower Subase, the measured tidal range is about 2.2 feet. The width of the river ranges from approximately 1,300 to 3,000 feet, and the width of the dredged channel ranges from 600 to 900 feet. Outside the channel (near the western shore of the river), river depths are relatively shallow (2 to 10 feet). There are shallow coves upstream and downstream of NSB-NLON, most of which are at least partially cut off from the river by a rail bed.

The Thames River at NSB-NLON supports a variety of invertebrate and bird life. A generalized food web for Zone 4, Zone 7, and Outer Pier 1 is presented in Figure 2-3. Since the habitat in each of these three areas is the same, biotic communities are also expected to be the same.

Much of the existing data on the benthic invertebrates in the Thames River were collected in support of proposed dredging projects. The most comprehensive study was performed for the draft Environmental Impact Statement (EIS) for the Seawolf project (DON, 1991). The draft EIS document compared data collected during that survey with previous benthic surveys performed in the Thames River. Applied Science Associates (ASA, 1989) also provided a comprehensive summary of benthic data from the Thames River. Benthic communities in the river differ from south to north and between channel and non-channel areas. Since most of the benthic surveys of the Thames River have been performed in anticipation of dredging, the work has focused on the channel. The benthic communities south of the I-95 bridge (two miles south of NSB-NLON) are more representative of Long Island Sound. As is expected in an estuary, benthic abundance and species richness decreased from the mouth of the river north to NSB-NLON (Maguire Group, Inc., 1990). Species composition is similar in the area north of the I-95 bridge, but abundances are lower, probably due to the shallower, less saline water in this area. Species composition in the channel is dominated by several taxa, including bivalves and polychaetes.

Taxa identified in the Thames River benthic samples collected in November 1993 during studies conducted in support of the Phase II RI included nemertean, turbellarian, and annelid worms; gastropods; bivalves; crustaceans; and a few species of other phyla (Brown and Root, 1997). A few species of annelid worms were dominant at most of the Thames River benthic stations. These included *Mediomastus ambiseta, Cossura longocirrata,* and *Streblospio benedicti. M. ambiseta* accounted for 12 to 55 percent of individuals at each station. The mollusks *Mulinia lateralis, Yoldia limatula, Tellina agilis, Mya arenaria* (softshell clam), and *Nucula annulata* were relatively abundant at some stations. The only crustacean observed at most stations was the amphipod *Ampelisca abdita.* The mean number of individuals per station in the Phase II RI samples ranged from 178 to 1,242. The total number of taxa per station ranged from 18 to 55.

The EA conducted as part of the April 1994 study for the Pier 17 replacement (Maguire Group, Inc., 1994) included the collection of three samples for benthic analysis. These samples found species assemblages as observed in the Phase II RI. Most of the Thames River is closed to recreational shellfishing due to contamination by fecal bacteria (Citak, 1991). Shellfish beds in a few areas of the river are open to commercial shellfishing on a conditionally restricted basis. Conditional restriction means that shellfish from these areas must be depurated in approved waters for 45 days. Shellfish in these beds include hardshell clams *(Mercenaria mercenaria)* and oysters *(Crassostrea virginica).* The conditionally restricted shellfish beds are located in the town waters of Waterford and Ledyard.

Some commercial lobstering occurs in the river, mainly in the areas south of the I-95 bridge, which is over 1.5 miles downstream of NSB-NLON. Recreational fishing for blue crab also occurs along the river, especially in the shallower waters of the coves during the summer months. Recreational crabbing usually

occurs in July, August, and September (McLeod, 1993). When the water gets colder, blue crabs move into deeper water and south toward Long Island Sound. Abundant fish species in the Thames River include winter flounder, tomcod, and window pane flounder in the deeper channel areas and mummichog and striped killifish near shore. The Thames River also serves as a feeding area for long-range coastal migrant fish such as menhaden, bluefish, striped bass, and mackerel, and seasonal migrants such as tautog, weakfish, porgy, and whiting. Striped bass also overwinter in the estuarine portion of the Thames River. An important recreational fishery in this area is based on striped bass (Minta, 1992). Historically, the construction of dams on the Shetucket and Yantic Rivers has limited the use of anadromous fish runs in the Thames River to species that could spawn and survive below these dams (Minta, 1992). Prior to construction of the dams in the 1800s, the river supported many anadromous species including Atlantic salmon and Atlantic sturgeon. Currently, the only anadromous species known to spawn in the vicinity of Norwich are alewife, blueblack herring, and rainbow smelt. A small recreational fishery for American shad exists in the Shetucket River upstream of the Thames River estuary.

Bird species observed frequently on the river include herring gulls, great black-backed gulls, cormorants, and mute swans. Many duck species, in particular mallards, are observed on the river and overwinter in the coves around Mamacoke Island, opposite the river from NSB-NLON (Askins, 1994). During the winter, up to 1,000 ducks have been observed. These include large numbers of canvasback ducks, hooded mergansers, mallards, black ducks, gadwalls, and redhead ducks. Greater scaup and common goldeneye use the area temporarily. The areas around Zones 4 and 7, and Outer Pier 1 are too deep to be utilized for feeding by mallards, black ducks and swans, which, because they do not dive to obtain food, only feed in shallow areas. Gulls may feed on small fish at the water surface in these areas, but do not have contact with sediment or sediment dwelling organisms. Sediments in the majority of Zones 4 and 7 are beyond the diving depth of invertebrate-feeding diving ducks such as greater scaup and redheads, as well as wading birds. Cormorants, which are piscivorous, likely have the greatest potential for contact with sediment, as they can dive to depths in excess of 25 feet and may eat benthic-dwelling fish that have higher sediment exposure than fish inhabiting upper layers of the water.

Visits to the site revealed that the shoreline along the subase is highly developed and access to the waterfront area by terrestrial or semi-aquatic mammals is limited. In addition, no suitable habitat exists in Zone 4, Zone 7, or Outer Pier 1 for aquatic mammals.

Although two State terrestrial endangered species have been sighted in the NSB-NLON area (the plants *Zizia aptera* and *Ranunculus cymbalacia)* there are no aquatic endangered species that utilize NSB-NLON (Askins, 1994). One State threatened species, the Atlantic Sturgeon (*Acipenser oxyrhynchus)*, has the potential to be found in the Thames River adjacent to NSB-NLON.

Complete ecological exposure pathways that will be evaluated in the BERA are direct contact and sediment ingestion by benthic invertebrates and food chain and incidental sediment ingestion by piscivorous birds. Complete exposure pathways to invertebrate-feeding birds are assumed to be minimal due to the water depths in Zone 4, Zone 7, and Outer Pier 1. There are no complete exposure pathways to riparian or aquatic mammals due to lack of suitable habitat and lack of shoreline access.

2.5 Contaminants of Potential Concern

This section provides a general overview of contaminant toxicity and bioaccumulation, as they apply to the CSM and the COPCs evaluated in the risk assessment.

2.5.1 Metals

Ten metals were identified and analyzed as COPCs in sediments from the Thames River Study Areas: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se), and zinc (Zn). Each is discussed below.

The solubility of inorganic arsenic is greatly influenced by its chemical form and by pH. In acidic and neutral waters, As(V) is strongly sorbed to sediments, while As(III) is only weakly sorbed. Data from studies on experimental animals indicate that trivalent inorganic arsenic (As[III]) is more toxic than pentavalent. It is also evident that arsenic in solution is more toxic than undissolved arsenic, probably because of better absorption. Arsenic in the body targets cell mitochondria, and exposure has been tied to developmental and genotoxic effects in animals (ATSDR, 2000a).

Barium is an inorganic constituent for which little toxicity information is available. It is known to exhibit some toxicity, however is not bioaccumulative. It is distributed widely in soils and sediments, and in aquatic forms occurs in both soluble and insoluble forms.

Cadmium is more mobile in aquatic environments than many metals. Sorption to sediment is greatest in sediments with high organic content, although changes in pH and redox potential of the waterbody can greatly influence movement of cadmium between water and sediment. During anaerobic conditions, cadmium is more likely to be released from sediment to water. In mammals and birds, the liver and kidneys are the primary organs affected by cadmium toxicity. Ingestion of cadmium has also been shown to result in iron-poor blood in animals (ATSDR, 1999a). Cadmium also binds to the epithelial cells of gills in fish, resulting in respiratory problems.

Chromium toxicity is highly influenced by the valence state of chromium present in the sediment. In the Thames River surface sediment, Cr(III) is the most likely valence state, since chromium(VI) forms in anaerobic subsurface sediment only under strong reducing conditions. Mammalian toxicity of ingested Cr(III) is low, and the metal is considered an essential nutrient. Similar to lead, chromium has low solubility and is likely to remain sorbed to sediment particles.

Copper binds strongly in sediments with organic matter and iron oxides, so transport in sediments along the Thames River in the dissolved state is not expected to be great. Copper has been shown to bioconcentrate in fish, but biomagnification up the food chain does not occur. Copper in small amounts is a necessary essential nutrient, but in large amounts can cause liver and kidney damage, and effects on the blood (ATSDR, 1990a). Copper binds to fish gills, causing tissue necrosis of the gills and impaired respiratory function in fish (Rand and Petrocelli, 1985).

Lead is not very mobile in surface waters, due to its low solubility. Movement of lead is most likely to occur as a result of resuspension and movement of sediment particles to which lead has adsorbed. In animals, lead has been shown to impact many organs in the body, with the central nervous system, kidneys, and reproductive system being the most sensitive (ATSDR, 1999b).

Mercury can occur in aquatic sediment in two forms: inorganic mercury and methylated mercury. Inorganic mercury sorbs to organic material in sediment at pH greater than 4, and once sorbed to particulate matter, does not readily desorb. This makes sediments an important repository for mercury in the environment. Inorganic mercury can be converted to methylmercury in a process mediated by various microorganisms under both aerobic and anaerobic conditions. Methylmercury is the most hazardous form of mercury due to its stability, high affinity for lipids, and its ability to penetrate membranes in living organisms. Methylmercury is rapidly accumulated by aquatic organisms and biomagnified up the food chain. The central nervous system and the kidneys are the two most sensitive organs to mercury

exposure, and studies have documented adverse impacts to reproduction and development due to long term exposures to mercury (ATSDR, 1999c). Inorganic mercury does not bioaccumulate.

Nickel in aquatic environments tends to bind with iron oxides in the sediment. Ingesting large amounts of nickel has been demonstrated to cause lung disease in mammals, and adversely impact blood, liver, kidneys, immune system, and reproduction and development (ATSDR, 1997).

Selenium combines with oxygen and sulfide minerals in the environment to form a variety of compounds, some of which have a high degree of solubility in water. In animals, selenium can replace sulfur molecules in the body, targeting the lungs, and subsequent cardiovascular, hepatic, and renal systems. Selenium has been demonstrated to bioconcentrate in aquatic organisms, and high levels of ingested selenium can result in reproductive effects in mammals and malformations in birds (ATSDR, 1996).

Zinc released into aquatic systems primarily settles into bottom sediments. Highest adsorption of zinc to sediments occurs at pH values greater than 7 and under low salinity conditions. Zinc is actively bioaccumulated in aquatic systems, and bioavailability and toxicity are highest under conditions of low pH, low alkalinity, low dissolved oxygen, and elevated temperatures. As with copper, zinc interferes with fish respiration through binding to gill epithelia (ATSDR, 1994).

2.5.2 Organic Constituents

A variety of organic constituents were analyzed for in sediment from the Thames River Study Areas. They include PAHs, PCBs, and pesticides. Each is described below.

PAHs are a group of aromatic compounds that contain two or more benzene rings. They are considered to be one of more acutely toxic fractions of petroleum and are found in crude oil, used motor oil, incompletely burned coal, and creosote. Frequently, PAHs are subdivided into two classes: low molecular weight PAHs (LMW PAHs) with two or three rings, and high molecular weight PAHs (HMW PAHs) with more than three rings. In marine environments, HMW PAHs are removed from the water column primarily by volatilization and adsorption to suspended sediments; the LMW PAHs are removed mainly by volatilization and biodegradation. PAHs have been shown to bioconcentrate in aquatic plants and invertebrates, but since many vertebrates, including fish, can metabolize PAHs, biomagnification is not a significant concern. Exposure to PAHs has been shown to cause reproductive impairment and birth defects in mice (ATSDR, 1995).

PCBs in aquatic systems are persistent, relatively insoluble in water, and have a high affinity for organic matter in sediments. Like other organochlorine compounds, PCBs are lipophilic, and have been demonstrated to bioaccumulate in aquatic organisms and biomagnify to higher trophic levels. Toxic mechanisms differ among PCB congeners, with some groups of congeners exhibiting endocrine disruption, neurotoxicity, carcinogenicity, or teratogenicity. Exposure to PCBs has been shown to cause liver and kidney damage in mammals, and growth and reproductive effects in fish and birds (ATSDR, 2000b).

Chlorinated pesticides, including DDx compounds (i.e., DDT and its metabolites [DDE and DDD]), aldrin, chlordane, and dieldrin, are widespread in aquatic systems due to their past use as pesticides and their persistence in the environment. These pesticides bind tightly to organic material in sediment, and because of their lipophilic properties, biomagnify through the food chain. Acute doses of these pesticides in animals affect the central nervous system, which can cause tremors, seizures, and death.

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3.0 VALIDATION STUDY DATA RESULTS

3.1 Summary of Data Quality Objectives

The data quality objectives (DQOs) for the Thames River Validation Study were specified in the Validation Study Work Plan (Battelle and Neptune & Company, 2004) and were designed to answer the primary overarching question:

> "Are exposures to elevated chemical constituents in Zone 4, Zone 7, and the outer area of Pier 1 posing unacceptable risk to ecological receptors inhabiting each of those areas and thus require the need for consideration of further risk management action?"

The DQOs were based on the CSM and ecological setting presented in Section 2.0, with each line of evidence having its own set of DQOs. These DQOs specify the data to be collected and the interpretation of that data. They are presented in Appendix A: Table A-1 DQO for sediment chemistry, Table A-2 DQO for invertebrate toxicity, and Table A-3 DQO for upper-trophic level dose modeling.

Because adequate numbers of fish could not be collected from each area, comparison of NSB-NLON fish tissue concentrations to Reference Area concentrations could not be conducted as specified in the DQO for modeling to upper-trophic level receptors (Table A-3). The utility of the fish tissue data for use in the BERA and the revised manner in which it was used for risk purposes are discussed in Section 3.3. Specific decision rules for interpreting the magnitude and extent of risk associated with each line of evidence were also presented in the Work Plan (Battelle and Neptune & Company, 2004) and are discussed further in the ecological problem formulation in the BERA (Section 4.1)

3.2 Sediment Chemistry Results

This section presents the results of the 2004 and 2007 surface sediment chemistry analyses, and the 2004 fish tissue chemistry analyses. Any specific quality control issues are discussed in their appropriate sections. Details of the specific sample collection details can be found in the Thames River Validation Study Work Plan (Battelle and Neptune & Company, 2004), the Thames River Validation Study Work Plan Addendum (Battelle and Neptune & Company, 2007), and the Thames River Validation Study Survey Reports (Battelle, 2004; 2007b).

Surface sediment grab samples were defined as the upper 5 cm of sediment. This definition was used to ensure that the collected samples represented the biotic zone of the sediment, thereby avoiding potential confounding issues associated with ammonia production in the invertebrate bioassays. In addition, this top layer of sediment is most available to ecological receptors by direct contact, thereby causing the most potential for unacceptable ecological risk. Six surface sediment samples were collected in 2004 from Zone 4, six from Zone 7, five from Outer Pier 1, and six from the Reference Area, for a total of 23 surface sediment samples. All samples were analyzed for conventional parameters (grain size, total organic carbon [TOC], and acid volatile sulfides/simultaneously extracted metals [AVS/SEM]), metals, PAHs, pesticides, and PCBs. Sampling locations for Zone 7, Zone 4, and Outer Pier 1 are shown in Figures 3-1 through 3-3.

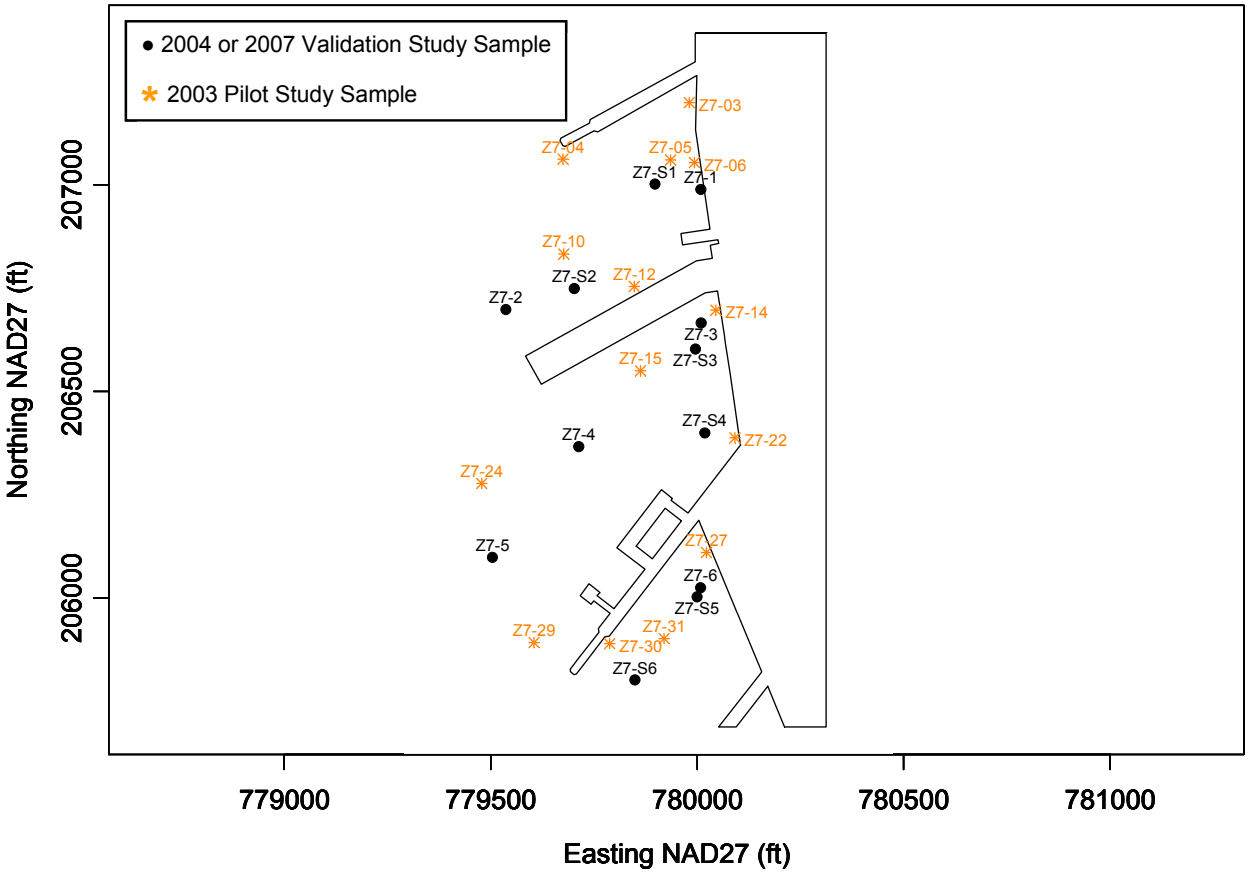

Figure 3-1. Zone 7 Sampling Locations

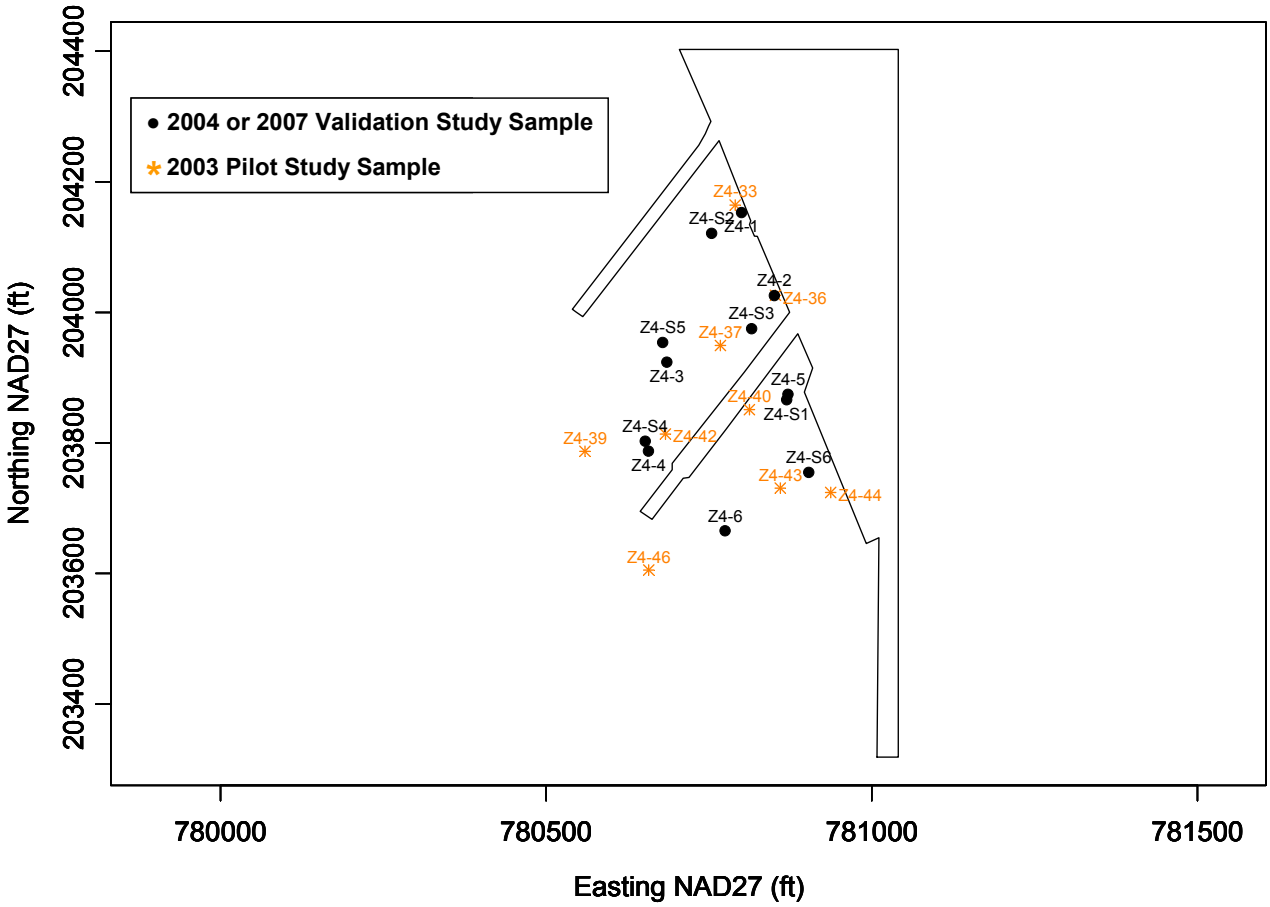

Figure 3-2. Zone 4 Sampling Locations

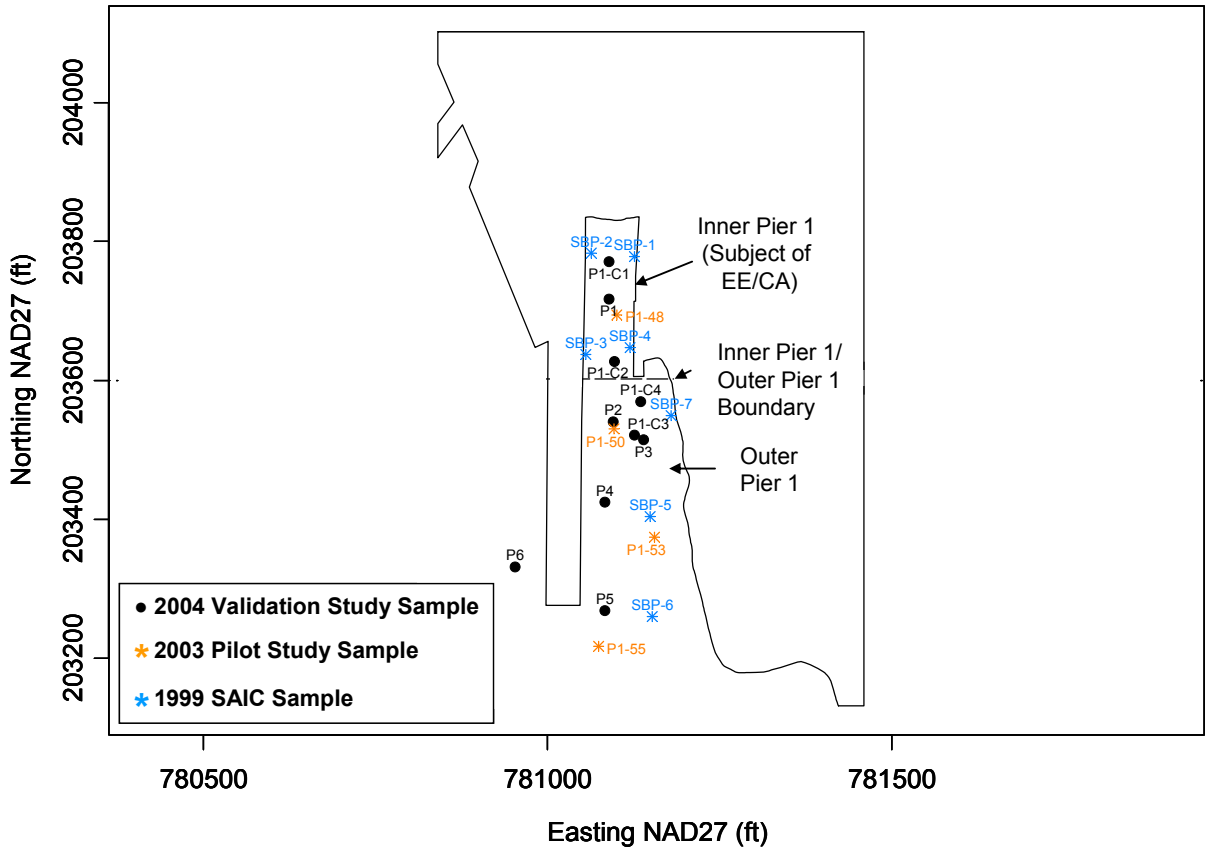

Figure 3-3. Pier 1 Sampling Locations

Following the data validation process, results for each NSB-NLON Study Area (Zone 4, Zone 7, and Outer Pier 1) were evaluated spatially for trends in the COPC results. They were also compared to Reference Area samples to identify areas where chemical concentrations were elevated relative to regional background concentrations.

3.2.1 Data Analysis Conventions

This section is a brief summary of how the dataset was prepared for analysis and a brief discussion of the statistical evaluations. Details of the actual data analyses and evaluation are presented in Appendix A. Bivariate plots, bubble plots, and box plots for sediment and bioassay samples are also shown in Appendix A.

The sediment, tissue, and bioassay results for the Thames River Validation Study were compiled and loaded into a database prior to data evaluation. Complete sediment chemistry results, quality control narratives, and quality control data are provided in Appendix B. Sediment core data were collected from each area for use in the FS for estimating volumes associated with any potential remedial footprint and are included in Appendix B. Fish tissue data results are provided in Appendix C and bioassay results are provided in Appendix D.

Data summations were calculated for Total PCBs, Total DDx, Total LMW PAHs, and Total HMW PAHs. For all of these total values, when a sample was not detected above the reporting limit, the value was included in the summation at one-half the reporting limit. The impact of including non-detects at one-half the reporting limit is negligible due to the low achieved detection limits and the rarity of non-detects in the datasets.

The sediment and bioassay results were reviewed for spatial patterns. Statistical comparisons between areas were performed, summary statistics were generated, and risk parameters were calculated. Sediment exposure point concentrations (EPCs) were calculated for Zone 4, Zone 7, Outer Pier 1, and the Reference Area. Background comparison tests (distribution shift tests) were used to compare the NSB-NLON data to the Reference Area data. The parametric *t*-test (Zar, 1984) and Gehans modification to the non-parametric Wilcoxon Rank Sum test (Gehan, 1965) evaluate complete shifts between distributions (i.e., characterized by differences between the centers of the distributions); the quantile and slippage tests (Gilbert, 1987) are used to evaluate partial differences between two distributions (i.e., characterized by differences in the upper tails of the distributions). Altogether, these tests evaluate distributional shifts between the Reference Area and Study Area data. The EPC results and background comparison results are presented later in this section.

3.2.2 Conventional Parameters

Grain size, TOC, and AVS/SEM data results for surface sediment samples are presented in the following sections.

3.2.2.1 Grain Size

Grain size data are summarized as percentages of clay, silt, sand, and gravel (Table 3-1). Percent fines (silt plus clay fractions) were also calculated for evaluation. All six of the Zone 7 locations sampled in 2004 contained percent fines in excess of 95%. Five of the six Zone 7 locations sampled in 2007 contained percent fines greater than 90%. The remaining 2007 location (Z7-1) was primarily sand, with percent fines less than 25%. Zone 4 sediments contained a wider range of grain size distributions in both 2004 and 2007, with four of the 12 sampling locations containing less than 50% fines, and five of the 12 sampling locations greater than 90% fines. Locations Z4-S6, Z4-1, and Z4-2 were primarily comprised of sand, while Z4-S1 was primarily comprised of sand and gravel. All five of the Outer Pier 1 samples were dominated by fine-grained material, with percent fines ranging from a low of 76.1% to a high of 94.2%. Reference Area sediments were generally sandier than NSB-NLON sediments, with only a single sampling location consisting of greater than 90% fines. The remaining 11 Reference Area locations ranged from 40% to 75% fines.

3.2.2.2 Total Organic Carbon

Total organic carbon influences the sediments ability to bind organic constituents. TOC data are presented in Table 3-1. TOC in Zone 7 ranged from 28,000 mg/kg dry weight at location Z7-1 to 91,200 mg/kg dry weight at location Z7-S2. Lower TOC values are generally associated with coarser grained sediments, which holds true in all of the NSB-NLON Study Areas. TOC in Zone 4 ranged from 19,300 mg/kg at location Z4-S6 to 65,200 mg/kg location Z4-3. Consistent with its narrow distribution of grain sizes, Outer Pier 1 had a narrower range of TOC concentrations than the other NSB-NLON areas, with TOC ranging from 39,700 mg/kg to 56,300 mg/kg. Reference Area TOC was, on average, lower than NSB-NLON areas, consistent with the Reference Area's coarser grain sizes. Six of the 12 Reference Area samples had TOC concentrations less than 30,000 mg/kg and 11 of the 12 samples had TOC less than 50,000 mg/kg. The remaining reference sample with a TOC of 102,000 mg/kg was also the finest-grained Reference Area sample (RA-6).

3.2.2.3 Acid Volatile Sulfides/Simultaneously Extracted Metals

An AVS/SEM sample was collected in the field from the top 5 cm in each of the surface sediment samples. This analysis provided the concentration of specific metals (Cd, Cu, Ni, Pb, Ag, Zn, and Hg) associated with sulfides in the sediments. When evaluating the data, an SEM/AVS ratio is calculated by summing the concentrations of the SEM and dividing by the AVS concentration. The SEM/AVS ratio is used as an indicator of potential bioavailability of metals in the sediment. An SEM/AVS ratio greater than 1 is used as a rule of thumb for indicating potentially bioavailable metals, and therefore a higher likelihood of toxicity; a ratio less than 1 indicates less likelihood of bioavailability and toxicity.

Two Zone 7 samples and three Zone 4 samples had SEM/AVS ratios greater than 1 (Table 3-1). Locations Z7-4 and Z7-6 in Zone 7 had SEM/AVS ratios of 1.1 and 1.4 respectively. Zone 4 locations Z4-S1 and Z4-2 both had SEM/AVS ratios in excess of 2 (2.5 and 2.2, respectively), while location Z4-1 had a SEM/AVS ration of 1.2. The three Zone 4 locations with SEM/AVS greater than 1 are all located near the quay wall, where chemical concentrations are also highest. The implications of the SEM/AVS ratio with regard to the invertebrate toxicity testing are discussed further in the BERA (Section 4.0). Outer Pier 1 SEM/AVS ratios were all less than 1, with a maximum of 0.18 measured at location P3. SEM/AVS ratios in the Reference Area sediments ranged from 0.11 in station R-S2 to 1.2 in RA-4. Two 2007 Zone 7 sampling locations and three 2007 Reference Area locations had AVS reported as non-detects, and are therefore shown to have SEM/AVS rations of "NA" (not applicable).

Table 3-1. Conventional Parameters in Surface Sediment Samples

Station ID	Year Collected	Sample ID	Percent Clay	Percent Silt	Percent Sand	Percent Gravel	Percent Fines	Ratio of SEM/AVS	TOC (mg/kg dry wt)
Zone 7									
Z7-S1	2004	DAD-10	43.5	54.4	2.1	0	97.9	0.82	44400
Z7-S2	2004	DAD-11	26.5	71	2.5	0	97.5	0.82	91200
Z7-S3	2004	DAD-12	37.1	60.5	2.5	0	97.6	0.17	53800
Z7-S4	2004	DAD-13	40.9	56.1	3.0	0	97.0	0.68	51700
Z7-S4R	2004	DAD-14	33.4	62.9	3.7	0	96.3	0.48	81500
Z7-S5	2004	DAD-15	36.7	60.4	2.9	0	97.1	0.46	48600
Z7-S6	2004	DAD-16	50.5	48.4	1.0	0	98.9	0.55	48000
Z7-1	2007	GAB-7	8.1	16.3	71.0	4.6	24.4	0.48	28000
Z7-2	2007	GAB-8	28.6	65.1	6.3	0	93.7	NA	60000
Z7-3	2007	GAB- 9	26.2	67.9	5.8	0.2	94.1	0.42	57200
Z7-4	2007	GAB-10	33.5	62.2	4.2	0.1	95.7	1.1	53000
Z7-5	2007	GAB-11	28.4	59.5	11.5	0.5	87.9	NA	44200
Z7-6	2007	GAB-12	28.9	65.8	3.7	1.5	94.7	1.4	58400
Zone 4									
Z4-S1	2004	DAD-1	15.3	13.2	36.6	34.8	28.5	2.5	27600
Z4-S2	2004	DAD-2	22.3	69.7	8.1	0	92.0	0.12	52400
Z4-S3	2004	DAD-3	26.1	60	13.8	0	86.1	0.25	50200
Z4-S4	2004	DAD-4	23.7	68.9	7.4	0	92.6	0.088	50200
Z4-S5	2004	DAD-5	30.8	65.2	4.0	0	96.0	0.54	42700
Z4-S6	2004	DAD-6	16.2	24.9	57.4	1.5	41.1	0.54	19300
Z4-S6R	2004	DAD-7	12.7	40.4	46.3	0.7	53.1	0.73	25600
Z4-1	2007	GAB-1	14.0	24.6	53.7	7.8	38.6	1.2	48700
Z4-2	2007	GAB-2	12.6	22.0	50.1	15.3	34.6	2.2	45800

Table 3-1. Conventional Parameters in Surface Sediment Samples (continued)

Station ID	Year Collected	Sample ID	Percent Clay	Percent Silt	Percent Sand	Percent Gravel	Percent Fines	Ratio of SEM/AVS	TOC (mg/kg dry wt)
Z4-3	2007	GAB-3	21.4	71.4	6.7	0.5	92.8	0.27	65200
Z4-4	2007	GAB-4	24.0	69.0	6.4	0.5	93.0	0.26	55000
Z4-4D	2007	GAB-20	21.1	71.7	7.3	0	92.8	0.73	44900
Z4-5	2007	GAB-5	30.5	39.4	26.2	3.9	69.9	0.66	31800
Z4-6	2007	GAB-6	26.2	59.4	13.3	0.9	85.6	0.098	46200
Outer Pier 1									
P2	2004	DAD-21	16.4	71.7	21.8	0	78.1	0.089	56300
P3	2004	DAD-22	28.1	54.9	16.5	0.6	83.0	0.18	45400
P4	2004	DAD-23	16.2	76.7	7.1	0	92.9	0.09	39700
P4R	2004	DAD-24	21.8	70.8	7.4	0	92.6	0.051	45300
P5	2004	DAD-25	26.2	68	5.8	0	94.2	0.086	52300
P6	2004	DAD-26	17.7	58.4	23.9	0	76.1	0.13	42500
Reference Area									
R-S1	2004	DAD-32	11.1	56.2	32.6	0	67.3	0.39	34400
R-S2	2004	DAD-33	10.4	41.6	48.0	0	52.0	0.11	21300
R-S3	2004	DAD-34	18.8	34.2	43.4	3.6	53.0	0.26	25400
R-S4	2004	DAD-35	11	33.7	55.2	0	44.7	0.25	21100
R-S5	2004	DAD-36	17.1	53.6	29.3	0	70.7	0.70	34000
R-S6	2004	DAD-37	14.1	61.7	24.2	0	75.8	0.31	37700
RA-1	2007	GAB-13	8.8	41.2	50.0	0	50.0	NA	24000
RA-1D	2007	GAB-19	8.9	38.4	49.6	3.0	47.1	1.1	20200
RA-2	2007	GAB-14	15.4	33.5	41.0	10.1	48.9	NA	24000
RA-3	2007	GAB-15	14.7	28.3	47.1	9.9	43.0	NA	26000
RA-4	2007	GAB-16	15.0	58.8	22.2	4.0	73.8	1.2	47400
RA-5	2007	GAB-17	14.9	57.7	21.1	6.3	72.6	0.57	43700
RA-6	2007	GAB-18	20.7	70.3	8.9	0	90.9	0.19	102000

NA - AVS data were reported as not detected and rejected.

3.2.3 Metals

Nine inorganic constituents (As, Ba, Cd, Cr, Cu, Pb, Ni, Se, and Zn) were carried forward from the SLERA (Battelle and Neptune & Company, 2004) and analyzed in sediments collected in 2004 and 2007 from the NSB-NLON Study Areas and Reference Area. In addition, mercury was analyzed in 2004 from Outer Pier 1 and Reference Area sediment because there was not sufficient historical information to eliminate mercury as a potential upper-trophic level COPC in the SLERA (i.e., not enough Outer Pier 1 data to conduct background comparisons).

Box plots showing the distribution of each metal in the Zone 7, Zone 4, and Outer Pier 1 samples relative to the Reference Area are provided in Appendix A, Figures A-58 through A-67. Summary statistics for metals in the Reference Area sediments are shown in Table 3-2. Summary statistics for metals in the Study Area surface sediments are presented in Table 3-3. The normality of the data distribution in each area was evaluated with the Shapiro-Wilk test. If the data were normally distributed, a 95% upper confidence limit (UCL) on the mean was calculated from the t-statistic. If data were not normally distributed, a 95% UCL on the mean was calculated using a bootstrap methodology. Additional information on the tests for normality and 95% UCL calculations is provided in Appendix A.

Table 3-3 includes results of the four "background comparison" tests comparing Zone 4, Zone 7, and Outer Pier 1 to the Reference Area. These four tests (t-test, Gehan test, quantile test, and slippage test) compare the distribution of data in each Study Area to the distribution of data in the Reference Area. A p-value of less than 0.05 in any one of the four tests indicates that concentrations of that constituent in that specific Study Area is elevated compared to the Reference area. Additional details on the conduct of the background comparisons are provided in Appendix A.

As shown in Table 3-3, all nine metals in each Study Area are elevated compared to the Reference Area. A review of the mean and maximum concentrations in each area shows that chromium, copper, lead, nickel, and zinc have higher in concentrations in Zone 4 than in Zone 7 and Outer Pier 1. The highest metal concentrations in Zone 4 are immediately adjacent to the quay wall (locations Z4-1, Z4-S1, and Z4-2), and as shown in the box plot for zinc (Figure 3-4), the remainder of the concentrations across Zone 4 are only slightly elevated compared to the other areas.

Table 3-2. Summary Statistics for Metals in Surface Sediment in the Thames River Reference Area

Analyte	N	Num Detect	Min Detect (mg/kg)	Median (mg/kg)	Mean (mg/kg)	Max Detect (mg/kg)	Standard Deviation (mg/kg)	Data Distribution Normal?	95% UCL
Arsenic	12	12	3.33	5.92	7.47	14.7	3.38	Yes	9.22
Barium	12	12	55.2	89.2	91.9	146	30.4	Yes	107.6
Cadmium	12	12	0.224	0.374	0.512	1.32	0.312	No	0.711
Chromium	12	12	38.3	65.4	69.4	114	23.5	Yes	81.6
Copper	12	12	14.9	46.7	52.2	104	27.6	Yes	66.6
Lead	12	12	13.5	48.4	50.1	101	28.1	Yes	64.7
Nickel	12	12	16.1	20.3	22.5	32.2	5.596	Yes	25.4
Selenium	12	12	0.279	0.504	0.575	1.19	0.233	No	0.732
Zinc	12	12	54.4	98.7	117	245	61.5	No	151
Mercury	6	6	0.072	0.266	0.253	0.377	0.115	Yes	0.348

Table 3-3. Summary Statistics for Metals in Surface Sediment in NSB-NLON Study Areas

Analyte	N	Detect	Min Detect (mg/kg)	Median (mg/kg)	Mean (mg/kg)	Max Detect (mg/kg)	Standard Deviation (mg/kg)	Normal Data Distribution?	95% UCL	Comparison to Reference Area				
										t-test p-value	Gehan p-value	Quantile p-value	Slippage p-value	Different from Reference?
Zone 4														
Arsenic	12	12	7.4	12.8	12.3	13.9	1.89	No	13	0.0002	0.001	0.5	1	Yes
Barium	12	12	93	156	182	475	97.6	No	268	0.004	0.0003	0.109	0.002	Yes
Cadmium	12	12	0.212	0.614	0.834	2.81	0.665	No	1.34	0.075	0.025	0.5	0.5	Yes
Chromium	12	12	53.9	87.28	122	321	92.1	No	182	0.039	0.012	0.5	0.25	Yes
Copper	12	12	59.9	106.4	208	735	217	No	340	0.015	0.0004	0.109	0.007	Yes
Lead	12	12	54.9	104	195	841	238	No	353	0.03	0.0003	0.109	0.002	Yes
Nickel	12	12	14.3	27.64	59.2	286	82.1	No	115	0.075	0.042	0.109	0.109	Yes
Selenium	12	12	0.396	0.773	0.87	1.88	0.404	Yes	1.08	0.021	0.019	0.5	0.239	Yes
Zinc	12	12	163	244	1088	3718	1470	No	1908	0.022	0.0002	0.109	0.007	Yes
Zone 7														
Arsenic	12	12	10.7	15.4	15.1	21.9	2.85	Yes	16.6	0.00001	0.0001	0.109	0.002	Yes
Barium	12	12	115	160	164	245	34.9	Yes	182	0.00001	0.0001	0.109	0.002	Yes
Cadmium	12	12	0.51	0.667	0.813	2.18	0.468	No	1.23	0.039	0.007	0.5	0.5	Yes
Chromium	12	12	87.6	94.9	95	107	5.45	Yes	97.8	0.002	0.002	0.891	1	Yes
Copper	12	12	91.8	109	116	203	30	No	141	0.00001	0.0001	0.109	0.002	Yes
Lead	12	12	58.6	79.8	82.2	109	12.4	Yes	88.7	0.001	0.003	0.891	0.5	Yes
Nickel	12	12	26.4	30.7	31.4	44	4.83	No	34.3	0.0002	0.0006	0.109	0.007	Yes
Selenium	12	12	0.565	0.821	0.823	0.955	0.116	Yes	0.884	0.002	0.001	0.5	1	Yes
Zinc	12	12	185	201	229	497	86.8	No	304	0.0009	0.001	0.5	0.239	Yes
Outer Pier 1														
Arsenic	5	5	12.5	13.1	13.5	15.3	1.16	Yes	14.6	0.000	0.006	0.515	0.294	Yes
Barium	5	5	118	124	131	155	15.1	Yes	145	0.002	0.010	0.515	0.294	Yes
Chromium	5	5	76.7	88.6	85.2	92	6.88	Yes	91.7	0.026	0.046	1.000	1.000	Yes
Copper	5	5	76.5	102	106	136	22.9	Yes	128	0.001	0.004	0.074	0.074	Yes
Lead	5	5	78.9	111	140	295	88.5	No	217	0.043	0.003	0.074	0.015	Yes
Mercury	5	5	0.353	0.442	0.451	0.574	0.084	Yes	0.531	0.005	0.005	0.455	0.015	Yes
Nickel	5	5	25.1	26.5	26.7	28.9	1.42	Yes	28.1	0.014	0.103	1.000	1.000	Yes
Selenium	5	5	0.624	0.722	0.723	0.833	0.097	Yes	0.815	0.042	0.020	0.515	1.000	Yes
Zinc	5	5	183	218	226	262	34.6	Yes	259.2	0.000	0.006	0.074	0.074	Yes

Shaded cells indicate p-values < 0.05.

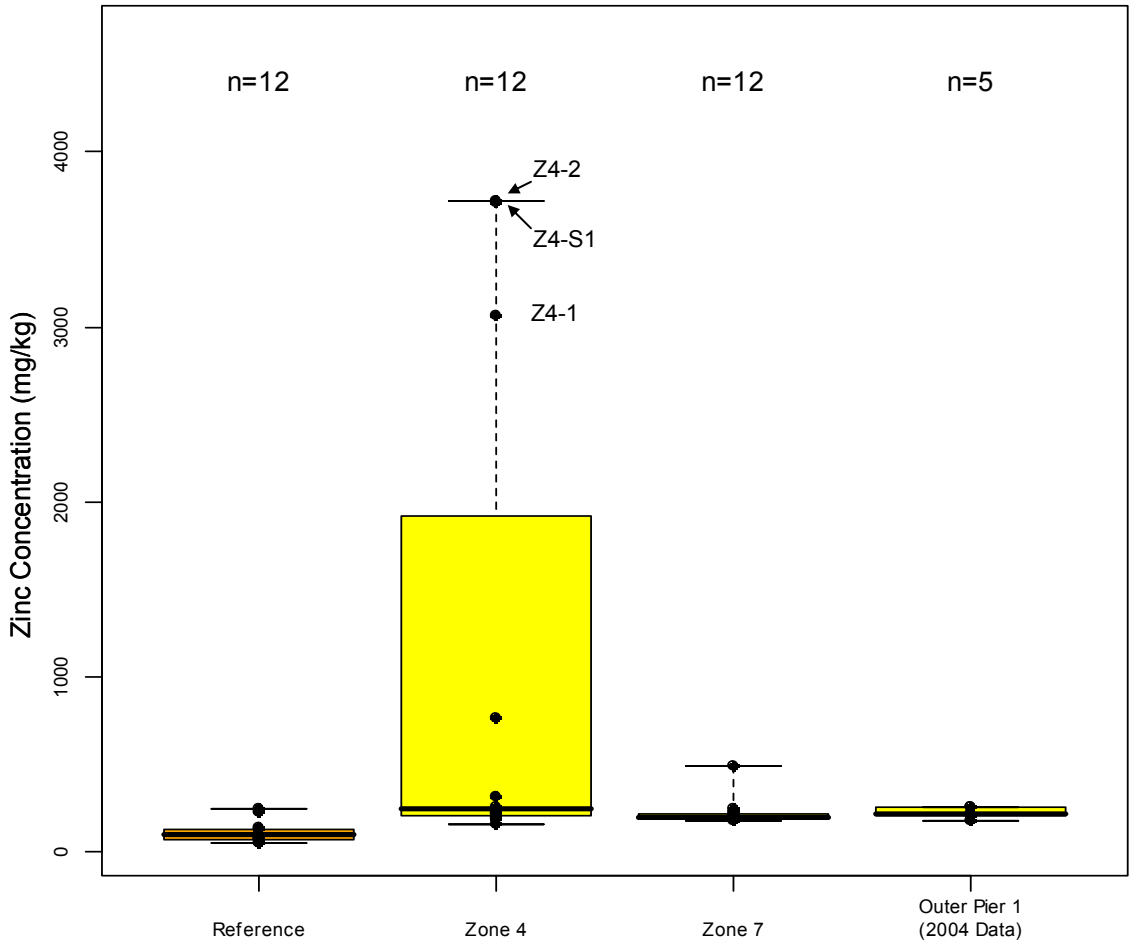

Figure 3-4. Zinc Concentrations in Each Area (Z4-2 and Z4-S1 plot on top of one another)

3.2.4 PAH and TPH

Twenty-four PAHs were carried forward from the SLERA (Battelle and Neptune & Company, 2004) and analyzed in 2004 and 2007 in Study Area and Reference Area sediment. Box plots showing the distribution of individual PAHs in Zone 7, Zone 4, and Outer Pier 1 samples relative to the Reference Area are provided in Appendix A, Figures A-7 through A-30. Box plots showing the distribution of total LMW PAHs, and total HMW PAHs in Zone 7, Zone 4, and Outer Pier 1 samples relative to the Reference Area are also provided in Appendix A, Figures A-74 and A-75, respectively. Likewise, box plots of total petroleum hydrocarbon – diesel range organics (TPH-DRO) and -motor oil range organics (MRO) are shown in Appendix A Figures A-70 and A-71, respectively.

Summary statistics for PAHs in the Reference Area sediments are shown in Table 3-4. Summary statistics for PAHs in the Study Area surface sediments are presented in Table 3-5. As with metals data, the normality of the data distribution in each area was evaluated with the Shapiro-Wilk test, and the appropriate 95% UCL on the mean was calculated for each PAH, depending on the distribution of the data.

Table 3-4. Summary Statistics for PAH and TPH in Surface Sediment in the Thames River Reference Area

Analyte	N	Detect	Min Detect (µg/kg)	Median (µg/kg)	Mean (µg/kg)	Max Detect (µg/kg)	Standard Deviation (µg/kg)	Normal Data Distribution ?	95% UCL
Naphthalene	12	12	6.48	24.8	24.5	44.5	14.9	Yes	32.2
2-Methylnaphthalene	12	12	5.43	19.7	19.4	33.2	11.2	No	24.7
1-Methylnaphthalene	12	12	3.75	11.1	10.9	20.2	6.13	Yes	14.1
2,6-Dimethylnaphthalene	12	12	3.9	12.2	12.3	21.5	6.85	Yes	15.8
2,3,5-Trimethylnaphthalene	12	12	1.33	4.07	4.23	8.48	2.5	Yes	5.53
Biphenyl	12	12	1.91	7.07	7.21	13.9	4.22	Yes	9.4
Acenaphthylene	12	12	10.3	37	43.5	103	29.9	Yes	59
Acenaphthene	12	12	2.31	8.51	9.72	26.4	6.89	Yes	13.3
Fluorene	12	12	4.85	17.1	20	51.4	13.9	Yes	27.2
Anthracene	12	12	12.7	65.7	69.6	148	46.2	Yes	93.5
Phenanthrene	12	12	56.9	196	240	737	195	No	365
1-Methylphenanthrene	12	12	10.9	40.5	45.9	124	33.7	Yes	63.4
Fluoranthene	12	12	151	518	587	1719	448	No	844
Pyrene	12	12	174	609	681	1806	489	Yes	934
Benzo(a)anthracene	12	12	59.4	262	273	655	184	Yes	368
Chrysene	12	12	80.9	327	358	898	249	Yes	487
Benzo(b)fluoranthene	12	12	83.1	317	345	901	246	Yes	473
Benzo(k)fluoranthene	12	12	87.4	353	373	897	250	Yes	503
Benzo(e)pyrene	12	12	74.7	296	317	774	215	Yes	429
Benzo(a)pyrene	12	12	87.7	353	384	940	262	Yes	520
Perylene	12	12	76.7	186	200	501	132	Yes	269
Indeno(1,2,3-cd)pyrene	12	12	72.6	272	307	827	227	Yes	424
Dibenz(a,h)anthracene	12	12	14	59.6	65.3	163	46.6	Yes	89.4
Benzo(g,h,i)perylene	12	12	66.3	245	273	705	193	Yes	373
Total LMWPAH	12	12	100	382	427	1144	310	Yes	587
Total HMWPAH	12	12	568.4	2151	2347	6180	1669	Yes	3213
TPH-DRO	12	8	19	26	27.71	70	19.69	Yes	37.9
TPH-MRO	12	12	92	315	316	710	187	Yes	413

Table 3-5. Summary Statistics for PAHs in Surface Sediment in NSB-NLON Study Areas

Analyte	N	Detect	Min Detect (µg/kg)	Median (µg/kg)	Mean (µg/kg)	Max Detect (µg/kg)	Stand. Dev. (µg/kg)	Normal Data Distribution?	95% UCL	Comparison to Reference				
										t-test p-value	Gehan p-value	Quantile p-value	Slippage p-value	Different from Reference?
Zone 4														
Naphthalene	12	12	76.4	117	176	508	138	No	267	0.001	1.6E-05	0.109	3.7E-07	Yes
2-Methylnaphthalene	12	12	45.2	60.1	73.4	147	34.1	No	94.4	7.8E-05	1.6E-05	0.109	3.7E-07	Yes
1-Methylnaphthalene	12	12	21.8	34.7	40.7	86.7	21.7	No	53.5	0.0003	1.6E-05	0.109	3.7E-07	Yes
2,6-Dimethylnaphthalene	12	12	368	52.5	60.1	97.4	22.1	Yes	71.5	3.5E-06	1.6E-05	0.109	3.7E-07	Yes
2,3,5-Trimethylnaphthalene	12	12	8.63	20	21.2	47	12.1	Yes	27.5	0.0002	1.6E-05	0.109	3.7E-07	Yes
Biphenyl	12	12	17.8	31.9	38.8	71.2	19.1	Yes	48.8	5.7E-05	1.6E-05	0.109	3.7E-07	Yes
Acenaphthylene	12	12	88.9	145	158	278	60.9	Yes	189	1.3E-05	3.4E-05	0.109	0.0002	Yes
Acenaphthene	12	12	39.3	325	543	1423	474	Yes	789	0.001	1.6E-05	0.109	3.7E-07	Yes
Fluorene	12	12	84.7	380	424	949	277	Yes	567	0.0002	1.6E-05	0.109	3.7E-07	Yes
Anthracene	12	12	416	980	1079	2388	609	Yes	1395	6.4E-05	1.6E-05	0.109	3.7E-07	Yes
Phenanthrene	12	12	515	2443	2587	6401	1773	Yes	3506	0.0004	2.1E-05	0.109	4.8E-06	Yes
1-Methylphenanthrene	12	12	72.8	220	219	365	104	Yes	274	5.0E-05	3.4E-05	0.109	3.4E-05	Yes
Fluoranthene	12	12	2080	6888	7770	17700	4237	Yes	9967	5.2E-05	1.6E-05	0.109	3.7E-07	Yes
Pyrene	12	12	2880	5771	6497	12310	2861	Yes	7980	9.1E-06	1.6E-05	0.109	3.7E-07	Yes
Benzo(a)anthracene	12	12	1069	2424	2920	7279	1791	Yes	3849	0.0002	1.6E-05	0.109	3.7E-07	Yes
Chrysene	12	12	1259	3040	3379	7557	1972	Yes	4401	0.0001	1.6E-05	0.109	3.7E-07	Yes
Benzo(b)fluoranthene	12	12	1005	1759	2062	3939	997	Yes	2579	3.9E-05	1.6E-05	0.109	3.7E-07	Yes
Benzo(k)fluoranthene	12	12	1071	1848	2071	3964	947	Yes	2562	2.6E-05	1.6E-05	0.109	3.7E-07	Yes
Benzo(e)pyrene	12	12	782	1325	1474	2817	630	Yes	1800	1.8E-05	1.6E-05	0.109	3.7E-07	Yes
Benzo(a)pyrene	12	12	1031	1616	1860	3557	790	Yes	2270	1.5E-05	1.6E-05	0.109	3.7E-07	Yes
Perylene	12	12	290	592	594	1018	197	Yes	696	7.2E-06	4.3E-05	0.109	0.0002	Yes
Indeno(1,2,3-cd)pyrene	12	12	650	953	1053	2054	394	No	1283	1.2E-05	3.4E-05	0.109	0.0002	Yes
Dibenz(a,h)anthracene	12	12	162	244	279	703	148	No	389	0.0002	2.1E-05	0.109	4.8E-06	Yes
Benzo(g,h,i)perylene	12	12	552	779	841	1612	299	No	1031	1.3E-05	5.5E-05	0.109	0.002	Yes
Total LMWPAH	12	12	1289	5077	5041	10520	2932	Yes	6561	9.7E-05	1.6E-05	0.109	3.7E-07	Yes
Total HMWPAH	12	12	9060	19370	22710	48160	11420	Yes	28620	3.2E-05	1.6E-05	0.109	3.7E-07	Yes
TPH- DRO	12	12	29	102.5	182	870	232.1	No	371	0.021	0.000	0.109	0.001	Yes
TPH- MRO	12	12	360	880	883	1900	466.5	Yes	1125	0.001	0.000	0.109	0.002	Yes
Zone 7														
Naphthalene	12	12	21.7	68.4	75.9	195	45.4	No	102	0.001	0.0001	0.109	3.4E-05	Yes
2-Methylnaphthalene	12	12	16.4	36.9	40.5	69	15.5	Yes	48.5	0.0005	0.0004	0.109	0.0002	Yes
1-Methylnaphthalene	12	12	11.2	19.2	20.6	31.7	6.57	Yes	24	0.0006	0.001	0.109	0.0193	Yes
2,6-Dimethylnaphthalene	12	12	10.5	30.8	34.8	61.1	17.3	Yes	43.8	0.0004	0.0003	0.109	0.0002	Yes
2,3,5-Trimethylnaphthalene	12	12	3.85	7.55	11.3	39.1	10	No	18.2	0.017	0.003	0.109	0.047	Yes
Biphenyl	12	12	6.98	15.4	16.1	27.7	5.97	Yes	19.2	0.0002	0.0003	0.109	0.002	Yes
Acenaphthylene	12	12	37.2	82.3	86.2	184	35.7	No	108	0.002	0.002	0.5	0.24	Yes
Acenaphthene	12	12	18.9	47.1	62.3	185	49.8	No	96.5	0.002	3.4E-05	0.109	0.0002	Yes
Fluorene	12	12	34.2	67.5	82.9	165	42.6	Yes	105	0.0001	3.4E-05	0.109	0.0002	Yes
Anthracene	12	12	140	222	276	641	154	No	374	0.0003	2.1E-05	0.109	4.8E-06	Yes
Phenanthrene	12	12	269	493	560	1010	241	Yes	685	0.0009	0.0003	0.109	0.109	Yes
1-Methylphenanthrene	12	12	45.9	79.4	117	516	129	No	221	0.044	0.005	0.5	0.239	Yes
Fluoranthene	12	12	829	1405	1680	2856	654	Yes	2019	6.2E-05	0.0001	0.109	0.019	Yes

Table 3-5. Summary Statistics for PAHs in Surface Sediment in NSB-NLON Study Areas (continued)

Analyte	N	Detect	Min Detect (µg/kg)	Median (µg/kg)	Mean (µg/kg)	Max Detect (µg/kg)	Stand. Dev. (µg/kg)	Normal Data Distribution?	95% UCL	Comparison to Reference				
										t-test p-value	Gehan p-value	Quantile p-value	Slippage p-value	Different from Reference?
Pyrene	12	12	788	1421	1618	3343	674	Yes	1967	0.0004	0.0003	0.109	0.047	Yes
Benzo(a)anthracene	12	12	384	622	728	1526	313	No	920	0.0002	0.0001	0.109	0.007	Yes
Chrysene	12	12	569	843	934	1862	365	No	1168	0.0001	0.0001	0.109	0.019	Yes
Benzo(b)fluoranthene	12	12	471	701	737	1095	192	Yes	836	0.0001	0.0003	0.109	0.109	Yes
Benzo(k)fluoranthene	12	12	493	743	780	1294	228	Yes	898	0.0002	0.0006	0.109	0.109	Yes
Benzo(e)pyrene	12	12	378	594	624	1060	182	Yes	718	0.0006	0.001	0.5	0.5	Yes
Benzo(a)pyrene	12	12	430	727	761	1452	265	Yes	899	0.001	0.001	0.5	0.24	Yes
Perylene	12	12	164	364	355	472	96.4	Yes	405	0.002	0.004	0.5	1	Yes
Indeno(1,2,3-cd)pyrene	12	12	324	564	568	881	145	Yes	643	0.002	0.001	0.5	0.5	Yes
Dibenz(a,h)anthracene	12	12	69.9	124	129	214	38.2	Yes	149	0.0007	0.002	0.5	0.5	Yes
Benzo(g,h,i)perylene	12	12	253	484	483	794	134	Yes	553	0.003	0.002	0.5	0.5	Yes
Total LMWPAH	12	12	577	998	1184	2204	527	Yes	1457	0.0002	0.0002	0.109	0.047	Yes
Total HMWPAH	12	12	3139	5069	5850	11250	2251	Yes	7017	0.0002	0.0002	0.109	0.019	Yes
TPH - DRO	12	11	23	59.5	61.62	190	45.45	No	94.4	0.016	0.004	0.239	0.047	Yes
TPH - MRO	12	12	240	475	516.7	880	205.5	Yes	623	0.010	0.010	0.109	0.109	Yes
Outer Pier 1														
Naphthalene	5	5	40.42	72.96	69.17	81.95	16.5	No	77.47	0.001	0.002	0.074	0.002	Yes
2-Methylnaphthalene	5	5	29.22	46.47	42.59	49.47	8.045	Yes	84.91	0.000	0.002	0.074	0.002	Yes
1-Methylnaphthalene	5	5	12.48	18.46	18.57	22.65	3.899	Yes	50.26	0.005	0.010	0.074	0.074	Yes
2,6-Dimethylnaphthalene	5	5	27.58	31.81	32.61	40.19	4.854	Yes	22.29	0.000	0.001	0.074	0.000	Yes
2,3,5-Trimethylnaphthalene	5	5	5.39	7.24	7.088	8.22	1.06	Yes	37.23	0.002	0.029	0.515	1.000	Yes
Biphenyl	5	5	13.31	14.82	15.52	18.23	2.03	Yes	8.099	0.000	0.001	0.074	0.002	Yes
Acenaphthylene	5	5	96	171.5	163.1	210.7	41.85	Yes	17.45	0.001	0.001	0.074	0.002	Yes
Acenaphthene	5	5	33.72	40.27	45.04	66.65	12.74	Yes	203	0.001	0.001	0.074	0.000	Yes
Fluorene	5	5	101	123	140	216.3	46.23	Yes	57.19	0.002	0.001	0.074	0.000	Yes
Anthracene	5	5	561.8	788.6	1207	3195	1115	No	2232	0.042	0.001	0.074	0.000	Yes
Phenanthrene	5	5	852.1	1218	1230	1929	433.8	Yes	2271	0.003	0.001	0.074	0.000	Yes
1-Methylphenanthrene	5	5	100.4	112.3	132.8	198.2	39.61	Yes	1643	0.002	0.002	0.074	0.074	Yes
Fluoranthene	5	5	2966	4301	4965	7992	1911	Yes	170.6	0.003	0.001	0.074	0.000	Yes
Pyrene	5	5	3273	4287	4793	6238	1355	Yes	6787	0.001	0.001	0.074	0.000	Yes
Benzo(a)anthracene	5	5	2005	2811	2832	4037	868.7	Yes	6085	0.001	0.001	0.074	0.000	Yes
Chrysene	5	5	2080	3798	3772	5543	1298	Yes	3660	0.002	0.001	0.074	0.000	Yes
Benzo(b)fluoranthene	5	5	1371	2401	2577	3914	933.1	Yes	5010	0.003	0.001	0.074	0.000	Yes
Benzo(k)fluoranthene	5	5	1452	2432	2408	3054	605.4	Yes	3467	0.001	0.001	0.074	0.000	Yes
Benzo(e)pyrene	5	5	1011	1743	1791	2486	548.6	Yes	2985	0.001	0.001	0.074	0.000	Yes
Benzo(a)pyrene	5	5	1244	2069	2140	2957	636.6	Yes	2314	0.001	0.001	0.074	0.000	Yes
Perylene	5	5	325.1	613	598.4	791.9	177.5	Yes	2747	0.002	0.002	0.074	0.002	Yes
Indeno(1,2,3-cd)pyrene	5	5	599.8	1210	1192	1705	435.2	Yes	767.6	0.004	0.001	0.074	0.002	Yes
Dibenz(a,h)anthracene	5	5	160.1	301.3	303.7	459.9	119.6	Yes	417.7	0.005	0.001	0.074	0.002	Yes
Benzo(g,h,i)perylene	5	5	531.3	1065	977.9	1340	323.1	Yes	1286	0.003	0.001	0.074	0.002	Yes
Total LMWPAH	5	5	1995	2168	2897	5048	1291	Yes	4127	0.006	0.001	0.074	0.000	Yes
Total HMWPAH	5	5	13740	18370	18810	24700	5194	Yes	23760	0.001	0.001	0.074	0.000	Yes

Shaded cells indicate p-values < 0.05

As described in Appendix A, background tests were conducted to compare the Study Area PAH concentrations to PAH concentrations in the Reference Area. Table 3-5 includes results of the four "background comparison" tests. P-values were less than 0.05 in at least two of the four statistical tests for every PAH constituent in the Study Areas, indicating PAH concentrations are elevated in these areas when compared to the upstream Reference Area. PAH concentrations were highest in Zone 4, with highest concentrations along the quay wall (2007 location Z4-1) and along the northern edge of Pier 2 (2004 locations Z4-S3 and Z4-S4). As shown in the box plot for HMW PAHs (Figure 3-5), concentrations across Zone 4 were elevated when compared to Zone 7, and Zone 7 concentrations were slightly elevated compared to the Reference Area concentrations.

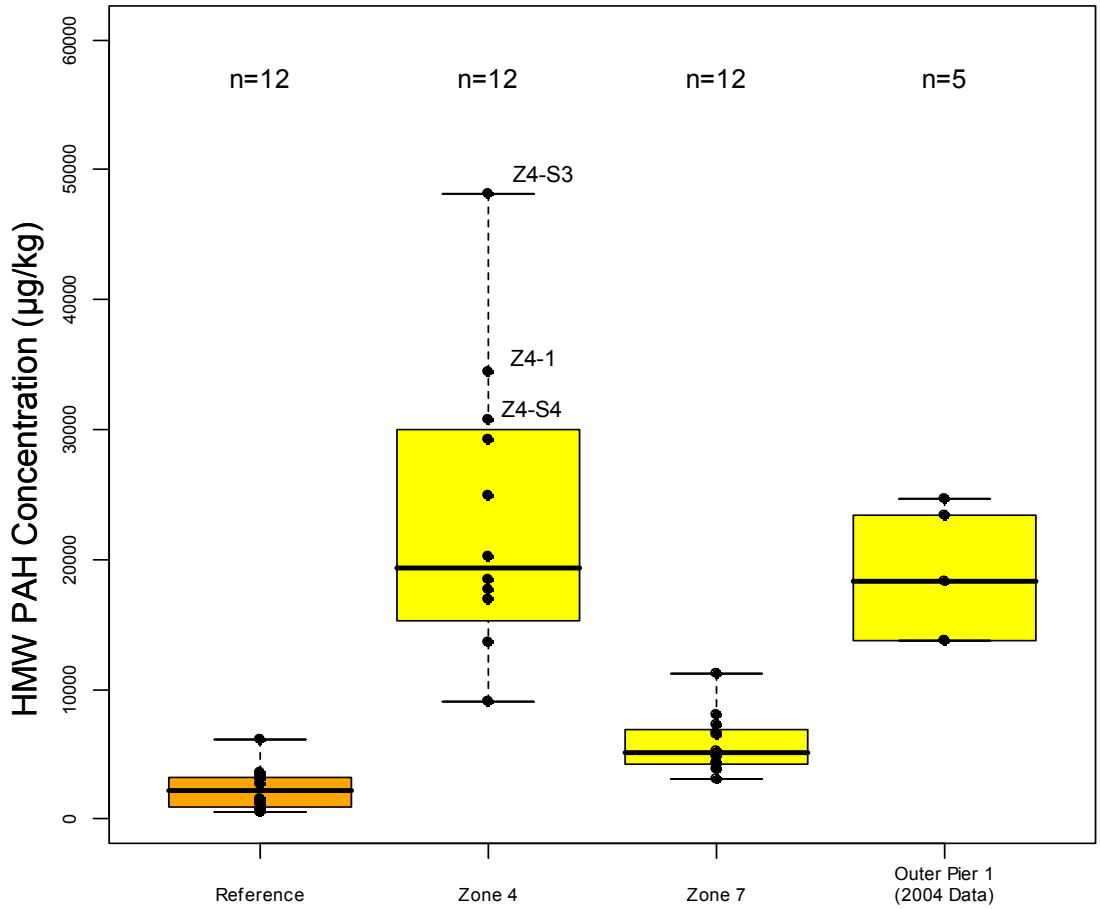

Figure 3-5. HMW PAH Concentrations in Each Area

3.2.5 PCBs and Pesticides

Five pesticides (4,4'-DDD, 4,4'-DDE, 4'4-DDT, alpha-chlordane, and trans-nonachlor) as well as total PCBs were carried forward as sediment COPCs from the SLERA (Battelle and Neptune & Company, 2004) and analyzed in 2004 and 2007 in Study Area and Reference Area sediment. Three additional pesticides (gamma-BHC, dieldrin, and heptachlor) were analyzed in Outer Pier 1 and Reference Area sediment because there was not sufficient historical information to eliminate them as potential COPCs in the SLERA (i.e., not enough Outer Pier 1 data to conduct background comparisons).

Box plots showing the distribution of individual pesticides and PCB congeners in Zone 7, Zone 4, and Outer Pier 1 samples relative to the Reference Area data are provided in Appendix A, Figures A-31 through A-57. Box plots of total DDx, and total PCBs are provided in Figures A-72 and A-73, respectively. Summary statistics for pesticides and PCBs in the Reference Area sediments are shown in Table 3-6. Summary statistics for pesticides and PCBs in the Study Area surface sediments are presented in Table 3-7. Gamma-BHC and heptachlor were not detected in any Study Area or Reference Area sample. The remaining pesticides and PCBs were detected in the majority of the Study Area and Reference Area samples.

As with the other surface sediment data, the normality of the data distribution in each area was evaluated for each constituent with the Shapiro-Wilk test, and the appropriate 95% UCL on the mean was calculated for each constituent, depending on the distribution of the data. Background tests were conducted comparing Zone 4, Zone 7, and Outer Pier 1 concentrations to concentrations in the Reference Area.

Table 3-7 includes results of the four "background comparison" tests for pesticides and PCBs. Total DDx did not fail any of the four background tests in either Zone 4 or Zone 7, and 4,4'-DDT did not fail any of the background tests in Outer Pier 1, indicating that concentrations of these constituents were not different from Reference Area concentrations. Total PCBs, 4,4'-DDE, alpha-chlordane, 4,4'-DDD, and trans-nonachlor failed at least one of the distribution comparison tests in each area, and are therefore considered elevated compared to background. Dieldrin in Zone 4 and Outer Pier 1 failed the Reference Area comparisons, although dieldrin in Zone 7 was not significantly different than Reference Area concentrations. Total PCBs were considered elevated compared to Reference Area concentrations even though the maximum concentration of 1844 µg/kg observed at Reference Area Station R-S6 was five times greater than the maximum Zone 4 concentration of 367 µg/kg. As shown in the box plot for total PCBs (Figure 3-6), even though the Reference Area contains the one extreme data point, the middle half of the data distributions (25th to 75th percentiles) for Zone 4 and Zone 7 are elevated compared to the Reference Area data distribution.

Table 3-6. Summary Statistics for Pesticides and PCBs in Surface Sediment in the Thames River Reference Area

Analyte	N	Detect	Min Detect (µg/kg)	Median (µg/kg)	Mean (µg/kg)	Max Detect (µg/kg)	Standard Deviation (µg/kg)	Normal Data Distribution?	95% UCL
4,4'-DDD	12	12	0.47	1.64	2.09	5.79	1.71	Yes	2.98
4,4'-DDE	12	12	0.59	1.96	2.39	7.04	1.96	No	3.53
4,4'-DDT	12	12	0.2	0.86	1.24	4.33	1.3	No	2.03
Total DDx	12	12	1.31	5.38	5.72	15.2	4.32	Yes	7.96
alpha-Chlordane	12	11	0.15	0.32	0.44	1.83	0.47	No	0.757
Dieldrin	6	4	0.57	0.735	0.791	2.23	0.803	Yes	1.45
gamma-BHC	12	0	NA	0.029	0.029	NA	0	NA	NA
trans-nonachlor	12	12	0.09	0.27	0.39	1.56	0.401	No	0.687
Heptachlor	12	0	NA	0.03	0.033	NA	0.019	No	0.04
Total PCBs	12	12	13.7	51.3	196	1844	520	No	654

Table 3-7. Summary Statistics for Pesticides and PCBs in Surface Sediment in NSB-NLON Study Areas.

Analyte	N	Detect	Min Detect (µg/kg)	Median (µg/kg)	Mean (µg/kg)	Max Detect (µg/kg)	Standard Deviation (µg/kg)	Normal Data Distribution?	Comparison to Reference					
									95% UCL	t-test p-value	Gehan p-value	Quantile p-value	Slippage p-value	Different from Reference?
Zone 4														
4,4'-DDD	6	6	1.83	2.79	3.87	10.3	3.2	No	6.61	0.123	0.067	0.569	0.333	No
4,4'-DDE	12	12	2.47	3.62	4.81	13.4	2.93	No	7.01	0.014	0.003	0.5	0.5	Yes
4,4'-DDT	12	11	1.1	2.47	2.25	3.53	0.937	Yes	2.73	0.021	0.019	0.891	1	Yes
Total DDx	12	12	3.5	7.3	8.99	27.2	6.35	Yes	12.3	0.078	0.067	0.5	0.5	No
alpha-Chlordane	12	12	0.57	0.82	0.92	2.52	0.521	No	1.34	0.014	0.0002	0.761	0.5	Yes
Dieldrin	6	5	1.53	2.6	2.21	3.52	1.24	Yes	3.23	0.023	0.033	0.227	0.03	Yes
gamma-BHC	6	0	NA	0.01	0.01	NA	0	NA	NA	NA	NA	NA	NA	NA
trans-nonachlor	12	12	0.29	0.545	0.608	1.51	0.306	No	0.827	0.075	0.005	0.5	1	Yes
Heptachlor	6	0	NA	0.015	0.015	NA	0	NA	NA	NA	NA	NA	NA	No
Total PCBs	12	12	62.7	135	153	367	86	Yes	198	0.61	0.001	0.5	1	Yes
Zone 7														
4,4'-DDD	6	6	1.7	3.03	3.26	5.73	1.35	Yes	4.37	0.07	0.056	0.569	1	No
4,4'-DDE	12	12	2.05	3.2	3.96	7.43	1.58	Yes	4.78	0.021	0.007	0.5	0.5	Yes
4,4'-DDT	12	12	0.55	1.69	1.86	4.07	0.909	Yes	2.32	0.096	0.014	0.891	1	Yes
Total DDx	12	12	3.36	5.68	7.44	17.2	4.32	Yes	9.68	0.17	0.113	0.5	0.5	No
alpha-Chlordane	12	12	0.34	0.645	0.682	1.03	0.214	Yes	0.793	0.062	0.004	0.5	1	Yes
Dieldrin	6	3	2.08	1.08	1.16	2.37	1.19	No	1.895	0.27	0.212	0.227	0.227	No
gamma-BHC	6	0	NA	0.01	0.01	NA	0	NA	NA	NA	NA	NA	NA	NA
trans-nonachlor	12	12	0.34	0.62	0.572	0.73	0.143	Yes	0.647	0.08	0.004	0.5	1	Yes
Heptachlor	6	0	NA	0.015	0.015	NA	0	NA	NA	NA	NA	NA	NA	NA
Total PCBs	12	12	46.2	90.1	109	272	63.7	Yes	142	0.712	0.008	0.5	1	Yes
Outer Pier 1														
4,4'-DDD	5	5	1.49	3.09	4.172	7.96	2.632	Yes	6.681	0.080	0.046	0.515	0.294	Yes
4,4'-DDE	5	5	3.02	3.98	4.132	5.83	1.041	Yes	5.125	0.016	0.018	0.515	1.000	Yes
4,4'-DDT	5	4	1.67	2.16	2.692	7.34	2.74	Yes	5.304	0.155	0.103	0.515	0.294	No
Total DDx	5	5	4.58	9.23	11	18.91	5.641	Yes	16.37	0.055	0.037	0.515	0.294	Yes
alpha-Chlordane	5	5	0.66	0.96	0.888	1.11	0.1941	Yes	1.073	0.007	0.004	0.515	1.000	Yes
Dieldrin	5	5	1.9	3.21	3.218	4.1	0.826	Yes	4.005	0.000	0.005	0.455	0.015	Yes
gamma-BHC	5	0	NA	0.07	0.082	NA	0.04563	NA	NA	NA	NA	NA	NA	NA
trans-nonachlor	5	5	0.4	0.54	0.532	0.74	0.1418	Yes	0.6672	0.150	0.036	0.515	1.000	Yes
Heptachlor	5	0	NA	0.075	0.089	NA	0.04992	NA	NA	NA	NA	NA	NA	NA
Total PCBs	5	5	73.11	116	120	184.5	40.38	Yes	158.5	0.689	0.008	0.515	1.000	Yes

Shaded cells indicate p-values <0.05.

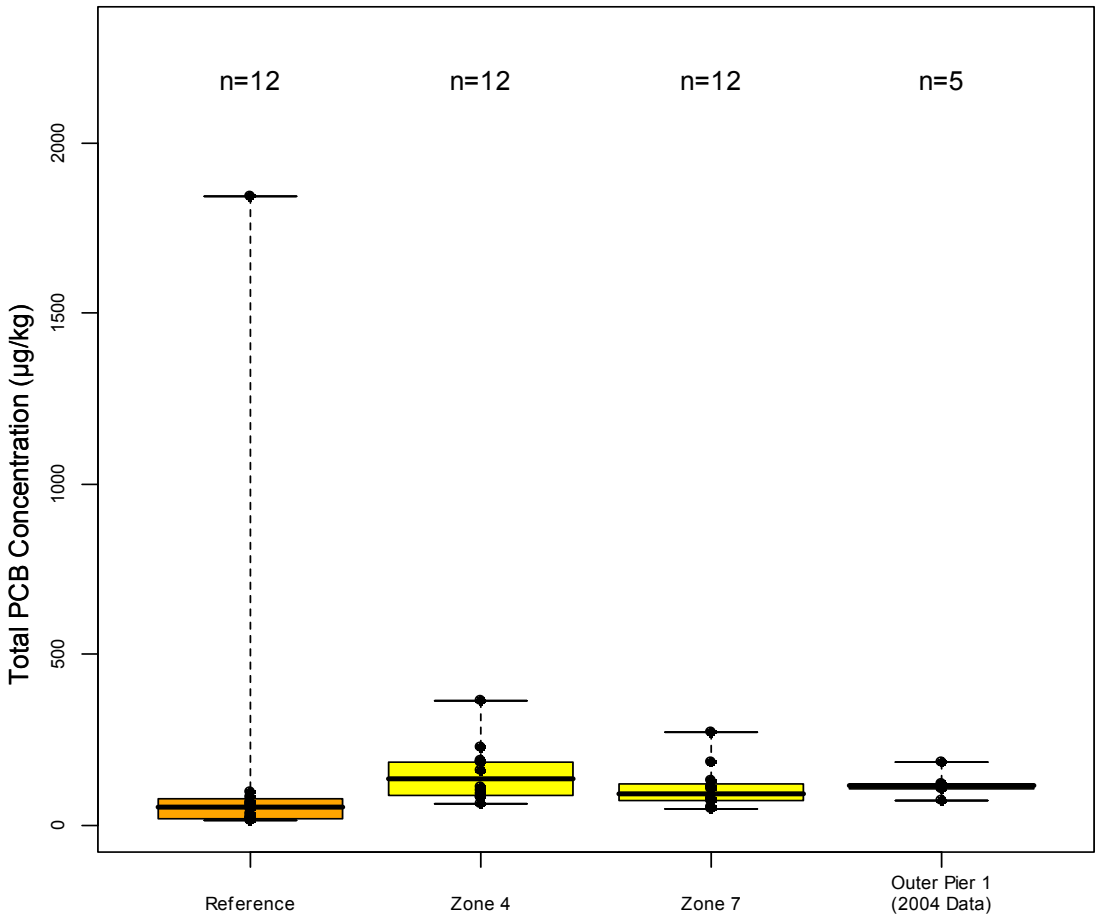

Figure 3-6. Total PCB Concentrations in Each Area

3.3 Fish Tissue Chemistry Results

This section presents the results of the 2004 fish tissue chemistry analyses. Details of the fish sample collection can be found in the Thames River Validation Study Work Plan (Battelle and Neptune & Company, 2004), and the Thames River Validation Study Survey Report (Battelle, 2004). Complete fish tissue chemistry results, quality control narratives, and quality control data are provided in Appendix C.

As described in the Sampling and Analysis Plan (Battelle and Neptune & Company, 2004), five discrete fish samples (composites) each from Outer Pier 1, Zone 4, Zone 7, and the Reference Area (a minimum of 20 fish each, weighing at least 50 g total) were to be collected to allow for the calculation of fish EPCs from each area, and to facilitate comparisons of tissue chemical concentrations between areas. Attempts were made to obtain sufficient fish tissue with both trawl nets and seines. Although several trawl attempts were made in Outer Pier 1, Zone 4, and the Reference Area, success was limited. Furthermore, only two areas appeared to have habitat suitable for fish collection with seine nets: the Reference Area and the boat ramp at Pier 1. The water depth in the other Study Areas was not adequate to deploy seine nets. The shallow water depth and pier structures around the boat ramp in Pier 1 appeared to provide sufficient habitat for forage fish where samples were collected.

As a result of the limited catch, fish were composited by species, rather than by location. In addition, two archived fish tissue samples that were collected in the Inner Pier 1 Area during a field collection pilot

study in July, 2004 were included in the dataset. This compositing scheme still provided sufficient data to support the dose model used in the BERA, but did not allow for statistical comparison of fish tissue concentrations between each area, nor allow for direct calculation of EPCs in each area. Instead, fish tissue data were paired with available sediment chemistry from the areas of collection to calculate bioaccumulation factors (BAFs) that were then extrapolated to Zones 4 and 7.

Fish tissue samples were analyzed for the specific metals carried forward as upper-trophic level COPCs from the SLERA (Battelle and Neptune & Company, 2004). These COPCs were Cr, Pb, and Zn for Zones 4 and 7, and Cr, Pb, Hg, and Zn in Outer Pier 1. A summary of the fish species included in the samples and the tissue chemistry results is presented in Table 3-8. Two American shad samples (one from Pier 1, and one from the Reference Area contained higher concentrations of Cr than the other fish species, with the maximum observed Cr concentration in the Reference Area shad. Reference Area fish also had slightly greater Hg concentrations than Pier 1 fish. The Pier 1 Inner Area is known to contain elevated levels of Cr, Pb, and Zn in the sediment and is the subject of an ongoing EE/CA investigation (Battelle, 2007a [in press]). Elevated concentrations of metals are not known to occur in the Reference Area sediments, making the seemingly lack of differences between Reference Area and Pier 1 fish tissue concentrations a source of uncertainty.

The available fish tissue data and Pier 1 and Reference Area sediment data was used to derive a range of BAF to replace the default BAFs used in the SLERA. These BAFs are discussed further in the BERA in Section 4.3.

Table 3-8. Results of Fish Tissue Collection and Analysis

Area	Sample ID	Collection Date	Species	Number in Composite	Percent Moisture	Chromium Result (µg/g dry wt)	Mercury Result (µg/g dry wt)	Lead Result (µg/g dry wt)	Zinc Result (µg/g dry wt)
Inner Pier 1	DAF-001	7/21/2004	Menhaden	128[a]	77.75	1.71	0.109	7.19	109
Inner Pier 1	DAF-001R	7/21/2004	Menhaden	128[a]	77.75	1.7	0.111	8.09	110
Inner Pier 1	DAD-43	10/14/2004	American Shad	24	78.89	4.86	0.126	9.58	109
Inner Pier 1	DAD-44	10/14/2004	Killifish	10	71.33	1.7	0.0986	3.04	117
Inner Pier 1	DAD-45	10/14/2004	Summer Flounder	10	77.75	0.903	0.0788	4.3	134
Inner Pier 1	DAD-46	10/14/2004	Silverside	12	77.88	0.951	0.135	0.62	132
Outer Pier 1	DAD-49	10/14/2004	Scup/Windowpane Flounder	1 scup / 4 flounder	90.33	2.64	0.0549	1.19	44.7
Outer Pier 1	DAD-51	10/14/2004	Scup/Windowpane Flounder	1 scup / 2 flounder	81.98	0.699	0.119	0.244	79.7
Reference Area	DAD-41	10/14/2004	American Shad	45	79.93	6.46	0.138	7	119
Reference Area	DAD-42	10/14/2004	Silverside	15	75.58	0.775	0.157	0.459	115

[a] A total of 128 menhaden caught in a beach seine were split into two replicate samples.

4.0 BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents the results of the BERA for Zone 4, Zone 7, and Outer Pier 1. The objective of this BERA is to quantify risk to ecological receptors under current conditions in the three Study Areas. The chemical constituent data used in the BERA were collected during the 2004 and 2007 Thames River Validation Study field surveys and the bioassay data used in the BERA were collected during the 2007 field investigation.

This risk assessment follows USEPA Ecological Risk Assessment Guidance for Superfund (USEPA, 1997) and is consistent with Navy policy for conducting ecological risk assessments (DON, 1999). A SLERA was conducted in 2004 for Zone 4, Zone 7, and Outer Pier 1. A total of 42 chemical constituents (9 metals and 33 organic compounds) were identified as COPCs based on potential risk to benthic organisms, while four metals were identified as COPCs based on potential risk to upper-trophic level piscivorous birds. The list of COPCs carried forward from each area for evaluation in the BERA is shown in Table 4-1.

Table 4-1. List of COPCs Carried Forward from the SLERA and their Endpoints

COPC	Zone 4		Zone 7		Outer Pier 1	
	Benthic Organisms	Piscivorous Birds	Benthic Organisms	Piscivorous Birds	Benthic Organisms	Piscivorous Birds
Arsenic	X		X		X	
Barium	X		X		X	
Cadmium	X					
Chromium	X	X	X	X	X	X
Copper	X		X		X	
Lead	X	X	X	X	X	X
Mercury					X	X
Nickel	X		X		X	
Selenium	X		X		X	
Zinc	X	X	X	X	X	
Benzo(a)anthracene	X		X		X	
Benzo(a)pyrene	X		X		X	
Benzo(b)fluoranthene	X					
Benzo(e)pyrene	X		X		X	
Benzo(g,h,i)perylene	X		X		X	
Benzo(k)fluoranthene	X					
Biphenyl	X		X		X	
Chrysene	X		X		X	
Dibenz(a,h)anthracene	X		X		X	
Fluoranthene	X		X		X	
Indeno(1,2,3-cd)pyrene	X		X		X	
Perylene	X		X		X	
Pyrene	X		X		X	
1-methylnaphthalene	X		X		X	
2-methylnaphthalene	X		X		X	
1-methylphenenthrene	X		X		X	

Table 4-1. List of COPCs Carried Forward from the SLERA and their Endpoints, continued

COPC	Zone 4		Zone 7		Outer Pier 1	
	Benthic Organisms	Piscivorous Birds	Benthic Organisms	Piscivorous Birds	Benthic Organisms	Piscivorous Birds
Acenaphthene	X		X		X	
2,3,5-trimethylnaphthalene	X		X		X	
2,6-dimethylnaphthalene	X		X		X	
Acenaphthylene	X					
Anthracene	X		X		X	
Fluorene	X		X		X	
Naphthalene	X					
Phenanthrene	X		X		X	
Total HMW PAH	X		X		X	
Total LMW PAH	X		X		X	
Total PAH	X		X		X	
Total PCB	X				X	
4,4'-DDE			X			
4,4'-DDT	X		X		X	
Alpha-chlordane	X				X	
Dieldrin	X				X	
Trans-nonachlor	X				X	

4.1 Ecological Problem Formulation

The ecological problem formulation identifies the risk questions, assessment endpoints, and measurement endpoints for the BERA. The ecological problem formulation is summarized in Tables 4-2 and the decision rules for interpreting results are presented in Table 4-3. The problem formulation step is consistent with the CSM presented in Section 2.0. This problem formulation identified the following complete exposure pathways and receptors for consideration:

- Sediment contact and ingestion by benthic invertebrates
- Ingestion of contaminated prey by piscivorous birds (represented by the double-crested cormorant)

Due to the developed nature of the shoreline, access to the waterfront area by terrestrial or semi-aquatic mammals is severely restricted and suitable habitat for use by marine mammals is not present. As such, risk to upper-trophic level mammals was not evaluated in this BERA. In addition, due to the high water depth in most of Zone 4 and Zone 7, ingestion of benthic invertebrates by diving ducks is presumed to be a rare event that does not contribute significantly to the diet of these birds. Therefore, benthic-feeding birds (i.e., diving ducks) were not evaluated in this BERA because they are expected to have a much lower frequency of exposure than the piscivorous birds that were modeled (represented by the double-crested cormorant). Based on these complete exposure pathways, the following assessment and measurement endpoints were identified and evaluated:

Assessment Endpoint 1: Maintenance of sustainable populations of benthic invertebrates in NSB New London Zone 4, Zone 7, and the Outer Area of Pier 1.

Measurement Endpoint 1: To assess potential risk to benthic invertebrates, a 28-day laboratory bioassay was conducted using the amphipod *Leptocheirus plumulosus* as a surrogate for all benthic invertebrates. The 28-day bioassay provided an acute toxicity endpoint (mortality), a chronic toxicity endpoint (growth), and a reproductive toxicity endpoint (number of offspring per adult). Given the relatively high salinities in the Thames River, *L. plumulosus* was deemed a more appropriate test organism than other commonly used amphipods such as *Hyalella azteca* due to its higher tolerance of saline conditions.

Assessment Endpoint 2: Protection of populations of piscivorous birds in NSB New London Zone 4, Zone 7, and Outer Pier 1.

Measurement Endpoint 2: To assess risk to piscivorous birds, a food chain model was constructed using the double-crested cormorant (*Phalacrocorax auritus*) as a surrogate for all piscivorous birds inhabiting the Study Areas. Double-crested cormorants dive for their prey and therefore would be able to capture bottom-feeding fish in the Study Areas. Bottom-feeding fish that are in direct contact with contaminated sediments have a greater potential for accumulating chemical contaminants in their tissues than sport fish or pelagic fish which spend less time associated with the sediment. The double-crested cormorant's diet was assumed to be comprised entirely of fish. The double-crested cormorant is also an upper-trophic level piscivore which makes it maximally exposed to contaminants present in the food chain, and therefore a conservative surrogate for all piscivorous birds at NSB New London.

Osprey were also considered as a surrogate for piscivorous birds in the area, but the cormorant was deemed to be a better surrogate due to its ability to capture fish in deep water, and because it has a slightly higher fish ingestion rate than the osprey (0.25 g/g-d vs. 0.21 g/g-d).

Concentrations of COPCs in whole body forage fish tissue collected from each Study Area were used to estimate a range of site-specific BAFs to calculate dose inputs to the cormorant food chain model. EPCs for estimating an ingestion dose to the cormorant in each area were calculated using the 95% UCL of the mean sediment COPC concentrations.

Decision rules for interpreting the results for each line of evidence are presented in Table 4-3. The Validation Study Work Plan included a criterion for determining acceptability of the Reference Area results as a point of comparison for Lower Subase results. This criterion stated that mean *L. plumulosus* survival in the Reference Area must be greater than 70%; if Reference Area survival was less than 70% than the Reference Area data would not be used for evaluation of Lower Subase data. Mean *L. plumulosus* survival in the Reference Area was 88%, validating the use of the Reference Area data as a point of comparison for Lower Subase data.

The Validation Study Work Plan presented decision rules for determining magnitude of extent of impact for the invertebrate survival line of evidence, using a 30% difference from Reference Area mean as a threshold for distinguishing low magnitude risk from high magnitude risk. However, the Work Plan did not quantify magnitude of risk for the invertebrate growth and reproduction lines of evidence, but simply stated that any area that was statistically different than the Reference Area was high magnitude risk. Following an evaluation of the variability of the bioassay data and the associated power of the statistical tests to detect specific relative percent differences between site and reference data, similar decision rules were developed for the growth and reproduction lines of evidence. A reduction in growth of 30% was selected as the minimum impact of interest for the following reasons: First, a 30% reduction in growth is less significant ecologically than a 30% reduction in survival, which is the accepted threshold for differentiating low magnitude vs. high magnitude risk for the survival line of evidence. Secondly, an ecologically significant reduction in growth (i.e., 30%) will likely manifest itself in other lines of

evidence, such as reduced numbers of offspring produced or survival. Any location that had growth that was statistically different than Reference Area but reduced by less than 30% compared to mean Reference Area growth was defined as low magnitude risk. Any location that had growth reduction greater than 30% but less than 50% was defined as moderate magnitude risk, and any location where growth reduction was greater than or equal to 50% was defined as high magnitude risk.

As with the growth line of evidence, no threshold was proposed in the Work Plan for differentiating the magnitude of risk for the reproduction line of evidence, although a reduction of 25% was suggested by USEPA at the August 2007 Partnering Team Meeting as a generally accepted threshold for ecological significance. Based on this suggestion, the magnitude of risk decision rules were defined as follows: Any location that had reproduction (as measured by number of offspring produced) statistically different than Reference Area but the difference was less than 25% (i.e., location reproduction was at least 75% of Reference reproduction), then that location was classified as low magnitude risk. Any location that had reproduction reduced greater than 25% but less than 50% was defined as moderate magnitude risk, and any location where reproduction was reduced by more than or equal to 50% was defined as high magnitude risk.

Table 4-2. Ecological Problem Formulation Summary

Assessment Endpoint	Risk Question	Measurement Endpoint	Decision Rules	Uncertainties and Assumptions
Maintenance of healthy benthic invertebrate populations in NSB New London Study Areas (Zone 4, Zone 7 and Outer Pier 1).	Do COPCs in surface sediment at Zones 4 and 7 and Outer Pier 1 at NSB New London pose unacceptable acute or chronic risk to benthic invertebrates suggesting the need for consideration of remedial action?	28-day laboratory bioassay measuring survival, growth, and reproduction of the amphipod *Leptocheirus plumulosus* exposed to sediments from Zone 4, Zone 7, and the Reference Area.	See Table 4-3.	• Bioassay locations in Zones 4 and 7 were chosen to represent a gradient of sediment chemistry, from low to high concentrations. • Any dose-response relationships and site-derived effects levels will then be extrapolated to Outer Pier 1 based on Outer Pier 1 sediment chemistry.
Protection of populations of piscivorous birds in NSB New London Study Areas (Zone 4, Zone 7, and Outer Pier 1).	Do COPCs in Zones 4 and 7 and Outer Pier 1 at NSB New London pose a potential chronic risk to piscivorous birds suggesting the need for consideration of remedial action?	Use of site-collected fish tissue data to derive fish BAFs to calculate a 95% UCL daily dose to the double-crested cormorant and compare to appropriate chemical-specific avian TRVs.	See Table 4-3	• The fish and sediment collected from Pier 1 and the Reference Area will be used to calculate metals BAFs. • TRVs for chromium and lead will be obtained from USEPA Ecological Soil Screening Levels (1997). TRVs for mercury and zinc will be those developed by Oak Ridge National Laboratory. • The actual amount of time a cormorant would spend foraging at an active site such as NSB New London is uncertain.

Table 4-3. Decision Rules for Determining Risk for Each Line of Evidence

Endpoint	No Unacceptable Risk Findings	Unacceptable Risk Findings	Next Steps
Bioassay Results: *L. plumulosus* Survival	If mean *L. plumulosus* survival at any NSB-NLON Study Area location is not statistically different than the Reference Area survival[1], then that location is classified as **no unacceptable risk (i.e., risk not different than regional conditions)**.	If mean *L. plumulosus* survival at any NSB-NLON Study Area location is statistically different from Reference Area survival as defined in the DQOs, then that location is classified as unacceptable risk. • If survival is ≥ 70% of mean Reference Area survival: **low magnitude risk**. • If survival is < 70% of mean Reference Area survival: **high magnitude risk**.	• If unacceptable risk is observed for any of the *L. plumulosus* endpoints, then Study Area-specific dose-response correlations will be calculated for COPCs or COPC indices. • Footprints of areas exceeding site-specific effects levels will be developed for the COPCs or indices with the highest correlations, and those footprints will be evaluated further in the Thames River FS.
Bioassay Results: *L. plumulosus* Growth	If mean *Leptocheirus* growth at any NSB-NLON Study Area location is not statistically different than Reference Area growth, then that location is classified as **no unacceptable risk (i.e., risk not different than regional conditions)**.	If mean *L. plumulosus* growth at any NSB-NLON Study Area location is statistically different from both laboratory controls and Reference Area growth, then that location is classified as **unacceptable risk**. • If growth is ≥ 70% of Reference Area growth: **low magnitude risk** • If growth is ≥ 50% but < 70% of Reference Area: **moderate magnitude risk** • If growth is < 50% of Reference Area: **high magnitude risk**	
Bioassay Results: *L. plumulosus* Reproduction	If mean *L. plumulosus* reproduction at any NSB-NLON Study Area location is not statistically different than Reference Area reproduction, then that location is classified as **no unacceptable risk (i.e., risk not different than regional conditions)**.	If mean *L. plumulosus* reproduction at any NSB-NLON Study Area location is statistically different from Reference Area reproduction, then that location is classified as **unacceptable risk**. • If reproduction is ≥ 75% of Reference Area reproduction: **low magnitude risk** • If reproduction is ≥ 50% but < 75% of Reference Area: **moderate magnitude risk** • If growth is < 50% of Reference Area: **high magnitude risk**	
Food-chain Modeling to Piscivorous Birds	• If the COPC dose in an area exceeds the NOAEL or LOAEL TRV, then site-specific bioaccumulation estimates will be used to back-calculate NOAEL and LOAEL PRGs for those constituents. • Areas not exceeding NOAEL PRGs will be considered **having no unacceptable risk.**	• If the COPC dose in an area exceeds the NOAEL or LOAEL TRV, then site-specific bioaccumulation estimates will be used to back-calculate NOAEL and LOAEL PRGs for those constituents. • Areas exceeding NOAEL PRGs, but not exceeding LOAEL PRGs, will be considered **low magnitude unacceptable risk.** • Areas exceeding LOAEL PRGs will be considered **high magnitude unacceptable risk.**	Footprints of areas exceeding NOAEL and LOAEL PRGs will be developed, and those footprints evaluated further in the Thames River FS.

4.2 Invertebrate Bioassay Results

To assess risk to benthic invertebrates, toxicity bioassays using the amphipod *Leptocheirus plumulosus* were conducted on sediment collected from six locations in Zone 4, six locations in Zone 7, and six locations in the Reference Area. Ten replicates were run per sampling location, with amphipod survival, growth, and reproduction measured in each replicate. Bioassays were originally conducted on sediments collected in 2004; however, a laboratory control failure invalidated data from those tests. Bioassay tests were then repeated with sediment collected in 2007, and these results are evaluated in the BERA. The 2004 bioassays originally included six locations from Pier 1. However since the sediment chemistry in Outer Pier 1 was deemed to be similar to Zone 7, sediment for the 2007 bioassays was limited to Zones 4 and 7. Any dose-response relationships observed and site-derived effects levels are extrapolated to Outer Pier 1 based on sediment chemistry in that area. Data for all bioassay replicates and the laboratory QC report is provided in Appendix D. A summary of the bioassay results for each endpoint at each sampling location is provided in Table 4-4; results by area are shown in Table 4-5.

Table 4-4. Summary of *Leptocheirus plumulosus* Bioassay Results

Area	Sampling Location	# of Reps	Survival (%)			Growth (weight in mg)			Reproduction (offspring per surviving adult)		
			Median	Mean	SD	Median	Mean	SD	Median	Mean	SD
Zone 4	Z4-1	10	0.90	86	14	1.41	1.26	0.38	1.6	1.79	1.14
	Z4-2	10	0.05	10	13	0.62	0.58	0.13	0	0	0
	Z4-3	10	0.775	70	23	1.15	1.13	0.29	0.94	0.92	0.57
	Z4-4	10	0.85	79	19	1.31	1.24	0.24	1.62	1.53	0.96
	Z4-5	10	0.90	89	9	1.79	1.69	0.28	3.4	3.46	1.6
	Z4-6	10	0.675	67	28	1.67	1.25	0.66	3.21	2.77	1.81
Zone 7	Z7-1	10	0.925	88	16	1.95	1.81	0.35	4.01	3.96	0.96
	Z7-2	10	0.95	94	9	1.63	1.63	0.14	3.28	3.59	1.17
	Z7-3	10	0.825	75	32	1.44	1.36	0.4	2.75	2.63	1.14
	Z7-4	10	0.85	72	31	1.71	1.42	0.58	1.96	2.16	1.19
	Z7-5	10	0.95	95	6	1.47	1.45	0.31	3.17	3.3	1.52
	Z7-6	10	0.85	84	18	1.58	1.42	0.45	1.43	2.02	1.21
Reference Area	RA-1	10	0.975	91	22	1.9	1.71	0.46	3.88	4.01	1.25
	RA-2	10	0.95	92	8	1.81	1.7	0.44	3.65	4.09	2.21
	RA-3	10	0.875	83	23	1.72	1.6	0.29	2.98	3.67	2.06
	RA-4	10	0.90	80	23	1.34	1.28	0.37	1.97	1.91	0.92
	RA-5	10	0.925	91	5	1.77	1.78	0.23	3.32	3.49	1.72
	RA-6	10	0.975	94	11	1.98	1.94	0.26	4.79	4.77	1.85
Laboratory Control		10	0.85	86	11	1.59	1.67	0.36	4.51	5	1.92

Table 4-5. Summary of *Leptocheirus plumulosus* Bioassay Results by Area

Endpoint	Area	N	Min	Median	Mean	Max	Standard Deviation
Survival (%)	Reference	60	20	95	88	1	17
	Zone 4	60	0	80	67	1	32
	Zone 7	60	0	95	84	1	22
	Lab Control	10	65	85	86	1	11
Growth (weight in mg)	Reference	60	0.46	1.79	1.67	2.32	0.39
	Zone 4	56	0.34	1.33	1.24	1.99	0.47
	Zone 7	59	0.50	1.62	1.52	2.24	0.41
	Lab Control	10	1.27	1.59	1.67	2.24	0.36
Reproduction (offspring/ living adult)	Reference	60	0.29	3.32	3.66	8.84	1.87
	Zone 4	56	0	1.58	1.87	6.79	1.59
	Zone 7	59	0.67	2.78	2.94	6.95	1.41
	Lab Control	10	1.92	4.51	5.0	8.26	1.92

4.2.1 Survival

Mean laboratory control survival was 86%, and all control replicates had at least 65% survival, meaning the bioassay met the criteria for acceptance as discussed in the Work Plan (Battelle and Neptune & Company, 2004). Reference Area survival ranged from a mean of 80% at location RA-4, to a mean of 94% at RA-6. Mean survival across the Reference Area as a whole was 88% (Table 4-5). Zone 7 survival ranged from 72% at location Z7-4 to 95% at location Z7-5. Mean survival across Zone 7 was 84%, slightly lower than the Reference Area mean. Zone 4 had a minimum mean survival of 10% at location Z4-2 and a maximum mean survival of 89% at location Z4-5. Overall mean survival in Zone 4 was 67%, which was lower than all the other areas.

A box plot showing the range and distribution of the replicate survival data at each location is shown in Figure 4-1. Three locations in Zone 4 (Z4-2, Z4-3, and Z4-6) and two locations in Zone 7 (Z7-3 and Z7-4) had survival that was statistically significantly different when compared to the overall mean Reference Area survival. Table 4-6 provides a relative comparison of survival for the Study Area locations that were significantly different than Reference Area survival. Four of the five locations that were significantly different than the Reference Area had survival that was greater than 75% of the Reference Area survival, while one location (Z4-2) had survival that was only 11% of that observed in the Reference Area.

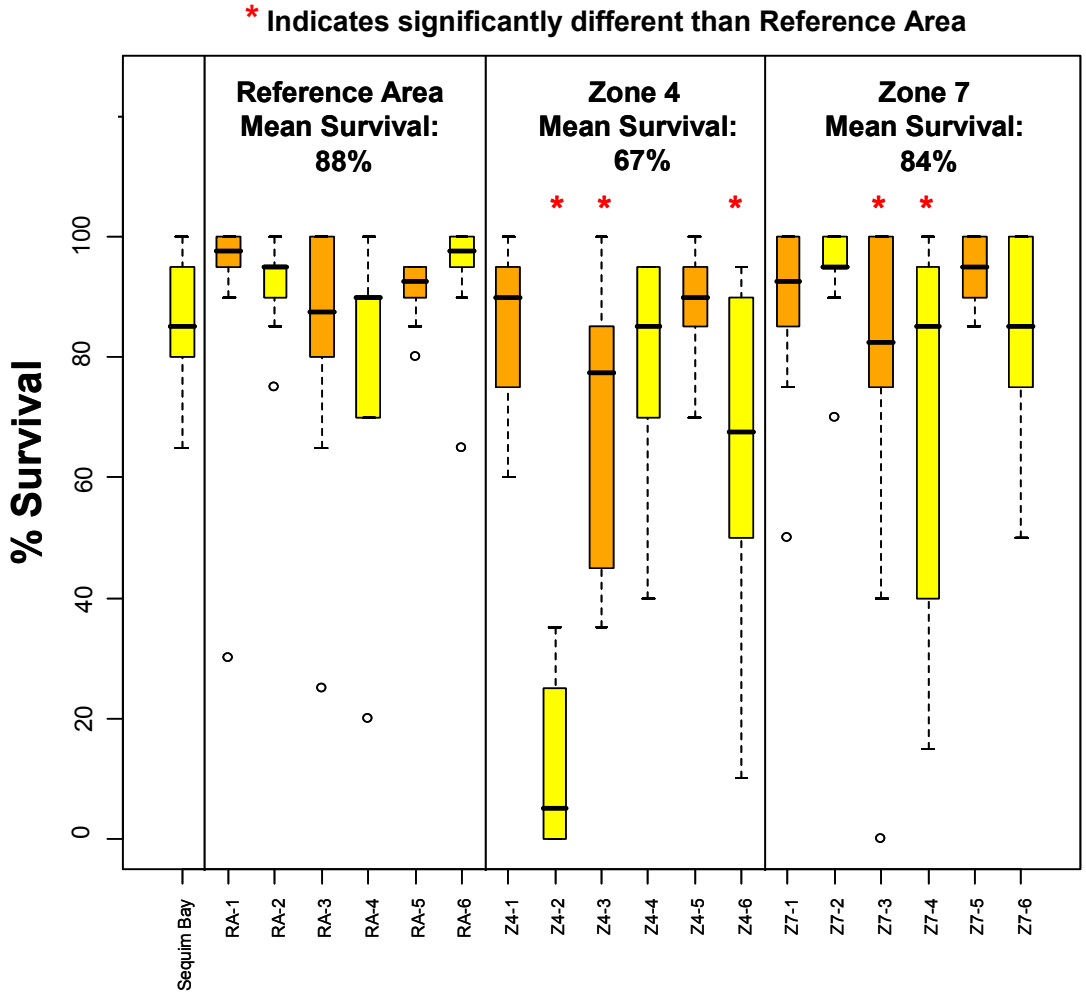

Figure 4-1. Survival of *Leptocheirus plumulosus* by Location

Table 4-6. Relative Comparison of NSB-NLON Study Area Survival Compared to Reference Area

Location[a]	Mean Location Survival	Mean Reference Survival	Location Survival as % of Reference Survival
Zone 4			
Z4-2	10%	88%	11%
Z4-3	70%	88%	80%
Z4-6	67%	88%	76%
Zone 7			
Z7-3	75%	88%	85%
Z7-4	72%	88%	82%

[a] Only those sampling locations that were statistically different than reference are shown.

4.2.2 Growth

Because the *L. plumulosus* bioassay was initiated using organisms of the same age and size, growth was evaluated as a function of mean organism weight at each location at the end of the 28-day test period. Overall, organisms exposed to the Reference Area sediment averaged 1.67 mg (Table 4-5), with a minimum average of 1.28 mg at location RA-4, and a maximum of 1.94 mg at location RA-6 (Table 4-4). Amphipods exposed to Zone 7 sediment were, on average, just under 10% smaller than Reference Area organisms, with an average weight of 1.52 mg. Location means in Zone 7 ranged from 1.36 mg per amphipod at location Z7-3 to 1.81 mg per amphipod at location Z7-1 (Table 4-4).

Figure 4-2 is a box plot showing the range and distribution of the replicate growth data at each location. It shows that, although there are only slight overall differences between Zone 7 and Reference Area growth, growth at four Zone 7 locations (Z7-3, Z7-4, Z7-5, and Z7-6) is statistically significantly different than the Reference Area growth.

Growth at Zone 4 was lower than that in Zone 7 and in the Reference Area. The four Zone 7 locations that showed statistically significant differences in growth were 13 to 19% smaller than Reference Area amphipods (Table 4-7); whereas the five Zone 4 locations that showed statistically significant differences in growth were 25 to 65% smaller than Reference Area amphipods.

Table 4-7 provides a relative comparison of growth for the Study Area locations that were significantly different than the Reference Area. Overall, Zone 4 amphipods were approximately 25% smaller than Reference Area amphipods. Location Z4-2 had the smallest amphipods of all locations, with an average weight of 0.58 mg per amphipod. Maximum Zone 4 growth was observed at location Z4-5, which averaged 1.69 mg per amphipod. Location Z4-5 was the only Zone 4 location where growth was not statistically different than mean Reference Area growth.

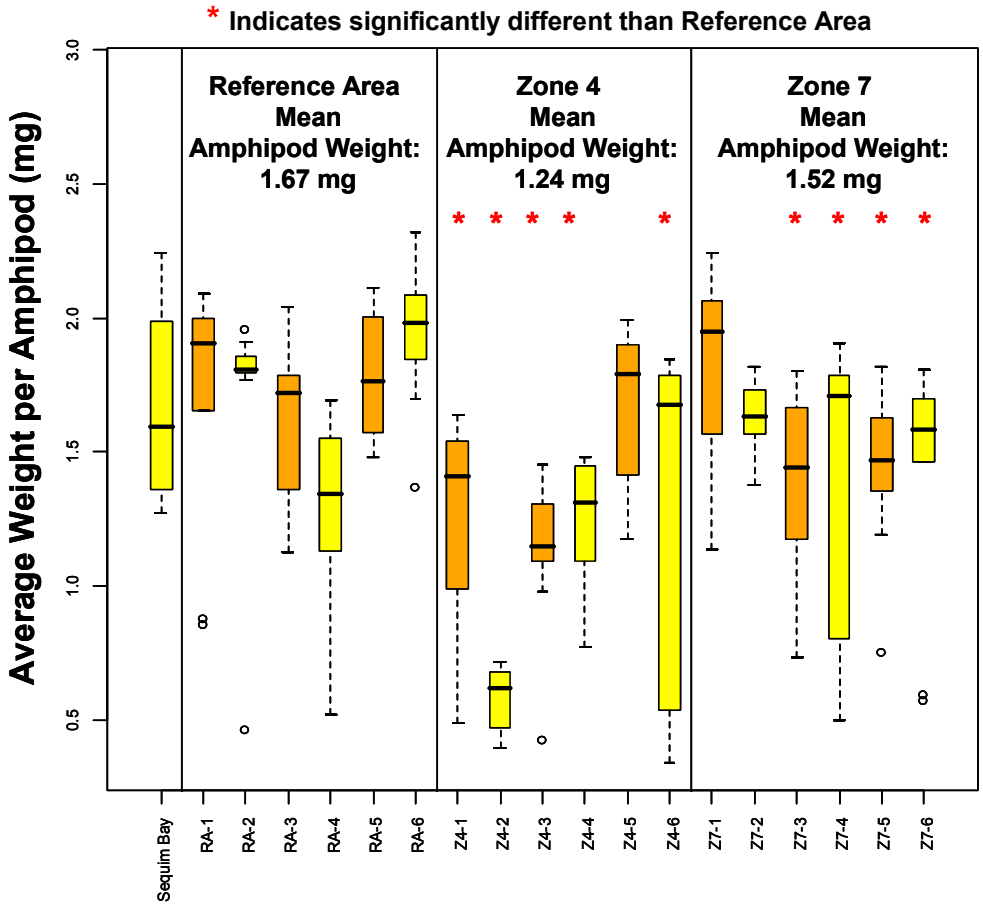

Figure 4-2. Growth of *Leptocheirus plumulosus* by Location

Table 4-7. Relative Comparison of NSB-NLON Study Area Growth Compared to Reference Area

Location[a]	Mean Location Weight (mg)	Mean Reference Weight (mg)	Size Difference Between Location and Reference
Zone 4			
Z4-1	1.26	1.67	25%
Z4-2	0.58	1.67	65%
Z4-3	1.13	1.67	33%
Z4-4	1.24	1.67	26%
Z4-6	1.25	1.67	25%
Zone 7			
Z7-3	1.36	1.67	19%
Z7-4	1.42	1.67	15%
Z7-5	1.45	1.67	13%
Z7-6	1.42	1.67	15%

[a] Only those sampling locations that were statistically different than reference are shown.

4.2.3 Reproduction

Reproduction of *L. plumulosus* was evaluated by counting the number of neonates per living adult at test termination (Day 28). Reproduction is generally a more variable endpoint than survival or growth, which held true for all the areas evaluated in the bioassays, as discussed below. The results are graphically depicted in Figure 4-3.

Reference Area reproduction ranged from a minimum of 1.91 offspring per adult at location RA-4 to a maximum of 4.77 offspring per adult at location RA-6 (Table 4-4), with an overall Reference Area mean of 3.66 offspring per adult.

Zone 7 reproduction averaged approximately 20% fewer offspring than Reference Area, with an overall area average of 2.94 offspring per living adult (Table 4-5). Zone 7 ranged from 2.02 offspring per adult at location Z7-6 to 3.96 offspring per adult at location Z7-1 (Table 4-4). Locations Z7-4, and Z7-6 had statistically fewer offspring per adult when compared to the Reference Area (Figure 4-3).

Zone 4 had fewer offspring per adult than in Zone 7. Overall, Zone 4 reproduction was slightly greater than half the Reference Area reproduction (1.87 offspring/adult vs 3.66 offspring/adult) (Table 4-5). Location Z4-2 had no reproduction, which was in line with the markedly reduced growth and high amphipod mortality observed at this location (Table 4-4). Maximum reproduction observed in Zone 4 was at location Z4-5, which had an average of 3.46 offspring per living adult. Locations Z4-5 and Z4-6 were the only Zone 4 locations with reproduction not statistically significantly different than the Reference Area (Figure 4-3).

Table 4-8 provides a relative comparison of reproduction in the Study Area and Reference Area locations that were significantly different than the Reference Area reproduction. The two Zone 7 locations that showed statistically significant differences in reproduction had 43 to 44% fewer offspring than the Reference Area; and the four Zone 4 locations that showed statistically significant differences had 51 to 100% fewer offspring than the Reference Area.

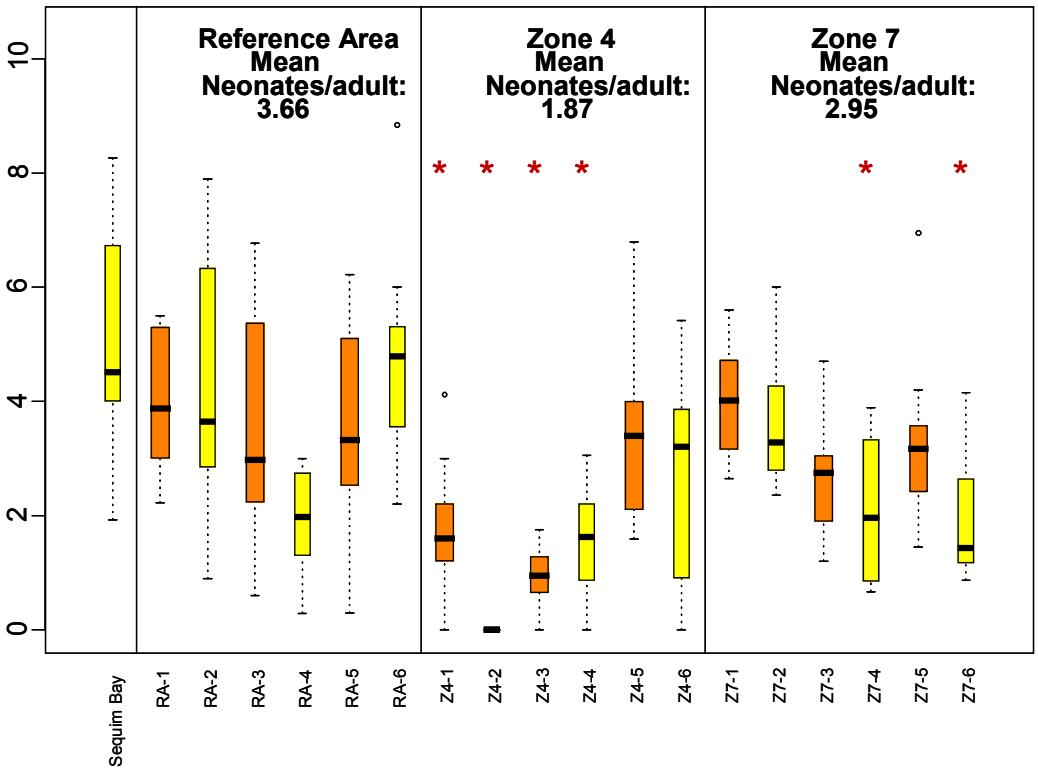

Figure 4-3. Reproduction of *Leptocheirus plumulosus* by Location

Table 4-8. Relative Comparison of NSB-NLON Study Area Reproduction Compared to Reference Area

Location[a]	Location Mean Neonates per Adult	Reference Mean Neonates per Adult	Reduction In Location Mean (%)
Zone 4			
Z4-1	1.79	3.66	51%
Z4-2	0	3.66	100%
Z4-3	0.92	3.66	75%
Z4-4	1.53	3.66	58%
Zone 7			
Z7-4	2.16	3.66	44%
Z7-6	2.01	3.66	43%

[a] Only those sampling locations that were statistically different than reference are shown.

4.3 Piscivorous Bird Dose Assessment

Risks to piscivorous birds (as represented by the double-crested cormorant) assumed a site use factor (SUF) of 1 for double-crested cormorants in each of the Study Areas at NSB New London. In reality, the SUF for any piscivorous bird is dependent on the availability of prey at the site. Cormorants and other diving birds will remain in the area as long as prey is available, and move to more productive areas when prey is scarce. Additional exposure factors used for the double-crested cormorant dose model are presented in Table 4-9.

The body weight of the cormorant selected for use in the food chain model (2.162 kg) is the lowest of three mean body weights reported for adult cormorants in the California Wildlife Biology, Exposure Factor, and Toxicity Database (CalEcotox) (California Office of Environmental Health Hazard Assessment [OEHHA], 1999). The cormorant ingestion rate was calculated using the allometric equation to calculate ingestion rates for seabirds (Equation 3-6 from the USEPA Wildlife Exposure Factors Handbook [USEPA, 1993]). The resulting ingestion rate of 108 g/day dry weight converts to 540 g/day wet weight assuming a moisture content of 80% in the fish. This ingestion rate is consistent with observations reported by Johnson et al. (2003) that double-crested cormorants consume approximately 25% of their body weight on a wet weight basis each day. The ingestion dose to the cormorant was calculated using Equation 1.

$$Dose = \frac{(C_{sed} * DI_{sed}) + (C_{sed} * BAF * DI_{fish}) * SUF}{BW} \qquad \text{(Equation 1)}$$

where:

Dose	=	average daily chemical dose to cormorant (mg/kg-d)
C_{sed}	=	maximum chemical concentration in the sediment (mg/kg)
DI_{sed}	=	daily incidental ingestion of sediment (kg/d)
BAF	=	chemical specific sediment to fish bioaccumulation factor for COPCs (unitless)
DI_{fish}	=	daily ingestion of fish (kg/d)
SUF	=	site use factor (unitless)
BW	=	cormorant body weight (kg)

Table 4-9. Food-chain Exposure Parameters for the Double-crested Cormorant

Exposure Parameter	Abbreviation	Source	Unit	Value
Body weight	BW	1	kg	2.162
Ingestion rate	IR	calculated	kg/kg-day	0.05
Daily ingestion	DI_{total}	2	kg/day	0.110
Percent of sediment in diet	%Soil	3	percent	2
Daily sediment ingestion	DI_{soil}	calculated	kg/day	0.0022
Percent fish in diet	%Fish	default	percent	100
Daily fish ingestion	DI_{fish}	calculated	kg/day	0.108
Foraging distance	FR	4	km	3.5 (min) 15.7 (mean) 61.8 (max)
Site Use Factor (max of 1)	SUF	default	unitless	1

Sources:
1) Lowest of three reported mean body weights for adult double-crested cormorants from OEHHA/CalEcotox (1999).
2) Allometry based on Equation 3-6, from USEPA (1993).
3) Based on reported values of blue-winged teal and ring-necked duck, from Beyer et al. (1994).
4) Based on values reported in OEHHA/CalEcotox (1999).

Basis and Rationale for Double-crested Cormorant Exposure Parameters

Body weight: OEHHA/CalEcotox (1999) reported mean adult cormorant body weights from three separate studies. The lowest mean body weight was chosen to remain conservative in the dose assessment. The chosen value represents mean body weight of adult females, which average smaller in size than adult males.

Ingestion rate: This value was back-calculated from the daily ingestion and the body weight ($IR = DI_{total} / BW$).

Daily ingestion: This value was calculated as $DI\ (\text{g/day}) = 0.495 \cdot BW(\text{g})^{0.704}$ dry weight (Equation 3-6 for seabirds [USEPA, 1993]). This equation is adapted from Nagy (1987).

Percent of sediment in diet: No sediment ingestion value was available for the double-crested cormorant, so sediment ingestion for blue-winged teal and ring-necked duck as reported by Beyer et al. (1994) was used as a surrogate value.

Daily sediment ingestion: Calculated on the basis of the reported percent sediment ingestion in diet and the daily ingestion ($\%sed \cdot DI_{total} = DI_{sed}$).

Percent fish in diet: Although some studies show that the double-crested cormorant consumes invertebrates as well as fish (OEHHA/CalEcotox, 1999), for assessing risk to piscivorous birds the diet of cormorants at NSB New London is assumed to be 100% fish.

Daily fish ingestion: Calculated as $\%fish \cdot DI_{total} = DI_{fish}$.

SUF: Site use factor is assumed to be 1 in each area. Cormorant foraging distances are highly variable, but cormorants will stay within an area as long as prey is easily available.

Estimated concentrations of the four food chain COPCs (Cr, Hg, Pb, and Zn) in fish were calculated using bioaccumulation factors (BAFs) derived from fish and sediment data collected in Pier 1 and the Reference Area. Efforts to collect fish from Zone 4 and Zone 7 for the purposes of calculating area-specific fish

EPCs had limited success; therefore, BAFs were calculated based on areas where fish were collected, and were applied to Zone 4 and Zone 7 sediment EPCs to estimate fish concentrations. BAFs were calculated for Pier 1 and the Reference Area by dividing the average fish concentration of each COPC in each area, by the average sediment COPC concentration in that area. The BAFs from each of the three areas were then averaged to obtain an overall average BAF for each of the four food chain COPCs (Table 4-10). As shown in Table 4-10, there was a wide range of BAFs, especially for zinc, when comparing the three areas where fish collection took place. This was mainly due to the fact that Reference Area fish concentrations were similar to Study Area fish concentrations, even though the Reference Area sediment concentrations were lower. This resulted in high BAFs for the Reference Area compared Pier 1. To deal with this variability, food chain doses were calculated using both the average BAF across the three areas and the maximum BAF observed across the three areas.

The estimated daily dose was compared to literature-based, chronic no observed adverse effects level (NOAEL) and lowest observed effects level (LOAEL) avian toxicity reference values (TRVs) to determine if chemicals in the sediments and food chain pose a potential risk to piscivorous birds (Equation 2). The ratio of the dose to the TRV provides a hazard quotient (HQ). HQ values exceeding 1 indicate potential risk to upper-trophic level receptors; whereas HQ values less than 1 indicate no potential risk. Table 4-11 provides a list of TRVs and associated sources.

$$HQ = \frac{Dose}{TRV} \qquad \text{(Equation 2)}$$

Table 4-10. Derivation of Metal BAFs for Piscivorous Bird Food Chain Dose Model

	Chromium			Lead			Mercury			Zinc		
	Mean Fish Concentration (mg/kg)	**Mean Sediment Concentration (mg/kg)**	**BAF**	**Mean Fish Concentration (mg/kg)**	**Mean Sediment Concentration (mg/kg)**	**BAF**	**Mean Fish Concentration (mg/kg)**	**Mean Sediment Concentration (mg/kg)**	**BAF**	**Mean Fish Concentration (mg/kg)**	**Mean Sediment Concentration (mg/kg)**	**BAF**
Inner Pier 1	1.97	258	0.008	5.47	1889	0.003	0.11	3.18	0.03	119	6409	0.02
Outer Pier 1	1.7	88	0.02	0.72	141	0.005	0.087	0.738	0.12	62.2	304	0.2
Reference Area	3.6	63	0.06	3.73	42.6	0.088	0.15	0.253	0.6	117	96	1.2
	Mean Chromium BAF		**0.03**	**Mean Lead BAF**		**0.03**	**Mean Mercury BAF**		**0.25**	**Mean Zinc BAF**		**0.5**
	Max Chromium BAF		**0.06**	**Max Lead BAF**		**0.088**	**Max Mercury BAF**		**0.6**	**Max Zinc BAF**		**1.2**

Table 4-11. TRVs Used in the Double-crested Cormorant Food Chain Model

COPC	Avian NOAEL TRV (mg/kg·d)	Reference	Avian LOAEL TRV (mg/kg·d)	Reference
Chromium	2.66	USEPA, 2005a	5	Sample et al., 1996
Lead	1.63	USEPA, 2005b	42.7	Calculated from USEPA, 2005b[a]
Mercury	0.0064	Sample et al., 1996	0.064	Sample et al., 1996
Zinc	14.5	Sample et al., 1996	131	Sample et al., 1996

[a] Geometric mean of 15 lead LOAELs bounded by NOAELs for growth or reproduction endpoints reported in USEPA (2005b).

Results of the food-chain dose modeling to double-crested cormorant are presented in Table 4-12. No COPCs had doses exceeding LOAEL TRVs in any NSB-NLON Study Area, even when maximum BAFs were used, although some COPCs exceeded NOAEL TRVs as discussed below.

Chromium doses were less than NOAEL TRVs (HQ values < 1) for both mean BAFs and maximum BAFs in Zone 7, Zone 4, and Outer Pier 1, indicating no unacceptable risk exists to piscivorous birds from chromium in NSB-NLON sediments.

Lead doses were less than NOAEL TRVs for mean and maximum BAFs in Zone 7 and Outer Pier 1, indicating no unacceptable risk to piscivorous birds from lead in these areas. Lead doses slightly exceeded NOAEL TRVs (HQ = 1.19) in Zone 4 when maximum BAFs were used. Potential risk to piscivorous birds from lead in Zone 4 sediment is discussed further in the risk characterization section (Section 4.4).

Zinc doses exceeded the NOAEL TRV (HQ = 1.29) in Zone 7 when maximum BAFs were used, but not when average BAFs were used. Zinc doses exceeded the NOAEL TRV for both average and maximum BAFs in Zone 4 (maximum BAF HQ = 8.02, average BAF HQ = 3.42). Potential risk to piscivorous birds from zinc in Zone 4 and Zone 7 sediment is discussed further in Section 4.4.

Mercury in Outer Pier 1 exceeded NOAEL TRVs for both the average BAF (HQ = 1.15) and maximum BAFs (HQ = 2.6). Potential food-chain risk from mercury is discussed further in the risk characterization section.

Table 4-12. Double-crested Cormorant Food-chain Model Results Using Both Mean and Maximum Bioaccumulation Factors

Analyte	95% UCL Sediment Concentration (mg/kg dry wt.)	BAF	Average Fish Concentration (mg/kg dry wt.)	Average Calculated Dose (mg/kg-d)	LOAEL Avian TRV (mg/kg-d)	NOAEL Avian TRV (mg/kg-d)	HQ2 (Dose/ LOAEL TRV)	HQ1 (Dose/ NOAEL TRV)
Zone 7								
Chromium (mean BAF)	97.8	0.03	2.94	0.249	5	2.66	0.050	0.094
Chromium (max BAF)	97.8	0.06	5.87	0.398	5	2.66	0.080	0.150
Lead (mean BAF)	88.7	0.03	2.66	0.226	42.7	1.63	0.005	0.138
Lead (max BAF)	88.7	0.09	7.98	0.496	42.7	1.63	0.012	0.304
Zinc (mean BAF)	304	0.5	152	8.038	131	14.5	0.061	0.554
Zinc (max BAF)	304	1.2	365	18.86	131	14.5	0.144	1.30
Zone 4								
Chromium (mean BAF)	182	0.03	5.46	0.463	5	2.66	0.09	0.17
Chromium (max BAF)	182	0.06	10.9	0.741	5	2.66	0.15	0.27
Lead (mean BAF)	353	0.03	10.6	0.898	42.7	1.63	0.02	0.55
Lead (max BAF)	353	0.09	31.8	1.98	42.7	1.63	0.05	1.21
Zinc (mean BAF)	1908	0.5	954	50.5	131	14.5	0.39	3.48
Zinc (max BAF)	1908	1.2	2290	118	131	14.5	0.90	8.17
Outer Pier 1								
Chromium (mean BAF)	91.7	0.03	2.75	0.233	5	2.66	0.05	0.09
Chromium (max BAF)	91.7	0.06	5.5	0.373	5	2.66	0.07	0.14
Lead (mean BAF)	217	0.03	6.51	0.552	16	1.6	0.03	0.35
Lead (max BAF)	217	0.09	19.5	1.21	16	1.6	0.08	0.76
Mercury (mean BAF)	0.531	0.25	0.133	0.007	0.064	0.0064	0.11	1.14
Mercury (max BAF)	0.531	0.6	0.319	0.017	0.064	0.0064	0.26	2.61

Shaded cells indicate an HQ > 1.

4.4 Risk Characterization

This section characterizes risk for the two assessment endpoints identified in the ecological problem formulation based on the results presented in Sections 4.2 and 4.3. The risk characterization also bounds any specific sub-areas within each of the three Study Areas that may pose potential unacceptable risk to benthic invertebrates and/or piscivorous birds.

4.4.1 Benthic Invertebrate Risk

The first step in characterizing risk for benthic invertebrates is to establish a cause and effect, or dose-response relationship, which links the bioassay results and the sediment chemistry results. Statistically significant differences were observed between Study Area and Reference Area bioassay results for all three measurement endpoints (survival, growth, and reproduction). Regression analyses were conducted for each endpoint against a variety of individual chemicals, sums of chemicals (e.g., total PCBs, total HMW PAH, total LMW PAH), and chemical indices (e.g., effects range median-quotients [ERM-Qs]) for any correlations between chemical concentration and toxicity.

The ERM-Q combines risk-related inputs from multiple COPCs into a single measure. ERM-Q calculations for the NSB-NLON Thames River areas were limited to those chemical constituents identified as COPCs in the ecological screening assessment, as presented in Table 4-13. Each chemical's concentration is normalized to its effects range-median (ER-M) and the normalized concentrations are averaged. The contribution to the ERM-Q from each chemical can be compared directly, and the ERM-Q reflects the total risk. The ER-M is a published concentration of the median toxicity level for a given chemical (Long, 1995). ERM values have been developed based on an assimilation of data from a vast literature search. The median value for a chemical represents the threshold such that a concentration above the value is likely to be toxic to a wide range of organisms. Equation 3 is the formula used to calculate ERM-Q values. Table 4-13 lists each COPC used in the numerator and its associated ER-M used in the denominator.

$$\mathrm{ERM-Q} = \frac{1}{n}\sum_{i=1}^{n}\frac{\left[\mathrm{COPC}_i\right]}{\mathrm{ERM}_i} \qquad \text{(Equation 3)}$$

where:

[COPC] = the concentration of an individual COPC
ERM = the published median concentration above which a toxic effect is likely (Table 4-13)
n = the total number of COPCs
i = indexes the COPCs

In addition to the standard ERM-Q, which serves as an index of potential toxicity across multiple chemicals, the regression analyses also consider an ERM-Q based only on inorganic constituents (Metals ERM-Q) and an ERM-Q based only on organic constituents (Organic ERM-Q). This was done to recognize that different toxicological modes of actions may result in different expressions of toxicological effects (e.g., metals may result in acute toxicity [mortality], while PCBs and PAHs may result in chronic effects). The Metals ERM-Q was calculated using only the eight metals listed in Table 4-13, while the Organic ERM-Q was calculated using the PAH, PCB, and pesticide constituents listed in Table 4-13. Individual chemical concentrations at each sampling location and the associated ERM-Qs are summarized in Table A-16 in Appendix A.

Table 4-13. COPCs and ER-M Values Used in ERM-Q Calculations

Analyte	units	ERM	Source
Arsenic	mg/kg	70	Long et al, 1995
Cadmium	mg/kg	9.6	Long et al, 1995
Chromium	mg/kg	370	Long et al, 1995
Copper	mg/kg	270	Long et al, 1995
Lead	mg/kg	218	Long et al, 1995
Nickel	mg/kg	51.6	Long et al, 1995
Selenium	mg/kg	1.4	Long and Morgan, 1991
Zinc	mg/kg	410	Long et al, 1995
Total HMW PAH[a]	µg/kg	9600	Long et al, 1995
Total LMW PAH[b]	µg/kg	3160	Long et al, 1995
Total PCB[c]	µg/kg	180	Long et al, 1995
Total 4-4'-DDx[d]	µg/kg	46.1	Long et al, 1995
alpha-chlordane[e]	µg/kg	6	Long and Morgan, 1991

[a] Total HMW PAH is the sum of 6 high molecular weight PAH compounds: Benzo(a)anthracene, Benzo(a)pyrene, Chrysene, Dibenz (a,h)anthracene, Fluoranthene, and Pyrene.

[b] Total LMW PAH is the sum of 7 low molecular weight PAH compounds: 2-Methyl naphthalene, Acenaphthene, Acenaphthylene, Anthracene, Fluorene, Naphthalene, Phenanthrene.

[c] Total PCB calculated as is 2 times the sum of 18 PCB congeners: Cl2(08), Cl3(18), Cl3(28), Cl4(44), Cl4(52), Cl4(66), Cl5(101), Cl5(105), Cl5(118), Cl6(128), Cl6(138), Cl6(153), Cl7(170), Cl7(180), Cl7(187), Cl8(195), Cl9(206), Cl10(209).

[d] Total 4,4'-DDx is the sum of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.

[e] The ERM for chlordane was used as a surrogate value for alpha-chlordane.

Regression statistics for bioassay survival, growth, and reproduction versus sediment chemistry are shown in Table 4-14. Graphs of the regressions for each COPC are included in Appendix A. Statistically significant correlations were found between amphipod toxicity and the majority of individual chemicals and chemical indices. This is due to the fact that elevated concentrations of many chemicals are co-located across locations in Zone 4 and Zone 7. For instance in Zone 4, location Z4-2, which is located along the quay wall, had the highest concentration of metals and second highest concentration of PAHs in any bioassay sample; location Z4-1, also along the quay wall, had the highest PAH concentrations and second highest metals concentrations observed. As a result, it is difficult to determine the effects of any individual chemical, and gives added utility to the various ERM-Q chemical indices. R-squared (r^2) values greater than 0.5 are highlighted in Table 4-14. The greater the r^2 value, the stronger the correlation between the chemical and the toxicity observed. The relatively modest r^2 values are not unexpected due to the wide array of chemical stressors and the variability of physico-chemical conditions across the site.

Regressions were also calculated for PCBs normalized to TOC [(ng PCB per g sed)/ (g TOC/g sed) = ng PCB per g TOC] and metals that were normalized to AVS and OC [(AVS – SEM)/f_{OC}]. AVS and OC-normalized metals regressions showed no statistically significant correlations with any bioassay endpoint (Table 4-14). Normalizing PCBs to TOC improved the relationship between PCB concentration and survival (r^2 increased from 0.469 to 0.587), but there was little to no improvement in the correlation between PCB concentration and growth or reproduction. Although the relationship between survival and TOC-normalized PCBs improved, the correlation is greatly influenced by a single data point and, if not for that point, the slope of the line would essentially be nearly flat (Figure A-121 in Appendix A). Given the lack of correlation observed when normalizing metals to AVS and the lack of improvement in the PCB correlations for the most sensitive endpoints, the non-normalized metals and PCB data were used for further evaluation of the invertebrate toxicity data.

4.4.1.1 Correlations Between Sediment Chemistry and Amphipod Survival

As discussed in Section 4.2.1, three Zone 4 locations (Z4-2, Z4-3, and Z4-6) and two Zone 7 locations (Z7-3 and Z7-4) had survival that was significantly different (i.e., lower) than mean Reference Area survival. According to the decision rules for amphipod survival presented in Table 4-3, survival that is statistically different than Reference Area survival and less than 70% of mean Reference Area survival is considered to be a finding of high magnitude risk. Mean Reference Area survival was 88%, which means the survival threshold for a determination of high magnitude risk is 62% (88% x 0.70). Of the three Zone 4 locations and two Zone 7 locations with survival that was different than Reference Area survival, only location Z4-2 (mean survival of 10%) was less than the 62% threshold. Therefore, Z4-2 is classified high magnitude risk, while Z4-3, Z4-6, Z7-3, and Z7-4 are classified as low magnitude risk.

A review of the correlation statistics in Table 4-14 indicates that arsenic, Total HMW PAHs, Total LMW PAHs, and the Organic ERM-Q were not significantly correlated with amphipod survival. The remaining COPCs, COPC sums, and COPC indices (hereafter cumulatively referred to as chemical indicators) were significantly correlated with survival. Seven chemical indicators (ERM-Q, Metals ERM-Q, copper, lead, nickel, selenium, and Total 4,4'-DDx) had r^2 values greater than 0.5. With the metals, however, this may be slightly misleading because, as illustrated in the regression for lead in Figure 4-4, there are 16 locations with relatively low lead concentrations and high survival, and one location with elevated lead concentrations and low survival, and virtually no data in the middle. The survival regression lines were influenced by one data point (Z4-2) with high toxicity, which was high in both metals and organic constituent concentrations. This is reflective of the "hotspot" type of distribution of the metals in Zone 4, where elevated concentrations occur in sediments along the quay wall that have not been dredged, and lower concentrations occur throughout the rest of the area. The uncertainty associated with the slope of the regression line is increased by the lack of mid-range survival toxicity data and, if not for the single data point with high toxicity, the slope of the line would be shallower, resulting in higher PRGs for the survival endpoint. However, the actual slope of the regression line is somewhat uncertain due to the lack of mid-range toxicity data; the ERM-Q and Metals ERM-Q showed the highest correlative fit with the data. The regression of amphipod survival vs. the ERM-Q is shown in Figure 4-5 and the regression of survival vs. the Metals ERM-Q is shown in Figure 4-6.

Table 4-14. Regression Statistics for Sediment Chemistry vs Bioassay Results

Chemical Indicator	n	Intercept	P (int=zero)	Slope	R2	Correlation Coefficient	Regression p-value	Statistically Significant?
Chemistry vs. Growth								
ERM-Q	18	1.814	1.36E-13	-0.419	0.529	-0.728	0.001	Yes
Metals ERM-Q	18	1.763	1.30E-13	-0.314	0.476	-0.690	0.002	Yes
Organic ERM-Q	18	1.856	1.86E-12	-0.544	0.465	-0.682	0.002	Yes
Arsenic	18	1.809	1.57E-05	-0.020	0.042	-0.205	0.415	No
Cadmium	18	1.822	1.57E-10	-0.267	0.259	-0.509	0.031	Yes
Chromium	18	1.900	9.85E-12	-0.003	0.443	-0.665	0.003	Yes
Copper	18	1.765	3.51E-13	-0.001	0.433	-0.658	0.003	Yes
Lead	18	1.750	1.47E-14	-0.001	0.560	-0.748	3.6E-04	Yes
Nickel	18	1.753	4.88E-14	-0.004	0.509	-0.714	8.8E-04	Yes
Selenium	18	2.226	1.38E-10	-0.734	0.563	-0.750	3.4E-04	Yes
Zinc	18	1.688	9.24E-14	-2.02E-04	0.397	-0.630	0.005	Yes
a-Chlordane	18	1.835	4.31E-11	-0.333	0.319	-0.565	0.015	Yes
Total 4,4'-DDx	18	1.978	7.11E-12	-0.041	0.522	-0.722	7.1E-04	Yes
Total HPAH	18	1.755	5.33E-12	-2.12E-05	0.299	-0.547	0.019	Yes
Total LPAH	18	1.716	3.87E-12	-7.14E-05	0.254	-0.504	0.033	Yes
Total PCB	18	1.934	1.32E-13	-0.003	0.632	-0.795	8.1E-05	Yes
TOC-normalized PCB	18	1.96	1.92E-13	-1.49E-05	0.636	-0.797	1.0E-04	Yes
AVS and OC-normalized metals	18	1.53	3.80E-12	-5.23E-05	0.092	-0.303	0.221	No
Chemistry vs. Reproduction								
ERM-Q	18	3.49	8.27E-09	-1.415	0.444	-0.666	0.003	yes
Metals ERM-Q	18	3.29	1.56E-08	-1.006	0.360	-0.600	0.008	yes
Organic ERM-Q	18	3.77	7.27E-09	-2.095	0.507	-0.712	0.001	yes
Arsenic	18	3.76	3.15E-03	-0.092	0.064	-0.253	0.310	no
Cadmium	18	3.32	7.07E-06	-0.694	0.129	-0.359	0.143	no
Chromium	18	3.77	2.01E-07	-0.010	0.363	-0.602	0.008	yes
Copper	18	3.30	2.71E-08	-0.004	0.336	-0.580	0.012	yes
Lead	18	3.24	4.50E-09	-0.004	0.413	-0.643	0.004	yes
Nickel	18	3.24	1.09E-08	-0.011	0.366	-0.605	0.008	Yes
Selenium	18	4.73	2.29E-06	-2.308	0.409	-0.640	0.004	Yes

Table 4-14. Regression Statistics for Sediment Chemistry vs Bioassay Results, continued

Chemical Indicator	n	Intercept	P (int=zero)	Slope	R2	Correlation Coefficient	Regression p-value	Statistically Significant?
Zinc	18	3.05	1.11E-08	-6.58E-04	0.311	-0.558	0.016	Yes
a-Chlordane	18	3.33	3.96E-06	-0.829	0.146	-0.382	0.118	No
Total 4,4'-DDx	18	3.82	9.77E-07	-0.115	0.309	-0.555	0.017	Yes
Total HPAH	18	3.40	3.87E-08	-8.42E-05	0.348	-0.590	0.010	Yes
Total LPAH	18	3.29	2.26E-08	-3.06E-04	0.344	-0.586	0.011	Yes
Total PCB	18	4.01	7.25E-10	-0.011	0.637	-0.798	0.000	Yes
TOC-normalized PCB	18	4.06	2.16E-09	-5.35E-05	0.603	-0.777	1.0E-04	Yes
AVS and OC-normalized metals	18	2.51	4.24E-07	-1.99E-04	0.098	-0.313	0.207	No
Chemistry vs. Survival								
ERM-Q	18	0.99	1.83E-12	-0.261	0.510	-0.714	8.7E-04	Yes
Metals ERM-Q	18	0.97	2.82E-13	-0.216	0.562	-0.750	3.4E-04	Yes
Organic ERM-Q	18	0.96	6.57E-10	-0.236	0.218	-0.467	0.051	No
Arsenic	18	0.82	6.02E-04	0.002	7.36E-04	0.027	0.915	No
Cadmium	18	1.05	7.19E-11	-0.223	0.449	-0.670	0.002	Yes
Chromium	18	1.03	2.54E-10	-0.002	0.371	-0.609	0.007	Yes
Copper	18	0.97	9.32E-13	-8.14E-04	0.512	-0.716	8.4E-04	Yes
Lead	18	0.96	3.04E-14	-8.24E-04	0.637	-0.798	7.2E-05	Yes
Nickel	18	0.97	2.00E-14	-0.003	0.665	-0.815	3.7E-05	Yes
Selenium	18	1.23	2.31E-09	-0.442	0.508	-0.713	9.0E-04	Yes
Zinc	18	0.92	3.18E-13	-1.40E-04	0.476	-0.690	0.002	Yes
a-Chlordane	18	1.05	2.62E-11	-0.260	0.484	-0.696	0.001	Yes
Total 4,4'-DDx	18	1.10	5.72E-11	-0.026	0.518	-0.719	7.6E-04	Yes
Total HPAH	18	0.92	5.07E-10	-8.79E-06	0.128	-0.358	0.144	No
Total LPAH	18	0.87	7.14E-10	-1.69E-05	0.036	-0.189	0.454	No
Total PCB	18	1.04	2.80E-11	-0.002	0.469	-0.685	0.002	Yes
TOC-normalized PCB	18	1.08	4.58E-12	-9.07E-06	0.587	-0.766	2.0E-04	yes
AVS and OC-normalized metals	18	0.83	7.50E-11	-1.39E-05	0.016	-0.127	0.615	no

Shaded cells indicate r^2 coefficients > 0.50

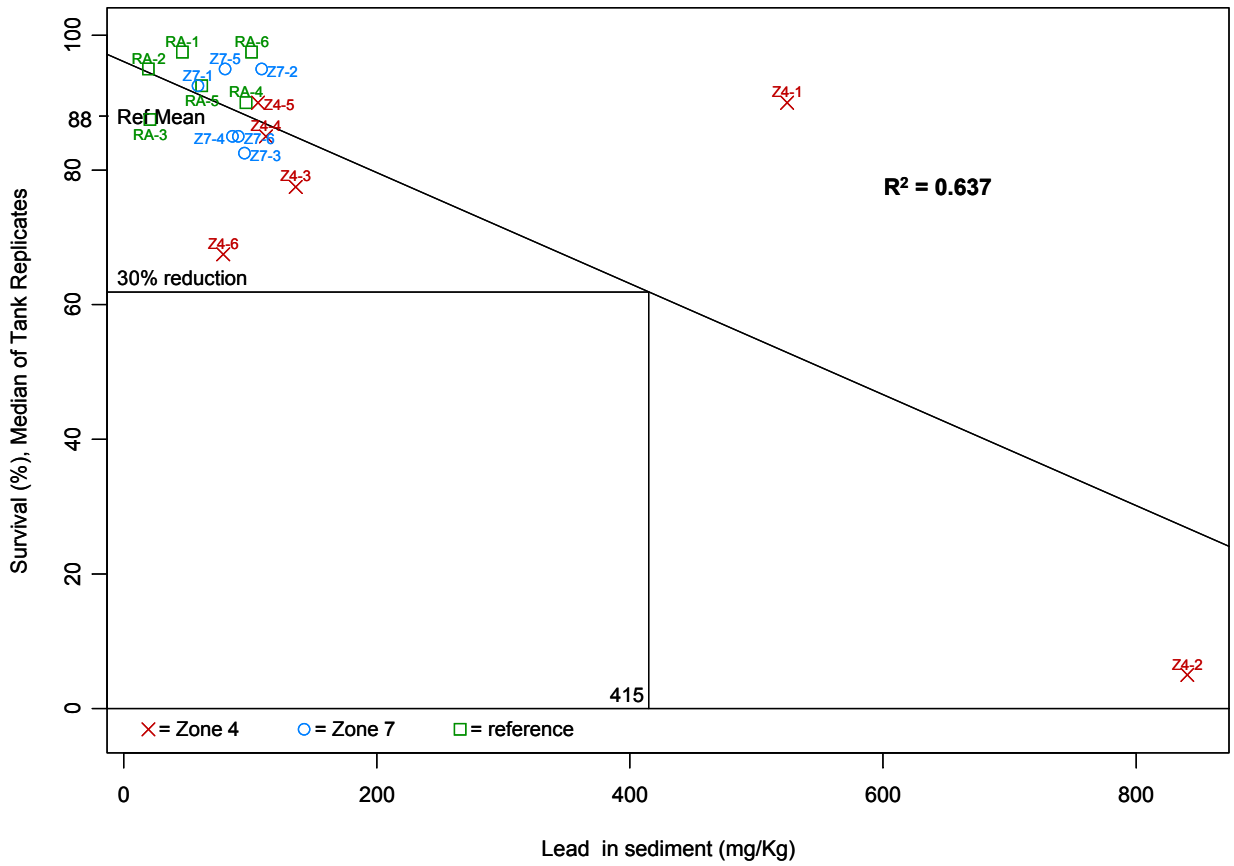

Figure 4-4. Regression of Amphipod Survival vs. Lead

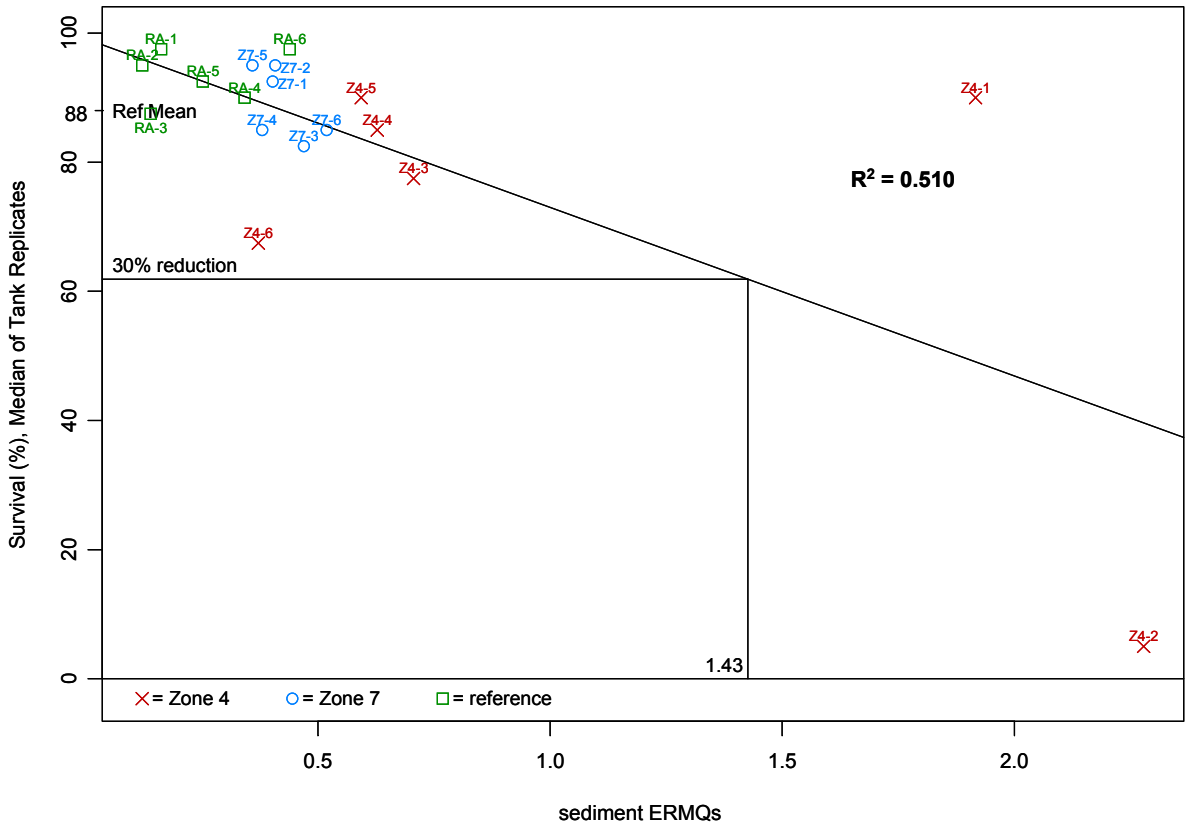

Figure 4-5. Regression of Amphipod Survival vs. ERM-Q

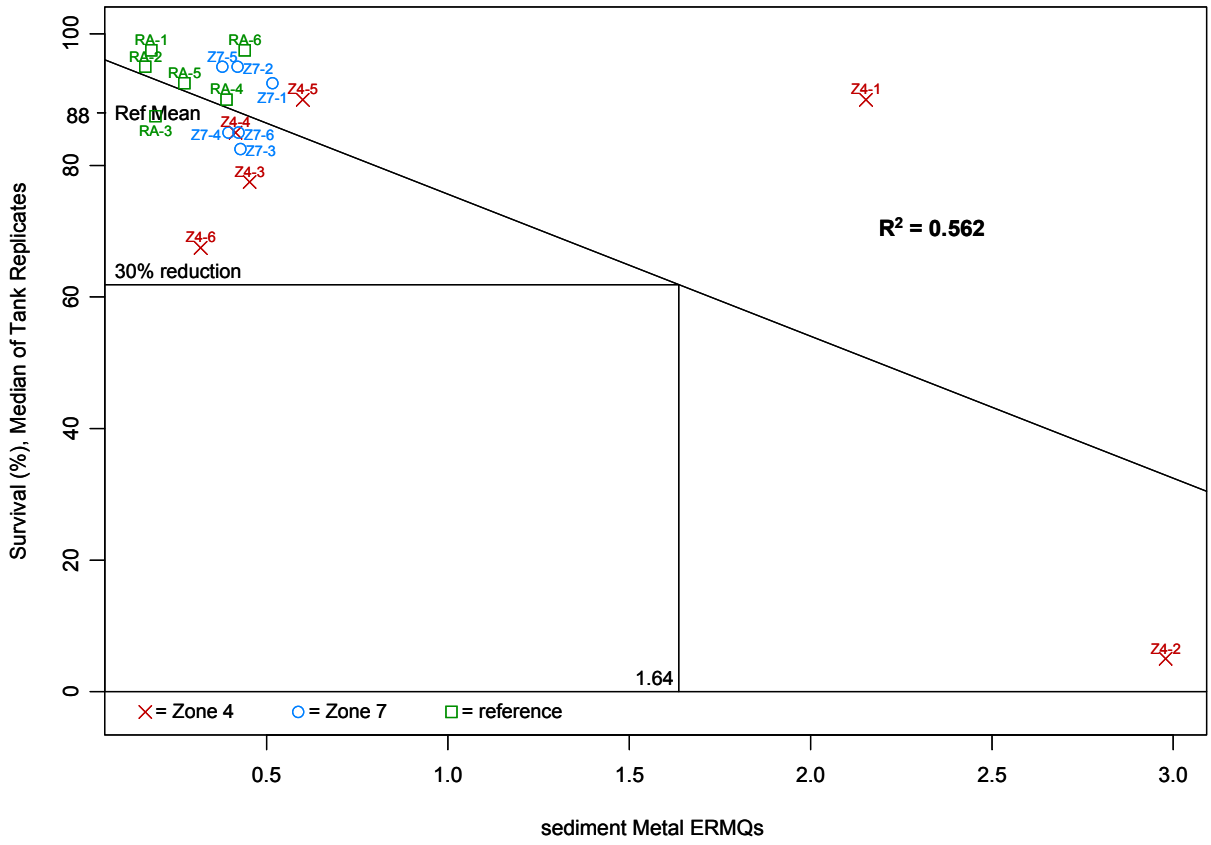

Figure 4-6. Regression of Amphipod Survival vs. Metals ERM-Q

4.4.1.2 Correlations Between Sediment Chemistry and Amphipod Growth

As discussed in Section 4.2.2, five Zone 4 locations (Z4-1, Z4-2, Z4-3, Z4-4, and Z4-6) and four Zone 7 locations (Z7-3, Z7-4, Z7-5, and Z7-6) had growth that was significantly different (i.e., lower) than mean Reference Area growth. According to the decision rules in Table 4-3, these findings represent unacceptable risk. Determining what level of growth reduction is significant in an ecological sense is a difficult question to answer. Smaller organisms may be less "fit" in an ecological context, producing fewer offspring, having shorter life spans, or being generally less able to cope with ecological stressors, but in general, there is a great deal of variability in body size within populations of a given species. As discussed in Section 4.1, a reduction in growth of 30% was selected as the minimum impact of interest.

Table 4-14 shows that arsenic was the only chemical indicator not significantly correlated with amphipod growth in the bioassays. Six chemical indicators (ERM-Q, lead, nickel, selenium, Total 4,4'-DDx, and Total PCBs) had r^2-values greater than 0.5. As with the survival correlations, the metals data has the bulk of the data clustered on the low chemical concentration end of the graph (Figure 4-7), with limited mid-range metals chemistry data available.

Total PCBs and ERM-Q provide the best correlations with the best distribution of data. Figure 4-7 shows the regression of amphipod growth vs. ERM-Q, with ERM-Q levels corresponding to growth reductions

of 30% and 50% compared to the Reference Area identified on the graph. A 30% reduction in growth corresponds to an ERM-Q of 1.54, while a 50% reduction in growth corresponds to an ERM-Q of 2.34. Figure 4-8 shows the regression of amphipod growth vs. Total PCBs. A growth reduction of 30% corresponds to a Total PCB sediment concentration of 270 µg/kg, while a growth reduction of 50% corresponds to a Total PCB concentration of 387 µg/kg.

For the growth line of evidence, it does not matter whether Reference Area performance or laboratory control performance is chosen as the benchmark for comparisons, because both Reference Area and laboratory controls had mean growth of 1.67 mg, with almost identical standard deviations.

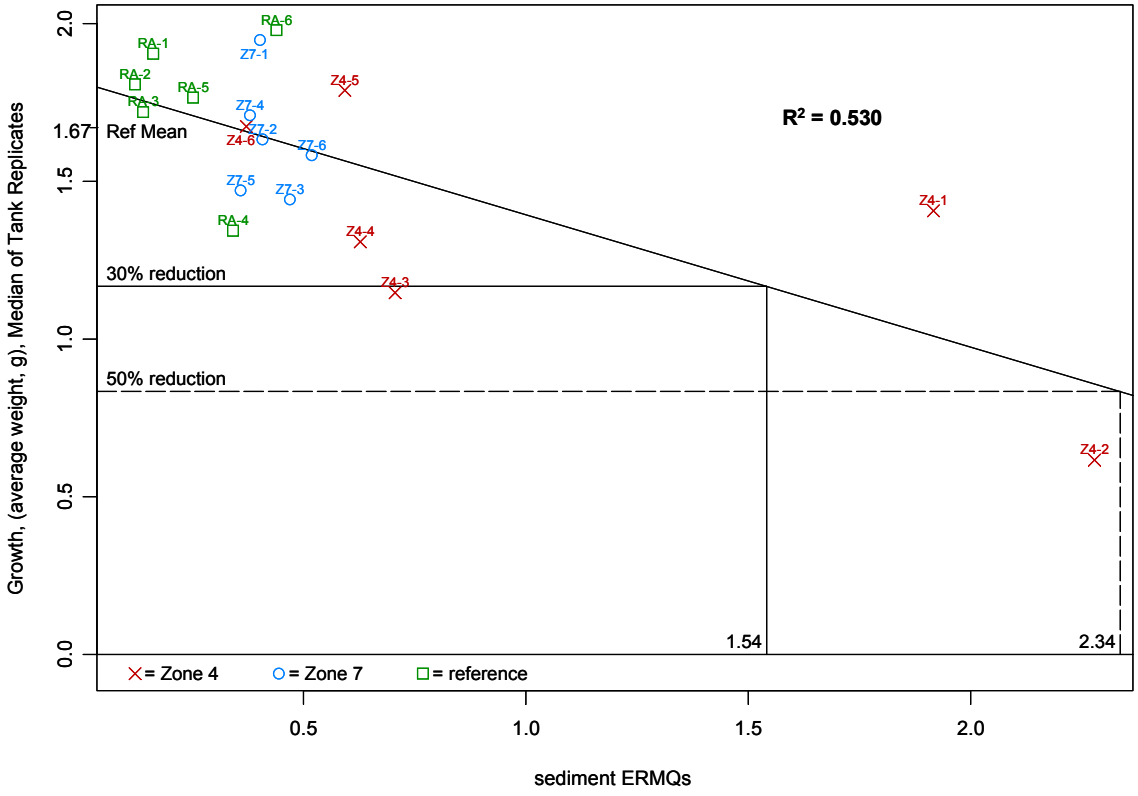

Figure 4-7. Regression of Amphipod Growth vs. ERM-Q

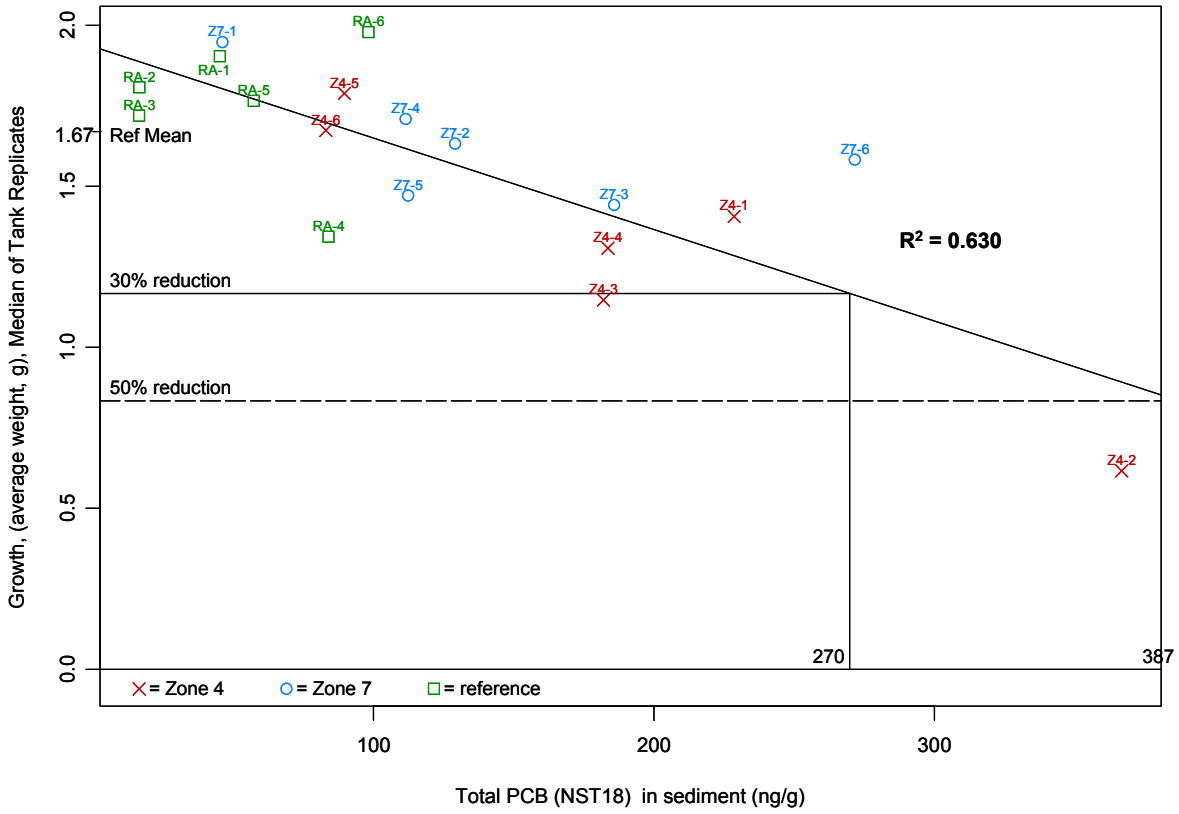

Figure 4-8. Regression of Amphipod Growth vs. Total PCBs

4.4.1.3 Correlations Between Sediment Chemistry and Amphipod Reproduction

As discussed in Section 4.2.3, four Zone 4 locations (Z4-1, Z4-2, Z4-3, and Z4-4) and two Zone 7 locations (Z7-4 and Z7-6) had reproduction that was significantly different (i.e., lower) than mean Reference Area reproduction. According to the decisions rules in Table 4-3, these findings represent unacceptable risk. As with the growth line of evidence, no threshold was proposed in the Work Plan DQOs for differentiating magnitude of risk for the reproduction line of evidence, although a reduction of 25% was suggested by USEPA at the August 2007 Partnering Team Meeting as a generally accepted threshold for ecological significance.

Table 4-14 shows that arsenic, cadmium, and alpha-chlordane were not significantly correlated with amphipod reproduction. All other chemical indicators were significantly correlated with reproduction, but only two of those, Organic ERM-Q and Total PCBs, had r^2 values greater than 0.5 (although the ERM-Q was third highest with an r^2 of 0.44).

Figure 4-9 shows the regression of amphipod reproduction vs. Organic ERM-Q; Figure 4-10 shows the regression of amphipod reproduction vs. Total PCBs; and Figure 4-11 shows the regression of amphipod reproduction vs. ERM-Q. In all three figures, the levels corresponding to reductions in the number of offspring produced at 25% and 50% of the Reference Area are identified. An Organic ERM-Q of 0.489 correlates with a 25% reduction in the number of offspring produced, while an Organic ERM-Q of 0.925

correlates with a 50% reduction in the number of offspring. For Total PCB concentrations, 121 µg/kg and 208 µg/kg correlate to reductions in the numbers of offspring produced at 25% and 50% of the Reference Area. The ERM-Q associated with a 25% reduction in offspring was 0.528 and the ERM-Q for a 50% reduction in offspring was 1.17.

The Organic ERM-Q is calculated using Total PCBs ($r^2 = 0.637$), Total DDx, LPAH, HPAH (all with $r^2 < 0.38$), and alpha-chlordane ($r^2 = 0.146$). If Total PCBs are omitted from the Organic ERM-Q calculation, the resulting Organic ERM-Q has an r^2 of 0.40. Based on these values, it would appear that when the Organic ERM-Q includes Total PCBs, the r^2 (0.52) is driven by the PCB component of the quotient. Therefore, it is more appropriate to use Total PCBs as the reproduction toxicity indicator instead of the Organic ERM-Q. As agreed to with the BTAG during the February 2008 monthly production call, the Organic ERM-Q is discounted from further evaluation as a toxicity indicator in lieu of the Total PCB concentration.

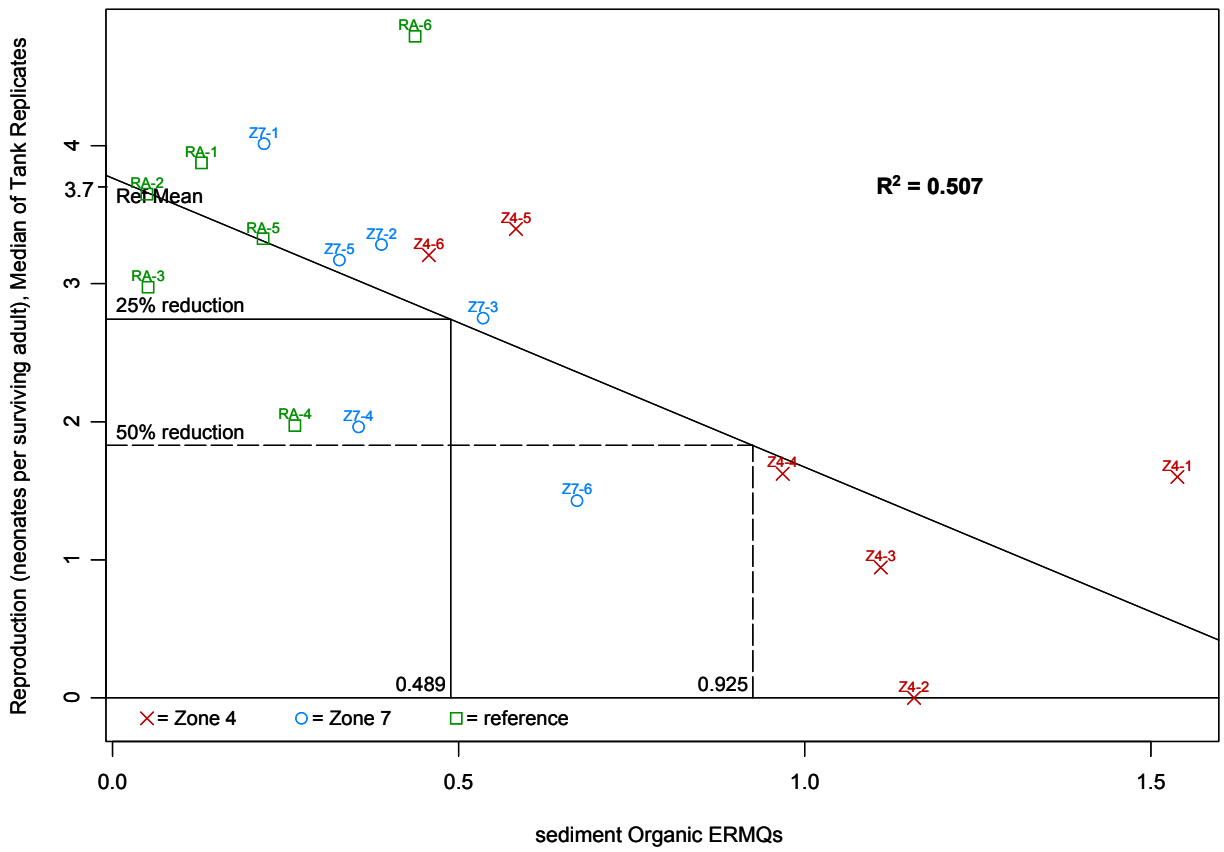

Figure 4-9. Regression of Amphipod Reproduction vs. Organic ERM-Q

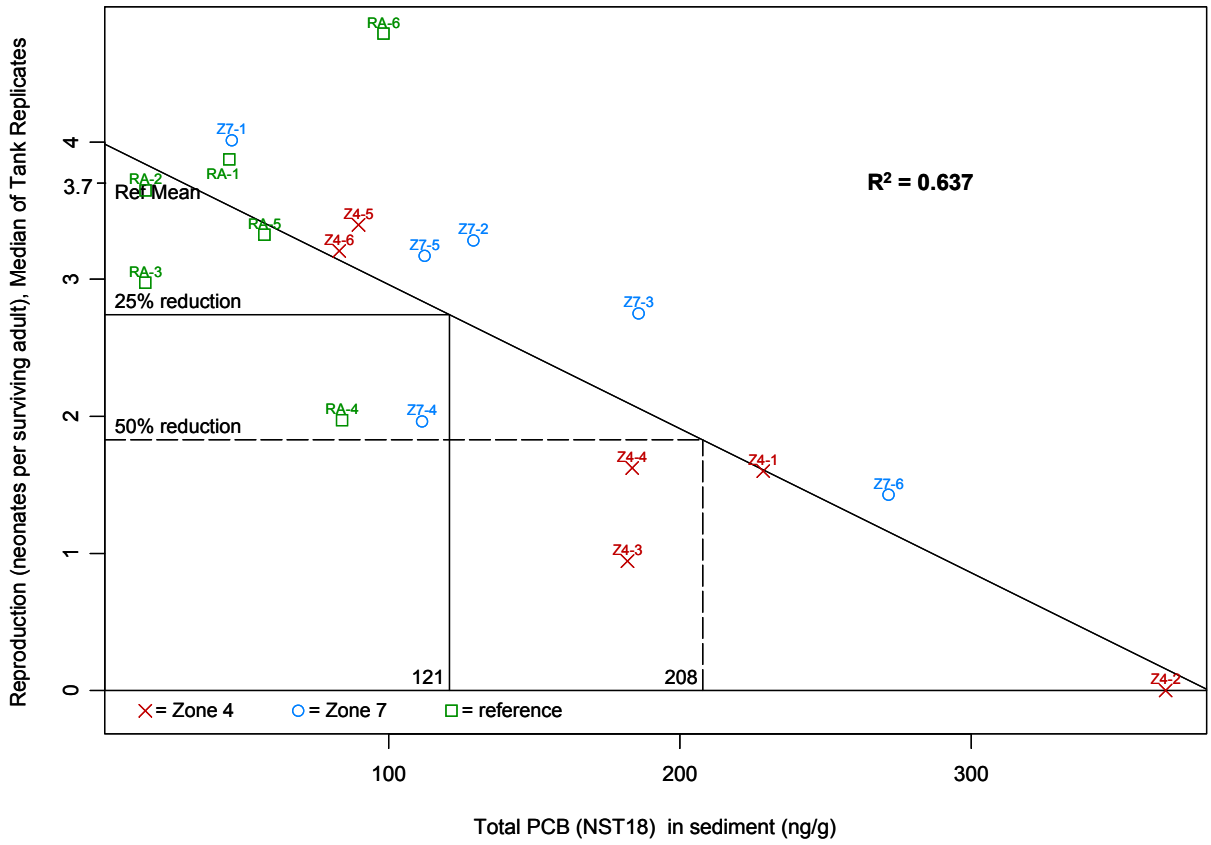

Figure 4-10. Regression of Amphipod Reproduction vs. Total PCBs

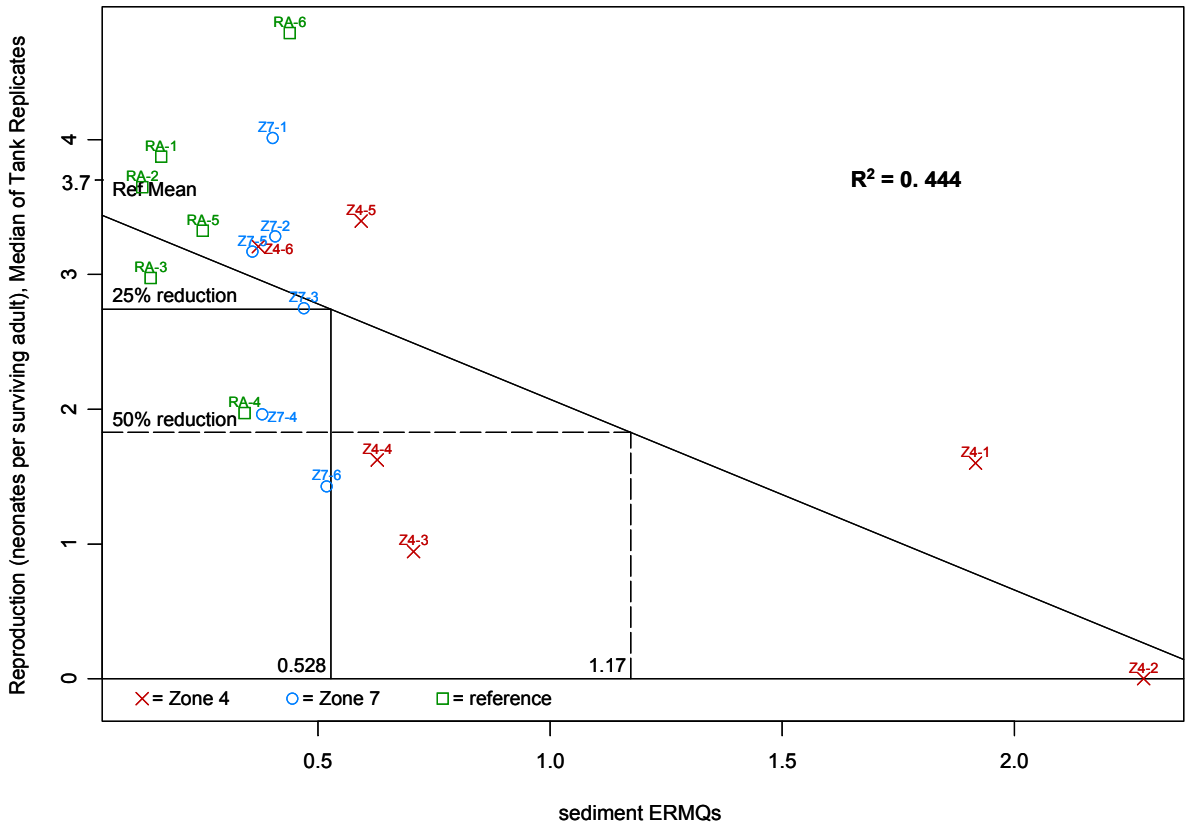

Figure 4-11. Regression of Amphipod Reproduction vs. ERM-Q

4.4.1.4 Determining Areas Associated with Risk to Benthic Invertebrates

Based on the correlations discussed in the previous sections, the ERM-Q values associated with a 30% reduction in amphipod survival (high magnitude risk), 30% reduction in amphipod growth (moderate magnitude risk), and a 25% reduction in production of amphipod offspring (moderate magnitude risk) will serve as preliminary remediation goals (PRGs) for the purposes of developing footprints associated with unacceptable risk to benthic invertebrate communities. In addition to the ERM-Q based PRGs, PRGs were also developed for the Organic ERM-Q based on a 25% reduction in offspring (moderate risk), Total PCBs based on a 30% reduction in growth and a 25% reduction in offspring (moderate risk), and the Metals ERM-Q based on a 30% reduction in survival (high risk). For the growth and reproduction lines of evidence, PRGs associated with a 50% reduction in growth and reproduction (high magnitude risk) were also identified and footprint contours were developed. The PRGs associated with each line of evidence and each chemical indicator are shown in Table 4-15. As discussed in the previous section, the Organic ERM-Q was eliminated from further evaluation because the correlation between Organic ERM-Q and toxicity is being driven by the Total PCB component of the quotient, and Total PCBs are evaluated separately.

Table 4-15. Identification of PRGs Based on Bioassay Toxicity

Chemical Indicator	Reproduction		Survival	Growth	
	25% PRG	50% PRG	30% PRG	30% PRG	50% PRG
ERM-Q (unitless)	0.53	1.17	1.43	1.54	2.34
Metals ERM-Q (unitless)	NC	NC	1.64	NC	NC
Total PCBs (µg/kg)	121	208	NC	270	387

NC = PRG not calculated because correlating $r^2 < 0.5$

The PRG footprints are based on local regression models built using Locfit (Local Regression and Likelihood, available at: http://cm.bell-labs.com/cm/ms/departments/sia/project/locfit/) for S-plus (Lucent Technologies, 2001). This spatial model fits a quadratic polynomial surface concentration to the selected study area(s). The model predicts concentrations on a user-specified grid using a fraction of the nearest neighbors (results from nearest sampled locations) and weighting observations so that data values closest to the grid point receive the largest weight (tricube weight function). The tricube weight function is a standard choice for inverse distance weighting. The functional form is $W(x)=(1-|x|^3)^3$, $|x|<1$, where x is the distance between the data point and grid point standardized to a maximum distance. The choice of the fraction of nearest neighbors serves as a smoothing parameter, with the smaller the fraction having a more jagged surface. While the weight function ensures that the predicted grid concentration is most responsive to the data in the close vicinity, the smoothing parameter considers a large fraction of the data to develop the overall surface pattern. Zone 7, Zone 4, and Pier 1 were fit separately because of the likely different nature of the source term and the distance between them. A number of smoothing parameters (fractions of nearest neighbors) were used and evaluated visually using posting plots to show which sample concentrations fell within the contours. The fits were evaluated statistically using residual diagnostics. The criteria indicated that the number of sampling locations was the primary factor in the selection of the smoothing parameter and that fractions of 0.5 to 0.95 performed well.

Zone 7

ERM-Qs for Zone 7 are presented by sampling location in Figure 4-12, and the associated footprints are shown in Figure 4-13. Concentrations in Figure 4-12 are color-coded according to the range of ERM-Q PRGs in Table 4-15. In Zone 7, the only ERM-Q PRG footprint contour is based on the PRG for a 25% reduction in amphipod reproduction (ERM-Q PRG = 0.53) and encompasses approximately 2.8 acres. There are no ERM-Q PRG footprints for reduced amphipod survival or growth, because no contours in Zone 7 exceeded the survival ERM-Q PRG of 1.43 or the growth ERM-Q PRG of 1.54.

Total PCBs (in parts per billion [ppb], equivalent to µg/kg) by sampling location are plotted relative to PCB PRGs in Figure 4-14. The Total PCB PRG footprints are shown in Figure 4-15. Although Total PCBs and Organic ERM-Qs showed the highest correlation with amphipod reproduction, the footprints associated with Total PCB PRGs show little overlap in Zone 7 with the Organic ERM-Q PRG footprint. This is because total PCB concentrations in Zone 7 generally contribute less to the ERM-Q values than PAH concentrations, and PCB concentrations in Zone 7 are not co-located with PAH concentrations. The footprint for the PRG associated with a 25% reduction in offspring (Total PCBs > 121 µg/kg) encompasses 1.14 acres in the southern portion of Zone 7, south of Pier 15. There were no footprints areas in Zone 7 exceeding the PRG for 50% reduction in offspring (Total PCBs > 208 µg/kg). There are no Total PCB PRG footprints for reduced amphipod growth, because no footprint areas in Zone 7 exceeded the growth PRG for Total PCBs of 270 µg/kg.

Metals ERM-Qs by sampling location are plotted relative to Metals ERM-Q PRGs in Figure 4-16. No contour exceeded 1.64 (PRG for survival) in Zone 7, so there is no footprint associated with adverse impact to benthic invertebrate survival based on the Metals ERM-Q PRG.

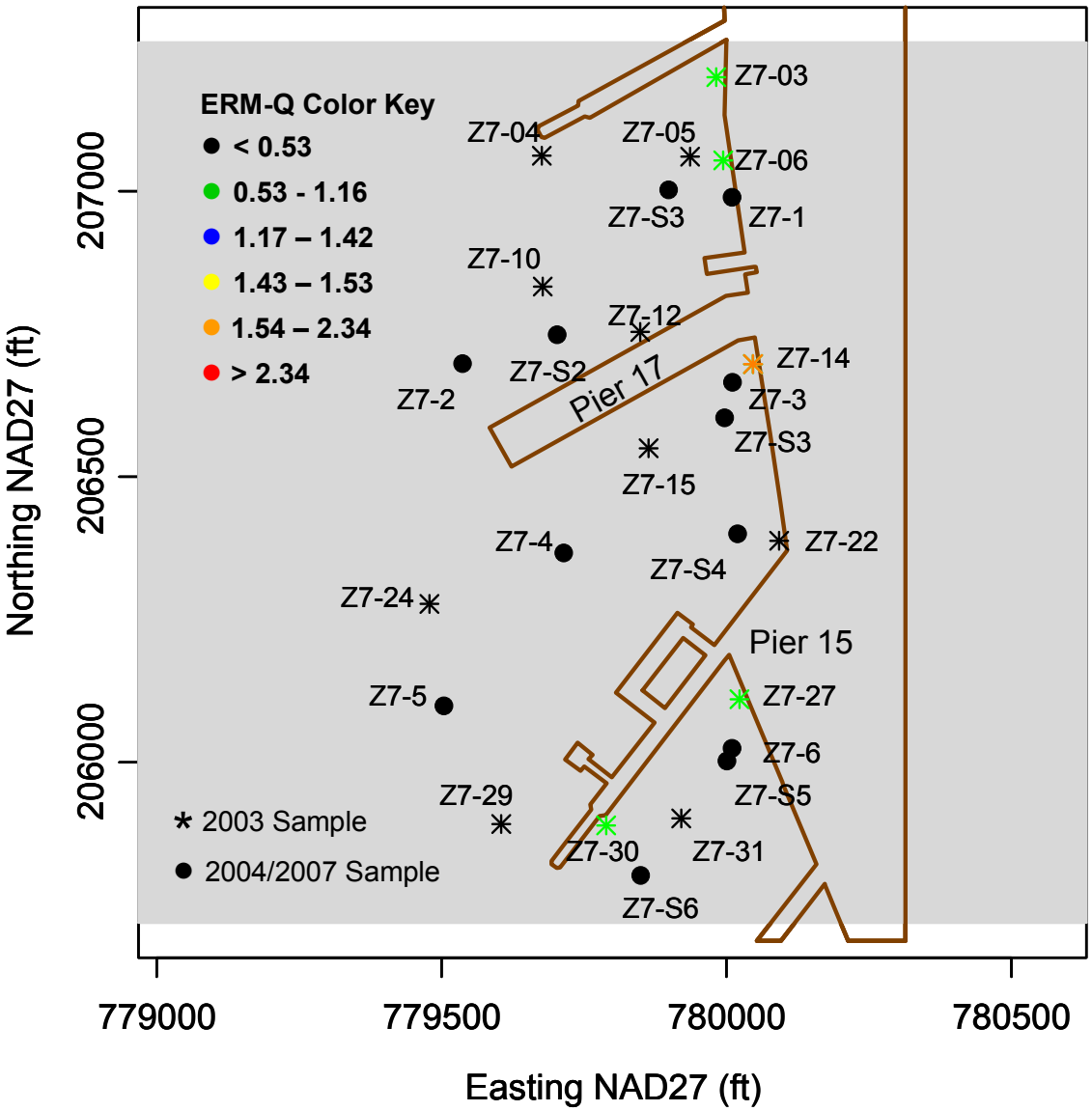

Figure 4-12. Zone 7 ERM-Qs by Sample Location

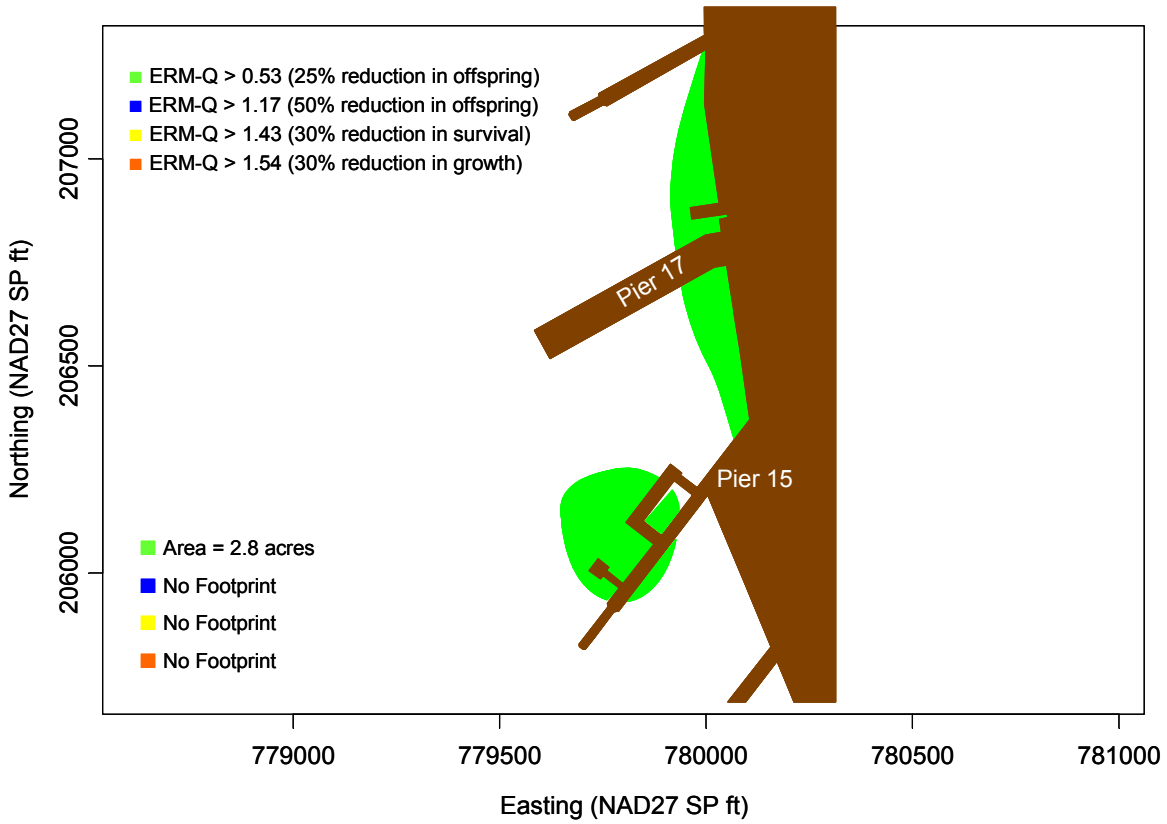

Figure 4-13. Zone 7 Footprints Exceeding ERM-Q PRGs

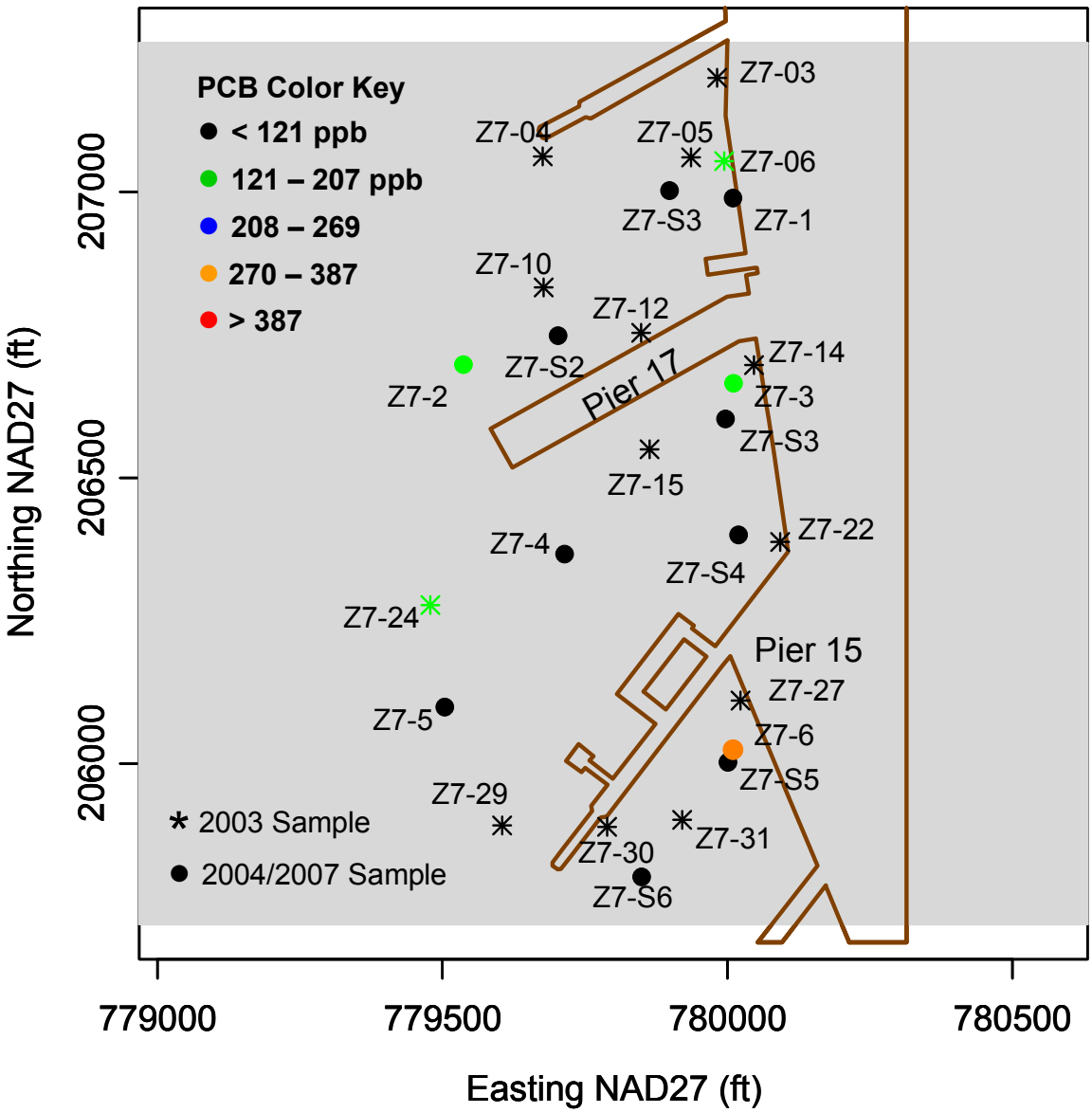

Figure 4-14. Zone 7 Total PCBs (µg/kg) by Sample Location

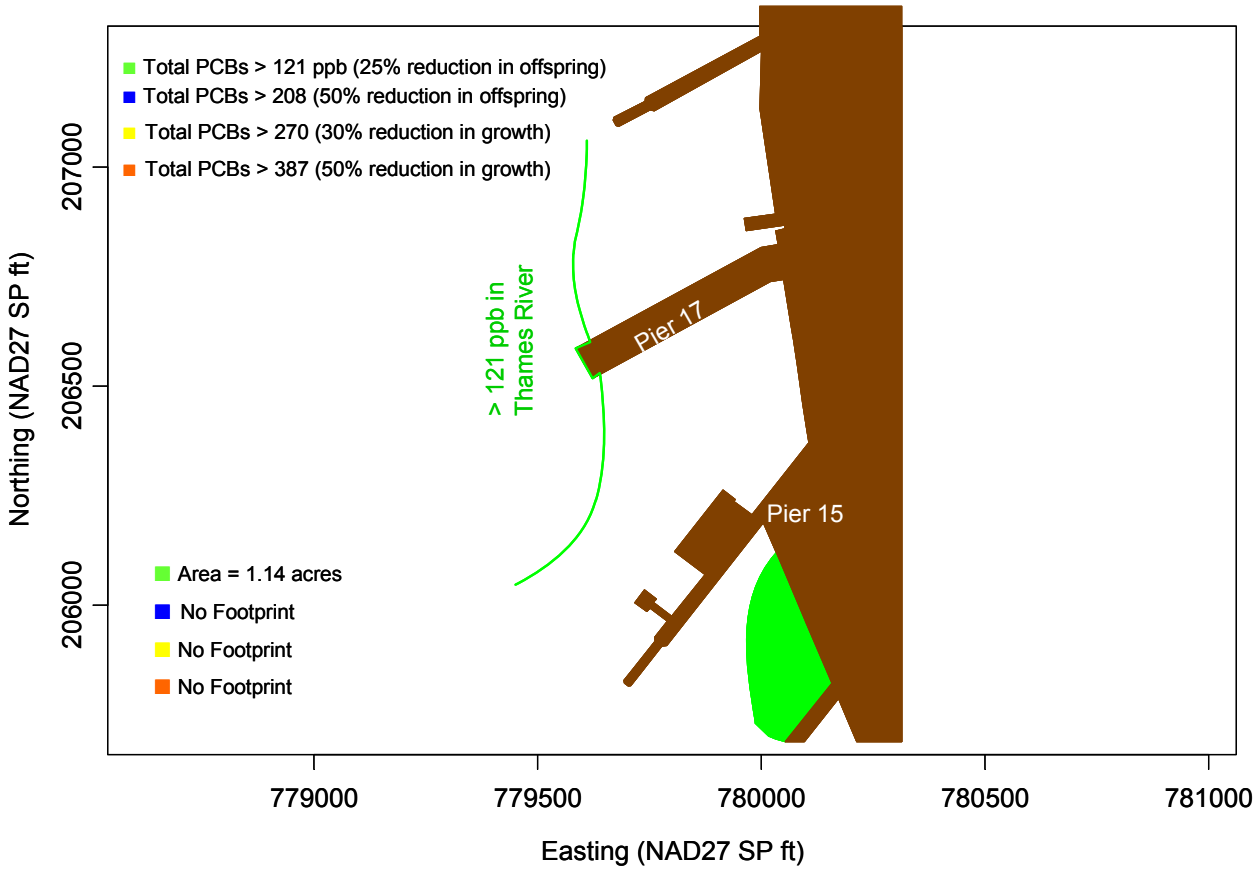

Figure 4-15. Zone 7 Footprints Exceeding Total PCB PRGs

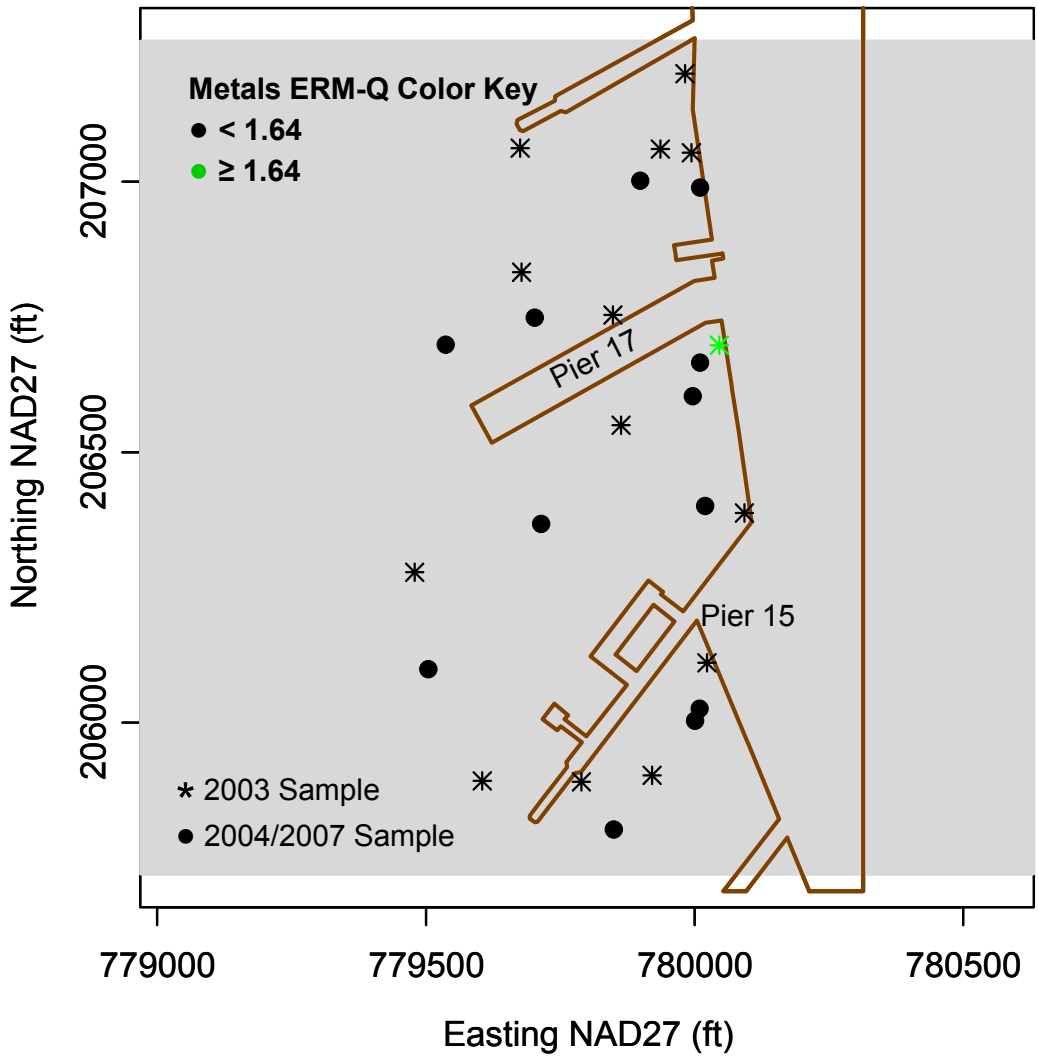

Figure 4-16. Zone 7 Metals ERM-Qs by Sample Location

<u>Zone 4</u>

ERM-Qs for Zone 4 sampling locations are plotted in Figure 4-17, and associated footprints are shown in Figure 4-18. Concentrations in Figure 4-17 are color-coded according to the range of ERM-Q PRGs in Table 4-15. In Zone 4, the ERM-Q footprint associated with a 25% reduction in the number of offspring produced (ERM-Q > 0.53, green footprint in Figure 4-18) encompasses approximately 2.23 acres around Pier 2, while the ERM-Q footprint associated with a 50% reduction in the number of offspring (ERM-Q > 1.17, blue footprint is Figure 4-18) totals approximately 0.35 acres immediately offshore of the Zone 4 quay wall. The ERM-Q associated with a 30% reduction in survival (ERM-Q > 1.43, yellow footprint) is very similar to the ERM-Q associated with a 30% reduction in growth (ERM-Q > 1.54, orange footprint).

The area of the ERM-Q greater than 1.43 encompasses approximately 0.24 acres adjacent to the quay wall in Zone 4, while a slightly smaller sub-area (ERM-Q > 1.54, orange footprint in Figure 4-18) of approximately 0.21 acres in size is associated with adverse impacts to all three bioassay lines of evidence (survival, reproduction, growth).

Metals ERM-Qs for Zone 4 sampling locations are plotted in Figure 4-19. The Metals ERM-Q PRG footprint associated with a 30% reduction in survival (Metals ERM-Q > 1.64) encompasses 0.22 acres, and is subsumed by the ERM-Q footprint for survival described above. The Metals ERM-Q PRG footprint is presented in Figure 4-20.

Total PCBs (µg/kg) for Zone 4 sampling locations are plotted in Figure 4-21. The Total PCBs PRG footprints are shown in Figure 4-22. Total PCB PRG footprints are similar in size and shape to the total ERM-Q footprints and encompass the quay wall area. The Total PCB footprint associated with a 25% reduction in reproduction (Total PCB > 121 µg/kg) is approximately 0.56 acres; the footprint associated with a 50% decrease in reproduction (Total PCB > 208 µg/kg) encompasses 0.36 acres. Subsumed within that footprint are the footprints for a 30% reduction in growth (Total PCB > 270 µg/kg; 0.27 acres) and the footprint for a 50% reduction in growth (0.16 acres).

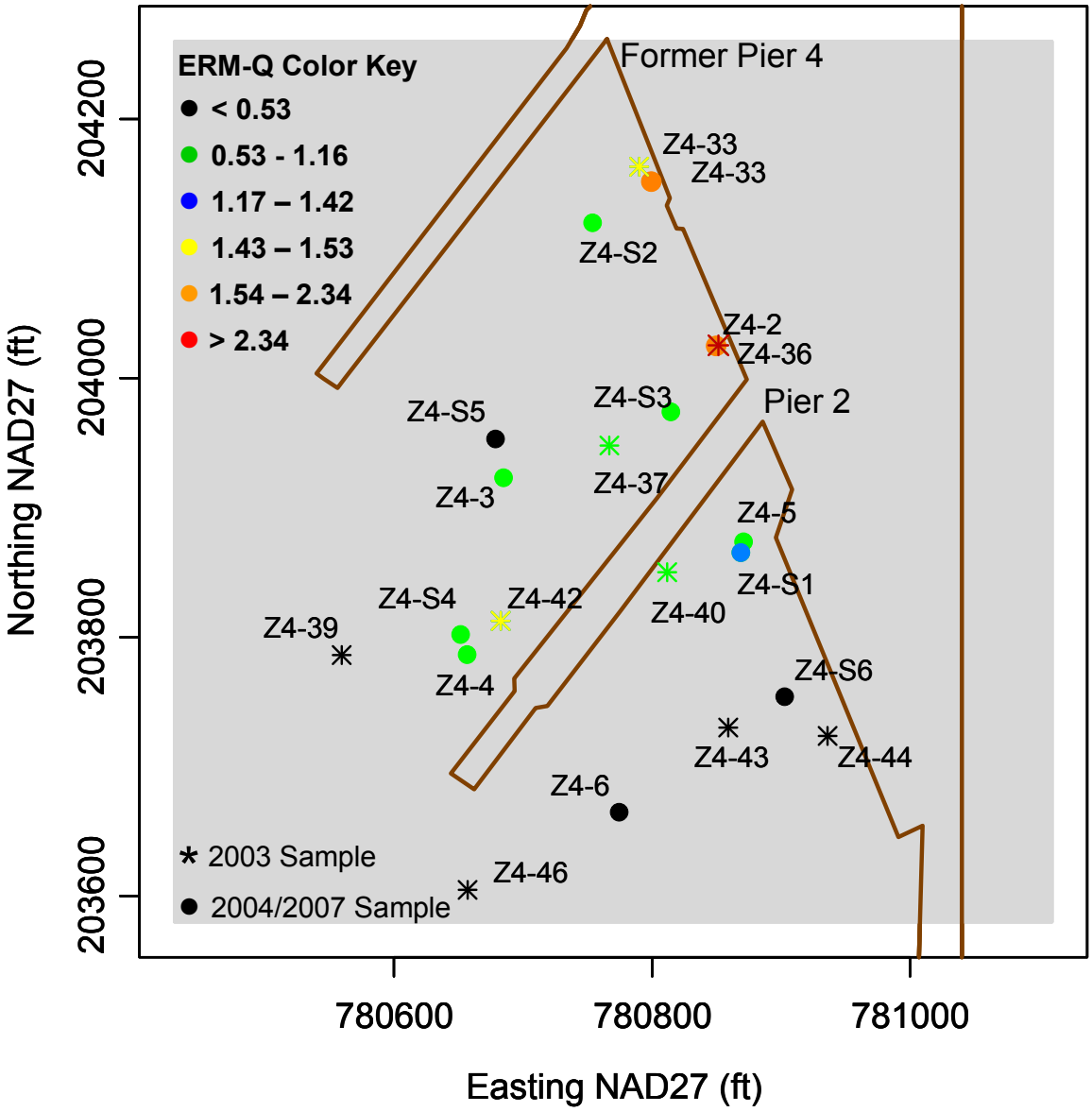

Figure 4-17. Zone 4 ERM-Qs by Sample Location

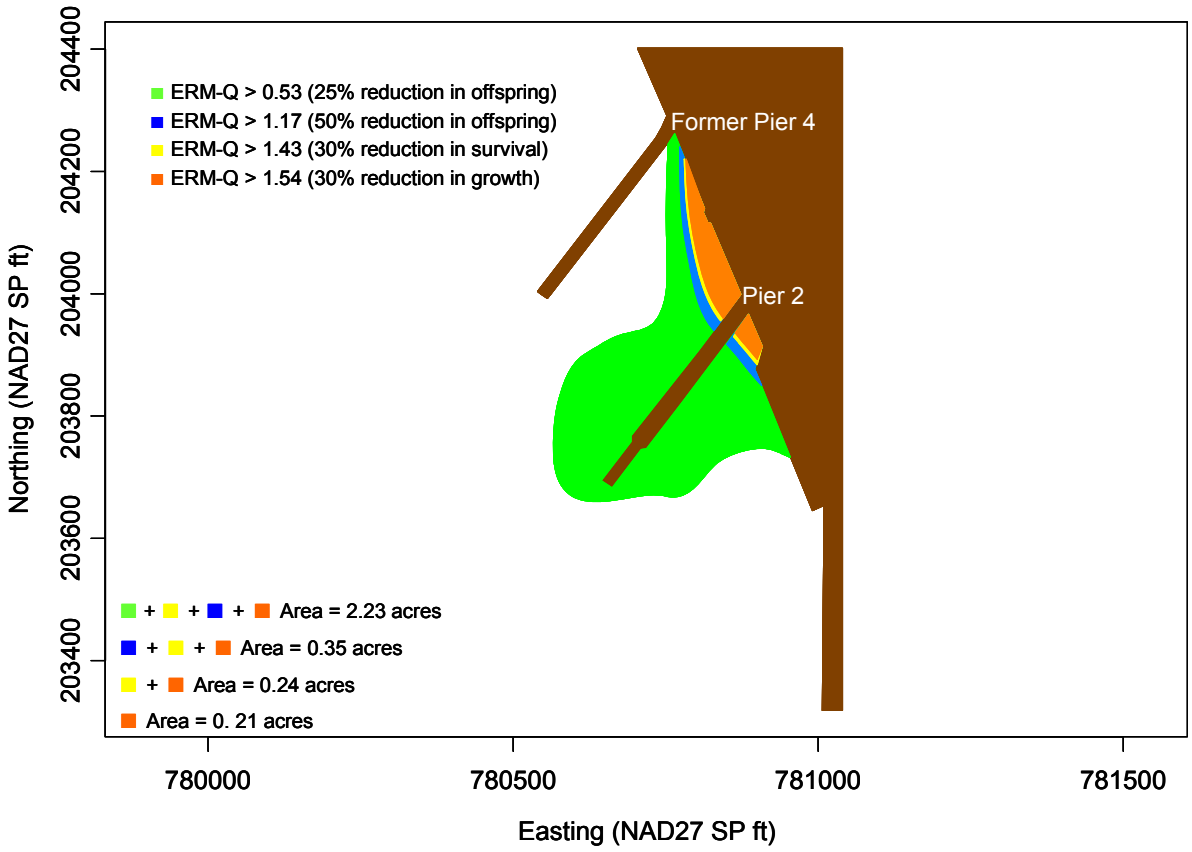

Figure 4-18. Zone 4 Footprints Exceeding ERM-Q PRGs

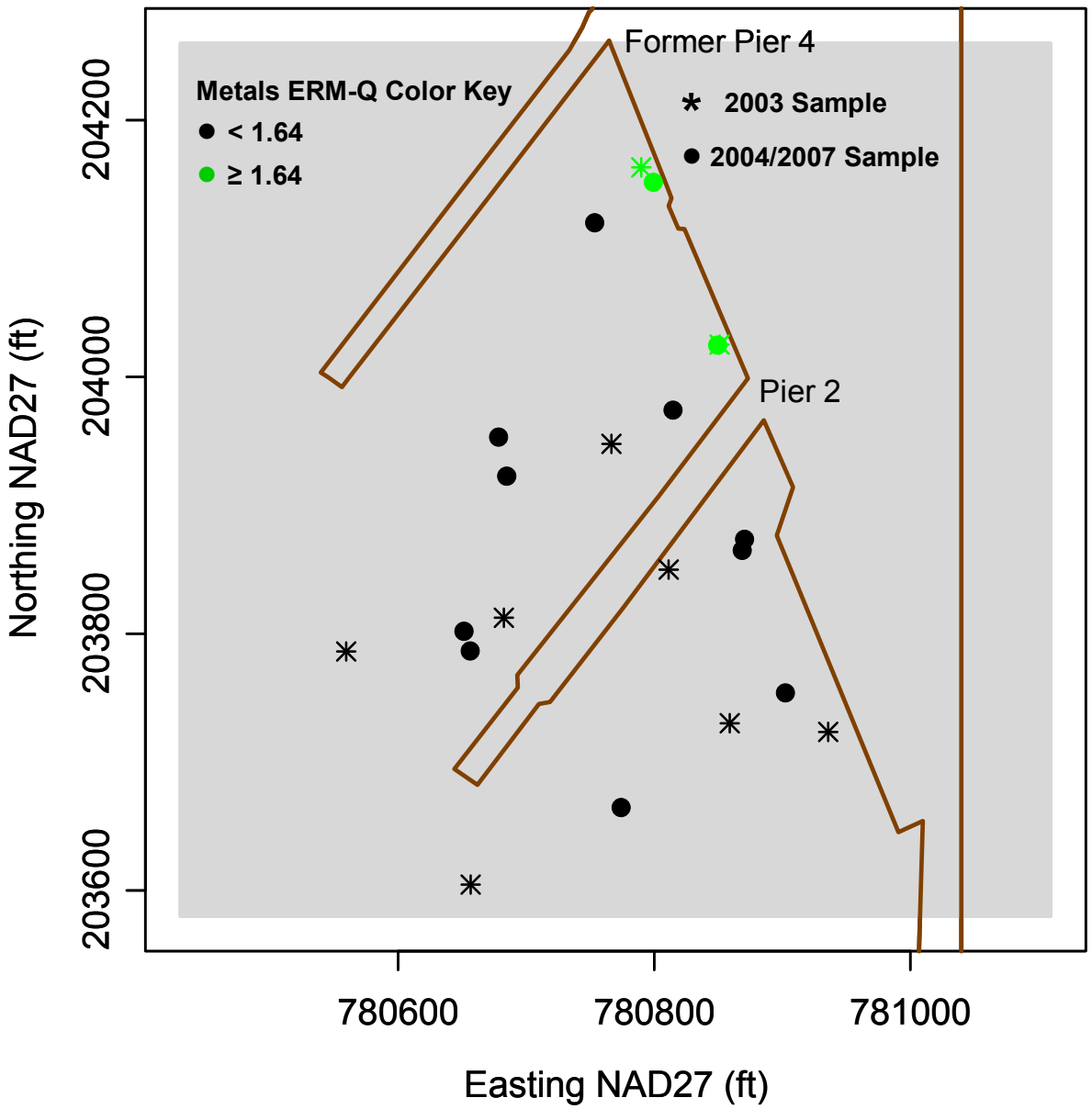

Figure 4-19. Zone 4 Metals ERM-Qs by Sample Location

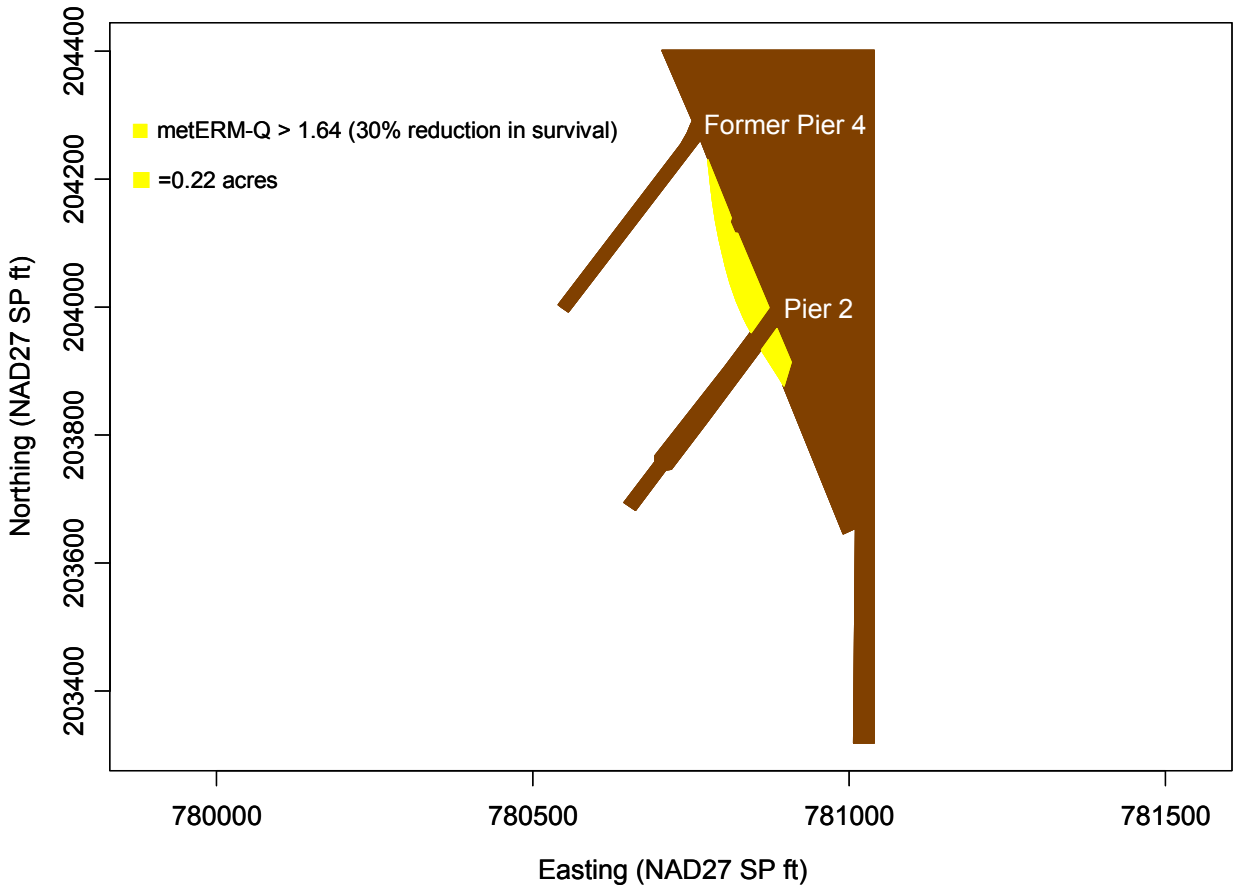

Figure 4-20. Zone 4 Footprints Exceeding Metals ERM-Q PRGs

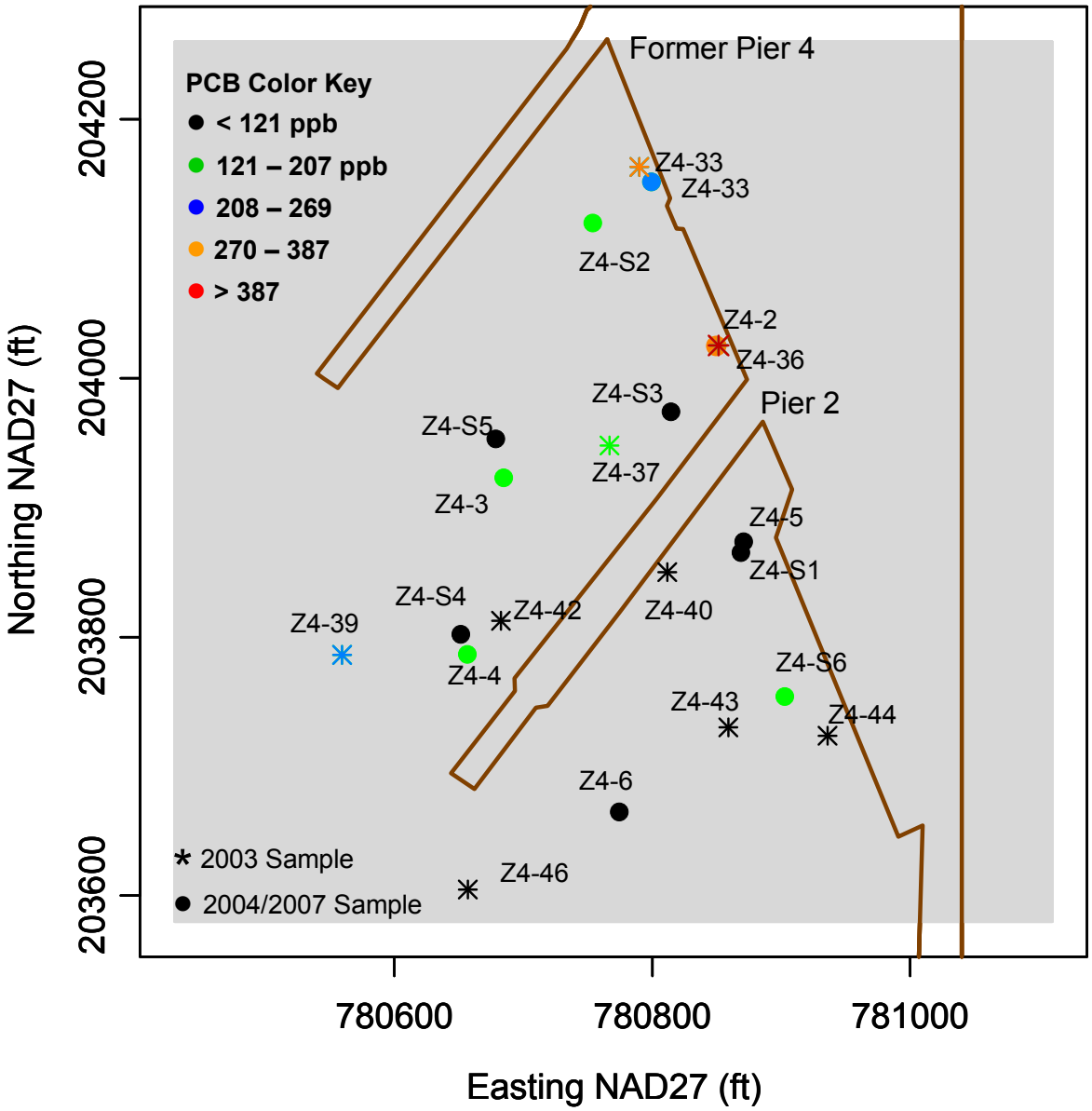

Figure 4-21. Zone 4 Total PCBs (µg/kg) by Sample Location

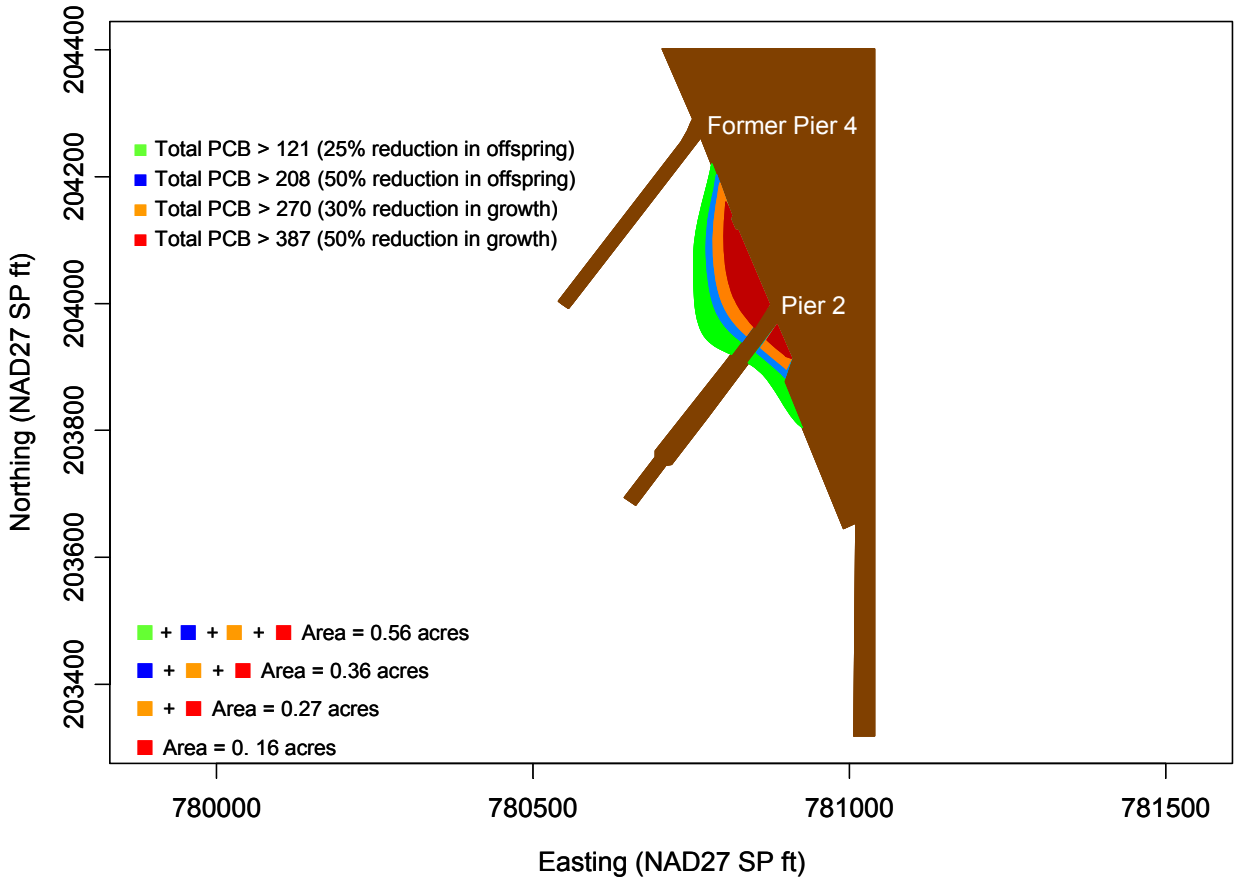

Figure 4-22. Zone 4 Footprints Exceeding Total PCB PRGs

Outer Pier 1

ERM-Qs for Outer Pier 1 sampling locations are plotted in Figure 4-23, and the associated footprints are shown in Figure 4-24. Concentrations in Figure 4-23 are color-coded according to the range of ERM-Q PRGs in Table 4-15. The ERM-Q PRG for a 25% decrease in reproduction (ERM-Q > 0.53) encompasses 0.68 acres, beginning at the base of the Pier 1 boat ramp and proceeding down the east side of the pier. Within that footprint is a small area of approximately 175 sq. ft. (0.004 acres) that exceeds the ERM-Q PRG for a 50% reduction in reproduction (ERM-Q > 1.17). No footprints exceed the ERM-Q PRGs for invertebrate survival or growth.

Total PCBs (µg/kg) for Outer Pier 1 sampling locations are plotted in Figure 4-25. Footprints associated with the Total PCB PRGs for Outer Pier 1 are shown in Figure 4-26. The Total PCB PRG footprint for a 25% decrease in reproduction (Total PCBs > 121 µg/kg) is slightly larger (0.80 acres) but similar in shape to the ERM-Q footprints for the same endpoint. The Total PCB PRG footprint for a 50% decrease in reproduction (Total PCBs > 208 µg/kg) is approximately 0.17 acres. There are no Total PCB PRG

footprints for reduced amphipod growth, because no footprint contours in Outer Pier 1 exceeded the growth PRG for Total PCBs of 270 µg/kg.

Metals ERM-Qs for Outer Pier 1 sampling locations are plotted in Figure 4-27. Metals ERM-Qs did not exceed 1.64 (PRG for survival) in Outer Pier 1, so there is no footprint associated with adverse impact to benthic invertebrates based on the Metals ERM-Q PRG.

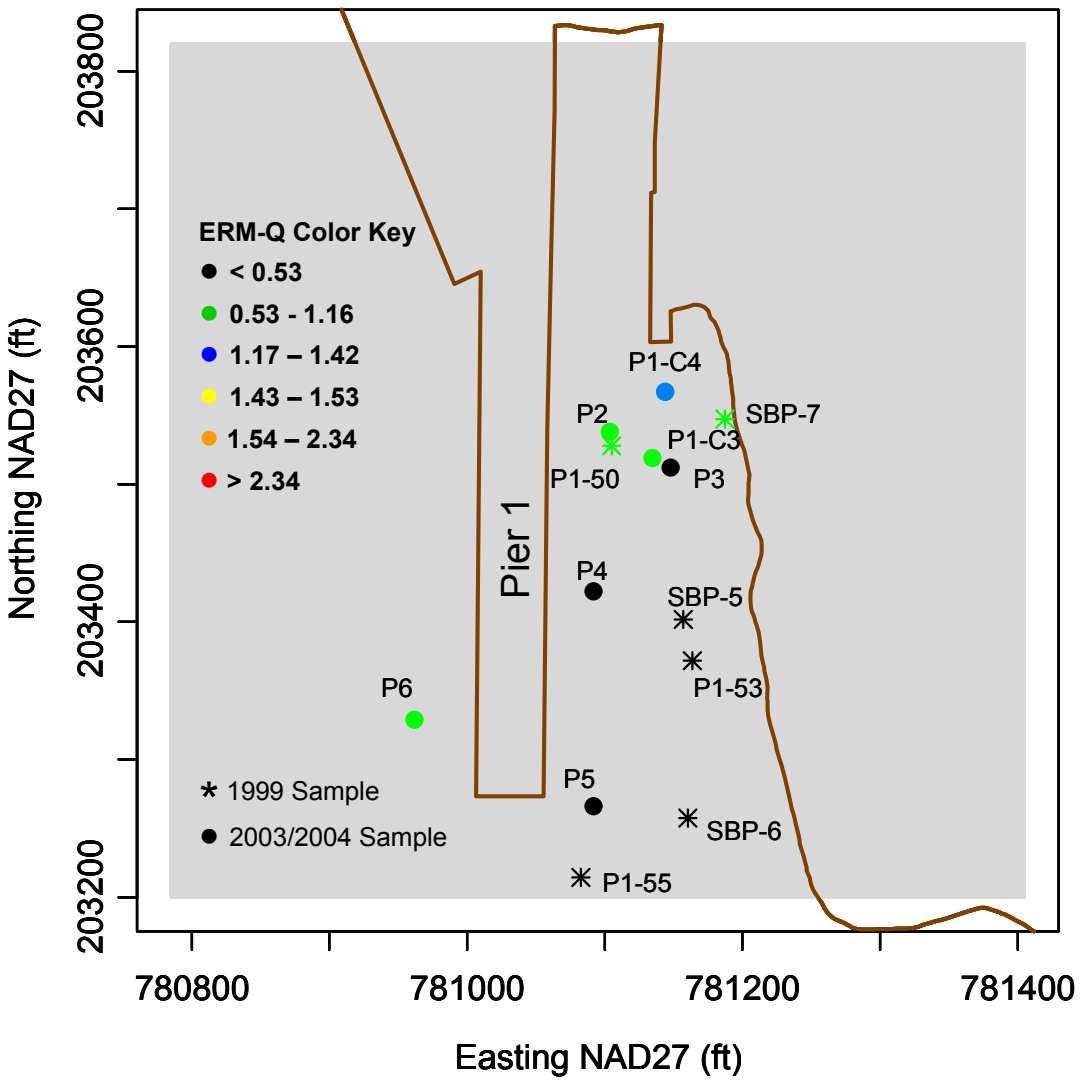

Figure 4-23. Outer Pier 1 ERM-Qs by Sample Location

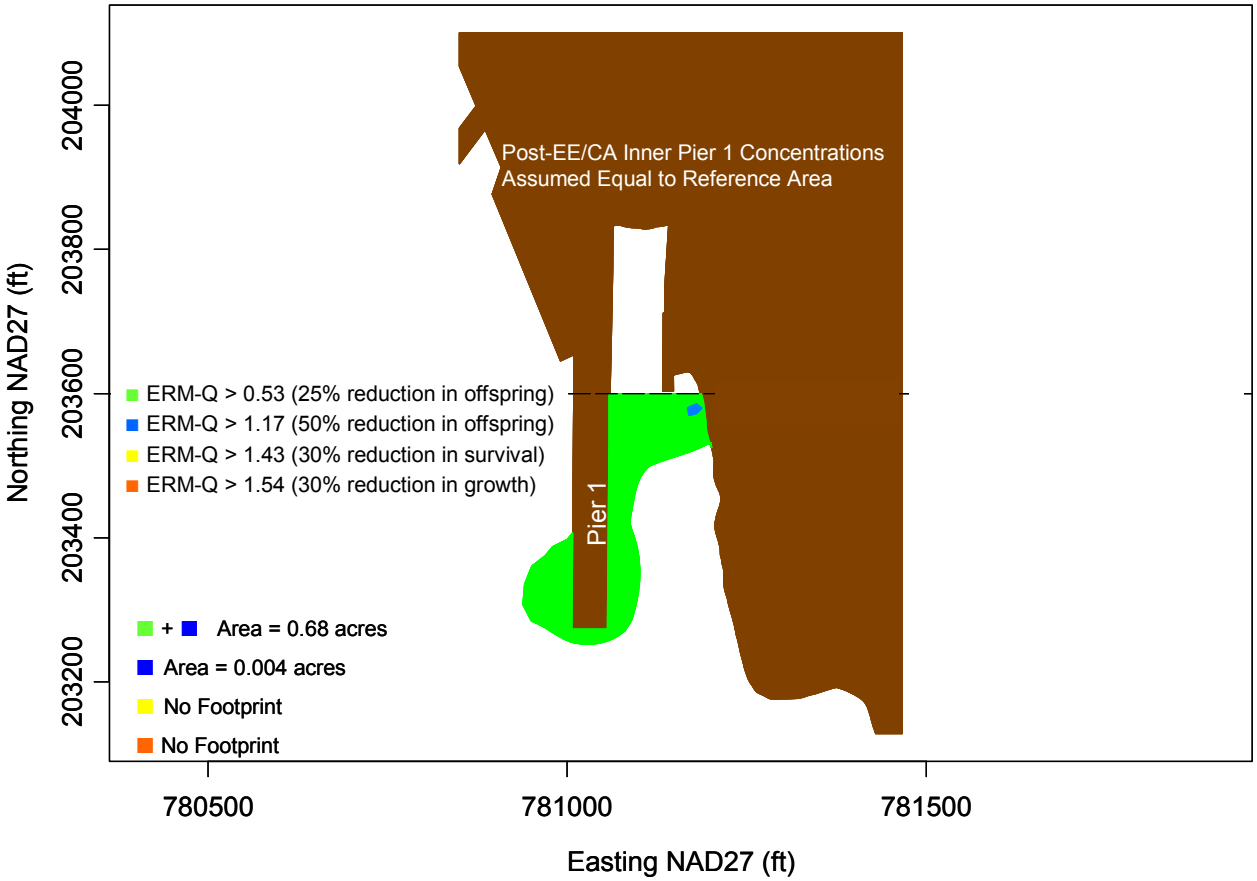

Figure 4-24. Outer Pier 1 Footprints Exceeding ERM-Q PRGs

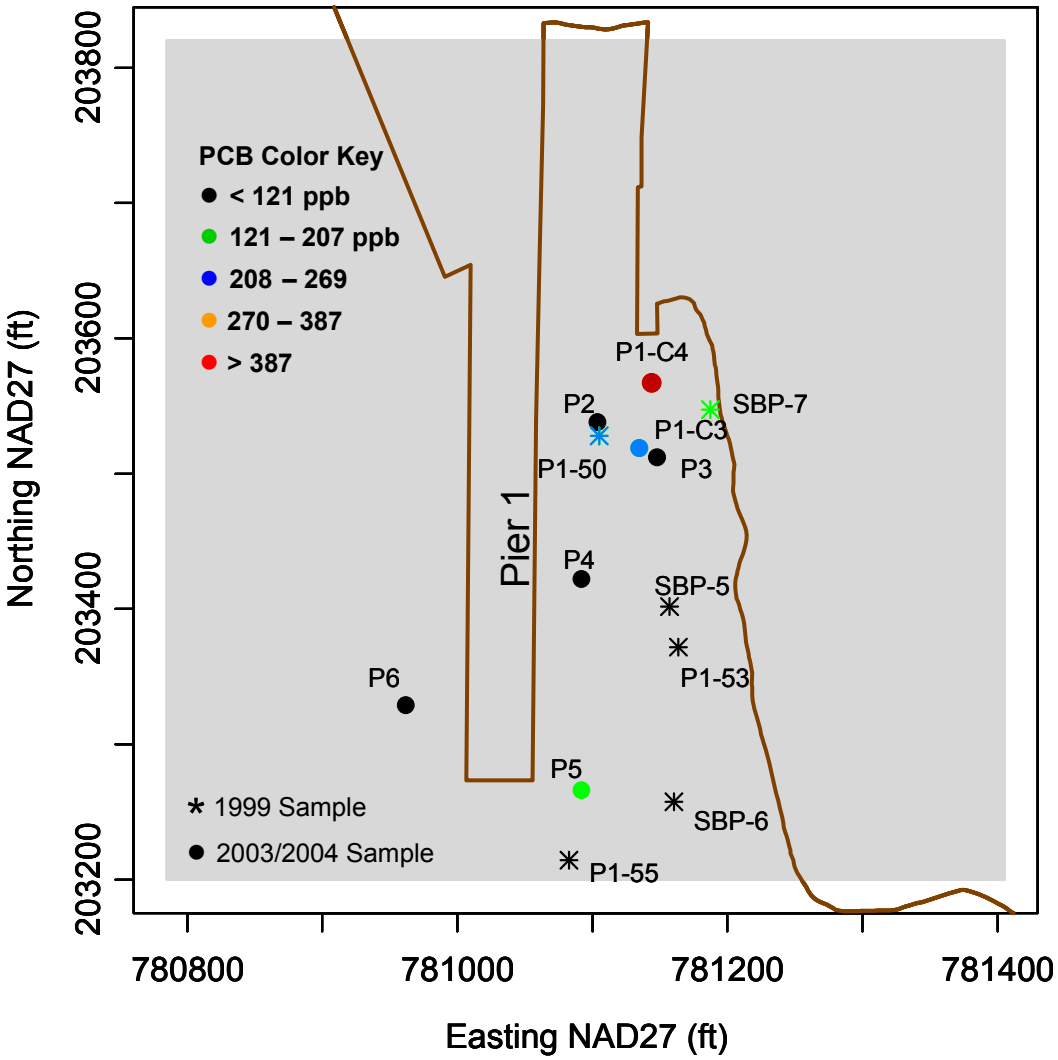

Figure 4-25. Outer Pier 1 Total PCBs (µg/kg) by Sample Location

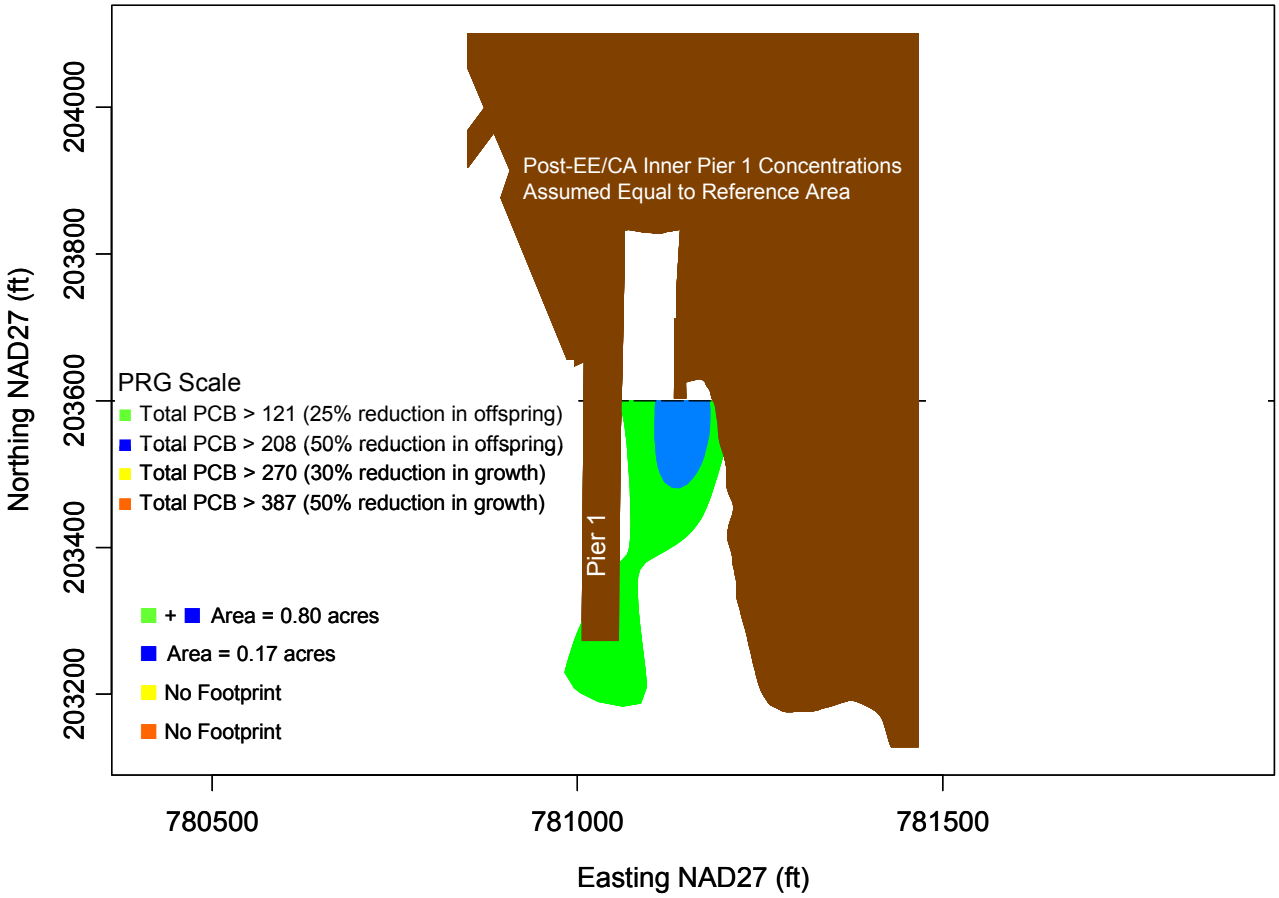

Figure 4-26. Outer Pier 1 Footprints Exceeding Total PCB PRGs

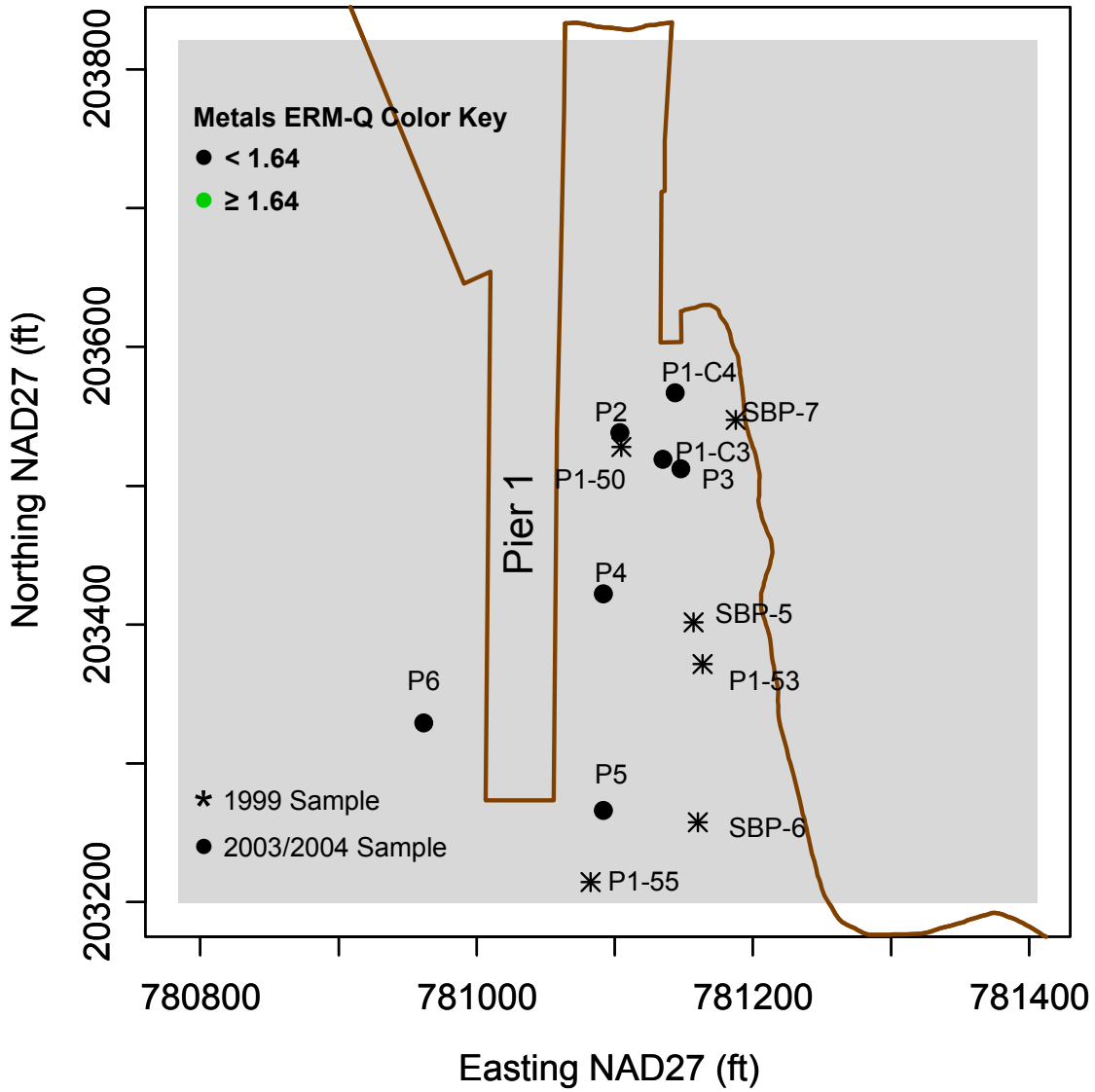

Figure 4-27. Outer Pier 1 Metals ERM-Qs by Sample Location

4.4.2 Risk to Piscivorous Birds

The decision rules in Table 4-3 for interpretation of the dose modeling to piscivorous birds specify that a high magnitude risk exists if modeled doses exceed LOAEL TRVs, and a low magnitude risk exists if COPC doses exceed NOAEL TRVs but are less than LOAEL TRVs.

Results show that no COPC doses exceeded LOAEL TRVs in any Study Area, indicating no high magnitude risk to piscivorous birds. Low magnitude risk was found to exist from lead in Zone 4 with the maximum lead BAF, but not when the mean BAF for lead was used in the dose model. Doses of zinc to piscivorous birds exceeded the NOAEL TRV only in Zone 4 when the mean zinc BAF was used, and in Zone 4 and Zone 7 when the maximum zinc BAF was used, leading to a finding of low magnitude risk to piscivorous birds from zinc in sediment in these areas. Low magnitude risk also was determined to exist from mercury in Outer Pier 1 sediments for both mean and maximum mercury BAFs.

Based on the findings of low magnitude risk to piscivorous birds from lead, zinc, and mercury in at least one of the Study Areas, NOAEL PRGs based on risk to piscivorous birds were back-calculated from the dose equation presented in Section 4.3. In this back-calculation, the dose was set equal to the NOAEL TRV, and the site-specific BAFs were used to solve for the sediment concentration that corresponds with the TRV. Because a range of BAFs were used for each COPC, two NOAEL PRGs were calculated for each COPC. The mean NOAEL PRG was back-calculated using the mean BAF and a conservative NOAEL PRG was back-calculated using the maximum BAF. Results of the food-chain PRG calculations are shown in Table 4-16. Although no calculated doses exceeded LOAEL TRVs, LOAEL-based PRGs are also presented in Table 4-16 for bounding purposes.

Table 4-16. Identification of PRGs Based on Risk to Piscivorous Birds

COPC	Mean BAF	Mean NOAEL PRG (mg/kg)	Mean LOAEL PRG (mg/kg)	Max BAF	Conservative NOAEL PRG (mg/kg)	Conservative LOAEL PRG (mg/kg)
Lead	0.03	648	16,950	0.09	296	7,750
Zinc	0.5	560	5,040	1.2	238	2,150
Mercury	0.25	0.46	4.6	0.6	0.21	2.1

Zone 7

Table 4-17 shows the number of 2004 and 2007 sampling locations that had COPC concentrations exceeding both the mean and conservative PRGs based on risk to piscivorous birds. Zinc was the only potential upper-trophic level risk driver in Zone 7. No locations in Zone 7 had zinc concentrations exceeding the mean NOAEL PRG of 560 mg/kg. Two of 12 Zone 7 locations had zinc concentrations exceeding the conservative zinc NOAEL PRG of 238 mg/kg. Both of these locations (Z7-1 and Z7-6) were located near the quay wall (Z7-1 north of Pier 17, and Z7-6 just to the south of Pier 15). Given that no areas in Zone 7 exceeded the mean NOAEL PRG, and exceedances of the conservative NOAEL PRG were limited in number and extent, it is unlikely that unacceptable risk to food chain receptors exists due to COPCs in Zone 7 sediment.

Zone 4

Lead and zinc were the only potential upper-trophic level risk drivers in Zone 4. As shown in Table 4-17, lead concentrations exceeded the mean NOAEL lead PRG of 648 mg/kg at one location (Z4-2) and the conservative NOAEL lead PRG of 296 mg/kg at two locations (Z4-1 and Z4-2), both immediately adjacent to the quay wall north of Pier 2. Locations Z4-1 and Z4-2 also contained zinc concentrations exceeding the zinc mean NOAEL PRG of 648 mg/kg, as did locations Z4-S1 and Z4-5 located near the quay wall just south of Pier 2. Locations Z4-1, Z4-2, and Z4-S1 contained zinc concentrations greater than the conservative LOAEL PRG, although not greater than the mean LOAEL PRG. The four exceedances of the mean zinc NOAEL PRG are representative of the undredged sediment shelf adjacent to the quay wall, typically avoided by maintenance dredging activities so as not to compromise the integrity of the quay wall. The areal extent of this undredged area is small, extending approximately 50 feet from the quay wall along the length of the wall, so exposure to the area by piscivorous birds is likely small. This area is also the area associated with adverse impacts to two or more of the invertebrate bioassay lines of evidence.

Outer Pier 1

Mercury is the only potential risk driver to piscivorous birds identified in Outer Pier 1. Surface sediment concentrations of mercury exceeded the mean NOAEL PRG for mercury (0.46 mg/kg) at four of seven Outer Pier 1 locations (including the surface interval of two core samples). These four locations (P2, P3, P1-C3, and P1-C4) are the four Outer Pier 1 locations closest to the Inner Pier 1 Area that is the subject of an ongoing EE/CA. Mercury concentrations at P1-C4 also exceeded the conservative LOAEL PRG, but no locations had mercury concentrations exceeding the mean LOAEL PRG.

Table 4-17. Sampling Locations Exceeding PRGs for Upper-Trophic Level COPCs

COPC	Mean NOAEL PRG (mg/kg)	Locations Exceeding Mean NOAEL PRG	Conservative NOAEL PRG (mg/kg)	Locations Exceeding Conservative NOAEL PRG	Mean LOAEL PRG (mg/kg)	Locations Exceeding Mean LOAEL PRG	Conservative LOAEL PRG (mg/kg)	Locations Exceeding Conservative LOAEL PRG
Zone 7								
Zinc	560	0/12	238	2/12	5,040	0/12	2,150	0/12
Zone 4								
Lead	648	1/12	296	2/12	6,950	0/12	7,750	0/12
Zinc	560	4/12	238	7/12	5,040	0/12	2,150	3/12
Outer Pier 1								
Mercury	0.46	4/7[a]	0.21	7/7[a]	4.6	0/7	2.1	1/7[a]

[a] Includes the surface intervals of two core samples.

4.5 Uncertainty Evaluation

There were several sources of uncertainty associated with calculations of risk to ecological receptors in the NSB-NLON Study Areas of the Thames River. Major sources of uncertainty associated with each of the ecological lines of evidence and their potential impacts on the risk results are discussed in this section. Attempts were made to err on the conservative side when dealing with all of the uncertainties identified, resulting in potential overestimation of risks as opposed to underestimation of risks.

4.5.1 Sediment Chemistry Uncertainties

The ecological risk assessment used surface sediment data collected in 2004 and 2007 to assess risk to benthic invertebrates and upper-trophic level receptors under current site conditions. In addition, data collected during the RSC Pilot Study in 2003 were used to develop footprints. The surface sediment sample locations from the three sampling years have adequate spatial coverage of Zone 4, Zone 7, and Outer Pier 1 sediments. In general, they show sufficient differences in COPC concentrations compared to Reference Area sediments to suggest that COPC concentrations in Lower Subase sediments are related to historical or current Subase operations. Up-river sediments are not pristine, however, and one Reference Area sample contained total PCB concentrations of 1844 µg/kg, which is over three times greater than the maximum concentration observed in either Zone 4 or Zone 7. Although median PCB concentrations in Subase sediments were significantly higher than median PCB concentrations in Reference Area sediments, the single high Reference Area concentration resulted in higher mean and 95%UCL PCB concentrations for the Reference Area than in any of the Lower Subase areas. The data also show that PCB concentrations in Zone 7, on average, are higher offshore in the river than in the area of the piers or adjacent to the quay wall (Figures 4-14 and 4-15). Regional concentrations of COPCs in the surrounding Thames River areas need to be considered when making risk management decisions for the Lower Subase to ensure that any potential remedial decisions can achieve long-term risk reduction.

Although the surface sediment samples achieved good horizontal spatial coverage of Zone 4, Zone 7, and Outer Pier 1, the spatial variability of the COPC concentrations in the sediments results in uncertainty about sediment concentrations between sampling locations. For this reason, the identification of the PRG footprints were identified using an interpolative model that used area weighted averages, not single point concentrations. The model uses all data points from an area but gives higher weight to closer points than to distant points when interpolating concentrations. The use of weighted averages to derive footprint contours is more relevant from an ecological exposure standpoint than using point concentrations because ecological receptors are exposed to a larger area than represented by single sample locations.

4.5.2 Bioassay Uncertainties

In the bioassays, all attempts were made to handle uncertainties associated with potential confounding factors to the laboratory tests, such as measuring and managing for ammonia production, and ensuring that dissolved oxygen levels remained within acceptable limits. In 2007, these attempts proved successful in eliminating mortality associated with confounding factors, and increased the ease with which the bioassay data could be interpreted. There is always uncertainty when trying to extrapolate from laboratory tests to field conditions, with the main uncertainty being that by controlling too many variables in the laboratory, the tests do not duplicate field conditions experienced by the organisms present at the site. This uncertainty was offset by ensuring that any observed toxicity was due to potentially elevated site chemistry, which would be the focus of any remedial activities.

The success in controlling and minimizing uncertainties associated with the bioassays led to high confidence in interpreting these results in the ecological risk assessment. However it is always difficult to identify specific causal agents associated with bioassay effects when the test media (i.e., the site sediment) consists of a mixture of chemical constituents, and elevated levels of those chemical

constituents are often co-located. To compensate for this uncertainty, correlative analyses looked at a variety of individual chemical analytes, sums of analytes, and indices to normalize concentrations of individual chemicals to standard benchmarks (e.g., ERM-Qs). No chemical indicator had r^2 values greater than 0.67, meaning that, at best, sediment chemistry explained only two-thirds of the variability observed in the bioassay results. Because of the high variability and complex chemical mixtures present, the ERM-Q COPC indices were the primary chemical indicators on which the footprints were based.

4.5.3 Upper-trophic Level Modeling Uncertainties

Uncertainty was associated with the results of the food chain modeling, mainly due to the difficulty in gathering site-specific exposure parameters and toxicity information for the upper-trophic level receptors, and the uncertainty associated with the bioaccumulation factors generated for the Thames River.

Exposure parameter estimates were based on published literature, which are often variable. Cormorant ingestion rates, body weights, and site use factors were all based on literature estimates. Mean body weights and ingestion rates were chosen over single point estimates. Values were chosen to be realistic, yet still retain some degree of conservatism. Site use factors likely contained the most uncertainty of all the exposure parameters. Double-crested cormorants are capable of traveling great distances from nesting or roosting areas to forage for food, with reported maximum foraging distances exceeding 60 km (OEHHA/ CalEcotox, 1999). However, as is the case with most piscivorous birds, cormorants will stay and forage in an area as long as prey is available. When prey densities drop too low, the cormorants will move to more productive foraging areas. The model used in the BERA assumes a SUF of 1, indicating that the cormorants gather 100% of their prey from the individual Study Areas, which is a conservative estimate. For instance, the Outer Pier 1 area is approximately 2 acres in size. Although it is reasonable to assume that a cormorant may spend time fishing in that area (one was noted in Outer Pier 1 during a site visit on August 22, 2007), it is highly unlikely that a 2-acre area will hold fish at high enough densities to sustain a wide-ranging forager such as a cormorant, much less supply adequate food for a cormorant population. Potential risk to cormorants from mercury in Outer Pier 1 is only realized if the cormorant SUF exceeds 0.85 when the mean BAF is considered and 0.3 when the maximum BAF is considered. If cormorants obtain less than 30% of their prey from Outer Pier 1, mercury HQs fall to less than 1 even with the maximum BAF. If the mean BAF represents site conditions, a cormorant must obtain more than 85% of its food from Outer Pier 1 to trigger low magnitude risk. It is also worth noting that the 95% UCL Reference Area concentration of mercury results in a NOAEL HQ of 1.75 based on the Reference Area dose to the cormorant, assuming a Reference Area SUF of 1, and using the maximum site BAF of 0.6. Given the minimal HQ of 1.15 using the mean BAF and the overly conservative nature of the Outer Pier 1 SUF, it is unlikely that Outer Pier 1 poses unacceptable risk to piscivorous birds. Outer Pier 1 is a smaller area than Zone 4 and zinc concentrations in Zone 4 are proportionally higher relative to zinc PRGs than mercury concentrations are to mercury PRGs in Outer Pier 1. In Zone 4, the cormorant's SUF would need to be less than 0.25 to obtain HQs less than 1 using the mean BAF, and 0.1 or less to obtain HQs less than 1 using the maximum BAF. Given the larger size of Zone 4, an SUF of 0.1 or more may be within reason, especially if the pier pilings and associated submerged structures tend to shelter fish.

The other primary source of uncertainty in the calculated food chain doses is associated with the sediment-to-fish BAFs, and small fish tissue sample size. Reference Area and Outer Pier 1 were not well represented in the fish samples, with only two samples from each of those areas. The Inner Pier 1 fish samples were actually collected near the Inner/Outer Pier 1 boundary where sediment concentrations drop dramatically, so these fish may have been exposed to a wide range of chemical concentrations. To attempt to compensate for these uncertainties, the dose modeling effort used both mean and maximum BAFs to capture the range of potential exposures. As a result, the maximum zinc BAF of 1.2 was more conservative than the default BAF of 1 that was used in the SLERA.

4.6 Ecological Risk Conclusions and Risk Management Recommendations

The results of the ecological risk assessment were used to identify areas to be considered in the FS. Toxicity bioassays, in general, are useful in evaluating sediments because they show where statistical differences occur between areas with regard to the endpoints measured (survival, growth, and reproduction). However, bioassays do not inherently identify what defines an unacceptable ecological impact. For instance, a 30% decrease in growth may be statistically different, but that doesn't necessarily mean that 30% smaller organisms represent an adversely impacted community. Therefore, the risk assessment relies on a weight-of-evidence process for ecological risk decision-making which embodies our best understanding of what is being observed at the site based on multiple lines of evidence.

In selecting areas to move forward for evaluation in the Feasibility Study, two footprints were initially identified for each Study Area: a multiple endpoint risk footprint that is defined by sediments that pose moderate or high risk for **two or more lines** of evidence (greater than 30% reduction in survival, greater than 30% reduction in growth, and/or 25% reduction in reproduction); and a single endpoint risk footprint that is based on sediments where any **single** bioassay line of evidence is reduced by 50% or more, or has food chain doses that are greater than the LOAEL TRV. All single line of evidence risk footprints are based on the invertebrate reproduction line of evidence, which is inherently the most variable bioassay line of evidence. Multiple endpoint and single endpoint footprints in each area are summarized in Table 4-18 and discussed further below.

Based on a weight of evidence approach, the Validation Study proposes that footprints associated with a 50% impact to any single line of evidence be carried forward to the FS for evaluation of remedial actions to ameliorate ecological risk. The footprints based on a 50% impact to any single line of evidence were slightly larger than the multiple endpoint footprints for Zone 4 and Outer Pier 1.

Table 4-18. Footprints for Consideration in the NSB-NLON Feasibility Study

Area	Multiple Endpoint Footprint		Single Endpoint Footprint	
	Footprint Size (acres)	Basis	Footprint Size (acres)	Basis
Zone 7	0	No unacceptable risk to more than one line of evidence	0	No 50% impact to any line of evidence based on ERM-Q, Metals ERM-Q, or Total PCB PRG
Zone 4	0.29	Unacceptable risk based on invertebrate reproduction and growth for Total PCBs > 270 µg/kg and/or ERM-Q > 1.43[a]	0.39	Greater than 50% reduction in benthic invertebrate reproduction based on ERM-Q > 1.17 and/or Total PCBs > 208 µg/kg[a]
Outer Pier 1	0	No unacceptable risk to more than one line of evidence	0.17	Greater than 50% reduction in benthic invertebrate reproduction based on Total PCB > 208 µg/kg.

a. Footprints similar in size and shape

Zone 7

There are no contour areas associated with moderate or high risk for benthic invertebrate growth or benthic invertebrate survival in Zone 7; therefore, there is no multiple endpoint risk footprint in Zone 7 because no area showed unacceptable risk to more than one line of evidence. Likewise, no footprint exhibits a 50% impact to any individual line of evidence based on ERM-Q, Total PCBs, or Metals ERM-Q.

Based on the weight-of-evidence approach, no areas of Zone 7 are recommended for evaluation in the FS due to the lack of risk to more than one endpoint and the overall low risk classification based on the reproduction endpoint when averaged across Zone 7.

Zone 4

The multiple endpoint risk footprint in Zone 4 encompasses approximately 0.29 acres adjacent to the quay wall immediately to the north and south of Pier 2. This footprint is based on primarily the Total PCB footprint exceeding 270 µg/kg (30% reduction in growth), extended slightly on each end by the ERM-Q footprint exceeding 1.43 (30% reduction in survival). This area is primarily associated with sediments that have not been dredged due to their proximity to the quay wall, and pose high magnitude risk to benthic invertebrate survival (>30%), moderate risk to benthic invertebrate growth (>30%), and high risk to benthic invertebrate reproduction (>50%) (Figures 4-18 and 4-22). In addition, the area poses low magnitude risk to piscivorous birds due to elevated zinc concentrations.

The single endpoint footprint in Zone 4 encompasses 0.39 acres adjacent to the quay wall and is based on the area exceeding the ERM-Q PRG for a 50% reduction in benthic invertebrate reproduction (ERM-Q > 1.17, Figure 4-18) and exceeding the Total PCB PRG for a 50% reduction in benthic invertebrate reproduction (Total PCBs > 208 µg/kg, Figure 4-22). The northern edge of this footprint is influenced by the lack of sediment chemistry data along the quay wall north of the former Pier 4. Since the undredged area along the quay wall extends the length of Zone 4, the true area of potential risk based on impacts to multiple endpoints is likely this entire undredged sediment shelf in Zone 4, represented by the dashed line in Figure 4-28.

Based upon the weight of evidence approach, the Validation Study recommends that the single endpoint risk footprint be carried forward to the FS to evaluate alternatives for amelioration of ecological risk. Furthermore, as discussed above, the area associated with ecological risk likely encompasses the entire quay wall sediment shelf, which extends approximately 50 feet offshore from the quay wall for the entire length of Zone 4 (Figure 4-28).

Outer Pier 1

There is no multiple endpoint risk footprint in Outer Pier 1 because no area shows unacceptable risk for more than one line of evidence. The single endpoint risk footprint encompasses 0.17 acres and is associated with Total PCB concentrations greater than 208 µg/kg, corresponding to more than 50% reduction in benthic invertebrate reproduction (Figure 4-26).

Based on the weight of evidence approach, the 0.17 acres of Outer Pier 1 posing high potential risk to benthic invertebrate reproduction are recommended for evaluation in the FS (Figure 4-29). Additional sampling to refine the western boundary of this footprint will be conducted as part of the FS or as part of the EE/CA for Inner Pier 1.

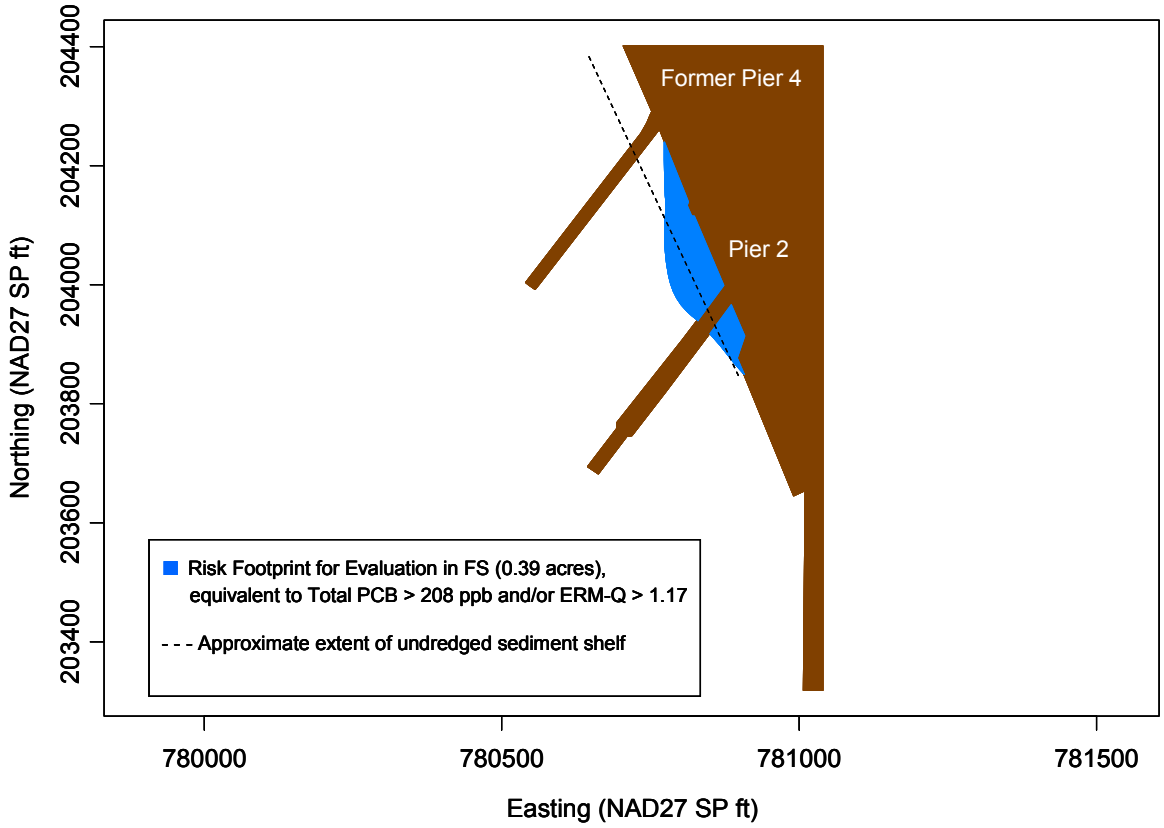

Figure 4-28. Zone 4 Risk Footprint for Evaluation in the FS

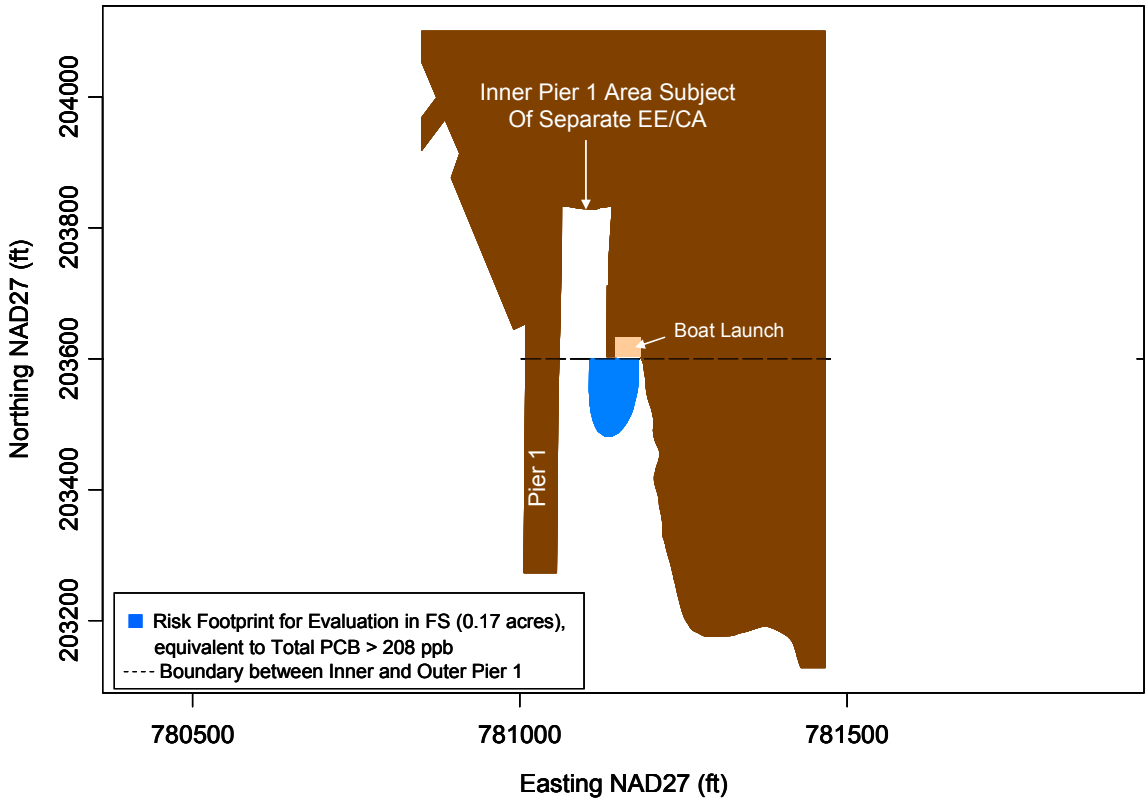

Figure 4-29. Outer Pier 1 Risk Footprint for Evaluation in the FS

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5.0 SUMMARY AND CONCLUSIONS

This section summarizes the conclusions of the Thames River Validation Study for sediments in Zone 4, Zone 7, and Outer Pier 1 at NSB-NLON, and provides the associated recommendations for moving forward to the Lower Subase FS.

5.1 Conclusions of the BERA

A total of forty-two COPCs identified in the SLERA (Battelle and Neptune & Company, 2004) were evaluated in the BERA. The BERA evaluated risk to benthic invertebrates using laboratory bioassays measuring growth, survival, and reproduction of the amphipod *Leptocheirus plumulosus*. Risks to upper-trophic level wildlife were evaluated through a food chain model to estimate daily doses of COPCs to the double-crested cormorant as a surrogate for piscivorous birds foraging in the Study Areas. Fish tissue collected in Pier 1 and the Reference Area was used to estimate mean and maximum sediment-to-fish BAFs for the upper-trophic level COPCs. The BAFs were then used in the food chain dose model for each area.

Dose modeling to piscivorous birds showed potential low-level risk (NOAEL HQ > 1, LOAEL HQ < 1) from zinc in Zone 7, lead and zinc in Zone 4, and mercury in Outer Pier 1. Doses did not exceed LOAEL TRVs for any constituent in any area, even when conservative BAFs and SUFs were used. Evaluation of the uncertainties associated with site-specific BAFs and cormorant SUFs combined with the low HQs for zinc in Zone 7, lead in Zone 4, and mercury in Outer Pier 1 suggest that the COPCs do not pose unacceptable risk to piscivorous birds in these areas. Zinc in Zone 4 was determined to pose potential unacceptable risk from sediments along the quay wall, which generally exceeded the zinc LOAEL PRG and are recommended for further evaluation in the FS.

Statistical comparisons of Zone 4 and Zone 7 bioassay results to Reference Area results showed that survival in Zone 7 was statistically different than Reference Area mean survival at two of the six sampling locations; and Zone 4 survival was statistically different than Reference Area survival in three of the six sampling locations. Overall mean survival in Zone 7 was reduced by approximately 5% from mean Reference Area survival, while mean Zone 4 survival was reduced by 20% from mean Reference Area survival.

Four Zone 7 locations showed statistically significant growth when compared to the Reference Area. Zone 7 organisms averaged about 10% smaller than Reference Area organisms. Growth results in Zone 4 showed greater reduction compared to Reference Area than did growth data from Zone 7. Overall, Zone 4 *L. plumulosus* averaged approximately 25% smaller than Reference Area amphipods, with statistically significant differences observed at five of the six Zone 4 sampling locations.

Reproduction in Zone 7 resulted in approximately 20% fewer offspring compared to average Reference Area reproduction, with statistically significant differences observed at two of the six bioassay locations. Zone 4 had a greater reduction in the number of offspring produced than did Zone 7, affecting four of the six locations. Overall reproduction in Zone 4 was slightly greater than 50% of Reference Area reproduction (1.87 offspring/adult vs. 3.66 offspring/adult).

Bioassay results for all three lines of evidence were compared to chemistry results, including individual metals and pesticides, Total HMW PAHs, Total LMW PAHs, Total PCBs, and three COPC indices (ERM-Q, Organic ERM-Q, and Metals ERM-Q). Several individual metals had correlating r^2-values greater than 0.6; however, due to the "hotspot" nature of the metals distributions, the distribution of the data had many points with low metals concentrations and low toxicity, and a single point with high metals

concentrations and high toxicity, with virtually no data in the middle. Organic ERM-Q was eliminated from consideration as a toxicity indicator due to the fact that its correlation was driven primarily by Total PCBs, which are considered separately. Therefore, it was decided to use the ERM-Q and Metals ERM-Q chemical indices ($r^2 > 0.5$) and Total PCBs ($r^2 > 0.6$) for the purposes of developing sediment PRGs and footprints. From the ERM-Q and PCB correlations, the following PRGs were identified:

- ERM-Qs associated with 30% reduction in survival, 30% reduction in growth, 50% reduction in growth, 25% reduction in offspring, 50% reduction offspring
- Metals ERM-Q associated with 30% reduction in survival
- Total PCBs associated with 30% reduction in growth, 50% reduction in growth, 25% reduction in offspring, 50% reduction in offspring

5.2 Identification of Areas Recommended for Evaluation in the Feasibility Study

In each Study Area, footprint contours were established based on the PRG thresholds identified above. The various PRG footprints were evaluated to arrive at two footprints for each area: a multiple endpoint risk footprint that identified areas posing risk based on **two or more** endpoints (benthic invertebrate survival reduced by more than 30%, growth reduced by more than 30%, or reproduction reduced by more than 25%, and/or exceeding NOAEL food chain PRGs; and a single endpoint risk footprint identifying the maximum area exceeding the 50% effects level for any **single** endpoint or exceeding LOAEL food chain PRGs). Based on a weight-of-evidence approach, footprints posing potential risk to more than one endpoint are recommended for further evaluation in the FS.

Based on the criteria identified above, there is no footprint in Zone 7 for evaluation in the FS because no area showed unacceptable risk for more than one line of evidence, and no area showed a 50% impact to any single line of evidence.

The multiple endpoint risk footprint in Zone 4 encompasses approximately 0.29 acres adjacent to the quay wall immediately to the north and south of Pier 2. It is based on adverse impacts to benthic invertebrate survival (>30%), growth (>30%), and reproduction (>50%), and areas posing low magnitude risk to piscivorous birds due to elevated zinc concentrations. The specific PRGs for this area are ERM-Q > 1.43 and/or Total PCBs > 270 µg/kg. The footprints for both PRGs are similar in shape and size. The single endpoint footprint in Zone 4 encompasses 0.39 acres adjacent to the quay wall and is based on the area exceeding the ERM-Q PRG for a 50% reduction in benthic invertebrate reproduction (ERM-Q > 1.17) and/or exceeding the Total PCB PRG for a 50% reduction in benthic invertebrate reproduction (Total PCBs > 208 µg/kg). The footprints for these PRGs are also similar in size and shape. All of the footprints are confined to the near-shore area adjacent to the quay wall in Zone 4, which is an area that has not been dredged due to operational and structural integrity concerns. The area associated with ecological risk encompasses the entire quay wall sediment shelf, which extends approximately 50 feet offshore of the quay wall in Zone 4. The entirety of this sediment shelf in Zone 4 will be evaluated in the FS.

There is no multiple endpoint footprint for evaluation in Outer Pier 1, because no area showed unacceptable risk to more than one line of evidence. The single endpoint footprint recommended for evaluation in Outer Pier 1 is 0.17 acres and is associated with a greater than 50% reduction in benthic invertebrate reproduction. This area is located just offshore of the boat ramp and the boundary line for Inner Pier 1, which is the subject of a proposed EE/CA. The outer western and southern boundaries of this footprint will be further refined by additional sampling to be conducted as part of the FS or the Inner Pier 1 EE/CA.

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A.1.0 INTRODUCTION

The goal of the Thames River Validation Study is to assess ecological impacts of COPCs that may have migrated from Navy source areas or may have been deposited due to activities associated with the berthing of submarines and ships in the pier areas of the NSB-NLON Subase. Two pier areas, Zone 4 and Zone 7, are the primary focus of this study. A third area, Outer Pier 1, is also discussed but was not re-sampled in 2007; therefore, statistical analyses for Outer Pier 1 include 2004 data only. A Reference Area is included in this study for the purpose of conducting background comparisons. The Reference Area is located upstream of the Naval shipyards and represents habitat undisturbed by Navy activities. Surface sediment grab samples were collected from all areas and subjected to chemical analysis. Bioassays were performed on 2007 sediment collected from Zone 4, Zone 7, and the Reference Area.

The DQOs upon which this data analysis is based were originally developed as part of the Work Plan (Battelle and Neptune & Company, 2004). They state the relevance of the data to the overall project by developing the problem and the associated decision rules, evaluating decision errors, and optimizing the sampling design. The DQOs are presented in Tables A-1 through A-3.

A.1.1 Data

In October 2004, six surface sediment grab samples were collected from Zone 4, Zone 7, Pier 1 and the Reference Area. Chemical analyses were performed on these samples to evaluate levels of PAHs, PCBs, pesticides, metals and petroleum products contained within the sediment. These data were combined with the 2007 data to give a better understanding of the nature and extent of COPCs from these three areas. Pier 1 data were divided into Inner Pier 1 and Outer Pier 1 data sets. Only Outer Pier 1 data were used in statistical analyses. Data from Inner Pier 1 are used to support the EE/CA for that area.

Six surface sediment grab samples were collected from Zone 4, Zone 7, and the Reference Area in 2007. These samples were used in a 28-day chronic toxicity test with the amphipod *Leptocheirus plumulosus.* Results from three endpoints (survival, growth, and reproduction) are reported for these three areas, as well as from laboratory control sediments. Chemical analyses were performed on all sediments to evaluate levels of PAHs, PCBs, pesticides, metals, and petroleum products. No samples were collected from Outer Pier 1 during the 2007 field survey and no bioassays were conducted for Outer Pier 1

Both duplicate and replicate values are included in the datasets. These data are typically used for quality control purposes, therefore, only the original sample is used in statistical calculations for site characterization. Final laboratory qualifiers are used to determine if a result is a detect or nondetect. Samples reported as "U" are treated as nondetects in statistical analyses and are replaced with one-half the detection limit prior to performing statistical calculations on the data. Finally, the data package contains other types of quality control information (laboratory control samples, blanks, matrix spikes etc.) from the laboratory analyses, data results from these activities are not used in statistical calculations, only sediment data are used for site characterization.

Sixty-five analytes are included in this study consisting of four chemical categories (PAHs, PCBs/Pesticides, inorganic constituents, and petroleum products). A fifth category called "Totals" is reported from the statistical analysis and includes total DDx, total PCBs, total LMWPAH and total HMWPAH. Total DDx is calculated as the sum of the following constituents: 4,4-DDD, 4,4-DDE, and 4,4-DDT. Total PCBs is calculated as two times the sum of the following congeners: Cl10(209, Cl2(8), Cl3(18), Cl3(28), Cl4(44), Cl4(52), Cl4(66), Cl5(101), Cl5(105), Cl5(118), Cl6(128), Cl6(138), Cl6(153), Cl7(170), Cl7(180), Cl7(187), Cl8(195), and Cl9(206). Total LMWPAH is calculated as the sum of the

following analytes: 2-Methylnaphthalene, Acenaphthene, Anthracene, Fluorene, Naphthalene, Phenanthrene, and Acenaphthylene. Finally, total HMWPAH is calculated as the sum of the following analytes: Benzo(a)anthracene, Benzo(a)pyrene, Fluoranthene, Chrysene, Pyrene, Dibenz(ah)anthracene. PAHs and PCBs/Pesticides are reported as ng/g dry weight, the inorganic constituents are reported as µg/g, and the petroleum products are reported as mg/g.

In summary, bioassay data includes results from six sampling locations within each area (Zone 4, Zone 7, and a Reference Area) for three endpoints (survival, growth, and reproduction). Sediment chemistry data includes results from six sampling locations within each area (Zone 4, Zone 7, and a Reference Area) for two sampling periods (2004 and 2007). Therefore, sediment chemistry data for Zone 4, Zone 7, and the Reference Area includes a total of 12 data points for each area. Sediment chemistry data for Outer Pier 1 includes five additional sampling locations for 2004 only.

A.2.0 DATA ANALYSIS

A.2.1 Bioassay Results

Sediment samples collected during the 2007 field survey were used in a 28-day benthic acute toxicity test with the amphipod *Leptocheirus plumulosus* with survival, growth, and reproduction endpoints evaluated. Chronic toxicity testing using was performed following guidance provided in "Methods for Assessing the Chronic Toxicity of Marine and Estuarine Sediment-associated Contaminants with the Amphipod *Leptocheirus plumulosus*" (USEPA, 2001). In total, *L. plumulosus* was exposed to 18 Thames River sediments (six in Zone 4, six in Zone 7, and six in the Reference Area) and a laboratory control sediment. Results from each of the endpoints are presented in detail in the following sections.

A.2.1.1 Survival

Mean percent survival in the laboratory control was 86% (Table A-4), which meets the recommended performance criteria of "greater than or equal to 80%" prescribed by USEPA guidance (USEPA, 2001). No single control replicate had less than 60% survival (Figures A-1 and A-2), again meeting the performance criteria described in USEPA guidance (USEPA, 2001). Specifically, control replicates ranged from 65% to 100%.

Mean percent survival values for Zone 4, Zone 7, and the Reference Area are 67%, 84%, and 88% (Table A-4), respectively. Survival in Zone 4 ranged from 10% (Z4-2) to 89% (Z4-5); survival in Zone 7 ranged from 72% (Z7-4) to 95% (Z7-5), and survival in the Reference Area ranged from 80% (RA-4) to 94% (RA-6) (Table A-5).

Figure A-1 presents percent survival results in side-by-side boxplots for the laboratory control (Sequim Bay, n=10), Reference Area (n=60), Zone 4 (n=60), and Zone 7 (n=60). These boxplots visually display the information provided in the summary statistics discussed above. For example, the boxplot for Zone 4 in Figure A-1 ranges from 10% to 89%. Based on a visual inspection of the boxplots, it appears that some sampling locations within Zones 4 and 7 may be different from the Reference Area. To evaluate this hypothesis, statistical tests were performed on the individual sampling locations comparing each to the Reference Area. This kind of analysis allows a quantitative determination of which sampling locations are statistically different from the Reference Area rather than relying on visual interpretations.

Results from the Analysis of Variance (ANOVA), adjusted for replicates, are presented in Table A-6. Test statistics and probability values (p-value) are presented in Table A-6 and are evaluated using an

alpha of 0.05. Test results indicate mean survival in Zone 4 sampling locations Z4-2, Z4-3, and Z4-6 is significantly lower than mean survival in the Reference Area. Furthermore, in Zone 7, statistical tests indicate mean survival in sampling locations Z7-3 and Z7-4 is also significantly lower than mean survival in the Reference Area.

A.2.1.2 Growth

Growth, as measured by neonate dry weight, was observed in all control replicates. This result meets the performance criteria recommended by USEPA guidance (USEPA, 2001). The Battelle Sequim laboratory report (Appendix D) indicates initial "mean dry weights of an average amphipod at the initiation of testing were 0.026 mg, 0.019 mg, and 0.021 mg per individual" for each of the three starts. Table A-4 presents summary statistics for growth at the completion of the 28-day exposure. The mean weight of an amphipod in the laboratory control is 1.67 mg, the mean weight of an average amphipod in the Zone 4 and Zone 7 sediments after the 28-day exposure was 1.24 mg and 1.524 mg, respectively, and finally, the mean weight of an average amphipod in the Reference Area sediments was 1.67 mg.

Table A-4 provides summary statistics for each area as a whole and Table A-7 presents summary statistics for each sampling location. The statistics in Table A-7 indicate sampling location Z4-2 had the lowest mean dry weight (0.58 mg) at the end of the bioassay relative to any other sampling location. In contrast, sampling locations Z4-5 (1.69 mg), Z7-1 (1.81 mg), and Z7-2 (1.63 mg) performed as well or better than the average Reference Area weight (1.67 mg).

Side-by-side boxplots of the growth data are presented in Figures A-3 and A-4. Figure A-3 presents data for each area as a whole in a single boxplot, whereas Figure A-4 presents the data for each sampling location in individual boxplots. Visual examination of Figure A-4 indicates dry weight in some sampling locations within Zone 4 and Zone 7 may be different from the dry weight in the Reference Area. Statistical tests were performed to quantitatively evaluate differences between individual sampling locations and the Reference Area. Results from the ANOVA analysis, including an adjustment for replicates, are presented in Table A-6.

All ANOVA hypothesis tests are statistically significant with the exception of comparisons between sampling locations Z4-5 (p-value = 0.5638), Z7-1 (p-value = 0.8703), and Z7-2 (p-value = 0.3958) to the Reference Area. Results from these three locations are interpreted as the mean dry weight in these sampling locations is similar to that in the Reference Area. All other test results indicate growth values in all other sampling locations are significantly less than the Reference Area.

A.2.1.3 Reproduction

Summary statistics for reproduction, measured as the number of neonate offspring produced by *L. plumulosus* adults, are provided in Table A-4. *L. plumulosus* adults produced an average of 5.0 neonates per surviving adult in control sediments. Furthermore, neonate offspring were recorded for every control replicate. These two results meet the performance criteria recommended by USEPA guidance (USEPA, 2001). Average number of offspring per surviving adult produced in Zone 4, Zone 7, and the Reference Area were 1.87, 2.9, and 3.66, respectively.

Table A-8 provides reproduction summary statistics for each sampling location. The average number of neonates produced in Study Area sediments ranged from 0 (Z4-2) to 3.96 (Z7-1). All sampling locations in Zone 4 reported low reproduction except at sampling location Z4-6, which reported an average of 3.46 offspring per surviving adult. Similarly, three of the six sampling locations in Zone 7 reported low reproduction.

Side-by-side boxplots of the total number of neonates produced by are presented in Figures A-5 and A-6. Figure A-5 presents data for each area as a whole, whereas Figure A-6 presents the data for each sampling location. Visual examination of Figure A-5 indicates average reproduction for some sampling locations within Zone 4 and Zone 7 may be different than the reproduction reported for the Reference Area. Statistical tests were performed to make quantitative comparisons between individual sampling locations and the Reference Area. Results from ANOVA analyses, adjusting for replicates, are presented in Table A-6.

In Zone 4, all ANOVA tests are statistically significant with the exception of the comparison between Z4-5 and the Reference Area (p-value = 0.2877) when evaluating total offspring produced. When normalizing to offspring per surviving adult, locations Z4-5 and Z4-6 were not significantly different that reference area. In Zone 7, three of the six sampling locations are statistically different than the Reference Area. Reproduction measured as total offspring produced was significantly lower than the Reference Area in Z7-3, Z7-4, and Z7-6; however, when normalized to offspring per surviving adult, only locations Z7-4 and Z7-6 were significantly different than the Reference Area.

A.2.2 Sediment Chemistry Results

Exploratory data analysis often includes numerical and visual presentations of the data, as well as distributional testing to quantify differences between the Reference Area and Study Area data. Numerical summaries involve computing basic statistics that give an overview of the data. Visual presentations can include boxplots that graphically display the distributional form of the data and any outliers or unusual values that may be present in the data.

Distributional comparison tests are used to quantify differences between the Reference Area and Study Area data. Differences can exist as complete shifts of the distributions (i.e., the site-specific data are systematically greater than the Reference Area), or partial shifts that indicate some of the site-specific data are greater than the Reference Area data. Distributional comparison tests are used to statistically confirm what is seen in the exploratory data analysis. The parametric *t*-test (Zar, 1984) and Gehan's modification to the non-parametric Wilcoxon Rank Sum test (Gehan, 1965) evaluate complete shifts between distributions (i.e., characterized by differences between the centers of the distributions); the quantile (75th and 90th) and slippage tests (Gilbert, 1987) are used to evaluate partial differences between two distributions (i.e., characterized by differences in the upper tails of the distributions). Together these five tests evaluate distributional shifts between the Reference Area and Study Area data.

In the following sections, numerical summaries, graphical presentations, and statistical tests are used to summarize the sediment chemistry results from samples collected within the Reference Area, Zone 4, Zone 7, and Outer Pier 1. These results present a weight-of-evidence for understanding the potential ecological impacts of COPCs that may have migrated from Navy source areas or may have been deposited due to Navy activities in the area. The specific methodology used for summarizing the data is discussed further in the following section.

A.2.2.1 Analysis

Summary statistics for the Reference Area are presented first followed by basic summary statistics and the results from distributional comparisons to the Reference Area for Zone 4, Zone 7, and Outer Pier 1. Tables A-9 through A-15 and Figures A-7 through A-75 are presented immediately following the descriptions in the exploratory data analysis section. Figures A-76 through A-120 present the regression equations for each constituent vs. each endpoint (survival, growth, and reproduction).

Statistics presented in each summary table include sample size (N), number of detects, minimum detect, median, mean, standard deviation, maximum detect, Shapiro-Wilk p-value, *t* UCL and bootstrap BCa UCL. The sample size is the total number data values available for analysis for a given analyte. The number of detects is the number of values (ranging from zero to N) recorded as detects in the dataset. The mean and median are values that describe the center of the distribution, while the standard deviation reflects the amount of spread around the mean. The Shapiro-Wilk p-value is used to determine whether the data are normally distributed about the mean. Shaprio-Wilk p-values less than 0.05 indicate that the distribution of the data is significantly different from normal. Finally, two upper confidence limits (UCL) are presented in the summary tables, the *t* UCL and the bootstrap BCa UCL. The Shapiro-Wilk p-value is used to determine which of these two UCLs is a more appropriate measure of the upper confidence limit on the mean. If the data are determined to be normally distributed, the *t* UCL is used, otherwise the bootstrap BCa UCL is used.

Side-by-side boxplots are presented in Figures A-7 through A-75 and are used to provide a visual display the data. Each of the solid boxes in the figures represents the middle 50% of the data around the median (the solid line within the box). The whiskers extend to the maximum and minimum data points in the distribution. Detected data values are shown as solid circles in the boxplots and nondetected data values are plotted as "x" in the boxplots. In each of the plots, the Reference Area data is plotted first as an orange box followed by Zone 4, Zone 7, and Outer Pier 1 which are all plotted as yellow boxes. When data is missing for a particular analyte, the x-axis will show the place-holder for the area but no box will appear in the figure. Finally, sample sizes are printed above each box for clarity.

Distributional comparisons are conducted for analytes having at least two detects in their dataset. The statistical significance of the five distributional comparison tests is assessed at an alpha level of 0.05. For Reference Area comparisons, the alternative hypothesis is that Study Area concentrations (Zone 4, Zone 7, or Outer Pier 1) are elevated over Reference Area concentrations. If any of the five distributional comparison tests is significant for a particular sampling location, the location is considered elevated over the Reference Area.

A detailed description of the summary statistics, boxplots, and distributional comparison results for the Reference Area, Zone 4, Zone 7, and Outer Pier 1 are provided in the sections that follow.

A.2.2.2 Reference Area Results

Most of the Reference Area data contain values from two sampling events, 2004 and 2007. Since six surface sediment samples were collected during each event, it is possible for each Reference Area analyte to have a maximum of 12 data values for statistical testing. When there are not enough detects in the Reference Area dataset, distributional comparisons were not performed and a qualitative analysis of the side-by-side boxplots were conducted instead.

Summary statistics for the Reference Area are presented in Table A-9. All PAHs have a sample size of 12, and for all PAHs, these 12 values are reported as detects. PCBs/pesticides also have sample sizes of 12 except for dieldrin, gBHC, lindane and Cl8(195) which have sample sizes of six. For these four analytes, only dieldrin reports any detected values (n=4). Eight other analytes in this category report portions of their data as nondetects. Metals data all have sample sizes of 12 except for mercury (n=6). All metals data are reported as detects.

Initial inspection of the side-by-side boxplots indicates many of the PCBs/pesticides have extreme values in their distributions. Twelve of the congeners have maximum detection values that are much larger than the mean of the data. Several specific examples include Cl4(44) which reports a mean of 4.5 ng/g and a maximum detect of 37.81 ng/g (Figure A-41) which is eight times larger than the mean. Cl5(105) reports

an extreme value of 57.12 ng/g which is ten times greater than its mean value of 5.6 ng/g (Table A-9 and Figure A-46). Finally, Cl6(138) reports a mean value of 15.09 ng/g and a maximum detect of 157.5 ng/g, which is ten times greater than the mean (Figure A-50). Another category that reports an extreme value is the total PCBs category; the mean total PCBs is 196.5 ng/g and the maximum is 1844 ng/g (Table A-9 and Figure A-73).

A.2.2.3 Zone 4

Summary statistics for Zone 4 are presented in Table A-10. All PAHs, metals, petroleum products, and totals categories have sample sizes of 12 with all values reported as detects. For PCBs/pesticides, five of the analytes (4,4-DDD, dieldrin, g-BHC, heptachlor, and Cl8(195)) have samples sizes of six values. 4,4-DDD reports six detects, dieldrin reports five detects and g-BHC, heptachlor, and Cl8(195) report no detected values. Six other analytes in the PCB congeners/pesticides category report fewer than 12 detects (4,4-DDD, Cl2(8), Cl4(77), Cl9(206), and Cl10(209)) with congener Cl5(126) reporting no detects. For g-BHC, heptachlor, Cl8(195), and Cl5(126), no distributional comparison tests are performed since no detected values are available for statistical calculations. In general, there do not appear to be any extreme values in any of the Zone 4 analyte distributions. The general forms of the distributions include symmetrical and slightly skewed to the right.

Side-by-side boxplots for Zone 4 sediment chemistry are shown in Figures A-7 through A-75; boxplots for PAHs are plotted first in Figures A-7 through A-30. Boxplots of the 24 PAHs indicate all distributions are elevated when compared to the Reference Area. Specifically, in every boxplot, the median PAH value is greater than the maximum Reference Area value. Furthermore, in many cases, the minimum PAH value is larger than the maximum Reference Area value, indicating there is a distinct shift above the Reference Area values.

Boxplots for PCBs/pesticides are shown in Figures A-31 through A-57, A-68, and A-69. Many of the PCB/pesticide plots appear to have differences between Study Area and Reference Area medians. For example, 4,4-DDD, 4,4-DDE, 4,4-DDT, a-Chlordane, and trans-nonachlor appear to be elevated over reference area concentrations. Furthermore, many of the PCB/pesticides appear to have right-skewed distributions, as illustrated by the larger values in the upper tails of the distributions.

Metals are illustrated in Figures A-58 through A-67. No mercury data are available for Zone 4, hence the blank space in Figure A-67. All metal concentrations appear to be greater than Reference Area concentrations. For many metals, the median value of the distribution is greater than the third quartile value of the Reference Area distribution.

Petroleum products are shown in Figures A-70 and A-71, and totals boxplots are presented in Figures A-72 through A-75. Diesel fuel, motor oil, total DDx, and total PCBs appear to be elevated over Reference Area values. Boxplots of total LMWPAH and total HMWPAH show complete, distinct shifts between the Zone 4 and Reference Area data.

Distributional comparison tests were performed on the Zone 4 data using the Reference Area data. Test results for all five distributional comparisons are presented in Table A-11. If any of the five tests is statistically significant, the analyte is considered elevated over the Reference Area. For Zone 4, all PAHs, all PCB congeners/pesticides, metals, petroleum products and all totals, except total DDx, are elevated when compared to Reference Area concentrations. Total DDx is the single comparison that is not statistically significant for any of the five distributional tests. These results can be confirmed by viewing the Zone 4 data compared to the Reference Area data as seen in boxplots A-7 through A-75.

A.2.2.4 Zone 7

Summary statistics for Zone 7 are presented in Table A-12. All PAHs, metals, and totals categories have sample sizes of 12 with all values reported as detects. For PCBs/pesticides, five of the analytes (4,4-DDD, dieldrin, g-BHC, heptachlor, and Cl8(195)) have samples sizes of six. 4,4-DDD reports six detects, dieldrin reports three detects and g-BHC, heptachlor, and Cl8(195) report no detected values. Six other analytes in the PCBs/pesticides category report fewer than 12 detects with Cl5(126) reporting no detected values. For g-BHC, heptachlor, Cl8(195), and Cl5(126), no distributional comparison tests are performed since no detected values are available for statistical calculations. For petroleum products, both diesel fuel and motor oil have 12 data points with diesel fuel reporting 11 detects and motor oil reporting 12 detects.

None of the analytes exhibit large discrepancies between the mean value and the maximum detected value. In general, the distributions are roughly symmetrical or slightly skewed to the right. This observation can be confirmed by viewing the Zone 7 data in the side-by-side boxplots shown in Figures A-7 through A-75.

Distributional comparison tests were performed on the Zone 7 data. Sediment chemistry concentrations were compared to Reference Area concentrations. Test results (p-values) for the five distributional comparisons are shown in Table A-13. All PAHs, 20 of the 28 PCB congeners/Pesticides, nine metals, all petroleum products, and three of the four totals are statistically significant. Results indicate that these analyses are elevated when compared to Reference Area concentrations. Seven PCB congeners/pesticides are not statistically significant when compared to Reference Area concentrations. Furthermore, total DDx (Figure A-72) and dieldrin (Figure A-69) are not different than Reference Area concentrations.

A.2.2.5 Outer Pier 1

Five surface sediment samples were obtained during the field sampling activities in 2004. Therefore, five data values are available for summary statistics, boxplots, and distributional comparisons to background. Summary statistics for Outer Pier 1 data are shown in Table A-14. All PAHs, metals, and totals report all five samples as detects. In the PCB/pesticides category, 4,4-DDT reports four detects, heptachlor reports no detects, lindane reports no detects, Cl2(8) reports one detect, Cl3(18) reports three detects, Cl4(77) reports four detects and Cl5(126) reports no detects. All other PCBs/pesticides report five detects of the five samples analyzed. Distributional testing is not performed on data with fewer than three detects, therefore test results for heptachlor, lindane, Cl2(8), and Cl5(126) are presented in Table A-15 as NA (no analyses performed on these data).

Side-by-side boxplots for Outer Pier 1 are presented in Figures A-7 through A-75. Outer Pier 1 data are plotted as the far right boxplot in each figure. Qualitative analysis of the boxplots indicates none of the distributions appear to exhibit extreme values. In general, many of the distributions are either fairly symmetric or slightly skewed to the right.

Table A-15 presents the p-values for the five distributional comparison tests performed on the Outer Pier 1 data. Probability values (p-values) are statistically significant if they are less than the alpha value of 0.05. Furthermore, if any of the distributional tests is significant, the analyte is considered elevated over Reference Area concentrations. Therefore, all PAHs and all totals are elevated over Reference Area concentrations. Furthermore, statistical test results indicate all PCBs/pesticides except 4,4-DDT and congener Cl6(128) are different from Reference Area values. Finally, cadmium is the only metal which is not elevated over Reference Area concentrations. For all other metals, at least one of the five tests is statistically significant when compared to the Reference Area.

A.2.3 References

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Tables

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Table A-1. Data Quality Objectives for Sediment Toxicity

Step 1: State the Problem Sediment concentrations of chemical constituents associated with past Navy activities at NSB New London Thames River Zones 4 and 7, and Pier 1, have been measured at levels exceeding ecological screening benchmarks. Moreover, sediment chemical constituent concentrations in portions of Zones 4 and 7, and the outer area of Pier 1, exceed concentrations in upstream Reference Area sediment. Further testing is needed to determine if the site-specific chemical concentrations in sediment from Zones 4 and 7, and the outer area of Pier 1, are different from chemical concentrations in the Thames River Reference Area sediment.
Step 2: Identify the Decisions **Primary Question:** Is consideration of any remedial action required at any of the Thames River Lower Subase sites due to chemical concentrations in sediment from Zones 4 or 7, or the outer area of Pier 1, considered toxic based on the agreed upon ecological assessment endpoints (see Tables 3-2 and 3-3) and determined to be statistically different from sediment concentrations in the up-stream Thames River Reference Area?
Step 3: Identify Inputs to the Decision 1. Identify the analytical method sensitivity (detection limits) necessary to measure COPCs at concentrations of concern i.e., sediment screening thresholds. 2. Identify COPC concentrations for each sediment sample from Zone 4, Zone 7, Pier 1 (outer area), and the Thames River Reference Area. 3. Additional data such as grain size, and TOC shall also be collected to assist in identifying potential confounding factors, and ammonia, DO, and salinity shall be monitored during the conduct of the bioassays to control potential laboratory confounding factors. Further, TPH and full spectrum PAH constituent components shall also be collected to support PAH "fingerprinting", if PAH constituents are determined to be a likely toxic contributor to benthic risk. 4. Additional selected locations within Zones 4 and 7, and Pier 1 (outer area), shall have sediment cores collected and analyzed for COPC concentrations to assist in the later design of the site-specific feasibility study estimates of contaminant volumes. (Propose that the cores shall be chemically evaluated at 2-foot increments to bedrock or 8 feet. Eight feet is typically the maximum dredge depth to meet ship docking requirements for these Thames River Lower Subase areas)
Step 4: Define the Study Boundaries Spatial boundaries for Thames River Zone 4, Zone 7, and the outer portion of Pier 1, and the Thames River Reference Area, remain the same as previously defined. Sediment samples will use only the top 5 cm of sediment from each sampling location to ensure samples are taken from the biologically active zone of sediment.

Sediment samples for the cores shall be a composite of each 2-foot increment.

Step 5: Develop a Decision Rule(s)

For the primary question of identified above, the null and alternative hypotheses for any given chemical (COPC) and any given Subase site may be written as,

H_o: $\mu_{TRi} = \mu_{Ref}$

H_a: $\mu_{TRi} > \mu_{Ref}$

where μ_{TRi} is the mean sediment chemical concentration at each of the Thames River Lower Subase sites and μ_{Ref} is the mean sediment chemical concentration at the Reference Area. Dunnett's test (Dunnett 1955) will be used to evaluate these hypotheses.

For any given chemical, Dunnett's test will yield 3 separate test statistics and associated p-values, one from each of the pairwise comparisons. Each test statistic and associated p-value will be evaluated separately from the other two comparisons. If the p-value from the comparison is less than or equal to 0.1, then reject that null hypothesis and conclude that the mean sediment chemical concentration from that Subase site is greater than the mean sediment chemical concentration at the Reference Area. If the p-value from the comparison is greater than 0.1, then fail to reject that null hypothesis and conclude there is no significant difference in sediment chemical concentration between that Subase site and the Reference Area.

Step 6: Evaluate Decision Errors

All statistical comparisons of means for Thames River Lower Subase sites versus the Reference Area will be conducted controlling for an experiment-wise $\alpha = 0.10$, experiment wise $\beta = 0.20$, and $\Delta = 50\%$. The Δ of 50% was selected given the variances observed for the COPC ERM-Q. The ERM-Q was used as the integrator of potential COPC toxicity across multiple COPCs, and was used in this case as a surrogate for the variability observed across all COPCs. The alpha design parameter was selected based on the EPA Superfund ERA guidance and the beta was based on the Navy's management desire to ensure that action will be taken if necessary.

Step 7: Optimize the Design for Obtaining Data

To achieve DQO decision error specifications, six (6) sediment samples need to be collected from each of Zone 4, Zone 7, and outer Pier 1 and the Reference Area.

Table A-2. Data Quality Objectives for Invertebrate Toxicity

Step 1: State the Problem

Sediment concentrations of chemical constituents associated with past Navy activities at NSB New London have been measured in portions of Zones 4 and 7, and the outer area of Pier 1 at levels exceeding ecological screening benchmarks, as well as exceeding concentrations in up-stream Thames River Reference Area sediment. Further testing is needed to determine if these chemical constituents are exhibiting toxicity to benthic invertebrates, and therefore, are negatively impacting populations of benthic invertebrates in areas offshore of the Thames River Lower Subase.

Step 2: Identify the Decisions

Primary Question:

Is consideration of any remedial action required due to chemical constituents in sediment at Thames River Lower Subase Zone 4, Zone 7, or the outer area of Pier 1, exhibiting toxicity to *Leptocheirus plumulosus,* a surrogate for all benthic invertebrates?

Subordinate questions that must be answered in order to resolve the above decision:

1. In a controlled 28-day laboratory experiment, is *Leptocheirus plumulosus* survival significantly lower when exposed to sediment from Zone 4, Zone 7 and outer area of Pier 1, as compared to survival when exposed to laboratory control sediment or to sediment from the Thames River Reference Area?
2. In a controlled 28-day laboratory experiment, is *Leptocheirus plumulosus* growth significantly lower when exposed to sediment from Zone 4, Zone 7 and outer area of Pier 1, as compared to growth when exposed to laboratory control sediment or to sediment from the Thames River Reference Area?
3. In a controlled 28-day laboratory experiment, is *Leptocheirus plumulosus* reproduction significantly lower when exposed to sediment from Zone 4, Zone 7 and outer area of Pier 1, as compared to reproduction when exposed to laboratory control sediment or to sediment from the Thames River Reference Area?

Step 3: Identify Inputs to the Decision

1. Determine survival, growth, and reproduction results for laboratory benthic invertebrate bioassays conducted using sediment from Zone 4, Zone 7 and Pier 1 (outer area) and the upstream Thames River Reference Area.
2. Additional data such as grain size, ammonia, oxygen levels, salinity and the like, shall also be collected to assist in identifying potential confounding factors.

Step 4: Define the Study Boundaries

Spatial boundaries for Zone 4, Zone 7, and the outer portion of Pier 1, and the Thames River Reference Area remain the same as previously defined.

Sediment samples for *L. plumulosus* bioassays will use only the top 5 cm of sediment from each sampling location to ensure the bioassay samples are taken from the biologically active zone of sediment.

Step 5: Develop a Decision Rule(s)

***Leptocheirus plumulosus* Survival Decision Rules:**

For comparison to laboratory controls or Reference Area in subordinate question number 1, the null and alternative hypotheses may be written for each sediment sample and for the laboratory control or reference area sample as,

H_o: $\mu_{TRi} \geq \mu_{Lab}$

H_a: $\mu_{TRi} < \mu_{Lab}$

where μ_{TRi} is the mean number of *L. plumulosus* surviving the 28-day bioassay after exposure to sediment from a sample (*i* = 1, 2, 3, 4, 5 or 6) within one of the three Thames River Lower Subase sites and p_{Lab} is the mean number of *L. plumulosus* surviving the 28-day bioassay exposed to the laboratory controls or Reference Area sediments. Two sample *t*-tests (Gilbert 1987) will be used to evaluate these hypotheses.

If the p-value from a comparison is less than or equal to 0.1, then reject the null hypothesis and conclude that the mean number of *L. plumulosus* surviving from that sample within the Subase site is greater than the mean number of *L. plumulosus* surviving from the laboratory control or Reference Area sediments. If the p-value from the comparison is greater than 0.1, then fail to reject that null hypothesis and conclude there is no significant difference between the mean number of *L. plumulosus* surviving from the sample within the Subase site and the laboratory control or Reference Area.

***Leptocheirus plumulosus* Growth Decision Rules:**

For subordinate question number two, the null and alternative hypotheses may be written as,

H_o: $\mu_{TRi} \geq \mu_{Lab}$

H_a: $\mu_{TRi} < \mu_{Lab}$

where μ_{TRi} is the mean growth after exposure to sediment from a sample (*i* = 1, 2, 3, 4, 5 or 6) within one of the three Thames River Lower Subase sites and p_{Lab} is the mean growth after exposure to the laboratory controls or Reference Area. Two sample *t*-tests (Gilbert 1987) will be used to evaluate these hypotheses.

If the p-value from a comparison is less than or equal to 0.1, then reject the null hypothesis and conclude that the mean growth from that sample within the Subase site is greater than the mean growth from the laboratory control or Reference Area. If the p-value from the comparison is greater than 0.1, then fail to reject that null hypothesis and conclude there is no significant difference between the mean growth from the sample within the Subase site and the laboratory control or Reference Area.

***Leptocheirus plumulosus* Reproduction Decision Rules:**

For subordinate question number 3, the null and alternative hypotheses may be written

as,

H_o: $\mu_{TRi} \geq \mu_{Lab}$

H_a: $\mu_{TRi} < \mu_{Lab}$

where μ_{TRi} is the mean number of offspring produced from the 28-day bioassay after exposure to sediment from a sample (i = 1, 2, 3, 4, 5 or 6) within one of the Thames River Lower Subase sites and p_{Lab} is the mean number of offspring produced from the 28-day bioassay exposed to the laboratory controls or Reference Area. Two sample *t*-tests (Gilbert 1987) will be used to evaluate these hypotheses.

If the p-value from a comparison is less than or equal to 0.1, then reject the null hypothesis and conclude that the mean number of offspring produced from that sample within the Subase site is greater than the mean number of offspring produced from the laboratory control or Reference Area. If the p-value from the comparison is greater than 0.1, then fail to reject that null hypothesis and conclude there is no significant difference between the mean number of offspring produced from the sample within the Subase site and the laboratory control or Reference Area.

Upon the completion of the statistical comparisons, the findings will be evaluated according to the specific decision rules for determining magnitude of impact and dose-response relationship presented in the BERA (Section 4).

Step 6: Evaluate Decision Errors

All statistical comparisons between the Thames River Lower Subase sites and the laboratory control or reference area will be conducted using $\alpha = 0.10$, $\beta = 0.20$ and $\Delta = 40\%$.

Step 7: Optimize the Design for Obtaining Data

Statistical analyses using estimates of mean and variance calculated from laboratory experiments indicate ten bioassay replicates per sediment sampling location and the laboratory control is adequate to achieve DQO decision error specifications. The number of bioassay replicates proposed here is based on multilaboratory variability studies derived from the EPA Protocol for this bioassay.

Table A-3. Data Quality Objectives for Food Chain Modeling

Step 1: State the Problem

Sediment concentrations of chemical constituents associated with past Navy activities at NSB New London in portions of Thames River Lower Subase Zones 4 and 7, and the outer area of Pier 1, have been measured at levels exceeding ecological screening benchmarks as well as concentrations in upstream reference sediment. Site-specific data are needed to determine whether these constituents are moving through the food-chain into forage fish at concentrations that pose a potential risk to piscivorous feeding birds.

Step 2: Identify the Decisions

Primary Risk Question:
Is consideration of any remedial action required due to risk to piscivorous birds from ingestion of forage fish tissue with elevated chemical concentrations collected from Thames River Lower Subase Zone 4, Zone 7, and outer area Pier 1? Are chemical concentrations in forage fish tissue in these areas statistically different from chemical concentrations in forage fish tissue from the upstream Thames River Reference Area?

Step 3: Identify Inputs to the Decision

Concentration of COPCs in composite forage fish tissue collected from the Thames River Zones 4 and 7, and outer areas of Pier 1, and the Reference Area.

Step 4: Define the Study Boundaries

Spatial boundaries for Zone 4, Zone 7, and the outer portion of Pier 1, and the Thames River Reference Area remain the same as previously defined.

Step 5: Develop a Decision Rule(s)

For the primary question of interest, the null and alternative hypotheses for any given chemical and for any given Subase site may be written as,

H_o: $\mu_{TRi} = \mu_{Ref}$

H_a: $\mu_{TRi} > \mu_{Ref}$

where μ_{TRi} is the mean fish tissue chemical concentration at each of the Thames River Lower Subase sites and μ_{Ref} is the mean fish tissue chemical concentration at the Reference Area. Dunnett's test (Dunnett 1955) will be used to evaluate these hypotheses.

For any given chemical, Dunnett's test will yield 3 separate test statistics and associated p-values, one from each of the pairwise comparisons. Each test statistic and associated p-value will be evaluated separately from the other two comparisons. If the p-value from the comparison is less than or equal to 0.1, then reject the null hypothesis and conclude that the mean concentration in the fish tissue from that Subase site is greater than the mean concentration in the fish tissue from the Reference Area. If the

p-value from the comparison is greater than 0.1, then fail to reject that null hypothesis and conclude there is no significant difference in fish tissue chemical concentration between that Subase site and the Reference Area.

Step 6: Evaluate Decision Errors

All statistical comparisons of Thames River site means versus Reference Area means, will be conducted controlling for an experiment wise $\alpha = 0.10$, $\beta = 0.20$ and $\Delta = 100\%$. Due to the lack of Thames River forage fish tissue historical data, data from another east coast site was used to estimate variance of DDx and PCBs. This other site had sediment with higher COPC concentrations and higher sediment COPC variability compared to these observed at the Thames River Lower Subase locations. If local fish tissue data for variance estimates can be found, it shall be used. Currently, practical forage fish sample sizes are proposed for the Thames River Lower Subase Zones 4 and 7, and outer area of Pier 1, as the habitat is not viewed as conducive for forage fish given the depth of 20-40 feet away from the quay wall. Sediment concentrations in the inner Pier 1 area suggests that this area is likely a candidate for expedited response, and thus further evaluation of habitat for forage fish COPC exposure is not warranted.

Step 7: Optimize the Design for Obtaining Data

Based on statistical analyses of available data, sampling efforts need to include five (5) composite fish samples from each of Zone 4, Zone 7, Pier 1 (outer area), and the Reference Area. This sample size will ensure that decision makers are confident that large differences in forage fish tissue COPC concentrations are not neglected.

Table A-4. Summary Statistics for Bioassay Results.

Endpoint	Area	N	Min	Median	Mean	Max	Standard Deviation
Survival (%)	Reference	60	0.20	0.95	0.88	1	0.17
	Zone 4	60	0	0.80	0.67	1	0.32
	Zone 7	60	0	0.95	0.84	1	0.22
	Control	10	0.65	0.85	0.86	1	0.11
Growth (mg)	Reference	60	0.46	1.79	1.67	2.32	0.39
	Zone 4	56	0.34	1.33	1.24	1.99	0.47
	Zone 7	59	0.50	1.62	1.52	2.24	0.41
	Control	10	1.27	1.59	1.67	2.24	0.36
Reproduction (# offspring/surviving adult)	Reference	60	0.29	3.32	3.66	8.84	1.87
	Zone 4	56	0	1.58	1.87	6.79	1.59
	Zone 7	59	0.67	2.78	2.9	6.95	1.41
	Control	10	1.95	4.51	5.0	8.26	1.92

Table A-5. Summary Statistics for Survival at Individual Sampling Locations.

Location	N	Min	Median	Mean	Max	Standard Deviation
RA-1	10	0.30	0.98	0.91	1	0.22
RA-2	10	0.75	0.95	0.92	1	0.08
RA-3	10	0.25	0.88	0.83	1	0.23
RA-4	10	0.20	0.90	0.80	1	0.23
RA-5	10	0.80	0.93	0.91	0.95	0.05
RA-6	10	0.65	0.98	0.94	1	0.11
Z4-1	10	0.60	0.90	0.86	1	0.14
Z4-2	10	0.00	0.05	0.10	0.35	0.13
Z4-3	10	0.35	0.78	0.70	1	0.23
Z4-4	10	0.40	0.85	0.79	0.95	0.19
Z4-5	10	0.70	0.90	0.89	1	0.09
Z4-6	10	0.10	0.68	0.67	0.95	0.28
Z7-1	10	0.50	0.93	0.88	1	0.16
Z7-2	10	0.70	0.95	0.94	1	0.09
Z7-3	10	0.00	0.83	0.75	1	0.32
Z7-4	10	0.15	0.85	0.72	1	0.31
Z7-5	10	0.85	0.95	0.95	1	0.06
Z7-6	10	0.50	0.85	0.84	1	0.18
Sequim Bay	10	0.65	0.85	0.86	1	0.11

Table A-6. ANOVA Results and Probability Values (p-value)

	Survival		Growth		Reproduction	
	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value
Zone 4-1	0.37	0.3550	3.16	0.0009	3.74	0.0001
Zone 4-2	12.09	0.0000	6.73	0.0000	5.60	0.0000
Zone 4-3	2.84	0.0026	4.16	0.0000	5.59	0.0000
Zone 4-4	1.45	0.0743	3.36	0.0005	4.21	0.0000
Zone 4-5	-0.01	0.5051	-0.16	0.5638	0.56	0.2877
Zone 4-6	3.38	0.0005	3.23	0.0008	2.32	0.0108
Zone 7-1	0.14	0.4439	-1.13	0.8703	-0.12	0.5463
Zone 7-2	-0.78	0.7827	0.27	0.3953	-0.14	0.5547
Zone 7-3	2.07	0.0201	2.31	0.0112	2.12	0.0177
Zone 7-4	2.53	0.0062	1.91	0.0289	3.37	0.0005
Zone 7-5	-0.94	0.8251	1.69	0.0465	0.36	0.3596
Zone 7-6	0.76	0.2248	1.96	0.0256	3.28	0.0006

Table A-7. Summary Statistics for Growth (mg dry weight)

Sediment	N	Min	Median	Mean	Max	Standard Deviation
RA-1	10	0.85	1.90	1.71	2.09	0.46
RA-2	10	0.46	1.81	1.70	1.96	0.44
RA-3	10	1.13	1.72	1.60	2.04	0.29
RA-4	10	0.52	1.34	1.28	1.69	0.37
RA-5	10	1.48	1.77	1.78	2.11	0.23
RA-6	10	1.36	1.98	1.94	2.32	0.26
Z4-1	10	0.49	1.41	1.26	1.64	0.38
Z4-2	6	0.39	0.62	0.58	0.72	0.13
Z4-3	10	0.42	1.15	1.13	1.45	0.29
Z4-4	10	0.77	1.31	1.24	1.48	0.24
Z4-5	10	1.17	1.79	1.69	1.99	0.28
Z4-6	10	0.34	1.67	1.25	1.85	0.66
Z7-1	10	1.13	1.95	1.81	2.24	0.35
Z7-2	10	1.38	1.63	1.63	1.82	0.14
Z7-3	9	0.73	1.44	1.36	1.80	0.40
Z7-4	10	0.50	1.71	1.42	1.90	0.58
Z7-5	10	0.75	1.47	1.45	1.82	0.31
Z7-6	10	0.57	1.58	1.42	1.81	0.45
Sequim Bay	10	1.27	1.59	1.67	2.24	0.36

Table A-8. Summary Statistics for Reproduction (number offspring/surviving adult)

Sediment	N	Min	Median	Mean	Max	Standard Deviation
RA-1	10	2.22	3.88	4.01	5.5	1.25
RA-2	10	0.89	3.65	4.09	7.89	2.21
RA-3	10	0.6	2.98	3.67	6.76	2.06
RA-4	10	0.29	1.97	1.91	3.0	0.92
RA-5	10	0.29	3.32	3.49	6.22	1.72
RA-6	10	2.2	4.79	4.77	8.84	1.85
Z4-1	10	0	1.6	1.79	4.12	1.14
Z4-2	6	0	0	0	0	0
Z4-3	10	0	0.94	0.92	1.75	0.57
Z4-4	10	0	1.62	1.53	3.06	0.96
Z4-5	10	1.59	3.4	3.46	6.79	1.6
Z4-6	10	0	3.21	2.77	5.42	1.81
Z7-1	10	2.65	4.01	3.96	5.6	0.96
Z7-2	10	2.36	3.28	3.59	6.0	1.17
Z7-3	9	1.2	2.75	2.63	4.7	1.14
Z7-4	10	0.67	1.96	2.16	3.89	1.19
Z7-5	10	1.45	3.17	3.3	6.95	1.52
Z7-6	10	0.87	1.43	2.02	4.15	1.21
Sequim Bay	10	1.92	4.51	5.00	8.26	1.92

Table A-9. Summary Statistics for Reference Area Chemistry Data.

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
PAHs (ng/g)										
Naphthalene	12	12	6.48	24.76	24.5	44.5	14.86	0.06237	32.2	31.07
2-Methylnaphthalene	12	12	5.43	19.73	19.43	33.19	11.21	0.0308	25.25	24.73
1-Methylnaphthalene	12	12	3.75	11.07	10.95	20.23	6.132	0.05717	14.13	13.73
2,6-dimethylnaphthalene	12	12	3.9	12.25	12.27	21.54	6.848	0.05715	15.82	15.53
2,3,5-trimethylnaphthalene	12	12	1.33	4.075	4.234	8.48	2.503	0.2284	5.532	5.411
Biphenyl	12	12	1.91	7.075	7.208	13.91	4.223	0.1385	9.397	9.314
Acenaphthylene	12	12	10.29	36.99	43.51	103.4	29.86	0.2033	58.99	59.39
Acenaphthene	12	12	2.31	8.515	9.723	26.44	6.892	0.07024	13.3	13.56
Fluorene	12	12	4.85	17.13	19.96	51.37	13.95	0.1335	27.19	27.73
Anthracene	12	12	12.75	65.72	69.58	147.9	46.16	0.219	93.51	90.75
Phenanthrene	12	12	56.95	196.1	240.1	737	195.4	0.0228	341.4	365.1
1-Methylphenanthrene	12	12	10.93	40.55	45.91	123.6	33.67	0.1144	63.37	63.55
Fluoranthene	12	12	150.7	517.9	586.6	1719	448.3	0.03691	819	843.9
Pyrene	12	12	174.3	609.2	680.7	1806	489.2	0.09478	934.3	945.3
Benzo(a)anthracene	12	12	59.44	262.4	272.8	654.6	184.5	0.1831	368.5	366.2
Chrysene	12	12	80.93	327.4	357.9	897.6	248.7	0.1468	486.8	492.6
Benzo(b)fluoranthene	12	12	83.12	317	345.4	900.9	245.7	0.1283	472.8	463
Benzo(k)fluoranthene	12	12	87.45	352.7	373.2	897	249.7	0.1934	502.7	512.2
Benzo(e)pyrene	12	12	74.72	296.1	317.2	773.7	215.4	0.1985	428.9	430
Benzo(a)pyrene	12	12	87.75	353.4	384.3	939.8	262.4	0.1655	520.3	510.4
Perylene	12	12	76.7	186	200.4	501	132.4	0.05106	269.1	268.7
Indeno(1,2,3-cd)pyrene	12	12	72.61	271.6	306.5	826.6	226.8	0.08337	424.1	425.1
Dibenz(ah)anthracene	12	12	14.01	59.62	65.27	163.2	46.64	0.1351	89.45	89.44

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Benzo(ghi)perylene	12	12	66.3	244.7	273.3	704.6	192.8	0.1222	373.2	372.4
PCBs and Pesticides (ng/g)										
4,4'-DDD	12	12	0.47	1.64	2.092	5.79	1.715	0.06071	2.981	2.984
4,4'-DDE	12	12	0.59	1.965	2.393	7.04	1.956	0.02249	3.407	3.527
4,4'-DDT	12	12	0.2	0.865	1.237	4.33	1.302	0.002984	1.912	2.029
a-Chlordane	12	11	0.15	0.325	0.4396	1.83	0.4697	0.000453	0.6831	0.7571
Dieldrin	6	4	0.57	0.735	0.7908	2.23	0.8034	0.2184	1.452	1.4
g-BHC	6	0	NA	0.01	0.01	NA	0	NA	NA	NA
Trans-nonachlor	12	12	0.09	0.27	0.39	1.56	0.4015	0.000613	0.5982	0.6867
Heptachlor	12	0	NA	0.03	0.03292	NA	0.01912	0.003633	0.04283	0.04042
Lindane	6	0	NA	0.0475	0.0475	NA	0.005244	0.8201	0.05181	0.05
Cl2.8	12	2	1.07	0.0625	0.2696	1.78	0.5612	2.83E-05	0.5605	0.605
Cl3.18	12	5	0.32	0.05	0.7596	6.57	1.857	8.33E-06	1.722	2.423
Cl3.28	12	12	0.3	1.565	2.026	7.52	1.924	0.002025	3.023	3.338
Cl4.44	12	12	0.41	1.48	4.537	37.81	10.52	3.96E-06	9.991	13.6
Cl4.52	12	12	0.31	1.81	9.145	89.53	25.35	2.29E-06	22.29	31.04
Cl4.66	12	12	0.82	2.535	3.634	16.92	4.351	8.15E-05	5.89	7.706
Cl4.77	12	5	0.55	0.0425	0.4604	1.75	0.6247	0.002646	0.7843	0.7908
Cl5.101	12	12	0.33	2.69	15.02	146.7	41.54	2.50E-06	36.55	50.24
Cl5.105	12	12	0.24	0.84	5.643	57.12	16.22	1.97E-06	14.05	19.75
Cl5.118	12	12	0.4	2.17	13.33	138.4	39.42	1.79E-06	33.76	47.68
Cl5.126	12	0	NA	0.0425	0.0475	NA	0.02935	0.003795	0.06272	0.06167
Cl6.128	12	12	0.44	1.19	3.912	32.23	8.953	3.82E-06	8.554	11.94
Cl6.138	12	12	0.53	2.165	15.09	157.5	44.87	1.81E-06	38.35	66.55
Cl6.153	12	12	0.67	2.7	15.36	156	44.34	1.96E-06	38.35	53.86
Cl7.170	12	12	0.18	0.515	2.065	18.32	5.136	3.30E-06	4.728	6.679
Cl7.180	12	12	0.35	1.225	4.315	37.19	10.4	3.65E-06	9.704	13.46

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Cl7.187	12	12	0.26	0.975	2.217	14.47	3.942	1.82E-05	4.26	5.644
Cl8.195	6	0	NA	0.015	0.015	NA	0	NA	NA	NA
Cl9.206	12	6	0.36	0.1875	0.4933	2.82	0.8138	0.000305	0.9153	1.069
Cl10.209	12	6	0.51	0.2625	0.4275	1.31	0.4927	0.008808	0.6829	0.7029
Metals (ug/g)										
Arsenic	12	12	3.33	5.925	7.468	14.7	3.379	0.05178	9.22	9.147
Barium	12	12	55.21	89.16	91.88	146.3	30.39	0.2083	107.6	106.4
Cadmium	12	12	0.224	0.374	0.5118	1.32	0.3119	0.004003	0.6735	0.7113
Chromium	12	12	38.28	65.43	69.39	114.3	23.49	0.4333	81.57	81.72
Copper	12	12	14.9	46.72	52.24	103.9	27.6	0.4182	66.55	67.22
Lead	12	12	13.46	48.37	50.13	101.1	28.15	0.3862	64.72	65.5
Nickel	12	12	16.13	20.35	22.49	32.24	5.596	0.1237	25.39	25.15
Selenium	12	12	0.279	0.5035	0.5746	1.192	0.2329	0.00816	0.6953	0.7318
Zinc	12	12	54.4	98.72	117.2	245	61.49	0.0135	149.1	151.2
Mercury	6	6	0.072	0.266	0.253	0.377	0.1154	0.6817	0.3479	0.311
Petroleum Products (ug/g)										
Diesel Fuel	12	8	19	26	27.71	70	19.69	0.13	37.92	38.21
Motor Oil	12	12	92	315	316	710	187	0.4823	412.9	412.5
Totals (ng/g)										
Total DDx	12	12	1.31	5.385	5.722	15.24	4.32	0.3382	7.961	8.404
Total PCBs	12	12	13.7	51.28	196.5	1844	519.7	0.01093	465.9	654.3
Total LMWPAH	12	12	100	382.3	426.8	1144	310.1	0.3942	587.5	574.5
Total HMWPAH	12	12	568.4	2151	2347	6180	1669	0.3615	3213	3221

NA – not applicable

Table A-10. Summary Statistics for Zone 4 Chemistry Data.

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
PAHs (ng/g)										
Naphthalene	12	12	76.43	116.9	176.3	507.7	137.9	0.002	247.9	266.7
2-Methylnaphthalene	12	12	45.2	60.09	73.36	147.5	34.13	0.003	91.05	94.42
1-Methylnaphthalene	12	12	21.77	34.67	40.75	86.75	21.74	0.009	52.02	53.51
2,6-dimethylnaphthalene	12	12	35.98	52.55	60.08	97.42	22.09	0.109	71.54	71.23
2,3,5-trimethylnaphthalene	12	12	8.63	19.98	21.23	47	12.12	0.080	27.51	27.21
Biphenyl	12	12	17.85	31.86	38.85	71.17	19.13	0.127	48.77	48.89
Acenaphthylene	12	12	88.89	144.7	157.8	278.4	60.88	0.251	189.4	188.7
Acenaphthene	12	12	39.34	324.7	543.4	1423	474.3	0.075	789.3	777.7
Fluorene	12	12	84.68	379.7	423.9	949.2	277	0.320	567.5	554.9
Anthracene	12	12	416.2	980.1	1079	2388	609.4	0.123	1395	1457
Phenanthrene	12	12	515.4	2443	2587	6401	1773	0.244	3506	3523
1-Methylphenanthrene	12	12	72.79	220.3	219.4	365.4	104.5	0.263	273.6	275.6
Fluoranthene	12	12	2080	6888	7770	17700	4237	0.360	9967	10010
Pyrene	12	12	2880	5771	6497	12310	2861	0.327	7980	7925
Benzo(a)anthracene	12	12	1069	2424	2920	7279	1791	0.074	3849	4099
Chrysene	12	12	1259	3040	3379	7557	1972	0.165	4401	4454
Benzo(b)fluoranthene	12	12	1005	1759	2062	3939	997.2	0.095	2579	2662
Benzo(k)fluoranthene	12	12	1071	1848	2071	3964	947.3	0.139	2562	2547
Benzo(e)pyrene	12	12	782.2	1325	1474	2817	630.3	0.166	1800	1810
Benzo(a)pyrene	12	12	1031	1616	1860	3557	789.8	0.144	2270	2332
Perylene	12	12	290.2	591.9	594	1018	196.6	0.610	695.9	697.6
Indeno(1,2,3-cd)pyrene	12	12	649.6	953.5	1053	2054	394.4	0.029	1258	1283
Dibenz(a,h)anthracene	12	12	161.8	243.7	279	703.3	148	0.001	355.7	389.2

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Benzo(g,h,i)perylene	12	12	552.1	779.3	841	1612	299.1	0.028	996.1	1031
PCBs and Pesticides (ng/g)										
4,4'-DDD	6	6	1.83	2.795	3.873	10.28	3.202	0.003	6.507	6.612
4,4'-DDE	12	12	2.47	3.625	4.807	13.42	2.926	0.000	6.324	7.01
4,4'-DDT	12	11	1.1	2.475	2.246	3.53	0.9367	0.259	2.732	2.612
a-Chlordane	12	12	0.57	0.82	0.9192	2.52	0.5211	0.000	1.189	1.336
Dieldrin	6	5	1.53	2.6	2.207	3.52	1.243	0.445	3.229	2.842
g-BHC	6	0	NA	0.01	0.01	NA	0	NA	NA	NA
Trans-nonachlor	12	12	0.29	0.545	0.6083	1.51	0.3056	0.001	0.7668	0.8267
Heptachlor	6	0	NA	0.015	0.015	NA	0	NA	NA	NA
Cl2.8	12	10	0.61	2.02	3.879	12.76	4.208	0.018	6.061	6.173
Cl3.18	12	12	1.26	3.175	6.153	16.48	5.875	0.005	9.199	9.42
Cl3.28	12	12	2.96	6.5	8.32	18.17	5.658	0.028	11.25	11.19
Cl4.44	12	12	2.84	5.41	5.713	14.55	3.204	0.005	7.374	7.628
Cl4.52	12	12	2.43	6.29	6.777	17.38	4.344	0.039	9.029	9.34
Cl4.66	12	12	1.96	5.71	5.938	15.51	3.416	0.005	7.709	8.25
Cl4.77	12	5	3.05	0.035	1.707	4.84	2.116	0.001	2.804	2.819
Cl5.101	12	12	2.11	6.135	7.836	17.89	5.13	0.156	10.5	10.6
Cl5.105	12	12	0.82	1.88	2.562	6.86	1.689	0.026	3.438	3.728
Cl5.118	12	12	1.73	3.55	5.434	15.98	4.154	0.009	7.588	8.031
Cl5.126	12	0	NA	0.045	0.08542	NA	0.08519	0.008	0.1296	0.1342
Cl6.128	12	12	1.24	1.865	2.257	3.96	0.9601	0.090	2.755	2.712
Cl6.138	12	12	1.81	4.105	5.899	15.39	4.078	0.044	8.013	8.433
Cl6.153	12	12	2.53	4.77	7.012	14.76	4.29	0.049	9.236	9.309
Cl7.170	12	12	0.71	1.715	1.722	3.93	0.9142	0.118	2.196	2.221
Cl7.180	12	12	1.14	2.615	3.225	7.56	1.781	0.116	4.148	4.347

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Cl7.187	12	12	0.91	2.225	2.521	5.31	1.166	0.262	3.125	3.211
Cl8.195	6	0	NA	0.015	0.015	NA	0	NA	NA	NA
Cl9.206	12	6	0.31	0.1625	0.4892	1.86	0.602	0.009	0.8013	0.8021
Cl10.209	12	6	0.95	0.4825	0.7783	2.58	0.9178	0.012	1.254	1.246
Metals (ug/g)										
Arsenic	12	12	7.4	12.85	12.33	13.9	1.891	0.007	13.31	12.97
Barium	12	12	92.97	156.5	182.2	475	97.57	0.000	232.8	268.3
Cadmium	12	12	0.212	0.614	0.8337	2.81	0.665	0.000	1.178	1.335
Chromium	12	12	53.89	87.28	122.3	321	92.14	0.000	170	182.2
Copper	12	12	59.91	106.4	208	735	217.1	0.000	320.6	340.3
Lead	12	12	54.86	103.8	195.1	840.6	238.3	0.000	318.7	352.6
Nickel	12	12	14.31	27.64	59.25	286.4	82.06	0.000	101.8	114.6
Selenium	12	12	0.396	0.7735	0.8695	1.883	0.4043	0.095	1.079	1.116
Zinc	12	12	163.1	244.2	1088	3718	1470	0.000	1850	1908
Petroleum Products (ug/g)										
Diesel Fuel	12	12	29	102.5	181.8	870	232.1	0.000	302.1	370.8
Motor Oil	12	12	360	880	883.3	1900	466.5	0.220	1125	1105
Totals (ng/g)										
Total DDx	12	12	3.505	7.305	8.99	27.23	6.352	0.594	12.28	13.62
Total PCBs	12	12	62.72	135.5	153.1	366.8	86.03	0.630	197.6	203.9
Total LMWPAH	12	12	1289	5077	5041	10520	2932	0.377	6561	6532
Total HMWPAH	12	12	9060	19370	22710	48160	11420	0.858	28620	29300

NA – not applicable

Table A-11. Results (p-values) from Statistical Comparisons between Zone 4 and the Reference Area

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
PAHs						
Naphthalene	0.002	0.001	0.000	0.007	0.109	0.000
2-Methylnaphthalene	0.003	0.000	0.000	0.007	0.109	0.000
1-Methylnaphthalene	0.009	0.000	0.000	0.007	0.109	0.000
2,6-dimethylnaphthalene	0.109	0.000	0.000	0.007	0.109	0.000
2,3,5-trimethylnaphthalene	0.080	0.000	0.000	0.007	0.109	0.000
Biphenyl	0.127	0.000	0.000	0.007	0.109	0.000
Acenaphthylene	0.251	0.000	0.000	0.007	0.109	0.000
Acenaphthene	0.075	0.001	0.000	0.007	0.109	0.000
Fluorene	0.320	0.000	0.000	0.007	0.109	0.000
Anthracene	0.123	0.000	0.000	0.007	0.109	0.000
Phenanthrene	0.244	0.000	0.000	0.007	0.109	0.000
1-Methylphenanthrene	0.263	0.000	0.000	0.007	0.109	0.000
Fluoranthene	0.360	0.000	0.000	0.007	0.109	0.000
Pyrene	0.327	0.000	0.000	0.007	0.109	0.000
Benzo(a)anthracene	0.074	0.000	0.000	0.007	0.109	0.000
Chrysene	0.165	0.000	0.000	0.007	0.109	0.000
Benzo(b)fluoranthene	0.095	0.000	0.000	0.007	0.109	0.000
Benzo(k)fluoranthene	0.139	0.000	0.000	0.007	0.109	0.000
Benzo(e)pyrene	0.166	0.000	0.000	0.007	0.109	0.000
Benzo(a)pyrene	0.144	0.000	0.000	0.007	0.109	0.000
Perylene	0.610	0.000	0.000	0.007	0.109	0.000
Indeno-1,2,3(cd)pyrene	0.029	0.000	0.000	0.007	0.109	0.000
Dibenz(a,h)ahanthracene	0.001	0.000	0.000	0.007	0.109	0.000
Benzo(g,h,i)perylene	0.028	0.000	0.000	0.007	0.109	0.002
PCBs and Pesticides						
4,4'-DDD	0.003	0.123	0.067	0.561	0.569	0.333
4,4'-DDE	0.000	0.014	0.003	0.320	0.500	0.500
4,4'-DDT	0.259	0.021	0.019	0.320	0.891	1.000
a-Chlordane	0.000	0.014	0.000	0.077	0.761	0.500
Dieldrin	0.445	0.023	0.033	0.091	0.227	0.030
g-BHC	NA	NA	NA	NA	NA	NA
Trans-nonachlor	0.001	0.075	0.005	0.320	0.500	1.000
Heptachlor	NA	NA	NA	NA	NA	NA

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
Cl2.8	0.018	0.006	0.000	0.007	0.109	0.001
Cl3.18	0.005	0.005	0.000	0.077	0.109	0.109
Cl3.28	0.028	0.001	0.000	0.007	0.109	0.007
Cl4.44	0.005	0.358	0.000	0.077	0.500	1.000
Cl4.52	0.039	0.622	0.002	0.077	0.500	1.000
Cl4.66	0.005	0.082	0.005	0.077	0.500	1.000
Cl4.77	0.001	0.036	0.230	0.077	0.109	0.019
Cl5.101	0.156	0.718	0.014	0.077	0.500	1.000
Cl5.105	0.026	0.737	0.009	0.077	0.500	1.000
Cl5.118	0.009	0.748	0.010	0.077	0.500	1.000
Cl5.126	NA	NA	NA	NA	NA	NA
Cl6.128	0.090	0.732	0.053	0.320	0.500	1.000
Cl6.138	0.044	0.753	0.011	0.077	0.500	1.000
Cl6.153	0.049	0.735	0.010	0.077	0.500	1.000
Cl7.170	0.118	0.588	0.003	0.077	0.500	1.000
Cl7.180	0.116	0.637	0.008	0.158	0.500	1.000
Cl7.187	0.262	0.401	0.010	0.320	0.500	1.000
Cl8.195	NA	NA	NA	NA	NA	NA
Cl9.206	0.009	0.506	0.451	0.320	0.891	1.000
Cl10.209	0.012	0.130	0.249	0.320	0.500	0.239
Metals						
Arsenic	0.007	0.000	0.001	0.077	0.500	1.000
Barium	0.000	0.005	0.000	0.007	0.109	0.002
Cadmium	0.000	0.075	0.025	0.320	0.500	0.500
Chromium	0.000	0.039	0.012	0.320	0.500	0.239
Copper	0.000	0.015	0.000	0.007	0.109	0.007
Lead	0.000	0.030	0.000	0.007	0.109	0.002
Nickel	0.000	0.075	0.042	0.077	0.109	0.109
Selenium	0.095	0.021	0.019	0.077	0.500	0.239
Zinc	0.000	0.022	0.000	0.007	0.109	0.007
Petroleum Products						
Diesel Fuel	0.000	0.021	0.000	0.007	0.109	0.001
Motor Oil	0.220	0.001	0.000	0.007	0.109	0.002
Totals						
Total DDx	0.594	0.078	0.067	0.320	0.500	0.500
Total PCBs	0.630	0.610	0.001	0.077	0.500	1.000
Total LMWPAH	0.377	0.000	0.000	0.007	0.109	0.000

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
Total HMWPAH	0.858	0.000	0.000	0.007	0.109	0.000

NA - no analyses performed on these data

Table A-12. Summary Statistics for Zone 7 Chemistry Data.

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
PAHs (ng/g)										
Naphthalene	12	12	21.68	68.36	75.92	195.6	45.37	0.035	99.45	101.7
2-Methylnaphthalene	12	12	16.4	36.91	40.5	69.03	15.48	0.270	48.53	47.97
1-Methylnaphthalene	12	12	11.21	19.2	20.57	31.73	6.569	0.275	23.98	23.81
2,6-dimethylnaphthalene	12	12	10.52	30.83	34.82	61.07	17.34	0.410	43.81	43.72
2,3,5-trimethylnaphthalene	12	12	3.85	7.55	11.32	39.15	10.04	0.001	16.53	18.21
Biphenyl	12	12	6.98	15.42	16.1	27.74	5.966	0.676	19.19	19.19
Acenaphthylene	12	12	37.25	82.33	86.22	184.5	35.71	0.011	104.7	108
Acenaphthene	12	12	18.95	47.12	62.3	185.1	49.81	0.007	88.12	96.52
Fluorene	12	12	34.21	67.53	82.86	164.6	42.57	0.116	104.9	102.5
Anthracene	12	12	139.6	222	275.8	641.4	153.7	0.013	355.5	374.4
Phenanthrene	12	12	269.5	493	560.1	1010	241.3	0.104	685.2	701.4
1-Methylphenanthrene	12	12	45.88	79.41	117.2	516.2	129.2	0.000	184.2	221.3
Fluoranthene	12	12	829.5	1405	1680	2856	654.2	0.221	2019	1989
Pyrene	12	12	788.4	1421	1618	3343	674.1	0.076	1967	1999
Benzo(a)anthracene	12	12	383.6	622.3	728.5	1526	313.1	0.046	890.8	919.9
Chrysene	12	12	569.3	842.6	934.3	1862	364.8	0.042	1123	1168
Benzo(b)fluoranthene	12	12	470.7	700.7	736.9	1095	191.6	0.839	836.2	822
Benzo(k)fluoranthene	12	12	493	743.5	780.1	1294	227.7	0.503	898.1	901.7
Benzo(e)pyrene	12	12	377.9	593.8	623.6	1060	182.2	0.345	718.1	721.6
Benzo(a)pyrene	12	12	429.8	727.2	761	1452	265.3	0.067	898.5	906.4
Perylene	12	12	164.5	363.9	355.1	471.6	96.43	0.226	405.1	394.5
Indeno(1,2,3-cd)pyrene	12	12	323.9	564.3	568.1	881.4	144.8	0.919	643.1	644.9
Dibenz(a,h)anthracene	12	12	69.86	124.1	128.8	213.9	38.17	0.789	148.6	148

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Benzo(g,h,i)perylene	12	12	252.6	484.4	483.5	793.9	134.2	0.564	553	552.9
PCBs and Pesticides (ng/g)										
4,4'-DDD	6	6	1.7	3.035	3.26	5.73	1.352	0.315	4.373	4.383
4,4'-DDE	12	12	2.05	3.205	3.957	7.43	1.58	0.095	4.776	4.817
4,4'-DDT	12	12	0.55	1.69	1.857	4.07	0.9086	0.242	2.328	2.358
a-Chlordane	12	12	0.34	0.645	0.6817	1.03	0.2143	0.708	0.7928	0.7783
Dieldrin	6	3	2.08	1.085	1.164	2.37	1.186	0.012	2.14	1.895
g-BHC	6	0	NA	0.01	0.01	NA	0	NA	NA	NA
Trans-nonachlor	12	12	0.34	0.62	0.5725	0.73	0.1432	0.112	0.6467	0.6308
Heptachlor	6	0	NA	0.015	0.015	NA	0	NA	NA	NA
Cl2.8	12	7	0.48	0.615	2.847	14.83	4.338	0.001	5.095	5.727
Cl3.18	12	11	0.75	1.92	3.841	20.04	5.417	0.000	6.65	7.912
Cl3.28	12	12	1.38	3.26	5.549	21.99	5.607	0.000	8.456	9.884
Cl4.44	12	12	1.38	2.85	3.62	9.19	2.079	0.012	4.698	4.968
Cl4.52	12	12	1.63	2.515	3.942	11.34	2.826	0.005	5.407	5.849
Cl4.66	12	12	1.67	5.015	5.422	10.82	2.368	0.305	6.649	6.618
Cl4.77	12	3	2.02	0.0525	0.6392	3.05	1.103	0.000	1.211	1.382
Cl5.101	12	12	2.08	3.48	4.92	10.11	2.867	0.037	6.406	6.412
Cl5.105	12	12	0.84	1.91	2.075	3.53	0.9058	0.109	2.545	2.498
Cl5.118	12	12	2	2.685	3.317	5.86	1.304	0.066	3.993	4.011
Cl5.126	12	0	NA	0.0675	0.07167	NA	0.05416	0.001	0.09974	0.09708
Cl6.128	12	12	1.14	1.775	2.638	12.41	3.112	0.000	4.252	4.678
Cl6.138	12	12	2.47	2.945	3.983	7.55	1.87	0.006	4.953	4.949
Cl6.153	12	12	2.97	3.705	5.086	10.22	2.544	0.004	6.405	6.468
Cl7.170	12	12	0.63	0.955	1.292	3.08	0.8767	0.001	1.747	1.758
Cl7.180	12	12	1.39	1.85	2.877	7.32	1.917	0.004	3.871	4.071

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Cl7.187	12	12	1.2	1.62	2.129	4.24	1.061	0.005	2.679	2.755
Cl8.195	6	0	NA	0.015	0.015	NA	0	NA	NA	NA
Cl9.206	12	5	0.63	0.0525	0.3883	1.08	0.4595	0.002	0.6265	0.6079
Cl10.209	12	6	1.1	0.5575	0.715	1.71	0.7437	0.003	1.101	1.104
Metals (ug/g)										
Arsenic	12	12	10.7	15.4	15.13	21.9	2.855	0.329	16.61	16.7
Barium	12	12	114.6	160	163.7	245.5	34.91	0.358	181.8	181.2
Cadmium	12	12	0.508	0.667	0.8133	2.18	0.4679	0.000	1.056	1.233
Chromium	12	12	87.57	94.92	95.03	106.9	5.446	0.659	97.85	97.82
Copper	12	12	91.79	108.8	116.1	203.1	29.98	0.001	131.7	141.4
Lead	12	12	58.63	79.77	82.24	109	12.41	0.515	88.67	88.25
Nickel	12	12	26.36	30.71	31.38	43.96	4.826	0.012	33.88	34.29
Selenium	12	12	0.565	0.821	0.8235	0.955	0.1163	0.168	0.8838	0.8672
Zinc	12	12	185.4	201.3	228.6	497.1	86.8	0.000	273.6	303.8
Petroleum Products (ug/g)										
Diesel Fuel	12	11	23	59.5	61.62	190	45.45	0.003	85.19	94.42
Motor Oil	12	12	240	475	516.7	880	205.5	0.607	623.2	619.2
Totals (ng/g)										
Total DDx	12	12	3.36	5.685	7.443	17.23	4.318	0.210	9.682	9.746
Total PCBs	12	12	46.16	90.09	109.3	271.6	63.73	0.626	142.3	150
Total LMWPAH	12	12	577	998	1184	2204	526.6	0.660	1457	1455
Total HMWPAH	12	12	3139	5069	5850	11250	2251	0.971	7017	7125

NA – not applicable

Table A-13. Results (p-values) from Statistical Comparisons between Zone 7 and the Reference Area

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
PAHs						
Naphthalene	0.035	0.001	0.000	0.007	0.109	0.000
2-Methylnaphthalene	0.270	0.001	0.000	0.007	0.109	0.000
1-Methylnaphthalene	0.275	0.001	0.001	0.077	0.109	0.019
2,6-dimethylnaphthalene	0.410	0.000	0.000	0.007	0.109	0.000
2,3,5-trimethylnaphthalene	0.001	0.017	0.003	0.077	0.109	0.047
Biphenyl	0.676	0.000	0.000	0.007	0.109	0.002
Acenaphthylene	0.011	0.002	0.002	0.077	0.500	0.239
Acenaphthene	0.007	0.002	0.000	0.007	0.109	0.000
Fluorene	0.116	0.000	0.000	0.007	0.109	0.000
Anthracene	0.013	0.000	0.000	0.007	0.109	0.000
Phenanthrene	0.104	0.001	0.000	0.077	0.109	0.109
1-Methylphenanthrene	0.000	0.044	0.005	0.077	0.500	0.239
Fluoranthene	0.221	0.000	0.000	0.077	0.109	0.019
Pyrene	0.076	0.000	0.000	0.077	0.109	0.047
Benzo(a)anthracene	0.046	0.000	0.000	0.007	0.109	0.007
Chrysene	0.042	0.000	0.000	0.077	0.109	0.019
Benzo(b)fluoranthene	0.839	0.000	0.000	0.077	0.109	0.109
Benzo(k)fluoranthene	0.503	0.000	0.001	0.077	0.109	0.109
Benzo(e)pyrene	0.345	0.001	0.001	0.077	0.500	0.500
Benzo(a)pyrene	0.067	0.001	0.001	0.077	0.500	0.239
Perylene	0.226	0.002	0.004	0.077	0.500	1.000
Indeno(1,2,3-cd)pyrene	0.919	0.002	0.001	0.077	0.500	0.500
Dibenz(a,h)anthracene	0.789	0.001	0.002	0.077	0.500	0.500
Benzo(g,h,i)perylene	0.564	0.003	0.002	0.077	0.500	0.500
PCBs and Pesticides						
4,4'-DDD	0.315	0.070	0.056	0.561	0.569	1.000
4,4'-DDE	0.095	0.021	0.007	0.320	0.500	0.500
4,4'-DDT	0.242	0.096	0.014	0.320	0.891	1.000
a-Chlordane	0.708	0.062	0.004	0.077	0.500	1.000
Dieldrin	0.012	0.270	0.212	0.500	0.227	0.227
g-BHC	NA	NA	NA	NA	NA	NA
Trans-nonachlor	0.112	0.080	0.004	0.158	0.500	1.000
Heptachlor	NA	NA	NA	NA	NA	NA

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
Cl2.8	0.001	0.033	0.002	0.077	0.109	0.019
Cl3.18	0.000	0.042	0.001	0.077	0.500	0.500
Cl3.28	0.000	0.030	0.002	0.077	0.500	0.239
Cl4.44	0.012	0.614	0.004	0.077	0.500	1.000
Cl4.52	0.005	0.753	0.030	0.320	0.500	1.000
Cl4.66	0.305	0.114	0.003	0.077	0.500	1.000
Cl4.77	0.000	0.316	0.427	0.680	0.109	0.109
Cl5.101	0.037	0.791	0.102	0.320	0.500	1.000
Cl5.105	0.109	0.769	0.016	0.077	0.500	1.000
Cl5.118	0.066	0.801	0.037	0.320	0.500	1.000
Cl5.126	NA	NA	NA	NA	NA	NA
Cl6.128	0.000	0.676	0.136	0.680	0.891	1.000
Cl6.138	0.006	0.795	0.022	0.320	0.500	1.000
Cl6.153	0.004	0.780	0.014	0.320	0.500	1.000
Cl7.170	0.001	0.691	0.018	0.320	0.500	1.000
Cl7.180	0.004	0.677	0.014	0.320	0.500	1.000
Cl7.187	0.005	0.529	0.016	0.320	0.500	1.000
Cl8.195	NA	NA	NA	NA	NA	NA
Cl9.206	0.002	0.649	0.475	0.320	0.891	1.000
Cl10.209	0.003	0.139	0.162	0.077	0.109	0.019
Metals						
Arsenic	0.329	0.000	0.000	0.007	0.109	0.002
Barium	0.358	0.000	0.000	0.007	0.109	0.002
Cadmium	0.000	0.039	0.007	0.320	0.500	0.500
Chromium	0.659	0.002	0.002	0.320	0.891	1.000
Copper	0.001	0.000	0.000	0.007	0.109	0.002
Lead	0.515	0.001	0.003	0.320	0.891	0.500
Nickel	0.012	0.000	0.001	0.007	0.109	0.007
Selenium	0.168	0.002	0.001	0.077	0.500	1.000
Zinc	0.000	0.001	0.001	0.320	0.500	0.239
Petroleum Products						
Diesel Fuel	0.003	0.016	0.004	0.077	0.239	0.047
Motor Oil	0.607	0.010	0.010	0.077	0.109	0.109

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
Totals						
Total DDx	0.210	0.170	0.113	0.320	0.500	0.500
Total PCBs	0.626	0.712	0.008	0.077	0.500	1.000
Total LMWPAH	0.660	0.000	0.000	0.077	0.109	0.047
Total HMWPAH	0.971	0.000	0.000	0.077	0.109	0.019

NA - no analyses performed on these data

Table A-14. Summary Statistics for Outer Pier 1 Chemistry Data.

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
PAHs (ng/g)										
Naphthalene	5	5	40.42	72.96	69.17	81.95	16.5	0.035	84.91	77.47
2-Methylnaphthalene	5	5	29.22	46.47	42.59	49.47	8.045	0.166	50.26	46.64
1-Methylnaphthalene	5	5	12.48	18.46	18.57	22.65	3.899	0.576	22.29	20.56
2,6-dimethylnaphthalene	5	5	27.58	31.81	32.61	40.19	4.854	0.678	37.23	36.41
2,3,5-trimethylnaphthalene	5	5	5.39	7.24	7.088	8.22	1.06	0.580	8.099	7.598
Biphenyl	5	5	13.31	14.82	15.52	18.23	2.03	0.647	17.45	16.93
Acenaphthylene	5	5	96	171.5	163.1	210.7	41.85	0.450	203	186.1
Acenaphthene	5	5	33.72	40.27	45.04	66.65	12.74	0.147	57.19	57.07
Fluorene	5	5	101	123	140	216.3	46.23	0.227	184.1	181.7
Anthracene	5	5	561.8	788.6	1207	3195	1115	0.002	2271	2232
Phenanthrene	5	5	852.1	1218	1230	1929	433.8	0.253	1643	1578
1-Methylphenanthrene	5	5	100.4	112.3	132.8	198.2	39.61	0.144	170.6	163.7
Fluoranthene	5	5	2966	4301	4965	7992	1911	0.549	6787	6478
Pyrene	5	5	3273	4287	4793	6238	1355	0.226	6085	5777
Benzo(a)anthracene	5	5	2005	2811	2832	4037	868.7	0.482	3660	3482
Chrysene	5	5	2080	3798	3772	5543	1298	0.999	5010	4571
Benzo(b)fluoranthene	5	5	1371	2401	2577	3914	933.1	0.925	3467	3120
Benzo(k)fluoranthene	5	5	1452	2432	2408	3054	605.4	0.618	2985	2708
Benzo(e)pyrene	5	5	1011	1743	1791	2486	548.6	0.958	2314	2086
Benzo(a)pyrene	5	5	1244	2069	2140	2957	636.6	0.961	2747	2482
Perylene	5	5	325.1	613	598.4	791.9	177.5	0.773	767.6	691.8
Indeno(1,2,3-cd)pyrene	5	5	599.8	1210	1192	1705	435.2	0.951	1607	1441
Dibenz(a,h)anthracene	5	5	160.1	301.3	303.7	459.9	119.6	0.937	417.7	378.1
Benzo(g,h,i)perylene	5	5	531.3	1065	977.9	1340	323.1	0.822	1286	1142

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
PCBs and Pesticides (ng/g)										
4,4'-DDD	5	5	1.49	3.09	4.172	7.96	2.632	0.564	6.681	6.098
4,4'-DDE	5	5	3.02	3.98	4.132	5.83	1.041	0.411	5.125	5.064
4,4'-DDT	5	4	1.67	2.16	2.692	7.34	2.74	0.118	5.304	5.17
a-Chlordane	5	5	0.66	0.96	0.888	1.11	0.1941	0.433	1.073	1
Dieldrin	5	5	1.9	3.21	3.218	4.1	0.826	0.483	4.005	3.658
Trans-nonachlor	5	5	0.4	0.54	0.532	0.74	0.1418	0.421	0.6672	0.632
Heptachlor	5	0	NA	0.075	0.089	NA	0.04992	0.069	0.1366	0.133
Lindane	5	0	NA	0.07	0.082	NA	0.04563	0.099	0.1255	0.118
Cl2.8	5	1	0.67	0.115	0.246	0.67	0.2448	0.016	0.4793	0.472
Cl3.18	5	3	0.95	0.95	0.795	1.62	0.661	0.528	1.425	1.197
Cl3.28	5	5	2.7	2.95	2.978	3.45	0.2842	0.262	3.249	3.226
Cl4.44	5	5	3.21	3.84	3.994	5.21	0.7594	0.573	4.718	4.662
Cl4.52	5	5	3.11	4.29	5.158	9.29	2.419	0.118	7.464	7.394
Cl4.66	5	5	3.34	5.3	4.926	5.88	1.038	0.444	5.915	5.44
Cl4.77	5	4	2.17	4.24	3.152	4.81	2.019	0.195	5.077	4.104
Cl5.101	5	5	3.96	7.84	8.526	16.02	4.494	0.218	12.81	12.32
Cl5.105	5	5	1.43	3.85	3.366	4.61	1.393	0.334	4.694	4.136
Cl5.118	5	5	2.78	5.21	5.702	9.75	2.558	0.610	8.141	7.842
Cl5.126	5	0	NA	0.115	0.134	NA	0.07309	0.067	0.2037	0.198
Cl6.128	5	5	1.81	2.02	2.274	2.87	0.4729	0.220	2.725	2.628
Cl6.138	5	5	3.02	5.19	6.028	10.37	2.745	0.588	8.645	8.15
Cl6.153	5	5	3.75	6.13	7.354	13.27	3.626	0.394	10.81	10.41
Cl7.170	5	5	1	1.14	1.256	1.8	0.32	0.119	1.561	1.536
Cl7.180	5	5	1.8	2.12	2.496	3.72	0.7714	0.297	3.231	3.146
Cl7.187	5	5	1.86	2.39	2.312	2.84	0.3773	0.831	2.672	2.57
Cl9.206	5	5	0.54	0.86	0.92	1.74	0.4826	0.086	1.38	1.336

Analyte	N	Detect	Min Detect	Median	Mean	Max Detect	Standard Deviation	Shapiro-Wilk p-value	tUCL	Boot BCa UCL
Cl10.209	5	5	0.89	1.5	1.68	2.47	0.7101	0.357	2.357	2.154
Metals (ug/g)										
Arsenic	5	5	12.5	13.1	13.54	15.3	1.161	0.392	14.65	14.38
Barium	5	5	118	124	130.6	155	15.08	0.230	145	143
Cadmium	5	5	0.41	0.501	0.5026	0.6	0.08025	0.718	0.5791	0.553
Chromium	5	5	76.7	88.6	85.16	92	6.876	0.228	91.72	88.9
Copper	5	5	76.5	102	105.9	136	22.91	0.971	127.8	121
Lead	5	5	78.9	111	139.7	295	88.47	0.020	224.1	217.4
Mercury	5	5	0.353	0.442	0.4506	0.574	0.08417	0.937	0.5308	0.5116
Nickel	5	5	25.1	26.5	26.72	28.9	1.422	0.830	28.08	27.7
Selenium	5	5	0.624	0.722	0.7228	0.833	0.09653	0.311	0.8148	0.783
Zinc	5	5	183	218	226.2	262	34.62	0.387	259.2	250.6
Totals (ng/g)										
Total DDx	5	5	4.58	9.23	11	18.91	5.641	0.8191	16.37	15.13
Total PCBs	5	5	73.11	116	120	184.5	40.38	0.4231	158.5	149.1
Total LMWPAH	5	5	1995	2168	2897	5048	1291	0.05811	4127	4083
Total HMWPAH	5	5	13740	18370	18810	24700	5194	0.2279	23760	22270

NA – not applicable

Table A-15. Results (p-values) from Statistical Comparisons between Outer Pier 1 and the Reference Area

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
PAHs						
Naphthalene	0.035	0.001	0.002	0.002	0.074	0.002
2-Methylnaphthalene	0.166	0.000	0.002	0.002	0.074	0.002
1-Methylnaphthalene	0.576	0.005	0.010	0.053	0.074	0.074
2,6-dimethylnaphthalene	0.678	0.000	0.001	0.002	0.074	0.000
2,3,5-trimethylnaphthalene	0.580	0.002	0.029	0.330	0.515	1.000
Biphenyl	0.647	0.000	0.001	0.002	0.074	0.002
Acenaphthylene	0.450	0.001	0.001	0.002	0.074	0.002
Acenaphthene	0.147	0.001	0.001	0.002	0.074	0.000
Fluorene	0.227	0.002	0.001	0.002	0.074	0.000
Anthracene	0.002	0.042	0.001	0.002	0.074	0.000
Phenanthrene	0.253	0.003	0.001	0.002	0.074	0.000
1-Methylphenanthrene	0.144	0.002	0.002	0.053	0.074	0.074
Fluoranthene	0.549	0.003	0.001	0.002	0.074	0.000
Pyrene	0.226	0.001	0.001	0.002	0.074	0.000
Benzo(a)anthracene	0.482	0.001	0.001	0.002	0.074	0.000
Chrysene	0.999	0.002	0.001	0.002	0.074	0.000
Benzo(b)fluoranthene	0.925	0.003	0.001	0.002	0.074	0.000
Benzo(k)fluoranthene	0.618	0.001	0.001	0.002	0.074	0.000
Benzo(e)pyrene	0.958	0.001	0.001	0.002	0.074	0.000
Benzo(a)pyrene	0.961	0.001	0.001	0.002	0.074	0.000
Perylene	0.773	0.002	0.002	0.002	0.074	0.002
Indeno(123cd)pyrene	0.951	0.004	0.001	0.002	0.074	0.002
Dibenz(ah)anthracene	0.937	0.005	0.001	0.002	0.074	0.002
Benzo(ghi)perylene	0.822	0.003	0.001	0.002	0.074	0.002
PCBs and Pesticides						
4,4'-DDD	0.564	0.080	0.046	0.330	0.515	0.294
4,4'-DDE	0.411	0.016	0.018	0.330	0.515	1.000
4,4'-DDT	0.118	0.155	0.103	0.330	0.515	0.294
a-Chlordane	0.433	0.007	0.004	0.053	0.515	1.000
Dieldrin	0.483	0.000	0.005	0.061	0.455	0.015
Trans-nonachlor	0.421	0.150	0.036	0.330	0.515	1.000
Heptachlor	NA	NA	NA	NA	NA	NA
Lindane	NA	NA	NA	NA	NA	NA

Analyte	Shapiro-Wilk p-value	t-test	Gehan	Quantile (.75)	Quantile (.90)	Slippage
Cl2.8	NA	NA	NA	NA	NA	NA
Cl3.18	0.528	0.477	0.035	0.330	0.515	1.000
Cl3.28	0.262	0.060	0.013	0.330	0.515	1.000
Cl4.44	0.573	0.569	0.006	0.053	0.515	1.000
Cl4.52	0.118	0.700	0.013	0.330	0.515	1.000
Cl4.66	0.444	0.176	0.010	0.053	0.515	1.000
Cl4.77	0.195	0.020	0.005	0.002	0.074	0.002
Cl5.101	0.218	0.698	0.023	0.330	0.515	1.000
Cl5.105	0.334	0.681	0.012	0.053	0.515	1.000
Cl5.118	0.610	0.741	0.008	0.053	0.515	1.000
Cl5.126	NA	NA	NA	NA	NA	NA
Cl6.128	0.220	0.730	0.057	0.330	0.515	1.000
Cl6.138	0.588	0.750	0.010	0.053	0.515	1.000
Cl6.153	0.394	0.726	0.010	0.053	0.515	1.000
Cl7.170	0.119	0.701	0.023	0.330	0.515	1.000
Cl7.180	0.297	0.721	0.029	0.330	0.515	1.000
Cl7.187	0.831	0.468	0.029	0.330	1.000	1.000
Cl9.206	0.086	0.102	0.020	0.330	0.515	1.000
Cl10.209	0.357	0.006	0.003	0.053	0.074	0.015
Metals						
Arsenic	0.392	0.000	0.006	0.053	0.515	0.294
Barium	0.230	0.002	0.010	0.330	0.515	0.294
Cadmium	0.718	0.537	0.146	0.792	1.000	1.000
Chromium	0.228	0.026	0.046	0.330	1.000	1.000
Copper	0.971	0.001	0.004	0.053	0.074	0.074
Lead	0.020	0.043	0.003	0.053	0.074	0.015
Mercury	0.937	0.005	0.005	0.061	0.455	0.015
Nickel	0.830	0.014	0.103	0.792	1.000	1.000
Selenium	0.311	0.042	0.020	0.330	0.515	1.000
Zinc	0.387	0.000	0.006	0.330	0.074	0.074
Totals						
Total DDx	0.8191	0.055	0.037	0.330	0.515	0.294
Total PCBs	0.4231	0.689	0.008	0.053	0.515	1.000
Total LMWPAH	0.05811	0.006	0.001	0.002	0.074	0.000
Total HMWPAH	0.2279	0.001	0.001	0.002	0.074	0.000

NA - no analyses performed on these data

Table A-16. Chemical Concentrations Used in ERM-Q Calculations for Each Sampling Location and Associated ERM-Q Values

Station ID	Study Area	Year	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)	a-Chlordane (µg/kg)	Total 4,4'-DDx (µg/kg)	Total HPAH (µg/kg)	Total LPAH (µg/kg)	Total PCB (NST18)[1] (µg/kg)	Metals ERMQ[2]	Organic ERMQ[3]	ERMQ[4]
SBP-5	Pier 1 Outer	1999	12	0.5	61	120	110	25	NA	220	[0.75][5]	[2.25]	3429	795	62.2	0.337	0.196	0.291
SBP-6	Pier 1 Outer	1999	13	0.42	58	79	86	22	NA	160	[0.75]	[2.25]	2838	666	38.4	0.270	0.170	0.232
SBP-7	Pier 1 Outer	1999	8.3	0.91	39	140	100	14	NA	250	[0.7]	19.4	3.42E+04	7678	163	0.311	1.632	0.801
P1-50	Pier 1 Outer	2003	15.2	0.733	98.9	136	140	31.6	0.969	300	0.89	72.6	3.37E+04	5014.4	265.34	0.468	1.658	0.926
P1-53	Pier 1 Outer	2003	14.4	0.413	94.7	84	94	28.6	0.827	167	1.2	12.69	8489.01	1157.52	108.46	0.350	0.466	0.394
P1-55	Pier 1 Outer	2003	14.6	0.436	93.5	74	88	30.4	0.868	149	0.54	7.32	5515.48	823.15	88.74	0.345	0.315	0.333
T1SD3-A	Reference	2003	8.9	0.444	75.9	59.4	62.5	22.2	0.613	110	0.52	8.04	3416.12	561.51	78.52	0.253	0.246	0.250
T1SD3-B	Reference	2003	6.76	0.452	67.3	51.1	51.8	20.6	0.466	92.9	0.71	8.44	3235.03	607.7	94.67	0.214	0.271	0.236
T1SD3-C	Reference	2003	6.29	0.38	60.3	45.3	45.5	17.6	0.479	82.3	0.4	5.96	3214.58	540.72	68.85	0.194	0.217	0.203
T1SD3-D	Reference	2003	5.71	0.346	52.7	38.6	40.6	33.1	0.4	78.1	0.34	4.75	2216.18	389.49	53.02	0.213	0.162	0.193
T1SD4-A	Reference	2003	7.41	0.615	77.9	60.9	60.2	21.6	0.617	106	0.52	6.91	3715.87	560.81	96.77	0.250	0.268	0.257
T1SD4-B	Reference	2003	5.56	0.299	55.1	40.8	39.6	17.8	0.435	78.1	0.31	4.43	2252.36	336.24	54.71	0.180	0.159	0.172
T1SD4-C	Reference	2003	7.1	0.346	52.5	40.4	34	21.4	0.413	70.3	0.33	4.64	1463.26	234.38	62.33	0.183	0.146	0.169
T1SD4-D	Reference	2003	11.3	0.87	111	77.1	92.2	24.7	0.803	136	0.39	9.51	4233.5	720.38	117.49	0.331	0.319	0.326
Z4-33	Zone 4	2003	13.2	1.58	263	305	345	90.6	1.13	3310	0.75	8.65	2.27E+04	3305.4	301.54	1.802	1.080	1.524
Z4-36	Zone 4	2003	10.7	3.49	364	628	1240	188	2.24	4070	6.07	56.31	1.97E+04	2158.46	1046.65	3.086	2.158	2.729
Z4-37	Zone 4	2003	14.4	0.674	98.2	103	102	28.9	0.915	194	0.66	9.95	3.97E+04	3193.4	149.5	0.385	1.261	0.722
Z4-39	Zone 4	2003	10.7	1.41	125	98.6	109	25.9	0.89	182	0.96	22.05	1.00E+04	1659.55	232.38	0.386	0.699	0.506
Z4-40	Zone 4	2003	14.1	0.56	98.8	88.6	126	28.9	0.931	171	0.64	9.1	4.50E+04	8024.82	113.21	0.384	1.632	0.864
Z4-42	Zone 4	2003	14.9	0.519	101	94.4	95.2	30	1.02	170	0.6	9.34	8.47E+04	1.96E+04	114.84	0.381	3.194	1.463
Z4-43	Zone 4	2003	11.2	0.439	93.5	101	88.1	27.2	0.811	191	0.59	7.83	1.48E+04	1876.36	106.44	0.351	0.599	0.446
Z4-44	Zone 4	2003	11.3	0.297	71.1	147	124	38.1	0.661	958	0.33	4.04	7643.59	1311.82	53.5	0.631	0.330	0.515
Z4-46	Zone 4	2003	8.13	0.363	83.7	64.1	69.7	19.1	0.533	109	0.2	3.65	6977.52	1381.71	81.39	0.244	0.346	0.283
Z7-10	Zone 7	2003	14.3	0.399	102	89.3	77.4	29.7	0.891	152	0.4	7.71	4122.52	648.32	100.76	0.349	0.286	0.324
Z7-12	Zone 7	2003	14.5	0.483	94	96.7	82.9	31	0.998	164	0.52	7.86	5271.61	883	99.04	0.370	0.327	0.354
Z7-14	Zone 7	2003	12.3	0.592	95.8	396	2830	79.6	0.666	2050	0.48	8.3	6428.79	890.34	102.25	2.745	0.356	1.826
Z7-15	Zone 7	2003	14.8	0.448	93.2	130	80.1	31	0.935	167	0.45	8.65	5409.13	820.35	95.88	0.379	0.324	0.358

Table A-16. Chemical Concentrations Used in ERM-Q Calculations for Each Sampling Location and Associated ERM-Q Values

Station ID	Study Area	Year	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)	a-Chlordane (µg/kg)	Total 4,4'-DDx (µg/kg)	Total HPAH (µg/kg)	Total LPAH (µg/kg)	Total PCB (NST18)[1] (µg/kg)	Metals ERMQ[2]	Organic ERMQ[3]	ERMQ[4]
Z7-22	Zone 7	2003	9.54	0.371	60	70.8	53	20.5	0.497	132	0.32	5.01	1.74E+04	3518.75	49.66	0.240	0.672	0.406
Z7-24	Zone 7	2003	13	0.599	91.6	89.8	80.4	29.6	0.871	163	0.51	11.81	5135.26	857.06	186.26	0.349	0.436	0.383
Z7-27	Zone 7	2003	9.26	0.36	61.6	97.2	101	22.6	0.589	447	1.07	9.57	2.86E+04	3888.14	64.84	0.389	0.991	0.620
Z7-29	Zone 7	2003	11.7	0.371	71.2	133	48.4	48.1	0.78	127	0.34	5.05	3188.65	563.13	64.8	0.364	0.207	0.304
Z7-03	Zone 7	2003	6.03	0.278	54.5	88.5	47.1	18.4	0.328	121	7.76	168.4	9186.58	1499.3	53.01	0.212	1.334	0.643
Z7-30	Zone 7	2003	14.8	0.52	87.6	92.6	80.7	29.3	0.985	169	0.56	6.55	3.55E+04	1.03E+04	94.01	0.362	1.546	0.818
Z7-31	Zone 7	2003	15.7	0.498	92.4	99	84.8	29.8	0.944	166	0.5	10.71	6283.73	828.76	92.87	0.367	0.350	0.361
Z7-04	Zone 7	2003	16.3	0.508	106	112	81.8	29.5	1.09	170	0.54	9.45	8346.24	1069.18	95.67	0.391	0.407	0.397
Z7-05	Zone 7	2003	16	0.597	119	129	86.5	35.1	0.968	180	0.61	10.27	1.03E+04	1345.13	99.58	0.412	0.476	0.437
Z7-06	Zone 7	2003	13.9	1.36	157	134	184	51.5	0.992	242	1.83	37.73	2.83E+04	4682.13	158.59	0.550	1.286	0.833
R-S1	Reference	2004	5.89	0.39	69.12	51.71	50.42	18.57	0.46	104.58	0.34	6.91	2725.88	496.23	59.89	0.210	0.196	0.205
R-S2	Reference	2004	4.5	0.343	53.19	37.71	37.36	27.23	0.50	82.11	0.19	2.26	1292.54	223.78	32.8	0.205	0.094	0.162
R-S3	Reference	2004	5.96	0.343	61.73	40.72	35.91	16.57	0.50	92.86	0.17	2.05	1140.87	195.49	23.82	0.188	0.077	0.145
R-S4	Reference	2004	3.33	0.224	38.28	14.90	13.46	18.23	0.28	54.40	[0.045]	1.31	791.19	153.64	13.7	0.122	0.049	0.094
R-S5	Reference	2004	7.34	0.444	73.42	52.49	51.21	18.72	0.46	107.10	0.41	6.54	3122.98	557.98	65.58	0.216	0.215	0.216
R-S6	Reference	2004	8.51	0.653	82.15	64.43	67.40	21.98	0.59	136.94	0.54	9.33	3613.31	652.47	1844.48	0.267	2.224	1.020
RA-1 (fd)	Reference	2007	5.09	0.289	55.44	39.25	35.97	16.99	0.37	81.08	0.29	3.55	1555.49	264.56	37.18	0.169	0.116	0.149
RA-1	Reference	2007	5.63	0.328	54.24	41.74	46.33	16.13	0.44	82.37	0.31	4.23	1576.38	268.46	45.25	0.182	0.129	0.162
RA-2	Reference	2007	5.85	0.358	48.39	24.60	19.46	18.26	0.52	70.37	0.2	1.58	568.39	100.01	16.52	0.166	0.050	0.121
RA-3	Reference	2007	5.89	0.32	48.76	27.61	20.69	29.70	0.50	69.73	0.15	2.14	590.02	107.87	16.46	0.194	0.052	0.139
RA-4	Reference	2007	13	0.89	114.27	97.35	96.55	28.04	0.82	245.00	0.57	10.36	3218.21	622.81	83.98	0.390	0.264	0.341
RA-5	Reference	2007	9.02	0.529	83.93	69.76	61.63	24.17	0.63	130.30	0.52	6.71	3349.77	598.81	57.32	0.273	0.218	0.252
RA-6	Reference	2007	14.7	1.32	105.2	103.9	101.09	32.24	1.19	231.24	1.83	15.24	6180.14	1143.58	98.24	0.440	0.437	0.439
Z4-1	Zone 4	2007	12.5	0.827	321	567.5	524.34	164.7	1.27	3068	0.8	9.89	3.44E+04	7857.57	228.59	2.153	1.538	1.916
Z4-2	Zone 4	2007	10.5	2.81	313.4	735	840.59	286.4	1.88	3718	2.52	27.23	1.85E+04	2584.34	366.77	2.979	1.158	2.279
Z4-3	Zone 4	2007	13.9	1.06	104.8	121.1	135.78	32.25	1.07	233.54	0.73	11.99	1.76E+04	7331.26	181.99	0.453	1.110	0.706
Z4-3 (rep)	Zone 4	2007	14.6	1.07	108.6	122.1	144.59	33.34	1.09	239.85	0.73	11.99	1.76E+04	7331.26	181.99	0.467	1.110	0.714

Table A-16. Chemical Concentrations Used in ERM-Q Calculations for Each Sampling Location and Associated ERM-Q Values

Station ID	Study Area	Year	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)	a-Chlordane (µg/kg)	Total 4,4'-DDx (µg/kg)	Total HPAH (µg/kg)	Total LPAH (µg/kg)	Total PCB (NST18)[1] (µg/kg)	Metals ERMQ[2]	Organic ERMQ[3]	ERMQ[4]
Z4-4 (fd)	Zone 4	2007	13.2	0.925	99.66	112.5	118.56	32.53	0.85	209.28	0.61	8.51	1.09E+04	3049.21	105.25	0.408	0.594	0.479
Z4-4	Zone 4	2007	13	0.909	100.3	115.4	112.45	32.01	0.94	217.85	0.94	11.49	1.69E+04	5227.15	183.63	0.414	0.968	0.627
Z4-5	Zone 4	2007	13.8	0.645	86.59	197.8	106.14	30.01	0.88	765.93	0.64	8.02	1.36E+04	2267.75	89.67	0.600	0.583	0.593
Z4-6	Zone 4	2007	11	0.503	79.31	83.95	78.63	27.59	0.72	163.05	0.57	6.65	9060.3	2028.16	83.01	0.318	0.457	0.372
Z4-S1	Zone 4	2004	13.2	0.212	61.49	254.5	54.86	14.31	0.40	3707	0.68	5.17	2.92E+04	4926.54	62.72	1.397	1.035	1.258
Z4-S2	Zone 4	2004	13.9	0.583	84.62	97.32	101.52	26.44	0.80	320.95	0.9	5.23	2.49E+04	6064.5	161.69	0.398	1.135	0.681
Z4-S3	Zone 4	2004	12.6	0.54	85.74	95.18	93.94	26.58	0.61	254.82	0.84	3.505	4.82E+04	1.05E+04	109.24	0.353	1.834	0.923
Z4-S4	Zone 4	2004	13.5	0.52	87.97	84.97	89.39	27.70	0.68	202.11	0.59	4.25	3.07E+04	7770.04	81.09	0.341	1.260	0.694
Z4-S5	Zone 4	2004	12.7	0.49	88.14	83.65	84.46	26.08	0.75	190.83	0.94	6.49	2.03E+04	2617.81	100.28	0.334	0.759	0.497
Z4-S6	Zone 4	2004	7.4	0.905	53.89	59.91	119.41	16.97	0.43	216.01	0.88	7.96	9105.08	1288.84	187.92	0.285	0.544	0.384
Z4-S6 (rep)	Zone 4	2004	5.58	0.962	87.72	131.65	131.45	24.83	0.50	468.37	0.94	13.18	1.15E+04	1680.92	382.32	0.436	0.859	0.599
Z7-1	Zone 7	2007	10.7	2.18	97.77	203.10	58.63	43.96	0.57	497.07	0.49	6.76	3809.88	677.78	46.16	0.517	0.219	0.402
Z7-2	Zone 7	2007	15.9	0.831	101.31	115.67	109.01	33.65	0.96	209.04	0.92	11.27	4910.04	998.7	129.13	0.420	0.389	0.408
Z7-3	Zone 7	2007	14.6	1.07	106.9	133.20	95.44	33.69	0.94	229.89	0.93	17.23	6483.75	1394.23	185.85	0.428	0.536	0.469
Z7-4	Zone 7	2007	14.9	0.784	97.27	111.31	85.83	32.88	0.94	200.69	0.78	9.56	4864.62	997.23	111.45	0.395	0.356	0.380
Z7-5	Zone 7	2007	13.7	0.767	96.52	106.37	80.02	32.79	0.87	191.89	0.66	8.72	4215.08	873.59	112.41	0.378	0.328	0.359
Z7-6	Zone 7	2007	16	0.907	94.75	123.79	90.63	32.88	0.95	252.56	0.83	11.58	8083.58	1942.4	271.61	0.423	0.671	0.518
Z7-S1	Zone 7	2004	12.7	0.508	95.10	113.45	82.48	28.63	0.75	201.88	0.51	3.97	6623.89	1122.45	74.1	0.359	0.326	0.346
Z7-S2	Zone 7	2004	17.1	0.523	92.73	94.77	78.86	27.83	0.83	193.44	0.34	3.6	3138.59	576.97	54.38	0.359	0.189	0.293
Z7-S3	Zone 7	2004	21.9	0.567	87.57	91.79	76.08	28.05	0.81	187.33	0.5	4.12	4360	802.21	74.28	0.359	0.259	0.321
Z7-S4	Zone 7	2004	15.9	0.567	90.13	99.94	74.20	26.36	0.78	185.40	0.63	4.54	1.13E+04	2204.28	105.43	0.345	0.532	0.417
Z7-S4 (rep)	Zone 7	2004	13.4	0.547	89.70	108.27	75.19	27.42	0.74	191.54	0.56	4.07	5474.35	1173.14	72.78	0.346	0.305	0.330
Z7-S5	Zone 7	2004	12.1	0.545	89.66	103.19	79.52	28.42	0.75	205.88	1.03	3.36	7228.63	1765.69	74.75	0.351	0.394	0.367
Z7-S6	Zone 7	2004	16.1	0.511	90.71	96.84	76.14	27.42	0.74	187.65	0.56	4.61	5228.14	849.52	72.04	0.345	0.281	0.320
P1-C3	Pier 1 Outer	2004	11.6	0.734	101.2	202.5	164.55	42.27	0.83	367.87	1.81	15.78	1.48E+04	1727.25	220.38	0.541	0.792	0.637
P1-C4	Pier 1 Outer	2004	7.22	0.746	73.83	260.6	157.48	30.70	0.54	705.92	21.2	121.6	1.09E+04	1526.49	577.64	0.596	2.199	1.213
P2	Pier 1 Outer	2004	12.7	0.6	92.04	119.7	110.52	27.12	0.62	261.88	0.66	9.23	2.42E+04	5048.03	107.9	0.382	1.007	0.622

Table A-16. Chemical Concentrations Used in ERM-Q Calculations for Each Sampling Location and Associated ERM-Q Values

Station ID	Study Area	Year	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Zinc (mg/kg)	a-Chlordane (µg/kg)	Total 4,4'-DDx (µg/kg)	Total HPAH (µg/kg)	Total LPAH (µg/kg)	Total PCB (NST18)[1] (µg/kg)	Metals ERMQ[2]	Organic ERMQ[3]	ERMQ[4]
P3	Pier 1 Outer	2004	12.5	0.501	78.86	101.5	90.83	25.11	0.63	207.46	1	18.91	1.34E+04	1995.08	119.76	0.335	0.655	0.458
P4	Pier 1 Outer	2004	13.1	0.563	89.57	136.3	122.90	28.95	0.72	261.01	0.71	7.94	1.80E+04	2108.37	116.16	0.409	0.696	0.519
P5	Pier 1 Outer	2004	15.3	0.41	88.63	76.46	78.86	26.48	0.80	182.80	1.11	14.32	1.36E+04	2168.24	184.46	0.335	0.724	0.485
P6	Pier 1 Outer	2004	14.1	0.439	76.71	95.20	295.06	26.03	0.83	217.82	0.96	4.65	2.32E+04	3164.18	73.44	0.474	0.818	0.606

NA = Not Analyzed

[1]The majority of Total PCB concentrations included a mix of detected and nondetected congeners. Nondetects were included in the total at one-half the reported detection limit.

[2]Metals ERM-Q was calculated using arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc.

[3]Organic ERM-Q was calculated using a-chlordane, Total 4,4'-DDx, Total HPAH, Total LPAH, and Total PCBs.

[4]ERM-Q was calculated with all 13 constituents listed in the table with the exception of the 3 1999 Outer Pier 1 samples which omitted selenium because it was not analyzed in those samples.

[5]Concentrations in parentheses represent nondetects that were included in the calculations at one half the reporting limit (value listed is DL/2).

Figures

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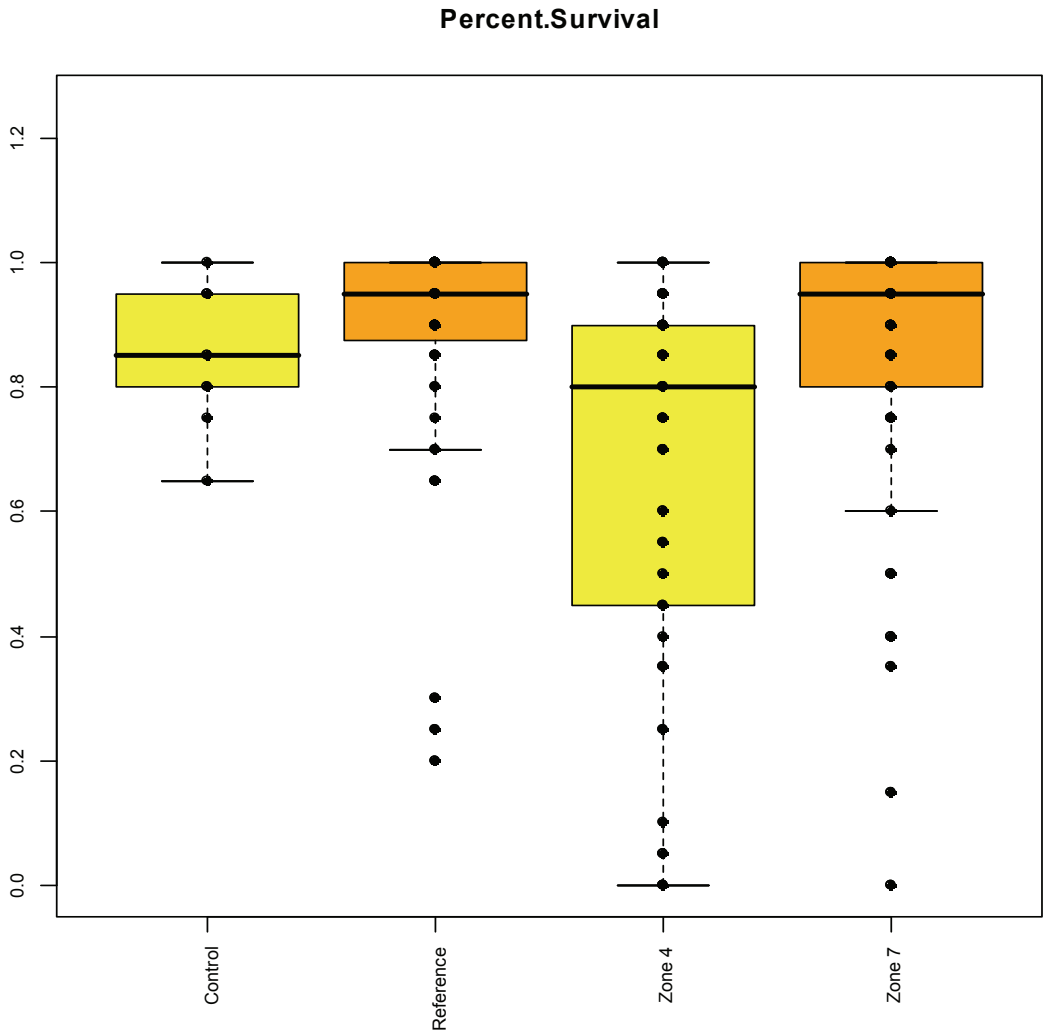

Figure A-1. Amphipod Survival Results by Area

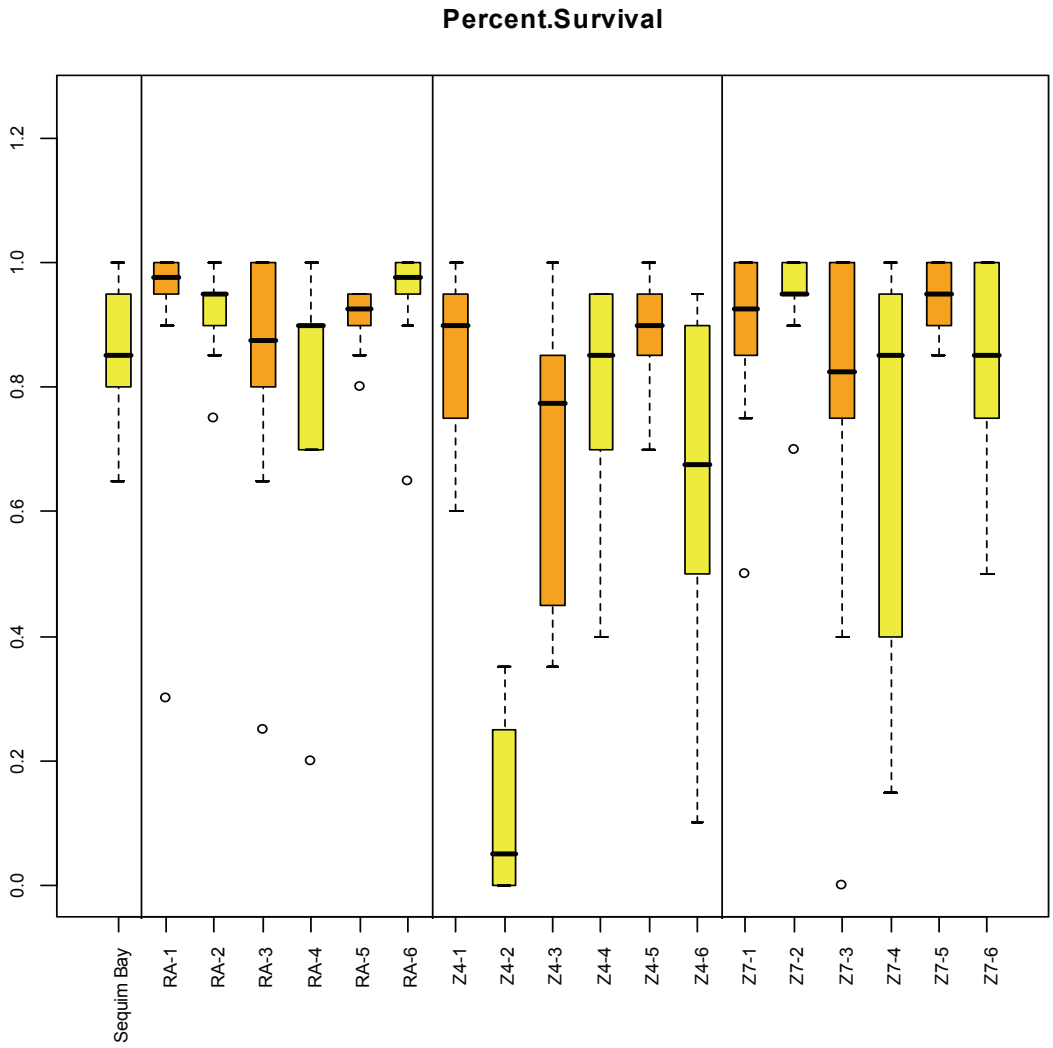

Figure A-2. Amphipod Survival Results by Individual Sampling Location

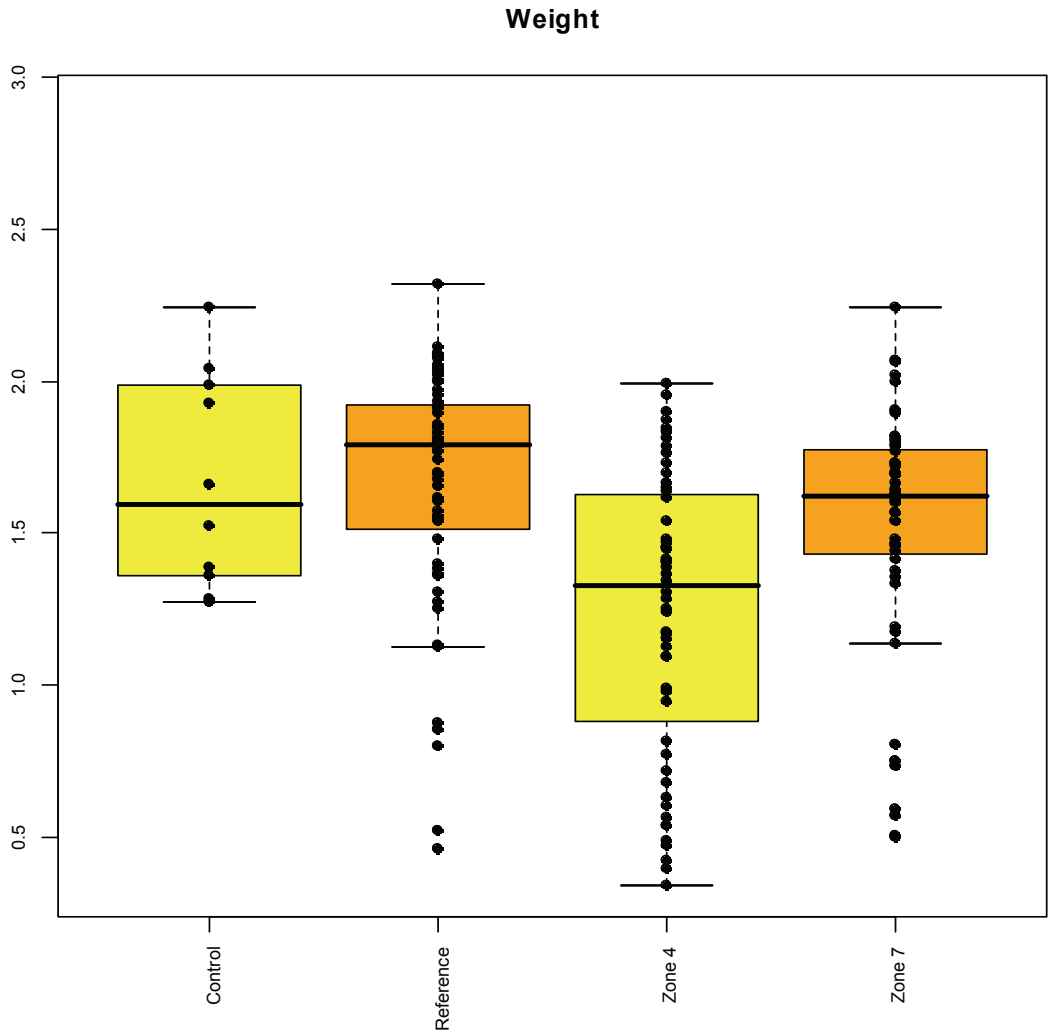

Figure A-3. Amphipod Growth Results (mg dry weight) by Area

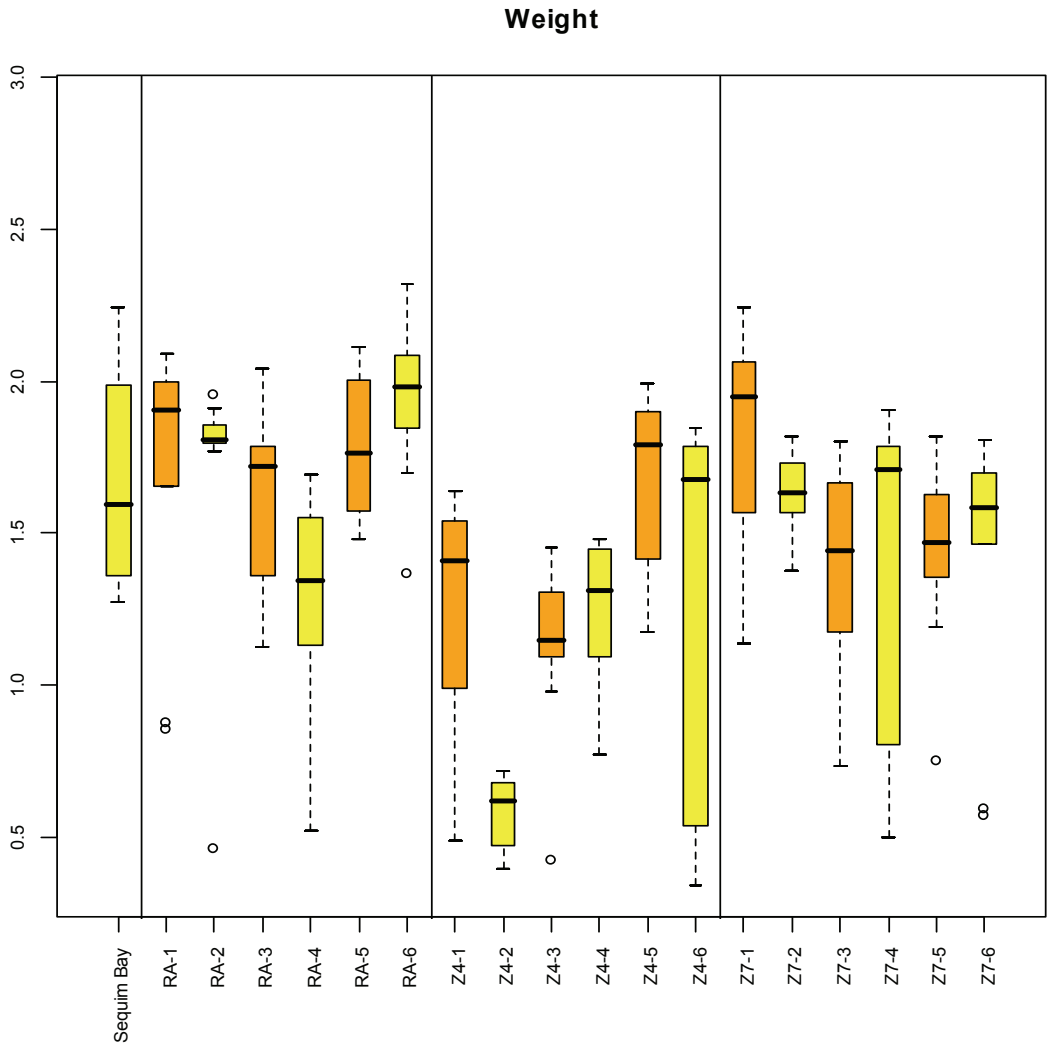

Figure A-4. Amphipod Growth Results (mg dry weight) by Individual Sampling Locations

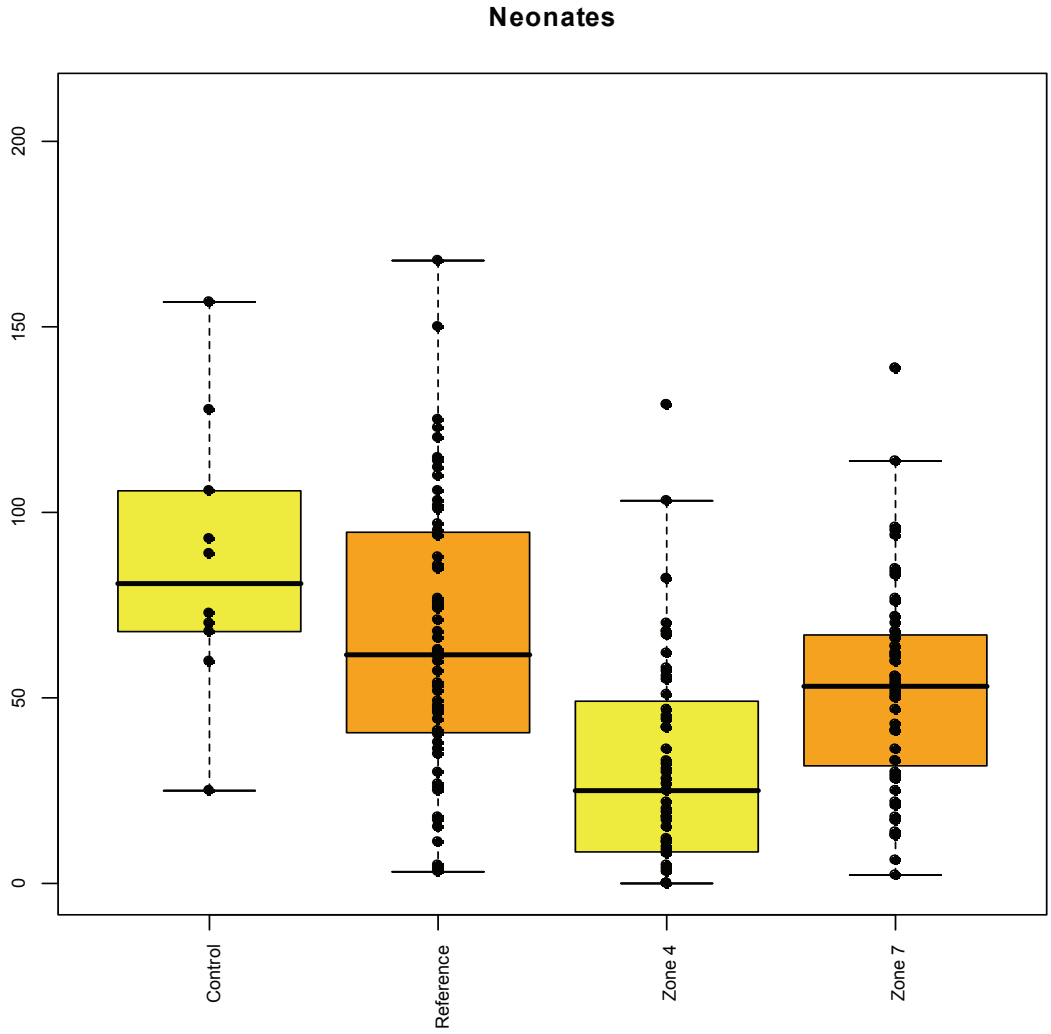

Figure A-5. Amphipod Reproduction Results (total number of neonates produced) by Area

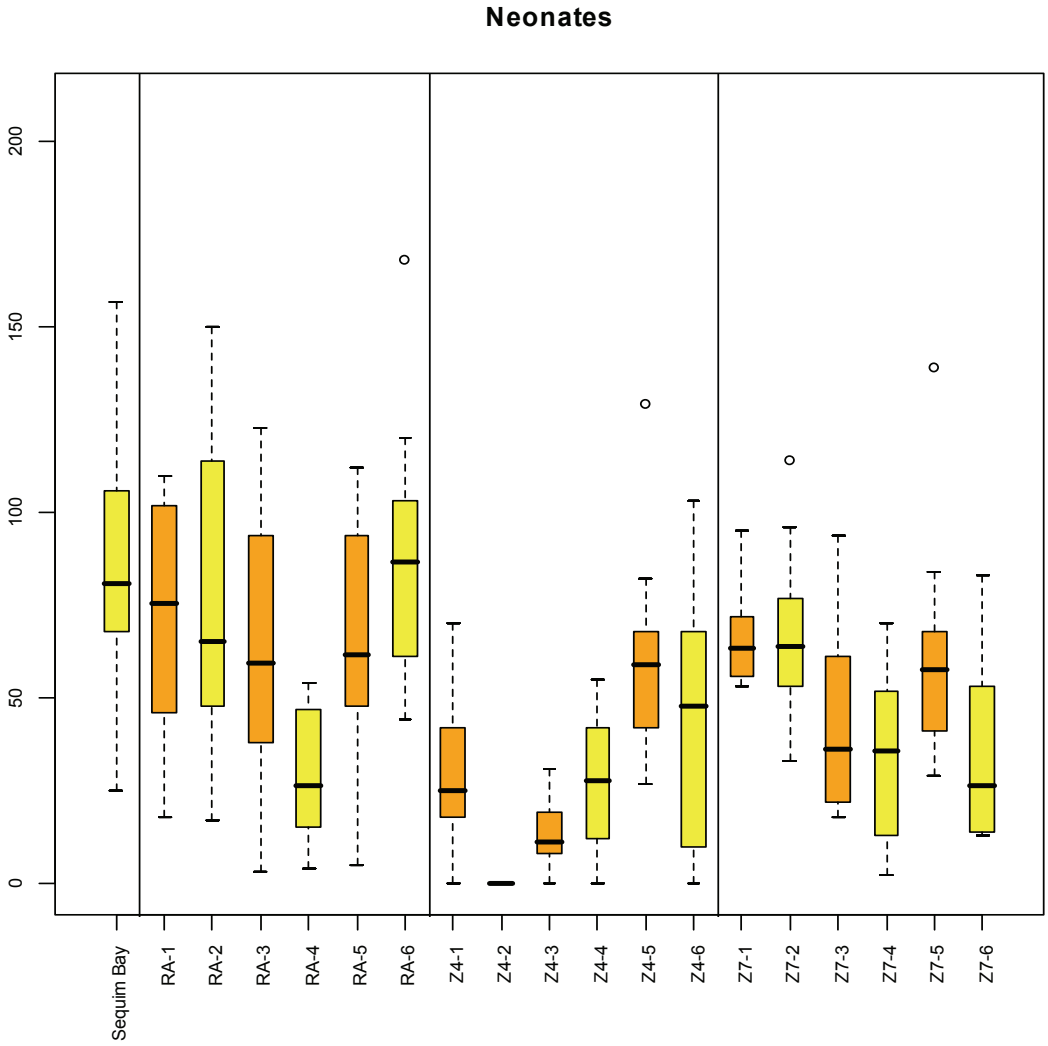

Figure A-6. Amphipod Reproduction Results (total number of neonates produced) by Individual Sampling Locations

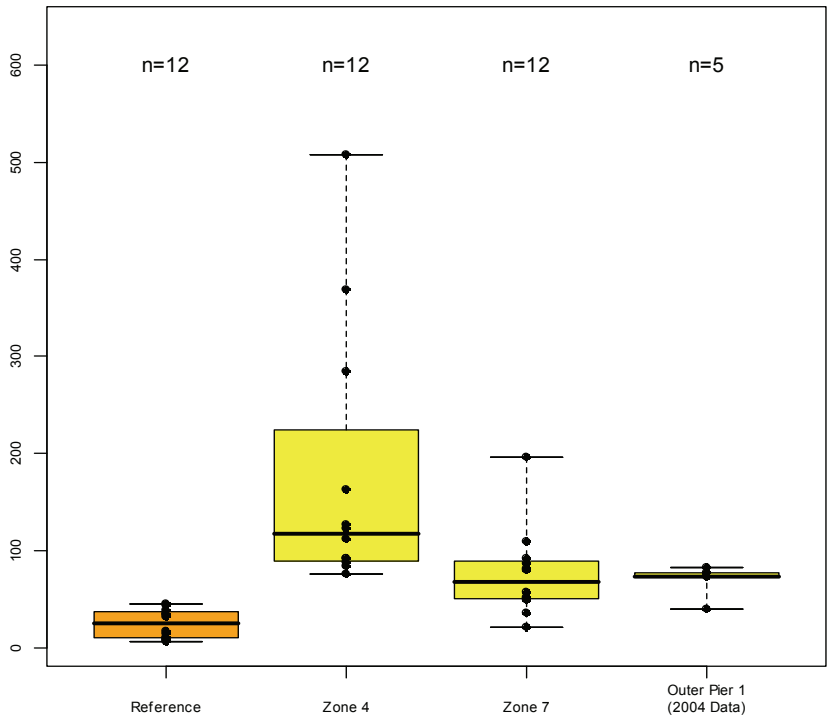

Figure A - 7. Boxplot of Naphthalene for Reference, Zone 4, Zone 7 and Outer Pier 1

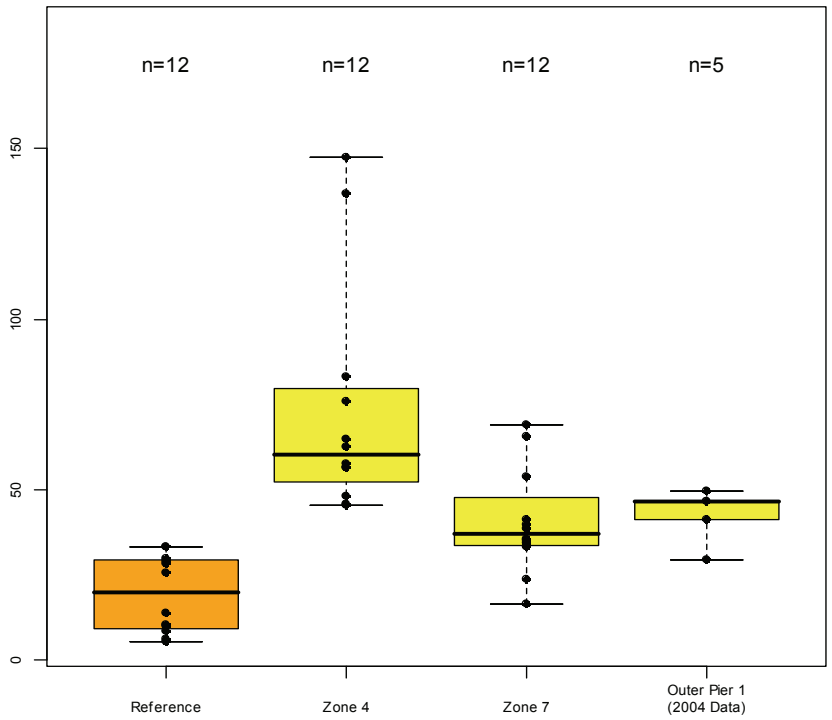

Figure A - 8. Boxplot of 2Methylnaphthalene for Reference, Zone 4, Zone 7 and Outer Pier 1

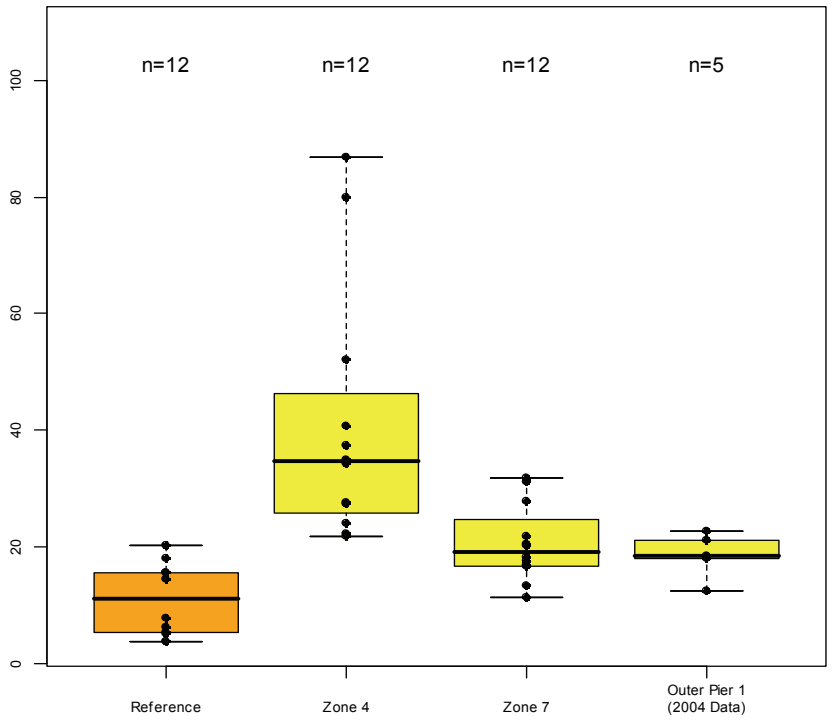

Figure A - 9. Boxplot of 1Methylnaphthalene for Reference, Zone 4, Zone 7 and Outer Pier 1

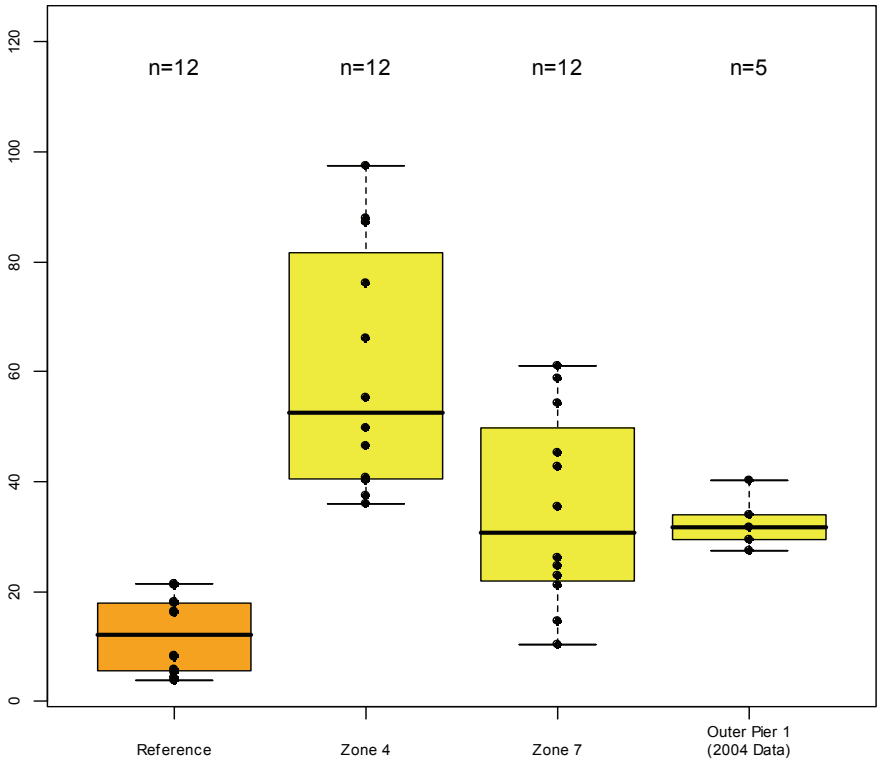

Figure A - 10. Boxplot of 26dimethylnaphthalene for Reference, Zone 4, Zone 7 and Outer Pie

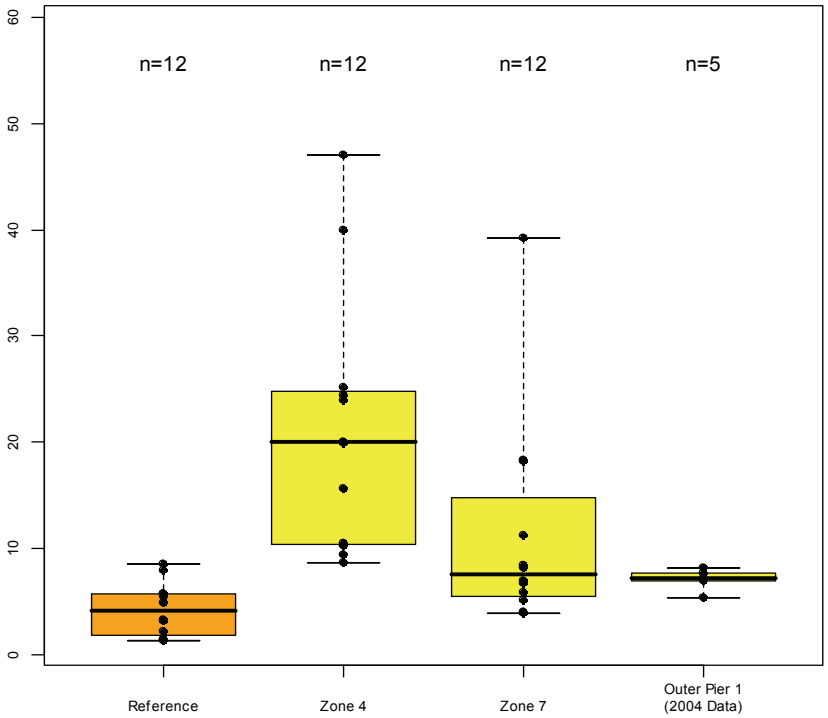

Figure A - 11. Boxplot of 235trimethylnaphthalene for Reference, Zone 4, Zone 7 and Outer Pier 1

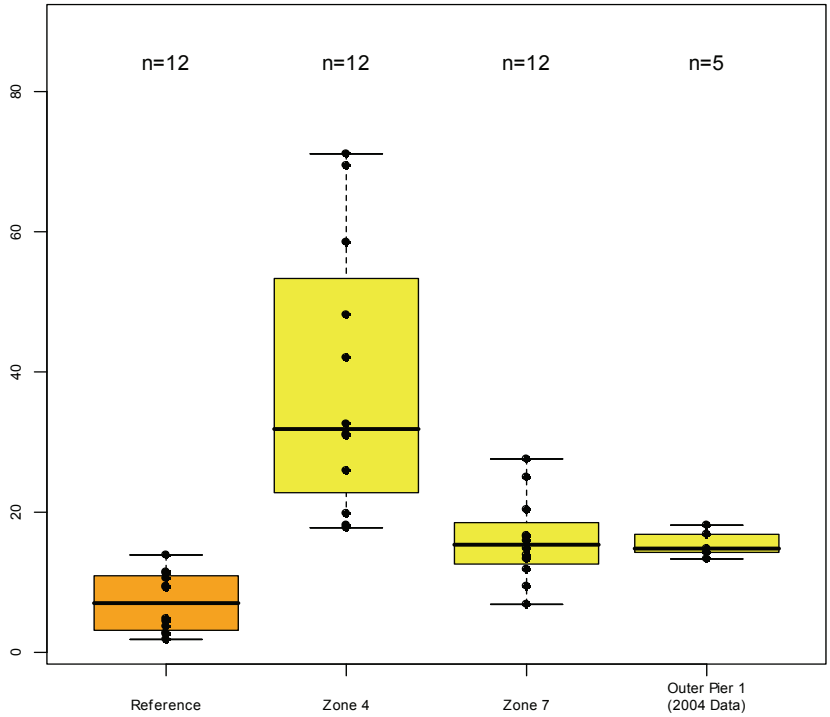

Figure A - 12. Boxplot of Biphenyl for Reference, Zone 4, Zone 7 and Outer Pier 1

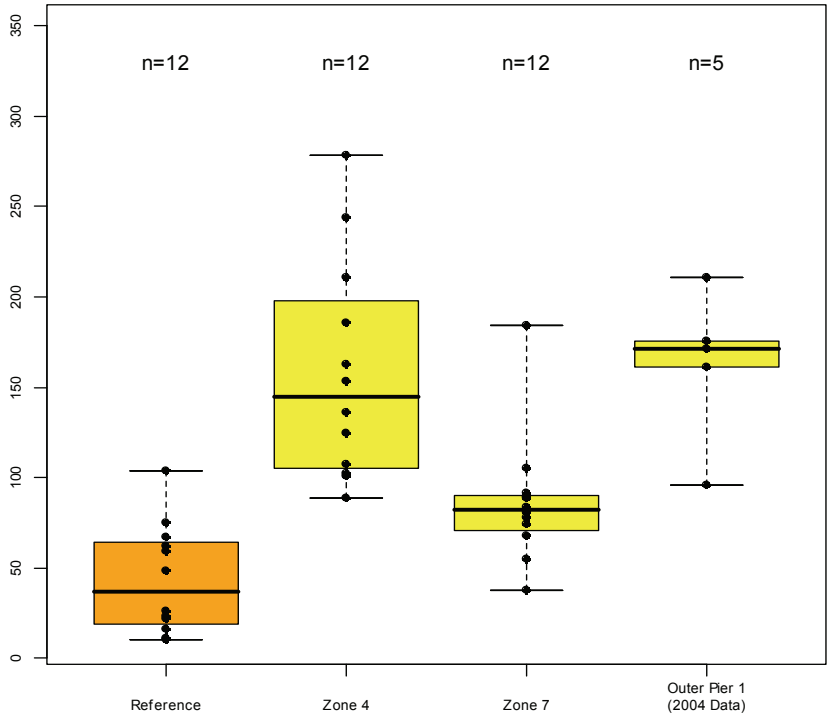

Figure A - 13. Boxplot of Acenaphthylene for Reference, Zone 4, Zone 7 and Outer Pier 1

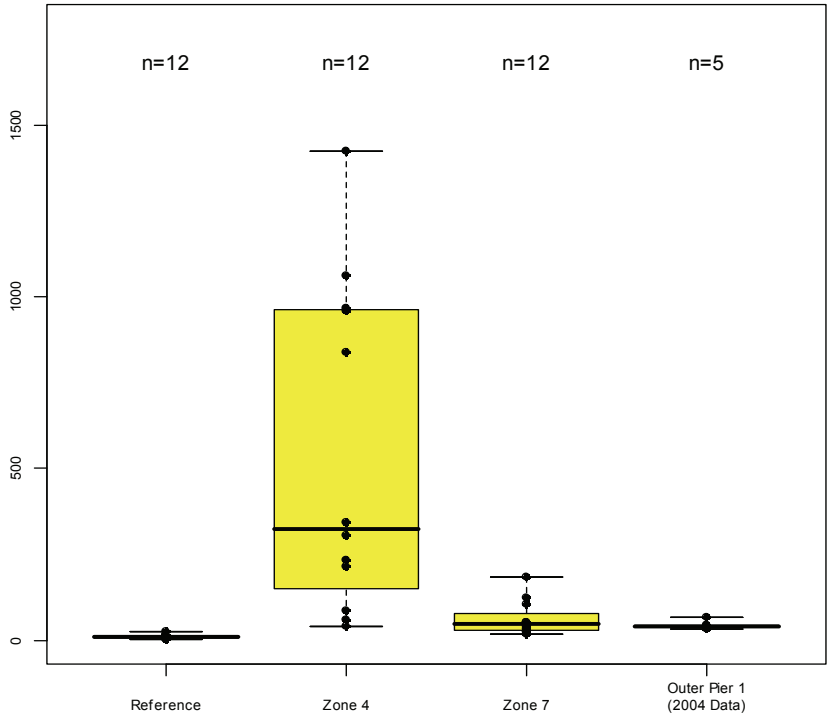

Figure A - 14. Boxplot of Acenaphthene for Reference, Zone 4, Zone 7 and Outer Pier 1

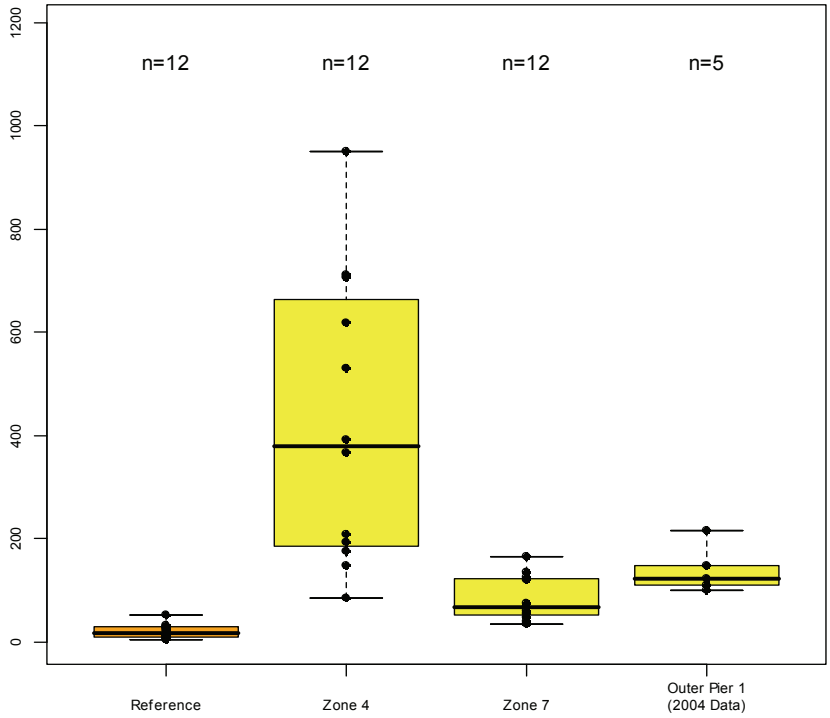

Figure A - 15. Boxplot of Fluorene for Reference, Zone 4, Zone 7 and Outer Pier 1

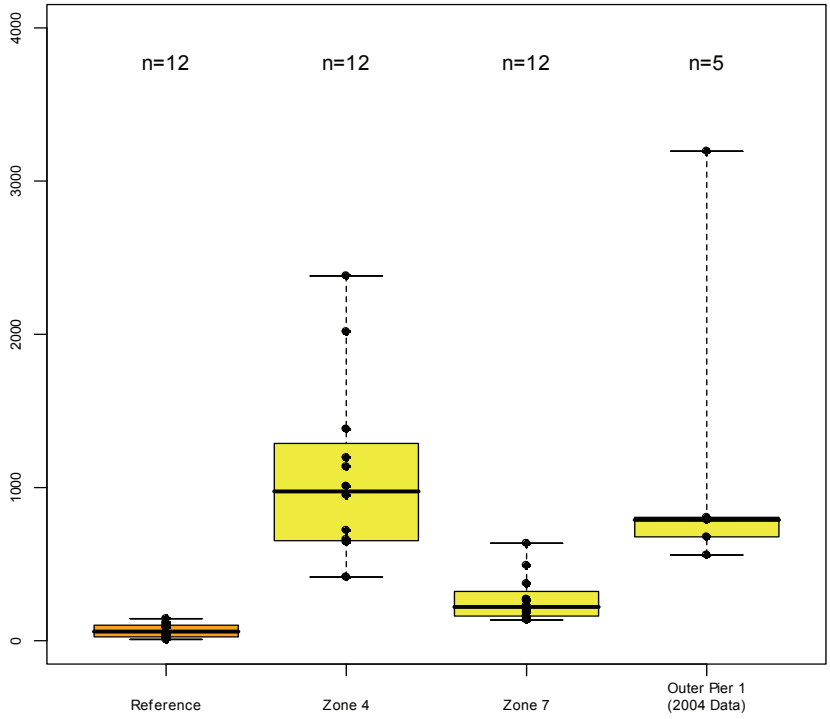

Figure A - 16. Boxplot of Anthracene for Reference, Zone 4, Zone 7 and Outer Pier 1

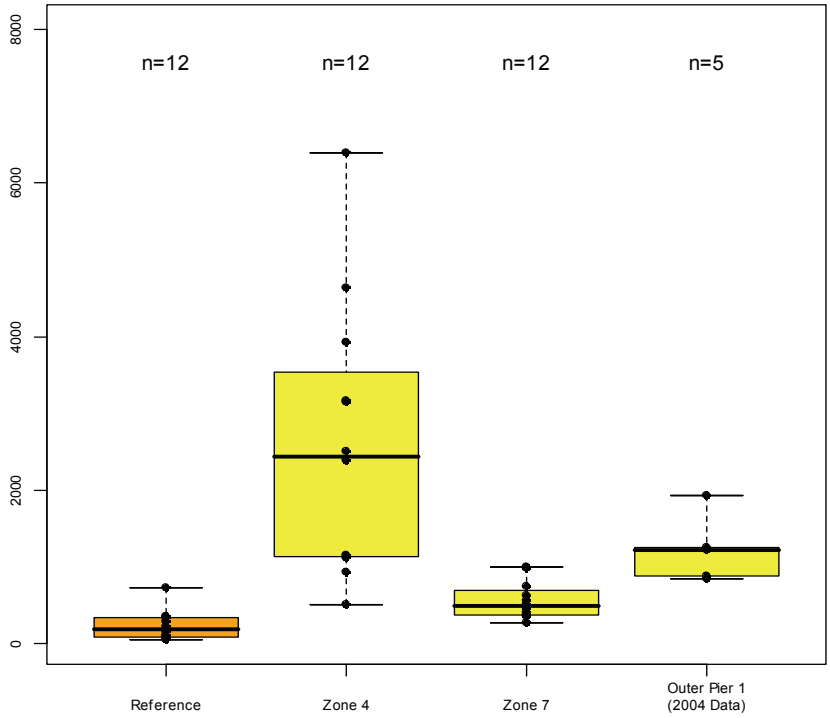

Figure A - 17. Boxplot of Phenanthrene for Reference, Zone 4, Zone 7 and Outer Pier 1

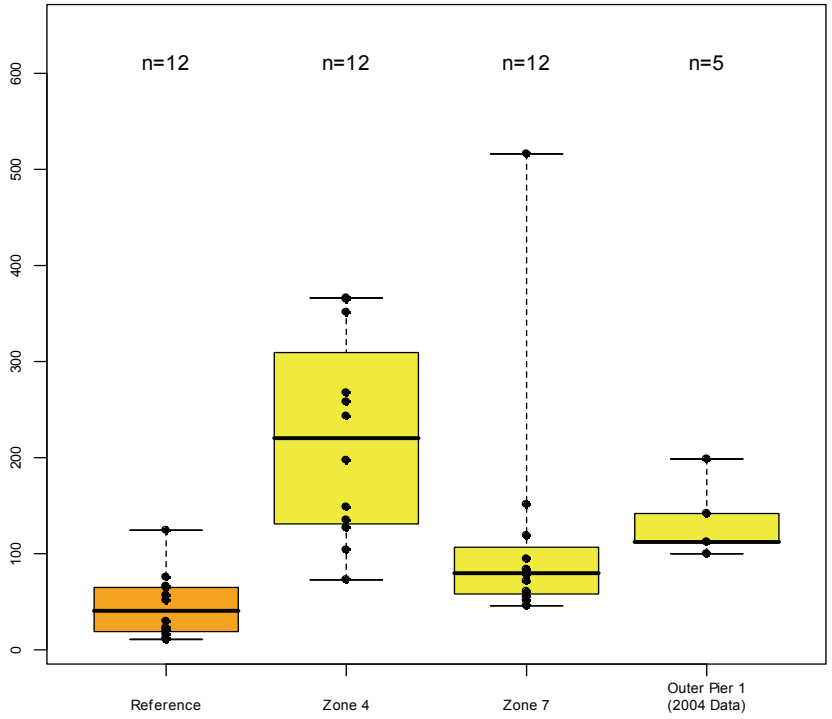

Figure A - 18. Boxplot of 1Methylphenanthrene for Reference, Zone 4, Zone 7 and Outer Pier

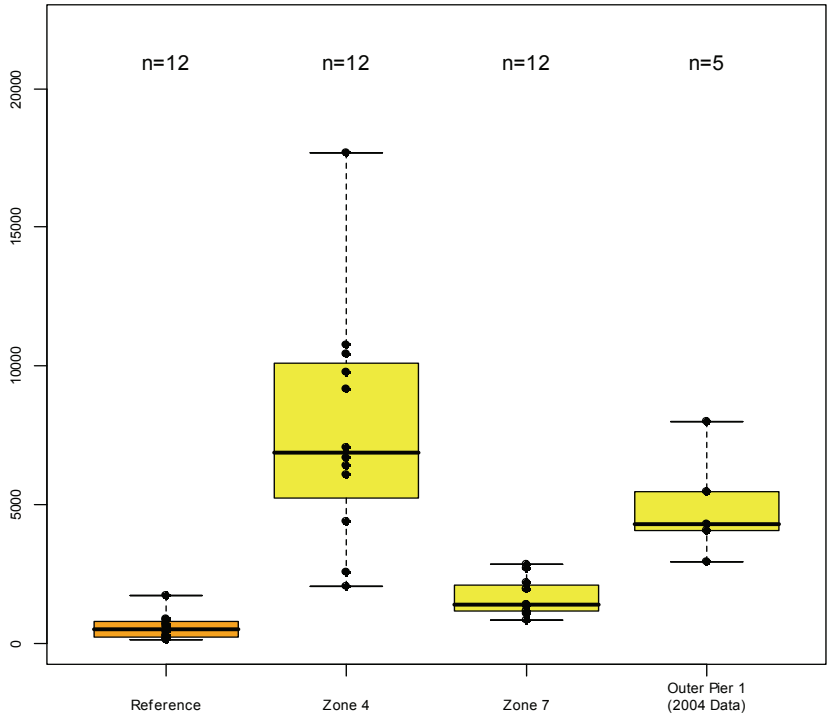

Figure A - 19. Boxplot of Fluoranthene for Reference, Zone 4, Zone 7 and Outer Pier 1

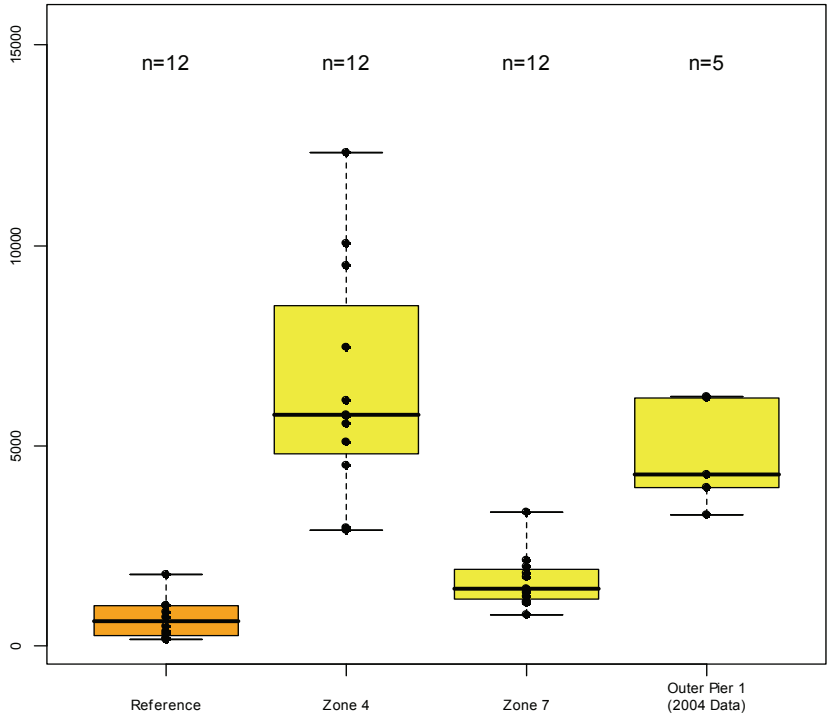

Figure A - 20. Boxplot of Pyrene for Reference, Zone 4, Zone 7 and Outer Pier 1

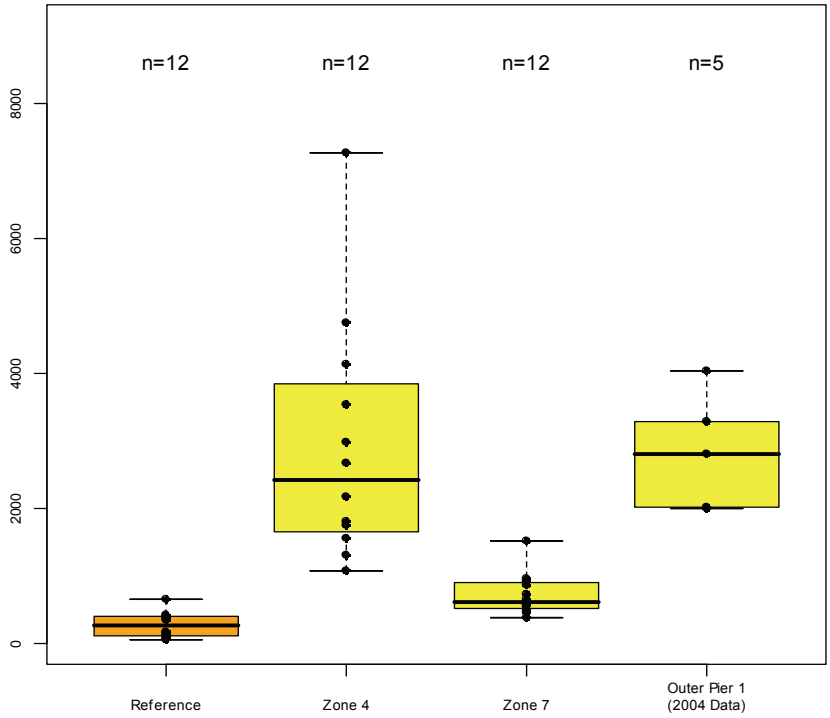

Figure A - 21. Boxplot of Benzo(a)anthracene for Reference, Zone 4, Zone 7 and Outer Pier

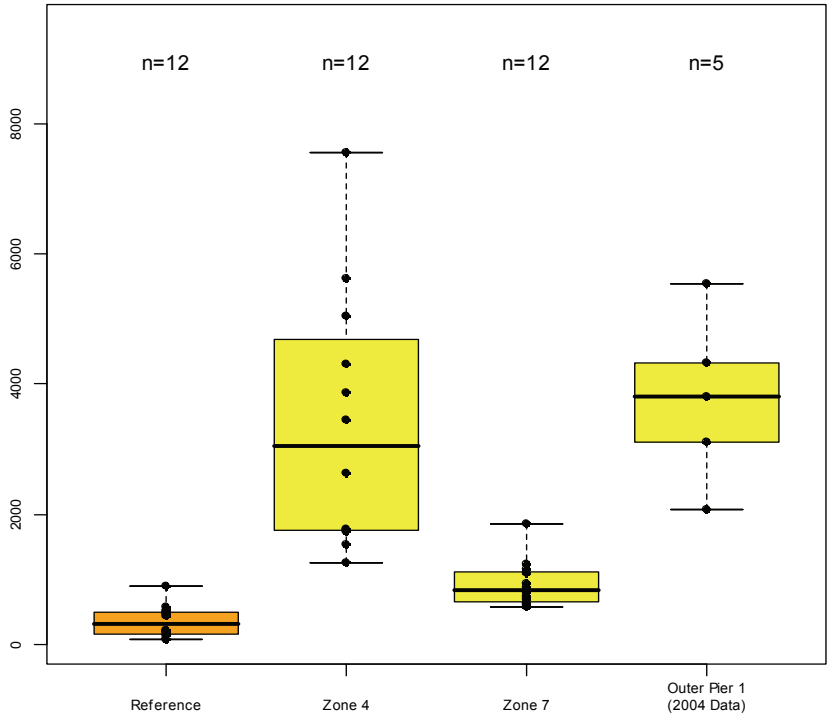

Figure A - 22. Boxplot of Chrysene for Reference, Zone 4, Zone 7 and Outer Pier 1

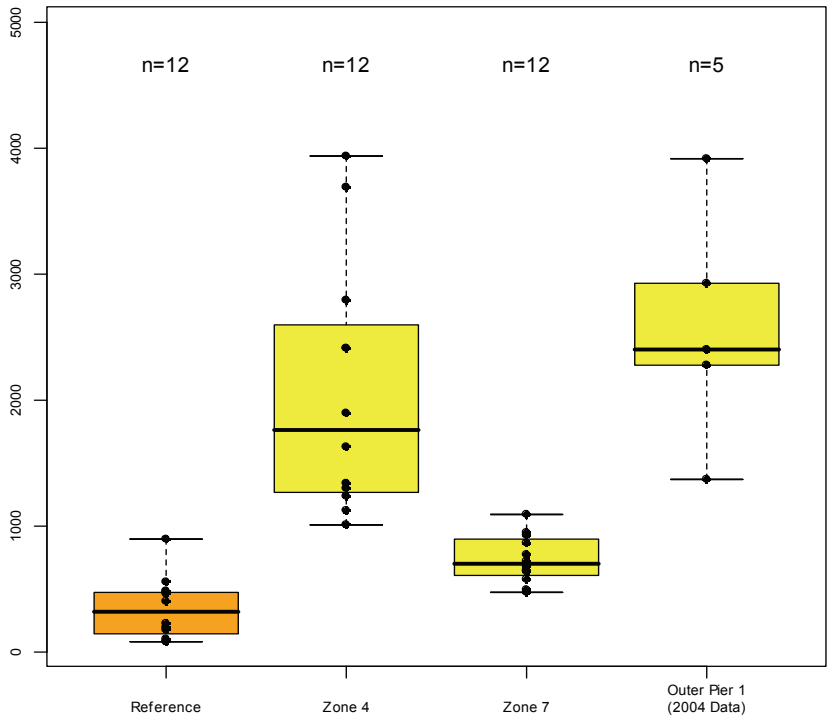

Figure A - 23. Boxplot of Benzo(b)fluoranthene for Reference, Zone 4, Zone 7 and Outer Pier

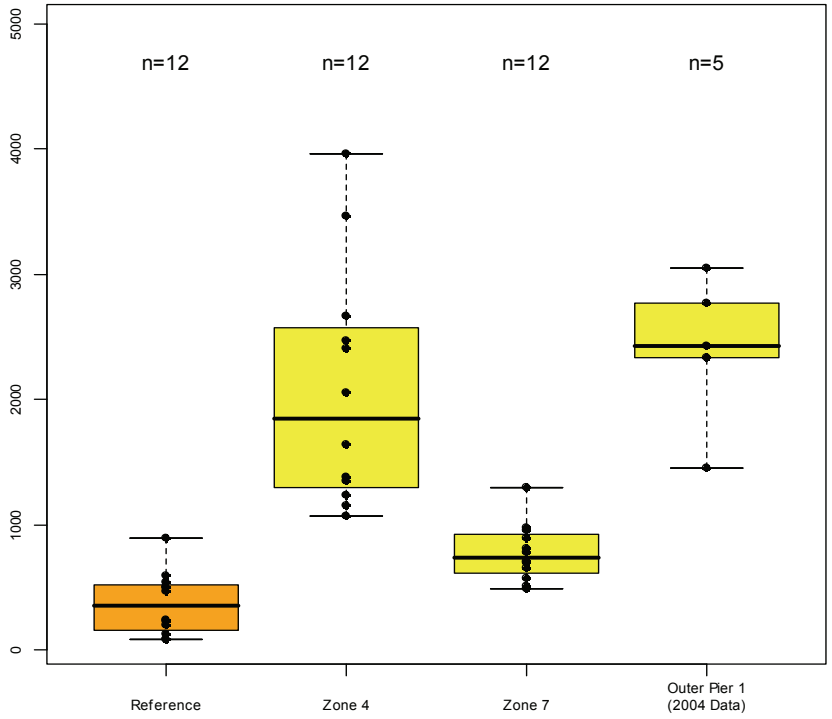

Figure A - 24. Boxplot of Benzo(k)fluoranthene for Reference, Zone 4, Zone 7 and Outer Pier

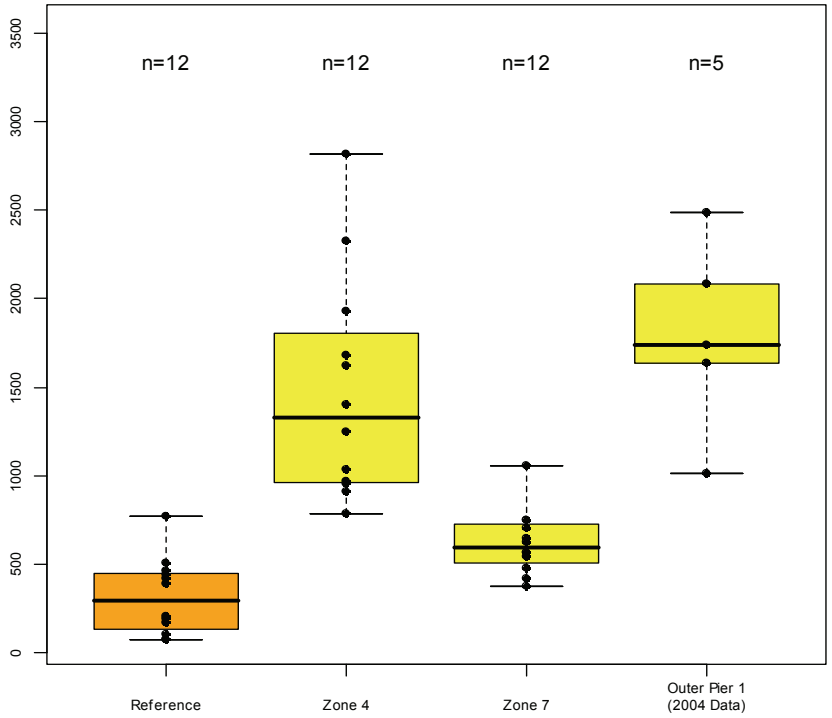

Figure A - 25. Boxplot of Benzo(e)pyrene for Reference, Zone 4, Zone 7 and Outer Pier 1

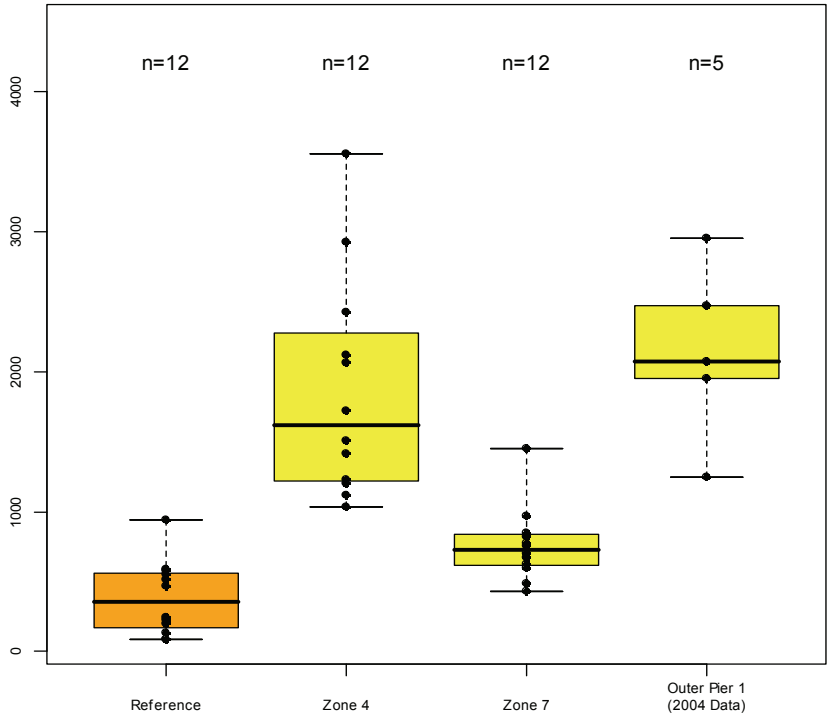

Figure A - 26. Boxplot of Benzo(a)pyrene for Reference, Zone 4, Zone 7 and Outer Pier 1

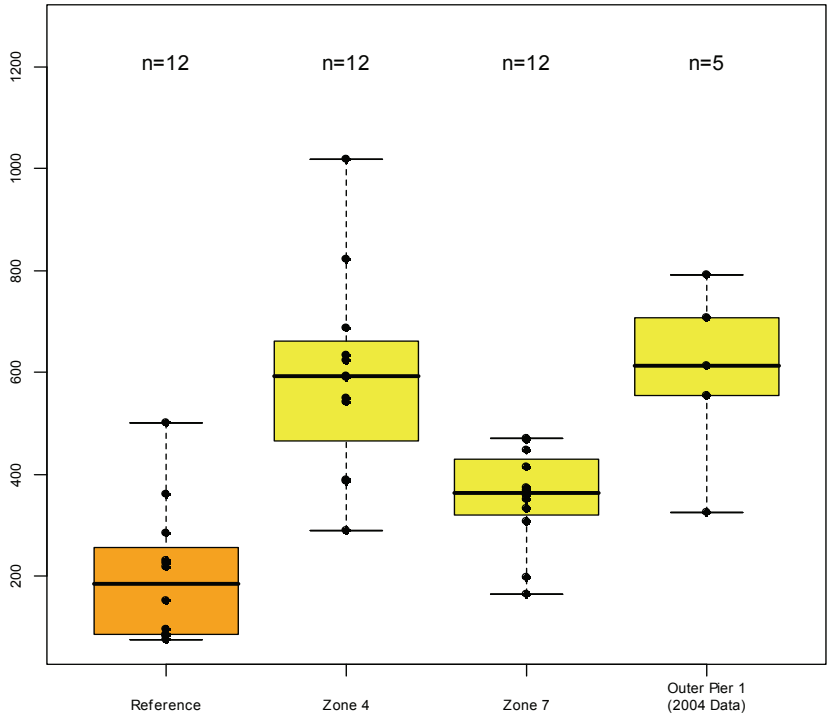

Figure A - 27. Boxplot of Perylene for Reference, Zone 4, Zone 7 and Outer Pier 1

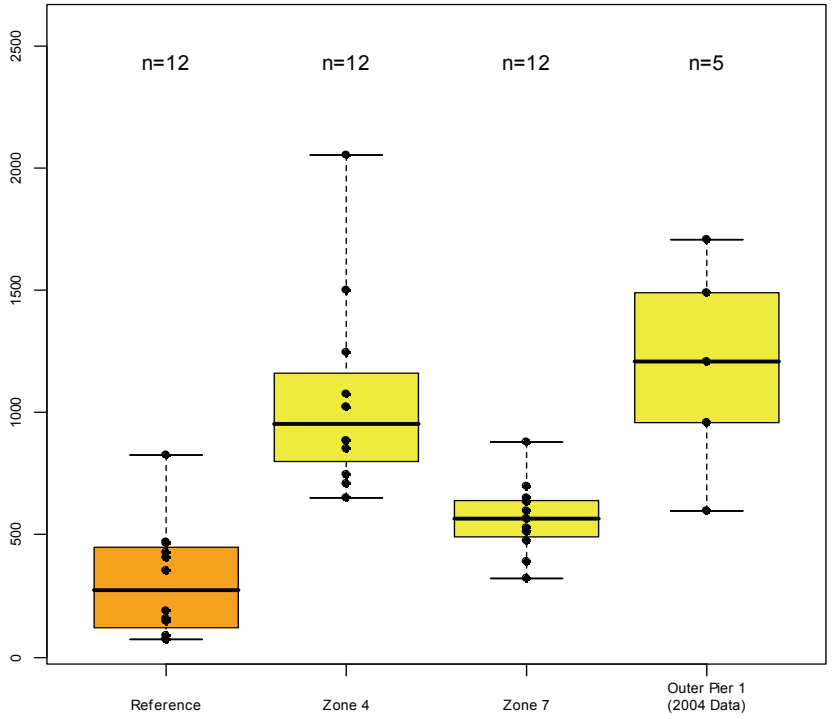

Figure A - 28. Boxplot of Indeno(123cd)pyrene for Reference, Zone 4, Zone 7 and Outer Pier

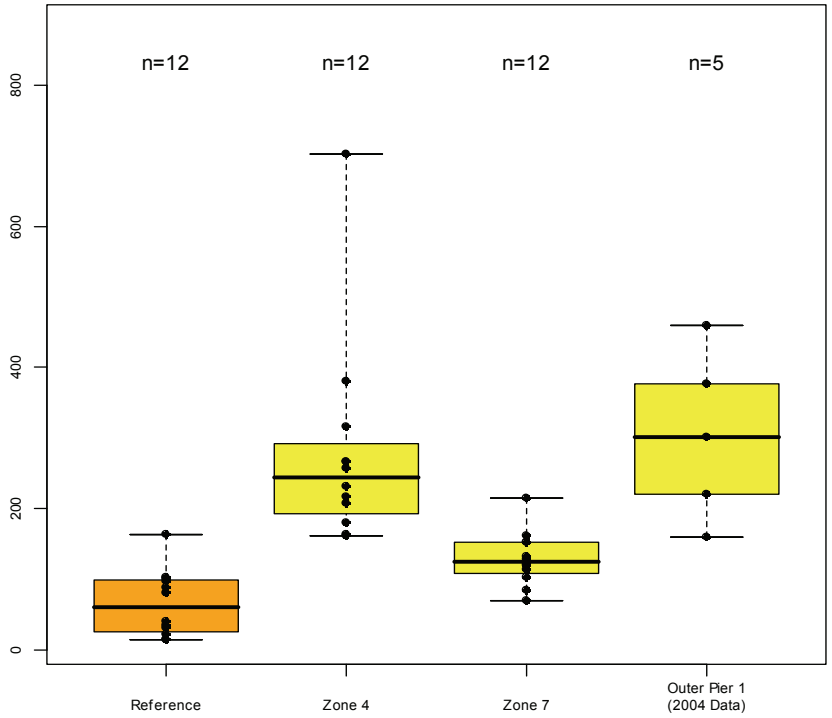

Figure A - 29. Boxplot of Dibenz(ah)anthracene for Reference, Zone 4, Zone 7 and Outer Pier

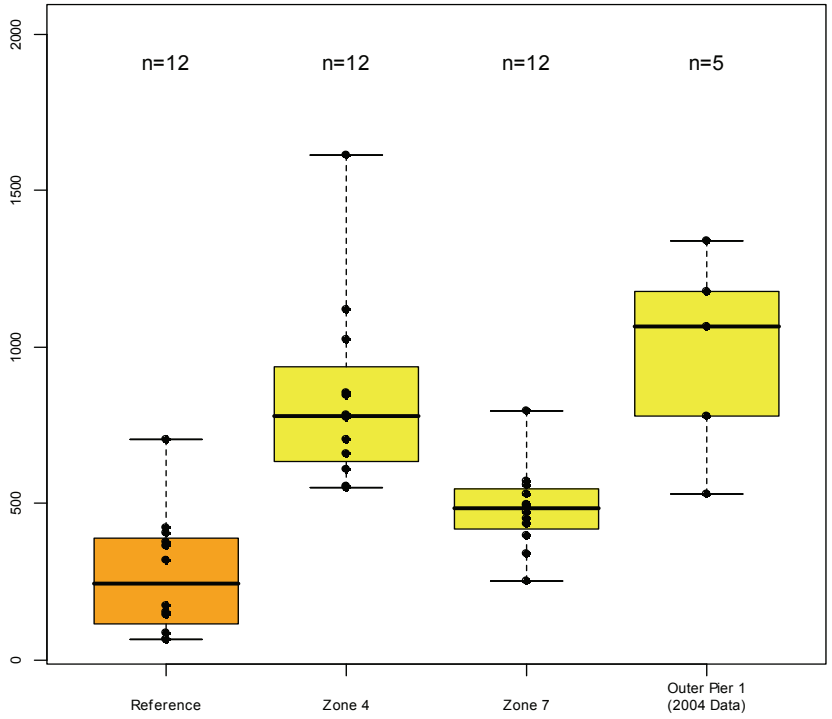

Figure A - 30. Boxplot of Benzo(ghi)perylene for Reference, Zone 4, Zone 7 and Outer Pier 1

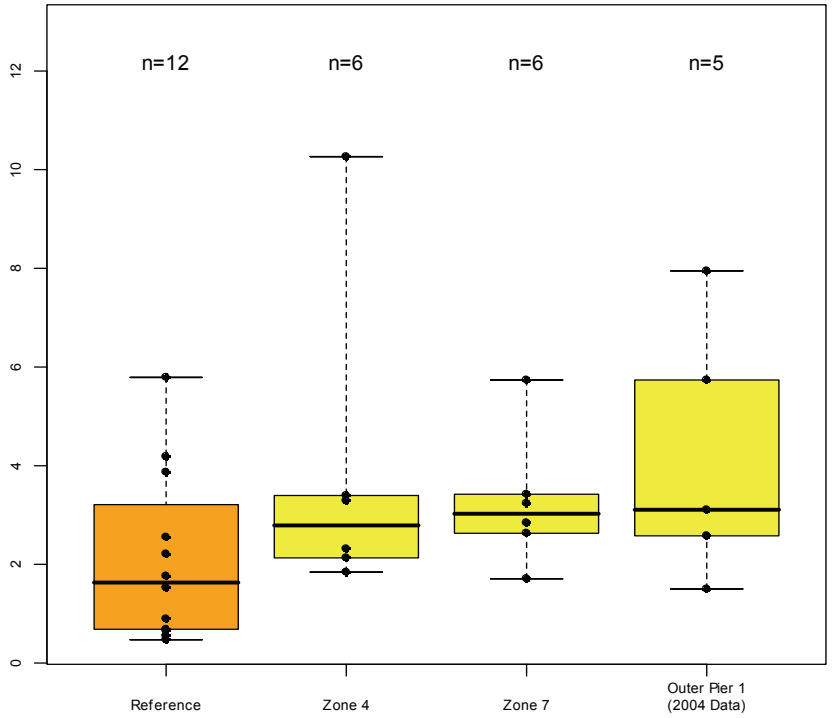

Figure A - 31. Boxplot of 44DDD for Reference, Zone 4, Zone 7 and Outer Pier 1

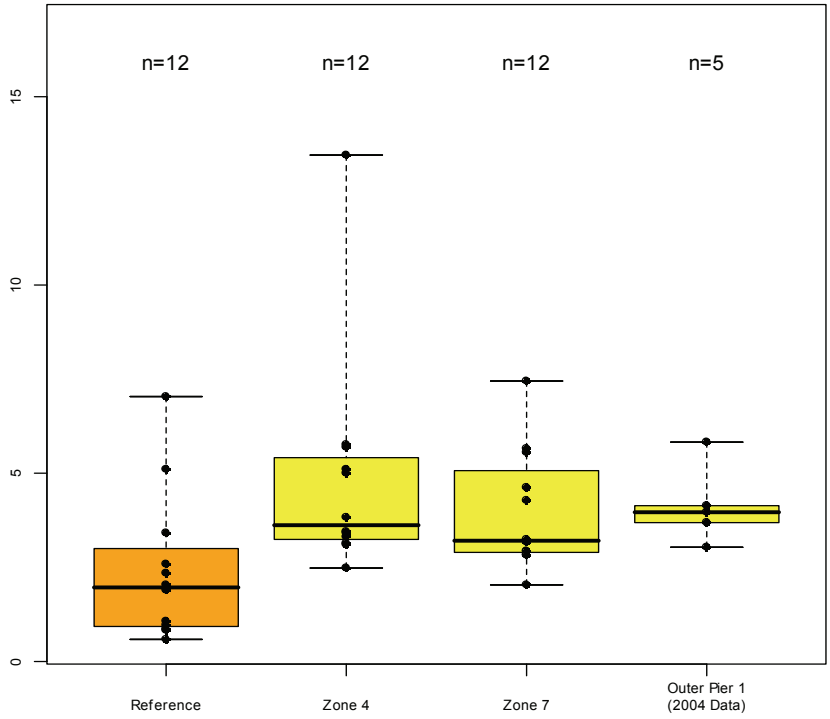

Figure A - 32. Boxplot of 44DDE for Reference, Zone 4, Zone 7 and Outer Pier 1

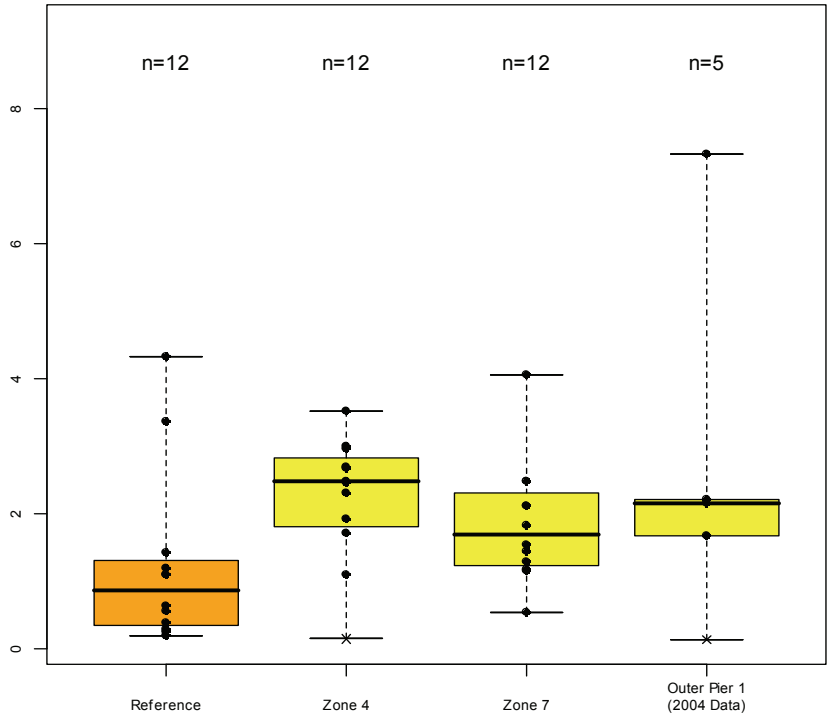

Figure A - 33. Boxplot of 44DDT for Reference, Zone 4, Zone 7 and Outer Pier 1

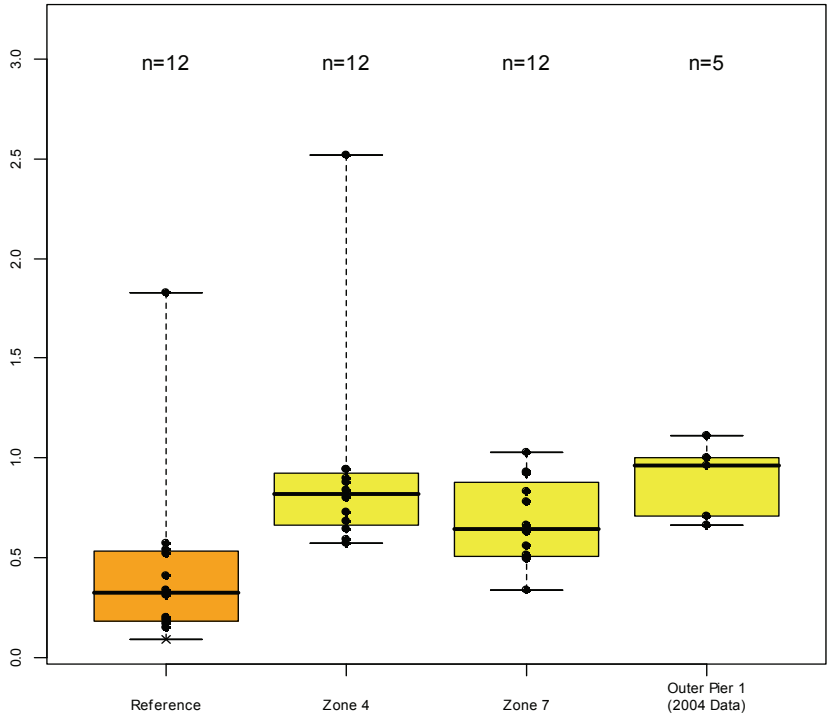

Figure A - 34. Boxplot of aChlordane for Reference, Zone 4, Zone 7 and Outer Pier 1

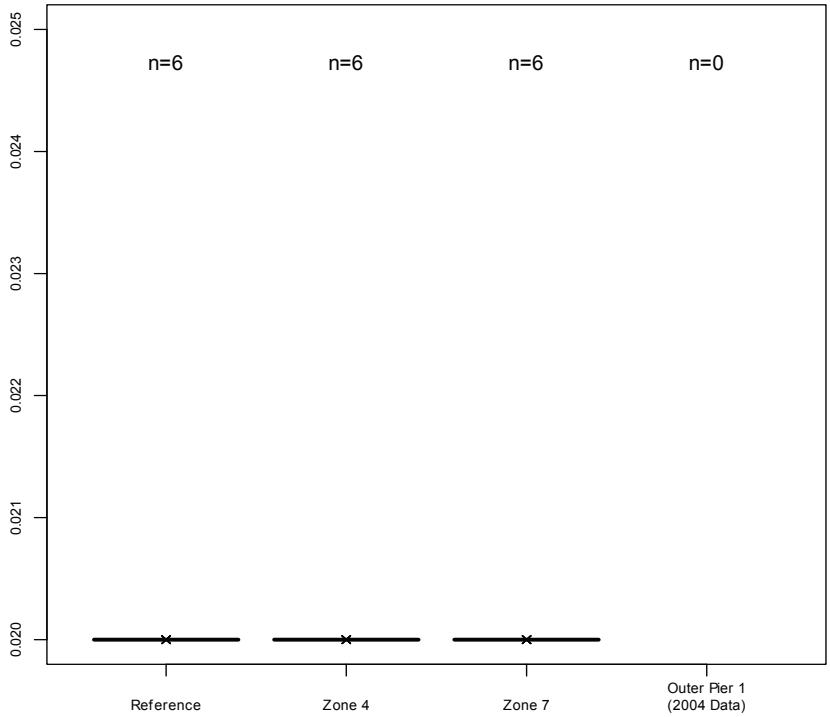

Figure A - 35. Boxplot of gBHC for Reference, Zone 4, Zone 7 and Outer Pier 1

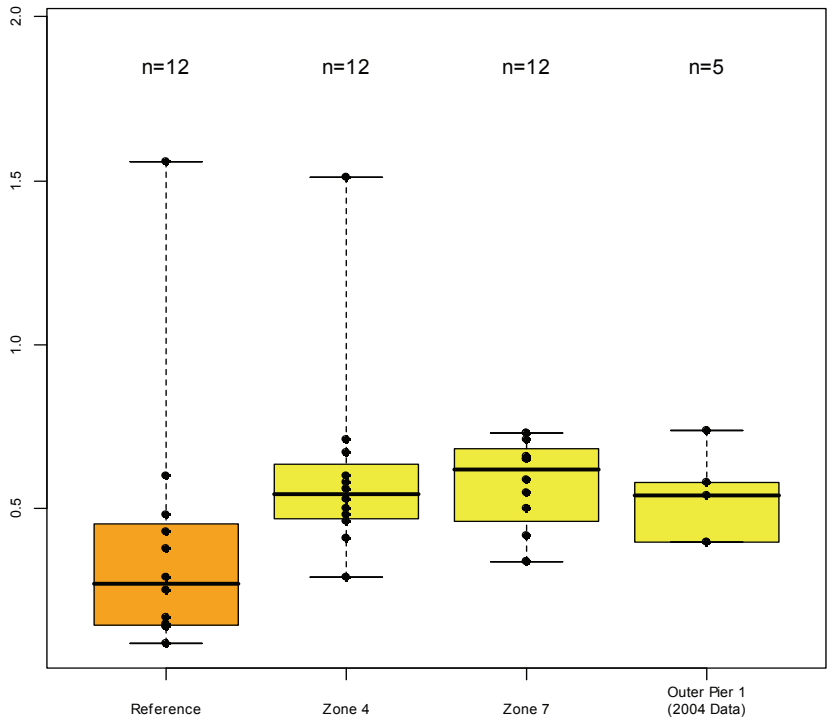

Figure A - 36. Boxplot of Trans.nonachlor for Reference, Zone 4, Zone 7 and Outer Pier 1

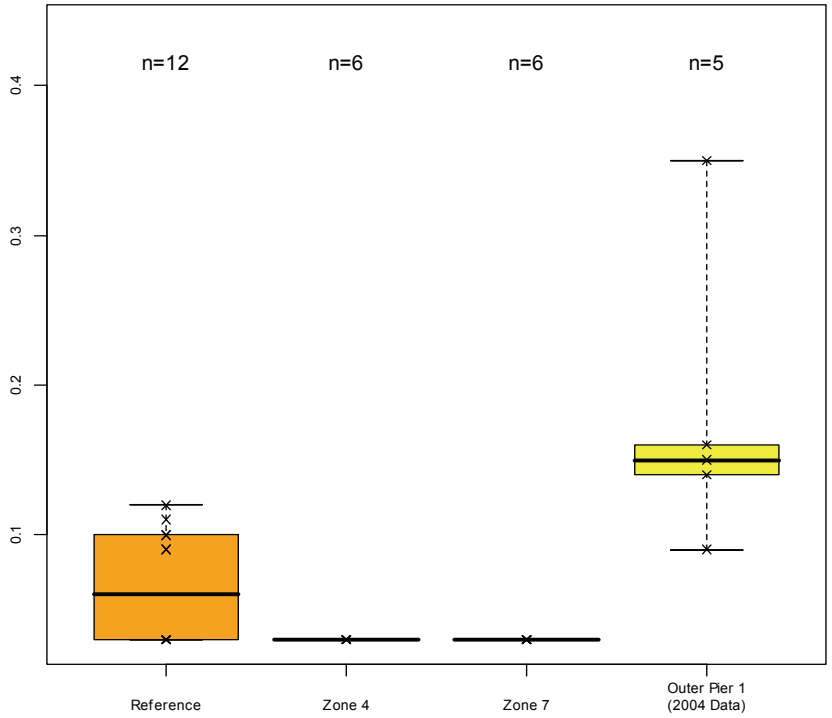

Figure A - 37. Boxplot of Heptachlor for Reference, Zone 4, Zone 7 and Outer Pier 1

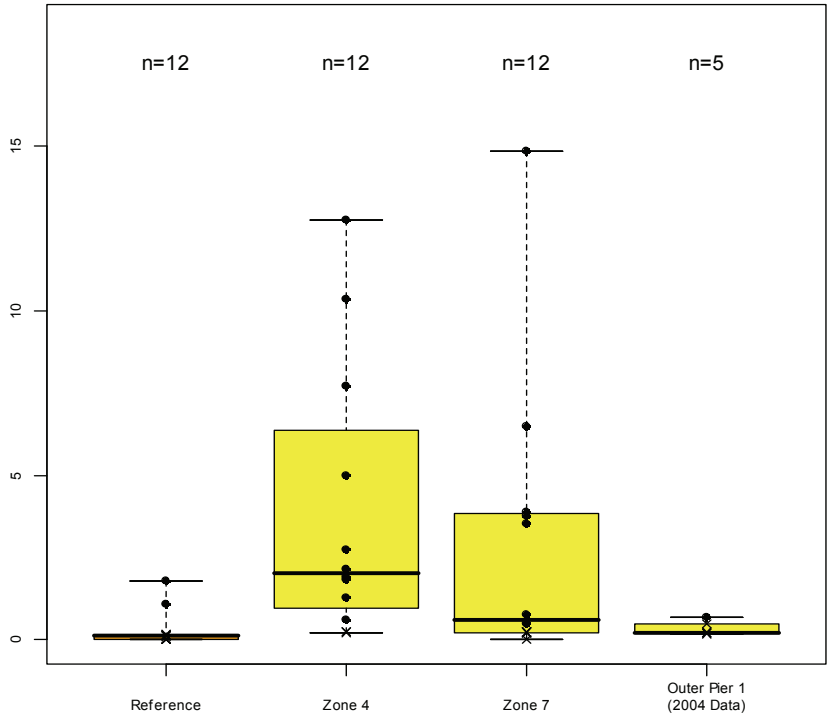

Figure A - 38. Boxplot of Cl2.8 for Reference, Zone 4, Zone 7 and Outer Pier 1

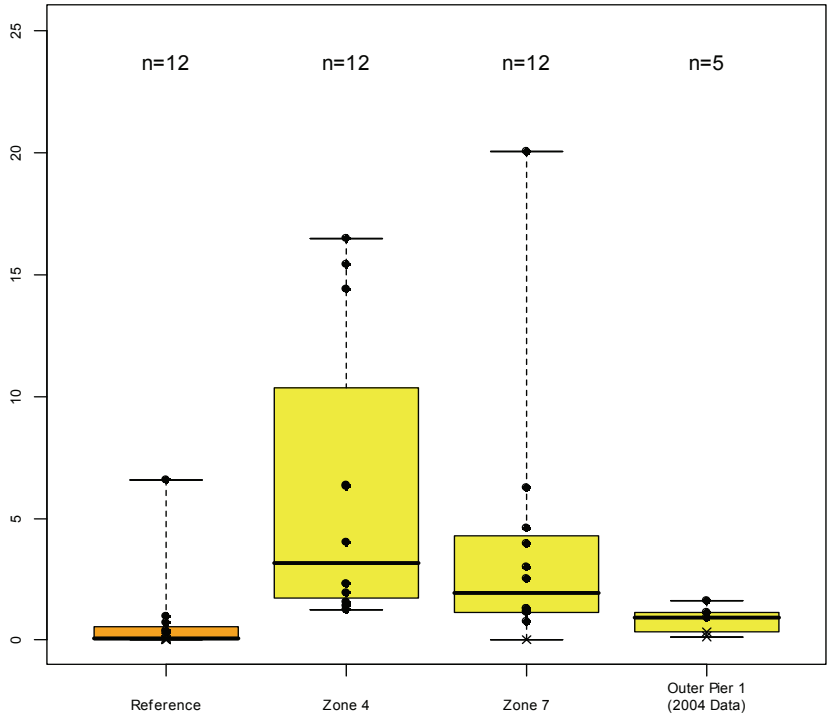

Figure A - 39. Boxplot of Cl3.18 for Reference, Zone 4, Zone 7 and Outer Pier 1

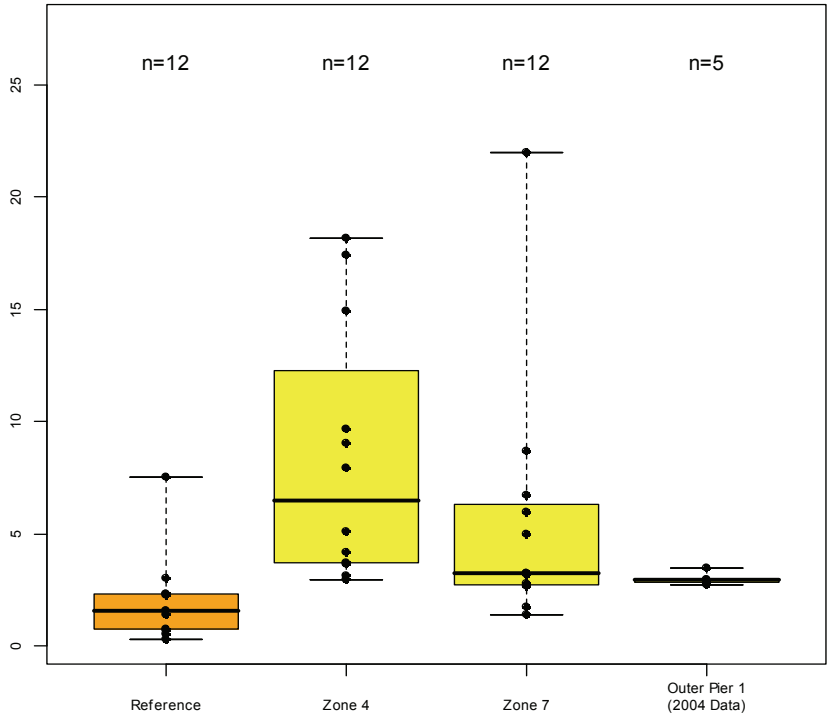

Figure A - 40. Boxplot of Cl3.28 for Reference, Zone 4, Zone 7 and Outer Pier 1

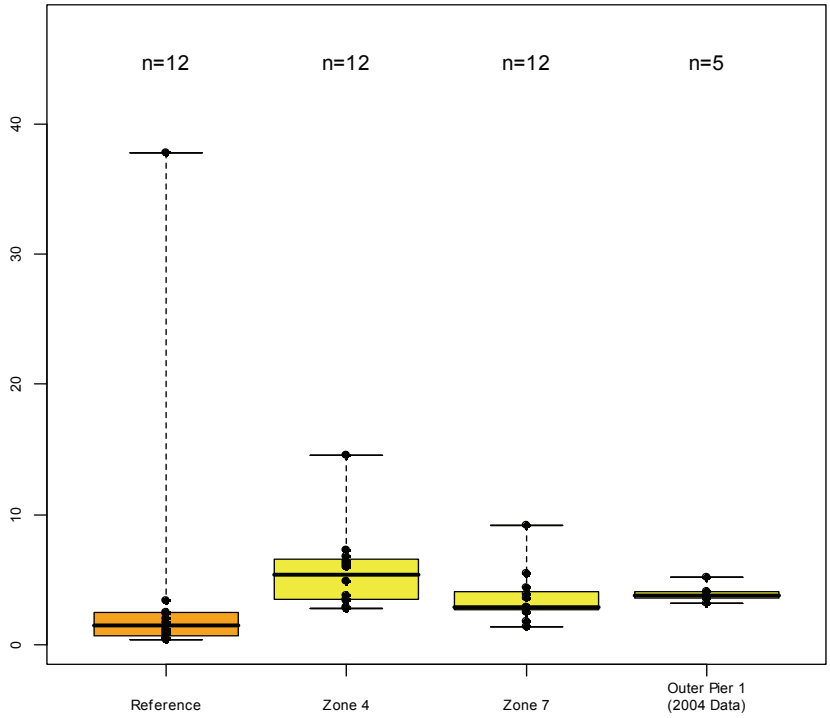

Figure A - 41. Boxplot of Cl4.44 for Reference, Zone 4, Zone 7 and Outer Pier 1

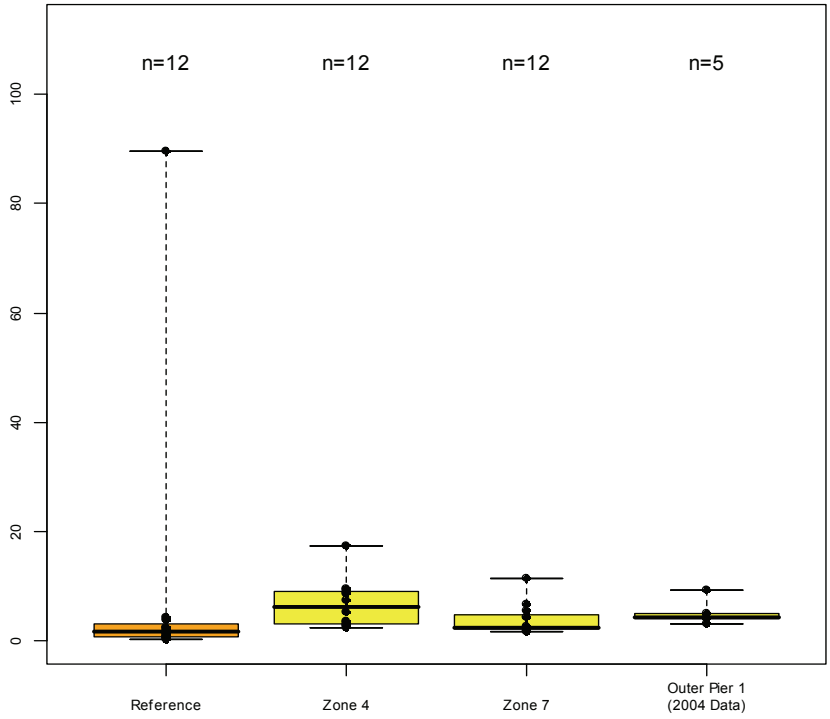

Figure A - 42. Boxplot of Cl4.52 for Reference, Zone 4, Zone 7 and Outer Pier 1

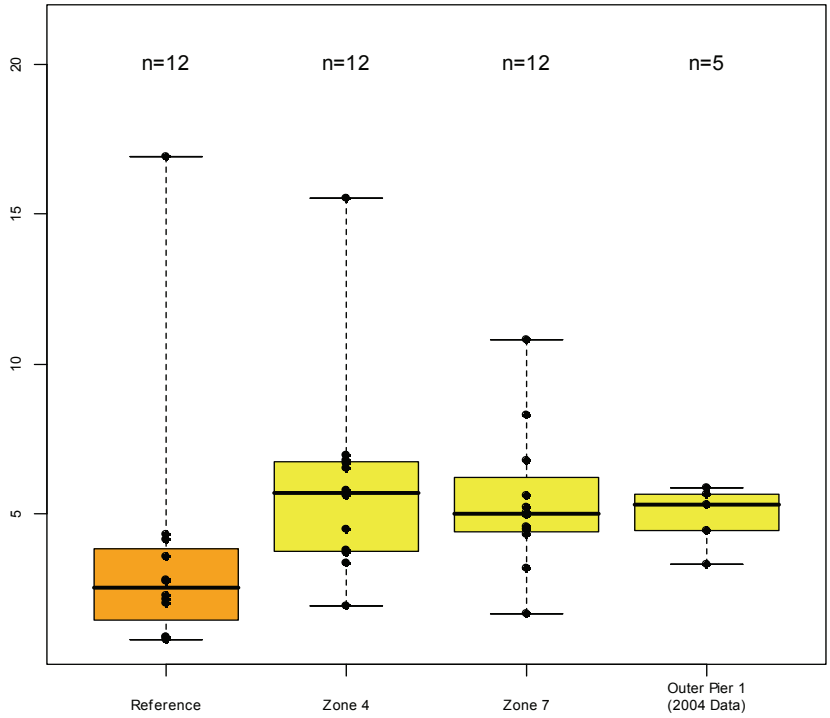

Figure A - 43. Boxplot of Cl4.66 for Reference, Zone 4, Zone 7 and Outer Pier 1

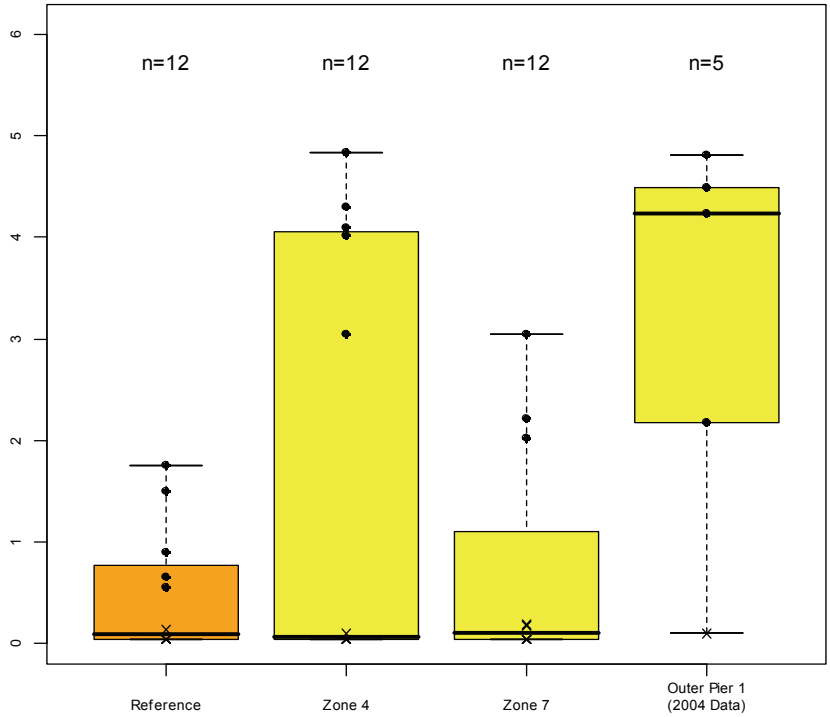

Figure A - 44. Boxplot of Cl4.77 for Reference, Zone 4, Zone 7 and Outer Pier 1

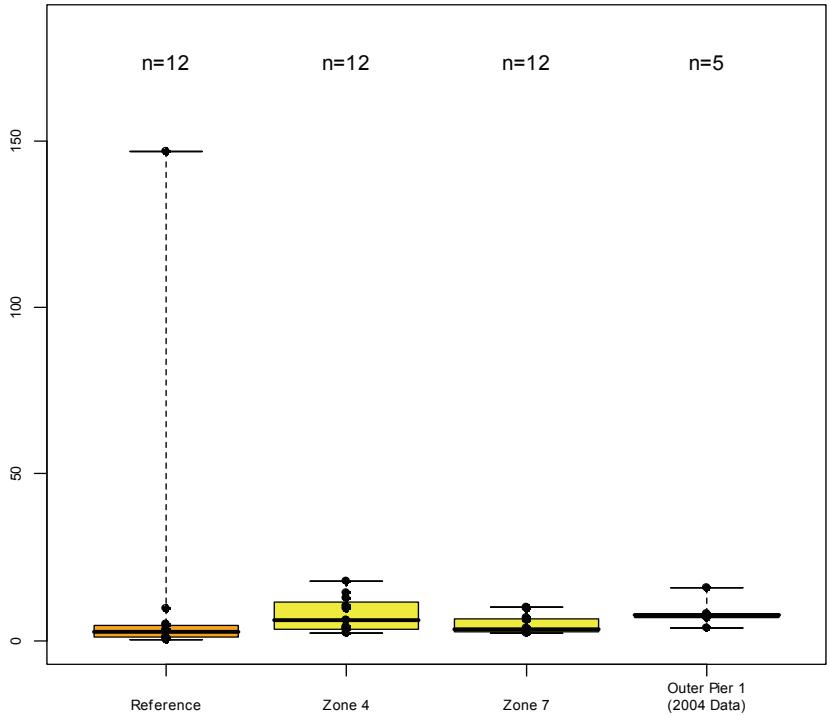

Figure A - 45. Boxplot of Cl5.101 for Reference, Zone 4, Zone 7 and Outer Pier 1

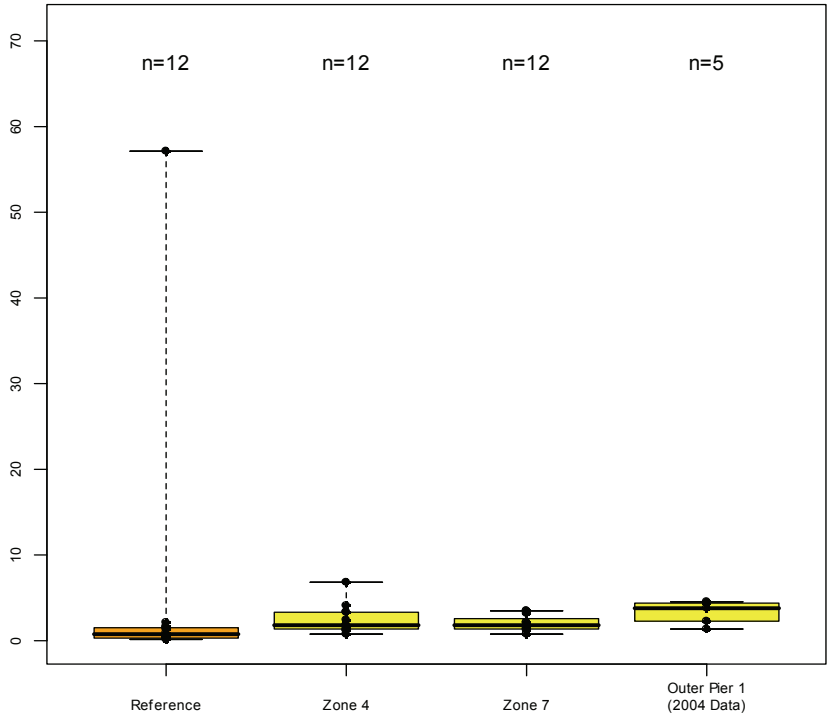

Figure A - 46. Boxplot of Cl5.105 for Reference, Zone 4, Zone 7 and Outer Pier 1

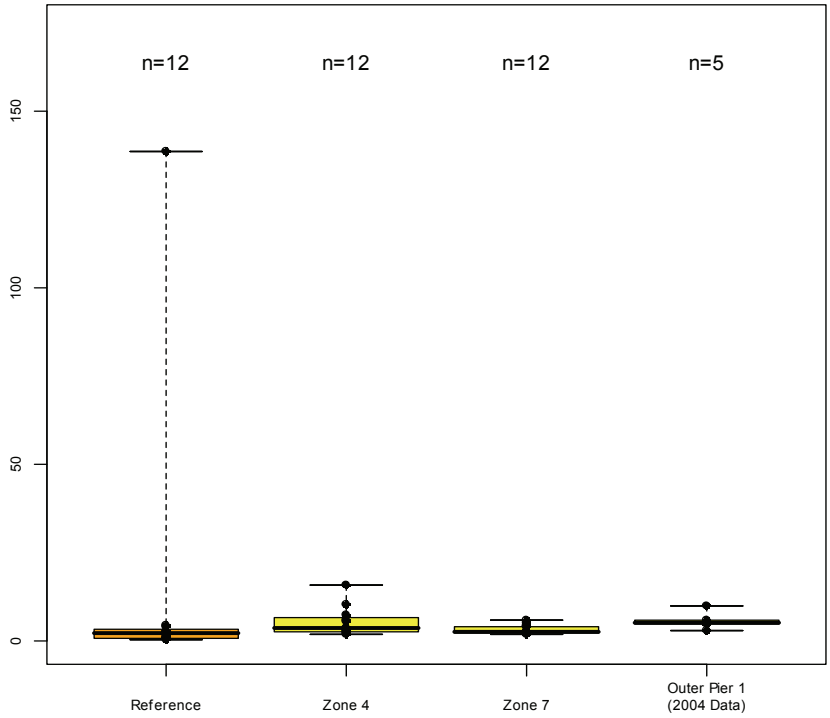

Figure A - 47. Boxplot of Cl5.118 for Reference, Zone 4, Zone 7 and Outer Pier 1

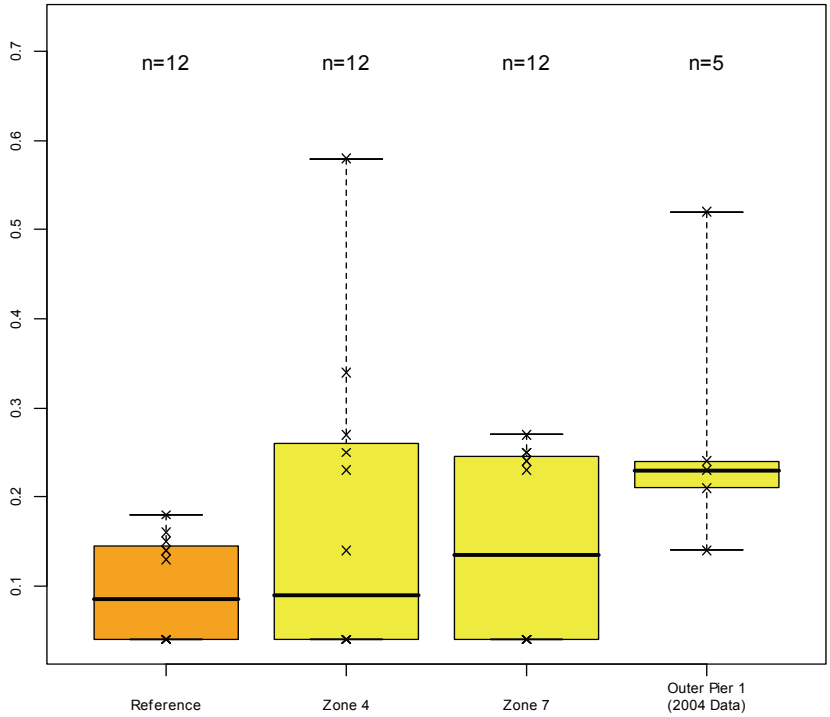

Figure A - 48. Boxplot of Cl5.126 for Reference, Zone 4, Zone 7 and Outer Pier 1

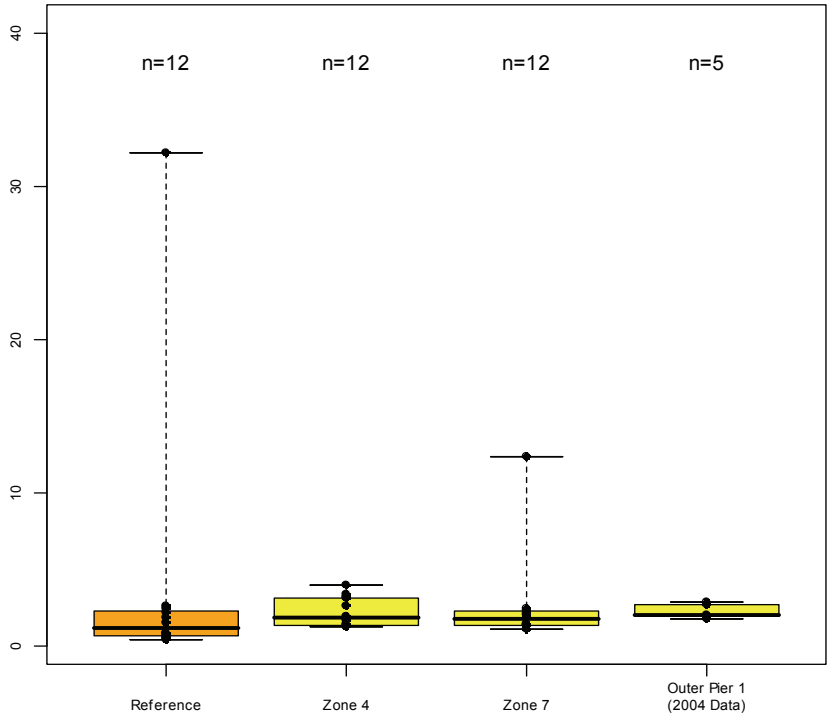

Figure A - 49. Boxplot of Cl6.128 for Reference, Zone 4, Zone 7 and Outer Pier 1

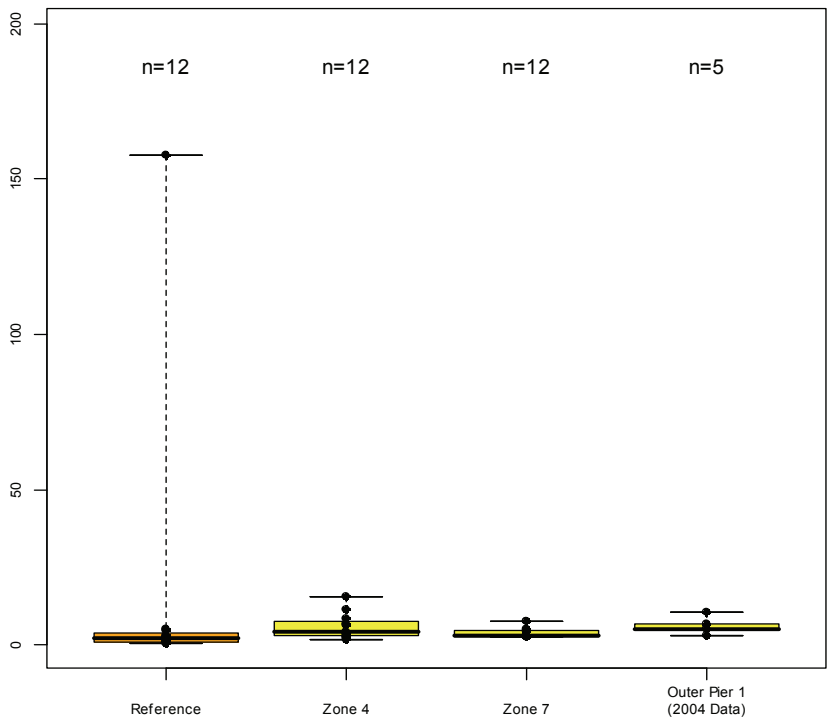

Figure A - 50. Boxplot of Cl6.138 for Reference, Zone 4, Zone 7 and Outer Pier 1

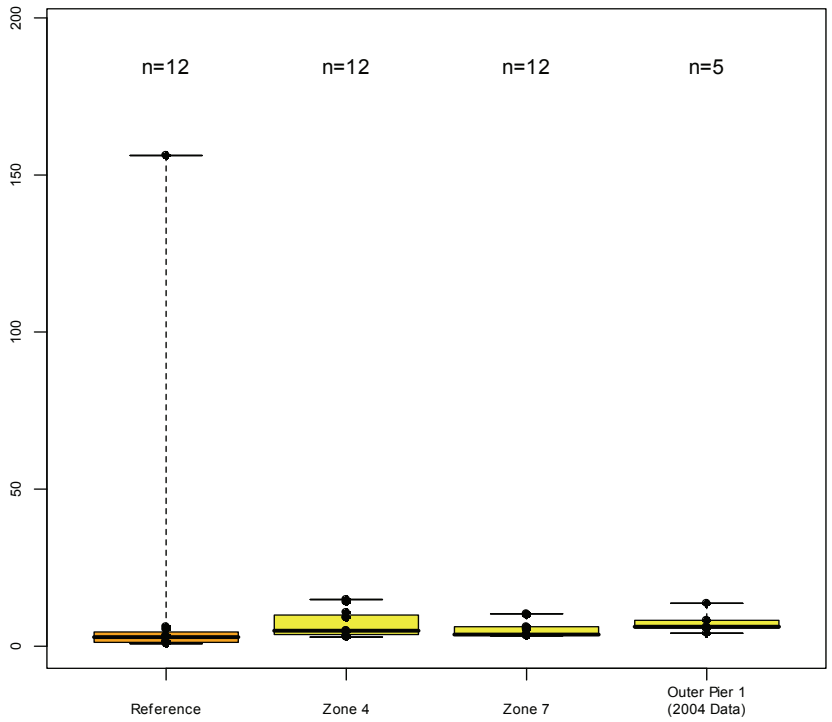

Figure A - 51. Boxplot of Cl6.153 for Reference, Zone 4, Zone 7 and Outer Pier 1

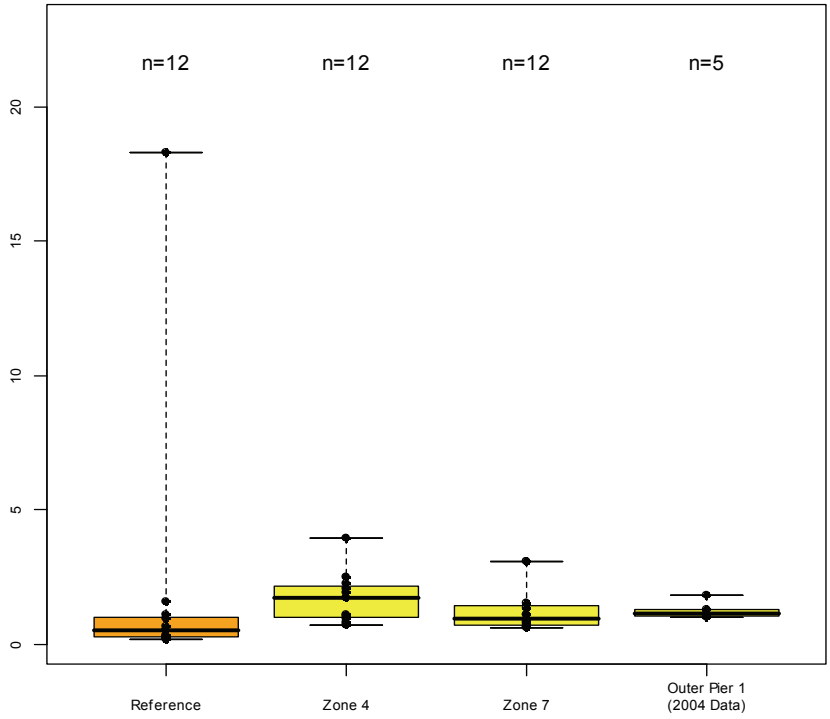

Figure A - 52. Boxplot of Cl7.170 for Reference, Zone 4, Zone 7 and Outer Pier 1

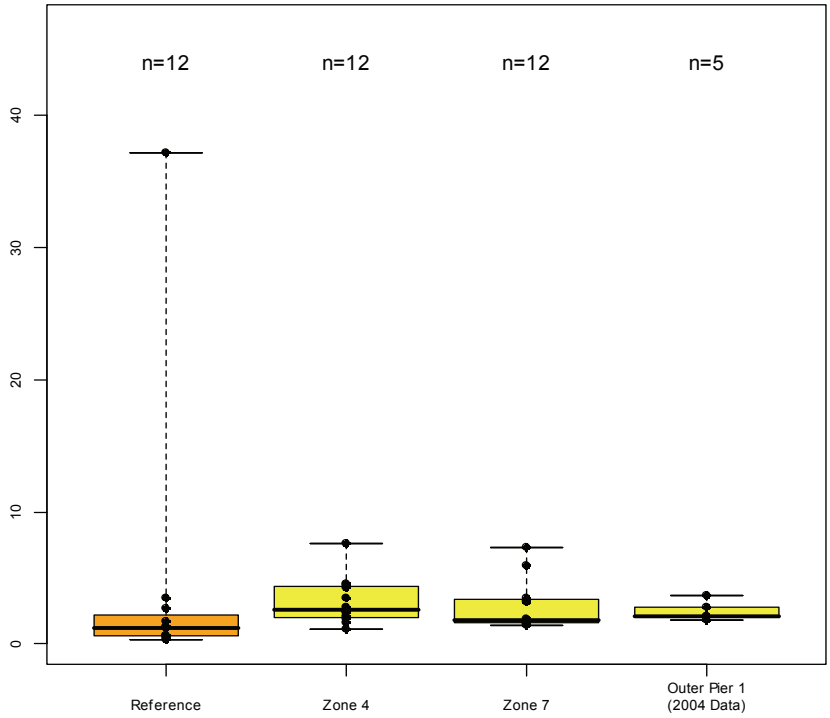

Figure A - 53. Boxplot of Cl7.180 for Reference, Zone 4, Zone 7 and Outer Pier 1

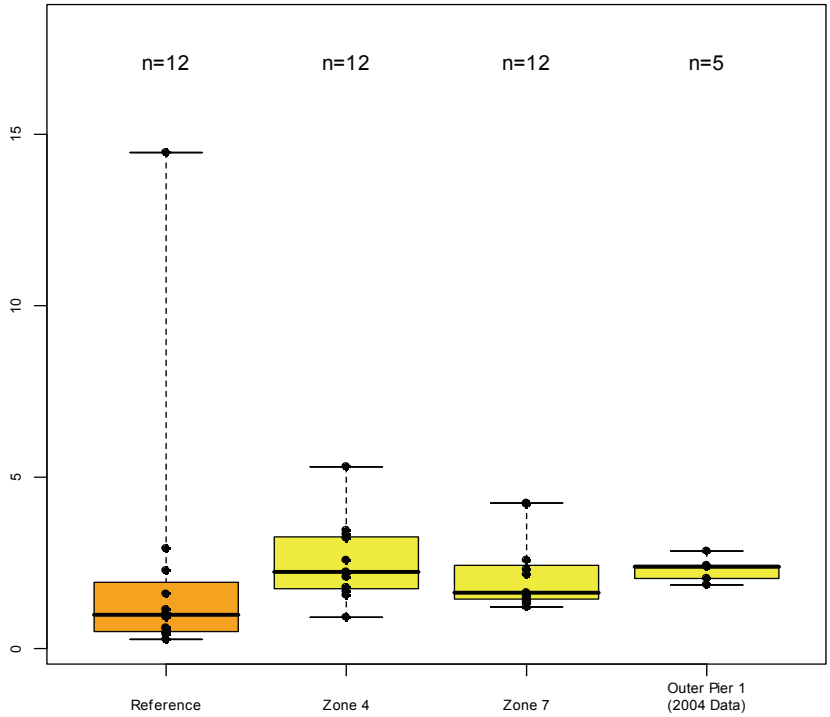

Figure A - 54. Boxplot of Cl7.187 for Reference, Zone 4, Zone 7 and Outer Pier 1

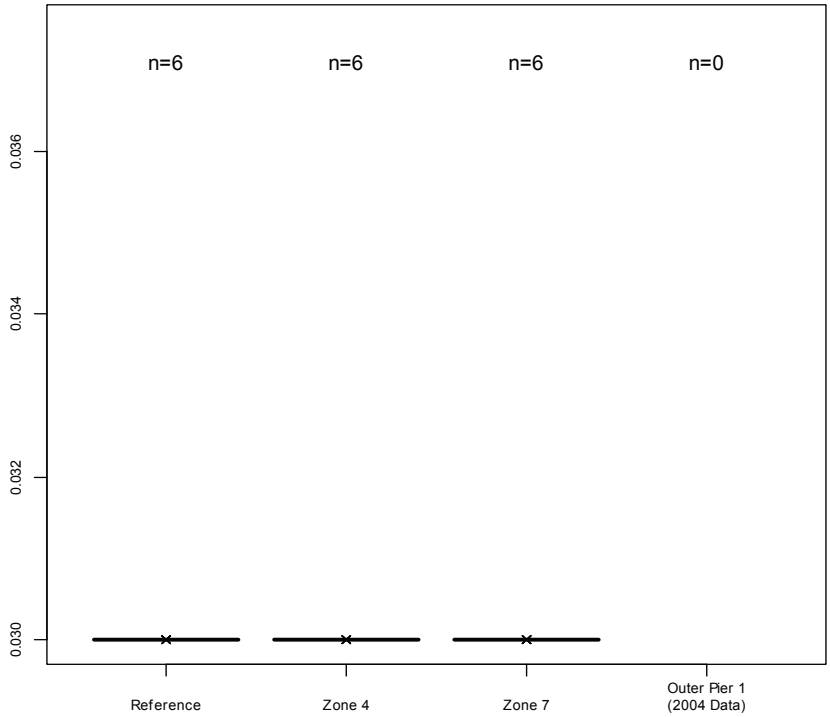

Figure A - 55. Boxplot of Cl8.195 for Reference, Zone 4, Zone 7 and Outer Pier 1

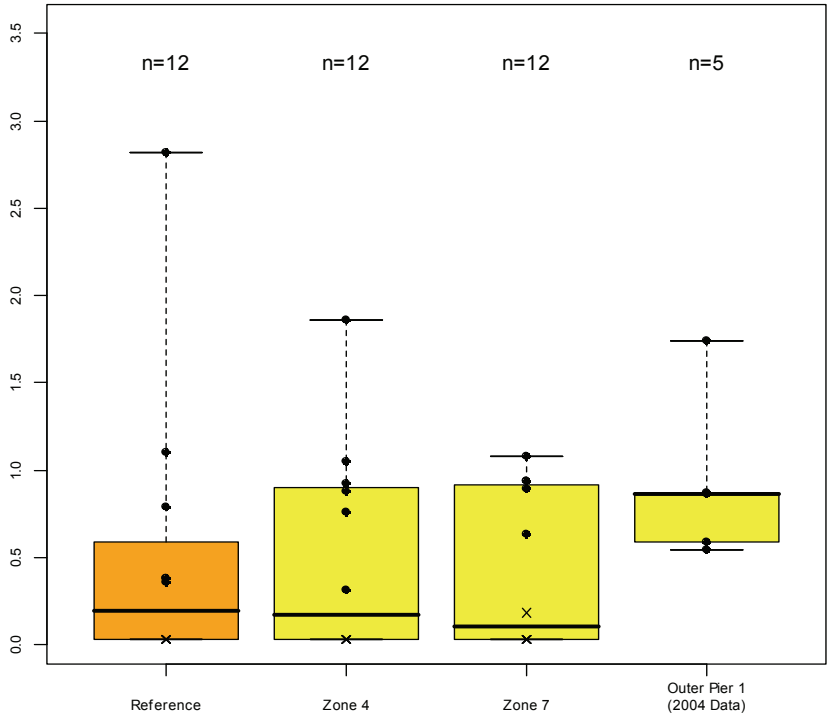

Figure A - 56. Boxplot of Cl9.206 for Reference, Zone 4, Zone 7 and Outer Pier 1

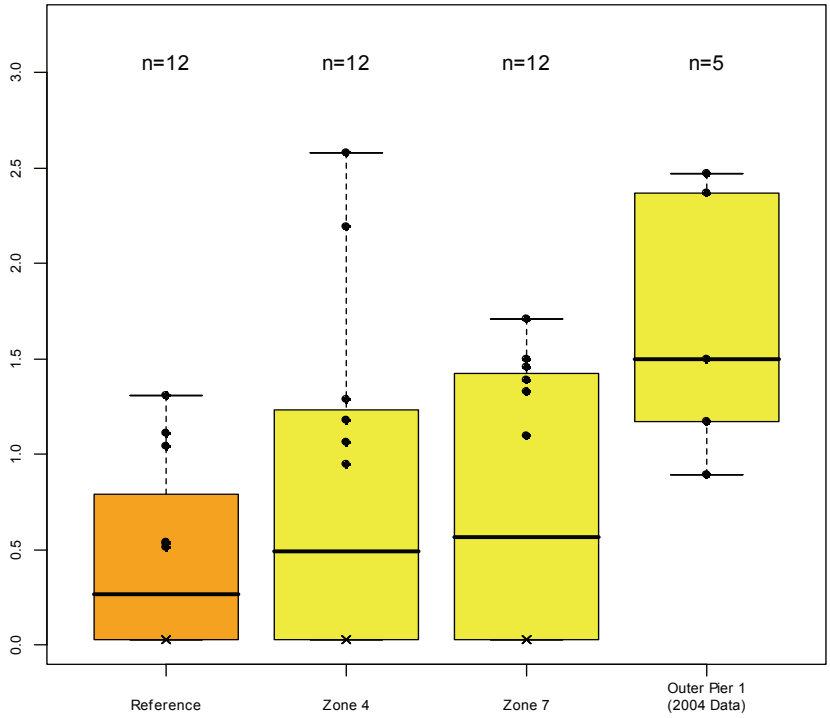

Figure A - 57. Boxplot of Cl10.209 for Reference, Zone 4, Zone 7 and Outer Pier 1

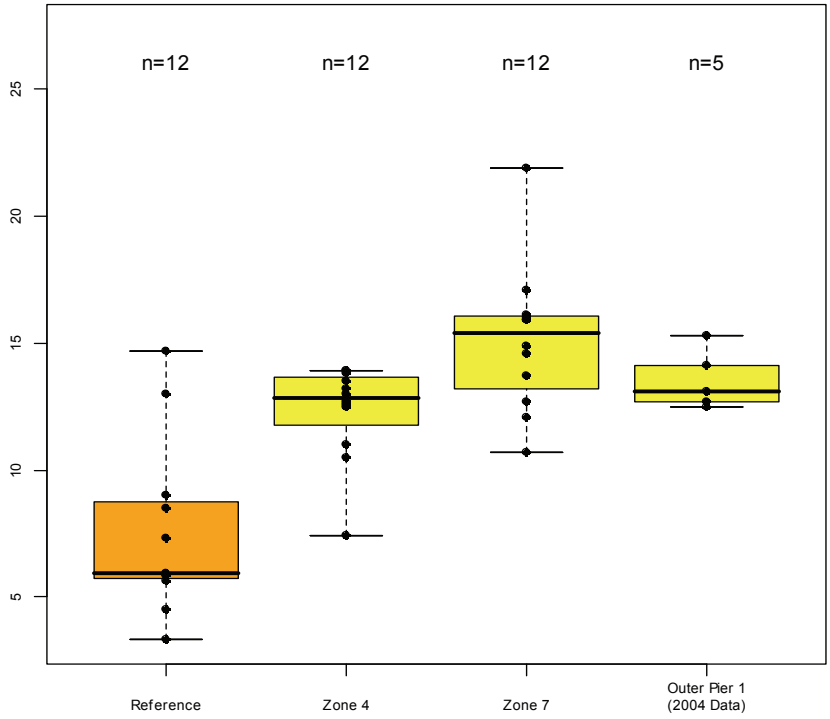

Figure A - 58. Boxplot of Arsenic for Reference, Zone 4, Zone 7 and Outer Pier 1

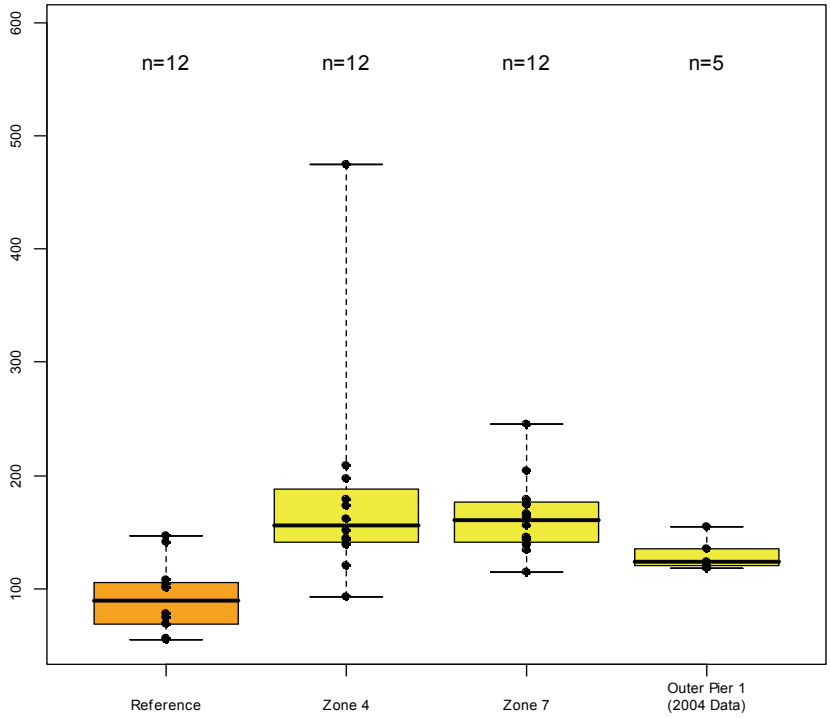

Figure A - 59. Boxplot of Barium for Reference, Zone 4, Zone 7 and Outer Pier 1

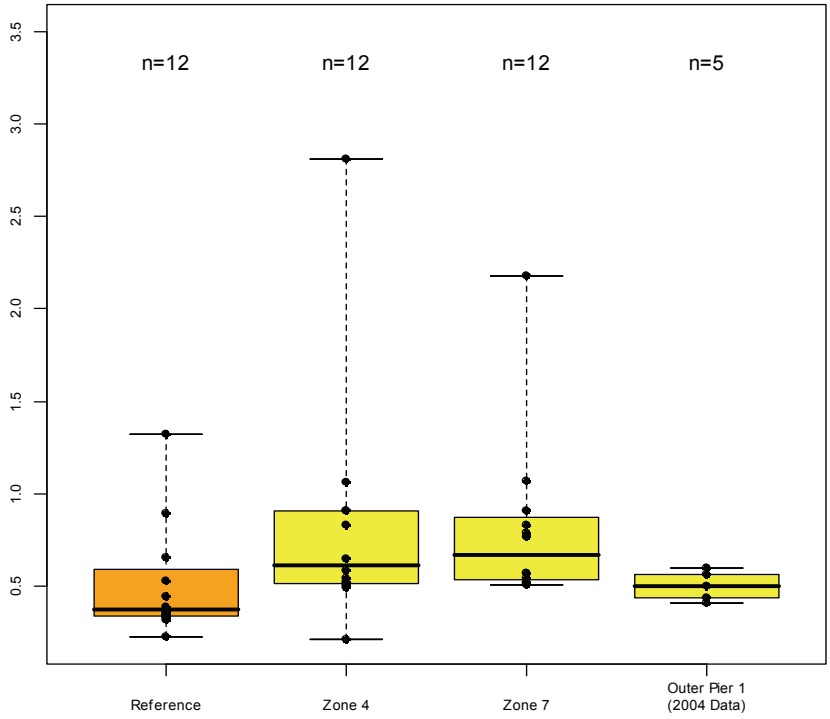

Figure A - 60. Boxplot of Cadmium for Reference, Zone 4, Zone 7 and Outer Pier 1

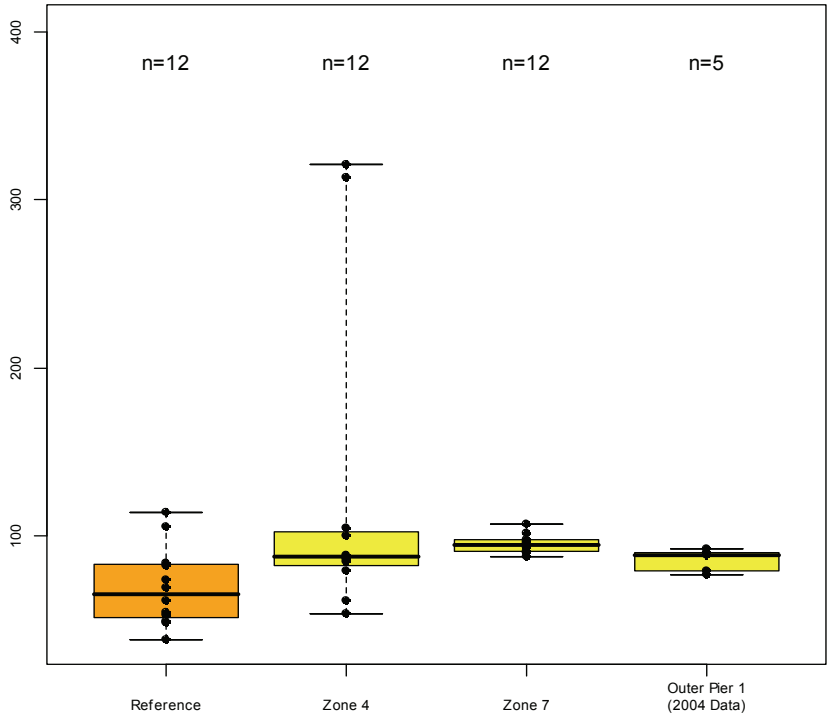

Figure A - 61. Boxplot of Chromium for Reference, Zone 4, Zone 7 and Outer Pier 1

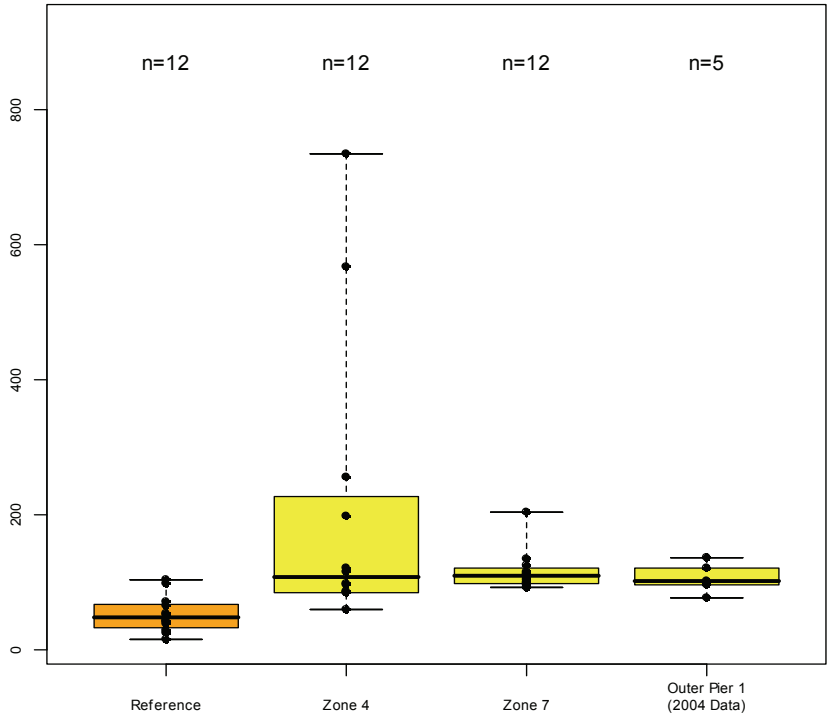

Figure A - 62. Boxplot of Copper for Reference, Zone 4, Zone 7 and Outer Pier 1

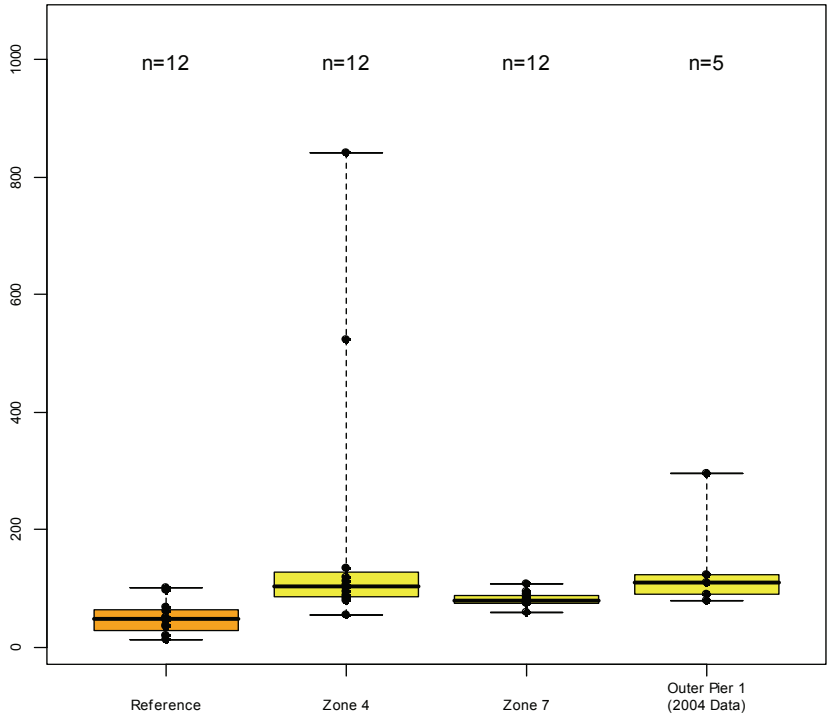

Figure A - 63. Boxplot of Lead for Reference, Zone 4, Zone 7 and Outer Pier 1

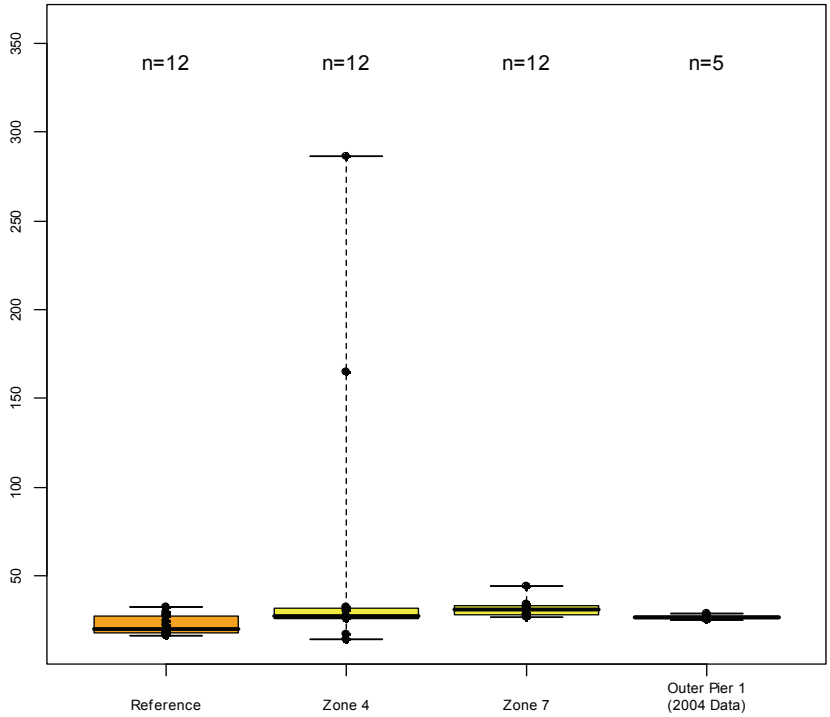

Figure A - 64. Boxplot of Nickel for Reference, Zone 4, Zone 7 and Outer Pier 1

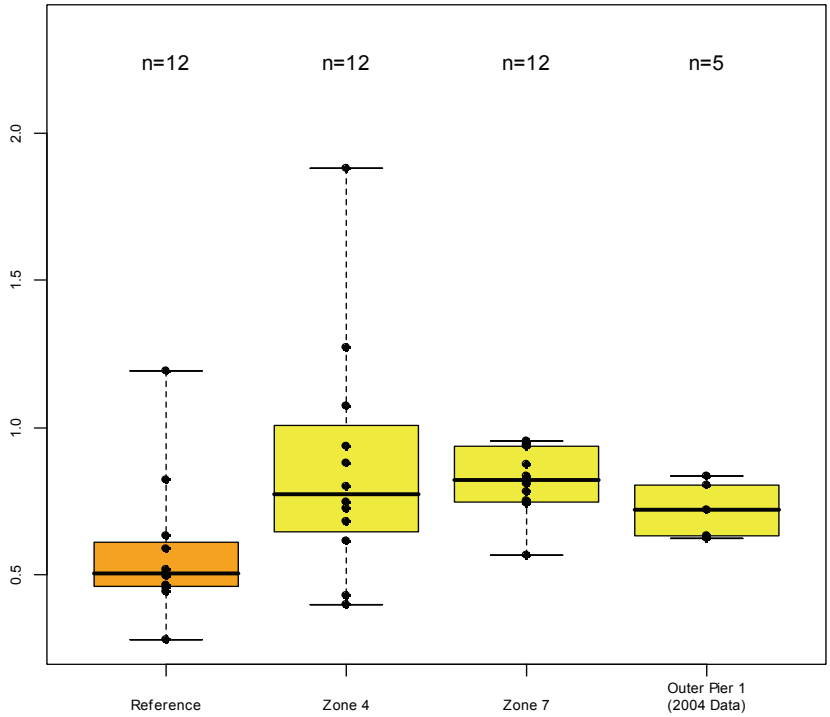

Figure A - 65. Boxplot of Selenium for Reference, Zone 4, Zone 7 and Outer Pier 1

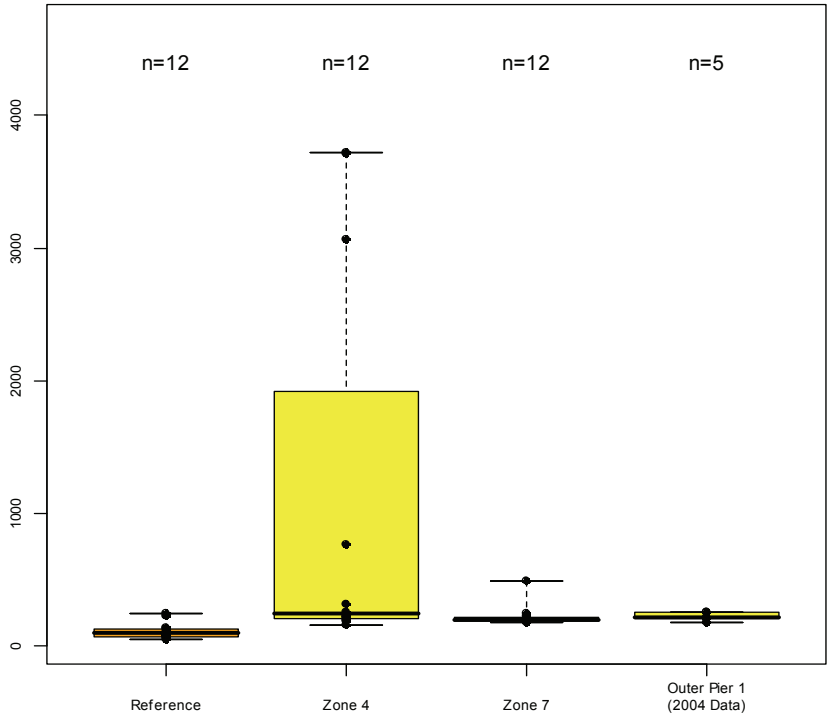

Figure A - 66. Boxplot of Zinc for Reference, Zone 4, Zone 7 and Outer Pier 1

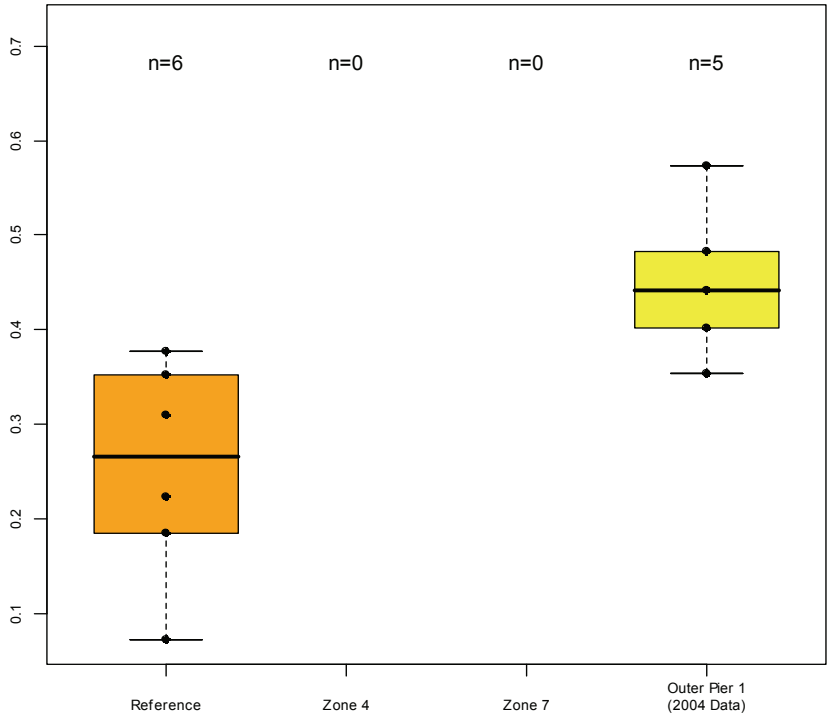

Figure A - 67. Boxplot of Mercury for Reference, Zone 4, Zone 7 and Outer Pier 1

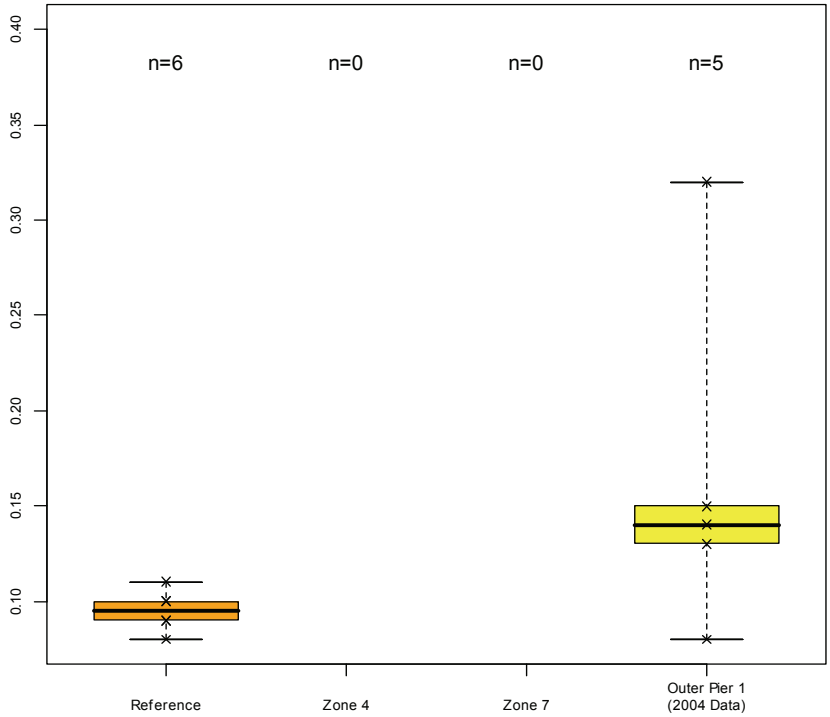

Figure A - 68. Boxplot of Lindane for Reference, Zone 4, Zone 7 and Outer Pier 1

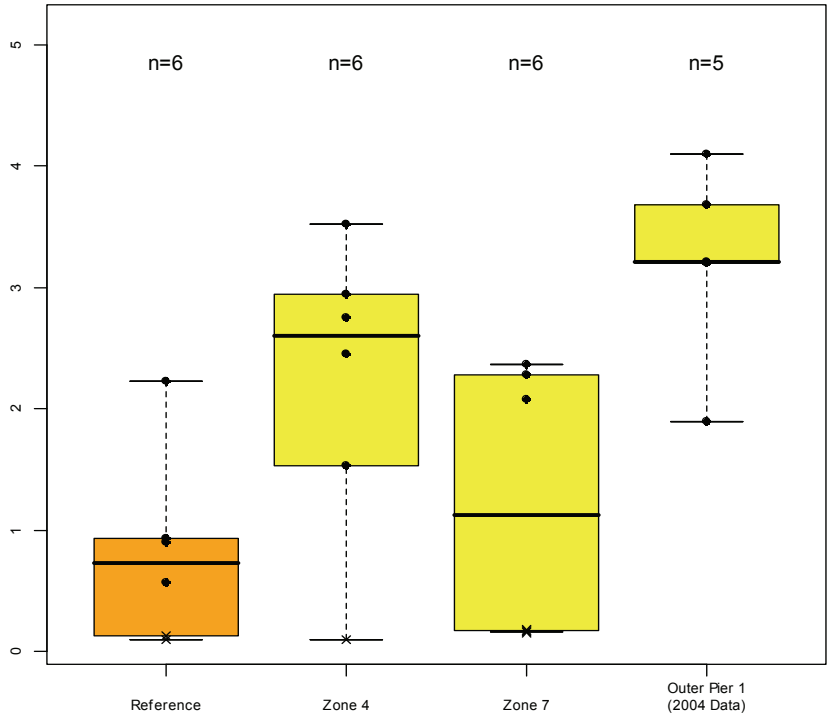

Figure A - 69. Boxplot of Dieldrin for Reference, Zone 4, Zone 7 and Outer Pier 1

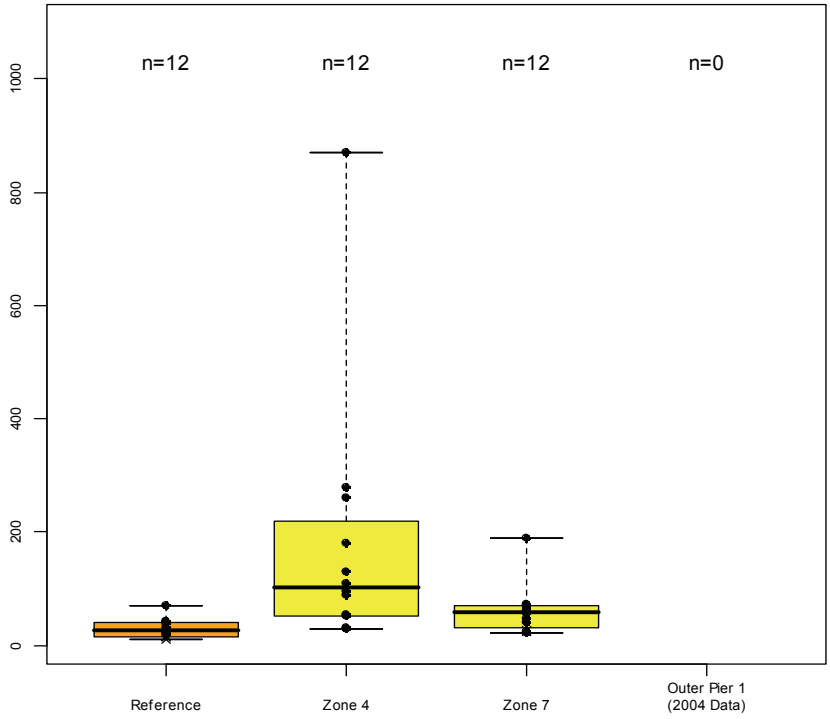

Figure A - 70. Boxplot of Diesel Fuel for Reference, Zone 4, Zone 7 and Outer Pier 1

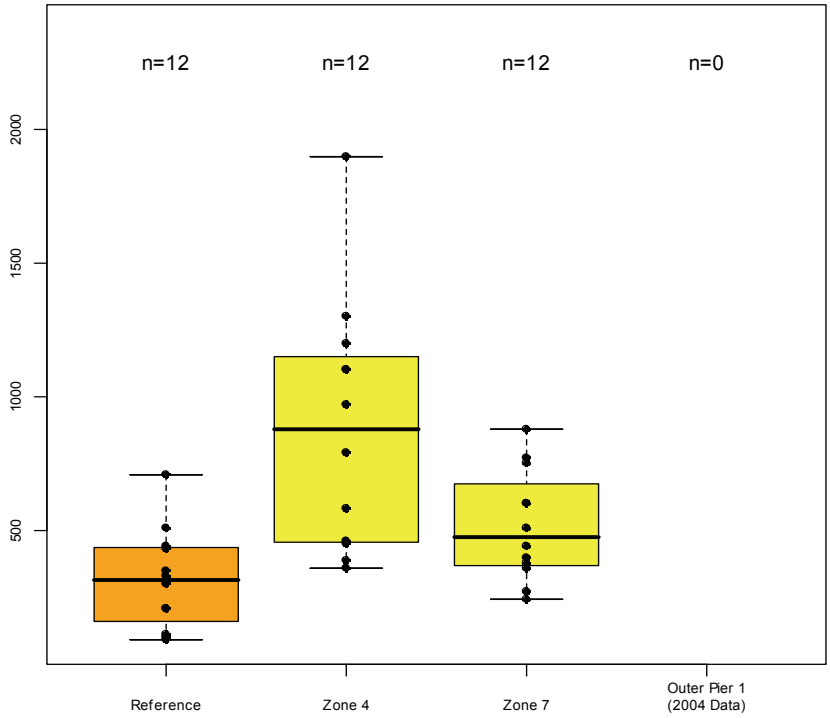

Figure A - 71. Boxplot of Motor Oil for Reference, Zone 4, Zone 7 and Outer Pier 1

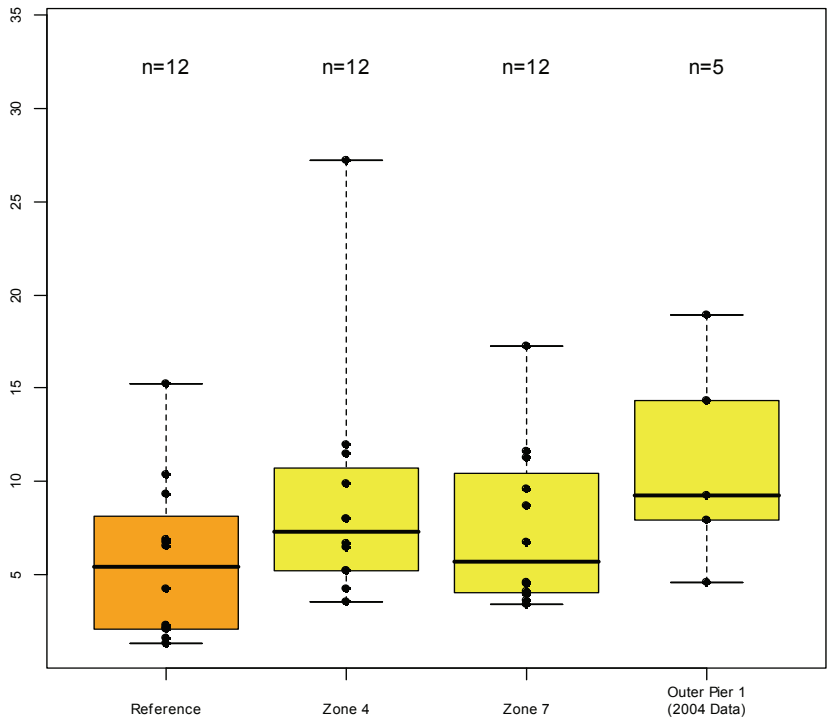

Figure A - 72. Boxplot of Total DDx for Reference, Zone 4, Zone 7, and Outer Pier 1

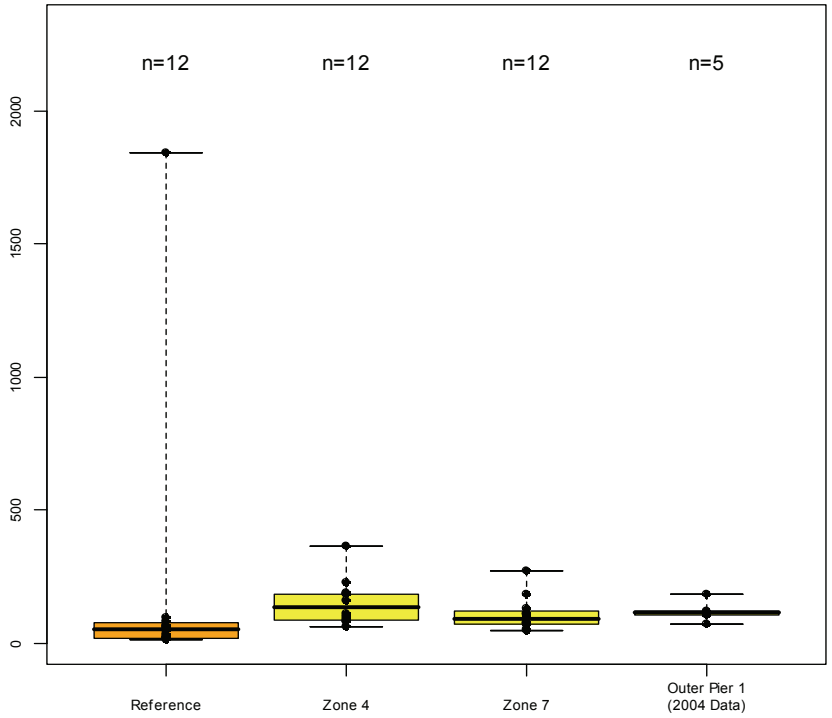

Figure A - 73. Boxplot of Total PCBs for Reference, Zone 4, Zone 7, and Outer Pier 1

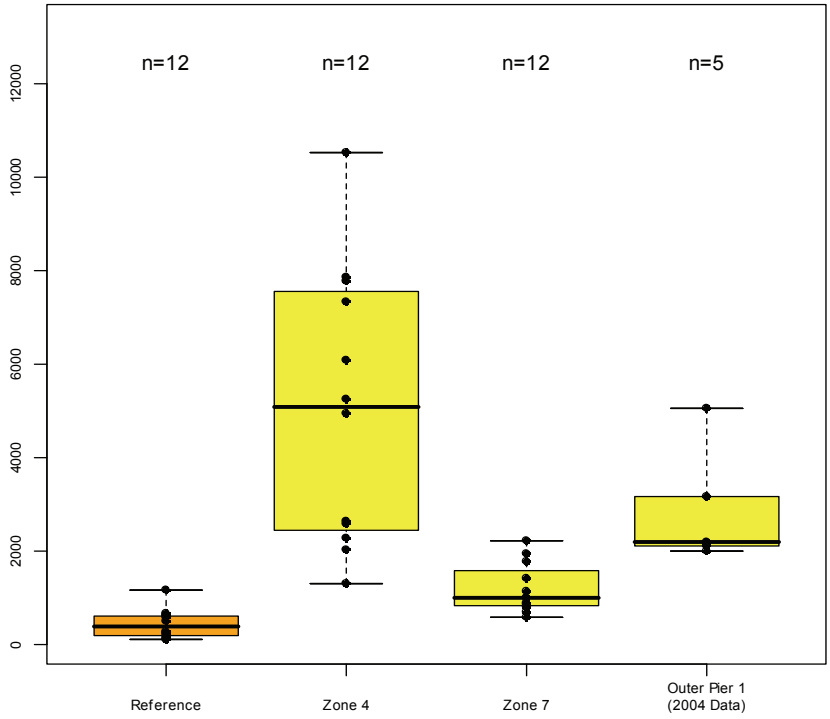

Figure A - 74. Boxplot of Total LMWPAH for Reference, Zone 4, Zone 7, and Outer Pier 1

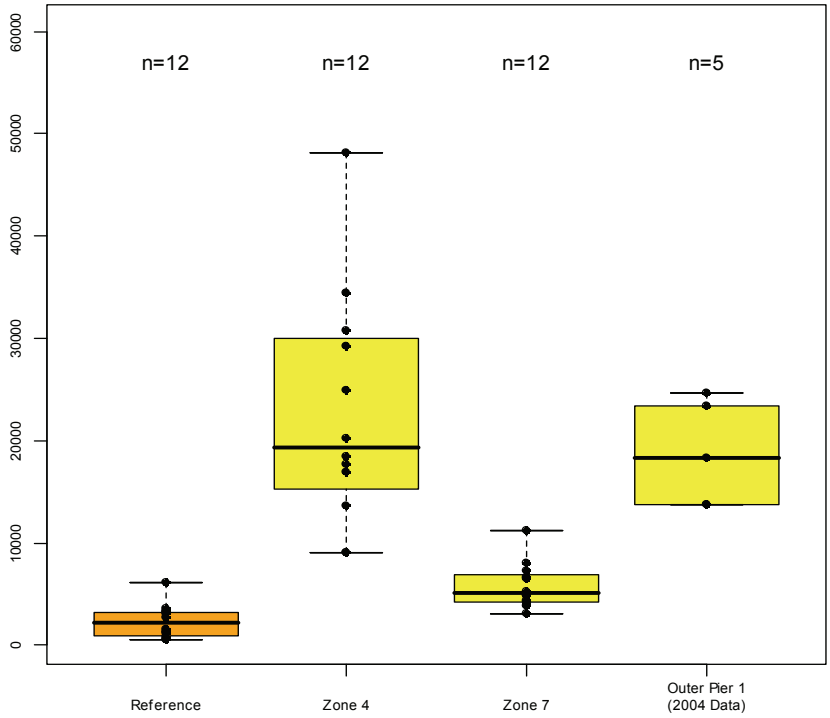

Figure A - 75. Boxplot of Total HMWPAH for Reference, Zone 4, Zone 7, and Outer Pier 1

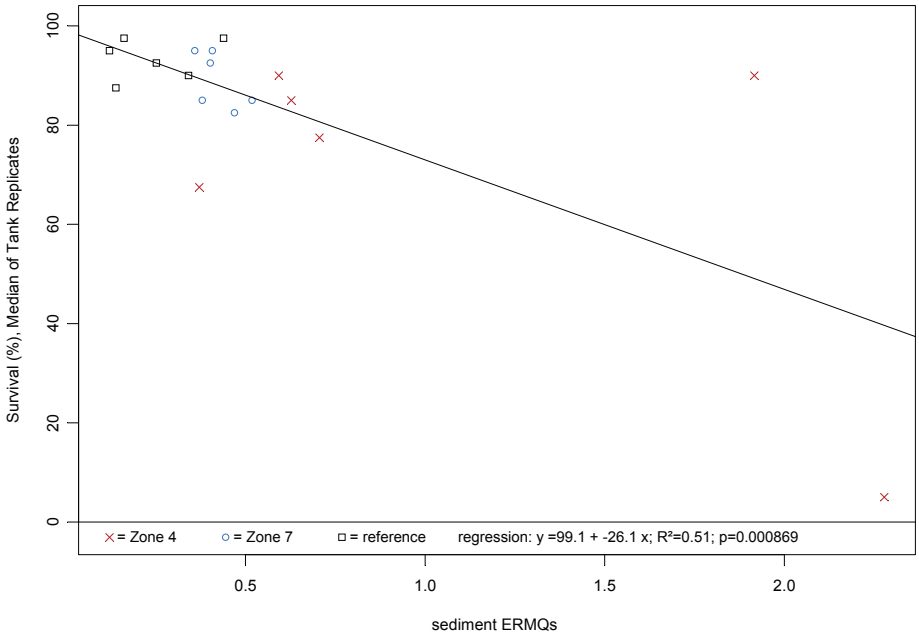

Figure A-76. Regression of ERM-Q vs Survival

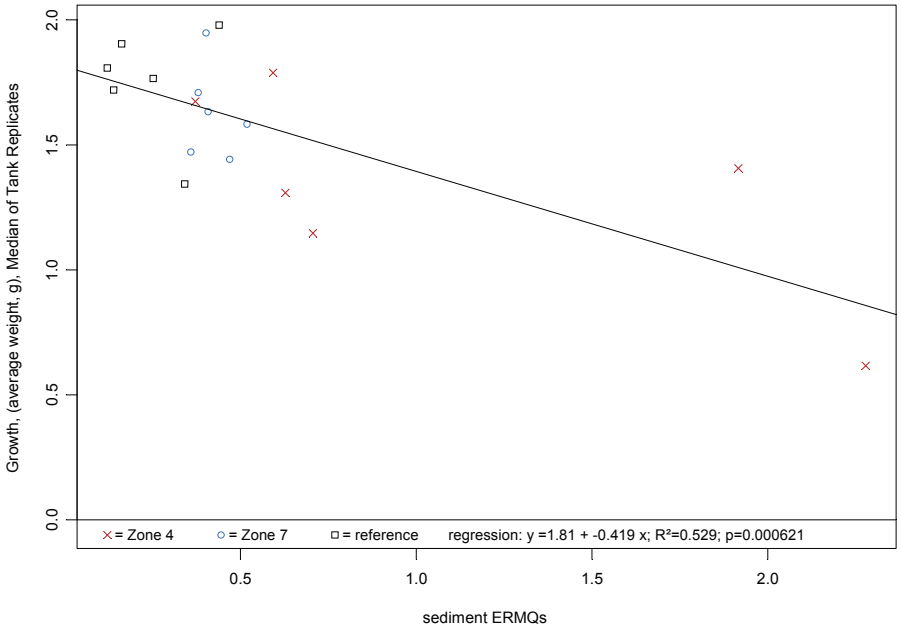

Figure A-77. Regression of ERMQ vs Growth

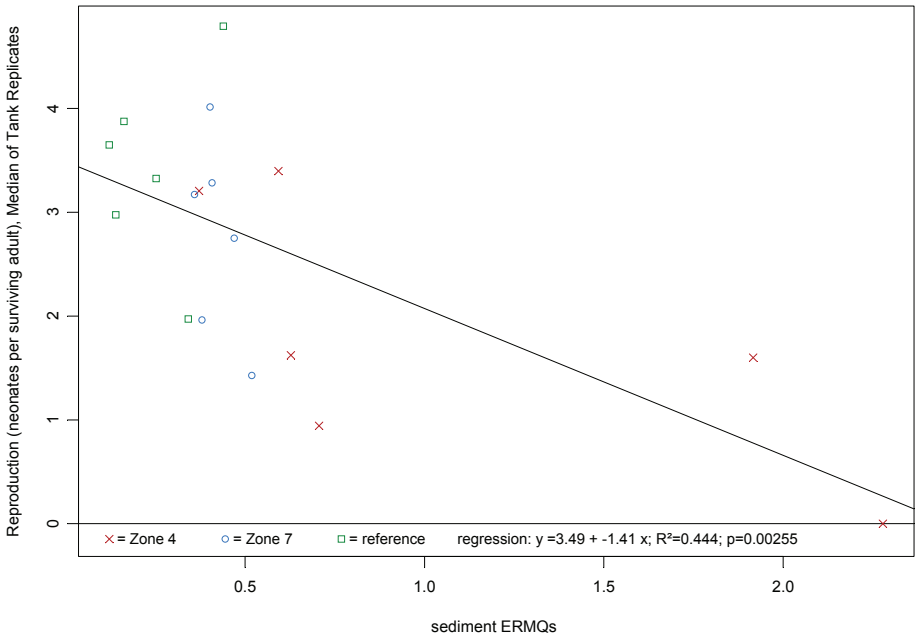

Figure A-78. Regression of ERMQ vs Reproduction

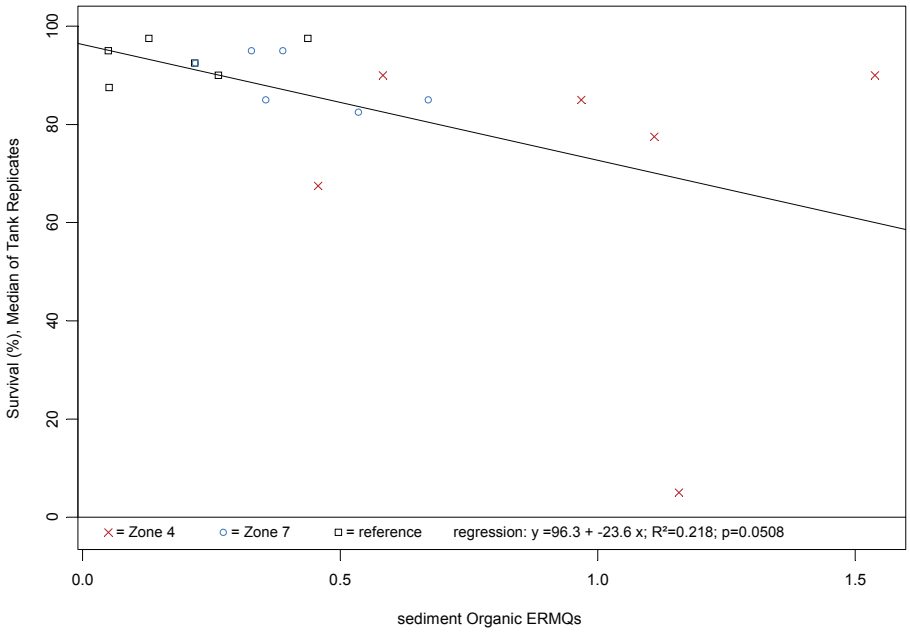

Figure A-79. Regression of Organic ERMQ vs Survival

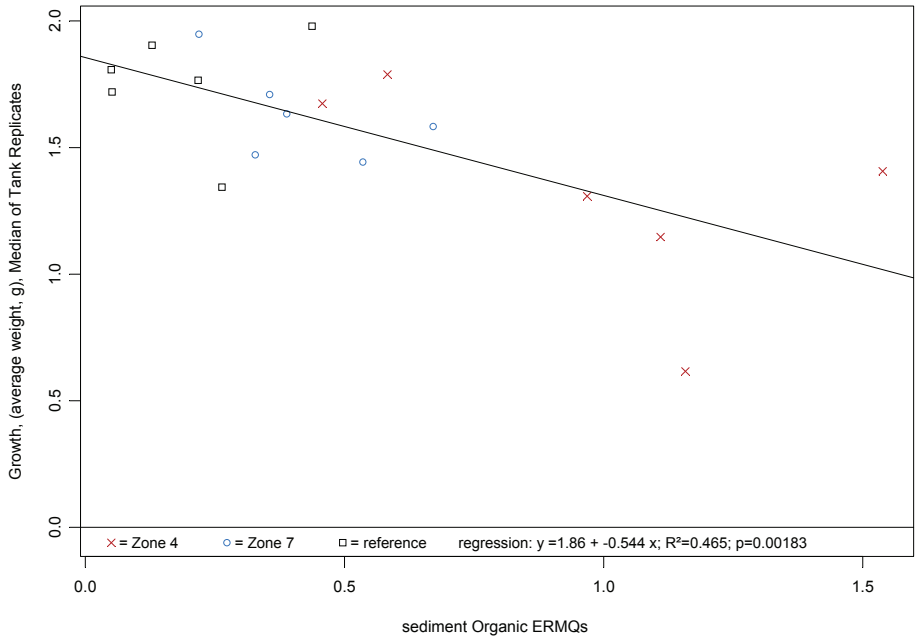

Figure A-80. Regression of Organic ERMQ vs Growth

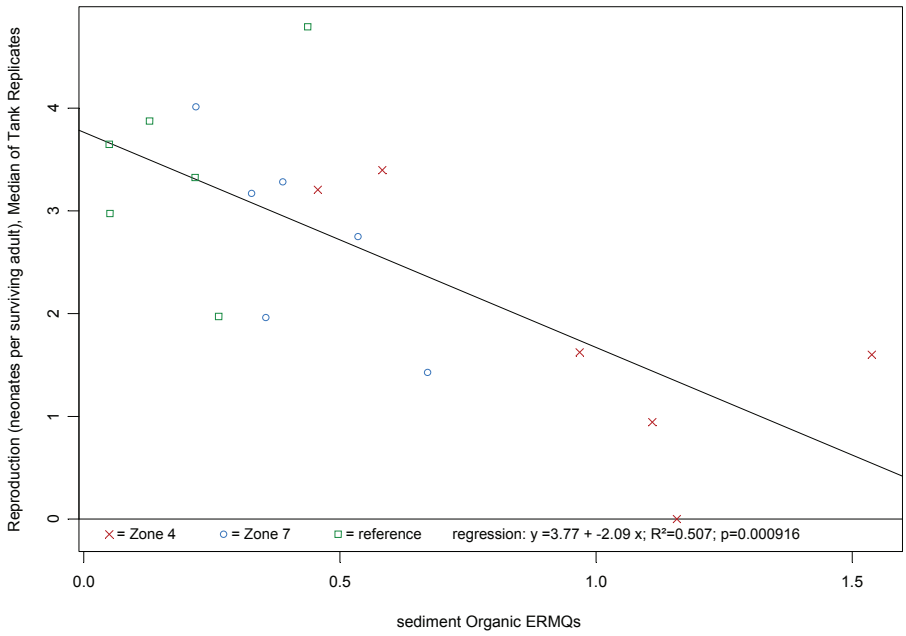

Figure A-81. Regression of Organic ERMQ vs Reproduction

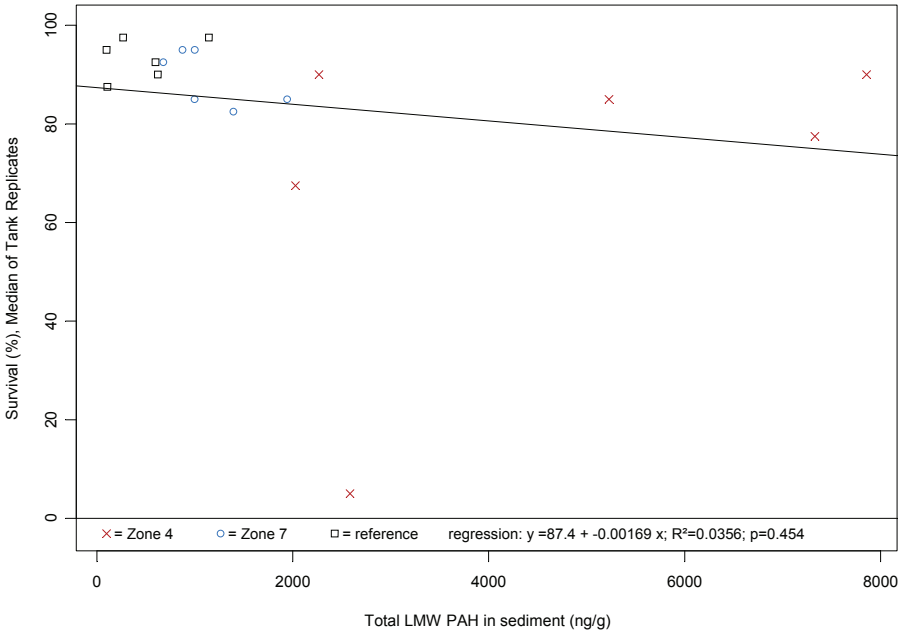

Figure A-82. Regression of Total LPAH vs Survival

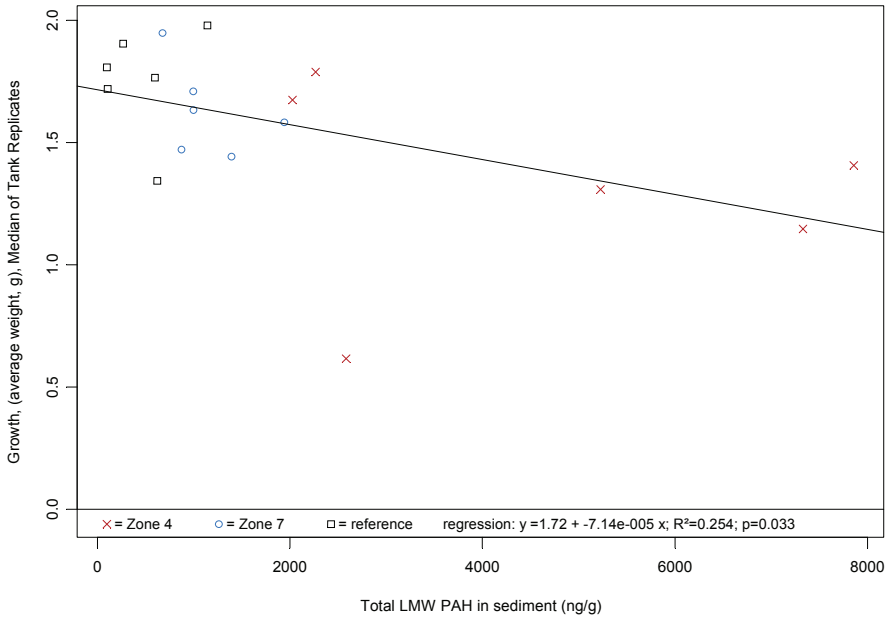

Figure A-83. Regression of Total LPAH vs Growth

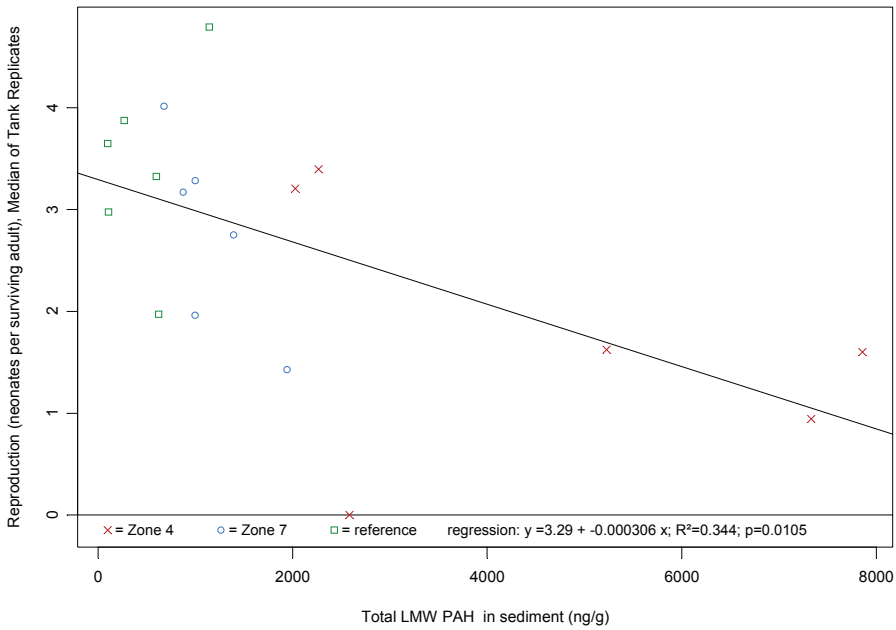

Figure A-84. Regression of Total LPAH vs Reproduction

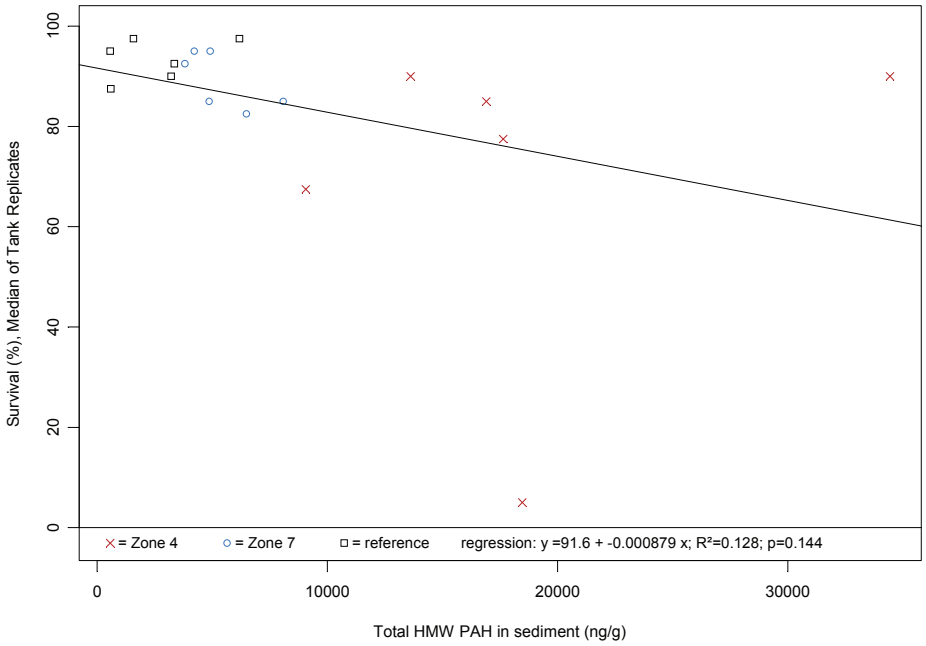

Figure A-85. Regression of Total HPAH vs Survival

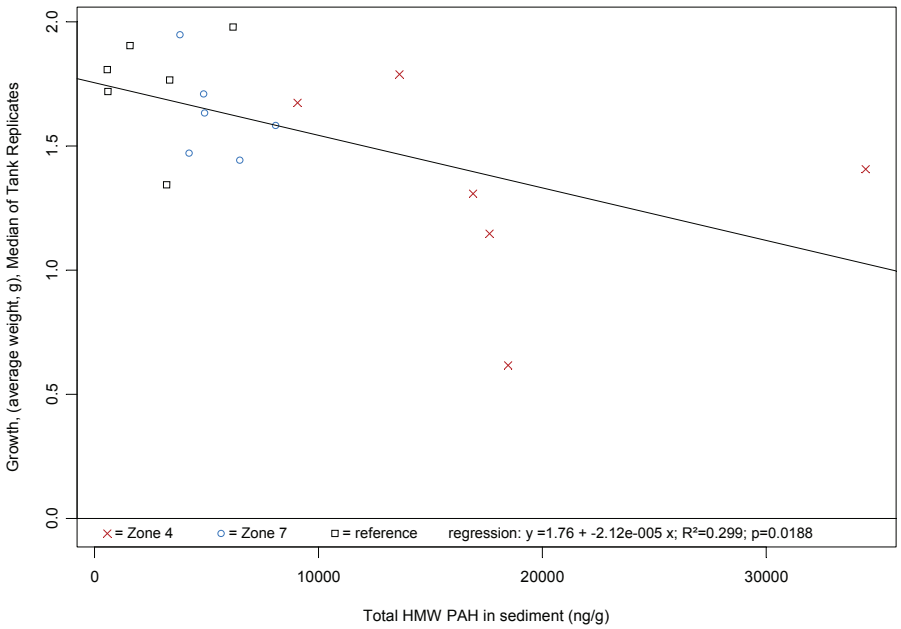

Figure A-86. Regression of Total HPAH vs Growth

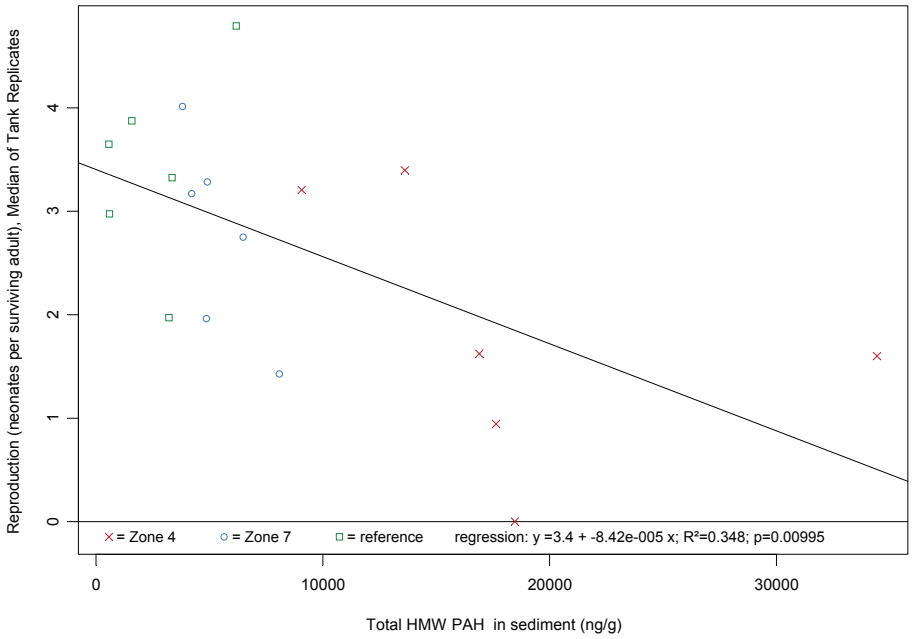

Figure A-87. Total HPAH vs Reproduction

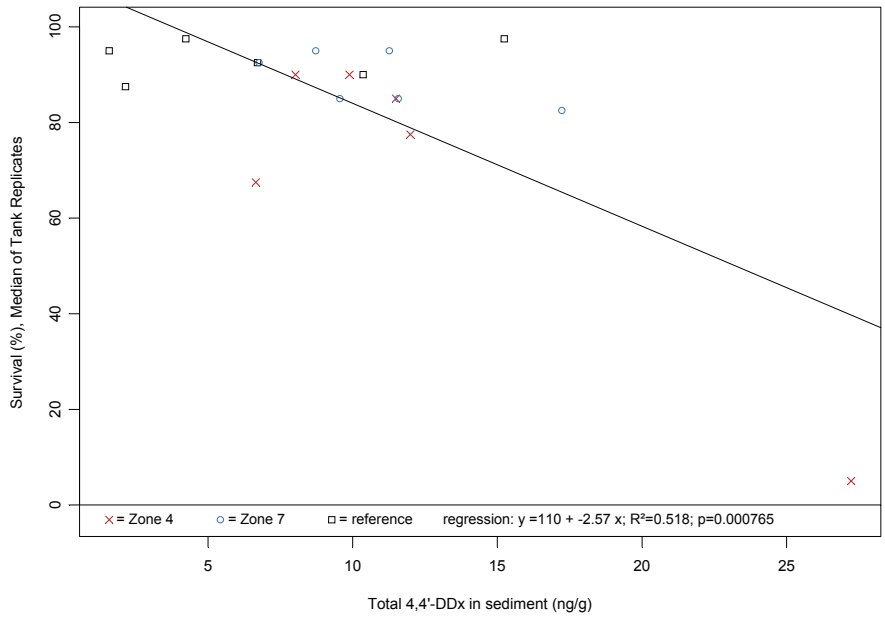

Figure A-88. Regression of Total 4,4'-DDx vs Survival

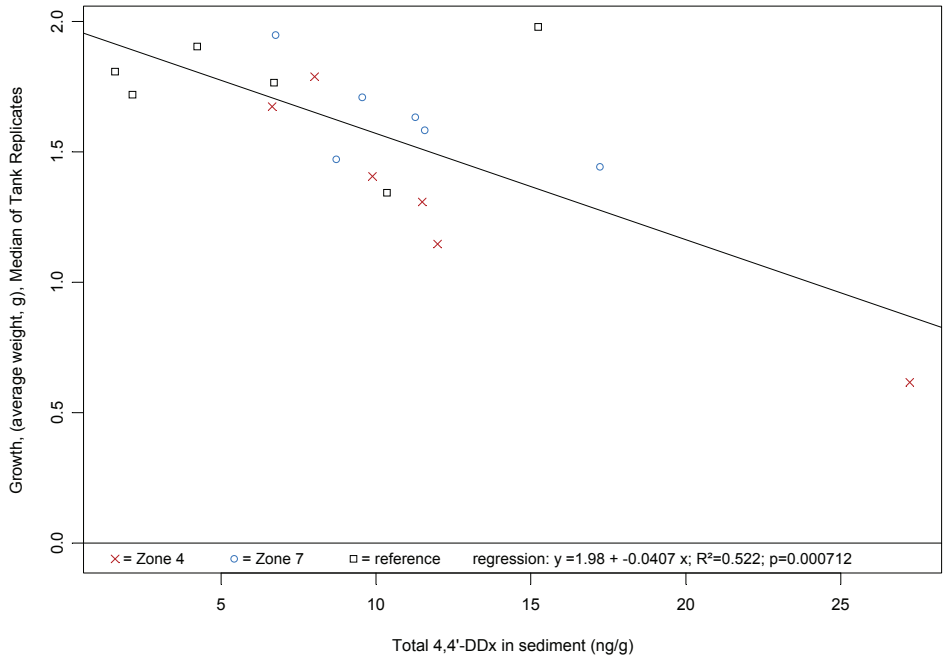

Figure A-89. Regression of Total 4,4'-DDx vs Growth

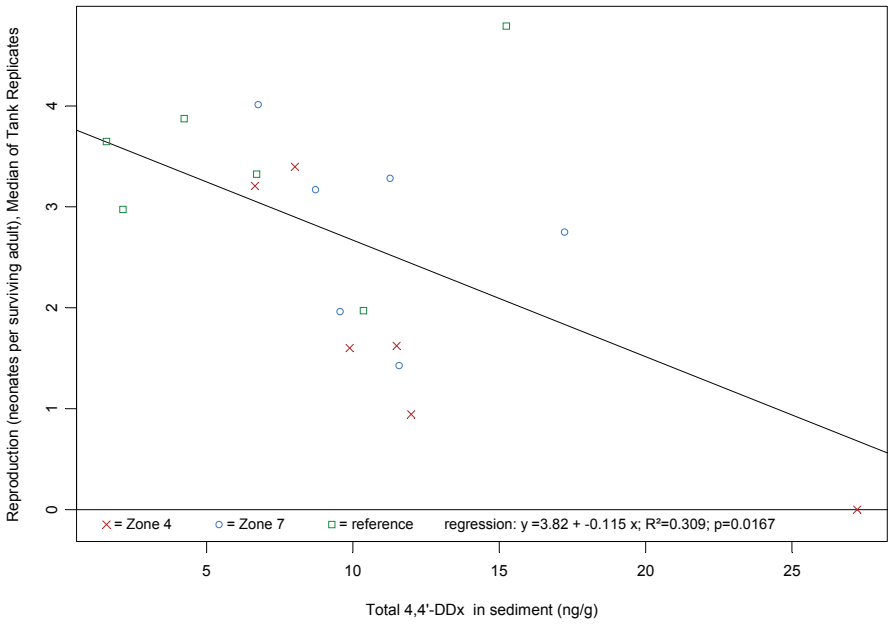

Figure A-90. Regression of Total 4,4'-DDx vs Reproduction

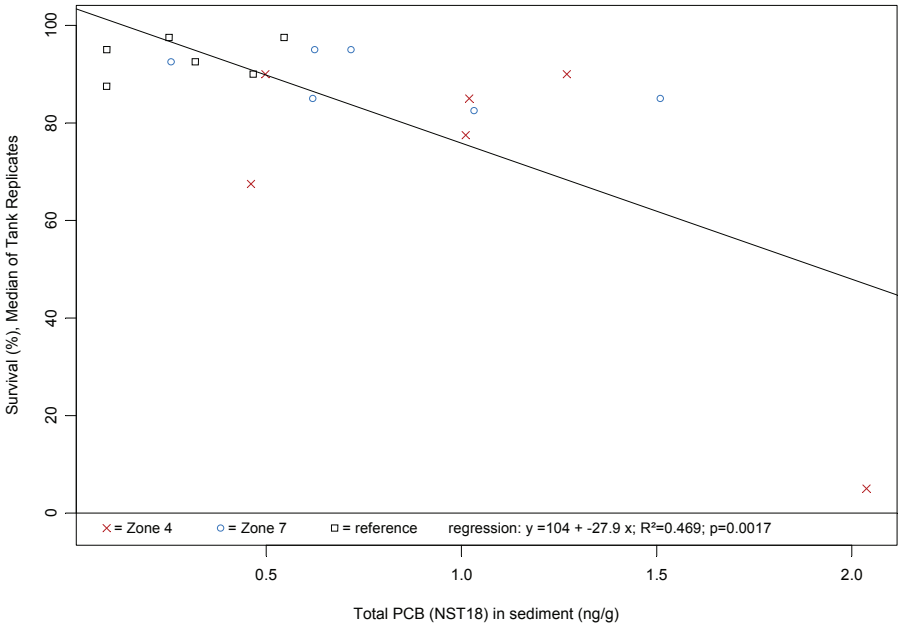

Figure A-91. Regression of Total PCB vs Survival

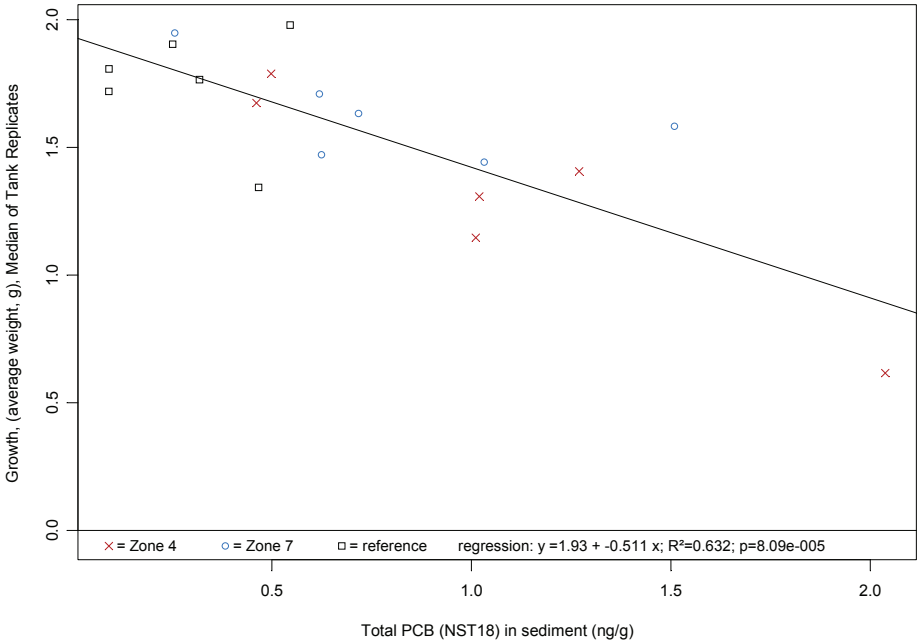

Figure A-92. Regression of Total PCB vs Growth

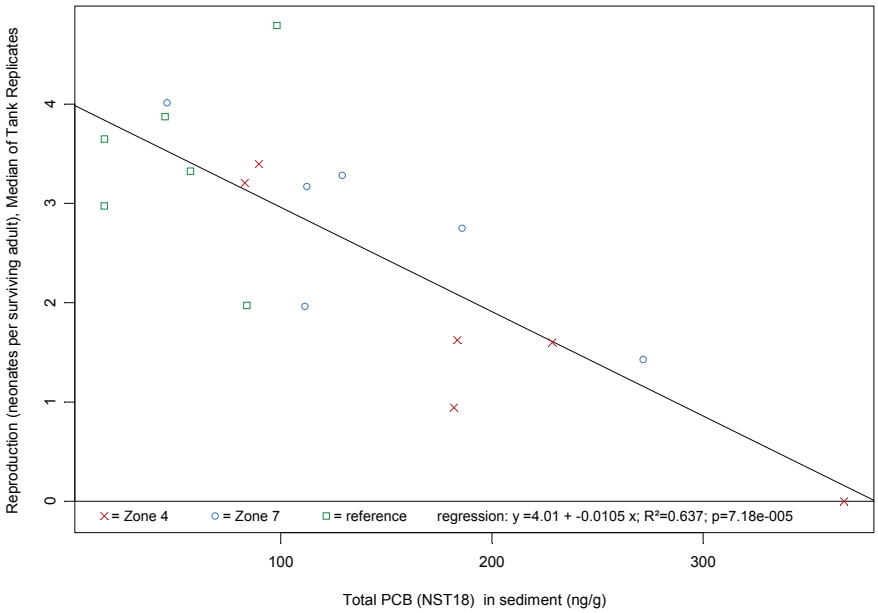

Figure A-93. Regression of Total PCB vs Reproduction

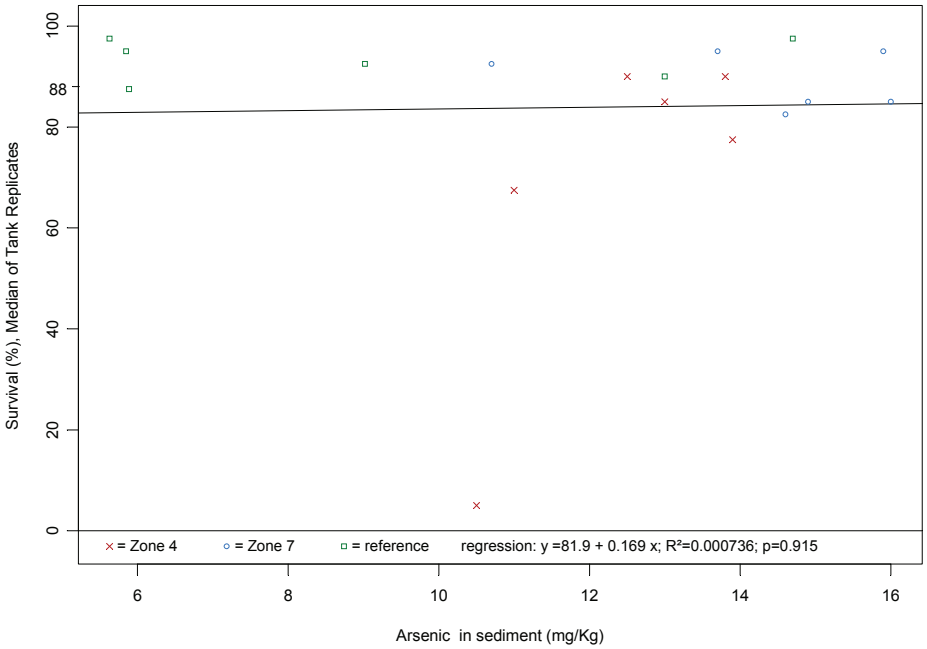

Figure A-94. Regression of Arsenic vs Survival

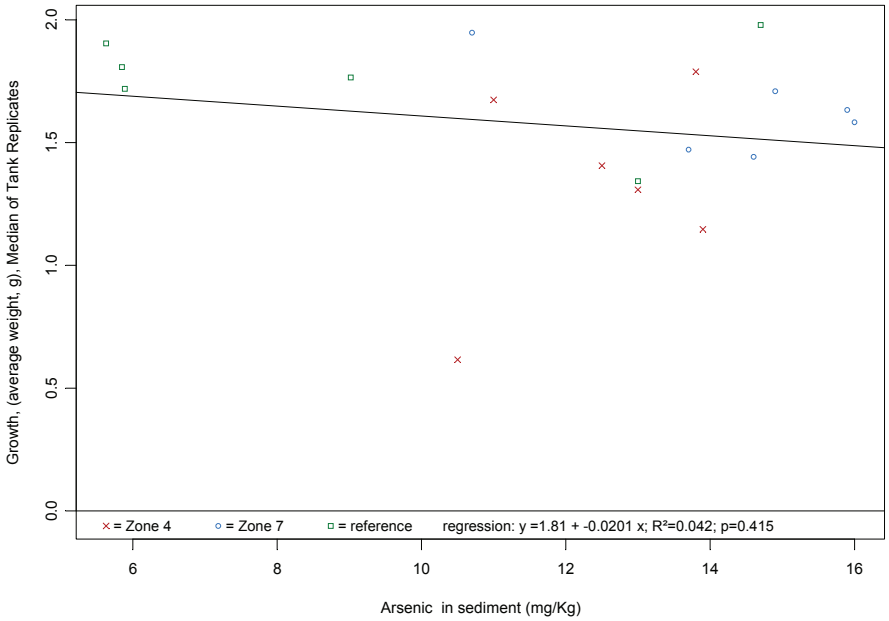

Figure A-95. Regression of Arsenic vs Growth

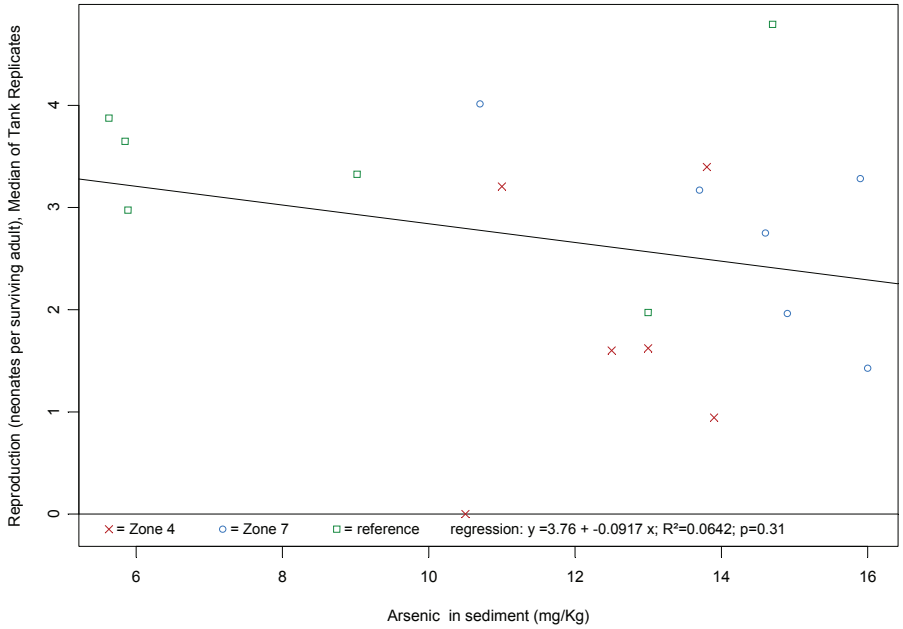

Figure A-96. Regression of Arsenic vs Reproduction

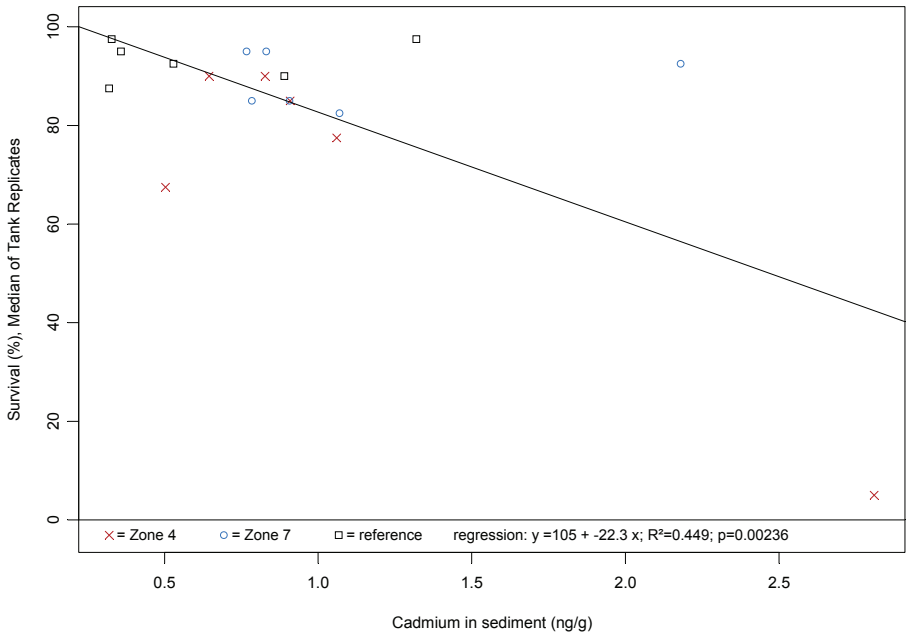

Figure A-97. Regression of Cadmium vs Survival

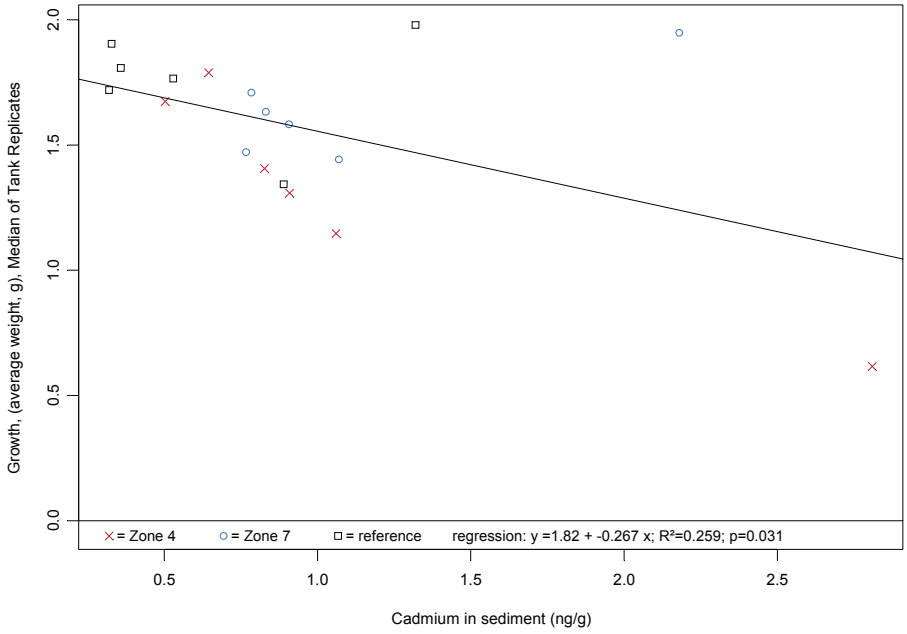

Figure A-98. Regression of Cadmium vs Growth

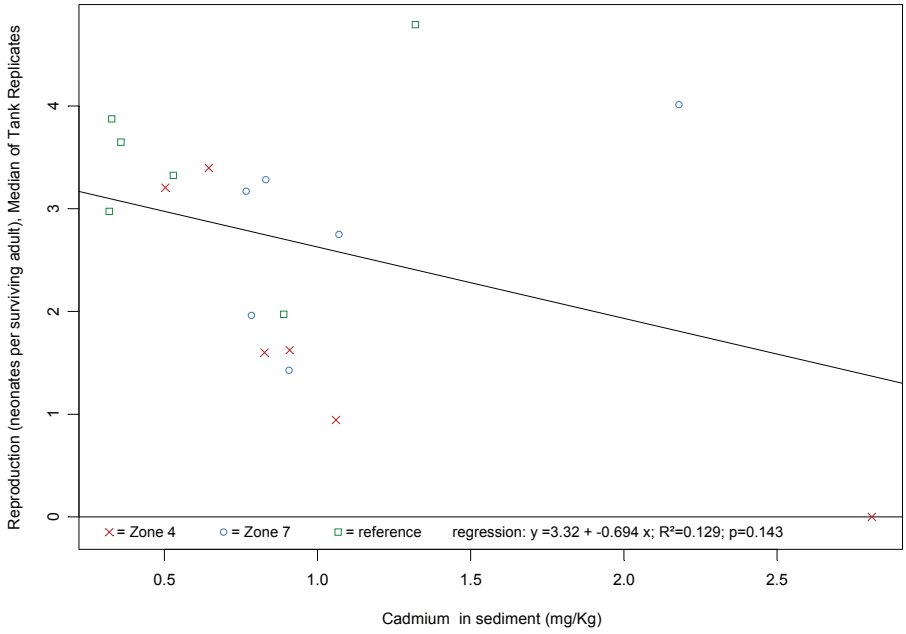

Figure A-99. Regression of Cadmium vs Reproduction

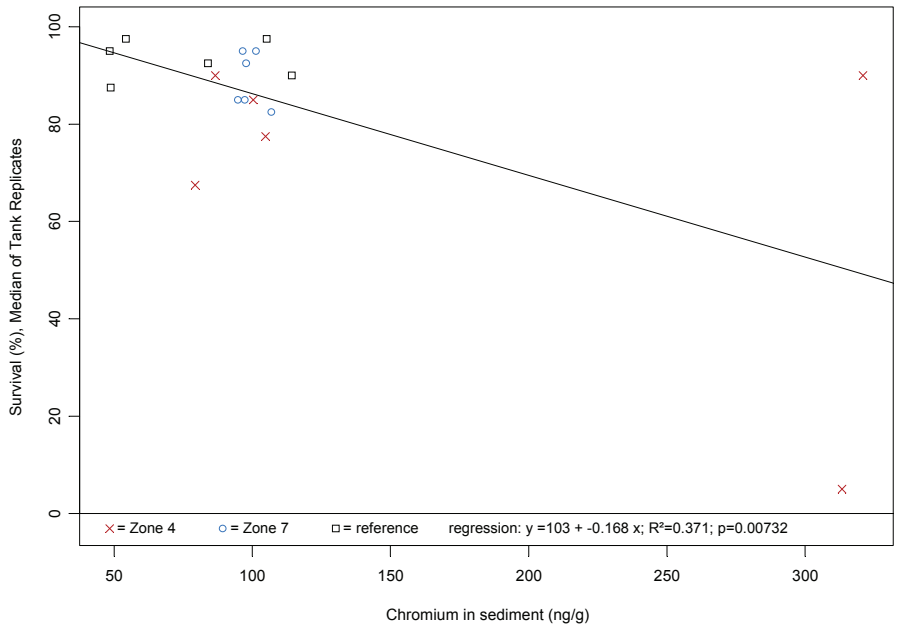

Figure A-100. Regression of Chromium vs Survival

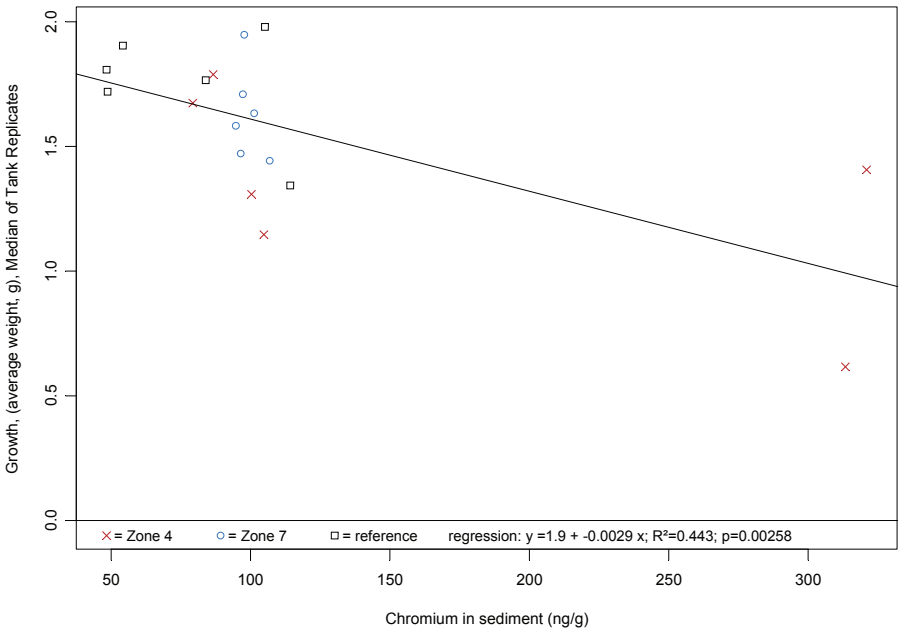

Figure A-101. Regression of Chromium vs Growth

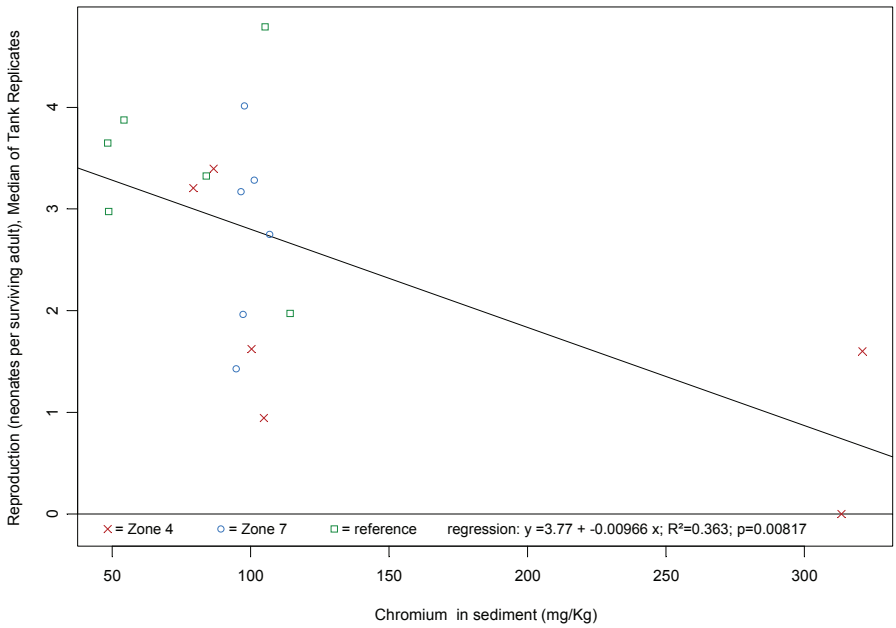

Figure A-102. Regression of Chromium vs Reproduction

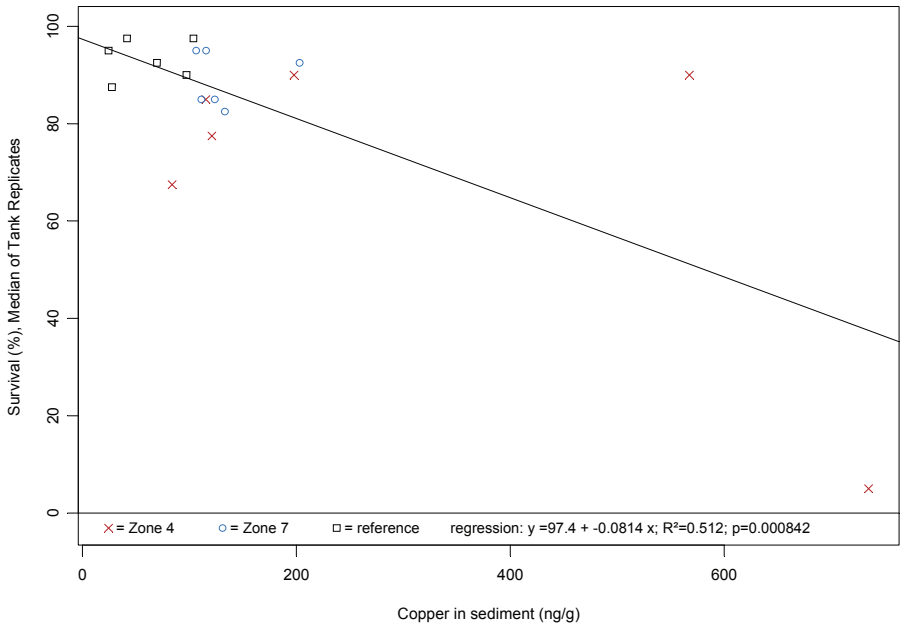

Figure A-103. Regression of Copper vs Survival

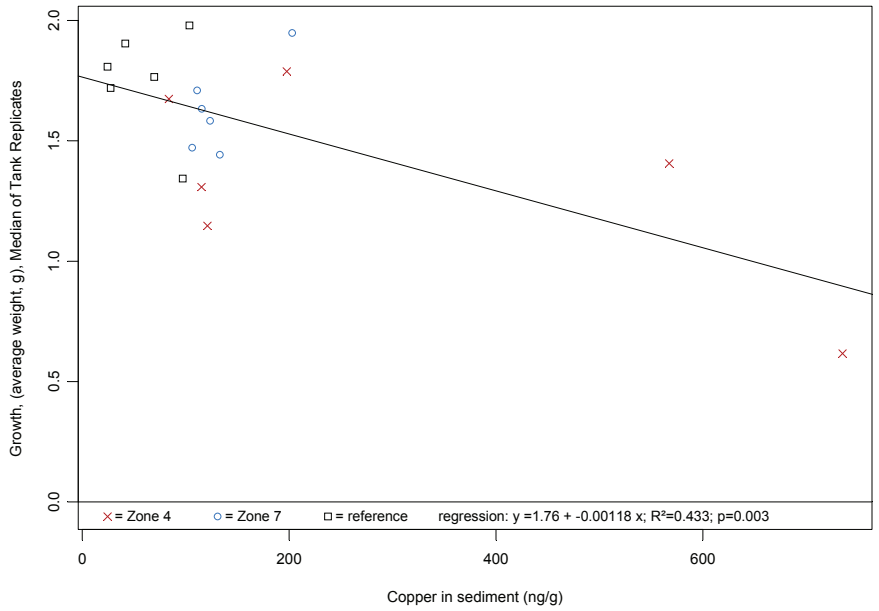

Figure A-104. Regression of Copper vs Growth

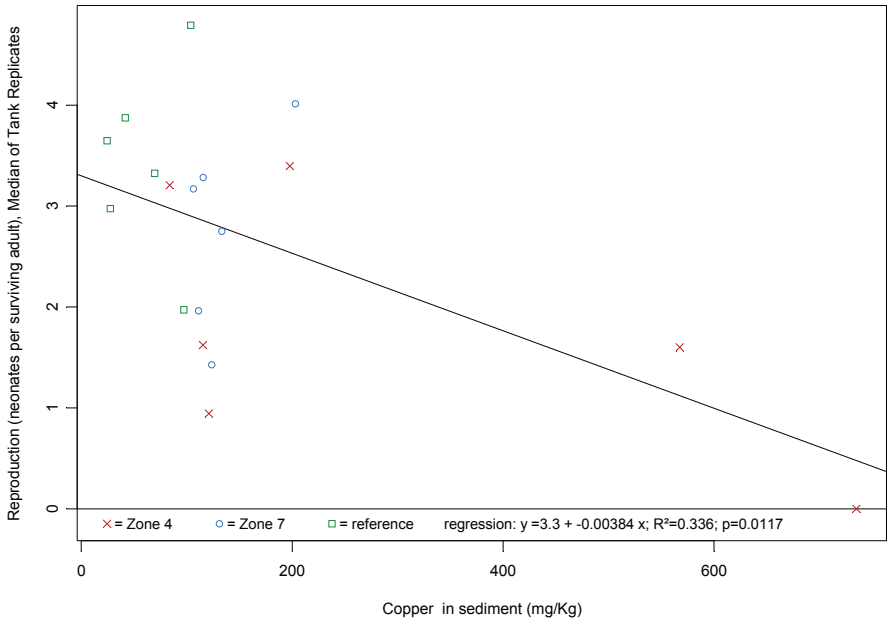

Figure A-105. Regression of Copper vs Reproduction

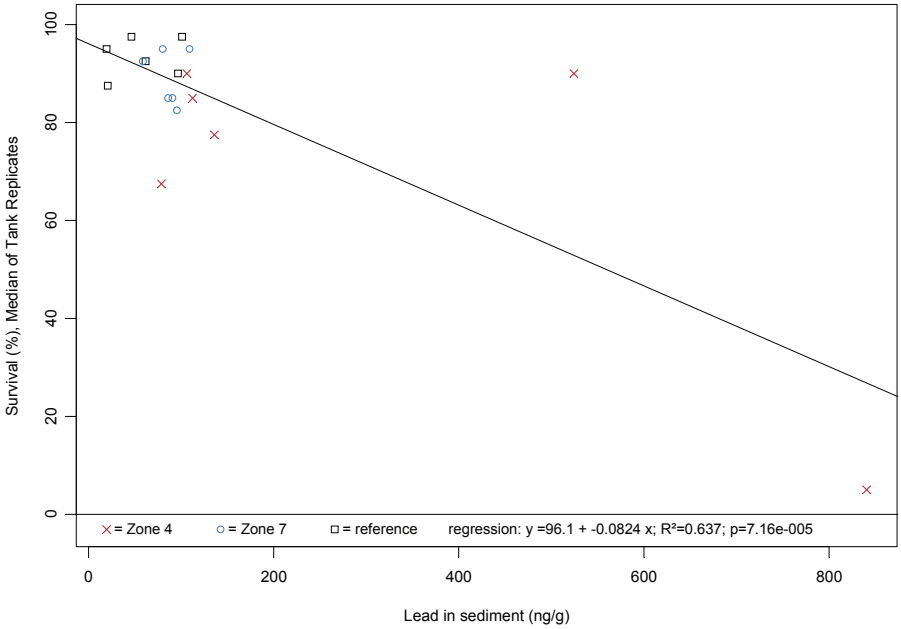

Figure A-106. Regression of Lead vs Survival

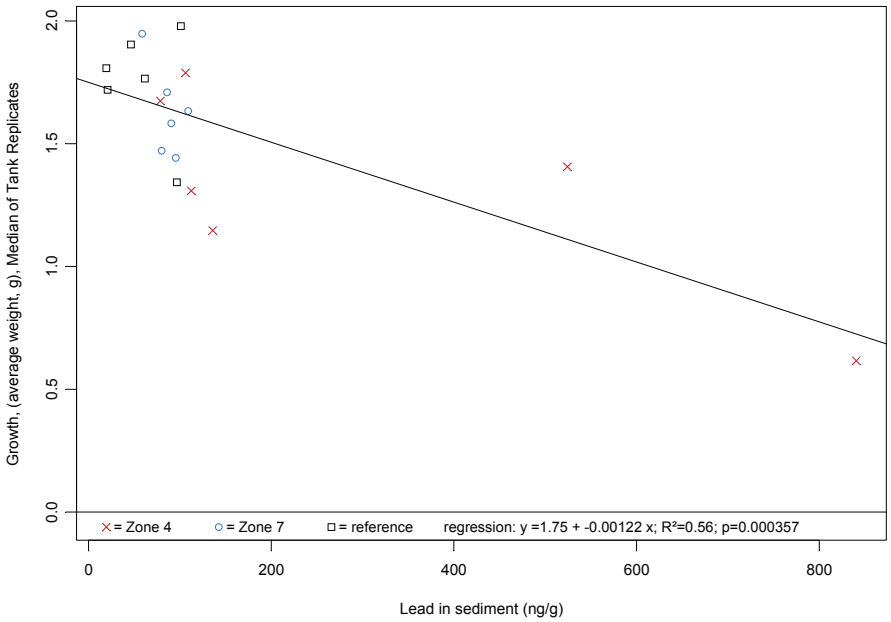

Figure A-107. Regression of Lead vs Growth

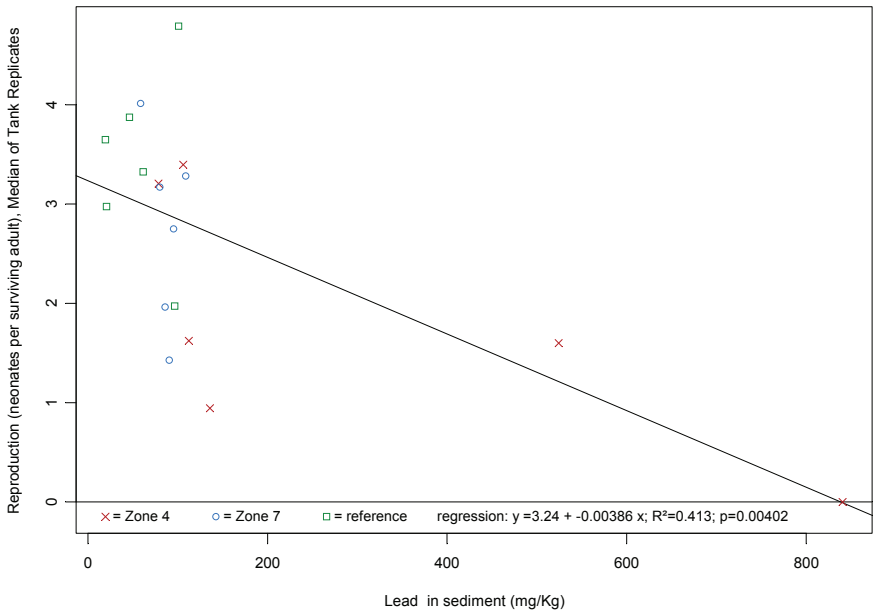

Figure A-108. Regression of Lead vs Reproduction

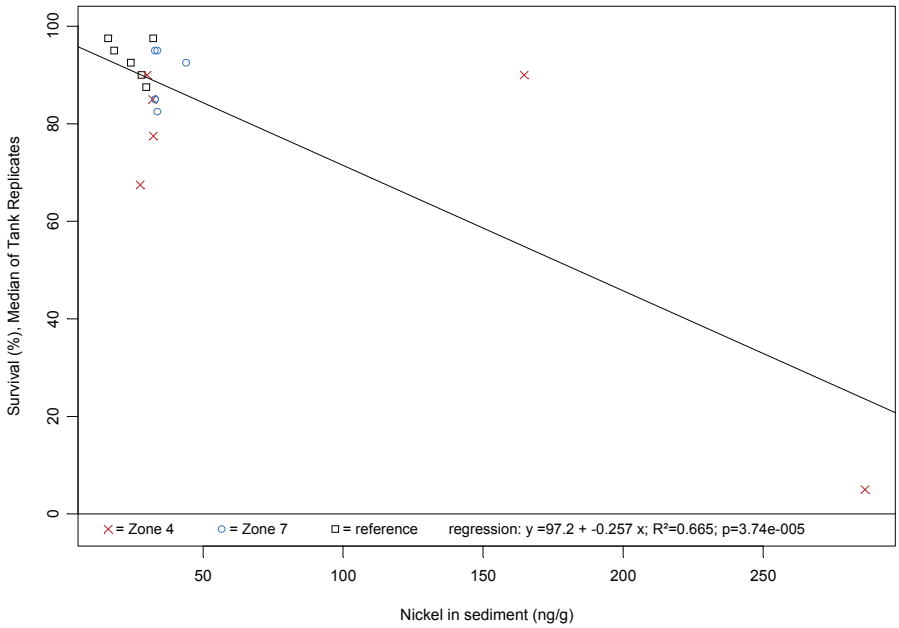

Figure A-109. Regression of Nickel vs Survival

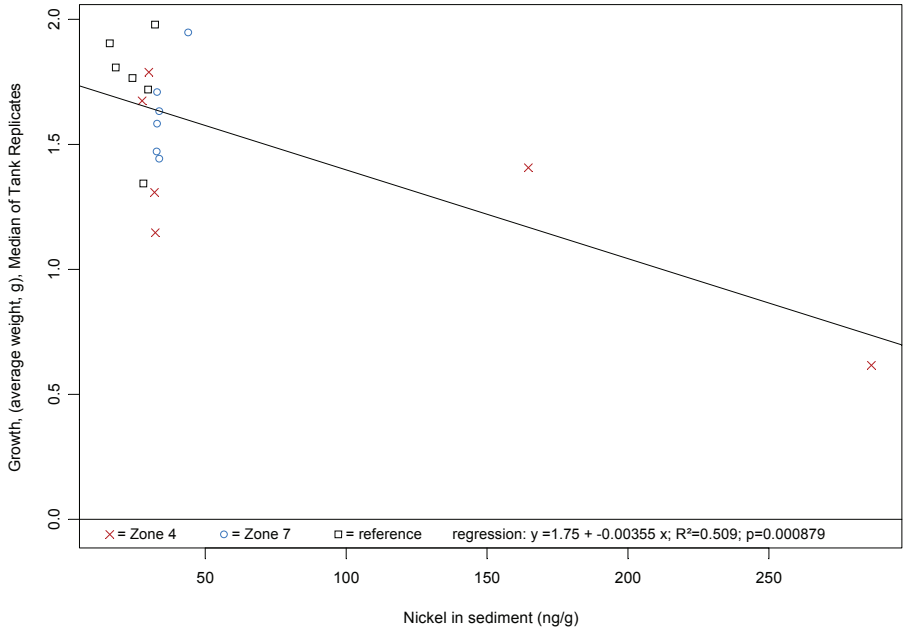

Figure A-110. Regression of Nickel vs Growth

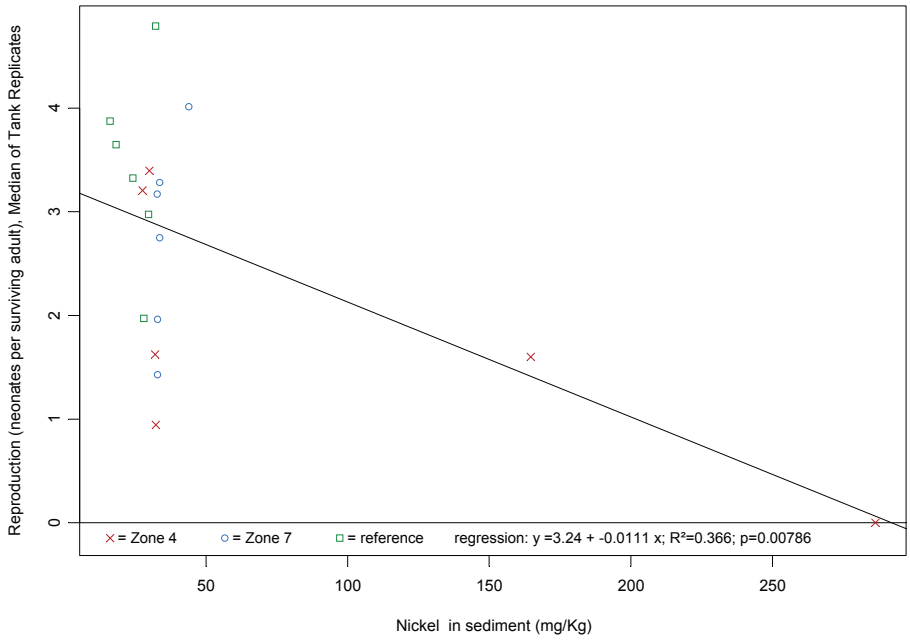

Figure A-111. Regression of Nickel vs Reproduction

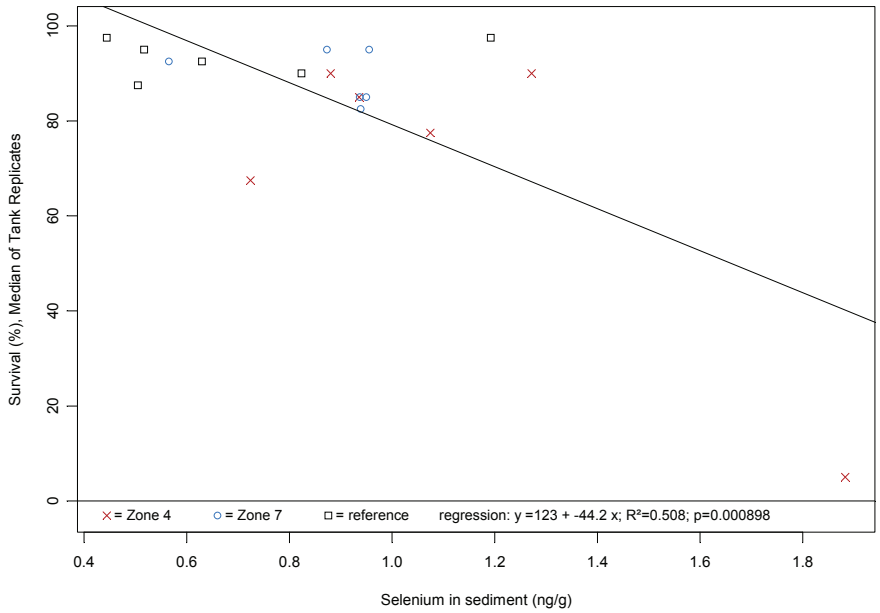

Figure A-112. Regression of Selenium vs Survival

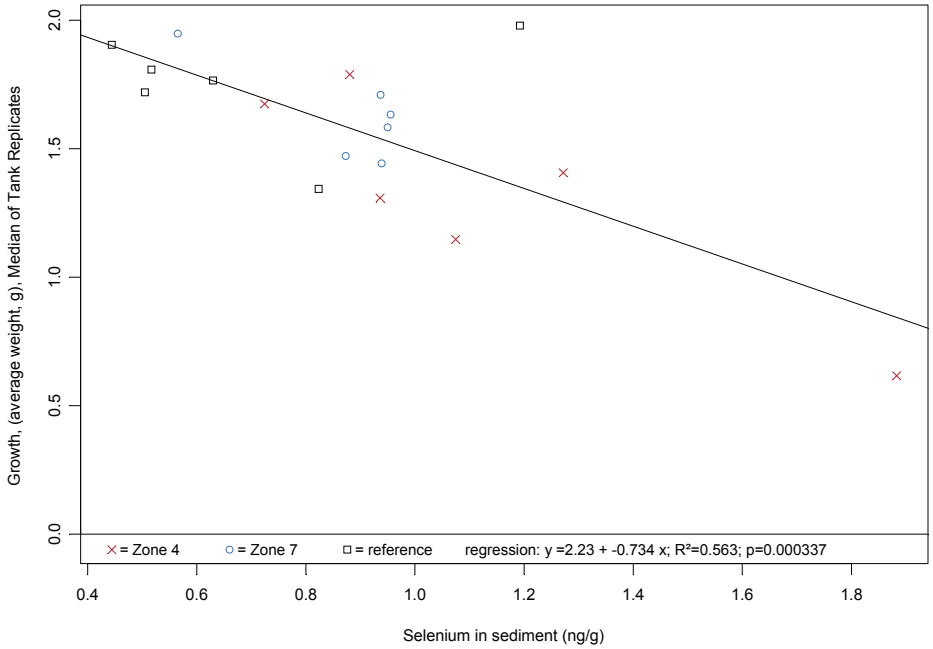

Figure A-113. Regression of Selenium vs Growth

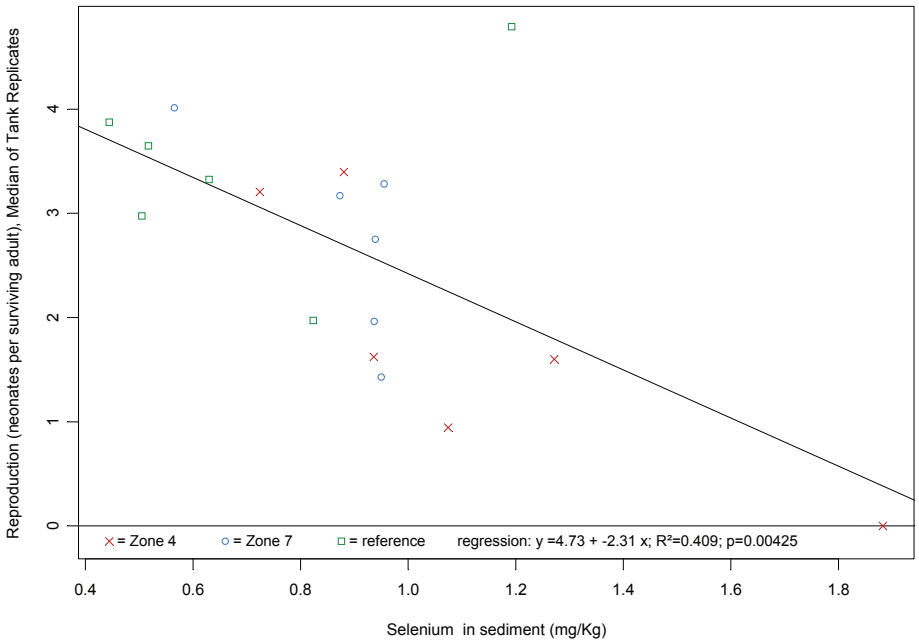

Figure A-114. Regression of Selenium vs Reproduction

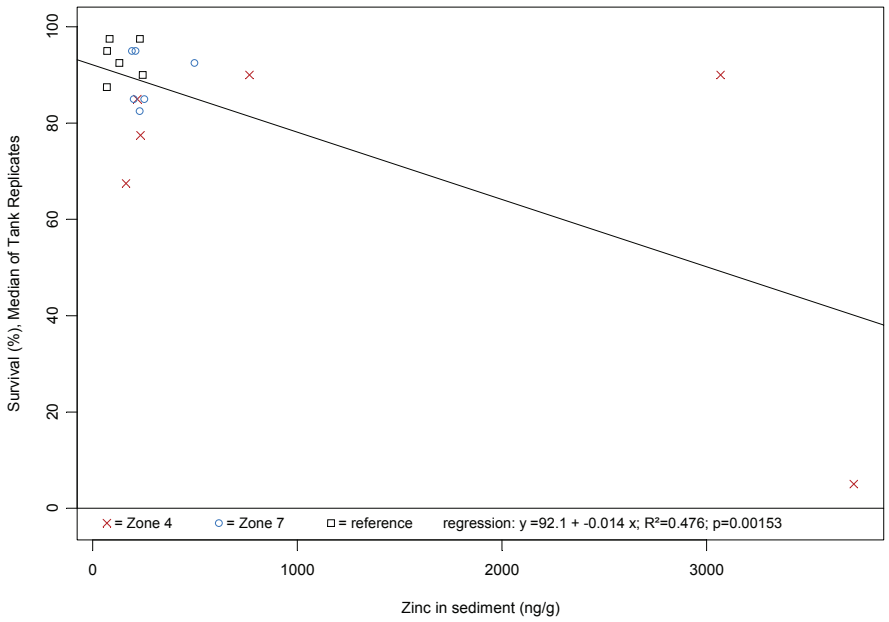

Figure A-115. Regression of Zinc vs Survival

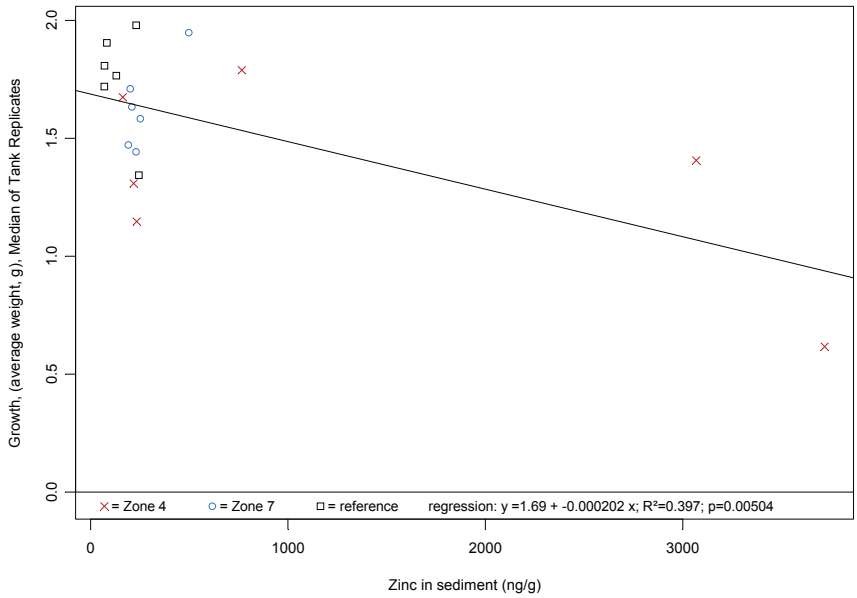

Figure A-116. Regression of Zinc vs Growth

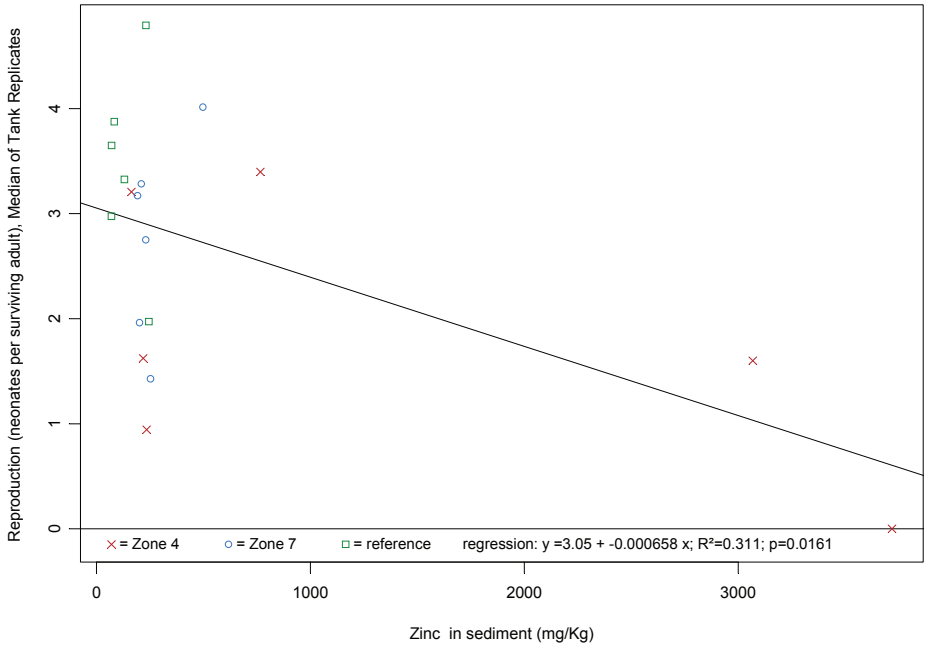

Figure A-117. Regression of Zinc vs Reproduction

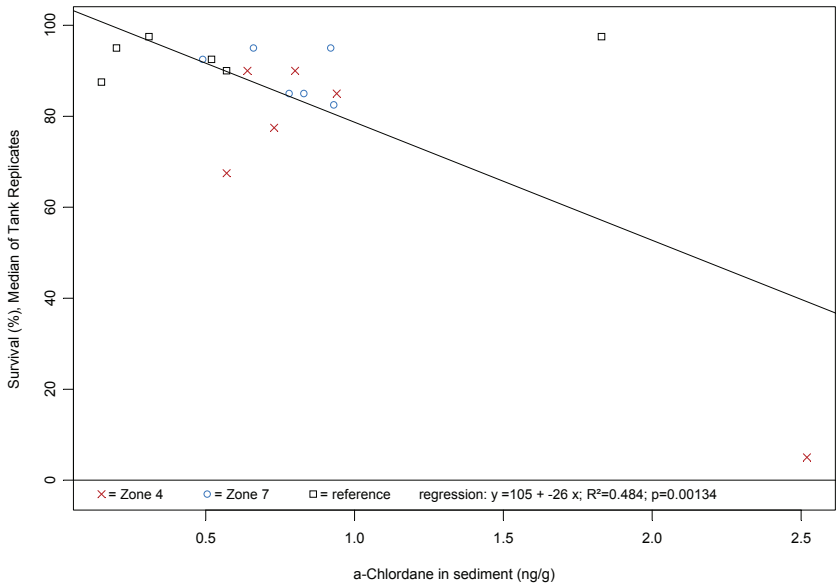

Figure A-118. Regression of a-Chlordane vs Survival

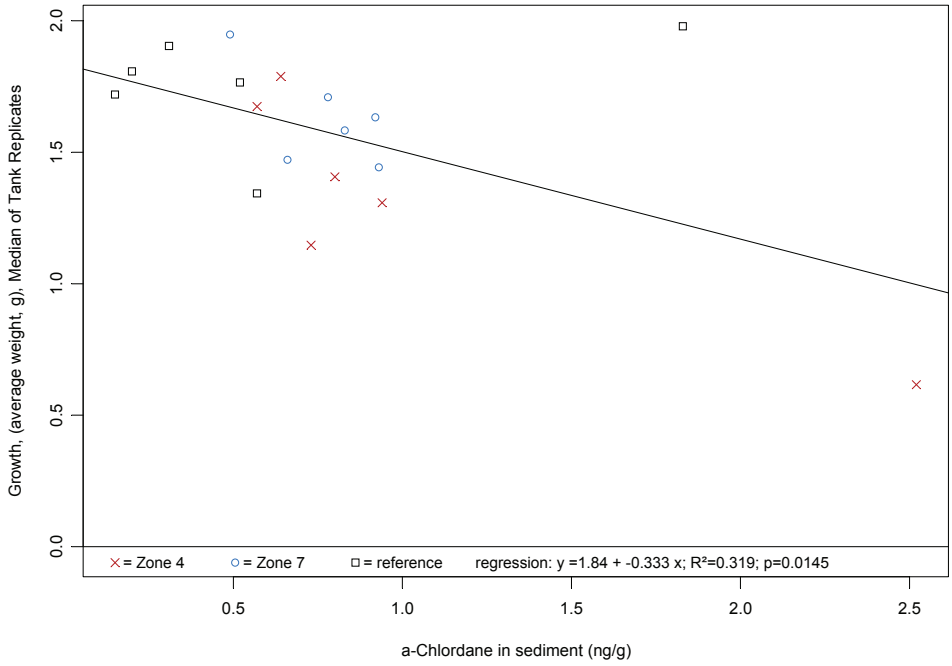

Figure A-119. Regression of a-Chlordane vs Growth

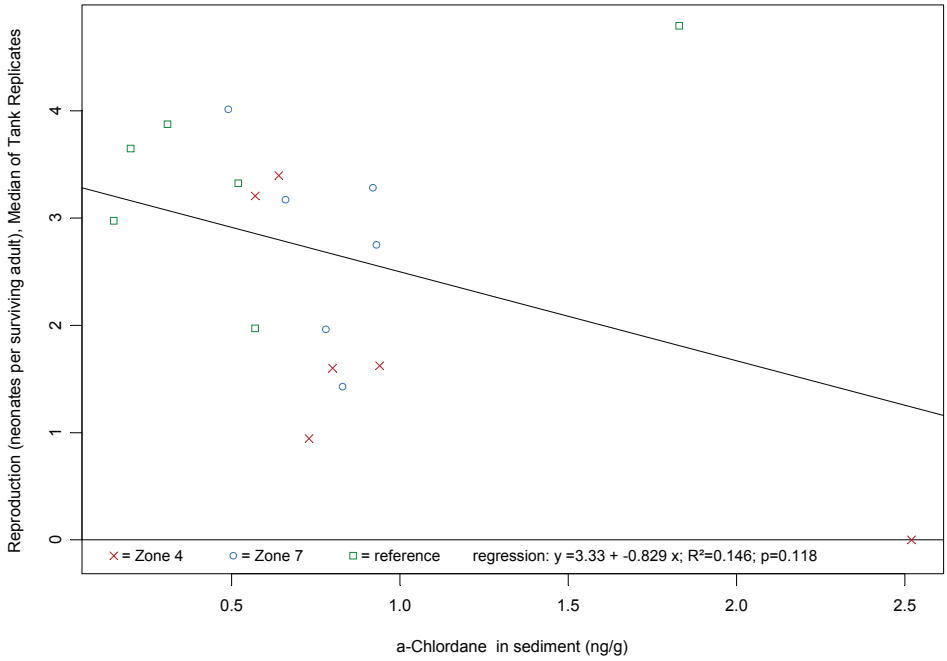

Figure A-120. Regression of a-Chlordane vs Reproduction

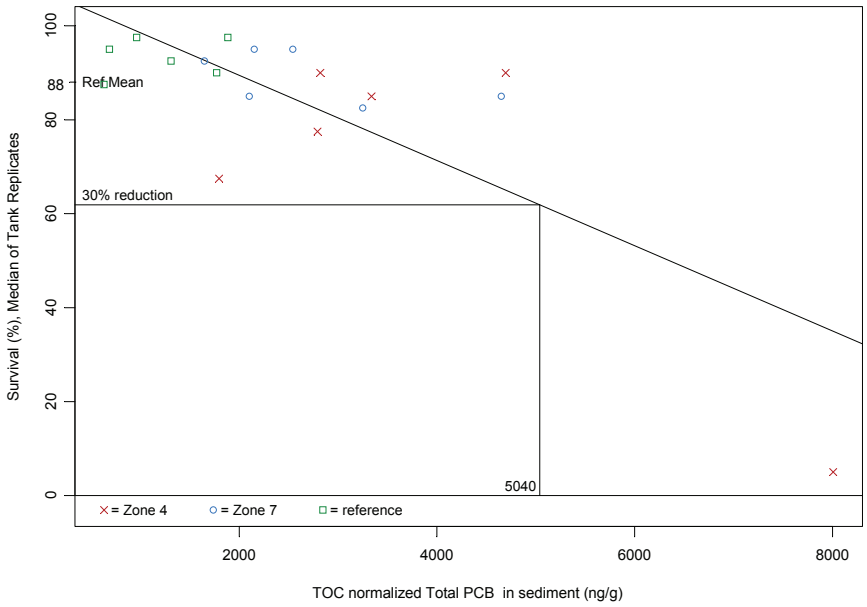

Figure A-121. Regression of TOC-normalized Total PCB vs Survival

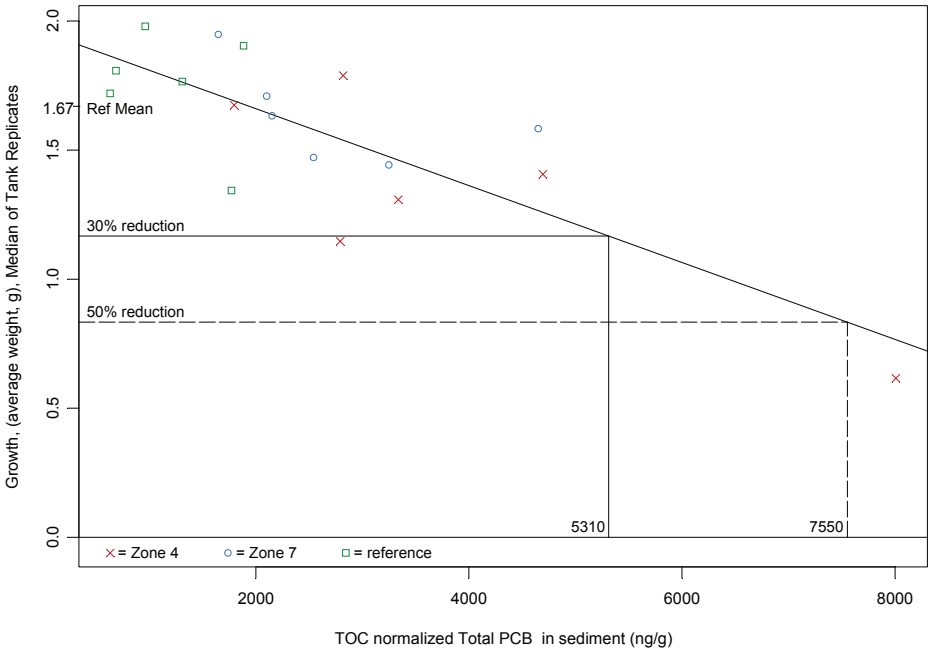

Figure A-122. Regression of TOC-normalized Total PCB vs Growth

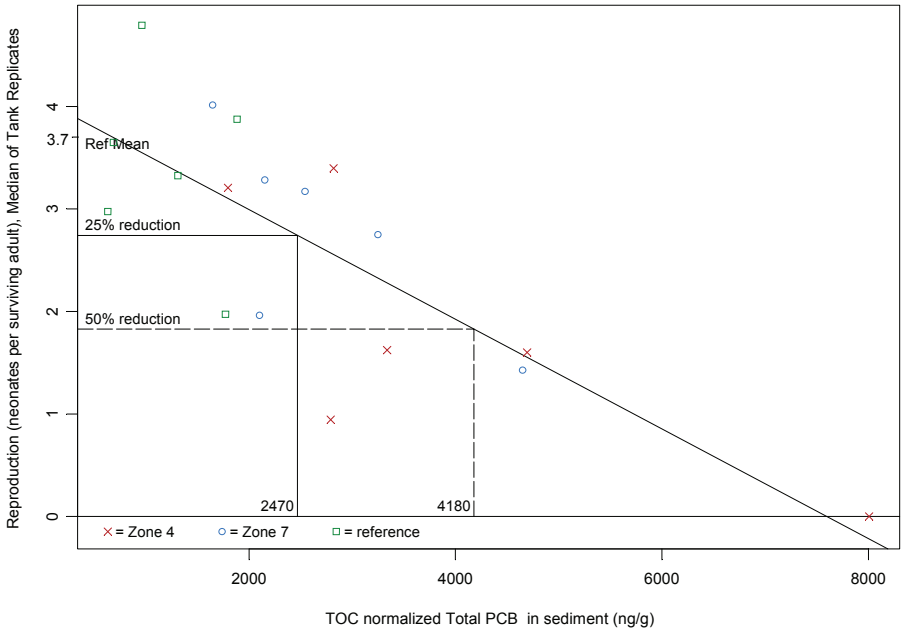

Figure A-123. Regression of TOC-normalized Total PCB vs Reproduction

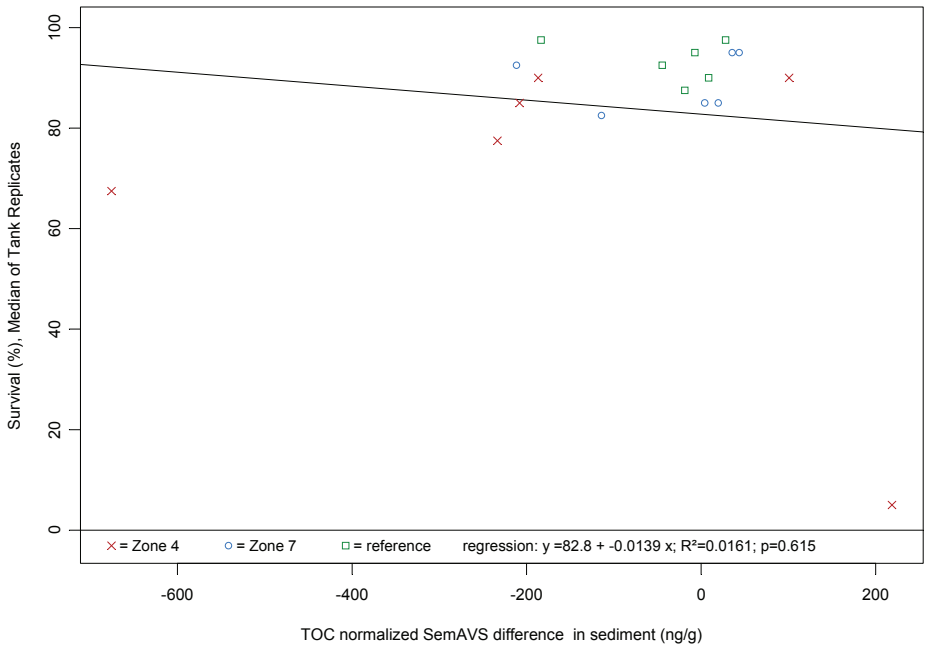

Figure A-124. Regression of TOC-normalized AVS-SEM vs Survival

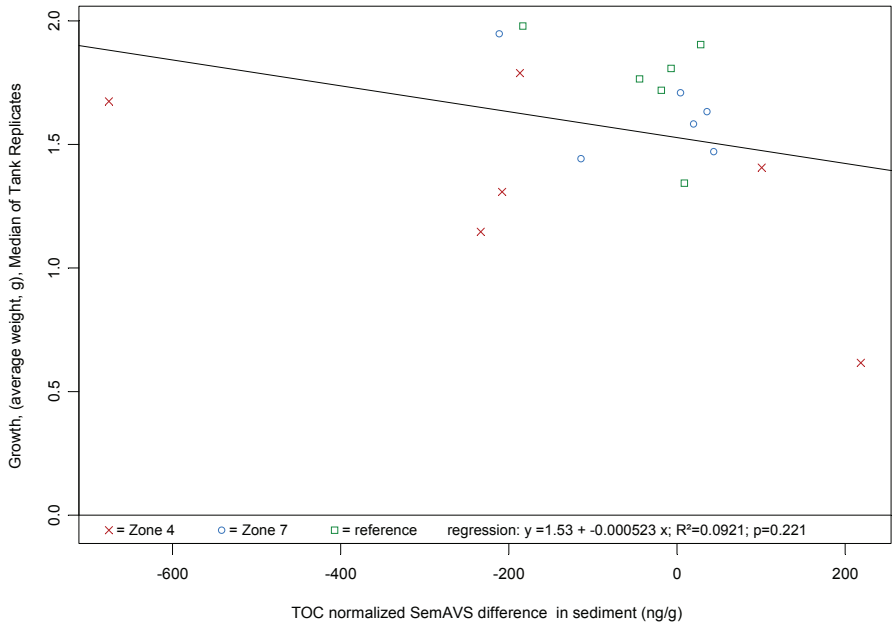

Figure A-125. Regression of TOC-normalized AVS-SEM vs Growth

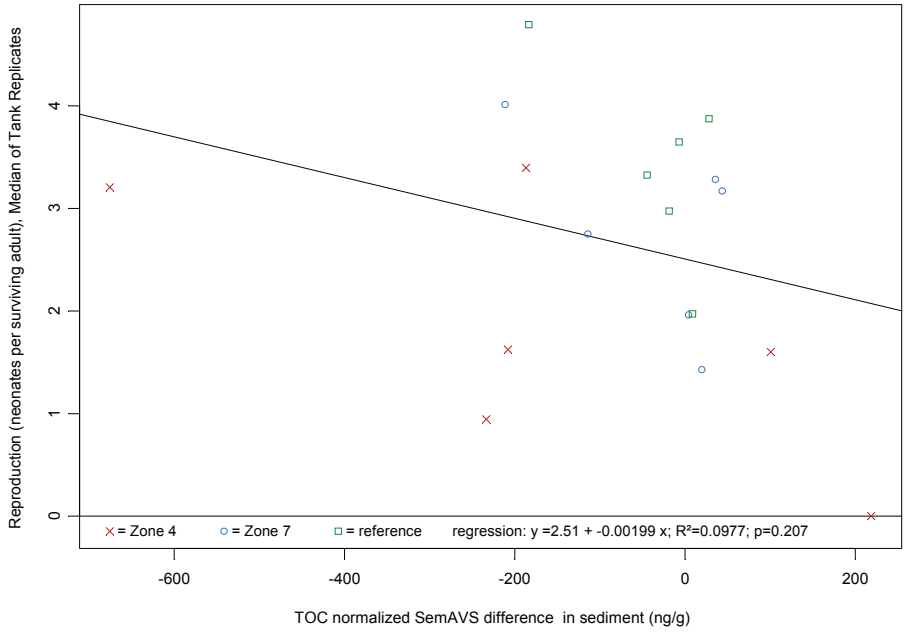

Figure A-126. Regression of TOC-normalized AVS-SEM vs Reproduction

APPENDIX B

Sediment Data

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Thames River Validation Study
Subase New London
Metals in Surface Sediment
(ug/g dry weight)

Suite	METAL																																		
Units	ug/g dry																																		
Analyte					Arsenic			Barium			Cadmium			Chromium			Copper			Lead			Mercury			Nickel			Selenium			Zinc		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	12.5			197.64			0.83			320.99			567.55			524.34						164.65			1.27			3,067.86		
Zone 4	Z4-2	2007	GAB-002	SS	10.5			475.01			2.81			313.38			734.98			840.59						286.37			1.88			3,718.45		
Zone 4	Z4-3	2007	GAB-003	LDUP	14.6			190.88			1.07			108.58			122.05			144.59						33.34			1.09			239.85		
Zone 4	Z4-3	2007	GAB-003	SS	13.9			178.4			1.06			104.82			121.09			135.78						32.25			1.07			233.54		
Zone 4	Z4-4	2007	GAB-004	SS	13.			172.73			0.91			100.34			115.41			112.45						32.01			0.94			217.85		
Zone 4	Z4-4	2007	GAB-020	FDUP	13.2			193.24			0.93			99.66			112.47			118.56						32.53			0.85			209.28		
Zone 4	Z4-5	2007	GAB-005	SS	13.8			150.95			0.65			86.59			197.82			106.13						30.01			0.88			765.93		
Zone 4	Z4-6	2007	GAB-006	SS	11.			162.07			0.5			79.31			83.95			78.63						27.59			0.72			163.05		
Zone 4	Z4-S1	2004	DAD-1	SS	13.2			92.97			0.21			61.49			254.53			54.86						14.31			0.4		J	3,706.84		
Zone 4	Z4-S2	2004	DAD-2	SS	13.9			144.88			0.58			84.62			97.32		J	101.52		J				26.44			0.8			320.95		
Zone 4	Z4-S3	2004	DAD-3	SS	12.6			143.			0.54			85.74			95.18		J	93.94		J				26.58			0.61			254.82		
Zone 4	Z4-S4	2004	DAD-4	SS	13.5			209.21			0.52			87.97			84.97		J	89.39		J				27.7			0.68			202.11		
Zone 4	Z4-S5	2004	DAD-5	SS	12.7			138.89			0.49			88.14			83.65			84.46						26.08			0.75		J	190.83		
Zone 4	Z4-S6	2004	DAD-6	SS	7.4			120.8			0.91			53.89			59.91			119.41						16.97			0.43		J	216.01		
Zone 4	Z4-S6	2004	DAD-7	FDUP	5.58			143.43			0.96			87.72			131.65		J	131.45		J				24.83			0.5			468.37		
Zone 7	Z7-1	2007	GAB-007	SS	10.7			114.62			2.18			97.77			203.1			58.63						43.96			0.57			497.07		
Zone 7	Z7-2	2007	GAB-008	SS	15.9			163.64			0.83			101.28			115.67			109.01						33.65			0.96			209.04		
Zone 7	Z7-3	2007	GAB-009	SS	14.6			204.06			1.07			106.85			133.2			95.44						33.69			0.94			229.89		
Zone 7	Z7-4	2007	GAB-010	SS	14.9			174.47			0.78			97.27			111.31			85.83						32.88			0.94			200.69		
Zone 7	Z7-5	2007	GAB-011	SS	13.7			245.46			0.77			96.52			106.37			80.02						32.79			0.87			191.89		
Zone 7	Z7-6	2007	GAB-012	SS	16.			178.51			0.91			94.75			123.79			90.63						32.88			0.95			252.56		
Zone 7	Z7-S1	2004	DAD-10	SS	12.7			133.85			0.51			95.1			113.45		J	82.48		J				28.63			0.75			201.88		
Zone 7	Z7-S2	2004	DAD-11	SS	17.1			156.38			0.52			92.73			94.77		J	78.86		J				27.83			0.83			193.44		
Zone 7	Z7-S3	2004	DAD-12	SS	21.9			145.29			0.57			87.57			91.79		J	76.08		J				28.05			0.81			187.33		
Zone 7	Z7-S4	2004	DAD-13	SS	15.9			143.31			0.57			90.13			99.94			74.2						26.36			0.78		J	185.4		
Zone 7	Z7-S4	2004	DAD-14	FDUP	13.4			159.78			0.55			89.7			108.27		J	75.19		J				27.42			0.74			191.54		
Zone 7	Z7-S5	2004	DAD-15	SS	12.1			166.69			0.55			89.66			103.19		J	79.52		J				28.42			0.75			205.88		
Zone 7	Z7-S6	2004	DAD-16	SS	16.1			138.41			0.51			90.71			96.84			76.14						27.42			0.74		J	187.65		
Outer Pier 1	P1-C3	2004	DAD-29	Core	11.6			156.92			0.73			101.24			202.53			164.55		J	0.58			42.27		J	0.83			367.87		J
Outer Pier 1	P1-C4	2004	DAD-30	Core	7.22			105.82			0.75			73.83			260.64			157.48		J	2.77			30.7		J	0.54			705.92		J
Outer Pier 1	P2	2004	DAD-21	SS	12.7			117.89			0.6			92.04			119.77			110.52			0.57			27.12			0.62		J	261.88		
Outer Pier 1	P3	2004	DAD-22	SS	12.5			121.08			0.5			78.86			101.53			90.83			0.48			25.11			0.63		J	207.46		
Outer Pier 1	P4	2004	DAD-23	SS	13.1			135.45			0.56			89.57			136.37		J	122.9		J	0.44			28.95			0.72			261.01		
Outer Pier 1	P5	2004	DAD-25	SS	15.3			154.87			0.41			88.63			76.46			78.86			0.4			26.48			0.8		J	182.8		
Outer Pier 1	P6	2004	DAD-26	SS	14.1			124.4			0.44			76.71			95.2		J	295.06		J	0.35			26.03			0.83			217.82		
Reference	R-S1	2004	DAD-32	SS	5.89			68.87			0.39			69.12			51.71		J	50.42		J	0.31			18.57			0.46			104.58		
Reference	R-S2	2004	DAD-33	SS	4.5			56.02			0.34			53.19			37.71		J	37.36		J	0.22			27.23			0.5			82.11		
Reference	R-S3	2004	DAD-34	SS	5.96			74.7			0.34			61.73			40.72		J	35.91		J	0.19			16.57			0.5			92.86		
Reference	R-S4	2004	DAD-35	SS	3.33			55.21			0.22			38.28			14.9		J	13.46		J	0.07			18.23			0.28			54.4		
Reference	R-S5	2004	DAD-36	SS	7.34			77.56			0.44			73.42			52.49		J	51.21		J	0.38			18.72			0.46			107.1		
Reference	R-S6	2004	DAD-37	SS	8.51			101.05			0.65			82.15			64.43		J	67.4		J	0.35			21.98			0.59			136.94		
Reference	RA-1	2007	GAB-013	SS	5.63			68.72			0.33			54.24			41.74			46.33						16.13			0.44			82.37		
Reference	RA-1	2007	GAB-019	SS	5.09			76.8			0.29			55.44			39.25			35.97						16.99			0.37			81.08		
Reference	RA-2	2007	GAB-014	SS	5.85			100.75			0.36			48.39			24.6			19.46						18.26			0.52			70.37		
Reference	RA-3	2007	GAB-015	SS	5.89			107.3			0.32			48.76			27.61			20.69						29.7			0.5			69.73		
Reference	RA-4	2007	GAB-016	SS	13.			146.34			0.89			114.27			97.35			96.55						28.04			0.82			245.		
Reference	RA-5	2007	GAB-017	SS	9.02			104.89			0.53			83.93			69.76			61.63						24.17			0.63			130.3		
Reference	RA-6	2007	GAB-018	SS	14.7			141.15			1.32			105.2			103.93			101.09						32.24			1.19			231.24		

LDUP = laboratory duplicate
FDUP = field duplicate
SS= surface sediment
J = Estimated value. The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.

Thames River Validation Study
Subase New London
PAHs in Surface Sediment
(ng/g dry weight)

Suite	PAH																																	
Units	ng/g dry																																	
Analyte					1-Methylnaphthalene			1-Methylphenanthrene			2,3,5-trimethylnaphthalene			2,6-dimethylnaphthalene			2-Methylnaphthalene			Acenaphthene			Acenaphthylene			Anthracene			Benzo(a)anthracene			Benzo(a)pyrene		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	27.54			351.02			24.36			66.11		J	83.28		J	343.72			278.39			2,388.42	D	J	4,746.06	D		3,557.48	D	
Zone 4	Z4-2	2007	GAB-002	SS	34.31			148.26			19.89			49.74			64.81			231.87			100.83			662.59			2,169.44	D		1,510.61	D	
Zone 4	Z4-3	2007	GAB-003	SS	79.9			365.4			47.			97.42			147.51			1,422.81			135.9			1,009.9			1,808.03			1,412.		
Zone 4	Z4-4	2007	GAB-004	SS	86.75			266.87			39.92			87.18			136.72			964.92	D		124.25			721.42			1,758.4	D		1,202.66	D	
Zone 4	Z4-4	2007	GAB-020	FDUP	49.97			168.62			21.51			51.18			87.08			565.97			81.65			491.13			1,195.68			934.42		
Zone 4	Z4-5	2007	GAB-005	SS	27.38			126.8			10.3			35.98			45.91			85.34			107.1			643.71			1,562.23			1,229.58		
Zone 4	Z4-6	2007	GAB-006	SS	37.3			103.8			10.43			40.81			75.76			214.07			88.89			416.18			1,068.78			1,030.7		
Zone 4	Z4-S1	2004	DAD-1	SS	35.02			196.93			20.07			46.53			56.49			305.69			210.91			1,197.81			3,537.48	B		2,121.91	B	
Zone 4	Z4-S2	2004	DAD-2	SS	24.11			243.59			23.93			55.35			45.2			837.1			153.42			1,382.52			2,977.64	D		2,426.48		
Zone 4	Z4-S3	2004	DAD-3	SS	40.69			364.89			15.65			76.05			62.68			1,059.35			243.74			2,016.07			7,278.68	B		2,927.8	B	
Zone 4	Z4-S4	2004	DAD-4	SS	52.05			257.37			25.19			88.04			57.49			956.93			185.28			1,137.64			4,144.95	B		2,062.66	B	
Zone 4	Z4-S5	2004	DAD-5	SS	22.16			134.84			8.63			37.44			56.38			59.71			162.76			950.28			2,678.41	B		1,721.85	B	
Zone 4	Z4-S6	2004	DAD-6	SS	21.77			72.79			9.33			40.32			48.1			39.34			102.58			422.31			1,309.16			1,117.98		
Zone 4	Z4-S6	2004	DAD-7	FDUP	35.84			110.93			12.2			68.31			76.88			59.34			102.06			499.62			1,612.68			1,294.67		
Zone 7	Z7-1	2007	GAB-007	SS	13.32			51.17			3.99			10.52			16.4			31.44			37.25			154.48			467.97			429.83		
Zone 7	Z7-2	2007	GAB-008	SS	20.5			84.21			8.11			24.76			38.38			51.21			77.88			168.26			582.5			697.55		
Zone 7	Z7-3	2007	GAB-009	SS	27.77			94.07			11.18			35.57			53.77			122.95			88.23			263.74			729.2			772.41		
Zone 7	Z7-4	2007	GAB-010	SS	20.19			80.25			8.46			26.09			39.51			49.79			73.9			210.03			564.93			673.64		
Zone 7	Z7-5	2007	GAB-011	SS	18.21			71.08			6.99			22.88			35.44			44.46			67.58			167.55			498.95			597.4		
Zone 7	Z7-6	2007	GAB-012	SS	31.73			118.94			18.23			45.24			65.64			185.06			91.32			491.11			970.18			969.17		
Zone 7	Z7-S1	2004	DAD-10	SS	17.55			78.56			6.64			54.22			35.27			40.82			89.39			272.42			872.41	B		822.7	B	
Zone 7	Z7-S2	2004	DAD-11	SS	11.21			45.88			3.85			14.78			23.74			18.95			54.95			139.56			383.56			483.96		
Zone 7	Z7-S3	2004	DAD-12	SS	16.7			55.27			5.79			21.16			33.08			23.38			80.78			191.5			554.26	B		629.4	B	
Zone 7	Z7-S4	2004	DAD-13	SS	31.2			516.23			39.15			61.07			69.03			102.88			184.48			641.36			1,526.34			1,451.78		
Zone 7	Z7-S4	2004	DAD-14	FDUP	27.85			62.34			6.09			42.86			54.96			96.05			84.05			241.48			716.04	B		735.6	B	
Zone 7	Z7-S5	2004	DAD-15	SS	21.69			151.19			18.35			58.72			41.36			51.4			105.07			375.94			929.57	B		847.15	B	
Zone 7	Z7-S6	2004	DAD-16	SS	16.82			60.11			5.11			42.8			34.39			25.2			83.87			233.89			662.14			756.78		
Outer Pier 1	P1-C3	2004	DAD-29	Core	26.62			103.47			8.32			32.47			52.41			44.			175.19			522.33			2,238.4	B		1,864.69	B	
Outer Pier 1	P1-C4	2004	DAD-30	Core	15.92	J		119.04			8.18	U		9.05	U		30.61	J		54.02	J		92.39			380.23			1,167.16	B		1,510.91	B	
Outer Pier 1	P2	2004	DAD-21	SS	18.08			141.59			7.24			33.88			49.47			39.46			210.73			3,194.92			4,037.05	B		2,957.26	B	
Outer Pier 1	P3	2004	DAD-22	SS	22.65			111.57			6.96			29.57			46.58			33.72			171.51			685.4			2,013.88	B		2,069.45	B	
Outer Pier 1	P4	2004	DAD-23	SS	18.46			112.35			5.39			31.81			41.23			40.27			175.84			806.			2,810.79	B		2,472.81	B	
Outer Pier 1	P5	2004	DAD-25	SS	21.18			100.43			8.22			40.19			46.47			45.12			96.			561.83			2,004.52	B		1,243.82	B	
Outer Pier 1	P6	2004	DAD-26	SS	12.48		J	198.23			7.63			27.58			29.22		J	66.65			161.48		J	788.56		J	3,292.41		J	1,954.41		J
Reference	R-S1	2004	DAD-32	SS	15.59			50.84			5.71			17.85			28.06			10.64			48.13			124.36			351.95			464.66		
Reference	R-S2	2004	DAD-33	SS	7.78			23.53			3.31			8.37			13.79			5.08			21.59			41.89			160.59			223.6		
Reference	R-S3	2004	DAD-34	SS	5.34			20.37			2.16			5.92			10.11			3.73			23.36			30.92			130.58			197.31		
Reference	R-S4	2004	DAD-35	SS	5.12			16.54			1.33			5.43			8.56			6.39			15.88			30.79			103.7			134.62		
Reference	R-S5	2004	DAD-36	SS	15.56			56.77			4.84			16.53			29.			12.67			61.62			100.03			407.44	B		518.31	B	
Reference	R-S6	2004	DAD-37	SS	18.03			64.17			5.48			18.07			33.11			13.74			74.78			107.4			427.47	B		589.77	B	
Reference	RA-1	2007	GAB-013	SS	6.25			30.27			3.13			8.03			10.27			5.72			25.85			41.18			172.92			242.12		
Reference	RA-1	2007	GAB-019	FDUP	7.6			31.56			4.21			9.04			13.1			5.41			25.32			42.23			182.34			254.25		
Reference	RA-2	2007	GAB-014	SS	3.75			10.93			1.39			3.9			5.43			2.31			11.24			12.75			59.44			88.96		
Reference	RA-3	2007	GAB-015	SS	3.77			11.73			1.37			4.3			6.15			2.82			10.29			13.67			62.95			87.75		
Reference	RA-4	2007	GAB-016	SS	15.64			75.35			8.48			21.54			29.87			14.15			66.79			94.48			357.24			576.09		
Reference	RA-5	2007	GAB-017	SS	14.36			66.78			5.69			16.14			25.66			12.98			59.18			89.55			384.51			548.55		
Reference	RA-6	2007	GAB-018	SS	20.23			123.64			7.92			21.11			33.19			26.44			103.41			147.89			654.59			939.81		

Thames River Validation Study
Subase New London
PAHs in Surface Sediment
(ng/g dry weight)

Suite	PAH																																				
Units	ng/g dry																																				
Analyte					Benzo(b)fluoranthene			Benzo(e)pyrene			Benzo(g,h,i)perylene			Benzo(k)fluoranthene			Biphenyl			Chrysene			Dibenz(a,h)anthracene			Fluoranthene			Fluorene			Indeno(1,2,3-cd)pyrene			Naphthalene		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	3,939.38	D		2,817.11	D		1,611.71	D		3,963.7	D		48.28			5,626.7	D		703.34		J	9,764.36	D		712.29			2,053.75	D		126.93		
Zone 4	Z4-2	2007	GAB-002	SS	1,627.66	D		1,245.19			782.13			1,638.1			31.14			2,627.16	D		266.53			6,102.24	D		207.54			1,019.96			162.97		
Zone 4	Z4-3	2007	GAB-003	SS	1,338.28			1,035.29			702.51			1,380.93			69.44			1,771.89			207.66			6,684.72	D		949.17			887.08			507.74		
Zone 4	Z4-4	2007	GAB-004	SS	1,118.24	D		911.72	D		660.27			1,150.23			71.17			1,739.25	D		215.95			6,420.66	D		529.19			852.25			369.35		
Zone 4	Z4-4	2007	GAB-020	FDUP	909.63			693.25			484.3			924.97			40.6			1,154.41			139.46			3,954.77			321.95			597.74			267.18		
Zone 4	Z4-5	2007	GAB-005	SS	1,297.61			969.59			607.45			1,350.27			18.16			1,750.84			161.78			4,407.07	D		148.44			744.91			91.28		
Zone 4	Z4-6	2007	GAB-006	SS	1,005.04			782.23			556.92			1,070.55			31.07			1,258.85			163.74			2,595.37			194.06			711.32			111.41		
Zone 4	Z4-S1	2004	DAD-1	SS	2,406.5	B		1,679.12			854.62			2,408.56			32.57			5,039.4	B		257.1			10,787.63	B		366.68			1,020.75			284.4		
Zone 4	Z4-S2	2004	DAD-2	SS	2,794.24			1,932.			1,022.97			2,666.41			25.95			3,872.42	D		316.01			9,175.89	D		392.7			1,243.25			83.6		
Zone 4	Z4-S3	2004	DAD-3	SS	3,684.13	B		2,326.11			1,121.17			3,461.52			42.13			7,556.92	B		380.19			17,702.57	D		619.13			1,500.01			122.38		
Zone 4	Z4-S4	2004	DAD-4	SS	2,406.41	B		1,623.01			844.02			2,469.9			58.62			4,313.86	B		266.5			10,432.38			706.23			1,073.82			91.56		
Zone 4	Z4-S5	2004	DAD-5	SS	1,890.93	B		1,404.92			776.42			2,057.93			19.86			3,452.61	B		230.23			7,091.56	B		176.13			882.86			88.01		
Zone 4	Z4-S6	2004	DAD-6	SS	1,240.04			956.7			552.14			1,237.29			17.85			1,538.53			178.8			2,080.33			84.68			649.57			76.43		
Zone 4	Z4-S6	2004	DAD-7	FDUP	1,416.12			1,119.9			698.05			1,476.55			27.74			1,747.12			194.04			2,534.65			117.53			800.51			101.08		
Zone 7	Z7-1	2007	GAB-007	SS	496.32			377.89			252.63			493.			6.98			632.95			69.86			1,101.76			39.68			323.88			21.68		
Zone 7	Z7-2	2007	GAB-008	SS	647.91			564.54			474.33			709.29			15.9			732.67			120.22			1,361.92			66.56			563.83			79.74		
Zone 7	Z7-3	2007	GAB-009	SS	720.38			620.65			496.61			777.65			25.05			879.33			132.61			1,975.26			121.01			595.32			109.75		
Zone 7	Z7-4	2007	GAB-010	SS	643.74			543.58			453.4			654.03			16.57			700.52			113.19			1,386.47			68.5			530.11			86.15		
Zone 7	Z7-5	2007	GAB-011	SS	573.55			476.93			398.38			576.63			14.94			616.72			101.62			1,172.04			60.32			475.07			80.96		
Zone 7	Z7-6	2007	GAB-012	SS	926.63			751.42			560.63			975.48			27.74			1,147.96			161.33			2,695.98			164.6			696.95			195.6		
Zone 7	Z7-S1	2004	DAD-10	SS	866.93	B		706.05			573.34			896.72			13.46			1,088.2	B		151.8			1,963.12	B	J	74.95			649.18			49.36		
Zone 7	Z7-S2	2004	DAD-11	SS	470.71			420.67			337.71			512.62			9.52			569.33			83.86			829.48			34.21			391.47			36.04		
Zone 7	Z7-S3	2004	DAD-12	SS	680.93	B		566.9			434.95			702.08			11.93			805.86	B		117.93			1,167.37	B	J	48.41			511.57			51.07		
Zone 7	Z7-S4	2004	DAD-13	SS	1,095.13			1,059.5			793.92			1,294.08			20.37			1,861.82			213.95			2,855.51			135.67			881.4			91.69		
Zone 7	Z7-S4	2004	DAD-14	FDUP	788.14	B		651.88			475.31			837.97			20.62			1,029.12	B		124.31			1,530.36	B		105.99			553.81			54.09		
Zone 7	Z7-S5	2004	DAD-15	SS	951.62	B		747.88			531.37			955.95			16.79			1,241.18	B		151.24			2,222.63	B		125.15			633.51			56.99		
Zone 7	Z7-S6	2004	DAD-16	SS	768.97			647.67			494.41			813.11			13.9			935.2			127.97			1,423.34			55.26			564.83			52.06		
Outer Pier 1	P1-C3	2004	DAD-29	Core	2,068.74	B		1,604.67			937.72			2,195.96			20.02			2,585.02	B		271.4			2,864.06	B		105.31			1,091.79			90.5		
Outer Pier 1	P1-C4	2004	DAD-30	Core	1,564.42	B		1,356.09			817.29			1,834.62			9.19	U		1,635.16	B		233.45			2,422.82	B		86.29			908.26			60.26		
Outer Pier 1	P2	2004	DAD-21	SS	3,914.49	B		2,486.08			1,340.4			3,054.45			16.98			5,542.68	B		459.88			5,468.48	B		216.3			1,705.45			72.91		
Outer Pier 1	P3	2004	DAD-22	SS	2,277.98	B		1,742.71			1,064.55			2,332.45			14.82			3,113.26	B		301.32			2,965.52	B		101.04			1,210.06			72.96		
Outer Pier 1	P4	2004	DAD-23	SS	2,921.21	B		2,081.95			1,175.74			2,766.05			14.24			4,328.2	B		376.36			4,095.51	B		110.99			1,487.64			81.95		
Outer Pier 1	P5	2004	DAD-25	SS	1,370.98	B		1,010.51			531.27			1,452.18			18.23			2,080.32	B		160.14			4,301.28	B		122.98			599.78			77.62		
Outer Pier 1	P6	2004	DAD-26	SS	2,400.65		J	1,633.82		J	777.53		J	2,432.46		J	13.31			3,797.91	D		220.56		J	7,992.24	D		148.73			956.21		J	40.42		J
Reference	R-S1	2004	DAD-32	SS	403.91			387.39			317.6			468.25			13.91			487.17			80.28			614.37			21.38			351.87			34.44		
Reference	R-S2	2004	DAD-33	SS	194.99			189.3			151.64			229.59			4.92			204.87			34.84			308.64			11.12			157.12			17.11		
Reference	R-S3	2004	DAD-34	SS	176.94			168.39			142.96			199.32			3.69			186.92			31.1			285.55			8.81			146.5			14.29		
Reference	R-S4	2004	DAD-35	SS	103.			103.83			86.98			128.89			2.79			131.24			20.44			186.25			8.29			89.77			10.69		
Reference	R-S5	2004	DAD-36	SS	471.27	B		440.07			364.54			503.08			9.51			509.99	B		96.26			728.51	B		26.35			404.59			38.85		
Reference	R-S6	2004	DAD-37	SS	554.07	B		508.75			424.04			596.49			10.63			582.14	B		102.74			885.83	B		30.09			469.69			44.5		
Reference	RA-1	2007	GAB-013	SS	230.11			204.71			171.79			237.21			4.47			209.88			38.97			421.48			12.88			191.37			9.52		
Reference	RA-1	2007	GAB-019	FDUP	230.			208.1			177.98			243.05			4.96			214.34			43.42			393.09			12.			205.27			15.47		
Reference	RA-2	2007	GAB-014	SS	83.12			75.22			67.83			88.71			1.91			80.93			14.01			150.7			4.85			74.04			6.48		
Reference	RA-3	2007	GAB-015	SS	83.56			74.72			66.3			87.45			2.56			83.99			14.07			159.66			5.62			72.61			7.59		
Reference	RA-4	2007	GAB-016	SS	483.75			460.32			404.64			537.25			11.46			445.01			99.96			729.19			31.22			464.73			32.41		
Reference	RA-5	2007	GAB-017	SS	459.21			420.06			376.26			505.02			9.23			474.85			87.36			849.54			27.58			429.28			33.84		
Reference	RA-6	2007	GAB-018	SS	900.94			773.67			704.57			897.02			11.42			897.57			163.25			1,719.15			51.37			826.64			44.23		

Thames River Validation Study
Subase New London
PAHs in Surface Sediment
(ng/g dry weight)

Suite	PAH																		
Units	ng/g dry																		
Analyte					Perylene			Phenanthrene			Pyrene			Total HPAH			Total LPAH		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	1,017.93	D	J	3,924.54	D		10,040.52	D		34,438.46			7,857.57		
Zone 4	Z4-2	2007	GAB-002	SS	548.71		J	1,153.73			5,786.98	D		18,462.96			2,584.34		
Zone 4	Z4-3	2007	GAB-003	SS	592.02		J	3,158.23	D		5,754.68	D		17,638.98			7,331.26		
Zone 4	Z4-4	2007	GAB-004	SS	624.6		J	2,381.3	D		5,564.57	D		16,901.49			5,227.15		
Zone 4	Z4-4	2007	GAB-020	FDUP	428.01		J	1,234.25			3,500.92			10,879.66			3,049.21		
Zone 4	Z4-5	2007	GAB-005	SS	389.76		J	1,145.97			4,500.55	D		13,612.05			2,267.75		
Zone 4	Z4-6	2007	GAB-006	SS	385.77		J	927.79			2,942.86			9,060.3			2,028.16		
Zone 4	Z4-S1	2004	DAD-1	SS	591.77			2,504.56			7,471.9	B		29,215.42			4,926.54		
Zone 4	Z4-S2	2004	DAD-2	SS	686.72			3,169.96			6,116.23	D		24,884.67			6,064.5		
Zone 4	Z4-S3	2004	DAD-3	SS	822.41			6,401.38			12,314.22	D	J	48,160.38			10,524.73		
Zone 4	Z4-S4	2004	DAD-4	SS	634.98			4,634.91			9,491.93		J	30,712.28			7,770.04		
Zone 4	Z4-S5	2004	DAD-5	SS	542.9			1,124.54			5,097.67	B		20,272.33			2,617.81		
Zone 4	Z4-S6	2004	DAD-6	SS	290.21			515.4			2,880.28			9,105.08			1,288.84		
Zone 4	Z4-S6	2004	DAD-7	FDUP	350.89			724.41			4,125.34			11,508.5			1,680.92		
Zone 7	Z7-1	2007	GAB-007	SS	164.49		J	376.85			1,107.51			3,809.88			677.78		
Zone 7	Z7-2	2007	GAB-008	SS	413.95		J	516.67			1,415.18			4,910.04			998.7		
Zone 7	Z7-3	2007	GAB-009	SS	448.25		J	634.78			1,994.94			6,483.75			1,394.23		
Zone 7	Z7-4	2007	GAB-010	SS	369.77		J	469.35			1,425.87			4,864.62			997.23		
Zone 7	Z7-5	2007	GAB-011	SS	358.08		J	417.28			1,228.35			4,215.08			873.59		
Zone 7	Z7-6	2007	GAB-012	SS	471.58		J	749.07			2,138.96			8,083.58			1,942.4		
Zone 7	Z7-S1	2004	DAD-10	SS	373.54			560.24			1,725.66	B		6,623.89			1,122.45		
Zone 7	Z7-S2	2004	DAD-11	SS	199.41			269.52			788.4			3,138.59			576.97		
Zone 7	Z7-S3	2004	DAD-12	SS	308.65			373.99			1,085.18	B		4,360.			802.21		
Zone 7	Z7-S4	2004	DAD-13	SS	468.35			979.17			3,342.86			11,252.26			2,204.28		
Zone 7	Z7-S4	2004	DAD-14	FDUP	327.95			536.52			1,338.92	B		5,474.35			1,173.14		
Zone 7	Z7-S5	2004	DAD-15	SS	351.29			1,009.78			1,836.86	B	J	7,228.63			1,765.69		
Zone 7	Z7-S6	2004	DAD-16	SS	333.86			364.85			1,322.71			5,228.14			849.52		
Outer Pier 1	P1-C3	2004	DAD-29	Core	852.28			737.51			5,269.8	B		14,821.97			1,727.25		
Outer Pier 1	P1-C4	2004	DAD-30	Core	396.86			822.69			4,123.02	B		10,859.07			1,526.49		
Outer Pier 1	P2	2004	DAD-21	SS	791.93			1,264.24			6,238.28	B		24,243.75			5,048.03		
Outer Pier 1	P3	2004	DAD-22	SS	612.99			883.87			3,273.45	B		13,435.56			1,995.08		
Outer Pier 1	P4	2004	DAD-23	SS	706.88			852.09			4,287.16	B	J	17,994.47			2,108.37		
Outer Pier 1	P5	2004	DAD-25	SS	325.14			1,218.22			3,961.3	B		13,591.24			2,168.24		
Outer Pier 1	P6	2004	DAD-26	SS	555.29		J	1,929.12			6,207.26	D	J	23,244.23			3,164.18		
Reference	R-S1	2004	DAD-32	SS	153.56			229.22			727.45			2,725.88			496.23		
Reference	R-S2	2004	DAD-33	SS	84.9			113.2			360.			1,292.54			223.78		
Reference	R-S3	2004	DAD-34	SS	85.67			104.27			309.41			1,140.87			195.49		
Reference	R-S4	2004	DAD-35	SS	360.46			73.04			214.94			791.19			153.64		
Reference	R-S5	2004	DAD-36	SS	231.48			289.46			862.47	B	J	3,122.98			557.98		
Reference	R-S6	2004	DAD-37	SS	284.21			348.85			1,025.36	B		3,613.31			652.47		
Reference	RA-1	2007	GAB-013	SS	96.97		J	163.04			491.01			1,576.38			268.46		
Reference	RA-1	2007	GAB-019	FDUP	97.95		J	151.03			468.05			1,555.49			264.56		
Reference	RA-2	2007	GAB-014	SS	85.16		J	56.95			174.35			568.39			100.01		
Reference	RA-3	2007	GAB-015	SS	76.7		J	61.73			181.6			590.02			107.87		
Reference	RA-4	2007	GAB-016	SS	218.41		J	353.89			1,010.72			3,218.21			622.81		
Reference	RA-5	2007	GAB-017	SS	226.6		J	350.02			1,004.96			3,349.77			598.81		
Reference	RA-6	2007	GAB-018	SS	501.01		J	737.05			1,805.77			6,180.14			1,143.58		

Definitions

FDUP = field duplicate
SS= surface sediment
J = Estimated value. The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimatior
B=Blank contamination. The anlalyte was detected above the RL in an associated blank. For this study, blank contamination indicate
that the analyte was found in both a sample and the associated blank. The "B" is reported on the result associated with the field sample:
D=Dilution run. Initial run outside linear range of instrument. The sample was diluted to within the calibration range and re-run.
Only analytes above the calibration range are reported from a further dilution
U=Undetected at the MDL: The associated value is the MDL, adjusted by any dilution factor

Thames River Validation Study
Subase New London
PCBs in Surface Sediment
(ng/g dry weight)

Suite	PCB CONGENERS																																								
Units	ng/g dry																																								
Analyte					Cl2(8)			Cl3(18)			Cl3(28)			Cl4(44)			Cl4(52)			Cl4(66)			Cl4(77)			Cl5(101)			Cl5(105)			Cl5(118)			Cl5(126)			Cl6(128)		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	12.76			14.4			14.93			7.32			9.59			6.78			0.04	U	U	12.74			1.78			5.44			0.04	U	U	2.61		
Zone 4	Z4-2	2007	GAB-002	SS	10.34			16.48			18.17			14.55			17.38			15.51			0.04	U	U	17.89			6.86			15.98			0.04	U	U	3.96		
Zone 4	Z4-3	2007	GAB-003	SS	7.72			6.3			9.66			5.95			8.57			6.51			0.04	U	U	9.64			1.88			6.03			0.04	U	U	3.4		
Zone 4	Z4-4	2007	GAB-004	SS	4.99			4.01			7.92			6.41			9.25			6.7			0.04	U	U	10.55			2.5			7.46			0.04	U	U	3.13		
Zone 4	Z4-4	2007	GAB-020	FDUP	3.09			2.31			4.65			3.83			4.78			5.23			0.04	U	U	6.34			1.39			4.2			0.04	U	U	1.59		
Zone 4	Z4-5	2007	GAB-005	SS	2.13			1.42			3.67			2.93			3.31			3.38			0.04	U	U	6.15			1.32			3.63			0.04	U	U	1.94		
Zone 4	Z4-6	2007	GAB-006	SS	1.91			1.26			3.13			2.84			2.88			3.72			0.04	U	U	6.12			1.27			3.31			0.04	U	U	1.79		
Zone 4	Z4-S1	2004	DAD-1	SS	1.29		NJ	2.34			3.69			3.5			2.43			3.8			4.3	ME		2.11			0.82			1.73			0.34	U		1.29		
Zone 4	Z4-S2	2004	DAD-2	SS	0.25	U		15.43			17.41			6.79			7.37			6.98			4.02	ME		3.41			1.88			2.9			0.27	U		1.42		
Zone 4	Z4-S3	2004	DAD-3	SS	2.75		NJ	6.36		J	9.03		J	6.14		J	5.21		J	1.96		J	4.1	ME	J	4.01		J	3.39		J	2.38		J	0.23	U		1.24		J
Zone 4	Z4-S4	2004	DAD-4	SS	0.23	U		1.94			4.19			3.42			2.89			5.62			3.05	ME		3.27			3.42			2.5			0.25	U		1.38		
Zone 4	Z4-S5	2004	DAD-5	SS	1.81		NJ	2.33			5.08			3.84			3.64			5.8			4.84	ME		3.73			1.48			3.47			0.58	U		1.69		
Zone 4	Z4-S6	2004	DAD-6	SS	0.61		NJ	1.57			2.96			4.87			8.8			4.5			0.1	U		14.41			4.15			10.38			0.14	U		3.24		
Zone 4	Z4-S6	2004	DAD-7	FDUP	0.14	U		2.61			3.7			7.72			14.83			6.62			0.11	U		30.07			7.97			16.55			0.15	U		5.48		
Zone 7	Z7-1	2007	GAB-007	SS	0.02	U	U	0.03	U	U	1.38			1.38			1.77			1.67			0.04	U	U	3.79			0.84			2.04			0.04	U	U	1.35		
Zone 7	Z7-2	2007	GAB-008	SS	3.76			4.63			6.73			4.36			5.48			5.63			0.04	U	U	7.01			1.69			4.28			0.04	U	U	2.46		
Zone 7	Z7-3	2007	GAB-009	SS	6.47			6.26			8.66			5.53			6.7			6.78			0.04	U	U	10.11			2.17			5.86			0.04	U	U	2.31		
Zone 7	Z7-4	2007	GAB-010	SS	3.52			3.01			5.01			3.59			4.33			5.06			0.04	U	U	6.4			1.42			3.87			0.04	U	U	2.26		
Zone 7	Z7-5	2007	GAB-011	SS	3.88			3.94			5.95			3.86			4.3			4.3			0.04	U	U	6.15			1.45			3.95			0.04	U	U	2.09		
Zone 7	Z7-6	2007	GAB-012	SS	14.83			20.04			21.99			9.19			11.34			8.32			0.04	U	U	9.65			2.21			5.27			0.04	U	U	2.08		
Zone 7	Z7-S1	2004	DAD-10	SS	0.75		NJ	2.54			2.66			2.75			2.32			4.97			2.02	ME		2.63			3.52			2.33			0.23	U		1.33		
Zone 7	Z7-S2	2004	DAD-11	SS	0.24	U		0.75			1.74			1.77			1.63			3.2			0.19	UME		2.08			2.13			2.			0.25	U		1.14		
Zone 7	Z7-S3	2004	DAD-12	SS	0.48		NJ	1.2			2.78			2.54			2.23			4.48			2.21	ME		3.17			3.21			2.53			0.27	U		1.41		
Zone 7	Z7-S4	2004	DAD-13	SS	0.23	U		1.13			3.26			2.77			2.43			10.82			0.18	U		2.53			1.39			2.64			0.25	U		12.41		
Zone 7	Z7-S4	2004	DAD-14	FDUP	0.22	U		1.16			2.88			2.67			2.4			4.71			2.42	ME		2.82			2.84			2.45			0.24	U		1.34		
Zone 7	Z7-S5	2004	DAD-15	SS	0.23	U		1.28		J	3.17		J	2.85		J	2.17		J	5.25		J	3.05	ME	J	3.17		J	3.53		J	2.31		J	0.24	U		1.35		J
Zone 7	Z7-S6	2004	DAD-16	SS	0.22	U		1.3			3.26			2.85			2.6			4.58			0.17	U		2.35			1.34			2.73			0.24	U		1.47		
Pier 1	P1-C3	2004	DAD-29	Core	0.5	U	UJ	1.88			5.23			6.94			9.7			9.18			3.26	ME		16.08			5.08			11.65			0.53	U		3.35		
Pier 1	P1-C4	2004	DAD-30	Core	15.52	U		11.	U		11.62	U		20.68			16.81			20.54			12.17	U		33.7			10.36	U		21.11			16.66	U		9.37	U	
Pier 1	P2	2004	DAD-21	SS	0.23	U		0.95			2.96			3.58			3.98			5.88			2.17	ME		7.84			4.52			4.75			0.24	U		1.98		
Pier 1	P3	2004	DAD-22	SS	0.49	U		0.35	U		2.95			3.84			4.29			5.3			4.24	ME		6.77			2.42			6.02			0.52	U		2.69		
Pier 1	P4	2004	DAD-23	SS	0.21	U		1.16		J	3.45		J	4.13		J	5.12		J	5.65		J	4.81	ME	J	8.04		J	4.61		J	5.21		J	0.23	U		1.81		J
Pier 1	P5	2004	DAD-25	SS	0.67		NJ	1.62			2.83			5.21			9.29			4.46			0.1	U		16.02			3.85			9.75			0.14	U		2.87		
Pier 1	P6	2004	DAD-26	SS	0.19	U		0.14	U		2.7		J	3.21		J	3.11		J	3.34		J	4.49	ME	J	3.96		J	1.43		J	2.78		J	0.21	U		2.02		J
Reference	R-S1	2004	DAD-32	SS	0.13	U		0.7			3.			2.03			2.41			3.57			1.5	ME		2.51			1.71			2.45			0.14	U		1.5		
Reference	R-S2	2004	DAD-33	SS	0.12	U		0.32			1.42			0.99			1.18			2.01			0.65	ME		2.5			0.65			1.31			0.13	U		0.78		
Reference	R-S3	2004	DAD-34	SS	0.15	U		0.11	U		0.78			0.83			0.77			2.17			0.89	ME		0.76			0.48			0.82			0.16	U		0.57		
Reference	R-S4	2004	DAD-35	SS	0.13	U		0.09	U		0.3			0.41			0.31			0.89			0.55	ME		0.33			0.37			0.4			0.14	U		0.85		
Reference	R-S5	2004	DAD-36	SS	0.14	U		0.96			2.33			2.5			2.4			4.34			1.75	ME		2.87			2.16			2.2			0.15	U		2.44		
Reference	R-S6	2004	DAD-37	SS	1.78		NJ	6.57			7.52			37.81	D		89.53	D		16.92			0.13	U		146.69	D		57.12	D		138.43	D		0.18	U		32.23	D	
Reference	RA-1	2007	GAB-013	SS	1.07			0.39			1.55			1.23			1.56			2.29			0.04	U	U	3.32			0.73			2.14			0.04	U	U	0.88		
Reference	RA-1	2007	GAB-019	FDUP	0.02	U	U	0.03	U	U	1.42			1.07			1.37			2.23			0.04	U	U	2.83			0.62			1.83			0.04	U	U	0.8		
Reference	RA-2	2007	GAB-014	SS	0.02	U	U	0.03	U	U	0.54			0.53			0.61			0.89			0.04	U	U	1.15			0.24			0.75			0.04	U	U	0.44		
Reference	RA-3	2007	GAB-015	SS	0.02	U	U	0.03	U	U	0.68			0.52			0.74			0.82			0.04	U	U	1.02			0.32			0.82			0.04	U	U	0.5		
Reference	RA-4	2007	GAB-016	SS	0.02	U	U	0.03	U	U	2.32			2.44			3.84			2.78			0.04	U	U	4.78			1.43			3.92			0.04	U	U	2.23		
Reference	RA-5	2007	GAB-017	SS	0.02	U	U	0.03	U	U	1.58			1.73			2.06			2.79			0.04	U	U	4.67			0.95			2.48			0.04	U	U	1.9		
Reference	RA-6	2007	GAB-018	SS	0.02	U	U	0.03	U	U	2.29			3.42			4.33			4.14			0.04	U	U	9.61			1.56			4.25			0.04	U	U	2.63		

Thames River Validation Study
Subase New London
PCBs in Surface Sediment
(ng/g dry weight)

Suite	PCB CONGENERS																																		
Units	ng/g dry																																		
Analyte					Cl6(138)			Cl6(153)			Cl7(170)			Cl7(180)			Cl7(187)			Cl8(195)			Cl9(206)			Cl10(209)			Total PCB			Total PCB (NST18)		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	6.46			9.06			2.5			4.45			3.43			0.03	U	U	0.03	U	UJ	0.03	U	UJ	228.84			228.68		
Zone 4	Z4-2	2007	GAB-002	SS	15.39			14.03			3.93			7.56			5.31			0.03	U	U	0.03	U	UJ	0.03	U	UJ	367.02			366.86		
Zone 4	Z4-3	2007	GAB-003	SS	6.82			8.76			2.25			4.26			3.2			0.03	U	U	0.03	U	UJ	0.03	U	UJ	182.24			182.08		
Zone 4	Z4-4	2007	GAB-004	SS	8.45			10.44			2.04			4.6			3.32			0.03	U	U	0.03	U	UJ	0.03	U	UJ	183.88			183.72		
Zone 4	Z4-4	2007	GAB-020	FDUP	4.41			5.23			1.09			2.41			2.03			0.03	U	U	0.03	U	UJ	0.03	U	UJ	105.5			105.34		
Zone 4	Z4-5	2007	GAB-005	SS	4.2			4.51			1.71			2.41			2.08			0.03	U	U	0.03	U	UJ	0.03	U	UJ	89.92			89.76		
Zone 4	Z4-6	2007	GAB-006	SS	4.01			4.22			1.08			2.15			1.77			0.03	U	U	0.03	U	UJ	0.03	U	UJ	83.26			83.1		
Zone 4	Z4-S1	2004	DAD-1	SS	1.81			2.53			0.71			1.14			0.91						0.31			0.95			72.			62.72		
Zone 4	Z4-S2	2004	DAD-2	SS	3.55			4.89			1.72			2.82			2.21						0.76			1.18			170.52			161.94		
Zone 4	Z4-S3	2004	DAD-3	SS	2.53		J	3.15		J	0.95		J	1.87		J	1.67		J				0.92		J	1.06		J	117.9			109.24		
Zone 4	Z4-S4	2004	DAD-4	SS	2.55			3.14			0.82			1.59			1.53						0.88			1.29			87.92			81.32		
Zone 4	Z4-S5	2004	DAD-5	SS	3.72			4.65			1.05			2.37			2.24						1.05			2.19			111.12			100.28		
Zone 4	Z4-S6	2004	DAD-6	SS	11.3			14.76			1.91			3.48			2.58						1.86			2.58			188.4			187.92		
Zone 4	Z4-S6	2004	DAD-7	FDUP	21.65			36.43	D		6.12			14.69			10.09						3.86			2.7			382.98			382.46		
Zone 7	Z7-1	2007	GAB-007	SS	2.47			2.97			0.65			1.39			1.31			0.03	U	U	0.03	U	UJ	0.03	U	UJ	46.46			46.3		
Zone 7	Z7-2	2007	GAB-008	SS	5.09			6.07			1.53			3.24			2.56			0.03	U	U	0.03	U	UJ	0.03	U	UJ	129.38			129.22		
Zone 7	Z7-3	2007	GAB-009	SS	7.55			9.9			3.06			7.32			4.2			0.03	U	U	0.03	U	UJ	0.03	U	UJ	186.1			185.94		
Zone 7	Z7-4	2007	GAB-010	SS	4.66			5.69			1.11			3.46			2.29			0.03	U	U	0.03	U	UJ	0.03	U	UJ	111.7			111.54		
Zone 7	Z7-5	2007	GAB-011	SS	4.37			5.28			1.33			3.16			2.15			0.03	U	U	0.03	U	UJ	0.03	U	UJ	112.66			112.5		
Zone 7	Z7-6	2007	GAB-012	SS	7.4			10.22			3.08			5.9			4.24			0.03	U	U	0.03	U	UJ	0.03	U	UJ	271.86			271.7		
Zone 7	Z7-S1	2004	DAD-10	SS	2.69			3.25			0.63			1.65			1.44						0.18	U		1.5			78.78			74.28		
Zone 7	Z7-S2	2004	DAD-11	SS	2.49			3.02			0.67			1.52			1.2						0.63			1.1			55.5			54.62		
Zone 7	Z7-S3	2004	DAD-12	SS	2.86			3.71			0.79			1.83			1.64						0.89			1.39			79.24			74.28		
Zone 7	Z7-S4	2004	DAD-13	SS	2.64			3.66			1.08			1.67			1.52						0.94			1.71			106.52			105.66		
Zone 7	Z7-S4	2004	DAD-14	FDUP	2.78			3.5			0.74			1.68			1.64						1.14			1.53			78.32			73.		
Zone 7	Z7-S5	2004	DAD-15	SS	2.55		J	3.56		J	0.75		J	1.51		J	1.4		J				1.08		J	1.33		J	81.56			74.98		
Zone 7	Z7-S6	2004	DAD-16	SS	3.03			3.7			0.83			1.87			1.6						0.94			1.46			73.08			72.26		
Pier 1	P1-C3	2004	DAD-29	Core	12.25			14.19			2.15			4.33			3.4						1.63			2.65			227.96			220.38		
Pier 1	P1-C4	2004	DAD-30	Core	24.8			29.57			13.04	U		12.92	U		11.29	U					13.05	U		13.44	U		635.3			577.64		
Pier 1	P2	2004	DAD-21	SS	4.94			5.69			1.			2.12			2.05						0.59			0.89			112.72			107.9		
Pier 1	P3	2004	DAD-22	SS	6.62			7.93			1.27			2.77			2.84						0.86			2.47			129.28			119.76		
Pier 1	P4	2004	DAD-23	SS	5.19		J	6.13		J	1.07		J	2.07		J	1.86		J				0.87		J	1.5		J	126.24			116.16		
Pier 1	P5	2004	DAD-25	SS	10.37			13.27			1.8			3.72			2.39						1.74			2.37			184.94			184.46		
Pier 1	P6	2004	DAD-26	SS	3.02		J	3.75		J	1.14		J	1.8		J	2.42		J				0.54		J	1.17		J	82.84			73.44		
Reference	R-S1	2004	DAD-32	SS	2.23			2.72			0.64			1.24			1.03						1.1			1.04			63.3			60.02		
Reference	R-S2	2004	DAD-33	SS	1.25			1.52			0.3			0.64			0.55						0.38			0.54			34.48			32.92		
Reference	R-S3	2004	DAD-34	SS	0.94			1.22			0.29			0.67			0.59						0.36			0.53			26.18			24.08		
Reference	R-S4	2004	DAD-35	SS	0.53			0.67			0.18			0.35			0.26						0.38			0.51			15.3			13.92		
Reference	R-S5	2004	DAD-36	SS	2.53			3.1			0.52			1.33			1.14						0.79			1.11			69.52			65.72		
Reference	R-S6	2004	DAD-37	SS	157.49	D		156.04	D		18.32			37.19	D		14.47						2.82			1.31			1,845.1			1,844.48		
Reference	RA-1	2007	GAB-013	SS	2.1			2.68			0.51			1.21			0.92			0.03	U	U	0.03	U	UJ	0.03	U	UJ	45.5			45.34		
Reference	RA-1	2007	GAB-019	FDUP	1.81			2.17			0.57			0.93			0.87			0.03	U	U	0.03	U	UJ	0.03	U	UJ	37.48			37.32		
Reference	RA-2	2007	GAB-014	SS	0.8			0.87			0.25			0.67			0.45			0.03	U	U	0.03	U	UJ	0.03	U	UJ	16.82			16.66		
Reference	RA-3	2007	GAB-015	SS	0.7			0.88			0.2			0.55			0.41			0.03	U	U	0.03	U	UJ	0.03	U	UJ	16.76			16.6		
Reference	RA-4	2007	GAB-016	SS	4.65			6.04			1.08			3.48			2.93			0.03	U	U	0.03	U	UJ	0.03	U	UJ	84.28			84.12		
Reference	RA-5	2007	GAB-017	SS	2.92			3.27			0.93			1.72			1.59			0.03	U	U	0.03	U	UJ	0.03	U	UJ	57.62			57.46		
Reference	RA-6	2007	GAB-018	SS	4.96			5.31			1.56			2.73			2.26			0.03	U	U	0.03	U	UJ	0.03	U	UJ	98.54			98.38		

Definitions
FDUP = field duplicate
SS= surface sediment
J = Estimated value. The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.
D=Dilution run. Initial run outside linear range of instrument. The sample was diluted to within thecalibration range and re-run. Only analytes above the calibration range are reported from a further dilution.
U=Undetected at the MDL: The associated value is the MDL, adjusted by any dilution factor.
N=Presumptive evidence of presence of the constituent
M=Duplicate inject precision did not agree.
E=Estimate result outside linear range of instrument.

Thames River Validation Study
Subase New London
Pesticides in Surface Sediment
(ng/g dry weight)

Suite	Pesticides																																	
Units	ng/g dry																																	
Analyte					4,4'-DDD			4,4'-DDE			4,4'-DDT			Total 4,4'-DDx			a-Chlordane			Dieldrin			g-BHC			Heptachlor			Lindane			trans-Nonachlor		
Area	Station Id	Year	Client Id	Field Sample Type	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 4	Z4-1	2007	GAB-001	SS	2.3			5.1			2.49			9.89			0.8						0.02	U	U	0.03	U	U				0.46		
Zone 4	Z4-2	2007	GAB-002	SS	10.28			13.42			3.53			27.23			2.52						0.02	U	U	0.03	U	U				1.51		
Zone 4	Z4-3	2007	GAB-003	SS	3.29			5.7			3.			11.99			0.73						0.02	U	U	0.03	U	U				0.67		
Zone 4	Z4-4	2007	GAB-004	SS	3.4			5.77			2.32			11.49			0.94						0.02	U	U	0.03	U	U				0.71		
Zone 4	Z4-4	2007	GAB-020	FDUP	2.19			4.09			2.23			8.51			0.61						0.02	U	U	0.03	U	U				0.4		
Zone 4	Z4-5	2007	GAB-005	SS	2.14			3.42			2.46			8.02			0.64						0.02	U	U	0.03	U	U				0.58		
Zone 4	Z4-6	2007	GAB-006	SS	1.83			3.11			1.71			6.65			0.57						0.02	U	U	0.03	U	U				0.5		
Zone 4	Z4-S1	2004	DAD-1	SS				2.47			2.7			5.17			0.68			1.53												0.29		
Zone 4	Z4-S2	2004	DAD-2	SS				3.3			1.93			5.23			0.9			2.94												0.6		
Zone 4	Z4-S3	2004	DAD-3	SS				3.43		J	0.15	U		3.58			0.84		J	2.75		J										0.56		J
Zone 4	Z4-S4	2004	DAD-4	SS				3.15			1.1			4.25			0.59			2.45												0.48		
Zone 4	Z4-S5	2004	DAD-5	SS				3.82			2.67			6.49			0.94			3.52												0.53		
Zone 4	Z4-S6	2004	DAD-6	SS				4.99			2.97			7.96			0.88			0.1	U											0.41		
Zone 4	Z4-S6	2004	DAD-7	SS				7.46			5.72			13.18			0.94			3.93												0.38		
Zone 7	Z7-1	2007	GAB-007	SS	1.7			2.94			2.12			6.76			0.49						0.02	U	U	0.03	U	U				0.42		
Zone 7	Z7-2	2007	GAB-008	SS	3.24			5.54			2.49			11.27			0.92						0.02	U	U	0.03	U	U				0.73		
Zone 7	Z7-3	2007	GAB-009	SS	5.73			7.43			4.07			17.23			0.93						0.02	U	U	0.03	U	U				0.73		
Zone 7	Z7-4	2007	GAB-010	SS	2.83			4.62			2.11			9.56			0.78						0.02	U	U	0.03	U	U				0.65		
Zone 7	Z7-5	2007	GAB-011	SS	2.63			4.26			1.83			8.72			0.66						0.02	U	U	0.03	U	U				0.55		
Zone 7	Z7-6	2007	GAB-012	SS	3.43			5.66			2.49			11.58			0.83						0.02	U	U	0.03	U	U				0.71		
Zone 7	Z7-S1	2004	DAD-10	SS				2.82			1.15			3.97			0.51			2.08												0.34		
Zone 7	Z7-S2	2004	DAD-11	SS				2.05			1.55			3.6			0.34			0.18	U											0.34		
Zone 7	Z7-S3	2004	DAD-12	SS				2.94			1.18			4.12			0.5			2.37												0.5		
Zone 7	Z7-S4	2004	DAD-13	SS				3.25			1.29			4.54			0.63			0.17	U											0.65		
Zone 7	Z7-S4	2004	DAD-14	FDUP				2.94			1.13			4.07			0.56			2.24												0.51		
Zone 7	Z7-S5	2004	DAD-15	SS				2.81		J	0.55		J	3.36			1.03		J	2.28		J										0.66		J
Zone 7	Z7-S6	2004	DAD-16	SS				3.16			1.45			4.61			0.56			0.16	U											0.59		
Pier 1	P1-C3	2004	DAD-29	Core	7.49			6.46			1.83			15.78			1.81			4.51						0.35	U		0.33	U		1.09		
Pier 1	P1-C4	2004	DAD-30	Core	72.23			17.96			31.41			121.6			21.2			13.79						11.01	U		10.26	U		13.71		
Pier 1	P2	2004	DAD-21	SS	3.09			3.98			2.16			9.23			0.66			3.68						0.16	U		0.15	U		0.54		
Pier 1	P3	2004	DAD-22	SS	5.74			5.83			7.34			18.91			1.			4.1						0.35	U		0.32	U		0.74		
Pier 1	P4	2004	DAD-23	SS	2.58		J	3.69		J	1.67		J	7.94			0.71		J	3.2		J				0.15	U		0.14	U		0.58		J
Pier 1	P5	2004	DAD-25	SS	7.96			4.14			2.22			14.32			1.11			1.9						0.09	U		0.08	U		0.4		
Pier 1	P6	2004	DAD-26	SS	1.49		J	3.02		J	0.14	U		4.65			0.96		J	3.21		J				0.14	U		0.13	U	UJ	0.4		J
Reference	R-S1	2004	DAD-32	SS	1.52			2.02			3.37			6.91			0.34			0.1	U		0.09			0.1	U					0.25		
Reference	R-S2	2004	DAD-33	SS	0.88			1.08			0.3			2.26			0.19			0.93			0.08			0.09	U					0.15		
Reference	R-S3	2004	DAD-34	SS	0.68			0.98			0.39			2.05			0.17			0.9			0.1			0.11	U					0.14		
Reference	R-S4	2004	DAD-35	SS	0.47			0.59			0.25			1.31			0.09	U		0.57			0.09			0.09	U					0.09	J	
Reference	R-S5	2004	DAD-36	SS	2.55			2.57			1.42			6.54			0.41			2.23			0.1			0.1	U					0.38		
Reference	R-S6	2004	DAD-37	SS	5.79			2.35			1.19			9.33			0.54			0.13	U		0.11			0.12	U					0.6		
Reference	RA-1	2007	GAB-013	SS	1.76			1.91			0.56			4.23			0.31						0.02	U	U	0.03	U	U				0.29		
Reference	RA-1	2007	GAB-019	FDUP	1.13			1.75			0.67			3.55			0.29						0.02	U	U	0.03	U	U				0.24		
Reference	RA-2	2007	GAB-014	SS	0.55			0.83			0.2			1.58			0.2						0.02	U	U	0.03	U	U				0.14	J	J
Reference	RA-3	2007	GAB-015	SS	0.66			0.85			0.63			2.14			0.15						0.02	U	U	0.03	U	U				0.17		
Reference	RA-4	2007	GAB-016	SS	4.17			5.09			1.1			10.36			0.57						0.02	U	U	0.03	U	U				0.48		
Reference	RA-5	2007	GAB-017	SS	2.21			3.4			1.1			6.71			0.52						0.02	U	U	0.03	U	U				0.43		
Reference	RA-6	2007	GAB-018	SS	3.87			7.04			4.33			15.24			1.83						0.02	U	U	0.03	U	U				1.56		

LDUP = laboratory duplicate
FDUP = field duplicate
SS= surface sediment
J = Estimated value. The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.
U=Undetected at the MDL: The associated value is the MDL, adjusted by any dilution factor.

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Metals in Core Sediment
(µg/g dry wt)

				Arsenic			Barium			Cadmium			Chromium			Copper			Lead			Mercury		
Area Name	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7C2	DAD 19 2'-4'	2-4 ft	14.1			167			1.06			106			136			110		J	NA		
Zone 7	Z7C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	11.4			133			0.250			61.0			16.0			11.4		J	NA		
Zone 7	Z7C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	11.8			144			0.283			62.7			15.0			11.3		J	NA		
Zone 7	Z7C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	15.1			154			1.09			107			130			102		J	NA		
Zone 7	Z7C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	13.9			161			0.270			63.1			15.5			11.6		J	NA		
Zone 7	Z7C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	9.87			133			0.362			58.2			16.1			9.21		J	NA		
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	12.4			135			1.2			110			134			95.1		J	NA		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	12.5			127			0.329			63.5			22.0			17.9		J	NA		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	11.6			112			0.414			61.1			24.8			16.0		J	NA		
Zone 4	Z4C1	DAD 8 2'-4'	2 ft - 4 ft	14.2			176			1.34			112			128			149		J	NA		
Zone 4	Z4C1	DAD 8 4'-5'	4 ft - 5 ft	12.5			150			1.72			127			129			162		J	NA		
Zone 4	Z4C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.0942	J		16.5			0.0286	J		14.6			2.84			1.79		J	NA		
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	2.55			57.0			0.314			28.4			21.8			31.5		J	NA		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	1.16			39.7			0.136			22.4			15.5			26.6		J	NA		
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	12.9			171			1.88			123			180			165		J	1.02		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	10.3			212			1.84			111			142			147		J	1.17		
Pier 1	P1-C5	DAD 31 4'-6'R	4 ft - 6 ft	9.10			215			1.71			114			139			161		J	1.10		
Pier 1	P1-C3	DAD 29 0-2'7"	0 - 2 ft 7 in	11.6			157			0.734			101			203			165		J	0.575		
Pier 1	P1-C4	DAD 30 0-2'	0 - 2 ft	7.22			106			0.746			73.8			261			157		J	2.77		
Pier 1	P1-C2	DAD 28 0-2'	0 - 2 ft	8.66			207			1.82			112			624			399		J	4.00		
Pier 1	P1-C2	DAD 28 2'-4'	2 - 4 ft	6.08			116			0.401			62.0			503			230		J	1.79		
Pier 1	P1-C2	DAD 28 4'-5' 1/4"	4 ft - 5 ft	6.23			176			0.02	U		68.4			231		J	415		J	0.628		

Notes:

U	Undetected at the method detection limit: The associated data value is the method detection limit, adjusted by any dilution factor used in the analysis (i.e., the sample-specific MDL).
J	Estimated value: The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.
NA	This metal was not analyzed from these areas (see SAP).

Thames River Validation Study
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Metals in Core Sediment
(µg/g dry wt)

				Nickel			Selenium			Zinc		
Area Name	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7C2	DAD 19 2'-4'	2-4 ft	40.5		J	0.854			255		J
Zone 7	Z7C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	26.7		J	0.814			76.5		J
Zone 7	Z7C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	26.7		J	0.872			80.6		J
Zone 7	Z7C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	32.2		J	0.801			239		J
Zone 7	Z7C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	27.8		J	0.798			78.8		J
Zone 7	Z7C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	25.0		J	0.711			69.8		J
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	31.3		J	0.704			228		J
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	27.0		J	0.775			92.9		J
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	25.2		J	0.762			81.5		J
Zone 4	Z4C1	DAD 8 2'-4'	2 ft - 4 ft	36.9		J	0.909			275		J
Zone 4	Z4C1	DAD 8 4'-5'	4 ft - 5 ft	43.2		J	0.748			351		J
Zone 4	Z4C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	3.70		J	0.02	U		12.6		J
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	10.7		J	0.106			67.6		J
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	6.76		J	0.031	J		37.6		J
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	56.0		J	0.885			405		J
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	35.6		J	0.794			281		J
Pier 1	P1-C5	DAD 31 4'-6'R	4 ft - 6 ft	34.3		J	0.795			284		J
Pier 1	P1-C3	DAD 29 0-2'7"	0 - 2 ft 7 in	42.3		J	0.828			368		J
Pier 1	P1-C4	DAD 30 0-2'	0 - 2 ft	30.7		J	0.541			706		J
Pier 1	P1-C2	DAD 28 0-2'	0 - 2 ft	93.2		J	1.03			1744		J
Pier 1	P1-C2	DAD 28 2'-4'	2 - 4 ft	28.1		J	0.252			573		J
Pier 1	P1-C2	DAD 28 4'-5' 1/4"	4 ft - 5 ft	53.2			0.444			2300		

Notes:

U — Undetected at the method detection limit: The associated data value is the method detection limit, adjusted by any dilution factor used in the analysis (i.e., the sample-specific MDL).

J — Estimated value: The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.

NA — This metal was not analyzed from these areas (see SAP).

Thames River Validation Study
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PAHs in Core Sediment
(ng/g dry wt)

				Naphthalene			2-Methylnaphthalene			1-methylnaphthalene			Biphenyl			2,6-dimethylnaphthalene			Acenaphthylene			Acenaphthene		
Area	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	163.94			74.76			37.33			28.94			42.57			187.5			80.4		
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	2.31			0.53	J		0.68	J		0.78	J		0.22	U		0.87	J		2.1		
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	1.51			0.53	J		0.3	J		0.73	J		0.21	U		0.3	J		0.21	U	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	91.94			57.04			26.3			21.42			32.07			102.54			26.63		
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	1.67			0.39	J		0.43	J		0.69	J		0.21	U		0.26	J		0.62	J	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	2.62			0.59	J		0.31	J		1.06	J		0.22	U		0.1	U		0.65	J	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	104.11			60.42			31.95			20.86			35.29			101.97			33.35		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	8.83			4.56			3.08			2.39			2.68			8.77			4.09		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	4.71			2.51			1.81			1.6			1.85			4.08			2.57		
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.36		J	0.1	J	J	0.07	J	J	0.07	J	J	0.05	U	UJ	0.12	J	J	0.91		J
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	25.37			8.68			4.3			4.03			5.64			21.07			6.35		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	18.59			5.24			2.48			2.24			2.96			8.18			3.22		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	193.87			90			45.9			36.91			58.61			221.36			402.25		
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	216.55			109.96			56.39			51.79			65.77			262.68			513.73		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	92.79	D		52.19	D		32.89	D		18.04	D		45.11	D		74.97	D		121.15	D	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	63.33			26.55			14.54			10.41			20.78			40.63			64.73		
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	61.61			19.18			14.99			7.96			21.67			16.01			213.17		
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	129.53			86.52			41.5			32.05			55.17			151.18			111.71		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	136.18			83.48			40.05			32.85			76.24			83.75			127.88		
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	90.5			52.41			26.62			20.02			32.47			175.19			44		
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	60.26			30.61	J		15.92	J		9.19	U		9.05	U		92.39			54.02	J	

Notes:

U Undetected at the MDL: The associated value is the MDL, adjusted by any dilution factor

D Dilution run. Initial run outside linear range of instrument
The sample was diluted to within the calibration range and re-run.
Only analytes above the calibration range are reported from a further dilution.

B Blank contamination.
The anlalyte was detected above the RL in an associated blank.
For this study, blank contamination indicates that the analyte was found in both a sample and the associated blank.
The "B" will be reported on the result associated with the field samples.

J Estimated value. The analyte was positively identified but is less than the sample-specific reporting limit. The quantization is an estimate.

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PAHs in Core Sediment
(ng/g dry wt)

				2,3,5-trimethylnaphthalene			Fluorene			Anthracene			Phenanthrene			1-Methylphenanthrene			Fluoranthene		
Area	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	8.14			146.24			669.41			810.8			112.68			3379.65	B	
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	0.2	U		2.34			1.56			3.73			0.75	J		8.58	B	
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	0.19	U		1.33	J		0.95	J		1.64			0.46	J		2.48	B	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	10.27			76.16			279.85			521.14			85.49			1631	B	
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	0.19	U		0.99	J		1.12	J		1.53			0.64	J		2.61	B	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	0.2	U		1.22	J		1.29	J		1.66			0.74	J		2.51	B	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	9.49			66.42			213.05			535.51			79.38			1517.23	B	
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	1.28	J		6.11			16.21			33.3			5.73			108.8	B	
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	0.38	J		3.58			8.17			17.73			3.59			55.58	B	
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.05	J	J	0.18	J	J	0.2	J	J	0.35		J	0.02	U	UJ	1.29		J
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	1.24			12.52			41.45			67.81			10.64			199.44		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	0.7			6.17			17.83			30.8			4.76			72.56		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	22.95			264.14			1970.89			1463.13			206.63			8725.32	B	
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	18.67			293.64			990.78			1762.59			238.02			11841.93	B	
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	27.16	D		192.65	D		1116	D		2317.82	D		250.82	D		7427.24	D	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	8.57			123.57			942.73			1786.14			180.57			4827.17	D	
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	64.09			83.74			601.02			993.49			157.72			2618.69	D	
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	25.86			201.38			447.88			985.24			140.52			3997.81	B	
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	35.99			224.3			474.39			877.34			137.99			2604.65	B	
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	8.32			105.31			522.33			737.51			103.47			2864.06	B	
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	8.18	U		86.29			380.23			822.69			119.04			2422.82	B	

Notes:

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B Blank contamination.
The anlalyte was detected above the RL in an associated blank.
For this study, blank contamination indicates that the analyte was found in both a sample and the associated blank.
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Thames River Validation Study
Subase New London
PAHs in Core Sediment
(ng/g dry wt)

				Pyrene			Benzo(a)anthracene			Chrysene			Benzo(b)fluoranthene			Benzo(k)fluoranthene			Benzo(e)pyrene		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	4411.54	B		1923.43	B		2423.93	B		1621.89	B		1865.53			1290.32		
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	8.84	B		3.06	B		4.42	B		3.28	B		3.72			2.71		
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	2.16	B		0.67	J		1.54	B		0.99	J		1.44	J		0.81	J	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	1787.85	B		671.4	B		911.95	B		810.71	B		868.87			731.19		
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	2.27	B		0.55	J		1.9	B		1.5	B		1.43	J		1.19	J	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	2.52	B		0.66	J		1.95	B		1.08	J		1.53	J		0.93	J	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	1822.18	B		705.14	B		939.01	B		764.74	B		881.85			690.24		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	112.58	B		43.06	B		61.19	B		52.83	B		61.5			48.57		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	54.33	B		20.42	B		29.03	B		24.07	B		28.57			22.39		
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	1.47		J	0.47		J	0.65		J	0.38		J	0.54	J	J	0.37		J
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	685.96			125.27			153.89			195			208.25			159.19		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	265.93			39.47			54.03			74.69			78.41			62.18		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	6588.42	B		3646.51	B		4138.77	B		2421.68	B		2641.32			1862.4		
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	9014.39	B		2959.79	B		3333.03	B		2228.77	B		2478.17			1780.93		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	13809.73	D		3865.98	D		4350.83	D		4329.38	D		4900.05	D		3474.62	D	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	9497.79	D		2659.19	D		3141.59	D		2541.91	D		2963.46	D		2556.94		
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	2623.55	D		1101.7			1147.05			703.5			731.35			514.75		
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	3534.56	B		1325.63	B		1692.79	B		1455.03	B		1528.34			1231.16		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	2652.9	B		908.78	B		1047.95	B		882.76	B		921.9			772.03		
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	5269.8	B		2238.4	B		2585.02	B		2068.74	B		2195.96			1604.67		
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	4123.02	B		1167.16	B		1635.16	B		1564.42	B		1834.62			1356.09		

Notes:

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J Estimated value. The analyte was positively identified but is less than t
sample-specific reporting limit. The quantization is an estimate.

Thames River Validation Study
Subase New London
PAHs in Core Sediment
(ng/g dry wt)

				Benzo(a)pyrene			Perylene			Indeno(1,2,3-cd)pyrene			Dibenz(a,h)anthracene			Benzo(g,h,i)perylene		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	1621.01	B		1200.06			979.39			227.53			839.11		
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	3.4	B		277.62			2.6			0.15	U		2.31		
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	0.61	J		147.02			1.09	J		0.14	U		0.92	J	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	798.77	B		1177.08			556.01			121.98			527.4		
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	1.01	J		178.64			1.38	J		0.15	U		1.13	J	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	0.58	J		286.89			0.83	J		0.15	U		1.09	J	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	775.52	B		1096.22			518.48			116.47			483.49		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	53.4	B		223.81			48.02			9.25			39.6		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	24.82	B		217.58			17.71			3.92			17.79		
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.43		J	0.34		J	0.24	J	J	0.29	J	J	0.33		J
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	194.61			42.69			122.81			29.43			108.19		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	71.26			14.35			47.68			11.96			41.54		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	2328.03	B		1539.02			1225.79			294.02			1092.35		
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	2175.85	B		1553.01			1316.08			284.04			1168.92		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	4329.69	D		1124.55	D		2550.67	D		636.02	D		2344.42	D	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	2644.52	D		787.74			1962.4			656.51			1442.65		
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	657.17			231.33			372.49			94.26			285.53		
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	1374.96	B		1140.47			977.52			216.24			896.49		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	828.52	B		463.31			538.5			137.37			504.33		
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	1864.69	B		852.28			1091.79			271.4			937.72		
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	1510.91	B		396.86			908.26			233.45			817.29		

Notes:

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The sample was diluted to within the calibration range and re-run.
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J Estimated value. The analyte was positively identified but is less than t sample-specific reporting limit. The quantization is an estimate.

Thames River Validation Study
Subase New London
Pesticides in Core Sediment
(ng/g dry wt)

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				4,4'-DDD			4,4'-DDE			4,4'-DDT			a-chlordane			Lindane			Trans-nonachlor			Dieldrin		
Area	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7-C2	DAD19 2'-4'	2-4 ft	NA			6.24			1.5			1.43			NA			0.77			4.02		
Zone 7	Z7-C2	DAD19 4'6"-6'	4 ft 6 in - 6 ft	NA			0.98			0.27	U		0.25	U		NA			0.27	U		0.29	U	
Zone 7	Z7-C2	DAD19 6'-7'6"	6 ft - 7 ft 6 in	NA			0.27	U		0.25	U		0.23	U		NA			0.26	U		0.27	U	
Zone 7	Z7-C1	DAD17 2'-3'2"	2 ft - 3 ft 2 in	NA			5.73			1.24			0.79			NA			0.71			3.62		
Zone 7	Z7-C1	DAD17 3'8"-6'	3 ft 8 in - 6 ft	NA			0.28	U		0.25	U		0.24	U		NA			0.26	U		0.27	U	
Zone 7	Z7-C1	DAD17 6'-7'10"	6 ft - 7 ft 10 in	NA			0.29	U		0.26	U		0.25	U		NA			0.27	U		0.28	U	
Zone 7	Z7-C1R	DAD18 2'-3'9"	2 ft - 3 ft 9 in	NA			5.9			1.23			0.9			NA			0.71			3.75		
Zone 7	Z7-C1R	DAD18 3'9"-6'	3 ft 9 in - 6 ft	NA			0.57			0.26	U		0.24	U		NA			0.26	U		0.4		
Zone 7	Z7-C1R	DAD18 6'-8'	6 ft - 8 ft	NA			0.32			0.26	U		0.25	U		NA			0.27	U		0.28	U	
Zone 4	Z4-CI	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	NA			0.06	U	UJ	0.06	U	UJ	0.05	U	UJ	NA			0.06	U	UJ	0.06	U	UJ
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	NA			0.82			0.14			0.31			NA			0.23			0.59		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	NA			0.34			0.07			0.11			NA			0.07			0.35		
Zone 4	Z4-C1	DAD8 2'-4'	2 ft - 4 ft	NA			8.59			2.07			1.97			NA			1.23			4.84		
Zone 4	Z4-C1	DAD8 4'-5'	4 ft - 5 ft	NA			10.85			2.17			3.29			NA			2.64			6.59		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	118.8	D		14.21		J	3.72		J	14.54		J	0.09	U		8.44		J	16.21		J
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	5.04			3.99			0.19			0.9			0.07	U		0.3			1.74		
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	1.08			0.07	U		0.06	U		0.06	U		0.06	U		0.06	U		0.43		
Pier 1	P1-C5	DAD31 2'-4'	2 ft - 4 ft	12.16			11.04			3.46			4.45			0.3	U		3.07			0.34	U	
Pier 1	P1-C5	DAD31 4'-6'	4 ft - 6 ft	19.69			13.05			1.02			2.5			0.25	U		1.66			13.98		
Pier 1	P1-C3	DAD29 0-2'7"	0 ft - 2 ft 7 in	7.49			6.46			1.83			1.81			0.33	U		1.09			4.51		
Pier 1	P1-C4	DAD30 0-2'	0 ft - 2 ft	72.23			17.96			31.41			21.2			10.26	U		13.71			13.79		

Notes:

U	Undetected at the method detection limit: The associated data value is the method detection limit, adjusted by any dilution factor used in the analysis (i.e., the sample-specific MDL).
D	Dilution run. The initial run for these samples had the analyte at a level above the calibration range (unable to quantify accurately).
NA	This constituent was not analyzed from these areas (see SAP).
J	Indicates an estimated value.

Thames River Validation Study
Subase New London
Pesticides in Core Sediment
(ng/g dry wt)

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Area	Station ID	Sample ID	Sample Depth	Heptachlor Result	Heptachlor Lab Qual	Heptachlor Final Qual
Zone 7	Z7-C2	DAD19 2'-4'	2-4 ft	NA		
Zone 7	Z7-C2	DAD19 4'6"-6'	4 ft 6 in - 6 ft	NA		
Zone 7	Z7-C2	DAD19 6'-7'6"	6 ft - 7 ft 6 in	NA		
Zone 7	Z7-C1	DAD17 2'-3'2"	2 ft - 3 ft 2 in	NA		
Zone 7	Z7-C1	DAD17 3'8"-6'	3 ft 8 in - 6 ft	NA		
Zone 7	Z7-C1	DAD17 6'-7'10"	6 ft - 7 ft 10 in	NA		
Zone 7	Z7-C1R	DAD18 2'-3'9"	2 ft - 3 ft 9 in	NA		
Zone 7	Z7-C1R	DAD18 3'9"-6'	3 ft 9 in - 6 ft	NA		
Zone 7	Z7-C1R	DAD18 6'-8'	6 ft - 8 ft	NA		
Zone 4	Z4-CI	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	NA		
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	NA		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	NA		
Zone 4	Z4-C1	DAD8 2'-4'	2 ft - 4 ft	NA		
Zone 4	Z4-C1	DAD8 4'-5'	4 ft - 5 ft	NA		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	0.1	U	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	0.07	U	
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	0.06	U	
Pier 1	P1-C5	DAD31 2'-4'	2 ft - 4 ft	0.32	U	
Pier 1	P1-C5	DAD31 4'-6'	4 ft - 6 ft	0.27	U	
Pier 1	P1-C3	DAD29 0-2'7"	0 ft - 2 ft 7 in	0.35	U	
Pier 1	P1-C4	DAD30 0-2'	0 ft - 2 ft	11.01	U	

Notes:

U	Undetected at the method detection limit: The associated data value is the method detection limit, adjusted by any dilution factor used in the analysis (i.e., the sample-specific MDL).
D	Dilution run. The initial run for these samples had the analyte at a level above the calibration range (unable to quantify accurately).
NA	This constituent was not analyzed from these areas (see SAP).
J	Indicates an estimated value.

Thames River Validation Study
Subase New London
PCBs in Core Sediment
(ng/g dry wt)

				Cl2(8)			Cl3(18)			Cl3(28)			Cl4(44)			Cl4(52)			Cl4(66)			Cl4(77)		
Area	Station ID	Sample ID	Sample Depth	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual	Result	Lab Qual	Final Qual
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	2.44		NJ	4.5			8.4			6.67			7.29			9.77			4.63	ME	
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	0.38	U		0.28	J		0.29	U		0.45			0.27	U		0.32	U		0.3	U	
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	0.36	U		0.26	U		0.27	U		0.23	U		0.25	U		0.3	U		0.28	U	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	2.25		NJ	2.87			5.83			5.36			6.54			7.52			3.32	ME	
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	0.37	U		0.26	U		0.27	U		0.23	U		0.25	U		0.3	U		0.29	U	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	0.38	U		0.41			0.28	U		0.24	U		0.26	U		0.31	U		0.3	U	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	2.33		NJ	4.54			6.7			6.18			8.45			8.24			2.98	ME	
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	0.37	U		0.5			0.52			0.91			0.51			0.68			0.29	U	
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	0.38	U	UJ	0.41			0.28	U		0.77			0.29			0.46			0.3	U	
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	3.52		NJ	6.13			10.94			8.83			9.59			11.69			4.63	ME	
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	11.17		NJ	26.54			30.54			16.86			21.71			17.62			4.24	ME	
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.08	U	UJ	0.06	U	UJ	0.06	U	UJ	0.05	U	UJ	0.06	U	UJ	0.07	U	UJ	0.06	U	UJ
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	0.41		NJ	1.11			1.97			1.83			2.34			2.41			0.07		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	0.22		NJ	0.47			0.84			0.81			0.98			1.08			0.06	U	
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	5.01		NJ	10.9		J	13.52		J	71.09	D		157.97	D		37.53	D		0.11	U	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	0.11	U		1.55			2.27			16.37			35.99	D		6.61			0.08	U	
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	0.09	U		0.24			0.07	U		5.61			23.43			2.29			0.07	U	
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	7.04		NJ	10.81			18.93			17.16			22.02			23.61			0.35	U	
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	2.5		NJ	10.89			18.86			17.67			23.21			20.97			2.99	ME	
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	0.5	U	UJ	1.88			5.23			6.94			9.7			9.18			3.26	ME	
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	15.52	U		11	U		11.62	U		20.68			16.81			20.54			12.17	U	

Notes:
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The sample was diluted to within the calibration range and re-run.
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N Presumptive evidence of presence of the constituent
J Indicates an estimated value.

Thames River Validation Study
Subase New London
PCBs in Core Sediment
(ng/g dry wt)

				Cl5(101)			Cl5(105)			Cl5(118)			Cl5(126)			Cl6(128)			Cl6(138)			Cl6(153)		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	8.59			2.56			6.66			0.52	U		2.27			7.22			9.71		
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	0.32	U		0.26	U		0.33	U		0.41	U		0.23	U		0.35	U		0.39	U	
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	0.3	U		0.24	U		0.31	U		0.39	U		0.22	U		0.33	U		0.37	U	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	5.96			2.09			5.8			0.55	U		2.3			6.34			9.15		
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	0.3	U		0.24	U		0.31	U		0.39	U		0.22	U		0.33	U		0.37	U	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	0.31	U		0.25	U		0.32	U		0.41	U		0.23	U		0.35	U		0.38	U	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	9.38			2.36			6.63			0.5	U		2.42			7.35			10.34		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	0.76			0.25	U		0.59			0.4	U		0.22	U		0.78			0.9		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	0.65			0.25	U		0.34			0.41	U		0.23	U		0.54			0.57		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	11.47			3.36			9.16			0.54	U		4.08			9.17			12.58		
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	16.22			4.94			12.97			0.52	U		5.76			13.92			19.45		
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.07	U	UJ	0.05	U	UJ	0.07	U	UJ	0.09	U	UJ	0.05	U	UJ	0.07	U	UJ	0.08	U	UJ
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	2.96			1			2.04			0.1	U		0.74			2.07			2.52		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	1.22			0.44			0.89			0.09	U		0.35			0.88			1.07		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	301.58	D		99.52	D		244.42	D		0.15	U		53.2	D		277.25	D		268.18	D	
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	52.16	D		12.28			44.71	D		0.11	U		7.02			44.25	D		44.33	D	
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	26.53	D		7.85			21.23			0.1	U		4.67			20.44			21.78	D	
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	31.94			9.78			21.94			0.48	U		8.81			23.54			28.01		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	24.13			8.64			18.68			0.4	U		5.09			18			22.4		
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	16.08			5.08			11.65			0.53	U		3.35			12.25			14.19		
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	33.7			10.36	U		21.11			16.66	U		9.37	U		24.8			29.57		

Notes:
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N Presumptive evidence of presence of the constituent
J Indicates an estimated value.

Thames River Validation Study
Subase New London
PCBs in Core Sediment
(ng/g dry wt)

				Cl7(170)			Cl7(180)			Cl7(187)			Cl9(206)			Cl10(209)		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C2	DAD 19 2'-4'	2-4 ft	1.93			4.32			3.57			2.42			3.03		
Zone 7	Z7-C2	DAD 19 4'6"-6'	4 ft 6 in - 6 ft	0.32	U		0.32	U		0.28	U		0.32	U		0.33	U	
Zone 7	Z7-C2	DAD 19 6'-7'6"	6 ft - 7 ft 6 in	0.3	U		0.3	U		0.26	U		0.3	U		0.31	U	
Zone 7	Z7-C1	DAD 17 2'-3'2"	2 ft - 3 ft 2 in	1.78			3.95			3.2			2.35			3.52		
Zone 7	Z7-C1	DAD 17 3'8"-6'	3 ft 8 in - 6 ft	0.31	U		0.3	U		0.27	U		0.31	U		0.32	U	
Zone 7	Z7-C1	DAD 17 6'-7'10"	6 ft - 7 ft 10 in	0.32	U		0.32	U		0.28	U		0.32	U		0.33	U	
Zone 7	Z7-C1R	DAD 18 2'-3'9"	2 ft - 3 ft 9 in	2.11			4.3			3.34			2.25			3.27		
Zone 7	Z7-C1R	DAD 18 3'9"-6'	3 ft 9 in - 6 ft	0.31	U		0.4			0.3			0.31	U		0.41		
Zone 7	Z7-C1R	DAD 18 6'-8'	6 ft - 8 ft	0.32	U		0.35			0.28	U		0.32	U		0.52		
Zone 4	Z4-C1	DAD 8 2'-4'	2 ft - 4 ft	2.32			5.15			4.3			2.58			3.75		
Zone 4	Z4-C1	DAD 8 4'-5'	4 ft - 5 ft	4.24			9.02			6.53			4.36			4.97		
Zone 4	Z4-C1	DAD 8 5'6"-7'3"	5 ft 6 in - 7 ft 3 in	0.07	U	UJ	0.07	U	UJ	0.06	U	UJ	0.07	U	UJ	0.07	U	UJ
Zone 4	Z4-C2	DAD 9 2'-4'	2 ft - 4 ft	0.49			0.99			0.68			0.48			0.56		
Zone 4	Z4-C2	DAD 9 4'-5'5"	4 ft - 5 ft 5 in	0.15			0.46			0.31			0.29			0.38		
Pier 1	P1-C2	DAD 28 0'-2'	0 ft - 2 ft	11.31		J	44.77	D		9.32		J	1.67		J	1.08		J
Pier 1	P1-C2	DAD 28 2'-4'	2 ft - 4 ft	3.32			5.47			2.89			0.81			0.82		
Pier 1	P1-C2	DAD 28 4'-5'1/4"	4 ft - 5 ft	1.88			2.92			1.6			0.95			0.46		
Pier 1	P1-C5	DAD 31 2'-4'	2 ft - 4 ft	5.46			11.02			8.07			4.33			4.02		
Pier 1	P1-C5	DAD 31 4'-6'	4 ft - 6 ft	3.43			7.87			5.17			3.87			3.78		
Pier 1	P1-C3	DAD 29 0-2'7"	0 ft - 2 ft 7 in	2.15			4.33			3.4			1.63			2.65		
Pier 1	P1-C4	DAD 30 0-2'	0 ft - 2 ft	13.04	U		12.92	U		11.29	U		13.05	U		13.44	U	

Notes:
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D Dilution run. Initial run outside linear range of instrument The sample was diluted to within the calibration range and re-run. Only analytes above the calibration range are reported from a further dilution.
N Presumptive evidence of presence of the constituent
J Indicates an estimated value.

Thames River Validation Study
Subase New London
TPH-DRO in Core Sediment
(mg/kg)

				Diesel fuel			Motor Oil		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result (mg/kg)**	**Lab Qual**	**Final Qual**	**Result (mg/kg)**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C1	DAD17 2-3_2-Z7-C1	2 ft - 3 ft 2 in	110			870		
Zone 7	Z7-C1	DAD17 3_8-6-Z7-C1	3 ft 8 in - 6 ft	14	U		65		
Zone 7	Z7-C1	DAD17 6-7_10-Z7-C1	6 ft - 7 ft 10 in	14	U		110		
Zone 7	Z7-C1R	DAD18 2-3_9-Z7-C1R	2 ft - 3 ft 9 in	110			960		
Zone 7	Z7-C1R	DAD18 3_9-6-Z7-C1R	3 ft 9 in - 6 ft	17			150		
Zone 7	Z7-C1R	DAD18 6-8-Z7-C1R	6 ft - 8 ft	15			150		
Zone 7	Z7-C2	DAD19 2-4-Z7-C2	2 ft - 4 ft	120			960		
Zone 7	Z7-C2	DAD19 4_6-6-Z7-C2	4 ft 6 in - 6 in	14	U		87		
Zone 7	Z7-C2	DAD19 6-7_6-Z7-C2	6 ft - 7 ft 6 in	13	U		81		
Zone 4	Z4-C1	DAD8 2-4-Z4-C1	2 ft - 4 ft	150			1300		
Zone 4	Z4-C1	DAD8 4-5-Z4-C1	4 ft - 5 ft	250			1800		
Zone 4	Z4-C1	DAD8 5_6-7_3-Z4-C1	5 ft 6 in - 7 ft 3 in	7.6	U		19	U	
Zone 4	Z4-C2	DAD9 2-4-Z4-C2	2 ft - 4 ft	31			160		
Zone 4	Z4-C2	DAD9 4-5_5-Z4-C2	4 ft - 5 ft 5 in	12			67		
Pier 1	P1-C2	DAD28 4-5-P1-C2	4 ft - 5 ft	180		J	670		J
Pier 1	P1-C2	DAD28 0-2-P1-C2	0 ft - 2 ft	710			3300		
Pier 1	P1-C2	DAD28 2-4-P1-C2	2 ft - 4 ft	280			1400		
Pier 1	P1-C3	DAD29 0-2_7-P1-C3	0 ft - 2 ft 7 in	100			1000		
Pier 1	P1-C4	DAD30 0-2-P1-C4	0 ft - 2 ft	150			910		
Pier 1	P1-C5	DAD31 2-4-P1-C5	2 ft - 4 ft	360			2000		
Pier 1	P1-C5	DAD31 4-6-P1-C5	4 ft - 6 ft	710			2100		

Notes:
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Thames River Validation Study
Subase New London
TOC and Grain Size in Core Sediment

				TOC			Percent Solids			Gravel			Coarse Sand			Medium Sand			Fine Sand		
Area	Station ID	Sample ID	Sample Depth	Result (mg/kg)	Lab Qual	Final Qual	Result (%)	Lab Qual	Final Qual	Result (%)	Lab Qual	Final Qual	Result (%)	Lab Qual	Final Qual	Result (%)	Lab Qual	Final Qual	Result (%)	Lab Qual	Final Qual
Zone 7	Z7-C1	DAD17 2-3_2-Z7-C1	2 ft - 3 ft 2 in	43400			35.2			0			0			0.2			5.4		
Zone 7	Z7-C1	DAD17 3_8-6-Z7-C1	3 ft 8 in - 6 ft	28300			49.4			0			0			0.3			4.1		
Zone 7	Z7-C1	DAD17 6-7_10-Z7-C1	6 ft - 7 ft 10 in	48500			47.4			0			0			0.2			6.1		
Zone 7	Z7-C1R	DAD18 2-3_9-Z7-C1R	2 ft - 3 ft 9 in	33100			37.2			0			0			0.3			6.3		
Zone 7	Z7-C1R	DAD18 3_9-6-Z7-C1R	3 ft 9 in - 6 ft	30800			47.6			0			0.2			0.3			5.2		
Zone 7	Z7-C1R	DAD18 6-8-Z7-C1R	6 ft - 8 ft	48400			46.9			0			0			0.6			6.6		
Zone 7	Z7-C2	DAD19 2-4-Z7-C2	2 ft - 4 ft	33800			34.2			0			0.2			0.8			3.8		
Zone 7	Z7-C2	DAD19 4_6-6-Z7-C2	4 ft 6 in - 6 in	38300			47.5			0			0			0.5			4		
Zone 7	Z7-C2	DAD19 6-7_6-Z7-C2	6 ft - 7 ft 6 in	37400			53.3			0			0.1			0.7			5		
Zone 4	Z4-C1	DAD8 2-4-Z4-C1	2 ft - 4 ft	34300			34.8			0			0			0			5		
Zone 4	Z4-C1	DAD8 4-5-Z4-C1	4 ft - 5 ft	42400			34.5			0			0			0			4.9		
Zone 4	Z4-C1	DAD8 5_6-7_3-Z4-C1	5 ft 6 in - 7 ft 3 in	566	U		88.4			13			9.6			29.2			44.1		
Zone 4	Z4-C2	DAD9 2-4-Z4-C2	2 ft - 4 ft	3560			82			1			2.1			23.9			56.5		
Zone 4	Z4-C2	DAD9 4-5_5-Z4-C2	4 ft - 5 ft 5 in	1700			85.4			13.5			7.6			25.1			46.4		
Pier1	P1-C2	DAD28 0-2-P1-C2	0 ft - 2 ft	23900			53			6.4			0.3			7.2			27.9		
Pier1	P1-C2	DAD28 2-4-P1-C2	2 ft - 4 ft	10500			69.3			0.2			0.8			13.5			48.6		
Pier1	P1-C2	DAD28 4-5-P1-C2	4 ft - 5 ft	14300		J	76.9			25.2			10			22.7			25		
Pier1	P1-C3	DAD29 0-2_7-P1-C3	0 ft - 2 ft 7 in	35000			35.8			0.4			0.9			2.5			10.7		
Pier1	P1-C4	DAD30 0-2-P1-C4	0 ft - 2 ft	15100			66.6			12.5			8			14			24.7		
Pier1	P1-C5	DAD31 2-4-P1-C5	2 ft - 4 ft	35800			37.8			0			0.2			1.8			10.1		
Pier1	P1-C5	DAD31 4-6-P1-C5	4 ft - 6 ft	34300			46.8			43.4			0.9			5.6			8.9		

Notes:

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Thames River Validation Study
Subase New London
TOC and Grain Size in Core Sediment

				Silt			Clay		
Area	**Station ID**	**Sample ID**	**Sample Depth**	**Result (%)**	**Lab Qual**	**Final Qual**	**Result (%)**	**Lab Qual**	**Final Qual**
Zone 7	Z7-C1	DAD17 2-3_2-Z7-C1	2 ft - 3 ft 2 in	71.9			22.5		
Zone 7	Z7-C1	DAD17 3_8-6-Z7-C1	3 ft 8 in - 6 ft	39.1			56.5		
Zone 7	Z7-C1	DAD17 6-7_10-Z7-C1	6 ft - 7 ft 10 in	43.6			50.1		
Zone 7	Z7-C1R	DAD18 2-3_9-Z7-C1R	2 ft - 3 ft 9 in	74.8			18.6		
Zone 7	Z7-C1R	DAD18 3_9-6-Z7-C1R	3 ft 9 in - 6 ft	41.3			53.1		
Zone 7	Z7-C1R	DAD18 6-8-Z7-C1R	6 ft - 8 ft	55.6			37.1		
Zone 7	Z7-C2	DAD19 2-4-Z7-C2	2 ft - 4 ft	73.8			21.5		
Zone 7	Z7-C2	DAD19 4_6-6-Z7-C2	4 ft 6 in - 6 in	42.5			53.1		
Zone 7	Z7-C2	DAD19 6-7_6-Z7-C2	6 ft - 7 ft 6 in	35.1			59.1		
Zone 4	Z4-C1	DAD8 2-4-Z4-C1	2 ft - 4 ft	73.4			21.5		
Zone 4	Z4-C1	DAD8 4-5-Z4-C1	4 ft - 5 ft	73			22.1		
Zone 4	Z4-C1	DAD8 5_6-7_3-Z4-C1	5 ft 6 in - 7 ft 3 in	2.2			1.8		
Zone 4	Z4-C2	DAD9 2-4-Z4-C2	2 ft - 4 ft	10			6.6		
Zone 4	Z4-C2	DAD9 4-5_5-Z4-C2	4 ft - 5 ft 5 in	3.7			3.7		
Pier1	P1-C2	DAD28 0-2-P1-C2	0 ft - 2 ft	47.6			10.6		
Pier1	P1-C2	DAD28 2-4-P1-C2	2 ft - 4 ft	30			6.9		
Pier1	P1-C2	DAD28 4-5-P1-C2	4 ft - 5 ft	14.1			3		
Pier1	P1-C3	DAD29 0-2_7-P1-C3	0 ft - 2 ft 7 in	72.5			13.1		
Pier1	P1-C4	DAD30 0-2-P1-C4	0 ft - 2 ft	28.6			12.1		
Pier1	P1-C5	DAD31 2-4-P1-C5	2 ft - 4 ft	63.7			24.2		
Pier1	P1-C5	DAD31 4-6-P1-C5	4 ft - 6 ft	26.6			14.7		

Notes:

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J Indicates an estimated value.

APPENDIX A

Analytical Chemistry Data Package
Inorganics Analysis

Project: Thames River Validation Study
December 2004

Analysis of Hg in Reference Sediment

Battelle Project No. 48350
CF No. 2279

Battelle
. . . Putting Technology To Work

Marine Sciences Laboratory
1529 West Sequim Bay Road
Sequim, WA 98382
PM: Jill M. Brandenberger
(360) 681-4564

CERTIFICATION STATEMENT AND DATA RELEASE

Battelle Marine Sciences Laboratory is releasing the following data set:

THAMES RIVER VALIDATION STUDY DECEMBER 2004

Analysis of Hg in Sediment

We certify that the data contained within this data set is authentic:

1/13/05

Jill M. Brandenberger
MSL Metals Chemistry Project Manager

Date

1/10/05

Janet Cloutier
MSL QA Officer

Date

BATTELLE MARINE SCIENCES LABORATORIES
Jill Brandenberger, Project Manager
1529 West Sequim Bay Road
Sequim, Washington 98382
(360) 681-4564

Thames River Validation Study
Subase New London
Metals in Reference Sediment
(concentrations in µg/g dry wt)

SPONSOR CODE	Site Description	BDO Code	MSL Code	Collection Date	Percent Moisture	Hg	Original Hg Data Analysis Date 11/02/04
					CAS CODE:	7439-97-6	7439-97-6
					Method:	CVAA	CVAA
Target Detection Limit[1]						0.002	0.002
Laboratory Achieved Method Detection Limits (MDLs) [2]						**0.0043**	**0.0043**
Laboratory Achieved Reporting Limit (RL)						**0.014**	**0.014**
DAD-33	R-S2	S5628	2279-23	10/13/2004	45.89	0.223	NA
DAD-34	R-S3	S5629	2279-24	10/13/2004	55.70	0.185	NA
DAD-35	R-S4	S5630	2279-25	10/13/2004	45.68	0.0720	NA
DAD-32	R-S1	S5633	2279-28	10/13/2004	49.42	0.309	NA
DAD-37	R-S6	S5636	2279-31	10/13/2004	60.33	0.352	NA
DAD-36	R-S5	S5640	2279-35	10/13/2004	53.53	0.377	NA
DAD-23	P4	S5644	2279-39	10/12/2004	68.87	0.450	0.442
Procedural Blanks							
MB 1			Blank 102804r1			0.0110 J	0.0200
MB 2			Blank 102804r2			0.00600 J	0.00560 J
Laboratory Control Sample(LCS) Results							
LCS 1			LCS 102804r1			2.04	2.07
MB 1			Blank 102804r1			0.0110 J	0.0200
	Spike concentration					*2.0*	*2.0*
	PERCENT RECOVERY, LCS-1					**101%**	**103%**
LCS 2			LCS 102804r2			1.91	1.96
MB 2			Blank 102804r2			0.00600 J	0.00560 J
	Spike concentration					*2.0*	*2.0*
	PERCENT RECOVERY, LCS-2					**95%**	**98%**
Matrix Spike Results							
MS 2			2279-39MS			2.49	2.54
MSD 2			2279-39MSD			2.70	2.64
DAD-23	P4	S5644	2279-39	10/12/2004	68.87	0.450	0.442
	Spike concentration, MS					1.97	1.97
	Spike concentration, MSD					2.04	2.04
	PERCENT RECOVERY, MS					**104%**	**106%**
	PERCENT RECOVERY, MSD					**110%**	**108%**
	RPD					**6%**	**1%**
Standard Reference Material							
SRM 1			1944 102804r1			3.83	3.82
SRM 2			1944 102804r2			3.55	3.47
	Certified or Reference Value					3.4	3.4
	range					± 0.5	± 0.5
	Percent Difference SRM 1					**13%**	**12%**
	Percent Difference SRM 2					**4%**	**2%**

FOOTNOTES:

[1] Target detection limit reported from Thames River Validation Study Work Plan, Appendix C

[2] Laboratory achieved MDL reported from the MSL 2004 Sediment MDL study.

SL Spiking level insufficient relative to native sample concentration.

B Blank contamination: The analyte was detected above the reporting limit in an associated blank. For this study, blank contamination indicates that the analyte was found in both a sample and the associated blank. The "B" will be reported on the result associated with the field samples, not the blank. If the concentration in the related field sample is >5 times that detected in the blank, no flag will be applied.

D Dilution run. Initial run outside linear range of instrument

J Estimated value: The analyte was positively identified but is less than the sample-specific reporting limit; the quantization is an estimation.

U Undetected at the method detection limit: The associated data value is the method detection limit, adjusted by any dilution factor used in the analysis (i.e., the sample-specific MDL).

N Spiked sample or SRM not within control limits

* Duplicate analysis not within control limits

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Hg
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: REFERENCE Sediment

SAMPLE CUSTODY AND PROCESSING: The samples were received in two batches on 10/15/04 and 10/21/04. All samples were received in good condition (i.e., no sample containers were broken or leaking). Samples were assigned a Battelle Central File (CF) identification number (2279) and were entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

MSL Code:	**2279-1 thru -21**	**2279-22 thru -49**
Description:	Sediment	Sediment
Collection date	10/11/04	10/12/04 and 10/13/04
Laboratory arrival date	10/15/04	10/21/04
Cooler temperature on arrival	4.3°C	3.5°C
Freeze Dryer (MSL-C-003):	10/16/04 thru 10/28/04	
Digestion Date (HNO_3/HCl, SOP MSL-I-006)	10/28/04	
CVAA Analysis Date (Hg, MSL-I-016)	01/12/05	

METHODS: All sediment samples were digested for mercury (Hg) on 10/28/04. Samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-006, *Mixed Acid Sediment Digestion*. An approximately 200-mg (dry weight) aliquot of each sample was combined with nitric and hydrochloric acids (aqua regia) in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested sediment to achieve analysis volume. Digested sediment samples were submitted for Hg analysis.

The digested samples were analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016, *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The base method for this procedure is EPA Method 245.5.

All results were reported in units of µg/g on a dry-weight basis.

HOLDING TIMES: All samples were digested on 10/28/04 and the Pier 1 plus QC samples were analyzed on 11/02/04. This is within the recommended holding time for Hg of 28 days from sample collection. The reference sediment samples were digested with the Pier 1 samples on 10/28/04; however, they were not analyzed for Hg. The reference samples, QC samples, and one Pier 1 sample were analyzed for Hg on 01/12/05. The reference sediment samples were not analyzed within the 28 day holding time; however, they were digested and stored in a nitric/hydrochloric acid solution (aqua regia) of pH <2.0 within this holding time. The second analysis of the QC samples and Pier 1 sample confirmed the Hg concentrations were stable in the acid solution. Therefore, the data are not considered to be impacted by the analysis outside the 28-day holding time.

QA/QC NARRATIVE

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Target MDL (µg/g)	Achieved MDL (µg/g)	Achieved Reporting Limits (µg/g)
Hg	CVAA	70-130%[1]	±30%[2]	≤25%	0.002	0.0043	0.014

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the 2004 Sediment MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of quartz sand. The achieved MDL for Ba, Hg, Ni, and Zn is slightly higher than the target due to variation between annual MDL studies. Impact to the quality and usability of the data is insignificant as the sample concentrations are a minimum of two orders of magnitude higher than the achieved MDL. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

PROCEDURAL BLANKS: Two procedural blanks were analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL. The second analysis of the blanks confirmed the original data.

LABORATORY CONTROL SAMPLE (LCS) ACCURACY: Two LCSs were analyzed with the samples. Percent recoveries for the LCS samples were 101% and 95% and were within the QC criterion of 70-130% recovery. The original percent recoveries for the LCS samples were 103% and 98%.

MATRIX SPIKE/ MATRIX SPIKE DUPLICATE (MS/MSD) ACCURACY: One sample was selected for matrix spike/matrix spike duplicate (MS/MSD). The MS/MSD recoveries were 104% and 110% and were within the QC criterion of 70-130% recovery. The original percent recoveries for the MS/MSD were 106% and 108%.

REPLICATE PRECISION: Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate matrix spike results. The RPD result was 6% and within the QC criterion of ±30%.

STANDARD REFERENCE MATERIAL ACCURACY: SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM 1944 New York/New Jersey Waterway Sediment was analyzed with each batch of samples. The percent differences for SRM 1944 were 13% and 4% and were within the QC criterion of ≤25%. The original percent differences were 12% and 2%.

TRAFFIC REPORT

Entry Date	10/25/2004
CF#	2279
Add#	kit, ADD #7099 (ICP-OES), #7113 (Re-digest)
Project Name	**Thames River Validation Study**
Matrix	sediment
Sample ID Nos. (# of Samples)	**2279*1-49 All Metals and [Hg on 2279*4-7, 19-22, 27, 32, 39, 41, 43, 46, 49]**
Sample Disposal Date	*10/21/2005*
Sample Receipt	2279*1-21 rec'd 10/15/04@1230; 2279*22-49 rec'd 10/21/2004 @ 1220

Percent Moisture Summary (MSL-C-003)	
Date, Time in Freeze Dryer	2279*1-21: 10/16/04, 1655 2279*22-49: 10/21/2004, 1515
Date, Time out of Freeze Dryer	2279*1-21: 10/21/04, 0630 2279*22-49: 10/28/2004, 0835
Percent Moisture Summary	10/28/2004
Digestion/Extraction (MSL-I-006)	
Digestion/ Extraction (#1)	Aqua Regia
Date, Time Completed	Start: 10/28/04, 1600 End: 10/29/04, 0930
Digestion/ Extraction (#2)	AR Redigest (Add #7113)
Date Completed	Start: 11/12/04, 1400: End: 11/14/04, 1115
Instrument Analysis	
ICP-MS Analysis Completed	Original analysis -10/29/2004
CVAA (Hg) Analysis Completed	(Aqua Regia, #1) 110204-HGL and 011205HGBL. Individual sample analysis times are noted on Hg benchsheet.
ICP-OES Analysis Completed	11/8/04, Redigestion 11/19/04
FIAS (Se) Analysis Completed	11/2/2004
Data	
Data Summary Completed	11/19/2004
Narrative Completed	11/19/2004
QC	
Date to QC Review	11/22/2004
QC Review Completed	11/23/2004
Results Submitted to Client	11/23/2004
Samples Disposed	*Do not dispose until 10/05 pending client acceptance of data*

Jill M. Brandenberger, 11/23/2004
Project Manager/Date

Reference SOP: MSL-I-0028

Prepared using Sample Tracking Worksheet, LIMS

Analytical Run Checksheet
TotalHg Analysis

Project Name: Mary Thames River Validation
CF# 2279
Kit or Addendum # 7169
Analysis: ~~Sediment~~/Tissue MSL-I-016

Analysis Date: 1/12/05
Instrument: Total Hg CVAA
Run ID: 011205HGBL

Data Quality Objective List

	Method DQOs	DQO Met? (y/n)	Initials	Client DQOs	DQO Met? (y/n)	Initials
Calibration	NA	y	MAP	20.995	y	MAP
ICV	±15%			±15%		
CCVs	±15%			±15%		
Blank Criteria	NA			LRL		
Blank Spk Recovery	NA			70-130%		
SRMs Recovery	75-125%			±25%		
MS/MSD Recovery	75-125%			70-130%		
MS/MSD RPD	±25%			70-130%		
Replicate RPD	±25%	✓	✓	±30%		✓

If DQO not noted on kit/addendum please write NA in blank

Comments: (Include if a DQO wasn't met, note what, why, the action taken, and decision made. Also please note any rerun, deviation, or discussion with PMs when results are affected. If more room is needed, write on backside or on additional piece of pap

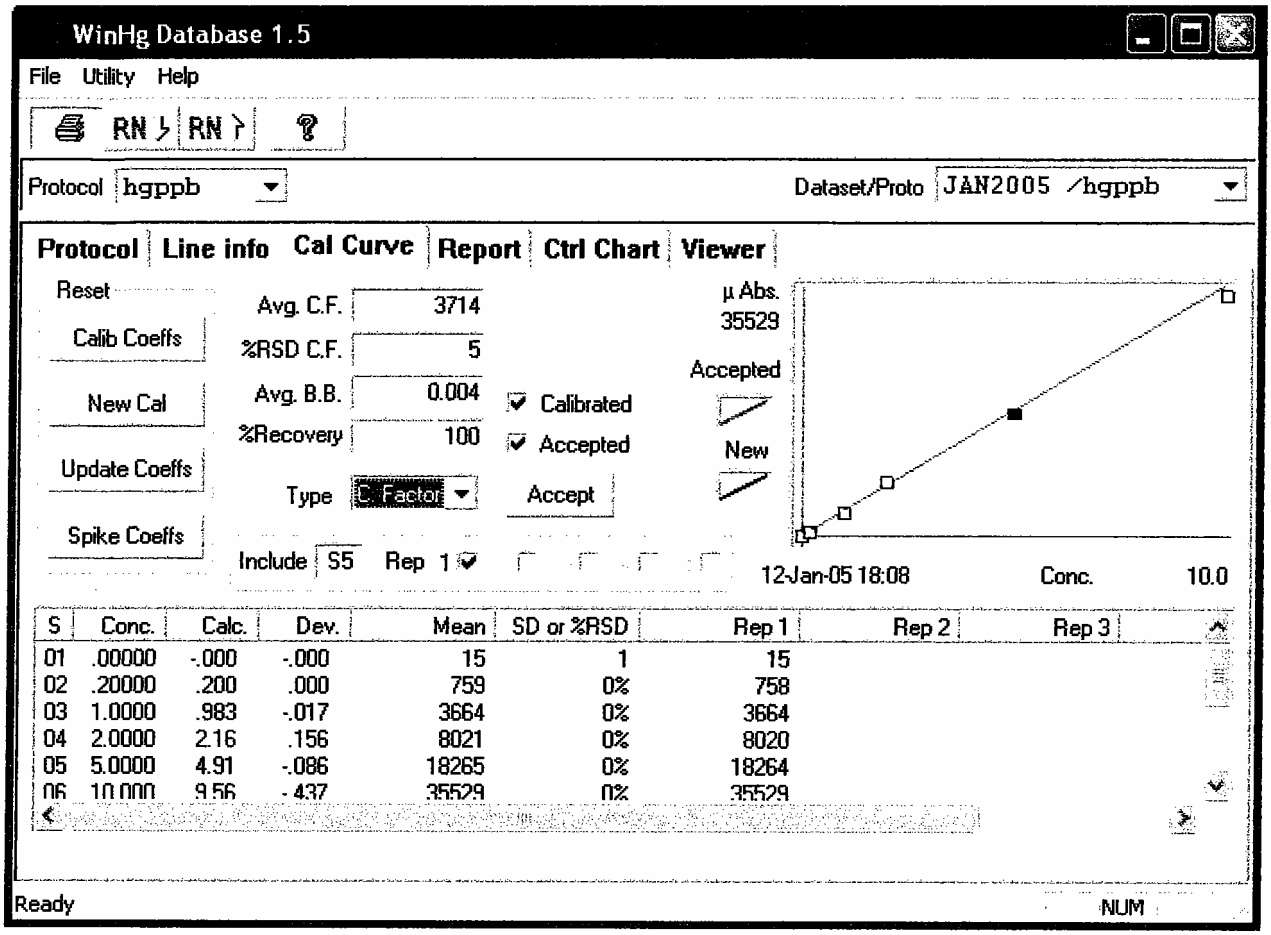
Signatures for reviews as per MSL-Q-005 and MSL-D-004

Analyst (technical review)	Date	Project Manager (peer review)	Date
Mary Ann Pacitti	1/12/05	[illegible]	1/13/05

PROJECT ID:			Thames River Validation Task 2			ANALYST:	Deuth				
ANALYSIS:			LEEMAN HYDRA AA - HGBL			FILE #:	2279		CAL FACTOR	3714	
ANALYSIS DATE:			01/12/05			ADD #:	7169		Y-INTERCEPT	15	
MATRIX:			Sediment						Digest Blk	0.01467	
CALCULATED BY PEAK AREA						IDL/ng	0.00917				
Digestion:			Aqua Regia			MDL/µg/g	0.00432				
ANALYTIC RUN#:		**011205HGBL**									
DIGESTION DATE	VIAL #	SEQ #	BATTELLE ID	PEAK TIME	DIGEST WT g	SAMP VOL ml	DILUT FACT	PEAK UNITS	**TOTAL HG** [Hg]µg/g	P. Blank corrected	% RECOV
10/28/04	1-2	104	Blank 102804r1	18:19	0.200	21.171	2.0	205	0.0110		
10/28/04	1-6	108	Blank 102804r2	18:26	0.200	20.979	2.0	114	0.0060		
10/28/04	1-21	123	Blank 102804r3	18:52	0.200	19.980	2.0	509	0.0270		
10/28/04	1-3	105	LCS 102804L1r1	18:20	0.200	21.370	7.0	10154	2.0400	2.0253	101.3%
10/28/04	1-7	109	LCS 102804L1r2	18:28	0.200	20.785	7.0	9742	1.9100	1.8953	94.8%
10/28/04	1-22	124	LCS 102804L1r3	18:54	0.200	20.111	7.0	10414	1.9700	1.9553	97.8%
10/28/04	1-4	106	1944 102804r1	18:22	0.197	21.705	7.0	18452	3.8300	3.8153	112.6%
10/28/04	1-8	110	1944 102804r2	18:29	0.197	21.817	7.0	17046	3.5500	3.5353	104.4%
10/28/04	1-23	125	1944 102804r3	18:55	0.201	20.926	7.0	19059	3.7400	3.7253	110.0%
10/28/04	1-5	107	PACS2 102804r1	18:23	0.204	22.041	7.0	15281	3.1100	3.0953	102.3%
10/28/04	1-9	111	PACS2 102804r2	18:31	0.213	20.986	7.0	16923	3.1400	3.1253	103.3%
10/28/04	1-24	126	PACS2 102804r3	18:57	0.197	20.726	7.0	14503	2.8700	2.8553	94.4%
10/28/04	1-10	112	2279-23	18:32	0.206	21.008	2.0	4075	0.2230	0.2083	
10/28/04	1-11	113	2279-24	18:34	0.198	21.121	2.0	3236	0.1850	0.1703	
10/28/04	1-13	115	2279-25	18:38	0.221	20.950	2.0	1417	0.0720	0.0573	
10/28/04	1-14	116	2279-28	18:39	0.213	20.794	2.0	5882	0.3090	0.2943	
10/28/04	1-15	117	2279-31	18:41	0.199	21.526	2.0	6051	0.3520	0.3373	
10/28/04	1-16	118	2279-35	18:43	0.209	22.065	2.0	6648	0.3770	0.3623	
10/28/04	1-17	119	2279-39	18:45	0.215	21.629	2.0	8310	0.4500	0.4353	
10/28/04	1-18	120	2279-39MSL1	18:47	0.203	21.630	7.0	12434	2.4900	2.4753	103.6%
10/28/04	1-19	121	2279-39MSDL1	18:49	0.196	21.537	7.0	13069	2.7000	2.6853	110.3%
SPIKE DATA											
Sample Number:			LCSL1r1	LCSL1r2	LCSL1r3	#39MS	#39MSD		**SRM**		
Amount Spiked:			2.0000	2.0000	2.0000	1.9700	2.0400				
Sample Only:			0.0147	0.0147	0.0147	0.4500	0.4500		PACS-2	3.04±0.20	
Sample + Spike:			2.0400	1.9100	1.9700	2.4900	2.7000		NIST 1944	3.4±0.~~09~~ 0.5	
Amount Recovered:			2.0253	1.8953	1.9553	2.0400	2.2500				
Percent Recovery:			101.3%	94.8%	97.8%	103.6%	110.3%				
RPD:							6.30%				

TOTAL MERCURY

DIGESTION DATE	VIAL #	SEQ #	BATTELLE ID	PEAK TIME	DIGEST WT g	SAMP VOL ml	DILUT FACT	PEAK UNITS	TOTAL HG [Hg]µg/g	P. Blank corrected	% RECOV
										VALUE	
ICV	1-1	103	Std #268	18:17				38187	10.3000	10.00	103.0%
CCV	1-12	114	Std #1381	18:36				8289	2.2300	2.00	111.5%
CCV	1-20	122	Std #1382	18:50				18710	5.0300	5.00	100.6%
CCV	1-25	127	Std #1383	18:59				35888	9.6600	10.00	96.6%
Cal Ext	1-26	128	Std #1384	19:00				180892	48.7000	50.00	97.4%
CCV	1-36	138	Std #1381	19:18				7823	2.1000	2.00	105.0%
CCV	1-43	145	Std #1383	19:29				37874	10.2000	10.00	102.0%


WinHg Database 1.5
File Utility Help
Protocol hgppb
Dataset/Proto JAN2005 /hgppb
Protocol Line info Cal Curve Report Ctrl Chart Viewer
Reset
Calib Coeffs
New Cal
Update Coeffs
Spike Coeffs
Avg. C.F. 3714
%RSD C.F. 5
Avg. B.B. 0.004
%Recovery 100
Type C. Factor
Calibrated
Accepted
Accept
Include S5 Rep 1
µ Abs.
35529
Accepted
New
12-Jan-05 18:08
Conc. 10.0
S Conc. Calc. Dev. Mean SD or %RSD Rep 1 Rep 2 Rep 3
01 .00000 -.000 -.000 15 1 15
02 .20000 .200 .000 759 0% 758
03 1.0000 .983 -.017 3664 0% 3664
04 2.0000 2.16 .156 8021 0% 8020
05 5.0000 4.91 -.086 18265 0% 18264
06 10.000 9.56 -.437 35529 0% 35529
Ready
NUM

POST-RUN REPORT

Line	Conc.	Units	SD/RSD	1	2	3	4	5
*** Standard: 1 Rep: 1				Seq: 87	14:13:05 12 Jan 05	HG		
Hg	.000	ppb	126					
*** Standard: 2 Rep: 1				Seq: 88	14:14:45 12 Jan 05	HG		
Hg	.200	ppb	59					
*** Standard: 3 Rep: 1				Seq: 89	14:16:23 12 Jan 05	HG		
Hg	1.00	ppb	6					
*** Standard: 4 Rep: 1				Seq: 90	14:18:22 12 Jan 05	HG		
Hg	2.00	ppb	172					
*** Standard: 5 Rep: 1				Seq: 91	17:19:49 12 Jan 05	HG		
Hg	5.00	ppb	271					
*** Standard: 6 Rep: 1				Seq: 92	17:21:39 12 Jan 05	HG		
Hg	10.0	ppb	-345					
*** Standard: 1 Rep: 1				Seq: 93	17:30:40 12 Jan 05	HG		
Hg	.000	ppb	-95					
*** Standard: 2 Rep: 1				Seq: 94	17:32:31 12 Jan 05	HG		
Hg	.200	ppb	44					
*** Standard: 3 Rep: 1				Seq: 95	17:34:08 12 Jan 05	HG		
Hg	1.00	ppb	3664					
*** Standard: 4 Rep: 1				Seq: 96	17:35:50 12 Jan 05	HG		
Hg	2.00	ppb	8195					
*** Standard: 5 Rep: 1				Seq: 97	17:37:39 12 Jan 05	HG		
Hg	5.00	ppb	18264					
*** Standard: 6 Rep: 1				Seq: 98	17:39:46 12 Jan 05	HG		
Hg	10.0	ppb	35529					

POST-RUN REPORT

```
Line   Conc.  Units     SD/RSD      1       2       3       4       5
-----------------------------------------------------------------------------

*** Standard: 1 Rep: 1              Seq:  99      17:49:37 12 Jan 05   HG

Hg    .000    ppb      112
                                                                        =
*** Standard: 2 Rep: 1              Seq:  100     17:51:15 12 Jan 05   HG

Hg    .200    ppb      758
                                                                        =
*** Standard: 1 Rep: 1              Seq:  101     17:56:24 12 Jan 05   HG

Hg    .000    ppb      15
                                                                        =
*** Standard: 4 Rep: 1              Seq:  102     17:59:07 12 Jan 05   HG

Hg    2.00    ppb      8020
                                                                        =
*** Sample ID: Std #268              Seq:  103    18:17:33 12 Jan 05   HG
                           2279#
Hg    10.3    ppb      38187
                                                                        =
=============================================================================
*** Sample ID: Blank 1028            Seq:  104    18:19:09 12 Jan 05   HG
                           2279#                Wgt .20000 Vol .04230
Hg    .011    ppb      205
                                                                        =
=============================================================================
*** Sample ID: LCS 102804            Seq:  105    18:20:45 12 Jan 05   HG
                           2279#                Wgt .20000 Vol .14960
Hg    2.04    ppb      10154
                                                                        =
=============================================================================
*** Sample ID: 1944 10280            Seq:  106    18:22:21 12 Jan 05   HG
                           2279#                Wgt .19700 Vol .15190
Hg    3.83    ppb      18452
                                                                        =
=============================================================================
*** Sample ID: PACS2 1028            Seq:  107    18:23:57 12 Jan 05   HG
                           2279#                Wgt .20400 Vol .15430
Hg    3.11    ppb      15281
                                                                        =
=============================================================================
*** Sample ID: Blank 1028            Seq:  108    18:26:24 12 Jan 05   HG
                           2279#                Wgt .20000 Vol .04200
Hg    .006    ppb      114
                                                                        =
=============================================================================
```

POST-RUN REPORT

```
Line   Conc.  Units     SD/RSD      1       2       3       4       5
-----------------------------------------------------------------------------

*** Sample ID: LCS 102804            Seq:  109    18:28:00 12 Jan 05   HG
                            2279#                Wgt .20000 Vol .14550
Hg    1.91    ppb      9742
                                                                        =
=============================================================================
*** Sample ID: 1944 10280            Seq:  110    18:29:37 12 Jan 05   HG
                            2279#                Wgt .19700 Vol .15270
Hg    3.55    ppb      17046
                                                                        =
=============================================================================
*** Sample ID: PACS2 1028            Seq:  111    18:31:13 12 Jan 05   HG
                            2279#                Wgt .21300 Vol .14690
Hg    3.14    ppb      16923
                                                                        =
=============================================================================
*** Sample ID: 2279-23               Seq:  112    18:32:53 12 Jan 05   HG
                            2279#                Wgt .20600 Vol .04200
Hg    .223    ppb      4075
                                                                        =
=============================================================================
*** Sample ID: 2279-24               Seq:  113    18:34:33 12 Jan 05   HG
                            2279#                Wgt .19800 Vol .04220
Hg    .185    ppb      3236
                                                                        =
=============================================================================
*** Sample ID: Std #1381             Seq:  114    18:36:14 12 Jan 05   HG
                            2279#
Hg    2.23    ppb      8289
                                                                        =
=============================================================================
*** Sample ID: 2279-25               Seq:  115    18:38:11 12 Jan 05   HG
                            2279#                Wgt .22100 Vol .04190
Hg    .072    ppb      1417
                                                                        =
=============================================================================
*** Sample ID: 2279-28               Seq:  116    18:39:48 12 Jan 05   HG
                            2279#                Wgt .21300 Vol .04160
Hg    .309    ppb      5882
                                                                        =
=============================================================================
*** Sample ID: 2279-31               Seq:  117    18:41:45 12 Jan 05   HG
                            2279#                Wgt .19900 Vol .04310
Hg    .352    ppb      6051
                                                                        =
=============================================================================
*** Sample ID: 2279-35               Seq:  118    18:43:32 12 Jan 05   HG
                            2279#                Wgt .20900 Vol .04410
Hg    .377    ppb      6648
                                                                        =
=============================================================================
```

POST-RUN REPORT

Line	Conc.	Units	SD/RSD	1	2	3	4	5

*** Sample ID: 2279-39 Seq: 119 18:45:30 12 Jan 05 HG
2279# Wgt .21500 Vol .04330
Hg .450 ppb 8310

*** Sample ID: 2279-39MSL Seq: 120 18:47:17 12 Jan 05 HG
2279# Wgt .20300 Vol .15140
Hg 2.49 ppb 12434

*** Sample ID: 2279-39MSD Seq: 121 18:49:03 12 Jan 05 HG
2279# Wgt .19600 Vol .15080
Hg 2.70 ppb 13069

*** Sample ID: Std #1382 Seq: 122 18:50:39 12 Jan 05 HG
2279#
Hg 5.03 ppb 18710

*** Sample ID: Blank 1028 Seq: 123 18:52:15 12 Jan 05 HG
2279# Wgt .20000 Vol .04000
Hg .027 ppb 509

*** Sample ID: LCS 102804 Seq: 124 18:54:08 12 Jan 05 HG
2279# Wgt .20000 Vol .14080
Hg 1.97 ppb 10414

*** Sample ID: 1944 10280 Seq: 125 18:55:56 12 Jan 05 HG
2279# Wgt .20100 Vol .14650
Hg 3.74 ppb 19059

*** Sample ID: PACS2 1028 Seq: 126 18:57:36 12 Jan 05 HG
2279# Wgt .19700 Vol .14510
Hg 2.87 ppb 14503

*** Sample ID: Std #1383 Seq: 127 18:59:18 12 Jan 05 HG
2279#
Hg 9.66 ppb 35888

*** Sample ID: Std #1384 Seq: 128 19:00:55 12 Jan 05 HG
2279#
Hg 48.7 ppb 180892

POST-RUN REPORT

```
Line   Conc.  Units     SD/RSD      1       2       3       4       5
-------------------------------------------------------------------------------

*** Sample ID: rinse 3X              Seq:  129    19:02:56 12 Jan 05   HG

Hg    .084    ppb      326
                                                                          =
===============================================================================
*** Sample ID: Blank 0111            Seq:  130    19:05:04 12 Jan 05   HG
                            2333#                Wgt .20000 Vol .04210
Hg    .009    ppb      172
                                                                          =
===============================================================================
*** Sample ID: LCS 011105            Seq:  131    19:06:44 12 Jan 05   HG
                            2333#                Wgt .20000 Vol .14930
Hg    1.84    ppb      9179
                                                                          =
*** Sample ID: LCS 011105            Seq:  132    19:08:26 12 Jan 05   HG
                            2333#                Wgt .20000 Vol .14850
Hg    1.81    ppb      9048
                                                                          =
===============================================================================
*** Sample ID: MESS 3 011            Seq:  133    19:10:05 12 Jan 05   HG
                            2333#                Wgt .20400 Vol .04340
Hg    .086    ppb      1509
                                                                          =
===============================================================================
*** Sample ID: 1944 01110            Seq:  134    19:11:42 12 Jan 05   HG
                            2333#                Wgt .19700 Vol .15400
Hg    4.08    ppb      19395
                                                                          =
===============================================================================
*** Sample ID: 2333-3r1              Seq:  135    19:13:22 12 Jan 05   HG
                            2333#                Wgt .23500 Vol .04440
Hg    1.40    ppb      27537
                                                                          =
===============================================================================
*** Sample ID: 2333-3r2              Seq:  136    19:14:59 12 Jan 05   HG
                            2333#                Wgt .20200 Vol .04370
Hg    1.46    ppb      25145
                                                                          =
===============================================================================
*** Sample ID: 2333-3r3              Seq:  137    19:16:46 12 Jan 05   HG
                            2333#                Wgt .19800 Vol .04430
Hg    1.38    ppb      22977
                                                                          =
===============================================================================
*** Sample ID: Std #1381             Seq:  138    19:18:23 12 Jan 05   HG
                            2333#
Hg    2.10    ppb      7823
                                                                          =
===============================================================================
```

POST-RUN REPORT

```
Line   Conc.  Units     SD/RSD      1       2       3       4       5
-----------------------------------------------------------------------------

*** Sample ID: 2333-4PDL1            Seq:  139    19:20:00 12 Jan 05   HG
                            2333#                Wgt .20500 Vol .04300
Hg    .032    ppb      590
                                                                        =
=============================================================================
*** Sample ID: 2333-4PDL2            Seq:  140    19:21:39 12 Jan 05   HG
                            2333#                Wgt .19800 Vol .04370
Hg    .009    ppb      166
                                                                        =
=============================================================================
*** Sample ID: 2333-4PDL3            Seq:  141    19:23:18 12 Jan 05   HG
                            2333#                Wgt .20300 Vol .04350
Hg    .013    ppb      245
                                                                        =
=============================================================================
*** Sample ID: 2333-4PDL4            Seq:  142    19:24:58 12 Jan 05   HG
                            2333#                Wgt .20100 Vol .04340
Hg    .011    ppb      206
                                                                        =
=============================================================================
*** Sample ID: 2333-4MSL1            Seq:  143    19:26:35 12 Jan 05   HG
                            2333#                Wgt .19800 Vol .15380
Hg    2.21    ppb      10567
                                                                        =
=============================================================================
*** Sample ID: F55703 Tes            Seq:  144    19:28:13 12 Jan 05   HG
                            2333#                Wgt .33100 Vol .04310
Hg    .926    ppb      26420
                                                                        =
=============================================================================
*** Sample ID: Std #1383             Seq:  145    19:29:52 12 Jan 05   HG
                            2333#
Hg    10.2    ppb      37874
                                                                        =
```

TOTAL MERCURY

PROJECT ID: Thames River Validation Task 2 & TEC Kings Point
ANALYSIS: LEEMAN ANALYST: Deuth
ANALYSIS DATE: 12-Jan-05 FILE #: 2279 & 2333
MATRIX: Sediment

VIAL #	FILE #	SAMPLE ID	DIGEST WT g	DIGEST VOL ml	ANALYSIS SAMPLE VOL ml	2% HCl VOL ml	TOTAL VOL ml	DILUT FACTOR	CALC VOL - L
S1		0							
S2		0.2 µg/l							
S3		1.0 µg/l							
S4		2.0 µg/l							
S5		5.0 µg/l							
S6		10.0 µg/l							
1-1	ICV	Std #268							
1-2		Blank 102804r1	0.200	21.171	**3.000**	3	6	2.0	0.0423
1-3		LCS 102804L1r1	0.200	21.370	**1.000**	6	7	7.0	0.1496
1-4		1944 102804r1	0.197	21.705	**1.000**	6	7	7.0	0.1519
1-5		PACS2 102804r1	0.204	22.041	**1.000**	6	7	7.0	0.1543
1-6		Blank 102804r2	0.200	20.979	**3.000**	3	6	2.0	0.0420
1-7		LCS 102804L1r2	0.200	20.785	**1.000**	6	7	7.0	0.1455
1-8		1944 102804r2	0.197	21.817	**1.000**	6	7	7.0	0.1527
1-9		PACS2 102804r2	0.213	20.986	**1.000**	6	7	7.0	0.1469
1-10		2279-23	0.206	21.008	**3.000**	3	6	2.0	0.0420
1-11		2279-24	0.198	21.121	**3.000**	3	6	2.0	0.0422
1-12		Std #1381							
1-13		2279-25	0.221	20.950	**3.000**	3	6	2.0	0.0419
1-14		2279-28	0.213	20.794	**3.000**	3	6	2.0	0.0416
1-15		2279-31	0.199	21.526	**3.000**	3	6	2.0	0.0431
1-16		2279-35	0.209	22.065	**3.000**	3	6	2.0	0.0441
1-17		2279-39	0.215	21.629	**3.000**	3	6	2.0	0.0433
1-18		2279-39MSL1	0.203	21.630	**1.000**	6	7	7.0	0.1514
1-19		2279-39MSDL1	0.196	21.537	**1.000**	6	7	7.0	0.1508
1-20		Std #1382							
1-21		Blank 102804r3	0.200	19.980	**3.000**	3	6	2.0	0.0400
1-22		LCS 102804L1r3	0.200	20.111	**1.000**	6	7	7.0	0.1408
1-23		1944 102804r3	0.201	20.926	**1.000**	6	7	7.0	0.1465
1-24		PACS2 102804r3	0.197	20.726	**1.000**	6	7	7.0	0.1451
1-25		Std #1383							
1-26		Std #1384							
1-27		rinse 3X							
1-28		Blank 011105	0.200	21.059	**3.000**	3	6	2.0	0.0421
1-29		LCS 011105L1	0.200	21.334	**1.000**	6	7	7.0	0.1493
1-30	DO Hg 1/12/2	LCS 011105~~L2~~ L1	0.200	~~21.217~~ 21.334	**1.000**	6	7	7.0	~~0.1485~~ 0.142
1-31		MESS 3 011105	0.204	21.698	**3.000**	3	6	2.0	0.0434
1-32		1944 011105	0.197	21.998	**1.000**	6	7	7.0	0.1540
1-33		2333-3r1	0.235	22.195	**3.000**	3	6	2.0	0.0444
1-34		2333-3r2	0.202	21.839	**3.000**	3	6	2.0	0.0437
1-35		2333-3r3	0.198	22.147	**3.000**	3	6	2.0	0.0443
1-36		Std #1381							
1-37		2333-4PDL1	0.205	21.489	**3.000**	3	6	2.0	0.0430

TOTAL MERCURY

VIAL #	FILE #	SAMPLE ID	DIGEST WT g	DIGEST VOL ml	SAMPLE VOL ml	2% HCl VOL ml	TOTAL VOL ml	DILUT FACTOR	CALC VOL - L
1-38		2333-4PDL2	0.198	21.864	**3.000**	3	6	2.0	0.0437
1-39		2333-4PDL3	0.203	21.728	**3.000**	3	6	2.0	0.0435
1-40		2333-4PDL4	0.201	21.723	**3.000**	3	6	2.0	0.0434
1-41		2333-4MSL1	0.198	21.972	**1.000**	6	7	7.0	0.1538
1-42		F55703 Test	0.331	21.532	**3.000**	3	6	2.0	0.0431
1-43		Std #1383							

DAILY PIPET VERIFICATION LOG

PIPET ID	RANGE	VOLUME(ml)	WT (g)	OK	DATE	INITIALS
					1/12/05	
#8287 - Hg27	1-10 ml	6.0	6.013	✓	1/12/05	MAD
↓	↓	↓	5.983	✓	1/12/05	MAD
			5.991	✓	1/12/05	MAD
N 82918	1-5 ml	3.0	3.030	✓	1/12/05	MAD
↓	↓	↓	3.029	✓	1/12/05	MAD
			3.019	✓	1/12/05	MAD
A 79518	1 ml	1 ml	0.998	✓	1/12/05	MAD
↓	↓	↓	0.997	✓	1/12/05	MAD
			0.998	✓	1/12/05	MAD

Record

TSP/Tekran Standards
+ Leeman
SN: RM126_09

Leeman Standards

0.2 µg/L Hg

1ml of 50 µg/L Hg Std# HPS# 434153

diluted to 250 ml 2% HCl 01/24/06

Peer Review - LN 1/4/05

Std#	Pipette#		Date	Analyst
#1379	A79578	1.005 1.009 1.006	1/4/05	MAD

Leeman Standard

1.0 µg/L Hg

25µl of HPS #434153 (10µg/ml) 01/24/06 MAD

diluted to 250 ml 2% HCl

Peer Review - LN 1/4/05

Std#	Pipette#		Date	Analyst
#1380	E24050	0.024 0.025 0.024	1/4/05	MAD

Leeman Standard
2.0 µg/L Hg
50 ml of HPS # 434153 (10 µg/ml) aqp 12/06
diluted to 250 ml 2% HCl

Peer Review - 1/4/05 LN

Std #	Pipette #		Date	Analyst
#1381	E32976	0.050 0.052 0.050 0.049	1/4/05	MAD

Leeman Standard
5.0 µg/L Hg
125 µl of HPS # 434153 (10 µg/ml) aqp
diluted to 250 µl 2% HCl

Peer Review - 1/4/05 LN

Std #	Pipette #		Date	Analyst
#1382	E32976	0.125 0.124 0.125	1/4/05	MAD

Leeman Standard
10.0 µg/L Hg
250 µl of HPS #434153 (10 µg/ml) 01/13/04
diluted to 250 µl

Peer Review - LN 1/5/04

Std#	Pipette#		Date	Analyst
#1383	~~1286905~~ 1285916 MAD	MAD 0.251 ~~1.261~~ 0.250 ~~1.264~~ 0.250	1/4/05	MAD

Leeman Standard
50.0 µg/L Hg
1.25 ml of HPS #434153 (10 µg/ml) 01/06
diluted to 250 ml 2% HCl

Peer Review- LN 1/4/05

Std#	Pipette#		Date	Analyst
#1384	1082916	1.272 1.261 1.264	1/4/05	MAD

BALANCE # 5

CALIBRATION, MAINTENANCE, ETC. LOGBOOK

SW: PM126-01

RECORD

MSL-C-009

Use and Performance Checks of Balances

Make Fisher

Model XL 300

S/N 09630

BNL # 5

Performance check criteria ± 1%

Weight set # A227 calibrated/certified

alternate weight set # 11242 calibrated/certified 2/10/2000

MSL-C-009
Use and Performance Checks of Balances

00003

Date	Std 0.500g	Std 1.000g	Std 150.000g
12/13/04 [illegible]	0.800	1.000	150.000
12/14/04 MAD	0.500	1.000	149.999
12/15/04 MAD	0.500	1.000	149.999
12/16/04 MAD	0.500	1.000	149.999
12/17/04 [illegible]	.500	1.000	149.997
12/20/04 MAD	0.500	1.000	149.~~998~~ 999 MAD
12/21/04 MAD	0.500	1.000	150.000
12/22/04 MAD	0.500	1.000	150.000
12/27/04 [illegible]	0.500	1.000	149.998
12/28/04 MAD	0.500	1.000	150.000
12/29/04 [illegible]	0.500	1.000	150.000
1-3-05 [illegible]	0.499	1.000	149.997
1/4/05 MAD	0.500	1.000	150.000
1/5/05 MAD	0.500	1.000	150.000
1/11/05 MAD	0.500	1.000	150.001
1/12/05 MAD	0.500	1.000	150.000

PCB/PESTICIDES – Water QA/QC Summary
Batch 04-0425

PROJECT: Thames River 2004 Validation Study
PARAMETER: PCB/PESTICIDES
LABORATORY: Battelle, Duxbury, MA
MATRIX: Water (Equipment Blanks)
SAMPLE CUSTODY: An equipment blank sample, associated with the sediment collection done 10/12/04 – 10/13/04, was received by the Organic Lab Sample Custodian on 10/18/04. The sample was logged into LIMS and received a unique ID. No custody issues were noted. The water sample was stored at 4° C until sample preparation could begin. The equipment blank was extracted along with the appropriate QC samples in batch 04-0425.

	Reference Method	Method Blank	Surrogate Recovery	LCS Recovery	Detection Limits (ng/L)
PCB/PESTICIDES	General NS&T	< RL	40-120% Recovery	40-120% Recovery	MDL: ~0045 – 1.14

METHOD: Water and elutriate samples were extracted for PCB and pesticides following general NS&T methods. Approximately 1 liter of water was spiked with surrogates and extracted three times with dichloromethane using separatory funnel techniques. The combined extract was dried over anhydrous sodium sulfate and concentrated. The extract was then concentrated, fortified with RIS, and split for the required analysis. The extract intended for PCB/Pesticide analysis solvent exchanged into hexane. Extracts were analyzed using gas chromatography/electron capture detection (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: The equipment blank sample was extracted within 16-days of sample collection and analyzed within 40 days of extraction. The 7-day holding time for water samples was not met. All equipment blank data has been qualified with a "T".

Batch	Extraction Date	Analysis Date
04-0425	10/29/04	11/03/04

PCB/PESTICIDES – Water QA/QC Summary
Batch 04-0425

BLANK: A procedural blank (PB) sample was prepared with the analytical batch. Procedural blank samples are analyzed to ensure the sample extraction and analysis methods are free of contamination.

04-0425 – No exceedences noted.

Comments – All target analytes were not detected in the procedural blank.

LABORATORY CONTROL SAMPLE: A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target PCB/PESTICIDES were calculated to measure data quality in terms of accuracy.

04-0425 – All target analytes were recovered within the laboratory control limits (40-120%).

Comments – None.

SURROGATES: Three surrogate compounds were added prior to extraction, including Naphthalene-d8, Phenanthrene-d10, and Chrysene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0425 – Percent recoveries for all surrogate compounds were within the laboratory control limits specified by the method (40 – 120% recovery).

Comments – None.

PAH – Water QA/QC Summary
Batch 04-0425

PROJECT: Thames River 2004 Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Water (Equipment Blanks)
SAMPLE CUSTODY: An equipment blank sample, associated with the sediment collection done 10/12/04 – 10/13/04, was received by the Organic Lab Sample Custodian on 10/18/04. The sample was logged into LIMS and received a unique ID. No custody issues were noted. The water sample was stored at 4° C until sample preparation could begin. The equipment blank was extracted along with the appropriate QC samples in batch 04-0425.

	Reference Method	Method Blank	Surrogate Recovery	LCS Recovery	Detection Limits (ng/L)
PAH	General NS&T	< RL	40-120% Recovery	40-120% Recovery	MDL: ~0.57 – 2.32

METHOD: Water samples were extracted for PAH following general NS&T methods. Approximately 1 liter of water was spiked with surrogates and extracted three times with dichloromethane using separatory funnel techniques. The combined extract was dried over anhydrous sodium sulfate and concentrated. The extract was then fortified with RIS and split quantitatively for the required analyses. Extracts were analyzed using gas chromatography/mass spectrometry (GC/MS), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: The equipment blank sample was extracted within 16-days of sample collection and analyzed within 40 days of extraction. The 7-day holding time for water samples was not met. All equipment blank data has been qualified with a "T".

Batch	Extraction Date	Analysis Date
04-0425	10/29/04	11/06/04

PAH – Water QA/QC Summary
Batch 04-0425

BLANK: A procedural blank (PB) sample was prepared with the analytical batch. Procedural blank samples are analyzed to ensure the sample extraction and analysis methods are free of contamination.

04-0425 – No exceedences noted.

Comments – No target analytes were detected above the laboratory control limit (< RL), however trace amounts of Naphthalene and Phenanthrene were detected in the procedural blank. All these concentrations were below the reporting limit (RL). The data was qualified with a "J". No further corrective action was taken.

LABORATORY CONTROL SAMPLE: A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target PAH were calculated to measure data quality in terms of accuracy.

04-0425 – All target analytes were recovered within the laboratory control limits (40-120%).

Comments – None.

SURROGATES: Three surrogate compounds were added prior to extraction, including Naphthalene-d8, Phenanthrene-d10, and Chrysene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0425 – Percent recoveries for all surrogate compounds were within the laboratory control limits specified by the method (40 – 120% recovery).

Comments – None.

Pesticide/PCB – Water/Elutriate QA/QC Summary
Batch 07-0078

PROJECT: Thames River Validation Study
PARAMETER: Pesticide/PCB
LABORATORY: Battelle, Duxbury, MA
MATRIX: Rinsate Blanks
SAMPLE CUSTODY: Rinsate blank samples were collected on 4/25/3007 and 4/26/2007. Samples were hand delivered to Battelle on 5/1/2007. No custody issues were noted. Samples were logged into Battelle LIMS and received unique IDs. They were stored at 4°C until sample preparation could begin.

	Reference Method	Method Blank	Surrogate Recovery	LCS Recovery	Detection Limits (ng/L)
Pesticide/PCB	General NS&T	<xMRL	40-120%	40-120% Recovery	MDL: ~0.36 – 0.91

METHOD: Rinsate samples were extracted for PCB and pesticides following general NS&T methods. Approximately 1 liter of water was spiked with surrogates and extracted three times with dichloromethane using separatory funnel techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, fortified with internal standards (IS), and solvent exchanged into hexane. Extracts were analyzed using gas chromatography/electron capture detection (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the IS compounds. Data was evaluated against 2006 MDLs.

HOLDING TIMES: Rinsate samples were extracted within 7 days of sample collection. All extracts were analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
07-0078	5/2/2007	5/6/2007 – 5/7/2007

Pesticide/PCB – Water/Elutriate QA/QC Summary
Batch 07-0078

BLANK:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

07-0078 –No target pesticide or PCB were detected in the PB.

Comments – None.

LABORATORY CONTROL SAMPLE:

A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target analytes were calculated to measure data quality in terms of accuracy.

07-0078 – No exceedences noted. All percent recoveries of spiked target analytes were within the laboratory control limit (40-120%).

Comments –None.

SURROGATES:

Two surrogate compounds were added prior to extraction, including PCB 34 and 152 and reported with this data set. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

07-0078 – No exceedences noted. All surrogates were recovered within the laboratory control limits (40%-120%)

Comments – None.

CALIBRATION:

The GC/ECD is calibrated with a minimum 6-level calibration. The co-efficient of determination for the initial calibration (ICAL) must be > 0.995. Continuing calibration check (CCC) samples are analyzed minimally every 24 hours. The percent difference for the CCC samples must be < 20%. Additionally an Instrument Calibration Check (ICC) sample is run after each initial calibration. The percent difference for the ICC also must be < 20%.

07-0078 – No ICAL exceedence noted.
2 ICC exceedences noted.
No CCV exceedences noted

Comments – PCB 206 and PCB 209 were both under-recovered in the ICC. PCB 206 has historically been low in this ICC and the cause is currently under investigation. All other calibration criteria have been met for these compounds. Additionally the LCS sample had acceptable PCB 206 and PCB 209 data, indicating the ICC exceedence has little impact on the data.

PAH – Water QA/QC Summary
Batch 07-0078

PROJECT: Thames River Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Serum Water
SAMPLE CUSTODY: Rinsate blank samples were collected on 4/25/3007 and 4/26/2007. Samples were hand delivered to Battelle on 5/1/2007. No custody issues were noted. Samples were logged into Battelle LIMS and received unique IDs. They were stored at 4°C until sample preparation could begin.

	Reference Method	Method Blank	Surrogate Recovery	LCS Recovery	Detection Limits (ng/L)
PAH	General NS&T	< RL	40-120% Recovery	40-120% Recovery	MDL: ~0.23 – 2.36

METHOD: Water samples were extracted for PAH following general NS&T methods. Approximately 1 liter of water was spiked with surrogates and extracted three times with dichloromethane using separatory funnel techniques. The combined extract was dried over anhydrous sodium sulfate and concentrated. The extract was then fortified with RIS and split quantitatively for the required analyses. Extracts were analyzed using gas chromatography/mass spectrometry (GC/MS), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds. Data was evaluated against 2006 MDLs.

NOTE: Sample preparation records indicate that the initial extract (first extraction) was cloudy and foamy.

HOLDING TIMES: Samples were prepared for analysis in one analytical batch and were extracted within 7 days of sample collection and analyzed within 40 days of extraction. All holding times were met.

Batch	Extraction Date	Analysis Date
07-0078	5/2/2007	5/24/2007

PAH – Water QA/QC Summary
Batch 07-0078

BLANK: One procedural blank (PB) sample was prepared with the analytical batch. The procedural blank was analyzed to ensure the sample extraction and analysis methods were free of contamination.

07-0078 – 1 exceedence noted.

Comments – Various PAH compounds were detected in the blank, but most concentrations were less than the laboratory control limit (<RL), except for naphthalene. This compound was detected in the blank at a concentration greater than the RL. Any field sample concentrations that were not detected at a concentration greater than five times the concentration associated blank have been qualified with a "B". This resulted in phenanthrene being "B" qualified in sample GAB-EB2. All rinsate samples had concentrations of naphthalene greater than five times the concentration detected in the blank, indicating this exceedence has little impact on the data. The naphthalene PB concentration was qualified with an "N" and no further corrective action was taken.

LABORATORY CONTROL SAMPLE: A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target PAH were calculated to measure data quality in terms of accuracy.

07-0078 –All target analytes were recovered within the laboratory control limits specified by the client (40% - 120%).

Comments – None.

SURROGATES: Four surrogate compounds were added prior to extraction, including naphthalene-d8, acenaphthene-d10, phenanthrene-d10, and benzo(b)fluoranthene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

07-0078 – All percent recoveries were within the laboratory control limits (40% - 120%).

Comments – None.

CALIBRATIONS: The GC/MS is calibrated with a minimum of a 6 level curve. The RSD between response factors for the individual target analytes in the initial calibration (ICAL) must be $\leq$30%. Each batch of samples analyzed is bracketed by a calibration check sample, run at a frequency of minimally every 12 hours. This PD between the initial calibration RF and the continuing calibration verification (CCV) sample should be $\leq$25% for individual analytes. Additionally an initial calibration check (ICC) sample is run immediately after each initial calibration. The percent difference between the ICC and the initial calibration should be $\leq$ 25%.

07-0078 –No exceedences noted.

Comments – All calibration criteria were met.

QA/QC NARRATIVE

PROJECT: Thames River – Subase New London

PARAMETER: Metals: Arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), selenium (Se), and zinc (Zn)

LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington

MATRIX: Equipment Blank Water

SAMPLE CUSTODY AND PROCESSING: Three equipment blank water samples were received on 05/01/07. The samples were received in good condition (i.e., no sample containers were broken or leaking). The samples were assigned a Battelle Central File (CF) identification number (2713) and entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

Lab Sample IDs: Description:	**2713*21-23** Equipment Blank
Collection date	04/25/07 and 04/26/07
Laboratory arrival date	05/01/07
pH measurement date	Upon arrival 05/01/07
Preservation	0.2% double distilled nitric acid in field
Cooler temperature on arrival	2.9°C
ICP-MS analysis (MSL-I-022) As, Ba, Cd, Cr, Cu, Ni, Se, Pb, Zn Analyzed with sediment	06/06/07

METHODS: The equipment blank water was analyzed for all metals by inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. Samples were acid solubilized prior to analysis by ICP-MS in accordance with the total recoverable metals (TRM) method in Battelle SOP *MSL-I-022*. The analysis guidelines for this procedure are adapted from USEPA Method 1638 Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma-Mass Spectrometry. The TRM methodology is adapted from USEPA Method 1640 - Determination of Trace Elements in Ambient Waters by On-Line Chelation Preconcentration and Inductively Coupled Plasma-Mass Spectrometry.

All results are reported in units of µg/L.

HOLDING TIMES: The recommended holding time is six months for all other metals. All samples were analyzed within the established holding times.

QA/QC NARRATIVE

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Recovery	SRM Accuracy	Achieved Method Detection Limits (µg/L)	Reporting Limits (µg/L)
As	ICP-MS	75-125%	≤20%	0.1	0.3
Ba	ICP-MS	75-125%	≤20%	0.01	0.03
Cd	ICP-MS	75-125%	≤20%	0.01	0.03
Cr	ICP-MS	75-125%	≤20%	0.6	2
Cu	ICP-MS	75-125%	≤20%	0.04	0.1
Ni	ICP-MS	75-125%	≤20%	0.1	0.3
Se	ICP-MS	75-125%	≤20%	0.1	0.3
Pb	ICP-MS	75-125%	≤20%	0.01	0.03
Zn	ICP-MS	75-125%	≤20%	0.3	1

DETECTION LIMITS: Analytical results were reported to laboratory achieved method detection limits (MDL) as determined from the 2007 TRM MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of deionized water spiked at levels appropriate for each analyte of interest. The MDLs are not reported from our ultra-low level methods, but rather a screening approach where equipment was not specifically tuned for ultra-low (less than 0.1 ppb) detection limits. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

CALIBRATION VERIFICATION: The equipment blank waters were analyzed at the same time as the sediment. The continuing calibration verification (CCV - units of µg/L) samples were analyzed every ten samples. The CCV samples were all within the QC criterion of ±15% of the true value and the initial calibration verification sample (ICV) was within the QC criterion of ±10%.

PROCEDURAL BLANKS: A minimum of one procedural blank was analyzed with the samples. The blank concentrations were less than the reporting limit (RL) for all metals. The concentration of Ni was greater than 0.5 * RL; no further action was taken as the low MDLs reported also generate RL that are sufficiently low enough to evaluate blank contamination based solely on the values greater than the RL. The data are not blank corrected.

LABORATORY CONTROL SAMPLE ACCURACY: Two laboratory control samples (LCS) were analyzed with this set of water samples. The equipment blank waters are deionized water; therefore, the LCS samples also serve as a matrix spike sample. Percent recoveries for the LCS samples ranged were within the QC acceptance criterion of ± 25% recovery.

REPLICATE PRECISION: Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate results. The RPD results for the duplicate LCS samples were within the QC criterion of ≤20%.

STANDARD REFERENCE MATERIAL ACCURACY: Standard reference material (SRM) accuracy was expressed as the percent difference (PD) between the measured and certified or reference value. The certified freshwater reference material (SRM) 1640 was analyzed for metals by ICP-MS. The percent differences were within the QC criterion of ≤20%.

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Metals
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: Equipment Blank Water

SAMPLE CUSTODY AND PROCESSING: One equipment blank water sample was received on October 27, 2004. The sample was received in good condition (i.e., no sample containers were broken or leaking). The sample was assigned a Battelle Central File (CF) identification number (2279) and entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

Lab Sample IDs: Description:	**2279-50** Equipment Blank
Collection date	10/13/04
Laboratory arrival date	10/27/04
pH measurement date	10/27/04
Preservation w/HNO_3	10/27/04
Cooler temperature on arrival	3.5°C
CVAF analysis (MSL-I-013, Hg)	11/11/04
ICP-MS analysis (MSL-I-022) As, Ba, Cd, Cr, Cu, Ni, Se, Pb, Zn	11/14/04

METHODS: The equipment blank water was analyzed for arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), selenium (Se), lead (Pb), zinc (Zn), and mercury (Hg).

The sample was analyzed for total Hg by cold-vapor atomic fluorescence (CVAF) spectroscopy according to Battelle SOP MSL-I-013, *Total Mercury in Aqueous Samples by CVAF*, following EPA Method 1631 revision E.

The sample was analyzed for all other metals by inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. This procedure is based on modification from EPA Method 1638 and 200.8.

All results are reported in units of µg/L.

HOLDING TIMES: The recommended holding times for metals analyses are 90 days from sample collection for Hg analysis and 6 months for all other metals. All samples were analyzed within the established holding times.

QA/QC NARRATIVE

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Recovery	SRM Accuracy	Achieved Method Detection Limits (µg/L)	Reporting Limits (µg/L)
As	ICP-MS	70-130%	≤25%	0.018	0.057
Ba	ICP-MS	70-130%	≤25%	0.0031	0.010
Cd	ICP-MS	70-130%	≤25%	0.0050	0.016
Cr	ICP-MS	70-130%	≤25%	0.016	0.051
Cu	ICP-MS	70-130%	≤25%	0.0050	0.016
Hg	CVAF	70-130%	≤25%	0.00012	0.00037
Ni	ICP-MS	70-130%	≤25%	0.011	0.035
Se	ICP-MS	70-130%	≤25%	0.017	0.054
Pb	ICP-MS	70-130%	≤25%	0.0052	0.017
Zn	ICP-MS	70-130%	≤25%	0.045	0.14

DETECTION LIMITS: Analytical results were reported to laboratory achieved method detection limits (MDL) as determined from the 2004 Freshwater MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of deionized water spiked at levels appropriate for each analyte of interest. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

PROCEDURAL BLANKS: A minimum of two procedural blanks were analyzed with the equipment blank. The mean blank was not detected above the reporting limit (RL). The data are not blank corrected.

LABORATORY CONTROL SAMPLE ACCURACY: Two laboratory control samples (LCS) or ongoing precision and recovery (OPR) samples for Hg were analyzed with this set of water samples. The equipment blank waters are deionized water; therefore, the LCS samples also serve as a matrix spike sample. Percent recoveries for the LCS samples ranged from 86% to 114% and were within the QC acceptance criterion of ± 30% recovery.

REPLICATE PRECISION: Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate results. The RPD results for the equipment blank water ranged from 0% to 3% and were within the QC criterion of ≤30%.

STANDARD REFERENCE MATERIAL ACCURACY: Standard reference material (SRM) accuracy was expressed as the percent difference (PD) between the measured and certified or reference value. Two certified freshwater reference materials (SRMs) were analyzed with the set of water samples: 1640 for metals analyzed by ICP-MS and 1641d for Hg.

The percent differences ranged from 1% to 4% and were within the QC criterion of ≤25%.

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Hg
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: REFERENCE Sediment

SAMPLE CUSTODY AND PROCESSING: The samples were received in two batches on 10/15/04 and 10/21/04. All samples were received in good condition (i.e., no sample containers were broken or leaking). Samples were assigned a Battelle Central File (CF) identification number (2279) and were entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

MSL Code:	**2279-1 thru -21**	**2279-22 thru -49**
Description:	Sediment	Sediment
Collection date	10/11/04	10/12/04 and 10/13/04
Laboratory arrival date	10/15/04	10/21/04
Cooler temperature on arrival	4.3°C	3.5°C
Freeze Dryer (MSL-C-003):	10/16/04 thru 10/28/04	
Digestion Date (HNO_3/HCl, SOP MSL-I-006)	10/28/04	
CVAA Analysis Date (Hg, MSL-I-016)	01/12/05	

METHODS: All sediment samples were digested for mercury (Hg) on 10/28/04. Samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-006, *Mixed Acid Sediment Digestion*. An approximately 200-mg (dry weight) aliquot of each sample was combined with nitric and hydrochloric acids (aqua regia) in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested sediment to achieve analysis volume. Digested sediment samples were submitted for Hg analysis.

The digested samples were analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016, *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The base method for this procedure is EPA Method 245.5.

All results were reported in units of µg/g on a dry-weight basis.

HOLDING TIMES: All samples were digested on 10/28/04 and the Pier 1 plus QC samples were analyzed on 11/02/04. This is within the recommended holding time for Hg of 28 days from sample collection. The reference sediment samples were digested with the Pier 1 samples on 10/28/04; however, they were not analyzed for Hg. The reference samples, QC samples, and one Pier 1 sample were analyzed for Hg on 01/12/05. The reference sediment samples were not analyzed within the 28 day holding time; however, they were digested and stored in a nitric/hydrochloric acid solution (aqua regia) of pH <2.0 within this holding time. The second analysis of the QC samples and Pier 1 sample confirmed the Hg concentrations were stable in the acid solution. Therefore, the data are not considered to be impacted by the analysis outside the 28-day holding time.

QA/QC NARRATIVE

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Target MDL (µg/g)	Achieved MDL (µg/g)	Achieved Reporting Limits (µg/g)
Hg	CVAA	70-130%[1]	±30%[2]	≤25%	0.002	0.0043	0.014

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the 2004 Sediment MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of quartz sand. The achieved MDL for Ba, Hg, Ni, and Zn is slightly higher than the target due to variation between annual MDL studies. Impact to the quality and usability of the data is insignificant as the sample concentrations are a minimum of two orders of magnitude higher than the achieved MDL. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

PROCEDURAL BLANKS: Two procedural blanks were analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL. The second analysis of the blanks confirmed the original data.

LABORATORY CONTROL SAMPLE (LCS) ACCURACY: Two LCSs were analyzed with the samples. Percent recoveries for the LCS samples were 101% and 95% and were within the QC criterion of 70-130% recovery. The original percent recoveries for the LCS samples were 103% and 98%.

MATRIX SPIKE/ MATRIX SPIKE DUPLICATE (MS/MSD) ACCURACY: One sample was selected for matrix spike/matrix spike duplicate (MS/MSD). The MS/MSD recoveries were 104% and 110% and were within the QC criterion of 70-130% recovery. The original percent recoveries for the MS/MSD were 106% and 108%.

REPLICATE PRECISION: Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate matrix spike results. The RPD result was 6% and within the QC criterion of ±30%.

STANDARD REFERENCE MATERIAL ACCURACY: SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM 1944 New York/New Jersey Waterway Sediment was analyzed with each batch of samples. The percent differences for SRM 1944 were 13% and 4% and were within the QC criterion of ≤25%. The original percent differences were 12% and 2%.

QA/QC NARRATIVE

PROJECT: Thames River – Subase New London

PARAMETER: Metals: Arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), selenium (Se), and zinc (Zn)

LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington

MATRIX: Sediment

SAMPLE CUSTODY AND PROCESSING: Twenty sediment samples were received on 05/01/07. The samples were received in good condition (i.e., no sample containers were broken or leaking). The samples were assigned a Battelle Central File (CF) identification number (2713) and entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

MSL Code:	**2713*1-20**
Description:	Sediment
Collection date	04/25/07 and 04/26/07
Laboratory arrival date	05/01/07
Cooler temperature on arrival	2.9°C
Freeze Dryer (MSL-C-003):	05/07/07 through 05/11/07
Digestion Date (HNO_3/HCl, SOP MSL-I-006)	05/14/07
FIAS Analysis Date (Se, MSL-I-30)	06/08/07
ICP-OES Analysis Date (MSL-I-033: Ba, Cr, Cu, Ni, Pb, Zn)	05/29/07
ICP-MS Analysis Date (MSL-I-022: As and Cd)	06/06/07

METHODS: Sediment samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-006, *Mixed Acid Sediment Digestion*. An approximately 200-mg (dry weight) aliquot of each sample was combined with nitric and hydrochloric acids (aqua regia) in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested sediment to achieve analysis volume. Digested sediment samples were submitted for analysis by three methods.

Digested samples were analyzed for Se using hydride generation flow injection atomic spectroscopy (FIAS) according to Battelle SOP MSL-I-030 Determination of Metals in Aqueous and Digestate Samples by HGAA-FIAS. This method conforms to specifications in EPA Method 200 series and SW-846, 7000 series with modifications to allow for the low-level trace metal analysis.

Digested samples were analyzed for As and Cd using inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The base methods for this procedure are EPA Method 1638 and EPA Method 200.8 with adaptations for the

QA/QC NARRATIVE

METHODS: analysis of trace metals in digested sediment and tissue samples.

Digested samples were analyzed for all other metals using inductively coupled plasma optical emissions spectroscopy (ICP-OES) according to Battelle SOP MSL-I-033, *Determination of Elements in Aqueous and Digestate Samples by ICP-OES*. This procedure is based on two methods modified and adapted for analysis of low-level samples: EPA Method 6010B and 200.7.

All results were reported in units of µg/g on a dry-weight basis.

HOLDING TIMES: The recommended holding time for these metals in sediment is six months. All samples were analyzed within the recommended holding times.

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Achieved MDL (µg/g)	Achieved Reporting Limits (µg/g)
As	ICP-MS	75-125%[1]	±25%[2]	≤20%	0.4	1
Ba	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.02	0.1
Cd	ICP-MS	75-125%[1]	±25%[2]	≤20%	0.004	0.01
Cr	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.03	0.1
Cu	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.04	0.1
Ni	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.1	0.3
Se	FIAS	75-125%[1]	±25%[2]	≤20%	0.01	0.03
Pb	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.08	0.3
Zn	ICP-OES	75-125%[1]	±25%[2]	≤20%	0.07	0.2

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the Annual Sediment MDL study, the current MDL. The MDL for As, Pb, and Ni are currently under revision for the 2007 study; therefore the 2006 MDL study was reported. The impact to the project is negligible as the sample concentrations are at least an order of magnitude higher than the MDL and a seven year running average of the annual MDLs indicate they do not change significantly compared to reported sample concentrations. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of quartz sand. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

QA/QC NARRATIVE

CALIBRATION VERIFICATION:	The continuing calibration verification (CCV - units of µg/L) samples were analyzed every ten samples. The CCV samples were all within the QC criterion of ±15% of the true value and the initial calibration verification sample (ICV) was within the QC criterion of ±10%.
PROCEDURAL BLANKS:	One procedural blank was analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL for all metals.
LABORATORY CONTROL SAMPLE (LCS) ACCURACY:	One LCS was analyzed with the samples. Percent recoveries for the LCS sample were within the QC criterion of 75-125% recovery.
MATRIX SPIKE ACCURACY:	One sample was selected for matrix spike/matrix spike duplicate (MS/MSD). The MS/MSD recoveries were within the QC criterion of 75-125% recovery.
REPLICATE PRECISION:	One sample was selected for laboratory duplicates for these samples. Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate results. The RPD results were within the QC criterion of ≤ 25% RPD for all metals.
STANDARD REFERENCE MATERIAL ACCURACY:	SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM 1944 New York/New Jersey Waterway Sediment was analyzed with each batch of samples. The percent differences for certified or reference values in SRM 1944 were within the QC criterion of ≤20% for all metals.

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Metals (As, Ba, Cd, Cr, Cu, Hg, Ni, Se, Pb, Zn)
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: Sediment

SAMPLE CUSTODY AND PROCESSING: The samples were received in two batches on 10/15/04 and 10/21/04. All samples were received in good condition (i.e., no sample containers were broken or leaking). Samples were assigned a Battelle Central File (CF) identification number (2279) and were entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

MSL Code:	**2279-1 thru -21**	**2279-22 thru -49**
Description:	Sediment	Sediment
Collection date	10/11/04	10/12/04 and 10/13/04
Laboratory arrival date	10/15/04	10/21/04
Cooler temperature on arrival	4.3°C	3.5°C
Freeze Dryer (MSL-C-003):	10/16/04 thru 10/28/04	
Digestion Date (HNO_3/HCl, SOP MSL-I-006)	10/28/04, Redigestion 11/12/04	
CVAA Analysis Date (Hg, MSL-I-016)	Pier 1 samples only 11/02/04	
FIAS Analysis Date (Se, MSL-I-30)	11/02/04	
ICP-OES Analysis Date (MSL-I-033: Ba, Cr, Cu, Ni, Pb, Zn)	11/08/04 Redigestion 11/19/04	
ICP-MS Analysis Date (MSL-I-022: As and Cd)	10/29/04	

METHODS: Sediment samples were analyzed for ten metals: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), selenium (Se), lead (Pb), and zinc (Zn). Samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-006, *Mixed Acid Sediment Digestion*. An approximately 200-mg (dry weight) aliquot of each sample was combined with nitric and hydrochloric acids (aqua regia) in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested sediment to achieve analysis volume. Digested sediment samples were submitted for analysis by three methods.

Digested samples were analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016, *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The base method for this procedure is EPA Method 245.5.

Digested samples were analyzed for Se using hydride generation flow injection atomic spectroscopy (FIAS) according to Battelle SOP MSL-I-030 Determination of Metals in Aqueous and Digestate Samples by HGAA-FIAS. This method conforms to specifications in EPA Method 200 series and SW-846, 7000 series with modifications to allow for the low-level trace metal analysis.

QA/QC NARRATIVE

METHODS: Digested samples were analyzed for As and Cd using inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The base methods for this procedure are EPA Method 1638 and EPA Method 200.8 with adaptations for the analysis of trace metals in digested sediment and tissue samples.

Digested samples were analyzed for all other metals using inductively coupled plasma optical emissions spectroscopy (ICP-OES) according to Battelle SOP MSL-I-033, *Determination of Elements in Aqueous and Digestate Samples by ICP-OES*. This procedure is based on two methods modified and adapted for analysis of low-level samples: EPA Method 6010B and 200.7.

All results were reported in units of µg/g on a dry-weight basis.

HOLDING TIMES: The recommended holding times are 28 days from sample collection to analysis for Hg and six months for all other metals. All samples were analyzed within the recommended holding times.

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Target MDL (µg/g)	Achieved MDL (µg/g)	Achieved Reporting Limits (µg/g)
As	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.07	0.03	0.1
Ba	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.02	0.1	0.3
Cd	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.02	0.02	0.06
Cr	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.5	0.06	0.2
Cu	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.2	0.09	0.3
Hg	CVAA	70-130%[1]	±30%[2]	≤25%	0.002	0.0043	0.014
Ni	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.04	0.1	0.3
Se	FIAS	70-130%[1]	±30%[2]	≤25%	0.1	0.02	0.06
Pb	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.2	0.08	0.3
Zn	ICP-OES	70-130%[1]	±30%[2]	≤25%	0.1	0.3	1.0

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the 2004 Sediment MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of quartz sand. The achieved MDL for Ba, Hg, Ni, and Zn is slightly higher than the target due to variation between annual MDL studies. Impact to the quality and usability of the data is insignificant as the sample concentrations are a minimum of two orders of magnitude higher than the achieved MDL. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

QA/QC NARRATIVE

ANALAYTICAL NOTE:	Sediment Digestion The original sediment digestion data indicated the Cr concentrations could be biased low; therefore the samples were digested a second time with all project QC samples. The data for Cr and Cu are reported from the second digestion batch.
CONTINUING CALIBRATION VERIFICATION (CCV):	CCV (units of µg/L) samples were analyzed every ten samples. The CCV samples were all within the QC criterion of ±15% of the true value.
CONTINUING CALIBRATION BLANKS (CCB):	CCB (units of µg/L) samples were analyzed after CCV samples to evaluate instrument carryover. The CCB samples were within the QC criterion with the exception of a few CCBs for Ba, Pb, and Zn. The data are all a minimum of three orders of magnitude greater than the detected CCB samples.
PROCEDURAL BLANKS:	Three procedural blanks were analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL with the exception of one blank for As and Zn and two blanks for Hg. The data associated with these blanks are all greater than 5 times the detected blank; therefore, the data are not flagged.
LABORATORY CONTROL SAMPLE (LCS) ACCURACY:	Three LCS were analyzed with the samples. Percent recoveries for the LCS samples ranged from 81% to 106% and were within the QC criterion of 70-130% recovery.
MATRIX SPIKE/ MATRIX SPIKE DUPLICATE (MS/MSD) ACCURACY:	Three samples were selected for matrix spike/matrix spike duplicate (MS/MSD). Two of the three samples (2279-6 and -39) selected for MS/MSD contained highly elevated concentrations of a combination Cr, Cu, Pb, and Zn. Therefore, the spiking level was insufficient relative to the native sample concentration. The recoveries were not calculated for these metals and in all cases; acceptable matrix spike recovery was demonstrated in an alternate sample with lower native metal concentrations. The MS/MSD recoveries ranged from 74% to 118% and were within the QC criterion of 70-130% recovery with the exception of one spike for Ni (161%). This MS was considered an outlier as the duplicate was within the QC criterion and acceptable MS recoveries for Ni were demonstrated in the other five spikes. Analytical Post Spike An analytical post spike for samples 2279-6 and -39 was reported for Cr, Cu, and Zn if the MS/MSD spiking level was not sufficient. The reported post spikes were within the QC criterion. The post spike solution did not contain Pb; therefore, acceptable matrix spike recovery was evaluated using the recoveries of sample 2279-43.
REPLICATE PRECISION:	Three samples were selected for laboratory duplicates for these samples. Precision of duplicate analyses was expressed as the relative percent difference (RPD) of replicate results. The RPD results ranged from 0% to 29% and were within the QC criterion of ±30% for all metals except Cu (52%) and Pb (91%) in sample 2279-22. The sample was predigested in duplicate. The redigestion results confirmed the original data; therefore, the poor sample precision was a function of sample heterogeneity.
STANDARD REFERENCE MATERIAL ACCURACY:	SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM 1944 New York/New Jersey Waterway Sediment was analyzed with each batch of samples. The percent differences for SRM 1944 ranged from 0% to 18% and were within the QC criterion of ≤25% with the exception of replicate for Se (32%). Acceptable SRM accuracy was demonstrated in the additional two replicates of SRM 1944 and in SRM PACS-2 (not reported; 20%).

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0415

PROJECT: Thames River 2004 Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected between 10/11/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian. Samples collected 10/11/04 were hand delivered to the custodian on 10/15/04, while samples collected 10/12/04 and 10/13/04 were hand delivered on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator or freezer until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PAH	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.07 – 0.13

METHOD: Sediment samples were extracted for Pesticide/PCB following general NS&T methods. Approximately 30 g of sediment was spiked with surrogates and extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified by GPC/HPLC. The post-HPLC extract was concentrated, fortified with recovery internal standards and split for the required analyses. Extracts intended for Pesticide/PCB analysis were solvent exchanged into hexane then analyzed using gas chromatography/electron capture detector (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at either 4.0°C or –20.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in two analytical batches and were extracted within approximately 14 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0415	10/26/04	11/06/05 – 11/08/05

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0415

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0415 – No exceedences noted.

Comments – No target analytes were detected in the procedural blank at a concentration greater than the reporting limit (RL).

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy.

04-0415 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0415 – Three percent recovery exceedences noted.
Twenty-seven RPD exceedences noted.

Comments – Three analytes, PCB 8, PCB 18, and PCB 206, were under-recovered in sample S5512MS (background DAD8 5'6" – 7'3"), at 26%, 39%, and 39%, respectively. Low SIS recoveries are also present in this sample. Chromatography and calculations were reviewed. The exceedences were qualified with an "N". Although it is not noted in the sample preparation records, these recoveries are indicative of an extract loss during sample prep. Accuracy for these compounds has adequately been demonstrated in both the LCS and MSD QC samples.

The under-recoveries in sample S5512MS resulted in exceeding RPDs for all twenty-seven analytes. The exceedences were qualified with an "N". No further corrective action was taken.

SURROGATES:

Four surrogate compounds were added prior to extraction, including PCB 14, PCB 34, PCB 104, and PCB 112. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0415 – Four exceedences noted.

Comments – Percent recoveries for all surrogate compounds were within the laboratory control limits (40 – 120% recovery), except for PCB 14 and PCB 34 in sample S5512MS, and PCB 14 and 104 in sample S5515 (DAD28 0'-2'). Chromatography and calculations were reviewed. PCB 14 and PCB 34 were under-recovered in sample S5512MS at 37% and 39%, respectively. Although it is not noted in the sample preparation records, these recoveries are indicative of an extract loss during sample prep. These under-recoveries have been qualified with an "N". In sample S5515, PCB 14 and PCB 104 are over-recovered at 1659% and 175%, respectively. The analyst notes these exceedences are due to matrix interference caused by the relatively high contamination level of this sample. These over-

recoveries were qualified with an “NMI”. No further corrective action was taken.

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0414

PROJECT: Thames River 2004 Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected between 10/11/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian. Samples collected 10/11/04 were hand delivered to the custodian on 10/15/04, while samples collected 10/12/04 and 10/13/04 were hand delivered on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator or freezer until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PAH	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.07 – 0.46

METHOD: Sediment samples were extracted for organics following general NS&T methods. Approximately 30g of sediment were spiked with SIS, and then extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified on a HPLC cleanup column. Due to an HPLC malfunction, the samples were purified using HPLC techniques twice. The post-HPLC extract was concentrated, split for analysis, and fortified with RIS. PAH extracts were analyzed using gas chromatography/mass spectrometry detection (GC/MS) with the MS operated in the selected ion monitoring (SIM) mode, following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at either 4.0°C or –20.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in two analytical batches and were extracted within approximately 14 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0414	10/26/04	11/13/04 – 11/15/04

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0414

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0414 – Six exceedences noted.

Comments – Six target analytes were detected in the blank at a concentration greater than the reporting limit (RL). Chromatography and calculations were reviewed. No discrepancies were found. All field sample data for the exceeding compounds, that was greater than the sample-specific RL, was qualified with a "B". This resulted in 112 "B" qualifiers. However, it is important to note that almost all sample concentration are greater than five times the concentration detected in the associated blank. Concentrations of target analytes detected in the procedural blank at a level greater than the RL range from 1.64 to 3.86 ng/g. Concentrations for these same target analytes range from 0.55 to 11,841.93 ng/g in the field samples.

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy.

04-0414 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0414 – No exceedences noted.

Comments –Twelve target compounds in both samples S5648MS and S5648MSD (background sample DAD-24) are not recovered within the laboratory control limits (40 – 120% recovery, see table for specifics). However, no MS/MSD compounds were spiked at a concentration greater than five times the background. Therefore, this data is not suitable for data quality assessment. Chromatography and calculations were reviewed. No discrepancies were found. Since contingency criteria were met, no qualifiers will apply to the percent recovery exceedences.

Because of the high background concentration found in the MS/MSD samples, twelve RPDs are greater than the laboratory control limits ($\leq$30%). These exceedences were qualified with an "N".

SURROGATES:

Three surrogate compounds were added prior to extraction, including Napthahlene-d8, Phenanthrene-d10, and Chrysene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0414 – Percent recoveries for all surrogate compounds were within the laboratory control limits (40 – 120% recovery).

Comments – None

PCB and Pesticides – Sediment QA/QC SUMMARY
QC Batches 04-0414

PROJECT: Thames River 2004 Validation Study
PARAMETER: PCB and Pesticides
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected between 10/11/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian. Samples collected 10/11/04 were hand delivered to the custodian on 10/15/04, while samples collected 10/12/04 and 10/13/04 were hand delivered on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator or freezer until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PAH	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.25 – 0.49

METHOD: Sediment samples were extracted for Pesticide/PCB following general NS&T methods. Approximately 30 g of sediment was spiked with surrogates and extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified by GPC/HPLC. The post-HPLC extract was concentrated, fortified with recovery internal standards and split for the required analyses. Extracts intended for Pesticide/PCB analysis were solvent exchanged into hexane then analyzed using gas chromatography/electron capture detector (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at either 4.0°C or –20.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in two analytical batches and were extracted within approximately 14 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0414	10/26/04	11/09/04 – 11/11/04

PCB and Pesticides – Sediment QA/QC SUMMARY
QC Batches 04-0414

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0414 – No exceedences noted.

Comments – No target analytes were detected in the procedural blank.

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy.

04-0414 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0414 – All target analytes were recovered within the laboratory control limits (40%-120%). All RPDs were within the laboratory control limits ($\leq$ 30%)

Comments – None

SURROGATES:

Four surrogate compounds were added prior to extraction, including PCB 14, PCB 34, PCB 104, and PCB 112. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0414 – Twenty exceedences.

Comments – Most samples had unacceptable surrogate recoveries for PCB 104, and to a less extent PCB 14 and PCB 34 (see tables for specifics). These outliers can be attributed to matrix interference. These exceedences have been qualified with an "NMI". No further corrective action was taken.

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0393

PROJECT: Thames River 2004 Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected on 10/12/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PAH	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.03 – 0.17

METHOD: Sediment samples were extracted for organics following general NS&T methods. Approximately 30g of sediment were spiked with SIS, and then extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified on a HPLC cleanup column. The post-HPLC extract was concentrated, split for analysis, and fortified with RIS. PAH extracts were analyzed using gas chromatography/mass spectrometry detection (GC/MS) with the MS operated in the selected ion monitoring (SIM) mode, following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at 4.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in analytical batches of no more than twenty field samples and were extracted within approximately 13 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0393	10/25/04	11/05/04 – 11/20/04

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0393

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0393 – No exceedences noted.

Comments – No target analytes were detected in the blank at a concentration greater than the reporting limit (RL) in sample BF223PB-P, the procedural blank that was prepared with the field samples. However, due to a failing midcheck, several samples had to be reanalyzed on a different sequence (see analysis Miscellaneous Documentation Form for further details).

These extracts were not evaluated against BF223PB-P, but to procedural blanks that ran on the same sequence as the samples, BF287PB-P, which is from Thames River batch 04-0414. This procedural blank had six target analyte compounds detected at a concentration greater than the sample-specific RL. Chromatography and calculations were reviewed. No discrepancies were found. All associated field sample data for the exceeding compounds, that was greater than the sample-specific RL, was qualified with a "B". This resulted in ten samples having 56 "B" qualifiers combined. However, it is important to note that all sample concentration are greater than five times the concentration detected in the associated blank. Concentrations of target analytes detected in the procedural blank at a level greater than the RL range from 1.64 to 3.86 ng/g. Concentrations for these same target analytes range from 427.47 to 7556.92 ng/g in the field samples.

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy.

04-0393 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0393 –One percent recovery exceedence noted
Fifteen RPD exceedences noted.

Comments –In sample S5627MS (background DAD-26), Naphthalene was under-recovered at 2%. Chromatography and calculations were reviewed. No discrepancies were found. The exceedence was qualified with an "N". Several other compound recoveries in both the MS and MSD sample were recovered outside the laboratory control limits (40-120%), however most target analytes were not spiked at a concentration great enough to be used for data quality assessment.

Because of the high background concentration found in the MS/MSD samples, fifteen RPDs are greater than the laboratory control limits ($\leq$30%). These exceedences were qualified with an "N".

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0393

SURROGATES: Three surrogate compounds were added prior to extraction, including Napthahlene-d8, Phenanthrene-d10, and Chrysene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0393 – One exceedence noted.

Comments – All percent recoveries for all surrogate compounds were within the laboratory control limits (40 – 120% recovery), except for Naphthalene-d8 in sample S5627MS. Chromatography and calculations were reviewed. No discrepancies were found. The project manager was notified and the exceedence was qualified with an "N". No further corrective action was taken.

PCB AND PESTICIDES – Sediment QA/QC SUMMARY
QC Batches 04-0393

PROJECT: Thames River 2004 Validation Study
PARAMETER: PCB and pesticides
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected on 10/12/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PCB AND PESTICIDES	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.11 – 0.21

METHOD: Sediment samples were extracted for Pesticide/PCB following general NS&T methods. Approximately 30 g of sediment was spiked with surrogates and extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified by GPC/HPLC. The post-HPLC extract was concentrated, fortified with recovery internal standards and split for the required analyses. Extracts intended for Pesticide/PCB analysis were solvent exchanged into hexane then analyzed using gas chromatography/electron capture detector (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at 4.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in analytical batches of no more than twenty field samples and were extracted within approximately 13 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0393	10/25/04	11/03/04 – 11/05/04

PCB AND PESTICIDES – Sediment QA/QC SUMMARY
QC Batches 04-0393

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0393 – No exceedences noted.

Comments – All analytes were not detected in the procedural blank.

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PCB and pesticides were calculated to measure data quality in terms of accuracy.

04-0393 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PCB and pesticides were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0393 – One percent recovery exceedence noted.
Six RPD exceedences noted.

Comments – All target analytes were recovered within the laboratory control limits (40%-120%). No recovery for PCB 77 could calculated in sample S5627MS or S5627MSD (background DAD-26) because the matrix spike was not spiked with PCB 77 at a concentration greater than five times the background. No further corrective action was necessary.

Exceeding RPDs were calculated for the following six compounds: PCB 77, PCB 118, PCB 128, PCB 138, PCB 153, and PCB 180. These exceeding RPDs can be attributed to the contamination level in the background sample. RPD exceedences can be qualified with an "N".

SURROGATES:

Four surrogate compounds were added prior to extraction, including PCB 14, PCB 34, PCB 104, and PCB 112. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0393 – Six exceedences noted.

Comments – PCB 104 is over-recovered in samples S5627 (DAD-26), S5632 (DAD-27), S5637 (DAD-20), S5642 (DAD-15), and S5644 (DAD-23) at 139%, 159%, 258%, 144%, 143%, and 122%, respectively. The analyst notes that these exceedences are due to matrix interference. The data has been qualified with an "NMT". No further corrective action was taken.

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0415

PROJECT: Thames River 2004 Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected between 10/11/04 and 10/13/04 for the Thames River 2004 Validation Study. Sediment samples were stored at 4.0°C until they were delivered to the Laboratory Sample Custodian. Samples collected 10/11/04 were hand delivered to the custodian on 10/15/04, while samples collected 10/12/04 and 10/13/04 were hand delivered on 10/18/04. All samples were received in good condition. No custody issues were noted. Samples were then logged into Battelle LIMS and received unique IDs. The samples were either stored in an access controlled walk-in refrigerator or freezer until sample preparation could begin. Samples were prepared in batches of no more than twenty field samples, with the appropriate quality control.

QA/QC DATA QUALITY OBJECTIVES:

	Reference Method	Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Precision	Achieved Practical Detection Limit (ng/g DW)
PAH	General NS&T	< Sample Specific RL	40-120% Recovery	40-120% (Analyte conc. in MS must be > 5 times reported background conc.)	≤ RPD Analyte conc. in MS must be > 5 times reported background conc.	~0.02 – 0.11

METHOD: Sediment samples were extracted for organics following general NS&T methods. Approximately 30g of sediment were spiked with SIS, and then extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, and further purified on a HPLC cleanup column. The post-HPLC extract was concentrated, split for analysis, and fortified with RIS. PAH extracts were analyzed using gas chromatography/mass spectrometry detection (GC/MS) with the MS operated in the selected ion monitoring (SIM) mode, following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Sediment samples were stored at either 4.0°C or –20.0°C until extraction. All samples were extracted within holding times; 14-days for refrigerated samples, or 1-year holding for frozen.

Samples were prepared for analysis in two analytical batches and were extracted within approximately 14 days of sample collection and analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
04-0415	10/26/04	11/12/04 – 11/22/04

PAH – Sediment QA/QC SUMMARY
QC Batches 04-0415

BLANKS:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

04-0415 – No exceedences noted.

Comments – No target analytes were detected in the procedural blank at a concentration greater than the reporting limit (RL).

LABORATORY CONTROL SAMPLE (Blank Spike)

A laboratory control sample (LCS) was prepared each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy.

04-0415 – All target analytes were recovered within the laboratory control limits (40%-120%).

Comments – None.

MATRIX SPIKE/MATRIX SPIKE DUPLICATE:

A matrix spike (MS) sample and a matrix spike duplicate (MSD) sample were prepared with each analytical batch. The percent recoveries of PAH were calculated to measure data quality in terms of accuracy. The relative percent difference (RPD) between the two samples was calculated to measure data in terms of precision.

04-0415 – Twenty percent recovery exceedences noted.
Twenty-four RPD exceedences noted.

Comments – Twenty target analytes were under-recovered in sample S5512MS. Low SIS recoveries are also present in this sample. Chromatography and calculations were reviewed. The sample was re-analyzed. The re-analysis provided similar results. No discrepancies were found. The exceedences were qualified with an "N". Although it is not noted in the sample preparation records, these recoveries are indicative of an extract loss during sample prep. Accuracy for these compounds has adequately been demonstrated in both the LCS and MSD QC samples.

The under-recoveries in sample S5512MS resulted in exceeding RPDs for all twenty-four analytes. The exceedences were qualified with an "N". No further corrective action was taken.

SURROGATES:

Three surrogate compounds were added prior to extraction, including Napthahlene-d8, Phenanthrene-d10, and Chrysene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

04-0415 – Two exceedences noted.

Comments – Percent recoveries for all surrogate compounds were within the laboratory control limits (40 – 120% recovery), except for Naphthalene-d8 and Phenanthrene-d10 in sample S5512MS. Chromatography and calculations were reviewed. The sample was re-analyzed. The re-analysis provided similar results. No discrepancies were found. The exceedences were qualified with an "N". Although it is not noted in the sample preparation records, these recoveries are indicative of an extract loss during sample prep.

Pesticide/PCB – Sediment QA/QC Summary
Batch 07-0079

PROJECT: Thames River Validation Study
PARAMETER: Pesticide/PCB
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected on 4/25/3007 and 4/26/2007. Samples were hand delivered to Battelle on 5/1/2007. No custody issues were noted. Samples were logged into Battelle LIMS and received unique IDs. They were stored at 4°C until sample preparation could begin.

	Reference Method	Method Blank	Surrogate Recovery	LCS/MS Recovery	Sample Replicate Relative Standard Deviation	Detection Limits (ng/g DRY WT)
Pesticide/PCB	General NS&T	<RL	40-120% Recovery	40-120% Recovery (conc. in MS must be >5x background)	≤30% RPD (analytes must be > 5 X ssMDL to be used for data quality assessment)	~ 0.02 – 0.04

METHOD: Sediment samples were extracted for PCB and pesticides following general NS&T methods. Approximately 30 g of sediment was spiked with surrogates and extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, cleaned for sulfur using copper, and further purified by GPC/HPLC. The post-HPLC extract was concentrated, fortified with recovery internal standards and split for the required analyses. Extracts intended for pesticide and PCB analysis were solvent exchanged into hexane then analyzed using gas chromatography/electron capture detector (GC/ECD), following general NS&T methods. Sample data were quantified by the method of internal standards, using the Recovery Internal Standard (RIS) compounds.

HOLDING TIMES: Samples were prepared for analysis in one analytical batch and were extracted within 14 days of sample collection analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
07-0079	5/4/2007	5/14/2007 – 5/18/2007

Pesticide/PCB – Sediment QA/QC Summary
Batch 07-0079

BLANK:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

07-0079 – No target pesticides or PCB were detected in the procedural blank.

Comments – None.

LABORATORY CONTROL SAMPLE:

A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target analytes were calculated to measure data quality in terms of accuracy.

07-0079 –No exceedences noted.

Comments – All percent recoveries of spiked target analytes were within the laboratory control limit (40-120%).

MATRIX SPIKE

A matrix spike (MS) sample was prepared with each analytical batch. The percent recoveries of target analytes were calculated to measure data quality in terms of accuracy.

07-0079 –No exceedences noted.

Comments – All percent recoveries of spiked target analytes were within the laboratory control limit (40-120%).

REPLICATES:

Duplicate analysis was performed on the test sediment sample. RPDs between duplicate analyses were calculated to measure data quality in terms of precision.

07-0079 – No exceedences noted.

Comments – The RPD between duplicate analyses of all target analytes were within the laboratory control limits (<30% RPD).

SURROGATES:

Four surrogate compounds were added prior to extraction, including PCB 14, PCB 34, PCB 61 and PCB 152. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

07-0079 – Percent recoveries for all surrogate compounds were within the laboratory control limits (40 – 120% recovery).

Comments – None.

Pesticide/PCB – Sediment QA/QC Summary
Batch 07-0079

CALIBRATIONS: The GC/ECD was calibrated with a 7-point initial calibration curve (ICAL). The r^2 value for the quadratic calibration must be > 0.995 for all analytes. An Instrument Calibration Check (ICC), prepared from a different source from that used for the ICAL, was analyzed after the ICAL. The calculated concentration of target analytes in the ICC should be <20 percent different (PD) from the true concentration in the ICC standard. Continuing calibration verification (CCV) standards were analyzed every 24-hr (minimally) to verify that the instrument response remains in calibration. The PD between concentrations from the CCV and ICAL should be <20% for individual analytes.

07-0079 – ICAL: No exceedences noted.
ICC: 2 exceedences noted.
CCV: No exceedences noted.

Comments – In the ICC sample PCB 206 and PCB 209 were under-recovered. The PD were calculated to be 30.1% and 23.7%, respectively. Calculations and chromatography were reviewed. No discrepancies were found. The exceedences were qualified with an "N" on the ICC report. Compounds met all other calibration requirements. No further corrective action was taken. Additionally, these compounds passed all LCS and MS requirements.

PAH – SEDIMENT QA/QC SUMMARY
Batch 07-0079

PROJECT: Thames River Validation Study
PARAMETER: PAH
LABORATORY: Battelle, Duxbury, MA
MATRIX: Sediment
SAMPLE CUSTODY: Sediment samples were collected on 4/25/3007 and 4/26/2007. Samples were hand delivered to Battelle on 5/1/2007. No custody issues were noted. Samples were logged into Battelle LIMS and received unique IDs. They were stored at 4°C until sample preparation could begin.

	Reference Method	Method Blank	Surrogate Recovery	LCS Recovery	MS Recovery	Sample Replicate Relative Percent Difference	Detection Limits (ug/kg dry wt)
PAH	General NS&T	<RL	40-120% Recovery	40-120% Recovery	40-120% Recovery (analyte conc. in MS must be >5x background)	≤30% RPD (analytes must be >5 x MDL to be used for data quality assessment)	MDL: 0.02 – 1.03

METHOD: Sediment samples were extracted for PAH following general NS&T methods. Approximately 30 g of sediment was spiked with surrogates and extracted three times with dichloromethane using shaker table techniques. The combined extract was dried over anhydrous sodium sulfate, concentrated, processed through alumina cleanup column, concentrated, cleaned for sulfur using copper, and further purified by GPC/HPLC. The post-HPLC extract was concentrated, fortified with internal standards (IS) and split for the required analyses. Extracts intended for PAH analysis were analyzed using gas chromatography/mass spectrometry (GC/MS) operating in the selected ion monitoring (SIM) mode, following general NS&T methods. Sample data were quantified by the method of internal standards, using the spiked IS compounds. All extracts are solvent exchanged into hexane prior to instrument analysis.

HOLDING TIMES: Sediment samples were prepared for analysis in one analytical batch and were extracted within the 14-day holding time from sample collection. All extracts were analyzed within 40 days of extraction.

Batch	Extraction Date	Analysis Date
07-0079	5/4/2007	5/24/2007 – 5/31/2007

PAH – SEDIMENT QA/QC SUMMARY
Batch 07-0079

BLANK:

A procedural blank (PB) was prepared with each analytical batch. Blanks were analyzed to ensure the sample extraction and analysis methods were free of contamination.

07-0079 – No target analytes were detected in the procedural blanks at a concentration greater than the laboratory control limit (>RL).

Comments: None

LABORATORY CONTROL SAMPLE:

A laboratory control sample (LCS) was prepared with each analytical batch. The percent recoveries of target analytes were calculated to measure data quality in terms of accuracy.

07-0079 – 1 exceedence noted.

Comments: All target analytes were recovered within the specified laboratory control limits (40-120%), except for perylene. This compound was under-recovered at 34%. Chromatography and calculations were reviewed. No discrepancies were found. This compound passed all calibration criteria. The under-recovery appears to be isolated to the LCS sample, and it maybe related to the matrix used to generate this sample. The laboratory is currently investigating this issue. The exceedence was flagged with an "N" and no further corrective action was taken.

MATRIX SPIKE

A matrix spike (MS) sample was prepared with each analytical batch. The percent recoveries of target analytes were calculated to measure data quality in terms of accuracy.

07-0079 – No exceedence noted.

Comments: Although some target analytes were recovered outside the specified laboratory control limits (40-120%), these compounds were not spiked at a concentration great enough to be used for data quality assessment (> 5 x background concentration). No further corrective action was taken.

REPLICATES:

Replicate (duplicate) samples were prepared with each analytical batch. The RPD between duplicate analyses is calculated to measure data quality in terms of precision.

07-0079 – 4 exceedences noted.

Comments – RPDs were calculated to be in exceedence for 2-methylnaphathalene, 2-6 dimethylnaphthalene, anthracene, and dibenz(a,h)anthracene. High moisture content may have impacted the variability of PAH concentrations. The exceedences were qualified with an "*" and no further corrective action was taken.

PAH – SEDIMENT QA/QC SUMMARY
Batch 07-0079

SURROGATES: Four surrogate compounds were added prior to extraction, including naphthalene-d8, acenaphthene-d10, phenanthrene-d10, and benzo(a)pyrene-d12. The recovery of each surrogate compound was calculated to measure data quality in terms of accuracy (extraction efficiency).

07-0079 – 1 exceedences noted.

Comments: All surrogate percent recoveries were within the laboratory control limits (40-120%), except for naphthalene-d8 in samples R6578. This surrogate was under-recovered at 29%. Chromatography and calculations were reviewed. No discrepancies were found. The exceedences were qualified with an "N". The concentrations of naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene may be biased low in this sample. Additionally, naphthalene-d8 was initially under-recovered in sample R5666DUP-P at 16%. Since all other SIS recoveries were acceptable, the exceedence appeared to be due to the extract being concentrated to quickly on the N-evap blow down. The archived non-fractionated portion of the extract was analyzed and results improved. The results from the archive extract are reported.

CALIBRATIONS: The GC/MS is calibrated with a minimum of an 8 level curve. The RSD between response factors for the individual target analytes in the initial calibration (ICAL) must be <30%. Each batch of samples analyzed is bracketed by a calibration check sample, run at a frequency of minimally every 12 hours. This PD between the initial calibration RF and the continuing calibration verification (CCV) sample should be <25% for individual analytes. Additionally an initial calibration check (ICC) sample is run immediately after each initial calibration. The percent difference between the ICC and the initial calibration should be < 25%.

07-0079 – No exceedences noted.

Comments: None.

APPENDIX C

Fish Tissue Data

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Thames River Validation Study
Subase New London
Fish Tissue Metals
(ug/g wet weight)

				Chromium						Mercury						Lead						Zinc					
Area Name	**Sample ID**	**Collection Date**	**Percent Moisture**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**	**Result**	**Lab Qual**	**Final Qual**
Inner Pier 1	DAF-001	7/21/2004	77.75	1.33			1.71			0.0848			0.109			5.59			7.19			84.8			109		
Inner Pier 1	DAF-001R	7/21/2004	77.75	1.32			1.7			0.0864			0.111			6.29			8.09			85.5			110		
Inner Pier 1	DAD-43	10/14/2004	78.89	3.83			4.86			0.0995			0.126			7.56			9.58			86			109		
Inner Pier 1	DAD-44	10/14/2004	71.33	1.21			1.7			0.0703			0.0986			2.17			3.04			83.5			117		
Inner Pier 1	DAD-45	10/14/2004	77.75	0.702			0.903			0.0613			0.0788			3.34			4.3			104			134		
Inner Pier 1	DAD-46	10/14/2004	77.88	0.741			0.951			0.105			0.135			0.483			0.62			103			132		
Outer Pier 1	DAD-49	10/14/2004	90.33	2.38			2.64			0.0496			0.0549			1.07			1.19			40.4			44.7		
Outer Pier 1	DAD-51	10/14/2004	81.98	0.573			0.699			0.0974			0.119			0.2			0.244			65.3			79.7		
			MIN	**0.573**			**0.699**			**0.0496**			**0.0549**			**0.2**			**0.244**			**40.4**			**44.7**		
			MAX	**3.83**			**4.86**			**0.105**			**0.135**			**7.56**			**9.58**			**104**			**134**		
Reference Area	DAD-41	10/14/2004	79.93	5.16			6.46			0.11			0.138			5.6			7			95.1			119		
Reference Area	DAD-42	10/14/2004	75.58	0.586			0.775			0.119			0.157			0.347			0.459			86.9			115		

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Metals (Cr, Hg, Pb, Zn)
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: Tissue

SAMPLE CUSTODY AND PROCESSING: The samples were received on 11/10/04. All samples were received in good condition (i.e., no sample containers were broken or leaking). Samples were assigned a Battelle Central File (CF) identification number (2279) and were entered into the MSL sample tracking and project management system.

SAMPLE PROCESSING INFORMATION:

MSL Code:	**2279-51 thru -59**
Description:	Tissue
Collection date	07/21/04, 10/14/04
Laboratory arrival date	11/10/04
Cooler temperature on arrival	2.6°C
Freeze Dryer (MSL-C-003):	11/11/04 thru 11/14/04
Digestion Date (HNO_3/$HClO_4$, SOP MSL-I-003)	11/24/04
CVAA Analysis Date (Hg, MSL-I-016)	11/30/04
ICP-MS Analysis Date (MSL-I-022: As and Cd)	11/30/04

METHODS: Tissue samples were analyzed for four metals: chromium (Cr), mercury (Hg), lead (Pb), and zinc (Zn). Samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-003, *TAMU Sediment and Tissue Digestion*. An approximately 500-mg (dry weight) aliquot of each sample was combined with nitric and perchloric acids in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested tissue to achieve analysis volume. Digested samples were submitted for analysis by two methods.

Digested samples were analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016, *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The base method for this procedure is EPA Method 245.6.

Digested samples were analyzed for Cr, Pb and Zn using inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The base methods for this procedure are EPA Method 1638 and EPA Method 200.8 with adaptations for the analysis of trace metals in digested sediment and tissue samples.

All results are reported in units of µg/g on a dry-weight basis. Sample results are also reported in µg/g wet weight using the sample specific percent moisture.

QA/QC NARRATIVE

HOLDING TIMES: The recommended holding times as listed in the work plan (October 2004) are one year frozen for all metals. All samples were analyzed within the recommended holding times.

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Target MDL (µg/g wet weight)	Achieved MDL (µg/g wet weight)	Achieved Reporting Limits (µg/g wet weight)
Cr	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.05	0.0181	0.0577
Hg	CVAA	70-130%[1]	±30%[2]	≤25%	0.0005	0.000867	0.00276
Pb	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.01	0.00329	0.0105
Zn	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.3	0.120	0.382

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the 2004 Tissue MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of cellulose tissue. The MDL are determined using dried tissue, which are converted to wet weight MDLs using the average sample percent moisture. The achieved MDL for Hg is slightly higher than the target. The target was provided from a previous annual MDL study. Impact to the quality and usability of the data is insignificant as the sample concentrations are a minimum of two orders of magnitude higher than the achieved MDL. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

CONTINUING CALIBRATION VERIFICATION (CCV): CCV (units of µg/L) samples were analyzed every ten samples. The CCV samples were all within the QC criterion of ±15% of the true value.

CONTINUING CALIBRATION BLANKS (CCB): CCB (units of µg/L) samples were analyzed after CCV samples to evaluate instrument carryover. The CCB samples were less than three times the instrument detection limit for all metals.

PROCEDURAL BLANKS: One procedural blank was analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL for all metals.

LABORATORY CONTROL SAMPLE (LCS) ACCURACY: One LCS was analyzed with the samples. Percent recoveries for the LCS sample ranged from 90% to 100% and were within the QC criterion of 70-130% recovery.

QA/QC NARRATIVE

MATRIX SPIKE/ MATRIX SPIKE DUPLICATE (MS/MSD) ACCURACY:	One sample was selected for a matrix spike/matrix spike duplicates (MS/MSD). The MS/MSD recoveries ranged from 86% to 99% and were within the QC criterion of 70-130% recovery for all metals. Precision for the MS/MSD pair was expressed as the relative percent difference (RPD) of replicate results. The RPD results ranged from 1% to 2% and were within the QC precision criterion of ±30%.
REPLICATE PRECISION:	One samples were selected for a laboratory duplicate. The RPD results ranged from 1% to 12% and were within the QC criterion of ±30% for all metals.
STANDARD REFERENCE MATERIAL ACCURACY:	SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM DORM 2 Dogfish Tissue was analyzed with the samples. The percent differences for SRM DORM 2 ranged from 9% to 19% and were within the QC criterion of ≤25% for all metals.

QA/QC NARRATIVE

PROJECT: Thames River Validation – Subase New London

PARAMETER: Metals (Cr, Hg, Pb, Zn)
LABORATORY: Battelle Marine Sciences Laboratory (MSL), Sequim, Washington
MATRIX: Tissue

SAMPLE CUSTODY AND PROCESSING: The samples were received on 11/10/04. All samples were received in good condition (i.e., no sample containers were broken or leaking). Samples were assigned a Battelle Central File (CF) identification number (2279) and were entered into the MSL sample tracking and project management system.

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METHODS: Tissue samples were analyzed for four metals: chromium (Cr), mercury (Hg), lead (Pb), and zinc (Zn). Samples were freeze-dried and homogenized using a ball-mill according to Battelle SOP MSL-C-003, *Percent Dry Weight and Homogenizing Dry Sediment, Soil and Tissue*. Sediment samples were digested in accordance with Battelle SOP MSL-I-003, *TAMU Sediment and Tissue Digestion*. An approximately 500-mg (dry weight) aliquot of each sample was combined with nitric and perchloric acids in a Teflon bomb and heated in an oven at 130ºC (±10ºC) for a minimum of eight hours. After heating and cooling, deionized water was added to the digested tissue to achieve analysis volume. Digested samples were submitted for analysis by two methods.

Digested samples were analyzed for Hg using cold-vapor atomic absorption spectroscopy (CVAA) according to Battelle SOP MSL-I-016, *Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption*. The base method for this procedure is EPA Method 245.6.

Digested samples were analyzed for Cr, Pb and Zn using inductively coupled plasma-mass spectrometry (ICP-MS) according to Battelle SOP MSL-I-022, *Determination of Elements in Aqueous and Digestate Samples by ICP/MS*. The base methods for this procedure are EPA Method 1638 and EPA Method 200.8 with adaptations for the analysis of trace metals in digested sediment and tissue samples.

All results are reported in units of µg/g on a dry-weight basis. Sample results are also reported in µg/g wet weight using the sample specific percent moisture.

QA/QC NARRATIVE

HOLDING TIMES: The recommended holding times as listed in the work plan (October 2004) are one year frozen for all metals. All samples were analyzed within the recommended holding times.

DATA QUALITY CRITERIA (DQC):

Analyte	Analytical Method	Range of Spike Recovery	Replicate Precisions (RPD)	SRM Accuracy (Percent Difference)	Target MDL (µg/g wet weight)	Achieved MDL (µg/g wet weight)	Achieved Reporting Limits (µg/g wet weight)
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Pb	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.01	0.00329	0.0105
Zn	ICP-MS	70-130%[1]	±30%[2]	≤25%	0.3	0.120	0.382

[1] Spike concentration must be >5 times the background levels to be used for data quality assessment.
[2] Evaluated for analytes >5 times MDL to be used for data quality assessment.

DETECTION LIMITS: Analytical results were reported to the laboratory achieved method detection limits (MDL) as determined from the 2004 Tissue MDL study. The MDL study is determined annually according to 40 CFR Part 136 Appendix B and defined as seven replicates of cellulose tissue. The MDL are determined using dried tissue, which are converted to wet weight MDLs using the average sample percent moisture. The achieved MDL for Hg is slightly higher than the target. The target was provided from a previous annual MDL study. Impact to the quality and usability of the data is insignificant as the sample concentrations are a minimum of two orders of magnitude higher than the achieved MDL. The achieved reporting limit (RL) is determined as 3.18 times the achieved MDL. Data were evaluated and flagged in accordance with the following criteria:

U Undetected at the MDL, MDL reported.

J Estimated Value. The value is less than the reporting limit.

N Spiked sample outside QC criteria.

* Duplicate analysis not within control limits.

CONTINUING CALIBRATION VERIFICATION (CCV): CCV (units of µg/L) samples were analyzed every ten samples. The CCV samples were all within the QC criterion of ±15% of the true value.

CONTINUING CALIBRATION BLANKS (CCB): CCB (units of µg/L) samples were analyzed after CCV samples to evaluate instrument carryover. The CCB samples were less than three times the instrument detection limit for all metals.

PROCEDURAL BLANKS: One procedural blank was analyzed with the samples. Analyte concentrations in the procedural blanks were less than the RL for all metals.

LABORATORY CONTROL SAMPLE (LCS) ACCURACY: One LCS was analyzed with the samples. Percent recoveries for the LCS sample ranged from 90% to 100% and were within the QC criterion of 70-130% recovery.

QA/QC NARRATIVE

MATRIX SPIKE/ MATRIX SPIKE DUPLICATE (MS/MSD) ACCURACY:	One sample was selected for a matrix spike/matrix spike duplicates (MS/MSD). The MS/MSD recoveries ranged from 86% to 99% and were within the QC criterion of 70-130% recovery for all metals. Precision for the MS/MSD pair was expressed as the relative percent difference (RPD) of replicate results. The RPD results ranged from 1% to 2% and were within the QC precision criterion of ±30%.
REPLICATE PRECISION:	One samples were selected for a laboratory duplicate. The RPD results ranged from 1% to 12% and were within the QC criterion of ±30% for all metals.
STANDARD REFERENCE MATERIAL ACCURACY:	SRM accuracy was expressed as the percent difference (PD) between the measured and certified or reference SRM values. SRM DORM 2 Dogfish Tissue was analyzed with the samples. The percent differences for SRM DORM 2 ranged from 9% to 19% and were within the QC criterion of ≤25% for all metals.

APPENDIX D

Bioassay Data

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Thames River Validation Study
Naval Submarine Base – New London
Groton, Connecticut

Leptocheirus plumulosus
28-d Bioassay Data Report

June 29, 2007

Prepared by
Roy K. Kropp
Battelle Pacific Northwest Division
1529 W. Sequim Bay Road
Sequim, WA 98382

PNWD-3848

1.0 Introduction

Chronic toxicity testing of the New London/Thames River sediments was performed following guidance provided in *Methods for Assessing the Chronic Toxicity of Marine and Estuarine Sediment-associated Contaminants with the Amphipod* Leptocheirus plumulosus - *First Edition* (EPA 2001).

2.0 Methods

2.1 Test Organism Collection

The marine amphipod *Leptocheirus plumulosus*, was used to evaluate the toxicity of the test sediments. *Leptocheirus plumulosus* neonates used to initiate the toxicity tests were obtained from in-house cultures maintained at the Battelle Marine Sciences Laboratory (MSL). The brood stock for the cultures was obtained from Chesapeake Cultures, Hayes, Virginia. The cultures had been continuously maintained at MSL for about nine weeks prior to the start of testing. Organisms exhibiting abnormal behavior or appearance were not used in toxicity tests.

2.2 Sediment Sample Preparation

The New London/Thames River sediment samples were collected April 24–26, 2007 and received on May 1, 2007. Cooler temperatures, which were measured upon arrival at MSL, ranged from 3.2 ºC to 4.7 ºC. All sample containers arrived in good condition. Porewater samples for the determination of ammonia concentrations were collected from each sample. Laboratory control sediment was collected from Sequim Bay, WA on May 14, 2007. Prior to its use, the laboratory control sediment was pressed through a 0.5-mm-mesh sieve to remove any live organisms that might interfere with the test results. All sediment samples were stored in a walk-in cold room at 4 ºC ± 2 ºC until used in toxicity tests.

2.3 *Leptocheirus plumulosus* Solid-Phase (Benthic) Chronic Toxicity Test

Benthic acute toxicity testing was performed using neonate *Leptocheirus plumulosus* in a 28-day static-renewal exposure with mortality, growth, and reproductive (neonate production) endpoints. *L. plumulosus* was exposed to 18 New London/Thames River test sediments and a laboratory control (Sequim Bay) sediment. Because of the number of sediment samples to be tested, and the large number of replicates per treatment (10), the toxicity test was initiated over three consecutive days, with each initiation comprised of 64, 63, and 63 replicates, respectively. All replicates of all treatments were randomly assigned unique position numbers; all positions then were randomly assigned to start day so that any potential temporal and spatial variation was also randomly distributed. The test design allows the entire data set to be analyzed together.

Prior to initiation, water-quality measurements of the conditions (temperature, pH, dissolved oxygen, and salinity) in each container were made. During the test, these parameters were measured three times per week in one replicate per treatment, but were measured in all replicates at test termination. Total porewater ammonia was measured in a surrogate container on Day 0 and Day 28. The test was initiated by introducing 20 organisms into each test chamber. During each test initiation (Starts 1, 2, 3), three replicates of 20 amphipods were collected for initial dry weight measurements. Organisms were randomly allocated to treatments, and treatment replicates were randomly positioned on water tables. Random positions for test chambers were assigned by using the discrete random number generator in Microsoft Excel® spreadsheet software. Amphipods were fed a ground TetraMin® slurry during the test by following the recipe and rate described in EPA (2001). The bioassay included a concurrent, 96-h, water-only,

reference toxicant (cadmium at seven concentrations) test to assess the sensitivity of the test population. The cadmium reference toxicant data were examined to estimate a dose-response and the median lethal concentration was calculated by using trimmed Spearman-Karber method. Specific test conditions for the benthic toxicity test are provided in Table 1.

At test termination, treatments were carefully rinsed over nested 0.5-mm-mesh and 0.25-mm-mesh sieves, to remove surviving adults and neonates. Adults, which were retained on the larger mesh sieve, were sorted from the samples, counted, and prepared for dry-weight measurements. Neonates passed through the larger mesh sieve and were retained on the finer mesh sieve. All of the material (sediment, debris, neonates) retained on the fine-mesh sieve was rinsed into a labeled jar. Alcohol (70% denatured ethanol) containing rose bengal (a vital stain) was added to each jar. To count the neonates, the alcohol and rose bengal were rinsed from the sample, which was placed in a large tray and examined for the presence of neonates. Neonates (stained pink by the rose bengal) were removed from the sample and counted. The dry weights of the surviving adults, and the amphipods collected during the test initiation, were rinsed in distilled water, placed on clean Kim Wipe™ pieces to blot dry, and placed into tared aluminum weighing pans. The number of amphipods in each pan was recorded and the pans placed into a drying oven set at 60 °C for at least 24 h. Prior to weighing, the pans were removed from the oven and allowed to cool to room temperature in a covered desiccator. Amphipods were weighed to the nearest 0.01 mg. The average neonate weight was subtracted from the total amphipod weight determined at termination to yield a 28-day growth estimate.

Table 1. *Leptocheirus* Solid-Phase Acute Toxicity Test Conditions

	Amphipod 28-Day Chronic Toxicity
Test Organism Species:	*Leptocheirus plumulosus*
Source:	MSL culture started with brood stock from commercial culture (Chesapeake Cultures, Hayes, VA); neonates raised at MSL
Age:	Neonates, ~24-h old
Holding Conditions:	temperature 24–26 °C salinity 20 ‰ ± 2 ‰
Test Type (Setup):	
Method:	EPA 600/R-01/020
Duration:	28 days
Test Material:	Sediment
Endpoint(s):	Survival, growth, reproduction
Number of Treatments:	19 total NSB_NLON Test: 12 Reference: 6 Control : 1 (Sequim Bay)
Number of Replicates:	10, plus 2 surrogates for Day 0 and 28 porewater samples
Test Chamber:	1-L flow-through Mason jar
Test Volume:	175 mL (2cm) sediment, fill to 900 mL w/ 20 ‰ seawater
Ammonia Purging:	None
Porewater surrogates:	2 per treatment (Day 0 and 28); these do NOT get animals
Flow Conditions:	Static-renewal: 3 times per week (MWF) replace 400 mL overlying water volume via periodic flow through
Number of organisms per replicate:	20
Other Setup Notes:	Aeration needs to begin ASAP after layering
Initiation Note:	Collect 3 sets of 20 neonates for dry weight determination.

	Amphipod 28-Day Chronic Toxicity
Test Conditions:	
Lighting:	16 h light: 8 h dark
Temperature:	Single Measurement: 22–28 °C 28-D Mean: 23–27 °C Note: measure temperature of water tables daily; may use min/max thermometer
pH:	7.0–9.0
Dissolved Oxygen:	Single Measurement: ≥50% saturation (= 3.6 mg/L) 28-D Mean: ≥60% saturation (= 4.4 mg/L) 100% saturation: 7.4 mg/L at test conditions
Salinity:	Single Measurement: 17–23 ‰ 28-D Mean: 18–22 ‰
Ammonia:	Porewater <60 mg/L total ammonia
Monitoring:	
NH_3 Frequency:	Porewater total NH_3 from surrogates: Days 0 and 28
Sulfide Frequency	None
WQ Frequency:	All reps: Day 0, Day 28; 1 rep/treatment three times per week: Days 1–27; more measurements may be required if WQ outside acceptable ranges
Observation Frequency:	1 hr after initiation, then three times per week (e.g., MWF)
Feeding:	3 times per week, MWF after water renewals. 20 mg/d TetraMin®, increase to 40 mg/d after Day 13
Other Monitoring Notes:	Individuals that fail to bury within 1 hr of initiation (or appear inactive) may be removed and replaced Daily water table temperatures need to be measured; may use min/max thermometer
Termination Notes:	Count and record number of survivors; QC 10% of counts Prepare surviving adults for dry-weight measurements Preserve and stain neonates
Test Validity Criteria:	≥80% survival in laboratory control, measurable growth, reproduction in all control replicates
Reference Toxicant:	Cadmium chloride
Concentration Series	0, 0.06, 0.12, 0.24, 0.48, 0.96, 1.92 mg/L
# reps	1 per cadmium concentration; 3 for control
test volume	750 mL test volume
test containers	Straight-sided Mason jars for Sonde
# animals/rep	20 animals /rep
other notes:	Small piece of crumpled nytex screen in each jar WQ and observations on all jars daily
Reference Toxicant Test Validity Criteria:	90% control survival or ability to calculate a dose response

3.0 Results

Benthic toxicity tests (Figure 1) were initiated on May 16–18, 2007 and terminated on June 13–15, 2007. Summaries of the water quality data and test endpoint data for individual replicates are in Attachments A and B, respectively.

3.1 Water Quality and Porewater Ammonia Measurements

During the 28-day test, water quality parameters remained within the required ranges, except for DO concentrations measured in two replicates on Day 28 of the test (Attachment A). The DO concentration in one replicate of sediment Z7-1 was 2.0 mg/L and that in one replicate of sediment RA-6 was 2.6 mg/L, both below the minimum guideline of 3.6 mg/L (Attachment A). Because both occurred on the last day of the test, no corrective action was necessary.

Porewater ammonia content in the bulk sediments was measured upon arrival at MSL. Ammonia concentrations ranged from 1.8 mg/L to 17.2 mg/L (Attachment A). Porewater ammonia concentration was also measured in surrogate containers on Day 0 and Day 28. Day 0 ammonia concentrations ranged from 1.9 mg/L to 9.7 mg/L (Attachment A). All values were well below the minimum value of 60 mg/L recommended as the threshold for allowing the test to be initiated (EPA 2001). Day 28 ammonia concentrations ranged from 0.2 mg/L to 2.4 mg/L (Attachment A).

3.2 Reference Toxicant Tests

Two reference toxicant (cadmium) tests were run. The first test using neonates was conducted November 12–16, 2004 with cadmium concentrations of 0, 0.16, 0.26, 0.43, 0.72, 1, and 2 mg/L. The test was not successful because control survival was poor and a dose response could not be calculated. The test was repeated November 19–23, 2004 using a broader range of concentrations (Table 1). The amphipods were fed during the second test because it was felt that the lack of feeding contributed to the unsuccessful first test. Neonates do not have large energy reserves and the lack of feeding them very likely contributes to their difficulty in surviving the 4-d exposure. A single sample of each test concentration was run for the second test, except that three replicates were used for the control treatment. The additional control replicates were used to examine variability within the control (i.e., unstressed) treatment. Control survival for the second reference toxicant test was 88.3%. Individual replicates showed 95%, 95%, and 75% survival, which indicates that the water-only exposure of neonate amphipods may be an inherently variable test. A dose response was calculable. The calculated LC_{50} for this test was 0.35 mg/L cadmium, with a 95% confidence limit range of 0.26–0.46 mg/L cadmium (Attachment B), which was within the control chart range (mean ± 2 standard deviations) calculated for the species for eight previous tests at MSL (0.24–0.68 mg/L). The EPA Protocol (EPA 2001) states that the typical range for cadmium LC50 values for a test run at 20‰ is 0.2 to 0.7 mg/L cadmium. As a check on the dose preparations, the cadmium concentrations in two samples were analyzed after completion of the 4-d exposure. Treatments with nominal cadmium concentrations of 0.06 mg/L and 0.96 mg/L were measured as 0.05 mg/L and 0.95 mg/L, respectively.

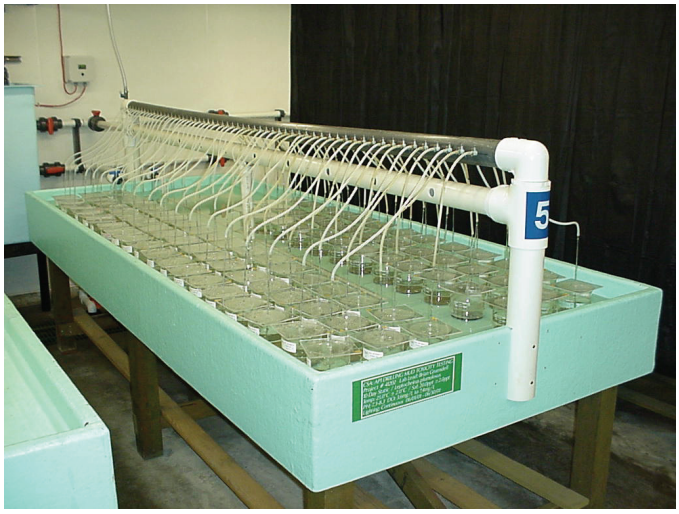

Figure 1. A typical *Leptocheirus plumulosus* test set up.

3.3 Sediment Test Results: Survival

Mean survival in the laboratory control treatment was 86% [coefficient of variation (CV) = 13%] (Table 2), which is greater than the acceptance guideline of 80% (EPA 2001). Mean survival in the New London sediments ranged from 10% (treatment Z4-2) to 95% (treatment Z7-5) (Table 2).

3.4 Sediment Test Results: Reproduction

The mean total number of neonates produced in the laboratory control treatment per living adult was 5.00 (CV = 38%) (Table 3). Neonates were produced in all control-treatment replicates, which meets the suggested guideline for test acceptability (EPA 2001). The mean number of neonates produced per living adult in the New London sediments ranged from 0.0 (treatment Z4-2) to 4.77 (treatment RA-6) (Table 3).

3.5 Sediment Test Results: Growth

The mean dry weights of an average amphipod at the initiation of the test were 0.026 mg, 0.019 mg, and 0.021 mg per individual for starts 1, 2, and 3, respectively. The mean dry weight of an average amphipod in the laboratory control treatment after the 28-day exposure was 1.67 mg (CV = 21%) (Table 4). Growth was demonstrated for all control-treatment replicates, which meets the suggested test guideline (EPA 2001). The mean dry weight of an average amphipod in the New London sediments after the 28-day exposure ranged from 0.58 mg (treatment Z4-2) to 1.94 mg (treatment RA-6) (Table 4).

Table 2. Mean, Standard Deviation (SD), and Coefficient of Variation (CV) Proportion Survival for the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

Treatment	Proportion Survival		
	Mean	SD	CV
RA-1	0.91	0.22	24%
RA-2	0.92	0.08	8%
RA-3	0.83	0.23	28%
RA-4	0.80	0.23	29%
RA-5	0.91	0.05	6%
RA-6	0.94	0.11	11%
Z4-1	0.86	0.14	16%
Z4-2	0.10	0.13	131%
Z4-3	0.70	0.23	33%
Z4-4	0.79	0.19	24%
Z4-5	0.89	0.09	10%
Z4-6	0.67	0.28	42%
Z7-1	0.88	0.16	18%
Z7-2	0.94	0.09	9%
Z7-3	0.75	0.32	43%
Z7-4	0.72	0.31	43%
Z7-5	0.95	0.06	6%
Z7-6	0.84	0.18	22%
Sequim Bay	0.86	0.11	13%

Table 3. Mean, Standard Deviation (SD), and Coefficient of Variation (CV) Total Number of Neonates Produced per Living Adult during the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

Treatment	Total Number of Neonates		
	Mean per Replicate [1]	SD	CV
RA-1	4.01	1.25	31%
RA-2	4.09	2.21	54%
RA-3	3.67	2.06	56%
RA-4	1.91	0.92	48%
RA-5	3.49	1.72	49%
RA-6	4.77	1.85	39%
Z4-1	1.79	1.14	64%
Z4-2	0.00	0.00	
Z4-3	0.92	0.57	61%
Z4-4	1.53	0.96	63%
Z4-5	3.46	1.60	46%
Z4-6	2.77	1.81	65%
Z7-1	3.96	0.96	24%
Z7-2	3.59	1.17	33%
Z7-3	2.63	1.14	43%
Z7-4	2.16	1.19	55%
Z7-5	3.30	1.52	46%
Z7-6	2.02	1.21	60%
Sequim Bay	5.00	1.92	38%

[1] **Per living adult**

Table 4. Mean, Standard Deviation (SD), and Coefficient of Variation (CV) Dry Weight of an Average Amphipod for the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

	Weight per Average Amphipod at 28 Days (mg) [1, 2]		
Treatment	**Mean**	**SD**	**CV**
Start 1 Initial Weight [3]	0.02550	0.00361	14%
Start 2 Initial Weight [3]	0.01888	0.00560	30%
Start 3 Initial Weight [3]	0.02117	0.00202	10%
RA-1	1.70958	0.46186	27%
RA-2	1.69951	0.43925	26%
RA-3	1.59745	0.29214	18%
RA-4	1.28186	0.37480	29%
RA-5	1.78255	0.23095	13%
RA-6	1.93503	0.26135	14%
Z4-1	1.26099	0.37993	30%
Z4-2	0.58237	0.12548	22%
Z4-3	1.13237	0.29088	26%
Z4-4	1.23488	0.24023	19%
Z4-5	1.68837	0.28351	17%
Z4-6	1.25249	0.65730	52%
Z7-1	1.81336	0.34743	19%
Z7-2	1.63344	0.14105	9%
Z7-3	1.35692	0.39952	29%
Z7-4	1.42160	0.57694	41%
Z7-5	1.45008	0.31308	22%
Z7-6	1.41485	0.44978	32%
Sequim Bay	1.66941	0.35602	21%

[1] Includes data from all replicates.

[2] Calculated per replicate as total weight divided by number of amphipods weighed.

[3] Initial weights based on three replicates of 20 amphipods each; collected at test initiation.

4.0 References

U. S. Environmental Protection Agency (EPA). 2001. *Methods for Assessing the Chronic Toxicity of Marine and Estuarine Sediment-associated Contaminants with the Amphipod* Leptocheirus plumulosus - *First Edition*. EPA/600/R-01/020. Washington, DC.

ATTACHMENTS

Attachment A
Water Quality Parameters

Table A-1. Summary of water quality parameters measured during the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

	Temperature (° C)		Salinity (ppt)		Dissolved Oxygen (mg/L)	pH Units	
	Min	Max	Min	Max	Min	Min	Max
Target Range	**22–28**		**17–23**		**>3.6**	**7.0–9.0**	
RA-1	22.7	26.0	19.8	21.6	5.6	7.6	8.0
RA-2	22.8	26.1	20.1	21.7	5.9	7.6	8.2
RA-3	22.8	26.1	20.1	21.7	5.0	7.6	8.1
RA-4	22.8	26.1	20.2	21.7	5.4	7.6	8.1
RA-5	22.4	25.9	20.1	21.7	5.7	7.6	8.3
RA-6	23.1	26.1	20.1	21.1	4.6 [1]	7.0	8.1
Z4-1	22.8	26.1	20.1	21.8	5.4	7.6	8.2
Z4-2	23.2	26.0	20.1	21.8	5.8	7.7	8.2
Z4-3	22.8	26.0	20.0	21.9	5.5	7.6	8.2
Z4-4	22.9	26.1	20.0	22.0	5.6	7.6	8.4
Z4-5	22.7	25.7	20.0	22.1	5.7	7.5	8.3
Z4-6	23.3	26.0	20.1	22.0	5.6	7.6	8.2
Z7-1	22.8	26.0	20.1	21.4	4.2 [2]	7.5	8.4
Z7-2	22.7	25.8	20.2	21.8	5.5	7.5	7.9
Z7-3	22.7	26.1	20.1	22.0	5.5	7.6	8.1
Z7-4	22.8	25.8	20.2	21.9	5.8	7.5	8.0
Z7-5	22.8	25.9	20.1	21.8	5.7	7.5	8.0
Z7-6	22.8	26.0	20.0	22.1	5.1	7.5	8.1
Sequim Bay	23.1	26.0	20.0	21.8	5.8	7.6	8.5

[1] Value of 2.6 mg/L recorded on Day 28 of test.
[2] Value of 2.0 mg/L recorded on Day 28 of test.

Table A-2. Bulk porewater, Day-0, and Day-28 porewater total ammonia concentrations for the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

	Porewater Total Ammonia Concentration (mg/L)		
Treatment	**Bulk Sediment [1]**	**Day 0 [2]**	**Day 28 [2]**
RA-1	2.5	4.4	1.5
RA-2	1.8	2.9	2.4
RA-3	2.1	2.0	0.2
RA-4	2.6	1.9	0.4
RA-5	3.8	2.3	0.4
RA-6	16.1	3.6	1.7
Z4-1	5.5	4.2	1.0
Z4-2	5.5	3.5	0.7
Z4-3	16.8	5.7	0.7
Z4-4	17.2	9.1	1.3
Z4-5	7.0	5.5	0.6
Z4-6	7.1	4.1	0.9
Z7-1	3.8	3.7	1.0
Z7-2	10.3	4.5	0.8
Z7-3	13.6	9.7	1.0
Z7-4	7.8	3.3	0.5
Z7-5	6.4	2.8	0.3
Z7-6	7.5	5.3	0.8
Sequim Bay	NA	2.7	0.3

[1] Measured from a subsample taken from the shipping container
[2] Measured from sediment in surrogate containers

Attachment B
Reference Toxicant and
Sediment Exposure Replicate Data

Table B-1. Results of the Second 96-h reference toxicant test conducted during the 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

Cadmium Concentration (mg/L)	Number Alive	Number Dead or Missing	Proportion Alive
0	19	1	0.95
0	19	1	0.95
0	15	5	0.75
0 (average)	17.7 [1]	2.3 [1]	0.88
0.06	6	14	0.30
0.12	18	2	0.90
0.24	13	7	0.65
0.48	6	14	0.30
0.96	1	19	0.05
1.92	0	20	0

Trimmed Spearman-Karber Method. Montana State Univ.

Raw Dose : .060 .120 .240 .480 .960 1.920
Number : 20 20 20 20 20 20
Mortalities: 14.00 2.00 7.00 14.00 19.00 20.00

Abbotts No. : .100000

Corrected P: .3148 .3148 .3148 .6667 .9444 1.0000
Spearman-Karber Trim (calc): 32.00%

Spearman-Karber Estimates:
LC50: .35
95% Lower Confidence: .26
95% Upper Confidence: .46

[1] Average of three replicates; rounded to whole number for LC_{50} calculation

Table B-2. Number alive, dead or missing, and proportion alive for individual replicates; 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
RA-1	18	2	0.90
RA-1	20	0	1.00
RA-1	20	0	1.00
RA-1	6	14	0.30
RA-1	19	1	0.95
RA-1	19	1	0.95
RA-1	20	0	1.00
RA-1	20	0	1.00
RA-1	19	1	0.95
RA-1	20	0	1.00
RA-2	18	2	0.90
RA-2	19	1	0.95
RA-2	17	3	0.85
RA-2	19	1	0.95
RA-2	19	1	0.95
RA-2	15	5	0.75
RA-2	18	2	0.90
RA-2	20	0	1.00
RA-2	19	1	0.95
RA-2	20	0	1.00
RA-3	17	3	0.85
RA-3	20	0	1.00
RA-3	20	0	1.00
RA-3	17	3	0.85
RA-3	20	0	1.00
RA-3	20	0	1.00
RA-3	16	4	0.80
RA-3	13	7	0.65
RA-3	5	15	0.25
RA-3	18	2	0.90
RA-4	4	16	0.20
RA-4	18	2	0.90
RA-4	18	2	0.90

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
RA-4	17	3	0.85
RA-4	18	2	0.90
RA-4	19	1	0.95
RA-4	14	6	0.70
RA-4	20	0	1.00
RA-4	18	2	0.90
RA-4	14	6	0.70
RA-5	18	2	0.90
RA-5	18	2	0.90
RA-5	19	1	0.95
RA-5	17	3	0.85
RA-5	19	1	0.95
RA-5	18	2	0.90
RA-5	19	1	0.95
RA-5	19	1	0.95
RA-5	19	1	0.95
RA-5	16	4	0.80
RA-6	19	1	0.95
RA-6	20	0	1.00
RA-6	13	7	0.65
RA-6	19	1	0.95
RA-6	20	0	1.00
RA-6	18	2	0.90
RA-6	20	0	1.00
RA-6	20	0	1.00
RA-6	19	1	0.95
RA-6	20	0	1.00
Z4-1	20	0	1.00
Z4-1	17	3	0.85
Z4-1	17	3	0.85
Z4-1	12	8	0.60
Z4-1	14	6	0.70
Z4-1	19	1	0.95
Z4-1	19	1	0.95
Z4-1	15	5	0.75
Z4-1	20	0	1.00

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
Z4-1	19	1	0.95
Z4-2	7	13	0.35
Z4-2	5	15	0.25
Z4-2	0	20	0.00
Z4-2	1	19	0.05
Z4-2	1	19	0.05
Z4-2	0	20	0.00
Z4-2	0	20	0.00
Z4-2	5	15	0.25
Z4-2	1	19	0.05
Z4-2	0	20	0.00
Z4-3	7	13	0.35
Z4-3	9	11	0.45
Z4-3	16	4	0.80
Z4-3	16	4	0.80
Z4-3	7	13	0.35
Z4-3	15	5	0.75
Z4-3	15	5	0.75
Z4-3	17	3	0.85
Z4-3	20	0	1.00
Z4-3	18	2	0.90
Z4-4	19	1	0.95
Z4-4	18	2	0.90
Z4-4	14	6	0.70
Z4-4	18	2	0.90
Z4-4	16	4	0.80
Z4-4	8	12	0.40
Z4-4	19	1	0.95
Z4-4	19	1	0.95
Z4-4	16	4	0.80
Z4-4	11	9	0.55
Z4-5	16	4	0.80
Z4-5	18	2	0.90
Z4-5	14	6	0.70
Z4-5	20	0	1.00
Z4-5	17	3	0.85
Z4-5	18	2	0.90
Z4-5	18	2	0.90
Z4-5	17	3	0.85
Z4-5	20	0	1.00

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
Z4-5	19	1	0.95
Z4-6	11	9	0.55
Z4-6	10	10	0.50
Z4-6	2	18	0.10
Z4-6	18	2	0.90
Z4-6	18	2	0.90
Z4-6	12	8	0.60
Z4-6	19	1	0.95
Z4-6	9	11	0.45
Z4-6	19	1	0.95
Z4-6	15	5	0.75
Z7-1	19	1	0.95
Z7-1	10	10	0.50
Z7-1	19	1	0.95
Z7-1	17	3	0.85
Z7-1	18	2	0.90
Z7-1	17	3	0.85
Z7-1	15	5	0.75
Z7-1	20	0	1.00
Z7-1	20	0	1.00
Z7-1	20	0	1.00
Z7-2	20	0	1.00
Z7-2	20	0	1.00
Z7-2	18	2	0.90
Z7-2	14	6	0.70
Z7-2	19	1	0.95
Z7-2	20	0	1.00
Z7-2	19	1	0.95
Z7-2	19	1	0.95
Z7-2	19	1	0.95
Z7-2	19	1	0.95
Z7-3	15	5	0.75
Z7-3	0	20	0.00
Z7-3	20	0	1.00
Z7-3	20	0	1.00
Z7-3	19	1	0.95
Z7-3	16	4	0.80
Z7-3	20	0	1.00
Z7-3	15	5	0.75
Z7-3	17	3	0.85

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
Z7-3	8	12	0.40
Z7-4	18	2	0.90
Z7-4	20	0	1.00
Z7-4	7	13	0.35
Z7-4	20	0	1.00
Z7-4	3	17	0.15
Z7-4	15	5	0.75
Z7-4	16	4	0.80
Z7-4	18	2	0.90
Z7-4	8	12	0.40
Z7-4	19	1	0.95
Z7-5	19	1	0.95
Z7-5	17	3	0.85
Z7-5	21	0	1.00
Z7-5	17	3	0.85
Z7-5	20	0	1.00
Z7-5	20	0	1.00
Z7-5	18	2	0.90
Z7-5	19	1	0.95
Z7-5	19	1	0.95
Z7-5	20	0	1.00
Z7-6	12	8	0.60
Z7-6	20	0	1.00
Z7-6	20	0	1.00
Z7-6	20	0	1.00
Z7-6	16	4	0.80
Z7-6	18	2	0.90
Z7-6	16	4	0.80
Z7-6	10	10	0.50
Z7-6	20	0	1.00
Z7-6	15	5	0.75
Sequim Bay	16	4	0.80
Sequim Bay	13	7	0.65
Sequim Bay	17	3	0.85
Sequim Bay	16	4	0.80
Sequim Bay	15	5	0.75
Sequim Bay	20	0	1.00
Sequim Bay	19	1	0.95
Sequim Bay	17	3	0.85
Sequim Bay	19	1	0.95

Treatment	Number Alive	Number Dead or Missing	Proportion Alive
Sequim Bay	19	1	0.95

Table B-3. Neonate counts for individual replicates; 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

TRT	Rep	Neonate Number Counted	Adults Number Counted	Neonates per Adult
RA-1	1	40	18	2.2
RA-1	2	75	20	3.8
RA-1	3	74	20	3.7
RA-1	4	18	6	3.0
RA-1	5	102	19	5.4
RA-1	6	76	19	4.0
RA-1	7	106	20	5.3
RA-1	8	46	20	2.3
RA-1	9	95	19	5.0
RA-1	10	110	20	5.5
RA-2	1	62	18	3.4
RA-2	2	125	19	6.6
RA-2	3	68	17	4.0
RA-2	4	150	19	7.9
RA-2	5	35	19	1.8
RA-2	6	48	15	3.2
RA-2	7	114	18	6.3
RA-2	8	57	20	2.9
RA-2	9	17	19	0.9
RA-2	10	77	20	3.9
RA-3	1	38	17	2.2
RA-3	2	53	20	2.7
RA-3	3	66	20	3.3
RA-3	4	115	17	6.8
RA-3	5	123	20	6.2
RA-3	6	41	20	2.1
RA-3	7	86	16	5.4
RA-3	8	30	13	2.3
RA-3	9	3	5	0.6
RA-3	10	94	18	5.2
RA-4	1	11	4	2.8
RA-4	2	27	18	1.5
RA-4	3	15	18	0.8
RA-4	4	47	17	2.8
RA-4	5	54	18	3.0
RA-4	6	41	19	2.2
RA-4	7	4	14	0.3

TRT	Rep	Neonate Number Counted	Adults Number Counted	Neonates per Adult
RA-4	8	26	20	1.3
RA-4	9	49	18	2.7
RA-4	10	25	14	1.8
RA-5	1	112	18	6.2
RA-5	2	60	18	3.3
RA-5	3	48	19	2.5
RA-5	4	5	17	0.3
RA-5	5	74	19	3.9
RA-5	6	94	18	5.2
RA-5	7	63	19	3.3
RA-5	8	97	19	5.1
RA-5	9	52	19	2.7
RA-5	10	36	16	2.3
RA-6	1	101	19	5.3
RA-6	2	120	20	6.0
RA-6	3	61	13	4.7
RA-6	4	168	19	8.8
RA-6	5	103	20	5.2
RA-6	6	88	18	4.9
RA-6	7	71	20	3.6
RA-6	8	85	20	4.3
RA-6	9	53	19	2.8
RA-6	10	44	20	2.2
Z4-1	1	20	20	1.0
Z4-1	2	70	17	4.1
Z4-1	3	0	17	0.0
Z4-1	4	17	12	1.4
Z4-1	5	25	14	1.8
Z4-1	6	36	19	1.9
Z4-1	7	57	19	3.0
Z4-1	8	18	15	1.2
Z4-1	9	25	20	1.3
Z4-1	10	42	19	2.2
Z4-2	1	0	7	0.0
Z4-2	2	0	5	0.0
Z4-2	3		0	
Z4-2	4	0	1	0.0
Z4-2	5	0	1	0.0
Z4-2	6		0	
Z4-2	7		0	

TRT	Rep	Neonate Number Counted	Adults Number Counted	Neonates per Adult
Z4-2	8	0	5	0.0
Z4-2	9	0	1	0.0
Z4-2	10		0	
Z4-3	1	0	7	0.0
Z4-3	2	8	9	0.9
Z4-3	3	11	16	0.7
Z4-3	4	28	16	1.8
Z4-3	5	9	7	1.3
Z4-3	6	19	15	1.3
Z4-3	7	15	15	1.0
Z4-3	8	11	17	0.6
Z4-3	9	31	20	1.6
Z4-3	10	3	18	0.2
Z4-4	1	18	19	0.9
Z4-4	2	55	18	3.1
Z4-4	3	12	14	0.9
Z4-4	4	47	18	2.6
Z4-4	5	30	16	1.9
Z4-4	6	4	8	0.5
Z4-4	7	42	19	2.2
Z4-4	8	32	19	1.7
Z4-4	9	25	16	1.6
Z4-4	10	0	11	0.0
Z4-5	1	82	16	5.1
Z4-5	2	68	18	3.8
Z4-5	3	56	14	4.0
Z4-5	4	42	20	2.1
Z4-5	5	44	17	2.6
Z4-5	6	62	18	3.4
Z4-5	7	33	18	1.8
Z4-5	8	27	17	1.6
Z4-5	9	67	20	3.4
Z4-5	10	129	19	6.8
Z4-6	1	10	11	0.9
Z4-6	2	22	10	2.2
Z4-6	3	0	2	0.0
Z4-6	4	82	18	4.6
Z4-6	5	51	18	2.8
Z4-6	6	45	12	3.8
Z4-6	7	103	19	5.4

TRT	Rep	Neonate Number Counted	Adults Number Counted	Neonates per Adult
Z4-6	8	5	9	0.6
Z4-6	9	68	19	3.6
Z4-6	10	58	15	3.9
Z7-1	1	60	19	3.2
Z7-1	2	56	10	5.6
Z7-1	3	72	19	3.8
Z7-1	4	72	17	4.2
Z7-1	5	85	18	4.7
Z7-1	6	61	17	3.6
Z7-1	7	66	15	4.4
Z7-1	8	95	20	4.8
Z7-1	9	53	20	2.7
Z7-1	10	54	20	2.7
Z7-2	1	66	20	3.3
Z7-2	2	51	20	2.6
Z7-2	3	77	18	4.3
Z7-2	4	33	14	2.4
Z7-2	5	62	19	3.3
Z7-2	6	68	20	3.4
Z7-2	7	53	19	2.8
Z7-2	8	114	19	6.0
Z7-2	9	56	19	2.9
Z7-2	10	96	19	5.1
Z7-3	1	33	15	2.2
Z7-3	2	0	0	
Z7-3	3	76	20	3.8
Z7-3	4	94	20	4.7
Z7-3	5	36	19	1.9
Z7-3	6	21	16	1.3
Z7-3	7	61	20	3.1
Z7-3	8	18	15	1.2
Z7-3	9	47	17	2.8
Z7-3	10	22	8	2.8
Z7-4	1	70	18	3.9
Z7-4	2	17	20	0.9
Z7-4	3	13	7	1.9
Z7-4	4	41	20	2.1
Z7-4	5	2	3	0.7
Z7-4	6	50	15	3.3
Z7-4	7	30	16	1.9

TRT	Rep	Neonate Number Counted	Adults Number Counted	Neonates per Adult
Z7-4	8	64	18	3.6
Z7-4	9	6	8	0.8
Z7-4	10	52	19	2.7
Z7-5	1	50	19	2.6
Z7-5	2	41	17	2.4
Z7-5	3	41	21	2.0
Z7-5	4	60	17	3.5
Z7-5	5	84	20	4.2
Z7-5	6	139	20	7.0
Z7-5	7	62	18	3.4
Z7-5	8	55	19	2.9
Z7-5	9	68	19	3.6
Z7-5	10	29	20	1.5
Z7-6	1	14	12	1.2
Z7-6	2	53	20	2.7
Z7-6	3	43	20	2.2
Z7-6	4	83	20	4.2
Z7-6	5	17	16	1.1
Z7-6	6	28	18	1.6
Z7-6	7	64	16	4.0
Z7-6	8	13	10	1.3
Z7-6	9	25	20	1.3
Z7-6	10	13	15	0.9
Sequim Bay	1	89	16	5.6
Sequim Bay	2	25	13	1.9
Sequim Bay	3	73	17	4.3
Sequim Bay	4	70	16	4.4
Sequim Bay	5	106	15	7.1
Sequim Bay	6	93	20	4.7
Sequim Bay	7	60	19	3.2
Sequim Bay	8	68	17	4.0
Sequim Bay	9	128	19	6.7
Sequim Bay	10	157	19	8.3

Table B-4. Dry Weights (28-day Growth) for individual replicates; 28-d *Leptocheirus plumulosus* Test; New London/Thames River Sediments, May 16 to June 15, 2007.

Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)
RA-1	1	2.09283	RA-2	1	1.77061	RA-3	1	1.12707
RA-1	2	1.91633	RA-2	2	1.83134	RA-3	2	1.74112
RA-1	3	1.89233	RA-2	3	1.79818	RA-3	3	1.80450
RA-1	4	0.87217	RA-2	4	1.85397	RA-3	4	1.39685
RA-1	5	0.85397	RA-2	5	1.79936	RA-3	5	1.69783
RA-1	6	1.65480	RA-2	6	1.91178	RA-3	6	1.76633
RA-1	7	1.82612	RA-2	7	1.95506	RA-3	7	1.78487
RA-1	8	1.97112	RA-2	8	1.80033	RA-3	8	1.25345
RA-1	9	1.99555	RA-2	9	0.45989	RA-3	9	1.36250
RA-1	10	2.02062	RA-2	10	1.81462	RA-3	10	2.04001
RA-4	1	1.13112	RA-5	1	1.60728	RA-6	1	2.02796
RA-4	2	1.38283	RA-5	2	1.91272	RA-6	2	2.07300
RA-4	3	1.69445	RA-5	3	1.47989	RA-6	3	1.91576
RA-4	4	1.27524	RA-5	4	2.04994	RA-6	4	2.08924
RA-4	5	1.54217	RA-5	5	1.57292	RA-6	5	2.08562
RA-4	6	1.30450	RA-5	6	1.55606	RA-6	6	1.69828
RA-4	7	0.52312	RA-5	7	1.67608	RA-6	7	1.36350
RA-4	8	1.61633	RA-5	8	1.85533	RA-6	8	1.93000
RA-4	9	1.55006	RA-5	9	2.11270	RA-6	9	2.32164
RA-4	10	0.79883	RA-5	10	2.00258	RA-6	10	1.84533
Z4-1	1	0.98712	Z4-2	1	0.62879	Z4-3	1	0.42255
Z4-1	2	1.24177	Z4-2	2	0.71850	Z4-3	2	1.16772
Z4-1	3	0.48942	Z4-2	3		Z4-3	3	0.97821
Z4-1	4	0.81633	Z4-2	4	0.60450	Z4-3	4	1.09012
Z4-1	5	1.46950	Z4-2	5	0.39450	Z4-3	5	1.12598
Z4-1	6	1.63585	Z4-2	6		Z4-3	6	1.45217
Z4-1	7	1.53818	Z4-2	7		Z4-3	7	1.09178
Z4-1	8	1.41017	Z4-2	8	0.67912	Z4-3	8	1.30744
Z4-1	9	1.61762	Z4-2	9	0.46883	Z4-3	9	1.40212
Z4-1	10	1.40397	Z4-2	10		Z4-3	10	1.28561

Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)
Z4-4	1	1.47924	Z4-5	1	1.81200	Z4-6	1	0.53748
Z4-4	2	0.77006	Z4-5	2	1.76506	Z4-6	2	0.56312
Z4-4	3	1.15383	Z4-5	3	1.89826	Z4-6	3	0.34112
Z4-4	4	0.94667	Z4-5	4	1.41183	Z4-6	4	1.83450
Z4-4	5	1.09237	Z4-5	5	1.66413	Z4-6	5	1.65106
Z4-4	6	1.36383	Z4-5	6	1.95161	Z4-6	6	1.69717
Z4-4	7	1.38883	Z4-5	7	1.17334	Z4-6	7	1.78462
Z4-4	8	1.45345	Z4-5	8	1.87274	Z4-6	8	0.53778
Z4-4	9	1.44763	Z4-5	9	1.34200	Z4-6	9	1.73292
Z4-4	10	1.25294	Z4-5	10	1.99270	Z4-6	10	1.84517
Z7-1	1	2.06924	Z7-2	1	1.37633	Z7-3	1	1.17378
Z7-1	2	1.72383	Z7-2	2	1.81883	Z7-3	2	
Z7-1	3	1.41515	Z7-2	3	1.56778	Z7-3	3	1.69412
Z7-1	4	1.13413	Z7-2	4	1.79169	Z7-3	4	1.66700
Z7-1	5	2.02112	Z7-2	5	1.73134	Z7-3	5	1.61924
Z7-1	6	2.06391	Z7-2	6	1.60662	Z7-3	6	0.73487
Z7-1	7	2.24350	Z7-2	7	1.63849	Z7-3	7	1.80150
Z7-1	8	1.99662	Z7-2	8	1.62766	Z7-3	8	0.74683
Z7-1	9	1.56650	Z7-2	9	1.45608	Z7-3	9	1.33236
Z7-1	10	1.89962	Z7-2	10	1.71954	Z7-3	10	1.44258
Z7-4	1	1.69056	Z7-5	1	1.62462	Z7-6	1	0.59112
Z7-4	2	1.78250	Z7-5	2	1.47935	Z7-6	2	1.46533
Z7-4	3	0.50598	Z7-5	3	0.74688	Z7-6	3	1.61550
Z7-4	4	1.64512	Z7-5	4	1.81979	Z7-6	4	1.53962
Z7-4	5	0.49778	Z7-5	5	1.46250	Z7-6	5	1.56737
Z7-4	6	1.76617	Z7-5	6	1.46350	Z7-6	6	1.80834
Z7-4	7	1.72821	Z7-5	7	1.54217	Z7-6	7	1.69758
Z7-4	8	1.90283	Z7-5	8	1.19059	Z7-6	8	1.69550
Z7-4	9	0.80237	Z7-5	9	1.81673	Z7-6	9	1.59800
Z7-4	10	1.89450	Z7-5	10	1.35462	Z7-6	10	0.57017
			Sequim Bay	1	2.24383			
			Sequim Bay	2	1.38681			
			Sequim Bay	3	1.27354			
			Sequim Bay	4	1.98883			
			Sequim Bay	5	1.28117			

Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)	Treatment	Replicate	Net 28-d Growth per Lepto (mg)
			Sequim Bay	6	1.92862			
			Sequim Bay	7	2.04217			
			Sequim Bay	8	1.36171			
			Sequim Bay	9	1.52608			
			Sequim Bay	10	1.66134			

APPENDIX E

Responses to Comments

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Appendix E. Responses to Comments – Thames River Validation Study

Comment Number/Location	Comment	Response
General Comments from USEPA, received 12/19/07		

EPA Comment 1.
p. 1, paragraph 2
p. 2, paragraphs 1 & 2
	The Draft Thames River Validation Study identifies footprints of chemical contamination in the three study areas based on exceedances of PRGs. The PRGs were based on the three endpoints in the toxicity tests and on risk to piscivorous birds, and were developed for ERM-Qs rather than for individual chemicals. For ERM-Q exceedances based on more than one endpoint, EPA recommends further evaluation in the FS. The only site identified for further evaluation is Zone 4, with a 0.31 acre footprint adjacent to quay wall. The Zone 4 footprint is based on observed reductions in survival, growth, and reproduction in bioassays and associated exceedances of the total ERM-Q, total metals ERM-Q, total organic ERM-Q, and total PCB ERM-Q. The exceedances in Zone 7 and Pier 1 were not recommended for further evaluation because they were only based on one toxic endpoint. The ERM-Q exceedances were based on the following findings of the ecological risk assessment:
	
	<u>Zone 7</u>
	• Food chain model - low level risk to piscivorous birds (zinc)
	• Bioassay
	  o Survival significantly different from reference in 2 of 6 locations
	  o Growth significantly different from reference in 4 of 6 locations
	  o Reproduction significantly different from reference in 3 of 6 locations
	
	<u>Zone 4</u>
	• Food chain model - low level risk to piscivorous birds (lead and zinc)
		Comment noted. Issues raised in this comment are addressed is subsequent responses to comments below.

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	• Bioassay - generally greater negative effects than in Zone 7
	  o Survival significantly different from reference in 3 of 6 locations
	  o Growth significantly different from reference in 5 of 6 locations
	  o Reproduction effects greater than in Zone 7
	
	<u>Outer Pier 1</u>
	• Food chain model - low level risk to piscivorous birds (mercury)
	
	EPA is pleased that the identification of PRGs and chemical footprints is fairly logical and transparent. The food chain modeling is mostly sound and the discussion of the bioassay results accurately reflects the data in Appendix D, with a few exceptions. These exceptions and the need for enhanced clarity in some aspects of the report are detailed below.
	
	The report indicates that only multiple endpoint footprints, not single endpoint footprints, are targeted for further evaluation. This approach may ignore a problem in areas where potential significant risk has been identified, even if it is in only one endpoint. It is not appropriate to eliminate areas for further evaluation if potential unacceptable risk has been identified for any line of evidence, unless there is a reason to question the data used to identify the risk. Chemicals often affect organisms in specific ways and a toxic effect can be seen in one part of a body without being seen in another. If a chemical affects the reproductive process in an organism but does not affect growth or survival, it may simply be a difference in how the chemical affects the cellular functions associated with these different endpoints. The lack of significant effects in survival and growth should not be viewed as evidence that the reproductive impact is not real. It may be worthwhile to further delineate the chemical	

Comment Number/Location	Comment	Response
	contamination in areas where reproductive effects are the only line of evidence exhibiting potential unacceptable risk.	
EPA Comment 2. p. 2, paragraph 3	The discussion of the toxicity test results relies on comparisons of means between the sites and the reference area. The box plots on pages 49, 51, and 53 present median values rather than mean values. Please explain why mean values were not used in the box plots.	Box plots are meant to show the **distribution** of the replicate data for each sampling location. The customary presentation of box plots is that the "box" represents the middle 50% of the data (25th percentile to 75th percentile), with a line or bar representing the median of the data points to show the mid-point of the measured data, not an arithmetic average of all data. All box plots in the Validation Study Report follow standard presentation. The red asterisks denoting statistical differences in means between NSB-NLON locations vs reference area were placed on the box plots simply as a courtesy to facilitate the reader in identifying which locations were significantly different when visually comparing the data distribution in the box plot. The mean values used in the statistical comparisons are shown in Table 4-4.
EPA Comment 3. p. 2, paragraph 4	As shown in Tables 4-4 and A-8 (Appendix A), among other locations, the measure used to evaluate reproductive effects in the sediment toxicity tests is the number of offspring per surviving adult. The values presented in these tables are not consistent with the data presented in Appendix D. The data in Appendix D (*e.g.*, Table 3 and Table B-3, page D-22) show that the values used for the statistical comparison are total offspring per replicate, not offspring per surviving adult. If the critical endpoint is offspring *per* adult, the evaluation needs to be redone using the corrected values.	The reviewer is correct in noting that the critical endpoint is **number of offspring per surviving adult**, and that the statistical analyses, regressions, and footprint derivations for the reproduction line of evidence were originally done with total offspring per replicate, and not offspring per surviving adult. The analyses have been corrected; the updated results and figures are presented below and will be incorporated into the revised document. Regression statistics changed only slightly, with Total PCBs and Organic ERM-Q still the only chemical indicators with R^2 values exceeding 0.5 (see attached Table 1). Based upon the revised regressions, PRGs for Total ERM-Q, Organic ERM-Q, and Total PCBs associated with 25% and 50% reductions in reproduction are slightly higher than those originally presented (see attached Table 2 and Figures 1 through 3). Footprints based on the reproduction line of evidence were recalculated for each area based upon the revised

Comment Number/Location	Comment	Response
		PRGs, with the higher PRGs resulting in smaller footprint areas associated with reproductive effects. The revised PRGs resulted in revisions to Figures 4-12 through 4-17, 4-19, 4-20, and 4-23 through 4-32. The revised figures are shown in the attached file and will be incorporated into the revised Validation Study report.
EPA Comment 4. p. 2, paragraph 5	The food chain modeling for the cormorant evaluated potential risk from exposure to chromium, lead, mercury, and zinc in sediment and fish tissue. The exposure parameters and TRVs are appropriate and adequately protective and the HQs seem to be calculated correctly, with a minor exception. In some instances EPA could not quite reproduce the HQs presented in Table 4-12. The differences were minor and EPA calculated lower HQs than those presented in the report. For example, the NOAEL and LOAEL HQs for chromium (based on the mean BAF) were 0.09 and 0.05. The values in Table 4-12 are 0.11 and 0.06. While these differences do not affect the overall site risks, please check the calculations for errors that could be problematic.	The food chain HQ calculations were checked for accuracy. The discrepancies noted were due to rounding in the cormorant fish ingestion rate and sediment ingestion rate. Rounding was made consistent throughout the calculations and the HQs revised accordingly.
EPA Comment 5. p. 2, paragraph 6	As requested previously by EPA, the derivation of the ERM-Qs should be more transparent. The report presents ERM-Qs for the various chemical groups but does not reveal how the ERM-Qs were calculated. Please provide the ERM-Q calculations and include a table showing COPC concentrations at each site with associated ERM values, in order to determine if the ERM-Qs are accurate and based on an appropriate number of COPCs. Transparency in the ERM-Q derivation is needed so that EPA can confirm the PRGs in Table 4-15. Since the selected chemical footprints (*e.g.*, Figure 4-13) are based on spatial distributions of ERM-Qs (*e.g.*, Figure 4-12), a table presenting the data on which the spatial distributions are based should be included.	The equation for the calculation of the ERM-Qs is currently presented as Equation 3 in Section 4.4.1 of the draft Validation Study report. The list of chemicals included in the ERM-Q calculations and their associated ERM-Q values are presented in Table 4-13, and the chemicals included in the Metals ERM-Q and Organic ERM-Q calculations are described in the text in Section 4.4.1. A table detailing the ERM-Q calculations showing relevant COPC concentrations for each sampling location will be added to Appendix A to clarify how the ERM-Qs were calculated.
EPA Comment 6.	As shown in Figures 4-27 through 4-33, the area in Outer Pier 1	The footprints in Outer Pier 1 were developed under the assumption

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p. 3, paragraph 1	adjacent to the line separating Inner and Outer Pier 1 is identified as a low risk area. The footprints for this area were apparently calculated using only Outer Pier 1 data. If data from Inner Pier 1 were used, the modeled footprint extending into Outer Pier 1 would be different. Given that the sediments in Inner Pier 1 are deemed sufficiently contaminated to require remediation, the sediments in Outer Pier 1 adjacent to the border with Inner Pier 1 should not be assumed to be "low risk." As the southern extent of the Inner Pier 1 excavation is predetermined and will not be based on a comparison of confirmatory samples to PRGs, there is a data gap in the area beyond the excavation into Outer Pier 1. EPA recommends that the Navy take a few samples in this area to confirm the "low risk" description that is currently assumed.	that the sediments in Inner Pier 1 would be completely removed as recommended in the Draft Engineering Evaluation/Cost Analysis (EE/CA) that was submitted on September 27, 2007. Under this assumption, the concentrations in Inner Pier 1 were set equivalent to the reference area (i.e., background) for the evaluation of sediments in Outer Pier 1, since the appropriate question is what potential risk is presented by these Outer Pier 1 sediments after the Inner Pier 1 sediments have been removed. The boundary of the Inner Pier 1 excavation was predetermined based on existing sediment chemistry data which showed that COPC concentrations decreased by over an order of magnitude in the vicinity of the end of the boat ramp.
EPA Comment 7. p. 3, paragraph 2	EPA generally agrees with the Validation Study's methodology, but believes that greater emphasis should be placed on the results of the toxicity test, as this is the strongest line of evidence for direct ecological effects at the site. Any two toxicity test endpoints (such as 25% reduction in reproduction and 50% reduction in reproduction, or a growth effect and a reproduction effect) should be considered to be multiple lines of evidence. Areas represented by the samples exhibiting these responses should be evaluated further in the Feasibility Study (FS). Also, the dose-response in the toxicity test with metals and PCBs should be examined by normalizing for AVS and TOC to see whether the R^2 improves for either of these parameters. If the correlation is strong for either metals or PCBs based on the best fit to the toxicity data, these corresponding areas should be evaluated in the FS. If not, the total ERM-Q should be used to calculate areas to be evaluated in the FS.	The decision rules in Table 4-3 and the Validation Study as a whole are written with the assumption that three endpoints are evaluated in toxicity tests: growth, survival, and reproduction. Within each endpoint, different levels of effect were identified to aid in identifying potential magnitude of impact. These included 30% and 50% reduction in growth; 30% reduction in survival; and 25% and 50% reduction in reproduction. The 30% and 50% reductions in growth were not considered separate endpoints, but rather different "levels of effect" within an endpoint. This may simply be a semantic difference in the definition of "endpoint", and what the reviewer is suggesting is that any 50% effect level for a single endpoint is significant enough that it deserves further evaluation in the FS. The footprint selected in the draft Validation Study for further evaluation in the FS shows adverse impacts to at least two of the bioassay endpoints, with much of the identified area showing adverse impact to all three bioassay endpoints (growth, survival, and reproduction). As discussed at the bottom of page 101 and on the top of page 102: "This area is primarily associated with sediments that have

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		never been dredged due to their proximity to the quay wall, and pose high magnitude risk to benthic invertebrate survival (>30% reduction), moderate risk to benthic invertebrate growth (>30% reduction), and high risk to benthic invertebrate reproduction (>50% reduction). In addition, the area poses low magnitude risk to piscivorous birds due to elevated zinc concentrations. " The revised Validation Study will recommend maximum and minimum footprints for further evaluation in the FS, as described below in the response to EPA Comment 10. Normalization of PCB and Metals data is discussed below in response to EPA Comment 9.
EPA Comment 8. p. 3, paragraph 3	EPA believes that the available data should be further evaluated, and additional areas (or simply a larger areal extent) should be addressed in the Feasibility Study. EPA believes that the toxicity and sediment chemistry data suggest several overall conclusions that should be further considered in the final report: • There are patterns in the data that suggest a dose-response relationship for amphipod survival, growth, and reproduction and chemical stressors, particularly for total PCBs, although the signal is confounded by small sample size and the presence of multiple stressors. • As expected with ERM-Qs near 1, the dose-response relationship is difficult to discern for survival, and clearer for growth and reproduction, with reproduction as the most sensitive endpoint. • These data indicate risk between the ER-L and the ER-M, where site risks cannot be eliminated based on benchmarks, and sensitive toxicity test endpoints indicate effects. Areas where risk is indicated based on toxicity should be considered in the FS, even though remediation may not be	The report evaluated a wide array of dose-response relationships for each endpoint, as discussed in the regression analysis in Section 4 and Appendix A. The footprinting efforts focus on evaluating all potential dose-response relationships for constituents with R^2 values > 0.50. The report will clarify that these regression analyses represent dose-response relationships for chemical stressors and the observed toxicity, and reiterate that relatively modest R^2 values are not unexpected due to the wide array of chemical stressors present and the variability of physico-chemical conditions across the site. In addition, discussion will be added to address the normalizing parameters evaluated as part of the response to EPA Comment 9. It is important to keep in mind that statistical relevance and ecological relevance are not always one and the same, and the use of the dose response regressions focused on identifying ecologically relevant endpoints for those chemical indicators that exhibited statistical relevance and had R^2 values greater than 0.5.

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	ultimately required in all cases.	
EPA Comment 9. p. 3, paragraphs 4 & 5 p. 4, paragraphs 1 & 2	Since the Navy has gone to considerable expense and effort to perform a very sensitive toxicity test, and to analyze the sediments for contaminants as well as ancillary analyses including TOC and AVS/SEM, EPA believes these data should be thoroughly used. One example of the toxicity pattern can be seen in the regressions of organic ERM-Qs and PCB ERM-Qs vs. amphipod reproduction (Figures 4-9 and 4-10, respectively). It makes sense that the R^2 values are only 0.52 and 0.61, considering that points below the response line may have been influenced by metals, and points above the response line may be influenced by mitigating factors such as AVS or TOC. Admittedly it is challenging to present these multiple factors in a few figures. Please graph the amphipod response vs. total PCBs on a ng/gram organic carbon basis, and metals on the basis of AVS to metals ratios, using the formula: (AVS-SEM)/fOC. The dose-response for PCBs indicates that survival is the least sensitive endpoint, followed by growth, with reproduction being the most sensitive. Consider the data presented in Figure 4-8, Regression of Amphipod Growth vs. Total PCBs, and Figure 4-10, Regression of Amphipod Reproduction vs. Total PCBs. The estimated 30% reduction line for growth falls at 270 ng/g total PCBs, and the estimated 25% reduction line for reproduction line falls at 109 ng/g total PCBs. (Survival data vs. PCBs were not plotted, but the survival effects may not have been sufficient to show any trend with multiple variables.) Overall, the data seem to indicate chemical-related impairment, with total PCBs offering the best fit with toxicity in most cases. EPA recommends that additional regressions accounting for	Per the review comment, regressions were recalculated using PCBs normalized to TOC [(ng PCB per g sed)/ (g TOC/g sed) = ng PCB per g TOC] and metals normalized to AVS and OC [(AVS – SEM)/fOC]. AVS-normalized metals regressions showed no statistically significant correlations with any bioassay endpoint (see Table 3 and Figures 4 through 6). Normalizing PCBs to TOC improved the relationship between PCB concentration and survival (R^2 increased from 0.469 to 0.587), but there was little to no improvement in the correlation between PCB concentration and growth or reproduction (see Table 3 and Figures 7 through 9). Figure 7 illustrates that although the relationship between survival and TOC-normalized PCBs improved, the correlation is greatly influenced by the single point in the lower right of the figure, and if not for that point, the slope of the line would essentially be nearly flat. Given the lack of correlation observed when normalizing metals to AVS and the lack improvement in the PCB correlations for the most sensitive endpoints, no further normalization of PCB and metals results is proposed. The data points on Figures 4-4 through 4-33 will be labeled to facilitate comparisons.

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	mitigating factors (AVS and TOC) for metals and PCBs be presented, to evaluate whether the data correlate better with toxicity. Please label the data points with the sample ID to facilitate review of the maps.	
EPA Comment 10. p. 4, paragraph 3	The decision rules presented in the document and the recommendations for areas to be evaluated in the FS conflict. The decision rules in Table 4-3 state that if unacceptable risk is observed for growth or reproduction in the *L. plumulosus* toxicity test, then Study Area-specific dose-response correlations would be calculated and areas exceeding the effects levels would be evaluated further in the FS. Zone 4 and Outer Pier 1 have areas that exceed an effects level for organic chemicals associated with 50% reduction in offspring, yet these areas are not recommended for consideration in the FS. EPA believes that these areas should be evaluated further in the FS. Consideration of multiple endpoints in the toxicity test would likely expand the area in Zone 4, and enlarge the Pier 1 area already slated for removal.	Table 4-18 shows the footprints that were developed which are based on risk to single endpoints (survival OR growth OR reproduction) as well as the footprints that are based on risk to more than one endpoint. The only areas that show risk based on more than one endpoint is in Zone 4 (shows risk to all endpoints). It is worth noting here that the Organic ERM-Q footprint associated with a 50% reduction in reproduction in Zone 7 is centered on the drydock area of Pier 15, and no sample locations are actually located inside this footprint. The footprint is likely an artifact of the model, driven by two data points on the south side of Pier 15, which causes the footprint to extend into the unsampled drydock area. No samples were collected in the drydock area because this area has been heavily over-dredged for operational reasons. The most conservative (i.e. largest) footprints in each area showing a 50% reduction in any single endpoint (reproduction) are based upon the Organic ERM-Q. Based upon comments received and discussions in the monthly conference calls, there appear to be valid reasons to dismiss Organic ERM-Q as a toxicity indicator for reproduction. As was noted in the January 3 conference call, the Organic ERM-Q contains Total PCBs, which has an $R^2 = 0.61$, Total DDx, LPAH, HPAH (all with $R^2 < 0.38$) and alpha-chlordane ($R^2 = 0.13$). If PCBs are omitted from the Organic ERM-Q calculation, the resulting Organic ERM-Q has an R^2 of 0.40. Based on these R^2 values, it would appear that the Organic ERM-Q (including PCBs) R^2 value of 0.52 is being driven by the PCB component of the quotient, and

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		therefore it is more appropriate to use Total PCBs as the reproduction toxicity indicator instead of Organic ERM-Q. The Organic ERM-Q footprint associated with a 50% reduction in reproduction in Zone 4 encompasses all of the 2007 sampling locations, yet the mean number of offspring per surviving adult in samples Z4-3 through Z4-7 (those locations not adjacent to the quay wall) was 2.17, which represent a 40% reduction from the reference area mean of 3.66 offspring per surviving adult. Thus the Organic ERM-Q footprint appears to be overly conservative compared to the Total PCB footprint. Discounting the Organic ERM-Q indicator, there are no footprints in Zone 7 impacting multiple endpoints, and there are no footprints in Zone 7 associated with a 50% reduction in any individual endpoint. In Zone 4, the footprint associated with impacts to more than one endpoint is approximately 0.31 acres (Figure 4-34 in draft Validation Study report, which represents the combined footprints for ERM-Q > 1.43 and Total PCB > 270 ppb), while the footprint associated with a 50% reduction in any single endpoint is approximately 0.40 acres (combined footprints for ERM-Q > 1.17 and Total PCBs > 208 ppb – see revised Figures 4-20 and 4-26 in the accompanying Powerpoint file). In Outer Pier 1 there is no footprint associated with impact to more than one endpoint, while the footprint associated with a 50% impact to any single line of evidence is 0.17 acres associated with Total PCB concentrations > 208 ppb. Based on the rationale presented above, the Navy proposes eliminating the Organic ERM-Q as a toxicity indicator and proposes evaluating maximum and minimum footprints in the FS as follows: **Zone 7:** Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0 acres (no 50% impact based on Total ERM-Q, Metals ERM-Q, or Total PCB PRGs)

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		Zone 4: Minimum Footprint: 0.31 acres (area showing risk to more than one endpoint based on Total ERM-Q > 1.43 and Total PCBs > 270 ppb) Maximum Footprint: 0.40 acres (area with 50% impact to a single line of evidence based on Total ERM-Q > 1.17 and Total PCB > 208 ppb) **Outer Pier 1:** Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0.17 acres (area with 50% impact to a single line of evidence based on Total PCB > 208 ppb)
Specific Comments from USEPA (Attachment A)		
p. 105, §5.1	The first sentence of the second paragraph states that potential low-level risk to piscivorous birds was determined for mercury in Zone 7. The HQ for mercury was greater than 1.0 at Pier 1, not in Zone 7. Please correct. The final sentence of the fourth paragraph is confusing and seems to simply restate the previous sentence. Please clarify.	The sentence will be revised to state that the low-level risk to piscivorous birds was determined for mercury in Outer Pier 1, not Zone 7. The last sentence of the fourth paragraph will be deleted.
p. 105, §5.2	This section states that Figure 4-22 describes the Zone 4 multiple risk footprint. Figure 4-22 describes the area exceeding Metals ERM-Q PRGs. Please clarify.	Figure 4-22 will be corrected to read Figure 4-26.
General Comment from NOAA, received 11/7/07		
p. 1 paragraph 1	Thank you for the Draft Thames River Validation Study Report, Naval Submarine Base – New London, Groton, CT dated October 2007 prepared by Battelle. The report is especially well laid out with tables and figures well designed and well placed. In fact the data is studied to such a great degree that absolute conclusions are hard to reach.	Comment noted.
Specific Comments from NOAA		
1	The ERM-Q methodology is well received. Table 4-13 includes	The text will be modified to note that survival regression lines were

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	the appropriate chemical constituents. Because survival is the strongest indication of toxicity that endpoint is examined first; the resulting regression statistics from Table 4-14 and the following Figures 4-4 through 4-6 show that the metals are primary contaminant of concern. And it is Station Z4-2 where the high metal concentration matches closely with severe mortality. But as discussed on Page 63 (Section 4.4.1.1, Correlation Between Sediment Chemistry and Amphipod Survival), this one toxic station may cause a somewhat inaccurate ERM-Q of concern. I am not certain of the statement that the "ERM-Qs or the Metals ERM-Qs are probably the best estimator of amphipod survival". Although the ERM-Q is the correct numerical sediment tool, the ERM-Q corresponding to a 30% reduction as shown in Figures 4-5 and 4-6 are not exact for the reasons given in the text; i.e., only one highly toxic station is related to a high ERM-Q.	influenced by the one highly toxic data point (Z4-2), which was high in both metals and organic constituent concentrations. The uncertainty associated with the slope of the regression line is increased by the lack of mid-range survival toxicity data, and if not for the single highly toxic data point, the slope of the line would be shallower, resulting in higher survival PRGs. Though the actual slope of the regression line is somewhat uncertain because of the lack of mid-range toxicity data, the Total ERM-Q and metals concentrations showed the highest correlative fit with the data.
2	Despite some concerns introduced above, and discussed in the text (e.g., Section 5-1), the conclusions fit the data. NOAA agrees that the area exceeding potential risk based on 50% effects level for one endpoint or greater than 30%/25% for two endpoints should be evaluated for potential remediation. However, I interpret the footprints exceeding the ERM-Qs differently then what is presented in Section 5.2 (Identification of Areas Recommended for Evaluation in the Feasibility Study) along with its related Table 4-18. This all likely reflects my definition of endpoints for the reduction in offspring as 1. >25% reduction in offspring and 2. >50% reduction in offspring. Comments/questions below: • Figure 4-15 showing the Zone 7 footprint exceeding the Organic ERM-Q PRG demonstrates a 1.6 acre area that exceeds two endpoints; although the other ERM-Q PRGs (and PCB PRG) do not reflect more than one endpoint exceedence. I assume the Navy believes the Organic ERM-	As discussed above, the Navy defined three bioassay "endpoints" in the risk assessment: survival, growth, and reproduction. The Navy does not define different levels of effect on any one of these measurements as separate endpoints, but rather as a way to measure magnitude of impact to an "endpoint". The differences referenced in this comment are due to the fact that the reviewer is considering different levels of effect within an endpoint (as defined by the Navy) to actually represent two endpoints. To address this discrepancy, the Navy proposes evaluating maximum and minimum footprints for each area, where the minimum footprint represents the area showing impact to two or more endpoints (as defined by the Navy), and the maximum footprint represents the area showing a 50% impact to any single endpoint. The Navy proposes that the Organic ERM-Q PRG is of lesser importance for the reasons discussed in response to EPA Comment #10, and proposes evaluating maximum and minimum footprints as

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	Q PRG is of lesser import than the other PRGs, and I do not necessarily disagree. I just can't find a justification for eliminating these 1.6 acres for further review in the FS. Table 4-18 indicates that the area of concern exceeds only one endpoint but I believe it is two. • Figure 4-20 shows an area exceeding the proposed criteria at 0.40 acres. Figure 4-34 shows 0.31 acres. Please explain the difference. Similar to that above for Zone 7, the Organic ERM-Q PRG (Figure 4-24) shows a much larger area of concern, 2.3 acres. • And similar to above, for Outer Pier 1, I would argue that the area of concern is 0.51 acres when using the Organic ERM-Q PRG, 0.22 acres when using the PCB PRG, and 0.03 acres when using the total ERM-Q PRG. I prefer using the total ERM-Q as it incorporates all of the contamination and that was the reasoning behind its development.	follows in the FS: **Zone 7:** Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0 acres (no 50% impact based on Total ERM-Q, Metals ERM-Q, or Total PCB PRGs) **Zone 4:** Minimum Footprint: 0.31 acres (area showing risk to more than one endpoint based on Total ERM-Q > 1.43 and Total PCBs > 270 ppb) Maximum Footprint: 0.40 acres (area with 50% impact to a single line of evidence based on Total ERM-Q > 1.17 and Total PCB > 208 ppb) **Outer Pier 1:** Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0.17 acres (area with 50% impact to a single line of evidence based on Total PCB > 208 ppb)
3	In the Executive Summary (Page ii), a PCB ERM-Q threshold is identified for reductions in growth and reproduction but the concentrations shown are not ERM-Qs, rather they are total PCB concentrations. Figures 4-8 and 4-10 shows this data correctly with the titles "Regression of Amphipod Growth/Reproduction vs. Total PCBs"	Total PCBs were evaluated as concentrations, not as ERM-Qs. This will be clarified throughout the text, tables, and figures.
4	It would be very helpful (at least to me!) if the Regression Figures (Figures 4-4 to 4-11) provided the station number. The circles, squares and Xs designate Zone 7, Reference, and Zone 4, respectively but there is room for the actual station number. In	Station IDs will be added to Figures 4-4 through 4-33.

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	fact, when I tried to do this myself, I found four of six Zone 4 survival toxicity test results from Appendix D Table 2 below 80% mean survival (4-2, 4-3, 4-4, 4-6) but only three (4-2, 4-4, 4-6) plotted this way on Figures 4-4, 4-5, and 4-6. Nor can I get the Reproduction and Growth Tables from Appendix D (Tables 3 and 4) to match perfectly with Figures 4-7 through 4-11. Similarly, Table 4-4 had the same issue. In addition, Figures 4-12 through 4-33 (many of them anyway!) should provide the station number next to their location thereby eliminating the need to keep going back to Figures 3-1, 3-2 and 3-3.	
Additional Comments from USEPA Region 1, received February 7, 2008		
GC1.	EPA continues to maintain that more than one line of evidence is not needed to retain an area for further evaluation in an FS. Historically EPA has viewed a statistically significant response in survival, growth, or reproduction compared with a reference in a toxicity test as sufficient evidence of risk to warrant consideration in the FS. The food chain modeling to birds is, in EPA's view, not a different line of evidence, but rather a single line of evidence for a different receptor group. As such, it does not confirm or deny risk indicated by a toxicity test. Rather, it is useful for indicating areas that may pose a risk to more than one receptor group. EPA understands the difficulty of developing cleanup goals based on toxicity data in which multiple contaminants are present, and toxicity may be driven by different combinations of chemicals in the various samples submitted for toxicity testing. (In fact, when the toxicity data were first presented by the Navy, EPA indicated that linear regressions alone were not likely to produce a clear "answer.") An ideal cleanup goal would result in removal of all samples that produced a toxic response, leaving sediments that did not produce a toxic response in place. Based	The Navy proposes to evaluate the Maximum Footprints, as noted in the comment, in the Feasibility Study for the Lower Subase. These areas include 0.39 acres is Zone 4 and 0.17 acres in Outer Pier 1. The final numbers are slightly different than what was proposed in the original responses to comments because the two footprints (based on Total PCBs and ERM-Qs) had not yet been combined. The Minimum Footprint in Zone 4 is approximately 0.3 acres.

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	on a review of the original draft Validation Study Report, as well as the response to EPA comments and additional calculations, it appears that the regression approach using ERM quotients did not produce any single ERM quotient-based number that would be entirely protective. Further, no individual contaminant produced a strong correlation with toxic responses. Of the available options based on the regression approach, the most protective ERM quotient-based cleanup goal would be the Total ERM quotient associated with a 25% reduction in reproduction. This would capture all toxic samples in Zone 4, while leaving out nearly all non-toxic samples. A closer review of the data suggests that this might be too conservative since there is a degree of uncertainty regarding the particular risk-driving chemicals and the lack of useful data in the range between non-toxic and overtly toxic samples. Based on this uncertainty, EPA agrees, with the reservations noted below, with the maximum areas described in the response to EPA comment 10 in the Navy Response to Comments, which are repeated here: Zone 7: Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0 acres (no 50% impact based on Total ERM-Q, Metals ERM-Q, or Total PCB PRGs) Zone 4: Minimum Footprint: 0.31 acres (area showing risk to more than one endpoint based on Total ERM-Q > 1.43 and Total PCBs > 270 ppb) Maximum Footprint: 0.40 acres (area with 50% impact to a single line of evidence based on Total ERM-Q > 1.17 and Total PCB > 208 ppb)	

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	Outer Pier 1: Minimum Footprint: 0 acres (no areas showing risk to multiple endpoints) Maximum Footprint: 0.17 acres (area with 50% impact to a single line of evidence based on Total PCB > 208 ppb)	
	EPA has two remaining questions regarding this plan: 1.Since the original plan was to exclude outer Pier I from toxicity testing, and apply the toxicity testing results from Zones 4 and 7 to Outer Pier I, why not use a Total ERM-Q>1.17 and Total PCBs>208 to establish a footprint for Outer Pier I? 2. When the Navy performs the additional analysis for Outer Pier I, would these decision rules be applied to the new data to modify the footprint as appropriate? EPA also believes that the proposal not to choose the most conservative available endpoints to establish a clean-up area should be further supported in the revised Validation Report using EPA's Risk Management Principals. Please qualify the ecological significance of the risk findings in light of USEPA (1997) at http://www.epa.gov/oswer/riskassessment/ecorisk/ecorisk.htm and OSWER Final Directive 9285.7-28, Ecological Risk Assessment and Risk Management Principles for Superfund Sites, dated October 7, 1999 at http://www.epa.gov/oswer/riskassessment/ecorisk/pdf/final99.pdf where six factors are considered when deciding whether to take CERCLA action. The magnitude, uncertainty, and quality of the affected resource must be considered when evaluating each factor. EPA can provide examples upon request.	1. The PRGs based on ERM-Q >1.17 and Total PCBs >208 ppb have been used to determine a footprint for the Outer Pier 1 area. This area encompasses approximately 0.17 acres and is located just south of the boat ramp and adjacent to the boundary between Inner and Outer Pier 1. 2. Following additional sampling in Outer Pier 1, these same decision rules will be used to modify the footprint if necessary. Risk management decisions and consideration of all of the potential alternatives available to ameliorate ecological risk will be evaluated in the Feasibility Study for the Lower Subase.

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GC5	EPA noted that the derivation of the ERM-Qs should be transparent. EPA recommended that the Navy include a table showing COPC concentrations at each site with associated ERM-Q values. EPA looks forward to reviewing this information to confirm the ERM-Qs.	A table (A-16) has been added to Appendix A that shows the concentrations of each COPC used to derive the ERM-Qs and the resulting values for each sampling location.
GC6	Based on the discussions held on January 25, 2008, EPA is pleased that the Navy has agreed to further delineate the Outer Pier 1 area and looks forward to reviewing a sampling plan.	The Navy proposes to take additional samples in Outer Pier 1 either during remedial actions in Inner Pier 1 or during the Feasibility Study for the Lower Subase.

Table 1. Revised Correlation Statistics for Reproduction Endpoint

Chemical Indicator	n	R^2 Using Offspring per Replicate (from draft Report)	Corrected R^2 Using Offspring per Surviving Adult
ERM-Q	18	0.422	0.444
Metals ERM-Q	18	0.331	0.360
Organic ERM-Q	18	0.523	0.507
Arsenic	18	0.095	0.064
Cadmium	18	0.159	0.129
Chromium	18	0.357	0.363
Copper	18	0.324	0.336
Lead	18	0.371	0.413
Nickel	18	0.323	0.366
Selenium	18	0.388	0.409
Zinc	18	0.284	0.311
a-Chlordane	18	0.130	0.146
Total 4,4'-DDx	18	0.330	0.309
Total HPAH	18	0.367	0.348
Total LPAH	18	0.374	0.344
Total PCB	18	0.608	0.637

Table 2. Revised PRGs for Reproduction Line of Evidence

	25% Reduction PRG Using Offspring per Replicate (from draft Report)	50% Reduction PRG Using Offspring per Replicate (from draft Report)	Corrected 25% Reduction PRG Using Offspring per Surviving Adult	Corrected 50% Reduction PRG Using Offspring per Surviving Adult
Total ERM-Q	0.441	1.07	0.528	1.17
Organic ERM-Q	0.434	0.84	0.489	0.925
Total PCB	109 ppb	190 ppb	121 ppb	208 ppb

Table 3. Regression Statistics for TOC-normalized PCBs and AVS and OC-normalized Metals

Chemical indicator	n	Intercept	p (int=zero)	Slope	Normalized R^2	Non-Normalized R^2	Correlation Coefficient	Regression p-value	Statistically Significant?
Survival Median of Tanks									
PCBs normalized to TOC	18	1.08	4.58E-12	-9.07E-05	0.587	0.469	-0.7664	0.0002	yes
Metals normalized to AVS and OC	18	0.83	7.50E-11	-1.39E-04	0.016	NA	-0.1271	0.6153	no
Growth Median of Tanks									
PCBs normalized to TOC	18	1.96	1.92E-13	-1.49E-04	0.636	0.632	-0.7977	0.0001	yes
Metals normalized to AVS and OC	18	1.53	3.80E-12	-5.23E-04	0.092	NA	-0.3035	0.2208	no
Reproduction Median of Tanks									
PCBs normalized to TOC	18	4.06	2.16E-09	-5.35E-04	0.603	0.608	-0.7768	0.0001	yes
Metals normalized to AVS and OC	18	2.51	4.24E-07	-0.002	0.098	NA	-0.3126	0.2067	no

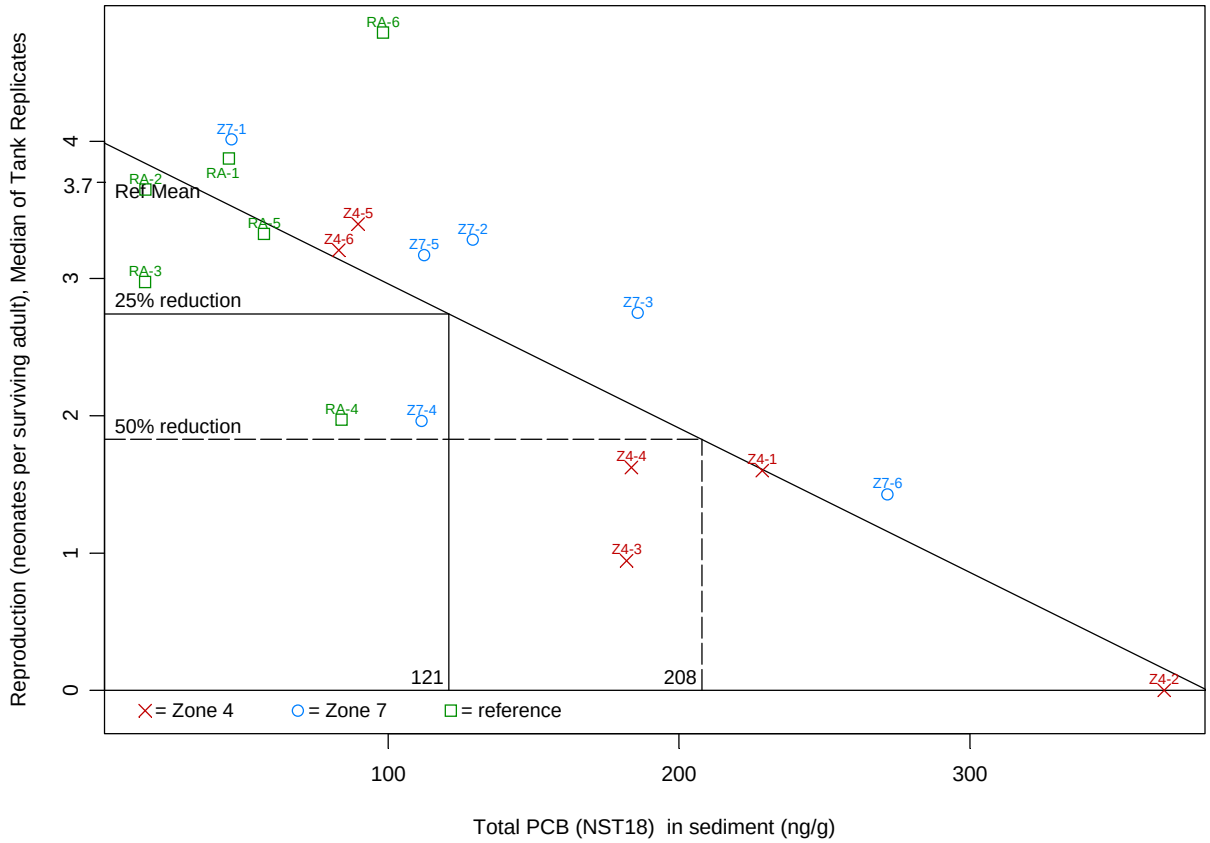

Figure 1. Revised Regression of Number of Offspring per Surviving Adult vs. Total PCBs.

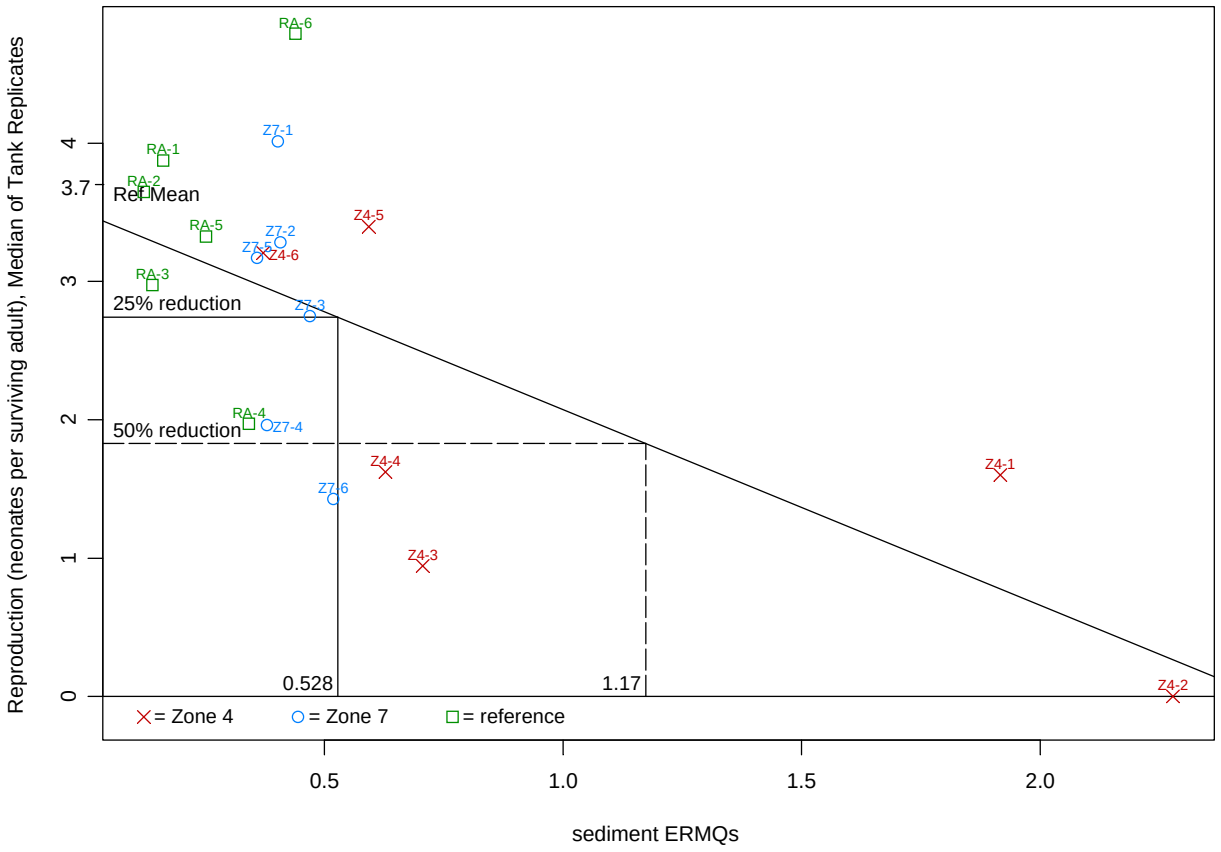

Figure 2. Revised Regression of Number of Offspring per Surviving Adult vs. Total ERM-Q

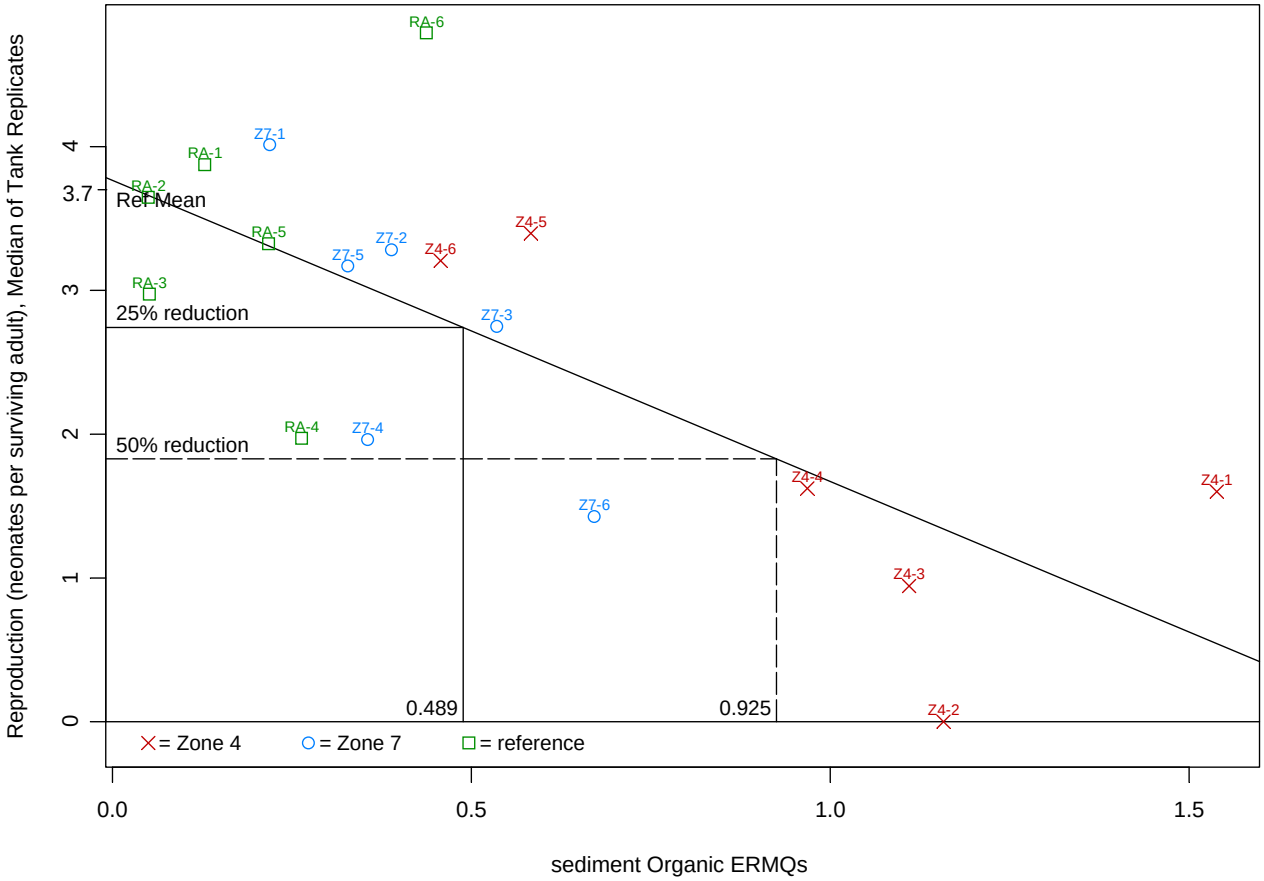

Figure 3. Revised Regression of Number of Offspring per Surviving Adult vs. Organic ERM-Q

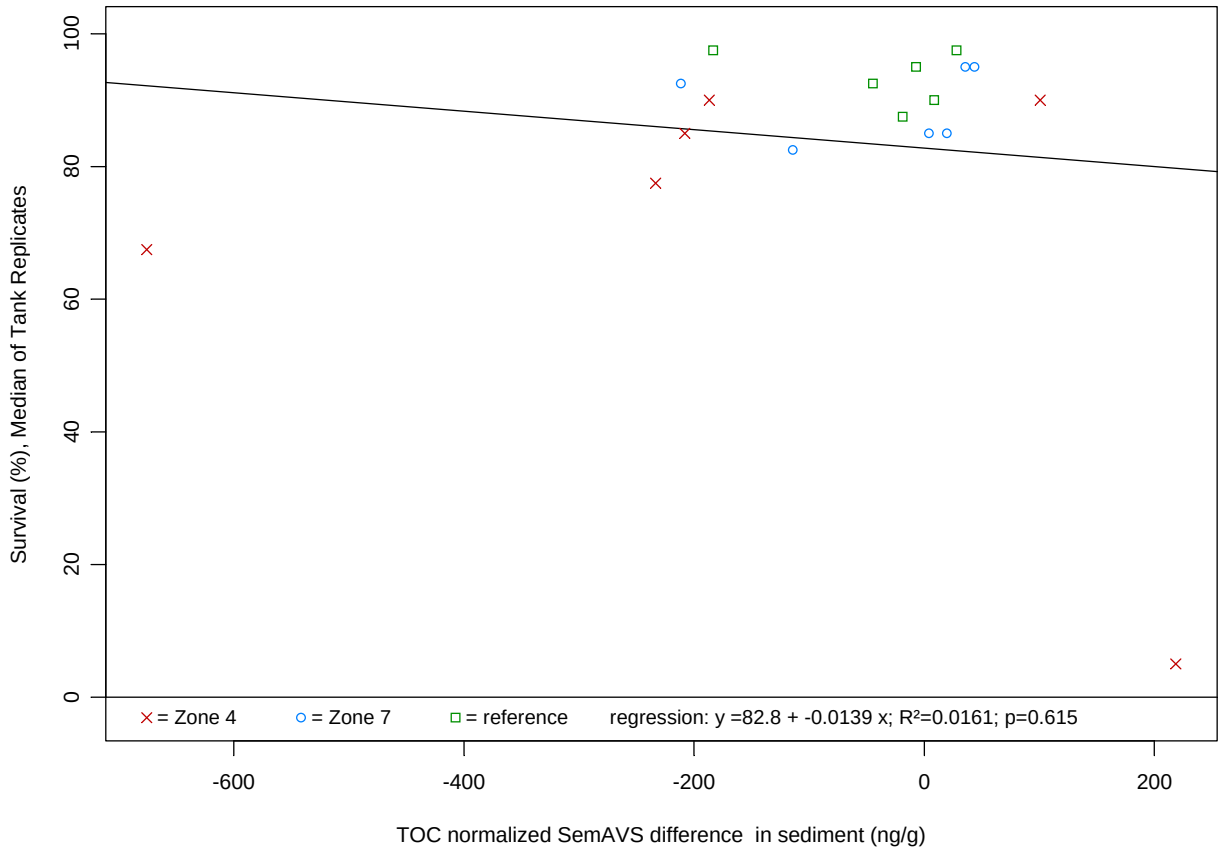

Figure 4. **Regression of (SEM – AVS)/fOC vs *Leptocheirus* Survival**

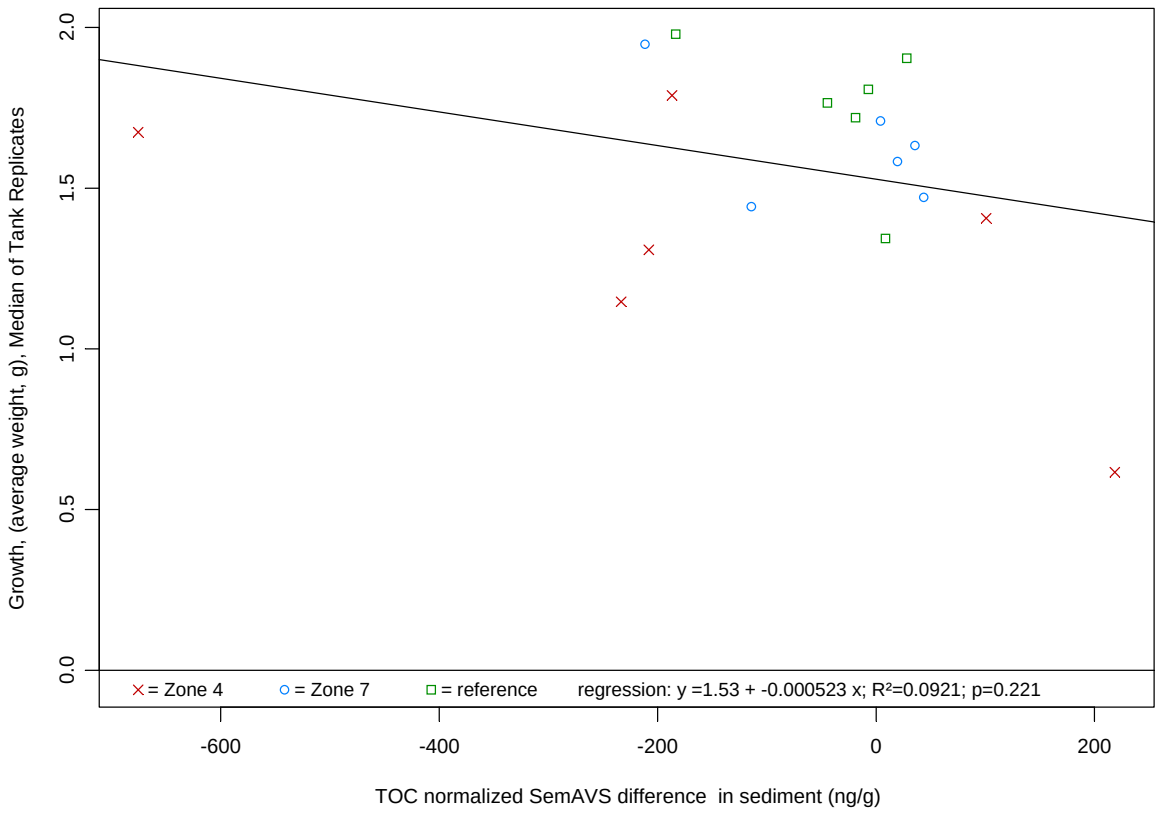

Figure 5. Regression of (SEM – AVS)/fOC vs *Leptocheirus* Growth

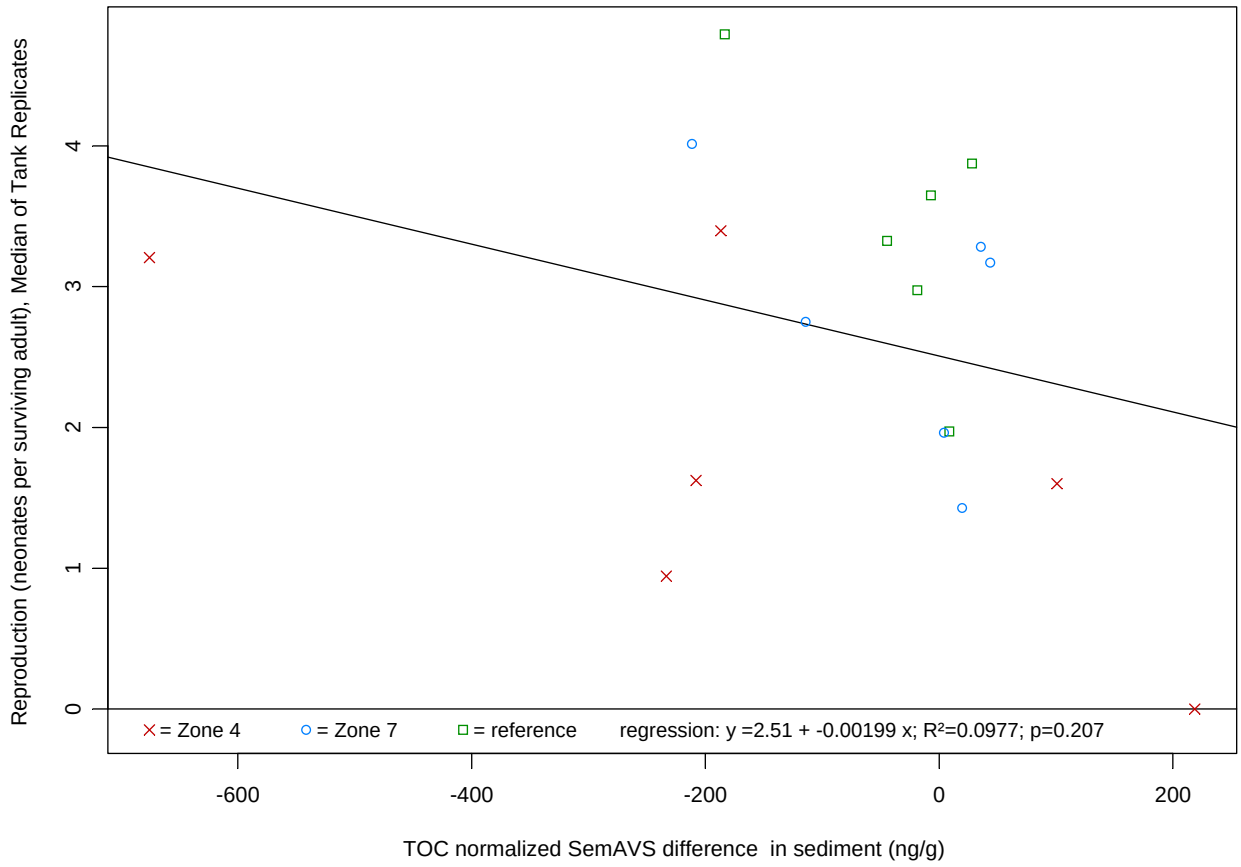

Figure 6. Regression of (SEM – AVS)/fOC vs *Leptocheirus* Reproduction

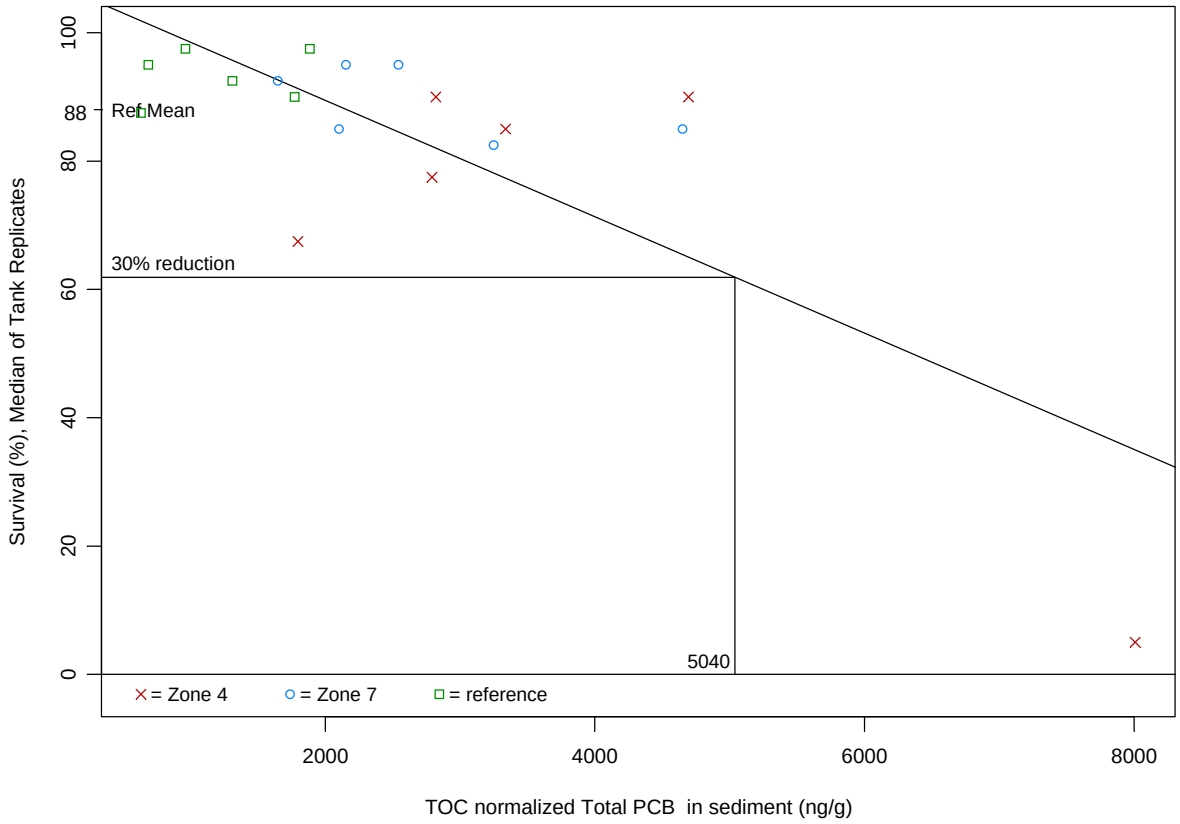

Figure 7. Regression of *Leptochirus* Survival vs. TOC normalized Total PCB.

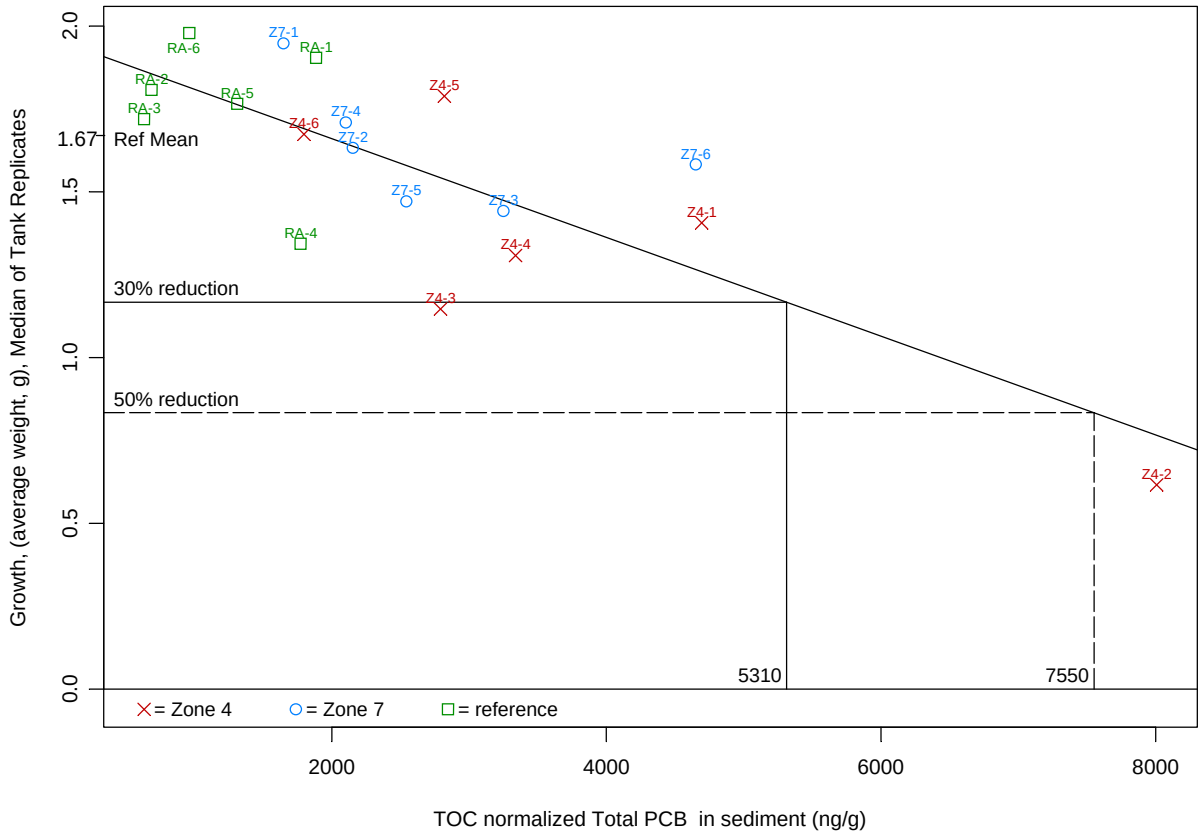

Figure 8. Regression of *Leptocheirus* Growth vs. TOC normalized Total PCB

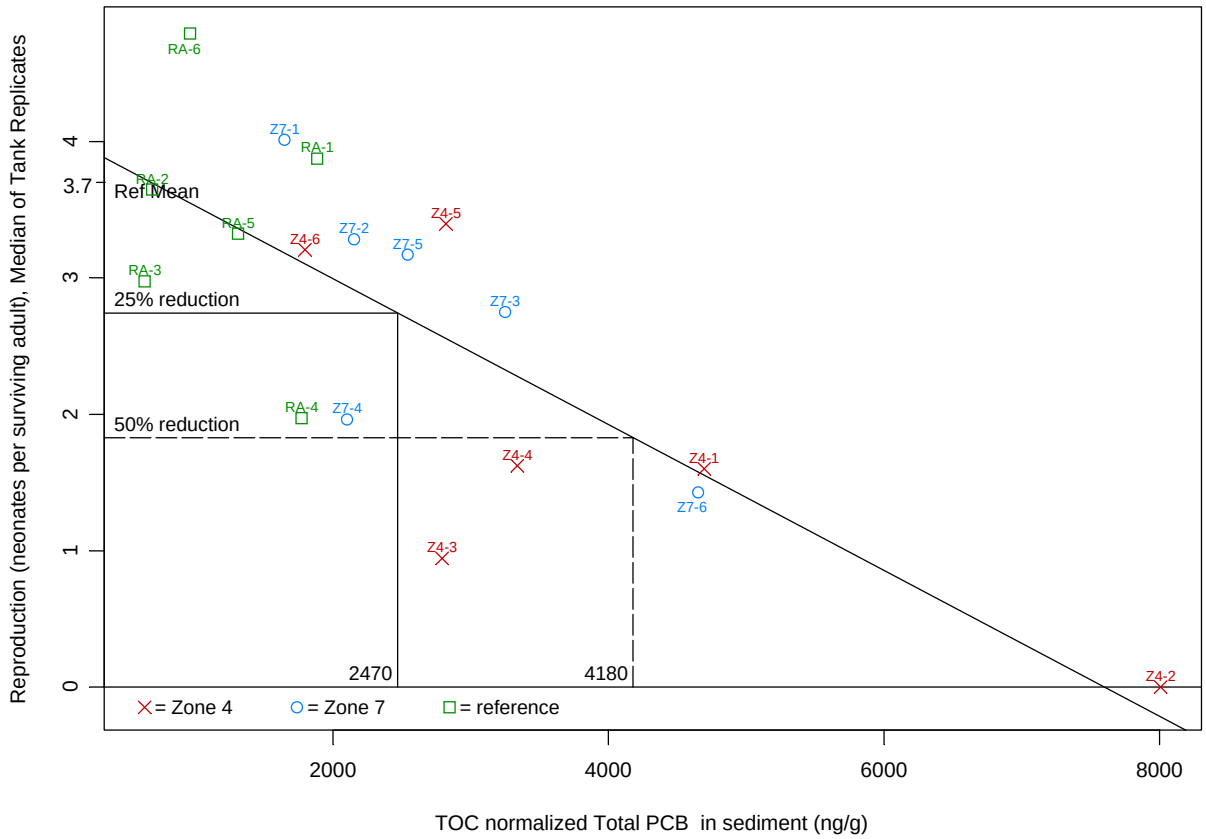

Figure 9. Regression of *Leptocheirus* Reproduction vs. TOC normalized Total PCB