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Final

DERECKTOR SHIPYARD MARINE ECOLOGICAL RISK ASSESSMENT REPORT:

TECHNICAL REPORT AND APPENDICES A-E

NAVAL EDUCATION AND TRAINING CENTER NEWPORT, RHODE ISLAND

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Project Number 6884

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Reference: CLEAN Contract No. N62472-90-D-1298
Contract Task Order No. 0254

Subject: Marine Ecological Risk Assessment, Former Robert E. Derecktor Shipyard

Dear Mr. Shafer:

Enclosed are four copies of the Final Marine Ecological Risk Assessment for the Former Robert E. Derecktor Shipyard at the Naval Education and Training Center (NETC) in Middletown Rhode Island. This report was prepared by our subcontract team consisting of Science Applications International Corporation (SAIC) of Narragansett Rhode Island and the University of Rhode Island Graduate School of Oceanography.

This submittal includes the technical report and Appendix A, as was discussed at the last EAB meeting. If you have any questions regarding this material, please do not hesitate to contact me at 508-658-7899.

Very truly yours,

Stephen S. Parker
Project Manager

SSP/

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FOREWORD

The Final Derecktor Shipyard Marine Ecological Risk Assessment Report has been prepared as a revision to the Draft (July 1996) and Draft Final (February 1997) versions. Revisions were made to these documents in response to comments and concerns received from the Rhode Island Department of Environmental Management, United States Environmental Protection Agency, National Oceanic and Atmospheric Administration and others as represented at meetings of the Naval Education and Training Center Ecorisk Advisory Board (EAB) and Restoration Advisory Board (RAB).

This final document includes only the technical report and Appendix A. Appendices B, C, D, and E were not revised as a result of any comments received during the review process. Therefore, Appendices B, C, D, and E published and distributed as Draft in July 1996 should be considered as final.

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1.0. EXECUTIVE SUMMARY

This report summarizes the results of a Marine Ecological Risk Assessment (ERA) conducted for Derecktor Shipyard, which is part of the Naval Education and Training Center (NETC) in Newport, RI (Figure 1.0-1). The U.S. EPA's ERA framework and applicable EPA Region I guidance were used to generate and interpret the data required to complete this risk assessment. The objectives of this ERA were as follows:

- Assess ecological risks to the offshore environments of Narragansett Bay from chemical stressors associated with the Derecktor Shipyard;
- Develop information sufficient to support risk management decisions regarding site-specific remedial options; and
- Support communication to the public of the nature and extent of ecological risks associated with Derecktor Shipyard.

This assessment was designed to address only current conditions and levels of activity at the site, and does not address altered risks under potential future use scenarios involving fundamentally different conditions or activities at the site. This ERA builds upon and incorporates findings of previous studies at Derecktor Shipyard, and specifically addresses three data gaps remaining from these earlier studies. These data gaps are as follows:

- Need to better assess the chemical exposure to biological populations in surficial sediments adjacent to the site;

- Need to determine the potential migration of contaminants from the site to adjacent embayments;

- Need to expand the investigation of ecological risks to endemic populations in Narragansett Bay to include toxicity assessments, organism condition and benthic community structure.

The following sections summarize the findings of this assessment, including Problem Formulation, Sampling Summary, Site Characterization, Exposure and Ecological Effects Assessments, Characterization of Ecological Risks, and Risk Summary and Conclusions.

1.1. Problem Formulation

Problem Formulation involved determining the nature and extent of contamination of offshore (subtidal) media associated with Derecktor Shipyard sources. Specifically, this activity involved identification of contaminated media, identification of contaminants of concern (CoCs), evaluation of the spatial extent of contamination, identification of the ecological receptors potentially at risk from CoCs, and identification of appropriate assessment and measurement endpoints.

The analytical results used in this ERA were consistent with those of earlier studies (e.g., Quinn et *al.*, 1994) with respect to the specific classes of compounds which are present at high concentrations in the marine sediments adjacent to Derecktor Shipyard (see Section 3.1). It should be noted that the list of CoCs generated is conservative in that the screening procedure involved maximum contaminant concentrations and conservative benchmark concentrations.

Proposed CoCs for this study were identified by comparing concentrations measured in surface sediments at the site to NOAA Effects Range - Low (ER-L) benchmarks, which represent thresholds of potential biological effects. If appropriate sediment benchmarks did not exist, the measured concentrations were compared to concentrations at reference locations. Except for 2-methylnaphthalene and naphthalene, all polycyclic aromatic hydrocarbon (PAH) analytes (including calculated sums for low and high molecular weights and total PAHs), as well as the metals Ni, Zn, Cu, Cr, Pb, and Hg, were found to exceed benchmarks and were included as CoCs. Most of the organic contaminants lacking benchmarks (i.e., individual PCB congeners, butyltins, and organochlorine pesticides (OCPs)) exceeded concentrations detected at reference stations and were likewise included as CoCs. In summary, based on the initial screening process, all target analytes except aldrin, cadmium, hexachloro-benzene, 2-methylnaphthalene, naphthalene, and tetrabutyltin were included as CoCs for the ERA. These results were consistent with those of earlier studies with respect to the specific classes of compounds found to be elevated in the marine sediments adjacent to Derecktor Shipyard.

1.2. SAMPLING SUMMARY

Sampling was needed to acquire chemistry and toxicity data for surficial sediments in the area adjacent to the site, and to gather biological data to assess the potential impact to receptors. Sampling occurred in Coddington Cove and at two reference stations; Jamestown Potter Cove (JPC) on Conanicut Island and Castle Hill Cove (CHC) on Southern Aquidneck Island (Figure 1.2-1). Seventeen sampling stations located in Coddington Cove (Figure 1.2-2), both immediately adjacent to and in the wider area surrounding the Derecktor Shipyard, were sampled for sediment organic and inorganic chemical analysis, elutriate (resuspended sediment) analysis, toxicity studies and benthic infaunal analysis. Natural populations of blue mussels *(Mytilus edulis)*,

hard clams (*Mercenaria mercenaria*), cunner fish (*Tautogolabrus adpersus*) and American lobster (*Homarus americanus*) were also collected at a selected subset of stations to allow characterization of long-term contaminant exposure effects. Blue mussels also were deployed at selected locations to assess pelagic exposure pathways for contaminants.

1.3. SITE CHARACTERIZATION

Side-scan sonar, sub-bottom profiling sonar, and sediment core surveys were undertaken to determine the characteristics of both surface and underlying sediments within the Derecktor Shipyard/Coddington Cove study area; this combination of techniques provided more complete information than can be obtained by a limited number of surface and core samples. In addition, hydrographic surveys to measure current velocity and water column profiling of conductivity, temperature, and depth were undertaken to determine patterns of water circulation within the study area.

The results indicated that sediments in the Derecktor Shipyard/Coddington Cove study area were predominantly fine-grained at some stations (<40% sand content) and predominantly sandy (sand ≥ 70%) at others (Figure 1.3-1). Surface sediments in Coddington Cove tended to be finer-grained (i.e., contained more silt and clay) than underlying sandy sediments, probably due to the significantly decreased bottom energy and increased likelihood of fine-grained sediment deposition resulting from construction of the Coddington Cove breakwater in 1957. Sub-bottom reflectors observed in the geophysical profiles usually corresponded to acoustic discontinuities delineating lithologic units. In some locations, no strong sub-bottom reflectors were observed, indicating vertically uniform lithology.

The hydrodynamic surveys showed that the characteristic flow pattern occurs as a net counter-clockwise circulation within the interior of Coddington Cove. On average, maximum bottom velocities were found to be highest at the mouth of the cove and decreased in a counterclockwise manner following the general circulation pattern (Figure 1.3-1). Flow was such that, in general, the water column appeared well-mixed vertically. High bottom velocities extending well into the southeastern section of the cove were expected to prevent deposition of silt-sized particles, while the interior sections of the region between the piers and the northeastern region were generally sluggish and expected to be depositional zones (except nearshore and/or shallow areas that may be strongly affected by wave energy). Measured dissolved oxygen (DO) was above 7 mg/L at the measured stations (Figure 1.3-1). The WASP5 water quality model predicted that, in general, undesirably low DO levels should not occur throughout most of Coddington Cove during the critical summer months and therefore do not pose a threat to indigenous biota.

1.4. Exposure Assessment

Exposure Assessments included quantification or estimation of the concentrations of CoCs in environmental media in the exposure pathways from contaminant sources to ecological receptors. Several exposure pathways, which allow contaminant sources associated with historic activities at Derecktor Shipyard to impact biota, were identified. These include contaminant exposure to and bioaccumulation from water, sediments, and pore water through partitioning across organism cell membranes, incidental contact, ingestion of sediments by deposit-feeding invertebrates, and/or consumption of contaminated prey. The exposure assessment summarized below addresses the spatial distribution and concentration of contaminants in bottom sediments and biological tissues, as well as the possible fate and transport mechanisms by which shipyard-associated CoCs might reach receptors of concern

(i.e., bivalves, lobsters, other benthic community organisms, fish, and avian aquatic predators).

1.4.1. Sediment Contaminants

Inorganic Contaminants. Measurement of bulk sediment concentrations of nine metals were performed at 15 Coddington Cove Stations and two reference locations as a means of assessing degree of sediment contamination by trace metals and the potential availability/toxicity of the metals to biota. Ranges of concentrations (µg/g dry wt.) observed at the site were as follows: Arsenic - 3.0-12.5; Cadmium - 0.1-1.5; Chromium - 24-112; Copper - 1.5-180; Lead - 13-193; Mercury - 0.02-1.1; Nickel - 5-78; Silver - 0.2-1.8; and Zinc - 28-547. Three additional approaches used for metals assessments included: 1) aluminum normalization, 2) the relative concentrations of acid-volatile sulfides (AVS) and simultaneously-extracted metals (SEM), and 3) measurement of contaminant concentration in sediment elutriates. In general, the aluminum-normalized values for all measured anthropogenic trace metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) demonstrated a decreasing trend moving offshore from Derecktor Shipyard/ Coddington Cove. This pattern suggested that the shipyard is a point source for these metals.

One method of assessing divalent metal bioavailability is to determine the SEM/AVS ratio. Due to seasonal variations in AVS (minimum values in winter), SEM/AVS values greater than 0.5 were assumed to be bioavailable and potentially toxic to biota in the present investigation. The results showed that metals were likely to be bioavailable (ratio $\geq$0.5) at only three stations in Coddington Cove, as well as at the Jamestown Potter Cove reference Station JPC-2. The remaining 14 Coddington Cove stations and reference Station JPC-1 had low SEM/AVS ratios and relatively abundant AVS, indicating that metals are likely to be sequestered in insoluble sulfides and therefore are not bioavailable within most of the study area under present (redox)

conditions. Additional measures of metals availability (SEM-AVS, total SEM) were evaluated as part of risk characterization, discussed below.

Measurement of CoC concentrations in surface sediment elutriates showed that the EPA salt water chronic criterion was exceeded for arsenic at Coddington Cove Stations DSY-36 and DSY-38, and, except for Station DSY-36, the chronic criterion was equaled or exceeded for lead at all stations analyzed. In addition, the salt water acute criterion was exceeded for arsenic at Station DSY-39 and for copper at Station DSY-31 (a chronic criterion for copper is not available).

Organic Contaminants. Concentrations of organic contaminants at some subtidal stations in the Coddington Cove study area were found to exceed Effects Range-Low (ER-L) or Effects Range-Medium (ER-M) guidelines, indicating potential adverse impacts. Concentrations of Total PCBs at all stations except DSY-35 and DSY-41 exceeded the ER-L benchmark value, while Total PCB concentrations at Stations DSY-27, DSY-29, DSY-30, DSY-31 and DSY-32 exceeded the ER-M benchmark value of 180 ng/g. Concentrations of Total PAHs exceeded the ER-L benchmark of 4,022 ng/g at about half of the Derecktor Shipyard/Coddington Cove stations, and the concentration of 46,400 ng/g at Station DSY-29 (Field duplicate sample) exceeded the ER-M value. Concentrations of TBT exceeded 5 ng Sn/g, a level considered indicative of degraded ecological condition, at six stations (DSY-27, DSY-28, DSY-29, DSY-30, DSY-31, and DSY-36). Overall TBT values ranged from non-detected (<1 ng Sn/g) to 228 ng Sn/g at Station DSY-31. Concentrations of p,p'-DDE exceeded the ER-L benchmark value of 2.2 ng/g at five stations; overall values ranged from 0.1 ng/g at Stations DSY-35 and DSY-41 to slightly less than 7.0 ng/g at Stations DSY-27 and DSY-29 (including the field duplicate sample). Organic carbon normalized concentrations of organic contaminants followed a similar trend as that for direct sediment concentration measurements. One exception was

Station DSY-40, which had elevated ratios of all contaminants due to a combination of moderate contaminant levels and low organic carbon concentrations.

The mixtures of individual PCB congeners and PAH analytes in sediments in the Coddington Cove study area suggest certain substances as the main contributors of the contamination. The major PCB congeners were the 3- to 6-chlorine compounds (congeners 66, 101, 118, 153 and 138), which probably derived from Aroclor 1254, the major Aroclor formulation found in Narragansett Bay surface sediments. Major sources of PCBs to Narragansett Bay include rivers, combined sewer overflows/sewage discharges, and atmospheric deposition. The PCB composition at Coddington Cove Station DSY-29 FD was very different from that at the other stations, with congener 209 (decachlorobiphenyl) accounting for about 60% of the total congeners measured in the sample, and congener 206 being present in relatively large concentrations. This unique distribution of congeners, presumed to be indicative of the presence of "Deka" investment casting wax, may be the result of past activities at Derecktor Shipyard.

Concentrations of four- and five-ring pyrogenic PAH compounds (e.g., fluoranthene, pyrene and benzo(b,j,k)fluoranthene) were consistently the highest observed among stations in the Derecktor Shipyard/Coddington Cove study area. Sources of these compounds include combustion products in used motor oil, atmospheric deposition, creosote/coal tar and asphalt from local activities, terrestrial runoff, and sewage effluent and overflows. There was no evidence of fresh (unweathered) fuel oil in any of the samples, as indicated by qualitative measurements of total petroleum hydrocarbons.

Analyses of elutriate samples showed the presence of PCBs, PAHs, and small amounts of p,p'-DDE. Elutriate from Station DSY-25 had the highest concentration of both Total PAHs and Total PCBs; in addition, several other stations showed elevated levels of one or both contaminants relative to reference station values (e.g., Stations

DSY-27, DSY-29, DSY-31 for PCBs; DSY-25, DSY-27, DSY-29, DSY-32, DSY-33, and DSY-40 for PAHs). Additionally, eight of the elutriate samples exceeded the EPA marine chronic criterion (30 ng/L) for Total PCBs, including Jamestown Potter Cove reference station JPC-1. Although no EPA water criteria exist for PAHs, concentrations were below the Lowest Observed Effect Level (LOEL) of 300 µg/L. The relationships between elutriate concentration and sediment concentration were significant at the 95% confidence level for PCBs and at the 90% confidence level for PAHs, indicating that resuspended sediments can potentially contribute colloidal and/or dissolved organic contaminants to the water column. However, as previously indicated, this evaluation addresses only current conditions and levels of activity at the site, and was not intended to address future use scenarios involving fundamentally different conditions or activities at the site.

1.4.2. Tissue Residues

Inorganic Contaminants. Indigenous blue mussels from the Derecktor Shipyard/Coddington Cove (DSY) study area and the reference stations at Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) were analyzed for trace metal contaminants. Indigenous mussel tissue concentrations of cadmium, mercury, chromium, lead, and nickel at Coddington Cove stations were comparable to reference values and did not exhibit any distinct spatial patterns. Tissue concentrations of copper, silver, and arsenic exceeded reference at only a few stations in the study area, while zinc tissue concentrations were highest and exceeded reference at Stations DSY-25, DSY-27, DSY-28, DSY-35 and DSY-40.

Blue mussels were deployed for approximately 30 days along a transect extending from the harborfront to the mouth of Coddington Cove, as well as at Reference Stations JPC-1 and CHC-1. Following the deployment period, tissue concentrations of arsenic, cadmium, copper, silver, and mercury in mussels were either

lower than or comparable to "time-zero" (T_0) values, while tissue concentrations of lead, nickel, and chromium concentrations were comparable to reference values. However, zinc concentrations exceeded both reference and T_0 values at most stations.

Tissue concentrations of arsenic, cadmium, copper, silver, mercury, lead, nickel, chromium and zinc in the hard clams *Mercenaria mercenaria* and *Pitar morrhuana* collected from the Derecktor Shipyard/Coddington Cove study area were, in general, comparable to or only slightly higher than those from Reference Stations JPC-1 and CHC-1. Metal concentrations in the muscle tissue of American lobsters and fish (cunner and mummichog) from the Derecktor Shipyard/Coddington Cove study area likewise were mostly comparable to or only slightly higher than those from reference Stations JPC-1 and CHC-1.

Organic contaminants. Tissue concentrations of organic contaminants were analyzed in both indigenous and deployed (30 day deployment period) blue mussels. Generally, levels of organic contaminants in the reference station samples from Jamestown Potter Cove (JPC) and Castle Hill (CHC) were lower than in the study area samples. The highest tissue levels of organic contaminants in deployed mussels were generally observed at Stations DSY-26 through DSY-33 and Stations DSY-38 through DSY-40. Indigenous mussels showed high values relative to reference station values at a number of stations, including Stations DSY-26, DSY-27, DSY-28, DSY-35, DSY-36, and DSY-40.

Tissue concentrations of PCBs, PAHs and TBT in hard clams (mainly *Pitar*) from the reference site at Jamestown Potter Cove were generally lower than tissue concentrations in samples from the Derecktor Shipyard/Coddington Cove study area. The highest concentrations of organic contaminants in hard clams were observed at Stations DSY-31, DSY-32, DSY-36, and DSY-41. Concentrations of organic contaminants in the muscle tissue of both fish and lobsters from the study area

generally were in the same range as those from Reference Stations JPC-1 and CHC-1. TBT was not detected in any of the lobster muscle tissue samples.

1.5. Ecological Effects Assessment

The Ecological Effects Assessment involved a combination of toxicological literature review, site-specific investigations of the status of receptor species, toxicity evaluations of exposure media, and modeling exercises to predict the occurrence of adverse ecological impact. Ecological effects were quantified by determining the relationships between exposure patterns and resulting responses of ecological systems, as determined from the measurement endpoints identified during Problem Formulation. Site-specific evaluations of toxicity were conducted for bulk surface sediments using the 10-day amphipod (*Ampelisca abdita*) mortality test: For sediment elutriates, the sea urchin (*Arbacia punctulata*) fertilization and larval development tests were used. In addition, field-based assessments including benthic community structure analyses and biota condition were conducted.

1.5.1. Toxicity Evaluations

With the exception of Stations DSY-27 and DSY-28 in the Derecktor Shipyard/ Coddington Cove study area, statistically significant sediment toxicity to amphipods was not observed. In sediments from Station DSY-28, the unionized ammonia concentration was three times greater than the NOEC concentration for sea urchin larval development, suggesting possible ammonia toxicity rather than toxicity due to CoCs. In contrast, the significant toxicity response at Station DSY-27 could not be attributed to porewater ammonia and was likely due to CoCs.

The acute toxicity of elutriates prepared from Derecktor Shipyard/Coddington Cove and Jamestown Potter Cove sediments was assessed using the sea urchin (*Arbacia punctulata*) fertilization and larval development tests in order to evaluate the bioavailability and potential biological effects of contaminants to benthic and water column organisms during sediment resuspension events. Fertilization was not statistically different from the performance control at any of the site or reference stations, suggesting a lack of elutriate toxicity. However, statistically significant reductions in sea urchin normal larval development relative to the performance control ranged from 10 to 100%, and were observed in one or more of the dilutions of 14 of the 19 sediments tested (Stations DSY-25, DSY-26, DSY-28, DSY-29, DSY-31, DSY-32, DSY-33, DSY-36, DSY-37, DSY-38, DSY-39, DSY-40, and DSY-41). The 10% Inhibition Concentration (IC_{10}), is the elutriate dilution (%) causing 10% reduction in normal larval development. In general, IC_{10} values calculated for these stations indicated potential high toxicity at stations closest to shore and a reduction in potential toxicity with distance from the Derecktor Shipyard waterfront.

1.5.2. Field Effects Evaluations

Field effects evaluations included assessments of infaunal and epifaunal benthic community structure, biotic condition of indigenous and deployed bivalves, hematopoietic neoplasia in bivalves, fecal pollution indicators in bivalves, and cytochrome P450 activity in cunner.

Benthic Community Structure. Benthic organisms were sampled at subtidal stations within the Derecktor Shipyard/Coddington Cove study area and the Jamestown Potter Cove reference area to assess potential environmental stress on microinvertebrate populations. There was a basic difference in benthic community structure between silt-bottom and sand-bottom habitats, with greater variability in community structure among sand-bottom stations. With the exception of Station

DSY-29, all of the silt-bottom stations (silt-clay content ≥ 60%) had similar benthic community structure, while the sand-bottom stations (silt-clay content < 30%) had benthic communities which were both distinctly different from the silt-bottom communities and, for the most part, different from each other. Two stations with "intermediate" grain size, DSY-37 and JPC-2, had benthic community structure which was similar to that found at the silt-bottom stations.

Four species characteristic of silty sediments, including the bivalves *Nucula annulata* and *Macoma tenta*, the polychaete *Mediomastus ambiseta*, and the nereid worm *Nephtys incisa,* were found to be among the four most abundant and frequently observed (>67% of the time) at the silt-bottom stations in Coddington Cove. The small bivalve, *Nucula annulata*, was the overwhelming numerical dominant, accounting for over 90% of the total abundance at Station DSY-39, whereas the larger polychaete *Nephtys incisa* appeared to be the biomass dominant. The second most abundant species was the small polychaete *Mediomastus ambiseta*. Sub-dominants included the polychaete *Ninoe nigripes*, the small gastropods *Acteocina canaliculata*, *Nassarius trivittatus* and *Cylichnella oryza*, and the bivalves *Macoma tenta, Mulinia lateralis*, and *Yoldia limatula.* Several of these silt-bottom dominants were notably absent from Station 29, which had an abnormal benthic community structure relative to all the other silt-bottom stations. In general, the silt-bottom assemblage of Coddington Cove was recognized as being related to that found in deep silt-clay habitats in Narragansett Bay proper, Long Island Sound, Buzzards Bay and extending onto the near-shore continental shelf.

Organisms which numerically dominated the benthic community and which were also found exclusively at sand-bottom stations included the polychaetes *Aricidae catherinae, Glycera americana*, *Montocellina baptistae* and *Macroclymene zonalis*, *Oligochaeta* spp., the bivalve *Gemma gemma*, and the amphipod *Photis pollex*. However, with the exception of *Glycera*, none of these sand species was observed at

sandy Station DSY-41 and only *Glycera* was found at Station DSY-40. Likewise, *Glycera*, *Mediomastus*, *Nucula* and oligochaetes are conspicuously absent from Stations DSY-25 and DSY-41. Anoxic sediments were found at Station DSY-25, apparently due to a thick layer of decomposing algae (*Ulva*) which covered the rock and sand bottom. Consequently, only a few organisms were found at this station, none of which were among the numerical dominants found elsewhere in Coddington Cove. Species common to silt-bottom communities also were found at sand-bottom stations, but at lower densities than in their preferred habitat.

The oxygenated layer (apparent redox-potential discontinuity depth, or RPD depth) was relatively thin at Stations DSY-41 (0.5 to 1 cm) and DSY-40 (0.2 cm), pointing to excessive organic enrichment as a contributing factor in explaining the observed differences in benthic community structure observed at these stations. The unique benthic community structure at Station DSY-35 was due primarily to the absence of *Nucula* and the presence of the bivalve *Gemma gemma* and the polychaetes *Spiophanes bombyx* and *Tharyx crochet*; these latter three species were not found at any of the other sand-bottom stations and probably reflect both the very high sand content and proximity of Station DSY-35 to the intertidal zone.

Reference site comparisons were also performed based on EPA's Rapid Bioassessment Protocol approach, wherein community metrics (total species, total individuals, species dominance, richness, evenness, diversity and similarity) were calculated, normalized to values obtained at the reference location and scored into groups (quartiles) as the indicator for adverse impacts. Stations with overall habitat-specific benthic metric rankings in the 1st quartile (i.e., Stations DSY-25, DSY-27, DSY-29, DSY-32 and DSY-41) represented the most likely locations for potential benthic community impacts linked to CoCs from Derecktor Shipyard. Additional stations which might have intermediate impacts include Stations DSY-36, DSY-38,

DSY-39 and DSY-40, while the remaining Coddington Cove stations have low impact or baseline condition.

Bivalve condition indices. Bivalve condition indices of both deployed and indigenous blue mussels (*Mytilus edulis*) were examined to indicate the ecophysiological status of animals as a function of spatial proximity to Derecktor Shipyard. Indices were based on allometric relationships of length, tissue weight, and shell weight; high ratios were considered to be indicators of good condition. Three of the six stations closest to Derecktor Shipyard piers and shore installations (Stations DSY-26, DSY-27, and DSY-28) had the lowest values for indigenous mussel Shell Weight to Shell Length ratio (CI-SW/SL). Stations DSY-24 and DSY-35, located on the Coddington Cove shoreline, and the reference Stations JPC-1 and CHC-1, were found to have higher CI-SW/SL values relative to these stations. However, Stations DSY-24 and DSY-35 were located farther away from the main shipyard activities. Although a large degree of variation in index values for stations close to the shipyard was apparent, there also existed an apparent trend of increasing Tissue Weight to Shell Length ratio (CI-TW/SL) values with distance from the shipyard. All study area stations except Station DSY-27 had Tissue Dry Weight to Shell Weight (CI-TW/SW) values that fell within the narrow range of reference CI-TW/SW values. The CI-TW/SW for Station DSY-27 was more than two-fold higher than both reference stations.

For deployed mussels, there was a great deal of variation in the various biotic condition index values, potentially due to environmental factors other than water column and/or sediment contaminant levels. For example, food supply (as indicated by Total Suspended Solids (TSS) and chlorophyll *a* concentration) was found to vary significantly in Coddington Cove, and reduced tissue weight at the Castle Hill Cove reference site (CHC-1) relative to Jamestown Potter Cove was assumed to be the result of lower food availability at CHC-1. Similar tissue weight vs. chlorophyll *a* relationships were observed at Stations DSY-38, DSY-28, and DSY-40 and suggested that growth

processes in mussels at these stations had not been impacted by Shipyard-related conditions. In contrast, reduced tissue weight could not be attributed to low chlorophyll a concentrations at Station DSY-33, DSY-29, DSY-26 and DSY-31, suggesting possible Shipyard-related impacts on water column species like the blue mussel.

Hematopoietic Neoplasia in Bivalves. Blue mussels, *Mytilus edulis*, from Derecktor Shipyard were examined for incidence of hematopoietic neoplasia (Hn), which is a proliferative blood disorder of bivalve mollusks known to be progressive, fatal, and transmissible. Several studies indicate that this disease may be caused by contact with viruses, exposure to environmental contaminants or stressors, or by the synergistic effects of several etiologic agents. The incidence of hematopoietic neoplasia observed in indigenous *Mytilus edulis* collected from various stations was thus used to evaluate adverse ecological effects as a result of exposure to stressors related to Derecktor Shipyard.

Hn affliction rates ≥ 50%, with severity between 17-37%, were found at Stations DSY-26, DSY-29, DSY-31, DSY-40, and JPC-1, while animals examined at Stations DSY-35 and DSY-36 displayed affliction rates around 30% and severity of 0.1 and 0.2%, respectively. Frequencies of affliction in *M. edulis* ranged between 0 and 40% in field studies conducted at several different locations on the west coast of North America. Hence, the range of Hn affliction at Stations DSY-26, DSY-29, DSY-31 and DSY-40, as well as the reference Station JPC-1, were higher than previously reported.

Fecal Pollution Indicators in Deployed Mussels. Tissue from mussels deployed at locations in the Derecktor Shipyard/Coddington Cove study area, as well as at Jamestown Potter Cove reference locations, was analyzed for fecal pollution indicator bacteria to assess the sanitary quality of the marine environment. Fecal pollution indicator bacteria included total and fecal coliforms, fecal streptococci, and *Clostridium perfringens* spores.

Indicator densities for mussel tissue samples collected from Stations DSY-28 and DSY-31 were low for total coliforms, fecal coliforms, and fecal streptococci relative to other stations and the reference location, yet *Clostridium perfringens* was found at moderate to slightly elevated densities of 220-330 CFU/100 g (note: CFU = colony-forming units). This slightly elevated level of *C. perfringens*, however, was not remarkable in comparison to the other indicator levels, nor indicative of historical contamination. Possible explanations for the fecal indicator densities observed were untreated or poorly treated fecal contamination sources.

Indicator densities in mussel tissues generally indicated biological uptake during the deployment period, as site concentrations exceeded the time zero concentrations for three of four indicators. Since time zero concentrations exceeded deployed mussel concentrations for fecal streptococci, enrichment of this indicator cannot be quantitatively assessed.

Levels of *Costridium perfringens* in mussel samples collected from all stations were elevated, except Station DSY-31, which was low (< 100 CFU/100g). Elevated total coliform and *C. perfringens* indicator densities, and moderate fecal coliform density, were observed at Stations DSY-26, DSY-29, DSY-33 and especially DSY-40. Enrichment of only *C. perfringens* at DSY-28 and perhaps DSY-31 provided evidence of historic contamination, perhaps from ingestion of resuspended sediments.

Evaluation of Cunner for Cytochrome P450 Activity. Cytochrome P450 are enzymes which convert toxic compounds into less toxic forms by converting their lipophilic (fat-soluble) components into water soluble compounds which are more easily excreted. In the environment, aquatic species are exposed to contaminants such as PCBs, dioxins, and aromatic hydrocarbons, capable of inducing hepatic cytochrome P450 monooxygenase activity. Studies have shown that the degree of P450 induction

is highly correlated with the degree of contamination in aquatic animals themselves, the surrounding biota, or in the sediments.

Measurement of P450 in cunner (*Tautogolabrus adspersus*) was selected as a bioindicator of potential adverse effects of contaminant exposure. The measured activity at Station DSY-36 was less than reported literature values and thus did not suggest high CoC exposure.

1.6. Risk Characterization

Risk characterization is an integration of the results of the Exposure and Ecological Effects Assessments. The weight of evidence approach utilized in this ERA involved analysis of CoC concentrations *versus* observations of adverse effects, analysis of CoC bioaccumulation, comparisons of toxicity evaluations with observed ecological effects, comparisons of exposure point concentrations with established standards and criteria for offshore media, comparisons of exposure point concentrations with published information regarding the toxicity of CoCs, and qualitative comparisons of apparent adverse impacts with conditions at reference stations. The results of these analyses were summarized together with information obtained during each study to characterize ecological risks associated with the Derecktor Shipyard.

Comparison of CoC Concentrations with Criteria and Standards. Concentrations of contaminants of concern (CoC) were compared against effects-based screening benchmarks for sediments (NOAA ER-L and ER-M values), whereas elutriate concentrations were compared against EPA Water Quality Criteria. For each matrix, Hazard Quotients (HQs) were calculated as the measured concentration at the station divided by the benchmark concentration. An additional contaminant class-level index, called the Hazard Index, was also included; this was calculated as the sum of analyte-

specific Hazard Quotients within each of the CoC groups. This latter analysis was intended to provide a means of evaluating potential risks posed by analytes acting in an additive manner, but did not address potential synergistic or antagonistic interactions among contaminants.

Sediment Contaminants. Sediment concentrations of Total PCBs exceeded NOAA ER-L guidelines at most of the Derecktor Shipyard/Coddington Cove study area stations (Figure 1.6-1A). HQs for Total PAHs were elevated at Stations DSY-25 through DSY-32, as well as at Station DSY-40, with the highest sediment HQ observed at Station DSY-29. In general, the HQs for both low and high molecular weight PAHs followed the same trend as the HQs for Total PAHs. A similar, but less pronounced trend occurred for p,p'-DDE, where the highest sediment HQ was observed at Station DSY-29, exceeding the ER-L benchmark by nearly six-fold. HQs for the reference Station JPC-1 did not exceed a value of one (i.e. no risk) for any of the organic contaminants measured. Sediment concentrations of TBT exceeded the 5 ng Sn/g benchmark at six stations, a level considered indicative of degraded conditions.

Total PCBs exceeded ER-M benchmarks at Stations DSY-29 through DSY-32 and particularly at Station DSY-27, while Total PAH concentrations were higher than the ER-M benchmark only at Station DSY-29 (Figure 1.6-1A). Concentrations of p,p'-DDE did not exceed the ER-M benchmark at any station. Sediment TBT exceeded 50 ng Sn/g at three stations (Stations DSY-28, DSY-29 and DSY-31), a level considered indicative of degraded conditions. In general, the highest sediment concentrations of organic contaminants in surface sediments were usually observed at the nearshore stations closest to the piers and outfalls of Derecktor Shipyard. Stations DSY-40 and DSY-41 generally had lower values than surrounding stations, such as Stations DSY-28, DSY-29, and DSY-30.

ER-L Hazard Quotients for metals in sediments indicated that Station DSY-29 had the highest elevations of arsenic, chromium, copper, lead, nickel, mercury, and zinc, with minor elevations of these metals at a relatively small number of the other stations within the Derecktor Shipyard/Coddington Cove study area (Figure 1.6-1B). Concentrations of silver and cadmium were lower than ER-L benchmark values at all stations except DSY-29, where concentrations of each of these metals exceeded the ER-L values by approximately two-fold. Slightly elevated concentrations of mercury, lead, and nickel relative to benchmarks were observed at the reference Stations JPC-1 and JPC-2, and arsenic and chromium also were slightly elevated at Station JPC-2 only. The ER-M benchmark was exceeded only for zinc at Station (Figure 1.6-1B).

Within the Derecktor Shipyard/Coddington Cove study area, the anthropogenic metals generally exhibited three spatial patterns: (1) concentrations of copper, zinc and chromium were highest at nearshore stations; (2) mercury, lead, arsenic and nickel exhibited high concentrations at both nearshore and offshore stations; and (3) silver and cadmium concentrations were generally low. Trace metal concentrations for the reference stations in Jamestown Potter Cove were generally lower than the sediment quality guidelines.

Elutriate Contaminants. In general, CoCs in sediment elutriates only showed elevated levels of PCBs, arsenic, copper and lead relative to EPA Ambient Water Quality Criteria (AWQC) for saltwater (Figure 1.6-2). Other CoCs generally were not found in the elutriate samples at levels above analytical detection limits. Comparisons of elutriates and sediment concentrations for PCBs and PAHs suggested that resuspended sediments can contribute colloidal and/or dissolved organic contaminants to the water column in elutriate preparations and, presumably, in the field. Statistically significant elutriate/sediment relationships were not observed for metals.

Simultaneously Extractable Metals. Three measures of divalent metals bioavailability (SEM/AVS, SEM-AVS, total SEM) were applied to assess possible adverse impacts of Cu, Cr Pb, Ni and Zn across the site. The SEM concentration divided by AVS concentration (SEM/AVS) metric data identified four stations with ratios greater than 0.5, including Station DSY-33, DSY-35, DSY-37 and reference Station JPC-2. An SEM-AVS concentration of 5 µmol/g dry weight, the benchmark used by the National Sediment Quality Inventory (U.S. EPA, 1996 was not exceeded across the site. Finally, because of volatility and seasonal variability of AVS, the total SEM concentration is of interest, in that SEM might become bioavailable if all AVS were lost from the sediment. Assuming a total absence of AVS in the sediment, SEM concentrations would exceed the SEM-AVS threshold value of 5 µmol/g at Stations DSY-27, DSY-28, DSY-29, and DSY-30). The results suggest a low overall likelihood of adverse impacts from divalent metals across the site (Figure 1.6-2).

Assessment of Tissue Residue Exposure and Effects in Target Receptors. The potential exposure and effects of CoC tissue residues in target species were evaluated by 1) comparison of site tissue concentrations with reference tissue residue concentrations (Tissue Concentration Ratios); and 2) comparison of tissue residues against tissue residue effects benchmarks (Tissue Screening Concentrations and Critical Body Residues).

Tissue Residue-based Exposure Assessments. Site vs. Reference Tissue Concentration Ratios (TCRs) were employed to evaluate the potential significance of CoC tissue residues in target species. The analysis involves the comparison of receptor- and analyte-specific tissue body burdens from the Derecktor Shipyard/Coddington Cove stations against the corresponding data for the Jamestown Potter Cove and Castle Hill Cove reference stations. A TCR summary by CoC showed that in most cases, mean TCRs exceeded three (i.e. "++", Figure 1.6-3), and in the case of indigenous mussels at harborfront Stations DSY-25, DSY-26 and DSY-27), TCR

values > 10 (i.e. "+++") were observed. Cunner was unique in its apparent enrichment for Total PCBs and p,p'-DDE, where tissue concentrations greater than three times reference at several stations were observed. Enrichment factors for metals appeared to be generally less than those observed for organics; only for cadmium in IBM at Station DSY-24 was the TCR greater than three.

Tissue Residue-based Effects Assessment. Effects of CoC residues in target species evaluated by comparison of tissue concentrations against water quality-based benchmarks (Tissue Screening Concentration HQs (TSC)). Potential impacts on receptors from the site as well as the reference locations are caused primarily by metals exposure, particulary copper in lobsters, for which TSC-HQs greater than 40 were often observed (i.e. "+++") , while numerous CoC-receptor pairs had values > 10 ("++", Figure 1.6-3). As for lobster, there exists uncertainty in the effects assumption given the degree of mobility of the species which would allow the possibility that the primary chemical exposure may not necessarily have occurred at the sample location. The CBR-HQ summary by station indicated that only low adverse impacts ("+") were generally likely for all species at the site due copper and zinc with the one exception of copper in lobster at offshore station DSY-39 where a intermediate ("++") rank was observed (Figure 6.1-3).

Analysis of Bioaccumulation and Trophic Transfer. Relationships between contaminant exposure and tissue residue concentration for organics (PCBs, PAHs, pesticides and TBT) and nine CoC metals, as well as consumption of organics and metals by avian receptors feeding on aquatic receptors were evaluated to determine the degree of CoC bioavailability to fish, bivalves and lobster at Derecktor Shipyard/Coddington Cove stations as well as possible adverse effects of trophic transfer from these species to avian receptors.

Analysis of Organic Contaminant Bioaccumulation. Relationships between organic contaminant exposure and tissue residue concentrations for the target species were evaluated through correlation analysis, as well as Biota-Sediment Accumulation Factors (BSAFs). Tissue residue-exposure relationships revealed weak correlations for organics.

For BSAF analyses, the data indicate that bioaccumulation of organics in bivalves, lobster and fish were similar, suggesting that behavioral differences among species (feeding, habitat preference) were relatively unimportant compared to exposure conditions in predicting the concentration of organic contaminants in the target receptors of concern.

Analysis of Metals Bioaccumulation. Tissue residue-exposure relationships for CoC etals were not generally apparent. Unlike the BSAFs for organics, the overall pattern of BAFs for metals did indicate differences in the degree of bioaccumulation into tissues: 1) High (Zn, As); 2) Intermediate (Hg, Cu); 3) Low (Cr, Mn, Fe, Al); and 4) Very Low (Ag, Ni, Pb). The biochemical properties of the metals in the first group suggest that remobilization via resuspension or ingestion is the most probable exposure route to target receptors. The low bioavailability of metals in the fourth group is attributed to the fact that these metals are highly particle associated (particularly Pb) and thus are unlikely to be transported far from their source, or rapidly diluted due to affinity for dissolved phase exposure (Ag and Ni). Metals in the second and third groups have intermediate bioavailability are therefore affected by a variety of processes, ranging from dissolved-particulate partitioning to internal metabolic regulation. These differences in metals bioavailability suggest that the species behavior can play an important role in controlling bioaccumulation of metals.

Trophic Transfer of CoCs to Avian Receptors. Adverse effects on avian aquatic predators resulting from the ingestion of contaminated food within the study area were

assessed by comparison of estimated consumption rates to Toxicity Reference Values. The receptor-exposure pathway scenarios evaluated included the herring gull (*Larus argentatus*) and Great Blue Heron (*Ardea herodias*) feeding on cunner, indigenous and deployed blue mussels, American lobsters, and the hard clams *Mercenaria mercenaria* and *Pitar morrhuana*. Calculated Hazard Quotients were greater than one at all stations including reference locations; notably greater potential for adverse effects were found for gulls and heron consuming PCBs in cunner from Stations DSY-28, DSY-29 and DSY-36. However, given conservative assumptions regarding the predator feeding habits and migration, the data suggest that consumption of prey from the Derecktor Shipyard study area does not pose a high risk to either gulls or herons.

Analysis of Toxicity versus CoC Concentrations. Toxicity occurs when CoCs in the environment become bioavailable above concentrations which cannot be physiologically managed by the organism. The relationship of CoC concentrations in bulk sediment and sediment elutriates with toxicity responses of two bioassay species, the amphipod and the sea urchin, was evaluated to provide elucidation of potential exposure-response relationships. No relationship was observed between amphipod survival and increasing metal bioavailability in sediments (measured as both SEM/AVS ratio and SEM-AVS difference). There was a weak correlation found between amphipod survival and SEM metals concentration, suggesting that metals at Stations DSY-27 and DSY-28 may have been responsible for the slight toxicity observed. There was also some evidence that this result may also be related to the high concentrations of PCBs, p,p'-DDE, and/or TBT observed at these stations.

Sediments were not toxic at any station based on the sea urchin fertilization test. For the larval development assay, CoCs found at concentrations of potential toxicological significance were PCBs, lead and arsenic. There was a good correlation ($R^2 = 0.54$) between the IC_{10} (the % elutriate concentration at which a 10% reduction in normal larval development was observed) and the elutriate Hazard Quotient for Pb

based on the saltwater chronic water quality criteria, with Stations DSY-37, DSY-39, and DSY-33 exhibiting greater toxicity at higher Total Pb Hazard Quotients. A weak relationship was also observed between the larval development IC_{10} and the elutriate Hazard Quotient for PCBs.

Overall toxicity at the site was assessed as intermediate ("++") at Stations DSY-26, DSY-28 and DSY-29, low ("+") at Stations DSY-25, DSY-31 through DSY-33, DSY-37 through DSY-39 and DSY-41, and baseline ("-") at DSY-27, DSY-30 and DSY-34 through DSY-36 and DSY-40 (Figure 1.6-4). Toxicity at reference locations JPC-1 and JPC-2 was also assigned a baseline ranking.

The results of amphipod and sea urchin toxicity testing supported the conclusion that metals are primarily responsible for observed toxicity of sediment elutriates in the Derecktor Shipyard/Coddington Cove study area. The slight effects observed on amphipods was best explained by SEM metals concentration in the sediment, while elutriate toxicity - CoC exposure relationships for sea urchin larval development suggest Pb may be responsible, although Stations DSY-27 and DSY-28 were also high in PCBs, p,p'-DDE, and TBT.

Analysis of CoC Concentration versus Effects Measurements. Exposure-response relationships between CoC concentrations in sediments and specific field effects measurement endpoints were evaluated to assess whether increased levels of sediment contamination are associated with increased effects to biota. Measurement endpoints evaluated in this assessment included benthic community structure, biota condition of indigenous and deployed mussels, hematopoietic neoplasia in indigenous mussels, cytochrome P450 activity in fish and fecal pollution indicator concentrations in deployed mussels.

Impacts on Benthic Communities. The analysis of benthic community metrics from the Derecktor Shipyard/ Coddington Cove study area in relation to reference location conditions and CoC concentrations was performed in order to identify potentially impacted benthic assemblages. Reference site comparisons were based on EPA's Rapid Bioassessment Protocol approach, wherein community metrics (total species, total individuals, species dominance, richness, evenness, diversity and similarity) were calculated, normalized to values obtained at the reference location and scored into groups (quartiles) as the indicator for adverse impacts.

Based on EPA Rapid Bioassessment Protocol ranking, overall habitat-specific benthic impacts were high ("+++") at Stations DSY-25, DSY-27, DSY-29, DSY-32 and DSY-41 (Figure 1.6-4). Shallow depths of sediment oxygenation (redox depth) were found in surface sediments at Stations DSY-25, DSY-29, DSY-40 and DSY-41 suggesting that near-bottom hypoxia or sewage-associated organic enrichment may contribute somewhat to the altered benthic community structure at these stations. Since sediments at Stations DSY-40 and DSY-41 are low in TOC content, conditions of high oxygen demand at these stations may be intermittent, and may be due to factors other than organic carbon, such as nutrient enrichment. Intermediate ("++") benthic impacts were assigned to Stations DSY-36, DSY-38, DSY-39, and DSY-40, while low ("+") impacts were apparent at Stations DSY-28, DSY-30, DSY-34 and DSY-35.

Potential exposure-response relationships between CoC concentrations and benthic community metrics were assessed using two approaches: 1) univariate (Pearson correlation) analysis of individual CoC/metric pairs and 2) multivariate analysis of the combined benthic structure data set using a technique called multidimensional scaling (MDS). For univariate results, an increase in the percent dominant taxa for the benthic community was noted in relation to increasing concentrations of Pb in sediments, suggesting a possible exposure-response relationship, particularly for Stations DSY-29 and DSY-27. Patterns of composition based on multi-dimensional

scaling techniques identified the altered benthic community at Station DSY-29 as being associated with elevated total PAHs, copper and lead.

Bivalve Condition-Exposure Relationships. Overall impacts on bivalve condition were most apparent for Stations DSY-26, DSY-29, DSY-31 and DSY-33 (Figure 1.6-4). Exposure-response relationships were observed between total PCBs in indigenous mussel tissue and shell weight/length ratio, while reduced shell length in deployed mussels was correlated with Pb concentrations in sediment elutriates. In the case of total PCBs, causality was uncertain because corresponding tissue residues were at least three orders of magnitude lower than residue effects concentrations reported in the literature. For the deployed mussel data, where 100% elutriate (1:4 sediment:water preparation) HQs approached two, uncertainty exists as to whether field elutriate concentrations of PCBs could be high enough to cause the observed response.

Hematopoietic Neoplasia-Exposure Relationships. No significant relationships were observed between incidence or severity of hematopoietic neoplasia (Hn) in blue mussels versus either CoC tissue residue or CoC sediment concentration. There was some limited evidence, although not statistically significant, that the Hn affliction rate was related to PAH exposure.

Deployed Mussel Fecal Pollution Indicators - Exposure Relationships. Fecal pollution indicator concentrations in deployed mussels were used to better characterize the pathways for CoCs and non-CoCs into the environment and, specifically, into target species. Due to spatial proximity, fecal pollution indicator effects at Station DSY-41 were assumed to be equivalent to those measured at Station DSY-40 (these two stations are referred to jointly as DSY-40/41 in the fecal pollution indicator assessment). High fecal indicator concentrations were observed at Station DSY-40/41, while intermediate concentrations were observed at Stations DSY-26 and DSY-33

(Figure 1.6-4). Although no exposure-response correlations were observed between fecal indicator concentrations and condition indices of deployed mussels, a statistically significant correlation was found between fecal indicator concentrations and Low Molecular Weight PAH concentrations in deployed mussel tissue suggesting a possible common contributing source for the two, which might be sewage-related.

Fish Cytochrome P450 Activity - CoC Exposure Relationships. The cytochrome P450 assay was conducted on cunner samples from the Derecktor Shipyard/ Coddington Cove study area in order to detect potential PAH-related exposure and effects. Low P450 activity was found at Stations DSY-36. Comparisons with the literature data suggest that sediment PAH concentrations at Station DSY-29 may be sufficiently high to cause high P450 activity and perhaps inhibited capacity to metabolize PAHs (Figure 1.6-4).

Risk Synthesis. The interpretation of ecological risk in this assessment is based on a weight of evidence approach. The weight of evidence is in turn based on the analysis of exposure and effects data, as represented by the endpoints discussed in the previous sections. The following categorization of ecological risks has been developed for the Derecktor Shipyard ERA:

> *Baseline* risk is defined as the probability of adverse exposure and/or ecological effects equivalent to that from contamination and other environmental conditions not associated with the site.
>
> A *Low* probability of ecological risks suggests possible, but minimal impacts based on some of the exposure or effects-based weights of evidence, while impacts are undetectable by the majority of exposure and effects-based weights of evidence. Conditions of low risk probability typically lack demonstrable exposure-response relationships.

An *Intermediate* probability of ecological risk occurs for site conditions falling between high and low probabilities of risk. As such, the intermediate risk probability condition is typically characterized by multiple exposure or effects weights of evidence suggesting that measurable exposure or effects, but not both, are occurring at the site. Typically, quantitative exposure-response relationships are lacking. Intermediate risk probability may also be indicated if the spatial extent of apparent impact is highly localized (e.g., a single station), or if the impact occurs for periods of very limited duration.

Conditions indicating *High* probability of ecological risk occurs when numerous weights of evidence suggest pronounced contaminant exposure and effects, the spatial extent of apparent impact is great, the impact is likely to be persistent over long periods of time, and the available data support demonstrable exposure-response relationships.

A single ranking strategy for the synthesis of WoE indicators was used to obtain the probability of adverse Exposure/Effect (E/E) WoE designation in order to provide a consistent evaluation of the data in a manner consistent with the risk definitions discussed above for example, the extent to which CoC concentrations exceed benchmarks and how often this exposure/effect was observed among the individual WoE. The findings of exposure and effects WoE are evaluated jointly in important evaluations of the strength of exposure-response relationships conjunction in order to interpret the overall probability of adverse ecological risks by sampling station. The ranking approach is based on best professional judgement, since the "true" ecological risk of, for example, benchmark exceedence or observed toxicity, is not presently known.

Sediment Hazard Quotient Adverse Exposure Ranking. The sediment HQ data suggests overall highest probability of adverse exposure at Station DSY-27, DSY-29 and DSY-31 (Table 1.7-1). None of the stations were assigned to the intermediate adverse exposure category. The remaining low adverse exposure stations had multiple CoCs exceeding the ER-L but none exceeding the ER-M. Finally, baseline adverse exposure were assigned to Stations DSY-33, DSY-35 and DSY-41, and reference Stations JPC-1 and JPC-2, since no more than one CoC exceeded the ER-L benchmark.

Elutriate Hazard Quotient Adverse Exposure Ranking. CoC concentrations measured in sediment elutriate preparations suggested low overall probability of adverse exposure (Table 1.7-1). In two cases (Stations DSY-31 and DSY-39), one analyte was found to exceed Acute Water Quality Criteria while other analytes exceeded Chronic Water Quality Criteria, but this finding was deemed insufficient to merit an intermediate ranking for the station, given that it is highly unlikely that field concentrations for these CoCs during a resuspension event would approach concentrations obtained in the laboratory preparation.

SEM Bioavailability Adverse Exposure Ranking. Measures of sediment SEM bioavailability (total SEM, SEM/AVS and SEM-AVS) suggested possible, but low adverse exposure from divalent metal exposure at Station DSY-27 through DSY-30 (high total SEM) and at Stations DSY-33, DSY-35, DSY-37 and JPC-2 (Table 1.7-1). Intermediate or higher adverse exposure due to divalent SEM metals was not generally evident for the Coddington Cove study area.

Tissue Concentration Ratio Adverse Exposure Ranking. CoC elevations in target species relative to reference suggest the highest probability of adverse exposure for harborfront Stations DSY-25 through DSY-27, due to high residues in indigenous mussels and intermediate elevations in cunner, deployed mussels and/or lobster

(Table 1.7-1). Intermediate TCR-based exposure at DSY-24, DSY-28, DSY-29 and DSY-36 supports an intermediate adverse exposure assignment for the overall ranking, while TCR elevations at in various species at Stations DSY-33, DSY-35 and indicated low adverse exposure ranking was assigned to these locations.

Tissue Residue Adverse Effects Rankings. The highest probability of effects from tissue CoCs was observed at Stations DSY-27 and DSY-29 due primarily to bioaccumulation of Cu in lobster. Five stations were assigned intermediate adverse effects (DSY-25, DSY-33, DSY-35, DSY-38 and DSY-39) while the remaining stations (DSY-24, DSY-26, DSY-28, DSY-31, DSY-32, DSY-34, DSY-36, DSY-37, DSY-40 and DSY-41) were evaluated as low probability of adverse effects overall (Table 1.7-1).

Laboratory Toxicity Adverse Effects Ranking. The overall station-specific laboratory toxicity ranking summarized in Table 1.7-1 primarily reflects results of the larval development results. An overall intermediate adverse effects probability was assigned in three cases (Stations DSY-26, DSY-28 and DSY-29), while nine stations (Stations DSY-25, DSY-31 through DSY-33, DSY-37 through DSY-39, and DSY-41) were given a low adverse effects ranking. Finally, for those stations where only low toxicity (i.e., DSY-36 and DSY-40) or no toxicity (i.e., Stations DSY-34 and DSY-35, and reference Stations JPC-1 and JPC-2) was observed, a classification of baseline adverse effects was assigned.

Field Effects Ranking. The overall adverse effects ranking for field effects indicators (benthic community structure, bivalve condition, hematopoietic neoplasia, Cytochrome P450 activity and fecal pollution indicators) suggested high adverse effects at Stations DSY-29 and DSY-40/41, and intermediate adverse effects for Stations DSY-25, DSY-26 and DSY-33, while low adverse effects were observed for Stations DSY-27, DSY-28, DSY-30, DSY-31, DSY-32, DSY-36, DSY-38 and DSY-39

(Table 1.7-1). At the remaining stations, field effects indicators suggest no adverse effects to target species.

Avian Predator Effects Ranking. The food web modeling for avian aquatic predators assumed that the target bird species were feeding maximally on the most contaminated of prey items available at a given station. Despite the conservative assumptions employed, greater than intermediate adverse effects were not apparent, and intermediate adverse effects were assigned to Stations DSY-28, DSY-29 and DSY-36 (Table 1.7-1). The remainder of stations were assigned to the low adverse effects category.

Synthesis of Exposure and Effects Weights of Evidence. The interpretation of ecological risk in this assessment was based on a weight of evidence approach. The weight of evidence was in turn based on the analysis of exposure and effects data, as well as measures discussed in the previous sections. Multiple measures of exposure-based and effects-based weights of evidence were used. Exposure-based weights of evidence included Hazard Quotients (HQs) for numerous CoC sediment and sediment elutriate contaminants, divalent metal bioavailability measures, and Tissue Concentration Ratios (TCRs) for each target receptor. Effects-based weights included Tissue Residue Effects (TSCs and CBRs) for each receptor, Laboratory Toxicity for three endpoints, Field Effects (benthic community structure, bivalve condition, neoplasia, P450 activity in cunner, and fecal pollution indicators in bivalve tissue) and exposure to avian aquatic receptors from ingestion of contaminated prey.

The results for each of the indicators within the weights of evidence described above were summarized using a semi-quantitative ranking scheme so as to allow their inclusion in exposure and effects assessment summaries, and finally in the overall risk assessment summary, as presented in Table 1.6-1. The individual WoE ranking is intended to characterize the relative degree of CoC-related response, for example, the

extent to which CoC concentrations exceed benchmark criteria (HQ>ER-L = low risk ("+") and HQ>ER-M = significant risk ("++"), etc). This type of ranking scheme is intended only as a qualitative tool. Similarly, the overall ranking of weights of evidence within and between the exposure and effects-based summaries (Baseline, Low, Intermediate, High) is based upon preponderance of the data; i.e. where a greater number of endpoints suggest varying degrees of adverse exposure and/or effects, it is presumed that a greater probability of adverse risk exists. No differential priority or weight is given to any particular endpoint. As previously stated, the ranking approach is somewhat arbitrary and is based on best professional judgement. Hence, the risk manager is encouraged to keep in mind the nature of the risk ranking approach when evaluating the general outcome of the risk assessment.

The summary of exposure-based and effects-based weights of evidence and characterization of risk for the Derecktor Shipyard Marine Ecological Risk Assessment is presented in Table 6.7-1. The classification of risk for the Derecktor Shipyard Marine ERA is grouped into four primary classes: baseline, low, intermediate, and high.

High Risk Probability Stations. High ecological risk is that suggested by numerous weights of evidence suggest adverse exposure/effects, as well as demonstrable exposure-response relationships. Stations DSY-27 and DSY-29 are categorized as high risk stations. The nature of the contamination, being in the sediment, suggests the risk is likely to be persistent over a long period of time, although the spatial extent of apparent impact may be limited as nearby stations do not display similar levels of risk.

Intermediate Risk Probability Stations. Intermediate ecological risks are assigned to Stations DSY-24, DSY-25, DSY-26, DSY-28, DSY-31, DSY-33, DSY-40, DSY-41, and reference Station CHC-1. Indication of

CoC exposure was most evident from comparison of tissue concentrations to the reference stations values, while effects indicators include tissue residue effects, laboratory toxicity and field effects Hence, intermediate risk is assigned for these stations, although there is considerable uncertainty as to the degree to which CoC-related impacts have contributed to observed effects at these stations..

Low Risk Probability Stations. A low risk probability was assigned to seven of eighteen Coddington Cove stations (DSY-30, DSY-32, and DSY-34 through DSY-39), as well as reference Station JPC-1. For these stations, the data suggest possible, but low risks based on the majority of exposure and effects-based weights of evidence, and no exposure-response relationships were observed. While these stations have CoC concentrations exceeding ER-L benchmarks, the weights of evidence are most notable for the observed Effects data, particularly tissue residue effects, but also some laboratory toxicity and field effects.

Baseline Risk Probability Stations. Baseline risk was assigned only for reference Station JPC-2.

In most cases, the Exposure WoE was the same or greater as the Effects WoE which is expected when the exposure pathway being evaluated is correct, i.e. sediment or sediment-associated CoCs are causing adverse exposure which results in adverse effects. Conditions at Station DSY-25, DSY-28 and DSY-33 are cases where non-CoC related impacts might be occurring or that CoCs may not be sediment-associated. In each case, tissue-related exposure exceeded that which was indicated from sediment, elutriate or SEM WoE, suggesting that CoCs reaching the target species may be originating from non-sediment sources (e.g. through the water column). Thus, the significance and characteristics of CoC exposure pathways at these stations (including

DSY-40/41) are less certain than at other locations where exposure-based WoE rank is equivalent or greater than the respective effects-based WoE rank.

Risk Uncertainty. The final synthesis focused on elucidating concordance both within and among the exposure-based and effects-based weights of evidence to characterize overall risk for the Derecktor Shipyard/Coddington Cove study area. Multiple weights of evidence were used to reduce uncertainty because the probability that multiple exposure and effects indicators could spuriously suggest risk (or lack of it) decreases as the number of indicators in agreement increases.

At the high probability risk stations (DSY-29 and DSY-27) pronounced contaminant exposure and effects was suggested by numerous weights of evidence and exposure-response relationships were well demonstrated. The nature of the contamination, being in the sediment, suggests the impact that the risk is likely to be persistent over a long period of time, although the spatial extent of apparent impact may be limited as nearby stations do not display similar levels of risk. This suggests that the overall uncertainty of the risk designation is low.

At the low risk stations (Stations DSY-30, DSY-32, DSY-34 through DSY-39), the majority of exposure and effects-based weights of evidence were low, and few exposure-response relationships were observed between exposure and effects indicators. This also suggests that the overall uncertainty of the risk designation is low.

Among the Coddington Cove stations assigned an intermediate probability of ecological risk (including harborfront Stations DSY-24 through DSY-26 and DSY-28, as well as Stations DSY-31, DSY-33, DSY-40 and DSY-41), the data suggests that measurable (and occasionally high) exposure and/or effects were occurring, but not generally as high as for the high risk stations described above, and unlike the high risk stations, quantitative exposure-response relationships are generally lacking. For some

of the stations (i.e. Stations DSY-25, DSY-26, DSY-28 and DSY-33) elevated risks from CoC residues in target receptors is not accompanied by similarly high risk related to CoC concentrations in indicating that the contaminant distribution in sediments is highly localized (and was not adequately characterized) or may not be entirely sediment related, such that the responsible exposures may be of more limited duration (e.g. not as persistent as if sediments were the CoC reservoir). This suggests that the uncertainty of the risk designation is somewhat greater than that observed for low and high risk stations.

Other CoC Sources. A weight of evidence evaluation such as used in this study, while addressing the location and relative degree of risk, does not specifically address the ultimate source of this risk (i.e., Derecktor Shipyard vs. other contaminant sources). This uncertainty has been addressed in this ERA through the inclusion of reference locations and the analysis of spatial trends in CoCs, exposure pathways, and other endpoints (e.g. pathogens) which might suggest alternative CoC sources; therefore, an attempt has been made to minimize this source of uncertainty to the maximal extent that time and resources permit.

Surface water runoff via storm drains near the shipyard harborfront is suspected as the most probable route of ongoing CoC transport into Coddington Cove. It is also considered possible that groundwater percolating out of the shipyard area and entering Coddington Cove carries CoCs, however, this ERA did not collect any data to address the groundwater issue. Contamination contribution from remote sources, such as the City of Newport sewage outfall, is also deemed possible as a result of water exchange between Coddington Cove and Narragansett Bay. The existence of significantly elevated CoCs in Coddington Cove subsurface sediment layers relative to surface sediments may represent an increased risk for indigenous biota should resuspension of these buried sediments occur. However, geophysical and hydrographic studies suggest that natural deposition/erosion patterns do not support this scenario under

currently existing conditions in the cove, but future use scenarios should be carefully considered with respect to the validity of this assumption. Hence, this ERA has concluded that indigenous biological communities in the immediate vicinity of the harborfront were are at risk primarily due to shipyard-related stressors, although uncertainty exists as to the partitioning of exposure between sediment and water transport pathways.

Uncertainty in Risk Estimation. The conclusions drawn in this assessment are based on an extensive database of sediment chemistry, biological indicators, and toxicity evaluations, with broad spatial and temporal coverage. The present study provides multiple weights of evidence for assessment of impacts in the vicinity of Derecktor Shipyard, hence there would appear a high probability of accurately concluding the occurrence of risk is expected. The present study was conducted under a comprehensive Work/Quality Assurance Plan, and data validation has been performed and found to meet the study requirements. Potential errors in the study design and protocols were minimized through peer review and evaluation. Data collection activities were reasonably complete. Thus, it is concluded that the overall uncertainty with regard to the accuracy of risk estimations has been satisfactorily minimized.

1.7. Conclusions and Recommendations

Based on the results of the Marine Ecological Risk Assessment for Derecktor Shipyard/Coddington Cove, the following conclusions and recommendations are put forth for consideration in risk management:

- In the assessment of marine ecological risks to aquatic species of concern (mussels, clams, lobster, cunner and seabirds), Stations DSY-27 and

DSY-29 were determined to pose a high probability of ecological risk from shipyard-related Contaminants of Concern (CoCs). The principal CoCs responsible for this risk were organics (PCBs, PAHs and tributyltin) and metals (copper, lead and zinc). Seabirds (herring gull and great blue heron) were also at intermediate risk due to potential ingestion of PCBs in cunner at Station DSY-29. Based on the extent of adverse exposure and effects and demonstrable exposure-response relationships observed, the assigned degree of risk is considered unacceptable from an ecological perspective, and thus these locations should receive highest priority in the risk management decision process.

- An intermediate probability of ecological risks was assigned to Stations DSY-24, DSY-25, DSY-26, DSY-28, DSY-31, DSY-33, DSY-40, and DSY-41, as well as reference Station CHC-1. In general, the same aquatic receptors and CoCs as observed for high risk stations were of concern, but at lower levels. Exceptions included higher tributyltin in sediment at Station DSY-31, and higher PAHs in mussels at Stations DSY-25 and DSY-26. Seabirds continued to be at intermediate risk due to potential ingestion of PCBs in cunner at Station DSY-28. Given an indication of adverse exposure or effects but a lack of clear exposure-response relationships, the overall risk at these stations is considered acceptable from an ecological perspective. However, the associated uncertainty is sufficiently high as to merit the evaluation of these stations as priority areas in the risk management decision process.

- A low probability of ecological risks was assigned to the remaining Coddington Cove stations (DSY-30, DSY-32, and DSY-34 through DSY-39), as well as the reference Station JPC-1. Although the data for these stations suggest possible adverse exposure or effects, CoC

concentrations were generally low and definitive exposure-response relationships were not observed. Based on these observations, the observed risks at these stations are considered acceptable from an ecological perspective, and relatively low priority should be given to these locations in the risk management decision process.

- A baseline probability of risk was assigned to reference Station JPC-2, given a lack of evidence for adverse exposure or effects. Ecological risks at this location are considered not only acceptable but representative of relatively pristine environmental conditions for the general study area.

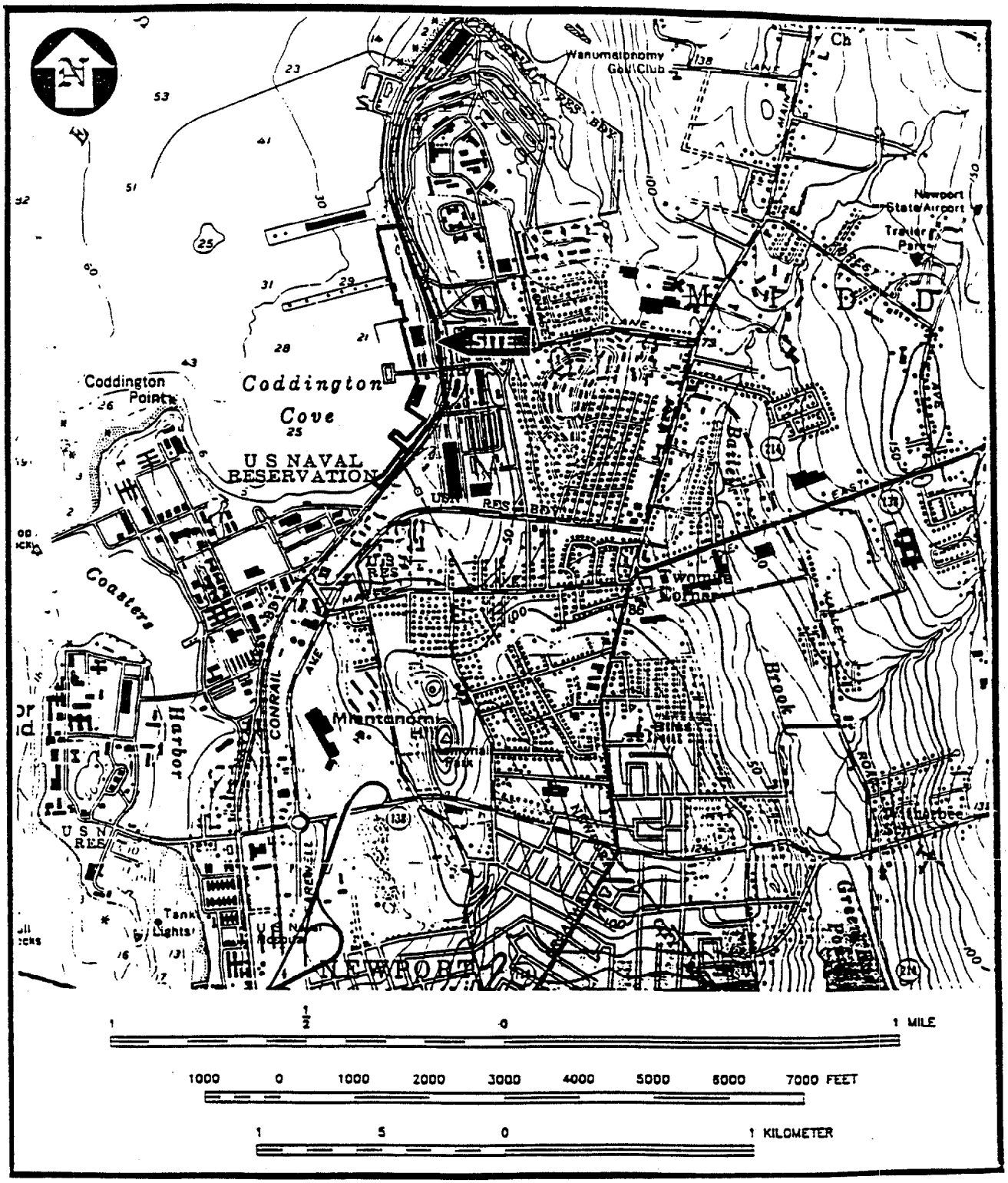


Figure 1.0-1. Site location map for the Derecktor Shipyard Marine Ecological Risk Assessment.

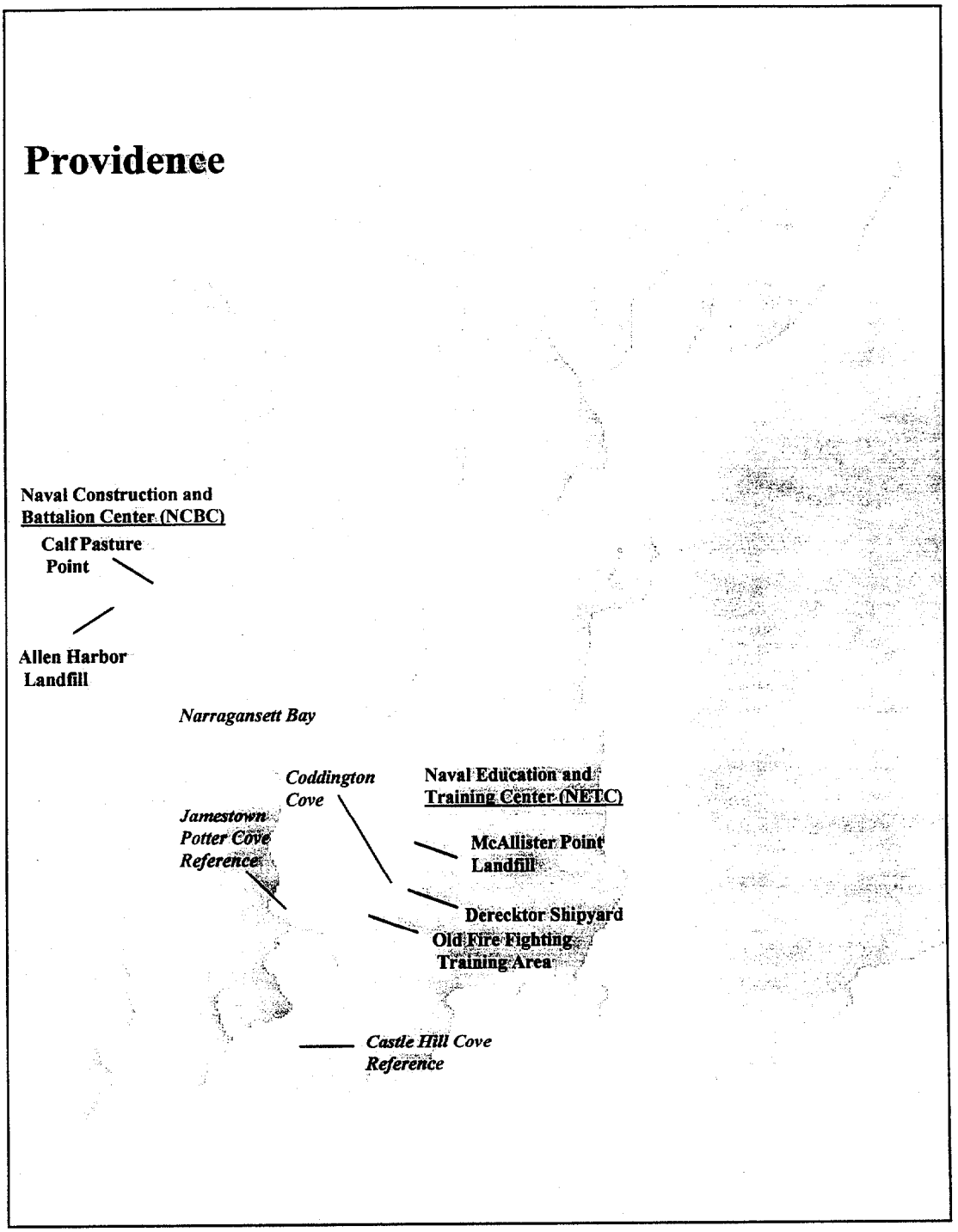


Figure 1.2-1. Location of the Derecktor Shipyard/Coddington Cove study area and reference locations in Narragansett Bay, RI.

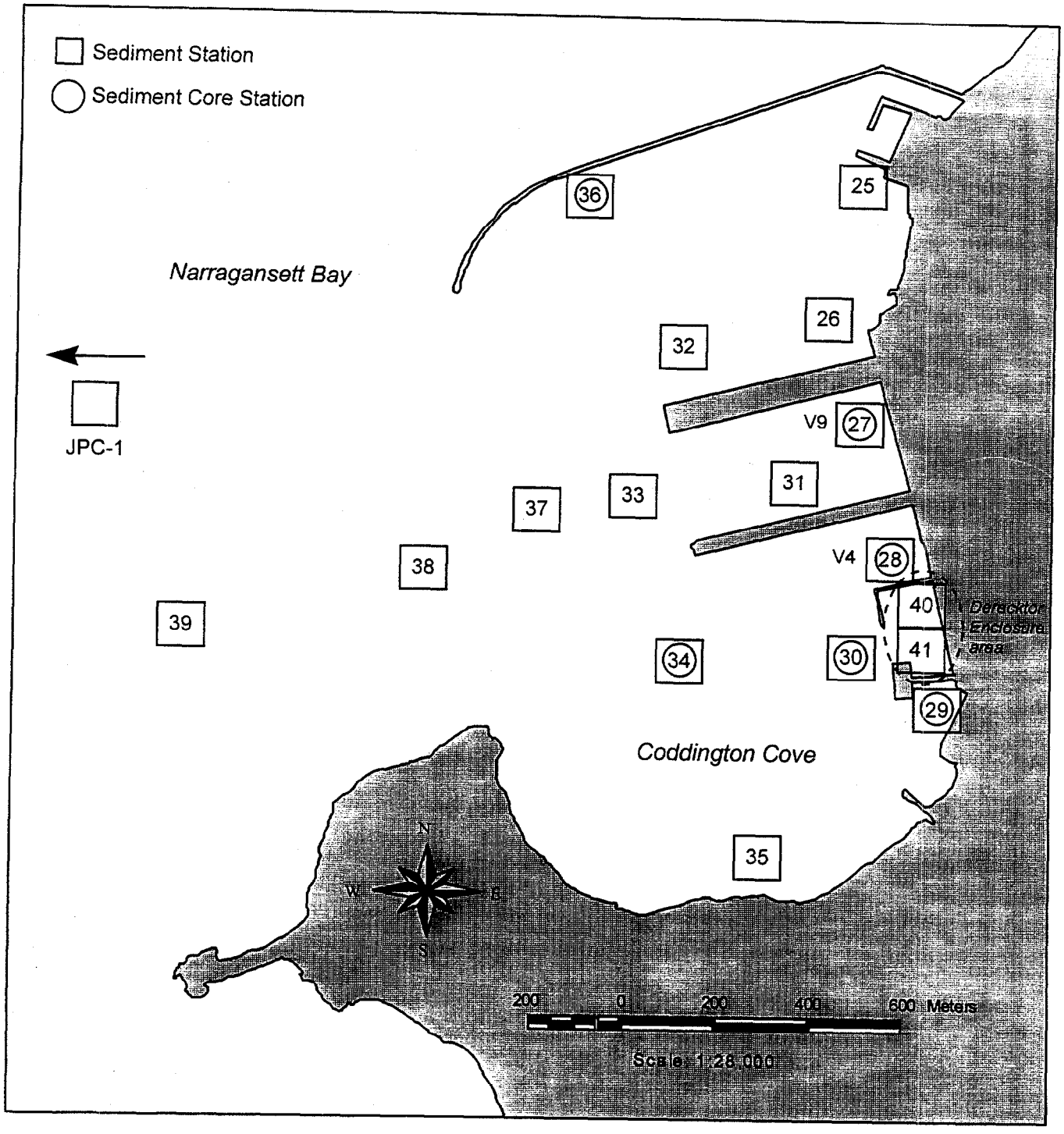


Figure 1.2-2. Surface sediment and sediment core sampling stations in the Derecktor Shipyard/Coddington Cove study area.

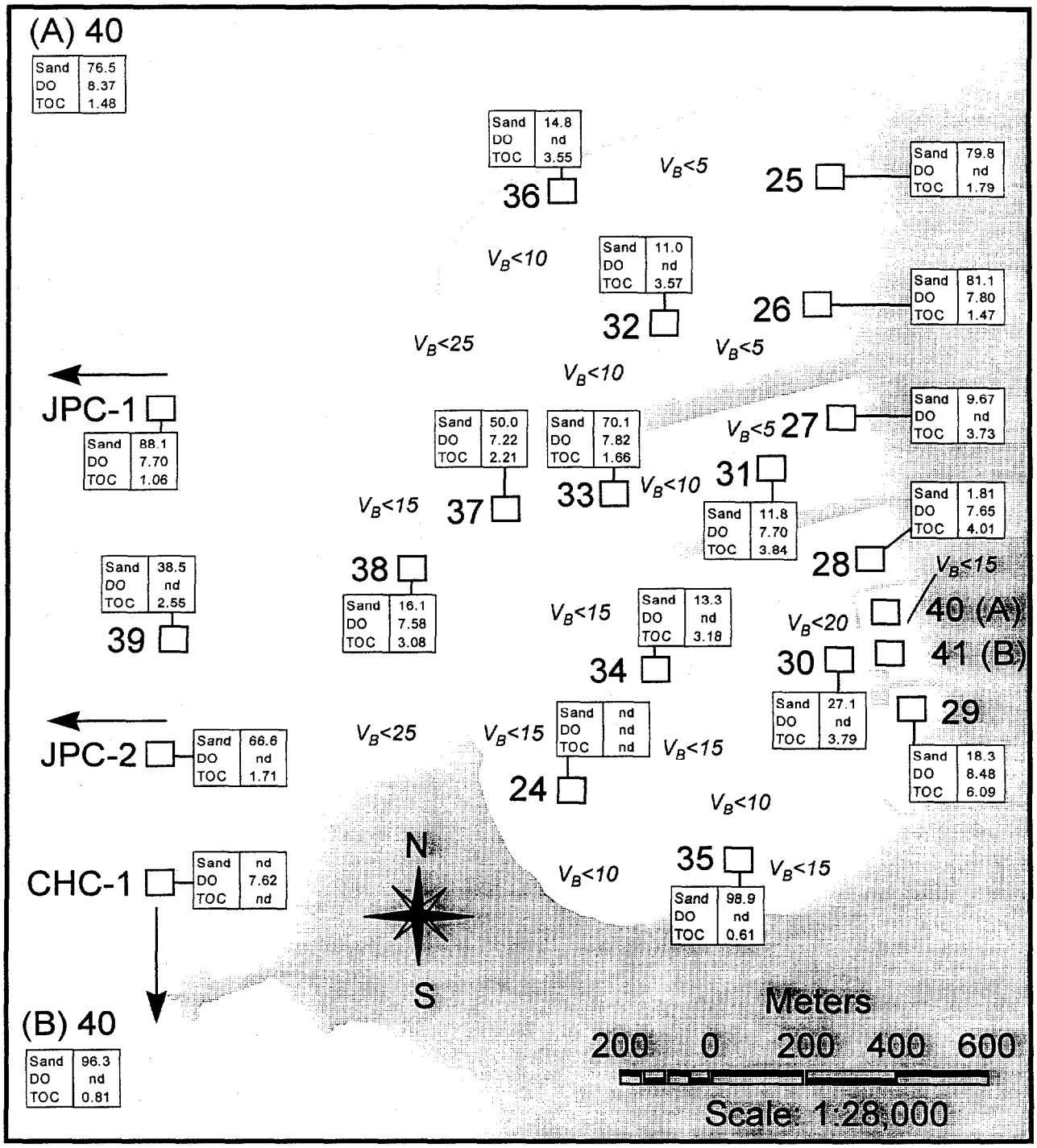


Figure 1.3-1. Hydrographic and geophysical data from the Derecktor Shipyard/ Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. V_B indicates maximum bottom velocity observed in cm/s. "Sand" = percent sand content in sediments; "DO" = measured dissolved oxygen in mg/L; "TOC" = percent Total Organic Carbon in sediments.

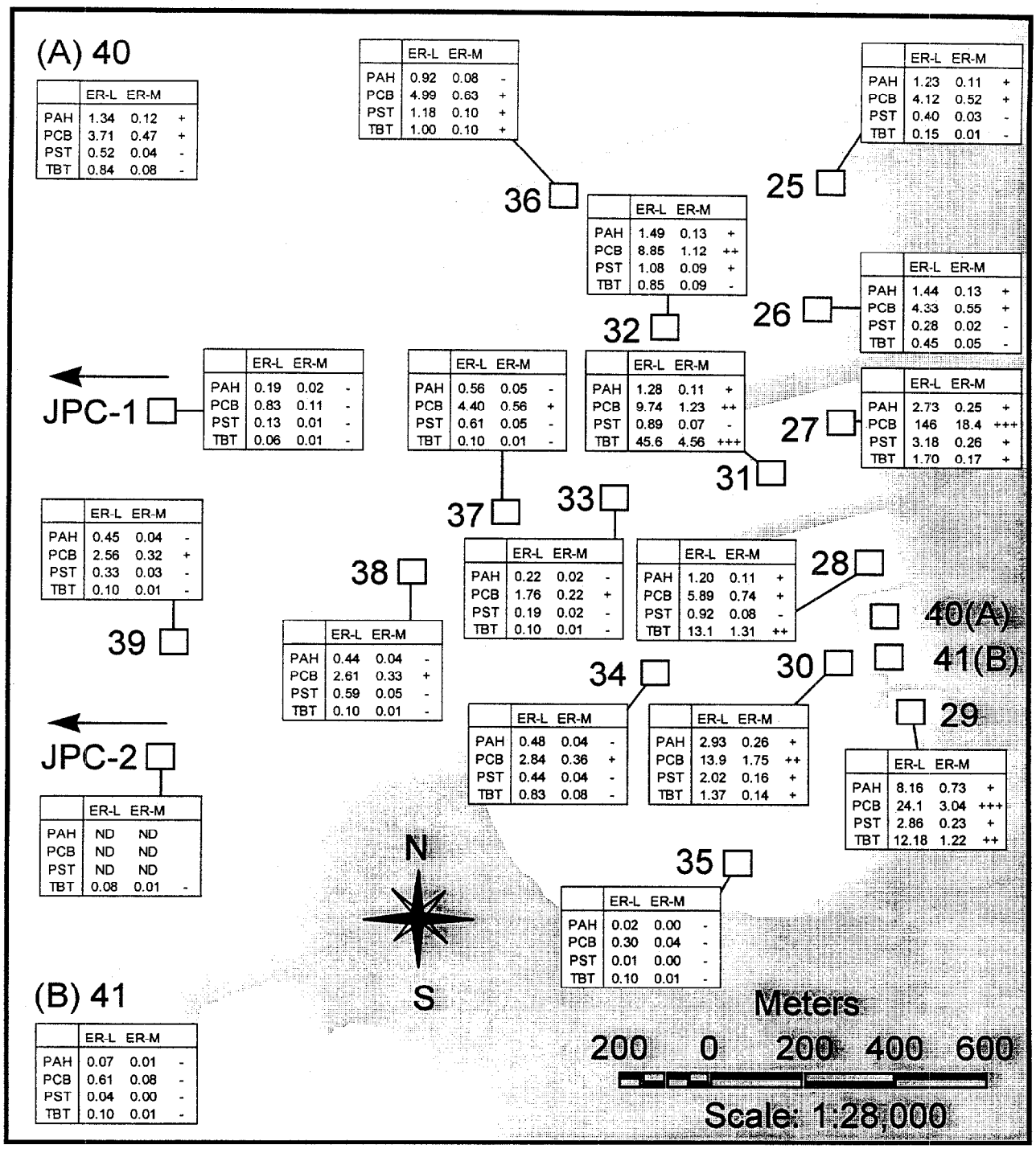


Figure 1.6-1A. Hazard Quotients (HQs) and risk rankings for organic contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. PAH=Total PAHs; PCB=Total PCBs; PST=p,p'-DDE; TBT=Tributyltin. ND=no data. Benchmarks for PCBs, PAHs, and PST from NOAA ER-L/ER-M benchmarks (Long *et al.*, 1995). TBT benchmark from Macauley *et al.*, 1994. Refer to Section 6.1 for discussion of the Sediment HQ weight of evidence and explanation of rankings.

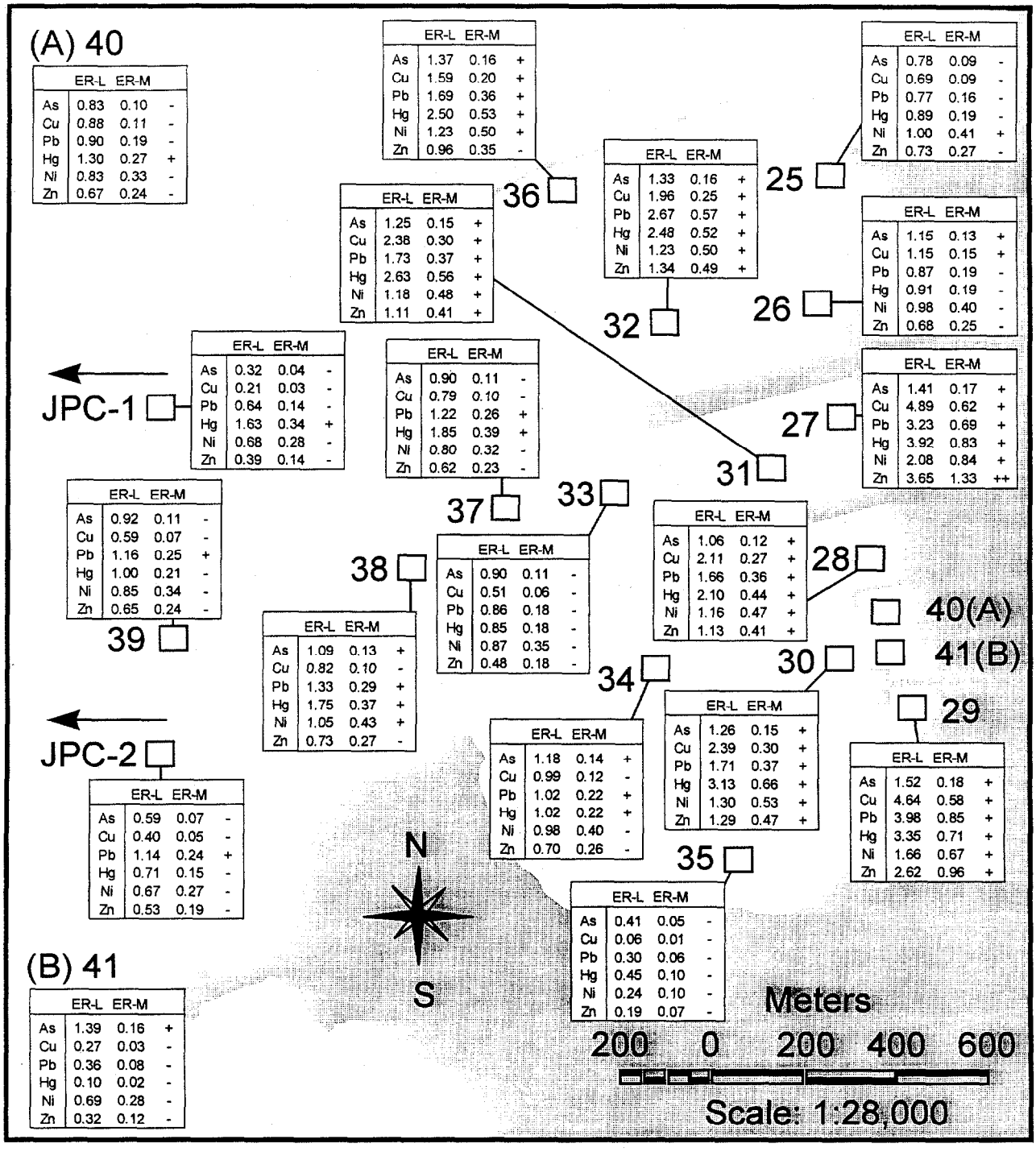


Figure 1.6-1B. Hazard Quotients (HQs) and risk rankings for metals contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. As=arsenic; Cu=copper; Pb=lead; Hg=mercury; Ni=nickel; Zn=zinc. Hazard Quotients based on ER-L and ER-M benchmarks (Long *et al.*, 1995). Refer to Section 6.1 for discussion of the Sediment HQ weight of evidence and explanation of rankings.

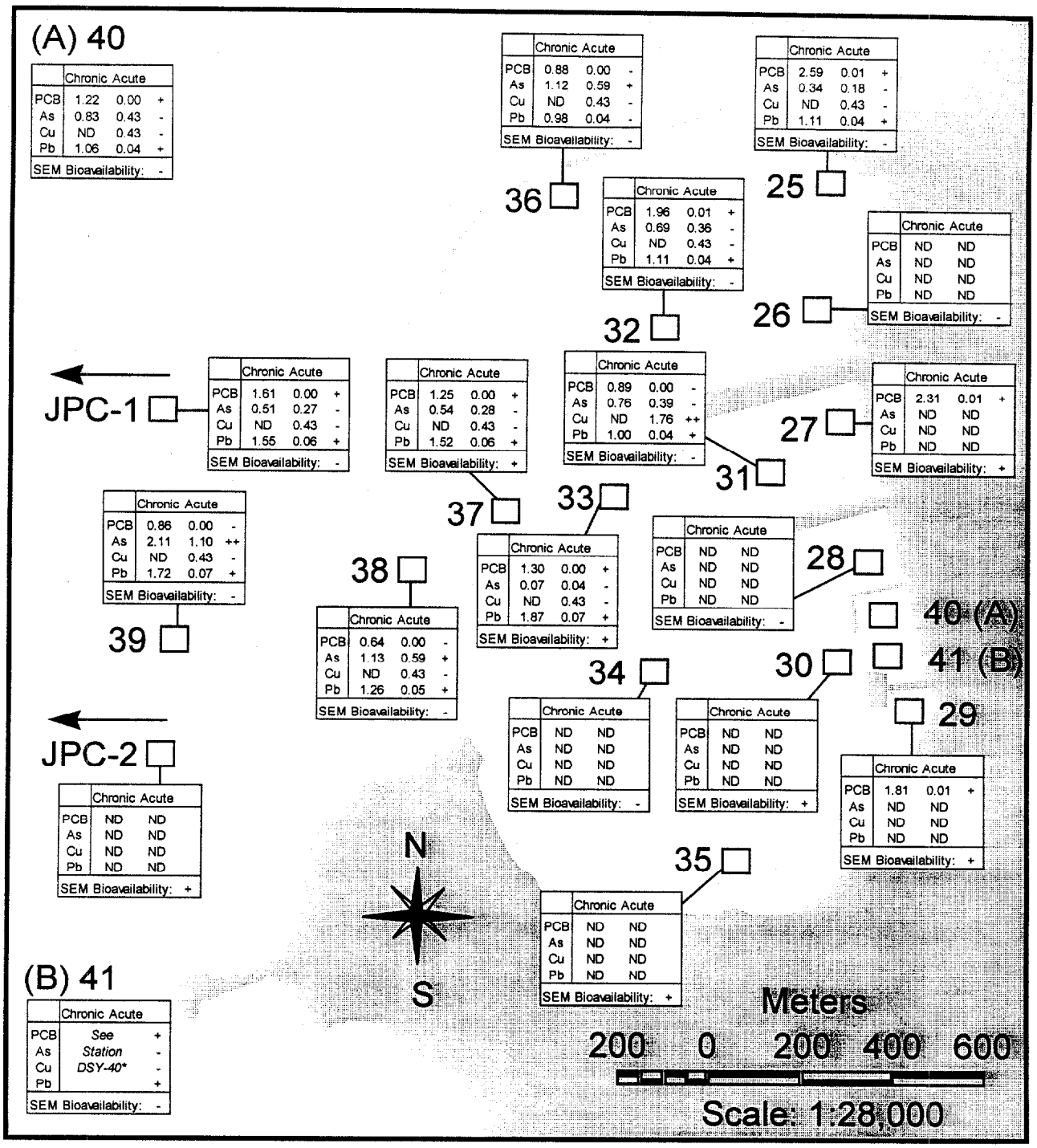


Figure 1.6-2. SEM Bioavailability and Hazard Quotients for elutriates prepared from sediments collected in the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. Benchmarks for elutriates=EPA Water Quality Criteria- Saltwater Chronic and Saltwater Acute values. As=arsenic; Cu=copper; Pb=lead; PCB=Total PCBs. Refer to Section 6.1 for discussion of the sediment elutriate weight of evidence and explanation of rankings. Refer to Section 6.4 for discussion of the Simultaneously Extractable Metals (SEM) Bioavailability weight of evidence and explanation of rankings. *No data available for elutriate exposure at Station DSY-41; ranking assumed to be the same as for Station DSY-40 due to spatial proximity.

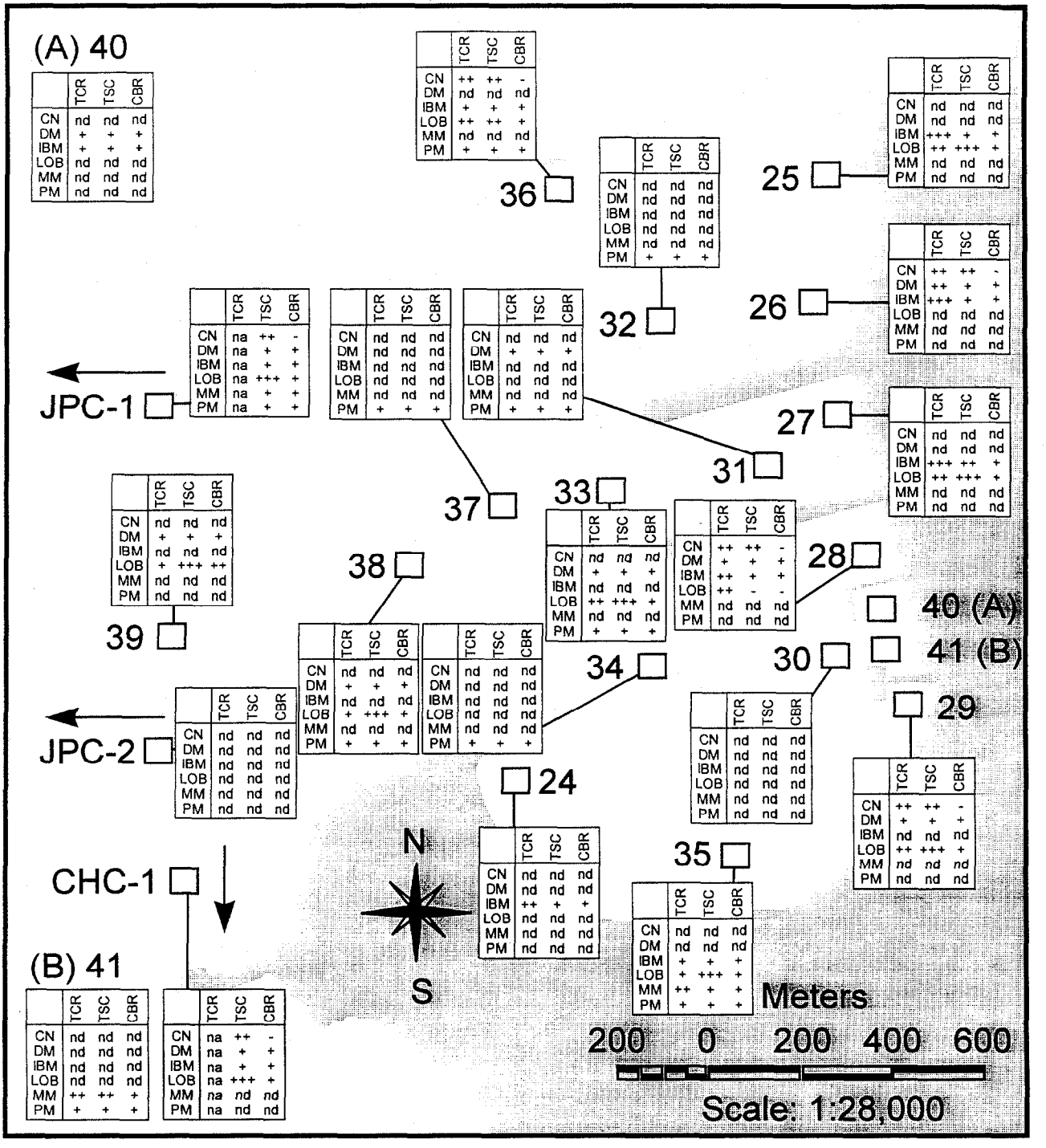


Figure 1.6-3. Tissue Concentration Ratios and Tissue Residue Effects Hazard Quotients (HQs) for target species collected from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference stations. CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM= *Pitar morrhuana.* TCR=Tissue Concentration Ratio; TSC=Tissue Screening Concentration HQ; CBR=Critical Body Residue HQ. nd=no data; na=not applicable, values based on comparison to reference station values. Refer to Section 6.2 for discussion of Tissue Concentration Ratio and Tissue Residue Effects weights of evidence and explanation of rankings.

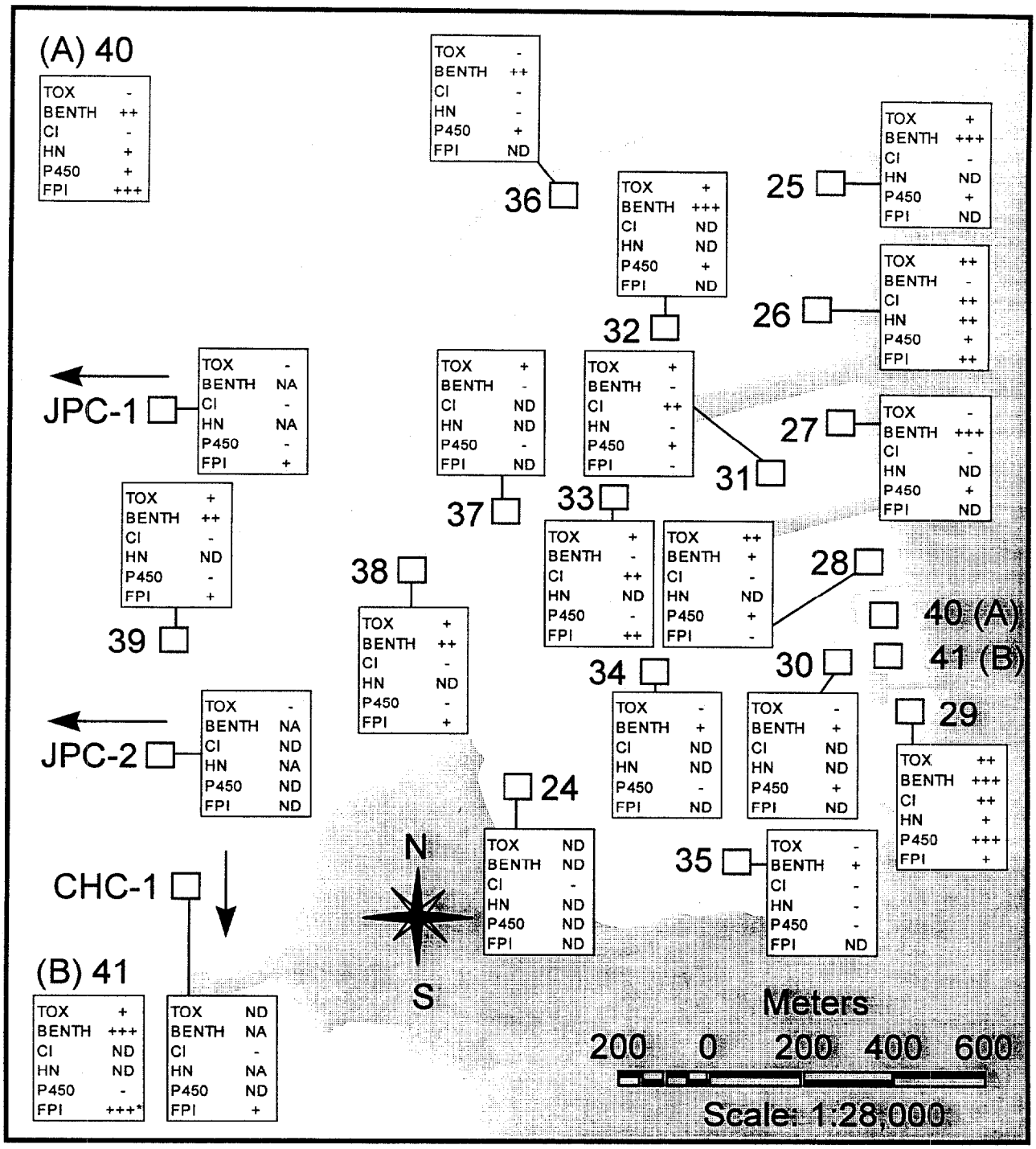


Figure 1.6-4. Field Effects Indicators and Overall Laboratory Toxicity results for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference stations. TOX=Overall Toxicity; BENTH=Benthic Community Structure; CI=Bivalve Condition Indices; HN=Hematopoietic Neoplasia; P450=Cytochrome P450; FPI=Fecal Pollution Indicators. ND=no data; NA=not applicable, values based on comparison to reference station values. Refer to Sections 5.2 and 6.4 for discussion of Laboratory Toxicity weight of evidence and explanation of risk rankings. Refer to Sections 5.3 and 6.5 for discussion of Field Effects weight of evidence and explanation of risk rankings. *No data available for fecal pollution indicator effects at Station DSY-41; ranking assumed to be the same as for Station DSY-40 due to spatial proximity.

Table 1.6-1. Overall Summary of Exposure and Effects-based Weights of Evidence and Characterization of Risk for the Derecktor Shipyard Marine Ecological Risk Assessment.

	WEIGHTS OF EVIDENCE										
	EXPOSURE					EFFECTS					
Station	Sediment Hazard Quotients[1]	Elutriate HQs[2]	SEM and AVS[3]	Tissue Conc. Ratio[4]	Rank[9]	Tissue Residue Effects[5]	Laboratory Toxicity[6]	Field Effects[7]	Avian Predators[8]	Rank[9]	Overall Risk Probability Ranking[10]
DSY-24				++	I	+		-	+	L	Intermediate
DSY-25	+	+	-	+++	I	++	+	++	+	I	Intermediate
DSY-26	+		-	+++	I	+	++	++	+	I	Intermediate
DSY-27	+++	+	+	+++	H	+++	-	++	+	H	High
DSY-28	+		+	++	L	+	++	+	++	I	Intermediate
DSY-29	+++	+	+	++	H	+++	++	+++	++	H	High
DSY-30	+		+		L		-	+		B	Low
DSY-31	+++	+	-	+	I	+	+	+	+	L	Intermediate
DSY-32	+	+	-	+	L	+	+	++	+	L	Low
DSY-33	-	+	+	+	L	++	+	++	+	I	Intermediate
DSY-34	+		-	+	L	+	-	-	+	L	Low
DSY-35	-		+	+	L	++	-	-	+	L	Low
DSY-36	+	+	-	++	L	+	-	+	++	L	Low
DSY-37	+	+	+	+	L	+	+	-	+	L	Low
DSY-38	+	+	-	+	L	++	+	+	+	L	Low
DSY-39	+	+	-	+	L	++	+	+	+	L	Low
DSY-40	+	+	-	+	L	+	-	+++	+	I	Intermediate
DSY-41	-	+	-	+	L	+	+	+++	+	I	Intermediate
JPC-1	-	+	-		B	+++	-	-	+	I	Low
JPC-2	-		+		B		-	-	+	B	Baseline
CHC-1						+++		-		I	Intermediate

1- Sediment Hazard Quotient Risk Ranking: see Table 6.6-1.
2- Elutriate Hazard Quotient Risk Ranking: see Table 6.6-1.
3- SEM and AVS Risk Ranking: see Table 6.6-1.
4- Tissue Concentration Ratios Risk Ranking: see Table 6.6-1.
5- Tissue-based Risk Ranking: Based on Site vs. Reference Tissue Concentration Ratio (Table 6.6-1), Tissue Screening Concentration (Table 6.6-2) and Critical Body Residues (Table 6.6-2).
6- Laboratory Toxicity Risk Ranking: see Table 6.6-2.
7- Field Effects Ranking: Based on results of Condition Index, Benthic Community Structure, Hematopoietic neoplasia, cytochrome P450, and fecal pollution indicators; see Table 6.6-2.
8- Avian Predator effects ranking based on Toxicity Reference Value Hazard Quotients; see Table 6.6-2.
9- Overall Exposure/Effects (E/E) Ranking:
B = Baseline Risk; L = Low Risk Probability; I = Intermediate Risk Probability; H = High Risk Probability.
B = Low (+) E/E ranking observed for only one indicator or baseline E/E ranking observed for all indicators;
L = Intermediate (++) E/E ranking observed for only one indicator or low (+) E/E ranking observed for two or more indicators;
I = High (+++) E/E ranking observed for only one indicator or intermediate (++) E/E ranking observed for two or more indicators;
H = Intermediate (++) or greater E/E ranking observed for two indicators including high (+++) E/E ranking observed for one indicator.
10- Overall Risk Ranking (See also Section 6.6):
Baseline = No greater than Baseline (B) ranking for E/E WoE summaries;
Low = No greater than Low (L) ranking for E/E WoE summaries;
Intermediate = No greater than Intermediate (I) ranking for E/E WoE summaries, or High (H) ranking for one WoE and no greater than Low (L) ranking for the other WoE summary;
High = High (H) ranking for one WoE summary and Intermediate (I) or greater ranking for the other WoE summary.

2.0. INTRODUCTION

This report describes the results of a marine ecological risk assessment conducted for Derecktor Shipyard, which is part of the Naval Education and Training Center (NETC), Newport, RI, located in the lower East Passage of Narragansett Bay. The Derecktor Shipyard was a privately operated ship maintenance yard from 1979 to 1992. The property was leased to Robert E. Derecktor but owned by the U.S. Navy. The Navy had also used the site for shipbuilding activities from 1962 to 1978. The site location is shown in Figure 2.0-1.

NETC must comply with requirements specified under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Contingency Plan (NCP), and Rhode Island State Statutes. The Federal regulations mandate assessment of the risk of hazardous waste disposal sites on human health and the environment, and identification of appropriate cleanup levels. In 1995, Brown and Root Environmental contracted the University of Rhode Island (URI) and Science Applications International Corporation (SAIC) to conduct a site-specific offshore ecological investigation and to prepare an offshore ecological risk assessment for Derecktor Shipyard. The purpose of this report is to communicate the results of the assessment of ecological risks to Narragansett Bay systems posed by the contaminants associated with the shipyard.

2.1. SITE CHARACTERIZATION

The ERA described in this report has been prepared following the Work/Quality Assurance Project Plan (W/QAPjP) for Narragansett Bay Ecorisk and Monitoring for Navy Sites, referred to herein as the "Master Work Plan", and the site-specific W/QAPjP

for Derecktor Shipyard included as Addendum B of the Master Plan (URI/SAIC, 1995). This assessment focuses on the impacts of shipyard-related contaminants on subtidal habitats of Derecktor Shipyard and greater Narragansett Bay. This assessment does not consider terrestrial, freshwater wetland, or human health risks associated with the site. Furthermore, this assessment only reflects currently existing conditions and levels of activity at the site, and does not address altered risks under potential future use scenarios involving fundamentally different conditions or activities at the site.

The Master Work Plan and the Derecktor Shipyard Addendum collectively provide a thorough description of the approaches and methodologies utilized to conduct the Derecktor Shipyard ERA. The scope of this report is to present the results of the ERA and includes an overview of the sampling and analysis activities conducted in support of the ERA. Complete descriptions of sampling and analytical methodologies are provided in the Work Plan; any deviations from the plan are noted where appropriate in this report and in the QA/QC Appendix.

This ERA report follows the organization suggested in Eco Update (U.S. EPA, 1991) with appropriate elements from the EPA Region I Supplemental Risk Assessment Guidance for the Superfund Program (U.S. EPA, 1989b) and Risk Assessment Guidance for Superfund, Volume II Environmental Evaluation Manual (U.S. EPA, 1989). These guidance documents recommend a "weight of evidence" approach to assess potential ecological risks. The approach should be based on evaluation of contaminant analytical data relative to environmental benchmarks, direct field observations, selected field and laboratory studies from the scientific literature, potential for bioaccumulation of chemicals and food web exposure modeling. Evaluation of risks is based on the preponderance of data; locations where a greater number of endpoints suggest adverse risks are presumed to indicate a greater probability of adverse risk. No preferential priority or weight is given to any particular indicator.

To guarantee that the required activities were conducted to meet these objectives, the ERA was conducted following general U.S. EPA guidance (1989, 1992b), and input provided by U.S. EPA Region I, the State of Rhode Island, and Natural Resource Trustees, representatives of which jointly constitute the Narragansett Bay Ecorisk Advisory Group. The scope of this ERA report includes:

1. Problem Formulation. This involved determining the nature and extent of contamination of offshore (subtidal) media associated with shipyard sources. Specifically, this activity involved identification of contaminated media, identification of contaminants of concern (CoCs), evaluation of the spatial extent of contamination, identification of the ecological receptors potentially at risk from CoCs, and identification of appropriate assessment and measurement endpoints. The information generated during the Problem Formulation was integrated into a conceptual model, which identified the possible exposure scenarios and mechanisms of ecological impact associated with the CoCs. This evaluation addresses only current conditions and levels of activity at the site, and does not address potential future use scenarios involving fundamentally different conditions or activities at the site.

2. Exposure and Ecological Effects Assessments. These assessments included collection of information to quantify chemical exposures and observed or predicted ecological effects resulting from exposure. The Exposure Assessment involved quantification or estimation of the concentrations of CoCs in environmental media in the exposure pathways from source to ecological receptors. The Ecological Effects Assessment involved a combination of toxicological literature review, *in situ* characterizations of the status of receptor species, toxicity evaluations of exposure media, and modeling exercises to predict the occurrence of

adverse ecological impact. Site-specific Exposure and Ecological Effects Assessment activities were determined based on the conceptual model developed during Problem Formulation.

3. Characterization of Ecological Risks. Risk characterization is an integration of the results of the Exposure and Ecological Effects Assessments. This represents a weight of evidence approach involving analysis of CoC concentrations *versus* observations of adverse effects, analysis of CoC bioaccumulation, comparisons of toxicity evaluations with observed ecological effects, comparisons of exposure point concentrations with established standards and criteria for offshore media, comparisons of exposure point concentrations with published information regarding the toxicity of CoCs, and qualitative comparisons of apparent adverse impacts with conditions at reference stations. The results of these analyses are summarized together with information obtained during each study to characterize ecological risks associated with the Derecktor Shipyard.

4. Communication of Study Results. Communication of the study objectives, methods, and findings of the ERA is provided in a format which supports informed risk management decisions for the site. Results of weights of evidence are assembled into a summary risk table in order to further communicate risks in support of risk management decisions.

Based on these guidelines, this ERA presents background information integrated with contemporary data to develop the Problem Formulation (Section 3); Exposure Assessment (Section 4); Ecological Effects Assessments (Section 5); Risk Characterization (Section 6); Summary and Conclusions (Section 7); References (Section 8); and Appendices, including raw data for Chemistry Exposure Assessments

(Appendix A); Effects Assessments (Appendix B); QA/QC and Data Validation Summary Information (Appendix C); Geophysical/Hydrographic Data (Appendix D); and Field Log Data (Appendix E).

2.2. Purpose, Scope, and Objectives

The purpose of this report is to describe information collected for evaluation of risks from contaminants associated with Derecktor Shipyard to marine ecological receptors in Coddington Cove and greater Narragansett Bay. The general approach taken in this investigation followed that described in the main body of the Master Work Plan (URI and SAIC, 1995).

The U.S. EPA's ERA Framework (1992b) and applicable EPA Region I guidance were used to generate and interpret the data required to complete this risk assessment. The objectives of this ERA are as follows:

- Assess ecological risks to the offshore environments of Coddington Cove and Narragansett Bay from chemical stressors associated with the Derecktor Shipyard;

- Develop information sufficient to support risk management decisions regarding site-specific remedial options; and

- Support communication to the public of the nature and extent of ecological risks associated with Derecktor Shipyard.

This ERA builds upon and incorporates findings of previous studies at Derecktor Shipyard, and specifically addresses three data gaps remaining from these earlier studies. These data gaps are as follows:

- Need to better assess the chemical exposure to biological populations in surficial sediments adjacent to the shipyard site;

- Need to determine the potential migration of contaminants from the shipyard to adjacent embayments;

- Need to expand the investigation of ecological risks to marine and semi-aquatic populations in Narragansett Bay to include toxicity assessments, organism condition, food web exposure modeling, and benthic community structure.

The following sections present and discuss the data requirements and data products of the Derecktor Shipyard ERA, including Problem Formulation, Exposure and Ecological Effects Assessments, and Characterization of Ecological Risks.

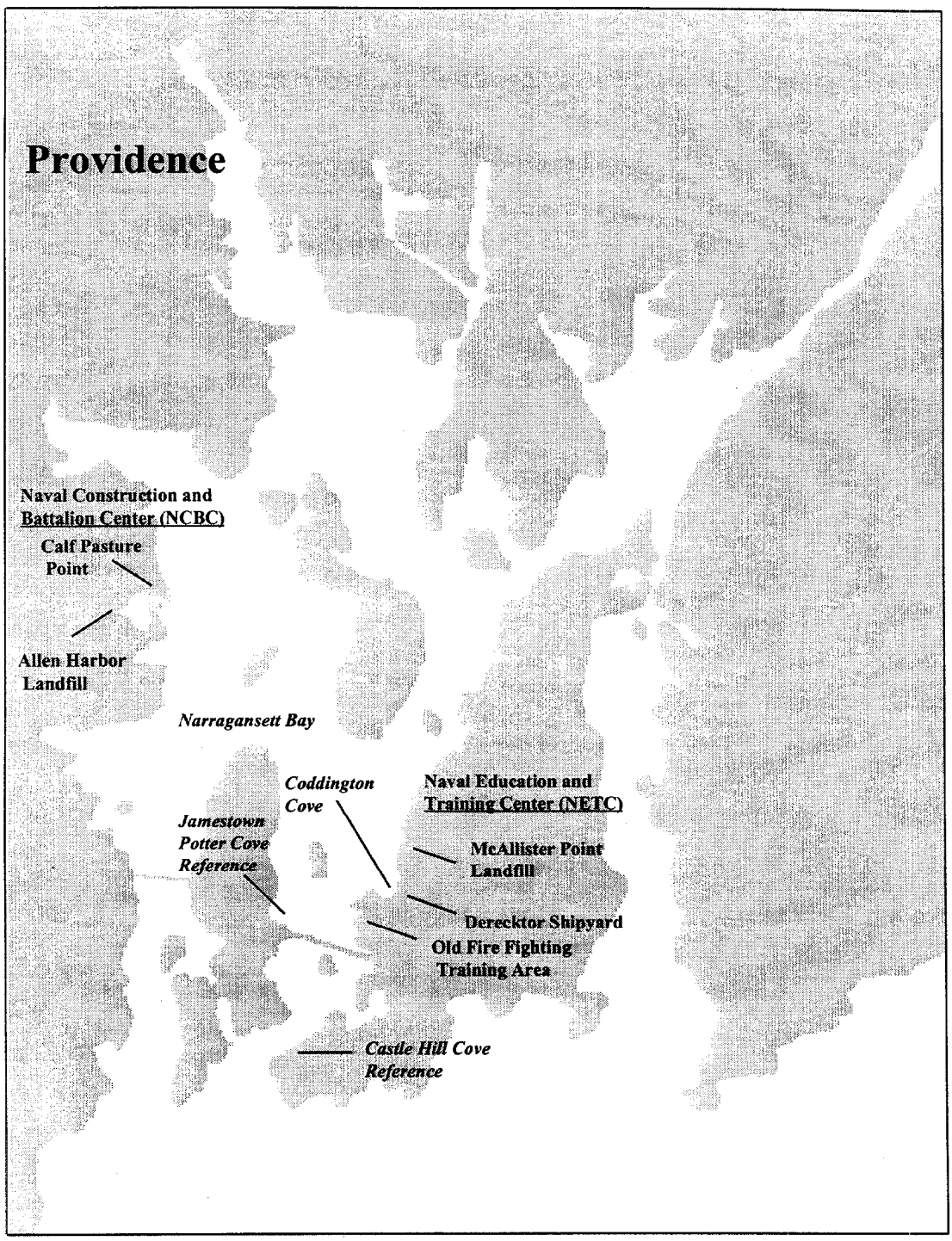


Figure 2.0-1. Location of the Derecktor Shipyard/Coddington Cove study area and reference locations in Narragansett Bay, RI.

3.0. PROBLEM FORMULATION

Five principal activities have been conducted in support of the Problem Formulation component for the Derecktor Shipyard ERA:

- Site Description, including characterization of the nature and extent of contamination of offshore media associated with Derecktor Shipyard (Section 3.1);
- Specification of assessment and measurement endpoints (Section 3.2);
- Identification of contaminants of concern (CoCs; Section 3.3);
- Identification of the ecological receptors potentially at risk from site-related CoCs (Section 3.4); and
- Development of a site-specific conceptual model of marine ecological risks associated with the Derecktor Shipyard (Section 3.5).

A summary of sampling and analysis activities related to the ERA effort is also provided (Section 3.6).

3.1. SITE CHARACTERIZATION

The primary objectives of the site characterization are to identify the types and spatial extent of habitats that are present in the marine environment adjacent to Derecktor Shipyard, and identify the species and biological communities that may be

exposed to site-related contaminants. In Section 3.1.1, the general geologic and hydrographic characteristics of the study area are described. Section 3.1.2 summarizes onshore site characterization information as presented in the Preliminary Assessment Report (PA) for Derecktor Shipyard (ENSR, 1993). Section 3.1.3 presents the results of Phase I offshore field investigations designed to characterize the magnitude and extent of shipyard-related chemical contamination.

3.1.1. Study Area Description

The Robert E. Derecktor Shipyard of Rhode Island (Derecktor) is located at the southeastern end of Narragansett Bay (Figure 3.1-1). The western boundary of Derecktor opens onto Coddington Cove. The surface area of Coddington Cove is about 6.5×10^5 m^2. The most recent harbor-wide bathymetric survey was conducted by the National Ocean Survey in 1957, which indicates water depths ranging from intertidal (<1.5 m) in the northeastern and particularly southern areas, to between 10-12 m adjacent to the main piers, and gradually deepening to 16 m at the cove entrance (Figure 3.1-2). A bathymetric study performed by SAIC in 1986 (SAIC, 1986) in a portion of the cove south of the main pier was found to be in good agreement with the NOS survey. The cove is protected to the north by the Coddington Cove breakwall. To the southwest, the cove is surrounded by high cliffs formed by glacial scouring during the Pennsylvanian Era. This geology is common for much of the shoreline along the southwestern coast of Aquidneck Island.

Previous investigations of Coddington Cove hydrography are lacking, but generalized features can be discerned from general knowledge of Narragansett Bay. Characterized as a temperate, partially to well-mixed estuary, the bay is oriented north to south, originating in the Providence River to the north and terminating into Rhode Island Sound to the south. The strength and pattern of water circulation in the Bay varies over a range of temporal and spatial scales in response to a variety of competing

driving mechanisms. Most obvious is the diurnal tidal circulation which, for example, can exceed 2 knots in the main channel of Narragansett Bay adjacent to Coddington Cove. The interaction of strong tidal circulation with highly variable bottom topography can result in localized areas of substantial bottom energy for sediment resuspension and vertical mixing into the water column. Less apparent, but of considerable importance is the non-tidal circulation component that is driven by wind and, to a lesser extent, fresh water input.

Atmospheric conditions within New England are strongly influenced by winds from the northwest during the winter months, due to the high pressure weather systems off the Canadian shield. During spring-summer months, Bermuda high pressure systems drive winds from the southwest; the intensity of the wind is determined by the magnitude of land mass heating and resultant convection currents. The geographic orientation of Narragansett Bay makes bay waters and coastline particularly exposed to summer southerly sea breezes, hurricanes and winter "northeaster" storms. Weisburg (1976), for example, found a 50-50% split between tide- and wind-derived mixing energy over extended time periods, suggesting that wind events can permeate the entire water column and be more important than tidal flow in the bay.

Coddington Cove has no major fresh water source, therefore circulation patterns and energies within the cove are expected to be dominated by some combination of tidal and wind forcing. In the present study, a detailed investigation of circulation dynamics for Coddington Cove was conducted so as to permit the evaluation of chemical transport and fate in the study area. These results are discussed in Section 4.2.

3.1.2. Onshore Site Characterization

Derecktor Shipyard consists of 41.35 acres of land and improvements, surrounded on the north, east and south property boundaries by the Naval Education and Training Center (NETC). Approximately 80 percent of the shipyard is covered by buildings or pavement; no natural fresh water bodies are located within Derecktor Shipyard.

Subsurface soils occurring at NETC are derived from glacial till which is sufficiently permeable to permit the vertical migration of surface water into the groundwater. Even where exposed bedrock occurs, numerous cracks and fissures exist so to also permit surface water infiltration.

Groundwater at Derecktor Shipyard is classified as "GB" by the Rhode Island Department of Environmental Management (RIDEM), indicating that it is considered not suitable for drinking water without treatment due to known or presumed degradation. Also, the groundwater is shallow (less than 10 feet below the surface in most areas) and tends to flow to the west and discharge into Narragansett Bay. Thus, groundwater is a potential pathway for contaminants entering surface waters at NETC to be released into Coddington Cove.

The Derecktor Shipyard site was investigated in the Initial Assessment Study (Envirodyne Engineers, 1983) and the Confirmation Study (Loureiro Engineering Associates, 1986). The onshore Remedial Investigation (RI) included ambient air and radiological surveys, soil gas surveys, geophysical surveys, surface soil sampling, test borings, test pits, ground water monitoring-well installation and sampling, and leachate spring sampling. The findings of the onshore RI, presented in two reports (TRC, 1992; TRC, 1994b), indicated that elevated levels of PAH and metals contaminants are present in the soil at the site (Table 3.1-1). Levels of these contaminants exceed

National Oceanic and Atmospheric Administration (NOAA) benchmarks for marine sediments (Long *et al.*, 1995), assuming similar concentrations of contaminants in soils and sediments due to direct soil runoff into the cove (Table 3.1-1). Metals detected in the groundwater of this area also exceeded EPA Water Quality Criteria (Table 3.1-2).

3.1.3. Phase I Offshore Field Investigations

In 1993-94, scientists from the Graduate School of Oceanography, University of Rhode Island, collected surface sediment samples from stations offshore of Derecktor Shipyard, NETC, and a selected reference station located in Jamestown Potter Cove in Narragansett Bay (Figure 2.0-1). The purpose of this investigation was to characterize the embayment area located adjacent to the shipyard for magnitude and extent of chemical contamination which may be shipyard-related. These samples were analyzed for grain size distribution, organic carbon content, inorganic contaminants, and organic contaminants. Station locations are shown in Figure 3.1-3.

Grain Size Distributions/Total Organic Carbon. The results of grain size analysis of the surface sediment samples revealed that many shallow water stations (1, 2, 4, 9, 10 and 17), and most offshore stations (13, 14, 16 and 24), had high sand contents, whereas the remaining stations (5, 6, 8, 11, 12, 18, 19, 20, 22 and 23) were relatively fine grained. Core sample analyses indicated that sediments collected at Stations 1 and 3 were extremely variable down core, whereas sediments collected at Station 12 were relatively fine-grained and uniform down core. The organic carbon content of the Coddington Cove surface sediments was inversely correlated to the grain size distribution. Coarser sediments had lower organic content, whereas finer sediments had higher organic content. These relationships are consistent with the hypothesis that shallow and offshore areas are exposed to erosional forces which winnow the lighter, smaller and more organic particles from the sediment, leaving the coarser, lower organic content sediments behind.

Inorganic Contaminants. The results of metals analysis for Coddington Cove surface sediment samples using partial digestion methods revealed a wide range of variation in metal concentrations, a significant component of which can be attributed to lithologic variation. (Note that the partial digestion method results in lower estimates of bulk sediment metal concentrations than the total digestion methods used in the present investigation and thus are not directly comparable). Maximum concentrations of nickel, lead, chromium, zinc, copper, mercury, and silver, normalized to grain size, were found adjacent to the outfall pipes at the former Derecktor Shipyard. Normalization of the trace metal concentrations to the total aluminum concentration also indicated higher metals concentrations adjacent to the outfall pipes which decreased with distance from the outfalls. These results suggested that shipyard-related activities were resulting in trace metal loading to Coddington Cove.

Acid Volatile Sulfide (AVS) and Simultaneously Extractable Metals (SEM) studies were undertaken on the surface sediment samples obtained from Coddington Cove in order to determine the potential bioavailability of divalent trace metals. AVS concentrations in the surface sediments of Coddington Cove were relatively high, and ratios of SEM/AVS were very low (i.e. $<<1.0$), suggesting that despite elevated concentrations, the divalent metals may not be bioavailable to aquatic biota.

Previous studies of Narragansett Bay sediments (King, 1994; Corbin, 1989) have shown that anthropogenic metals concentrations decrease exponentially down-bay from the major sources in the Providence metropolitan area. For example, the maximum concentrations of copper found in Narragansett Bay are comparable to those found in the Providence River, and the copper concentrations at Station 12 are comparable to those found at mid-bay stations. The concentrations of selected anthropogenic metals, including copper, zinc, lead and nickel, in Coddington Cove sediments were found to be elevated relative to sediments typical of lower Narragansett Bay. The concentrations of two other anthropogenic metals, chromium and cadmium,

were found to be slightly elevated by similar comparison. These results indicate that a major local source of anthropogenic metals exists in Coddington Cove.

Organic Contaminants. Table 3.1-3 provides a summary of the organic contaminants found in surface sediments (top 2 cm) from 24 stations in Coddington Cove collected during the Phase I URI 1994 Survey. The locations of several of the stations (i.e., Station 1 through Station 4) were selected because of their proximity to outfalls discharging into Coddington Cove and to piers with shipping activity (i.e., Station 11; Figure 3.1-3). A comparison of Total PCBs, Total PAHs, p,p'-DDE and tributyltin (TBT) for all 24 stations revealed that, overall, Station 3 and Station 11 had the highest concentrations of total PCBs and total PAHs, Station 3 had the highest level of p,p'-DDE, while Station 2, 3, 19, 22, and 23 had the highest levels of TBTs.

Total PCBs are calculated by multiplying the sum of individual congeners measured in each sample by a conversion factor (2.0) to obtain comparable data as would be obtained from the analysis of individual Aroclor mixtures (NOAA, 1989). Total PCBs ranged from 9.4 ng/g at Station 16 to 733.3 ng/g at Station 3. The concentrations of individual PCB congeners in surface sediments from Stations 5, 18, and 20 revealed that CB077/154 (unresolved mixture of 2 congeners), CB138, CB153 and CB118 were the major constituents.

The PAHs found to be most elevated included fluoranthene, pyrene, and chrysene. Total PAHs is the sum of all the individual Polycyclic Aromatic Hydrocarbons (PAHs) measured in each sample (24 total). Total PAHs ranged from 285 ng/g at Station 16 to 66,000 and 81,700 ng/g at Station 2 and Station 3, respectively.

The pesticide p,p'-DDE was the most abundant organochlorine pesticide (OCP) species in the samples, and was found to vary from non-detected concentrations at Stations 18 and Station 20 to 13.6 ng/g at Station 3.

Butyltins are reported as the weight of tin (Sn) within the organic matrix (e.g., ng Sn/g). Tributyltin was the major butyltin species observed, with concentrations in sediments ranging from 31.7 ng Sn/g at Station 1 to 371.7 ng Sn/g at Station 2.

All of the sediment cores measured in the study (Stations 1, 3, and 12) revealed evidence of organic contaminants down to the deepest sections analyzed. Organic contaminant distributions in core sections from Station 12 revealed that the contaminant concentrations either remained constant or increased with depth in the core. Based on the presence of TBT (and its approximate usage start date), all sections of this core were deposited after 1960. The presence of C_{10}- benzotriazole (manufactured after 1970) in the 22-24 cm section, as well as its absence in the last deeper section, indicates that the latter was deposited before 1970 (Pruell and Quinn, 1985). Thus, the sedimentation rate at this location, based solely on these chemical markers, is estimated to be 1 cm/yr.

3.1.4. Coddington Cove Habitat Investigations

In 1991, the Narragansett Bay Project contracted Applied Science Associates to map habitats and natural resources in and around Narragansett Bay. Aerial photo data collected in April 1988 were obtained, interpreted, and translated into ArcInfo Geographic Information System (GIS) format (French *et al.*, 1992).

A variety of habitat types exist around Derecktor Shipyard, ranging from the upland and pavement areas, to the fringe salt marsh and rocky intertidal in the southern cove area (Figure 3.1-4). Coddington Cove proper is classified in its entirety as estuarine open water and is approximately 1.4 km^2 in surface area. Habitat other than open water and pavement in the cove area which may be suitable for wading birds is approximately 0.2 km^2. Extensive areas of the cove were substantially modified during base construction. The tide flows in and out of cove on a twice-daily basis through the

open access to Narragansett Bay. Typical tidal fluctuations between high and low tides are on the order of 3 to 4 feet.

3.2. Assessment and Measurement Endpoints

A target analyte list was developed in response to the regulatory requirements of the Remedial Investigation/Feasibility Study (RI/FS) for the Naval Education and Training Center (NETC), Newport, and through recognition of a number of potential chemical stressors associated with past disposal practices and other Naval operations (Table 3.2-1). The list was based on those chemical contaminants detected during previous offshore (i.e., Quinn *et al.*, 1994) and on-shore investigations (e.g., TRC, 1994), and includes both metals (Hg, Ni, Zn, Cu, Cd, Cr, Pb, and Hg) and organic compounds (PAHs, PCBs, butyltins, and organochlorine pesticides (OCPs)). This list also includes several other metals (Al, Fe, Mn) which may at least in part be reflective of background conditions. The list reflects current understanding of those chemicals which are both of toxicological importance and persistent in estuarine systems. It encompasses selected potentially toxic chemicals which may serve as indicators of human activity (although for different uses) and whose discharge into the environment has been enhanced through industrialization (NOAA, 1991).

In keeping with the requirements of the RI/FS process, and based on the potential ecological effects of the chemical stressors (identified above), a suite of assessment and measurement endpoints were identified as important in the ecological risk assessment. As indicated in Table 3.2-2, these include the vitality of pelagic, epibenthic, and infaunal communities, as represented by common and/or natural resource species in Narragansett Bay. Target receptors chosen to be representative of these habitats/trophic modes are discussed in Section 3.4.

Exposure point measurements employed as indicators of the assessment endpoints are presented in Table 3.2-3. The exposure point measurements were selected based on their relevance to:

- The assessment endpoint and receptors of concern, their relevance to expected modes of action, and effects of CoCs;
- Determination of adverse ecological effects;
- Availability of practical methods for their evaluation; and
- Their usefulness in extrapolating to other endpoints.

Most of these measurement endpoints have been used in other studies, and have proven to be informative indicators of ecological status in marine and estuarine systems with respect to the stressors identified as important in this assessment. Many serve a dual purpose in that they provide information relevant to two or more assessment endpoints.

In addition to the measurement endpoints used to evaluate the occurrence of, or potential for, adverse ecological effects, exposure point measurements were employed to evaluate exposure conditions. As shown in Table 3.2-3, these exposure point measurements include chemistry measurements made in environmental media (water, sediment, elutriate, and biota), as well as geochemical attributes of exposure media which may influence the availability of contaminants to receptors.

The exposure point measurements include fecal pollution indicators, which are microbial organisms whose abundance is measured as the concentration of the organism per unit of matrix (e.g., no./ml, no./g wet tissue). These organisms are

released into the environment via discharges of human and/or animal feces, or improperly treated sewage effluent (Cabelli, 1978). As such, fecal indicators reflect potential contaminant migration pathways and other indirect stresses caused by co-mingled contaminants in waste streams, and/or other undesirable ecological changes associated with fecal pollution (e.g. nutrient-induced sediment organic enrichment and anoxia, and altered ecological function due to shifts in species composition). For the exposure assessment, these organisms act as chemical surrogates for other, unmeasured compounds, and their concentration provides information on the relative importance of various pollutant sources to the environment, assuming the concentration of other unmeasured compounds would be available in proportional amounts to the measured indicator. As effects indicators, the strength of relationship between this measurement endpoint and other, related endpoints (biota condition, benthic community structure) will be used to support the determination of the probability that habitat disruption has occurred. Data on three fecal pollution indicators (*Clostridium perfringens*, fecal coliforms (including *Escheria coli*), and total coliforms) are included in the weight of evidence summary as a way of reducing the uncertainty about the accuracy of this weight of evidence.

These measurement endpoints will be used as the weight-of-evidence in the exposure assessment component of the risk characterization summary. The protocols and methods used to evaluate measurement endpoints and exposure point measurements are discussed further in Section 4.0.

3.3. Contaminants of Concern

Proposed Contaminants of Concern (CoCs) have been identified for this investigation using a rationale which links the source (Derecktor Shipyard) to potential marine receptors in adjacent Coddington Cove and Narragansett Bay through plausible

exposure pathways. The selection process involves sequential evaluation of target analyte concentrations, first considering the frequency of detection, then elevation relative to minimum effects benchmarks. For analytes lacking benchmarks, site concentrations were compared against reference concentrations.

Benchmarks are numerical criteria or guidelines which establish chemical concentrations presumed to be protective of biological systems. For derivation of CoCs in this ERA, site sediment concentrations are of primary consideration as sediments are the major reservoir for CoC constituents. Available (i.e., nationally recognized) benchmarks for sediments include the Apparent Effects Threshold (AET; U.S. EPA, 1989a), Effects Range-Low and Effects Range-Median (Long *et al.*, 1995), and Equilibrium Partitioning-based Aquatic Life criteria (EqP-AL; U.S. EPA 1989b, Adams *et al.*, 1992). The AET approach uses data from matched chemistry and biological effects measures, and is the concentration of a selected chemical above which statistically significant biological effects are expected to occur (U.S. EPA, 1989a). Effects Range-Low (ER-L) and Effects Range-Median (ER-M) are benchmarks representing the 10th and 50th percentiles, respectively, of ranked chemical concentrations (predicted or measured) at which biological effects were observed. The Equilibrium Criteria-Aquatic Life Approach (Adams *et al.*, 1992) predicts effects in porewater for non-ionic organic contaminants based on the water quality benchmark, accounting for partitioning between dissolved and particulate phases. For three of the chemicals measured in site sediments for this ERA, the EPA has promulgated criteria known as Sediment Quality Criteria (SQC; DiToro *et al.*, 1991). Each benchmark has advantages and disadvantages as well as differing degrees of applicability for various chemical groups.

For this ERA, the lowest of the matrix-specific benchmarks was used as the screening value for each compound (Table 3.3-1). In most cases, the NOAA ER-L was the minimum benchmark value. For chemical constituents lacking benchmarks,

sediment concentrations measured at reference locations were used as the basis of comparison.

Results of the screening process for the development of the marine sediment CoC list are summarized in Table 3.3-2. Frequency of detection was calculated as the percentage of total site samples analyzed which had detected concentrations. The range of concentrations reported for site data excludes non-detected values. One-half of the Sample Quantitation Limit was substituted for non-detected values calculating the mean concentration of each compound for both the site and reference stations. The 95% upper confidence limit was calculated according to standard statistical procedures (Snedecor and Cochran, 1980), assuming a one-tailed distribution (i.e. only data exceeding the upper 95% confidence limit are of interest). Where the 95% UCL was greater than the site maximum concentration, the maximum concentration was used to screen against benchmark or reference data. Lastly, information on bioaccumulation persistence and toxicity was also considered in the selection of CoCs.

All PAH analytes (including calculated sums for low and high molecular weights and total PAHs) were found to exceed benchmarks where comparisons were possible. Two PAHs (2-methylnaphthalene and naphthalene) did not exceed benchmarks, and were excluded as CoCs. For metals, all analytes, with the exception of cadmium, had maximum concentrations in bulk sediments which exceeded benchmarks. For organic contaminants lacking benchmarks, all analytes exceeded background concentrations. Because their frequency of detection was < 5%, aldrin and hexachlorobenzene were excluded as CoCs.

As a result of the screening process, all target analytes except for aldrin, cadmium, hexachlorobenzene, 2-methylnaphthalene, naphthalene, and tetrabutyltin were included as CoCs for the ERA. The analytical results used in this ERA were consistent with those of earlier studies (e.g., Quinn *et al.*, 1994) with respect to the

specific classes of compounds which are elevated in the marine sediments adjacent to Derecktor Shipyard (see Section 3.1). It should be noted that this list of CoCs is conservative in that the screening procedure involved maximum contaminant concentrations and conservative benchmark concentrations. Final consideration of CoCs for offshore exposure media will be made following completion of the Exposure Assessment (see Section 4.0 of this report).

3.4. Receptors of Concern

Identification of ecological systems/species/receptors of concern (hereafter collectively termed "receptors of concern") involved evaluations of the importance of each potential receptor (or "candidate") to the ecology of the Derecktor Shipyard study area and Narragansett Bay, its sensitivity to stressors associated with the site, and its aesthetic, recreational, and commercial importance as a natural resource of Narragansett Bay. The site characterization for Derecktor Shipyard identified a number of estuarine systems and habitat types (Section 3.1.3). The nature of chemical stressors originating from Derecktor Shipyard operations suggests that several ecological receptors may be potentially at risk, including:

- Nearshore habitats directly adjacent to shipyard areas;
- Pelagic communities, including plankton and fish;
- Infaunal benthic communities in sediment depositional areas;
- Soft- and hard-bottom epibenthic communities; and

- Commercially, recreational, and/or aesthetically important natural resource species.

Although French *et al.* (1992) provides a bay-wide perspective of habitat types (Section 3.1.3), the lack of specific, detailed information on critical habitats which are potentially present in the general vicinity of Derecktor Shipyard represents a data gap which is not addressed in this study.

The estuarine systems and habitats of Derecktor Shipyard include primarily subtidal environments, consisting of wharves and piers, sand- or silt- bottom, with limited coverage of intertidal environments. The identification of estuarine systems and habitats potentially at risk from Derecktor Shipyard contaminants provides a natural progression to the selection of target receptors of concern for this ecological risk assessment (Table 3.4-1). These target receptors, and the rationale for their selection, include:

- Blue mussel (*Mytilus edulis*): This species is a locally abundant and ecologically important filter-feeding bivalve found in intertidal and subtidal habitats. It is an important food source for birds, fish, starfish, and occasionally humans. Blue mussels are surrogates for epibenthic species in the intertidal environment, where they are potentially exposed to water-borne and particulate-bound contaminants. Blue mussels may also serve as surrogate species for pelagic species when collected from mid-upper water column (i.e., deployment of mussels on mooring floats).

- Cunner (*Tautogolabrus adspersus)*/Mummichog (*Fundulus spp.*): These species are locally abundant and ecologically important estuarine fish which feed opportunistically upon both animals and plants, and have limited home range due to territorial behaviors. When abundant, they may

be an important food source for birds and other fish, and are a surrogate for other pelagic fish species potentially exposed to water-borne and bulk sediment contaminants.

- Winter flounder (*Pleuronectes (=Pseudopleuronectes a.) americanus*): This species is a locally abundant, ecologically and economically important fish. It feeds upon benthic organisms and has a wide range of exposure due to its migratory behavior. It is an important food source for birds, predatory fish, and humans. Flounder represent other demersal fish species potentially exposed to water-borne and bulk sediment contaminants. Toxicity exposure information for fish, except for direct contact exposure, is scarce. This species was observed inshore near Derecktor Shipyard (RIDEM, 1993).

- Lobster (*Homarus americanus*): This species is locally abundant, and an ecologically and economically important subtidal crustacean which feeds opportunistically as a scavenger. It is an important food source for fish and humans. The lobster represents an epibenthic species potentially exposed to water-borne and bulk sediment contaminants.

- Hard clams (*Mercenaria mercenaria/Pitar morrhuana*): These morphologically and ecologically similar subtidal bivalve filter feeders are locally abundant, and are ecologically and economically important. They are important food sources for birds and occasionally humans. Hard clams are representative of infaunal species potentially exposed to bulk sediment and pore water contaminants.

- Benthic community: The benthic community (including sponges, corals, mollusks, segmented worms, arthropods (including crustaceans), starfish,

and chordates (tunicates and fish)), is an ecologically important, potentially rich assemblage of species with numerous life histories and feeding strategies. It is an important food source for birds, fish, and benthic and epibenthic invertebrates. The benthic community is potentially exposed to contaminants in bulk sediments, pore water, and the water column.

Many of these receptors are important resource species for Narragansett Bay, but also can be considered surrogate receptors for larger groups of species. For instance, the hard clam, *Mercenaria mercenaria,* is an important commercial species for Rhode Island, as well as an indicator species for infaunal bivalves in general. However, as discussed in a later section, not all of these species occurred at all of the sampling stations.

Stressors introduced to the bay may indirectly affect avian receptors. For example, bivalves and fish contaminated with chemicals may be consumed by shorebirds, resulting in direct or indirect biological effects. For this reason, avian target receptors of concern include:

- Great Blue Heron (*Ardea herodias*) / Herring Gull (*Larus argentatus*): These species are local avian aquatic predators which feed upon invertebrates and fish. The heron is a top-level carnivore and represents wading shorebirds (e.g., snowy egret, *Egretta thula*) which are principally piscivorus and may also occur on site. Herring gulls are common to the area and display an omnivorous feeding habit. Impacts on these species will be assessed through food web modeling.

3.5. CONCEPTUAL MODELS

Conceptual models are developed to provide a framework for hypotheses concerning how a given stressor might cause ecological impacts on receptors of concern (U.S. EPA, 1992). Four models, comprising the overall conceptual model for this assessment, have been developed using a tiered strategy. Models in the initial tiers are more general and inherently carry greater uncertainty, whereas the more complex fourth-tier models have greater complexity and certainty for the specific pathways being evaluated. In the process of further refinement of models in subsequent tiers, hypotheses are retained or rejected based on existing knowledge of contaminants and receptors of concern. However, as previously indicated, the conceptual model approach in this assessment addresses only current conditions and levels of activity at the site, and does not address future use scenarios involving fundamentally different conditions or activities at the site.

The initial three tiers describe stressor origin, transport, fate, and effects at different spatial and temporal scales. Tier I represents the general north to south gradient of chemical contamination in Narragansett Bay, Tier II represents the initial release and transport of site-specific CoCs to the bay from the Derecktor Shipyard and other NETC sites, and Tier III represents the longer-term transport, fate, and effects of those CoCs. The fourth tier models include specific receptors and stressors as identified in Section 3.3 and 3.4, respectively. Each of the four model tiers is described in detail below.

3.5.1. Tier I Model

The first tier of the conceptual model (Figure 3.5-1) describes the general down-bay (i.e., north to south), higher-to-lower gradient in stressor concentration. Although many sources contribute to this gradient, and local sources may influence specific

stressor concentrations anywhere in Narragansett Bay, this model suggests that contaminant concentrations in the immediate vicinity of Navy facilities should be evaluated within the context of the ecology of the entire lower bay. As a result of this model evaluation, a reference station which occupies a similar "urbanized" environment opposite Derecktor Shipyard in Jamestown's Potter Cove, is appropriate to identify baseline ecological conditions without shipyard-related influences, while the reference station at Castle Hill Cove provides a relatively non-impacted environment for comparative purposes.

3.5.2. Tier II Model

The second tier of the conceptual model describes the local release of contaminants from Derecktor Shipyard and other NETC sites into greater Narragansett Bay (Figure 3.5-2). The first hypothesis framed by this model is that CoCs are being transported from land-based sources to adjacent coves and Narragansett Bay, predominately *via* surface runoff and ground water (including seeps) routes, although air transport of chemical pollutants bound to soil and dust particles also may occur.

The geographical configuration of the Derecktor Shipyard study area is such that it is somewhat sheltered from the main flow of tidal currents in the bay, and hence opportunity for sediment deposition in Coddington Cove is probable. Accordingly, water circulation provides a hydrographic continuity between the shipyard nearshore environment and greater Narragansett Bay. Various areas of Derecktor Shipyard may experience longer water residence time due to more restricted circulation, and thus sediments may have higher concentrations of CoCs than areas with more dynamic circulation. Thus, localized gradients in contaminant concentrations would be expected, with the highest levels predicted in areas of restricted circulation most notably those immediately adjacent to the shipyard.

3.5.3. Tier III Model

The third tier of the model describes details of the aquatic behavior of contaminants hypothesized to exert ecological effects within the Narragansett Bay system (Figure 3.5-3). The model arrows indicate that the short-term behavior of contaminants in the water column depends on their solubility, degradation rates, and sorption to particulate matter. Bound contaminants may be transported with the current in association with particles, but may also settle to the bottom in localized depositional areas, such as those areas suspected for the shipyard. Individual molecules may remain in a dissolved state or will adsorb and desorb in a dynamic fashion, maintaining an apparent equilibrium relative to sorption state. Dissolved contaminants are transported to other parts of Coddington Cove and possibly Narragansett Bay by prevailing current patterns.

Once on the bottom, local currents may result in bedload transport of sediment, resulting in a further redistribution of the contaminants. Subsequent deposition of uncontaminated particles may bury earlier settling particles, and eventually block them from contact with ecological systems. Chemical-specific partitioning dynamics will occur in the sediments and interstitial (pore) waters in response to the geochemical conditions (e.g., redox potential) of those sediments. Contaminants may be available to biological systems in the water column, pore water, and surficial sediments, resulting in direct toxicological effects and/or biological uptake and transfer through food webs.

Based on this generalized conceptual model, ecosystems potentially at risk are hypothesized to include nearshore habitats, pelagic, benthic and epibenthic communities, and natural resource species. In addition, stressor partitioning dynamics suggest that risks to receptors should be highest in nearshore areas adjacent to the shipyard site, and that the assessment should focus on CoCs associated with depositional sediments. Stressors which conform to this model of contaminant behavior

include metals, organic contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs), butyltins, and Organo-Chlorine Pesticides (OCPs).

3.5.4. Tier IV Models

The description of stressor dynamics suggests risks to the aforementioned systems to be highest in areas adjacent to Derecktor Shipyard. Although risks to other ecological systems present in the Narragansett Bay area cannot be dismissed, this conceptual model focuses the assessment on ecosystems considered to be directly influenced by depositional sediments near the shipyard.

The initial three tiers describe the origin, transport and fate of stressors at different spatial and temporal scales. To complete the model, receptors and stressors specific to the Derecktor Shipyard are added in the fourth and final tier, which describes exposure pathways (from source to receptor) hypothesized for the site.

The fourth tier conceptual models describe hypothesized exposure pathways relating CoCs to the receptors of concern identified in Table 3.4-1. These models were developed for receptors by ecological habit (pelagic, epibenthic, infaunal and avian aquatic predator), and their respective exposure pathways are illustrated in Figure 3.5-4 through Figure 3.5-7. Measurement endpoints directly evaluating the effects of CoCs on avian aquatic species are not included in this study. However, an evaluation of the potential impacts to species group from ingestion of prey organisms hypothesized to be part of the exposure pathways to the predator is characterized through measurement of the spatial distribution and residue concentration of the food source. Hence, relevant issues for this trophic group with regard to the ERA framework are addressed from this perspective.

Illustrated in Figures 3.5-4 through 3.5-7 are the routes of CoC transport from terrestrial sources, through intermediate sources (groundwater runoff, soils), to the proximal source of exposure, and to receptors. These proximal sources become the exposure points in the Exposure Assessment (Section 4.0). Also illustrated are the measurement endpoints which will be evaluated in the Ecological Effects Assessment (Section 5.0).

3.6. Sampling and Analysis Summary

This section describes data collection and analysis activities required to develop the information base necessary to complete the ecological risk assessment. As discussed in Section 2, the sampling was needed to acquire chemistry and toxicity data for surficial sediments in the area adjacent to the shipyard, and to gather biological data to assess the condition of potentially affected receptors. Measurements of organic and metal contaminant concentrations in sediment and organisms, and studies of pore water metal concentrations and SEM/AVS ratios, were performed in conjunction with toxicity, biological condition, and community analysis studies to assess the potential impact of the shipyard on the biota. In the sections that follow, a brief discussion is presented on station locations and selection rationale, and sampling and analysis methods for chemical, geotechnical and biological endpoints. A complete description of the methods and QA/QC procedures is contained in the Master Work Plan, Appendix C, or included herein as appropriate. Documentation of field activity and sample collection is included in Appendix E-1.

3.6.1. Sediment and Biota Sampling Activities

Sampling was done from three research vessels as well as from shore. For relatively shallow stations (< 3 meters of water), a 7-meter pontoon boat and a 6-meter

support motorboat owned by the URI Graduate School of Oceanography were used for sampling. For deeper stations, the 20 meter URI Ocean Engineering Department research vessel CT-1, was used for sampling. The research vessels were moored at the Navy facilities in Coddington Cove when not in use.

Sediments. The locations of the sampling stations adjacent to Derecktor Shipyard are shown in Figure 3.6-1. A total of 17 stations in Coddington Cove were sampled to characterize harborfront (Stations DSY-25 to DSY-29) and pier-side conditions (Stations DSY-30 to DSY-32) as well as areas more removed from shoreside activities (DSY-33 to DSY-39). Additionally, sediment and biota sampling locations were added in the Derecktor enclosure area (DSY-40 and DSY-41) as a special area of potential concern, because a prior video survey conducted by Navy divers noted an apparent lack of benthic life forms in this vicinity. Vibracore samples were taken at 15 locations throughout the study area (Figure 3.6-2) in order to characterize core sediment grain size and lithology. However, sediment chemistry analyses of vibracore samples were performed only at Stations V4 and V9.

Reference collections for sediments and biota were taken at Jamestown Potter Cove (JPC) on Conanicut Island, which is due west of Coaster Harbor (Figure 2.0-1). As identified in the first Tier model (Figure 3.5-1), Potter Cove and Coddington Cove are located approximately in the same position along the Narragansett Bay pollution gradient, and hence would be expected to have similar CoC exposure in the absence of Navy-related facilities. Another similarity between the JPC reference site and the Derecktor Shipyard/Coddington Cove study area includes the proximity to Waste Water Treatment Facility Outfalls (WWTFOs): Coddington Cove is adjacent to the City of Newport WWTFO, whereas Potter Cove is adjacent to the City of Jamestown WWTFO. The JPC reference site shares similarity to Coddington Cove with respect to natural habitat; the subtidal environment includes muddy bottom inshore (JPC-1) and sand habitat offshore (JPC-2).

A second reference site, Castle Hill Cove (CHC), is a small embayment approximately 2 miles south of Coddington Cove (Figure 2.0-1). The site was primarily intended for assessment of baseline biota CoC residues and field effects measurements because the habitat lacks soft sediment due to strong currents and minimal sediment loading. The cove does contain some urbanized activities, including boat dockage and a small Coast Guard facility, which may result in contaminant introductions. There is also information to suggest that a sewage outfall may have at one time been in operation in the cove, although the surrounding area is quite rural.

A sample collection and laboratory analysis summary is shown in Table 3.6-1. At all 19 surface stations (including two reference stations at Jamestown Potter Cove), surface sediments (0-15 cm) were collected. A Van Veen grab was used to collect surface sediments; 3-4 grabs were often required to collect a sufficient sample for both chemistry and toxicity analyses. The surface material from each grab was composited in a 12-liter, pre-cleaned polyethylene bucket, stirred with a titanium stirrer for ~30 seconds, and then scooped into pre-cleaned containers for organic and inorganic chemistry, elutriate analyses and toxicity studies. Additional grab samples were obtained at each station and used for benthic infaunal analysis. Between stations, the scoop was rinsed in sequence with distilled water, 1:1 nitric acid, methanol and de-ionized water. Field-rinsates of the scoop were collected and analyzed as field blanks. The samples were stored on blue ice during collection and, upon return to the laboratory, at -20°C and 4°C for chemistry and toxicity studies, respectively.

Cores (down to ~1 meter) were collected for chemical analysis at seven stations. A standard piston corer, the biological corer, was used to retrieve cores of about 1 m in length. A mid-depth (~ 20-50 cm) and deep section (~ 60-80 cm) of each core was analyzed for chemical contaminants. The corer used polycarbonate tubes and was deployed using a series of 3 meter long extension rods to push the corer into the sediment. Vibracore samples were collected at two additional stations (i.e., Stations V4

and V9; see Appendix D for core descriptions). The cores were transported in the vertical position to the lab for storage at 4°C until logging and sectioning. Sectioning was completed within 48 hr of collection. Sectioned sediment samples were stored at -20°C until chemical analysis. Sediment sample stations are indicated in Figure 3.6-1.

Biota. The biota sampling summary for the Derecktor Shipyard ERA is also presented in Table 3.6-1. In every possible case, the biota sampling location was paired with a sediment sampling location, so as to allow exposure-response relationships to be investigated. Biota sampling included the following:

- *Benthic Community Structure*. Sampling for benthic community structure (DIV) was conducted at each of the 17 sediment sampling locations in Coddington Cove (Figure 3.6-1), two locations in the Jamestown Potter Cove reference area, and one location at Castle Hill Cove (Table 3.6-1). Duplicate 400 cm^2 Van Veen grab samples were obtained and sieved aboard ship to 0.5 mm. Organisms were picked from the screen and preserved separately for taxonomic analyses.

- *Epibenthic Receptors (Indigenous Blue mussels)*. Natural populations of blue mussels *(Mytilus edulis)* were collected at Stations DSY-25 through DSY-28, and Station DSY-40, to allow characterization of long-term exposure and effects on epibenthic populations in the immediate vicinity of Derecktor Shipyard (Figure 3.6-3). In addition, collections were taken at Stations DSY-24, DSY-35, and DSY-36 (Quinn, *et al.*, 1994) in order to characterize the nearshore environment where epibenthic scavengers and birds may have more active feeding. Collections of indigenous mussels were also taken in intertidal areas at two reference stations (JPC-1 and CHC-1). In Coddington Cove adjacent to the Derecktor Shipyard, the environment above the sediment water interface is entirely artificial,

consisting of docks/piers and concrete abutments. Collections were made at low tide by hand-picking specimens off these structures. Collections of indigenous mussels were taken in intertidal areas at the two reference sites. Incidence of hematopoietic neoplasia in mussel tissue was assessed on samples collected from each of these locations.

- *Infaunal Receptors (Hard Clams). Mercenaria mercenaria* were collected at Stations DSY-35 and DSY-41 and JPC-1 while *Pitar morrhuana* were collected at Stations DSY-31 through DSY-38, DSY-41 and at JPC-1 (Figure 3.6-4). Relatively low densities of both species across the study area and deeper offshore waters precluded bull raking as the sampling method and necessitated the use of SCUBA divers for collection.

- *Fish Receptors.* Cunner (*Tautogolabrus adspersus*) were collected at Stations DSY-26 through DSY-29, as well as shoreward of Stations DSY-35 and DSY-36 (Figure 3.6-5). Successful collection was restricted to the nearshore environment. Reference collections of cunner were taken at JPC-1 and CHC-1. In addition, a single mummichog (*Fundulus spp.*) was obtained at Station JPC-1. Evidence of cytochrome P450 activation in cunner was assessed at Station DSY-36.

- *Epibenthic Scavengers (Lobsters).* American rock lobsters (*Homarus americanus*) were collected at nine stations in Coddington Cove and two reference sites (Figure 3.6-6). Traps were deployed at harbor front Stations DSY-25, DSY-27, DSY-28, DSY-29; at central Coddington Cove Stations DSY-33, DSY-35 and DSY-36; and at Outer Coddington Cove Stations DSY-38 and DSY-39. Collections of lobsters were taken in the intertidal area at reference Stations JPC-1 and CHC-1.

- *Pelagic Exposure Pathways.* Mussels for deployment were obtained from a known clean area in Barnstable County, MA, often used by the EPA ERLN laboratory. Mussels were deployed at 1 m above bottom at eight stations in Coddington Cove and in deep areas at reference Stations JPC-1 and CHC-1 (Figure 3.6-7). The strategy was to characterize harbor front water quality conditions via Stations DSY-26, DSY-28, DSY-29, and in the enclosure at Station DSY-40, as well as a possible gradient in water quality extending out from the harbor along Stations DSY-31, DSY-33, DSY-38 and DSY-39. A time-zero sample was also collected to establish baseline conditions. Each station consisted of four cages on separate sub-surface floats. A composite of the four replicates was generated for a single chemical analysis at that station; condition indices were assessed on individual replicates.

In addition to chemical analyses and condition indices, mussels collected at these locations were examined for fecal pollution indicators. Data on chlorophyll *a*, total suspended solids, temperature and salinity were measured at the beginning, middle and end of the deployment, in support of interpretation of mussel growth data.

3.6.2. Geophysical/Hydrographic Sampling Activities

This section briefly details the sampling approach taken to characterize sediment distribution spatially and with depth, as well as determine the water circulation pattern near Derecktor Shipyard and adjacent Coddington Cove, including the exchange between Coddington Cove and Narragansett Bay. Further detail is provided in Sections 4.2.1 through 4.2.4.

- *Geophysical Surveys.* The geophysical survey utilized a composite Datasonics Chirp Sub-bottom Sonar and Side-Scan Sonar system. Side

scan sonar was used for surface characterization; chirp sonar was used to determine depth of sediment units. The study area, shown in Figure 3.6-8, included Coddington Cove, and a small area outside the mouth of Coddington Cove up to the Newport Sewage Treatment Plant outfall offshore of Coddington Point. The sidescan/chirp probe was towed behind a vessel along pre-designated survey lines spaced approximately 20-50 m apart. This survey strategy provided >90% bottom coverage of the survey area. Navigation was provided at Differential Global Positioning System (DGPS) accuracy (resolution to ± 3 m).

- *Hydrographic Surveys.* Transects examined during hydrographic surveys are shown in Figure 3.6-9. Data on current velocity vs. depth was collected in real time using an RD Instruments Broadbeam 1200 Acoustic Doppler Current Profiler (ADCP). This device was used for vertical profiling of water currents from a moving ship with $\pm$ 5 cm sec^{-1} accuracy. The design of the hydrographic survey was such that the pattern of water circulation driven by semi-diurnal tides, as well as longer-term, non-tidal net flow driven by winds and density variations, could be determined. Energetics and flow patterns within Coddington Cove also were assessed from the data.

To determine the effect of tidal variation during the survey (and remove its effect from the data interpretation), a pressure (tide)/conductivity/temperature gauge was deployed at the mouth of Coddington Cove. In addition, numerous Conductivity, Temperature, and Depth (CTD) surveys were also conducted to determine seawater density distributions.

3.6.3. Sediment and Biota Chemical Analyses

Sediments. The concentrations of selected metals, PCB congeners, pesticides, PAHs and butyltins in surface and core sediment samples were determined as described in the Work Plan (refer to Table 3-2 of Master Work Plan). In addition, the concentrations of Simultaneously Extractable Metals (SEM) and Acid Volatile Sulfides (AVS) in these sediments were determined.

Tissues. Tissue analytes included the same suite as determined in sediments. Shell and/or exoskeletal material were not analyzed for any species. Bivalve and fish tissues were frozen whole after collection and archived for later analysis. Samples of bivalves from the collection were selected at random and tissues excised at the organic or inorganic lab, depending on the analysis. Lobster specimens were resected immediately following euthanasia; a composite of muscle tissue groups (composite of tail and claw) was obtained for chemical analyses. In addition, the lipid content of the biota tissue was determined.

Elutriate testing. Elutriate chemical analyses were performed on selected samples. Measurements included organics as well as SEM/AVS concentration. The elutriate was prepared as a 1:4 dilution of whole sediment followed by centrifugation (USACE/EPA, 1992). Splits of particle-free water were prepared for chemical and toxicological analyses.

Whole water samples. During the sample collection period, and during the hydrographic study, whole water samples were collected at 1 m above bottom at several stations in Coddington Cove. Water was collected with a Go-flo or Niskin bottle and analyzed for temperature, salinity, pH, suspended solids, dissolved oxygen, and ammonia concentration. Methods for these analyses are described in Appendix C of the Master Work Plan.

Grain Size/Total Organic Content. Percentages of sand, silt and clay in sediment samples from each station were determined. Samples were pre-treated for removal of carbonates and organics, and then sieved using the Elzone Model 180XY particle size analyzer. Estimation of sediment total organic carbon (TOC) content was accomplished by determining the weight lost on ignition at 550°C. Details of the method are contained in URI and SAIC (1995).

3.6.4. Biological Assays

Toxicity Testing. The toxicity of whole surface sediment and sediment elutriates was assessed using the amphipod (*Ampelisca abdita*) 10-day acute test and the sea urchin (*Arbacia punctulata*) fertilization and embryo larval tests, respectively. A complete description of these test methods is contained in URI and SAIC (1995).

Condition Indices. Condition indices were evaluated for both indigenous blue mussels and deployed mussels through separate determination of tissue dry weight, shell weight and shell length, and calculation of morphometric ratios using these data.

Benthic Community Structure Analyses. Benthic community structure analysis included determination of species richness and dominance, use of multivariate statistical techniques such as clustering and multidimensional scaling, as well as inspection of data for number of opportunistic forms present. Identifications were carried out to the species level. Sampling and counting techniques closely followed those used in the EPA Environmental Monitoring and Assessment Program and in the benthic infauna survey of Coddington Cove carried out by Menzie-Cura & Associates in August 1993 (TRC, 1994).

Fecal Pollution Indicators. Total and fecal coliforms (including *E. coli*), fecal streptococci and enterococci, as well as *Clostridium perfringens* spores, were

enumerated in deployed mussel tissue using the FDA most probable number method (details in Appendix B-2-4).

Hematopoietic neoplasia assessment. Indigenous blue mussels collected from the Derecktor Shipyard/Coddington Cove stations and reference locations were assayed for the presence of a proliferative blood cell disorder called hematopoietic neoplasia. Blood of mussels was syringe-extracted from the abductor muscle and fixed/stained for microscopic examination. Details of the method are contained in URI and SAIC (1995).

Cytochrome P450 Assays. Cytochrome P450 Assays of fish tissue collected from Station DSY-36 were performed to assess induction of enzymes used to metabolize PAH compounds. Composite samples of fish liver were frozen in liquid nitrogen until sufficient biomass was obtained for analysis.

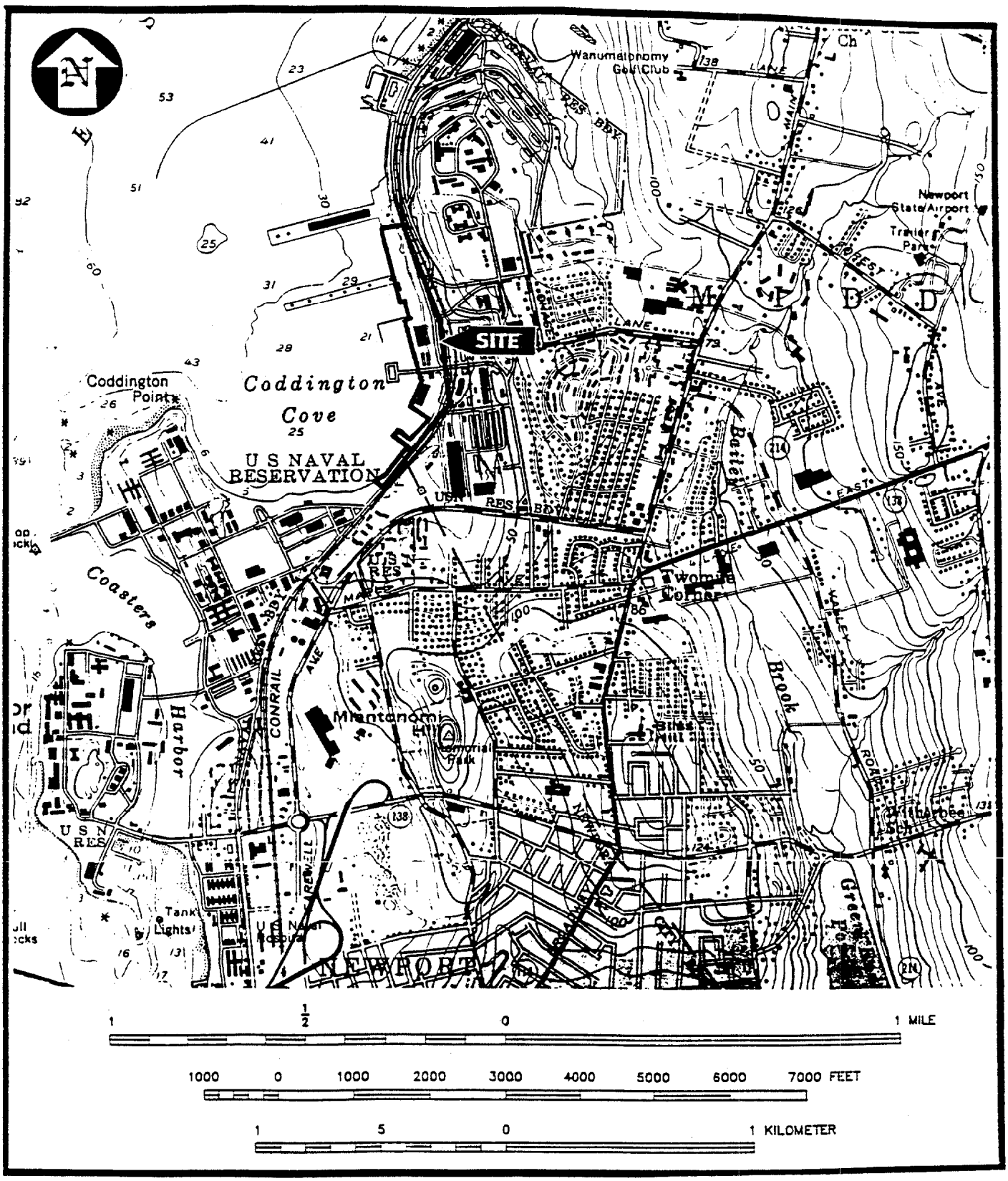
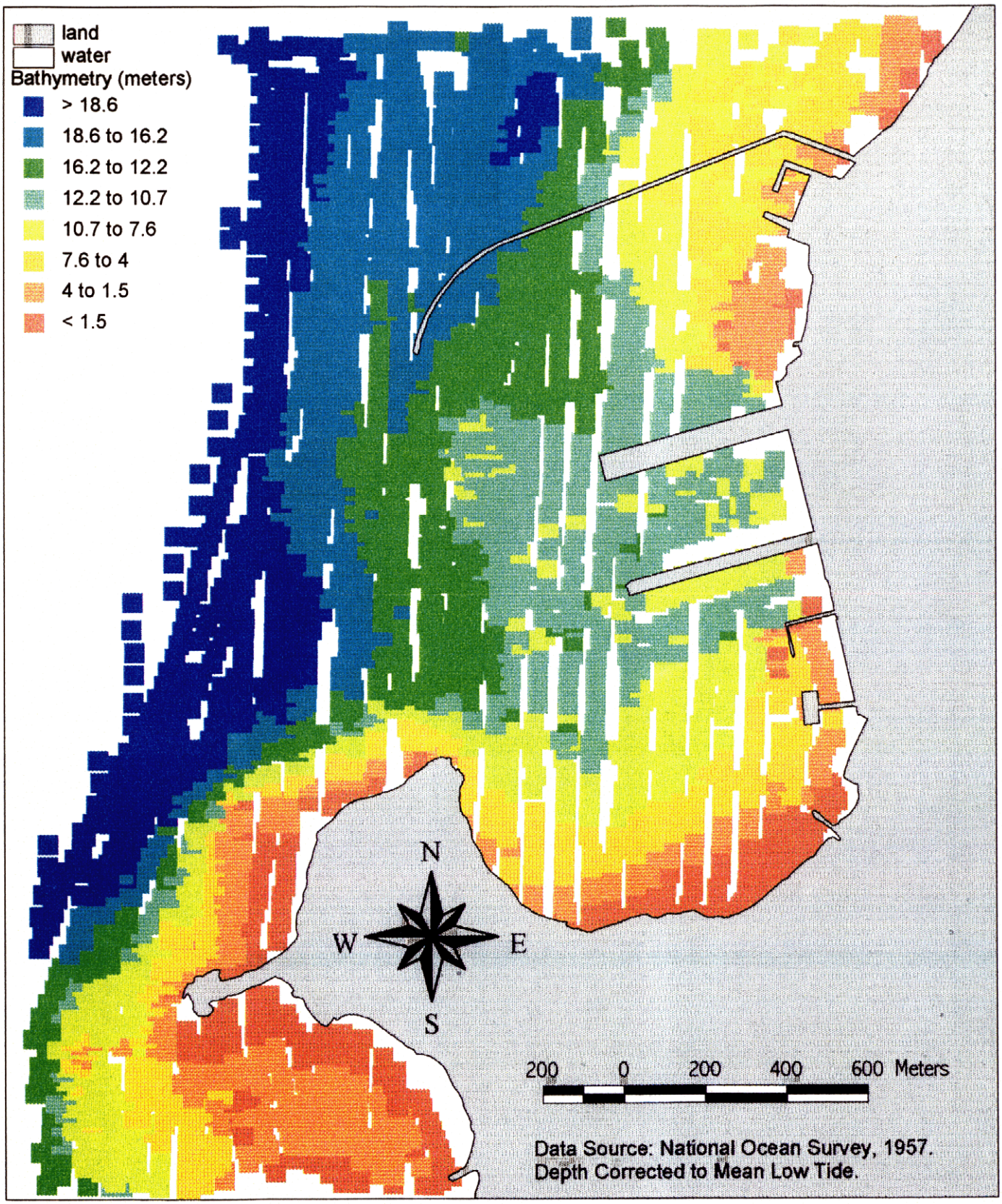


Figure 3.1-1. Site location map for the Derecktor Shipyard Marine Ecological Risk Assessment.

Figure 3.1-2. Bathymetry of Coddington Cove, RI.



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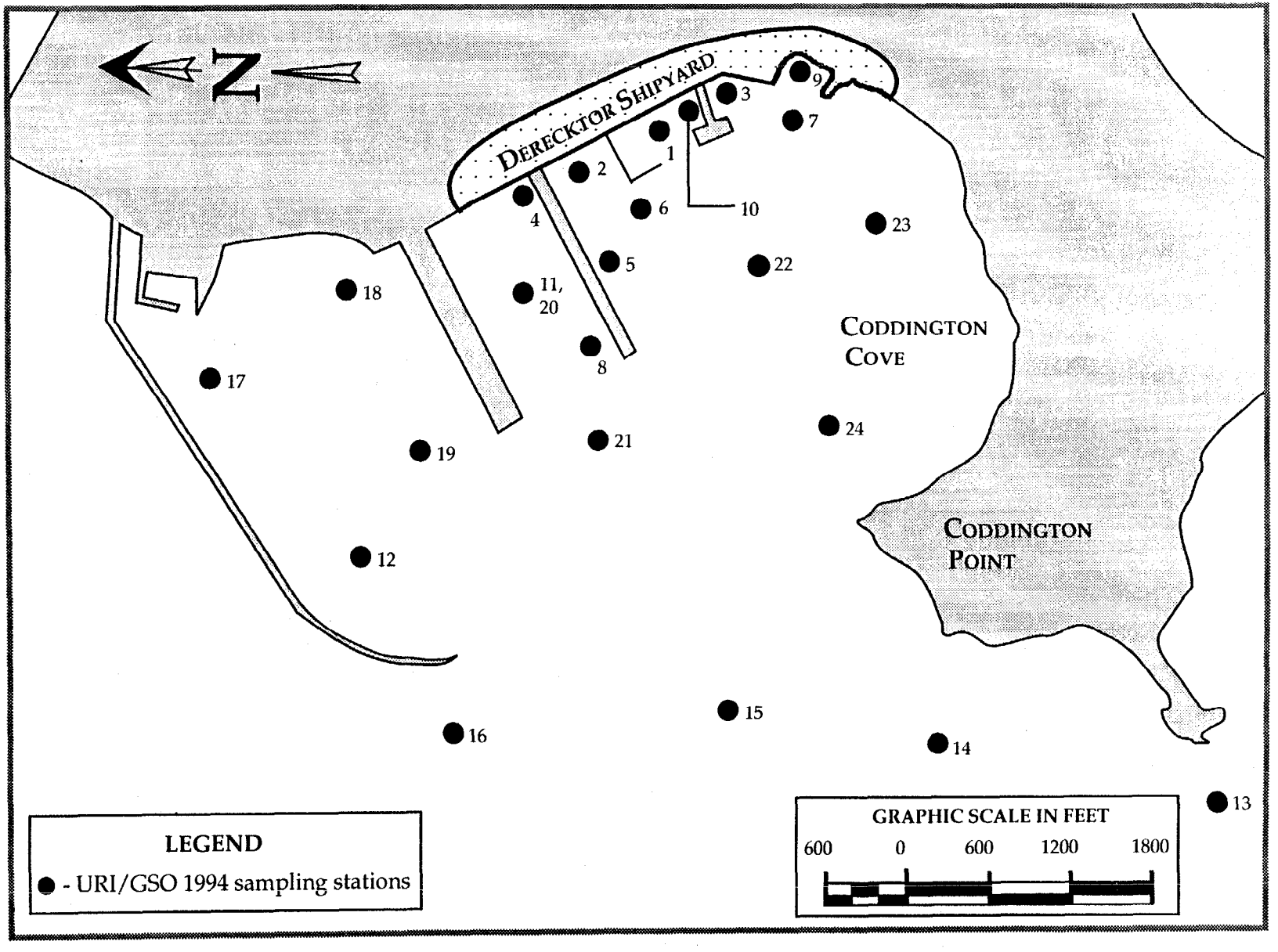

Figure 3.1-3. Derecktor Shipyard/Coddington Cove stations sampled by GSO during 1993 and 1994 (Quinn *et al.*, 1994b).

Figure 3.1-4. Coastal Habitats in the vicinity of the Derecktor Shipyard/Coddington Cove Study Area.

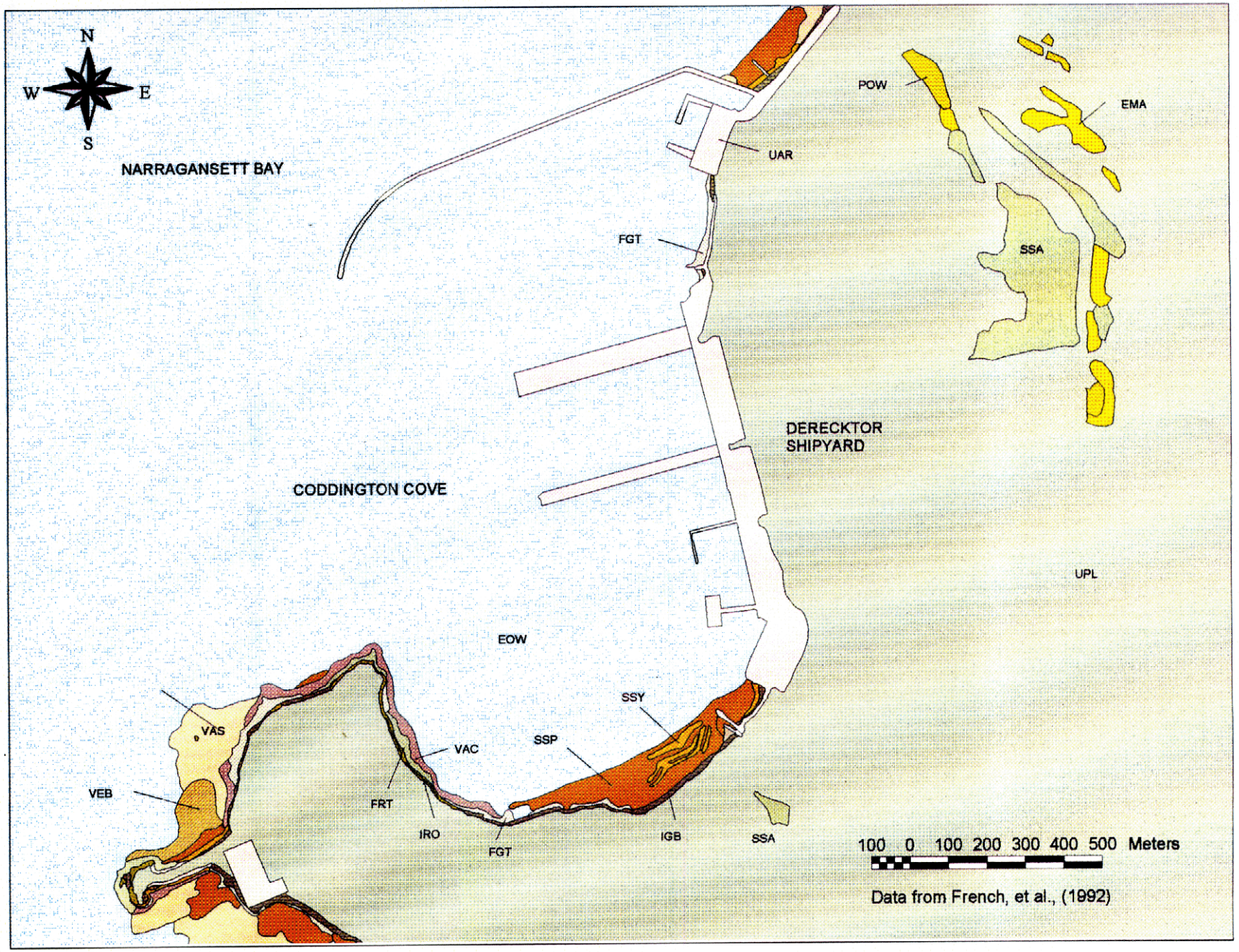

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Figure 3.1-4 (continued). Habitat coding for Figure 3.1-4.

Habitat Code	Description
EMA	Estuarine emergent wetland, marsh/wet meadow
EOW	Estuarine open water
FGT	Fringe gravel terrace
FOA	Forested conifer wetland
FOB	Forested deciduous wetland
FGT	Fringe gravel terrace
FRT	Fringing rock terrace
FSF	Fringing sand flat
IGB	Intertidal gravel beach
IRO	Intertidal rock outcrop
POW	Palustrine open water
SSA	Scrub-shrub wetland: Shrub swamp
SSP	Subtidal sand (depositional)
SSY	Subtidal sand (dynamic)
UAR	Supratidal artificial
UPL	Upland
VAC	Macroalgal
VAS	Macroalgal
VEB	Eelgrass

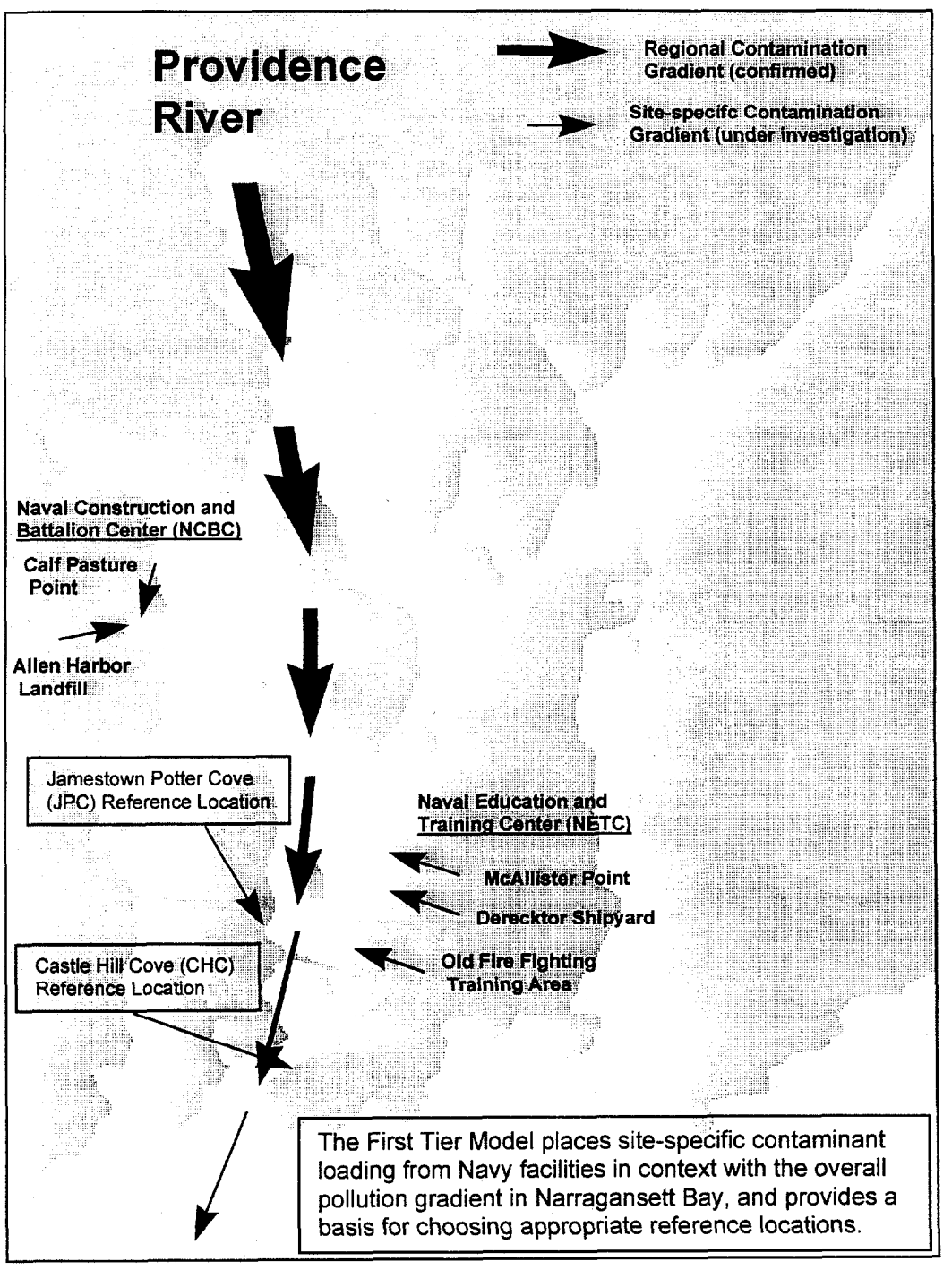

Figure 3.5-1. First Tier conceptual model for contaminant transport in Narragansett Bay.

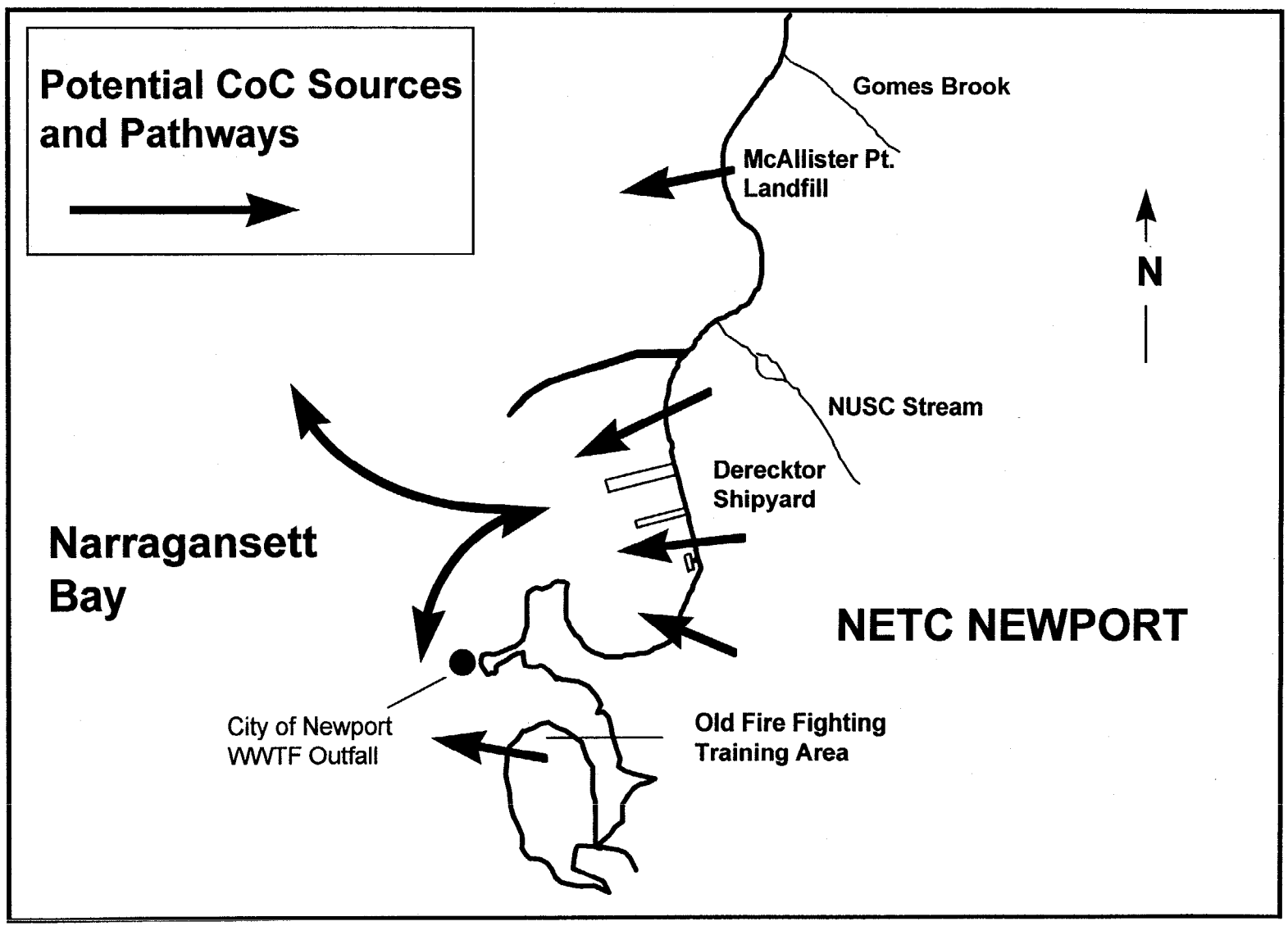

Figure 3.5-2. Second Tier conceptual model of contaminant transport for Derecktor Shipyard/Coddington Cove.

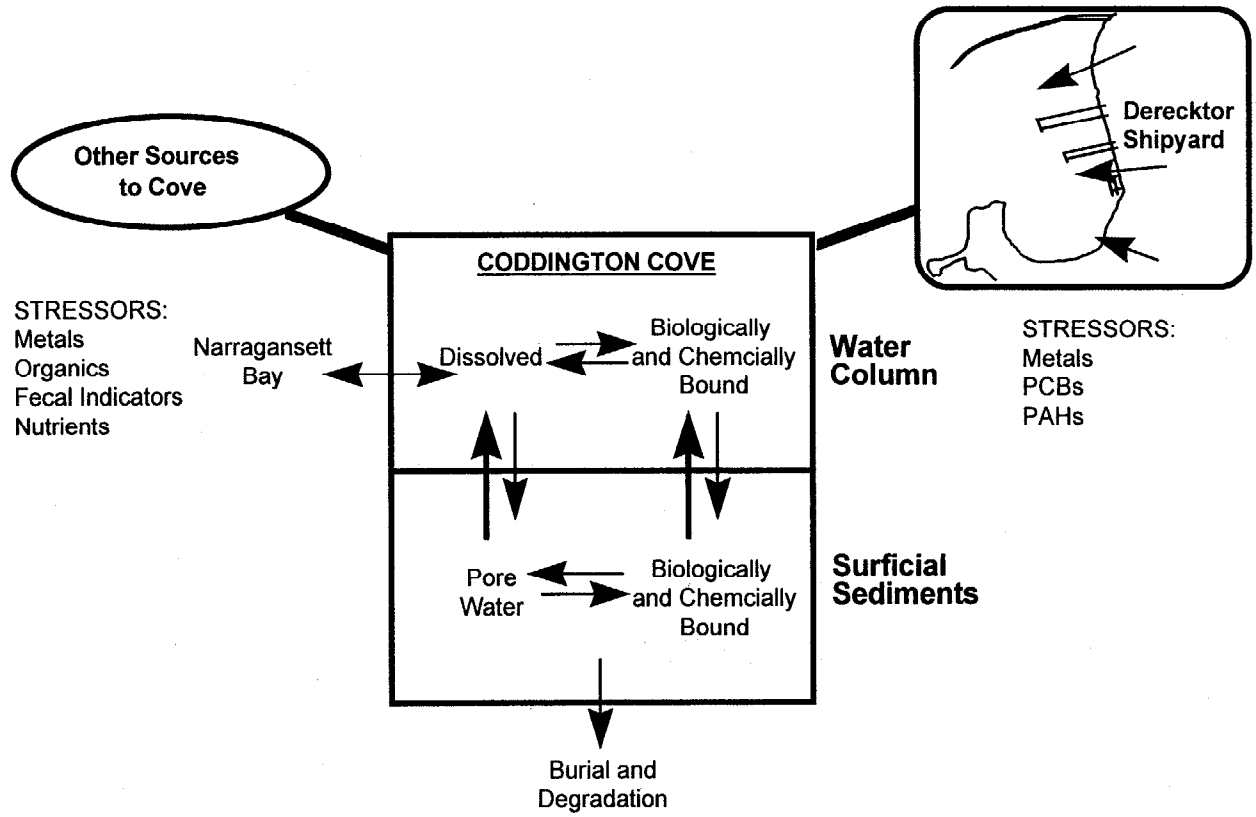

Figure 3.5-3. Third Tier conceptual model of contaminant behavior for Derecktor Shipyard/Coddington Cove.

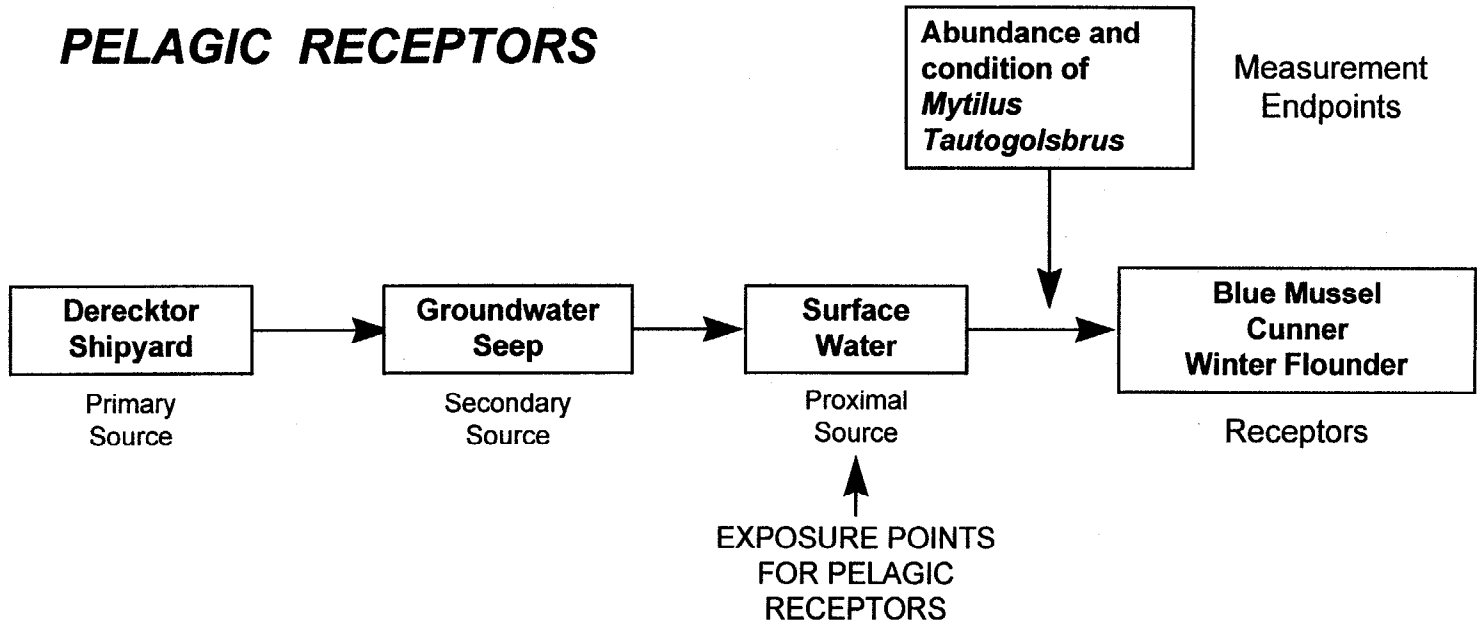

Figure 3.5-4. Fourth tier conceptual model of contaminant transport in the Derecktor Shipyard/Coddington Cove study area: Exposure pathway to pelagic receptors.

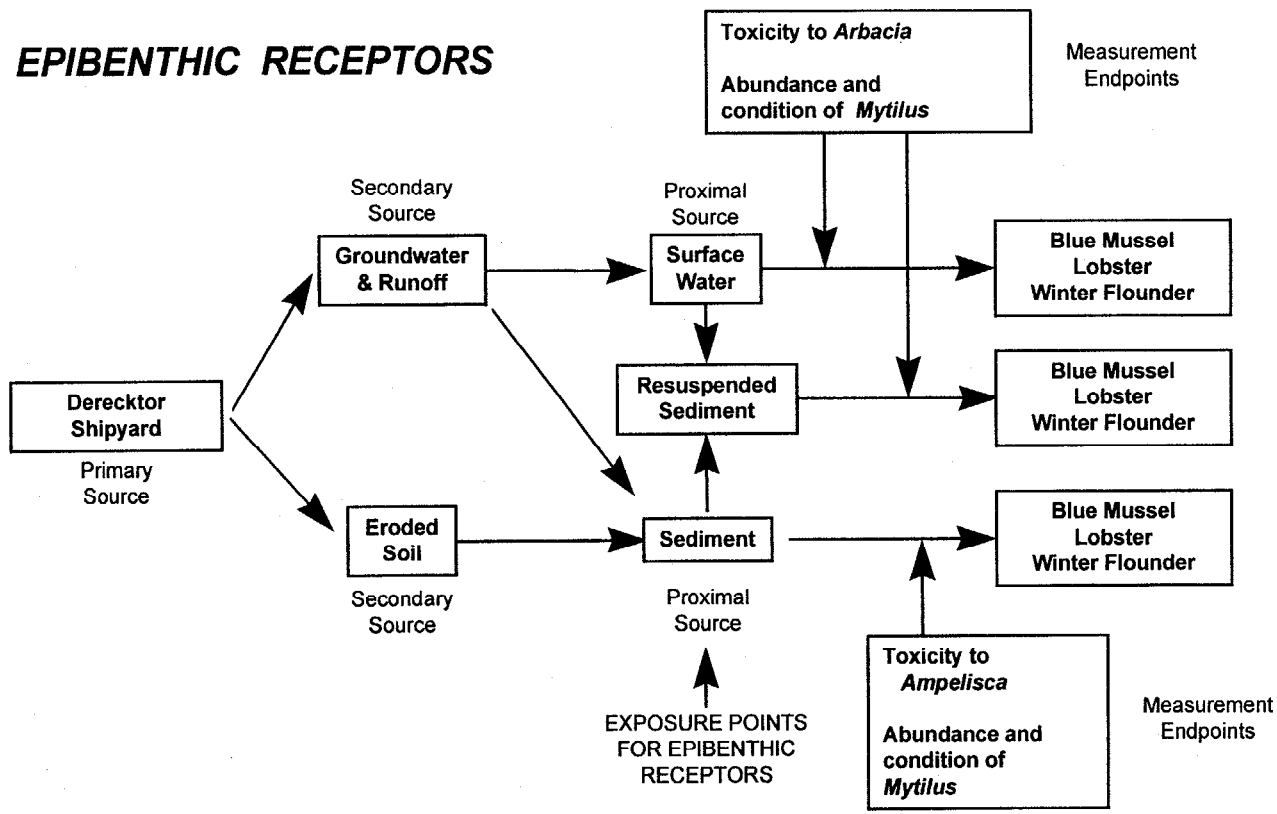

Figure 3.5-5. Fourth tier conceptual model of contaminant transport in the Derecktor Shipyard/Coddington Cove study area: Exposure pathway to epibenthic receptors.

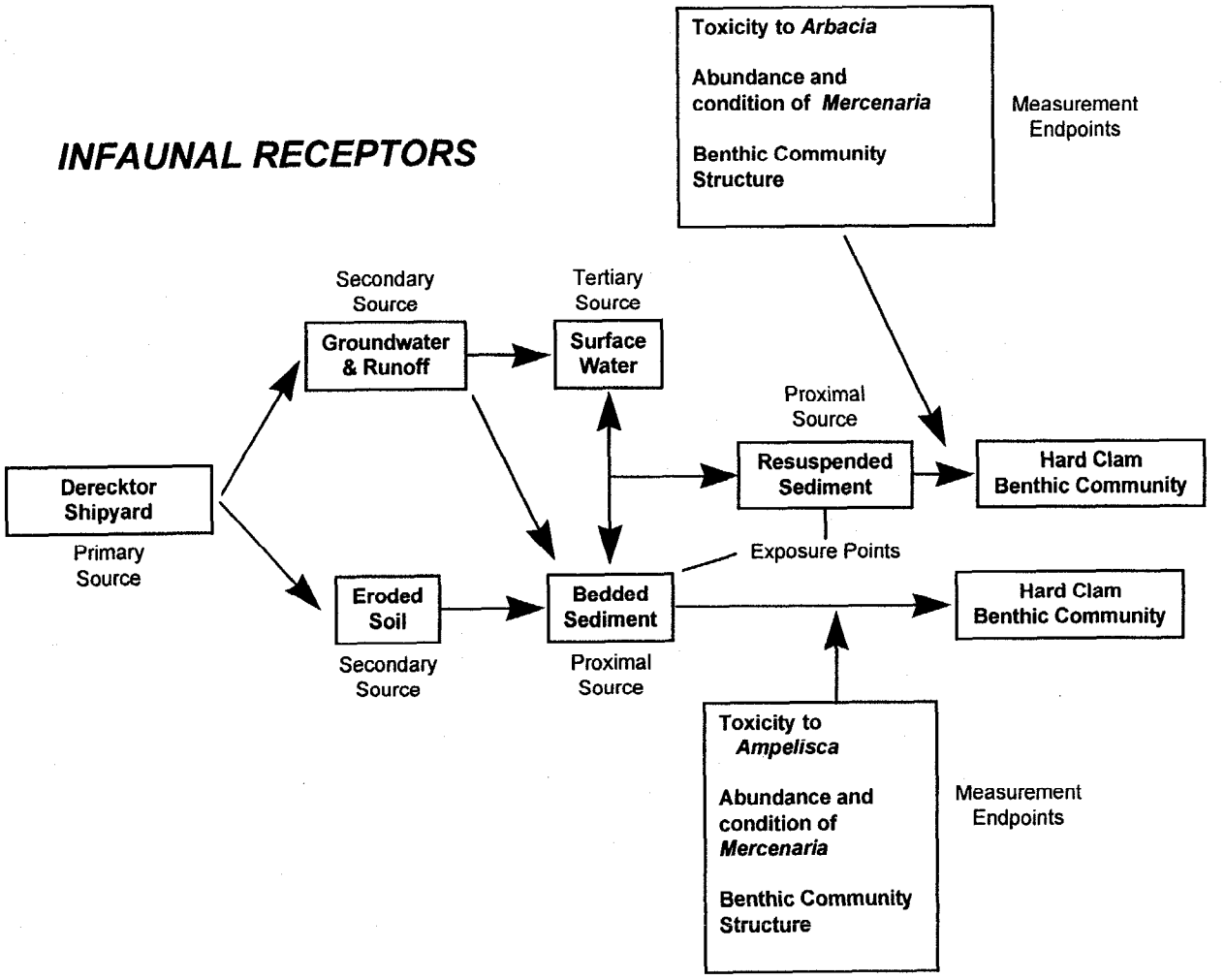

Figure 3.5-6. Fourth tier conceptual model of contaminant transport in the Derecktor Shipyard/Coddington Cove study area: Exposure pathway to infaunal receptors.

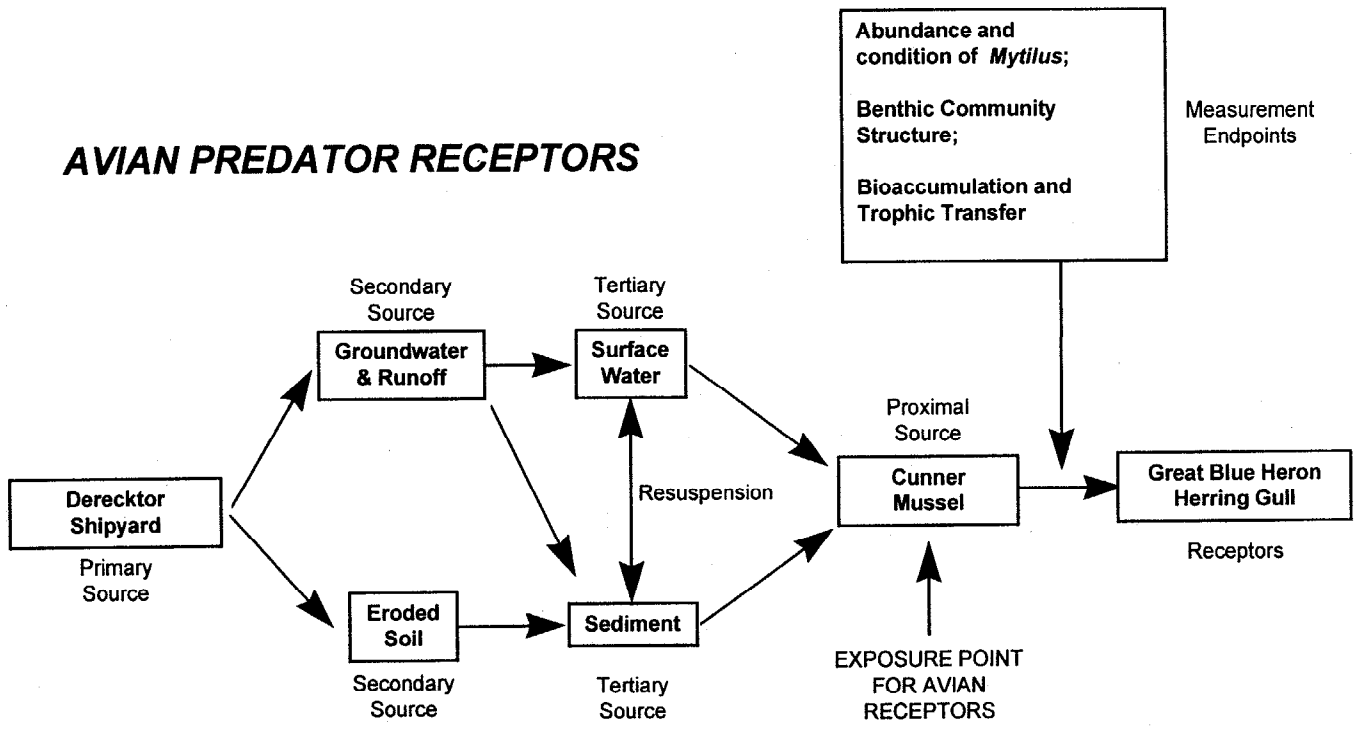

Figure 3.5-7. Fourth tier conceptual model of contaminant transport in the Derecktor Shipyard/Coddington Cove study area: Exposure pathway to avian receptors.

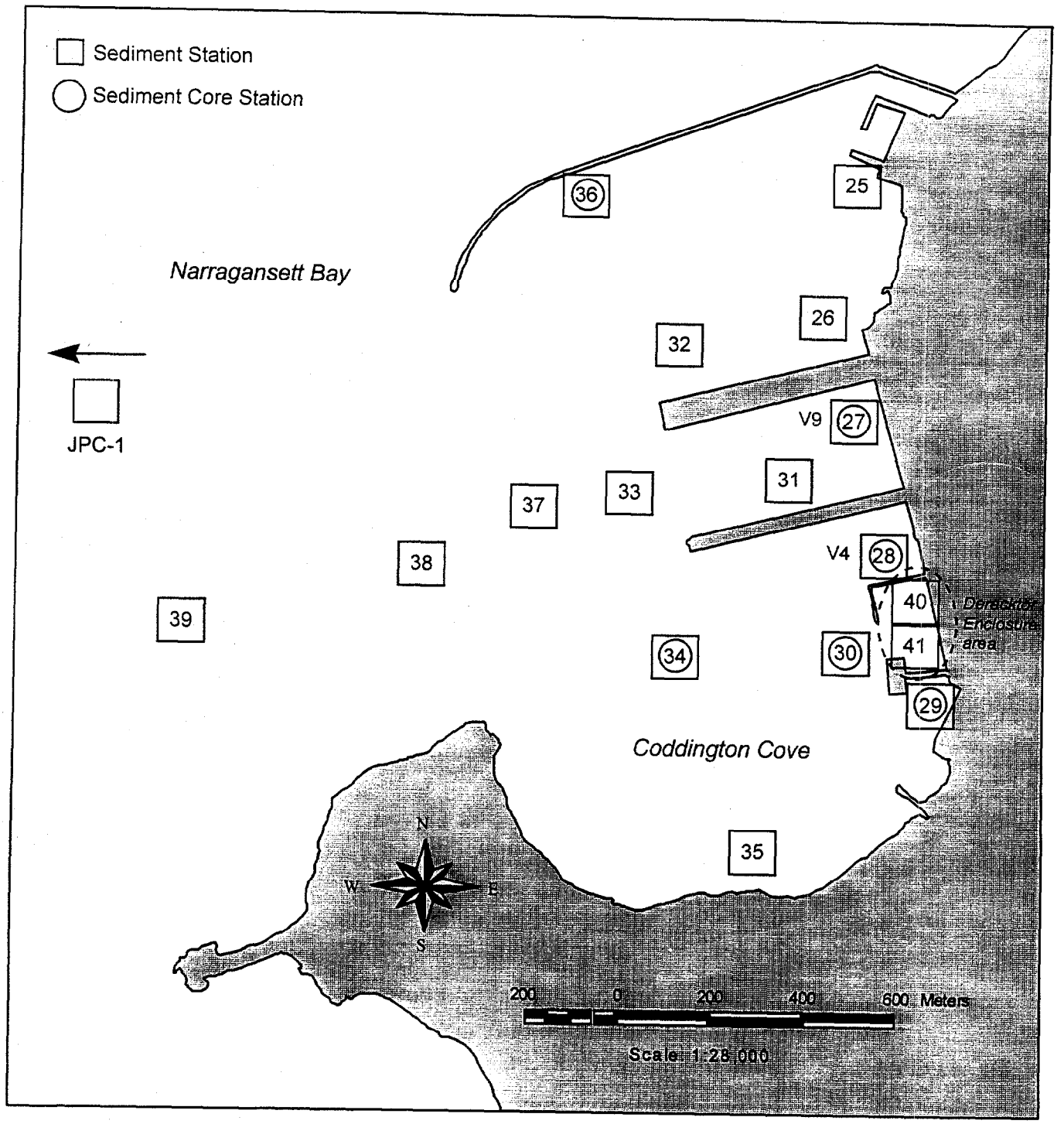

Figure 3.6-1. Surface sediment and sediment core sampling stations in the Derecktor Shipyard/Coddington Cove study area.

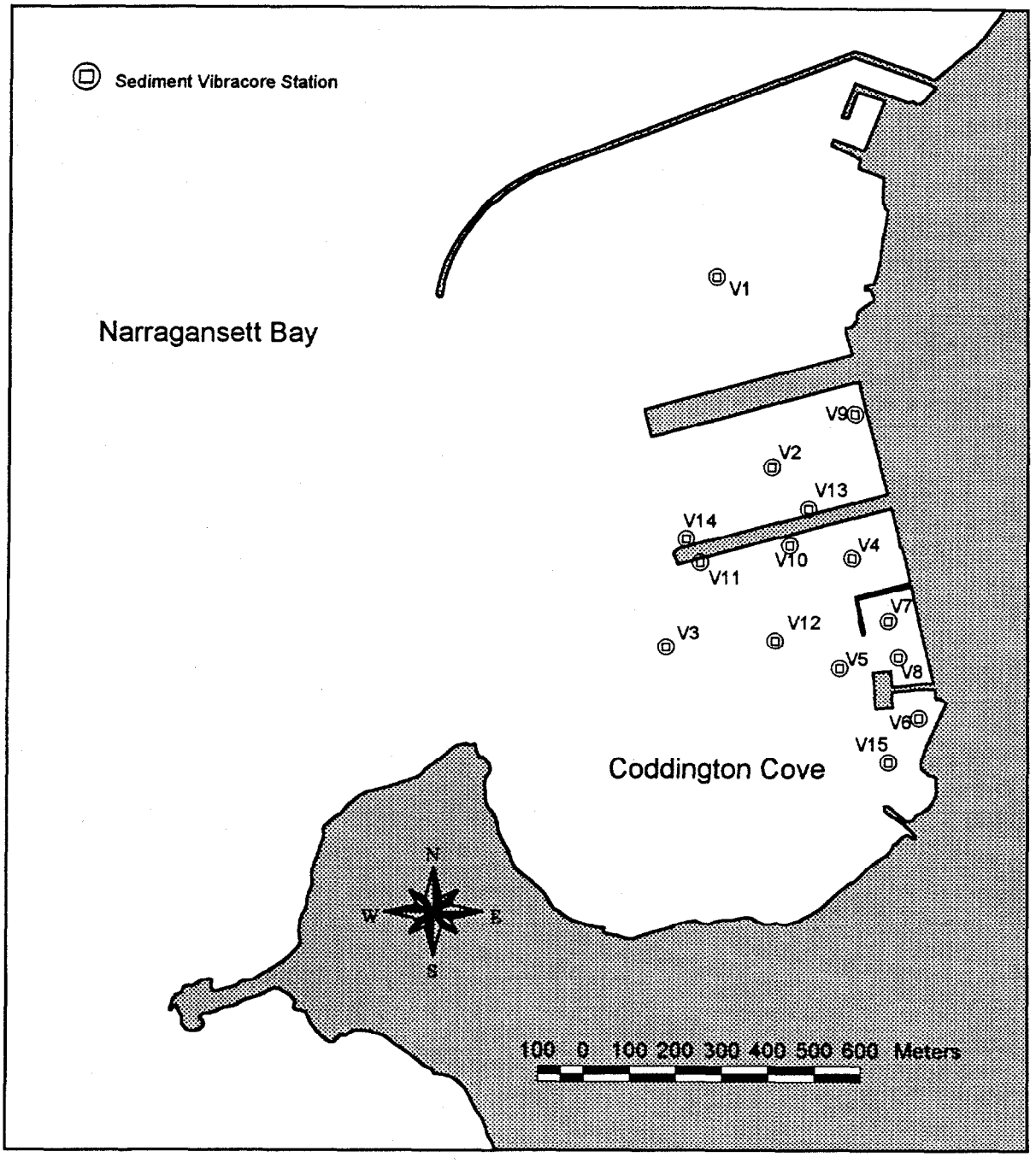

Figure 3.6-2. Sediment vibracore sampling stations in the Derecktor Shipyard/Coddington Cove study area.

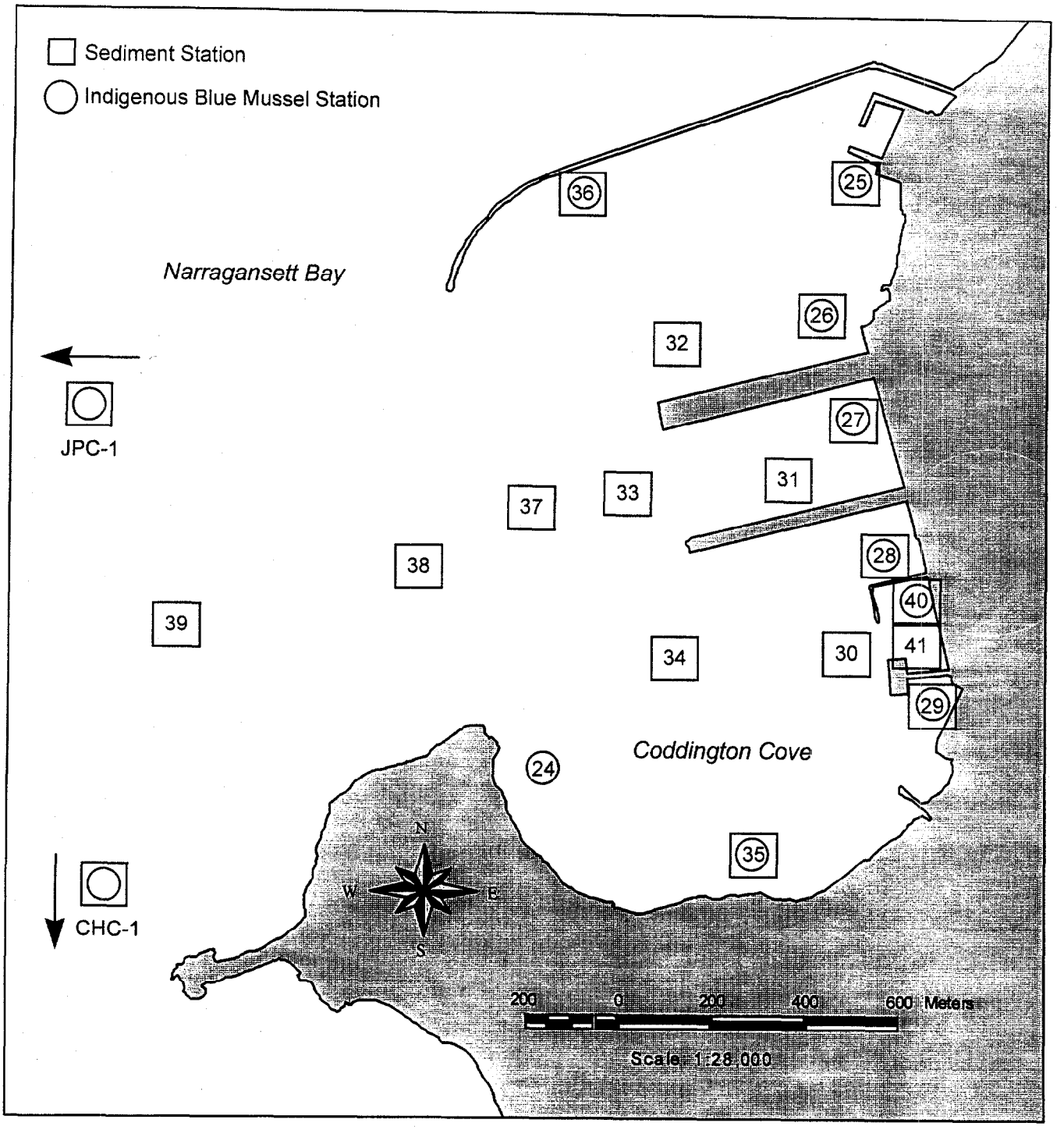

Figure 3.6-3. Indigenous blue mussel sampling stations in the Derecktor Shipyard/ Coddington Cove study area.

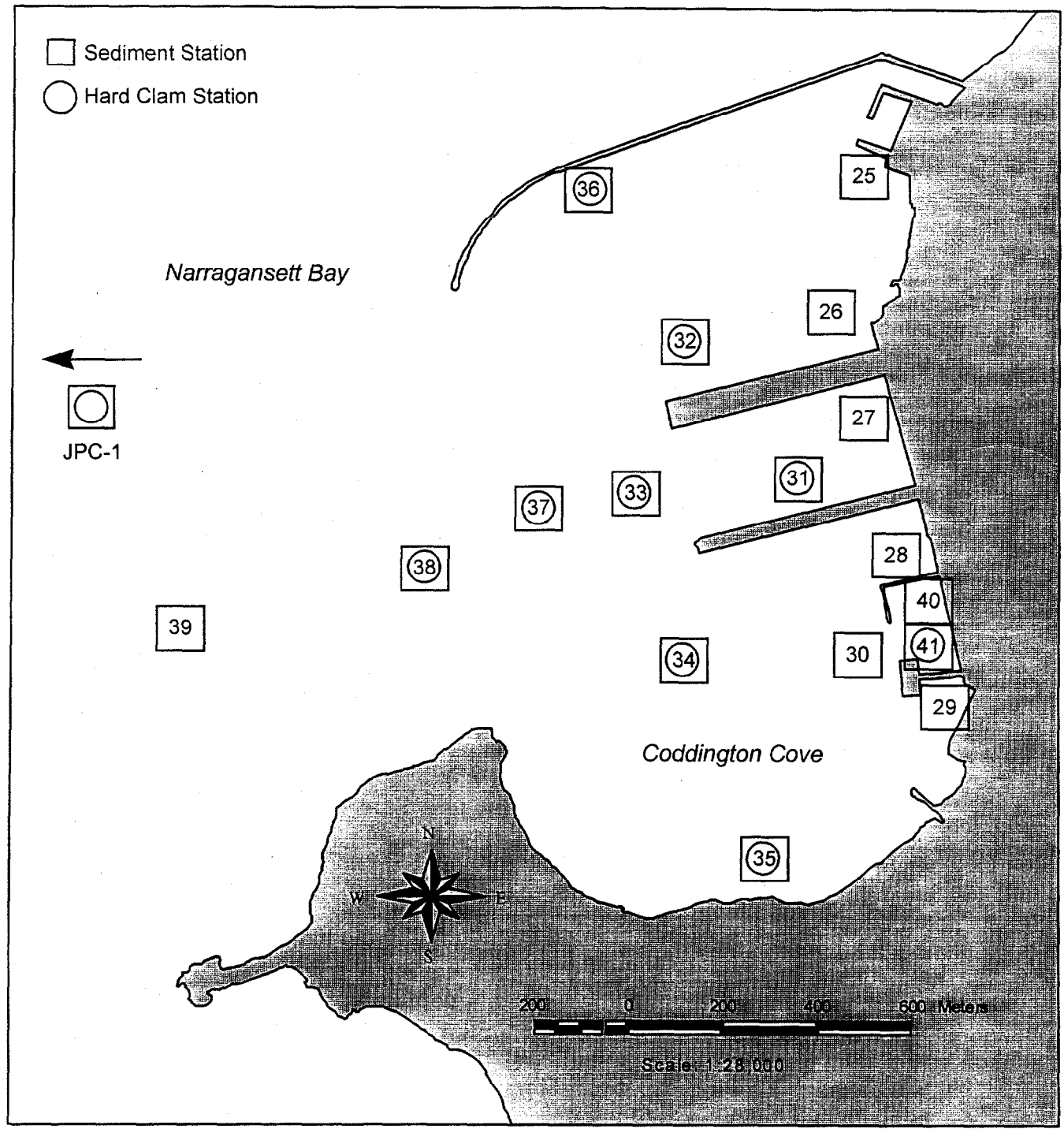

Figure 3.6-4. Hard clam sampling stations in the Derecktor Shipyard/Coddington Cove study area.

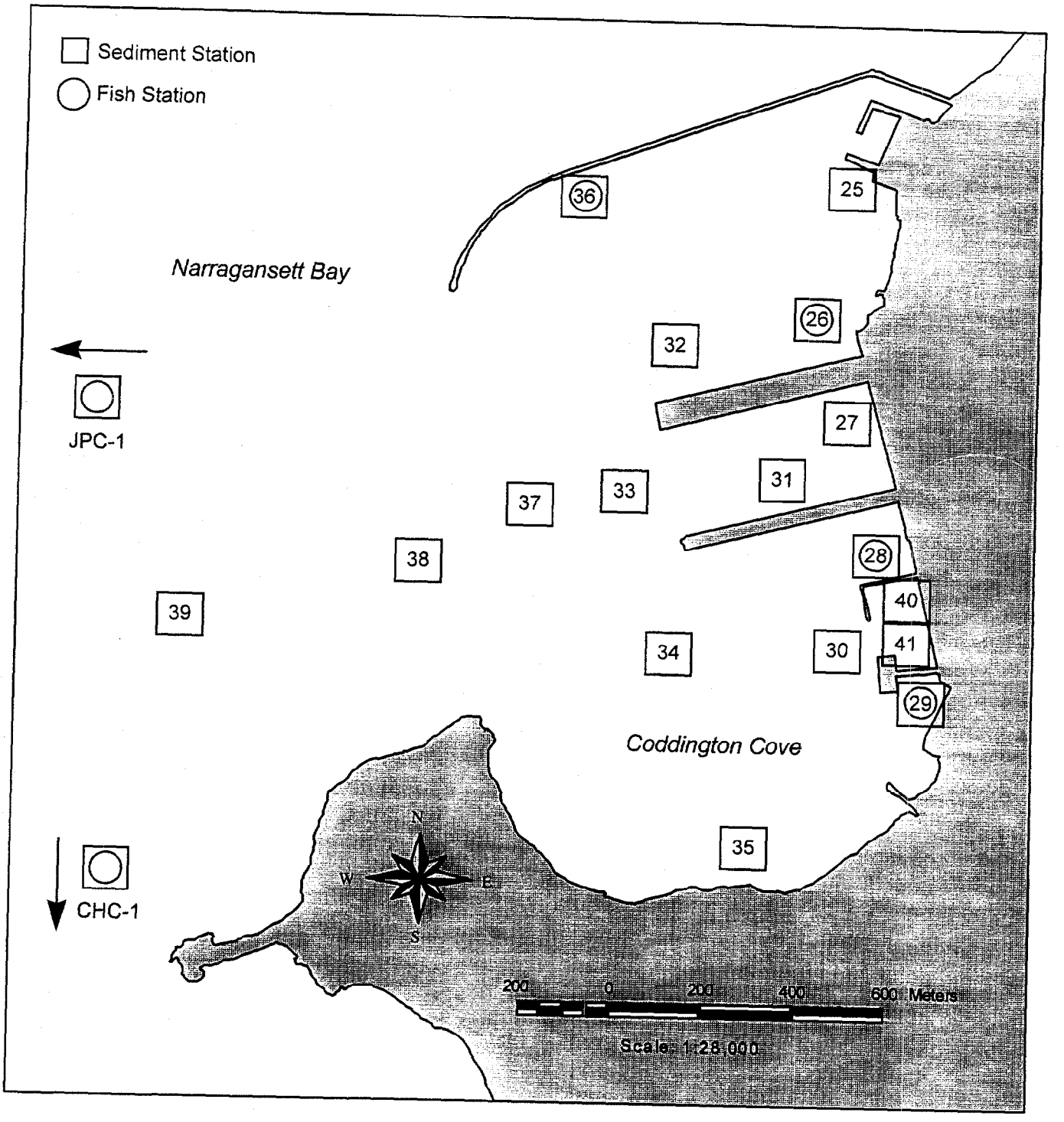

Figure 3.6-5. Fish sampling stations in the Derecktor Shipyard/Coddington Cove study area.

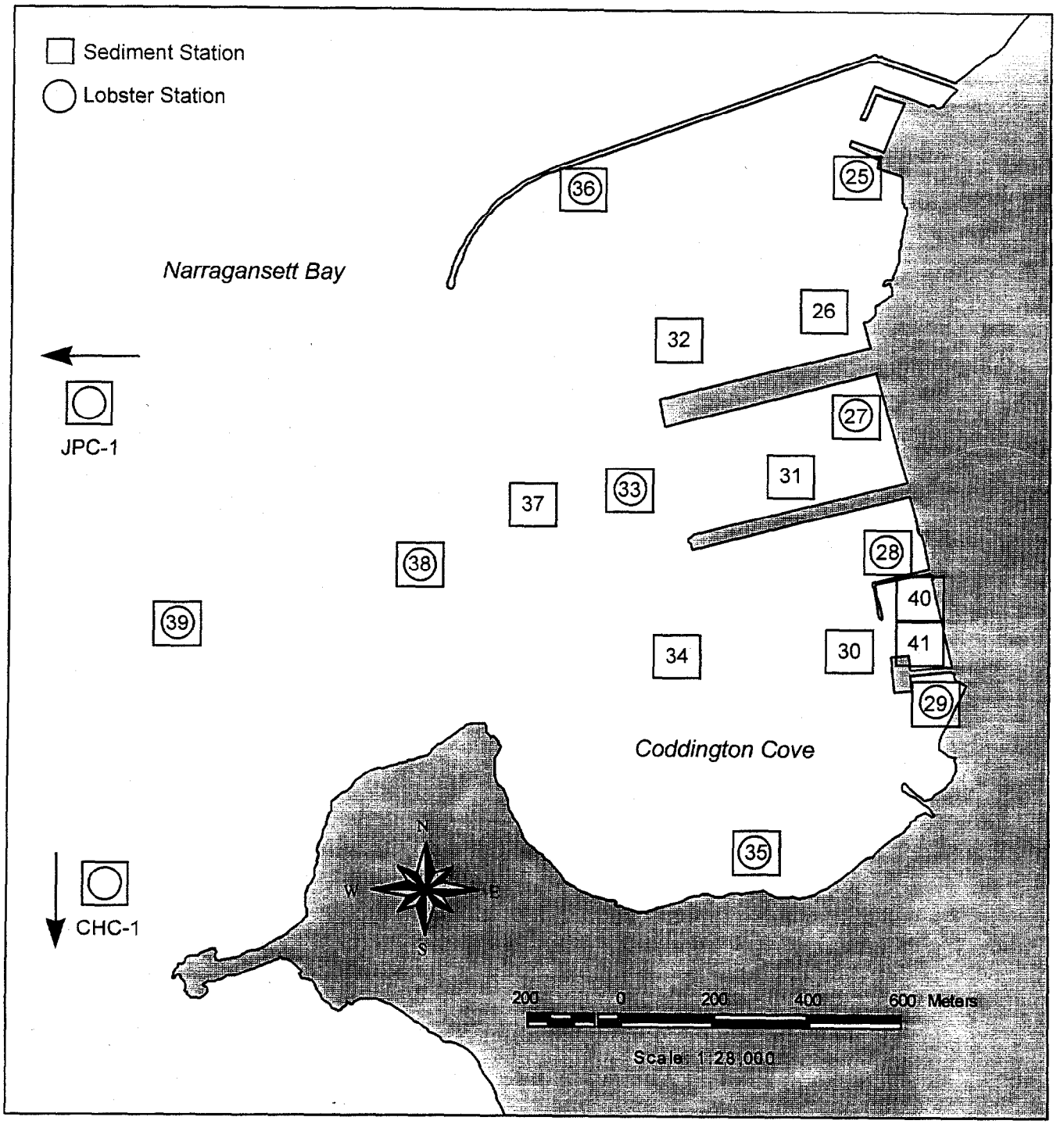

Figure 3.6-6. Lobster sampling stations in the Derecktor Shipyard/Coddington Cove study area.

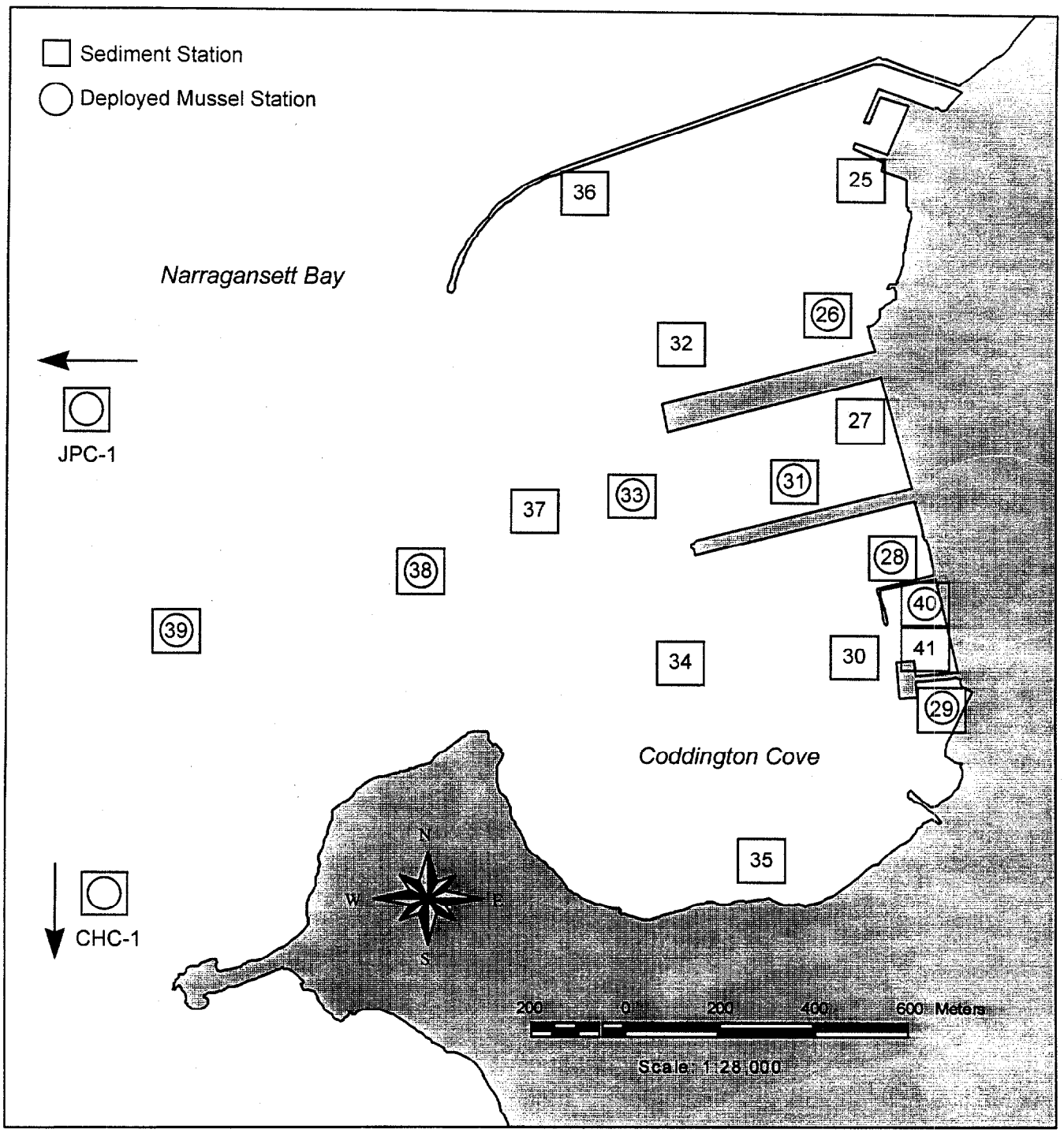

Figure 3.6-7. Deployed mussel sampling stations in the Derecktor Shipyard/Coddington Cove study area.

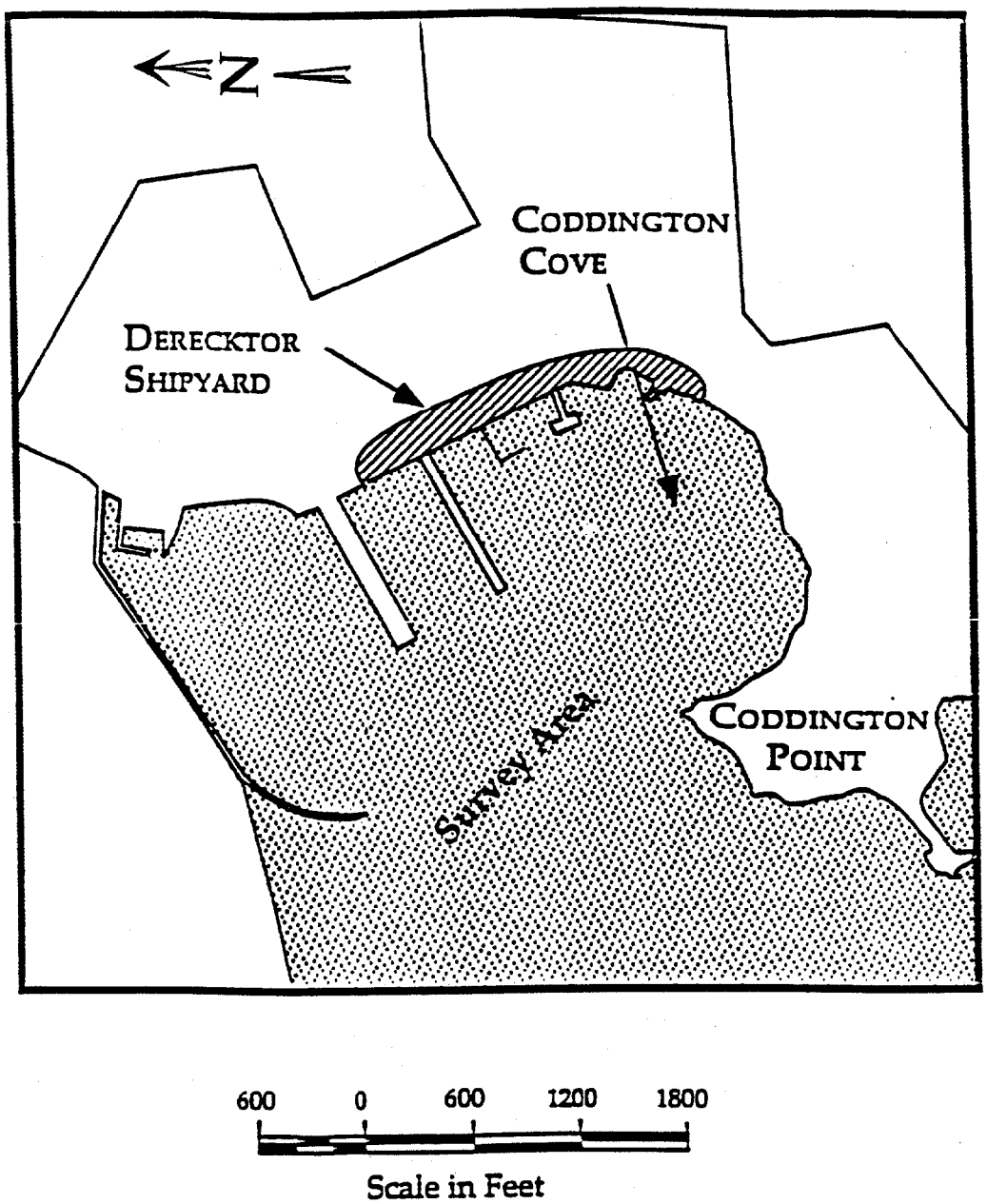

Figure 3.6-8. Geophysical survey area for the Derecktor Shipyard Marine Ecological Risk Assessment.

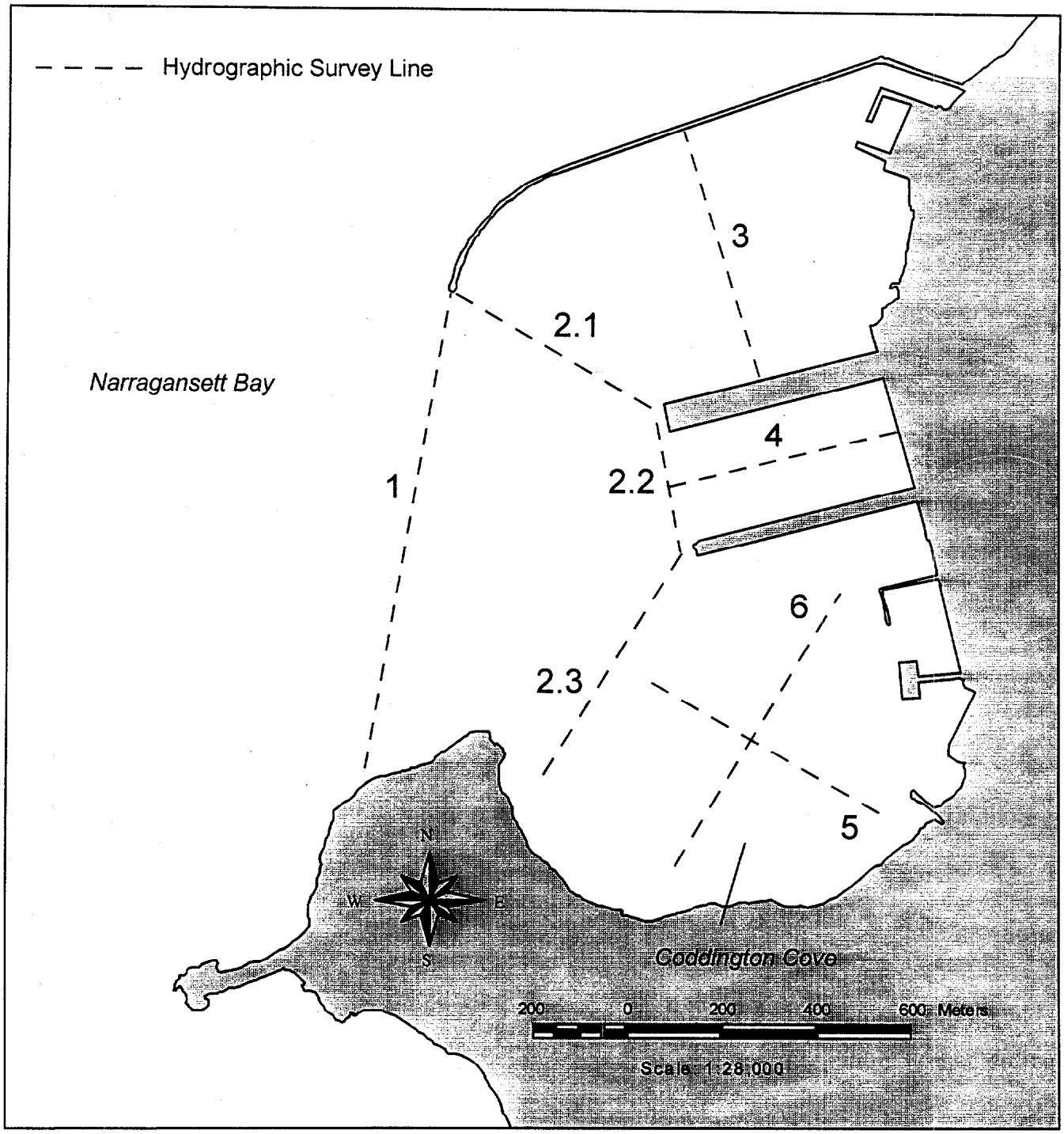

Figure 3.6-9. Hydrographic survey lines in the Derecktor Shipyard/Coddington Cove study area.

TABLE 3.1-1. Derecktor Shipyard soil contaminant concentrations.

Contaminant	Maximum Site Soil Concentration[1]	Exceeds Benchmark?[2] ER-L	ER-M
PAHs (ng/g dry)			
Benzo(a)anthracene	830	Yes	No
Benzo(a)pyrene	920	Yes	No
Chrysene	850	Yes	No
Fluoranthene	1100	Yes	No
Phenanthrene	770	Yes	No
Pyrene	2700	Yes	Yes
Metals (ug/g dry)			
Arsenic	22.5	Yes	No
Cadmium	0.56	No	No
Chromium	31	No	No
Copper	550	Yes	Yes
Lead	380	Yes	Yes
Mercury	0.14	No	No
Nickel	68	Yes	Yes
Silver	0	No	No
Zinc	1200	Yes	Yes

[1]Data from TRC (1994)
[2]Benchmarks from Long *et al.*, (1995)
ER-L = NOAA Effects Range-Low
ER-M = NOAA Effects Range-Median

TABLE 3.1-2. Derecktor Shipyard groundwater contaminant concentrations.

Contaminant	Maximum Site Groundwater Concentration[1] (µg/L)	AWQC Chronic[2] (µg/L)	Exceeds AWQC?
Arsenic	240	36	Yes
Chromium	430	50	Yes
Copper	442	2.9	Yes
Lead[3]	455	8.5	Yes
Nickel	540	8.3	Yes
Zinc	1,190	86	Yes

[1]Data from TRC (1994)
[2]U.S. EPA Quality Criteria for Water (1992)
[3]total metal

TABLE 3.1-3. Summary of organic contaminants in surface (0-2 cm) sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area.[1]

Station	Concentration[2] Total PCBs[3] (ng/g)	Sum PAHs (ng/g)	p,p'-DDE (ng/g)	TBT (ng Sn/g)	Total Organic Carbon (mg/g)	TOC-normalized Concentration PCBs (ng/mg TOC)	PAHs (ng/mg TOC)
1	67.6	4380	0.2	31.7	20.6	3.3	212.6
2	209.1	66600	3.1	371.7	13.0	16.1	5120.0
3	733.3	81700	13.6	255.0	26.3	27.9	3110.0
4	194.6	6240	0.0	154.5	31.7	6.1	196.8
5	105.4	5070	1.7	201.7	67.0	1.6	75.7
6	132.1	5940	2.1	125.1	43.7	3.0	135.9
7	73.4	4740	3.6	61.4	26.7	2.7	177.5
8	148.4	6540	1.8	130.5	46.3	3.2	141.3
9	28.1	690	0.8	71.5	15.1	1.9	45.7
10	11.7	561	3.5	63.5	15.3	0.8	36.7
11	658.2	5510	1.5	139.3	61.7	10.7	89.3
12	176.0	5000	2.5	115.5	53.3	3.3	93.8
13	22.3	993	0.6	138.0	6.4	3.5	155.2
14	23.0	500	0.4	94.3	10.1	2.3	49.5
15	54.8	3560	1.2	110.0	20.6	2.7	172.8
16	9.4	285	0.4	82.7	2.6	3.6	109.8
17	243.8	3770	0.4	81.2	10.1	24.1	373.3
18	292.8	14100	0.0	167.0	29.5	9.9	478.0
19	216.6	10300	1.8	220.4	42.1	5.1	244.7
20	367.0	22100	0.0	197.0	32.9	11.2	671.7
21	92.3	2160	0.8	109.4	11.5	8.0	187.8
22	178.2	3710	2.0	244.0	29.4	6.1	126.2
23	150.1	4960	3.7	219.7	28.6	5.2	173.4
24	25.9	1300	0.5	119.7	14.0	1.8	92.9

[1]Data from Quinn *et al.*, (1994).
[2]All measurements are dry weight.
[3]PCB sum of congeners x 2

TOC = Total Organic Carbon
TBT = Tributyltin
PCBs = Polychlorinated Biphenyls
PAHs = Polycyclic Aromatic Hydrocarbons

Table 3.2-1. Target analytes for chemical characterization for the Derecktor Shipyard Marine Ecological Risk Assessment.

Analyte		Sample matrix	Target method detection limits[a]
Polycyclic Aromatic Hydrocarbons (PAHs)		sediment biota	5 ng/g 10 ng/g
naphthalene	fluoranthene		
2-methylnaphthalene	pyrene		
1-methylnaphthalene	benz[a] anthracene		
biphenyl	chrysene		
2,6-dimethylnaphthalene	benzo [b] fluoranthene		
acenaphthylene	benzo [k] fluoranthene		
acenaphthene	benzo [e] pyrene		
1,6,7-trimethylnaphthalene	benzo [a] pyrene		
fluorene	perylene		
phenanthrene	indeno [1,2,3-cd] pyrene		
anthracene	dibenz [a,h] anthracene		
1-methylphenanthrene	benzo [ghi] perylene		
Organo-Chlorine Pesticides (OCPs)		sediment biota	1 ng/g 2 ng/g
Aldrin			
hexachlorobenzene			
Mirex			
o.p' - DDE			
p.p' - DDE			

Table 3.2-1 (continued). Target analytes for chemical characterization for the Derecktor Shipyard Marine Ecological Risk Assessment.

Analyte				Sample matrix	Target method detection limits[a]
Polychlorinated Biphenyl (PCB) Congeners					
				sediment	1 ng/g
				biota	2 ng/g
8	(2 4')[b]	126	(3 3'4 4'5)		
18	(2 2'5)	128	(2 2'3 3'4 4')		
28	(2 4 4')	138	(2 2'3 4 4'5)		
29	(2 4 5)	153	(2 2'4 4'5 5')		
44	(2 2'3 5')	154	(2 2'4 4'5 6')		
50	(2 2'4 6)	170	(2 2'3 3'4 4'5)		
52	(2 2'5 5')	180	(2 2'3 4 4'5 5')		
66	(2 3'4 4')	187	(2 2'3 4'5 5'6)		
77	(3 3'4 4')	188	(2 2'3 4'5 6 6')		
87	(2 2'3 4 5')	195	(2 2'3 3'4 4'5 6)		
101	(2 2'3 5 5')	200	(2 2' 3 3' 4 5 6 6')		
104	(2 2'4 6 6')	206	(2 2'3 3'4 4'5 5'6)		
105	(2 3 3'4 4')	209	(2 2'3 3'4 4'5 5'6 6')		
118	(2 3'4 4'5)				
Major elements					
aluminum				sediment	0.18 µg/g
				water	75.0 µg/L
				biota	0.18 µg/g
iron				sediment	0.5 µg/g
				water	20.0 µg/L
				biota	0.5 µg/g
manganese				sediment	0.01 µg/g
				water	0.50 µg/L
				biota	0.01 µg/g

Table 3.2-1 (continued). Target analytes for chemical characterization for the Derecktor Shipyard Marine Ecological Risk Assessment.

Analyte	Sample matrix	Target method detection limits[a]
Trace elements		
copper	sediment	0.01-0.7 µg/g
nickel	water	0.5-3.0 µg/L
chromium	biota	0.01-0.7 µg/g
lead		
silver		
cadmium	sediment	0.05 µg/g
	water	0.20 µg/L
	biota	0.005 µg/g
zinc	sediment	0.003 µg/g
	water	0.10 µg/L
	biota	0.003 µg/g
arsenic	sediment	0.08 µg/g
	water	3.0 µg/L
	biota	0.08 µg/g
mercury	sediment	0.125 µg/g
	water	0.10 µg/L
	biota	0.125 µg/g
Butyltins	sediment	1.0 ng Sn/g
	biota	1.0 ng Sn/g
monobutyltin		
dibutyltin		
tributyltin		

[a] Sediments and tissues measured on a dry weight basis.
[b] congener number (position of chlorines).

Table 3.2-2. Assessment and measurement endpoints for the Derecktor Shipyard Marine Ecological Risk Assessment.

Assessment Endpoint/Receptor	Measurement Endpoint
Vitality of Pelagic Community: Blue Mussel[1] Cunner Winter Flounder	Deployed Blue Mussel Condition, Tissue Residues Cunner Tissue Residues, P450 Metabolism Sediment Elutriate Chemistry and Toxicity Water Quality Model for Dissolved Oxygen (DO Transport) Fecal Pollution Indicator Residues in Mussels
Vitality of Epibenthic Community: Blue Mussel Lobster Benthic Community	Indigenous Blue Mussel Condition, Tissue Residues and Hematopoietic neoplasia Lobster Tissue Residues Benthic Community Structure Bulk Sediment and Elutriate Toxicity Sediment Chemistry, Ammonia, Redox, DO Transport
Vitality of Infaunal Community: Hard Clams Benthic Community	Hard Clam Condition and Tissue Residues Porewater Toxicity to Sea Urchin Gametes Bulk Sediment Toxicity to Amphipods Benthic Community Structure Sediment Chemistry, Ammonia, Redox, DO Transport

1- Representative of pelagic species when deployed in cages 1 meter above bottom.

TABLE 3.2-3. Exposure point measurements for the Derecktor Shipyard Marine Ecological Risk Assessment.

Exposure Medium/ Receptor	Exposure Point Measurement
Water	o Dissolved oxygen (O_2) concentration o Elutriate chemistry o Tissue chemistry
Sediment	o Bulk sediment and elutriate chemistry o Bulk sediment and elutriate toxicity o Geotechnical characteristics (grain size) o Ammonia o Total organic carbon o SEM and AVS[1]
Biota	o Tissue chemistry o Fecal pollution indicator concentration

[1]SEM = Simultaneously Extractable Metal
AVS = Acid Volatile Sulfides

Table 3.3-1. Target analyte sediment benchmarks for the Derecktor Shipyard Marine Ecological Risk Assessment.

		Sediment Benchmark[1]					
Group	Target Analyte[2]	AET	AL	ER-L	ER-M	SQC	MB
Metals	Arsenic	57		8.2	70		8.2
	Cadmium	5.1		1.2	9.6		1.2
	Chromium	260		81.0	370		81.0
	Copper	390		34.0	270		34.0
	Lead	450		46.7	218		46.7
	Mercury	0.41		0.15	0.71		0.15
	Nickel	140		20.9	51.6		20.9
	Silver	6.1		1.0	3.7		1.0
	Zinc	410		150	410		150
PAHs	1,6,7-Trimethylnaphthalene						NA
	1-Methylnaphthalene						NA
	1-Methylphenanthrene						NA
	2,6-Dimethylnaphthalene						NA
	2-Methylnaphthalene			70.0	670		70.0
	Acenaphthene	500	1300	16.0	500	1300	16.0
	Acenaphthylene	1300	71000	44.0	640		44.0
	Anthracene	960	580	85.3	1100		85.3
	Benzo(a)anthracene	1300	4000	261	1600		261
	Benzo(a)pyrene	1600	73000	430	1600		430
	Benzo(b,j,k)fluoranthene	3200	3800				3200
	Benzo(e)pyrene						NA
	Benzo(g,h,i)perylene						NA
	Biphenyl						NA
	Chrysene		409000	384	2800		384
	Dibenz(a,h)anthracene			63.4	260		63.4
	Fluoranthene	1700	6200	600	5100	6200	600
	Fluorene	540	2000	19.0	540		19.0
	High Molecular Weight PAHs			1700	9600		1700
	Indeno(1,2,3-cd)pyrene						NA
	Low Molecular Weight PAHs			552	3160		552
	Naphthalene	2100	11000	160	2100		160
	Perylene						NA
	Phenanthrene	1500	1800	240	1500	1800	240
	Pyrene	2600	97000	665	2600		665
	Total PAHs			4022	44792		4022
PCBs	PCB Sum of Congeners x 2			22.7	180		22.7
Pesticides	Aldrin		2.0				2.0
	Hexachlorobenzene	22.0	6000				22.0
	Mirex						NA
	o,p'-DDE						NA
	p,p'-DDE[3]			2.2	27.0		2.2
TBT	Dibutyltin						NA
	Monobutyltin						NA
	Tetraibutyltin						NA
	Tributyltin[4]			5.0			NA

1 - Benchmark units (dry wt): Metals (MET) - ug/g; PAHs, PCBs, Pesticides - ng/g; Butyltins (TBT) ng Sn/g.
2 - Analytes measured by Quinn *et al.* (1994) and in present study.
3 - ER-M Benchmark for p,p'-DDE assumed to be the same as for o,p'-DDE.
4 - Benchmark for tributyltin taken from Macauley *et al.*, 1994.
AET = Apparent Effects Threshold (PTI Environmental Services, 1988).
AL = Equilibrium Partitioning- Aquatic Life (based on 1 % TOC) (U.S. EPA, 1989b, Adams, Kimerle and Barnett, 1992).
ER-L = NOAA Effects Range-Low (Long et al., 1995).
ER-M = NOAA Effects Range-Median (Long et al., 1995).
SQC = EPA Sediment Quality Criteria (U.S. EPA, 1993a,b,c).
MB = Minimum of Benchmarks.
NA = Benchmark not available.

TABLE 3.3-2. Sediment data summary and selection of contaminants of concern (CoCs) for the Derecktor Shipyard Marine Ecological Risk Assessment.

SEDIMENT[2]

CLASS	ANALYTE	FREQUENCY OF DETECTION AT SITE			RANGE OF SITE CONCENTRATION[a]		MEAN SITE CONCENTRATION[b]	SITE 95% UPPER CONFIDENCE LIMIT	MEAN REFERENCE CONCENTRATION[b]	MINIMUM BENCHMARK[c]	95% UCL or MAX CONCENTRATION[d]		FREQUENCY OF DETECTION > 5%?	IS TARGET ANALYTE A CoC?
		# Detects	# Samples	%	Minimum	Maximum					Exceeds Minimum Benchmark?	Exceeds Reference?		
MET	Arsenic	33	33	100%	3.00	12.46	8.15	12.28	3.73	8.2	YES	YES	YES	YES
	Cadmium	33	33	100%	0.07	1.45	0.46	1.11	0.23	1.2	NO	YES	YES	NO
	Chromium	33	33	100%	24.25	112.75	62.68	104.57	42.75	81.0	YES	YES	YES	YES
	Copper	27	33	82%	1.50	179.50	60.13	151.82	10.38	34.0	YES	YES	YES	YES
	Lead	33	33	100%	12.80	192.60	66.60	154.53	41.45	46.7	YES	YES	YES	YES
	Mercury	29	33	88%	0.02	1.08	0.30	0.75	0.18	0.2	YES	YES	YES	YES
	Nickel	33	33	100%	5.00	77.75	23.53	45.55	14.13	20.9	YES	YES	YES	YES
	Silver	25	33	76%	0.14	1.82	0.55	1.26	0.20	1.0	YES	YES	YES	YES
	Zinc	33	33	100%	28.50	547.25	147.10	373.39	68.63	150.0	YES	YES	YES	YES
PAH	1,6,7-Trimethylnaphthalene	26	33	79%	0.16	59.06	9.41	29.10	0.73	NA	NA	YES	YES	YES
	1-Methylnaphthalene	26	33	79%	0.37	155.95	23.57	74.77	1.29	NA	NA	YES	YES	YES
	1-Methylphenanthrene	29	33	88%	0.50	576.92	66.27	255.86	4.75	NA	NA	YES	YES	YES
	2,6-Dimethylnaphthalene	29	33	88%	0.55	112.32	29.82	79.69	3.09	NA	NA	YES	YES	YES
	2-Methylnaphthalene	26	33	79%	0.00	145.25	28.78	80.27	1.92	70	YES	-	YES	YES
	Acenaphthene	26	33	79%	0.23	820.10	63.30	332.52	0.71	16	YES	-	YES	YES
	Acenaphthylene	28	33	85%	0.61	326.77	78.33	216.68	5.33	44	YES	-	YES	YES
	Anthracene	30	33	91%	0.91	2040.00	279.06	994.66	10.61	85.3	YES	-	YES	YES
	Benzo(a)anthracene	32	33	97%	0.00	4490.00	551.93	2304.47	22.55	261	YES	-	YES	YES
	Benzo(a)pyrene	30	33	91%	0.00	4130.00	558.04	2043.67	31.44	430	YES	-	YES	YES
	Benzo(b,j,k)fluoranthene	33	33	100%	1.91	8490.00	1156.05	4321.31	62.41	3200	YES	-	YES	YES
	Benzo(e)pyrene	31	33	94%	1.50	3000.00	465.37	1608.50	26.59	NA	NA	YES	YES	YES
	Benzo(g,h,i)perylene	33	33	100%	1.10	1780.00	253.07	873.80	18.64	NA	NA	YES	YES	YES
	Biphenyl	26	33	79%	0.42	55.42	11.38	30.43	0.67	NA	NA	YES	YES	YES
	Chrysene	33	33	100%	0.66	4670.00	569.29	2211.41	24.96	384	YES	-	YES	YES
	Dibenz(a,h)anthracene	32	33	97%	0.30	570.74	76.53	271.73	5.05	63.4	YES	-	YES	YES
	Fluoranthene	33	33	100%	1.34	11000.00	914.61	4329.37	49.64	600	YES	-	YES	YES
	Fluorene	27	33	82%	0.58	1020.00	82.81	409.30	2.28	19	YES	-	YES	YES
	High Molecular Weight PAHs	33	33	100%	7.36	34320.74	3906.94	16020.66	182.60	19	YES	-	YES	YES
	Indeno(1,2,3-cd)pyrene	32	33	97%	0.94	1840.00	251.57	880.50	17.29	NA	NA	YES	YES	YES
	Low Molecular Weight PAHs	33	33	100%	5.81	12822.43	999.76	4762.40	45.40	19	YES	-	YES	YES
	Naphthalene	26	33	79%	0.00	136.11	35.76	91.83	2.70	160	NO	-	YES	NO
	Perylene	32	33	97%	2.11	928.70	144.96	488.94	9.64	NA	NA	YES	YES	YES
	Phenanthrene	33	33	100%	1.06	8460.00	507.19	2938.28	21.86	240	YES	-	YES	YES
	Pyrene	32	33	97%	0.00	9870.00	1282.48	5265.87	48.96	665	YES	-	YES	YES
	Total PAHs	33	33	100%	25.43	64100.00	7256.03	28967.18	373.00	4022	YES	-	YES	YES

Notes 1 - Data summary includes surface and core data collected during the present study.

2 - Concentration and benchmark units (dry wt): Metals (MET) - ug/g; PAHs, PCBs, Pesticides (PST) - ng/g; Butyltins (TBT) ng Sn/g.

a - The range of concentrations reported for site data excludes non-detected values.

b - 1/2 Sample Quantitation Limits substituted for non-detects when calculating mean of site and reference station data.

c - Minimum benchmark - see report Table 3.3-1.

d - If 95% UCL is greater than the Maximum Concentration, as indicated with a "+", then Maximum Concentration is used to screen against benchmark or reference.

NA = Benchmark Not Available.

- = Site concentrations of organic contaminants were compared to reference concentrations only when no appropriate benchmark was available.

TABLE 3.3-2 (con't). Sediment data summary and selection of contaminants of concern (CoCs) for the Derecktor Shipyard Marine Ecological Risk Assessment.

SEDIMENT[2]

CLASS	ANALYTE	FREQUENCY OF DETECTION AT SITE # Detects	# Samples	%	RANGE OF SITE CONCENTRATION[a] Minimum	Maximum	MEAN SITE CONCENTRATION[b]	SITE 95% UPPER CONFIDENCE LIMIT	MEAN REFERENCE CONCENTRATION[b]	MINIMUM BENCHMARK[c]	95% UCL or MAX CONCENTRATION[d] Exceeds Minimum Benchmark?	Exceeds Reference?	FREQUENCY OF DETECTION > 5%?	IS TARGET ANALYTE A CoC?
PCB	101 (2 2'3 5 5')	33	33	100%	0.26	220.22	14.51	79.15	0.41	NA	NA	YES	YES	YES
	105 (2 3 3'4 4')	28	33	85%	0.04	137.44	8.61	52.06	0.09	NA	NA	YES	YES	YES
	118 (2 3'4 4'5)	27	33	82%	0.25	242.41	18.93	96.64	0.29	NA	NA	YES	YES	YES
	128 (2 2'3 3'4 4')	28	33	85%	0.06	73.00	5.43	28.56	0.13	NA	NA	YES	YES	YES
	138 (2 2'3 4 4'5)	31	33	94%	0.07	265.35	19.99	100.44	0.48	NA	NA	YES	YES	YES
	153 (2 2'4 4'5 5')	31	33	94%	0.06	174.00	14.66	67.63	0.49	NA	NA	YES	YES	YES
	170 (2 2'3 3'4 4'5)	28	33	85%	0.05	44.16	4.69	19.34	0.17	NA	NA	YES	YES	YES
	18 (2 2'5)	28	33	85%	0.09	27.54	2.00	10.61	0.08	NA	NA	YES	YES	YES
	180 (2 2'3 4 4'5 5')	30	33	91%	0.06	53.17	6.84	24.97	0.28	NA	NA	YES	YES	YES
	187 (2 2'3 4'5 5'6)	32	33	97%	0.05	25.82	3.86	12.69	0.23	NA	NA	YES	YES	YES
	195 (2 2'3 3'4 4'5 6)	29	33	88%	0.02	3.83	0.86	2.55	0.11	NA	NA	YES	YES	YES
	206 (2 2'3 3'4 4'5 5'6)	32	33	97%	0.20	17.39	3.07	9.03	0.36	NA	NA	YES	YES	YES
	209 (2 2'3 3'4 4'5 5'6 6')	33	33	100%	0.20	105.27	5.61	35.17	0.38	NA	NA	YES	YES	YES
	28 (2 4 4')	33	33	100%	0.06	28.34	2.44	11.04	0.16	NA	NA	YES	YES	YES
	44 (2 2'3 5')	33	33	100%	0.09	65.05	4.27	23.62	0.30	NA	NA	YES	YES	YES
	52 (2 2'5 5)	33	33	100%	0.05	130.50	8.17	46.64	0.56	NA	NA	YES	YES	YES
	66 (2 3'4 4')	33	33	100%	0.08	179.58	8.06	59.04	0.17	NA	NA	YES	YES	YES
	8 (2 4)	27	33	82%	0.06	65.95	3.39	24.02	0.00	NA	NA	YES	YES	YES
	PCB Sum of Congeners x 2	33	33	100%	2.85	3310.00	250.44	746.52	9.46	22.7	YES	-	YES	YES
PST	Aldrin	2	33	6%	0.12	0.13	0.13	995.00	0.00	2.0	+ NO	-	YES	NO
	Hexachlorobenzene	7	33	21%	0.06	0.38	0.15	0.15	0.00	22.0	NO	-	YES	NO
	Mirex	21	33	64%	0.07	8.58	1.17	1.34	0.00	NA	NA	YES	YES	YES
	o,p'-DDE	28	33	85%	0.25	65.22	4.85	8.26	0.27	NA	NA	YES	YES	YES
	p,p'-DDE	33	33	100%	0.03	17.06	2.93	23.71	0.14	2.2	+ YES	-	YES	YES
	Dibutyltin	14	33	42%	0.82	86.93	14.96	21.92	0.50	NA	NA	YES	YES	YES
	Monobutyltin	13	33	39%	1.05	45.50	7.79	46.74	0.50	NA	+ NA	YES	YES	YES
	Tetrabutyltin	4	33	12%	0.29	0.60	0.43	20.13	0.37	NA	+ NA	YES	YES	YES
	Tributyltin	14	33	42%	0.73	228.12	39.36	39.57	0.35	NA	NA	YES	YES	YES

Notes 1 - Data summary includes surface and core data collected during the present study.

2 - Concentration and benchmark units (dry wt): Metals (MET) - ug/g; PAHs, PCBs, Pesticides (PST) - ng/g; Butyltins (TBT) ng Sn/g.

a - The range of concentrations reported for site data excludes non-detected values.

b 1/2 - Sample Quantitation Limits substituted for non-detects when calculating mean of site and reference station data.

c - Minimum benchmark - see report Table 3.3-1.

d - If 95% UCL is greater than the Maximum Concentration, as indicated with a "+", then Maximum Concentration is used to screen against benchmark or reference.

NA = Benchmark Not Available.

- = Site concentrations of organic contaminants were compared to reference concentrations only when no appropriate benchmark was available.

TABLE 3.4-1. Habitats and ecological systems/species/receptors of concern for the Derecktor Shipyard Marine Ecological Risk Assessment.

Habitat	Ecological System/Species/Receptor of Concern
Pelagic	blue mussel (*Mytilus edulis*)[1] cunner (*Tautogolabrus adspersus*) mummichog (*Fundulus heteroclitus*) winter flounder (*Pleuronectes americanus*)[2]
Epibenthic	blue mussel (*Mytilus edulis*) lobster (*Homarus americanus*) winter flounder (*Pleuronectes americanus*)[2]
Infaunal	hard clam (*Mercenaria mercenaria*, *Pitar morrhuana*) benthic community
Avian Aquatic	great blue heron (*Ardea herodias*) herring gull (*Larus argentatus*)

[1]Representative of pelagic species when deployed in cages in the water column one meter above the bottom.
[2]Formerly *Pseudopleuronectes americanus*

TABLE 3.6-1. Sample collection and analysis summary for the Derecktor Shipyard Marine Ecological Risk Assessment.

STATION	SEDIMENT CHEMISTRY						TISSUE CHEMISTRY							GEOTECHNICAL			WATER			BIOASSAY							
	BULK SEDIMENT*			ELUTRIATE		SEM/AVS	MUSSELS		HARD CLAMS			FISH		GRAIN SIZE									CI				
	SUR	MID DEPTH	BOTTOM	METALS	ORGANICS	SUR	IBM	DM	*Mercenaria*	*Pitar*	LOBSTER	MF	CN	SUR	CORE	TOC	BOD/ SOD	DO/NH4/ TSS/CHL	CTD	AMP	ARB	DIV	DM	IBM	HN	MICRO	P450
DSY-24							1												1					1			
DSY-25	1			1	1	1	1				1			1		1			2	1	1	1		1			
DSY-26	1						1	1					1	1		1	1	3	2	1	1	1	1	1	1	1	
DSY-27	1				1		1				1			1		1	1		2	1	1	1		1			
DSY-28	1	1	1				1	1			1		1	1	1	2		3	2	1	1	1	1	1		1	
DSY-29	1	1	1		1			1			1		1	1	1	2		3	2	1	1	1	1		1	1	
DSY-30	1	1	1											1	1	2	1			1	1	1					
DSY-31	1	1	1	1	1	1		1		1				1	1	2	1	2	3	1	1	1	1		1	1	
DSY-32	1			1	1	1				1				1		1	1		2	1	1	1					
DSY-33	1			1	1	1		1		1	1			1		1	1	3	3	1	1	1	1			1	
DSY-34	1	1	1							1				1	1	2	1		1	1	1	1					
DSY-35	1						1		1	1	1			1		1	1		2	1	1	1		1	1		
DSY-36	1	1	1	1	1	1	1			1	1		1	1	1	2			1	1	1	1		1	1		1
DSY-37	1			1	1	1				1				1		1		3	1	1	1	1					
DSY-38	1			1	1	1		1		1	1			1		1		2	2	1	1	1	1			1	
DSY-39	1			1	1	1		1			1			1		1			2	1	1	1	1			1	
DSY-40	1			1	1	1	1	1						1		1	1	3		1	1	1	1	1	1	1	
DSY-41	1								1	1				1		1			2	1	1	1					
JPC-1	1			1	1	1	1	1	1	1	1	1	1	1		1	1	3	1	1	1	1	1	1	1	1	
JPC-2	1*													1		1				1	1	1					
CHC-1							1	1			1		1	1		1		3	1			1	1	1		1	
DSY-V4		1	1											1	1												
DSY-V9		1	1											1	1												
T_0								1															1			1	
TOTAL	19	8	8	10	12	10	10	11	3	10	11	1	6	22	8	26	10	28	32	19	19	20	11	10	7	11	1

DSY = Derecktor Shipyard
JPC = Jamestown Potter Cove
CHC = Castle Hill Cove
T_0 = Time Zero

*Bulk sediment testing for metals and organics
SUR = Surface
* = Metals and TBT only

DM = Deployed Blue Mussel = *Mytilus edulis*
IBM = Indigenous Blue Mussel = *Mytilus edulis*
HARD CLAM = *Mercenaria mercanaria* and *Pitar morrhuana*
LOBSTER = *Homarus americanus*

MF = Mummichog Fish = *Fundulus heteroclitus*
CN = Cunner = *Tautogolabrus adspersus*

TOC = Total Organic Carbon
SOD/BOD = Sediment Oxygen Demand/Biological Oxygen Demand
DO/NH4 = Dissolved Oxygen/ Ammonia
TSS/CHL = Total Suspended Solids/Chlorophyll *a*

CTD = Conductivity/Temperature/Depth

AMP =Sediment Amphipod Survival Test
ARB = Elutriate Test With Arbacia
DIV = Benthic Community Structure Analysis
CI = Bivalve Condition Index

HN = Hematopoietic Neoplasia
MICRO = Fecal Pollution Indicators in Mussel Tissue
P450 = Cytochrome P450 Assay

4.0. EXPOSURE ASSESSMENT

Exposure assessment in the Derecktor Shipyard/Coddington Cove investigation involves the evaluation of the site-specific conceptual models with respect to hypothesized exposure pathways to target receptors and includes the direct measurement of exposure point concentrations along these pathways. For this assessment, Derecktor Shipyard is considered to be the primary (but not proximal) source of CoCs in nearshore areas. In addition to direct measurement of chemistry, other exposure measures (identified in Table 3.2-3) are assessed to aid in the interpretation of chemical exposure conditions. Methods and QA/QC considerations and protocols relevant to analytical chemistry are presented in the master Work Plan and previously in Section 3.6.

Exposure information derived from previous investigations at the site has been evaluated for applicability to this assessment and used as appropriate. Accompanying the description of these data is a discussion of the comparability of the various data sets as well as an evaluation of the uncertainty associated with the exposure analyses.

Exposure Assessment results are described below in four sections: an examination of sources and exposure pathways of CoCs (Section 4.1), analyses of fate and transport for CoCs through geotechnical, geophysical, hydrographic, and modeling activities (Section 4.2), estimates of exposure point concentrations (Section 4.3), and an analysis of the uncertainty related to the exposure assessment (Section 4.4). Exposure modeling and risk characterization for avian predators have been consolidated into Section 6.3.3 in order to enhance the clarity of the presentation.

4.1. Sources and Exposure Pathways of CoCs

Several exposure pathways are likely to exist from contaminant sources associated with historical activities at Derecktor Shipyard. Early characterization studies of shipyard contaminants (discussed in Section 3.1) have concluded that PAHs, PCBs, numerous metals, and the chlorinated pesticide p,p'-DDE, were present in concentrations which may potentially represent significant ecological risk. These results were supported by analyses of soil, ground water, and seep water samples.

Sources and exposure pathways for contaminants from the shipyard to the marine environment and associated biota were introduced in Section 3.5 as a series of conceptual models. First Tier exposure pathways are related to the relative magnitude of site-specific sources versus regional sources. Initial exposure pathways as defined by the second tier model are expected to occur primarily via surface and ground water flows from the shipyard. The third tier model describes the behavior of dissolved and particle-bound contaminants in the aquatic environment, including transport by and/or association with surface water, sediments, pore water, and biota. Finally, the fourth tier model identifies sources and exposure pathways for biological receptors, including: surface water exposures of pelagic organisms such as fish and filter-feeding infauna and epifauna; soil (particle), sediment, and pore water exposures to bottom-dwelling fish, infauna and epifauna; and the potential for fish and invertebrate prey to function as proximal sources and exposure points for upper level predators such as fish-eating birds.

Contaminant exposure routes for aquatic biota can involve exposure through water, sediments, and pore water via partitioning across cell membranes, incidental contact or feeding mode ingestion of sediments (e.g., by bottom deposit-feeding organisms), and consumption of contaminated prey. Thus, it is important to identify the behavior and potential effects of CoCs as a key part of the risk assessment. Based on

the general models described above, a more detailed evaluation of exposure pathways can be derived for specific classes of CoCs as related to their chemical and physical behavior, and characteristics such as specific bioaccumulation potentials. The toxicity of CoCs is addressed in Section 5.1.

Some organic contaminants identified in source samples, including the organochlorinated pesticides (OCPs) such as p,p'-DDE and the polychlorinated biphenyls (PCBs), share similar properties in that they are characterized by relatively low solubilities in water and high solubilities in lipid phases of animal tissues. The low water solubilities tend to result in a net transfer of such compounds from aqueous to particulate phases, with subsequent accumulation in sediments and to a lesser degree, pore water (via partitioning; Clayton *et al.*, 1977). Transfer of this type of CoC to organisms living on or in the sediments can occur through direct uptake (e.g., dermal contact or sediment ingestion), through partitioning to interstitial pore water, or through food web transfer. Because of the tendency for these compounds to remain adsorbed to sediments, there should be relatively low dissolved-phase concentrations above the sediments, thereby minimizing direct exposures to pelagic organisms via the water column.

It is notable that respiratory surfaces of water-breathing organisms, such as fish and invertebrates, provide an effective transfer mechanism for these lipid-soluble organic contaminants between the aqueous environment and lipid-rich tissues. Thus, the concentrations of highly lipid-soluble organic contaminants in these organisms may be somewhat controlled by these transfer mechanisms. Consequently, contaminant concentrations in these species may be more dependent on the lipid content as related, for example, to reproductive condition, than on magnification of the chemical within a food web (Clayton *et al.*, 1977). In contrast to water-breathing organisms, air-breathing organisms associated with aquatic environments (e.g., water fowl or aquatic predatory birds) do not have external surfaces that readily facilitate the transfer of lipid-soluble

chemicals between internal lipid and external water phases. Consequently, biomagnification in these species is likely to be the determinant factor for the tissue concentration of these contaminants. As noted in Clayton *et al.* (1977), concentrations of contaminants such as PCBs in water-breathing biota from different trophic levels (e.g., zooplankton, herring, and salmon) can be very similar when the values are lipid-normalized. In contrast, concentrations in air-breathing aquatic biota (e.g., birds, seals) can vary widely among species and be considerably higher than in water-breathing biota.

Other organic contaminants, particularly PAHs, also tend to have low water solubilities (solubility decreases with increasing molecular weight) and primarily are found associated with particles and sediments (Pruell and Quinn, 1986). Thus, the principal risk from PAHs would be to bottom-dwelling fish and invertebrates, including filter-feeders that ingest PAH-laden particles. However, in contrast to chlorinated compounds such as PCBs, there appears to be a reduced association of PAHs with lipid-rich tissues (Tracey and Hansen, 1996). Because PAH exposures tend to derive primarily from weathered sources (e.g., combusted fossil fuels), these compounds may be more highly particle-bound and hence less bioavailable than would be predicted from their chemical structure (Tracey and Hansen, 1996). In addition, marine vertebrates, (e.g., fish) are very capable of metabolizing PAHs. These factors perhaps explain why this compound class is not bioaccumulated to the same extent as lipophilic organics. The primary effects from PAHs are as carcinogens, particularly at the point of contact, as influenced by the formation of metabolic intermediates.

Metals, such as silver, lead, zinc, arsenic, manganese, mercury, and chromium(+3), all are relatively insoluble in aqueous media and tend to be associated with particles and sediments. Thus, organism exposure pathways are expected to be similar to those noted for the organic contaminants. In contrast, nickel, copper, cadmium, and to a lesser extent, chromium(+6), are relatively soluble and

characteristically are associated with dissolved phases. Various complex reactions ultimately result in the deposition of these metals in bottom sediments. Subsequent biogeochemical processes (e.g. arsenic methylation) can result in releases of metals from sediments back into the water column. It is also notable that metal speciation in aquatic environments may alter fate and transport; most of the chromium, for example occurs as the less toxic chromium(+3). Physiological requirements and adaptations may also affect the ultimate fate of trace metals. For example, elevated concentrations of copper and zinc are highly toxic to aquatic biota, but both metals may be accumulated to high concentrations in some species due to physiological adaptations. In general, primary consumers such as bivalves will tend to have higher metals concentrations in tissues than predatory fish (Paine, 1995). However, some metals such as mercury are of special concern because of high potentials for bioconcentration and magnification (i.e., a progressive increase in concentrations from the source of exposure through the trophic levels) within food webs.

4.2. Geotechnical, Geophysical, Hydrographic and Dissolved Oxygen Studies

Sections 4.2.1 to 4.2.4 discuss the results of geotechnical (grain size, core lithology), geophysical (side-scan and sub-bottom acoustic sonar surveys), hydrographic (water circulation) and dissolved oxygen monitoring surveys, respectively. The above information is synthesized in Section 4.2.5 with respect to factors controlling the distribution, fate and transport of contaminants, as well as the distribution and abundance of benthic communities, within the study area.

4.2.1. Geotechnical Investigations

This section provides a summary of results for grain size, organic carbon analyses and lithological description of sediment cores. The sampling locations for

surface and core sediments were discussed in Section 3.6 (Figure 3.6-1). A total of 20 surface sediments and 16 core sections were analyzed for grain size.

Sediment Grain Size. Comprehensive analytical details for grain size analyses are contained in URI and SAIC (1995). The classification system used to describe sediment lithology is based on the sand content of the sediments and follows that used by McMaster (1960) to map the sediments of the Narragansett Bay system. Figure 4.2-1 shows the classification and percent sand content of surface sediments sampled from the Derecktor Shipyard/Coddington Cove study area during the present investigation. The results indicate that the sediments in the study area are quite variable with respect to sand content, ranging from less than 10% sand at Station DSY-27 to greater than 98% sand at Station DSY-35.

The results of grain size analyses of surface (as discussed above) and core sediments are summarized in Figure 4.2-2A and 4.2-2B, respectively. In this analysis, the silt and clay fractions are also discriminated. The most noteworthy temporal trend is that, in general, the surface sediments in Coddington Cove tend to be finer-grained (i.e., contain more silt), while sandier sediments are found at greater depths in the core. A likely explanation for this observation is that the construction of the Coddington Cove breakwater in 1957 has significantly decreased bottom energy within the study area and consequently increased the likelihood of deposition for finer-grained sediments. Complete grain size analysis data are presented in Appendix Table A-1-5.1.

Organic Carbon. The percent of Total Organic Carbon (TOC) in surface and core sediments, determined by loss-on-ignition (URI and SAIC, 1995), is summarized in Table 4.2-1. The organic carbon content of surface sediment varied between 0.6% (DSY-35) to 6.0% (DSY-29), which is typical for Narragansett Bay sediments (King *et al.*, 1995). The surface sediments contained significantly more organic carbon than the deeper sediments from the cores. This increase of organic carbon in the surface

sediments may reflect a change in the depositional characteristics of the study area as discussed above, as well as possible changes in organic loading to the area and loss of organic carbon to diagenesis (transformation) at depth. A significant inverse relationship was observed between TOC and the grain size of the surface and core sediments (Figure 4.2-3A and 4.2-3B, respectively).

Magnetic Susceptibility Profiles and Core Descriptions. Piston cores approximately one meter in length were obtained from six stations within the study area (Figure 3.6-1). Profiles of magnetic susceptibility (MS), a measure of the concentration of iron-bearing minerals, were determined and the lithology of the cores was characterized. Previous studies of Narragansett Bay sediments (Corbin, 1989) indicate that higher magnetic susceptibility values are usually associated with finer-grained sediments, which, in polluted environments, are typically a reservoir for chemical contaminants.

Three of the stations studied (Stations DSY-28, DSY-29, and DSY-30) were observed to have areas of higher magnetic susceptibility at depth and reduced susceptibility values in the immediate (0-5 cm) surficial zone (Figure 4.2-4). Station DSY-28 and, to a lesser extent, Station DSY-31, exhibited secondary sub-surface maxima in susceptibility. Station DSY-34 exhibited a reversal of this patten, where higher MS values were found at the surface with decreasing values at depth. A third type of pattern was observed at Station DSY-36, in which uniform MS was observed in the top 40 cm, followed by a change at 50 cm, where MS increased, suggesting a layer of finer sediment in the 50-70 cm depth range.

Core descriptions indicate that sediments throughout the study area were dark in color and also tended to smell of sulfur, typically associated with anoxic conditions. The results are of importance with respect to pollutant fate and/or transport, as anoxic conditions produce higher concentrations of Acid Volatile Sulfide (AVS) complexes,

which sequester divalent trace metals in insoluble sulfides and decrease the bioavailability (and possible toxicity) of these metals (DiToro *et al.*, 1990).

4.2.2. Geophysical Investigations

In 1995, a side-scan and sub-bottom acoustic sonar survey of the Derecktor Shipyard/Coddington Cove study area was undertaken to characterize more broadly the distribution of sediment types within the study area beyond that which could be inferred from the limited number of surface and core sample data discussed in Section 4.2.1.

Processing of side scan data consisted primarily of spatially rectifying the individual track lines at a coarse (5 m) resolution to produce a raw, hard copy mosaic, from which gross patterns of surface sediment distribution were mapped. The surface sediment and vibracore grain size data from this study, the McAllister Point study (SAIC and URI, 1996), and a previous URI/GSO study (Quinn *et al.*, 1994) were used to assist in translation of intensity and texture patterns observed in the mosaic.

A map depicting the interpreted grain size variation of surface sediments is shown in Figure 4.2-5. In general, sediments along the shoreline and beyond the breakwater are composed primarily of > 50% sand. It is noteworthy, however, that a large area of fine-grained sediment (less than 10% sand) is located in the vicinity of the shipyard piers. Slightly coarser (10-25% sand) sediments are located just seaward of the southern pier and along the breakwater. Sediments from the central portion of the mouth of Coddington Cove are generally comprised of 25-50% sand, while sediments seaward of Coddington Cove tend to be coarser (50-75% sand). The area of 25-50% sand in Figure 4.2-5 designated by the question mark ("?") indicates an interpretation based solely on the intensity of side-scan sonar return which has not been verified by sediment sampling.

Acoustic sub-bottom sonar surveys were conducted to characterize the lithology of sub-surface sediments at broader spatial scales than could be accomplished by core sampling alone. For this analysis, selected images from acoustic sub-bottom surveys were chosen at locations where "ground-truth" data from deep sediment core samples (vibracores) was available. The locations of the vibracore stations are shown in Figure 3.6-2. Fewer vibracore samples were taken than samples for surface sediment and sediment core analyses, such that the interpreted distribution of deep sediment lithology contains greater uncertainty.

A representative sub-bottom profile, lithologic description of a vibracore, and grain-size analysis data for selected samples from the vibracore are shown in Figure 4.2-6. Full core descriptions are provided in Appendix D-1. Acoustic discontinuities observed in the geophysical profiles, called sub-bottom reflectors, usually correspond to abrupt historical changes in sediment type and distribution. In some locations, no strong sub-bottom reflectors were observed in the core, indicating that the sedimentation pattern was, for the most part, continuous and uniform over the time interval being characterized. Although the data appear adequate to provide estimates of the spatial distribution, continuity, and volume of lithologic units (potentially containing CoCs) within the study area, this processing step was beyond the scope of the present investigation.

A qualitative analysis of the distribution of blasting sand, rust, and paint chips found at vibracore stations indicated that this material was confined to surface sediments (Table 4.2-2). These materials were most abundant at Stations V10 and V11 located near the south side of the southern pier. In addition, Brown and Root Environmental Corporation observed possible sand blast grit in the surface sediments at Stations V4 and V9. Field logs and samples from these stations are contained in Appendix D-1.

In March 1986, SAIC conducted a survey involving REMOTS sediment profile imaging at 110 stations located in the area south of the southern pier (Figure 4.2-7). The REMOTS camera obtains undisturbed, cross-sectional images of the upper 20 cm of the seafloor, and computer image analysis is used to measure a variety of physical, chemical and biological parameters (Rhoads and Germano 1982; 1986). The March 1986 survey showed that surface sediments in the sampling area were primarily fine-grained (i.e., silt-clay). Many of the REMOTS images, particularly those from stations located immediately adjacent to the pier, showed extremely black sediments and shallow redox depths, indicative of high sediment oxygen demand typically linked to organic over-enrichment. Sandblasting material consisting of black particles was observed either at the sediment surface or mixed down into the sediment column in the REMOTS images from 18 of the 110 stations. These stations were primarily located adjacent to the southern pier or near a moored vessel south of the pier (Figure 4.2-7). These results are in agreement with those of the vibracore survey and suggest that the influence of past sandblasting activities on surface sediments in Coddington Cove was highly localized, restricted mainly to the pier/bulkhead areas where the sandblasting occurred.

In 1987, the Department of the Army conducted a chemical analysis of sediment samples in the vicinity of Pier 1 and Pier 2 of the Naval Education and Training Center, an area subject to periodic historic releases of sand blast grit (USACE, 1987 and USACE 1988, respectively). The three trace metals of toxicological significance included in the analyses were Cu, Pb and Zn (titanium was also measured). Sampling locations for the two investigations are shown in Figure 4.2-8; raw data are presented in Table 4.2-3.

The USACE applied threshold values of 200 ppm and 400 ppm to each of the three trace metals in order to assess levels of contamination in the sediment. Zinc concentrations exceeded 400 ppm in approximately half (15) of the 31 samples

analyzed, and nine of the remaining samples exceeded 200 ppm (Table 4.2-3). Concentrations of Cu and Pb were generally lower than those reported for zinc. Copper exceeded 400 ppm at six stations, and exceeded 200 ppm at seven of the remaining stations. Lead exceeded 400 ppm at four stations and 200 ppm at six of the remaining stations. Most stations for which higher concentrations of metals were reported were adjacent to Pier 1. The highest concentrations of Cu were reported for Station F adjacent to Pier 1 (Figure 4.2-8A), while highest concentrations of Pb (1250 ppm) and Zn (2780 ppm) were reported for Station S4 adjacent to Pier 2 (Figure 4.2-8B).

A priority pollutant scan for organic comtaminants was also conducted for five of the 31 metals stations (Stations G, M, Q, S4 and S9). Of these, only two stations Stations S4 and M) had quantifiable concentrations of organics (> 0.3 ppm), including phenanthrene, fluoranthene, pyrene, butylbenzylphthalate, bis(2-Ethylhexyl)phthalate, chrysene and benzo(b)fluoranthene, and the PCB mixtures A1254 and A1260. While organic concentrations at Station M were less than 0.8 ppm, those found at Station S4 ranged from 11.8 to 44.6 ppm for PAHs and 1.9 to 4.8 ppm for PCBs. The report concluded that the latter location may have been due to some form of coal tar, asphalt or crude oil present in the sample.

4.2.3. Hydrographic Studies

Hydrographic studies of the Derecktor Shipyard/Coddington Cove system were conducted to elucidate the general circulation patterns and bottom energies responsible for controlling resuspension/deposition dynamics of sediments, and, accordingly, chemical contaminants of concern.

The data needed to characterize exchange patterns between the cove and the bay, as well as the circulation patterns and energies within the cove, were obtained with

a shipboard Acoustic Doppler Current Profiler (ADCP). A complete discussion of the instrument and methods for data collection and analysis are found in Appendix D-2.

Vertical profiles of water speed and direction were collected along transect lines oriented across the mouth of (transect 1) and internal to (transects 2-6) Coddington Cove, respectively (Figure 4.2-9). Typically, each transect was occupied in succession and a complete set of all transects required approximately 1.5 hours. In addition, time series data were collected in a fixed position located in the Derecktor Enclosure area (Figure 4.2-9).

Field sampling days were selected to cover a range in tidal amplitudes for both the ebb and flood stages of the semi-diurnal tidal oscillation, including: 1) low amplitude, flooding conditions, 2) low amplitude, ebbing conditions and 3) high amplitude, flooding conditions. An additional field sampling day was conducted during the spring to provide data during the high runoff season and to characterize potential seasonal variability of flow within the cove.

Narragansett Bay-Coddington Cove Exchange Patterns. Data from transect 1 provide information on exchange patterns between Coddington Cove and Narragansett Bay. A consistent pattern in circulation at the mouth was apparent in each of the fall sampling days. Early in the flooding portion of the tide a characteristic inflow (south) - outflow (north) pattern was recorded (Figure 4.2-10A). As the flood tide proceeded the region of inflow expanded towards the north and maximum velocities (> 20 cm/s) became concentrated near the bottom (Figure 4.2-10B). Strong (up to 50 cm/s) outflow was still seen at the northern end of the section, near the breakwater. Sampling closer to maximum flood conditions indicated the mouth flow was vertically stratified, with inflow at the bottom and outflow at the surface (Figure 4.2-10C). It is particularly surprising that even at or near slack water, this anti-clockwise flow pattern across the mouth remained (Figure 4.2-10D). While some variability was seen in the details of the

flow pattern at the mouth, the basic lateral structure of inflow and outflow at the southern and northern ends of the transect, respectively, was also recorded for ebbing tide (Figures 4.2-10E and 4.2-10F).

The onset of a strong wind event (20 knots out of the southwest) was observed to enhance surface inflow at the southern end of the mouth of Coddington Cove near Coddington Point. As the wind increased, this inflow expanded northward over the entirety of the cove mouth, resulting in a vertically stratified system with inflow at the surface and outflow at depth (Figure 4.2-10G).

Circulation Patterns inside Coddington Cove. The strategy for characterization of internal circulation patterns in Coddington Cove involved dividing the cove into subsections; laterally averaged velocity profiles were obtained for each subsection and used to calculate volume flux within Coddington Cove (Figure 4.2-11). Results showed that the characteristic flow pattern (volume flux) recorded at the mouth during the fall surveys set up a net anti-clockwise circulation within the interior of the cove (Figure 4.2-11).

Internal circulation of Coddington Cove during a short wind event (1 hr @ 15 kt) caused a net surface inflow of about 8 cm/s into the northeastern corner of the cove (Figure 4.2-12A), which was higher than typical tidally driven flows for this area. In response, this flow was balanced by a deeper return flow (Figure 4.2-12B) as required to conserve mass within the estuary. The fact that lateral flow to the south (i.e., underneath the piers) did not occur suggests that the piers represent a partial barrier to lateral flow.

A time series of velocity profiles was recorded within the Coddington Cove Enclosure during each of the field days. Water velocities were found to range between 8.5 and 11.5 cm/s and tended to increase towards the end of the flood. Although the

water column appeared well mixed vertically, the data indicated a lack of mixing between the enclosure and greater Coddington Cove. Instead, the flow within this region displayed a circular, swirling motion. The lack of non-tidal exchange suggests that the flushing of water (and constituent CoCs) within the enclosure would be appreciably less than that of open cove areas.

4.2.4. Dissolved Oxygen Modeling for Coddington Cove

The Water Quality System Analysis Program (Ambrose *et al.*, 1993 - WASP5) was used to simulate annual variations in dissolved oxygen for Coddington Cove. The primary objective of the modeling is to estimate the water quality conditions during critical summer months which might adversely affect target receptors. A modeling approach was preferred over a direct measurement program because worst-case scenarios could be tested and required field measurements did not necessarily need to be conducted during summer months. The first level of complexity in EUTRO WASP5 was used, which simulates Biological Oxygen Demand (BOD)/Dissolved Oxygen (DO) interactions. The primary field data required for the simulation are the water exchange rates, temperature/salinity structure and water/sediment SOD measurements. Field DO data were also collected for model validation purposes.

Data Input. Water quality observations were made on October 4, October 25, and November 10, 1995. Water and sediment samples were collected from 10 stations and analyzed for dissolved oxygen, sediment oxygen demand, chlorophyll *a,* total suspended solids and ammonia. The water quality observations indicated low biomass productivity and low ammonia relative to the reference station (Table 4.2-4). Dissolved oxygen concentrations ranged from 7.22 to 8.48 mg/L or >90% saturation. Sediment Oxygen Demand (SOD) measurements, corrected for a temperature of 20°C, ranged from 0.17 to 0.27 g O_2/m^2-day (Table 4.2-5). These rates suggest a moderate sediment oxygen demand exerted on the water column, relative to literature values, showing a

range from 2 to 33 g O_2/m^2-day in the vicinity of municipal wastewater treatment and paper mill outfalls, to 0.05-0.10 g O_2/m^2-day for some U.S. rivers (Thomann and Mueller 1987, Bowie *et al.*, 1985). The water quality observations were used to validate WASP5 and model water quality conditions during the critical summer months. Complete results of oxygen demand and water quality test are presented in Appendices B-2-6 and B-2-7, respectively.

The WASP5 input was obtained from hydrographic and water quality measurements taken during the fall of 1995. The water quality measurements at different stations in Coddington Cove revealed little spatial variation, suggesting that water quality is relatively homogenous in the cove with no apparent "hot spots". Consequently, a cove-wide water quality simulation was used to simulate the overall Dissolved Oxygen (DO) response. This approach assumed the simulated water quality is the same in all model segments, such that the focus of the model was on the aggregate behavior of the cove as a whole. This approach was also supported by the observed regular counterclockwise circulation and the relatively steady observed interfacial hydrodynamic fluxes (discussed in Section 4.2.3).

The data shown in Figure 4.2-10, depicting the flow pattern and fluxes across the different hydrographic survey lines, were used to develop the spatially steady integrated flux across the model boundaries. The first level of WASP5 model permits the simulation of the BOD/DO interactions. The main components of the DO budget are the carbonaceous BOD (CBOD) deoxygenation, the atmospheric oxygen re-aeration, and the sediment oxygen demand. The calibration runs consisted of adjusting these components until a good agreement was reached with the observed and simulated DO values. Since these processes are temperature-dependent, an annual average water temperature distribution was developed (Figure 4.2-13). The water temperature distribution assumes an average monthly temperature of 25°C during July and August.

Simulation Results. Figure 4.2-14 depicts the simulated DO response in Coddington Cove. The observed DO measurements from the three surveys which are also presented show good agreement with the model results. Figure 4.2-15 depicts the annual DO responses to three different SOD rates (0.15, 0.35, and 0.55 g O_2/m^2-day). The observed DO values are averaged using the observations from all the segments. The observed DO values represent the mean DO in the cove at the time of the survey. The DO envelope response from the three SOD rates indicates that the SOD rate of 0.35 g O_2/m^2-day captures best the observed DO concentrations in Coddington Cove. In addition, the data indicate that during critical summer months the dissolved oxygen concentration reaches a minimum of 6.8 mg/L in response to the optimum SOD rate of 0.35 g O_2/m^2-day. This DO concentration is well above the threshold concentration (2 mg/L) generally considered stressful to aquatic organisms (Strobel *et al.*, 1995).

A worst-case scenario was developed to estimate the DO response using an extreme water temperature distribution. The distribution, which is depicted in Figure 4.2-16, assumes a maximum summer water temperature of 30°C. Dissolved oxygen predictions were made using this extreme distribution and the optimum SOD rate of 0.35 g O_2/m^2-day. The DO response to this scenario indicates a worst case minimum DO value of around 6.0 mg/L. As discussed above, this concentration is well above the threshold concentration generally considered stressful to aquatic organisms.

Conclusions. In conclusion, the application of WASP5 provided useful information on the water quality response in Coddington Cove. SOD rates measurements were verified and the critical DO response was estimated indicating that the average dissolved oxygen in the cove approaches a minima of 6 mg/L during summer. In general, these results do not demonstrate that low dissolved oxygen is adversely impacting indigenous biota within Coddington Cove. However, localized hypoxia may occur at some specific locations (e.g., Stations DSY-40 and DSY-41); such phenomena are not resolvable using the above modeling approach.

4.2.5. Synthesis of Fate and Transport Investigations

Taken together, the results of the above studies provide an estimate the likelihood of sediment resuspension potential and hypoxia, as well as an assessment of the probable transport direction and fate of fine-grained particulates in Coddington Cove which likely govern both the distribution of sediment types and CoCs. From comparisons of Figure 3.1-2 and Figure 4.2-5, there is an obvious correspondence between coarse grained (> 50% sand) sediments and shallow water depths (< 4 m) in the nearshore areas of the cove. Similarly, there is good correspondence between high silt sediments (< 25% sand) and water depths in the 7.6 to 12.2 m range. Hence, the overwhelming influence of water depth, most likely related to strength of bottom energies from wind-generated waves, on sediment distributions is clearly evident. These data alone, however, do not allow interpretation as to the sources and relative contribution of particle types that are contained within the sediment mixture; the interaction between the circulation pattern, bottom energy and sediment grain size must be understood.

To address this issue, the maximum bottom velocity observed within different regions of the cove during the field program was calculated in 5 cm/s increments. Using these data, the expected pattern of fine silt (particles <0.1 mm; maximum bottom velocity <5 cm/s;), fine sand (<0.8 mm; maximum bottom velocity <10 cm/s) and coarse sand (> 0.8 mm; maximum bottom velocity >10 cm/s) deposition was predicted (Figure 4.2-17). The results show that the overall pattern of circulation and bottom energy in Coddington Cove is such that while the majority of the sediment should be carried out with the vigorous outflow, some is expected to fall out of suspension depending on bottom energies. Accordingly, the sediments, once resuspended or imported into the cove, will be transported, sorted and deposited by particle size in a counterclockwise pattern.

In the southern cove area, fine grained sediments (and associated CoCs) are expected to enter Coddington Cove from around Coddington Point, as opposed to sources to the north (i.e., Derecktor Shipyard). In contrast, particulate-associated CoCs entering the cove from the Shipyard may be expected to spread northward along the harbor front, particularly in the interior sections of the cove between the piers and in the northeastern harbor area. Finally, the high bottom velocities which extend well into the southeastern section of the cove should inhibit the deposition of fine-grained particulates and associated CoCs, regardless of source.

Within the Derecktor Enclosure Area, restricted circulation relative to greater Coddington Cove was evident from hydrographic measurements. The near-bottom velocity maxima data predicts that the enclosure area would permit some deposition to occur (Figure 4.2-17) and field observations suggest that the current is circular and would tend to retain particulates. The modeled DO levels do not appear to be at levels of concern although the model resolution is insufficient to specifically address highly localized areas. The issue of restricted circulation in relation to possible effects on benthic communities will be addressed further in Section 6.

4.3. CHEMICAL CHARACTERIZATION

This section evaluates the spatial distribution and concentration of contaminants in sediments and biological tissues to describe the possible fate and transport of contaminants from Derecktor Shipyard to receptors of concern. The sections below present data obtained from the analysis for organic and inorganic contaminants in offshore sediments, sediment elutriates and organisms from the Derecktor Shipyard/ Coddington Cove study area. The samples were collected and stored according to established protocols and were analyzed using standard methods. All procedures used in this investigation have been described in detail in the Final Work/Quality Assurance

Project Plan - Narragansett Bay Ecorisk and Monitoring for Navy Sites (URI and SAIC, 1995).

Sediment samples were collected from stations in Coddington Cove, and at two reference sites in Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC). All Coddington Cove station locations are shown in Figure 3.6-1. Surficial sediment (approximately 0-18 cm) was collected at these stations, representing recently deposited sediments within the zone of greatest biological activity. Subsurface sediment piston core and vibracore samples (from >20 cm in depth) were also collected to enable evaluation of the contaminant distribution in subsurface sediment layers.

4.3.1. Trace Metal Contaminants

A total of 20 surface sediments, 16 core sections, and 11 elutriate samples were analyzed for twelve trace metals by the total digestion method. In addition, the surface sediment samples were analyzed for Acid Volatile Sulfides (AVS) and Simultaneously Extractable Metals (SEM). Sediment trace metals, AVS, and SEM values are reported on a dry weight basis. Elutriate values are reported on a volumetric basis. Complete analytical details are provided in the Draft Final Work/ Quality Assurance Project Plan (SAIC and URI, 1995).

4.3.1.1. Sediments

Trace metals - total digestion. The surface sediments and selected core sections were analyzed for twelve trace metals using a total sediment digestion method, and the results are summarized in Table 4.3-1. The metals aluminum, iron, and manganese are considered to be primarily derived from the natural breakdown of rock and soil (i.e., lithogenic) and are not generally considered to be toxic in the observed concentrations. Non-lithogenic trace metals (e.g., arsenic, cadmium, chromium,

copper, lead, mercury, nickel, silver, and zinc) are naturally occurring in relatively low background concentrations, but are generally considered to be anthropogenic. Complete trace metal analysis data are presented in Appendix A-1-1.

Concentrations of trace metals in surface sediments of Coddington Cove are shown in Figure 4.3-1. Three metals, including Ag, Hg and Cd were found to range from slightly higher than detection limits (0.13, 0.03 and 0.13 µg/g, respectively) to concentrations approaching 2 µg/g at Station DSY-29. Arsenic, also an abundant crustal constituent in the Rhode Island formation, was 3-12 µg/g uniformly across all stations, with the exception of Station DSY-29 (> 25 µg/g). The trace elements Ni and Cu ranged from 10-30 and 30-80 µg/g, respectively at most stations, but were approximately two and five times higher, respectively at Station DSY-29. Elevated concentrations of Ni and Cu were also observed at Station DSY-27, but were about half of the concentrations observed at Station DSY-29.

Patterns observed for chromium, lead, and zinc were similar to Cu and Ni, being highest at Stations DSY-27 and DSY-29. Concentrations of Cr, Pb and Zn at Station DSY-29 were approximately 170, 350 and 800 µg/g, respectively. Concentrations of Cr, Pb, and Zn at other Coddington Cove stations (excluding Stations DSY-27 and DSY-29) were generally comparable or less than those found at the reference stations. The remaining elements, Mn, Fe, and Al, are all primarily lithogenic in nature. However, these elements generally show an enrichment pattern at various Derecktor Shipyard/ Coddington Cove stations which is similar to that of anthropogenic metals, particularly at Station DSY-29. This would suggest that these metals may also exist as introduced contaminants in sediments at some study area stations.

As discussed above, the concentration of trace metals in sediments is dependent on the lithology and is generally inversely correlated to the sediment grain size. Numerous approaches have been used in previous studies to normalize trace

metal concentrations for variations in sediment grain size and identify point sources of contamination. The assumption in these studies is that the normalized concentrations of trace metals will be highest at stations proximal to the point source of contamination. In this study, anthropogenic trace metal concentrations were normalized to the concentration of the lithogenic metal aluminum. Normalization of the dry weight metals concentrations to aluminum allows for estimation of levels of naturally occurring metals in estuarine sediments (Summers *et al.*, 1996). The primary assumption of the normalization method is that aluminum is most abundant in fine sediments (clays and silts) and therefore the normalized values will be relatively lower for fine sediments and relatively higher for coarse sediments (sand). Overall, aluminum normalization has been found to significantly reduce the influence of grain size and allow more accurate determination of the spatial distribution of trace metals in the environment relative to possible point sources of contamination (Summers *et al.*, 1996). In this analysis, an EPA-recommended approach has been used; other normalization approaches may yield different results.

Aluminum-normalized trace metal values at Coddington Cove stations relative to similar values at outer cove Station DSY-39 are defined as Metal Enrichment Factors (MEFs). MEFs are dimensionless and are used to indicate the spatial distribution and relative abundance of a particular metal independent of expected crustal constituents (Table 4.3-2). Offshore Station DSY-39 was used as the point of comparison, since potential shipyard-related contamination at this site was deemed least likely, though regional sources would still influence metals distribution. However, a qualitative comparison of the concentrations observed at this station reveal generally comparable values with that of the reference location.

The spatial patterns of MEFs for lead, copper, and zinc concentrations are shown in Figures 4.3-2 through 4.3-4, respectively. Relative to Station DSY-39, lead appears elevated by greater than two-fold at Stations DSY-27 and DSY-32, and by

greater than three-fold at Station DSY-29 (Figure 4.3-2). Copper appears to be elevated by greater than three-fold at Stations DSY-30 through DSY-32, and greater than six- to seven-fold at Stations DSY-27 and DSY-29, respectively (Figure 4.3-3). Similarly, MEFs for zinc were elevated at Stations DSY-27 (MEF=4.4) and DSY-29 (MEF=3.7; Figure 4.3-4). In summary, all anthropogenic trace metals generally demonstrated a decreasing trend in normalized values moving offshore from Derecktor Shipyard/Coddington Cove. This pattern would suggest that the shipyard is a point source for these metals.

Temporal trends in contaminant inputs and the thickness of contaminated sediments were determined by chemical and stratigraphic studies of sediment cores. Sediment core studies were done at seven stations within the Derecktor Shipyard/ Coddington Cove study area (Figure 3.6-1). The trace metal results from these studies are summarized in Table 4.3-1, and comparisons of the results for the anthropogenic metals relative to ER-L and ER-M guidelines (Long *et al.*, 1995) are shown in Figure 4.3-5 (A through I). In general, subsurface maxima in trace metal contamination existed at Stations DSY-27 and DSY-28 in the Derecktor Shipyard area of Coddington Cove and at Station DSY-36 adjacent to the breakwater. All of the anthropogenic metals exceeded the ER-L guidelines at multiple stations and sediment depths. In addition, concentrations exceeded ER-M guidelines for zinc in some depths at Stations DSY-27 and DSY-28 (Figure 4.3-5A); for nickel in 24-34 cm at Station DSY-28 (Figure 4.3-5F); and for mercury in some depths at Stations DSY-28 and DSY-36 (Figure 4.3-5G). The comparison of measured concentrations of metals in sediments with established criteria is discussed further in Section 6.1.

Simultaneously Extracted Metals (SEM) and Acid Volatile Sulfide (AVS) study of surface sediments. The ratio of SEM/AVS provides a second criterion for determining the potential toxicity of divalent metals in sediments. In general, toxicity of metals in sediments is correlated with metals activity in interstitial porewater. SEM/AVS analyses

address the bioavailability of divalent metals in sediments, and thus are conceptually similar to the equilibrium partitioning (EqP) method. In general terms, DiToro *et al.* (1990) have shown that metal availability, particularly in anoxic sediments, is controlled by insoluble metal sulfides that act to bind divalent metals such as cadmium, copper, mercury, nickel, lead, and zinc. Acid treatment releases these reactive sulfides, which can then be analyzed as acid volatile sulfides. Conceptually, if divalent metals are bound to AVS, they will not be toxic to sediment biota. Therefore, a comparison of the amount of AVS and SEM in the sediment will allow a determination of metal bioavailability and potential toxicity. Until recently, if the SEM/AVS ratio was greater than one (>1), metals have generally been assumed to be bioavailable. However, based on recent scientific developments and due to the seasonal variations in AVS (minimum values in winter), SEM/AVS values greater than 0.5 were conservatively interpreted in this study as indicative of potential bioavailability.

For the present evaluation, samples for SEM/AVS were collected at 20 surface stations. All SEM/AVS samples were analyzed in duplicate. SEM and AVS results are summarized in Appendix A-1-4 and SEM/AVS ratios are spatially shown in Figure 4.3-6. The results indicate that metals are likely to be bioavailable (ratio $\geq$ 0.5) at Stations DSY-33, DSY-35, and DSY-37, and at the control Station JPC-2. The surface sediment map (Figure 4.2-1) indicates that these stations have moderately to highly sandy sediments. Stations throughout the rest of the study area have low SEM/AVS ratios and relatively abundant AVS (Appendix Tables A-1-4.3 and A-1-1.2, respectively; SEM data presented in Appendix Table A-1-4.1). For these reasons, trace metals are likely to be sequestered in insoluble sulfides and are unlikely to be bioavailable within most of the study area.

4.3.1.2. Elutriates

Metals analyses were performed on an elutriate sample from each of ten stations. These analyses provide a third criterion for evaluating the potential toxicity of sediments. The results of the elutriate trace metal analyses are summarized in Table 4.3-3 (complete data presented in Appendix A-1-2). Six metals (aluminum, arsenic, copper, iron, lead, and manganese) were measured at levels above the Limit of Quantitative Detection (LQD) in the elutriate samples. Comparison of these levels to EPA salt water quality criteria (EPA, 1986) showed that the salt water chronic criterion was exceeded for arsenic at Stations DSY-36 and DSY-38, and was equaled or exceeded for lead at all stations analyzed, with the exception of Station DSY-36 (Figure 4.3-7). In addition, the salt water acute criterion was exceeded for arsenic at Station DSY-39 and for copper at Station DSY-31.

4.3.1.3. Tissue Residues

Indigenous Blue Mussels. Indigenous blue mussels were collected from the Derecktor Shipyard/Coddington Cove (DSY) study area (Figure 3.6-2), and the reference stations at Jamestown Potter Cove and Castle Hill Cove. Figure 4.3-8 shows the distribution of metal contaminants in tissue residues for indigenous blue mussels. Cadmium and mercury were less than 2 µg/g at all stations (Figure 4.3-8A), while chromium, lead, and nickel were less than 6 µg/g (Figure 4.3-8B), concentrations which were comparable to reference. Concentrations of copper exceeded reference at Station DSY-27, and arsenic exceeded reference at Stations DSY-24 through DSY-26 (Figure 4.3-8C). Highest concentrations were observed for zinc, which exceeded reference at Stations DSY-25, DSY-27, DSY-28, DSY-35 and DSY-40 (Figure 4.3-8D). Silver was not detected in tissues from any station. Complete results of tissue analyses are presented in Appendix A-1-3.

Deployed Blue Mussels. Blue mussels were deployed 1 m above bottom at eight stations in Coddington Cove, as well as at reference Stations JPC-1 and CHC-1 (Figure 3.6-6). Prior to deployment, concentrations of metals in mussel tissue were measured in a subset of the mussel population used for deployment; this value was considered the "time-zero" concentration (T_0). Figure 4.3-9 shows the distribution of metal contaminants in tissue residues of the deployed blue mussels after 30 days in the field. Concentrations of cadmium, silver, and mercury were less than 2 µg/g and higher than reference concentrations while being comparable to T_0 values (Figure 4.3-9A). Lead, nickel, and chromium were less than 5 µg/g and were comparable to reference values, but generally higher than T_0; Ni residues at Station DSY-28 were the exception as 5 µg/g levels were observed (Figure 4.3-9B). Concentrations of arsenic and copper were generally less than 10 µg/g and were lower than T_0 residue concentrations (Figure 4.3-9C). In contrast, concentrations of zinc exceeded reference and T_0 values at Stations DSY-31, DSY-33, DSY-39, and DSY-40 (Figure 4.3-9D).

Hard Clams. The hard clams *Mercenaria mercenaria* and *Pitar morrhuana* were collected from eleven Derecktor Shipyard/Coddington Cove study area stations (Figure 3.6-3), and reference Station JPC-1. Concentrations of cadmium, mercury and silver were less than 1.5 µg/g, though silver concentrations were higher than reference at Stations DSY-32, DSY-37 and DSY-41 (Figure 4.3-10A). Chromium, lead and nickel were less than 5 µg/g and were generally comparable to reference values, with the exception of 1.5-fold higher concentrations of lead at Stations DSY-32 and DSY-37, and higher concentrations of nickel at Stations DSY-31 (*Pitar*) and DSY-35 (*Mercenaria*; Figure 4.3-10B). Concentrations of arsenic and copper in both hard clam species were less than 16 µg/g and generally consistent with reference concentrations, though copper was slightly higher than reference at Stations DSY-31 and DSY-41 (Figure 4.3-10C). Concentrations of zinc were generally less than reference; only Station DSY-28 exhibited zinc concentrations higher than reference (Figure 4.3-10D).

Lobsters. Lobsters were collected from nine Derecktor Shipyard/Coddington Cove study area stations (Figure 3.6-5), as well as from reference Stations JPC-1 and CHC-1. Concentrations of cadmium, lead, and mercury were less than 1.0 µg/g, though reference concentrations were exceeded for lead by 1.5- to 2-fold at Stations DSY-33 and DSY-35, and 1 to 2-fold for mercury and cadmium at most stations, with the exception of non-detect values for cadmium at Stations DSY-28 and DSY-36 (Figure 4.3-11A). Chromium and nickel concentrations were comparable to reference station values (<2.5 µg/g); however, silver concentrations exceeded reference at Stations DSY-25, DSY-27, DSY-29, DSY-35, and DSY-38 (Figure 4.3-11B). Concentrations of copper and zinc at Coddington Cove stations ranged from approximately 45-200 µg/g and 100-170 µg/g, respectively, and were generally less than reference concentrations. Exceptions were observed for copper at Stations DSY-25, DSY-27, DSY-38, and DSY-39, and for zinc at Stations DSY-29, DSY-38, and DSY-39 (Figure 4.3-11C). Concentrations of arsenic were generally less than reference, except at Stations DSY-25, DSY-29 and DSY-38, though all stations were less than 30 µg/g or 1.5-fold of reference (Figure 4.3-11D).

Fish. Fish were collected from four stations in the Derecktor Shipyard/ Coddington Cove study area, as well as reference Stations JPC-1 and CHC-1. The concentrations of cadmium, nickel, and silver in fish were less than 2.0 µg/g (Figure 4.3-12A), with several non-detect concentrations observed for nickel (Station CHC-1) and silver (Stations DSY-29, DSY-36, and JPC-1). Chromium, lead, and mercury concentrations were consistent (<1.5 µg/g), with the reference residue concentration exceeded slightly for chromium at Station DSY-26 and for lead at Stations DSY-29 and DSY-36 (Figure 4.3-12B). Concentrations of copper in fish were comparable to or below reference, while zinc exceeded reference values by about two-fold at Stations DSY-26 and DSY-36 (Figure 4.3-12C). Concentrations of arsenic exceeded reference at Stations DSY-28 and DSY-29, but were less than 8 µg/g (Figure 4.3-12D).

4.3.2. Organic Contaminants

A total of 19 surface sediments, 16 core sections and 12 elutriate samples were analyzed for 18 polychlorinated biphenyl (PCB) congeners, 23 polycyclic aromatic hydrocarbons (PAHs), 5 organochlorine pesticides (OCPs) and 4 butyltins (BTs). The sum of the PCB congeners times 2 is the Total PCBs (equivalent to the total Aroclors), and the sum of the 23 PAHs is the Total PAHs. The pesticide p,p'-DDE was the major OCP species detected, and tributyltin (TBT) was the predominant butyltin species found in the samples. All sediment values are reported on a dry weight basis, and elutriate values are reported on a per-liter basis. Complete analytical details have been previously reported by SAIC and URI (1995). In many cases, the pesticides o,p'-DDE and aldrin could not be quantified accurately due to analytical interferences from co-eluting PCB congeners.

4.3.2.1. Sediments

Concentrations of organic contaminants in surface and core sediments from the Derecktor Shipyard/Coddington Cove study area are presented in Tables 4.3-4 and 4.3-5, respectively (raw data are presented in Appendix A-1-1). Ratios of contaminant concentrations relative to TOC concentrations (i.e., TOC-normalized concentrations) were calculated and are also presented in these tables. The station designated DSY-29-FD is a field duplicate of Station DSY-29. For Total PCBs (Figure 4.3-13A), the values at Stations DSY-27 and DSY-29 through DSY-32 exceeded 180 ng/g (ER-M benchmark); overall values ranged from 7 ng/g at Stations DSY-35 to 3,310 ng/g at Station DSY-27. Total PCBs exceeded reference at all stations except Stations DSY-35 and DSY-41 (Figure 4.3-13A). Concentrations of Total PAHs (Figure 4.3-13A) exceeded 4,022 ng/g (ER-L benchmark) at about half of the stations; overall values ranged from 62 ng/g at Station DSY-35 to 46,400 ng/g at Station DSY-29 FD, which exceeded the ER-M value. Concentrations of TBT (Figure 4.3-13B) exceeded the

benchmark value of 5 ng Sn/g (Macauley *et al.*, 1994) at six stations (Stations DSY-27, DSY-28, DSY-29, DSY-30, DSY-31, and DSY-36); overall values ranged from non-detected (<1 ng Sn/g) to 228 ng Sn/g at Station DSY-31. Concentrations of p,p'-DDE (Figure 4.3-13B) exceeded 2.2 ng/g (ER-L benchmark) at five stations; overall values ranged from 0.1 ng/g at Stations DSY-35 and DSY-41 to slightly less than 7.0 ng/g at Stations DSY-27, DSY-29, and DSY-29 FD (Figure 4.3-13B).

Surface sediment organic carbon normalized values for contaminants followed a similar trend as that for the direct sediment concentration measurements (Table 4.3-4). One exception was noted for Station DSY-40, which had elevated ratios of all contaminants due to a combination of moderate contaminant levels and low organic carbon concentrations.

The distributions of individual PCB congeners and PAH compounds for three stations are shown in Figure 4.3-14 and 4.3-15, respectively. Station DSY-29-FD was selected because of its elevated concentrations of PCBs and PAHs relative to the other stations from Coddington Cove. Stations DSY-31 and DSY-36 were selected because of their location near the piers (Station DSY-31) or the breakwater (Station DSY-36). For the PCBs, the congener distribution was very similar at Stations DSY-31 and DSY-36 (Figure 4.3-14), as well as at most of the other stations from the study area. The major congeners were the 3- to 6-chlorine congeners: 66, 101, 118, 153 and 138, which probably derived from AR1254, the major Aroclor formulation in Narragansett Bay surface sediments, as well as smaller amounts of AR1260 (Latimer *et al.*, 1991; Quinn *et al.*, 1992). Major sources of PCBs to Narragansett Bay include rivers, combined sewer overflows/sewage discharges, and atmospheric deposition (Latimer and Quinn, 1996). Station DSY-29 FD had a very different PCB composition, with the congener 209 (decachlorobiphenyl) accounting for about 60% of the total congeners measured, and congener 206 present in relatively large concentrations. This unique distribution of congeners may indicate the presence of "Deka" investment casting wax

(John F. Brown, G.E. Corporate Research and Development, personal communication, 1995) from past activities at Derecktor Shipyard.

Four- and five-ring pyrogenic compounds (e.g., fluoranthene, pyrene and benzo(b,j,k)fluoranthene) were the major PAH components in the surface sediments (Figure 4.3-15). Concentrations of these three PAH analytes were consistently the highest observed among stations in the Derecktor Shipyard/Coddington Cove study area. Three representative stations (DSY-29 FD, DSY-31, and DSY-36) are shown in Figure 4.3-15, where a similar pattern in the distribution of PAH analytes was observed. Sources of these compounds include combustion products in used motor oil, atmospheric deposition, creosote/coal tar and asphalt from local activities, river and land runoff, and sewage effluents and overflows (Pruell and Quinn, 1988; Quinn *et al.*, 1992; Battelle, 1994; Latimer and Quinn, 1996). There was no evidence of fresh (unweathered) fuel oil in any of the samples, as indicated by qualitative measurements of total petroleum hydrocarbons.

Concentrations of organic contaminants with depth in sediment cores from three representative stations are presented in Figures 4.3-16 through 4.3-18, and in Table 4.3-5. At Station DSY-28, the concentrations of all contaminants showed a subsurface maximum at a depth of 24-34 cm and/or 76-86 cm (Figure 4.3-16). At the two depths, Total PCBs exceeded 22.7 ng/g (ER-L benchmark), and both p,p'-DDE and the PAHs were elevated. Since TBT was first introduced to the environment in 1960 (T. Wade, Texas A&M University, personal communication, 1995), sediments at a depth of 105 cm or more (which have no measurable concentrations of TBT) were assumed to have been deposited before that date. However, PCBs have been available since 1930 and DDT was first used in 1940 (Latimer *et al.*, 1991). Thus, sediments at a depth of 105 to 140 cm were deposited after 1930 (small amounts of Total PCBs are present) but before 1960 (TBT is absent). An estimated sedimentation rate based on detection of PCBs is 140 cm in 65 years (1930 to 1995), or about

2.2 cm/yr. The corresponding value, based on detection of TBT, is 86 cm in 35 years (1960 to 1995) or about 2.5 cm/yr. These values are in good agreement and suggest a relatively high natural sedimentation rate at Station DSY-28. However, another possibility is that the observed trends with sediment depth are not due to natural sedimentation but rather to "dumping" and/or "washing" of materials from the adjacent piers and docks. The effects of bioturbation on the observed contaminant distributions are unknown at this time.

Trends in the concentrations of organic contaminants with depth in sediments from Station DSY-29 are shown in Figure 4.3-17. The 0-18 cm sample represents the surface sediment, while piston core samples represent deeper sediments. Only p,p'-DDE showed a subsurface maximum at 16-26 cm; all other contaminants decreased with depth to very low values at 44-54 cm. Since no TBT was detected at 16-26 cm, the sedimentation rate was calculated to be approximately 18 cm in 35 years, or about 0.5 cm/yr. PCBs indicate that the estimated rate is 54 cm in 65 years, or about 0.8 cm/yr. These estimates suggest a considerably slower sediment input at this station compared to Station DSY-28.

The data for Station DSY-36 are presented in Figure 4.3-18 and, as for Station DSY-28, there exist subsurface maxima for most contaminants. Since Station DSY-36 is somewhat distant from the piers and docks, high Total PCB values at 40-50 cm are particularly noteworthy. Estimated sedimentation rates are 100 cm in 65 years, or about 1.5 cm/yr, based on PCB detection, and 18 cm in 35 years, or 0.5 cm/yr, based on TBT detection. The poorer agreement in estimates for this station may be attributed to changes in sedimentation rates over time, due to the construction of the nearby Coddington Cove breakwater in 1957.

4.3.2.2. Elutriates

Analyses of elutriate samples showed the presence of PCBs, PAHs, and small amounts of p,p'-DDE (Table 4.3-6; complete data presented in Appendix A-1-2). These samples were prepared by mixing surface sediment and seawater for 1 hour at room temperature, allowing the mixture to stand for 18 hours at 4°C, then filtering and centrifuging to produce a solution containing both dissolved and colloidal material. The concentrations of Total PCBs and Total PAHs are shown in Figure 4.3-19. Elutriate from Station DSY-25 had the highest concentration of both contaminants, and several other stations showed elevated levels of one or both contaminants relative to the reference station (e.g., Stations DSY-27, DSY-29, DSY-31 for PCBs; DSY-25, DSY-27, DSY-29, DSY-32, DSY-33, and DSY-40 for PAHs). Additionally, eight of the samples exceeded the marine chronic criteria of 30 ng/L for Total PCBs (EPA, 1992), including the reference station, JPC-1. Although no water criteria exist for PAHs, concentrations were below 900 ng/L or 275-fold lower than the lowest reported LC_{50} value for individual PAHs (250 µg/L; Eisler, 1987). A comparison of the elutriates and sediment concentrations of PCBs and PAHs is shown in Figure 4.3-20 using data from twelve stations, as well as the field blank, for both sediments and elutriates. Station DSY-25 was considerably above the regression line for both contaminants. The relationships between elutriate concentration and sediment concentration are significant at the 95% confidence level for PCBs and at the 90% confidence level for PAHs, indicating that resuspended sediments can contribute colloidal and/or dissolved organic contaminants to the water column.

Comparison with Historical Data for Derecktor Shipyard/Coddington Cove. Quinn *et al.* (1994) analyzed sediment samples from the Derecktor Shipyard/ Coddington Cove study area, employing essentially the same analytical methods, but with somewhat less stringent QC procedures than the current investigation. The data from the two studies are comparable on a relative and/or semi-quantitative basis.

Surface and core sediment samples were collected in November 1993 and June 1994 by diver and/or a Smith MacIntyne grab sample from 24 stations in the Derecktor Shipyard/Coddington Cove study area. The range of concentrations (on a dry weight basis) for the surface sediments (top 2 cm) in the 1994 study were as follows:

PCBs:	9.4 ng/g to 733 ng/g
PAHs:	285 ng/g to 81,700 ng/g
p,p'-DDE:	0.2 ng/g to 13.6 ng/g
TBT:	32 ng Sn/g to 372 ng Sn/g

There was fairly good agreement in sediment chemistry of organic contaminants between the 1994 study and the current investigation, although Stations DSY-27 and DSY-29 had considerably higher PCBs than previously observed. In both cases, the sampling results demonstrated that the highest concentration of contaminants were adjacent to the piers and outfalls of Derecktor Shipyard.

4.3.2.3. Tissue Residues

Deployed and Indigenous Mussels. Figure 4.3-21 compares the concentrations of organic contaminants in blue mussels deployed for 30 days and mussels indigenous to the study area (complete analytical data are presented in Appendix A-2-2). Highest values for deployed mussels relative to the references were generally observed at Stations DSY-26 through DSY-33 and Stations DSY-38 through DSY-40. Indigenous mussels showed high values relative to the references at a number of stations, including Stations DSY-26, DSY-27, DSY-28, DSY-35, DSY-36, and DSY-40. In many cases, there was fairly good agreement between the indigenous and deployed tissue residue values. However, Station DSY-26 exhibited relatively poor agreement. Subsequently, a second sample of both indigenous and deployed mussels from Station DSY-26 was analyzed, and the values for PAHs were found to be in good agreement

(relative percent difference [RPD]<10%) with the first analyses. The agreement between PCBs and p,p'-DDE in the indigenous samples was also acceptable (RPD<30%). However, the value from the second analysis of PCBs (600 ng/g) in deployed mussels was much lower than that from the first analysis (1780 ng/g).

Generally, the reference station samples at Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) were lower than the study area samples. However, TBT concentrations in indigenous mussels at Station CHC-1 were the second highest of all stations measured. Furthermore, the concentration of TBT (977 ng Sn/g) for indigenous mussels at Station DSY-27 was exceptionally high, considering the sediment values at this location were quite low.

Hard Clams. The highest concentrations of organic contaminants in hard clams (mainly *Pitar*) from the study area were generally observed at Stations DSY-31, DSY-32, DSY-36, and DSY-41 (Figure 4.3-22). Concentrations of PCBs and PAHs in hard clams from the reference site at Jamestown Potter Cove were generally lower than samples from the Derecktor Shipyard/Coddington Cove study area. This was also true for TBT, although a high concentration of TBT (50 ng Sn/g) was observed in *Pitar* at Station JPC-1. In general, the lipophilic contaminants (i.e., PCBs, PAHs and p,p'-DDE) were usually more concentrated in mussel samples than clam samples, probably due to the higher lipid content of mussel tissues (4.3 to 7.6%; median value = 5.9%) compared to clams (1.0 to 4.0%; median value = 2.5%).

Lobster. Concentrations of organic contaminants in lobster muscle tissue were highest at Stations DSY-27, DSY-28 and DSY-38 (Figure 4.3-23). Samples from the reference sites (JPC-1 and CHC-1) were in the same range as the samples from the Derecktor Shipyard/Coddington Cove study area. All TBT values were below the method detection limit.

Fish. In general, fish tissue samples from Stations DSY-28 and DSY-29 had the highest concentrations of organic contaminants within the study area, but concentrations in the reference samples exceeded many concentrations found for stations from the study area (Figure 4.3-24). High PAH values for Stations DSY-28 and CHC-1 are considered unusual, since fish (and lobsters) can metabolize these compounds to varying degrees (Neff, 1979). PCBs and p,p'-DDE were concentrated in the fish tissue, probably as a result of high lipid content (7.5 to 12.5%; median value = 10.1% for cunner).

4.4. UNCERTAINTY

Contaminant sources, distribution and concentration in the Derecktor Shipyard/ Coddington Cove study area have been relatively well characterized based on data from present and previous studies. However, the exposure pathways as reflected by the first through fourth tier models (Section 3.5) are necessarily conceptual and cannot account for all the complexities of a natural ecosystem, including proximal and distal sources, as well as potential receptors. These uncertainties also are driven by incomplete knowledge of the chemical behavior of the CoCs, even though considerable information is available on solubility, partitioning, and toxicity for several analytes. Nonetheless, existing information on the chemical contaminants and a reasonably thorough understanding of the cove ecosystem have allowed sufficient and relevant data to be targeted, collected, and interpreted for the risk assessment.

Spatial variability. Fate and transport evaluations for the exposure assessment focused on spatial (horizontal) and vertical (sediment layering) patterns as well as data comparability among the matrices sampled (sediment, elutriate and tissue). The placement of sampling stations was largely based on providing "visually complete" (essentially "gridded") coverage of the various areas of the cove, including both coarse-

grained and fine-grained habitats found both in harborfront and open cove areas. Station placement was guided additionally by results from prior studies; however, visual coverage was still the principal method applied. The uncertainty associated with any sampling station is whether it is truly representative of the habitat and impact/reference zone being evaluated. Collection of station replicates is one method that allows assessment of within-station variability (i.e., the representativeness of a sample). Although only single samples were generally collected per station for this study, agreement among field duplicate measurements suggests that small scale spatial variation was not problematic. Hence, comparison of the data variability among stations is the primary method used to assess adequacy and representativeness of the sampling grid. There are uncertainties of extrapolations (and assumptions) from point measurements to broader spatial areas, but geotechnical, geophysical and hydrographic studies have helped fill the "gap", by providing quantitative information on spatial scales of variability in sediment lithologic properties (e.g. TOC, grain size, erodability) which strongly influence CoC distribution. Additional quantitative approaches using Geographic Information Systems (GIS) technology, including the development of concentration contours have been recently reported (Clifford *et al.*, 1995); this approach appears to provide an effective, unbiased method for estimating spatial extent of exposure, thereby minimizing interpretive uncertainty and maximizing data usage. Application of these techniques may be useful when sediment remediation strategies are investigated. QA/QC and data validation for sample inventory and analysis are presented in Appendix C-3.

Temporal variability. Another area of uncertainty for the exposure assessment is the temporal comparability of data. The general study design assumes that there have not been substantial changes in environmental conditions and chemical contaminant concentrations at individual sampling sites, as representative of particular habitat and sampling zones. In practice, however, interannual and seasonal variations occur in every environment, thereby changing to some degree the conditions that influence

contaminant sources, exposure pathways, and receptors. For the present study, more accurate navigation (± 3 m) and deeper sampling (surface sediment interval = 0-18 cm) was employed than in earlier studies (Loran Navigation: ± 100 m; surface sediment interval = 0-2 cm). Nonetheless, the assumption that temporal changes in sediment chemistry are not significant appears correct. Differences between concentrations of representative CoCs for sets of stations that were sampled for the two studies and located very near or coincident with each other were relatively small.

The exposure point estimates are based on representative chemical analytes that, due to practicality, are a subset of the total possible compounds that could be analyzed. However, the analytes have been carefully selected as a result of extensive screening and analyses during the present and previous studies and are considered to be appropriately conservative and representative of source contaminants. Calculations of SEM for use in comparisons with AVS values utilize sediment data on copper, zinc, lead, nickel, cadmium, and mercury. Each of these metals, except mercury, is commonly accepted as reacting in the presence of sulfides in a manner which fulfills the assumptions of the AVS paradigm. However, there is ongoing debate about the appropriateness of including mercury in the calculations. This is because mercury can react in a manner that is more similar to an organic compound than a divalent metal. For this assessment, mercury has been included in the SEM calculation. In some cases, its incorporation does affect the final SEM/AVS ratios. However, the inclusion of this metal primarily serves to increase the ratio value, thereby representing a more conservative effects measure. QA/QC and data validation for metals and organics are presented in Appendices C-1 and C-2, respectively.

Finally, sediment elutriates were prepared and chemically analyzed to evaluate potential CoC exposure to target receptors during sediment resuspension events. This evaluation of potential resuspension events addressed only current conditions and levels of activity at the site, and did not address future use scenarios involving

fundamentally different conditions or activities at the site. Although CoC concentrations marginally exceeding water quality criteria were observed, there exists great uncertainty with regard to the equivalency of elutriate concentrations prepared in the laboratory with those concentrations which might occur in Coddington Cove during sediment resuspension events. Because the water-only fraction of the elutriate is prepared from sediment mixtures exceeding 100 g/L of suspended solids, whereas field suspended solids concentration in Coddington Cove are three orders of magnitude lower (e.g., < 100 mg/L), it is considered unlikely that water quality criteria are ever exceeded in the field during natural resuspension events.

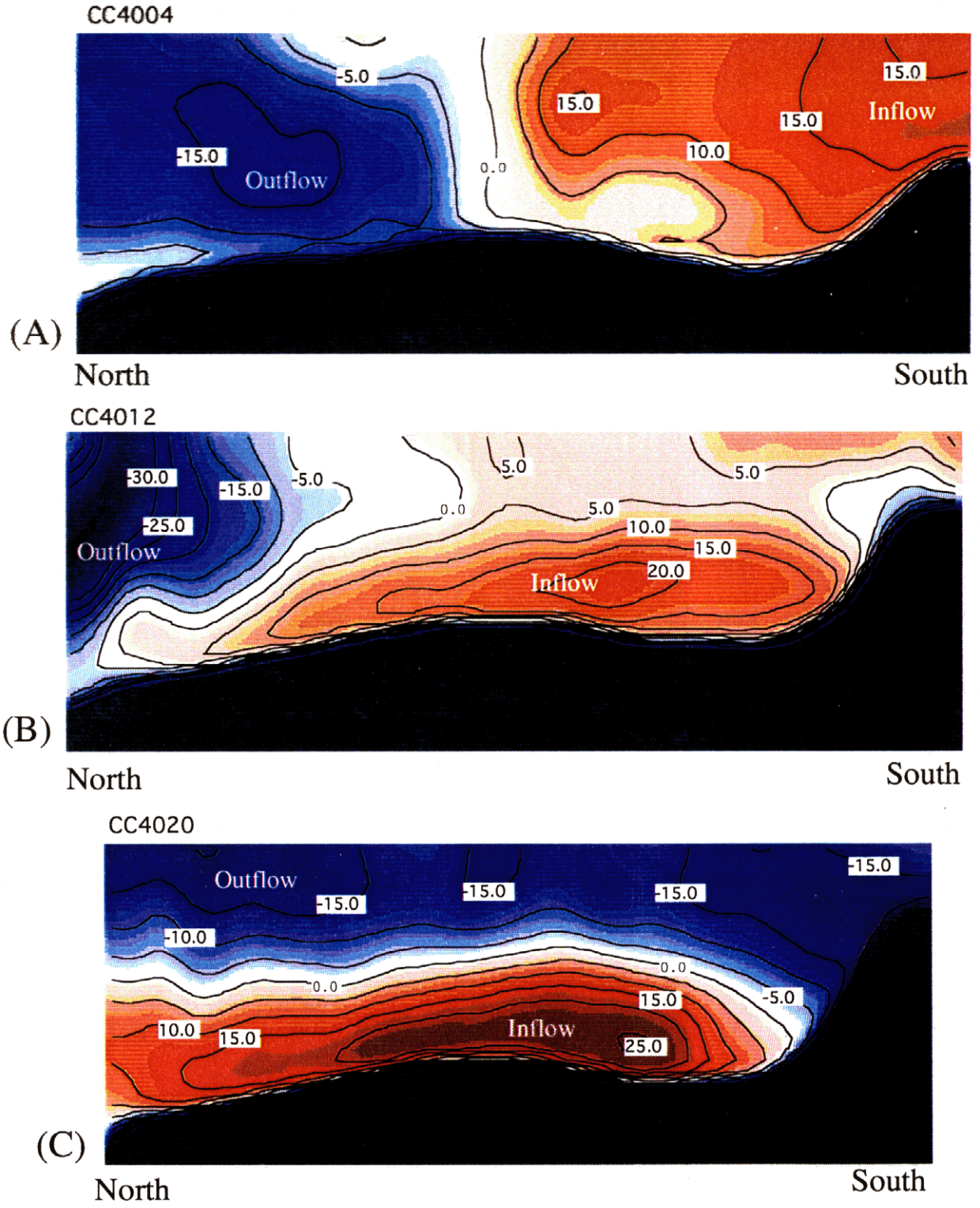

Figure 4.2-10. Velocity contour plots across the mouth of Coddington Cove (transect 1 shown in Figure 4.2-8). Data are in cm/sec. A) early flood (4.5 hr before high water); B) mid flood (3 hr before high water); and C) late flood (1.5 hr before high water).

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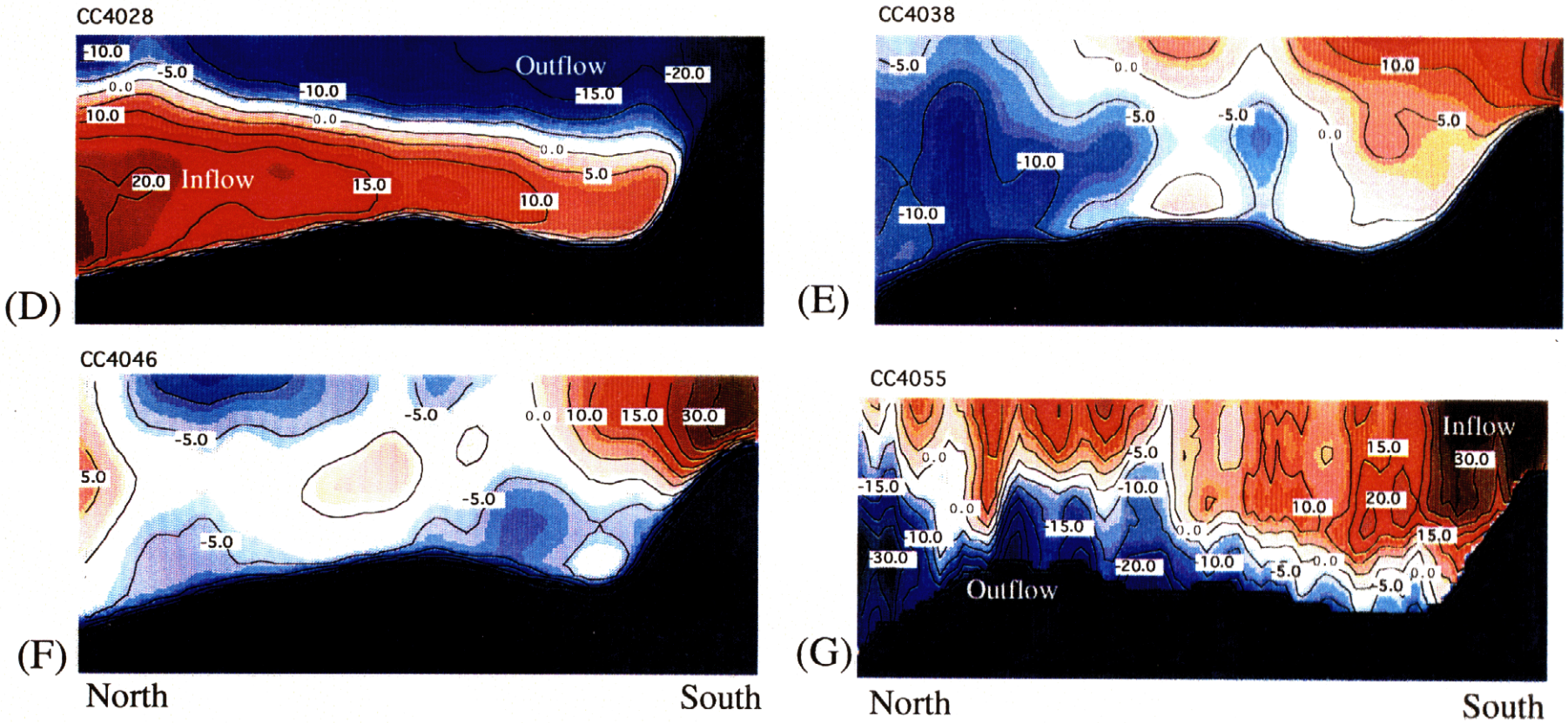


Figure 4.2-10 (continued). Velocity contour plots across the mouth of Coddington Cove (transect 1 shown in Figure 4.2-8). Data are in cm/sec. D) high water; E) early ebb (1.75 hr after high water); F) mid-ebb (3 hr after high water); and G) late ebb (4.5 hr after high water). A progression is noted from the vertically structured flow with inflow at the bottom (C,D) to a wind-dominated pattern with inflow at the surface and outflow at depth (G).

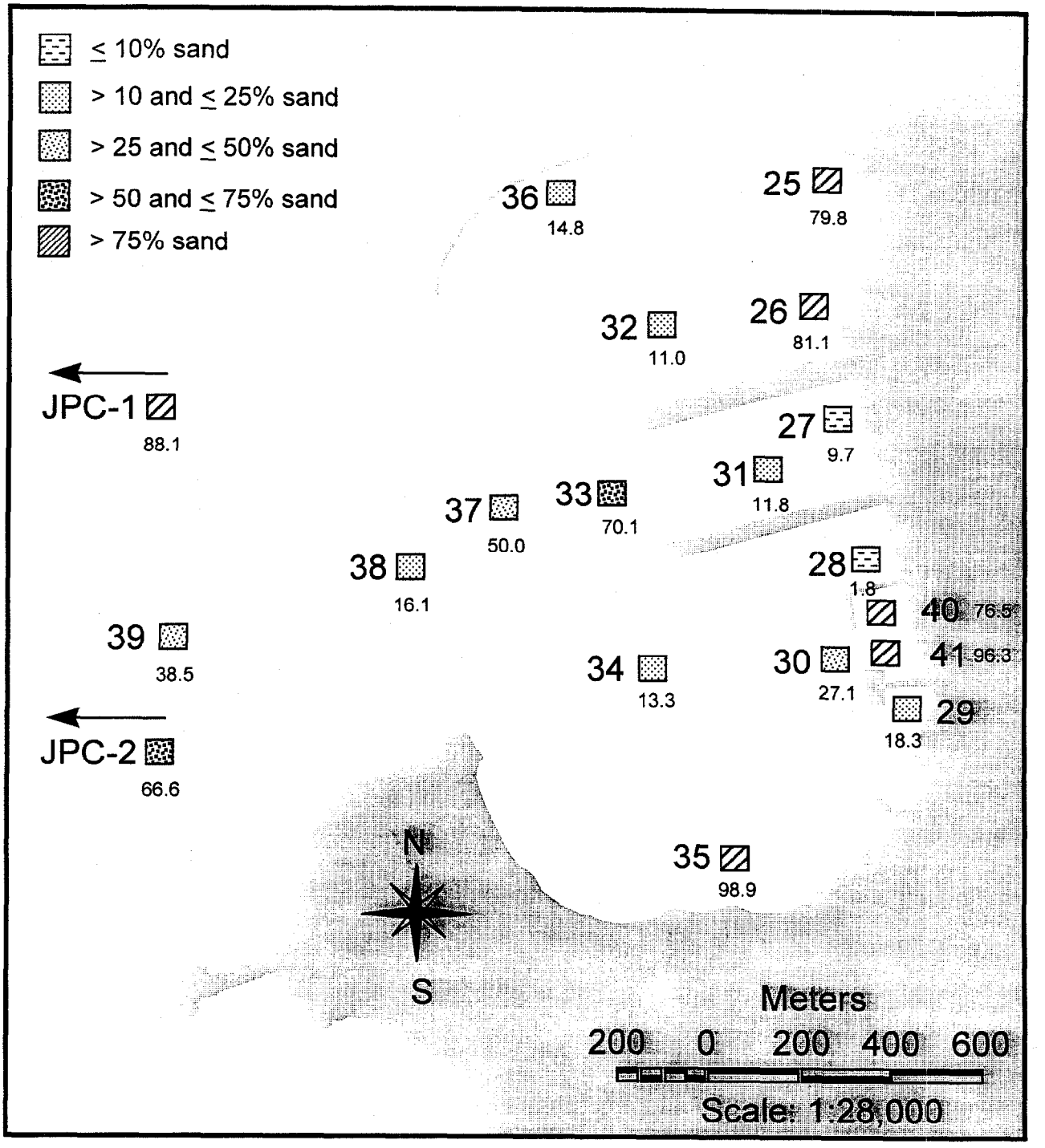


Figure 4.2-1. Distribution of sand in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area. Large number indicate station designation; small numbers indicate percent sand.

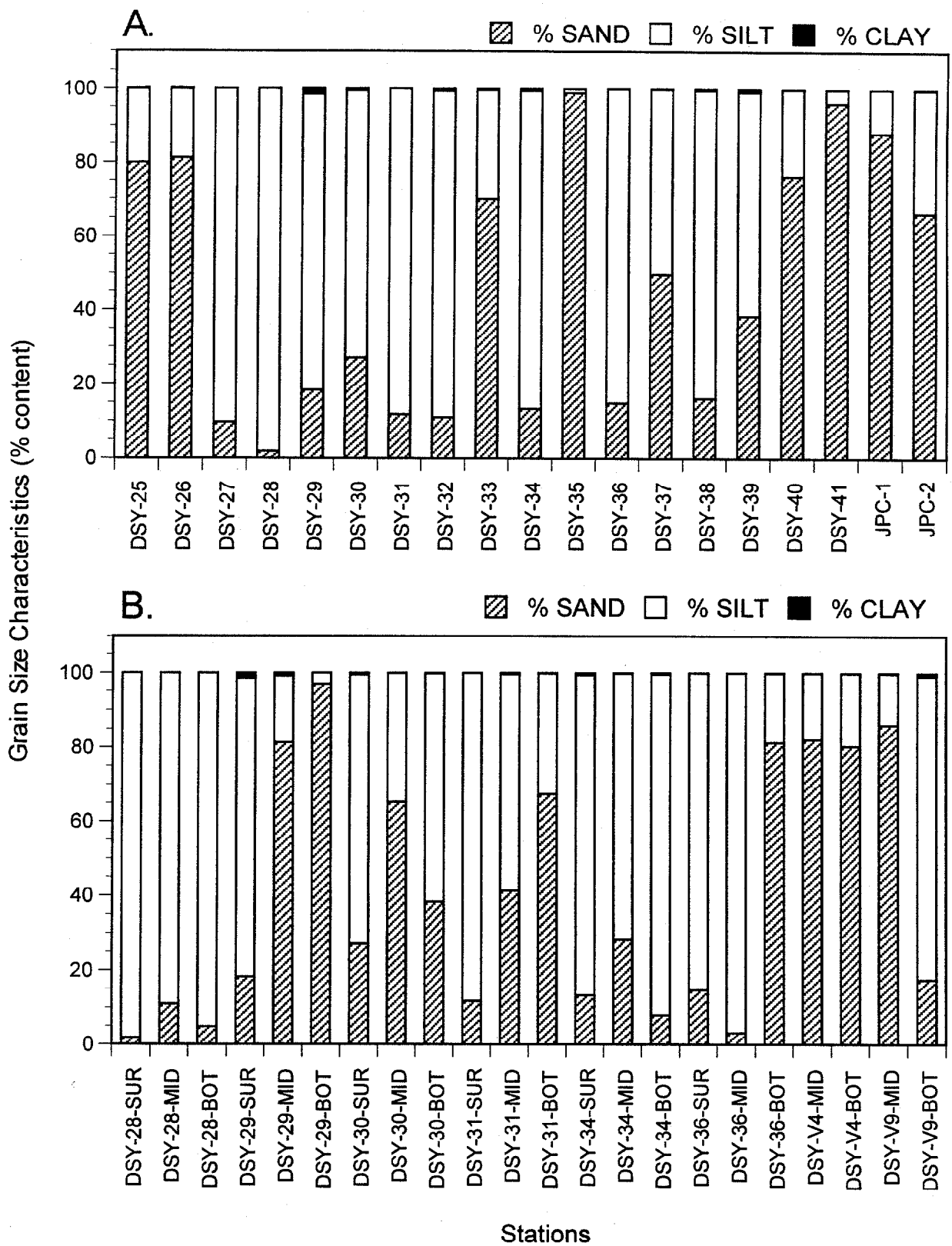


Figure 4.2-2. Grain size characteristics in A) surface and B) core sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations. Codes: SUR = surface, MID = mid depth, BOT = bottom, and V = vibracore station.

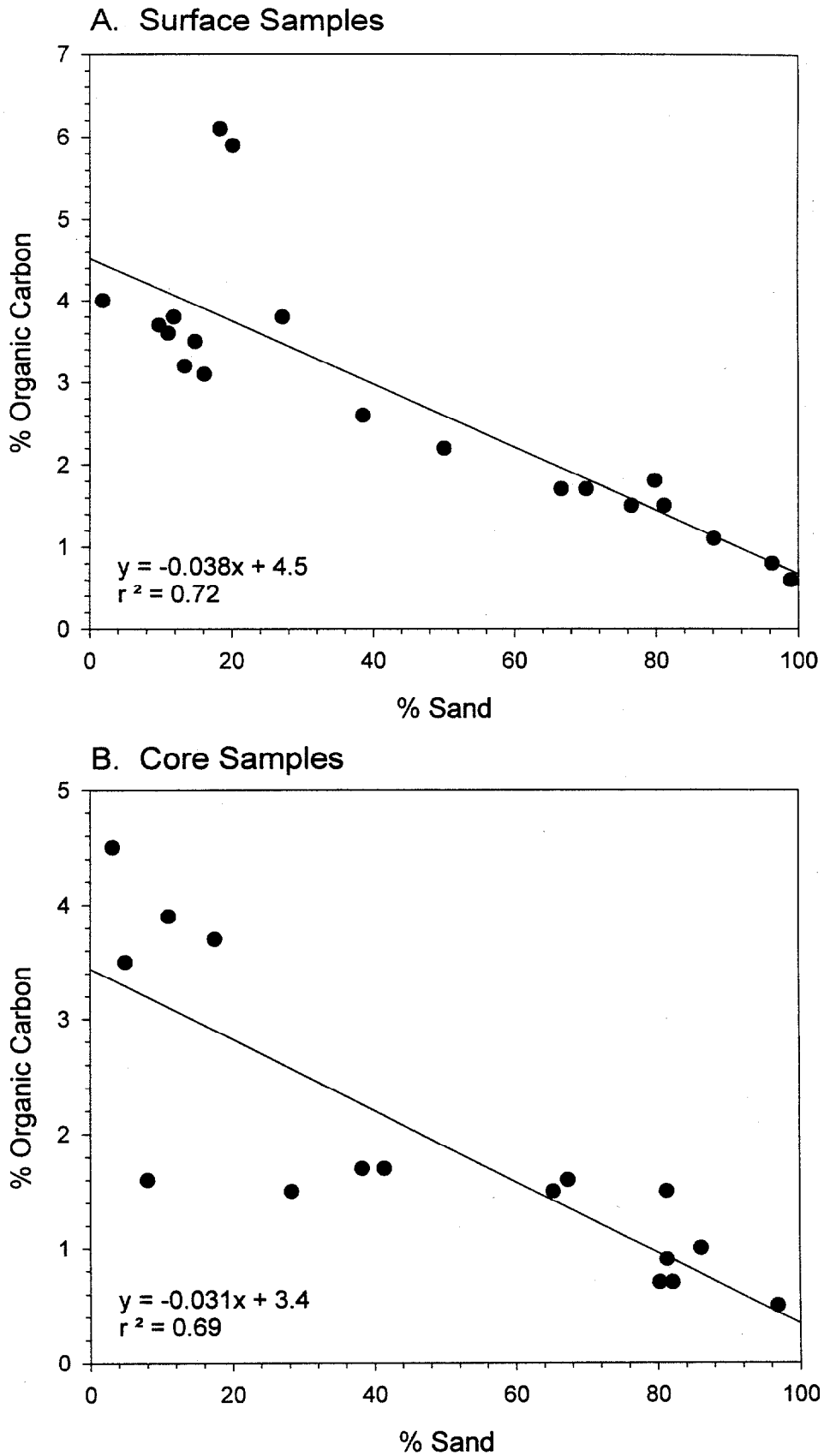


Figure 4.2-3. Relationship between sand content and total organic carbon content for surface and core sediments collected from the Derecktor Shipyard/ Coddington Cove study area.

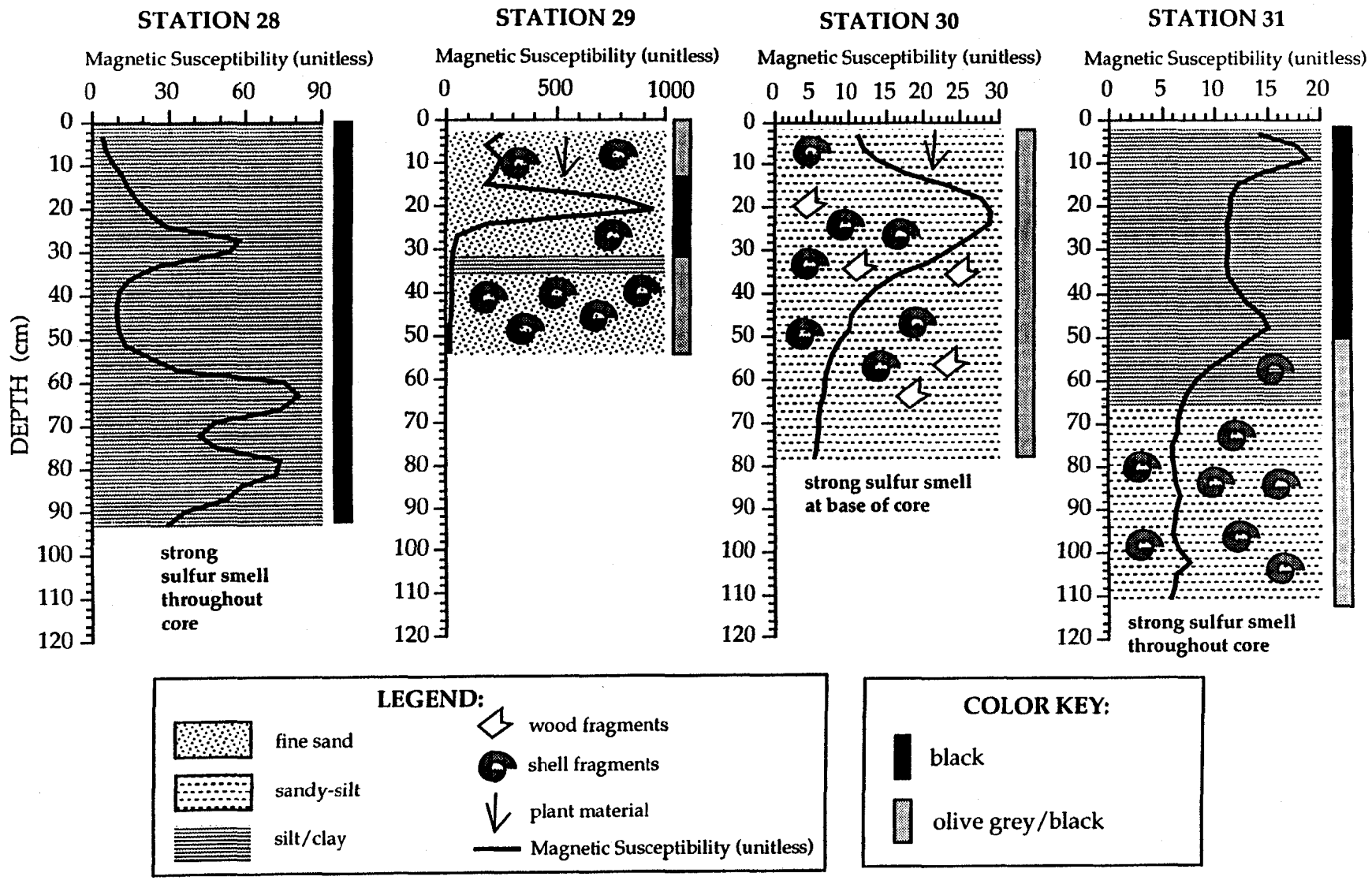


Figure 4.2-4. Characterization of sediment magnetic susceptibility and lithology for the Derecktor Shipyard/Coddington Cove study area.

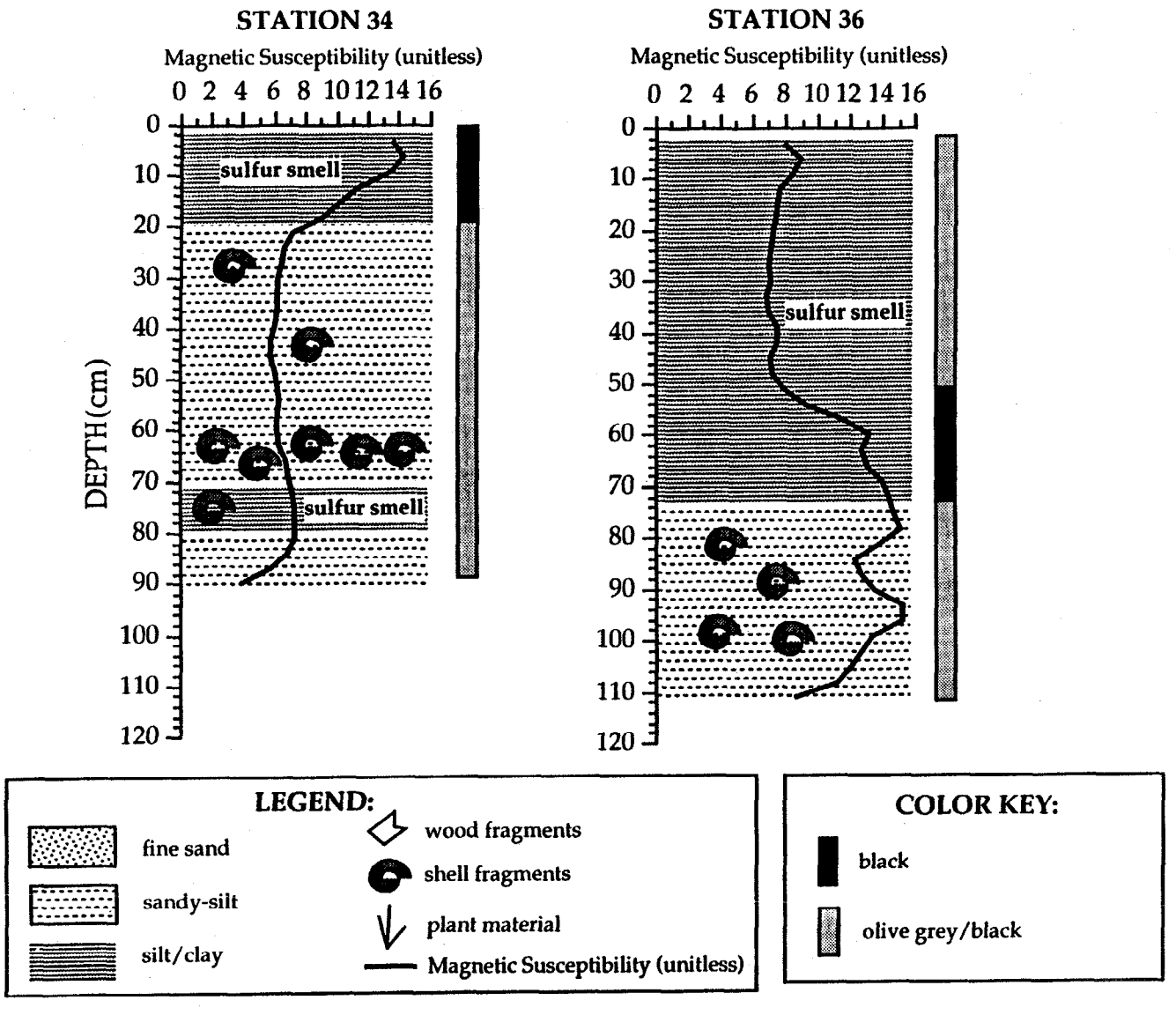


Figure 4.2-4. (continued). Characterization of sediment magnetic susceptibility and lithology for the Derecktor Shipyard/Coddington Cove study area.

Greater than 75% sand

25 - 50% sand

Less than 10% sand

50 - 75% sand

10 - 25% sand

Extent of data

?: Designates an interpretation that is based solely on the intensity of the side-scan sonar return, and has not been "ground-truthed" by sediment sampling.

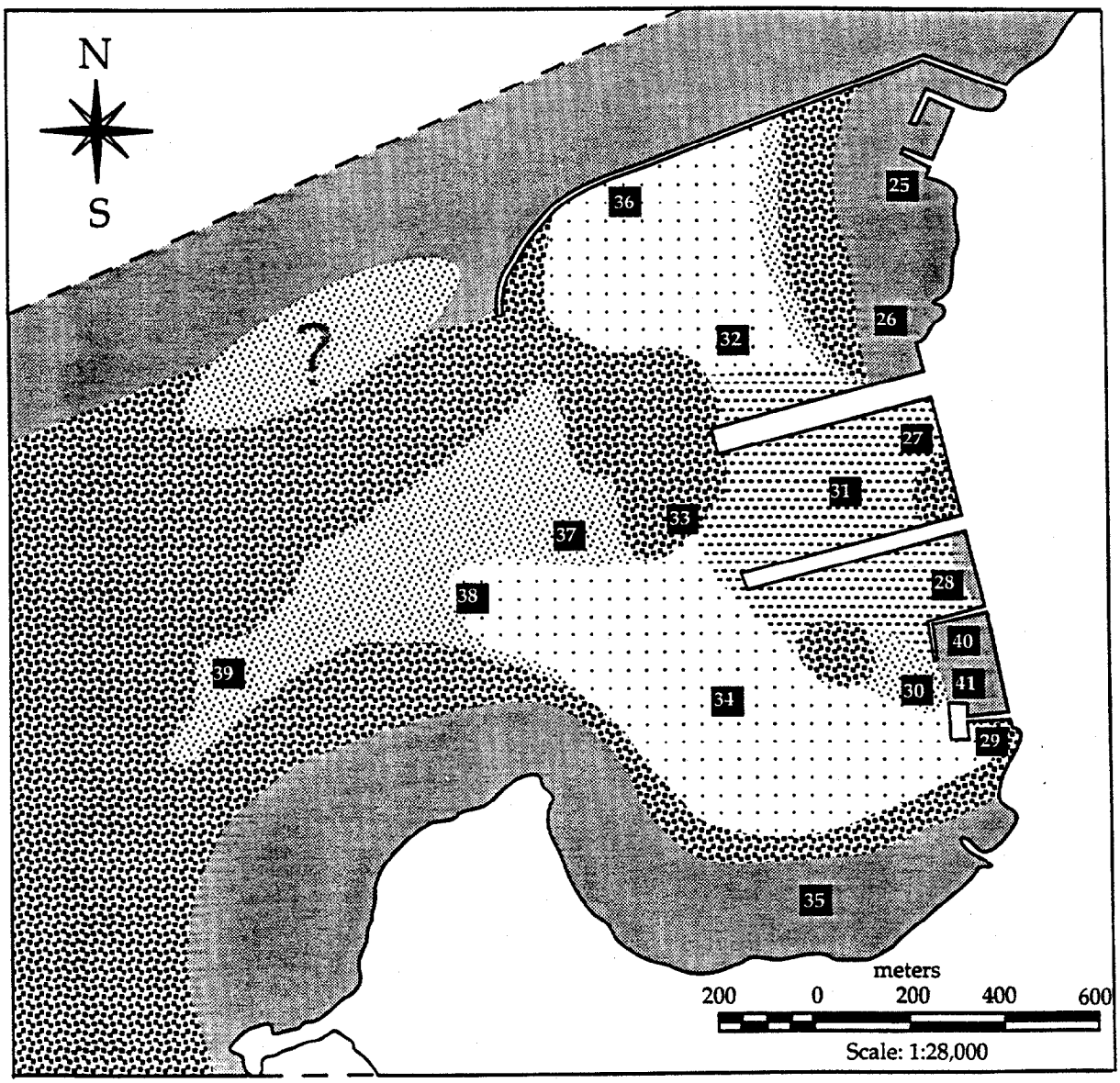


Figure 4.2-5. Grain size characteristics of surface sediments (0-18 cm) in the Derecktor Shipyard/Coddington Cove study area as inferred from geotechnical and geophysical investigations.

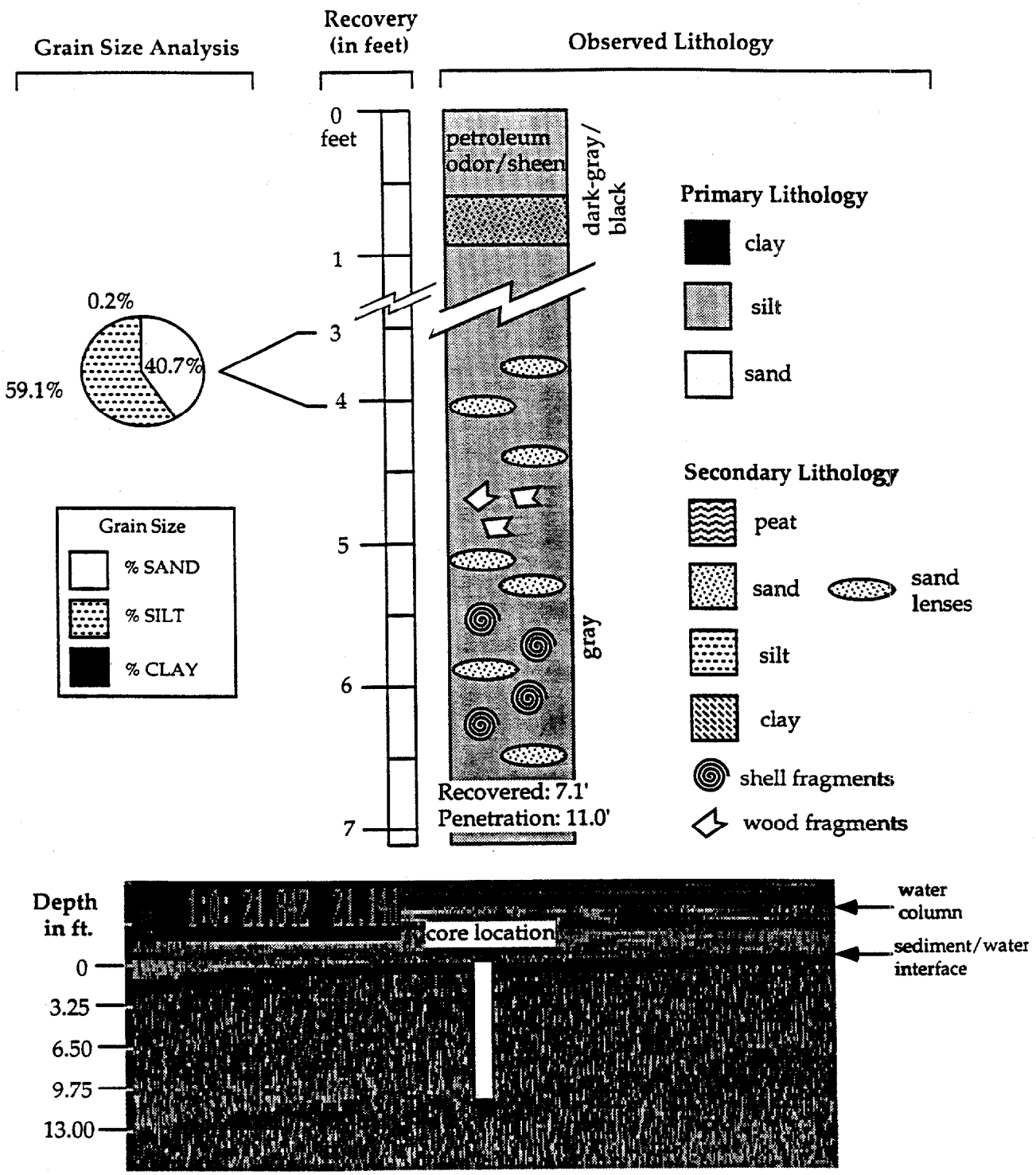


Figure 4.2-6. Sub-bottom profile, observed lithology, and grain size analysis results for DSY-28 (vibracore station V-5) from the Derecktor Shipyard/Coddington Cove study area.

Figure 4.2-7. Distribution of sandblast material in surface sediments of Coddington Cove.

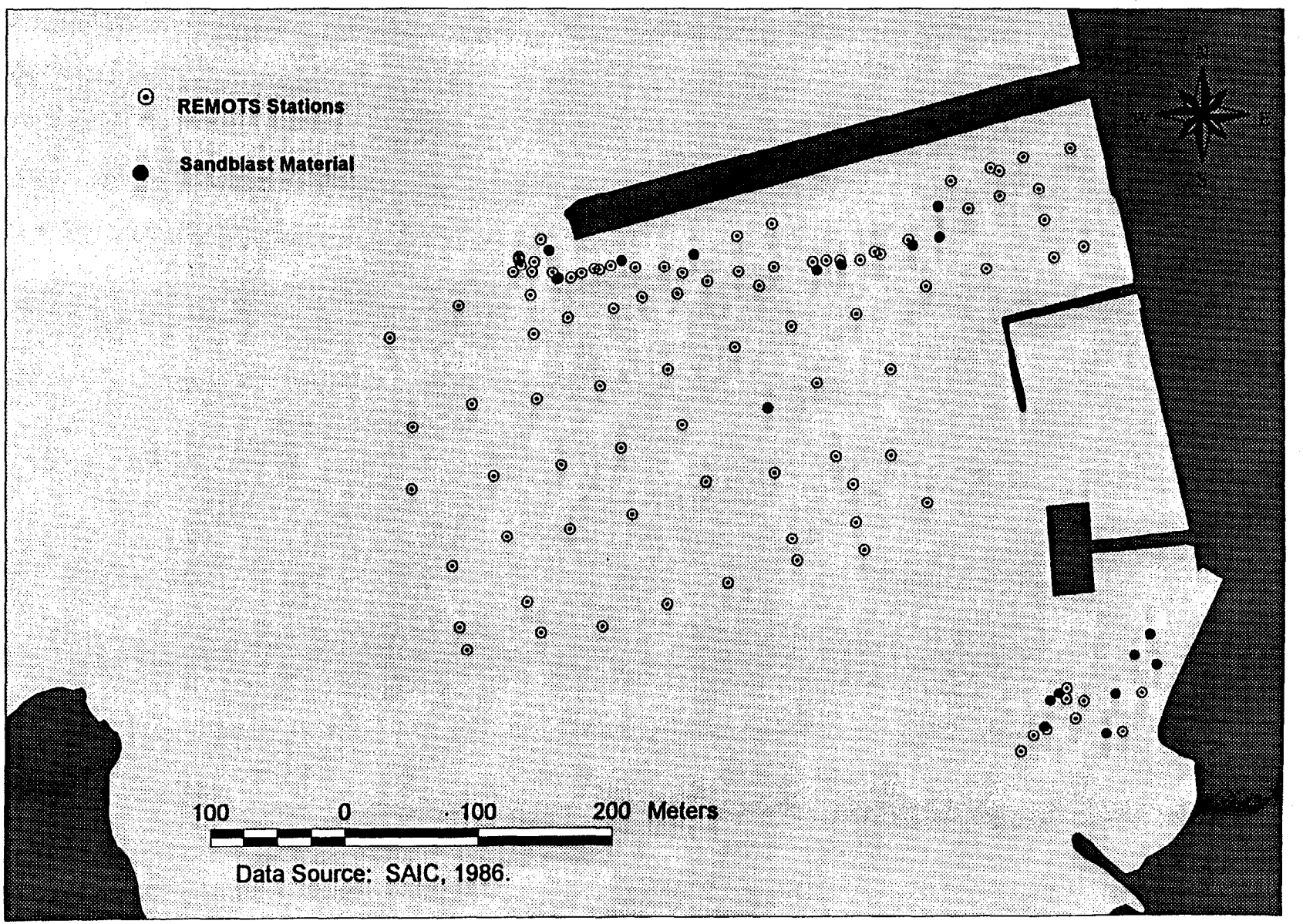


Figure 4.2-8. Sampling locations for sediments collected for chemical analysis near Piers 1 and 2 of the NETC during 1987-1988.

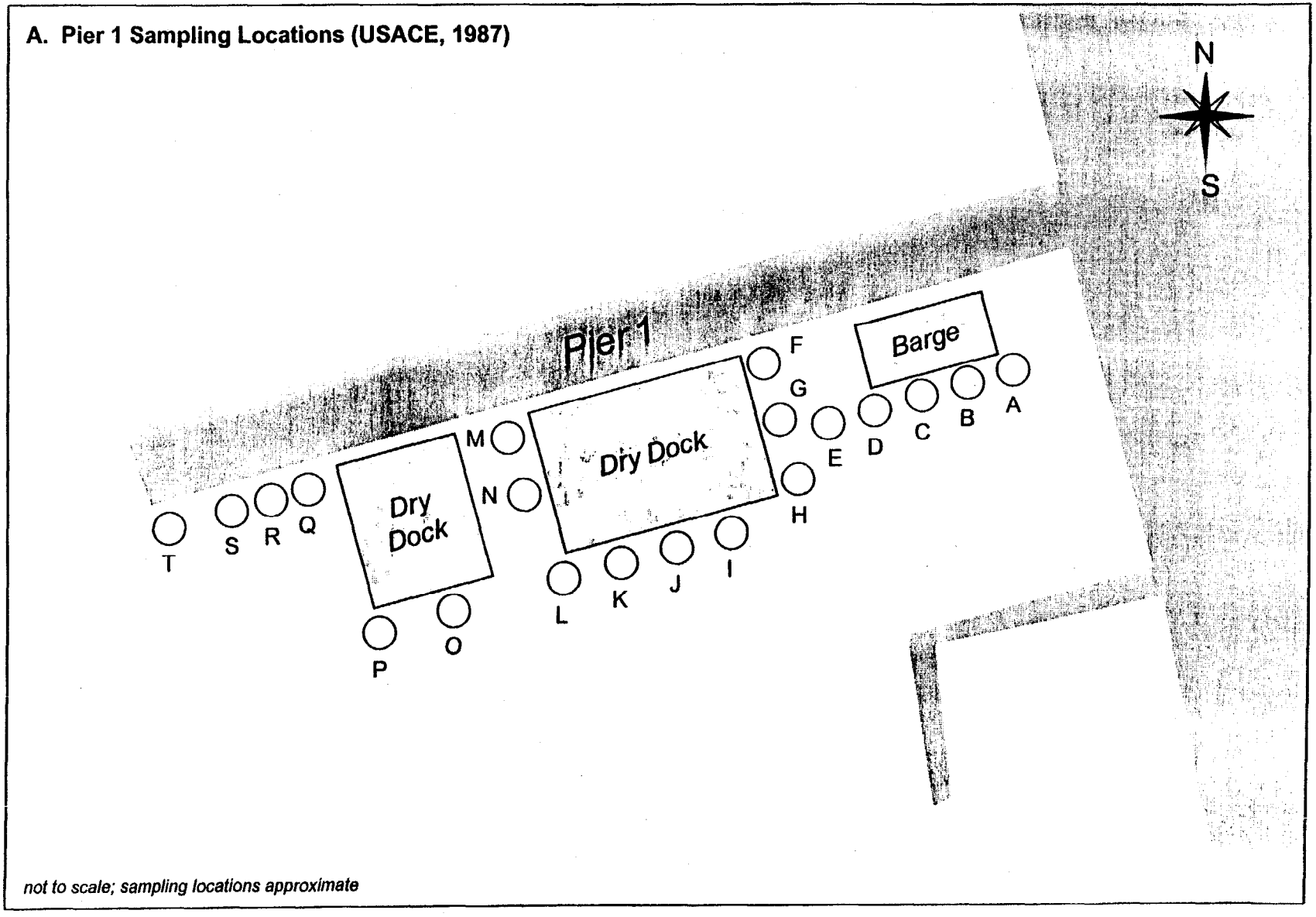
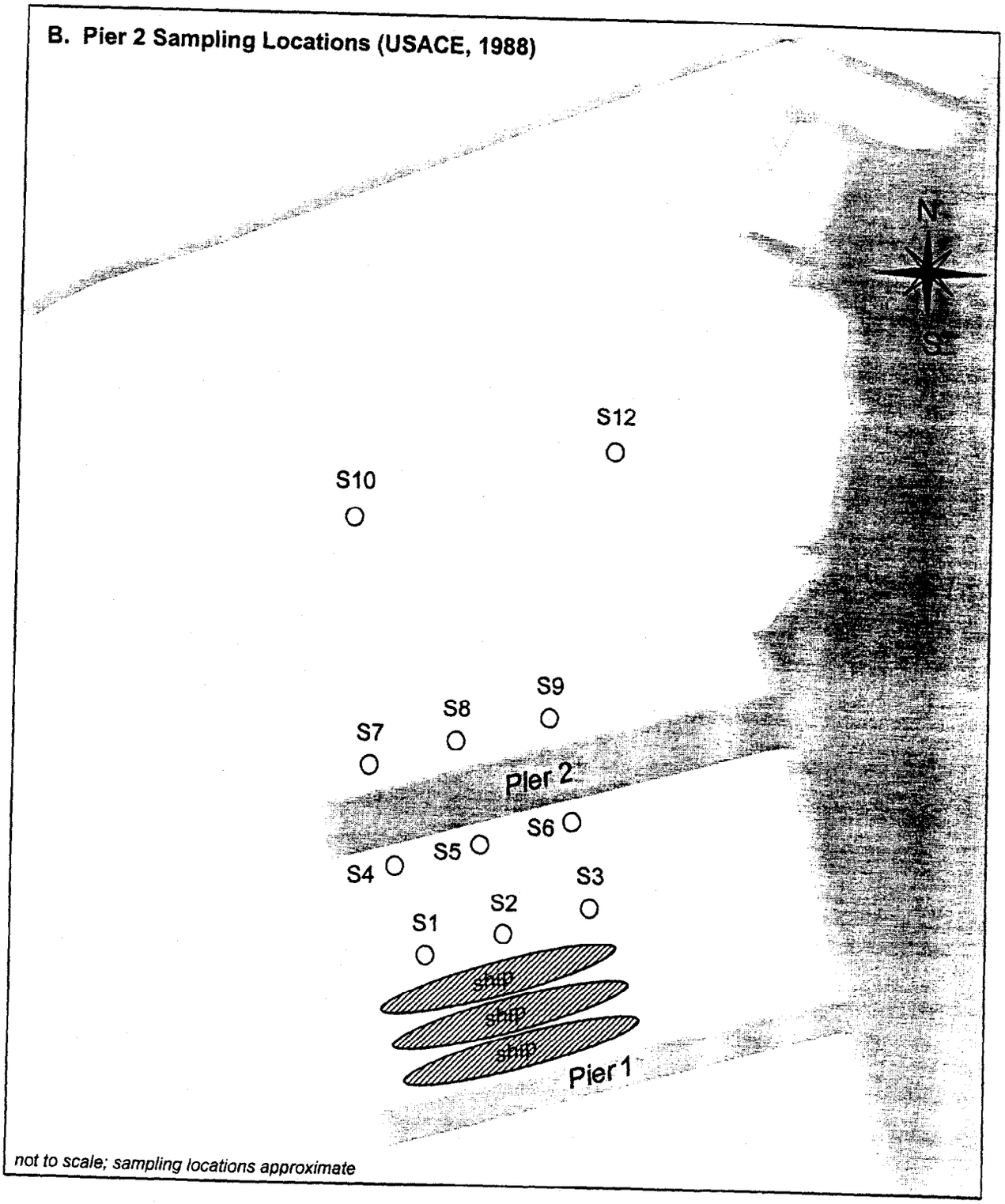
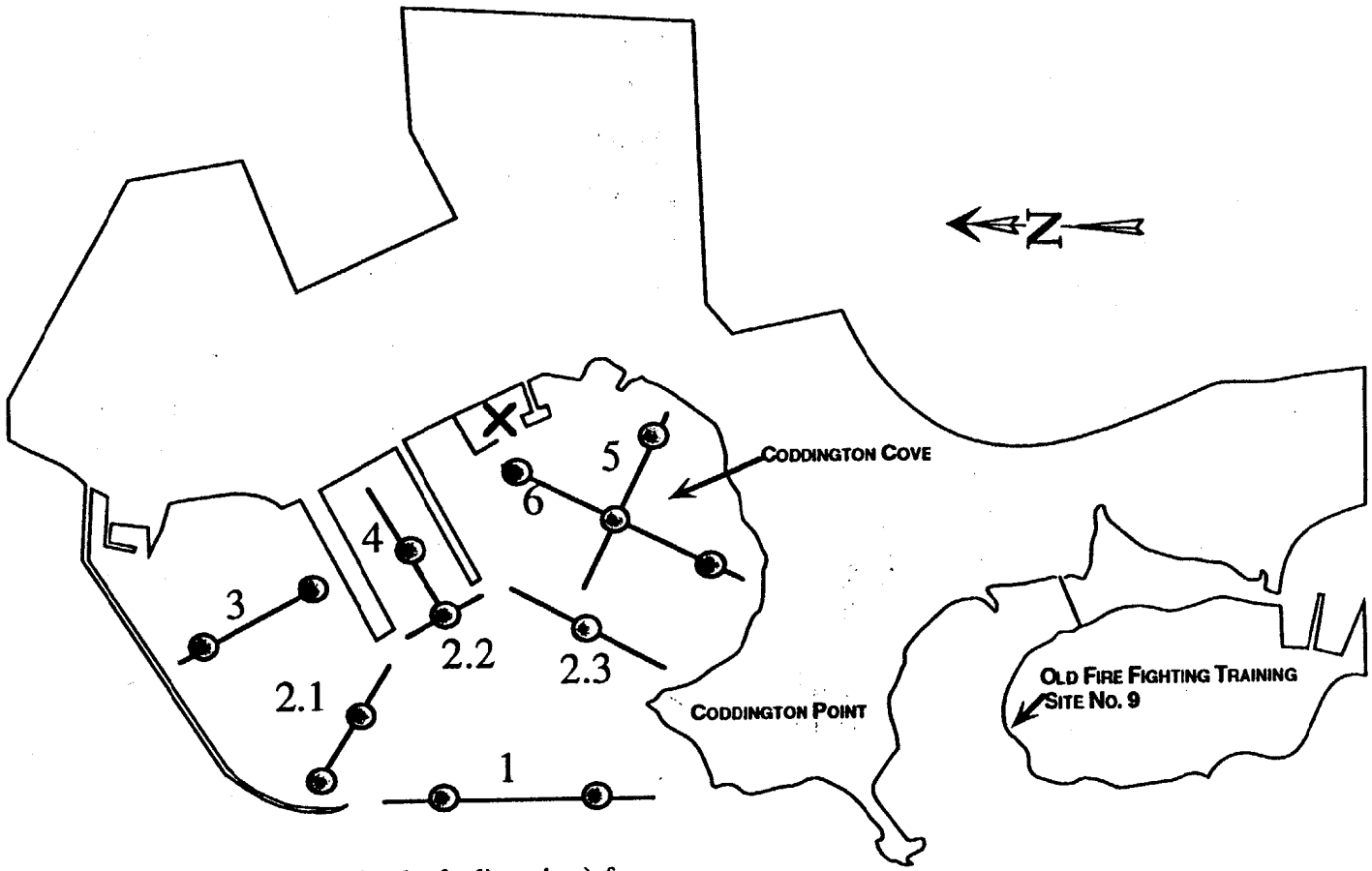


Figure 4.2-8 (continued). Sampling locations for sediments collected for chemical analysis near Piers 1 and 2 of the NETC during 1987-1988.





⊙ = site of velocity vectors (magnitude & direction) for both deep and shallow flow.

X = times series data; velocity magnitude only

Figure 4.2-9. Hydrographic sampling locations for the Derecktor Shipyard/Coddington Cove study area. Lines represent ship transects along which vertical water velocity measurements were made. Shaded circles represent locations where depth-averaged velocities were calculated.

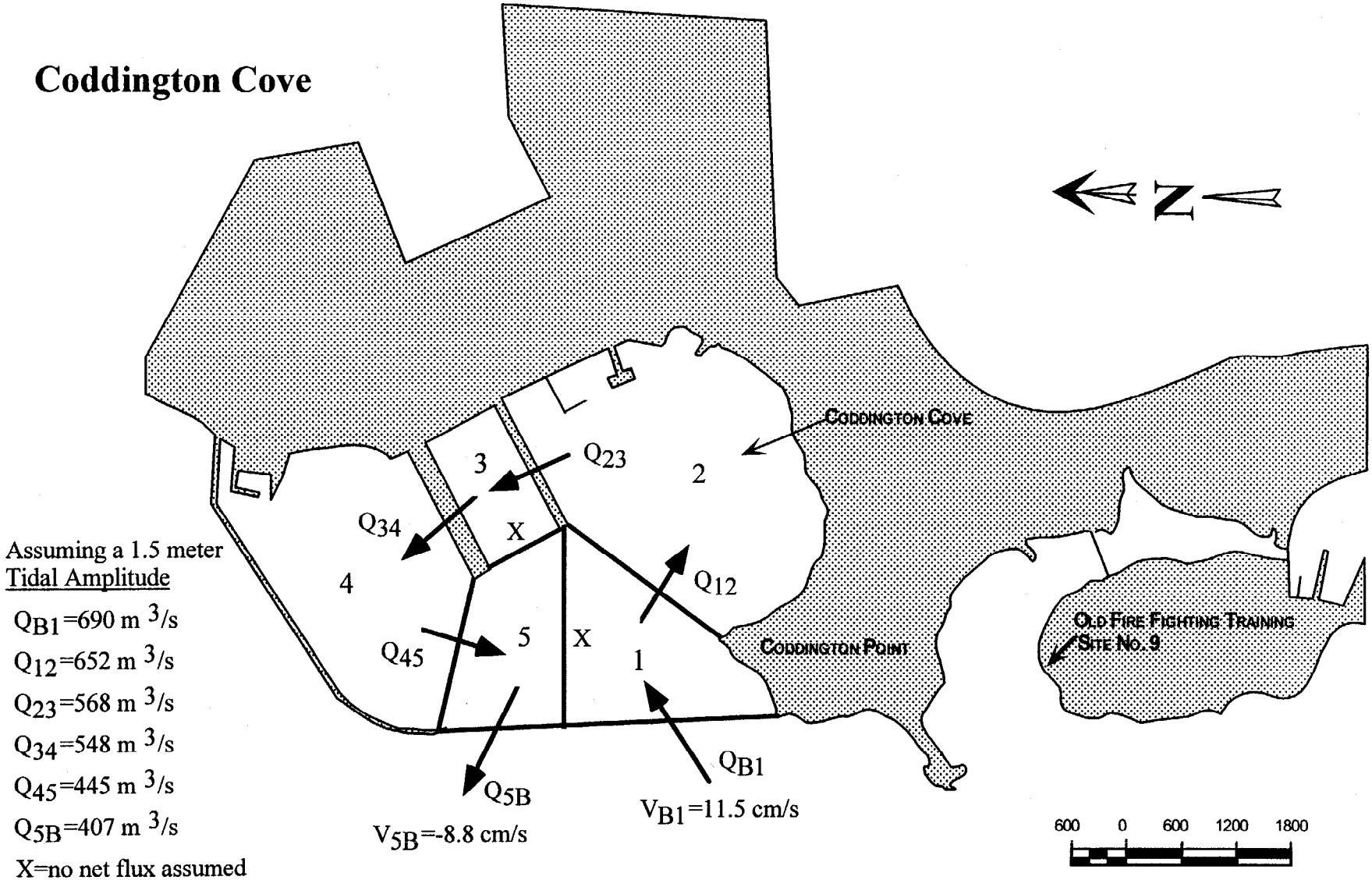


Figure 4.2-11. Mass transport (volume flux) of water in the Derecktor Shipyard/Coddington Cove study area.

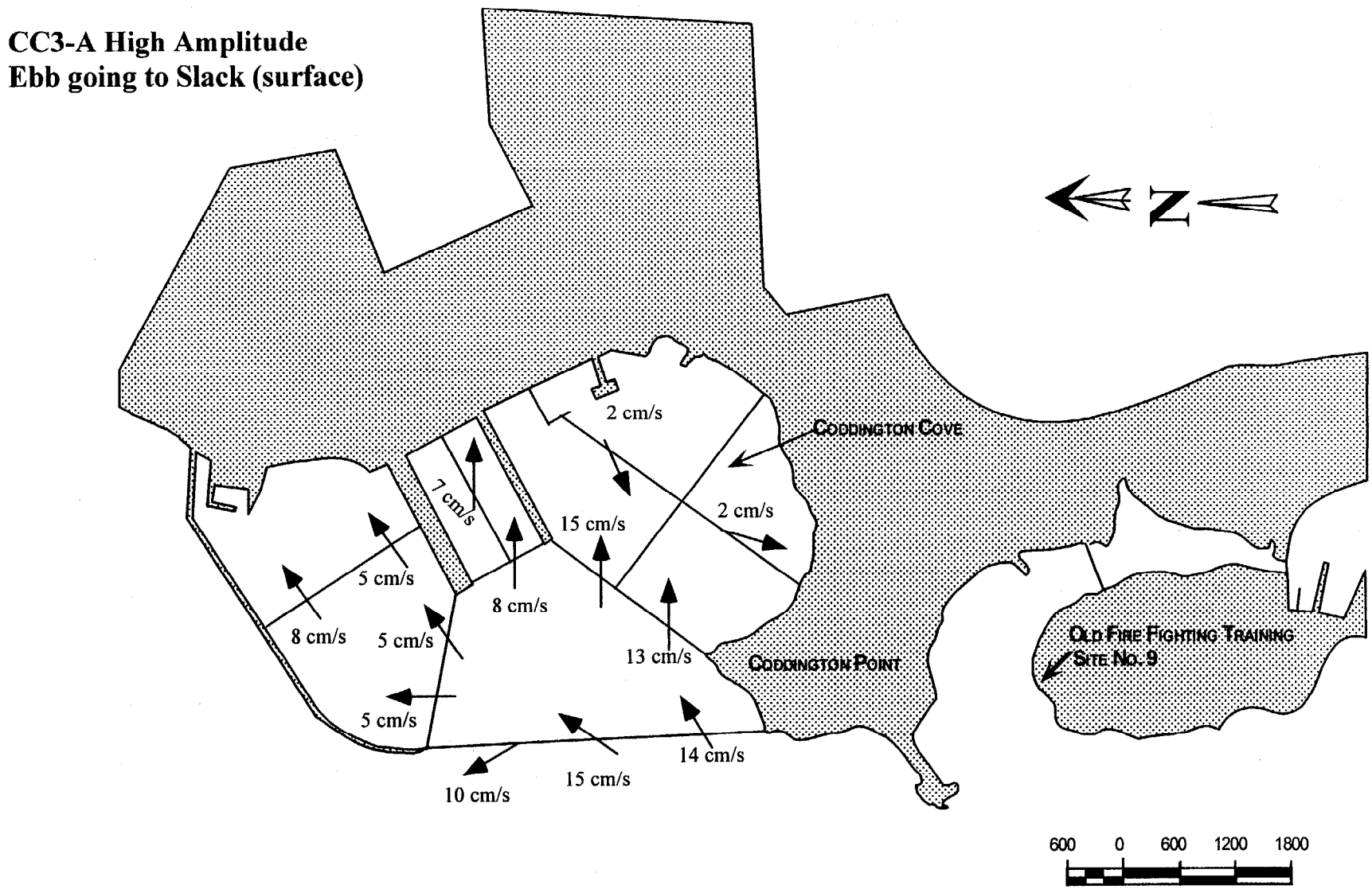


Figure 4.2-12A. Surface velocity in the Derecktor Shipyard/Coddington Cove study area during a short wind event.

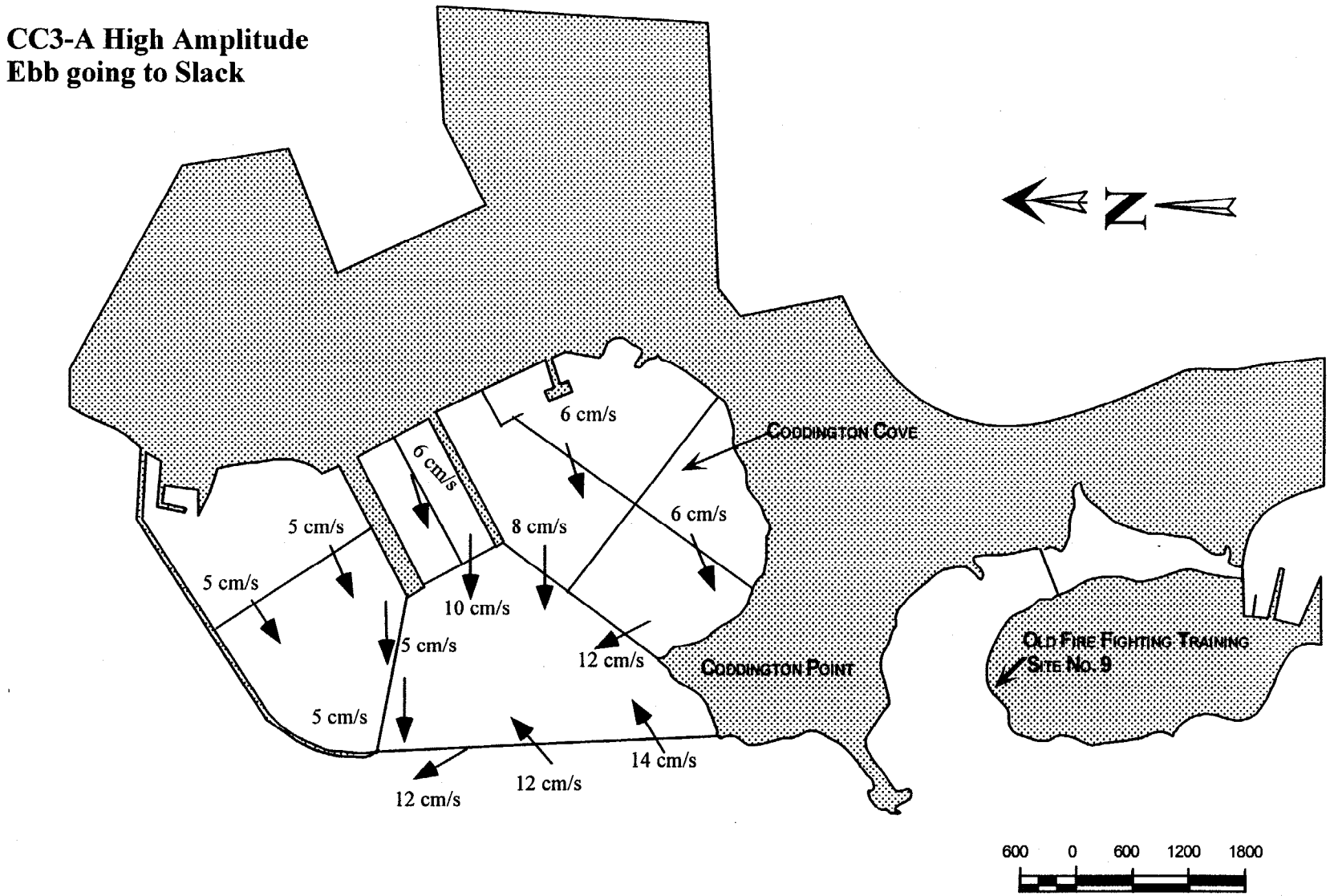


Figure 4.2-12B. Bottom velocity in the Derecktor Shipyard/Coddington Cove study area during a short wind event.

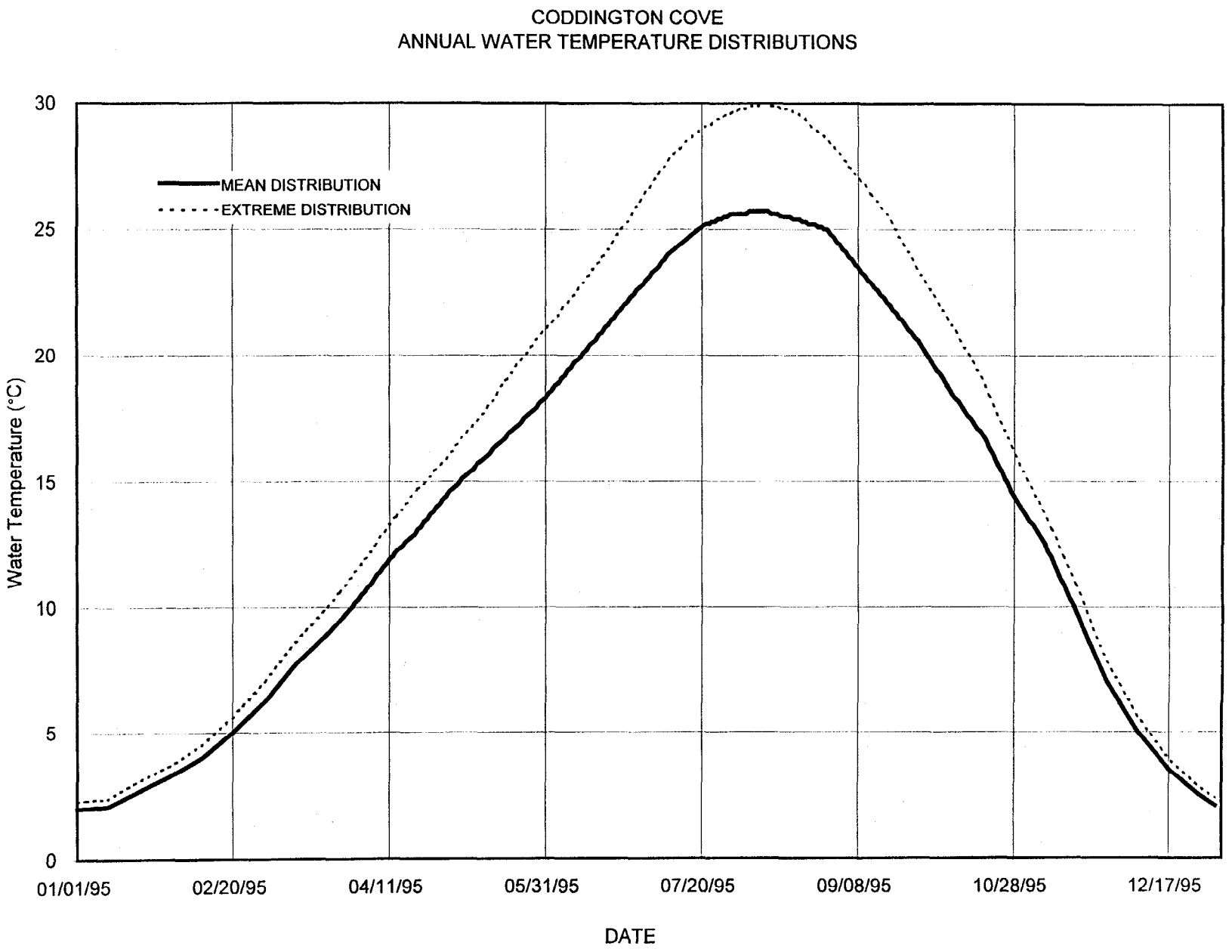


Figure 4.2-13. Annual temperature distribution for the Derecktor Shipyard/Coddington Cove study area water column.

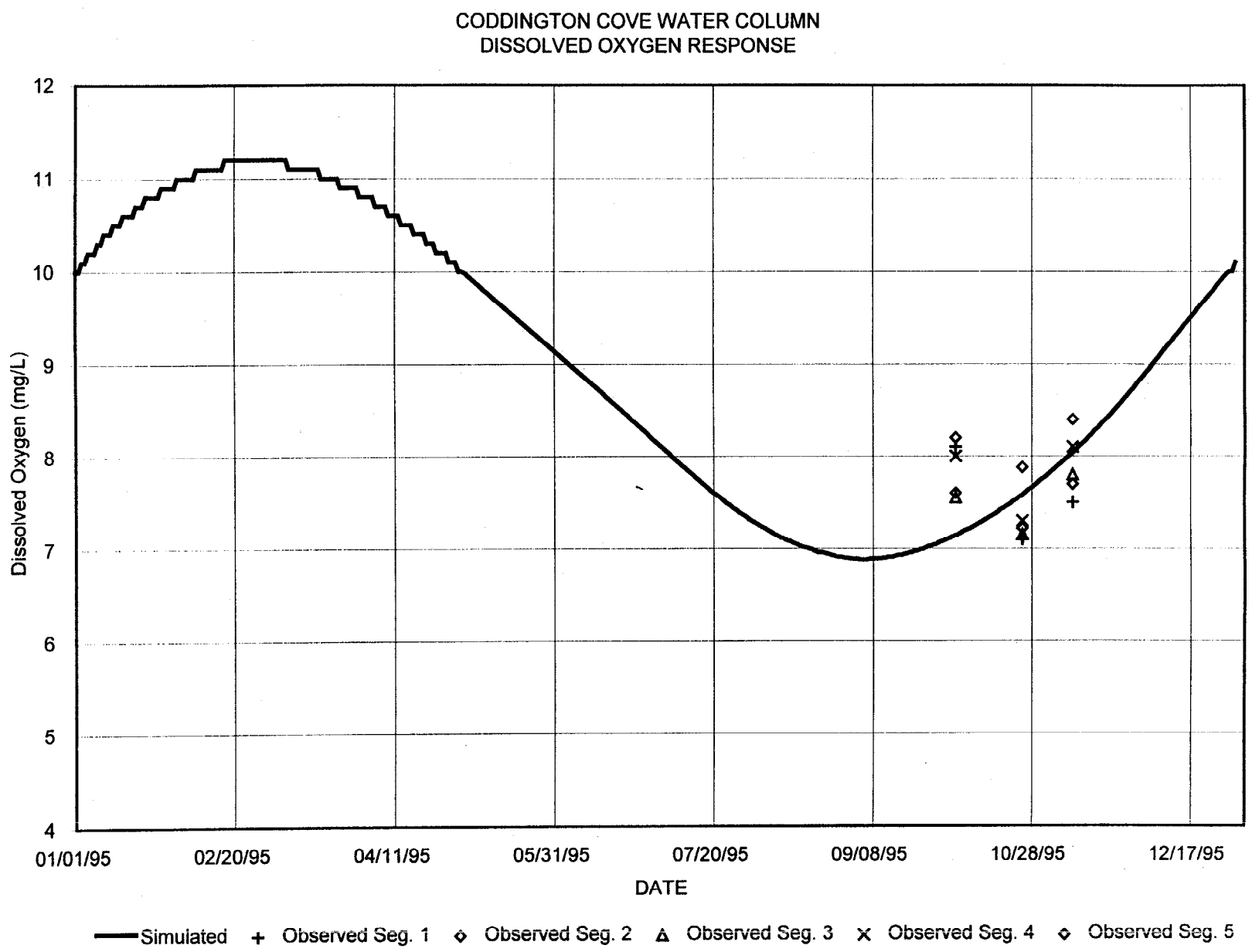


Figure 4.2-14. Comparison of simulated and measured dissolved oxygen (DO) responses of the Derecktor Shipyard/Coddington Cove study area. Data include point measurements from five zones (segments of Coddington Cove).

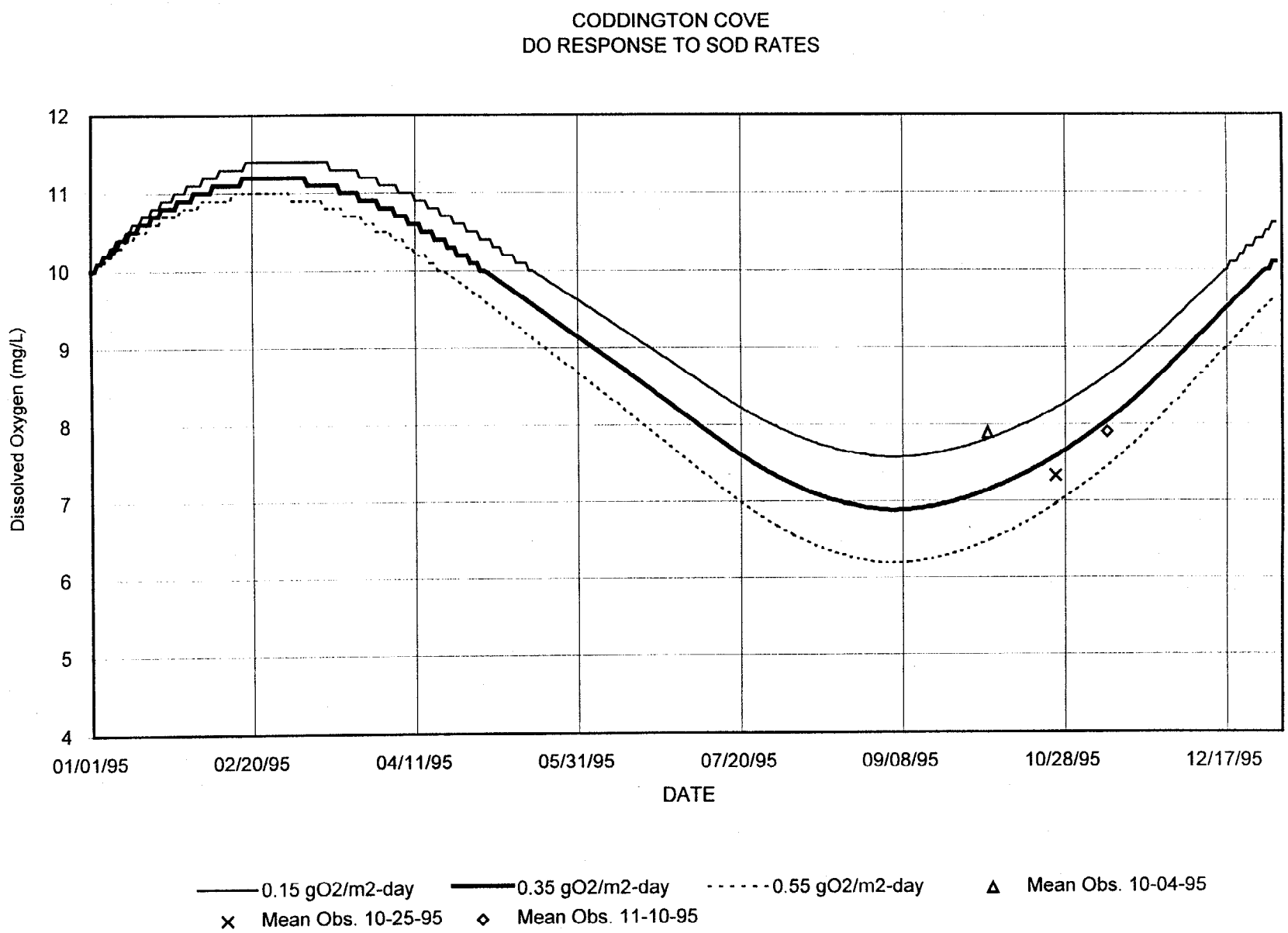


Figure 4.2-15. Dissolved oxygen (DO) response to varying sediment oxygen demand (SOD) rates for the Derecktor Shipyard/Coddington Cove study area.

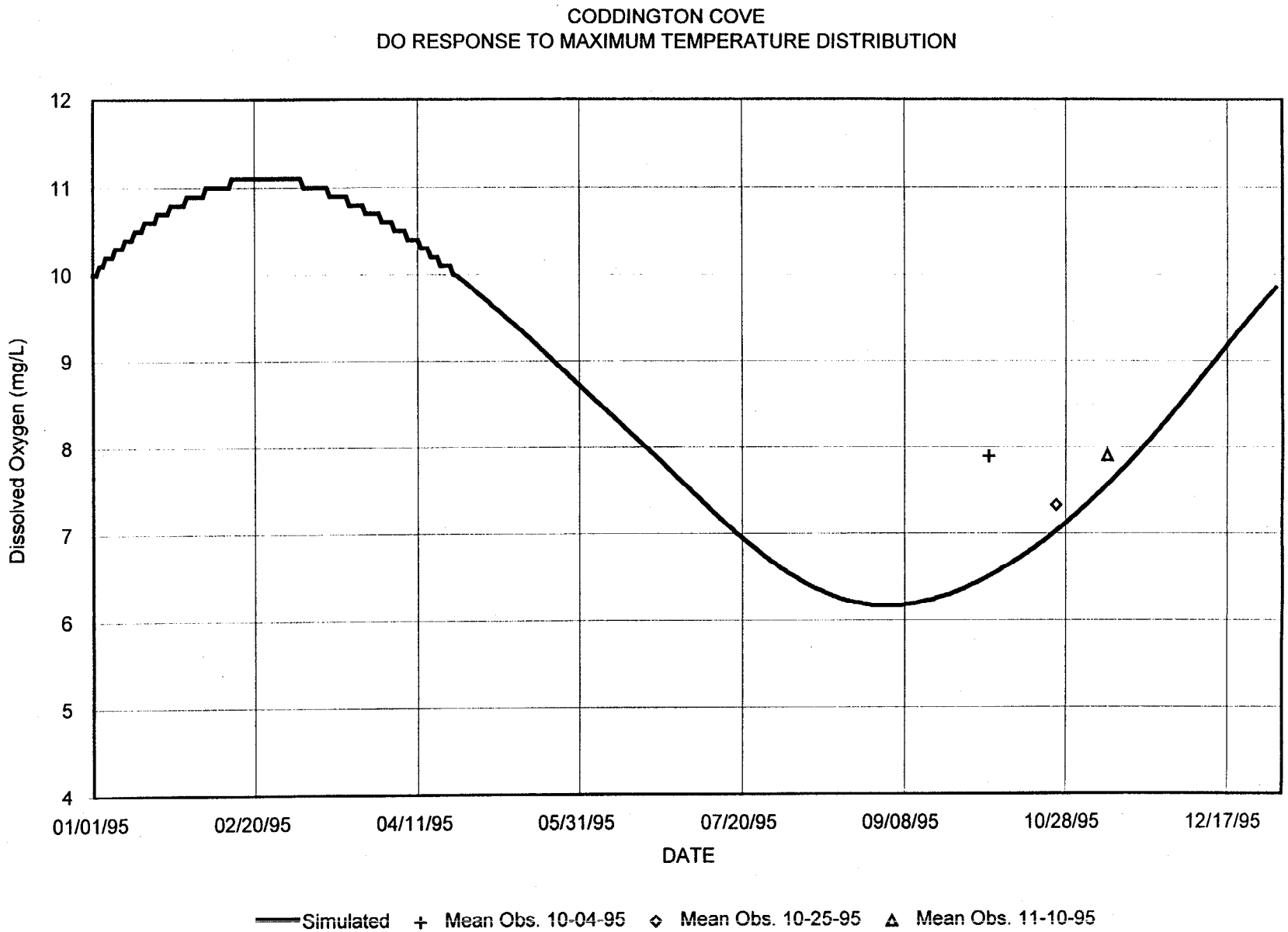


Figure 4.2-16. Simulated dissolved oxygen (DO) response to an annual maximum temperature distribution and measured DO for the Derecktor Shipyard/Coddington Cove study area water column.

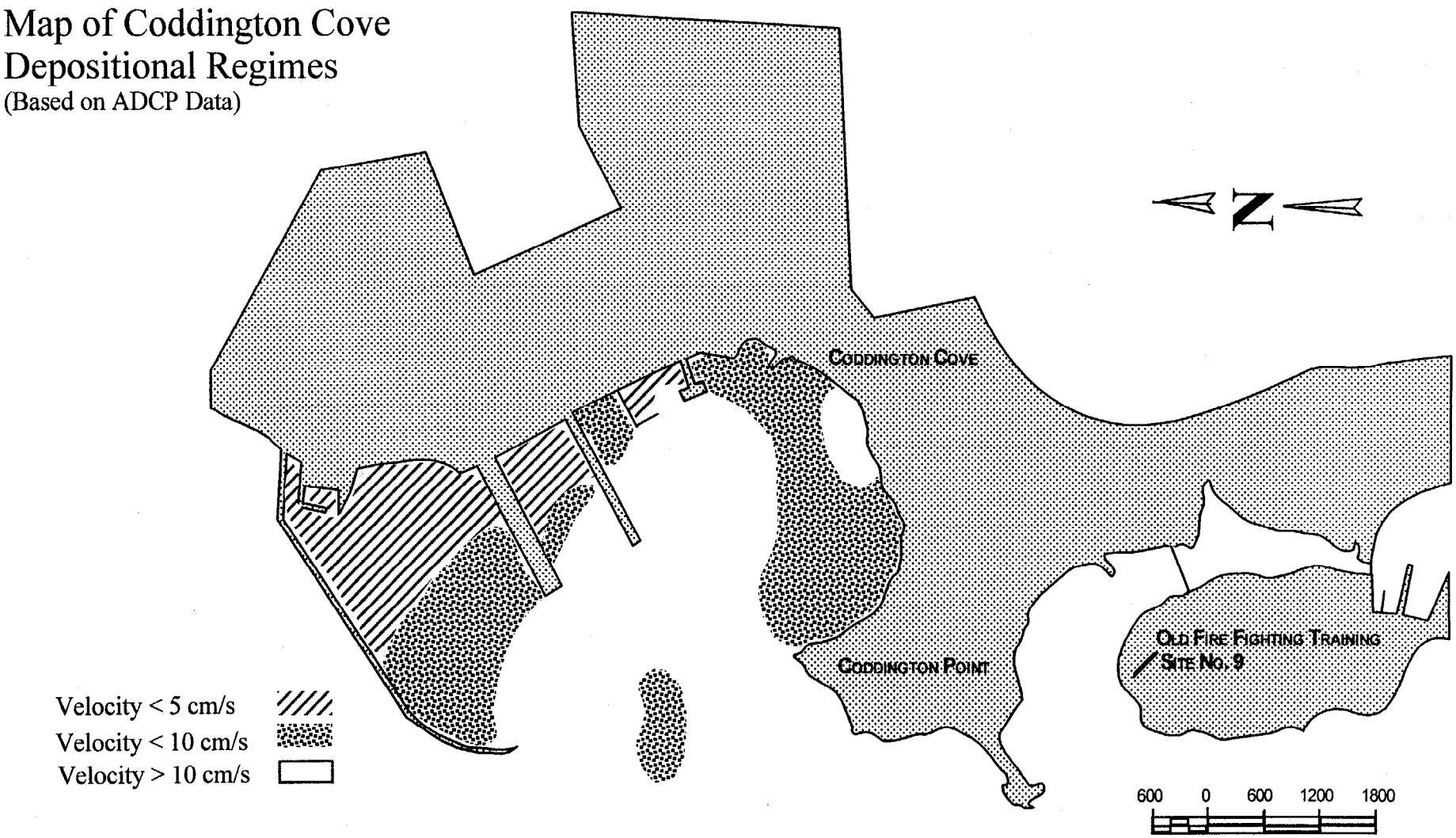


Figure 4.2-17. Interpretive map of near-bottom deposition/erosion energies for the Derecktor Shipyard/Coddington Cove study area. Striped and speckled regions represent zones permitting particles <0.1 mm and <0.8 mm to be deposited, respectively.

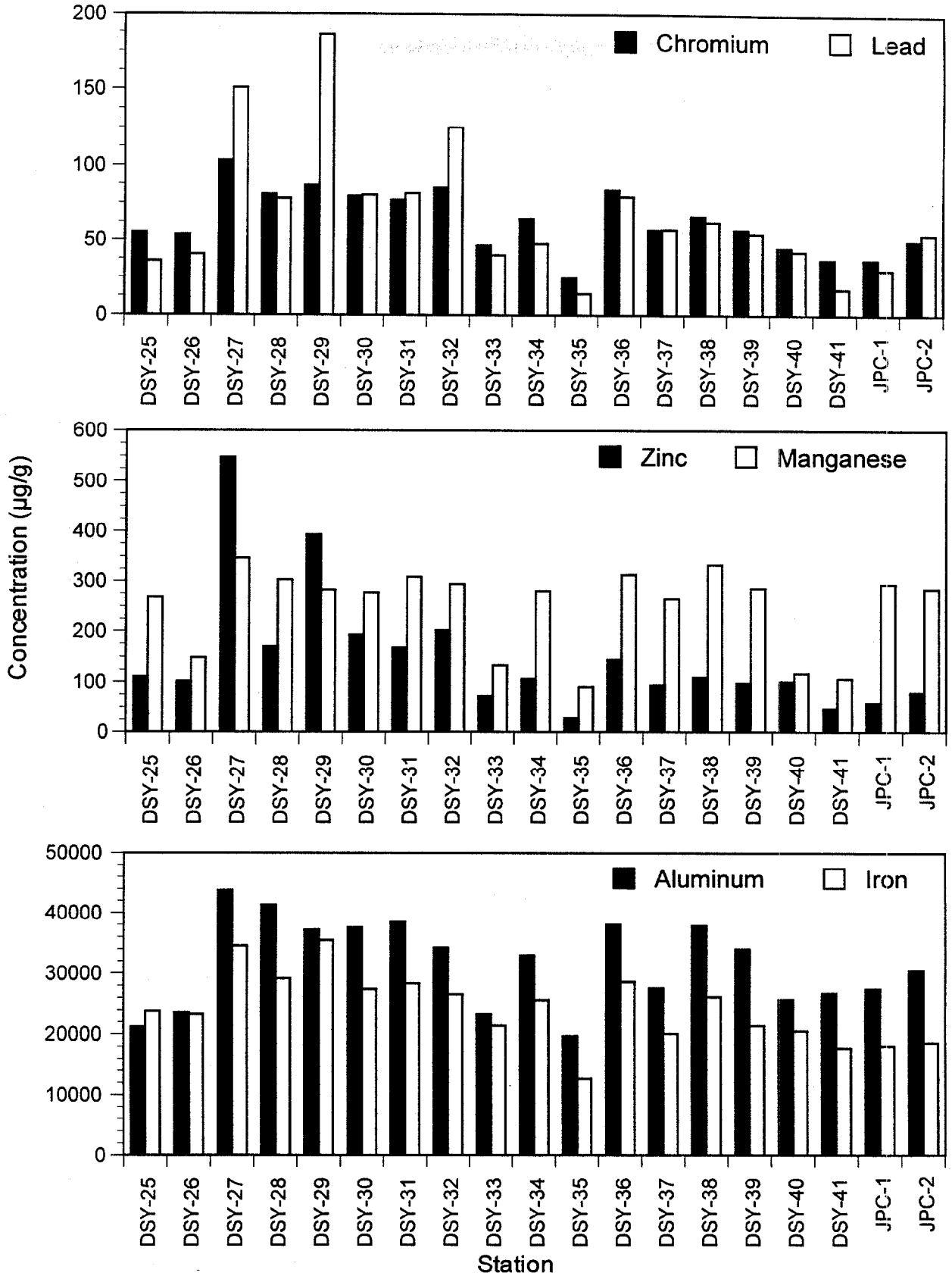


Figure 4.3-1. Concentration of trace metals in surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations.

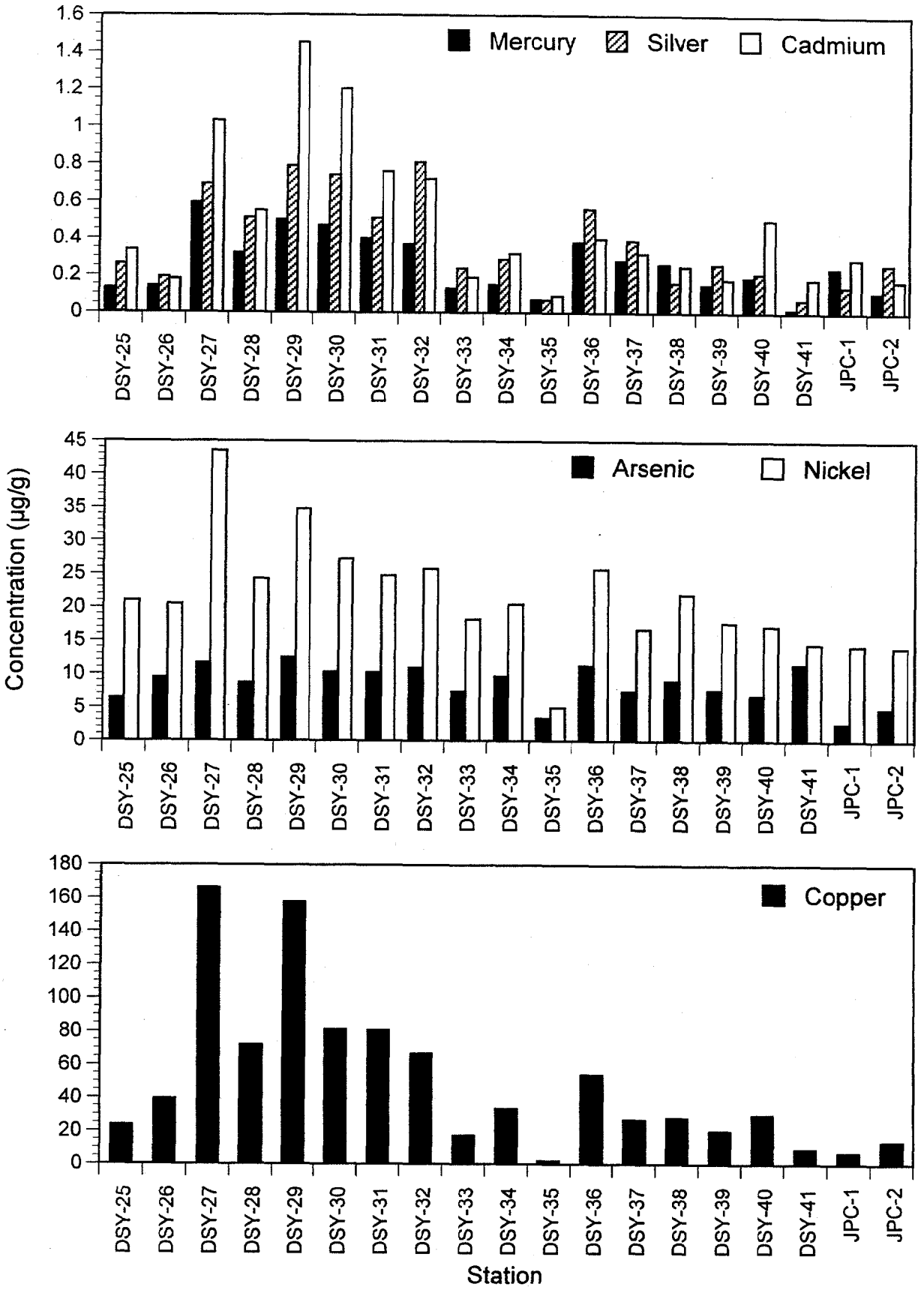
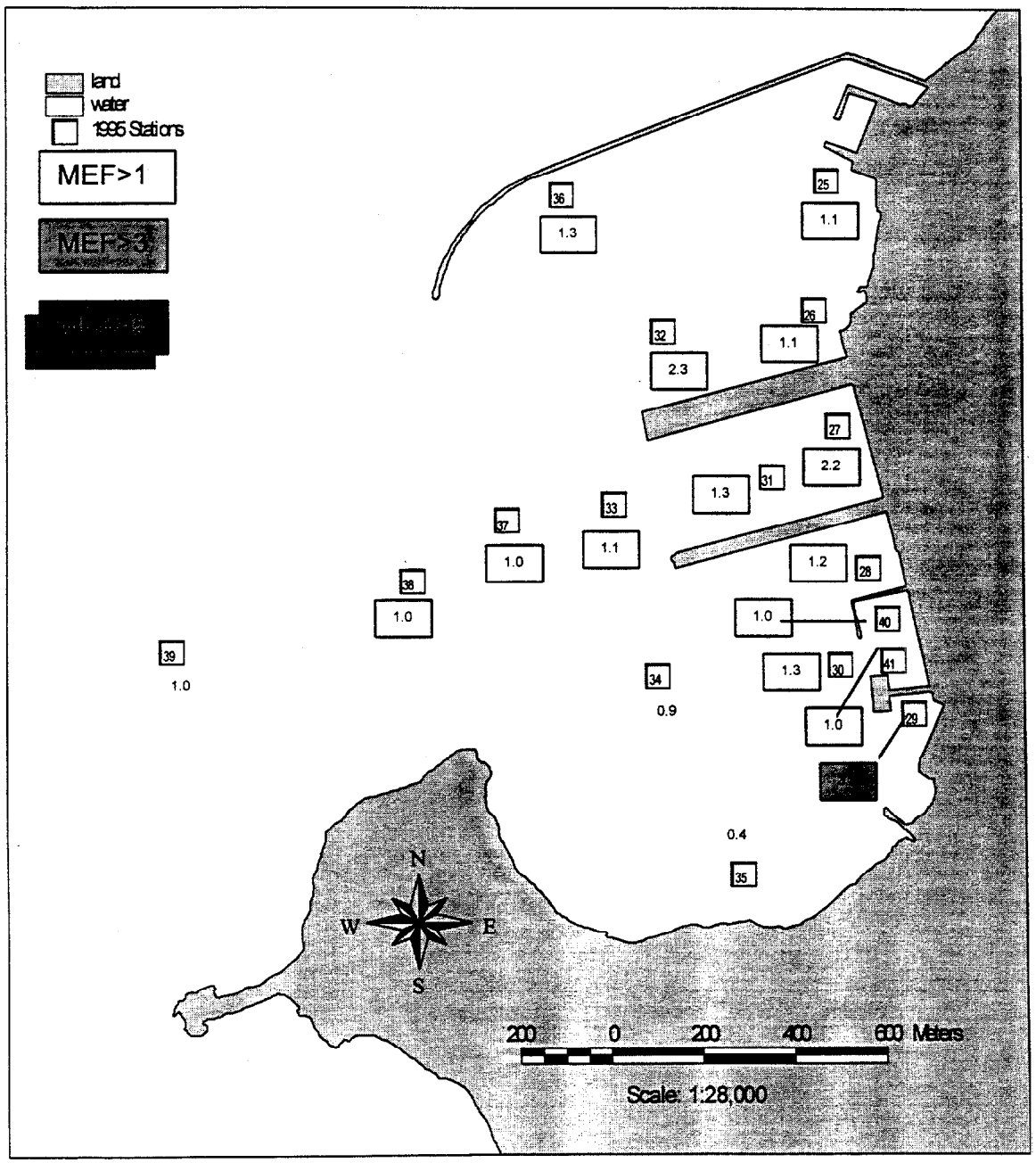


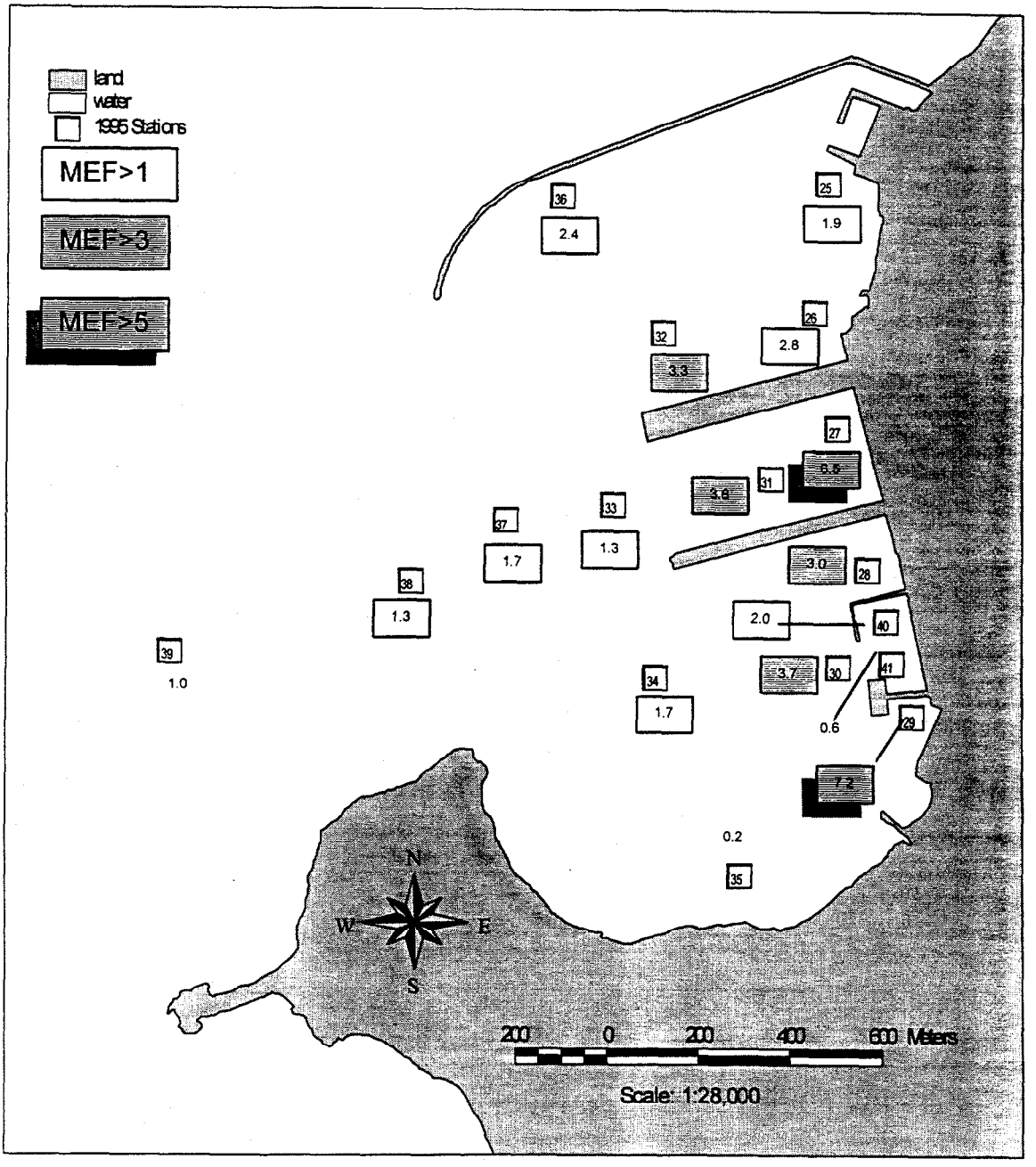
Figure 4.3-1 (continued). Concentration of trace metals in surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations.

Figure 4.3-2. Metal Enrichment Factor (MEF) for lead in surface (0-18 cm) sediments collected from the Derecktor Shipyard / Coddington Cove (DSY) study area.



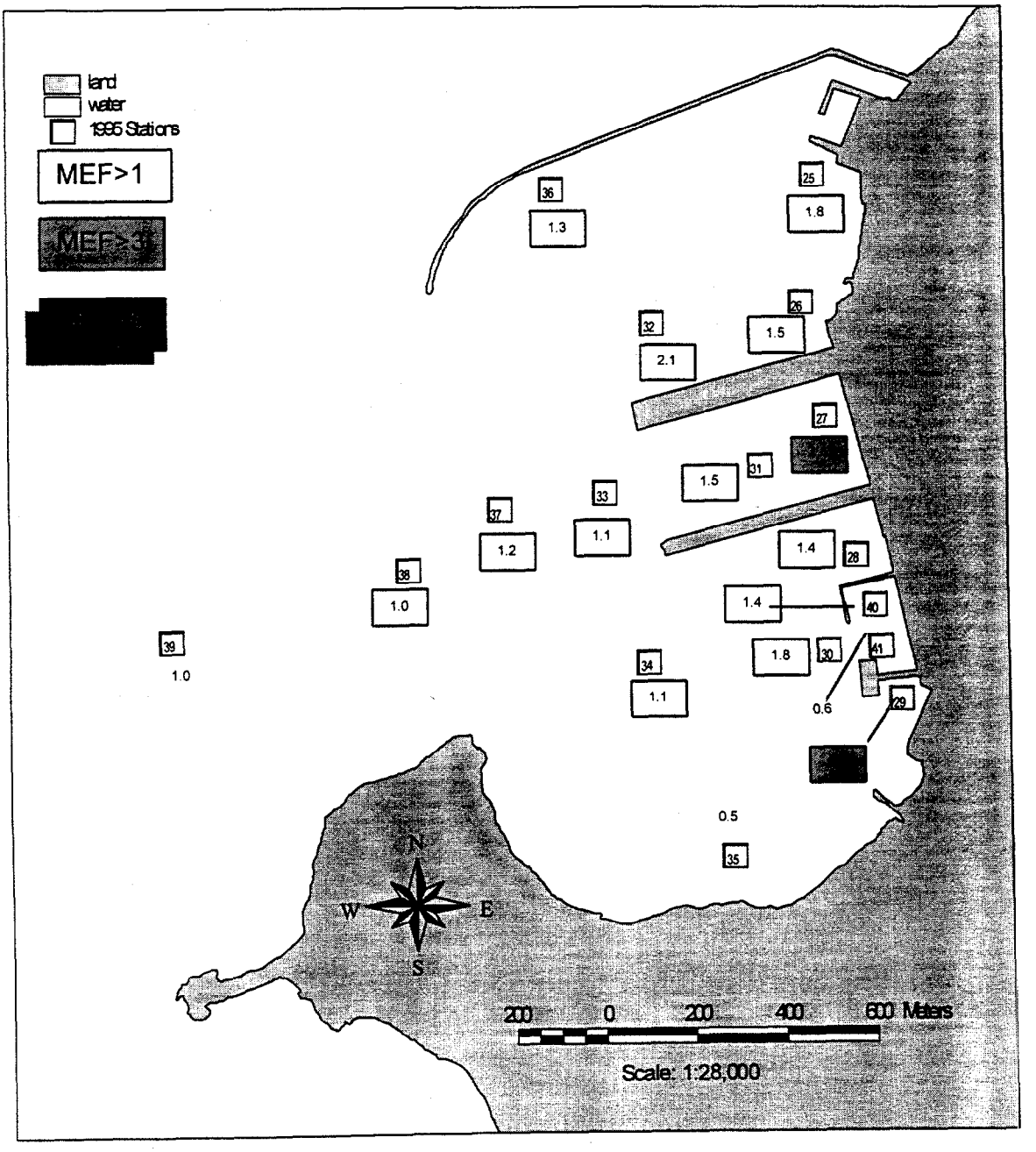
MEF = Aluminum-normalized metal concentration ratios in sediments vs. offshore Station DSY-39.

Figure 4.3-3. Metal Enrichment Factor (MEF) for copper in surface (0-18 cm) sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area.



MEF = Aluminum-normalized metal concentration ratios in sediments vs. offshore Station DSY-39.

Figure 4.3-4. Metal Enrichment Factor (MEF) for zinc in surface (0-18 cm) sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area.



MEF = Aluminum-normalized metal concentration ratios in sediments vs. offshore Station DSY-39.

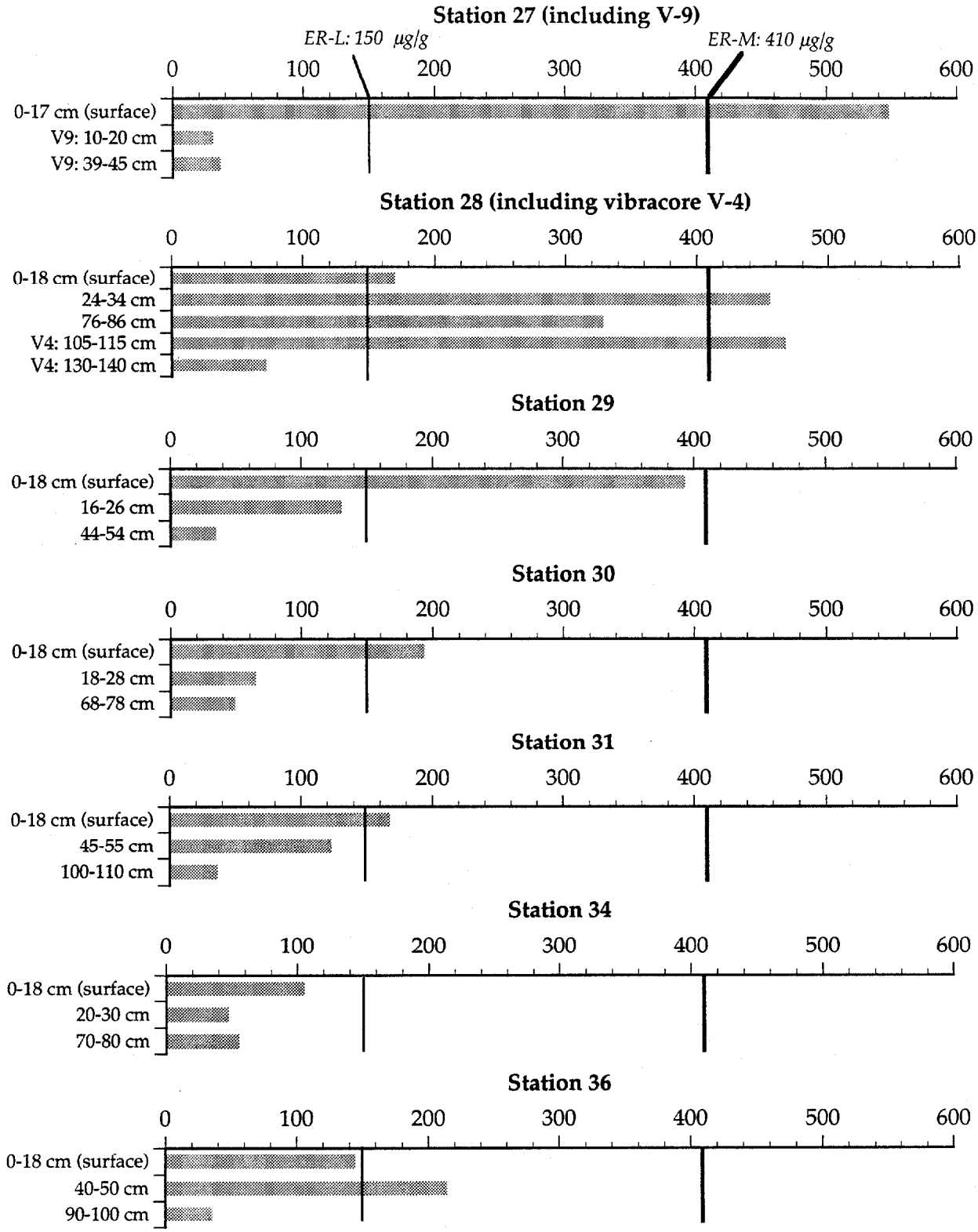


Figure 4.3-5A. Concentration of zinc (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

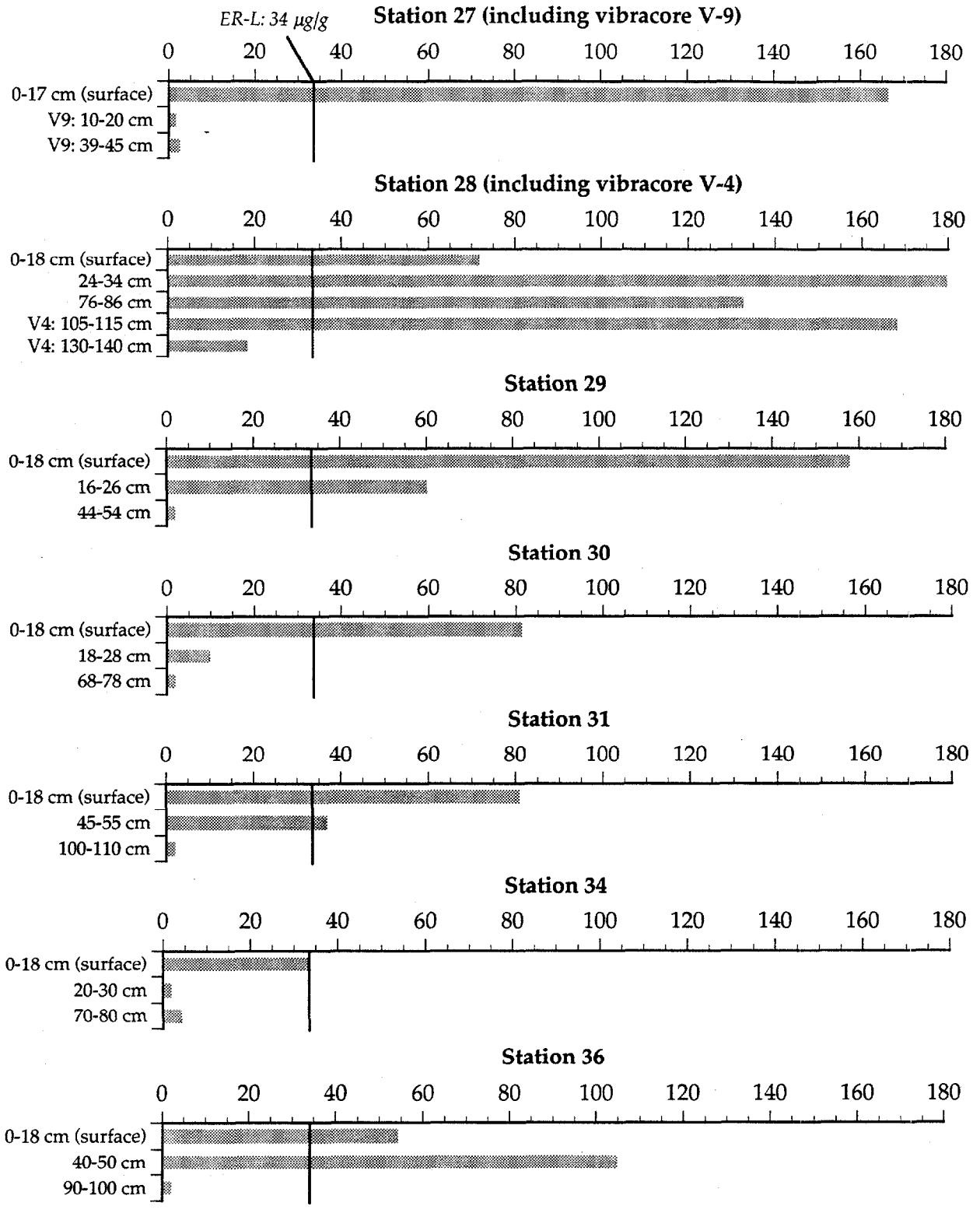


Figure 4.3-5B. Concentration of copper (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

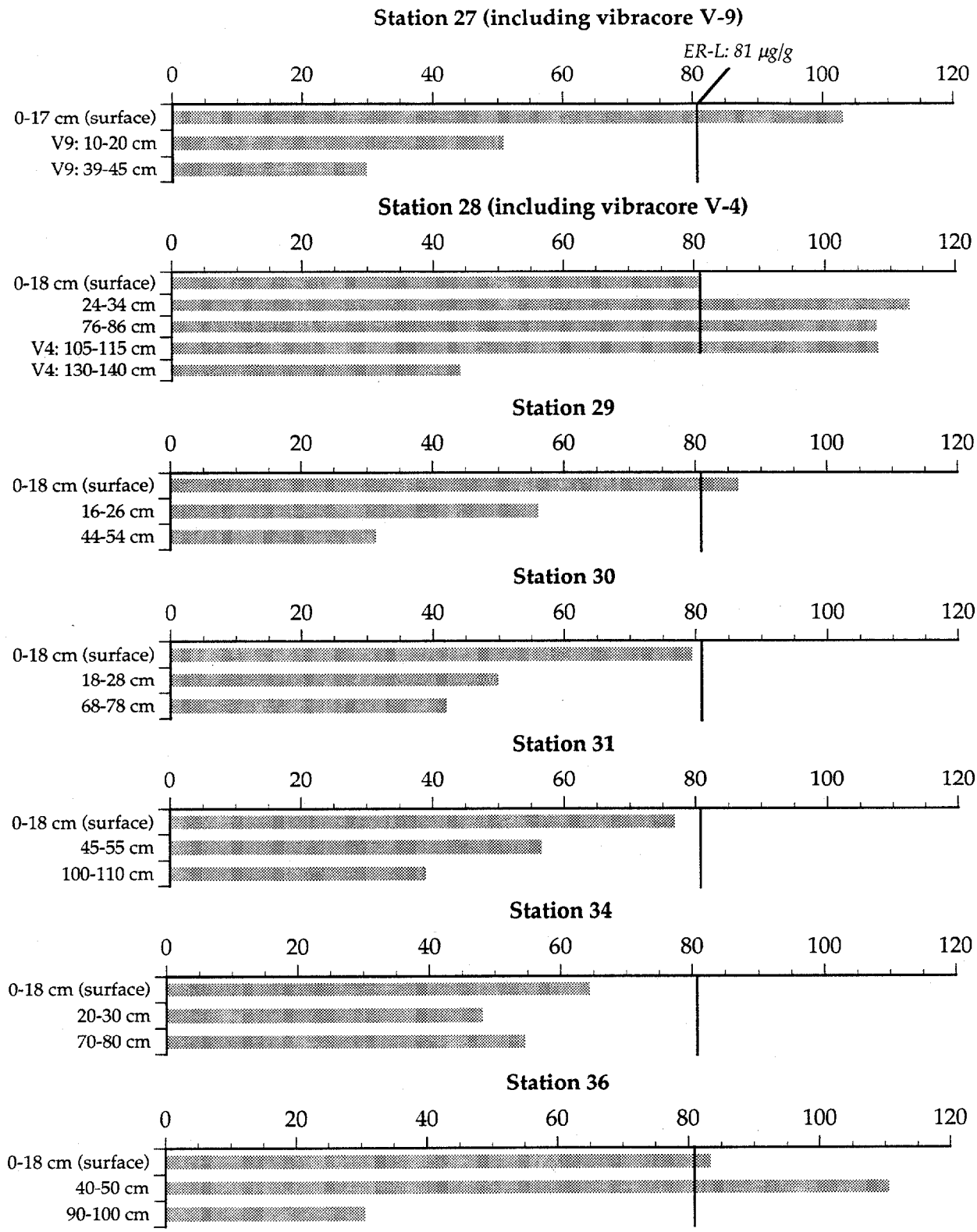


Figure 4.3-5C. Concentration of chromium (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

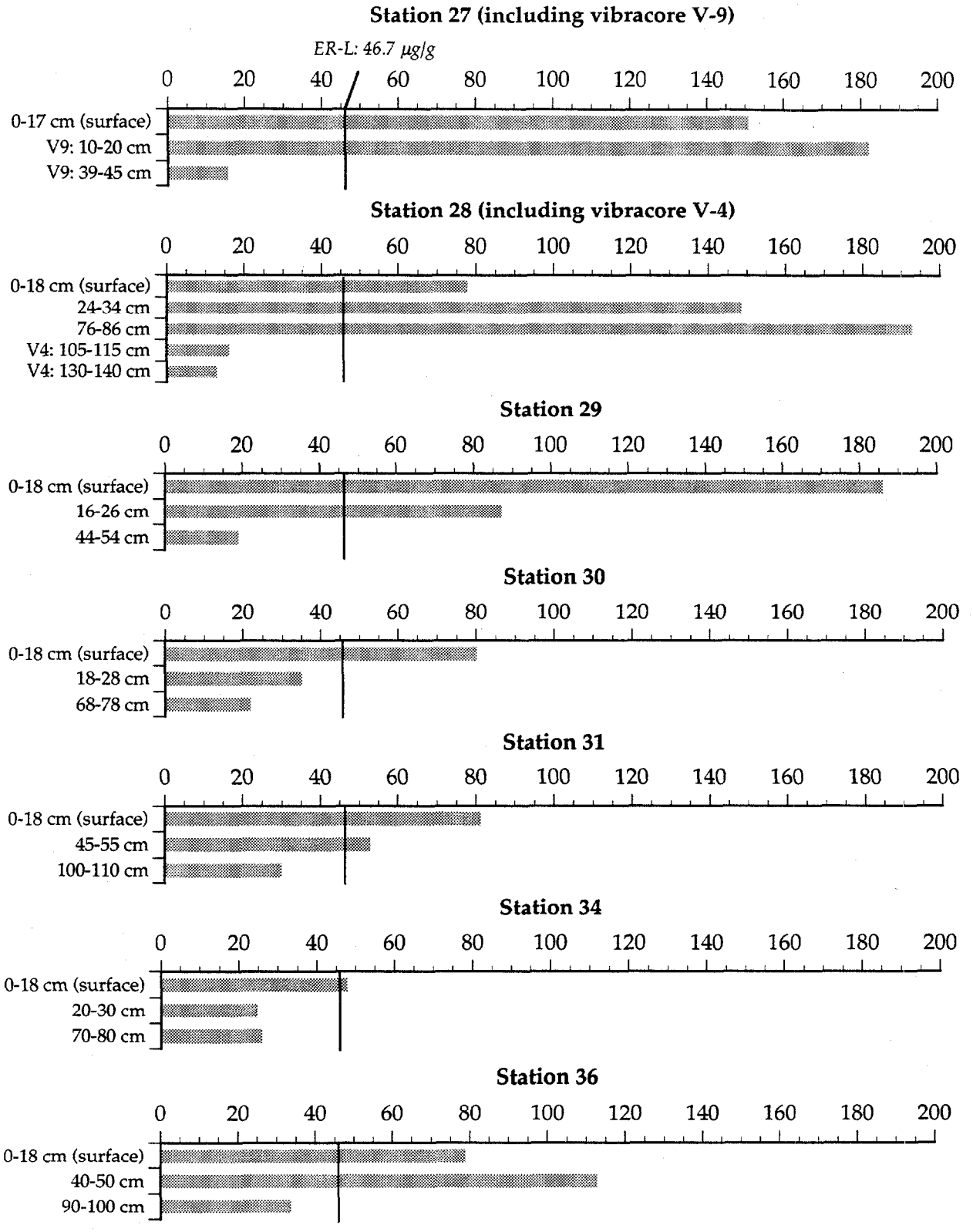


Figure 4.3-5D. Concentration of lead (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

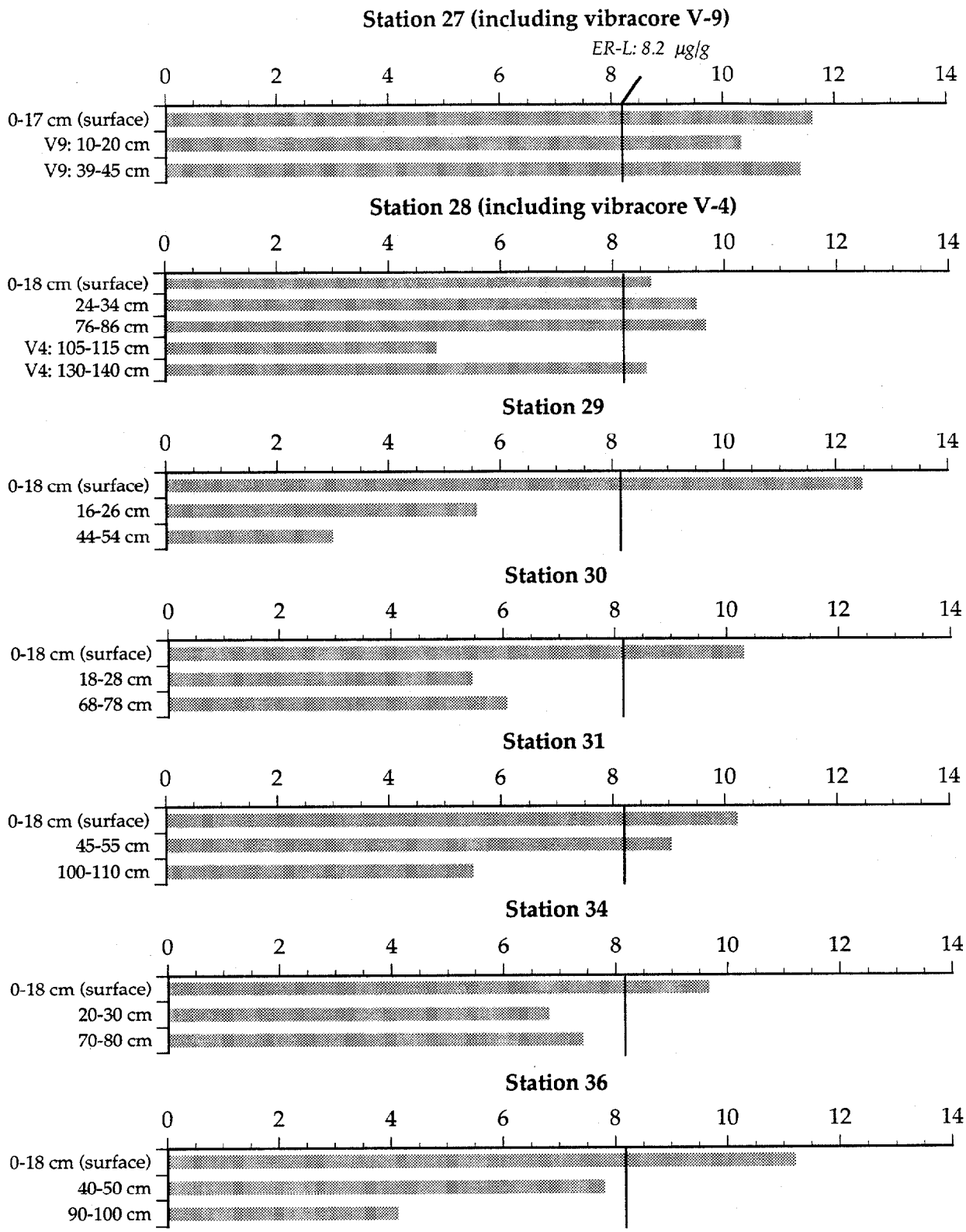


Figure 4.3-5E. Concentration of arsenic (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

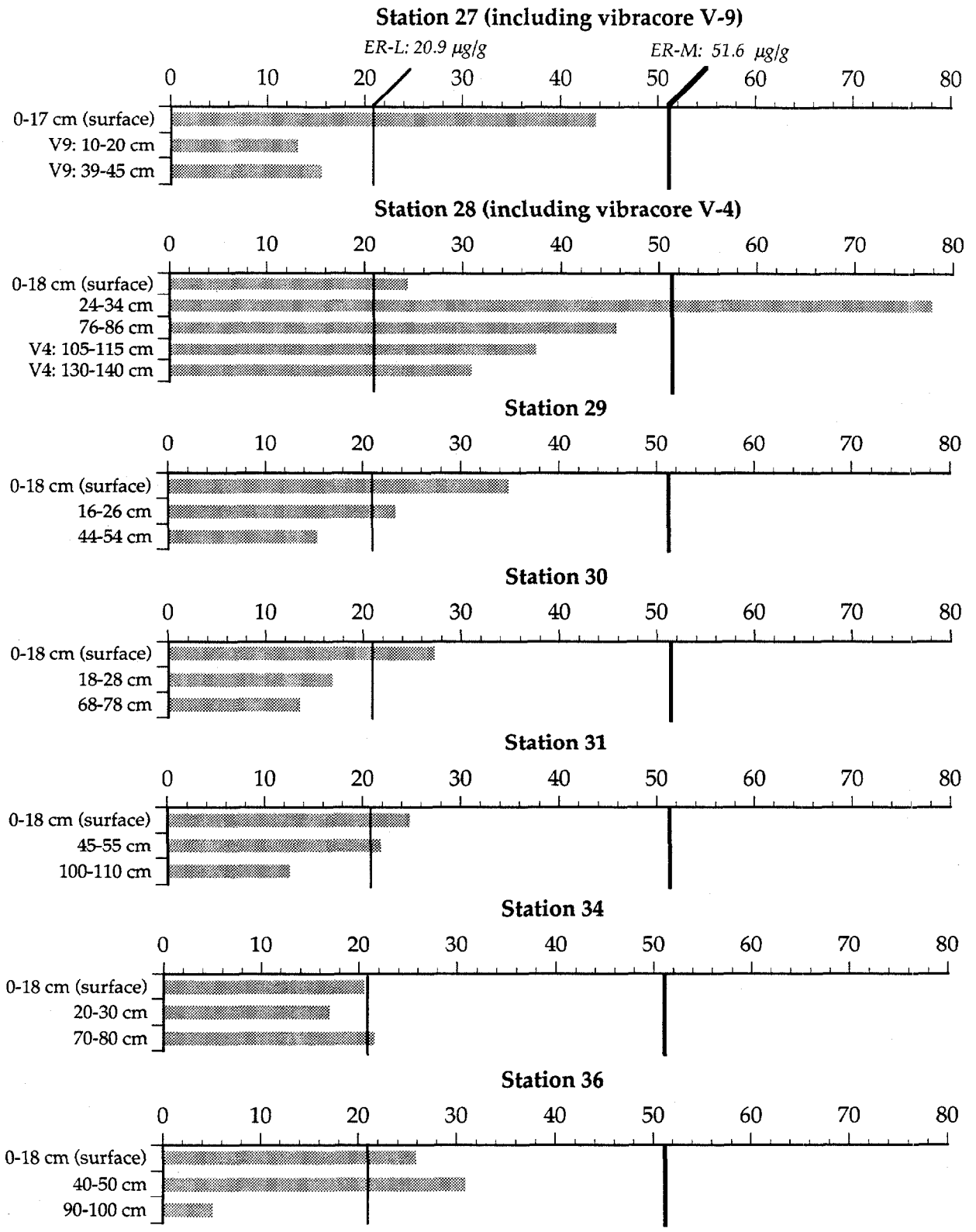


Figure 4.3-5F. Concentration of nickel (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

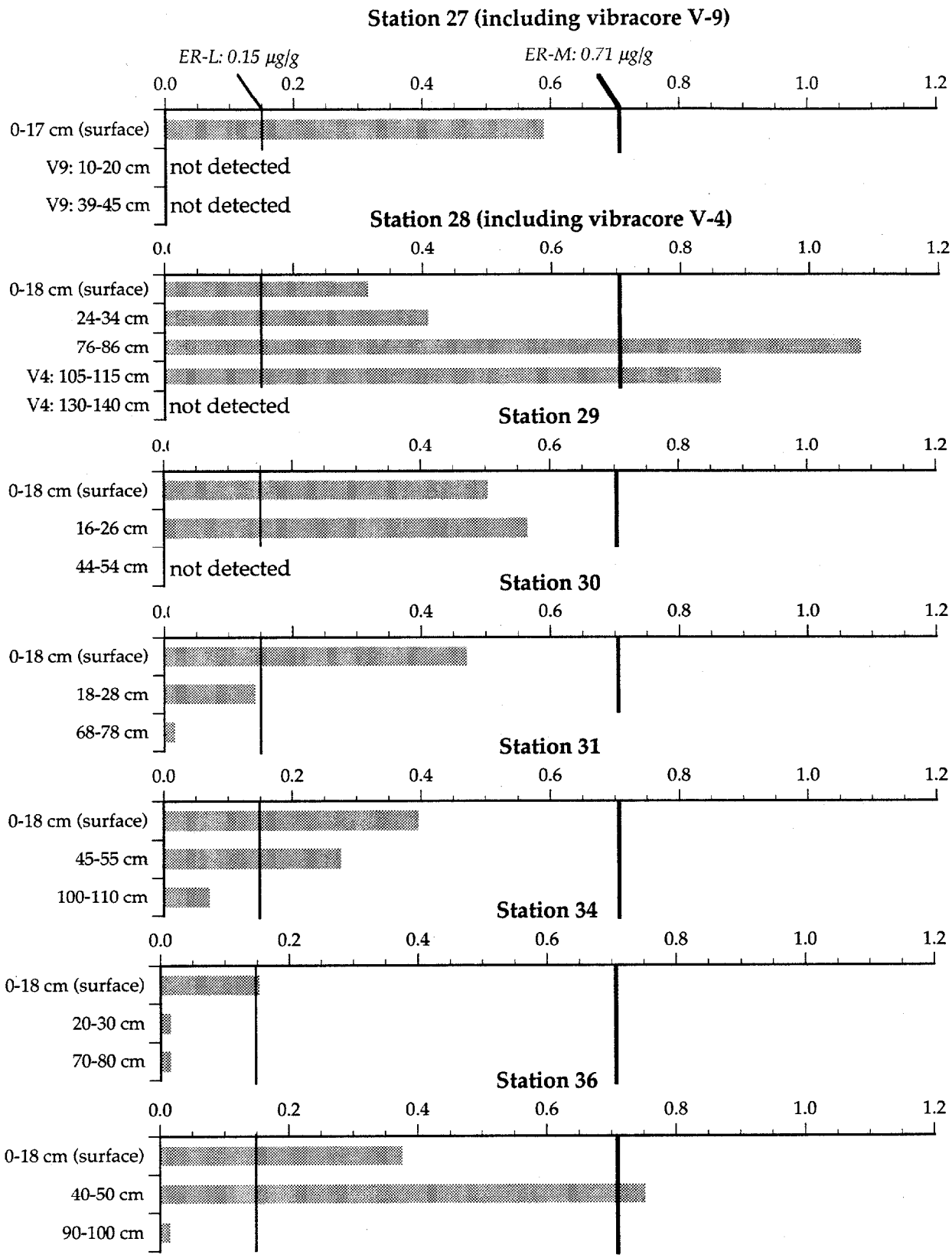


Figure 4.3-5G. Concentration of mercury (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

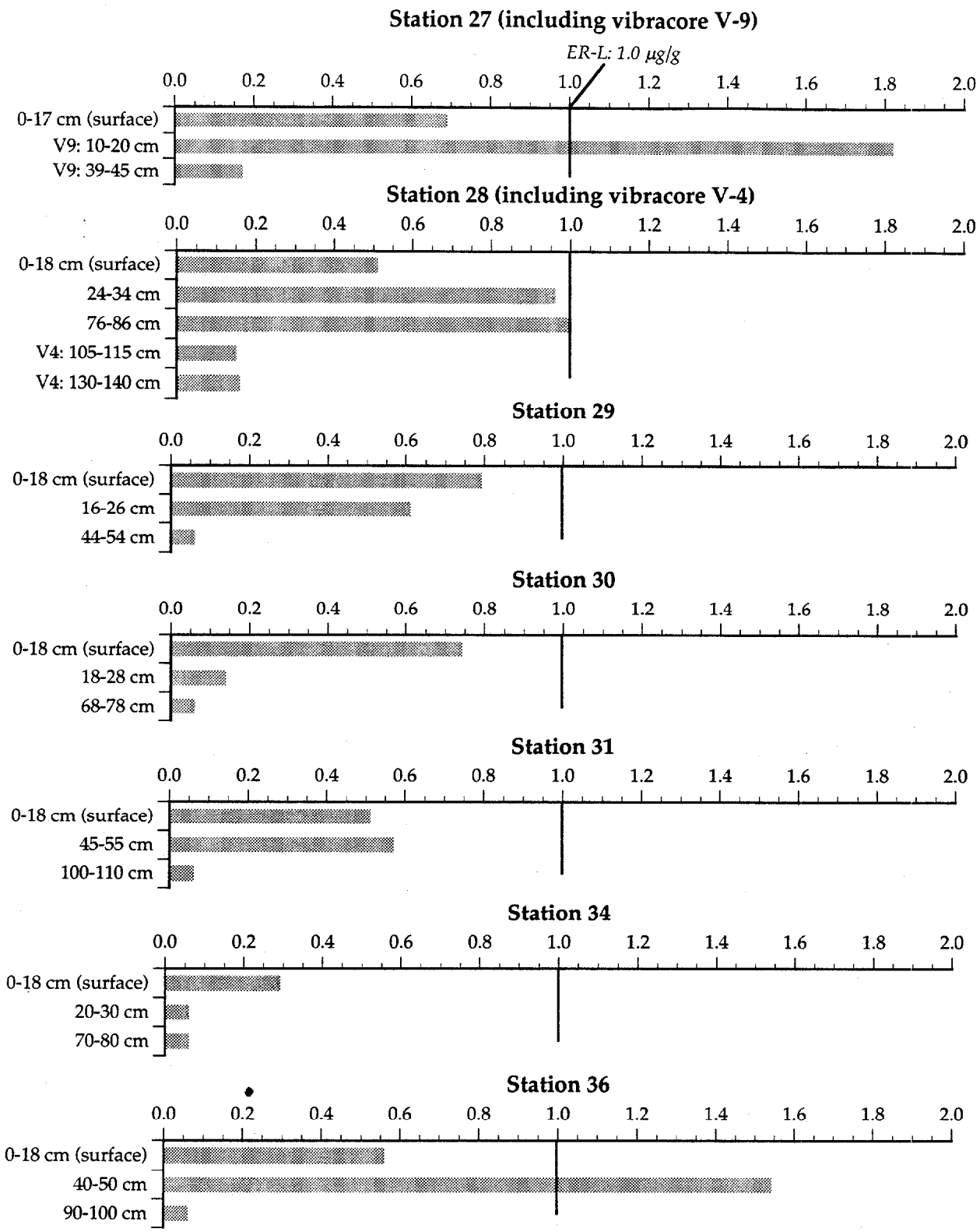


Figure 4.3-5H. Concentration of silver (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

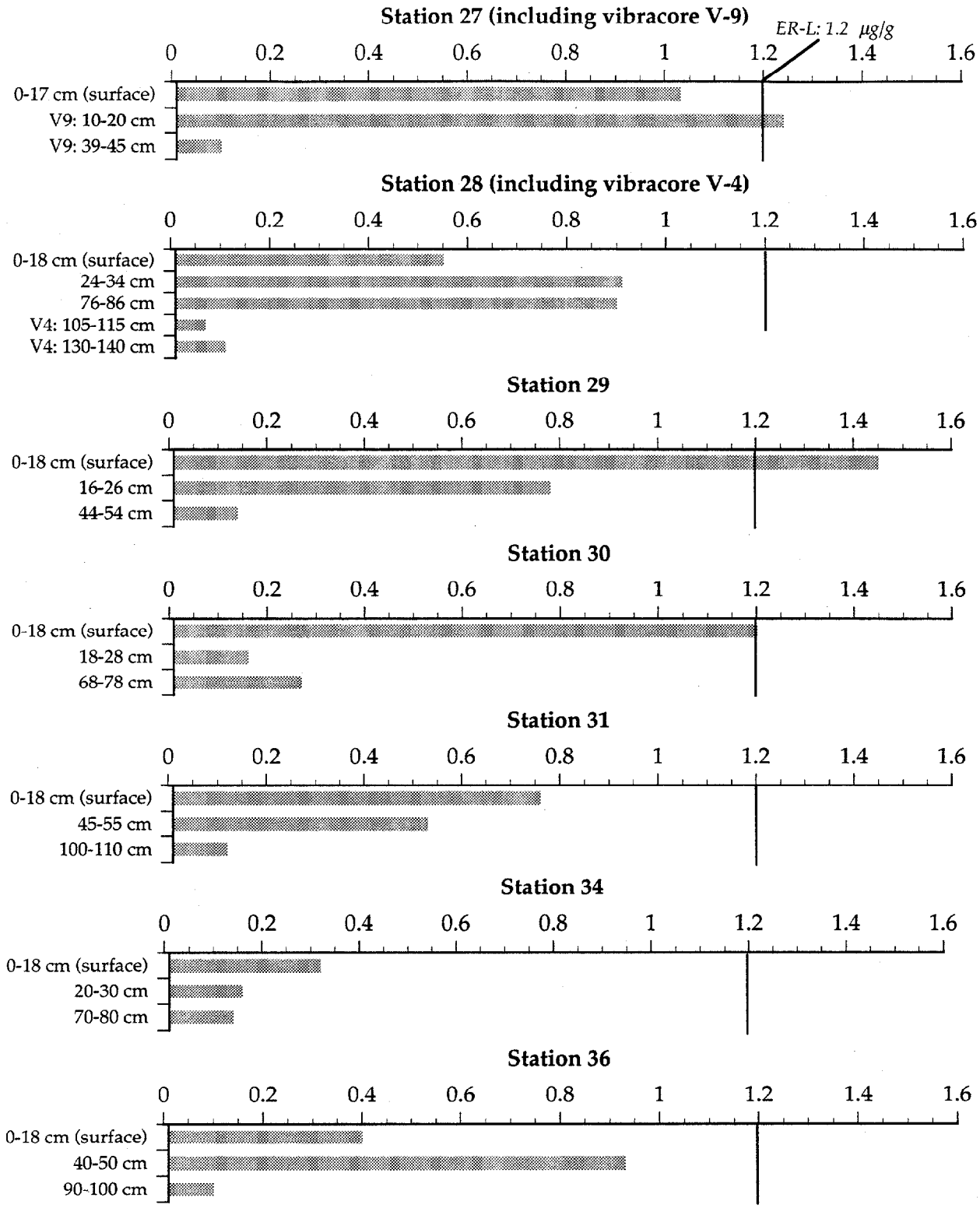


Figure 4.3-5l. Concentration of cadmium (µg/g) in sediment cores in the Derecktor Shipyard/Coddington Cove study area.

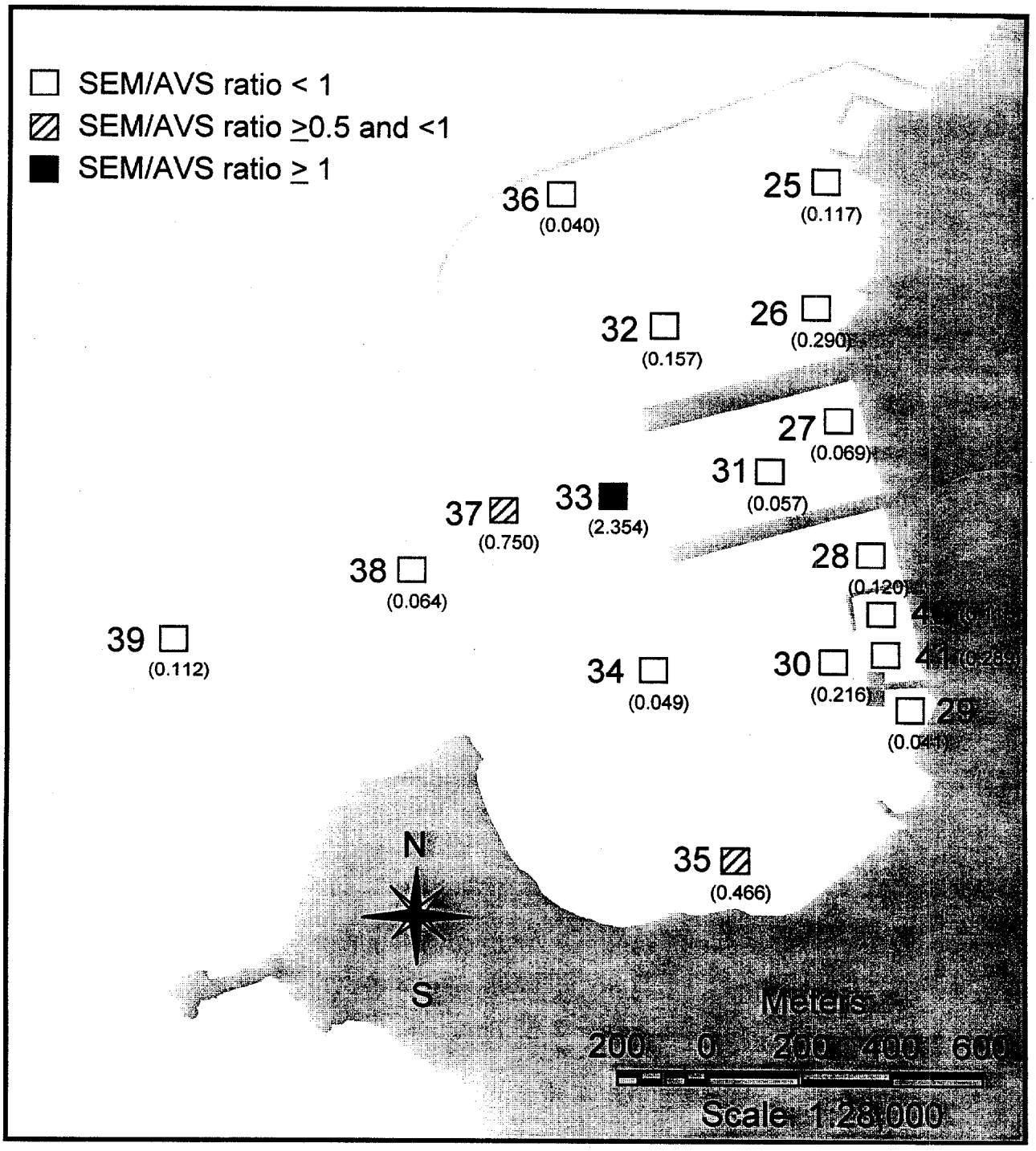
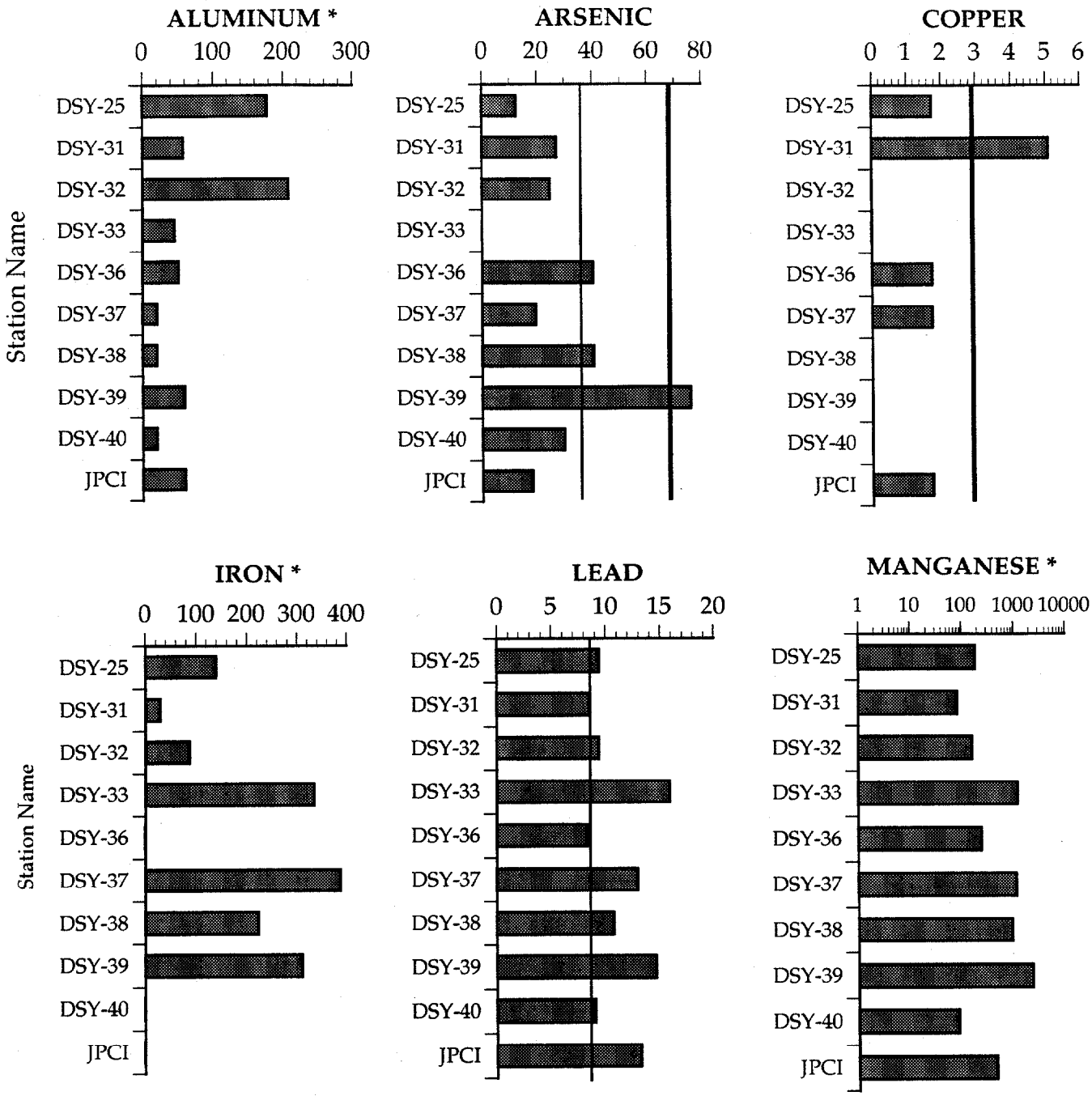


Figure 4.3-6. Ratio of Simultaneously Extractable Metals (SEM) to Acid Volatile Sulfide (AVS) in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area.



NOTES:

1. The following metals were detected at concentrations below the Limit of Quantitative Detection or were not detected, and therefore are not plotted: Silver, Cadmium, Mercury, Nickel, Zinc
2. Asterisks (*) indicate metals for which no saltwater quality criteria have been set.
3. Light vertical line designates the Saltwater Chronic Value. Dark vertical line indicates Saltwater Acute Value. (Both from EPA, 1986.)

Figure 4.3-7. Concentration of metals (µg/L) in elutriate samples from the Derecktor Shipyard/Coddington Cove study area.

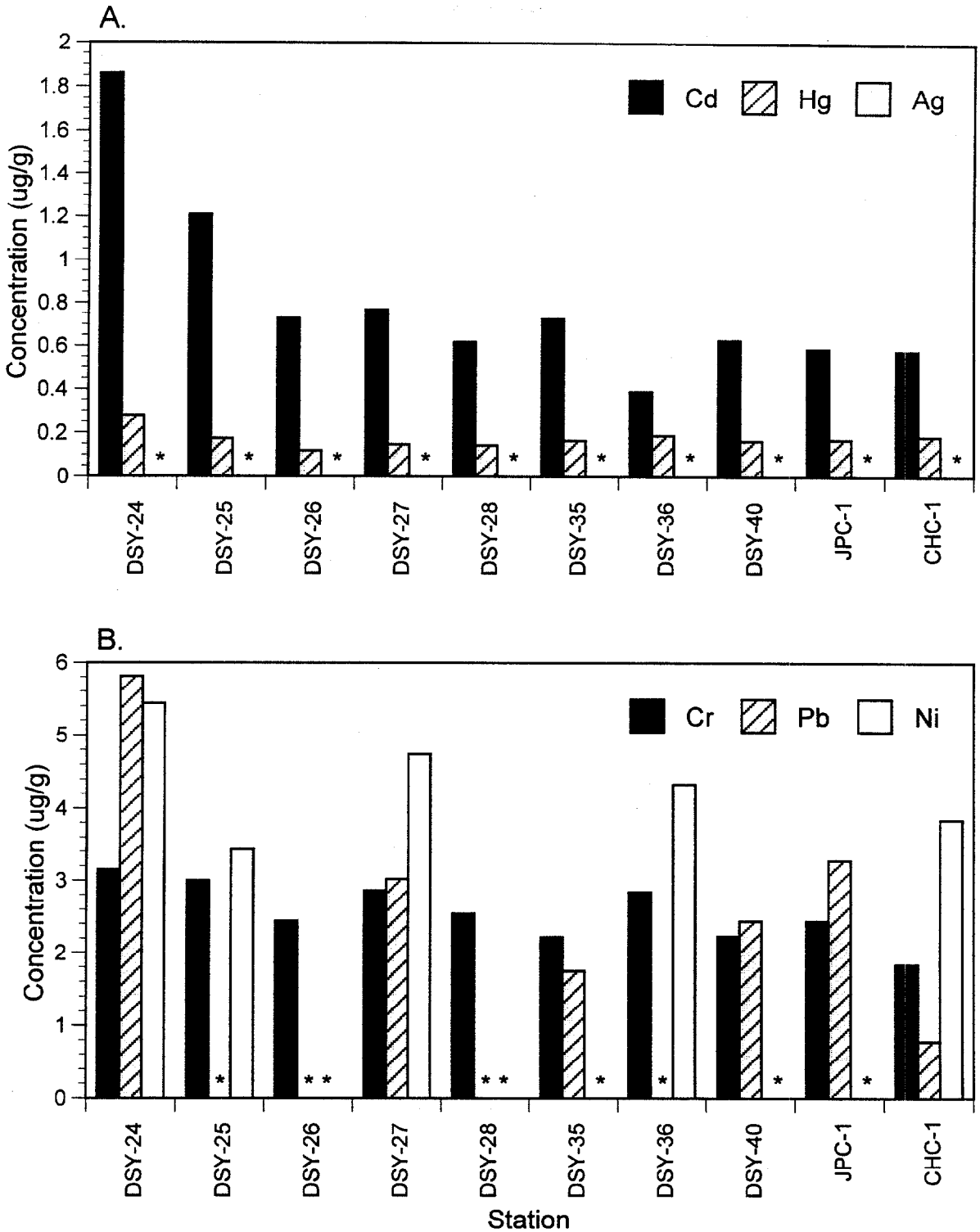


Figure 4.3-8. Concentration of metals in indigenous blue mussels from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc.
* = not detected.

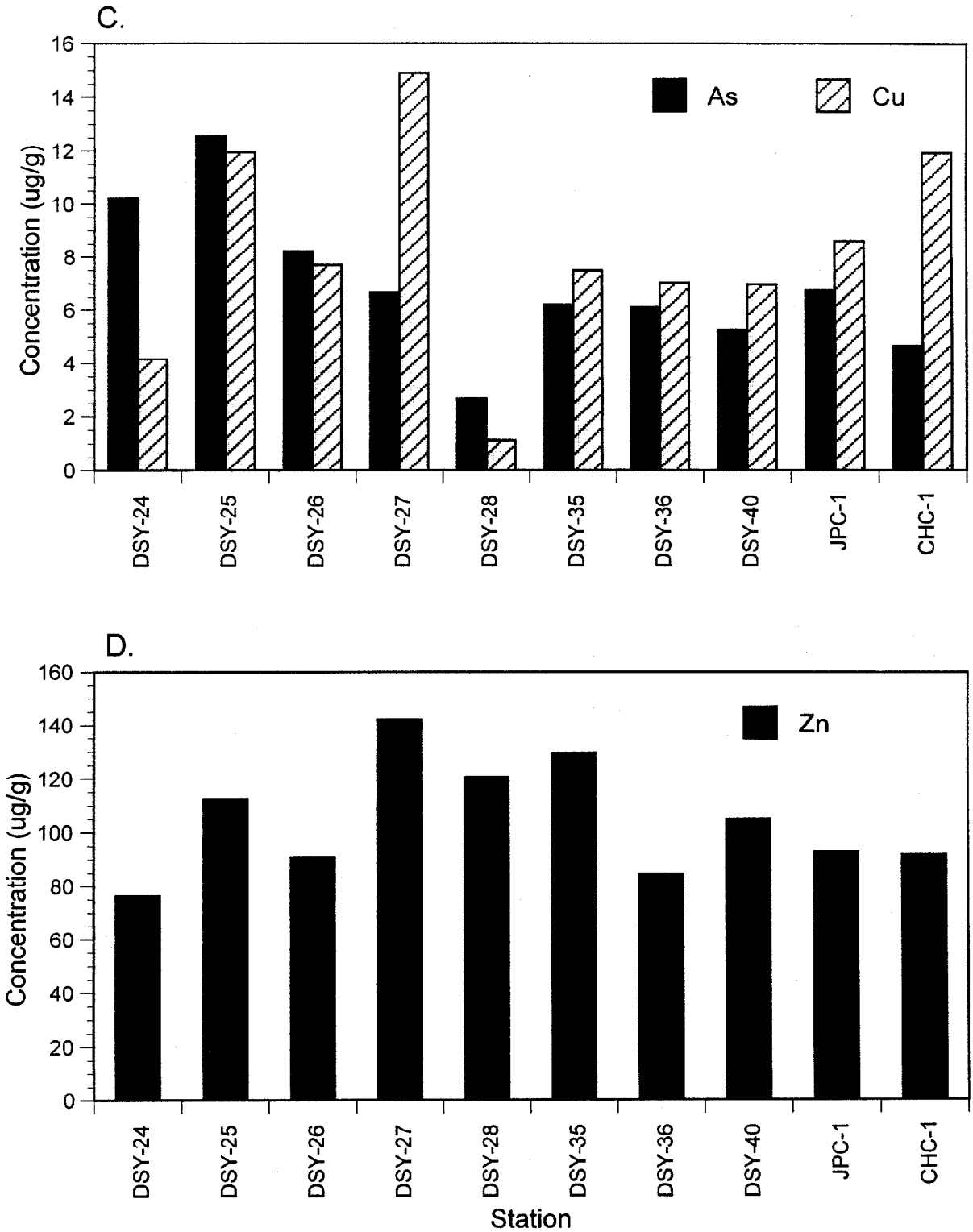


Figure 4.3-8 (continued). Concentration of metals in indigenous blue mussels from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc.
* = not detected.

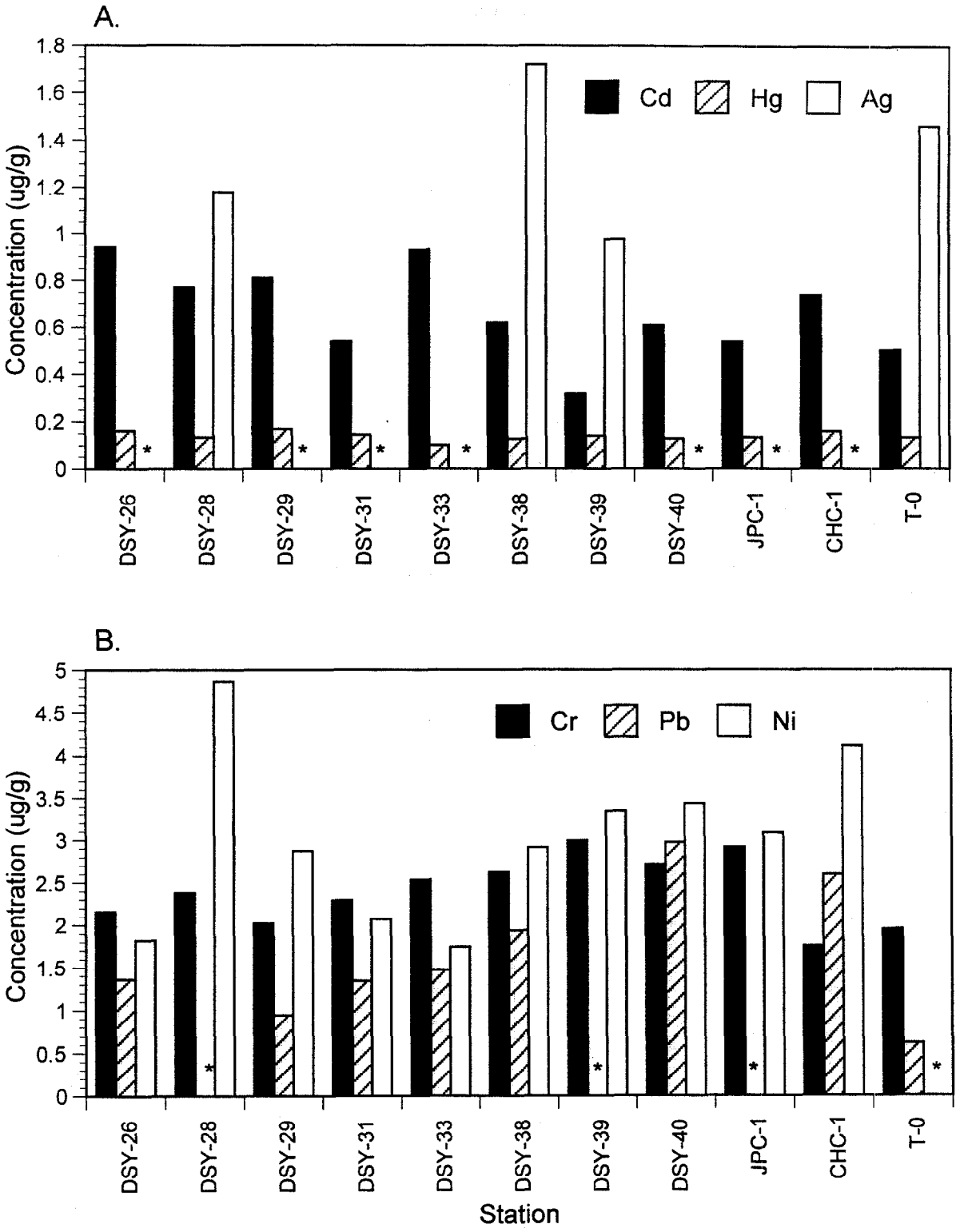


Figure 4.3-9. Concentration of metals in blue mussels deployed in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc.
* = not detected. T-0 = time-zero.

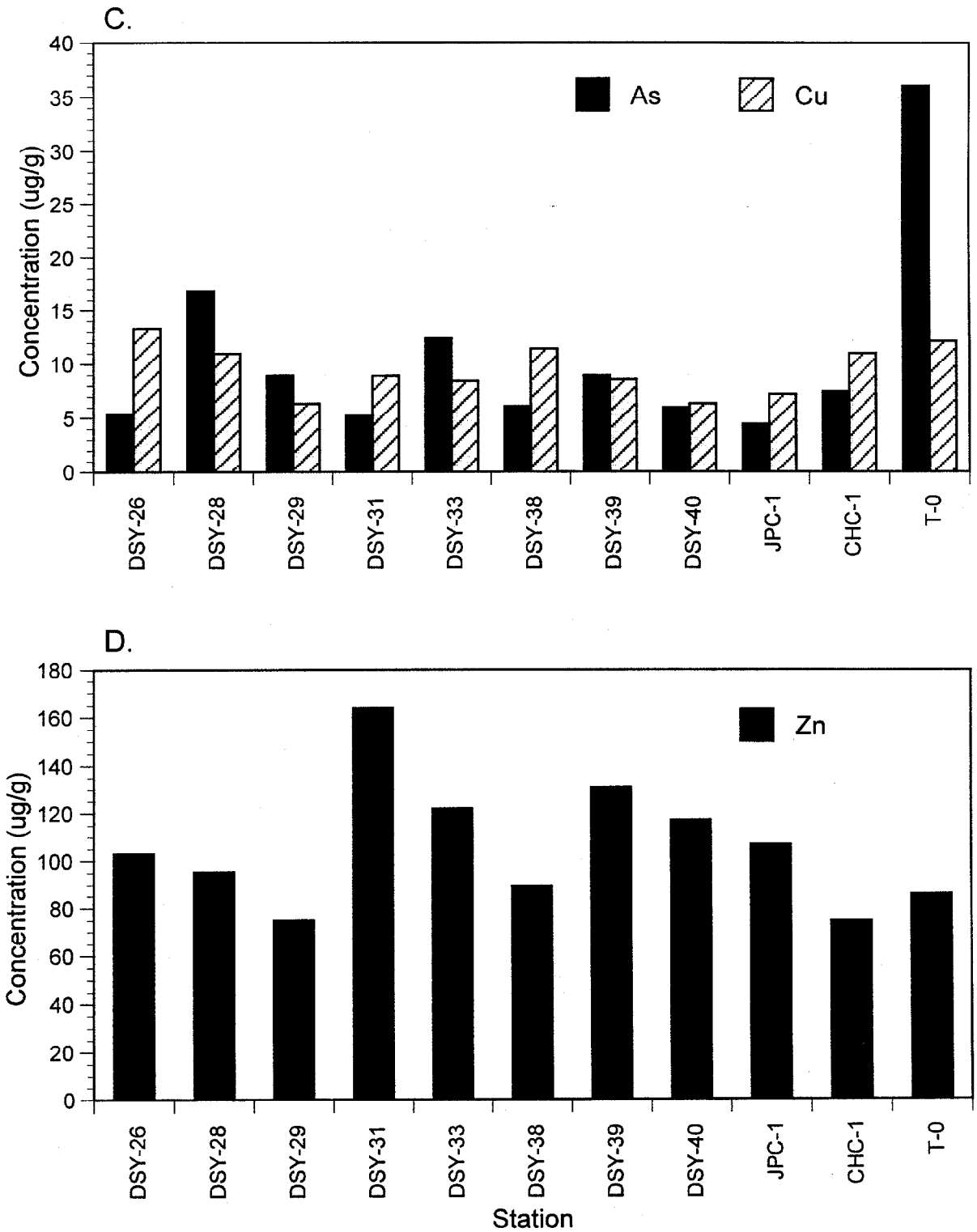


Figure 4.3-9 (continued). Concentration of metals in blue mussels deployed in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc.
* = not detected. T-0 = time-zero.

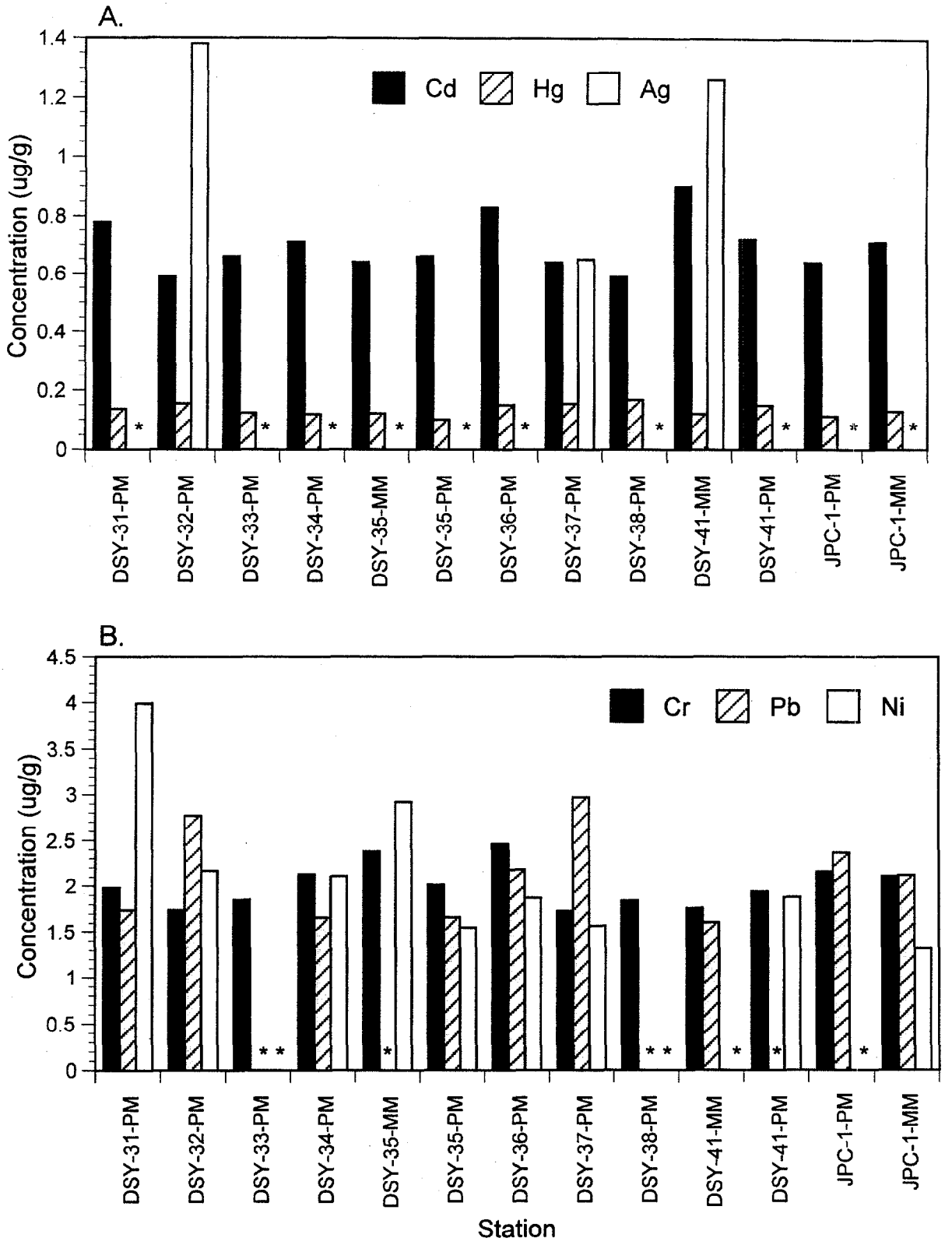


Figure 4.3-10. Concentration of metals in hard clams (*Mercenaria mercenaria* (MM) and *Pitar morrhuana* (PM)) in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc. * = not detected.

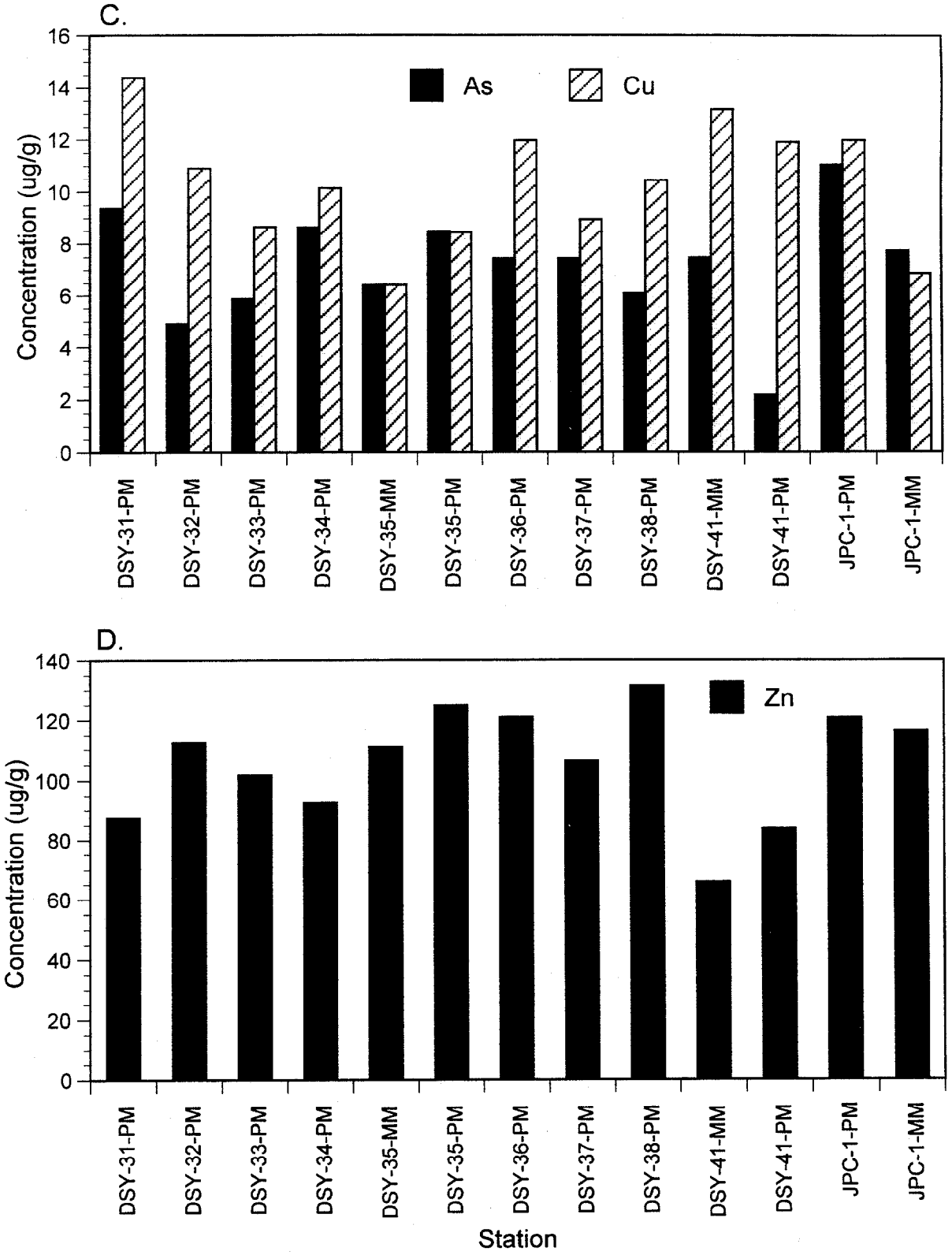


Figure 4.3-10 (continued). Concentration of metals in hard clams (*Mercenaria mercenaria* (MM) and *Pitar morrhuana* (PM)) in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, mercury, and silver; B) chromium, lead, and nickel; C) arsenic and copper; and D) zinc. * = not detected.

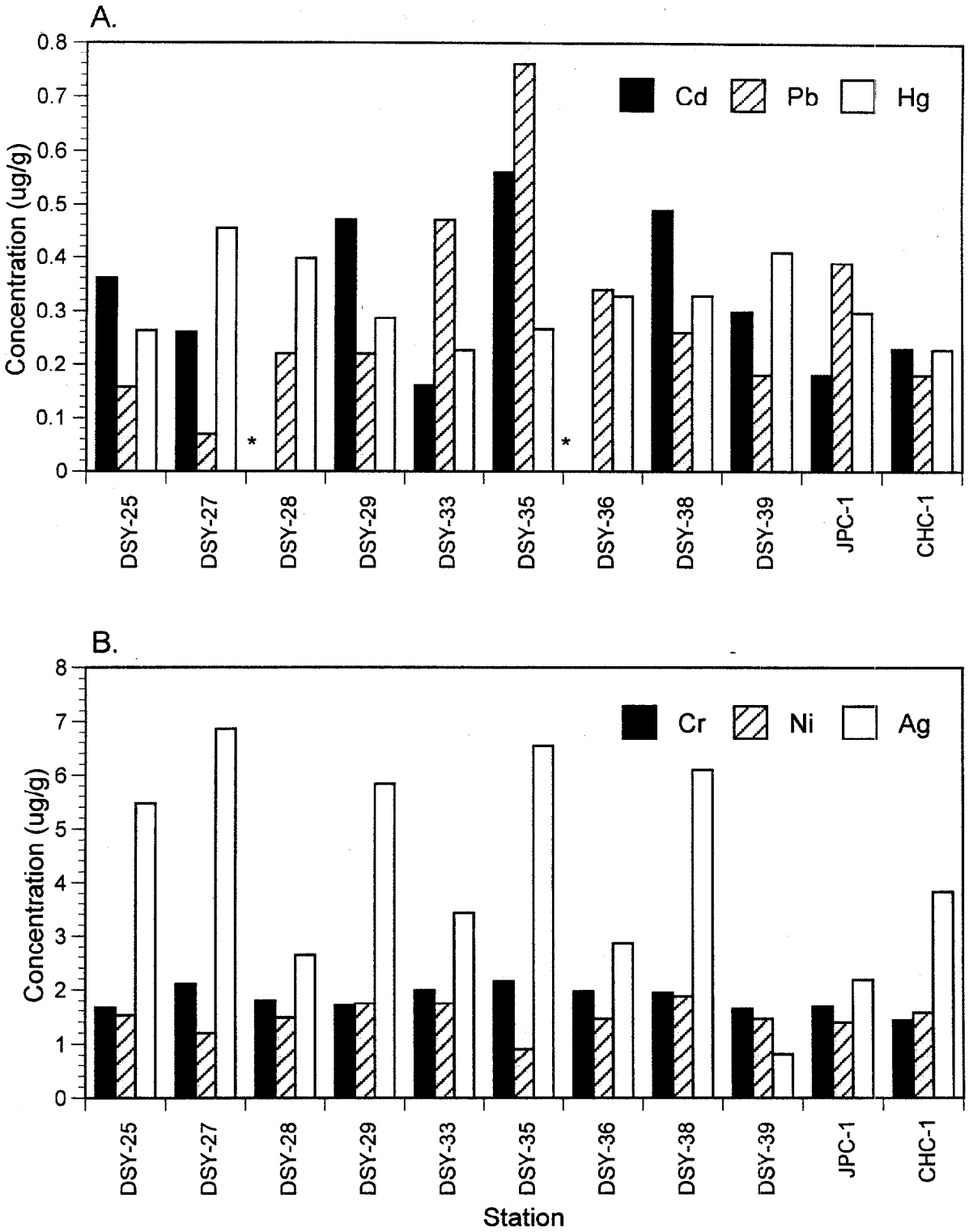
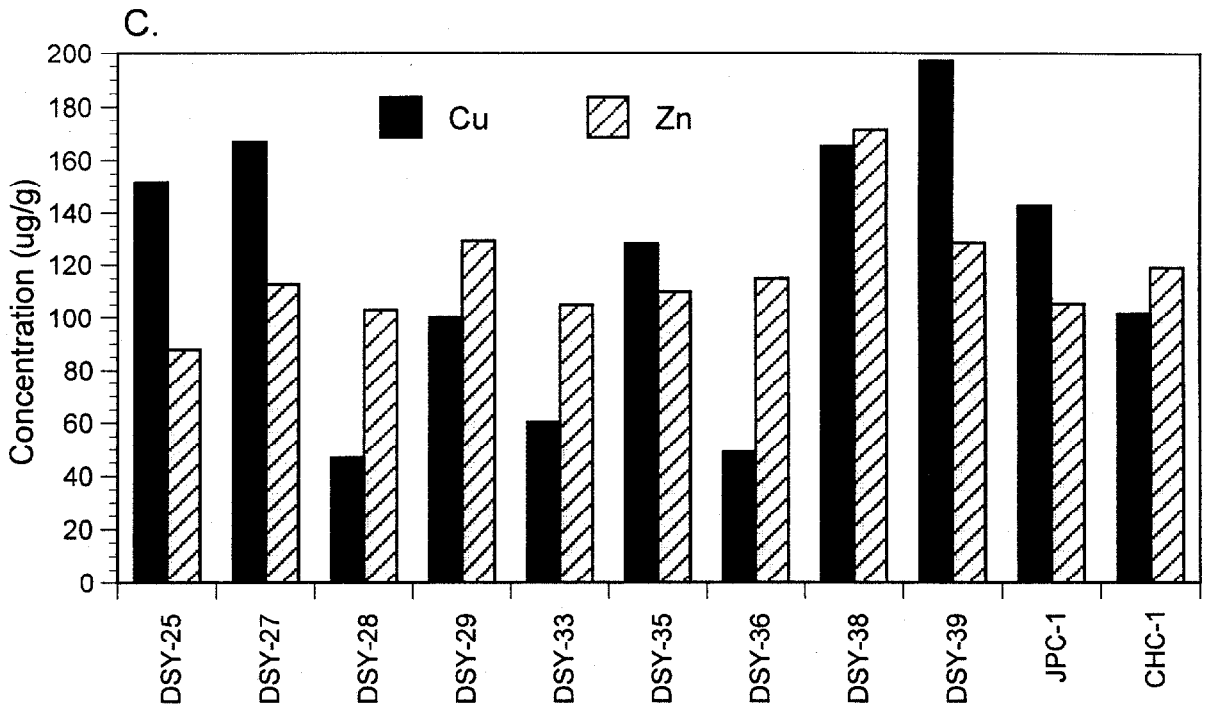


Figure 4.3-11. Concentration of metals in lobster muscle from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, lead, and mercury; B) chromium, nickel, and silver; C) copper and zinc; and D) arsenic.
* = not detected.



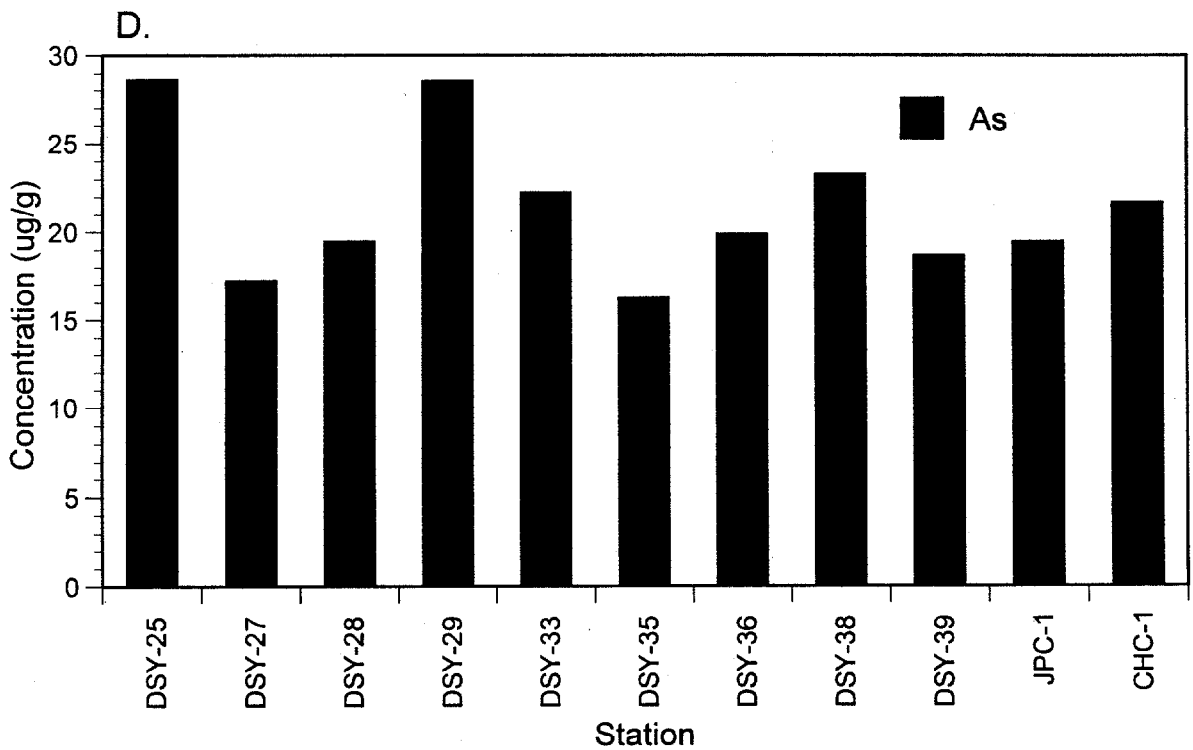


Figure 4.3-11 (continued). Concentration of metals in lobster muscle from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, lead, and mercury; B) chromium, nickel, and silver; C) copper and zinc; and D) arsenic. * = not detected.

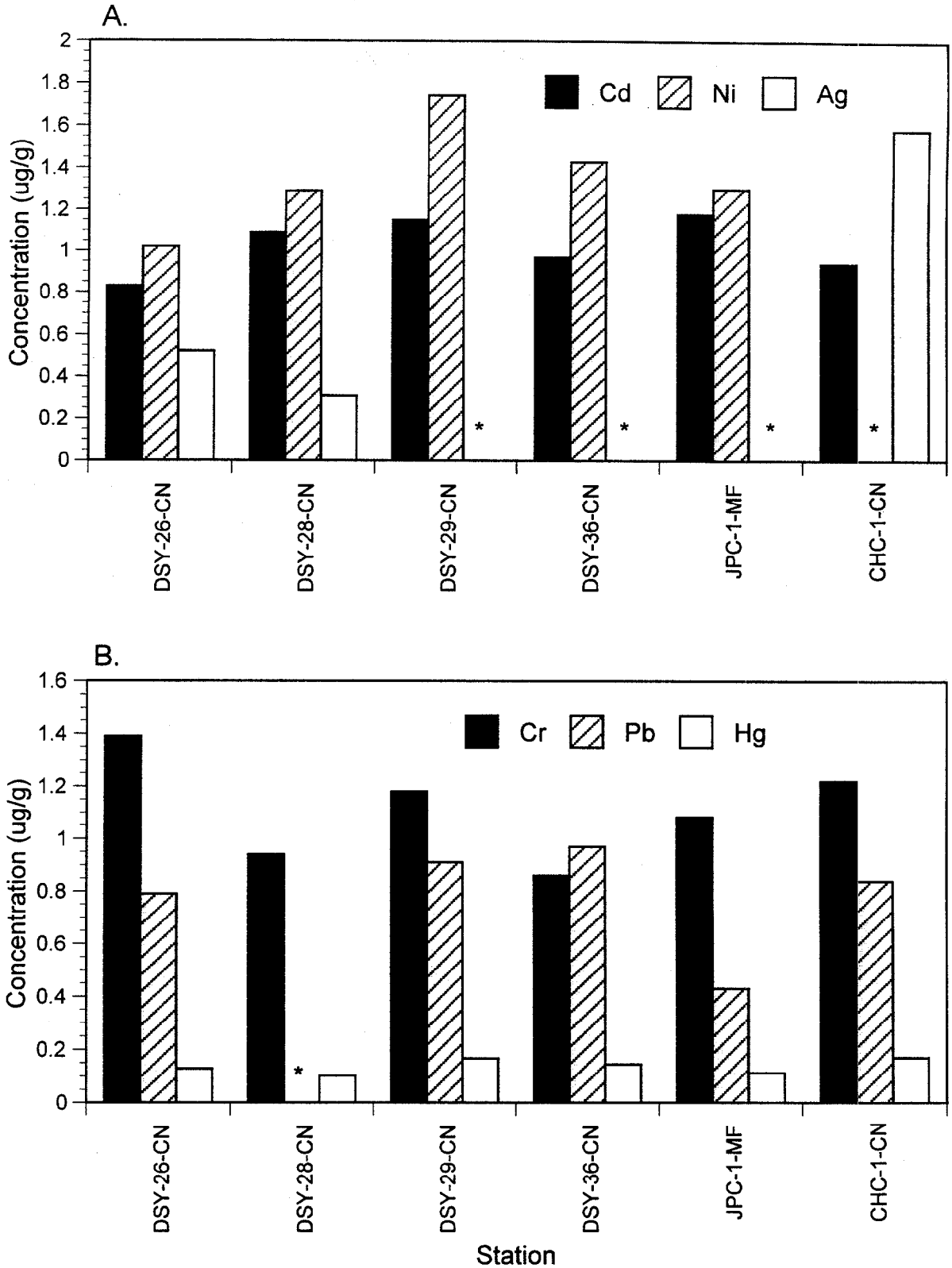
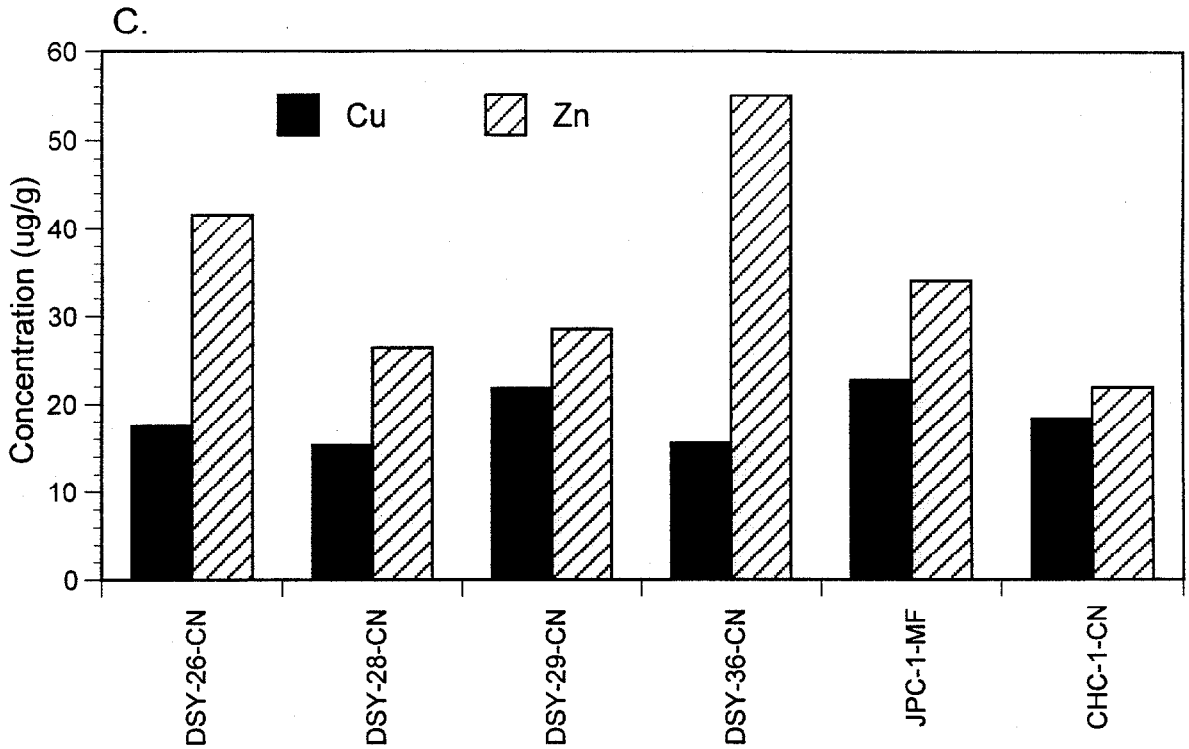


Figure 4.3-12. Concentration of metals in fish (*Fundulus heteroclitus* (MF) and *Tautogolabrus adspersus* (CN)) from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, nickel, and silver; B) chromium, lead, and mercury; C) copper and zinc; and D) arsenic.
* = not detected.



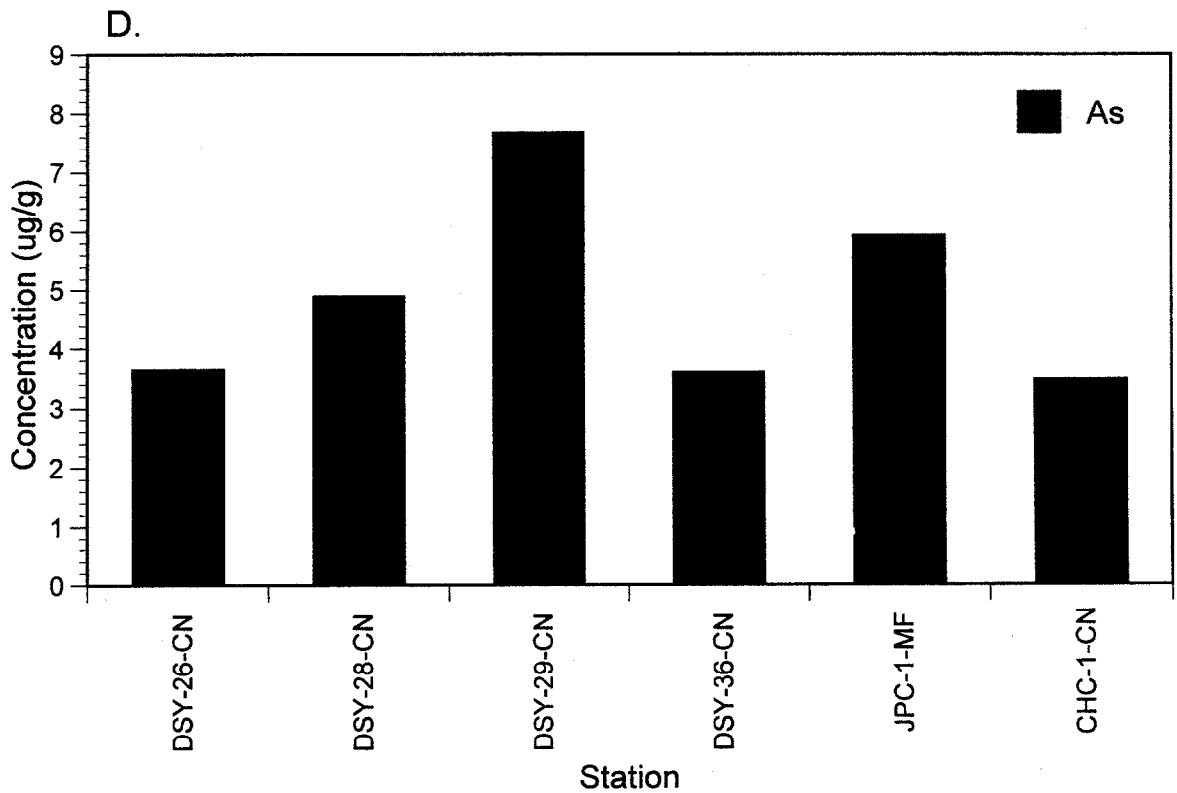


Figure 4.3-12 (continued). Concentration of metals in fish (*Fundulus heteroclitus* (MF) and *Tautogolabrus adspersus* (CN)) from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) cadmium, nickel, and silver; B) chromium, lead, and mercury; C) copper and zinc; and D) arsenic.
* = not detected.

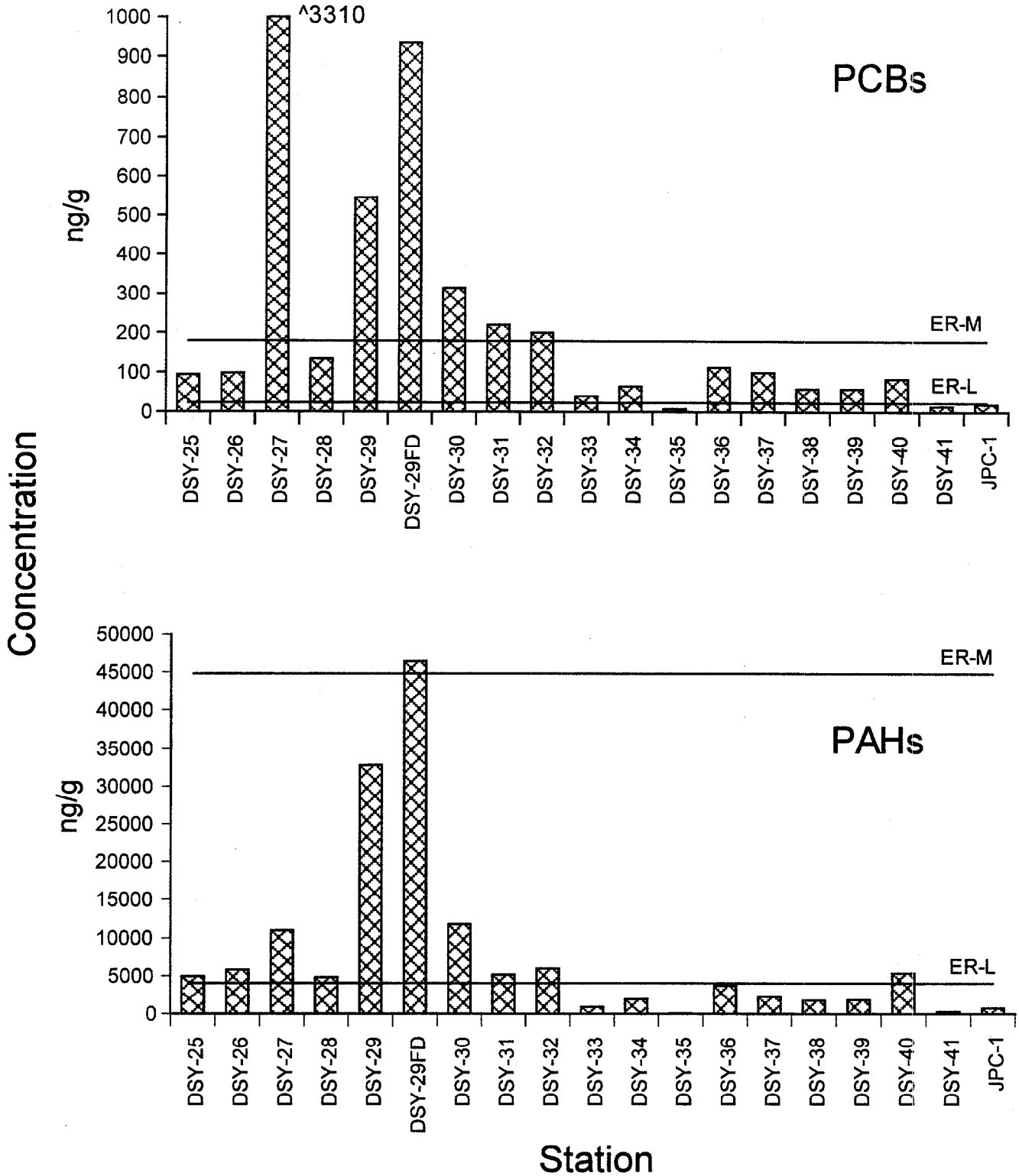


Figure 4.3-13. Concentration of organic contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference Station JPC-1. For PCBs and PAHs, horizontal lines indicate ER-L and ER-M guidelines (Long *et al.*, 1995). FD = field duplicate.

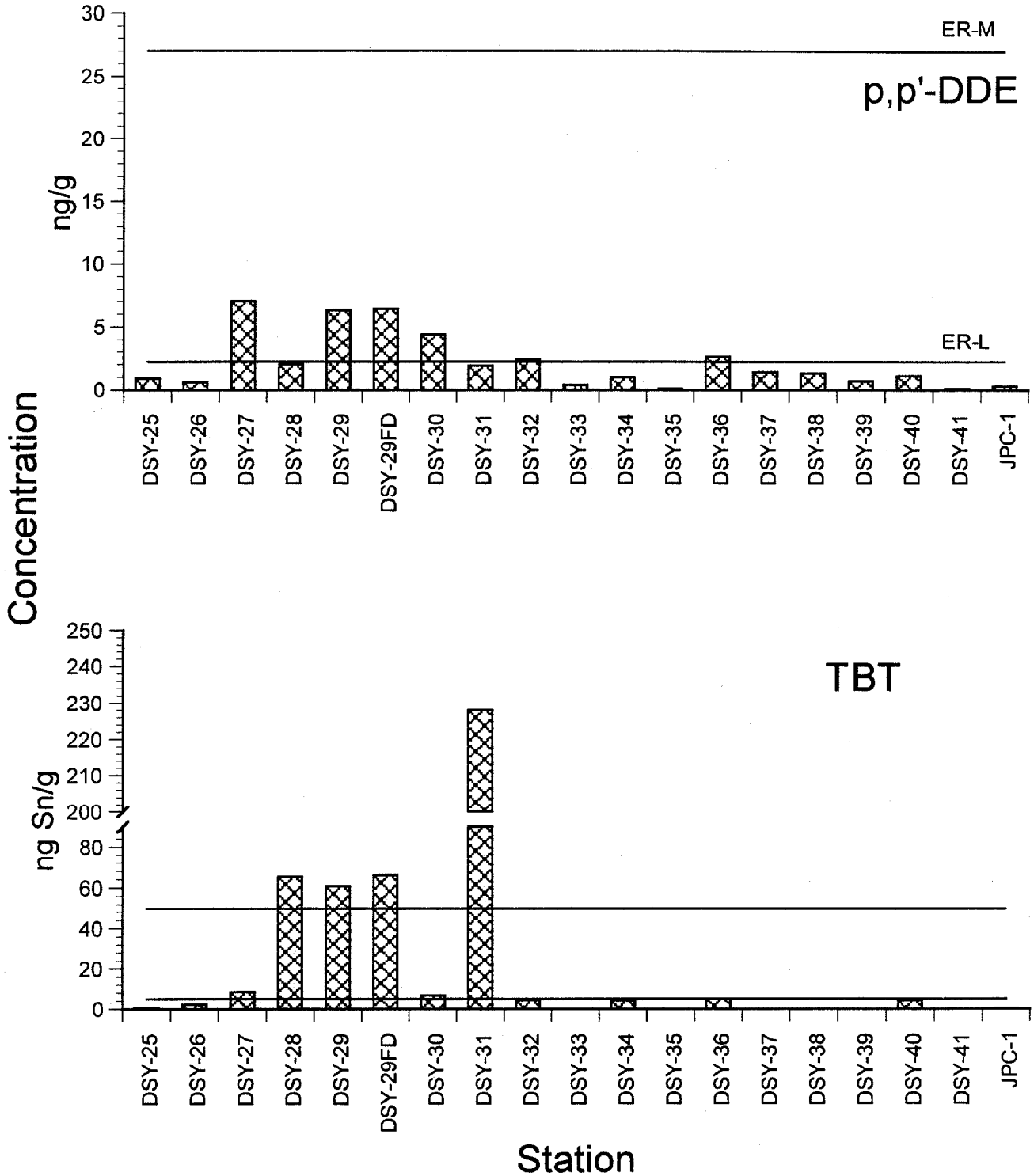


Figure 4.3-13 (continued). Concentration of organic contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference Station JPC-1. For p,p'-DDE, horizontal lines indicate ER-L and ER-M guidelines (Long *et al.*, 1995). For TBT, horizontal lines indicate lower (5 ng Sn/g) and upper (50 ng Sn/g) benchmarks from Macauley *et al.*, 1994. FD = field duplicate.

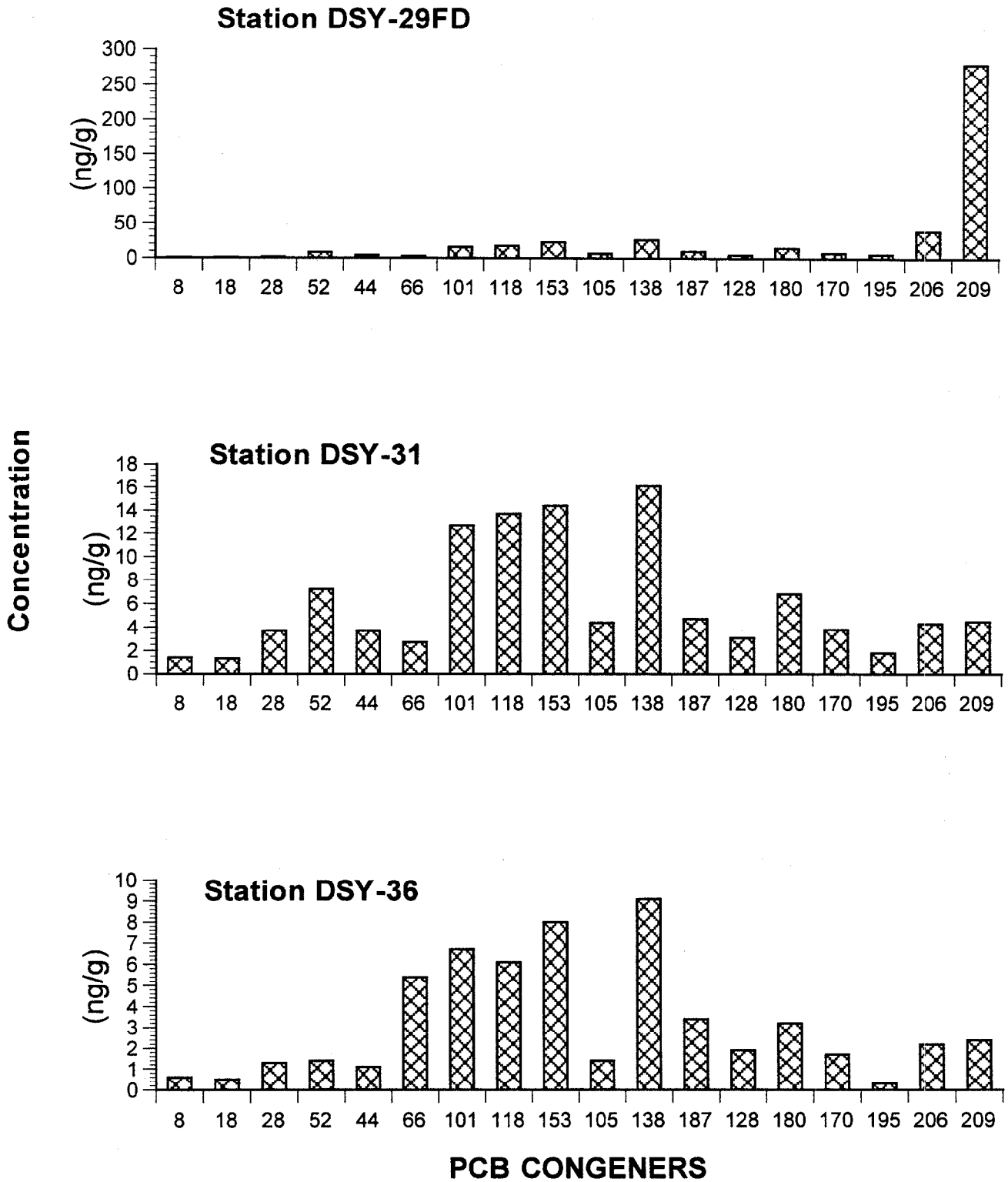


Figure 4.3-14. Concentration (ng/g dry weight sediment) of PCB congeners in surface sediments (0-18cm) from the Derecktor Shipyard/Coddington Cove study area.

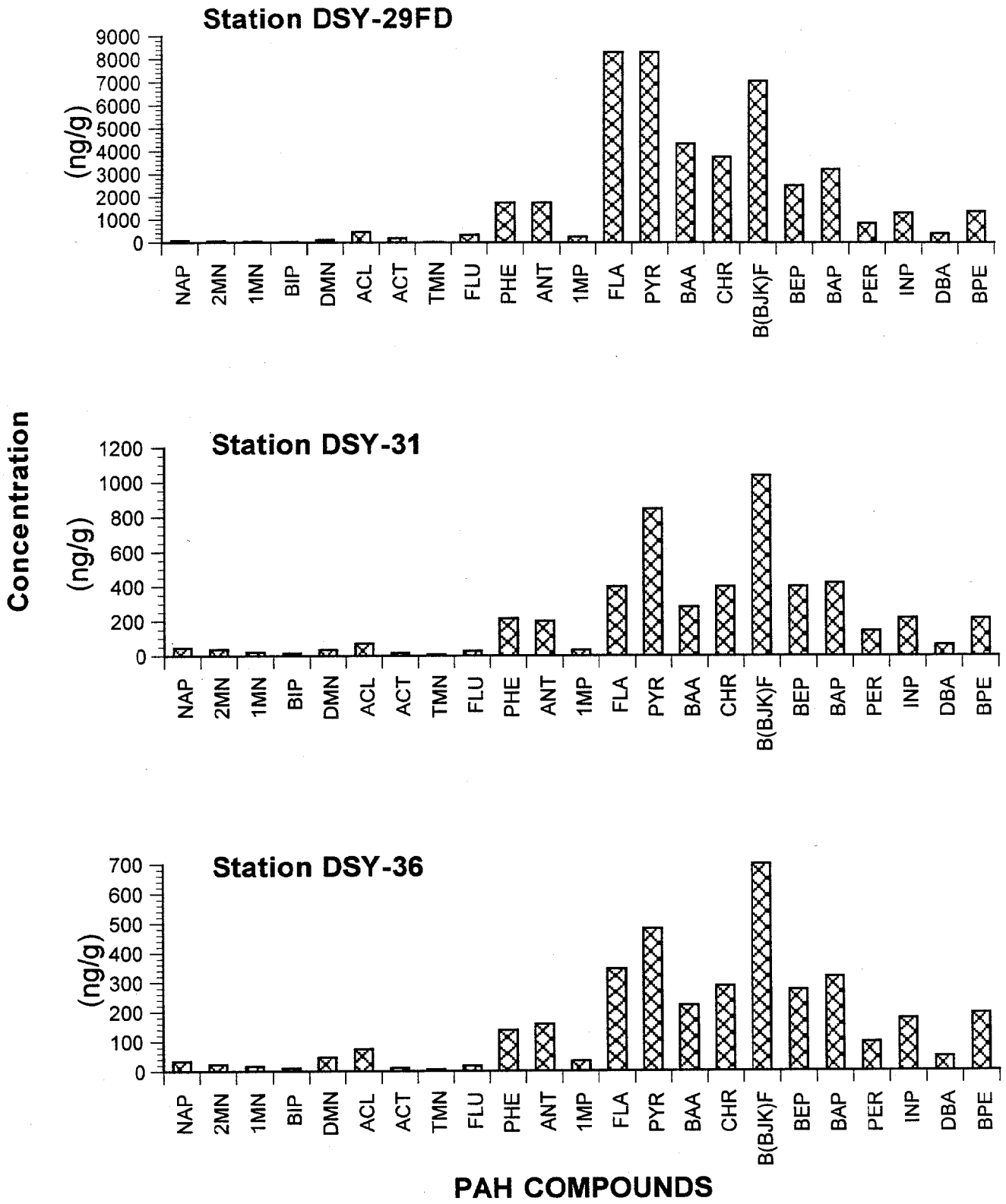


Figure 4.3-15A. Concentration (ng/g dry weight sediment) of PAH compounds in surface sediments (0-18cm) from the Derecktor Shipyard/Coddington Cove study area. See Figure 4.3-15B for explanation of PAH codes.

Figure 4.3-15B. Explanation of PAH codes for Figure 4.3-15A.

COMPGRP	Code	Analyte Name	CAS - NO.
PAH	1MN	1-Methylnaphthalene	90-12-0
PAH	1MP	1-Methylphenanthrene	832-69-9
PAH	2MN	2-Methylnaphthalene	91-57-6
PAH	ACL	Acenaphthylene	208-96-8
PAH	ACT	Acenaphthene	83-32-9
PAH	ANT	Anthracene	120-12-7
PAH	B(BJK)F	Benzo(k)fluoranthene	207-08-9
PAH	BAA	Benzo(a)anthracene	56-55-3
PAH	BAP	Benzo(a)pyrene	50-32-8
PAH	BEP	Benzo(e)pyrene	192-97-2
PAH	BIP	Biphenyl	92-52-4
PAH	BPE	Benzo(g,h,i)perylene	191-24-2
PAH	CHR	Chrysene	218-01-9
PAH	DBA	Dibenz(a h)anthracene	53-70-3
PAH	DMN	2,6-Dimethylnaphthalene	581-42-0
PAH	FLA	Fluoranthene	206-44-0
PAH	FLU	Fluorene	86-73-7
PAH	INP	Indeno(1,2,3-cd)pyrene	193-39-5
PAH	NAP	Naphthalene	91-20-3
PAH	PER	Perylene	198-55-0
PAH	PHE	Phenanthrene	85-01-8
PAH	PYR	Pyrene	129-00-0
PAH	TMN	1,6,7-Trimethylnaphthalene	2245-38-7

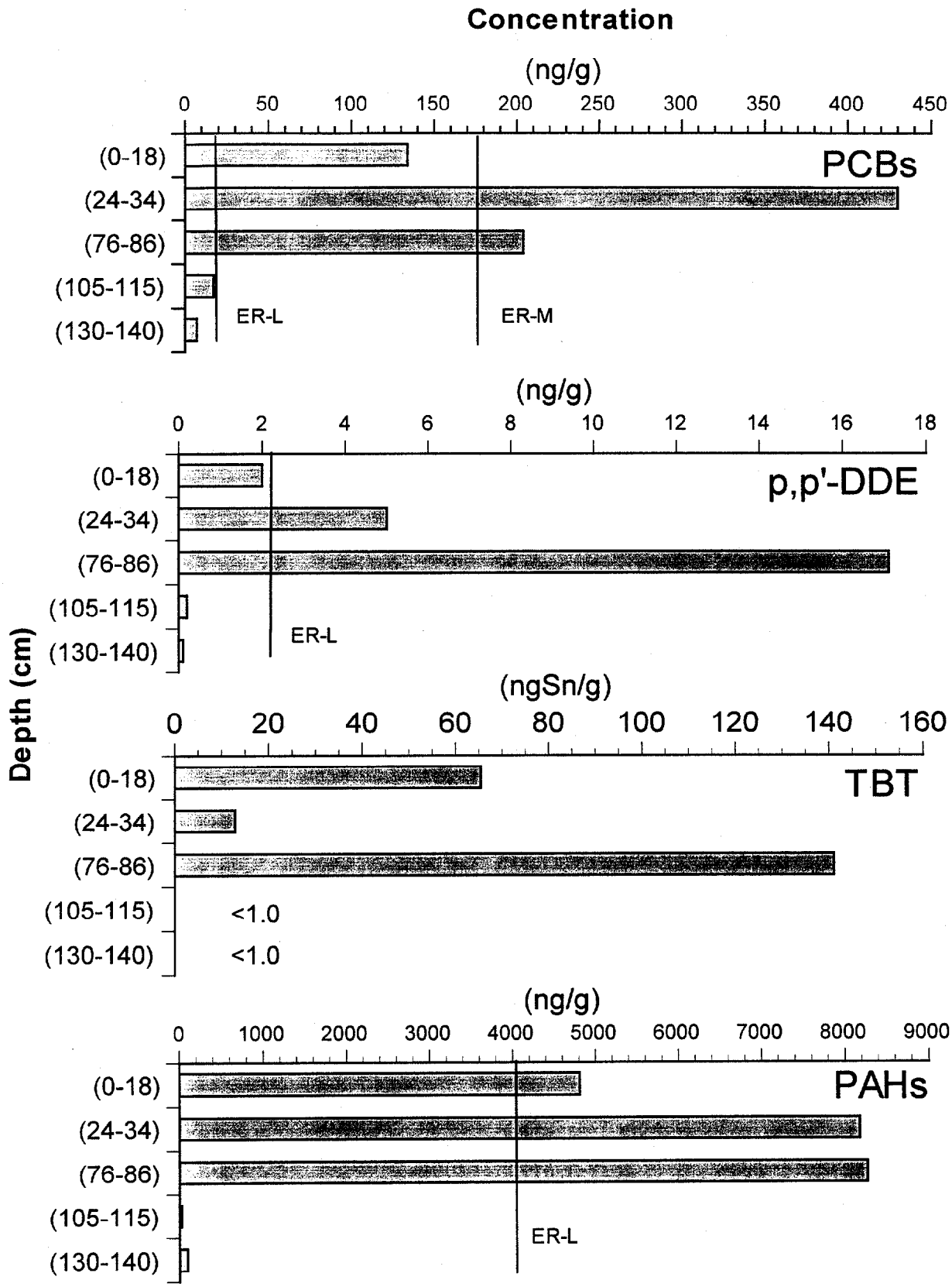


Figure 4.3-16. Concentration (ng/g dry weight sediment) of organic contaminants in Station DSY-28 sediment core from Derecktor Shipyard/ Coddington Cove. The vertical lines are the ER-L and ER-M guidelines (Long *et al.*, 1995).

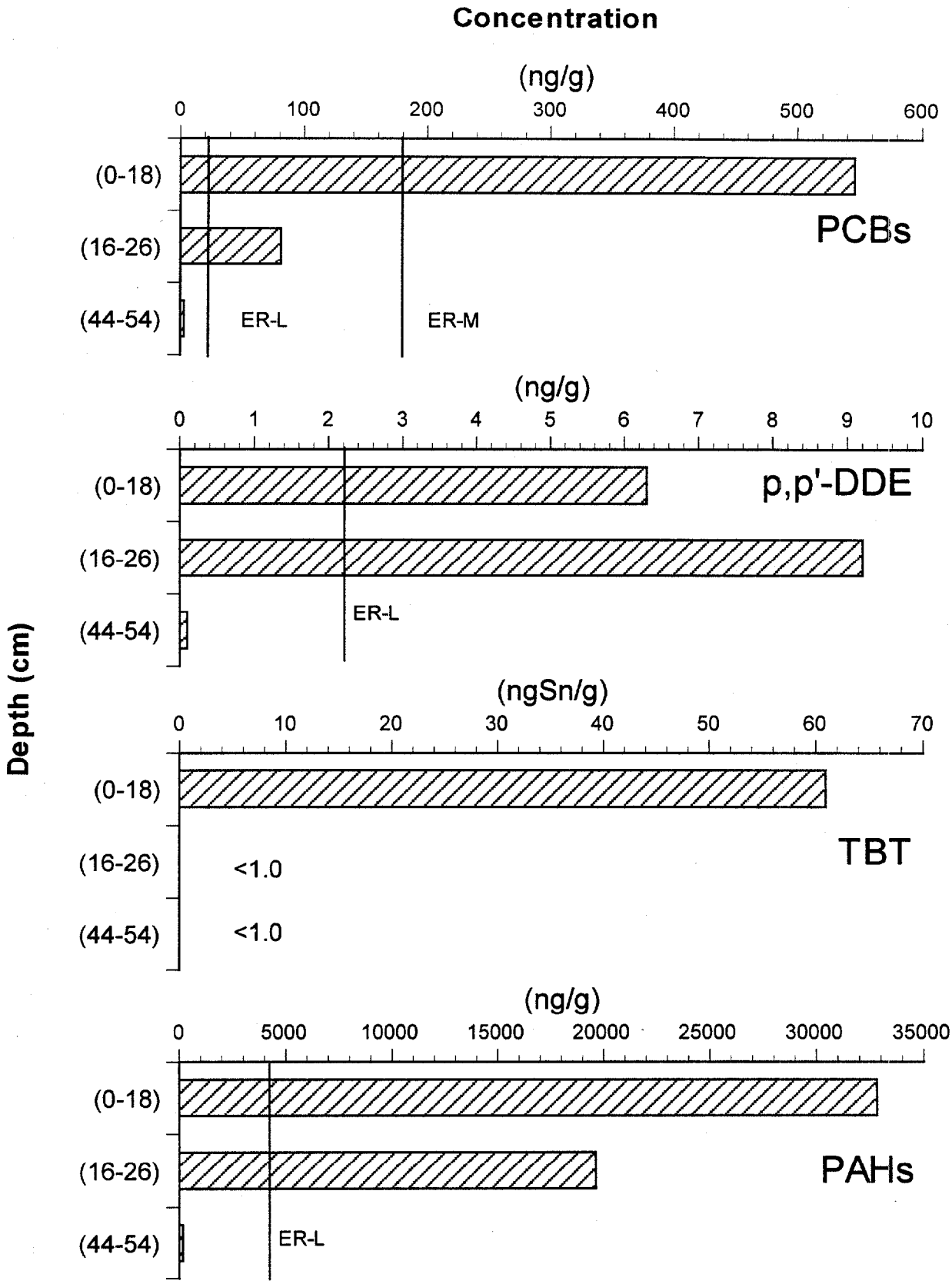


Figure 4.3-17. Concentration (ng/g dry weight sediment) of organic contaminants in Station DSY-29 sediment core from Derecktor Shipyard/ Coddington Cove. The vertical lines are the ER-L and ER-M guidelines (Long *et al.*, 1995).

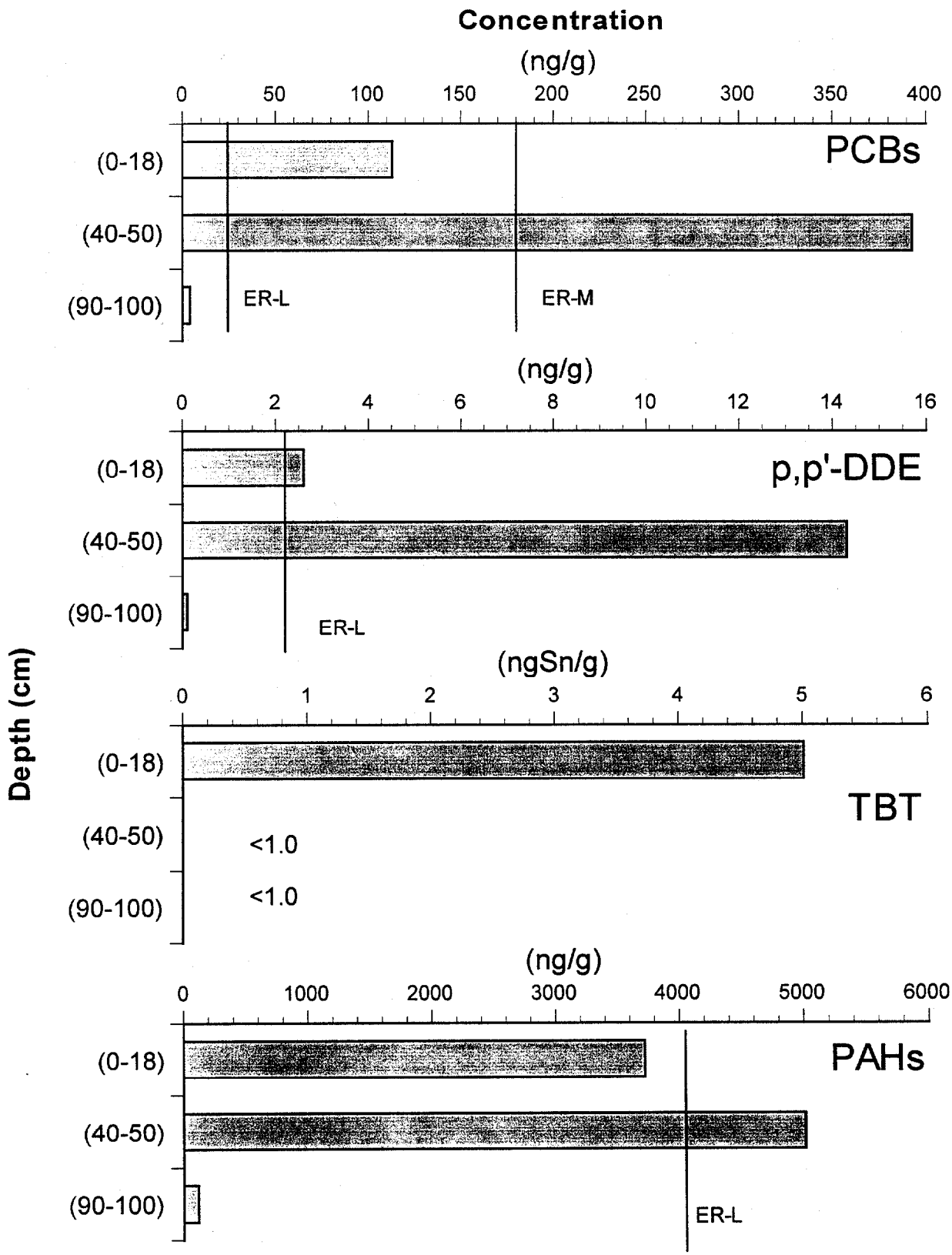


Figure 4.3-18. Concentration (ng/g dry weight sediment) of organic contaminants in Station DSY-36 sediment core from Derecktor Shipyard/ Coddington Cove. The vertical lines are the ER-L and ER-M guidelines (Long *et al.*, 1995).

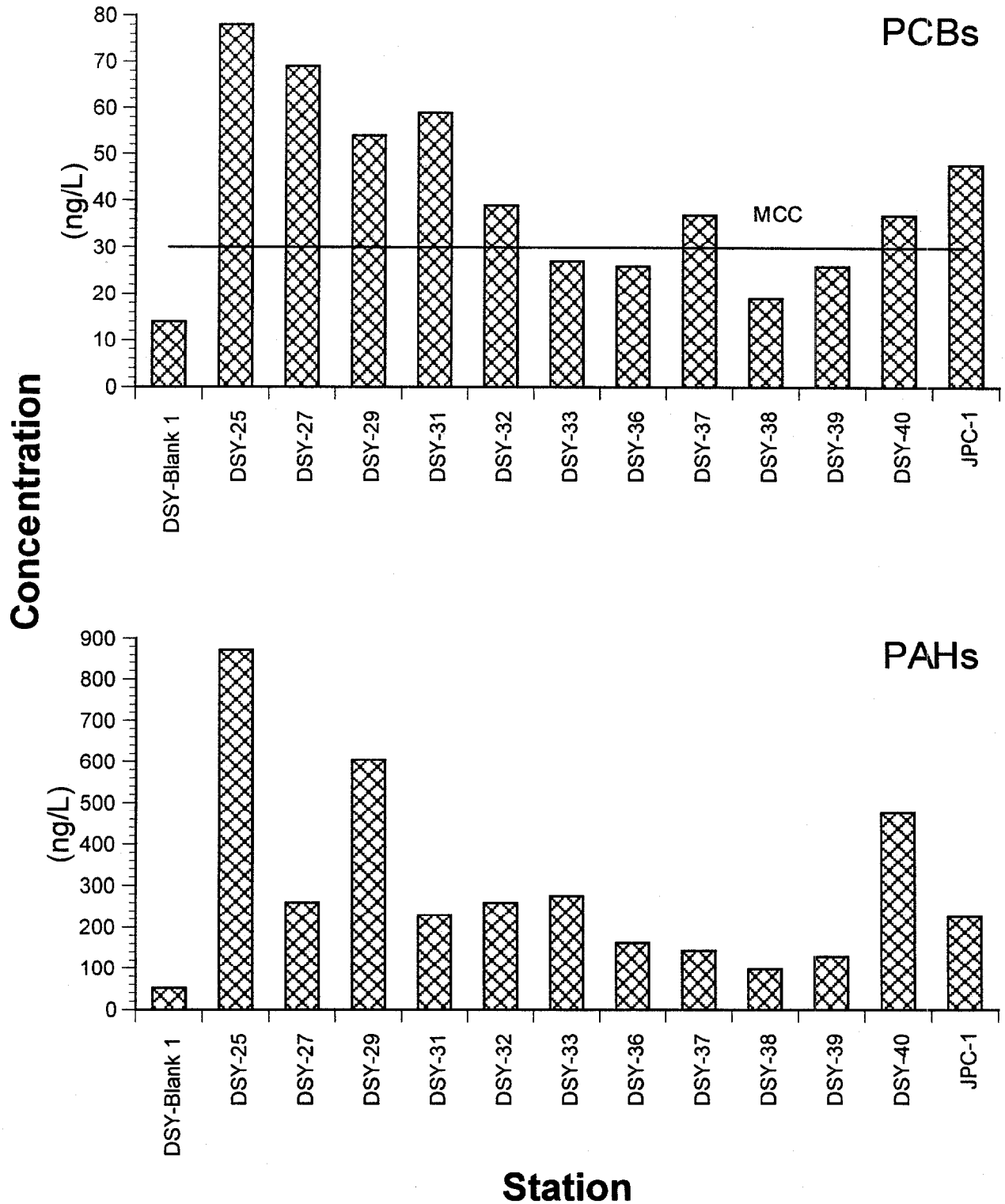
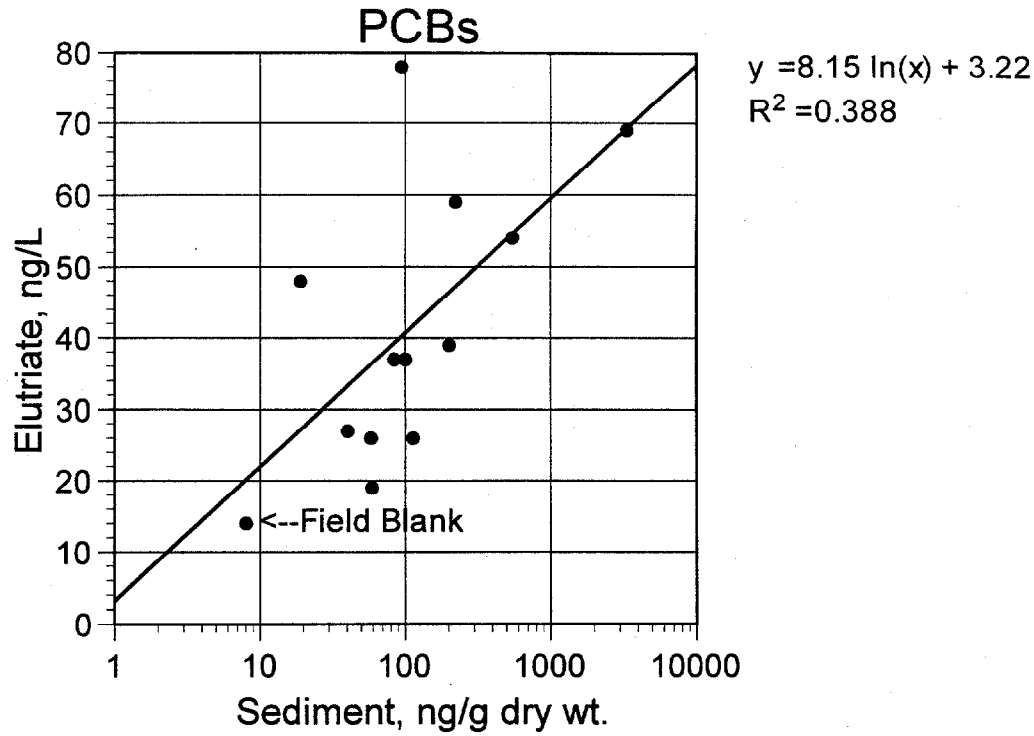


Figure 4.3-19. Concentration (ng/L elutriate) of organic contaminants in elutriate samples from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference location. MCC = marine chronic criteria of 30ng/L for total PCBs (U.S. EPA, 1992).



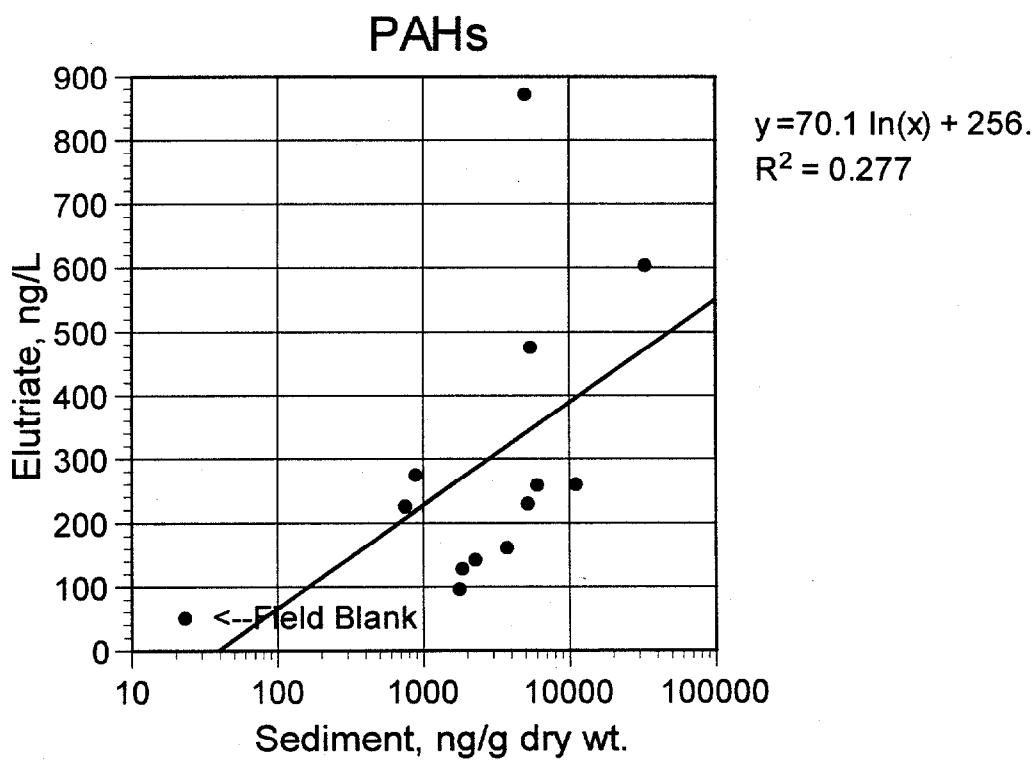


Figure 4.3-20. Plot of Total PCBs and Total PAHs in elutriate versus surface sediments (0-18cm) from twelve Derecktor Shipyard/ Coddington Cove study area stations and one field blank.

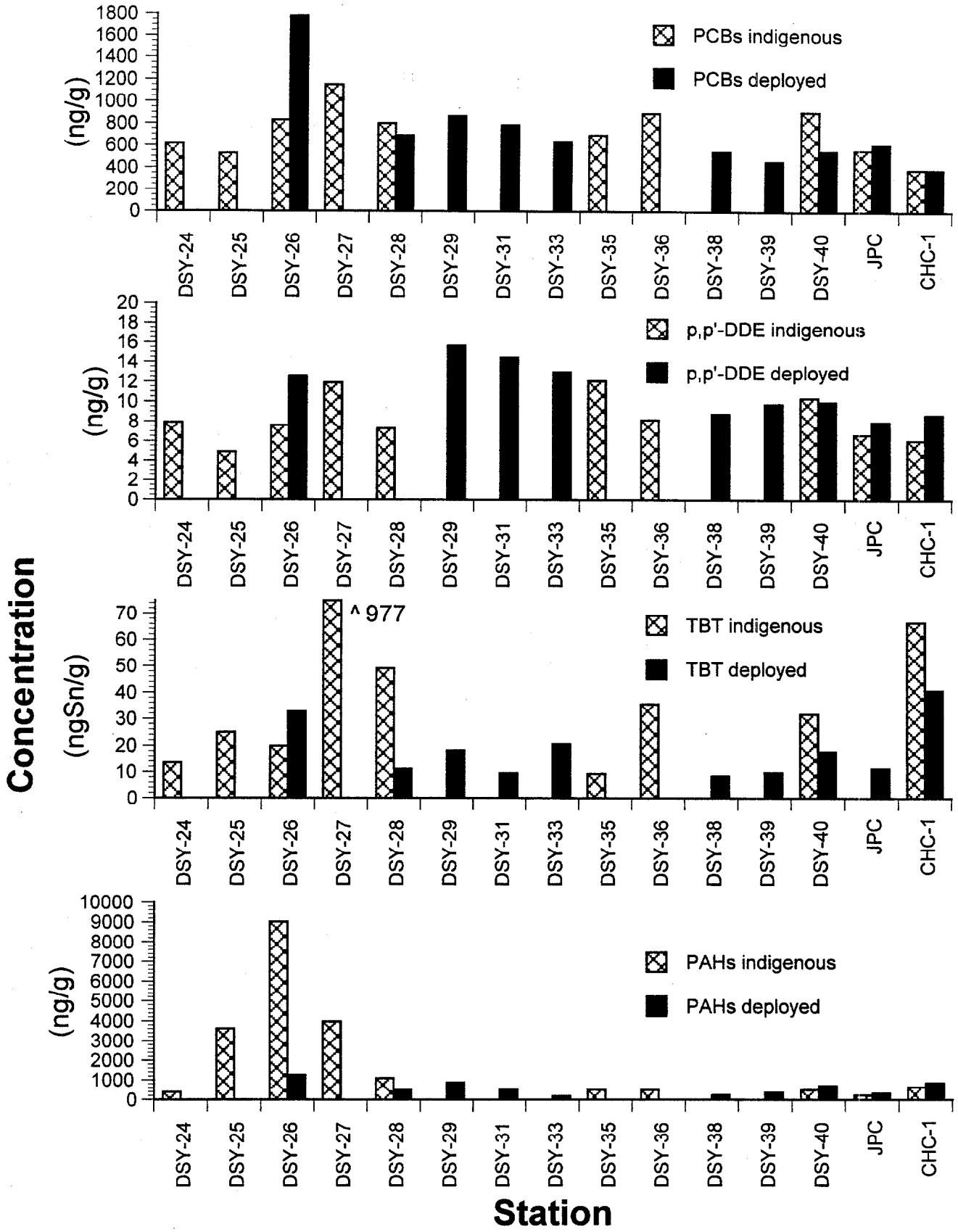


Figure 4.3-21. Concentration (ng/g dry weight tissue) of organic contaminants in indigenous and deployed blue mussels from the Derecktor Shipyard/ Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

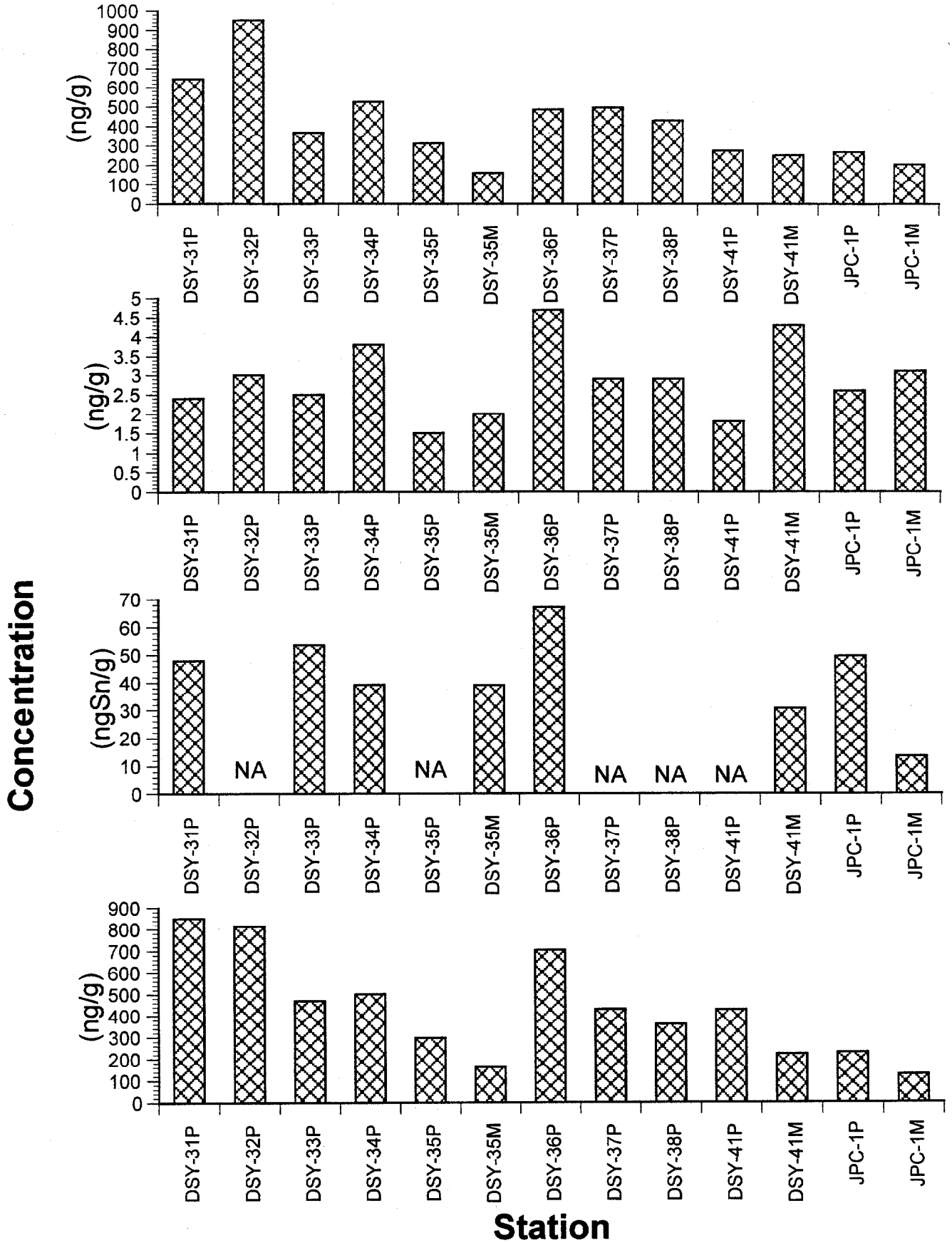


Figure 4.3-22. Concentration (ng/g dry weight tissue) of organic contaminants in tissue of hard clams (*Pitar morrhuana* (P) and *Mercenaria mercenaria* (M)) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations.

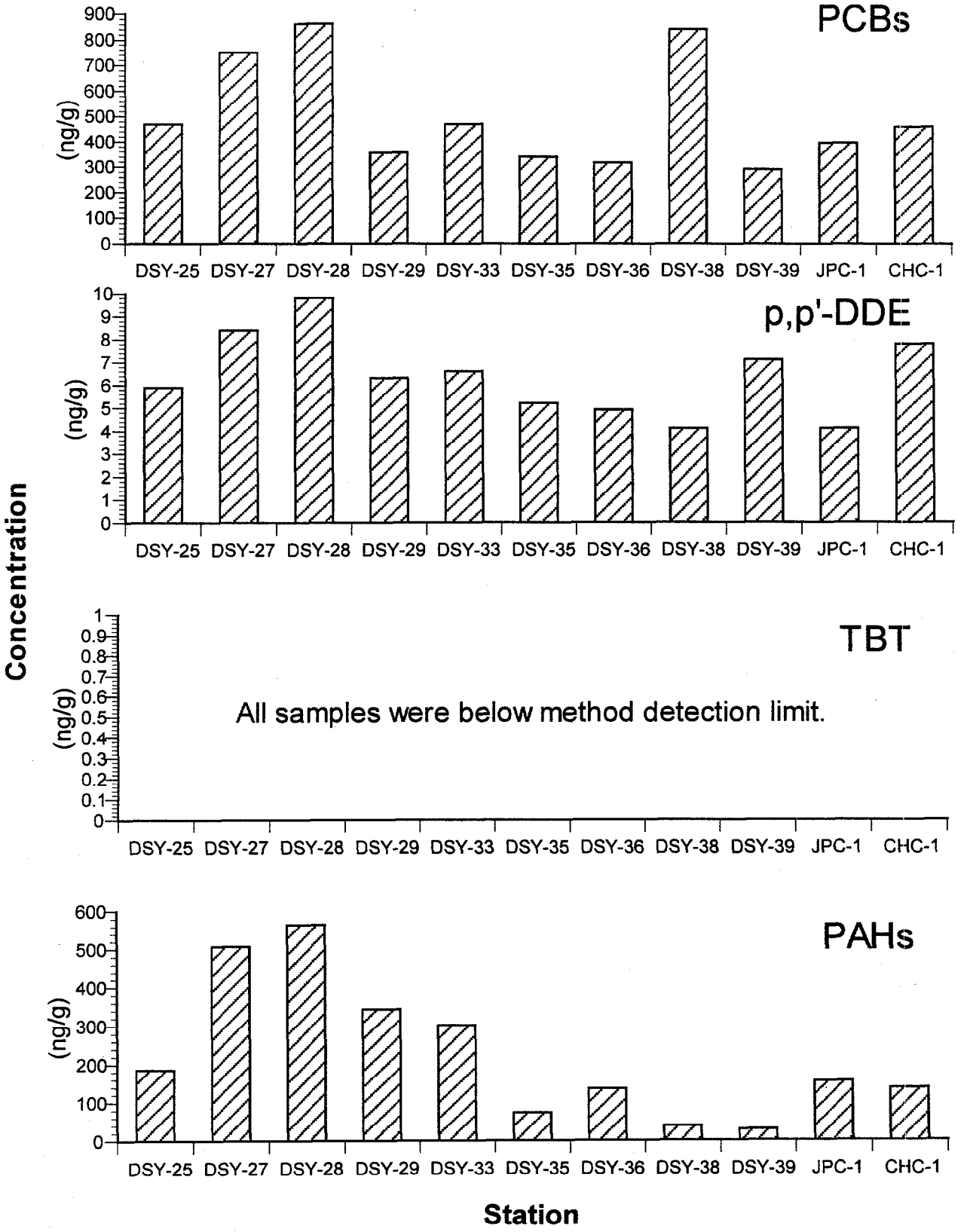


Figure 4.3-23. Concentration (ng/g dry weight tissue) of organic contaminants in lobster muscle tissue from the Derecktor Shipyard/ Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) locations stations.

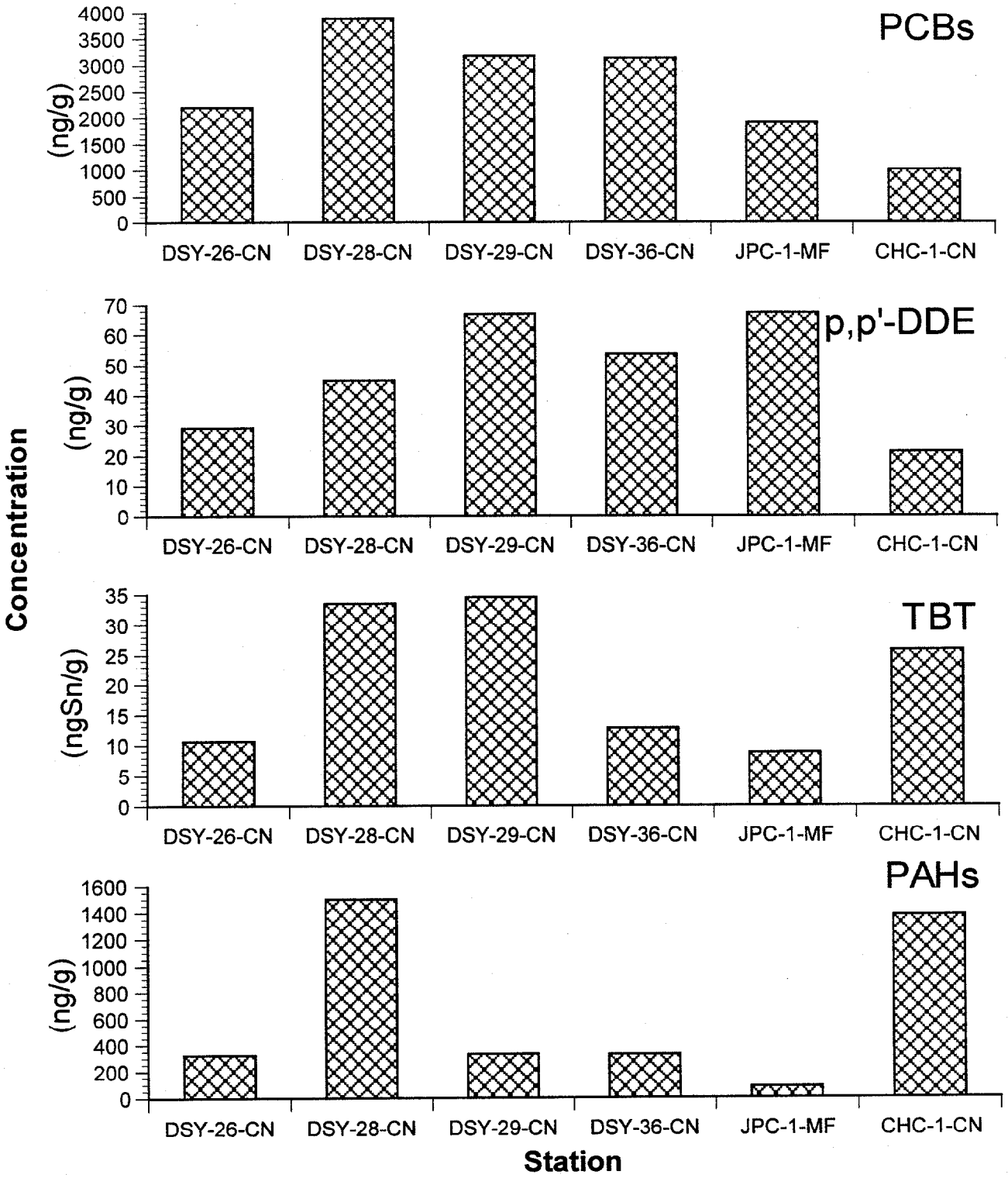


Figure 4.3-24. Concentration (ng/g dry weight tissue) of organic contaminants in fish (*Tautogolabrus adspersus* (CN) and *Fundulus heteroclitus* (MF)) tissue from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. (CN=Cunner; MF= Mummichogs.)

Table 4.2-1. Total Organic Carbon Content (TOC) of surface and core sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations.

	Surface		Mid-Depth		Bottom	
Station	Interval (cm)[1]	TOC (%)	Interval (cm)[1]	TOC (%)	Interval (cm)[1]	TOC (%)
DSY-25	0-12	1.79				
DSY-26	0-18	1.47				
DSY-27	0-17	3.73				
DSY-28	0-18	4.01	24-34	3.87	76-86	3.49
DSY-29	0-18	6.01	16-26	1.49	44-54	0.49
DSY-30	0-18	3.79	18-28	1.51	68-78	1.73
DSY-31	0-18	3.84	45-55	1.65	100-110	1.56
DSY-32	0-18	3.57				
DSY-33	0-14	1.66				
DSY-34	0-18	3.18	20-30	1.52	70-80	1.59
DSY-35	0-14	0.61				
DSY-36	0-18	3.55	40-50	4.50		
DSY-37	0-18	2.21				
DSY-38	0-18	3.08				
DSY-39	0-18	2.55				
DSY-40	0-14	1.48				
DSY-41	0-13	0.81				
DSY-V4			105-115	0.67	130-140	0.75
DSY-V9			10-20	3.72	39-45	1.00
JPC-1	0-14	1.06				
JPC-2	0-16	1.71				

[1]Sampling interval in the surface sample (collected by Van Veen grab) or core sample (V = vibracore).

Table 4.2-2. Abundance of blasting sand, rust, and paint chips in sediments from the Derecktor Shipyard/Coddington Cove study area.

Station	Depth (cm)	Abundant	Common	Rare	Absent
V1	0-1			X	
V1	3-4				X
V2	5-6				X
V3	3-4				X
V8	2.5-3.5				X
V10	0-1	X			
V10	4-5				X
V11	0-1	X			
V11	4-5				X
V11	7-8				X
V12	0-1		X		
V12	4.8-5.8				X
V13	0-1		X		
V13	5-6				X
V14	0-1			X	
V14	7-8				X
V15	0-1		X		
V15	2-3				X

Abundant: Greater than 25% of total sand-sized particles.
Common: 5 - 25% of total sand-sized particles.
Rare: Less than 5% of total sand-sized particles.
Absent: 0% of total sand-sized particles.

Table 4.2-3. Concentrations of three trace metals in sediments collected near Piers 1 and 2 of the NETC 1987-1988.

Study	Station	Sample Number	Trace Metals (ppm)		
			Cu	Pb	Zn
USACE, 1987 (Pier 1)	A	1815	926	320	537
	B	1816	183	86	288
	C	1817	145	103	261
	D	1818	146	76	303
	E	1819	339	212	496
	F	1820	3116	231	473
	G	1821	315	91	420
	H	1822	322	123	477
	I	1823	262	291	504
	J	1824	279	196	529
	K	1825	139	90	216
	L	1826	163	126	259
	M	1827	1188	502	630
	N	1828	684	654	617
	O	1829	87	304	528
	P	1830	148	146	522
	Q	1831	162	70	333
	R	1832	456	700	580
	S	1833	148	65	244
	T	1834	228	65	564
USACE, 1988 (Pier 2)	S1	2941	92	59	188
	S2	2942	83	57	158
	S3	2943	115	64	208
	S4	2944	881	1250	2780
	S5	2945	77	69	199
	S6	2946	174	69	237
	S7	2947	75	60	176
	S8	2948	273	289	725
	S9	2949	42	52	172
	S10	2950	77	66	159
	S12	2951	66	56	167

See Figure 4.2-8 for station locations.

Table 4.2-4. Summary of water quality measurements for the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.[1]

Station	DO (mg/L)		Total Ammonia (mg/L)		Un-Ionized Ammonia (mg/L)		Chlorophyll a (ug/L)		TSS (mg/L)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
DSY-26	7.80	0.44	0.07	0.06	0.002	0.001	1.49	1.77	27.64	10.53
DSY-28	7.65	0.53	0.06	0.03	0.002	0.001	1.00	0.98	17.15	11.84
DSY-29	8.48	0.23	0.03	0.03	0.000	0.001	1.71	2.96	21.46	12.72
DSY-31	7.70	0.33	0.05	0.02	0.001	0.001	0.83	1.44	23.00	13.80
DSY-33	7.82	0.28	0.06	0.04	0.002	0.001	1.74	1.61	19.23	6.40
DSY-37	7.22	0.31	0.04	0.04	0.001	0.001	0.70	0.60	25.09	15.66
DSY-38	7.58	0.50	0.04	0.04	0.001	0.001	0.79	0.70	29.27	7.72
DSY-40	8.37	0.20	0.06	0.08	0.001	0.002	1.47	1.76	27.39	9.54
CHC-1	7.62	0.63	0.01	0.02	0.000	0.001	0.35	0.61	19.27	3.53
JPC-1	7.70	0.39	0.03	0.03	0.000	0.000	0.78	0.80	17.56	3.66

[1]Samples were collected on 10/4/95, 10/25/95, and 11/10/95.
DO = Dissolved Oxygen
TSS = Total Suspended Solids
SD = Standard Deviation

Table 4.2-5. Summary of sediment oxygen demand (SOD) measurements for the Derecktor Shipyard/Coddington Cove (DSY) study area.

Sample ID	Calculated SOD ($g/m^2/day$)[1]	Coefficient of Variation[2]	Normalized SOD[3]
DSY-26	0.21	23.50	0.65
DSY-27	0.25	11.60	0.77
DSY-30	0.17	23.00	0.53
DSY-31	0.18	16.00	0.55
DSY-32	0.17	14.30	0.54
DSY-33	0.15	17.10	0.47
DSY-34a	0.27	11.60	0.86
DSY-34b	0.17	17.30	0.53
DSY-40	0.19	20.60	0.59
Mean	0.20	17.20	0.55

1 - Calculated SOD = [Water-only uptake] - [sediment-water uptake]. Temperature = 20°C.
2 - Mean responses of 6 replicate pairs.
3 - Calculated SOD was normalized using the formula: $SOD_{20C}+SOD@T/1.06^{(T-20)}$.

Table 4.3-1. Concentration (µg/g) of metals in surface and core sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference locations.

Surface Samples

Station	DSY-25	DSY-26	DSY-27	DSY-28	DSY-29	DSY-29*	DSY-30	DSY-31	DSY-32	DSY-33	DSY-34	DSY-35	DSY-36	DSY-37	DSY-38	DSY-39	DSY-40	DSY-41	JPC-1	JPC-2
Depth (cm)	0-12	0-18	0-17	0-18	0-18	0-18	0-18	0-18	0-18	0-14	0-18	0-14	0-18	0-18	0-18	0-18	0-14	0-13	0-14	0-16
Aluminum	21201	23629	43768	41308	37148	38108	37525	38455	34225	23360	32958	19687	38025	27560	37845	34008	25730	26763	27475	30460
Arsenic	6.4	9.4	11.6	8.7	12.5	12.3	10.3	10.2	10.9	7.4	9.7	3.4	11.2	7.4	8.9	7.6	6.8	11.4	2.6	4.8
Cadmium	0.3	0.2	1.0	0.6	1.5	2.2	1.2	0.8	0.7	0.2	0.3	0.1	0.4	0.3	0.3	0.2	0.5	0.2	0.3	0.2
Chromium	55.0	53.5	103.0	80.5	86.5	88.0	79.3	76.8	84.8	46.5	64.3	24.3	83.3	56.5	66.0	56.5	44.5	36.8	36.5	49.0
Copper	23.5	39.3	166.3	71.8	157.8	165.0	81.3	80.8	66.8	17.3	33.5	<3.75(U)	54.0	27.0	28.0	20.0	29.8	9.3	7.0	13.8
Iron	23831	23354	34533	29155	35453	36348	27418	28335	26545	21406	25630	12660	28620	20072	26180	21418	20511	17739	18092	18617
Lead	35.9	40.4	150.7	77.7	185.9	172.5	80.0	81.0	124.8	40.0	47.6	14.0	78.8	56.9	62.2	54.0	42.1	17.0	29.7	53.2
Manganese	268.5	148.5	346.5	302.5	282.3	289.8	276.5	307.5	293.5	133.5	280.0	90.3	312.8	265.0	333.8	285.3	116.5	106.0	293.5	284.3
Mercury	0.1	0.1	0.6	0.3	0.5	0.5	0.5	0.4	0.4	0.1	0.2	0.1	0.4	0.3	0.3	0.1	0.2	0.03(B)	0.2	0.1
Nickel	21.0	20.5	43.5	24.3	34.8	36.0	27.3	24.8	25.8	18.3	20.5	<10.0(B)	25.8	16.8	22.0	17.8	17.3	14.5	14.3	14.0
Silver	0.3	0.2	0.7	0.5	0.8	1.0	0.7	0.5	0.8	0.2	0.3	<0.13(B)	0.6	0.4	0.2	0.3	0.2	0.13(B)	0.1	0.3
Zinc	110.0	101.5	547.3	169.3	392.8	403.3	192.8	167.0	201.3	72.3	105.5	28.5	144.3	93.5	109.0	97.3	100.3	47.3	58.0	79.3

Core Samples

Station	DSY-28	DSY-28	DSY-29	DSY-29	DSY-30	DSY-30	DSY-31	DSY-31	DSY-34	DSY-34	DSY-36	DSY-36	DSY-V4	DSY-V4	DSY-V9	DSY-V9
Depth (cm)	24-34	76-86	16-26	44-54	18-28	68-78	45-55	100-110	20-30	70-80	40-50	90-100	105-115	130-140	10-20	39-45
Aluminum	30315	38435	17663	18495	26628	23277	27678	34225	32773	24773	31103	16196	29659	17498	18218	18200
Arsenic	9.5	9.7	5.6	3.0	5.5	6.1	9.0	5.5	6.8	7.4	7.8	4.1	4.9	8.6	10.3	11.4
Cadmium	0.9	0.9	0.8	0.1	0.2	0.3	0.5	0.1	0.2	0.1	0.9	0.1	0.1	0.1	1.2	0.1
Chromium	112.8	107.8	56.0	31.3	49.8	42.0	56.5	38.8	48.0	54.5	110.5	30.5	108.0	44.0	50.8	29.8
Copper	179.5	132.5	60.0	<3.75(B)	9.8	<3.75(B)	36.8	<3.75(B)	<3.75(B)	4.3	104.5	<3.75(B)	168.0	18.3	1.5	2.5
Iron	32305	35298	22019	16446	21970	21069	24123	17772	21320	23520	28668	13836	30379	33278	15478	17196
Lead	148.4	192.6	87.1	19.0	34.9	21.7	52.7	29.9	24.5	25.7	112.5	33.5	16.1	12.8	182.0	15.5
Manganese	331.5	338.0	137.0	113.0	140.8	214.0	219.8	253.5	294.3	312.0	317.3	132.3	268.3	343.3	193.5	189.0
Mercury	0.4	1.1	0.6	ND	0.1	<0.03	0.3	0.1	<0.03	<0.03	0.8	<0.03	0.9	<0.03(U)	<0.03(U)	<0.03(U)
Nickel	77.8	45.5	23.3	15.3	16.8	13.5	21.8	12.5	17.0	21.5	30.8	<10.0	37.3	30.8	13.0	15.5
Silver	1.0	1.0	0.6	<0.13(B)	0.1	<0.13(B)	0.6	<0.13(B)	<0.13(B)	<0.13(B)	1.5	<0.13(B)	0.2	0.2	1.8	0.2
Zinc	455.0	327.8	130.5	34.5	64.5	48.5	122.8	36.0	47.0	55.5	213.8	35.5	466.5	71.3	29.8	36.0

ND = non-detect, * = field duplicate, "<" = concentrations below the Method Limit of Quantitation (MLQ).
Data qualification scheme is based on "Data Qualifiers for Inorganic Analytical Data, Laboratory Qualifiers" as described in SAIC QA Technical Procedure No TP-DM-300-7.
(U) - Indicates that the analyte was analyzed for but not detected.
(B) - Indicates that the reported value was obtained from a reading that was less than the Contract Required Detection Limit, but greater than or equal to the Instrument Detection Limit.

Table 4.3.2. Metal Enrichment Factors for surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference location.

	Metal Enrichment Factor[1,2] (unitless)										
Station	Arsenic	Cadmium	Chromiu	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Zinc
DSY-25	**1.3**	3.0	**1.6**	**1.9**	**1.8**	**1.1**	**1.5**	**1.4**	**1.9**	**1.6**	**1.8**
DSY-26	**1.8**	**1.4**	**1.4**	**2.8**	**1.6**	**1.1**	0.7	**1.3**	**1.7**	1.0	**1.5**
DSY-27	**1.2**	4.4	**1.4**	6.5	**1.3**	**2.2**	0.9	3.0	**1.9**	**2.0**	4.4
DSY-28	0.9	**2.5**	**1.2**	**3.0**	**1.1**	**1.2**	0.9	**1.7**	**1.1**	**1.6**	**1.4**
DSY-29	**1.5**	7.4	**1.4**	7.2	**1.5**	3.2	0.9	3.1	**1.8**	**2.7**	3.7
DSY-30	**1.2**	6.0	**1.3**	3.7	**1.2**	**1.3**	0.9	**2.8**	**1.4**	**2.5**	**1.8**
DSY-31	**1.2**	3.7	**1.2**	3.6	**1.2**	**1.3**	1.0	**2.3**	**1.2**	**1.7**	**1.5**
DSY-32	**1.4**	4.0	**1.5**	3.3	**1.2**	**2.3**	1.0	**2.5**	**1.4**	3.1	**2.1**
DSY-33	**1.4**	**1.5**	**1.2**	**1.3**	**1.5**	**1.1**	0.7	**1.2**	**1.5**	**1.3**	**1.1**
DSY-34	**1.3**	**1.8**	**1.2**	**1.7**	**1.2**	0.9	1.0	**1.1**	**1.2**	**1.1**	**1.1**
DSY-35	0.8	0.9	0.7	0.2	1.0	0.4	0.5	0.8	0.5	0.4	0.5
DSY-36	**1.3**	**2.0**	**1.3**	**2.4**	**1.2**	**1.3**	1.0	**2.2**	**1.3**	**1.9**	**1.3**
DSY-37	**1.2**	**2.2**	**1.2**	**1.7**	**1.2**	**1.3**	**1.1**	**2.3**	**1.2**	**1.8**	**1.2**
DSY-38	**1.1**	**1.2**	1.0	**1.3**	**1.1**	1.0	**1.1**	**1.6**	**1.1**	0.6	1.0
DSY-39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DSY-40	**1.2**	3.7	1.0	**2.0**	**1.3**	1.0	0.5	**1.7**	**1.3**	**1.1**	**1.4**
DSY-41	**1.9**	**1.3**	0.8	0.6	**1.1**	**0.4**	0.5	0.1	1.0	0.3	0.6
JPC-1	0.4	**2.0**	0.8	0.4	1.0	**0.7**	**1.3**	**2.0**	1.0	0.6	0.7
JPC-2	0.7	**1.1**	1.0	0.8	1.0	**1.1**	**1.1**	0.8	0.9	**1.1**	0.9
Maximum	1.9	7.4	1.6	7.2	1.8	3.2	1.5	3.1	1.9	3.1	4.4

1 - MEF = Aluminum-normalized sediment metal concentration ratios at each station.
Benchmark = Station DSY-39 aluminum-normalized sediment metal concentration.

2 - Bold/underlined values = MEF > 1; bordered cells = MEF > 3; shaded cells = MEF>5.

Table 4.3-3. Metal concentrations (µg/L) in elutriate samples from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference location.

Station	DSY-Blank	DSY-25	DSY-31	DSY-32	DSY-33	DSY-36	DSY-37	DSY-38	DSY-39	DSY-40	JPC-1
Aluminum	<40(B)	178	58	208	45	51	<40(B)	<40(B)	59	<40(B)	60
Arsenic	<5.0(U)	12.4	27.2	24.8	<5.0(U)	40.4	19.6	40.7	76.0	30.0	18.3
Cadmium	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)	<0.2(U)
Chromium	<0.8(U)	<0.8(B)	<0.8(B)	<0.8(B)	<0.8(U)	<0.8(U)	<0.8(U)	<0.8(U)	<0.8(B)	<0.8(U)	<0.8(U)
Copper	<2.5(U)	<2.5(B)	5.1	<2.5(U)	<2.5(U)	<2.5(B)	<2.5(B)	<2.5(U)	<2.5(U)	<2.5(U)	<2.5(B)
Iron	<60(U)	140	<60(B)	88	334	<60(U)	387	223	310	<60(U)	<60(U)
Lead	<2.9(U)	9.4	8.5	9.4	15.9	8.3	12.9	10.7	14.6	9.0	13.2
Manganese	<8(U)	187	83	163	1213	242	1126	935	2284	87	465
Mercury	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)	<0.1(U)
Nickel	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)	<8.0(B)
Silver	<0.5(B)	<0.5(B)	<0.5(B)	<0.5(B)	<0.5(B)	<0.5(U)	<0.5(B)	<0.5(U)	<0.5(B)	<0.5(U)	<0.5(U)
Zinc	<9(B)	<9(B)	<9(B)	<9(B)	<9(U)	<9(B)	<9(B)	<9(B)	<9(B)	<9(U)	<9(B)

µg/L = micrograms per liter.
"<" designate concentrations below the Limit of Quantitative Detection (LQD).

Data qualification scheme is based on "Data Qualifiers for Inorganic Analytical Data, Laboratory Qualifiers" as described in SAIC QA Technical Procedure No TP-DM-300-7.
(U) - Indicates that the analyte was analyzed for but not detected.
(B) - Indicates that the reported value was obtained from a reading that was less than the Limit of Quantitative Detection Limit, but greater than or equal to the Instrument Detection Limit.

Table 4.3-4. Concentration of organic contaminants in surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference location.

Chemical	Sediment Contaminant Concentration																		
Station	DSY-25	DSY-26	DSY-27	DSY-28	DSY-29	DSY-29FD	DSY-30	DSY-31	DSY-32	DSY-33	DSY-34	DSY-35	DSY-36	DSY-37	DSY-38	DSY-39	DSY-40	DSY-41	JPC-1
Depth (cm)	0-12	0-18	0-17	0-18	0-18	0-18	0-18	0-18	0-18	0-14	0-18	0-14	0-18	0-18	0-18	0-18	0-14	0-13	0-14
A. Sediment Concentration																			
Total PCBs (ng/g)	93.6	98.2	3,310	134	546	936	315	221	201	39.9	64.6	6.7	113	99.9	59.3	58.2	84.1	13.8	18.9
p,p'-DDE (ng/g)	0.9	0.6	7.0	2.0	6.3	6.4	4.4	1.9	2.4	0.4	1.0	0.1	2.6	1.4	1.3	0.7	1.1	0.1	0.3
TBT (ng Sn/g)	0.7	2.3	8.5	65.4	60.9	66.2	6.9	228	4.3	<1.0	4.1	<1.0	5.0	<1.0	<1.0	<1.0	4.2	<1.0	0.3
Total PAHs (ng/g)	4,940	5,800	11,000	4,810	32,800	46,400	11,800	5,150	5,980	879	1,930	61.7	3,720	2,250	1,750	1,830	5,390	291	746
Organic Carbon (mg/g	18.0	15.0	37.0	40.0	61.0	59.0	38.0	38.0	36.0	17.0	32.0	6.0	35.0	22.0	31.0	26.0	15.0	8.0	11.0
B. TOC-Normalized Concentration																			
Total PCBs (ng/g)	5.2	6.5	89.5	3.3	9.0	15.9	8.3	5.8	5.6	2.3	2.0	1.1	3.2	4.5	1.9	2.2	5.6	1.7	1.7
p,p'-DDE (ng/g)	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
TBT (ng Sn/g)	0.0	0.2	0.2	1.6	1.0	1.1	0.2	6.0	0.1	ND	0.1	ND	0.1	ND	ND	ND	0.3	ND	0.0
Total PAHs (ng/g)	274	387	297	120	538	786	311	136	166	51.7	60.3	10.3	106	102	56.5	70.4	359	36.4	67.8

FD = field duplicate; TOC = total organic carbon.
Total PCBs = sum of polychlorinated biphenyls; TBT = tributyltin; Total PAHs = sum of polycyclic aromatic hydrocarbons; ND = non-detect.

Table 4.3-5. Concentration of organic contaminants in surface and core sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area.

Chemical	Sediment Contaminant Concentration										
	DSY-27			DSY-28					DSY-29		
	Depth (cm)			Depth (cm)					Depth (cm)		
	0-17[1]	10-20[2]	39-45[3]	0-18[1]	24-34[2]	76-86[2]	105-115[3]	130-140[3]	0-18[1]	16-26[2]	44-54[2]
A. Sediment Concentration											
Total PCBs (ng/g)	3,310	1,380	91.3	134	430	204	16.8	7.4	546	81.0	3.0
p,p'-DDE (ng/g)	7.0	9.6	0.5	2.0	5.0	17.1	0.2	0.1	6.3	9.2	0.1
TBT (ng Sn/g)	8.5	7.3	<1.0	65.4	12.9	141	<1.0	<1.0	60.9	<1.0	<1.0
Total PAHs (ng/g)	11,000	34,700	3,300	4,810	8,170	8,260	25.0	96.0	32,800	19,600	157
Organic Carbon (mg/g)	37.0	37.0	10.0	40.0	39.0	35.0	7.0	7.0	61.0	15.0	5.0
B. TOC-Normalized Concentration											
Total PCBs (ng/mg TOC)	89.5	37.3	9.1	3.3	11.0	5.8	2.4	1.1	9.0	5.4	0.6
p,p'-DDE (ng/mg TOC)	0.2	0.3	0.1	0.1	0.1	0.5	0.0	0.0	0.1	0.6	0.0
TBT (ng Sn/mg TOC)	0.2	0.2	NC	1.6	0.3	4.0	NC	NC	1.0	NC	NC
Total PAHs (ng/mg TOC)	297	938	330	120	209	1,830	3.6	13.7	538	1,307	31.4

1 - surface sample.
2 - piston core sample.
3 - vibracore sample.

Total PCBs = sum of polychlorinated biphenyls; TBT = tributyltin;
Total PAHs = sum of polycyclic aromatic hydrocarbons; NC = not calculated.
TOC = Total Organic Carbon.

Table 4.3-5. (continued). Concentration of organic contaminants in surface and core sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area.

Chemical	Sediment Contaminant Concentration											
	DSY-30			DSY-31			DSY-34			DSY-36		
	Depth (cm)			Depth (cm)			Depth (cm)			Depth (cm)		
	0-18[1]	18-28[2]	68-78[2]	0-18[1]	45-55[2]	100-110[2]	0-18[1]	20-30[2]	70-80[2]	0-18[1]	40-50[2]	90-100[2]
A. Sediment Concentration												
Total PCBs (ng/g)	315	13.0	5.3	221	147	3.2	64.6	20.9	5.0	113	393	4.1
p,p'-DDE (ng/g)	4.4	0.6	0.2	1.9	4.9	0.2	1.0	0.2	0.2	2.6	14.3	0.1
TBT (ng Sn/g)	6.9	<1.0	<1.0	228	<1.0	<1.0	4.1	<1.0	<1.0	5.0	<1.0	<1.0
Total PAHs (ng/g)	11,800	1,710	37.9	5,150	1,640	39.0	1,930	299	41.0	3,720	5,010	118
Organic Carbon (mg/g)	38.0	15.0	17.0	38.0	17.0	16.0	32.0	15.0	16.0	35.0	45.0	9.0
B. TOC-Normalized Concentration												
Total PCBs (ng/mg TOC)	8.3	0.9	0.3	5.8	8.6	0.2	2.0	1.4	0.3	3.2	8.7	0.5
p,p'-DDE (ng/mg TOC)	0.1	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.1	0.3	0.0
TBT (ng Sn/mg TOC)	0.2	NC	NC	6.0	NC	NC	0.1	NC	NC	0.1	NC	NC
Total PAHs (ng/mg TOC)	311	114	2.2	135.5	96.5	2.4	60.3	19.9	2.6	106	111	13.1

1 - surface sample.
2 - piston core sample.
3 - vibracore sample.

Total PCBs = sum of polychlorinated biphenyls; TBT = tributyltin;
Total PAHs = sum of polycyclic aromatic hydrocarbons; NC = not calculated.
TOC = Total Organic Carbon.

Table 4.3-6. Concentration of organic contaminants in elutriate samples from the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference location[1].

	Elutriate Contaminant Concentration												
Contaminant	DSY Blank 1	DSY-25	DSY-27	DSY-29	DSY-31	DSY-32	DSY-33	DSY-36	DSY-37	DSY-38	DSY-39	DSY-40	JPC -1
Total PCBs (ng/L)	14.3	77.8	69.4	54.3	58.8	39.1	26.6	26.3	37.4	19.2	25.9	36.7	48.4
p,p'-DDE (ng/L)	<2.3(U)	0.42(J)	0.42(J)	0.63(J)	0.64(J)	0.30(J)	0.31(J)	0.39(J)	0.71(J)	0.25(J)	0.61(J)	0.59(J)	1.01(J)
TBT (ng Sn/L)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)	<5.0(U)
Total PAHs (ng/L)	51.0	872	260	604	230	259	275	162	143	97.3	129	476	226

DSY Blank 1 = field blank.
Total PCBs = sum of polychlorinated biphenyls; TBT = tributyltin; Total PAHs = sum of polycyclic aromatic hydrocarbons.
Non detected values are listed as < Method Detection Limit (MDL).
1 - Elutriates taken from surface sediments (0-18 cm).
(U) - Indicates that the analyte was analyzed for but not detected.
(J) - Indicates that the reported value was obtained from a reading that was less than the Limit of Quantitative Detection Limit, but greater than or equal to the Instrument Detection Limit.

5.0. ECOLOGICAL EFFECTS ASSESSMENT

Ecological effects are quantified from the relationships between exposure patterns and resulting responses of ecological systems, as determined from measurement endpoints identified during Problem Formulation (Section 3). Ecological effects assessments include literature-reported evaluations of the known effects of CoCs to receptors of concern (Section 5.1); direct measurement of the toxicity of exposure media (Section 5.2), in this case sediments and elutriates of sediments, to appropriately sensitive marine species (the amphipod *Ampelisca* and the sea urchin *Arbacia*, respectively); site-specific investigations of the abundance and condition of receptors of concern (Section 5.3); and collation of toxicity-based criteria and standards for exposure media identified in exposure pathways (Section 5.4). Uncertainty associated with these assessments is discussed in Section 5.5.

5.1. KNOWN EFFECTS OF COCS

Contaminants of concern as identified in Section 3 consist primarily of PAHs, PCBs, the pesticides DDE and mirex, the metals Ag, As, Cd, Cr, Cu, Hg, Ni, Pb and Zn, and the butyltins.

Potential effects of the CoCs on biological receptors are influenced strongly by their chemical behavior, solubility, and toxicity. For example, Ni, Cu, Cd, and Cr^{+6} have relatively high solubility and thus higher dissolved phase concentrations than many organic contaminants, such as PAHs and relatively insoluble metals, (e.g., Ag, Pb, Zn, and Cr^{+3}). Subsequently, dissolved contaminants may be transported throughout the water column by current and tidal flows, while contaminants associated with particles tend to be transported horizontally, commonly settling to the bottom in sediment

depositional areas. Once on the bottom, the sediment particles can be transported as bedload or resuspended, resulting in redistribution of the contaminants. Dissolved or particle/sediment-bound contaminants may be available to biological receptors in the water column, pore waters and sediments, potentially resulting in biological uptake and/or direct toxicological effects. Impacts to organisms can then be strongly influenced, for example, by the affinity of various contaminants for tissue lipids and the type of cellular or subcellular effects associated with particular compounds and elements.

The following describes the chemical behavior and known effects of key contaminants of concern.

Arsenic. Arsenic in surface water can undergo complex patterns of transformation, including oxidation-reduction reactions, biotransformation, precipitation, and adsorption, resulting in extremely mobile behavior in aquatic systems. Sorption of arsenic onto clays, iron oxides, manganese compounds, and organic material is a typical fate. Sediment can serve as a reservoir for arsenic, and sediment-bound arsenic (arsenate/arsenite) that has been methylated by aerobic and anaerobic bacteria may be released back into the water column (ATSDR, 1987a). Bioconcentration of arsenic occurs in aquatic organisms, primarily in algae and lower invertebrates. Biomagnification in aquatic food webs does not appear to be significant, although some fish and invertebrates contain high levels of arsenic compounds that are relatively inert toxicologically (ATSDR, 1987a). Arsenic in seafood occurs primarily as complex methylated or organic chemical species which are less toxic and more readily excreted than inorganic arsenic. The Effects Range-Low (ER-L) and Effects Range-Medium (ER-M) benchmarks, defined by Long *et al.* (1995) as the lower 10th and 50th percentiles of all concentrations of a contaminant observed to cause a biological effect, over a range of studies and species, are 8.2 and 70 mg/kg, respectively (also see Section 5.4). Acute responses to inorganic arsenic in water-only exposures where observed in

marine organisms at 2,319 ppm (Long *et al.*, 1990). During tests of sediments from Commencement Bay, where arsenic concentrations ranged between 2,257 to 28.3 mg/kg, mortality ranged between 15.7 and 2.5% to the amphipod *Rhepoxynius abronius,* respectively (Long *et al.*, 1990). Arsenic concentrations as high as 1,005 mg/kg were detected in Puget Sound sediments where highly toxic (i.e., 95% mortality) responses were indicated, and concentrations as low as 22.6 mg/kg where survival was >87% (Long *et al.*, 1990). Severe mortality (i.e., 100%) to the polychaete *Nereis virens* was observed during exposures to Black Rock Harbor sediment where the arsenic concentration was 1.88 mg/kg (Long *et al.*, 1990).

There is good evidence that arsenic is carcinogenic in humans, although evidence of arsenic-induced carcinogenicity in animals is mostly negative. In addition, very high oral doses of sodium arsenite may be teratogenic and ferotoxic. Arsenic is a weak inducer of chromosomal aberrations, and is a known teratogen in vertebrates (Eisler, 1988). Arsenic exposure may produce behavioral impairment, and leads to death at high concentrations. In aquatic invertebrates, arsenic exposure may lead to decreased growth, reproductive impairment, and death. Pre-exposure to sublethal levels of arsenic may result in increased tolerance to this element upon re-exposure (Eisler, 1988). It is generally agreed that inorganic arsenic is more toxic than organic arsenic, and that trivalent forms are more toxic than are pentavalent forms.

Cadmium. Cadmium in the water column may partition to dissolved and particulate organic carbon. Cadmium speciation yields primarily the divalent form of the metal, Cd^{+2}, between pH 4.0 and pH 7.0 (Stephenson *et al.*, 1989). Studies indicate that the divalent cadmium ion is responsible for observed biological effects. Acid volatile sulfides can influence the toxicity and bioaccumulation of cadmium in sediments. Cadmium is not a highly mobile element in the aquatic food web, nor does it biomagnify (Kay, 1985). Studies with zebrafish indicate no maternal transfer of cadmium to young, and cadmium measured in bird eggs was not a reliable indicator of

environmental exposure (Kay, 1985). Tissue residue toxicity relationships for cadmium may be variable because detoxification processes allow organisms to sequester this metal in various unavailable forms while analytical measurements continue to detect its presence (Klerks and Bartholomew, 1991). Whole body residues may fail to predict effects concentrations at the organ level because concentrations in target organs may be larger than whole body residues (McKinney, 1993). In freshwater studies, cadmium has been associated with high mortality, reduced growth, and inhibited reproduction (Eisler, 1985). Generally, resistance to cadmium was higher in marine organisms when compared to freshwater species (Eisler, 1985). Marine organism LC_{50}s ranged from 320 to 430 µg/L, whereas effects in freshwater organisms have been observed at 1-2 µg/L.

In tests of Puget Sound sediment, statistically significant effects were noted in the amphipod, oyster larvae, and Microtox™ bioassays, at cadmium concentrations ranging between 6.7 and 9.6 mg/kg (Long *et al.*, 1990). Cadmium concentrations of 1.2 and 1.7 mg/kg were measured in tests of San Francisco Bay sediments and caused significant toxicity in the amphipod and bivalve larvae bioassays, respectively (Long *et al.*, 1990). Highly toxic effects (i.e. 75% mortality) were noted in amphipod tests of Commencement Bay sediments with 41.6 mg/kg cadmium (Long *et al.*, 1990). Low abundances of echinoderms and arthropods were observed in Southern California where cadmium concentrations were 6.2 and 4.3 mg/kg, respectively (Long *et al.*, 1990). Complete mortality was observed in tests using the polychaete *Nereis verens* exposed to Black Rock Harbor sediments at 1.6 mg/kg cadmium (Long *et al.*, 1990). Baltimore Harbor sediments were toxic to mummichogs and spot, where the cadmium concentration in these sediments was 22.8 mg/kg (Long *et al.*, 1990). The ER-L and ER-M benchmarks for cadmium over a range of studies and species, are 1.2 and 9.6 mg/kg, respectively (Long *et al.*, 1995).

Chromium. Chromium(+6) occurs only rarely in nature, except from anthropogenic contamination, because it is readily reduced to chromium(+3) in the presence of oxidizable organic matter. However, chromate and dichromate (chromium(+6)) compounds are stable in many natural waters because of the low concentration of reducing material, and thus may undergo intermedia transport. In contrast, chromium(+3) compounds, the form most commonly observed in biological systems, are generally insoluble in water. The effects of chromium on wildlife, fish, and invertebrates have been summarized by Eisler (1986):

> "...chromium is mutagenic, carcinogenic, and teratogenic to a wide variety of organisms, and Cr^{+6} [hexavalent Cr] has the greatest biological activity. However, information is lacking on the biological activities of water soluble Cr^{+3} [trivalent Cr] compounds, organochromium compounds, and their ionic states. Aquatic plants and marine polychaete worms appear to be the most sensitive groups tested. In exposures to Cr^{+6}, growth of algae was inhibited at 10.0 ppb, and reproduction of marine polychaete worms was inhibited at 12.5 ppb. At higher concentrations, Cr^{+6} is associated with abnormal enzyme activities, altered blood chemistry, lowered resistance to pathogenic organisms, behavioral modifications, disrupted feeding, histopathology, osmoregulatory upset, alterations in population structure and species diversity indices, and inhibition of photosynthesis. Not all sublethal effects observed were permanent, but the potential for acclimatization of organisms to Cr is not well documented."

Cr exposure at high concentrations can produce death. Sensitivity to Cr varies widely among species, even among those which are closely related (Eisler, 1986). Chromium(+6) is classified as a human carcinogen, but chromium(+3) still is being evaluated for its carcinogenic potential. Most of the chromium in aquatic environments eventually is expected to precipitate in sediments. The ER-L and ER-M values for

chromium in sediments are 81 and 370 mg/kg, respectively (Long *et al.*, 1995). Acute toxicity to marine organisms in water-only exposures is evident at concentrations ranging from 2000 to 105,000 ppm (Long *et al.*, 1990). Tests with the amphipod *Rhepoxynius abronius* indicate toxic effects in sediments from Commencement Bay where chromium levels ranged between 16.2 to 19.7 mg/kg (Long *et al.*, 1990). Survival greater than 97% was observed in the polychaete *Neanthes arenaceodentata* exposed to San Diego Bay sediment with 299.5 mg/kg chromium (Long *et al.*, 1990).

Copper. The two processes that primarily influence the fate of copper in the aquatic environment are sorption and chemical speciation. Speciation is determined by the oxidation-reduction potential of the copper compound and the media pH. In contaminated settings, copper may form complexes with organic material in the water; however, copper ultimately settles out of the water column and is deposited in sediments. Various processes including sorption onto clay minerals, hydrous iron, manganese oxides, and organic material reduce the level of copper compounds in aquatic media. In organically rich sediments, the sorbed and precipitated copper may become redissolved through complexation and can persist in the water for long periods.

Copper is an essential element for most organisms, although the distinction between deficiency and toxicity in some organisms, including algae and some invertebrates, is small if there is limited ability to control absorption. Fish are sensitive to copper, and it is thought that their gills do not provide an effective barrier to absorption (Hammond and Beliles, 1980). Copper is toxic to aquatic plants and animals at relatively low levels. In addition to affecting survival, Cu exposure has been associated with development of histopathological lesions in mollusks and fish (Martin, 1977; Gardner and LaRoche, 1973), inhibition of egg hatching in fish (Gardner and LaRoche, 1973), impairment of fertilization and larval development in polychaetes and echinoderms (Reisch, 1964; Young and Nelson, 1974; Bougis, 1965), and retardation of growth in hydroids (Karbe, 1972). Cu is particularly active in disruption of

enzymatic systems (Albergoni and Piccinni, 1983). Copper is not strongly bioaccumulated and does not appear to transfer significantly through aquatic (or terrestrial) food webs. Bioconcentration factors are in the range of 10 to 100, although in some mollusks it can reach 30,000 (U.S. EPA, 1984). This may be because copper proteins in the blood of many bivalves act as oxygen carriers. For example, American oysters have been documented to have tissue concentrations of 1,500 mg/kg (Hammond and Beliles, 1980). Acute toxic effects on lower marine biota have been demonstrated at water concentrations ranging from 5.8 to 600 µg/L (U.S. EPA , 1986; Anderson *et al.*, 1991). The ER-L and ER-M values for copper in sediments are 34 and 270 mg/kg, respectively (Long *et al.*, 1995). In water-only exposures, acute responses of marine organisms were observed at concentrations ranging from 5.8 to 600 ppm (Long *et al.*, 1990). Mortality responses in the amphipod *Rhepoxynius abronius* ranged between 79% to 13% in sediments from Commencement Bay where corresponding copper concentrations ranged between 2820 to 85.1 mg/kg (Long *et al.*, 1990). In oyster bioassays, a highly toxic developmental response (i.e., >44% abnormal larvae) was observed in tests of sediments with 918 mg/kg copper from Commencement Bay (Long *et al.*, 1990). Eighteen to 67% mortality to *Rhepoxynius abronius* was observed in tests of sediments from San Francisco Bay, where copper concentrations were between 72 and 85 mg/kg, respectively (Long *et al.*, 1990). No survival was observed in exposures of the polychaete *Nereis virens* to Black Rock Harbor sediment with 612 mg/kg copper (Long *et al.*, 1990).

Lead. The chemistry of lead in aqueous solutions is highly complex because of its occurrence in many forms, although it has a tendency to form compounds of low solubility. The divalent form (Pb^{+2}) is the stable ionic species of lead. Hydroxide, carbonate, sulfide and, more rarely, sulfate may act as solubility controls. Lead may occur either as adsorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended living or non-living organic matter in the water (ATSDR, 1988b). The ER-L and ER-M values for lead in sediments are 46.7 and

218 mg/kg, respectively (Long *et al.*, 1995). In freshwater tests, adverse effects to test organisms occur between 1.3 and 7.7 ppm (Long *et al.*, 1990). Studies indicate that marine organisms in water-only exposures are more sensitive (Long *et al.*, 1990). The proposed marine water quality standard for California is 8 ppm (Long *et al.*, 1990). Statistically significant responses to amphipods, oyster larvae, and Microtox™ were observed in Puget Sound sediment tests at concentrations ranging between 530 and 660 mg/kg (Long *et al.*, 1990).

Lead can bioaccumulate in some bivalves, such as mussels, but does not appear to bioaccumulate in fish. In vertebrates, Pb is known to modify the structure and function of the kidney, bone, central nervous system, and the hematopoietic system, and produces adverse biochemical, histopathological, neuropsychological, ferotoxic, teratogenic, and reproductive effects. Inhibition of blood delta aminolevulnic acid dehydratase (ALAD), an enzyme critical in heme formation, has been observed as a result of exposure to Pb in invertebrates, birds, and a variety of marine fish. At sufficiently high concentrations, Pb effects manifest in estuarine organisms as reduced growth, fecundity, and survivorship. Lead is classified as a probable human carcinogen, based on animal (primarily rat) studies (Eisler, 1988).

Mercury. Mercury forms a wide variety of complexes with organic ligands, the compounds of which (e.g., methylmercury) are toxicologically and environmentally significant (Nriagu, 1979). Mercury is very persistent when released into the environment, with the major removal mechanism occurring by adsorption onto particles and subsequent settlement to sediments. Mercury can become methylated to a highly toxic form, methylmercury, by biological and chemical processes (Nriagu, 1979). Methylation occurs most readily under anaerobic conditions. Mercury has no known essential status or function in organisms, and is a mutagen and teratogen (U.S. EPA, 1985b). Bioaccumulation and toxic effects of mercury in aquatic systems are highly complex and are influenced by water temperature, salinity, hardness, pH, age of an

organism, prior exposure, reproductive state (related to lipid content), trophic level, and metabolism. Mercury is considered to be one of the most toxic of the heavy metals (Nriagu, 1979). At higher concentrations, mercury is toxic to a wide range of marine invertebrates and fish, and its acute toxicity varies among species. For instance, Hg is acutely toxic to the mysid shrimp *Mysidopsis bahia* at concentrations as low as 3.5 µg/L, whereas the acute value for winter flounder is 1,678 µg/L (U.S. EPA, 1985b). In general, fish tend to be less sensitive to Hg than are crustaceans and mollusks.

In addition to mortality, Hg exposure can result in impairment of reproduction, development, and growth in estuarine plants and animals. For example, productivity and time to first reproduction in *Mysidopsis* was affected in 28-d life cycle tests at mercury concentrations of 1.6 µg/L. Methylmercury can be bioconcentrated and biomagnified through aquatic food webs, with higher concentrations generally observed at the higher trophic levels (e.g., carnivorous fish and piscivorous birds; Nriagu, 1979). Concentrations of mercury in ocean sediments have been shown to be reflected in the tissues of epifauna (Klein and Goldberg, 1970). Bioconcentration factors range upwards to almost 200,000 for marine zooplankton (Hirota *et al.*, 1983), and transfer rates in piscivorous fish and birds have been documented up to 36,000 (Eisler, 1981). Adverse effects on reproduction in birds have been demonstrated at concentrations as low as 5 mg/kg. The ER-L and ER-M values for mercury in sediments are 0.15 and 0.71 mg/kg, respectively (Long *et al.*, 1995). Acute toxicity in water-only exposures of mercury to marine organisms is observed between 3.5 and 1,678 ppm (Long *et al.*, 1990). Statistically significant responses in Puget Sound sediment tests were observed at concentrations ranging between 0.4 and 2.1 mg/kg to amphipods, oyster larvae, and Microtox™ (Long *et al.*, 1990). Highly toxic (i.e., 67 and >78% mortality) effects to the amphipod *Rhepoxynius abronius* were observed in tests of Commencement Bay and San Francisco Bay sediments with 11.2 mg/kg and 1.0 mg/kg mercury, respectively (Long *et al.*, 1990).

Nickel. Very little information on the fate of nickel in the environment could be found in the literature. It is generally characterized as moderately soluble in water. U.S. EPA (1986) provides the following insights into the adverse effects of nickel:

> "Mechanisms of nickel toxicity are varied and complex, and, as with other heavy metals, significant effects occur at cell membranes and membranous tissues, such as gills. In fish, hematological effects such as hyperglycemia, lymphopenia, and erythocytosis have been reported in association with nickel intoxication..."

Nickel exposure has resulted in reduced photosynthesis in aquatic plants (plankton and macrophytes), inhibition of enzyme systems in a variety of organisms, stunted growth and development, reproductive impairment, and at sufficiently high levels, death. Exposure levels associated with these effects are summarized in U.S. EPA (1986). Nickel is classified as a human carcinogen (U.S. EPA, 1992a). The ER-L and ER-M values for nickel in sediments are 20.9 and 51.6 mg/kg, respectively (Long *et al.*, 1995). Acute toxicity to marine organisms has been observed in water-only exposures to nickel at 151.7 ppm (Long *et al.*, 1990). In tests with sediments from Puget Sound, statistically significant toxicity to amphipods, oyster larvae, and Microtox™ was observed at concentrations ranging between 28 and >120 mg/kg (Long *et al.*, 1990). Exposures of the amphipod *Rhepoxynius abronius* indicated highly toxic responses (i.e., 67 and >78% mortality) to Commencement Bay and San Francisco Bay sediments with 41 mg/kg and 113 mg/kg nickel, respectively (Long *et al.*, 1990). No survival was observed in the polychaete *Nereis virens* when exposed to 52.0 mg/kg nickel in Black Rock Harbor sediment (Long *et al.*, 1990).

Silver. The toxicity of silver to aquatic life is apparently dependent on water hardness: the harder the water, the higher the silver concentration that is needed to be toxic. Silver and its compounds have high chronic toxicity to aquatic life. As with all of

the CoCs discussed in this section, the adverse effects of silver include impairments to survival, growth, development, and reproduction in estuarine organisms. Quoting from the U.S. EPA (1987a):

> "Symptoms of silver intoxication in aquatic organisms appear to be similar to those caused by other heavy metals. Separation and disruption of the gill epithelium is frequently observed, resulting in esphisia. Damage may be the result of silver ions reacting directly at the gill membrane, or as an indirect result of hematological osmotic imbalances."

Such effects on gill structure often manifest as impairments to respiration, an effect particularly noted on mollusks (U.S. EPA, 1987b). Other effects noted in laboratory exposures (summarized in U.S. EPA, 1987b) include reductions in chlorophyll *a* in phytoplankton populations, ionic imbalance in polychaete coelomic fluid, histo-pathological changes, impairment of fertilization success and abnormal larval development, and disruption of enzymatic systems. There is no conclusive evidence that silver is carcinogenic to humans. The ER-L and ER-M values for silver in sediments are 1.0 and 3.7 mg/kg, respectively (Long *et al.*, 1995). Studies indicate that marine water-only concentrations of silver should not exceed 2.3 ppm (Long *et al.*, 1990). In Puget Sound sediment tests, statistically significant toxicity to amphipods, oyster larvae, and Microtox™ were observed at concentrations ranging between >0.6 and >3.7 mg/kg. In San Francisco Bay sediments, toxicity to amphipods and oyster larvae occurred at concentrations ranging between 1.1 and >8.6 mg/kg (Long *et al.*, 1990). Tests of sediments from Commencement Bay and San Francisco Bay indicate highly toxic effects (i.e., >78 and 67%, respectively) to the amphipod *Rhepoxynius abronius* at silver concentrations of 0.2 and 1.7 mg/kg, respectively (Long *et al.*, 1990). Survival in the sanddab *Citarichtys stigmaeus* was >82% when exposed to San Diego sediments with 0.8 mg/kg silver (Long *et al.*, 1990).

Zinc. Sorption onto sediments is probably the most common fate of zinc in the aquatic environment (Eisler, 1993). Small amounts may be partitioned into the dissolved phase through speciation into soluble zinc compounds. Formation of complexes with organic and inorganic ligands may increase the mobility of zinc in aquatic media, but these complexes also have a tendency to be adsorbed more strongly onto sediments. The ER-L and ER-M values for zinc in sediments are 150 and 410 mg/kg, respectively (Long *et al.*, 1995). Acute LC_{50}s for marine fish in water-only exposures to zinc range from 192 to 320,400 ppm (Long *et al.*, 1990). Chronic responses of marine mysids in water-only exposures were noted at 120 ppm (Long *et al.*, 1990). Statistically significant responses in Puget Sound sediment tests were observed at concentrations ranging between 870 and 1600 mg/kg to amphipods, oyster larvae, and Microtox™ (Long *et al.*, 1990). A highly toxic response in the amphipod *Rhepoxynius abronius* was observed during testing of sediment with 707 mg/kg zinc from Puget Sound (Long *et al.*, 1990). A significant toxic response (i.e., 43% mortality) was observed during exposures of the amphipod *Rhepoxynius abronius* to San Francisco Bay sediment with 158 mg/kg zinc (Long *et al.*, 1990). No survival was observed in the polychaete *Nereis virens* exposed to Black Rock Harbor sediment with 334 mg/kg zinc (Long *et al.*, 1990).

Zinc is an essential element in maintaining many physiological processes, and zinc deficiency can result in severe adverse effects on growth, reproduction, and survival in plants and animals. However, exposure to excess concentrations of zinc can result in a range of adverse physiological and ecological effects. According to Eisler (1993):

> "The most sensitive aquatic species were adversely affected at nominal water concentrations between 10 and 25 µg Zn/L, including representative species of plants, protozoans, sponges, mollusks, crustaceans, echinoderms, fish, and amphibians. Acute LC_{50} (96-h) values were

between 32 and 40,930 µg/L for freshwater invertebrates, 66 and 40,900 µg/L for freshwater teleosts, 195 and >320,000 µg/L for marine invertebrates, and 191 and 38,000 µg/L for marine teleosts. Acute toxicity...was markedly affected by the age and nutrient status of the organism... Pancreatic degeneration occurred in ducks fed diets containing 2,500 mg Zn/kg ration. Ducks died when fed diets containing 3,000 mg Zn/kg feed."

Thus, according to Eisler (1993), adverse effects include decreased growth, survival, and reproduction. Some noncarcinogenic effects of zinc to humans and animals are evident, but information on carcinogenic effects could not be located in the literature.

Butyltins. Butyltin compounds include dibutyltin (DBT), monobutyltin (MBT), and tributyltin (TBT). Generally, DBT and MBT represent biodegradable and therefore less toxic degradation products of TBT. Of the three, TBT is the more prominent compound found (Clarke *et al.*, 1988; Bryan and Gibbs, 1991; Fent and Hunn, 1995). Tributyltin leached from anti-fouling paints inhibits the attachment of fouling organisms (sessile invertebrates) and has been shown to be toxic even at very low concentrations (Wade *et al.*, 1990). In fact, studies have demonstrated that TBT is damaging at concentrations far below those indicated for other marine pollutants (Clarke *et al.*, 1988). TBT concentrations in aquatic sediments likely reflect partitioning between butyltins and suspended particles in the water column, although up to 99% of the TBT may reside in the sediments. Nonetheless, TBT contaminated sediments can represent a substantial source of organotin to aquatic waters (Huggett *et al.*, 1986, as reported in Wade *et al.*, 1990). Studies by Wade *et al.* (1990) determined that the average ratio of TBT concentrations in bivalves compared to sediments collected nearby is 18 (range 6.8 - 57 in coastal waters of the U.S.), suggesting a moderate bioaccumulation potential. Fent and Hunn (1995) indicate that because TBT has significant lipid

solubility with log *n*-octanol/water partition constant of ca. 3.5, a high affinity for bioaccumulation may exist. Although regulations have been introduced and water column concentrations have declined, TBT concentrations in sediments have persisted at levels high enough to induce chronic effects in susceptible aquatic organisms such as marine mollusks (Fent and Hunn, 1995). Fent and Hunn (1995) suggest that degradation of TBT is slow in sediments, with a half-life in the range of two to three years. Others have indicated a half-life of less than one year for aerobic sediments and two years for anaerobic sediments (Bryan and Gibbs, 1991). In addition, other studies have shown the ability of some species of fish, crustaceans, bivalves, and microorganisms to bioconcentrate TBT to levels which are orders of magnitude higher than the exposure concentration (Clarke *et al.*, 1988).

Acute effects of TBT have been observed in the water column where TBT concentrations of 1 ng/L have been associated with reduced reproduction (i.e. egg laying) in the freshwater snail (Fent and Hunn, 1995). Histologic alterations were observed in young European minnows exposed to 0.8 µg/L TBT (Fent and Hunn, 1995). Reduced growth was noted in long-term exposures of rainbow trout yolk sac fry to 0.2 µg/L TBT, and a NOEC of 0.04 µg/L TBT was estimated for this organism (Fent and Hunn, 1995). Immunotoxic effects were observed in the guppy at 0.32 µg/L TBT. In studies of the zooplankton, *Acartia tonsa*, reductions in survival in acute tests were observed at the lowest measurable concentration, 0.029 µg/L, and NOECs and LOECs for survival during chronic tests were 0.024 and 0.017 µg/L, respectively (Bushong *et al.*, 1990). In studies of sediments, data indicate that concentrations of TBT are one to several thousand times higher than concentrations found in the overlying water (Bryan and Gibbs, 1991). In an assessment of sediments, bivalves were virtually eliminated when TBT concentrations exceeded 0.8 µg/g (Fent and Hunn, 1995). Although ER-L and ER-M ranges are unavailable for TBT, studies have shown that mollusks respond to TBT concentrations as low as 10 ng/g, while some copepod crustaceans,

echinoderms, polychaetes, tunicates, phytoplankton, and fish respond to TBT concentrations which range between 10 and 100 ng/g (Bryan and Gibbs, 1991).

Polycyclic Aromatic Hydrocarbons (PAHs). High molecular weight (HMW) PAHs (e.g., chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)-fluoranthene, benzo(a)pyrene, and dibenzo(a,h)anthracene) typically have low solubility in water, high partition coefficients (i.e., higher affinity for organic matter, such as in soil and sediments, than water), and slow degradation. Based on the low water solubility and high affinity to organic matter, significant leaching of HMW PAHs into groundwater is not expected. Solubility of PAHs generally decreases with increasing molecular weight; the less soluble the PAH compound, the more likely it will adsorb to soil or sediment particles. The primary removal mechanisms for PAHs in aquatic environments are by volatilization, photochemical reactions, and microbial degradation (ATSDR, 1989b). ER-L and ER-M sediment values in µg/kg for various PAH CoCs are 16 and 500 for acenaphthene, 44 and 640 for acenapthylene, 85.3 and 640 for anthracene, 261 and 1,600 for benzo(a)anthracene, 430 and 1,600 for benzo(a)pyrene, 384 and 2800 for chrysene, 63.4 and 260 for dibenz(a,h)anthracene, 19 and 540 for fluorene, 600 and 5,100 for fluoranthene, 240 and 1,500 for phenanthrene, and 665 and 2,600 for pyrene, respectively (Long *et al.*, 1995).

Amphipods, oyster larvae, and Microtox™ exhibited statistically significant responses to acenaphthene in Puget Sound sediment tests at concentrations ranging between 500 and 630 µg/kg (Long *et al.*, 1990). A significant toxic response (i.e., 43% mortality) was observed during exposures of the amphipod *Rhepoxynius abronius* to San Francisco Bay sediment with 7.6 µg/kg acenaphthene (Long *et al.*, 1990). A highly toxic response was observed during tests using *Rhepoxynius abronius* (i.e., 80% mortality) in sediment from Commencement Bay with 654 µg/kg acenaphthene (Long *et al.*, 1990). Significant toxicity was observed in the amphipod

Ampelisca abdita exposed to Black Rock Harbor sediment with 30 µg/kg acenaphthene (Long *et al.*, 1990).

In Puget Sound sediment tests, amphipods, oyster larvae, and Microtox™ exhibited statistically significant responses to anthracene at concentrations ranging between 960 and 1,900 µg/kg (Long *et al.*, 1990). Bioassays of San Francisco Bay sediments using bivalve larvae and amphipods indicated significant effects at 24 µg/kg and 1,100 µg/kg anthracene, respectively (Long *et al.*, 1990). Tests of sediments from Commencement Bay and Eagle Harbor, Washington, were highly toxic to the amphipod *Rhepoxynius abronius* at 363 and 7,597 µg/kg anthracene, respectively (Long *et al.*, 1990). In tests with the fish *Leiostomus xanthurus*, the 24-hr and 28-day LC_{50}s for anthracene were 147,840 and 6,600 µg/kg, respectively (Long *et al.*, 1990).

Effects of benzo(a)anthracene where observed in bivalve larvae and the fish *Leiostomus xanthurus* when concentrations ranged from 60 µg/kg (in tests of sediments from San Francisco Bay) to 350,000 µg/kg (in bioassays of sediments from the Elizabeth River), respectively (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 1,300 and 1,600 µg/kg benzo(a)anthracene (Long *et al.*, 1990). Statistically significant toxicity in the bivalve and amphipod bioassays was observed in exposures to sediments from San Francisco Bay with 60 and 1,100 µg/kg of benzo(a)-anthracene (Long *et al.*, 1990). Amphipod mortality exceeded 80% in tests of sediments from Commencement Bay and Eagle Harbor where benzo(a)anthracene concentrations were 931 and 11,088 µg/kg, respectively (Long *et al.*, 1990). In tests with the fish *Leiostomus xanthurus,* the 24-hr and 28-day LC_{50}s for benzo(a)anthracene were 196,000 and 8,750 µg/kg, respectively (Long *et al.*, 1990).

Effects of benzo(a)pyrene were observed in bioassays of sediments from San Francisco Bay and Lake Union, Washington, where concentrations ranged from 400 to

220,000 µg/kg (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 1,600 and 2,400 µg/kg benzo(a)pyrene (Long *et al.*, 1990). Statistically significant toxicity in the bivalve and amphipod bioassays was observed in exposures to sediments from San Francisco Bay with >1,800 and 1,300 µg/kg of benzo(a)-pyrene, respectively (Long *et al.*, 1990). Amphipod mortality exceeded 80% in tests of sediments from Commencement Bay and Eagle Harbor where benzo(a)pyrene concentrations were 1,192 and 3,485 µg/kg, respectively (Long *et al.*, 1990). In tests with the fish *Leiostomus xanthurus*, the 24-hr and 28-day LC_{50}s for benzo(a)pyrene were 55,160 and 2,462 µg/kg, respectively (Long *et al.*, 1990).

Responses were observed in amphipod and fish tests of sediments from San Francisco Bay and the Elizabeth River, with chrysene concentrations ranging from 80 µg/kg to 317,000 µg/kg, respectively (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 1,400 and 2,800 µg/kg chrysene (Long *et al.*, 1990). Statistically significant differences in the bivalve larval and amphipod bioassays were indicated when San Francisco Bay sediment concentrations of chrysene were 1,700 and 2,100 µg/kg, respectively (Long *et al.*, 1990). Amphipod mortality exceeded 80% in tests of sediments from Commencement Bay and Eagle Harbor, where chrysene concentrations were 1,363 and 10,574 µg/kg, respectively (Long *et al.*, 1990).

Effects were observed when dibenz(a,h)anthracene concentrations were as low as 42 µg/kg in bivalve larval bioassays of San Francisco Bay sediments (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 230 and 260 µg/kg dibenz(a,h)-anthracene (Long *et al.*, 1990). Statistical differences in the bivalve larval and amphipod bioassays with San Francisco Bay sediments were indicated when concentrations of dibenz(a,h)anthracene were 260 and 300 µg/kg, respectively

(Long *et al.*, 1990). Amphipod mortality exceeded 80% in tests of sediments from Commencement Bay and Eagle Harbor, where dibenz(a,h)anthracene concentrations were 72 and 263 µg/kg, respectively (Long *et al.*, 1990). Significant toxicity to bivalve larvae was observed in sediments from Eagle Harbor with 63 µg/kg dibenz(a,h)-anthracene (Long *et al.*, 1990).

The amphipod *Grandidierella japonica* exhibited a significant response to sediment from southern California with 11 µg/kg fluorene (Long *et al.*, 1990). The 24-hour and 28-day LC_{50}s for the fish *Leiostomus xanthurus* exposed to Elizabeth River sediments, were 700,000 and 17,500 µg/kg fluorene, respectively (Long *et al.*, 1990). Liver somatic condition indices were elevated in winter flounder exposed to 220,550 µg/kg fluorene in spiked sediment bioassays (Long *et al.*, 1990). Mixed function oxygenase (i.e., P450) induction in winter flounder liver and kidney was elevated in spiked sediment tests with 176,510 and 285,290 µg/kg fluorene (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed at 540 µg/kg fluorene (Long *et al.*, 1990). Statistical differences in the bivalve larval and amphipod bioassays with San Francisco Bay sediments were indicated when concentrations of fluorene were 11 and 210 µg/kg, respectively (Long *et al.*, 1990).

Bioassays of sediments from southern California and the Elizabeth River indicated significant responses to amphipods at 382 µg/kg fluoranthene (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 1,700 and 3,900 µg/kg fluoranthene (Long *et al.*, 1990). Statistical differences in the bivalve larval and amphipod bioassays with San Francisco Bay sediments were indicated when concentrations of fluoranthene were 2,000 and >3,700 µg/kg, respectively (Long *et al.*, 1990). The 24-hour and 28-day LC_{50}s for the fish *Leiostomus xanthurus* exposed to

Elizabeth River sediments, were 327,200 and 59,250 µg/kg fluoranthene, respectively (Long *et al.*, 1990).

Responses in bivalve larval bioassays were observed using sediments from San Francisco Bay with 88 µg/kg phenanthrene (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 1,500 and 5,400 µg/kg phenanthrene (Long *et al.*, 1990). Amphipod mortality exceeded 80% in tests of sediments from Commencement Bay and Eagle Harbor, where phenanthrene concentrations were 2,838 and 33,603 µg/kg, respectively (Long *et al.*, 1990). Significant amphipod mortality (i.e., 67%) was observed in tests of San Francisco Bay sediments with 242 µg/kg phenanthrene (Long *et al.*, 1990). The 24-hour and 28-day LC_{50}s for the fish *Leiostomus xanthurus* exposed to Elizabeth River sediments, were 2,363,200 and 105,500 µg/kg phenanthrene, respectively (Long *et al.*, 1990). Elevated liver somatic condition indices were observed in winter flounder exposed to 340 µg/kg phenanthrene in spiked sediment tests (Long *et al.*, 1990). Mixed function oxygenase (i.e., P450) induction in winter flounder liver and kidney was elevated in spiked sediment tests with 270 and 429 µg/kg phenanthrene, respectively (Long *et al.*, 1990).

Elevated liver somatic condition indices were observed in winter flounder exposed to 360 µg/kg pyrene in spiked sediment tests (Long *et al.*, 1990). Mixed function oxygenase (i.e., P450) induction in winter flounder liver and kidney was elevated in spiked sediment tests with 300 and 182 µg/kg pyrene, respectively (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 2,600 and 4,300 µg/kg pyrene (Long *et al.*, 1990). Amphipod mortality exceeded 80% and 65% in tests of sediments from Commencement Bay and San Francisco Bay, where pyrene concentrations were 1,820 and 777 µg/kg, respectively (Long *et al.*, 1990). The 24-

hour and 28-day LC_{50}s for the fish *Leiostomus xanthurus* exposed to Elizabeth River sediments, were 1,350,000 and 33,750 µg/kg pyrene, respectively (Long *et al.*, 1990).

PAHs as a group contain a number of individual organic compounds as discussed above and thus may vary in toxicity and ecological effects. According to Eisler (1987):

> "A wide variety of PAH-caused adverse biological effects have been reported in numerous species of organisms under laboratory conditions, including effects on survival, growth, metabolism, and especially tumor formation. Inter- and intraspecies responses to carcinogenic PAHs were quite variable, and were significantly modified by many chemicals including other PAHs that are weakly carcinogenic or noncarcinogenic. Until these interaction effects are clarified, the results of single substance laboratory tests may be extremely difficult to apply to field situations of suspected PAH contaminants."

Responses to Total PAHs were observed in sediment tests where concentrations ranged between 870 and 21,200,000 µg/kg (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed with 5,200 µg/kg low molecular weight PAHs and between 12,000 and 18,000 µg/kg high molecular weight PAHs (Long *et al.*, 1990). Statistically significant effects in the bivalve larval development and amphipod bioassays were observed in tests of sediments from San Francisco Bay with 870 and >15,000 µg/kg Total PAHs, respectively (Long *et al.*, 1990). Toxic responses (i.e., >80% amphipod mortality and >44% abnormal larval development) were noted in tests of Commencement Bay sediments with 6,977 and 3,835 µg/kg low molecular weight PAHs and with 9,794 and 9,042 µg/kg high molecular weight PAHs, respectively (Long *et al.*, 1990). Negative growth was noted in nematode bioassays using Hudson-Raritan Estuary sediments with

42,769 µg/kg Total PAHs (Long *et al.*, 1990). Elevated liver somatic condition indices were observed in winter flounder exposed to 228,722 µg/kg Total PAHs in spiked sediment tests (Long *et al.*, 1990). Mixed function oxygenase (i.e., P450) induction in winter flounder liver and kidney was elevated in spiked sediment tests with 183,060 and 295,860 µg/kg Total PAHs, respectively (Long *et al.*, 1990). The 24-hour and 28-day LC_{50}s for the fish *Leiostomus xanthurus* exposed to Elizabeth River sediments, were 530,000 and 21,200,000 µg/kg Total PAHs, respectively (Long *et al.*, 1990).

In addition to the interactions alluded to by Eisler (1987), an understanding of the potential bioaccumulation (and hence potential effects) of PAHs is confounded by the fact that many aquatic vertebrate (primarily fish) and, to a lesser degree, some invertebrate (polychaetes, crustaceans, and mollusks) species possess enzymatic systems which support metabolism of PAHs (National Research Council of Canada, 1983), such that the level of exposure of these organisms to PAHs cannot be directly inferred from the PAH concentrations present (or absent) in their tissues. Such enzymatic systems have also been observed in some bacteria, fungi, and algae. With respect to PAH activation and carcinogenesis, the National Research Council of Canada (1983, p. 13) states:

> "Structure-activity relationships for mutagenic and carcinogenic activity seem to favor 4-, 5- and 6-ring PAHs rather than smaller or larger compounds. It is believed that PAHs require metabolic activation to exert their carcinogenic effects...with carcinogenesis being initiated by the binding of electrophilic metabolites to critical cellular constituents. Enzymes other than mixed function oxidase (MFO), which may influence the rate of production or destruction of reactive metabolites, are found in aquatic animals and may play an important role in toxicity."

Hence, although the metabolism of PAHs is more common for aquatic vertebrates, significant food chain transfer may occur between invertebrates such as bivalves (e.g. mussels, clams) that do not metabolize PAHs and vertebrates (e.g. seabirds) whose diet may consist of substantial quantities of these prey types. This exposure pathway is addressed in the current investigation as the fourth tier model for avian aquatic receptors (Figure 3.4-7).

Mirex. Mirex, a chlorinated insecticide, is the active ingredient used in bait to control the fire ant, harvester ant, and the Texas leaf-cutting ant. Mirex, marketed under the trade name Dechlorane, is also used in flame-retardant coatings. Mirex is a white, odorless, crystalline solid, partially soluble in some solvents, and only slightly soluble in water (i.e. maximum solubility in water is 0.20 mg/L at 24°C). In aquatic tests with plankton, photosynthesis was inhibited 16%, 10%, 33%, and 19% after exposure to 1 ppb mirex for 5, 10, 15, and 20 days, respectively (Verschueren, 1983). In tests of mirex using the freshwater cnidarian *Hydra spp.*, 1-day, 2-day, 3-day, 4-day, 5-day, and 6-day LC_{50}s were measured at 100,000, 682, 23, 4, 1, and 0.5 ppm, respectively (Verschueren, 1983). In the 96-hour test with the algae, *Tetrahymena pyriformis*, growth was inhibited by 96% at 0.9 ppb mirex (Verschueren, 1983). Decreased feeding activity was observed in the adult polychaete *Arenicola cristata* during 30 day exposures to <0.003 - 0.062 µg/L, and decreased survival of prey (i.e., *Paleomentes vulgaris*) was observed in tests with the fish *Lagodon rhomboides* during 13 day exposures to 0.025 - 0.046 µg/L (Verschueren, 1983). EC_{50}s and LC_{50}s for the juvenile pink shrimp (*Penaues duorarum*), blue crab (*Callinectes sapidus*), eastern oyster (*Crassostrea virginica*), and the fish (*Leiostomus xanthurus*) were 720, 2000, 2000, and 2000 µg/L, respectively (U.S. EPA, 1987b). Increased mortality was observed in acute and chronic tests with shrimp, blue crabs, fiddler crabs, and finfish exposed to particles of fire ant bait (0.3% mirex) in food and/or water (Lowe *et al.*, 1971).

DDE. DDE, a metabolite of DDT, is very persistent in the environment. Few specific data are available regarding the environmental fate of DDE; however, both DDT and DDD in water are subject to sedimentation, volatilization, photodegradation, and food web uptake. DDT is absorbed by humans in direct proportion to dietary exposure. Human epidemiological data are not available for DDE, although based on its structural similarity to DDT, it is classified as a probable human carcinogen. Bioconcentration factors for DDE are from 10^3 to 10^5. The ER-L and ER-M values in sediments for DDE are 2.2 and 27 µg/kg, respectively (Long *et al.*, 1995). Statistically significant responses to DDE were noted in tests of sediments from Puget Sound in the amphipod bioassay and in the evaluation of benthic community composition where DDE concentrations were 15 and 9 µg/kg, respectively (Long *et al.*, 1990). Statistically significant effects in the bivalve larval development and amphipod bioassays were observed in tests of sediments from San Francisco Bay with 2.2 µg/kg DDE (Long *et al.*, 1990). Significant toxicity to amphipods and bivalve larvae were noted in tests of sediments from San Francisco Bay with 1 and 3 µg/kg DDE (Long *et al.*, 1990).

PCBs. PCBs, also known by the commercial name Aroclors, vary substantially in their chemical, physical, and biological properties based on their degree of chlorination. The less chlorinated Aroclors will sorb less strongly onto sediments than the highly chlorinated components. Sediment and suspended particulate transport is the dominant mode of PCBs in aqueous solutions. The ER-L and ER-M values for total PCBs in sediments are 22.7 and 180 µg/kg, respectively (Long *et al.*, 1995).

Responses to PCBs were observed in tests of marine sediments where concentrations ranged between 36.6 and 10,800 µg/kg (Long *et al.*, 1990). In tests of Puget Sound sediment, statistically significant effects to amphipods, oyster larvae, and Microtox™ were observed between 130 and 2,500 µg/kg PCBs (Long *et al.*, 1990). Statistically significant effects in the bivalve larval development and amphipod bioassays were observed in tests of sediments from San Francisco Bay with 54 and

260 µg/kg PCBs, respectively (Long *et al.*, 1990). Toxic responses (>80% amphipod mortality and >44% abnormal bivalve larval development) were noted in tests of Commencement Bay sediments with 38 and 368 µg/kg PCBs, respectively (Long *et al.*, 1990). Negative growth was noted in nematode bioassays using Hudson-Raritan Estuary sediments with 638 µg/kg PCBs (Long *et al.*, 1990).

PCBs as a group contain a number of individual congeners which vary with respect to toxicity. Exposure to PCBs in various combinations has resulted in effects on growth of phytoplankton through impairment of photosynthesis and cell division, and has been shown to influence competitive interactions between phytoplankton species (Mosser *et al.*, 1972; Fisher *et al.*, 1974). PCBs also affect reproduction in fish (Hansen *et al.*, 1974), growth in bivalves (Parrish *et al.*, 1972), molting physiology of crustaceans (Fingerman and Fingerman, 1977), and may adversely affect population dynamics in fish (Munns *et al.,* 1994). Hansen *et al.* (1974) demonstrated the adverse influence of PCB exposure (as Aroclor 1254) on recruitment and development of benthic and epibenthic estuarine communities in laboratory exposure systems. At high enough concentrations, PCBs cause death in a number of estuarine organisms (Hansen, 1974).

In summary, the CoCs identified in Section 3.3 can be characterized by their tendency to be associated with dissolved or particulate/sediment fractions, assuming that other, non-contaminant related factors (e.g. TOC, AVS) are similar in concentration:

- Dissolved fraction components - salts of nickel, copper, cadmium, and chromium(+6) have a tendency to be more prevalent in the dissolved phase than those of other metals when conditions permit;

- Particulate/sedimentary fraction components - PAHs, PCBs, DDE, silver, lead, zinc, arsenic, mercury, and chromium(+3) have a greater tendency to be particle-associated than the above group, again assuming comparable geochemical conditions.

This information will be used to aid in the interpretation of contaminant distribution, bioaccumulation and toxicity as discussed in the following sections.

5.2. Toxicity Evaluations

Site-specific evaluations of bulk surface sediments were conducted using the 10-day amphipod (*Ampelisca abdita*) mortality test. Evaluations of sediment elutriates were conducted using the sea urchin (*Arbacia punctulata*) fertilization test and the sea urchin larval development test. Elutriates were used, not to predict bulk sediment toxicity, but rather to determine the potential for water-column impacts in the event that sediments are resuspended and contaminants become bioavailable. Toxicity testing of elutriates is a common technique used particularly by the U.S. Army Corps of Engineers to evaluate the effects of dredged material during disposal processes (U.S. EPA/U.S. ACE, 1991). Both the bulk sediment and elutriate tests are directed tools used to evaluate the bioavailability of contaminants in the respective media. Comparison of these results to field effects measurements (discussed in Section 5.3) will provide a detailed spatial evaluation of potential impacts to aquatic biota.

5.2.1. Amphipod Test Results

Background. The euryhaline benthic amphipod, *Ampelisca abdita*, which ranges from Newfoundland to Florida and the Gulf of Mexico, was used to evaluate the toxicity of sediments from Derecktor Shipyard/Coddington Cove. This tube-dwelling amphipod

constructs a soft, upright, membranous tube 3 to 4 cm long in fine-grained sediments from the intertidal zone to a depth of 60 m. *Ampelisca* ingest either surface-deposited particles or particles in suspension, and respire in both overlying and interstitial waters.

The 10-day amphipod test has been used extensively to assess the toxicity to *Ampelisca abdita* of laboratory-spiked and field collected sediments (DiToro *et al.*, 1992; Scott and Redmond, 1989; Long *et al.*, 1990). In addition, *Ampelisca abdita* has been used routinely for sediment toxicity tests conducted by SAIC in support of numerous EPA programs (SAIC, 1990a; SAIC, 1991; SAIC, 1992a; and SAIC, 1993a). *Ampelisca abdita* was the most sensitive species tested in the U.S. EPA/U.S. ACE Field Verification Program, and has represented the toxicological basis for EPA research on the availability of metals in relation to acid volatile sulfides in marine sediments (Gentile *et al.*, 1987 and DiToro *et al.*, 1992). *Ampelisca abdita* has also been used to characterize the toxicity of sediments from the Calcasieu River, LA, which cover a broad range of salinity and grain size (SAIC, 1990b). It was the first species used to demonstrate the toxicity of sediments from New Bedford Harbor, MA, and subsequently was used to assess the effectiveness of capping procedures as part of a Pilot Dredging Project on site remediation techniques (USACE, 1989). SAIC has recently conducted toxicity tests of sediments from New York Harbor for EPA Region II and the New York District (SAIC, 1992b; SAIC, 1994a and SAIC, 1995), as well as a series of tests for NOAA which characterize toxicity of sediments from the Hudson-Raritan Estuary, Long Island Sound, Boston Harbor, and Tampa Bay (SAIC, 1992c; SAIC, 1992d; SAIC, 1993b and SAIC, 1994b).

Methodology. Amphipod tests (5 replicates each) were conducted on surface sediments from 17 subtidal stations at Derecktor Shipyard/Coddington Cove, NETC and two reference stations at Jamestown Potter Cove and Castle Hill Cove. Amphipods were exposed to test sediments for 10 days under static conditions, following SAIC Environmental Testing Center (ETC) SOPs developed according to ASTM and EPA

procedures (ASTM, 1990 and U.S. EPA, 1994; Appendix B-1-1). Water quality parameters were monitored throughout the test; twice during each test, temperature, salinity, dissolved oxygen (DO), and pH were measured in two replicates selected through a computerized random and blind sampling process. In addition, samples were analyzed for ammonia in order to assess any potential toxic effects of ammonia under the static test conditions. Sediments were press-sieved and homogenized before placement into the test chambers, after which, sub-samples were collected for porewater ammonia analyses.

Performance control sediments were collected during May 1994 from the central Long Island Sound (LIS) reference stations of the U.S. Army Corps of Engineers (COE) New England Division. Sediments from this reference station have been used for the COE Disposal Areas Monitoring System, the Field Verification Program, and the EPA's EMAP Virginian Province Monitoring in 1990-1993. Sediments from this site are fine-grained (>90% silt-clay) and have an organic carbon content of about 2%. An extensive database has demonstrated the non-toxic nature of this sediment in solid-phase tests with *Ampelisca abdita.* The survival of *Ampelisca abdita* exposed to this collection of LIS sediment was consistent with all previous LIS collections used at the SAIC ETC (November 1989, May 1991, and August 1993). Performance control survival for 43 of the most recent tests performed at the SAIC ETC are presented in Appendix B-1-1.

Data analyses. Stations with a mean survival less than that of the LIS performance control were compared statistically to the control using a one-way, un-paired *t*-test (alpha=0.05) assuming unequal variance. An examination of a large historical data set from the ETC has shown that *Ampelisca abdita* percentage survival data meet the requirement of normality, therefore data were not transformed. Significant toxicity for *Ampelisca abdita* has been defined as survival statistically less than the performance control and $\leq$ 80% of the mean control survival (U.S. EPA, 1994).

Statistical power curves created from SAIC's extensive testing database with *A. abdita* show that the power to detect a 20% difference from the control is approximately 90%. Sites meeting both requirements (statistically different than the performance control and survival ≤ 80% of the control) were flagged.

Results. Data are summarized in Table 5.2-1 and are shown graphically in Figure 5.2-1. Mean performance control survival (not shown) ranged from 95 to 97%. Mean sample survival, normalized to performance controls, ranged from 70 to 103%. Mean survival at Stations DSY-27 and DSY-28 (i.e., 79 and 70%, respectively) was statistically different from the performance control and was <80% of the mean control survival. Complete data are presented in Appendix B-1-1.

Total ammonia was not elevated above the No Observed Effect Concentration (NOEC) at any of the stations tested. Unionized ammonia values in sediment porewaters during the amphipod test ranged from non-detected at several stations to 1.25 mg/L at Stations DSY-28. The unionized ammonia NOEC of 0.40 mg/L at pH 7.7 (U.S. EPA, 1994) was exceeded at four stations, DSY-25, DSY-28, DSY-29, DSY-38, and slightly at reference Station JPC-1. As Figure 5.2-2 illustrates, the reduced survival at Station DSY-28 was associated with an unionized ammonia concentration greater than three times the NOEC concentration, suggesting possible ammonia toxicity, although CoCs may also contribute to the toxicity at this station. Ammonia measured in the porewater from Station DSY-27 was 0.02 mg/L. Therefore, the significant toxicity response at DSY-27 (i.e. 79% survival) cannot be attributed to porewater ammonia.

In a previous study of Narragansett Bay, Rhode Island (Scott *et al.*, 1991), statistically significant amphipod toxicity was observed at four of 31 stations in the Providence, Seekonk, and Blackstone Rivers, of which the lowest had 69% survival. Observations of marginal toxicity despite high CoC concentrations were attributed to a

possible loss of test sensitivity because of flow-through exposure conditions during the performance of these tests, as opposed to the static system used in the current study.

5.2.2. Sea Urchin Fertilization Test Results

Background. The acute toxicity of elutriates prepared from Derecktor Shipyard/ Coddington Cove and Jamestown Potter Cove sediments was assessed in order to evaluate the bioavailability and biological effects of contaminants to benthic and water column organisms during resuspension events. This section discusses results of sediment elutriate toxicity tests using sea urchin (*Arbacia punctulata*) fertilization. This assay is used routinely by the U.S. EPA and by the National Pollutant Discharge Elimination System (NPDES) to determine ambient and effluent water quality, and to evaluate the effects of pollutants on aquatic life (U.S. EPA, 1988).

The purple sea urchin, *Arbacia punctulata*, exists along the North American east coast from Cape Cod to Florida. It adheres to rocks, or lives in widely separated aggregations on rocky and shelly bottoms. Its life cycle includes external fertilization and a period of planktonic embryo-larval development, followed by settlement and metamorphosis to the adult life stage. Sea urchin gametes are widely used for toxicological studies (Bay *et al.*, 1993).

Methodology. Sea urchin fertilization tests (2 replicates each) were conducted on elutriates of surface sediments from the same stations for which bulk sediment amphipod toxicity tests were performed (Table 5.2-1). Elutriates were prepared using a modified version of the methods described in the SOP in Appendix B-1-1, entitled "Preparation of Elutriates from Dredged Material Samples". Briefly, sediment and seawater were mixed (1:4), the suspended material was allowed to settle, and the supernatant was collected for testing.

The sea urchin fertilization test was conducted following ETC SOPs (SOP No. SCT-01, Appendix B-1-1), in accordance with U.S. EPA procedures (U.S. EPA, 1988). Four male urchins were placed in seawater in shallow bowls, and were stimulated to release sperm by touching the exoskeleton for about 30 seconds with steel electrodes attached to a 12 V transformer. Sperm were collected using a 1 mL disposable syringe fitted with an 18-gauge, blunt tipped needle. The sperm were held on ice and were used within 1 hr of release. Sperm were then diluted with seawater to a concentration of 5×10^7 sperm cells/mL.

Four female urchins were placed in seawater in shallow bowls, and were stimulated to release eggs in the same manner as for male urchins. Eggs were collected with a syringe and held in seawater at room temperature for up to two hours with aeration. The eggs were washed with seawater three times by gentle centrifugation (500xg) for three minutes in a conical centrifuge tube. The eggs were diluted with seawater to a concentration of 2,000 eggs/mL and were aerated until used.

One mL suspensions of eggs and sperm from each of two replicates were transferred to a Sedgwick-Rafter counting chamber. Using a compound microscope (100X), one hundred eggs were examined for fertilization, indicated by the presence of a membrane surrounding the egg. When data varied by more than 10%, a third replicate was examined. The performance control, natural seawater (NSW), was collected daily from lower Narragansett Bay during an incoming tide, and passed through a .45 µm filter. Performance control data for the 35 most recent tests performed at the ETC are presented in Appendix B-1-1 (in this test, fertilization results for *Arbacia* exposed to NSW were consistent with all previous NSW collections at the ETC since 1990).

Data Analysis. The number of fertilized eggs per 100 were recorded and the data statistically analyzed. Stations with mean fertilization less than that of the natural

seawater (NSW) performance control were compared statistically to the control using a two-sample, one-way, unpaired Student's *t*-test (alpha=0.05), assuming unequal variance. This procedure tests the hypothesis that the fertilization mean for the NSW control and the elutriate sample are equal. Samples were evaluated for statistical significance (p=0.05), as well as potential ecological impact.

Results. Data are summarized in Table 5.2-1. The mean fertilization in the NSW performance control, which was used to normalize the field data, ranged from 95% to 97%. Site fertilization (after normalization to performance control fertilization) ranged from 89% at Stations DSY-32, DSY-34, and DSY-39 to 103% at Station DSY-26. Fertilization was not statistically different from the NSW performance control at any of the site or reference stations. Complete results are presented in Appendix B-1-1.

5.2.3. Sea Urchin Larval Development Test Results

This section discusses results of sediment elutriate toxicity tests using sea urchin (*Arbacia punctulata*) larval development. Results were assessed as discussed for the sea urchin fertilization test. In the sea urchin larval development test, however, the endpoint evaluated was the abnormal and/or under-development of the pluteus larva stage of *Arbacia*, formed after fertilization of the egg. The development response was measured in each of three dilutions (100%, 50%, and 10%) of elutriate per station/ sample. The use of multiple dilution series provides information which can be used to assess the overall toxic potency of the preparation, by developing a point estimate of the Effect Concentration (EC) which causes a given percent reduction in development (e.g., IC_{10}, the estimated concentration at which a 10% reduction in normal larval development will occur).

Methodology. Development tests (3 replicates each) were conducted on elutriates of surface sediments from the same stations for which bulk sediment tests

and sea urchin fertilization tests were performed (Table 5.2-1). Elutriate dilutions of 10%, 50%, and 100% were tested in conjunction with an NSW performance control.

The larval development test was conducted in accordance with modified U.S. EPA procedures (Mueller *et al.*, 1992). Sperm and egg suspensions were prepared as described above for the fertilization test, then mixed to a final concentration of 1:2000 egg:sperm ratio. After 20 minutes, 1 mL of fertilized egg suspension was added to 200 mL of elutriate sample in each of three replicates and incubated for 48 hours at 20 ± 1°C. Following the 48 h incubation period, two 10-mL sample replicates were collected from each chamber and placed in scintillation vials. The test was terminated by adding 2 mL of 5% buffered formalin with rose bengal to each vial. Using a compound microscope (100X), the entire contents of each vial was examined for abnormal or under-developed pluteus larva.

Data Analysis. Treatments in which 100% larval normality was observed, or in which percent normality was equal to or higher than the NSW control treatment, were not statistically evaluated since there existed no indication of adverse effects attributable to the elutriate sample (U.S. EPA/U.S.ACE, 1991). Stations with mean abnormal larva counts higher than that of the NSW performance control were compared statistically to the control, following the same statistical procedures used for the fertilization test results. Linear interpolation was used to calculate the IC_{10}s (a point estimate of the concentration that would cause a 10% reduction in normal development) of samples. Statistically significant responses were flagged, as indicated in Table 5.2-1.

Results. Results of the larval development assay are presented graphically in Figure 5.2-3, and spatial distribution of sea urchin elutriate toxicity is presented in Figure 5.2-4. The occurrence of abnormal larvae in the NSW performance control ranged from 5 to 17%. Statistically significant reductions in normal development

relative to the control ranged from 10 to 100%, and were observed in one or more of the dilutions of 13 of the 19 sediments (DSY-25, DSY-26, DSY-28, DSY-29, DSY-31, DSY-32, DSY-33, DSY-36, DSY-37, DSY-38, DSY-39, DSY-40, and DSY-41) tested (Appendix B-1). IC_{10} values, measured in percent elutriate dilution, were calculated for these 14 stations where responses were noted. IC_{10} values decrease as toxicity of the sample increases; thus, IC_{10} = 3.34% at Station DSY-28, IC_{10} = 8.91% at Station DSY-26, and IC_{10} = 9.35% at Station DSY-29 indicate highly toxic samples in which relatively low concentrations of elutriate are able to induce a response. Conversely, IC_{10} >100% at Station JPC-2 indicated the least toxic samples, where elutriates were able to induce a toxic response only at very high elutriate concentrations or not at all. The spatial pattern of IC_{10} values generally indicated low IC_{10} values (potential high toxicity) at near shore stations, and increasing IC_{10} values (reduction in potential toxicity) with distance from the harborfront.

Unionized ammonia concentrations are presented in Table 5.2-1 and are shown graphically in Figure 5.2-5. Until recently, a benchmark value for unionized ammonia applicable to sea urchin development testing had not been available. New data indicate NOEC and LOEC unionized ammonia values of .037 and .090 mg/L, respectively (Carr *et al.*, 1996). This would suggest, based on the LOEC value, a potential response to ammonia during elutriate exposures for Station DSY-28.

5.3. Biological Field Investigations

5.3.1. Infaunal Distribution and Abundance

Benthic organisms at subtidal stations within Coddington Cove and at reference stations were sampled in order to describe the benthic community structure and detect potential effects of environmental stress related to Derecktor Shipyard activities.

Examination of gradients within the study area, comparisons with the Jamestown Potter Cove reference locations, and results of historical studies were used as a basis for the assessment. Background for the interpretation of the condition of Coddington Cove subtidal habitats is provided by recent surveys of the East Passage and Narragansett Bay (City of Newport, 1985; French *et al.*, 1992c) and by the studies carried out at the McAllister Point Landfill (SAIC and URI, 1995). In this section, the focus is primarily on the description of benthic communities; an analysis of potential CoC-related impacts is discussed in Section 6.5.

5.3.1.1. Infaunal Assessment Methods

Sample collection and enumeration. On four collecting trips between September 27 and October 26, 1995, duplicate 0.05 m^2 grab samples for benthic invertebrate identification were taken at the same 17 stations designated for surface sediment sampling within Coddington Cove (Figure 3.6-1), as well as two stations within Potter Cove, Jamestown, Rhode Island. The locations of previous surface sediment sampling stations were marked by floats so as to facilitate revisiting each station without precision navigation equipment. Depth of sampler penetration was recorded as distance from the sediment surface to the top of the grab. Depth of the oxidized sediment zone was measured in a core subsample taken from one grab per station.

Samples were sieved to 0.5 mm, preserved, and organisms removed and identified. Notes were made of the size distribution of key species, and specimens were archived for possible additional taxonomic determination/verification, histopathology, and population analysis. Damaged or immature specimens which were difficult to identify were entered as known species or combined in more inclusive taxa to simplify interpretation of changes in species number.

Habitat Classification. Prior to the inspection of data for possible site-related shifts in benthic community composition, it is imperative to ensure that natural factors governing benthic characteristics, namely grain size, are considered. The grain size data discussed previously (Section 4.2 and Figure 4.2-1) indicates that, of the 17 Coddington Cove stations sampled for benthic community analysis, the sediments from ten of the stations are predominantly silt/clay (defined here as ≥ 60% silt-clay). Another Coddington Cove station (DSY-37) has about 50% sand, whereas the six remaining Coddington Cove stations and the reference Station JPC-1 are predominantly sand (defined as ≥ 70% sand). As discussed in Section 4.2, the sandy sediments are found along the shore in the northern and southern parts of Coddington Cove (Stations DSY-25, DSY-26, DSY-35), west of the piers (Station DSY-33), within the Derecktor inner dock (Stations DSY-40 and DSY-41), and in Jamestown Potter Cove (Reference Station JPC-1). Coddington Cove Station DSY-37 and Jamestown Potter Cove Reference Station JPC-2 are considered "intermediate" stations in terms of sediment grain size, having silt-clay content between 30% and 60%.

In this study, two complimentary multivariate techniques, clustering and non-metric multi-dimensional scaling (MDS), were used to provide an "exploratory" analysis of variation in benthic community data with respect to sediment grain size distribution. Clustering is a statistical technique used to classify (cluster) the stations into mutually-similar groups based on benthic community composition and species abundance. MDS attempts to provide an ordination, or "map", of the stations such that distances between stations reflect corresponding (dis)similarities in benthic community structure: nearby stations on the map have similar communities, while those that are far apart have few species in common or have the same species at different levels of abundance or biomass. Like the cluster analysis, non-metric MDS ordination (Kruskal and Wish, 1978) is performed on a similarity matrix derived from species abundance data (Clarke and Green, 1988; Clarke, 1993), using the Bray-Curtis similarity index (Bray and Curtis, 1957).

For the present analysis, a decision was made to apply the double square root transformation to the abundance data prior to clustering and MDS to downweight the contribution of the most abundant species while increasing the contribution of rarer species in assessing the degree of similarity among samples. The net effect of employing this transformation is to provide a more in-depth multivariate comparison of the benthic communities among stations, as opposed to the shallower comparison which would result if only the most abundant species were allowed to dominate the assessment.

Counts for all species in all samples are given in Appendix B-1-1. In the dendogram resulting from the cluster analysis (Figure 5.3-1), six "groups" of stations can be distinguished at the 40% similarity level:

1. a group consisting of Stations DSY-27, DSY-28, DSY-30, DSY-31, DSY-32, DSY-34, DSY-36, DSY-37, DSY-38, DSY-39, and JPC-2.
2. a group consisting of Stations DSY-26, DSY-33, and JPC-1.
3. a group consisting of Stations DSY-25 and DSY-41.
4. Station DSY-29.
5. Station DSY-35.
6. Station DSY-40.

The two-dimensional MDS ordination (Figure 5.3-2A) shows a grouping of stations which is highly consistent with the results of the cluster analysis. These MDS results provide independent confirmation that in terms of overall benthic community structure, the sampled stations fall into the six distinct "groups" or clusters defined above. In two-dimensional MDS, the "stress" value provides a measure of whether or not a given plot provides a usable summary of the sample relationships. As a rule of thumb, a stress value equal to or less than 0.05 indicates that the two-dimensional plot provides an excellent representation of sample relationships, with no prospect of

misinterpretation, whereas a stress value > 0.3 indicates that the position of the plotted points are nearly arbitrary. The stress value of 0.05 for the two-dimensional MDS plot in Figure 5.3-2 indicates that this is a reliable and useful representation of patterns in benthic community structure among the stations sampled in this study.

Following the clustering and MDS ordination, an analysis was performed to select the measured environmental variable or combination of variables (e.g., grain size, TOC, water content) which best explain the observed benthic community patterns. This analysis was based on maximizing a rank correlation between the benthic and environmental variable similarity matrices, as described in Clarke and Ainsworth (1993). The analysis showed that sediment grain size alone was the variable which best explained the benthic community patterns (rank correlation, $\rho_w = 0.54$).

Figure 5.3-2B helps to illustrate the strong influence of sediment grain size in explaining the observed similarities and differences in benthic communities among stations. With the exception of Station DSY-29, all of the silt-bottom stations (silt-clay content $\geq$ 60%) had a 50% similarity in their benthic community structure, while the sand-bottom stations (silt-clay content < 30%) had benthic communities which were both distinctly different from the silt-bottom communities and, for the most part, different from each other (Figure 5.3-2B). Sand-bottom Stations DSY-25 and DSY-41 had similar communities, and the communities found at sand-bottom Stations DSY-26, DSY-33 and JPC-1 were also similar (but different from those at Stations DSY-25 and DSY-41). Sand-bottom Stations DSY-35 and DSY-40 and silt-bottom Station DSY-29 were characterized by communities which were different from all other stations (Figure 5.3-2A and 5.3-2B). The two stations with "intermediate" grain size, DSY-37 and JPC-2, had benthic community structure which was similar to that found at the silt-bottom stations (i.e., both DSY-37 and JPC-2 cluster together with the silt-bottom stations (except DSY-29) in Figure 5.3-2A and 5.3-2B). Therefore, these two stations

are considered as silt-bottom stations in further discussions of benthic community patterns.

The above analyses confirm that silt-bottom and sand-bottom benthic communities have distinct structures, with greater variability in community structure among the sand-bottom stations. Hence, the silt-bottom and sand-bottom community types are discussed separately in the following sections so as to better elucidate potential influences from Derecktor Shipyard on the benthic communities.

Metric Selection. A wide variety of metrics are often used in benthic assessments for pollution-related impacts. In the present investigation, seven metrics were selected, including 1) Total Species Observed, 2) Total Individuals Observed, 3) Percent Dominant Taxa, 4) Margalef Species Richness, 5) Shannon-Weiner Diversity, 6) Pielou's Evenness, and 7) the Bray-Curtis Similarity Index. The calculation of Total Species Observed was derived from the full benthic data set. Total Individuals Observed is the sum of abundances for the twenty most common species, calculated separately for silt and sand habitats. Percent dominant taxa was calculated as the ratio of the abundance found for the most abundant species (i.e. dominant) to the total abundance for the twenty most common species. The species richness, diversity and evenness metrics were calculated based on the full benthic data set using PRIMER (1988). Further description of the calculation and function of these metrics is presented in EPA *Rapid Bioassessment Protocols* (U.S.EPA, 1989e).

The Bray-Curtis Similarity Index values represent the percent similarity between the station of interest and the corresponding reference site for the twenty most common species in each habitat type. This community structure metric involves a hierarchical, agglomerative clustering procedure performed on a similarity matrix derived from double square root transformed species abundance data (Bray and Curtis, 1957; Clarke, 1993).

Benthic Community Assessment Protocols. A quartile-based, four-level scoring scheme for evaluation of habitat and metric-specific data was developed following EPA Rapid Bioassessment Protocols (U.S. EPA, 1989e). Calculated quartiles, based on the range of data for a specific metric, divide the distribution of data into equal "quarters", defined as the 25th, 50th, and 75th percentiles. Separate scoring schemes were developed for silt- and sand-bottom habitats. In general, habitat-specific quartiles were calculated for site data, based on the station-specific metric value expressed as a percent of that obtained at the corresponding silt or sand reference location. Exceptions were Percent Dominant Taxa, which was evaluated as the actual percent contribution, and not as the percent comparability to reference location per EPA guidance (U.S. EPA, 1989e), and the Bray-Curtis Similarity index, where a comparison to reference is already incorporated into the metric. Furthermore, the calculated quartile for the "Total Individuals" metric may be unreliable for stations at which total individuals observed were less than 100 (Stations DSY-29 and DSY-40).

Calculated quartiles for each metric are presented in Table 5.3-1. Each habitat/station/metric-specific value was assigned a number of "points" based on its relation to the appropriate quartile distribution (U.S. EPA, 1989e); those values included in the first or lowest quartile were assigned 0 points (<25th percentile), values in the second quartile (25th - 50th percentile) were assigned 2 points, values in the third quartile (50th - 75th percentile) were assigned 4 points, and values in the highest or fourth quartile (>75th percentile) were assigned 6 points.

Quartile values for overall benthic metric ranking for each habitat (silt and sand) are incorporated into Table 5.3-2. Quartile distributions were calculated on the overall metric ratios for each habitat. Input data consisted of the ratio of the sum of points for each station to total possible points (i.e., 42). Based on the overall habitat-specific quartile distribution, each station was assigned a benthic metric ranking as follows:

stations included in the first quartile = "+++", second quartile = "++", third quartile = "+", and fourth quartile = "-".

5.3.1.2. Infaunal Community Assessment Results

Description of the silt-bottom faunal community. Silt-bottom habitats (<40% sand) of Coddington Cove were observed to extend from well outside the cove (Stations DSY-37, DSY-38 and DSY-39) to the harborfront (DSY-27, DSY-28 and DSY-29), near the piers (DSY-30, DSY-31 and DSY-32), but also to northern and southern mid-cove areas (DSY-34 and DSY-36; Figure 4.2-5). The extension of silt habitat into shore is a reversal of the usual pattern observed in Narragansett Bay proper and at the Jamestown Potter Cove reference area, where sediments closer to shore typically increase in grain size and decrease in both water content and organic content as influences from shoaling, freshwater input and anthropogenic influences are enhanced. Construction of the Coddington Cove breakwater and piers has been shown to greatly impact hydrographic patterns and sediment deposition patterns. In the absence of these structures, the benthic habitat of Coddington Cove would most likely be characterized by a much higher sand content.

The silt-bottom benthic community assemblage of Coddington Cove is recognizable as being related to that found in deep silt-clay habitats in Narragansett Bay proper, Long Island Sound, Buzzards Bay and extending onto the near-shore continental shelf. This group of organisms was named the *Nephtys-Nucula-Yoldia* community by Sanders (1956). In general, the bivalves were most abundant, followed by polychaetes, then gastropods (Table 5.3-2A). The small bivalve *Nucula annulata* was the overwhelming numerical dominant in the silt-bottom sediments of Coddington Cove, accounting for over 90% of the total abundance at Station DSY-39, whereas the polychaete *Nephtys incisa* appeared to be the biomass dominant. The second most abundant species was the small polychaete *Mediomastus ambiseta*. Sub-dominants

included the polychaete *Ninoe nigripes*, the small gastropods *Acteocina canaliculata*, *Nassarius trivittatus* and *Cylichnella oryza*, and the bivalves *Macoma tenta, Mulinia lateralis*, and *Yoldia limatula.*

The silty, unconsolidated nature of sediments throughout the cove could be the result of either anthropogenic or physical processes, however, biological processes may also play a role in perpetuating this condition. Rhoads and Young (1970) concluded that reworking of silty sediments by high densities of deposit feeders could produce a high water-content surface easily suspended by currents. This could clog the filtering mechanisms of suspension feeders and prevent attachment of sessile epifauna. The density of deposit feeders observed in Coddington Cove is within the range reported by Rhoads and Young (1970) to exert this effect.

Although the composition and abundance of silt-bottom fauna in most of Coddington Cove is relatively uniform, some of the dominant species do show spatial gradients. The bivalve *Nucula* was found at densities exceeding 1000 individuals per sample offshore, but less than 100 per sample in comparable sediments of inshore areas (Figure 5.3-3). An increase in density offshore is consistent with the apparent general preference of this species for higher salinity and lower temperature. In Narragansett Bay, *Nucula* is most abundant in the lower East Passage where such conditions occur (French *et al.*, 1991).

In contrast to *Nucula*, the polychaete *Mediomastus ambiseta* was more abundant in the fine-grained sediments of the central portion of the study area (Figure 5.3.4). In Narragansett Bay proper, *Mediomastus* is found at highest densities in the Upper Bay (French *et al.*, 1991) a trend attributed to the preference/tolerance of this species for a wider variation in salinity, temperature, and water quality and the ability to better utilize high levels of organic matter.

Mediomastus is a head-down deposit feeder which ingests sediment at the bottom of a lined burrow and deposits pellets on the surface. Numerous tiny tubes of *M. ambiseta* were seen at the surface of central and inner Cove samples. This "conveyor belt" feeding type can produce high rates of vertical mixing. The oxidized zone of nearshore samples was 2 cm with distinct discontinuity, most likely indicating the depth of burrowing of this species.. In contrast, the bivalve *Nucula*, the nereid worm *Nephtys incisa*, as well as many of the polychaete species, ingest sediments on, or within a few millimeters of the sediment surface, hence they have relatively less influence on sediment oxygenation. The depth of the oxidized zone in most of the outer cove samples was 3-5 cm, suggesting that sediment re-oxygenation is at least in part controlled by bioturbation.

Four species characteristic of silty sediments, including the bivalves *Nucula annulata* and *Macoma tenta*, the polychaete *Mediomastus ambiseta*, and the nereid worm *Nephtys incisa,* were found to be among the four most abundant and frequently observed (>67% of the time) at the silt-bottom stations in Coddington Cove (Figure 5.3-5). Notable exceptions included the lack of these species at Station DSY-29 and absence of *Macoma* from Stations DSY-30, DSY-32 and DSY-38. Sediments of Station DSY-29 were observed to contain drift algae, concrete fragments, cordage and wire; constituents which were not observed for other stations in Coddington Cove. These potential indications of anthropogenic impacts will be revisited in Section 6.5, where possible CoC-related effects are discussed.

Several species known to be capable of very deep burrowing in silt-bottom habitats and also found in Narragansett Bay include the polychaete *Sabaco (Asychis) elongatus*, with tubes up to 80 cm long, and the mantis shrimp *Squilla empusa*, which burrows 3 meters deep. *Squilla* tubes were not observed in Coddington Cove samples. *Sabaco* tubes were seen in just a few Coddington Cove samples but, based on their

density, this species is expected to play only a minor role in bioturbation relative to the species discussed above.

Analysis of the silt-bottom community metrics. Mean total species and mean total individuals observed for silt-bottom stations in Coddington Cove were 15.4 and 966, respectively, versus 21 and 392 for the same parameters at the Jamestown Potter Cove Reference Station JPC-2 (Table 5.3-2A). While the overall reduction in total species may be attributed to shipyard-related impacts, the trend may also be explained by a lack of habitat diversity to support suspension feeders and/or other motile epifaunal species. The JPC-2 reference station had markedly lower silt-clay content than the silt-bottom stations in Coddington Cove, and the relative variety of sediment grain sizes and surface features at Station JPC-2 would favor the presence of both suspension- and deposit-feeding infaunal species. As a result, there was a greater number of species sampled, even though many of the epifaunal forms are represented by only a few individuals. Based on the quartile distribution analysis, total species observed for Stations DSY-27, DSY-29 and DSY-32 were in the 1st quartile (bottom 25th percentile) group, indicating the greatest departure from the reference condition. Total individuals observed for Stations DSY-29, DSY-30 and DSY-34, and percent dominant taxa for Stations DSY-29, DSY-36 and DSY-39 were also in the 1st quartile group. The richness, diversity, and evenness metrics were generally in agreement and suggested greatest reductions relative to reference at Stations DSY-27, DSY-29, DSY-32, DSY-36, DSY-38, and DSY-39. Bray-Curtis Similarity values for Stations DSY-28, DSY-29, and DSY-32 were in the 1st quartile group, and thus most dissimilar relative to the reference location benthic community structure.

Applying the overall silt benthic metric ranking criteria, identified in Table 5.3-1, the data presented in Table 5.3-2.A suggest a high probability of impacts at Stations DSY-27, DSY-29, and DSY-32, intermediate impacts for Stations DSY-36, DSY-38, and DSY-39, and a low probability of impacts at Stations DSY-28, DSY-30 and

DSY-34. Impacts are not apparent for benthic communities at Stations DSY-31 and DSY-37.

Description of the sand-bottom faunal community. The sand-bottom communities were characterized as those stations having sediments with >70% sand content. As discussed in Section 4.2, sand-bottom habitats were generally found along the inner perimeter of Coddington Cove, but also occurred in the central cove area east of the northern pier extending towards the breakwall and continuing offshore into deeper water. As sand is the primary habitat of lower Narragansett Bay, the observed lithology was expected. Sand sampling stations for benthic community analysis included locations along shore in the northern and southern parts of the Cove (Stations DSY-25, DSY-26, DSY-35), west of the piers (Station DSY-33), within the Derecktor enclosure (Stations DSY-40, DSY-41), and in Jamestown Potter Cove (JPC-1).

Organisms which numerically dominated the benthic community and which were also found exclusively at the sand-bottom stations included the polychaetes *Aricidae catherinae, Glycera americana*, *Montocellina baptistae* and *Macroclymene zonalis*, *Oligochaeta* spp., the bivalve *Gemma gemma*, and the amphipod *Photis pollex*. Species common to silt-bottom communities also were found, but at lower densities than in their preferred habitat. With the exception of *Glycera*, none of these sand species were observed at Stations DSY-40 and DSY-41.

The distributions of four invertebrate species which were numerically-dominant at sand-bottom stations in Coddington Cove are shown in Figure 5.3-6. The data show that *Glycera*, *Mediomastus*, *Nucula* and oligochaetes were conspicuously absent from Stations DSY-25 and DSY-41. Anoxic sediments were found at Station DSY-25, apparently due to a thick layer of decomposing algae (*Ulva*) which covered the rock and sand bottom. Consequently, only a few organisms were found at this station, none of

which were among the numerical dominants found elsewhere in Coddington Cove (Table 5.3-2B).

The oxygenated layer (apparent redox-potential discontinuity depth) was relatively thin at Stations DSY-41 (0.5 to 1 cm) and DSY-40 (0.2 cm), pointing to excessive organic enrichment as a possible explanation for the differences in benthic community structure observed at these stations. In contrast to Stations DSY-25, DSY-40 and DSY-41, oxygenated sediments to 2-3 cm were observed at the other sand-bottom stations and at reference Station JPC-1. The unique benthic community structure at Station DSY-35 is due primarily to the absence of *Nucula* and the presence of the bivalve *Gemma gemma* and the polychaetes *Spiophanes bombyx* and *Tharyx crochet*; these latter three species were not found at any of the other sand-bottom stations. Station DSY-35 had the highest sand content of all those sampled (99%), and the polychaete *Spiophanes bombyx* in particular is known to require high sand content for construction of its distinctive surface tubes. In addition, *Gemma gemma* is known to favor sandy sediments in the intertidal zone; Station DSY-35 is uniquely located in the intertidal zone of southern Coddington Cove. Thus, habitat variables appear to be responsible for the unique benthic community found at Station DSY-35.

Analysis of the sand-bottom community metrics. The mean total species and total individuals observed for the six sand-bottom stations in Coddington Cove were 10.8 and 168.5 respectively, as compared to 39 and 450 for the same metrics at Jamestown Potter Cove Reference Station JPC-1 (Table 5.3-2B). As a result of defaunated conditions at Stations DSY-25 and DSY-41, total species and total individuals ranked in the 1st quartile (i.e. <25%). Percent dominant taxa for Station DSY-35 ranked in the 1st quartile group, although the range of values for this metric (0.26 - 0.31) was quite low. Species richness and diversity at Station DSY-40 and evenness at Station DSY-33 were also in the 1st quartile among sand stations. Of the six Coddington Cove sand-bottom stations, Stations DSY-25 and DSY-41 were devoid

of macrofauna and hence most dissimilar (Bray-Curtis similarity index = 0%). Station DSY-40, while not defaunated, was found to contain only seven species, and abundance was just 12% of the reference value. While metrics for Station DSY-35 benthic community were below those for other sand-bottom stations, this station was not as highly impacted as Stations DSY-25, DSY-40, and DSY-41. Applying the overall sand benthic metric ranking criteria, identified in Table 5.3-1, the data presented in Table 5.3-2.B suggest a high probability of impacts at Stations DSY-25 and DSY-41, intermediate impacts at DSY-40, and a low probability of impacts at Station DSY-35. Impacts are not apparent for benthic communities at Stations DSY-26 and DSY-33.

Summary of benthic community impacts. The above stations with overall benthic metric rankings in the 1st quartile (i.e., Stations DSY-25, DSY-27, DSY-29, DSY-32 and DSY-41) represent the most likely locations for potential benthic community impacts linked to CoCs from Derecktor Shipyard. These results are carried forward to effects summary assessment discussed in Section 6.6 (Table 6.6-2). Additional stations which might have intermediate impacts include Stations DSY-36, DSY-38, DSY-39 and DSY-40, while the remaining Coddington Cove stations have low impact or baseline condition. It should be noted that a conservative weight of evidence approach was taken in the overall assessment of benthic impacts, in that a departure from reference is assumed to be indicative of CoC-related adverse environmental effects, which may increase the likelihood of "false positives", e.g. assumption of impact when in fact impact has not occurred. Reference locations are considered to be adequately representative of conditions not impacted by the site, as indicated by the low CoC concentrations measured in sediments and tissues at these locations during this study. Thus, exposure-response relationships between CoC concentration and patterns of benthic community structure are further evaluated, with particular attention paid to the most affected stations, in Section 6.5 to validate the above interpretations.

5.3.2. Bivalve Condition Indices

The health of bivalve mollusks under varying environmental conditions has often been evaluated using measures of condition indices, growth rate, and survival rate (Brown and Hartwick, 1988). While biotic condition indices derived from allometric relationships were developed primarily for detecting the ecophysiological health of organisms in aquaculture settings (e.g. Lucas and Benninger, 1985), their use has become more common in water quality monitoring programs (Lawrence and Scott, 1982).

Lucas and Benninger (1985) and Mann (1978) recommended the use of the ratio of dry tissue weight to dry shell weight as an index, where low index values are indicative of energy deficits resulting from environmental stress. The ratio of dry tissue weight to shell volume (calculated from length) has also been proposed as a condition index, because the proportion of internal shell body occupied by tissue should reflect the status (related to fitness) of a bivalve's metabolic reserves (Brown and Hartwick, 1988). Also, the ratio of shell weight to shell length indicates shell thickness; enhanced shell thickness is interpreted as an indication of stunted shell growth resulting from crowding or other environmental influences.

The biotic condition of both deployed and indigenous blue mussels (*Mytilus edulis*) was examined as part of the Derecktor ERA. Measurements and subsequently calculated indices of biotic condition were compared to chemical, biological and toxicological measurements in order to evaluate the likelihood that stressors related to Derecktor Shipyard are causing adverse ecological impacts.

5.3.2.1. Methods

Collection and Deployment. Indigenous mussels were collected by hand from Derecktor Shipyard and reference locations from October 1 through November 5, 1995. Indigenous mussel sampling stations included nine intertidal stations in Coddington Cove (Stations DSY-24, DSY-25, DSY-26, DSY-27, DSY-28, DSY-29, DSY-35, DSY-36, DSY-40), and two reference stations, located at Potter Cove, near the Town of Jamestown on Conanicut Island (JPC-1), and Castle Hill Cove, off southern Aquidneck Island (CHC-1; Figure 3.6-2).

Blue mussels used in the deployment study were collected from a tidal creek connected to Cape Cod Bay, near East Sandwich, Massachusetts. This site is routinely used as a source of mussels for the U.S. EPA Biomonitoring Program, and is known to be relatively toxin-free (Nelson *et al.*, 1988). Approximately 2,000 mussels were collected. From this population, two hundred mussels were sorted by size (5.0-5.3 cm length), numbered on the shell with a diamond etching tool, and measured to the nearest 0.01 cm with vernier calipers. The selected length range (5.0-5.3 cm) represents animals young enough to permit appreciable growth during the deployment period, yet large enough to provide sufficient tissue biomass for chemistry analysis.

Twenty-five mussels, including five numbered mussels, were placed in polyethylene mesh bags. Four replicate bags per station were prepared. Each bag was attached to a float and mooring block such that the bag would remain suspended approximately 1 meter above the bottom. The float/mooring assembly was connected in series to form a trawl. Each trawl had additional line on each end for connection to surface marker floats. The trawls were then deployed, one trawl per station, from October 2-3, 1995 at eight stations in Coddington Cove (Stations DSY-26, DSY-28, DSY-29, DSY-31, DSY-33, DSY-38, DSY-39, DSY-40), as well as two reference stations (CHC-1, JPC-1). Figure 3.6-6 indicates the location of deployment stations in

Coddington Cove. An additional set of 25 mussels, including 20 from the numbered and measured population, were set aside for chemical and biological measurements according to approved SOP procedures. This set is referred to as "time zero" mussels, the data from which are intended for comparison against chemical and biological results for the deployed mussels. On graphs and in tables, results for time zero mussels are indicated by number T_0-DM.

Approximately half way through the thirty day deployment period, the trawls were hauled from the water to check the overall condition and mortality of the mussels, and then returned to the water. During this interim assessment, three of the trawls (DSY-31, DSY-33 and DSY-38) were found to have been dragged (maximum of approximately 30 feet) from their original deployed positions (presumably by boat traffic) and were repositioned. Deployed trawls were removed for final analysis on November 1, 1995.

Analysis. Following the collection of indigenous and deployed mussels, the length, tissue wet weight, tissue dry weight and shell weight were recorded. The ratios of dry Tissue Weight to Shell Length (CI-TW/SL), dry Tissue Weight to Shell Weight (CI-TW/SW), and Shell Weight to Shell Length (CI-SW/SL) were then calculated for use as indices of mussel condition.

For the indigenous mussels, the mean parameter values for a station were calculated using all mussels collected at the station (e.g., n=1). For deployed mussels, the mean values were calculated in two steps: first, the means of five individuals in each trawl bag were averaged, and then the mean of individual bags (n=4) for each station was obtained. Mortality (i.e., the number of dead mussels/total mussels) was also recorded. Biotic index calculations were not performed for moribund individuals.

5.3.2.2. Results and Discussion

A summary of the results for indigenous and deployed mussel measurements, condition indices and mortality is presented below.

Indigenous Mussels. Figure 5.3-7 shows the mean parameter results ± standard error. The horizontal dashed line on each graph indicates the mean of the two reference station values. Average indigenous mussel length for the two reference stations differed by approximately 10%, from 45.0 mm at Station JPC-1 to 49.6 mm at Station CHC-1 (Figure 5.3-7A).

The highest mean shell length was 50.7 mm (DSY-40), 14% higher than the lowest mean value of 44.4 mm (DSY-26, DSY-36). Values for four of the assessment stations (DSY-26, DSY-27, DSY-28, DSY-36) were slightly below the lower limit of the range of reference station values. Values for Stations DSY-24, DSY-25, and DSY-35 were within the reference station range, and Station DSY-40 had an average length slightly above the upper limit of the reference station range.

Average mussel shell weight for the two reference stations differed by 53%, from 5.7 g at Station JPC-1 to 8.7 g at Station CHC-1 (Figure 5.3-7B). The highest mean shell weight (7.5 g at Station DSY-25) was almost two-fold (93%) higher than the lowest value (3.9 g at Station DSY-28). Average shell weight values for Stations DSY-24, DSY-25, DSY-35, and DSY-40 were within the range of the reference values, while the remaining station weights were below the lowest average reference value.

Average mussel tissue weight for the two reference stations differed by 16%, from 0.46 g at Station CHC-1 to 0.54 g at Station JPC-1 (Figure 5.3-7C). The highest mean weight was 0.60 g at Stations DSY-27, 73% higher than the lowest mean value of 0.35 g at Station DSY-28. Average tissue weights for Stations DSY-25 and DSY-27

were above the upper limit of the reference value range, while the tissue weights from the remaining stations were below the lower limit of the reference range, varying from 75% to 95% of the lowest average reference station value.

Average mussel Shell Weight to Shell Length ratio (CI-SW/SL) for the two reference stations differed by 36%, from 0.117 g/mm at Station JPC-1 to 0.159 g/mm at Station CHC-1 (Figure 5.3-7D). The highest assessment station value (0.144 g/mm at Station DSY-25) was 82% greater than the lowest value (0.079 g/mm at Station DSY-28). The average CI-SW/SL values for Stations DSY-24, DSY-25, and DSY-40 were within the range of the average reference values, while the remaining station values were appreciably below the lowest average reference value.

Figure 5.3-7D shows that three of the six stations closest to Derecktor Shipyard piers and shore installations had the lowest values for indigenous mussel CI-SW/SL (DSY-26, DSY-27, and DSY-28). Stations DSY-24 and DSY-35, located on the Coddington Cove shoreline, and the reference Stations JPC-1 and CHC-1, were found to have higher CI-SW/SL values relative to these stations. However, Stations DSY-24 and DSY-35 were also located farther away from the main shipyard activities.

The average Tissue Dry Weight to Shell Length (CI-TW/SL) values for indigenous mussels at the two reference stations differed by 22%, from 0.009 g/mm at Station CHC-1 to 0.011 g/mm at Station JPC-1 (Figure 5.3-7E). The highest mean value (0.0125 g/mm at Station DSY-27) was approximately 82% greater than the lowest value (0.0065 g/mm at Station DSY-28).

Average CI-TW/SL values for Stations DSY-24 and DSY-36 fell within the reference station range. The mean values for Station DSY-25 and DSY-27 were higher than the upper limit of the reference value range, whereas values for Stations DSY-26, DSY-28, DSY-35 and DSY-40 were below the lowest reference station average.

Figure 5.3-7E also shows that although a large degree of variation in index values for stations close to the shipyard is apparent, there exists an apparent trend of increasing CI-TW/SL value with distance from the shipyard.

Average station values for Tissue Dry Weight to Shell Weight (CI-TW/SW) for indigenous mussels at the two reference stations differed by approximately 67%, ranging from 0.057 g/mm at Station CHC-1 to 0.095 g/g at Station JPC-1 (Figure 5.3-7F). The highest CI-TW/SW mean value (0.158 g/g at Station DSY-27) was greater than two-fold higher (132%) than the lowest value (0.068 g/g at Station DSY-40). All stations except Station DSY-27 had CI-TW/SW values that fell within the narrow range of reference CI-TW/SW values. The CI-TW/SW for Station DSY-27 was more than two-fold higher than both reference stations. It is also noteworthy that the reference station CHC-1 had the lowest index.

Deployed Mussels. Figure 5.3-8 shows the mean parameter results ± standard error for deployed mussels. The horizontal dashed line on each graph indicates the mean of the two reference station values.

Time zero (T_0) average deployed mussel shell length was 51.3 mm. Average mussel shell length following deployment for the two reference stations differed by only 0.9%, ranging from 52.4 mm at Station CHC-1 to 52.9 mm at Station JPC-1 (Figure 5.3-8A). The highest mean length of 57.96 mm at Station DSY-28 was 14% above the lowest value of 50.7 mm at Station DSY-31. The data shown in Figure 5.3-8A can be divided into roughly three tiers. Average lengths for Stations DSY-31, DSY-33, and DSY-39 were very close to the Time zero value, and below the reference station range. Average lengths for mussels at Stations DSY-29 and DSY-38 were very near those of the reference stations, while those at Stations DSY-26, DSY-28, and DSY-40 were all above the reference range.

Time zero average dry shell weight was 6.5 g (Figure 5.3-8B). Average shell weight for the two reference stations differed by 12%, from 6.9 g at Station CHC-1 to 7.7 g at Station JPC-1. The highest mean station value (8.8 g at Station DSY-28) was approximately 36% greater than the lowest value (6.5 g at Station DSY-31). Stations DSY-31 and DSY-39 were fairly close to the T_0 value, and below the reference stations range. Average shell weights for mussels at Stations DSY-29, DSY-33, and DSY-38 fell within the range of the reference station values. Average weights for mussels at Stations DSY-26, DSY-28, and DSY-40 were greater than the reference station averages.

Time zero average dry tissue weight was 0.457 g. Average mussel tissue dry weight for the two reference stations differed by 34%, from 0.51 g at Station CHC-1 to 0.69 g at Station JPC-1 (Figure 5.3-8C). The highest mean station tissue dry weight (0.91 g at Station DSY-40) was approximately two-fold (102%) greater than the lowest value (0.45 g at Station DSY-39). Mean tissue dry weights for mussels at Stations DSY-31 and DSY-39 were close to the T_0 value, and below the reference station range. Stations DSY-26, DSY-28, DSY-29, DSY-33, and DSY-38 had mean tissue weights within the range of the reference station values. The mean tissue weight for Station DSY-40 was substantially greater than the highest reference station value.

Time zero average Shell Weight to Shell Length ratio (CI-SW/SL) was 0.126 g/mm. Average mussel Shell Weight to Shell Length ratio for the two reference stations differed by 11%, from 0.130 g/mm at Station CHC-1 to 0.144 g/mm at Station JPC-1 (Figure 5.3-8D). The highest mean station value (0.152 g/mm at Station DSY-28) was approximately 20% greater than the lowest value (0.127 g/mm at Station DSY-31). The CI-SW/SL values for Stations DSY-31 and DSY-39 were very close to the T_0 value. CI-SW/SL values for Stations DSY-29, DSY-33, DSY-38 and DSY-39 fell within the range of the reference station values. Mean values for Stations DSY-26, DSY-28 and DSY-40 were at least slightly greater than the reference station values.

Time zero average Tissue Dry Weight to Shell Length ratio (CI-TW/SL) was 0.009 g/mm. CI-TW/SL for deployed mussels at the two reference stations differed by 30%, from 0.010 g/mm at Station CHC-1 to 0.013 g/mm at Station JPC-1 (Figure 5.3-8E). The highest assessment station value (0.017 g/mm at Station DSY-40) was slightly less than two-fold (89%) greater than the lowest value (0.009 g/mm at Station DSY-39). The CI-TW/SL for Station DSY-39 was essentially the same as the T_0 value. Station DSY-40 had a substantially higher CI-TW/SL value than the remaining stations, which had CI-TW/SL values within the range of the reference stations.

Time zero average Tissue Dry Weight to Shell Weight ratio (CI-TW/SW) was 0.071. Average CI-TW/SW values for mussels deployed at the two reference stations differed by 19%, from 0.078 at Station CHC-1 to 0.093 at Station JPC-1 (Figure 5.3-8F). The highest mean CI-TW/SW value (0.117 g/mm at Station DSY-40) was approximately 65% greater than the lowest value (0.071 g/mm at Station DSY-39). Stations DSY-28 and DSY-39 had CI-TW/SW values which were very close to the T_0 value, and below the reference station range. The CI-TW/SW value for Station DSY-40 was elevated relative to the highest reference value. The remaining station CI-TW/SW values were either close to or within the range of the reference values.

Mortality of deployed mussels ranged from 0% at several stations (DSY-28, DSY-31, DSY-38 and CHC-1) to 23.75% at Station DSY-39 (Table 5.3-3). Intermediate mortality rates of 5%-12.5% were observed at the remaining stations. The observed mortality did not appear to reflect any spatial pattern which could be related to proximity to the Shipyard.

Much of the observed variation in mussel condition index and mortality values may be due to differences in water column and/or sediment contaminant levels; however, other environmental factors may also contribute to this variation. Variation in food supply (as indicated by TSS and chlorophyll *a* concentration, Table 4.2-3) was

evident in Coddington Cove. To assist in discriminating between food availability and potential CoC effects, relationships between deployed mussel tissue weight vs. chlorophyll *a* concentration measured in water samples at the deployment stations was inspected (Figure 5.3-9). In this analysis, it was assumed that in the absence of CoC effects, mussel tissue weight (and perhaps, to a lesser degree, other growth measures) would be directly proportional to chlorophyll *a* concentration; this relationship is defined as a line connecting the reference locations. In this case, reduced tissue weight at the Castle Hill Cove reference site (CHC-1) relative to Jamestown Potter Cove is assumed to be the result of lower food availability at Station CHC-1. Similar tissue weight vs. chlorophyll *a* relationships were observed at Stations DSY-38, DSY-28, and DSY-40, suggesting that growth processes in mussels at these stations has not been impacted by shipyard-related conditions. In contrast, four other stations (particularly Stations DSY-33 and DSY-29, but also Stations DSY-26 and DSY-31) fell substantially below the line, suggesting possible shipyard-related impacts on these water column indicator species. Exposure-response analyses, discussed in Section 6.5, are used to elucidate these possible impacts.

5.3.3. Evaluation of the Blue Mussel for Hematopoietic Neoplasia

Hematopoietic neoplasia is a proliferative blood disorder of bivalve mollusks known to be progressive, fatal, and transmissible (Elston *et al.*, 1988). Several studies indicate that this disease may be caused by contact with viruses, exposure to environmental contaminants or stressors, or by the synergistic effects of several etiologic agents (Peters, 1988). The incidence of hematopoietic neoplasia observed in blue mussels, *Mytilus edulis*, collected from each station was compared to chemical, biological, and toxicological measurements to evaluate adverse ecological effects as a result of exposure to stressors related to Derecktor Shipyard.

Collection, Transportation, and Holding. Details of methods for collection and analysis are provided in Appendix B. Briefly, indigenous mussels from 10 stations in Derecktor Shipyard (DSY-26, DSY-27, DSY-28, DSY-29, DSY-31, DSY-35, DSY-36, DSY-40, CHC-1, and JPC-1) were collected and transported in insulated coolers, and then held in ambient flowing seawater in plastic cages. Hemolymph from the pericardial region of the mussel adductor muscle was sampled, fixed and stained. Up to one thousand cells per animal were examined microscopically.

Blood samples from each animal were examined for the presence of three cell types: 1) normal cells, characterized by numerous pseudopodia, round regular nuclei, and abundant cytoplasm; 2) abnormal but non-neoplastic rounded cells with pycnotic-like nuclei; and 3) neoplastic cells, being enlarged cells with large, hyperchromatic nuclei surrounded by little cytoplasm. Although abnormal cells are distinguished, their appearance indicates a moribund, but non-neoplastic, cell. Incidence of neoplasia was reported as both the affliction rate (% animals with Hn cells/station) and severity rate (average no. Hn cells/affected animal).

Results and Discussion. Examination of slides from Stations DSY-26, DSY-29, DSY-31, DSY-40, and JPC-1 indicated affliction rates $\geq$ 50% and severity between 17-37% (Table 5.3-4). In contrast, animals examined at Stations DSY-35 and DSY-36 displayed affliction rates of ca. 30% and incidence rates of 0.1 and 0.2%, respectively (Table 5.3-4). Although slides were prepared from animals collected at Stations DSY-27, DSY-28, and CHC-1, microscopic examination indicated insufficiently stained cell organelles, preventing quantitation of Hn parameters.

Hematopoietic neoplasia (Hn) has been reported in *Mytilus edulis* in field studies at Baffin and Vancouver Islands, Canada; Yaquina Bay, Oregon; Puget Sound, Washington; as well as in England, British Columbia, Denmark, and Finland (summarized by Peters *et al.*, 1988). At these locations, frequencies of affliction in

M. edulis ranged between 0 and 40%. Hence, the range of Hn affliction at Stations DSY-26, DSY-29, DSY-31, and DSY-40, as well as at the reference Station JPC-1, were higher than found in other locations in North America and Europe. Possible exposure response relationships between CoCs and Hn affliction are discussed in Section 6.5.

5.3.4. Fecal Pollution Indicators in Deployed Mussels

Tissues from mussels deployed at locations in Derecktor Shipyard, as well as at reference locations, were analyzed for fecal pollution indicator bacteria. Fecal pollution indicator bacteria are commonly used to assess the sanitary quality of marine environments. Studies have consistently shown a direct association between inputs of sewage and other fecal materials and the concentrations of fecal pollution indicator bacteria in water, sediments, and marine organisms (APHA, 1970; FDA, 1992b; Institute of Medicine, 1991; Mitchell, 1978).

Untreated contamination is suspected when elevated levels of vegetative bacteria, such as total and fecal coliforms and fecal streptococci, as well as spore-forming bacteria, such as *Clostridium perfringens*, are observed. Untreated contamination sources include animal waste (shore birds), run-off (fertilizers and animals wastes), human wastes (boat discharges) and untreated or improperly treated sewage effluent. *C. perfringens* bacteria may produce an endospore which is very resistant to adverse environmental conditions, and thus allows for extended survival (Cabelli, 1978). Therefore, elevated levels of *Clostridium perfringens* serve as an indicator of historic sewage contamination.

Methods. Fecal pollution indicator bacteria measured in this investigation included: total and fecal coliforms, fecal streptococci, and *Clostridium perfringens* spores. Details of methods for analysis of mussel tissues for indicator bacteria are

provided in Appendix B. Briefly, mussels were collected from the 10 deployment stations and placed in waterproof plastic bags on blue ice, then stored at 4 ± 2 °C until analyzed (within 24 h of collection).

When available, a minimum of 12 shellfish were used to obtain a representative sample (approximately 100 g of shellfish liquor and meats). Shellfish meats and buffer water were blended. Dilutions of the sample were cultured and examined according to the test procedures outlined in the SAIC ETC Microbiological SOPs presented in Appendix B.

Time Zero Mussels. Time zero mussels (T_0-DM) were collected to assess baseline conditions for fecal indicators. Because samples were inadvertently frozen with chemistry samples, it precluded the enumeration of vegetative bacterial cells, and necessitated a recollection for this endpoint. In contrast, *Clostridium perfringens* spores are resistant to freezing, such that these data are assumed to be adequate for baseline assessment.

Resampled mussels (Cape Cod Fresh) were assayed for total and fecal coliforms, fecal streptococci, and *C. perfringens* following proper procedures. A subset of mussels was also frozen (Cape Cod Frozen) then analyzed for only *C. perfringens* spores for comparison with the initial T_0 samples (T_0-DM).

Data presented in Table 5.3-5 show low densities (<350 CFU/100 g) of *C. perfringens* in the Cape Cod Fresh and Frozen mussels as expected. Densities were also low in the original T_0-DM levels, suggesting a lack of temporal variation in fecal indicator exposure concentrations at the Cape Cod site. Levels of vegetative bacteria found in the Cape Cod Fresh mussels were low (20 and <18 CFU/100 g for total and fecal coliforms respectively) to moderate (140 CFU/100 g) for fecal streptococci.

Deployed Mussels. Densities of cultured fecal indicator colony-forming units (CFUs) were enumerated and classified as low (<100 CFU/100 g), moderate (100-300 CFU/100 g), or elevated (>300 CFU/100 g). Indicator densities in mussel tissues generally indicate biological uptake during the deployment period, as site and reference indicator densities exceeded the T_0 concentrations for three of four indicators. Fecal streptococci was the exception; T_0 concentrations were greater than deployed mussel concentrations, hence, enrichment of this indicator cannot be quantitatively assessed.

Elevated total coliform and *C. perfringens* indicator densities, and moderate fecal coliform densities, were observed at Stations DSY-26, DSY-29, DSY-33 and especially DSY-40, indicating recent exposure to fecal contamination (Table 5.3-5). At Stations DSY-28 and DSY-31, however, total coliforms and fecal coliforms were low, while *Clostridium perfringens* densities were low to intermediate. The change in relative abundances of *Clostridium* and non-*Clostridium* indicators suggests that either the non-*Clostridium* indicators were depurated, or alternatively, ingestion of sediments containing mainly *Clostridium* had occurred.

In another study, Burkhardt (1991) found seasonal differences in the ability of the hard clam *Mercenaria mercenaria* to accumulate fecal coliforms and *Clostridium perfringens*, with elevated accumulation rates in the spring compared to the other seasons. As temperatures decreased (i.e. <7°C), physiological activity and therefore accumulation rates also decreased. No accumulation was observed when water temperatures were <4.5°C. It was also observed that accumulation rates for *C. perfringens* were higher than accumulation rates for fecal coliforms, which may be influenced by parameters such as particle size and shape. These observations imply that the data from the present study are best used for relative comparisons among stations, not as absolute concentrations, since organism behavior and seasonality may play a large role in fecal indicator residue concentrations.

5.3.5. Evaluation of the Cunner, *Tautogolabrus adspersus*, for P450 Activity

Cytochrome P450 are enzymes which convert toxic compounds into less toxic forms by converting their lipophilic (fat-soluble) components into water soluble compounds which are more easily excreted. In the environment, aquatic species are exposed to contaminants such as PCBs, dioxins, and aromatic hydrocarbons, capable of inducing hepatic cytochrome P450 monooxygenase activity. It has been demonstrated that the degree of P450 induction is highly correlated with the degree of contamination in aquatic animals themselves, the surrounding biota or in the sediments (Stegeman and Hahn, 1994).

In the present study, measurement of P450 activity in cunner was selected as a bioindicator of potential adverse effects of contaminant exposure. The technique used for determining the induction response was to measure 7-ethoxyresorufin-*O*-deethylase (EROD) activity, which is an indirect measure of the P450 protein (enzyme) being produced to detoxify contaminants. The use of this assay to measure enzyme activity has been validated in a number of field and laboratory studies with fish monitored for biochemical effects of organic contaminants (Goksoyr and Husoy, 1992). Complete details of the P450 method are contained in Appendix B-2-5.

Results. Three composite replicates of three fish each collected from Station DSY-36 were evaluated using the EROD assay. Abundances of fish at other stations did not permit P450 analyses. The P450 activity (estimated in pmol of EROD formed per mg of protein per min) for each composite is listed below.

Composite A	31.3 pmol/mg/min
Composite B	23.4 pmol/mg/min
Composite C	25.0 pmol/mg/min

The mean value for all three composites is 26.6 (± 4.18 SD).

Literature values for ethoxyresorufin activity in the croaker fish *(Limanda limanda*) collected from unpolluted North Sea regions ranged from 50-300 pmol/mg/min (Renton and Addison, 1992); while spot *(Leiostomus xanthurus)*, collected from reference and contaminated sites in the Chesapeake Bay and Elizabeth River ranged from 230 to 1292 pmol/mg/min, respectively (Van Veld *et al.*, 1990). Thus, the measured activity at Station DSY-36 in the present study suggests relatively low CoC exposure.

5.4. Existing Toxicity-Based Criteria and Standards

Toxicity-based criteria and standards provide the basis for comparing expected or actual environmental concentrations of contaminants to toxicological benchmark concentrations, thereby allowing an estimation or quantification of risk. For the present risk assessment, the primary benchmarks utilized were 1) ER-L/ER-M values presented in Long *et al.* (1995); 2) EPA Chronic Water Quality Criteria (WQC) for marine waters (used in this study to assess chemical concentrations in groundwater from the shipyard and sediment elutriates), and 3) EPA Sediment Quality Criteria (SQC), as presently available or as predicted from WQC and partitioning parameters (see Section 3.3). Discussion of each of these bechmarks and its relation to the present risk assessment is included below.

ER-L/ER-M values. The ER-L and ER-M concentrations correspond to the lower 10th and 50th percentiles, respectively, of all concentrations of a contaminant observed to cause a biological effect, over a range of studies and species (Long and Morgan, 1990; Long *et al.,* 1995). Conceptually, ER-Ls are similar to LOELs (lowest observed effect levels), which represent the lowest toxicant concentration observed in bioassays

to cause biological effects. Another type of benchmark, called AET (Apparent Effects Threshold; PTI 1988, U.S. EPA, 1989b), was developed to address individual contaminants in sediments and represents the level of individual chemicals above which statistically significant biological effects are always expected to occur. As discussed in Section 3, the ER-L values are typically more conservative (i.e., corresponding to lower benchmark levels) than AET or SQC values, usually representing concentrations that are an order of magnitude lower. For the present assessment, ER-Ls are employed as a lower benchmark, with ER-Ms used as an upper range benchmark.

Water Quality Criteria. The EPA Water Quality Criteria (WQC) were used to calculate screening benchmarks for shipyard groundwater samples collected during the Phase II RI (TRC, 1994), as well as for elutriate metals samples collected in Phase II of the present investigation. Water-based aquatic life criteria are based on the total recoverable concentration of the metal as sampled from test chambers during aquatic toxicity tests. However, it is recognized that the dissolved metal concentration more closely approximates the bioavailable fraction of the metal in the water column than does the total extractable concentration. Lussier *et al.* (1995) addressed this issue through paired (unfed and fed) toxicity tests with *Mysidopsis bahia*, *Mysidopsis lateralis* and *Ampelisca abdita*. Data from these tests were used to derive conversion factors between the dissolved phase effect concentration of metals and the total recoverable concentration of metals. For most metals (As, Cd, Cr^{+6}, Pb, Ni, Se, and Zn), the conversion factor was 0.95 or greater, indicating that the presence of food (which could potentially alter metal bioavailability) had minimal effect on the derived Water Quality Criteria. One exception was Cu, for which the conversion factor (0.83) indicated that the expected dissolved phase concentration is 83% of the promulgated criteria. These findings suggest that WQC can be used to evaluate dissolved (measured) metal concentrations in organically rich environments (e.g., abundant food resources). For

this evaluation, Hazard Quotients were calculated as the ratio of the elutriate dissolved metal concentration to the criterion level for individual analytes.

Sediment Quality Criteria. For non-ionic organic substances, Sediment Quality Criteria (SQC) are derived directly from the product of the Water Quality Criteria (WQC), Final Chronic Value (FCV), and the organic carbon partition coefficient (K_{oc}) of the chemical (Di Toro et al., 1991). Hence, the SQC approach uses the WQC FCV as the appropriate effects concentration for protection of benthic organisms, even though the FCVs were derived from water column species. The primary uncertainties with this approach are: 1) whether the pathway of chemical exposure (e.g., water column, interstitial water or ingested sediment) under equilibrium conditions is an important determinant in chemical bioavailability, and 2) if organism habitat or feeding behavior may result in more limited exposure to non-ionic organic contaminants (e.g., epibenthic or filter-feeding organisms receive significantly less exposure than infaunal species).

Recent research has found that no differences in organic CoC bioaccumulation were observed among benthic species of differing trophic mode (Tracey and Hansen, 1996), which greatly reduces the uncertainty of applicability of SQC values as criteria for ecological effects assessment in the present investigation. The present assessment also provided suitable data for demonstration of this relationship (Section 6.3).

5.5. UNCERTAINTY

Numerous assumptions are made concerning the applicability of 1) toxicity evaluations, 2) biological field investigations, and 3) particular benchmarks used as criteria and/or standards to evaluate impacts to biota. These assumptions bear upon the certainty of risk derived from these effects-based measures; i.e. whether the observed response falsely suggests an effect where none exists (a "false positive") or

alternatively, fails to detect an effect where one is occurring (a "false negative"). An assessment of uncertainty in each area follows.

Toxicity evaluations. The evaluation of ecological effects of contaminated sediments using toxicity tests is essential because chemical concentrations alone are not accurate predictors of biological effects. The principal advantage of the sediment toxicity testing approach is that the tests are performed in a manner comparable to WQC derivation exercises (e.g., mortality or sublethal effects are observed), hence the data are directly comparable to these criteria. Uncertainties associated with toxicity testing conducted in the present study are that the responses may not be chemical-specific, and the responses observed may not represent chronic effects. In addition, there is uncertainty in the comparability between the sediment test species and the water test species upon which the WQC are derived (EPA, 1989c).

Biological investigations. Field survey approaches, such as the benthic community structure and biota condition endpoints measured in this study, have the advantage of providing assessments of *in situ* effects without significant sampling artifacts. However, methods for interpretation of the data, particularly for community structure, are not standardized and thus difficult to compare between studies. Large field sampling programs have attempted to develop reliable benthic community indices of impacts with limited success (Schimmel, 1994). Often, a large amount of field data is required, including both seasonal and spatial coverage, such that benthic impacts can be discerned. In the present investigation, a suite of benthic community metrics were selected following those used in the EMAP-Virginian Province assessment program (Schimmel, 1994). Although the utility of the selected metrics was assumed to be adequate, it is uncertain as to which metrics are better, worse or simply redundant predictors of CoC impacts related to the site. Additional uncertainty exists in the taxonomic identification of species, as well as in their enumeration and relative sensitivity to various pollutants.

There exists a lack of historical data from quantitative benthic community studies of the Newport area before 1985. Sampling and sample preparation techniques used in the present study were similar to those employed in four recent surveys in the area (City of Newport, 1985; French, 1991; TRC, 1994, SAIC and URI, 1996), yet there is variation between each study in the level of identification of some taxa and differences in the identifications based on recent taxonomic research. Techniques are available to improve comparability between studies, such as combining species into higher taxa, or focusing on long-lived species and on seasonally stable parameters. Sources of natural variation (grain size, water content of sediments, depth, tidal circulation, etc.) also hinder discrimination between stations with regard to potential effects of contaminants on benthic communities.

In addition, resources limit the ability to measure every parameter at every site with 100% accuracy and precision. Therefore, the possibility of erroneous conclusions always exists, i.e., false negatives (true trend, response, or pattern is not detected) and false positives (apparent trend, response, or pattern is actually due to natural variability). For standard methods (e.g., use of toxicity tests to measure acute and chronic responses in aquatic organisms), most sources of erroneous conclusions, including inadequate sampling designs, experimental designs, measurement methods, data recording and data analysis techniques, can be recognized in the review of project sampling plans and through QA/QC programs which include SOPs and the use of positive and negative controls. For newer technologies, particularly biochemical and physiological measurements at cellular and subcellular levels of biological organization (i.e., biomarkers), such as induction of EROD activity and incidence of hematopoietic neoplasia, procedures for reducing erroneous conclusions are still in developmental stages. Despite shortcomings, biomarkers are highly valuable in retrospective risk assessments, where environments are already affected and detectable effects can be observed and measured (Suter, 1990). Biomarker measurements can aid in the determination of actual effects, and thus cause, magnitude, and ultimate

consequences. Although biomarkers are not yet predictive of higher-level effects at the population, community, or ecosystem levels of organization, they are useful measures of exposure; they are often evident even when contaminants are below detectable levels and may provide clinical evidence of causative agents (Landis and Yu, 1995).

Sublethal physiological and behavioral indicators of impact within a population (i.e., growth, reproductive success, and condition) are traditional methods used to assess the health of populations (Landis and Yu, 1995). However, no single index can provide predictive capability for evaluating population level changes. In addition, sublethal indices may change with season, reproductive status, and age. Condition indices of mussels, which are useful sentinel organisms given their sessile lifestyle, extensive distribution and abundance, and proven ability to thrive in confinement, have become important in global monitoring programs. However, introduced mussels do not usually become full participants in the ecosystem; therefore, integration of assessments of both indigenous and deployed mussel condition provide more complete characterization of spatial and temporal heterogeneity.

Benchmarks. As summarized in Section 5.4, the derivation of ER-L/ER-Ms is based on very conservative assumptions concerning use of the lower 10th and 50th percentiles, respectively, of all concentrations of a contaminant that have been observed to cause biological effects. In the derivation of screening criteria (Section 3.3), ER/L values in particular are generally lower by one order of magnitude for most parameters (including AET values, representing the only other effects-based benchmark that is commonly applied), and hence were most often the benchmark of lowest value for each CoC. The uncertainty is the level of conservatism that is appropriate to assess ecological risk. ER-Ls are used in this assessment to provide a protective evaluation; however, these benchmarks may be overly conservative as they do not account for site-specific factors that can mitigate (buffer) the responses of ecological systems to particular contaminants. The incorporation of toxicity data at

various effects levels and for species from different phyla and trophic levels is an attempt to add another measure of realism to the final assessment. A further issue with the use of the ER-L/ER-Ms (or AETs) is the relatively limited list of chemicals for which values are available compared to the overall list of contaminants from the study, leaving the possible effects of some contaminants not fully assessed.

Use of Surrogate/Indicator Species. The species evaluated in this study, including hard clams (*Mercenaria* and *Pitar*), mussels (indigenous and deployed), fish (cunner and mummichogs), two bioassay organisms (*Ampelisca* and *Arbacia*), and macrofauna (from benthic community structure measurements), are used as indicators of the assumed general response of the various communities within the study region. These species represent a variety of biological endpoints which have been shown to be sensitive to contaminant inputs and whose relationship to a particular habitat and community is well established. It also was deemed important to maintain consistency in the use of the same species, for purposes of data comparability, among the various phases of the risk assessment. Nonetheless, the use of surrogate or indicator species is associated with some undefined level of uncertainty, since one or a few species cannot duplicate precisely the response of the numerous species that comprise the various communities of the region.

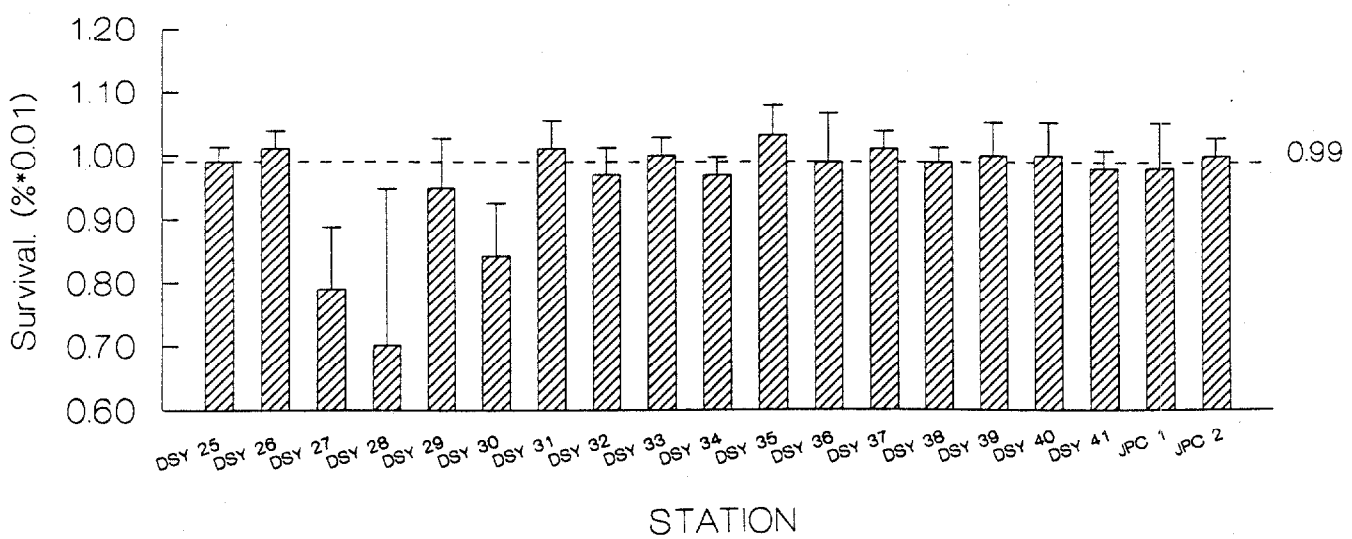


Figure 5.2-1. Plot of amphipod (*Ampelisca*) survival (%) in sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations. Dashed line indicates median across reference stations. Values are mean ± the Standard Error of the mean.

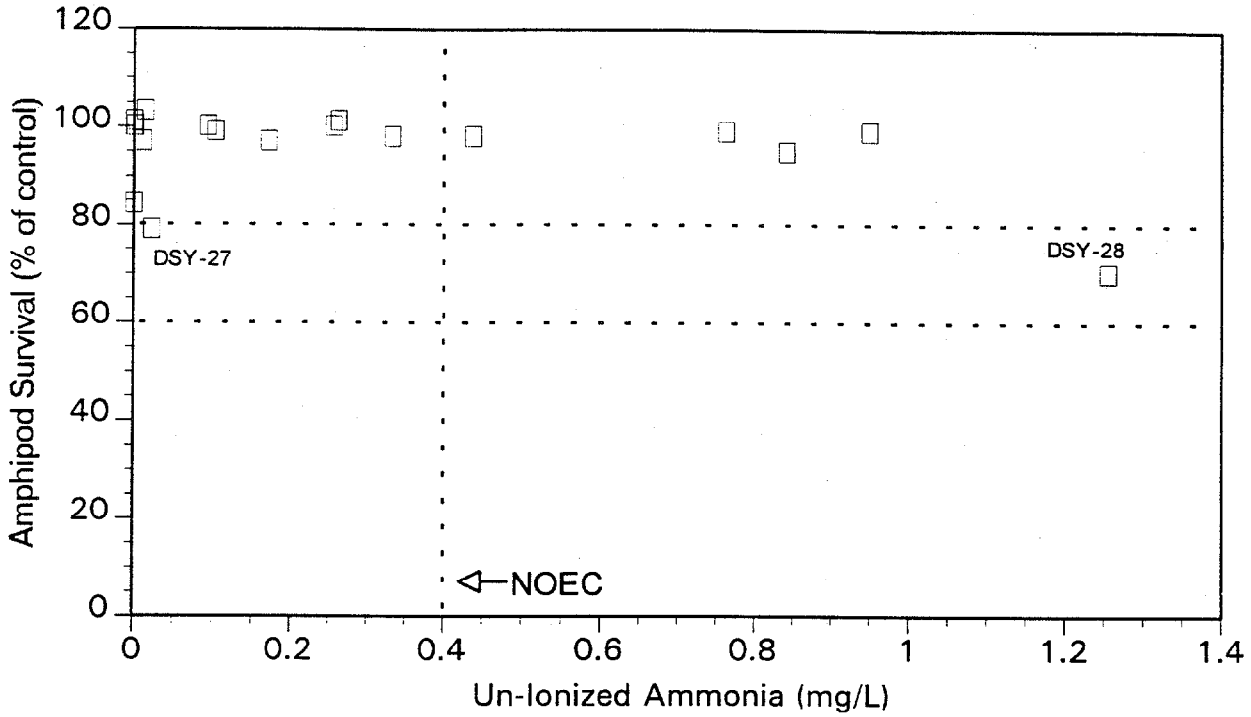


Figure 5.2-2. Amphipod (*Ampelisca*) survival vs. un-ionized ammonia measured in sediment porewaters from the Derecktor Shipyard/Coddington Cove (DSY) study area. The horizontal dashed lines indicate interpretive threshold values for slight (<80% of control) and severe (<60% of control) impact on amphipod survival. The vertical dashed line at 0.4 mg/L indicates the No Observable Effects Concentration (NOEC) for un-ionized ammonia at pH 7.7 (U.S. EPA, 1994).

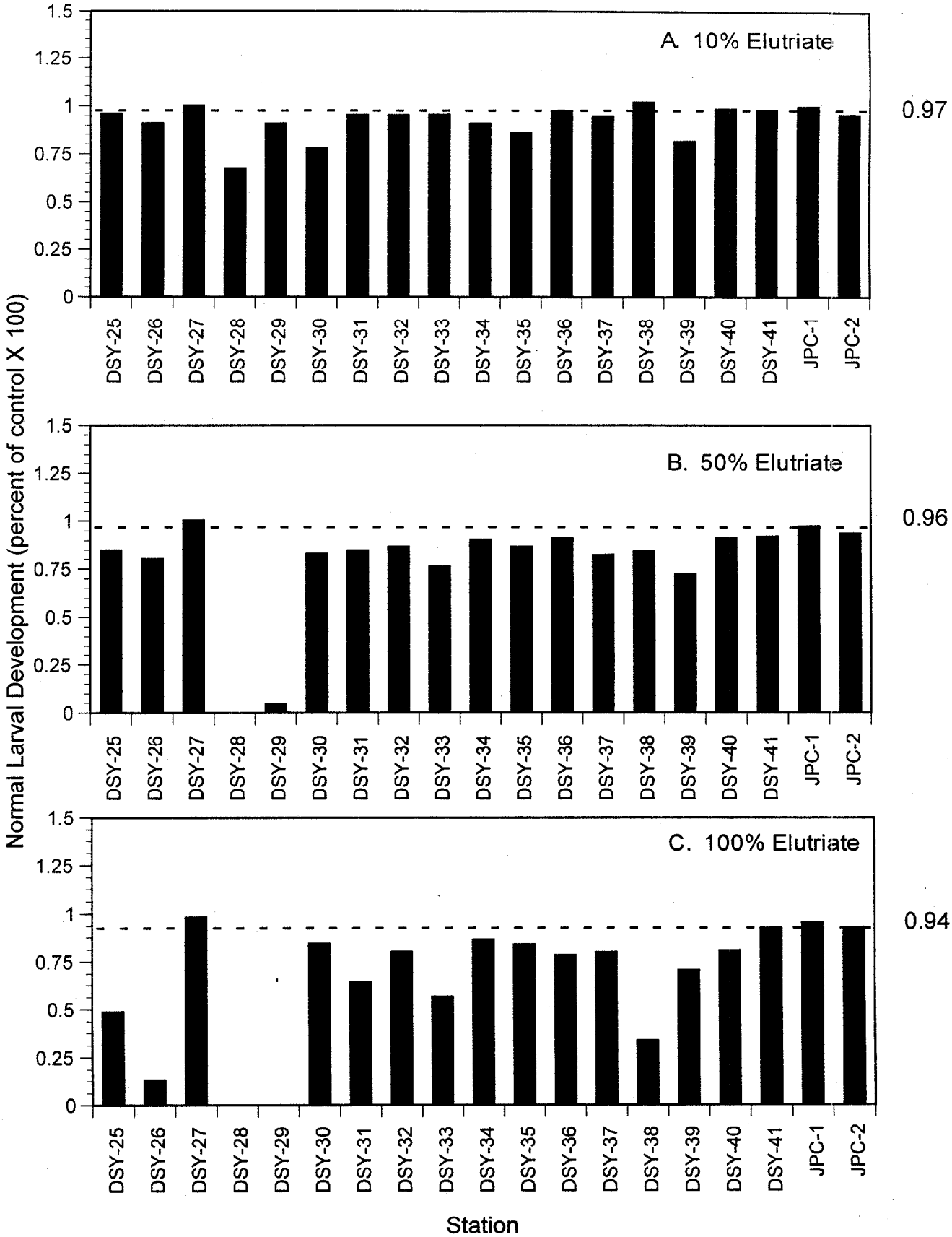


Figure 5.2-3. Plot of sea urchin *(Arbacia)* larval development abnormality (%) in sediment elutriates from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations. A) 10% elutriate, B) 50% elutriate, and C) 100% elutriate. Dashed line and number indicate median across reference locations.

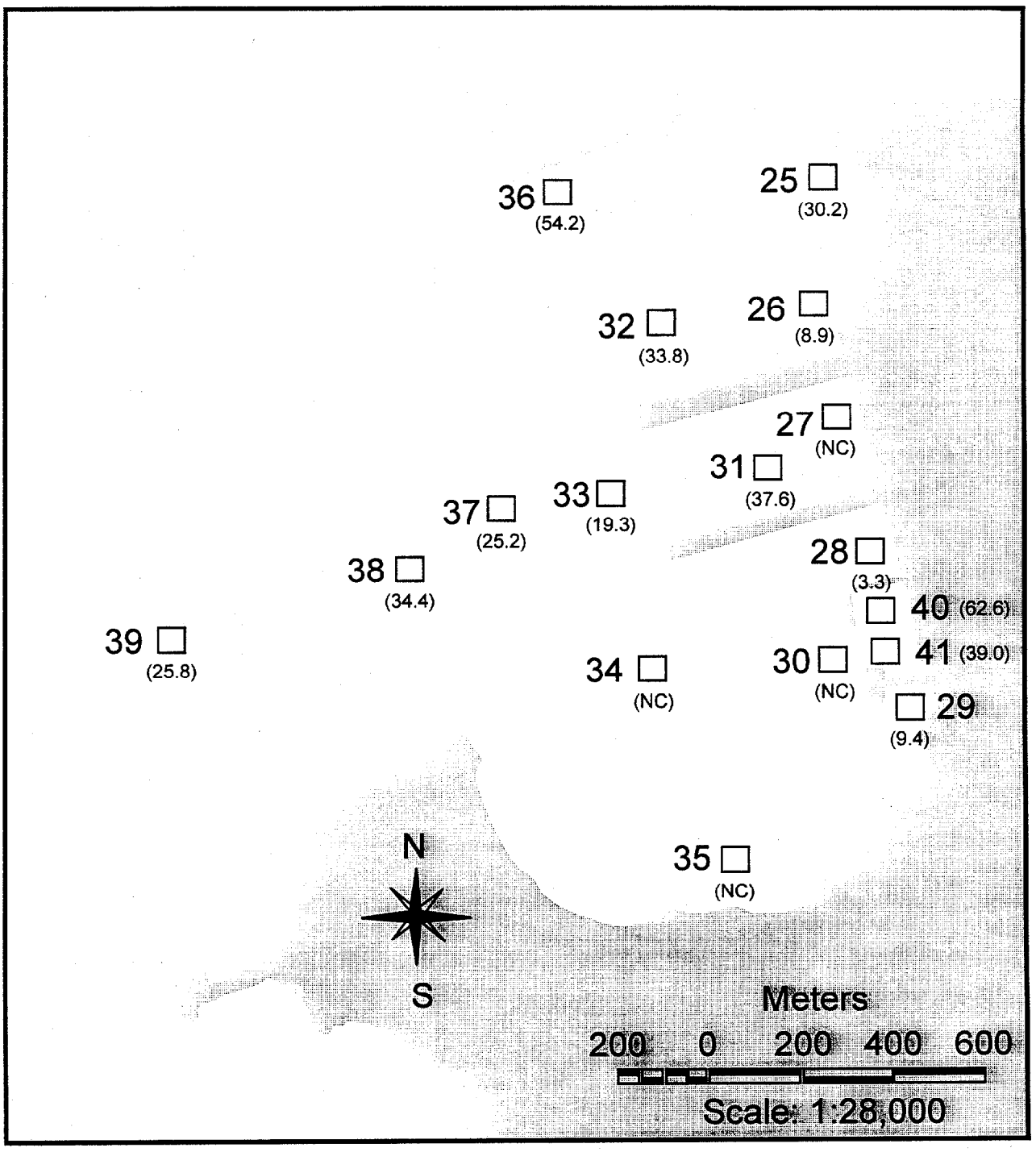


Figure 5.2-4. Spatial distribution of sea urchin (*Arbacia punctulata*) elutriate toxicity for sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area. Inhibition Concentration (IC_{10}) is the elutriate concentration causing 10% reduction in normal larval development. NC = IC_{10} value not calculated for the station since adverse effects were not detected in the elutriate toxicity test.

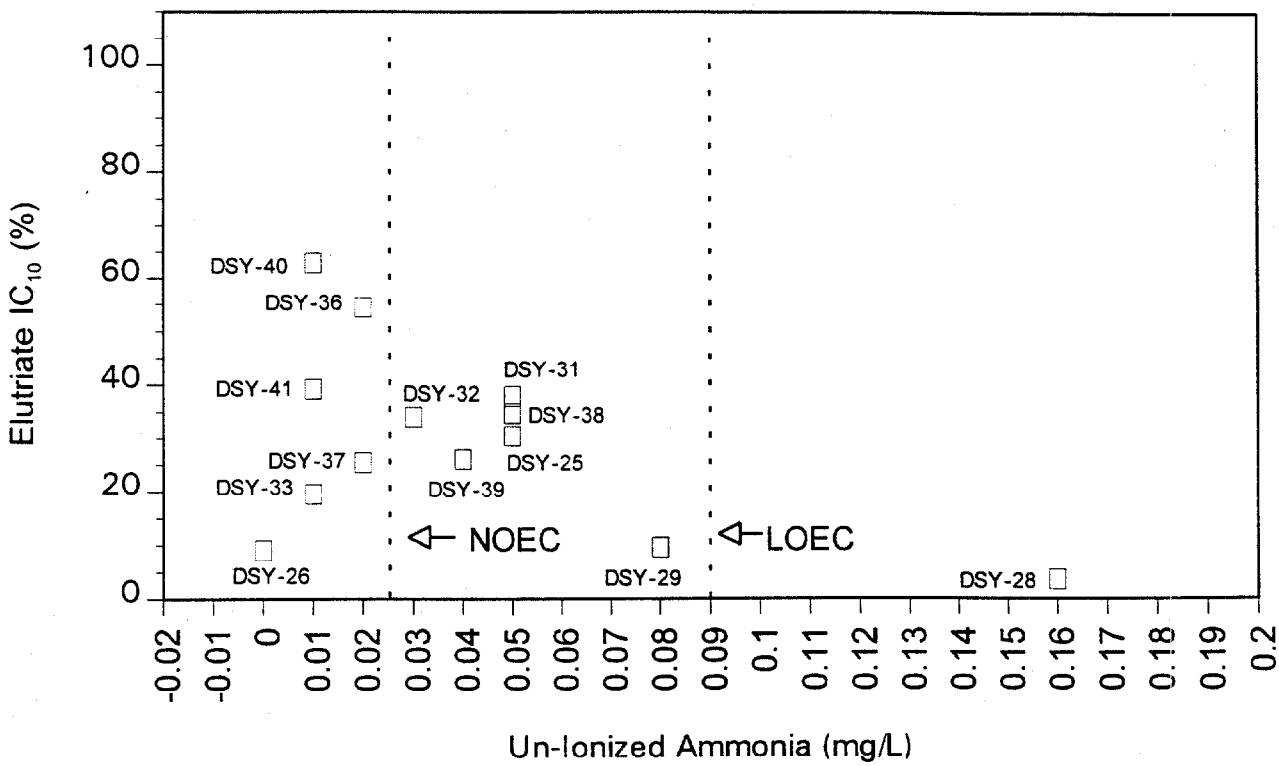


Figure 5.2-5. Elutriate IC_{10} (Elutriate Concentration causing 10% inhibition in normal sea urchin larval development) vs. un-ionized ammonia in 100% elutriate prepared from sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area. The vertical dashed lines indicate the No Observable Effects Concentration (NOEC) and the Lowest Observable Effects Concentration (LOEC) for un-ionized ammonia (0.037 and 0.09 mg/l, respectively) as proposed by Carr *et al.*, (in press).

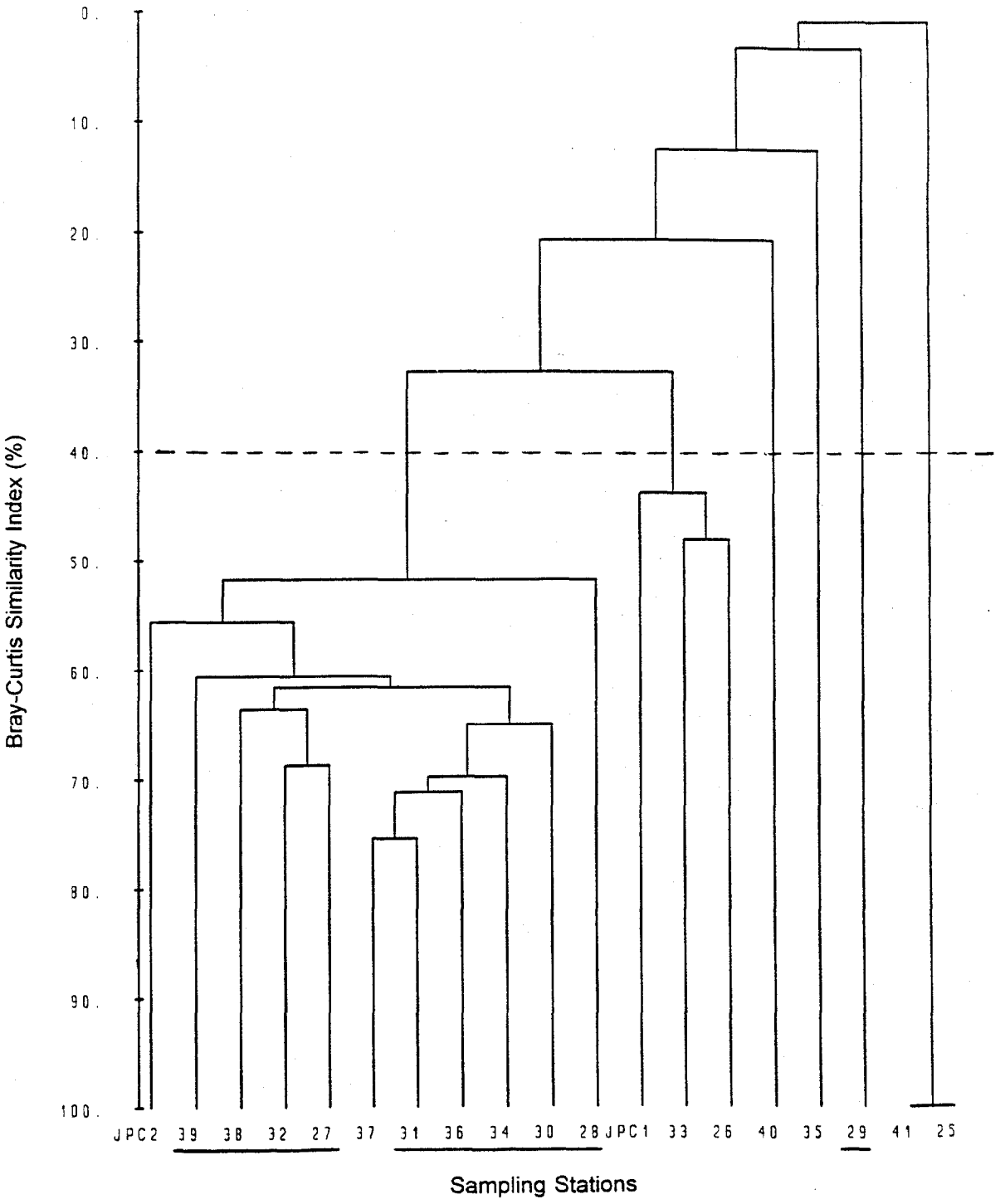


Figure 5.3-1. Dendogram for hierarchical clustering of 19 benthic community sampling stations, using group-average linking of Bray-Curtis similarities calculated on double square root transformed abundance data. At the 40% similarity level (dashed line), six station clusters are shown. Stations with predominantly silt-clay are underlined. Stations identified by number only correspond to the Derecktor Shipyard/Coddington Cove study area; JPC stations correspond to the Jamestown Potter Cove reference area.

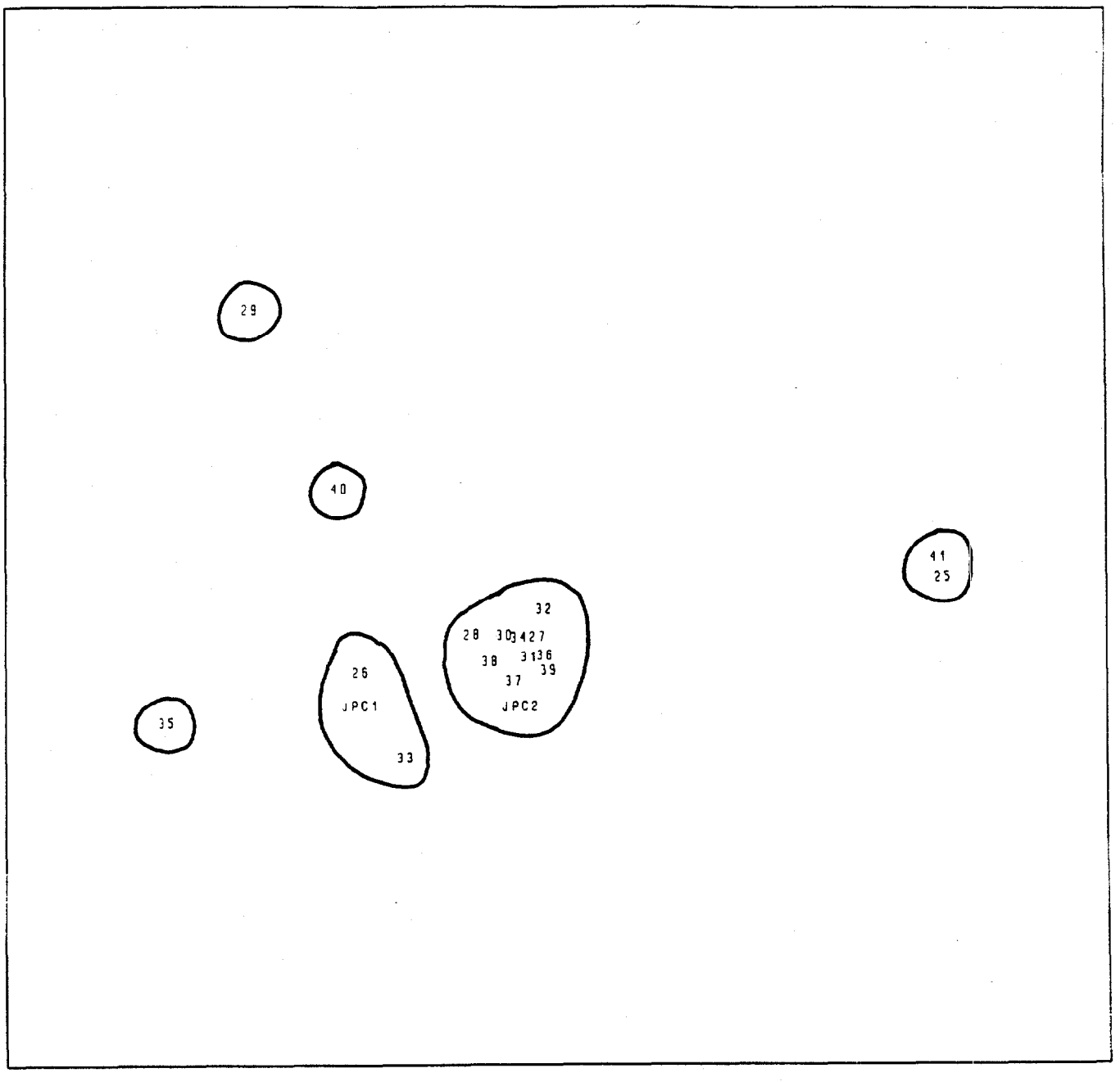


Figure 5.3-2A. Two-dimensional MDS configuration of nineteen benthic community sampling stations, based on Bray-Curtis similarities calculated on double square root transformed species abundance data from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference stations. Stress = 0.05 (see explanation in text). The six station groups from the cluster analysis (Figure 5.3-1) are circles. Stations identified by number only correspond to the Derecktor Shipyard/ Coddington Cove study area; JPC stations correspond to Jamestown Potter Cove reference locations.

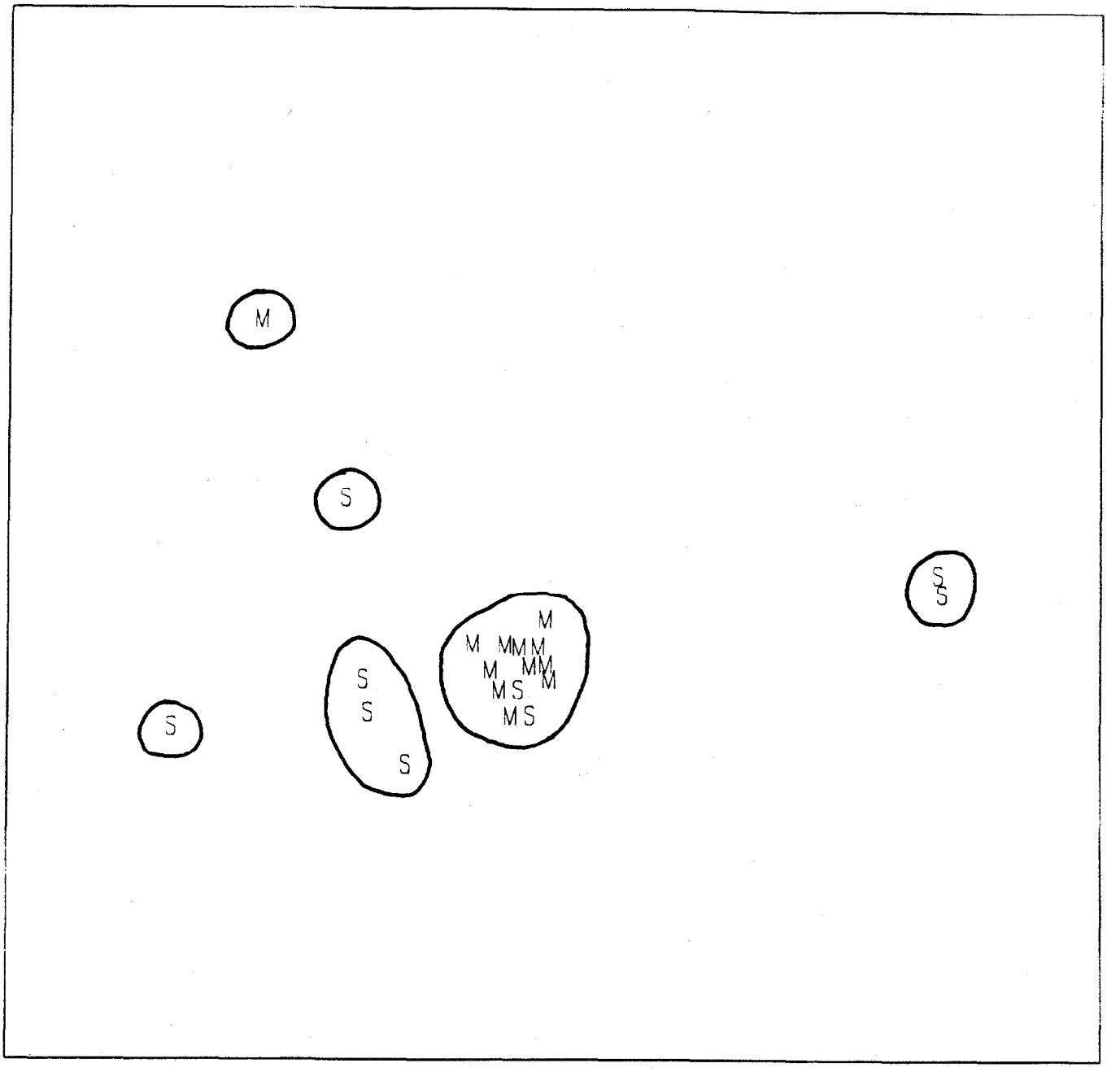


Figure 5.3-2B. Two-dimensional MDS configuration of nineteen benthic community sampling stations, based on Bray-Curtis similarities calculated on double square root transformed species abundance data from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference stations. The same MDS plot as in Figure 5.3-2A, but with the letter M used to denote silt-bottom stations (silt-clay ≥ 60%), the letter S used to denote sand-bottom stations (silt-clay < 30%), and the letters MS used to denote intermediate stations (silt-clay between 30% and 60%).

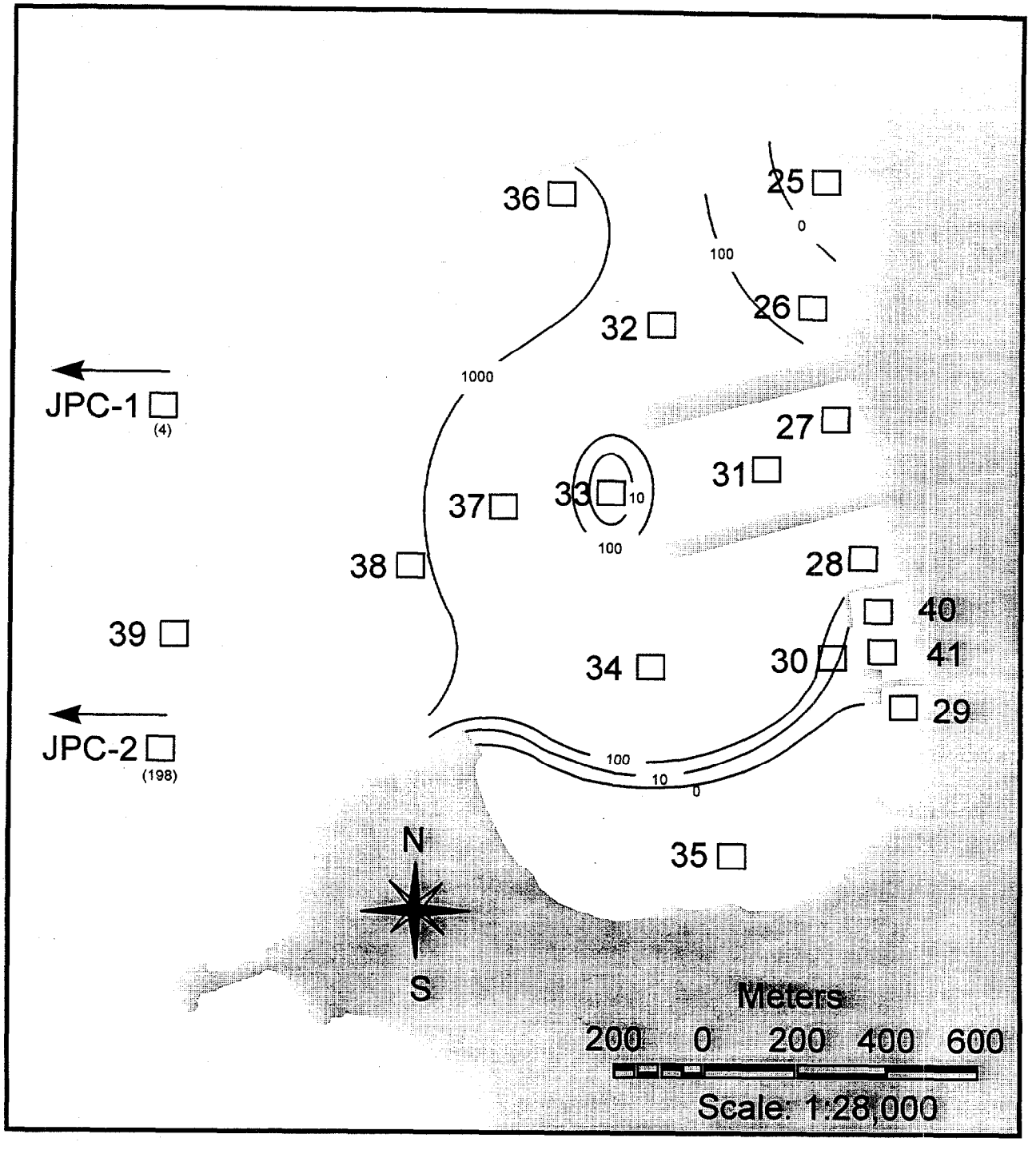


Figure 5.3-3. Distribution of the bivalve *Nucula annulata* in the Derecktor Shipyard/ Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference stations. Numbers in parenthesis indicate station-specific average.

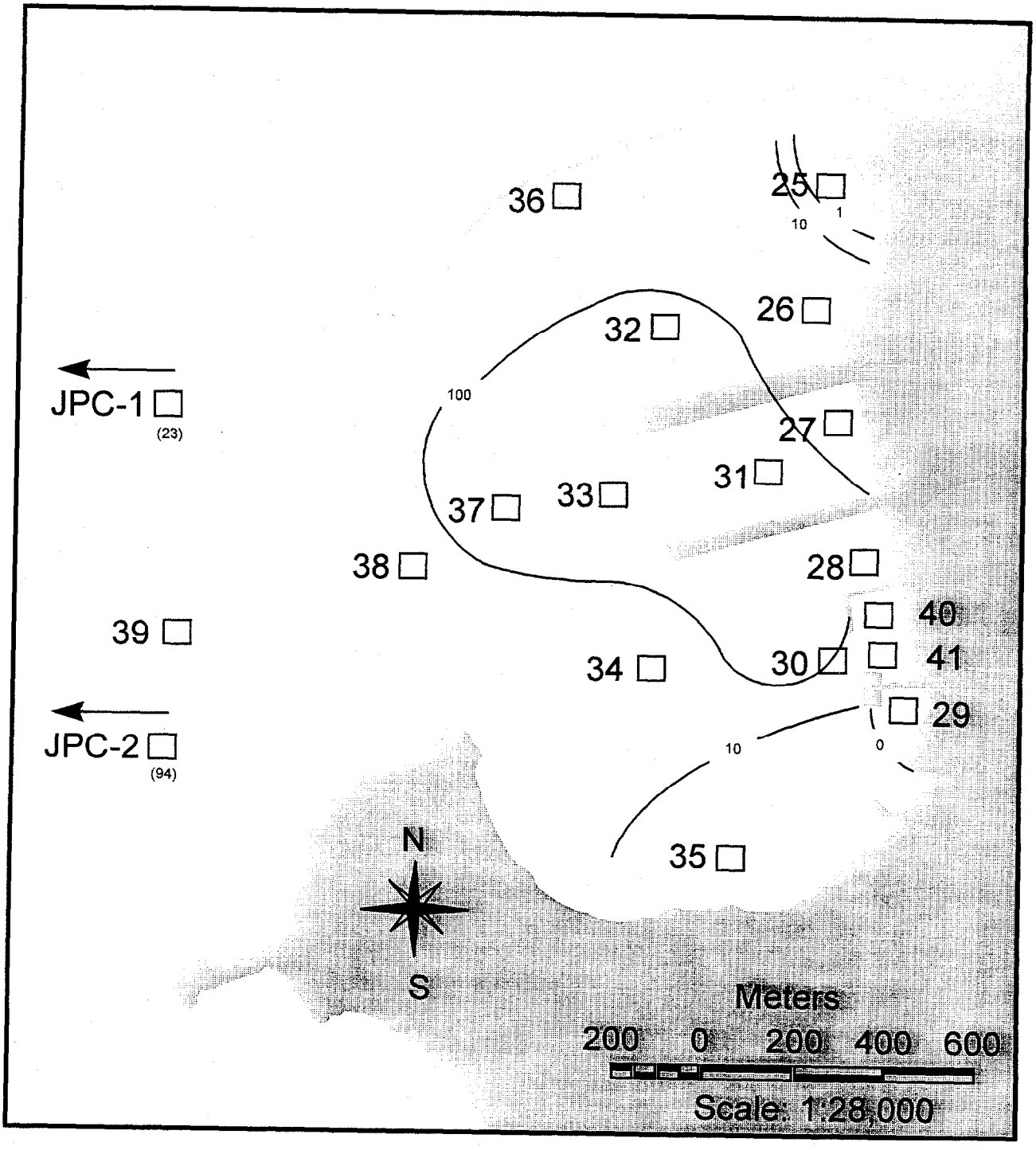


Figure 5.3-4. Distribution of the polychaete *Mediomastus ambiesta* in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference stations. Numbers in parenthesis indicate station-specific average.

Figure 5.3-5. Distribution and abundance of four dominant silt-bottom benthic invertebrate species in surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference location.

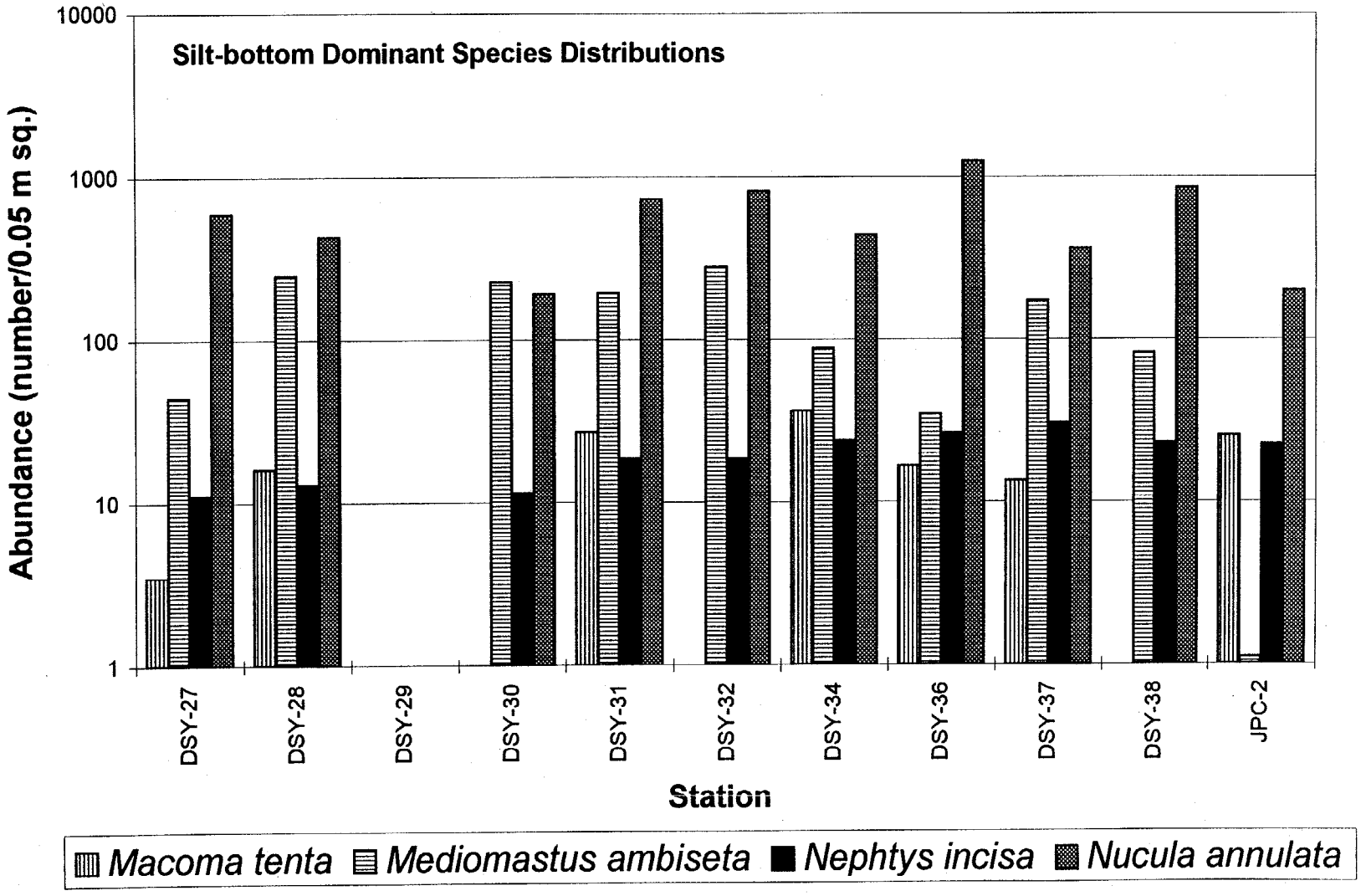
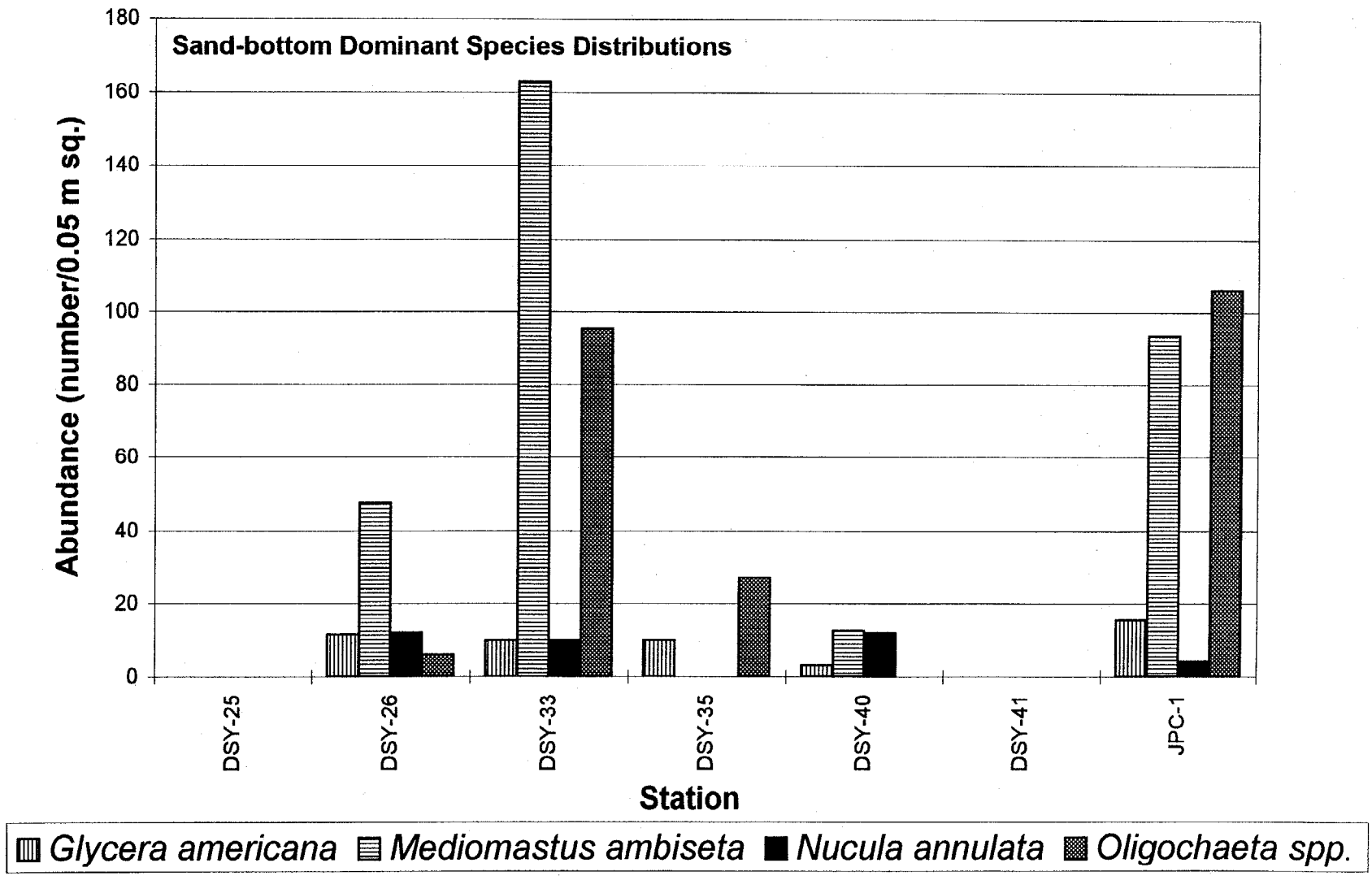


Figure 5.3-6. Distribution and abundance of four dominant and most commonly observed sand-bottom benthic invertebrate species in surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference location.



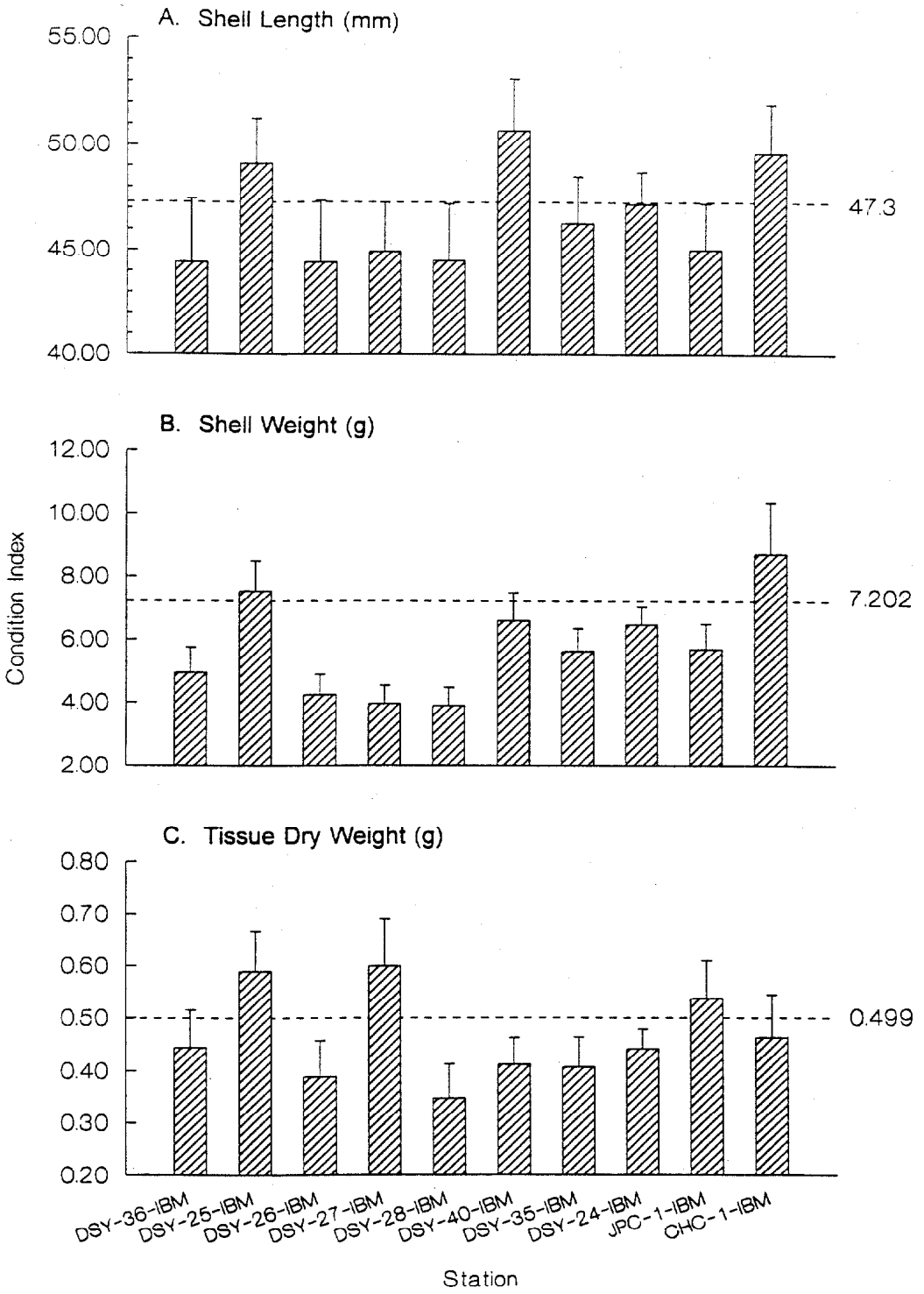


Figure 5.3-7. Condition Indices for Indigenous Blue Mussels (IBM) from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) shell length (mm), B) shell weight (g), C) tissue dry weight (g), D) shell weight to shell length ratio (g/mm), E) tissue dry weight to shell length ratio (g/mm), and F) tissue dry weight to shell weight ratio (g/g). Dashed line indicates median across reference stations (JPC and CHC). Values are ± the Standard Error of the mean.

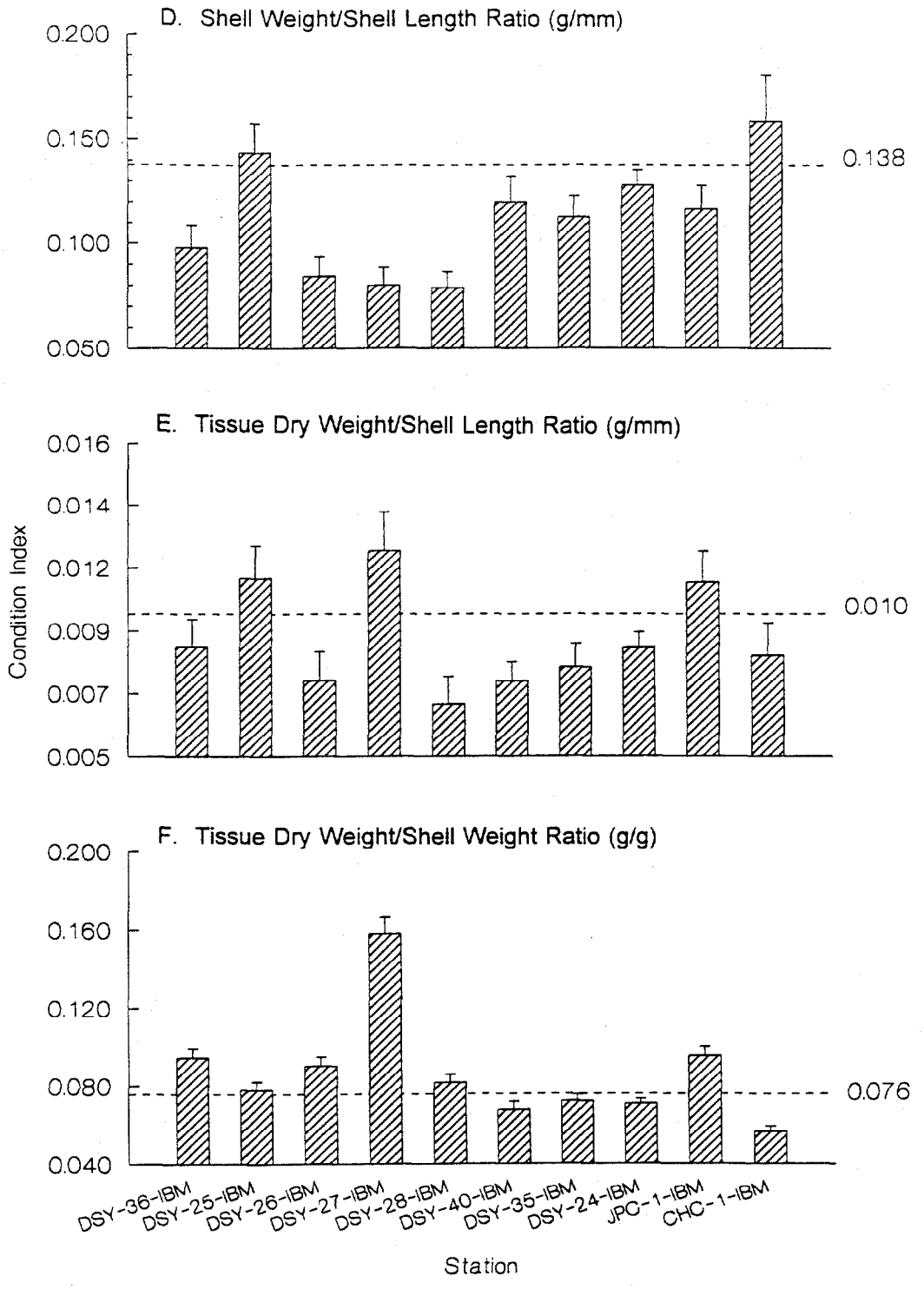


Figure 5.3-7. (continued). Condition Indices for Indigenous Blue Mussels (IBM) from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) shell length (mm), B) shell weight (g), C) tissue dry weight (g), D) shell weight to shell length ratio (g/mm), E) tissue dry weight to shell length ratio (g/mm), and F) tissue dry weight to shell weight ratio (g/g). Dashed line indicates median across reference stations (JPC and CHC). Values are ± the Standard Error of the mean.

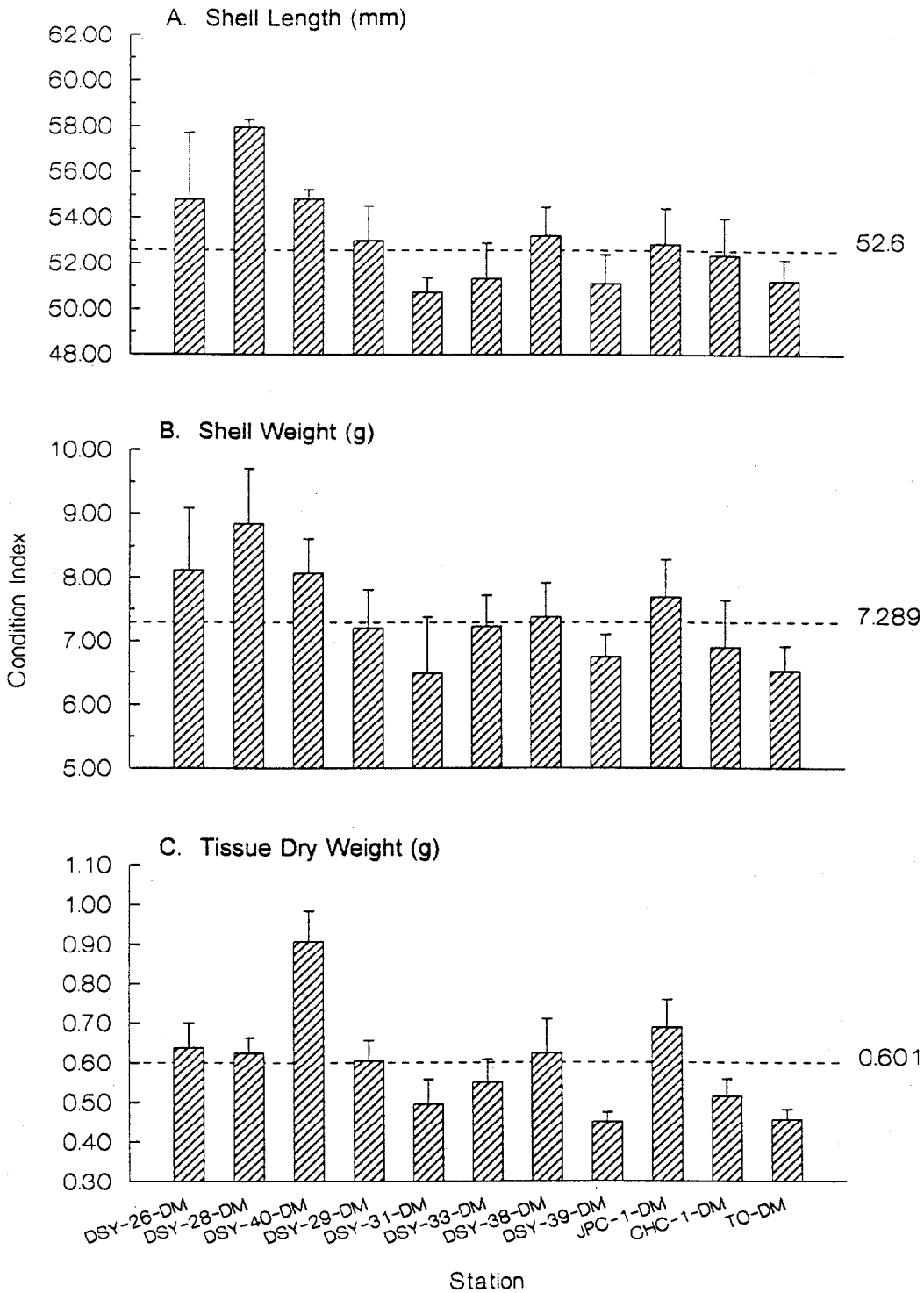


Figure 5.3-8. Condition Indices for Deployed Blue Mussels (DM) at the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. A) shell length (mm), B) shell weight (g), C) tissue dry weight (g), D) shell weight to shell length ratio (g/mm), E) tissue dry weight to shell length ratio (g/mm), and F) tissue dry weight to shell weight ratio (g/g). Dashed line indicates median across reference stations (JPC and CHC). Values are ± the Standard Error of the mean. TO-DM = Time zero testing of deployed blue mussels.

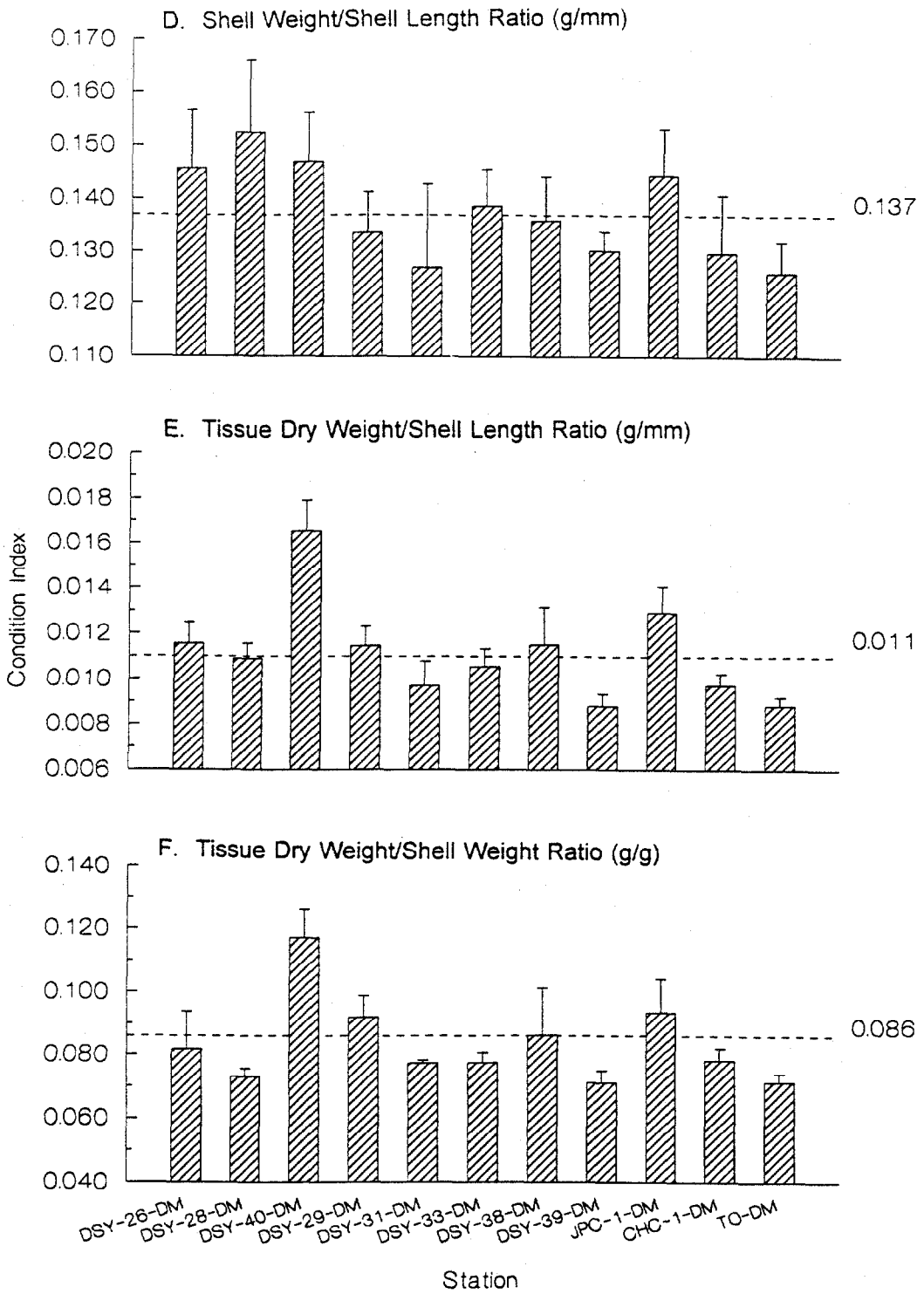


Figure 5.3-8. (continued). Condition Indices for Deployed Blue Mussels (DM) at the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.. A) shell length (mm), B) shell weight (g), C) tissue dry weight (g), D) shell weight to shell length ratio (g/mm), E) tissue dry weight to shell length ratio (g/mm), and F) tissue dry weight to shell weight ratio (g/g). Dashed line indicates median across reference stations (JPC and CHC). Values are ± the Standard Error of the mean. TO-DM = Time zero testing of deployed blue mussels.

Figure 5.3-9. Dry tissue weight vs. Chlorophyll *a* in blue mussels deployed in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Line indicates regression fit through reference data.

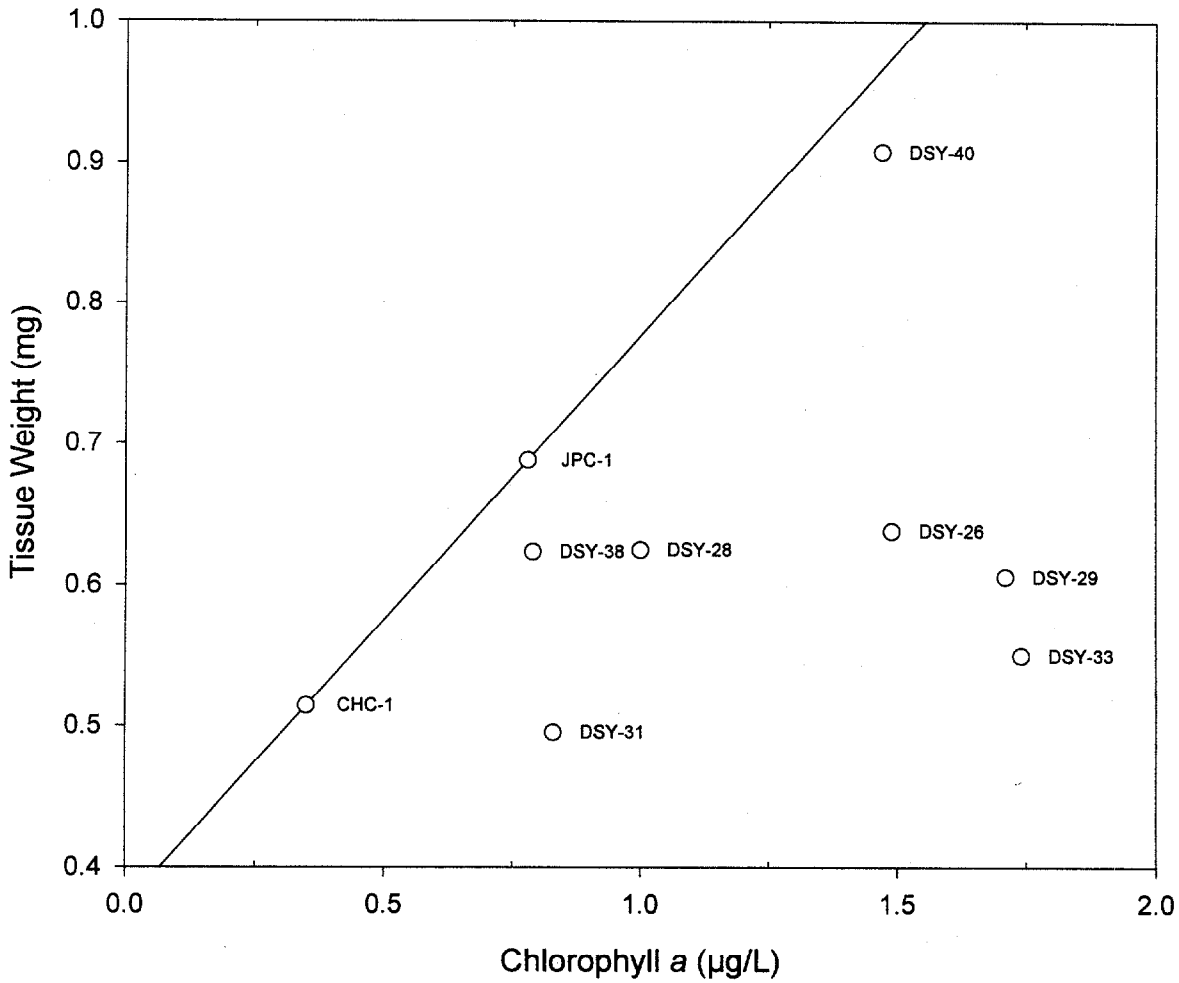


Table 5.2-1. Summary of toxicity test results using *Ampelisca* survival, *Arbacia* fertilization, and *Arbacia* larval development for the Derecktor Shipyard Marine Ecological Risk Assessment.

Sample ID[5]	10-Day Solid-Phase Tests *Ampelisca abdita*			Sediment Elutriate Tests *Arbacia punctulata*				
	Un-Ionized Ammonia (mg/L)	Survival		Un-Ionized Ammonia (mg/L)	Fertilization		Larval Development	
		Mean[1]	Flag[5]		Mean[2]	Flag[5]	IC_{10}[3]	Flag[5]
DSY-25	0.95	99.0	-	0.05	96.4	-	30.2	*++
DSY-26	0.26	101	-	0.00	103	-	8.91	*+++
DSY-27	0.02	78.9	*+	0.03	98.4	-	nc	-
DSY-28	1.25	70.1	*+	0.16	94.2	-	3.34	*+++
DSY-29	0.84	94.8	-	0.08	91.6	-	9.35	*+++
DSY-30	ND	84.2	-	0.03	96.9	-	nc	-
DSY-31	ND	101	-	0.05	92.7	-	37.6	*++
DSY-32	0.17	96.9	-	0.03	88.6	-	33.8	*++
DSY-33	0.26	100	-	0.01	92.2	-	19.3	*++
DSY-34	0.01	96.8	-	0.04	88.6	-	nc	-
DSY-35	0.01	103	-	0.00	96.9	-	nc	-
DSY-36	0.10	99.0	-	0.02	93.8	-	54.2	*+
DSY-37	0.26	101	-	0.02	95.9	-	25.2	*++
DSY-38	0.76	99.0	-	0.05	95.9	-	34.4	*++
DSY-39	ND	100	-	0.04	89.1	-	25.8	*++
DSY-40	ND	100	-	0.01	96.9	-	62.6	*+
DSY-41	0.33	97.9	-	0.01	94.8	-	39.0	*++
JPC-1	0.44	97.9	-	0.03	98.4	-	nc	-
JPC-2	0.09	100	-	0.01	100	-	>100	-

Notes:

1 - Percent *Ampelisca* survival in bulk sediment sample. Data normalized to the control.

2 - Percent fertilized *Arbacia* eggs in elutriate of sediment sample. Data normalized to the control.

3 - Estimate of the concentration which would cause a 10% reduction in normal larval development. Refer to section 5.2.3. of the text for explanation of calculations of the estimated value. Values are measured as % full-strength elutriate concentration (1:4 sediment/water mixture).

4 - DSY = Derecktor Shipyard, Coddington Cove; JPC = Jamestown Potter Cove

5 - Toxicity Flag Codes:

Ampelisca survival: - = no effect; * = statistically < control; *+ = statistically < control and 60-80% of control; *++ = statistically < control and < 60% control; *+++ = statistically < control and < 10% control.

Arbacia fertilization: - = no effect; * = statistically < control; *+ = statistically < control and 50-70% of control; *++ = statistically < control and < 50% control; *+++ = statistically < control and < 10% control.

Arbacia normal larval development: - = not toxic; * = one or more dilutions statistically< control; *+ = 70% or less elutriate concentration causes 10% abnormal development; *++ = 50% or less elutriate concentration causes 10% abnormal development; *+++ = 10% or less elutriate concentration causes 10% abnormal development.

nc = Not calculated.

ND = No data.

Table 5.3-1. Biological Condition Scoring Criteria for assessment of benthic communities in the Derecktor Shipyard/Coddington Cove Study Area.

Habitat	Metric	Biological Condition Scoring Criteria[1]			
		1st Quartile (0 pts.)	2nd Quartile (2 pts.)	3rd Quartile (4 pts.)	4th Quartile (6 pts.)
Silt	Total Species Observed[4]	< 0.67	0.67 - 0.81	0.81 - 0.86	> 0.86
	Total Individuals[4]	< 1.74	1.74 - 2.17	2.17 - 2.85	> 2.85
	%Dominant Taxa[3]	> 0.88	0.71 - 0.88	0.59 - 0.71	< 0.59
	Margalef Species Richness[4]	< 0.60	0.60 - 0.66	0.66 - 0.76	> 0.76
	Shannon-Wiener Diversity[4]	< 0.31	0.31 - 0.41	0.41 - 0.70	> 0.70
	Pielou's Evenness[4]	< 0.39	0.39 - 0.57	0.57 - 0.76	> 0.76
	Bray-Curtis Similarity[2]	< 46.0	46.0 - 54.0	54.0 - 61.5	> 61.5
Overall Silt Benthic Metric Ranking:[5]		< 0.31	0.31 - 0.38	0.38 - 0.67	> 0.67
Sand	Total Species Observed[4]	< 0.04	0.04 - 0.27	0.27 - 0.46	> 0.46
	Total Individuals[4]	< 0.03	0.03 - 0.25	0.25 - 0.45	> 0.45
	%Dominant Taxa[3]	> 0.29	0.28 - 0.29	0.27 - 0.28	< 0.27
	Margalef Species Richness[4]	< 0.35	0.35 - 0.48	0.48 - 0.57	> 0.57
	Shannon-Wiener Diversity[4]	< 0.72	0.72 - 0.80	0.80 - 0.87	> 0.87
	Pielou's Evenness[4]	< 1.02	1.02 - 1.09	1.09 - 1.16	> 1.16
	Bray-Curtis Similarity[2]	< 6.00	6.00 - 27.0	27.0 - 38.3	> 38.3
Overall Sand Benthic Metric Ranking:[5]		< 0.08	0.08 - 0.48	0.48 - 0.69	> 0.69

1 - Scoring estimated as quartile distribution of habitat and metric specific site data.
2 - Quartile based on range of values obtained; a comparison to reference is incorporated into index.
3 - Scoring evaluates actual % contribution, not percent comparability to reference location.
4 - Score is a ratio of study site to reference location.
5 - Expressed as decimal fraction of total possible points (42 pts. total) - no point score assigned to this ranking

Table 5.3-2. Distribution of the 20 most common benthic invertebrate species in silt- and sand-bottom habitats at the Derecktor Shipyard/ Coddington Cove (DSY) study area stations and the Jamestown Potter Cove (JPC) reference locations.

A. SILT-BOTTOM HABITATS[3]

		Abundance (no./ 0.05 m^2)[1]												
		Stations											Site	REF
Class	Species	DSY-27	DSY-28	DSY-29	DSY-30	DSY-31	DSY-32	DSY-34	DSY-36	DSY-37	DSY-38	DSY-39	Mean	JPC-2
AMPHIPODA	*Ampelisca abdita/vadorum*	0	5	2	5	0	0	1	0	0	0	0	1.2	0
	Leptocheirus pinguis	1	1	0	0	0	0	0	0	14	0	0	1.5	0
BIVALVIA	*Macoma tenta*	4	16	0	0	27	0	37	17	14	0	21	12.2	0
	Mulinia lateralis	0	12	0	8	9	0	7	3	11	0	20	6.2	0
	Nucula annulata	595	431	0	192	740	818	441	1246	359	860	2299	725.3	198
	Pitar morrhuanus	0	1	0	0	0	0	2	3	4	0	8	1.5	4
	Tellina agilis	6	11	0	10	5	0	0	0	7	7	17	5.5	0
	Yoldia limatula	0	7	0	0	9	0	2	7	7	5	0	3.3	5
GASTROPODA	*Acteocina canaliculata*	2	0	0	8	13	0	7	15	17	0	1	5.6	0
	Acteon punctostriatus	2	0	0	8	7	1	7	4	8	0	0	3.2	0
	Cylichnella oryza	9	0	0	20	27	3	10	8	53	4	39	15.6	3
	Nassarius trivittatus	3	10	0	0	16	8	0	6	3	14	11	6.4	1
NEMERTINEA	*Tubulanus pellucidus*	5	0	0	5	4	7	20	2	11	1	2	5.0	0
OLIGOCHAETA	*Oligochaeta spp.*	0	68	0	22	5	0	3	0	0	0	0	8.8	0
POLYCHAETA	*Mediomastus ambiseta*	45	250	0	228	193	281	88	35	173	83	29	127.5	23
	Nephtys incisa	11	13	0	12	19	19	24	27	31	23	56	21.1	15
	Ninoe nigripes	11	0	0	5	4	3	5	7	13	7	3	5.0	0
	Spio spp.	0	0	0	0	0	2	4	0	0	0	3	0.8	0
	Streblospio benedicti	0	12	0	0	0	0	0	0	0	0	0	1.1	0
	Tharyx acutus	0	9	0	4	0	0	0	1	1	1	0	1.4	0
BENTHIC COMMUNITY METRICS/ RANK	Total Species[2]	13 +++	18 +	1 +++	15 ++	19 -	11 +++	18 +	17 ++	23 -	16 ++	18 +	15.4	21
	Total Individuals[2]	700 ++	849 ++	2 +++	532 +++	1082 +	1148 -	661 +++	1384 -	739 ++	1012 +	2519 -	966	392
	%Dominant Taxa	0.85 ++	0.51 -	1.00 +++	0.43 -	0.68 +	0.71 ++	0.67 +	0.90 +++	0.49 -	0.85 ++	0.91 +++	0.73	0.51
	Margalef Species Richness[2]	1.8 +++	2.5 +	0.0 +++	2.2 +	2.6 -	1.4 +++	2.6 -	2.2 ++	3.3 -	2.2 ++	2.2 ++	2.1	3.4
	Shannon-Wiener Diversity[2]	0.7 ++	1.4 -	0.0 +++	1.6 -	1.2 +	0.8 ++	1.3 +	0.6 +++	1.8 -	0.7 ++	0.5 +++	0.95	1.97
	Pielou's Evenness[2]	0.3 ++	0.5 -		0.6 -	0.4 +	0.3 ++	0.5 +	0.2 +++	0.6 -	0.2 +++	0.2 +++	0.37	0.65
	Bray-Curtis Similarity Index (%)[2]	56 +	45 +++	0 +++	54 +	64 -	38 +++	64 -	59 +	65 -	47 ++	54 +	50	NA
Overall Silt Benthic Metric Ranking:[4]		0.29 +++	0.67 +	0.00 +++	0.67 +	0.81 -	0.29 +++	0.67 +	0.33 ++	0.90 -	0.33 ++	0.38 ++		

1 - Mean of two replicate grabs per station.
2 - 1st quartile (0 pts.) = "+++"; 2nd quartile (2 pts.) = "++"; 3rd quartile (4 pts.) = "+"; 4th quartile (6 pts.) = "-". See Table 5.3-1 for metric specific point assignments.
3 - Sediment composition < 40% sand, except JPC-2 = 65% sand and DSY-37 = 50% sand.
4 - Overall Benthic Metric Ranking: expressed as decimal fraction of total possible points (42); see Table 5.3-1.

Table 5.3-2 (continued). Distribution of the 20 most common benthic invertebrate species in silt- and sand-bottom habitats at the Derecktor Shipyard/Coddington Cove (DSY) study area stations and the Jamestown Potter Cove (JPC) reference locations.

B. SAND-BOTTOM HABITATS[3]

		Abundance (no./ 0.05 m^2)[1]													
		Stations												Site	REF
Class	Species	DSY-25		DSY-26		DSY-33		DSY-35		DSY-40		DSY-41		Mean	JPC-1
AMPHIPODA	*Ampelisca abdita/vadorum*	0		2		0		0		4		0		1.0	16
	Leptocheirus pinguis	0		0		79		0		0		0		13.1	0
	Photis pollex	0		0		27		0		0		0		4.4	0
BIVALVIA	*Gemma gemma*	0		0		0		41		0		0		6.8	0
	Nucula annulata	0		12		10		0		12		0		5.7	4
	Tellina agilis	0		25		0		29		0		0		8.9	24
GASTROPODA	*Crepidula plana*	0		10		0		0		0		0		1.7	0
OLIGOCHAETA	*Oligochaeta spp.*	0		6		96		27		0		0		21.4	106
POLYCHAETA	*Aricidea catherinae*	0		0		23		66		0		0		14.8	55
	Glycera americana	0		12		10		10		3		0		5.8	16
	Macroclymene zonalis	0		5		4		0		0		0		1.4	9
	Mediomastus ambiseta	0		48		163		0		13		0		37.2	94
	Montocellina baptisteae	0		12		44		0		0		0		9.3	2
	Neanthes succinea	0		0		0		0		11		0		1.8	0
	Nephtys incisa	0		0		8		0		0		0		1.3	0
	Ninoe nigripes	0		15		57		0		0		0		12.0	7
	Polycirrus eximius	0		9		18		0		0		0		4.4	2
	Spiophanes bombyx	0		0		0		15		0		0		2.5	0
	Tharyx acutus	0		8		0		0		0		0		1.3	5
	Tharyx crochet	0		0		0		8		0		0		1.3	0
BENTHIC	Total Species[2]	0	+++	19	-	25	-	14	+	7	++	0	+++	10.8	39
COMMUNITY	Total Individuals[2]	0	+++	177	+	574	-	212	-	49	++	0	+++	168.5	450
METRICS/	%Dominant Taxa			0.27	-	0.28	++	0.31	+++	0.26	-			0.28	0.24
RANK	Margalef Species Richness[2]			3.5	+	3.8	-	2.4	++	1.5	+++			2.81	6.2
	Shannon-Wiener Diversity[2]			2.5	-	2.3	+	2.0	++	1.8	+++			2.13	2.7
	Pielou's Evenness[2]			0.8	+	0.7	+++	0.8	++	0.9	-			0.80	0.7
	Bray-Curtis Similarity Index (%)[2]	0	+++	46	-	41	-	30	+	24	++	0	+++	23.5	NA
Overall Sand Benthic Metric Ranking:[4]		0.00	+++	0.86	-	0.71	-	0.48	+	0.43	++	0.00	+++		

1 - Mean of two replicate grabs per station.
2 - 1st quartile (0 pts.) = "+++"; 2nd quartile (2 pts.) = "++"; 3rd quartile (4 pts.) = "+"; 4th quartile (6 pts.) = "-". See Table 5.3-1 for metric specific point assignments.
3 - Sediment composition $\geq$ 70% sand.
4 - Overall Benthic Metric Ranking: expressed as decimal fraction of total possible points (42); see Table 5.3-1.

Table 5.3-3. Deployed mussel mortality for the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	% Mortality Mean	SD
DSY-26	12.5	14.4
DSY-28	0	0
DSY-29	5	10
DSY-31	0	0
DSY-33	10	11.5
DSY-38	0	0
DSY-39	23.75	20.5
DSY-40	6.25	12.5
JPC-1	5	10
CHC-1	0	0

Table 5.3-4. Results of hematopoietic neoplasia assessment of blue mussels collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference location.

Station	Affliction (%) [1]		Severity (%) [2]		Risk Ranking
	Mean	Flag[3]	Mean	Flag[3]	
DSY-26	100.0	++	19.3	-	++
DSY-29	75.0	+	28.1	-	+
DSY-31	50.0	-	17.9	-	-
DSY-35	30.0	-	0.6	-	-
DSY-36	31.3	-	0.3	-	-
DSY-40	80.0	+	24.1	-	+
JPC-1	65.0		37.0		

1- Percent of animals found with neoplastic cells; 20 indviduals collected from each station.

2- Percent neoplastic cells found/affected animal.

3 - Flag: "++" = > 90% occurrence; "+" = 70-90% occurrence; "-" = < 70% occurrence.

4 - Risk Ranking: both indicator "++" = "+++"; otherwise maximum of indicator specific rankings.

Table 5.3-5. Results of fecal pollution indicator concentrations in blue mussels deployed in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove reference locations[1].

Station Number	Total Coliforms CFU[2]/100 g		Fecal Coliforms CFU[2]/100 g		Fecal Streptococci CFU[2]/100 g		*Clostridium perfringens* CFU[2]/100 g		Overall Ranking[3]
DSY-26	490	++	20	-	20	-	790	++	++
DSY-28	45	-	<18	-	<18	-	330	+	-
DSY-29	340	+	130	+	78	-	790	++	+
DSY-31	68	-	<18	-	<18	-	220	+	-
DSY-33	490	++	45	-	20	-	490	++	++
DSY-38	130	+	20	-	20	-	330	+	+
DSY-39	170	+	45	-	20	-	330	+	+
DSY-40	1700	+++	110	+	78	-	790	++	+++
JPC-1	230	+	45	-	45	-	490	++	+
CHC-1	130	+	45	-	20	-	490	++	+
T_0-DM-AVG[4]	ND		ND		ND		50	-	-
Cape Cod Fresh[5]	20	-	<18	-	140	+	140	+	+
Cape Cod Frozen[6]	ND		ND		ND		83	-	-

1 - Indicator-specific rankings: "-" = <100 CFU/100 g; "+" = 100-350 CFU/100 g (low); "++" = >350 CFU/100 g (intermediate); "+++" = >1000 CFU/100 g (high).
2 - CFU = Colony forming units
3 - Overall Ranking: "+++" = exposure observed for two or more indicators and high (+++) exposure observed in at least one indicator; "++" = intermediate (++) exposure observed for two or more indicators or high (+++) exposure for one indicator; "+" = low (+) exposure observed for two or more indicators or intermediate (++) exposure for one indicator; "-" = low (+) exposure observed for only one indicator or no exposure for all indicators.
4 - Cape Cod T_0 mussels collected on 10/2/95, depurated in fresh marine water for 96 h, frozen at -20°C and assayed on 4/3/96 for spore-forming bacteria only. Data presented are means of replicate samples assayed.
5 - Cape Cod mussels collected on 3/31/96, depurated in fresh marine water for 96 h and assayed on 4/3/96 for vegetative and spore-forming bacteria.
6 - Cape Cod mussels collected on 3/31/96, depurated in fresh marine water for 96 h, frozen for 2 hours at -20°C (to eliminate vegetative bacteria), and assayed on 4/3/96 for spore-forming bacteria only.
ND= No data.

6.0. RISK CHARACTERIZATION

In the Risk Characterization phase of the Derecktor Shipyard ERA, the following activities have been conducted: (1) Comparisons of exposure point concentrations against established standards and criteria for sediments and water quality (Section 6.1); (2) Assessment of tissue residue exposure and effects in target receptors (Section 6.2); (3) An analysis of CoC bioaccumulation/trophic transfer in fish, bivalves, lobster and birds (Section 6.3); (4) Comparison of laboratory-based toxicity results against CoC sediment and elutriate concentrations (Section 6.4); (5) Analysis of CoC concentration versus effects measurements (Section 6.5); (6) Risk Synthesis (Section 6.6); and (7) Analysis of Uncertainties associated with the above interpretations (Section 6.7).

6.1. COMPARISON OF CoC CONCENTRATIONS WITH CRITERIA AND STANDARDS

In this section, concentrations of contaminants of concern (CoC) are compared with effects-based screening benchmarks. For sediments, comparisons were made against the NOAA ER-L and ER-M values (Long *et al.*, 1995), whereas elutriate concentrations were compared against EPA Water Quality Criteria. For the contaminants in each matrix for which there were benchmarks available, Hazard Quotients were developed by dividing the contaminant concentration measured at the station by the benchmark concentration. An additional contaminant class-level index, called the Hazard Index, was also included, calculated as the sum of analyte-specific Hazard Quotients within each of the CoC groups. This latter analysis was intended to provide a means of evaluating potential adverse exposures posed by analytes acting in an additive manner; however, the Hazard Index does not address potential synergistic or antagonistic interactions among contaminants.

6.1.1. Bulk Sediment Contaminants

Figures 6.1-1 through 6.1-4 present the spatial dis relative to ER-L and ER-M benchmarks for organic conta from the Derecktor Shipyard/Coddington Cove study are Cove reference Station JPC-1. Calculated ER-L and ER- Hazard Indices for sediments are presented in Appendix Total PCBs in all sediments tested, with the exception of DSY-41 and the reference Station JPC-1, exceeded the l Long *et al.*, 1995). The highest concentrations for PCBs Stations DSY-27 and DSY-29, where values exceeded tl than 146- and 41-fold, respectively (Figure 6.1-1, Appen but less pronounced trend occurred for p,p'-DDE (Figure sediment concentrations were observed at Stations DSY DSY-29 (ER-L HQ = 2.9; Appendix Table A-2-1.1). Tota elevated at Stations DSY-25 through DSY-32, as well as highest sediment concentration observed at Station DSY Table A-2-1.1). In general, low and high molecular weig followed the same trend as for Total PAHs.

No benchmarks exist for TBT, although a concentrat has been suggested as being indicative of degraded condit ecological effects (Macauley *et al.*, 1994). Concentratior (Figure 6.1-4) exceeded 5 ng Sn/g by more than ten-fold and especially DSY-31, where the concentration was gre suggested benchmark (Appendix Table A-2-1.1). Statio DSY-36 also marginally exceeded the benchmark. HQs did not exceed one for any contaminant measured (App

The above results illustrate the spatial distribution of organic contaminants in surface sediments from the Derecktor Shipyard/Coddington Cove study area. Highest HQs were generally observed near the harbor front area (Stations DSY-25 through DSY-29), as well as Stations DSY-30, DSY-31, and DSY-32, i.e., inshore stations closest to the piers and outfalls of Derecktor Shipyard. Stations DSY-40 and DSY-41 generally had lower values than surrounding stations, such as Stations DSY-28, DSY-29, and DSY-30, perhaps because of hydrographic isolation from Coddington Cove proper.

Concentrations of metals in sediments from the Derecktor Shipyard/Coddington Cove study area relative to the ER-L and ER-M benchmarks are presented in Figure 6.1-5 through 6.1-13. Calculated ER-L and ER-M Hazard Quotients and Hazard Indices are presented in Appendix Tables A-2-1.1 and A-2-1.2, respectively. Mercury concentrations were elevated at Stations DSY-27 through DSY-32, DSY-34, DSY-36 through DSY-38, with a slight elevation at Station DSY-40 (Figure 6.1-5). Concentrations of lead exceeded the ER-L benchmark at Stations DSY-27 through DSY-32, DSY-34 and DSY-36 through DSY-39, and approached the ER-M concentration at Station DSY-29 (Figure 6.1-6). Concentrations of copper exceeded the ER-L in sediments from Stations DSY-26 through DSY-32 and at Station DSY-36 (Figure 6.1-7).

Arsenic concentrations exceeded the ER-L benchmark at Stations DSY-26 through DSY-32, DSY-34, DSY-36, DSY-38, and DSY-41, with only a slight elevation at DSY-38 (Figure 6.1-8). Concentrations of nickel exceeded the ER-L benchmark at Stations DSY-27 through DSY-32, Station DSY-36, and marginally at Stations DSY-25 and DSY-38 (Figure 6.1-9). Concentrations of zinc exceeded the ER-L benchmark value at Stations DSY-27 through DSY-32, and exceeded the ER-M value at Station DSY-27 (Figure 6.1-10).

Concentrations of chromium in surface sediments were elevated slightly above the ER-L at Stations DSY-27, DSY-29, DSY-32, and DSY-36 (Figure 6.1-11). Cadmium exceeded the ER-L benchmark only at Station DSY-29 and was equal to the ER-L benchmark at Station DSY-30 (Figure 6.1-12). Concentrations of silver were lower than ER-L benchmark values at all stations (Figure 6.1-13).

Spatial variations of anthropogenic trace metal concentrations within the Derecktor Shipyard/Coddington Cove study area can be grouped into three spatial patterns: (1) adverse exposure from copper, zinc and chromium were generally highest at nearshore stations (Figures 6.1-7, 6.1-10 and 6.1-11, respectively); (2) adverse exposure from mercury, lead, arsenic and nickel were generally comparable between nearshore and offshore stations (Figures 6.1-5, 6.1-6, 6.1-8 and 6.1-9, respectively); and (3) adverse exposure from cadmium and silver concentrations were generally low (Figures 6.1-12 and 6.1-13). Trace metal concentrations for the reference stations in Jamestown Potter Cove were generally lower than the sediment quality guidelines (Long *et al.*, 1995), although Station JPC-1 exceeded the ER-L for mercury, and Station JPC-2 exceeded the ER-L for lead (Figures 6.1-5 and 6.1-6; Appendix Table A-2-1.1).

ER-L and ER-M Hazard Indices for metals and for PAHs (sum of station-specific HQs) are shown in Figure 6.1-14. The data suggest highest adverse exposure for metals at Stations DSY-27 (ER-L HI $\approx$ 22, ER-M HI $\approx$ 4.9) and DSY-29 (ER-L HI $\approx$ 21, ER-M HI $\approx$ 4.4, Figure 6.1-14A). Particularly high HIs were observed for PAHs at Stations DSY-27 (ER-L HI $\approx$ 29, ER-M $\approx$ 3.8), DSY-29 (ER-L HI $\approx$ 101, ER-M HI $\approx$ 12), and DSY-30 (ER-L HI $\approx$ 50, ER-M $\approx$ 5). Hazard Indices for PCBs, pesticides, and butyltins were the same as the corresponding Hazard Quotients, since only one analytical parameter (i.e., Total PCBs, p,p'-DDE, and tributyltin, respectively) is available for each case.

6.1.2. Sediment Elutriate Contaminants

Elutriates of sediments from twelve stations (Stations DSY-25, DSY-27, DSY-29, DSY-31, DSY-32, DSY-33, DSY-36 through DSY-40, and JPC-1) were analyzed for metal and organic contaminant concentrations. Elutriate metals were not measured at Stations DSY-27 and DSY-29. Due to spatial proximity, elutriate contaminant concentrations at Station DSY-41 were assumed to be equivalent to those measured at Station DSY-40; thus, in this section, these two stations are referred to jointly as DSY-40/41, in reference to the sediment elutriate assessment. Complete results of sediment elutriate analyses relative to EPA Ambient Water Quality Criteria - Saltwater Chronic values and Saltwater Acute values are presented in Appendices A-2-2.1 and A-2-2.2, respectively; raw elutriate concentrations are found in Appendix Table A-1-2.

In general, elutriates only showed elevated levels of PCBs, arsenic and lead relative to EPA Ambient Water Quality Criteria (AWQC) for saltwater (U.S. EPA, 1986; Appendix Tables A-2-2.1 and A-2-2.2). Concentrations of Total PCBs were highest at Station DSY-25, and levels above the corresponding EPA Ambient Water Quality Criterion - Saltwater Chronic (AWQC-SC = 30 ng/L) were also detected at Stations DSY-27, DSY-29, DSY-31, DSY-33, DSY-37, DSY-40/41, and the reference Station JPC-1 (Figure 6.1-15A). Concentrations of arsenic were elevated above the corresponding AWQC-SC (36 µg/L) in elutriates from Stations DSY-36, DSY-38, and DSY-39 (Figure 6.1-15B). Additionally, levels of lead exceeded the corresponding AWQC-SC (8.5 µg/L) at Stations DSY-25, DSY-32, DSY-33, DSY-37 through DSY-40/41, and the reference Station JPC-1 (Figure 6.1-15C). Other CoCs were not present above detection limits, with the exception of copper, at one station, DSY-31. The highest Total PAH concentration in elutriates was 0.87 µg/L at Station DSY-25; this value is well below the NOEC concentration of 30 µg/L (U.S. EPA, 1986).

The comparison of elutriate and sediment concentrations for PCBs and PAHs, discussed previously in Section 4.3, indicates that resuspended sediments can potentially contribute colloidal and/or dissolved organic contaminants to the water column in elutriate preparations and, presumably, during sediment resuspension in Coddington Cove. Similar comparisons for metals suggested that resuspension events may increase dissolved phase exposure for arsenic, but not for lead. However, this evaluation addresses only current conditions and levels of activity at the site, and does not address future use scenarios involving fundamentally different conditions or activities at the site. In elutriate preparations, 25% (25,000 mg/g) suspended solids concentration was achieved in the initial dilution of bulk sediment with Narragansett Bay water (i.e. 100% elutriate), but this concentration is generally unlikely to occur in the field. One possible zone where such exposure concentrations might temporarily exist is at the sediment water interface during major storm events or during mechanical disruption, in which case PAHs, PCBs, and arsenic may be important CoCs in regard to adverse exposure to aquatic receptors.

6.1.3. Simultaneously Extractable Metals

The toxicity of divalent metals is believed to be predictable from measures of Simultaneously Extractable Metals (SEM) concentrations in sediments relative to Acid Volatile Sulfides (AVS) also in the sediment matrix (DiToro *et al.*, 1994). The concentration of SEM is operationally defined by the chemical extraction procedure, which is less robust in comparison to conventional (e.g. strong acid) sediment digestion methods. The concentration of AVS is also operationally defined by the extraction procedure (i.e. sulfides released during sample acidification, hence "acid volatile"). Because sulfides in sediments form stable bonds with metals under anoxic conditions, toxicity of metals is limited when the molar concentration of AVS exceeds that of SEM. However, sulfides are easily oxidized to sulfates which do not bind metals. For this reason, the interpretation of metal bioavailability must consider possible scenarios

which may control AVS concentrations, including seasonality, but also sample handling and processing.

To aid in this interpretation, various measures of SEM bioavailability are presented in Table 6.1-1. Raw data for SEM and AVS are presented in Appendix A-1-4. SEM bioavailability rankings for each of the metrics, as well as an overall SEM ranking, have been applied to permit incorporation of this information into Section 6.6 (Risk Summary).

SEM concentration divided by AVS concentration (SEM/AVS) reveals four stations with ratios greater than 0.5, including Station DSY-33, DSY-35, DSY-37 and reference Station JPC-2. An SEM-AVS concentration of 5 µmol/g dry weight was previously shown to be an approximate threshold for toxicity to amphipods by the National Sediment Quality Inventory (U.S. EPA, 1996). However, in the present investigation, the result of SEM concentration less AVS concentration (SEM-AVS) indicates that SEM metals were not available at toxic concentrations (Table 6.1-1). Finally, because of volatility and seasonal variability of AVS, the total SEM concentration is of interest, in that SEM might become bioavailable if all AVS were lost from the sediment. For example, in the present investigation, assuming a total absence of AVS in the sediment, SEM concentrations would exceed the SEM-AVS threshold value of 5 µmol/g at Stations DSY-27, DSY-28, DSY-29, and DSY-30 (Table 6.1-1).

6.2. Assessment of Tissue Residue Exposure and Effects in Target Receptors

This section evaluates tissue residues in target species as indicators of CoC-related exposure and effects. CoC exposure was assessed by comparison of site tissue residue concentrations with reference tissue residue concentrations (Tissue Concentration Ratios, Section 6.2.1), while effects of CoCs in target species was

addressed by comparison of tissue residues against tissue benchmarks derived from water quality criteria (Tissue Screening Concentration HQs; Section 6.2.2.1), and comparison of tissue residues against threshold concentrations for narcotic effects (Critical Body Residue HQs, Section 6.2.2.2). A summary of tissue residue-related impacts is presented in Section 6.2.2.3.

6.2.1. Tissue Residue-based Exposure Assessments

Site vs. Reference Tissue Concentration Ratios (TCRs) were employed to evaluate the potential significance of CoC tissue residues in target species. The analysis involves the comparison of receptor- and analyte-specific tissue body burdens from the Derecktor Shipyard/Coddington Cove stations against the corresponding data for the Jamestown Potter Cove and Castle Hill Cove reference stations. Comparisons of site tissue concentrations against reference stations were made only for the same species and analytes. For this analysis, species- and analyte-specific data collected from the reference stations were numerically averaged to yield a single best estimate for the reference-based value. For organics data, tissue concentrations were normalized to the lipid content of the organism. Site and reference values below the Method Detection Limit (MDL) were not used to calculate TCRs in this analysis.

Tissue Concentration Ratio (TCR) rankings for organic contaminants and metals in target receptors from the Derecktor Shipyard/Coddington Cove study area, presented in Table 6.2-1, were based on sixteen PAHs, Total PCBs, p,p'-DDE, tributyltin, and all nine anthropogenic metals. Results were ranked according to the following method: "-" indicates TCR ≤ 1, "+" indicated TCR >1, "++" indicates TCR >3, and "+++" indicates TCR >10. Complete results are presented in Appendix Tables A-2-3.1 through A-2-3.5.

Table 6.2-1a, which summarizes TCR rankings by station, reveals the highest enrichment in target species at Stations DSY-25 through DSY-27 due to PAH exposure.

Additionally, Total PCBs were elevated at Stations DSY-26, DSY-28, DSY-29, and DSY-36, and p,p-DDE was elevated at Stations DSY-29 and DSY-36. TBT enrichment was evident at Stations DSY-27 and DSY-35. In contrast, metal enrichment for target species was generally less than three-fold; one exception was observed for cadmium in indigenous mussels at Station DSY-24.

From Table 6.2-1b, which presents TCR rankings by species, it is readily apparent that indigenous blue mussels (IBM) exhibited the highest CoC enrichments among target species, particulary for PAHs at Stations DSY-25 through DSY-27. Total PAH TCRs greater than three were observed for lobster at Stations DSY-27 and DSY-28. Other species did not exhibit similar enrichment, although TCRs greater than three were noted for various PAH analytes. Cunner was unique in its apparent enrichment for Total PCBs and p,p'-DDE, where tissue concentrations greater than three times reference at several stations were observed. TBT TCRs greater than three were noted only for IBM at Station DSY-27 and *Mercenaria mercenaria* (MM) at Station DSY-35. Enrichment factors for metals appeared to be generally less than those observed for organics; only for cadmium in IBM at Station DSY-24 was the TCR greater than three.

In summary, TCRs indicated that the greatest CoC exposure to target species occurred at Stations DSY-25, DSY-26 and DSY-27, particularly for indigenous blue mussels but also lobster and cunner, and that PAHs were the primary CoC class of concern. These species-specific results are carried forward to the exposure-based weight of evidence summary presented in Section 6.6 (Table 6.6-1). Note that some uncertainty exists with regard to the interpretation of PAH results in cunner, because metabolic activities may reduce PAH tissue concentrations, which would potentially cause the TCR value to be underestimated.

6.2.2. Tissue Residue-based Effects Assessment

In this section, effects of CoC residues in target species are evaluated by comparison of tissue concentrations against water quality-based benchmarks (Tissue Screening Concentration HQs; Section 6.2.2.1), and thresholds for narcotic effects (Critical Body Residue HQs, Section 6.2.2.2).

6.2.2.1. Tissue Screening Concentration Assessments

The fundamental basis for Tissue Screening Concentration (TSC) Assessments is the assumption that the product of the Water Quality Criteria value for a given CoC and the Bioconcentration Factor (BCF, tissue-water concentration ratio) should provide an estimate of the tissue concentration which is also protective to the species. A recent study by Shepard (1995) involving a literature survey of paired residue/effects data for 100+ chemicals demonstrated that only 19% of the TSCs derived in the above manner were higher than tissue residues found to be associated with toxic effects (i.e., the derived TSC was protective of aquatic life 81% of the time). CoCs for which the TSC approach was not protective primarily included PAHs; it was hypothesized that these compounds exhibited enhanced toxicity through the activity of metabolic breakdown products which are not measured (Shepard, 1995). Exclusion of these compounds from the analysis improved the protectiveness of TSCs to a level comparable to that of water quality criteria (93%).

Given this first demonstration that TSCs can provide a level of protection equivalent to WQC, TSCs were adopted for this ERA to assess potential effects of tissue residue concentrations in target receptors. A Hazard Quotient approach was taken in this analysis, in which the measured tissue concentration is divided by the TSC effect concentration to calculate the TSC Hazard Quotient (TSC-HQ).

The analyte-specific residue concentrations presumed to be adverse to the organism (TSC effect concentrations) were taken as reported by from Shepard (1995) in Table 6.2-2. For the present study, CoC residues in target species, reported as a dry weight basis in Appendix Table A-1-3, were converted to wet weight using sample-specific values that are reported in Appendix Table A-2-4.1 so as to allow direct comparison with the TSC benchmark. Rankings of TSC-HQ, summarized by station and species, are presented in Table 6.2-3. TSCs were evaluated for all nine metals, fifteen PAHs, Total PCBs, p,p'-DDE, and tributyltin.

TSC-HQ values for target receptors are summarized in Table 6.2-3. It is apparent from the data that potential impacts on receptors from the site as well as the reference locations are caused primarily by metals exposure, particulary copper, for which TSC-HQs greater than 40 were often observed (Table 6.2-3A). Table 6.2-3B, which presents TSC-HQs by target species, reveals lobster as the species exhibiting greatest potential impacts for both Coddington Cove stations and reference locations, again driven by exposure to copper in particular. In contrast, TSC-HQs for PAHs, PCBs, and p,p'-DDE generally suggest a lack of residue-based adverse effects to the target species. An intermediate adverse effect due to TBT was observed due to residues found in indigenous blue mussels at Station DSY-28. Low adverse effects related to various metals (As, Cd, Cr, Pb, Ni, and Zn) were noted for hard clams, deployed mussels, and cunner throughout the site.

In summary, the magnitude of the TSC-HQs and spatial location suggest that metals, particularly copper, impact most species across the study area as well as the reference locations. Lobsters appear to be subject to greatest adverse effects, though indigenous blue mussels and cunner also may be subject to adverse effects. As for lobster, there exists uncertainty in the effects assumption given the degree of mobility of the species which would allow the possibility that the primary chemical exposure may not necessarily have occurred at the sample location. Possible residue impacts are not

limited to nearshore stations and, as previously mentioned, are observed even at reference locations. The species-specific results are carried forward to the Tissue Residue Effects summary in Section 6.2.2.3 (Table 6.2-6).

6.2.2.2. Critical Body Residue Assessments

The above analyses have addressed the potential impacts of individual CoCs when found at elevated concentrations within the tissues of target species. However, even when CoCs in target tissues are below the effects threshold for specific toxic action (e.g., central nervous system, respiratory, digestive disruptions), the combined presence of the chemical mixture may still cause non- specific toxicity through a phenomenon called narcosis (McCarty *et al.*, 1992). Narcosis is a physiologically debilitating condition caused by CoC-related swelling of cell membranes. Critical Body Residues (CBRs) represent the concentrations at which narcotic effects on the species may occur. The utility of CBR analysis for this ERA is enhanced by the fact that the organic CoCs for the present ERA (i.e., PAHs, PCBs, pesticides) generally fall into a class of compounds which can contribute to the narcotic mode of toxic action (McCarty *et al.*, 1992). The CBR approach is also believed to apply to organometals (e.g. butyltins) and metals (McCarty and Mackay, 1993). Hence, narcosis theory does appear to be relevant to the various CoC classes considered in this analysis.

CBR values are expressed as the molar tissue concentrations (µMol/g dry wt) of CoCs measured in the tissue (e.g., µg CoC/g dry weight divided by CoC molecular weight (µg CoC/µMol CoC)) and are compared against representative CBR benchmark values found in the literature (Table 6.2-4). Typically, CBR benchmarks are the Lowest Observed Adverse Effect (LOAEC) concentration after chronic (e.g. > 3 weeks) exposure to a given CoC. Where CBR benchmarks are derived from acute exposures, however, the equivalent chronic critical body residue concentrations can be estimated from the acutely toxic CBR by applying the acute:chronic ratio of the respective water or

sediment concentration toxicity relationship. For the present investigation, the total PAH LOAEC acute CBR value reported by Arnold and Biddinger (1995) was converted to a LOAEC chronic value assuming a 1:10 acute:chronic ratio. CBR benchmarks reported as wet tissue concentration are converted to a dry weight value assuming an average of 80% water content in the target species. Although it is known that tissue lipid concentration may increase the CBR benchmark by approximately 14% per each percent of lipid between 3% and 8% lipid concentration (McCarty and McKay, 1993), variation in lipid among target species was not considered in the present analyses.

To assess possible effects of tissue body burdens in the present ERA, measured tissue concentrations (calculated as µMol/g dry wt) of specific CoCs were divided by the available CBR benchmark found in the literature (Table 6.2-4) to derive CBR Hazard Quotients (CBR-HQs). In all, thirteen CBR benchmarks were obtained, including nine metals, Total PAHs, Total PCBs, p,p'-DDE, and tributyltin.

CBR-HQ rankings by chemical class and sorted by station and species are presented in Table 6.2-5. CBR-HQ results by station (Table 6.2-5A) reveal potential impacts due copper and zinc at various stations across the study area and at the reference locations. Table 6.2-5B further indicates that potential metal residue effects for copper are restricted to lobster, while all species, except cunner, are subject to low adverse effects due to zinc. To what extent the lobster population in general may be impacted on a year-round basis is likely to depend upon the migratory behavior of the species. Research is underway to evaluate the potential for both migratory and non-migratory sub-populations in Narragansett Bay (C. Deacutis, RIDEM, 1997), although the results are not presently available to address this issue. The species-specific CBR results are carried forward to the Tissue Residue Effects summary in Section 6.2.2.3 (Table 6.2-6).

6.2.2.3. Tissue Residue Effects Summary

Tissue Screening Concentration and Critical Body Residue Hazard Quotients have been evaluated in Section 6.2.2 to determine the probability of tissue residue-based effects by species and station. When considered jointly, the sensitivity/accuracy of these metrics follows the pattern for ER-L and ER-M-based effects interpretation, in that the lower concentration metric (in this case, TSCs and ER-Ls) are expected to identify many more CoCs of possible toxicological significance (hence, greater sensitivity), but with less certainty of implied adverse effects than higher concentration metrics (e.g., CBRs and ER-Ms). Conversely, the CBR metric represents a high accuracy/low sensitivity endpoint in that adverse field effects have been documented in some species where CoC residues exceeded CBR benchmarks. However, the CBR value is typically derived from less sensitive endpoints (such as lethality), and acute:chronic ratios may be applied to acute measurements to predict possible chronic threshold values. This extrapolation leads to loss of sensitivity.

Species-specific tissue residue effects ranking are summarized in Table 6.2-6. The reported results are the maximum of the indicator-specific rankings; these species-specific results are carried forward to the effects-based weight of evidence summary presented in Section 6.6 (Table 6.6-2). As the data reveals, lobster is the target receptor susceptible to highest adverse exposure (depending on migratory behavior), both at study area sites and at reference locations, with the ranking determined by the TSC-HQ result. Cunner and indigenous blue mussel values also appear to suggest adverse exposure potential. However, as discussed previously, the data for cunner should be interpreted with caution, as the measured residues for PAHs may not reflect true exposure due to potential PAH metabolism, and thus the observed HQs may not accurately reflect true adverse effects for this target species.

It is notable from the comparison of TCR values (an exposure indicator) with that of TSC and CBR HQs (effects indicators), that the TCR analysis identified mainly PAHs as a potential cause of adverse impact whereas the TSC and CBR analyses identified metals as the primary CoCs of concern. The differences between the two findings can be attributed to the fact that the TCR analysis is reference-based, while the TSC and CBR analyses are compared to benchmarks. Although PAHs are elevated in receptors of Coddington Cove, the residues are not likely to cause adverse effects due to low toxicity, while metals are of concern at the site, but this concern also extends to reference locations due to an apparent ubiquitous distribution of the observed metals.

6.3. Analysis of Bioaccumulation and Trophic Transfer

In sections below, the relationships between contaminant exposure and tissue residue concentration for organics (Section 6.3.1), metals (Section 6.3.2) and trophic transfer of metals and organics to avian receptors feeding on aquatic receptors (Section 6.3.3) are discussed. These relationships are presented in a framework intended to elucidate the essential operative transport and fate mechanisms that control chemical bioavailability and trophic transfer in the exposure pathway models for target receptors (outlined in Sections 3.4 and 3.5). Using these exposure models, the relative degree of CoC bioavailability in fish, bivalves and lobster at Derecktor Shipyard/ Coddington Cove stations versus reference stations, is discussed with respect to differences between species and habitat.

6.3.1. Analysis of Organic Contaminant Bioaccumulation

The purpose of this analysis is to identify potential differences in organic contaminant exposure for target species representing different habitat or feeding types. For each organic contaminant class (PCBs, PAHs, pesticides, and butyltins), exposure

pathway differences were evaluated through Tissue Residue - Exposure Relationships as well as Biota-Sediment Accumulation Factors (BSAFs).

Tissue Residue - Exposure Relationships. Figure 6.3-1 presents a comparison of Total PCBs and Total PAHs in indigenous and deployed blue mussels in relation to surface sediments from eight Derecktor Shipyard/Coddington Cove stations and one reference station (JPC-1). Deployed blue mussels (DM) were suspended in cages 1 m above the bottom at selected stations, then retrieved after approximately 30 days. This duration has been reported to allow enough time to establish equilibrium between mussels and water column concentrations for these CoCs (Pruell *et al.*, 1986). The DM tissue-sediment relationship for PAHs ($R^2 = 0.53$; significant at the 95% confidence level) was much stronger than for PCBs ($R^2 = 0.07$; not significant at the 95% confidence level). For indigenous blue mussels, the relationship for PCBs ($R^2 = 0.60$; significant at the 95% confidence level) was stronger than that for the PAHs ($R^2 = 0.197$). The concentrations of PCBs in deployed mussels and PAHs in indigenous mussels were highest at Station DSY-26 (Figure 6.3-1). The PAH concentrations detected in mussel tissue at Station DSY-26 were confirmed in a second analysis for both deployed and indigenous samples; however, PCB values were considerably lower (1700 µg/g versus 600 µg/g) for the second analysis of deployed mussel tissue. This lower PCB value for deployed mussel tissue was more consistent with PCB concentrations detected in this target receptor at other stations. Upon exclusion of the original Station DSY-26 data, an improvement in the regression relationship between sediment concentrations and deployed mussel concentrations for PCBs is obtained ($y = 94.4 \ln(x) + 223$; $R^2 = 0.553$). Relationships between other CoC-target receptor pairings either were not significant or lacked the necessary data points to support regression analysis.

Biota-Sediment Accumulation Factors (BSAFs), defined as the lipid normalized concentration of the CoC in an organism (µg/g lipid) divided by the organic carbon-

normalized concentration of the same chemicals in sediment (µg/g OC), were calculated to assess the potential role of habitat type and/or trophic mode on bioaccumulation of organic contaminants.

BSAFs from the present analysis were compared for similarity of central tendency across species within specific chemical classes (PCBs, PAHs, pesticides, and butyltins) using box plots (Figure 6.3-2). The box plots present the median value, as well as the range in values ± 25% about the median (box top and bottom), and the vertical lines represent the outside range or "whiskers" (approximately = 95% confidence limits). Asterisks and open circles are values exceeding the 95% and 99% confidence limits of the data set, respectively. The dashed line represents the overall median of the species-specific median values for each compound class. In this analysis, data were included only for those analyte pairings where both the tissue and sediment concentrations were detected (i.e., substituted ½ MDL values were not used), so as to improve the accuracy of the evaluation as well as the relevancy to trophic transfer issues.

For the present study, the overall median BSAF values for PAHs, PCBs, pesticides and butyltins were 0.12, 5.0, 3.85, and 1.9, respectively (Figure 6.3-2). In general, there was considerable overlap in central tendency about the median BSAF value for all species. Butyltins were perhaps the exception, where cunner and deployed mussel BSAFs were lower than indigenous mussels and *Pitar morrhuana* (butyltin data for *Mercenaria mercenaria* and lobster were not available). However, the applicability of the EqP model to this contaminant class may not be entirely appropriate, as butyltins are a combination of organic and inorganic components.

Results of the present study are similar to BSAF values calculated from literature values for infaunal deposit feeders, scavengers, filter feeders and benthically-coupled fish (Tracey and Hansen, 1996), where BSAFs for PAHs were uniformly lower (mean

0.34) than PCB (1.03) or pesticide (1.36) classes. In another study of Narragansett Bay species (SAIC, 1995b), these values were 0.27, 1.57 and 1.62, respectively. The similarity in BSAFs across species demonstrate that varying habitat of the target receptor, including epibenthic/filter feeders (indigenous and deployed mussels), infaunal (clams), epibenthic scavengers (lobsters), and epibenthic predators (fish) does not alter the bioavailability of organic chemicals in the sediments. Thus, the functional contaminant exposure pathways among target receptors are similar, allowing the use of a single exposure pathway model to predict the ultimate fate (i.e., tissue accumulation) of organic contaminants for this exposure and effects assessment.

6.3.2. Analysis of Metals Bioaccumulation

The bioavailability of metals for target receptors was assessed through Tissue Residue - Exposure Relationships analysis of Bioaccumulation Factors (BAFs). Whereas BSAF factors are based on Equilibrium Partitioning (EqP) theory, i.e. non-ionic organic contaminants are assumed to be at steady-state between the carbon-normalized sediment concentration and the lipid-normalized tissue concentration (DiToro, *et al.*, 1991), the BAF model simply assumes that the ratio of tissue to sediment concentration is a measure of bioavailability.

Tissue Residue - Exposure Relationships. As discussed for organics, the degree of similarity of exposure to sediment associated contaminants between indigenous and deployed blue mussels was assessed. Pearson's Pairwise Comparisons were performed for all metal CoC-receptor pairings in order to elucidate possible correlations between tissue residues and metals exposure. At best, only weak correlations were observed between concentration of target analytes of toxicological interest in sediments and respective receptor residue concentrations ($R^2 \approx 0.50$). Stronger correlations were observed in regressions of tissue residues for indigenous versus deployed mussels for crustal analytes, especially for aluminum ($R^2 = 0.82$) and manganese ($R^2 = 0.79$).

These results suggest that the mechanism of exposure to contaminants for indigenous and deployed mussels is similar. Hence, deployed tissue residue data are adequate to serve as an approximate indicator of metal bioavailability from sediment to pelagic species.

As discussed above, CoC-receptor correlation analysis for metals did not produce meaningful relationships. Thus, the approach of Bioaccumulation Factors (BAFs) was taken, which involves the analysis of the ratio of CoC tissue residues from bivalves, fish, and lobster relative to sediment concentrations at Derecktor Shipyard/ Coddington Cove stations. Similar to the analysis of BSAFs performed for organics, BAFs were evaluated in order to elucidate potential differences between species and tissue type with regard to metal bioavailability for target receptor species. Factors governing differential metals bioaccumulation among species are poorly understood relative to that for organic contaminants, such that analyses were conducted on a metal-by-metal basis and only raw concentration data were used.

BAFs for each of the organisms analyzed for metals (bivalves, fish and lobsters) were calculated for all CoC-receptor pairings. In addition, three non-CoC metals (Fe, Mn and Al) were evaluated to assess patterns that might reflect differential bioavailability due to crustal components. As with BSAF plots, the BAF box plots represent several measures of central tendency (refer to Section 6.3.1 for explanation of box plots). The median metal pairing of each species was used to calculate the overall BAF for the analyte.

Results show both species-specific and metal-specific differences in BAF values (Figure 6.3-3). Highest BAFs were associated with Zn (1.05), As (0.875), Hg (0.55), and Cu (0.33). The pattern of bioaccumulation among bivalves and lobster exhibited a similar trend for most metals. Elevated metals bioaccumulation was detected in lobster tissue for As, Pb, and Ni. Fish generally exhibited both reduced bioaccumulation and

lower variation than was observed among other species. Median BAFs for other CoC metals did not exceed 0.05, with the exception of high BAFs for nickel in lobster and deployed mussel tissues.

BAFs for metals fell into four groups relative to the propensity for accumulation into tissues:

High:	1)	Zn (1.05), As (0.875)
Intermediate:	2)	Hg (0.55), Cu (0.33)
Low:	3)	Cr (0.035), Mn (0.007), Fe (0.006), Al (0.0016)
Very Low:	4)	Ag (0.0006), Ni (1E-05), Pb (5E-06).

This pattern can be partly explained by the fact that the bioavailability of sediment-associated heavy metals is related to the concentration of iron oxides in sediment as well as insoluble sulfides (Bryan and Langston, 1992); sand-associated metals are expected to be more bioavailable than silt-associated metals for this reason. However, other differences in bioavailability may be explained by the chemical properties of the metals themselves. For example, the most bioavailable metals included arsenic and zinc; because of their relatively high solubility compared to most heavy metals, these metals exhibit extremely mobile behavior in aquatic systems, and in surface waters can undergo complex patterns of transformation including oxidation-reduction reactions, biotransformation, precipitation, and adsorption. Thus, this behavior suggests that remobilization of these metals via resuspension and ingestion is the most probable exposure route of these CoCs to target receptors.

Metals in the fourth group (Ag, Ni and Pb) were the least bioavailable forms. Both Ag and Pb tend to be highly particle associated, while Ni is moderately water-soluble. The particle-associated nature of Ag and Pb suggests that these metals are

unlikely to be transported far from the source, whereas high Ni accumulation is probably related to dissolved phase exposure.

Metals in the second and third groups, above, tend to show comparable BAFs among species. Mercury and copper, like zinc, are very persistent, and are generally removed from the environment by particle adsorption and subsequent settlement to sediments. Mercury is well known to bioaccumulate in marine organisms, and has received considerable attention because of its toxicity relative to other metals (Wren *et al.*, 1995). Manganese is generally characterized as moderately soluble in water, whereas Cr^{+3}, the form of chromium most commonly observed in biological systems and likely to be the form measured in the present study, is generally insoluble in water. The bioavailability of metals with intermediate BAFs is most likely affected by a variety of processes, ranging from dissolved-particulate partitioning to internal metabolic regulation; therefore, bioaccumulation is the result of the exposure to the metals in both water and sediment.

In summary, the observed bioavailability of metals in this study is consistent with the known behavior of metals with respect to mobility and solubility, and suggests that both species and habitat play an important role in controlling bioaccumulation of metals in target receptors.

6.3.3. Trophic Transfer of CoCs to Avian Receptors

Adverse effects to avian aquatic predators from the ingestion of contaminated food within the study area were assessed by comparison of prey concentrations and prey-derived CoC dosage to two Toxicity Reference Values (TRV-Dose, TRV-Exposure Point Concentration (EPC)) derived following the methods described in Opresko *et al.* (1996). In this approach, dietary No-Observable-Adverse-Effects-Level (NOAEL) benchmarks were derived from data obtained primarily from laboratory tests with birds

and converted into values applicable to each avian receptor of concern (RoC) for the Derecktor Shipyard Marine ERA, assuming that the laboratory-based benchmarks are applicable to similar species of similar body size at other sites (Opresko *et al.*, 1995). In the TRV-EPC approach, a "NOAEL-equivalent" prey concentration (Opresko *et al.*, 1995) was estimated and directly compared to measured prey concentrations (also mg/kg dry weight) as a screening procedure for CoC selection. In the TRV-Dose approach, a target species dosage model was employed to calculate uptake of CoCs as dependent upon exposure factors specific to the RoC (including size-dependent food consumption rate, foraging behavior, migratory behavior, and food preference) and compared to the NOAEL benchmark.

6.3.3.1. Bird Dose Calculations

The herring gull (*Larus argentatus*) and great blue heron (*Ardea herodias*) are species representative of aquatic birds which feed on invertebrates and fish in nearshore marine areas such as Coddington Cove (Section 3). The herring gull may be considered omnivorous whereas great blue heron feeds primarily upon fish (U.S. EPA, 1993). The Oak Ridge National Laboratory (Sample and Suter, 1994) avian predator exposure model was used to estimate exposure to CoCs based on ingestion (dose):

1) Dose = (EPC) * (FCR) * (a/fa) * (MF) * FF

where:

Dose = Bird dose of CoC contaminant (mg CoC/kg bird/day, dry weight);

EPC = Exposure Point Concentration of contaminant in prey within on-site foraging area (mg CoC/kg prey, dry weight);

FCR = Food Consumption Rate; (kg dry weight prey consumed/kg bird/day);

a/fa = on-site foraging area/total foraging area of a bird (km^2/km^2);

MF = Migration Factor; fraction of the year bird is in the area (yr/yr); and

FF = Feeding Fraction, or contribution of the prey type to the total diet (kg/kg).

The model assumes that the intake of contaminants via other exposure routes, such as water ingestion, are minimal in comparison to intake via food ingestion. A daily dose of a given CoC was calculated assuming that:

- The receptor body weights are for adult specimens;
- The receptors food consumption rates are accurately predicted from body weight using the appropriate allometric relationships;
- The bird usage of the site, and therefore consumption of food from the site, are in proportion to the size of feeding habitat at the site relative to the home range size of the species (a/fa; Opresko *et al.*, 1996). In this study, it is assumed that the avian predator lives and feeds exclusively at the site (i.e. a/fa = 1).
- The birds at the site undergo spring/fall migration as found for other east coast populations;
- The birds may feed exclusively on any of the target receptor prey (serving as suitable surrogates of prey species) for the ERA;

Documentation of the avian aquatic receptor exposure factors for this ERA are provided in Table 6.3-1. The three primary factors which discriminate the two avian predator species are body weight, lifestyle/habitat preference (wading vs. open water),

and the total home range/foraging area. While the first two parameters are readily determined from the literature, the third parameter is typically site-specific.

The great blue heron, has a specific habitat preference for shallow (0.5 m) water for wading while fishing. Hence, its home range in the open estuarine environment of Narragansett Bay is primarily restricted to intertidal areas. For this ERA, it is assumed that the great blue heron feeds exclusively at the site. This assumption is required because the habitat usage patterns for this species are not well known, and hence it is possible that individuals from a colony could heavily utilize habitats in Coddington Cove. For similar reasons, the effects assessment for the herring gull also assumes the receptor feeds exclusively at the site.

Based on input data from the foraging models and other exposure factors identified in Table 6.3-1, the CoC-specific exposure factor (EF) for each avian aquatic receptor is calculated. Dose of CoCs to the receptor (mg CoC/kg-bird/day) is subsequently calculated as follows:

Dose = EF (kg prey/kg bird/day) * EPC (mg CoC/kg prey).

Section 6.3.3.2 discusses the procedure for determination of CoC dose threshold benchmarks for the contaminants for which potential adverse effects were assessed. These benchmarks, or Toxicity Reference Values (TRV), were calculated based on procedures discussed in Opresko *et al.*, 1996).

6.3.3.2. Toxicity Reference Values for Avian Aquatic Receptors.

The general method used in deriving screening benchmarks for receptors selected for this ERA was based on EPA methodology for deriving human toxicity values (e.g., Reference Values, Reportable Quantities, and unit risks for

carcinogenicity) from laboratory animal data. First, No Observed Adverse Effect Levels (NOAELs) and/or Lowest Observed Adverse Effect Levels (LOAELs) were identified from studies conducted exclusively on avian test species, which include data for domestic and wild birds. Where possible, aquatic bird test data were selected in preference over data for other bird species. The equivalent NOAEL for the receptor of concern (wildlife NOAEL) was obtained by scaling the laboratory data (test NOAEL) on the basis of differences in body size according to the following equation:

$$\text{NOAEL-Dose} = \text{test NOAEL} \times [\text{test bw/wildlife bw}]^{1/3}$$ (Opresko *et al.*, 1995)

where: wildlife bw = body weight of wildlife species in kg
test bw = body weight of laboratory species in kg
test NOAEL = experimental dose in mg CoC/kg RoC/day

In cases where only a LOAEL was available, the NOAEL was estimated as being equivalent to 1/10th of the LOAEL. If the only available data consisted of a NOAEL (or a LOAEL) for a subchronic exposure (approximately 10 weeks or less), then the equivalent NOAEL or LOAEL for a chronic exposure was estimated as being 1/10th of the value for the subchronic exposure. If only acute exposure data (LD_{50}) were available, an acute-chronic ratio of 8:1 (Shepard, 1995) was applied to first estimate the chronic (e.g. LOAEL) benchmark. This LOAEL value was then converted into the corresponding NOAEL as described above, and used as the NOAEL-Dose TRV.

The NOAEL-EPC TRV is defined as the concentration in food (in mg CoC/kg dry weight of food) which would result in a dose equivalent to the NOAEL (assuming no exposure through other environmental media), after Opresko *et al.*, 1996. This benchmark is used as a screening tool, and has the advantage over the NOAEL-Dose method in that a predator exposure model is not required.

The NOAEL-EPC TRV was calculated from the food factor *f*, which is the amount of food consumed per unit body weight per day:

TRV-EPC = wildlife NOAEL/f (Opresko *et al.*, 1996)

Food factors for aquatic predators were derived from the Food Consumption Rate (FCR, in kg prey dry weight/day) and the receptor body weight (bw in kg):

f = FCR/bw (Opresko *et al.*, 1996).

Food consumption rates (FCR) for herring gulls were estimated from the allometric regression model of Nagy (1987), while for great blue heron, the model of Kushlan (1978, as cited in U.S. EPA, 1993) was used (Table 6.3-1).

Toxicity Reference Values (TRVs) calculated in the above manner are summarized in Table 6.3-2 for gulls and heron. Although TRV data are available for metals, Total PCBs and tributyltins, test data are available for only seven of eighteen PAHs, two of five pesticides and one of three butyltins measured in the present investigation.

6.3.3.3. Adverse Effects to Avian Aquatic Receptors.

The receptor-exposure pathway scenarios evaluated for herring gull and great blue heron include cunner, indigenous and deployed blue mussels, lobsters, and the hard clams *Mercenaria mercenaria* and *Pitar morrhuana* as prey. In reality, herring gulls and great blue herons are not likely to feed on all of the aforementioned species, but consumption of these surrogate prey species by avian aquatic predators has been modeled as part of a comprehensive and conservative approach in the assessment of potential risk.

Measured prey concentrations and calculated CoC doses to avian receptors were compared to EPC-based Toxicity Reference Values (TRV-EPC) and Dose-based TRVs (TRV-Dose) to estimate adverse effects for each avian target species from prey consumption. The exposure point concentrations of CoCs included six prey species (cunner, deployed mussels, indigenous mussels, lobster, *Mercenaria* and *Pitar*; Appendix Table A-1-3) collected from Coddington Cove, assuming that these species are surrogates for other organisms which might be part of the diet of gulls or herons, and that the predators consume their prey whole. (Note that the conversion of dry weight to wet tissue CoC concentrations was not required since the TRV endpoints are expressed on a dry weight basis). While great blue heron are primarily piscivorous in habit, the literature suggests occasional invertebrate consumption. The herring gull is omnivorous (U.S. EPA, 1993).

Station- and analyte-specific TRV-EPC and TRV-Dose Hazard Quotients for herring gull and great blue heron consuming prey in the Derecktor Shipyard/ Coddington Cove study area and the Jamestown Potter Cove and Castle Hill Cove reference locations are presented in Appendix Tables A-1-6.2 and A-1-6.3, respectively. Predator-specific Hazard Quotient rankings are presented in Table 6.3-3. For herring gull, the Hazard Quotients derived using prey concentration as the benchmark (HQ-EPCs) suggest that greatest adverse effects (HQ > 10) result from ingestion of PCBs in cunner at Stations DSY-28, DSY-29 and DSY-36 (Table 6.3-3A). Adverse effects were also apparent for metals, particularly As, Cr, Cu and Zn, but these were of lower magnitude in that HQs > 1 were frequently observed at both site and reference locations. In contrast, PAHs, pesticides, and tributyltin did not exhibit any evidence of adverse exposure. Using the dose-based TRV, a similar pattern but lower magnitude of apparent adverse effect was observed (Table 6.3-3B). For example, PCB-related adverse effects at Stations DSY-28, DSY-29 and DSY-36 were not as evident using the TRV-Dose benchmark, as those determined based on the TRV-EPC benchmark.

Apparent adverse effects to great blue heron generally followed that of the herring gull; HQ-EPCs suggested that greatest adverse effects would result from ingestion of PCBs in cunner at Stations DSY-28, DSY-29 and DSY-36, while lesser adverse effects are apparent for metals (Table 6.3-3C). Similarly, the HQ-Dose values for heron suggest low adverse effects across the site, and, in general, the reference locations (Table 6.3-3D). The only CoC-prey pairs which indicated adverse effects at the site without adverse effects being apparent at the reference locations were PCBs and Cr in indigenous mussels (IBM) and Cu in lobster (LOB).

The station- and analyte-specific rankings of potential adverse effects in Table 6.3-3 A through D are brought forward into Table 6.3-4 to provide an overall adverse effect ranking for each avian predator by station. Assuming the maximum indicated adverse effect across all CoCs measured for prey species at a given station and subsequently the maximum of prey-specific adverse effects, the station-specific overall adverse effect ranking for the predator was obtained. Results show good agreement between the two avian receptors; PCBs in cunner at Station DSY-28 (herring gull) as well as Stations DSY-29 and DSY-36 (herring gull and great blue heron) appear to provide the most important CoC-receptor pathway of concern. These results are brought forward to the effects assessment summary in Table 6.6-2.

The above effects analysis for CoC exposure to the gull and heron was based on the NOAEL benchmark, which is a factor of ten below the Lowest Observable Adverse Effect Level (LOAEL) benchmark typically representing a chronic or sub-chronic (non-lethal) endpoint. In addition, the assumption that the gull or heron would feed exclusively on prey species from Coddington Cove is highly improbable. This fact is demonstrated in Figure 6.3-4, where the available Coddington Cove habitat represents approximately 1.2% and 3.4% for gulls and heron, respectively, of the total available habitat within each species' range. Hence, it is likely that the calculated HQs for CoCs

in prey species of Coddington Cove, including PCBs, do not actually represent a high probability of adverse effect to the avian aquatic predators.

6.4. Analysis of Toxicity *versus* CoC Concentrations

This section evaluates the relationship between the sediment and sediment elutriate CoC concentrations and the toxicity responses for two bioassay species, the amphipod and the sea urchin. The analysis of results focuses on elucidation of potential exposure-response relationships. For this assessment, the measurement endpoints evaluated included the following:

- Toxicity of bulk sediments to amphipod survival;
- Toxicity of elutriates to sea urchin normal larval development.

Toxicity occurs when CoCs in the environment become bioavailable above concentrations which cannot be physiologically managed by the organism. In the present investigation, tissue residues of laboratory bioassay species were not measured, hence the primary evidence to ascertain apparent toxicity and identify the potentially responsible CoCs was to examine the degree to which the measured CoC in sediments and elutriates exceeded a known benchmark or criteria, and assess the strength of relationships between the observed toxicity and the exposure concentrations measured in sediments and elutriates.

As discussed in Section 6.1, divalent metal bioavailability may be predicted from sediment SEM and AVS relationships. In contrast, the bioavailability of organic CoCs is believed to be controlled by the partitioning between the organic carbon fraction of sediment/porewater and the lipid fraction of tissue. Hence potential CoC exposure -

toxicity relationships are considered in relation to the bulk sediment concentration as well as the Total Organic Carbon (TOC) normalized concentration, with the inherent assumption that high TOC sediments will have lower CoC bioavailability than low TOC sediments with the same unit CoC concentration. In addition, sediment TOC measurements are used in lieu of dissolved organic carbon data (not measured in this study) when assessing bioavailability CoCs in elutriate preparations with the assumption that sediment and elutriate TOC concentrations should be positively and linearly correlated.

6.4.1. Amphipod Sediment Toxicity

The amphipod toxicity response to bedded sediment was evaluated by comparison of relationships between survival versus 1) bioavailable metals (related to SEM and AVS concentrations), and 2) representative organic contaminants (Total PAHs, Total PCBs, p,p'-DDE, and tributyltin).

Relationships between amphipod toxicity and three measures of metal bioavailability are presented in Figure 6.4-1. No relationship between survival and increasing SEM/AVS ratios was observed (Figure 6.4-1A). Further inspection of the data using the difference of SEM and AVS (SEM-AVS) as the indicator of metal bioavailability again suggested no apparent exposure-response relationship (Figure 6.4-1B). Because of the volatility of AVS in the presence of oxygen, and hence the possibility that some AVS could be lost during sampling or analysis, the relationship between amphipod toxicity vs. SEM metal concentration was investigated. The resulting relationship (Figure 6.4-1C) indicated a weak correlation between amphipod survival and SEM metals concentration, suggesting that metals at Stations DSY-27 and DSY-28 might be responsible for observed toxicity if AVS were actually lost prior to or during laboratory exposures.

Patterns observed for amphipod survival versus sediment concentrations of Total PAHs, Total PCBs, p,p'-DDE and tributyltins (Figure 6.4-2A), and versus the corresponding TOC-normalized sediment concentrations (Figure 6.4-2B) were not suggestive of exposure-response relationships. However, reduced amphipod survival was observed at Station DSY-27, which had the highest Total PCBs and p,p'-DDE concentrations, possibly implicating these CoCs in the observed effects. In addition, the highest TOC-normalized concentration of TBT was detected at Station DSY-28, for which reduced amphipod survival was also observed. Hence, there does exist some evidence that reduced survival in amphipods at Stations DSY-27 and DSY-28 may be related to PCBs, p,p'-DDE and TBT.

6.4.2. Sea Urchin Elutriate Toxicity

Sea urchin toxicity responses were used to evaluate bioavailability of metal and organic contaminants in sediment elutriates. The toxicity endpoint evaluated was normal larval development. The sea urchin fertilization response was also assessed, but as discussed in Section 5.2, this endpoint yielded uniformly high values (>92% of control) for all exposures. Hence, no exposure-response relationships were investigated for fertilization, since lack of variation in the toxicity results would not support meaningful statistical analyses. However, the lack of observed effect for this endpoint is re-addressed in the synthesis of risks (Section 6.6).

CoCs found to be below method detection limits in the elutriates included pesticides, butyltins and most metals except arsenic, lead, and copper. These CoCs were not evaluated further.

Total PAHs in elutriate samples were highest at Station DSY-25 (872 ng/L; Table 4.3-6). This concentration is well below the lowest available EPA ambient chronic salt water quality criterion for the PAH phenanthrene (4,600 ng/L), which is by

far the lowest criterion value of all PAH compounds. In comparison, the criterion for acenaphthene is 710,000 ng/L, and that for fluoranthene is 16,000 ng/L. Hence, it is apparent that PAHs are most likely not responsible for observed toxicity in elutriates, since measured concentrations are orders of magnitude below threshold concentrations for toxicity.

The sea urchin larval development responses also were compared to metals concentrations measured in the elutriates. For copper, elutriate concentrations were above detection only at Station DSY-31 (5.1 µg/L). This level is above the EPA Ambient Water Quality Criteria-Acute concentration of 2.9 µg/L. The undiluted elutriate was marginally toxic to larvae (approximately 60% normal larval development), but was not toxic in the fertilization test (Table 5.2-1). Hence, with the exception of sediments at Station DSY-31, it is unlikely that copper is an important CoC with regard to explaining observed reductions in larval development.

The other CoCs found at concentrations of potential toxicological significance in elutriates were PCBs, lead and arsenic. Exposure-response relationships between elutriate toxicity and concentrations of these CoCs are shown in Figure 6.4-3. Elutriate toxicity is expressed as the IC_{10} concentration, which is the percent elutriate concentration at which a 10% reduction in normal larval development is observed. CoC concentration is expressed in terms of the Hazard Quotient, which is the measured elutriate concentration divided by the EPA Water Quality Criteria-Saltwater Chronic Value. For Total PCBs, there was an apparent, but weak correlation ($R^2 = 0.15$) between the IC_{10} and the elutriate Hazard Quotient based on the saltwater chronic water quality criteria, with Stations DSY-25, DSY-29, and DSY-33 exhibiting greater toxicity at higher Total PCB Hazard Quotients (Figure 6.4-3A). A relationship between elutriate toxicity and Hazard Quotients for arsenic was not apparent, suggesting this CoC is not causing the observed reductions in sea urchin normal larval development.

In contrast to the above, a statistically significant inverse relationship was observed between elutriate toxicity and Hazard Quotients for Pb ($R^2 = 0.54$; Figure 6.4-3A). Further statistical analysis of the regression relationship suggested that when the (relatively) non-toxic Stations DSY-36 and DSY-40 were removed from consideration, the best fit line to the data was highly significant ($y = -17.4x + 53$; $R^2 = 0.84$). TOC normalizations did not improve the above regressions, as generally similar IC_{10} vs. CoC concentrations were observed in each case (Figure 6.4-3B).

Unfortunately, analytical data for metals were not obtained for the three potentially most toxic sediment elutriates (based on larval development responses), which were from Stations DSY-26, DSY-28 and DSY-29 (Table 5.2-1). However, based on the fact that sediment CoC concentrations (40.4, 77.7, and 185.9 µg/g, respectively) and elutriate toxicity (IC_{10} = 8.9, 3.3, and 9.4%, respectively) were higher than for corresponding values at Station DSY-33 (40.0 µg/g; IC_{10} = 19.3%), it would appear reasonable to assume that Pb in elutriates may be responsible for toxicity observed at Stations DSY-26, DSY-28 and DSY-29.

With regard to the absolute concentrations of Pb in elutriate expected to be toxic, the Pb AWQC-SC LC_{50} value (8.5 µg/L) compares favorably with IC_{10}, IC_{20} and IC_{50} effects levels (3.7 ± 0.9 µg/L (n=9), 7.0 ± 2.1 µg/L (n=6) and 9.0 ± 0.2 µg/L (n=2), respectively) that were measured in the present investigation. Notice, however, that the water quality criterion is based on a lethality endpoint and the present data are based on a sub-lethal endpoint. The proximity between the water quality criterion and the IC values is perhaps not unexpected, since abnormal development at early larval stages would probably result in mortality.

In summary, the results of amphipod and sea urchin toxicity data, when considered collectively, support the conclusion that metals, particularly Pb, may be primarily responsible for observed toxicity of sediments and sediment elutriates. The

slight effects observed on amphipods was best explained by SEM metals concentration in the sediment, although Stations DSY-27 and DSY-28 were also high in PCBs, p,p'-DDE, and TBT. Elutriate toxicity to sea urchin larval development was best explained by lead exposure, although PCBs, p,p'-DDE, and TBT may contribute the observed response.

The differences in sensitivity between test endpoints may be partially explained by the fact that the sea urchin larval development test is typically considered a "metals-sensitive" test, because the short-term duration of the larval development exposure (48 hr) favors effects due to CoCs with higher solubility and membrane permeability (e.g., metals). In contrast, the amphipod test is expected to be responsive to both metals and organic CoCs when present in sufficient concentrations since the exposure duration (10 days) should permit larger compounds with lower solubility (e.g., organic compounds) to reach target organs. In addition, divalent metals bound by AVS in bedded sediments are likely to become more bioavailable when AVS is oxidized in the elutriate mixture, while similar increase in bioavailability may not necessarily occur for organic compounds.

6.5. Analysis of CoC Concentration versus Effects Measurements

This section evaluates the relationships between CoC concentrations and specific field effects measurement endpoints. As in Section 6.4, the analysis focuses on elucidation of "exposure-response" relationships, i.e., whether increased levels of contamination are associated with increased effects to biota. As before, the CoC concentration range over which a relationship exists (if any) is also evaluated with respect to criteria, benchmarks or other relevant data that represent threshold levels for effects.

Measurement endpoints that are evaluated in this assessment include the following:

- infaunal community structure,
- biota condition of indigenous and deployed mussels,
- hematopoietic neoplasia in indigenous mussels,
- fecal pollution indicator concentrations in deployed mussels, and
- cytochrome P450 induction in fish.

Correspondence of these measures with those of previous studies in the vicinity of Derecktor Shipyard/Coddington Cove and in the primary literature are discussed.

6.5.1. Assessment of Derecktor Shipyard Impacts on Benthic Communities

The analysis of benthic community metrics from the Derecktor Shipyard/ Coddington Cove study area and reference locations (presented in Section 5.3) was performed in order to identify potentially impacted benthic assemblages, using values obtained at the reference location as the threshold benchmark for adverse impacts. In the sections below, the analysis focuses on exposure-response relationships between CoC concentrations and benthic community metrics. Two approaches are employed: 1) univariate (Pearson correlation) analysis of individual CoC/metric pairs and 2) multivariate analysis of the combined benthic structure data set using a technique called multidimensional scaling (MDS).

Univariate correlation analyses. The likelihood of changes in benthic community metrics being the result of sediment CoC concentrations was assessed by conducting Pearson correlation analyses, generating scatter plots and performing linear regressions for representative organic and inorganic contaminants. Because the

analysis is intended to elucidate those CoCs which may have adverse effects on benthic community structure, emphasis is placed on the discussion of regression results exhibiting exposure-response relationships between CoC concentrations and the metric index. For this discussion, results were considered relevant if regression slopes were statistically different from zero ($P_F \leq 0.05$) and the regression fit explain > 50% of the variation in the data (i.e. $r^2 > 0.50$). Data for both silt- and sand-bottom communities were pooled for the overall regression analysis. Prior to analysis, data for each metric, with the exception of the Bray-Curtis Similarity Index, were normalized to corresponding habitat-specific reference values (Section 5.3.1), in an attempt to eliminate grain size as a covariate effect in the overall regression analysis.

Results of these comparisons for the seven individual benthic community metrics as well as the overall bioassessment score discussed in Section 5.3 are shown in Figure 6.5-1A. The 95% confidence limits are indicated in the graphs; where the limits are not shown, it is because the confidence limits exceed the bounds of the graph. In general, the regression relationships were not statistically significant. Relevant exposure-response relationships were observed only with the metrics % dominant taxa and species evenness for As ($r = 0.55$, $P_F = 0.04$ and $r = -0.52$, $P_F = 0.05$, respectively) and Pb ($r = 0.57$, $P_F = 0.03$ and $r = -0.55$, $P_F = 0.04$, respectively). Note that although the % dominant taxa-CoC relationship is positive, it is inferred that an increase in single species dominance condition is not favorable to a stable benthic community.

Further detail of the percent dominant taxa versus sediment Pb concentration is shown in Figure 6.5-1B. The range of dominance values observed was five-fold, while Pb concentrations varied 18-fold. The station with highest Pb station is Station DSY-29, which has concentrations approaching the ER-M value (218 µg/g dry weight), while Pb concentrations at Stations DSY-32 and DSY-27 were three- to four-fold greater than the ER-L value (46.7 µg/g). In contrast, an exposure-response relationship for As is doubtful as concentrations varied only about two-fold and maximum values

were only marginally above the ER-L (see Figure 6.1-8). Thus, the results support the hypothesis that Pb in sediments may adversely impact benthic community structure at Station DSY-29, and possibly DSY-32 and DSY-27 as well.

As discussed in Section 5.3, the overall habitat-specific bioassessment scores indicate the highest probability of impacted benthic community at Station DSY-25, DSY-27, DSY-29, DSY-32 and DSY-41, with intermediate probability of impacts for Stations DSY-36, DSY-38, DSY-39 and DSY-40. Due to the complete absence of benthic organisms at Stations DSY-25 and DSY-41, these two stations were similar to each other and markedly different from both the JPC-1 reference station and the other stations of Coddington Cove. Defaunated conditions at Station DSY-25 may have been exacerbated by anoxia caused by overgrowth and suffocation by algae (*Ulva*); it is assumed that either local nutrient sources promoting algal growth or wind-driven rafting were responsible for this condition. Hypoxic conditions were also apparent in the inner dock area, where the oxygenated layer was thin at Stations DSY-40 (0.2 cm) and DSY-41 (0.5 to 1 cm). This condition may have arisen from excessive nutrient enrichment, possibly from a source associated with high organic materials, despite the fact that these stations have sediments low in TOC content. Although high levels of organic matter may have been present at Stations DSY-40 and DSY-41 in the past, such levels were not observed during this investigation. This may potentially be the result of wave action and episodic flushing events in the enclosure area.

The presence of the CoC-intolerant but eutrophication-tolerant species, *Ampelisca* at Station DSY-40 is consistent with this hypothesis. Total coliforms in mussels deployed in this area were high, suggesting a recent exposure to fecal contamination (Table 5.3-5), and indicative of organic enrichment that would promote dissolved oxygen depletion. Thus, among the highly impacted stations, the reduced bioassessment scores for community structure at Station DSY-29, and to a lesser extent at Stations DSY-27 and DSY-32, are most likely relate to by Pb exposure.

Multivariate analyses. The two-dimensional MDS ordination of benthic community data (discussed in Section 5.3 and presented in Figure 5.3-2A and 5.3-2B) showed that, with the exception of Station DSY-29, the silt-bottom stations (<40% sand) had similar benthic communities. In contrast, sand-bottom stations (≥70% sand) clustered as several different groups, indicating that multiple factors may be responsible for the observed variation in benthic community composition within this bottom type.

In order to explore potential exposure-response relationships between the benthic community data and various physical and chemical variables measured in this study (e.g., sediment TOC, grain size, contaminant concentrations, etc.), "bubble graphs" were used as companion plots to the benthic community results, in which the magnitude of the variable measured at each station is represented as a symbol on the graph in the same spatial orientation as the community data, but the size of the symbol is scaled to the magnitude of the measured variable (after Warwick *et al.*, 1990; Clarke and Ainsworth, 1993). The objective is to provide a simple, easily-understood visual representation of the association between benthic community structure and each measured variable.

This presentation technique was applied to the grain size data used to classify the silt-bottom and sand-bottom communities discussed above. In Figure 6.5-2B, it can be seen that the stations with high silt-clay content are represented by larger circles and, with the exception of Station DSY-29, are grouped together, whereas stations with low silt-clay content are shown as smaller circles and are clearly separate from the larger circles. The circle at Station DSY-29 and circles at other silt-bottom stations are similar in size, which indicates that grain size does not explain the observed difference in benthic community structure between Station DSY-29 and the other silt-bottom stations.

The association between benthic community structure and sediment TOC (Figure 6.5-2C) is very similar to that for silt-clay, reflecting the co-variance of silt-clay content and TOC concentration typically found in marine sediments. There is some suggestion that TOC may at least partly explain the difference in the benthic community at Station DSY-29, as this station had the highest TOC concentration (demonstrated by the larger circle) of all those sampled. However, some fraction of the TOC at this station undoubtedly is attributed to the presence of organic contaminants, which may also be having a negative impact on the benthic community (discussed later).

The depth of the oxygenated layer (redox-potential discontinuity or RPD) in surface sediments can provide an indirect measure of the frequency/extent of low dissolved oxygen conditions (hypoxia) in overlying waters and can also serve to indicate the degree of sediment organic enrichment, which in coastal environments is often linked to inputs from sources associated with fecal materials. In response to severe near-bottom hypoxia and/or at extreme levels of organic loading, the RPD can approach zero, indicating anoxic sediment conditions. The association between benthic community structure and RPD depth for Derecktor Shipyard/Coddington Cove stations is shown in Figure 6.5-2D. Extremely shallow and/or zero RPD depths are associated with Stations DSY-25, DSY-29, DSY-40 and DSY-41, which had unique benthic community structure compared to other silt- or sand-bottom stations. Thus, near-bottom hypoxic conditions and/or organic enrichment appears to be playing a role in altering benthic community structure at these stations. The RPD depth at Station DSY-35 appears to fall within the range of RPD depths measured at other sand-bottom stations (DSY-26, DSY-33, and reference Station JPC-1). Therefore, hypoxia and organic enrichment are not viewed as likely explanations for the unique benthic community structure found at Station DSY-35.

Figure 6.5-3B clearly illustrates that the unique benthic community at Station DSY-29 is associated with a relatively high concentration of Total PAH. Station DSY-29

is the only station with elevated Total PAH relative to the others (in particular the other silt-bottom stations), leading to the conclusion that high Total PAHs may be a primary explanation for the abnormal benthic community at this station.

Although a full range of DDE concentrations was found at silt-bottom stations (large and small hexagons in the main silt-bottom station cluster in Figure 6.5-3C), all these stations except Station DSY-29 had similar benthic communities. Total DDE alone fails to explain the abnormal benthic community at Station DSY-29, because an equally high concentration was found at another silt-bottom station, which did not have an abnormal benthic community (Figure 6.5-3C). All of the sand-bottom stations had relatively low total DDE, leading to the conclusion that this CoC by itself does not appear to be responsible for between-station differences in benthic communities.

There was also a lack of association between benthic community structure and sediment concentrations for Total PCBs and TBT (Figures 6.5-3D and 6.5-4A). For both contaminants, relatively low concentrations were found at both silt- and sand-bottom stations. Elevated Total PCB and TBT concentrations, found at only one of the silt-bottom stations, are not associated with any apparent difference in benthic community structure at this station compared to the other silt-bottom stations (Figures 6.5-3D and 6.5-4A).

The three metals found to account for the most numerous and largest exceedences of ER-L benchmarks were zinc, copper and lead; these three were therefore selected for further analysis by the MDS method. From Figure 6.5-4B to 6.5-4D, it is clear that the sand-bottom stations all had relatively low concentrations of zinc, copper and lead. These CoCs therefore do not provide any explanation for the differences in benthic communities among these stations. Both high and low concentrations of zinc, copper and lead were found at the silt-bottom stations comprising the main station cluster (Figures 6.5-4B through 6.5-4D), indicating that

metal elevations are not resulting in benthic community differences among these stations. Copper and lead are both high at Station DSY-29 compared to other silt-bottom stations, which suggests that these metal contaminants may be contributing, along with Total PAH, to the abnormal benthic community structure at this station. Thus, with the exception of Station DSY-29, there is little evidence to suggest that the metal CoCs including zinc, copper and lead are responsible for between-station differences in benthic community structure.

6.5.2. Bivalve Condition-Exposure Relationships

Variation in biotic condition for bivalves was compared with tissue and sediment CoC concentrations by conducting Pearson correlation analyses, generating scatter plots and performing linear regressions for representative organic and inorganic contaminants. Results of these comparisons for both indigenous and deployed mussels are shown in Figures 6.5-5 and 6.5-6, respectively, with complete results presented in Appendix B-2-2. The 95% confidence limits are indicated in the graphs; where the limits are not shown, it is because the confidence limits exceed the bounds of the graph.

Because the analysis is intended to elucidate those CoCs which may have adverse effects on biotic condition, emphasis is placed on the discussion of regression results exhibiting inverse (i.e. negative) relationships between the Condition Index (CI) and CoC concentrations. However, all regressions which exhibited statistically significant relationships (i.e. non-zero slopes) are annotated (*) accordingly.

Relationships between indigenous blue mussel condition indices and tissue residue concentrations are shown in Figure 6.5-5A. In general, the regression relationships were not statistically significant. Statistically-significant adverse

(i.e., negative slope) exposure-response relationships were observed only for Total PCBs, where increasing PCB concentration in tissue was related to a decrease in both shell weight and the shell weight to length ratio. Interestingly, a similar analysis of CI data vs. sediment concentrations did not find any negative correlations which were statistically significant (Figure 6.5-5B), suggesting that tissue residues for indigenous blue mussel may be a better predictor of CoC impacts on biotic condition for this species and habitat than are sediment concentrations. This observation is not unexpected, since the ultimate fate of CoCs exerting toxicity is in the tissue of the organism.

Further detail of the indigenous mussel CI/PCB residue relationship for Total PCBs is shown in Figure 6.5-5C. The range of shell weight/shell length ratios observed spans a factor of two, indicating that for the same length mussel, there is a two-fold difference in shell dry weight. PCB concentrations in the mussel tissue ranged up to > 1100 ng/g dry weight. Relatively little information is available on the PCB residue effect concentration on shell growth of mussels, or for bivalves in general. Nebeker and Pugliski (1974) reported reduced growth rate of oyster (*Crassostrea virginica*) spat at tissue residue concentrations of about 2800 µg/g dry weight (converted from 425 µg/g wet wt. assuming 85% water content). In the present study, tissue residues were less than 1.2 µg/g dry wt, or at least three orders of magnitude lower than the reported residue effects concentration. Hence there is considerable uncertainty whether PCBs are in reality causing the observed condition index response.

Correlations of deployed mussel condition indices vs. CoC concentrations in tissue and sediment were performed as discussed above for indigenous mussels. For CI - Tissue residue relationships, the strongest inverse relationship observed was for tissue dry weight to shell weight ratio vs. copper tissue concentration (Figure 6.5-6A), however the relationship was not statistically significant ($r = -0.54$, $P_f = .08$). No statistically-significant relationships were observed for the corresponding CI regressions

against sediment or sediment elutriate concentrations (Figures 6.5-6B and 6.5-6C, respectively). One potentially suggestive relationship is observed upon closer examination of the CI vs. elutriate Pb relationship, presented in Figure 6.5-6D, which reveals an inverse regression when Station DSY-31 is excluded ($r = 0.95$; $P_f = .014$). The rationale for excluding the DSY-31 data is that another CoC may be responsible for the observed effect at this location; elutriate Cu concentrations at Station DSY-31 were unique in being both above detection and above the Marine Water Quality Criteria-Chronic Value (2.9 ug/L). The relationship suggests that exposure to resuspended Pb at Stations DSY-33 and DSY-39 may have affected processes promoting shell growth in mussels. Deployed mussels were also impacted at Station DSY-33 relative to reference as suggested from tissue weight-chlorophyll *a* relationships (Figure 5.3-9). In addition, sea urchin normal larval development was reduced at high Pb concentrations in laboratory exposures to sediment elutriates (Figure 6.4-3).

Uncertainty exists with regard to Pb effects on mussel shell growth because, unlike the laboratory exposures, the deployed mussels are not likely to experience field concentrations at the elutriate levels, nor was Pb found to be elevated in deployed mussel tissues (Figure 4.3-9). However, the discrepancy may relate to the form in which Pb is measured versus the concentration that is actually bioavailable and most toxic; Pb is present primarily in divalent form but is most toxic in the methylated form ($(CH_3)_4Pb$; D'Itri, 1990). In sediments, methylated Pb is estimated to be less than 10% of total Pb, but this fraction may increase substantially in resuspended sediments (D'Itri, 1990). This fact, coupled with the high filtration efficiency of mussels for particles, may explain why bioaccumulation patterns are not correlated with exposure and effects information.

6.5.3. Hematopoietic Neoplasia-Exposure Relationships

Incidence of hematopoietic neoplasia (Hn), including measures of affliction rate (% of affected population) and severity (% Hn cells/per animal) in indigenous blue mussels, was investigated for relationships with CoC exposure. Results are presented in a series of graphs similar to those for the two bivalve condition indices discussed above. Complete results are presented in Appendix B-2-3. No significant relationships were observed for either Hn vs. CoC tissue residue (Figure 6.5-7A) or CoC sediment concentration (Figure 6.5-7B). Because a previous study (SAIC, 1996) of soft shell clams (*Mya arenaria*) in Allen Harbor had found significant Hn incidence at PAH concentrations <900 ng/g Total PAH dry tissue wt. (converted from 85 nMol/g dry wt), this possibility was examined further for the mussels in the present study. The results, presented in Figure 6.5-7C, show a general increase in Hn with PAH concentration, and thus the finding, although not statistically significant, is not inconsistent with the hypothesis that Hn affliction rate is related in some way to PAH exposure. However, literature data implicating this (or any other) CoC class as the cause of this proliferative disease are lacking.

6.5.4. Deployed Mussel Fecal Pollution Indicators - Exposure Relationships

Fecal pollution indicator concentrations in deployed mussels were used to better characterize the pathways for CoCs and non-CoCs into the environment and, specifically, into target species. Complete results are presented in Appendix B-2-4. The analysis of bivalve condition index exposure data (Section 6.5-2) has identified possible impacts at Stations DSY-26, DSY-29 and DSY-33, while Hn-exposure relationships suggest CoC-related impacts at perhaps DSY-40. Fecal pollution indicator data (Table 5.3-3) were also highest at these four stations, suggesting spatial association between higher CoCs, higher fecal pollution indicator concentrations and possible effects on bivalves. Due to spatial proximity, fecal pollution indicator

concentrations at Station DSY-41 were assumed to be equivalent to those measured at Station DSY-40. Although direct effects from fecal pollution indicators are not expected, further elucidation of the above associations may help clarify sources, migration pathways and effects of CoCs on Coddington Cove biota.

In order to assess the importance of the observed fecal pollution indicator densities in deployed mussel tissue, it is instructive to consider the sanitary quality of the environment at stations selected for mussel deployment. Benchmarks for bivalve indicator concentration are not available for this purpose; rather, water-based benchmarks are provided in the National Shellfish Sanitation Program for Shellfish Growing Waters, Manual of Operations Part I (FDA, 1992). In this document, FDA recommends approval of shellfish (bivalve) growing areas when the sanitary survey verifies that median fecal coliform indicator concentrations across stations do not exceed 70 colony forming units (CFU) per 100 mL.

To apply this standard, the measured tissue fecal indicator concentrations must be converted to water concentrations. Here, data from Burkhardt (1991) are used which show that the fecal coliform Accumulation Factors (AF = tissue/water ratio) for *Mercenaria mercenaria* during early fall (11°C) is 0.6. Similar results were observed for the oyster, *Crassostrea virginica*. Assuming comparable AFs for *Mytilus edulis* as for the above bivalves, and considering the highest observed fecal coliform indicator densities in the mussels (130 CFU/100g at DSY-29), equivalent water concentrations are estimated to be 217 CFU/100 ml. Hence, the tissue data suggest that in the area of DSY-29, water concentrations of fecal coliforms may exceed the FDA standard by approximately three-fold.

No exposure-response correlations were observed between fecal indicator concentrations and condition indices of deployed mussels. Possible correlations between fecal pollution indicators and CoCs also were tested. The only statistically-

significant correlations ($P_F \leq 0.05$) observed were between fecal indicator concentrations and Low Molecular Weight PAH concentrations in mussel tissue (Figure 6.5-8). The strongest correlation was observed for *Clostridium* ($r = 0.85$; $P_F = 0.002$). Burkhardt (1991) estimated an AF of 46 for *Clostridium* vs. an AF of 0.6 for fecal coliforms, and the elimination rates (defined as time required to achieve 90% of the pre-exposure condition) for *Clostridium perfringens* and fecal coliforms were 50 and 19 days, respectively. The differences in AFs and elimination rates may account for the generally higher tissue accumulation of *Clostridium* in the present study and the reduced variance in the results observed relative to the other indicators.

These findings suggest potential common sources for the low molecular weight PAHs and fecal indicators. While mussels may accumulate *Clostridium* spores from resuspended sediments, this does not explain the accumulation of the more labile fecal indicators which do not accumulate in sediments because of salinity intolerance. It is also unlikely that the fecal indicators are derived from animal waste sources, since such sources do not contain high concentrations of PAHs. The PAH and fecal pollution indicator exposures are most likely recent, based on the relatively rapid elimination rates for fecal pollution indicators by mussels and the known exposure duration of the deployed mussels. Thus, it would appear that a sewage-related source of low-molecular weight PAHs may be contributing to the exposure of mussels to PAHs, and accordingly, the exposure of sediments at those locations where both PAHs and fecal indicators are highest. This finding, however, does not discount the likelihood that historical industrial practices at the shipyard have also contributed to PAH contamination, and mussels are probably also exposed to shipyard-related PAHs via resuspended sediments.

6.5.5. Fish Cytochrome P450 Activity - CoC Exposure Relationships

The cytochrome P450 assay was conducted on cunner samples from the Derecktor Shipyard/Coddington Cove study area in order to detect potential PAH

exposure. Complete results are presented in Appendix B-2-5. PAH tissue residues in fish may be a less reliable indicator of PAH exposure because fish, unlike the invertebrate target species selected for the ERA, have the ability to metabolize and depurate these compounds.

The cytochrome P-450 system includes several families of heme proteins that work as enzymes to catalyze detoxification reactions of foreign compound substrates, such as PAHs. During these reactions, apolar (lipid-soluble) chemicals are converted to more water-soluble and readily excretable metabolites.

The response of this enzyme system in both freshwater and marine fish exposed to a variety of contaminants has been evaluated in a number of laboratory and field studies. In an investigation of PAH contaminated sediments, total cytochrome P-450 activity in the liver of spot (*Leiostomus xanthrus*), an Atlantic croaker fish, was observed to increase linearly (in relation to sediment concentration) above the lowest observed effect concentration ($LOEC_{P450}$; 3.1 ppm) up to the maximum observed effect concentration ($MOEC_{P450;}$ 96 ppm), while in the gut, the $MOEC_{P450}$ was 16 ppm but reduced by 40% and 37% at 3.1 ppm and 43 ppm respectively (Van Veld et al 1990). The authors concluded that, for spot, gut P450 measurements may be a more useful indicator of dietary exposure to PAHs than liver tissue measurements.

These results suggest a bi-phasic exposure-response relationship wherein the enzyme system responds rapidly at very low levels of exposure (e.g. 3.1 ppm sediment), then the enzyme system reaches maximum activity at intermediate exposure concentrations because an inhibition of activity occurs at higher exposure concentrations due to the direct effect of the CoC on the enzyme system itself (Hahn, 1996). These results suggest two endpoints of potential ecological significance; 1) the CoC concentration threshold for P450 induction and 2) the CoC concentration at which maximum P450 activity levels occur. The P450 induction concentration indicates an

exposure which initiates energy expenditure for detoxification, while the concentration related to the P450 maxima reflects the threshold for highest metabolic expenditures as well as adverse effects on detoxification capacity, hence the potential onset of greatest reductions in physiological fitness.

The availability of fish in the Derecktor Shipyard/Coddington Cove study area for P450 assay was limited. With the present data, it could only be concluded that the measured P450 activity in cunner collected at Station DSY-36 was at the low end of literature-reported P450 responses in other fish species (See Section 5.3.5). However, in order to extend the interpretation of possible PAH-related impacts on fish, the $LOEC_{P450}$ and $MLOEC_{P450}$ concentrations observed by Van Veld *et al.* (1990) were applied to the data, and results interpreted as follows:

- $< LOEC_{P450}$= baseline probability of effects (-);
- $LOEC_{P450}$ to $MOEC_{P450}$ = low probability of effects (+);
- $> MOEC_{P450}$ = intermediate probability of effects (++); and
- $> 2X\ MOEC_{P450}$ = high probability of effects (+++).

Results of this analysis are presented in Figure 6.5-9, where the total PAH concentration in surface sediments is plotted by station with respect to the above benchmarks. Stations which fall between the $LOEC_{P450}$ and $MOEC_{P450}$ include Stations DSY-25 through DSY-28, DSY-30 through DSY-32, DSY-36 and DSY-40, indicating a low probability of impacts related to P450 activation in cunner if exposed to sediments at those stations. Here, it is notable that the literature-based $LOEC_{P450}$ value for PAHs in sediments (3100 ng/g) is in good agreement with the measured P450 activity for cunner exposed to Station DSY-36 (sediment PAH = 3746 ng/g). In contrast, the PAH

sediment concentration at Station DSY-29 (>32,800 ng/g) would appear to pose a high probability of adverse effects as the value was two-fold greater than the $MOEC_{P450}$ benchmark. PAHs at other stations did not appear to pose any potential for adverse effects to cunner based on the P450 endpoint. These impact evaluations are carried forward to the effects-based weight of evidence summary presented in Section 6.6 (Table 6.6-2).

6.6. Risk Synthesis

The interpretation of ecological risk in this assessment is based on a weight of evidence approach. The weight of evidence is in turn based on the analysis of exposure and effects data, as represented by the endpoints discussed in the previous sections.

The following categorization of ecological risks has been developed for the Derecktor Shipyard ERA:

Baseline risk is defined as the probability of adverse exposure and/or ecological effects equivalent to that from contamination and other environmental conditions not associated with the site.

A *Low* probability of ecological risks suggests possible, but minimal impacts based on some of the exposure or effects-based weights of evidence, while impacts are undetectable by the majority of exposure and effects-based weights of evidence. Conditions of low risk probability typically lack demonstrable exposure-response relationships.

An *Intermediate* probability of ecological risk occurs for site conditions falling between high and low probabilities of risk. As such, the intermediate risk probability condition is typically characterized by multiple exposure or effects weights of evidence suggesting that measurable exposure or effects, but not both, are occurring at the site. Typically, quantitative exposure-response relationships are lacking. Intermediate risk probability may also be indicated if the spatial extent of apparent impact is highly localized (e.g., a single station), or if the impact occurs for periods of very limited duration.

Conditions indicating *High* probability of ecological risk occurs when numerous weights of evidence suggest pronounced contaminant exposure and effects, the spatial extent of apparent impact is great, the impact is likely to be persistent over long periods of time, and the available data support demonstrable exposure-response relationships.

The intent of the above risk categorizations is not to place rigorous boundaries on actions that risk managers may take with respect to the results of the study, but merely to provide definition and uniformity for the description of risks as discussed in the following section.

In the exposure (Section 4.0) and effects (Section 5.0) sections of this ERA, as well as in risk characterization (Sections 6.1 through 6.5), the individual weights of evidence were interpreted and summarized using semi-quantitative ranking schemes so as to allow their inclusion into an analysis of the overall risk indicated for each of the primary weight of evidence categories. In Sections 6.6.1 and 6.6.2, below, the process of synthesizing information obtained on individual indicators and translating the result into an exposure/effects Weight of Evidence (WoE) ranking is presented. The primary exposure-based WoEs are Sediment Hazard Quotients, Elutriate Hazard Quotients, SEM Bioavailability and Tissue Concentration Ratios, while Tissue Residue Effects,

Laboratory Toxicity, Field Effects Indicators, and Avian Predators are included as effects-based WoE.

A single ranking strategy for the synthesis of WoE indicators to obtain the probability of adverse Exposure/Effect (E/E) WoE designation was adopted for the ERA in order to provide a consistent evaluation of the data in a manner consistent with the risk definitions discussed above, as follows:

Baseline Adverse E/E Probability (B):	Baseline E/E ranking for all indicators, or low (+) E/E ranking observed for only one indicator;
Low Adverse E/E Probability (L):	Low (+) E/E ranking observed for two or more indicators, or intermediate (++) E/E ranking for only one indicator;
Intermediate Adverse E/E Probability (I):	Intermediate (++) E/E ranking observed for two or more indicators, or high (+++) E/E ranking for one indicator;
High Adverse E/E Probability (H):	Intermediate (++) or greater E/E ranking observed for two or more indicators, <u>and</u> high (+++) E/E ranking for one or more indicators.

The above ranking strategy was intended to characterize the extent and pervasiveness of CoC-related, exposure- or effect-specific WoEs, for example, the extent to which CoC concentrations exceed benchmarks and how often this exposure/effect was observed among the individual WoE. The above rankings for exposure-based WoE do not consider exposure-response relationships; this information is incorporated into the effects-based WoE evaluation.

Results of the evaluations of the WoE data are presented in exposure and effect WoE summary tables in Sections 6.6.1 and 6.6.2, respectively. In Section 6.6.3, the findings of exposure and effects WoE are evaluated jointly in order to interpret the overall probability of adverse ecological risks by sampling station, as follows:

Baseline Risk:	No greater than Baseline (B) ranking for E/E WoE summaries;
Low Risk:	No greater than Low (L) ranking for E/E WoE summaries;
Intermediate Risk:	Intermediate (I) risk ranking for both E/E WoE summaries, <u>or</u> High (H) ranking for one E/E WoE summary and no greater than Low (L) ranking for the other E/E WoE summary;
High Risk:	High (H) ranking for one E/E WoE summary <u>and</u> Intermediate (I) or greater ranking for the other E/E WoE summary.

The synthesis of risk is supported by the information presented in Exposure and Effects summary tables, as well as equally important evaluations of the strength of exposure-response relationships and/or presence of confounding factors which could artificially mask or enhance perceived risks.

This type of ranking scheme is intended only as a qualitative tool. The ranking approach is based on best professional judgement, since the "true" ecological risk of, for example, benchmark exceedence or observed toxicity, is not presently known. Hence, the risk manager is encouraged to keep in mind the nature of the risk ranking approach when evaluating the general outcome of the risk assessment.

6.6.1. Exposure-Based Weight of Evidence

Exposure-based weights of evidence include Hazard Quotients (HQs) for CoC sediment and elutriate contaminants, SEM metal bioavailability, and CoC residues in

target species relative to reference as assessed through Tissue Concentration Ratios (TCRs).

Sediment Hazard Quotients. Chemical concentrations of CoCs measured in sediments are compared against benchmarks to elucidate potential adverse effects on target species from exposure to contaminant concentrations in surface sediments. Sediment HQs are summarized for five major chemical classes: PAHs (including all PAH analytes where individual benchmarks exist, as well as Low Molecular Weight, High Molecular Weight and Total PAH summations), Total PCBs, the pesticide p,p'-DDE, tributyltin, and nine metals. These sediment HQs are ranked and sorted by station. Though ER-L and ER-M benchmarks are not available for tributyltin, the alternate sediment concentration identified by Macauley *et al.* (1994), as discussed in Section 6.1, was applied, so as to include this CoC in the weight of evidence summary.

The pattern observed in Sediment Hazard Quotient data (Table 6.6-1) reveals that stations in closest proximity to the middle and lower harborfront (DSY-27 through DSY-29) and piers (DSY-30 through DSY-32) have CoC concentrations which exceed ER-M values. CoC sediment concentrations exceed upper benchmarks by greater than two-fold at Station DSY-27 (PCBs), DSY-29 (PCBs and PAHs) and DSY-31 (TBT; Figure 6.6-1A). Concentrations in excess of ER-M were also noted for PCBs at Stations DSY-30, DSY-31, DSY-32, and for metals at Station DSY-27 (Figure 6.6-1B), while tributyltin at Stations DSY-28 and DSY-29 exceeded the upper benchmark. Various CoCs in sediments from outer harbor Stations DSY-33 through DSY-39 exceeded the ER-L benchmark, but were below the ER-M benchmark.

<u>Sediment Hazard Quotient Adverse Exposure Ranking</u>. The sediment HQ data suggests overall highest probability of adverse exposure at Station DSY-27, DSY-29 and DSY-31. None of the stations were assigned to the intermediate adverse exposure category, since multiple CoCs above the ER-M benchmark were not observed. In three

cases, a singular CoC exceeded the ER-M (Stations DSY-30 and DSY-32 for PCBs, and Station DSY-28 for tributyltin) but, according to the ranking criteria, the station was not assigned to the intermediate adverse exposure category. This decision is supported by the fact that the CoC-specific ER-M benchmark was developed from field data where multiple CoCs (possibly at higher concentrations) could have contributed to the observed adverse effect, and hence a given CoC (e.g. PCBs) is unlikely to have been singularly responsible for the observed effect. (This possibility, however, is further evaluated by exposure-response analysis in the effects-based WoE evaluation, such that a possible PCB effect will not go undetected as a result of the above assumption). The remaining low adverse exposure stations had multiple CoCs exceeding the ER-L but none exceeding the ER-M. Finally, baseline adverse exposure were assigned to Stations DSY-33, DSY-35 and DSY-41, and reference Stations JPC-1 and JPC-2, since no more than one CoC exceeded the ER-L benchmark.

Elutriate Hazard Quotients. Sediment-water mixtures (elutriates) were prepared for most stations and chemically analyzed to predict worst-case impacts of sediment resuspension events on target species. Analysis of sediment elutriates found only a few CoCs at detectable concentrations, including As, Cu, Pb and Total PCBs. Due to spatial proximity, elutriate contaminant concentrations at Station DSY-41 were assumed to be equivalent to those measured at Station DSY-40. The Water Quality Criteria-Saltwater Acute (WQC-SA) criteria were exceeded at Station DSY-31 (Cu) near Pier 1 and at offshore Station DSY-39 (As) even though the respective sediment concentrations were not above ER-L. Pb and PCB concentrations were above Water Quality Criteria-Saltwater Chronic (WQC-SC) criteria at the majority of stations for which elutriates were prepared. Inferred adverse exposure at these stations were generally comparable to the respective sediment-associated adverse exposure, which is not unexpected as both benchmarks were derived at comparable levels of protection (ER-L = no effect for 90% of species, WQC-SC = no effect for 95% of species).

Notable exceptions were observed for PCBs for Stations DSY-27 and DSY-29 where sediment concentrations exceeded ER-M concentrations, but elutriate concentrations did not exceed WQC-SA criteria. This observation suggests that the release of PCBs to the water column during sediment resuspension events is not an important exposure pathway. However, the evaluations in this assessment address only current conditions and levels of activity at the site, and does not address potential future use scenarios involving fundamentally different conditions or activities at the site. In contrast, Pb in sediments at Stations DSY-25, DSY-33 and DSY-40/41 were not above ER-L benchmarks but the WQC-SC was exceeded in the corresponding elutriates, such that the release of Pb to the water column during sediment resuspension may be an important exposure pathway. These results point to the utility of considering both sediment and elutriate evaluations as weights of evidence for exposure characterization.

Elutriate Hazard Quotient Adverse Exposure Ranking. CoC concentrations measured in sediment elutriate preparations suggested lower overall probability of adverse exposure than that indicated by bulk sediment concentrations for each of the sampled stations (Figure 6.6-2). In two cases (Stations DSY-31 and DSY-39), one analyte was found to exceed Acute Water Quality Criteria while other analytes exceeded Chronic Water Quality Criteria (Table 6.6-1). This finding was deemed insufficient to merit an intermediate ranking for the station, given that it is highly unlikely that field concentrations for these CoCs during a resuspension event would approach concentrations obtained in the laboratory preparation.

SEM Bioavailability. Simultaneously Extracted Metals (SEM) bioavailability is a measure of the simultaneous and cumulative impact of 5 divalent metals (Cu, Cr, Pb, Ni and Zn) on sediment toxicity. Overall, SEM bioavailability is of low concern throughout the study area and reference locations (Figure 6.6-2).

SEM Bioavailability Adverse Exposure Ranking. Measures of sediment SEM bioavailability (total SEM, SEM/AVS and SEM-AVS; discussed in Section 6.4) suggested possible, but low adverse exposure from divalent metal exposure at Station DSY-27 through DSY-30 (high total SEM) and at Stations DSY-33, DSY-35, DSY-37 and JPC-2 (SEM/AVS ratios greater than 0.5). At no stations did SEM concentrations exceed AVS concentrations (SEM-AVS) by more than 5 µmol/g, the benchmark recommended by the EPA National Sediment Quality Inventory (U.S. EPA, 1996) for identifying sediments of concern. Thus, intermediate or higher adverse exposure due to divalent SEM metals was not generally evident for the Coddington Cove study area, and the majority of stations reflect baseline or low adverse exposure condition.

Tissue Concentration Ratios. Tissue Concentration Ratios were calculated as the station-specific residue concentration at the site compared to the reference location for each CoC-receptor pair. The metric is intended to elucidate those CoCs and receptors which are chemically enriched at the site relative to regional background conditions. Hence, it is principally an indicator of chemical exposure but does not predict effects.

CoC residues suggest high exposure of CoCs for indigenous mussels at Stations DSY-25 through DSY-27, while intermediate elevations in CoC residues (i.e., three-fold higher than reference values) were observed for cunner, deployed mussels and lobster collected from harborfront Stations DSY-25 through DSY-29 (Figure 6.6-3). Various other indications of intermediate TCRs were observed, including Station DSY-33 (lobster), Station DSY-35 (*Mercenaria*), Station DSY-36, (lobster and cunner), and Station DSY-41 (*Mercenaria*). These residue elevations above reference were mainly due to bioaccumulation of various PAHs. As noted previously, TCR values for cunner may be underestimates because of PAH metabolism capabilities. This uncertainty is addressed further in Section 6.6.2.

Tissue Concentration Ratio Adverse Exposure Ranking. CoC elevations in target species relative to reference suggest the highest probability of adverse exposure for harborfront Stations DSY-25 through DSY-27, where high residues in indigenous mussels in conjunction with intermediate elevations in cunner, deployed mussels and/or lobster collected from the same location were at least three-fold higher than reference values. Comparable results for intermediate CoC elevations among cunner and lobster observed at DSY-28, DSY-29 and DSY-36 supports an intermediate adverse exposure assignment for the overall ranking. Intermediate elevations in indigenous mussels at DSY-24 was conservatively assumed to suggest intermediate overall adverse exposure, since data from another species was lacking to provide confirmation of the observed exposure. At three stations (DSY-33, DSY-35 and DSY-41), an intermediate elevation was observed in one species, but the result was not confirmed by comparable enrichment in another species such that a low adverse exposure ranking was assigned to these locations. The remaining stations had one or more species with slight CoC elevation in species tissues relative to reference suggesting a low probability of adverse exposure.

6.6.2. Effects-based Weight of Evidence Summary

Tissue Residues. As discussed in Section 6.2, possible impacts of CoC residues on target species were assessed through Tissue Screening Concentration (TSC) and Critical Body Residue (CBR) Hazard Quotients. Results of these tissue residue-based effects estimates are summarized in Table 6.6-2. Data have been summarized by species to focus assessment of impacts on the target receptors.

The highest probability of effects from tissue CoCs was suggested for lobster because of Cu residues in organisms collected at Stations DSY-25, DSY-27, DSY-29, DSY-33, DSY-35, DSY-38 and DSY-39 as well as reference Stations JPC-1 and

CHC-1. In addition, residues in target species from two stations not in the above group also suggested an intermediate probability of effects (cunner at Stations DSY-26, DSY-28 and DSY-36; lobster at Station DSY-36; *Mercenaria* at DSY-41).

Tissue Residue Adverse Effects Rankings. Rankings for the two high adverse effects probability stations (DSY-27 and DSY-29) were due to bioaccumulation of Cu in lobster, accompanied by an intermediate probability of effects for cunner (at Station DSY-29) and for indigenous mussels (at Station DSY-27). The five stations assigned intermediate adverse effects (DSY-25, DSY-33, DSY-35, DSY-38 and DSY-39) were due to high Cu-related residues in lobster with at least one other low probability effect ranking for another target species. Stations with at most one intermediate effect indicator and at least one low effect indicators (DSY-24, DSY-26, DSY-28, DSY-31, DSY-32, DSY-34, DSY-36, DSY-37, DSY-40 and DSY-41) were evaluated as low probability of adverse effects overall.

Laboratory Toxicity. Toxicity endpoints allow assessment of both chemical exposure as well as potential impacts on target receptors, such as macrobenthos (amphipods) and epibenthic invertebrates (sea urchins). In this ERA, the sediment bioassays with amphipod, *Ampelisca*, and the elutriate bioassays with the sea urchin, *Arbacia*, are used to assess possible impacts from in-place and resuspended sediments, respectively.

Laboratory toxicity results indicated sediment toxicity to amphipods only at Stations DSY-27 and DSY-28. Toxicity of resuspended sediments was not evident given successful fertilization of sea urchin eggs in sediment elutriates. However, evidence of possible impacts of resuspended sediments was observed from sea urchin larval development test results, particularly at Stations DSY-26, DSY-28 and DSY-29.

Laboratory Toxicity Adverse Effects Ranking. The overall station-specific laboratory toxicity ranking is summarized in Table 6.6-2 and Figure 6.6-4. In evaluating the ecological significance of the larval development results, it is apparent that there is a low probability that field CoC concentrations will reach the elutriate exposure concentrations obtained in the laboratory. Hence, the observation of high toxicity for the larval development endpoint without confirmation of a least intermediate probability of effect for another toxicity endpoint does not warrant a conclusion of high adverse effects for the station. Thus, in these cases (i.e., Stations DSY-26, DSY-28 and DSY-29), an overall intermediate adverse effects probability was assumed. Similarly, the observation of intermediate toxicity for the larval development endpoint without confirmation from another toxicity endpoint (i.e., Stations DSY-25, DSY-31 through DSY-33, DSY-37 through DSY-39, and DSY-41) does not warrant assignment of intermediate adverse effects for the station; in these cases, a low adverse effects probability was assumed. Finally, for those stations where only low toxicity (i.e., DSY-36 and DSY-40) or no toxicity (i.e., Stations DSY-34 and DSY-35, and reference Stations JPC-1 and JPC-2) in the larval development test was observed, a classification of baseline adverse effects was assigned. In the case of Station DSY-27, the marginal toxicity observed for amphipods (79% survival), in lieu of a lack of elutriate toxicity, also does not suggest that adverse effects of CoCs are occurring (e.g. baseline adverse effects).

Analysis of exposure-response relationships support the above conclusions given that in was not possible to identify specific CoCs causing the slight toxicity to amphipods in sediments. Exposure-response relationships between Pb in elutriate and sea urchin larval development were observed, particularly at Stations DSY-33 and DSY-37, where concentrations exceeded the EPA Water Quality Criteria-Saltwater Chronic Value for this CoC (Figure 6.4-3B), and by extrapolation from sediment concentrations, elutriate effects observed at Stations DSY-26, DSY-28 and DSY-29 as

well. Hence the observed effects are supported by plausible exposure-response relationships.

Field Effects. Field effects parameters, summarized in Table 6.6-2 and Figure 6.6-4, include benthic community structure, bivalve condition indices, neoplasia, cytochrome P450 and tissue concentrations of fecal pollution indicators.

Benthic Community Structure. From analyses of benthic community metrics discussed in Section 6.5.1, the highest probability of adverse effects were apparent at Stations DSY-25, DSY-27, DSY-29, DSY-32 and DSY-41, with intermediate adverse effects observed at Stations DSY-36, DSY-38, DSY-39, and DSY-40 (Table 6.6-2; Figure 6.6-4). The high adverse effects designation for Station DSY-29, and to a lesser extent for Stations DSY-27 and DSY-32, were supported by a plausible exposure-response relationship between Pb concentration in the sediment and the % dominant taxa measured at the station (Figure 6.5-1). Results of multivariate analyses suggested that defaunated communities at Stations DSY-25 and DSY-41 may be related in part to hypoxic sediments at these locations as the cause for the absence of a benthic community was not readily apparent from sediment CoC concentrations. Although the cause for this hypoxia is unclear, this condition may have been associated with past conditions of excessive nutrient enrichment and/or restricted circulation, which may have since subsided as a result of episodic flushing. Exposure-response relationships were most apparent for PAHs for Station DSY-29, although Pb- and Cu-related impacts were also suggested. Exposure-response relationships for other stations were not apparent.

Bivalve Condition. Growth responses for deployed mussels (dry tissue weight vs. chlorophyll a) discussed in Section 5.3 (Figure 5.3-9) identified reductions in mussel condition at Stations DSY-26, DSY-29, DSY-31 and DSY-33, contributing to the intermediate probability of adverse effects shown in Table 6.6-2 and Figure 6.6-4.

Significant exposure-response relationships for deployed mussels were noted between shell length and Pb concentrations in sediment elutriates for Station DSY-33, providing some support of suspected effects. Elutriate measurements were not performed for Station DSY-26 and DSY-29, but corresponding sediments were high in Pb, hence elutriates would also be expected to be elevated. Growth responses at Station DSY-31 were also somewhat reduced, but the observed effect was not attributable to Pb. Instead, concentrations of Cu in elutriate were unique at this station. Cu concentrations exceeded the EPA Water Quality Criteria-Saltwater Acute Value for this CoC by nearly two-fold. As Cu concentrations in elutriates from other stations were not detected, exposure response relationships could not be developed. Thus, some effect of Pb on deployed mussels appears plausible but not sufficiently robust to warrant a conclusion of high adverse effects probability. Hence, the adverse effects ranking in Table 6.6-2 was kept as intermediate for these stations, while no effect was concluded for the remainder of sampled locations.

Significant exposure-response relationships were found between PCB concentrations in indigenous mussel tissue residues and the shell weight/length ratio condition index, with reduced condition occurring at higher PCB concentrations for Stations DSY-26 through DSY-28 (Figure 6.5-4C). However, literature data were lacking to support the suggested impact of PCBs on mussel shell growth. Hence, the adverse effects ranking as established for deployed mussel data was maintained.

Hematopoietic Neoplasia. Station DSY-26 exhibited the highest Hn affliction rate (100%), and was assigned an intermediate ("++") adverse effects ranking (Table 5.3-3, Table 6.6-2). Stations DSY-29 and DSY-40, which exhibited a 70-90% occurrence of Hn (Table 5.3-3) were given a low ("+") adverse effects ranking. Relationships between incidence of Hematopoietic neoplasia (Hn) in indigenous mussels (Figure 6.6-4) and CoC concentrations in sediments were examined and generally found to be absent. Although there did appear to be a tentative relationship

between Hn and PAH concentrations in tissues at Stations DSY-26 and the strength of the relationship did not warrant an increase in the adverse effects ranking for these stations.

Cytochrome P450 Activity. Data on Cytochrome P450 activity, used as an indicator of PAH exposure, was actually measured for cunner at only one station (Station DSY-36), and was found to be low relative to literature values. Because of the data limitation, however, the potential for P450 activity was further evaluated by application of sediment-based benchmarks for P450 induction to observed sediment PAH concentrations. The results show highest probability of activity and assumed impacts at Station DSY-29, but low or baseline probability at remaining stations (Table 6.6-2, Figure 6.6-4).

Fecal Pollution Indicators. Fecal pollution indicators were measured in deployed mussel tissues as an indicator of potential contaminant transport pathways and sewage-related impacts on target species. Due to spatial proximity, fecal pollution indicator effects at Station DSY-41 were assumed to be equivalent to those measured at Station DSY-40 (these two stations are referred to jointly as DSY-40/41 in the fecal pollution indicator assessment). Evidence of high fecal pollution in the Derecktor Shipyard/ Coddington Cove study area was found for Stations DSY-26, DSY-33 and DSY-40/41, due to high values for both total coliforms and *Clostridium perfringens* in mussel tissue (Table 6.6-2, Figure 6.6-4). However, high values for these two parameters, particularly *Clostridium*, were also found at reference Stations JPC-1 and CHC-1.

Relationships between fecal pollution indicator concentrations and deployed mussel condition were not observed, although statistically significant correlations were found between Low Molecular Weight PAH (LMW PAH) tissue concentration and fecal pollution indicator concentrations (Figure 6.5-8). Because non-sediment-associated

forms (coliforms and *Streptococci*) and *Clostridium* (commonly abundant in both sediment and water) were correlated suggests that the source of exposure was occurring primarily through the water column. Hence, the data suggest that exposure via the water column is the primary transport pathway of LMW PAHs to this, and perhaps other, pelagic species. The sources of these PAHs is unknown, but adverse effects posed by this CoC class and transport pathway may be important, given that increased Hn incidence also appeared to be related to PAH exposure.

Field Effects Ranking. The overall adverse effects ranking for field effects suggested high adverse effects at Stations DSY-29, DSY-40 and DSY-41, and intermediate adverse effects were observed for DSY-25, DSY-26, DSY-27, DSY-32, and DSY-33 (Table 6.6-2). It is notable that stations with intermediate or greater overall adverse effects exhibited this response for three of four indicators. Low adverse effects were observed for Stations DSY-28, DSY-30, DSY-31, DSY-36, DSY-38 and DSY-39 (Table 6.6-2). At the remaining stations, field effects indicators suggest no adverse effects to target species.

Avian Predators. The food web modeling for avian aquatic predators assumed that the target bird species were feeding maximally on the most contaminated of prey items available at a given station. Despite the conservative assumptions employed, greater than intermediate adverse effects were not apparent (Table 6.6-2). Those station-CoC-prey receptor pairings which were above other site or reference values occurred for gulls consuming PCBs in cunner at Stations DSY-28, DSY-29 and DSY-36. Intermediate adverse effects were assigned to these three stations, although the conservative estimate of exclusive onsite and prey usage would suggest that this adverse effect estimate may be overly conservative. The remainder of stations were assigned to the low adverse effects category.

6.6.3. Synthesis of Exposure and Effects Weights of Evidence

Discussion of each of the weights of evidence and applicable exposure-response relationships has been presented in the previous sections. The focus of this section is to elucidate concordance among exposure-based and effects-based weights of evidence, in order to characterize overall risk for the Derecktor Shipyard/Coddington Cove study area.

The summary of exposure-based and effects-based weights of evidence and characterization of risk for the Derecktor Shipyard Marine Ecological Risk Assessment is presented in Table 6.6-3. The classification of risk for the Derecktor Shipyard Marine ERA is grouped into four primary classes: baseline, low, intermediate, and high.

High Risk Probability Stations. As described above, high ecological risk is that suggested by numerous weights of evidence, as well as demonstrable exposure-response relationships. In the present investigation, Stations DSY-27 and DSY-29 are categorized as high risk stations.

Intermediate Risk Probability Stations. Intermediate ecological risks are typically associated with multiple exposure- or effects-based weights of evidence suggesting are occurring at the site. However, quantitative exposure-response relationships are typically lacking. Intermediate risk probability may also be indicated by highly localized apparent impact, or impact of very limited duration. Stations which demonstrate intermediate exposure or effects include Stations DSY-24, DSY-25, DSY-26, DSY-28, DSY-31, DSY-33, DSY-40, DSY-41 and reference Station CHC-1.

Low Risk Probability Stations. A low risk probability was indicated for the remainder of Coddington Cove stations not included in the high or intermediate risk

categories. The stations included Station DSY-30, DSY-32, and DSY-34 through DSY-39, as well as reference Station JPC-1.

Baseline Risk Probability Stations. Baseline risk was assigned only for reference Station JPC-2.

In most cases, the Exposure WoE was the same or greater as the Effects WoE which is expected when the exposure pathway being evaluated is correct, i.e. sediment or sediment-associated CoCs are causing adverse exposure which results in adverse effects. In instances where this is not occurring, there exists greater possibility that some of the observed effect is not CoC-related. For example, Derecktor Enclosure Stations DSY-40 and DSY-41 were characterized by exposure rankings which were less than effects ranking; part of this response may be related to apparent localized hypoxia at these stations. The hydrographic study did detect a lack of circulation across the enclosed area where Stations DSY-40/41 are located, and high fecal pollution indicators and PAHs in deployed mussels also were found in this area (Station DSY-40), suggesting effluent sources of both CoCs and constituents which may consume oxygen. Although the dissolved oxygen model did not suggest the Cove was subject to anoxic conditions, nor was sediment oxygen demand higher than typical for temperate estuaries, isolated anoxic events are still deemed possible given that the approach was not designed to address highly localized hydrographic areas.

Conditions at Station DSY-25, DSY-28 and DSY-33 are other cases where non-CoC related impacts might be occurring or that CoCs may not be sediment-associated. In each case, tissue-related exposure exceeded that which was indicated from sediment, elutriate or SEM WoE, suggesting that CoCs reaching the target species may be originating from non-sediment sources (e.g. through the water column). Thus, the significance and characteristics of CoC exposure pathways at these stations (including

DSY-40/41) are less certain than at other locations where exposure-based WoE rank is equivalent or greater than the respective effects-based WoE rank.

6.7. Risk Uncertainty

Uncertainty Factors Related to Weights of Evidence (WoE). The weight of evidence in this assessment is dependent upon analyses of exposure and effects data, and their integration into risk characterization determinations. The purpose of the uncertainty analysis is to identify the potential uncertainty sources as well as their possible relationship to the true degree of adverse exposure or effects as inferred from field measurements and laboratory tests used to support the individual WoE. Depending on the nature of the test endpoint or its method of interpretation, the uncertainty may tend to either over- or underestimate the true degree of adverse impacts (e.g., "false positive" and "false negative" results, respectively).

For the present investigation, lists of potential uncertainties believed to be important for exposure and effects measurement endpoints are summarized in Table 6.7-1 and Table 6.7-2, respectively, and are discussed in the following sections.

Uncertainties discussed in the exposure phase of this assessment (Section 4.3) included:

- Adequacy of CoC selection and behavioral characterization,
- Adequacy of fate and transport evaluations, including station selection, spatial (horizontal) and vertical (sediment layering) patterns, and sample representativeness,

- Adequacy of characterization of temporal/spatial variability in CoC distribution,

- Reliability of exposure point estimation methods, including sampling methods for SEM and AVS and data utilization, and

- Specific areas of contamination identified in historic studies which were not addressed in the current investigation.

Uncertainties discussed in the effects assessment phase (Section 5.5) included:

- Adequacy of toxicity data, including comparability among test species and methods,

- Adequacy of biological investigations, including the appropriateness of the benthic community structure and condition endpoints measured, data analysis techniques, data availability limitations, taxonomic identification and inference as to the relative sensitivity of various species to pollutants,

- Appropriateness of chemical concentration benchmarks for tissue residues,

- Adequacy and availability of national criteria as benchmarks, and

- Appropriateness of the selected bioassay species as surrogates for the indigenous community.

These exposure and effects uncertainties compound one another, as exposure and effects data are integrated in the risk characterization. In addition to these uncertainties, there are additional uncertainties which have been identified during the risk characterization, including:

- Limited toxicological data for target receptor species,

- Incomplete knowledge of community ecology, including natural history (e.g., size of feeding range and site use) of many species, species sensitivities to contaminants, and trophic transfer of CoCs, and natural changes and variability in biological/ecological systems, and

- Adequacy of bioaccumulation and toxicological models.

In the present ERA, tissue residues have been used as an indication of exposure and possible effects; however, their utility as weight of evidence in ecological risk assessments is currently limited since evidence linking ecological effects directly with contaminant concentrations in tissue is generally lacking. In addition, more complete understanding of bioaccumulation and trophic transfer is required to evaluate the role of tissue residues in the status of natural resources, and to provide data for evaluating risks to human health associated with seafood consumption.

The utility of field effects indicators including community structure measurements, such as the relative abundance and numbers of species, has considerable uncertainty with regard to ecological significance. For instance, it is unclear whether an increase in species numbers is occurring at the detriment of total abundance, or whether the observed shifts in community composition have adversely impacted food web dynamics. In addition, the seasonal and temporal variation in sensitivity to pollutants has not been assessed, and leads to uncertainty given that, for

example, seasonal rainfall will affect CoC runoff or groundwater generation from the site, or various life stages present at different times may have differential chemical sensitivity. Possible effects have been inferred for cunner based on predicted activation of P450 enzyme systems due to sediment PAH exposure. However, the benchmarks were derived for another species, hence the degree to which the benchmark is applicable to cunner is highly uncertain. Also, the degree to which the estimated P450 activity exerts a true, adverse physiological effect that translates into reduced fitness of the population is unknown.

There are seasonal changes in redox potential as well as the concentrations of sediment organic carbon and acid volatile sulfides. Redox depth was shallow during the measurement period; however, these data were not collected seasonally nor at a time period when these parameters are at seasonal minimums. Each of these factors has the potential to affect both the toxicity and bioaccumulation of the CoCs.

The application of organic (BSAF) and inorganic (BAF) bioaccumulation models have several uncertainties. The BSAF model relies on an empirical assumption that porewater concentrations are in equilibrium with sediment concentrations. This may not be the case, especially at sites such as Derecktor Shipyard where CoC releases could (and likely are) episodic and variable tidally, and over the short- and long-term. Uncertainty with BAF models (e.g. species-specific bioaccumulation patterns for various metals) is highly site-specific and may vary among species.

Uncertainties associated with the calculated Hazard Quotients and Hazard Indices exist because they do not necessarily reflect all chemicals or activities of chemical mixtures. An additive approach to HQs was taken in order to integrate multiple contaminant effects, since information is very limited on the toxicity of simultaneous exposure to mixtures of contaminants. However, this estimation does not

incorporate potential synergistic or antagonistic interactions among chemicals, nor does it encompass risks from chemicals which were not measured.

Given that Risk Characterization is a synthesis of findings from the Exposure and Effects Assessments, it follows that uncertainties associated with these components of the Risk Assessment can be nullifying, additive or even compounded. A prime example is in the application of Hazard Quotients and derived Indices, where the numerator and denominator each represent point concentrations with an unknown departure from the "true" concentration. Exposure-toxicity relationships suffer the same uncertainty; separate error in estimates of survival and exposure concentration, for example, can compound or obscure true dose-response relationships or falsely suggest others which are misleading or unfounded.

The weight of evidence approach to characterization of risk is effective in reducing uncertainty because the probability that multiple exposure and effects indicators could spuriously suggest risk (or lack of it) decreases as the number of indicators in agreement increases. However, this approach in fact only reduces uncertainty with respect to the location and magnitude of risk. It does not specifically address the ultimate source of this risk (i.e., Derecktor Shipyard vs. other contaminant sources), nor does it address potential future use scenarios involving fundamentally different conditions or activities at the site. This uncertainty has been addressed in the present study through the inclusion of reference locations and the analysis of spatial trends in CoCs, exposure pathways, and other endpoints (e.g. pathogens) which might suggest alternative CoC sources; therefore, an attempt has been made to minimize this source of uncertainty to the maximal extent that time and resources permit.

Estimation of Uncertainty in Risk Designations. At the high probability risk stations (DSY-29 and DSY-27) pronounced contaminant exposure and effects was suggested by numerous weights of evidence and exposure-response relationships

were well demonstrated. The nature of the contamination, being in the sediment, suggests the impact that the risk is likely to be persistent over a long period of time, although the spatial extent of apparent impact may be limited as nearby stations do not display similar levels of risk. This suggests that the overall uncertainty of the risk designation is low.

At the low risk stations (Stations DSY-30, DSY-32, DSY-34 through DSY-39), the majority of exposure and effects-based weights of evidence were low, and few exposure-response relationships were observed between exposure and effects indicators. This also suggests that the overall uncertainty of the risk designation is low.

Among the eight Coddington Cove stations assigned an intermediate probability of ecological risk (including harborfront Stations DSY-24 through DSY-26 and DSY-28, as well as Stations DSY-31, DSY-33, DSY-40 and DSY-41), the data suggests that measurable (and occasionally high) exposure and/or effects were occurring, but not generally as high as for the high risk stations described above, and unlike the high risk stations, quantitative exposure-response relationships are generally lacking. For some of the stations (i.e. Stations DSY-25, DSY-26, DSY-28 and DSY-33) elevated risks from CoC residues in target receptors is not accompanied by similarly high risk related to CoC concentrations in indicating that the contaminant distribution in sediments is highly localized (and was not adequately characterized) or may not be entirely sediment related, such that the responsible exposures may be of more limited duration (e.g. not as persistent as if sediments were the CoC reservoir). This suggests that the uncertainty of the risk designation is somewhat greater than that observed for low and high risk stations.

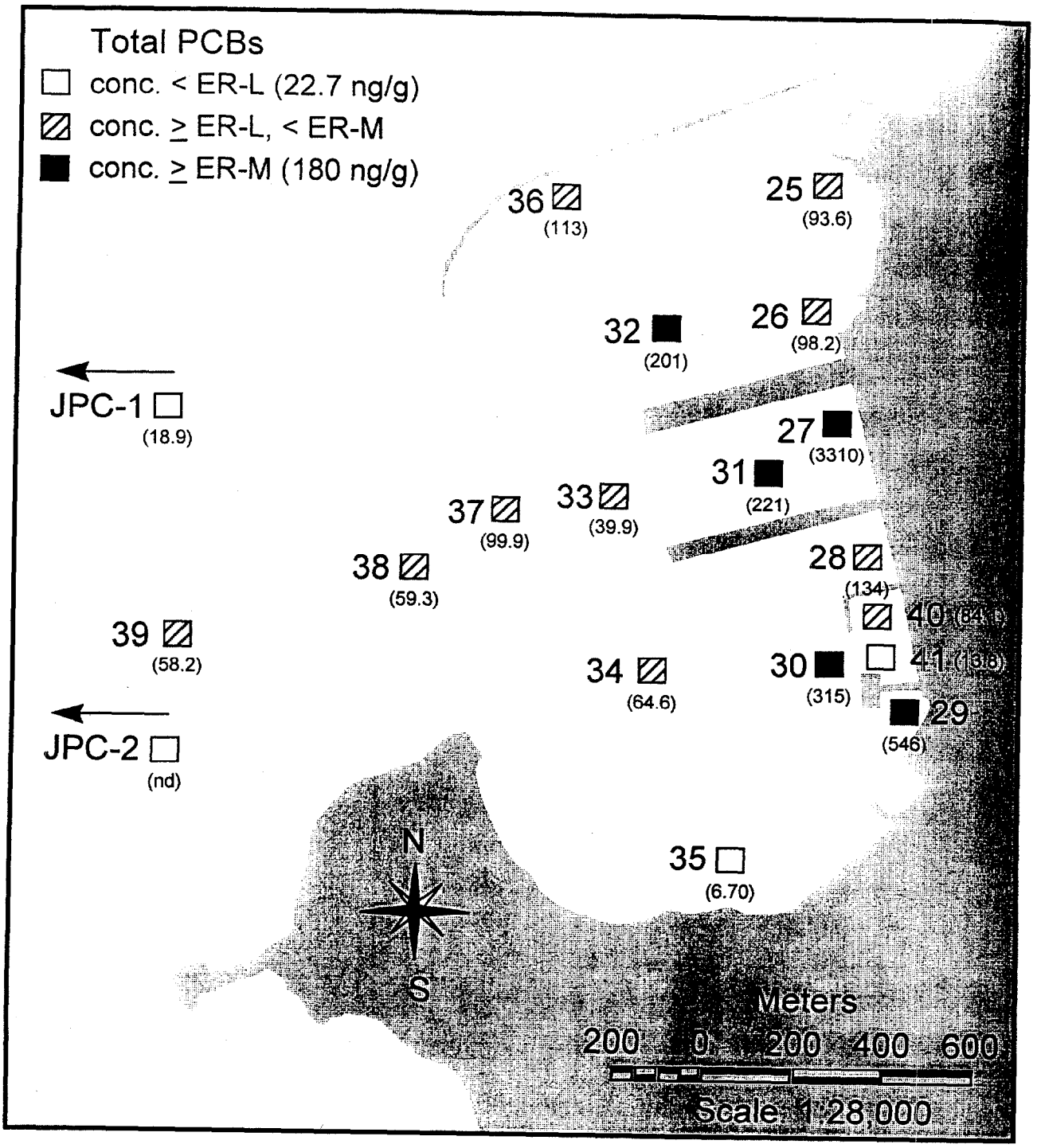


Figure 6.1-1. Concentrations (ng/g dry weight of sediment) of Total PCBs in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

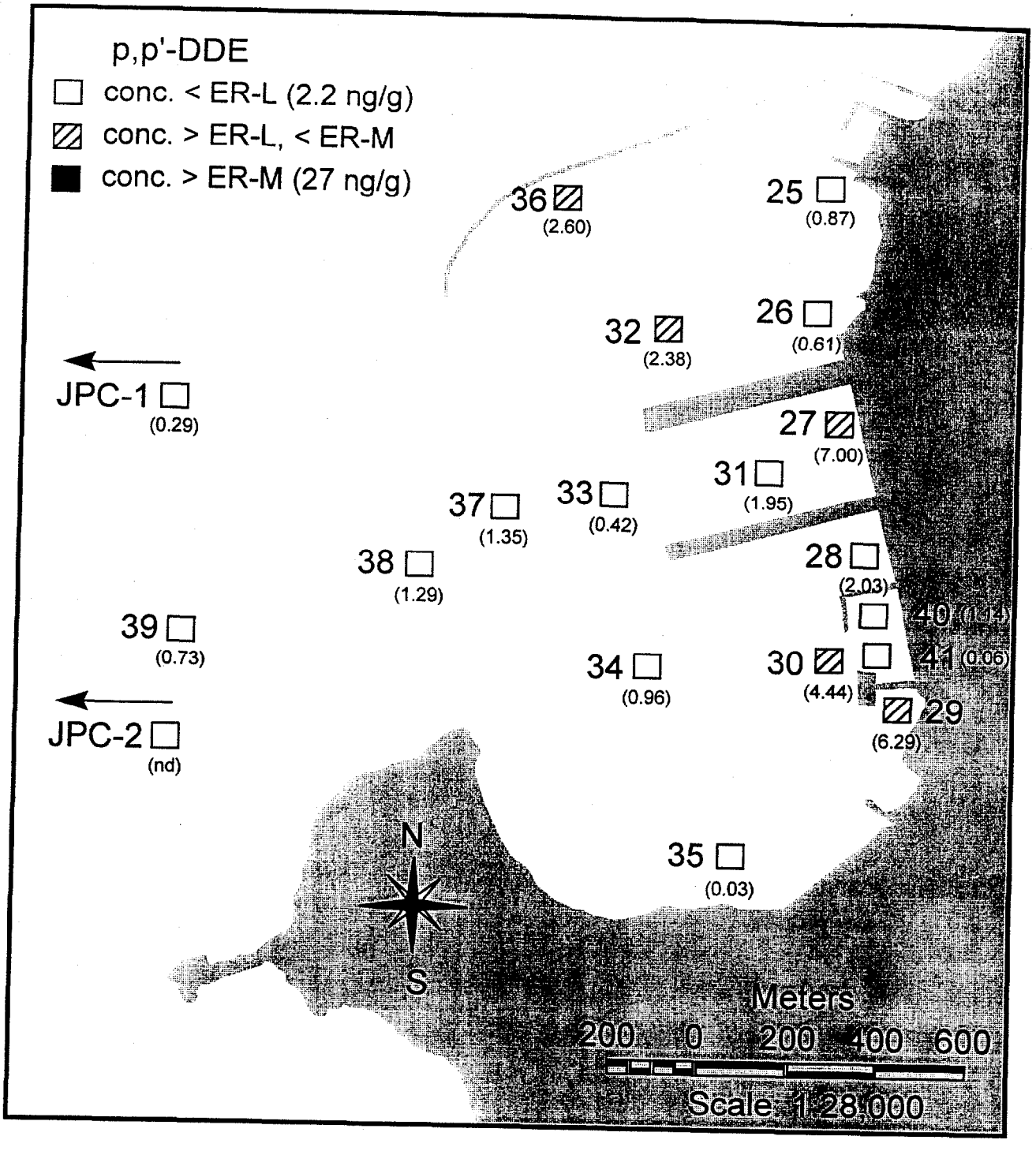


Figure 6.1-2. Concentrations (ng/g dry weight of sediment) of p,p'-DDE in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

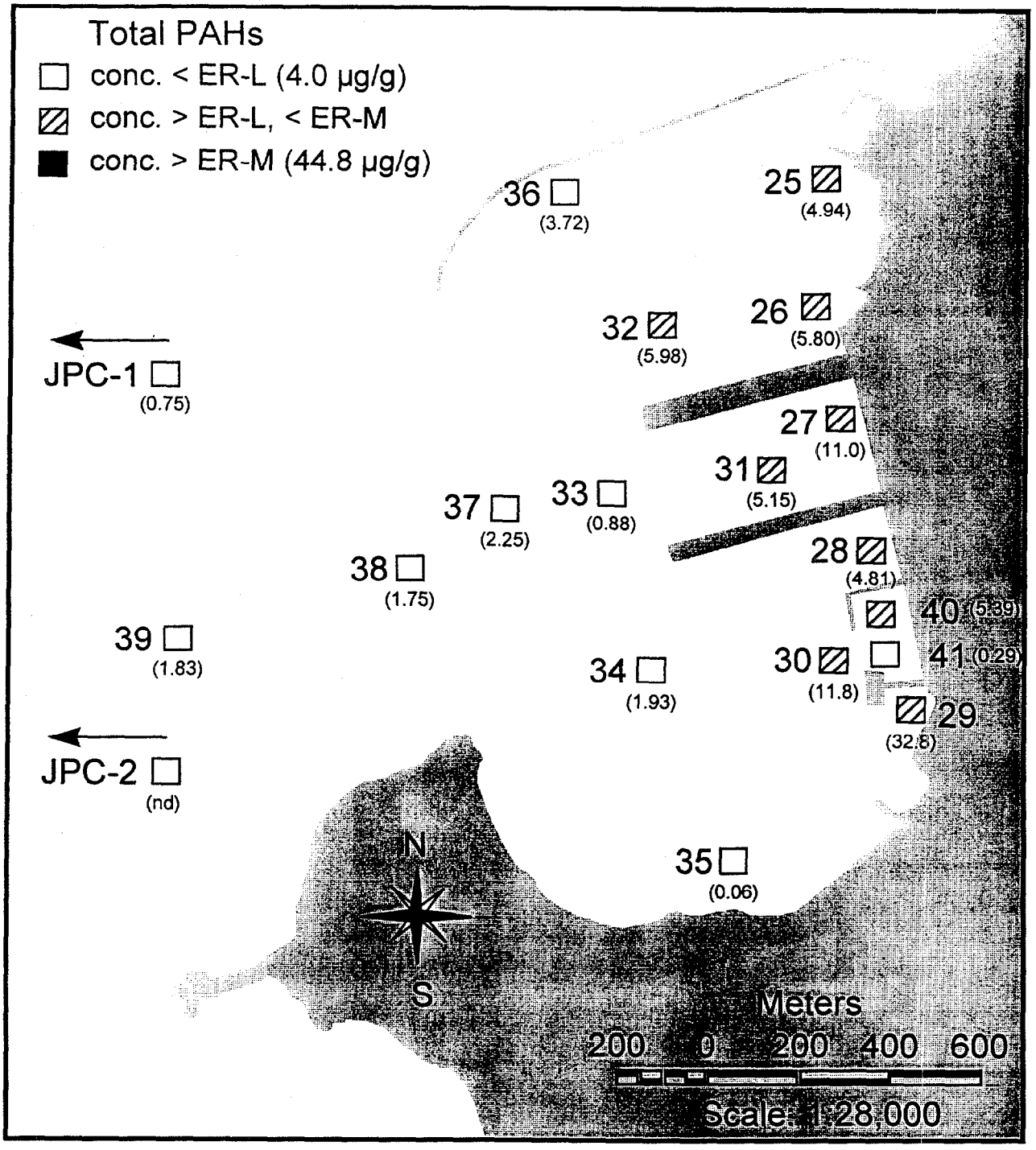


Figure 6.1-3. Concentrations (µg/g dry weight of sediment) of Total PAHs in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

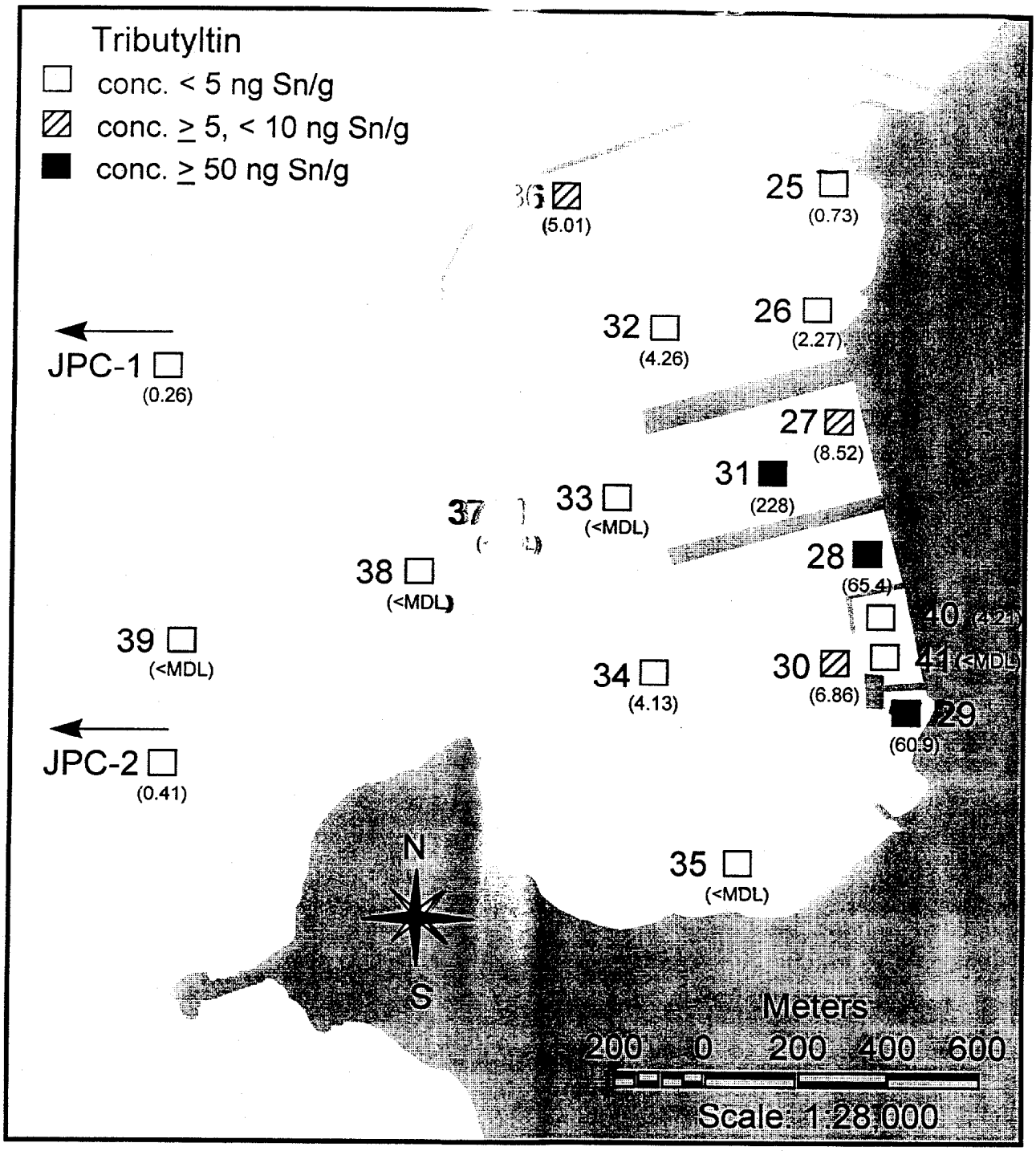


Figure 6.1-4. Concentrations (ng Sn/g dry weight of sediment) of tributyltin in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks taken from Macauley *et al.*, 1994). <MDL = less than Method Detection Limit.

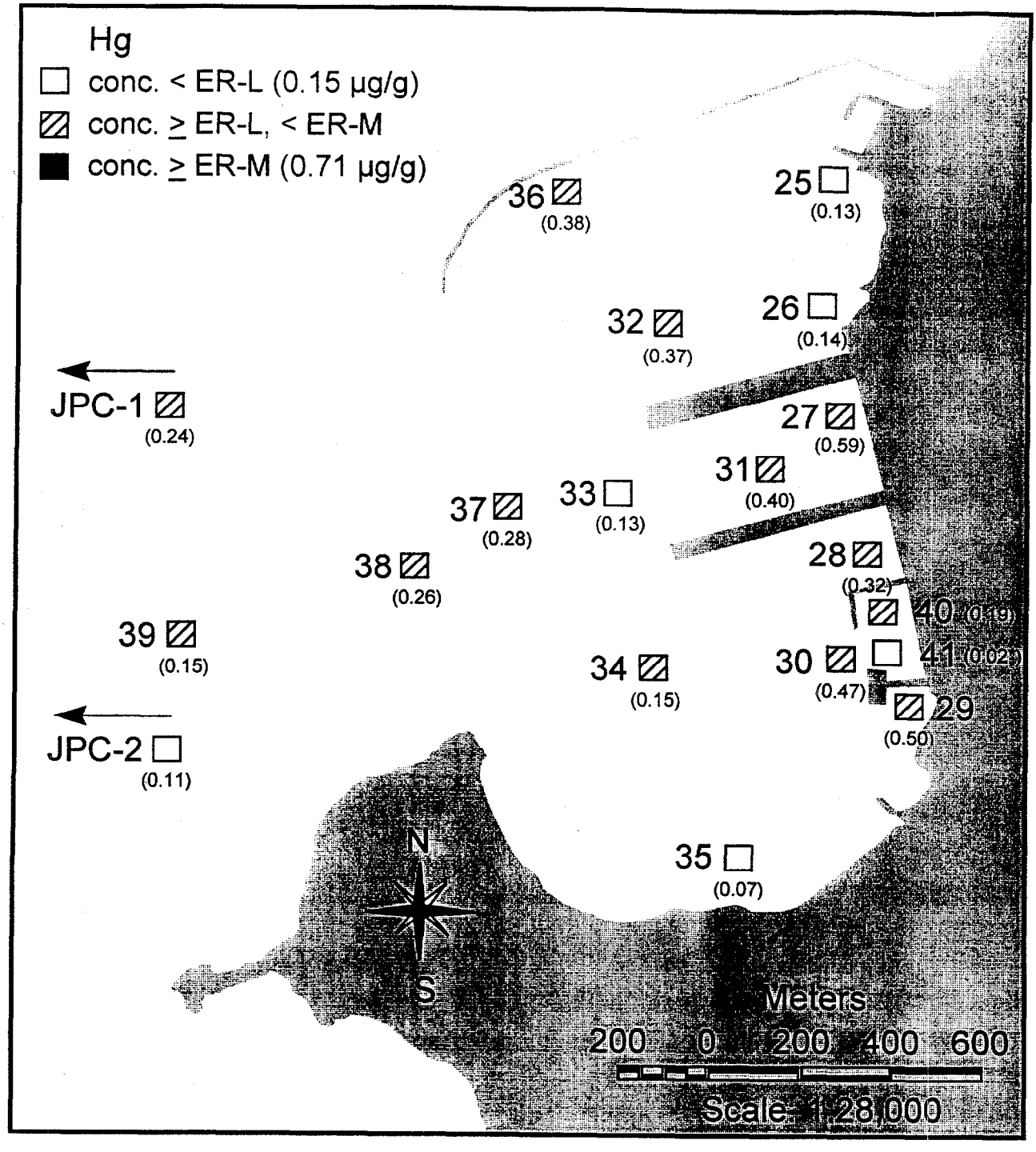


Figure 6.1-5. Concentrations (µg/g dry weight of sediment) of mercury in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995). * = concentration less than Method Limit of Quantitation.

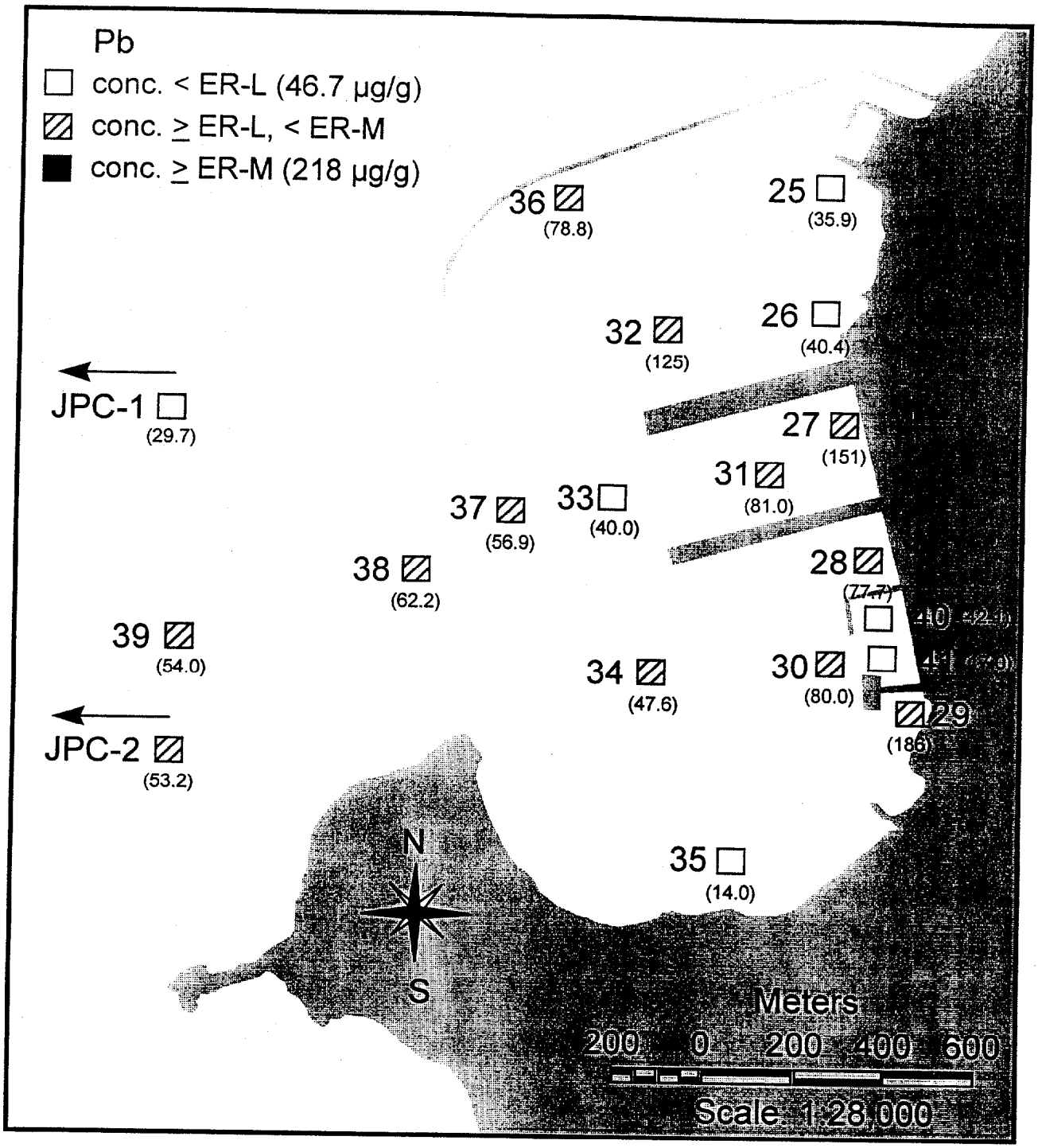


Figure 6.1-6. Concentrations (µg/g dry weight of sediment) of lead in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

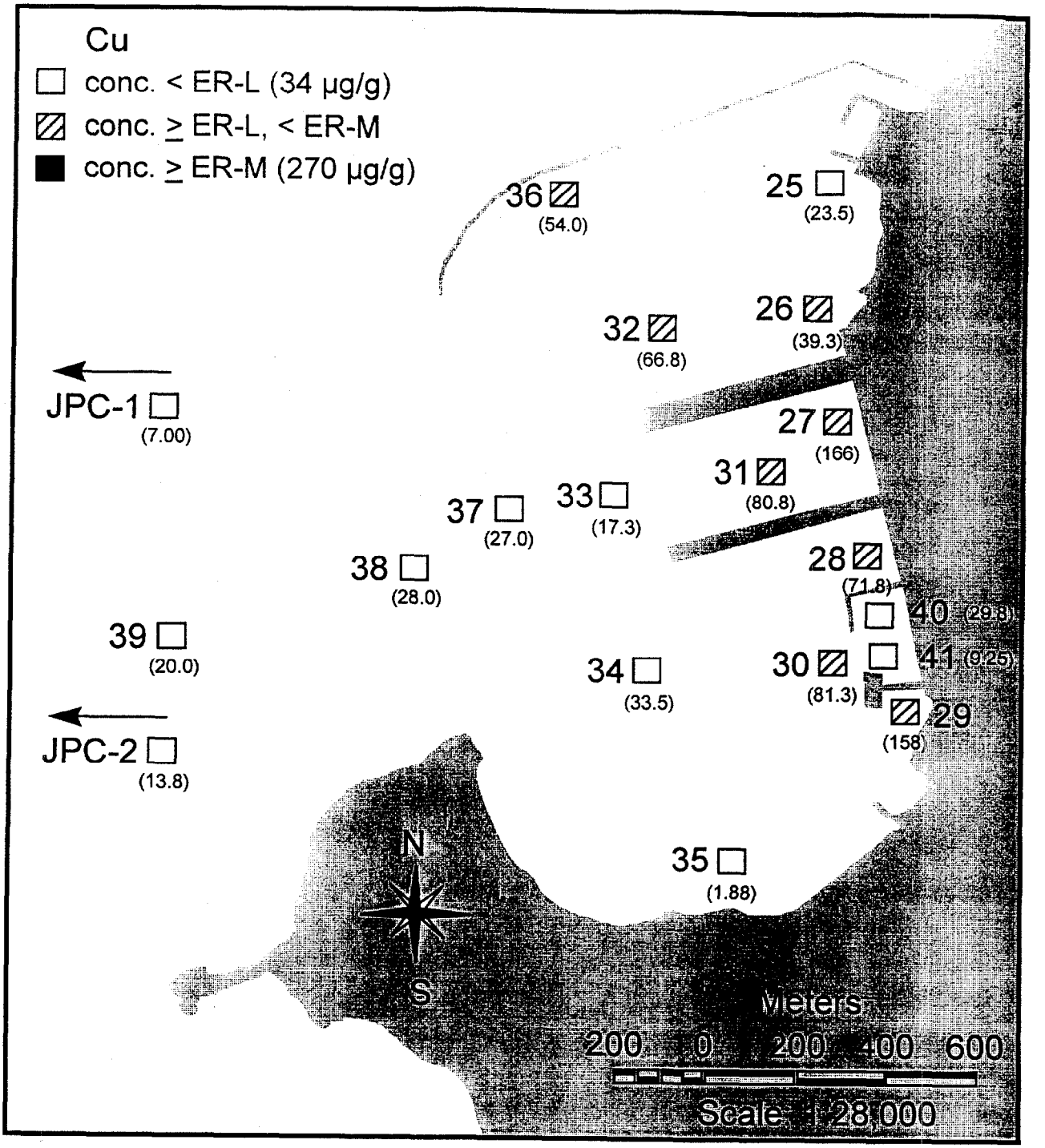


Figure 6.1-7. Concentrations (µg/g dry weight of sediment) of copper in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

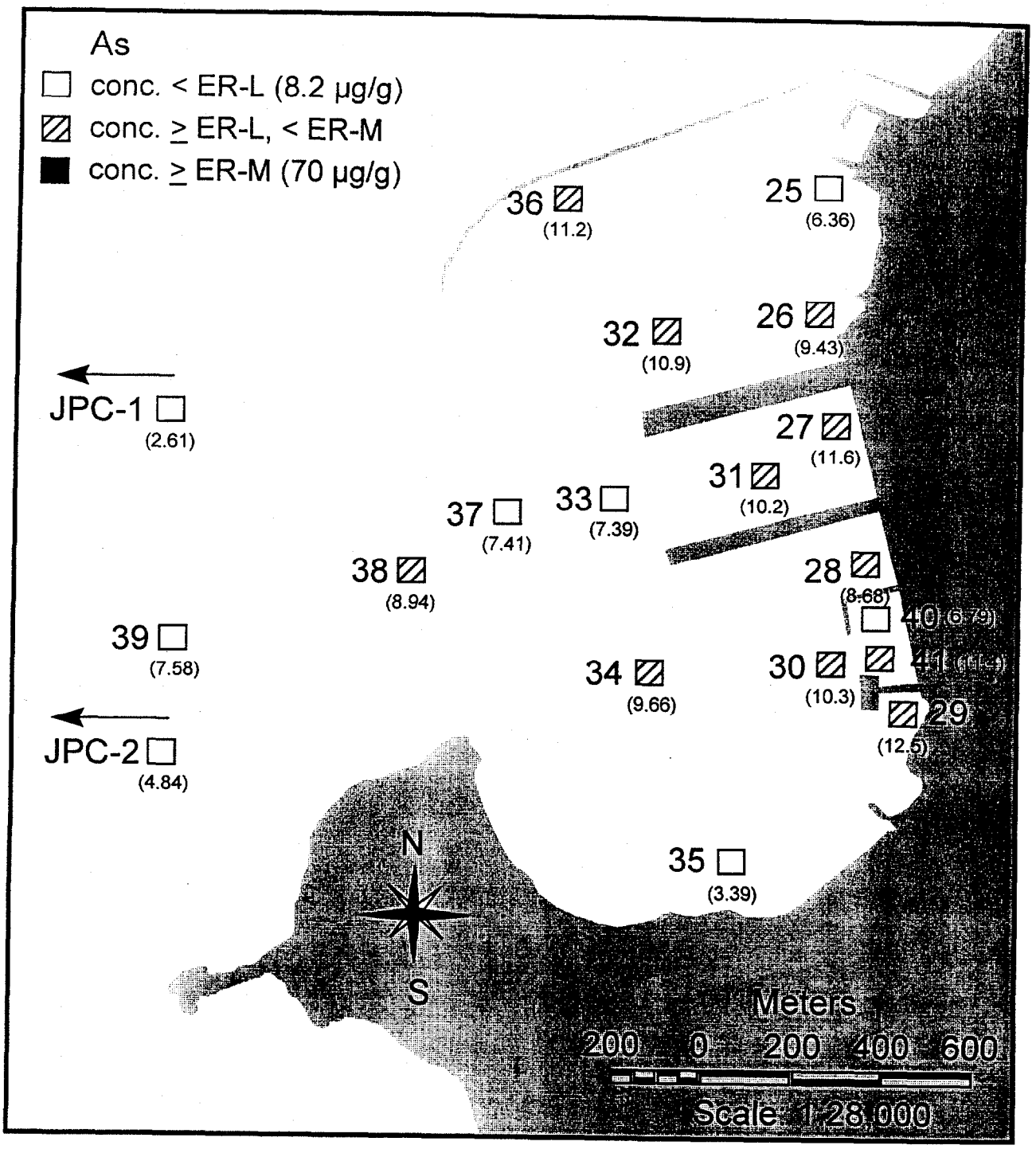


Figure 6.1-8. Concentrations (µg/g dry weight of sediment) of arsenic in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

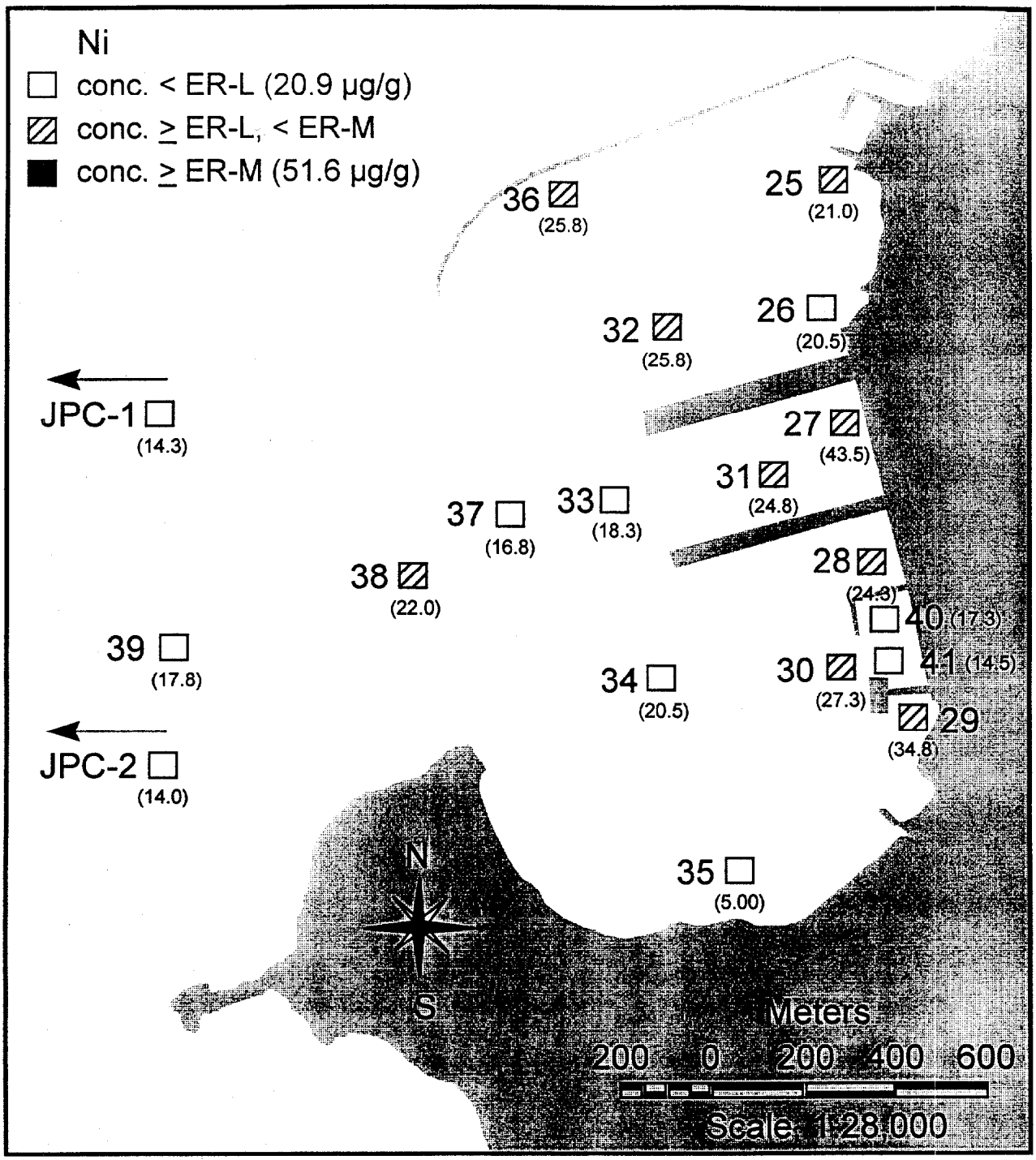


Figure 6.1-9. Concentrations (µg/g dry weight of sediment) of nickel in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

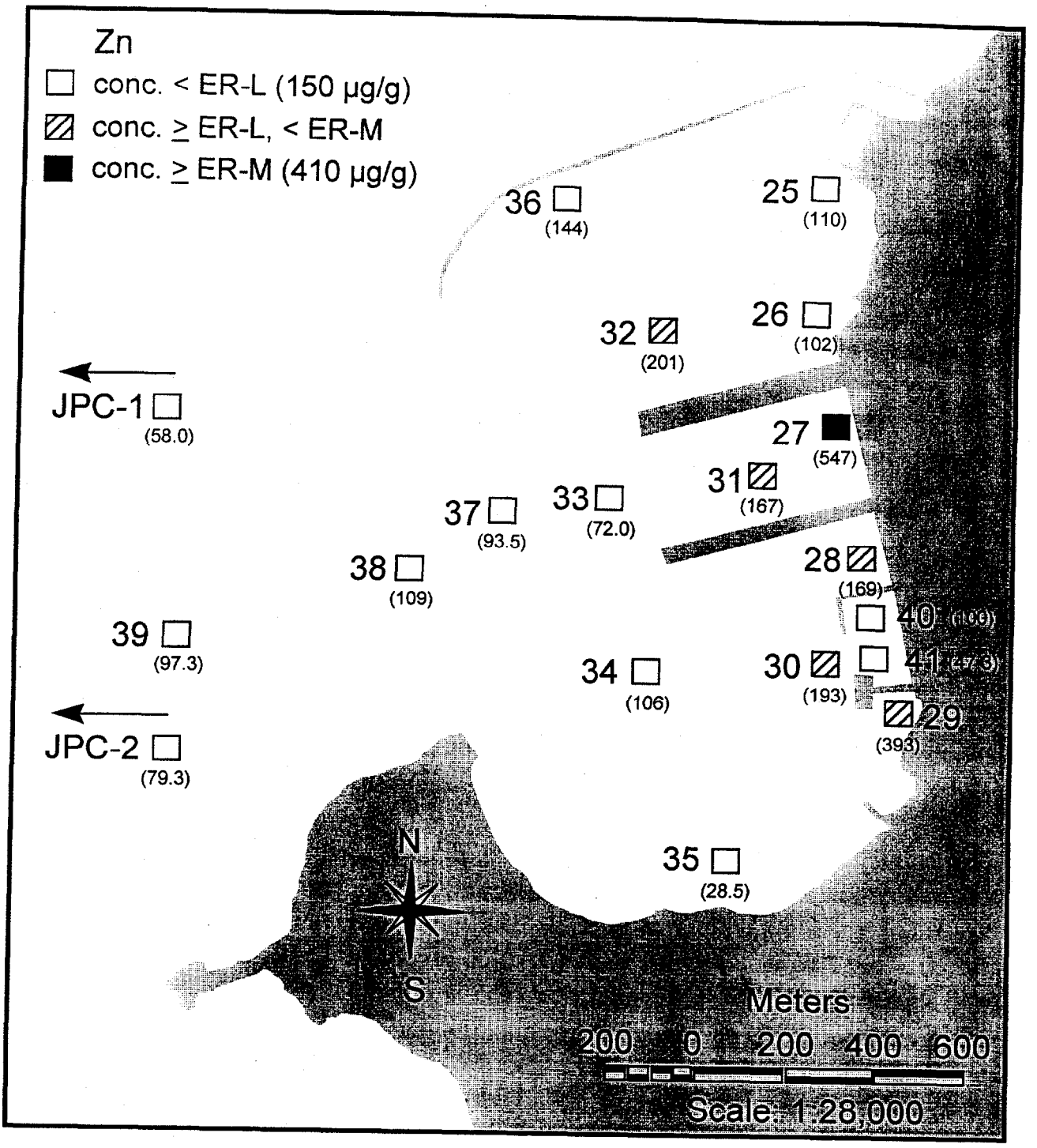


Figure 6.1-10. Concentrations (µg/g dry weight of sediment) of zinc in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

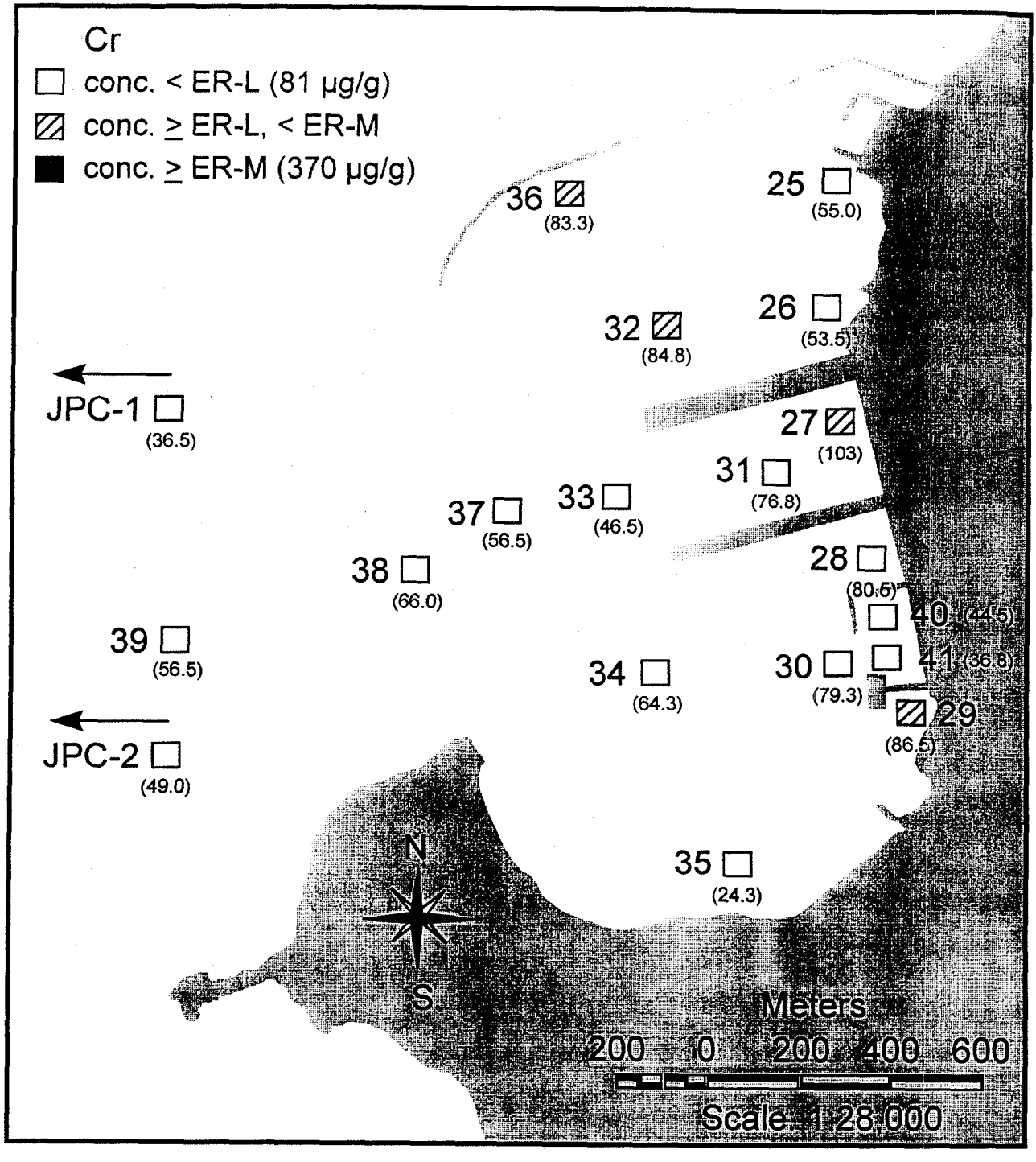


Figure 6.1-11. Concentrations (µg/g dry weight of sediment) of chromium in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

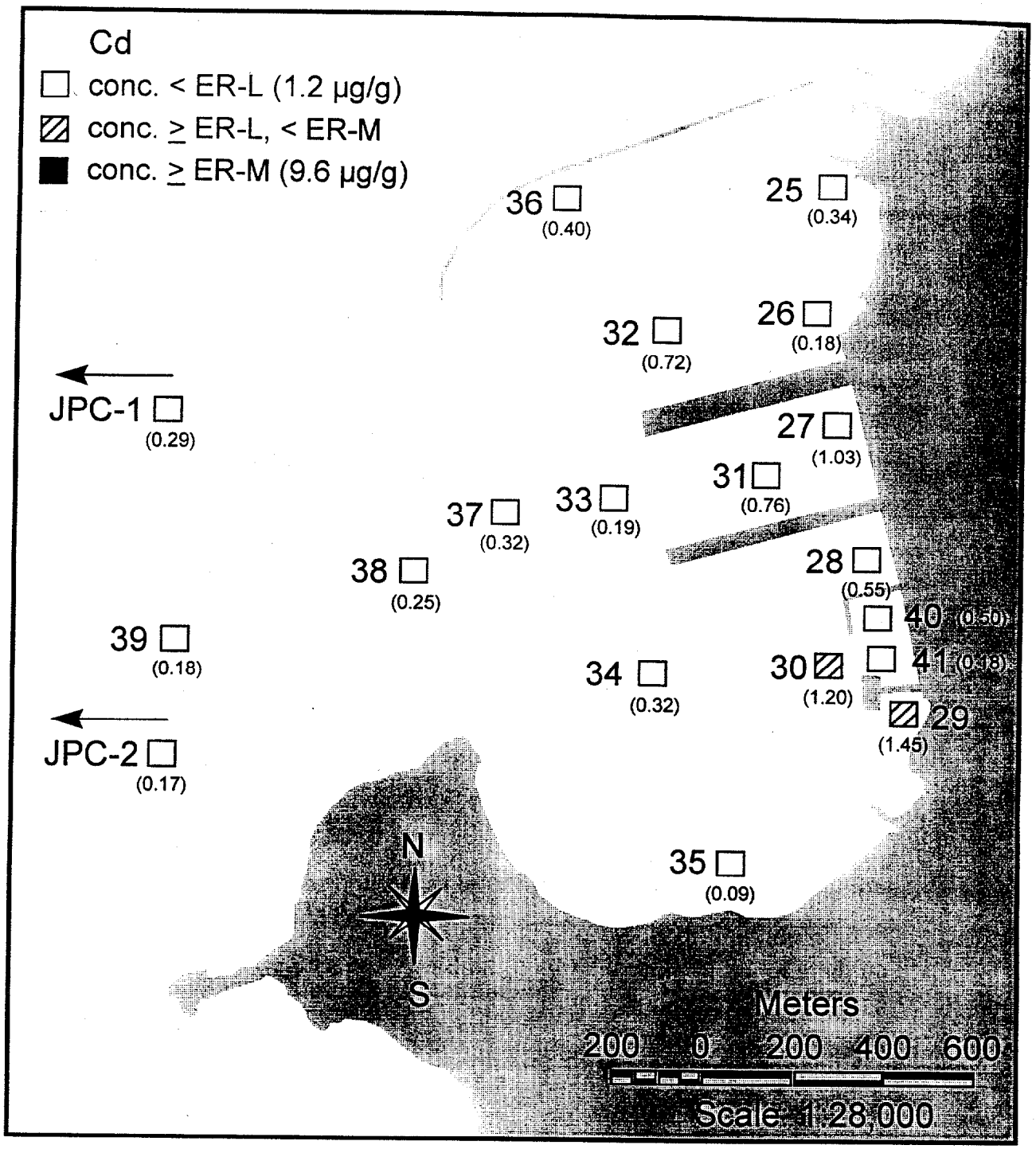


Figure 6.1-12. Concentrations (µg/g dry weight of sediment) of cadmium in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

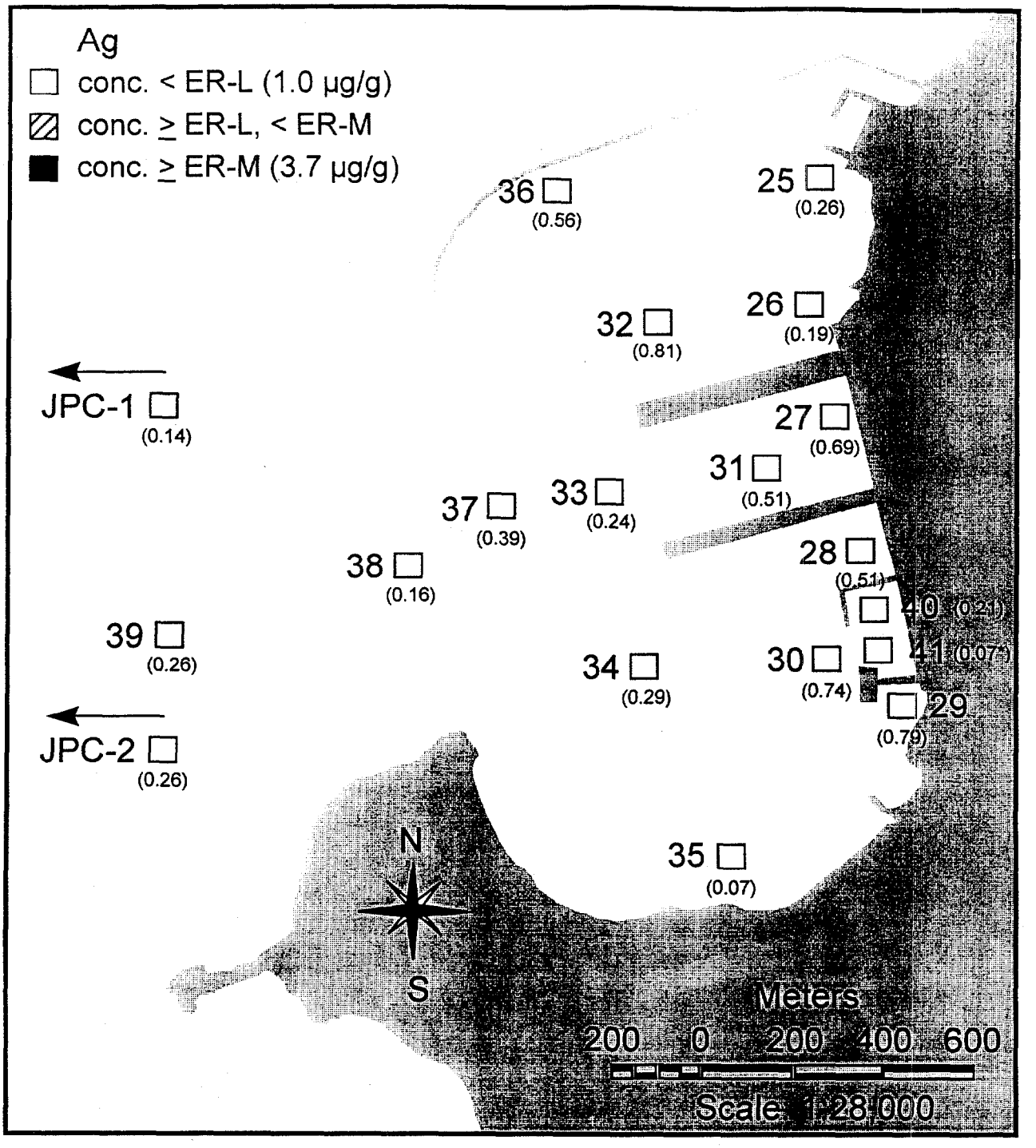


Figure 6.1-13. Concentrations (µg/g dry weight of sediment) of silver in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference locations. Benchmarks = NOAA ER-L and ER-M (Long *et al.*, 1995).

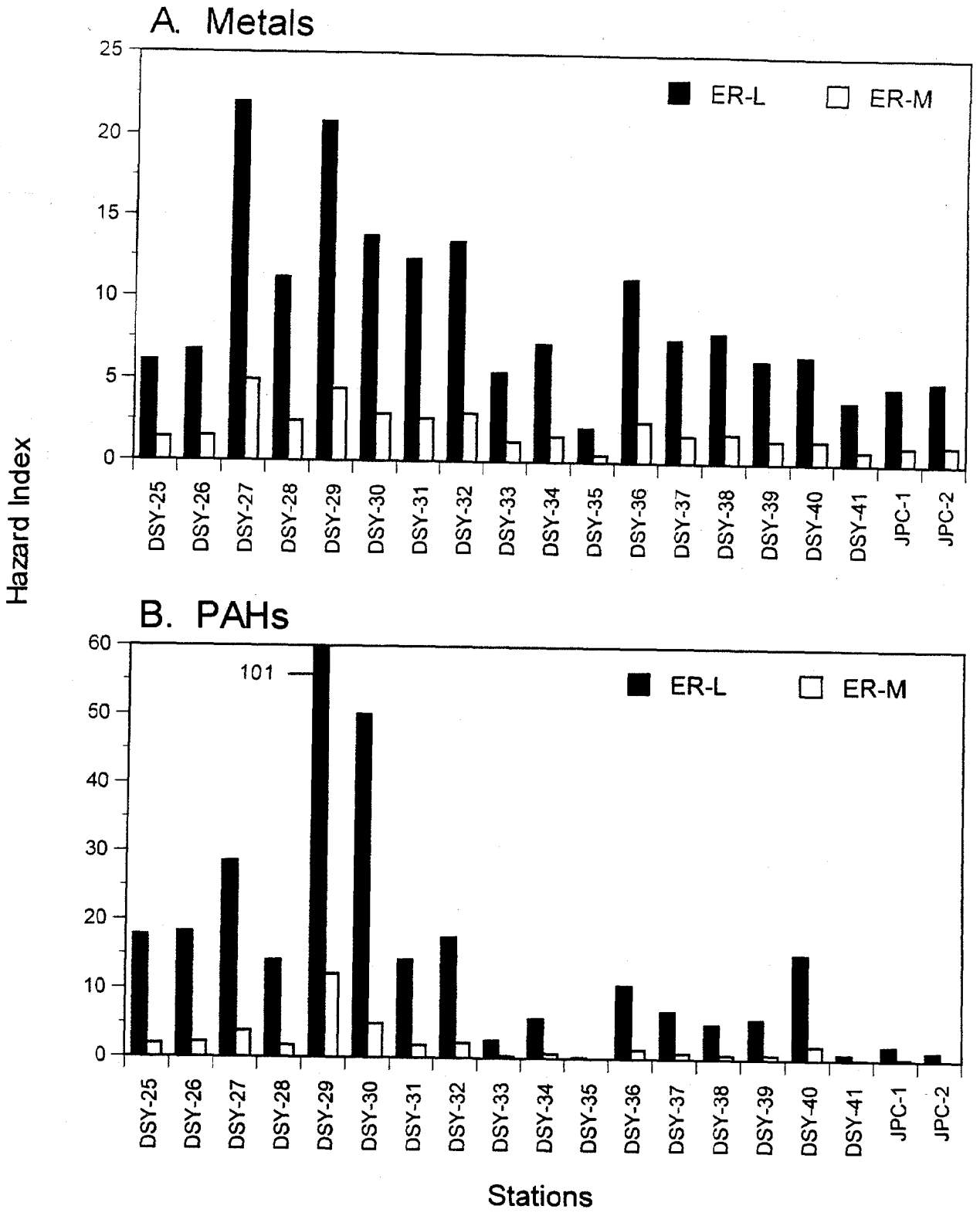


Figure 6.1-14. Hazard Indices for A) metals and B) PAHs in surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations. ER-L and ER-M benchmarks from Long *et al.*, 1995.

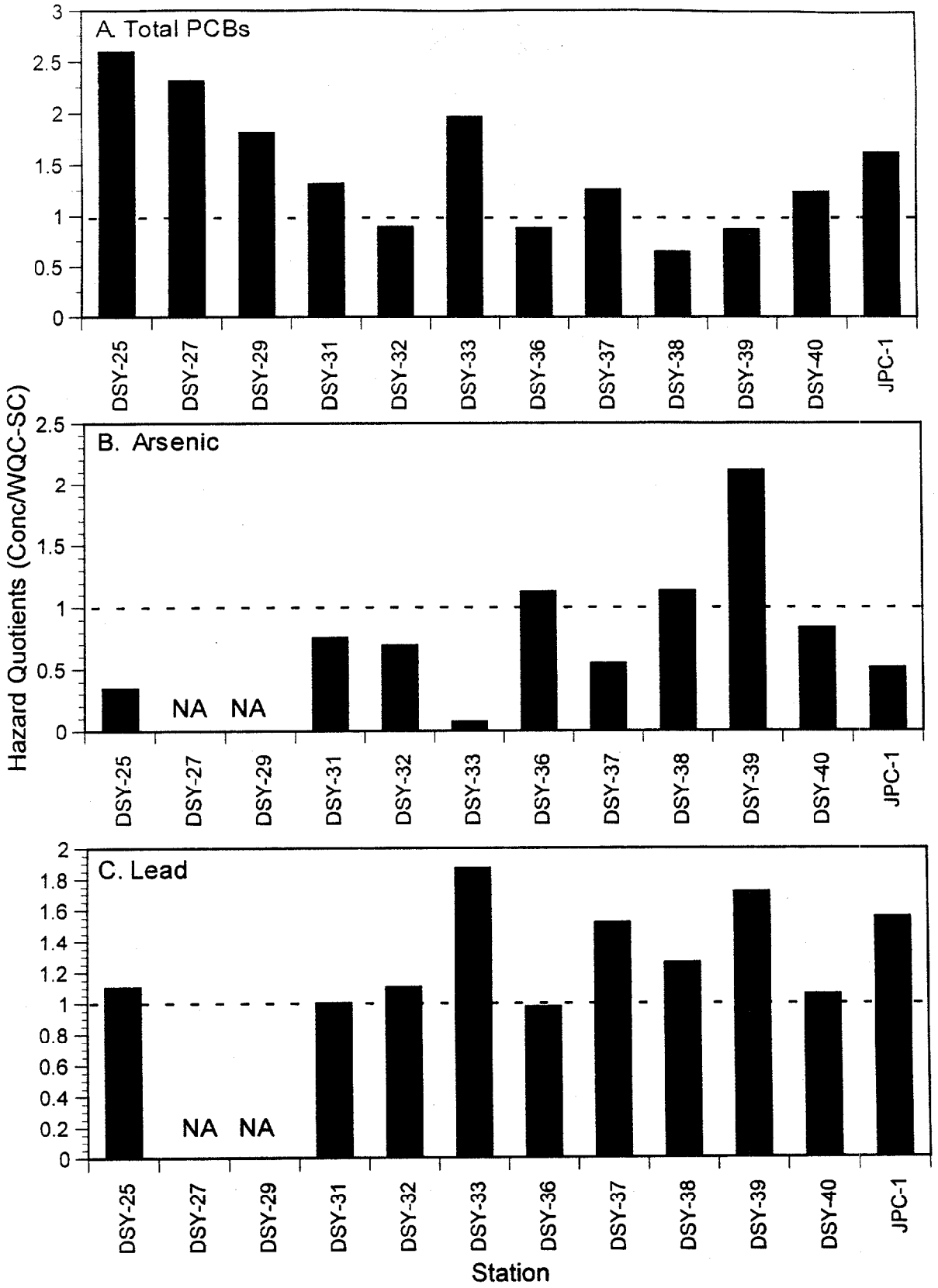
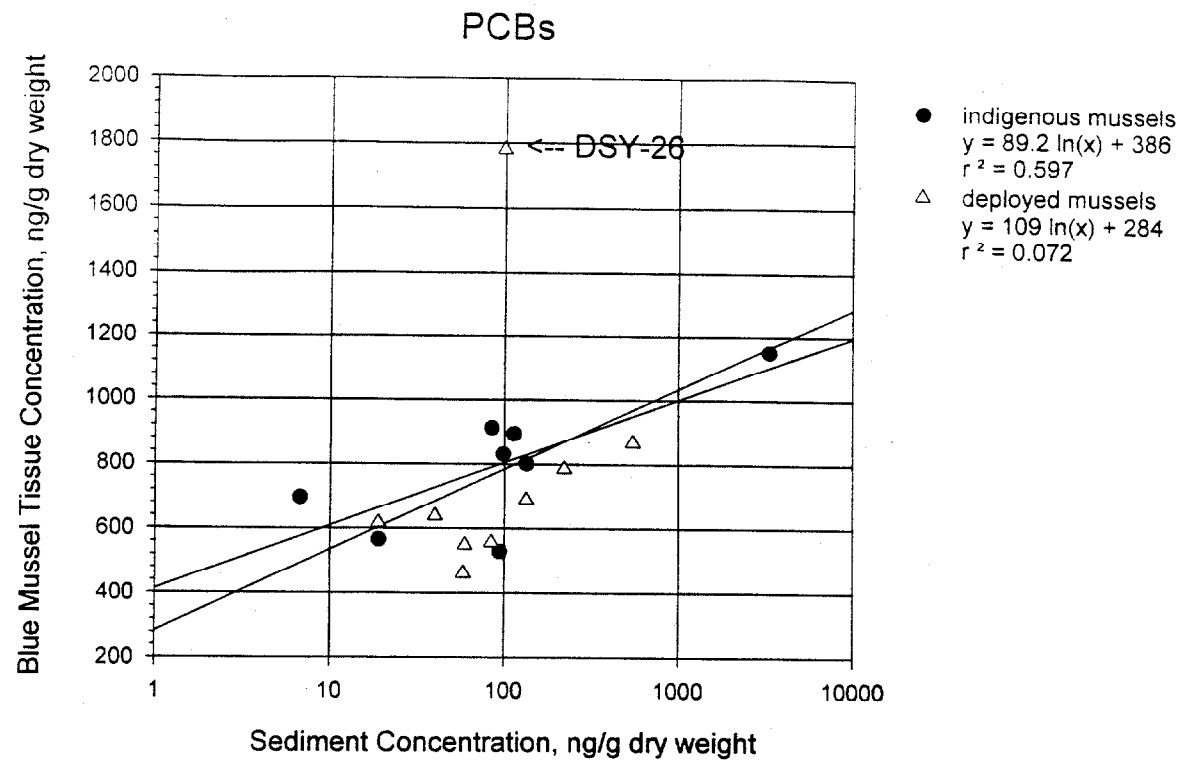


Figure 6.1-15. Hazard Quotients for A) Total PCBs, B) arsenic, and C) lead in elutriate prepared from surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference location. Criteria = EPA Ambient Water Quality Criteria-Saltwater Chronic (AWQC-SC) Values (U.S. EPA, 1992). Dashed line indicates HQ = 1. NA = Not analyzed.



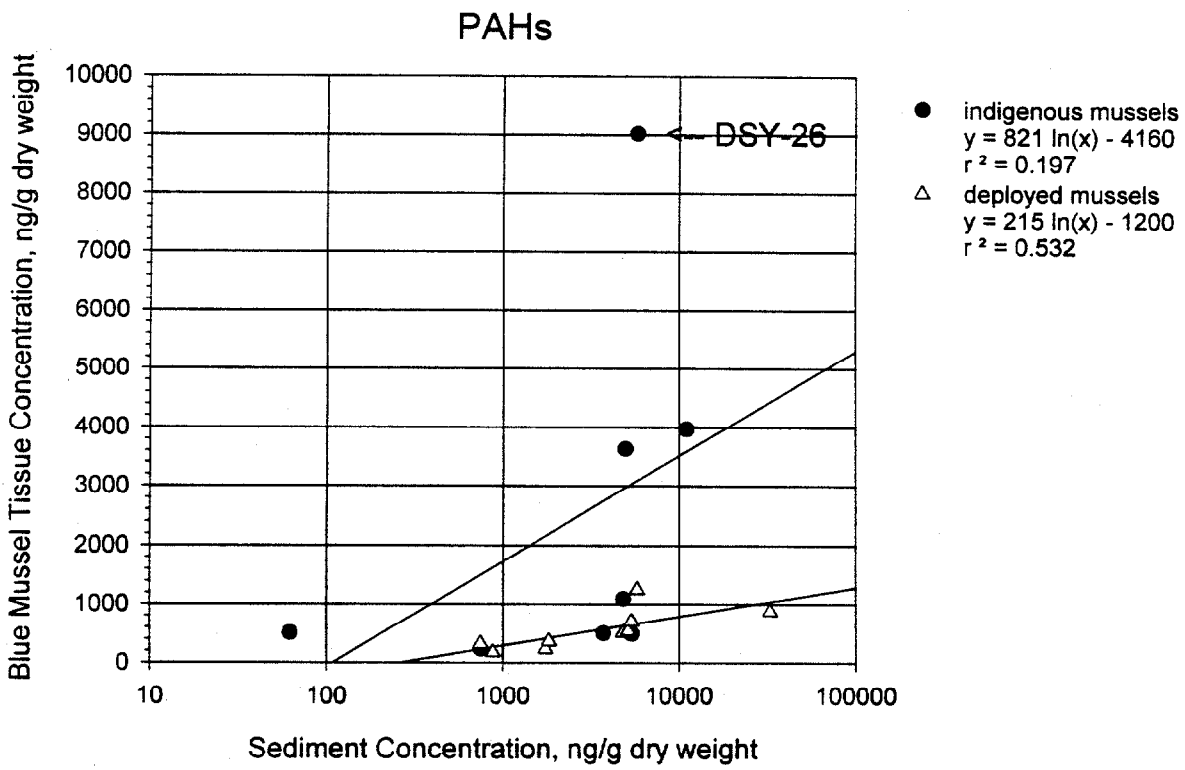


Figure 6.3-1. Comparison of concentrations in indigenous blue mussel and deployed mussel tissues versus concentrations in surface sediments (0-18 cm) for A) Total PCBs and B) Total PAHs for eight stations in the Derecktor Shipyard/Coddington Cove study area and Jamestwon Potter Cove reference location JPC-1.

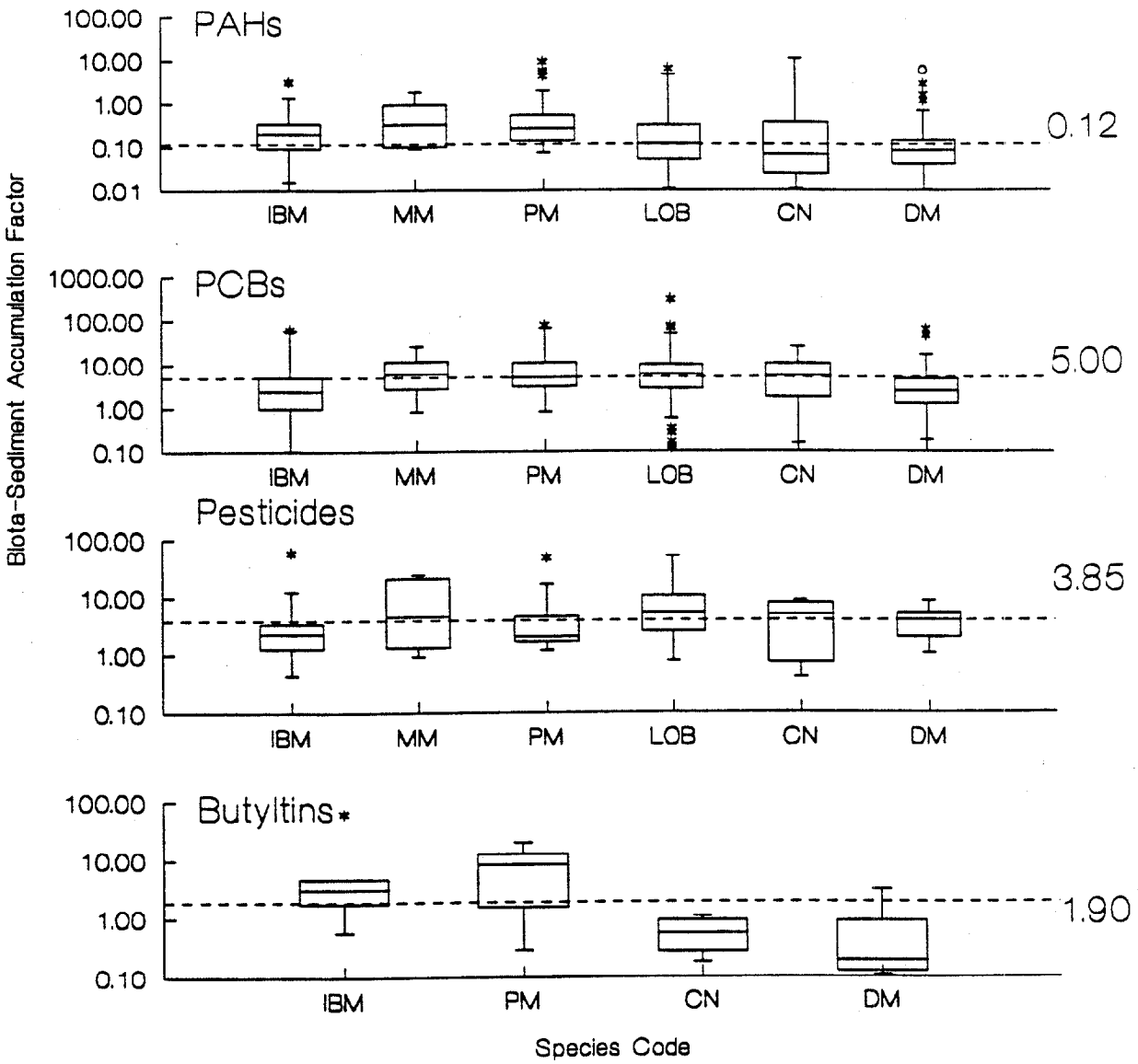


Figure 6.3-2. Box plots of Biota-Sediment Accumulation Factors (BSAFs) for organic contaminants and target species selected for the Derecktor Shipyard Marine Ecological Risk Assessment. The dashed line and number indicate the median value across species groups for each CoC class. Codes: IBM = *Mytilus edulis* (indigenous blue mussels); MM = *Mercenaria mercenaria*; PM = *Pitar morrhuana*; LOB = *Homarus americanus* (lobster); CN = *Tautogolabrus adspersus* (cunner); DM = *Mytilus edulis* (deployed mussels). Refer to the text in Section 6.3.1 for explanations of box plot symbols.

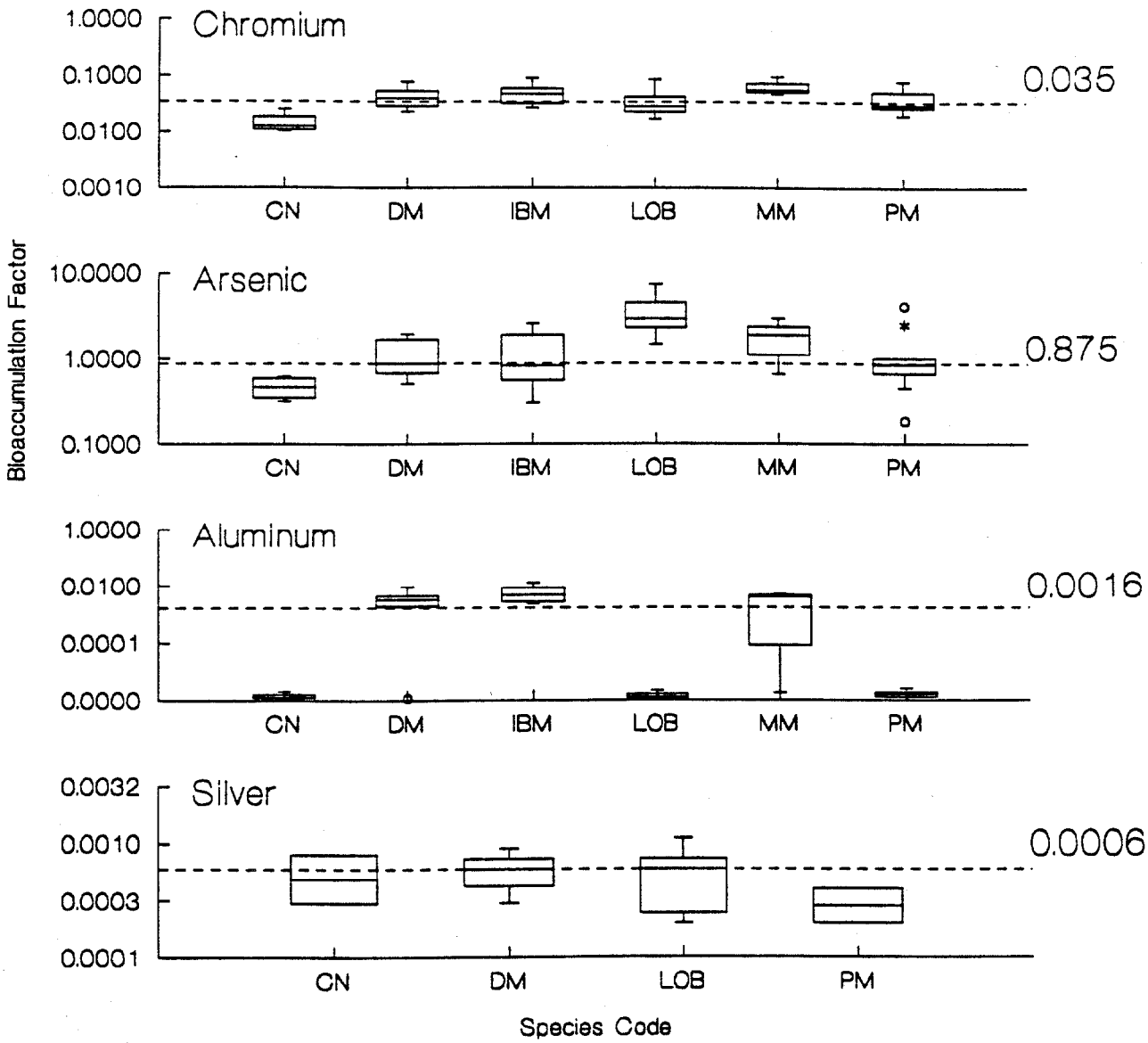


Figure 6.3-3. Box plots of Bioaccumulation Factors (BAFs) for metals and target species for the Derecktor Shipyard Marine Ecological Risk Assessment. The dashed line and number indicate the median value across species groups for each metal. Codes: IBM = *Mytilus edulis* (indigenous blue mussels); MM = *Mercenaria mercenaria*; PM = *Pitar morrhuana*; LOB = *Homarus americanus* (lobster); CN = *Tautogolabrus adspersus* (cunner); DM = *Mytilus edulis* (deployed mussels). Refer to the text in Section 6.3.1 for explanations of box plot symbols.

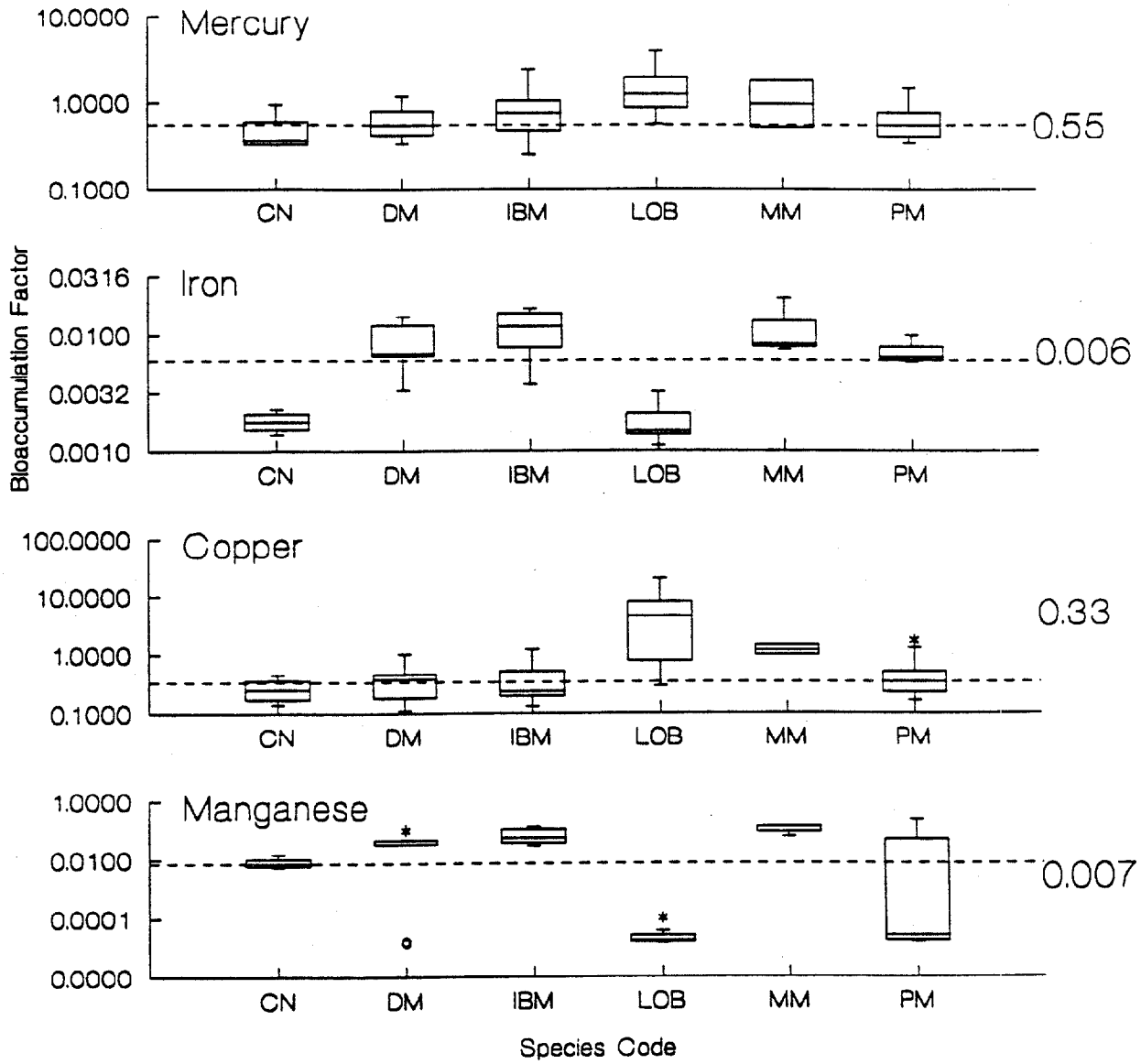


Figure 6.3-3. (continued). Box plots of Bioaccumulation Factors (BAFs) for metals and target species for the Derecktor Shipyard Marine Ecological Risk Assessment. The dashed line and number indicate the median value across species groups for each metal. Codes: IBM = *Mytilus edulis* (indigenous blue mussels); MM = *Mercenaria mercenaria*; PM = *Pitar morrhuana*; LOB = *Homarus americanus* (lobster); CN = *Tautogolabrus adspersus* (cunner); DM = *Mytilus edulis* (deployed mussels). Refer to the text in Section 6.3.1 for explanations of box plot symbols.

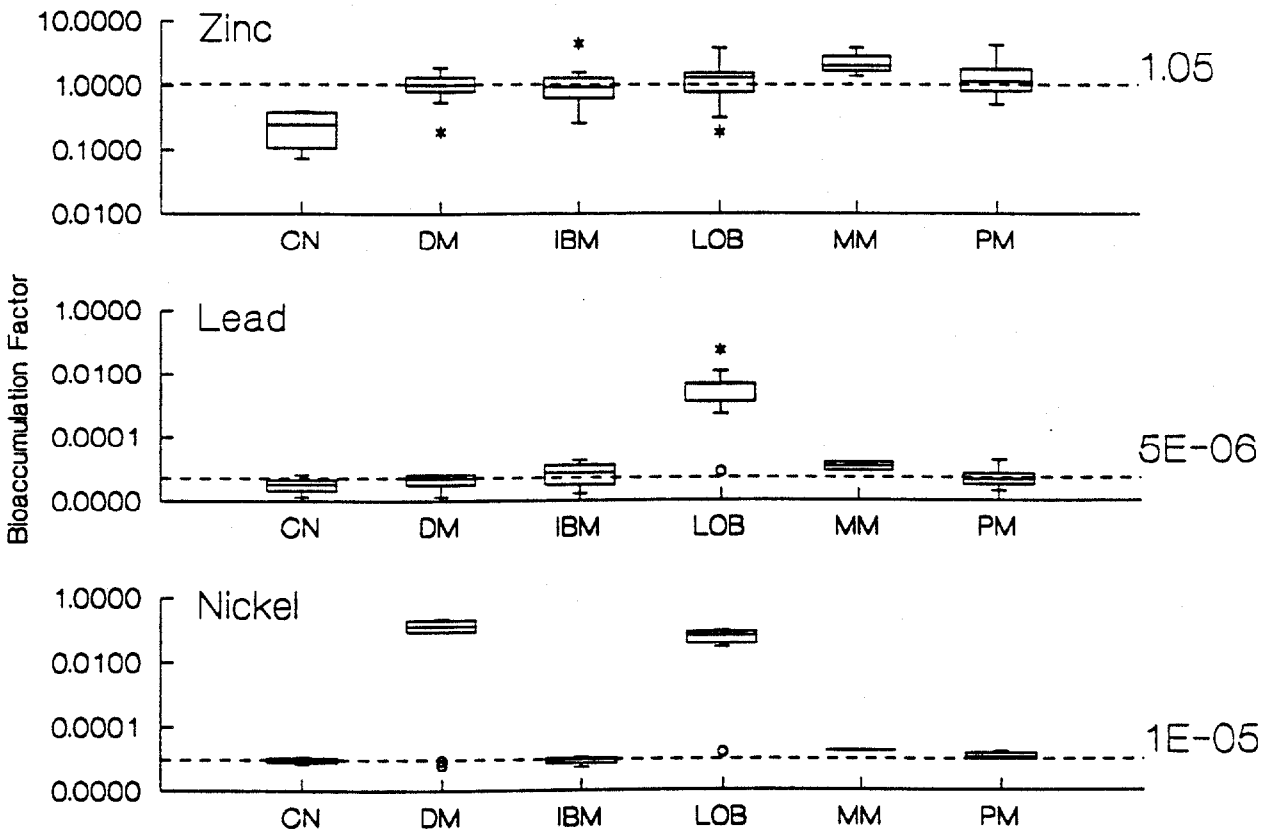


Figure 6.3-3. (continued). Box plots of Bioaccumulation Factors (BAFs) for metals and target speceies for the Derecktor Shipyard Marine Ecological Risk Assessment. The dashed line and number indicate the median value across species groups for each metal. Codes: IBM = *Mytilus edulis* (indigenous blue mussels); MM = *Mercenaria mercenaria*; PM = *Pitar morrhuana*; LOB = *Homarus americanus* (lobster); CN = *Tautogolabrus adspersus* (cunner); DM = *Mytilus edulis* (deployed mussels). Refer to the text in Section 6.3.1 for explanations of box plot symbols.

Figure 6.3-4. Avian Aquatic Predator on-site vs. total habitat availability comparison for the Derecktor Shipyard/Coddington Cove Marine ERA. A.) Herring Gull ; B.) Great Blue Heron.

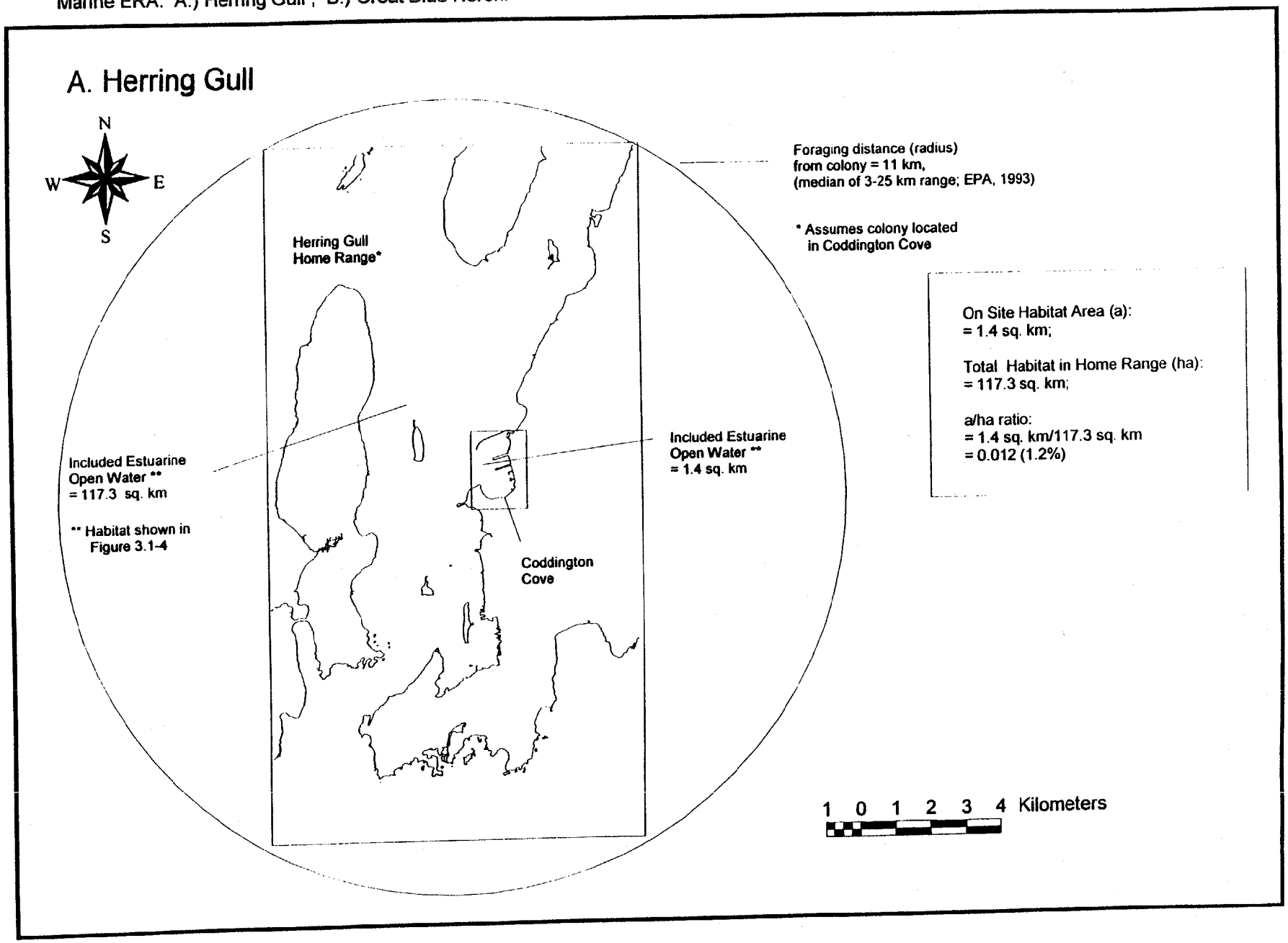
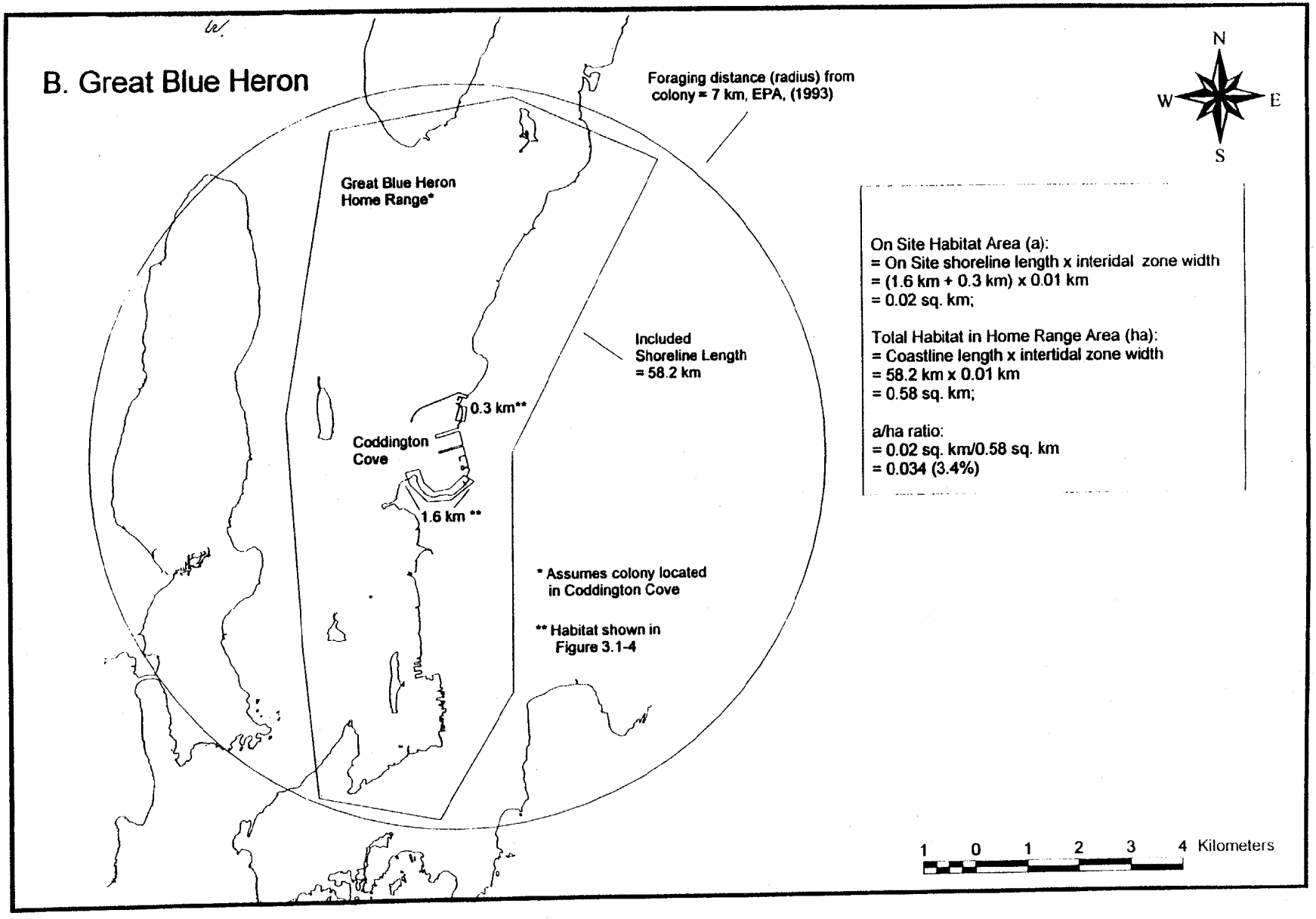


Figure 6.3-4. continued. Avian Aquatic Predator on-site vs. total habitat availability comparison for the Derecktor Shipyard/Coddington Cove Marine ERA. A.) Herring Gull B.) Great Blue Heron



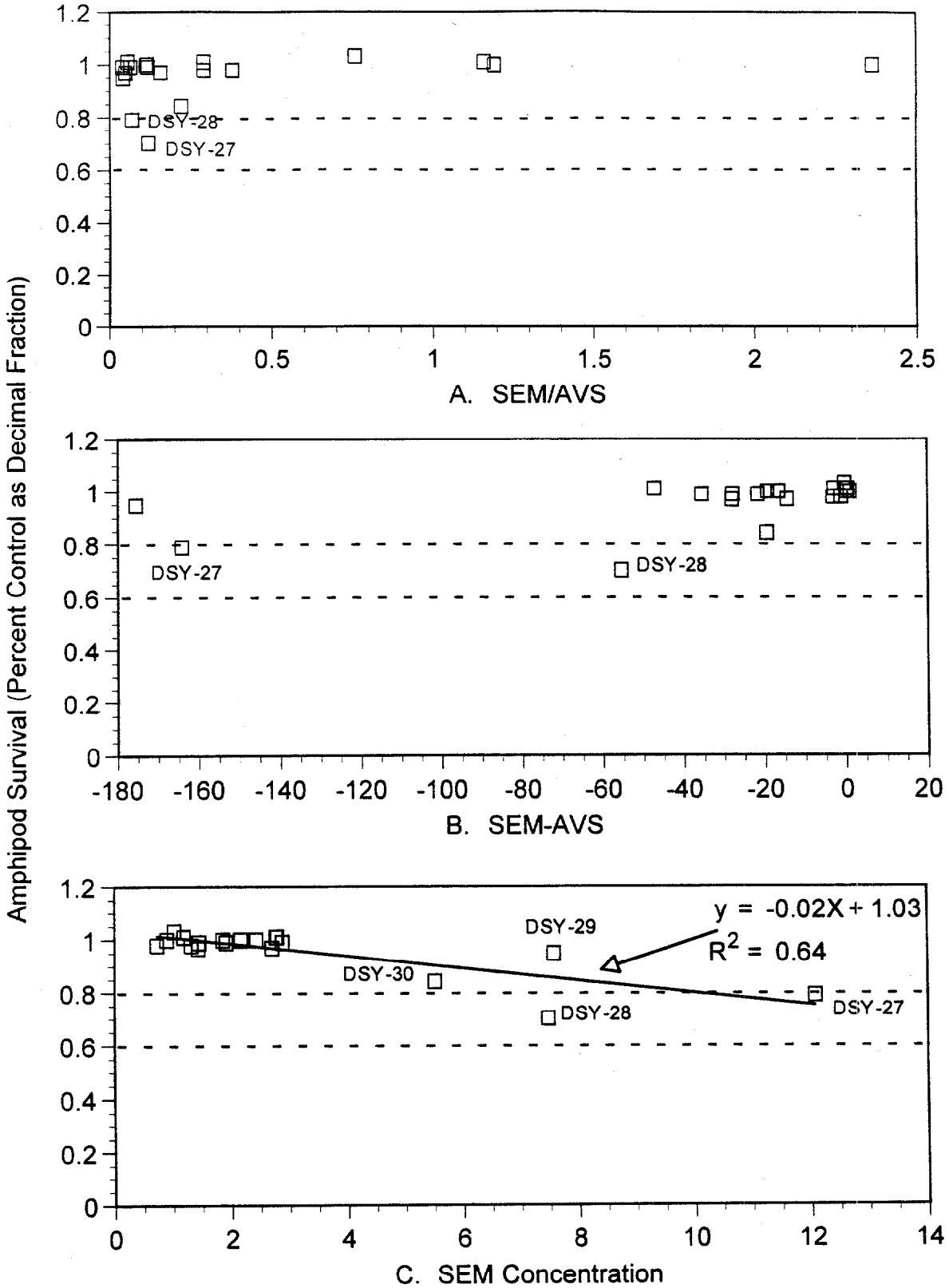


Figure 6.4-1. Amphipod (*Ampelisca*) survival versus A) SEM/AVS, B) SEM-AVS, and C) SEM concentration (µmol/g) in whole sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove reference locations. Dashed lines indicate interpretive threshold values for possible (80%) and probable (60%) impact on amphipod survival.

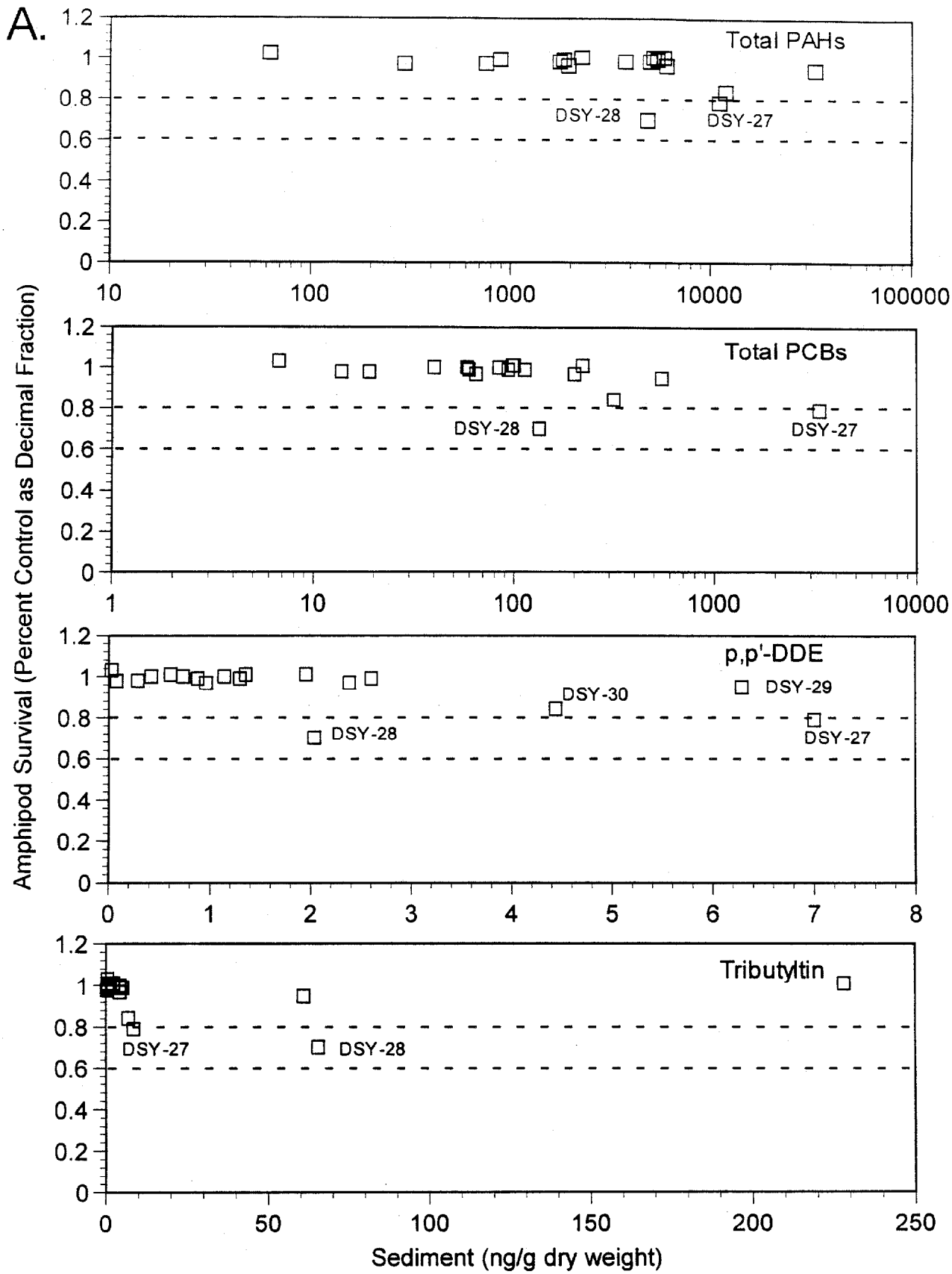


Figure 6.4-2. Amphipod survival versus organic contaminants in bulk surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference locations. Dashed lines indicate interpretive threshold values for possible (<80%) and probable (<60%) impacts on amphipod survival. A) Concentrations of Total PAHs, Total PCBs, p,p'-DDE, and tributyltin, and B) concentrations normalized to TOC.

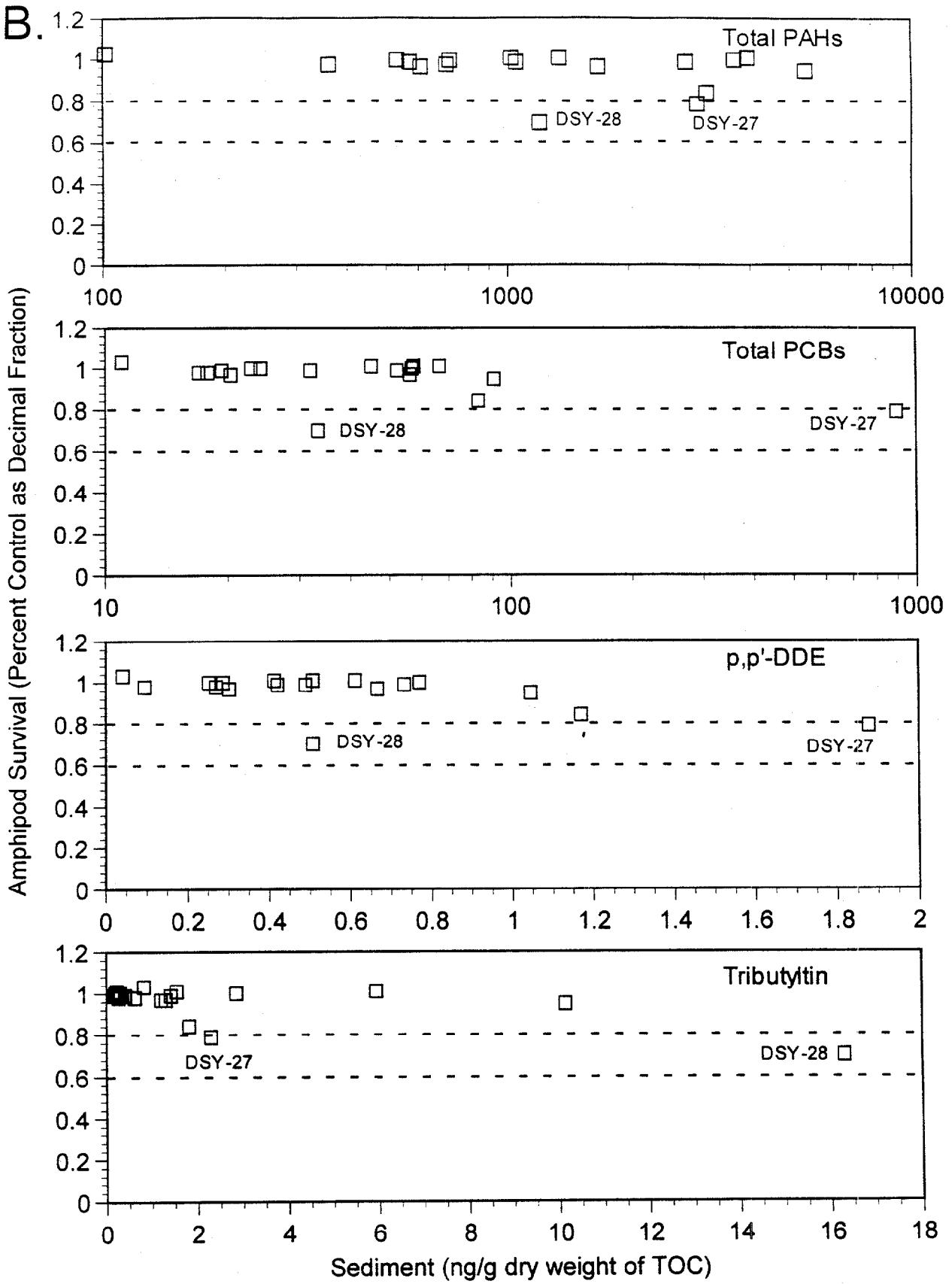


Figure 6.4-2 (continued). Amphipod survival versus organic contaminants in bulk surface sediments from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) reference locations. Dashed lines indicate interpretive threshold values for possible (<80%) and probable (<60%) impacts on amphipod survival. A) Concentrations of Total PAHs, Total PCBs, p,p'-DDE, and tributyltin, and B) concentrations normalized to TOC.

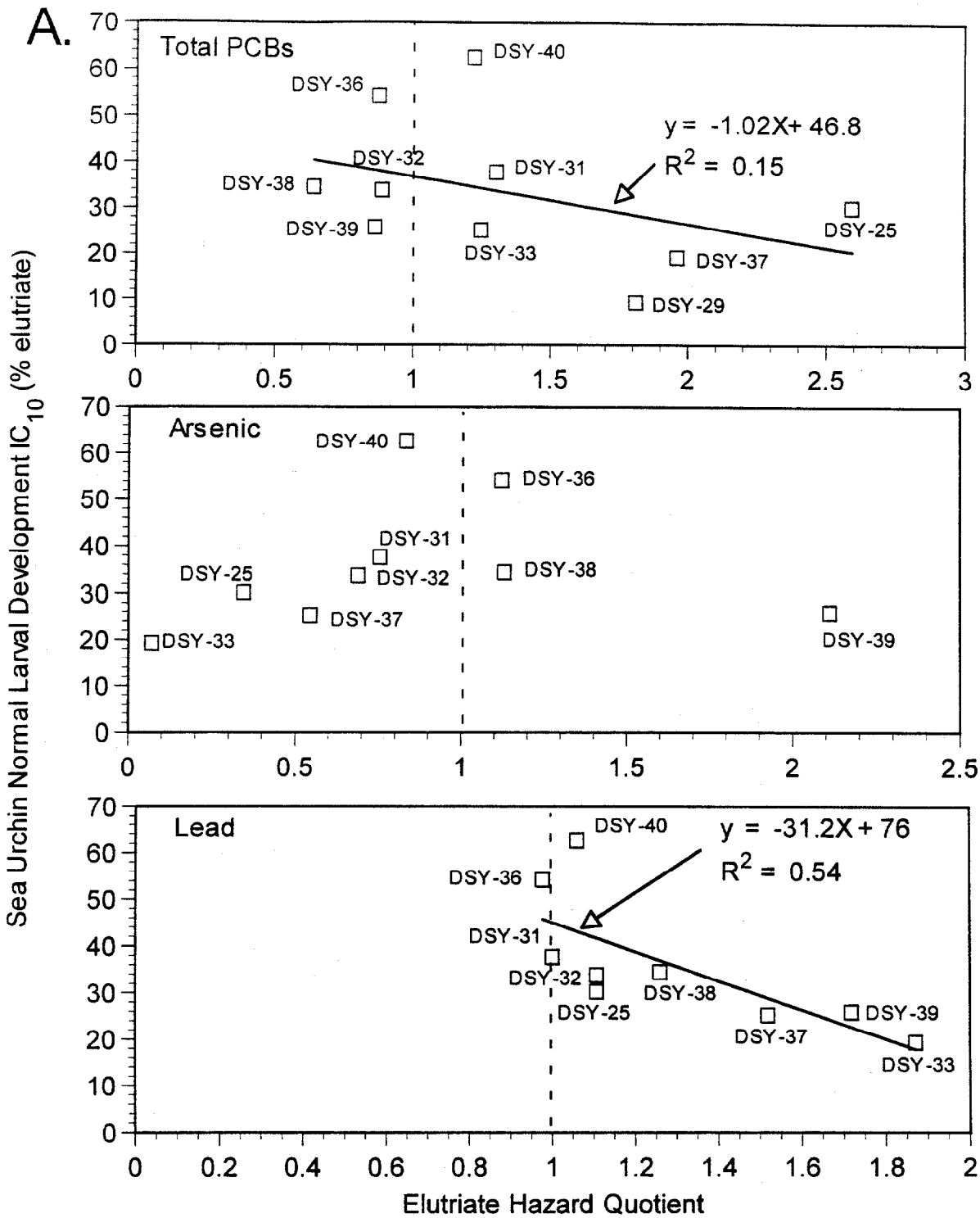


Figure 6.4-3. Elutriate IC_{10} versus elutriate Hazard Quotients for CoCs (elutriate concentration/water criterion) prepared from surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area. Criteria = EPA chronic water quality criteria. Dashed line indicates threshold for adverse effects. A) Measured concentrations of Total PCBs, arsenic, and lead; and B) measured concentrations of Total PCBs, arsenic, and lead, normalized to TOC.

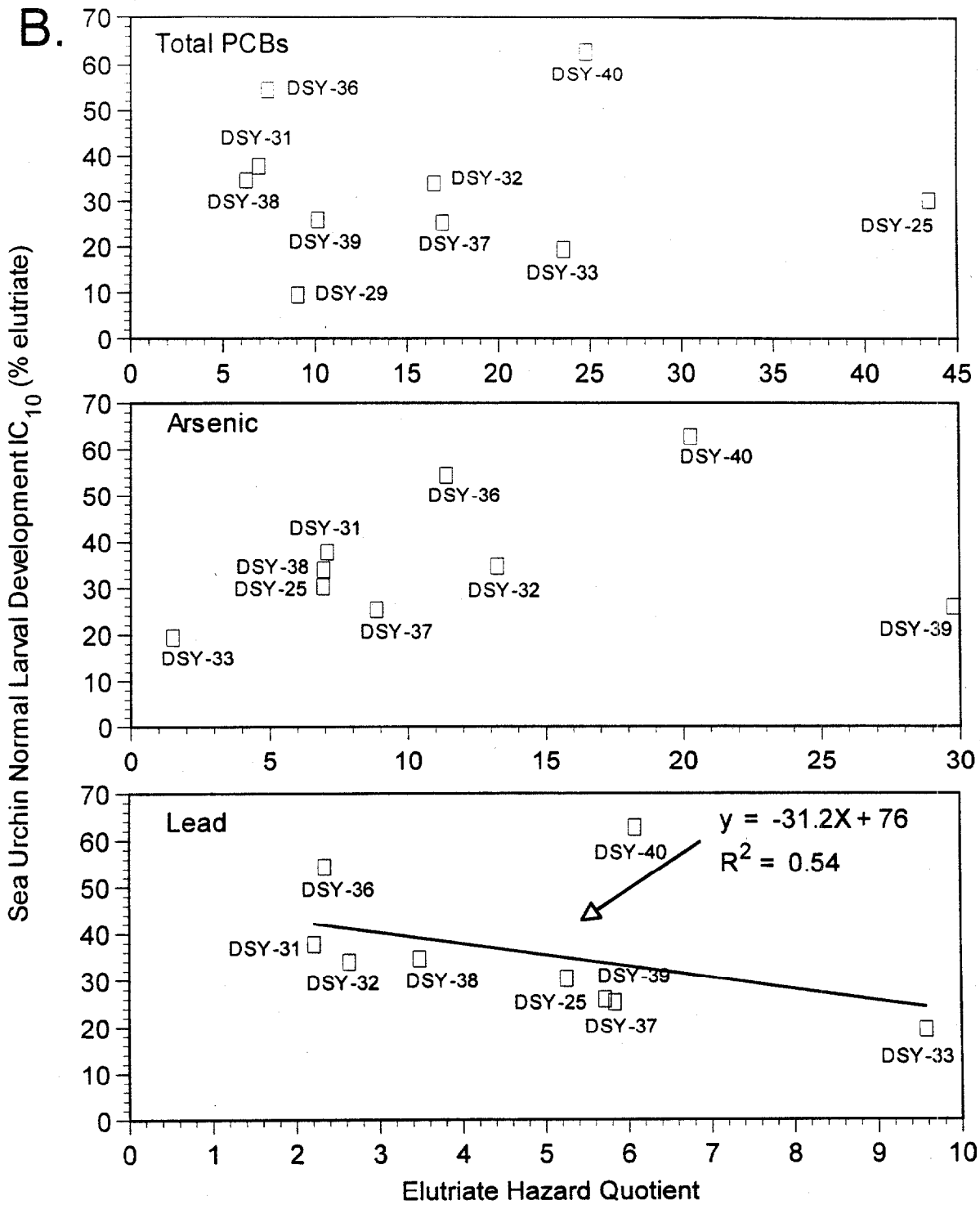


Figure 6.4-3 (continued). Elutriate IC_{10} versus elutriate Hazard Quotients for CoCs (elutriate concentration/water criterion) prepared from surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area. Criteria = EPA chronic water quality criteria. Dashed line indicates threshold for adverse effects. A) Measured concentrations of Total PCBs, arsenic, and lead; and B) measured concentrations of Total PCBs, arsenic, and lead, normalized to TOC.

Figure 6.5-1. Benthic Community Structure metrics for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH= Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TOTSPP=total species; TOTIND=total individuals; DOMTAX=percent dominant taxa; SPPRCH=Margalef species richness; SW_DIV=Shannon-Weiner diversity; SPPEVN=Pielou's eveness; BC_SIM=Bray-Curtis similarity index; SCORE=overall risk ranking score. * indicates statistically significant relationship.

A. Benthic Community Structure Metrics vs. CoC Concentrations.

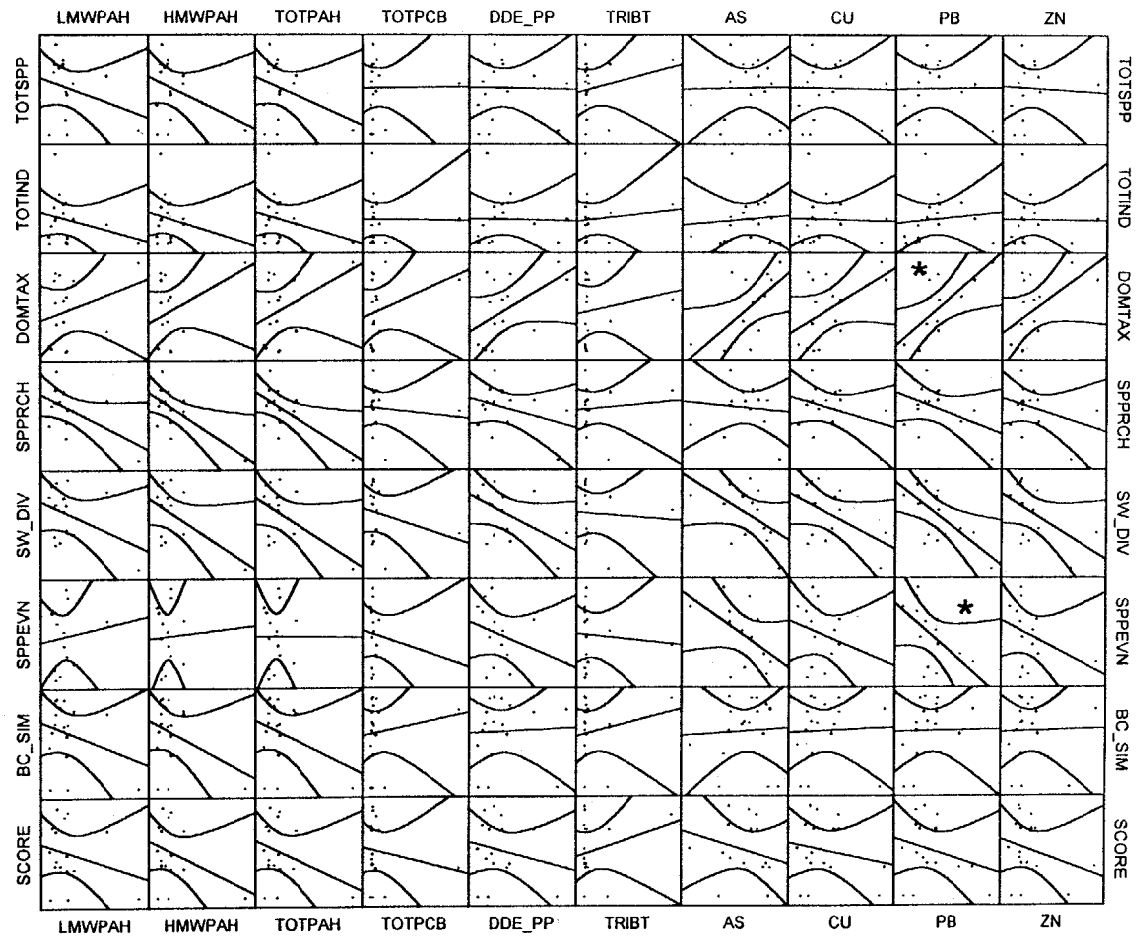
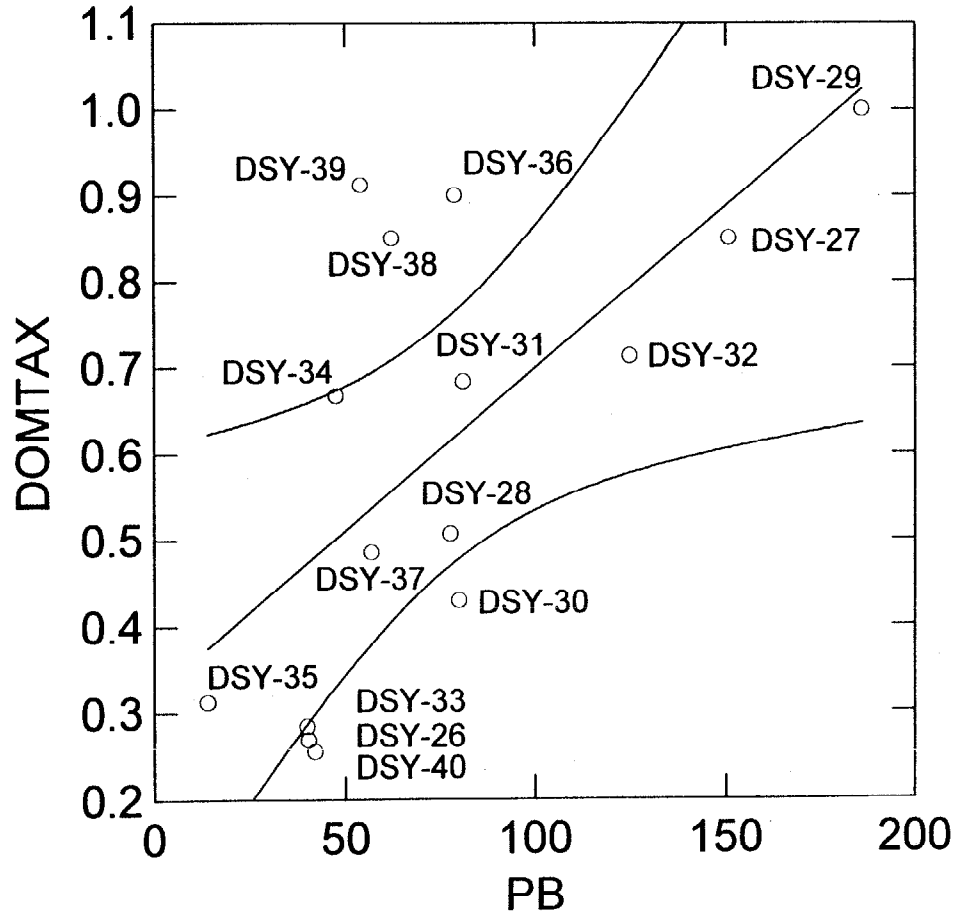


Figure 6.5-1 (continued). Benthic Community Structure metrics for the Derecktor Shipyard/Coddington Cove study area a Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH= Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TOTSPP=total species; TOTIND=total individuals; DOMTAX=percent dominant taxa; SPPRCH=Margalef species richness; SW_DIV=Shannon-Weiner diversity; SPPEVN=Pielou's eveness; BC_SIM=Bray-Curtis similarity index; SCORE=overall risk ranking score.

B. Percent Dominant Taxa versus Pb concentration in sediments.



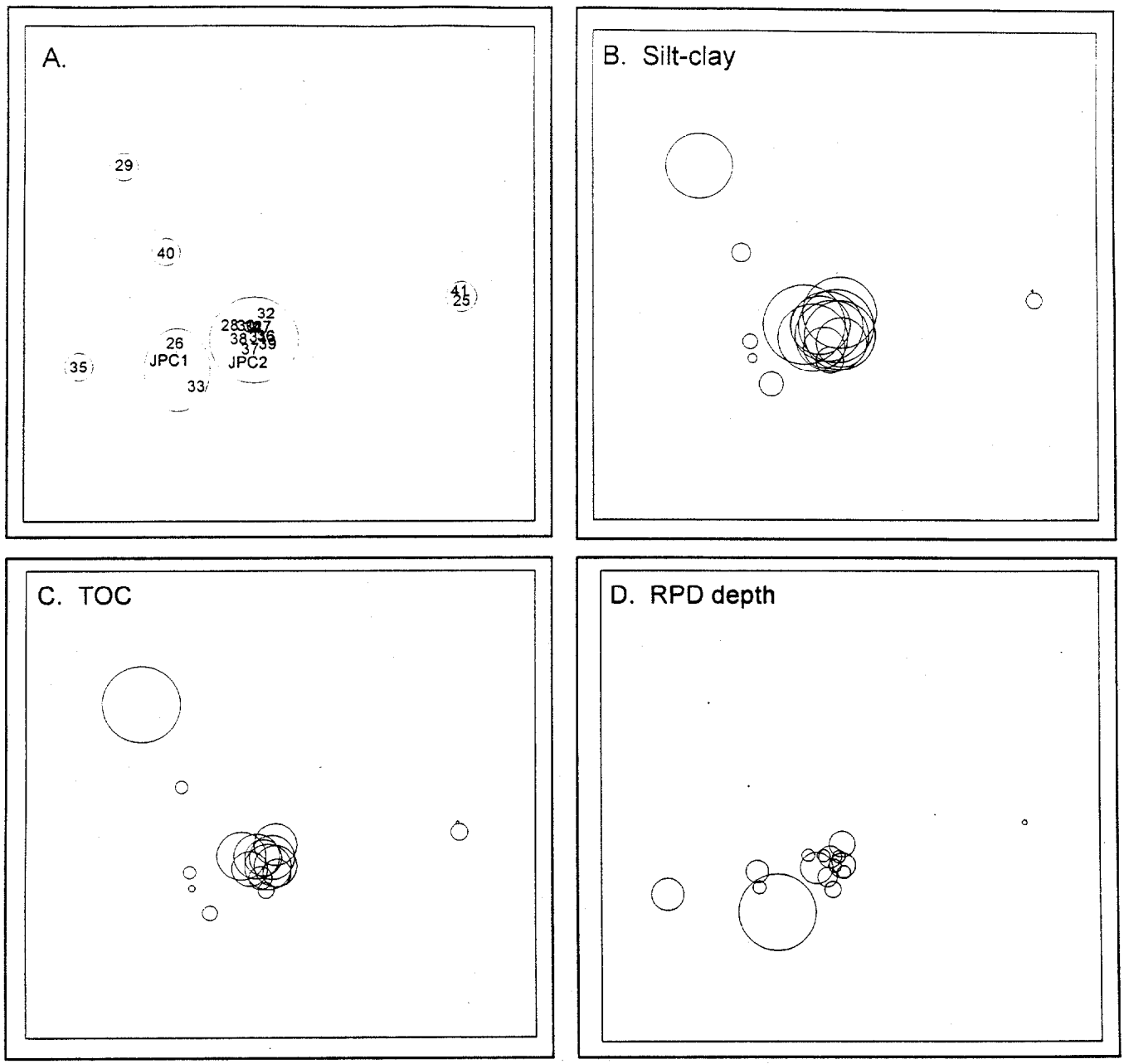


Figure 6.5-2. Two-dimensional Multidimensional Scaling (MDS) plots depicting the association between benthic community structure and measured environmental variables for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference locations.
A) Plot of Bray-Curtis similarities from double square root transformed species abundance data at nineteen benthic community sampling stations, with cluster analysis results superimposed (Note: same as Figure 5.3-2A). B) Same MDS plot with superimposed circles of increasing size representing increasing proportions of silt-clay in the sediment. C) Same MDS plot with superimposed circles of increasing size representing increasing sediment TOC concentrations. D) Same MDS plot with superimposed circles of increasing size representing increasing depth of the oxygenated layer (Redox-Potential Discontinuity or RPD) in the sediment.

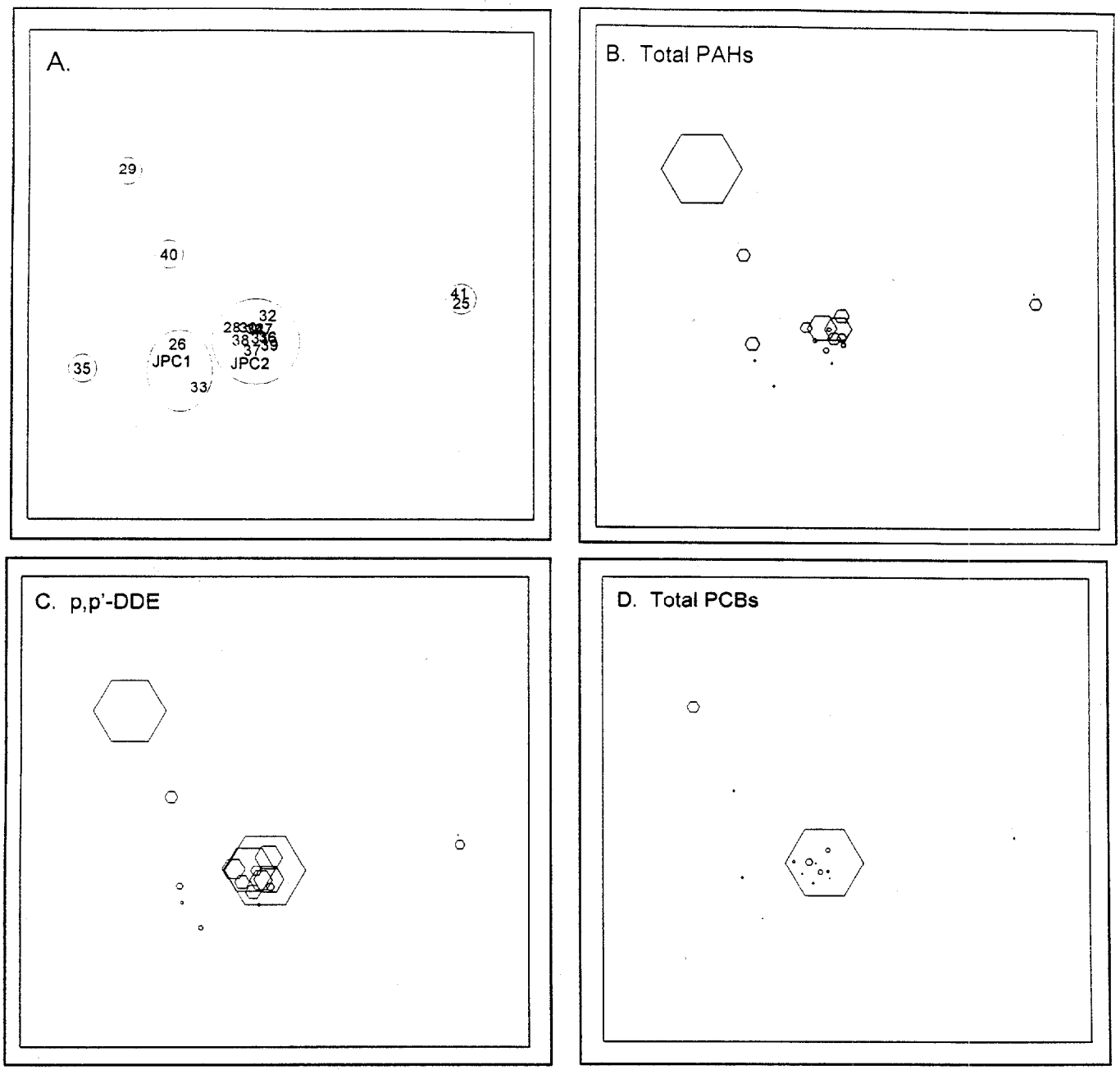


Figure 6.5-3. Two-dimensional Multidimensional Scaling (MDS) plots depicting the association between benthic community structure and measured environmental variables for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference locations.
A) Plot of Bray-Curtis similarities from double square root transformed species abundance data at nineteen benthic community sampling stations, with cluster analysis results superimposed (Note: same as Figure 5.3-2A). B) Same MDS plot with superimposed hexagons of increasing size representing increasing sediment concentration of Total PAHs. C) Same MDS plot with superimposed hexagons of increasing size representing increasing sediment concentration of p,p'-DDE. D) Same MDS plot with superimposed hexagons of increasing size representing increasing sediment concentration of Total PCBs.

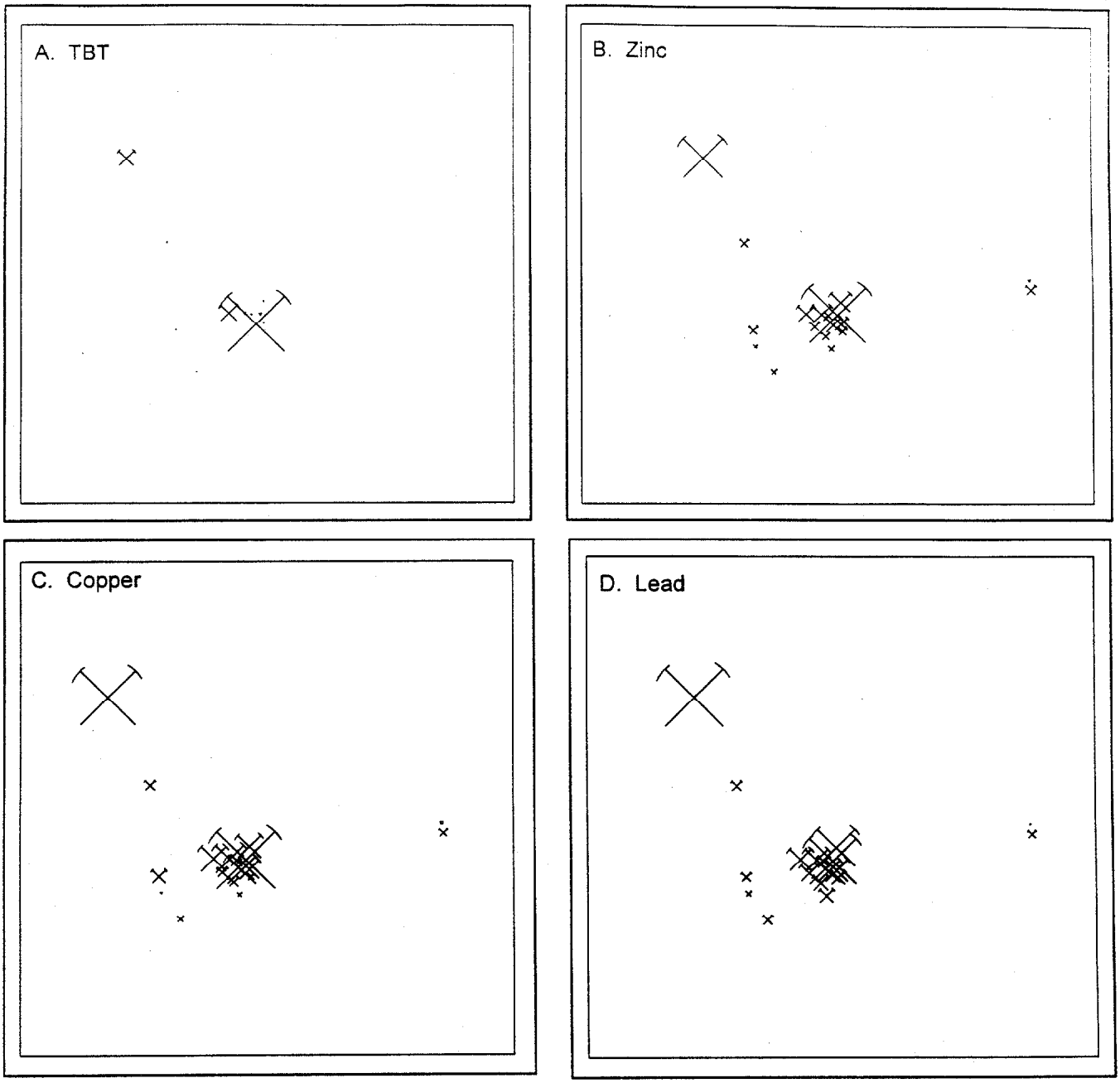


Figure 6.5-4. Two-dimensional Multidimensional Scaling (MDS) plots depicting the association between benthic community structure and measured environmental variables for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove reference locations. A) Same MDS plot as Figure 6.5-2.A with superimposed pick-ax symbols of increasing size representing increasing sediment concentration of TBT. B) Same MDS plot with superimposed pick-ax symbols of increasing size representing increasing sediment concentration of zinc. C) Same MDS plot with superimposed pick-ax symbols of increasing size representing increasing sediment concentration of copper. D) Same MDS plot with superimposed pick-ax symbols of increasing size representing increasing sediment concentration of lead.

Figure 6.5-5. Condition Indices (CI) for indigenous mussels from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH=Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TISSWT=tissue weight; SHELLWT=shell weight; LENGTH=shell length; TISDRYLE=tissue dry weight to shell length ratio; TISDRYSH=tissue dry weight to shell weight ratio; SHELLWT= shell weight to length ratio.

A. CI vs. Indigenous Blue Mussel Tissue Residues.

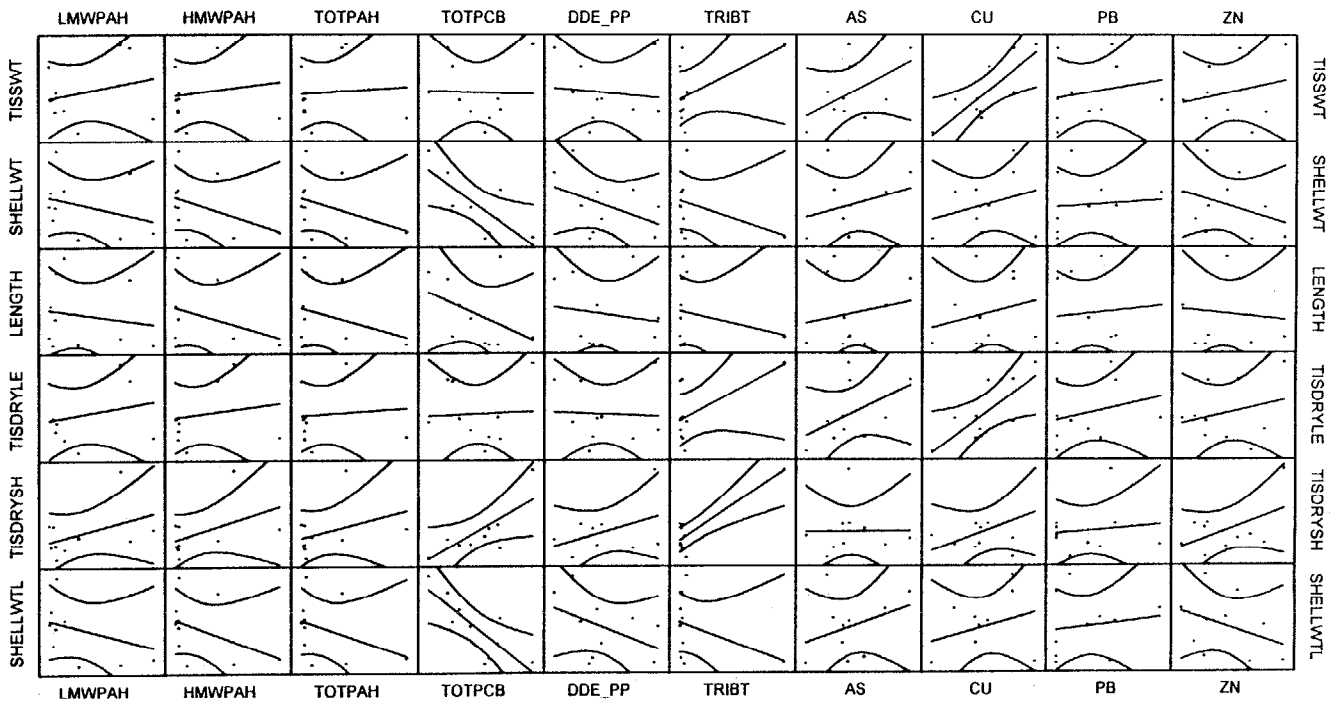


Figure 6.5-5 (continued). Condition Indices (CI) for indigenous mussels from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH=Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TISSWT=tissue weight; SHELLWT=shell weight; LENGTH=shell length; TISDRYLE=tissue dry weight to shell length ratio; TISDRYSH=tissue dry weight to shell weight ratio; SHELLWT= shell weight to length ratio.

B. CI vs. Sediment Concentrations.

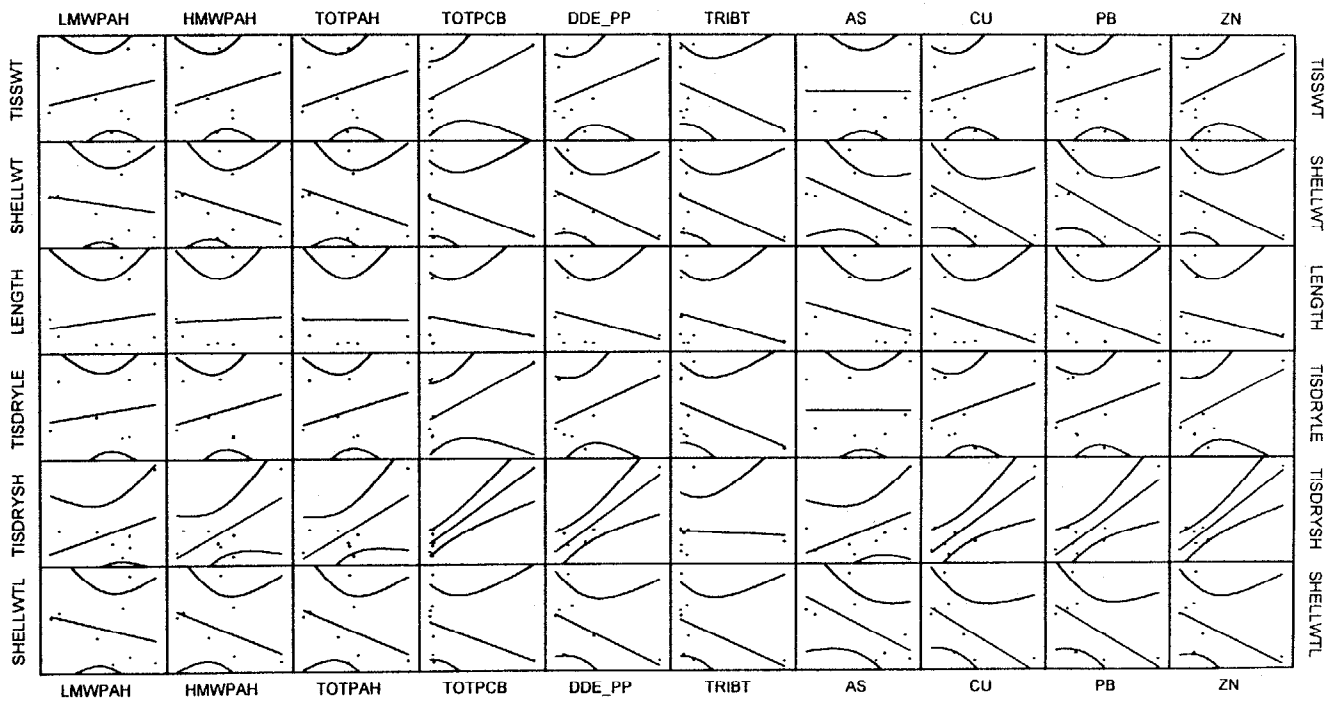


Figure 6.5-5 (continued). Condition Indices (CI) for indigenous blue mussels from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits.

C. Condition Index of Shell Weight\Shell Length vs. Total PCBs in tissue residues of indigenous blue mussels.

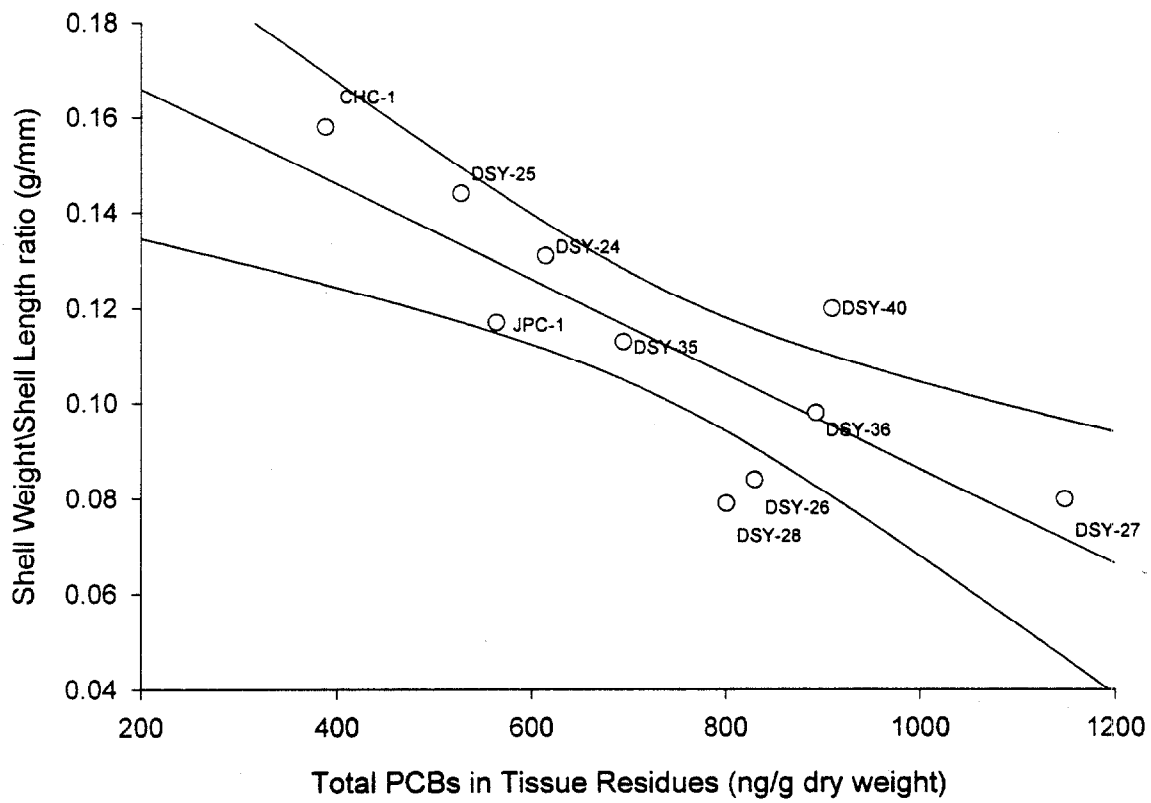


Figure 6.5-6. Condition Indices (CI) for blue mussels deployed in the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH=Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TISSWT=tissue weight; SHELLWT=shell weight; LENGTH=shell length; TISDRYLE=tissue dry weight to shell length ratio; TISDRYSH=tissue dry weight to shell weight ratio; SHELLWT= shell weight to length ratio.

A. CI vs. Deployed Blue Mussel Tissue Residues.

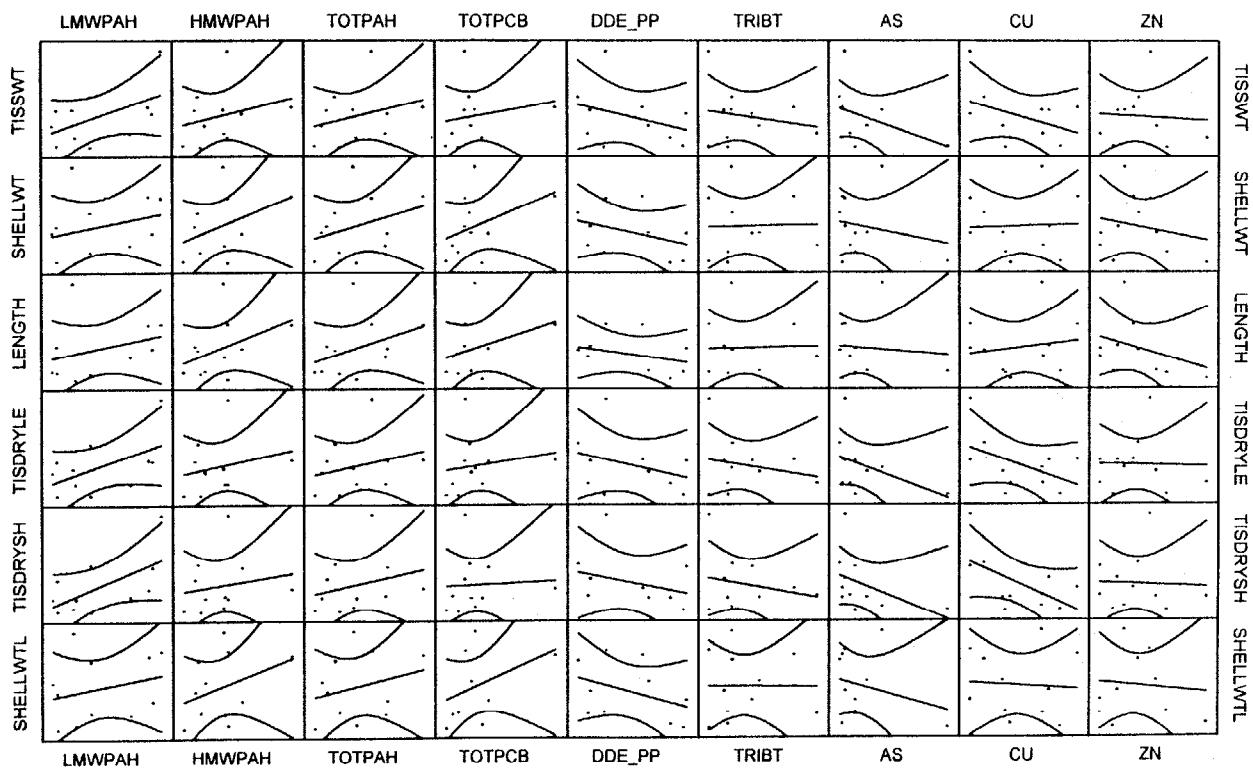


Figure 6.5-6 (continued). Condition Indices (CI) for blue mussels deployed in the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH=Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TISSWT=tissue weight; SHELLWT=shell weight; LENGTH=shell length; TISDRYLE=tissue dry weight to shell length ratio; TISDRYSH=tissue dry weight to shell weight ratio; SHELLWT= shell weight to length ratio.

B. CI vs. Sediment Concentrations.

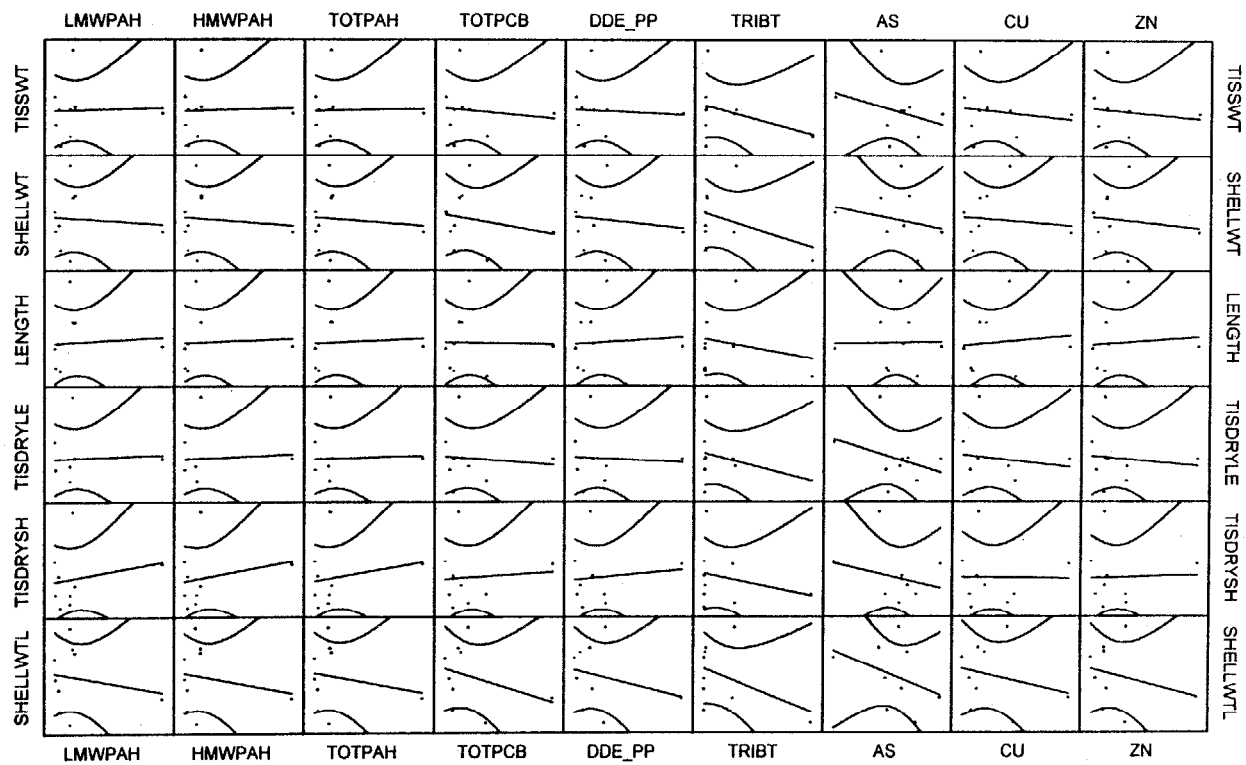


Figure 6.5-6 (continued). Condition Indices (CI) for blue mussels deployed in the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations. Lines indicate regression fit ± 95% confidence limits. LMWPAH=Low Molecular Weight PAHs; HMWPAH=High Molecular Weight PAHs; TOTPAH=Total PAHs; TOTPCB=Total PCBs; DDE_PP=p,p'-DDE; TRIBT=tributyltin; AS=arsenic; CU=copper; PB=lead; ZN=zinc; TISSWT=tissue weight; SHELLWT=shell weight; LENGTH=shell length; TISDRYLE=tissue dry weight to shell length ratio; TISDRYSH=tissue dry weight to shell weight ratio; SHELLWT= shell weight to length ratio.

C. CI vs. Sediment Elutriate Concentrations.

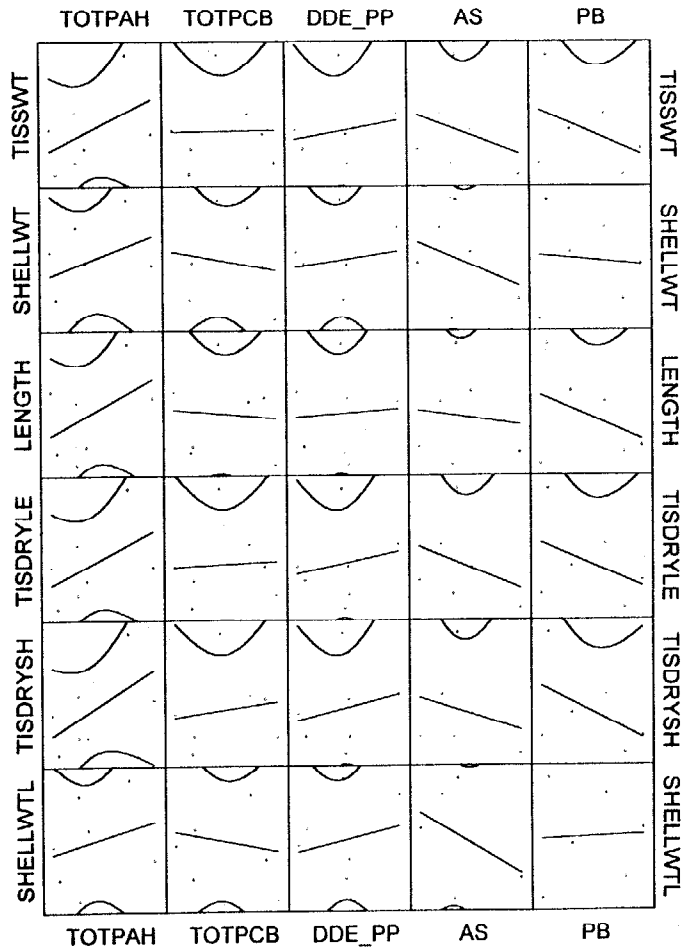


Figure 6.5-6 (continued). Condition Indices (CI) for blue mussels deployed in the Derecktor Shipyard/Coddington Cove study area and the Jamestown Potter Cove and Castle Hill Cove reference locations. Elutriates prepared from sediments collected in the Derecktor Shipyard/Coddington Cove study area and the Jamestown Potter Cove reference station JPC-1.

D. Condition Index of Length vs. Pb in Elutriates for deployed mussels.

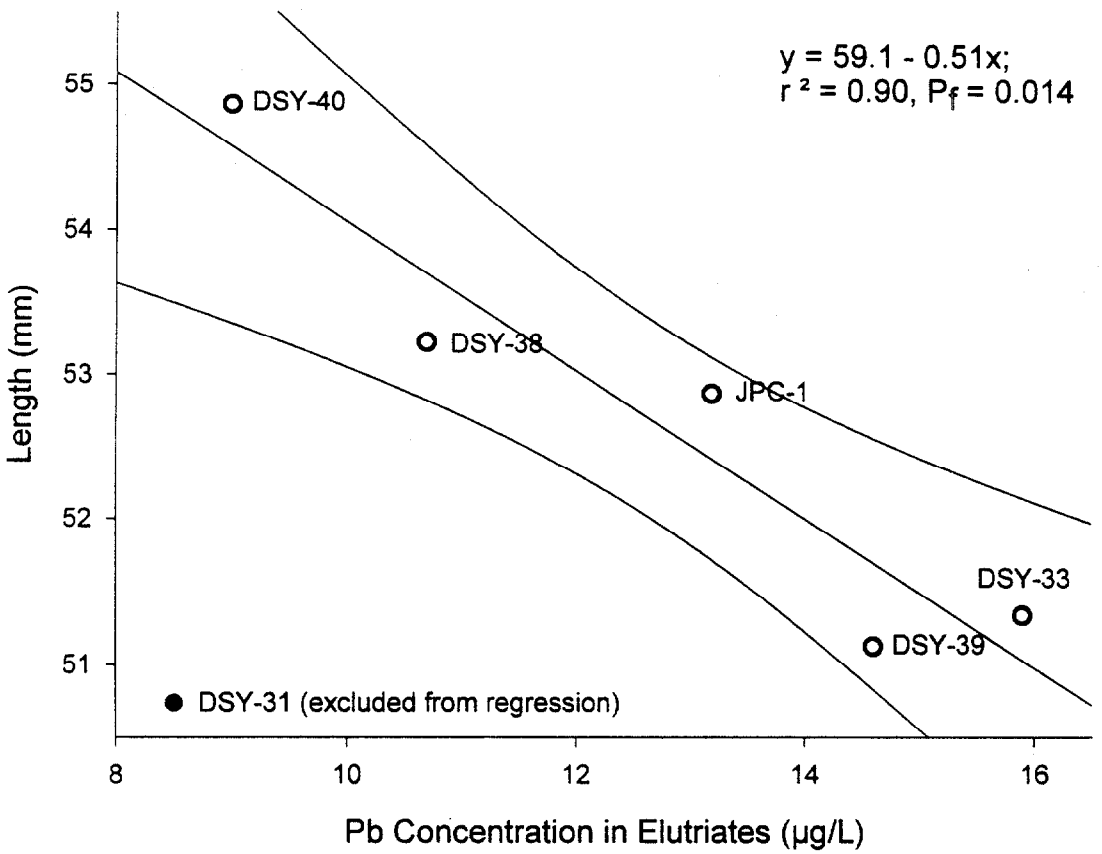


Figure 6.5-7. Incidence of hematopoietic neoplasia (Hn) occurring in blue mussels indigenous to Derecktor Shipyard/Coddington Cove study area vs. CoC concentrations. A) Hn vs. indigenous blue mussels CoC tissue residues, B) Hn vs. CoC sediment concentrations, and C) the condition index (CI) parameter of affliction rate (%) vs. low molecular weight PAH tissue concentration (ng/g dry tissue). Lines indicate regression fit ± 95% confidence limits. Codes: LMWPAH=low molecular weight PAH; HMWPAH=high molecular weight PAH; TOTPAH= Total PAHs; TOTPCB=Total PCBs; DDEPP=p,p'-DDE; TRIBT=tributyltin; AFFLICT=% of animals observed with Hn; SEVERITY=% number of cells with Hn per affected animal.

A. Hn vs. Indigenous Blue Mussels CoC Tissue Residues

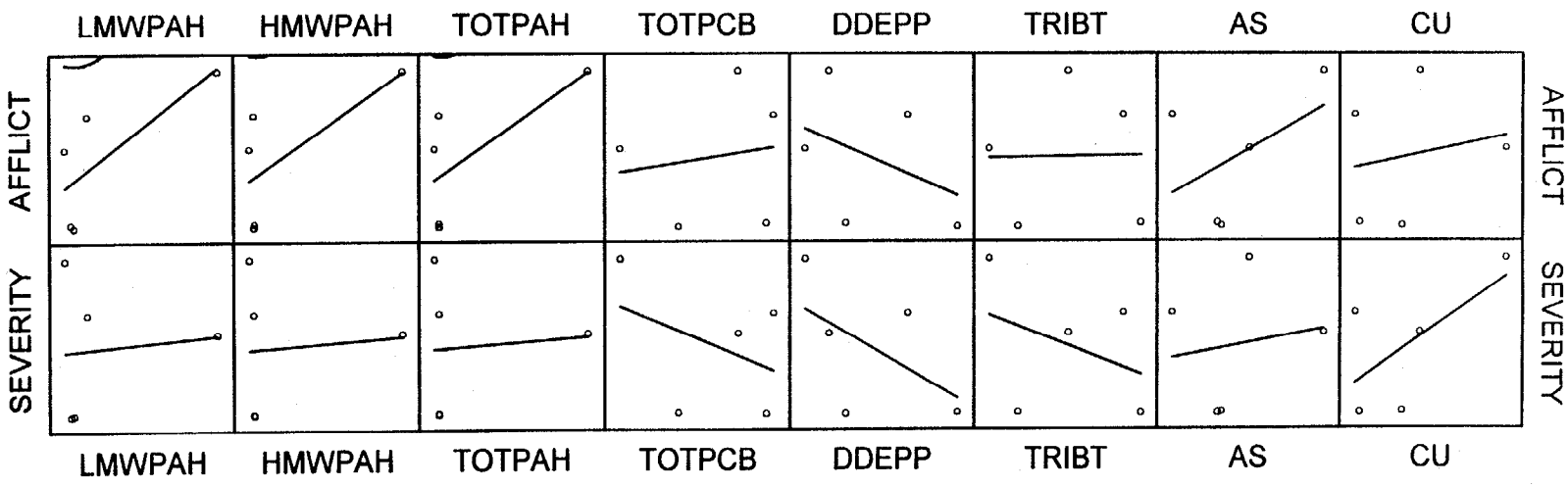


Figure 6.5-7 (continued). Incidence of hematopoietic neoplasia (Hn) occurring in blue mussels indigenous to Derecktor Shipyard/Coddington Cove study area vs. CoC concentrations. A) Hn vs. indigenous blue mussels CoC tissue residues, B) Hn vs. CoC sediment concentrations, and C) the condition index (CI) parameter of affliction rate (%) vs. low molecular weight PAH tissue concentration (ng/g dry tissue). Lines indicate regression fit ± 95% confidence limits. Codes: LMWPAH=low molecular weight PAH; HMWPAH=high molecular weight PAH; TOTPAH= Total PAHs; TOTPCB=Total PCBs; DDEPP=p,p'-DDE; TRIBT=tributyltin; AFFLICT=% of animals observed with Hn; SEVERITY=% number of cells with Hn per affected animal.

B. Hn vs. CoC Sediment Concentrations

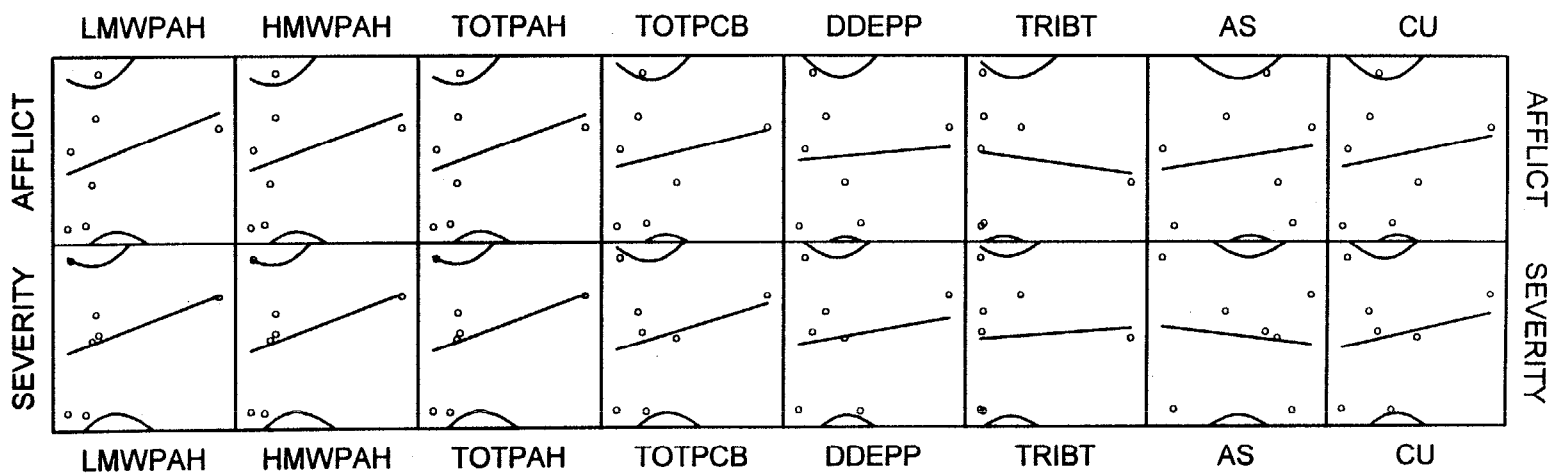
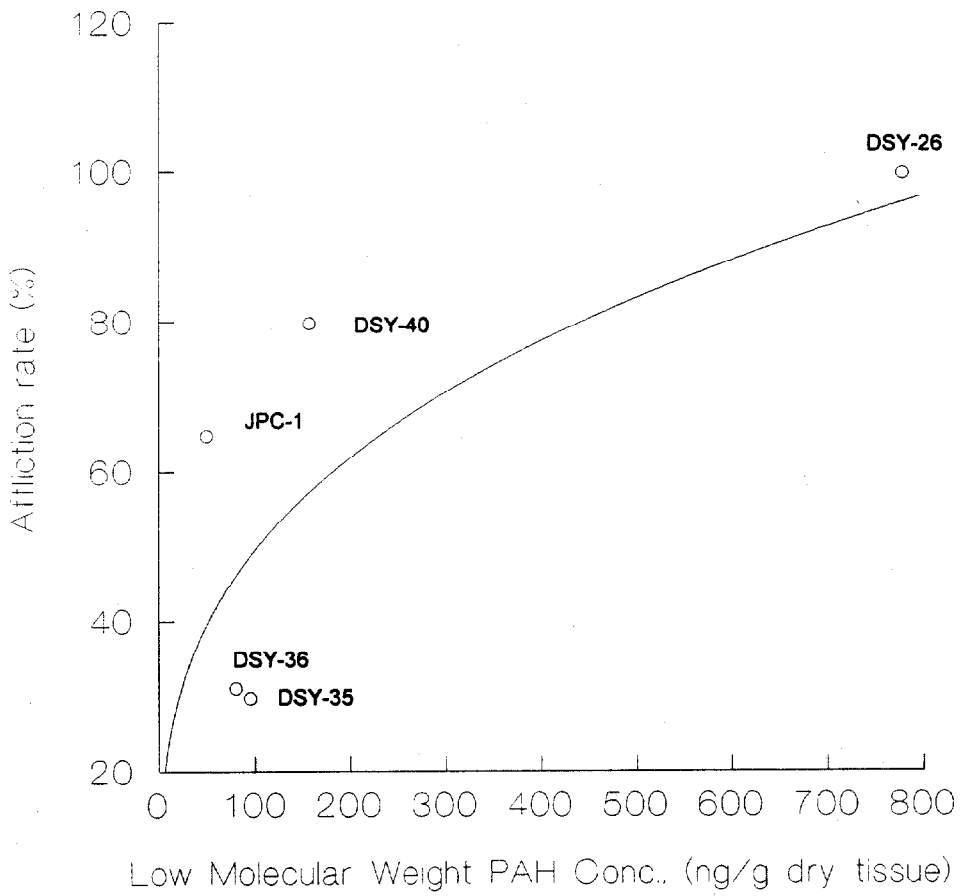


Figure 6.5-7 (continued). Incidence of hematopoietic neoplasia (Hn) occurring in blue mussels indigenous to the Derecktor Shipyard/Coddington Cove (DSY) study area vs. CoC concentrations. A) Hn vs. indigenous blue mussel (CoC) tissue residues, B) Hn vs. CoC sediment concentrations, and C) the condition index (CI) parameter of affliction rate (%) vs. low molecular weight PAH tissue concentration (ng/g dry tissue). Lines indicate regression fit ± 95% confidence limits.

C. Affliction Rate (% affected population) vs. Low Molecular Weight PAH Tissue Concentration.



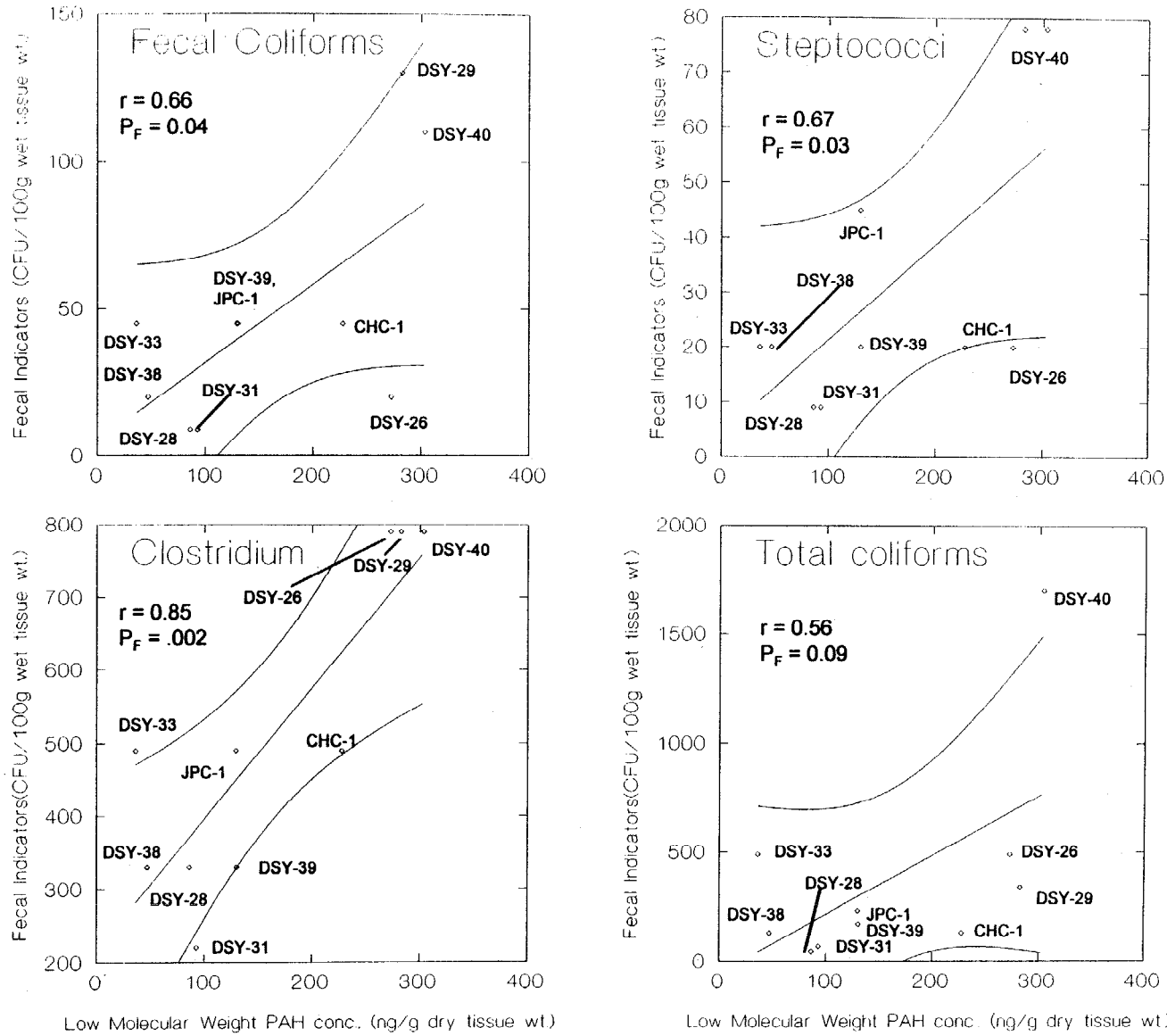


Figure 6.5-8. Fecal pollution indicators vs. Low Molecular Weight PAHs in blue mussels deployed in the Derecktor Shipyard/Coddington Cove study area and the Jamestown Potter Cove and Castel Hill Cove reference locations. CFU = colony forming units.

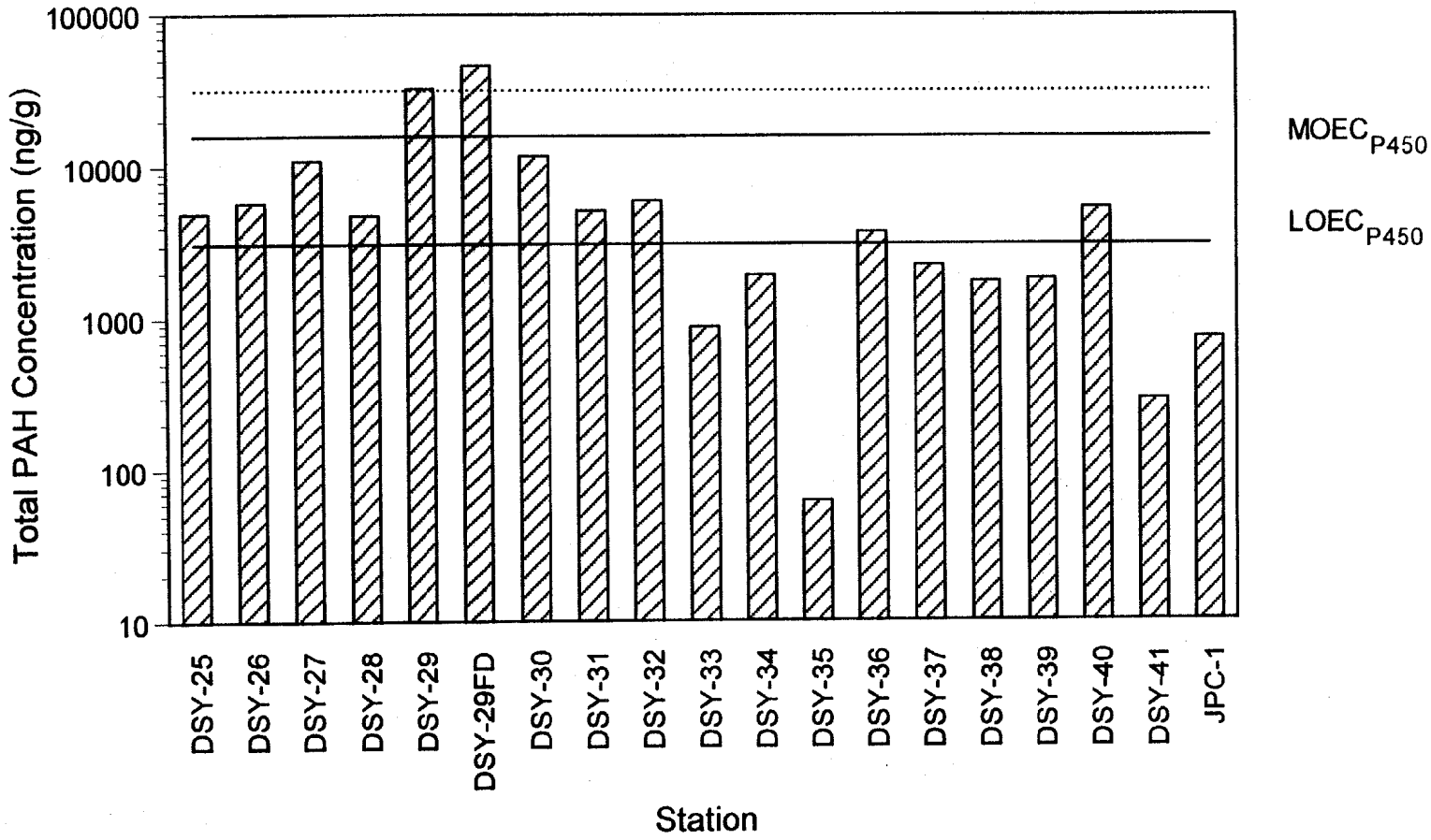


Figure 6.5-9. Concentration of Total PAHs (ng/g) in surface sediments collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove reference station (JPC-1) versus the cytochrome P450 activity benchmarks (Van Veld *et al.*, 1990). Horizontal solid lines indicate threshold values for lower ($LOEC_{P450}$) and upper ($MOEC_{P450}$) benchmarks; dashed line indicates 2X upper benchmark.

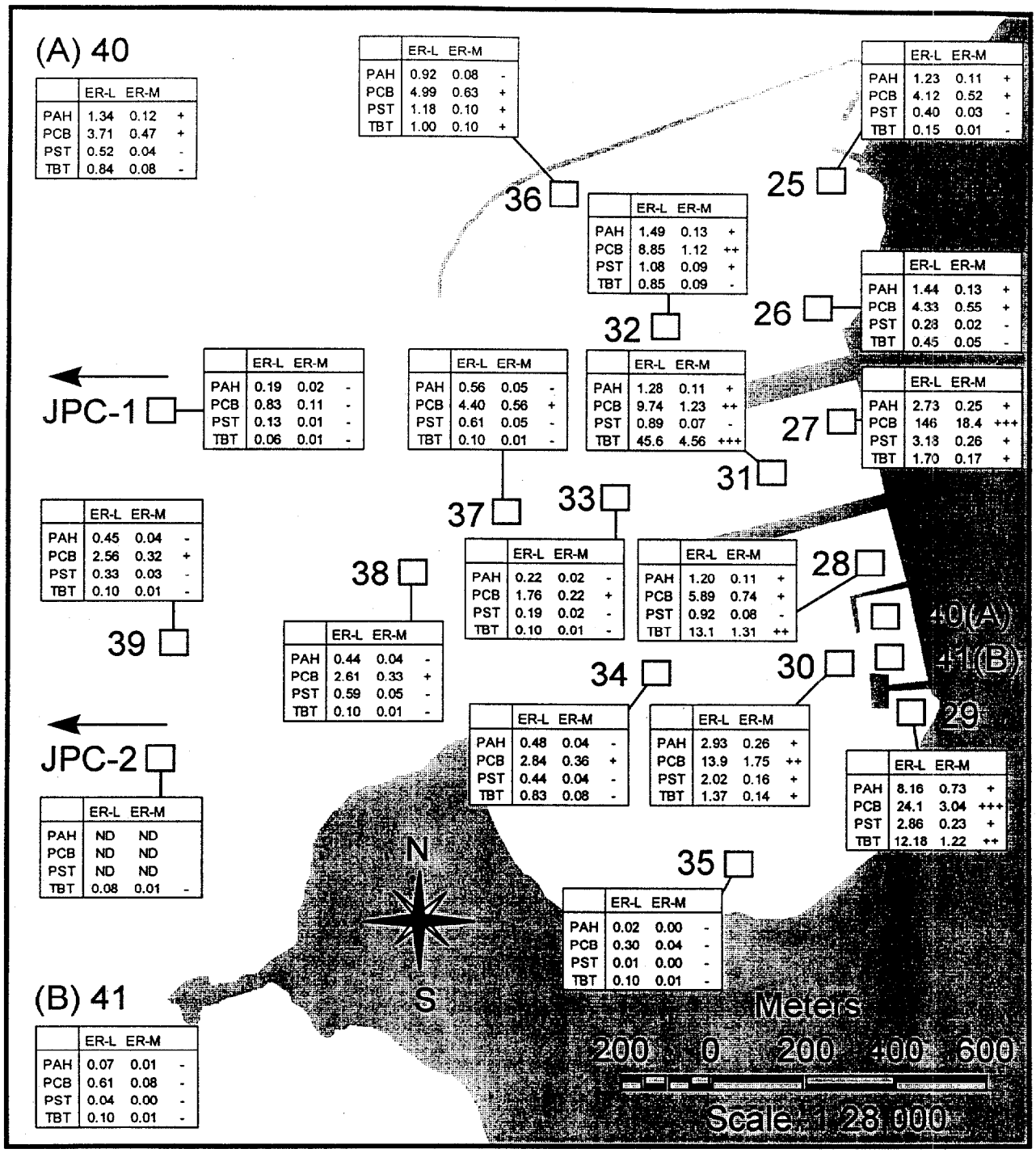


Figure 6.6-1A. Hazard Quotients (HQs) and risk rankings for organic contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. PAH=Total PAHs; PCB=Total PCBs; PST=p,p'-DDE; TBT=Tributyltin. ND=no data. Benchmarks for PCBs, PAHs, and PST from NOAA ER-L/ER-M benchmarks (Long *et al.*, 1995). TBT benchmark from Macauley *et al.*, 1994. Refer to Section 6.1 for discussion of the Sediment HQ weight of evidence and explanation of rankings.

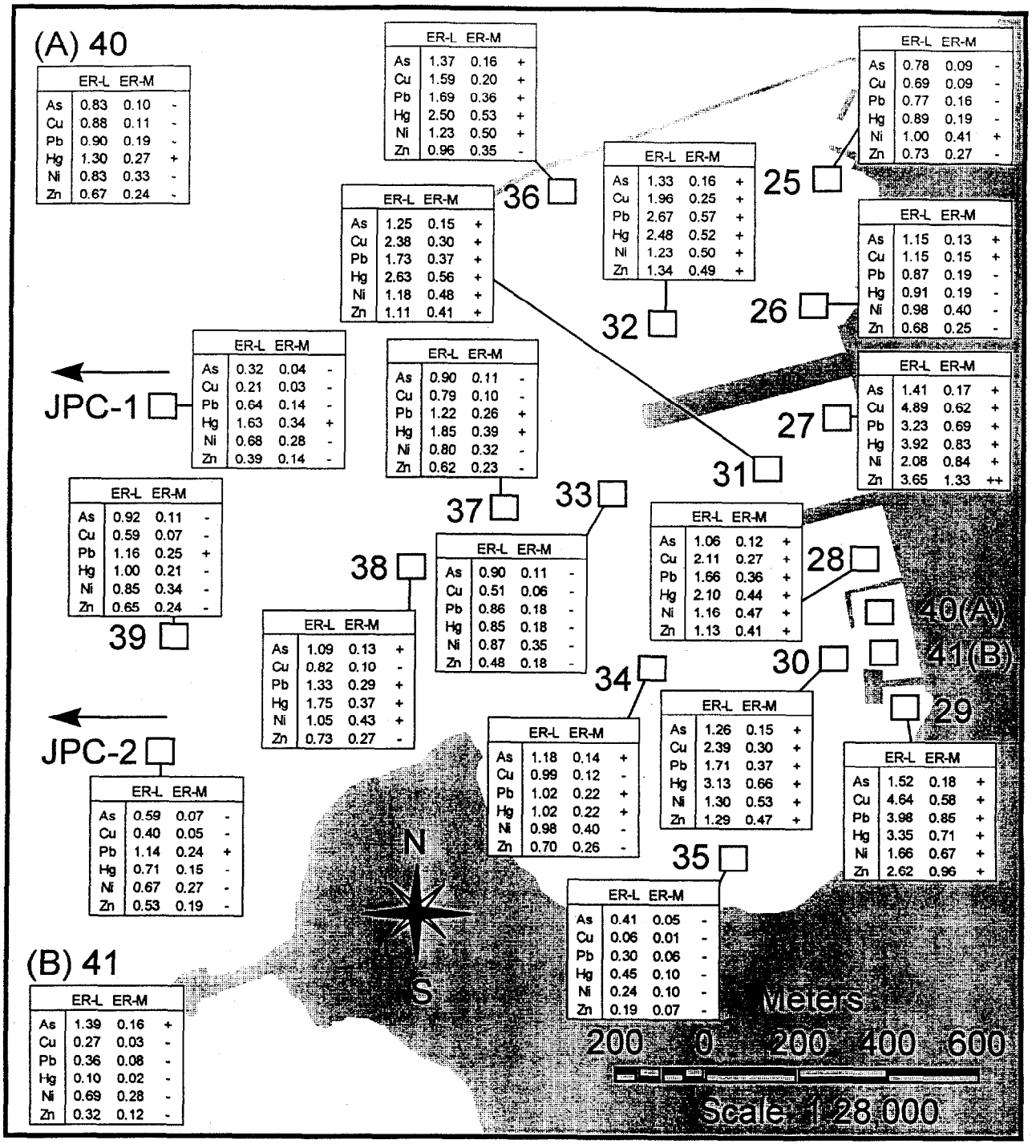


Figure 6.6-1B. Hazard Quotients (HQs) and risk rankings for metals contaminants in surface sediments (0-18 cm) from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. As=arsenic; Cu=copper; Pb=lead; Hg=mercury; Ni=nickel; Zn=zinc. Hazard Quotients based on ER-L and ER-M benchmarks (Long *et al.*, 1995). Refer to Section 6.1 for discussion of the Sediment HQ weight of evidence and explanation of rankings.

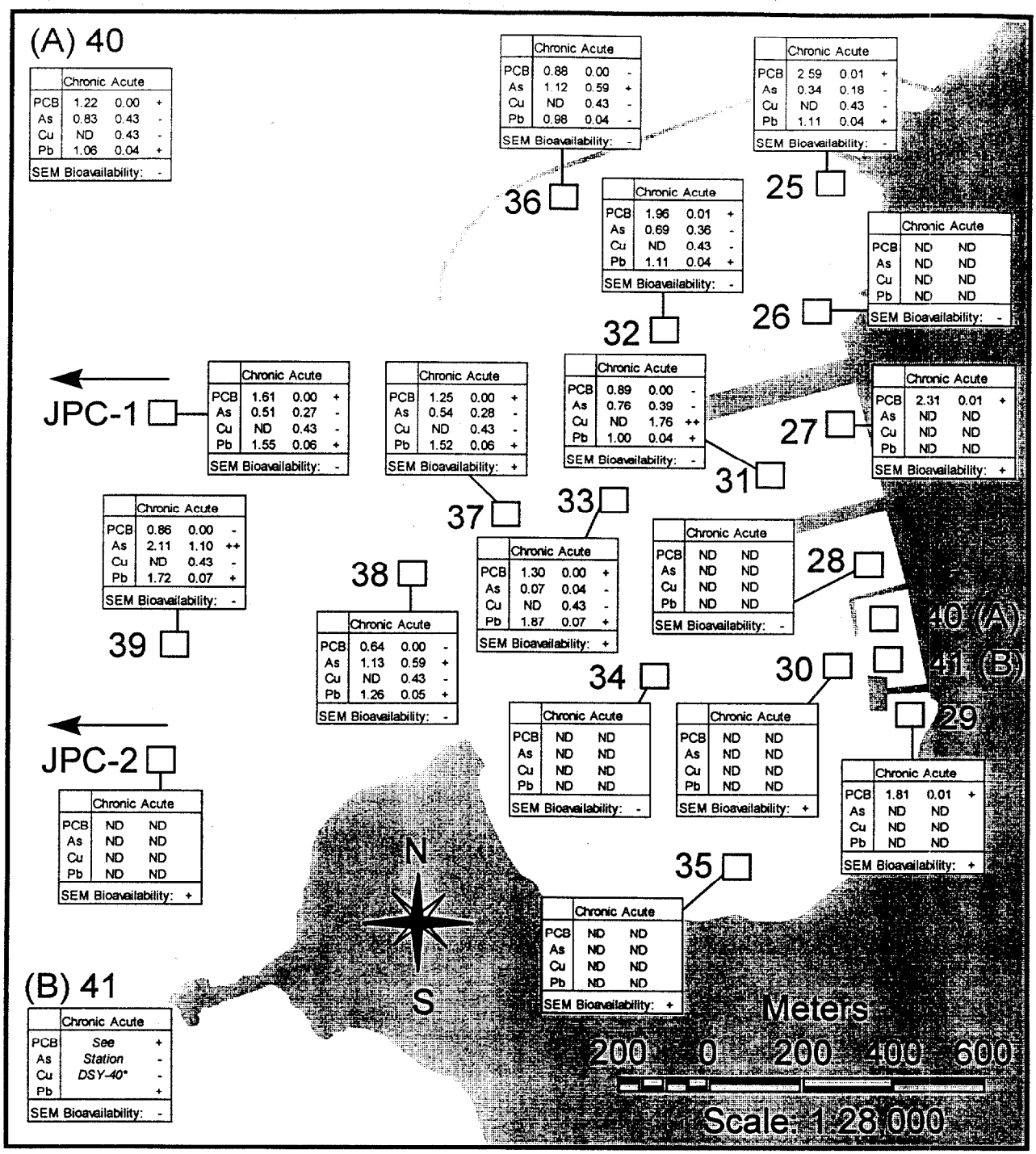


Figure 6.6-2. SEM Bioavailability and Hazard Quotients for elutriates prepared from sediments collected in the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) reference stations. Benchmarks for elutriates=EPA Water Quality Criteria- Saltwater Chronic and Saltwater Acute values. As=arsenic; Cu=copper; Pb=lead; PCB=Total PCBs. Refer to Section 6.1 for discussion of the sediment elutriate weight of evidence and explanation of rankings. Refer to Section 6.4 for discussion of the Simultaneously Extractable Metals (SEM) Bioavailability weight of evidence and explanation of rankings. *No data available for elutriate exposure at Station DSY-41; ranking assumed to be the same as for Station DSY-40 due to spatial proximity.

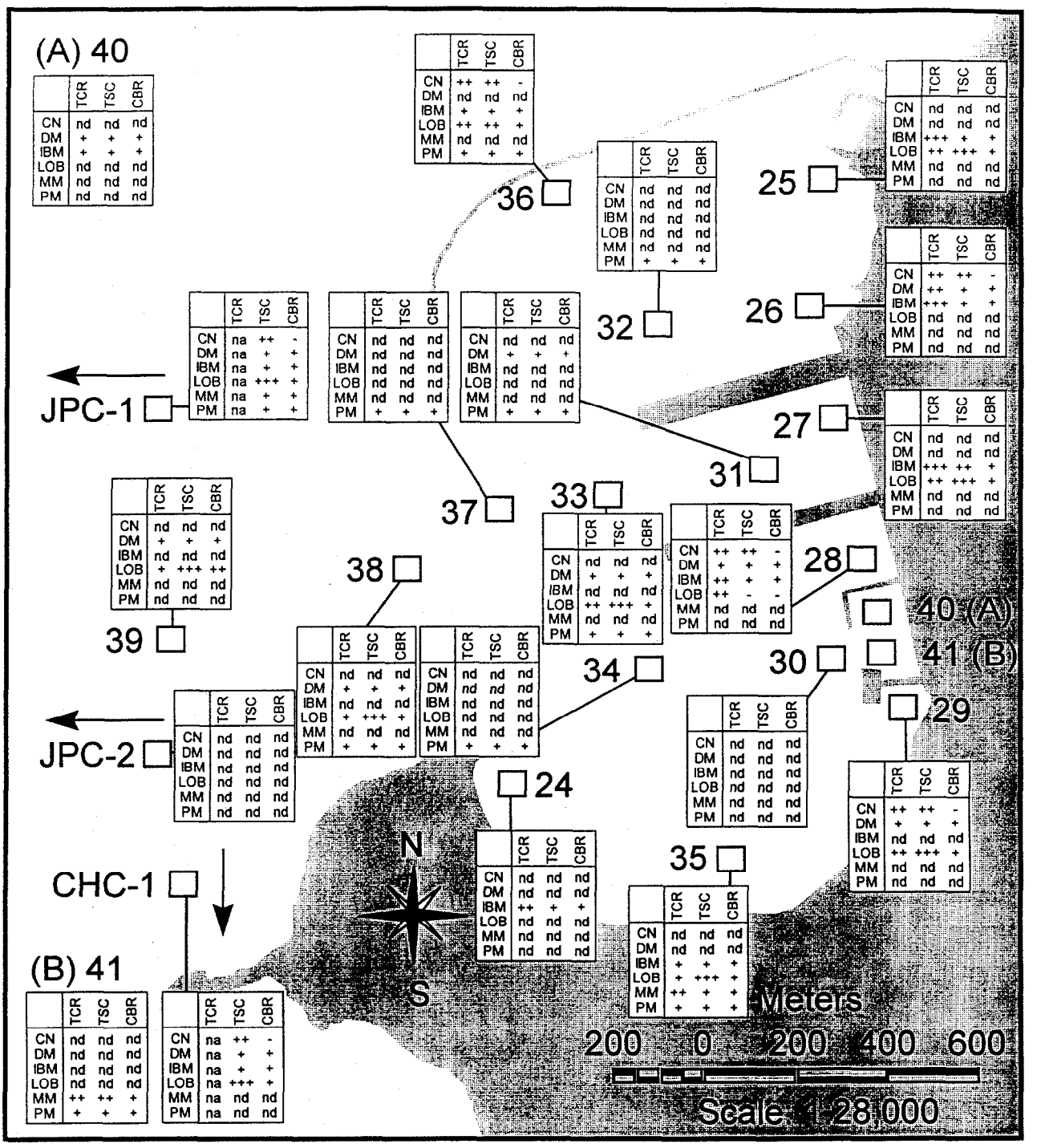


Figure 6.6-3. Tissue Concentration Ratios and Tissue Residue Effects Hazard Quotients (HQs) for target species collected from the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference stations. CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM= *Pitar morrhuana.* TCR=Tissue Concentration Ratio; TSC=Tissue Screening Concentration HQ; CBR=Critical Body Residue HQ. nd=no data; na=not applicable, values based on comparison to reference station values. Refer to Section 6.2 for discussion of Tissue Concentration Ratio and Tissue Residue Effects weights of evidence and explanation of rankings.

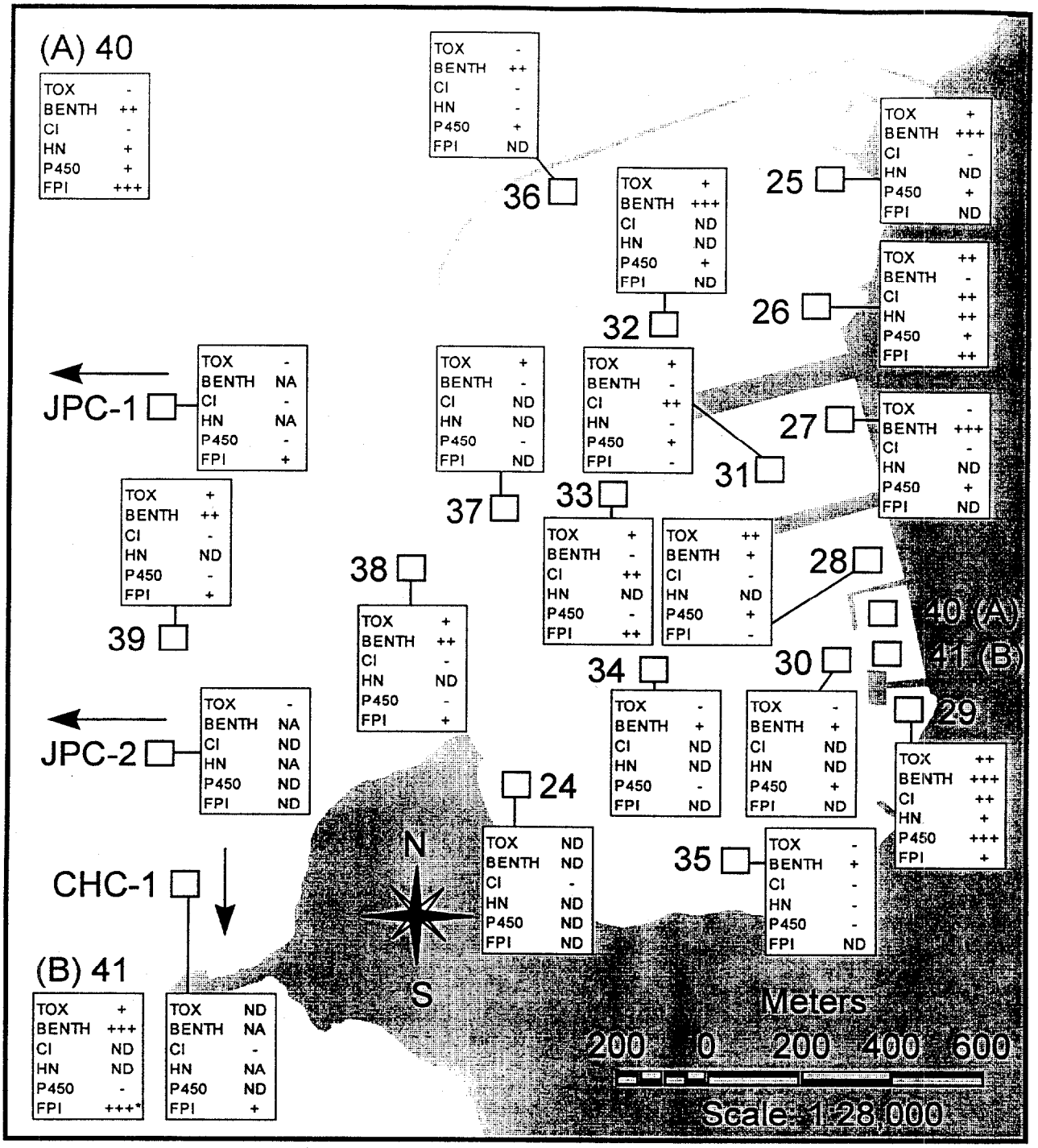


Figure 6.6-4. Field Effects Indicators and Overall Laboratory Toxicity results for the Derecktor Shipyard/Coddington Cove study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference stations. TOX=Overall Toxicity; BENTH=Benthic Community Structure; CI=Bivalve Condition Indices; HN=Hematopoietic Neoplasia; P450=Cytochrome P450; FPI=Fecal Pollution Indicators. ND=no data; NA=not applicable, values based on comparison to reference station values. Refer to Sections 5.2 and 6.4 for discussion of Laboratory Toxicity weight of evidence and explanation of risk rankings. Refer to Sections 5.3 and 6.5 for discussion of Field Effects weight of evidence and explanation of risk rankings. *No data available for fecal pollution indicator effects at Station DSY-41; ranking assumed to be the same as for Station DSY-40 due to spatial proximity.

TABLE 6.1-1. Results of Simultaneously Extractable Metal (SEM) and Acid Volatile Sulfide (AVS) measurements in sediments and qualitative evaluation of divalent metal bioavailability for the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) reference locations.

Station	AVS[1] (µMole/g dry)	SEM[1] (µMole/g dry)	SEM[1] FLAG[2]	SEM/AVS Ratio	SEM/AVS FLAG[2]	SEM-AVS (µMole/g dry)	SEM-AVS FLAG[2]	Risk Ranking[3]
DSY-25	24.6	2.88	-	0.12	-	-21.7	-	-
DSY-26	4.08	1.18	-	0.29	-	-2.89	-	-
DSY-27	176.4	12.1	+	0.07	-	-164.4	-	+
DSY-28	63.0	7.47	+	0.12	-	-55.5	-	+
DSY-29	183.2	7.57	+	0.04	-	-175.6	-	+
DSY-30	25.0	5.51	+	0.22	-	-19.5	-	+
DSY-31	50.1	2.79	-	0.06	-	-47.3	-	-
DSY-32	17.2	2.70	-	0.16	-	-14.5	-	-
DSY-33	0.79	1.86	-	2.36	+	1.07	-	+
DSY-34	29.5	1.43	-	0.05	-	-28.1	-	-
DSY-35	1.35	1.02	-	0.76	+	-0.32	-	+
DSY-36	36.9	1.44	-	0.04	-	-35.5	-	-
DSY-37	2.39	2.77	-	1.16	+	0.38	-	+
DSY-38	29.8	1.91	-	0.06	-	-27.9	-	-
DSY-39	21.7	2.43	-	0.11	-	-19.2	-	-
DSY-40	18.8	2.16	-	0.12	-	-16.6	-	-
DSY-41	4.52	1.31	-	0.29	-	-3.21	-	-
JPC-1	1.92	0.73	-	0.38	-	-1.19	-	-
JPC-2	0.75	0.89	-	1.19	+	0.14	-	+

1 - Mean of two replicates per station.
2 - SEM Codes: SEM Conc. > 5 µmol/g = "+"; SEM/AVS > 0.5 = "+" ; SEM-AVS > 5 µmol/g = "+".
3 - Overall Risk Ranking: "-" = no exposure, "+" = exposure seen in one indicator,
"++" = exposure seen in two indicators, "+++" = exposure in all indicators.

Table 6.2-1a. Tissue Concentration Ratio (TCR) Rankings for Target Receptors for the Derecktor Shipyard Marine ERA by Station[1].

Station	Species[2]	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	HMW PAHs	LMW PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[3]
DSY-24	IBM			-	-	-	-	-		-	-	-	-		-	-	-	+	+	-	+	++	+	-	+	+	+		-	++
DSY-25	IBM			++	+++	++	++	++		+++	+	+++	++		++	++	++	+	-	-	+	+	+	+		-	-		+	+++
	LOB									++		++	-			++	+	+	-		+	+	+	+	-	-	+	+	-	++
DSY-26	CN		++				++			++	+	++	-		++	+	-	+	+	-	+	-	+	-	-	-		-	+	++
	DM		+	+	+	+		+		++		++	+		+	++	+	++	+	+	-	+	-	+	-	+	-		+	++
	IBM			++	+++	+++	+++	+++		+++	+	+++	++		++	+++	+++	+	+	-	+	+	+	-		-			-	+++
DSY-27	IBM			+	++	++	+	++		+++	+	++	++		++	+++	++	+	+	++	+	+	+	+	+	-	+		+	+++
	LOB				+					++		++	+		+	++	++	+	+		-	+	+	+	-	+	-	+	+	++
DSY-28	CN	-	++	-			-			++	+	++	-		+	+	+	++	+	+	+	+	-	-		-		-	+	++
	DM				-	+		+		+		+	-		+	+	-	+		-	+	+	+	+		-	+		+	+
	IBM			+	++	+	+	+		++	+	+	+		++	+	+	+	+	-	-	+	+	-		-			+	++
	LOB				-					++		++	+		+	++	++	+	+											++
DSY-29	CN	-	++				++			++	+	++	+		++	+	-	++	++	+	+	+	-	+	+	-			+	++
	DM		+	-	+	+		+		+		+	+		+	+	+	+	+	-	+	+	-	-	-	+	-		-	+
	LOB									++	+	++	+		+	++	+	-	+		+	+	+	-	-	+	+	+	+	++
DSY-31	DM				+	+		+		+		+	-		+	+	+	+	+	-	-	-	-	-	-	-	-		+	+
	PM				+	+	+	+		+		+	-		-	+	+	+	-	-	-	+	-	+	-	+			-	+
DSY-32	PM			+	+	-	+	-		+		+	-		-	+	+	-	-		-	-	-	-	+	+			-	+
DSY-33	DM									+		-	-			+	-	+	+	-	+	+	+	-	-	-	-		+	+
	LOB									+		+	+		+	++	+	+	+		+	-	+	-	+	-	+	+	-	++
	PM				-	-	-	-		-	-	-	-		-	-	-	-	-	-	-	+	-	-		+			-	+
DSY-34	PM				-	-	-	-		-	-	-	-		+	-	-	-	-	-	-	+	-	-	-	+			-	+
DSY-35	IBM				+	-		+		+	-	+	+		+	+	+	+	+	-	+	+	+	-	-	-			+	+
	LOB				-					+		+	-		-	+	-	-	-		-	+	+	+	+	+	-	+	-	+
	MM					+	+	-		+	+	+	+		++	+	+	+	-	++	-	-	+	-		-	+		-	++
	PM				-	-	-	-		+	-	-	-		+	-	-	-	-		-	+	-	-	-	-			+	+
DSY-36	CN									++	+	+	-		+	+	-	++	++	-	+	+	-	-	+	-			+	++
	IBM			-	+	-	-	+		+	-	+	-		+	+	-	+	+	-	+	-	+	-		+	+		-	+
	LOB				+					++		++	-		+	++	+	+	-		-		+	-	+	+	-	-	+	++
	PM				+	-	+	+		+		+	-		+	+	+	-	-	-	-	+	+	-	-	+			+	+
DSY-37	PM				+	+	+	+		+		+	+		+	+	+	+	-		-	-	-	-	+	+			-	+
DSY-38	DM			-	-	-	-	-		-		-	-		-	-	-	+	+	-	+	-	+	+	-	-	-		-	+
	LOB				-					+		-	-		-	-	-	-	+		+	+	+	+	-	+	+	+	+	+
	PM			-	-	-	-	-		-	-	-	-		-	-	-				-	-	-	-		+			+	+
DSY-39	DM		+	-		-		-	+	-		-	-			-	-	+	+	-	+	-	+	-		-	-		+	+
	LOB				-					-		-	-		-	-	-	+	-		-	+	+	+	-	+	-	-	+	+
DSY-40	DM		+	+	+	+		-		+		+	+		+	+	+	+	+	-	+	-	+	-	+	-	-		+	+
	IBM			+	+	-	-	-		+	-	-	+		+	+	-	+	+	-	-	+	+	-	+	-			+	+
DSY-41	MM			+	+		++			++	+	+	+		+	++	+	+	+	+	-	+	-	+	-	-			-	++
	PM			+	+	-	-	-		+	+	+	-		-	+	-	-	-		-	+	-	-		+			-	+

1 - Species/Station-specific Rankings: TCR>10 = "+++"; TCR>3 = "++"; TCR>1 = "+"; TCR<1 or TCR=1 = "-".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*.

3 - Risk Ranking = maximum of species/station-specific rankings.

TCR = ratio of CoC concentration in an organism at the sampling location to the same organism at the reference location.

Table 6.2-1b. Tissue Concentration Ratio (TCR) Rankings for Target Receptors for the Derecktor Shipyard Marine ERA by Species[1]

Species[2]	Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	HMW PAHs	LMW PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[3]
CN	DSY-26		++				++			++	+	++	-		++	+	-	+	+	-	+	-	+	-	-	-		-	+	++
	DSY-28	-	++	-			-			++	+	++	-		+	+	+	++	+	+	+	+	-	-		-		-	+	++
	DSY-29	-	++				++			++	+	++	+		++	+	-	++	++	+	+	+	-	+	+	-			+	++
	DSY-36									++	+	+	-		+	+	-	++	++	-	+	+	-	-	+	-			+	++
DM	DSY-26		+	+	+	+		+		++		++	+		+	++	+	++	+	+	-	+	-	+	-	+	-		+	++
	DSY-28				-	+		+		+		+	-		+	+	-	+		-	+	+	+	+		-	+		+	+
	DSY-29		+	-	+	+		+		+		+	+		+	+	+	+	+	-	+	+	-	-	-	+	-		-	+
	DSY-31				+	+		+		+		+	-		+	+	+	+	+	-	-	-	-	-	-	-	-		+	+
	DSY-33									+		-	-			+	-	+	+	-	+	+	+	-	-	-	-		+	+
	DSY-38			-	-	-	-	-		-		-	-		-	-	-	+	+	-	+	-	+	+	-	-	-		-	+
	DSY-39		+	-		-		-	+	-		-	-			-	-	+	+	-	+	-	+	-		-	-		+	+
	DSY-40		+	+	+	+		-		+		+	+		+	+	+	+	+	-	+	-	+	-	+	-	-		+	+
IBM	DSY-24			-	-	-	-	-		-	-	-	-		-	-	-	+	+	-	+	++	+	-	+	+	+		-	++
	DSY-25			++	+++	++	++	++		+++	+	+++	++		++	++	++	+	-	-	+	+	+	+		-	-		+	+++
	DSY-26			++	+++	+++	+++	+++		+++	+	+++	++		++	+++	+++	+	+	-	+	+	+	-		-			-	+++
	DSY-27			+	++	++	+	++		+++	+	++	++		++	+++	++	+	+	++	+	+	+	+	+	-	+		+	+++
	DSY-28			+	++	+	+	+		++	+	+	+		++	+	+	+	+	-	-	+	+	-		-			+	++
	DSY-35				+	-		+		+	-	+	+		+	+	+	+	+	-	+	+	+	-	-	-			+	+
	DSY-36			-	+	-	-	+		+	-	+	-		+	+	-	+	+	-	+	-	+	-		+	+		-	+
	DSY-40			+	+	-	-	-		+	-	-	+		+	+	-	+	+	-	-	+	+	-	+	-			+	+
LOB	DSY-25									++		++	-			++	+	+	-		+	+	+	+	-	-	+	+	-	++
	DSY-27				+					++		++	+		+	++	++	+	+		-	+	+	+	-	+	-	+	+	++
	DSY-28				-					++		++	+		+	++	++	+	+											++
	DSY-29									++	+	++	+		+	++	+	-	+		+	+	+	-	-	+	+	+	+	++
	DSY-33									+		+	+		+	++	+	+	+		+	-	+	-	+	-	+	+	-	++
	DSY-35				-					+		+	-		-	+	-	-	-		-	+	+	+	+	+	-	+	-	+
	DSY-36				+					++		++	-		+	++	+	+	-		-		+	-	+	+	-	-	+	++
	DSY-38				-					+		-	-		-	-	-		+		+	+	+	+	-	+	+	+	+	+
	DSY-39				-					-		-	-		-	-	-	+	-		-	+	+	+	-	+	-	-	+	+
MM	DSY-35					+	+	-		+	+	+	+		++	+	+	+	-	++	-	-	+	-		-	+		-	++
	DSY-41			+	+		++			++	+	+	+		+	++	+	+	+	+	-	+	-	+	-	-			-	++
PM	DSY-31				+	+	+	+		+		+	-		-	+	+	+	-	-	-	+	-	+	-	+			-	+
	DSY-32			+	+	-	+	-		+		+	-		-	+	+	-	-		-	-	-	-	+	+			-	+
	DSY-33				-	-	-	-		-	-	-	-		-	-	-	-	-	-	-	+	-	-		+			-	+
	DSY-34				-	-	-	-		-	-	-	-		+	-	-	-	-	-	-	+	-	-	-	+			-	+
	DSY-35				-	-	-	-		+	-	-	-		+	-	-	-	-		-	+	-	-	-	-			+	+
	DSY-36				+	-	+	+		+		+	-		+	+	+	-	-	-	-	+	+	-	-	+			+	+
	DSY-37				+	+	+	+		+		+	+		+	+	+	+	-		-	-	-	-	+	+			-	+
	DSY-38			-	-	-	-	-		-	-	-	-		-	-	-				-	-	-	-		+			+	+
	DSY-41			+	+	-	-	-		+	+	+	-		-	+	-	-	-		-	+	-	-		+			-	+

1 - Species/Station-specific Rankings: TCR>10 = "+++"; TCR>3 = "++"; TCR>1 = "+"; TCR<1 or TCR=1 = "-".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*.

3 - Risk Ranking = maximum of species/station-specific rankings.

TCR = ratio of CoC concentration in an organism at the sampling location to the same organism at the reference location.

Table 6.2-2. Tissue Screening Concentration (TSC) benchmarks for evaluation of CoC impacts on target species for the Derecktor Shipyard Marine ERA.

Chemical Class	Analyte	Tissue[1] Screening Conc., (µg/g wet)
Metals	Arsenic	1.6
	Cadmium	0.042
	Chromium	0.18
	Copper	0.17
	Lead	0.064
	Mercury	0.12
	Nickel	0.33
	Silver	0.37
	Zinc	2.8
PAHs	Acenaphthene	126
	Acenaphthylene	4.5
	Anthracene	18
	Benzo(a)anthracene	173
	Benzo(a)pyrene	416
	Benzo(b)fluoranthene	419
	Benzo(g,h,i)perylene	1,009
	Benzo(k)fluoranthene	416
	Chrysene	173
	Dibenz(a,h)anthracene	167
	Fluoranthene	18
	Fluorene	11
	Indeno(1,2,3-cd)pyrene	1,009
	Naphthalene	6.5
	Phenanthrene	12
	Pyrene	42
PCBs	Sum PCB Congeners x 2	0.44
Pesticides	Aldrin	0.71
	Hexachlorobenzene	32
	Mirex	0.018
	o,p'-DDE	0.054
	p,p'-DDE	0.054
TBT	Tributyltin	4.1E-03

[1]Shepard, (1995)

Table 6.2-3a. Tissue Screening Concentration Hazard Quotients (TSC-HQ) Rankings for Target Receptors for the Derecktor Shipyard Marine ERA **by Station**[1].

Station	Species[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b,j,k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[3]
DSY-24	IBM	-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-25	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
	DM	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
DSY-27	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	+	-	+	++
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	+	+	+++
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	-	-	-	-	+	++
	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	+	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										-
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	++	+	-	-	-	+	++
	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
DSY-31	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	+	+	-	+	-	+	+
DSY-32	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-33	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	+	-	-	+	+	+++
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	+
DSY-34	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-35	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	+	-	-	+	+	+++
	MM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-36	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	+	-	-	-	+	++
	IBM	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	++	-	-	-	+	+	++
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-37	PM	-	-	-		-	-	-		-	-	-	-		-	-	+	-	-	-	-	-	+	+	-	-	-	+	+
DSY-38	DM	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
DSY-39	DM	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-			-	-	+	+	-	-	+	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	+	+	+++	-	-	-	-	+	+++
DSY-40	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				-	+	+	+	+	-	-	-	+	+
DSY-41	MM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
JPC-1	CN[4]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	LOB	-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	-	+	+++
	MM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
CHC-1	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	+	-	-	-	+	++
	DM	-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	+	+	+++

1 - Species/Station-specific Rankings: TSC-HQ>40 = "+++"; TSC-HQ>10 = "++"; TSC-HQ>1 = "+"; TSC-HQ<1 or TSC-HQ=1 = "-".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*.

3 - Risk Ranking = maximum of species/station-specific rankings.

4 - Cunner measurements not available at JPC-1; values are for mummichog.

TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark. TSC Benchmarks are presented in Table 6.2-2.

DSY=Derecktor Shipyard; JPC=Jamestown Potter Cove; CHC=Castle Hill Cove.

Table 6.2-3b. Tissue Screening Concentration Hazard Quotients (TSC-HQ) Rankings for Target Receptors for the Derecktor Shipyard Marine ERA **by Species**[1].

Station	Species[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b,j,k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[3]
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	-	-	-	-	+	++
DSY-29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	++	+	-	-	-	+	++
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	+	-	-	-	+	++
JPC-1[4]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	++	+	-	-	-	+	++
DSY-26	DM	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	+	-	+	+
DSY-29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-31		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-38		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-39		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-			-	-	+	+	-	-	+	-	+	+
DSY-40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
CHC-1		-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-24	IBM	-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-25		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
DSY-26		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
DSY-27		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	+	-	+	++
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	+	+
DSY-35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
DSY-40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				-	+	+	+	+	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	-	+	+
DSY-25	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
DSY-27		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	+	+	+++
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										-
DSY-29		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	+	-	-	+	+	+++
DSY-35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+++	+	-	-	+	+	+++
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	++	-	-	-	+	+	++
DSY-38		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	+	+	+++	-	-	-	+	+	+++
DSY-39		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	+	+	+++	-	-	-	-	+	+++
JPC-1		-	-	-		-	-	-		-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	-	+	+++
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+++	-	-	-	+	+	+++
DSY-35	MM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	-	+	+
DSY-41		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	++	+	-	-	-	+	++
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-31	PM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	+	+	-	+	-	+	+
DSY-32		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	+
DSY-34		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+
DSY-37		-	-	-		-	-	-		-	-	-	-		-	-	+	-	-	-	-	-	+	+	-	-	-	+	+
DSY-38		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
DSY-41		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	+	+	+	+	-	-	-	+	+

1 - Species/Station-specific Rankings: TSC-HQ>40 = "+++"; TSC-HQ>10 = "++"; TSC-HQ>1 = "+"; TSC-HQ<1 or TSC-HQ=1 = "-".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenana mercenana*; PM=*Pitar morrhuana*.

3 - Risk Ranking = maximum of species/station-specific rankings.

4 - Cunner measurements not available at JPC-1; values are for mummichog.

TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark. TSC Benchmarks are presented in Table 6.2-2.

DSY=Derecktor Shipyard; JPC=Jamestown Potter Cove; CHC=Castle Hill Cove.

Table 6.2-4. Critical Body Residue (CBR) benchmarks used for assessment of risks to aquatic receptors from tissue residues for the Derecktor Shipyard Marine Ecological Risk Assessment.[1]

Compound	Mol. wt (µg/µMol)	*Test Species*	Group	Effect	CBR Chronic (µMol/g dry wt)	Comment	Reference
Arsenic	74.9	*Daphnia magna*	Crustacean	10% density loss - 3wk	2.3	(a)	1
Cadmium	112.4	*Hyallela azteca*	Amphipod	80% mortality- 10wk	0.27		2
Chromium	52.0	*Daphnia magna*	Crustacean	10% density loss - 3wk	5.4		1
Mercury	200.6	*Hyallela azteca*	Amphipod	80% mortality- 10wk	0.45	(a)	3
Copper	63.6	*Hyallela azteca*	Amphipod	71% mortality- 10wk	1.4	(a)	3
Lead	207.2	*Hyallela azteca*	Amphipod	69% mortality- 10wk	0.72	(a)	3
Nickel	58.7	*Neanthes arenaceodentata*	polychaete worm	acute mortality- 10d	1.8	(b)	4
Silver	109.7	*Corbicula fluminea*	bivalve mollusc	50% reduced growth - 3wk	1.1	(a)	5
Zinc	6.7	*Hyallela azteca*	Amphipod	65% mortality- 10wk	62.5	(a)	1
Total PAHs	202.6	*Mytilus edulis*	bivalve mollusc	reduced feeding rate	0.40	(a)	7
p,p'-DDE	318	*Salmo truta*	fish	egg hatchability	1.1	(a,c)	8
Tributyltin	325.50	*Mytilus edulis*	bivalve mollusc	reduced feeding rate	0.03	(a)	9
Total PCBs	347.5	*Pimephales promelas*	fish	reduced fecundity	0.20	(a)	10

1 - converted to dry weight assuming $CBR_{dry\ wt} = CBR_{wet\ wt} \times 5$;

(a) value reported on mass basis (e.g. µg/g) - converted to volume basis (µMol/g)

(b) converted to chronic value assuming chronic CBR = acute CBR/10.

(c) Reported concentration = NOAEL, converted to LOAEL, assuming LOAEL= NOAEL x 10.

References:

1 - Enserink, Mass-Diepeveen and Van Leeuwen, 1991.
2 - Borgmann *et al.*, 1991.
3 - Borgmann, Norwood, and Clarke, 1993.
4 - Pesch *et al.*, 1995.
5 - Diamond *et al.*, 1990.
6 - Harkey, Kane-Driscoll and Landrum, 1995.
7 - Arnold and Biddinger, 1995.
8 - Mac *et al.*, 1981.
9 - Widdows *et al.*, 1990.
10 - USACE, 1995.

Table 6.2-5a. Critical Body Residue Hazard Quotients (CBR-HQ) Rankings for Target Receptors for the Derecktor Shipyard Marine Ecological Risk Assessment **by Station**[1].

		Organics				Metals[3D]									
Station	Species[2]	Total PAHs[3A]	Total PCBs[3A]	Pesticides[3B]	Butyltins[3C]	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[4]
DSY-24	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-25	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-27	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DM	-	-		-	-	-	-	-	-	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-										-
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-31	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-32	PM	-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-33	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-34	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-35	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
	MM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-36	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-37	PM	-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-38	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
	PM	-				-	-	-	-	-	-	-	-	+	+
DSY-39	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	++	-	-	-	-	+	++
DSY-40	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-41	MM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-		-	-	-	-	-	-	-	-	+	+
JPC-1	CN[5]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
	MM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
CHC-1	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+

1 - Analyte-specific Rankings: CBR-HQ< 1= "-"; CBR-HQ>1 = +; CBR-HQ>3 = "++"; CBR-HQ>40 = "+++".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*.

3 - Critical Body Residues Benchmarks: See Table 6.2-3.

4 - Species/Station-specific Rankings: maximum of analyte-specific rankings.

5 - Cunner measurements not available at JPC-1; values are for mummichog.

CBR-HQ = measured CBR/CBR Benchmark. CBR Benchmarks presented in Table 6.2-4.

DSY=Derecktor Shipyard; JPC=Jamestown Potter Cove; CHC=Castle Hill Cove.

Table 6.2-5b. Critical Body Residue Hazard Quotients (CBR-HQ) Rankings for Target Receptors for the Derecktor Shipyard Marine Ecological Risk Assessment **by Species**[1].

		Organics				Metals[3B]									
Station	Species[2]	Total PAHs[3A]	Total PCBs[3A]	Pesticides[3B]	Butyltins[3C]	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Risk Ranking[4]
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	-	-
DSY-29		-	-	-	-	-	-	-	-	-	-	-	-	-	-
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	-	-
JPC-1[5]		-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	-	-
DSY-26	DM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-28		-	-		-	-	-	-	-	-	-	-	-	+	+
DSY-29		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-31		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-38		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-39		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-40		-	-	-	-	-	-	-	-	-	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-24	IBM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-25		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-26		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-27		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-28		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-35		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-40		-	-	-	-	-	-	-	-	-	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+
CHC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-25	LOB	-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-27		-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-28		-	-	-	-										-
DSY-29		-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-35		-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-38		-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-39		-	-	-	-	-	-	-	++	-	-	-	-	+	++
JPC-1		-	-	-	-	-	-	-	+	-	-	-	-	+	+
CHC-1		-	-	-	-	-	-	-	+	-	-	-	-	+	+
DSY-35	MM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-41		-	-	-	-	-	-	-	-	-	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-31	PM	-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-32		-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-33		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-34		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-35		-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-36		-	-	-	-	-	-	-	-	-	-	-	-	+	+
DSY-37		-	-	-		-	-	-	-	-	-	-	-	+	+
DSY-38		-				-	-	-	-	-	-	-	-	+	+
DSY-41		-	-	-		-	-	-	-	-	-	-	-	+	+
JPC-1		-	-	-	-	-	-	-	-	-	-	-	-	+	+

1 - Analyte-specific Rankings: CBR-HQ< 1= "-"; CBR-HQ>1 = +; CBR-HQ>3 = "++"; CBR-HQ>40 = "+++".

2 - Species: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*.

3 - Critical Body Residues Benchmarks: See Table 6.2-3.

4 - Species/Station-specific Rankings: maximum of analyte-specific rankings.

5 - Cunner measurements not available at JPC-1; values are for mummichog.

CBR-HQ = measured CBR/CBR Benchmark. CBR Benchmarks presented in Table 6.2-4.

DSY=Derecktor Shipyard; JPC=Jamestown Potter Cove; CHC=Castle Hill Cove.

Table 6.2-6. Tissue Residue Effects Rankings for species collected from the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Cunner			Deployed Mussels			Indigenous Mussels			Lobster			*Mercenaria*			*Pitar*		
	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]	TCS-HQ[1]	CBR-HQ[2]	Risk Ranking[3]
DSY-24							+	+	+									
DSY-25							+	+	+	+++	+	+++						
DSY-26	++	-	++	+	+	+	+	+	+									
DSY-27							++	+	++	+++	+	+++						
DSY-28	++	-	++	+	+	+	+	+	+	-	-	-						
DSY-29	++	-	++	+	+	+				+++	+	+++						
DSY-30																		
DSY-31				+	+	+										+	+	+
DSY-32																+	+	+
DSY-33				+	+	+				+++	+	+++				+	+	+
DSY-34																+	+	+
DSY-35							+	+	+	+++	+	+++	+	+	+	+	+	+
DSY-36	++	-	++				+	+	+	++	+	++				+	+	+
DSY-37																+	+	+
DSY-38				+	+	+				+++	+	+++				+	+	+
DSY-39				+	+	+				+++	++	+++						
DSY-40				+	+	+	+	+	+									
DSY-41													++	+	++	+	+	+
JPC-1[4]	++	-	++	+	+	+	+	+	+	+++	+	+++	+	+	+	+	+	+
CHC-1	++	-	++	+	+	+	+	+	+	+++	+	+++						

1 - TSC-HQ = Tissue Screening Concentration Hazard Quotients; see Table 6.2-3b.
2 - CBR-HQ = Critical Body Residue Hazard Quotients; see Table 6.2-5b.
3 - Species-specific Tissue Residue Effects ranking = maximum of indicator-specific rankings.
4 - Cunner measurements not available at JPC-1; values are for mummichog.

Table 6.3-1. Documentation of Avian Aquatic Receptor Exposure Factors for the Derecktor Shipyard Marine ERA.

Receptor Group	Body Weight (BW; kg)	Food Consumption Rate (FCR; kg dry wt/day)	On-site Feeding Area: Foraging Area Ratio (a/fa)	Migration Factor (MF)	Feeding Fraction, FF (kg prey/kg total diet)	Exposure Factor[1] (EF; kg dry wt/day)
Herring gull	1.00 (EPA, 1993)	0.50 Estimated using allometric equation specific for seabirds: $FCR = 0.495BW^{0.704}$ (Nagy et al., 1987)	1.0 Assumes receptor feeds exclusively at site.	0.6 Spring/Fall Feb. - Aug. NW Atlantic populations (Burger, 1982)	1.0 Target receptors: Cunner Deployed blue mussels Indigenous blue mussels Lobster *Mercenaria mercenaria* *Pitar morrhuana*	0.30
Great Blue Heron	2.23 (EPA, 1993)	0.42 Estimated using allometric equation specific for herons: $Log\ FCR=0.966*logBW - 0.64$ (Kushlan, 1978, cited in EPA, 1993)	1.0 Assumes receptor feeds exclusively at site.	0.7 Spring/Fall Mar. - Oct. Northern U.S. (Palmer, 1962)	1.0 Target receptors: Cunner Deployed blue mussels Indigenous blue mussels Lobster *Mercenaria mercenaria* *Pitar morrhuana*	0.28

1 - EF = FCR * a/fa * MF * FF

Table 6.3-2. Documentation of Toxicity Reference Values (TRVs) used for calculation of risks to Avian Aquatic Receptors of Concern (RoC) consuming prey in the Derecktor Shipyard/Coddington Cove study area.

		RECEPTOR		TEST SPECIES DATA							TOXICITY REFRENCE VALUES (TRVs)			
Chemical Class	Target Analyte	RoC[D]	BW[1] (kg)	Test Species	BW (Kg)	Endpoint	Endpoint Value[2]	Reference	Safety Factor[3]	Benchmark NOAEL[B]	RoC TRV-DOSE[4]	FCR[5]	Food Factor, f[6]	RoC TRV-EPC[C,7]
MET	Arsenic[E]	Gull	1.00	Mallard duck	1.000	Chronic NOAEL	5.14	Opresko et al. 1995	1	5.14	5.14	0.61	0.61	8.42
		Heron	2.23	Mallard duck	1.000	Chronic NOAEL	5.14	Opresko et al. 1995	1	5.14	3.93	1.07	0.48	8.18
	Cadmium[F]	Gull	1.00	Mallard duck	1.000	Chronic NOAEL	1.15	Opresko et al. 1995	1	1.15	1.15	0.61	0.61	1.89
		Heron	2.23	Mallard duck	1.000	Chronic NOAEL	1.15	Opresko et al. 1995	1	1.15	0.88	1.07	0.48	1.83
	Chromium[G]	Gull	1.00	Black duck	1.250	Chronic NOAEL	1.00	Opresko et al. 1995	1	1.00	1.08	0.61	0.61	1.77
		Heron	2.23	Black duck	1.250	Chronic NOAEL	1.00	Opresko et al. 1995	1	1.00	0.82	1.07	0.48	1.72
	Copper[H]	Gull	1.00	Chicken, 1-70 days old	0.534	Chronic NOAEL	47.0	Opresko et al. 1995	1	47.0	38.1	0.61	0.61	62.6
		Heron	2.23	Chicken, 1-70 days old	0.534	Chronic NOAEL	47.0	Opresko et al. 1995	1	47.0	29.2	1.07	0.48	60.7
	Lead[I]	Gull	1.00	American kestrel	0.130	Chronic NOAEL	3.85	Opresko et al. 1995	1	3.85	1.95	0.61	0.61	3.20
		Heron	2.23	American kestrel	0.130	Chronic NOAEL	3.85	Opresko et al. 1995	1	3.85	1.49	1.07	0.48	3.11
	Mercury[J]	Gull	1.00	Japanese Quail	0.150	Chronic NOAEL	0.45	Opresko et al. 1995	1	0.45	0.24	0.61	0.61	0.39
		Heron	2.23	Japanese Quail	0.150	Chronic NOAEL	0.45	Opresko et al. 1995	1	0.45	0.18	1.07	0.48	0.38
	Nickel[K]	Gull	1.00	Mallard duck, 1-90 days ol	0.782	Chronic NOAEL	77.4	Opresko et al. 1995	1	77.4	71.3	0.61	0.61	117
		Heron	2.23	Mallard duck, 1-90 days ol	0.782	Chronic NOAEL	77.4	Opresko et al. 1995	1	77.4	54.6	1.07	0.48	114
	Silver	Gull	1.00	Mallard duck (juvenile)	0.600	4 wk. NOAEL	8.30	Van Vleet 1982	10	0.83	0.70	0.61	0.61	1.15
		Heron	2.23	Mallard duck (juvenile)	0.600	4 wk. NOAEL	8.30	Van Vleet 1982	10	0.83	0.54	1.07	0.48	1.11
	Zinc[L]	Gull	1.00	White Leghorn Hens	1.935	Chronic NOAEL	14.5	Opresko et al. 1995	1	14.5	18.1	0.61	0.61	29.64
		Heron	2.23	White Leghorn Hens	1.935	Chronic NOAEL	14.5	Opresko et al. 1995	1	14.5	13.8	1.07	0.48	28.77
PAH	1,6,7-Trimethylnaphthalene			No Data										
	1-Methylnaphthalene			No Data										
	1-Methylphenanthrene			No Data										
	2,6-Dimethylnaphthalene			No Data										
	2-Methylnaphthalene	Gull	1.00	Mallard duck	1.000	7 mo LOAEL	600	See Naphthalene	10	60	60.0	0.61	0.61	98.4
		Heron	2.23	Mallard duck	1.000	7 mo LOAEL	600	See Naphthalene	10	60	45.9	1.07	0.48	95.5
	Acenaphthene	Gull	1.00	Red-winged blackbird	0.065	Acute LD_{50}	101	Schafer et al. 1983	80	1.26	0.51	0.61	0.61	0.83
		Heron	2.23	Red-winged blackbird	0.065	Acute LD_{50}	101	Schafer et al. 1983	80	1.26	0.39	1.07	0.48	0.81
	Acenapthylene	Gull	1.00	Red-winged blackbird	0.065	Acute LD_{50}	101	See Acenaphthene	80	1.26	0.51	0.61	0.61	0.83
		Heron	2.23	Red-winged blackbird	0.065	Acute LD_{50}	101	See Acenaphthene	80	1.26	0.39	1.07	0.48	0.81
	Anthracene	Gull	1.00	Red-winged blackbird	0.065	Acute LD_{50}	111	Schafer et al. 1983	80	1.39	0.56	0.61	0.61	0.92
		Heron	2.23	Red-winged blackbird	0.065	Acute LD_{50}	111	Schafer et al. 1983	80	1.39	0.43	1.07	0.48	0.89
	Benz[a]anthracene			No Data										
	Benzo[a]pyrene			No Data										
	Benzo[b]fluoranthene			No Data										
	Benzo(e)pyrene			No Data										
	Benzo(g,h,i)perylene			No Data										
	Benzo[k]fluoranthene			No Data										
	Biphenyl			No Data										
	Chrysene			No Data										
	Dibenz[a,h]anthracene			No Data										
	Fluoranthene			No Data										
	Fluorene	Gull	1.00	Red-winged blackbird	0.065	Acute LD_{50}	101	Schafer et al. 1983	80	1.26	0.51	0.61	0.61	0.83
		Heron	2.23	Red-winged blackbird	0.065	Acute LD_{50}	101	Schafer et al. 1983	80	1.26	0.39	1.07	0.48	0.81
	Indeno[1,2,3-cd]pyrene		0.08	No Data										
	Naphthalene	Gull	1.00	Mallard duck	1.000	7 mo LOAEL	600	Eisler 1987	10	60	60.0	0.61	0.61	98.4
		Heron	2.23	Mallard duck	1.000	7 mo LOAEL	600	Eisler 1987	10	60	45.9	1.07	0.48	95.5
	Perylene													
	Phenanthrene	Gull	1.00	Mallard duck	1.000	7 mo LOAEL	600	Eisler 1987	10	60	60.0	0.61	0.61	98.4
		Heron	2.23	Mallard duck	1.000	7 mo LOAEL	600	Eisler 1987	10	60	45.9	1.07	0.48	95.5
	Pyrene			No Data										
PCB	Total PCBs (c)	Gull	1.00	Ring-necked pheasant	1.000	Chronic NOAEL	0.18	Opresko et al. 1995[a]	1	0.18	0.18	0.61	0.61	0.30
		Heron	2.23	Ring-necked pheasant	1.000	Chronic NOAEL	0.18	Opresko et al. 1995[a]	1	0.18	0.14	1.07	0.48	0.29
PST	Aldrin	Gull	1.00	Ring-necked pheasant (juv)	0.800	7 wk. NOAEL	0.05	Hall et al. 1971	10	0.005	0.005	0.61	0.61	0.008
		Heron	2.23	Ring-necked pheasant (juv)	0.800	7 wk. NOAEL	0.05	Hall et al. 1971	10	0.005	0.004	1.07	0.48	0.007
	Hexachlorobenzene			No Data										
	Mirex			No Data										
	o,p'-DDE			No Data										
	p,p'-DDE	Gull	1.00	Mallard duck	1.000	1.5 yr. NOAEL	1.36	Heath et al. 1972	1	1.36	1.36	0.61	0.61	2.23
		Heron	2.23	Mallard duck	1.000	1.5 yr. NOAEL	1.36	Heath et al. 1972	1	1.36	1.04	1.07	0.48	2.17
BT	Monobutyltin			No Data										
	Dibutyltin			No Data										
	Tributyltin	Gull	1.00	Japenese Quail	0.150	Chronic NOAEL	6.80	Van Vleet 1982	1	6.8	3.61	0.61	0.61	5.93
		Heron	2.23	Japenese Quail	0.150	Chronic NOAEL	6.80	Van Vleet 1982	1	6.8	2.77	1.07	0.48	5.75

1 - body weight, 2 - (mg CoC/kg-bw/day); 3 - Conversion factor for non-Chronic NOAEL data; 4 - test species NOAELx(bw test/bw Roc)$^{1/3}$; see Section 6.3; 5 - Food Consumption Rate (kg prey/day); see Section 6.3; 6 - FCR/BW_{RoC} body weight; 7 - RoC NOAEL/f; EPC=Exposure Point Concentratoin. A) Based on Arochlor 1254 toxicity; B) NOAEL = No Observable Effect Level (mg CoC/kg-RoC/day); C) NOAEL level for CoC concentration in food (mg CoC/kg prey dry weight); D) Receptor of Concern; E) assumed to be in the form of sodium arsenite; F) assumed to be in the form of cadmium chloride; G) assumed to be in the form of Cr(+3); H) assumed to be in the form of copper oxide; I) assumed to be in the form of metal; J) assumed to be in the form of mercuric chloride; K) assumed to be in the form of nickel sulfate; L) assumed to be in the form of zinc sulfate.

Table 6.3-3. Qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

A. Herring Gull HQ (Benchmark = TRV-EPC).

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin	Risk Ranking
DSY-26	CN	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	++
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	++
DSY-36	CN	-	-	-	-	-	-	-	-	+		-	-	-	-		-	++	-	-	-	++
JPC-1	CN	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	CN	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	DM	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-		-	+
DSY-29	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-31	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-38	DM	-	-	+	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-39	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-40	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	DM	-	-	+	-	+	-	-	-	+		-	-	-	-		-	+	-	-	-	+
CHC-1	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-24	IBM	+	-	+	-	+	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-25	IBM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	IBM	-	-	+	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-40	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	IBM	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-25	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	LOB	+	-	+	+	-	+	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	LOB										-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	LOB	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	LOB	+	-	+	+	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-36	LOB	+	-	+	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-38	LOB	+	-	+	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-39	LOB	+	-	-	+	-	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	LOB	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	MM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-41	MM	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
JPC-1	MM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-31	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-32	PM	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-		+
DSY-33	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-34	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-		+
DSY-36	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-37	PM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+		-		+
DSY-38	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-					+
DSY-41	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
JPC-1	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+

TRV = Toxicity Reference Value; data from Table 6.3-2. EPC = Exposure Point Concentration (Prey Species Concentration); Data from Appendix A2.
HQ = Hazard Quotient = Prey EPC/TRV-EPC; Risk Ranking: HQ>1 = "+", HQ>10 = "++", HQ>20 = "+++".

Table 6.3-3 (continued). Qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

B. Herring Gull HQ (Benchmark = TRV-Dose).

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin	Risk Ranking
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	CN	-	-	-	-	-	-	-	-	-		-	-	-	-		-	+	-	-	-	+
JPC-1	CN	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-		-	+
DSY-29	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-31	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-38	DM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	-	-	-	-	+
DSY-39	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-40	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
JPC-1	DM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	-	-	-	-	+
CHC-1	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-24	IBM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-25	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-26	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	IBM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-40	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	IBM	+	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
CHC-1	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-25	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-27	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	LOB										-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-33	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	LOB	-	-	-	+	-	-	-	+	+		-	-	-	-		-	-	-	-	-	+
DSY-36	LOB	+	-	-	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-38	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-39	LOB	+	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-41	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
JPC-1	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-31	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-32	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
DSY-33	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-34	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
DSY-36	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-37	PM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	-		-		+
DSY-38	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-					+
DSY-41	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
JPC-1	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+

TRV = Toxicity Reference Value: data from Table 6.3-2. Data from Appendix A2.

HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey concentration X 0.3; Risk Ranking: HQ>1 = "+", HQ>10 = "++", HQ>20 = "+++".

Table 6.3-3 (continued). Qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

C. Great Blue Heron HQ (Benchmark = TRV-EPC).

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin	Risk Ranking
DSY-26	CN	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	++
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-	++
DSY-36	CN	-	-	-	-	-	-	-	-	+		-	-	-	-		-	++	-	-	-	++
JPC-1	CN	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	CN	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	DM	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-		-	+
DSY-29	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-31	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-38	DM	-	-	+	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-39	DM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-40	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-24	IBM	+	+	+	-	+	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-25	IBM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	IBM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	IBM	-	-	+	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-40	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	IBM	-	-	+	-	+	-	-	-	+		-	-	-	-		-	+	-	-	-	+
CHC-1	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-25	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	LOB	+	-	+	+	-	+	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	LOB										-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	LOB	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	LOB	+	-	+	+	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-36	LOB	+	-	+	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-38	LOB	+	-	+	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-39	LOB	+	-	-	+	-	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	MM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-41	MM	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
JPC-1	MM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-31	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-32	PM	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-		+
DSY-33	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-34	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-		+
DSY-36	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-37	PM	-	-	+	-	-	-	-	-	+		-	-	-	-		-	+		-		+
DSY-38	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-					+
DSY-41	PM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
JPC-1	PM	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+

TRV = Toxicity Reference Value; data from Table 6.3-2. EPC = Exposure Point Concentration (Prey Species Concentration); Data from Appendix A2.
HQ = Hazard Quotient = Prey EPC/TRV-EPC; Risk Ranking: HQ>1 = "+", HQ>10 = "++", HQ>20 = "+++".

Table 6.3-3 (continued). Qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

D. Great Blue Heron HQ (Benchmark = TRV-Dose).

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin	Risk Ranking
DSY-26	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	CN	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
JPC-1	CN	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	DM	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-		-	+
DSY-29	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-31	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-33	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-38	DM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-39	DM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-40	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	DM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
CHC-1	DM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-24	IBM	-	-	+	-	+	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-25	IBM	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-26	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-27	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-35	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-36	IBM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	+	-	-	-	+
DSY-40	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	IBM	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
CHC-1	IBM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-25	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-27	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-28	LOB										-	-	-	-	-	-	-	+	-	-	-	+
DSY-29	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-33	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	LOB	+	-	-	+	-	-	-	+	+		-	-	-	-		-	-	-	-	-	+
DSY-36	LOB	+	-	-	-	-	-	-	+	+		-	-	-	-		-	+	-	-	-	+
DSY-38	LOB	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-39	LOB	+	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
JPC-1	LOB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
CHC-1	LOB	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-41	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
JPC-1	MM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-31	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-32	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
DSY-33	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-34	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
DSY-35	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
DSY-36	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
DSY-37	PM	-	-	-	-	-	-	-	-	+		-	-	-	-		-	-		-		+
DSY-38	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-					+
DSY-41	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		+
JPC-1	PM	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+

TRV = Toxicity Reference Value; data from Table 6.3-2. Data from Appendix A2.

HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey concentration X 0.28; Risk Ranking: HQ>1 = "+", HQ>10 = "++", HQ>20 = "+++".

Table 6.3-4. Overall qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

A. Herring Gull

	Cunner			Deployed Mussels			Indigenous Mussels			Lobster			*Mercenaria*			*Pitar*			
Station	HQ-EPC[1]	HQ-Dose[2]	Risk Ranking[3]	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	Overall Exposure Ranking
DSY-24							+	+	+										+
DSY-25							+	+	+	+	+	+							+
DSY-26	+	+	+	+	+	+	+	+	+										+
DSY-27							+	+	+	+	+	+							+
DSY-28	++	+	++	+	+	+	+	+	+	+	+	+							++
DSY-29	++	+	++	+	+	+				+	+	+							++
DSY-30																			
DSY-31				+	+	+										+	+	+	+
DSY-32																+	+	+	+
DSY-33				+	+	+				+	+	+				+	+	+	+
DSY-34																+	+	+	+
DSY-35							+	+	+	+	+	+	+	+	+	+	+	+	+
DSY-36	++	+	++				+	+	+	+	+	+				+	+	+	++
DSY-37																+	+	+	+
DSY-38				+	+	+				+	+	+				+	+	+	+
DSY-39				+	+	+				+	+	+							+
DSY-40				+	+	+	+	+	+										+
DSY-41													+	+	+	+	+	+	+
JPC-1[4]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
CHC-1	+	+	+	+	+	+	+	+	+	+	+	+							+

1 - HQ-EPC = EPC/TRV-EPC; see Table 6.3-3.
2 - HQ-Dose = Dose/TRV-Dose; see Table 6.3-3.
3 - Species-specific ranking = maximum of indicator-specific rankings.
4 - Cunner measurements not available at JPC-1; values are for mummichog.

Table 6.3-4 (continued). Overall qualitative summary of CoC risks to Avian Aquatic Receptors consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

B. Great Blue Heron

Station	Cunner			Deployed Mussels			Indigenous Mussels			Lobster			*Mercenaria*			*Pitar*			Overall Exposure Ranking
	HQ-EPC[1]	HQ-Dose[2]	Risk Ranking[3]	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	HQ-EPC	HQ-Dose	Risk Ranking	
DSY-24							+	+	+										+
DSY-25							+	+	+	+	+	+							+
DSY-26	+	+	+	+	+	+	+	+	+										+
DSY-27							+	+	+	+	+	+							+
DSY-28	++	+	++	+	+	+	+	+	+	+	+	+							++
DSY-29	++	+	++	+	+	+				+	+	+							++
DSY-30																			
DSY-31				+	+	+										+	+	+	+
DSY-32																+	+	+	+
DSY-33				+	+	+				+	+	+				+	+	+	+
DSY-34																+	+	+	+
DSY-35							+	+	+	+	+	+	+	+	+	+	+	+	+
DSY-36	++	+	++				+	+	+	+	+	+				+	+	+	++
DSY-37																+	+	+	+
DSY-38				+	+	+				+	+	+				+	+	+	+
DSY-39				+	+	+				+	+	+							+
DSY-40				+	+	+	+	+	+										+
DSY-41													+	+	+	+	+	+	+
JPC-1[4]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
CHC-1	+	+	+	+	+	+	+	+	+	+	+	+							+

1 - HQ-EPC = EPC/TRV-EPC; see Table 6.3-3.
2 - HQ-Dose = Dose/TRV-Dose; see Table 6.3-3.
3 - Species-specific ranking = maximum of indicator-specific rankings.
4 - Cunner measurements not available at JPC-1; values are for mummichog.

Table 6.6-1. Summary of Exposure-based Weights of Evidence for the Derecktor Shipyard Marine Ecological Risk Assessment.

Station	Sediment Hazard Quotients (HQs)[1]																															Elutriate HQs[2]					SEM[3]	Tissue Concentration Ratios[4]						
	PAHs[1A]																	PCBs[1]	PST[1A]	BT[1B]	Metals[1A]										Exposure Ranking[5]						Exposure Ranking[5]						Exposure Ranking[5]
	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	HMW PAHs	LMW PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHS	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc		Total PCBs	Arsenic	Copper	Lead			Cunner	Deployed Mussels	Indigenous Mussels	Lobster	Mercenaria	Pitar	
DSY-24																																						++					++
DSY-25	-	+	+	+	+	-	+	-	-	+	+	+	-	+	-	+	+	-	-	-	-	-	-	-	-	+	-	-	+	+	-	+		+	-			+++	++				+++
DSY-26	-	-	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	-	+	-	-	+	-	-	-	-	-	+						-	++	++	+++					+++
DSY-27	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+++	+	+	+	-	+	+	+	+	+	-	++	+++	+				+	+			+++	++				+++
DSY-28	-	+	+	+	+	-	-	+	-	+	+	+	-	-	-	+	+	-	++	+	-	-	+	+	+	+	-	+	+						+	++	+	++	++				++
DSY-29	+	+	+	++	++	++	++	++	+	+	++	++	-	++	+++	+	+++	+	++	+	+	+	+	+	+	+	-	+	+++	+			+	+	+	++	+		++				++
DSY-30	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	++	+	+	+	+	-	+	+	+	+	-	+	+						+								
DSY-31	-	+	+	+	+	-	+	-	-	+	+	+	-	-	+	+	++	-	+++	+	-	-	+	+	+	+	-	+	+++	-	-	++	+	+	-		+				+	+	+
DSY-32	-	-	+	+	+	+	+	+	-	+	+	+	-	-	+	+	++	+	-	+	-	+	+	+	+	+	-	+	+	+	-	+	+	+	-						+	+	+
DSY-33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+		+		++		+	+	+
DSY-34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	+	-	-	-	+						-							+	+
DSY-35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						+			+	+	++	+	+	+
DSY-36	-	-	+	+	-	-	-	-	-	-	+	-	-	-	-	-	+	+	+	+	-	+	+	+	+	+	-	-	+	-	+	+	+	+	-	++		+	++			+	++
DSY-37	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+	+	-	+	+	+	+							+	+
DSY-38	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	+	+	+	-	-	+	-	+	+	+	+	-		+		+			+	+
DSY-39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	++	+	+	+	-		+		+				+
DSY-40	-	+	+	+	-	-	+	-	+	+	+	+	-	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	+	+	-	+	+	+	-		+	+					+
DSY-41[6]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-					+	-					++	+	+
JPC-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	+	-								
JPC-2																			-	-	-	-	-	+	-	-	-	-	-						+								
CHC-1																																											

PAH = Polycyclic Aromatic Hydrocarbons; PCB = Polychlorinated Biphenyls; PST = Pesticides; BT = Butyltins; SEM = Simultaneously Extractable Metals;
WQC = EPA Water Quality Criteria; LMW = Low Molecular Weight; HMW = High Molecular Weight.
Exposure rankings for stations for which only one indicator observation was available are equal to the indicator observation ranking.
1- Benchmark for PCBs, PAHs, PST = NOAA ER-L/ER-M (Long et al., 1995); TBT benchmark = 5 ng Sn/g dry wt. (lower, Macauley et al., 1994) and 50 ng Sn/g dry wt. (upper).
1A - Hazard Quotient Codes for Sediment Concentrations: < ER-L = "-" ; ER-L to ER-M = "+" ; >=ER-M = "++"; >=2x ER-M = "+++".
1B - Tributyltin Codes: lower HQ<1 = "-"; lower HQ>=1 = "+"; upper HQ>=1 = "++"; upper HQ>=2 = "+++".
2 - Analytes included for which WQC are available and CoCs were above detection.
Hazard Quotient Codes for Elutriate Concentrations: < WQC-Chronic = - ; WQC-Chronic to Acute = "+" ; > WQC-Acute = "++"; "+++" = > 2 x WQC-Acute.
3 - SEM Bioavailability Codes (see Table 6.1-1).
Exposure Ranking: "-" = no exposure, "+" = exposure seen in one indicator, "++" = exposure seen in two indicators, "+++" = exposure in all indicators.
4 - Site vs. Reference Tissue Concentration Ratios (TCRs; Table 6.2-1).
TCR Codes: TCR>=10 = "+++"; TCR>=3 = "++"; TCR>1 = "+"; TCR<1 or TCR=1 = "-".
5 - Exposure Ranking: "+++" = intermediate (++) or higher exposure observed for two or more indicators, one of which indicates high (+++) exposure;
"++" = intermediate (++) exposure observed for two or more indicators or high (+++) exposure for one indicator; "+" = low (+) exposure observed for two or more indicators
or intermediate (++) exposure for one indicator; "-" = low (+) exposure observed for only one indicator or no exposure for all indicators. See text in Section 6.6.
6 - No data available for elutriate exposure at Station DSY-41; ranking assumed to be the same as Station DSY-40 due to spatial proximity to Station DSY-40.

Table 6.6-2. Summary of Effects-based Weights of Evidence for the Derecktor Shipyard Marine Ecological Risk Assessment.

Station	Tissue Residue Effects[1]							Laboratory Toxicity[2]				Field Effect Indicators[3]						Avian Predator[4]		
	Cunner	Deployed Mussels	Indigenous Mussels	Lobster	*Mercenaria*	*Piter*	Effects Ranking[5]	*Ampelisca* Survival	*Arbacia* Fertilization	*Arbacia* Development	Effects Ranking[5]	Benthic Community Structure[3A]	Bivalve Condition Index[3B]	Hematopoietic neoplasia[3C]	Cytochrome P450[3D]	Fecal Pollution Indicators[3E]	Effects Ranking[5]	Herring Gull	Great Blue Heron	Effects Ranking[5]
DSY-24			+				+						-				-	+	+	+
DSY-25			+	+++			++	-	-	*++	+	+++	-		+		++	+	+	+
DSY-26	++	+	+				+	-	-	*+++	++	-	++	++	+	++	++	+	+	+
DSY-27			++	+++			+++	*+	-	-	-	+++	-		+		++	+	+	+
DSY-28	++	+	+	-			+	*+	-	*+++	++	+	-		+	-	+	++	++	++
DSY-29	++	+		+++			+++	-	-	*+++	++	+++	++	+	+++	+	+++	++	++	++
DSY-30								-	-	-	-	+			+		+			
DSY-31		+				+	+	-	-	*++	+	-	++	-	+	-	+	+	+	+
DSY-32						+	+	-	-	*++	+	+++			+		++	+	+	+
DSY-33		+		+++		+	++	-	-	*++	+	-	++		-	++	++	+	+	+
DSY-34						+	+	-	-	-	-	+			-		-	+	+	+
DSY-35			+	+++	+	+	++	-	-	-	-	+	-	-	-		-	+	+	+
DSY-36	++		+	++		+	+	-	-	*+	-	++	-	-	+		+	++	++	++
DSY-37						+	+	-	-	*++	+	-			-		-	+	+	+
DSY-38		+		+++		+	++	-	-	*++	+	++	-		-	+	+	+	+	+
DSY-39		+		+++			++	-	-	*++	+	++	-		-	+	+	+	+	+
DSY-40		+	+				+	-	-	*+	-	++	-	+	+	+++	+++	+	+	+
DSY-41[6]					++	+	+	-	-	*++	+	+++			-	+++	+++	+	+	+
JPC-1	++	+	+	+++	+	+	+++	-	-	-	-	-	-		-	+	-	+	+	+
JPC-2								-	-	-	-	-					-	+	+	+
CHC-1	++	+	+	+++			+++						-			+	-			

Effects rankings for stations for which only one indicator observation was available are equal to the indicator observation ranking.
1- Assessment of possible adverse effects due to CoCs in target species tissues; see Table 6.2-4.
2- Reduced survival, fertilization or development in bioassay species exposed to sediments or sediment elutriates. See Table 5.2-1 for test-specific ranks.
3- Reduced fitness in field species exposed to sediments or sediment elutriates.
3A - see Tables 5.3-1 and 5.3-2.
3B - see Figure 5.3-9.
3C - see Table 5.3-4.
3D - see Section 6.5 text and Figure 6.5-9.
3E - see Table 5.3-5.
4 - Toxicity Reference Value Hazard Quotient (TRV-HQ); see Table 6.3-4.
5 - Effects Ranking: "+++" = intermediate (++) or higher effect observed for two or more indicators, one of which indicates high (+++) effect; "++" = intermediate (++) effect observed for two or more indicators or high (+++) effect for one indicator; "+" = low (+) effect observed for two or more indicators or intermediate (++) effect for one indicator; "-" = low (+) effect observed for only one indicator or no effect for all indicators. See text in Section 6.6.
6 - No data available for fecal pollution indicator effects at Station DSY-41; ranking assumed to be the same as Station DSY-40 due to spatial proximity to Station DSY-40.

Table 6.6-3. Overall Summary of Exposure and Effects-based Weights of Evidence and Characterization of Risk for the Derecktor Shipyard Marine Ecological Risk Assessment.

	WEIGHTS OF EVIDENCE										
	EXPOSURE					EFFECTS					
Station	Sediment Hazard Quotients[1]	Elutriate HQs[2]	SEM and AVS[3]	Tissue Conc. Ratio[4]	Rank[9]	Tissue Residue Effects[5]	Laboratory Toxicity[6]	Field Effects[7]	Avian Predators[8]	Rank[9]	Overall Risk Probability Ranking[10]
DSY-24				++	I	+		-	+	L	Intermediate
DSY-25	+	+	-	+++	I	++	+	++	+	I	Intermediate
DSY-26	+		-	+++	I	+	++	++	+	I	Intermediate
DSY-27	+++	+	+	+++	H	+++	-	++	+	H	High
DSY-28	+		+	++	L	+	++	+	++	I	Intermediate
DSY-29	+++	+	+	++	H	+++	++	+++	++	H	High
DSY-30	+		+		L		-	+		B	Low
DSY-31	+++	+	-	+	I	+	+	+	+	L	Intermediate
DSY-32	+	+	-	+	L	+	+	++	+	L	Low
DSY-33	-	+	+	+	L	++	+	++	+	I	Intermediate
DSY-34	+		-	+	L	+	-	-	+	L	Low
DSY-35	-		+	+	L	++	-	-	+	L	Low
DSY-36	+	+	-	++	L	+	-	+	++	L	Low
DSY-37	+	+	+	+	L	+	+	-	+	L	Low
DSY-38	+	+	-	+	L	++	+	+	+	L	Low
DSY-39	+	+	-	+	L	++	+	+	+	L	Low
DSY-40	+	+	-	+	L	+	-	+++	+	I	Intermediate
DSY-41	-	+	-	+	L	+	+	+++	+	I	Intermediate
JPC-1	-	+	-		B	+++	-	-	+	I	Low
JPC-2	-		+		B		-	-	+	B	Baseline
CHC-1						+++		-		I	Intermediate

1- Sediment Hazard Quotient Risk Ranking: see Table 6.6-1.
2- Elutriate Hazard Quotient Risk Ranking: see Table 6.6-1.
3- SEM and AVS Risk Ranking: see Table 6.6-1.
4- Tissue Concentration Ratios Risk Ranking: see Table 6.6-1.
5- Tissue-based Risk Ranking: Based on Site vs. Reference Tissue Concentration Ratio (Table 6.6-1), Tissue Screening Concentration (Table 6.6-2) and Critical Body Residues (Table 6.6-2).
6- Laboratory Toxicity Risk Ranking: see Table 6.6-2.
7- Field Effects Ranking: Based on results of Condition Index, Benthic Community Structure, Hematopoietic neoplasia, cytochrome P450, and fecal pollution indicators; see Table 6.6-2.
8- Avian Predator effects ranking based on Toxicity Reference Value Hazard Quotients; see Table 6.6-2.
9- Overall Exposure/Effects (E/E) Ranking:
B = Baseline Risk; L = Low Risk Probability; I = Intermediate Risk Probability; H = High Risk Probability.
Rankings for stations for which only one WoE observation was available are equal to the WoE observation ranking.
B = Low (+) E/E ranking observed for only one indicator or baseline E/E ranking observed for all indicators;
L = Intermediate (++) E/E ranking observed for only one indicator or low (+) E/E ranking observed for two or more indicators;
I = High (+++) E/E ranking observed for only one indicator or intermediate (++) E/E ranking observed for two or more indicators;
H = Intermediate (++) or greater E/E ranking observed for two indicators including high (+++) E/E ranking observed for one indicator.
10- Overall Risk Ranking (See also Section 6.6):
Baseline = No greater than Baseline (B) ranking for E/E WoE summaries;
Low = No greater than Low (L) ranking for E/E WoE summaries, or Intermediate (I) ranking for one WoE summary and no greater than Baseline (B) ranking for the other WoE summary;
Intermediate = No greater than Intermediate (I) ranking for E/E WoE summaries, or High (H) ranking for one WoE and no greater than Low (L) ranking for the other WoE summary;
High = High (H) ranking for one WoE summary and Intermediate (I) or greater ranking for the other WoE summary.

Table 6.7-1. Potential sources of uncertainty and relationship to true degree of adverse exposure as inferred from tests performed to support the Weight of Evidence (WoE) approach for the Derecktor Shipyard Marine Ecological Risk Assessment.

Weight of Evidence	Sources of Uncertainty	Code
General	• Some proximal and distal contaminant sources, as well as potential sensitive receptors, may not be accounted for in conceptual exposure pathways;	↑↓
	• Knowledge of the chemical behavior of the CoCs is incomplete; test results may not reflect true CoC exposure conditions;	↑↓
	• Inadequate spatial and temporal representation of the evaluated habitat and site/reference zone by a limited number of sampling stations, and associated extrapolations (and assumptions) from point measurements to broader spatial areas;	↑↓
	• Representativeness of target analyte list leading to CoC selection may be inadequate, potentially resultin in an incomplete characterization of potentially significant adverse chemical exposure;	↓
	• The sediment sampling plan, including station selection, spatial (horizontal) and vertical (sediment layering) patterns, and sample representativeness may inadequately characterize true CoC distributions;	↑↓
	• Areas of contamination identified in historic studies not specifically addressed in the current investigation.	↓
Sediment Hazard Quotients	• Hazard Quotients not developed for all CoCs due to limited availability of benchmarks;	↓
	• The pesticides o,p'-DDE and aldrin were not quantified accurately due to analytical interferences;	↓
	• Hazard Index does not address potential synergistic or antagonistic interactions among contaminants;	↑↓
	• Sediment benchmarks used to derive Hazard Quotients and Indices were derived from data where potential synergistic or antagonistic interactions among contaminants may have been present.	↑
Elutriate Hazard Quotients	• Evaluation of potential resuspension events addressed only current conditions and levels of activity; future use scenarios involving fundamentally different conditions were not evaluated;	↑↓
	• Elutriate concentrations prepared in the laboratory are expected to greatly exceed anticipated concentrations occurring at the site during both normal- and storm-driven sediment resuspension events.	↑
SEM and AVS	• Concentration of AVS may be reduced by sampling procedure, increasing apparent metal bioavailability;	↑
	• Other binding factors (e.g. organic carbon) may decrease metal bioavailability in conditions of low AVS.	↑
Tissue Concentration Ratios	• Metabolic activities may reduce PAH tissue concentrations in cunner;	↓
	• Reference tissue residue concentrations used as benchmarks are likely to be below the threshold for adverse exposure.	↑

↑ = "false positive", e.g. true degree of adverse exposure is likely to be overestimated by the test.
↓ = "false negative", e.g. true degree of adverse exposure is likely to be underestimated by the test.
↑↓ = true degree of adverse exposure may be either underestimated or overestimated by the test.

Table 6.7-2. Potential sources of uncertainty and relationship to true degree of adverse effects as inferred from tests performed to support the Weight of Evidence (WoE) approach for the Derecktor Shipyard Marine Ecological Risk Assessment.

Weight of Evidence	Sources of Uncertainty	Code
General	• Appropriateness of selected bioassay and target species as surrogates for the indigenous community; • Limited toxicological data for target receptor species; • Incomplete knowledge of community ecology and of potential synergistic or antagonistic impacts of CoC	↑↓ ↑↓ ↑↓
Tissue Residue Effects	• Degree of mobility of lobster and cunner as related to the assumed relationship between tissue residue and station-specific CoC concentrations in sediments; • Variation in lipid content among target species as a factor governing bioavailability and potential effects; • Limited number of Toxicity Reference Values (TRVs) available as benchmarks for assessment of tissue residue impacts; • Extent to which metabolic activities in cunner reduce parent PAH tissue residue concentrations to unmeasured constituents of potential toxicological significance; • Lack of empirical evidence linking contaminant concentrations in tissue with presumed effects.	↑↓ ↑↓ ↓ ↓ ↑↓
Laboratory Toxicity (*Arbacia* and *Ampelisca*)	• Sampling/test procedures may modify CoC bioavailability; • Non-chemical-specific responses obscuring exposure-response relationships; • Responses observed may not represent potential for chronic effects; • Differences in CoC bioavailability and species/endpoint sensitivity between sediment and water tests not accounted for in data interpretation; • Elutriate test species fertilization response affected by resuspended solids.	↑↓ ↑↓ ↑↓ ↑↓ ↑
Field Effects	• Effects of natural variation in field measurements of community metrics; • Accuracy of indicators (e.g., diversity and numbers of species) for detection of effects is unknown;	↑↓ ↑↓
Community Structure	• Seasonal and temporal variation in sensitivity to pollutants was not assessed; • Methods for data interpretation and community based benchmarks are not standardized; • Taxonomic identification of some species/individuals is uncertain, thus affecting community metrics; • Availability of historical data from quantitative benthic community studies in the study area is lacking; • Relative sensitivity of observed species to various pollutants is unknown.	↑↓ ↑↓ ↑↓ ↑↓ ↑↓
Bivalve Condition	• Sensitivity of surrogate species may not be comparable to indigenous species; • Sublethal indices may change with season, reproductive status, and age.	↑↓ ↑↓
Hematopoietic neoplasia	• Incomplete knowledge as to degree of natural variation in response; • Assumed relationship between neoplasia incidence and site-related CoC exposure may be spurious.	↑↓ ↑
P450	• P450 benchmarks for cunner derived from another species; • Degree to which estimated increases in P450 activity reflects a true, adverse physiological effect is unknown.	↑↓ ↑↓
Fecal Pollution Indicators (FPI)	• Direct/indirect relationships between tissue residue FPI concentrations and adverse affects are presumed; • Individual temporal variation and comparability among target receptor FPI tissue residue concentration i unknown.	↑↓ ↑↓
Avian Predators	• Intake of contaminants via other exposure routes such as water ingestion not considered; • Birds may not feed exclusively at the site; • Prey species used in modeling may not be adequate surrogates for other organisms in the diet of gulls or herons.	↓ ↑ ↑↓

Codes: ↑ = "false positive", e.g. true degree of adverse effects is likely to be overestimated by the test.
↓ = "false negative", e.g. true degree of adverse effects is likely to be underestimated by the test.

7.0. SUMMARY AND CONCLUSIONS

This section summarizes the results of the marine Ecological Risk Assessment conducted for the Derecktor Shipyard, located at the Naval Education and Training Center (NETC) in Newport, RI. The U.S. EPA's ERA Framework and applicable EPA Region I guidance were used to generate and interpret the data required to complete this risk assessment. The objectives of this study were to:

- Assess ecological risks to the offshore environments of Coddington Cove and Narragansett Bay from chemical stressors associated with Derecktor Shipyard;

- Develop information sufficient to support risk management decisions regarding site-specific remedial options; and

- Support communication to the public of the nature and extent of ecological risks associated with Derecktor Shipyard.

The following sections present and discuss the findings of this Marine Ecological Risk Assessment (ERA), including Problem Formulation, Site Characterization, Exposure and Ecological Effects Assessments, Characterization of Ecological Risks, Risk Synthesis and Uncertainty Analysis.

7.1. SYNTHESIS OF STUDY FINDINGS

A summary of environmental risk for the Derecktor Shipyard/Coddington Cove study area was presented in Table 6.6-3. The table includes a summary of the

measurement on exposure-based endpoints (i.e., Hazard Quotients based on chemical concentrations in sediments and elutriates, measures of SEM bioavailability, and tissue concentration ratios) and effects-based endpoints (i.e., tissue residue effects, laboratory toxicity tests, and field effects and effects on avian predators). The tissue data was used to represent a measurement endpoint for potential effects, as well as exposure point measures as related to food web transfers of contaminated prey to avian aquatic predators.

The identified risks by station are based primarily upon summaries of each weight of evidence, with special attention paid to concordance between exposure- and effects-based weights of evidence. This evaluation of weights of evidence addresses only current conditions and levels of activity at the site, and does not address future use scenarios involving fundamentally different conditions and activities at the site. Estimated risks at the Derecktor Shipyard/ Coddington Cove stations were grouped into four primary classes: baseline, low, intermediate and high, based on definitions outlined in Section 6.6.

High Risk Stations. In the present investigation, two stations (Stations DSY-27 and DSY-29) were assigned to the high risk category. Risks to avian predators at Station DSY-29 ranked only as intermediate although the exposure assumptions used were highly conservative. Plausible exposure-response relationships were observed for some CoC-receptor pairings (e.g., .sediment PAHs with benthic community structure; sediment PCBs and indigenous mussel condition).

Intermediate Risk Stations. Intermediate ecological risks are those risks which are supported by multiple weights of evidence which clearly indicate that significant exposure and/or effects are occurring at the site. The presumption of intermediate risks should also be supported by suggestive, but perhaps not highly quantitative, exposure-response relationships, or appear to be restricted to areas of highly localized apparent

impact or very limited duration. Derecktor Shipyard stations which appear to show an association between exposure and effects and were included in the intermediate risk grouping include Stations DSY-24, DSY-25, DSY-26, DSY-28, DSY-31, DSY-33, DSY-40 and DSY-41. Reference Station CHC-1 was also identified as an intermediate risk station. Indication of CoC exposure was most evident from comparison of tissue concentrations to the reference stations values, while effects indicators include tissue residue effects, laboratory toxicity and field effects (Table 6.6-3). Hence, intermediate risk is assigned for these stations, although there is considerable uncertainty as to the degree to which CoC-related impacts have contributed to observed effects at these stations.

Low Risk Stations. Low risks are assigned to eight Coddington Cove stations, including pier Stations DSY-30 and DSY-32, and the outer harbor Stations DSY-34 through DSY-39, as well as reference Station JPC-1. While these stations have CoC concentrations exceeding ER-L benchmarks, the weights of evidence are most notable for the observed Effects data, particularly tissue residue effects, but also some laboratory toxicity and field effects.

Baseline Risk Stations. Baseline risk was assigned only for reference Station JPC-2.

7.2. Other Potential Sources of Stress and CoCs

Ongoing CoC transport into Coddington Cove may be from surface water runoff via storm drains near the shipyard harborfront. It is also possible that groundwater percolating out of the shipyard area and entering Coddington Cove may be carrying CoCs; however, this ERA did not collect any data to address the groundwater issue.

Contamination from other sources may potentially enter Coddington Cove via exchange with Narragansett Bay. The City of Newport sewage treatment plant outfall is located to the southwest of the site, and prevailing water circulation patterns would suggest the possibility of diluted effluent entering the cove during the flood tide. A bimodal trend in CoC tissue residue concentrations, where some offshore stations (e.g., DSY-38 and DSY-39) had sediment and biota CoC levels which were comparable in magnitude to harborfront areas, provides some evidence that the Newport sewage treatment plant outfall is a possible source of CoCs.

This assessment found some evidence to suggest that CoC concentrations exceeding benchmarks extend > 140 cm into the sediment, and visual observations of oil sheen in cores taken in the vicinity of piers suggest the possibility of localized contamination near the piers. The existence of significantly elevated CoCs in subsurface sediment layers at certain stations (e.g. vibracore Stations V4 and V9) relative to surface sediments may represent an increased risk for indigenous biota should resuspension of these buried sediments occur, depending on future use scenarios. However, geophysical and hydrographic studies suggest that natural deposition/erosion patterns do not represent ecological risks from these buried CoCs under existing conditions within the cove. Hence, it is concluded that indigenous biological communities in the immediate vicinity of the harborfront are at risk primarily due to shipyard-related stressors, although uncertainty exists as to the partitioning of contaminants between sediment and water transport pathways.

7.3. Limitations of the Assessment

The conclusions drawn in this assessment are based on an extensive database of sediment and tissue chemistry, biological indicators, and toxicity evaluations, supported by geophysical and hydrographic information, with broad spatial and

temporal coverage. The data are internally consistent and supportive, and of high quality, meeting and exceeding, for example, detection limits as specified by the NOAA Status and Trends Program. Therefore, the values can be interpreted with confidence for comparisons to commonly accepted guidelines, such as ER-L values (Long *et al.*, 1995).

The assessment of ecological risk is a process of minimizing uncertainty with regard to characterization of exposure and effects, and the integration of these data as cause-effect relationships. The risk conclusions reached in this study are based on weight of evidence; those areas exhibiting more numerous lines of evidence for or against adverse impact are associated with less uncertainty in the conclusion. This evaluation addresses only current conditions and levels of activity at the site, and does not address potential future use scenarios involving fundamentally different conditions and activities at the site. The present study provides extensive weights of evidence and spatial coverage for evaluation of risks in the Derecktor Shipyard/Coddington Cove study area proper; however, localized small areas, such as immediately adjacent to or directly beneath the piers have not been specifically addressed and are of unknown concern. In addition, the present investigation was synoptic, not seasonal in design, and therefore uncertainty exists in that seasonal effects were not specifically considered. However, sediment chemical data results from the present study were generally comparable to that of a prior investigation (Quinn *et al.*, 1994), which suggests that interannual variability would not appear to introduce great uncertainty into this assessment.

The present study was conducted under a comprehensive Work/Quality Assurance Plan, and data validation has been performed and found to meet the study requirements. Potential errors in the study design and protocols were minimized through peer review and evaluation. Data collection activities were reasonably complete, but perhaps limited by less than desirable abundances of fish for metals

chemistry as well as biomarker (cytochrome P450) measurements both in Coddington Cove and at the reference site. However, the available site tissue CoC residue data for various species does suggest general similarity in chemical concentrations and bioaccumulation trends among species, particularly for organic contaminants. This finding reduces the uncertainty in the extrapolation of exposure and effects determinations for target receptor species which were directly measured to other resource species (e.g., winter flounder) whose present abundances did not permit collection.

7.4. Conclusions and Recommendations

Based on the results of the Marine Ecological Risk Assessment for Derecktor Shipyard/Coddington Cove, the following conclusions and recommendations are put forth for consideration in risk management:

- In the assessment of marine ecological risks to aquatic species of concern (mussels, clams, lobster, cunner and seabirds), Stations DSY-27 and DSY-29 were determined to pose a high probability of ecological risk from shipyard-related Contaminants of Concern (CoCs). The principal CoCs responsible for this risk were organics (PCBs, PAHs and tributyltin) and metals (copper, lead and zinc). Seabirds (herring gull and great blue heron) were also at intermediate risk due to potential ingestion of PCBs in cunner at Station DSY-29. Based on the extent of adverse exposure and effects and demonstrable exposure-response relationships observed, the assigned degree of risk is considered unacceptable from an ecological perspective, and thus these locations should receive highest priority in the risk management decision process.

- An intermediate probability of ecological risks was assigned to Stations DSY-24, DSY-25, DSY-26, DSY-28, DSY-31, DSY-33, DSY-40, and DSY-41, as well as reference Station CHC-1. In general, the same aquatic receptors and CoCs as observed for high risk stations were of concern, but at lower levels. Exceptions included higher tributyltin in sediment at Station DSY-31, and higher PAHs in mussels at Stations DSY-25 and DSY-26. Seabirds continued to be at intermediate risk due to potential ingestion of PCBs in cunner at Station DSY-28. Given an indication of adverse exposure or effects but a lack of clear exposure-response relationships, the overall risk at these stations is considered acceptable from an ecological perspective. However, the associated uncertainty is sufficiently high as to merit the evaluation of these stations as priority areas in the risk management decision process.

- A low probability of ecological risks was assigned to the remaining Coddington Cove stations (DSY-30, DSY-32, and DSY-34 through DSY-39), as well as the reference Station JPC-1. Although the data for these stations suggest possible adverse exposure or effects, CoC concentrations were generally low and definitive exposure-response relationships were not observed. Based on these observations, the observed risks at these stations are considered acceptable from an ecological perspective, and relatively low priority should be given to these locations in the risk management decision process.

- A baseline probability of risk was assigned to reference Station JPC-2, given a lack of evidence for adverse exposure or effects. Ecological risks at this location are considered not only acceptable but representative of relatively pristine environmental conditions for the general study area.

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APPENDIX A-1.
ANALYTICAL CHEMISTRY RESULTS

APPENDIX A-1-1.
SEDIMENT DATA

Appendix A-1-1. Results of sediment chemical analyses for the Derecktor Shipyard Marine Ecological Risk Assessment.

Type	Analyte	DSY-25-S	DQ	DSY-26-S	DQ	DSY-27-S	DQ	DSY-28-B	DQ	DSY-28-M	DQ	DSY-28-S	DQ	DSY-29-B	DQ	DSY-29-M	DQ	DSY-29-S	DQ	DSY-30-B	DQ	DSY-30-M	DQ	DSY-30-S	DQ	DSY-31-B	DQ	DSY-31-M	DQ	DSY-31-S	DQ
MET	Aluminum	21201.25		23628.50		43767.50		38435.00		30315.00		41307.50		18495.25		17663.00		37147.50		23276.50		26827.50		37525.00		34225.00		27677.50		38455.00	
MET	Arsenic	6.38		9.43		11.60		9.66		9.50		8.68		3.00		5.57		12.46		6.07		5.45		10.30		5.49		9.04		10.22	
MET	Cadmium	0.34	2	0.18	2	1.03	2	0.90	2	0.91	2	0.55	2	0.14	2	0.78	2	1.45		0.27	2	0.16	2	1.20	2	0.12	2	0.53	2	0.76	2
MET	Chromium	55.00		53.50		103.00		107.75		112.75		80.50		31.25		56.00		86.50		42.00		49.75		79.25		38.75		58.50		76.75	
MET	Copper	23.50		39.25		166.25		132.50		179.50		71.75		1.88	1	60.00		157.75		1.88	1	9.75		81.25		1.88	1	36.75		80.75	
MET	Iron	23830.75		23353.50		34532.50		35297.50		32305.00		29155.00		16445.75		22018.50		35452.50		21068.75		21970.25		27417.50		17771.75		24123.00		28335.00	
MET	Lead	35.90		40.40		150.70		192.60		146.40		77.70		19.00		87.10		165.90		21.70		34.90		60.00		29.90		52.70		81.00	
MET	Manganese	268.50		148.50		346.50		338.00		331.50		302.50		113.00		137.00		282.25		214.00		140.75		276.50		253.50		219.75		307.50	
MET	Mercury	0.13		0.14		0.59		1.08		0.41		0.32		0.02	1	0.57		0.50		0.02	2	0.14		0.47		0.07		0.28		0.40	
MET	Nickel	21.00		20.50		43.50		45.50		77.75		24.25		15.25		23.25		34.75		13.50		16.75		27.25		12.50		21.75		24.75	
MET	Silver	0.26		0.19		0.69		1.00		0.96		0.51		0.07	1	0.61		0.79		0.07	1	0.14		0.74		0.07	1	0.57		0.51	
MET	Zinc	110.00		101.50		547.25		327.75		455.00		169.25		34.50		130.50		392.75		48.50		64.50		192.75		36.00		122.75		167.00	
PAH	1,6,7-Trimethylnaphthalene	6.19		4.34		7.87		59.06		8.90		6.41		0.54	1	17.61		27.94		0.54	1	3.74		19.25		0.54	1	4.09		7.90	
PAH	1-Methylnaphthalene	10.93		7.83		20.47		155.95		27.71		19.85		3.26	1	52.95		50.07		3.26	1	10.85		55.11		3.26	1	10.34		20.42	
PAH	1-Methylphenanthrene	52.56		43.54		61.44		576.92		49.98		38.57		2.24	2	194.91		266.56		2.72	1	18.59		114.16		2.72	1	14.13		32.53	
PAH	2,6-Dimethylnaphthalene	27.20		18.65		38.46		105.31		39.17		34.23		1.78	1	23.93		112.32		4.39		6.83		70.70		2.49	2	17.07		34.64	
PAH	2-Methylnaphthalene	11.22		13.66		32.72		145.25		35.11		43.87		5.30	1	26.72		73.47		5.30	1	12.17		88.19		5.30	1	15.08		36.86	
PAH	Acenaphthene	41.74		12.21		23.89		820.10		20.79		17.27		0.44	1	158.06		188.59		0.44	1	9.44		196.96		0.44	1	4.18		17.14	
PAH	Acenaphthylene	75.65		93.84		142.33		210.61		108.80		74.63		0.77	1	119.64		300.15		0.77	1	19.26		91.94		0.77	1	22.41		71.00	
PAH	Anthracene	302.15		268.40		382.62		2040.00		323.31		183.43		4.52		541.48		1220.00		0.91	2	49.86		455.85		1.09	1	51.07		200.30	
PAH	Benzo(a)anthracene	328.19		517.94		808.57		4490.00		513.22		294.02		6.77		1640.00		2700.00		0.85	2	105.18		696.69		1.80	2	66.89		280.58	
PAH	Benzo(a)pyrene	395.81		434.27		924.00		4130.00		697.52		377.47		9.53		1550.04		2380.00		2.42	1	137.73		811.84		2.02	2	147.09		420.82	
PAH	Benzo(b,j,k)fluoranthene	876.60		998.77		2240.00		8490.00		1550.31		911.35		34.64		2750.00		5350.00		4.01	2	266.78		1640.00		5.90	2	295.19		1040.00	
PAH	Benzo(e)pyrene	345.32		365.01		829.19		3000.00		602.83		362.45		11.88		1140.00		1950.00		2.04	1	103.84		772.67		1.50	2	155.73		401.42	
PAH	Benzo(g,h,i)perylene	199.71		201.17		499.83		1780.00		373.00		247.10		7.10		700.79		1110.00		1.47	2	74.57		451.59		1.55	2	92.95		214.71	
PAH	Biphenyl	6.89		6.66		15.06		55.42		12.69		12.61		0.64	1	12.58		29.91		0.64	1	2.85		23.76		0.64	1	6.54		14.41	
PAH	Chrysene	484.81		591.70		911.52		4670.00		646.43		363.69		15.32		1590.00		2800.00		1.33	2	109.96		715.69		2.56	2	100.04		398.97	
PAH	Dibenz(a,h)anthracene	60.86		61.34		131.23		570.74		99.62		66.60		1.86	2	223.37		317.43		0.84	2	17.69		130.12		0.77	2	25.85		62.93	
PAH	Fluoranthene	490.40		686.48		801.42		11000.00		649.30		458.77		20.37		2860.00		4970.00		1.87	2	239.16		1490.00		2.58	2	104.25		399.33	
PAH	Fluorene	44.13		53.89		61.63		1020.00		42.18		31.45		1.34	1	137.67		293.64		1.34	1	15.74		176.61		1.34	1	9.15		28.12	
PAH	High Molecular Weight PAHs	2343.59	4	3031.39	4	5526.74	4	34320.74	4	4116.09	4	2210.24	4	82.12	4	11413.41	4	18467.43	4	9.06	4	846.81	4	5594.37	4	13.40	4	743.85	4	2408.60	4
PAH	Indeno(1,2,3-cd)pyrene	195.39		209.32		473.05		1840.00		332.01		222.56		5.91		673.03		1020.00		1.29	2	70.60		398.24		1.32	2	74.79		217.99	
PAH	Low Molecular Weight PAHs	776.11	4	775.26	4	1020.22	4	12822.43	4	880.69	4	608.69	4	19.03	4	2278.71	4	3761.46	4	13.04	4	261.55	4	2415.67	4	13.22	4	180.03	4	614.82	4
PAH	Naphthalene	17.98		16.16		41.75		126.47		47.65		37.54		2.60	1	55.15		76.08		2.60	1	13.64		136.11		2.60	1	17.91		45.30	
PAH	Perylene	103.96		133.30		248.74		928.70		176.18		133.40		4.96		367.97		610.95		17.47		38.48		207.40		11.58		45.35		141.52	
PAH	Phenanthrene	283.23		316.90		335.28		8460.00		302.85		220.50		4.07	2	1240.00		1609.54		1.67	2	141.44		1270.00		1.88	2	60.24		216.10	
PAH	Pyrene	583.52		739.67		1950.00		9460.00		1510.00		649.69		28.27		3550.00		5300.00		1.75	2	237.10		1750.03		3.67	2	299.73		845.97	
PAH	Total PAHs	4940.00	4	5800.00	4	11000.00	4	84100.00	4	8170.00	4	4810.00	4	157.00	4	19600.00	4	32800.00	4	37.90	4	1710.00	4	11800.00	4	39.00	4	1840.00	4	5150.00	4
PCB	101 (2 2'3 5 5')	6.48		5.72		220.22		10.11		21.29		5.51		0.26		4.32		16.70		0.28		0.29		19.00		0.31		7.48		12.75	
PCB	105 (2 3 3'4 4')	1.75		1.82		137.44		3.73		6.40		2.04		0.04	1	1.40		6.61		0.04	1	0.10		7.04		0.04	1	3.35		4.39	
PCB	118 (2 3'4 4'5)	5.02		6.20		242.41		12.38		22.62		7.09		0.14	1	4.51		18.38		0.14	1	0.35		19.56		0.14	1	7.82		13.74	
PCB	128 (2 2'3 3'4 4')	1.37		1.34		73.00		2.79		6.99		1.89		0.04	1	1.00		5.14		0.10		0.04	1	6.25		0.04	1	2.45		3.07	
PCB	138 (2 2'3 4 4'5)	5.92		7.21		265.35		15.80		33.33		10.86		0.09	2	5.99		27.04		0.13	2	0.24	2	26.57		0.07	2	10.37		16.11	
PCB	153 (2 2'4 4'5 5')	4.37		6.16		174.00		14.71		27.51		9.97		0.10	2	5.23		22.80		0.08	1	0.15	2	20.54		0.08	1	7.99		14.43	
PCB	170 (2 2'3 3'4 4'5)	0.89		1.53		44.16		4.00		12.86		3.13		0.04	1	1.66		7.25		0.04	1	0.22		6.29		0.04	1	2.59		3.83	
PCB	18 (2 2'5)	0.67		0.79		8.38		0.96		3.05		0.45		0.02	1	0.23		0.68		0.09		0.20		1.30		0.02	1	1.19		1.34	
PCB	180 (2 2'3 4 4'5 5')	1.86		2.74		53.17		7.32		21.95		5.77		0.08	2	3.67		13.79		0.24		0.06	2	11.57		0.05	1	6.43		6.80	
PCB	187 (2 2'3 4'5 5'6)	1.81		1.92		25.82		5.86		11.49		3.94		0.12		2.69		8.54		0.05		0.19		7.02		0.01	1	4.14		4.66	
PCB	195 (2 2'3 3'4 4'5 6)	0.16		0.51		2.93		0.84		2.16		0.96		0.02	1	0.58		3.83		0.02	1	0.02	1	1.01		0.02		1.11		1.80	
PCB	206 (2 2'3 3'4 4'5 5'6)	1.52		2.13		7.45		5.33		6.89		3.12		0.25		2.58		17.39		0.02	1	1.13		6.27		0.20		2.69		4.33	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	0.91		2.04		5.05		5.20		4.44		3.99		0.23		2.46		105.27		1.13		1.79		6.82		0.21		2.12		4.50	
PCB	28 (2 4 4')	2.06		1.26		12.92		2.11		6.25		1.50		0.06		0.51		1.66		0.09		0.59		2.54		0.15		2.17		3.67	
PCB	44 (2 2'3 5')	2.04		1.98		65.05		2.59		6.79		1.47		0.09		0.98		3.94		0.14		0.20		4.49		0.19		3.06		3.69	
PCB	52 (2 2'5 5)	3.21		3.62		130.50		4.51		12.82		2.85		0.05	2	1.78		9.69		0.28		0.46		9.22		0.30		5.42		7.23	
PCB	66 (2 3'4 4')	6.16		1.63		179.58		2.95		5.87		1.65		0.10		1.00		3.87		0.14		0.39		0.94		0.11		2.44		2.72	
PCB	8 (2 4)	0.59		0.53		5.64		0.75		2.52		0.66		0.06	1	0.15		0.60		0.06	1	0.11		1.22		0.06	1	0.51		1.43	
PCB	PCB Sum of Congeners	46.81	4	49.12	4	1650.00	4	101.93	4	215.23	4	66.85	4	1.43	4	40.74	4	273.19	4	2.67	4	6.48	4	157.64	4	1.60	4	73.35	4	110.49	4
PCB	PCB Sum of Congeners x 2	93.61	4	98.24	4	3310.00	4	203.86	4	430.46	4	133.71	4	2.85	4	81.48	4	546.38	4	5.34	4	12.96	4	315.29	4	3.20	4	146.69	4	220.99	4
PST	Aldrin	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.12	2	0.13	2	0.10	1
PST	Hexachlorobenzene	0.08	1	0.12	2	0.12	2	0.10	2	0.09	2	0.09	2	0.08	1	0.08	1	0.16	2	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1
PST	Mirex	0.10	1	0.19	2	2.59		0.39		1.66		0.17	2	0.10	1	0.10	1	0.10	1	0.10	1	0.13	2	5.03		0.10	1	0.16	2	0.33	
PST	o,p'-DDE	0.10	1	1.52		65.22		3.03		6.34		1.87		0.10	1	1.12		4.96		0.10	1	0.42		5.66		0.28		2.45		3.63	
PST	p,p'-DDE	0.87		0.61		7.00		17.06		5.01		2.03		0.12		9.25		6.29		0.23		0.59		4.44		0.16		4.88		1.95	
TBT	Dibutyltin	0.82	2	2.58		5.56		43.40		5.03		21.00		0.50	1	0.50	1	20.58		0.50	1	0.50	1	4.06		0.50	1	0.50	1	86.93	
TBT	Monobutyltin	0.50	1	1.05		4.80		14.99		2.90		8.88		0.50	1	0.50	1	8.65		0.50	1	0.50	1	2.45		0.50	1	0.50	1	45.50	
TBT	Tetrabutyltin	0.50	1	0.29	2	0.50	1	0.50	1	0.50	1	0.60	2	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.45	2
TBT	Tributyltin	0.73	2	2.27		8.52		140.54		12.87		65.36		0.50	1	0.50	1	60.89		0.50	1	0.50	1	6.86		0.50	1	0.50	1	228.12	

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt.

Data Qualifiers (DQ): 1=ND (not detected) or U (undetected); 2=B or J (estimated values); 3=I (interference); 4=Z (calculated values). Station codes: S = surface; M = mid; B = bottom

Appendix A-1-1. (continued).

Type	Analyte	DSY-32-S	DQ	DSY-33-S	DQ	DSY-34-B	DQ	DSY-34-M	DQ	DSY-34-S	DQ	DSY-35-S	DQ	DSY-36-B	DQ	DSY-36-M	DQ	DSY-36-S	DQ	DSY-37-S	DQ	DSY-38-S	DQ	DSY-39-S	DQ	DSY-40-S	DQ	DSY-41-S	DQ	DSY-V4-B	DQ
MET	Aluminum	34225.00		23359.50		24773.00		32772.50		32957.50		19687.25		18196.25		31102.50		38025.00		27580.00		37845.00		34007.50		25730.00		26762.50		17407.75	
MET	Arsenic	10.93		7.39		7.41		6.79		9.66		3.39		4.11		7.79		11.21		7.41		8.94		7.58		6.79		11.43		8.59	
MET	Cadmium	0.72	2	0.19	2	0.14	2	0.16	2	0.32	2	0.09	2	0.10	2	0.93	2	0.40	2	0.32	2	0.25	2	0.18	2	0.50	2	0.18	2	0.11	2
MET	Chromium	84.75		46.50		54.50		48.00		64.25		24.25		30.50		110.50		83.25		56.50		66.00		56.50		44.50		36.75		44.00	
MET	Copper	66.75		17.25		4.25		1.88	1	33.50		1.88	1	1.88	1	104.50		54.00		27.00		28.00		20.00		29.75		9.25		18.25	
MET	Iron	26545.00		21405.75		23519.75		21319.75		25630.00		12660.00		13836.00		28667.50		28620.00		20071.50		26180.00		21417.75		20511.00		17739.25		33277.75	
MET	Lead	124.80		40.00		25.70		24.50		47.60		14.00		33.50		112.50		78.80		56.90		62.20		54.00		42.10		17.00		12.80	
MET	Manganese	293.50		133.50		312.00		294.25		280.00		90.25		132.25		317.25		312.75		265.00		333.75		285.25		116.50		106.00		343.25	
MET	Mercury	0.37		0.13		0.02	2	0.02	2	0.15		0.07		0.02	2	0.75		0.38		0.28		0.28		0.15		0.19		0.02	2	0.02	1
MET	Nickel	25.75		18.25		21.50		17.00		20.50		5.00	2	5.00	2	30.75		25.75		16.75		22.00		17.75		17.25		14.50		30.75	
MET	Silver	0.81		0.24		0.07	1	0.07	1	0.29		0.07	1	0.07	1	1.54		0.58		0.39		0.16		0.26		0.21		0.07	1	0.16	
MET	Zinc	201.25		72.25		55.50		47.00		105.50		28.50		35.50		213.75		144.25		93.50		109.00		97.25		100.25		47.25		71.25	
PAH	1,6,7-Trimethylnaphthalene	7.89		2.04		0.54	1	0.77	2	4.43		0.16	2	0.54	1	11.56		6.41		4.74		4.04		4.57		4.66		0.45	2	0.54	1
PAH	1-Methylnaphthalene	17.57		5.11	2	3.26	1	1.63	2	12.70		0.37	2	3.26	1	26.36		16.71		12.63		9.17		9.27		9.41		1.27	2	3.26	1
PAH	1-Methylphenanthrene	51.57		8.88		2.72	1	2.53	2	18.31		0.50	2	2.03	2	41.60		33.92		39.80		30.93		20.22		38.26		2.22	2	2.72	1
PAH	2,6-Dimethylnaphthalene	43.59		9.91		1.78		4.96		9.56		1.69	2	1.78	1	82.87		46.60		18.82		18.31		14.31		17.33		2.36	2	1.78	1
PAH	2-Methylnaphthalene	32.08		9.66	2	5.30	1	2.98	2	24.22		0.65	2	5.30	1	49.55		23.00		17.64		13.96		15.17		16.39		2.01	2	5.30	1
PAH	Acenaphthene	14.29		3.31		0.44	1	0.78	2	8.55		0.23	2	0.44	1	27.38		11.00		7.41		6.53		10.15		16.20		1.71		0.44	1
PAH	Acenaphthylene	131.30		11.85		0.77	1	5.21		28.68		0.61	2	1.31	2	76.23		74.94		34.51		25.06		22.52		95.65		0.77		0.77	1
PAH	Anthracene	298.06		31.49		1.09	1	10.00		64.35		1.60	2	2.57		144.02		157.57		140.82		94.02		77.19		233.92		11.10		2.06	2
PAH	Benzo(a)anthracene	367.70		50.03		0.75	2	19.37		100.90		2.76	2	6.82		263.80		221.59		144.42		111.56		97.70		233.59		13.76		9.71	
PAH	Benzo(a)pyrene	494.69		67.85		2.42	1	21.03		147.63		4.14	2	10.31		432.41		319.44		163.80		119.82		143.00		316.65		18.55		6.23	
PAH	Benzo(b,j,k)fluoranthene	1100.00		155.34		3.04	2	49.30		348.29		10.95	2	22.04		865.17		699.67		308.41		259.85		302.35		835.60		47.26		13.22	
PAH	Benzo(e)pyrene	417.17		63.45		2.04	1	21.25		141.09		5.02		9.11		449.42		274.88		139.52		111.85		125.90		333.01		19.44		4.69	
PAH	Benzo(g,h,i)perylene	286.71		50.33		1.10	2	15.95		97.60		4.12		8.09		300.70		195.14		125.85		94.65		96.67		183.69		12.18		1.97	2
PAH	Biphenyl	15.37		3.18		0.64	1	0.98	2	6.42		0.42	2	0.64	1	17.11		10.50		5.79		5.70		5.64		6.02		0.66	2	0.64	1
PAH	Chrysene	491.28		58.78		0.66	2	15.04		127.76		3.63	2	7.47	2	271.51		287.36		154.27		107.11		119.88		444.33		20.65		8.13	
PAH	Dibenz(a,h)anthracene	72.22		12.41		1.39	1	4.70		26.45		0.92	2	1.88	2	96.43		48.30		28.80		21.03		27.35		52.77		3.18		0.30	2
PAH	Fluoranthene	535.28		95.23		1.34	2	23.81		207.84		7.22	2	11.85		398.79		345.08		262.14		229.98		215.98		779.35		37.83		7.40	2
PAH	Fluorene	25.73		6.57		1.34	1	1.77	2	13.92		0.58	2	1.34	1	36.67		18.02		9.74		6.42		14.73		19.09		2.09	2	1.34	1
PAH	High Molecular Weight PAHs	2897.78	4	391.25	4	7.36	4	126.73	4	860.37	4	25.14	4	53.14	4	2129.07	4	1703.29	4	1115.87	4	843.90	4	830.61	4	3016.69	4	143.52	4	64.68	4
PAH	Indeno(1,2,3-cd)pyrene	263.62		45.31		0.94	2	16.64		93.27		3.15	2	7.16		303.87		177.64		100.45		80.23		91.28		165.57		11.44		2.16	2
PAH	Low Molecular Weight PAHs	725.95	4	119.91	4	12.59	4	35.26	4	272.21	4	8.01	4	19.34	4	635.44	4	456.21	4	320.09	4	236.35	4	279.43	4	705.85	4	39.69	4	14.02	4
PAH	Naphthalene	42.67		10.87		2.60	1	3.05	2	22.27		0.68	2	2.60	1	68.61		34.06		26.88		23.22		23.68		21.00		1.84	2	2.60	1
PAH	Perylene	150.48		23.92		27.44		22.69		61.03		2.11		7.15		144.03		97.64		53.29		51.09		51.92		78.70		7.31		5.75	
PAH	Phenanthrene	181.82		46.16		1.06	2	11.47		110.22		3.69	2	5.78		234.99		137.61		83.10		67.14		115.99		303.59		20.16		1.52	2
PAH	Pyrene	916.61		108.96		0.80	2	42.77		249.79		6.45	2	14.81		666.13		481.53		362.45		254.39		226.72		1190.00		49.54		32.91	
PAH	Total PAHs	5980.00	4	879.00	4	41.00	4	299.00	4	1930.00	4	61.70	4	118.00	4	5010.00	4	3720.00	4	2250.00	4	1750.00	4	1830.00	4	5390.00	4	291.00	4	96.00	4
PCB	101 (2 2'3 5 5')	14.32		1.74		0.28		1.35		2.87		0.51		0.31		21.17		6.73		6.36		2.80		2.09		3.93		0.52		0.57	
PCB	105 (2 3 3'4 4')	2.63		0.56		0.04		0.31		0.79		0.04	1	0.04	1	9.69		1.37		1.41		0.58		0.54		1.55		0.11		0.10	
PCB	118 (2 3'4 4'5)	11.28		2.34		0.14	1	1.10		3.51		0.14	1	0.14	1	22.94		6.11		5.30		2.49		2.25		4.85		0.36		0.25	2
PCB	128 (2 2'3 3'4 4')	3.14		0.55		0.10		0.41		0.87		0.04	1	0.04	1	8.19		1.86		1.77		0.83		0.60		1.42		0.23		0.06	2
PCB	138 (2 2'3 4 4'5)	15.18		2.89		0.20	2	1.30		4.86		0.14	1	0.14	1	34.73		9.08		7.39		5.13		4.14		7.10		0.59		0.31	
PCB	153 (2 2'4 4'5 5')	12.23		2.72		0.11	2	1.12		4.61		0.21		0.06	2	25.83		8.00		5.85		4.46		4.42		5.87		0.52		0.23	
PCB	170 (2 2'3 3'4 4'5)	2.30		0.80		0.04	1	0.33		1.39		0.13		0.05	2	8.52		1.75		1.40		1.34		1.52		1.71		0.17		0.04	1
PCB	18 (2 2'5)	0.91		0.26		0.15		0.02	1	0.24		0.02	1	0.02	1	2.09		0.49		0.34		0.68		0.25		0.34		0.27		0.47	
PCB	180 (2 2'3 4 4'5 5')	4.52		1.50		0.05	1	0.81		2.46		0.28		0.05	1	13.67		3.20		2.54		2.52		2.77		3.46		0.33		0.21	
PCB	187 (2 2'3 4'5 5'6)	4.26		1.19		0.08		0.48		1.89		0.08		0.06		9.05		3.40		2.40		1.91		1.85		2.26		0.29		0.06	
PCB	195 (2 2'3 3'4 4'5 6)	0.53		0.19		0.11		0.49		0.49		0.09		0.02	1	1.02		0.32		0.18		0.27		0.57		0.56		0.17		0.06	
PCB	206 (2 2'3 3'4 4'5 5'6)	2.68		1.12		0.21		0.58		1.81		0.44		0.41		7.49		2.23		2.79		1.12		1.93		2.39		0.69		0.23	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	4.34		1.29		0.20		0.70		1.98		0.38		0.39		5.46		2.40		3.10		1.55		2.07		2.84		0.79		0.25	
PCB	28 (2 4 4')	2.61		0.57		0.18		0.23		0.88		0.24		0.17		3.12		1.27		0.76		0.56		0.79		0.67		0.20		0.15	
PCB	44 (2 2'3 5')	2.59		0.54		0.23		0.30		0.85		0.38		0.28		6.03		1.12		1.05		0.47		0.93		0.80		0.52		0.23	
PCB	52 (2 2'5 5)	4.43		0.96		0.31		0.54		1.37		0.51		0.24		10.52		1.37		2.10		0.71		1.20		1.47		0.73		0.24	
PCB	66 (2 3'4 4')	11.28		0.46		0.14		0.34		0.88		0.12		0.08		5.57		5.36		4.77		2.08		0.90		0.71		0.24		0.11	
PCB	8 (2 4)	1.23		0.29		0.06	1	0.06	2	0.33		0.06	1	0.06	1	1.64		0.60		0.46		0.17		0.26		0.15		0.17		0.19	
PCB	PCB Sum of Congeners	100.46	4	19.97	4	2.48	4	10.47	4	32.29	4	3.35	4	2.05	4	196.73	4	56.64	4	49.95	4	29.67	4	29.08	4	42.07	4	6.88	4	3.72	4
PCB	PCB Sum of Congeners x 2	200.91	4	39.93	4	4.96	4	20.93	4	64.58	4	6.70	4	4.11	4	393.46	4	113.27	4	99.90	4	59.33	4	58.16	4	84.13	4	13.75	4	7.43	4
PST	Aldrin	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1	0.10	1
PST	Hexachlorobenzene	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1	0.08	1
PST	Mirex	0.71		0.10	1	0.10	1	0.08	2	0.29		0.10	1	0.10	1	2.22		0.37		0.36		0.34		0.10	1	0.23		0.10	1	0.13	2
PST	o,p'-DDE	0.26		0.63		0.27		0.65		0.90		0.26		0.34		7.87		0.25		0.10	1	0.10	1	0.71		1.07		0.40		0.33	
PST	p,p'-DDE	2.38		0.42		0.19		0.18		0.96		0.03		0.11		14.27		2.60		1.35		1.29		0.73		1.14		0.08		0.03	
TBT	Dibutyltin	2.71		0.50	1	0.50	1	0.50	1	3.38		0.50	1	0.50	1	0.50	1	3.22		0.50	1	0.50	1	0.50	1	4.90		0.50	1	0.50	1
TBT	Monobutyltin	1.12		0.50	1	0.50	1	0.50	1	1.85		0.50	1	0.50	1	0.50	1	2.32		0.50	1	0.50	1	0.50	1	3.32		0.50	1	0.50	1
TBT	Tetrabutyltin	0.38	2	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1
TBT	Tributyltin	4.26		0.50	1	0.50	1	0.50	1	4.13		0.50	1	0.50	1	0.50	1	5.01		0.50	1	0.50	1	0.50	1	4.21		0.50	1	0.50	1

Units: MET = µg/g dry wt.; PAH, PCB, PST = ng/g dry wt.; TBT = ng Sn/g dry wt.

Data Qualifiers (DQ): see Page 1. Station Codes: see Page 1.

Appendix A-1-1. (continued).

Type	Analyte	DSY-V4-M	DQ	DSY-V9-B	DQ	DSY-V9-M	DQ	JPC-1-S	DQ	JPC-2-S	DQ
MET	Aluminum	29658.75		18200.25		18218.00		27475.00		30460.00	
MET	Arsenic	4.65		11.38		10.32		2.61		4.84	
MET	Cadmium	0.07	2	0.10	2	1.24	2	0.29	2	0.17	2
MET	Chromium	108.00		29.75		50.75		36.50		49.00	
MET	Copper	168.00		2.50	2	1.50	2	7.00		13.75	
MET	Iron	30379.25		17196.00		15478.25		18091.50		18616.50	
MET	Lead	16.10		15.50		182.00		29.70		53.20	
MET	Manganese	268.25		189.00		193.50		293.50		284.25	
MET	Mercury	0.88		0.02	1	0.02	1	0.24		0.11	
MET	Nickel	37.25		15.50		13.00		14.25		14.00	
MET	Silver	0.15		0.17		1.82		0.14		0.26	
MET	Zinc	466.50		36.00		29.75		58.00		79.25	
PAH	1,6,7-Trimethylnaphthalene	0.54	1	1.89		15.71		1.46			
PAH	1-Methylnaphthalene	3.26	1	5.56		42.67		2.58	2		
PAH	1-Methylphenanthrene	2.21	2	14.22		148.39		9.49			
PAH	2,6-Dimethylnaphthalene	1.78	1	0.55	2	56.96		6.18			
PAH	2-Methylnaphthalene		3	3.50		31.72		3.83	2		
PAH	Acenaphthene	0.44	1	0.44		27.31		1.42			
PAH	Acenaphthylene	1.00		26.84		326.77		10.66			
PAH	Anthracene	1.09	1	91.18		987.97		21.21			
PAH	Benzo(a)anthracene		3	358.64		3740.00		45.10			
PAH	Benzo(a)pyrene		3	235.64		2380.00		62.67			
PAH	Benzo(b,j,k)fluoranthene	1.91	2	573.80		6100.00		124.81			
PAH	Benzo(e)pyrene	1.59	2	197.27		2070.00		53.19			
PAH	Benzo(g,h,i)perylene	25.00		49.27		846.94		37.28			
PAH	Biphenyl	0.64	1	0.64		18.11		1.35			
PAH	Chrysene	3.76		243.05		2690.00		49.91			
PAH	Dibenz(a,h)anthracene	1.07	2	22.71		257.28		10.10			
PAH	Fluoranthene	14.37		274.74		2580.00		99.28			
PAH	Fluorene	2.08	2	13.25		150.99		4.56			
PAH	High Molecular Weight PAHs	19.20	4	2075.22	4	21497.28	4	365.19	4		
PAH	Indeno(1,2,3-cd)pyrene	1.65	1	80.32		871.60		34.58			
PAH	Low Molecular Weight PAHs	5.81	4	226.10	4	2438.75	4	90.80	4		
PAH	Naphthalene		3	5.26		51.62		5.40			
PAH	Perylene	0.45	1	66.67		617.53		19.27			
PAH	Phenanthrene	1.20	2	85.84		862.37		43.71			
PAH	Pyrene		3	940.43		9870.00		97.93			
PAH	Total PAHs	25.43	4	3300.00	4	34723.90	4	746.00	4		
PCB	101 (2 2'3 5 5')	1.13		5.31		76.22		0.82			
PCB	105 (2 3 3'4 4')	0.18		2.47		42.75		0.18			
PCB	118 (2 3'4 4'5)	0.69		5.49		81.98		0.57			
PCB	128 (2 2'3 3'4 4')	0.15		1.27		25.18		0.25			
PCB	138 (2 2'3 4 4'5)	0.85		5.81		94.98		0.97			
PCB	153 (2 2'4 4'5 5')	0.70		4.09		85.41		0.98			
PCB	170 (2 2'3 3'4 4'5)	0.13		0.97		20.40		0.34			
PCB	18 (2 2'5)	0.45		2.13		27.54		0.15			
PCB	180 (2 2'3 4 4'5 5')	0.59		1.53		29.21		0.55			
PCB	187 (2 2'3 4'5 5'6)	0.30		0.88		14.69		0.47			
PCB	195 (2 2'3 3'4 4'5 6)	0.15		0.26		3.56		0.22			
PCB	206 (2 2'3 3'4 4'5 5'6)	0.39		0.60		9.72		0.71			
PCB	209 (2 2'3 3'4 4'5 5'6 6')	0.82		0.82		9.62		0.75			
PCB	28 (2 4 4')	0.18		2.06		28.34		0.33			
PCB	44 (2 2'3 5')	0.49		1.77		25.55		0.61			
PCB	52 (2 2'5 5)	0.87		3.88		46.25		1.11			
PCB	66 (2 3'4 4')	0.22		1.23		21.89		0.33			
PCB	8 (2 4)	0.07	2	5.26		65.95		0.06	1		
PCB	PCB Sum of Congeners	8.39	4	45.63	4	669.22	4	9.46	4		
PCB	PCB Sum of Congeners x 2	16.77	4	91.25	4	1380.00	4	18.91	4		
PST	Aldrin	0.10	1	0.10	1	0.10	1	0.10	1		
PST	Hexachlorobenzene	0.08	1	0.08	1	0.38		0.08	1		
PST	Mirex	0.07	2	0.43		8.58		0.10	1		
PST	o,p'-DDE	0.47		1.77		23.23		0.55			
PST	p,p'-DDE	0.20		0.50		9.61		0.29			
TBT	Dibutyltin	0.50	1	0.50	1	5.25		0.50	1	0.50	
TBT	Monobutyltin	0.50	1	0.50	1	3.38		0.50	1	0.50	
TBT	Tetrabutyltin	0.50	1	0.50	1	0.50	1	0.50	1	0.37	2
TBT	Tributyltin	0.50	1	0.50	1	7.27		0.28	2	0.41	2

Units: MET = µg/g dry wt.; PAH, PCB, PST = ng/g dry wt.; TBT = ng Sn/g dry wt.
Data Qualifiers (DQ): see Page 1. Station Codes: see Page 1.

APPENDIX A-1-2.
ELUTRIATE DATA

Appendix A-1-2. Results of sediment elutriate chemical analyses for the Derecktor Shipyard Marine Ecological Risk Assessment.

Type	Analyte	DSY-25	DQ	DSY-27	DQ	DSY-29	DQ	DSY-31	DQ	DSY-32	DQ	DSY-33	DQ	DSY-36	DQ	DSY-37	DQ	DSY-38	DQ	DSY-39	DQ	DSY-40	DQ	DSY-blank	DQ	JPC-1	DQ
MET	Aluminum	178.00						58.00		208.00		45.00		51.00		20.00	1	20.00	1	59.00		20.00	1	20.00	1	60.00	
MET	Arsenic	12.40						27.20		24.80		2.50	4	40.40		19.60		40.70		76.00		30.00		2.50	4	18.30	
MET	Cadmium	0.10	4					0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4
MET	Chromium	0.40	1					0.40	1	0.40	1	0.40	4	0.40	4	0.40	4	0.40	4	0.40	1	0.40	4	0.40	4	0.40	4
MET	Copper	1.25	1					5.10		1.25	4	1.25	4	1.25	1	1.25	1	1.25	4	1.25	4	1.25	4	1.25	4	1.25	1
MET	Iron	140.00						30.00	1	88.00		334.00		30.00	4	387.00		223.00		310.00		30.00	4	30.00	4	30.00	4
MET	Lead	9.40						8.50		9.40		15.90		8.30		12.90		10.70		14.60		9.00		0.75	4	13.20	
MET	Manganese	187.00						83.00		163.00		1213.00		242.00		1126.00		935.00		2284.00		87.00		4.00	4	465.00	
MET	Mercury	0.10	4					0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4	0.10	4
MET	Nickel	4.00	1					4.00	1	4.00	1	4.00	1	4.00	1	4.00	1	4.00	1	4.00	1	4.00	1	4.00	1	4.00	1
MET	Silver	0.25	1					0.25	1	0.25	1	0.25	1	0.25	4	0.25	1	0.25	4	0.25	1	0.25	4	0.25	1	0.25	4
MET	Zinc	4.50	1					4.50	1	4.50	1	4.50	4	4.50	1	4.50	1	4.50	1	4.50	1	4.50	4	4.50	1	4.50	1
PAH	1,6,7-Trimethylnaphthalene	2.27	2	4.95	4	4.95	4	0.80	2	0.97	2	1.39	2	0.78	2	0.86	2	0.91	2	1.01	2	0.77	2	1.05	2	2.56	2
PAH	1-Methylnaphthalene	6.77	2		3		3	3.03	2	3.11	2	6.97	2	4.03	2	4.08	2	4.78	2	4.47	2	2.38	2	2.73	2		3
PAH	1-Methylphenanthrene	7.89		3.55	4	8.74		1.49	2	2.19	2	3.23	2	1.48	2	2.35	2	1.31	2	2.26	2	2.94	2	3.55	4	4.13	2
PAH	2,6-Dimethylnaphthalene	3.66	2	2.00	4	2.00	4	1.18	2	2.34	2	4.28	2	1.29	2	2.05	2	1.27	2	1.66	2	0.92	2	2.00	4		3
PAH	2-Methylnaphthalene	11.35	2		3		3	4.56	2	4.81	2	9.76	2	5.75	2	6.21	2	6.07	2	5.08	2	4.27	2	4.65	2		3
PAH	Acenaphthene	27.69		1.95	2	3.95	2	2.22	2	2.65	2	2.22	2	1.97	2	1.70	2	2.07	2	2.13	2	2.45	2	0.65	2	3.55	2
PAH	Acenaphthylene	12.85		1.70	4	1.70	4	2.89	2	3.92		6.82		2.99	2	1.60	2	1.11	2	2.18	2	4.84		0.21	2	6.06	
PAH	Anthracene	46.78			3	8.06		6.33		9.60		8.68		5.91		4.44		2.97		4.43		14.08		0.63	2	7.97	
PAH	Benzo(a)anthracene	46.47			3	42.13		8.77	2	7.50	2	11.94	2	6.56	2	4.53	2	3.78	2	4.82	2	12.15	2	1.30	2	8.86	2
PAH	Benzo(a)pyrene	40.92		6.56	2	16.10		11.01		11.25		17.42		7.76		3.73	2	1.77	2	7.74		11.69		2.06	2	11.79	
PAH	Benzo(e)pyrene	57.10		12.54		23.58		13.78		17.04		18.11		11.54		9.64		5.04		9.56		23.80		2.80	2	17.06	
PAH	Benzo(g,h,i)perylene	34.67		5.01	2	9.31		9.26		14.14		19.40		8.44		7.28	2	3.39	2	9.03		15.45		2.47	2	14.69	
PAH	Benzo(k)fluoranthene	120.00		6.80	4	47.07		31.21		39.02		38.68		21.84		19.51		8.54	2	16.88		43.77		5.04	2	36.92	
PAH	Biphenyl	2.93	2	1.19	2	1.31	2	1.32	2	1.50	2	1.81	2	1.18	2	1.88	2	1.50	2	1.61	2	1.55	2	1.25	2		3
PAH	Chrysene	31.67			3		3	3.85	2	4.17	2	12.12	2	4.55	2	3.25	2	2.38	2	3.98	2	5.80	2	2.01	2	10.06	2
PAH	Dibenz(a,h)anthracene	8.25	2	11.50	4	11.50	4	1.99	2	4.51	2	3.80	2	0.59	2	1.40	2	11.50	4	11.50	4	1.61	2	0.83	2	11.50	4
PAH	Fluoranthene	78.24		17.03		117.80		11.30		12.47		25.27		13.31		12.53		11.00		12.02		19.00		1.19	2	28.93	
PAH	Fluorene	24.80		6.15	4	6.15	4	1.62	2	2.18	2	4.75	2	1.99	2	1.84	2	2.40	2	1.96	2	1.82	2	0.83	2	4.67	2
PAH	Indeno(1,2,3-cd)pyrene	26.90		3.98	2	5.19	2	6.21	2	10.68	2	14.12	2	5.05	2	4.50	2	2.30	2	4.88	2	9.37	2	2.81	2	9.22	2
PAH	Naphthalene	14.60			3		3	5.24	2	11.64		12.82		9.58		8.22		10.91		6.65	2	7.66		8.55			3
PAH	Perylene	10.64		1.65	4	1.65	4	3.09	2	4.22		4.42		2.37	2	1.78	2	1.25	2	3.16	2	3.99		2.35	2	4.04	
PAH	Phenanthrene	28.71		8.73	2	10.07	2	10.75		8.92	2	14.97		8.99	2	12.67		8.37	2	9.06	2	11.28		5.34	2	20.89	
PAH	Pyrene	227.00		202.90		311.16		87.72		79.89		31.70		33.60		27.37		14.17		14.49		274.48		2.17	2	34.55	
PAH	Total PAHs	872.16		260.00		604.00		229.63		258.70		274.71		161.56		143.45		97.29		129.06		476.08		51.00		225.95	
PCB	101 (2,2',4,4',6')	4.61	2	6.22		4.40	2	4.81	2	2.41	2	1.96	2	2.67	2	4.90	2	2.04	2	2.33	2	3.60	2	2.60	4	3.80	2
PCB	105 (2,3,3'4,4')	0.63	2	0.92	2	0.40	2	0.50	2	0.32	2	0.21	2	0.11	2	0.14	2	0.09	2	0.16	2	0.21	2	0.06	2	0.33	2
PCB	118 (2,3'4,4',5)	2.52		3.50		1.54	2	1.47	2	1.03	2	0.73	2	0.39	2	0.55	2	0.25	2	0.44	2	0.76	2	0.12	2	0.72	2
PCB	128 (2,2',3,3'4,4')	0.36	2	0.51	2	0.26	2	0.35	2	0.21	2	0.16	2	0.07	2	0.14	2	2.10	4	0.11	2	0.19	2	2.10	4	0.34	2
PCB	138 (2,2',3,4,4',5)	2.98		3.03		2.05		1.82	2	1.28	2	1.07	2	0.62	2	1.00	2	0.55	2	0.79	2	1.33	2	0.20	2	1.05	2
PCB	153 (2,2',4,4',5,5')	2.90		2.53		1.71	2	1.71	2	1.37	2	1.10	2	0.63	2	0.95	2	0.42	2	0.88	2	1.22	2	0.16	2	1.16	2
PCB	170 (2,2',3,3'4,4',5)	0.62	2	0.61	2	0.56	2	0.28	2	0.35	2	0.22	2	0.14	2	0.17	2	0.07	2	0.13	2	0.22	2	1.35	4	0.57	2
PCB	18 (2,2',5)	1.44	2	1.52	2	0.74	2	1.94	2	0.86	2	0.77	2	0.24	2	0.45	2	0.44	2	0.20	2	0.26	2	0.73	2	0.10	2
PCB	180 (2,2'3,4,4',5,5')	2.36		0.63	2	1.26	2	0.61	2	0.48	2	0.46	2	0.21	2	0.36	2	0.19	2	0.33	2	1.75	2	0.06	2	0.74	2
PCB	187 (2,2',3,4',5,5',6)	1.16	2	0.54	2	0.71	2	0.66	2	0.48	2	0.41	2	0.28	2	0.36	2	0.17	2	0.36	2	0.50	2	0.08	2	0.52	2
PCB	195 (2,2',3,3',4,4',5,6)	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.50	4	1.44	2
PCB	206 (2,2'3,3'4,4'5,5'6)	2.98		1.38	2	2.82	2	2.32	2	2.06	2	0.96	2	1.20	2	1.91	2	0.50	2	0.60	2	1.61	2	0.91	2	2.84	2
PCB	209 (2,2',3,3',4,4',5,5',6,6')	2.88	2	1.38	2	3.41	2	2.31	2	1.59	2	0.85	2	1.29	2	2.22	2	0.14	2	0.27	2	1.11	2	0.79	2	2.42	2
PCB	28 (2,4,4')	3.17		1.48	2	1.13	2	1.83	2	1.48	2	0.76	2	1.13	2	0.53	2	0.99	2	0.93	2	1.06	2	1.30	2	1.10	2
PCB	44 (2,2'3,5')	3.49	2	3.42	2	2.81	2	4.81	2	2.55	2	1.64	2	1.79	2	2.34	2	2.01	2	2.94	2	1.79	2	0.54	2	4.28	2
PCB	52 (2,2',5,5)	5.53		5.99		2.93	2	3.10	2	2.64	2	1.67	2	2.06	2	2.37	2	1.51	2	2.23	2	2.35	2	1.39	2	2.36	2
PCB	66 (2,3'4,4')	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4	3.60	4
PCB	8 (2,4)	1.29	2	1.06	2	0.41	2	0.88	2	0.44	2	0.34	2	0.29	2	0.32	2	0.22	2	0.25	2	0.37	2	0.83	2	0.42	2
PCB	Total PCBs (Sum Congenersx	77.82		69.45		54.32		58.83		39.09		26.62		26.26		37.43		19.20		25.87		36.66		14.33		48.37	
PST	Aldrin	1.60	4	0.88	2	0.94	2	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4	1.60	4
PST	Hexachlorobenzene	0.08	2	0.11	2	0.90	4	0.26	2	0.06	2	0.08	2	0.90	4	0.05	2	0.05	2	0.05	2	0.11	2	0.30	2	0.13	2
PST	Mirex	0.40	2	0.09	2	0.71	2	0.60	4	0.13	2	0.60	4	0.60	4	0.09	2	0.10	2	0.05	2	0.10	2	0.60	4	0.09	2
PST	o,p'-DDE	3.52		2.80	2	2.97	2	3.21		1.90	2	1.33	2	2.04	2	3.39		1.44	2	2.25	2	2.48	2	0.28	2	3.59	
PST	p,p'-DDE	0.42	2	0.42	2	0.63	2	0.64	2	0.30	2	0.31	2	0.39	2	0.71	2	0.25	2	0.61	2	0.59	2	1.15	4	1.01	2
TBT	Dibutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Monobutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tributyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt.

Data Qualifiers (DQ): 1=B (estimated values); 2=J (estimated values); 3=I (interference); 4=ND or U (not detected).

APPENDIX A-1-3.
TISSUE DATA

Appendix Table A-1-3.1. Results of tissue chemical analyses for the Derecktor Shipyard Marine Ecological Risk Assessment.

Type	Analyte	DSY-24-IBM	DQ	DSY-25-IBM	DQ	DSY-25-LOB	DQ	DSY-26-CN	DQ	DSY-26-DM	DQ	DSY-26-IBM	DQ	DSY-27-IBM	DQ	DSY-27-LOB	DQ	DSY-28-CN	DQ	DSY-28-DM	DQ	DSY-28-IBM	DQ	DSY-28-LOB	DQ	DSY-29-CN	DQ	DSY-29-DM	DQ
MET	Aluminum	145.73		58.21		5.0E-2	4	16.77		84.52		181.94		372.62		31.10		12.08		78.43		106.45		5.0E-2	4	25.62		68.43	
MET	Arsenic	10.22		12.56		28.64		3.64		5.32		8.22		6.68		17.19		4.89		16.84		2.68				7.67		8.94	
MET	Cadmium	1.86		1.21		0.38		0.83		0.94		0.73		0.77		0.28		1.09		0.77		0.62				1.15		0.81	
MET	Chromium	3.15		3.00		1.66		1.39		2.16		2.44		2.86		2.11		0.94		2.38		2.54				1.18		2.02	
MET	Copper	4.16		11.94		151.59		17.48		13.28		7.69		14.90		166.79		15.30		10.98		1.13				21.81		6.32	
MET	Iron	437.19		210.82		40.27		52.92		176.05		300.90		369.10		81.64		40.84		192.45		107.80		34.36		66.39		118.23	
MET	Lead	5.81		2.5E-4	4	0.16		0.79		1.36		2.5E-4	4	3.02		6.9E-2		2.5E-4	4	2.5E-4	4	2.5E-4	4			0.91		0.94	
MET	Manganese	17.34		11.24		2.58		2.24		6.98		5.59		31.84		1.39		2.34		14.41		38.32				1.97		18.82	
MET	Mercury	0.28		0.17		0.26		0.13		0.16		0.12		0.15		0.45		0.10		0.13		0.14				0.17		0.17	
MET	Nickel	5.44		3.43		1.52		1.02		1.82		2.5E-4	4	4.74		1.20		1.29		4.87		2.5E-4	4			1.74		2.87	
MET	Silver	1.5E-4	4	1.5E-4	4	5.47		0.52		1.5E-4	4	1.5E-4	4	1.5E-4	4	6.87		0.31		1.18		1.5E-4	4			1.5E-4	4	1.5E-4	4
MET	Zinc	76.33		112.43		87.87		41.51		102.92		90.97		142.27		112.75		26.47		95.25		120.65				28.54		74.94	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	19.16		3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene		1	14.87		5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.27	2	12.46		5.67	4	5.67	4	13.26		32.77		5.67	4
PAH	1-Methylphenanthrene	8.52	2	26.00		9.05	4	9.05	4	9.05	4	36.34		49.74		44.61		1210.00		9.05	4	9.05	4	83.72		32.58		9.05	4
PAH	2,6-Dimethylnaphthalene	43.87		13.80		5.25	4	5.25	4	26.95		16.09		24.70		5.25	4	5.25	4	5.25	4	5.25	4	12.56		5.25	4	47.15	
PAH	2-Methylnaphthalene		1	28.07		9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	7.65	2	14.12	2	9.40	4	9.40	4	12.28	2	23.95		9.40	4
PAH	Acenaphthene	2.65	4	15.66		2.65	4	28.90		67.31		2.65	4	2.65	4	32.54		45.70		2.65	4	2.65	4	2.65	4	39.49		150.54	
PAH	Acenaphthylene	11.51		74.50		2.89	4	2.89	4	49.52		89.51		59.11		2.89	4	3.91	2	2.89	4	34.78		2.89	4	2.89	4	31.21	
PAH	Anthracene	17.73		183.90		8.00	4	8.00	4	64.97		237.08		166.77		8.21	2	5.95	2	23.68		68.19		4.15	2	6.15	2	40.24	
PAH	Benzo(a)anthracene	15.25		280.52		3.36	4	12.70		75.61		1040.08		289.71		29.01		42.87		42.28		71.77		24.30		3.36	4	53.68	
PAH	Benzo(a)pyrene	7.91		114.52		3.62	4	19.10		3.62	4	548.05		73.10		28.73		1.58	2	3.62	4	33.86		24.95		11.99		3.62	4
PAH	Benzo(b,j,k)fluoranthene	43.30		551.35		6.20	4	48.20		119.63		2310.00		393.03		60.96		6.20	4	76.68		127.59		58.37		26.97		70.97	
PAH	Benzo(e)pyrene	36.94		274.49		3.90	4	21.70		88.63		820.01		233.84		20.01		3.90	4	60.79		107.90		20.12		3.90	4	59.32	
PAH	Benzo(g,h,i)perylene	20.84		48.06		1.56	4	19.50		1.56	4	147.61		29.20		8.21		1.56	4	1.56	4	1.56	4	11.71		1.56	4	1.56	4
PAH	Biphenyl	5.70	4	11.63		5.70	4	14.20		5.70	4	5.70	4	12.89		5.70	4	7.40	2	5.70	4	5.70	4	8.08	2	6.31	2	5.70	4
PAH	Chrysene	20.76		301.17		5.26	4	15.40		68.45		625.60		297.22		30.79		32.18		29.40		85.89		38.59		5.26	4	37.35	
PAH	Dibenz(a,h)anthracene	7.92		13.54		0.49	4	0.49	4	0.49	4	49.67		0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	58.94		740.57		100.49		31.80		342.88		1310.00		1160.00		88.46		24.84		116.19		245.79		72.90		38.51		170.79	
PAH	Fluorene	6.68		29.69		1.95	4	24.10		1.95	4	33.37		39.15		1.95	4	37.62		1.95	4	25.14		1.95	4	25.80		1.95	4
PAH	High Molecular Weight PAHs	159.02	5	1955.41	5	198.85	5	100.79	5	761.74	5	4613.60	5	2639.47	5	269.28	5	126.72	5	308.59	5	613.12	5	284.81	5	96.01	5	429.12	5
PAH	Indeno(1,2,3-cd)pyrene	11.87		35.47		1.54	4	14.20		1.54	4	120.93		26.78		8.64		1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	62.67	5	619.12	5	36.02	5	115.27	5	272.57	5	761.61	5	551.24	5	85.31	5	139.94	5	66.16	5	255.68	5	68.07	5	147.27	5	262.37	5
PAH	Naphthalene		1	135.71		1.68	4	1.68	4	1.68	4	183.13		1.68	4	12.00		1.68	4	1.68	4	1.68	4	12.00		1.68	4	1.68	4
PAH	Perylene		1	81.96		3.50	4	3.50	4	3.50	4	184.17			1	10.79		2.63	2	3.50	4		1	11.89		3.23	2	3.50	4
PAH	Phenanthrene	23.91		151.56		9.45	4	40.30		77.74		226.67		272.46		20.07		30.76		43.94		114.03		32.15		47.32		47.36	
PAH	Pyrene	48.23		505.09		85.64		21.30		270.70		1040.00		618.95		93.81		24.76		116.64		175.34		123.59		36.39		163.22	
PAH	Total PAHs	384.38	5	3630.00	5	186.00	5	322.00	5	1250.00	5	9020.00	5	3970.00	5	508.00	5	1500.00	5	509.57	5	1090.00	5	585.00	5	331.00	5	871.80	5
PCB	101 (2 2'3 5 5')	27.82		25.39		8.33		93.26		39.60		41.29		56.76		11.49		172.74		37.52		40.56		11.67		119.75		31.92	
PCB	105 (2 3 3'4 4')	4.74	2	3.98	2	7.32	2	30.40		528.29		7.25	2	9.63		95.72		39.69		10.37		6.42	2	36.21		38.99		126.06	
PCB	118 (2 3'4 4'5)	21.02		19.22		37.00		116.78		30.91		29.80		44.55		51.79		154.12		38.93		26.28		68.93		144.23		29.29	
PCB	128 (2 2'3 3'4 4')	14.44		7.95		4.66		24.47		11.76		16.39		19.52		7.50		38.29		12.17		11.58		12.39		31.43		11.02	
PCB	138 (2 2'3 4 4'5)	60.46		46.86		35.79		188.67		69.81		87.70		125.79		46.23		364.09		65.70		83.90		71.18		280.07		59.89	
PCB	153 (2 2'4 4'5 5')	91.54		69.81		58.40		292.62		82.44		124.61		172.85		65.82		550.06		83.31		119.09		99.11		417.55		78.44	
PCB	170 (2 2'3 3'4 4'5)	4.72		1.60		6.55		46.90		8.30		2.58		4.56		7.21		75.51		3.59		3.74		12.22		92.39		4.31	
PCB	18 (2 2'5)	2.81	2	3.25	4	3.25	4	2.35	2	16.88		2.73	2	6.25	2	2.24	2	1.40	2	3.25	4	3.25	4	3.53	2	1.48	2	3.25	4
PCB	180 (2 2'3 4 4'5 5')	11.71		8.39		15.02		115.45		19.10		12.09		27.61		18.87		202.72		15.56		16.89		34.24		209.88		17.21	
PCB	187 (2 2'3 4'5 5'6)	29.17		23.64		15.21		85.96		25.64		40.85		55.73		18.12		181.91		25.35		37.96		31.50		131.65		23.93	
PCB	195 (2 2'3 3'4 4'5 6)	0.40	4	1.18		1.60		4.75		1.42		0.40	4	0.94		2.66		5.84		1.72		2.97		4.69		8.22		1.58	
PCB	206 (2 2'3 3'4 4'5 5'6)	3.15		1.97		5.87		7.15		3.74		5.48		2.24		4.50		7.12		4.97		3.63		6.97		12.41		3.65	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	4.70		1.53		3.74		1.89		3.31		4.14		0.63	2	3.46		2.27		4.21		8.30		4.16		6.80		4.10	
PCB	28 (2 4 4')	5.78		14.23		9.08		7.91		10.19		16.39		10.15		7.26		5.79		11.11		9.89		4.52		4.40		6.52	
PCB	44 (2 2'3 5')	6.69		5.55		5.20		4.79		13.53		8.02		11.05		2.61		3.88		11.37		5.95		0.41	2	2.79		10.54	
PCB	52 (2 2'5 5)	11.68		21.25		7.55		35.95		20.43		14.23		19.85		9.61		47.80		15.92		21.85		9.24		30.92		20.69	
PCB	66 (2 3'4 4')	3.86	4	4.12	2	12.61		41.65		3.86	4	3.86	4	3.86	4	15.12		82.32		3.86	4	3.86	4	15.21		50.67		3.86	4
PCB	8 (2 4)	7.29		7.50		2.35	4		1	2.49	2	2.48	2	6.14		3.80	2		1	2.75	2	1.88	2	4.09	2		1	4.77	
PCB	PCB Sum of Congeners	307.72		264.14		233.94		1100.00		887.86		415.61		574.29		374.02		1940.00		344.55		400.92		430.27		1580.00		433.92	
PCB	PCB Sum of Congeners x 2	615.45	5	528.28	5	467.88	5	2200.00	5	1780.00	5	831.23	5	1150.00	5	748.04	5	3870.00	5	689.10	5	801.85	5	860.54	5	3170.00	5	867.83	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.40		0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	0.15	4	0.15	4	0.23	2	0.15	1	40.52		0.15	4	0.15	4	1.12		0.15	1	0.15	4	0.15	4	1.16		0.15	1	2.30	
PST	Mirex	3.55		0.46		0.75			1	5.32		2.24		2.02		1.24			1	3.02		3.69		0.65			1	2.06	
PST	o,p'-DDE	4.23		4.77		0.15	4	3.62		11.43		5.64		8.95		0.15	4	5.47		13.00		5.61		0.15	4	3.20		10.75	
PST	p,p'-DDE	7.85		4.85		5.88		29.10		12.55		7.56		11.89		8.43		44.83			1	7.30		9.80		67.05		15.68	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	40.88		3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tributyltin	13.52		25.04		3.00	4	10.56		32.71		19.88		977.01		3.00	4	33.45		11.00		49.08		3.00	4	34.52		18.05	

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana

Appendix Table A-1-3.1 (continued).

Type	Analyte	DSY-29-LOB	DQ	DSY-31-DM	DQ	DSY-31-PM	DQ	DSY-32-PM	DQ	DSY-33-DM	DQ	DSY-33-LOB	DQ	DSY-33-PM	DQ	DSY-34-PM	DQ	DSY-35-IBM	DQ	DSY-35-LOB	DQ	DSY-35-MM	DQ	DSY-35-PM	DQ	DSY-36-CN	DQ	DSY-36-IBM	DQ
MET	Aluminum	5.0E-2	4	79.62		55.01		22.97		100.92		3.89		84.62		71.38		81.85		5.0E-2	4	94.38		64.65		18.92		84.56	
MET	Arsenic	28.56		5.21		9.38		4.92		12.43		22.25		5.88		8.62		6.23		16.23		6.42		8.47		3.59		6.15	
MET	Cadmium	0.47		0.54		0.78		0.59		0.93		0.16		0.86		0.71		0.73		0.56		0.64		0.66		0.97		0.39	
MET	Chromium	1.71		2.29		1.98		1.74		2.53		1.99		1.85		2.13		2.22		2.16		2.38		2.01		0.86		2.84	
MET	Copper	100.38		8.91		14.38		10.92		8.44		60.35		8.64		10.14		7.50		128.39		6.42		8.43		15.54		7.04	
MET	Iron	27.98		195.32		164.52		177.87		288.26		31.15		190.89		201.62		204.63		40.35		256.72		123.64		49.24		197.32	
MET	Lead	0.22		1.34		1.74		2.77		1.47		0.47		2.5E-4	4	1.66		1.75		0.76		2.5E-4	4	1.66		0.97		2.5E-4	4
MET	Manganese	1.74		12.91		11.43		15.92		5.72		3.11		12.72		15.61		2.72		2.56		11.62		19.93		1.73		11.27	
MET	Mercury	0.29		0.15		0.14		0.15		0.10		0.23		0.12		0.12		0.17		0.27		0.12		0.10		0.15		0.19	
MET	Nickel	1.74		2.07		3.99		2.17		1.74		1.74		2.5E-4	4	2.11		2.5E-4	4	0.91		2.92		1.55		1.43		4.33	
MET	Silver	5.84		1.5E-4	4	1.5E-4	4	1.38		1.5E-4	4	3.43		1.5E-4	4	1.5E-4	4	1.5E-4	4	6.54		1.5E-4	4	1.5E-4	4	1.5E-4	4	1.5E-4	4
MET	Zinc	129.41		163.89		87.34		112.52		121.84		105.14		101.73		92.42		129.60		110.05		110.85		124.74		54.89		84.56	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene	9.85	2	5.67	4	5.67	4	5.67	4	5.67	4	11.58		5.67	4	5.67	4	5.67	4		1	5.67	4	5.67	4		1		1
PAH	1-Methylphenanthrene	78.83		9.05	4		1	60.78		9.05	4	86.91		158.49		125.29		9.89	2	9.05	4	4.29	2	47.09		209.13		6.79	2
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	19.25		5.25	4	5.25	4	5.25	4	5.25	4	4.56	2
PAH	2-Methylnaphthalene	14.88	2	9.40	4	9.40	4	9.40	4	9.40	4	13.77	2	9.40	4	9.40	4	9.40	4		1	9.40	4	9.40	4		1		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.83	2	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.89	4	13.52		2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	15.30	
PAH	Anthracene	8.00	4	33.41		30.36		27.53		8.00	4	8.00	4	13.37	2	19.82		25.48		3.11	2	8.00	4	6.60	2	8.00	4	29.00	
PAH	Benzo(a)anthracene	3.36	4	58.92		132.88		79.21		3.36	4	3.36	4	35.25		46.15		31.11		3.36	4	15.72		21.53				30.26	
PAH	Benzo(a)pyrene	13.09		3.62	4	44.99		42.60		3.62	4	3.62	4	22.19		22.44		3.62	4	3.62	4	6.97	2	16.15		3.62	4	12.53	
PAH	Benzo(b,j,k)fluoranthene	23.65		89.30		128.82		94.37		6.20	4	22.97		35.59		48.65		68.03		6.20	4	9.17	2	16.37		6.20	4	70.95	
PAH	Benzo(e)pyrene	9.66		45.64		3.90	4	3.90	4	3.90	4	11.89		3.90	4	3.90	4	52.28		3.90	4	1.81	2	3.70	2	3.90	4	48.57	
PAH	Benzo(g,h,i)perylene	12.67		1.56	4	25.77		34.22		1.56	4	1.56	4	13.25		11.20		14.15		1.56	4	1.56	4	1.56	4	1.56	4	10.06	
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	14.24		5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4	38.26		67.37		59.73		5.26	4	5.26	4	42.27		24.42		40.24		5.26	4	6.82	2	11.18				40.52	
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	39.03		118.77		178.61		152.28		87.34		32.14		57.18		73.39		104.83		32.88		47.51		69.25		19.44		105.11	
PAH	Fluorene	14.92		1.95	4	1.95	4	1.95	4	1.95	4	1.95	4	5.19		5.21		11.62		1.95	4	2.89	2	5.49		19.96		5.01	
PAH	High Molecular Weight PAHs	130.71	5	337.42	5	621.49	5	516.03	5	188.45	5	98.01	5	213.03	5	244.35	5	258.84	5	70.20	5	113.06	5	173.52	5	72.31	5	274.20	5
PAH	Indeno(1,2,3-cd)pyrene	10.57		1.54	4	20.43		26.87		1.54	4	1.54	4	8.78		7.89		10.38		1.54	4	1.54	4	1.54	4	1.54	4	5.99	
PAH	Low Molecular Weight PAHs	90.93	5	92.96	5	72.72	5	85.49	5	36.02	5	84.30	5	49.66	5	76.78	5	95.41	5	23.76	5	46.06	5	57.00	5	52.14	5	80.27	5
PAH	Naphthalene	19.42		1.68	4	1.68	4	1.68	4	1.68	4	35.20		1.68	4	1.68	4	1.68	4		1	1.68	4	1.68	4		1		1
PAH	Perylene	3.50	4	3.50	4		1	10.34		3.50	4	3.50	4	5.31	2	3.91	2		1	3.50	4	12.81		16.13		10.44			1
PAH	Phenanthrene	28.17		40.99		23.80		28.75		9.45	4	19.84		14.31	2	35.14		41.71		13.19	2	16.55	2	26.29		18.65	2	28.31	
PAH	Pyrene	69.49		117.37		197.15		181.73		88.38		53.14		55.67		77.45		78.56		24.59		35.55		54.92		48.77		85.29	
PAH	Total PAHs	344.00	5	542.65	5	850.00	5	812.00	5	175.72	5	302.00	5	470.00	5	501.00	5	505.50	5	74.00	5	162.00	5	297.00	5	326.00	5	498.24	5
PCB	101 (2 2'3 5 5')	9.32		48.61		21.64		16.17		35.53		10.68		19.54		7.65		34.64		5.22		5.33		18.71		122.61		39.90	
PCB	105 (2 3 3'4 4')	3.31	2	10.68		244.43		10.67		6.26	2	41.75		34.41		10.75		6.05	2	3.83	2	1.94	2	4.09	4	32.09		6.38	2
PCB	118 (2 3'4 4'5)	14.89		45.33		18.44		13.53		39.23		22.07		15.74		5.81		26.52		13.89		3.99	2	14.28		134.03		29.23	
PCB	128 (2 2'3 3'4 4')	3.54		11.66		4.67		3.52		10.34		4.27		3.54		1.50		20.25		2.45		0.98	2	6.54		29.89		19.87	
PCB	138 (2 2'3 4 4'5)	25.91		67.25		36.80		26.55		60.61		32.53		33.97		18.63		73.78		21.25		7.93		38.28		282.19		100.30	
PCB	153 (2 2'4 4'5 5')	35.44		95.88		52.35		37.77		86.14		47.06		52.06		23.58		103.67		30.59		17.13		53.09		431.10		144.40	
PCB	170 (2 2'3 3'4 4'5)	6.52		3.51		5.73		6.20		3.73		5.52		7.71		5.40		1.70		5.14		4.83		6.63		83.07		3.60	
PCB	18 (2 2'5)	4.13	2	3.25	4	2.73	2	3.25	4	1.45	2	1.24	2	3.25	4	3.25	4	3.25	4	10.73		3.25	4	3.25	4	0.78	2	3.25	4
PCB	180 (2 2'3 4 4'5 5')	14.20		15.86		18.30		14.25		15.37		14.69		20.03		13.66		11.26		10.58		11.32		18.76		187.97		17.51	
PCB	187 (2 2'3 4'5 5'6)	13.63		27.16		16.23		12.79		26.18		14.16		17.47		10.59		37.00		10.21		6.67		20.11		139.38		48.02	
PCB	195 (2 2'3 3'4 4'5 6)	4.29		1.95		2.29		1.48		1.02		4.11		4.05		1.75		0.40	4	2.00		1.07		3.04		8.58		0.40	4
PCB	206 (2 2'3 3'4 4'5 5'6)	6.35		5.66		7.84		5.01		1.85		6.46		6.45		6.41		2.57		3.61		4.87		7.28		17.42		2.92	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	5.71		4.70		6.44		4.61		0.42	2	4.36		5.18		6.60		2.65		3.07		2.54		6.20		7.93		3.33	
PCB	28 (2 4 4')	6.43		8.23		11.77		12.48		5.25		3.79		11.01		24.09		8.99		5.42		1.27	2	20.83		4.86		8.81	
PCB	44 (2 2'3 5')	0.34	2	15.97		3.84		0.38	4	9.80		4.92		11.79		7.37		6.27		8.66		0.64	2	1.16		2.61		6.92	
PCB	52 (2 2'5 5)	12.23		27.18		9.03		8.11		12.70		4.81		6.71		5.01		10.48		7.56		2.81	2	11.62		34.73		12.82	
PCB	66 (2 3'4 4')	11.36		3.86	4	12.75		10.61		3.86	4	10.31		12.21		6.91	2	3.86	4	6.80	2	6.36	2	15.55		45.10		3.86	4
PCB	8 (2 4)	2.35	4	3.05	2	2.35	4	2.35	4	3.20	2	1.83	2	2.35	4	2.35	4	2.19	2	7.28			1	2.35	4		1	3.33	2
PCB	PCB Sum of Congeners	177.58		392.85		475.26		183.75		319.09		234.54		261.87		155.70		348.02		158.26		79.68		242.05		1560.00		447.34	
PCB	PCB Sum of Congeners x 2	355.15	5	785.70	5	950.51	5	367.50	5	638.18	5	469.09	5	523.74	5	311.40	5	696.04	5	316.52	5	159.35	5	484.09	5	3130.00	5	894.67	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.97		0.15	4
PST	Hexachlorobenzene	1.16		0.15	4	0.97		0.34		0.15	4	0.49		1.14		0.52		0.15	4	1.28		0.15	1	0.71		0.15	1	0.15	4
PST	Mirex	1.07		3.86		0.48		1.06		2.70		1.55		0.86		0.56		1.32		0.59			1	0.66			1	2.94	
PST	o,p'-DDE	0.15	4	15.18		3.83		0.15	4	10.28		0.15	4	0.15	4	0.15	4	3.94		0.15	4	1.11		0.15	4	1.84		4.65	
PST	p,p'-DDE	6.31		14.54		2.99		2.52		12.96		6.64		3.80		1.52	2	12.15		4.89		1.97		4.75		53.56		8.16	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4
TBT	Tributyltin	3.00	4	9.50		47.91				20.58		3.00	4	53.80		39.25		9.18		3.00	4	39.10				12.57		35.48	

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.1 (continued).

Type	Analyte	DSY-36-LOB	DQ	DSY-36-PM	DQ	DSY-37-PM	DQ	DSY-38-DM	DQ	DSY-38-LOB	DQ	DSY-38-PM	DQ	DSY-39-DM	DQ	DSY-39-LOB	DQ	DSY-40-DM	DQ	DSY-40-IBM	DQ	DSY-41-MM	DQ	DSY-41-PM	DQ	JPC-1-DM	DQ	JPC-1-IBM	DQ
MET	Aluminum	10.46		42.98		73.82		86.31		6.0E-2	4	98.42		107.72		5.0E-2	4	132.66		126.87		101.18		60.01		241.62		338.19	
MET	Arsenic	19.84		7.43		7.43		6.08		26.08		6.08		8.94		18.66		5.96		5.27		7.46		2.16		4.42		6.77	
MET	Cadmium	2.5E-4	4	0.83		0.84		0.62		0.49		0.89		0.32		0.30		0.61		0.63		0.90		0.72		0.64		0.59	
MET	Chromium	1.97		2.46		1.73		2.62		1.95		1.84		2.99		1.64		2.71		2.23		1.76		1.94		2.91		2.44	
MET	Copper	49.16		11.98		8.93		11.44		165.20		10.44		8.59		196.89		6.32		6.99		13.15		11.90		7.21		8.62	
MET	Iron	41.84		175.44		121.95		377.17		29.17		160.38		143.00		30.29		245.29		293.70		131.51		108.71		90.36		303.97	
MET	Lead	0.34		2.18		2.97		1.93		0.28		2.5E-4	4	2.5E-4	4	0.18		2.97		2.44		1.61		2.5E-4	4	2.5E-4	4	3.28	
MET	Manganese			10.84		10.44		15.65		4.37		15.98		13.41		4.54		11.93		15.38		13.65		12.84		9.82		21.88	
MET	Mercury	0.33		0.15		0.15		0.13		0.33		0.17		0.14		0.41		0.13		0.17		0.12		0.15		0.13		0.17	
MET	Nickel	1.46		1.87		1.57		2.91		1.88		2.5E-4	4	3.34		1.46		3.43		2.5E-4	4	2.5E-4	4	1.88		3.08		2.5E-4	4
MET	Silver	2.87		1.5E-4	4	0.65		1.72		6.10		1.5E-4	4	0.98		0.82		1.5E-4	4	1.5E-4	4	1.26		1.5E-4	4	1.5E-4	4	1.5E-4	4
MET	Zinc	115.06		120.84		106.18		89.39		171.40		131.34		130.62		128.73		116.96		104.89		65.75		83.67		106.76		92.83	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene		1	5.67	4		1		1	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4		1
PAH	1-Methylphenanthrene	9.05	4	120.22		9.05	4	9.05	4	9.05	4	75.52		9.05	4	9.05	4	9.05	4	9.05	4	6.68	2	78.68		9.05	4	9.05	4
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	6.36	2	5.25	4	5.25	4	13.09		5.25	4	32.65		5.25	4	5.25	4	5.25	4	5.25	4	5.25	4
PAH	2-Methylnaphthalene		1	9.40	4		1		1	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	5.58		67.41		2.65	4	130.66		2.65	4	6.53		6.44		64.38		2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.89	4	11.89		2.89	4	5.40	2	32.51		2.89	4	49.67		22.64		4.56	2	8.54		2.89	4	11.32	
PAH	Anthracene	5.29	2	29.98		10.14	2	11.90	2	2.84	2	10.66	2	8.00	4	1.80	2	40.94		34.15		10.91	2	19.67		21.72		11.79	2
PAH	Benzo(a)anthracene	3.36	4	66.19		55.98		14.79		3.36	4	45.70		17.76		3.36	4	42.12		24.68			1	41.39		16.52		15.80	
PAH	Benzo(a)pyrene	3.62	4	32.32		23.14		8.07		3.62	4	20.67		3.62	4	3.62	4	3.62	4	6.24	2	11.08		17.34		3.62	4	7.81	
PAH	Benzo(b,j,k)fluoranthene	30.77		90.62		58.08		32.66		6.20	4	40.49		6.20	4	6.20	4	6.20	4	55.47		13.26		22.82		35.85		35.76	
PAH	Benzo(e)pyrene	3.90	4	3.90	4	8.20		30.76		3.90	4	3.90	4	44.38		3.90	4	48.57		47.00		3.05	2	3.00	2	31.96		26.39	
PAH	Benzo(g,h,i)perylene	1.56	4	14.62		26.35		1.56	4	1.56	4	12.63		23.08		1.56	4	1.56	4	1.56	4	3.71		1.56	4	1.56	4	1.56	4
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4	51.24		37.63		14.40		5.26	4	27.97		19.70		5.26	4	22.76		29.49			1	31.39		13.96		16.91	
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	33.15		0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	38.65		124.32		74.79		38.98		16.55	2	43.50		40.91		9.23	2	144.05		105.45		68.50		79.70		48.11		46.22	
PAH	Fluorene	1.95	4	1.95	4	1.95	4	1.95	4	1.95	4	4.74		1.95	4	1.95	4	1.95	4	14.34		3.62	2	7.95		1.95	4	6.46	
PAH	High Molecular Weight PAHs	94.52	5	390.20	5	275.20	5	119.94	5	38.32	5	181.57	5	158.44	5	32.52	5	336.89	5	247.82	5	145.53	5	253.48	5	139.20	5	122.19	5
PAH	Indeno(1,2,3-cd)pyrene	1.54	4	10.89		1.54	4	1.54	4	1.54	4	9.15		27.86		1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	31.32	5	80.23	5	45.02	5	46.87	5	31.48	5	46.65	5	130.40	5	27.82	5	303.41	5	157.60	5	50.22	5	70.03	5	129.79	5	49.96	5
PAH	Naphthalene		1	1.68	4		1		1	1.68	4	1.68	4	1.68	4	1.68	4	1.68	4	15.08		1.68	4	1.68	4	1.68	4		1
PAH	Perylene	3.50	4	16.58		25.61		1.44	2	3.50	4	4.05	2	3.50	4	3.50	4	3.50	4		1	12.41		13.51		3.50	4		1
PAH	Phenanthrene	18.54	2	31.69		27.39		18.48	2	10.06	2	9.19	2	9.45	4	7.46	2	68.90		59.34		13.31	2	16.35	2	27.77		17.75	2
PAH	Pyrene	43.14		115.64		83.17		43.21		9.04		43.25		43.31		10.56		123.86		81.47		65.47		83.17		56.50		34.96	
PAH	Total PAHs	136.00	5	704.00	5	430.00	5	232.93	5	38.00	5	359.00	5	383.15	5	29.00	5	704.38	5	495.35	5	223.00	5	428.00	5	316.78	5	231.16	5
PCB	101 (2 2'3 5 5')	12.54		13.87		12.11		28.18		7.17			3	24.46		37.38		29.82		44.13		8.14		7.62		26.38		25.13	
PCB	105 (2 3 3'4 4')	208.63		6.82		5.13	2	5.62	2	2.57	2		3	7.55	2	8.33		4.92	2	7.91	2	5.50	2	4.09	4	59.72		3.52	2
PCB	118 (2 3'4 4'5)	33.35		14.13		11.15		24.71		13.10			3	16.32		28.46		24.16		35.14		8.25		7.33		22.29		17.29	
PCB	128 (2 2'3 3'4 4')	5.88		4.85		5.08		8.01		2.29			3	7.26		5.56		11.58		23.00		4.37		1.91		9.18		9.61	
PCB	138 (2 2'3 4 4'5)	38.25		47.30		39.87		48.76		21.50			3	42.06		43.10		53.63		98.16		14.86		21.59		49.85		49.54	
PCB	153 (2 2'4 4'5 5')	45.95		50.45		58.18		71.46		32.23			3	58.59		60.31		70.23		136.33		22.60		32.99		71.10		80.29	
PCB	170 (2 2'3 3'4 4'5)	7.95		6.80		7.39		4.47		6.19			3	3.16		7.09		5.39		3.58		11.21		4.37		3.95		3.15	
PCB	18 (2 2'5)	3.25	4	3.01	2	1.66	2	3.25	4	3.25	4		3	3.25	4	3.25	4	2.79	2	3.25	4	3.25	4	1.01	2	2.60	2	1.08	2
PCB	180 (2 2'3 4 4'5 5')	14.97		23.66		26.17		12.77		12.24			3	10.23		18.78		17.58		19.50		12.94		19.23		14.23		12.68	
PCB	187 (2 2'3 4'5 5'6)	12.36		20.21		20.51		20.67		9.91			3	15.81		17.15		21.47		44.74		7.49		13.08		19.33		25.13	
PCB	195 (2 2'3 3'4 4'5 6)	2.53		1.03		3.12		2.88		2.11			3	1.54		2.55		2.50		2.80		1.09		2.84		1.03		4.75	
PCB	206 (2 2'3 3'4 4'5 5'6)	4.85		8.08		4.16		4.98		3.81			3	5.47		7.21		4.61		3.51		4.94		4.39		3.24		4.24	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	4.55		9.86		5.08		11.17		3.12			3	5.42		5.78		7.01		4.15		1.91		3.43		2.75		2.60	
PCB	28 (2 4 4')	4.01		1.05	2	2.52	2	6.39		4.28			3	6.72		40.80		3.69		8.91		5.31		0.27	2	4.02		17.21	
PCB	44 (2 2'3 5')	6.19		4.03		0.82		8.26		7.21			3	8.76		6.75		6.39		7.94		2.04		2.26		5.75		6.67	
PCB	52 (2 2'5 5)	7.24		7.03		2.58	2	14.06		5.24			3	14.81		13.10		11.42		13.35		3.74	2	5.02		10.17		12.63	
PCB	66 (2 3'4 4')	10.62		22.32		10.15		3.86	4	10.59			3	3.86	4	19.39		3.86	4	3.86	4	11.04		9.73		3.86	4	3.86	4
PCB	8 (2 4)	2.35	4	2.35	4		3	2.15	2	1.80	2		3	2.10	2	2.35	4	1.18	2	2.74	2		1	2.35	4	2.73	2	6.87	
PCB	PCB Sum of Congeners	419.88		248.31		213.68		274.50		145.33				230.27		321.74		278.17		455.87		125.43		137.06		308.31		282.38	
PCB	PCB Sum of Congeners x 2	839.71	5	492.62	5	427.37	5	549.01	5	290.66	5		5	460.54	5	643.47	5	556.34	5	911.74	5	250.86	5	274.11	5	616.62	5	564.71	5
PST	Aldrin	0.15	4	0.15	4		3	0.15	4	0.15	4		3	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	0.42		2.82			3	0.67		0.58			3	0.93		0.63		0.48		0.15	4	0.15	1	0.58		4.55		0.15	4
PST	Mirex	0.38		0.41		0.20	2	5.54		0.30	2		3	3.21		0.81		2.24		2.63			1	0.40		2.70		1.28	
PST	o,p'-DDE	3.59		2.80		2.09		7.09		0.15	4		3	8.84		7.09		5.42		5.69		0.15	4	1.82		4.35		3.15	
PST	p,p'-DDE	4.10		2.88		2.93		8.84		7.06			3	9.82		2.39		9.96		10.37		4.33		1.81	2	7.96		6.71	
TBT	Dibutyltin	3.00	4	3.00	4			3.00	4	3.00	4			3.00	4	3.00	4	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4			3.50	4	3.50	4			3.50	4	3.50	4	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4			2.50	4	2.50	4			2.50	4	2.50	4	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4
TBT	Tributyltin	3.00	4	67.14				8.32		3.00	4			9.66		3.00	4	3.00		31.70		30.61				11.16		3.00	4

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference), 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.1 (continued).

Type	Analyte	JPC-1-LOB	DQ	JPC-1-MF	DQ	JPC-1-MM	DQ	JPC-1-PM	DQ	CHC-1-CN	DQ	CHC-1-DM	DQ	CHC-1-IBM	DQ	CHC-1-LOB	DQ	T0-DM	DQ
MET	Aluminum	5.0E-2	4	5.0E-2	4	108.83		39.62		14.92		61.09		59.62		5.0E-2	4	100.14	
MET	Arsenic	19.43		5.92		7.73		11.04		3.48		7.48		4.68		21.68		36.05	
MET	Cadmium	0.18		1.18		0.71		0.64		0.94		0.74		0.58		0.23		0.50	
MET	Chromium	1.68		1.08		2.11		2.16		1.22		1.75		1.84		1.43		1.95	
MET	Copper	142.69		22.74		6.87		11.97		18.39		11.04		11.93		101.92		12.16	
MET	Iron	38.69		75.43		149.98		138.92		68.39		158.98		192.16		25.42		178.82	
MET	Lead	0.39		0.43		2.12		2.37		0.84		2.59		0.78		0.18		0.62	
MET	Manganese	3.12		1.87		17.63		6.12		3.21		4.95		4.98				4.29	
MET	Mercury	0.30		0.11		0.13		0.11		0.17		0.16		0.18		0.23		0.13	
MET	Nickel	1.39		1.30		1.32		2.5E-4	4	2.5E-4	4	4.11		3.84		1.57		2.5E-4	4
MET	Silver	2.19		1.5E-4	4	1.5E-4	4	1.5E-4	4	1.58		1.5E-4	4	1.5E-4	4	3.84		1.46	
MET	Zinc	105.62		34.08		116.26		120.64		21.97		74.64		91.68		118.98		85.83	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene	5.67	4	5.67	4	5.67	4	5.67	4	68.24		22.18		5.67	4	5.67	4		1
PAH	1-Methylphenanthrene	104.56		9.05	4	29.57		78.03		1080.00		15.22	2	9.05	4	81.77		9.05	4
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	5.25	4	12.27		70.80		22.16		5.25	4	5.25	4
PAH	2-Methylnaphthalene	9.40	4	9.40	4	9.40	4	9.40	4	90.98		55.42		9.40	4	9.40	4		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	10.01		55.15		2.65	4	2.65	4	2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.62	2	3.03	2	5.10	2	39.89		17.47		2.89	4	2.89	4
PAH	Anthracene	8.00	4	2.02	2	6.06	2	6.14	2	8.00	4	42.79		25.09		6.36	2	5.99	2
PAH	Benzo(a)anthracene	3.36	4		1	10.53		26.48			1	45.39		47.31		3.36	4	3.36	4
PAH	Benzo(a)pyrene	3.62	4	3.62	4	4.20	2	8.00		3.76	2	21.74		31.00		3.62	4	6.04	2
PAH	Benzo(b,j,k)fluoranthene	6.20	4	6.20	4	6.18	2	15.90		6.20	4	94.84		109.63		6.20	4	10.80	2
PAH	Benzo(e)pyrene	3.90	4	3.90	4	1.08	2	1.97	2	3.90	4	67.50		86.11		3.90	4	13.66	
PAH	Benzo(g,h,i)perylene	1.56	4	1.56	4	1.56	4	1.56	4	1.56	4	30.40		30.40		1.56	4	1.56	4
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	7.11	2	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4		1	9.77	2	17.42			1	36.07		49.49		5.26	4	5.26	4
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	21.18		0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	10.20	2	8.55	4	21.60		25.82		7.69	2	103.33		84.89		14.46	2	15.91	2
PAH	Fluorene	12.56		27.30		3.71	2	3.18	2	13.65		1.95	4	18.70		1.95	4	6.15	
PAH	High Molecular Weight PAHs	34.98	5	55.81	5	68.12	5	109.42	5	36.16	5	316.34	5	287.07	5	46.75	5	44.39	5
PAH	Indeno(1,2,3-cd)pyrene	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	15.51		1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	52.71	5	55.10	5	32.00	5	34.53	5	177.82	5	227.71	5	102.01	5	39.38	5	47.65	5
PAH	Naphthalene	1.68	4	1.68	4	1.68	4	1.68	4	34.68		1.68	4	1.68	4	1.68	4		1
PAH	Perylene	3.50	4	3.50	4	4.24	2	4.21	2	7.43		38.67			1	3.50	4		1
PAH	Phenanthrene	15.54	2	9.17	2	5.88	2	8.45	2	15.40	2	30.83		29.01		14.45	2	29.97	
PAH	Pyrene	12.05		43.15		21.54		31.22		24.22		88.63		73.89		19.57		13.34	
PAH	Total PAHs	155.00	5	82.00	5	127.00	5	230.00	5	1380.00	5	849.63	5	638.67	5	137.00	5	101.86	5
PCB	101 (2'2'3'5'5')	7.41		60.02		6.15		9.29		43.55		16.86		16.59		17.75		22.36	
PCB	105 (2'3'3'4'4')	6.69	2	21.58		1.41	2	2.35	2	12.29		3.50	2	3.43	2	5.62	2	2.15	2
PCB	118 (2'3'4'4'5)	13.78		90.63		5.70		7.52		64.40		21.15		19.33		11.16		4.64	2
PCB	128 (2'2'3'3'4'4')	5.58		19.52		1.21		1.06		7.44		9.88		13.22		7.90		9.11	
PCB	138 (2'2'3'4'4'5)	21.45		160.03		10.56		22.48		79.89		34.44		31.92		14.94		17.70	
PCB	153 (2'2'4'4'5'5')	31.35		263.80		27.14		30.99		147.00		48.84		48.08		22.10		17.78	
PCB	170 (2'2'3'3'4'4'5)	7.93		37.99		4.27		4.49		18.07		3.28		1.87		4.11		1.10	
PCB	18 (2'2'5)	25.83		2.73	2	3.25	4	1.00	2	2.09	2	3.25	4	3.25	4	57.84		2.23	2
PCB	180 (2'2'3'4'4'5'5')	10.55		98.89		16.07		13.60		45.29		8.92		4.85		3.92		3.98	
PCB	187 (2'2'3'4'5'5'6)	20.30		82.19		10.53		10.80		35.22		11.96		14.02		31.52		6.37	
PCB	195 (2'2'3'3'4'4'5'6)	0.40	4	4.45		0.48	2	1.70		4.07		1.85		1.26		0.40	4	0.40	4
PCB	206 (2'2'3'3'4'4'5'5'6)	9.55		5.61		2.94		6.97		5.50		1.85		3.81		17.00		8.45	
PCB	209 (2'2'3'3'4'4'5'5'6'6')	8.34		2.98		2.82		5.03		1.63		1.88		4.40		0.72	4	9.41	
PCB	28 (2'4'4')	14.74		10.75		1.92	2	1.50	2	4.89		7.63		16.39		20.58		14.10	
PCB	44 (2'2'3'5')	2.09		3.76		1.21		2.05		1.25		4.69		0.38	4	0.38	4	14.10	
PCB	52 (2'2'5'5)	6.10		21.32		2.81	2	3.48	2	17.97		14.17		12.78		11.46		14.75	
PCB	66 (2'3'4'4')	6.89	2	42.95		7.00	2	9.01		16.73		3.86	4	3.86	4	4.59	2	3.86	4
PCB	8 (2'4)	2.35	4		1		1	2.35	4		1	2.05	2	2.34	2	2.35	4	2.35	4
PCB	PCB Sum of Congeners	198.58		949.21		102.21		133.33		507.28		192.96		194.31		230.50		148.24	
PCB	PCB Sum of Congeners x 2	397.16	5	1900.00	5	204.41	5	266.66	5	1010.00	5	385.93	5	388.62	5	461.00	5	296.49	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	1.43		0.15	1	0.15	1	0.18	2	0.15	1	0.58		0.15	4	5.23		1.56	
PST	Mirex	0.99			1		1	0.42			1	1.17		1.86		1.45		3.15	
PST	o,p'-DDE	0.15	4	5.74		1.21		1.83		2.81		4.77		1.44		8.54		7.62	
PST	p,p'-DDE	4.11		67.39		3.14		2.59		21.19		8.67		6.13		7.77		15.45	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	15.27		3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tributyltin	3.00	4	8.73		13.35		49.55		25.79		40.68		66.56		3.00	4	3.00	4

Units: MET = µg/g dry wt ; PAH, PCB and PST = ng/g dry wt ; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.1. Results of tissue chemical analyses for the Derecktor Shipyard Marine Ecological Risk Assessment.

Type	Analyte	DSY-24-IBM	DQ	DSY-25-IBM	DQ	DSY-25-LOB	DQ	DSY-26-CN	DQ	DSY-26-DM	DQ	DSY-26-IBM	DQ	DSY-27-IBM	DQ	DSY-27-LOB	DQ	DSY-28-CN	DQ	DSY-28-DM	DQ	DSY-28-IBM	DQ	DSY-28-LOB	DQ	DSY-29-CN	DQ	DSY-29-DM	DQ
MET	Aluminum	145.73		58.21		5.0E-2	4	16.77		84.52		181.94		372.82		31.10		12.08		78.43		106.45		5.0E-2	4	25.62		68.43	
MET	Arsenic	10.22		12.56		28.64		3.64		5.32		8.22		6.68		17.19		4.89		18.84		2.68				7.67		8.94	
MET	Cadmium	1.86		1.21		0.36		0.83		0.94		0.73		0.77		0.26		1.09		0.77		0.62				1.15		0.81	
MET	Chromium	3.15		3.00		1.66		1.39		2.16		2.44		2.86		2.11		0.94		2.38		2.54				1.18		2.02	
MET	Copper	4.16		11.94		151.59		17.48		13.28		7.69		14.90		166.79		15.30		10.98		1.13				21.81		6.32	
MET	Iron	437.19		210.82		40.27		52.92		176.05		300.90		369.10		81.64		40.84		192.45		107.80		34.36		68.39		118.23	
MET	Lead	5.81		2.5E-4	4	0.16		0.79		1.36		2.5E-4	4	3.02		6.9E-2		2.5E-4	4	2.5E-4	4	2.5E-4	4			0.91		0.94	
MET	Manganese	17.34		11.24		2.56		2.24		6.98		5.59		31.84		1.39		2.34		14.41		38.32				1.97		18.82	
MET	Mercury	0.28		0.17		0.26		0.13		0.18		0.12		0.15		0.45		0.10		0.13		0.14				0.17		0.17	
MET	Nickel	5.44		3.43		1.52		1.02		1.82		2.5E-4	4	4.74		1.20		1.29		4.87		2.5E-4	4			1.74		2.87	
MET	Silver	1.5E-4	4	1.5E-4	4	5.47		0.52		1.5E-4	4	1.5E-4	4	1.5E-4	4	8.87		0.31		1.18		1.5E-4	4			1.5E-4	4	1.5E-4	4
MET	Zinc	76.33		112.43		87.87		41.51		102.92		90.97		142.27		112.75		26.47		95.25		120.65				28.54		74.94	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	19.16		3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene		1	14.87		5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.27	2	12.46		5.67	4	5.67	4	13.28		32.77		5.67	4
PAH	1-Methylphenanthrene	8.52	2	26.00		9.05	4	9.05	4	9.05	4	38.34		49.74		44.61		1210.00		9.05	4	9.05	4	83.72		32.58		9.05	4
PAH	2,6-Dimethylnaphthalene	43.87		13.80		5.25	4	5.25	4	26.95		16.09		24.70		5.25	4	5.25	4	5.25	4	5.25	4	12.56		5.25	4	47.15	
PAH	2-Methylnaphthalene		1	28.07		9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	7.65	2	14.12	2	9.40	4	9.40	4	12.28	2	23.95		9.40	4
PAH	Acenaphthene	2.65	4	15.68		2.65	4	28.90		67.31		2.65	4	2.65	4	32.54		45.70		2.65	4	2.65	4	2.65	4	39.49		150.54	
PAH	Acenaphthylene	11.51		74.50		2.89	4	2.89	4	49.52		89.51		59.11		2.89	4	3.91	2	2.89	4	34.78		2.89	4	2.89	4	31.21	
PAH	Anthracene	17.73		183.90		6.00	4	6.00	4	64.97		237.08		166.77		8.21	2	5.95	2	23.68		68.19		4.15	2	6.15	2	40.24	
PAH	Benzo(a)anthracene	15.25		280.52		3.36	4	12.70		75.61		1040.08		289.71		29.01		42.87		42.26		71.77		24.30		3.36	4	53.66	
PAH	Benzo(e)pyrene	7.91		114.52		3.62	4	19.10		3.62	4	548.05		73.10		28.73		1.58	2	3.62	4	33.86		24.95		11.99		3.62	4
PAH	Benzo(b,j,k)fluoranthene	43.30		551.35		6.20	4	46.20		119.63		2310.00		393.03		60.96		6.20	4	76.68		127.59		58.37		26.97		70.97	
PAH	Benzo(e)pyrene	38.94		274.49		3.90	4	21.70		88.63		820.01		233.84		20.01		3.90	4	60.79		107.90		20.12		3.90	4	59.32	
PAH	Benzo(g,h,i)perylene	20.84		48.06		1.56	4	19.50		1.56	4	147.61		29.20		8.21		1.56	4	1.56	4	1.56	4	11.71		1.56	4	1.56	4
PAH	Biphenyl	5.70	4	11.63		5.70	4	14.20		5.70	4	5.70	4	12.69		5.70	4	7.40	2	5.70	4	5.70	4	6.08	2	6.31	2	5.70	4
PAH	Chrysene	20.76		301.17		5.26	4	16.40		68.45		625.80		297.22		30.79		32.18		29.40		85.89		38.59		5.26	4	37.35	
PAH	Dibenz(a,h)anthracene	7.92		13.54		0.49	4	0.49	4	0.49	4	49.67		0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	58.94		740.57		100.49		31.80		342.88		1310.00		1160.00		86.46		24.84		116.19		245.79		72.90		38.51		170.79	
PAH	Fluorene	6.88		29.69		1.95	4	24.10		1.95	4	33.37		39.15		1.95	4	37.82		1.95	4	25.14		1.95	4	25.80		1.95	4
PAH	High Molecular Weight PAHs	159.02	5	1955.41	5	198.85	5	100.79	5	761.74	5	4613.60	5	2639.47	5	269.28	5	126.72	5	308.59	5	613.12	5	284.81	5	96.01	5	429.12	5
PAH	Indeno(1,2,3-cd)pyrene	11.87		35.47		1.54	4	14.20		1.54	4	120.93		26.78		8.64		1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	62.67	5	619.12	5	36.02	5	115.27	5	272.57	5	781.81	5	551.24	5	85.31	5	139.94	5	88.18	5	255.88	5	68.07	5	147.27	5	282.37	5
PAH	Naphthalene		1	135.71		1.68	4	1.68	4	1.68	4	183.13		1.68	4	12.00		1.68	4	1.68	4	1.68	4	12.00		1.68	4	1.68	4
PAH	Perylene		1	81.96		3.50	4	3.50	4	3.50	4	184.17			1	10.79		2.63	2	3.50	4		1	11.89		3.23	2	3.50	4
PAH	Phenanthrene	23.91		151.56		9.45	4	40.30		77.74		226.67		272.46		20.07		30.76		43.94		114.03		32.15		47.32		47.36	
PAH	Pyrene	48.23		505.09		85.64		21.30		270.70		1040.00		818.95		93.81		24.76		116.64		175.34		123.59		36.39		163.22	
PAH	Total PAHs	384.38	5	3630.00	5	186.00	5	322.00	5	1250.00	5	9020.00	5	3970.00	5	508.00	5	1500.00	5	509.57	5	1090.00	5	565.00	5	331.00	5	871.60	5
PCB	101 (2 2'3 5 5')	27.62		25.39		6.33		93.26		39.60		41.29		56.76		11.49		172.74		37.52		40.58		11.67		119.75		31.92	
PCB	105 (2 3 3'4 4')	4.74	2	3.98	2	7.32	2	30.40		528.29		7.25	2	9.63		95.72		39.69		10.37		6.42	2	36.21		38.99		126.06	
PCB	118 (2 3'4 4'5)	21.02		19.22		37.00		116.78		30.91		29.60		44.55		51.79		154.12		38.93		26.28		68.93		144.23		29.29	
PCB	128 (2 2'3 3'4 4')	14.44		7.95		4.66		24.47		11.76		16.39		19.52		7.50		38.29		12.17		11.58		12.39		31.43		11.02	
PCB	138 (2 2'3 4 4'5)	60.46		46.86		35.79		188.67		69.81		87.70		125.79		46.23		364.09		65.70		83.90		71.18		280.07		59.89	
PCB	153 (2 2'4 4'5 5')	91.54		69.81		58.40		292.62		82.44		124.61		172.85		65.82		550.06		83.31		119.09		99.11		417.55		78.44	
PCB	170 (2 2'3 3'4 4'5)	4.72		1.60		6.55		46.90		8.30		2.58		4.56		7.21		75.51		3.59		3.74		12.22		92.39		4.31	
PCB	18 (2 2'5)	2.81	2	3.25	4	3.25	4	2.35	2	16.88		2.73	2	6.25	2	2.24	2	1.40	2	3.25	4	3.25	4	3.53	2	1.48	2	3.25	4
PCB	180 (2 2'3 4 4'5 5')	11.71		8.39		15.02		115.45		19.10		12.09		27.61		18.87		202.72		15.56		16.89		34.24		209.88		17.21	
PCB	187 (2 2'3 4'5 5'6)	29.17		23.64		15.21		85.96		25.64		40.65		55.73		18.12		181.91		25.35		37.96		31.50		131.65		23.93	
PCB	195 (2 2'3 3'4 4'5 6)	0.40	4	1.18		1.60		4.75		1.42		0.40	4	0.94		2.66		5.84		1.72		2.97		4.69		8.22		1.58	
PCB	206 (2 2'3 3'4 4'5 5'6)	3.15		1.97		5.87		7.15		3.74		5.48		2.24		4.50		7.12		4.97		3.63		6.97		12.41		3.65	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	4.70		1.53		3.74		1.89		3.31		4.14		0.83	2	3.46		2.27		4.21		8.30		4.16		6.80		4.10	
PCB	28 (2 4 4')	5.78		14.23		9.08		7.91		10.19		16.39		10.15		7.26		5.79		11.11		9.89		4.52		4.40		6.52	
PCB	44 (2 2'3 5')	6.69		5.55		5.20		4.79		13.53		8.02		11.05		2.61		3.88		11.37		5.95		0.41	2	2.79		10.54	
PCB	52 (2 2'5 5)	11.68		21.25		7.55		35.95		20.43		14.23		19.85		9.61		47.80		15.92		21.85		9.24		30.92		20.69	
PCB	66 (2 3'4 4')	3.86	4	4.12	2	12.61		41.65		3.86	4	3.86	4	3.86	4	15.12		82.32		3.86	4	3.86	4	15.21		50.67		3.86	4
PCB	8 (2 4)	7.29		7.50		2.35	4		1	2.49	2	2.48	2	6.14		3.80	2		1	2.75	2	1.88	2	4.09	2		1	4.77	
PCB	PCB Sum of Congeners	307.72		264.14		233.94		1100.00		887.86		415.61		574.29		374.02		1940.00		344.55		400.92		430.27		1580.00		433.92	
PCB	PCB Sum of Congeners x 2	615.45	5	528.28	5	467.88	5	2200.00	5	1780.00	5	831.23	5	1150.00	5	748.04	5	3870.00	5	689.10	5	801.85	5	860.54	5	3170.00	5	867.83	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.40		0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	0.15	4	0.15	4	0.23	2	0.15	1	40.52		0.15	4	0.15	4	1.12		0.15	1	0.15	4	0.15	4	1.16		0.15	1	2.30	
PST	Mirex	3.55		0.46		0.75			1	5.32		2.24		2.02		1.24			1	3.02		3.69		0.65			1	2.06	
PST	o,p'-DDE	4.23		4.77		0.15	4	3.82		11.43		5.64		8.95		0.15	4	5.47		13.00		5.81		0.15	4	3.20		10.75	
PST	p,p'-DDE	7.85		4.85		5.88		29.10		12.55		7.56		11.89		8.43		44.83			1	7.30		9.80		67.05		15.68	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	40.88		3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tributyltin	13.52		25.04		3.00	4	10.56		32.71		19.88		977.01		3.00	4	33.45		11.00		49.08		3.00	4	34.52		18.05	

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference);
2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: CN=cunner;
DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana.

Appendix Table A-1-3.1 (continued).

Type	Analyte	DSY-29-LOB	DQ	DSY-31-DM	DQ	DSY-31-PM	DQ	DSY-32-PM	DQ	DSY-33-DM	DQ	DSY-33-LOB	DQ	DSY-33-PM	DQ	DSY-34-PM	DQ	DSY-35-IBM	DQ	DSY-35-LOB	DQ	DSY-35-MM	DQ	DSY-35-PM	DQ	DSY-36-CN	DQ	DSY-36-IBM	DQ
MET	Aluminum	5.0E-2	4	79.62		55.01		22.97		100.92		3.89		84.62		71.38		81.85		5.0E-2	4	94.38		64.85		18.92		84.56	
MET	Arsenic	28.56		5.21		9.36		4.92		12.43		22.25		5.88		8.62		6.23		16.23		6.42		8.47		3.59		6.15	
MET	Cadmium	0.47		0.54		0.78		0.59		0.93		0.16		0.86		0.71		0.73		0.58		0.64		0.66		0.97		0.39	
MET	Chromium	1.71		2.29		1.98		1.74		2.53		1.99		1.85		2.13		2.22		2.16		2.38		2.01		0.86		2.84	
MET	Copper	100.38		8.91		14.38		10.92		8.44		60.35		8.84		10.14		7.50		128.39		6.42		8.43		15.54		7.04	
MET	Iron	27.98		195.32		164.52		177.87		288.26		31.15		190.89		201.62		204.63		40.35		256.72		123.64		49.24		197.32	
MET	Lead	0.22		1.34		1.74		2.77		1.47		0.47		2.5E-4	4	1.66		1.75		0.76		2.5E-4	4	1.66		0.97		2.5E-4	4
MET	Manganese	1.74		12.91		11.43		15.92		5.72		3.11		12.72		15.61		2.72		2.56		11.62		19.93		1.73		11.27	
MET	Mercury	0.29		0.15		0.14		0.15		0.10		0.23		0.12		0.12		0.17		0.27		0.12		0.10		0.15		0.19	
MET	Nickel	1.74		2.07		3.99		2.17		1.74		1.74		2.5E-4	4	2.11		2.5E-4	4	0.91		2.92		1.55		1.43		4.33	
MET	Silver	5.84		1.5E-4	4	1.5E-4	4	1.38		1.5E-4	4	3.43		1.5E-4	4	1.5E-4	4	1.5E-4	4	6.54		1.5E-4	4	1.5E-4	4	1.5E-4	4	1.5E-4	4
MET	Zinc	129.41		163.89		87.34		112.52		121.84		105.14		101.73		92.42		129.60		110.05		110.85		124.74		54.89		84.56	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene	9.85	2	5.67	4	5.67	4	5.67	4	5.67	4	11.58		5.67	4	5.67	4	5.67	4		1	5.67	4	5.67	4		1		1
PAH	1-Methylphenanthrene	78.83		9.05	4		1	60.78		9.05	4	86.91		158.49		125.29		9.89	2	9.05	4	4.29	2	47.09		209.13		6.79	2
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	5.25	4	19.25		5.25	4	5.25	4	5.25	4	5.25	4	4.56	2
PAH	2-Methylnaphthalene	14.88	2	9.40	4	9.40	4	9.40	4	9.40	4	13.77	2	9.40	4	9.40	4	9.40	4		1	9.40	4	9.40	4		1		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.83	2	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.89	4	13.52		2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	2.89	4	15.30	
PAH	Anthracene	8.00	4	33.41		30.38		27.53		8.00	4	8.00	4	13.37	2	19.82		25.48		3.11	2	8.00	4	6.60	2	8.00	4	29.00	
PAH	Benzo(a)anthracene	3.36	4	58.92		132.88		79.21		3.36	4	3.36	4	35.25		46.15		31.11		3.36	4	15.72		21.53				30.26	
PAH	Benzo(a)pyrene	13.09		3.62	4	44.99		42.60		3.62	4	3.62	4	22.19		22.44		3.62	4	3.62	4	6.97	2	16.15		3.62	4	12.53	
PAH	Benzo(b,j,k)fluoranthene	23.65		89.30		128.82		94.37		6.20	4	22.97		35.59		48.65		66.03		6.20	4	9.17	2	16.37		6.20	4	70.95	
PAH	Benzo(e)pyrene	9.66		45.64		3.90	4	3.90	4	3.90	4	11.89		3.90	4	3.90	4	52.26		3.90	4	1.81	2	3.70	2	3.90	4	48.57	
PAH	Benzo(g,h,i)perylene	12.67		1.56	4	25.77		34.22		1.56	4	1.56	4	13.25		11.20		14.15		1.56	4	1.56	4	1.56	4	1.56	4	10.06	
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	14.24		5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4	38.28		67.37		59.73		5.26	4	5.26	4	42.27		24.42		40.24		5.26	4	6.82	2	11.18				40.52	
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	39.03		118.77		178.61		152.28		87.34		32.14		57.16		73.39		104.83		32.88		47.51		69.25		19.44		105.11	
PAH	Fluorene	14.92		1.95	4	1.95	4	1.95	4	1.95	4	1.95	4	5.19		5.21		11.62		1.95	4	2.89	2	5.49		19.96		5.01	
PAH	High Molecular Weight PAHs	130.71	5	337.42	5	621.49	5	516.03	5	188.45	5	98.01	5	213.03	5	244.35	5	258.84	5	70.20	5	113.06	5	173.52	5	72.31	5	274.20	5
PAH	Indeno(1,2,3-cd)pyrene	10.57		1.54	4	20.43		28.87		1.54	4	1.54	4	8.78		7.89		10.38		1.54	4	1.54	4	1.54	4	1.54	4	5.99	
PAH	Low Molecular Weight PAHs	90.93	5	92.96	5	72.72	5	85.49	5	36.02	5	84.30	5	49.66	5	76.79	5	95.41	5	23.78	5	46.06	5	57.00	5	52.14	5	80.27	5
PAH	Naphthalene	19.42		1.68	4	1.68	4	1.68	4	1.68	4	35.20		1.68	4	1.68	4	1.68	4		1	1.68	4	1.68	4		1		1
PAH	Perylene	3.50	4	3.50	4		1	10.34		3.50	4	3.50	4	5.31	2	3.91	2		1	3.50	4	12.61		16.13		10.44			1
PAH	Phenanthrene	28.17		40.99		23.80		28.75		9.45	4	19.84		14.31	2	35.14		41.71		13.19	2	18.55	2	28.29		18.65	2	28.31	
PAH	Pyrene	69.49		117.37		197.15		161.73		88.38		53.14		55.67		77.45		78.56		24.59		35.55		54.92		48.77		85.29	
PAH	Total PAHs	344.00	5	542.65	5	850.00	5	812.00	5	175.72	5	302.00	5	470.00	5	501.00	5	505.50	5	74.00	5	162.00	5	297.00	5	326.00	5	498.24	5
PCB	101 (2 2'3 5 5')	9.32		48.81		21.64		16.17		35.53		10.68		19.54		7.65		34.64		5.22		5.33		16.71		122.61		39.90	
PCB	105 (2 3 3'4 4')	3.31	2	10.68		244.43		10.67		6.26	2	41.75		34.41		10.75		6.05	2	3.83	2	1.94	2	4.09	4	32.09		6.38	2
PCB	118 (2 3'4 4'5)	14.89		45.33		18.44		13.53		39.23		22.07		15.74		5.81		26.52		13.89		3.99	2	14.26		134.03		29.23	
PCB	128 (2 2'3 3'4 4')	3.54		11.66		4.67		3.52		10.34		4.27		3.54		1.50		20.25		2.45		0.98	2	6.54		29.89		19.87	
PCB	138 (2 2'3 4 4'5)	25.91		67.25		36.80		26.55		60.61		32.53		33.97		18.63		73.78		21.25		7.93		38.28		282.19		100.30	
PCB	153 (2 2'4 4'5 5')	35.44		95.86		52.35		37.77		86.14		47.06		52.06		23.58		103.67		30.59		17.13		53.09		431.10		144.40	
PCB	170 (2 2'3 3'4 4'5)	6.52		3.51		5.73		6.20		3.73		5.52		7.71		5.40		1.70		5.14		4.83		6.63		83.07		3.60	
PCB	18 (2 2'5)	4.13	2	3.25	4	2.73	2	3.25	4	1.45	2	1.24	2	3.25	4	3.25	4	3.25	4	10.73		3.25	4	3.25	4	0.78	2	3.25	4
PCB	180 (2 2'3 4 4'5 5')	14.20		15.86		18.30		14.25		15.37		14.69		20.03		13.66		11.26		10.58		11.32		18.76		187.97		17.51	
PCB	187 (2 2'3 4'5 5'6)	13.63		27.16		16.23		12.79		26.18		14.16		17.47		10.59		37.00		10.21		6.67		20.11		139.38		48.02	
PCB	195 (2 2'3 3'4 4'5 6)	4.29		1.95		2.29		1.48		1.02		4.11		4.05		1.75		0.40	4	2.00		1.07		3.04		6.58		0.40	4
PCB	206 (2 2'3 3'4 4'5 5'6)	6.35		5.66		7.84		5.01		1.85		6.46		6.45		6.41		2.57		3.61		4.87		7.28		17.42		2.92	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	5.71		4.70		6.44		4.61		0.42	2	4.36		5.18		6.60		2.65		3.07		2.54		6.20		7.93		3.33	
PCB	28 (2 4 4')	6.43		8.23		11.77		12.48		5.25		3.79		11.01		24.09		8.99		5.42		1.27	2	20.83		4.86		8.81	
PCB	44 (2 2'3 5')	0.34	2	15.97		3.84		0.38	4	9.60		4.92		11.79		7.37		8.27		8.66		0.64	2	1.16		2.61		6.92	
PCB	52 (2 2'5 5)	12.23		27.18		9.03		8.11		12.70		4.81		6.71		5.01		10.48		7.56		2.61	2	11.62		34.73		12.82	
PCB	66 (2 3'4 4')	11.36		3.86	4	12.75		10.61		3.86	4	10.31		12.21		6.91	2	3.86	4	6.80	2	6.38	2	15.55		45.10		3.86	4
PCB	8 (2 4)	2.35	4	3.05	2	2.35	4	2.35	4	3.20	2	1.63	2	2.35	4	2.35	4	2.19	2	7.28			1	2.35	4		1	3.33	2
PCB	PCB Sum of Congeners	177.58		392.65		475.26		183.75		319.09		234.54		281.87		155.70		348.02		158.28		79.68		242.05		1560.00		447.34	
PCB	PCB Sum of Congeners x 2	355.15	5	785.70	5	950.51	5	367.50	5	638.18	5	469.09	5	523.74	5	311.40	5	696.04	5	316.52	5	159.35	5	484.09	5	3130.00	5	894.67	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.97		0.15	4
PST	Hexachlorobenzene	1.16		0.15	4	0.97		0.34		0.15	4	0.49		1.14		0.52		0.15	4	1.26		0.15	1	0.71		0.15	1	0.15	4
PST	Mirex	1.07		3.86		0.48		1.06		2.70		1.55		0.86		0.56		1.32		0.59			1	0.66			1	2.94	
PST	o,p'-DDE	0.15	4	15.18		3.83		0.15	4	10.26		0.15	4	0.15	4	0.15	4	3.94		0.15	4	1.11		0.15	4	1.84		4.65	
PST	p,p'-DDE	6.31		14.54		2.99		2.52		12.96		6.64		3.80		1.52	2	12.15		4.89		1.97		4.75		53.56		8.16	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4
TBT	Tributyltin	3.00	4	9.50		47.91				20.56		3.00	4	53.80		39.25		9.18		3.00	4	39.10				12.57		35.48	

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.1 (continued).

Type	Analyte	DSY-36-LOB	DQ	DSY-36-PM	DQ	DSY-37-PM	DQ	DSY-38-DM	DQ	DSY-38-LOB	DQ	DSY-38-PM	DQ	DSY-39-DM	DQ	DSY-39-LOB	DQ	DSY-40-DM	DQ	DSY-40-IBM	DQ	DSY-41-MM	DQ	DSY-41-PM	DQ	JPC-1-DM	DQ	JPC-1-IBM	DQ
MET	Aluminum	10.46		42.96		73.82		86.51		6.0E-2	4	96.42		107.72		6.0E-2	4	132.66		125.87		101.10		60.01		241.62		338.19	
MET	Arsenic	19.84		7.43		7.43		6.08		26.08		8.08		8.94		18.68		8.96		5.27		7.46		2.16		4.42		6.77	
MET	Cadmium	2.5E-4	4	0.83		0.64		0.62		0.49		0.89		0.32		0.30		0.61		0.63		0.90		0.72		0.64		0.59	
MET	Chromium	1.97		2.46		1.73		2.62		1.95		1.84		2.99		1.64		2.71		2.23		1.76		1.94		2.01		2.44	
MET	Copper	49.16		11.96		8.93		11.44		165.20		10.44		8.59		196.89		6.32		8.99		13.15		11.90		7.21		8.62	
MET	Iron	41.84		175.44		121.95		377.17		29.17		160.38		143.00		30.29		245.29		293.70		131.51		108.71		90.36		303.97	
MET	Lead	0.34		2.18		2.97		1.93		0.26		2.5E-4	4	2.5E-4	4	0.18		2.97		2.44		1.61		2.5E-4	4	2.5E-4	4	3.28	
MET	Manganese			10.84		10.44		15.65		4.37		15.98		13.41		4.54		11.93		15.38		13.65		12.84		9.82		21.88	
MET	Mercury	0.33		0.15		0.15		0.13		0.33		0.17		0.14		0.41		0.13		0.17		0.12		0.15		0.13		0.17	
MET	Nickel	1.46		1.87		1.57		2.91		1.88		2.5E-4	4	3.34		1.46		3.43		2.5E-4	4	2.5E-4	4	1.88		3.08		2.5E-4	4
MET	Silver	2.87		1.5E-4	4	0.65		1.72		6.10		1.5E-4	4	0.98		0.82		1.5E-4	4	1.5E-4	4	1.26		1.5E-4	4	1.5E-4	4	1.5E-4	4
MET	Zinc	115.06		120.84		108.16		89.39		171.40		131.34		130.62		128.73		118.96		104.89		85.75		83.67		108.76		92.83	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene		1	5.67	4		1		1	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4	5.67	4		1
PAH	1-Methylphenanthrene	9.05	4	120.22		9.05	4	9.05	4	9.05	4	75.52		9.05	4	9.05	4	9.05	4	9.05	4	6.68	2	76.66		9.05	4	9.05	4
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	6.38	2	5.25	4	5.25	4	13.09		5.25	4	32.65		5.25	4	5.25	4	5.25	4	5.25	4	5.25	4
PAH	2-Methylnaphthalene		1	9.40	4		1		1	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4	9.40	4		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	2.65	4	5.58		67.41		2.65	4	130.86		2.65	4	6.53		6.44		64.38		2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.89	4	11.69		2.89	4	5.40	2	32.61		2.89	4	49.67		22.64		4.56	2	6.54		2.89	4	11.32	
PAH	Anthracene	5.29	2	29.98		10.14	2	11.90	2	2.84	2	10.66	2	8.00	4	1.80	2	40.94		34.15		10.91	2	19.67		21.72		11.79	2
PAH	Benzo(a)anthracene	3.36	4	66.19		55.98		14.79		3.36	4	45.70		17.76		3.36	4	42.12		24.68			1	41.39		16.52		15.80	
PAH	Benzo(a)pyrene	3.62	4	32.32		23.14		8.07		3.62	4	20.67		3.62	4	3.62	4	3.62	4	6.24	2	11.08		17.34		3.62	4	7.81	
PAH	Benzo(b,j,k)fluoranthene	30.77		90.62		58.08		32.66		6.20	4	40.49		6.20	4	6.20	4	6.20	4	55.47		13.26		22.82		35.85		35.76	
PAH	Benzo(e)pyrene	3.90	4	3.90	4	8.20		30.75		3.90	4	3.90	4	44.38		3.90	4	48.57		47.00		3.05	2	3.00	2	31.96		26.39	
PAH	Benzo(g,h,i)perylene	1.56	4	14.62		26.35		1.56	4	1.56	4	12.83		23.08		1.56	4	1.56	4	1.56	4	3.71		1.56	4	1.56	4	1.56	4
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4	51.24		37.63		14.40		5.26	4	27.97		19.70		5.26	4	22.76		29.49			1	31.39		13.96		16.91	
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	33.15		0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	38.65		124.32		74.78		38.98		16.55	2	43.50		40.91		9.23	2	144.05		105.45		68.50		79.70		48.11		46.22	
PAH	Fluorene	1.95	4	1.95	4	1.95	4	1.95	4	1.95	4	4.74		1.95	4	1.95	4	1.95	4	14.34		3.82	2	7.95		1.95	4	6.46	
PAH	High Molecular Weight PAHs	94.52	5	390.20	5	275.20	5	119.94	5	38.32	5	181.57	5	158.44	5	32.52	5	336.89	5	247.82	5	145.53	5	253.48	5	139.20	5	122.19	5
PAH	Indeno(1,2,3-cd)pyrene	1.54	4	10.89		1.54	4	1.54	4	1.54	4	9.15		27.86		1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	31.32	5	80.23	5	45.02	5	46.87	5	31.46	5	46.65	5	130.40	5	27.82	5	303.41	5	157.60	5	50.22	5	70.03	5	129.79	5	49.96	5
PAH	Naphthalene		1	1.68	4		1		1	1.68	4	1.68	4	1.68	4	1.68	4	1.68	4	15.08		1.68	4	1.68	4	1.68	4		1
PAH	Perylene	3.50	4	16.58		25.61		1.44	2	3.50	4	4.05	2	3.50	4	3.50	4	3.50	4		1	12.41		13.51		3.50	4		1
PAH	Phenanthrene	18.64	2	31.69		27.39		18.48	2	10.06	2	9.19	2	9.45	4	7.46	2	68.90		59.34		13.31	2	18.35	2	27.77		17.75	2
PAH	Pyrene	43.14		115.64		83.17		43.21		9.04		43.25		43.31		10.56		123.86		81.47		65.47		83.17		56.50		34.96	
PAH	Total PAHs	138.00	5	704.00	5	430.00	5	232.93	5	38.00	5	359.00	5	363.15	5	29.00	5	704.38	5	495.35	5	223.00	5	428.00	5	316.78	5	231.16	5
PCB	101 (2 2'3 5 5')	12.54		13.67		12.11		28.18		7.17			3	24.46		37.38		26.62		44.13		8.14		7.82		26.36		25.13	
PCB	105 (2 3 3'4 4')	208.63		8.82		5.13	2	5.62	2	2.57	2		3	7.55	2	8.33		4.92	2	7.91	2	5.50	2	4.09	4	59.72		3.52	2
PCB	118 (2 3'4 4'5)	33.35		14.13		11.15		24.71		13.10			3	16.32		28.46		24.16		35.14		8.25		7.33		22.29		17.29	
PCB	128 (2 2'3 3'4 4')	5.68		4.85		5.08		8.01		2.29			3	7.26		5.58		11.58		23.00		4.37		1.91		9.18		9.61	
PCB	138 (2 2'3 4 4'5)	38.25		47.30		39.87		48.76		21.50			3	42.06		43.10		53.63		98.16		14.86		21.59		49.85		49.54	
PCB	153 (2 2'4 4'5 5')	45.95		50.45		56.18		71.46		32.23			3	58.59		60.31		70.23		136.33		22.60		32.99		71.10		80.29	
PCB	170 (2 2'3 3'4 4'5)	7.95		6.60		7.39		4.47		6.19			3	3.16		7.09		5.39		3.58		11.21		4.37		3.95		3.15	
PCB	18 (2 2'5)	3.25	4	3.01	2	1.66	2	3.25	4	3.25	4		3	3.25	4	3.25	4	2.79	2	3.25	4	3.25	4	1.01	2	2.60	2	1.08	2
PCB	180 (2 2'3 4 4'5 5')	14.97		23.66		28.17		12.77		12.24			3	10.23		18.78		17.58		19.50		12.94		19.23		14.23		12.66	
PCB	187 (2 2'3 4'5 5'6)	12.36		20.21		20.51		20.67		9.91			3	15.81		17.15		21.47		44.74		7.49		13.08		19.33		25.13	
PCB	195 (2 2'3 3'4 4'5 6)	2.53		1.03		3.12		2.88		2.11			3	1.54		2.55		2.50		2.80		1.09		2.84		1.03		4.75	
PCB	206 (2 2'3 3'4 4'5 5'6)	4.85		8.08		4.16		4.98		3.81			3	5.47		7.21		4.61		3.51		4.94		4.39		3.24		4.24	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	4.55		9.86		5.08		11.17		3.12			3	5.42		5.78		7.01		4.15		1.91		3.43		2.75		2.60	
PCB	28 (2 4 4')	4.01		1.05	2	2.52	2	6.39		4.28			3	6.72		40.80		3.69		8.91		5.31		0.27	2	4.02		17.21	
PCB	44 (2 2'3 5')	6.19		4.03		0.82		8.26		7.21			3	8.76		6.75		6.39		7.94		2.04		2.26		5.75		6.67	
PCB	52 (2 2'5 5)	7.24		7.03		2.58	2	14.06		5.24			3	14.81		13.10		11.42		13.35		3.74	2	5.02		10.17		12.63	
PCB	66 (2 3'4 4')	10.62		22.32		10.15		3.86	4	10.59			3	3.86	4	19.39		3.86	4	3.86	4	11.04		9.73		3.86	4	3.86	4
PCB	8 (2 4)	2.35	4	2.35	4		3	2.15	2	1.80	2		3	2.10	2	2.35	4	1.18	2	2.74	2		1	2.35	4	2.73	2	6.87	
PCB	PCB Sum of Congeners	419.86		246.31		213.68		274.50		145.33				230.27		321.74		278.17		455.87		125.43		137.06		308.31		282.36	
PCB	PCB Sum of Congeners x 2	839.71	5	492.62	5	427.37	5	549.01	5	290.66	5		5	460.54	5	643.47	5	556.34	5	911.74	5	250.86	5	274.11	5	616.62	5	564.71	5
PST	Aldrin	0.15	4	0.15	4		3	0.15	4	0.15	4		3	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	0.42		2.82			3	0.67		0.58			3	0.93		0.63		0.48		0.15	4	0.15	1	0.58		4.55		0.15	4
PST	Mirex	0.38		0.41		0.20	2	5.54		0.30	2		3	3.21		0.81		2.24		2.63			1	0.40		2.70		1.28	
PST	o,p'-DDE	3.59		2.80		2.09		7.09		0.15	4		3	6.64		7.09		5.42		5.69		0.15	4	1.82		4.35		3.15	
PST	p,p'-DDE	4.10		2.88		2.93		8.64		7.06			3	9.82		2.39		9.96		10.37		4.33		1.81	2	7.96		6.71	
TBT	Dibutyltin	3.00	4	3.00	4			3.00	4	3.00	4			3.00	4	3.00	4	3.00	4	3.00	4	3.00	4			3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4			3.50	4	3.50	4			3.50	4	3.50	4	3.50	4	3.50	4	3.50	4			3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4			2.50	4	2.50	4			2.50	4	2.50	4	2.50	4	2.50	4	2.50	4			2.50	4	2.50	4
TBT	Tributyltin	3.00	4	67.14				8.32		3.00	4			9.66		3.00	4	3.00		31.70		30.61				11.16		3.00	4

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.1 (continued).

Type	Analyte	JPC-1-LOB	DQ	JPC-1-MF	DQ	JPC-1-MM	DQ	JPC-1-PM	DQ	CHC-1-CN	DQ	CHC-1-DM	DQ	CHC-1-IBM	DQ	CHC-1-LOB	DQ	T0-DM	DQ
MET	Aluminum	5.0E-2	4	5.0E-2	4	108.83		39.62		14.92		61.09		59.62		5.0E-2	4	100.14	
MET	Arsenic	19.43		5.92		7.73		11.04		3.48		7.48		4.68		21.68		36.05	
MET	Cadmium	0.18		1.18		0.71		0.64		0.94		0.74		0.58		0.23		0.50	
MET	Chromium	1.68		1.08		2.11		2.16		1.22		1.75		1.84		1.43		1.95	
MET	Copper	142.69		22.74		6.87		11.97		18.39		11.04		11.93		101.92		12.18	
MET	Iron	38.69		75.43		149.98		138.92		68.39		158.98		192.16		25.42		178.82	
MET	Lead	0.39		0.43		2.12		2.37		0.84		2.59		0.78		0.18		0.62	
MET	Manganese	3.12		1.87		17.63		8.12		3.21		4.95		4.98				4.29	
MET	Mercury	0.30		0.11		0.13		0.11		0.17		0.18		0.18		0.23		0.13	
MET	Nickel	1.39		1.30		1.32		2.5E-4	4	2.5E-4	4	4.11		3.84		1.57		2.5E-4	4
MET	Silver	2.19		1.5E-4	4	1.5E-4	4	1.5E-4	4	1.58		1.5E-4	4	1.5E-4	4	3.84		1.46	
MET	Zinc	105.62		34.06		116.26		120.64		21.97		74.64		91.68		118.98		85.83	
PAH	1,6,7-Trimethylnaphthalene	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4	3.76	4
PAH	1-Methylnaphthalene	5.67	4	5.67	4	5.67	4	5.67	4	68.24		22.18		5.67	4	5.67	4		1
PAH	1-Methylphenanthrene	104.56		9.05	4	29.57		78.03		1080.00		15.22	2	9.05	4	81.77		9.05	4
PAH	2,6-Dimethylnaphthalene	5.25	4	5.25	4	5.25	4	5.25	4	12.27		70.60		22.16		5.25	4	5.25	4
PAH	2-Methylnaphthalene	9.40	4	9.40	4	9.40	4	9.40	4	90.98		55.42		9.40	4	9.40	4		1
PAH	Acenaphthene	2.65	4	2.65	4	2.65	4	2.65	4	10.01		55.15		2.65	4	2.65	4	2.65	4
PAH	Acenaphthylene	2.89	4	2.89	4	2.62	2	3.03	2	5.10	2	39.89		17.47		2.89	4	2.89	4
PAH	Anthracene	8.00	4	2.02	2	6.06	2	6.14	2	8.00	4	42.79		25.09		6.36	2	5.99	2
PAH	Benzo(a)anthracene	3.36	4		1	10.53		26.48			1	45.39		47.31		3.36	4	3.36	4
PAH	Benzo(a)pyrene	3.62	4	3.62	4	4.20	2	8.00		3.76	2	21.74		31.00		3.62	4	6.04	2
PAH	Benzo(b,j,k)fluoranthene	6.20	4	6.20	4	6.18	2	15.90		6.20	4	94.84		109.63		6.20	4	10.80	2
PAH	Benzo(e)pyrene	3.90	4	3.90	4	1.08	2	1.97	2	3.90	4	67.50		88.11		3.90	4	13.66	
PAH	Benzo(g,h,i)perylene	1.56	4	1.56	4	1.56	4	1.56	4	1.56	4	1.56	4	30.40		1.56	4	1.56	4
PAH	Biphenyl	5.70	4	5.70	4	5.70	4	5.70	4	7.11	2	5.70	4	5.70	4	5.70	4	5.70	4
PAH	Chrysene	5.26	4		1	9.77	2	17.42			1	36.07		49.49		5.26	4	5.26	4
PAH	Dibenz(a,h)anthracene	0.49	4	0.49	4	0.49	4	0.49	4	0.49	4	21.18		0.49	4	0.49	4	0.49	4
PAH	Fluoranthene	10.20	2	8.55	4	21.60		25.82		7.69	2	103.33		84.89		14.46	2	15.91	2
PAH	Fluorene	12.56		27.30		3.71	2	3.18	2	13.65		1.95	4	16.70		1.95	4	8.15	
PAH	High Molecular Weight PAHs	34.98	5	55.81	5	68.12	5	109.42	5	36.16	5	316.34	5	287.07	5	46.75	5	44.39	5
PAH	Indeno(1,2,3-cd)pyrene	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	1.54	4	15.51		1.54	4	1.54	4
PAH	Low Molecular Weight PAHs	52.71	5	55.10	5	32.00	5	34.53	5	177.82	5	227.71	5	102.01	5	39.38	5	47.65	5
PAH	Naphthalene	1.68	4	1.68	4	1.68	4	1.68	4	34.68		1.68	4	1.68	4	1.68	4		1
PAH	Perylene	3.50	4	3.50	4	4.24	2	4.21	2	7.43		38.67			1	3.50	4		1
PAH	Phenanthrene	16.54	2	9.17	2	5.88	2	8.45	2	15.40	2	30.83		29.01		14.45	2	29.97	
PAH	Pyrene	12.05		43.15		21.54		31.22		24.22		88.63		73.89		19.57		13.34	
PAH	Total PAHs	155.00	5	82.00	5	127.00	5	230.00	5	1380.00	5	849.63	5	638.67	5	137.00	5	101.86	5
PCB	101 (2 2'3 5 5')	7.41		80.02		6.15		9.29		43.55		16.86		16.59		17.75		22.36	
PCB	105 (2 3 3'4 4')	6.69	2	21.58		1.41	2	2.35	2	12.29		3.50	2	3.43	2	5.62	2	2.15	2
PCB	118 (2 3'4 4'5)	13.78		90.63		5.70		7.52		64.40		21.15		19.33		11.16		4.64	2
PCB	128 (2 2'3 3'4 4')	5.58		19.52		1.21		1.06		7.44		9.88		13.22		7.90		9.11	
PCB	138 (2 2'3 4 4'5)	21.45		160.03		10.56		22.48		79.89		34.44		31.92		14.94		17.70	
PCB	153 (2 2'4 4'5 5')	31.35		263.80		27.14		30.99		147.00		48.84		48.08		22.10		17.78	
PCB	170 (2 2'3 3'4 4'5)	7.93		37.99		4.27		4.49		18.07		3.28		1.87		4.11		1.10	
PCB	18 (2 2'5)	25.83		2.73	2	3.25	4	1.00	2	2.09	2	3.25	4	3.25	4	57.84		2.23	2
PCB	180 (2 2'3 4 4'5 5')	10.55		98.89		16.07		13.60		45.29		8.92		4.85		3.92		3.98	
PCB	187 (2 2'3 4'5 5'6)	20.30		82.19		10.53		10.80		35.22		11.96		14.02		31.52		6.37	
PCB	195 (2 2'3 3'4 4'5 6)	0.40	4	4.45		0.48	2	1.70		4.07		1.85		1.26		0.40	4	0.40	4
PCB	206 (2 2'3 3'4 4'5 5'6)	9.55		5.61		2.94		6.97		5.50		1.85		3.81		17.00		8.45	
PCB	209 (2 2'3 3'4 4'5 5'6 6')	8.34		2.98		2.82		5.03		1.63		1.88		4.40		0.72	4	9.41	
PCB	28 (2 4 4')	14.74		10.75		1.92	2	1.50	2	4.89		7.63		16.39		20.58		14.10	
PCB	44 (2 2'3 5')	2.09		3.76		1.21		2.05		1.25		4.69		0.38	4	0.38	4	14.10	
PCB	52 (2 2'5 5)	6.10		21.32		2.81	2	3.48	2	17.97		14.17		12.78		11.46		14.75	
PCB	66 (2 3'4 4')	6.89	2	42.95		7.00	2	9.01		16.73		3.86	4	3.86	4	4.59	2	3.86	4
PCB	8 (2 4)	2.35	4		1		1	2.35	4		1	2.05	2	2.34	2	2.35	4	2.35	4
PCB	PCB Sum of Congeners	198.58		949.21		102.21		133.33		507.28		192.96		194.31		230.50		148.24	
PCB	PCB Sum of Congeners x 2	397.16	5	1900.00	5	204.41	5	266.66	5	1010.00	5	385.93	5	388.62	5	461.00	5	296.49	5
PST	Aldrin	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4	0.15	4
PST	Hexachlorobenzene	1.43		0.15	1	0.15	1	0.18	2	0.15	1	0.58		0.15	4	5.23		1.58	
PST	Mirex	0.99			1		1	0.42			1	1.17		1.86		1.45		3.15	
PST	o,p'-DDE	0.15	4	5.74		1.21		1.83		2.81		4.77		1.44		8.54		7.62	
PST	p,p'-DDE	4.11		67.39		3.14		2.59		21.19		8.67		6.13		7.77		15.45	
TBT	Dibutyltin	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	3.00	4	15.27		3.00	4	3.00	4
TBT	Monobutyltin	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4	3.50	4
TBT	Tetrabutyltin	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4	2.50	4
TBT	Tributyltin	3.00	4	8.73		13.35		49.55		25.79		40.68		66.56		3.00	4	3.00	4

Units: MET = µg/g dry wt.; PAH, PCB and PST = ng/g dry wt.; TBT = ng Sn/g dry wt. Data Qualifiers (DQ): 1=I (interference); 2=J (estimated values); 3=NC (not calculated); 4=ND (not detected); 5=Z (calculated values). Species codes: see Page 1.

Appendix Table A-1-3.2. Results of tissue lipid analyses for the Derecktor Shipyard Marine ERA.

Station	Cunner	Deployed Mussels	Indigenous Blue Mussels	Lobster	Mummichog	*Mercenaria mercenaria*	*Pitar morrhuana*
DSY-24			5.41				
DSY-25			4.44	2.53			
DSY-26	9.09	6.89					
DSY-27			6.77	2.33			
DSY-28	11.4	6.19	5.40	2.83			
DSY-29	8.69	6.92		2.44			
DSY-31		5.73					2.79
DSY-32							3.25
DSY-33		6.07		2.51			3.21
DSY-34							3.69
DSY-35			5.00	2.36		2.01	2.40
DSY-36	8.37		5.37	1.79			2.40
DSY-37							1.10
DSY-38		5.85		2.57			4.03
DSY-39		5.94		2.02			
DSY-40		7.37	6.31				
DSY-41						2.14	2.11
JPC-1		7.66	6.07	2.53	12.5	2.59	0.93
CHC-1	11.8	6.10	4.28	2.28			
T0-DM		6.92					

Units: % = decigram/g dry weight

APPENDIX A-1-4.
SEM AND AVS DATA

Appendix A-1-4.1. Summary of Simultaneously Extractable Metals (SEM) concentrations in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment.

Sample	Depth	Replicate 1 Metals (µg/g)								Replicate 2 Metals (µg/g)							
Name	(cm)	Cu	Zn	Pb	Ni	Cd	Cd DQ[3]	Hg[4]	Hg DQ[3]	Cu	Zn	Pb	Ni	Cd	Cd DQ[3]	Hg[4]	Hg DQ[3]
DSY-25	0-12	20.79	110.79	26.50	37.86	0.14		3.54		21.88	126.81	28.61	31.53	0.21		4.07	
DSY-26	0-18	19.85	46.27	17.66	5.34	<0.09	B	<2	B	20.93	43.87	16.21	5.20	<0.09	B	<2	B
DSY-27	0-17	2.31	864.67	169.59	12.05	1.13		2.57		1.99	566.26	189.08	13.69	0.78		2.67	
DSY-28	0-18	152.20	324.63	71.95	61.95	<0.09	B	8.50		97.50	225.50	67.00	50.50	0.25		14.39	
DSY-29	0-18	12.75	436.86	122.16	43.92	0.98		9.07		ND	387.41	105.19	27.04	0.93		8.63	
DSY-29 FD[1]	0-18	49.74	429.74	106.32	53.68	1.32		14.88		62.44	447.32	126.59	52.44	1.22		20.53	
DSY-30	0-18	1.26	86.24	38.38	3.56	0.33		<2	B	3.11	88.40	38.66	4.76	0.40		<2	B
DSY-31	0-18	26.39	141.75	52.78	12.93	0.30		2.39		37.13	183.28	54.81	14.48	0.30		2.74	
DSY-32	0-18	27.22	96.34	53.08	31.54	0.18		<2		24.76	98.46	53.44	8.46	0.22		2.31	
DSY-33	0-14	27.07	44.46	19.98	9.29	<0.09	B	3.36		29.83	44.11	20.34	9.88	0.02		2.66	
DSY-34	0-18	16.03	67.21	32.31	7.98	0.12		<2	B	11.90	64.33	31.43	7.42	0.12		2.31	
DSY-35	0-14	5.05	22.22	3.92	6.16	<0.09	B	<2	B	7.47	22.60	3.28	6.55	<0.09	B	<2	B
DSY-35 RP[2]	0-14	3.72	14.06	3.12	3.22	<0.09	B	<2	B	4.83	13.47	2.92	3.53	<0.09	B	<2	B
DSY-36	0-18	38.01	94.87	52.18	13.76	0.11		<2	B	40.81	92.35	50.74	13.53	<0.09	B	2.62	
DSY-37	0-18	33.43	72.81	35.49	10.99	0.12		2.60		44.57	100.10	35.30	35.10	0.10		2.59	
DSY-37 RP[2]	0-18	19.82	51.99	32.69	4.70	0.13		<2	B	20.68	52.30	32.99	4.33	0.13		<2	B
DSY-38	0-18	46.53	93.20	37.49	12.85	<0.09	B	3.31		34.10	84.16	38.98	26.45	<0.09	B	3.20	
DSY-39	0-18	31.63	91.50	34.82	13.49	<0.09	B	2.02		30.19	98.32	35.20	14.39	<0.09	B	2.51	
DSY-40	0-14	9.23	91.49	27.03	9.15	0.23		<2	B	10.34	96.58	26.36	9.48	0.27		<2	B
DSY-41	0-13	3.70	20.36	5.77	5.40	<0.09	B	2.08		2.86	36.49	6.60	3.13	<0.09	B	<2	B
JPC-1	0-14	15.09	34.52	12.20	5.32	0.09		<2	B	11.29	28.68	11.18	5.46	<0.09	B	<2	B
JPC-2	0-16	3.86	21.19	40.85	20.16	6.27		2.03		3.84	24.79	40.36	18.88	7.71		<2	B

1 - FD designates field duplicate.

2 - RP designates replicate analysis.

3 - Data qualifiers apply only to cadmium and mercury. B = estimated values.

4 - Concentrations for Hg in ng/g.

"< " designates concentrations below the Method Limit of Quantitation (MLQ).

Appendix A-1-4.2. Summary of Acid Volatile Sulfide (AVS) concentrations in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment.

Sample ID	Depth (cm)	Dry Weight (g)	AVS (µm/g dry)	RPD[3]
DSY-25 Replicate 1	0-12	1.40	23.80	
DSY-25 Replicate 2	0-12	1.44	25.36	6.3
DSY-26 Replicate 1	0-18	4.61	4.22	
DSY-26 Replicate 2	0-18	4.75	3.93	7.1
DSY-27 Replicate 1	0-17	1.95	174.99	
DSY-27 Replicate 2	0-17	2.06	177.86	1.6
DSY-28 Replicate 1	0-18	0.41	59.65	
DSY-28 Replicate 2	0-18	0.40	66.25	10.5
DSY-29 Replicate 1	0-18	0.51	185.74	
DSY-29 Replicate 2	0-18	0.54	180.58	2.8
DSY-29 FD[1] Replicate 1	0-18	0.38	161.81	
DSY-29 FD[1] Replicate 2	0-18	0.41	180.25	10.8
DSY-30 Replicate 1	0-18	3.96	25.76	
DSY-30 Replicate 2	0-18	4.24	24.26	6.0
DSY-31 Replicate 1	0-18	2.63	51.90	
DSY-31 Replicate 2	0-18	2.68	48.22	7.4
DSY-32 Replicate 1	0-18	2.73	17.07	
DSY-32 Replicate 2	0-18	2.73	17.34	1.6
DSY-33 Replicate 1	0-14	4.10	0.80	
DSY-33 Replicate 2	0-14	4.14	0.77	3.8
DSY-34 Replicate 1	0-18	2.47	31.36	
DSY-34 Replicate 2	0-18	2.52	27.68	12.5
DSY-35 Replicate 1	0-14	5.23	1.55	
DSY-35 Replicate 2	0-14	5.30	1.14	30.5
DSY-35 RP[2] Replicate 1	0-14	4.97	1.13	
DSY-35 RP[2] Replicate 2	0-14	5.07	0.87	26.0
DSY-36 Replicate 1	0-18	2.71	36.18	
DSY-36 Replicate 2	0-18	2.72	35.71	1.3
DSY-37 Replicate 1	0-18	3.24	2.88	
DSY-37 Replicate 2	0-18	3.00	1.89	41.5
DSY-37 RP[2] Replicate 1	0-18	3.87	2.78	
DSY-37 RP[2] Replicate 2	0-18	3.95	3.24	15.3
DSY-38 Replicate 1	0-18	2.91	28.65	
DSY-38 Replicate 2	0-18	2.93	30.92	7.6
DSY-39 Replicate 1	0-18	3.07	20.65	
DSY-39 Replicate 2	0-18	3.21	22.69	9.4
DSY-40 Replicate 1	0-14	3.90	18.33	
DSY-40 Replicate 2	0-14	4.07	19.24	4.8
DSY-41 Replicate 1	0-13	4.78	4.56	
DSY-41 Replicate 2	0-13	4.76	4.48	1.8
JPC-1 Replicate 1	0-14	4.40	1.95	
JPC-1 Replicate 2	0-14	4.41	1.89	3.1
JPC-2 Replicate 1	0-16	3.86	0.70	
JPC-2 Replicate 2	0-16	3.84	0.80	13.3

1 - FD designates field duplicate.
2 - RP designates replicate analysis.
3 - RPD = Redox Potential Depth.

Appendix A-1-4.3. Summary of SEM/AVS ratios in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment.

Sample	Depth	AVS (µmol/g dry sed)		Percent	Replicate 1 (µmol/g dry sample)						Replicate 2 (µmol/g dry sample)						SEM/AVS	
Name	(cm)	Rep. 1	Rep. 2	Diff.	Cu	Zn	Pb	Ni	Cd	Hg	Cu	Zn	Pb	Ni	Cd	Hg	Rep. 1	Rep. 2
DSY-25	0-12	23.80	25.36	6.3	0.327	1.695	0.128	0.645	0.001	1.8E-05	0.344	1.940	0.138	0.537	0.002	2.0E-05	0.117	0.117
DSY-26	0-18	4.22	3.93	7.1	0.312	0.708	0.085	0.091	5.8E-04	4.6E-06	0.329	0.671	0.078	0.089	5.6E-04	6.3E-06	0.284	0.297
DSY-27	0-17	174.99	177.86	1.6	0.036	13.227	0.819	0.205	0.010	1.3E-05	0.031	8.662	0.913	0.233	0.007	1.3E-05	0.082	0.055
DSY-28	0-18	59.65	66.25	10.5	2.395	4.966	0.347	1.055	0.002	4.2E-05	1.534	3.450	0.323	0.860	0.002	7.2E-05	0.147	0.093
DSY-29	0-18	185.74	180.58	2.8	0.201	6.683	0.590	0.748	0.009	4.5E-05	0.000	5.926	0.508	0.461	0.008	4.3E-05	0.044	0.038
DSY-29 FD[1]	0-18	161.81	180.25	10.8	0.000	5.926	0.508	0.461	0.008	7.4E-05	0.983	6.843	0.611	0.893	0.011	1.0E-04	0.043	0.052
DSY-30	0-18	25.76	24.26	6.0	0.983	6.843	0.611	0.893	0.011	4.0E-06	0.049	1.352	0.187	0.081	0.004	6.3E-06	0.363	0.069
DSY-31	0-18	51.90	48.22	7.4	0.049	1.352	0.187	0.081	0.004	1.2E-05	0.584	2.804	0.265	0.247	0.003	1.4E-05	0.032	0.081
DSY-32	0-18	17.07	17.34	1.6	0.584	0.568	0.885	0.934	0.129	4.9E-06	0.390	1.506	0.258	0.144	0.002	1.2E-05	0.182	0.133
DSY-33	0-14	0.80	0.77	3.8	0.390	1.506	0.258	0.144	0.002	1.7E-05	0.469	0.675	0.098	0.168	2.1E-04	1.3E-05	2.875	1.832
DSY-34	0-18	31.36	27.68	12.5	0.469	0.675	0.098	0.168	2.1E-04	6.1E-06	0.187	0.984	0.152	0.126	0.001	1.2E-05	0.045	0.052
DSY-35	0-14	1.55	1.14	30.5	0.187	0.984	0.152	0.126	0.001	7.1E-06	0.118	0.346	0.016	0.112	1.7E-04	7.3E-06	0.936	0.518
DSY-35 RP[2]	0-14	1.13	0.87	26.0	0.118	0.346	0.016	0.112	1.7E-04	6.3E-06	0.076	0.206	0.014	0.060	1.8E-04	6.2E-06	0.523	0.410
DSY-36	0-18	38.18	35.71	6.7	0.076	0.206	0.014	0.060	1.8E-04	9.0E-06	0.642	1.413	0.245	0.230	6.5E-04	1.3E-05	0.009	0.071
DSY-37	0-18	2.88	1.89	41.5	0.642	1.413	0.245	0.230	6.5E-04	1.3E-05	0.701	1.531	0.170	0.598	8.9E-04	1.3E-05	0.879	1.588
DSY-37 RP[2]	0-18	2.78	3.24	15.3	0.701	1.531	0.170	0.598	8.9E-04	7.3E-06	0.326	0.800	0.159	0.074	0.001	6.7E-06	1.080	0.420
DSY-38	0-18	28.65	30.92	7.6	0.326	0.800	0.159	0.074	0.001	1.7E-05	0.537	1.287	0.188	0.451	6.1E-04	1.6E-05	0.047	0.080
DSY-39	0-18	20.65	22.69	9.4	0.537	1.287	0.188	0.451	6.1E-04	1.0E-05	0.475	1.504	0.170	0.245	5.5E-04	1.3E-05	0.119	0.106
DSY-40	0-14	18.33	19.24	4.8	0.475	1.504	0.170	0.245	5.5E-04	4.0E-06	0.163	1.478	0.127	0.162	0.002	8.1E-06	0.131	0.100
DSY-41	0-13	4.56	4.48	1.8	0.163	1.478	0.127	0.162	0.002	1.0E-05	0.045	0.558	0.032	0.053	7.5E-04	6.5E-06	0.424	0.154
JPC-1	0-14	1.95	1.89	3.1	0.045	0.558	0.032	0.053	7.5E-04	7.3E-06	0.178	0.439	0.054	0.093	6.1E-04	6.0E-06	0.353	0.404
JPC-2	0-16	0.70	0.80	13.3	0.178	0.439	0.054	0.093	6.1E-04	1.0E-05	0.060	0.379	0.195	0.322	0.069	8.9E-06	1.092	1.281

1 - FD designates field duplicate.

2 - RP designates replicate analysis.

SEM = Simultaneously Extractable Metals; AVS = Acid Volatile Sulfides.

APPENDIX A-1-5.
GRAIN SIZE/TOC DATA

Appendix A-1-5.1. Sediment grain size analysis for the Derecktor Shipyard Marine Ecological Risk Assessment.

SAMPLE NAME	Depth (cm)	Dry Weight (g) >63	Dry Weight (g) <63	% Vol >3.9u	% Vol >15.6u	% Sand	% Silt	% Clay	%SILT 63-15.6u	%SILT <15.6u
DSY-25	0-12	1.8554	0.4686	99.31	70.43	79.8	20.0	0.1	14.2	6.0
DSY-26	0-18	2.1438	0.5008	98.93	55.17	81.1	18.7	0.2	10.4	8.5
DSY-27	0-17	0.1240	1.1578	99.98	55.38	9.7	90.3	0.0	50.0	40.3
DSY-28	0-18	0.0220	1.1944	99.99	55.91	1.8	98.2	0.0	54.9	43.3
DSY-29	0-18	0.1768	0.7905	98.23	54.43	18.3	80.3	1.4	44.5	37.2
DSY-29 FD[1]	0-18	0.1949	0.7757	99.99	48.66	20.1	79.9	0.0	38.9	41.0
DSY-30	0-18	0.4398	1.1823	99.25	61.73	27.1	72.3	0.5	45.0	27.9
DSY-31	0-18	0.1872	1.4015	99.99	60.09	11.8	88.2	0.0	53.0	35.2
DSY-32	0-18	0.1769	1.4271	99.30	59.45	11.0	88.3	0.6	52.9	36.1
DSY-33	0-14	1.7221	0.7330	98.85	64.18	70.1	29.5	0.3	19.2	10.7
DSY-34	0-18	0.2267	1.4745	99.37	65.94	13.3	86.1	0.5	57.2	29.5
DSY-35	0-14	2.8754	0.0312	99.92	54.51	98.9	1.1	0.0	0.6	0.5
DSY-36	0-18	0.1713	0.9846	99.99	54.80	14.8	85.2	0.0	46.7	38.5
DSY-37	0-18	1.0336	1.0353	99.70	69.32	50.0	49.9	0.2	34.7	15.4
DSY-38	0-18	0.2604	1.3570	99.51	67.39	16.1	83.5	0.4	56.5	27.4
DSY-39	0-18	0.8464	1.3505	98.69	62.37	38.5	60.7	0.8	38.3	23.1
DSY-40	0-14	1.8590	0.5720	99.99	57.82	76.5	23.5	0.0	13.6	9.9
DSY-41	0-13	2.9240	0.1127	98.68	51.13	96.3	3.7	0.0	1.9	1.8
JPC-1	0-14	2.3120	0.3122	100.0	66.42	88.1	11.9	0.0	7.9	4.0
JPC-2	0-16	1.5526	0.7769	99.47	69.85	66.6	33.2	0.2	23.3	10.1
DSY-28	24-34	0.1499	1.2155	99.98	53.27	11.0	89.0	0.0	47.4	41.6
DSY-28	76-86	0.0612	1.1980	99.99	52.16	4.9	95.1	0.0	49.6	45.5
DSY-29	16-26	2.3430	0.5383	95.56	66.81	81.3	17.9	0.8	12.5	6.2
DSY-29	44-54	3.1072	0.0981	99.25	65.71	96.9	3.0	0.0	2.0	1.0
DSY-30	18-28	1.7655	0.9373	99.85	81.52	65.3	34.6	0.1	28.3	6.4
DSY-30	68-78	0.9596	1.5439	99.67	76.52	38.3	61.5	0.2	47.2	14.5
DSY-31	45-55	0.9571	1.3569	99.49	72.62	41.4	58.3	0.3	42.6	16.1
DSY-31	100-110	1.8889	0.9125	99.68	73.78	67.4	32.5	0.1	24.0	8.5
DSY-34	20-30	0.7625	1.9358	99.82	79.51	28.3	71.6	0.1	57.0	14.7
DSY-34	70-80	0.1977	2.2745	99.66	73.22	8.0	91.7	0.3	67.4	24.6
DSY-36	40-50	0.0410	1.2845	99.98	54.49	3.1	96.9	0.0	52.8	44.1
DSY-36	90-100	2.6215	0.6011	99.50	68.96	81.3	18.6	0.1	12.9	5.8
DSY-V4	105-115	2.5698	0.5587	99.73	78.74	82.1	17.8	0.0	14.1	3.8
DSY-V4	130-140	2.4108	0.5901	99.55	77.16	80.3	19.6	0.1	15.2	4.5
DSY-V9	20-Oct	0.2983	1.4068	98.93	56.02	17.5	81.6	0.9	46.2	36.3
DSY-V9	39-45	2.8721	0.4656	99.14	62.92	86.1	13.8	0.1	8.8	5.2

1 - FD designates field duplicate.

Appendix A-1-5.2. Sediment Total Organic Carbon analysis for the Derecktor Shipyard Marine Ecological Risk Assessment.

SAMPLE NAME	Depth (cm)	Crucible wt (g)	Dry Weight (g) wet	100C	550C	% water	Total Organic Matter (%)	Total Organic Carbon (%)
DSY-25	0-12	4.520	1.281	5.341	5.307	35.9	4.1	1.8
DSY-26	0-18	4.721	1.434	5.776	5.740	26.4	3.4	1.5
DSY-27	0-17	4.258	1.110	4.733	4.692	57.2	8.6	3.7
DSY-28	0-18	4.733	1.285	5.196	5.153	64.0	9.3	4.0
DSY-29	0-18	4.278	1.002	4.583	4.540	69.6	14.1	6.1
DSY-29 FD[1]	0-18	4.707	1.139	5.049	5.002	70.0	13.7	5.9
DSY-30	0-18	4.578	1.095	5.102	5.056	52.1	8.8	3.8
DSY-31	0-18	4.183	1.343	4.745	4.695	58.2	8.9	3.8
DSY-32	0-18	4.063	1.449	4.680	4.629	57.4	8.3	3.6
DSY-33	0-14	4.696	1.767	5.945	5.897	29.3	3.8	1.7
DSY-34	0-18	4.703	1.330	5.341	5.294	52.0	7.4	3.2
DSY-35	0-14	4.466	1.611	5.740	5.722	20.9	1.4	0.6
DSY-36	0-18	4.699	1.168	5.186	5.146	58.3	8.2	3.5
DSY-37	0-18	4.846	1.342	5.608	5.569	43.2	5.1	2.2
DSY-38	0-18	4.868	1.248	5.444	5.403	53.8	7.1	3.1
DSY-39	0-18	4.663	1.087	5.272	5.236	44.0	5.9	2.6
DSY-40	0-14	4.243	1.794	5.441	5.400	33.2	3.4	1.5
DSY-41	0-13	4.103	1.757	5.487	5.461	21.2	1.9	0.8
JPC-1	0-14	4.709	1.990	6.256	6.218	22.3	2.5	1.1
JPC-2	0-16	4.805	1.704	5.941	5.896	33.3	4.0	1.7
DSY-28	24-34	4.875	1.210	5.355	5.312	60.3	9.0	3.9
DSY-28	76-86	4.547	1.360	5.055	5.014	62.6	8.1	3.5
DSY-29	16-26	4.742	1.779	6.051	6.006	26.4	3.4	1.5
DSY-29	44-54	4.605	1.825	6.094	6.077	18.4	1.1	0.5
DSY-30	18-28	4.645	1.871	6.044	5.995	25.2	3.5	1.5
DSY-30	68-78	4.247	1.611	5.322	5.279	33.3	4.0	1.7
DSY-31	45-55	4.226	1.626	5.299	5.258	34.0	3.8	1.7
DSY-31	100-110	4.922	1.434	5.975	5.937	26.6	3.6	1.6
DSY-34	20-30	4.527	1.334	5.410	5.379	33.8	3.5	1.5
DSY-34	70-80	4.629	1.847	5.906	5.859	30.9	3.7	1.6
DSY-36	40-50	4.956	1.236	5.455	5.403	59.6	10.4	4.5
DSY-36	90-100	5.007	1.870	6.530	6.499	18.6	2.0	0.9
DSY-V4	105-115	4.106	2.033	5.846	5.819	14.4	1.6	0.7
DSY-V4	130-140	4.244	2.101	6.096	6.064	11.9	1.7	0.7
DSY-V9	20-Oct	4.280	1.498	5.058	4.991	48.1	8.6	3.7
DSY-V9	39-45	4.237	2.174	6.102	6.059	14.2	2.3	1.0

1 - FD designates field duplicate.

APPENDIX A-2.
HAZARD QUOTIENT/TISSUE CONCENTRATION RATIOS

APPENDIX A-2-1.
SEDIMENT HAZARD QUOTIENTS

Appendix A-2-1.1. Hazard Quotients and Hazard Indices of CoCs in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = NOAA ER-L.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	PAH Hazard Index[1]	Total PCBs	PCB Hazard Index[1]	p,p'-DDE	Pesticide Hazard Index[1]
ER-L	70.0	16.0	44.0	85.3	261	430	384	63.4	600	19.0	1700	552	160	240	665	4022		22.7		2.20	
DSY-25	0.16	2.61	1.72	3.54	1.26	0.92	1.26	0.96	0.82	2.32	1.38	1.41	0.11	1.18	0.88	1.23	17.7	4.12	4.12	0.40	0.40
DSY-26	0.20	0.76	2.13	3.15	1.98	1.01	1.54	0.97	1.14	2.84	1.78	1.40	0.10	1.32	1.11	1.44	18.3	4.33	4.33	0.28	0.28
DSY-27	0.47	1.49	3.23	4.49	3.10	2.15	2.37	2.07	1.34	3.24	3.25	1.85	0.26	1.40	2.93	2.73	28.5	146	146	3.18	3.18
DSY-28	0.63	1.08	1.70	2.15	1.13	0.88	0.95	1.05	0.76	1.66	1.30	1.10	0.23	0.92	0.98	1.20	14.1	5.89	5.89	0.92	0.92
DSY-29	1.05	11.8	6.82	14.3	10.3	5.53	7.29	5.01	8.28	15.5	10.9	6.81	0.48	6.71	7.97	8.16	101	24.1	24.1	2.86	2.86
DSY-30	1.26	12.3	2.09	5.34	2.67	1.89	1.86	2.05	2.48	9.30	3.29	4.38	0.85	5.29	2.63	2.93	50.0	13.9	13.9	2.02	2.02
DSY-31	0.53	1.07	1.61	2.35	1.08	0.98	1.04	0.99	0.67	1.48	1.42	1.11	0.28	0.90	1.27	1.28	14.2	9.74	9.74	0.89	0.89
DSY-32	0.46	0.89	2.98	3.49	1.49	1.15	1.28	1.14	0.89	1.35	1.70	1.32	0.27	0.76	1.38	1.49	17.5	8.85	8.85	1.08	1.08
DSY-33	0.14	0.21	0.27	0.37	0.19	0.16	0.15	0.20	0.16	0.35	0.23	0.22	0.07	0.19	0.16	0.22	2.61	1.76	1.76	0.19	0.19
DSY-34	0.35	0.53	0.65	0.75	0.39	0.34	0.33	0.42	0.35	0.73	0.51	0.49	0.14	0.46	0.38	0.48	5.82	2.84	2.84	0.44	0.44
DSY-35	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.00	0.02	0.01	0.02	0.17	0.30	0.30	0.01	0.01
DSY-36	0.33	0.69	1.70	1.85	0.85	0.74	0.75	0.76	0.58	0.95	1.00	0.83	0.21	0.57	0.72	0.92	10.7	4.99	4.99	1.18	1.18
DSY-37	0.25	0.46	0.78	1.65	0.55	0.38	0.40	0.45	0.44	0.51	0.66	0.58	0.17	0.35	0.55	0.56	6.95	4.40	4.40	0.61	0.61
DSY-38	0.20	0.41	0.57	1.10	0.43	0.28	0.28	0.33	0.38	0.34	0.50	0.43	0.15	0.28	0.38	0.44	5.12	2.61	2.61	0.59	0.59
DSY-39	0.22	0.63	0.51	0.90	0.37	0.33	0.31	0.43	0.36	0.78	0.49	0.51	0.15	0.48	0.34	0.45	5.83	2.56	2.56	0.33	0.33
DSY-40	0.23	1.01	2.17	2.74	0.89	0.74	1.16	0.83	1.30	1.00	1.77	1.28	0.13	1.26	1.79	1.34	15.3	3.71	3.71	0.52	0.52
DSY-41	0.03	0.11	0.02	0.13	0.05	0.04	0.05	0.05	0.06	0.11	0.08	0.07	0.01	0.08	0.07	0.07	0.83	0.61	0.61	0.04	0.04
JPC-1	0.05	0.09	0.24	0.25	0.17	0.15	0.13	0.16	0.17	0.24	0.21	0.16	0.03	0.18	0.15	0.19	2.01	0.83	0.83	0.13	0.13
JPC-2																					

Hazard Quotients calculated as sediment *concentration/benchmark*.

See Appendix A-1-1 for sediment concentrations.

1 - Hazard Index calculated as sum of analyte-specific Hazard Quotients.

2 - All benchmarks from Long *et al.*, 1995, except tributyltin from Macauley *et al.*, 1994.

Appendix A-2-1.1 (continued). Hazard Quotients and Hazard Indices of CoCs in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = NOAA ER-L.

Station	Tributyltin	Butyltin Hazard Index[1]	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Metals Hazard Index[1]
ER-L	5.00		8.20	1.20	81.0	34.0	46.7	0.15	20.9	1.00	150	
DSY-25	0.15	0.15	0.78	0.28	0.68	0.69	0.77	0.89	1.00	0.26	0.73	6.09
DSY-26	0.45	0.45	1.15	0.15	0.66	1.15	0.87	0.91	0.98	0.19	0.68	6.74
DSY-27	1.70	1.70	1.41	0.86	1.27	4.89	3.23	3.92	2.08	0.69	3.65	22.0
DSY-28	13.1	13.1	1.06	0.46	0.99	2.11	1.66	2.10	1.16	0.51	1.13	11.2
DSY-29	12.2	12.2	1.52	1.21	1.07	4.64	3.98	3.35	1.66	0.79	2.62	20.8
DSY-30	1.37	1.37	1.26	1.00	0.98	2.39	1.71	3.13	1.30	0.74	1.29	13.8
DSY-31	45.6	45.6	1.25	0.63	0.95	2.38	1.73	2.63	1.18	0.51	1.11	12.4
DSY-32	0.85	0.85	1.33	0.60	1.05	1.96	2.67	2.48	1.23	0.81	1.34	13.5
DSY-33	0.10	0.10	0.90	0.16	0.57	0.51	0.86	0.85	0.87	0.24	0.48	5.44
DSY-34	0.83	0.83	1.18	0.27	0.79	0.99	1.02	1.02	0.98	0.29	0.70	7.24
DSY-35	0.10	0.10	0.41	0.08	0.30	0.06	0.30	0.45	0.24	0.07	0.19	2.09
DSY-36	1.00	1.00	1.37	0.33	1.03	1.59	1.69	2.50	1.23	0.56	0.96	11.3
DSY-37	0.10	0.10	0.90	0.27	0.70	0.79	1.22	1.85	0.80	0.39	0.62	7.54
DSY-38	0.10	0.10	1.09	0.21	0.81	0.82	1.33	1.75	1.05	0.16	0.73	7.96
DSY-39	0.10	0.10	0.92	0.15	0.70	0.59	1.16	1.00	0.85	0.26	0.65	6.28
DSY-40	0.84	0.84	0.83	0.42	0.55	0.88	0.90	1.30	0.83	0.21	0.67	6.57
DSY-41	0.10	0.10	1.39	0.15	0.45	0.27	0.36	0.10	0.69	0.07	0.32	3.81
JPC-1	0.06	0.06	0.32	0.24	0.45	0.21	0.64	1.63	0.68	0.14	0.39	4.69
JPC-2	0.08	0.08	0.59	0.14	0.60	0.40	1.14	0.71	0.67	0.26	0.53	5.05

Hazard Quotients calculated as sediment concentration/benchmark.

See Appendix A-1-1 for sediment concentrations.

1 - Hazard Index calculated as sum of analyte-specific Hazard Quotients.

2 - All benchmarks from Long *et al*., 1995, except tributyltin from Macauley *et al.*, 1994.

Appendix A-2-1.2. Hazard Quotients and Hazard Indices of CoCs in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = NOAA ER-M.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	PAH Hazard Index[1]
ER-M	670	500	640	1100	1600	1600	2800	260	5100	540	9600	3160	2100	1500	2600	44792	
DSY-25	0.02	0.08	0.12	0.27	0.21	0.25	0.17	0.23	0.10	0.08	0.24	0.25	0.01	0.19	0.22	0.11	1.95
DSY-26	0.02	0.02	0.15	0.24	0.32	0.27	0.21	0.24	0.13	0.10	0.32	0.25	0.01	0.21	0.28	0.13	2.22
DSY-27	0.05	0.05	0.22	0.35	0.51	0.58	0.33	0.50	0.16	0.11	0.58	0.32	0.02	0.22	0.75	0.25	3.84
DSY-28	0.07	0.03	0.12	0.17	0.18	0.24	0.13	0.26	0.09	0.06	0.23	0.19	0.02	0.15	0.25	0.11	1.75
DSY-29	0.11	0.38	0.47	1.11	1.69	1.49	1.00	1.22	0.97	0.54	1.92	1.19	0.04	1.07	2.04	0.73	12.1
DSY-30	0.13	0.39	0.14	0.41	0.44	0.51	0.26	0.50	0.29	0.33	0.58	0.76	0.06	0.85	0.67	0.26	4.99
DSY-31	0.06	0.03	0.11	0.18	0.18	0.26	0.14	0.24	0.08	0.05	0.25	0.19	0.02	0.14	0.33	0.11	1.83
DSY-32	0.05	0.03	0.21	0.27	0.24	0.31	0.18	0.28	0.10	0.05	0.30	0.23	0.02	0.12	0.35	0.13	2.20
DSY-33	0.01	0.01	0.02	0.03	0.03	0.04	0.02	0.05	0.02	0.01	0.04	0.04	0.01	0.03	0.04	0.02	0.32
DSY-34	0.04	0.02	0.04	0.06	0.06	0.09	0.05	0.10	0.04	0.03	0.09	0.09	0.01	0.07	0.10	0.04	0.71
DSY-35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
DSY-36	0.03	0.02	0.12	0.14	0.14	0.20	0.10	0.19	0.07	0.03	0.18	0.14	0.02	0.09	0.19	0.08	1.34
DSY-37	0.03	0.01	0.05	0.13	0.09	0.10	0.06	0.11	0.05	0.02	0.12	0.10	0.01	0.06	0.14	0.05	0.86
DSY-38	0.02	0.01	0.04	0.09	0.07	0.07	0.04	0.08	0.05	0.01	0.09	0.07	0.01	0.04	0.10	0.04	0.63
DSY-39	0.02	0.02	0.04	0.07	0.06	0.09	0.04	0.11	0.04	0.03	0.09	0.09	0.01	0.08	0.09	0.04	0.69
DSY-40	0.02	0.03	0.15	0.21	0.15	0.20	0.16	0.20	0.15	0.04	0.31	0.22	0.01	0.20	0.46	0.12	1.98
DSY-41	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.10
JPC-1	0.01	0.00	0.02	0.02	0.03	0.04	0.02	0.04	0.02	0.01	0.04	0.03	0.00	0.03	0.04	0.02	0.27
JPC-2																	

Station	Total PCBs	PCB Hazard Index[1]	p,p'-DDE	Pesticide Hazard Index[1]
ER-M	180		27.0	
DSY-25	0.52	0.52	0.03	0.03
DSY-26	0.55	0.55	0.02	0.02
DSY-27	18.4	18.4	0.26	0.26
DSY-28	0.74	0.74	0.08	0.08
DSY-29	3.04	3.04	0.23	0.23
DSY-30	1.75	1.75	0.16	0.16
DSY-31	1.23	1.23	0.07	0.07
DSY-32	1.12	1.12	0.09	0.09
DSY-33	0.22	0.22	0.02	0.02
DSY-34	0.36	0.36	0.04	0.04
DSY-35	0.04	0.04	0.00	0.00
DSY-36	0.63	0.63	0.10	0.10
DSY-37	0.56	0.56	0.05	0.05
DSY-38	0.33	0.33	0.05	0.05
DSY-39	0.32	0.32	0.03	0.03
DSY-40	0.47	0.47	0.04	0.04
DSY-41	0.08	0.08	0.00	0.00
JPC-1	0.11	0.11	0.01	0.01
JPC-2				

Hazard Quotients calculated as sediment concentration/benchmark.

See Appendix A-1-1 for sediment concentrations.

1 - Hazard Index calculated as sum of analyte-specific Hazard Quotients.

2 - All benchmarks from Long *et al*., 1995, except tributyltin from Macauley *et al.*, 1994.

Appendix A-2-1.2 (continued). Hazard Quotients and Hazard Indices of CoCs in sediments for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = NOAA ER-M.

Station	Tributyltin	Butyltin Hazard Index[1]	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Metals Hazard Index[1]
ER-M	50.0		70.0	906	370	270	218	0.71	51.6	3.70	410	
DSY-25	0.01	0.01	0.09	0.00	0.15	0.09	0.16	0.19	0.41	0.07	0.27	1.43
DSY-26	0.05	0.05	0.13	0.00	0.14	0.15	0.19	0.19	0.40	0.05	0.25	1.50
DSY-27	0.17	0.17	0.17	0.00	0.28	0.62	0.69	0.83	0.84	0.19	1.33	4.94
DSY-28	1.31	1.31	0.12	0.00	0.22	0.27	0.36	0.44	0.47	0.14	0.41	2.43
DSY-29	1.22	1.22	0.18	0.00	0.23	0.58	0.85	0.71	0.67	0.21	0.96	4.40
DSY-30	0.14	0.14	0.15	0.00	0.21	0.30	0.37	0.66	0.53	0.20	0.47	2.89
DSY-31	4.56	4.56	0.15	0.00	0.21	0.30	0.37	0.56	0.48	0.14	0.41	2.61
DSY-32	0.09	0.09	0.16	0.00	0.23	0.25	0.57	0.52	0.50	0.22	0.49	2.94
DSY-33	0.01	0.01	0.11	0.00	0.13	0.06	0.18	0.18	0.35	0.06	0.18	1.25
DSY-34	0.08	0.08	0.14	0.00	0.17	0.12	0.22	0.22	0.40	0.08	0.26	1.60
DSY-35	0.01	0.01	0.05	0.00	0.07	0.01	0.06	0.10	0.10	0.02	0.07	0.46
DSY-36	0.10	0.10	0.16	0.00	0.23	0.20	0.36	0.53	0.50	0.15	0.35	2.48
DSY-37	0.01	0.01	0.11	0.00	0.15	0.10	0.26	0.39	0.32	0.10	0.23	1.67
DSY-38	0.01	0.01	0.13	0.00	0.18	0.10	0.29	0.37	0.43	0.04	0.27	1.80
DSY-39	0.01	0.01	0.11	0.00	0.15	0.07	0.25	0.21	0.34	0.07	0.24	1.45
DSY-40	0.08	0.08	0.10	0.00	0.12	0.11	0.19	0.27	0.33	0.06	0.24	1.43
DSY-41	0.01	0.01	0.16	0.00	0.10	0.03	0.08	0.02	0.28	0.02	0.12	0.81
JPC-1	0.01	0.01	0.04	0.00	0.10	0.03	0.14	0.34	0.28	0.04	0.14	1.10
JPC-2	0.01	0.01	0.07	0.00	0.13	0.05	0.24	0.15	0.27	0.07	0.19	1.18

Hazard Quotients calculated as sediment concentration/benchmark.

See Appendix A-1-1 for sediment concentrations.

1 - Hazard Index calculated as sum of analyte-specific Hazard Quotients.

2 - All benchmarks from Long *et al*., 1995, except tributyltin from Macauley *et al.*, 1994.

APPENDIX A-2-2.
ELUTRIATE HAZARD QUOTIENTS

Appendix A-2-2.1. Hazard Quotients for CoCs in sediment elutriates for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = EPA Ambient Water Quality Criteria - Saltwater Chronic (AWQC-SC) value.

Station	Total PCBs	Arsenic	Copper[1]	Lead	Mercury	Nickel	Silver	Zinc
AWQC-SC[2]	*0.03*	*36*		*8.5*	*0.025*	*8.3*	*2.3*	*86*
DSY-25	2.59	0.34	ND	1.11	4.00	0.48	0.27	0.05
DSY-27	2.31	ND	ND	ND	ND	ND	ND	ND
DSY-29	1.81	ND	ND	ND	ND	ND	ND	ND
DSY-31	0.89	0.76	ND	1.00	4.00	0.48	0.27	0.05
DSY-32	1.96	0.69	ND	1.11	4.00	0.48	0.27	0.05
DSY-33	1.30	0.07	ND	1.87	4.00	0.48	0.27	0.05
DSY-36	0.88	1.12	ND	0.98	4.00	0.48	0.27	0.05
DSY-37	1.25	0.54	ND	1.52	4.00	0.48	0.27	0.05
DSY-38	0.64	1.13	ND	1.26	4.00	0.48	0.27	0.05
DSY-39	0.86	2.11	ND	1.72	4.00	0.48	0.27	0.05
DSY-40	1.22	0.83	ND	1.06	4.00	0.48	0.27	0.05
JPC-1	1.61	0.51	ND	1.55	4.00	0.48	0.27	0.05

HQ=sediment elutriate concentration/AWQC-SC.

ND = No data

JPC-1 = Jamestown Potter Cove reference station

See Appendix A-1-2 for elutriate concentrations.

1 - AWQC-SC value for copper not available; chronic HQs for copper not calculated.

2 - AWQC-SC data from EPA, 1986. Units are µg/L.

Appendix A-2-2.2. Hazard Quotients for CoCs in sediment elutriates for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = EPA Ambient Water Quality Criteria - Saltwater Acute value.

Station	Total PCBs	Arsenic	Copper	Lead	Mercury	Nickel	Silver	Zinc
AWQC-SA[1]	*10.0*	*69*	*2.9*	*220*	*2.1*	*75*	*7.2*	*95*
DSY-25	7.8E-03	0.18	0.43	4.3E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-27	6.9E-03	ND	ND	ND	ND	ND	ND	ND
DSY-29	5.4E-03	ND	ND	ND	ND	ND	ND	ND
DSY-31	2.7E-03	0.39	1.76	3.9E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-32	5.9E-03	0.36	0.43	4.3E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-33	3.9E-03	3.6E-02	0.43	7.2E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-36	2.6E-03	0.59	0.43	3.8E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-37	3.7E-03	0.28	0.43	5.9E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-38	1.9E-03	0.59	0.43	4.9E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-39	2.6E-03	1.10	0.43	6.6E-02	0.05	5.3E-02	3.5E-02	4.7E-02
DSY-40	3.7E-03	0.43	0.43	4.1E-02	0.05	5.3E-02	3.5E-02	4.7E-02
JPC-1	4.8E-03	0.27	0.43	6.0E-02	0.05	5.3E-02	3.5E-02	4.7E-02

HQ=sediment elutriate concentration/AWQC-SC.

ND = No data

JPC-1 = Jamestown Potter Cove reference station

APPENDIX A-2-3.
TISSUE CONCENTRATION RATIOS

Appendix A-2-3.1. Site vs. reference tissue concentration ratios in **cunner** collected for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = CoC concentration at reference.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Reference Concentration[1]	*7.69*	*0.85*	*0.43*	*NA*	*NA*	*0.32*	*NA*	*NA*	*0.65*	*1.15*	*3.06*	*15.0*	*2.93*	*1.30*	*2.05*	*117*	*85.3*	*1.79*	*2.18*	*3.48*	*0.94*	*1.22*	*18.4*	*0.84*	*0.17*	*NA*	*1.58*	*22.0*
DSY-26		3.76				6.62			5.38	2.30	3.63	0.84		3.41	1.15	0.30	2.84	1.79	0.53	1.05	0.88	1.14	0.95	0.94	0.76		0.33	1.89
DSY-28	0.16	4.74	0.80			0.44			3.35	2.88	3.64	0.82		2.07	1.06	1.13	3.98	2.20	1.35	1.41	1.16	0.77	0.83		0.61		0.20	1.20
DSY-29	0.36	5.37				4.35			6.82	2.57	3.61	1.13		4.18	2.05	0.33	4.27	4.31	1.82	2.20	1.22	0.97	1.19	1.08	0.99			1.30
DSY-36									3.57	2.07	2.83	0.41		1.71	2.85	0.33	4.38	3.58	0.69	1.03	1.03	0.70	0.85	1.15	0.86			2.50

Tissue Concentrations Ratios calculated as Station Tissue Concentration/Average Reference Tissue Concentration.
See Appendix Table A-1-3.1 for tissue concentrations and units; see Appendix Table A-1-3.2 for lipid data.
Blank cells indicate ratios not calculated; see text Section 6.2.
1 - Where available, species- and analyte-specific data collected from the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations were numerically averaged to yield a single estimate for the reference-based value. NA = reference data not available.

Appendix A-2-3.2. Site vs. reference tissue concentration ratios in **deployed blue mussels** for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = CoC concentration at reference.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Reference Concentration[1]	*9.09*	*8.72*	*6.54*	*4.93*	*4.80*	*3.56*	*3.87*	*3.47*	*11.6*	*NA*	*35.0*	*27.1*	*NA*	*4.34*	*11.0*	*90.3*	*71.9*	*1.23*	*4.06*	*5.95*	*0.64*	*2.33*	*9.13*	*2.59*	*0.15*	*3.60*	*NA*	*90.7*
DSY-26		1.12	1.10	1.92	2.29		2.57		4.29		3.16	1.46		2.60	3.59	2.01	3.60	1.48	1.17	0.89	1.47	0.93	1.46	0.53	1.10	0.51		1.13
DSY-28				0.78	1.42		1.23		1.62		1.42	0.51		1.64	1.72	0.91	1.55		0.44	2.83	1.20	1.02	1.20		0.91	1.35		1.05
DSY-29		2.49	0.69	1.18	1.62		1.39		2.12		1.77	1.50		1.58	2.15	1.39	1.74	1.84	0.64	1.50	1.27	0.87	0.69	0.36	1.15	0.80		0.83
DSY-31				1.18	2.14		1.72		1.78		1.68	0.60		1.65	1.87	1.05	1.91	2.06	0.41	0.88	0.84	0.98	0.98	0.52	0.99	0.58		1.81
DSY-33									1.24		0.89	0.22			1.33	0.32	1.46	1.74	0.83	2.09	1.45	1.09	0.92	0.57	0.69	0.48		1.34
DSY-38			0.31	0.41	0.53	0.39	0.64		0.57		0.59	0.30		0.73	0.67	0.44	1.31	1.23	0.35	1.02	0.97	1.12	1.25	0.75	0.87	0.81		0.99
DSY-39		1.30	0.84		0.62		0.86	1.61	0.59		0.76	0.81			0.67	0.68	1.08	1.35	0.40	1.50	0.50	1.28	0.94		0.96	0.93		1.44
DSY-40		2.03	1.03	1.13	1.19		0.80		1.68		1.30	1.52		2.15	1.53	1.06	1.05	1.10	0.10	1.00	0.95	1.16	0.69	1.15	0.88	0.95		1.29

Tissue Concentrations Ratios calculated as Station Tissue Concentration/Average Reference Tissue Concentration.

See Appendix Table A-1-3.1 for tissue concentrations and units; see Appendix Table A-1-3.2 for lipid data.

Blank cells indicate ratios not calculated; see text Section 6.2.

1 - Where available, species- and analyte-specific data collected from the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations were numerically averaged to yield a single estimate for the reference-based value. NA = reference data not available.

Appendix A-2-3.3. Site vs. reference tissue concentration ratios in **hard clams** collected for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = CoC concentration at reference.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
MM-Reference Concentration[1]	*NA*	*NA*	*1.01*	*2.34*	*4.07*	*1.62*	*3.77*	*NA*	*8.34*	*1.43*	*26.3*	*12.4*	*NA*	*2.27*	*8.32*	*49.1*	*79.0*	*1.21*	*5.16*	*7.73*	*0.71*	*2.11*	*6.87*	*2.12*	*0.13*	*1.32*	*NA*	*116*
PM-Reference Concentration[1]	*NA*	*NA*	*3.24*	*6.57*	*28.3*	*8.56*	*18.6*	*NA*	*27.6*	*3.40*	*117*	*36.9*	*NA*	*9.04*	*33.4*	*246*	*285*	*2.77*	*53.0*	*11.0*	*0.64*	*2.16*	*12.0*	*2.37*	*0.11*	*NA*	*NA*	*121*
DSY-31-PM				1.66	1.68	1.88	1.30		2.32		1.90	0.71		0.94	2.12	1.24	1.19	0.39	0.32	0.85	1.22	0.92	1.20	0.73	1.22			0.72
DSY-32-PM			1.28	1.29	0.86	1.53	0.99		1.70		1.36	0.71		0.98	1.67	1.01	0.40	0.28		0.45	0.92	0.81	0.91	1.17	1.39			0.93
DSY-33-PM									1.24		0.89	0.22			1.33	0.32	1.46	1.74	0.83	2.09	1.45	1.09	0.92	0.57	0.69	0.48		1.34
DSY-34-PM				0.82	0.44	0.71	0.35		0.72	0.42	0.57	0.56		1.05	0.63	0.55	0.30	0.15	0.20	0.78	1.11	0.99	0.85	0.70	1.06			0.77
DSY-35-MM					1.92	2.14	0.90		2.83	1.00	2.14	1.85		4.06	2.13	1.64	1.00	0.81	3.77	0.83	0.90	1.13	0.93		0.94	2.21		0.95
DSY-35-PM				0.42	0.32	0.79	0.25		1.05	0.67	0.62	0.64		1.30	0.69	0.50	0.71	0.72		0.77	1.03	0.93	0.70	0.70	0.90			1.03
DSY-36-PM				1.90	0.97	1.57	1.15		1.88		1.39	0.90		1.46	1.44	1.19	0.72	0.43	0.53	0.67	1.30	1.14	1.00	0.92	1.34			1.00
DSY-37-PM				1.40	1.79	2.45	1.83		2.45		2.13	1.10		2.75	2.26	1.58	1.36	0.96		0.67	1.00	0.80	0.75	1.25	1.38			0.88
DSY-38-PM			0.41	0.40	0.40	0.60	0.37		0.39	0.35	0.38	0.31		0.25	0.32	0.36				0.55	0.92	0.85	0.87		1.50			1.09
DSY-41-MM			2.11	2.18		3.19			3.83	1.24	2.58	1.90		2.74	3.67	2.12	1.48	1.67	2.77	0.97	1.27	0.83	1.91	0.76	0.93			0.57
DSY-41-PM			1.25	1.42	0.69	0.96	0.80		1.37	1.11	1.03	0.90		0.86	1.18	0.83	0.46	0.31		0.20	1.13	0.90	0.99		1.34			0.69

Tissue Concentrations Ratios calculated as Station Tissue Concentration/Average Reference Tissue Concentration.
See Appendix Table A-1-3.1 for tissue concentrations and units; see Appendix Table A-1-3.2 for lipid data.
Blank cells indicate ratios not calculated; see text Section 6.2.
1 - Where available, species- and analyte-specific data collected from the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations were numerically averaged to yield a single estimate for the reference-based value. NA = reference data not available.

Appendix A-2-3.4. Site vs. reference tissue concentration ratios in **indigenous blue mussels** collected for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = CoC concentration at reference.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Reference Concentration[1]	*NA*	*NA*	*2.97*	*3.90*	*6.83*	*4.26*	*7.17*	*NA*	*13.7*	*2.48*	*43.6*	*16.0*	*NA*	*4.85*	*11.5*	*93.6*	*91.9*	*1.27*	*15.5*	*5.73*	*0.59*	*2.14*	*10.3*	*2.03*	*0.18*	*3.84*	*NA*	*92.3*
DSY-24			0.72	0.84	0.41	0.34	0.54		0.79	0.51	0.67	0.72		0.91	0.77	0.76	1.24	1.14	0.16	1.79	3.18	1.47	0.40	2.86	1.57	1.42		0.83
DSY-25			5.64	10.6	9.25	6.04	9.45		12.1	2.69	10.1	8.69		7.03	9.88	8.72	1.29	0.86	0.36	2.19	2.07	1.40	1.16		0.98	0.89		1.22
DSY-26			5.58	11.2	28.2	23.8	16.2		17.7	2.49	19.6	9.03		8.65	16.7	17.8	1.67	1.10	0.24	1.44	1.25	1.14	0.75		0.67			0.99
DSY-27			2.94	6.31	6.27	2.53	6.12		12.5	2.33	8.95	5.08		8.30	10.5	6.26	1.85	1.39	9.29	1.17	1.32	1.34	1.45	1.49	0.83	1.23		1.54
DSY-28			2.17	3.24	1.95	1.47	2.22		3.32	1.88	2.61	2.96		4.36	2.82	2.16	1.62	1.07	0.58	0.47	1.06	1.19	0.11		0.81			1.31
DSY-35				1.30	0.91		1.12		1.53	0.93	1.19	1.19		1.72	1.36	1.08	1.51	1.91	0.12	1.09	1.25	1.04	0.73	0.86	0.94			1.40
DSY-36			0.96	1.38	0.83	0.55	1.05		1.43	0.38	1.17	0.93		1.09	1.38	0.99	1.81	1.20	0.42	1.07	0.67	1.33	0.69		1.06	1.13		0.92
DSY-40			1.21	1.39	0.57	0.23	0.65		1.22	0.91	0.90	1.56		1.94	1.12	0.84	1.57	1.29	0.32	0.92	1.08	1.04	0.68	1.20	0.93			1.14

Tissue Concentrations Ratios calculated as Station Tissue Concentration/Average Reference Tissue Concentration.

See Appendix Table A-1-3.1 for tissue concentrations and units; see Appendix Table A-1-3.2 for lipid data.

Blank cells indicate ratios not calculated; see text Section 6.2.

1 - Where available, species- and analyte-specific data collected from the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations were numerically averaged to yield a single estimate for the reference-based value. NA = reference data not available.

Appendix A-2-3.5. Site vs. reference tissue concentration ratios in **lobster** collected for the Derecktor Shipyard Marine Ecological Risk Assessment. Benchmark = CoC concentration at reference.

Station	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	High Molecular Weight PAHs	Low Molecular Weight PAHs	Naphthalene	Phenanthrene	Pyrene	Total PAHs	Total PCBs	p,p'-DDE	Tributyltin	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
Reference Concentration[1]	*NA*	*NA*	*NA*	*2.79*	*NA*	*NA*	*NA*	*NA*	*5.18*	*4.96*	*17.1*	*19.0*	*NA*	*6.23*	*6.67*	*60.6*	*179*	*2.51*	*NA*	*20.6*	*0.21*	*1.56*	*122*	*0.29*	*0.26*	*1.48*	*3.02*	*112*
DSY-25									7.66		4.58	0.75			5.07	1.21	1.03	0.92		1.39	1.76	1.07	1.24	0.55	1.00	1.03	1.81	0.78
DSY-27				1.26					7.15		6.73	1.92		1.38	6.03	3.59	1.79	1.44		0.84	1.27	1.36	1.36	0.24	1.72	0.81	2.28	1.00
DSY-28				0.53					4.98		5.88	1.27		1.82	6.56	3.30	1.70	1.38										
DSY-29									3.08	1.23	3.12	1.96		1.85	4.27	2.32	0.81	1.03		1.39	2.29	1.10	0.82	0.77	1.09	1.18	1.94	1.15
DSY-33									2.47		2.28	1.76		1.27	3.17	1.98	1.04	1.05		1.08	0.78	1.28	0.49	1.65	0.86	1.18	1.14	0.94
DSY-35				0.47					2.69		1.73	0.53		0.90	1.56	0.52	0.75	0.82		0.79	2.73	1.39	1.05	2.67	1.01	0.61	2.17	0.98
DSY-36				1.06					4.18		3.09	0.92		1.67	3.62	1.26	2.62	0.91		0.97		1.27	0.40	1.19	1.24	0.99	0.95	1.02
DSY-38				0.40					1.24		0.87	0.64		0.63	0.53	0.24	0.63	1.09		1.27	2.39	1.25	1.35	0.91	1.25	1.27	2.02	1.53
DSY-39				0.32					0.88		0.94	0.72		0.59	0.78	0.24	1.78	0.47		0.91	1.46	1.05	1.61	0.63	1.56	0.99	0.27	1.15

Tissue Concentrations Ratios calculated as Station Tissue Concentration/Average Reference Tissue Concentration.

See Appendix Table A-1-3.1 for tissue concentrations and units; see Appendix Table A-1-3.2 for lipid data.

Blank cells indicate ratios not calculated; see text Section 6.2.

1 - Where available, species- and analyte-specific data collected from the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations were numerically averaged to yield a single estimate for the reference-based value. NA = reference data not available.

APPENDIX A-2-4.
PREDATORY AVIAN AQUATIC RECEPTORS

Appendix A-2-4.1. Dry tissue weight to wet tissue weight ratio for biota collecte
Derecktor Shipyard Marine Ecological Risk Assessment.

Station	Cunner	Deployed Mussels	Indigenous Blue Mussels	Lobster	Mummichog	*Mercenaria mercenaria*	*Pitar morrhuana*
DSY-24			0.089				
DSY-25			0.088	0.153			
DSY-26	0.154	0.117	0.126				
DSY-27			0.130	0.148			
DSY-28	0.168	0.108	0.105	0.135			
DSY-29	0.156	0.143		0.139			
DSY-31		0.106					0.091
DSY-32							0.108
DSY-33		0.114		0.167			0.089
DSY-34							0.095
DSY-35			0.138	0.151		0.143	0.116
DSY-36	0.152		0.118	0.136			0.075
DSY-37							0.028
DSY-38		0.128		0.114			0.103
DSY-39		0.120		0.153			
DSY-40		0.155	0.142				
DSY-41						0.154	0.123
JPC-1		0.137	0.108	0.123	0.174	0.182	0.087
CHC-1	0.146	0.128	0.105	0.129			
T-0		0.070					

Appendix Table A-2-4.2. Dose of CoCs to **Herring Gull** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-24-IBM	DSY-25-IBM	DSY-25-LOB	DSY-26-CN	DSY-26-DM	DSY-26-IBM	DSY-27-IBM	DSY-27-LOB	DSY-28-CN	DSY-28-DM	DSY-28-IBM	DSY-28-LOB	DSY-29-CN
	Exposure Factor	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*
MET	Arsenic	3.07	3.77	8.59	1.09	1.60	2.47	2.00	5.16	1.47	5.05	0.80		2.30
MET	Cadmium	0.56	0.36	0.11	0.25	0.28	0.22	0.23	7.8E-2	0.33	0.23	0.19		0.35
MET	Chromium	0.95	0.90	0.50	0.42	0.65	0.73	0.86	0.63	0.28	0.71	0.76		0.35
MET	Copper	1.25	3.58	45.48	5.24	3.98	2.31	4.47	50.0	4.59	3.29	0.34		6.54
MET	Lead	1.74	7.5E-5	4.7E-2	0.24	0.41	7.5E-5	0.91	2.1E-2	7.5E-5	7.5E-5	7.5E-5		0.27
MET	Mercury	8.4E-2	5.2E-2	7.9E-2	3.9E-2	4.9E-2	3.6E-2	4.4E-2	0.14	3.1E-2	4.0E-2	4.3E-2		5.0E-2
MET	Nickel	1.63	1.03	0.46	0.31	0.55	7.5E-5	1.42	0.36	0.39	1.46	7.5E-5		0.52
MET	Silver	4.5E-5	4.5E-5	1.64	0.16	4.5E-5	4.5E-5	4.5E-5	2.06	9.3E-2	0.35	4.5E-5		4.5E-5
MET	Zinc	22.9	33.7	26.4	12.5	30.9	27.3	42.7	33.8	7.94	28.58	36.20		8.56
PAH	2-Methylnaphthalene		8.42	2.82	2.82	2.82	2.82	2.82	2.29	4.24	2.82	2.82	3.68	7.18
PAH	Acenaphthene	0.80	4.70	0.80	8.67	20.2	0.80	0.80	9.76	13.7	0.80	0.80	0.80	11.8
PAH	Acenaphthylene	3.45	22.4	0.87	0.87	14.9	26.9	17.73	0.87	1.17	0.87	10.4	0.87	0.87
PAH	Anthracene	5.32	55.2	2.40	2.40	19.5	71.1	50.03	2.46	1.79	7.10	20.5	1.25	1.85
PAH	Fluorene	2.07	8.91	0.59	7.23	0.59	10.0	11.74	0.59	11.3	0.59	7.54	0.59	7.74
PAH	Naphthalene		40.7	0.50	0.50	0.50	54.9	0.50	3.60	0.50	0.50	0.50	3.60	0.50
PAH	Phenanthrene	7.17	45.5	2.84	12.1	23.3	68.0	81.74	6.02	9.23	13.2	34.2	9.65	14.2
PCB	Total PCBs	185	158	140	660	534	249	345	224	1161	207	241	258	951
PST	Aldrin	4.5E-2	4.5E-2	4.5E-2	0.12	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2
PST	p,p'-DDE	2.36	1.46	1.76	8.73	3.77	2.27	3.57	2.53	13.4		2.19	2.94	20.1
TBT	Tributyltin	4.06	7.51	0.90	3.17	9.81	5.96	293	0.90	10.0	3.30	14.7	0.90	10.4

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.30 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.2 (continued). Dose of CoCs to **Herring Gull** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-29-DM	DSY-29-LOB	DSY-31-DM	DSY-31-PM	DSY-32-PM	DSY-33-DM	DSY-33-LOB	DSY-33-PM	DSY-34-PM	DSY-35-IBM	DSY-35-LOB	DSY-35-MM	DSY-35-PM
Exposure Factor		*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*
MET	Arsenic	2.68	8.57	1.56	2.81	1.48	3.73	6.68	1.76	2.59	1.87	4.87	1.93	2.54
MET	Cadmium	0.24	0.14	0.16	0.23	0.18	0.28	4.8E-2	0.20	0.21	0.22	0.17	0.19	0.20
MET	Chromium	0.61	0.51	0.69	0.59	0.52	0.76	0.60	0.56	0.64	0.67	0.65	0.71	0.60
MET	Copper	1.90	30.1	2.67	4.31	3.28	2.53	18.1	2.59	3.04	2.25	38.52	1.93	2.53
MET	Lead	0.28	6.6E-2	0.40	0.52	0.83	0.44	0.14	7.5E-5	0.50	0.53	0.23	7.5E-5	0.50
MET	Mercury	5.1E-2	8.6E-2	4.4E-2	4.1E-2	4.6E-2	3.1E-2	6.8E-2	3.7E-2	3.6E-2	5.0E-2	8.0E-2	3.6E-2	3.0E-2
MET	Nickel	0.86	0.52	0.62	1.20	0.65	0.52	0.52	7.5E-5	0.63	7.5E-5	0.27	0.88	0.47
MET	Silver	4.5E-5	1.75	4.5E-5	4.5E-5	0.41	4.5E-5	1.03	4.5E-5	4.5E-5	4.5E-5	1.96	4.5E-5	4.5E-5
MET	Zinc	22.5	38.8	49.2	26.2	33.8	36.6	31.5	30.5	27.7	38.9	33.0	33.3	37.4
PAH	2-Methylnaphthalene	2.82	4.47	2.82	2.82	2.82	2.82	4.13	2.82	2.82	2.82		2.82	2.82
PAH	Acenaphthene	45.2	0.80	0.80	0.80	0.80	0.80	0.80	0.85	0.80	0.80	0.80	0.80	0.80
PAH	Acenaphthylene	9.36	0.87	0.87	0.87	4.06	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
PAH	Anthracene	12.1	2.40	10.0	9.11	8.26	2.40	2.40	4.01	5.95	7.64	0.93	2.40	1.98
PAH	Fluorene	0.59	4.47	0.59	0.59	0.59	0.59	0.59	1.56	1.56	3.48	0.59	0.87	1.65
PAH	Naphthalene	0.50	5.83	0.50	0.50	0.50	0.50	10.56	0.50	0.50	0.50		0.50	0.50
PAH	Phenanthrene	14.2	8.45	12.3	7.14	8.63	2.84	5.95	4.29	10.5	12.51	3.96	5.57	8.49
PCB	Total PCBs	260	107	236	285	110	191	141	157	93.4	209	95.0	47.8	145
PST	Aldrin	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2
PST	p,p'-DDE	4.70	1.89	4.36	0.90	0.76	3.89	1.99	1.14	0.46	3.64	1.47	0.59	1.42
TBT	Tributyltin	5.42	0.90	2.85	14.4		6.17	0.90	16.1	11.8	2.75	0.90	11.73	

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.30 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.2 (continued). Dose of CoCs to **Herring Gull** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-36-CN	DSY-36-IBM	DSY-36-LOB	DSY-36-PM	DSY-37-PM	DSY-38-DM	DSY-38-LOB	DSY-38-PM	DSY-39-DM	DSY-39-LOB	DSY-40-DM	DSY-40-IBM	DSY-41-MM
Exposure Factor		*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*
MET	Arsenic	1.08	1.85	5.95	2.23	2.23	1.82	7.82	1.82	2.68	5.60	1.79	1.58	2.24
MET	Cadmium	0.29	0.12	7.5E-5	0.25	0.19	0.19	0.15	0.18	0.10	9.0E-2	0.18	0.19	0.27
MET	Chromium	0.26	0.85	0.59	0.74	0.52	0.79	0.59	0.55	0.90	0.49	0.81	0.67	0.53
MET	Copper	4.66	2.11	14.7	3.59	2.68	3.43	49.6	3.13	2.58	59.1	1.90	2.10	3.95
MET	Lead	0.29	7.5E-5	0.10	0.65	0.89	0.58	7.8E-2	7.5E-5	7.5E-5	5.4E-2	0.89	0.73	0.48
MET	Mercury	4.4E-2	5.7E-2	0.10	4.5E-2	4.6E-2	3.8E-2	0.10	5.0E-2	4.2E-2	0.12	3.9E-2	5.0E-2	3.6E-2
MET	Nickel	0.43	1.30	0.44	0.56	0.47	0.87	0.56	7.5E-5	1.00	0.44	1.03	7.5E-5	7.5E-5
MET	Silver	4.5E-5	4.5E-5	0.86	4.5E-5	0.20	0.52	1.83	4.5E-5	0.29	0.25	4.5E-5	4.5E-5	0.38
MET	Zinc	16.5	25.4	34.5	36.3	31.8	26.8	51.4	39.4	39.2	38.6	35.09	31.47	19.73
PAH	2-Methylnaphthalene				2.82			2.82	2.82	2.82	2.82	2.82	2.82	2.82
PAH	Acenaphthene	0.80	0.80	0.80	0.80	0.80	0.80	0.80	1.67	20.2	0.80	39.3	0.80	1.96
PAH	Acenaphthylene	0.87	4.59	0.87	0.87	0.87	3.57	0.87	1.62	9.75	0.87	14.9	6.79	1.37
PAH	Anthracene	2.40	8.70	1.59	8.99	3.04	3.57	0.85	3.20	2.40	0.54	12.3	10.2	3.27
PAH	Fluorene	5.99	1.50	0.59	0.59	0.59	0.59	0.59	1.42	0.59	0.59	0.59	4.30	1.15
PAH	Naphthalene				0.50			0.50	0.50	0.50	0.50	0.50	4.52	0.50
PAH	Phenanthrene	5.59	8.49	5.56	9.51	8.22	5.54	3.02	2.76	2.84	2.24	20.7	17.8	3.99
PCB	Total PCBs	939	268	252	148	128	165	87.2		138	193	167	274	75.3
PST	Aldrin	0.29	4.5E-2	4.5E-2	4.5E-2		4.5E-2	4.5E-2		4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2
PST	p,p'-DDE	16.1	2.45	1.23	0.87	0.88	2.65	2.12		2.95	0.72	2.99	3.11	1.30
TBT	Tributyltin	3.77	10.6	0.90	20.14		2.50	0.90		2.90	0.90	0.90	9.51	9.18

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.30 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.2 (continued). Dose of CoCs to **Herring Gull** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-41-PM	JPC-1-MF	JPC-1-DM	JPC-1-IBM	JPC-1-LOB	JPC-1-MM	JPC-1-PM	CHC-1-CN	CHC-1-DM	CHC-1-IBM	CHC-1-LOB
	Exposure Factor	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*	*0.30*
MET	Arsenic	0.65	1.33	2.03	5.83	1.78	2.32	3.31	1.04	2.24	1.40	6.50
MET	Cadmium	0.22	0.16	1.8E-1	0.05	0.35	0.21	0.19	0.28	0.22	0.17	6.9E-2
MET	Chromium	0.58	0.87	0.73	0.50	0.32	0.63	0.65	0.37	0.53	0.55	0.43
MET	Copper	3.57	2.16	2.6	42.81	6.82	2.06	3.59	5.52	3.31	3.58	30.6
MET	Lead	7.5E-5	0.00	0.98	0.12	1.3E-1	0.64	0.71	0.25	0.78	0.23	5.4E-2
MET	Mercury	4.5E-2	4.0E-2	5.1E-2	9.0E-2	3.4E-2	3.8E-2	3.4E-2	5.1E-2	4.8E-2	5.5E-2	6.8E-2
MET	Nickel	0.56	9.2E-1	7.5E-5	0.42	0.39	0.40	7.5E-5	7.5E-5	1.23	1.15	0.47
MET	Silver	4.5E-5	4.5E-5	4.5E-5	6.6E-1	4.5E-5	4.5E-5	4.5E-5	0.47	4.5E-5	4.5E-5	1.15
MET	Zinc	25.1	32.0	27.8	31.7	10.2	34.9	36.2	6.6	22.4	27.5	35.7
PAH	2-Methylnaphthalene	2.82	2.82		2.82	2.82	2.82	2.82	27.3	16.6	2.82	2.82
PAH	Acenaphthene	1.93	19.31	0.80	0.80	0.8	0.80	0.80	3.00	16.5	0.80	0.80
PAH	Acenaphthylene	2.56	0.87	3.39	0.87	0.87	0.79	0.91	1.53	12.0	5.24	0.87
PAH	Anthracene	5.90	6.52	3.54	2.40	0.61	1.82	1.84	2.40	12.8	7.53	1.91
PAH	Fluorene	2.39	0.59	1.94	3.77	8.19	1.11	0.95	4.09	0.59	5.01	0.59
PAH	Naphthalene	0.50	0.50		0.50	0.50	0.50	0.50	10.4	0.50	0.50	0.50
PAH	Phenanthrene	4.91	8.33	5.32	4.66	2.75	1.76	2.53	4.62	9.25	8.70	4.34
PCB	Total PCBs	82.2	185	169	119	570	61.3	80.0	303	116	117	138
PST	Aldrin	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2	4.5E-2
PST	p,p'-DDE	0.54	2.39	2.01	1.2	20.22	0.94	0.78	6.36	2.60	1.84	2.33
TBT	Tributyltin		3.35	0.90	0.90	2.62	4.01	14.87	7.74	12.2	20.0	0.90

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.30 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.3. Dose of CoCs to **Great Blue Heron** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-24-IBM	DSY-25-IBM	DSY-25-LOB	DSY-26-CN	DSY-26-DM	DSY-26-IBM	DSY-27-IBM	DSY-27-LOB	DSY-28-CN	DSY-28-DM	DSY-28-IBM	DSY-28-LOB	DSY-29-CN
Exposure Factor		*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*
MET	Arsenic	2.86	3.52	8.02	1.02	1.49	2.30	1.87	4.81	1.37	4.72	0.75		2.15
MET	Cadmium	0.52	0.34	0.10	0.23	0.26	0.20	0.22	7.3E-2	0.31	0.22	0.17		0.32
MET	Chromium	0.88	0.84	0.46	0.39	0.60	0.68	0.80	0.59	0.26	0.67	0.71		0.33
MET	Copper	1.16	3.34	42.45	4.89	3.72	2.15	4.17	46.7	4.28	3.07	0.32		6.11
MET	Lead	1.63	7.0E-5	4.4E-2	0.22	0.38	7.0E-5	0.85	1.9E-2	7.0E-5	7.0E-5	7.0E-5		0.25
MET	Mercury	7.8E-2	4.9E-2	7.4E-2	3.6E-2	4.5E-2	3.3E-2	4.1E-2	0.13	2.9E-2	3.7E-2	4.0E-2		4.7E-2
MET	Nickel	1.52	0.96	0.43	0.29	0.51	7.0E-5	1.33	0.34	0.36	1.36	7.0E-5		0.49
MET	Silver	4.2E-5	4.2E-5	1.53	0.15	4.2E-5	4.2E-5	4.2E-5	1.92	8.7E-2	0.33	4.2E-5		4.2E-5
MET	Zinc	21.4	31.5	24.6	11.6	28.8	25.5	39.8	31.6	7.41	26.7	33.8		7.99
PAH	2-Methylnaphthalene		7.86	2.63	2.63	2.63	2.63	2.63	2.14	3.95	2.63	2.63	3.44	6.71
PAH	Acenaphthene	0.74	4.39	0.74	8.09	18.8	0.74	0.74	9.11	12.8	0.74	0.74	0.74	11.1
PAH	Acenaphthylene	3.22	20.9	0.81	0.81	13.9	25.1	16.55	0.81	1.10	0.81	9.7	0.81	0.81
PAH	Anthracene	4.96	51.5	2.24	2.24	18.2	66.4	46.70	2.30	1.67	6.63	19.1	1.16	1.72
PAH	Fluorene	1.93	8.31	0.55	6.75	0.55	9.34	10.96	0.55	10.6	0.55	7.04	0.55	7.22
PAH	Naphthalene		38.0	0.47	0.47	0.47	51.3	0.47	3.36	0.47	0.47	0.47	3.36	0.47
PAH	Phenanthrene	6.69	42.4	2.65	11.3	21.8	63.5	76.29	5.62	8.61	12.3	31.9	9.00	13.2
PCB	Total PCBs	172	148	131	616	498	233	322	209	1084	193	225	241	888
PST	Aldrin	4.2E-2	4.2E-2	4.2E-2	0.11	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2
PST	p,p'-DDE	2.20	1.36	1.65	8.15	3.51	2.12	3.33	2.36	12.6		2.04	2.74	18.8
TBT	Tributyltin	3.79	7.01	0.84	2.96	9.16	5.57	274	0.84	9.37	3.08	13.7	0.84	9.7

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.28 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.3 (continued). Dose of CoCs to **Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-29-DM	DSY-29-LOB	DSY-31-DM	DSY-31-PM	DSY-32-PM	DSY-33-DM	DSY-33-LOB	DSY-33-PM	DSY-34-PM	DSY-35-IBM	DSY-35-LOB	DSY-35-MM	DSY-35-PM
Exposure Factor		*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*
MET	Arsenic	2.50	8.00	1.46	2.62	1.38	3.48	6.23	1.65	2.41	1.74	4.54	1.80	2.37
MET	Cadmium	0.23	0.13	0.15	0.22	0.17	0.26	4.5E-2	0.18	0.20	0.20	0.16	0.18	0.18
MET	Chromium	0.57	0.48	0.64	0.55	0.49	0.71	0.56	0.52	0.60	0.62	0.60	0.67	0.56
MET	Copper	1.77	28.1	2.49	4.03	3.06	2.36	16.9	2.42	2.84	2.10	35.95	1.80	2.36
MET	Lead	0.26	6.2E-2	0.38	0.49	0.78	0.41	0.13	7.0E-5	0.46	0.49	0.21	7.0E-5	0.46
MET	Mercury	4.7E-2	8.0E-2	4.1E-2	3.8E-2	4.3E-2	2.9E-2	6.4E-2	3.4E-2	3.3E-2	4.6E-2	7.4E-2	3.4E-2	2.8E-2
MET	Nickel	0.80	0.49	0.58	1.12	0.61	0.49	0.49	7.0E-5	0.59	7.0E-5	0.25	0.82	0.43
MET	Silver	4.2E-5	1.64	4.2E-5	4.2E-5	0.39	4.2E-5	0.96	4.2E-5	4.2E-5	4.2E-5	1.83	4.2E-5	4.2E-5
MET	Zinc	21.0	36.2	45.9	24.5	31.5	34.1	29.4	28.5	25.9	36.3	30.8	31.0	34.9
PAH	2-Methylnaphthalene	2.63	4.17	2.63	2.63	2.63	2.63	3.86	2.63	2.63	2.63		2.63	2.63
PAH	Acenaphthene	42.1	0.74	0.74	0.74	0.74	0.74	0.74	0.79	0.74	0.74	0.74	0.74	0.74
PAH	Acenaphthylene	8.74	0.81	0.81	0.81	3.79	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
PAH	Anthracene	11.3	2.24	9.35	8.50	7.71	2.24	2.24	3.74	5.55	7.13	0.87	2.24	1.85
PAH	Fluorene	0.55	4.18	0.55	0.55	0.55	0.55	0.55	1.45	1.46	3.25	0.55	0.81	1.54
PAH	Naphthalene	0.47	5.44	0.47	0.47	0.47	0.47	9.86	0.47	0.47	0.47		0.47	0.47
PAH	Phenanthrene	13.3	7.89	11.5	6.66	8.05	2.65	5.56	4.01	9.84	11.68	3.69	5.19	7.92
PCB	Total PCBs	243	99.4	220	266	103	179	131	147	87.2	195	88.6	44.6	136
PST	Aldrin	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2
PST	p,p'-DDE	4.39	1.77	4.07	0.84	0.71	3.63	1.86	1.06	0.43	3.40	1.37	0.55	1.33
TBT	Tributyltin	5.05	0.84	2.66	13.4		5.76	0.84	15.1	11.0	2.57	0.84	10.95	

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.28 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.3 (continued). Dose of CoCs to **Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-36-CN	DSY-36-IBM	DSY-36-LOB	DSY-36-PM	DSY-37-PM	DSY-38-DM	DSY-38-LOB	DSY-38-PM	DSY-39-DM	DSY-39-LOB	DSY-40-DM	DSY-40-IBM	DSY-41-MM
Exposure Factor		*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*
MET	Arsenic	1.01	1.72	5.56	2.08	2.08	1.70	7.30	1.70	2.50	5.22	1.67	1.48	2.09
MET	Cadmium	0.27	0.11	7.0E-5	0.23	0.18	0.17	0.14	0.17	9.0E-2	8.4E-2	0.17	0.18	0.25
MET	Chromium	0.24	0.80	0.55	0.69	0.48	0.73	0.55	0.52	0.84	0.46	0.76	0.62	0.49
MET	Copper	4.35	1.97	13.8	3.35	2.50	3.20	46.3	2.92	2.41	55.1	1.77	1.96	3.68
MET	Lead	0.27	7.0E-5	0.10	0.61	0.83	0.54	7.3E-2	7.0E-5	7.0E-5	5.0E-2	0.83	0.68	0.45
MET	Mercury	4.1E-2	5.3E-2	9.2E-2	4.2E-2	4.3E-2	3.6E-2	9.2E-2	4.7E-2	3.9E-2	0.11	3.6E-2	4.6E-2	3.3E-2
MET	Nickel	0.40	1.21	0.41	0.52	0.44	0.81	0.53	7.0E-5	0.94	0.41	0.96	7.0E-5	7.0E-5
MET	Silver	4.2E-5	4.2E-5	0.80	4.2E-5	0.18	0.48	1.71	4.2E-5	0.27	0.23	4.2E-5	4.2E-5	0.35
MET	Zinc	15.4	23.7	32.2	33.8	29.7	25.0	48.0	36.8	36.6	36.0	32.7	29.4	18.4
PAH	2-Methylnaphthalene				2.63			2.63	2.63	2.63	2.63	2.63	2.63	2.63
PAH	Acenaphthene	0.74	0.74	0.74	0.74	0.74	0.74	0.74	1.56	18.9	0.74	36.6	0.74	1.83
PAH	Acenaphthylene	0.81	4.28	0.81	0.81	0.81	3.33	0.81	1.51	9.10	0.81	13.9	6.34	1.28
PAH	Anthracene	2.24	8.12	1.48	8.39	2.84	3.33	0.79	2.98	2.24	0.50	11.5	9.56	3.06
PAH	Fluorene	5.59	1.40	0.55	0.55	0.55	0.55	0.55	1.33	0.55	0.55	0.55	4.02	1.07
PAH	Naphthalene				0.47			0.47	0.47	0.47	0.47	0.47	4.22	0.47
PAH	Phenanthrene	5.22	7.93	5.19	8.87	7.67	5.17	2.82	2.57	2.65	2.09	19.3	16.6	3.73
PCB	Total PCBs	876	251	235	138	120	154	81.4		129	180	156	255	70.2
PST	Aldrin	0.27	4.2E-2	4.2E-2	4.2E-2		4.2E-2	4.2E-2		4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2
PST	p,p'-DDE	15.0	2.28	1.15	0.81	0.82	2.48	1.98		2.75	0.67	2.79	2.90	1.21
TBT	Tributyltin	3.52	9.93	0.84	18.80		2.33	0.84		2.70	0.84	0.84	8.88	8.57

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog;
MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.28 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.3 (continued). Dose of CoCs to **Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and the Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Type	Analyte	DSY-41-PM	JPC-1-MF	JPC-1-DM	JPC-1-IBM	JPC-1-LOB	JPC-1-MM	JPC-1-PM	CHC-1-CN	CHC-1-DM	CHC-1-IBM	CHC-1-LOB
	Exposure Factor	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*
MET	Arsenic	0.60	1.24	1.90	5.44	1.66	2.16	3.09	0.97	2.09	1.31	6.07
MET	Cadmium	0.20	0.15	1.7E-1	0.05	0.33	0.20	0.18	0.26	0.21	0.16	6.4E-2
MET	Chromium	0.54	0.81	0.68	0.47	0.30	0.59	0.60	0.34	0.49	0.52	0.40
MET	Copper	3.33	2.02	2.4	39.95	6.37	1.92	3.35	5.15	3.09	3.34	28.5
MET	Lead	7.0E-5	0.00	0.92	0.11	1.2E-1	0.59	0.66	0.24	0.73	0.22	5.0E-2
MET	Mercury	4.2E-2	3.8E-2	4.8E-2	8.4E-2	3.2E-2	3.6E-2	3.1E-2	4.8E-2	4.5E-2	5.2E-2	6.4E-2
MET	Nickel	0.53	8.6E-1	0.00	0.39	0.36	0.37	7.0E-5	7.0E-5	1.15	1.08	0.44
MET	Silver	4.2E-5	4.2E-5	0.00	6.1E-1	4.2E-5	4.2E-5	4.2E-5	0.44	4.2E-5	4.2E-5	1.08
MET	Zinc	23.4	29.9	26.0	29.57	9.5	32.6	33.8	6.15	20.9	25.7	33.3
PAH	2-Methylnaphthalene	2.63	2.63		2.63	2.63	2.63	2.63	25.5	15.5	2.63	2.63
PAH	Acenaphthene	1.80	18.03	0.74	0.74	0.7	0.74	0.74	2.80	15.4	0.74	0.74
PAH	Acenaphthylene	2.39	0.81	3.17	0.81	0.81	0.73	0.85	1.43	11.2	4.89	0.81
PAH	Anthracene	5.51	6.08	3.30	2.24	0.56	1.70	1.72	2.24	12.0	7.03	1.78
PAH	Fluorene	2.23	0.55	1.81	3.52	7.64	1.04	0.89	3.82	0.55	4.68	0.55
PAH	Naphthalene	0.47	0.47		0.47	0.47	0.47	0.47	9.71	0.47	0.47	0.47
PAH	Phenanthrene	4.58	7.78	4.97	4.35	2.57	1.65	2.37	4.31	8.63	8.12	4.05
PCB	Total PCBs	76.8	173	158	111	532	57.2	74.7	283	108	109	129
PST	Aldrin	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2	4.2E-2
PST	p,p'-DDE	0.51	2.23	1.88	1.1	18.87	0.88	0.72	5.93	2.43	1.72	2.17
TBT	Tributyltin		3.12	0.84	0.84	2.44	3.74	13.87	7.22	11.4	18.6	0.84

CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels; LOB=lobster; MF=mummichog; MM=*Mercenaria mercenaria*; PM=*Pitar morrhuana*. See Appendix A-1-3 for tissue concentrations.
Dose = prey tissue concentration X exposure factor. Exposure factor for herring gull = 0.28 (Table 6.3-1).
Units: MET = µg CoC/kg bird/day; PAH, PCB, PST, TBT = ng CoC/kg bird/day.

Appendix Table A-2-4.4. **TRV-EPC Hazard Quotients for Herring Gull** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*8.42*	*1.89*	*1.77*	*62.6*	*3.20*	*0.39*	*117*	*1.15*	*29.6*	*98435*	*833*	*833*	*915*	*833*	*98435*	*98435*	*295*	*7.61*	*2231*	*5928*
DSY-26	CN	0.43	0.44	0.79	0.28	0.25	0.33	8.7E-3	0.45	1.40	9.5E-5	3.5E-2	3.5E-3	8.7E-3	2.9E-2	1.7E-5	4.1E-4	7.45	5.3E-2	1.3E-2	1.8E-3
DSY-28	CN	0.58	0.58	0.53	0.24	7.8E-5	0.26	1.1E-2	0.27	0.89	1.4E-4	5.5E-2	4.7E-3	6.5E-3	4.5E-2	1.7E-5	3.1E-4	13.11	2.0E-2	2.0E-2	5.6E-3
DSY-29	CN	0.91	0.61	0.67	0.35	0.28	0.43	1.5E-2	1.3E-4	0.96	2.4E-4	4.7E-2	3.5E-3	6.7E-3	3.1E-2	1.7E-5	4.8E-4	10.73	2.0E-2	3.0E-2	5.8E-3
DSY-36	CN	0.43	0.51	0.49	0.25	0.30	0.37	1.2E-2	1.3E-4	1.85		3.2E-3	3.5E-3	8.7E-3	2.4E-2		1.9E-4	10.60	0.13	2.4E-2	2.1E-3
JPC-1	CN	0.52	0.29	1.65	0.12	7.8E-5	0.34	2.6E-2	1.3E-4	3.60	9.5E-5	7.7E-2	3.5E-3	2.4E-2	2.3E-3	1.7E-5	2.8E-4	2.09	2.0E-2	3.6E-3	1.9E-3
CHC-1	CN	0.41	0.50	0.69	0.29	0.26	0.43	2.1E-6	1.38	0.74	9.2E-4	1.2E-2	6.1E-3	8.7E-3	1.6E-2	3.5E-4	1.6E-4	3.42	2.0E-2	9.5E-3	4.4E-3
DSY-26	DM	0.63	0.50	1.22	0.21	0.43	0.41	1.6E-2	1.3E-4	3.47	9.5E-5	8.1E-2	5.9E-2	7.1E-2	2.3E-3	1.7E-5	7.9E-4	6.03	2.0E-2	5.6E-3	5.5E-3
DSY-28	DM	2.00	0.41	1.35	0.18	7.8E-5	0.34	4.2E-2	1.03	3.21	9.5E-5	3.2E-3	3.5E-3	2.6E-2	2.3E-3	1.7E-5	4.5E-4	2.33	2.0E-2		1.9E-3
DSY-29	DM	1.06	0.43	1.14	0.10	0.29	0.43	2.5E-2	1.3E-4	2.53	9.5E-5	0.18	3.7E-2	4.4E-2	2.3E-3	1.7E-5	4.8E-4	2.94	2.0E-2	7.0E-3	3.0E-3
DSY-31	DM	0.62	0.29	1.30	0.14	0.42	0.37	1.8E-2	1.3E-4	5.53	9.5E-5	3.2E-3	3.5E-3	3.7E-2	2.3E-3	1.7E-5	4.2E-4	2.66	2.0E-2	6.5E-3	1.6E-3
DSY-33	DM	1.48	0.49	1.43	0.13	0.46	0.26	1.5E-2	1.3E-4	4.11	9.5E-5	3.2E-3	3.5E-3	8.7E-3	2.3E-3	1.7E-5	9.6E-5	2.16	2.0E-2	5.8E-3	3.5E-3
DSY-38	DM	0.72	0.33	1.48	0.18	0.60	0.33	2.5E-2	1.50	3.02		3.2E-3	1.4E-2	1.3E-2	2.3E-3		1.9E-4	1.86	2.0E-2	4.0E-3	1.4E-3
DSY-39	DM	1.06	0.17	1.69	0.14	7.8E-5	0.36	2.9E-2	0.85	4.41	9.5E-5	8.1E-2	3.9E-2	8.7E-3	2.3E-3	1.7E-5	9.6E-5	1.56	2.0E-2	4.4E-3	1.6E-3
DSY-40	DM	0.71	0.32	1.53	0.10	0.93	0.33	2.9E-2	1.3E-4	3.95	9.5E-5	0.16	6.0E-2	4.5E-2	2.3E-3	1.7E-5	7.0E-4	1.88	2.0E-2	4.5E-3	5.1E-4
JPC-1	DM	0.80	0.31	1.38	0.14	1.03	0.43	2.1E-6	1.3E-4	3.13		3.2E-3	1.4E-2	1.3E-2	7.8E-3		1.8E-4	1.91	2.0E-2	3.0E-3	5.1E-4
CHC-1	DM	0.89	0.39	0.99	0.18	0.81	0.41	3.5E-2	1.3E-4	2.52	5.6E-4	6.6E-2	4.8E-2	4.7E-2	2.3E-3	1.7E-5	3.1E-4	1.31	2.0E-2	3.9E-3	6.9E-3
DSY-24	IBM	1.21	0.99	1.78	6.6E-2	1.82	0.71	4.7E-2	1.3E-4	2.57		3.2E-3	1.4E-2	1.9E-2	8.3E-3		2.4E-4	2.08	2.0E-2	3.5E-3	2.3E-3
DSY-25	IBM	1.49	0.64	1.70	0.19	7.8E-5	0.45	2.9E-2	1.3E-4	3.79	2.9E-4	1.9E-2	8.9E-2	0.20	3.6E-2	1.4E-3	1.5E-3	1.79	2.0E-2	2.2E-3	4.2E-3
DSY-26	IBM	0.98	0.39	1.38	0.12	7.8E-5	0.30	2.1E-6	1.3E-4	3.07	9.5E-5	3.2E-3	0.11	0.26	4.0E-2	1.9E-3	2.3E-3	2.81	2.0E-2	3.4E-3	3.4E-3
DSY-27	IBM	0.79	0.41	1.62	0.24	0.94	0.38	4.1E-2	1.3E-4	4.80	9.5E-5	3.2E-3	7.1E-2	0.18	4.7E-2	1.7E-5	2.8E-3	3.89	2.0E-2	5.3E-3	0.16
DSY-28	IBM	0.32	0.33	1.44	1.8E-2	7.8E-5	0.37	2.1E-6	1.3E-4	4.07	9.5E-5	3.2E-3	4.2E-2	7.5E-2	3.0E-2	1.7E-5	1.2E-3	2.72	2.0E-2	3.3E-3	8.3E-3
DSY-35	IBM	0.74	0.39	1.26	0.12	0.55	0.42	2.1E-6	1.3E-4	4.37	9.5E-5	3.2E-3	3.5E-3	2.8E-2	1.4E-2	1.7E-5	4.2E-4	2.36	2.0E-2	5.4E-3	1.5E-3
DSY-36	IBM	0.73	0.21	1.61	0.11	7.8E-5	0.48	3.7E-2	1.3E-4	2.85		3.2E-3	1.8E-2	3.2E-2	6.0E-3		2.9E-4	3.03	2.0E-2	3.7E-3	6.0E-3
DSY-40	IBM	0.63	0.33	1.26	0.11	0.76	0.42	2.1E-6	1.3E-4	3.54	9.5E-5	3.2E-3	2.7E-2	3.7E-2	1.7E-2	1.5E-4	6.0E-4	3.09	2.0E-2	4.6E-3	5.3E-3
JPC-1	IBM	2.31	0.10	0.95	2.28	0.12	0.76	1.2E-2	1.91	3.56	9.5E-5	3.2E-3	3.5E-3	8.7E-3	1.5E-2	1.7E-5	1.6E-4	1.34	2.0E-2	1.8E-3	5.1E-4
CHC-1	IBM	0.56	0.31	1.04	0.19	0.24	0.47	3.3E-2	1.3E-4	3.09	9.5E-5	3.2E-3	2.1E-2	2.7E-2	2.0E-2	1.7E-5	2.9E-4	1.32	2.0E-2	2.7E-3	1.1E-2

TRV = Toxicity Reference Value. EPC = Exposure Point Concentration (prey tissue concentration). HQ = Hazard Quotient = Prey EPC/TRV-EPC (Table 6.3-2 for TRV benchmarks).

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.4 (continued). **TRV-EPC Hazard Quotients for Herring Gull** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*8.42*	*1.89*	*1.77*	*62.6*	*3.20*	*0.39*	*117*	*1.15*	*29.6*	*98435*	*833*	*833*	*915*	*833*	*98435*	*98435*	*295*	*7.61*	*2231*	*5928*
DSY-25	LOB	3.40	0.19	0.94	2.42	4.9E-2	0.67	1.3E-2	4.76	2.96	9.5E-5	3.2E-3	3.5E-3	8.7E-3	2.3E-3	1.7E-5	9.6E-5	1.58	2.0E-2	2.6E-3	5.1E-4
DSY-27	LOB	2.04	0.14	1.19	2.67	2.2E-2	1.16	1.0E-2	5.98	3.80	7.8E-5	3.9E-2	3.5E-3	9.0E-3	2.3E-3	1.2E-4	2.0E-4	2.53	2.0E-2	3.8E-3	5.1E-4
DSY-28	LOB										1.2E-4	3.2E-3	3.5E-3	4.5E-3	2.3E-3	1.2E-4	3.3E-4	2.91	2.0E-2	4.4E-3	5.1E-4
DSY-29	LOB	3.39	0.25	0.97	1.60	6.9E-2	0.73	1.5E-2	5.08	4.37	1.5E-4	3.2E-3	3.5E-3	8.7E-3	1.8E-2	2.0E-4	2.9E-4	1.20	2.0E-2	2.8E-3	5.1E-4
DSY-33	LOB	2.64	8.5E-2	1.13	0.96	0.15	0.58	1.5E-2	2.99	3.55	1.4E-4	3.2E-3	3.5E-3	8.7E-3	2.3E-3	3.6E-4	2.0E-4	1.59	2.0E-2	3.0E-3	5.1E-4
DSY-35	LOB	1.93	0.30	1.22	2.05	0.24	0.68	7.8E-3	5.69	3.71		3.2E-3	3.5E-3	3.4E-3	2.3E-3		1.3E-4	1.07	2.0E-2	2.2E-3	5.1E-4
DSY-36	LOB	2.36	1.3E-4	1.11	0.79	0.11	0.84	1.2E-2	2.50	3.88		3.2E-3	3.5E-3	5.8E-3	2.3E-3		1.9E-4	2.84	2.0E-2	1.8E-3	5.1E-4
DSY-38	LOB	3.10	0.26	1.10	2.64	8.1E-2	0.84	1.6E-2	5.31	5.78	9.5E-5	3.2E-3	3.5E-3	3.1E-3	2.3E-3	1.7E-5	1.0E-4	0.98	2.0E-2	3.2E-3	5.1E-4
DSY-39	LOB	2.21	0.16	0.93	3.15	5.6E-2	1.05	1.2E-2	0.71	4.34	9.5E-5	3.2E-3	3.5E-3	2.0E-3	2.3E-3	1.7E-5	7.6E-5	2.18	2.0E-2	1.1E-3	5.1E-4
JPC-1	LOB	0.70	0.63	0.61	0.36	0.13	0.29	1.1E-2	1.3E-4	1.15	9.5E-5	3.2E-3	3.5E-3	2.2E-3	3.3E-2	1.7E-5	9.3E-5	6.43	2.0E-2	3.0E-2	1.5E-3
CHC-1	LOB	2.57	0.12	0.81	1.63	5.6E-2	0.58	1.3E-2	3.34	4.01	9.5E-5	3.2E-3	3.5E-3	7.0E-3	2.3E-3	1.7E-5	1.5E-4	1.56	2.0E-2	3.5E-3	5.1E-4
DSY-35	MM	0.76	0.34	1.35	0.10	7.8E-5	0.31	2.5E-2	1.3E-4	3.74	9.5E-5	3.2E-3	3.5E-3	8.7E-3	3.5E-3	1.7E-5	1.9E-4	0.54	2.0E-2	8.8E-4	6.6E-3
DSY-41	MM	0.89	0.48	1.00	0.21	0.50	0.30	2.1E-6	1.10	2.22	9.5E-5	7.8E-3	5.5E-3	1.2E-2	4.6E-3	1.7E-5	1.4E-4	0.85	2.0E-2	1.9E-3	5.2E-3
JPC-1	MM	0.92	0.38	1.19	0.11	0.66	0.33	1.1E-2	1.3E-4	3.92	9.5E-5	3.2E-3	3.1E-3	6.6E-3	4.5E-3	1.7E-5	6.0E-5	0.69	2.0E-2	1.4E-3	2.3E-3
DSY-31	PM	1.11	0.41	1.12	0.23	0.54	0.35	3.4E-2	1.3E-4	2.95	9.5E-5	3.2E-3	3.5E-3	3.3E-2	2.3E-3	1.7E-5	2.4E-4	3.22	2.0E-2	1.3E-3	8.1E-3
DSY-32	PM	0.58	0.31	0.98	0.17	0.87	0.39	1.9E-2	1.20	3.80	9.5E-5	3.2E-3	1.6E-2	3.0E-2	2.3E-3	1.7E-5	2.9E-4	1.24	2.0E-2	1.1E-3	
DSY-33	PM	0.70	0.35	1.05	0.14	7.8E-5	0.31	2.1E-6	1.3E-4	3.43	9.5E-5	3.4E-3	3.5E-3	1.5E-2	6.2E-3	1.7E-5	1.5E-4	1.77	2.0E-2	1.7E-3	9.1E-3
DSY-34	PM	1.02	0.38	1.21	0.16	0.52	0.30	1.8E-2	1.3E-4	3.12	9.5E-5	3.2E-3	3.5E-3	2.2E-2	6.3E-3	1.7E-5	3.6E-4	1.05	2.0E-2	6.8E-4	6.6E-3
DSY-35	PM	1.01	0.35	1.14	0.13	0.52	0.26	1.3E-2	1.3E-4	4.21	9.5E-5	3.2E-3	3.5E-3	7.2E-3	6.6E-3	1.7E-5	2.9E-4	1.64	2.0E-2	2.1E-3	
DSY-36	PM	0.88	0.44	1.39	0.19	0.68	0.38	1.6E-2	1.3E-4	4.08	9.5E-5	3.2E-3	3.5E-3	3.3E-2	2.3E-3	1.7E-5	3.2E-4	1.67	2.0E-2	1.3E-3	1.1E-2
DSY-37	PM	0.88	0.34	0.98	0.14	0.93	0.39	1.3E-2	0.57	3.58		3.2E-3	3.5E-3	1.1E-2	2.3E-3		2.8E-4	1.45		1.3E-3	
DSY-38	PM	0.72	0.31	1.04	0.17	7.8E-5	0.43	2.1E-6	1.3E-4	4.43	9.5E-5	6.7E-3	6.5E-3	1.2E-2	5.7E-3	1.7E-5	9.3E-5				
DSY-41	PM	0.26	0.38	1.10	0.19	7.8E-5	0.38	1.6E-2	1.3E-4	2.82	9.5E-5	7.7E-3	1.0E-2	2.1E-2	9.5E-3	1.7E-5	1.7E-4	0.93	2.0E-2	8.1E-4	
JPC-1	PM	1.31	0.34	1.22	0.19	0.74	0.29	2.1E-6	1.3E-4	4.07	9.5E-5	3.2E-3	3.6E-3	6.7E-3	3.8E-3	1.7E-5	8.6E-5	0.90	2.0E-2	1.2E-3	8.4E-3

TRV = Toxicity Reference Value. EPC = Exposure Point Concentration (prey tissue concentration). HQ = Hazard Quotient = Prey EPC/TRV-EPC (Table 6.3-2 for TRV benchmarks).

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.5. **TRV-Dose Hazard Quotients for Herring Gull** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*5.14*	*1.15*	*1.08*	*38.1*	*1.95*	*0.24*	*71.3*	*0.70*	*18.1*	*60000*	*508*	*508*	*558*	*508*	*60000*	*60000*	*180*	*4.64*	*1360*	*3613*
DSY-26	CN	0.21	0.22	0.39	0.14	0.12	0.16	4.3E-3	0.22	0.69	4.7E-5	1.7E-2	1.7E-3	4.3E-3	1.4E-2	8.4E-6	2.0E-4	3.67	2.6E-2	6.4E-3	8.8E-4
DSY-28	CN	0.29	0.28	0.26	0.12	3.8E-5	0.13	5.4E-3	0.13	0.44	7.1E-5	2.7E-2	2.3E-3	3.2E-3	2.2E-2	8.4E-6	1.5E-4	6.45	9.7E-3	9.9E-3	2.8E-3
DSY-29	CN	0.45	0.30	0.33	0.17	0.14	0.21	7.3E-3	6.4E-5	0.47	1.2E-4	2.3E-2	1.7E-3	3.3E-3	1.5E-2	8.4E-6	2.4E-4	5.28	9.7E-3	1.5E-2	2.9E-3
DSY-36	CN	0.21	0.25	0.24	0.12	0.15	0.18	6.0E-3	6.4E-5	0.91		1.6E-3	1.7E-3	4.3E-3	1.2E-2		9.3E-5	5.22	6.2E-2	1.2E-2	1.0E-3
JPC-1	CN	0.26	0.14	0.81	5.7E-2	3.8E-5	0.17	1.3E-2	6.4E-5	1.77	4.7E-5	3.8E-2	1.7E-3	1.2E-2	1.2E-3	8.4E-6	1.4E-4	1.03	9.7E-3	1.8E-3	9.3E-4
CHC-1	CN	0.20	0.25	0.34	0.14	0.13	0.21	1.1E-6	0.68	0.36	4.5E-4	5.9E-3	3.0E-3	4.3E-3	8.1E-3	1.7E-4	7.7E-5	1.68	9.7E-3	4.7E-3	2.1E-3
DSY-26	DM	0.31	0.25	0.60	0.10	0.21	0.20	7.7E-3	6.4E-5	1.71	4.7E-5	4.0E-2	2.9E-2	3.5E-2	1.2E-3	8.4E-6	3.9E-4	2.97	9.7E-3	2.8E-3	2.7E-3
DSY-28	DM	0.98	0.20	0.66	8.6E-2	3.8E-5	0.17	2.0E-2	0.51	1.58	4.7E-5	1.6E-3	1.7E-3	1.3E-2	1.2E-3	8.4E-6	2.2E-4	1.15	9.7E-3		9.1E-4
DSY-29	DM	0.52	0.21	0.56	5.0E-2	0.14	0.21	1.2E-2	6.4E-5	1.24	4.7E-5	8.9E-2	1.8E-2	2.2E-2	1.2E-3	8.4E-6	2.4E-4	1.45	9.7E-3	3.5E-3	1.5E-3
DSY-31	DM	0.30	0.14	0.64	7.0E-2	0.21	0.18	8.7E-3	6.4E-5	2.72	4.7E-5	1.6E-3	1.7E-3	1.8E-2	1.2E-3	8.4E-6	2.0E-4	1.31	9.7E-3	3.2E-3	7.9E-4
DSY-33	DM	0.73	0.24	0.70	6.6E-2	0.23	0.13	7.3E-3	6.4E-5	2.02	4.7E-5	1.6E-3	1.7E-3	4.3E-3	1.2E-3	8.4E-6	4.7E-5	1.06	9.7E-3	2.9E-3	1.7E-3
DSY-38	DM	0.36	0.16	0.73	9.0E-2	0.30	0.16	1.2E-2	0.74	1.48		1.6E-3	7.0E-3	6.4E-3	1.2E-3		9.2E-5	0.92	9.7E-3	2.0E-3	6.9E-4
DSY-39	DM	0.52	8.3E-2	0.83	6.8E-2	3.8E-5	0.18	1.4E-2	0.42	2.17	4.7E-5	4.0E-2	1.9E-2	4.3E-3	1.2E-3	8.4E-6	4.7E-5	0.77	9.7E-3	2.2E-3	8.0E-4
DSY-40	DM	0.35	0.16	0.75	5.0E-2	0.46	0.16	1.4E-2	6.4E-5	1.94	4.7E-5	7.7E-2	2.9E-2	2.2E-2	1.2E-3	8.4E-6	3.4E-4	0.93	9.7E-3	2.2E-3	2.5E-4
JPC-1	DM	0.40	0.15	0.68	6.8E-2	0.50	0.21	1.1E-6	6.4E-5	1.54		1.6E-3	6.7E-3	6.3E-3	3.8E-3		8.9E-5	0.94	9.7E-3	1.5E-3	2.5E-4
CHC-1	DM	0.44	0.19	0.49	8.7E-2	0.40	0.20	1.7E-2	6.4E-5	1.24	2.8E-4	3.3E-2	2.4E-2	2.3E-2	1.2E-3	8.4E-6	1.5E-4	0.64	9.7E-3	1.9E-3	3.4E-3
DSY-24	IBM	0.60	0.49	0.88	3.3E-2	0.89	0.35	2.3E-2	6.4E-5	1.27		1.6E-3	6.8E-3	9.5E-3	4.1E-3		1.2E-4	1.03	9.7E-3	1.7E-3	1.1E-3
DSY-25	IBM	0.73	0.32	0.84	9.4E-2	3.8E-5	0.22	1.4E-2	6.4E-5	1.87	1.4E-4	9.3E-3	4.4E-2	0.10	1.8E-2	6.8E-4	7.6E-4	0.88	9.7E-3	1.1E-3	2.1E-3
DSY-26	IBM	0.48	0.19	0.68	6.1E-2	3.8E-5	0.15	1.1E-6	6.4E-5	1.51	4.7E-5	1.6E-3	5.3E-2	0.13	2.0E-2	9.2E-4	1.1E-3	1.39	9.7E-3	1.7E-3	1.7E-3
DSY-27	IBM	0.39	0.20	0.80	0.12	0.46	0.19	2.0E-2	6.4E-5	2.36	4.7E-5	1.6E-3	3.5E-2	9.0E-2	2.3E-2	8.4E-6	1.4E-3	1.92	9.7E-3	2.6E-3	8.1E-2
DSY-28	IBM	0.16	0.16	0.71	8.9E-3	3.8E-5	0.18	1.1E-6	6.4E-5	2.00	4.7E-5	1.6E-3	2.1E-2	3.7E-2	1.5E-2	8.4E-6	5.7E-4	1.34	9.7E-3	1.6E-3	4.1E-3
DSY-35	IBM	0.36	0.19	0.62	5.9E-2	0.27	0.21	1.1E-6	6.4E-5	2.15	4.7E-5	1.6E-3	1.7E-3	1.4E-2	6.9E-3	8.4E-6	2.1E-4	1.16	9.7E-3	2.7E-3	7.6E-4
DSY-36	IBM	0.36	0.10	0.79	5.5E-2	3.8E-5	0.24	1.8E-2	6.4E-5	1.40		1.6E-3	9.0E-3	1.6E-2	3.0E-3		1.4E-4	1.49	9.7E-3	1.8E-3	2.9E-3
DSY-40	IBM	0.31	0.16	0.62	5.5E-2	0.38	0.21	1.1E-6	6.4E-5	1.74	4.7E-5	1.6E-3	1.3E-2	1.8E-2	8.5E-3	7.5E-5	3.0E-4	1.52	9.7E-3	2.3E-3	2.6E-3
JPC-1	IBM	1.14	4.7E-2	0.47	1.12	6.0E-2	0.37	5.8E-3	0.94	1.75	4.7E-5	1.6E-3	1.7E-3	4.3E-3	7.4E-3	8.4E-6	7.8E-5	0.66	9.7E-3	9.1E-4	2.5E-4
CHC-1	IBM	0.27	0.15	0.51	9.4E-2	0.12	0.23	1.6E-2	6.4E-5	1.52	4.7E-5	1.6E-3	1.0E-2	1.3E-2	9.9E-3	8.4E-6	1.5E-4	0.65	9.7E-3	1.4E-3	5.5E-3

TRV = Toxicity Reference Value. HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey tissue concentration X 0.30 (Table 6.3-2). See Appendix Table A-2-4.2 for dose concentration

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.5 (continued). **TRV-Dose Hazard Quotients for Herring Gull** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*5.14*	*1.15*	*1.08*	*38.1*	*1.95*	*0.24*	*71.3*	*0.70*	*18.1*	*60000*	*508*	*508*	*558*	*508*	*60000*	*60000*	*180*	*4.64*	*1360*	*3613*
DSY-25	LOB	1.67	9.4E-2	0.46	1.19	2.4E-2	0.33	6.4E-3	2.34	1.46	4.7E-5	1.6E-3	1.7E-3	4.3E-3	1.2E-3	8.4E-6	4.7E-5	0.78	9.7E-3	1.3E-3	2.5E-4
DSY-27	LOB	1.00	6.8E-2	0.59	1.31	1.1E-2	0.57	5.0E-3	2.94	1.87	3.8E-5	1.9E-2	1.7E-3	4.4E-3	1.2E-3	6.0E-5	1.0E-4	1.25	9.7E-3	1.9E-3	2.5E-4
DSY-28	LOB										6.1E-5	1.6E-3	1.7E-3	2.2E-3	1.2E-3	6.0E-5	1.6E-4	1.43	9.7E-3	2.2E-3	2.5E-4
DSY-29	LOB	1.67	0.12	0.48	0.79	3.4E-2	0.36	7.3E-3	2.50	2.15	7.4E-5	1.6E-3	1.7E-3	4.3E-3	8.8E-3	9.7E-5	1.4E-4	0.59	9.7E-3	1.4E-3	2.5E-4
DSY-33	LOB	1.30	4.2E-2	0.55	0.47	7.2E-2	0.28	7.3E-3	1.47	1.75	6.9E-5	1.6E-3	1.7E-3	4.3E-3	1.2E-3	1.8E-4	9.9E-5	0.78	9.7E-3	1.5E-3	2.5E-4
DSY-35	LOB	0.95	0.15	0.60	1.01	0.12	0.33	3.8E-3	2.80	1.83		1.6E-3	1.7E-3	1.7E-3	1.2E-3		6.6E-5	0.53	9.7E-3	1.1E-3	2.5E-4
DSY-36	LOB	1.16	6.5E-5	0.55	0.39	5.2E-2	0.41	6.1E-3	1.23	1.91		1.6E-3	1.7E-3	2.8E-3	1.2E-3		9.3E-5	1.40	9.7E-3	9.0E-4	2.5E-4
DSY-38	LOB	1.52	0.13	0.54	1.30	4.0E-2	0.41	7.9E-3	2.61	2.85	4.7E-5	1.6E-3	1.7E-3	1.5E-3	1.2E-3	8.4E-6	5.0E-5	0.48	9.7E-3	1.6E-3	2.5E-4
DSY-39	LOB	1.09	7.8E-2	0.46	1.55	2.8E-2	0.51	6.1E-3	0.35	2.14	4.7E-5	1.6E-3	1.7E-3	9.7E-4	1.2E-3	8.4E-6	3.7E-5	1.07	9.7E-3	5.3E-4	2.5E-4
JPC-1	LOB	0.35	0.31	0.30	0.18	6.6E-2	0.14	5.5E-3	6.4E-5	0.57	4.7E-5	1.6E-3	1.7E-3	1.1E-3	1.6E-2	8.4E-6	4.6E-5	3.17	9.7E-3	1.5E-2	7.2E-4
CHC-1	LOB	1.27	6.0E-2	0.40	0.80	2.8E-2	0.29	6.6E-3	1.65	1.98	4.7E-5	1.6E-3	1.7E-3	3.4E-3	1.2E-3	8.4E-6	7.2E-5	0.77	9.7E-3	1.7E-3	2.5E-4
DSY-35	MM	0.38	0.17	0.66	5.1E-2	3.8E-5	0.15	1.2E-2	6.4E-5	1.84	4.7E-5	1.6E-3	1.7E-3	4.3E-3	1.7E-3	8.4E-6	9.3E-5	0.27	9.7E-3	4.4E-4	3.2E-3
DSY-41	MM	0.44	0.23	0.49	0.10	0.25	0.15	1.1E-6	0.54	1.09	4.7E-5	3.9E-3	2.7E-3	5.9E-3	2.3E-3	8.4E-6	6.7E-5	0.42	9.7E-3	9.6E-4	2.5E-3
JPC-1	MM	0.45	0.19	0.59	5.4E-2	0.33	0.16	5.6E-3	6.4E-5	1.93	4.7E-5	1.6E-3	1.5E-3	3.3E-3	2.2E-3	8.4E-6	2.9E-5	0.34	9.7E-3	6.9E-4	1.1E-3
DSY-31	PM	0.55	0.20	0.55	0.11	0.27	0.17	1.7E-2	6.4E-5	1.45	4.7E-5	1.6E-3	1.7E-3	1.6E-2	1.2E-3	8.4E-6	1.2E-4	1.58	9.7E-3	6.6E-4	4.0E-3
DSY-32	PM	0.29	0.15	0.48	8.6E-2	0.43	0.19	9.1E-3	0.59	1.87	4.7E-5	1.6E-3	8.0E-3	1.5E-2	1.2E-3	8.4E-6	1.4E-4	0.61	9.7E-3	5.6E-4	
DSY-33	PM	0.34	0.17	0.52	6.8E-2	3.8E-5	0.15	1.1E-6	6.4E-5	1.69	4.7E-5	1.7E-3	1.7E-3	7.2E-3	3.1E-3	8.4E-6	7.2E-5	0.87	9.7E-3	8.4E-4	4.5E-3
DSY-34	PM	0.50	0.19	0.59	8.0E-2	0.26	0.15	8.9E-3	6.4E-5	1.53	4.7E-5	1.6E-3	1.7E-3	1.1E-2	3.1E-3	8.4E-6	1.8E-4	0.52	9.7E-3	3.4E-4	3.3E-3
DSY-35	PM	0.49	0.17	0.56	6.6E-2	0.26	0.13	6.5E-3	6.4E-5	2.07	4.7E-5	1.6E-3	1.7E-3	3.6E-3	3.2E-3	8.4E-6	1.4E-4	0.81	9.7E-3	1.0E-3	
DSY-36	PM	0.43	0.22	0.69	9.4E-2	0.34	0.19	7.9E-3	6.4E-5	2.01	4.7E-5	1.6E-3	1.7E-3	1.6E-2	1.2E-3	8.4E-6	1.6E-4	0.82	9.7E-3	6.4E-4	5.6E-3
DSY-37	PM	0.43	0.17	0.48	7.0E-2	0.46	0.19	6.6E-3	0.28	1.76		1.6E-3	1.7E-3	5.5E-3	1.2E-3		1.4E-4	0.71		6.5E-4	
DSY-38	PM	0.36	0.15	0.51	8.2E-2	3.8E-5	0.21	1.1E-6	6.4E-5	2.18	4.7E-5	3.3E-3	3.2E-3	5.7E-3	2.8E-3	8.4E-6	4.6E-5				
DSY-41	PM	0.13	0.19	0.54	9.4E-2	3.8E-5	0.19	7.9E-3	6.4E-5	1.39	4.7E-5	3.8E-3	5.0E-3	1.1E-2	4.7E-3	8.4E-6	8.2E-5	0.46	9.7E-3	4.0E-4	
JPC-1	PM	0.64	0.17	0.60	9.4E-2	0.36	0.14	1.1E-6	6.4E-5	2.00	4.7E-5	1.6E-3	1.8E-3	3.3E-3	1.9E-3	8.4E-6	4.2E-5	0.44	9.7E-3	5.7E-4	4.1E-3

TRV = Toxicity Reference Value. HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey tissue concentration X 0.30 (Table 6.3-2). See Appendix Table A-2-4.2 for dose concentration

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.6. **TRV-EPC Hazard Quotients for Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*8.18*	*1.83*	*1.72*	*60.7*	*3.11*	*0.38*	*114*	*1.11*	*28.8*	*95532*	*808*	*808*	*888*	*808*	*95532*	*95532*	*287*	*7.39*	*2165*	*5753*
DSY-26	CN	0.44	0.45	0.81	0.29	0.25	0.34	9.0E-3	0.47	1.44	9.8E-5	3.6E-2	3.6E-3	9.0E-3	3.0E-2	1.8E-5	4.2E-4	7.68	5.5E-2	1.3E-2	1.8E-3
DSY-28	CN	0.60	0.60	0.55	0.25	8.1E-5	0.27	1.1E-2	0.28	0.92	1.5E-4	5.7E-2	4.8E-3	6.7E-3	4.7E-2	1.8E-5	3.2E-4	13.50	2.0E-2	2.1E-2	5.8E-3
DSY-29	CN	0.94	0.63	0.69	0.36	0.29	0.44	1.5E-2	1.3E-4	0.99	2.5E-4	4.9E-2	3.6E-3	6.9E-3	3.2E-2	1.8E-5	5.0E-4	11.06	2.0E-2	3.1E-2	6.0E-3
DSY-36	CN	0.44	0.53	0.50	0.26	0.31	0.38	1.3E-2	1.3E-4	1.91		3.3E-3	3.6E-3	9.0E-3	2.5E-2		2.0E-4	10.92	0.13	2.5E-2	2.2E-3
JPC-1	CN	0.72	0.64	0.63	0.37	0.14	0.30	1.1E-2	1.3E-4	1.18	9.8E-5	3.3E-3	3.6E-3	2.3E-3	3.4E-2	1.8E-5	9.6E-5	6.63	2.0E-2	3.1E-2	1.5E-3
CHC-1	CN	0.43	0.51	0.71	0.30	0.27	0.45	2.2E-6	1.42	0.76	9.5E-4	1.2E-2	6.3E-3	9.0E-3	1.7E-2	3.6E-4	1.6E-4	3.52	2.0E-2	9.8E-3	4.5E-3
DSY-26	DM	0.65	0.51	1.26	0.22	0.44	0.43	1.6E-2	1.3E-4	3.58	9.8E-5	8.3E-2	6.1E-2	7.3E-2	2.4E-3	1.8E-5	8.1E-4	6.21	2.0E-2	5.8E-3	5.7E-3
DSY-28	DM	2.06	0.42	1.39	0.18	8.1E-5	0.35	4.3E-2	1.06	3.31	9.8E-5	3.3E-3	3.6E-3	2.7E-2	2.4E-3	1.8E-5	4.6E-4	2.40	2.0E-2		1.9E-3
DSY-29	DM	1.09	0.44	1.18	0.10	0.30	0.44	2.5E-2	1.3E-4	2.60	9.8E-5	0.19	3.9E-2	4.5E-2	2.4E-3	1.8E-5	5.0E-4	3.03	2.0E-2	7.2E-3	3.1E-3
DSY-31	DM	0.64	0.29	1.34	0.15	0.43	0.38	1.8E-2	1.3E-4	5.70	9.8E-5	3.3E-3	3.6E-3	3.8E-2	2.4E-3	1.8E-5	4.3E-4	2.74	2.0E-2	6.7E-3	1.7E-3
DSY-33	DM	1.52	0.51	1.48	0.14	0.47	0.27	1.5E-2	1.3E-4	4.24	9.8E-5	3.3E-3	3.6E-3	9.0E-3	2.4E-3	1.8E-5	9.9E-5	2.23	2.0E-2	6.0E-3	3.6E-3
DSY-38	DM	0.74	0.34	1.53	0.19	0.62	0.34	2.6E-2	1.54	3.11		3.3E-3	1.5E-2	1.3E-2	2.4E-3		1.9E-4	1.92	2.0E-2	4.1E-3	1.4E-3
DSY-39	DM	1.09	0.17	1.74	0.14	8.1E-5	0.37	2.9E-2	0.88	4.54	9.8E-5	8.3E-2	4.0E-2	9.0E-3	2.4E-3	1.8E-5	9.9E-5	1.61	2.0E-2	4.5E-3	1.7E-3
DSY-40	DM	0.73	0.33	1.58	0.10	0.96	0.34	3.0E-2	1.3E-4	4.07	9.8E-5	0.16	6.1E-2	4.6E-2	2.4E-3	1.8E-5	7.2E-4	1.94	2.0E-2	4.6E-3	5.2E-4
JPC-1	DM	0.54	0.29	1.70	0.12	8.1E-5	0.35	2.7E-2	1.3E-4	3.71	9.8E-5	8.0E-2	3.6E-3	2.4E-2	2.4E-3	1.8E-5	2.9E-4	2.15	2.0E-2	3.7E-3	1.9E-3
CHC-1	DM	0.91	0.40	1.02	0.18	0.83	0.42	3.6E-2	1.3E-4	2.59	5.8E-4	6.8E-2	4.9E-2	4.8E-2	2.4E-3	1.8E-5	3.2E-4	1.35	2.0E-2	4.0E-3	7.1E-3
DSY-24	IBM	1.25	1.02	1.84	6.9E-2	1.87	0.73	4.8E-2	1.3E-4	2.65		3.3E-3	1.4E-2	2.0E-2	8.5E-3		2.5E-4	2.15	2.0E-2	3.6E-3	2.4E-3
DSY-25	IBM	1.53	0.66	1.75	0.20	8.1E-5	0.46	3.0E-2	1.3E-4	3.91	2.9E-4	1.9E-2	9.2E-2	0.21	3.7E-2	1.4E-3	1.6E-3	1.84	2.0E-2	2.2E-3	4.4E-3
DSY-26	IBM	1.00	0.40	1.42	0.13	8.1E-5	0.31	2.2E-6	1.3E-4	3.16	9.8E-5	3.3E-3	0.11	0.27	4.1E-2	1.9E-3	2.4E-3	2.90	2.0E-2	3.5E-3	3.5E-3
DSY-27	IBM	0.82	0.42	1.67	0.25	0.97	0.39	4.2E-2	1.3E-4	4.95	9.8E-5	3.3E-3	7.3E-2	0.19	4.8E-2	1.8E-5	2.9E-3	4.01	2.0E-2	5.5E-3	0.17
DSY-28	IBM	0.33	0.34	1.48	1.9E-2	8.1E-5	0.38	2.2E-6	1.3E-4	4.19	9.8E-5	3.3E-3	4.3E-2	7.7E-2	3.1E-2	1.8E-5	1.2E-3	2.80	2.0E-2	3.4E-3	8.5E-3
DSY-35	IBM	0.76	0.40	1.29	0.12	0.56	0.44	2.2E-6	1.3E-4	4.50	9.8E-5	3.3E-3	3.6E-3	2.9E-2	1.4E-2	1.8E-5	4.4E-4	2.43	2.0E-2	5.6E-3	1.6E-3
DSY-36	IBM	0.75	0.21	1.66	0.12	8.1E-5	0.50	3.8E-2	1.3E-4	2.94		3.3E-3	1.9E-2	3.3E-2	6.2E-3		3.0E-4	3.12	2.0E-2	3.8E-3	6.2E-3
DSY-40	IBM	0.64	0.34	1.30	0.12	0.79	0.43	2.2E-6	1.3E-4	3.65	9.8E-5	3.3E-3	2.8E-2	3.8E-2	1.8E-2	1.6E-4	6.2E-4	3.18	2.0E-2	4.8E-3	5.5E-3
JPC-1	IBM	0.83	0.32	1.42	0.14	1.06	0.45	2.2E-6	1.3E-4	3.23		3.3E-3	1.4E-2	1.3E-2	8.0E-3		1.9E-4	1.97	2.0E-2	3.1E-3	5.2E-4
CHC-1	IBM	0.57	0.32	1.07	0.20	0.25	0.48	3.4E-2	1.3E-4	3.19	9.8E-5	3.3E-3	2.2E-2	2.8E-2	2.1E-2	1.8E-5	3.0E-4	1.36	2.0E-2	2.8E-3	1.2E-2

TRV = Toxicity Reference Value. EPC = Exposure Point Concentration (prey tissue concentration). HQ = Hazard Quotient = Prey EPC/TRV-EPC (Table 6.3-2 for TRV benchmarks).

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.6 (continued). **TRV-EPC Hazard Quotients for Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*8.18*	*1.83*	*1.72*	*60.7*	*3.11*	*0.38*	*114*	*1.11*	*28.8*	*95532*	*808*	*808*	*888*	*808*	*95532*	*95532*	*287*	*7.39*	*2165*	*5753*
DSY-25	LOB	3.50	0.20	0.97	2.50	5.1E-2	0.69	1.3E-2	4.91	3.05	9.8E-5	3.3E-3	3.6E-3	9.0E-3	2.4E-3	1.8E-5	9.9E-5	1.63	2.0E-2	2.7E-3	5.2E-4
DSY-27	LOB	2.10	0.14	1.23	2.75	2.2E-2	1.19	1.1E-2	6.16	3.92	8.0E-5	4.0E-2	3.6E-3	9.2E-3	2.4E-3	1.3E-4	2.1E-4	2.61	2.0E-2	3.9E-3	5.2E-4
DSY-28	LOB										1.3E-4	3.3E-3	3.6E-3	4.7E-3	2.4E-3	1.3E-4	3.4E-4	3.00	2.0E-2	4.5E-3	5.2E-4
DSY-29	LOB	3.49	0.26	1.00	1.65	7.1E-2	0.75	1.5E-2	5.24	4.50	1.6E-4	3.3E-3	3.6E-3	9.0E-3	1.8E-2	2.0E-4	2.9E-4	1.24	2.0E-2	2.9E-3	5.2E-4
DSY-33	LOB	2.72	8.7E-2	1.16	0.99	0.15	0.60	1.5E-2	3.08	3.65	1.4E-4	3.3E-3	3.6E-3	9.0E-3	2.4E-3	3.7E-4	2.1E-4	1.64	2.0E-2	3.1E-3	5.2E-4
DSY-35	LOB	1.98	0.31	1.26	2.11	0.24	0.70	8.0E-3	5.87	3.83		3.3E-3	3.6E-3	3.5E-3	2.4E-3		1.4E-4	1.10	2.0E-2	2.3E-3	5.2E-4
DSY-36	LOB	2.42	1.4E-4	1.15	0.81	0.11	0.86	1.3E-2	2.57	4.00		3.3E-3	3.6E-3	6.0E-3	2.4E-3		1.9E-4	2.93	2.0E-2	1.9E-3	5.2E-4
DSY-38	LOB	3.19	0.27	1.14	2.72	8.4E-2	0.86	1.7E-2	5.47	5.96	9.8E-5	3.3E-3	3.6E-3	3.2E-3	2.4E-3	1.8E-5	1.1E-4	1.01	2.0E-2	3.3E-3	5.2E-4
DSY-39	LOB	2.28	0.16	0.96	3.24	5.8E-2	1.08	1.3E-2	0.74	4.47	9.8E-5	3.3E-3	3.6E-3	2.0E-3	2.4E-3	1.8E-5	7.8E-5	2.25	2.0E-2	1.1E-3	5.2E-4
JPC-1	LOB	2.37	0.10	0.98	2.35	0.13	0.78	1.2E-2	1.96	3.67	9.8E-5	3.3E-3	3.6E-3	9.0E-3	1.6E-2	1.8E-5	1.6E-4	1.39	2.0E-2	1.9E-3	5.2E-4
CHC-1	LOB	2.65	0.13	0.83	1.68	5.8E-2	0.60	1.4E-2	3.45	4.14	9.8E-5	3.3E-3	3.6E-3	7.2E-3	2.4E-3	1.8E-5	1.5E-4	1.61	2.0E-2	3.6E-3	5.2E-4
DSY-35	MM	0.78	0.35	1.39	0.11	8.1E-5	0.32	2.6E-2	1.3E-4	3.85	9.8E-5	3.3E-3	3.6E-3	9.0E-3	3.6E-3	1.8E-5	1.9E-4	0.56	2.0E-2	9.1E-4	6.8E-3
DSY-41	MM	0.91	0.49	1.03	0.22	0.52	0.31	2.2E-6	1.13	2.29	9.8E-5	8.1E-3	5.6E-3	1.2E-2	4.7E-3	1.8E-5	1.4E-4	0.88	2.0E-2	2.0E-3	5.3E-3
JPC-1	MM	0.94	0.39	1.23	0.11	0.68	0.34	1.2E-2	1.3E-4	4.04	9.8E-5	3.3E-3	3.2E-3	6.8E-3	4.6E-3	1.8E-5	6.2E-5	0.71	2.0E-2	1.5E-3	2.3E-3
DSY-31	PM	1.14	0.43	1.15	0.24	0.56	0.36	3.5E-2	1.3E-4	3.04	9.8E-5	3.3E-3	3.6E-3	3.4E-2	2.4E-3	1.8E-5	2.5E-4	3.32	2.0E-2	1.4E-3	8.3E-3
DSY-32	PM	0.60	0.32	1.01	0.18	0.89	0.41	1.9E-2	1.24	3.91	9.8E-5	3.3E-3	1.7E-2	3.1E-2	2.4E-3	1.8E-5	3.0E-4	1.28	2.0E-2	1.2E-3	
DSY-33	PM	0.72	0.36	1.08	0.14	8.1E-5	0.32	2.2E-6	1.3E-4	3.54	9.8E-5	3.5E-3	3.6E-3	1.5E-2	6.4E-3	1.8E-5	1.5E-4	1.83	2.0E-2	1.8E-3	9.4E-3
DSY-34	PM	1.05	0.39	1.24	0.17	0.53	0.31	1.9E-2	1.3E-4	3.21	9.8E-5	3.3E-3	3.6E-3	2.2E-2	6.5E-3	1.8E-5	3.7E-4	1.09	2.0E-2	7.0E-4	6.8E-3
DSY-35	PM	1.03	0.36	1.17	0.14	0.53	0.26	1.4E-2	1.3E-4	4.34	9.8E-5	3.3E-3	3.6E-3	7.4E-3	6.8E-3	1.8E-5	3.0E-4	1.69	2.0E-2	2.2E-3	
DSY-36	PM	0.91	0.45	1.43	0.20	0.70	0.39	1.6E-2	1.3E-4	4.20	9.8E-5	3.3E-3	3.6E-3	3.4E-2	2.4E-3	1.8E-5	3.3E-4	1.72	2.0E-2	1.3E-3	1.2E-2
DSY-37	PM	0.91	0.35	1.01	0.15	0.96	0.40	1.4E-2	0.58	3.69		3.3E-3	3.6E-3	1.1E-2	2.4E-3		2.9E-4	1.49		1.4E-3	
DSY-38	PM	0.74	0.32	1.07	0.17	8.1E-5	0.44	2.2E-6	1.3E-4	4.57	9.8E-5	6.9E-3	6.7E-3	1.2E-2	5.9E-3	1.8E-5	9.6E-5				
DSY-41	PM	0.26	0.39	1.13	0.20	8.1E-5	0.39	1.7E-2	1.3E-4	2.91	9.8E-5	8.0E-3	1.1E-2	2.2E-2	9.8E-3	1.8E-5	1.7E-4	0.96	2.0E-2	8.4E-4	
JPC-1	PM	1.35	0.35	1.26	0.20	0.76	0.29	2.2E-6	1.3E-4	4.19	9.8E-5	3.3E-3	3.8E-3	6.9E-3	3.9E-3	1.8E-5	8.8E-5	0.93	2.0E-2	1.2E-3	8.6E-3

TRV = Toxicity Reference Value. EPC = Exposure Point Concentration (prey tissue concentration). HQ = Hazard Quotient = Prey EPC/TRV-EPC (Table 6.3-2 for TRV benchmarks).

1 - Units dry weight: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.7. **TRV-Dose Hazard Quotients for Great Blue Heron** consuming prey in the Derecktor Shipyard/Coddington Co (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*3.93*	*0.88*	*0.82*	*29.2*	*1.49*	*0.18*	*54.6*	*0.54*	*13.8*	*45925*	*389*	*389*	*427*	*389*	*45925*	*45925*	*138*	*3.55*	*1041*	*2766*
DSY-26	CN	0.26	0.26	0.47	0.17	0.15	0.20	5.2E-3	0.27	0.84	5.7E-5	2.1E-2	2.1E-3	5.2E-3	1.7E-2	1.0E-5	2.5E-4	4.47	3.2E-2	7.8E-3	1.1E-3
DSY-28	CN	0.35	0.35	0.32	0.15	4.7E-5	0.16	6.6E-3	0.16	0.54	8.6E-5	3.3E-2	2.8E-3	3.9E-3	2.7E-2	1.0E-5	1.9E-4	7.86	1.2E-2	1.2E-2	3.4E-3
DSY-29	CN	0.55	0.37	0.40	0.21	0.17	0.26	8.9E-3	7.8E-5	0.58	1.5E-4	2.8E-2	2.1E-3	4.0E-3	1.9E-2	1.0E-5	2.9E-4	6.44	1.2E-2	1.8E-2	3.5E-3
DSY-36	CN	0.26	0.31	0.29	0.15	0.18	0.22	7.3E-3	7.8E-5	1.11		1.9E-3	2.1E-3	5.2E-3	1.4E-2		1.1E-4	6.36	7.6E-2	1.4E-2	1.3E-3
JPC-1	CN	0.31	0.17	0.99	6.9E-2	4.7E-5	0.21	1.6E-2	7.8E-5	2.16	5.7E-5	4.6E-2	2.1E-3	1.4E-2	1.4E-3	1.0E-5	1.7E-4	1.25	1.2E-2	2.1E-3	1.1E-3
CHC-1	CN	0.25	0.30	0.41	0.18	0.16	0.26	1.3E-6	0.83	0.44	5.5E-4	7.2E-3	3.7E-3	5.2E-3	9.8E-3	2.1E-4	9.4E-5	2.05	1.2E-2	5.7E-3	2.6E-3
DSY-26	DM	0.38	0.30	0.73	0.13	0.26	0.25	9.3E-3	7.8E-5	2.08	5.7E-5	4.9E-2	3.6E-2	4.3E-2	1.4E-3	1.0E-5	4.7E-4	3.62	1.2E-2	3.4E-3	3.3E-3
DSY-28	DM	1.20	0.24	0.81	0.11	4.7E-5	0.20	2.5E-2	0.62	1.93	5.7E-5	1.9E-3	2.1E-3	1.6E-2	1.4E-3	1.0E-5	2.7E-4	1.40	1.2E-2		1.1E-3
DSY-29	DM	0.64	0.26	0.69	6.1E-2	0.18	0.26	1.5E-2	7.8E-5	1.52	5.7E-5	0.11	2.2E-2	2.6E-2	1.4E-3	1.0E-5	2.9E-4	1.76	1.2E-2	4.2E-3	1.8E-3
DSY-31	DM	0.37	0.17	0.78	8.5E-2	0.25	0.22	1.1E-2	7.8E-5	3.32	5.7E-5	1.9E-3	2.1E-3	2.2E-2	1.4E-3	1.0E-5	2.5E-4	1.60	1.2E-2	3.9E-3	9.6E-4
DSY-33	DM	0.88	0.30	0.86	8.1E-2	0.28	0.16	8.9E-3	7.8E-5	2.47	5.7E-5	1.9E-3	2.1E-3	5.2E-3	1.4E-3	1.0E-5	5.8E-5	1.30	1.2E-2	3.5E-3	2.1E-3
DSY-38	DM	0.43	0.20	0.89	0.11	0.36	0.20	1.5E-2	0.90	1.81		1.9E-3	8.6E-3	7.8E-3	1.4E-3		1.1E-4	1.12	1.2E-2	2.4E-3	8.4E-4
DSY-39	DM	0.64	0.10	1.02	8.2E-2	4.7E-5	0.22	1.7E-2	0.51	2.64	5.7E-5	4.9E-2	2.3E-2	5.2E-3	1.4E-3	1.0E-5	5.8E-5	0.94	1.2E-2	2.6E-3	9.8E-4
DSY-40	DM	0.42	0.19	0.92	6.1E-2	0.56	0.20	1.8E-2	7.8E-5	2.37	5.7E-5	9.4E-2	3.6E-2	2.7E-2	1.4E-3	1.0E-5	4.2E-4	1.13	1.2E-2	2.7E-3	3.0E-4
JPC-1	DM	0.48	0.19	0.83	8.3E-2	0.62	0.26	1.3E-6	7.8E-5	1.88		1.9E-3	8.2E-3	7.7E-3	4.7E-3		1.1E-4	1.15	1.2E-2	1.8E-3	3.0E-4
CHC-1	DM	0.53	0.24	0.59	0.11	0.49	0.24	2.1E-2	7.8E-5	1.51	3.4E-4	4.0E-2	2.9E-2	2.8E-2	1.4E-3	1.0E-5	1.9E-4	0.78	1.2E-2	2.3E-3	4.1E-3
DSY-24	IBM	0.73	0.59	1.07	4.0E-2	1.09	0.43	2.8E-2	7.8E-5	1.55		1.9E-3	8.3E-3	1.2E-2	5.0E-3		1.5E-4	1.25	1.2E-2	2.1E-3	1.4E-3
DSY-25	IBM	0.89	0.38	1.02	0.11	4.7E-5	0.27	1.8E-2	7.8E-5	2.28	1.7E-4	1.1E-2	5.4E-2	0.12	2.1E-2	8.3E-4	9.2E-4	1.07	1.2E-2	1.3E-3	2.5E-3
DSY-26	IBM	0.59	0.23	0.83	7.4E-2	4.7E-5	0.18	1.3E-6	7.8E-5	1.84	5.7E-5	1.9E-3	6.5E-2	0.16	2.4E-2	1.1E-3	1.4E-3	1.69	1.2E-2	2.0E-3	2.0E-3
DSY-27	IBM	0.48	0.24	0.97	0.14	0.57	0.23	2.4E-2	7.8E-5	2.88	5.7E-5	1.9E-3	4.3E-2	0.11	2.8E-2	1.0E-5	1.7E-3	2.34	1.2E-2	3.2E-3	0.10
DSY-28	IBM	0.19	0.20	0.86	1.1E-2	4.7E-5	0.22	1.3E-6	7.8E-5	2.44	5.7E-5	1.9E-3	2.5E-2	4.5E-2	1.8E-2	1.0E-5	7.0E-4	1.63	1.2E-2	2.0E-3	5.0E-3
DSY-35	IBM	0.44	0.23	0.75	7.2E-2	0.33	0.25	1.3E-6	7.8E-5	2.62	5.7E-5	1.9E-3	2.1E-3	1.7E-2	8.4E-3	1.0E-5	2.5E-4	1.41	1.2E-2	3.3E-3	9.3E-4
DSY-36	IBM	0.44	0.12	0.96	6.8E-2	4.7E-5	0.29	2.2E-2	7.8E-5	1.71		1.9E-3	1.1E-2	1.9E-2	3.6E-3		1.7E-4	1.82	1.2E-2	2.2E-3	3.6E-3
DSY-40	IBM	0.38	0.20	0.76	6.7E-2	0.46	0.25	1.3E-6	7.8E-5	2.12	5.7E-5	1.9E-3	1.6E-2	2.2E-2	1.0E-2	9.2E-5	3.6E-4	1.85	1.2E-2	2.8E-3	3.2E-3
JPC-1	IBM	1.38	5.7E-2	0.57	1.37	7.3E-2	0.46	7.1E-3	1.14	2.14	5.7E-5	1.9E-3	2.1E-3	5.2E-3	9.0E-3	1.0E-5	9.5E-5	0.81	1.2E-2	1.1E-3	3.0E-4
CHC-1	IBM	0.33	0.18	0.62	0.11	0.15	0.28	2.0E-2	7.8E-5	1.86	5.7E-5	1.9E-3	1.3E-2	1.6E-2	1.2E-2	1.0E-5	1.8E-4	0.79	1.2E-2	1.6E-3	6.7E-3

TRV = Toxicity Reference Value. HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey tissue concentration X 0.28 (Table 6.3-2). See Appendix Table A-2-4.2 for dose concentration

1 - Units: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

Appendix Table A-2-4.7 (continued). **TRV-Dose Hazard Quotients for Great Blue Heron** consuming prey in the Derecktor Shipyard/ Coddington Cove (DSY) study area and Jamestown Potter Cove (JPC) and Castle Hill Cove (CHC) reference locations.

Station	Species	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Fluorene	Naphthalene	Phenanthrene	Total PCBs	Aldrin	p,p'-DDE	Tributyltin
TRV Benchmark[1]		*3.93*	*0.88*	*0.82*	*29.2*	*1.49*	*0.18*	*54.6*	*0.54*	*13.8*	*45925*	*389*	*389*	*427*	*389*	*45925*	*45925*	*138*	*3.55*	*1041*	*2766*
DSY-25	LOB	2.04	0.11	0.56	1.45	2.9E-2	0.40	7.8E-3	2.86	1.78	5.7E-5	1.9E-3	2.1E-3	5.2E-3	1.4E-3	1.0E-5	5.8E-5	0.95	1.2E-2	1.6E-3	3.0E-4
DSY-27	LOB	1.22	8.3E-2	0.72	1.60	1.3E-2	0.69	6.2E-3	3.59	2.28	4.7E-5	2.3E-2	2.1E-3	5.4E-3	1.4E-3	7.3E-5	1.2E-4	1.52	1.2E-2	2.3E-3	3.0E-4
DSY-28	LOB										7.5E-5	1.9E-3	2.1E-3	2.7E-3	1.4E-3	7.3E-5	2.0E-4	1.75	1.2E-2	2.6E-3	3.0E-4
DSY-29	LOB	2.03	0.15	0.58	0.96	4.1E-2	0.44	8.9E-3	3.05	2.62	9.1E-5	1.9E-3	2.1E-3	5.2E-3	1.1E-2	1.2E-4	1.7E-4	0.72	1.2E-2	1.7E-3	3.0E-4
DSY-33	LOB	1.58	5.1E-2	0.68	0.58	8.8E-2	0.35	8.9E-3	1.79	2.13	8.4E-5	1.9E-3	2.1E-3	5.2E-3	1.4E-3	2.1E-4	1.2E-4	0.95	1.2E-2	1.8E-3	3.0E-4
DSY-35	LOB	1.16	0.18	0.73	1.23	0.14	0.41	4.7E-3	3.42	2.23		1.9E-3	2.1E-3	2.0E-3	1.4E-3		8.0E-5	0.64	1.2E-2	1.3E-3	3.0E-4
DSY-36	LOB	1.41	8.0E-5	0.67	0.47	6.4E-2	0.50	7.5E-3	1.50	2.33		1.9E-3	2.1E-3	3.5E-3	1.4E-3		1.1E-4	1.71	1.2E-2	1.1E-3	3.0E-4
DSY-38	LOB	1.86	0.16	0.66	1.58	4.9E-2	0.50	9.6E-3	3.19	3.47	5.7E-5	1.9E-3	2.1E-3	1.9E-3	1.4E-3	1.0E-5	6.1E-5	0.59	1.2E-2	1.9E-3	3.0E-4
DSY-39	LOB	1.33	9.5E-2	0.56	1.89	3.4E-2	0.63	7.5E-3	0.43	2.61	5.7E-5	1.9E-3	2.1E-3	1.2E-3	1.4E-3	1.0E-5	4.5E-5	1.31	1.2E-2	6.4E-4	3.0E-4
JPC-1	LOB	0.42	0.38	0.37	0.22	8.1E-2	0.17	6.7E-3	7.8E-5	0.69	5.7E-5	1.9E-3	2.1E-3	1.3E-3	2.0E-2	1.0E-5	5.6E-5	3.86	1.2E-2	1.8E-2	8.8E-4
CHC-1	LOB	1.54	7.3E-2	0.49	0.98	3.4E-2	0.35	8.1E-3	2.01	2.41	5.7E-5	1.9E-3	2.1E-3	4.2E-3	1.4E-3	1.0E-5	8.8E-5	0.94	1.2E-2	2.1E-3	3.0E-4
DSY-35	MM	0.46	0.20	0.81	6.2E-2	4.7E-5	0.19	1.5E-2	7.8E-5	2.24	5.7E-5	1.9E-3	2.1E-3	5.2E-3	2.1E-3	1.0E-5	1.1E-4	0.32	1.2E-2	5.3E-4	4.0E-3
DSY-41	MM	0.53	0.29	0.60	0.13	0.30	0.18	1.3E-6	0.66	1.33	5.7E-5	4.7E-3	3.3E-3	7.2E-3	2.8E-3	1.0E-5	8.1E-5	0.51	1.2E-2	1.2E-3	3.1E-3
JPC-1	MM	0.55	0.23	0.72	6.6E-2	0.40	0.20	6.8E-3	7.8E-5	2.35	5.7E-5	1.9E-3	1.9E-3	4.0E-3	2.7E-3	1.0E-5	3.6E-5	0.42	1.2E-2	8.5E-4	1.4E-3
DSY-31	PM	0.67	0.25	0.67	0.14	0.33	0.21	2.0E-2	7.8E-5	1.77	5.7E-5	1.9E-3	2.1E-3	2.0E-2	1.4E-3	1.0E-5	1.5E-4	1.93	1.2E-2	8.0E-4	4.9E-3
DSY-32	PM	0.35	0.19	0.59	0.10	0.52	0.24	1.1E-2	0.72	2.28	5.7E-5	1.9E-3	9.7E-3	1.8E-2	1.4E-3	1.0E-5	1.8E-4	0.75	1.2E-2	6.8E-4	
DSY-33	PM	0.42	0.21	0.63	8.3E-2	4.7E-5	0.19	1.3E-6	7.8E-5	2.06	5.7E-5	2.0E-3	2.1E-3	8.8E-3	3.7E-3	1.0E-5	8.7E-5	1.06	1.2E-2	1.0E-3	5.4E-3
DSY-34	PM	0.61	0.23	0.72	0.10	0.31	0.18	1.1E-2	7.8E-5	1.87	5.7E-5	1.9E-3	2.1E-3	1.3E-2	3.8E-3	1.0E-5	2.1E-4	0.63	1.2E-2	4.1E-4	4.0E-3
DSY-35	PM	0.60	0.21	0.68	8.1E-2	0.31	0.15	8.0E-3	7.8E-5	2.53	5.7E-5	1.9E-3	2.1E-3	4.3E-3	4.0E-3	1.0E-5	1.7E-4	0.98	1.2E-2	1.3E-3	
DSY-36	PM	0.53	0.26	0.84	0.11	0.41	0.23	9.6E-3	7.8E-5	2.45	5.7E-5	1.9E-3	2.1E-3	2.0E-2	1.4E-3	1.0E-5	1.9E-4	1.00	1.2E-2	7.8E-4	6.8E-3
DSY-37	PM	0.53	0.20	0.59	8.6E-2	0.56	0.24	8.1E-3	0.34	2.15		1.9E-3	2.1E-3	6.7E-3	1.4E-3		1.7E-4	0.87		7.9E-4	
DSY-38	PM	0.43	0.19	0.62	0.10	4.7E-5	0.26	1.3E-6	7.8E-5	2.66	5.7E-5	4.0E-3	3.9E-3	7.0E-3	3.4E-3	1.0E-5	5.6E-5				
DSY-41	PM	0.15	0.23	0.66	0.11	4.7E-5	0.23	9.6E-3	7.8E-5	1.69	5.7E-5	4.6E-3	6.2E-3	1.3E-2	5.7E-3	1.0E-5	1.0E-4	0.56	1.2E-2	4.9E-4	
JPC-1	PM	0.79	0.20	0.73	0.11	0.44	0.17	1.3E-6	7.8E-5	2.44	5.7E-5	1.9E-3	2.2E-3	4.0E-3	2.3E-3	1.0E-5	5.2E-5	0.54	1.2E-2	7.0E-4	5.0E-3

TRV = Toxicity Reference Value. HQ = Hazard Quotient = Prey Dose/TRV-Dose; Dose = prey tissue concentration X 0.28 (Table 6.3-2). See Appendix Table A-2-4.2 for dose concentration

1 - Units: metals = µg CoC/g prey (= mg CoC/kg prey); organics = ng CoC/g prey. See Appendix A-1-3 for tissue concentrations.

APPENDIX A-2-5.
TISSUE SCREENING CONCENTRATION HAZARD QUOTIENTS

Appendix A-2-5. Tissue Screening Concentration Hazard Quotients for the Derecktor Shipyard Marine Ecological Risk Assessment.

Type	Analyte	DSY-24-IBM	DSY-25-IBM	DSY-25-LOB	DSY-26-CN	DSY-26-DM	DSY-26-IBM	DSY-27-IBM	DSY-27-LOB	DSY-28-CN	DSY-28-DM	DSY-28-IBM	DSY-28-LOB	DSY-29-CN
MET	Arsenic	0.57	0.69	2.74	0.35	0.39	0.65	0.54	1.59	0.51	1.14	0.18		0.75
MET	Cadmium	3.95	2.53	1.31	3.04	2.62	2.18	2.38	0.92	4.36	1.98	1.55		4.27
MET	Chromium	1.56	1.46	1.41	1.19	1.41	1.70	2.06	1.73	0.88	1.43	1.49		1.02
MET	Copper	2.19	6.17	136.70	15.83	9.15	5.68	11.37	145.10	15.11	6.98	0.70		19.99
MET	Lead	8.11	3.43E-04	0.38	1.90	2.49	4.91E-04	6.12	0.16	6.56E-04	4.22E-04	4.11E-04		2.22
MET	Mercury	0.21	0.13	0.34	0.17	0.16	0.12	0.16	0.56	0.14	0.12	0.13		0.22
MET	Nickel	1.47	0.91	0.71	0.48	0.65	9.52E-05	1.86	0.54	0.66	1.60	7.98E-05		0.82
MET	Silver	3.62E-05	3.56E-05	2.27	0.22	4.75E-05	5.09E-05	5.26E-05	2.75	0.14	0.34	4.27E-05		6.32E-05
MET	Zinc	2.43	3.53	4.81	2.28	4.31	4.08	6.59	5.96	1.59	3.68	4.54		1.59
PAH	Acenaphthene	1.16E-05	5.59E-05	2.20E-06	2.72E-06	1.88E-06	1.09E-05	3.22E-06	3.53E-05	6.26E-05	2.64E-06	2.73E-06	3.82E-05	6.09E-05
PAH	Acenaphthylene	1.65E-04	1.13E-03	4.06E-04	8.29E-05	2.28E-04	1.45E-03	9.83E-05	9.87E-05	1.29E-03	2.50E-03	1.70E-03	9.48E-05	1.46E-04
PAH	Anthracene	6.48E-05	3.04E-04	1.46E-04	4.57E-05	8.79E-05	8.98E-04	6.81E-05	6.84E-05	4.23E-04	1.65E-03	1.20E-03	6.74E-05	5.55E-05
PAH	Benzo(a)anthracene		3.35E-05	2.86E-05	2.51E-06	7.87E-06	1.42E-04	2.98E-06	1.13E-05	5.12E-05	7.55E-04	2.17E-04	2.48E-05	4.16E-05
PAH	Benzo(a)pyrene	1.32E-06	6.68E-06	7.80E-06	1.12E-06	1.70E-06	2.42E-05	1.33E-06	7.07E-06	1.02E-06	1.66E-04	2.28E-05	1.02E-05	6.37E-07
PAH	Benzo(b,j,k)fluoranthene	2.17E-06	2.91E-05	2.76E-05	1.93E-06	9.29E-06	1.16E-04	2.28E-06	1.78E-05	3.37E-05	6.98E-04	1.23E-04	2.17E-05	2.50E-06
PAH	Benzo(g,h,i)perylene	2.25E-07	1.97E-07	3.15E-06	1.99E-07	1.84E-06	4.19E-06	2.36E-07	2.98E-06	1.81E-07	1.84E-05	3.75E-06	1.20E-06	2.59E-07
PAH	Chrysene		2.66E-05	2.99E-05	3.93E-06	1.07E-05	1.53E-04	4.66E-06	1.37E-05	4.64E-05	4.54E-04	2.23E-04	2.63E-05	3.12E-05
PAH	Dibenz(a,h)anthracene	4.28E-07	1.62E-05	3.07E-07	3.80E-07	4.24E-06	7.12E-06	4.50E-07	4.52E-07	3.44E-07	3.74E-05	3.81E-07	4.34E-07	4.92E-07
PAH	Fluoranthene	6.23E-05	7.34E-04	4.94E-04	1.04E-04	2.92E-04	3.62E-03	8.56E-04	2.72E-04	2.23E-03	9.14E-03	8.36E-03	7.10E-04	2.32E-04
PAH	Fluorene	1.81E-04	2.27E-05	1.59E-04	2.29E-05	5.59E-05	2.37E-04	2.72E-05	3.37E-04	2.08E-05	3.81E-04	4.62E-04	2.62E-05	5.77E-04
PAH	Indeno(1,2,3-cd)pyrene	2.22E-07	1.95E-07	1.61E-06	1.97E-07	1.05E-06	3.09E-06	2.34E-07	2.17E-06	1.79E-07	1.51E-05	3.44E-06	1.27E-06	2.56E-07
PAH	Naphthalene	7.78E-04	3.30E-05	2.71E-05	3.34E-05		1.83E-03	3.96E-05	3.98E-05	3.03E-05	3.54E-03	3.35E-05	2.73E-04	4.34E-05
PAH	Phenanthrene	1.87E-04	3.28E-04	2.53E-04	1.56E-04	1.78E-04	1.11E-03	1.21E-04	5.17E-04	7.59E-04	2.37E-03	2.94E-03	2.47E-04	4.30E-04
PAH	Pyrene	8.40E-05	2.70E-04	1.84E-04	6.03E-05	1.03E-04	1.06E-03	3.13E-04	7.81E-05	7.55E-04	3.11E-03	2.53E-03	3.30E-04	9.89E-05
PCB	Sum PCBs X 2	0.33	0.11	9.24E-02	0.14	0.12	0.11	0.16	0.77	0.47	0.24	0.34	0.25	1.48
PST	Aldrin	3.08E-05	2.70E-05	2.21E-05	2.73E-05	1.89E-05	1.86E-05	3.24E-05	8.74E-05	2.48E-05	2.65E-05	2.74E-05	3.12E-05	3.55E-05
PST	Hexachlorobenzene	6.83E-07	2.33E-06	4.91E-07	2.12E-05	4.19E-07	4.12E-07	1.12E-06	7.22E-07	1.48E-04	5.89E-07	6.08E-07	5.16E-06	7.87E-07
PST	Mirex		8.32E-03	1.08E-02	1.05E-02	1.76E-02	2.26E-03	6.40E-03		3.46E-02	1.56E-02	1.46E-02	1.02E-02	
PST	o,p'-DDE	7.58E-03	1.13E-02	2.79E-03	2.05E-02	7.00E-03	7.77E-03	4.26E-04	1.03E-02	2.48E-02	1.31E-02	2.15E-02	4.11E-04	1.70E-02
PST	p,p'-DDE	5.72E-02	2.05E-02	1.19E-02	1.86E-02	1.30E-02	7.90E-03	1.67E-02	8.30E-02	2.72E-02	1.76E-02	2.86E-02	2.31E-02	0.14
TBT	Tributyltin	0.92	1.27	1.70	9.47E-02	0.29	0.54	0.11	0.40	0.93	0.61	30.90	0.11	1.37

Species codes: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels;
LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana.
TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark.

Appendix A-2-5 (continued).

Type	Analyte	DSY-29-DM	DSY-29-LOB	DSY-31-DM	DSY-31-PM	DSY-32-PM	DSY-33-DM	DSY-33-LOB	DSY-33-PM	DSY-34-PM	DSY-35-IBM	DSY-35-LOB	DSY-35-MM	DSY-35-PM
MET	Arsenic	0.80	2.48	0.35	0.53	0.33	0.88	2.33	0.33	0.51	0.54	1.53	0.57	0.61
MET	Cadmium	2.76	1.55	1.37	1.69	1.51	2.52	0.64	1.40	1.61	2.40	2.01	2.17	1.82
MET	Chromium	1.61	1.32	1.35	1.00	1.04	1.60	1.85	0.91	1.13	1.71	1.81	1.89	1.29
MET	Copper	5.32	82.02	5.57	7.69	6.92	5.65	59.43	4.52	5.68	6.10	113.70	5.39	5.75
MET	Lead	2.10	0.48	2.22	2.47	4.67	2.61	1.23	3.47E-04	2.47	3.78	1.79	5.57E-04	3.01
MET	Mercury	0.20	0.33	0.13	0.10	0.14	0.10	0.32	9.12E-02	9.44E-02	0.19	0.33	0.14	0.10
MET	Nickel	1.24	0.73	0.67	1.10	0.71	0.60	0.88	6.74E-05	0.61	1.05E-04	0.42	1.26	0.54
MET	Silver	5.80E-05	2.19	4.31E-05	3.69E-05	0.40	4.61E-05	1.55	3.61E-05	3.86E-05	5.61E-05	2.66	5.78E-05	4.70E-05
MET	Zinc	3.83	6.42	6.22	2.84	4.33	4.95	6.29	3.23	3.15	6.40	5.92	5.65	5.16
PAH	Acenaphthene	2.27E-06	2.22E-06	2.85E-06	4.88E-05	1.71E-04	2.92E-06	2.23E-06	1.91E-06	2.27E-06	2.39E-06	3.52E-06	2.00E-06	2.00E-06
PAH	Acenaphthylene	6.93E-05	8.14E-04	8.68E-05	9.99E-05	9.92E-04	8.91E-05	6.81E-05	5.83E-05	3.24E-04	7.30E-05	1.07E-04	5.70E-05	6.11E-05
PAH	Anthracene	1.42E-04	3.99E-04	3.12E-05	5.33E-05	3.20E-04	6.17E-05	1.97E-04	1.53E-04	1.65E-04	5.06E-05	7.44E-05	6.60E-05	1.05E-04
PAH	Benzo(a)anthracene	2.64E-05	4.37E-05	1.90E-05	3.03E-06	4.44E-05	2.70E-06	3.62E-05	6.99E-05	4.94E-05	2.21E-06	3.25E-06	1.81E-05	2.54E-05
PAH	Benzo(a)pyrene	9.39E-07	8.57E-06	8.12E-06	4.49E-06	1.24E-06	4.37E-06	9.23E-07	9.84E-06	1.10E-05	9.89E-07	1.45E-06	4.74E-06	5.14E-06
PAH	Benzo(b,j,k)fluoranthene	1.99E-05	3.23E-05	1.90E-05	1.01E-05	2.44E-05	7.90E-06	2.28E-05	2.82E-05	2.45E-05	1.70E-06	9.24E-06	7.61E-06	1.11E-05
PAH	Benzo(g,h,i)perylene	1.67E-07	1.62E-07	1.57E-06	2.40E-07	2.20E-07	1.74E-06	1.64E-07	2.32E-06	3.66E-06	1.75E-07	2.58E-07	1.17E-06	1.06E-06
PAH	Chrysene	1.84E-05	5.23E-05	3.02E-05	4.74E-06	3.09E-05	4.22E-06	2.35E-05	3.54E-05	3.72E-05	3.46E-06	5.09E-06	2.17E-05	1.35E-05
PAH	Dibenz(a,h)anthracene	3.17E-07	3.09E-07	3.97E-07	4.57E-07	4.20E-07	4.08E-07	3.12E-07	2.67E-07	3.16E-07	3.34E-07	4.91E-07	2.61E-07	2.80E-07
PAH	Fluoranthene	6.98E-04	1.44E-03	5.48E-04	3.33E-04	1.36E-03	3.01E-04	7.01E-04	9.02E-04	9.12E-04	5.52E-04	2.99E-04	2.82E-04	3.89E-04
PAH	Fluorene	1.92E-05	2.41E-04	2.40E-05	3.65E-04	2.54E-05	1.88E-04	1.88E-05	1.61E-05	1.91E-05	2.02E-05	2.97E-05	4.19E-05	4.52E-05
PAH	Indeno(1,2,3-cd)pyrene	1.65E-07	1.61E-07	2.07E-07	2.38E-07	2.18E-07	1.45E-06	1.62E-07	1.84E-06	2.87E-06	1.74E-07	2.55E-07	7.74E-07	7.46E-07
PAH	Naphthalene	2.79E-05	2.72E-05	2.50E-04	4.03E-05	3.70E-05	4.15E-04	2.74E-05	2.35E-05	2.79E-05	2.94E-05	9.07E-04	2.30E-05	2.46E-05
PAH	Phenanthrene	3.96E-04	1.00E-03	3.63E-04	6.14E-04	5.64E-04	3.26E-04	3.63E-04	1.80E-04	2.58E-04	8.96E-05	2.77E-04	1.06E-04	2.79E-04
PAH	Pyrene	3.00E-04	4.40E-04	3.99E-04	1.35E-04	5.56E-04	2.30E-04	2.97E-04	4.27E-04	4.66E-04	2.39E-04	2.12E-04	1.18E-04	1.76E-04
PCB	Sum PCBs X 2	0.17	0.19	0.26	1.12	0.28	0.11	0.19	0.20	9.00E-02	0.17	0.18	0.11	6.74E-02
PST	Aldrin	2.28E-05	2.23E-05	2.86E-05	3.29E-05	3.02E-05	2.93E-05	2.24E-05	1.92E-05	2.28E-05	2.40E-05	3.54E-05	1.88E-05	2.01E-05
PST	Hexachlorobenzene	5.07E-07	4.94E-07	4.89E-06	7.30E-07	1.03E-05	5.02E-06	4.98E-07	2.75E-06	1.13E-06	5.33E-07	2.57E-06	3.18E-06	1.54E-06
PST	Mirex	1.82E-02	2.16E-02	4.91E-03		1.64E-02	8.23E-03	2.16E-02	2.43E-03	6.36E-03	1.70E-02	1.44E-02	4.22E-03	2.96E-03
PST	o,p'-DDE	2.60E-02	1.13E-02	3.76E-04	9.22E-03	2.85E-02	3.86E-04	2.99E-02	6.45E-03	2.99E-04	2.16E-02	4.65E-04	2.47E-04	2.65E-04
PST	p,p'-DDE		1.42E-02	2.46E-02	0.19	4.15E-02	1.62E-02	2.86E-02	5.03E-03	5.04E-03	2.73E-02	2.06E-02	6.25E-03	2.68E-03
TBT	Tributyltin	0.29	1.26	9.91E-02	1.31	0.63	0.10	0.25	1.06		0.57	0.12	1.17	0.91

Species codes: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels;
LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana.
TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark.

Appendix A-2-5 (continued).

Type	Analyte	DSY-36-CN	DSY-36-IBM	DSY-36-LOB	DSY-36-PM	DSY-37-PM	DSY-38-DM	DSY-38-LOB	DSY-38-PM	DSY-39-DM	DSY-39-LOB	DSY-40-DM	DSY-40-IBM	DSY-41-MM
MET	Arsenic	0.34	0.46	1.68	0.35	0.13	0.49	1.86	0.39	0.67	1.79	0.58	0.47	0.72
MET	Cadmium	3.51	1.10	8.08E-04	1.49	0.43	1.89	1.33	1.45	0.91	1.09	2.25	2.12	3.30
MET	Chromium	0.73	1.87	1.49	1.03	0.27	1.86	1.24	1.05	1.99	1.40	2.34	1.75	1.51
MET	Copper	13.87	4.90	39.26	5.30	1.48	8.61	111.10	6.32	6.04	177.35	5.77	5.82	11.92
MET	Lead	2.30	4.62E-04	0.72	2.56	1.31	3.86	0.46	4.02E-04	4.67E-04	0.43	7.20	5.40	3.87
MET	Mercury	0.18	0.19	0.37	9.40E-02	3.62E-02	0.14	0.31	0.14	0.14	0.52	0.17	0.19	0.15
MET	Nickel	0.66	1.55	0.60	0.43	0.13	1.13	0.65	7.79E-05	1.21	0.68	1.61	1.07E-04	1.17E-04
MET	Silver	6.15E-05	4.80E-05	1.05	3.05E-05	4.97E-02	0.59	1.88	4.17E-05	0.32	0.34	6.29E-05	5.74E-05	0.52
MET	Zinc	2.98	3.58	5.58	3.25	1.07	4.09	7.00	4.83	5.58	7.04	6.48	5.30	3.62
PAH	Acenaphthene	2.91E-06	3.17E-06	3.00E-06	2.44E-06	3.19E-06	2.49E-06	2.86E-06	1.58E-06	5.94E-07	2.69E-06	2.40E-06	4.56E-06	6.40E-05
PAH	Acenaphthylene	8.87E-05	9.65E-05	9.15E-05	7.43E-05	9.73E-05	4.02E-04	8.71E-05	4.83E-05	1.81E-05	3.38E-04	7.33E-05	1.23E-04	8.64E-04
PAH	Anthracene	1.96E-04	2.60E-05	6.34E-05	4.25E-05	6.75E-05	1.91E-04	3.99E-05	1.25E-04	1.59E-05	8.46E-05	1.80E-05	6.09E-05	5.32E-05
PAH	Benzo(a)anthracene	2.49E-05	2.92E-06	1.30E-05	1.44E-05		2.07E-05	2.64E-06	2.88E-05	9.15E-06	1.09E-05	2.22E-06	2.72E-05	1.23E-05
PAH	Benzo(a)pyrene	1.20E-06	1.31E-06	2.39E-06	4.50E-06	1.32E-06	3.57E-06	1.18E-06	5.85E-06	1.57E-06	2.48E-06	9.94E-07	5.11E-06	1.04E-06
PAH	Benzo(b,j,k)fluoranthene	2.20E-05	2.24E-06	3.15E-06	4.56E-06	2.26E-06	2.02E-05	1.00E-05	1.64E-05	3.95E-06	1.00E-05	1.70E-06	1.00E-05	1.78E-06
PAH	Benzo(g,h,i)perylene	1.94E-06	2.32E-07	2.20E-07	1.79E-07	2.34E-07	1.18E-06	2.09E-07	1.09E-06	7.38E-07	1.97E-07	1.76E-07	1.31E-06	2.74E-06
PAH	Chrysene	3.22E-05	4.58E-06	5.62E-06	7.49E-06		2.77E-05	4.13E-06	2.23E-05	6.15E-06	1.07E-05	3.48E-06	1.66E-05	1.36E-05
PAH	Dibenz(a,h)anthracene	4.06E-07	4.42E-07	4.19E-07	3.40E-07	4.45E-07	3.47E-07	3.98E-07	2.21E-07	8.29E-08	3.75E-07	3.35E-07	3.02E-07	2.37E-05
PAH	Fluoranthene	8.05E-04	2.75E-04	3.76E-04	4.46E-04	1.64E-04	6.91E-04	2.92E-04	5.20E-04	1.17E-04	2.77E-04	1.05E-04	2.49E-04	2.72E-04
PAH	Fluorene	1.46E-04	2.67E-05	3.75E-05	5.79E-05	2.75E-04	5.39E-05	2.41E-05	1.33E-05	5.01E-06	2.27E-05	2.03E-05	4.43E-05	2.12E-05
PAH	Indeno(1,2,3-cd)pyrene	1.42E-06	2.30E-07	2.18E-07	1.77E-07	2.32E-07	7.03E-07	2.07E-07	8.13E-07	4.31E-08	1.95E-07	1.74E-07	9.33E-07	3.30E-06
PAH	Naphthalene	3.57E-05		3.69E-05	3.00E-05				1.95E-05			2.95E-05	2.66E-05	3.09E-05
PAH	Phenanthrene	4.81E-04	1.66E-04	2.21E-04	2.73E-04	2.36E-04	2.79E-04	2.10E-04	1.99E-04	6.45E-05	1.97E-04	9.58E-05	7.88E-05	9.42E-05
PAH	Pyrene	2.59E-04	8.81E-05	1.21E-04	1.52E-04	1.76E-04	2.40E-04	1.39E-04	2.07E-04	5.60E-05	1.32E-04	2.46E-05	1.06E-04	1.23E-04
PCB	Sum PCBs X 2	0.22	0.11	5.17E-02	0.13	1.08	0.24	0.26	8.43E-02	2.75E-02	0.16	7.55E-02		0.13
PST	Aldrin	2.92E-05	3.18E-05	3.01E-05	2.45E-05	2.06E-04	2.50E-05	2.87E-05	1.59E-05		2.70E-05	2.42E-05		2.53E-05
PST	Hexachlorobenzene	6.48E-07	5.91E-06	6.69E-07	2.56E-06	7.11E-07	5.55E-07	1.78E-06	6.64E-06		2.66E-06	2.06E-06		3.46E-06
PST	Mirex	1.02E-02	4.94E-03		4.22E-03		1.93E-02	2.70E-03	1.73E-03	3.10E-04	3.94E-02	1.93E-03		2.13E-02
PST	o,p'-DDE	1.01E-02	4.18E-04	2.94E-03	3.22E-04	5.16E-03	1.02E-02	9.03E-03	3.91E-03	1.09E-03	1.68E-02	3.18E-04		1.96E-02
PST	p,p'-DDE	3.11E-02	1.36E-02	5.22E-03	1.02E-02	0.15	1.79E-02	1.03E-02	4.02E-03	1.53E-03	2.10E-02	1.49E-02		2.18E-02
TBT	Tributyltin	0.31	0.11	1.36		0.47	1.02	0.10	1.23		0.26	8.37E-02		0.28

Species codes: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels;
LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana.
TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark.

Appendix A-2-5 (continued).

Type	Analyte	DSY-41-PM	JPC-1-DM	JPC-1-IBM	JPC-1-LOB	JPC-1-MF	JPC-1-MM	JPC-1-PM	CHC-1-CN	CHC-1-DM	CHC-1-IBM	CHC-1-LOB
MET	Arsenic	0.17	0.38	0.46	1.49	0.65	0.88	0.60	0.32	0.60	0.31	1.75
MET	Cadmium	2.10	1.76	1.52	0.53	4.90	3.07	1.32	3.26	2.25	1.45	0.71
MET	Chromium	1.32	2.22	1.47	1.15	1.05	2.13	1.04	0.99	1.24	1.07	1.03
MET	Copper	8.59	5.82	5.49	103.30	23.33	7.35	6.12	15.77	8.30	7.35	77.57
MET	Lead	4.79E-04	5.36E-04	5.55	0.75	1.17	6.02	3.22	1.91	5.17	1.28	0.36
MET	Mercury	0.15	0.15	0.15	0.31	0.17	0.19	8.09E-02	0.21	0.17	0.16	0.25
MET	Nickel	0.70	1.28	8.20E-05	0.52	0.69	0.73	6.58E-05	1.10E-04	1.59	1.22	0.62
MET	Silver	4.98E-05	5.56E-05	4.39E-05	0.73	7.07E-05	7.37E-05	3.52E-05	0.62	5.18E-05	4.24E-05	1.34
MET	Zinc	3.67	5.23	3.59	4.64	2.12	7.55	3.74	1.14	3.41	3.43	5.50
PAH	Acenaphthene	3.22E-06	1.61E-04	2.98E-06	7.99E-06	6.28E-06	7.01E-05	2.28E-06	2.59E-06	3.67E-06	3.82E-06	1.83E-06
PAH	Acenaphthylene	9.82E-05	1.71E-03	7.12E-04	1.56E-04	2.33E-04	8.79E-05	2.72E-04	7.89E-05	1.12E-04	1.06E-04	5.85E-05
PAH	Anthracene	1.53E-05	3.53E-04	2.68E-04	9.34E-05	1.34E-04	1.65E-04	7.09E-05	5.47E-05	1.95E-05	6.12E-05	2.96E-05
PAH	Benzo(a)anthracene	2.97E-06	3.78E-05	2.02E-05		2.94E-05	1.31E-05	9.88E-06	2.39E-06		1.11E-05	1.33E-05
PAH	Benzo(a)pyrene	1.33E-06	1.35E-06	2.12E-06	4.10E-06	5.12E-06	1.19E-06	2.03E-06	1.07E-06	1.52E-06	1.84E-06	1.67E-06
PAH	Benzo(b,j,k)fluoranthene	2.28E-06	2.31E-06	1.89E-05	4.91E-06	6.73E-06	1.18E-05	9.30E-06	1.83E-06	2.60E-06	2.70E-06	3.32E-06
PAH	Benzo(g,h,i)perylene	2.36E-07	2.39E-07	2.18E-07	5.67E-07	1.89E-07	2.11E-07	1.67E-07	1.90E-07	2.69E-07	2.80E-07	1.34E-07
PAH	Chrysene	4.66E-06	2.04E-05	2.41E-05		2.23E-05	1.11E-05	1.06E-05	3.74E-06		1.03E-05	8.75E-06
PAH	Dibenz(a,h)anthracene	4.49E-07	4.55E-07	4.15E-07	4.52E-07	3.60E-07	4.02E-07	3.18E-07	3.61E-07	5.12E-07	5.33E-07	2.55E-07
PAH	Fluoranthene	7.86E-05	1.24E-03	8.29E-04	5.86E-04	5.43E-04	3.67E-04	2.78E-04	6.97E-05	8.29E-05	2.18E-04	1.25E-04
PAH	Fluorene	2.71E-05	2.75E-05	1.85E-04	5.35E-05	8.87E-05	2.43E-05	6.35E-05	1.40E-04	4.33E-04	6.13E-05	2.51E-05
PAH	Indeno(1,2,3-cd)pyrene	2.34E-07	2.37E-07	2.16E-07	2.35E-07	1.87E-07	2.09E-07	1.65E-07	1.88E-07	2.66E-07	2.77E-07	1.33E-07
PAH	Naphthalene	3.96E-05	4.01E-05	3.28E-04	3.98E-05	3.17E-05	3.54E-05		3.18E-05	4.51E-05	4.70E-05	2.24E-05
PAH	Phenanthrene	9.52E-05	8.91E-04	7.00E-04	1.71E-04	1.67E-04	3.17E-04	1.60E-04	1.59E-04	1.33E-04	8.91E-05	6.11E-05
PAH	Pyrene	3.85E-05	4.58E-04	2.75E-04	2.40E-04	2.43E-04	1.84E-04	9.01E-05	3.53E-05	1.79E-04	9.32E-05	6.46E-05
PCB	Sum PCBs X 2	0.22	0.20	0.29	8.78E-02	7.65E-02	0.19	0.14	0.11	0.75	8.44E-02	5.26E-02
PST	Aldrin	3.24E-05	3.28E-05	2.99E-05	3.25E-05	2.59E-05	2.90E-05	2.29E-05	2.60E-05	3.69E-05	3.84E-05	1.83E-05
PST	Hexachlorobenzene	3.01E-06	2.35E-06	6.63E-07	7.22E-07	2.21E-06	1.95E-05	5.07E-07	5.50E-06	8.18E-07	8.52E-07	4.76E-07
PST	Mirex	6.93E-03	1.93E-02	2.06E-02		2.70E-03	2.06E-02	7.71E-03	6.80E-03			2.04E-03
PST	o,p'-DDE	2.01E-02	1.56E-02	1.49E-02	4.28E-04	4.15E-03	1.11E-02	6.31E-03	3.42E-04	1.85E-02	4.08E-03	2.95E-03
PST	p,p'-DDE	6.76E-03	2.86E-02	2.72E-02	1.24E-02	4.11E-03	2.02E-02	1.34E-02	9.36E-03	0.22	1.06E-02	4.16E-03
TBT	Tributyltin	0.11	0.11	1.09	1.15		0.37	7.92E-02	9.01E-02	0.37	0.59	1.05

Species codes: CN=cunner; DM=deployed mussels; IBM=indigenous blue mussels;
LOB=lobster; MF=mummichog; MM=Mercenaria mercenaria; PM=Pitar morrhuana.
TSC-HQ = CoC Tissue Wet Weight/TSC Benchmark.

APPENDIX A-2-6.
CRITICAL BODY RESIDUE HAZARD QUOTIENTS

Appendix A-2-6. Critical Body Residue Hazard Quotients for Target Receptors for the Derecktor Shipyard Marine Ecological Risk Assessment.

		Organics				Metals								
Station	Species[1]	Total PAHs	Total PCBs	Pesticides	Butyltins	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
DSY-24	IBM	1.9E-3	1.8E-3	2.5E-5	4.2E-5	0.14	1.7E-2	6.1E-2	6.5E-2	2.8E-2	1.4E-3	9.3E-2	1.4E-6	1.17
DSY-25	IBM	1.8E-2	1.5E-3	1.5E-5	7.7E-5	0.17	1.1E-2	5.8E-2	0.19	1.2E-6	8.7E-4	5.8E-2	1.4E-6	1.72
	LOB	9.2E-4	1.3E-3	1.8E-5	9.2E-6	0.38	3.2E-3	3.2E-2	2.39	7.6E-4	1.3E-3	2.6E-2	5.0E-2	1.34
DSY-26	CN	1.6E-3	6.3E-3	9.2E-5	3.2E-5	4.9E-2	7.4E-3	2.7E-2	0.28	3.8E-3	6.4E-4	1.7E-2	4.7E-3	0.64
	DM	6.2E-3	5.1E-3	3.9E-5	1.0E-4	7.1E-2	8.4E-3	4.2E-2	0.21	6.6E-3	8.1E-4	3.1E-2	1.4E-6	1.57
	IBM	4.5E-2	2.4E-3	2.4E-5	6.1E-5	0.11	6.5E-3	4.7E-2	0.12	1.2E-6	5.9E-4	4.3E-6	1.4E-6	1.39
DSY-27	IBM	2.0E-2	3.3E-3	3.7E-5	3.0E-3	8.9E-2	6.8E-3	5.5E-2	0.23	1.5E-2	7.4E-4	8.1E-2	1.4E-6	2.18
	LOB	2.5E-3	2.2E-3	2.6E-5	9.2E-6	0.23	2.3E-3	4.1E-2	2.62	3.3E-4	2.3E-3	2.0E-2	6.3E-2	1.72
DSY-28	CN	7.4E-3	1.1E-2	1.4E-4	1.0E-4	6.5E-2	9.7E-3	1.8E-2	0.24	1.2E-6	5.1E-4	2.2E-2	2.8E-3	0.40
	DM	2.5E-3	2.0E-3		3.4E-5	0.22	6.8E-3	4.6E-2	0.17	1.2E-6	6.7E-4	8.3E-2	1.1E-2	1.46
	IBM	5.4E-3	2.3E-3	2.3E-5	1.5E-4	3.6E-2	5.5E-3	4.9E-2	1.8E-2	1.2E-6	7.2E-4	4.3E-6	1.4E-6	1.85
	LOB	2.8E-3	2.5E-3	3.1E-5	9.2E-6									
DSY-29	CN	1.6E-3	9.1E-3	2.1E-4	1.1E-4	0.10	1.0E-2	2.3E-2	0.34	4.4E-3	8.4E-4	3.0E-2	1.4E-6	0.44
	DM	4.3E-3	2.5E-3	4.9E-5	5.5E-5	0.12	7.2E-3	3.9E-2	0.10	4.5E-3	8.4E-4	4.9E-2	1.4E-6	1.15
	LOB	1.7E-3	1.0E-3	2.0E-5	9.2E-6	0.38	4.2E-3	3.3E-2	1.58	1.1E-3	1.4E-3	3.0E-2	5.3E-2	1.98
DSY-31	DM	2.7E-3	2.3E-3	4.6E-5	2.9E-5	7.0E-2	4.8E-3	4.4E-2	0.14	6.5E-3	7.2E-4	3.5E-2	1.4E-6	2.51
	PM	4.2E-3	2.7E-3	9.4E-6	1.5E-4	0.12	6.9E-3	3.8E-2	0.23	8.4E-3	6.8E-4	6.8E-2	1.4E-6	1.34
DSY-32	PM	4.0E-3	1.1E-3	7.9E-6		6.6E-2	5.2E-3	3.3E-2	0.17	1.3E-2	7.7E-4	3.7E-2	1.3E-2	1.72
DSY-33	DM	8.7E-4	1.8E-3	4.1E-5	6.3E-5	0.17	8.3E-3	4.9E-2	0.13	7.1E-3	5.1E-4	3.0E-2	1.4E-6	1.86
	LOB	1.5E-3	1.3E-3	2.1E-5	9.2E-6	0.30	1.4E-3	3.8E-2	0.95	2.3E-3	1.1E-3	3.0E-2	3.1E-2	1.61
	PM	2.3E-3	1.5E-3	1.2E-5	1.7E-4	7.8E-2	5.9E-3	3.6E-2	0.14	1.2E-6	6.1E-4	4.3E-6	1.4E-6	1.56
DSY-34	PM	2.5E-3	9.0E-4	4.8E-6	1.2E-4	0.12	6.3E-3	4.1E-2	0.16	8.0E-3	5.9E-4	3.6E-2	1.4E-6	1.41
DSY-35	IBM	2.5E-3	2.0E-3	3.8E-5	2.8E-5	8.3E-2	6.5E-3	4.3E-2	0.12	8.4E-3	8.3E-4	4.3E-6	1.4E-6	1.98
	LOB	3.7E-4	9.1E-4	1.5E-5	9.2E-6	0.22	5.0E-3	4.2E-2	2.02	3.7E-3	1.3E-3	1.6E-2	6.0E-2	1.68
	MM	8.0E-4	4.6E-4	6.2E-6	1.2E-4	8.6E-2	5.7E-3	4.6E-2	0.10	1.2E-6	6.0E-4	5.0E-2	1.4E-6	1.70
	PM	1.5E-3	1.4E-3	1.5E-5		0.11	5.9E-3	3.9E-2	0.13	8.0E-3	5.0E-4	2.6E-2	1.4E-6	1.91
DSY-36	CN	1.6E-3	9.0E-3	1.7E-4	3.9E-5	4.8E-2	8.6E-3	1.7E-2	0.24	4.7E-3	7.2E-4	2.4E-2	1.4E-6	0.84
	IBM	2.5E-3	2.6E-3	2.6E-5	1.1E-4	8.2E-2	3.5E-3	5.5E-2	0.11	1.2E-6	9.4E-4	7.4E-2	1.4E-6	1.29
	LOB	6.7E-4	2.4E-3	1.3E-5	9.2E-6	0.26	2.2E-6	3.8E-2	0.77	1.6E-3	1.6E-3	2.5E-2	2.6E-2	1.76
	PM	3.5E-3	1.4E-3	9.1E-6	2.1E-4	0.10	7.4E-3	4.7E-2	0.19	1.1E-2	7.5E-4	3.2E-2	1.4E-6	1.85
DSY-37	PM	2.1E-3	1.2E-3	9.2E-6		0.10	5.7E-3	3.3E-2	0.14	1.4E-2	7.7E-4	2.7E-2	5.9E-3	1.62
DSY-38	DM	1.1E-3	1.6E-3	2.8E-5	2.6E-5	8.1E-2	5.5E-3	5.0E-2	0.18	9.3E-3	6.4E-4	5.0E-2	1.6E-2	1.37
	LOB	1.9E-4	8.4E-4	2.2E-5	9.2E-6	0.35	4.4E-3	3.8E-2	2.60	1.3E-3	1.6E-3	3.2E-2	5.6E-2	2.62
	PM	1.8E-3				8.1E-2	5.2E-3	3.5E-2	0.16	1.2E-6	8.4E-4	4.3E-6	1.4E-6	2.01
DSY-39	DM	1.8E-3	1.3E-3	3.1E-5	3.0E-5	0.12	2.8E-3	5.8E-2	0.14	1.2E-6	7.0E-4	5.7E-2	8.9E-3	2.00
	LOB	1.4E-4	1.9E-3	7.5E-6	9.2E-6	0.25	2.7E-3	3.2E-2	3.10	8.7E-4	2.0E-3	2.5E-2	7.5E-3	1.97
DSY-40	DM	3.5E-3	1.6E-3	3.1E-5	9.2E-6	8.0E-2	5.4E-3	5.2E-2	0.10	1.4E-2	6.4E-4	5.8E-2	1.4E-6	1.79
	IBM	2.4E-3	2.6E-3	3.3E-5	9.7E-5	7.0E-2	5.6E-3	4.3E-2	0.11	1.2E-2	8.2E-4	4.3E-6	1.4E-6	1.60
DSY-41	MM	1.1E-3	7.2E-4	1.4E-5	9.4E-5	0.10	8.0E-3	3.4E-2	0.21	7.8E-3	6.0E-4	4.3E-6	1.1E-2	1.01
	PM	2.1E-3	7.9E-4	5.7E-6		2.9E-2	6.4E-3	3.7E-2	0.19	1.2E-6	7.4E-4	3.2E-2	1.4E-6	1.28
JPC-1	MF	4.0E-4	5.5E-3	2.1E-4	2.7E-5	7.9E-2	1.0E-2	2.1E-2	0.36	2.1E-3	5.7E-4	2.2E-2	1.4E-6	0.52
	DM	1.6E-3	1.8E-3	2.5E-5	3.4E-5	5.9E-2	4.8E-3	5.6E-2	0.11	1.2E-6	6.7E-4	5.2E-2	1.4E-6	1.63
	IBM	1.1E-3	1.6E-3	2.1E-5	9.2E-6	9.0E-2	5.2E-3	4.7E-2	0.14	1.6E-2	8.5E-4	4.3E-6	1.4E-6	1.42
	LOB	7.7E-4	1.1E-3	1.3E-5	9.2E-6	0.26	1.6E-3	3.2E-2	2.25	1.9E-3	1.5E-3	2.4E-2	2.0E-2	1.62
	MM	6.3E-4	5.9E-4	9.9E-6	4.1E-5	0.10	6.3E-3	4.1E-2	0.11	1.0E-2	6.4E-4	2.2E-2	1.4E-6	1.78
	PM	1.1E-3	7.7E-4	8.1E-6	1.5E-4	0.15	5.7E-3	4.2E-2	0.19	1.1E-2	5.6E-4	4.3E-6	1.4E-6	1.85
CHC-1	CN	6.8E-3	2.9E-3	6.7E-5	7.9E-5	4.6E-2	8.4E-3	2.3E-2	0.29	4.1E-3	8.5E-4	4.3E-6	1.4E-2	0.34
	DM	4.2E-3	1.1E-3	2.7E-5	1.2E-4	0.10	6.6E-3	3.4E-2	0.17	1.3E-2	7.9E-4	7.0E-2	1.4E-6	1.14
	IBM	3.2E-3	1.1E-3	1.9E-5	2.0E-4	6.2E-2	5.2E-3	3.5E-2	0.19	3.8E-3	9.2E-4	6.5E-2	1.4E-6	1.40
	LOB	6.8E-4	1.3E-3	2.4E-5	9.2E-6	0.29	2.0E-3	2.8E-2	1.60	8.7E-4	1.1E-3	2.7E-2	3.5E-2	1.82

1 - Species: CN =cunner, DM=deployed mussels, IBM=indigenous blue mussels, LOB=lobster, MM=*Mercenaria mercenaria*, MF=mummichog fish, PM=*Pitar morrhuana*.
CBR-HQ = CBR/CBR Benchmark.