PTI
ENVIRONMENTAL SERVICES
15375 SE 30th Place
Suite 250
Bellevue, Washington 98007

FINAL REPORT

REFERENCE AREA PERFORMANCE STANDARDS FOR PUGET SOUND

Prepared for

U.S. Environmental Protection Agency
Region 10, Office of Coastal Waters
1200 Sixth Avenue
Seattle, Washington 98101

and

Washington Department of Ecology
Olympia, Washington

EPA Contract 68-D8-0085
PTI Contract C744-28

September 1991

Pub #06-09-096

CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF ACRONYMS

AET	apparent effects threshold
AVS	acid-volatile sulfides
CLP	Contract Laboratory Program
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
HPAH	high molecular weight polycyclic aromatic hydrocarbon
LAET	lowest apparent effects threshold
LPAH	low molecular weight polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSAMP	Puget Sound Ambient Monitoring Program
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance and quality control
SMS	sediment management standards
TOC	total organic carbon
WAC	Washington Administrative Code

EXECUTIVE SUMMARY

The Puget Sound Reference Areas Survey reported here was conducted by the Washington Department of Ecology (Ecology) and the U.S Environmental Protection Agency Region 10, Office of Puget Sound, to document suitable reference conditions in Puget Sound and define reference area performance standards. Reference area performance standards are criteria for suitable reference conditions expressed as habitat characteristics (e.g., chemical concentrations) and biological properties (e.g., toxicity bioassay response). The performance standards are needed to provide an objective and consistent basis for assessing contaminated sediments in various environments of Puget Sound.

ESTABLISHMENT OF PERFORMANCE STANDARDS

Sound-wide performance standards for reference area samples will provide a consistent basis for comparison and use of sediment data collected under Puget Sound Estuary Program (PSEP) guidelines as part of the Puget Sound Ambient Monitoring Program (PSAMP), the Puget Sound Dredged Disposal Analysis program (PSDDA), the Sediment Management Standards (SMS) program, and other sediment management programs. Performance standards are to be established for the three common measures of sediment toxicity: sediment contaminant concentrations, benthic infauna abundances, and bioassay responses. Stratification of reference area performance standards by biogeographic zone, season, water depth, and sediment type may be appropriate, with different types of stratification for chemistry, infauna, and bioassay data. Interim reference area performance standards and data gaps were presented in Pastorok et al. (1989). The present work increases the size of the chemistry and bioassay data sets for the biogeographic regions of southern Puget Sound, northeastern Puget Sound, and the Strait of Georgia.

STUDY DESIGN

Samish Bay, Holmes Harbor, and Carr Inlet were selected as potentially suitable reference areas based on geographic location and available chemical and biological data. In the present study, chemical and biological conditions were evaluated in June 1990 by the analysis of 1) physical/chemical sediment characteristics, including chemical concentrations, total organic carbon, acid-volatile sulfides, total solids, and grain size distribution and 2) sediment toxicity as determined by amphipod mortality, bivalve larvae mortality and abnormality, echinoderm embryo mortality and abnormality, juvenile polychaete mortality and biomass, and saline Microtox® bacterial luminescence bioassays. Within each reference area, seven sampling sites were selected to represent a gradient of sediment grain size distribution within a broad range of percent fine-grained (<63 μm) material. All sample analyses were conducted in accordance with PSEP guidelines.

SEDIMENT CHEMISTRY RESULTS

Median values for data on contaminant concentrations based on the 1990 survey were similar to the median of pooled historical data for four interim reference areas (i.e., Carr Inlet, Dabob Bay, Samish Bay, and Sequim Bay) identified by Ecology (Pastorok et al. 1989), with the exception of chromium. The median concentrations of chromium for the areas sampled in the 1990 survey, when combined with the chromium results for the four interim reference areas, resulted in a median concentration 25 percent greater than the median associated with only the four interim reference areas; however, the range of chromium values of the 1990 survey were well within the range associated with the interim reference areas. For each of the conventional variables and chemical concentrations, most of the 1990 survey results exhibited frequency distribution patterns similar to those for the four interim reference areas.

No pesticides or polychlorinated biphenyls were detected in any of the samples associated with this survey. In comparison to the four interim reference areas, the results of this study suggest that the observed concentrations of most metals and most organic compounds in sediments at the nine stations were relatively low. Exceptions include benzoic acid, butyl benzyl phthalate, and 4-methylphenol. These chemicals were present at Station SM30 in Samish Bay at concentrations that may be associated with adverse biological effects based on exceedances of the state sediment management standards. Therefore, this station was rejected from future consideration as a potential reference area.

All 1990 survey areas, with the exception of Samish Bay Station SM30, are in accordance with the criteria for the selection of Puget Sound reference areas as identified in Pastorok et al. (1989). The selection criteria require that the lowest apparent effects threshold (LAET) values not be exceeded by more than one chemical contaminant (other than phthalates, which are common laboratory contaminants, and sulfides). 4-Methylphenol exceeded the LAET value at more than one station within an area (Carr Inlet Stations CR02 and CR20 and Samish Bay Stations SM30 and SM34). However, these stations were not eliminated from consideration as Puget Sound reference areas because 4-methylphenol was the only contaminant exceeding an LAET. In addition, adverse biological effects were not apparent from the bioassay results.

SEDIMENT BIOASSAY RESULTS

Bioassay responses in reference area sediments were generally less than the PSEP quality control limits for negative control samples. Differences between bioassay responses to reference area sediments and those to West Beach sediments were relatively small despite their statistical significance ($P \leq 0.05$) for approximately half of the stations sampled in this study. Except for two Holmes Harbor samples, exceedances of quality control limits for control samples were not regarded as evidence of contamination. Samples from Holmes Harbor Stations HM01 and HM02 greatly exceeded the quality control limit specified in this study for juvenile polychaete mortality in control samples; mortality at these stations was 50 and 44 percent, respectively. Nevertheless, the growth of the surviving worms (as measured by average individual biomass) was comparable to that at other stations in Holmes Harbor and other reference areas. Confirmation of the apparent toxicity at Stations HM01 and HM02 by resampling and reanalysis would help to confirm the value of Holmes Harbor as a reference area.

Percent mortality for the amphipod test was less than the interim performance standards for reference areas in all cases. The bivalve larvae quality control limit for mortality in controls was exceeded by all reference area sediments. Systematic high bivalve mortalities have been observed in PSDDA studies (PTI 1988; Kendall 1991, pers. comm.) and are not considered indicative of significant toxicity in these samples. Bivalve mortality showed no relationship to ammonia, which has been implicated as a cause of high bivalve mortality in PSDDA tests. Possible explanations for the high bivalve larvae mortality values, which contradict the results of the other bioassays based on comparisons to quality control limits for controls, are that 1) the estimate of the number of initial larvae was not representative of the true number of initial larvae, 2) the bivalve were unusually sensitive (responses to positive controls were all high, so that an LC_{50} could not be calculated), or 3) some unmeasured bioassay condition was responsible.

Significant correlations ($P \leq 0.05$) between bioassay responses and physical sediment parameters were observed only for the two larval bioassays. Larval responses (both abnormality or the combined endpoint) were significantly correlated with finer grain sizes and higher percentages of organic carbon.

Bivalve larvae abnormality and echinoderm larvae mortality were significantly correlated with the concentrations of several chemicals. Juvenile polychaete biomass was also significantly correlated with one chemical (fluorene). Despite the existence of a relationship between chemical concentrations and bioassay results in this data set, the absolute magnitude of these bioassay responses are low enough to indicate the absence of toxic effects in these reference area samples based upon comparison of bioassay responses to quality control limits for control samples.

PERFORMANCE STANDARDS

Performance standards were computed using all previous data from interim reference areas (Carr Inlet, Sequim Bay, Dabob Bay, and Samish Inlet) and the data from this study. Performance standards were established by the 90th percentile of the range of each chemical or biological variable. Performance standards have been developed for the amphipod mortality endpoint, bivalve larvae, echinoderm embryo abnormality and combined endpoints, and *Neanthes* biomass endpoint. Performance standards based on the 90th percentile of the distribution of bioassay responses could not be developed for the Microtox® test because no significant decreases in bacterial bioluminescence were observed in this study. Therefore, it is recommended that a nonsignificant ($P > 0.05$) decrease in bioluminescence be established as the reference area performance standard for the Microtox® bioassay.

CONCLUSIONS AND RECOMMENDATIONS

The 1990 survey of reference areas has increased the amount of data available for establishment of subtidal chemistry and selected bioassay performance standards. Most of the stations sampled within the Carr Inlet, Samish Bay, and Holmes Harbor reference areas are uncontaminated, as indicated by chemistry and bioassay results. One station in Samish Bay appears contaminated and is unsuitable for collection of reference sediments. Equivocal results were observed for two stations in Holmes Harbor, and use of these stations should be avoided unless subsequent studies establish that they are not contaminated.

The LAET for 4-methylphenol was exceeded at several stations. Because adverse biological effects were not observed at these stations, the stations were included in the formulation of revised reference area performance standards.

Amphipod bioassay mortality results from the 1990 survey showed a slight, but nonsignificant, correlation with sediment grain size. The highest value of mean mortality observed in the amphipod tests was less than the PSEP quality control limit of 10 percent for control samples. This observation indicates that stratification of bioassay performance standards by grain size is unnecessary for this survey. The relationship between bioassay results and grain size should be examined in subsequent reference area studies. Furthermore, the relationship between grain size and mortality may be different in contaminated sediments. In any case, collecting reference area sediment with a grain size similar to that of the test site would minimize the effect of such a relationship even if it is small. The bioassay performance standards presented in this report are not stratified by grain size.

Performance standards have been developed for 14 chemicals and for 5 bioassay endpoints. A performance standard for the bivalve larvae combined endpoint (mortality plus abnormality) was not developed because of extremely high mortalities observed in these tests; a percentile-based numerical performance standard for the Microtox® bioassay was not developed because of the absence of sufficient data showing a positive response. It is recommended that a nonsignificant ($P>0.05$) decrease in bioluminescence be established as the reference area performance standard for the Microtox® bioassay.

Several of the data gaps identified in Pastorok et al. (1989) remain unfilled, including data to support the development of performance standards for benthic macroinvertebrates and for low-salinity and intertidal habitats. Additional data from other possible reference areas, especially data collected recently under PSAMP and PSDDA, would help refine the existing performance standards and extend them to additional chemical and biological measures of toxicity.

INTRODUCTION

The Washington Department of Ecology (Ecology) has issued sediment management standards [SMS; Chapter 173-204 Washington Administrative Code (WAC)] for identifying and classifying contaminated sediments in Puget Sound. The SMS and other regulatory programs mandate that reference areas (i.e., relatively uncontaminated areas) be sampled to provide data suitable for comparison with data on potentially contaminated sediments. Reference area performance standards are qualitative and quantitative criteria for suitable reference conditions that are defined in terms of habitat characteristics (e.g., chemical concentrations) and biological properties (e.g., toxicity bioassay responses). The performance standards are needed to provide an objective and consistent basis for assessing contaminated sediments in various environments of Puget Sound. Reference area performance standards provide a means of assessing the acceptability of reference sediment, whether it is collected from a previously identified reference area or from some other location. Development of reference area performance standards follows the recommendation of the U.S. Environmental Protection Agency (EPA) Science Advisory Board. The goal of Ecology and EPA is to develop standards that are applicable to multiple Puget Sound sediment management programs [e.g., the Puget Sound Dredged Disposal Analysis (PSDDA), the Puget Sound Estuary Program (PSEP), SMS).

The Puget Sound Reference Areas Survey reported here was conducted by Ecology and EPA Region 10, Office of Coastal Waters, to document suitable reference conditions in Puget Sound. Samish Bay, Holmes Harbor, and Carr Inlet were selected as potentially suitable reference areas based on geographic location and available chemical and biological data. These areas are distributed in northern, central, and southern regions of the sound, respectively, and available data indicated relatively low concentrations of contaminants in sediments (Pastorok et al. 1989). In the present study, chemical and biological conditions were evaluated by the analysis of 1) physical/chemical sediment characteristics, including chemical concentrations, total organic carbon (TOC), acid-volatile sulfides (AVS), total solids, and grain size distribution and 2) sediment toxicity as determined by amphipod mortality, bivalve larvae mortality and abnormality, echinoderm embryo mortality and abnormality, juvenile polychaete mortality and biomass, and saline Microtox® bacterial luminescence bioassays. Within each reference area, sampling sites were selected to represent a gradient of sediment grain size distribution based on a broad range of percent fine-grained (<63 μm) material.

INTERIM PERFORMANCE STANDARDS

Ultimately, performance standards for reference areas will be developed from a comprehensive database containing information on sites throughout Puget Sound. A sound-wide database is needed to characterize the range of conditions expected in reference areas. For example, sediment chemistry, sediment toxicity bioassay response, and benthic macroinvertebrate communities may vary in relation to sediment grain size distribution and TOC content or region-specific geological properties (e.g., proportion of various minerals and background metals concentrations). Interim performance standards for reference areas were defined based on available data (Pastorok et al. 1989). These interim performance standards are shown in Table 1. The data collected during the present study were used to refine the interim performance standards expressed as quantitative values (e.g., maximum sediment chemical concentrations or bioassay responses).

POTENTIAL REFERENCE AREAS

The following criteria were used by Pastorok et al. (1989) to select potential reference areas for use in Ecology's sediment management program:

- The area is ranked low for current contaminant source concerns and for predicted impacts of future population growth

- The median concentration of each chemical evaluated in the area is less than the interim performance standard (i.e., 90th percentile concentration derived from data at individual stations for all potential reference areas)

- Lowest apparent effects threshold (LAET) values are not exceeded for more than one chemical contaminant (other than phthalates, which are common laboratory contaminants, and sulfides) and at more than one station within the area

- The mean value of amphipod mortality for the reference area does not exceed the interim performance standard (e.g., guideline developed from Barrick et al. 1988 or model of DeWitt et al. 1988).

Potential reference areas meeting these criteria are shown in Table 2. Interim reference areas proposed for use by the sediment management program were Carr Inlet, Dabob Bay, Samish Bay, and Sequim Bay (Pastorok et al. 1989). Selection of these four areas was based upon the large quantity of available data and the areas' locations in different biogeographic zones of Puget Sound.

TABLE 1. INTERIM PERFORMANCE STANDARDS FOR REFERENCE AREAS

Variable	Performance Standard[a]
Organic Compounds (µg/kg DW)	
LPAH	240
HPAH	1,200
PCB	30
Inorganics (mg/kg DW)	
Arsenic	19
Cadmium	1.4
Copper	58
Chromium	150
Mercury	0.19
Lead	30
Nickel	65
Silver	0.78
Zinc	110
Total Organic Carbon (% DW)	3.0
Sulfides (mg/kg DW)	84
Bioassays	
Amphipod mortality (%)	25
Bivalve larvae abnormality (%)	b
Microtox - saline (EC_{50}, µL/mL)	b
Microtox - organic (EC_{50}, µL/mL)	b
Benthic Macroinvertebrates (No./m^2)	b
Polychaete abundance	b
Gastropod abundance	b
Bivalve abundance	b
Amphipod abundance	b
Total abundance	b
Number of species	b

[a] These performance standards apply only to marine subtidal sediments. For each chemical variable, the interim performance standard is equal to the 90th percentile of the distribution of sediment concentration values for potential reference areas

[b] Quantitative interim performance standards cannot be defined on a sound-wide basis because of limited available data. Qualitative performance standards are described in the text.

TABLE 2. SUMMARY OF AVAILABLE DATA FOR POTENTIAL REFERENCE AREAS[a]

Location	Chemistry[b] High Median	Chemistry[b] >AET	High Amphipod Mortality[c]	Number of Stations with Sediment Chemistry[d] Data	Number of Stations with Biological Data
Admiralty Inlet	--[e]	--	--	6	0
Carr Inlet	+	yes	1	22	13
Case Inlet	--	yes	yes, 3	40	55
Dabob Bay	+	+	+	34	11
Discovery Bay	+	+	+	53	2
Hood Canal, central/lower	--	--	--	15	0
Padilla Bay	--	--	+	2	1
Port Madison	+	yes	--	51	0
Port Orchard	--	--	--	4	0
Poverty Bay	--	--	+	0	1
President Point	LPAH	--	--	3	1
Quartermaster Harbor	LPAH, Ag, Pb, Hg	yes	--	8	0
Rich Passage	Pb	--	--	1	0
Rosario Strait	--	--	--	1	0
Samish Bay	(sulfide)[f]	(yes)[f]	(yes), 1	59	32
Saratoga Passage	--	--	--	10	0
Sequim Bay	(sulfide)[f]	(yes)[f]	(yes)	30	55
West Beach	+	+	NA[g]	6	2
Wollochet Bay	--	--	--	2	0

[a] From Pastorok et al. (1989).

[b] High median (i.e., median exceeds the interim performance standard) or exceedance of the apparent effects threshold for one or more chemicals at one or more stations based on detected values (phthalates excluded).

TABLE 2. (Continued)

[c] Median mortality $\geq$25 percent or more than 33 percent of stations with mean amphipod mortality values $\geq$25 percent. Parentheses indicate that high percentage of fine-grained material in sediments may account for high mortality values at most sites. The number of stations that exceed the optional interim performance standard derived from the model of Dewitt et al. (1988) is also shown.

[d] Count includes stations which have only sediment conventionals data.

[e] + = low contamination or low amphipod mortality
- = inadequate data (i.e., poor coverage of U.S. Environmental Protection Agency priority pollutants polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and metals; no amphipod bioassay data)

[f] Single station.

[g] NA = not applicable; West Beach is the native sediment control for the amphipod bioassay.

DEVELOPMENT OF PERFORMANCE STANDARDS

The proposed structure of the performance standards is based on consideration of key environmental variables that influence natural sediment conditions. The performance standards are based on an evaluation of all suitable data compiled in Pastorok et al. (1989) and data collected during the present study. The simplified scheme proposed for the structure of the performance standards reflects the limited amount of data for reference areas. Not all of the areas used to define the interim performance standards (Pastorok et al. 1989) are recommended for use as reference areas in the future. Interim reference areas were selected by integrating information on degree of contamination, biological effects, potential anthropogenic disturbance, habitat characteristics, and geographic location.

STRUCTURE OF PERFORMANCE STANDARDS

Performance standards are defined as criteria to identify suitable reference conditions based on sediment variables (i.e., contaminant concentrations, bioassay responses, benthic macroinvertebrate abundances). For each variable, the performance standard recommended below is generally expressed as the 90th percentile of the observed distribution of values for potential reference areas. As more data are developed for various potential reference areas, the performance standards should be revised. At that time, it may be warranted to define the standards as the 95th or the 99th percentile of the distribution of reference area values based on sample size or skewness of the distribution.

A hierarchical structure is proposed for reference area performance standards, consisting of four tiers of environmental variables:

- Biogeographic region, including estuarine (i.e., low-salinity) subareas defined by interstitial water salinity of sediments
- Season within biogeographic region
- Water depth (or tidal height) within season and within region
- Sediment type within a particular range of water depths, within season, and within region.

For benthic macroinvertebrate variables, performance standards should be defined within each tier of this system. For example, an acceptable range of abundance would be defined for each major taxon of benthic macroinvertebrates for sediments of a certain range of grain sizes, within a certain range of water depths, within a certain season, and within a certain biogeographic zone. However, not all tiers may be relevant to a particular variable. Chemistry variables are not stratified by season, water depth, or sediment type.

Different biogeographic regions within Puget Sound are proposed as the first level of the hierarchical system. Interim biogeographic regions were defined (Pastorok et al. 1989) by gross physical features, expected influence of fresh waters, and requirements for locating representative reference areas throughout Puget Sound. The latter requirements were imposed to satisfy the logistical constraints of sampling and to ensure that one or more of the selected reference areas were located relatively close to contaminated areas that might be evaluated. The first level of the performance standards system includes the following biogeographic zones:

- **Strait of Juan de Fuca/Strait of Georgia**—Areas generally north and west of Admiralty Inlet, including associated bays (e.g., Sequim Bay, Discovery Bay, Padilla Bay, Samish Bay, San Juan Islands, and Boundary Bay)
- **Hood Canal**—Hood Canal (in its entirety) and associated bays (e.g., Dabob Bay, Port Ludlow)
- **Northeastern Puget Sound**—Saratoga Passage and associated bays (e.g., Holmes Harbor, Penn Cove, Oak Harbor, Port Susan, and Skagit Bay)
- **Puget Sound Main Basin**—Areas from the northern boundary of Admiralty Bay in the north to the Tacoma Narrows in the south, and associated bays (e.g., Oak Bay, Useless Bay, Port Madison, and Poverty Bay)
- **Southern Puget Sound**—Areas south of the Tacoma Narrows (e.g., Carr Inlet, Case Inlet, Nisqually Reach, Skookum Inlet).

Further subdivision of these areas will likely be necessary in the future as more data become available from the Puget Sound Ambient Monitoring Program (PSAMP), PSDDA, or the Ecology sediment management program.

Based on gross oceanographic features, these zones might be expected to have somewhat different benthic macroinvertebrate communities. However, the importance of these differences at the major taxon level is unknown. Each of the large biogeographic zones also defines an area within which at least one reference area should be located to allow efficient sampling. Within the large-scale zones, smaller biogeographic zones corresponding to estuarine systems (<25 ppt salinity) within Puget Sound should be defined. Because salinity measurements on interstitial water in sediments are generally not available, these estuarine zones cannot be defined precisely at this time.

Within each biogeographic region or estuarine subarea, reference conditions should be defined for different seasons. Ranges of water depths for subtidal stations and tidal heights for intertidal stations should also be incorporated into the performance standards system. Within each season and range of depths (or tidal heights), the final tier of environmental variables should be organized into various sediment types defined as combinations of ranges of percent fine-grained material.

The proposed structure of the performance standards for each kind of sediment variable is summarized in Table 3. All variables should be stratified by major biogeographic zone and sediment interstitial water salinity because of the potentially important influence of these factors. Chemistry of sediments is strongly affected by interstitial water salinity and by natural materials (e.g., plant material, glacial silt) carried by rivers that create low-salinity areas. Because of potential physicochemical influences on organism responses to toxic chemicals (DeWitt et al. 1988), stratification of performance standards for the amphipod bioassay by sediment grain size (or some covariate) may be warranted in some circumstances. Also, different kinds of bioassays or modifications of present bioassays will be required to test the toxicity of low-salinity sediments. The Microtox® test is the only available bioassay currently used for assessing Puget Sound sediments that can be applied immediately to freshwater sediments. Stratification of performance standards for bioassays to account for seasonal effects is not recommended. However, the availability of test organisms may limit the application of a given bioassay on a seasonal basis. The structure of the performance standards is most complex for benthic macroinvertebrate variables because of the well known variation in benthic communities with changes in environmental variables. Because of the variability of benthic macroinvertebrate populations in intertidal habitats and low-salinity environments, it is recommended that this indicator of toxicity not be used as part of a biological testing scheme for these habitats.

QUALITY ASSURANCE AND QUALITY CONTROL OF PERFORMANCE STANDARDS DATABASE

Options and recommendations are presented in this section for procedures to screen anomalous data from the reference area database. In general, data collection efforts and quality assurance and quality control (QA/QC) procedures should follow regional protocols (PSEP 1986c; Pastorok et al. 1989). Specific recommendations for QA/QC of chemical and biological data are provided in the text below.

Chemical Data

Chemical data that have passed quality assurance review may still be qualified. Qualified data (e.g., data qualified as estimates) may be less certain

TABLE 3. PROPOSED GENERAL STRUCTURE OF REFERENCE AREA PERFORMANCE STANDARDS

	Performance Standards Stratum[a]			
Sediment Variable	Biogeographic[b] Zone	Season	Water Depth[c]	Grain Size
Chemistry	Yes	No	No	No
Bioassays	Yes	No	No	Yes[d]
Benthic macroinvertebrates	Yes	Yes	Yes	Yes

[a] Environmental variable by which the performance standards for a sediment variable are stratified.

[b] Incorporates stratification by estuarine subarea within each large-scale biogeographic region defined in the text.

[c] Incorporates stratification into intertidal and subtidal areas.

[d] Stratification of bioassay data to derive reference area performance standards requires further investigation.

than data that have not been qualified but the degree of uncertainty is typically undefined. Potential options for addressing the use of chemical data with qualifiers to develop reference area performance standards include:

- **Option** 1—Exclude undetected data (i.e., data with a "B" or "U" qualifier).
- **Option** 2—Exclude the above and any data subjected to large recovery corrections (i.e., organic data for which greater than an order-of-magnitude recovery correction was applied based on surrogate recovery standards in the sample). (For data on organic compounds and metals that have not been recovery-corrected using the isotope dilution technique, a control limit of 50-75 percent recovery is recommended by PSEP 1986c.)
- **Option** 3—Exclude the above and any data that have been qualified as "estimates." (This option would have a major impact on use of many data sets, including use of any tentatively identified compounds that are by definition qualified as estimates.)

Option 1 or 2 is recommended for development of reference area performance standards. Option 2, however, addresses concerns about setting reference criteria too high (i.e., in case large recovery corrections overestimate sediment concentrations). Option 3 limits the appropriate use of data qualified as "estimates." Data are qualified as "estimates" for a wide variety of reasons, which should be considered on a case-by-case basis as part of the quality assurance screening of data prior to entry into the reference area database. Option 1 was implemented in Pastorok et al. (1989) and during the present study.

Biological Data

Use of reference data with abnormally high variability (e.g., unusually high standard deviation) could reduce the ability to discriminate between test samples and reference conditions when attempting to identify adverse biological effects. Barrick et al. (1988) propose screening Puget Sound biological data to qualify mean values with abnormally high variance. For example, a value of 20 percent was proposed as a QA/QC limit on the standard deviation in the amphipod mortality test. In this case, the critical value for the standard deviation of mean mortality was derived by examining the values for the 23 reference stations from the eight studies in the sediment quality values (SEDQUAL) database. All but one value (i.e., a value of 31 percent) of the standard deviation ranged from 4.0 to 16 percent (Barrick et al. 1988). It is recommended that in the future the guideline of 20 percent for the standard deviation of the mean mortality of amphipods be applied to reference area data.

DERIVATION OF PERFORMANCE STANDARD VALUES

The current performance standards have been developed only for subtidal reference conditions throughout Puget Sound. Available data are inadequate to support full implementation of the recommended system of hierarchical performance standards. The performance standards represent upper limits to the concentrations of chemicals or of bioassay responses in acceptable reference area samples. Results from some samples collected from potential reference areas during the 1990 survey are not used based upon the apparent toxicity of those samples, as indicated by either exceedance of more than one LAET value or extreme bioassay responses (i.e., high mortality of bivalve larvae). Performance standards can be applied to identify suitable reference sediment from any location (within the constraints of any applicable regulatory program), and are not intended to define or establish a finite list of reference areas.

The current standards are established by the 90th percentile of all observed reference area data, as recommended based on a review of existing data and previously used project-specific reference standards (Pastorok et al. 1989). The use of a percentile is a conservative approach relative to the use of a confidence limit. A percentile-based performance standard ensures that reference samples used for future studies will fall within the range of established reference area conditions, whereas an approach based on confidence limits might allow use of samples that show a chemical concentration or toxicity test response that is higher than the highest established reference area condition. As the size of the reference area data set increases, use of an alternative percentile (e.g., the 95th or 99th) may be appropriate (Pastorok et al. 1989).

Chemical concentrations were used to compute the performance standards only if the chemicals were detected. Undetected chemicals (ordinarily represented by the detection limit) were not included because use of detection limits would introduce a bias controlled by the analytical precision of the methods and instruments used. Performance standards cannot currently be computed for some of the PSEP and PSDDA chemicals of concern because these chemicals have rarely been detected in potential reference areas.

1990 REFERENCE AREAS SURVEY

Three of the potential reference areas identified in Pastorok et al. (1989) were selected for further investigation, with the purpose of better defining reference area conditions in Puget Sound and investigating differences between biogeographic zones and sediment types. The three areas selected were Samish Bay, Holmes Harbor, and Carr Inlet. Selection of these areas was based on biogeographic location and accessibility relative to urban areas of the Puget Sound region (where contaminated sites are generally located).

The 1990 survey was designed to collect data that could be used to address the stratification of reference area performance standards for both sediment chemical concentrations and bioassay responses. Performance standards for infauna abundances and low-salinity and intertidal environments were not addressed.

METHODS

Sample collection and analysis procedures used for this survey followed the specifications of PSEP (1986a,b,c,d) unless otherwise noted. Procedures are briefly described below. For additional details, refer to PTI (1990).

Field Collection

Sample types, station locations, and sample collection procedures are described in the following sections.

Sample Types and Station Locations—Sediment samples were collected from three reference areas (Carr Inlet, Samish Bay, and Holmes Harbor) for analysis of sediment contaminants, conventional variables, and sediment toxicity. The numbers and kinds of samples collected are summarized below:

- **Sediment chemistry samples**—A composite sample of sediment for analysis of TOC was collected from each of seven stations in each of the three reference areas (Station HM07, which is located in Saratoga Passage in an area with extremely fine-grained sediments, was designated as one of the stations in the Holmes Harbor series because comparable sediments were not found within the harbor). At each station, separate samples for analyses of AVS and volatile organic compounds were collected from a single grab sample. At one Holmes Harbor station (HM05), triplicate samples were collected, resulting in a total of 23 field samples. After sample collection, Ecology made a decision based on budget limitations to analyze chemistry samples from only three stations within each area and not analyze the samples for volatile organic compounds. For each area, three samples were selected to represent the minimum, approximate mid-range, and maximum values of percent fine-grained material in sediment.

- **Sediment grain size samples**—Subsamples from each of the 23 composite samples of sediment for chemical analyses were analyzed for grain-size distribution.

- **Bioassay samples**—Subsamples from each of the original 21 composite samples of sediment for chemical analysis were analyzed by the amphipod mortality, bivalve larvae mortality and abnormality, echinoderm embryo mortality and abnormality, juvenile polychaete mortality and biomass, and saline Microtox® bacterial luminescence bioassays.

The locations of the reference areas are shown in Figures 1–4. Exact station locations were determined in the field based on a preliminary determination of grain-size distributions prior to sampling (Appendix C). A 100-mL subsample was removed from the grab sample. The subsample was then wet-sieved through a 63-μm sieve until water passing through the sieve was clean. The retained material was rinsed into a graduated cylinder and allowed to settle until the supernatant was clean. The volume of retained material provided an estimate of the sand and gravel fraction of the sediment. The results of the wet-sieving method used in the field correlated well with the results of the laboratory analysis (Pearson $r=0.88$, $P<0.01$). The relationship between laboratory and field measurements is:

$$\text{Lab} = 0.73 \times \text{Field} + 17$$

Sample Collection and Handling—Sampling was conducted between June 18 and 27, 1990. A brief description of field sampling procedures is provided in this section; a more detailed description is provided in the project sampling and analysis plan (PTI 1990).

The composite sampling scheme for field sample collection was designed to collect data that were representative of conditions at each of the sampling stations. Sediment samples from 9 stations (i.e., three samples from each area) were analyzed for chemical contaminants and samples from all 21 stations (i.e., seven samples from each area) were analyzed for conventional analytes (PTI 1990).

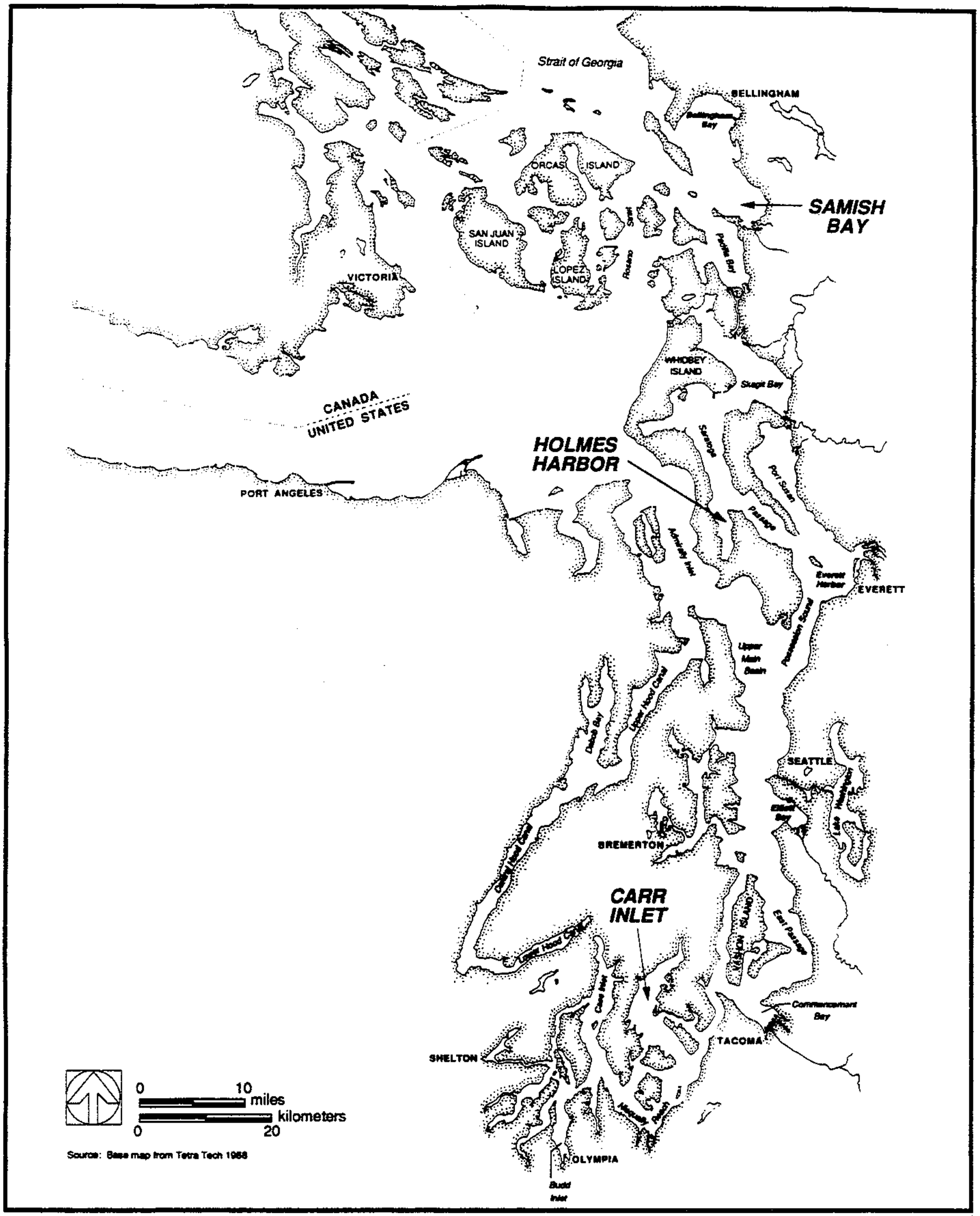


Figure 1. Locations of selected reference areas

C744-28 0991

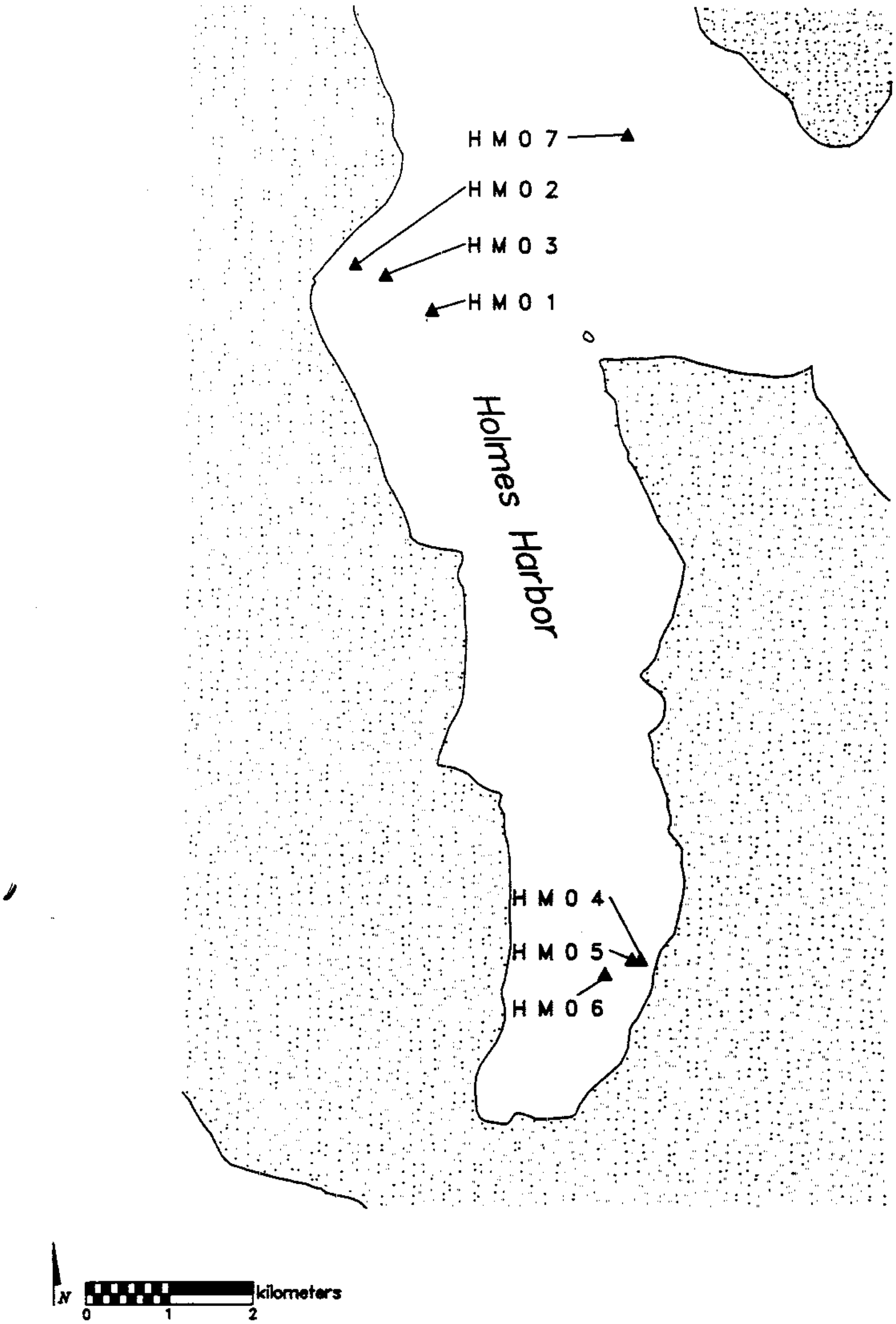


Figure 2. Stations sampled in Holmes Harbor.

C744-28 0991

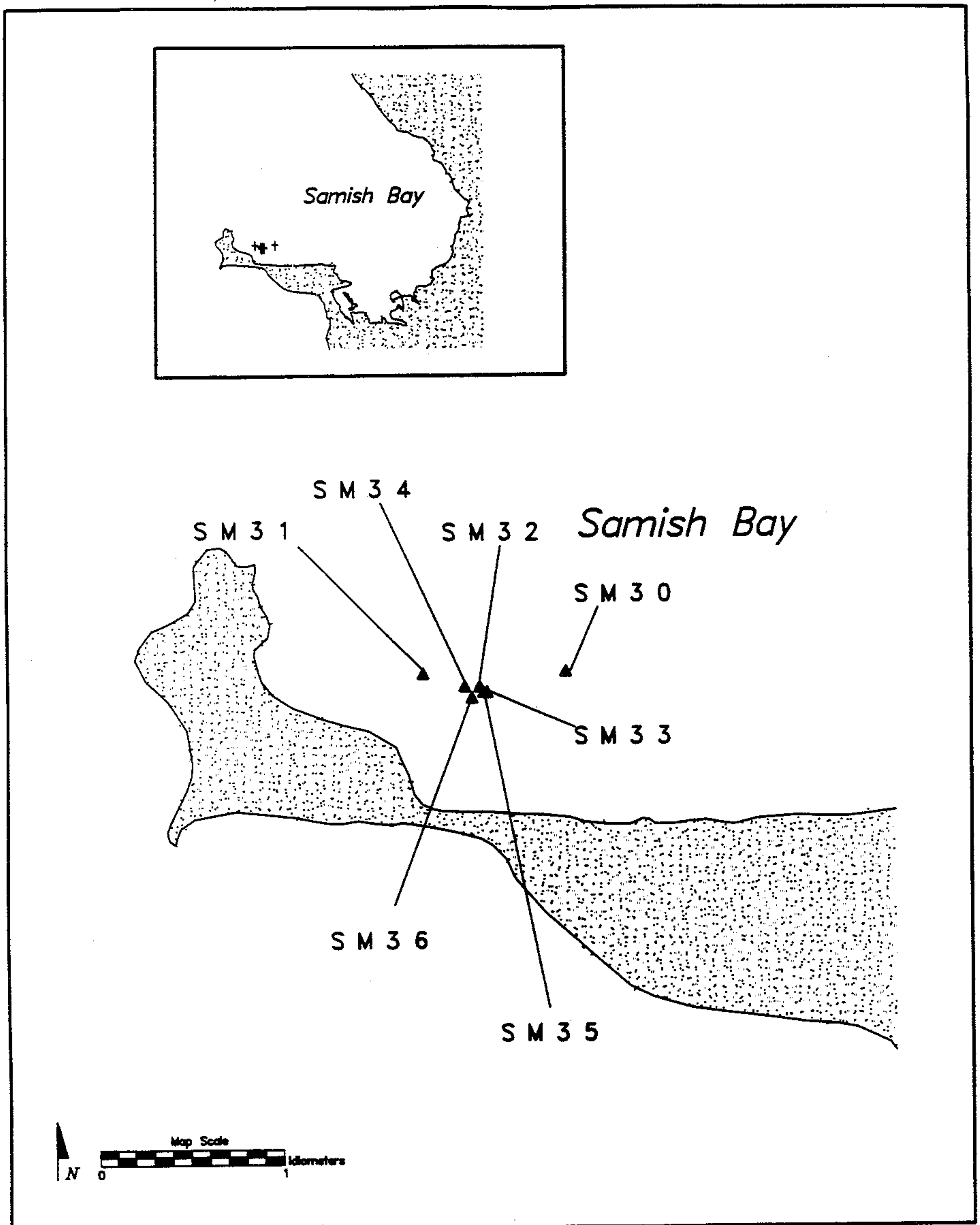


Figure 3. Stations sampled in Samish Bay.

C744-28 0991

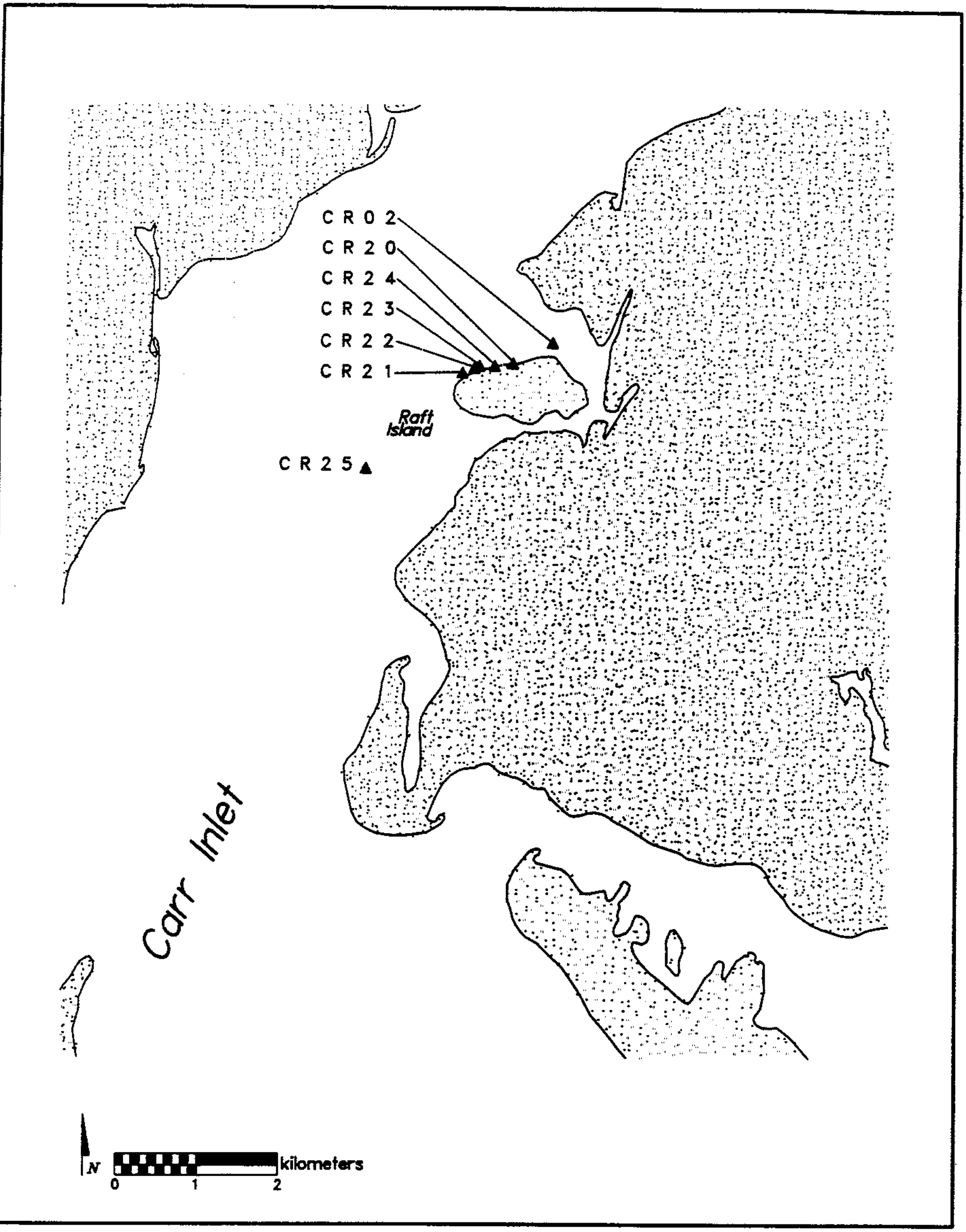


Figure 4. Stations sampled in Carr Inlet.

C744-28 0991

Sediment samples were collected using a dual modified 0.1-m^2 stainless steel van Veen grab sampler. Each sample consisted of sediment composited and homogenized from four to six grab samples at each station to improve the representativeness of the samples. Exceptions include samples for AVS and volatile organic compounds, which were collected from a single grab sample because these samples could not be composited without the loss of the components of interest. After collection, acceptability of each grab sample was evaluated in accordance with PSEP guidelines (PSEP 1986a,b,c,d).

Laboratory Analyses

All laboratory analyses were conducted in accordance with PSEP guidelines (PSEP 1986a,b,c,d).

Chemical Analyses—For each of the 1990 survey areas, a composited sample from each of three stations was analyzed for pesticides, polychlorinated biphenyls (PCBs), semivolatile organic compounds, and metals (a total of 9 samples from all areas). In addition, a composited sample from each of 7 stations in each survey area was analyzed for TOC, total solids, and grain-size distribution (a total of 21 samples from all areas). Seven grab samples from each of the three survey areas were collected for the analysis of AVS.

Concentrations of metals and organic compounds were determined following modified EPA Contract Laboratory Program (CLP) protocols (U.S. EPA 1987, 1988), as modified by PSEP (1986b,d) and the statement of work submitted to the laboratory. PSEP guidelines (PSEP 1986c) were followed for the analyses of all sediment conventional variables, except AVS, as discussed below.

Metals: Three separate digestions were completed for each sediment sample to accommodate the required metals analyses. These methods differ slightly from those specified in the sampling and analysis plan (PTI 1990). A strong acid digestion for silver analyses was used to meet the desired detection limits, and total dissolution fluoroboric acid digestion was used for all other metals analyses, as recommended by PSEP (1986d). Mercury analyses were conducted according to CLP (7/87) cold vapor procedures. Metals concentrations in the sediments were determined by inductively coupled plasma-atomic emission spectrometry or graphite furnace atomic absorption spectrometry, as appropriate, to attain the desired detection limits. Cold vapor atomic absorption spectrometry was used for the determination of mercury concentrations.

Semivolatile Organic Compounds: The sediment samples were analyzed for acid/base/neutral semivolatile compounds using gas chromatography/mass spectrometry by isotope dilution (U.S. EPA 1989). This technique is used to correct the analytical results for losses of the target compounds that may occur during the sample extraction and concentration procedures, differences in the injection volume, and possible variations in instrument sensitivity. The technique does not necessarily account for the efficiency of extraction from different sample matrices, but does for losses that can be approximated by spiked standards added to the sample prior to extraction. The sample extraction procedures used for this project were performed in accordance with modifications recommended by PSEP (1986b) to attain lower detection limits and improve sample analysis. These modifications include the following changes to EPA protocols (U.S. EPA 1988):

- Sample extraction using approximately 100 grams (wet weight basis)
- Sample extract cleanup using gel permeation chromatography
- Reduction of the final extract volume to 0.5 mL
- Analysis of standard concentrations of between 1 and 5 nanograms (on-column) to demonstrate instrument sensitivity near the required limit of detection.

Pesticides and PCBs: Concentrations of pesticides and PCB mixtures were determined by using a modified version of the CLP protocols (U.S. EPA 1988) for low-level analysis of sediment samples, as recommended by PSEP (1986b). These modifications include:

- Sample extraction using approximately 100 grams (wet weight basis)
- Use of an additional surrogate compound (4,4'-dibromo-octafluorobiphenyl) to monitor recovery on a sample-by-sample basis
- Sample extract cleanup using gel permeation chromatography
- Use of megabore capillary gas chromatography/electron capture detection analysis to enhance resolution and reduce potential interferences
- Use of a multi-point calibration of a common Aroclor mixture (Aroclor 1254) to supplement the multipoint calibration for pesticides.

The laboratory performed all recommended modifications, except for using the larger sample size. A 30-gram (wet-weight basis) aliquot was used for sample extractions; however, the laboratory compensated for this smaller weight by using a final extract volume of 1.0 mL instead of 10 mL. The change in extraction weight and final extract volume did not affect the quality of the data.

Conventionals: The grain-size distribution of sediment samples was determined on oxidized samples (using hydrogen peroxide) by standard sieve and pipet techniques (PSEP 1986c). After initial wet sieving through a 63-μm mesh, the gravel and sand fractions were separated by dry sieving techniques, and the silt and clay fractions were separated using pipet analysis. The TOC content of each sediment sample was determined by combustion in an elemental analyzer.

Analysis of AVS proceeded by a three-step procedure similar to a method commonly employed by commercial laboratories for total sulfide analysis in sediment. The samples were acidified with hydrochloric acid (pH <5 in the reaction vessel) to convert sulfides present in the sample to hydrogen sulfide (H_2S) and purged with nitrogen gas at room temperature for one hour [Di Toro et al. 1990; EPA Method 376.3 (U.S. EPA 1990)]. The released H_2S was swept into a zinc acetate trap (PSEP 1986c; Plumb 1981) by the nitrogen gas stream. The sulfides collected in the trap were measured titrimetrically [Standard Method 427D (APHA 1985)].

Biological Analyses—The five sediment toxicity bioassays evaluated in this study are listed in Table 4. PSEP guidelines (PSEP 1986a) were followed for all bioassays, except for deviations specified by EPA and Ecology during the performance of this work (deviations are noted in the following sections). QA/QC procedures applicable to sediment bioassays are described in the quality assurance project plan (PTI 1990).

Amphipod Mortality Bioassay: This acute test measures mortality and failure to rebury in adult amphipods exposed to test sediment for 10 days. Only the mortality endpoint was used in the data analysis for this study. The test species used in the present study was *Rhepoxynius abronius*. Protocols and QA/QC performance standards are described in PSEP (1986a).

Adult amphipods were collected in the field and acclimated to the test water temperature and salinity for 3–4 days prior to testing. For each bioassay replicate, 20 amphipods were exposed to a 2-cm layer of bedded test sediment in a 1-liter chamber filled with clean seawater. Five replicate analyses were conducted for each sample. After the 10-day exposure period, the surviving amphipods in each test chamber were sieved from the sediment and counted. Percent mortality was determined relative to the total of 20 individuals added to each chamber at the beginning of the test. The survivors were then exposed to clean control sediment, and the number that failed to rebury was determined. Percent nonreburial was determined relative to the number of survivors in each test chamber.

QA/QC procedures for the amphipod mortality test included the use of positive and negative controls and daily measurement of water quality conditions (i.e., temperature, salinity, pH, dissolved oxygen) in each test chamber. Mean

TABLE 4. BIOASSAYS CONDUCTED ON REFERENCE AREA SEDIMENTS

Test (Exposure)	Species/Stage	Response Variable
Amphipod (10-day)	*Rhepoxynius abronius* (adult)	Percent mortality
Bivalve (48-hour)	*Crassostrea gigas* (larvae)	Percent developmental abnormality Percent mortality
Echinoderm (72-hour)	*Dendraster excentricus* (embryo)	Percent developmental abnormality Percent mortality
Polychaete (20-day)	*Neanthes* sp. (juvenile)	Percent decrease in individual biomass Percent mortality
Microtox (15-minute) saline	*Photobacterium phosphoreum*	Percent decrease in bioluminescence

mortality of amphipods in the negative control must not exceed 10 percent for the test results to be considered valid. In the present study, cadmium chloride was used as the reference toxicant, and a sediment sample from West Beach on Whidbey Island, Washington, was used as the negative control.

Juvenile Polychaete Biomass Bioassay: This test measures mortality and biomass in juvenile polychaetes exposed to test sediment for 20 days. Only the average individual biomass endpoint was used in the present study. Protocols are described in PSEP (1986a). The test species used in the present study was *Neanthes* sp.

Juvenile polychaetes were obtained from laboratory cultures maintained by Dr. Donald Reish (California State University, Long Beach, California), acclimated to the test water temperature and salinity, and fed prawn flakes. For each bioassay replicate, five polychaetes of relatively uniform weight were exposed to 150 grams of test sediment in a 1-liter chamber filled with clean seawater. The starting average individual biomass was 0.34 mg dry weight in one test series and 1.4 mg dry weight in a second test series. Five replicate chambers were used for each sample. Every second day, approximately 40 mg of prawn flakes were added to each test chamber to provide a source of food. Every third day, 33 percent of the water volume in each chamber was exchanged with fresh seawater to prevent water quality from deteriorating. Before testing, three random subsamples of polychaetes (five individuals per subsample) were dried at 50°C for 24 hours and weighed to the nearest 0.1 mg to provide an estimate of initial biomass. After the 20-day exposure period, the survivors in each test chamber were counted. Percent mortality was determined relative to the total of five individuals added to each chamber at the start of the test. All survivors were dried at 50°C for 24 hours and weighed to the nearest 0.1 mg to determine final total biomass for each replicate. Average individual biomass for each replicate was determined by dividing the total biomass by the number of survivors.

QA/QC procedures included the use of positive and negative controls and measurement of water quality conditions (i.e., temperature, salinity, dissolved oxygen, pH) in each test chamber prior to each scheduled seawater exchange. In the present study, cadmium chloride was used as the reference toxicant and a sediment sample from West Beach on Whidbey Island, Washington, was used as the negative control. Mean mortality of polychaetes in the negative control must not exceed 10 percent for the test results to be considered valid. QA/QC performance criteria for control data for the growth endpoint have not been established for this test.

Echinoderm Embryo Abnormality Bioassay: This acute test measures developmental abnormalities and mortality in echinoderm embryos exposed to test sediment for 72 hours. The test species used in the present study was the sand dollar *Dendraster excentricus*. Protocols and QA/QC performance standards for the determination of developmental abnormalities are described in PSEP (1986a), except that the initial density of organisms was measured in only the seawater control chambers, not in all of the test chambers. Also, the seawater in the echinoderm tests was maintained at 31±1 ppt [not 28±1 ppt as specified in PSEP (1986a)] to optimize bioassay conditions [a revision of PSEP (1986a), in preparation, will specify a test salinity of 30-33 ppt ±1 ppt].

Adult echinoderms were collected in the field and spawned in the laboratory. For each bioassay replicate, approximately 20,000-40,000 embryos were added to a 1-liter test chamber within 2 hours of fertilization. Each test chamber contained 20 grams of bedded test sediment and was filled with clean seawater. After the sediment was added to each chamber, the mixture was shaken for 10 seconds and allowed to settle for 4 hours. Five replicate analyses were conducted for each sample. After the 72-hour exposure period, the seawater in each chamber was decanted and homogenized. 10-mL subsamples were then collected by pipette and fixed with a 5 percent formalin solution. All normal and abnormal embryos in each 10-mL subsample were counted using a microscope. An abnormal embryo was defined as one that failed to develop into a normal pluteus larva. Percent mortality was determined separately relative to the number of larvae that survived a 72-hour exposure to clean seawater. A combined endpoint based on abnormality and mortality was also estimated relative to the number of embryos surviving in the seawater control.

QA/QC procedures for the echinoderm abnormality test included the use of positive and negative controls and measurement of water quality conditions (i.e., temperature, salinity, pH, dissolved oxygen) at times of 0, 24, 48, and 72 hours after test initiation. Ammonia-nitrogen was measured in a subsample of water from the water quality control beaker for each sediment sample and from the seawater control at the start and at the end of the exposure period. The protocol for ammonia sample handling, storage, and analysis followed Standard Method 427C (APHA 1985). Mean mortality and abnormality of embryos in the negative seawater control must not be greater than 30 percent and 10 percent, respectively, for the test results to be considered valid. In the present study, cadmium chloride was used as the reference toxicant. Clean seawater and a sediment sample from West Beach were used as negative seawater and sediment controls, respectively (the sediment sample control supplements requirements of the PSEP guidelines).

Bivalve Larvae Abnormality Bioassay: This acute test measures developmental abnormalities and mortality in bivalve mollusc larvae exposed to test sediment for 48 hours. The test species used in the present study was the Pacific oyster, *Crassostrea gigas*. Protocols and QA/QC performance standards are described in PSEP (1986a), except that the initial density of organisms was measured in only the seawater control chambers, not in all of the test chambers.

Adult organisms were obtained from Pacific Coast Oyster. The adults were spawned in the laboratory after appropriate conditioning. For each bioassay replicate, 20,000–40,000 developing embryos from a pooled sample were added to a 1-liter test chamber within 2 hours of fertilization. Each test chamber contained 20 grams of bedded test sediment and was filled with clean seawater. After the sediment was added to each chamber, the mixture was shaken for 10 seconds and allowed to settle for 4 hours. Five replicate analyses were conducted for each sample. After the 48-hour exposure period, the seawater in each chamber was decanted and homogenized. A 10-mL subsample was then collected by pipette and fixed with a 5 percent solution of formalin. All normal and abnormal larvae in each 10-mL subsample were counted using a microscope. An abnormal larva was defined as one that failed to develop into the fully shelled, hinged, D-shaped prodissoconch I stage. Percent mortality was determined separately relative to the number of larvae that survived a 48-hour exposure to clean seawater. A combined endpoint based on abnormality and mortality was also estimated relative to the number of surviving larvae in the seawater control.

QA/QC procedures for the bivalve larvae abnormality test included the use of positive and negative controls and measurement of the water quality conditions (i.e., temperature, salinity, pH, and dissolved oxygen) in each test chamber at the beginning and end of the 48-hour exposure period. Ammonia-nitrogen was measured in a subsample of water from the water quality control beaker for each sediment sample and from the seawater control at the start and at the end of the exposure period. The protocol for ammonia sample handling, storage, and analysis followed Standard Method 427C (APHA 1985). Mean mortality and abnormality of embryos in the negative seawater control must not be greater than 30 percent and 10 percent, respectively, for the test results to be considered valid. In the present study, cadmium chloride was used as the reference toxicant, and a sediment sample from West Beach was used as the negative sediment control.

Microtox® Bioassay: This acute test measures the reduction in luminescence for bacteria exposed to a saline extract of test sediment for 15 minutes. The test species used in the present study was the bioluminescent bacterium *Photobacterium phosphoreum*. Protocols are described in PSEP (1986a).

Bacteria were obtained in a freeze-dried form and were rehydrated in the laboratory within 2 hours of testing. For each bioassay replicate, an aliquot of sediment extract and Microtox® diluent was placed in a cuvette and transferred to the automated toxicity analyzer system. A series of four extract dilutions and one diluent blank was evaluated for each sample. Duplicate subsamples of each final extract dilution were analyzed. Bioluminescence was measured initially and after the 15-minute exposure period, and the decrease in luminescence was determined by subtraction (with correction for blanks).

QA/QC procedures included the use of positive and negative controls. In the present study, phenol was used as the reference toxicant and extracts of West Beach, Washington, sediment were used as the negative controls.

Data Validation

All chemistry data were acceptable, with the exception of two results for pentachlorophenol which were rejected during the quality assurance review (PTI 1991a). All sample results and assigned qualifiers are presented in Appendix A.

All bioassay data were acceptable for their intended use, but some qualifiers were added to aid in interpretation of the data (PTI 1991b). As a result of this review, all Microtox® results were qualified because of variability in measurements of blanks, and bivalve larvae results from Stations CR20, CR21, SM35, SM36, and HM01 were qualified because of low salinities in the test chambers. The only deviation from PSEP (1986a) protocols was in the initial size of *Neanthes*. In one experimental group, the initial mean individual weight was approximately 0.36 mg, and in the other group, the initial mean individual weight was approximately 1.4 mg. Recommended initial weights are 0.5–1.0 mg (PSEP 1986a, which was issued after the bioassays were conducted for the present study). The lack of availability of worms of the appropriate weight accounted for this protocol deviation, which was not considered a sufficient reason to qualify the results. All bioassay results are presented in Appendix B.

Data Analysis

Data were entered into the SEDQUAL database for manipulation and storage. For most quantitative analyses, portions of the data set were transferred to SPSS® files. Laboratory results were evaluated as follows:

- General descriptions of results for conventional sediment variables, chemical concentrations, and bioassays were generated for the three reference areas, and areas of elevated or statistically significant ($P \leq 0.05$) toxicity were identified using the following techniques:

  - Statistical comparison between each sediment sample collected from a reference area and a negative control (West Beach sediment)

  - Comparison of the mean response in each amphipod bioassay to the guidelines developed by Barrick et al. (1988) and DeWitt et al. (1988).

  Bioassay results were also compared with the reference area data previously compiled by Pastorok et al. (1989) and other recent data (i.e., PSAMP, PSDDA, and PSEP).

- The relationships between the response of each bioassay and sediment chemicals and conventional variables were evaluated by scatterplots, correlation analysis, and regression analysis.

- Amphipod bioassay data collected as part of this survey were combined with reference data compiled by Pastorok et al. (1989). The combined data set was used to refine reference area performance standards for the amphipod bioassay.

- Quantitative performance standards for reference area data were developed for sediment chemicals and the bivalve, echinoderm, and polychaete bioassays based on the data from this survey and from Pastorok et al. (1989).

For each bioassay endpoint, the mean response to a sample was compared with the mean response to the corresponding control sample (West Beach sediment) using a *t*-test and a one-tailed comparisonwise probability level of $\alpha=0.05$. A one-tailed test was used because only statistically significant adverse effects (e.g., increased mortality relative to control) are considered relevant. Proportion data (e.g., percent mortality or percent abnormality) were analyzed with and without arcsine transformation. When variances were heterogeneous ($P \leq 0.05$ in a Cochran's *C*-test), an approximate *t*-test was used to test for differences between the reference area sample and the control sample.

1990 SURVEY RESULTS

Sediment Chemistry

In order to assess whether the 1990 survey stations could be used as reference areas for future use, data on sediment chemistry and conventional variables for the three reference areas were initially compared with a compilation of existing data from the four interim reference areas (Carr Inlet, Dabob Bay, Sequim Bay, and Samish Bay) selected by Pastorok et al. (1989). These comparisons were based upon median concentrations (detected data only), ranges, and frequency distribution patterns.

Median and Range Comparison—Median concentrations (on a dry weight basis) and ranges for each chemical and conventional variable are presented by area in Table 5. An analogous summary for all detected data pooled across all four interim reference areas is also presented. Median values for the 1990 survey areas were less than or similar to the cumulative median of the four interim reference areas, with the following exceptions: median concentrations of low molecular weight polycyclic aromatic hydrocarbons (LPAHs), high molecular

TABLE 5. MEDIAN AND RANGE VALUES FOR NEW SURVEY DATA AND INTERIM REFERENCE AREAS

	Detected Data Only			Detected and Undetected Data		
Compound	Range	N[a]	Median	Range	N	Median
1990 Survey Plus Four Interim Reference Bays[b]						
Organic Compounds (µg/kg)						
LPAH[c]	2.5-240	22	41	2.5-600*U*[d]	35	70
HPAH[e]	22-370	25	120	22-2,400*U*	35	160
PCBs[f]	2.7-48	10	14	0.10*U*-48	39	15
Total Phthalates[g]	0.50-2,900	18	90	0.50-2,900	18	90
Metals (mg/kg)						
Arsenic	1.90-27.0	40	6.90	1.90-27.0	40	6.90
Cadmium	0.070-4.50	39	0.460	0.070-4.50	39	0.460
Copper	3.90-76.0	39	33.0	3.90-76.0	40	33.0
Chromium	9.60-100	36	53.6	9.6-100	36	53.6
Mercury	0.006-0.231	98	0.071	0.006-	102	0.069
Lead	0.40-44.0	98	10.7	0.100*U*-	99	10.0
Nickel	11.0-64.3	36	32.0	11.0-64.3	36	32.0
Silver	0.014-1.00	92	0.118	0.014-1.00	96	0.116
Zinc	15.0-133	39	76.0	15.0-133	39	76.0
Conventionals (mg/kg)						
Total Organic Carbon (percent)	0.19-3.5	49	1.4	0.19-3.5	49	1.4
Sulfides	2.2-130	7	40	0.70-130	11	5.8
Acid-Volatile Sulfides	3.0-93	9	32	2.5*U*-93	23	4.1
Fine-Grained Sediment (percent)	2.2-99	147	73	2.2-99	147	73
1990 Survey - Carr Inlet Stations Only						
Organic Compounds (µg/kg)						
LPAH	11-22	3	21	11-22	3	21
HPAH	27-140	3	61	27-140	3	61
PCBs	--[h]	0	--	6.0*U*	3	6.0
Total Phthalates	--	0	--	--	0	--
Metals (mg/kg)						
Arsenic	3.40-4.50	3	3.50	3.40-4.50	3	3.50
Cadmium	0.07-0.46	3	0.300	0.07-0.46	3	0.300

TABLE 5. (Continued)

Compound	Detected Data Only			Detected and Undetected Data		
	Range	N[a]	Median	Range	N	Median
Copper	3.90-20.5	3	15.9	3.90-20.5	3	15.9
Chromium	28.6-66.6	3	63.0	28.6-66.6	3	63.0
Mercury	0.01-0.04	3	0.04	0.010-	3	0.04
Lead	8.00-13.5	3	9.4	8.00-13.5	3	9.4
Nickel	14.7-35.3	3	33.8	14.7-35.3	3	33.8
Silver	0.02-0.16	3	0.100	0.02-0.16	3	0.100
Zinc	23.1-59.9	3	52.8	23.1-59.9	3	52.8
Conventionals (mg/kg)						
Total Organic Carbon (percent)	0.20-1.20	7	0.60	0.20-1.20	7	0.60
Acid-Volatile Sulfides	5.6-38	4	33	2.5*U*-38	7	5.6
Fine-Grained Sediment (percent)	4.6-79	7	42	4.6-79	7	42
1990 Survey - Holmes Harbor Stations Only						
Organic Compounds (μg/kg)						
LPAH	9-47	2	28	9-47	2	28
HPAH	89-360	2	220	89-360	2	220
PCBs	--	0	--	6.0*U*-15*U*	3	6.0
Total Phthalates	--	0	--	--	0	--
Metals (mg/kg)						
Arsenic	2.40-9.90	3	7.40	2.40-9.90	3	7.40
Cadmium	0.11-1.60	3	0.190	0.11-1.60	3	0.190
Copper	4.90-40.6	3	28.3	4.90-40.6	3	28.3
Chromium	56.1-98.5	3	84.5	56.1-98.5	3	84.5
Mercury	0.01-0.12	3	0.060	0.010-0.12	3	0.060
Lead	7.70-30.0	3	14.3	7.70-30.0	3	14.3
Nickel	30.0-64.3	3	43.1	30.0-64.3	3	43.1
Silver	0.03-0.33	3	0.210	0.03-0.33	3	0.210
Zinc	32.5-111	3	79.6	32.5-111	3	79.6
Conventionals (mg/kg)						
Total Organic Carbon (percent)	0.20-2.60	9	1.60	0.20-2.60	9	1.60
Acid-Volatile Sulfides	3.0-93	4	40	2.7*U*-93	9	4.2
Fine-Grained Sediment (percent)	3.20-96	9	58	3.2-96	9	58

TABLE 5. (Continued)

Compound	Detected Data Only			Detected and Undetected Data		
	Range	N[a]	Median	Range	N	Median
1990 Survey - Samish Bay Stations Only						
Organic Compounds (μg/kg)						
LPAH	22-83	3	78	22-83	3	78
HPAH	110-300	3	240	110-300	3	240
PCBs	--	0	--	6.0*U*-15*U*	3	6.0
Total Phthalates	280	1	--	280	1	--
Metals (mg/kg)						
Arsenic	4.80-7.70	3	7.5	4.80-7.70	3	7.50
Cadmium	0.23-0.30	3	0.260	0.23-0.30	3	0.260
Copper	6.30-29.5	3	22.9	6.30-29.5	3	22.9
Chromium	38.2-75.7	3	66.3	38.2-75.7	3	66.3
Mercury	0.020-0.11	3	0.080	0.020-0.11	3	0.080
Lead	9.50-19.1	3	17.5	9.50-19.1	3	17.5
Nickel	20.4-43.4	3	35.6	20.4-43.4	3	35.6
Silver	0.050-0.19	3	0.140	0:050-0.19	3	0.140
Zinc	37.5-98.4	3	85.0	37.5-98.4	3	85.0
Conventionals (mg/kg)						
Total Organic Carbon (percent)	0.40-2.40	7	0.90	0.40-2.40	7	0.90
Acid-Volatile Sulfides	7.1	1	--	2.7*U*-7.1	7	3.1
Fine-Grained Sediment (percent)	11-96	7	29	11-96	7	29
Four Interim Reference Bays[i]						
Organic Compounds (μg/kg)						
LPAH	2.5-240	14	46	2.5-600*U*	27	170
HPAH	22-370	17	120	22-2,400*U*	27	160
PCBs	2.7-48	10	14	0.10*U*-48	30	20
Total Phthalates	0.50-2,900	17	73	0.50-2,900	17	73
Metals (mg/kg)						
Arsenic	1.90-27.0	31	6.90	1.90-27.0	31	6.90
Cadmium	0.10-4.50	30	0.655	0.10-4.50	30	0.655
Copper	4.90-76.0	29	37.0	4.90-76.0	30	36.0
Chromium	9.60-100	27	43.0	9.60-100	27	43.0

TABLE 5. (Continued)

Compound	Detected Data Only			Detected and Undetected Data		
	Range	N[a]	Median	Range	N	Median
Mercury	0.006-0.231	89	0.073	0.006-	93	0.070
Lead	0.40-44.0	89	10.3	0.100*U*-	90	10.2
Nickel	11.0-46.0	27	30	11.0-46.0	27	30
Silver	0.014-1.00	83	0.118	0.014-1.00	87	0.115
Zinc	15.0-133	30	76.5	15.0-133	30	76.5
Conventionals (mg/kg)						
Total Organic Carbon (percent)	0.19-3.5	26	1.4	0.19-3.5	26	1.4
Sulfides	2.2-130	7	40	0.70*U*-130	11	5.8
Acid-Volatile Sulfides	--	0	--	--	0	--
Fine-Grained Sediment (percent)	2.2-99	124	78	2.2-99	124	78

[a] N - number of samples.

[b] Carr Inlet, Dabob Bay, Holmes Harbor, Samish Bay, and Sequim Bay.

[c] LPAH - sum of detected low molecular weight polycyclic aromatic hydrocarbons. If all compounds were undetected, no sum was calculated.

[d] *U* - undetected at the value shown.

[e] HPAH - sum of detected high molecular weight polycyclic aromatic hydrocarbons. If all compounds were undetected, no sum was calculated.

[f] PCBs - sum of detected polychlorinated biphenyls. If all Aroclors were undetected, the lowest detection limit was used.

[g] Total phthalates - sum of all detected phthalates. When all phthalates were undetected, no total was calculated

[h] -- - Not available.

[i] Carr Inlet, Dabob Bay, Samish Bay, and Sequim Bay

weight polycyclic aromatic hydrocarbons (HPAHs), total phthalates, chromium, and lead in Samish Bay, median concentrations of chromium in Carr Inlet, and median concentrations of TOC, HPAH, chromium, lead, nickel, and silver in Holmes Harbor. These median values were the highest of all the reference areas (1990 survey plus the four interim reference areas). However, with the exception of chromium and total phthalates, these slightly higher levels did not significantly impact the median (less than 10 percent difference) when combined with the interim reference area data. The median concentrations of chromium for the areas sampled in the 1990 survey, when combined with the chromium results for the four interim reference areas, resulted in a median concentration 25 percent greater than the median associated with only the four interim reference areas. The one total phthalate value from the 1990 survey, when combined with the total phthalate results for the four interim reference areas, resulted in a median concentration 23 percent greater than the median associated with only the four interim reference areas. However, the range of total phthalates and chromium values of the new survey are well within the ranges associated with the interim reference areas.

Median concentration and range comparisons for AVS data were not possible because AVS data are not available for the four interim reference areas.

Frequency Distribution Comparison—Frequency distributions of conventional variables and chemical concentrations for the four interim reference areas, including the 1990 survey results (cross-hatched), are presented in Figures 5–8. The selection of conventional variables and chemical concentrations for these frequency distribution comparisons was limited to those for which data were available for the four interim reference areas. For each variable, most of the 1990 survey samples exhibited frequency distribution patterns similar to those for the four interim reference areas. Frequency distribution comparisons for AVS data were not possible because AVS data are not available for the four interim reference areas.

The frequency distributions for percent fine-grained material are presented for each station for each survey area in Figure 9. The frequency distributions of percent fine grained material illustrate the gradient in grain size distribution that was achieved during sampling. Overall, the samples include a good distribution of values throughout a broad range of percent fine-grained material. Gaps in the frequency distributions of grain size for individual areas did not affect calculation of the performance standards, which were based on pooled data from all areas.

Comparison With Available Guidelines—Chemical data were also evaluated by comparison of the results from the 1990 survey with chemical indicators of biological toxicity for Puget Sound. These comparisons were based on LAET values reported in Barrick et al. (1988). The 1990 survey data were normalized for dry weight or organic carbon as necessary.

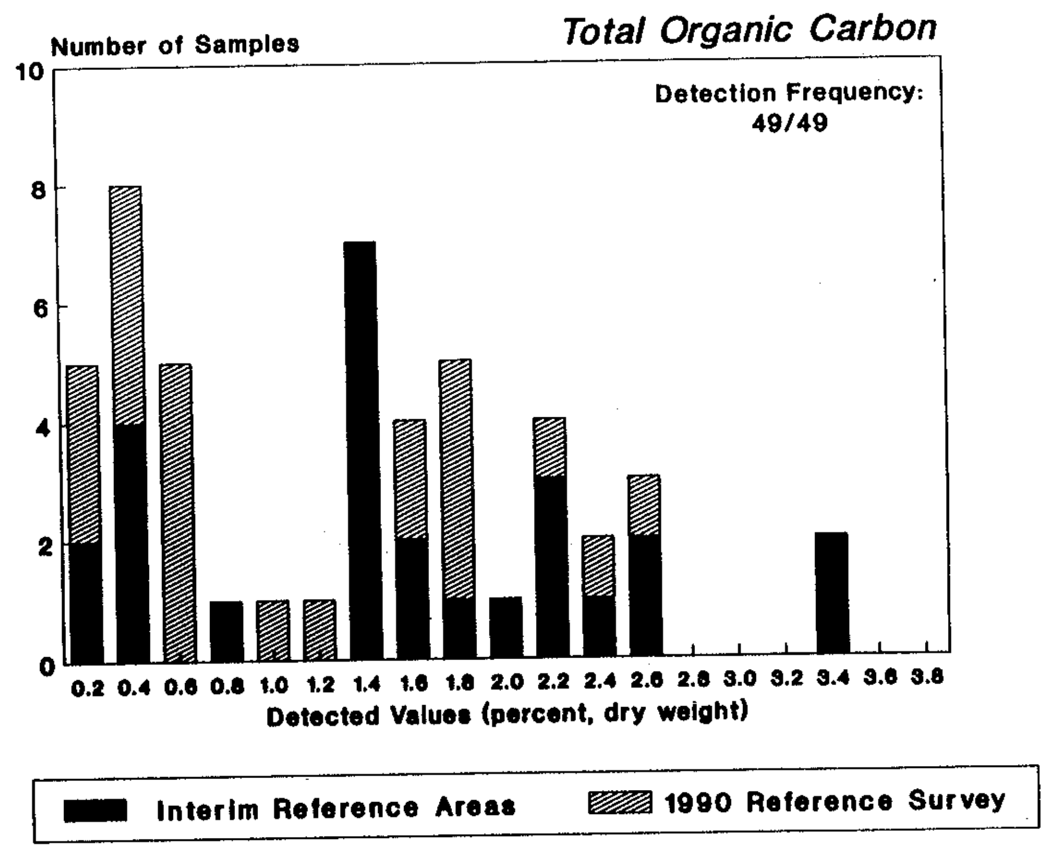


Figure 5. Frequency distribution of detected total organic carbon.

C744-28 0991

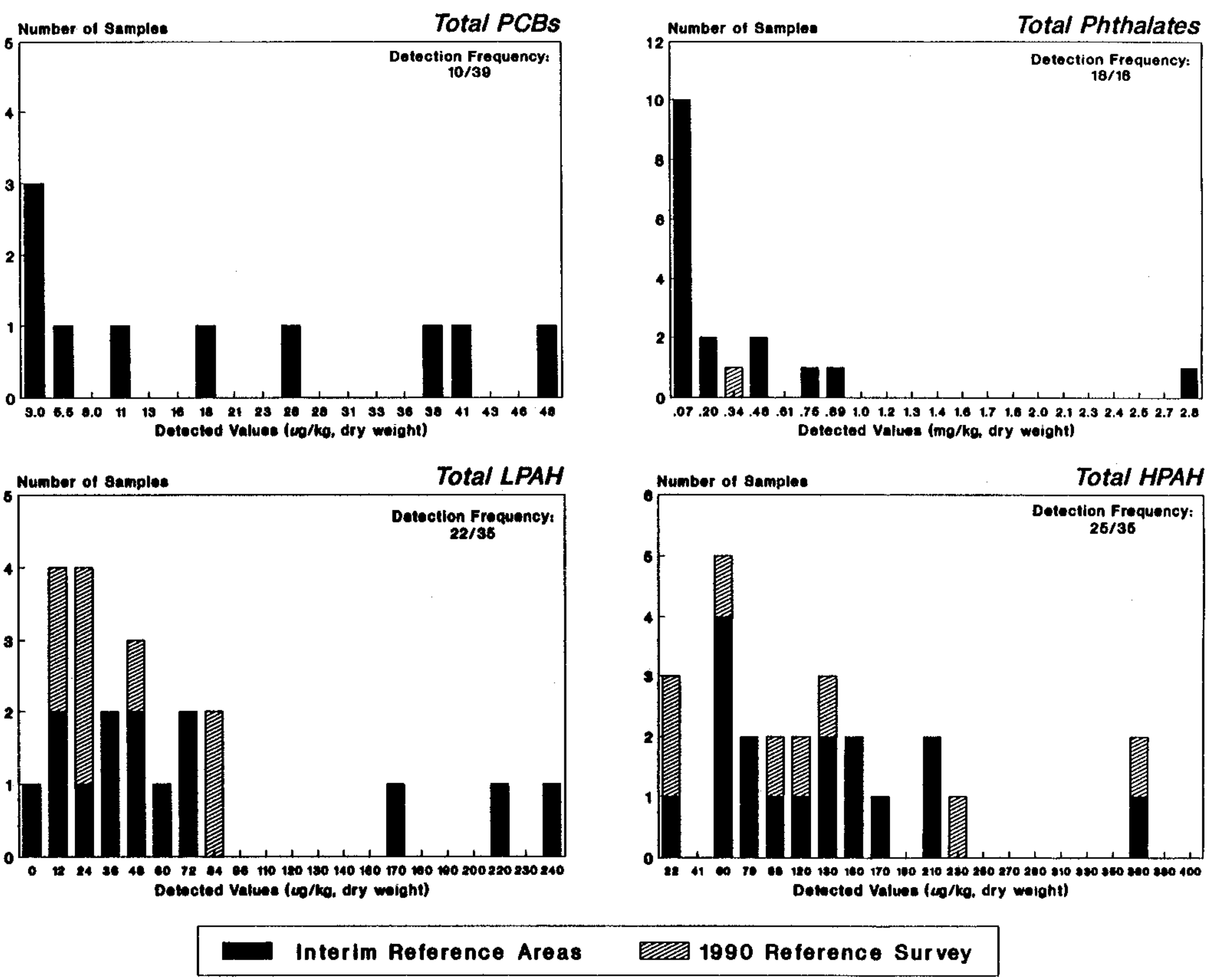


Figure 6. Frequency distributions of polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and total phthalates.

C744-28 0991

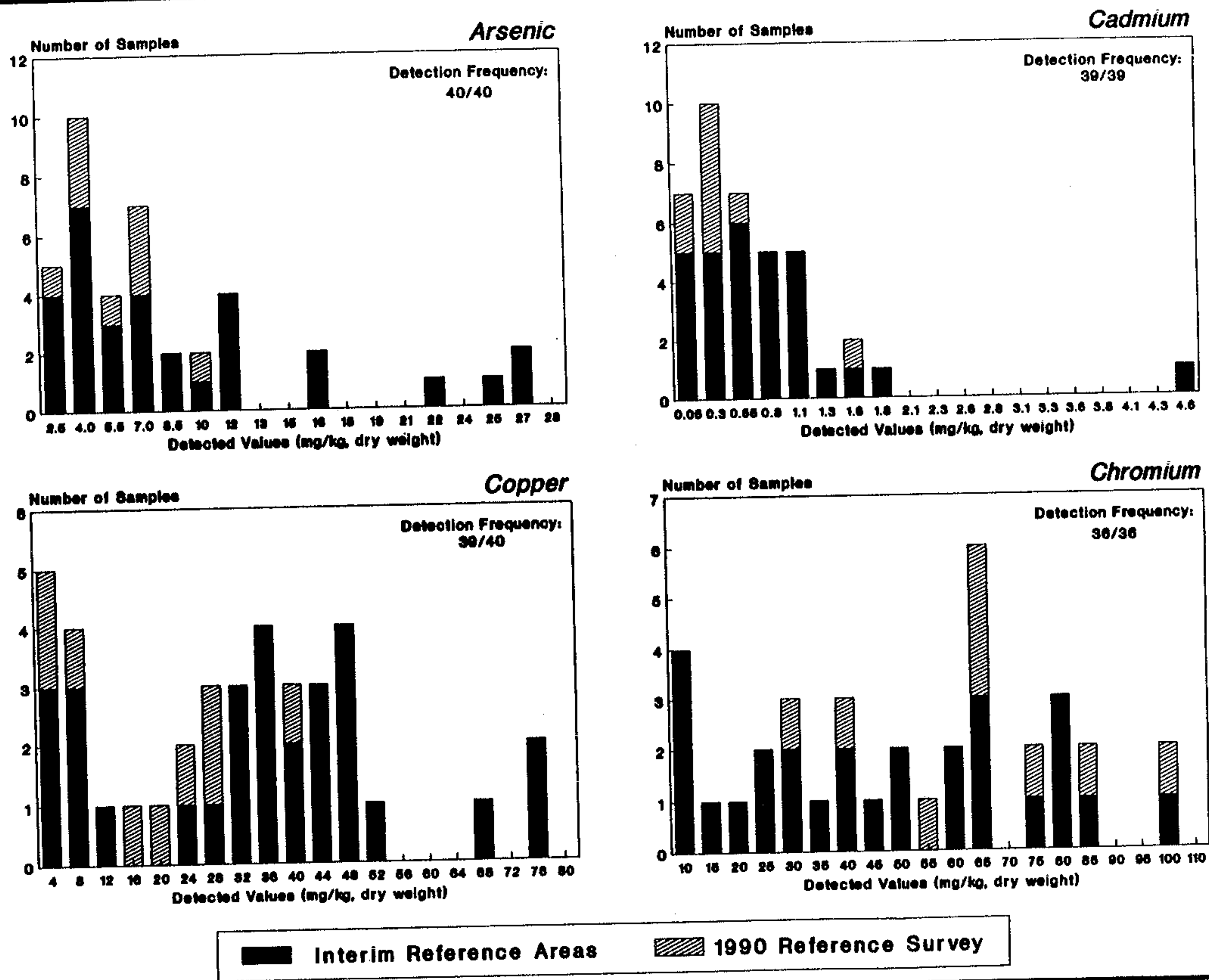


Figure 7. Frequency distributions of detected metals concentrations (arsenic, cadmium, copper, and chromium).

C744-28 0991

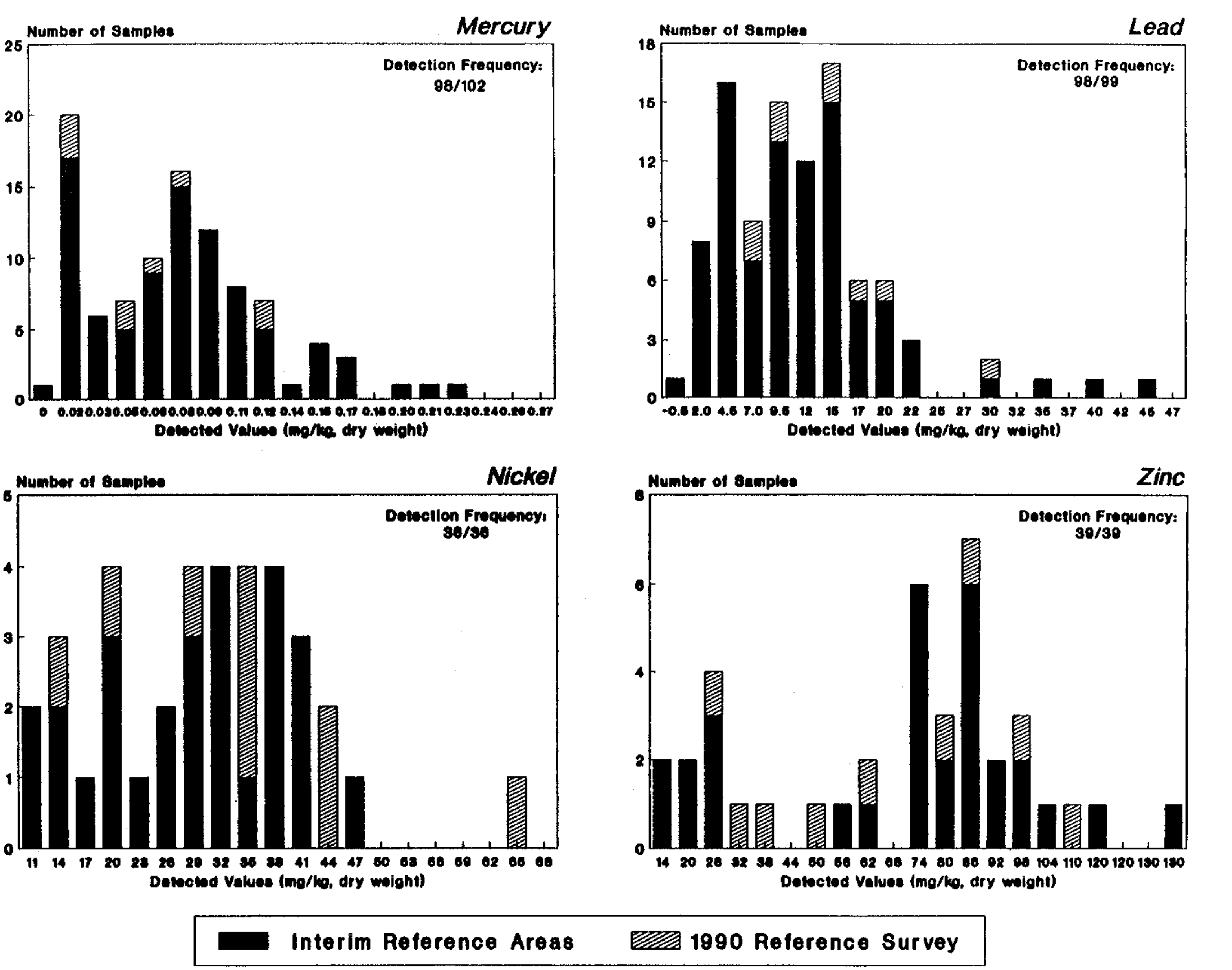


Figure 8. Frequency distributions of detected metals concentrations (mercury, lead, nickel, and zinc).

C744-28 0991

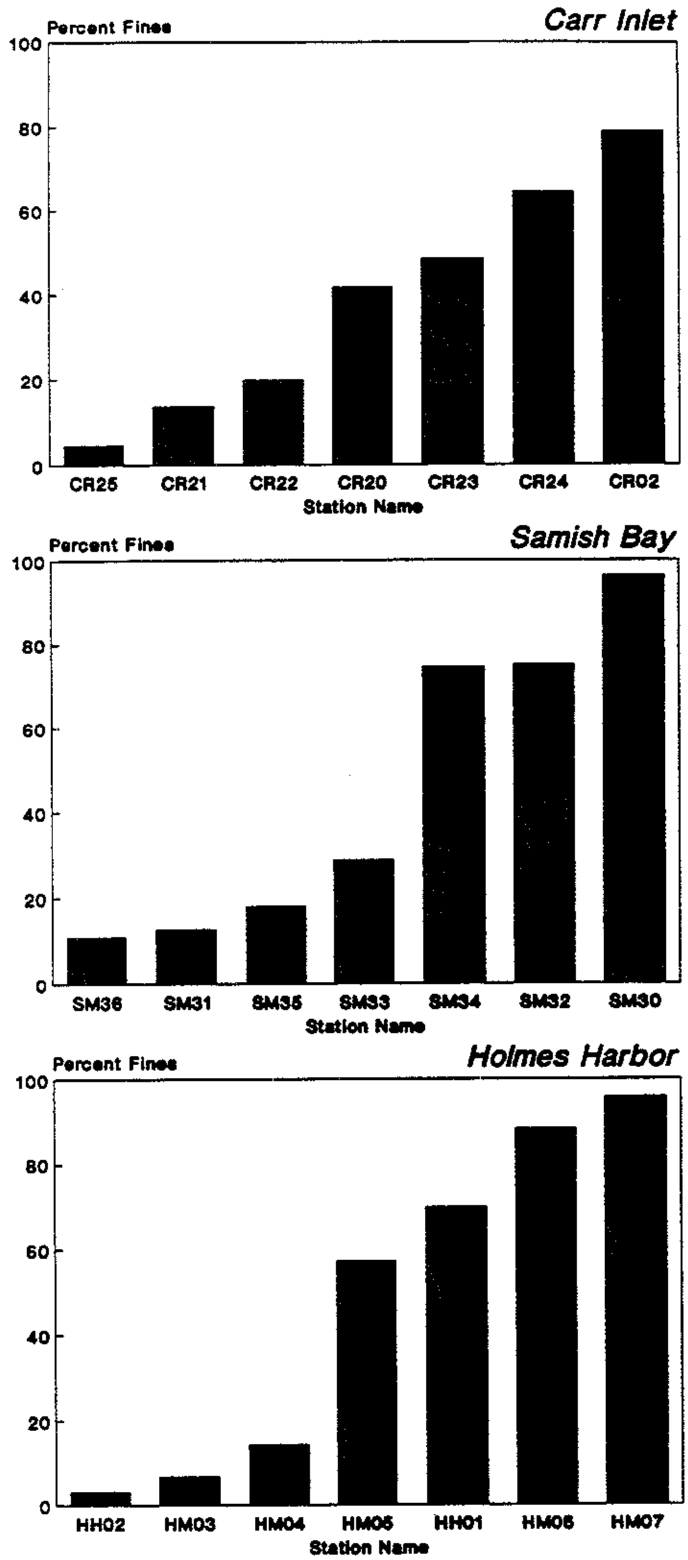


Figure 9. Distribution of percent fine-grained sediments by station and bay.

Concentrations of the following chemicals exceeded the LAET values (factors of exceedance are in parenthesis):

- Carr Inlet—Station CR02 - 4-methylphenol (1.6)
- Carr Inlet—Station CR20 - 4-methylphenol (1.1)
- Holmes Harbor—Station HM07 - 4-methylphenol (1.0)
- Samish Bay—Station SM30 - benzoic acid (1.7), butyl benzyl phthalate (2.4), and 4-methylphenol (1.8)
- Samish Bay—Station SM34 - 4-methylphenol (2.2).

LAET comparisons for conventional data were not performed. Although LAET values could be calculated for these variables, such LAET values are not currently in use.

4-Methylphenol exceeded the LAET value at more than one station within an area (Carr Inlet Stations CR02 and CR20 and Samish Bay Stations SM30 and SM34). However, these stations were not eliminated from consideration as Puget Sound reference areas based on the 4-methylphenol exceedances alone because adverse biological effects were not apparent from the bioassay results and only 4-methylphenol concentrations exceeded the LAET; the reference area criteria presented in Pastorok et al. (1989) are therefore met.

All 1990 survey areas, with the exception of Samish Bay Station SM30, are considered to be in accordance with the criteria for the selection of Puget Sound reference areas for future use in the sediment management program. These selection criteria state that "lowest apparent effects threshold (LAET) values are not exceeded for more than one chemical contaminant (other than phthalates, which are common laboratory contaminants, and sulfides)" (Pastorok et al. 1989). Samish Bay Station SM30 was rejected based upon these exceedances.

Bioassay Response

Sediment toxicity bioassay results are summarized in Table 6. Separate mortality and abnormality responses for the larval tests and both mortality and individual biomass responses for the juvenile polychaete test are included in Table 6. The different initial weights for the two series of juvenile polychaete tests had no apparent effect on the final biomass (Appendix B). Negative responses observed in the Microtox® bioassay correspond to greater light production in the test sediments relative to the blanks; this phenomenon is interpreted as no toxic response. Negative values for bivalve and echinoderm mortality are a consequence of greater numbers of survivors than were estimated to be in the test chambers at the beginning of the bioassay (initial organism abundances are estimated to be equal to the number of survivors in the seawater control).

TABLE 6. SUMMARY OF MEAN BIOASSAY RESPONSES FOR PUGET SOUND REFERENCE AREAS

	Amphipod	Microtox	Bivalve larvae			Echinoderm embryo			*Neanthes*	
	% Mortality (n=5)	Gamma (n=2)[a]	% Abnormality[b] (n=5)	% Mortality[c] (n=5)	% Combined[d] (n=5)	% Abnormality[b] (n=10)	% Mortality[c] (n=10)	% Combined[d] (n=10)	% Mortality (n=5)	Av. Ind. Biomass (n=5)
Carr Inlet										
CR02	12	−0.09	2.3	82	82	2.9	9.8	12	4.0	18
CR20	12	−0.13	4.9	73	74	2.8	−2.7	0.24	0.0	15
CR21	6.0	−0.13	4.1	81	80	2.3	−11	−8.3	4.0	16
CR22	9.0	−0.16	2.4	58	59	1.7	2.9	4.5	4.0	16
CR23	13	−0.11	2.8	61	62	2.8	−0.4	2.4	4.0	17
CR24	12	−0.07	0.55	78	78	2.2	−0.1	2.1	0.0	15
CR25	7.0	−0.10	1.2	75	76	3.3	1.8	5.0	0.0	14
Holmes Harbor										
HH01	11	−0.50	11	90	91	4.6	8.5	13	52	16
HH02	11	−0.40	2.7	43	45	7.1	5.5	12	40	14
HM03	2.0	−0.44	1.9	49	50	6.3	5.3	11	0.0	13
HM04	3.0	−0.63	5.4	72	74	4.6	17	21	4.0	16
HM05	10	−0.31	6.1	78	79	6.2	12	17	0.0	17
HM06	7.0	−0.41	9.0	87	88	5.5	13	18	4.0	15
HM07	1.0	−0.42	6.5	77	79	4.7	18	22	0.0	14
Samish Bay										
SM30	12	−0.31	6.4	80	81	4.6	1.6	6.1	0.0	13
SM31	7.0	−0.32	1.1	78	78	4.5	4.0	8.3	4.0	13
SM32	19	−0.30	5.9	72	73	8.1	11	18	0.0	15
SM33	10	−0.23	1.8	79	79	4.7	9.0	13	0.0	15
SM34	6.5	−0.19	2.0	80	80	5.7	6.6	12	0.0	15
SM35	4.0	−0.27	2.0	76	76	5.5	4.8	10	0.0	15
SM36	7.0	−0.48	2.5	80	81	5.2	0.3	5.5	0.0	15
West Beach										
Group 1	1.0	−0.12	1.7	−5.4	−3.6	2.9	0.1	3.0	0.0	14
Group 2	9.0	−0.31	––[e]	––	––	3.8	7.2	11	20	19
Group 3	2.0	−0.46	––	––	––	––	––	––	––	––
Group 4	––	−0.67	––	––	––	––	––	––	––	––
Seawater Control										
Group 1	––[f]	––[f]	1.7	−1.7	0.0	4.0	−4.1	0.0	––[f]	––
Group 2	––	––	––	––	––	4.0	−4.2	0.0	––	––

[a] Results for the 100−percent sample.
[b] Percent abnormality for the larval and embryo tests is calculated as the number of abnormal individuals relative to the number of survivors.
[c] Percent mortality for the larval and embryo tests is the number of dead individuals relative to the estimated number of survivors in the seawater control.
[d] The combined endpoint for the larval and embryo tests is calculated as the sum of dead and abnormal individuals relative to the estimated number of survivors in the seawater control.
[e] –– = No data.
[f] Negative controls for the amphipod, Microtox, and *Neanthes* bioassays were performed on West Beach sediment only.

Assessment of Significant Toxicity—The typical approach to determining significant toxicity in a test sediment is by means of a statistical comparison (e.g., a *t*-test) between the bioassay responses in the sample and in a sample from a reference area. This approach is not feasible in this study because all of the samples were from reference areas. Instead, the following three approaches were used:

- Statistical comparison between bioassay responses to the reference area sediments and to the corresponding control (West Beach) sediments
- Comparison of bioassay responses in reference area sediments to SMS, PSEP, and PSDDA quality control limits for control samples
- Comparison of bioassay responses to guidelines established by Barrick et al. (1988) and DeWitt et al. (1988).

The West Beach control samples are primarily sand, whereas some reference area samples are more than 90 percent silt and clay (by weight). Comparison of *Rhepoxynius* and *Neanthes* responses to control and reference area sediments presumes the absence of grain size effects on bioassay response (this presumption is supported by the absence of significant correlations between sediment grain size and response for these two bioassays in this study; see *Relationship of Bioassay Response to Physical Parameters* section).

Statistical Comparisons—The results of the first analysis indicated that roughly half of the bioassay results (excluding the Microtox® test results) showed significantly greater response (e.g., higher amphipod mortality, lower *Neanthes* growth; $P \leq 0.05$, one-tailed *t*-test) than West Beach control samples. These results are summarized in Table 7. Approximately one quarter of the remaining bioassay tests (i.e., one-eighth overall) showed significantly less response (e.g., lower amphipod mortality, higher *Neanthes* growth) than West Beach control samples. Low variability among bioassay replicates for each sample allowed even relatively small differences between reference area and West Beach bioassay responses to be identified as significant.

Quality Control Limit Comparisons—The results of the second analysis illustrate that the differences between reference area and West Beach bioassay responses are relatively small despite their statistical significance. Table 8 shows the PSEP, PSDDA, and SMS quality control limits for control samples and performance standards for reference areas. In most cases, bioassay responses were less than the quality control criteria for control samples. Reference area sediment samples collected during this survey were effectively indistinguishable from clean sediment control samples. These results are summarized in Table 9. Note that the quality control criterion for the juvenile polychaete bioassay is based

TABLE 7. SIGNIFICANT BIOASSAY RESPONSES RELATIVE TO WEST BEACH CONTROL SAMPLES

Station	Sample	Amphipod Mortality	Bivalve Abnormality	Bivalve Combined	Echinoderm Abnormality	Echinoderm Combined	*Neanthes* Av. Ind. Biomass
Carr Inlet							
CR02	SD0002	X		X			
CR20	SD0003	X	X	X			
CR21	SD0004			X			
CR22	SD0005	X		X			
CR23	SD0006			X			
CR24	SD0007	X		X			
CR25	SD0008	X		X			
Holmes Harbor							
HH01	SD0017		X	X	X	X	X
HH02	SD0018	X		X	X	X	X
HM03	SD0019			X	X	X	
HM04	SD0020			X	X	X	
HM05	SD0021	X	X	X	X	X	
HM06	SD0024		X	X	X	X	
HM07	SD0025		X	X	X	X	
Samish Bay							
SM30	SD0010		X	X	X		X
SM31	SD0011			X	X		
SM32	SD0012	X	X	X	X	X	
SM33	SD0013			X	X	X	
SM34	SD0014			X	X	X	
SM35	SD0015			X	X		
SM36	SD0016			X	X		

[a] Significance determined using a one–tailed, two–sample *t*–test with $P \leq 0.05$.

TABLE 8. QUALITY CONTROL LIMITS AND PERFORMANCE STANDARDS FOR BIOASSAYS

Bioassay	Endpoint	Control Sample Quality Control Limits		Reference Area Sample Performance Standard		
		PSEP [a]	SMS [b]	PSEP	SMS	PSDDA
Amphipod	Mortality	10%	10%	25%	25%	20% over control
Bivalve larvae	Abnormality	10%	-- [c]	20% over control	--	
	Mortality	30%	--	--	--	
	Combined [d]	40%	50%	--	--	80% of control
Echinoderm embryo	Abnormality	10%	--	20% over control	--	
	Mortality	30%	--	--	--	
	Combined	40%	50%	--	--	80% of control
Juvenile polychaete	Mortality	--	10%	--	--	
	Biomass	--	--	--	80% of control	20% over control

[a] PSEP = Puget Sound Estuary Program

[b] SMS = Sediment management standards.

[c] -- = Quality control limits or performance standards have not been established for these bioassay endpoints.

[d] PSEP does not explicitly define a control limit for the combined endpoint; the value of 40 percent shown here is the maximum possible given the control limits for the individual mortality and abnormality endpoints.

TABLE 9. EXCEEDANCES OF BIOASSAY QUALITY CONTROL LIMITS FOR CONTROLS [a]

Station	Sample	Amphipod Mortality	Bivalve Abnormality	Bivalve Mortality	Bivalve Combined	Echinoderm Abnormality	Echinoderm Mortality	Echinoderm Combined	*Neanthes* Mortality
Carr Inlet									
CR02	SD0002	X		X	X				
CR20	SD0003	X		X	X				
CR21	SD0004			X	X				
CR22	SD0005			X	X				
CR23	SD0006	X		X	X				
CR24	SD0007	X		X	X				
CR25	SD0008			X	X				
Holmes Harbor									
HH01	SD0017	X	X	X	X				X
HH02	SD0018	X		X	X				X
HM03	SD0019			X	X				
HM04	SD0020			X	X				
HM05	SD0021			X	X				
HM06	SD0024			X	X				
HM07	SD0025			X	X				
Samish Bay									
SM30	SD0010	X		X	X				
SM31	SD0011			X	X				
SM32	SD0012	X		X	X				
SM33	SD0013			X	X				
SM34	SD0014			X	X				
SM35	SD0015			X	X				
SM36	SD0016			X	X				

[a] Based on comparisons with Puget Sound Estuary Program (PSEP) quality control limits. When PSEP limits were not available, sediment management standards quality control limits were used. (Table 8 shows the quality control limits used for this comparison.)

on mortality, although the bioassay endpoint specified by the SMS is growth (biomass).

The use of quality control limits for controls to judge reference area samples is not an established technique. However, this technique does allow some samples to be unequivocally characterized as clean; any sample for which the bioassay result falls below the quality control limit for controls can only be characterized as clean. The converse interpretation—that samples for which bioassay results exceed the quality control limits are contaminated—is not necessarily justified. Regulatory guidelines for identifying contaminated sediments are an alternative means of setting an upper limit to the bioassay response that might be observed in a clean sample. For example, the SMS biological criterion for identifying contaminated sediments is a 20-percent bioassay response. Reference area bioassay responses that are above the PSEP quality control limits for control samples and below a regulatory guideline are possibly subject to different interpretations. Reference area bioassay responses observed in this study were generally below or only slightly above the quality control limits for control samples and, except for two Holmes Harbor samples, the observed exceedances of quality control limits for control samples are not regarded as evidence of toxicity.

The only systematic exceedance of the quality control criterion for controls is shown by the bivalve larvae bioassay relative to the quality control limit for percent mortality. All of the bivalve larvae mortality results depend upon a single estimate of the number of initial larvae that is made from the seawater control at the conclusion of the bioassay. A possible explanation for the results of the bivalve larvae mortality endpoint, which contradict the results of the other bioassays based on comparisons to quality control limits for controls, is that the estimate of the number of initial larvae was not representative of the true number of initial larvae. However, the negative control sample (West Beach sediment), showed low mortalities as expected. A second possibility is that high mortality was caused by some unmeasured aspect of the bioassay test. Ammonia, which has been implicated as a cause of bivalve larvae mortality in PSDDA tests (Kendall 1991, pers. comm.), showed no significant relationship to mortality in these tests. A third possibility is that the bivalve larvae were unusually sensitive as a consequence of unevaluated factors affecting the organisms used, such as age, sex, or season. The bivalve larvae did show high sensitivity to the entire range of reference toxicant (CdCl2) concentrations used in the positive control samples. Because the systematically high bivalve larvae mortalities were contrary to the results of the other bioassays, these results are not considered indicative of significant toxicity in the reference area sediments tested. High mortality has often been observed in sediment tests using bivalve larvae.

On the basis of comparison to quality control limits for controls (and excluding bivalve larvae mortality), the amphipod bioassay appears to be the most sensitive test. Eight stations exceeded this quality control limit. Amphipod mortality was less than the existing performance standards for reference areas in all cases (see Tables 6 and 8). Results of the amphipod bioassay are not considered indicative of significant toxicity in these reference area samples. Other data sets (e.g., Pastorok and Becker 1990) show that the amphipod bioassay is moderately sensitive relative to other bioassays conducted for the present study.

Samples from Holmes Harbor Stations HM01 and HM02 greatly exceeded the quality control limit on juvenile polychaete mortality in control samples established for this study; mortality at these stations was 50 and 44 percent, respectively. Nevertheless, the growth of the surviving worms (as measured by average individual biomass) was comparable to that at other stations in Holmes Harbor and other reference areas. Although previous experience with this test indicates that mortality is typically a less sensitive indicator of contamination than is growth reduction, this relationship does not appear to be true at the Holmes Harbor stations. This unusual effect, the complete mortality in one of the control replicates for this bioassay group, and the absence of any elevated contaminant concentrations in the sediment at Stations HM01 and HM02, indicate that these bioassay results should be interpreted with caution. Although amphipod mortality and bivalve larvae abnormality were each above the quality control limit for controls at Station HM01, the exceedances were only 1 percent in each case and are not considered to provide clear support for the apparent toxicity indicated by juvenile polychaete mortality. Resampling and reanalysis of sediments from Stations HM01 and HM02 would help to firmly establish the value of Holmes Harbor as a reference area.

Because the differences between responses for all bioassays in control and reference area samples were so small (except for the juvenile polychaete bioassay at Stations HM01 and HM02), and because the reference area sediments generally did not exceed the quality control limits for control samples, these differences, although statistically significant, are not considered indicative of significant toxicity in the reference area samples.

Other Guidelines: Barrick et al. (1988) present recommended guidelines for acceptability of reference area amphipod bioassay data based on a review of all Puget Sound data then available. The guidelines stipulate that amphipod mortality in reference area samples must be less than 25 percent and the standard deviation of the response be less than 20 percent. Amphipod mortality in all samples from the current study passes the guidelines, as shown by Table 10.

DeWitt et al. (1988) developed an empirical relationship between amphipod survivorship and percent fine-grained sediments in 315 samples from nonurban Puget Sound sediments. Based on this data set, they present a formula for the lower 95 percent prediction limit of amphipod survival that is expected to be observed in bioassays of reference area sediment.

The survival of amphipods in bioassays conducted on sediments from Carr Inlet, Holmes Harbor, and Samish Bay performed during this study were all

TABLE 10. MEAN AND STANDARD DEVIATION OF PERCENT MORTALITY RESPONSES

Station	Amphipod Mean	Amphipod SD [a]	Bivalve larvae Mean	Bivalve larvae SD	Echinoderm embryo Mean	Echinoderm embryo SD	*Neanthes* Mean	*Neanthes* SD
Carr Inlet								
CR02	12	9.1	82	2.0	9.8	16	4.0	8.9
CR20	12	6.7	73	2.3	−2.7	10	0.0	0.0
CR21	6.0	6.5	81	3.3	−11	8.4	4.0	8.9
CR22	9.0	8.2	58	10	2.9	9.7	4.0	8.9
CR23	13	16	61	6.4	−0.35	9.3	4.0	8.9
CR24	12	5.7	78	2.4	−0.08	6.9	0.0	0.0
CR25	7.0	5.7	75	2.8	1.8	16	0.0	0.0
Holmes Harbor								
HH01	11	11	90	1.3	8.5	7.4	52	50
HH02	11	6.5	43	8.6	5.5	12	40	55
HM03	2.0	2.7	49	9.9	5.3	11	0.0	0.0
HM04	3.0	4.5	72	6.2	17	10	4.0	8.9
HM05	10	7.1	77	11	12	4.8	0.0	0.0
HM06	7.0	4.5	86	5.0	13	11	4.0	8.9
HM07	1.0	2.2	77	6.3	18	18	0.0	0.0
Samish Bay								
SM30	12	8.4	80	3.1	1.6	10	0.0	0.0
SM31	7.0	4.5	78	1.5	4.0	9.1	4.0	8.9
SM32	19	6.5	72	3.1	10	15	0.0	0.0
SM33	10	7.9	79	7.2	9.0	7.0	0.0	0.0
SM34	6.5	4.2	79	11	6.6	8.8	0.0	0.0
SM35	4.0	6.5	76	3.3	4.8	13	0.0	0.0
SM36	7.0	13	80	5.0	0.28	7.4	0.0	0.0

[a] SD = Standard deviation.

above the lower 95 percent prediction limit for reference areas suggested by DeWitt et al. (1988), which may be interpreted as a lack of toxicity due to grain size effects in any of the sediments tested. However, the relationship between survivorship and particle size observed in this study differed considerably from the relationship observed by DeWitt et al. (1988). Predicted and observed survivorship are contrasted in Figure 10. Samples from this study showed no significant decrease in survivorship with an increasing proportion of fine particles in the sediment.

Relationship of Bioassay Response to Sediment Chemistry—Mean bioassay responses were compared to physical and chemical characteristics of the sediment from reference areas. Only Microtox® results were excluded from this analysis, as this bioassay showed no response in any sample.

Bioassay Response to Physical Parameters: Significant correlations ($P \leq 0.05$) between bioassay responses and physical parameters of the sediment were observed only for the two larval bioassays. Bivalve and echinoderm larvae are planktonic, not benthic, and under natural conditions probably have little interaction with benthic sediment. Because the experimental vessels contained sediment and not just seawater extracts (in accordance with PSEP guidelines), the bivalve and echinoderm larvae may have been affected by suspended sediment, thereby giving rise to the observed correlations. Neither the amphipod nor the juvenile polychaete bioassays, which use organisms that are ordinarily in direct contact with marine sediment, exhibited significant correlations with physical parameters of the bioassay sediment.

Significant correlations between bioassay responses and physical parameters are summarized in Figures 11–13. Larval responses (increases in abnormality or the combined endpoint for the echinoderm embryo test) were significantly correlated with finer grain sizes and higher percentages of organic carbon. Despite these significant correlations, echinoderm bioassay responses at the highest values of percent fine-grained sediments (99 percent) and TOC (3 percent) were lower than the quality control limit for control samples. The single larval abnormality response that exceeded the quality control limit (percent abnormality of bivalve larvae) occurred in a sample with intermediate grain size (70 percent fines) and TOC (1.8 percent).

The relatively small response (i.e., less than the quality control limit for control samples) at the highest levels of percent fine-grained sediments and TOC indicates that stratification of reference area performance standards by grain size is inappropriate for this data set. However, the existence of significant correlations between some bioassays endpoints and sediment grain size confirms the importance of selecting reference area sediments that have a grain size similar to that of test sediments.

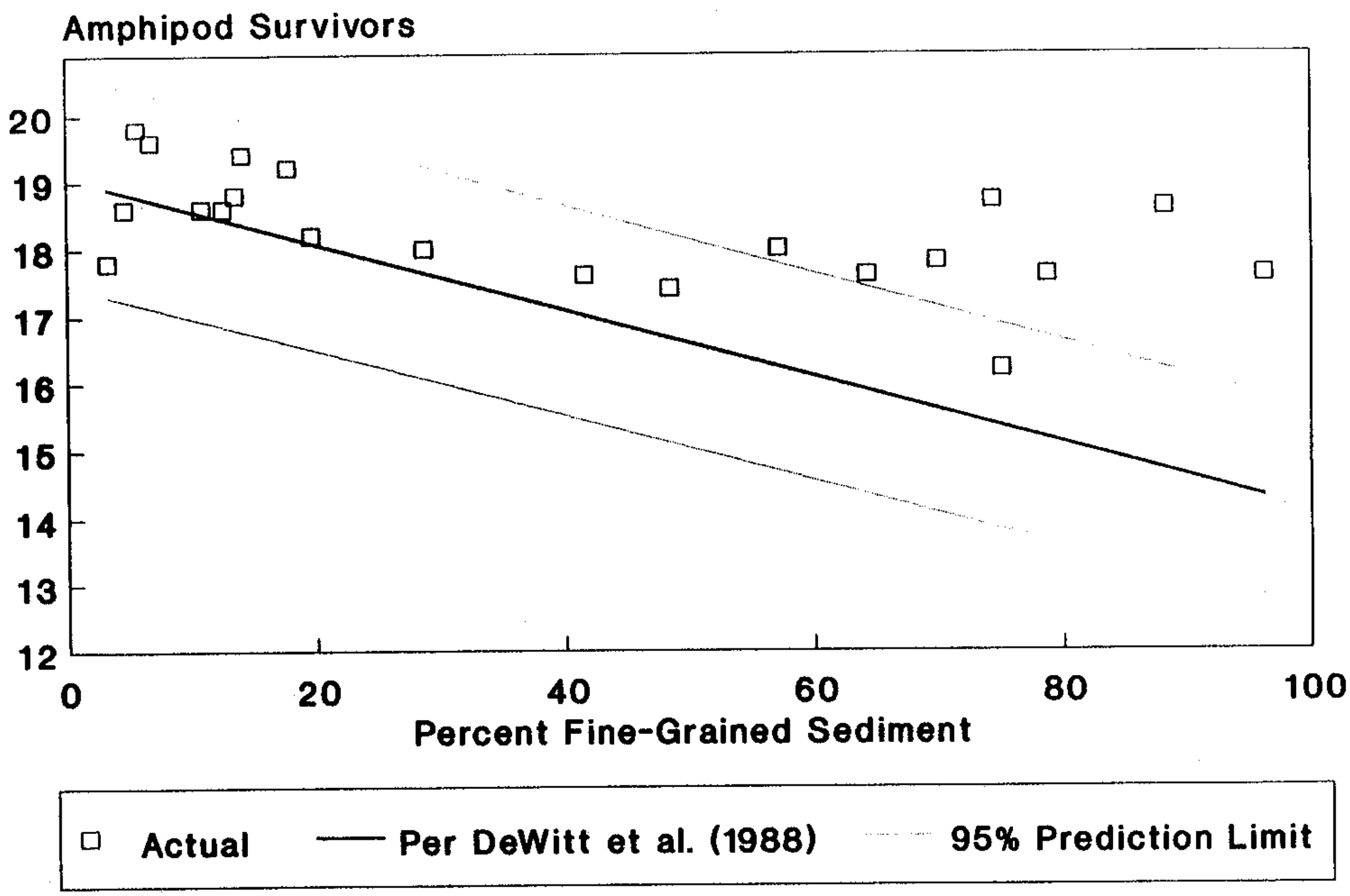
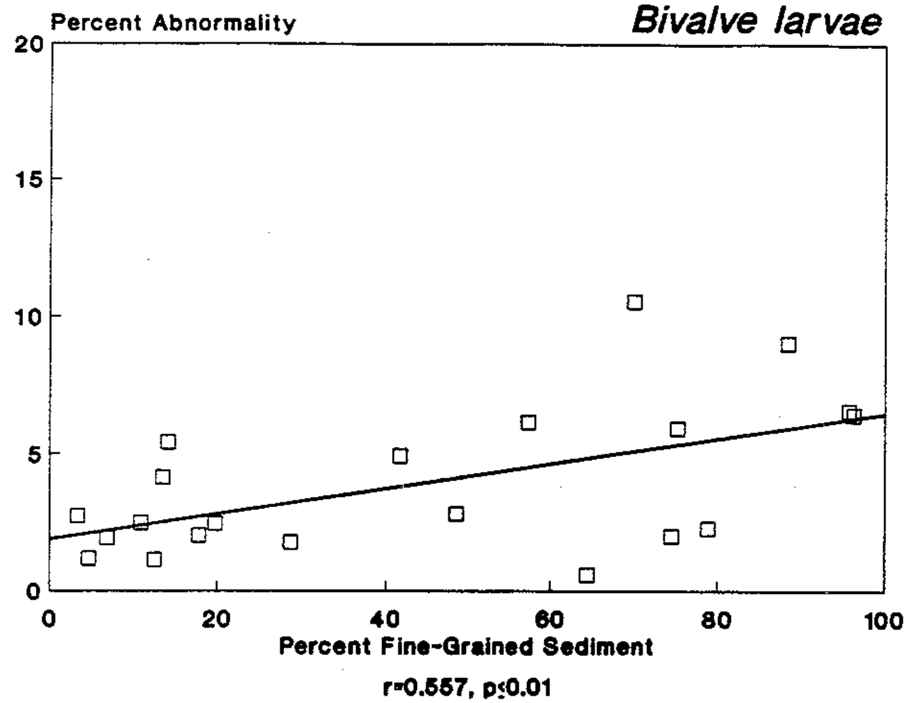


Figure 10. Observed and predicted survivorship of amphipods in relationship to percent fine-grained sediments.

C744-28 0991



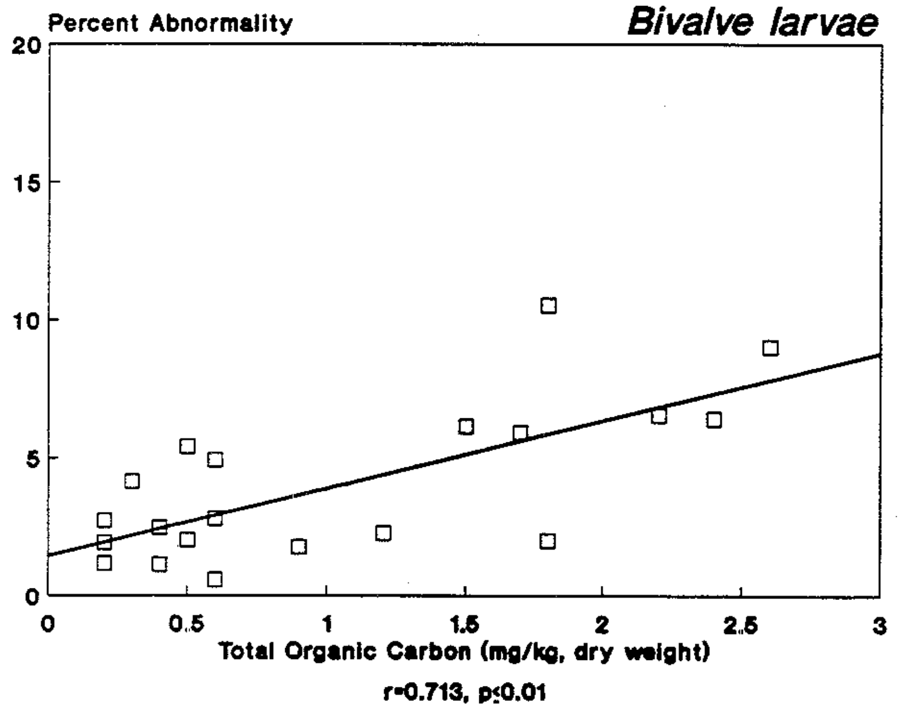
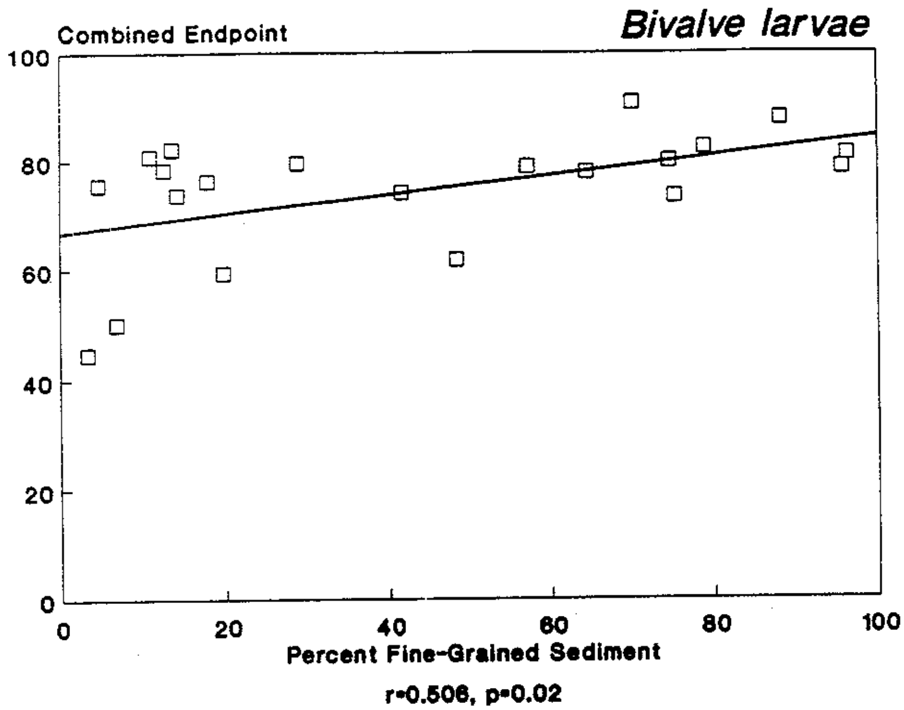


Figure 11. Bivalve larvae abnormality in relation to percent fine-grained sediments and total organic carbon.

C744-28 0991



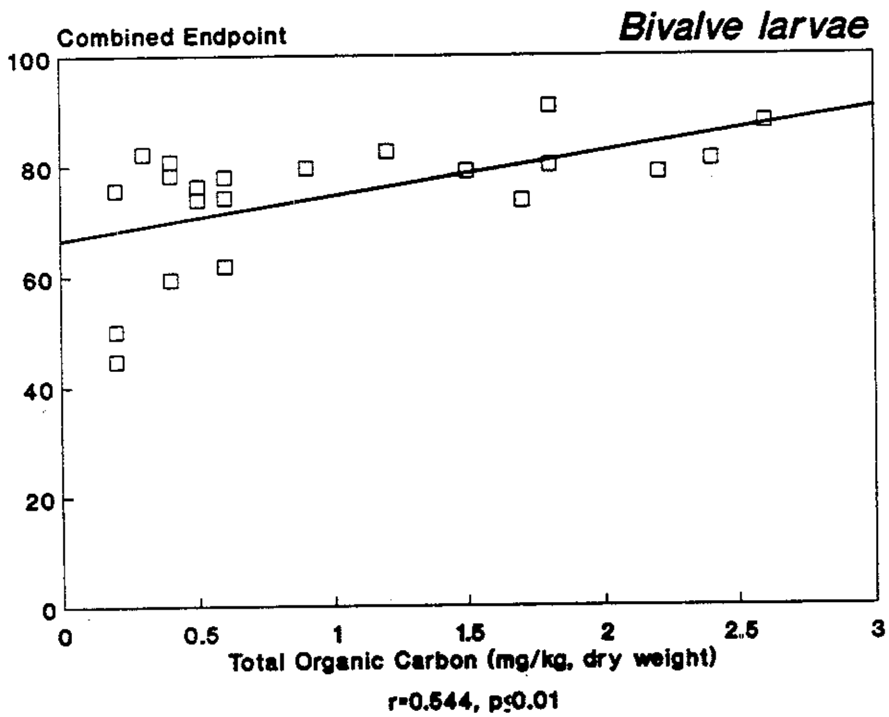


Figure 12. Bivalve larvae combined endpoint in relation to percent fine-grained sediments and total organic carbon.

C744-28 0991

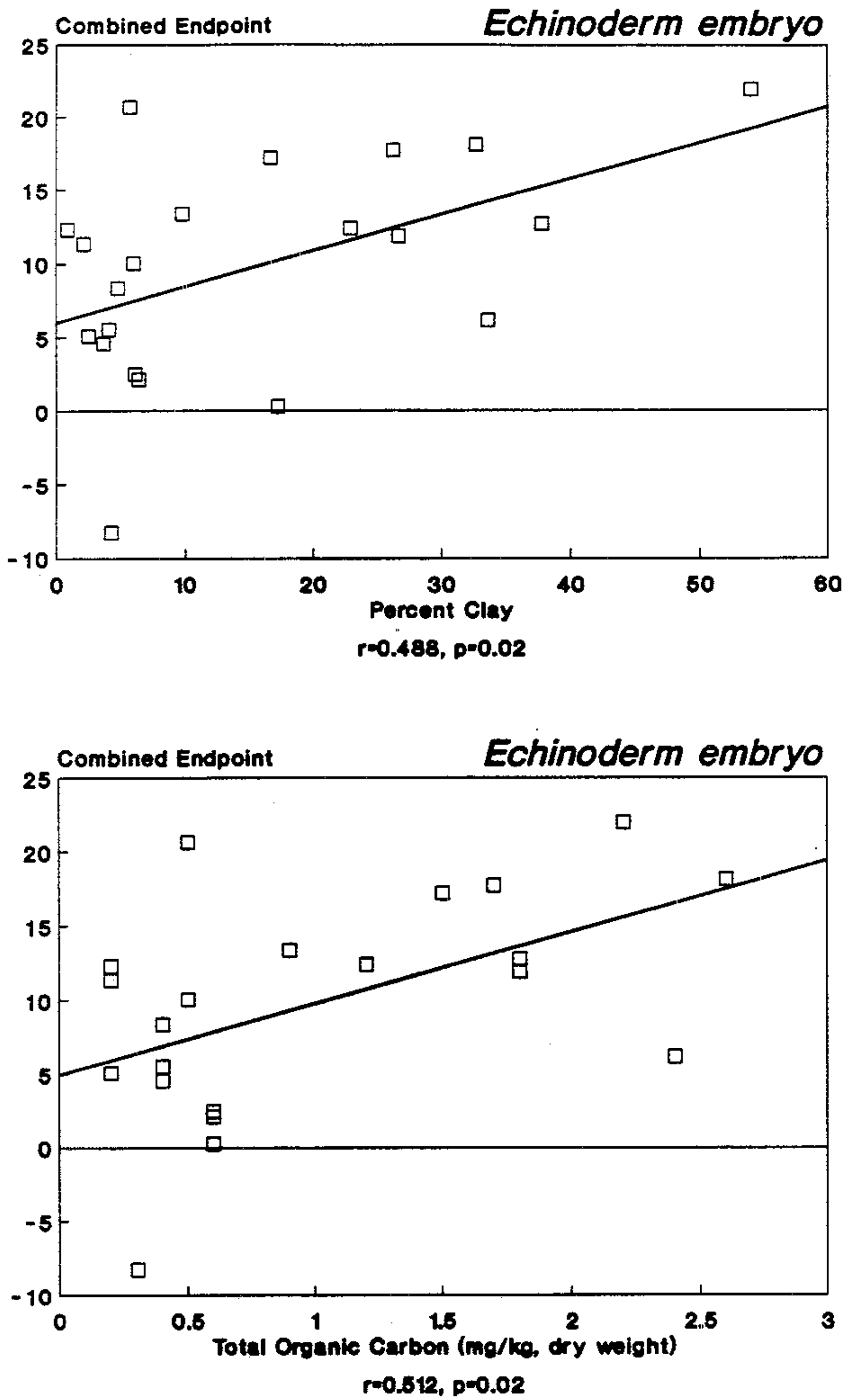


Figure 13. Echinoderm embryo combined endpoint in relation to percent clay and total organic carbon.

C744-28 0991

Bioassay Response to Chemical Concentrations—Bivalve larvae abnormality and echinoderm larvae mortality were significantly correlated with several chemicals (one-tailed, $P<0.01$), as shown in Table 11. The change in juvenile polychaete biomass was also significantly correlated with one chemical. These correlations were based on results for the nine samples for which chemistry as well as bioassay response was measured; only detected values were used for this analysis, so some of the correlations shown in Table 11 are based on fewer than nine points.

Significant correlations between chemicals and bioassay results should not be interpreted as a causal relationship. The chemicals listed in Table 11 are generally well correlated with one another, as shown in Table 12, as well as with other chemicals and conventionals (not shown).

Despite the significant correlations with chemical concentrations, the greatest bioassay responses in the reference areas tested do not, generally, exceed the upper limit of variation expected in nominally clean sediment (i.e., the quality control limits for blank samples). The absolute magnitude of the bioassay responses are low enough to indicate the absence of toxic effects in these reference area samples.

TABLE 11. SIGNIFICANT CORRELATIONS BETWEEN BIOASSAY RESULTS AND CHEMICAL CONCENTRATIONS [a]

Chemical	Bivalve larvae Abnormality	Echinoderm embryo Abnormality	Echinoderm embryo Mortality	*Neanthes* Average Individual Biomass
Arsenic	0.714	-- [b]	--	--
Cadmium	--	--	0.700	--
Chromium	0.801	--	0.713	--
Copper	0.779	--	0.677	--
Lead	0.640	--	0.715	--
Nickel	0.804	--	0.733	--
Zinc	0.747	--	0.584	--
Benzo(a)pyrene	0.989	--	--	--
Benzyl alcohol	--	0.884	0.858	--
Chrysene	0.943	--	--	--
Phenanthrene	0.998	--	--	--
Fluorene	--	--	--	0.7823

[a] Table displays Pearson correlation coefficients significant at $P \leq 0.01$.
[b] -- = Correlation coefficient is not significant.

TABLE 12. CORRELATIONS BETWEEN SELECTED CHEMICALS [a]

	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Benzo(a)-pyrene	Benzyl alcohol	Chrysene	Phenanthrene	Fluorene
Arsenic		-- [b]	0.823	0.878	0.894	0.872	0.928	--	--	--	--	--
Cadmium			--	--	--	--	--	--	--	--	--	--
Chromium				0.937	0.812	0.973	0.896	0.998	--	0.991	0.989	--
Copper					0.918	0.941	0.973	--	--	1.000	--	--
Lead						0.899	0.919	--	--	--	--	--
Nickel							0.903	1.000	--	--	0.996	--
Zinc								--	--	1.000	--	--
Benzo(a)pyrene									--	--	0.996	--
Benzyl alcohol										--	--	--
Chrysene											--	--
Phenanthrene												--
Fluorene												

[a] This table shows the significant correlation coefficients (at $P \leq 0.01$) for the upper triangle of a symmetric Pearson correlation matrix. The chemicals included in this table are all of those that had a significant correlation with one or more bioassay endpoints.

[b] -- = Correlation coefficient is not significant.

REFERENCE AREA PERFORMANCE STANDARDS

Performance standards were computed using all previous data from the reference areas recommended by Pastorok et al. (1989) (i.e., Carr Inlet, Sequim Bay, Dabob Bay, and Samish Inlet) and the data from this study. Performance standards are established by the 90th percentile of the range of each chemical or biological variable as recommended by Pastorok et al. (1989). The use of a percentile is a more conservative approach than the use of a confidence limit. A percentile-based performance standard ensures that reference samples used for future studies will fall within the range of previously observed reference area conditions, whereas an approach based on confidence limits might allow the use of samples that show a contaminant concentration or a toxicity outside the range of established reference area conditions.

SEDIMENT CHEMISTRY

Performance standards have been developed for all chemical contaminants and are presented in Table 13. Most of the data used to generate these values are from the current study, with the exception of Samish Bay Station SM30 which was rejected. Performance standards were not developed for AVS because of the limited amount of data. The performance standard for PCBs was not revised relative to the value in Pastorok et al. (1989) because PCBs were not detected in any of the 1990 survey samples.

The frequency distributions of the acceptable data are presented in Figures 14–17 (cross-hatched areas represent acceptable data from the 1990 survey). For each variable, the 1990 survey data appear to have very few outliers, so that the 90th percentile frequency distribution will not include unusually high values.

The reference area performance standard for phenol was computed without consideration of one anomalously high value (1,800 mg/kg dry weight) from a Carr Inlet station sampled during the Commencement Bay preliminary investigation. This value is more than 20 times higher than the next highest value and is considered to be an outlier that is generally unrepresentative of Carr Inlet or other reference areas.

The reference area performance standard for 4-methylnaphthalene (1,420 mg/kg dry weight) is higher than the LAET for this chemical (670 mg/kg dry weight). The highest concentrations of 4-methylphenol in reference areas were all observed in this study. A thorough review of analytical procedures has not raised any question about the accuracy of these measurements, and the values are not so high as to be clearly outliers. The reported values of 4-methylphenol

TABLE 13. PROPOSED REFERENCE AREA PERFORMANCE STANDARDS

Chemical	Proposed Performance Standard[a]
Metals (mg/kg)	
Antimony	--[b]
Arsenic	22
Cadmium	1.5
Chromium	85
Copper	53
Lead	20
Mercury	0.15
Nickel	42
Silver	0.32
Zinc	103
Phenols (μg/kg)	
Phenol	83
2-Methylphenol	--
4-Methylphenol	1,400
2,4-Dimethylphenol	--
Pentachlorophenol	--
Nonionic Organic Compounds (μg/kg)	
Low molecular weight PAHs[c]	200
Naphthalene	--
Acenaphthylene	--
Acenaphthene	--
Fluorene	--
Phenanthrene	--
Anthracene	--
High molecular weight PAHs	330
Fluoranthene	--
Pyrene	--

TABLE 13. (Continued)

Chemical	Proposed Performance Standard[a]
Benz(a)anthracene	--
Chrysene	--
Benzofluoranthenes	--
Benzo(a)pyrene	--
Indeno(1,2,3-c,d)pyrene	--
Dibenz(a,h)anthracene	--
Benzo(g,h,i)perylene	--
Chlorinated benzenes	
1,2-Dichlorobenzene	--
1,3-Dichlorobenzene	--
1,4-Dichlorobenzene	--
1,2,4-Trichlorobenzene	--
Hexachlorobenzene	--
Total PCBs[d]	47
Total phthalates	1,300
Dimethyl phthalate	--
Diethyl phthalate	--
Di-*n*-butyl phthalate	--
Butyl benzyl phthalate	--
Bis(2-ethylhexyl)phthalate	--
Di-*n*-octyl phthalate	--
Miscellaneous extractables	
2-Methylnaphthalene	--
Dibenzofuran	--
Hexachlorobutadiene	--
N-nitrosodiphenylamine	--
Benzoic acid	370
Benzyl alcohol	--
Pesticides (μg/kg)	
p,p'-DDD	--
p,p'-DDE	--
p,p'-DDT	--

TABLE 13. (Continued)

Chemical	Proposed Performance Standard[a]
Conventionals (mg/kg)	
Total organic carbon	2.5
Acid-volatile sulfides	--[e]

[a] 90th percentile values (dry weight measurements basis) of Carr Inlet, Daboob Bay, Holmes Harbor, Samish Bay, and Sequim Bay data from all accepted stations (rejecting Samish Bay Station SM30).

[b] -- – not available.

[c] PAH – polycyclic aromatic hydrocarbon.

[d] PCB – polychlorinated biphenyl.

[e] Insufficient data to calculate 90th percentile value.

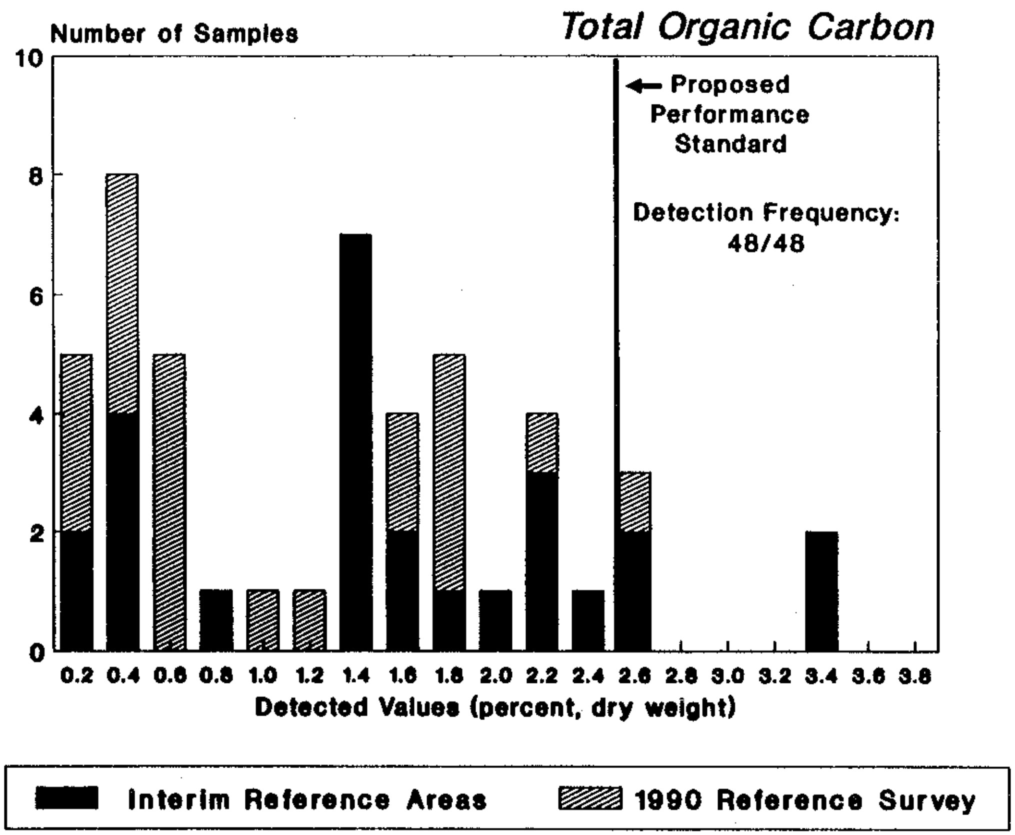


Figure 14. Frequency distribution of detected total organic carbon for acceptable stations, with the proposed performance standard.

C744-28 0991

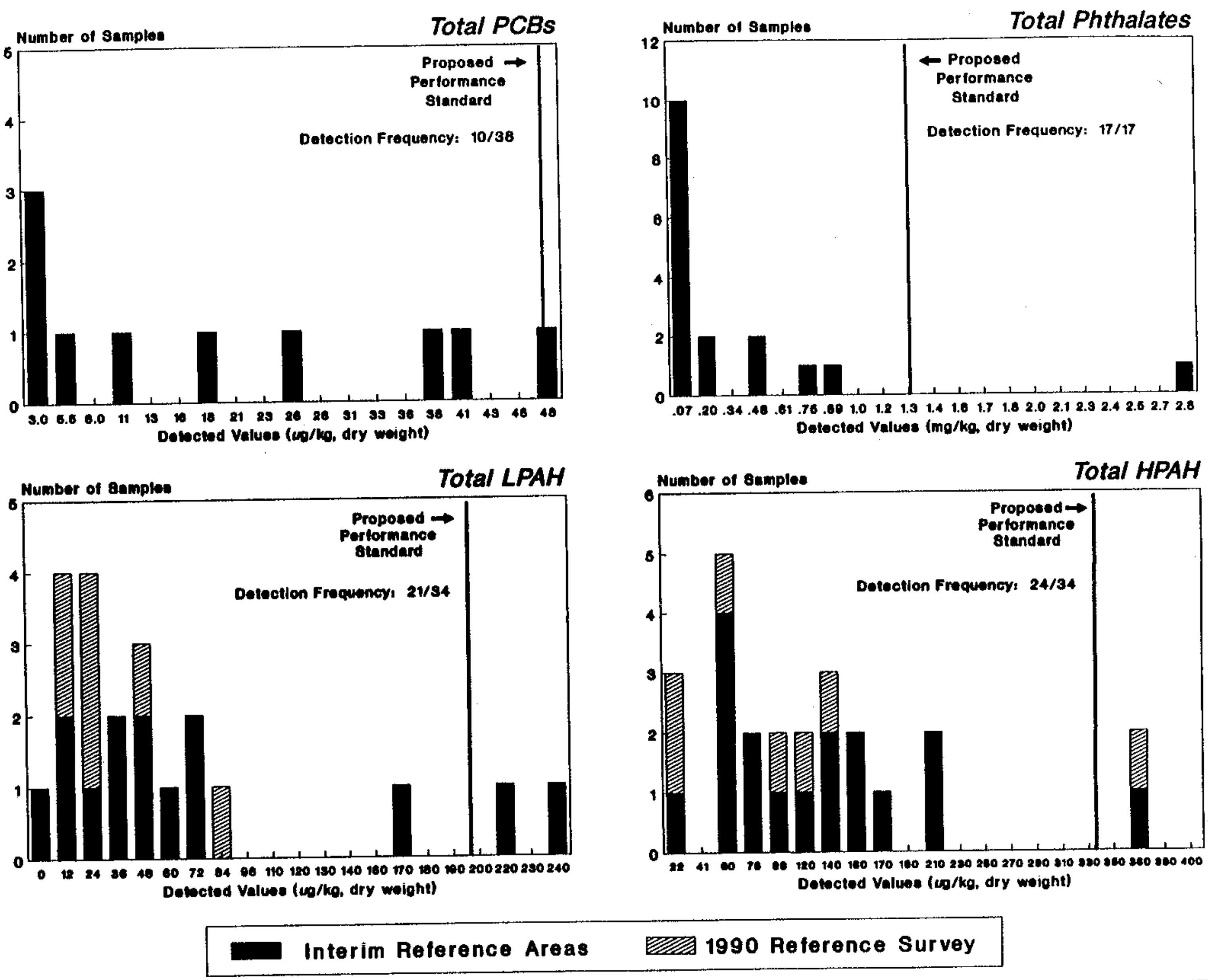


Figure 15. Frequency distributions of polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and total phthalates for acceptable stations, with the proposed performance standards.

C744-28 0991

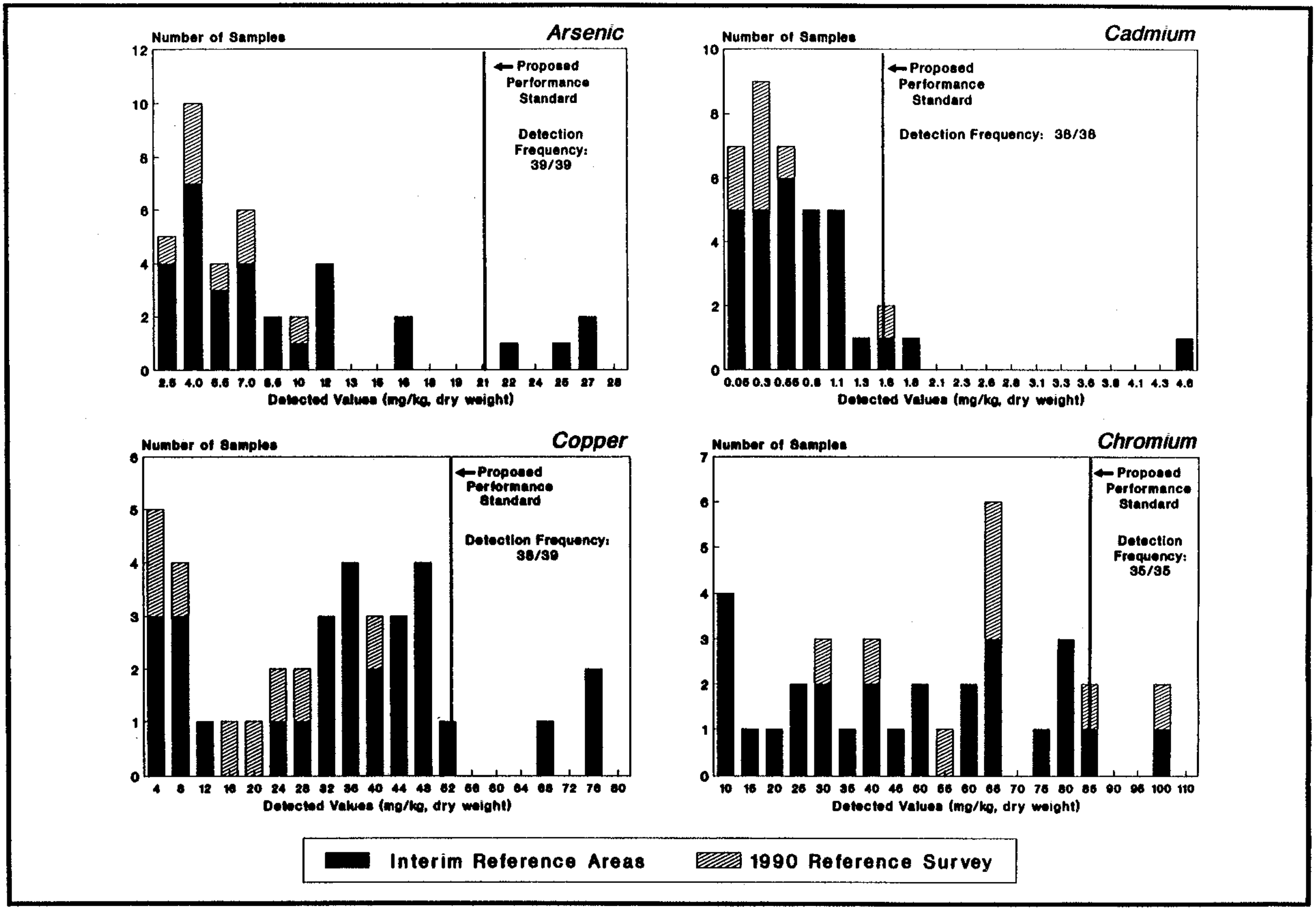


Figure 16. Frequency distributions of detected metals concentrations (arsenic, cadmium, copper, and chromium) for acceptable stations, with the proposed performance standards.

C744-26 0991

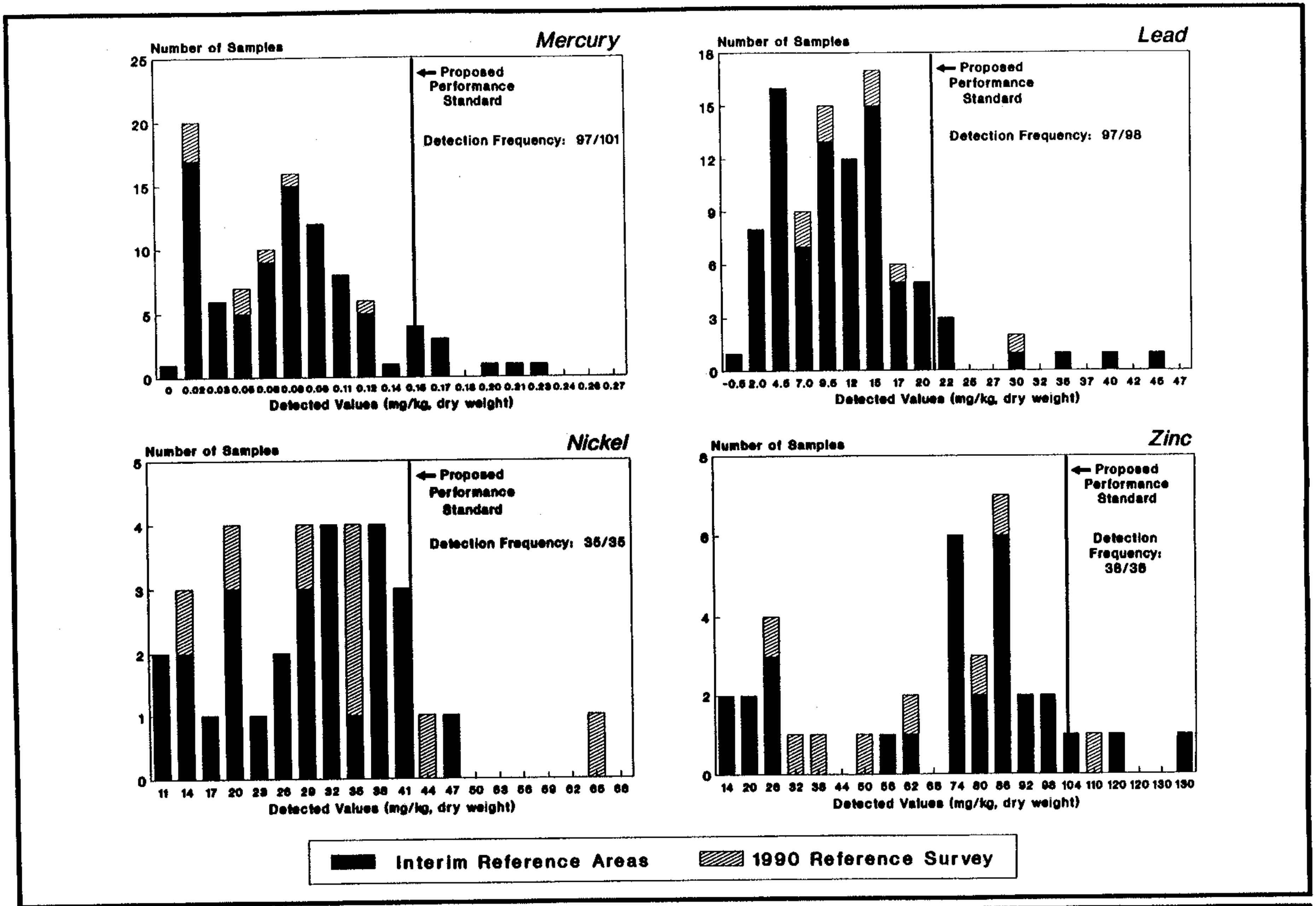


Figure 17. Frequency distributions of detected metals concentrations (mercury, lead, nickel, and zinc) for acceptable stations, with the proposed performance standards.

C744-28 0991

are therefore considered to be indicative of reference area conditions at the time of sampling. As the size of the database of reference area data increases with subsequent sampling, the true representativeness of these values will be more easily assessed. Also, if apparent effects threshold (AET) values are recalculated using the data from this survey, then the LAET will be adjusted to a value higher than the proposed reference area performance standard for 4-methylphenol.

A percentile-based performance standard for TOC is proposed. Because the toxicity of polar organic compounds may be affected by the concentration of organic matter in the sediment, stratification of comparisons of study sites with reference areas by TOC may be appropriate to account for natural variations in TOC. However, high TOC concentrations are generally associated with high sulfide concentrations, which are toxic. TOC concentrations in reference area sediments should therefore be matched with concentrations in test sediments only up to the proposed performance standard for TOC.

BIOASSAYS

Reference area performance standards have been developed for the amphipod, bivalve larvae, echinoderm embryo, and juvenile polychaete bioassays. The frequency distributions of bioassay responses with the performance standards are shown in Figure 18. Performance standards for both the abnormality and combined endpoints of the echinoderm embryo bioassay have been developed. A performance standard has been developed for only the abnormality endpoint of the bivalve larvae bioassay; the high bivalve larvae mortalities produce very high values for the combined endpoint. The reference area performance standards, including the 95 percent confidence limits on the 90th percentile values, are shown in Table 14. Most of the data used to generate these values are from the current study. Amphipod mortality and bivalve abnormality performance standards are based on the 90th percentile of the log-transformed data. Confidence limits for the 90th percentile values were calculated according to Gilbert (1987). This technique requires that the distribution be Gaussian (normal), so the calculation was made with log-transformed data, as appropriate. Table 14 shows both the 90th percentile of the data and the 90th percentile that is estimated based on a presumably normal distribution.

A performance standard for the biomass endpoint of the juvenile polychaete bioassay cannot be based on either final biomass alone or percent change from initial biomass because the animals may pass through log-phase growth during the bioassay. As a consequence, the final biomass may be sensitive to initial biomass in a nonlinear fashion. A performance standard for the juvenile polychaete bioassay might be based on empirical observations of the final biomass achieved in reference area samples for all values within a range of initial biomass values. In effect, a different performance standard, in terms of final biomass, would be established for each value of initial biomass. This approach requires a large data

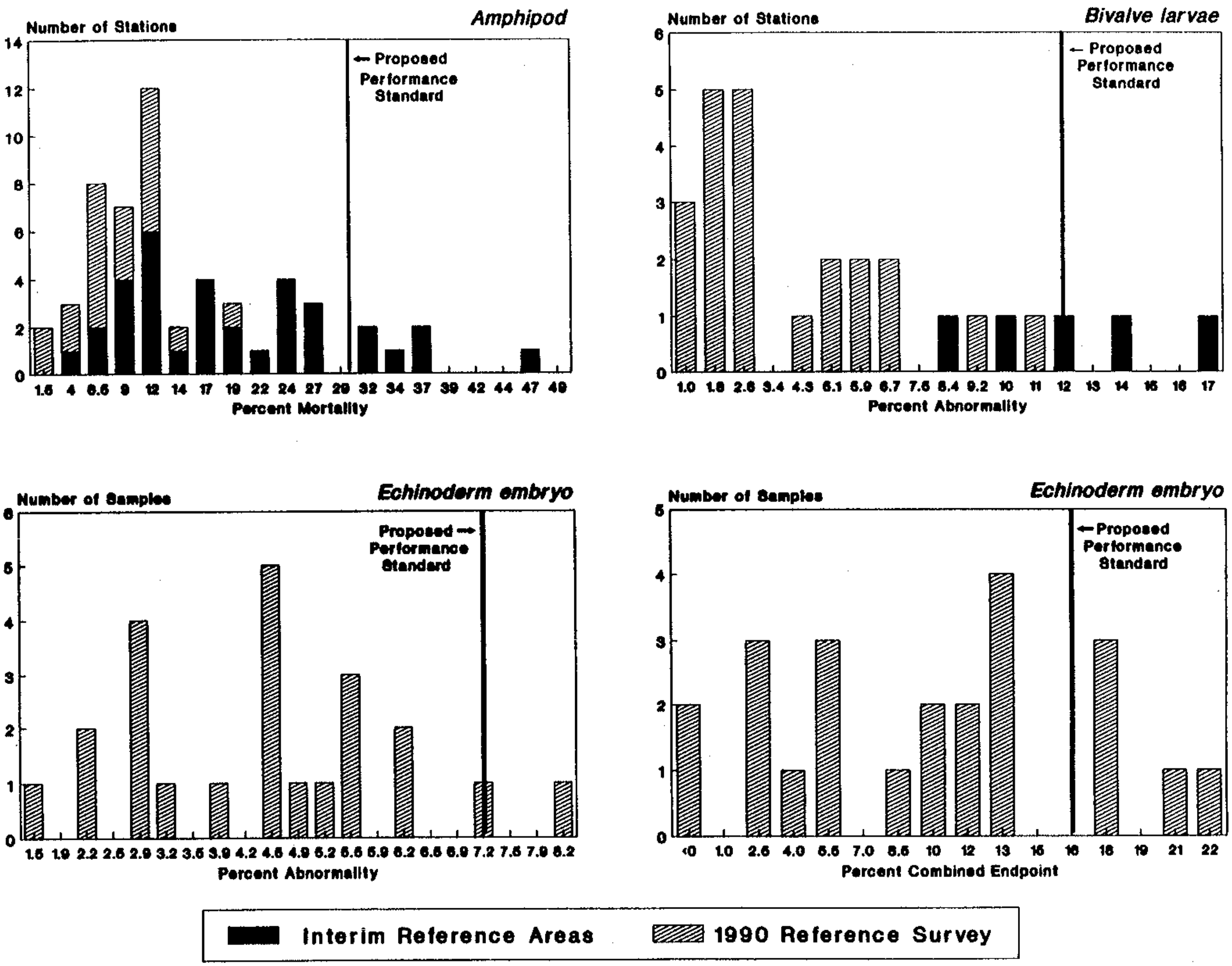
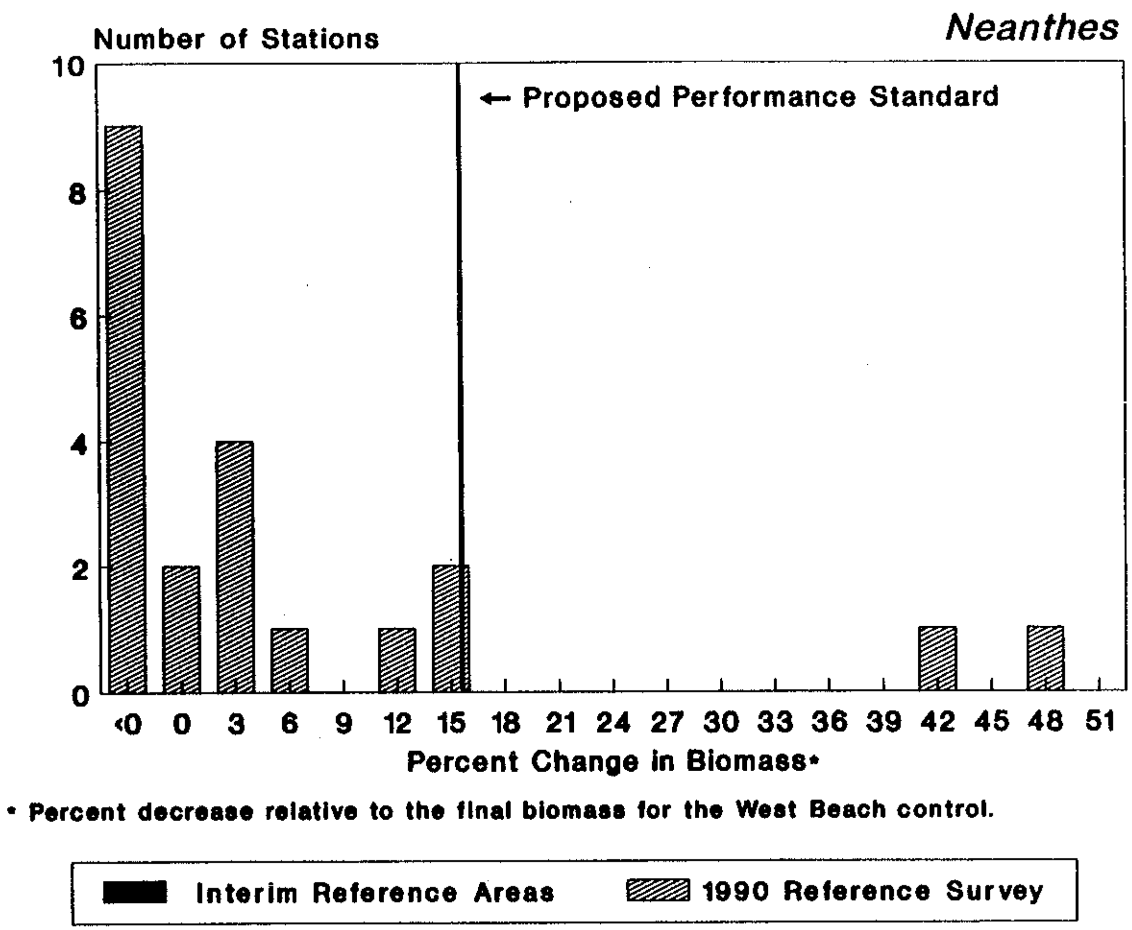


Figure 18. Frequency distributions of bioassay responses for acceptable stations, with the proposed performance standards.

C744-28 0891



Note: No frequency distribution is shown for Microtox because there were no light decreases.

Figure 18. (Continued)

C744-28 0891

TABLE 14. PERFORMANCE STANDARDS FOR SELECTED BIOASSAYS

Bioassay	Endpoint	Mean (%)	Standard Deviation	Number of Samples	Performance Standard (%)[a]	95% Upper Confidence Limit (%)[b]
Amphipod	Mortality [c]	12	2.1	52	30	40
Bivalve larvae	Abnormality [c]	3.8	2.4	26	12	19
	Combined	75	11	51	NA [d]	NA
Echinoderm embryo	Abnormality	4.6	1.8	21	7.2	7.9
	Combined	9.8	7.3	21	16	24
Juvenile polychaete	Change in biomass [e]	3.5	16	21	16	34
Microtox	Decrease in bioluminescence	0	0	21	NS [f]	NA

[a] 90th percentile value.

[b] Upper 95 percent confidence limit of the 90th percentile value (Gilbert 1987). See text for explanation

[c] These data were natural–log transformed prior to analysis.

[d] NA = not applicable.

[e] Change in biomass is computed as percent decrease relative to the final biomass for the West Beach control.

[f] NS = a nonsignificant decrease in bioluminescence relative to control.

set. In the absence of such a data set, another alternative is to base the reference area performance standard on comparisons to West Beach control samples.

The mean percent change in *Neanthes* biomass relative to West Beach control samples is 3.5 percent for the 21 samples in this study. The standard deviation of this value is 16.3, and the 90th percentile value is 16 percent. The samples from Stations HH01 and HH02 exceeded this 90th percentile. Use of percent change relative to control as the basis for a reference area performance standard may be invalid if control samples are from locations other than West Beach. West Beach is not native sediment for *Neanthes*, and the polychaetes may be expected to commonly grow larger in test sediments than in West Beach sediments, as was observed in this study and in Johns and Ginn (1990). In the absence of alternatives, or until a larger database of initial biomass-specific reference area results is accumulated, percent change of final biomass from control may be suitable as an interim performance standard (Table 14).

A percentile-based numerical performance standard was not developed for the Microtox® bioassay because of the limited amount of data showing positive responses [only four organic and one saline extract samples showed reduced bioluminescence (Pastorok et al. 1989)] and the fact that the Microtox® results from this study showed no negative response. It is recommended that a nonsignificant ($P > 0.05$) decrease in bioluminescence be established as the reference area performance standard for the Microtox® bioassay.

CONCLUSIONS AND RECOMMENDATIONS

REFERENCE AREA SEDIMENT CHEMISTRY

No pesticides or PCBs were detected in any of the reference area samples collected during this survey. In comparison to the four interim reference areas, the results of this study suggest that the observed concentrations of most metals and most organic compounds in sediments at the nine stations were relatively low. Exceptions included benzoic acid, butyl benzyl phthalate, and 4-methylphenol.

Benzoic acid, butyl benzyl phthalate, and 4-methylphenol were present at Samish Bay Station SM30 at concentrations that may be associated with adverse biological effects according to the SMS and LAET; therefore, this station was rejected from future consideration as a potential reference area.

Although 4-methylphenol exceeded the LAET for more than one station in a given area, these stations were not eliminated from consideration for Puget Sound reference areas based on the 4-methylphenol exceedances alone. The reasons are as follows:

- Adverse biological effects were not apparent from the bioassay results
- 4-Methylphenol concentrations exceeded only the oyster and Microtox® AET values of 670 mg/kg. Concentrations of 4-methylphenol for the 1990 survey were well below the amphipod and benthic AET values of 3,600 mg/kg and 1,800 mg/kg, respectively (Barrick et al. 1988).

4-Methylphenol is not expected to persist in sediment (Howard 1990); however, persistent high concentrations of 4-methylphenol have been observed in some Puget Sound sediments near industrial sources. These results have been explained as either large mass loadings of 4-methylphenol from the source or *in situ* production of 4-methylphenol in the sediments (PSEP 1991). One untested possibility is that 4-methylphenol could be produced by bacterial conversion of proteins (via *p*-hydroxyphenylacetate) accumulating in the sediments (Balba and Evans 1980).

AREAS OF ELEVATED OR SIGNIFICANT TOXICITY

Data collected during the current study suggest that the area represented by Stations HM01 and HM02 in Holmes Harbor may be significantly toxic relative to other reference areas. This tentative conclusion is based on the high mortality seen in some replicates of the juvenile polychaete bioassay. Contradictory evidence is provided by the other replicates of the juvenile polychaete test, which had 100-percent survival, and by other bioassays, which showed little or no toxic response. Resampling and analysis of Stations HM01 and HM02 are necessary to confirm or refute the possibility of elevated toxicity at these locations.

BIVALVE LARVAE MORTALITY

As in previous studies, bivalve larvae exhibited extremely high mortalities in the absence of corroborating evidence from either chemical measurements or other bioassay results. This apparent unreliability of the mortality endpoint (and therefore of the combined endpoint also) requires further investigation to determine the conditions under which it occurs and to provide guidance in the use and interpretation of the bivalve larvae bioassay. Until such an analysis is completed, the abnormality endpoint alone should be used.

NEANTHES BIOASSAY ENDPOINT

Although in the present study, the different initial weights of *Neanthes* used in the juvenile polychaete bioassay test had no apparent effect on the results (both groups achieved comparable final weights), the bioassay's insensitivity to different initial weights is not firmly established. Even when the final weights of animals from test sediment are compared to the final weight of animals from (West Beach) control sediment, different results may be expected depending on the initial weights of the worms—that is, the variance of the final weight may depend upon the initial weight used for both test and control sediments. Further investigation of the relationship between initial and final weights for this bioassay may be warranted.

MICROTOX® BIOASSAY PERFORMANCE STANDARD

The rarity of toxicity responses (i.e., decreases in bioluminescence) to reference area sediment may make the development of a numerical performance standard for this bioassay very difficult. Other alternatives for assessing the results of Microtox® bioassays performed on reference sediments should be considered. It is recommended that a nonsignificant ($P>0.05$) decrease in reference area performance standard for the Microtox® saline extract test.

PERFORMANCE STANDARDS FOR RARELY DETECTED CHEMICALS

Numerical performance standards may be difficult to derive for chemicals that are commonly undetected in reference areas. Depending upon the result of further data collection activities, alternative methods for establishing performance standards for these chemicals should be considered. One alternative would be an upper criterion for the detection limit; any actual detected measurements would have to be examined, perhaps on a case-by-case basis, with regard to such a criterion.

STRATIFICATION OF PERFORMANCE STANDARDS BY SEDIMENT TYPE

Fine-grained sediments were not associated with bioassay responses that were out of the range of PSEP quality control limits for control samples or the proposed performance standards for reference areas. In particular, the amphipod bioassay, which has been previously suggested to be influenced by grain size (DeWitt et al. 1988) showed no significant correlation with percent fine-grained sediments in this study. Although some larval bioassay responses were significantly correlated with fine-grained sediments, the highest responses observed were, nevertheless, relatively low. (The bivalve larvae combined endpoint is excluded from consideration because of the anomalously high mortalities.)

These results indicate that separate performance standards need not be developed for different ranges of grain sizes. Although the sampling for this study was conducted at a single time during the year and grain size at a station may change throughout the year, the samples collected represented a wide range of grain sizes, a range as wide as is expected to be observed at any single station throughout the year.

The wet-sieving technique is effective in selecting stations with a target grain size so that, even if changes occur in the grain size at the stations surveyed in this study, future investigators have available a procedure for finding another location within a reference area that matches the gross sediment characteristics of their test site.

SUITABILITY OF CARR INLET, HOLMES HARBOR, AND SAMISH BAY AS REFERENCE AREAS

With the exception of a caveat for Stations HM01 and HM02 in Holmes Harbor and rejection of Station SM30 in Samish Bay, all stations (Carr Inlet, Holmes Harbor, and Samish Bay) are suitable as reference areas based upon the range of sediment conditions available, low bioassay response, and low chemical concentrations.

REFERENCES

APHA. 1985. Standard methods for the examination of water and wastewater. 16th edition. American Public Health Association, Washington, DC.

Balba, M.T., and W.C. Evans. 1980. Methanogenic fermentation of the naturally occurring aromatic amino acids by a microbial consortium. Biochem. Soc. Trans. 8:625-627.

Barrick, R.C., D.S. Becker, L.B. Brown, et al. 1988. Sediment quality values refinement: 1988 update and evaluation of Puget Sound AET. Volume I. Final Report. Prepared for Tetra Tech, Inc. and U.S. Environmental Protection Agency. PTI Environmental Services, Bellevue, WA.

Dewitt, T.H., G.R. Ditsworth, and R.C. Swartz. 1988. Effects of natural sediment features on survival of the phoxocephalid amphipod, *Rhepoxynius abronius*. Mar. Environ. Res. 25:99-124.

Di Toro, D.M., J.D. Mahoney, D.J. Hansen, et al. 1990. Toxicity of cadmium in sediments: the role of acid volatile sulfide. Environ. Toxicol. Chem. 9:1487-1502.

Gilbert, R.O. 1987. Statistical methods for environmental pollution monitoring. Van Nostrond and Reinhold Co. Inc., New York, NY.

Howard, P.H. 1990. Handbook of environmental fate and exposure data for organic chemicals, Volume I. Lewis Publishers, Inc., Chelsea, MI.

Johns, D.M., and T.C. Ginn. 1990. *Neanthes* long-term exposure experiment: the relationship between juvenile growth and reproductive success. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA. EPA 910/9-90-010. PTI Environmental Services, Bellevue, WA.

Kendall, D.R. 1991. Personal communication (Memorandum to B. Betts, Washington Department of Ecology, dated August 5, 1991, regarding draft report, *Reference Area Performance Standards for Puget Sound*). U.S. Army Corps of Engineers Seattle District, Dredged Material Management Office, Seattle, WA.

Pastorok, R.A., and D.S. Becker. 1990. Comparative sensitivity of sediment toxicity bioassays at three Superfund sites in Puget Sound. pp. 123-139. In: Aquatic Toxicology and Risk Assessment: Thirteenth Volume, ASTM STP 1096. W.G. Landis and W.H. van der Schalie (eds). American Society for Testing and Materials, Philadelphia, PA.

Pastorok, R.A., R. Sonnerup, J.J. Greene, et al. 1989. Interim performance standards for Puget Sound reference areas. Prepared for Washington Department of Ecology, Sediment Management Unit, Olympia, WA. PTI Environmental Services, Bellevue, WA.

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. Environmental Laboratory, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MI.

PSEP. 1986a (revised 1991). Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Prepared for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA. PTI Environmental Services, Bellevue, WA.

PSEP. 1986b (revised 1990). Recommended guidelines for measuring organic compounds in Puget Sound water, sediment, and tissue samples. Prepared for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA. PTI Environmental Services, Bellevue, WA.

PSEP. 1986c. Recommended protocols for measuring conventional sediment variables in Puget Sound. Final Report. Prepared for the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers. Tetra Tech, Inc., Bellevue, WA.

PSEP. 1986d (revised 1990). Recommended protocols for measuring metals in Puget Sound water, sediment, and tissue samples. Prepared for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA. PTI Environmental Services, Bellevue, WA.

PSEP. 1991. Pollutants of concern in Puget Sound. Prepared for the U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA.

PTI. 1988. Puget Sound dredged disposal analysis baseline survey of Phase I disposal sites. Prepared for Washington Department of Ecology. PTI Environmental Services, Bellevue, WA.

PTI. 1990. Puget Sound reference areas survey: Sampling and analysis plan. Prepared for the U.S. Environmental Protection Agency, Seattle, WA. PTI Environmental Services, Bellevue, WA.

/ PTI. 1991a. Puget Sound reference areas survey quality assurance reports for chemical analysis. Prepared for the U.S. Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Olympia, WA. PTI Environmental Services, Bellevue, WA.

PTI. 1991b. Puget Sound reference areas survey quality assurance report for bioassay analyses. Prepared for the U.S. Environmental Protection Agency, Seattle, WA and Washington Department of Ecology, Olympia, WA. PTI Environmental Services, Bellevue, WA.

U.S. EPA. 1987. Contract Laboratory Program statement of work for inorganics analysis, multi-media, multi-concentration. SOW no. 788. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1988. U.S. EPA Contract Laboratory Program statement of work for organics analysis, multi-media, multi-concentration. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1989. Method 1625, revision C: semivolatile organic compounds by isotope dilution GC/MS. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Industrial Technology Division, Washington, DC.

U.S. EPA. 1990. Method 376.3, Revision 1.0: Determination of acid volatile sulfides in sediment. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Office of Research and Development, Cincinnati, OH.

ANNOTATED BIBLIOGRAPHY OF PUGET SOUND REFERENCE AREAS

The following is a list of sources containing information on Puget Sound reference area data.

Anderson, J.W., and E.A. Crecelius. 1986a. Physical, chemical, and biological analysis of sediments proposed to be dredged for the Oak Harbor marine expansion project, Oak Harbor, Whidbey Island, Washington. Final Report. Prepared for the U.S. Army Corps of Engineers, Seattle, WA. Battelle, Pacific Northwest Laboratories, Richland, WA.

Anderson, J.W., and E.A. Crecelius. 1986b. Collection and analyses of sediments from Kenmore navigational channel project for chemical contamination and biological effects. Final report. Prepared for the U.S. Army Corps of Engineers, Seattle District, Seattle, WA. Battelle, Pacific Northwest Laboratories, Richland, WA.

Barrick, R.C., and F.G. Prahl. 1987. Hydrocarbon geochemistry of the Puget Sound region. III. Polycyclic aromatic hydrocarbons in sediments. Estuarine Coastal Shelf Sci. 25:175-191.

Bates, T.S., and R. Carpenter. 1979. Organo-sulfur compound in sediments of the Puget Sound basin. Geochim. et Cosmochim. Acta 43:1209-1221.

Battelle. 1986. Reconnaissance survey of eight bays in Puget Sound. Vols. 1 and 2. Final Report. Prepared for the U.S. Environmental Protection Agency Region 10, Seattle, WA. Battelle, Marine Research Laboratory, Sequim, WA.

Broad, A.C., A.B. Benedict, and J.R. Mayer. 1983. Infaunal macrobenthos and sediment characteristics in Bellingham and Samish Bays. Prepared for the U.S. Environmental Protection Agency Region 10, Seattle, WA. Western Washington University, Bellingham, WA.

Chan, S.-L., M. Schiewe, and D. Brown. 1985a. Analysis of sediment samples for U.S. Army Corps of Engineers East, West, and Duwamish Waterways navigations improvement project, operations and maintenance sampling and testing of Duwamish River sediments (unpublished). Prepared for U.S. Army Corps of Engineers, Seattle District, Seattle, WA. National Oceanic and Atmospheric Administration, Seattle, WA.

Chan, S.-L., M. Schiewe, and D. Brown. 1985b. Analysis of sediment samples for U.S. Army Corps of Engineers Seattle Harbor navigation project, operations and maintenance sampling and testing of Duwamish River sediments. Prepared for U.S. Army Corps of Engineers, Seattle District, Seattle, WA. National Oceanic and Atmospheric Administration, Seattle, WA.

Chapman, P.M., R.N. Dexter, R.D. Kathman, and G.A. Erickson. (No date). Survey of biological effects of toxicants upon Puget Sound biota. IV: Interrelationships of infauna, sediment bioassay, and sediment chemistry data. Prepared for National Oceanic and Atmospheric Administration, Ocean Assessments Division, Coastal and Estuarine Assessments Branch, Pacific Office, Seattle, WA. E.V.S. Consultants, Vancouver, British Columbia, and Infometrix, Inc., Seattle, WA.

Chapman, P.M., R.N. Dexter, J. Morgan, R. Fink, D. Mitchell, R.M. Kocan, and M.L. Landolt. 1984. Survey of biological effects of toxicants upon Puget Sound biota. III: Tests in Everett Harbor, Samish and Bellingham Bays. NOAA Technical Memorandum NOS OMS-2. Prepared for National Oceanic and Atmospheric Administration. E.V.S. Consultants, Seattle, WA and Fish and Wildlife Health Consultants, Suquamish, WA.

Crecelius, E.A., M.H. Bothner, and R. Carpenter. 1975. Geochemistry of arsenic, antimony, mercury, and related elements in sediments of Puget Sound. Environ. Sci. Technol. 9:325-333.

Crecelius, E.A., and J.W. Anderson. 1986. Biological and chemical analysis of sediments for the design and construction of the U.S. Navy Homeport facility at East Waterway -Everett Harbor, Washington Phase III. Prepared for U.S. Army Corps of Engineers, Seattle District, Seattle, WA. Battelle, Pacific Northwest Laboratory, Richland, WA.

Dewitt, T.H., G.R. Ditsworth, and R.C. Swartz. 1988. Effects of natural sediment features on survival of the phoxocephalid amphipod, *Rhepoxynius abronius*. Mar. Environ. Res. 25:99-124.

Dewitt, T.H. 1989. Personal Communication (letter to Dr. R.A. Pastorok, PTI Environmental Services, Bellevue, WA. U.S. Environmental Protection Agency, Environmental Research Laboratory, Newport, OR.

Dexter, R.N., D.E. Anderson, E.A. Quinlan, L.S. Goldstein, R.M. Strickland, S.P. Pavlou, J.R. Clayton, Jr., R.M. Kocan, and M. Landolt. 1981. A summary of knowledge of Puget Sound related to chemical contaminants. NOAA Technical Memorandum OMPA-13. URS Company, Seattle, WA: JRB Associates, Bellevue, WA; and Fish and Wildlife Health Consultants, Suquamish, WA.

Evans-Hamilton, and D.R. Systems. 1987. Puget Sound environmental atlas. Vol 1. Prepared for U.S. Environmental Protection Agency, Puget Sound Water Quality Authority, and U.S. Army Corps of Engineers. Evans-Hamilton, Inc., Seattle, WA and D.R. Systems, Inc.

Long, E.R., and P.M. Chapman. 1985. A sediment quality triad: measures of sediment contamination, toxicity and infaunal community composition in Puget Sound. Mar. Pollu. Bull. 16:405-415.

Mowrer, J., J. Calambokidis, N. Musgrove, B. Drager, M.W. Beug, and S.G. Herman. 1977. Polychlorinated biphenyls in cottids, mussels, and sediment in southern Puget Sound, Washington. Bull. Environ. Contam. Toxicol., 18:588-594.

PTI. 1988. Puget Sound Dredge Disposal Analysis Baseline Survey of Phase I disposal sites. Technical Appendices. Prepared for Washington Department of Ecology, Olympia, WA. PTI Environmental Services, Belleuve, WA.

Prahl, F.G., and R. Carpenter. 1979. Role of zooplankton fecal pellets in the sedimentation of polycyclic aromatic hydrocarbons in Dabob Bay, Washington. Geochim. et Cosmochim. Acta 43:1959-1972.

Prahl, F.G., J.T. Bennett, and R. Carpenter. 1980. The early diagenesis of aliphatic hydrocarbons and organic matter in sedimentary particulates from Dabob Bay. Geochim. et Cosmochim. Acta 44:1967-1976.

Riley, R.G., E.A. Crecelius, R.E. Fitzner, B.L. Thomas, J.M. Gurtisen, and N.S. Bloom. 1983. Organic and inorganic toxicants in sediment and marine birds from Puget Sound. NOAA Technical Memorandum NOS OMS-1. National Oceanic and Atmospheric Administration, Rockville, MD.

Roberts, R. 1974. Marine sedimentological data of the inland waters of Washington state (Strait of Juan de Fuca and Puget Sound). Special Report 56, Ref.M74-74. University of Washington, Department of Oceanography, Seattle, WA.

Schiewe, M.H., D.W. Brown, and S.L. Chan. 1987. Seattle Harbor operations and maintenance project: physical/chemical/biological analyses of sediments proposed for operations and maintenance dredging. National Oceanic and Atmospheric Administration, Environmental Conservation Division, Northwest and Alaska Fisheries Center, Seattle, WA.

Tetra Tech. 1985. Commencement Bay nearshore/tideflats remedial investigation. Final Report. EPA-910/9-85-134b. Prepared for the Washington Department of Ecology and U.S. Environmental Protection Agency Region 10, Office of Puget Sound. Tetra Tech, Inc., Bellevue, WA.

Varanasi, U., S.-L. Chan, D. Brown, R. Clark, and E. Casillas. 1989. Summary report for the Olympia Harbor navigation improvement project, 1988: sediment chracterization and Microtox assays. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Environmental Conservation Division, Northwest Fisheries Center, Seattle, WA.

APPENDIX A

1990 Reference Area Survey Chemistry Data

TABLE A1. QUALIFIER CODES

Qualifer Code	Description
E	Estimate
G	Estimate is greater than value shown
L	Value is less than the maximum shown
M	Value is a mean
N	Presumptive evidence
R	Rejected
T	Detected below quantification limit shown
U	Undetected at the detection limit shown
Z	Blank corrected

TABLE A2. CONVENTIONALS DATA FOR THE 1990 REFERENCE AREA SURVEY (dry weight)

Station	Date	Sample	Field Rep	Acid Volatile Sulfides (mg/kg)	Total Organic Carbon (percent)	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	Percent Fines (Clay+Silt)	Total Solids (dry wt. as % of wet wt.)
CR02	06/19/90	SD0002		32 *E*	1.2 *M*	0	21	56	23	79	44 *M*
CR20	06/19/90	SD0003		38 *E*	0.6	0	58	24	17	42	54
CR21	06/19/90	SD0004		2.7 *UE*	0.3	0	86	9.3	4.2	14	71
CR22	06/19/90	SD0005		5.6 *E*	0.4	0	80	16	3.6	20	68
CR23	06/19/90	SD0006		2.9 *UE*	0.6	0.10 *L*	52	43	6.0	49	58
CR24	06/19/90	SD0007		35 *EM*	0.6	0	36	58	6.3	64	55
CR25	06/19/90	SD0008		2.5 *UE*	0.2	0.37 *M*	95 *M*	2.2 *M*	2.4 *M*	4.6 *M*	76
HH01	06/25/90	SD0017		5.9 *UE*	1.8	0.10	30	32	38	70	33
HH02	06/25/90	SD0018		2.7 *UE*	0.2	0.10	97	2.4	0.8	3.2	69
HM03	06/25/90	SD0019		2.8 *UE*	0.2	0.03 *M*	93 *M*	4.7 *M*	2.1 *M*	6.7 *M*	71
HM04	06/26/90	SD0020		3.0 *E*	0.5	0.10 *L*	86	8.5	5.6	14	63
HM05	06/26/90	SD0021	1	4.1 *UE*	1.5	0	43	41	17	57	49 *M*
HM05	06/26/90	SD0022	2	4.2 *UE*	1.6	0	42	40	19	58	56
HM05	06/26/90	SD0023	3	25 *E*	1.7	0	36	41	23	64	52
HM06	06/26/90	SD0024		54 *E*	2.6	0	12	56	33	88	35
HM07	06/26/90	SD0025		93 *E*	2.2	0.10 *L*	4.5 *L*	42	54	96	29
SM30	06/21/90	SD0010		7.1 *E*	2.4	0	3.8	63	34	96	35
SM31	06/21/90	SD0011		2.8 *UE*	0.4	0.10	88 *L*	7.8	4.7	13	89
SM32	06/21/90	SD0012		4.1 *UE*	1.7	0.10	25	49	26	75	38 *M*
SM33	06/21/90	SD0013		3.1 *UE*	0.9	0.80	71	19	10	29	60
SM34	06/22/90	SD0014		5.4 *UE*	1.8	0.20	25	48	27	74	37
SM35	06/22/90	SD0015		2.9 *UE*	0.5 *M*	0	82	12	5.9	18	67
SM36	06/22/90	SD0016		2.7 *UE*	0.4	0.10	89	6.8	4.0	11	68

TABLE A3. METALS DATA FOR THE 1990 REFERENCE AREA SURVEY (mg/kg, dry weight)

Station	Date	Sample	Antimony	Arsenic	Cadmium	Total Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc
CR02	06/19/90	SD0002	0.460 *U*	4.50	0.460	66.6	20.5	13.5	0.040 *T*	35.3	0.160 *T*	59.9
CR20	06/19/90	SD0003	0.590 *ET*	3.50 *T*	0.300	63.0	15.9	9.40	0.040	33.8	0.100 *T*	52.8
CR25	06/19/90	SD0008	0.430 *U*	3.40 *T*	0.070 *T*	28.6	3.90	8.00	0.010 *T*	14.7	0.020 *T*	23.1
HH02	06/25/90	SD0018	0.430 *U*	2.40 *T*	0.110 *T*	56.1	4.90	7.70	0.010 *T*	30.0	0.030 *T*	32.5
HM05	06/26/90	SD0021	0.430 *U*	7.40	1.60	84.5	28.3	14.3	0.060	43.1	0.210 *T*	79.6
HM07	06/26/90	SD0025	1.00 *T*	9.90	0.190 *T*	98.5	40.6	30.0	0.120	64.3	0.330	111
SM30	06/21/90	SD0010	0.660 *T*	7.70	0.260	75.7	29.5	19.1	0.110	43.4	0.190 *T*	98.4
SM34	06/22/90	SD0014	0.460	7.50	0.300	66.3	22.9	17.5	0.080	35.6	0.140 *T*	85.0
SM36	06/22/90	SD0016	0.430 *U*	4.80	0.230	38.2	6.30	9.50	0.020 *T*	20.4	0.050 *T*	37.5

TABLE A4. POLYCYCLIC AROMATIC HYDROCARBON DATA FOR THE 1990 REFERENCE AREA SURVEY (μg/kg, dry weight)

Station	Date	Sample	LPAH[a]	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Phenanthrene	Anthracene	2-Methyl-naphthalene	HPAH[b]	Fluoranthene
CR02	06/19/90	SD0002	21 *T*	8.0 *ZU*	8.0 *U*	8.0 *U*	8.0 *U*	10 *T*	11 *T*	8.0 *U*	140 *E*	31 *T*
CR20	06/19/90	SD0003	22 *E*	7.0 *ZU*	7.0 *U*	7.0 *U*	7.0 *U*	5.0 *E*	17 *T*	7.0 *U*	61 *E*	12 *T*
CR25	06/19/90	SD0008	11 *E*	6.0 *ZU*	6.0 *U*	6.0 *U*	6.0 *U*	2.0 *E*	9.0 *NT*	6.0 *U*	27 *E*	3.0 *E*
HH02	06/25/90	SD0018	--[c]	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*	--	12 *U*
HM05	06/26/90	SD0021	9 *E*	8.0 *ZU*	8.0 *U*	8.0 *U*	2.0 *E*	6.0 *E*	1.0 *E*	8.0 *U*	89 *E*	16 *T*
HM07	06/26/90	SD0025	47 *E*	15 *ZU*	15 *U*	15 *U*	8.0 *E*	32 *T*	7.0 *E*	15 *U*	360 *T*	62 *T*
SM30	06/21/90	SD0010	78 *E*	22 *ZU*	22 *U*	22 *U*	10 *N*	35 *T*	33 *NT*	22 *U*	240 *E*	52 *T*
SM34	06/22/90	SD0014	83 *E*	20 *ZU*	20 *U*	20 *U*	8.0 *N*	40 *T*	35 *T*	20 *U*	30 *T*	63 *T*
SM36	06/22/90	SD0016	22 *E*	6.0 *ZU*	6.0 *U*	6.0 *U*	2.0 *E*	17 *T*	3.0 *N*	6.0 *U*	110 *E*	25 *T*

[a] Sum of detected low molecular weight polycyclic aromatic hydrocarbons.
[b] Sum of detected high molecular weight polycyclic aromatic hydrocarbons.
[c] -- = No sum was computed when all compounds were undetected.

TABLE A4. (Continued)

Station	Date	Sample	Pyrene	Benz(a)–anthracene	Chrysene	Total Benzo–fluoranthenes (B+K)	Benzo(a)–pyrene	Indeno(1,2,3–c,d) pyrene	Dibenzo(a,h)–anthracene	Benzo(g,h,i)–perylene
CR02	06/19/90	SD0002	29 *T*	8.0 *E*	13 *T*	19 *E*	9.0 *T*	14 *T*	8.0 *U*	19 *NT*
CR20	06/19/90	SD0003	13 *T*	3.0 *NT*	5.0 *E*	12 *T*	4.0 *N*	12 *T*	7.0 *U*	14 *U*
CR25	06/19/90	SD0008	3.0 *E*	2.0 *E*	2.0 *E*	6.0 *E*	2.0 *E*	9.0 *NT*	6.0 *U*	12 *U*
HH02	06/25/90	SD0018	12 *U*	12 *U*	12 *U*	24 *U*	12 *U*	12 *U*	12 *U*	24 *U*
HM05	06/26/90	SD0021	22 *T*	6.0 *E*	8.0 *E*	16 *T*	5.0 *N*	16 *NT*	8.0 *U*	16 *U*
HM07	06/26/90	SD0025	69 *T*	25 *T*	43 *T*	60 *T*	20 *T*	77 *T*	15 *U*	30 *U*
SM30	06/21/90	SD0010	47 *T*	22 *T*	26 *T*	46 *T*	18 *T*	24 *NT*	22 *U*	44 *U*
SM34	06/22/90	SD0014	62 *T*	29 *T*	30 *T*	50 *T*	31 *T*	37 *T*	20 *U*	40 *U*
SM36	06/22/90	SD0016	25 *T*	10 *T*	10 *T*	15 *T*	9.0 *T*	4.0 *N*	6.0 *U*	8.0 *NT*

TABLE A5. PHENOL AND SUBSTITUTED PHENOL DATA FOR THE 1990 REFERENCE AREA SURVEY (μg/kg, dry weight)

Station	Date	Sample	Phenol	2-Chloro-phenol	2,4-Dichloro-phenol	2,4,5-Trichloro-phenol	2,4,6-Trichloro phenol	Penta-chlorophenol	4-Chloro-3-methylphenol	2-Methyl phenol
CR02	06/19/90	SD0002	89 *T*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	17 *U*	30 *ZU*	8.0 *U*
CR20	06/19/90	SD0003	13 *NT*	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	14 *U*	23 *ZU*	7.0 *U*
CR25	06/19/90	SD0008	7.0 *NT*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	12 *U*	20 *ZU*	6.0 *U*
HH02	06/25/90	SD0018	7.0 *N*	12 *U*	12 *U*	12 *U*	12 *U*	*R*	40 *ZU*	12 *U*
HM05	06/26/90	SD0021	71 *T*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	16 *U*	20 *ZU*	8.0 *U*
HM07	06/26/90	SD0025	66 *T*	15 *U*	15 *U*	15 *U*	15 *U*	30 *U*	60 *ZU*	15 *U*
SM30	06/21/90	SD0010	46 *T*	22 *U*	22 *U*	22 *U*	22 *U*	44 *U*	43 *ZU*	22 *U*
SM34	06/22/90	SD0014	17 *E*	20 *U*	20 *U*	20 *U*	20 *U*	41 *U*	70 *ZU*	20 *U*
SM36	06/22/90	SD0016	5.0 *N*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	*R*	26 *ZU*	6.0 *U*

TABLE A5. (Continued)

Station	Date	Sample	4-Methyl phenol	2,4-Dimethyl phenol	2-methyl-4,6-dinitrophenol	2-Nitrophenol	4-Nitrophenol	2,4-Dinitrophenol
CR02	06/19/90	SD0002	1,100 *E*	28 *ZU*	17 *U*	17 *U*	17 *U*	17 *U*
CR20	06/19/90	SD0003	740	24 *ZU*	14 *U*	14 *U*	14 *U*	14 *U*
CR25	06/19/90	SD0008	100	20 *ZU*	12 *U*	12 *U*	12 *U*	12 *U*
HH02	06/25/90	SD0018	8.0 *N*	36 *ZU*	24 *U*	24 *U*	24 *U*	24 *U*
HM05	06/26/90	SD0021	500	21 *ZU*	16 *U*	16 *U*	16 *U*	16 *U*
HM07	06/26/90	SD0025	690	60 *ZU*	30 *U*	30 *U*	30 *U*	30 *U*
SM30	06/21/90	SD0010	1,200	37 *ZU*	44 *U*	44 *U*	44 *U*	44 *U*
SM34	06/22/90	SD0014	1,500	70 *ZU*	41 *U*	41 *U*	41 *U*	41 *U*
SM36	06/22/90	SD0016	100	24 *ZU*	12 *U*	12 *U*	12 *U*	12 *U*

TABLE A6. PHTHALATE DATA FOR THE 1990 REFERENCE AREA SURVEY
(μg/kg, dry weight)

Station	Date	Sample	Dimethyl phthalate	Diethyl phthalate	Di-n-butyl phthalate	Butyl benzyl phthalate	Bis(2-ethylhexyl)-phthalate	Di-n-octyl phthalate
CR02	06/19/90	SD0002	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	16 *ZU*	8.0 *U*
CR20	06/19/90	SD0003	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	13 *ZU*	7.0 *U*
CR25	06/19/90	SD0008	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	7.0 *ZU*	6.0 *U*
HH02	06/25/90	SD0018	12 *U*	12 *U*	12 *U*	12 *U*	14 *ZU*	12 *U*
HM05	06/26/90	SD0021	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *ZU*	8.0 *U*
HM07	06/26/90	SD0025	15 *U*	15 *U*	15 *U*	15 *U*	44 *ZU*	15 *U*
SM30	06/21/90	SD0010	22 *U*	22 *U*	22 *U*	280	24 *ZU*	22 *U*
SM34	06/22/90	SD0014	20 *U*	20 *U*	22 *U*	20 *U*	28 *ZU*	20 *U*
SM36	06/22/90	SD0016	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	7.0 *ZU*	6.0 *U*

TABLE A7. CHLORINATED HYDROCARBON DATA FROM THE 1990 REFERENCE AREA SURVEY
(µg/kg, dry weight)

Station	Date	Sample	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	1,2,3-Trichloro-benzene	1,2,4-Trichloro-benzene	2-Chloro-naphthalene	Hexachloro-ethane	Hexachloro-benzene	Hexachloro-butadiene	Hexachloro-cyclopentadiene
CR02	06/19/90	SD0002	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	83 *ZU*	8.0 *U*	8.0 *U*	8.0 *U*
CR20	06/19/90	SD0003	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	82 *ZU*	7.0 *U*	7.0 *U*	7.0 *U*
CR25	06/19/90	SD0008	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	73 *ZU*	6.0 *U*	6.0 *U*	6.0 *U*
HH02	06/25/90	SD0018	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*	80 *ZU*	12 *U*	12 *U*	12 *U*
HM05	06/26/90	SD0021	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	73 *ZU*	8.0 *U*	8.0 *U*	8.0 *U*
HM07	06/26/90	SD0025	15 *U*	15 *U*	15 *U*	15 *U*	15 *U*	15 *U*	130 *ZU*	15 *U*	15 *U*	15 *U*
SM30	06/21/90	SD0010	22 *U*	22 *U*	22 *U*	22 *U*	22 *U*	22 *U*	160 *ZU*	22 *U*	22 *U*	22 *U*
SM34	06/22/90	SD0014	20 *U*	20 *U*	20 *U*	20 *U*	20 *U*	20 *U*	130 *ZU*	20 *U*	20 *U*	20 *U*
SM36	06/22/90	SD0016	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	57 *ZU*	6.0 *U*	6.0 *U*	6.0 *U*

TABLE A7. (Continued)

Station	Date	Sample	Nitro-benzene	1,2-Diphenyl-hydrazine	2,4-Dini-trotoluene	2,6-Dini-trotoluene	2-Nitro-aniline	2-Nitro-aniline	4-Bromophenyl phenyl ether	4-Chloro-aniline	4-Chlorophenyl phenyl ether	4-Nitro-aniline	Bis(2-chloro-ethyl) ether	Bis(2-chloro-ethoxy)methane
CR02	06/19/90	SD0002	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	40 *U*	40 *U*	8.0 *U*	25 *U*	8.0 *U*	17 *U*	8.0 *U*	8.0 *U*
CR20	06/19/90	SD0003	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	30 *U*	30 *U*	7.0 *U*	21 *U*	7.0 *U*	14 *U*	7.0 *U*	7.0 *U*
CR25	06/19/90	SD0008	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	30 *U*	30 *U*	6.0 *U*	18 *U*	6.0 *U*	12 *U*	6.0 *U*	6.0 *U*
HH02	06/25/90	SD0018	12 *U*	12 *U*	12 *U*	12 *U*	60 *U*	60 *U*	12 *U*	35 *U*	12 *U*	24 *U*	12 *U*	12 *U*
HM05	06/26/90	SD0021	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	40 *U*	40 *U*	8.0 *U*	24 *U*	8.0 *U*	16 *U*	8.0 *U*	8.0 *U*
HM07	06/26/90	SD0025	15 *U*	15 *U*	15 *U*	15 *U*	80 *U*	80 *U*	15 *U*	46 *U*	15 *U*	30 *U*	15 *U*	15 *U*
SM30	06/21/90	SD0010	22 *U*	22 *U*	22 *U*	22 *U*	22 *U*	110 *U*	22 *U*	66 *U*	22 *U*	44 *U*	22 *U*	22 *U*
SM34	06/22/90	SD0014	20 *U*	20 *U*	20 *U*	20 *U*	100 *U*	100 *U*	20 *U*	61 *U*	20 *U*	41 *U*	20 *U*	20 *U*
SM36	06/22/90	SD0016	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	30 *U*	30 *U*	6.0 *U*	19 *U*	6.0 *U*	12 *U*	6.0 *U*	6.0 *U*

TABLE A8. MISCELLANEOUS OXYGENATED COMPOUNDS FOR THE 1990 REFERENCE AREA SURVEY (μg/kg, dry weight)

Station	Date	Sample	Benzoic Acid	Benzyl Alcohol	Carbazole	Dibenzofuran	Diphenylamine	N-Nitroso di-n-propylamine	N-nitroso diphenylamine
CR02	06/19/90	SD0002	270 *E*	40 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*
CR20	06/19/90	SD0003	180 *E*	9.0 *E*	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*	7.0 *U*
CR25	06/19/90	SD0008	180 *E*	11 *E*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*
HH02	06/25/90	SD0018	180	33 *E*	12 *U*	12 *U*	12 *U*	12 *U*	12 *U*
HM05	06/26/90	SD0021	110 *E*	40 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*	8.0 *U*
HM07	06/26/90	SD0025	210 *E*	80 *U*	15 *U*	15 *U*	15 *U*	15 *U*	15 *U*
SM30	06/21/90	SD0010	1,100 *E*	23 *E*	22 *U*	22 *U*	22 *U*	22 *U*	22 *U*
SM34	06/22/90	SD0014	200 *E*	100 *U*	20 *U*	20 *U*	20 *U*	20 *U*	20 *U*
SM36	06/22/90	SD0016	170 *E*	13 *E*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*	6.0 *U*

TABLE A9. PESTICIDE AND PCB DATA FOR THE 1990 REFERENCE AREA SURVEY ($\mu g/kg$, dry weight)

Station	Date	Sample	Hexachlorocyclo-hexane-alpha	Hexachlorocyclo-hexane-beta	Hexachlorocyclo-hexane-delta	Hexachlorocyclo-hexane-gamma	Aldrin	Alpha Chlordane	Gamma Chlordane
CR02	06/19/90	SD0002	0.30 *UG*	0.30 *UG*	2.0 *UG*	0.30 *UG*	0.30 *UG*	0.50 *UG*	0.50 *UG*
CR20	06/19/90	SD0003	0.40 *U*	0.30 *U*	3.5 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
CR25	06/19/90	SD0008	0.30 *U*	0.30 *U*	0.70 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
HH02	06/25/90	SD0018	0.30 *U*	0.30 *U*	0.70 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
HM05	06/26/90	SD0021	0.30 *U*	0.30 *U*	0.80 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
HM07	06/26/90	SD0025	0.70 *U*	0.30 *U*	0.70 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
SM30	06/21/90	SD0010	0.30 *U*	0.30 *U*	0.80 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*
SM34	06/22/90	SD0014	0.30 *U*	0.30 *U*	0.70 *U*	0.30 *U*	1.20 *U*	0.50 *U*	0.50 *U*
SM36	06/22/90	SD0016	0.30 *U*	0.30 *U*	0.70 *U*	0.30 *U*	0.30 *U*	0.50 *U*	0.50 *U*

TABLE A9. (Continued)

Station	Date	Sample	Dieldrin	Alpha Endosulfan	Beta Endosulfan	Endosulfan sulfate	Endrin	Endrin ketone	Heptachlor
CR02	06/19/90	SD0002	0.60 *UG*	0.30 *UG*	0.60 *UG*	1.0 *UG*	0.60 *UG*	0.90 *UG*	0.30 *UG*
CR20	06/19/90	SD0003	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*
CR25	06/19/90	SD0008	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*
HH02	06/25/90	SD0018	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*
HM05	06/26/90	SD0021	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*
HM07	06/26/90	SD0025	0.60 *U*	0.30 *U*	0.60 *U*	2.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*
SM30	06/21/90	SD0010	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.70 *U*
SM34	06/22/90	SD0014	0.60 *U*	0.90 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.40 *U*
SM36	06/22/90	SD0016	0.60 *U*	0.30 *U*	0.60 *U*	1.0 *U*	0.60 *U*	0.90 *U*	0.30 *U*

TABLE A9. (Continued)

Station	Date	Sample	Heptachlor epoxide	Isophorone	Methoxychlor	Total PCBs[a]	P,P'-DDD	P,P'-DDE	P,P'-DDT	Toxaphene
CR02	06/19/90	SD0002	0.40 *UG*	8.0 *U*	1.2 *UG*	6.0 *UG*	0.60 *UG*	0.60 *UG*	0.60 *UG*	30 *UG*
CR20	06/19/90	SD0003	0.50 *U*	7.0 *U*	1.2 *U*	6.0 *U*	0.60 *U*	0.60 *U*	0.60 *U*	30 *U*
CR25	06/19/90	SD0008	0.30 *U*	6.0 *U*	1.2 *U*	6.0 *U*	0.60 *U*	0.60 *U*	0.60 *U*	30 *U*
HH02	06/25/90	SD0018	0.30 *U*	12 *U*	1.2 *U*	6.0 *U*	0.60 *U*	0.60 *U*	0.60 *U*	30 *U*
HM05	06/26/90	SD0021	0.80 *U*	8.0 *U*	1.2 *U*	6.0 *U*	1.0 *U*	0.60 *U*	0.60 *U*	30 *U*
HM07	06/26/90	SD0025	0.80 *U*	15 *U*	1.2 *U*	15 *U*	0.60 *U*	1.0 *U*	0.60 *U*	30 *U*
SM30	06/21/90	SD0010	1.00 *U*	22 *U*	1.2 *U*	15 *U*	0.60 *U*	0.80 *U*	0.60 *U*	30 *U*
SM34	06/22/90	SD0014	0.30 *U*	20 *U*	1.2 *U*	6.0 *U*	0.60 *U*	0.60 *U*	0.60 *U*	30 *U*
SM36	06/22/90	SD0016	0.30 *U*	6.0 *U*	1.2 *U*	6.0 *U*	0.60 *U*	0.60 *U*	0.60 *U*	30 *U*

[a] Sum of detected polychlorinated biphenyls. When all aroclors are undetected, the lowest detection limit is used.

APPENDIX B

1990 Reference Area Survey Bioassay Data

TABLE B1. RESULTS OF AMPHIPOD MORTALITY BIOASSAY

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Percent Mortality
CR02	06/19/90	SD0002		1	1	20	15	25
CR02	06/19/90	SD0002		1	2	20	20	0
CR02	06/19/90	SD0002		1	3	20	17	15
CR02	06/19/90	SD0002		1	4	20	18	10
CR02	06/19/90	SD0002		1	5	20	18	10
CR02	06/19/90	SD0002		1	AVG	20	17.6	12
CR20	06/19/90	SD0003		1	1	20	19	5
CR20	06/19/90	SD0003		1	2	20	17	15
CR20	06/19/90	SD0003		1	3	20	17	15
CR20	06/19/90	SD0003		1	4	20	16	20
CR20	06/19/90	SD0003		1	5	20	19	5
CR20	06/19/90	SD0003		1	AVG	20	17.6	12
CR21	06/19/90	SD0004		1	1	20	17	15
CR21	06/19/90	SD0004		1	2	20	20	0
CR21	06/19/90	SD0004		1	3	20	20	0
CR21	06/19/90	SD0004		1	4	20	19	5
CR21	06/19/90	SD0004		1	5	20	18	10
CR21	06/19/90	SD0004		1	AVG	20	18.8	6
CR22	06/19/90	SD0005		1	1	20	17	15
CR22	06/19/90	SD0005		1	2	20	17	15
CR22	06/19/90	SD0005		1	3	20	20	0
CR22	06/19/90	SD0005		1	4	20	20	0
CR22	06/19/90	SD0005		1	5	20	17	15
CR22	06/19/90	SD0005		1	AVG	20	18.2	9
CR23	06/19/90	SD0006		1	1	20	17	15
CR23	06/19/90	SD0006		1	2	20	20	0
CR23	06/19/90	SD0006		1	3	20	18	10
CR23	06/19/90	SD0006		1	4	20	12	40
CR23	06/19/90	SD0006		1	5	20	20	0
CR23	06/19/90	SD0006		1	AVG	20	17.4	13
CR24	06/19/90	SD0007		1	1	20	18	10
CR24	06/19/90	SD0007		1	2	20	18	10
CR24	06/19/90	SD0007		1	3	20	16	20
CR24	06/19/90	SD0007		1	4	20	17	15
CR24	06/19/90	SD0007		1	5	20	19	5
CR24	06/19/90	SD0007		1	AVG	20	17.6	12
CR25	06/19/90	SD0008		1	1	20	18	10
CR25	06/19/90	SD0008		1	2	20	20	0
CR25	06/19/90	SD0008		1	3	20	19	5
CR25	06/19/90	SD0008		1	4	20	17	15
CR25	06/19/90	SD0008		1	5	20	19	5
CR25	06/19/90	SD0008		1	AVG	20	18.6	7
HH01	06/25/90	SD0017		3	1	20	20	0
HH01	06/25/90	SD0017		3	2	20	15	25
HH01	06/25/90	SD0017		3	3	20	16	20
HH01	06/25/90	SD0017		3	4	20	20	0
HH01	06/25/90	SD0017		3	5	20	18	10
HH01	06/25/90	SD0017		3	AVG	20	17.8	11
HH02	06/25/90	SD0018		3	1	20	16	20
HH02	06/25/90	SD0018		3	2	20	18	10
HH02	06/25/90	SD0018		3	3	20	19	5
HH02	06/25/90	SD0018		3	4	20	17	15

TABLE B1. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Percent Mortality
HH02	06/25/90	SD0018		3	5	20	19	5
HH02	06/25/90	SD0018		3	AVG	20	17.8	11
HM03	06/25/90	SD0019		3	1	20	19	5
HM03	06/25/90	SD0019		3	2	20	20	0
HM03	06/25/90	SD0019		3	3	20	19	5
HM03	06/25/90	SD0019		3	4	20	20	0
HM03	06/25/90	SD0019		3	5	20	20	0
HM03	06/25/90	SD0019		3	AVG	20	19.6	2
HM04	06/26/90	SD0020		3	1	20	20	0
HM04	06/26/90	SD0020		3	2	20	19	5
HM04	06/26/90	SD0020		3	3	20	18	10
HM04	06/26/90	SD0020		3	4	20	20	0
HM04	06/26/90	SD0020		3	5	20	20	0
HM04	06/26/90	SD0020		3	AVG	20	19.4	3
HM05	06/26/90	SD0021	1	3	1	20	18	10
HM05	06/26/90	SD0021	1	3	2	20	18	10
HM05	06/26/90	SD0021	1	3	3	20	20	0
HM05	06/26/90	SD0021	1	3	4	20	16	20
HM05	06/26/90	SD0021	1	3	5	20	18	10
HM05	06/26/90	SD0021	1	3	AVG	20	18	10
HM06	06/26/90	SD0024		3	1	20	18	10
HM06	06/26/90	SD0024		3	2	20	18	10
HM06	06/26/90	SD0024		3	3	20	18	10
HM06	06/26/90	SD0024		3	4	20	19	5
HM06	06/26/90	SD0024		3	5	20	20	0
HM06	06/26/90	SD0024		3	AVG	20	18.6	7
HM07	06/26/90	SD0025		3	1	20	20	0
HM07	06/26/90	SD0025		3	2	20	20	0
HM07	06/26/90	SD0025		3	3	20	19	5
HM07	06/26/90	SD0025		3	4	20	20	0
HM07	06/26/90	SD0025		3	5	20	20	0
HM07	06/26/90	SD0025		3	AVG	20	19.8	1
SM30	06/21/90	SD0010		2	1	20	19	5
SM30	06/21/90	SD0010		2	2	20	18	10
SM30	06/21/90	SD0010		2	3	20	17	15
SM30	06/21/90	SD0010		2	4	20	15	25
SM30	06/21/90	SD0010		2	5	20	19	5
SM30	06/21/90	SD0010		2	AVG	20	17.6	12
SM31	06/21/90	SD0011		2	1	20	19	5
SM31	06/21/90	SD0011		2	2	20	17	15
SM31	06/21/90	SD0011		2	3	20	19	5
SM31	06/21/90	SD0011		2	4	20	19	5
SM31	06/21/90	SD0011		2	5	20	19	5
SM31	06/21/90	SD0011		2	AVG	20	18.6	7
SM32	06/21/90	SD0012		2	1	20	17	15
SM32	06/21/90	SD0012		2	2	20	15	25
SM32	06/21/90	SD0012		2	3	20	15	25
SM32	06/21/90	SD0012		2	4	20	16	20
SM32	06/21/90	SD0012		2	5	20	18	10
SM32	06/21/90	SD0012		2	AVG	20	16.2	19
SM33	06/21/90	SD0013		2	1	20	20	0
SM33	06/21/90	SD0013		2	2	20	18	10

TABLE B1. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Percent Mortality
SM33	06/21/90	SD0013		2	3	20	16	20
SM33	06/21/90	SD0013		2	4	20	19	5
SM33	06/21/90	SD0013		2	5	20	17	15
SM33	06/21/90	SD0013		2	AVG	20	18	10
SM34	06/22/90	SD0014		2	1	20	18	10
SM34	06/22/90	SD0014		2	2	20	19	5
SM34	06/22/90	SD0014		2	3	20	18	10
SM34	06/22/90	SD0014		2	4	20	18.5	8
SM34	06/22/90	SD0014		2	5	20	20	0
SM34	06/22/90	SD0014		2	AVG	20	18.7	7
SM35	06/22/90	SD0015		2	1	20	20	0
SM35	06/22/90	SD0015		2	2	20	20	0
SM35	06/22/90	SD0015		2	3	20	17	15
SM35	06/22/90	SD0015		2	4	20	20	0
SM35	06/22/90	SD0015		2	5	20	19	5
SM35	06/22/90	SD0015		2	AVG	20	19.2	4
SM36	06/22/90	SD0016		2	1	20	20	0
SM36	06/22/90	SD0016		2	2	20	20	0
SM36	06/22/90	SD0016		2	3	20	20	0
SM36	06/22/90	SD0016		2	4	20	14	30
SM36	06/22/90	SD0016		2	5	20	19	5
SM36	06/22/90	SD0016		2	AVG	20	18.6	7
WBEACH	06/26/90	WBEACH		1	1	20	19	5
WBEACH	06/26/90	WBEACH		1	2	20	20	0
WBEACH	06/26/90	WBEACH		1	3	20	20	0
WBEACH	06/26/90	WBEACH		1	4	20	20	0
WBEACH	06/26/90	WBEACH		1	5	20	20	0
WBEACH	06/26/90	WBEACH		1	AVG	20	19.8	1
WBEACH	06/26/90	WBEACH		2	1	20	18	10
WBEACH	06/26/90	WBEACH		2	2	20	20	0
WBEACH	06/26/90	WBEACH		2	3	20	19	5
WBEACH	06/26/90	WBEACH		2	4	20	17	15
WBEACH	06/26/90	WBEACH		2	5	20	17	15
WBEACH	06/26/90	WBEACH		2	AVG	20	18.2	9
WBEACH	06/26/90	WBEACH		3	1	20	20	0
WBEACH	06/26/90	WBEACH		3	2	20	18	10
WBEACH	06/26/90	WBEACH		3	3	20	20	0
WBEACH	06/26/90	WBEACH		3	4	20	20	0
WBEACH	06/26/90	WBEACH		3	5	20	20	0
WBEACH	06/26/90	WBEACH		3	AVG	20	19.6	2

TABLE B2. RESULTS OF MICROTOX SALINE LUMINESCENCE BIOASSAY

Station	Date	Sample	Field Rep	Analytical Group	(%) Dilution	Lab Rep	Initial Luminescence	Final Luminescence	Percent Decrease	Blank-Corrected Percent Decrease[a]
CR02	06/19/90	SD0002		1	0	1	96	90	6	--
CR02	06/19/90	SD0002		1	0	2	103	98	5	--
CR02	06/19/90	SD0002		1	7.3	1	106	110	-4	-9
CR02	06/19/90	SD0002		1	7.3	2	100	104	-4	-10
CR02	06/19/90	SD0002		1	14.5	1	93	101	-9	-14
CR02	06/19/90	SD0002		1	14.5	2	102	110	-8	-13
CR02	06/19/90	SD0002		1	29.1	1	102	116	-14	-19
CR02	06/19/90	SD0002		1	29.1	2	104	115	-11	-16
CR02	06/19/90	SD0002		1	58.1	1	93	110	-18	-24
CR02	06/19/90	SD0002		1	58.1	2	97	115	-19	-24
CR02	06/19/90	SD0002		2	100	1	101	91	10	-7
CR02	06/19/90	SD0002		2	100	2	114	101	11	-6
CR20	06/19/90	SD0003		1	0	1	92	87	5	--
CR20	06/19/90	SD0003		1	0	2	106	101	5	--
CR20	06/19/90	SD0003		1	7.3	1	102	104	-2	-2
CR20	06/19/90	SD0003		1	7.3	2	97	98	-1	-1
CR20	06/19/90	SD0003		1	14.5	1	100	106	-6	-6
CR20	06/19/90	SD0003		1	14.5	2	98	105	-7	-7
CR20	06/19/90	SD0003		1	29.1	1	96	107	-11	-11
CR20	06/19/90	SD0003		1	29.1	2	108	122	-13	-13
CR20	06/19/90	SD0003		1	58.1	1	92	112	-22	-22
CR20	06/19/90	SD0003		1	58.1	2	95	116	-22	-22
CR20	06/19/90	SD0003		2	100	1	92	83	10	-7
CR20	06/19/90	SD0003		2	100	2	106	101	5	-12
CR21	06/19/90	SD0004		1	0	1	94	89	5	--
CR21	06/19/90	SD0004		1	0	2	104	103	1	--
CR21	06/19/90	SD0004		1	7.3	1	109	119	-9	-12
CR21	06/19/90	SD0004		1	7.3	2	104	114	-10	-13
CR21	06/19/90	SD0004		1	14.5	1	104	121	-16	-19
CR21	06/19/90	SD0004		1	14.5	2	105	118	-12	-16
CR21	06/19/90	SD0004		1	29.1	1	106	125	-18	-21
CR21	06/19/90	SD0004		1	29.1	2	90	110	-22	-25
CR21	06/19/90	SD0004		1	58.1	1	95	119	-25	-28
CR21	06/19/90	SD0004		1	58.1	2	95	121	-27	-31
CR21	06/19/90	SD0004		2	100	1	110	101	8	-9
CR21	06/19/90	SD0004		2	100	2	101	95	6	-11
CR22	06/19/90	SD0005		1	0	1	100	101	-1	--
CR22	06/19/90	SD0005		1	0	2	108	109	-1	--
CR22	06/19/90	SD0005		1	7.3	1	95	104	-9	-9
CR22	06/19/90	SD0005		1	7.3	2	103	113	-10	-10
CR22	06/19/90	SD0005		1	14.5	1	115	124	-8	-8
CR22	06/19/90	SD0005		1	14.5	2	121	125	-3	-3
CR22	06/19/90	SD0005		1	29.1	1	102	118	-16	-16
CR22	06/19/90	SD0005		1	29.1	2	107	120	-12	-12
CR22	06/19/90	SD0005		1	58.1	1	98	121	-23	-23
CR22	06/19/90	SD0005		1	58.1	2	111	130	-17	-17
CR22	06/19/90	SD0005		2	100	1	98	93	5	-12
CR22	06/19/90	SD0005		2	100	2	108	105	3	-14
CR23	06/19/90	SD0006		1	0	1	95	96	-1	--
CR23	06/19/90	SD0006		1	0	2	87	95	-9	--
CR23	06/19/90	SD0006		1	7.3	1	101	109	-8	-8
CR23	06/19/90	SD0006		1	7.3	2	93	111	-19	-19

TABLE B2. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	(%) Dilution	Lab Rep	Initial Luminescence	Final Luminescence	Percent Decrease	Blank-Corrected Percent Decrease
CR23	06/19/90	SD0006		1	14.5	1	95	115	-21	-21
CR23	06/19/90	SD0006		1	14.5	2	89	106	-19	-19
CR23	06/19/90	SD0006		1	29.1	1	92	111	-21	-21
CR23	06/19/90	SD0006		1	29.1	2	101	118	-17	-17
CR23	06/19/90	SD0006		1	58.1	1	98	125	-28	-28
CR23	06/19/90	SD0006		1	58.1	2	92	118	-28	-28
CR23	06/19/90	SD0006		2	100	1	126	113	10	-7
CR23	06/19/90	SD0006		2	100	2	112	104	7	-10
CR24	06/19/90	SD0007		1	0	1	98	108	-10	--
CR24	06/19/90	SD0007		1	0	2	96	98	-2	--
CR24	06/19/90	SD0007		1	7.3	1	114	115	-1	-1
CR24	06/19/90	SD0007		1	7.3	2	112	116	-4	-4
CR24	06/19/90	SD0007		1	14.5	1	93	109	-17	-17
CR24	06/19/90	SD0007		1	14.5	2	90	106	-18	-18
CR24	06/19/90	SD0007		1	29.1	1	105	119	-13	-13
CR24	06/19/90	SD0007		1	29.1	2	104	117	-13	-13
CR24	06/19/90	SD0007		1	58.1	1	85	106	-25	-25
CR24	06/19/90	SD0007		1	58.1	2	90	111	-23	-23
CR24	06/19/90	SD0007		2	100	1	105	91	13	-3
CR24	06/19/90	SD0007		2	100	2	110	96	13	-4
CR25	06/19/90	SD0008		2	0	1	94	80	15	--
CR25	06/19/90	SD0008		2	0	2	86	70	19	--
CR25	06/19/90	SD0008		2	7.3	1	92	85	8	-9
CR25	06/19/90	SD0008		2	7.3	2	78	69	12	-5
CR25	06/19/90	SD0008		2	14.5	1	78	75	4	-13
CR25	06/19/90	SD0008		2	14.5	2	64	64	0	-17
CR25	06/19/90	SD0008		2	29.1	1	72	74	-3	-20
CR25	06/19/90	SD0008		2	29.1	2	76	78	-3	-19
CR25	06/19/90	SD0008		2	58.1	1	77	85	-10	-27
CR25	06/19/90	SD0008		2	58.1	2	91	101	-11	-28
CR25	06/19/90	SD0008		2	100	1	109	99	9	-8
CR25	06/19/90	SD0008		2	100	2	112	100	11	-6
SM30	06/21/90	SD0010		3	0	1	94	85	10	--
SM30	06/21/90	SD0010		3	0	2	87	81	7	--
SM30	06/21/90	SD0010		3	7.3	1	87	86	1	-7
SM30	06/21/90	SD0010		3	7.3	2	90	88	2	-6
SM30	06/21/90	SD0010		3	14.5	1	96	96	0	-8
SM30	06/21/90	SD0010		3	14.5	2	88	88	0	-8
SM30	06/21/90	SD0010		3	29.1	1	63	69	-10	-18
SM30	06/21/90	SD0010		3	29.1	2	86	90	-5	-13
SM30	06/21/90	SD0010		3	58.1	1	94	104	-11	-19
SM30	06/21/90	SD0010		3	58.1	2	76	102	-34	-42
SM30	06/21/90	SD0010		4	100	1	91	124	-36	-39
SM30	06/21/90	SD0010		4	100	2	92	130	-41	-44
SM31	06/21/90	SD0011		3	0	1	98	88	10	--
SM31	06/21/90	SD0011		3	0	2	97	88	9	--
SM31	06/21/90	SD0011		3	7.3	1	94	89	5	-4
SM31	06/21/90	SD0011		3	7.3	2	97	93	4	-6
SM31	06/21/90	SD0011		3	14.5	1	107	106	1	-9
SM31	06/21/90	SD0011		3	14.5	2	95	94	1	-9
SM31	06/21/90	SD0011		3	29.1	1	98	101	-3	-13
SM31	06/21/90	SD0011		3	29.1	2	85	89	-5	-14

TABLE B2. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	(%) Dilution	Lab Rep	Initial Luminescence	Final Luminescence	Percent Decrease	Blank-Corrected Percent Decrease
SM31	06/21/90	SD0011		3	58.1	1	91	102	-12	-22
SM31	06/21/90	SD0011		3	58.1	2	90	97	-8	-18
SM31	06/21/90	SD0011		4	100	1	83	122	-47	-49
SM31	06/21/90	SD0011		4	100	2	88	118	-34	-37
SM32	06/21/90	SD0012		3	0	1	98	97	1	--
SM32	06/21/90	SD0012		3	0	2	109	111	-2	--
SM32	06/21/90	SD0012		3	7.3	1	89	95	-7	-7
SM32	06/21/90	SD0012		3	7.3	2	97	101	-4	-4
SM32	06/21/90	SD0012		3	14.5	1	95	105	-11	-11
SM32	06/21/90	SD0012		3	14.5	2	77	84	-9	-9
SM32	06/21/90	SD0012		3	29.1	1	91	104	-14	-14
SM32	06/21/90	SD0012		3	29.1	2	106	117	-10	-10
SM32	06/21/90	SD0012		3	58.1	1	95	113	-19	-19
SM32	06/21/90	SD0012		3	58.1	2	98	118	-20	-20
SM32	06/21/90	SD0012		4	100	1	94	129	-37	-40
SM32	06/21/90	SD0012		4	100	2	92	124	-35	-37
SM33	06/21/90	SD0013		3	0	1	95	95	0	--
SM33	06/21/90	SD0013		3	0	2	91	93	-2	--
SM33	06/21/90	SD0013		3	7.3	1	70	74	-6	-6
SM33	06/21/90	SD0013		3	7.3	2	65	71	-9	-9
SM33	06/21/90	SD0013		3	14.5	1	95	106	-12	-12
SM33	06/21/90	SD0013		3	14.5	2	95	111	-17	-17
SM33	06/21/90	SD0013		3	29.1	1	86	99	-15	-15
SM33	06/21/90	SD0013		3	29.1	2	90	104	-16	-16
SM33	06/21/90	SD0013		3	58.1	1	95	115	-21	-21
SM33	06/21/90	SD0013		3	58.1	2	89	110	-24	-24
SM33	06/21/90	SD0013		4	100	1	103	129	-25	-25
SM33	06/21/90	SD0013		4	100	2	97	120	-24	-24
SM34	06/22/90	SD0014		3	0	1	106	105	1	--
SM34	06/22/90	SD0014		3	0	2	93	96	-3	--
SM34	06/22/90	SD0014		3	7.3	1	75	86	-15	-15
SM34	06/22/90	SD0014		3	7.3	2	98	113	-15	-15
SM34	06/22/90	SD0014		3	14.5	1	99	114	-15	-15
SM34	06/22/90	SD0014		3	14.5	2	100	112	-12	-12
SM34	06/22/90	SD0014		3	29.1	1	107	123	-15	-15
SM34	06/22/90	SD0014		3	29.1	2	104	120	-15	-15
SM34	06/22/90	SD0014		3	58.1	1	101	126	-25	-25
SM34	06/22/90	SD0014		3	58.1	2	94	115	-22	-22
SM34	06/22/90	SD0014		4	100	1	109	131	-20	-20
SM34	06/22/90	SD0014		4	100	2	110	129	-17	-17
SM35	06/22/90	SD0015		4	0	1	92	88	4	--
SM35	06/22/90	SD0015		4	0	2	103	108	-5	--
SM35	06/22/90	SD0015		4	7.3	1	87	92	-6	-6
SM35	06/22/90	SD0015		4	7.3	2	105	112	-7	-7
SM35	06/22/90	SD0015		4	14.5	1	91	100	-10	-10
SM35	06/22/90	SD0015		4	14.5	2	95	105	-11	-11
SM35	06/22/90	SD0015		4	29.1	1	95	109	-15	-15
SM35	06/22/90	SD0015		4	29.1	2	96	107	-11	-11
SM35	06/22/90	SD0015		4	58.1	1	89	109	-22	-22
SM35	06/22/90	SD0015		4	58.1	2	99	117	-18	-18
SM35	06/22/90	SD0015		4	100	1	100	122	-22	-22
SM35	06/22/90	SD0015		4	100	2	95	136	-43	-43

TABLE B2. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	(%) Dilution	Lab Rep	Initial Luminescence	Final Luminescence	Percent Decrease	Blank-Corrected Percent Decrease
SM36	06/22/90	SD0016		5	0	1	94	96	-2	--
SM36	06/22/90	SD0016		5	0	2	105	107	-2	--
SM36	06/22/90	SD0016		5	7.3	1	97	110	-13	-13
SM36	06/22/90	SD0016		5	7.3	2	98	109	-11	-11
SM36	06/22/90	SD0016		5	14.5	1	103	111	-8	-8
SM36	06/22/90	SD0016		5	14.5	2	95	108	-14	-14
SM36	06/22/90	SD0016		5	29.1	1	103	120	-17	-17
SM36	06/22/90	SD0016		5	29.1	2	96	110	-15	-15
SM36	06/22/90	SD0016		5	58.1	1	101	117	-16	-16
SM36	06/22/90	SD0016		5	58.1	2	99	118	-19	-19
SM36	06/22/90	SD0016		6	100	1	109	195	-79	-79
SM36	06/22/90	SD0016		6	100	2	92	192	-109	-109
HH01	06/25/90	SD0017		5	0	1	94	96	-2	--
HH01	06/25/90	SD0017		5	0	2	94	96	-2	--
HH01	06/25/90	SD0017		5	7.3	1	92	100	-9	-9
HH01	06/25/90	SD0017		5	7.3	2	96	102	-6	-6
HH01	06/25/90	SD0017		5	14.5	1	95	105	-11	-11
HH01	06/25/90	SD0017		5	14.5	2	93	103	-11	-11
HH01	06/25/90	SD0017		5	29.1	1	91	103	-13	-13
HH01	06/25/90	SD0017		5	29.1	2	96	108	-13	-13
HH01	06/25/90	SD0017		5	58.1	1	87	101	-16	-16
HH01	06/25/90	SD0017		5	58.1	2	93	108	-16	-16
HH01	06/25/90	SD0017		6	100	1	86	164	-91	-91
HH01	06/25/90	SD0017		6	100	2	83	171	-106	-106
HH02	06/25/90	SD0018		5	0	1	96	94	2	--
HH02	06/25/90	SD0018		5	0	2	100	99	1	--
HH02	06/25/90	SD0018		5	7.3	1	95	102	-7	-9
HH02	06/25/90	SD0018		5	7.3	2	95	100	-5	-7
HH02	06/25/90	SD0018		5	14.5	1	86	96	-12	-13
HH02	06/25/90	SD0018		5	14.5	2	86	98	-14	-15
HH02	06/25/90	SD0018		5	29.1	1	85	102	-20	-22
HH02	06/25/90	SD0018		5	29.1	2	74	87	-18	-19
HH02	06/25/90	SD0018		5	58.1	1	89	106	-19	-21
HH02	06/25/90	SD0018		5	58.1	2	90	106	-18	-19
HH02	06/25/90	SD0018		6	100	1	118	190	-61	-61
HH02	06/25/90	SD0018		6	100	2	115	200	-74	-74
HM03	06/25/90	SD0019		5	0	1	90	90	0	--
HM03	06/25/90	SD0019		5	0	2	95	96	-1	--
HM03	06/25/90	SD0019		5	7.3	1	90	99	-10	-10
HM03	06/25/90	SD0019		5	7.3	2	89	96	-8	-8
HM03	06/25/90	SD0019		5	14.5	1	89	100	-12	-12
HM03	06/25/90	SD0019		5	14.5	2	87	98	-13	-13
HM03	06/25/90	SD0019		5	29.1	1	85	99	-16	-16
HM03	06/25/90	SD0019		5	29.1	2	92	105	-14	-14
HM03	06/25/90	SD0019		5	58.1	1	4	5	-25	-25
HM03	06/25/90	SD0019		5	58.1	2	90	108	-20	-20
HM03	06/25/90	SD0019		6	100	1	111	200	-80	-80
HM03	06/25/90	SD0019		6	100	2	109	193	-77	-77
HM04	06/26/90	SD0020		7	0	1	96	94	2	--
HM04	06/26/90	SD0020		7	0	2	92	90	2	--
HM04	06/26/90	SD0020		7	7.3	1	93	94	-1	-3
HM04	06/26/90	SD0020		7	7.3	2	98	100	-2	-4

TABLE B2. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	(%) Dilution	Lab Rep	Initial Luminescence	Final Luminescence	Percent Decrease	Blank-Corrected Percent Decrease
HM04	06/26/90	SD0020		7	14.5	1	96	100	-4	-6
HM04	06/26/90	SD0020		7	14.5	2	94	100	-6	-9
HM04	06/26/90	SD0020		7	29.1	1	90	100	-11	-13
HM04	06/26/90	SD0020		7	29.1	2	90	99	-10	-12
HM04	06/26/90	SD0020		7	58.1	1	91	102	-12	-14
HM04	06/26/90	SD0020		7	58.1	2	94	105	-12	-14
HM04	06/26/90	SD0020		7	100	1	69	200	-190	-192
HM04	06/26/90	SD0020		7	100	2	78	200	-156	-159
HM05	06/26/90	SD0021	1	4	0	1	96	95	1	--
HM05	06/26/90	SD0021	1	4	0	2	131	126	4	--
HM05	06/26/90	SD0021	1	4	7.3	1	122	130	-7	-9
HM05	06/26/90	SD0021	1	4	7.3	2	123	132	-7	-10
HM05	06/26/90	SD0021	1	4	14.5	1	116	135	-16	-19
HM05	06/26/90	SD0021	1	4	14.5	2	118	130	-10	-13
HM05	06/26/90	SD0021	1	4	29.1	1	88	103	-17	-19
HM05	06/26/90	SD0021	1	4	29.1	2	127	142	-12	-14
HM05	06/26/90	SD0021	1	4	58.1	1	95	118	-24	-27
HM05	06/26/90	SD0021	1	4	58.1	2	121	142	-17	-20
HM05	06/26/90	SD0021	1	4	100	1	101	133	-32	-34
HM05	06/26/90	SD0021	1	4	100	2	92	136	-48	-50
HM06	06/26/90	SD0024		6	0	1	91	98	-8	--
HM06	06/26/90	SD0024		6	0	2	92	97	-5	--
HM06	06/26/90	SD0024		6	7.3	1	91	105	-15	-15
HM06	06/26/90	SD0024		6	7.3	2	88	104	-18	-18
HM06	06/26/90	SD0024		6	14.5	1	85	104	-22	-22
HM06	06/26/90	SD0024		6	14.5	2	85	105	-24	-24
HM06	06/26/90	SD0024		6	29.1	1	85	109	-28	-28
HM06	06/26/90	SD0024		6	29.1	2	87	111	-28	-28
HM06	06/26/90	SD0024		6	58.1	1	87	113	-30	-30
HM06	06/26/90	SD0024		6	58.1	2	81	105	-30	-30
HM06	06/26/90	SD0024		6	100	1	116	192	-66	-66
HM06	06/26/90	SD0024		6	100	2	116	200	-72	-72
HM07	06/26/90	SD0025		6	0	1	94	94	0	--
HM07	06/26/90	SD0025		6	0	2	93	95	-2	--
HM07	06/26/90	SD0025		6	7.3	1	97	105	-8	-8
HM07	06/26/90	SD0025		6	7.3	2	89	98	-10	-10
HM07	06/26/90	SD0025		6	14.5	1	95	104	-9	-9
HM07	06/26/90	SD0025		6	14.5	2	93	104	-12	-12
HM07	06/26/90	SD0025		6	29.1	1	98	110	-12	-12
HM07	06/26/90	SD0025		6	29.1	2	104	115	-11	-11
HM07	06/26/90	SD0025		6	58.1	1	97	115	-19	-19
HM07	06/26/90	SD0025		6	58.1	2	103	117	-14	-14
HM07	06/26/90	SD0025		6	100	1	112	200	-79	-79
HM07	06/26/90	SD0025		6	100	2	119	200	-68	-68

[a]Blank corrected values are calculated as the observed percent decrease minus the average percent decrease of the associated blank (0 percent dilution). When the blank had an increase in luminescence, a 0 percent decrease was used for the blank correction.

Note, the 100 percent dilutions were sometimes run in a separate analytical group from the rest of the dilution series for a given sample. Therefore, the blank correction value used for the 100 percent dilution may be different from the blank correction value used for the rest of the dilution series.

TABLE B3. RESULTS OF BIVALVE LARVAE ABNORMALITY BIOASSAY

Station	Date	Sample	Analytical Group	Lab Rep	Initial Count[a]	Number of Survivors	Normal Survivors	Percent Abnormality[b]	Percent Mortality	Percent Combined[c]
CR02	06/19/90	SD0002	1	1	493.2	95	95	0	81	81
CR02	06/19/90	SD0002	1	2	493.2	85	81	5	83	84
CR02	06/19/90	SD0002	1	3	493.2	89	88	1	82	82
CR02	06/19/90	SD0002	1	4	493.2	75	71	5	85	86
CR02	06/19/90	SD0002	1	5	493.2	101	100	1	80	80
CR02	06/19/90	SD0002	1	AVG	493.2	89	87	2	82	82
CR20	06/19/90	SD0003	1	1	493.2	144	136	6	71	72
CR20	06/19/90	SD0003	1	2	493.2	129	118	9	74	76
CR20	06/19/90	SD0003	1	3	493.2	136	129	5	72	74
CR20	06/19/90	SD0003	1	4	493.2	146	143	2	70	71
CR20	06/19/90	SD0003	1	5	493.2	118	114	3	76	77
CR20	06/19/90	SD0003	1	AVG	493.2	134.6	128	5	73	74
CR21	06/19/90	SD0004	1	1	493.2	94	91	3	81	82
CR21	06/19/90	SD0004	1	2	493.2	106	105	1	79	79
CR21	06/19/90	SD0004	1	3	493.2	76	73	4	85	85
CR21	06/19/90	SD0004	1	4	493.2	75	67	11	85	86
CR21	06/19/90	SD0004	1	5	493.2	110	106	4	78	79
CR21	06/19/90	SD0004	1	AVG	493.2	92.2	88.4	4	81	82
CR22	06/19/90	SD0005	1	1	493.2	125	123	2	75	75
CR22	06/19/90	SD0005	1	2	493.2	254	241	5	48	51
CR22	06/19/90	SD0005	1	3	493.2	243	239	2	51	52
CR22	06/19/90	SD0005	1	4	493.2	205	205	0	58	58
CR22	06/19/90	SD0005	1	5	493.2	203	197	3	59	60
CR22	06/19/90	SD0005	1	AVG	493.2	206	201	2	58	59
CR23	06/19/90	SD0006	1	1	493.2	198	179	10	60	64
CR23	06/19/90	SD0006	1	2	493.2	187	186	1	62	62
CR23	06/19/90	SD0006	1	3	493.2	209	208	0	58	58
CR23	06/19/90	SD0006	1	4	493.2	231	230	0	53	53
CR23	06/19/90	SD0006	1	5	493.2	146	141	3	70	71
CR23	06/19/90	SD0006	1	AVG	493.2	194.2	188.8	3	61	62
CR24	06/19/90	SD0007	1	1	493.2	101	101	0	80	80
CR24	06/19/90	SD0007	1	2	493.2	122	120	2	75	76
CR24	06/19/90	SD0007	1	3	493.2	94	94	0	81	81
CR24	06/19/90	SD0007	1	4	493.2	116	115	1	76	77
CR24	06/19/90	SD0007	1	5	493.2	117	117	0	76	76
CR24	06/19/90	SD0007	1	AVG	493.2	110	109.4	1	78	78
CR25	06/19/90	SD0008	1	1	493.2	136	135	1	72	73
CR25	06/19/90	SD0008	1	2	493.2	102	102	0	79	79
CR25	06/19/90	SD0008	1	3	493.2	115	113	2	77	77
CR25	06/19/90	SD0008	1	4	493.2	133	131	2	73	73
CR25	06/19/90	SD0008	1	5	493.2	125	123	2	75	75
CR25	06/19/90	SD0008	1	AVG	493.2	122.2	120.8	1	75	76
HH01	06/25/90	SD0017	1	1	493.2	44	38	14	91	92
HH01	06/25/90	SD0017	1	2	493.2	53	53	0	89	89
HH01	06/25/90	SD0017	1	3	493.2	46	38	17	91	92
HH01	06/25/90	SD0017	1	4	493.2	55	50	9	89	90
HH01	06/25/90	SD0017	1	5	493.2	59	51	14	88	90
HH01	06/25/90	SD0017	1	AVG	493.2	51.4	46	11	90	91
HH02	06/25/90	SD0018	1	1	493.2	265	260	2	46	47
HH02	06/25/90	SD0018	1	2	493.2	260	247	5	47	50
HH02	06/25/90	SD0018	1	3	493.2	356	343	4	28	30
HH02	06/25/90	SD0018	1	4	493.2	256	252	2	48	49

TABLE B3 (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Normal Survivors	Percent Abnormality	Percent Mortality	Percent Combined
HH02	06/25/90	SD0018	1	5	493.2	268	265	1	46	46
HH02	06/25/90	SD0018	1	AVG	493.2	281	273.4	3	43	45
HM03	06/25/90	SD0019	1	1	493.2	325	320	2	34	35
HM03	06/25/90	SD0019	1	2	493.2	271	270	0	45	45
HM03	06/25/90	SD0019	1	3	493.2	244	240	2	51	51
HM03	06/25/90	SD0019	1	4	493.2	204	196	4	59	60
HM03	06/25/90	SD0019	1	5	493.2	214	208	3	57	58
HM03	06/25/90	SD0019	1	AVG	493.2	251.6	246.8	2	49	50
HM04	06/26/90	SD0020	1	1	493.2	168	163	3	66	67
HM04	06/26/90	SD0020	1	2	493.2	125	119	5	75	76
HM04	06/26/90	SD0020	1	3	493.2	169	149	12	66	70
HM04	06/26/90	SD0020	1	4	493.2	125	122	2	75	75
HM04	06/26/90	SD0020	1	5	493.2	99	96	3	80	81
HM04	06/26/90	SD0020	1	AVG	493.2	137.2	129.8	5	72	74
HM05	06/26/90	SD0021	1	1	493.2	100	93	7	80	81
HM05	06/26/90	SD0021	1	2	493.2	38	36	5	92	93
HM05	06/26/90	SD0021	1	3	493.2	97	92	5	80	81
HM05	06/26/90	SD0021	1	4	493.2	135	130	4	73	74
HM05	06/26/90	SD0021	1	5	493.2	186	171	8	62	65
HM05	06/26/90	SD0021	1	AVG	493.2	111.2	104.4	6	77	79
HM06	06/26/90	SD0024	1	1	493.2	84	76	10	83	85
HM06	06/26/90	SD0024	1	2	493.2	91	79	13	82	84
HM06	06/26/90	SD0024	1	3	493.2	44	41	7	91	92
HM06	06/26/90	SD0024	1	4	493.2	37	37	0	92	92
HM06	06/26/90	SD0024	1	5	493.2	77	70	9	84	86
HM06	06/26/90	SD0024	1	AVG	493.2	66.6	60.6	9	86	88
HM07	06/26/90	SD0025	1	1	493.2	146	132	10	70	73
HM07	06/26/90	SD0025	1	2	493.2	94	86	9	81	83
HM07	06/26/90	SD0025	1	3	493.2	116	114	2	76	77
HM07	06/26/90	SD0025	1	4	493.2	139	133	4	72	73
HM07	06/26/90	SD0025	1	5	493.2	72	65	10	85	87
HM07	06/26/90	SD0025	1	AVG	493.2	113.4	106	7	77	79
SM30	06/21/90	SD0010	1	1	493.2	113	111	2	77	77
SM30	06/21/90	SD0010	1	2	493.2	86	77	10	83	84
SM30	06/21/90	SD0010	1	3	493.2	84	73	13	83	85
SM30	06/21/90	SD0010	1	4	493.2	117	108	8	76	78
SM30	06/21/90	SD0010	1	5	493.2	101	100	1	80	80
SM30	06/21/90	SD0010	1	AVG	493.2	100.2	93.8	6	80	81
SM31	06/21/90	SD0011	1	1	493.2	115	113	2	77	77
SM31	06/21/90	SD0011	1	2	493.2	107	105	2	78	79
SM31	06/21/90	SD0011	1	3	493.2	115	114	1	77	77
SM31	06/21/90	SD0011	1	4	493.2	97	97	0	80	80
SM31	06/21/90	SD0011	1	5	493.2	109	108	1	78	78
SM31	06/21/90	SD0011	1	AVG	493.2	108.6	107.4	1	78	78
SM32	06/21/90	SD0012	1	1	493.2	117	108	8	76	78
SM32	06/21/90	SD0012	1	2	493.2	143	139	3	71	72
SM32	06/21/90	SD0012	1	3	493.2	134	130	3	73	74
SM32	06/21/90	SD0012	1	4	493.2	143	128	10	71	74
SM32	06/21/90	SD0012	1	5	493.2	159	150	6	68	70
SM32	06/21/90	SD0012	1	AVG	493.2	139.2	131	6	72	73
SM33	06/21/90	SD0013	1	1	493.2	85	83	2	83	83
SM33	06/21/90	SD0013	1	2	493.2	143	138	3	71	72

TABLE B3 (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Normal Survivors	Percent Abnormality	Percent Mortality	Percent Combined
SM33	06/21/90	SD0013	1	3	493.2	54	52	4	89	89
SM33	06/21/90	SD0013	1	4	493.2	130	130	0	74	74
SM33	06/21/90	SD0013	1	5	493.2	103	103	0	79	79
SM33	06/21/90	SD0013	1	AVG	493.2	103	101.2	2	79	79
SM34	06/22/90	SD0014	1	1	493.2	50	50	0	90	90
SM34	06/22/90	SD0014	1	2	493.2	98	98	0	80	80
SM34	06/22/90	SD0014	1	3	493.2	71	69	3	86	86
SM34	06/22/90	SD0014	1	4	493.2	186	183	2	62	63
SM34	06/22/90	SD0014	1	5	493.2	101	96	5	80	81
SM34	06/22/90	SD0014	1	AVG	493.2	101.2	99.2	2	79	80
SM35	06/22/90	SD0015	1	1	493.2	112	111	1	77	77
SM35	06/22/90	SD0015	1	2	493.2	145	142	2	71	71
SM35	06/22/90	SD0015	1	3	493.2	104	103	1	79	79
SM35	06/22/90	SD0015	1	4	493.2	128	123	4	74	75
SM35	06/22/90	SD0015	1	5	493.2	111	109	2	77	78
SM35	06/22/90	SD0015	1	AVG	493.2	120	117.6	2	76	76
SM36	06/22/90	SD0016	1	1	493.2	107	106	1	78	79
SM36	06/22/90	SD0016	1	2	493.2	102	98	4	79	80
SM36	06/22/90	SD0016	1	3	493.2	73	71	3	85	86
SM36	06/22/90	SD0016	1	4	493.2	132	130	2	73	74
SM36	06/22/90	SD0016	1	5	493.2	75	72	4	85	85
SM36	06/22/90	SD0016	1	AVG	493.2	97.8	95.4	2	80	81
WBEACH	06/26/90	WBEACH	1	1	493.2	616	601	2	-25	-22
WBEACH	06/26/90	WBEACH	1	2	493.2	474	466	2	4	6
WBEACH	06/26/90	WBEACH	1	3	493.2	486	480	1	1	3
WBEACH	06/26/90	WBEACH	1	4	493.2	488	475	3	1	4
WBEACH	06/26/90	WBEACH	1	5	493.2	535	532	1	-8	-8
WBEACH	06/26/90	WBEACH	1	AVG	493.2	519.8	510.8	2	-5	-4

[a] Initial value is estimated as the number of survivors in the seawater control.

[b] Abnormality measures the number of abnormal individuals relative to the total number of survivors.

[c] Combined endpoint measures the number of dead and abnormal individuals relative to the initial value.

TABLE B4 RESULTS OF ECHINODERM EMBRYO ABNORMALITY BIOASSAY

Station	Date	Sample	Analytical Group	Lab Rep	Number of Survivors	Normal Survivors	Initial Count[a]	Percent Abnormality[b]	Percent Mortality	Percent Combined[c]
CR02	06/19/90	SD0002	2	1	227	223	254.7	2	11	12
CR02	06/19/90	SD0002	2	2	247	244	254.7	1	3	4
CR02	06/19/90	SD0002	2	3	253	246	254.7	3	1	3
CR02	06/19/90	SD0002	2	4	253	246	254.7	3	1	3
CR02	06/19/90	SD0002	2	5	146	140	254.7	4	43	45
CR02	06/19/90	SD0002	2	6	162	160	254.7	1	36	37
CR02	06/19/90	SD0002	2	7	266	258	254.7	3	-4	-1
CR02	06/19/90	SD0002	2	8	239	228	254.7	5	6	10
CR02	06/19/90	SD0002	2	9	264	254	254.7	4	-4	0
CR02	06/19/90	SD0002	2	10	241	233	254.7	3	5	9
CR02	06/19/90	SD0002	2	AVG	230	223	254.7	3	10	12
CR20	06/19/90	SD0003	2	1	278	271	254.7	3	-9	-6
CR20	06/19/90	SD0003	2	2	319	314	254.7	2	-25	-23
CR20	06/19/90	SD0003	2	3	245	240	254.7	2	4	6
CR20	06/19/90	SD0003	2	4	230	224	254.7	3	10	12
CR20	06/19/90	SD0003	2	5	274	266	254.7	3	-8	-4
CR20	06/19/90	SD0003	2	6	265	256	254.7	3	-4	-1
CR20	06/19/90	SD0003	2	7	235	219	254.7	7	8	14
CR20	06/19/90	SD0003	2	8	246	235	254.7	4	3	8
CR20	06/19/90	SD0003	2	9	259	255	254.7	2	-2	0
CR20	06/19/90	SD0003	2	10	264	261	254.7	1	-4	-2
CR20	06/19/90	SD0003	2	AVG	262	254	254.7	3	-3	0
CR21	06/19/90	SD0004	2	1	257	245	254.7	5	-1	4
CR21	06/19/90	SD0004	2	2	262	257	254.7	2	-3	-1
CR21	06/19/90	SD0004	2	3	304	296	254.7	3	-19	-16
CR21	06/19/90	SD0004	2	4	300	300	254.7	0	-18	-18
CR21	06/19/90	SD0004	2	5	285	279	254.7	2	-12	-10
CR21	06/19/90	SD0004	2	6	256	251	254.7	2	-1	1
CR21	06/19/90	SD0004	2	7	278	268	254.7	4	-9	-5
CR21	06/19/90	SD0004	2	8	285	278	254.7	2	-12	-9
CR21	06/19/90	SD0004	2	9	321	315	254.7	2	-26	-24
CR21	06/19/90	SD0004	2	10	276	270	254.7	2	-8	-6
CR21	06/19/90	SD0004	2	AVG	282	276	254.7	2	-11	-8
CR22	06/19/90	SD0005	2	1	205	203	254.7	1	20	20
CR22	06/19/90	SD0005	2	2	229	227	254.7	1	10	11
CR22	06/19/90	SD0005	2	3	236	233	254.7	1	7	9
CR22	06/19/90	SD0005	2	4	267	262	254.7	2	-5	-3
CR22	06/19/90	SD0005	2	5	278	274	254.7	1	-9	-8
CR22	06/19/90	SD0005	2	6	215	208	254.7	3	16	18
CR22	06/19/90	SD0005	2	7	266	261	254.7	2	-4	-2
CR22	06/19/90	SD0005	2	8	259	252	254.7	3	-2	1
CR22	06/19/90	SD0005	2	9	265	262	254.7	1	-4	-3
CR22	06/19/90	SD0005	2	10	253	250	254.7	1	1	2
CR22	06/19/90	SD0005	2	AVG	247	243	254.7	2	3	5
CR23	06/19/90	SD0006	2	1	262	255	254.7	3	-3	0
CR23	06/19/90	SD0006	2	2	200	191	254.7	5	21	25
CR23	06/19/90	SD0006	2	3	276	270	254.7	2	-8	-6
CR23	06/19/90	SD0006	2	4	261	259	254.7	1	-2	-2
CR23	06/19/90	SD0006	2	5	283	276	254.7	2	-11	-8
CR23	06/19/90	SD0006	2	6	244	243	254.7	0	4	5
CR23	06/19/90	SD0006	2	7	260	240	254.7	8	-2	6
CR23	06/19/90	SD0006	2	8	252	243	254.7	4	1	5

TABLE B4. (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Number of Survivors	Normal Survivors	Initial Count	Percent Abnormality	Percent Mortality	Percent Combined
CR23	06/19/90	SD0006	2	9	243	236	254.7	3	5	7
CR23	06/19/90	SD0006	2	10	275	272	254.7	1	-8	-7
CR23	06/19/90	SD0006	2	AVG	256	249	254.7	3	0	2
CR24	06/19/90	SD0007	2	1	264	257	254.7	3	-4	-1
CR24	06/19/90	SD0007	2	2	284	276	254.7	3	-12	-8
CR24	06/19/90	SD0007	2	3	263	259	254.7	2	-3	-2
CR24	06/19/90	SD0007	2	4	253	247	254.7	2	1	3
CR24	06/19/90	SD0007	2	5	265	258	254.7	3	-4	-1
CR24	06/19/90	SD0007	2	6	269	266	254.7	1	-6	-4
CR24	06/19/90	SD0007	2	7	224	220	254.7	2	12	14
CR24	06/19/90	SD0007	2	8	235	228	254.7	3	8	10
CR24	06/19/90	SD0007	2	9	246	245	254.7	0	3	4
CR24	06/19/90	SD0007	2	10	246	238	254.7	3	3	7
CR24	06/19/90	SD0007	2	AVG	255	249	254.7	2	0	2
CR25	06/19/90	SD0008	2	1	261	253	254.7	3	-2	1
CR25	06/19/90	SD0008	2	2	271	255	254.7	6	-6	0
CR25	06/19/90	SD0008	2	3	277	275	254.7	1	-9	-8
CR25	06/19/90	SD0008	2	4	305	292	254.7	4	-20	-15
CR25	06/19/90	SD0008	2	5	181	176	254.7	3	29	31
CR25	06/19/90	SD0008	2	6	177	171	254.7	3	31	33
CR25	06/19/90	SD0008	2	7	251	243	254.7	3	1	5
CR25	06/19/90	SD0008	2	8	270	263	254.7	3	-6	-3
CR25	06/19/90	SD0008	2	9	256	248	254.7	3	-1	3
CR25	06/19/90	SD0008	2	10	252	243	254.7	4	1	5
CR25	06/19/90	SD0008	2	AVG	250	242	254.7	3	2	5
SM30	06/21/90	SD0010	1	1	164	159	177	3	7	10
SM30	06/21/90	SD0010	1	2	201	189	177	6	-14	-7
SM30	06/21/90	SD0010	1	3	198	187	177	6	-12	-6
SM30	06/21/90	SD0010	1	4	177	168	177	5	0	5
SM30	06/21/90	SD0010	1	5	145	135	177	7	18	24
SM30	06/21/90	SD0010	1	6	193	185	177	4	-9	-5
SM30	06/21/90	SD0010	1	7	156	150	177	4	12	15
SM30	06/21/90	SD0010	1	8	169	162	177	4	5	8
SM30	06/21/90	SD0010	1	9	164	157	177	4	7	11
SM30	06/21/90	SD0010	1	10	175	170	177	3	1	4
SM30	06/21/90	SD0010	1	AVG	174	166	177	5	2	6
SM31	06/21/90	SD0011	1	1	166	157	177	5	6	11
SM31	06/21/90	SD0011	1	2	146	144	177	1	18	19
SM31	06/21/90	SD0011	1	3	193	178	177	8	-9	-1
SM31	06/21/90	SD0011	1	4	193	188	177	3	-9	-6
SM31	06/21/90	SD0011	1	5	167	160	177	4	6	10
SM31	06/21/90	SD0011	1	6	150	141	177	6	15	20
SM31	06/21/90	SD0011	1	7	169	156	177	8	5	12
SM31	06/21/90	SD0011	1	8	184	178	177	3	-4	-1
SM31	06/21/90	SD0011	1	9	171	166	177	3	3	6
SM31	06/21/90	SD0011	1	10	161	155	177	4	9	12
SM31	06/21/90	SD0011	1	AVG	170	162	177	5	4	8
SM32	06/21/90	SD0012	1	1	92	84	177	9	48	53
SM32	06/21/90	SD0012	1	2	161	130	177	19	9	27
SM32	06/21/90	SD0012	1	3	152	137	177	10	14	23
SM32	06/21/90	SD0012	1	4	168	154	177	8	5	13
SM32	06/21/90	SD0012	1	5	161	148	177	8	9	16

TABLE B4. (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Number of Survivors	Normal Survivors	Initial Count	Percent Abnormality	Percent Mortality	Percent Combined
SM32	06/21/90	SD0012	1	6	170	152	177	11	4	14
SM32	06/21/90	SD0012	1	7	191	184	177	4	-8	-4
SM32	06/21/90	SD0012	1	8	177	172	177	3	0	3
SM32	06/21/90	SD0012	1	9	167	158	177	5	6	11
SM32	06/21/90	SD0012	1	10	146	138	177	5	18	22
SM32	06/21/90	SD0012	1	AVG	159	146	177	8	10	18
SM33	06/21/90	SD0013	1	1	144	135	177	6	19	24
SM33	06/21/90	SD0013	1	2	156	147	177	6	12	17
SM33	06/21/90	SD0013	1	3	163	158	177	3	8	11
SM33	06/21/90	SD0013	1	4	151	148	177	2	15	16
SM33	06/21/90	SD0013	1	5	174	162	177	7	2	8
SM33	06/21/90	SD0013	1	6	161	145	177	10	9	18
SM33	06/21/90	SD0013	1	7	144	136	177	6	19	23
SM33	06/21/90	SD0013	1	8	164	159	177	3	7	10
SM33	06/21/90	SD0013	1	9	173	170	177	2	2	4
SM33	06/21/90	SD0013	1	10	180	174	177	3	-2	2
SM33	06/21/90	SD0013	1	AVG	161	153	177	5	9	13
SM34	06/22/90	SD0014	1	1	157	151	177	4	11	15
SM34	06/22/90	SD0014	1	2	164	158	177	4	7	11
SM34	06/22/90	SD0014	1	3	170	158	177	7	4	11
SM34	06/22/90	SD0014	1	4	170	168	177	1	4	5
SM34	06/22/90	SD0014	1	5	193	188	177	3	-9	-6
SM34	06/22/90	SD0014	1	6	150	142	177	5	15	20
SM34	06/22/90	SD0014	1	7	184	178	177	3	-4	-1
SM34	06/22/90	SD0014	1	8	168	162	177	4	5	8
SM34	06/22/90	SD0014	1	9	140	121	177	14	21	32
SM34	06/22/90	SD0014	1	10	158	134	177	15	11	24
SM34	06/22/90	SD0014	1	AVG	165	156	177	6	7	12
SM35	06/22/90	SD0015	1	1	220	212	177	4	-24	-20
SM35	06/22/90	SD0015	1	2	155	150	177	3	12	15
SM35	06/22/90	SD0015	1	3	155	148	177	5	12	16
SM35	06/22/90	SD0015	1	4	176	167	177	5	1	6
SM35	06/22/90	SD0015	1	5	171	167	177	2	3	6
SM35	06/22/90	SD0015	1	6	164	157	177	4	7	11
SM35	06/22/90	SD0015	1	7	173	157	177	9	2	11
SM35	06/22/90	SD0015	1	8	128	111	177	13	28	37
SM35	06/22/90	SD0015	1	9	174	161	177	7	2	9
SM35	06/22/90	SD0015	1	10	169	163	177	4	5	8
SM35	06/22/90	SD0015	1	AVG	169	159	177	5	5	10
SM36	06/22/90	SD0016	1	1	204	195	177	4	-15	-10
SM36	06/22/90	SD0016	1	2	174	168	177	3	2	5
SM36	06/22/90	SD0016	1	3	175	163	177	7	1	8
SM36	06/22/90	SD0016	1	4	161	152	177	6	9	14
SM36	06/22/90	SD0016	1	5	184	173	177	6	-4	2
SM36	06/22/90	SD0016	1	6	157	153	177	3	11	14
SM36	06/22/90	SD0016	1	7	183	174	177	5	-3	2
SM36	06/22/90	SD0016	1	8	171	165	177	4	3	7
SM36	06/22/90	SD0016	1	9	176	163	177	7	1	8
SM36	06/22/90	SD0016	1	10	180	167	177	7	-2	6
SM36	06/22/90	SD0016	1	AVG	177	167	177	5	0	5
HH01	06/25/90	SD0017	1	1	160	154	177	4	10	13
HH01	06/25/90	SD0017	1	2	165	152	177	8	7	14

TABLE B4. (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Number of Survivors	Normal Survivors	Initial Count	Percent Abnormality	Percent Mortality	Percent Combined
HH01	06/25/90	SD0017	1	3	191	184	177	4	-8	-4
HH01	06/25/90	SD0017	1	4	159	149	177	6	10	16
HH01	06/25/90	SD0017	1	5	154	148	177	4	13	16
HH01	06/25/90	SD0017	1	6	159	151	177	5	10	15
HH01	06/25/90	SD0017	1	7	145	135	177	7	18	24
HH01	06/25/90	SD0017	1	8	150	143	177	5	15	19
HH01	06/25/90	SD0017	1	9	175	171	177	2	1	3
HH01	06/25/90	SD0017	1	10	161	158	177	2	9	11
HH01	06/25/90	SD0017	1	AVG	162	155	177	5	9	13
HH02	06/25/90	SD0018	1	1	172	164	177	5	3	7
HH02	06/25/90	SD0018	1	2	178	165	177	7	-1	7
HH02	06/25/90	SD0018	1	3	170	157	177	8	4	11
HH02	06/25/90	SD0018	1	4	208	199	177	4	-18	-12
HH02	06/25/90	SD0018	1	5	137	116	177	15	23	34
HH02	06/25/90	SD0018	1	6	136	119	177	13	23	33
HH02	06/25/90	SD0018	1	7	177	168	177	5	0	5
HH02	06/25/90	SD0018	1	8	162	155	177	4	8	12
HH02	06/25/90	SD0018	1	9	174	162	177	7	2	8
HH02	06/25/90	SD0018	1	10	158	148	177	6	11	16
HH02	06/25/90	SD0018	1	AVG	167	155	177	7	6	12
HM03	06/25/90	SD0019	1	1	195	187	177	4	-10	-6
HM03	06/25/90	SD0019	1	2	176	163	177	7	1	8
HM03	06/25/90	SD0019	1	3	168	159	177	5	5	10
HM03	06/25/90	SD0019	1	4	165	156	177	5	7	12
HM03	06/25/90	SD0019	1	5	135	127	177	6	24	28
HM03	06/25/90	SD0019	1	6	151	141	177	7	15	20
HM03	06/25/90	SD0019	1	7	142	128	177	10	20	28
HM03	06/25/90	SD0019	1	8	180	168	177	7	-2	5
HM03	06/25/90	SD0019	1	9	180	166	177	8	-2	6
HM03	06/25/90	SD0019	1	10	184	175	177	5	-4	1
HM03	06/25/90	SD0019	1	AVG	168	157	177	6	5	11
HM04	06/26/90	SD0020	1	1	156	150	177	4	12	15
HM04	06/26/90	SD0020	1	2	145	135	177	7	18	24
HM04	06/26/90	SD0020	1	3	132	129	177	2	25	27
HM04	06/26/90	SD0020	1	4	131	129	177	2	26	27
HM04	06/26/90	SD0020	1	5	166	157	177	5	6	11
HM04	06/26/90	SD0020	1	6	171	162	177	5	3	8
HM04	06/26/90	SD0020	1	7	171	162	177	5	3	8
HM04	06/26/90	SD0020	1	8	148	141	177	5	16	20
HM04	06/26/90	SD0020	1	9	129	124	177	4	27	30
HM04	06/26/90	SD0020	1	10	124	116	177	6	30	34
HM04	06/26/90	SD0020	1	AVG	147	141	177	5	17	21
HM05	06/26/90	SD0021	1	1	147	140	177	5	17	21
HM05	06/26/90	SD0021	1	2	161	150	177	7	9	15
HM05	06/26/90	SD0021	1	3	153	142	177	7	14	20
HM05	06/26/90	SD0021	1	4	154	146	177	5	13	18
HM05	06/26/90	SD0021	1	5	156	150	177	4	12	15
HM05	06/26/90	SD0021	1	6	148	140	177	5	16	21
HM05	06/26/90	SD0021	1	7	177	169	177	5	0	5
HM05	06/26/90	SD0021	1	8	154	139	177	10	13	21
HM05	06/26/90	SD0021	1	9	159	146	177	8	10	18
HM05	06/26/90	SD0021	1	10	153	144	177	6	14	19

TABLE B4. (Continued)

Station	Date	Sample	Analytical Group	Lab Rep	Number of Survivors	Normal Survivors	Initial Count	Percent Abnormality	Percent Mortality	Percent Combined
HM05	06/26/90	SD0021	1	AVG	156	147	177	6	12	17
HM06	06/26/90	SD0024	1	1	146	131	177	10	18	26
HM06	06/26/90	SD0024	1	2	169	165	177	2	5	7
HM06	06/26/90	SD0024	1	3	152	140	177	8	14	21
HM06	06/26/90	SD0024	1	4	159	148	177	7	10	16
HM06	06/26/90	SD0024	1	5	182	174	177	4	-3	2
HM06	06/26/90	SD0024	1	6	136	131	177	4	23	26
HM06	06/26/90	SD0024	1	7	121	113	177	7	32	36
HM06	06/26/90	SD0024	1	8	138	132	177	4	22	25
HM06	06/26/90	SD0024	1	9	176	168	177	5	1	5
HM06	06/26/90	SD0024	1	10	155	148	177	5	12	16
HM06	06/26/90	SD0024	1	AVG	153	145	177	5	13	18
HM07	06/26/90	SD0025	1	1	160	155	177	3	10	12
HM07	06/26/90	SD0025	1	2	183	175	177	4	-3	1
HM07	06/26/90	SD0025	1	3	148	144	177	3	16	19
HM07	06/26/90	SD0025	1	4	171	168	177	2	3	5
HM07	06/26/90	SD0025	1	5	159	150	177	6	10	15
HM07	06/26/90	SD0025	1	6	158	154	177	3	11	13
HM07	06/26/90	SD0025	1	7	131	122	177	7	26	31
HM07	06/26/90	SD0025	1	8	160	146	177	9	10	18
HM07	06/26/90	SD0025	1	9	85	78	177	8	52	56
HM07	06/26/90	SD0025	1	10	95	90	177	5	46	49
HM07	06/26/90	SD0025	1	AVG	145	138	177	5	18	22
WBEACH	06/26/90	WBEACH	1	1	168	164	177	2	5	7
WBEACH	06/26/90	WBEACH	1	2	172	169	177	2	3	5
WBEACH	06/26/90	WBEACH	1	3	185	179	177	3	-5	-1
WBEACH	06/26/90	WBEACH	1	4	157	154	177	2	11	13
WBEACH	06/26/90	WBEACH	1	5	176	172	177	2	1	3
WBEACH	06/26/90	WBEACH	1	6	194	191	177	2	-10	-8
WBEACH	06/26/90	WBEACH	1	7	174	167	177	4	2	6
WBEACH	06/26/90	WBEACH	1	8	178	171	177	4	-1	3
WBEACH	06/26/90	WBEACH	1	9	175	173	177	1	1	2
WBEACH	06/26/90	WBEACH	1	10	190	177	177	7	-7	0
WBEACH	06/26/90	WBEACH	1	AVG	177	172	177	3	0	3
WBEACH	06/26/90	WBEACH	2	1	213	206	254.7	3	16	19
WBEACH	06/26/90	WBEACH	2	2	215	210	254.7	2	16	18
WBEACH	06/26/90	WBEACH	2	3	267	254	254.7	5	-5	0
WBEACH	06/26/90	WBEACH	2	4	249	245	254.7	2	2	4
WBEACH	06/26/90	WBEACH	2	5	264	252	254.7	5	-4	1
WBEACH	06/26/90	WBEACH	2	6	244	240	254.7	2	4	6
WBEACH	06/26/90	WBEACH	2	7	286	266	254.7	7	-12	-4
WBEACH	06/26/90	WBEACH	2	8	281	266	254.7	5	-10	-4
WBEACH	06/26/90	WBEACH	2	9	169	161	254.7	5	34	37
WBEACH	06/26/90	WBEACH	2	10	176	174	254.7	1	31	32
WBEACH	06/26/90	WBEACH	2	AVG	236	227	254.7	4	7	11

[a] Initial value is estimated as the number of survivors in the seawater control.

[b] Abnormality measures the number of abnormal individuals relative to the total number of survivors.

[c] Combined endpoint measures the number of dead and abnormal individuals relative to the initial value.

TABLE B5. RESULTS OF NEANTHES BIOMASS BIOASSAY

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Initial Biomass[a]	Final Biomass	Percent Mortality	Change in Biomass[b]
CR02	06/19/90	SD0002		1	1	5	5	7.4	92.5	0	-28
CR02	06/19/90	SD0002		1	2	5	4	7.4	78.4	20	-9
CR02	06/19/90	SD0002		1	3	5	5	7.4	96.7	0	-34
CR02	06/19/90	SD0002		1	4	5	5	7.4	91.9	0	-28
CR02	06/19/90	SD0002		1	5	5	5	7.4	66.9	0	7
CR02	06/19/90	SD0002		1	AVG	5	4.8	7.4	85.3	4	-18
CR20	06/19/90	SD0003		1	1	5	5	7.4	80.9	0	-12
CR20	06/19/90	SD0003		1	2	5	5	7.4	68.8	0	4
CR20	06/19/90	SD0003		1	3	5	5	7.4	101	0	-40
CR20	06/19/90	SD0003		1	4	5	5	7.4	72.7	0	-1
CR20	06/19/90	SD0003		1	5	5	5	7.4	57.5	0	20
CR20	06/19/90	SD0003		1	AVG	5	5	7.4	76.1	0	-6
CR21	06/19/90	SD0004		1	1	5	5	7.4	65.5	0	9
CR21	06/19/90	SD0004		1	2	5	5	7.4	84.7	0	-18
CR21	06/19/90	SD0004		1	3	5	4	7.4	71.5	20	1
CR21	06/19/90	SD0004		1	4	5	5	7.4	83.3	0	-16
CR21	06/19/90	SD0004		1	5	5	5	7.4	83.9	0	-16
CR21	06/19/90	SD0004		1	AVG	5	4.8	7.4	77.8	4	-8
CR22	06/19/90	SD0005		1	1	5	5	7.4	57.2	0	21
CR22	06/19/90	SD0005		1	2	5	4	7.4	65.8	20	9
CR22	06/19/90	SD0005		1	3	5	5	7.4	87.0	0	-21
CR22	06/19/90	SD0005		1	4	5	5	7.4	87.1	0	-21
CR22	06/19/90	SD0005		1	5	5	5	7.4	91.5	0	-27
CR22	06/19/90	SD0005		1	AVG	5	4.8	7.4	77.7	4	-8
CR23	06/19/90	SD0006		1	1	5	5	7.4	88.3	0	-23
CR23	06/19/90	SD0006		1	2	5	5	7.4	71.8	0	0
CR23	06/19/90	SD0006		1	3	5	4	7.4	80.3	20	-11
CR23	06/19/90	SD0006		1	4	5	5	7.4	68.7	0	5
CR23	06/19/90	SD0006		1	5	5	5	7.4	105	0	-46
CR23	06/19/90	SD0006		1	AVG	5	4.8	7.4	82.8	4	-15
CR24	06/19/90	SD0007		1	1	5	5	7.4	77.8	0	-8
CR24	06/19/90	SD0007		1	2	5	5	7.4	94.6	0	-31
CR24	06/19/90	SD0007		1	3	5	5	7.4	77.9	0	-8
CR24	06/19/90	SD0007		1	4	5	5	7.4	68.5	0	5
CR24	06/19/90	SD0007		1	5	5	5	7.4	67.8	0	6
CR24	06/19/90	SD0007		1	AVG	5	5	7.4	77.3	0	-7
CR25	06/19/90	SD0008		1	1	5	5	7.4	79.1	0	-10
CR25	06/19/90	SD0008		1	2	5	5	7.4	74.4	0	-3
CR25	06/19/90	SD0008		1	3	5	5	7.4	73.5	0	-2
CR25	06/19/90	SD0008		1	4	5	5	7.4	60.2	0	16
CR25	06/19/90	SD0008		1	5	5	5	7.4	71.9	0	0
CR25	06/19/90	SD0008		1	AVG	5	5	7.4	71.8	0	0
HH01	06/25/90	SD0017		2	1	5	2	1.8	29.3	60	61
HH01	06/25/90	SD0017		2	2	5	0	1.8	0.0	100	100
HH01	06/25/90	SD0017		2	3	5	0	1.8	0.0	100	100
HH01	06/25/90	SD0017		2	4	5	5	1.8	89.1	0	-18
HH01	06/25/90	SD0017		2	5	5	5	1.8	74.5	0	2
HH01	06/25/90	SD0017		2	AVG	5	2.4	1.8	38.6	52	49
HH02	06/25/90	SD0018		2	1	5	5	1.8	92.5	0	-22
HH02	06/25/90	SD0018		2	2	5	0	1.8	0.0	100	100
HH02	06/25/90	SD0018		2	3	5	0	1.8	0.0	100	100
HH02	06/25/90	SD0018		2	4	5	5	1.8	62.9	0	17

TABLE B5. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Initial Biomass[a]	Final Biomass	Percent Mortality	Change in Biomass[b]
HH02	06/25/90	SD0018		2	5	5	5	1.8	60.1	0	21
HH02	06/25/90	SD0018		2	AVG	5	3	1.8	43.1	40	43
HM03	06/25/90	SD0019		2	1	5	5	1.8	112	0	-47
HM03	06/25/90	SD0019		2	2	5	5	1.8	43.2	0	43
HM03	06/25/90	SD0019		2	3	5	5	1.8	56.2	0	26
HM03	06/25/90	SD0019		2	4	5	5	1.8	54.6	0	28
HM03	06/25/90	SD0019		2	5	5	5	1.8	69.2	0	9
HM03	06/25/90	SD0019		2	AVG	5	5	1.8	67.0	0	12
HM04	06/26/90	SD0020		2	1	5	5	1.8	93.7	0	-24
HM04	06/26/90	SD0020		2	2	5	4	1.8	67.4	20	11
HM04	06/26/90	SD0020		2	3	5	5	1.8	76.6	0	-1
HM04	06/26/90	SD0020		2	4	5	5	1.8	91.5	0	-21
HM04	06/26/90	SD0020		2	5	5	5	1.8	58.1	0	23
HM04	06/26/90	SD0020		2	AVG	5	4.8	1.8	77.5	4	-2
HM05	06/26/90	SD0021	1	2	1	5	5	1.8	103	0	-36
HM05	06/26/90	SD0021	1	2	2	5	5	1.8	78.0	0	-3
HM05	06/26/90	SD0021	1	2	3	5	5	1.8	92.9	0	-23
HM05	06/26/90	SD0021	1	2	4	5	5	1.8	81.6	0	-8
HM05	06/26/90	SD0021	1	2	5	5	5	1.8	64.7	0	15
HM05	06/26/90	SD0021	1	2	AVG	5	5	1.8	84.1	0	-11
HM06	06/26/90	SD0024		2	1	5	5	1.8	72.9	0	4
HM06	06/26/90	SD0024		2	2	5	5	1.8	79.6	0	-5
HM06	06/26/90	SD0024		2	3	5	4	1.8	68.0	20	10
HM06	06/26/90	SD0024		2	4	5	5	1.8	91.1	0	-20
HM06	06/26/90	SD0024		2	5	5	5	1.8	58.8	0	22
HM06	06/26/90	SD0024		2	AVG	5	4.8	1.8	74.1	4	2
HM07	06/26/90	SD0025		2	1	5	5	1.8	58.7	0	23
HM07	06/26/90	SD0025		2	2	5	5	1.8	87.2	0	-15
HM07	06/26/90	SD0025		2	3	5	5	1.8	63.3	0	17
HM07	06/26/90	SD0025		2	4	5	5	1.8	89.1	0	-18
HM07	06/26/90	SD0025		2	5	5	5	1.8	60.5	0	20
HM07	06/26/90	SD0025		2	AVG	5	5	1.8	71.8	0	5
SM30	06/21/90	SD0010		2	1	5	5	1.8	62.9	0	17
SM30	06/21/90	SD0010		2	2	5	5	1.8	62.7	0	17
SM30	06/21/90	SD0010		2	3	5	5	1.8	70.0	0	8
SM30	06/21/90	SD0010		2	4	5	5	1.8	78.1	0	-3
SM30	06/21/90	SD0010		2	5	5	5	1.8	49.6	0	35
SM30	06/21/90	SD0010		2	AVG	5	5	1.8	64.7	0	15
SM31	06/21/90	SD0011		2	1	5	5	1.8	61.0	0	20
SM31	06/21/90	SD0011		2	2	5	5	1.8	52.3	0	31
SM31	06/21/90	SD0011		2	3	5	5	1.8	81.0	0	-7
SM31	06/21/90	SD0011		2	4	5	4	1.8	50.9	20	33
SM31	06/21/90	SD0011		2	5	5	5	1.8	74.6	0	2
SM31	06/21/90	SD0011		2	AVG	5	4.8	1.8	64.0	4	16
SM32	06/21/90	SD0012		2	1	5	5	1.8	66.7	0	12
SM32	06/21/90	SD0012		2	2	5	5	1.8	71.2	0	6
SM32	06/21/90	SD0012		2	3	5	5	1.8	90.7	0	-20
SM32	06/21/90	SD0012		2	4	5	5	1.8	81.2	0	-7
SM32	06/21/90	SD0012		2	5	5	5	1.8	59.2	0	22
SM32	06/21/90	SD0012		2	AVG	5	5	1.8	73.8	0	3
SM33	06/21/90	SD0013		2	1	5	5	1.8	104	0	-37
SM33	06/21/90	SD0013		2	2	5	5	1.8	77.6	0	-2

TABLE B5. (Continued)

Station	Date	Sample	Field Rep	Analytical Group	Lab Rep	Initial Count	Number of Survivors	Initial Biomass[a]	Final Biomass	Percent Mortality	Change in Biomass[b]
SM33	06/21/90	SD0013		2	3	5	5	1.8	52.1	0	31
SM33	06/21/90	SD0013		2	4	5	5	1.8	75.4	0	1
SM33	06/21/90	SD0013		2	5	5	5	1.8	72.1	0	5
SM33	06/21/90	SD0013		2	AVG	5	5	1.8	76.3	0	-1
SM34	06/22/90	SD0014		2	1	5	5	1.8	74.2	0	2
SM34	06/22/90	SD0014		2	2	5	5	1.8	70.7	0	7
SM34	06/22/90	SD0014		2	3	5	5	1.8	89.6	0	-18
SM34	06/22/90	SD0014		2	4	5	5	1.8	73.0	0	4
SM34	06/22/90	SD0014		2	5	5	5	1.8	69.0	0	9
SM34	06/22/90	SD0014		2	AVG	5	5	1.8	75.3	0	1
SM35	06/22/90	SD0015		2	1	5	5	1.8	49.9	0	34
SM35	06/22/90	SD0015		2	2	5	5	1.8	91.4	0	-21
SM35	06/22/90	SD0015		2	3	5	5	1.8	88.2	0	-16
SM35	06/22/90	SD0015		2	4	5	5	1.8	85.0	0	-12
SM35	06/22/90	SD0015		2	5	5	5	1.8	58.9	0	22
SM35	06/22/90	SD0015		2	AVG	5	5	1.8	74.7	0	2
SM36	06/22/90	SD0016		2	1	5	5	1.8	85.9	0	-13
SM36	06/22/90	SD0016		2	2	5	5	1.8	82.9	0	-9
SM36	06/22/90	SD0016		2	3	5	5	1.8	72.2	0	5
SM36	06/22/90	SD0016		2	4	5	5	1.8	47.3	0	38
SM36	06/22/90	SD0016		2	5	5	5	1.8	84.7	0	-12
SM36	06/22/90	SD0016		2	AVG	5	5	1.8	74.6	0	2
WBEACH	06/26/90	WBEACH		1	1	5	5	7.4	55.3	0	23
WBEACH	06/26/90	WBEACH		1	2	5	5	7.4	74.8	0	-4
WBEACH	06/26/90	WBEACH		1	3	5	5	7.4	76.4	0	-6
WBEACH	06/26/90	WBEACH		1	4	5	5	7.4	84.2	0	-17
WBEACH	06/26/90	WBEACH		1	5	5	5	7.4	69.5	0	4
WBEACH	06/26/90	WBEACH		1	AVG	5	5	7.4	72.0	0	0
WBEACH	06/26/90	WBEACH		2	1	5	0	1.8	0.0	100	100
WBEACH	06/26/90	WBEACH		2	2	5	5	1.8	107	0	-41
WBEACH	06/26/90	WBEACH		2	3	5	5	1.8	125	0	-65
WBEACH	06/26/90	WBEACH		2	4	5	5	1.8	73.5	0	3
WBEACH	06/26/90	WBEACH		2	5	5	5	1.8	74.0	0	2
WBEACH	06/26/90	WBEACH		2	AVG	5	4	1.8	75.8	20	0

[a] Biomass is reported as the average individual biomass per worm in milligrams, dry weight.

[b] Change in biomass is calculated as the percent decrease relative to the final biomass in the appropriate West Beach control.

APPENDIX C

Survey Locations

TABLE C1. PUGET SOUND REFERENCE AREA SURVEY SURVEY LOCATIONS

	Latitude			Longitude		
Station	Deg.	Min.	Sec.	Deg.	Min.	Sec.
CR02	47	20	5	122	39	51
CR20	47	19	55	122	40	14
CR21	47	19	52	122	40	44
CR22	47	19	54	122	40	37
CR23	47	19	55	122	40	34
CR24	47	19	55	122	40	25
CR25	47	19	13	122	41	38
HH01	48	6	7	122	33	4
HH02	48	6	24	122	33	49
HM03	48	6	20	122	33	31
HM04	48	1	59	122	30	53
HM05	48	1	59	122	30	58
HM06	48	1	53	122	31	13
HM07	48	7	17	122	31	15
SM30	48	34	59	122	31	43
SM31	48	34	58	122	32	21
SM32	48	34	56	122	32	6
SM33	48	34	55	122	32	4
SM34	48	34	56	122	32	10
SM35	48	34	55	122	32	5
SM36	48	34	54	122	32	8

APPENDIX D

Historical Data

TABLE D1. CONVENTIONALS DATA FOR HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENT SAMPLES (mg/kg unless otherwise noted, dry weight)

Survey	Station	Date	Sample	Percent Clay	Percent Rocks	Percent Sand	Percent Silt	Percent Fines (Clay + Silt)	Sulfides	Total Organic Carbon (percent)	Total Volatile Solids (percent)	Total Solids [a]
BARRICK	DBE	01/01/76	DBE	--	--	--	--	--	--	3.5	--	--
CBMSQS	CR-11	01/01/84	CR-11	0	0.36	95	4.3	4.3	5.8 *E*	0.4	0.90	76
CBMSQS	CR-12	01/01/84	CR-12	0	0.11	87	13	13	0.7 *U*	0.3	1.0	76
CBMSQS	CR-13	01/01/84	CR-13	0	0.09	92	7.7	7.7	2.2 *E*	0.2	0.77	77
CBMSQS	CR-14	01/01/84	CR-14	2.7	0.05	77	20	23	2.6 *E*	0.4	1.2	74
CBPRELIM	CR-03	03/01/84	CR-03	4.2	0.01	81	15	19	1.0 *U*	0.5 *M*	1.3	71
CBPRELIM	CR-04	03/01/84	CR-04	0	0	92	8.4	8.4	1.4 *U*	0.3 *M*	1.3	72
DUWRIV1	SQ-09	04/19/85	SQ-09	69	--	--	4.5	73	--	1.4	7.6	--
EIGHTBAY	DB-01	05/22/84	DB-01	7.8	--	--	12	20	--	0.8	4.1	--
EIGHTBAY	DB-05	05/22/84	DB-05	10	--	--	13	24	--	1.4	5.5	--
EIGHTBAY	DB-07	05/22/84	DB-07	25	--	--	25	49	--	2.1	7.7	--
EIGHTBAY	DB1	09/10/83	DB1	--	--	--	--	80	--	--	--	--
EIGHTBAY	DB14	09/09/83	DB14	--	--	--	--	97	--	--	--	--
EIGHTBAY	DB-15	05/22/84	DB-15	40	--	--	49	90	--	2.7	13	--
EIGHTBAY	DB15	09/09/83	DB15	--	--	--	--	94	--	--	--	--
EIGHTBAY	DB16	09/09/83	DB16	--	--	--	--	98	--	--	--	--
EIGHTBAY	DB17	09/08/83	DB17	--	--	--	--	9.4	--	--	--	--
EIGHTBAY	DB18	09/08/83	DB18	--	--	--	--	30	--	--	--	--
EIGHTBAY	DB19	09/08/83	DB19	--	--	--	--	43	--	--	--	--
EIGHTBAY	DB2	09/10/83	DB2	--	--	--	--	98	--	--	--	--
EIGHTBAY	DB20	09/08/83	DB20	--	--	--	--	5.2	--	--	--	--
EIGHTBAY	DB21	09/08/83	DB21	--	--	--	--	14	--	--	--	--
EIGHTBAY	DB22	09/08/83	DB22	--	--	--	--	2.4	--	--	--	--
EIGHTBAY	DB23	09/09/83	DB23	--	--	--	--	2.2	--	--	--	--
EIGHTBAY	DB24	09/09/83	DB24	--	--	--	--	3.2	--	--	--	--
EIGHTBAY	DB25	09/09/83	DB25	--	--	--	--	2.7	--	--	--	--
EIGHTBAY	DB26	09/09/83	DB26	--	--	--	--	4.5	--	--	--	--
EIGHTBAY	DB3	09/10/83	DB3	--	--	--	--	99	--	--	--	--
EIGHTBAY	DB4	09/10/83	DB4	--	--	--	--	91	--	--	--	--
EIGHTBAY	DB5	09/10/83	DB5	--	--	--	--	32	--	--	--	--
EIGHTBAY	DB6	09/10/83	DB6	--	--	--	--	46	--	--	--	--
EIGHTBAY	DB7	09/10/83	DB7	--	--	--	--	83	--	--	--	--
EIGHTBAY	SM-01	04/24/84	SM-01	20	--	--	62	81	--	1.3	5.7	--
EIGHTBAY	SM-03	04/24/84	SM-03	26	--	--	55	81	--	1.9	7.5	--
EIGHTBAY	SM-07	04/24/84	SM-07	27	--	--	58	85	--	1.3	6.1	--
EIGHTBAY	SM1	08/06/83	SM1	--	--	--	--	88	--	--	--	--

TABLE D1. (Continued)

Survey	Station	Date	Sample	Percent Clay	Percent Rocks	Percent Sand	Percent Silt	Percent Fines (Clay + Silt)	Sulfides	Total Organic Carbon (percent)	Total Volatile Solids (percent)	Total Solids [a]
EIGHTBAY	SM10	08/08/83	SM10	--	--	--	--	93	--	--	--	--
EIGHTBAY	SM11	08/08/83	SM11	--	--	--	--	23	--	--	--	--
EIGHTBAY	SM12	08/08/83	SM12	--	--	--	--	25	--	--	--	--
EIGHTBAY	SM13	08/09/83	SM13	--	--	--	--	4.8	--	--	--	--
EIGHTBAY	SM14	08/09/83	SM14	--	--	--	--	4.1	--	--	--	--
EIGHTBAY	SM15	08/09/83	SM15	--	--	--	--	7.5	--	--	--	--
EIGHTBAY	SM16	08/09/83	SM16	--	--	--	--	89	--	--	--	--
EIGHTBAY	SM17	08/09/83	SM17	--	--	--	--	6.0	--	--	--	--
EIGHTBAY	SM18	08/09/83	SM18	--	--	--	--	93	--	--	--	--
EIGHTBAY	SM19	08/09/83	SM19	--	--	--	--	94	--	--	--	--
EIGHTBAY	SM2	08/06/83	SM2	--	--	--	--	94	--	--	--	--
EIGHTBAY	SM−20	04/24/84	SM−20	26	--	--	61	87	--	1.4	6.6	--
EIGHTBAY	SM20	08/09/83	SM20	--	--	--	--	78	--	--	--	--
EIGHTBAY	SM3	08/06/83	SM3	--	--	--	--	47	--	--	--	--
EIGHTBAY	SM4	08/06/83	SM4	--	--	--	--	97	--	--	--	--
EIGHTBAY	SM5	08/08/83	SM5	--	--	--	--	73	--	--	--	--
EIGHTBAY	SM6	08/08/83	SM6	--	--	--	--	95	--	--	--	--
EIGHTBAY	SM7	08/08/83	SM7	--	--	--	--	65	--	--	--	--
EIGHTBAY	SM8	08/08/83	SM8	--	--	--	--	95	--	--	--	--
EIGHTBAY	SM9	08/08/83	SM9	--	--	--	--	98	--	--	--	--
EIGHTBAY	SQ1	08/15/83	SQ1	--	--	--	--	17	--	--	--	--
EIGHTBAY	SQ10	09/17/83	SQ10	--	--	--	--	92	--	--	--	--
EIGHTBAY	SQ11	09/17/83	SQ11	--	--	--	--	62	--	--	--	--
EIGHTBAY	SQ12	09/17/83	SQ12	--	--	--	--	27	--	--	--	--
EIGHTBAY	SQ13	09/17/83	SQ13	--	--	--	--	50	--	--	--	--
EIGHTBAY	SQ−14	05/29/84	SQ−14	29	--	--	35	64	--	2.1	9.2	--
EIGHTBAY	SQ14	09/18/83	SQ14	--	--	--	--	58	--	--	--	--
EIGHTBAY	SQ15	09/18/83	SQ15	--	--	--	--	85	--	--	--	--
EIGHTBAY	SQ16	09/18/83	SQ16	--	--	--	--	74	--	--	--	--
EIGHTBAY	SQ−17	05/29/84	SQ−17	35	--	--	48	83	--	2.3	10	--
EIGHTBAY	SQ17	09/18/83	SQ17	--	--	--	--	88	--	--	--	--
EIGHTBAY	SQ−18	05/29/84	SQ−18	34	--	--	46	80	--	2.3	12	--
EIGHTBAY	SQ18	09/18/83	SQ18	--	--	--	--	86	--	--	--	--
EIGHTBAY	SQ19	09/18/83	SQ19	--	--	--	--	89	--	--	--	--
EIGHTBAY	SQ2	08/15/83	SQ2	--	--	--	--	72	--	--	--	--
EIGHTBAY	SQ−20	05/29/84	SQ−20	36	--	--	48	84	--	2.2	9.6	--

TABLE D1. (Continued)

Survey	Station	Date	Sample	Percent Clay	Percent Rocks	Percent Sand	Percent Silt	Percent Fines (Clay + Silt)	Sulfides	Total Organic Carbon (percent)	Total Volatile Solids (percent)	Total Solids [a]
EIGHTBAY	SQ20	09/18/83	SQ20	--	--	--	--	79	--	--	--	--
EIGHTBAY	SQ3	08/15/83	SQ3	--	--	--	--	14	--	--	--	--
EIGHTBAY	SQ4	08/15/83	SQ4	--	--	--	--	25	--	--	--	--
EIGHTBAY	SQ5	08/16/83	SQ5	--	--	--	--	74	--	--	--	--
EIGHTBAY	SQ6	08/16/83	SQ6	--	--	--	--	73	--	--	--	--
EIGHTBAY	SQ7	09/17/83	SQ7	--	--	--	--	97	--	--	--	--
EIGHTBAY	SQ8	09/17/83	SQ8	--	--	--	--	94	--	--	--	--
EIGHTBAY	SQ9	09/17/83	SQ9	--	--	--	--	81	--	--	--	--
MISCREFS	DB-89	01/01/76	89	--	--	--	--	--	--	3.3	--	--
NOADW86	CARRINL	05/01/86	CARRINL	--	0.97	70	--	38	8.0 *U*	--	1.9	69
NOADW86	DABOB	05/01/86	DABOB	--	1.8	91	--	6.9	40	--	1.7	82
NOADW86	SAMISH	05/01/86	SAMISH	--	0.17	27	--	54	130	--	4.8	49
NOADW86	SEQUIM17	05/01/86	SEQUIM17	--	0.58	21	--	78	130	--	8.7	29
OAKHRBR	SEQUIM	02/26/85	SEQUIM	26	0.50	11	62	88	--	2.5	--	--
OLYHAR88	SQ-01	01/01/88	SQ-01	--	--	--	--	82	--	--	--	--
PSDDA1	CRR01	05/17/88	CRR01C	17	0.05	49	34	51	58	1.6	5.4	43
REFGRAIN	DB-02	03/25/86	DB-02	--	--	1.0	--	99	--	--	8.1	--
REFGRAIN	DB-14	03/25/86	DB-14	--	--	0.60	--	99	--	--	10	--
REFGRAIN	DB-15	03/25/86	DB-15	--	--	21	--	79	--	--	9.5	--
REFGRAIN	DB-18	03/25/86	DB-18	--	--	59	--	41	--	--	1.8	--
REFGRAIN	SM-11	05/01/83	SM-11	--	--	78	--	21	--	--	3.0	--
REFGRAIN	SM-12	05/01/83	SM-12	--	--	8.8	--	91	--	--	7.9	--
ROBERT74	CR-021	02/24/69	021	14	0	21	65	79	--	--	--	--
ROBERT74	CR-022	02/24/69	022	26	0	13	61	87	--	--	--	--
ROBERT74	CR-023	02/24/69	023	37	0	7.0	56	93	--	--	--	--
ROBERT74	DB-H16	08/01/52	H16	56	0	1.3	43	99	--	--	--	--
ROBERT74	DB-H17	08/01/52	H17	37	0	8.7	55	91	--	--	--	--
ROBERT74	DB-H18	08/02/52	H18	59	0	2.2	39	98	--	--	--	--
ROBERT74	SM-122	07/17/60	122	2.7	0.25	78	19	22	--	--	--	--
ROBERT74	SM-123	07/17/60	123	2.1	0.04	92	6.0	8.1	--	--	--	--
ROBERT74	SM-124	07/17/60	124	2.2	0.06	91	7.2	9.4	--	--	--	--
ROBERT74	SM-125	07/17/60	125	1.7	0.02	91	7.1	8.8	--	--	--	--
ROBERT74	SM-127	07/17/60	127	4.9	0.16	59	36	41	--	--	--	--
ROBERT74	SM-128	07/17/60	128	2.8	0.21	84	13	16	--	--	--	--
ROBERT74	SM-129	07/17/60	129	3.6	0.15	82	15	18	--	--	--	--
ROBERT74	SM-130	07/17/60	130	2.9	1.6	76	19	22	--	--	--	--

TABLE D1. (Continued)

Survey	Station	Date	Sample	Percent Clay	Percent Rocks	Percent Sand	Percent Silt	Percent Fines (Clay + Silt)	Sulfides	Total Organic Carbon (percent)	Total Volatile Solids (percent)	Total Solids [a]
ROBERT74	SM−131	07/17/60	131	1.4	0.07	93	6.0	7.4	--	--	--	--
ROBERT74	SM−G3	11/02/59	G3	20	0.33	7.6	72	92	--	--	--	--
ROBERT74	SM−G4	11/02/59	G4	15	0	20	65	80	--	--	--	--
ROBERT74	SM−G5	05/21/60	G5	13	0.02	17	70	83	--	--	--	--
ROBERT74	SM−H02	05/21/60	H02	25	9.3	1.4	64	89	--	--	--	--
ROBERT74	SM−H03	11/02/59	H03	24	2.9	1.8	72	95	--	--	--	--
ROBERT74	SM−H1	11/02/59	H1	23	4.2	6.1	67	90	--	--	--	--
ROBERT74	SM−V01	04/19/60	V01	25	2.1	8.5	64	89	--	--	--	--
ROBERT74	SM−V02	04/19/60	V02	25	7.2	1.8	66	91	--	--	--	--
ROBERT74	SM−V03	04/19/60	V03	21	1.1	2.3	75	97	--	--	--	--
ROBERT74	SM−V11	04/19/60	V11	18	0.18	7.6	74	92	--	--	--	--
ROBERT74	SM−V12	04/19/60	V12	26	6.6	1.6	66	92	--	--	--	--
ROBERT74	SM−V13	04/19/60	V13	26	2.9	1.4	70	96	--	--	--	--
ROBERT74	SM−V14	04/19/60	V14	26	1.1	6.5	67	92	--	--	--	--
ROBERT74	SM−V15	04/19/60	V15	24	0.99	2.1	73	97	--	--	--	--

[a] Dry weight as % of wet weight.

TABLE D2. METALS DATA FOR HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENT SAMPLES (mg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	Antimony	Arsenic	Cadmium	Copper	Chromium	Lead	Mercury	Nickel	Silver	Zinc
CBMSQS	CR-11	01/01/84	CR-11		0.130	2.40	1.10	4.90	9.90	11.0	0.055	11.0	0.100 U	15.0
CBMSQS	CR-12	01/01/84	CR-12		0.100 U	3.80	1.40	7.30	11.0	13.0	0.098	14.0	0.100 U	19.0
CBMSQS	CR-13	01/01/84	CR-13		0.100 U	3.80	1.10	5.20	9.60	10.0	0.049	12.0	0.100 U	15.0
CBMSQS	CR-14	01/01/84	CR-14		0.140	3.80	1.50	7.80	11.0	12.0	0.034	13.0	0.100 U	17.0
CBPRELIM	CR-03	03/01/84	CR-03		0.100	2.60	0.330	8.00	23.0	4.40	0.010	27.6	0.120	23.6
CBPRELIM	CR-04	03/01/84	CR-04		0.100	3.80	0.290	5.00	24.4	4.80	0.010	26.7	0.020	24.1
CREC72	CR-01	01/01/72	CS-01		1.82	15.7	--	--	80.0	--	0.114	--	--	--
CREC72	SA-01	01/01/72	SA-01		0.790	15.7	--	--	107	--	0.098	--	--	--
CREC72	SA-02	01/01/72	SA-02		0.920	12.6	--	--	--	--	0.063	--	--	--
CREC72	SM-01	01/01/72	SM-01		--	--	--	--	--	--	0.200	--	--	--
CREC72	SM-02	01/01/72	SM-02		--	--	--	--	--	--	0.100	--	--	--
DUWRIV1	SQ-09	04/19/85	SQ-09		--	22.0	0.640	35.0	--	12.0	0.030 U	--	--	93.0
EIGHTBAY	DB1	09/10/83	DB1		--	--	--	--	--	15.0	0.089	--	0.109	--
EIGHTBAY	DB14	09/09/83	DB14		--	--	--	--	--	15.4	0.110	--	0.239	--
EIGHTBAY	DB15	09/09/83	DB15		--	--	--	--	--	16.3	0.091	--	0.183	--
EIGHTBAY	DB16	09/09/83	DB16		--	--	--	--	--	11.3	0.089	--	0.204	--
EIGHTBAY	DB17	09/08/83	DB17		--	--	--	--	--	4.10	0.016	--	0.016	--
EIGHTBAY	DB18	09/08/83	DB18		--	--	--	--	--	3.30	0.020	--	0.028	--
EIGHTBAY	DB19	09/08/83	DB19		--	--	--	--	--	3.90	0.025	--	0.042	--
EIGHTBAY	DB2	09/10/83	DB2		--	--	--	--	--	21.8	0.112	--	0.148	--
EIGHTBAY	DB20	09/08/83	DB20		--	--	--	--	--	1.80	0.020	--	0.014 L	--
EIGHTBAY	DB21	09/08/83	DB21		--	--	--	--	--	3.00	0.012	--	0.014 L	--
EIGHTBAY	DB22	09/08/83	DB22		--	--	--	--	--	1.80	0.006 L	--	0.014 L	--
EIGHTBAY	DB23	09/09/83	DB23		--	--	--	--	--	1.80	0.008	--	0.014 L	--
EIGHTBAY	DB24	09/09/83	DB24		--	--	--	--	--	2.40	0.008	--	0.014 L	--
EIGHTBAY	DB25	09/09/83	DB25		--	--	--	--	--	2.40	0.019	--	0.014 L	--
EIGHTBAY	DB26	09/09/83	DB26		--	--	--	--	--	2.70	0.016	--	0.014 L	--
EIGHTBAY	DB3	09/10/83	DB3		--	--	--	--	--	23.1	0.120	--	0.159	--
EIGHTBAY	DB4	09/10/83	DB4		--	--	--	--	--	20.6	0.094	--	0.109	--
EIGHTBAY	DB5	09/10/83	DB5		--	--	--	--	--	8.30	0.056	--	0.036	--
EIGHTBAY	DB6	09/10/83	DB6		--	--	--	--	--	14.8	0.087	--	0.094	--
EIGHTBAY	DB7	09/10/83	DB7		--	--	--	--	--	15.7	0.079	--	0.124	--
EIGHTBAY	DB-01	05/22/84	DB-01		0.100 U	1.90	0.100	28.0	49.0	0.40	0.016	27.0	0.370	72.0
EIGHTBAY	DB-05	05/22/84	DB-05		0.100 U	2.10	0.100	33.0	51.0	0.10 U	0.022	30.0	0.370	77.0
EIGHTBAY	DB-07	05/22/84	DB-07		0.100 U	3.40	0.200	50.0	60.0	5.60	0.029	33.0	0.780	86.0
EIGHTBAY	DB-15	05/22/84	DB-15		0.100 U	5.60	0.400	74.0	76.0	9.90	0.047	46.0	0.218	102
EIGHTBAY	SM1	08/06/83	SM1		--	--	--	--	--	14.7	0.109	--	0.079	--

TABLE D2. (Continued).

Survey	Station	Date	Sample	Field Rep	Antimony	Arsenic	Cadmium	Copper	Chromium	Lead	Mercury	Nickel	Silver	Zinc
EIGHTBAY	SM12	08/08/83	SM12		--	--	--	--	--	6.10	0.039	--	0.047	--
EIGHTBAY	SM13	08/09/83	SM13		--	--	--	--	--	2.70	0.009	--	0.016	--
EIGHTBAY	SM14	08/09/83	SM14		--	--	--	--	--	3.40	0.013	--	0.027	--
EIGHTBAY	SM15	08/09/83	SM15		--	--	--	--	--	3.60	0.021	--	0.014 *L*	--
EIGHTBAY	SM16	08/09/83	SM16		--	--	--	--	--	22.7	0.118	--	0.106	--
EIGHTBAY	SM17	08/09/83	SM17		--	--	--	--	--	3.30	0.033	--	0.019	--
EIGHTBAY	SM18	08/09/83	SM18		--	--	--	--	--	16.2	0.125	--	0.105	--
EIGHTBAY	SM19	08/09/83	SM19		--	--	--	--	--	18.6	0.137	--	0.119	--
EIGHTBAY	SM2	08/06/83	SM2		--	--	--	--	--	18.8	0.162	--	0.053	--
EIGHTBAY	SM20	08/09/83	SM20		--	--	--	--	--	15.2	0.083	--	0.075	--
EIGHTBAY	SM3	08/06/83	SM3		--	--	--	--	--	8.90	0.068	--	0.061	--
EIGHTBAY	SM4	08/06/83	SM4		--	--	--	--	--	20.2	0.166	--	0.137	--
EIGHTBAY	SM5	08/08/83	SM5		--	--	--	--	--	16.9	0.154	--	0.108	--
EIGHTBAY	SM6	08/08/83	SM6		--	--	--	--	--	15.3	0.117	--	0.084	--
EIGHTBAY	SM7	08/08/83	SM7		--	--	--	--	--	14.3	0.091	--	0.084	--
EIGHTBAY	SM8	08/08/83	SM8		--	--	--	--	--	16.8	0.146	--	0.117	--
EIGHTBAY	SM9	08/08/83	SM9		--	--	--	--	--	19.2	0.155	--	0.118	--
EIGHTBAY	SM-01	04/24/84	SM-01		0.100 *U*	4.50	0.140	33.0	32.0	5.00	0.080	20.2	0.104	74.0
EIGHTBAY	SM-03	04/24/84	SM-03		0.100 *U*	8.00	0.210	40.0	43.0	5.00	0.073	27.5	0.130	75.0
EIGHTBAY	SM-07	04/24/84	SM-07		0.100 *U*	4.60	0.170	33.0	35.0	6.00	0.069	19.7	0.108	76.0
EIGHTBAY	SM-20	04/24/84	SM-20		0.100 *U*	5.50	0.140	40.0	40.0	6.00	0.063	21.8	0.118	81.0
EIGHTBAY	SQ1	08/15/83	SQ1		--	--	--	--	--	6.50	0.025	--	0.063	--
EIGHTBAY	SQ10	09/17/83	SQ10		--	--	--	--	--	14.7	0.111	--	0.154	--
EIGHTBAY	SQ11	09/17/83	SQ11		--	--	--	--	--	8.20	0.061	--	0.107	--
EIGHTBAY	SQ12	09/17/83	SQ12		--	--	--	--	--	4.10	0.027	--	0.060	--
EIGHTBAY	SQ13	09/17/83	SQ13		--	--	--	--	--	13.0	0.061	--	0.123	--
EIGHTBAY	SQ14	09/18/83	SQ14		--	--	--	--	--	8.90	0.051	--	0.107	--
EIGHTBAY	SQ15	09/18/83	SQ15		--	--	--	--	--	13.8	0.096	--	0.186	--
EIGHTBAY	SQ16	09/18/83	SQ16		--	--	--	--	--	11.8	0.091	--	0.135	--
EIGHTBAY	SQ17	09/18/83	SQ17		--	--	--	--	--	13.8	0.090	--	0.160	--
EIGHTBAY	SQ18	09/18/83	SQ18		--	--	--	--	--	13.8	0.091	--	0.176	--
EIGHTBAY	SQ19	09/18/83	SQ19		--	--	--	--	--	15.1	0.086	--	0.217	--
EIGHTBAY	SQ2	08/15/83	SQ2		--	--	--	--	--	12.0	0.075	--	0.118	--
EIGHTBAY	SQ20	09/18/83	SQ20		--	--	--	--	--	13.0	0.071	--	0.142	--
EIGHTBAY	SQ3	08/15/83	SQ3		--	--	--	--	--	4.30	0.014	--	0.043	--
EIGHTBAY	SQ4	08/15/83	SQ4		--	--	--	--	--	5.20	0.014	--	0.043	--
EIGHTBAY	SQ5	08/16/83	SQ5		--	--	--	--	--	12.0	0.066	--	0.168	--

TABLE D2. (Continued).

Survey	Station	Date	Sample	Field Rep	Antimony	Arsenic	Cadmium	Copper	Chromium	Lead	Mercury	Nickel	Silver	Zinc
EIGHTBAY	SQ8	09/17/83	SQ8		--	--	--	--	--	13.9	0.111	--	0.179	--
EIGHTBAY	SQ9	09/17/83	SQ9		--	--	--	--	--	13.0	0.081	--	0.157	--
EIGHTBAY	SQ-14	05/29/84	SQ-14		0.100 *U*	5.60	0.900	43.0	60.0	6.80	0.041	37.0	0.107	76.0
EIGHTBAY	SQ-17	05/29/84	SQ-17		0.100 *U*	7.30	0.900	48.0	67.0	9.00	0.068	41.0	0.226	88.0
EIGHTBAY	SQ-18	05/29/84	SQ-18		0.100 *U*	6.90	1.10	48.0	66.0	8.50	0.060	39.0	0.223	85.0
EIGHTBAY	SQ-20	05/29/84	SQ-20		0.100 *U*	6.90	0.900	44.0	65.0	9.00	0.055	38.0	0.200	83.0
KENM86	SEQUIM	07/01/85	SEQUIM	1	--	12.0	0.870	37.0	--	10.3	0.082	--	--	97.0
NOADW86	CARRINL	05/01/86	CARRINL		0.150 *U*	11.0	0.450	10.0	13.0	4.80	0.030 *U*	16.0	0.241	23.5
NOADW86	DABOB	05/01/86	DABOB		0.150 *U*	8.10	0.640	34.0	32.0	3.50	0.020 *U*	31.0	0.279	57.9
NOADW86	SAMISH	05/01/86	SAMISH		0.200 *U*	12.0	0.990	23.0	22.0	7.40	0.080	19.0	0.330	60.5
NOADW86	SEQUIM17	05/01/86	SEQUIM17		0.350 *U*	27.0	1.70	37.0	39.0	8.30	0.070	33.0	0.863	73.7
OAKHRBR	SEQUIM	02/26/85	SEQUIM		--	7.30	0.900	48.0	--	9.00	0.068	--	--	88.0
OLYHAR88	SQ-01	01/01/88	SQ-01		0.072	10.8	0.970	29.1 *U*	86.7	8.50	0.016 *U*	35.4	0.260	89.0
PSDDA1	CRR01	05/17/88	CRR01C		4.50 *E*	16.0	4.50 *LM*	48.0	--	34.0	0.150	33.0	1.00 *E*	100
RILEY001	NG-10	08/01/82	NG-10	1	9.47	26.2	0.670	76.0	81.0	44.0	0.231	39.0	0.545	133
RILEY001	NG-10	08/01/82	NG-11	2	7.76	24.7	0.430	66.0	82.0	40.0	0.213	41.0	0.496	117
RILEY001	NG-9	08/01/82	NG-9		1.88	10.1	0.600	42.0	100	29.0	0.159	41.0	0.270	85.0

TABLE D3. LOW MOLECULAR WEIGHT POLYCYCLIC AROMATIC HYDROCARBONS IN HISTORICAL REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	LPAH [a]	Naphthalene	2–Methyl–naphthalene	Acenaph–thylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
CBMSQS	CR–11	01/01/84	CR–11		28	7.4	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	14	6.7
CBMSQS	CR–12	01/01/84	CR–12		34	13	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	12	8.6
CBMSQS	CR–13	01/01/84	CR–13		16	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	16	5.0 *U*
CBMSQS	CR–14	01/01/84	CR–14		45	7.5	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	16	22
CBPRELIM	CR–03	03/01/84	CR–03		11 *E*	1.0 *Z*	1.0 *U*	0.50 *U*	0.50 *U*	0.50	5.0 *Z*	3.0
CBPRELIM	CR–04	03/01/84	CR–04		2.0 *Z*	0.50 *U*	1.0 *U*	0.50 *U*	0.50 *U*	––	2.0 *Z*	0.50 *U*
DUWRIV1	SQ–09	04/19/85	SQ–09		2.5	3.0 *U*	9.1	37 *U*	2.8 *U*	2.5	40 *U*	2.3 *U*
DUWRIV2	SQ–21	07/01/85	SEQUIM		55	7.0	16	––	3.0 *U*	4.0 *U*	48	2.0 *U*
EIGHTBAY	DB–01	05/22/84	DB–01		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	DB–05	05/22/84	DB–05		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	DB–07	05/22/84	DB–07		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	DB–15	05/22/84	DB–15		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	SM–01	04/24/84	SM–01		170	40 *U*	––	40 *U*	40 *U*	40 *U*	170	40 *U*
EIGHTBAY	SM–03	04/24/84	SM–03		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	SM–07	04/24/84	SM–07		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	SM–20	04/24/84	SM–20		240 *U*	40 *U*	––	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
EIGHTBAY	SQ–14	05/29/84	SQ–14		600 *U*	100 *U*	––	100 *U*	100 *U*	100 *U*	100 *U*	100 *U*
EIGHTBAY	SQ–17	05/29/84	SQ–17		600 *U*	100 *U*	––	100 *U*	100 *U*	100 *U*	100 *U*	100 *U*
EIGHTBAY	SQ–18	05/29/84	SQ–18		600 *U*	100 *U*	––	100 *U*	100 *U*	100 *U*	100 *U*	100 *U*
EIGHTBAY	SQ–20	05/29/84	SQ–20		600 *U*	100 *U*	––	100 *U*	100 *U*	100 *U*	100 *U*	100 *U*
KENM86	SEQUIM	07/31/85	SEQUIM	1	240 *L*	210	160	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*
NOADW86	CARRINL	05/01/86	CARRINL		36 *L*	5.0 *U*	6.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	12	4.0 *U*
NOADW86	DABOB	05/01/86	DABOB		22 *U*	4.0 *U*	5.0 *U*	4.0 *U*	4.0 *U*	4.0 *U*	3.0 *U*	3.0 *U*
NOADW86	SAMISH	05/01/86	SAMISH		69 *L*	8.0 *U*	21	8.0 *U*	8.0 *U*	7.0 *U*	32	6.0 *U*
NOADW86	SEQUIM17	05/01/86	SEQUIM17		68 *U*	13 *U*	13 *U*	12 *U*	12 *U*	11 *U*	11 *U*	9.0 *U*
OAKHRBR	SEQUIM	02/26/85	SEQUIM		213	210	160	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*	5.0 *U*
OLYHAR88	SQ–01	01/01/88	SQ–01		70	19	18	3.0 *U*	4.0 *U*	6.0	42	3.0
PSDDA1	CRR01	05/17/88	CRR01C		47 *E*	7.2 *U*	3.0 *E*	2.1 *U*	7.2 *U*	7.2 *U*	35 *E*	12 *E*
RILEY001	NG–10	08/01/82	NG–10	1	62	16	4.0	––	––	2.0	12	32
RILEY001	NG–10	08/01/82	NG–11	2	80	32	10	––	––	6.0	21	21
RILEY001	NG–9	08/01/82	NG–9		42	10	4.0	––	––	4.0	10	18

[a] Sum of low molecular weight polycyclic aromatic hydrocarbons (does not include 2–methylnaphthalene).

TABLE D4. HIGH MOLECULAR WEIGHT POLYCYCLIC AROMATIC HYDROCARBONS IN HISTORICAL REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	HPAH [b]	Fluoranthene	Pyrene	Benzo(a) anthracene	Chrysene	Total Benzofluoranthenes (B+K)	Benzo (a) pyrene	Indeno (1,2,3-c,d) pyrene	Dibenzo (a,h) anthracene	Benzo (g,h,i) perylene
BARRICK	DBE	01/01/76	DBE		220	64	54	--	--	94	7.0	--	--	--
CBMSQS	CR-11	01/01/84	CR-11		65	16	16	5.5	9.2	18	5.0 U	5.0 U	5.0 U	5.0 U
CBMSQS	CR-12	01/01/84	CR-12		69	14	14	5.8	11	17	7.1	5.0 U	5.0 U	5.0 U
CBMSQS	CR-13	01/01/84	CR-13		22	11	11	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
CBMSQS	CR-14	01/01/84	CR-14		75	16	18	7.0	10	15	8.5	5.0 U	5.0 U	5.0 U
CBPRELIM	CR-03	03/01/84	CR-03		78 L	20	13 Z	8.0	19	8.0	3.0	4.0	0.40	3.0
CBPRELIM	CR-04	03/01/84	CR-04		34	14	11	4.0	5.0	--	--	--	--	--
DUWRIV1	SQ-09	04/19/85	SQ-09		140	53	35	2.7 U	16	9.1	8.3	6.6	3.3 U	8.3
DUWRIV2	SQ-21	07/01/85	SEQUIM		120	63	45	7.0	8.0	--	4.0 U	--	3.0 U	--
EIGHTBAY	DB-01	05/22/84	DB-01		900 U	40 U	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	DB-05	05/22/84	DB-05		900 U	40 U	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	DB-07	05/22/84	DB-07		900 U	40 U	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	DB-15	05/22/84	DB-15		900 U	40 U	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	SM-01	04/24/84	SM-01		160	76	88	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	SM-03	04/24/84	SM-03		220	97	120	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	SM-07	04/24/84	SM-07		68	68	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	SM-20	04/24/84	SM-20		900 U	40 U	40 U	40 U	40 U	40 U	100 U	200 U	200 U	200 U
EIGHTBAY	SQ-14	05/29/84	SQ-14		2,400 U	100 U	100 U	100 U	100 U	200 U	250 U	500 U	500 U	500 U
EIGHTBAY	SQ-17	05/29/84	SQ-17		2,400 U	100 U	100 U	100 U	100 U	200 U	250 U	500 U	500 U	500 U
EIGHTBAY	SQ-18	05/29/84	SQ-18		2,400 U	100 U	100 U	100 U	100 U	200 U	250 U	500 U	500 U	500 U
EIGHTBAY	SQ-20	05/29/84	SQ-20		2,400 U	100 U	100 U	100 U	100 U	200 U	250 U	500 U	500 U	500 U
KENM86	SEQUIM	07/31/85	SEQUIM	1	50 U	5.0 U	5.0 U	5.0 U	5.0 U	10 UM	5.0 U	5.0 U	5.0 U	5.0 U
NOADW86	CARRINL	05/01/86	CARRINL		98 L	10	16	7.0 U	19	16	9.0	7.0 U	7.0 U	7.0 U
NOADW86	DABOB	05/01/86	DABOB		54 L	5.0 U	9.0	4.0 U	8.0	4.0 U	6.0 U	6.0 U	6.0 U	6.0 U
NOADW86	SAMISH	05/01/86	SAMISH		150 L	22	41	9.0	7.0 U	23	15	20	6.0 U	6.0
NOADW86	SEQUIM1	05/01/86	SEQUIM17		130 L	10 U	34	10 U	20	10 U	10 U	11 U	11 U	11 U
OAKHRBR	SEQUIM	02/26/85	SEQUIM		--	5.0 U	5.0 U	5.0 U	5.0 U	10 UM	5.0 U	5.0 U	5.0 U	5.0 U
OLYHAR88	SQ-01	01/01/88	SQ-01		180	48	34	9.0	18	30	10	17	2.0 U	17
PSDDA1	CRR01	05/17/88	CRR01C		370 E	55 E	55 E	41 E	42 E	66 E	46 E	36 E	7.2 U	25 E
RILEY001	NG-10	08/01/82	NG-11	2	440	89	82	130	97	--	42	--	--	--
RILEY001	NG-10	08/01/82	NG-10	1	170	58	48	44	20	--	1.0 U	--	--	--
RILEY001	NG-9	08/01/82	NG-9		450	43	44	210	63	--	86	--	--	--

[b] Sum of high molecular weight polycyclic aromatic hydrocarbons.

TABLE D5. PHENOLS AND SUBSTITUTED PHENOLS IN HISTORIC REFERENC AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Phenol	2-Methylphenol	4-Methyl phenol	Pentachlorophenol
CBMSQS	CR-11	01/01/84	CR-11	10 *U*	10 *U*	10 *U*	50 *U*
CBMSQS	CR-12	01/01/84	CR-12	10 *U*	10 *U*	10 *U*	50 *U*
CBMSQS	CR-13	01/01/84	CR-13	44	10 *U*	26	50 *U*
CBMSQS	CR-14	01/01/84	CR-14	62	10 *U*	32	50 *U*
CBPRELIM	CR-03	03/01/84	CR-03	40	1 *U*	1.0 *U*	0.10
CBPRELIM	CR-04	03/01/84	CR-04	1800	1 *U*	1.0 *U*	0.50 *U*
EIGHTBAY	DB-01	05/22/84	DB-01	40 *U*	--	--	600 *U*
EIGHTBAY	DB-05	05/22/84	DB-05	40 *U*	--	--	600 *U*
EIGHTBAY	DB-07	05/22/84	DB-07	40 *U*	--	--	600 *U*
EIGHTBAY	DB-15	05/22/84	DB-15	40 *U*	--	--	600 *U*
EIGHTBAY	SM-01	04/24/84	SM-01	40 *U*	--	--	600 *U*
EIGHTBAY	SM-03	04/24/84	SM-03	40 *U*	--	--	600 *U*
EIGHTBAY	SM-07	04/24/84	SM-07	40 *U*	--	--	600 *U*
EIGHTBAY	SM-20	04/24/84	SM-20	40 *U*	--	--	600 *U*
EIGHTBAY	SQ-14	05/29/84	SQ-14	100 *U*	--	--	1,500 *U*
EIGHTBAY	SQ-17	05/29/84	SQ-17	100 *U*	--	--	1,500 *U*
EIGHTBAY	SQ-18	05/29/84	SQ-18	100 *U*	--	--	1,500 *U*
EIGHTBAY	SQ-20	05/29/84	SQ-20	100 *U*	--	--	1,500 *U*
NOADW86	CARRINL	05/01/86	CARRINL	3 *U*	5 *U*	6.0 *U*	--
NOADW86	DABOB	05/01/86	DABOB	7 *U*	5 *U*	6.0 *U*	--
NOADW86	SAMISH	05/01/86	SAMISH	17 *U*	12 *U*	12 *U*	--
NOADW86	SEQUIM17	05/01/86	SEQUIM17	29 *U*	20 *U*	21 *U*	--
OLYHAR88	SQ-01	01/01/88	SQ-01	72	8 *U*	560	5.0 *U*
PSDDA1	CRR01	05/17/88	CRR01C	75	7.2 *U*	7.2 *U*	12 *U*

TABLE D6. PHTHALATE ESTERS IN HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	Dimethyl phthalate	Diethyl phthalate	Di-N-butyl pthalate	Butyl benzyl phthalate	Bis(2-ethylhexyl) phthalate	Di-n-octyl phthalate
CBMSQS	CR-11	01/01/84	CR-11		50 *U*	10 *U*	760 *Z*	25 *U*	25 *B*	25 *U*
CBMSQS	CR-12	01/01/84	CR-12		50 *U*	13	25 *B*	25 *U*	25 *B*	25 *U*
CBMSQS	CR-13	01/01/84	CR-13		50 *U*	10	25 *B*	25 *U*	25 *B*	25 *U*
CBMSQS	CR-14	01/01/84	CR-14		50 *U*	18	30 *Z*	25 *U*	25 *B*	25 *U*
CBPRELIM	CR-03	03/01/84	CR-03		0.50 *B*	4.0 *Z*	30 *Z*	0.50 *U*	0.50 *B*	0.50 *B*
CBPRELIM	CR-04	03/01/84	CR-04		--	--	--	0.50 *U*	0.50 *B*	--
DUWRIV1	SQ-09	04/19/85	SQ-09		11	15	17	--	100	--
EBCHEM	PS-01	10/12/85	PS-01	1	0.70 *E*	--	--	10 *E*	--	10 *E*
EIGHTBAY	DB-01	05/22/84	DB-01		40 *U*	40 *U*	40 *U*	40 *U*	120 *U*	40 *U*
EIGHTBAY	DB-05	05/22/84	DB-05		40 *U*	40 *U*	75 *U*	40 *U*	190 *U*	40 *U*
EIGHTBAY	DB-07	05/22/84	DB-07		40 *U*	40 *U*	40 *U*	40 *U*	310 *U*	40 *U*
EIGHTBAY	DB-15	05/22/84	DB-15		40 *U*	40 *U*	40 *U*	40 *U*	360 *U*	40 *U*
EIGHTBAY	SM-01	04/24/84	SM-01		40 *U*	40 *U*	40 *U*	40 *U*	2,800	69
EIGHTBAY	SM-03	04/24/84	SM-03		40 *U*	40 *U*	40 *U*	40 *U*	340	160
EIGHTBAY	SM-07	04/24/84	SM-07		40 *U*	40 *U*	40 *U*	40 *U*	180	40 *U*
EIGHTBAY	SM-20	04/24/84	SM-20		40 *U*	40 *U*	40 *U*	40 *U*	740	100
EIGHTBAY	SQ-14	05/29/84	SQ-14		100 *U*	100 *U*	100 *U*	100 *U*	200 *U*	100 *U*
EIGHTBAY	SQ-17	05/29/84	SQ-17		100 *U*	100 *U*	100 *U*	100 *U*	200 *U*	100 *U*
EIGHTBAY	SQ-18	05/29/84	SQ-18		100 *U*	100 *U*	100 *U*	100 *U*	200 *U*	100 *U*
EIGHTBAY	SQ-20	05/29/84	SQ-20		100 *U*	100 *U*	100 *U*	100 *U*	200 *U*	100 *U*
NOADW86	CARRINL	05/01/86	CARRINL		3.0 *U*	2.0 *U*	5.0 *U*	2.0 *U*	470	3.0 *U*
NOADW86	DABOB	05/01/86	DABOB		0.10 *U*	2.0	2.0	2.0	56	3.0 *U*
NOADW86	SAMISH	05/01/86	SAMISH		0.30 *U*	5.0	4.0	2.0 *U*	14	0.60
NOADW86	SEQUIM17	05/01/86	SEQUIM17		0.40 *U*	7.0	31	15	51	3.0
OLYHAR88	SQ-01	01/01/88	SQ-01		6.0 *U*	5.0 *U*	4.0 *U*	18 *U*	31	10 *U*
PSDDA1	CRR01	05/17/88	CRR01C		7.2 *U*	7.2 *U*	7.2 *U*	7.2 *U*	35 *Z*	7.2 *U*

TABLE D7. CHLORINATED AROMATIC HYDROCARBONS IN HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	1,2,4-Trichloro-benzene	Hexachloro-benzene	Hexachloro-butadiene
CBMSQS	CR-11	01/01/84	CR-11		5.0 *U*	5.0 *U*	5.0 *U*	5 *U*	10 *U*	25 *U*
CBMSQS	CR-12	01/01/84	CR-12		5.0 *U*	5.0 *U*	5.0 *U*	5 *U*	10 *U*	25 *U*
CBMSQS	CR-13	01/01/84	CR-13		5.0 *U*	5.0 *U*	5.0 *U*	5 *U*	10 *U*	25 *U*
CBMSQS	CR-14	01/01/84	CR-14		5.0 *U*	5.0 *U*	5.0 *U*	5 *U*	10 *U*	25 *U*
CBPRELIM	CR-03	03/01/84	CR-03		0.50 *U*	0.50 *U*	0.50 *B*	0.50 *U*	0.50 *U*	0.50 *U*
CBPRELIM	CR-04	03/01/84	CR-04		0.50 *U*	0.50 *U*	0.50 *U*	0.50 *U*	0.50 *U*	0.50 *U*
DUWRIV1	SQ-09	04/19/85	SQ-09		40 *U*	40 *U*	40 *U*	--	0.50 *U*	1.3 *U*
DUWRIV2	SQ-21	07/01/85	SEQUIM		--	--	--	--	0.30 *U*	--
EIGHTBAY	DB-01	05/22/84	DB-01		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	DB-05	05/22/84	DB-05		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	DB-07	05/22/84	DB-07		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	DB-15	05/22/84	DB-15		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	SM-01	04/24/84	SM-01		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	SM-03	04/24/84	SM-03		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	SM-07	04/24/84	SM-07		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	SM-20	04/24/84	SM-20		40 *U*	40 *U*	40 *U*	80 *U*	400 *U*	160 *U*
EIGHTBAY	SQ-14	05/29/84	SQ-14		100 *U*	100 *U*	100 *U*	200 *U*	800 *U*	400 *U*
EIGHTBAY	SQ-17	05/29/84	SQ-17		100 *U*	100 *U*	100 *U*	200 *U*	800 *U*	400 *U*
EIGHTBAY	SQ-18	05/29/84	SQ-18		100 *U*	100 *U*	100 *U*	200 *U*	800 *U*	400 *U*
EIGHTBAY	SQ-20	05/29/84	SQ-20		100 *U*	100 *U*	100 *U*	200 *U*	800 *U*	400 *U*
NOADW86	CARRINL	05/01/86	CARRINL		50 *U*	50 *U*	50 *U*	12 *U*	0.70 *U*	0.30 *U*
NOADW86	DABOB	05/01/86	DABOB		50 *U*	50 *U*	50 *U*	10 *U*	0.50 *U*	0.30 *U*
NOADW86	SAMISH	05/01/86	SAMISH		50 *U*	50 *U*	50 *U*	19 *U*	0.50 *U*	0.50 *U*
NOADW86	SEQUIM17	05/01/86	SEQUIM17		50 *U*	50 *U*	50 *U*	30 *U*	0.60 *U*	1.0 *U*
OLYHAR88	SQ-01	01/01/88	SQ-01		--	--	--	3.0 *U*	0.40 *U*	0.50 *U*
PSDDA1	CRR01	05/17/88	CRR01C		7.2 *U*	7.2 *U*	7.2 *U*	7.2 *U*	7.2 *U*	7.9 *U*
RILEY001	NG-10	08/01/82	NG-11	2	--	--	--	--	0.10 *U*	--
RILEY001	NG-10	08/01/82	NG-10	1	--	--	--	--	0.10 *U*	--
RILEY001	NG-9	08/01/82	NG-9		--	--	--	--	0.10 *U*	--

TABLE D8. MISCELLANEOUS OXYGENATED COMPOUNDS IN HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Benzyl alcohol	Benzoic acid	Dibenzofuran	N-Nitroso diphenylamine
CBMSQS	CR-11	01/01/84	CR-11	10 *U*	25 *U*	5.0 *U*	5.0 *U*
CBMSQS	CR-12	01/01/84	CR-12	10 *U*	430	5.0 *U*	5.0 *U*
CBMSQS	CR-13	01/01/84	CR-13	10 *U*	210	5.0 *U*	5.0 *U*
CBMSQS	CR-14	01/01/84	CR-14	10 *U*	200	5.0 *U*	5.0 *U*
CBPRELIM	CR-03	03/01/84	CR-03	--	7.0	1.0 *U*	0.5 *U*
CBPRELIM	CR-04	03/01/84	CR-04	--	1.0 *U*	1.0 *U*	--
EIGHTBAY	DB-01	05/22/84	DB-01	--	--	--	1,000 *U*
EIGHTBAY	DB-05	05/22/84	DB-05	--	--	--	1,000 *U*
EIGHTBAY	DB-07	05/22/84	DB-07	--	--	--	1,000 *U*
EIGHTBAY	DB-15	05/22/84	DB-15	--	--	--	1,000 *U*
EIGHTBAY	SM-01	04/24/84	SM-01	--	--	--	1,000 *U*
EIGHTBAY	SM-03	04/24/84	SM-03	--	--	--	1,000 *U*
EIGHTBAY	SM-07	04/24/84	SM-07	--	--	--	1,000 *U*
EIGHTBAY	SM-20	04/24/84	SM-20	--	--	--	1,000 *U*
EIGHTBAY	SQ-14	05/29/84	SQ-14	--	--	--	2,500 *U*
EIGHTBAY	SQ-17	05/29/84	SQ-17	--	--	--	2,500 *U*
EIGHTBAY	SQ-18	05/29/84	SQ-18	--	--	--	2,500 *U*
EIGHTBAY	SQ-20	05/29/84	SQ-20	--	--	--	2,500 *U*
OLYHAR88	SQ-01	01/01/88	SQ-01	--	6.0 *U*	3.0 *U*	5.0 *U*
PSDDA1	CRR01	05/17/88	CRR01C	40 *U*	8.0 *E*	7.2 *U*	7.2 *U*

TABLE D9. PESTICIDES AND PCBS IN HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Field Rep	P,P'–DDT	P,P'–DDE	P,P'–DDD	Heptachlor	Aldrin	Dieldrin	Hexachlorocyclo–hexane–gamma	Hexachlorocyclo–hexane–alpha
CBMSQS	CR–11	01/01/84	CR–11		25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	––
CBMSQS	CR–12	01/01/84	CR–12		25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	––
CBMSQS	CR–13	01/01/84	CR–13		25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	––
CBMSQS	CR–14	01/01/84	CR–14		25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	25 *U*	––
CBPRELIM	CR–03	03/01/84	CR–03		10 *U*	10 *U*	10 *U*	10 *U*	10 *U*	10 *U*	10 *U*	––
CBPRELIM	CR–04	03/01/84	CR–04		––	––	10 *U*	10 *U*	10 *U*	10 *U*	10 *U*	––
DUWRIV1	SQ–09	04/19/85	SQ–09		0.5 *U*	0.5 *U*	0.5 *U*	––	––	––	––	––
DUWRIV2	SQ–21	07/01/85	SEQUIM		0.4 *U*	0.3 *U*	0.5 *U*	––	––	––	––	––
EIGHTBAY	DB–01	05/22/84	DB–01		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	DB–05	05/22/84	DB–05		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	DB–07	05/22/84	DB–07		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	DB–15	05/22/84	DB–15		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SM–01	04/24/84	SM–01		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SM–03	04/24/84	SM–03		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SM–07	04/24/84	SM–07		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SM–20	04/24/84	SM–20		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SQ–14	05/29/84	SQ–14		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SQ–17	05/29/84	SQ–17		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SQ–18	05/29/84	SQ–18		1 *U*	1 *U*	1 *U*	––	––	––	––	––
EIGHTBAY	SQ–20	05/29/84	SQ–20		1 *U*	1 *U*	1 *U*	––	––	––	––	––
MISCREFS	CR–15	07/01/75	15		––	––	––	––	––	––	––	––
NOADW86	CARRINL	05/01/86	CARRINL		1 *U*	0.8 *U*	2 *U*	1 *U*	1 *U*	1 *U*	0.8 *U*	0.4 *U*
NOADW86	DABOB	05/01/86	DABOB		1 *U*	0.7 *U*	1 *U*	0.8 *U*	1 *U*	1 *U*	0.7 *U*	0.3 *U*
NOADW86	SAMISH	05/01/86	SAMISH		0.8 *U*	0.5 *U*	1 *U*	0.7 *U*	0.6 *U*	0.8 *U*	0.5 *U*	0.5 *U*
NOADW86	SEQUIM17	05/01/86	SEQUIM17		1.0 *U*	0.7 *U*	1 *U*	1 *U*	0.9 *U*	1 *U*	0.7 *U*	1 *U*
OAKHRBR	SEQUIM	02/26/85	SEQUIM		––	––	––	––	––	––	––	––
OLYHAR88	SQ–01	01/01/88	SQ–01		0.6 *U*	0.4 *U*	0.7 *U*	0.5 *U*	0.5 *U*	0.4 *U*	0.4 *U*	––
PSDDA1	CRR01	05/17/88	CRR01C		4.0 *U*	4.0 *U*	4.0 *U*	2.0 *U*	2.0 *U*	4.0 *U*	2.0 *U*	2.0 *U*
RILEY001	NG–10	08/01/82	NG–10	1	––	––	––	––	––	––	––	––
RILEY001	NG–10	08/01/82	NG–11	2	––	––	––	––	––	––	––	––
RILEY001	NG–9	08/01/82	NG–9		––	––	––	––	––	––	––	––

[a] Sum of polychlorinated biphenyls.

TABLE D9. (Continued)

Survey	Station	Date	Sample	Field Rep	Hexachlorocyclo-hexane-beta	Hexachlorocyclo-hexane-delta	alpha-Endosulfan	beta-Endosulfan	Endosulfan sulfate	Endrin	Endrin Ketone	Methoxy-chlor
CBMSQS	CR-11	01/01/84	CR-11		--	--	--	--	--	--	--	--
CBMSQS	CR-12	01/01/84	CR-12		--	--	--	--	--	--	--	--
CBMSQS	CR-13	01/01/84	CR-13		--	--	--	--	--	--	--	--
CBMSQS	CR-14	01/01/84	CR-14		--	--	--	--	--	--	--	--
CBPRELIM	CR-03	03/01/84	CR-03		--	--	--	--	--	--	--	--
CBPRELIM	CR-04	03/01/84	CR-04		--	--	--	--	--	--	--	--
DUWRIV1	SQ-09	04/19/85	SQ-09		--	--	--	--	--	--	--	--
DUWRIV2	SQ-21	07/01/85	SEQUIM		--	--	--	--	--	--	--	--
EIGHTBAY	DB-01	05/22/84	DB-01		--	--	--	--	--	--	--	--
EIGHTBAY	DB-05	05/22/84	DB-05		--	--	--	--	--	--	--	--
EIGHTBAY	DB-07	05/22/84	DB-07		--	--	--	--	--	--	--	--
EIGHTBAY	DB-15	05/22/84	DB-15		--	--	--	--	--	--	--	--
EIGHTBAY	SM-01	04/24/84	SM-01		--	--	--	--	--	--	--	--
EIGHTBAY	SM-03	04/24/84	SM-03		--	--	--	--	--	--	--	--
EIGHTBAY	SM-07	04/24/84	SM-07		--	--	--	--	--	--	--	--
EIGHTBAY	SM-20	04/24/84	SM-20		--	--	--	--	--	--	--	--
EIGHTBAY	SQ-14	05/29/84	SQ-14		--	--	--	--	--	--	--	--
EIGHTBAY	SQ-17	05/29/84	SQ-17		--	--	--	--	--	--	--	--
EIGHTBAY	SQ-18	05/29/84	SQ-18		--	--	--	--	--	--	--	--
EIGHTBAY	SQ-20	05/29/84	SQ-20		--	--	--	--	--	--	--	--
MISCREFS	CR-15	07/01/75	15		--	--	--	--	--	--	--	--
NOADW86	CARRINL	05/01/86	CARRINL		0.9 *U*	0.4 *U*	0.5 *U*	0.5 *U*	0.5 *U*	0.4 *U*	--	--
NOADW86	DABOB	05/01/86	DABOB		0.8 *U*	0.3 *U*	0.4 *U*	0.4 *U*	0.4 *U*	0.3 *U*	--	--
NOADW86	SAMISH	05/01/86	SAMISH		1 *U*	1 *U*	1 *U*	1 *U*	1 *U*	0.5 *U*	--	--
NOADW86	SEQUIM17	05/01/86	SEQUIM17		2 *U*	1 *U*	1 *U*	1 *U*	1 *U*	0.7 *U*	--	--
OAKHRBR	SEQUIM	02/26/85	SEQUIM		--	20 *U*	--	--	--	--	--	--
OLYHAR88	SQ-01	01/01/88	SQ-01		--	--	--	--	--	--	--	--
PSDDA1	CRR01	05/17/88	CRR01C		2.0 *U*	2.0 *U*	6.0 *U*	4.0 *U*	4.0 *U*	4.0 *U*	4.0 *U*	8.0 *U*
RILEY001	NG-10	08/01/82	NG-10	1	--	--	--	--	--	--	--	--
RILEY001	NG-10	08/01/82	NG-11	2	--	--	--	--	--	--	--	--
RILEY001	NG-9	08/01/82	NG-9		--	--	--	--	--	--	--	--

[a] Sum of polychlorinated biphenyls.

TABLE D9. (Continued)

Survey	Station	Date	Sample	Field Rep	Toxaphene	PCB-1016	PCB-1242	PCB-1248	PCB-1254	PCB-1260	Total PCBs[a]
CBMSQS	CR-11	01/01/84	CR-11		--	--	7.0 *U*	7.0 *U*	--	--	7.0 *U*
CBMSQS	CR-12	01/01/84	CR-12		--	--	7.0 *U*	7.0 *U*	--	--	7.0 *U*
CBMSQS	CR-13	01/01/84	CR-13		--	--	7.0 *U*	7.0 *U*	--	--	7.0 *U*
CBMSQS	CR-14	01/01/84	CR-14		--	--	7.0 *U*	7.0 *U*	--	--	7.0 *U*
CBPRELIM	CR-03	03/01/84	CR-03		--	--	1.0	1.0	1.0	1.0	4.0
CBPRELIM	CR-04	03/01/84	CR-04		--	--	1.0	1.0	1.0	1.0	4.0
DUWRIV1	SQ-09	04/19/85	SQ-09		--	--	--	--	--	--	2.7
DUWRIV2	SQ-21	07/01/85	SEQUIM		--	--	--	--	--	--	37
EIGHTBAY	DB-01	05/22/84	DB-01		--	--	--	--	--	--	20 *U*
EIGHTBAY	DB-05	05/22/84	DB-05		--	--	--	--	--	--	20 *U*
EIGHTBAY	DB-07	05/22/84	DB-07		--	--	--	--	--	--	20 *U*
EIGHTBAY	DB-15	05/22/84	DB-15		--	--	--	--	--	--	20 *U*
EIGHTBAY	SM-01	04/24/84	SM-01		--	--	--	--	--	--	20 *U*
EIGHTBAY	SM-03	04/24/84	SM-03		--	--	--	--	--	--	20 *U*
EIGHTBAY	SM-07	04/24/84	SM-07		--	--	--	--	--	--	20 *U*
EIGHTBAY	SM-20	04/24/84	SM-20		--	--	--	--	--	--	20 *U*
EIGHTBAY	SQ-14	05/29/84	SQ-14		--	--	--	--	--	--	20 *U*
EIGHTBAY	SQ-17	05/29/84	SQ-17		--	--	--	--	--	--	20 *U*
EIGHTBAY	SQ-18	05/29/84	SQ-18		--	--	--	--	--	--	20 *U*
EIGHTBAY	SQ-20	05/29/84	SQ-20		--	--	--	--	--	--	20 *U*
MISCREFS	CR-15	07/01/75	15		--	--	--	--	--	--	5.7
NOADW86	CARRINL	05/01/86	CARRINL		--	--	--	--	--	--	41
NOADW86	DABOB	05/01/86	DABOB		--	--	--	--	--	--	10
NOADW86	SAMISH	05/01/86	SAMISH		--	--	--	--	--	--	25
NOADW86	SEQUIM17	05/01/86	SEQUIM17		--	--	--	--	--	--	48
OAKHRBR	SEQUIM	02/26/85	SEQUIM		--	--	--	--	--	--	--
OLYHAR88	SQ-01	01/01/88	SQ-01		--	--	--	--	--	--	17
PSDDA1	CRR01	05/17/88	CRR01C		200 *U*	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*	40 *U*
RILEY001	NG-10	08/01/82	NG-10	1	--	--	--	--	--	--	0.10 *U*
RILEY001	NG-10	08/01/82	NG-11	2	--	--	--	--	--	--	0.10 *U*
RILEY001	NG-9	08/01/82	NG-9		--	--	--	--	--	--	0.10 *U*

[a] Sum of polychlorinated biphenyls.

TABLE D10. VOLATILE ORGANIC COMPOUNDS IN HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS (μg/kg, dry weight)

Survey	Station	Date	Sample	Trichloroethene	Tetrachloroethylene	Ethylbenzene	Total Xylenes
EIGHTBAY	DB-01	05/22/84	DB-01	7.2 *U*	7.2 *U*	7.2 *U*	--
EIGHTBAY	DB-05	05/22/84	DB-05	7.9 *U*	7.9 *U*	7.9 *U*	--
EIGHTBAY	DB-07	05/22/84	DB-07	10 *U*	10 *U*	10 *U*	--
EIGHTBAY	DB-15	05/22/84	DB-15	16 *U*	16 *U*	16 *U*	--
EIGHTBAY	SM-01	04/24/84	SM-01	4.1 *U*	4.1 *U*	4.1 *U*	--
EIGHTBAY	SM-03	04/24/84	SM-03	13 *U*	13 *U*	13 *U*	--
EIGHTBAY	SM-07	04/24/84	SM-07	4.3 *U*	4.3 *U*	4.3 *U*	--
EIGHTBAY	SM-20	04/24/84	SM-20	4.5 *U*	4.5 *U*	4.5 *U*	--
EIGHTBAY	SQ-14	05/29/84	SQ-14	13 *U*	13 *U*	13 *U*	--
EIGHTBAY	SQ-17	05/29/84	SQ-17	13 *U*	13 *U*	13 *U*	--
EIGHTBAY	SQ-18	05/29/84	SQ-18	13 *U*	13 *U*	13 *U*	--
EIGHTBAY	SQ-20	05/29/84	SQ-20	15 *U*	15 *U*	15 *U*	--
NOADW86	CARRINL	05/01/86	CARRINL	50 *U*	50 *U*	50 *U*	50 *U*
NOADW86	DABOB	05/01/86	DABOB	50 *U*	50 *U*	50 *U*	50 *U*
NOADW86	SAMISH	05/01/86	SAMISH	50 *U*	50 *U*	50 *U*	50 *U*
NOADW86	SEQUIM17	05/01/86	SEQUIM17	50 *U*	50 *U*	50 *U*	50 *U*
OLYHAR88	SQ-01	01/01/88	SQ-01	2 *U*	2 *U*	2 *U*	5 *U*
PSDDA1	CRR01	05/17/88	CRR01C	0.9 *U*	0.7 *U*	1.2 *U*	2.6 *U*

TABLE D11. BIOASSAY RESPONSES FOR HISTORICAL PUGET SOUND REFERENCE AREA SEDIMENTS

Survey	Station	Date	Lab Replicate	Response
Amphipod (*Rhepoxynius abronius*) Percent Mortality				
CBMSQS	CR–11	01/01/84	1	80
CBMSQS	CR–11	01/01/84	2	15
CBMSQS	CR–11	01/01/84	3	5
CBMSQS	CR–11	01/01/84	4	15
CBMSQS	CR–11	01/01/84	5	10
CBMSQS	CR–11	01/01/84	Mean	25
CBMSQS	CR–12	01/01/84	1	10
CBMSQS	CR–12	01/01/84	2	5
CBMSQS	CR–12	01/01/84	3	15
CBMSQS	CR–12	01/01/84	4	10
CBMSQS	CR–12	01/01/84	5	15
CBMSQS	CR–12	01/01/84	Mean	11
CBMSQS	CR–13	01/01/84	1	10
CBMSQS	CR–13	01/01/84	2	15
CBMSQS	CR–13	01/01/84	3	5
CBMSQS	CR–13	01/01/84	4	5
CBMSQS	CR–13	01/01/84	5	0
CBMSQS	CR–13	01/01/84	Mean	7
CBMSQS	CR–14	01/01/84	1	5
CBMSQS	CR–14	01/01/84	2	15
CBMSQS	CR–14	01/01/84	3	15
CBMSQS	CR–14	01/01/84	4	0
CBMSQS	CR–14	01/01/84	5	15
CBMSQS	CR–14	01/01/84	Mean	10
DUWRIV2	SEQUIM	09/13/86	1	17
DUWRIV2	SEQUIM	09/16/86	2	4
DUWRIV2	SEQUIM	10/04/86	3	14
DUWRIV2	SEQUIM	10/07/86	4	11
DUWRIV2	SEQUIM	10/07/86	Mean	11.5
EIGHTBAY	DB–01	05/22/84	1	5
EIGHTBAY	DB–01	05/22/84	2	15
EIGHTBAY	DB–01	05/22/84	3	15
EIGHTBAY	DB–01	05/22/84	4	5
EIGHTBAY	DB–01	05/22/84	5	10
EIGHTBAY	DB–01	05/22/84	Mean	10
EIGHTBAY	DB–05	05/22/84	1	10
EIGHTBAY	DB–05	05/22/84	2	10
EIGHTBAY	DB–05	05/22/84	3	10
EIGHTBAY	DB–05	05/22/84	4	5
EIGHTBAY	DB–05	05/22/84	5	0
EIGHTBAY	DB–05	05/22/84	Mean	7
EIGHTBAY	DB–07	05/22/84	1	20
EIGHTBAY	DB–07	05/22/84	2	30
EIGHTBAY	DB–07	05/22/84	3	25
EIGHTBAY	DB–07	05/22/84	4	10
EIGHTBAY	DB–07	05/22/84	5	45
EIGHTBAY	DB–07	05/22/84	Mean	26
EIGHTBAY	DB–15	05/22/84	1	60
EIGHTBAY	DB–15	05/22/84	2	35
EIGHTBAY	DB–15	05/22/84	3	35
EIGHTBAY	DB–15	05/22/84	4	30

TABLE D11. (Continued)

Survey	Station	Date	Lab Replicate	Response
EIGHTBAY	DB-15	05/22/84	5	20
EIGHTBAY	DB-15	05/22/84	Mean	36
EIGHTBAY	SM-01	04/24/84	1	15
EIGHTBAY	SM-01	04/24/84	2	50
EIGHTBAY	SM-01	04/24/84	3	25
EIGHTBAY	SM-01	04/24/84	4	30
EIGHTBAY	SM-01	04/24/84	5	35
EIGHTBAY	SM-01	04/24/84	Mean	31
EIGHTBAY	SM-03	04/24/84	1	50
EIGHTBAY	SM-03	04/24/84	2	40
EIGHTBAY	SM-03	04/24/84	3	50
EIGHTBAY	SM-03	04/24/84	4	50
EIGHTBAY	SM-03	04/24/84	5	45
EIGHTBAY	SM-03	04/24/84	Mean	47
EIGHTBAY	SM-07	04/24/84	1	10
EIGHTBAY	SM-07	04/24/84	2	35
EIGHTBAY	SM-07	04/24/84	3	30
EIGHTBAY	SM-07	04/24/84	4	15
EIGHTBAY	SM-07	04/24/84	5	35
EIGHTBAY	SM-07	04/24/84	Mean	25
EIGHTBAY	SM1	08/06/83	1	20
EIGHTBAY	SM10	08/08/83	1	45
EIGHTBAY	SM11	08/08/83	1	30
EIGHTBAY	SM12	08/08/83	1	10
EIGHTBAY	SM13	08/09/83	1	0
EIGHTBAY	SM14	08/09/83	1	5
EIGHTBAY	SM15	08/09/83	1	0
EIGHTBAY	SM16	08/09/83	1	20
EIGHTBAY	SM17	08/09/83	1	0
EIGHTBAY	SM18	08/09/83	1	50
EIGHTBAY	SM19	08/09/83	1	25
EIGHTBAY	SM2	08/06/83	1	25
EIGHTBAY	SM-20	04/24/84	1	15
EIGHTBAY	SM-20	04/24/84	2	40
EIGHTBAY	SM-20	04/24/84	3	35
EIGHTBAY	SM-20	04/24/84	4	35
EIGHTBAY	SM-20	04/24/84	5	30
EIGHTBAY	SM-20	04/24/84	Mean	31
EIGHTBAY	SM20	08/09/83	1	15
EIGHTBAY	SM3	08/06/83	1	10
EIGHTBAY	SM4	08/06/83	1	30
EIGHTBAY	SM5	08/08/83	1	20
EIGHTBAY	SM6	08/08/83	1	10
EIGHTBAY	SM7	08/08/83	1	35
EIGHTBAY	SM7	08/08/83	2	10
EIGHTBAY	SM7	08/08/83	3	15
EIGHTBAY	SM7	08/08/83	Mean	20
EIGHTBAY	SM8	08/08/83	1	15
EIGHTBAY	SM9	08/08/83	1	60
EIGHTBAY	SQ1	08/15/83	1	10
EIGHTBAY	SQ1	08/15/83	2	35
EIGHTBAY	SQ1	08/15/83	3	25

TABLE D11. (Continued)

Survey	Station	Date	Lab Replicate	Response
EIGHTBAY	SQ1	08/15/83	Mean	23.3
EIGHTBAY	SQ10	09/17/83	1	15
EIGHTBAY	SQ11	09/17/83	1	40
EIGHTBAY	SQ12	09/17/83	1	45
EIGHTBAY	SQ13	09/17/83	1	5
EIGHTBAY	SQ−14	05/29/84	1	5
EIGHTBAY	SQ−14	05/29/84	2	20
EIGHTBAY	SQ−14	05/29/84	3	5
EIGHTBAY	SQ−14	05/29/84	4	20
EIGHTBAY	SQ−14	05/29/84	5	10
EIGHTBAY	SQ−14	05/29/84	Mean	12
EIGHTBAY	SQ14	09/18/83	1	5
EIGHTBAY	SQ15	09/18/83	1	5
EIGHTBAY	SQ16	09/18/83	1	25
EIGHTBAY	SQ−17	05/29/84	1	20
EIGHTBAY	SQ−17	05/29/84	2	0
EIGHTBAY	SQ−17	05/29/84	3	15
EIGHTBAY	SQ−17	05/29/84	4	5
EIGHTBAY	SQ−17	05/29/84	5	10
EIGHTBAY	SQ−17	05/29/84	Mean	10
EIGHTBAY	SQ17	09/18/83	1	25
EIGHTBAY	SQ−18	05/29/84	1	25
EIGHTBAY	SQ−18	05/29/84	2	25
EIGHTBAY	SQ−18	05/29/84	3	0
EIGHTBAY	SQ−18	05/29/84	4	0
EIGHTBAY	SQ−18	05/29/84	5	5
EIGHTBAY	SQ−18	05/29/84	Mean	11
EIGHTBAY	SQ18	09/18/83	1	5
EIGHTBAY	SQ19	09/18/83	1	0
EIGHTBAY	SQ2	08/15/83	1	10
EIGHTBAY	SQ−20	05/29/84	1	35
EIGHTBAY	SQ−20	05/29/84	2	20
EIGHTBAY	SQ−20	05/29/84	3	45
EIGHTBAY	SQ−20	05/29/84	4	20
EIGHTBAY	SQ−20	05/29/84	5	15
EIGHTBAY	SQ−20	05/29/84	Mean	27
EIGHTBAY	SQ20	09/18/83	1	40
EIGHTBAY	SQ3	08/15/83	1	5
EIGHTBAY	SQ4	08/15/83	1	10
EIGHTBAY	SQ5	08/16/83	1	5
EIGHTBAY	SQ6	08/16/83	1	5
EIGHTBAY	SQ7	09/17/83	1	5
EIGHTBAY	SQ8	09/17/83	1	15
EIGHTBAY	SQ9	09/17/83	1	20
EVERETT1	SQ−1	06/06/85	1	5
EVERETT1	SQ−1	06/06/85	2	10
EVERETT1	SQ−1	06/06/85	3	5
EVERETT1	SQ−1	06/06/85	4	5
EVERETT1	SQ−1	06/06/85	5	5
EVERETT1	SQ−1	06/06/85	Mean	6
KENM86	SEQUIM		1	25
KENM86	SEQUIM		2	35

TABLE D11. (Continued)

Survey	Station	Date	Lab Replicate	Response
KENM86	SEQUIM		3	15
KENM86	SEQUIM		4	35
KENM86	SEQUIM		5	20
KENM86	SEQUIM		Mean	26
NOADW86	CARRINL	06/01/86	Mean	12
NOADW86	DABOB	06/01/86	Mean	12
NOADW86	SAMISH	06/01/86	Mean	20
NOADW86	SEQUIM17	06/01/86	Mean	11.7
NOADW86	SEQUIM17	05/01/86	Mean	25
OAKHRBR	SEQUIM	02/26/85	1	35
OAKHRBR	SEQUIM	02/26/85	2	40
OAKHRBR	SEQUIM	02/26/85	3	30
OAKHRBR	SEQUIM	02/26/85	4	35
OAKHRBR	SEQUIM	02/26/85	5	45
OAKHRBR	SEQUIM	02/26/85	Mean	37
PSDDA1	CRR01	05/17/88	1	25
PSDDA1	CRR01	05/17/88	2	25
PSDDA1	CRR01	05/17/88	3	0
PSDDA1	CRR01	05/17/88	4	10
PSDDA1	CRR01	05/17/88	5	20
PSDDA1	CRR01	05/17/88	Mean	16
REFGRAIN	DB−02	03/25/86	1	60
REFGRAIN	DB−02	03/25/86	2	40
REFGRAIN	DB−02	03/25/86	3	35
REFGRAIN	DB−02	03/25/86	4	10
REFGRAIN	DB−02	03/25/86	5	30
REFGRAIN	DB−02	03/25/86	Mean	35
REFGRAIN	DB−06	03/25/86	1	25
REFGRAIN	DB−14	03/25/86	1	60
REFGRAIN	DB−14	03/25/86	2	0
REFGRAIN	DB−14	03/25/86	3	5
REFGRAIN	DB−14	03/25/86	4	5
REFGRAIN	DB−14	03/25/86	5	10
REFGRAIN	DB−14	03/25/86	Mean	16
REFGRAIN	DB−15	03/25/86	1	20
REFGRAIN	DB−15	03/25/86	2	35
REFGRAIN	DB−15	03/25/86	3	10
REFGRAIN	DB−15	03/25/86	4	25
REFGRAIN	DB−15	03/25/86	5	20
REFGRAIN	DB−15	03/25/86	Mean	22
REFGRAIN	DB−18	03/25/86	1	15
REFGRAIN	DB−18	03/25/86	2	25
REFGRAIN	DB−18	03/25/86	3	0
REFGRAIN	DB−18	03/25/86	4	5
REFGRAIN	DB−18	03/25/86	5	5
REFGRAIN	DB−18	03/25/86	Mean	10
Bivalve (*Crassostrea gigas*) Percent Abnormality				
CBMSQS	CR−11	01/01/84	1	20.7
CBMSQS	CR−11	01/01/84	2	12.8
CBMSQS	CR−11	01/01/84	Mean	16.8

TABLE D11 (Continued)

Survey	Station	Date	Lab Replicate	Response
CBMSQS	CR−12	01/01/84	1	9.4
CBMSQS	CR−12	01/01/84	2	13.1
CBMSQS	CR−12	01/01/84	Mean	11.3
CBMSQS	CR−13	01/01/84	1	10.8
CBMSQS	CR−13	01/01/84	2	8.9
CBMSQS	CR−13	01/01/84	Mean	9.9
CBMSQS	CR−14	01/01/84	1	14.8
CBMSQS	CR−14	01/01/84	2	13.7
CBMSQS	CR−14	01/01/84	Mean	14.3
Bivalve (*Mytilus edilus*) Percent Abnormality				
PSDDA1	CRR01	05/17/88	1	0
PSDDA1	CRR01	05/17/88	2	0
PSDDA1	CRR01	05/17/88	3	16.7
PSDDA1	CRR01	05/17/88	4	16.7
PSDDA1	CRR01	05/17/88	5	7.4
PSDDA1	CRR01	05/17/88	Mean	8.16