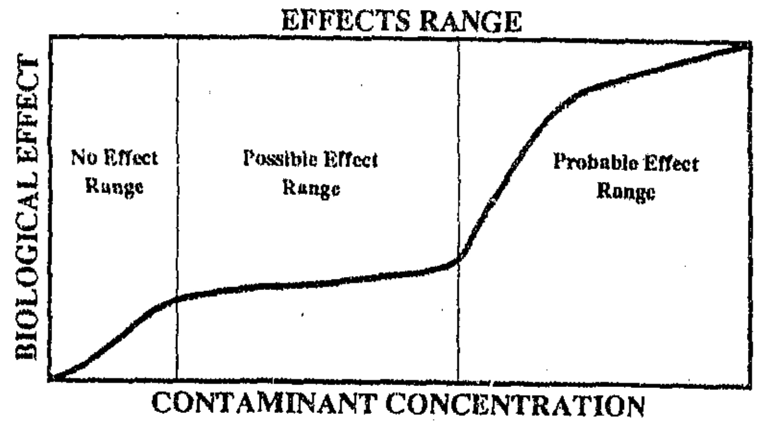
NOAA Technical Memorandum NOS OMA 52

THE POTENTIAL FOR BIOLOGICAL EFFECTS OF SEDIMENT-SORBED CONTAMINANTS TESTED IN THE NATIONAL STATUS AND TRENDS PROGRAM



Seattle, Washington

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

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Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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THE POTENTIAL FOR BIOLOGICAL EFFECTS OF SEDIMENT-SORBED CONTAMINANTS TESTED IN THE NATIONAL STATUS AND TRENDS PROGRAM

Edward R. Long and Lee G. Morgan

ABSTRACT

National Oceanic and Atmospheric Administration (NOAA) annually collects and chemically analyzes sediment samples from sites located in coastal marine and estuarine environments throughout the United States as a part of the National Status and Trends (NS&T) Program. While the chemical data provide indications of the relative degrees of contamination among the sampling sites, they provide neither a measure of adverse biological effects nor an estimate of the potential for effects. Data derived from a wide variety of methods and approaches were assembled and evaluated to identify informal guidelines for use in evaluation of the NS&T Program sediment data. The data from three basic approaches to the establishment of effects-based criteria were evaluated: the equilibrium-partitioning approach, the spiked-sediment bioassay approach, and various methods of evaluating synoptically collected biological and chemical data in field surveys. The chemical concentrations observed or predicted by the different methods to be associated with biological effects were sorted, and the lower 10 percentile and median concentrations were identified along with an overall apparent effects threshold. The lower 10 percentile in the data was identified as an Effects Range-Low (ER-L) and the median was identified as an Effects Range-Median (ER-M). Note that these ER-L and ER-M values are not to be construed as NOAA standards or criteria. The ambient NS&T Program sediment data from sampling sites were compared with the respective ER-L and ER-M values for each analyte. The comparisons were used to rank sites with regard to the potential for adverse biological effects, assuming that the sites in which the average chemical concentrations exceeded the most ER-L and ER-M values would have the highest potential for effects. The rankings indicated that a sampling site located in the Hudson-Raritan estuary had the highest potential for effects, followed by a site located in Boston Harbor, a site located in western Long Island Sound, and a site located in the Oakland estuary of San Francisco Bay.

INTRODUCTION

The concentrations of selected potentially toxic chemicals in marine and estuarine sediments have been quantified annually by NOAA in the NS&T Program since 1984. Sediments from about 200 sites nationwide have been sampled and analyzed for a variety of trace metals, petroleum hydrocarbons, and synthetic organic compounds. The chemical concentrations have been compared among sampling sites and among sampling years at many of the sites. These data have been useful in characterizing the chemical conditions at sampling sites (NOAA, 1987, 1988) and in determining whether or not conditions are changing over time. In selected geographic areas measures of biological effects have been performed to accompany the chemical analyses and used to determine or indicate the significance of the sediment contamination. However, biological measures of the effects or potential for effects of these mixtures of chemicals have not been determined at the majority of the sites.

The purpose of this report is to assess the relative likelihood or potential for adverse biological effects occurring due to exposure of biota to toxicants in sediments sampled and analyzed by the NS&T Program. In order to satisfy that objective, guidelines were developed for use in assessing the potential for effects. These guidelines were developed by employing a preponderance of evidence assembled from a variety of approaches and from data gathered in many geographic areas. These guidelines were used to rank and prioritize the NS&T Program sites with regard to the relative potential for contaminant-induced

effects. The severity and geographic extent of adverse effects may be determined by NOAA in intensive regional surveys in areas in which high-priority sites are located. These guidelines were not intended for use in regulatory decisions or any other similar applications.

METHODS

Overall Approach

A three-step approach was followed to complete the evaluation: (1) assemble and review currently available information in which estimates of the sediment concentrations of chemicals associated with adverse biological effects have been determined or could be derived; (2) determine apparent ranges in concentrations of individual chemicals in which effects are likely to occur, based upon a preponderance of evidence; and (3) evaluate the NS&T Program sediment chemical data relative to these consensus effects ranges. The first step involved reviewing reports either (1) in which effects-based sediment quality values were reported or (2) in which matched chemistry and biological effects data were listed, followed by an evaluation of the co-occurrence of chemical concentrations with measures of effects. These reports embraced controlled laboratory studies of effects of sediments spiked with individual chemicals, calculations of unacceptable concentrations based upon theoretical equilibrium partitioning principles, and evaluations of data from field studies in which matching chemical and biological measures were performed on subsamples of sediments. Among the reports reviewed, only those that met certain criteria were selected for further use. Chapman *et al.*, 1987 compared the estimated sediment quality values for three chemicals based upon four approaches, and noted that the values from the approaches were consistent.

The second step included screening the data by examining the degree of concordance between the biological and chemical data, sorting the remaining data in ascending order, and determining consensus ranges in values associated with adverse effects. A key element of the second step was the determination of the chemical concentrations above which adverse effects may be first expected and the concentrations above which adverse effects always or almost always may be expected. The intent was not to identify only the lowest concentration of contaminants at which an adverse effect had been observed or predicted for any organism.

The third step involved comparing the ambient sediment chemistry data from the NS&T Program with the respective ranges in chemical concentrations apparently associated with observations of effects. A comparison of proposed or preliminary sediment quality values and ambient concentrations of chemicals in United States sediments was previously conducted by Bolton *et al.*, 1985 and Lyman *et al.*, 1987 for the United States Environmental Protection Agency (U. S. EPA). Both reports involved a relatively small number of chemicals and sediment quality values derived from only one approach. The approach followed in this report is similar to the approach used in those two reports, but includes sediment quality values derived from many methods and evaluates data for 12 trace metals, 18 petroleum hydrocarbons, and 11 synthetic organic compounds or classes.

Approaches for Determining Effects-Based Sediment Quality Criteria

Since the purpose of this report is not to critique or evaluate the relative strengths and weaknesses of the various approaches that have been used to develop effects-based sediment quality values, only a brief description of each will be presented here. Chapman (1989) reviewed and compared the approaches currently being pursued to develop sediment quality values, but did not compare the concentrations resulting from those approaches. That report and the other documents cited herein should be consulted for more information on each of the respective approaches.

Effects-based sediment quality values derived from different numbers and types of approaches are available for some of the NS&T Program analytes. The values from some approaches are region-specific and those from other approaches are available for only a minority of the NS&T Program analytes. Because of the complementary strengths of each of the approaches, it was decided to determine if a consensus value in concentrations for each chemical was apparent and to use those consensus values in evaluating the NS&T Program

data. Conversely, because of the apparent weaknesses of each method alone, it was decided that values based upon a consensus of multiple approaches and multiple applications of each approach would have more credibility than values based upon only one approach.

Background Approach. Criteria have been established in various geographic areas of the United States and other countries based upon an approach involving the use of reference or background values in sediments. In this approach, the data from a pristine area have been used as the standard and concentrations in sediments from target areas that exceed these background values by some specified amount are considered unacceptable. In some cases the criteria were set at some value above the background concentration, say, at 125 percent of background or two standard deviations above the mean background concentration. This approach does not involve any determination or estimation of effects, but the criteria based upon this approach were included in this report for the purpose of comparing them with the criteria developed from the effects-based approaches. These criteria were listed in this report as presented in the cited documents without any modifications, however, they were not used to determine consensus ranges in concentrations associated with effects. Many had been listed and compared by Pavlou and Weston (1983).

Sediment-Water Equilibrium Partitioning (EP) Approach. In this approach the criteria are established for single chemicals at concentrations in sediment that ensure that the concentrations in interstitial water do not exceed the applicable U. S. EPA water quality criteria (Bolton *et al.*, 1985; JRB Associates, 1984). It is assumed that water quality criteria, when applied to the interstitial water of sediments, would protect infaunal organisms. Physical/chemical principles are used to predict the chemical concentrations that would occur in the interstitial water in equilibrium with those concentrations of the chemicals sorbed to particulates in the sediments, recognizing that the distribution of the chemicals between the two phases is highly influenced by the amount of organic carbon or acid volatile sulfides (AVS) present in the sediments. Tessier and Campbell (1987) reviewed many of the chemical and physical factors in sediments that can strongly influence the partitioning of trace metals between aqueous- and particle-bound phases of sediments and observed that, because of these factors, bulk chemical concentrations of trace metals were poor predictors of the bioavailability of these toxicants. Where criteria were listed in cited documents in units dry weight, they were used in this report without any modifications. Where criteria were listed in units of organic carbon, they were converted to units dry weight, assuming a stated organic carbon concentration (usually 1% total organic carbon [TOC]). Where the criteria were listed in the cited documents in units dry weight assuming a reported TOC concentration other than 1 percent (*e.g.*, 4%), those reported values were used in this report without modification.

Most of the EP-derived criteria listed herein were reported by the U. S. EPA, 1988. Since that report was published, new information has become available that strongly suggests that AVS are important in controlling availability of trace metals. The interim criteria reported by the U. S. EPA (1988) did not account for AVS. Nevertheless, these criteria were used in the present document as reported.

Also, some of the sediment/water partitioning coefficients used to calculate the criteria have changed as new data have been developed for some analytes. Although more recent EP-derived criteria are probably more accurate, some of the earlier values were also included in the present document as reported. In addition, some inaccuracy may be possible in the EP-derived values due to the methods used to determine the TOC content of the sediments. The organic carbon normalized partition coefficients (K_{OC}) used to calculate the criteria may differ by factors of 2 to 4 times depending upon whether percent volatile solids or percent organic carbon are determined (Dr. Peter Landrum, NOAA, personal communication).

Spiked-Sediment Bioassay (SSB) Approach. This approach involves exposing organisms to pristine sediments spiked in the laboratory with known amounts of single chemicals (or mixtures), observing either mortality and/or sublethal effects and determining dose-response relationships (*e.g.*, Swartz *et al.*, 1988). Usually the criteria were reported as LC50 or EC50 values, the lethal concentrations or effective concentrations resulting in 50 percent mortality or 50 percent change in some sublethal end-point relative to controls. Where the bioassays were performed specifically for the purpose of determining sediment

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quality criteria, the values were listed in this report without modification and the species used and the exposure duration were noted. Where the bioassays were performed to determine the relative toxicity of various chemicals, the resulting values were also listed here without modification. Where bioassays of prospective dredge material or other sediments were performed to determine the potential for bioaccumulation and the authors noted their observations on mortality during the tests, those observations were included in this report.

Screening Level Concentrations (SLC) Approach. Field-collected data are used in this approach and patterns in co-occurrence in sediment concentrations of chemicals and matching analyses of benthic infaunal composition are determined. The SLC are the estimated highest concentration of selected nonpolar organic chemicals that co-occur with approximately 95 percent of the infauna. A cumulative frequency distribution of all stations at which a particular species of infaunal invertebrate is present is plotted against the organic carbon-normalized concentration in sediment of the selected contaminant. The concentration of the contaminant at the locus representing the 90th percentile of the total number of stations at which the species was present is estimated by interpolation and established as the species screening level concentration (SSLC). Next, the SSLCs for a large number of species are plotted as a frequency distribution, and the concentration above which 95 percent of the SSLCs are found is determined as the SLC (Neff *et al.*, 1986). The SLC were calculated based upon data from many areas of the United States (Neff *et al.*, 1986; 1987). It is assumed that the contaminants occur in mixtures. The criteria reported in units organic carbon were converted to units dry weight in this document, assuming a TOC content of 1 percent.

Apparent Effects Threshold (AET) Approach. This approach also involves use of data from matched sediment chemistry and effects measures performed with field-collected sediment samples. Similar to the SLC approach, it is assumed that the chemicals occur in mixtures. An AET concentration is the sediment concentration of a selected chemical above which statistically significant ($P \leq 0.05$) biological effects (*e.g.*, depressions in the abundance of benthic infauna or elevated incidence of mortality in sediment toxicity tests) always occur and, therefore, are always expected (PTI Environmental Services, 1988). The AET values reported for Puget Sound were based upon the evaluation of data from many surveys of various portions of that region and were used in this document without modifications. Values reported in 1986 were based primarily upon data from studies performed in the waterways of Commencement Bay and were updated with additional data from other areas in Puget Sound in 1988. In addition, AET values were calculated by the present authors for data from Mississippi Sound generated by Lytle and Lytle, 1985 and for data from San Francisco Bay generated by many investigators in independent surveys (Long and Buchman, 1989; Chapman *et al.*, 1986; U.S. Navy, 1987; Word *et al.*, 1988). These latter values were calculated using the SedQual version 1.1 software developed by PTI Environmental Services, Inc. (1988) for U. S. EPA Region 10 and a sorting procedure, using Microsoft Excel software on a Macintosh computer.

Both the 1986 and the 1988 Puget Sound AET values were used in the present document. The 1988 values were based upon a larger data base than those determined in 1986, they may be more accurate than the former values, and they are being used in management decisions regarding Puget Sound. However, the 1986 concentrations also were used in this document since they were derived with methods equivalent to those used in 1988, with knowledge and data available at that time, and reflect another independent attempt to determine an unacceptable level of sediment contamination. However, whenever a 1988 AET value was exactly the same as a 1986 value, that concentration was only used once during the present data evaluation.

The Puget Sound Dredge Disposal Analysis (PSDDA) prepared screening level and maximum level values based upon the AET concentrations for Puget Sound. These values were listed in the present document without modification.

Bioeffects/Contaminant Co-Occurrence Analyses (COA) Approach. Similar to the SLC and AET approaches, this method also involves use of field-collected data in which chemical mixtures occur. It involves calculation of statistics of central tendency (*i.e.*, means, standard deviations, maxima, minima) in chemical concentrations associated with matching samples determined to have high, intermediate, and low indications of effects. For example, DeWitt *et al.*, 1988 listed means and standard deviations in concentrations of selected chemicals found to be nontoxic, intermediate in toxicity, and significantly toxic to the amphipod *Rhepoxynius abronius* in tests of Puget Sound sediments. Long (1989) listed the means, standard deviations, maxima, and minima in concentrations of nine physical and chemical parameters in sediments from the Commencement Bay waterways determined to be least, intermediate, and most toxic to *R. abronius*. Data from DeWitt *et al.*, 1988 were used in this report without modifications. The format used by Long (1989) was used and expanded to accommodate many more chemicals quantified in Commencement Bay sediments and the co-occurrence values are reported herein. In addition, many reports in which matching sediment chemistry and sediment toxicity and/or benthic data were listed were evaluated, co-occurrence analyses were performed and the results reported herein.

The COA data from these reports, were collected for purposes other than determining sediment effects thresholds, but, nevertheless, were used here to determine patterns in co-occurrence of effects and contamination. Only those data sets in which chemical concentrations of one or more analytes differed among sampling stations by over an order of magnitude were considered in these analyses. Measures of "effects" observed in studies with a smaller range in chemical concentrations may have been caused solely or in part by other factors. Given the different degrees of variability in analytical procedures among laboratories, orders-of-magnitude differences in chemical concentrations are likely representative of real differences among sites. Where some chemical concentrations were reported as less than the detection limits, one-half of the detection limits were used in the calculations of means and standard deviation. In those reports in which the authors identified statistically significant effects ("hits"), two categories of bioeffects response (hits and non-hits) were established and the means, standard deviation maxima, and minima in chemical concentrations associated with those categories were calculated. In those reports in which the authors did not identify statistically significant effects, a frequency distribution of the bioeffects data was examined, either two or three categories of severity of effects were determined where two or three modes, respectively, in response were evident, and the means, standard deviation, maxima, and minima in chemical concentrations were calculated for each category in bioeffects response. With regard to the latter reports, the determination of these categories of degree of effects was subjective and somewhat arbitrary. Only data from published reports were used in the COA; unpublished data from the numerous pre-dredging assessments that have been performed recently in the United States were not used.

This approach suffers from the same weaknesses as all of the others that involve the use of matching biological and chemical data collected in the field. The assumption must be made that the toxic chemicals have an influence on the biological responses that are measured that outweighs the influence of natural physicochemical factors. The assumption is also made that the chemicals that are quantified were those that were responsible for the measured effects, although co-varying chemicals not quantified may have had an influence upon the biological tests. Although the chemicals likely act together (*e.g.*, synergistically) as mixtures to influence the biological tests, their patterns in co-occurrence are estimated singly in the co-occurrence data analyses. Recognizing these weaknesses in the use of field-collected data, data from many geographic areas were evaluated and used in an attempt to evaluate co-occurrence patterns under different pollution conditions. For example, in the analyses of copper data, those data from areas known to be relatively highly contaminated with copper were given more credibility t' , those from areas known to be contaminated with other chemicals.

Evaluation of the Sediment Values from the Different Approaches.

Tessier and Campbell (1987) summarized the complexities of determining the significance of particulate trace metals contamination in aquatic environments. Uptake (and therefore, effects) of sediment-associated contaminants is largely a function of bioavailability. Bioavailability is strongly influenced by a complex suite of physical, chemical, and biological factors in the sediments. Trace metals can be adsorbed at particle surfaces, carbonate-bound, occluded in iron and/or manganese oxyhydroxides, bound to organic matter, sulphide-bound, matrix-bound, or dissolved in the interstitial water (Tessier and Campbell, 1987). The relative bioavailability of trace metals associated with these phases has the effect of hindering the prediction of effects, based upon bulk sediment chemical analyses. The oxidation-reduction potential and the concentration of sulphides in the sediments can strongly influence the concentration of trace metals and their availability. Possibly as a result of these complex phase associations, Lee and Mariani (1977) observed very little concordance between measures of bulk sediment chemical concentrations and measures of toxicity, using the shrimp *Palaemonetes pugio*, in surveys performed nationwide. They concluded, "These bioassays clearly demonstrate the lack of validity of bulk chemical criteria for judging the significance of contaminants associated with dredged sediments." The present evaluation was performed with knowledge of the complexities and uncertainties involved with attempting to associate bulk chemical data with various measures of biological effects. DiToro (1988) argued that it is essential to understand the reasons for varying bioavailability before broadly applicable criteria can be established. His argument was based upon the observation that the concentration-response curve for toxicity could be correlated with the chemical concentration in the pore water and not the total (bulk) sediment. However, with no nationally adopted, official, final effects-based standards available, the use of a preponderance of evidence derived from many approaches was judged by the present authors to be the best method for developing guidance for interpreting the NS&T Program sediment data. Furthermore, in order to develop a preponderance of evidence, many data sets were used in the present document that did not include measures, such as TOC content, that could have been used to explain varying toxicity. In addition, data derived in freshwater and saltwater were merged and treated equally, despite the possibility that bioavailability may differ between the two regimes and the concentration levels may affect the two different ecosystems in much different ways.

Approximately 150 reports were reviewed for possible use in this document. In about one-half of those reports, there was either no biological data to accompany the sediment chemistry data or vice versa, there was no discernible gradient in contamination for any of the analytes among samples (less than a ten-fold difference), the biological or chemical analytical methods were poorly documented, or the biological and chemical data were not derived from the same sampling locations. The reports in which the data did not satisfy these criteria were not used.

The data from the remaining 85 reports were assembled and listed for each of the NS&T Program analytes according to the categorical type of approach that was used. Then, they were subjected to a screening step. In this step, the data for each analyte were evaluated with consideration given to the methods that were used, the type and magnitude of biological end-point measured, and the degree of concordance between the chemical and biological data. Using these evaluation factors, professional judgment was used to eliminate and disregard some values for some of the chemicals where it appeared that the chemical under consideration was not likely a contributor to the gradient in biological effects. For example, if in a field study in which the investigators expressed the observation that one or more selected chemicals were known to be highly concentrated in their study area, but they also measured other analytes during their chemical analyses, the latter data were included in the data tables, but were excluded from further consideration. If matching chemical and biological data from field studies showed no concordance, the data were listed in the tables, but not given further consideration. If no gradient (generally, less than a two-fold difference) in chemical concentrations was reported between samples that indicated adverse effects and those that did not indicate effects, the data for that particular chemical also were not given further consideration. If no definitive AET concentration could be determined, the "greater-than" value reported was excluded during this screening step. The screening step was not performed to force consensus where none existed. It was performed before the data were sorted (the next step), so it was not possible to have *a priori* knowledge of the consensus range. No other quality assurance screening steps were performed with the data.

The data that remained following this screening step were from studies in which effects were either predicted or observed in association with increasing concentrations of the respective analyte. Then, they were sorted in ascending order and listed in Appendix tables for each chemical. Next, usually two values were determined from these remaining data for each chemical: an ER-L, a concentration at the low end of the range in which effects had been observed; and an ER-M, a concentration approximately midway in the range of reported values associated with biological effects. These two values were determined using a method similar to that used by Klapow and Lewis (1979) in establishing marine water quality standards for the State of California. For each chemical of interest, they assembled available data from spiked-water bioassays, examined the distribution of the reported LC50 values, and determined the lower 10- and 50-percentile concentrations among the ranges of values. In the present document, the ER-L values were concentrations equivalent to the lower 10 percentile of the screened available data, and indicated the low end of the range of concentrations in which effects were observed or predicted. They were used in the document as the concentrations above which adverse effects may begin or are predicted among sensitive life stages and/or species or as determined in sublethal tests. The ER-M values for the chemicals were the concentrations equivalent to the 50 percentile point in the screened available data. They were used in the document as the concentration above which effects were frequently or always observed or predicted among most species. The methods of Byrkit (1975) were used to determine the percentile values.

Except for the benthic community data, most of the biological measurements made in the different approaches involved the determination of mortality as the end-point. Some contaminants, such as PCB and some aromatic hydrocarbons, may be mutagenic or teratogenic, and not very toxic in acute tests of mortality. Mutagenicity and other chronic effects may occur at levels lower than those listed in this document in association with acute mortality.

Klapow and Lewis (1979) examined data collected from only one approach, spiked-water bioassays, and assumed that the data from different investigators and studies were equivalent and comparable. The methods commonly used in spiked-water bioassays are relatively standardized. However, they evaluated data derived from tests of different species, which, presumably, had different sensitivities. In the present case, the data were assembled from more than one approach and often from different methods used in any one approach. They included data from studies that involved species with different contaminant sensitivities; therefore, they are less likely to be equivalent and comparable. Nevertheless, following the screening step, they were used as if they were equivalent and comparable in the estimation of ER-L and ER-M values.

In addition to the objectively determined ER-L and ER-M values, overall apparent effects thresholds were subjectively identified for some chemicals. These thresholds were the concentrations above which effects usually or always occurred in association with increasing concentrations of the chemical. They were determined independently of the ER-L and ER-M values by visually examining the sorted data. They are not to be confused with the AET values reported for Puget Sound, San Francisco Bay, and Mississippi Sound. They were identified as an aid in evaluating the accuracy of the ER-L and ER-M values and were not used in ranking the NS&T Program sites.

Data compilation and analysis was as inclusive as possible and no weighting was given to data derived from one approach or another. As Klapow and Lewis (1979) pointed out, the use of the inclusive approach and the calculation of percentiles of the data help eliminate the undue influence of a single (possibly outlier) data point upon the establishment of consensus ranges in concentrations associated with effects. In the present evaluation, the assumption was made that patterns established between effects and chemical concentrations would be more credible if based upon data from several sediment quality criteria than if based upon data from only one approach or experiment.

The ER-L and ER-M values were established objectively by determining the lower 10 and 50 percentiles in the data. No other more rigorous statistical procedures were used, since the consensus ER-L and ER-M values were intended only for use by NOAA as general guidance in evaluating the NS&T Program data.

The relative degrees of confidence in the accuracy of the ER-L and ER-M values are described for each analyte. Values for which we had relatively high confidence were those that were supported by clusters of data with similar concentrations, by data derived from more than one approach, by a data set that included more than results from the use of the COA approach, by data derived from multiple geographic areas, and for which the overall apparent effects threshold was similar to or within the range of the ER-L and ER-M values. Values for which we had relatively low confidence were those that were supported by data with either a small cluster or no cluster of similar concentrations, by data derived from only one approach and/or from one geographic area, results derived only from the COA approach, and for which the overall apparent effects threshold was dissimilar to or outside the range of the ER-L and ER-M values.

Although the consensus ER-L and ER-M concentrations may be used by others as guidance in evaluating sediment contamination data, there is no intent expressed or implied that these values represent official NOAA standards.

Evaluation of Sediment Effects Values and NS&T Program Data.

Following the determination of the ER-L and ER-M values for each of the analytes, these values were compared with the NS&T Program data to determine which sites had sediments that exceeded these values. The averages of the concentrations of each NS&T Program analyte were calculated for each site, usually based upon 2 adjoining years of data (i.e., n = 3 samples x 2 years = 6 samples). Sites at which the average ambient concentrations exceeded the ER-L and ER-M values were listed for each analyte.

The potential for biological effects was assumed to be highest for those sites in which the sediments exceeded the most ER-M values. This potential was assumed to be lower for sites that exceeded many of the ER-L values, but not the ER-M values. Biological effects were assumed to be least likely at sites that exceeded none of these values. The sites were ranked accordingly.

RESULTS

Three data tables are presented for most NS&T Program analytes. The first appears in the text and lists all of the data from the various approaches that were assembled for each analyte: the type of biological test or measure that was performed or predicted, the geographic area in which the data were collected (if applicable), the chemical concentration associated with that observed or predicted measure of effects, and a reference citation keyed to the reference section of each table. The second appears in Appendix B and, again, lists all of the data. However, in these tables, the data have been sorted in ascending order with remarks regarding whether or not each data point was used to determine the ER-L and ER-M values. The third appears in the text and lists, in ascending order, only those concentrations that remained following examination and screening of the data and includes the ER-L and ER-M values with respect to the data that were used to derive them. The ER-L and ER-M values often were rounded to the nearest full integer as appropriate.

In the third table for each analyte, the type of approach was noted with a shorthand descriptor: EP for equilibrium partitioning, SSB for spiked-sediment bioassay, SLC for screening level concentration, AET for apparent effects threshold, and COA for co-occurrence analyses. Data available for some chemical analytes were judged to be insufficient to warrant the determination of ER-L and ER-M values.

<u>Trace Metals:</u>

Antimony

Acute and chronic toxicity of antimony to freshwater aquatic life occur at water concentrations as low as 9,000 and 1,600 parts per million (ppm), respectively; toxicity to algal species occurs at concentrations as low as 610 ppm; no saltwater criteria are available (EPA, 1986).

The data evaluated for sediment antimony are from measures of effects performed in Puget Sound and San Francisco Bay (Table 1), and the values available are from AET and co-occurrence calculations. The Puget Sound AET values range from 3.2 ppm to 200 ppm. The AET values for the amphipod bioassay and benthic community composition differed considerably between 1986 and 1988. AET values calculated by the present authors for San

Francisco Bay are 1.9 and 2.9 ppm for bivalve (*Crassostrea gigas, Mytilus edulis*) larvae and *R. abronius* amphipod bioassays, respectively. The data from Commencement Bay, Washington indicate that toxicity to both *R. abronius* and the larvae of the oyster *C. gigas* increased with increasing antimony concentrations in the sediments. Sediments that caused moderate bioassay toxicity to both species had a mean of 2.0 ± 5.5 ppm antimony, whereas sediments that were most highly toxic had means of 91.5 ± 184.3 and 27.5 ± 101.5 ppm antimony, respectively.

In San Francisco Bay, there was no concordance between sediment toxicity to amphipods and antimony concentration. Sediments that were least toxic or not toxic had higher mean antimony concentrations than those that were most toxic or significantly toxic. For example, samples in which *R. abronius* mortality was highest (67 ± 12%) had antimony concentrations below the detection limits, while those in which mortality was lowest (18 ± 6.6%) had a higher mean concentration. This lack of concordance suggests that some other sediment characteristic(s) had a greater influence upon the toxic response than antimony; therefore, the San Francisco Bay amphipod bioassay data were not considered in the estimations of ER-L and ER-M (Table B-1).

Biological effects were noted in San Francisco Bay and Commencement Bay sediments with mean antimony concentrations as low as about 2 ppm (Table 2). The data suggest an ER-L of about 2 ppm, equivalent to the lower 10 percentile of the data (Table 2). Commencement Bay sediments that were moderately toxic to both amphipods and bivalve larvae had a mean concentration of 2 ppm; the PSDDA screening level concentration was 2.6; and the lowest Puget Sound AET value was 3.2 ppm. The data suggest an ER-M of about 25 ppm, roughly equivalent to the 50 percentile of the data (Table 2). This value is supported by observations of high toxicity to bivalve larvae exposed to San Francisco Bay sediments (mean of 25 ppm) and Puget Sound AET from two different biological tests (both 26 ppm). With one exception, effects were always associated with antimony concentrations of 25 ppm or greater (Table B-1).

Data were available from only two approaches and from only two geographic regions. The degree of confidence in both the ER-L and ER-M values for antimony should be considered as moderate. Both values were supported by clusters of similar data, and the overall apparent effects threshold was equivalent to the ER-M value. The determination of the relationships between antimony concentrations and measures of biological effects is hindered by the the lack of data from the predictive EP approach and from single-chemical, SSBs

Table 1. Summary of sediment effects data available for antimony.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	5.3
	- oyster larvae bioassay	26.0
	- benthic community composition	3.2
	- Microtox™ bioassay	26.0
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	200.0
	- benthic community composition	150.0
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	2.6
	- maximum level criterion	26.0

Table 1. Antimony (continued)

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>1.9
	- *R. abronius* amphipod bioassay	>2.9
Co-occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic to *R. abronius* (15.7 ± 3.9 dead/20)	91.5 ± 184
	- moderately toxic to *R. abronius* (5.2 ± 1.1 dead/20)	2.0 ± 5
	- least toxic to R. abronius (2.5 ± 0.9 dead/20)	0.9 ± 1.0
	- highly toxic (44.5 ± 19.0% abnormal) to oyster larvae	27.5 ± 101.5
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	2.0 ± 5.5
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	1.0 ± 1.4
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67.0 ± 11.8% mortality) to *R. abronius*	na
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	2.7 ± 6.7
	- least toxic (18.4 ± 6.8% mortality) to *R. abronius*	9.0 ± 11.6
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	2.3 ± 6.3
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	9.9 ± 11.8
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	25 ± 0
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	6.6 ± 1
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	5 ± 11.2
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	8.6 ± 11.9
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	6.7 ± 12.3

Reference	Background Approach	Concentrations (ppm)
12	EPA Region VI proposed guideline	500.0

na - not available

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
12. Pavlou and Weston, 1983
20. U.S. ACOE, 1988
80. Tetra Tech, 1985
* Various, please see text

Table 2. Effects range–low and effects range–median values for antimony and 13 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
2.0	Commencement Bay, Washington bioassay COA
2.0	**ER-L**
2.0	Commencement Bay, Washington bioassay COA
3.2	Puget Sound, Washington AET - benthic
5.3	Puget Sound, Washington AET - amphipod
6.6	San Francisco Bay, California bioassay COA
8.6	San Francisco Bay, California bioassay COA
25.0	**ER-M**
25.0	San Francisco Bay, California bioassay COA
26.0	Puget Sound, Washington AET - oyster
26.0	Puget Sound, Washington AET - Microtox™
27.5	Commencement Bay, Washington bioassay COA
91.5	Commencement Bay, Washington bioassay COA
150.0	Puget Sound, Washington AET - benthic
200.0	Puget Sound, Washington AET - amphipod

Arsenic

Arsenic is carcinogenic and teratogenic in humans and other mammals. Acute toxicity, as well as sublethal effects, have been observed in fish and invertebrates. Acute toxicity can be highly different among species, including those that are taxonomically related, and can be highly influenced by temperature, pH, speciation, and many other factors. Inorganic arsenicals are generally more toxic than organic forms (Eisler, 1988a). Inorganic arsenic (V) is acutely toxic to freshwater aquatic animals at concentrations as low as 850 ppm in water, and can affect marine plants at concentrations as low as 13 to 56 ppm in water and marine animals at 2,319 ppm in water (EPA, 1986). Klapow and Lewis (1979) proposed a marine water quality standard of 8 ppm for total arsenic.

The data available for effects of arsenic in sediment are from three approaches: EP and field studies in which AET values and/or co-occurrence values have been calculated (Tables 3 and 4). Both acute and chronic marine values based upon EP principles are available. AETs for both Puget Sound and San Francisco Bay are available and vary from 54 ppm arsenic to 700 ppm. COA were performed with data from Puget Sound, Commencement Bay, San Francisco Bay, Waukegan Harbor, Black Rock Harbor, southern California, Sheboygan River, Trinity River, Baltimore Harbor, DuPage River, Kishwaukee River, and a dump site off Georgetown, South Carolina.

Data from many of the studies were not used in estimating the ER-L and ER-M values (Table B-2). The chemical data from San Francisco Bay indicated a pattern of concordance with the bivalve embryo bioassay data, but not with the amphipod bioassay. Thus, the latter were not considered in the estimation of ER-L and ER-M values. The arsenic concentration reported for Waukegan Harbor was below detection limits and was not considered further. The data from Southern California, Trinity River, DuPage River, and Kishwaukee River indicated relatively small ranges in arsenic concentrations and were not considered further. The Black Rock Harbor data were from a bioavailability/uptake experiment in which the concentrations of other metals were substantially higher than that of arsenic. No effects upon benthic communities were reported at arsenic concentrations up to 1.4 ppm at the Georgetown, South Carolina dumpsite. The bioassay data from Los Angeles Harbor were from a small sample size (two) and the ranges in concentrations for some of the other chemicals in the sediments were much higher than that for arsenic. The Sheboygan River data were from a small sample size (three), from an experiment whose objective was to determine uptake (mainly of PCBs), and where the range in arsenic values was very small.

The remaining data suggest an ER-L of about 33 ppm, the lower 10 percentile value of the data (Table 4). San Francisco Bay sediments that were moderately toxic to bivalve larvae had a mean concentration of 22.1 ppm, and the chronic marine value derived from EP is 33 ppm (assuming a 4% TOC content). In addition, two values based upon the background approach are consistent with this value: the New England class III level (>20 ppm) and The Netherlands Harbor moderately polluted level (23 to 32 ppm).

The ER-M suggested by the data (Table 4) is about 85 ppm; supported by the acute marine threshold predicted by EP methods (64 ppm), high toxicity in Baltimore Harbor samples (mean of 91.9 ppm) and Puget Sound AET for benthic community effects and amphipod bioassays (85 and 93 ppm , respectively). With one exception, effects were always observed in association with arsenic concentrations of 50 ppm or greater, an apparent effects threshold for arsenic (Table B-2). Many values calculated from data collected in Commencement Bay and nearby southern Puget Sound indicate very high arsenic concentrations (690 to 2257 ppm) in sediments associated with observed effects. This area was highly impacted by the atmospheric and aqueous discharge of arsenic from an industrial point source for many years and high arsenic concentrations have been frequently observed there.

The arsenic data are from three approaches and from several geographic areas, but do not include observations made in single-chemical, laboratory, SSBs. There appears to be relatively poor consistency and clustering among the available values at the low end of the range. Therefore, the degree of confidence in the ER-L should be considered as relatively poor. The ER-M value is supported by several observations and is roughly equivalent to an overall apparent effects threshold, and the degree of confidence in it should be considered as moderate.

Table 3. Summary of sediment effects data available for arsenic.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Thresholds		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	93
	- oyster larvae (*C. gigas*) bioassay	700
	- benthic community composition	85
	- Microtox™ bioassay	700
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	93
	- oyster larvae (*C. gigas*) bioassay	700
	- benthic community composition	57
	- Microtox™ bioassay	700
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	70
	- maximum level criterion	700
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- oyster/mussel larvae bioassay	54
	- amphipod bioassay	70

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Table 3. Arsenic (continued)

References	Biological Approaches	Concentrations (ppm)
Co-occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9% dead/20) to *R. abronius*	2257.1 ± 4213.7
	- moderately toxic (5.2 ± 1.1% dead/20) to *R. abronius*	63.2 ± 148
	- least toxic (2.5 ± 0.9% dead/20) to *R. abronius*	28.3 ± 26.6
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	689.9 ± 2350.9
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	58.7 ± 148.1
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	27.8 ± 30.8
26	PUGET SOUND, WASHINGTON	
	- highly toxic samples (95%LPL) to *R. abronius*	1005 ± 2777
	- moderately toxic (<87.5 to >95% LPL) to *R. abronius*	25.1 ± 23.1
	- non-toxic (>87.5% survival) to *R. abronius*	22.6 ± 28.1
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8%) to *R. abronius*	17.5 ± 14.2
	- moderately toxic (33.8 ± 4.7%) to *R. abronius*	10.4 ± 13.4
	- least toxic (18 ± 6.6%) to *R. abronius*	28 ± 21.5
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	14.65 ± 13.9
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	30.3 ± 22.4
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	50.7 ± 29.3
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	22.1 ± 19.4
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	13.7 ± 14.8
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	22.8 ± 22.1
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	22 ± 18.7
72	WAUKEGAN HARBOR, WISCONSIN highly toxic (66.3 ± 4.25 % mortality) to *H. azteca*	<47.2
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to *N. virens*	1.88
56	SOUTHERN CALIFORNIA	
	- Mean concordance with significant mortality (51.7%) to *G. japonica*	8.3
	- Mean concordancenot signicantly toxic (23.2% mortality) to *G. japonica*	5.8
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to *M. rosenbergii*	2.7 ± 0.2
39	DUWAMISH RIVER, WASHINGTON	
	- 0 to 10% mortality to *P. pugio* in 96-h bioassays	1.3
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio* in 96-h elutriate bioassays	2.8
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P.pugio* in 96-h elutriate bioassays	1.0

Table 8. Arsenic (continued).

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
39	NORWALK RIVER, CONNECTICUT	
	- 0% mortality to *P. pugio* in 96-h elutriate bioassays	3.4
39	LOS ANGELES, CALIFORNIA	
	- >50% mortality to *P. pugio* in 96-h 20% elutriate bioassays	12.8
75	TRINITY RIVER, TEXAS	
	- significant mortality to *Daphnia magna*	3.4 ± 1.8
	- non-toxic to *D. magna*	2.2 ± 1.2
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects on benthic community abundance or species richness	1.36
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs and spot in 48-hour bioassays	91.9 ± 78.6
	- least toxic to mummichogs and spot in 48-hour bioassays	32 ± 14.3
60	DUPAGE RIVER, ILLINOIS	
	- low number of taxa (6.7 ± 2.5)	7.4 ± 2.2
	- high number of taxa (15.8 ± 2)	5.9 ± 1.1
61	KISHWAUKEE RIVER, ILLINOIS	
	- low number of taxa (8.4 ± 0.5)	3.7 ± 1.0
	- high number of taxa (16.3 ± 4.6)	5.0 ± 1.8
Equilibrium Partitioning Approach		
17	EPA acute marine EP threshold (@4% TOC)	64
	EPA chronic marine EP threshold (@4% TOC)	33

References	Background Approach	Concentrations (ppm)
68	Great Lakes harbors sediments	
	- classification of non-polluted sediment	<3
	- classification of moderately polluted sediment	3.0-8.0
	- classification of heavily polluted sediment	>8
43	New England interim high contamination level for dredge material	>20
12	EPA Region V guideline for pollution classification of sediments	3
	USGS alert levels to flag 15 to 20% of samples analyzed	200
	Ontario Ministry of the Environment Dredge Spoil Guidelines	8
	EPA Region VI proposed guideline	5
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	12.5

Table 3. Arsenic (continued).

References	Background Approach	Concentrations (ppm)
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	>23
	- Class 2 (moderately contaminated)	23-32
	- Class 3 (contaminated)	32-110
	- Class 4 (heavily contaminated)	>220

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
12. Pavlou and Weston, 1983
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
23. Jansen, 1987
26. DeWitt *et al.*, 1988
39. Lee and Mariani, 1977
43. NERBC, 1980
56. Anderson *et al.*, 1988
60. Ilinois EPA, 1988a
61. Illinois EPA, 1988b
62. Tsai *et al.*, 1979
64. VanDolah *et al.*, 1984
68. Bahnick *et al.*, 1981
71 Simmers *et al.*, 1984
72. Ingersoll and Nelson, in press
74. Tatem, 1986
75. Qasim *et al.*, 1980
80. Tetra Tech, 1985

Table 4. Effects range--low and efects range--median values for arsenic and 16 concentrations used to determine these values arranged in ascending order.

Concentration (ppm)	End Point
22.1	San Francisco Bay, California bioassay COA
33.0	**ER-L**
33.0	EP chronic @4% TOC
50.7	San Francisco Bay, California bioassay COA
54.0	San Francisco Bay, California AET
57.0	Puget Sound, Washington AET - benthic
58.7	Commencement Bay, Washington bioassay COA
63.2	Commencement Bay, Washington bioassay COA
64.0	EP Acute @4% TOC
85.0	**ER-M**
85.0	Puget Sound, Washington AET - benthic
91.9	Baltimore Harbor, Maryland bioassay COA
93.0	Puget Sound, Washington AET - amphipod
689.9	Commencement Bay, Washington bioassay COA
700.0	Puget Sound, Washington AET - oyster
700.0	Puget Sound, Washington AET - Microtox™
1005.0	Puget Sound, Washington bioassay COA
2257.1	Commencement Bay, Washington bioassay COA

Cadmium

Eisler (1985) summarized available toxicological data for cadmium and concluded that concentrations in freshwater exceeding 10 parts per billion (ppb) are associated with high mortality, reduced growth, inhibited reproduction, and other adverse effects. He also concluded that resistance to cadmium was higher among marine species than among freshwater species; the LC50s for some marine organisms ranged from 320 to 430 ppb. Klapow and Lewis (1979) proposed a marine water quality standard of 3 ppm. Effects have been observed at concentrations as low as 1 ppm among freshwater animals in water, 2 ppm among freshwater plants in water, and 15.5 ppm among marine animals in water (EPA, 1986). The 96-h LC50 for *Mysidopsis bahia* is 16 µg/L Cd Cl^2 (U.S. EPA, 1987).

A relatively large amount of data exists for cadmium in sediments (Tables 5 and 6). AET values have been calculated with data from Puget Sound (range: 5.1 to 9.6 ppm) and San Francisco Bay (1.2 to 1.7 ppm). Acute and chronic marine threshold values (96 and 31 ppm, respectively, assuming 4 percent TOC content) based upon EP are available. Spiked-sediment bioassays have been performed with the amphipod *R. abronius* (range in LC 50s of 1.01 -20.8 ppm), the fish *Pimephales affinis* (LC50 of 11 ppm), and the polychaete *Nereis virens* (no effects in 40 ppm cadmium). The *R. abronius* bioassays have been performed with 4-d and 10-d exposure periods and with lethality and sublethal end-points. Matching chemical and biological data from field-collected samples are available from many geographic areas including Commencement Bay, San Francisco Bay, Southern California Bight, San Diego Bay, Hudson-Raritan Bay, Black Rock Harbor, Massachusetts Bay, and Baltimore Harbor; patterns in co-occurrence were determined for all of these and other data sets. In most cases, the chemical analyses determined that the sediments had contaminants other than cadmium that could have influenced the biological measures.

Either no measurable effects or very small apparent effects were observed in the data from bioassays of sediments from the Duwamish River (<0.5 ppm), Newport (<0.5 ppm), Stamford (2.8 ppm), Norwalk (4.1 ppm), New York Harbor (38.6 ppm), and in analyses of benthos at the Georgetown disposal site (<0.1 ppm). Mean cadmium concentrations differed very little between samples from Massachusetts Bay that had high, moderate, and low species richness (0.4 to 1.1 ppm). Relatively high survival in a suite of bioassays of San Diego Harbor was observed over a relatively large range in cadmium concentrations (0.9 to 32.5 ppm). Bioassay data from San Francisco Bay either lacked concordance with cadmium concentrations or indicated very little difference in mean concentration between the highly, moderately, or least toxic samples. Similarly, the AET values from San Francisco Bay are likely of limited value, since it appears other factors influenced the toxic responses. The Lake Union data indicated that only one site was significantly toxic and it was highly contaminated with petroleum hydrocarbons. Total species abundance in Southern California Bight sediments lacked concordance with the mean concentration of cadmium. Los Angeles Harbor sediments were more contaminated with chemicals other than cadmium (mean = 3.0 ppm). The data from bioassays of Waukegan Harbor were from a very small sample size (n=4) and those sediments had relatively high levels of many other contaminants. The Black Rock Harbor sediments were tested in an uptake/bioavailability study and had higher concentrations of metals other than cadmium. The data from the Sheboygan River bioassays were from an uptake study with a sample size of three and in sediments in which PCBs and other chemicals were highly elevated. Various tests with the clam *Macoma balthica* in Fraser River estuary sediments indicated a small gradient in cadmium concentrations among samples and a high proportion of the samples had cadmium concentrations below the detection limits (0.4 ppm). All of the data above were not used in the estimation of ER-L and ER-M values (Table B-3).

DuPage River sediments indicated no concordance between benthic taxa richness and mean cadmium concentrations. Most of the sediments sampled in the Kishwaukee River had cadmium concentrations below the detection limits of 1 ppm. An LC50 of 1.01 ppm developed from a *R. abronius* bioassay of foundry sands spiked with cadmium was, in effect, a bioassay of aqueous cadmium since no or very little fine-grained particles were available. Keweenaw Waterway sediments that were toxic to *Daphnia magna* contained higher concentrations of copper compared to cadmium. Sediments from Phillips Chain of Lakes, Torch Lake, and

Little Grizzly Creek were highly contaminated with copper; cadmium differed little between toxic and non-toxic sampling stations. Sediments from Cubatao River, Brazil were highly contaminated with chemicals other than cadmium. All of the data described above were not considered further in the estimation of ER-L and ER-M values (Table B-3).

The remaining data suggest an ER-L of about 5 ppm (5.3 rounded to 5.0 ppm) (Table 6). Puget Sound AET values based upon different biological indicators ranged from 5.1 to 6.7 ppm. Significant mortality occurred among the amphipod *Grandidierella japonica* in bioassays of southern California sediments that had a mean cadmium concentration of 5.3 ppm. Lowest species richness and lowest abundance of arthropods and echinoderms in southern California sediments occurred in samples with mean cadmium concentrations of 4.7, 4.3, and 6.2 ppm, respectively. The amphipod *R. abronius* avoided sediments spiked with 5.6 and 5.8 ppm cadmium; and in other *R. abronius* bioassays of cadmium-spiked sediments, LC50s as low as 6.9 ppm were observed. Effects were usually observed at cadmium concentrations of 5 ppm or greater, but there were many exceptions to this overall apparent effects threshold (Table B-3).

The data also suggest an ER-M of about 9 ppm (9.1 rounded to 9.0 ppm) (Table 6). Many LC50 and EC50 concentrations for SSBs performed with *R. abronius* are in the range of 8.2 to 11.5 ppm cadmium. The Puget Sound AET values based upon oyster embryo and Microtox™ bioassays are 9.6 ppm. Significant mortality to *Daphnia magna* exposed to Trinity River, Texas sediments occurred in samples with a mean cadmium concentration of 10.6 ppm. Significant reduction in survival of *P. affinis* occurred in sediments spiked with 11 ppm.

The degree of confidence in the ER-L and ER-M values for cadmium should be considered as very high. Data are available from many approaches, from multiple methods for some approaches, and they are relatively consistent. An overall apparent effects threshold coincided with the ER-L value.

Table 5. Summary of sediment effects data available for cadmium.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	6.7
	- oyster larvae (*C. gigas*) bioassay	9.6
	- benthic community composition	5.8
	- Microtox™ bioassay	9.6
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	6.7
	- oyster larvae (*C. gigas*) bioassay	9.6
	- benthic community composition	5.1
	- Microtox™ bioassay	9.6
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	0.96
	- maximum level criterion	9.6
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	1.7
	- amphipod bioassay	1.2

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Table 5. Cadmium (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	41.6 ± 79.8
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	2.9 ± 2.3
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	2.3 ± 1.3
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	15.3 ± 45.1
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	2.7 ± 2.0
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	1.9 ± 1.1
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	1.98
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	<0.5
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of *M. balthica*	1.2 ± 1
	- sediment populated by *M. balthica*	<0.04
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	0.4
	- significant 24-h avoidance behavior among *M. balthica*	1.4
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ±1 1.8% mortality) to *R. abronius*	0.8 ± 0.5
	- moderately toxic (33.8 ±4 .7% mortality) to *R. abronius*	0.5 ± 0.3
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	0.6 ± 0.3
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	0.6 ± 0.4
	- not toxic (18.4 ± 6.8% mortality) to R. abronius	0.6 ± 0.3
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	0.7 ± 0.3
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	0.7 ± 0.5
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	0.4 ± 0.1
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	0.6 ± 0.4
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	0.6 ± 0.3
49	PALOS VERDES SHELF, CALIFORNIA	
	- significantly toxic to *R. abronius*	28.7 ± 3.1
	- not toxic to *R. abronius*	8.9 ± 9.2
50	- major degradation to macrobenthos (20.2sp./0.1m. sq.)	28.7 ± 3.1
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	5.3
	- not toxic (23.2% mortality) to *G. japonica*	3.2
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	0.4 ± 0.3
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	0.5 ± 0.3
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	6.2 ± 13.1

Table 5. Cadmium (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
	- high arthropod abundance (148 ±5 8/0.1 sq. m.)	0.9 ± 1
	- moderate arthropod abundance (72.6 ± 6.8/0.1 sq. m.)	0.7 ± 0.7
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	4.3 ± 11.4
	- high species richness (96.3 ± 22.3/0.1 sq. m)	1.5 ± 4
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	0.6 ± 0.7
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	4.7 ± 12.2
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	9.4 ± 17.3
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	0.8 ± 1.1
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	1.1 ± 2
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	3.0
48	SAN DIEGO BAY, CALIFORNIA	
	- >97% survival of *P. staminea*	32.5
	- >97% survival of *M. elongata*	28.0
	- >97% survival of *N. arenaceodentata*	22.7
	- >97% survival of *C. stigmaeus* and *M. elongata*	32.5
66	- ≥82% survival of *C. stigmaeus*, *A. sculpta*, and *A. tonsa*	0.9
	- ≥86% survival of *N. arenaceeodentata*, and *M. nasuta*	0.9
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna*	1.2 ± 0.3
72	WAUKEGAN HARBOR, ILLLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	2.5
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in nematode, *C.germanica*	18.6 ± 8.9
	- positive rate of growth in nematode, *C.germanica*	11.8 ± 6.6
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to polychaete, *N. virens*	1.6
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (93.6 ± 9.4/0.1 sq. m.)	0.4 ± 0.1
	- moderate benthos species richness (58.2 ±1 0.5/0.1 sq. m.)	0.7 ± 0.6
	- low benthos species richness (31 ± 6.5/0.1 sq. m.)	1.1 ± 1.0
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	2.8 ± 0.5
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	<0.5
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	2.8
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	4.1

Table 5. Cadmium (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
40	C[illegible]ATAO RIVER, BRAZIL	
	- 24-hour EC-50 with *D. simillis*	0.2
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	1.7 ± 0.3
	- not toxic to *D. magna*	0.6 ± 0.3
	- mean conc. in highly toxic (northern) sediments to *D. magna*	1.5
	- mean conc. in least toxic (southern) sediments to *D. magna*	0.5
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna*	4.9
	- low mortality (0-5%) to *D. magna*	3.1 ± 0.6
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *Hexagenia* sp.	2.5
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	10.6 ± 8.7
	- low mortality to *D. magna*	4.8 ± 5.6
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<0.1
44	NEW YORK HARBOR, NEW YORK	
	- <10% mortality in adult *N. virens, M. mercenaria*, and *P. pugio*	38.6
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (5.1 ± 3.5 TLm) spot (5.9 ± 3.4 TLm)	22.8 ± 19.8
	- least toxic to mummichogs (43.2 ± 31.1 TLm) spot (24 ± 5.6 TLm)	2.0
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	1.3 ± 0.6
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	1.5 ± 0.9
60	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	.05 ± 0
	- highest number of benthic macroinvertebrate taxa (16.3 ± .6/site)	0.3 ± 0.8
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@4%TOC)	96
4	EPA chronic marine EP threshold (@4%TOC)	31
Spiked-sediment Bioassays		
70	Significant reduction in survival of *P. affinis* in 446- d bioassay	11
8	LC50 of *R. abronius* in 10-d bioassay (n=25)	9.81
	EC50 of *R. abronius* emergence in 10-d bioassay	9.72
	EC50 of *R. abronius* reburial in 10-d bioassay	9.07

Table 5. Cadmium (continued)

References	Biological Approaches	Concentrations (ppm)
Spiked-sediment Bioassays		
28	LC50 for *R. abronius* in 10-d bioassay (Yaquina Bay)	8.8
	LC50 for *R. abronius* in 10-d bioassay (Whidbey Island)	10
45	LC50 ± 95% C.L. for *R. abronius* (fresh) 10-d bioassay	8.7 (8.1 - 9.4)
	LC50 ± 95% C.L. for *R. abronius* juveniles	8.2 (7.6 - 8.9)
	LC50 ± 95% C.L. for *R. abronius* adults	11.5 (10.6 - 12.4)
9	LC50 for *R. abronius* survival, 10-d (n = 5 x 11 dilutions)	6.9
	EC50 for *R. abronius* reburial, 10-d (n = 5 x 11 dilutions)	6.5
	EC50 for *R. abronius* reburial, 4-d (n = 5 x 6 dilutions)	20.8
	LC50 for R. *abronius* survival, 4-d (n = 5 x 6 dilutions)	25.9
22	No observable mortality or behavioral effects to *N. virens* in 28 days	40
11	23.2% dead and 86% avoidance, 56 *R. abronius*, 72-h, 2-choice exeriment.	5.8
	44.4% avoidance, 45 *R. abronius* , 72-h, 2-choice experiment	5.6
27	LC76 for *R. abronius* in 72-h bioassay	8.5
	LC98 for *E. sencillus* in 72-h bioassay	8.4
73	LC50 for *R. abronius* exposed to foundry sands, 10-d bioassay	1.0 ± 1.1
	Overall LC50 for *R. abronius* exposed to sand (MS-1)	8.9

References	Background Approach	Concentrations (ppm)
68	Great Lakes harbors classification of non-polluted sediment	6
43	New England interim high contamination level for dredge material	>7
12	EPA Region V guideline for pollution classification of sediments	6
	USGS alert levels to flag 15 to 20% of samples analyzed	20
	Ontario Ministry of the Environment Dredge Spoil Guidelines	1
	EPA Region VI proposed guidelines	2
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	0.7
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<6
	- Class 2 (moderately contaminated)	6-19
	- Class 3 (contaminated)	19-32
	- Class 4 (heavily contaminated)	>32

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27. Oakden *et al.*, 1984b
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50. Swartz *et al.*, 1986
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72. Ingersoll and Nelson, 1989
73. Ott, 1986
74. Tatem, 1986
75. Qasim *et al.*, 1980
77. McGreer, 1982
79. Tietjen and Lee, 1984
80. Tetra Tech, 1985
82. Gilbert *et al.*, 1976
83. Word and Mearns, 1979

Table 6. Effects range-low and effects range-median values for cadmium and 36 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
4.3	Southern California arthropods COA
4.7	Southern California species richness COA
5.0	**ER-L**
5.1	Puget Sound, Washington AET - benthic
5.3	Southern California bioassay COA
5.6	SSB with *R. abronius*
8.4	SSB with *R. abronius*
5.8	Puget Sound, Washington AET - benthic
5.8	SSB with *R. abronius*
6.2	Southern California echinoderms COA
6.5	SSB with *R. abronius*
6.7	Puget Sound, Washington AET - amphipod
6.9	SSB with *R. abronius*
8.2	SSB with *E. sencillus*
8.5	SSB with *R. abronius*
8.7	SSB with *R. abronius*
8.8	SSB with *R. abronius*
8.9	SSB with *R. abronius*
9.0	**ER-M**
9.1	SSB with *R. abronius*
9.6	Puget Sound, Washington AET - oyster
9.6	Puget Sound, Washington AET - Microtox™
9.7	SSB with *R. abronius*
9.8	SSB with *R. abronius*
10.0	SSB with *R. abronius*
10.6	Trinity River, Texas bioassay COA
11.0	SSB with *P. affinis*
11.5	SSB with *R. abronius*
15.3	Commencement Bay, Washington bioassay COA
18.6	Hudson-Raritan, New York bioassay COA
20.8	SSB with R. *abronius* (4-day)
22.8	Baltimore Harbor, Maryland bioassay COA
25.9	SSB with *R. abronius* (4-day)
28.7	Palos Verdes Shelf, California bioassay COA
28.7	Palos Verdes Shelf, California benthos COA
31.0	EP chronic marine @4% TOC
41.6	Commencement Bay, Washington bioassay COA
96.0	EP acute marine @4% TOC

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Chromium

The toxicity of chromium is highly influenced by speciation; acute and chronic toxicity to aquatic and marine organisms has been tested with chromium (III) and chromium (VI). Acute toxicity of chromium (VI) to saltwater animals occurs at concentrations ranging from 2,000 to 105,000 ppm. Acute toxicity of chromium (III) has been observed at concentrations of 10,300 to 31,500 ppm (U. S. EPA, 1986). Eisler (1986) also observed a wide range in concentrations in water that caused effects: 445 to 2,000 ppb for chromium (VI) and 2,000 to 3,200 for chromium (III). Klapow and Lewis (1979) proposed a marine water quality standard of 2 ppm for total chromium.

A relatively large amount of data exists for chromium in sediments (Table 7). AET values were available for Puget Sound and were calculated from data available from several studies in San Francisco Bay. No single-chemical, SSB data were available and no SLC or EP data for chromium were available. Co-occurrence analyses were performed with data from studies performed with benthic community composition and toxicity tests. These studies had been performed in many areas, including Commencement Bay, Strait of Georgia, San Francisco Bay, off various areas of southern California, Hudson-Raritan Bay estuary, Massachusetts Bay, Trinity River, Baltimore Harbor, DuPage River, Kishwaukee River, and Phillips Chain of Lakes.

No effects among the benthos at the Georgetown, South Carolina disposal site were observed at up to 2.5 ppm chromium. Most of the bioassays of San Diego Bay sediments indicated high survival. Only one sample from Lake Union indicated toxicity and it was overwhelmingly dominated by PAH. Very little concordance between chromium and toxicity was observed in Commencement Bay samples. Southern California sediments that had moderate densities of echinoderms had mean concentrations of chromium similar to those that had high densities. Waukegan Waterway sediments toxic to *Hyalella azteca* were tested with only three samples. Kishwaukee sediments were more highly contaminated with PCBs than with chromium. Southern California sediments with moderate arthropod densities had chromium concentrations similar to those that had high densities of arthropods. Los Angeles Harbor sediments toxic to *P. pugio* were not highly contaminated with chromium. Three stations in the DuPage River had low numbers of benthic macroinvertebrate taxa, but only one had a high chromium concentration. Burrowing time for *Macoma balthica* exposed to Fraser River sediments was increased relative to controls, but most of the variance in the data was explained by the high concentrations of other chemicals. None of the data from these studies was used further in the estimation of ER-L and ER-M values (Table B-4).

The remaining data (Table 8) suggest an ER-L of about 80 ppm chromium, roughly the lower 10 percentile of the data. Massachusetts Bay sediments with low species richness had a mean chromium content of 81 ppm, as compared to a mean of 27 ppm in samples that had high species richness. Trinity River sediments that were significantly toxic to *Daphnia magna* had a mean of 72.6 ppm, as compared to samples that were not toxic that had a mean of 18.1 ppm. Southern California samples that were significantly toxic to *Grandidierella japonica* had a mean of 81.4 ppm, as compared to non-toxic samples with a mean of 73 ppm.

The data suggest an ER-M value of about 145 ppm, the 50 percentile value of the data (Table 8). This value is supported by significant toxicity of Sheboygan River sediments (128 ppm) and low southern California arthropod abundance (145.8 ppm).

The degree of confidence in the ER-L and ER-M values for chromium should be considered as moderate. There are no data from single-chemical, spiked-sediment bioassays and from EP principles. All of the available data are field collections of matching biological and chemical data and are, therefore, subject to the weaknesses described previously regarding co-occurrence analyses. Furthermore, there appears to be relatively little convergence, or consistency in the values reported from the various studies. Some of the poor consistency may be due to a lack of speciation data for chromium; all of the data were reported as total chromium, whereas the hexavalent form has been reported as the most toxic. No overall effects threshold is apparent from the available data.

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Table 7. Summary of sediment effects data available for chromium.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	270
	- benthic community composition	260
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	280
	- *R. abronius* amphipod bioassay	370
Co-occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic to *R. abronius* (15.7 ± 3.9 dead/20)	19.7 ± 11.3
	- moderately toxic to *R. abronius* (5.2 ± 1.1 dead/20)	17.7 ± 7.3
	- least toxic to *R. abronius* (2.5 ± 0.9 dead/20)	16.2 ± 8.1
	- highly toxic (44.5 ± 19.0% abnormal) to oyster larvae	22.2 ± 9
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	17.7 ± 7.3
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	11.8 ± 3.7
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	20
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	15.3
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	60
	- significant 24-h avoidance behavior among *M. balthica*	90
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	87.3 ± 22.1
	- sediment populated by feral *M. balthica*	42 ± 11
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67.0 ± 11.8% mortality to *R. abronius*	141.8 ± 86.5
	- moderately toxic (33.8 ± 4.7% mortality) to. *R. abronius*	163.3 ± 116.7
	- least toxic (18.4 ± 6.8% mortality) to *R. abronius*	195 ± 93.9
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	154.9 ± 102.1
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	202.6 ± 97.3
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	97.5 ± 66.7
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	164 ± 91.4
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	88.2 ± 82.7
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	133.7 ± 94.2
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	150.2 ± 85.9
50	PALOS VERDES SHELF , CALIFORNIA	
	- "major degradation" to macrobenthos (20.2sp/0.1m. sq.)	669.3 ± 172.9

Table 7. Chromium (continued)

References	Biological Approaches	Concentrations (ppm)
Co-occurrence Analyses		
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	81.4 ± 88.5
	- not toxic (23.2% mortality) to *G. japonica*	73 ± 124.4
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	29.6 ± 15.6
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	32.3 ± 17.5
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	201.3 ± 349
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	40.7 ± 30.9
	- moderate arthropod abundance (72.6 ± 6.8/0.1 sq. m.)	46.3 ± 43.3
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	145.8 ± 307.9
	- high species richness (96.3 ± 22.3/0.1 sq. m.)	62.3 ± 139.2
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	38.1 ± 36.3
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	156.6 ± 320.9
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	292.6 ± 459.3
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	42 ± 39.8
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	54 ± 83.5
39	LOS ANGELES HARBOR , CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	47.6
48	SAN DIEGO BAY, CALIFORNIA	
	- >97% survival of clam, *P. staminea*	299.5
	- >97% survival of shrimp, *M. elongata*	254.8
	- >97% survival of polychaete, *N. arenaceodentata*	299.5
	- >97% survival of sanddab, *C. stigmaeus*, and *M. elongata*	299.5
66	- ≥82% survival of *C. stigmaeus*, *A. sculpta*, and *A. tonsa*	26
	- ≥86% survival of *N. arenaceaodentata* and *M. nasuta*	26
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna*	87 ± 47
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	38.5
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5)	59.7 ± 28.7
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2)	34 ± 5.9
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5)	43.4 ± 22.5
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6)	29.2 ± 9.1
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	108.8 ± 19.6
	- not toxic to *D. magna*	36.3 ± 21.9
	- mean concentration in highly toxic (northern) sediments (to *D. magna*)	101.6
	- mean concentration in least toxic (southern) sediments (to *D. magna*)	29

Table 7. Chromium (continued)

References	Biological Approaches	Concentrations (ppm)
Co-occurrence Analyses		
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *Hexagenia* sp.	180
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna*	980
	- low mortality to *D. magna*	315.4 ± 236
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	128 ± 4
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in nematode, *C. germanica*	160.3 ± 85.4
	- positive rate of growth in nematode, *C. germanica*	144.6 ± 88.6
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to polychaete, *N. virens*	369.2
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (mean = 93.6 ± 9.4)	27 ± 11.1
	- moderate benthos species richness (mean = 58.2 ± 10.5)	60.9 ± 27.5
	- low benthos species richness (mean = 31 ± 6.5)	81 ± 29.3
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	19.9
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	86
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	67.5
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	2.46
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	72.6 ± 60.6
	- low mortality to *D. magna*	18.1 ± 16.8
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (5.1 ± 3.5) and spot (5.9 ± 3.4)	1646 ± 1628
	- least toxic to mummichogs (43.2 ± 31.1) and spot (24 ± 5.6)	335 ± 179.7

References	Background Approach	Concentrations (ppm)
68	Great Lakes harbors classification of non-polluted sediment	<25
	Great Lakes harbors classification of moderately polluted sediment	25-75
	Great Lakes harbors classification of heavily polluted sediment	>75
43	New England interim high contamination level for dredged material	>300

Table 7. Chromium (continued)

References	Background Approach	Concentrations (ppm)
12	EPA Region V guideline for pollution classification of sediments	25
	USGS alert levels to flag 15-20% of samples analyzed	200
	Ontario Ministry of the Environment Dredge Spoil Guidelines	25
	EPA Region VI proposed guidelines	100
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<190
	- Class 2 (moderately contaminated)	190-220
	- Class 3 (contaminated)	220-550
	- Class 3 (heavily contaminated)	>550

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* Various, please see text

Table 8. Effects range-low and effects range-median values for chromium and 21 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
60.9	Massachusetts Bay benthos COA
72.6	Trinity River, Texas bioassay COA
80.0	**ER-L**
81.0	Massachusetts Bay benthos COA
81.4	Southern California bioassay COA
87.0	Little Grizzly Creek, California bioassay COA
87.3	Fraser River, B.C. bivalves COA
90.0	Fraser River, B.C. bioassay COA
101.6	Keweenaw Waterway, Michigan bioassay COA
108.8	Keweenaw Waterway, Michigan bioassay COA
128.0	Sheboygan River, Wisconsin bioassay COA
145.0	**ER-M**
145.8	Southern California arthropod abundance COA
156.6	Southern California benthos COA
160.3	Hudson-Raritan Bay, New York estuary toxicity COA
180.0	Torch Lake, Michigan bioassay COA
201.3	Southern California echinoderm abundance COA
260.0	Puget Sound, Washington, AET - benthic
270.0	Puget Sound, Washington, AET - amphipod
369.2	Black Rock Harbor, Connecticut, bioassay COA

Table 8. (continued)

Concentrations (ppm)	End Point
669.3	Palos Verdes Shelf, California, benthos COA
980.0	Phillips Chain of Lakes, Wisconsin, bioassay COA
1646.0	Baltimore Harbor, Maryland, bioassay COA

Copper

Saltwater animals are acutely sensitive to copper in water at concentrations ranging from 5.8 ppm to 600 ppm, mysids indicate sensitivity in chronic life-cycle studies at 77 ppm, and freshwater animals are sensitive at concentrations as low at 16.7 ppm (EPA, 1986). Klapow and Lewis (1979) proposed a marine water quality standard of 5 ppm.

A considerable amount of data exist in which the concentration of copper in sediments can be associated with measures of effects (Table 9). EP values are available for acute and chronic marine conditions. Apparent effects threshold values for Puget Sound and San Francisco Bay are listed. Spiked-sediment bioassays have been performed with sediment collected in Puget Sound and Oregon. Matching sediment chemistry and biological data are available for many areas and the results of analyses of co-occurrence are listed in Table 9.

Several field studies are noteworthy as regards copper concentrations and measures of effects in sediments. Malueg *et al.* (1984a) sampled sites along the north and south reaches of the Keweenaw Waterway. Copper concentrations were very high in the north reaches and much lower in the southern part. The minimal concentration above which toxicity always occurred (equivalent to an AET) was 480 ppm. Kraft and Sypniewski (1981) also sampled benthos in the north and south reaches of the Keweenaw Waterway. The average copper concentration in the northern sampling stations was 589 ppm and was associated with a depressed average number of benthic taxa relative to the southern stations. Rygg (1985) reported that above 200 ppm copper, benthic community diversity was invariably depressed in Norwegian fjords. The lowest copper concentration in Little Grizzly Creek sediments above which toxicity was always observed by Malueg *et al.* (1984b) was 550 ppm.

In one of only two reports in which results of SSBs with copper were performed, Phelps *et al.* (1983) reported that the burrowing time for the littleneck clam *Protothaca staminea* was significantly decreased at sediment concentrations exceeding 17.8 ppm. There appeared to be a threshold between 14.7 and 17.8 ppm copper in this burrowing response. The sediments used in the tests had a background concentration of 12 ppm before spiking was performed. However, other field-collected sediments with ambient concentrations of 23 ppm caused no increase in burrowing time and sediments spiked with 10,240 ppm copper and Chelex 100 chelating agent also caused no increase in burrowing time. Therefore, it appears that copper concentrations of about 20 ppm may begin to induce sublethal behavioral effects when the copper is not tightly chelated or otherwise bound to the sediments. The data from toxicity tests of four samples from Waukegan Waterway (Ingersoll and Nelson, in press) indicate that copper concentrations in sediments and toxicity to *Hyalella azteca* were positively correlated, whereas there was poor concordance between the toxicity data and the concentrations of other chemicals. The minimum copper concentration associated with a significantly toxic sample was 19.5 ppm, similar to the 17.8 ppm value determined in the spiked bioassays.

The data from two studies (Massachusetts Bay benthos and Puget Sound spiked sediments) suggest that effects may begin at concentrations as low as 15 to 18 ppm, but very little other data provide confirmatory evidence that effects are commonly associated with concentrations this low (Table B-5). The lower 10 percentile of the data is equivalent to about 70 ppm (68.2 rounded to 70 ppm). This ER-L value is supported by bioassay data from a *Macoma* burrowing experiment with British Columbia sediments (67 ppm copper), significantly toxic sediments from the Trinity River (mean 68.4) and San Francisco Bay bioassay data (means of 68.2 and 76 ppm). An ER-M value (50 percentile) of about 390 ppm is

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supported by two Puget Sound AETs (390 ppm). With the exception of bioassays of San Diego Bay sediments performed with relatively resistant species, effects were always observed in association with copper concentrations of 300 ppm or greater (Table B-5).

It is noteworthy that LC50 values from six different bioassay series with copper-spiked sediments ranged from 681 to 2,296 ppm (Cairns *et al.*, 1984) as compared to the previously described ET50 of 17.8 ppm for a burrowing bivalve. Effects have been associated with copper concentrations ranging from 17.8 to 2820 ppm. However, the degree of confidence in the ER-L and ER-M values must be considered relatively high. A relatively large amount of data is available and they are from all of the major approaches. Both values are supported by clusters of data. The overall apparent effects threshold is similar to the ER-M value.

Table 9. Summary of sediment effects data available for copper.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	810
	- oyster larvae (*C. gigas*) bioassay	390
	- benthic community composition	310
	- Microtox™ bioassay	390
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	1300
	- oyster larvae (*C. gigas*) bioassay	390
	- benthic community composition	530
	- Microtox™ bioassay	390
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	81
	- maximum level criteria	810
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	110
	- *R. abronius* amphipod bioassay	180
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	2820 ± 4881
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	118 ± 98
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	85.1 ± 69
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	918 ± 2750
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	106 ± 93
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	73 ± 75
26	PUGET SOUND, WASHINGTON	
	- highly toxic to *R. abronius* (95% LPL)	1260 ± 3251
	- moderately toxic to *R. abronius* (<87.5% survival to >95% LPL)	138 ± 124
	- least toxic to *R. abronius* (>87.5% survival)	98 ± 90
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	156
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	43

Table 9. Copper (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	67
	- significant 24-h avoidance behavior among *M. balthica*	150
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	135 ± 57
	- sediment populated by feral *M. balthica*	28 ± 16
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	85 ± 63
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	64 ± 40
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	72 ± 41
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	70 ± 47
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	75 ± 43
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	88 ± 33
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	76 ± 51
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	35 ± 17
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	68 ± 48
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	47 ± 26
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna* and *Hexagenia* sp.	1374 ± 809
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	181
	- not toxic (23.2% mortality) to *G. japonica*	62
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	12 ± 6
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	13 ± 14
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	97 ± 177
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	16 ± 14
	- moderate arthropod abundance (72 ± 3.3/0.1 sq. m.)	15 ± 18
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	71 ± 155
	- high species richness (96.3 ± 22.3/0.1 sq. m.)	31 ± 60
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	15 ± 15
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	73 ± 166
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	147 ± 232
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	20 ± 22
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	21 ± 39
49	PALOS VERDES, CALIFORNIA	
	- significantly toxic to *R. abronius*	592 ± 126
	- not toxic to *R. abronius*	251 ± 227
	- major degradation to macrobenthos (20.2 sp/0.1 m. sq.)	592 ± 126
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	147

Table 9. Copper (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
48	SAN DIEGO BAY, CALIFORNIA	
	- >97% survival of clam, *P. staminea*	995
	- >97% survival of mysid, *M. elongata*	312
	- >97% survival of polychaete, *N. arenaceodentata*	995
	- >97% survival of sanddab, *C. stigmaeus* and mysid, *M. elongata*	995
66	- ≥82% survival of *C. stigmaeus*, *A. sculpta*, and *A. tonsa*	210
	- ≥86% survival of *N. arenaceaodentata* and *M. nasuta*	210
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	19.5
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	77 ± 39
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	62 ± 25
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	45 ± 53
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	19.5 ± 6
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	145 ± 2
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna* (n = 1)	540
	- low mortality to *D. magna* (n = 5)	135 ± 118
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	730 ± 205
	- not toxic to *D. magna*	43 ± 49
	- mean concentration in highly toxic (northern) sediments (to *D. magna*)	612
	- mean concentration in least toxic (southern) sediments (to *D. magna*)	24
78	- significantly depressed macrobenthos taxa richness	589
	- high macrobenthos taxa richness	33
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *Hexagenia* sp.	1800
69	MISSISSIPPI RIVER	
	- 80-100% survival (92 ± 6.3) of *G. pseudolimnaeus*, 4-d bioassay	17.8
	- 25% (n = 1) survival of mayfly (*Hexagenia* sp.), 4-d bioassay	2.2
	- 80-100% survival (90 ± 7.5) of mayfly (*Hexagenia* sp), 4-d bioassay	8 ± 5
	- 55% ± 10% survival of midges (*C. tentans*), 4-d bioassay	4 ± 3
	- 90% ± 5.8% survival of midges (*C. tentans*), 4-d bioassay	9 ± 4
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (93.6 ± 9.4)	5 ± 2
	- moderate benthos species richness (58.2 ± 10.5)	15 ± 7
	- low benthos species richness (31 ± 6.5)	16 ± 7

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Table 9. Copper (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in *C. germanica*	453 ± 311
	- positive rate of growth in *C. germanica*	251 ± 232
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to *N. virens*	612
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	218
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	224
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	12
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (TLm 5.1 ± 3.5) and spot (TLm5.9 ± 3.4)	1071 ± 948
	- least toxic to mummichogs (TLm 43.2 ± 31.1) and spot (TLm 24 ± 5.6)	158 ± 29
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	1
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	68 ± 62
	- low mortality to *D. magna*	18 ± 15
41	NORWEGIAN FJORDS, NORWAY	
	- 50% reduction from maximum in Hurlbert's benthic species diversity index	200
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@4% TOC)	216
4	EPA chronic marine EP threshold (@4% TOC)	136
Spiked-Sediment Bioassays		
53	TUALATIN RIVER, OREGON	
	- LC50 of midge, *C. tentans* in 10-d bioassay	2296
	- LC50 of cladoceran, *D. magna* in 48-h bioassay	937
	SOAP CREEK POND, OREGON	
	- LC50 of midge, *C. tentans* in 10-d bioassay	857
	- LC50 of cladoceran, *D. magna* in 48-h bioassay	681
	- LC50 of amphipod, *G. lacustris* in 10-d bioassay	964
	- LC50 of amphipod, *H. azteca* in 10-d bioassay	1078
32	PUGET SOUND, WASHINGTON	
	- ET50 for burrowing time of clam, *P. staminea*	17.8

Table 9. Copper (continued)

References	Background Approaches	Concentrations (ppm)
68	Great Lakes Harbors	
	- classification of non-polluted sediments	<25
	- classification of moderately polluted sediments	25-50
	- classification of heavily polluted sediments	>50
43	New England interim high contamination level for dredge material	>400
12	EPA Region V guideline for pollution classification of sediments	25
	USGS alert levels to flag 15 to 20% of samples analyzed	2000
	Ontario Ministry of the Environment Dredge Spoil Guidelines	25
	EPA Region VI proposed guidelines	50
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	68
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<60
	- Class 2 (moderately contaminated)	60-190
	- Class 3 (contaminated)	190-370
	- Class 4. (heavily contaminated)	>370

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82. Gilbert *et al.*, 1976
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* -Various, please see text

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Table 10. Effects range-low and effects range-median values for copper and 51 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
15.0	Massachusetts Bay benthos COA
17.8	Sublethal SSB with *Macoma*
19.5	Waukegan Waterway, Illinois bioassay COA
45.4	Kishwaukee River, Illinois benthos COA
67.0	*M. balthica* burrowing ET50 COA
68.2	San Francisco Bay, California bioassay COA
68.4	Trinity River, Texas bioassay COA
70.0	**ER-L**
76.0	San Francisco Bay, California bioassay COA
84.6	San Francisco Bay, California bioassay COA
87.7	San Francisco Bay, California bioassay COA
96.7	Southern California echinoderms COA
106.3	Commencement Bay, Washington bioassay COA
110.0	San Francisco Bay, California AET
117.8	Commencement Bay, Washington bioassay COA
134.6	Fraser River, B.C. benthos - *M. balthica* COA
136.0	EP chronic marine threshold
138.0	Puget Sound, Washington bioassay COA
145.0	Sheboygan River, Wisconsin bioassay COA
147.0	Los Angeles Harbor, California bioassay COA
150.0	Fraser River, B.C bioassay COA
156.0	Lake Union, Washington bioassay COA
180.0	San Francisco Bay, California AET
181.3	Southern California bioassay COA
200.0	Norway benthos COA
216.0	EP acute marine threshold
310.0	Puget Sound, Washington AET - benthic
390.0	**ER-M**
390.0	Puget Sound, Washington AET - oyster
390.0	Puget Sound, Washington AET - Microtox™
453.0	Hudson-Raritan Bay, New york bioassay COA
530.0	Puget Sound, Washington AET - benthic
540.0	Phillips Chain of Lakes, Wisconsin bioassay COA
589.0	Keweenaw Waterway, Michigan benthos COA
592.0	Palos Verdes Shelf, California, bioassay COA
592.0	Palos Verdes Shelf, California benthos COA
612.0	Black Rock Harbor, Connecticut bioassay COA
612.0	Keweenaw Waterway, Michigan bioassay COA
681.0	SSB with *Daphnia*
730.0	Keweenaw Waterway, Michigan bioassay COA
810.0	Puget Sound, Washington AET - amphipod
857.0	SSB with midge
918.0	Commencement Bay, Washington bioassay COA
937.0	SSB with *Daphnia*
964.0	SSB with amphipod
1071.0	Baltimore Harbor, Maryland bioassay COA
1078.0	SSB with amphipod
1260.0	Puget Sound, Washington bioassay COA
1300.0	Puget Sound, Washington AET - amphipod
1374.0	Little Grizzly Creek, California bioassay COA
1800.0	Torch Lake, Michigan bioassay COA
2296.0	SSB with midge
2820.0	Commencement Bay, Washington bioassay COA

Lead

Along with other adverse effects, lead can modify the function and structure of kidney, bone, the central nervous system, and the hepatopoietic system (Eisler, 1988b). Adverse effects upon daphnid reproduction has been observed at concentrations in water as low as 1 ppm, organolead compounds are generally more toxic than inorganic forms, adverse effects usually occur at concentrations ranging from 1.3 to 7.7 ppm in water; and marine animals may be more resistant to effects of lead than freshwater species (Eisler, 1988b). The proposed marine water quality standard for California was 8 ppm in water (Klapow and Lewis, 1979).

A relatively large amount of data exists for lead and measures of effects in sediments (Table 11). AET and EP values are available. Matching biological and chemical data from many studies performed in areas such as Puget Sound, Commencement Bay, San Francisco Bay, southern California, Hudson-Raritan estuary, and Trinity River are available. However, no single-chemical, SSB data are available.

No significant toxicity was observed in sediments from the Duwamish River, Stamford, Norwalk, and Newport at lead concentrations up to 277 ppm. San Francisco Bay sediments that were significantly toxic to amphipods had very little difference in lead concentrations compared to those that were not toxic. Total benthos abundance and some categories of other measures of benthic communities off southern California were not in concordance with lead concentrations. The minimum lead concentration associated with toxicity of Waukegan Harbor sediments was below the detection limits of 32 ppm. Lead concentrations did not differ remarkably among stations sampled in the Cubatao River, Brazil. The Little Grizzly Creek system toxicity tests suggested little concordance between toxicity and lead concentrations. These data were not considered further in the estimation of ER-L and ER-M values (Table B-6).

The minimum concentration above which effects were observed was about 27 ppm; significant toxicity to *Daphnia magna* was reported at this concentration (Table 12). Kishwaukee River macroinvertebrate taxa richness was lower in sediments with a mean lead concentration of 31 ppm, compared to a mean of 21 ppm in taxa-rich sediments. The data suggest an ER-L of about 35 ppm, equivalent to the lower 10 percentile of the data. This value is supported by increased burrowing time of *Macoma balthica* (32 ppm), depressed benthos diversity in Norwegian fjords (35 ppm), Los Angeles Harbor bioassay data (41.3 ppm), and depressed benthos species richness in Massachusetts Bay (mean 42 ppm). The 50 percentile value in the data suggests an ER-M of about 110 ppm; supported by Torch Lake and Commencement Bay bioassay data (110 ppm, mean 113 ppm, respectively), San Francisco Bay AET for amphipod bioassay (120 ppm), observations of the concentration associated with significant bioeffects in San Francisco Bay (130 ppm), and the EP chronic marine threshold of 132 ppm. Effects were usually observed at concentrations of 110 ppm or greater and always observed at concentrations of 300 ppm or greater (Table B-6).

The degree of confidence in the ER-L and ER-M values for lead should be considered as moderate and high, respectively. A relatively large amount of data exist to relate sediment concentrations with measures of effects, and both values are supported by small clusters of data. However, the chemical data are not speciated to indicate the proportion that is in organic and inorganic forms, there are no SSB data, the available data indicate a fairly wide range in concentrations associated with effects, and the overall apparent effects threshold lies outside the ER-L/ER-M range.

Table 11. Summary of sediment effects data available for lead.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	660
	- oyster larvae (*C. gigas*) bioassay	660
	- benthic community composition	300
	- Microtox™ bioassay	530
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	660
	- oyster larvae (*C gigas*) bioassay	660
	- benthic community composition	450
	- Microtox™ bioassay	530
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	66
	- maximum level criteria	660
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	140
	- *R. abronius* amphipod bioassay	120
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	1613 ± 2628
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	171 ± 192
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	78 ± 75
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	570 ± 1489
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	113 ± 123
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	105 ± 173
26	PUGET SOUND, WASHINGTON	
	- highly toxic to *R. abronius* (95%LPL)	750 ± 1763
	- mod. toxic to *R. abronius* (<87.5% survival to >95% LPL)	137 ± 140
	- least toxic to *R. abronius* (>87.5% survival)	47 ± 31
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	300
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	27.1
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	32
	- significant 24-h avoidance behavior among *M. balthica*	74
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	82 ± 49
	- sediment populated by feral *M. balthica*	14 ± 9

Table 11. Lead (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	96 ± 93
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	42 ± 27
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	51 ± 34
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	58 ± 61
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	54 ± 36
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	106 ± 87
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	63 ± 63
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	25 ± 17
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	59 ± 63
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	43 ± 33
7	- sediment quality triad minimum or no bioeffects	≤50
	- sediment quality triad significant bioeffects	≥130
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna* and *H. limbata*	32 ± 18
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	73 ± 42
	- not toxic (23.2% mortality) to *G. japonica*	46 ± 59
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	12 ± 13
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	10 ± 9
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	64 ± 118
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	12 ± 9
	- moderate arthropod abundance (72 ± 3.3/0.1 sq. m.)	13 ± 10
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	48 ± 103
	- high species richness (96.3 ± 22.3/0.1 sq. m.)	20 ± 34
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	11 ± 8
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	51 ± 111
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	95 ± 154
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	13 ± 10
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	17 ± 24
49	PALOS VERDES, CALIFORNIA	
	- "major degradation" to macrobenthos (20.2 sp/0.1 m. sq.)	312 ± 23
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	41
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	<32
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	144 ± 110
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	57 ± 20

Table 11. Lead (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	31 ± 26
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	21 ± 11
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	253 ± 47
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna* (n = 1)	160
	- low mortality to *D. magna* (n = 5)	79 ± 34
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	29 ± 8
	- not toxic to *D. magna*	11 ± 10
	- mean concentration in highly toxic (northern) sediments (to *D. magna*)	27
	- mean concentration in least toxic (southern) sediments (to *D. magna*)	10
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *H. limbata*	110
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (93.6 ± 9.4/0.1 sq. m.)	13 ± 4
	- moderate benthos species richness (58.2 ± 10.5/0.1 sq. m.)	42 ± 26
	- low benthos species richness (31 ± 6.5/0.1 sq. m.)	47 ± 17
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in *C. germanica*	321 ± 195
	- positive rate of growth in *C. germanica*	145 ± 132
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to *N. virens*	90
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	123
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	277
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	<1
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (TLm 5.1 ± 3.5) and spot (TLm 5.9 ± 3.4)	512 ± 213
	- least toxic to mummichogs (TLm 43.2 ± 31.1) and spot (TLm 24 ± 5.6)	213 ± 131
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<0.5
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	54 ± 27
	- low mortality to *D. magna*	35 ± 22

Table 11. Lead (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
40	CUBATAO RIVER, BRAZIL	
	- 24-h EC50 with *D. similis*	18
41	NORWEGIAN FJORDS, NORWAY	
	- 50% reduction from maximum in Hurlbert's benthic species diversity index	35
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@4% TOC)	3360
4	EPA chronic marine EP threshold (@4% TOC)	132

References	Background Approach	Concentrations (ppm)
68	Great Lakes Harbors	
	- classification of non-polluted sediments	<40
	- classification of moderately polluted sediments	40-60
	- classification of heavily polluted sediments	>60
43	New England interim high contamination level for dredge material	>200
12	EPA Region V guideline for pollution classification of sediments	40
	USGS alert levels to flag 15-20% of samples analyzed	500
	Ontario Ministry of the Environment Dredge Spoil Guidelines	50
	EPA Region VI proposed guidelines	50
	FWPCA Chicago Guidelines: LIGHT (no alteration to benthos)	0-40
	FWPCA Chicago Guidelines: MODERATE (pollutant tolerant benthos)	40-60
	FWPCA Chicago Guidelines: HEAVY (benthos absent or abundance reduced)	>60
	EPA Jensen Criteria for open water dredge material disposal	50
20	EPA/ACOE Puget Sound interim criteria (central basin background)	33
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<110
	- Class 2 (moderately contaminated)	110-460
	- Class 3 (contaminated)	460-660
	- Class 4. (heavily contaminated)	>660

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
7. Chapman *et al.*, 1987
12. Pavlou and Weston, 1983
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68. Bahnick *et al.*, 1981
71. Simmers *et al.*, 1984
72. Ingersoll and Nelson, in press
74. Tatem, 1986
75. Qasim *et al.*, 1980
77. McGreer, 1982
79. Tietjen and Lee, 1984
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82. Gilbert *et al.*, 1976

Table 11. Lead (continued)

References:

29. Yake et al., 1986
39. Lee and Mariani, 1977
40. Zagatto et al., 1987
62. Tsai et al., 1979
64. Van Dolah et al., 1984
67. McGreer, 1979
83. Word and Mearns, 1979
* -Various, please see text.

Table 12. Effects range-low and effects range-median values for lead and 47 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
26.6	Keweenaw Waterway, Michigan bioassay COA
29.0	Keweenaw Waterway, Michigan bioassay COA
30.6	Kishwaukee River Illinois, benthos COA
32.0	*M. balthica* burrowing ET50 COA
35.0	Norway benthos COA
35.0	**ER-L**
41.3	Los Angeles Harbor, California bioassay COA
42.1	San Francisco Bay, California bioassay COA
42.4	Massachusetts Bay, Massachusetts benthos COA
46.7	Massachusetts Bay, Massachusetts benthos COA
47.8	Southern California arthropods COA
≤50.0	San Francisco, California, triad minimum effects COA
51.0	Southern California species richness COA
53.7	Trinity River, Texas bioassay COA
58.9	San Francisco Bay, California bioassay COA
>60.0	FWPCA Classification: benthos absent COA
63.4	San Francisco Bay, California bioassay COA
64.4	Southern California echinoderms COA
73.1	Southern California bioassay COA
74.0	*M balthica* bioassay avoidance COA
81.7	Fraser River B.C., Canada benthos COA
89.6	Black Rock Harbor, Connecticut bioassay COA
95.7	San Francisco Bay, California bioassay COA
104.5	San Francisco Bay, California bioassay COA
110.0	**ER-M**
110.0	Torch Lake, Michigan bioassay COA
113.1	Commencement Bay, Washington bioassay COA
120.0	San Francisco Bay, California AET
≥130.0	San Francisco Bay, California triad significant effects COA
132.0	EP chronic marine @4% TOC
136.6	Puget Sound, Washington bioassay COA
140.0	San Francisco Bay, California AET
143.7	DuPage River, Illinois benthos COA
160.0	Phillips Chain of Lakes, Wisconsin bioassay COA
170.8	Commencement Bay, Washington bioassay COA
253.0	Sheboygan River, Wisconsin bioassay COA
300.0	Puget Sound, Washington AET - benthic
300.0	Lake Union, Washington bioassay COA
312.3	Palos Verdes Shelf, California benthos COA
320.9	Hudson-Raritan Bay, New York bioassay COA
450.0	Puget Sound, Washington AET - benthic
512.0	Baltimore Harbor, Maryland bioassay COA
530.0	Puget Sound, Washington AET - Microtox™
570.1	Commencement Bay, Washington bioassay COA
660.0	Puget Sound, Washington AET - amphipod

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Table 12. (continued)

Concentrations (ppm)	End Point
660.0	Puget Sound, Washington AET - oyster
750.2	Puget Sound, Washington bioassay COA
1613.0	Commencement Bay, Washington bioassay COA
3360.0	EP acute marine @4% TOC

Mercury

Acute toxicity of mercury (II) to freshwater invertebrates ranges from 2.2 to 2,000 ppm and from 3.5 to 1678 ppm for marine organisms (U.S. EPA, 1986). Klapow and Lewis (1979) proposed a marine water quality standard of 0.14 ppm mercury. Eisler (1987) reported that organomercury compounds--especially methylmercury--were more toxic than inorganic forms; lethal concentrations of total mercury to sensitive organisms varied from 0.1 to 2.0 ppm for aquatic fauna; mercury was the most toxic trace metal to aquatic organisms; and that toxicity was increased in the presence of zinc and lead.

A moderate amount of sediment data exist for mercury (Table 13). AET values for Puget Sound and San Francisco Bay are available. Matching chemistry and biological data for Puget Sound, San Francisco Bay, DuPage River, Phillips Chain of Lakes, Baltimore Harbor, and Trinity River are listed in Table 13 along with those from other areas. EP threshold values and data from two SSB experiments are available.

No toxicity was observed in bioassays of sediments from the Duwamish River, Stamford, Norwalk, and Newport with mercury concentrations up to 0.3 ppm. Very small gradients in mercury concentrations were observed in data from San Francisco Bay, southern California, Kishwaukee River, Keweenaw Waterway, Massachusetts Bay, and Trinity River. These data were not considered in the estimation of ER-L and ER-M values (Table B-7).

The remaining data suggest an ER-L value of about 0.15 ppm (0.17 rounded to 0.15 ppm), equivalent to the lower 10 percentile of the data (Table 14). This value is supported by bioassay data from Los Angeles Harbor (0.15 ppm), Lake Union (0.17 ppm), and *Macoma* burrowing bioassays of Fraser River sediments (0.18 ppm). Chronic effects are predicted by EP principles to occur at 0.032 ppm.

The data suggest an ER-M of about 1.3 ppm mercury, the 50 percentile value in the data. This value is supported by two San Francisco Bay AETs (1.3 and 1.5 ppm), moderate toxicity of Puget Sound sediments to amphipods (mean of 1.38 ppm), and significant toxicity of Little Grizzly Creek sediments to *Daphnia* (mean of 1.5 ppm). With several exceptions (principally data from San Diego Bay), effects were usually observed at concentrations of 1.0 ppm or greater (Table B-7).

The degree of confidence in the ER-L and ER-M estimates should be considered as moderate and high, respectively. There are clusters of data around the 0.15 and 1.3 ppm values, suggesting that these values are supported by a preponderance of evidence and an apparent effects threshold within the ER-L/ER-M range. However, the predicted chronic marine value (0.032 ppm) is considerably lower than the ER-L, the majority of the available data are from field studies, there are relatively little data from SSBs, and the available data from bioassays with *R. abronius* and *Pontoporeia affinis* were not consistent.

Table 13. Summary of sediment effects data available for mercury.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2.1
	- oyster larvae (*C. gigas*) bioassay	0.6
	- benthic community composition	0.9
	- Microtox™ bioassay	0.4
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2.1
	- oyster larvae (*C gigas*) bioassay	0.6
	- benthic community composition	2.1
	- Microtox™ bioassay	0.4
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	0.2
	- maximum level criteria	2.0
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	1.5
	- *R. abronius* amphipod bioassay	1.3
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	11.2 ± 22.8
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	0.3 ± 0.2
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	0.2 ± 0.1
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	3.5 ± 12.5
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	0.2 ± 0.1
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	0.2 ± 0.1
26	PUGET SOUND, WASHINGTON	
	- highly toxic to *R. abronius* (95%LPL)	5 ± 14.8
	- mod. toxic to *R. abronius* (<87.5% survival to >95% LPL)	1.4 ± 4.6
	- least toxic to *R. abronius* (>87.5% survival)	0.5 ± 0.5
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	0.2
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	0.1
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	0.2
	- significant 24-h avoidance behavior among *M. balthica*	0.5
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	0.4 ± 0.2
	- sediment populated by feral *M. balthica*	0.1 ± 0.1

Table 13. Mercury (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	1 ± 1
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	0.7 ± 0.8
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	0.5 ± 0.4
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	0.7 ± 0.8
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	0.6 ± 0.4
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	0.6 ± 0.4
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	0.9 ± 1
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	0.3 ± 0.2
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	0.7 ± 0.9
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	0.5 ± 0.3
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna* and *Hexagenia* sp.	1.5 ± 0.9
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	0.3 ± 0.1
	- not toxic (23.2% mortality) to *G. japonica*	0.3 ± 0.02
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	0.15
48	SAN DIEGO BAY, CALIFORNIA	
	- >97% survival of clam, *P. staminea*	66.5
	- >97% survival of mysid, *M. elongata*	58.2
	- >97% survival of *C. stigmaeus*, and *M. elongata*	254.4
66	- ≥82% survival of *C. stigmaeus, A. sculpta,*, and *A. tonsa*	2.7
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	0.1
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	1.6 ± 2
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	0.3 ± 0.2
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	0.1 ± 0.1
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	0.1 ± 0.1
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	<0.1
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna* (n = 1)	9.4
	- low mortality to *D. magna* (n = 5)	1 ± 1.3

Table 13. Mercury (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	0.2 ± 0.1
	- not toxic to *D. magna*	0.1 ± 0.1
	- mean concentration in highly toxic (northern) sediments (to *D. magna*)	0.2
	- mean concentration in least toxic (southern) sediments (to *D. magna*)	0.1
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and Hexagenia sp.	0.3
69	MISSISSIPPI RIVER	
	- 80-100% survival (92 ± 6.3) of G. *pseudolimnaeus*, 4-d bioassay	0.04
	- 25% (n=1) survival of mayfly (*Hexagenia* sp.) 4-d bioassay	<0.01
	- 80-100% survival (90 ± 7.5) of mayfly (*Hexagenia* sp), 4-d bioassay	0.01 ± 0.01
	- 55%±10% survival of midges (C. *tentans*), 4-d bioassay	0.01 ± 0
	- 90%±5.8% survival of midges (C. *tentans*), 4-d bioassay	0.01 ± 0.01
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness(93.6 ± 9.4)	0.06 ± 0.04
	- moderate benthos species richness (58.2 ± 10.5)	0.2 ± 0.1
	- low benthos species richness (31 ± 6.5)	0.1 ± 0.02
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in C. *germanica*	8.9 ± 7.5
	- positive rate of growth in C. *germanica*	5 ± 6.7
44	NEW YORK HARBOR, NEW YORK	
	- <10% mortality to *N. virens*, *M. mercenaria* and *P. pugio*; 100-d exposures	34.9
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	0.2
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	0.3
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	0.03
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (TLm 5.1 ± 3.5) and spot (TLm 5.9 ± 3.4)	1.6 ± 1.1
	- least toxic to mummichogs (TLm 43.2 ± 31.1) and spot (TLm 24 ± 5.6)	0.4 ± 0.1
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	0.6
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	0.3 ± 0.1
	- low mortality to *D. magna*	0.6 ± 0.7
40	CUBATAO RIVER, BRAZIL	
	- 24-h EC50 with *D. similis*	0.9

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Table 13. Mercury (continued)

References	Biological Approaches	Concentrations (ppm)
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@4% TOC)	0.6
4	EPA chronic marine EP threshold (@4% TOC)	0.03
Spiked-Sediment Bioassays		
63	No reduction in the activity behavior of *P. affinis*, 2-d experiment	0.65 - 1.15
	Significant reduction in the activity behavior of *P. affinis*, 5-d experiment	2.15 - 3.35
18	LC50 of *R. abronius* in 10-d bioassay	13.1

References	Background Approach	Concentrations (ppm)
68	Great Lakes Harbors	
	- classification of non-polluted sediments	<1
	- classification of heavily polluted sediments	≥1
43	New England interim high contamination level for dredge material	>1.5
12	EPA Region V guideline for pollution classification of sediments	1
	USGS alert levels to flag 15 to 20% of samples analyzed	20
	Ontario Ministry of the Environment Dredge Spoil Guidelines	0.3
	EPA Region VI proposed guidelines	1
	EPA Jensen Criteria for open water dredge material disposal	1
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	0.15
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<1.5
	- Class 2 (moderately contaminated)	1.5-9
	- Class 3 (contaminated)	9-16
	- Class 4 (heavily contaminated)	>16

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
12. Pavlou and Weston, 1983
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79. Tietjen and Lee, 1984
80. Tetra Tech, 1985
82. Gilbert *et al.*, 1976

* -Various, please see text.

Table 14. Effects range-low and effects range-median values for mercury and 30 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
0.032	EP Chronic Marine @4% TOC
0.08	Waukegan Harbor, Illinois bioassay COA
0.15	**ER-L**
0.15	Los Angeles Harbor, California bioassay COA
0.17	Lake Union, Washington bioassay COA
0.18	*M. balthica* burrowing bioassay COA
0.29	Torch Lake, Michigan bioassay COA
0.41	Puget Sound, Washington bioassay AET - Microtox™
0.42	Fraser River, B.C., Canada *M. balthica* bioassay COA
0.48	*M. balthica* avoidance bioassay COA
0.59	Puget Sound, Washington AET - oyster
0.6	EP acute marine @4% TOC
0.88	Puget Sound, Washington AET - benthic
0.9	San Francisco Bay, California bioassay COA
0.9	Cubatao River, Brazil bioassay COA
0.96	San Francisco Bay, California bioassay COA
1.3	**ER-M**
1.3	San Francisco Bay, California AET
1.38	Puget Sound, Washington bioassay COA
1.5	San Francisco Bay, California AET
1.5	Little Grizzly Creek, California bioassay COA
1.6	Baltimore Harbor, Maryland bioassay COA
1.6	DuPage River, Illinois benthos COA
2.1	Puget Sound, Washington AET - amphipod
2.1	Puget Sound, Washington AET - benthic
2.15-3.35	SSB with *Pontoporeia*
3.5	Commencement Bay, Washington bioassay COA
5.04	Puget Sound, Washington bioassay COA
8.9	Hudson-Raritan Bay, New York bioassay COA
9.4	Phillips Chain of Lakes, Wisconsin bioassay COA
11.2	Commencement Bay, Washington bioassay COA
13.1	SSB with *R. abronius*

Nickel

Acute toxicity to organisms occurs at nickel concentrations as low as 1101 ppm in freshwater and as low as 151.7 ppm in saltwater; chronic effects can occur at concentrations of 141 ppm or greater in saltwater; and toxicity is influenced greatly by water hardness and salinity (U.S. EPA, 1986). The 96-h LC50s for two species of estuarine fish were 38 and 70 mg/L nickel chloride (Mayer, 1987). The proposed California marine water quality standard for nickel is 20 ppm (Klapow and Lewis, 1979).

A moderate amount of data are available for sediments to estimate effects thresholds (Table 15), however all of the data are from matching biological and chemical analyses performed with field samples. AET values for Puget Sound are available and were calculated for San Francisco Bay and matching biological and chemical data are available from San Francisco Bay, Commencement Bay, the Keweenaw River, southern California, Massachusetts Bay, Baltimore Harbor, and other areas.

Data from the Cubatao River, Brazil lacked concordance between the biological measure and nickel concentrations. Very small gradients in nickel concentrations were reported in results from San Francisco Bay, Trinity Bay, Fraser River, and some categories of effects from Commencement Bay. The nickel concentration was below the detection limits of 31.8 ppm in a Waukegan Harbor sample that was toxic. Several of the Puget Sound AETs were not definitive. All of these data were not used in the determination of ER-L and ER-M values (Table B-8).

Effects were not observed in association with mean nickel concentrations below 21 ppm in sediments (Table B-8). Benthic species richness was moderate in Massachusetts Bay sediments with a mean nickel concentration of 21 ppm (Table 16). The lower 10 percentile value of the data suggest an ER-L of about 30 ppm (28 rounded to 30 ppm). This value is supported by a Puget Sound AET of 28 ppm, high oyster larvae toxicity in Commencement Bay sediments with a mean nickel concentration of 30 ppm, high toxicity in a Los Angeles Harbor sediment with 31 ppm, and low benthic species richness in Massachusetts Bay sediments with a mean of 33 ppm (Table 16). The 50 percentile value of the data suggests an ER-M of about 50 ppm (52 rounded to 50 ppm), supported by a 1986 Puget Sound AET (49 ppm) and 100 percent mortality in Black Rock Harbor sediments (52 ppm). No overall effects threshold was apparent.

The degree of confidence in the ER-L and ER-M values for nickel should be considered as moderate. The available data indicate relatively high consistency and clustering at or between the two values, but the data are only from field studies, include no SSBs or thresholds derived from the EP approach, and no overall effects threshold is apparent.

Table 15. Summary of sediment effects data available for nickel.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	>120
	- oyster larvae (*C. gigas*) bioassay	39
	- benthic community composition	49
	- Microtox™ bioassay	28
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	>140
	- benthic community composition	>140
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	28
	- maximum level criteria	120
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>170
	- *R. abronius* amphipod bioassay	>170
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	41 ± 32
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	20 ± 13
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	16 ± 7
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	30 ± 22
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	17 ± 8
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	12 ± 3

Table 15. Nickel (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	88
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	17.5
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	44 ± 3
	- sediment populated by feral *M. balthica*	34 ± 4
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	113 ± 42
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	99 ± 35
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	108 ± 25
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	105 ± 36
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	108 ± 27
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	93 ± 3
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	112 ± 31
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	78 ± 42
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	100 ± 35
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	102 ± 44
49	PALOS VERDES, CALIFORNIA	
	- "major degradation" to macrobenthos (20.2 sp/0.1 m. sq.)	94 ± 5
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna* and *H. limbata*	40 ± 16
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	24 ± 22
	- not toxic (23.2% mortality) to *G. japonica*	20 ± 15
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	31
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	<13.8
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	110 ± 0
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna* (n = 1)	350
	- low mortality to *D. magna* (n = 5)	106 ± 74
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	109 ± 19
	- not toxic to *D. magna*	35 ± 14
	- mean concentration in highly toxic (northern) sediments (to *D. magna*)	100
	- mean concentration in least toxic (southern) sediments (to *D. magna*)	29

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Table 18. Nickel (continued)

References	Biological Approaches	Concentrations (ppm)
	Co-Occurrence Analyses	
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *H. limbata*	150
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (93.6 ± 9.4/0.1 sq. m.)	10 ± 3
	- moderate benthos species richness (58.2 ± 10.5/0.1 sq. m.)	21 ± 11
	- low benthos species richness (31 ± 6.5/0.1 sq. m.)	33 ± 12
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to *N. virens*	52
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	38
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	43
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	10
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (TLm 5.1 ± 3.5) and spot (TLm5.9 ± 3.4)	97 ± 53
	- least toxic to mummichogs (TLm 43.2 ± 31.1) and spot (TLm 24 ± 5.6)	70 ± 14
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	6
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	29 ± 26
	- low mortality to *D. magna*	36 ± 29
40	CUBATAO RIVER, BRAZIL	
	- 24-h EC50 with *D. similis*	3

References	Background Approach	Concentrations (ppm)
68	Great Lakes Harbor	
	- classification of non-poluted sediments	<20
	- classification of modertely polluted sediments	20-50
	- classification of heavilypolluted sediments	>50
43	New England interim hih contamination level for dredge material	>100
12	EPA Region V guideline or pollution classification of sediments	20
	USGS alert levels to fia 15-20% of samples analyzed	2000
	Ontario Ministry of the Evironment Dredge Spoil Guidelines	25
	EPA Region VI proposedguidelines	50

Table 15. Nickel (continued)

References	Background Approach	Concentrations (ppm)
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<35
	- Class 2 (moderately contaminated)	35-65
	- Class 3 (contaminated)	65-80
	- Class 4 (heavily contaminated)	>80

References:

1. Beller *et al* 1986
2. PTI Environmental Services, 1988
12. Pavlou and Weston, 1983
20. U.S. ACOE, 1988
23. Jansen, 1987
29. Yake *et al.*, 1986
39. Lee and Mariani, 1977
40. Zagatto *et al.*, 1987
43. NERBC, 1980
49. Swartz *et al.*, 1985
54. Maleug *et al.*, 1984a
55. Maleug *et al.*, 1984b
56. Anderson *et al.*, 1988
62. Tsai *et al.*, 1979
64. Van Dolah *et al.* 1984
68. Bahnick *et al.*, 1981
71. Simmers *et al.*, 1984
72. Ingersoll and Nelson, In press
74. Tatem, 1986
75. Qasim *et al.*, 1980
77. McGreer, 1982
80. Tetra Tech, 1985
82. Gilbert *et al.*, 1976

* -Various, please see text

Table 16. Effects range-low and effects range-median values for nickel and 18 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
21	Massachusetts Bay benthos COA
28	Puget Sound, Washington, AET - Microtox™
30	ER-L
30	Commencement Bay, Washington, bioassay COA
31	Los Angeles Harbor, California, bioassay COA
33	Massachusetts Bay benthos COA
39	Puget Sound, Washington, AET - oyster
40	Little Grizzly Creek, California, bioassay COA
41	Commencement Bay, Washington bioassay COA
49	Puget Sound, Washington, AET - benthic
50	ER-M
52	Black Rock Harbor, Connecticut, bioassay COA
88	Lake Union, Washington, bioassay COA
94	Palos Verdes Shelf, California, benthos COA
97	Baltimore Harbor, Maryland, bioassay COA
100	Keweenaw River, Michigan, bioassay COA
109	Keweenaw River, Michigan, bioassay COA
110	Sheboygan River, Wisconsin, bioassay COA
150	Torch Lake, Michigan, bioassay COA
350	Phillips Chain of Lakes, Wisconsin, bioassay COA

Silver

Available data indicate that chronic toxicity to freshwater organisms may occur at concentrations in water as low as 0.12 ppm and that concentrations in seawater should not exceed 2.3 ppm at any time (U.S. EPA, 1986). The proposed California marine water standard is 0.45 ppm (Klapow and Lewis, 1979).

A relatively small amount of data exist for relating the concentrations of silver in sediments to measures of effects (Table 17). Definitive AETs for Puget Sound could not be calculated for many of the biological end-points and, therefore, are reported as greater-than values. Co-occurrence analyses were performed with data from Commencement Bay, San Francisco Bay, and southern California. Sublethal tests of sediments from the Strait of Georgia were performed with *Macoma balthica*.

There was little or no concordance between measures of toxicity to either amphipods or oyster larvae and silver concentrations in Commencement Bay. Also, amphipod bioassay data from San Francisco Bay and southern California indicated little concordance with respective silver concentrations. In addition, total benthic community abundance and silver concentrations on the southern California shelf indicated little concordance. San Diego Bay sediments with up to 0.8 ppm silver were not toxic in a variety of bioassays. Several of the Puget Sound AETs were not definitive. These data were not considered during the determination of ER-L and ER-M values (Table B-9).

From the remaining data, it appears that effects were not observed in association with silver concentrations of less than about 0.6 ppm (Table 18). The data suggest an ER-L of about 1.0 ppm, the lower 10 percentile value of the available data. This value is supported by results of an avoidance bioassay performed with *M. balthica* (1.0 ppm), San Francisco Bay bioassay data (1.0 ppm), and a San Francisco Bay AET (1.1 ppm). The ER-M suggested by the data is 2.2 ppm, the 50 percentile value of the available data. This value is supported by the absence of feral *M. balthica* in Fraser River sediments (2.1 ± 1.3 ppm), low arthropod abundance in southern California benthos (2.2 ± 3.9 ppm), low species richness in southern California benthos (2.5±4.1 ppm), and increased burrowing time of *M. balthica* exposed to Strait of Georgia sediments (2.6 ppm). With several exceptions, effects were observed at silver concentrations of 1.7 ppm or greater (Table B-9).

The degree of confidence in the silver ER-L and ER-M values should be considered as moderate. There is consistency in the clusters of data around the ER-L and ER-M values and a weak apparent effects threshold lies within ER-L/ER-M range. However, these values are based upon a relatively small amount of data and there are no data from SSBs, nor from EP approaches.

Table 17. Summary of sediment effects data available for silver.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	>3.7
	- oyster larvae (*C. gigas*) bioassay	>0.6
	- benthic community composition	5.2
	- Microtox™ bioassay	>0.6
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	6.1
	- benthic community composition	>6.1
	- oyster larvae (*C. gigas*) bioassay	>0.6
	- Microtox™ bioassay	>0.6
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	1.2
	- maximum level criteria	5.2
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	1.1
	- *R. abronius* amphipod bioassay	>8.6
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	0.2 ± 0.1
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	0.3 ± 0.1
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	0.3 ± 0.1
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	0.3 ± 0.1
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	0.3 ± 0.1
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	0.3 ± 0.1
26	PUGET SOUND, WASHINGTON	
	- highly toxic to *R. abronius* (95% LPL)	0.6 ± 1.0
	- moderately toxic to *R. abronius* (<87.5% survival to >95% LPL)	0.6 ± 0.6
	- least toxic to *R. abronius* (>87.5% survival)	0.3 ± 0.1
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	2.6
	- significant 24-h avoidance behavior among *M. balthica*	1
77	FRASER RIVER, B.C., CANADA	
	- sediment devoid of feral *M. balthica*	2.1 ± 1.3
	- sediment populated by feral *M. balthica*	0.8 ± 0.6
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	1.7 ± 2.6
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	0.9 ± 0.9
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	1.3 ± 1.8
	- significantly toxic (42.9 ± 19.2% mortality to *R. abronius*	1.2 ± 1.7
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	1.4 ± 1.9

Table 17. Silver (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	6.9 ± 2.5
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	1 ± 0.6
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	0.5 ± 0.4
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	1.7 ± 2.2
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	0.6 ± 0.5
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	1.3 ± 1.4
	- not toxic (23.2% mortality) to *G. japonica*	1.1 ± 1.9
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	0.6 ± 0.8
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	0.6 ± 0.7
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	3.1 ± 4.5
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	0.9 ± 1.6
	- moderate arthropod abundance (73 ± 6.8/0.1 sq. m.)	0.7 ± 1
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	2.2 ± 3.9
	- high species richness (96.3 ± 22.3/0.1 sq. m.)	0.9 ± 2.1
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	0.7 ± 0.8
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	2.5 ± 4.1
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	3.2 ± 5.6
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	1 ± 2
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	1.3 ± 1.8
66	SAN DIEGO BAY, CALIFORNIA	
	- ≥82% survival of sanddab *C. stigmaeus*, *A. sculpta*, and *A. tonsa*	0.8
	- ≥86% survival of *A. sculpta*, *N. arenacaedentata*;, and *M. nasuta*	0.8

Reference	Background Approach	Concentrations (ppm)
12	USGS alert levels to flag 15-20% of samples analyzed	1000

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
12. Pavlou and Weston, 1983
20. U.S. ACOE, 1988
26. DeWitt *et al.*, 1988
56. Anderson *et al.*, 1988
66. Salazar and Salazar, 1985
67. McGreer, 1979
77. McGreer, 1982
80. Tetra Tech, 1985
83. Word and Mearns, 1979
* -Various, please see text

Table 18. Effects range-low and effects range-median values for silver and 13 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
0.6	Puget Sound, Washington, bioassay COA
1.0	*M. balthica* avoidance bioassay COA
1.0	San Francisco Bay, California Bioassay COA
1.0	ER-L
1.1	San Francisco Bay, California AET
1.7	San Francisco Bay, California bioassay COA
2.1	Feral Fraser River *M. balthica* absent COA
2.2	Southern California arthropod abundance COA
2.2	ER-M
2.5	Southern California species richness COA
2.6	*M. balthica* burrowing time bioassay COA
3.1	Southern California echinoderm abundance COA
5.2	Puget Sound, Washington AET - benthic
6.1	Puget Sound, Washington AET - amphipod
6.9	San Francisco Bay, California bioassays COA

Tin

No data were found with which total tin concentrations could be related to effects in sediments. However, organotin concentrations in sediments can be related to toxicity with data from two small studies (Word *et al.*, 1988; Salazar and Salazar, 1985). Significant percent mortality among amphipods (*R. abronius*) was observed inconsistently (*i.e.*, some samples were toxic, some others were not) over a range of tributyltin concentrations of 18.7 to 2,214 ppm dry weight and over a range of total butyltin concentrations of 30 to 3,011 ppm dry weight in tests of Oakland Inner Harbor sediments (Word *et al.*, 1988). Over 86 percent survival of mysids (*Acanthomysis sculpta*) was observed in bioassays of San Diego Bay sediments with a range of tributyltin concentrations of 155 to 780 ppm wet weight (no moisture content data provided) (Salazar and Salazar, 1985).

Because of a lack of data, no consensus values can be determined for the concentrations of tin in sediments that are associated with biological effects.

Zinc

Freshwater daphnids are sensitive to zinc at concentrations as low as 51 ppm in water; chronic effects in daphnids have been observed at concentrations as low as 47 ppm; LC50s for saltwater fish range from 192 ppm to 320,400 ppm; and chronic effects among marine mysids occur as low as 120 ppm (U.S. EPA, 1986). The proposed marine water quality standard for California is 20 ppm (Klapow and Lewis, 1979).

A relatively large amount of data are available to use in relating measures of effects to zinc concentrations in sediments (Table 19). They are available from all of the major approaches to the development of sediment quality standards. AET values for Puget Sound and San Francisco Bay are listed in Table 19. Co-occurrence analyses were performed with data from Commencement Bay, San Francisco Bay, Puget Sound, southern California, DuPage River, Kishwaukee River, Keweenaw Waterway, Trinity River, Massachusetts Bay, Hudson-Raritan Estuary, Baltimore Harbor, and other areas. Chronic and acute EP thresholds are available, assuming a 4 percent TOC content. Data from SSB performed with *R. abronius* and *Ponotoporeia affinis* are available.

No effects to the benthos were observed at the Georgetown, South Carolina disposal site. No concordance between toxicity and zinc concentrations was apparent in tests of Cubatao River sediments. No concordance between total abundance of benthos and zinc concentrations was apparent for southern California. A relatively poor correlation between species diversity and zinc concentrations in Norwegian fjords was reported. A relatively small gradient in zinc concentrations was reported for sediments from the Kishwaukee River, Illinois. A relatively poor correlation between *M. balthica* burrowing time and zinc concentrations was reported. Relatively poor concordance between toxicity to amphipods and zinc concentrations was apparent in the data from San Francisco Bay. These data were not considered in the estimation of ER-L and ER-M values (Table B-10).

From the remaining data, it appears that biological effects have not been observed in association with zinc concentrations of about 50 ppm or less in sediments (Table 20). Behavioral effects upon the amphipod *R. abronius* and the shrimp *P. affinis* have been observed at zinc concentrations of 51 to 124 ppm. The data suggest an ER-L value of about 120 ppm, the lower 10 percentile value of the available data. This value is supported by observations of low species richness among Massachusetts Bay benthos (117 ± 42 ppm), significant mortality among *Daphnia magna* exposed to Trinity River sediments (121 ± 20 ppm), high mortality among *H. azteca* exposed to Waukegan Harbor sediments (127 ppm), and a San Francisco Bay AET based upon bivalve larvae bioassays (130 ppm). With a few exceptions, biological effects were usually observed at zinc concentrations of 260 ppm or greater (Table B-10). Also, the 50 percentile of the available data is equivalent to about 270 ppm, the ER-M suggested by the data. This value is supported by bioassay data from the Hudson-Raritan estuary (245 ± 201 ppm) and Little Grizzly Creek (267 ± 298 ppm), a Puget Sound AET (260 ppm), and an LC50 for a SSB with *R. abronius* (276 ppm).

The degree of confidence in the ER-L and ER-M values for zinc should be considered as relatively high. Both of the values are supported by a consistent cluster of data derived from more than one data set and/or approach. The available data strongly suggest that sublethal and other sensitive measures of effects occur at zinc concentrations of about 50 to 125 ppm and that effects almost always occur at or above zinc concentrations of 260 ppm. However, several of the Puget Sound AET values and the two EP thresholds suggest that thresholds for effects occur at concentrations much higher than the ER-L and ER-M values.

Table 19. Summary of sediment effects data available for zinc.

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	870
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	260
	- Microtox™ bioassay	1600
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	960
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	410
	- Microtox™ bioassay	1600
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	160
	- maximum level criterion	1600

Table 19. Zinc (continued)

References	Biological Approaches	Concentrations (ppm)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	130
	- *R. abronius* amphipod bioassay	230
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	941 ± 1373
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	211 ± 342
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	108 ± 79
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	387 ± 783
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	185 ± 335
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	107 ± 122
26	PUGET SOUND, WASHINGTON	
	- non-toxic (>87.5% survival of *R. abronius*)	114 ± 52
	- moderately toxic (<87.5% to >95% LPL to *R. abronius*)	195 ± 166
	- highly toxic (95% LPL to *R. abronius*)	707 ± 955
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	320
39	DUWAMISH RIVER, WASHINGTON	
	- 0-10% mortality to *P. pugio*	72
77	FRASER RIVER, B.C.,CANADA	
	- sediment devoid of *M. balthica*	169 ± 53
	- sediment populated by *M. balthica*	65 ± 19
67	STRAIT OF GEORGIA, B.C., CANADA	
	- significant increase in burrowing time (ET50) of *M. balthica*	109
	- significant 24-h avoidance behavior among *M. balthica*	172
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality to *R. abronius*	187 ± 115
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	146 ± 73
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	171 ± 91
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	158 ± 87
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	177 ± 96
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	205 ± 90
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	172 ± 92
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	89 ± 41
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	154 ± 91
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	136 ± 78
50	PALOS VERDES SHELF, CALIFORNIA	
	- "major degradation" to macrobenthos (20.2sp./0.1m. sq.)	739 ± 139

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Table 19. Zinc (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	348 ± 234
	- not toxic (23.2% mortality) to *G. japonica*	212 ± 243
83	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	50 ± 13
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	55 ± 34
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	230 ± 444
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	51 ± 24
	- moderate arthropod abundance (72.6 ± 6.8/0.1 sq. m.)	52 ± 28
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	182 ± 384
	- high species richness (96.3 ± 22.3/0.1 sq. m)	71 ± 106
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	50 ± 22
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	197 ± 415
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	347 ± 592
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	53 ± 28
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	73 ± 81
39	LOS ANGELES HARBOR, CALIFORNIA	
	- >50% mortality to *P. pugio* (20% elutriate bioassay)	223
55	LITTLE GRIZZLY CREEK, CALIFORNIA	
	- significant mortality to *D. magna*	267 ± 298
55	PHILLIPS CHAIN OF LAKES, WISCONSIN	
	- significant mortality to *D. magna*	570
	- low mortality (0-5%) to *D. magna*	216 ± 213
74	SHEBOYGAN RIVER, WISCONSIN	
	- significant mortality to prawn, *M. rosenbergii*	290 ± 10
72	WAUKEGAN HARBOR, ILLINOIS	
	- highly toxic (66.3 ± 4.25% mortality) to *H. azteca*	127
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	327 ± 162
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	182 ± 56
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	107 ± 31
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	96 ± 52
54	KEWEENAW WATERWAY, MICHIGAN	
	- significantly toxic to *D. magna*	168 ± 52
	- not toxic to *D. magna*	69 ± 24
	- mean concentration in highly toxic (northern) sediments to *D. magna*	154
	- mean concentration in least toxic (southern) sediments to *D. magna*	62

Table 19. Zinc (continued)

References	Biological Approaches	Concentrations (ppm)
Co-Occurrence Analyses		
55	TORCH LAKE, MICHIGAN	
	- significant mortality to *D. magna* and *H. limbata*.	310
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	121 ± 100
	- low mortality to *D. magna*	58 ± 41
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- high benthos species richness (93.6 ± 9.4/0.1 sq. m.)	32 ± 7
	- moderate benthos species richness (58.2 ± 10.5/0.1 sq. m.)	98 ± 64
	- low benthos species richness (31 ± 6.5/0.1 sq. m.)	117 ± 42
39	NEWPORT, RHODE ISLAND	
	- 0% mortality to *P. pugio*	55
71	BLACK ROCK HARBOR, CONNECTICUT	
	- 100% mortality to polychaete, *N. virens*	334
39	STAMFORD, CONNECTICUT	
	- 10% mortality to *P. pugio*	340
39	NORWALK, CONNECTICUT	
	- 0% mortality to *P. pugio*	636
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in nematode, *C.germanica*	449 ± 252
	- positive rate of growth in nematode, *C.germanica*	245 ± 201
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (5.1 ± 3.5 TLm) spot (5.9 ± 3.4 TLm)	1804 ± 2098
	- least toxic to mummichogs (43.2 ± 31.1 TLm) spot (24 ± 5.6 TLm)	738 ± 394
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	11
40	CUBATAO RIVER, BRAZIL	
	- 24-h EC-50 with *D. simillis*	20
41	NORWEGIAN FJORDS, NORWAY	
	- 50% reduction from max in Hurlbert's benthic species diversity index	80
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@4%TOC)	2240
4	EPA chronic marine EP threshold (@4%TOC)	760
Spiked-Sediment Bioassays		
11	54.7% dead out of 53 *R. abronius* in 72-h bioassay	613
	67.2% avoidance, out of 59 *R. abronius* in 72-h, 2-choice experiment	51
	66.7% avoidance, out of 45 *R. abronius*, in 72-h, 2-choice experiment	188

Table 19. Zinc (continued)

References	Biological Approaches	Concentrations (ppm)
Spiked-Sediment Bioassays		
18	LC50 for *R. abronius* in 10-d bioassay	276
63	Activity behavior of *Pontoporeia* significantly decreased, 5-day exposure	59-124
27	LC05 for Zn and LC76 for Cd, *R. abronius*, 72-h bioassay	79
	LC08 for Zn and LC98 for Cd, *R. abronius*, 72-h bioassay	76

References	Background Approach	Concentrations (ppm)
68	Great Lakes Harbors	
	- Classification of non-polluted sediments	<90
	- Classification of moderately polluted sediments	90-200
	- Classification of heavily polluted sediments	>200
43	New England interim high contamination level for dredge material	>400
12	EPA Region V guideline for pollution classification of sediments	90
	USGS alert levels to flag 15-20% of samples analyzed	5000
	Ontario Ministry of the Environment Dredge Spoil Guidelines	100
	EPA Region VI proposed guidelines	75
	FWPCA Chicago Guidelines:	
	- LIGHT (no alteration to benthos)	0-90
	- MODERATE: (predominance of pollutant-tolerant benthos)	90-200
	- HEAVY: (benthos absent or abundance reduced)	>200
	EPA Jensen Criteria for open water dredge material disposal	50
	EPA Region VI proposed guidelines for sediment disposal	75
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	105
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<370
	- Class 2 (moderately contaminated)	370-1160
	- Class 3 (contaminated)	1160-2330
	- Class 4 (heavily contaminated)	>2330

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
11. Oakden *et al.*, 1984a
12. Pavlou and Weston, 1983
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39 Lee and Mariani, 1977
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68. Bahnick *et al.*, 1981
71. Simmers *et al.*, 1984
72. Ingersoll and Nelson, In press
74. Tatem, 1986
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79. Tietjen and Lee, 1984
80. Tetra Tech, 1985
82. Gilbert *et al.*, 1976
83. Word and Mearns, 1979
* Various, Please see text

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Table 20. Effects range-low and effects range-median values for zinc and 46 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
51	Sublethal SSB with *R. abronius*
59 - 124	Sublethal SSB with *P. affinis*
98	Massachusetts Bay, Massachusetts benthos COA
117	Massachusetts Bay, Massachusetts benthos COA
120	ER-L
121	Trinity River, Texas bioassays COA
127	Waukegan Harbor, Illinois bioassays COA
130	San Francisco Bay, California AET
154	Keweenaw Waterway, Michigan bioassays COA
168	Keweenaw Waterway, Michigan bioassays COA
169	Feral Fraser River *M. balthica* absent COA
172	*M. balthica* avoidance bioassay COA
172	San Francisco Bay, California bioassays COA
182	Southern California arthropod abundance COA
185	Commencement Bay, Washington bioassays COA
188	Sublethal SSB with *R. abronius*
195	Puget Sound, Washington bioassays COA
197	Southern California species richness COA
205	San Francisco Bay, California bioassays COA
211	Commencement Bay, Washington bioassays COA
223	Los Angeles Harbor, California bioassays COA
230	San Francisco Bay, California AET
230	Southern California echinoderm abundance COA
260	Puget Sound, Washington AET - benthic
267	Little Grizzly Creek, California bioassays COA
270	ER-M
276	SSB with *R. abronius* LC50
290	Sheboygan River, Wisconsin bioassays COA
310	Torch Lake, Michigan bioassays COA
320	Lake Union, Washington bioassays COA
327	DuPage River, Illinois species richness COA
334	Black Rock Harbor, Connecticut bioassays COA
348	Southern California bioassays COA
387	Commencement Bay, Washington bioassays COA
410	Puget Sound, Washington AET - benthic
449	Hudson-Raritan Bay, New York bioassays COA
570	Phillips Chain of Lakes, Wisconsin bioassays COA
613	SSB with *R. abronius*
707	Puget Sound, Washington bioassays COA
739	Palos Verdes Shelf, California "major degradation" COA
760	EP marine chronic threshold @ 4% TOC
870	Puget Sound, Washington AET - amphipod
941	Commencement Bay, Washington bioassays COA
960	Puget Sound, Washington AET - amphipod
1600	Puget Sound, Washington AET - oyster
1600	Puget Sound, Washington AET - Microtox™
1804	Baltimore Harbor, Maryland bioassays COA
2240	EP marine acute threshold @ 4% TOC

Other Major and Trace Elements

Data with which measures of biological effects could be related to the concentrations of aluminum, iron, manganese, silicon, thallium, and selenium were not found. Therefore, no ER-L or ER-M values were determined for these analytes that are quantified in sediments by the NS&T Program.

PCBs

Acute toxicity of PCBs in water to freshwater aquatic organisms probably occurs at concentrations above 2.0 ppm and above 10 ppm for saltwater species (U.S. EPA, 1986). LC50s for Aroclor 1242 tested in 96-h bioassays with *Palaemonetes pugio* ranged from 15 to 57 ppm (Mayer, 1987)

A considerable amount of data exist with which PCB concentrations in sediments and measures of biological effects can be related (Table 21). Most of these data are from field studies and were evaluated with co-occurrence analyses. Matching biological and chemical data are available from Puget Sound, Commencement Bay, San Francisco Bay, southern California, San Diego Bay, DuPage River, Kishwaukee River, Waukegan Harbor, Mississippi River, Trinity River, Massachusetts Bay, Baltimore Harbor, Hudson-Raritan estuary, and other areas. AET were listed for Puget Sound and San Francisco Bay. An EP chronic marine threshold was available, along with marine and freshwater SLCs and results of two sSSB experiments.

Data from the Trinity River indicated no gradient in PCB concentrations among stations. Most of the Mississippi River data indicated no concordance between toxicity and PCB concentrations. No gradient in PCB concentrations among Massachusetts Bay stations was apparent. There was very little concordance between bivalve larvae bioassay results and PCB concentrations in San Francisco Bay. Data from southern California indicated no concordance between total abundance of benthos and PCB concentrations. There was no concordance between moderately and highly toxic samples and PCB concentrations in data from Commencement Bay. There was very little difference in PCB concentrations in samples from Puget Sound that were moderately toxic versus those that were highly toxic. No concordance was apparent between toxicity and PCB concentrations in tests of southern California sediments. San Diego Bay sediments were not highly toxic. These data were not considered in the estimation of ER-L and ER-M values (Table B-11).

It appears that biological effects may begin in association with PCB concentrations above about 3 ppb (Table 22). The ER-L suggested by the data is 50 ppb PCB (54 rounded to 50 ppm), equivalent to the lower 10 percentile value of the available data. This value is supported only by the two marine SLCs (36.6 and 42.6 ppb) and a San Francisco Bay AET for bivalve larvae (based upon data that indicated weak concordance--54 ppb). The data suggest an ER-M of about 400 ppb; a value supported by Commencement Bay samples highly toxic to oyster larvae (mean 368 ppb) and the mean concentration in southern California sediments with moderate species richness (400 ppb). With very few exceptions, effects were almost always associated with PCB concentrations of 370 ppb or more (Table B-11).

The degree of confidence in these values should be considered as moderate. There are data from all of the major approaches, the overall apparent effects threshold is roughly equivalent to the ER-M concentration, and consistent clusters of data support the ER-L and ER-M values. However, much of the data available from the various approaches are not consistent. The highest and lowest Puget Sound AETs differ by over an order of magnitude; the data from the only single-chemical SSB indicate relatively low acute toxicity and a value (LC50 of 10,800 ppb) inconsistent with much of the other data; PCB concentrations in Waukegan Harbor sediments determined to be toxic in Microtox™ tests differed by four orders of magnitude from those determined to be toxic in Puget Sound with the same test; and the marine and freshwater SLCs are much lower than the concentrations associated with benthic effects in other studies. Since the only data from a SSB unexpectedly indicated an LC50 much higher than the PCB concentrations associated with measures of effects in the field, PCBs in field-collected sediments may be highly particle-bound and not bioavailable and/or they may have a relatively minor role in causing biological effects such as acute mortality relative to other co-occurring contaminants.

Table 21. Summary of sediment effects data available for PCBs.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2500
	- oyster larvae (*C. gigas*) bioassay	1100
	- benthic community composition	1100
	- Microtox™ bioassay	130
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	3100
	- oyster larvae (*C. gigas*) bioassay	1100
	- benthic community composition	1000
	- Microtox™ bioassay	130
20	PSDDA GUIDELINES (based upon Puget Sound AET	
	- screening level concentration	130
	- maximum level criterion	2500
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	54
	- *R. abronius* amphipod bioassay	260
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7±3.9 dead/20) to *R. abronius*	38 ± 32
	- moderately toxic (5.2±1.1 dead/20) to *R. abronius*	251 ± 556
	- least toxic (2.5±0.9 dead/20) to *R. abronius*	61 ± 88
	- highly toxic (44.5±19% abnormal) to oyster larvae	368 ± 695
	- moderately toxic (23±2.3% abnormal) to oyster larvae	140 ± 262
	- least toxic (15.1±3.1% abnormal) to oyster larvae	28 ± 27
26	PUGET SOUND, WASHINGTON	
	- highly toxic (<95% LPL to *R. abronius*)	276 ± 365
	- moderately toxic (<87.5% to >95% LPL to *R. abronius*)	259 ± 407
	- non-toxic (≥87.5% survival of *R. abronius*)	99 ± 120
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	4300
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	169 ± 171
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	151 ± 260
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	94 ± 147
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	146 ± 218
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	101 ± 153
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	164 ± 100
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	165 ± 232
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	26 ± 16

Table 21. PCBs (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	127 ± 171
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	216 ± 376
7	- sediment quality triad minimum or no bioeffects	≤100
	- sediment quality triad significant bioeffects	≥160
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	272 ± 217
	- not toxic (23.2% mortality) to *G. japonica*	480 ± 724
83	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	1300 ± 2700
	- moderate echinoderm abundance (56.2 ± 23/0.1 sq. m.)	30 ± 50
	- high echinoderm abundance (191.3 ± 70.1/0.1 sq. m.)	20 ± 20
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	1000 ± 2400
	- moderate arthropod abundance (72.6 ± 6.8/0.1 sq. m.)	60 ± 70
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	80 ± 100
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	1110 ± 2610
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	400 ± 600
	- high species richness (96.3 ± 22.3/0.1 sq. m)	220 ± 540
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	160 ± 430
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	80 ± 140
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	2260 ± 3530
66	SAN DIEGO BAY, CALIFORNIA	
	- ≥82% survival of *C. stigmaeus, A. sculpta, A. tonsa*	25
	- ≥86% survival of *A. sculpta, N. arenacaedentata, M. nasuta*	25
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	190 ± 214
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	31 ± 19
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (8.4 ± 0.5/site)	128 ± 264
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	7 ± 6
24	WAUKEGAN HARBOR, ILLINOIS	
	- high Microtox™ toxicity (average EC50 of 47.7 ± 15.2)	355,050 ± 6,598,300
	- moderate Microtox™ toxicity (average EC50 of 128.7 ± 49.3)	1,141,300 ± 2,229,700
	- low Microtox™ toxicity (average EC50 of 368.1 ± 101.7)	ND-174
69	MISSISSIPPI RIVER	
	- 80 to 100% survival (92 ± 6.3) of *G. pseudolimnaeus*	60
	- 25% survival of mayfly (*Hexagenia* sp.; n = 1)	<1.13
	- 80-100% survival of mayfly (*Hexagenia* sp.)	12 ± 20
	- 55% ± 10% survival of midges (*C. tentans*)	0.7 ± 0.3
	- 90% ± 5.8% survival of midges (*C. tentans*)	15 ± 22
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	0.005 ± 0
	- low mortality to *D. magna*	0.005 ± 0

Table 21. PCBs (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- low benthos species richness (31 ± 6.5/0.1 sq. m.)	5 ± 5
	- moderate benthos species richness (58.2 ± 10.5/0.1 sq. m.)	5 ± 5
	- high benthos species richness (93.6 ± 9.4/0.1 sq. m.)	2 ± 1
58	BLACK ROCK HARBOR, CONNECTICUT	
	- significant toxicity to *A. abdita* in 10-day bioassay	1700
79	HUDSON-RARITAN BAY, NEW YORK	
	- negative rate of growth in nematode, *C.germanica*	638 ± 512
	- positive rate of growth in nematode, *C.germanica*	290 ± 502
44	NEW YORK HARBOR	
	- <10% mortality to *N. virens, M. mercenaria, P. pugio*	7280
62	BALTIMORE HARBOR, MARYLAND	
	- most toxic to mummichogs (TLm5.1 ± 3.5), spot (TLm5.9 ± 3.4)	1100 ± 800
	- least toxic to mummichogs (TLm43.2 ± 31.1), spot (TLm24 ± 5.6)	180 ± 160
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	50
National Screening Level Concentrations		
5	Freshwater sediments @ 1% TOC	2.9
	Marine sediments @ 1% TOC	42.6
14	Marine sediments @ 1% TOC	36.6
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@4%TOC) (hexa-CB)	280
Spiked Sediment Bioassays		
18	LC50 for *R. abronius* in 10-d bioassay	10800
65	significant toxicity to *R. abronius* in 10-d bioassay	1000 ± 300

References	Background Approach	Concentrations (ppb)
68	Great Lakes Harbors	
	- Classification of heavily polluted sediments	≥10000
43	New England interim high contamination level for dredge material	1000
12	EPA Region V guideline for pollution classification of sediments	1000-10000
	USGS alert levels to flag 15-20% of samples analyzed	20
	Ontario Ministry of the Environment Dredge Spoil Guidelines	50
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	380

Table 21. PCBs (continued)

References	Background Approaches	Concentrations (ppb)
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<100
	- Class 2 (moderately contaminated)	100-250
	- Class 3 (contaminated)	250-500
	- Class 4 (heavily contaminated)	>500

References:

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2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
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* -Various, please see text
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75. Qasim *et al.*, 1980
79. Tietjen and Lee, 1984
80. Tetra Tech, 1985
82. Gilbert *et al.*, 1976
83. Word and Mearns, 1979

Table 22. Effects range-low and effects range-median values for PCBs and 34 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
2.9	Freshwater SLC
36.6	Marine SLC
42.6	Marine SLC
50	**ER-L**
54	San Francisco Bay, California AET
≤100	San Francisco Bay, California triad minimum bioeffects COA
128	Kishwaukee River, Illinois benthos COA
130	Puget Sound, Washington AET - Microtox™
140	Commencement Bay, Washington bioassay COA
146	San Francisco Bay, California, bioassay COA
151	San Francisco Bay, California bioassay COA
≥160	San Francisco Bay, California triad significant bioeffects COA
165	San Francisco Bay, California bioassay COA
190	DuPage River, Illinois benthos COA
259	Puget Sound, Washington bioassay COA
260	San Francisco Bay, California AET
280	EP chronic marine @ 4% TOC
368	Commencement Bay, Washington bioassay COA
400	**ER-M**
400	Southern California benthos COA
638	Hudson-Raritan Bay, New York bioassay COA
1000	Puget Sound, Washington AET - benthic
1000	Southern California arthropod abundance COA

Table 22. (continued)

Concentrations (ppb)	End Point
1000	SSB with *R. abronius* (PCBs mixed with hydrocarbons)
1100	Puget Sound, Washington AET - oyster
1100	Puget Sound, Washington AET - benthic
1110	Baltimore Harbor, Maryland bioassay COA
1100	Southern California species richness COA
1300	Southern California echinoderm abundance COA
1700	Black Rock Harbor, Connecticut bioassay COA
2500	Puget Sound, Washington AET - amphipod
3100	Puget Sound, Washington AET - amphipod
4300	Lake Union, Washington toxicity COA
10800	SSB with *R. abronius* LC50
355050	Waukegan Harbor, Illinois bioassay COA
1141300	Waukegan Harbor, Illinois bioassay COA

Pesticides:

DDT and Metabolites

Data and estimates of threshold concentrations have been reported as the concentrations for each of the six isomers (p,p-DDT, o,p-DDT, p,p-DDD, o,p,-DDD, p,p-DDE, o,p-DDE); as the total of the two isomers each of DDT, DDD, and DDE; and as the concentration for the total of all six of these isomers of DDT. Therefore, within the limits of data availability, the data are treated separately here for each of the isomers and for the total. However, this approach has the unfortunate effect of reducing the amount of data available for any one of the isomers and for the total of the isomers.

The criterion to protect freshwater aquatic organisms is 0.001 ppm as a 24-h average and the concentration should not exceed 1.1 ppm at any time; the criterion to protect saltwater species is also 0.001 ppm as a 24-h average and the concentration should not exceed 0.13 ppm at any time (U.S. EPA, 1986). Available data indicate that acute toxicity of DDE occurs at concentrations as low as 1,050 ppm in freshwater and 14 ppm in saltwater (U.S. EPA, 1986). The LC50s for p,p'-DDT, p,p'-DDD, and p,p'-DDE were 0.45 ppm for a mysid (96-h test); 20 ppm for spot (48-h test); and over 100 ppm for spot (48-h test), respectively.

Data are available for either p,p'-DDT or the sum of o,p'-DDT and p,p'-DDT from Puget Sound AET, San Francisco Bay bioassays, Palos Verdes bioassays (with very small sample sizes), benthic effects at the Georgetown disposal site, SSB with *R. abronius*, and various applications of EP approaches (Table 23). The seven LC50s determined in the spiked bioassays averaged 49.5 ppb and ranged from 11.2 to 125.1 ppb, assuming 1 percent TOC content. The data for p,p'-DDT and the sum of the two isomers were treated as equivalent, since o,p'-DDT was rarely reported at high concentrations. There was no concordance between DDT concentrations in San Francisco Bay sediments and effects to bivalve larvae exposed to the sediments; neither the co-occurrence nor the AET data were used further. Likewise, there was no appreciable gradient in DDT concentration between samples least toxic to amphipods versus those moderately toxic to amphipods among San Francisco Bay sediments. Two of the Puget Sound AETs were not definitive. These data and the small amount of Palos Verdes data were not used to estimate ER-L and ER-M values (Table B-12). The remaining data suggest an ER-L of about 1.0 ppb DDT, the lower 10 percentile of the data (Table 24). This value is supported by EP-based thresholds of 0.7 and 1.6 ppb (assuming 1% TOC content). The data suggest an ER-M of about 7 ppb, roughly equivalent to the 50 percentile value of the data. This value is supported by moderate toxicity to bivalve larvae (6.6 ppb) and significant toxicity to amphipods (7.5 ppb) exposed to San Francisco Bay sediments. With several exceptions, effects were usually observed at concentrations of about 6 ppb or greater (Table B-12).

The degree of confidence in the p,p'-DDT ER-L and ER-M values should be considered as low. The data points do not cluster about the ER-L or ER-M values, especially at the upper end of the bioeffects range. Also, the values are based upon data from a few areas rather than over a broad range of areas. However, except for the EP-derived values, the highest and lowest threshold values differ by about an order of magnitude (3.9 to 49.5 ppb).

Table 23. Summary of sediment effects data available for p,p'-DDT.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	3.9
	- oyster larvae (*C. gigas*) bioassay	>6
	- benthic community composition	11
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	>270
	- oyster larvae (*C. gigas*) bioassay	>6
	- benthic community composition	34
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	9.6
	- *R. abronius* amphipod bioassay	9.6
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	12 ± 25
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	2 ± 2
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	1 ± 3
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	8 ± 18
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	1 ± 3
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	0.6 ± 0.2
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	7 ± 18
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	2 ± 4
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	5 ± 15
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	3 ± 6
49	PALOS VERDES, CALIFORNIA	
	- significantly toxic to *R. abronius* (n = 2)	83
	- not toxic to *R. abronius* (n = 1)	74
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@ 4% TOC)	840
	EPA chronic marine EP threshold (@ 4% TOC)	6.4
4	EPA chronic marine EP threshold (@ 4% TOC)	6

Table 23. p,p'-DDT (continued)

References	Biological Approaches	Concentrations (ppb)
Equilibrium Partitioning		
25	Sediment safe level based upon sediment/water partitioning coefficient and acute water quality criteria (@ 1% TOC)	210
	Sediment safe level based upon sediment/water partitioning coefficient and chronic water quality criteria (@ 1% TOC)	1.6
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	0.7
	99 percentile chronic marine permissable (sediment/water partition coefficient)	0.4
Spiked Sediment Bioassays		
16	Overall mean LC50 for *R. abronius* in Puget Sound, Washington sediments (@ 1% TOC) (LC50s ranged from 11.2 to 125.1 ppb)	49.5

References:

1. Beller et al., 1986
2. PTI Environmental Services, 1988
4. Bolton et al., 1985
9. Swartz et al., 198516.
16. Word et al., 1987
17. Lyman et al., 1987
25. Pavlou, 1987
64. Van Dolah et al., 1984
* -Various, please see text

Table 24. Effects range-low and effects range-median values for p,p'-DDT and 15 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
0.4	EP 99 percentile chronic marine
0.7	EP 95 percentile chronic marine
1.0	**ER-L**
1.6	EP chronic safe level @ 1% TOC
3.9	Puget Sound, Washington, AET - amphipod
6.0	EP chronic marine @ 4% TOC
6.4	EP chronic marine @ 4% TOC
6.6	San Francisco Bay, California, bioassay COA
7.0	**ER-M**
7.5	San Francisco Bay, California, bioassay COA
9.6	San Francisco Bay, California, AET
11.0	Puget Sound, Washington, AET - benthic
12.2	San Francisco Bay, California, bioassay COA
34.0	Puget Sound, Washington, AET - benthic
49.5	SSB with *R. abronius*: overall mean LC50
210.0	EP acute safe level @ 1% TOC
840.0	EP acute marine @ 4% TOC

For the p,p'-DDE isomer or total DDE, data are available from Puget Sound AET, San Francisco Bay bioassays and AET, Palos Verdes bioassays and benthic community analyses, Mississippi River bioassays, benthic community analyses at the Georgetown disposal site, and various uses of the EP approaches (Table 25). No effects upon benthos at the Georgetown site were observed at concentrations below the limits of detection of 50 ppb; there was no concordance between DDE concentrations in San Francisco Bay and significantly toxic versus non-toxic samples tested with bivalve larvae; nor for sediments that were highly versus moderately toxic to bivalves or moderately versus least toxic to amphipods. Low survival of *Hexagenia* sp. exposed to Mississippi River sediment was observed in only one sample and there was a very small gradient in DDE concentration among samples; therefore, these data were not used in estimating ER-L and ER-M values (Table B-13). The remaining data (Table 26) suggest an ER-L of about 2 ppb, the lower 10 percentile value of the available data. This value is supported by AET and bioassay data from San Francisco Bay sediments tested with *R. abronius* amphipods and bivalve larvae (2.2., 2.2, 2.1, 2.2 ppb). Effects were almost always seen in association with concentrations exceeding 2 ppb (Table B-13). The 50 percentile value of the data suggest an ER-M of about 15 ppb, a value supported by relatively few data points: Puget Sound AETs of 9 and 15 ppb.

The degree of confidence in the p,p'-DDE ER-L and ER-M values should be considered as moderate and low, respectively. There are few data points available and no measures of effects based upon SSBs. An apparent effects threshold could not be determined due to the lack of sufficient data. The ER-L value is supported by a small cluster of data from San Francisco Bay.

Table 25. Summary of sediment effects data available for DDE.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	15
	- benthic community composition	9
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	15
	- benthic community composition	9
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	2.2
	- *R. abronius* amphipod bioassay	2.2
Co-occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	3 ± 5
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	1 ± 1
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	1 ± 1
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	2 ± 4
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	1 ± 1
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	1 ± 1
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	2 ± 4
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	1 ± 1
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	2 ± 3
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	1 ± 1

Table 25. DDE (continued).

References	Biological Approaches	Concentrations (ppb)
Co-occurrence Analyses		
49	PALOS VERDES, CALIFORNIA	
	- significantly toxic to *R. abronius*	5157 ± 1065
	- not toxic to *R. abronius*	3374 ± 3153
	- major degradation" of macrobenthos (20.2 sp./0.1 m. sq.)	5157 ± 1065
69	MISSISSIPPI RIVER	
	- 80-100% survival (92 ± 6.3) of *G. pseudolimnaeus*, 4-d bioassay	0.28
	- 25% (n = 1) survival of mayfly (*Hexagenia* sp.), 4-d bioassay	<0.2
	- 80-100% survival (90 ± 7.5) of mayfly (*Hexagenia* sp.) 4-d bioassay	0.12 ± 0.06
	- 55% ± 10% survival of midges (*C. tentans*), 4-d bioassay	0.1 ± 0
	- 90% ± 5.8% survival of midges (*C. tentans*), 4-d bioassay	0.13 ± 0.07
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@4% TOC)	28000
17	EPA acute marine EP threshold (@4% TOC)	28000
25	Safe level based on sediment/water partitioning coefficient, acute water quality criteria	7000
13	99 percentile chronic marine permissable (sediment/water partition coefficient)	27
	95 percentile chronic marine permissable (sediment/water partition coefficent)	60

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
13. Pavlou *et al.*, 1987
17. Lyman *et al.*, 1987
25. Pavlou, 1987
49. Swartz *et al.*, 1985
50. Swartz *et al.*, 1986
69. Marking *et al.*, 1981
64. Van Dolah *et al.*, 1984

* -Various, please see text

Table 26. Effects range-low and effects range-median values for p,p'-DDE and 13 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
2.0	**ER-L**
2.1	San Francisco Bay, California, bioassay COA
2.2	San Francisco Bay, California, AET
2.2	San Francisco Bay, California, bioassay COA
2.2	San Francisco Bay, California, AET
3.4	San Francisco Bay, California, bioassay COA
9.0	Puget Sound, Washington, AET - benthic
15.0	**ER-M**
15.0	Puget Sound, Washington, AET - amphipod
27.0	EP 99 percentile chronic marine @ 1% TOC
60.0	EP 95 percentile chronic marine @ 1% TOC
5157.0	Palos Verdes, California, bioassay COA
5157.0	Palos Verdes, California, major benthic degradation COA
7000.0	EP acute safe level @ 1% TOC
28000.0	EP acute marine @ 1% TOC

Puget Sound and San Francisco Bay AET, San Francisco Bay bioassay data, Palos Verdes bioassay data, and EP-based thresholds are available for p,p'-DDD (Table 27). There were very small differences in DDD concentration in San Francisco Bay samples that were significantly toxic to bivalve larvae versus those that were not toxic, so these data were not used to estimate ER-L and ER-M values (Table B-14). Also, there was no concordance between DDD concentration and toxicity with the sediments that were highly and moderately toxic to bivalve larvae--these data were not used further (Table B-14). The Palos Verdes data were from a relatively small number of samples (n=6) and were not used to estimate ER-L/ER-M values, although they indicated no toxicity at a mean concentration two orders of magnitude higher than the concentrations in Puget Sound and San Francisco Bay. Lyman *et al.* (1987) listed the EP criterion for DDD as 13,000 ppb for acute effects. Bolton *et al.*, (1985) also listed the EP-based DDD threshold as 13 mg/kg (equivalent to 13,000 ppb dry weight), but did not identify this as a threshold for acute or chronic effects (the text implied that it was for chronic effects). The concentration identified by Lyman *et al.* (1987) was used to determine the ER-L and ER-M values. The lower 10 percentile value of the remaining data (Table 28) suggest an ER-L of about 2 ppb; a value also supported by a Puget Sound AET of 2 ppb. The data suggest an ER-M of about 20 ppb; a value supported by a Puget Sound AET (16 ppb). There were too little data to justify the identification of an apparent effects threshold. A small amount of data were available for o,p'-DDD and indicated no relationship with measures of biological effects, thereby precluding estimation of ER-L and ER-M values. Thus, the degree of confidence in the p,p'-DDD ER-L and ER-M values should be considered as low. A small amount of data are available from only two areas. There are no SSB data.

Table 27. Summary of sediment effects data available for DDD.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	43
	- benthic community composition	2

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Table 27. DDD (continued)

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	43
	- benthic community composition	16
*	SAN FRANCISCO BAY, CALIFORNIA, AET	
	- bivalve larvae bioassay	16
	- *R. abronius* amphipod bioassay	16
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	1 ± 2
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	1 ± 1
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	1 ± 1
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	1 ± 2
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	2 ± 0.1
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	1 ± 0.3
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	16 ± 23
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	10 ± 7
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	13 ± 21
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	13 ± 9
49	PALOS VERDES SHELF, CALIFORNIA	
	- significantly toxic to *R. abronius* (n = 3)	1090.7 ± 573
	- not toxic to *R. abronius*	324 ± 387.3
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@ 4% TOC)	13000
4	EPA chronic marine EP threshold (@ 4% TOC)	13000
13	99 percentile chronic marine permissable (@ 1% TOC)	6
	95 percentile chronic marine permissable (@ 1% TOC)	22
25	Sediment safe level based upon sediment/water partitioning coefficients and acute water quality criteria (@ 1% TOC)	3250

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
13. Pavlou *et al.*, 1987
17. Lyman *et al.*, 1987
25. Pavlou, 1987
49. Swartz *et al.*, 1985
64. Van Dolah *et al.*, 1984

* -Various, please see text.

Table 28. Effects range-low and effects range-median values for p,p'-DDD and 7 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
2.0	ER-L
2.0	Puget Sound, Washington, AET - benthic
6.0	EP 99 percentile chronic marine @ 1% TOC
16.0	Puget Sound, Washington, AET - benthic
20.0	ER-M
22.0	EP 95 percentile chronic marine @ 1% TOC
43.0	Puget Sound, Washington, AET - amphipod
3250.0	EP Acute Safe Level @ 1% TOC
13000.0	EP Acute Marine @ 1% TOC

Data available with which to evaluate total DDT (a summation of all the quantified isomers) include those from southern California bioassays and benthic communities; DuPage River benthic communities; Trinity River bioassays; SSBs performed with *Nereis virens*, *Crangon septemspinosa*, *Hyallella azteca*, and *R. abronius*; and various applications of EP approaches (Table 29). The DDT LC50 for the *C. septemspinosa* sediment bioassays was reported as ug/L in the data table and ug/kg in the text (McLeese and Metcalfe, 1980); it was assumed that the units of ug/kg were correct and they were used in the present document. There was no concordance between mean DDT concentrations and both high and moderate total abundance and high and moderate species richness among southern California benthic communities, so these data were not used in the estimation of ER-L and ER-M values (Table B-15). The lower 10 percentile of the remaining data (Table 30) suggest an ER-L value of about 3 ppb, a value poorly supported by two EP-derived thresholds (1.58 and 3.29 ppb) and a freshwater SLC (1.9 ppb). The ER-M value equivalent to the 50 percentile of the available data is about 350 ppb, a value supported by observations of moderate abundances of anthropods in southern California sediments (mean 350 ppb) and low taxa richness in DuPage River macrobenthos (mean 222 ppb). The series of SSBs with *H. azteca* demonstrate the importance of organic carbon in regulating bioavailability, and, therefore, toxicity of sediment-associated DDT. There was no overall apparent threshold in concentration of total DDT above which effects were usually or always observed (Table B-15). The degree of confidence in the ER-L and ER-M values should be considered as moderate. A moderate amount of data are available and they are from all the major approaches, however, there is very little clustering of the data.

Table 29. Summary of sediment effects data available for total DDT.

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	6.9
	- maximum level criterion	69
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	68±72
	- not toxic (23.2% mortality) to *G. japonica* (includes Palos Verdes sample)	1018±2424
	- not toxic (21.3% mortality) to *G. japonica* (excludes Palos Verdes sample)	28.6

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Table 29. DDT (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
83	- high echinoderm abundance (191.3±70.1/0.1 sq. m.)	50 ± 60
	- moderate echinoderm abundance (56.2±23/0.1 sq. m.)	90 ± 130
	- low echinoderm abundance (6.1 ± 7.2/0.1 sq. m.)	18260 ± 43080
	- high arthropod abundance (148 ± 58/0.1 sq. m.)	100 ± 150
	- moderate arthropod abundance (72.6 ± 6.8/0.1 sq. m.)	350 ± 710
	- low arthropod abundance (35.3 ± 15.8/0.1 sq. m.)	13420 ± 37670
	- high species richness (96.3 ± 22.3/0.1 sq. m)	2170 ± 7190
	- moderate species richness (72 ± 3.3/0.1 sq. m.)	250 ± 620
	- low species richness (51.2 ± 8.6/0.1 sq. m.)	14190 ± 40200
	- high total abundance (88.9 ± 35.4/0.1 sq. m.)	35300 ± 59540
	- moderate total abundance (75.6 ± 12.7/0.1 sq. m.)	210 ± 490
	- low total abundance (57.6 ± 13.6/0.1 sq. m.)	1410 ± 5440
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	222 ± 282
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	20 ± 18
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	31 ± 20
	- low mortality to *D. magna*	7 ± 10
National Screening Level Concentrations		
5	For freshwater sediments @ 1% TOC	1.9
	For marine sediments (@1%TOC)	428
14	For marine sediments (@1%TOC)	505
Equilibrium Partitioning		
15	Sediment-water partitioning coefficient/marine chronic criteria (1% TOC)	1.58
	Sediment-biota partitioning coefficient/marine chronic criteria (1% TOC)	3.29
6	EPA interim marine sediment quality criteria based upon EP @ 1% TOC	8.28
35	Lethal threshold in freshwater based on Koc coefficients	45.9
Spiked-Sediment Bioassays		
42	LD50 for cricket nymph, *G. pennsylvanicus* in 18-h bioassay	67232
34	LC50 for *N. virens* in 288-h bioassay (no deaths)	16500
35	LC50 for *C. septemspinosa* in 97-h bioassay	31
	Lethal threshold for *C. septemspinosa*	20

Table 29. DDT (continued)

References	Biological Approaches	Concentrations (ppb)
Spiked-Sediment Bioassays		
89	LC50 for *Hyallella azteca* @ 3% organic carbon	11,000
	LC50 for *Hyallella azteca* @ 7.2% organic carbon	19,600
	LC50 for *Hyallella azteca* @ 10.5% organic carbon	49,700

References	Background Approach	Concentrations (ppb)
12	USGS alert levels to flag 15-20% of samples analyzed	20
20	EPA/ACOE Puget Sound Interim Criteria (central basin background)	5
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<200
	- Class 2 (moderately contaminated)	200-2000
	- Class 3 (contaminated)	2000-10000
	- Class 4 (heavily contaminated)	>10000

References:

5. Neff *et al.*, 1986
6. EPA, 1988
12. Pavlou and Weston 1983
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
15. JRB Associates, 1984
20. U.S. ACOE, 1988
23. Jansen, 1987
34. McLeese *et al.*,1982
35. McLeese and Metcalfe, 1980
42. Harris, 1964

* -Various, please see text.

43. NERBC, 1980
56. Anderson *et al.*, 1988
75. Qasim *et al.*, 1980
83. Word and Mearns, 1979
89. Nebeker *et al.*, 1989

Table 30. Effects range-low and effects range-median values for total DDT and 21 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
1.58	EP marine chronic @ 1% TOC
1.9	Freshwater SLC @ 1% TOC
3.0	**ER-L**
3.29	EP marine chronic @ 1% TOC
8.28	Interim EP marine criteria @ 1% TOC
20.0	SSB lethal threshold with *Crangon*
31.0	SSB 97-h LC50 for *Crangon* bioassay
31.4	Trinity River, Texas, bioassay COA
45.9	Calculated freshwater EP threshold
90.0	Southern California echinoderm abundance COA
221.7	DuPage River, Illinois benthos COA
350	**ER-M**
350.0	Southern California arthropod avoidance COA
428.0	Marine SLC @ 1% TOC
505.0	Marine SLC @ 1% TOC
4950.0	Overall LC50 for *R. abronius* bioassay
11000.0	SSB LC50 *H. azteca* bioassay @ 3% TOC

Table 30. (continued)

Concentrations (ppb)	End Point
13420.0	Southern California arthropod abundance COA
14190.0	Southern California species richness COA
18260.0	Southern California echinoderm abundance COA
19600.0	SSB LC50 *H. azteca* bioassay @ 7.2% TOC
49700.0	SSB LC50 *H. azteca* bioassay @ 10.5% TOC
62732.0	SSB LD50 cricket nymph bioassay

Some of the DDD concentrations (1 to 16 ppb) in Puget Sound and San Francisco Bay sediments associated with toxicity were at the low end of the range and relatively similar to some of the thresholds predicted by the EP approach, however, they differed considerably from the mean DDD concentrations (324 to 1090 ppb) observed off Palos Verdes, California. There are relatively large disparities among the available data for total DDT from the same and different approaches. Values derived for total DDT from EP approaches (1.58 to 45.9 ppb) differ considerably from those derived from SSBs with marine animals (31 to 16,500 ppb). No deaths were observed in *N. virens* exposed to 16,500 ppb total DDT; whereas, an LC50 of 31 ppb and a lethal threshold of 20 ppb were calculated for bioassays performed with *C. septemspinosa*. Freshwater and saltwater SLCs for total DDT differed by over two orders of magnitude. Chronic thresholds predicted by the EP approach differed by about four orders of magnitude from mean concentrations associated with low echinoderm abundance off southern California, an area well documented to be highly contaminated with DDT and metabolites (Word and Mearns, 1979). Some of the EP-derived thresholds for the DDE isomers exceed those derived for total DDT. Overall, the degree of confidence in the ER-L and ER-M values for DDT and metabolites should be considered as relatively low, mainly since there are relatively large inconsistencies in the data derived from different approaches and different uses of some of the same approaches. These differences may be largely due to differences in organic carbon content of test sediments or other physical/chemical factors.

Lindane

In bioassays of marine fish and macroinvertebrates, 96-h LC50s of 0.077 to 190 ug/L (ppm) have been observed for lindane in saltwater (Mayer, 1987). Data with which to associate lindane concentrations in sediments with measures of effects are restricted to predictions based upon the EP approach (Table 31). A few samples tested with amphipod and bivalve larvae bioassays in San Francisco Bay had measurable amounts of lindane (up to 1.9 ppb dry weight), but most of the samples were not tested for this pesticide or had non-detectable concentrations, precluding use of the data to determine ER-L and ER-M values. The PSDDA screening level concentration was based upon analytical capabilities, not on AET or other measures of effects. No effects among benthic communities at the Georgetown, South Carolina dumpsite were observed in samples that had less than the detection limits of 50 ppb lindane. The remaining data from the EP approach predict that effects would occur at concentrations ranging from 1.57 to 12 ppb dry weight (Table 31). These data are insufficient to determine ER-L and ER-M values.

Table 31. Summary of sediment effects data available for lindane.

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	0.6 ± 0.8
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	not detected
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	not detected
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	0.33 ± 0.65
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	not detected
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	not detected
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	0.4 ± 0.7
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	not detected
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	0.3 ± 0.7
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	not detected
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
Equilibrium Partitioning		
6	EPA interim marine sediment quality criteria @ 1% TOC	1.57
4	EPA chronic marine EP threshold (@ 4% TOC)	12
25	Sediment safe level based upon sediment/water partitioning Coefficients and acute water quality criteria (@ 1% TOC)	3.1

References	Background Approach	Concentrations (ppb)
12	USGS alert level to flag 15-20% of samples analyzed	20
20	PSDDA guidelines (based upon analytical capabilities)	5.0

References:

4. Bolton *et al.*, 1985
6. EPA, 1988
12. Pavlou and Weston, 1983
20. U.S. ACOE, 1988
25. Pavlou, 1987
64. Van Dolah *et al.*, 1984

* -Various, please see text

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Chlordane

The chlordane water quality criteria are 0.0043 ppm as a 24-h average and not to exceed 2.4 ppm in freshwater at any time. In saltwater they are 0.004 ppm and 0.09 ppm, respectively (U.S. EPA, 1986). EC50s for estuarine organisms range from 2.4 to 260 ppm tested in 48-h bioassays (Mayer, 1987). Data with which to evaluate measures of effects and chlordane in sediments are available from EP methods, SSBs, and analyses of matching field-collected biological and chemical analyses (Table 32). The field-collected data are from San Francisco Bay, Trinity River, and DuPage River. No effects upon the benthic communities were observed at the Georgetown disposal site at chlordane concentrations below the limits of detection (<50 ppb). San Francisco Bay sediments that were highly toxic to bivalve larvae were not tested for chlordane concentrations so these data (and the AET for bivalve larvae) were not used to determine ER-L and ER-M values. Among the 20 San Francisco Bay sediments that were moderately toxic to amphipods, only 4 were tested for chlordane concentrations; no chlordane was detected in those 4 samples. Likewise, among the 22 samples that were least toxic to amphipods, 4 were tested for chlordane concentrations; and one had 2 ppb and the others had no detectable amount. These data were not considered further in the determination of ER-L and ER-M values (Table B-16). Effects are predicted by EP methods to occur at concentrations as low as 0.3 ppb (Table 33). The ER-L suggested by the data is 0.5 ppb, supported by two EP-derived concentrations (0.3, 0.6 ppb). The 50 percentile value in the available data is 6 ppb, an ER-M supported by San Francisco Bay bioassay data (means of 4.1 and 6.4 ppb). Effects were usually observed at concentrations of 2 ppb or greater (Table B-16).

The degree of confidence in these values for chlordane should be considered as low. Two of the EP-derived chronic thresholds are very low compared to the co-occurrence and SSB data; SSBs have not been performed with sensitive infaunal organisms such as amphipods; and the abundance of data from San Francisco Bay where chlordane concentrations are not particularly high may have biased the determination of the ER-L and ER-M values.

Table 32. Summary of sediment effects data available for chlordane.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	2.0
	- *R. abronius* amphipod bioassay	2.0
Co-occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	6.4 ± 7.5
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	Not detected
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	Not detected
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	3.5 ± 6.3
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	1 ± 1.4
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	No data
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	4.1 ± 6.6
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	0.5 ± 1
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	3.5 ± 6.3
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	1 ± 1.4

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Table 32. Chlordane (continued)

References	Biological Approaches	Concentrations (ppb)
Co-occurrence Analyses		
75	TRINITY RIVER, TEXAS.	
	- significant mortality to *D. magna*	31.3 ± 29.4
	- low mortality to *D. magna*	1.7 ± 2.3
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	25 ± 22.3
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	8.3 ± 4.3
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
Equilibrium Partitioning		
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	0.6
	99 percentile chronic marine permissable (sediment/water partition coefficient)	0.3
35	Lethal threshold in freshwater based on Koc coefficients	17.4
Spiked Sediment Bioassays		
34	LC50 for *N. virens*	≤5800
35	LC50 for *C. septemspinosa*	120

References	Background Approach	Concentrations (ppb)
20	PSDDA guidelines (based on analytical capability) screening level concentrations	5.0
12	USGS alert levels to flag 15-20% of samples analyzed	20

References:

12. Pavlou and Weston, 1983
13. Pavlou *et al.*, 1987
20. U.S. ACOE, 1988
34. McLeese *et al.*, 1982
35. McLeese and Metcalfe, 1980
60. Illinois EPA, 1988a
64. Van Dolah *et al.*, 1984
75. Qasim *et al.*, 1980
* Various, please see text.

Table 33. Effects range-low and effects range-median values for chlordane and 12 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
0.3	EP 99 percentile chronic marine
0.5	**ER-L**
0.6	EP 95 percentile chronic marine
2.0	San Francisco Bay, California, AET
3.5	San Francisco Bay, California, bioassay COA
3.5	San Francisco Bay, California, bioassay COA
4.1	San Francisco Bay, California, bioassay COA
6.0	**ER-M**
6.4	San Francisco Bay, California bioassay COA
17.4	EP freshwater lethal threshold
25.0	DuPage River, Illinois, benthos COA
31.3	Trinity River, Texas, bioassay COA
120.0	SSB LC50 for C. *septemspinosa*
<5800.0	SSB LC50 for N. *virens*

Heptachlor

The 96-h. LC50s for heptachlor in water range from 0.03 to 3.8 ug/L (ppm) for estuarine organisms (Mayer, 1987). The LC50 for heptachlor epoxide, a degradation product of heptachlor, was 0.04 ppm in a bioassay with pink shrimp (Mayer, 1987).

Sediment effects data are available only from one SLC, one SSB (with a cricket nymph), and two uses of the EP approach (Table 34). The PSDDA screening level is based upon assumed analytical capability, not an AET or some other measure of effects. The freshwater SLC (0.8 ppb dw) and the two EP thresholds (0.04, 0.06 ppb dw) are roughly within an order of magnitude of each other. The results of an 18-d bioassay of muck soil with cricket nymphs (of questionable applicability to marine and estuarine sediments) indicated an LD-50 of 4192 ppb dw, four orders of magnitude higher than the other concentrations. Because of the lack of sufficient data, ER-L and ER-M values cannot be determined.

Table 34. Summary of sediment effects data available for heptachlor.

References	Biological Approaches	Concentrations (ppb)
National Screening Level Concentrations		
5	For freshwater sediments @ 1% TOC	0.8
Equilibrium Partitioning		
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	0.06
	99 percentile chronic marine permissable (sediment/water partition coefficient)	0.04
Spiked-Sediment Bioassays		
42	LD50 for cricket nymph (*G. pennsylvanicus*)	4192

Table 34. Summary of sediment effects data available for heptachlor.

References	Background Approach	Concentrations (ppb)
20	PSDDA guidelines (based on analytical capability) screening level concentrations	5.0
12	USGS alert levels to flag 15-20% of samples analyzed	20
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated; ppb organic carbon)	<200
	- Class 2 (moderately contaminated; ppb organic carbon)	200-2000
	- Class 3 (contaminated; ppb organic carbon)	2000-10000
	- Class 4 (heavily contaminated; ppb organic carbon)	>10000

References:

5. Neff et al., 1986
12. Pavlou and Weston, 1983
13. Pavlou *et al.*, 1987
20. U.S. ACOE, 1988
23. Jansen, 1987
42. Harris, 1964.

Dieldrin

The 96-h LC50s for dieldrin range from 0.7 ug/L to 10 ug/L as determined with estuarine organisms tested in water (Mayer, 1987).

Sediment-related effects data are available from San Francisco Bay bioassays, Trinity River bioassays, DuPage River benthos studies, Kishwaukee River benthos studies, a freshwater SLC, the EP approach, and SSBs with two species (Table 35). The four San Francisco Bay samples that were highly toxic to bivalve larvae were not tested for dieldrin concentrations. There was little or no gradient in dieldrin concentrations among other San Francisco Bay samples. There also was no gradient in dieldrin concentration between Trinity River sediments that were highly toxic to *Daphnia* versus those that were not toxic. These data were not considered further (Table B-17). The lower 10 percentile of the remaining data suggest an ER-L of about 0.02 ppb, a value supported by two EP thresholds (0.01 and 0.02 ppb) (Table 36). The data suggest an ER-M of about 8 ppb, a value supported by Kishwaukee River benthic data (mean 7.4 ppb), and San Francisco Bay bioassay data (mean 8.2 ppb). No overall effects threshold is apparent.

The degree of confidence in the ER-L and ER-M values for dieldrin should be considered as low. A small amount of data are available; much of the co-occurrence data are from San Francisco Bay where the range in dieldrin concentrations is low; different uses of the EP approach resulted in predicted concentrations that differ by five orders of magnitude; and two independent spiked sediment bioassays resulted in LC50s that differed by four orders of magnitude. In addition, the ER-L is supported only by theoretical EP-derived concentrations and not verified by empirical evidence.

Table 35. Summary of sediment effects data available for dieldrin.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	6.6
	- *R. abronius* amphipod bioassay	6.6
Co-occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	10.3 ± 9.6
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	4.4 ± 2.3
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	5.2 ± 1.2
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	7.6 ± 7.5
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	6.2 ± 0.6
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	no data
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	8.2 ± 8.1
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	5.2 ± 1.2
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	7.6 ± 7.5
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	6.2 ± 0.6
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	25.5 ± 33.2
	- low mortality to *D. magna*	25.5 ± 61.1
60	DUPAGE RIVER, ILLINOIS	
	- least number of benthic macroinvertebrate taxa (6.7 ± 2.5/site)	16 ± 12.1
	- highest number of benthic macroinvertebrate taxa (15.8 ± 2/site)	5.6 ± 2.2
61	KISHWAUKEE RIVER, ILLINOIS	
	- least number of benthic macroinertebrate taxa (8.4 ± 0.5/site)	7.4 ± 4.8
	- highest number of benthic macroinvertebrate taxa (16.3 ± 4.6/site)	4.3 ± 2.1
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50
National Screening Level Concentrations		
5	For freshwater sediments @ 1% TOC	0.21
Equilibrium Partitioning		
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	0.02
	99 percentile chronic marine permissable (sediment/water partition coefficient)	0.01
35	Lethal threshold in freshwater based on Koc coefficients	11.9
6	EPA interim mean marine sediment quality criteria @ 1% TOC	57.7
	EPA interim mean freshwater sediment quality criteria @ 1% TOC	199

Table 35. Dieldrin (continued)

References	Biological Approaches	Concentrations (ppb)
Spiked Sediment Bioassays		
34	LC50 for *N. virens*	13000
35	LC50 for *C. septemspinosa*	4.1

References	Background Approach	Concentrations (ppb)
20	PSDDA guidelines (based on analytical capability)	5.0
12	USGS alert levels to flag 15 to 20% of samples analyzed	20
43	New England interim high contamination levels for dredge material	100

REFERENCES

5. Neff *et al.*, 1986
6. EPA, 1988
12. Pavlou and Weston, 1983
13. Pavlou *et al.*, 1987
20. U.S. ACOE, 1988
34. McLeese *et al.*, 1982
35. McLeese and Metcalfe, 1980
43. NERBC, 1980
60. Illinois EPA, 1988a
61. Illinois EPA, 1988b
64. Van Dolah *et al.*, 1984
75. Qasim *et al.*, 1980

* Various, please see text

Table 36. Effects range-low and effects range-median values for dieldrin and 14 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
0.01	EP 99 percentile chronic marine
0.02	**ER-L**
0.02	EP 95 percentile chronic marine
0.21	Freshwater SLC @ 1% TOC
4.1	SSB LC50 for *C. septemspinosa*
6.6	San Francisco Bay, California AET
6.6	San Francisco Bay, California AET
7.4	Kishwaukee River, Illinois benthos COA
8.0	**ER-M**
8.2	San Francisco Bay, California bioassay COA
10.3	San Francisco Bay, California bioassay COA
11.9	EP freshwater lethal threshold
16.0	DuPage River, Illinois benthos COA
57.7	EP interim marine criteria
199.0	EP interim freshwater criteria
13000.0	SSB LC50 for *N. virens*

Aldrin

The 48-h EC50s for aldrin tested with pink shrimp (*Penaeus duorarum*) and blue crab (*Callinectes sapidus*) were 0.32 and 23 ug/L, respectively; and the 48-h LC50s for spot (*Leiostomus xanthurus*) and mullet (*Mugil cephalus*) were 3.2 and 2 ug/L, respectively (Mayer, 1987). The criteria to protect freshwater and marine aquatic life are 3.0 and 1.3 ug/L, respectively (U.S. EPA, 1986).

A relatively small amount of data are available with which to assess the effects of aldrin in sediments (Table 37). These data are restricted to San Francisco Bay bioassay results and uses of the EP approach. Of the 53 San Francisco Bay sediments tested for toxicity with bivalve larvae, only 17 were analyzed for aldrin concentrations, and among those samples only 3 had detectable amounts (0.7, 1.1, and 1.9 ppb). Similarly, of the 39 samples tested with the amphipod bioassay, 15 were analyzed for aldrin content, and among those samples only the same 3 samples had detectable amounts. These data are insufficient to use in the determination of ER-L and ER-M values, as are the AET concentrations determined from them. The remaining data from four uses of the EP approach indicate a range of thresholds from 4.3 to 21 ppb dw. The EPA chronic marine concentration of 21 ppb would have been 5.2 ppb (equal to the concentration reported by Pavlou, 1987), if an assumption of a 1 percent TOC content had been made in the calculation. There do not appear to be any empirical data to compare with these predicted concentrations, so ER-L and ER-M values were not determined.

Table 37. Summary of sediment effects data available for aldrin.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>1.9
	- *R. abronius* amphipod bioassay	>1.9
Co-occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	0.3 ± 0.5
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	not detected
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	detected in one sample
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	0.1 ± 0.4
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	1.0 ± 1.3
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	not detected
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	0.2 ± 0.4
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	0.5 ± 1.0
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	0.1 ± 0.4
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	1.0 ± 1.3
Equilibrium Partitioning		
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	8.4
	99 percentile chronic marine permissable (sediment/water partition coefficient)	4.3
4	EPA chronic marine EP threshold @ 4% TOC	21.0

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Table 37. Aldrin (continued)

References	Biological Approaches	Concentrations (ppb)
Equilibrium Partitioning		
25	Sediment safe levels based on sediment/water partitioning coefficients and acute water quality criteria @ 1% TOC	5.2

References	Backgro Approach	Concentrations (ppb)
20	PSDDA guidelines (based on analytical capability)	5.0
12	USGS alert levels to flag 15 to 20% of samples analyzed	20.0

References:

4. Bolton *et al.*, 1985
13. Pavlou *et al.*, 1987
* Various, please see text
20. U.S. ACOE, 1988
25. Pavlou, 1987

Endrin

The 96-h LC50s for endrin tested with a variety of estuarine organisms ranged from 0.037 to 1.2 ug/L (Mayer, 1987). The concentration should not exceed 0.18 ug/L in freshwater or 0.037 ug/L in saltwater at any time (U.S. EPA, 1986).

A relatively small amount of data is available for this pesticide in sediments (Table 38), however there are data from most of the major approaches to the development of criteria. Matching chemical and toxicity data from the Trinity River are available. Data from various uses of the EP approaches and from two SSBs are available. None were eliminated from consideration in the determination of the ER-L and ER-M values (Table B-18). Effects are predicted at concentrations of 0.01 to 321 ppb by the EP approach. Spiked sediment bioassays performed with three species, indicated LC50s that differed by nearly three orders of magnitude. The ER-L and ER-M values are 0.02 and 45 ppb, respectively (Table 39). The ER-L value is supported by two EP-predicted concentrations, 0.01 and 0.02 ppb, and the ER-M value is supported by an LC50 for *Crangon septemspinosa* in spiked bioassays (47 ppb).

The ER-L value (0.02 ppb) is not supported by any empirical biological evidence from laboratory or field studies and the degree of confidence in the value should be considered as low. The ER-M value (45 ppb) is supported only by the LC50 from a SSB (47 ppb) and not by evidence from tests of mixtures, as would be experienced in the field; therefore, the degree of confidence in the ER-M should also be considered as low.

Table 38. Summary of sediment effects data available for endrin.

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
75	TRINITY RIVER, TEXAS	
	- significant mortality to *D. magna*	18.3 ± 2.0
	- low mortality to *D. magna*	3.8 ± 3.1
64	GEORGETOWN OCEAN DREDGED MATERIAL DISPOSAL SITE, SOUTH CAROLINA	
	- no effects upon benthos species richness or abundance	<50.0
Equilibrium Partitioning		
15	Sediment-water partitioning coefficient/marine chronic criteria (1% TOC)	174.0
	Sediment-biota partitioning coefficient/marine chronic criteria (1% TOC)	321.0
13	95 percentile chronic marine permissable (sediment/water partition coefficient)	0.02
	99 percentile chronic marine permissable (sediment/water partition coefficient)	0.01
6	EPA interim marine sediment quality criteria 1% TOC	2.15
6	EPA interim freshwater sediment quality criteria 1% TOC	10.4
35	Lethal threshold in freshwater based on Koc coefficients	15.4
Spiked-Sediment Bioassays		
34	LC50 for *N. virens*	28000.0
35	LC50 for *C. septemspinosa*	47.0
89	LC50 for *H. azteca* @ 3% TOC	4400
	LC50 for *H. azteca* @ 6.1% TOC	4800
	LC50 for *H. azteca* @ 11.2% TOC	6000

Reference	Background Approach	Concentrations (ppb)
12	USGS alert levels to flag 15-20% of samples analyzed	20.0

References:

6. EPA, 1988
12. Pavlou and Weston, 1983
13. Pavlou *et al.*, 1987
15. JRB Associates, 1984
34. McLeese *et al.*, 1982
35. McLeese and Metcalfe, 1980
64. Van Dolah *et al.*, 1984
75. Qasim et al., 1980
89. Nebeker *et al.*, 1989

Table 39. Effects range-low and effects range-median values for endrin and 13 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
0.01	EP 99 percentile chronic marine
0.02	**ER-L**
0.02	EP 95 percentile chronic marine
2.15	EP interim marine criteria @ 1% TOC
10.4	EP interim freshwater criteria @ 1% TOC
15.4	EP freshwater lethal threshold
18.3	Trinity River, Texas, bioassay COA
45.0	**ER-M**
47.0	SSB LC50 C. *septemspinosa*
174.0	EP chronic sediment/water marine @ 1% TOC
321.0	EP chronic sediment/biota marine @ 1% TOC
4400	SSB LC50 with *H. azteca* @ 3% TOC
4800	SSB LC50 with *H. azteca* @ 6.1% TOC
6000	SSB LC50 with *H. azteca* @ 11.2% TOC
28000.0	SSB LC50 with *N. virens*

Mirex

Only matching bioassay and chemical data from San Francisco Bay were found for mirex. They indicated very small differences in concentrations between highly and/or significantly toxic samples versus least and/or non-toxic samples. Therefore, ER-L and ER-M values could not be determined.

Polynuclear Aromatic Hydrocarbons:

Acenaphthene

Puget Sound AET, several EP-derived concentrations, data from bioassays of dilution series of Black Rock Harbor and Eagle Harbor sediments, and co-occurrence concentrations are available for acenaphthene (Table 40). The co-occurrence data are from Commencement Bay, Eagle Harbor (an area with documented high PAH concentrations), San Francisco Bay, and southern California. The bioassay data from San Francisco Bay indicated very little concordance with acenaphthene concentrations or a small gradient in concentrations, so neither the co-occurrence analysis data nor the AET concentrations were used in the determination of ER-L and ER-M values (Table B-19). Also, the southern California bioassay data showed no concordance with the acenaphthene concentrations. Because of a small gradient in the acenapthene concentrations in Black Rock Harbor sediments, those data also were not used further. The samples from both Commencement Bay and Eagle Harbor that were moderately toxic to amphipods indicated a small elevation in acenaphthene concentrations over those that were least toxic; thus the data were not used for ER-L and ER-M determinations.

The lower 10 percentile of the remaining data suggest an ER-L of about 150 ppb (Table 41). This value is supported by observations of moderate toxicity of Commencement Bay sediments to oyster larvae (mean 118.5 ppb) and the predicted LC50 in amphipod bioassays of a dilution series of Eagle Harbor sediments (150 ppb). Except for the observations of low and moderate toxicity to amphipods in Eagle Harbor sediments, effects were usually observed in association with acenaphthene concentrations of 150 ppb or greater. The data suggest an ER-M of about 650 ppb, a value supported by a Puget Sound AET for amphipod bioassays (630 ppb) and observations of highly toxic Commencement Bay sediments tested with amphipods (mean 654 ppb). The co-occurrence values from bioassays of Eagle Harbor and Commencement Bay sediments had very high standard deviations about the means, indicative of the very high variability in these data. All of the concentrations predicted by the EP method are in the high end of the range.

The degree of confidence in the ER-L and ER-M values should be considered as low. While an overall apparent effects threshold occurs at the ER-L concentration, there is relatively poor clustering of the data, the data are mostly from parts of Puget Sound, there are no single-chemical SSB data, and the concentrations derived from the EP methods are not consistent with those determined in tests of field-collected sediments.

Table 40. Summary of sediment effects data available for acenaphthene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	630
	- oyster larvae (*C. gigas*) bioassay	500
	- benthic community composition	500
	- Microtox™ bioassay	500
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2000
	- oyster larvae (*C. gigas*) bioassay	500
	- benthic community composition	730
	- Microtox™ bioassay	500
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	63
	- maximum level criterion	630
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	9
	- *R. abronius* amphipod bioassay	56
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	7.6 ± 21.6
	- moderately toxic (33.8 ± 4.7% mortality to *R. abronius*	5.4 ± 12.1
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	9.8 ± 15.9
	- significantly toxic (42.9 ≠ 19.2% mortality) to *R. abronius*	5.9 ± 16.8
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	11.8 ± 16.8
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	48 ± 18.4
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	3.3 ± 5.9
	- least toxic (23.3 ± 7.3% abnormal) to vivalve larvae	1.8 ± 4.0
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	9.4 ± 17.9
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	3.0 ± 5.2
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	654 ± 1049
	- moderately toxic (5.2 ± 1.1 dead/20 to *R. abronius*	127 ± 117
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	86 ± 97
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	306 ± 604
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	119 ± 105
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	57 ± 70

Table 40. Acenaphthene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	39557 ± 48678
	- moderately toxic (3.2 ± 1.8 dead/20) to *R. abronius*	6522 ± 8915
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	5599 ± 24392
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	150
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	4
	- not toxic (23.2% mortality) to *G. japonica*	7
58	BLACK ROCK HARBOR, CONNECTICUT	
	- significant toxicity to *A. abdita* in 10-d bioassay	30
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	66000
6	EPA interim freshwater sediment quality criteria based upon EP (@ 1% TOC)	7330
25	Sediment safe level based upon sediment/water partitioning coefficients and acute water quality criteria (@ 1% TOC)	23000
	Sediment safe level based upon sediment/water partitioning coefficients and chronic water quality criteria (@ 1% TOC)	16500

References	Background Approaches	Concentrations (ppb)
43	New England interim high contamination level for dredge material	500
12	USGS alert levels to flag 15 to 20% of samples analyzed	20
20	EPA/ACOE Puget Sound interim criteria (central basin background)	5
23	Rotterdam Harbor sediment quality classifications	
	- Class 1 (slightly contaminated)	<200
	- Class 2 (moderately contaminated)	200-2000
	- Class 3 (contaminated)	2000-10000
	- Class 4 (heavily contaminated)	>10000

References:

1. Bellar *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
6. EPA, 1988
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
25. Pavlou, 1987
56. Anderson *et al.*, 1988
58. Rogerson *et al.*, 1985
80. Tetra Tech, 1985
85. CH^2M Hill, 1989
* Various, please see text

Table 41. Effects range-low and effects range-median values for acenaphthene and 18 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
119	Commencement Bay, Washington bioassay COA
150	ER-L
150	Eagle Harbor, Washington bioassay COA
306	Commencement Bay, Washington bioassay COA
500	Puget Sound, Washington AET - oyster
500	Puget Sound, Washington AET - benthic
500	Puget Sound, Washington AET - Microtox™
630	Puget Sound, Washington AET - amphipod
650	ER-M
654	Commencement Bay ,Washington bioassay COA
730	Puget Sound, Washington AET - benthic
2000	Puget Sound, Washington AET - amphipod
7330	EP freshwater interim criteria @ 1% TOC
16500	EP chronic marine threshold @ 1% TOC
23000	EP acute marine threshold @ 1% TOC
39557	Eagle Harbor, Washington bioassay COA
66000	EP chronic marine threshold @ 4% TOC

Anthracene

Data available for anthracene are from studies involving Puget Sound AET; bioassays of sediments from Commencement Bay, Eagle Harbor, San Francisco Bay, Lake Union, southern California, and Elizabeth River; national SLCs; and several EP-derived concentrations (Table 42). San Francisco Bay sediments that were moderately toxic to amphipods indicated no concordance with anthracene concentrations. Also, San Francisco Bay sediments that were significantly toxic to amphipods had anthracene concentrations similar to those that were not toxic. Commencement Bay sediments that were moderately toxic to amphipods had anthracene concentrations similar to those that were least toxic. Eagle Harbor sediments moderately toxic to amphipods indicated little concordance with anthracene concentrations. These data were not used in the determination of ER-L and ER-M values (Table B-20).

Effects were associated with mean anthracene concentrations as low as 24 ppb (Table 43) in bioassays of San Francisco Bay sediments. However, since 34 out of the 39 samples tested there were significantly toxic, this concentration may not be of much significance. The lower 10 percentile of the data indicate an ER-L of about 85 ppb, a value supported by the predicted LC50 for anthracene from bioassays of a dilution series of Eagle Harbor sediments (70 ppb) and the anthracene concentrations (mean 85.3 ppb) in San Francisco Bay sediments that were moderately toxic to bivalve larvae. The 50 percentile value in the data is equivalent to about 960 ppb and is supported by two Puget Sound AETs (both 960 ppb). With the exception of bioassay data from Eagle Harbor, there appears to be an overall threshold in the effects data at about 300 ppb. Effects are almost always observed in association with anthracene concentrations exceeding 300 ppb (Table B-20).

The degree of confidence in the ER-L and ER-M values for anthracene should be considered as relatively low and moderate, respectively. The ER-L value is not supported by clustered, consistent data from multiple approaches. The ER-M is supported by a cluster of toxicity and AET concentrations, but these data are derived from only two regions. There is some evidence of an overall apparent effects threshold for anthracene at about 300 ppb in sediments, a concentration that lies within the ER-L/ER-M range.

Table 42. Summary of sediment effects data available for anthracene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	1900
	- oyster larvae (*C. gigas*) bioassay	960
	- benthic community composition	1300
	- Microtox™ bioassay	960
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	13000
	- oyster larvae (*C. gigas*) bioassay	960
	- benthic community composition	4400
	- Microtox™ bioassay	960
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	130
	- maximum level criterion	1300
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	24
	- *R. abronius* amphipod bioassay	1100
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	476 ± 549
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	265 ± 228
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	227 ± 198
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	363 ± 353
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	282 ± 207
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	148 ± 148
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	7597 ± 7264
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	1177 ± 1582
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	1490 ± 5389
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	70
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	120000
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	237 ± 455
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	63 ± 72
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	110 ± 257
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	119 ± 277
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	120 ± 269
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	923 ± 558
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	85 ± 119
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	15 ± 7.5

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Table 42. Anthracene (continued).

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	184 ± 347
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	34 ± 41
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	225
	- not toxic (23.2% mortality) to *G. japonica*	36
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	264000
	- LC50 (24-hr) for *L. xanthurus* exposed to 56% Elizabeth River sediment	147840
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	6600
National Screening Level Concentrations		
14	Marine sediments @ 1% TOC	163
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	44000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	190
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	380

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989
* Various, please see text

Table 43. Effects range-low and effects range-median values for anthracene and 26 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
24	San Francisco Bay, California AET
70	Eagle Harbor, Washington bioassay COA
85	ER-L
85	San Francisco Bay ,California bioassay COA
163	Marine SLC @ 1% TOC
184	San Francisco Bay, California bioassay COA
190	99 percentile EP chronic marine @ 1% TOC

Table 43. (continued)

Concentrations (ppb)	End Point
225	Southern California bioassay COA
237	San Francisco Bay, California bioassay COA
282	Commencement Bay, Washington bioassay COA
363	Commencement Bay, Washington bioassay COA
380	95 percentile EP chronic marine @ 1% TOC
476	Commencement Bay, Washington bioassay COA
923	San Francisco Bay, California bioassay COA
960	Puget Sound, Washington AET - oyster
960	**ER-M**
960	Puget Sound, Washington AET - Microtox™
1100	San Francisco Bay, California AET
1300	Puget Sound, Washington AET - benthic
1900	Puget Sound, Washington AET - amphipod
4400	Puget Sound, Washington AET - benthic
6600	Elizabeth River, Virginia bioassay COA
7597	Eagle Harbor, Washington bioassay COA
13000	Puget Sound, Washington AET - amphipod
44000	EP chronic marine @ 4% TOC
120000	Lake Union, Washington toxicity COA
147840	Elizabeth River, Virginia bioassay COA
264000	Elizabeth River, Virginia bioassay COA

Benzo(a)anthracene

Data available for this aromatic hydrocarbon include those from Puget Sound AET; San Francisco Bay AET and bioassay data; bioassay data from Commencement Bay, Eagle Harbor, Lake Union, Columbia River, southern California, and Elizabeth River; national SLCs; SSBs performed with *R. abronius* exposed to mixtures of hydrocarbons; and many EP-derived values (Table 44). There were small gradients in benzo(a)anthracene concentrations between San Francisco Bay sediments that were least toxic and moderately toxic to amphipods, between San Francisco Bay sediments that were not toxic and significantly toxic to amphipods, and between Commencement Bay sediments that were least toxic and moderately toxic to amphipods (Table B-21). In bioassays of lower Columbia River sediments, no toxicity to the amphipod *H. azteca* was observed in sediments that had up to 2200 ppb benzo(a)anthracene. These data were not used in the determination of ER-L and ER-M values.

Effects are suggested in association with benzo(a)anthracene concentrations as low as 60 to 80 ppb in sediments (Table 45). The lower 10 percentile value of the data is equivalent to about 230 ppb, the ER-L value. This value is supported by San Francisco Bay bioassay data (mean 232 ppb). The 50 percentile ER-M value in the data is equivalent to 1600 ppb; a concentration supported by a San Francisco Bay AET (1100 ppb), three Puget Sound AET concentrations (1300, 1600, 1600 ppb), and a threshold predicted by EP methods (1600 ppb). With the exception of Columbia River and Eagle Harbor bioassay data, effects were usually observed in association with concentrations above about 550 ppb (Table B-21). Severe acute toxicity was observed or predicted with concentrations of 10 ppm or greater (Table 45).

The degree of confidence in the ER-L value should be considered as moderate, since that value is not strongly supported by a convergence or cluster of data. However, the ER-M value is supported by data from at least two geographic areas and from the predictive EP approach, and there are few contradictory data at concentrations exceeding the ER-M. Also, the apparent effects threshold lies within the ER-L/ER-M range. Therefore, the degree of confidence in the ER-M value should be considered as moderate.

Table 44. Summary of sediment effects data available for benzo(a)anthracene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	1600
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	4500
	- Microtox™ bioassay	1300
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	5100
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	5100
	- Microtox™ bioassay	1300
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	450
	- maximum level criterion	4500
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	60
	- *R. abronius* amphipod bioassay	1100
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	931 ± 1323
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	520 ± 523
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	476 ± 437
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	801 ± 866
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	549 ± 384
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	235 ± 247
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	11088 ± 8941
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	7370 ± 9984
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	2496 ± 4157
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	80
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	170000
52	COLUMBIA RIVER, WASHINGTON/OREGON	
	- not toxic (0-13% mortality) to *H. azteca*	2200
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	300 ± 398
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	187 ± 156
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	168 ± 324

Table 44. Benzo(a)anthracene (continued).

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	236 ± 313
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	187 ± 359
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	919 ± 433
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	122 ± 126
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	56 ± 26
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	232 ± 337
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	41 ± 20
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	310 ± 180
	- not toxic (23.2% mortality) to *G. japonica*	60 ± 129
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	350000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	196000
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	8750
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	261
14	Marine sediments @ 1% TOC	261
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	220000
17	EPA acute marine EP threshold (@ 4% TOC)	220000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	1600
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	21000
6	EPA interim mean freshwater sediment quality criteria based upon EP @ 1% TOC	13200
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute quality criteria @ 1% TOC	55000
Spiked-Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	10000

Table 44. Benzo(a)anthracene (continued)

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
6. EPA, 1988
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
25. Pavlou, 1987
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
52. Johnson and Norton,, 1988
56. Anderson *et al.*, 1988
65. Plesha *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989

*-Various, please see text

Table 45. Effects range-low and effects range-median values for benzo(a)anthracene and 30 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
60	San Francisco Bay, California AET
80	Eagle Harbor, Washington bioassay COA
122	San Francisco Bay, California bioassay
230	**ER-L**
232	San Francisco Bay, California bioassay COA
261	Marine SLC
300	San Francisco Bay, California bioassay COA
310	Southern California bioassay COA
549	Commencement Bay,Washington bioassay COA
801	Commencement Bay, Washington bioassay COA
919	San Francisco Bay, California bioassay COA
931	Commencement Bay, Washington bioassay COA
1100	San Francisco Bay, California AET
1300	Puget Sound, Washington AET - Microtox™
1600	Puget Sound, Washington AET - amphipod
1600	**ER-M**
1600	Puget Sound, Washington AET - oyster
1600	99 percentile EP chronic marine @ 1% TOC
4500	Puget Sound, Washington AET - benthic
5100	Puget Sound,Washington AET - amphipod
5100	Puget Sound,Washington AET - benthic
7370	Eagle Harbor, Washington bioassay COA
8750	Elizabeth River, Virginia bioassay COA
10000	SSB with R. *abronius*: mixtures
11088	Eagle Harbor, Washington bioassay COA
13200	EP freshwater interim criteria @ 1% TOC
21000	95 percentile EP chronic marine @ 1% TOC
55000	EP acute marine threshold @ 1% TOC
170000	Lake Union, Washington toxicity COA
196000	Elizabeth River, Virginia bioassay COA
220000	EP acute marine threshold @ 4% TOC
350000	Elizabeth River, Virginia bioassay COA

Benzo(a)pyrene

Data are available for benzo(a)pyrene from Puget Sound AET, San Francisco Bay AET and bioassay data; bioassay data from Commencement Bay, Eagle Harbor, Lake Union, southern California, and Elizabeth River; national SLCs for marine sediments; concentrations predicted by EP methods; and SSBs performed with *R. abronius* exposed to a mixture of hydrocarbons (Table 46). Small gradients in benzo(a)pyrene concentrations were observed in bioassays of a dilution series of Eagle Harbor sediments, in San Francisco Bay sediments that were highly and moderately toxic to amphipods versus those that were least toxic, and in San Francisco Bay sediments that were significantly toxic versus those that were not toxic to amphipods. Those data were not used to determine the ER-L and ER-M values (Table B-22). The data from Eagle Harbor sediments that were highly toxic to amphipods also were not used, since they did not indicate concordance with benzo(a)pyrene concentrations.

Effects were observed in association with benzo(a)pyrene concentrations as low as 396 ppb (the national SLC for marine sediments) (Table 47). The lower 10 percentile value of the available data is equivalent to about 400 ppb, an ER-L value supported by marine SLCs of 396 and 397 and observations of significantly toxic San Francisco Bay sediments tested with bivalve larvae (mean of 404 ppb). With the exception of Eagle Harbor bioassay data, effects were usually observed in association with benzo(a)pyrene concentrations of roughly 700 ppb or more (Table B-22). The ER-M suggested by the data is about 2500 ppb, a value supported by a Puget Sound AET (2400 ppb) and the LC50 derived from bioassays of a dilution series of Elizabeth River sediments tested with spot (2462 ppb).

The degree of confidence in the ER-L and ER-M values should be considered as moderate. Although data are available from several areas and several approaches, and these values are supported by some convergence or clustering of the data, the clusters of concentrations cover a relatively wide range. The overall apparent effects threshold (about 700 ppb) lies within the ER-L/ER-M range. With very little conflicting evidence, it appears that effects are almost always associated with concentrations of about 700 ppb or more.

Table 46. Summary of sediment effects data available for benzo(a)pyrene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Thresholds		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2400
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	6800
	- Microtox™ bioassay	1600
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	3000
	- oyster larvae (*C. gigas*) bioassay	1600
	- benthic community composition	3600
	- Microtox™ bioassay	1600
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	680
	- maximum level criterion	6800
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>1800
	- *R. abronius* amphipod bioassay	1300

Table 46. Benzo(a)pyrene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	1192 ± 1643
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	890 ± 1322
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	596 ± 593
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	1261 ± 1620
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	684 ± 464
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	329 ± 385
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	3485 ± 2475
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	5335 ± 6488
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	1959 ± 1993
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	10
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	220000
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	486 ± 484
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	432 ± 344
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	400 ± 447
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	429 ± 382
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	423 ± 465
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	1091 ± 338
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	404 ± 428
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	129 ± 61
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	465 ± 471
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	210 ± 237
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	509 ± 354
	- not toxic (23.2% mortality) to *G. japonica*	63 ± 96
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	98500
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	55160
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	2462
National Screening Level Concentrations		
5	marine sediments @ 1% TOC	396
14	marine sediments @ 1% TOC	397

Table 46. Benzo(a)pyrene (continued)

References	Biological Approaches	Concentrations (ppb)
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	1800000
17	EPA acute marine EP threshold (@ 4% TOC)	1800000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	1800[illegible]
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	45000
6	EPA interim mean freshwater sediment quality criteria based upon EP @ 1% TOC	10630
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria	450000
Spiked Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	4100 ± 600

Reference	Background Approach	Concentrations (ppb organic carbon)
23	Rotterdam Harbor Sediment Quality Classifications	
	- Class 1 (slightly contaminated)	<0.3 OC
	- Class 2 (moderately contaminated)	0.3-0.6 OC
	- Class 3 (contaminated)	0.6-2 OC
	- Class 4 (heavily contaminated)	>2 OC

References:

1. Beller et al., 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
6. EPA, 1988
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
23. Jensen, 1987
25. Pavlou, 1987
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
65. Plesha *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989

* Various, please see text

Table 47. Effects range-low and effects range-median values for benzo(a)pyrene and 28 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
396	Marine SLC
397	Marine SLC
400	**ER-L**
404	San Francisco Bay, California bioassay COA
465	San Francisco Bay, California bioassay COA
509	Southern California bioassay COA
684	Commencement Bay, Washington bioassay COA
890	Commencement Bay, Washington bioassay COA
1091	San Francisco Bay, California bioassay COA
1192	Commencement Bay, Washington bioassay COA
1261	Commencement Bay,Washington bioassay COA
1300	San Francisco Bay, California AET
1600	Puget Sound, Washington AET - bivalve
1600	Puget Sound, Washington AET - Microtox™
2400	Puget Sound, Washington AET - amphipod
2462	Elizabeth River, Virginia bioassay COA
2500	**ER-M**
3000	Puget Sound, Washington AET - amphipod
3600	Puget Sound, Washington AET - benthic
4100	SSB with *R. abronius*: mixtures
5335	Eagle Harbor, Washington bioassay COA
6800	Puget Sound, Washington AET - benthic
10630	EP interim freshwater criteria @ 1% TOC
18000	99 percentile EP chronic marine @ 1% TOC
45000	95 percentile EP chronic marine @ 1% TOC
55160	Elizabeth River, Virginia bioassay COA
98500	Elizabeth River, Virginia bioassay COA
220000	Lake Union, Washington bioassay COA
450000	EP acute sediment safe level
1800000	EP chronic marine @ 4% TOC

Benzo(e)pyrene

The data available for benzo(e)pyrene are restricted to bioassays of sediments from San Francisco Bay, southern California, and Elizabeth River (Table 48). The amount and variety of data are insufficient to warrant the determination of ER-L and ER-M values. In San Francisco Bay, observations of effects were associated with mean concentrations of benzo(e)pyrene ranging from 194 ± 228 ppb to 624 ± 234 ppb. In southern California the mean concentration associated with high toxicity was 434 ± 318, within the range observed in San Francisco Bay. Toxicity to *L. xanthurus* was recorded at higher concentrations in bioassays of Elizabeth River sediments. Additional data are needed to determine a preponderance of evidence of the benzo(e)pyrene concentrations associated with adverse biological effects.

Table 48. Summary of sediment effects data available for benzo(e)pyrene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	92
	- *R. abronius* amphipod bioassay	690
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	366 ± 346
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	166 ± 130
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	153 ± 184
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	268 ± 276
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	157 ± 206
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	625 ± 234
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	194 ± 228
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	92 ± 44
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	250 ± 263
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	65 ± 27
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	434 ± 318
	- not toxic (23.2% mortality) to *G. japonica*	69 ± 106
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	78100
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	43736
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	1952

References:

47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
* Various, please see text.

Biphenyl

Data for biphenyl are available from bioassays of sediments from San Francisco Bay, southern California, Black Rock Harbor, and the Elizabeth River (Table 49). These data are insufficient to determine the ER-L and ER-M values in sediments associated with effects. Mean concentrations ranging from 6.6 ± 9.0 to 26.3 ± 9.0 ppb were associated with measures of toxicity in San Francisco Bay sediments. In southern California sediments, significant toxicity was associated with a mean concentration of 443 ppb. Elizabeth River sediments that were highly toxic to *L. xanthurus* had very high biphenyl concentrations.

Table 49. Summary of sediment effects data available for biphenyl.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	7
	- *R. abronius* amphipod bioassay	27
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	10 ± 13
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	7 ± 9
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	6 ± 8
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	7 ± 11
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	7 ± 8
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	26 ± 9
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	6 ± 6
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	1 ± 3
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	8 ± 10
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	2 ± 4
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to *G. japonica*	443
	- not toxic (23.2% mortality) to *G. japonica*	6
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	85000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	47600
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	2125
58	BLACK ROCK HARBOR, CONNECTICUT	
	- significant toxicity to *A. abdita* in 10-d bioassay	13.5

References:

47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
58. Rogerson *et al.*,
* Various, please see text

Chrysene

Data for chrysene are available from studies in which Puget Sound AETs were calculated; bioassays of sediments from Commencement Bay, Eagle Harbor, Lake Union, Columbia River, San Francisco Bay, southern California, and Elizabeth River were performed; national SLCs were determined; and various EP-derived thresholds were calculated (Table 50). Small gradients in chrysene concentrations were observed in bioassays of a dilution series of Eagle Harbor sediments and in amphipod bioassays of San Francisco Bay sediments. Also, a small gradient in chrysene concentrations was observed between Commencement Bay sediments that were moderately versus least toxic to amphipods. No toxicity was observed in Columbia

River sediments that had up to 4100 ppb chrysene. These data were not used to determine ER-L and ER-M values (Table B-23).

The lower 10 percentile value of the remaining data suggest an ER-L concentration of about 400 ppb (384 rounded to 400 ppb), a value supported by a marine SLC of 384 ppb (Table 51). Some measures of effects were observed in association with chrysene concentrations as low as a mean of 368 ppb. With the exceptions of Eagle Harbor and Columbia River bioassay data, effects almost always were observed or predicted at concentrations of about 900 ppb or more. The 50 percentile value of the data suggest an ER-M of about 2800 ppb, a value supported by two Puget Sound AETs (both 2800 ppb).

The degree of confidence in the ER-L and ER-M values should be considered as moderate. Data are available from a variety of geographic areas and approaches, but are not tightly clustered around the ER-L and ER-M values. There is an overall apparent effects threshold at about 900 ppb, supported by a variety of observed and predicted concentrations associated with effects and within the ER-L/ER-M range.

Table 50. Summary of sediment effects data available for chrysene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2800
	- oyster larvae (*C. gigas*) bioassay	2800
	- benthic community composition	6700
	- Microtox™ bioassay	1400
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	9200
	- oyster larvae (*C. gigas*) bioassay	2800
	- benthic community composition	9200
	- Microtox™ bioassay	1400
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	670
	- maximum level criterion	6700
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	1700
	- *R. abronius* amphipod bioassay	2100
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	1363 ± 1970
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	821 ± 732
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	748 ± 773
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	1218 ± 1286
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	902 ± 691
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	358 ± 365
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	10574 ± 7337
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	9203 ± 10972
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	3165 ± 4535

Table 50. Chrysene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	80
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	170000
52	COLUMBIA RIVER, WASHINGTON/OREGON	
	not toxic (0-13% mortality) to H. azteca	4100
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	517 ± 729
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	413 ± 385
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	378 ± 549
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	423 ± 512
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	405 ± 571
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	1679 ± 847
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	368 ± 466
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	82 ± 37
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	500 ± 671
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	198 ± 276
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	524 ± 284
	- not toxic (23.2% mortality) to *G. japonica*	127 ± 226
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	317000
	- LC50 (24-hr) for *L. xanthurus* exposed to 56% Elizabeth River sediment	177520
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	7930
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	384
14	Marine sediments @ 1% TOC	384
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	460000
17	EPA acute marine EP threshold (@ 4% TOC)	460000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	1200
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	4400

Table 50. Chrysene (continued)

References	Biological Approaches	Concentrations (ppb)
Equilibrium Partitioning		
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria	115000

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
25. Pavlou, 1987
29. Yake *et al.*, 1986
4.7 Roberts *et al.*, 1989
52. Johnson and Norton, 1988
56. Anderson *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989

* Various, please see text

Table 51. Effects range-low and effects range-median values for chrysene and 27 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
80	Predicted Eagle Harbor LC50–amphipod COA
368	San Francisco Bay, California bioassay COA
384	Marine SLC
400	**ER-L**
500	San Francisco Bay, California bioassay COA
524	Southern California bioassay COA
902	Commencement Bay, Washington bioassay COA
1200	99 percentile EP chronic marine @ 1% TOC
1218	Commencement Bay, Washington bioassay COA
1363	Commencement Bay, Washington bioassay COA
1400	Puget Sound, Washington AET - Microtox™
1679	San Francisco Bay, California bioassay COA
1700	San Francisco Bay, California bioassay COA
2100	San Francisco Bay, California bioassay COA
2800	Puget Sound, Washington AET - bivalve
2800	**ER-M**
2800	Puget Sound, Washington AET- amphipod
4400	95 percentile EP chronic marine @ 1% TOC
6700	Puget Sound, Washington AET - benthic
7930	Elizabeth River, Virginia bioassay
9200	Puget Sound, Washington AET - amphipod
9200	Puget Sound, Washington AET - benthic
9203	Eagle Harbor, Washington bioassay COA
10574	Eagle Harbor, Washington bioassay COA
115000	EP acute sediment safe level
170000	Lake Union, Washington bioassay COA
177520	Elizabeth River, Virginia bioassay COA
317000	Elizabeth River, Virginia bioassay COA
460000	EP chronic marine threshold @ 4% TOC

Dibenz(a,h)anthracene

Data are available for this aromatic hydrocarbon from determinations of Puget Sound and San Francisco Bay AETs, EP-derived thresholds, and evaluations of bioassay data from Commencement Bay, Eagle Harbor, and southern California (Table 52). There was either a small gradient or no concordance between dibenz(a,h)anthracene concentrations and toxicity to amphipods exposed to San Francisco Bay sediments. Commencement Bay and Eagle Harbor sediments that were highly toxic to amphipods had lower dibenz(a,h)anthracene concentrations than those respective samples that were moderately toxic. Therefore, these data were not considered in the determination of ER-L and ER-M values (Table B-24).

Effects in sediments were observed in association with mean dibenz(a,h)anthracene concentrations as low as 42 ± 46 ppb (Table 53). The lower 10 percentile of the data is equivalent to an ER-L value of about 60 ppb, a value supported by bioassay data from San Francisco Bay (mean 63 ± 80 ppb) and from southern California (mean 66 ± 46 ppb). The 50 percentile of the data suggest an ER-M of about 260 ppb, a value supported by three Puget Sound AETs (230, 230, 260 ppb), a San Francisco Bay AET (260 ppb), and Commencement Bay sediments that were highly toxic to oyster larvae (mean 263 ± 413 ppb). Except for amphipod bioassay data from Eagle Harbor and a San Francisco Bay AET for amphipod bioassays, effects were usually observed in association with concentrations of about 100 ppb or more (Table B-24). The threshold concentrations predicted by EP methods were considerably higher than those observed with measures of effects in field-collected samples.

The degree of confidence in the ER-L and ER-M values for dibenz(a,h)anthracene should be considered as moderate. A relatively small amount of data exist with which to relate chemical concentrations to measures of effects; there are no SSB data; and there was relatively poor concordance or small gradients in concentrations among samples that were toxic and those that were nontoxic. However, there was a degree of convergence among the data and there appears to be an effects threshold within the ER-L/ER-M range at about 100 ppb with few contradictory data.

Table 52. Summary of sediment effects data available for dibenz(a,h)anthracene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	260
	- oyster larvae (*C. gigas*) bioassay	230
	- benthic community composition	1200
	- Microtox™ bioassay	230
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	540
	- oyster larvae (*C. gigas*) bioassay	230
	- benthic community composition	970
	- Microtox™ bioassay	230
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	120
	- maximum level criterion	1200
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	260
	- *R. abronius* amphipod bioassay	300

Table 52. Dibenz(a,h)anthracene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	72 ± 139
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	183 ± 344
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	73 ± 71
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	263 ± 413
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	101 ± 58
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	55 ± 41
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	399 ± 252
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	797 ± 723
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	360 ± 298
	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	80 ± 88
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	44 ± 32
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	57 ± 77
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	55 ± 58
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	62 ± 80
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	217 ± 88
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	42 ± 46
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	15 ± 15
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	63 ± 80
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	21 ± 22
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	66 ± 46
	- not toxic (23.2% mortality) to *G. japonica*	24 ± 36
Equilibrium Partitioning		
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	12000
	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	35000
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria	240000

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
13. Pavlou *et al.*, 1987
20. U.S. ACOE, 1988
25. Pavlou, 1987
56. Anderson *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989
* Various, please see text

Table 53. Effects range-low and effects range-median values for dibenz(a,h)-anthracene and 18 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
42	San Francisco Bay, California bioassay COA
60	**ER-L**
63	San Francisco Bay, California bioassay COA
66	Southern California bioassay COA
101	Commencement Bay, Washington bioassay COA
183	Commencement Bay, Washington bioassay COA
217	San Francisco Bay, California bioassay COA
230	Puget Sound, Washington AET - oyster
230	Puget Sound, Washington AET - Microtox™
260	Puget Sound, Washington AET - amphipod
260	**ER-M**
260	San Francisco Bay, California AET
263	Commencement Bay, Washington bioassay COA
540	Puget Sound, Washington AET - amphipod
797	Eagle Harbor, Washington bioassay COA
970	Puget Sound, Washington AET - benthic
1200	Puget Sound, Washington AET - benthic
12000	99 percentile EP chronic marine @ 1% TOC
35000	95 percentile EP chronic marine @ 1% TOC
240000	EP acute sediment safe level

2,6-Dimethylnaphthalene

Very few data are available with which to relate the concentrations of 2,6-dimethylnaphthalene to measures of effects in sediments (Table 54). The San Francisco Bay bioassay data indicated relatively high toxicity to bivalve larvae in samples with 53 ± 29 ppb 2,6-dimethylnaphthalene; whereas in southern California, sediments with similar concentrations (56 ± 10 ppb) were not toxic to amphipods. Southern California sediments that were highly toxic to amphipods had concentrations (115 ± 278 ppb) that were similar to those in sediments spiked with hydrocarbon mixtures that were toxic to amphipods (150 ± 20 ppb). There are too few data to warrant determination of ER-L and ER-M values for this chemical.

Table 54. Summary of sediment effects data available for 2,6-dimethylnaphthalene.

References	Biological Approach	Concentrations (ppb)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	18 ± 28
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	10 ± 15
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	10 ± 19
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	13 ± 22
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	12 ± 20

Table 54. 2,6-dimethylnaphthalene (continued)

References	Biological Approach	Concentrations (ppb)
Co-Occurrence Analyses		
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	53 ± 29
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	9 ± 14
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	3 ± 4
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	14 ± 22
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	5 ± 5
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	115 ± 278
	- not toxic (23.2% mortality) to *G. japonica*	56 ± 110
Spiked Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	150 ± 20

References:

56. Anderson *et al.*, 1988
65. Plesha *et al.*, 1988
* Various, please see text

Fluoranthene

Data are available from studies in which Puget Sound AETs were determined; toxicity thresholds were predicted using EP methods; national SLCs were calculated; SSBs were performed; and bioassays were performed with sediments from Commencement Bay, Eagle Harbor, Lake Union, Columbia River, San Francisco Bay, southern California, Palos Verdes, and Elizabeth River (Table 55). Only three of the Palos Verdes samples were analyzed for fluoranthene concentrations. There was either a small gradient or no gradient in fluoranthene concentrations between San Francisco Bay sediments that were least, moderately, and most toxic to amphipods and significantly toxic versus not toxic to amphipods. There was no gradient in fluoranthene concentrations between Commencement Bay sediments that were least and moderately toxic to amphipods. Moderately toxic Eagle Harbor sediments had a lower mean fluoranthene concentration than those that were least toxic. These data were not used to determine ER-L and ER-M values (Table B-25).

Effects in sediments were observed in association with mean fluoranthene concentrations as low as 382 ± 617 ppb (Table 56). The lower 10 percentile value in the data suggest an ER-L of about 600 ppb, a concentration supported by the predicted LC50 derived from amphipod bioassays of a dilution series of Eagle Harbor sediments (600 ppb) and a marine SLC concentration assuming 1 percent TOC content (644 ppb). The 50 percentile value in the data suggest an ER-M of about 3600 ppb. This value is supported by a chronic marine EP-derived concentration (3100 ppb), an LC50 determined in a SSB (3300 ppb), an EP-derived chronic safe level (3600 ppb), a Puget Sound AET (3700 ppb), and a San Francisco Bay AET (3900 ppb). Effects were almost always observed in association with fluoranthene concentrations of about 1000 ppb (1 ppm) or more. There were two exceptions to this apparent threshold: bioassay data from the Columbia River, in which no effects were observed in sediments with up to 2100 ppb fluoranthene; and bioassay data from Eagle Harbor, where there was no toxicity in sediments with a mean concentration of 12080 ppb (Table B-25).

The degree of confidence in these ER-L and ER-M values should be considered as relatively high. Data are available from all of the major approaches; clusters of data support the values; and the overall apparent effects threshold lies within the range of ER-L and ER-M values.

Table 55. Summary of sediment effects data available for fluoranthene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	3900
	- oyster larvae (*C. gigas*) bioassay	2500
	- benthic community composition	6300
	- Microtox™ bioassay	1700
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	30000
	- oyster larvae (*C. gigas*) bioassay	2500
	- benthic community composition	24000
	- Microtox™ bioassay	1700
20	PSDDA GUIDELINES (based upon Puget Sound AET)	
	- screening level concentration	630
	- maximum level criterion	6300
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	2000
	- *R. abronius* amphipod bi[illegible]ay	>3700
Co-Occurrence Analyses		
80	COMMENCEMENT BA[illegible]ASHINGTON	
	- highly toxic (15.7 ± [illegible]d/20) to *R. abronius*	2360 ± 3330
	- moderately toxic (5[illegible] dead/20) to *R. abronius*	925 ± 864
	- least toxic (2.5 ± 0.9 [illegible]/20) to *R. abronius*	923 ± 865
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	1655 ± 2029
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	1046 ± 655
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	489 ± 492
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	71988 ± 95713
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	8895 ± 10337
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	12080 ± 51889
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon, sediment	600
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	570000
52	COLUMBIA RIVER, WASHINGTON/OREGON	
	- not toxic (0-13% mortality) to *H. azteca*	2100

Table 55. Fluoranthene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	794 ± 1210
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	509 ± 481
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	539 ± 842
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	584 ± 789
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	572 ± 880
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	2737 ± 1617
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	451 ± 562
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	136 ± 107
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	682 ± 1043
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	382 ± 617
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	382 ± 241
	- not toxic (23.2% mortality) to *G. japonica*	153 ± 307
49	PALOS VERDES SHELF, CALIFORNIA	
	- significantly toxic to *R. abronius*	193 ± 143
	- not toxic to *R. abronius*	98
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	2370000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	327200
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	59250
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	432
14	Marine sediments @ 1% TOC	644
Equilibrium Partitioning		
17	EPA acute marine EP threshold (@ 4% TOC)	36000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	1600
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	3100
6	EPA interim mean freshwater sediment quality criteria based upon EP @ 1% TOC	18800
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria	9000

Table 55. Fluoranthene (continued)

References	Biological Approaches	Concentrations (ppb)
Equilibrium Partitioning		
25	Sediment safe levels based upon sediment/water partitioning coefficients and chronic water quality criteria	3600
Spiked Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	15000
18	LC50 (10-d) for *R. abronius*	4200
19	LC50 for *R. abronius* @ 0.2% TOC	3300
	LC50 for *R. abronius* @ 0.3% TOC	6200
	LC50 for *R. abronius* @ 0.5% TOC	10500

Reference	Background Approach	Concentrations (ppb organic carbon)
23	Rotterdam Harbor Sediment Quality Classifications	
	- Class 1 (slightly contaminated)	<0.4 OC
	- Class 2 (moderately contaminated)	0.4-1 OC
	- Class 3 (contaminated)	1-4.5 OC
	- Class 4 (heavily contaminated)	>4.5 OC

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
5. Neff *et al.*, 1986
6. EPA, 1988
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
18 Swartz *et al.*, 1988
19. Swartz *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz et al., 1989
23. Jensen, 1987
25. Pavlou, 1987
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
49. Swartz *et al.*, 1985
52. Johnson and Norton, 1988
56. Anderson *et al.*, 1988
65. Plesha *et al.*, 1988
80. Tetra Tech, 1985
85. CH²M Hill, 1989

* Various, please see text

Table 56. Effects range-low and effects range-median values for fluoranthene and 33 concentraations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
382	Southern California bioassay COA
432	Marine SLC
451	San Francisco Bay, California bioassay COA
600	**ER-L**
600	Eagle Harbor, Washington bioassay COA
644	Marine SLC
682	San Francisco Bay, California bioassay COA

Table 56. (continued)

Concentrations (ppb)	End Point
1046	Commencement Bay, Washington bioassay COA
1600	99 percentile EP chronic marine @ 1% TOC
1655	Commencement Bay, Washington bioassay COA
1700	Puget Sound, Washington AET - Microtox™
2000	San Francisco Bay, California AET
2360	Commencement Bay, Washington bioassay COA
2500	Puget Sound, Washington AET - oyster
2737	San Francisco Bay, California bioassay COA
3100	95 percentile EP chronic marine @ 1% TOC
3300	SSB LC50 for *R. abronius* @ 0.2% TOC
3600	**ER-M**
3600	EP chronic sediment safe level
3900	Puget Sound, Washington AET - amphipod
4200	SSB LC50 for *R. abronius*
6200	SSB LC50 for *R. abronius* @ 0.3% TOC
6300	Puget Sound, Washington AET - benthic
9000	EP acute sediment safe level
10500	SSB LC50 for *R. abronius* @ 0.5% TOC
15000	SSB with *R. abronius*: mixtures
18800	EP interim freshwater criteria @ 1% TOC
24000	Puget Sound, Washington AET - benthic
30000	Puget Sound, Washington AET - amphipod
36000	EP acute marine threshold @ 4% TOC
59250	Elizabeth River, Virginia bioassay COA
71988	Eagle Harbor, Washington bioassay COA
327200	Elizabeth River, Virginia bioassay COA
570000	Lake Union, Washington bioassay COA
2370000	Elizabeth River, Virginia bioassay COA

Fluorene

Data for fluorene are available from studies in which Puget Sound AETs were calculated; national SLCs were determined; EP-derived thresholds were predicted; effects upon fish were determined in SSBs; and bioassays were performed with sediments from Commencement Bay, Eagle Harbor, Lake Union, San Francisco Bay, southern California, Elizabeth River, and Black Rock Harbor (Table 57). Data from SSBs with winter flounder (*Pseudopleuronectes americanus*) are available. The winter flounder were exposed to Venezuelan crude mixed into sediments placed in a layer in large aquaria for 4 months (Payne *et al.*, 1988). There was little or no concordance between fluorene concentrations and toxicity to amphipods in San Francisco Bay. There was a small gradient in fluorene concentrations between Commencement Bay and Eagle Harbor sediments that were least and moderately toxic to amphipods. These data were not used to determine the ER-L and ER-M values (Table B-26).

Effects determined with bivalve larvae bioassays of San Francisco Bay sediments were observed in association with very low levels of fluorene (Table 58). These data influenced the determination of the ER-L value of 35 ppb. The 50 percentile value in the data suggest an ER-M of 640 ppb, a value supported by three Puget Sound AETs (all 540 ppb), a Puget Sound AET for benthic communities (640 ppb), and high toxicity in Commencement Bay (mean 707 ppb). Except for the Eagle Harbor amphipod bioassay data, there is an overall apparent effects threshold at about 350 ppb. However, this apparent threshold is highly influenced by only Puget Sound and Commencement Bay data and not by other supporting data.

The degree of confidence in the ER-L and ER-M values for fluorene should be considered as low and moderate, respectively. Although there are data from several approaches and matching effects and chemical data from many geographic areas, the data indicate poor convergence around the ER-L value. The ER-L is supported by data only from San Francisco Bay and the ER-M is supported by data only from Puget Sound (including Commencement Bay). Some of the concentrations derived from the EP and SSB approaches suggest that the threshold for effects occurs at much higher concentrations than indicated by the ER-L and ER-M values.

Table 57. Summary of sediment effects data available for fluorene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	540
	- oyster larvae (*C. gigas*) bioassay	540
	- benthic community composition	640
	- Microtox™ bioassay	540
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	3600
	- oyster larvae (*C. gigas*) bioassay	540
	- benthic community composition	1000
	- Microtox ™ bioassay	540
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	64
	- maximum level criterion	640
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	11
	- *R. abronius* amphipod bioassay	210
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	707 ± 1341
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	147 ± 131
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	117 ± 113
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	353 ± 746
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	143 ± 119
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	75 ± 76
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	22811 ± 65559
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	187 ± 234
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	1017 ± 4679
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	210
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	40000

Table 57. Fluorene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	33 ± 77
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	30 ± 21
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	39 ± 49
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	29 ± 48
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	43 ± 51
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	162 ± 105
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	19 ± 30
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	6 ± 5
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	35 ± 64
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	16 ± 23
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	11
	- not toxic (23.2% mortality) to *G. japonica*	8
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	1250000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	700000
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	17500
58	BLACK ROCK HARBOR, CONNECTICUT	
	- significant toxicity to *A. abdita* in 10-d bioassay	93
National Screening Level Concentrations		
14	Marine sediments @ 1% TOC	101
Equilibrium Partitioning		
4	EPA chronic marine EP threshold(@ 4% TOC)	28000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	59
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	160
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria @ 1% TOC	7000
Spiked-Sediment Bioassays		
59	Liver somatic condition indices elevated in winter flounder	220550
	MFO induction in winter flounder liver significantly elevated	176510
	MFO induction in winter flounder kidney significantly elevated	285290

Table 57. Fluorene (continued)

References:

1. Beller *et al.*, 1986	21. Swartz et al., 1989	58. Rogerson *et al.*, 1985
2. PTI Environmental Services, 1988	25. Pavlou, 1987	59. Payne *et al.*, 1988
4. Bolton *et al.*, 1985	29. Yake *et al.*, 1986	80. Tetra Tech, 1985
13. Pavlou *et al.*, 1987	47. Roberts *et al.*, 1989	85. CH^2M Hill, 1989
14. Neff *et al.*, 1987	56. Anderson *et al.*, 1988	* Various, please see text
20. U.S. ACOE, 1988		

Table 58. Effects range-low and effects range-median values for fluorene and 28 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
11	San Francisco Bay, California AET
19	San Francisco Bay, California bioassay COA
35	**ER-L**
35	San Francisco Bay, California bioassay COA
59	99 percentile EP chronic marine @ 1% TOC
93	Black Rock Harbor, Connecticut bioassay COA
101	Marine SLC
143	Commencement Bay, Washington bioassay COA
160	95 percentile EP chronic marine @ 1% TOC
162	San Francisco Bay, California bioassay COA
210	Eagle Harbor, Washington bioassay COA
353	Commencement Bay, Washington bioassay COA
540	Puget Sound, Washington AET - amphipod
540	Puget Sound, Washington AET - oyster
540	Puget Sound, Washington AET - Microtox™
640	**ER-M**
640	Puget Sound, Washington AET - benthic
707	Commencement Bay, Washington bioassay COA
1000	Puget Sound, Washington AET - benthic
3600	Puget Sound, Washington AET - amphipod
7000	EP acute sediment safe level
17500	Elizabeth River, Virginia bioassay COA
22811	Eagle Harbor, Washington bioassay COA
28000	EP chronic marine @ 4% TOC
40000	Lake Union,Washington bioassay COA
176510	SSB with flounder
220550	SSB with flounder
285290	SSB with flounder
700000	Elizabeth River, Virginia bioassay COA
1250000	Elizabeth River, Virginia bioassay COA

1-methylnaphthalene

The data available for 1-methylnaphthalene are from bioassays of sediments from San Francisco Bay and southern California and amphipod bioassays of sediments spiked with mixtures of hydrocarbons. Many of the San Francisco Bay samples were not analyzed for 1-methylnaphthalene; the small amount of data available indicated poor concordance between toxicity and chemical concentrations. The mean concentration in southern California samples that were significantly toxic to amphipods was 192.8 ± 461.1 ppb versus 36.2 ± 65.6 ppb in

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non-toxic samples. The concentration of 1-methylnaphthalene was 500 ppb in a mixture of hydrocarbons that was toxic to amphipods. There are too little data to determine ER-L and ER-M values for this hydrocarbon.

2-methylnaphthalene

There are somewhat more data available for 2-methylnaphthalene (Table 59) than for 1-methylnaphthalene. They are from determinations of Puget Sound AET; bioassays of sediments from Commencement Bay, San Francisco Bay, southern California, and Elizabeth River; and amphipod bioassays of sediments spiked with hydrocarbon mixtures. There was a small gradient in 2-methylnaphthalene concentrations between San Francisco Bay samples that were least and moderately toxic to bivalve larvae. There was no concordance between toxicity to amphipods and 2-methylnaphthalene concentrations in San Francisco Bay. Commencement Bay sediments that were moderately toxic to both bivalve larvae and amphipods had 2-methylnaphthalene concentrations similar to those that were least toxic. These data were not used to determine the ER-L and ER-M values (Table B-27).

The lower 10 percentile of the data suggest an ER-L of about 65 ppb, a value supported by high toxicity in southern California sediments (mean 65 ± 154 ppb) (Table 60). The 50 percentile of the data suggest an ER-M of about 670 ppb, a value supported by four Puget Sound AETs (all 670 ppb). There appears to be an overall effects threshold at about 300 ppb, but it is supported by relatively few data and data mainly from Commencement Bay and other parts of Puget Sound (Table B-27).

The degree of confidence in the ER-L and ER-M values for 2-methylnaphthalene should be considered as low and moderate, respectively. They are supported by small clusters of data. There are no single-chemical, spiked-sediment data, no thresholds predicted by EP methods, and the matching biological and chemical data are from only a few geographic areas. However, the apparent effects threshold lies within the ER-L/ER-M range and is not contradicted by observations of no effects at greater concentrations.

Table 59. Summary of sediment effects data available for 2-methylnaphthalene.

References	Biological Approach	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	670
	- oyster larvae (*C. gigas*) bioassay	670
	- benthic community composition	670
	- Microtox™ bioassay	670
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	1900
	- oyster larvae (*C. gigas*) bioassay	670
	- benthic community composition	1400
	- Microtox™ bioassay	670
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	67
	- maximum level criterion	670
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	27
	- *R. abronius* amphipod bioassay	>130

Table 59. 2-methylnaphthalene (continued).

References	Biological Approach	Concentrations (ppb)
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	546 ± 490
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	213 ± 129
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	168 ± 169
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	326 ± 313
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	207 ± 169
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	165 ± 121
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	32 ± 41
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	34 ± 27
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	34 ± 33
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	31 ± 33
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	39 ± 35
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	98 ± 41
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	26 ± 23
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	20 ± 7
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	35 ± 36
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	24 ± 4
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	65 ± 154
	- not toxic (23.2% mortality) to *G. japonica*	16 ± 33
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	31800
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	1788
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	795
Spiked-Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	500

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
20. U.S. ACOE, 1988
47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
65. Plesha *et al.*, 1988
80. Tetra Tech, 1985
* Various, please see text

Table 60. Effects range-low and effects range-median values for 2-methylnaphthalene and 15 concentrations used to determine those values arranged in ascending order.

Concentrations (ppb)	End Point
27	San Francisco Bay, California AET
65	**ER-L**
65	Southern California bioassay COA
98	San Francisco Bay, California bioassay COA
326	Commencement Bay, Washington bioassay COA
500	SSB with *R. abronius*: mixtures
546	Commencement Bay, Washington bioassay COA
670	Puget Sound, Washington AET - amphipod
670	Puget Sound, Washington AET - oyster
670	Puget Sound, Washington AET - benthic
670	**ER-M**
670	Puget Sound, Washington AET - Microtox™
795	Elizabeth River, Virginia bioassay COA
1400	Puget Sound, Washington AET - benthic
1788	Elizabeth River, Virginia bioassay COA
1900	Puget Sound, Washington AET - amphipod
31800	Elizabeth River, Virginia bioassay COA

1-methylphenanthrene

There are no data available with which to relate effects in sediments to the concentrations of this hydrocarbon in sediments.

Naphthalene

Puget Sound and San Francisco Bay AET concentrations, freshwater and saltwater SLCs, and three EP-derived concentrations are available for naphthalene (Table 61). Also, co-occurrence analyses were performed with bioassay data from Commencement Bay, Eagle Harbor, Puget Sound, San Francisco Bay, Lake Union, southern California, and benthic community data from the Trinity River. Concentrations predicted or projected to co-occur with toxicity in dilution series of sediments from Black Rock Harbor and Eagle Harbor are available. Data from SSBs with winter flounder and spot (*Leistomus xanthurus*) are also available. The winter flounder were exposed to Venezuelan crude mixed into sediments placed in a layer in large aquaria for 4 months (Payne *et al.*, 1988). The spot were held for 28 days in cages that were placed upon and slightly immersed in Elizabeth River sediments added to large aquaria (Roberts *et al.*, 1989).

Naphthalene represented a small proportion of the total PAH in Black Rock Harbor and Eagle Harbor sediments that were tested in dilution series. There was either no concordance or a small gradient in naphthalene concentrations among San Francisco Bay sediments tested with amphipods. Moderately toxic Eagle Harbor sediments had lower naphthalene concentrations than least toxic samples. These data were not used to determine the ER-L and ER-M values (Table B-28).

The available data (Table 62) suggest an ER-L of about 340 ppb (the lower 10 percentile of the data), a value supported by moderate toxicity in Puget Sound. There is an overall apparent threshold in the data at about 500 ppb; effects have been almost always observed above that concentration in sediments. The 50 percentile value in the data (the ER-M) is about 2100 ppb, a value supported by four Puget Sound AETs (2100 ppb) and an LC50 from a series of bioassays of Elizabeth River sediments tested with spot (2375 ppb).

There is a relatively large amount of data and they are from all the major approaches. There is a consistent cluster of data from two approaches supporting the ER-M value, but not the ER-L value. The ER-L and ER-M values were influenced mainly by San Francisco Bay and Puget Sourd data, respectively. The degree of confidence in these values should be considered as moderate and high, respectively. Except for the Commencement Bay samples least toxic to amphipods and the Trinity River bioassay data, the majority of the data indicate that effects almost always occur at concentrations above about 500 ppb (0.5 ppm) napthalene. This overall apparent effects threshold is suggested by an EP-derived concentration (500 ppb) and moderately toxic Commencement Bay samples (mean 593 ± 505 ppb) and lies within the ER-L/ER-M range

Table 61. Summary of sediment effects data available for naphthalene.

Reference	Biological Approach	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2100
	- oyster larvae (*C. gigas*) bioassay	2100
	- benthic community composition	2100
	- Microtox™ bioassay	2100
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	2400
	- oyster larvae (*C. gigas*) bioassay	2100
	- benthic community composition	2700
	- Microtox™ bioassay	2100
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	210
	- maximum level criterion	2100
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>160
	- *R. abronius* amphipod bioassay	>160
Co-Occurrence Analyses		
57[1]	PUGET SOUND WASHINGTON	
	- highly toxic (15-minute EC50; 0.31 ± 0.13) to *P. phosphoreum*	3934 ± 8864
	- moderately toxic (15-minute EC50; 2.1 ± 0.8) to *P. phosphoreum*	343 ± 383
	- least toxic (15-minute EC50; 8.9 ± 3.3) to *P. phosphoreum*	36 ± 50
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	1564 ± 1735
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	594 ± 424
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	510 ± 499
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	973 ± 1041
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	593 ± 505
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	358 ± 326
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	1501 ± 2064
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	288 ± 201
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	456 ± 682
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	30

Table 61. Naphthalene (continued).

Reference	Biological Approach	Concentrations (ppb)
Co-Occurrence Analyses		
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	40000
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	64 ± 46
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	48 ± 25
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	58 ± 51
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	53 ± 38
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	65 ± 54
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	127 ± 32
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	43 ± 26
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	63 ± 57
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	53 ± 40
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	89 ± 64
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	77 ± 181
	- not toxic (23.2% mortality) to *G. japonica*	8 ± 16
51	TRINITY RIVER, TEXAS	
	- low benthic species richness (28.2 ± 2.9)	11500 ± 5600
	- high benthic species richness (33.3 ± 4.0)	5250 ± 1500
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	95000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	53200
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	2375
58	BLACK ROCK HARBOR, CONNECTICUT	
	- significant toxicity to *A. abdita* in 10-d bioassay	4.25
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	3670
14	Marine sediments @ 1% TOC	414
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	42000
17	EPA acute marine EP threshold (@ 4% TOC)	42000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	500

Table 61. Naphthalene (continued).

Reference	Biological Approach	Concentrations (ppb)
Equilibrium Partitioning		
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	720
Spiked-Sediment Bioassays		
59	Liver somatic condition indices elevated in winter flounder	7370
	MFO induction in winter flounder liver significantly elevated	6200
	MFO induction in winter flounder kidney significantly elevated	10710

[1] Total concentration includes sum of naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, 2,6-dimethylnaphthalene, and 2,3,5-trimethylnaphthalene.

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
51. Armstrong *et al.*, 1979
56. Anderson *et al.*, 1988
57. Schiewe *et al.*, 1985
58. Rogerson *et al.*, 1985
59. Payne *et al.*, 1988
80. Tetra Tech, 1985
85. CH^2M Hill, 1989

* Various, please see text

Table 62. Effects range-low and effects range-median values for naphthalene and 28 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
77	Southern California bioassay COA
127	San Francisco Bay, California bioassay COA
340	**ER-L**
343	Puget Sound, Washington bioassay COA
414	Marine SLC
500	99 Percentile EP chronic marine @ 1% TOC
593	Commencement Bay, Washington bioassay COA
594	Commencement Bay,Washington bioassay COA
720	95 percentile EP chronic marine @ 1% TOC
973	Commencement Bay, Washington bioassay COA
1501	Eagle Harbor, Washington bioassay COA
1564	Commencement Bay, Washington bioassay COA COA
2100	Puget Sound, Washington AET- amphipod
2100	Puget Sound, Washington AET - oyster
2100	**ER-M**
2100	Puget Sound, Washington AET - benthic
2100	Puget Sound, Washington AET - Microtox™
2375	Elizabeth River, Virginia bioassay COA
2400	Puget Sound, Washington AET - amphipod
2700	Puget Sound, Washington AET - benthic

Table 62. (continued)

Concentrations (ppb)	End Point
3670	Marine SLC
3934	Puget Sound, Washington bioassay COA
6200	SSB with flounder
7370	SSB with flounder
10710	SSB with flounder
11500	Trinity River,Texas benthos COA
40000	Lake Union, Washington bioassay COA
42000	EP acute marine threshold @ 4% TOC
53200	Elizabeth River, Virginia bioassay COA
95000	Elizabeth River, Virginia bioassay COA

Perylene

Data available for perylene are from studies in which bioassays of San Francisco Bay, southern California, and Elizabeth River sediments were performed (Table 63). There are too little data to warrant determination of ER-L and ER-M values, however, some of the available data suggest a degree of convergence. The San Francisco Bay AET for amphipod bioassays, San Francisco Bay sediments highly toxic to amphipods and bivalve larvae, and southern California sediments significantly toxic to amphipods had similar perylene concentrations (230, and means of 173, 212, and 175 ppb, respectively). The perylene concentrations in Elizabeth River sediments that were toxic to *L. xanthurus* were much higher (means of 1677 ppb and greater).

Table 63. Summary of sediment effects data available for perylene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Thresholds		
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	95
	- *R. abronius* amphipod bioassay	230
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	173 ± 124
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	139 ± 43
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	98 ± 68
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	159 ± 92
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	85 ± 68
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	212 ± 39
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	132 ± 92
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	81 ± 78
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	146 ± 86
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	32 ± 55

Table 63. Perylene (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.65% mortality) to G. *japonica*	175 ± 120
	- not toxic (23.2% mortality) to G. *japonica*	82 ± 118
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to L. *xanthurus* exposed to 100% Elizabeth River sediment	50700
	- LC50 (24-h) for L. *xanthurus* exposed to 56% Elizabeth River sediment	28392
	- LC50 (28-d) for L. *xanthurus* exposed to 2.5% Elizabeth River sediment	1677

References:

47. Roberts *et al.*, 1989
56. Anderson *et al.*, 1988
* Various, please see text

Phenanthrene

Data available for phenanthrene are from studies in which Puget Sound AETs were determined; SSBs were performed with amphipods and winter flounder; national SLCs were calculated; EP-derived thresholds were predicted; and bioassays of sediments from Commencement Bay, Eagle Harbor, Lake Union, San Francisco Bay, southern California, Columbia River, and Elizabeth River were performed (Table 64). San Francisco Bay sediments that were least, moderately, and highly toxic to amphipods had similar phenanthrene concentrations. San Francisco Bay sediments that were significantly toxic to bivalve larvae had similar concentrations of phenanthrene compared to those that were not toxic. Eagle Harbor sediments that were moderately toxic to amphipods had a lower mean phenenathrene concen[illegible]n than those that were least toxic. These data were not used to determine ER-L and [illegible]values (Table B-29).

The lower 10 [illegible]ile value of the data suggests an ER-L of about 225 ppb, a value supported by so[illegible] California and San Francisco Bay bioassay data (means of 222 ± 136 ppb and 224 ± [illegible]b, respectively) (Table 65). The 50 percentile of the data suggest an ER-M of about [illegible] ppb, a value supported by highly toxic Commencement Bay samples (mean of 1379 ± 2546 ppb) and an EP-derived criterion of 1390 ppb. There is an overall apparent effects threshold at about 260 ppb, but there are data from Commencement Bay, Eagle Harbor, and the Columbia River that contradict that observation.

The degree of confidence in the ER-L and ER-M values for phenanthrene should be considered as moderate. There are data from all of the major approaches and there is convergence within this range, but the data from a SSB with an amphipod suggest that the effects threshold among sensitive species may occur at concentrations much greater than the ER-L/ER-M range. The AET lies within the ER-L/ER-M range, but is contradicted by observations of no effects at higher concentrations determined in three study areas.

Table 64. Summary of sediment effects data available for phenanthrene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Thresholds		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	5400
	- oyster larvae (*C. gigas*) bioassay	1500
	- benthic community composition	3200
	- Microtox™ bioassay	1500
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	6900
	- oyster larvae (*C. gigas*) bioassay	1500
	- benthic community composition	5400
	- Microtox™ bioassay	1500
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	320
	- maximum level criterion	3200
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	88
	- *R. abronius* amphipod bioassay	510
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	2838 ± 4603
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	597 ± 513
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	478 ± 367
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	1379 ± 2546
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	593 ± 365
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	297 ± 263
85	EAGLE HARBOR, WASHINGTON	
	- highly toxic (19.1 ± 1.7 dead/20) to *R. abronius*	33603 ± 84430
	- moderately toxic (8.2 ± 1.8 dead/20) to *R. abronius*	2142 ± 2404
	- least toxic (2.6 ± 1.4 dead/20) to *R. abronius*	2600 ± 10009
21	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	950
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	410000
52	COLUMBIA RIVER, WASHINGTON/OREGON	
	- not toxic (0-13% mortality) to *H. azteca*	580
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	242 ± 203
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	228 ± 146
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	188 ± 197
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	220 ± 163
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	199 ± 205

Table 64. Summary of sediment effects data available for phenanthrene.

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	475 ± 160
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	224 ± 203
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	65 ± 30
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	233 ± 208
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	159 ± 216
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	222 ± 136
	- not toxic (23.2% mortality) to *G. japonica*	119 ± 242
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	220000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	2363200
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	105500
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	259
14	Marine sediments @ 1% TOC	368
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	56000
17	EPA acute marine EP threshold (@ 4% TOC)	56000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	110
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	240
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria @ 1% TOC	14000
6	EPA interim mean freshwater sediment quality criteria @ 1% TOC	1390
	EPA interim mean marine sediment quality criteria @ 1% TOC	1020
Spiked-Sediment Bioassays		
65	Significant toxicity to *R. abronius* with mixtures of aromatic and chlorinated hydrocarbons	500
59	liver somatic condition indices elevated in winter flounder	340
	MFO induction in winter flounder liver significantly elevated	270
	MFO induction in winter flounder kidney significantly elevated	429

Table 64. Phenanthrene (continued).

References	Biological Approaches	Concentrations (ppb)
Spiked-Sediment Bioassays		
21	LC50 (10-d) with *R. abronius*	3680

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
6. EPA, 1988
13. Pavlou *et al.*, 1987
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
25. Pavlou, 1987
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
52. Johnson *et al.*, 1988
56. Anderson *et al.*, 1988
59. Payne *et al.*, 1988
65. Plesha *et al.*, 1988
85. CH^{2}M Hill, 1989
80. Tetra Tech, 1985

* Various, please see text

Table 65. Effects range-low and effects range-median values for phenanthrene and 34 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
88	San Francisco Bay, California AET
110	99 percentile EP chronic marine @ 1% TOC
222	Southern California bioassay COA
224	San Francisco Bay, California bioassay COA
225	**ER-L**
240	95 percentile EP chronic marine @ 1% TOC
259	Marine SLC
270	SSB with flounder
340	SSB with flounder
368	Marine SLC
429	SSB with flounder
475	San Francisco Bay, California bioassay COA
500	SSB with *R. abronius*: mixtures
510	San Francisco Bay, California AET
593	Commencement Bay, Washington bioassay COA
597	Commencement Bay, Washington bioassay COA
950	Eagle Harbor, Washington bioassay COA
1020	EP interim marine criteria @ 1% TOC
1379	Commencement Bay, Washington bioassay COA
1380	**ER-M**
1390	EP interim freshwater criteria @ 1% TOC
1500	Puget Sound, Washington AET - oyster
1500	Puget Sound, Washington AET - Microtox™
2838	Commencement Bay, Washington bioassay COA
3200	Puget Sound, Washington AET - benthic
3680	SSB with *R. abronius* LC50
5400	Puget Sound, Washington AET- amphipod
5400	Puget Sound, Washington AET - benthic
6900	Puget Sound, Washington AET - amphipod
14000	EP acute sediment safe level

Table 65. (continued)

33603	Eagle Harbor, Washington bioassay COA
56000	EP chronic marine @ 4% TOC
105500	Elizabeth River, Virginia bioassay COA
220000	Elizabeth River, Virginia bioassay COA
410000	Lake Union, Washington bioassay COA
2363200	Elizabeth River, Virginia bioassay COA

Pyrene

Data available for pyrene are from studies in which Puget Sound AETs were determined; national SLCs were calculated; EP-derived thresholds were predicted; SSBs with winter flounder were conducted; and bioassays of sediments from Commencement Bay, Eagle Harbor, Lake Union, San Francisco Bay, southern California, and Elizabeth River were performed (Table 66). San Francisco Bay sediments that were significantly toxic to both amphipods and bivalve larvae had pyrene concentrations similar to the samples that were not toxic. San Francisco Bay sediments that were highly toxic to amphipods had pyrene concentrations similar to those that were least toxic. Commencement Bay sediments that were moderately toxic to amphipods had mean pyrene concentrations lower than those that were least toxic. Columbia River sediments with up to 2500 ppb pyrene were not toxic to amphipods. One each of the Puget Sound and San Francisco Bay AETs was not definitive. These data were not used to determine ER-L and ER-M values (Table B-30).

The lower 10 percentile of the data suggest an ER-L of about 350 ppb pyrene, a value supported by a predicted LC50 (350 ppb) for Eagle Harbor sediments tested with amphipods, and observations of altered liver somatic condition in winter flounder exposed to petroleum (360 ppb) (Table 67). The 50 percentile value in the data suggest an ER-M of about 2200 ppb, a value supported by San Francisco Bay bioassay data (mean of 2188 ppb). Except for the Columbia River bioassay data, most of the data suggest an overall effects threshold at about 1000 ppb (1 ppm) pyrene. However, as with the other aromatic hydrocarbons, this apparent effects threshold is highly influenced by the Puget Sound AET values.

The degree of confidence in the ER-L and ER-M values should be considered as moderate. Data are available from a number of approaches and geographic areas, an apparent effects threshold lies within the ER-L/ER-M range, and there is consistency and clustering of the available data. However, there are no data from single-chemical SSBs and most of the thresholds predicted by EP methods are much higher than the concentrations within the ER-L/ER-M range.

Table 66. Summary of sediment effects data available for pyrene.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	4300
	- oyster larvae (*C. gigas*) bioassay	3300
	- benthic community composition	>7300
	- Microtox™ bioassay	2600

Table 66. Pyrene (continued).

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
2	1988 PUGET SOUND AET	
	- *R. abronius* amphipod bioassay	16000
	- oyster larvae (*C. gigas*) bioassay	3300
	- benthic community composition	16000
	- Microtox™ bioassay	2600
20	PSDDA guidelines (based upon Puget Sound AET)	
	- screening level concentration	430
	- maximum level criterion	7300
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	>3400
	- *R. abronius* amphipod bioassay	2600
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	1820 ± 2252
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	865 ± 719
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	978 ± 996
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	1538 ± 1501
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	1078 ± 806
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	434 ± 442
21	EAGLE HARBOR, WASHINGTON	
	- predicted LC50 for *R. abronius* in 10-d dilution series with Yaquina Bay, Oregon sediment	350
29	LAKE UNION, WASHINGTON	
	- 95% mortality to *H. azteca*	750000
52	COLUMBIA RIVER, WASHINGTON/OREGON	
	- not toxic (0-13% mortality) to *H. azteca*	2500
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	777 ± 908
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	1110 ± 904
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	701 ± 866
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	896 ± 870
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	743 ± 902
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	2188 ± 776
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	724 ± 939
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	216 ± 102
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	806 ± 975
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	719 ± 1123
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	532 ± 372
	- not toxic (23.2% mortality) to *G. japonica*	184 ± 318

Table 66. Pyrene (continued).

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
47	ELIZABETH RIVER, VIRGINIA	
	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	1350000
	- LC50 (24-hr) for *L. xanthurus* exposed to 56% Elizabeth River sediment	756000
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	33750
National Screening Level Concentrations		
5	Marine sediments @ 1% TOC	434
14	Marine sediments @ 1% TOC	665
Equilibrium Partitioning		
4	EPA chronic marine EP threshold (@ 4% TOC)	198000
17	EPA acute marine EP threshold (@ 4% TOC)	198000
13	99 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	850
13	95 percentile chronic marine permissable contaminant derived from chronic water quality criteria @ 1% TOC	1900
6	EPA interim mean freshwater sediment quality criteria based upon EP@ 1% TOC	13100
25	Sediment safe levels based upon sediment/water partitioning coefficients and acute water quality criteria	49500
Spiked Sediment Bioassays		
59	Liver somatic condition indices elevated in winter flounder	360
	MFO induction in winter flounder liver significantly elevated	300
	MFO induction in winter flounder kidney significantly elevated	182

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
4. Bolton *et al.*, 1985
5. Neff *et al.*, 1986
6. EPA, 1988
13. Pavlou *et al.*, 1983
14. Neff *et al.*, 1987
17. Lyman *et al.*, 1987
20. U.S. ACOE, 1988
21. Swartz *et al.*, 1989
25. Pavlou, 1987
29. Yake *et al.*, 1986
47. Roberts *et al.*, 1989
52. Johnson *et al.*, 1988
56. Anderson *et al.*, 1988
59. Payne *et al.*, 1988
80. Tetra Tech, 1985
* Various, please see text

Table 67. Effects range-low and effects range-median values for pyrene and 28 concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
182	SSB with flounder
300	SSB with flounder
350	Eagle Harbor, Washington bioassay COA
350	**ER-L**
360	SSB with flounder
434	Marine SLC
532	Southern California bioassay COA
665	Marine SLC
724	San Francisco Bay, California bioassay COA
850	99 percentile EP chronic marine @ 1% TOC
1078	Commencement Bay,Washington bioassay COA
1110	San Francisco Bay, California bioassay COA
1538	Commencement Bay, Washington bioassay COA
1820	Commencement Bay, Washington bioassay COA
1900	95 percentile EP chronic marine @ 1% TOC
2188	San Francisco Bay, California bioassay COA
2200	ER-M
2600	Puget Sound, Washington AET - Microtox™
2600	San Francisco Bay, California AET
3300	Puget Sound, Washington AET - oyster
4300	Puget Sound, Washington AET - amphipod
13100	EP freshwater interim criteria @ 1% TOC
16000	Puget Sound, Washington AET - amphipod
16000	Puget Sound, Washington AET - benthic
33750	Elizabeth River, Virginia bioassay COA
49500	EP acute sediment safe level
198000	EP chronic marine @ 4% TOC
750000	Lake Union, Washington bioassay COA
756000	Elizabeth River, Virginia bioassay COA
1350000	Elizabeth River, Virginia bioassay COA

2,3,5-trimethylnaphthalene

No data were located with which to relate 2,3,5-trimethylnaphthalene concentrations in sediments to measures of biological effects.

Total Polynuclear Aromatic Hydrocarbons (PAH)

The data available for total PAH include those from SSBs and co-occurrence analyses of matching bioeffects and chemical data from various investigations in the field (Table 68). The SSBs were performed with amphipods, bivalve larvae, and the fish *L. xanthurus*. The matching data are from San Francisco Bay, southern California, Eagle Harbor, Puget Sound, Commencement Bay, Mississippi Sound, Forth Estuary (Scotland), Hampton Roads, Lower Columbia River, Massachusetts Bay, and Hudson-Raritan Bay. In addition to the COA, the Mississippi Sound data from two types of bioassays (amphipod *Gammarus mucronatus* and mysid *Mysidopsis almyra*) were evaluated to determine AET concentrations.

Some of the data were not used to determine the ER-L and ER-M values (Table B-31). Some of the data from San Francisco Bay bioassays performed with amphipods, from studies of meiofauna in Forth Estuary, from bioassays of Mississippi Sound performed with mysids and with amphipods, and from moderately toxic Hampton Roads sediments tested with shrimp were not used because they either lacked a gradient in concentration or lacked concordance between the biological and the chemical data. One each of the San Francisco Bay and Mississippi Sound AETs were not definitive.

The category of total PAH is difficult to evaluate since different individual PAHs have been quantified by different investigators and reported as total PAH (Table B-31). Therefore, the data available for evaluation are not necessarily equivalent. For example, some of the data were reported as total PAH or total hydrocarbons and the identity and number of quantified hydrocarbons were not specified. Among the data sets evaluated, a minimum of 4 PAHs and a maximum of 21 PAHs were quantified. However, there is enough similarity among the data to warrant a cautious review of the concentrations associated with measures of effects in sediments. Most investigators reported the sums of 13 to 18 individual hydrocarbons. No Puget Sound AET has been reported for the category of total PAH. Also, since the Commencement Bay data were reported as sums of these two categories (low molecular weight and high molecular weight PAH), COA were performed with sums of the two mean concentrations as an approximation of total PAH. The AET concentrations determined with the Mississippi Sound data also were of questionable value. No definitive AET for the amphipod bioassay could be determined; the sample with the highest PAH concentration that was significantly toxic had 205,000 ppb PAH. Only one other sample that was significantly toxic to mysids exceeded the AET concentration of 99,400 ppb PAH in the sample.

Effects were associated with total PAH concentrations as low as 870 ppb, the AET determined for San Francisco Bay sediments tested with bivalve larvae bioassays (Table 69). The lower 10 percentile value of the data is equivalent to about 4000 ppb (3800 rounded to 4000 ppb), the ER-L concentration. This value is supported by observations in San Francisco Bay of the concentration associated with minimum measures of bioeffects (3800 ppb) and significant toxicity to bivalve larvae (mean 4022 ppb). With several exceptions, effects were usually observed in association with total PAH concentrations of about 11000 ppb or greater. There is an apparent effects threshold among the data at about 22000 ppb; effects were usually observed at higher total PAH concentrations. The 50 percentile value in the data suggests an ER-M concentration of about 35000 ppb. This concentration is supported by the observations of low Massachusetts Bay species richness (mean of 35000 ppb) and high toxicity in Hampton Roads sediments (mean of 35700 ppb).

The majority of the data are available from matching biological and chemical analyses of field-collected samples, and, therefore, are subject to the weaknesses outlined earlier in this document. The data from the few SSBs in which individual PAH were quantified indicated very high LC50s (e.g., >180,000 ppb). The individual PAH that were quantified and the number of PAH that were quantified and summed differed among investigators. There are no effects thresholds predicted by EP methods available for a category of total PAH. Small clusters of data supported the ER-L and ER-M values. The total data set had an extremely wide range in concentrations. Because of these problems, the degree of confidence in the ER-L and ER-M values for total PAH should be considered as relatively low. However, there did appear to be a relatively clear overall threshold in the data. A much more standardized method of reporting results and more data are needed to determine the total PAH concentrations associated with measures of effects in sediments.

Table 68. Summary of sediment effects data available for total PAHs.

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET FOR LOW MOLECULAR WEIGHT PAH	
	- *R. abronius* amphipod bioassay	5200
	- oyster larvae (*C. gigas*) bioassay	5200
	- benthic community composition	6100
	- Microtox™ bioassay	5200

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Table 68. Total PAHs (continued)

References	Biological Approaches	Concentrations (ppb)
Apparent Effects Threshold		
1	1986 PUGET SOUND AET FOR HIGH MOLECULAR WEIGHT PAH	
	- *R. abronius* amphipod bioassay	18000
	- oyster larvae (*C. gigas*) bioassay	17000
	- benthic community composition	>51000
	- Microtox™ bioassay	12000
2	1988 PUGET SOUND AET FOR LOW MOLECULAR WEIGHT PAH	
	- *R. abronius* amphipod bioassay	24000
	- oyster larvae (*C. gigas*) bioassay	5200
	- benthic community composition	13000
	- Microtox™ bioassay	5200
2	1988 PUGET SOUND AET FOR HIGH MOLECULAR WEIGHT PAH	
	- *R. abronius* amphipod bioassay	69000
	- oyster larvae (*C. gigas*) bioassay	17000
	- benthic community composition	69000
	- Microtox™ bioassay	12000
20	- PSDDA screening level - low molecular weight PAH	610
	- PSDDA screening level - high molecular weight PAH	1800
	- PSDDA maximum level - low molecular weight PAH	6100
	- PSDDA maximum level - high molecular weight PAH	51000
*	SAN FRANCISCO BAY, CALIFORNIA AET	
	- bivalve larvae bioassay	870
	- *R. abronius* amphipod bioassay	>15000
84	MISSISSIPPI SOUND, MISSISSIPPI AET	
	- AET for amphipod bioassay	>205000
	- AET for mysid bioassay	99400
Co-Occurrence Analyses		
80	COMMENCEMENT BAY, WASHINGTON: LOW MOLECULAR WEIGHT PAH	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	6977 ± 8437
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	2031 ± 1316
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	1602 ± 1411
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	3835 ± 4852
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	2003 ± 1405
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	1019 ± 943
80	COMMENCEMENT BAY, WASHINGTON: HIGH MOLECULAR WEIGHT PAH	
	- highly toxic (15.7 ± 3.9 dead/20) to *R. abronius*	9794 ± 12821
	- moderately toxic (5.2 ± 1.1 dead/20) to *R. abronius*	6178 ± 6438
	- least toxic (2.5 ± 0.9 dead/20) to *R. abronius*	4865 ± 4800
	- highly toxic (44.5 ± 19% abnormal) to oyster larvae	9042 ± 9573
	- moderately toxic (23 ± 2.3% abnormal) to oyster larvae	5838 ± 4042
	- least toxic (15.1 ± 3.1% abnormal) to oyster larvae	2686 ± 2631

Table 68. Total PAHs (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
*	SAN FRANCISCO BAY, CALIFORNIA	
	- highly toxic (67 ± 11.8% mortality) to *R. abronius*	4227 ± 5025
	- moderately toxic (33.8 ± 4.7% mortality) to *R. abronius*	3966 ± 3524
	- least toxic (18 ± 6.6% mortality) to *R. abronius*	3323 ± 4337
	- significantly toxic (42.9 ± 19.2% mortality) to *R. abronius*	3832 ± 3927
	- not toxic (18.4 ± 6.8% mortality) to *R. abronius*	3527 ± 4520
	- highly toxic (92.4 ± 4.5% abnormal) to bivalve larvae	11735 ± 5499
	- moderately toxic (59.4 ± 11.3% abnormal) to bivalve larvae	3343 ± 4039
	- least toxic (23.3 ± 7.3% abnormal) to bivalve larvae	941 ± 429
	- significantly toxic (55.7 ± 22.7% abnormal) to bivalve larvae	4022 ± 4908
	- not toxic (31.9 ± 15.5% abnormal) to bivalve larvae	2557 ± 3816
7	- sediment quality triad significant bioeffects	≥9500
	- sediment quality triad minimum bioeffects	≤3800
	PUGET SOUND, WASHINGTON	
57	- highly toxic in Microtox™ bioassay	55630 ± 112530
	- moderately toxic in Microtox™ bioassay	13933 ± 17427
	- least toxic in Microtox™ bioassay	763 ± 727
26	- highly toxic (95% LPL) to *R. abronius*	11752 ± 14548
	- moderately toxic (<87.5% survival to <95% LPL) to *R. abronius*	7627 ± 7065
	- least toxic (<87.5% survival) to *R. abronius*	4201 ± 4612
52	COLUMBIA RIVER, WASHINGTON	
	- low toxicity (0-13% mortality) to *H. azteca*	19000
84	MISSISSIPPI SOUND, MISSISSIPPI	
	- highly toxic (90 ± 11.7% mortality) to mysid *M. almyra*	11400 ± 14100
	- moderately toxic (53.5 ± 7.4% mortality) to mysid *M. almyra*	66100 ± 83300
	- least toxic (8 ± 8.8% mortality) to mysid *M. almyra*	8550 ± 23000
	- significant mortality (71.8 ± 21.4%) to mysid *M. almyra*	41790 ± 66160
	- low mortality (8 ± 8.8%) to mysidd *M. almyra*	8550 ± 22990
	- highly toxic (76.9 ± 24.1% mortality) to amphipod *G. mucronatus*	47760 ± 74890
	- least toxic (14.4 ± 5.9% mortality) to amphipod *G. mucronatus*	9730 ± 22390
	- significantly toxic (80.7 ± 23.2% mortality) to amphipod *G. mucronatus*	21600 ± 31000
	- not toxic (16 ± 9.4% mortality) to amphipod *G. mucronatus*	18600 ± 47000
79	HUDSON-RARITAN ESTUARY, NEW YORK	
	- negative growth in nematode bioassay	42769 ± 46084
	- positive growth in nematode bioassay	21467 ± 31160
81	FORTH ESTUARY, SCOTLAND	
	- low meiofaunal density (112.4 ± 123/sample)	83800 ± 57900
	- moderate meiofaunal density (1334 ± 396/sample)	11800 ± 9700
	- high meiofaunal density (3542± 1774/sample)	10200 ± 9950

Table 68. Total PAHs (continued)

References	Biological Approaches	Concentrations (ppb)
Co-Occurrence Analyses		
82	MASSACHUSETTS BAY, MASSACHUSETTS	
	- low macrofaunal species richness (31 ± 6.5)	35000 ± 25400
	- moderate macrofaunal species richness (58.1 ± 10.4)	23100 ± 15400
	- high macrofaunal species richness (93.6 ± 9.4)	8700 ± 12600
31	HAMPTON ROADS, VIRGINIA	
	- highly toxic (70 ± 20.3% mortality) to *P. pugio* shrimp	35700 ± 42181
	- moderately toxic (8.8 ± 1.8% mortality) to *P. pugio* shrimp	12325 ± 10425
	- least toxic (2.2 ± 1.8% mortality) to *P. pugio* shrimp	16921 ± 20976
	ELIZABETH RIVER, VIRGINIA	
37	- 56% overall mortality among spot *L. xanthurus*	3900000
	- 100% fin erosion among spot *L. xanthurus*	3900000
47	- 100% mortality to *L. xanthurus* exposed to 100% Elizabeth River sediment	11872000
	- LC50 (24-h) for *L. xanthurus* exposed to 56% Elizabeth River sediment	530000
	- LC50 (28-d) for *L. xanthurus* exposed to 2.5% Elizabeth River sediment	21200000
56	SOUTHERN CALIFORNIA	
	- significantly toxic (51.7% mortality) to *G. japonica*	8363
	- not toxic (23.2% mortality) to *G. japonica*	2242
58	BLACK HARBOR, CONNECTICUT	
	- projected concentrations significantly toxic to *A. abdita* amphipod	11273
21	EAGLE HARBOR, WASHINGTON	
	- predicted LC50 concentration toxic to *R. abronius*	2590
Spiked-Sediment Bioassays		
59	- elevated liver/somatic indices in winter flounder *P. americanus*	228722
	- elevated liver MFO induction in winter flounder *P. americanus*	183060
	- elevated kidney MFO induction in winter flounder *P. americanus*	295860
28	- Bunker C oil LC50 for *R. abronius*	2240000
30	- low (7.4%) abnormality in oyster larvae (*C. gigas*) exposed to petroleum products	10000

References:

1. Beller *et al.*, 1986
2. PTI Environmental Services, 1988
7. Chapman *et al.*, 1987
20. U. S. ACOE, 1988
21. Swartz *et al.*, 1989
26. DeWitt *et al.*, 1988
28. Kemp *et al.*, 1986
30. E. V. S. Consultants, 1988
31. Alden and Butt, 1987
37. Hargis *et al.*, 1984
47. Roberts *et al.*, 1989
52. Johnson and Norton, 1988
56. Anderson *et al.*, 1988
57. Schiewe *et al.*, 1984
58. Rogerson *et al.*, 1988
59. Payne *et al.*, 1988
79. Tietjen *et al.*, 1984
80. Tetra Tech, 1985
81. Long, 1987
82. Gilbert *et al.*, 1976
84. Lytle and Lytle, 1985

* various, see text

Table 69. Effects range-low and effects range-median values for total PAHs and 34concentrations used to determine these values arranged in ascending order.

Concentrations (ppb)	End Point
870	San Francisco Bay AET--bivalve
2590	Predicted LC50 Eagle Harbor--amphipod COA
3343	San Francisco Bay moderately toxic--bivalve COA
3800	San Francisco Bay triad minimum bioeffects COA
4000	**ER-L**
4022	San Francisco Bay significantly toxic--bivalve COA
7627	Puget Sound moderately toxic--amphipod COA
7841	Commencement Bay moderately toxic--oyster COA
8363	Southern California significantly toxic--amphipod COA
9500	San Francisco Bay triad significant bioeffects COA
11273	Black Rock Harbor significantly toxic--amphipod COA
11735	San Francisco Bay highly toxic--bivalve COA
11752	Puget Sound highly toxic--amphipod COA
12877	Commencement Bay highly toxic--oyster COA
13933	Puget Sound moderately toxic--Microtox™ COA
16771	Commencement Bay highly toxic-amphipod COA
23100	Massachusetts Bay moderate species richness COA
35000	Massachusetts Bay low species richness COA
35000	**ER-M**
35700	Hampton Roads highly toxic--shrimp COA
41790	Mississippi Sound significantly toxic--mysid COA
42769	Hudson-Raritan highly toxic--nematode COA
47760	Mississippi Sound highly toxic--amphipod COA
55630	Puget Sound highly toxic--Microtox™ COA
66100	Mississippi Sound moderately toxic--mysid COA
83800	Forth Estuary low meiofauna density COA
99400	Mississippi Sound AET--mysid bioassay
183060	SSB with winter flounder liver MFO
228722	SSB with winter flounder liver condition
295860	SSB with winter flounder kidney MFO
530000	LC50 2.5% Elizabeth River--spot COA
2240000	SSB with LC50 Bunker C oil--amphipod
3900000	56% mortality Elizabeth River--spot COA
3900000	100% fin erosion Elizabeth River--spot COA
11872000	LC50 56% Elizabeth River--spot COA
21200000	LC100 100% Elizabeth River--spot COA

DISCUSSION

Review of ER-L and ER-M values

The ER-L and ER-M concentrations for each chemical and chemical group are summarized and listed in Table 70. Also, the ratios between the respective ER-L and ER-M values for each chemical are listed as a measure of the spread or range in the chemical concentrations. This ratio was generally lowest (average of 4.2 to 1) for the trace metals (especially cadmium, chromium, arsenic, nickel, and zinc) and highest (average of 8.1 to 1) for the organic compounds (excluding total DDT, endrin, and dieldrin).

The available data for some chemicals indicate agreements among the various approaches and the various data sets that were evaluated. For example, there is a relatively large amount of data available for cadmium generated from a variety of methods. The Puget Sound AET concentrations range from 5.1 ppm to 9.6 ppm; the 10-d LC50 concentrations from many SSBs with amphipods range from 5.6 to 11.5 ppm; and significant toxicity to amphipods and reduced echinoderm abundance in Southern California sediments occurred in samples with mean cadmium concentrations of 5.3 and 6.2 ppm, respectively. Effects were not observed in sediments with cadmium concentrations of less than about 4 ppm. With some exceptions, biological effects were usually observed in association with cadmium concentrations of 5 ppm or greater. The preponderance of evidence from these data suggest that effects are likely or expected as cadmium concentrations in sediments reach about 5 ppm. Also, the effect of adding or deleting data upon the ER-L and ER-M values for cadmium would likely be relatively small.

For some other chemicals, there was less agreement among the data from various approaches and the degree of confidence in the accuracy of the resulting ER-L and ER-M values was relatively low. For example, the Puget Sound AET concentrations for chromium are 260 and 270 ppm, whereas effects were observed elsewhere in association with mean concentrations as low as 61 ppm and as high as 1646 ppm. Many of the biological measures of effects were not in concordance with chromium concentrations, suggesting that chromium had a minimal role or no role in causation. In another example, the SLCs for total PCBs range from 2.9 ppb to 42.6 ppb based upon a relatively large amount of data; whereas, the Puget Sound AET concentrations range from 130 ppb to 3100 ppb, the San Francisco Bay AET range from 54 to 260 ppb, the chronic marine threshold predicted by EP methods is 280 ppb, and the LC50 from a SSB performed with amphipods is 10800 ppb. The effect of adding or deleting data upon the ER-L or ER-M values could be significant for some of the chemicals for which there is little consistency or clustering in the data. Obviously, for many chemicals there is yet much to be learned as regards the chemical concentrations in sediments that cause biological effects.

The chemical concentrations associated with no effects often were as informative as the concentrations associated with measures of effects. Sediment bioassays performed with relatively highly contaminated sediments from San Diego Bay, New York Harbor, and Eagle Harbor indicated low toxicity; whereas, sediments from other areas or tested with other approaches with similar or lower chemical concentrations were very toxic. Assuming that these tests were conducted with proper methods, the data may suggest different degrees of availability of the sediment-sorbed chemicals. Based upon the methods described, we had no reason to eliminate these data.

Overall, the degree of confidence in the accuracy of the ER-L and ER-M values should be considered as moderate for the metals group and PCBs and low for the pesticide and PAH groups. Much more data are needed to support or refute the ER-L and ER-M values for all groups and for individual analytes within the groups.

Also included in Table 70 is a summary of the subjectively determined, overall apparent effects threshold for each chemical; the concentrations at and above which biological effects were usually or always observed. The ER-L and ER-M values were established objectively with *a priori* selection criteria, i.e., the lower 10 percentiles and 50 percentiles of the available data. They were not established following review and evaluation of the data for each chemical. However, following a review of the available data for each chemical, apparent effects thresholds were often observed and noted. These thresholds were established with a subjective approach. Therefore, they were identified and listed as evidence to support the accuracy of the ER-L/ER-M values and as hypotheses to be evaluated with additional data. They were not used to rank the NS&T Program sites. For several chemical analytes (i.e., chromium, total DDT, dieldrin), there was no apparent effects threshold. For many of the pesticides and aromatic hydrocarbons, there were insufficient data to determine a threshold, noted as not sufficient data (NSD) in Table 70. For many of the analytes, e.g., mercury, there were inconsistent data at concentrations above the apparent effects thresholds, i.e., data from some studies indicated no effects at relatively high concentrations of the analyte. The apparent effects thresholds for most of the trace metals, PCBs, DDT, and some of the aromatic hydrocarbons were very similar to the respective ER-M values or within the ER-L/ ER-M range. However, the apparent threshold was outside the ER-L/ER-M range for antimony and lead. The apparent effects threshold for antimony was 25 ppm, a concentration equivalent to the ER-M concentration. The apparent effects threshold for lead (300 ppm) on

Table 70. Summary of ER-L, ER-M, and overall apparent effects thresholds concentrations for selected chemicals in sediment (dry weight).

Chemical Analyte	ER-L Concentration	ER-M Concentration	ER-L:ER-M Ratio	Overall Apparent Effects Threshold	Subjective Degree of Confidence in ER-L/ER-M Values
Trace Elements (ppm)					
Antimony	2	25	12.5	25	Moderate/moderate
Arsenic	33	85	2.6	50	Low/moderate
Cadmium	5	9	1.8	5	High/high
Chromium	80	145	1.8	No	Moderate/moderate
Copper	70	390	5.6	300	High/high
Lead	35	110	3.1	300	Moderate/high
Mercury	0.15	1.3	8.7	1	Moderate/high
Nickel	30	50	1.7	NSD*	Moderate/moderate
Silver	1	2.2	2.2	1.7	Moderate/moderate
Tin	NA	NA	NA	NA	NA
Zinc	120	270	2.2	260	High/high
Polychlorinated Biphenyls (ppb)					
Total PCBs	50	400	7.6	370	Moderate/moderate
DDT and Metabolites (ppb)					
DDT	1	7	7	6	Low/low
DDD	2	20	10	NSD	Moderate/low
DDE	2	15	7.5	NSD	Low/low
Total DDT	3	350	117	No	Moderate/moderate
Other Pesticides (ppb)					
Lindane	NA	NA	NA	NSD	NA**
Chlordane	0.5	6	12	2	Low/low
Heptachlor	NA	NA	NA	NSD	NA
Dieldrin	0.02	8	400	No	Low/low
Aldrin	NA	NA	NA	NSD	NA
Endrin	0.02	45	2250	NSD	Low/low
Mirex	NA	NA	NA	NSD	NA
Polynuclear Aromatic Hydrocarbons (ppb)					
Acenaphthene	150	650	4.3	150	Low/low
Anthracene	85	960	11.3	300	Low/moderate
Benzo(a)anthracene	230	1600	7	550	Low/moderate
Benzo(a)pyrene	400	2500	6.2	700	Moderate/moderate
Benzo(e)pyrene	NA	NA	NA	NSD	NA
Biphenyl	NA	NA	NA	NSD	NA
Chrysene	400	2800	7	900	Moderate/moderate
Dibenz(a,h)anthracene	60	260	4.3	100	Moderate/moderate
2,6-dimethylnaphthylene	NA	NA	NA	NSD	NA
Fluoranthene	600	3600	6	1000	High/high
Fluorene	35	640	18.3	350	Low/low
1-methylnaphthalene	NA	NA	NA	NSD	NA
2-methylnaphthalene	65	670	10.3	300	Low/moderate
1-methylphenanthrene	NA	NA	NA	NSD	NA
Naphthalene	340	2100	6.2	500	Moderate/high
Perylene	NA	NA	NA	NSD	NA
Phenanthrene	225	1380	6.1	260	Moderate/moderate
Pyrene	350	2200	6.3	1000	Moderate/moderate
2,3,5-trimethylnaphthalene	NA	NA	NA	NSD	NA
Total PAH	4000	35000	8.8	22000	Low/low

* NSD = not sufficient data
** NA = not available

the other hand, was considerably higher than the respective ER-M concentration (110 ppm), resulting in a somewhat lower degree of confidence in the ER-M value for lead.

Evaluation of NS&T Program Data

The ER-L and ER-M concentrations were compared with the ambient concentrations measured by both the Benthic Surveillance Project (3-letter site location codes) and Mussel Watch Project (4-letter site description codes) of the NS&T Program. The data from the NS&T Program were assembled from (usually) 2 successive years of measurements at numerous sites around the coastal United States. Overall average concentrations were calculated for each analyte measured in sediments from each site. Those sites in which the average analyte concentrations exceeded the respective ER-M values are listed in Table 71. Those sites in which the average analyte concentrations exceeded the respective ER-L values, but not the ER-M values, are listed in Table 72.

The ER-L and ER-M values for arsenic were not reached or exceeded at any NS&T sampling site. The average ambient concentrations of antimony, cadmium, copper, and total PAH did not exceed the respective ER-M values at any of the sites.

Among the trace metals, the ER-M value for chromium was exceeded by sediments from the most sites (25 out of about 200 sites). The average chromium concentration of 2114 ppm observed in the sediments from site SAL (located in Salem Harbor, Massachusetts) was the highest, exceeding the ER-M value by over an order of magnitude. Chromium concentrations also were very high at sites PAB (in San Pablo Bay, California) and HMB (in Humboldt Bay, California). Average lead concentrations were highest in site OEIH (in the Oakland estuary, California), exceeding the ER-M by about twofold. The ER-M of 1.3 ppm for mercury was exceeded by the average concentrations at six sites, including an average of 3.3 ppm at site HRUB (located in the Hudson/Raritan estuary, New Jersey). The average nickel concentrations at 21 sites exceeded the ER-M value for nickel. The average silver concentration of 7.2 ppm at site BOS (located in Boston Harbor, Massachusetts) exceeded the ER-M by about threefold. All but one of the sites that exceeded the silver ER-M were located in Northeast estuaries or bays.

The ER-M concentrations for many of the aromatic hydrocarbons were either not exceeded by the average ambient concentrations or exceeded at only one or two sites. Site HRUB exceeded many of the ER-M values for individual PAH and nearly exceeded the ER-M value for total PAH. Site BOS also had relatively high concentrations of some PAHs.

The average PCB concentration in site BOS was about 20 times higher than the ER-M for PCB. PCB concentrations also were high at site SAWB (located in Saint Andrew Bay in western Florida). The ER-M for total DDT was exceeded by four sites in southern California located near each other (PVRP, SPFP, SPB, SPC) and a site (CBSP) in Choctawatchee Bay, Florida. Chlordane concentrations at site CBSP and at site OEIH, located in the Oakland Inner Harbor, California, were over two-fold higher than the ER-M value.

The ER-L concentration for arsenic was not exceeded at any of the sites. The ER-L values for many of the metals, notably, chromium, copper, lead, mercury, nickel, and zinc, were exceeded by the ambient concentrations at many of the sites (Table 72). The average cadmium concentrations and acenaphthene concentrations exceeded the respective ER-L values at only two sites each. Average ambient concentrations of dieldrin, total DDT, anthracene, benzo(a)anthracene, fluoranthene, phenanthrene, and pyrene at many sites exceeded the respective ER-L values. The ER-L concentrations were sufficiently low for dieldrin and total DDT, that the average concentrations at the majority of the NS&T Program sites exceeded them. The dieldrin and total DDT data from the NS&T Program suggest that the ER-L values for these two contaminants are possibly unrealistically low, since the concentrations at such a large number of sites exceeded them.

Tables 73 and 74 summarize and rank the sites in which the average analyte concentrations exceeded the most ER-M and ER-L values, respectively. Those sites that had the greatest numbers of exceedances were those in which the potential for adverse effects

were assumed to be the highest. The sediment collected at the OEIH and HRUB sites exceeded the most ER-M concentrations (Table 73). Sites HRRB and NYSH (both in the Hudson/Raritan estuary), LITN (western Long Island Sound), and BOS also exceeded many of the ER-M concentrations.

Sites BHDI (Boston Harbor), LISI, LIMR, LIHH (all Long Island Sound), and CBMP (Chesapeake Bay) exceeded the most ER-L concentrations (Table 74). As expected, the sediments from many more sites exceeded the ER-L concentrations than exceeded the ER-M values.

Overall cumulative ranks of the top 30 sites are listed in Table 75. These ranks were determined by considering exceedances of both the ER-L and ER-M concentrations. One point was assigned for each ER-L concentration exceeded by the sediments at each site. The average ratio of the ER-L values to the ER-M values in Table 70 was 4.2 for the metals and 8.1 for the organics (excluding total DDT, dieldrin, and endrin). Using these average ratios, 4.4 points were assigned for each metal ER-M that was exceeded at a site and 8.4 points for each organic ER-M that was exceeded. Then, the sum of the points for the ER-L and ER-M exceedances at each site was determined and used to formulate an overall rank of the sites.

Based upon this approach, site HRUB ranked highest in overall potential for inducing sediment-related effects (Table 75), followed by sites BOS, OEIH, and LITN. Sites LISI and LIMR sediments exceeded 20 ER-L concentrations each, but exceeded none of the ER-M concentrations. Sites PVRP, SPFP, SPB, and SPC, all located near Los Angeles, California, exceeded relatively few ER-L values, but exceeded some of the ER-M concentrations for DDT, its derivatives, and other organics. Only one site along the Gulf of Mexico coastline, site CBSP in Choctawatchee Bay, Florida, ranked among the top 30 sites. It had high concentrations of pesticides.

The sampling sites with the highest potential for adverse effects are located within the Hudson/Raritan estuary, western Long Island Sound, Boston Harbor, Chesapeake Bay, New York Bight, Oakland Inner Harbor of San Francisco Bay, St. Andrew Bay, Salem Harbor, and in parts of southern California near Los Angeles and San Pedro. Out of a total of 212 sampling sites, 172 sites exceeded at least one ER-L value. Most of the sites that did not exceed ER-L values were located along the Gulf Coast and along the outer coastal regions of the Pacific Coast. Site UISB, located in a very remote portion of Alaska and assumed to be a relatively pristine area, exceeded the ER-L values for antimony, chromium, and nickel.

CONCLUSIONS AND RECOMMENDATIONS

Effects-based national sediment quality criteria are not currently available for all of the NS&T Program analytes. Three major approaches to the determination of effects-based sediment quality standards have been used to generate an estimate of the concentrations of selected toxicants in sediments that may be associated with or the cause of biological effects. The three approaches involve the use of equilibrium-partitioning principles, spiked-sediment bioassays, and various methods of evaluating matching biological effects and chemical data from analyses of field-collected samples. The resulting sediment quality values derived from all three approaches were used in the present document and treated as equal. A preponderance of evidence from the various approaches was used to establish informal guidelines for use in the evaluation of NOAA NS&T Program sediment chemical data. By using a preponderance of evidence, the influence of any single value in setting guidelines was minimized. These guidelines were in two forms: concentrations at the low end of the range and equivalent to the median of the range within which biological effects were observed.

ER-L values were determined as the concentrations equivalent to the lower 10 percentile of the available data in which effects were detected. These values represent an approximation of the concentrations at which adverse effects were first detected. The ER-M values were determined as the concentrations equivalent to the median (50 percentile) of the available data in which effects were detected. These values represent an estimate of the concentrations at or above which effects were often detected. Both the ER-L and ER-M values were established objectively by determining the lower 10 percentile and 50 percentile points in the data. This approach followed that of Klapow and Lewis (1979) in which marine

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water quality standards for California were established. In that effort, Klapow and Lewis (1979) evaluated only spiked water bioassay data, i.e., they compared apples with apples. In the present effort, data from a variety of approaches and from studies performed in areas with significantly different pollution histories were evaluated, equivalent to comparing grapes and watermelons. The necessity to compare grapes and watermelons is symptomatic of the current status of knowledge regarding the degree of sediment contamination that is associated with measures of biological effects.

ER-L and ER-M guidelines were identified for most (31) of the chemical analytes that are quantified by the NS&T Program. However, no guidelines could be established for some analytes due to a lack of sufficient data. For some analytes, there was a very low degree of confidence in the accuracy of the guidelines, due mainly to relatively poor consistency among the data from the various approaches and/or due to a lack of data from multiple complimentary approaches. For a few analytes, such as cadmium, there was good consistency among the data. Data from many approaches converged upon a relatively small range in concentrations and an overall apparent effects threshold agreed with or was within the effects range, and, therefore, there was a relatively high degree in confidence in the informal guidelines. Except for these latter few analytes, it is very obvious that more data are needed to reduce the uncertainty in the data.

Table 71. ER-M concentrations for each NS&T Program analyte, NS&T Program sites that exceed the ER-M concentrations, geographic locations of those sites, and the average concentrations (dry weight) of the analyte at the site.

Site Description	Location	Concentration
Antimony (≥25 ppm) *		
Arsenic (≥85 ppm) *		
Cadmium (≥9 ppm) *		
Chromium (≥145 ppm)		**ppm**
BBSM	Bellingham Bay, Washington	203.0
BHDI	Boston Harbor, Massachusetts	190.7
BHDB	Boston Harbor, Massachusetts	186.7
HRLB	Hudson-Raritan Estuary, New Jersey	147.2
HRRB	Hudson-Raritan Estuary, New Jersey	170.0
LITN	Long Island Sound, New York	161.4
NYSH	New York Bight, New Jersey	166.7
PVRP	Palos Verdes, California	156.7
PVMC	Port Valdez, Alaska	156.7
SFDB	San Francisco Bay, California	170.0
SFEM	San Francisco Bay, California	178.3
SFSM	San Francisco Bay, California	167.5
SPSP	San Pablo Bay, California	185.0
TBSR	Tomales Bay, California	218.3
YHSS	Yaquina Bay, Oregon	176.7
OEIH	Oakland Estuary, California	186.7
BOD	Bodega Bay, California	349.7
BOS	Boston Harbor, Massachusetts	263.3
HMB	Humboldt Bay, California	453.7
HUN	San Francisco Bay, California	269.7
OAK	Oakland Estuary, California	196.0
PAB	San Pablo Bay, California	521.8
RAR	Raritan Bay, New Jersey	188.9
SAL	Salem Harbor, Massachusetts	2114.7
SHS	San Francisco Bay, California	259.2

Table 71. (continued)

Site Description	Location	Concentration
Copper (≥390 ppm) *		
Lead (≥110 ppm)		ppm
BHDI	Boston Harbor, Massachusetts	110.0
BHDB	Boston Harbor, Massachusetts	132.3
HRLB	Hudson/Raritan Estuary, New Jersey	143.7
HRUB	Hudson/Raritan Estuary, New Jersey	137.3
HRRB	Hudson/Raritan Estuary, New Jersey	196.7
LIHH	Long Island Sound, New York	140.0
LITN	Long Island Sound, New York	172.2
NYSH	New York Bight, New Jersey	154.5
OEIH	Oakland Estuary, California	206.7
BOS	Boston Harbor, Massachusetts	127.0
LNB	Long Beach Harbor, California	126.3
RAR	Raritan Bay, New Jersey	182.3
SAL	Salem Harbor, Massachusetts	167.2
Mercury (≥1.3 ppm)		ppm
HRLB	Hudson/Raritan Estuary, New Jersey	1.6
HRUB	Hudson/Raritan Estuary, New Jersey	3.3
HRRB	Hudson/Raritan Estuary, New Jersey	2.4
NYSH	New York Bight, New Jersey	1.8
OEIH	Oakland Estuary, California	2.3
RAR	Raritan Bay, New Jersey	2.3
Nickel (≥50 ppm)		ppm
BBSM	Bellingham Bay, Washington	168.3
BPBP	Barber's Point, Hawaii	58.3
CBHP	Chesapeake Bay, Maryland	55.0
CBMP	Chesapeake Bay, Maryland	64.7
OEIH	Oakland Estuary, California	133.3
PVMC	Port Valdez, Alaska	65.7
SFDB	San Francisco Bay, California	90.8
SFEM	San Francisco Bay, California	110.0
SFSM	San Francisco Bay, California	112.5
SPFP	San Pedro Bay, California	55.0
SPSP	San Pablo Bay, California	121.8
TBSR	Tomales Bay, California	166.7
WIPP	Whidbey Island, Washington	56.4
BOD	Bodega Bay, California	54.8
HMB	Humboldt Bay, California	60.1
HUN	San Francisco Bay, California	100.3
OAK	Oakland Estuary, California	104.0
PAB	San Pablo Bay, California	87.8
SHS	San Francisco Bay, California	72.1
UCB	Chesapeake Bay, Maryland	62.2
Silver (≥2.2 ppm)		ppm
BHDI	Boston Harbor, Massachusetts	3.1
BHDB	Boston Harbor, Massachusetts	3.1
HRJB	Hudson/Raritan Estuary, New Jersey	2.4
HRLB	Hudson/Raritan Estuary, New Jersey	4.6

Table 71. (continued)

Site Description	Location	Concentration
Silver (continued)		ppm
HRUB	Hudson/Raritan Estuary, New Jersey	3.4
HRRB	Hudson/Raritan Estuary, New Jersey	4.8
LIHH	Long Island Sound, New York	4.9
LITN	Long Island Sound, New York	5.7
NBMH	Narragansett Bay, Rhode Island	2.2
NYSH	New York Bight	4.0
PVRP	Palos Verdes, California	2.8
BOS	Boston Harbor, Massachusetts	7.2
RAR	Raritan Bay, New Jersey	4.7
Zinc (≥270 ppm)		ppm
CBHP	Chesapeake Bay, Maryland	300.0
CBMP	Chesapeake Bay, Maryland	385.0
HRRB	Hudson/Raritan Estuary, New Jersey	366.7
LIHH	Long Island Sound, New York	283.3
NYSH	New York Bight, New Jersey	281.7
OEIH	Oakland Estuary, California	330.0
RAR	Raritan Bay, New Jersey	421.5
SDA	San Diego Bay, California	324.2
PCBs (≥380 ppb)		ppb
BBAR	Buzzards Bay, Massachusetts	451.2
BHDB	Boston Harbor, Massachusetts	642.2
HRRB	Hudson/Raritan Estuary, New Jersey	393.7
LITN	Long Island Sound, Connecticut	499.2
NYSH	New York Bight, New Jersey	431.2
PVRP	Palos Verdes, California	568.6
SAWB	Saint Andrew Bay, Florida	940.8
BOS	Boston Harbor, Massachusetts	7852
ELL	Elliott Bay, Washington	415
RAR	Hudson/Raritan Bay, New Jersey	529
SAL	Salem Harbor, Massachusetts	403
SDA	San Diego Harbor, California	399
Dieldrin (≥8 ppb)		ppb
BHDB	Boston Harbor, Massachusetts	12.9
OEIH	Oakland Estuary, California	12.0
LITN	Long Island Sound, New York	9.6
DDT (p,p' + o,p'-DDT) (≥7 ppb)		ppb
CBSP	Choctawatchee Bay, Florida	182.0
HRLB	Hudson/Raritan Estuary, New Jersey	9.1
MBTP	Matagorda Bay, Texas	9.6
MBTH	Moriches Bay, New York	14.9
OSBJ	Oceanside, California	7.6
OEIH	Oakland Estuary, California	10.1
PVRP	Palos Verdes, California	556.0
SPFP	San Pedro Harbor, California	7.1
SAWB	Saint Andrew Bay, Florida	8.3
RAR	Raritan Bay, New Jersey	8

Table 71. (continued)

Site Description	Location	Concentration
DDT (p,p' + o,p'-DDT) (continued)		ppm
SPB	San Pedro Bay, California	31.7
SPC	San Pedro Canyon, California	11.3
DDD (p,p' + o,p' - DDD) (≥20 ppb)		ppb
BHDB	Boston Harbor, Massachusetts	23.0
CBSP	Choctawatchee Bay, Florida	555.7
HRRB	Hudson/Raritan Estuary, New Jersey	27.3
HRLB	Hudson/Raritan Estuary, New Jersey	21.6
LIHH	Long Island Sound, Connecticut	24.6
LITN	Long Island Sound, Connecticut	47.8
NYSH	New York Bight, New Jersey	21.6
OEIH	Oakland Estuary, California	58.1
PVRP	Palos Verdes, California	815.2
SPFP	San Pedro Harbor, California	90.5
BOS	Boston Harbor, Massachusetts	44.2
LNB	Long Beach Harbor, California	30.7
SAL	Salem Harbor, Massachusetts	21.3
SPB	San Pedro Bay, California	45.7
SPC	San Pedro Canyon, California	54.0
DDE (p,p' + o,p' - DDE) (≥15 ppb)		ppb
ABWJ	Anaheim Bay, California	20.5
BHDB	Boston Harbor, Massachusetts	19.1
CBSP	Choctawatchee Bay, Florida	80.6
HRRB	Hudson/Raritan Estuary, New Jersey	15.7
HRLB	Hudson/Raritan Estuary, New Jersey	15.0
LITN	Long Island Sound, New York	21.7
MDSJ	Marina del Rey, California	57.4
NYSH	New York Bight, New York	19.3
NBBC	Newport Beach, California	19.4
OSBJ	Oceanside, California	27.8
PVRP	Palos Verdes, California	2063.3
SBSB	Point Santa Barbara, California	21.3
SPFP	San Pedro Harbor, California	663.5
BOS	Boston Harbor, Massachusetts	58.2
LNB	Long Beach Harbor, California	76.6
SEA	Seal Beach, California	22.2
SMB	Santa Monica Bay, California	19.0
SPB	San Pedro Bay, California	408.3
SPC	San Pedro Canyon, California	621.3
Total DDT (≥350 ppb)		ppb
CBSP	Choctawatchee Bay, Florida	818.3
PVRP	Palos Verdes, California	2936.4
SPFP	San Pedro Harbor, California	769.1
SPB	San Pedro Bay, California	485.4
SPC	San Pedro Canyon, California	578.6

Table 71. (continued)

Site Description	Location	Concentration
Chlordane (≥6 ppb)		ppb
CBSP	Choctawatchee Bay, Florida	18.9
HRJB	Hudson/Raritan Estuary, New Jersey	6.8
LIHH	Long Island Sound, New York	7.3
OEIH	Oakland Estuary, California	14.3
LITN	Long Island Sound, New York	8.5
Acenaphthene (≥650 ppb) *		ppb
Anthracene (≥960 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	1983.3
SAWB	Saint Andrew Bay, Florida	1082.3
SAL	Salem Harbor, Massachusetts	1100.6
Benzo(a)anthracene (≥1600 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	3258.3
Benzo(a)pyrene (≥2500 ppb)*		
Chrysene (≥2800 ppb) *		
Fluoranthene (≥3600 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	4616.7
Fluorene (≥640 ppb) *		
Naphthalene (≥2100 ppb) *		
Phenanthrene (≥1380 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	2505.8
Pyrene (≥2200 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	6096.7
2-methylnaphthalene (≥670 ppb)		ppb
HRUB	Hudson/Raritan Estuary, New Jersey	830.0
BOS	Boston Harbor, Massachusetts	3774.3
Dibenz(a,h)anthracene (≥260 ppb)		ppb
BOS	Boston Harbor, Massachusetts	385.6
Total PAH (≥35000 ppb)*		ppb

* Ambient concentrations at none of the sites exceeded or equaled the ER-M for these chemical analytes.

Table 72. ER-L and ER-M concentrations for each NS&T Program analyte, NS&T Program sites at which the average concentrations exceeded the ER-L concentrations but not the ER-M concentrations, geographic locations of those sites, and the average concentrations (dry weight) of the analyte at the site.

Site Description	Location	Concentration
Antimony (≥2 <10 ppm)		ppm
BBSM	Bellingham Bay, Washington	3.6
BHDI	Boston Harbor, Massachusetts	6.5
BHDH	Boston Harbor, Massachusetts	7.4
BHHB	Boston Harbor, Massachusetts	3.9
CBMP	Chesapeake Bay, Maryland	3.9
CBTP	Commencement Bay, Washington	4.6
EBFR	Elliott Bay, Washington	6.4
HRJB	Hudson/Raritan Estuary, New Jersey	3.3
HRLB	Hudson/Raritan Estuary, New Jersey	3.6
HRUB	Hudson/Raritan Estuary, New Jersey	5.0
HRRB	Hudson/Raritan Estuary, New Jersey	6.0
LIHH	Long Island Sound, New York	3.2
LITN	Long Island Sound, New York	4.4
NBMH	Narragansett Bay, Rhode Island	2.4
NYSH	New York Bight, New Jersey	5.5
PVMC	Port Valdez, Alaska	2.9
SSBI	South Puget Sound, Washington	4.4
SIWP	Sinclair Inlet, Washington	9.7
UISB	Unakwit Inlet, Alaska	2.5
WIPP	Whidbey Island, Washington	3.4
BOS	Boston Harbor, Massachusetts	7.7
RAR	Raritan Bay, New Jersey	3.2
SAL	Salem Harbor, Massachusetts	3.2
UCB	Upper Chesapeake Bay, Maryland	2.1
Arsenic (≥33 <70 ppm) *		
Cadmium (≥5 <9 ppm)		ppm
PVRP	Palos Verdes, California	6.7
SAL	Salem Harbor, Massachusetts	6.2
Chromium (≥80 <145 ppm)		ppm
CBHP	Chesapeake Bay, Maryland	113
CBRP	Coos Bay, Oregon	89.2
DBAP	Delaware Bay, Delaware	90.7
DBBD	Delaware Bay, Delaware	87.0
EBFR	Elliott Bay, Washington	89.7
HRJB	Hudson-Raritan Estuary, New Jersey	113.7
HRUB	Hudson-Raritan Estuary, New Jersey	90.3
HMBJ	Humboldt Bay, California	98.3
LISI	Long Island Sound, Connecticut	81.7
LIHH	Long Island Sound, New York	131.7
LIHU	Long Island Sound, New York	80.6
LIMR	Long Island Sound, New York	109.6
BUZ	Buzzards Bay, Massachusetts	85.6
CHS	Charleston Harbor, South Carolina	81.1
COO	Coos Bay, Oregon	81.0
CSC	Casco Bay, Maine	92.6
ELL	Elliott Bay, Washington	91.8

Table 72 (continued)

Site Description	Location	Concentration
Chromium (continued))		ppm
FRN	Frenchman Bay, Maine	90.1
GRB	Great Bay, New Jersey	115.3
MOB	Mobile Bay, Alabama	91.7
NAR	Narragansett Bay, Rhode Island	101.6
NIS	Puget Sound, Washington	114.9
PEN	Pensacola Bay, Florida	102.1
PNB	Penobscot Bay, Maine	106.1
NBMH	Narragansett Bay, Rhode Island	140.0
PBSI	Penobscot Bay, Maine	93.8
PRPR	Point Roberts, Washington	89.5
SPFP	San Pedro Harbor, California	123.3
SIWP	Sinclair Inlet, Washington	135.0
TBHP	Tillamook Bay, Oregon	134.3
UISB	Unakwit Inlet, Alaska	128.3
WIPP	Whidbey Island, Washington	105.1
YBOP	Yaquina Bay, Oregon	107.3
JFNB	Neah Bay, Washington	114.7
SDA	San Diego Bay, California	129.8
SEA	Seal Beach, California	108.3
SPB	San Pedro Bay, California	93.0
SPC	San Pedro Canyon, California	106.5
UCB	Upper Chesapeake Bay, Maryland	125.2
WLI	West Long Island Sound, New York	134.2
Copper (≥70 <310 ppm)		ppm
BHDI	Boston Harbor, Massachusetts	103.3
BHDH	Boston Harbor, Massachusetts	118.0
HRLB	Hudson/Raritan Estuary, New Jersey	115.3
HRUB	Hudson/Raritan Estuary, New Jersey	101.0
HRRB	Hudson/Raritan Estuary, New Jersey	150.0
LINR	Long Island Sound, Connecticut	167.0
LIHH	Long Island Sound, New York	160.0
LIHU	Long Island Sound, New York	78.0
LIMR	Long Island Sound, New York	95.8
LITN	Long Island Sound, New York	178.8
NBMH	Narragansett Bay, Rhode Island	82.3
NYSH	New York Bight, New Jersey	126.7
PVRP	Palos Verdes, California	75.0
SPFP	San Pedro Harbor, California	181.7
SIWP	Sinclair Inlet, Washington	72.5
OEIH	Oakland Estuary, California	173.3
BOS	Boston Harbor, Massachusetts	157.1
ELL	Elliott Bay, Washington	93.0
NAR	Narragansett Bay, Rhode Island	79.2
OAK	Oakland Estuary, California	71.7
RAR	Raritan Bay, New Jersey	178.0
SAL	Salem Harbor, Massachusetts	82.3
SDA	San Diego Bay, California	207.3
SPB	San Pedro Bay, California	80.4
WLI	West Long Island Sound, New York	109.2

Table 72 (continued)

Site Description	Location	Concentration
Lead (≥35 <110 ppm)		ppm
ABWJ	Anaheim Bay, California	36.2
BHHB	Boston Harbor, Massachusetts	35.5
BBAR	Buzzards Bay, Massachusetts	48.5
CBHP	Chesapeake Bay, Maryland	72.2
CBSP	Choctawatchee Bay, Florida	86.7
HRJB	Hudson/Raritan Estuary, New Jersey	95.3
LICR	Long Island Sound, Connecticut	39.2
LISI	Long Island Sound, Connecticut	53.8
LIHU	Long Island Sound, New York	60.7
LIMR	Long Island Sound, New York	82.2
MBTH	Moriches Bay, New York	44.8
NBMH	Narragansett Bay, Rhode Island	91.7
NBCI	Narragansett Bay, Rhode Island	40.7
PVRP	Palos Verdes, California	49.7
SAWB	Saint Andrew Bay, Florida	40.9
SFDB	San Francisco Bay, California	38.7
SFEM	San Francisco Bay, California	35.0
SFSM	San Francisco Bay, California	35.8
SPFP	San Pedro Harbor, California	48.8
SIWP	Sinclair Inlet, Washington	61.8
SSBI	South Puget Sound, Washington	35.2
TBHB	Tampa Bay, Florida	62.8
GRB	Great Bay, New Jersey	36.6
NAR	Narragansett Bay, Rhode Island	60.0
OAK	Oakland Estuary, California	43.5
PEN	Pensacola Bay, Florida	41.7
SDA	San Diego Bay, California	86.9
SPB	San Pedro Bay, California	47.1
UCB	Upper Chesapeake Bay, Maryland	51.1
WLI	West Long Island Sound, New York	71.1
Mercury (≥0.15<1.0 ppm)		ppm
BBSM	Bellingham Bay, Washington	0.23
BHDI	Boston Harbor, Massachusetts	.69
BHDH	Boston Harbor, Massachusetts	.83
BHHB	Boston Harbor, Massachusetts	.21
CBHP	Chesapeake Bay, Maryland	.21
CBMP	Chesapeake Bay, Maryland	.22
DBBD	Delaware Bay, Delaware	.15
HHKL	Honolulu Harbor, Hawaii	.16
LICR	Long Island Sound, Connecticut	.16
LISI	Long Island Sound, Connecticut	.31
LIHH	Long Island Sound, New York	.60
LIHU	Long Island Sound, New York	.27
LIMR	Long Island Sound, New York	.37
MBGP	Matagorda Bay, Texas	.22
MBTH	Moriches Bay, New York	.29
NBDI	Narragansett Bay, Rhode Island	.15
NBMH	Narragansett Bay, Rhode Island	.81
NBCI	Narragansett Bay, Rhode Island	.16
PVRP	Palos Verdes, California	.40
PBSI	Penobscot Bay, Maine	.21

Table 72 (continued)

Site Description	Location	Concentration
Mercury (continued)		ppm
SAWB	Saint Andrew Bay, Florida	.32
SDHI	San Diego Bay, California	.34
SFDB	San Francisco Bay, California	.28
SFEM	San Francisco Bay, California	.32
SFSM	San Francisco Bay, California	.30
SPSP	San Pablo Bay, California	.27
SPFP	San Pedro Harbor, California	.46
SIWP	Sinclair Inlet, Washington	.80
SSBI	South Puget Sound, Washington	.21
TBSR	Tomales Bay, California	.37
DAN	Dana Point, California	.18
ELL	Elliott Bay, Washington	.43
GRB	Great Bay, New Jersey	.42
HUN	San Francisco Bay, California	.18
LUT	Lutak Inlet, Alaska	.24
NAH	Nahku Bay, Alaska	.23
NAR	Narragansett Bay, Rhode Island	.30
NIS	Puget Sound, Washington	.17
OAK	Oakland Estuary, California	.50
OLI	Oliktok Point, Alaska	.27
PAB	San Pablo Bay, California	.37
Nickel (≥30 <50 ppm)		ppm
BHDH	Boston Harbor, Massachusetts	30.8
CHFJ	Charleston Harbor, South Carolina	33.0
DBAP	Delaware Bay, Delaware	30.3
DBBD	Delaware Bay, Delaware	32.0
HRLB	Hudson/Raritan Estuary, New Jersey	33.5
HRUB	Hudson/Raritan Estuary, New Jersey	35.3
HRRB	Hudson/Raritan Estuary, New Jersey	40.3
LIHH	Long Island Sound, New York	41.2
LIMR	Long Island Sound, New York	38.7
LITN	Long Island Sound, New York	43.4
PRPR	Point Roberts, Washington	39.8
SIWP	Sinclair Inlet, Washington	47.0
SSBI	South Puget Sound, Washington	49.0
TBHP	Tillamook Bay, Oregon	42.7
BOS	Boston Harbor, Massachusetts	33.4
ELL	Elliott Bay, Washington	36.5
FRN	Frenchman Bay, Maine	31.9
LNB	Long Beach, California	41.7
MOB	Mobile Bay, Alabama	35.3
NIS	Puget Sound, Washington	33.5
OLI	Oliktok Point, Alaska	36.5
PNB	Penobscot Bay, Maine	32.6
RAR	Raritan Bay, New Jersey	39.3
SPB	San Pedro Bay, California	39.0
WLI	West Long Island Sound, New York	33.3

Table 72 (continued)

Site Description	Location	Concentration
Silver (≥1.0 <2.2 ppm)		**ppm**
BHHB	Boston Harbor, Massachusetts	1.1
CBSP	Choctawatchee Bay, Florida	1.0
LIMR	Long Island Sound, New York	1.4
MDSJ	Marina del Rey, California	1.0
SPFP	San Pedro Bay, California	1.0
OEIH	Oakland Estuary, California	1.3
NAR	Narragansett Bay, Rhode Island	1.2
SAL	Salem Harbor, Massachusetts	1.8
WLI	West Long Island Sound, New York	1.6
Zinc (≥120 <260 ppm)		**ppm**
BBSM	Bellingham Bay, Washington	128.3
BHDI	Boston Harbor, Massachusetts	145.2
BHDH	Boston Harbor, Massachusetts	182.8
DBAP	Delaware Bay, Delaware	139.0
HRJB	Hudson/Raritan Estuary, New Jersey	143.7
HRUB	Hudson/Raritan Estuary, New Jersey	204.7
LICR	Long Island Sound, Connecticut	127.2
LISI	Long Island Sound, Connecticut	161.5
LIHU	Long Island Sound, New York	181.3
LIMR	Long Island Sound, New York	213.3
NBMH	Narragansett Bay, Rhode Island	190.0
PVRP	Palos Verdes, California	193.3
PVMC	Port Valdez, Alaska	150.0
SDHI	San Diego Bay, California	124.3
SFDB	San Francisco Bay, California	136.7
SFSM	San Francisco Bay, California	127.5
SPSP	San Pablo Bay, California	131.7
SIWP	Sinclair Inlet, Washington	132.7
SSBI	South Puget Sound, Washington	123.3
TBSR	Tomales Bay, California	120.0
ELL	Elliott Bay, Washington	176.8
GRB	Great Bay, New Jersey	159.0
HUN	San Francisco Bay, California	127.3
LNB	Long Beach, California	195.7
LUT	Lutak Inlet, Alaska	180.8
MOB	Mobile Bay, Alabama	159.2
NAH	Nahku Bay, Alaska	191.3
NAR	Narragansett Bay, Rhode Island	143.4
OAK	Oakland Estuary, California	171.7
PEN	Pensacola Bay, Florida	138.2
SAL	Salem Harbor, Massachusetts	218.5
SEA	Seal Beach, California	125.0
SPB	San Pedro Bay, California	155.0
UCB	Upper Chesapeake Bay, Maryland	240.8
WLI	West Long Island Sound, New York	234.2
Acenaphthene (≥150 <650 ppb)		ppb
HRUB	Hudson/Raritan Bay, New Jersey	368.3
BOS	Boston Harbor, Massachusetts	158.8

Table 72 (continued)

Site Description	Location	Concentration
Anthracene (≥85 <900 ppb)		**ppb**
BHDI	Boston Harbor, Massachusetts	97.0
BHDH	Boston Harbor, Massachusetts	160.7
CBHP	Chesapeake Bay, Maryland	145.0
CBMP	Chesapeake Bay, Maryland	168.3
HRJB	Hudson/Raritan Estuary, New Jersey	160.0
HRLB	Hudson/Raritan Estuary, New Jersey	441.7
LICR	Long Island Sound, Connecticut	113.1
LIHR	Long Island Sound, Connecticut	140.0
LISI	Long Island Sound, Connecticut	262.0
LIHH	Long Island Sound, Connecticut	125.5
LITN	Long Island Sound, Connecticut	458.7
MSBB	Mississippi Sound, Mississippi	153.0
NBMH	Narragansett Bay, Rhode Island	85.7
NYSH	New York Bight, New York	228.3
PBPI	Penobscot Bay, Maine	93.3
PBSI	Penobscot Bay, Maine	89.7
SIWP	Sinclair Inlet, Washington	116.7
OEIH	Oakland Estuary, California	170.0
BOS	Boston Harbor, Massachusetts	804.9
BUZ	Buzzards Bay, Massachusetts	143.4
CHS	Charleston Harbor, South Carolina	135.6
CSC	Casco Bay, Maine	152.2
DEL	Delaware Bay, Delaware	110.0
ELL	Elliott Bay, Washington	156.7
GRB	Great Bay, New Jersey	120.8
HUN	San Francisco Bay, California	100.2
NAR	Narragansett Bay, Rhode Island	187.9
RAR	Raritan Bay, New Jersey	260.0
SDA	San Diego Bay, California	830.7
UCB	Upper Chesapeake Bay, Maryland	97.4
WLI	West Long Island Sound, New York	354.4
Benzo(a)anthracene (≥230 <1600 ppb)		**ppb**
BHDI	Boston Harbor, Massachusetts	470.0
BHDH	Boston Harbor, Massachusetts	816.7
BBAR	Buzzards Bay, Massachusetts	397.0
CBMP	Chesapeake Bay, Maryland	308.3
CBSP	Choctawatchee Bay, Florida	398.2
HRJB	Hudson/Raritan, New Jersey	261.7
HRLB	Hudson/Raritan, New Jersey	993.3
LICR	Long Island Sound, Connecticut	462.1
LIHR	Long Island Sound, Connecticut	443.3
LIMR	Long Island Sound, New York	335.0
LISI	Long Island Sound, Connecticut	530.7
LIHH	Long Island Sound, Connecticut	370.0
LITN	Long Island Sound, Connecticut	1107.9
NYSH	New York Bight, New Jersey	468.3
PBPI	Penobscot Bay, Maine	369.7
PBSI	Penobscot Bay, Maine	238.3
SAWB	Saint Andrew Bay, Florida	962.0
SFSM	San Francisco Bay, California	280.0
SIWP	Sinclair Inlet, [illegible]	[illegible]

Table 72 (continued)

Site Description	Location	Concentration
Benzo(a)anthracene(continued))		ppm
OEIH	Oakland Estuary, California	356.7
BOS	Boston Harbor, Massachusetts	971.7
ELL	Elliott Bay, Washington	308.3
HUN	San Francisco Bay, California	230.0
RAR	Raritan Bay, New Jersey	428.5
SAL	Salem Harbor, Massachusetts	635.7
SDA	San Diego Bay, California	361.7
WLI	West Long Island Sound, New York	246.4
Benzo(a)pyrene (≥400 <2600 ppb)		ppb
BBAR	Buzzards Bay Massachusetts	434.3
BHDH	Boston Harbor, Massachusetts	838.3
BHDI	Boston Harbor, Massachusetts	433.3
CBSP	Choctawatchee Bay, Florida	620.1
HHKL	Honolulu Harbor, Hawaii	413.3
HRLB	Hudson/Raritan Estuary, New Jersey	1005.0
HRUB	Hudson/Raritan Estuary, New Jersey	2958.3
LICR	Long Island Sound, Connecticut	477.9
LIHR	Long Island Sound, Connecticut	446.7
LIHH	Long Island Sound, New York	505.0
LIMR	Long Island Sound, New York	418.8
LISI	Long Island Sound, Connecticut	551.7
LITN	Long Island Sound, Connecticut	1305.0
NYSH	New York Bight, New Jersey	513.3
SAWB	Saint Andrew Bay, Florida	848.1
OEIH	Oakland Estuary, California	763.3
BOS	Boston Harbor, Massachusetts	555.2
HUN	San Francisco Bay, California	436.7
RAR	Raritan Bay, New Jersey	514.5
SAL	Salem Harbor, Massachusetts	504.8
SDA	San Diego Bay, California	935.0
WLI	West Long Island Sound, New York	409.2
Chrysene (≥400 <2800 ppb)		ppb
BBAR	Buzzards Bay, Massachusetts	422.7
BHDI	Boston Harbor, Massachusetts	545.0
BHDH	Boston Harbor, Massachusetts	960.0
CBMP	Chesapeake Bay, Maryland	483.3
HRLB	Hudson/Raritan Estuary, New Jersey	1000.0
HRUB	Hudson/Raritan Estuary, New Jersey	2653.3
LICR	Long Island Sound, Connecticut	510.0
LIHR	Long Island Sound, Connecticut	563.3
LIMR	Long Island Sound, New York	490.0
LISI	Long Island Sound, Connecticut	683.8
LIHH	Long Island Sound, Connecticut	561.7
LITN	Long Island Sound, Connecticut	1244.2
NYSH	Long Island Sound, Connecticut	541.7
OEIH	Oakland Estuary, California	566.7
SAWB	Saint Andrews Bay, Florida	419.8
BOS	Boston Harbor, Massachusetts	777.1
ELL	Elliott Bay, Washington	653.3

Table 72 (continued)

Site Description	Location	Concentration
Chrysene (continued))		ppm
RAR	Raritan Bay, New Jersey	519.8
SAL	Salem Harbor, Massachusetts	595.0
SDA	San Diego Bay, California	920.0
Fluoranthene (≥600 <3600 ppb)		ppb
BHDI	Boston Harbor, Massachusetts	723.3
BHDH	Boston Harbor, Massachusetts	1031.7
CBMP	Chesapeake Bay, Maryland	1338.8
CBSP	Choctawatchee Bay, Florida	646.7
HRLB	Hudson/Raritan Estuary, New Jersey	1481.7
LICR	Long Island Sound, Connecticut	778.3
LIHR	Long Island Sound, Connecticut	1216.7
LISI	Long Island Sound, Connecticut	1323.3
LIHH	Long Island Sound, Connecticut	835.0
LIMR	Long Island Sound, Connecticut	846.7
LITN	Long Island Sound, Connecticut	1576.2
NYSH	New York Bight, New Jersey	698.3
PBPI	Penobscot Bay, Maine	926.7
SAWB	Saint Andrew Bay, Florida	1503.7
OEIH	Oakland Estuary, California	826.7
BOS	Boston Harbor, Massachusetts	1401.4
ELL	Elliott Bay, Washington	618.3
RAR	Raritan Bay, New Jersey	615.7
SAL	Salem Harbor, Massachusetts	1031.9
Fluorene (≥35 <540 ppb)		ppb
BHDI	Boston Harbor, Massachusetts	37.0
BHDH	Boston Harbor, Massachusetts	54.8
CBHP	Chesapeake Bay, Maryland	134.5
CBMP	Chesapeake Bay, Maryland	145.0
HRJB	Hudson/Raritan Estuary, New Jersey	55.7
HRLB	Hudson/Raritan Estuary, New Jersey	114.8
HRUB	Hudson/Raritan Estuary, New Jersey	358.3
LISI	Long Island Sound, Connecticut	130.0
LIHH	Long Island Sound, Connecticut	66.8
LITN	Long Island Sound, Connecticut	109.9
MSBB	Mississippi Sound, Mississippi	68.8
NYSH	New York Bight, New Jersey	68.3
SAWB	Saint Andrew Bay, Florida	109.5
BOS	Boston Harbor, Massachusetts	246.0
ELL	Elliott Bay, Washington	83.8
RAR	Raritan Bay, New Jersey	49.2
SDA	San Diego Bay, California	129.0
SJR	Saint Johns River, Florida	43.2
UCB	Upper Chesapeake Bay, Maryland	87.8
Naphthalene (≥340 <2100 ppb)		ppb
CBMP	Chesapeake Bay, Maryland	415.0
HRUB	Hudson/Raritan Estuary, New Jersey	698.3
SAWB	Saint Andrew Bay, Florida	459.3

Table 72 (continued)

Site Description	Location	Concentration
Naphthalene (continued)		ppb
BOS	Boston Harbor, Massachusetts	1415.7
UCB	Upper Chesapeake Bay, Maryland	403.2
Phenanthrene (≥225 <1380 ppb)		ppb
BBSM	Bellingham Bay, Washington	285.0
BHDI	Boston Harbor, Massachusetts	353.3
BHDH	Boston Harbor, Massachusetts	543.3
BBRH	Buzzards Bay, Massachusetts	310.0
CBHP	Chesapeake Bay, Maryland	511.7
CBMP	Chesapeake Bay, Maryland	611.7
CBSP	Choctawatchee Bay, Florida	247.0
HRJB	Hudson/Raritan Estuary, New Jersey	269.0
HRLB	Hudson/Raritan Estuary, New Jersey	683.3
LICR	Long Island Sound, Connecticut	355.8
LIHR	Long Island Sound, Connecticut	600.0
LISI	Long Island Sound, Connecticut	872.7
LIHH	Long Island Sound, Connecticut	391.7
LIMR	Long Island Sound, Connecticut	345.0
LITN	Long Island Sound, Connecticut	753.3
MSBB	Mississippi Sound, Mississippi	295.8
NBDI	Narragansett Bay, Rhode Island	303.7
NYSH	New York Bight, New Jersey	366.7
PBPI	Penobscot Bay, Maine	398.0
PBSI	Penobscot Bay, Maine	261.7
SAWB	Saint Andrew Bay, Florida	448.8
OEIH	Oakland Estuary, California	326.7
BOS	Boston Harbor, Massachusetts	979.0
ELL	Elliott Bay, Washington	461.7
HUN	San Francisco Bay, California	321.7
RAR	Raritan Bay, New Jersey	310.4
SAL	Salem Harbor, Massachusetts	605.9
SDA	San Diego Bay, California	295.8
UCB	Upper Chesapeake Bay, Maryland	367.6
Pyrene (≥350 <2200 ppb)		ppb
BBMB	Barataria Bay, Louisiana	357.2
BPBP	Barbers Point, Hawaii	417.0
BIBI	Block Island, New Jersey	356.7
BHDI	Boston Harbor, Massachusetts	670.0
BHDH	Boston Harbor, Massachusetts	962.8
BBAR	Buzzards Bay, Massachusetts	458.3
BBRH	Buzzards Bay, Massachusetts	390.0
CBHP	Chesapeake Bay, Maryland	575.0
CBMP	Chesapeake Bay, Maryland	1058.3
CBSP	Choctawatchee Bay, Florida	572.8
HRJB	Hudson/Raritan Estuary, New Jersey	450.0
HRLB	Hudson/Raritan Estuary, New Jersey	1726.7
LICR	Long Island Sound, Connecticut	822.9
LIHR	Long Island Sound, Connecticut	1516.7
LISI	Long Island Sound, Connecticut	1226.7
LIHH	Long Island Sound, Connecticut	841.7

Table 72 (continued)

Site Description	Location	Concentration
Pyrene (continued)		ppb
LIMR	Long Island Sound, Connecticut	781.7
LITN	Long Island Sound, Connecticut	1927.1
NBDI	Narragansett Bay, Rhode Island	451.7
NBMH	Narragansett Bay, Rhode Island	426.7
NYSH	New York Bight, New Jersey	820.0
PBPI	Penobscot Bay, Maine	673.3
PBSI	Penobscot Bay, Maine	416.7
SAWB	Saint Andrew Bay, Florida	1659.0
SFDB	San Francisco Bay, California	543.3
SFSM	San Francisco Bay, California	617.5
SPFP	San Pedro Harbor, California	986.7
SIWP	Sinclair Inlet, Washington	590.0
OEIH	Oakland Estuary, California	1026.7
BOS	Boston Harbor, Massachusetts	1076.9
ELL	Elliott Bay, Washington	781.7
HUN	San Francisco Bay, California	773.3
OAK	Oakland Estuary, California	386.7
RAR	Raritan Bay, New Jersey	821.1
SAL	Salem Harbor, Massachusetts	1760.0
SDA	San Diego Bay, California	803.3
WLI	West Long Island Sound, New York	791.5
2-methylnaphthalene (≥65 <670 ppb)		ppb
BHDI	Boston Harbor, Massachusetts	87.7
BHDH	Boston Harbor, Massachusetts	107.8
BBAR	Buzzards Bay, Massachusetts	79.0
CBHP	Chesapeake Bay, Maryland	253.3
CBMP	Chesapeake Bay, Maryland	256.7
CBBP	Commencement Bay, Washington	76.0
HRJB	Hudson/Raritan Estuary, New Jersey	96.7
HRLB	Hudson/Raritan Estuary, New Jersey	195.0
LISI	Long Island Sound, Connecticut	66.7
LIHH	Long Island, Sound, Connecticut	67.5
LITN	Long Island Sound, Connecticut	258.8
NYSH	New York Bight, New Jersey	178.3
PBSI	Penobscot Bay, Maine	142.5
SAWB	Saint Andrew Bay, Florida	203.5
SPFP	San Pedro Harbor, California	120.7
COM	Commencement Bay, Washington	80.0
ELL	Elliott Bay, Washington	79.3
OLI	Oliktok Point, Alaska	142.7
RAR	Raritan Bay, New Jersey	116.3
UCB	Upper Chesapeake Bay, Maryland	248.0
Dibenz(a,h)anthracene (≥60 <260 ppb)		ppb
BAR	Barataria Bay, Louisiana	101.7
ELL	Elliott Bay, Washington	66.2
PEN	Pensacola Bay, Florida	85.8
RAR	Raritan Bay, New Jersey	111.5
SAL	Salem Harbor, Massachusetts	76.4

Table 72 (continued)

Site Description	Location	Concentration
Dibenz(a,h)anthracene (continued)		**ppb**
SDA	San Diego Bay, California	162.0
WLI	West Long Island Sound, New York	71.6
Total PAH (≥4000 <35000 ppb)		**ppb**
BHDI	Boston Harbor, Massachusetts	4054
BHDH	Boston Harbor, Massachusetts	6603
CBMP	Chesapeake Bay, Maryland	5950
HRLB	Hudson/Raritan Estuary, New Jersey	9388
HRUB	Hudson/Raritan estuary	29324
LICR	Long Island Sound, Connecticut	4000
LIHR	Long Island Sound, Connecticut	5573
LISI	Long Island Sound, Connecticut	5660
LIHH	Long Island Sound, Connecticut	4592
LITN	Long Island Sound, Connecticut	10395
NYSH	New York Bight, New Jersey	5070
OEIH	Oakland Estuary, California	5065
SAWB	Saint Andrew Bay, Florida	9233
BOS	Boston Harbor, Massachusetts	15045
ELL	Elliott Bay, Washington	4477
RAR	Raritan Bay, New Jersey	4649
SAL	Salem Harbor, Massachusetts	7180
SDA	San Diego Bay, California	5915
Chlordane (≥0.5 <6 ppb)		**ppb**
ABWJ	Anaheim Bay, California	0.9
BHDB	Boston Harbor, Massachusetts	2.4
BHDI	Boston Harbor, Massachusetts	3.2
BHHD	Boston Harbor, Massachusetts	0.7
BBRH	Buzzards Bay, Massachusetts	0.5
CASI	Cape Ann, Massachusetts	0.5
CHFJ	Charleston Harbor, South Carolina	0.5
CBHP	Chesapeake Bay, Maryland	1.8
CBMP	Chesapeake Bay, Maryland	1.1
CBIB	Chesapeake Bay, Maryland	0.6
DBAP	Delaware Bay, Delaware	0.6
DBKI	Delaware Bay, Delaware	0.5
GBYC	Galveston Bay, Texas	0.6
HRRB	Hudson/Raritan Estuary, New Jersey	4.2
HRLB	Hudson/Raritan estuary, New Jersey	5.0
HRUB	Hudson/Raritan Estuary, New Jersey	1.7
LICR	Long Island Sound, Connecticut	2.4
LIHR	Long Island Sound, Connecticut	2.5
LISI	Long Island Sound, Connecticut	1.0
LIHU	Long Island Sound, Connecticut	1.5
LIMR	Long Island Sound, Connecticut	3.0
MDSJ	Marina del Rey, California	1.1
MSBB	Mississippi Sound, Mississippi	1.0
MSPB	Mississippi Sound, Mississippi	0.5
MBTH	Moriches Bay, New York	0.9

Table 72. (continued)

Site Description	Location	Concentration
Chlordane (continued)		ppb
NYSH	New York Bight, New York	3.8
NBNB	Naples Bay, Florida	1.2
NBCI	Narragansett Bay, Rhode Island	0.7
NBDI	Narragansett Bay, Rhode Island	0.9
NBMH	Narragansett Bay, Rhode Island	0.9
OSBJ	Oceanside, California	0.6
PVRP	Palos Verdes, California	1.9
PBPI	Penobscot Bay, Maine	0.8
PBSI	Penobscot Bay, Maine	0.6
SBSB	Point Santa Barbara, California	1.0
RBHC	Rookery Bay, Florida	0.6
SPSM	San Pablo Bay, California	1.0
SPSP	San Pablo Bay, California	0.6
SPFP	San Pedro Harbor, California	2.6
SAWB	Saint Andrew Bay, Florida	2.2
SJCB	Saint Johns River, Florida	0.9
TBMK	Tampa Bay, Florida	1.6
TBPB	Tampa Bay, Florida	2.5
DDT (p,p' + o,p'-DDT) (≥1 <7 ppb)		ppb
BHDB	Boston Harbor, Massachusetts	2.2
BHDI	Boston Harbor, Massachusetts	4.2
CBHP	Chesapeake Bay, Maryland	1.8
CBMP	Chesapeake Bay, Maryland	1.3
CBSR	Choctawatchee Bay, Florida	6.6
CRYB	Columbia River, Oregon	1.4
DBAP	Delaware Bay, Delaware	1.2
DBFE	Delaware Bay, Delaware	5.6
HRRB	Hudson/Raritan Estuary, New Jersey	2.6
HRJB	Hudson/Raritan Estuary, New Jersey	5.3
HRUB	Hudson/Raritan Estuary, New Jersey	5.8
LICR	Long Island Sound, Connecticut	5.0
LIHR	Long Island Sound, Connecticut	6.9
LIHH	Long Island Sound, Connecticut	5.5
LIHU	Long Island Sound, Connecticut	1.6
LIMR	Long Island Sound, Connecticut	2.2
LITN	Long Island Sound, Connecticut	6.1
MDSJ	Marina del Rey, California	2.0
MBSC	Monterey Bay, California	1.5
NYSH	New York Bight, New York	4.6
NBMH	Narragansett Bay, Rhode Island	1.2
PBSI	Penobscot Bay, Maine	1.2
PLLH	Point Loma, California	2.8
SBSB	Point Santa Barbara, California	1.5
SFDB	San Francisco Bay, California	3.3
SFEM	San Francisco Bay, California	4.9
SPSM	San Pablo Bay, California	4.6
SPSP	San Pablo Bay, California	2.0
SIWP	Sinclair Inlet, Washington	5.5
SSBI	South Puget Sound, Washington	3.2
TBHB	Tampa Bay, Florida	1.5
TBPB	Tampa Bay, Florida	2.0
WIPP	Whidbey Island, Washington	3.0

Table 72. (continued)

Site Description	Location	Concentration
DDT (p,p' + o,p'-DDT) (continued)		ppb
BOS	Boston Harbor, Massachusetts	2.1
GRB	Great Bay, New Jersey	1.3
LNB	Long Beach Harbor, California	2.7
SAL	Salem Harbor, Massachusetts	2.6
SMB	Santa Monica Bay, California	1.0
DDD (p,p' + o,p'-DDD) (≥2 <20 ppb)		ppb
ABWJ	Anaheim Bay, California	4.6
BBAR	Buzzards Bay, Massachusetts	2.1
BBSM	Bellingham Bay, Washington	2.4
BHDI	Boston Harbor, Massachusetts	12.6
BHHB	Boston Harbor, Massachusetts	3.3
CBHP	Chesapeake Bay, Maryland	8.5
CBMP	Chesapeake Bay, Maryland	8.0
CBSR	Choctawatchee Bay, Florida	2.6
CRYB	Columbia River, Oregon	2.3
DBAP	Delaware Bay, Delaware	7.5
DBFE	Delaware Bay, Delaware	6.3
DBKI	Delaware Bay, Delaware	3.9
ECSP	East Cote Blanche, Louisiana	2.0
HRJB	Hudson/Raritan Estuary, New Jersey	19.0
HRUB	Hudson/Raritan Estuary, New Jersey	13.2
LIHR	Long Island Sound, Connecticut	19.7
LISI	Long Island Sound, Connecticut	4.7
LIHU	Long Island Sound, Connecticut	7.7
LIMR	Long Island Sound, Connecticut	13.7
MDSJ	Marina del Rey, California	13.2
MBLR	Matagorda Bay, Texas	5.5
MBTD	Matagorda Bay, Texas	2.8
MSBB	Mississippi Sound, Mississippi	2.5
MBCP	Mobile Bay, Alabama	3.5
BMTH	Moriches Bay, New York	9.2
NBCI	Narragansett Bay, Rhode Island	3.5
NBMH	Narragansett Bay, Rhode Island	5.1
NBBC	Narragansett Bay, Rhode Island	3.7
OSBJ	Oceanside, California	14.8
PBSI	Penobscot Bay, Maine	2.6
SBSB	Point Santa Barbara, California	10.1
SDHI	San Diego Bay, California	4.7
SFDB	San Francisco Bay, California	8.4
SFEM	San Francisco Bay, California	18.0
SFSM	San Francisco Bay,. California	3.4
SPSM	San Pablo Bay, California	14.7
SPSP	San Pablo Bay, California	6.9
SIWP	Sinclair Inlet, Washington	2.8
SSBI	South Puget Sound, Washington	2.0
SAWB	Saint Andrew Bay, Florida	16.2
SJCB	Saint Johns River, Florida	5.8
TBHB	Tampa Bay, Florida	5.0
TBPB	Tampa Bay, Florida	3.1
WIPP	Whidbey Island, Washington	3.4
COM	Commencement Bay, Washington	2.7
CSC	Casco Bay, Maine	2.0

Table 72. (continued)

Site Description	Location	Concentration
DDD (p,p' + o,p'-DDD) (continued)		**ppb**
ELL	Elliott Bay, Washington	8.2
GRB	Great Bay, New Jersey	3.8
HUN	San Francisco Bay, California	3.0
MRD	Mississippi Delta, Mississippi	3.8
NAR	Narragansett Bay, Rhode Island	2.4
OAK	Oakland Estuary, California	3.7
RAR	Raritan Bay, New Jersey	19.3
SDA	San Diego Bay, California	5.6
SEA	Seal Beach, California	5.1
SJR	Saint Johns River, Florida	2.2
SMB	Santa Monica Bay, California	4.9
UCB	Upper Chesapeake Bay, Maryland	3.1
WLI	West Long Island Sound, New York	3.7
DDE (p,p' + o,p'-DDE) (≥2 <15 ppb)		**ppb**
APDB	Apalachicola Bay, Florida	3.2
BBAR	Buzzards Bay, Massachusetts	6.1
BBRH	Buyzzards Bay, Massachusetts	2.8
BHDI	Boston Harbor, Massachusetts	7.3
BHHB	Boston Harbor, Massachusetts	2.1
CBHP	Chesapeake Bay, Maryland	3.7
CBMP	Chesapeake Bay, Maryland	4.2
CBSR	Choctawatchee Bay, Florida	3.3
DBAP	Delaware Bay, Delaware	6.5
DBBD	Delaware Bay, Delaware	3.1
DBFE	Delaware Bay, Delaware	4.1
DBKI	Delaware Bay, Delaware	3.8
HRJB	Hudson/Raritan Estuary, New Jersey	14.0
HRUB	Hudson/Raritan Estuary, New Jersey	6.5
LJLJ	La Jolla, California	6.5
LICR	Long Island Sound, Connecticut	5.2
LIHR	Long Island Sound, Connecticut	2.8
LISI	Long Island Sound, Connecticut	2.0
LIHH	Ling Island Sound, Connecticut	11.1
LIHU	Long Island Sound, Connecticut	3.9
LIMR	Long Island Sound, Connecticut	5.3
MBTP	Matagordo Bay, Texas	2.1
MBVB	Mission Bay, Callifornia	4.3
MBCP	Mobile Bay, Alabama	5.3
MBTH	Moriches Bay, New York	2.4
MBSC	Monterey Bay, California	3.8
NBMH	Narragansett Bay, Rhode Island	3.9
PLLH	Point Loma, California	12.9
SFDB	San Francisco Bay, California	4.9
SFEM	San Francisco Bay, California	5.1
SFSM	San Francisco Bay, California	3.1
SPSM	San Pablo Bay, California	6.3
SPSP	San Pablo Bay, California	3.8
SAWB	Saint Andrew Bay, Florida	14.7
TBPB	Tampa Bay, Florida	5.4
WIPP	Whidbey Island, Washington	3.3
APA	Apalachicola Bay, Florida	2.1

Table 72. (continued)

Site Description	Location	Concentration
DDE (p,p' + o,p'-DDE) (continued)		**ppb**
SDHI	San Diego Bay, California	3.7
GRB	Great Bay, New Jersey	2.3
MOB	Mobile Bay, Alabama	3.0
NAR	Narragansett Bay, Rhode Island	2.6
RAR	Raritan Bay, New Jersey	8.6
SAL	Salem Harbor, Massachusetts	7.3
SDA	San Diego Bay, California	3.5
SDF	San Diego Bay, California	13.6
WLI	West Long Island Sound, New York	2.4
Total DDT (≥3 <350 ppb)		**ppb**
ABWJ	Anaheim Bay, California	25.8
APDB	Apalachicola Bay, Florida	5.2
ABOB	Atchafalaya Bay, Louisiana	4.1
BBAR	Buzzards Bay, Massachusetts	8.2
BBSM	Bellingham Bay, Washington	4.5
BHHB	Boston Harbor, Massachusettz	5.9
BHDI	Boston Harbor, Massachusetts	24.1
BHDB	Boston Harbor, Massachusetts	44.4
CASI	Cape Ann, Massachusetts	3.3
CBMP	Chesapeake Bay, Maryland	13.5
CBHP	Chesapeake Bay, Maryland	13.9
CBSR	Choctawhatchee Bay, Florida	12.5
CRYB	Columbia River, Oregon	4.9
DBBD	Delaware Bay, Delaware	5.9
DBKI	Delaware Bay, Delaware	7.8
DBAP	Delaware Bay, Delaware	15.2
DBFE	Delaware Bay, Delaware	17.2
ECSP	East Cote Blanche, Louisiana	3.2
HRRB	Hudson/Raritan Estuary, New Jersey	45.6
HRUB	Hudson/Raritan Estuary, New York	25.4
HRJB	Hudson/Raritan Estuary, New York	38.3
HRLB	Hudson/Raritan Estuary, New Jork	45.6
LJLJ	La Jolla, California	8.6
LISI	Long Island Sound, Connecticut	7.0
LICR	Long Island Sound, Connecticut	120.0
LIHR	Long Island Sound, Connecticut	290.4
LIHU	Long Island Sound, New York	13.2
LIMR	Long Island Sound, New York	21.2
LIHH	Long Island Sound, New York	41.3
LITN	Long Island Sound, New York	75.6
MDSJ	Marina del Rey, California	72.6
MBLR	Matagorda Bay, Texas	7.9
MSTP	Matagorda Bay, Texas	14.5
MBVB	Mission Bay, California	5.1
MBCP	Mobile Bay, Alabama	9.4
MBSC	Monterey Bay, California	7.4
MBTH	Moriches Bay, New York	26.5
NYSH	New York Bight, New Jersey	45.5
NBDI	Narragansett Bay, Rhode Island	4.0
NBCI	Narragansett Bay, Rhode Island	5.1
NEMH	Narragansett Bay, Rhode Island	10.2
NBBC	Newport Beach, California	24.9

Table 72. (continued)

Site Description	Location	Concentration
Total DDT (continued)		ppb
OEIH	Oakland Estuary, California	88.5
OSBJ	Oceanside, California	50.1
PBPI	Penobscot Bay, Maine	3.7
PBSI	Penobscot Bay, Maine	4.5
PLLH	Point Loma, California	17.7
SBSB	Point Santa Barbara, California	32.9
SDHI	San Diego Bay, California	9.0
SFSM	San Francisco Bay, California	6.8
SFDB	San Francisco Bay, California	16.6
SFEM	San Francisco Bay, California	38.0
SPSP	San Pablo Bay, California	12.6
SPSM	San Pablo Bay, California	25.6
SIWP	Sinclair Inlet, Washington	9.3
SSBI	South Puget Sound, Washington	6.4
SAWB	Saint Andrew Bay, Florida	41.1
SJCB	Saint Johns River, Florida	8.2
TBHB	Tampa Bay, Florida	8.4
TBPB	Tampa Bay, Florida	10.4
WIPP	Whidbey Island, Washington	9.6
BOS	Boston Harbor, Massachusetts	104.5
CHS	Charleston Harbor, South Carolina	3.5
COM	Commencement Bay, Washington	3.5
ELL	Elliott Bay, Washington	9.1
GRB	Great Bay, New Jersey	7.4
HUN	San Francisco Bay, California	3.8
LNB	Long Beach Harbor, California	110.0
MOB	Mobile Bay, Alabama	3.2
MRD	Mississippi Delta, Mississippi	4.7
NAR	Narragansett Bay, Rhode Island	5.2
OAK	Oakland Estuary, California	5.3
RAR	Raritan Bay, New Jersey	35.9
SAL	Salem Harbor, Massachusetts	31.2
SAP	Sapelo Sound, Georgia	3.2
SDA	San Diego Harbor, California	9.3
SDF	San Diego Bay, California	14.6
SEA	Seal Beach, California	27.6
SMB	Santa Monica Bay, California	24.9
UCB	Upper Chesapeake Bay, Maryland	5.8
WLI	West Long Island Sound, New York	6.6
PCBs (≥50 <380 ppb)		ppb
BBGH	Buzzards Bay, Massachusetts	51.3
BBRH	Buzzards Bay, Massachusetts	231.0
BHDI	Boston Harbor, Massachusetts	231.4
CBHP	Chesapeake Bay, Maryland	111.4
CBMP	Chesapeake Bay, Maryland	90.1
CBSP	Chesapeake Bay, Maryland	109.8
HRJB	Hudson/Raritan Estuary, New Jersey	327.7
HRLB	Hudson/Raritan Estuary, New Jersey	370.5
HRUB	Hudson/Raritan Estuary, New Jersey	177.7
LICR	Long Island Sound, Connecticut	137.7
LIHH	Long Island Sound, Connecticut	229.2
LIHR	Long Island Sound, Connecticut	190.5

Table 72. (continued)

Site Description	Location	Concentration
PCBs (continued)		ppb
LIMR	Long Island Sound, Connecticut	119.9
LISI	Long Island Sound, Connecticut	63.6
MBTH	Moriches Bay, New York	81.7
OEIH	Oakland Estuary, California	361.5
SDHI	San Diego Bay, California	99.8
SFDB	San Francisco Bay, California	71.9
SFEM	San Francisco Bay, California	74.9
SFSM	San Francisco Bay, California	70.7
BUZ	Buzzards Bay, Massachusetts	192
CSC	Casco Bay, Maine	58
DEL	Delaware Bay, Delaware	131
GRB	Great Bay, New Jersey	79
LNB	Long Beach, California	205
NAR	Narragansett Bay, Rhode Island	221
OAK	Oakland Estuary, California	61
SJR	Saint Johns River, Florida	98
SPB	San Pedro Bay, California	194
SPC	San Pedro Canyon, California	159
UCB	Upper Chesapeake Bay, Maryland	90
WLI	West Long Island Sound, New York	174
Dieldrin (≥0.02 <8 ppb)		ppb
ABWJ	Anaheim Bay, California	0.3
APCP	Apalachicola Bay, Florida	0.2
APDB	Apalachicola Bay, Florida	0.3
ABOB	Atchafalaya Bay, Louisiana	0.7
BBMB	Barataria Bay, Louisiana	0.2
BBSD	Barataria Bay, Louisiana	0.3
BIBI	Block Island, Rhode Island	0.6
BBBE	Bodega Bay, California	0.05
HBDI	Boston Harbor, Massachusetts	4.0
BHHB	Boston Harbor, Massachusetts	1.2
BSBG	Breton Sound, Louisiana	0.1
BSSI	Breton Sound, Louisiana	0.1
BBAR	Buzzards Bay, Massachusetts	5.0
BBGN	Buzzards Bay, Massachusetts	0.9
BBRH	Buzzards Bay, Massachusetts	2.7
CLCL	Caillou Lake, Louisiana	0.1
CLSJ	Calcasieu Lake, Louisiana	0.4
CKBP	Cedar Key, Florida	0.1
CBBI	Charlotte Harbor, Florida	0.2
CBHP	Chesapeake Bay, Maryland	3.0
CBMP	Chesapeake Bay, Maryland	1.1
CBDP	Chesapeake Bay, Maryland	0.1
CBIB	Chesapeake Bay, Maryland	0.1
CBCI	Chincoteague Bay, Virginia	0.1
CBSP	Choctawatchee Bay, Florida	4.4
CBSR	Choctawatchee Bay, Florida	0.4
CRYB	Columbia River, Oregon	0.5
CBRP	Coos Bay, Oregon	0.1
DBAP	Delaware Bay, Delaware	1.3

Table 72. (continued)

Site Description	Location	Concentration
Dieldrin (continued)		ppb
DBBD	Delaware Bay, Delaware	0.6
DBFE	Delaware Bay, Delaware	2.2
DBKI	Delaware Bay, Delaware	0.7
ECSP	East Cote Blanche, Louisiana	0.3
ESBD	Espiritu Santo, Texas	0.03
ESSP	Espiritu Santo, Texas	0.1
GBCR	Galveston Bay, Texas	0.2
GBTD	Galveston Bay, Texas	0.3
GBYC	Galveston Bay, Texas	0.4
BHWJ	Gray's Harbor, Washington	0.05
HHKL	Honolulu Harbor, Hawaii	0.1
HRRB	Hudson/Raritan Estuary, New Jersey	7.9
HRJB	Hudson/Raritan Estuary, New Jersey	5.6
HRLB	Hudson/Raritan Estuary, New Jersey	5.4
HRUB	Hudson/Raritan Estuary, New Jersey	3.3
HMBJ	Hudson/Raritan Estuary, New Jersey	0.3
JHJH	Joseph Harbor Bayou, Louisiana	0.3
LJLJ	Point La Jolla, California	0.2
LBMP	Lake Borgne, Louisiana	0.1
LICR	Long Island Sound, Connecticut	3.5
LIHR	Long Island Sound, Connecticut	3.0
LISI	Long Island Sound, Connecticut	1.1
LIHH	Long Island Sound, Connecticut	7.1
LIHU	Long Island Sound, Connecticut	1.5
LIMR	Long Island Sound, New York	3.0
MDSJ	Marina del Rey, California	0.5
MBEM	Matagorda Bay, Texas	0.03
MBGP	Matagorda Bay, Texas	0.1
MBLR	Matagorda Bay, Texas	0.3
MBTP	Matagorda Bay, Texas	0.03
MBAR	Mesquite Bay, Texas	0.1
MBYB	Mission Bay, Texas	0.1
MSBB	Mississippi Sound, Mississippi	0.2
MSPC	Mississippi Sound, Mississippi	0.2
MBCP	Mobile Bay, Alabama	0.4
MBSC	Monterey Bay, California	0.3
MBTH	Moriches Bay, New York	0.5
NYSH	New York Bight, New Jersey	6.8
NBNB	Naples Bay, Florida	0.6
NBCI	Narragansett Bay, Rhode Island	0.7
NBDI	Narragansett Bay, Rhode Island	0.9
NBMH	Narragansett Bay, Rhode Island	2.8
NBBC	Newport Beach, California	0.2
OSBJ	Oceanside, California	0.5
PGLP	Pacific Grove, California	0.2
PVRP	Palos Verdes, California	6.2
PBPI	Penobscot Bay, Maine	0.2
PBSI	Penobscot Bay, Maine	0.5
PLLH	Point Loma, California	0.5
PRPR	Point Roberts, Washington	0.3
SBSB	Point Santa Barbara, California	0.5
QIUB	Quinby Inlet, Virginia	0.5
RBHC	Rookery Bay, Florida	0.1
SLBB	Sabine Lake, Texas	

Table 72. (continued)

Site Description	Location	Concentration
Dieldrin (continued)		ppb
SAMP	San Antonio Bay, Texas	0.03
SDHI	San Diego Bay, California	1.9
SFDB	San Francisco Bay, California	2.8
SFEM	San Francisco Bay, California	1.5
SFSM	San Francisco Bay, California	0.4
SLSL	San Luis Obispo, California	0.1
SPSP	San Pablo Bay, California	0.8
SPFP	San Pedro Harbor, California	2.4
SRTI	Savannah River, Georgia	0.2
SSBI	South Puget Sound, Washington	0.2
SAWB	Saint Andrew Bay, Florida	0.6
SJCB	Saint Johns River, Florida	1.5
TBCB	Tampa Bay, Florida	0.1
TBHB	Tampa Bay, Florida	0.1
TBMK	Tampa Bay, Florida	0.2
TBPB	Tampa Bay, Florida	0.3
TBLF	Terrebonne Bay, Louisiana	0.1
TBSR	Tomales Bay, California	0.2
VBSP	Vermillion Bay, Louisiana	0.3
BOS	Boston Harbor, Massachusetts	3.2
BUZ	Buzzards Bay, Massachusetts	0.07
COM	Commencement Bay, Washington	0.33
DEL	Delaware Bay, Delaware	0.71
HUN	San Francisco Bay, California	0.27
LCB	Lower Chesapeake Bay, Virginia	0.12
LNB	Long Beach Harbor, California	1.30
MOB	Mobile Bay, Alabama	0.21
MRD	Mississippi Delta, Mississippi	1.16
NAR	Narragansett Bay, Rhode Island	1.68
PAB	San Pablo Bay, California	0.13
RAR	Raritan Bay, New Jersey	1.72
WLI	West Long Island Sound, New York	0.15

* Ambient concentrations at none of the sites exceeded or equaled the ER-L for these chemical analytes.

Table 73. The NS&T Program sediment sampling sites in which the average chemical concentrations exceeded the respective ER-M values, ranked in descending order of the number of times exceeded.

Number of times exceeded	Site Codes*
10	OEIH
9	HRUB
8	HRRB, LITN, NYSH, BOS
7	BHDB, HRLB, PVRP, RAR
5	CBSP, LIHH, SPFP, SAL
4	SPB, SPC
3	BHDI, SAWB, LNB
2	BBSM, CBHP, CBMP, HRJB, OSBJ, PVMC, SFEM SFSM, SPSP, TBSR, BOD, HMB, HUN, OAK, PAB, SDA, SHS, UCB
1	ABWJ, BBAR, BPBP, MBTH, MBTP, MDSJ, NBBC, NBMH, SFDB, WIPP, YHSS, ELL, SEA, SMB

* Specific locations are listed in the glossary.

Table 74. The NS&T Program sediment sampling sites in which the average chemical concentrations exceeded the respective ER-L values, ranked in descending order of the number of times exceeded.

Number of times exceeded	Site Codes*
21	BHDI
20	LIHH, LIMR, LISI
18	CBMP
17	HRUB, LICR, HRLB, SAWB, ELL, RAR, SAL
16	HRJB, LIHR, NYSH, BOS, SAL
15	CBHP, BHDB, LITN, WLI
14	NBMH, SDA
13	SIWP
12	OEIH, PBSI, UCB
11	LIHU, SFSM
10	BBAR, SFDB, SPFP, GRB, NAR
9	CBSP, BHHB, SPSP, SSBI, HUN
8	DBAP, MBTH, PBPI, SFEM, OAK
7	HRRB, MSBB, SDHI, TBPB, WIPP
6	DBBD, MDSJ, NBCI, NBDI, PVRP, SSBI, SPB
5	ABWJ, BBSM, BBRH, CBSR, DBFE, DBKI, SBSB, SJCB, TBHB, LNB, MOB
4	CRYB, MBCP, MBTP, MBSC, OSBJ, PLLH, PRPR, SPSM, BUZ, CSC, PEN, SEA
3	APDB, ECSP, HHKL, LJLJ, MBLR, MBYB, NBBC, TBSR, CHS, COM, NAH, NIS, OLI, SJR, SMB
2	ABOB, BBGN, CASI, CBIB, CHFJ, EBFR, HMBJ, MBGP, NBNB, PVMC, RBHC, TBHP, TBMK, UISB, DEL, FRN, LUT, MRD, PNB, SAP, SDF
1	APCP, BBBE, BBSD, BIBI, BBMB, BBNR, BPBP, BSBG, BSSI, CBBI, CBBP, CBDP, CBCI, CBMP, CBRP, CBTP, CBRP, CLCL, CLSJ, CKBP, ESSP, ESBD, GBCR, GBTD, GBYC, GHWJ, MBAR, MSPC, MSPB, PGLP, QIUB, SAMP, SLBB, SLSL, SRTI, TBCB, TBLF, VBSP, YBOP, APA, BAR, COO, DBA, DAN, PAB, SPC

* Specific locations are listed in the glossary.

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The accuracy of the guidelines for metals often exceeded that for organic compounds. Many of the metals are likely more water soluble than the organics, possibly resulting in relatively higher and more consistent bioavailability, and, therefore, less variability in the data.

The ER-L and ER-M guidelines were used to evaluate and rank the relative potential for biological effects at the NS&T Program sampling sites. Those sites in which the ambient chemical concentrations exceeded the most ER-L and ER-M values were identified as having the highest potential for adverse effects. The sites with the highest potential for effects were sites HRUB, located in the Hudson-Raritan Estuary; site LITN, located in western Long Island Sound; site BOS, in Boston Harbor; and site OEIH, in the Oakland Estuary of San Francisco Bay. Sites with the highest potential for effects were generally located within the Hudson-Raritan Estuary, Long Island Sound, Boston Harbor, Chesapeake Bay, New York Bight, Salem Harbor, Saint Andrew Bay, and parts of southern California near Los Angeles and San Pedro.

The potential for contaminated sediments causing adverse biological effects should be verified by either an examination of available data or implementation of a survey at the high-potential sites. Biological effects data are available for one of the highly ranked NS&T Program sites: site OEIH in Oakland Harbor, California. Site OEIH was tested with five sediment bioassays (Long and Buchman, 1989) and the benthic community was examined at that site (unpublished data). Most of the bioassay end-points indicated relatively high toxicity in the site OEIH sediments and the benthic community had lower total abundance and crustacean abundance than at many other nearby sites in San Francisco Bay.

The data examined in the present document were the results of the use of widely varying methods. Subsequent evaluations of data such as these would be facilitated if the data were from the use of similar methods. That is, spiked-sediment bioassays should be performed with one species or, at least, with species from the same taxonomic groups (such as amphipods). Bioassays of field-collected sediments should be performed with multiple species, but at least one of the species should be used universally. The use of standardized methods is recommended.

Sediment quality values from EP, AET, and SLC methods usually are presented as absolutes, i.e., a chemical concentration not accompanied by any measure of uncertainty or variability. Values generated in spiked-sediment bioassays often are accompanied by the 95 percent confidence interval. The data reviewed in this document and with which the co-occurrence analyses were performed often indicated relatively high variability in analyses of field-collected samples (i.e., the standard deviations frequently equalled or exceeded the means). While these indications of variability may be discouraging, they do provide a suggestion as to the degree of confidence currently available for attributing biological effects to sediment-sorbed contaminants without using a preponderance of evidence from multiple approaches.

The data assembled and reported herein were evaluated by objectively determining the lower 10 percentiles and the medians in the data and by subjectively determining the overall apparent effects thresholds in the data. The same data could be evaluated using many other approaches, depending upon study objectives. For example, the screened sorted data could be used to identify the contaminant concentrations below which effects have never been observed. Also, percentiles in the data other than the lower 10 and 50 percentiles could be determined. For example, the lower 5 percentile value of the data could be examined and assumed to be analogous to a level that may protect 95 percent of the species. The ER-L, ER-M, and overall apparent effects thresholds derived from the available data could be used as hypotheses to be tested in empirical toxicity experiments. The present evaluation should be updated with additional data as they become available and should be supplemented with an evaluation of the chemical data normalized to TOC, AVS, and any other appropriate parameters in addition to dry weight.

Table 75. Overall cumulative ranks of NS&T Program sites, based upon exceedances of ER-L and ER-M values. One point was assigned for each ER-L exceeded, 4.2 points for each metal ER-M exceeded, and 8.1 points for each organic ER-M exceeded.

Site	No. of ER-L values exceeded	ER-M values exceeded for metals No. x 4.2 = points		ER-M values exceeded for organics No. x 8.1 = points		Total points	Overall rank
HRUB	17	3	13	6	49	79	1
BOS	16	3	13	5	41	70	2
LITN	15	3	13	5	41	69	3
OEIH	12	6	25	4	32	69	3
NYSH	16	5	21	3	24	61	5
BHDB	15	3	13	4	32	60	6
HRLB	17	4	17	3	24	58	7
PVRP	6	2	8	5	41	55	8
RAR	17	5	21	2	16	54	9
HRRB	7	5	21	3	24	52	10
CBSP	9	0	0	5	41	50	11
LIHH	20	3	13	2	16	49	12
SAL	16	2	8	3	24	48	13
SPFP	10	1	4	4	32	6	14
SAWB	17	0	0	3	24	41	15
SPB	6	0	0	4	32	38	16
BHDI	21	3	13	0	0	34	17
SPC	0	0	0	4	32	32	18
HRJB	16	1	4	1	8	28	19
SDA	14	1	4	1	8	26	20
ELL	17	0	0	1	8	25	21
LNB	5	1	4	2	16	25	21
CBHP	15	2	8	0	0	23	23
LISI	20	0	0	0	0	20	25
OSBJ	4	0	0	2	16	20	25
LIMR	20	0	0	0	0	20	25
SFSM	11	2	8	0	0	19	27
SPSP	9	2	8	0	0	17	28
OAK	8	2	8	0	0	16	29
SFEM	8	2	8	0	0	16	29

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APPENDIX A

CO-OCCURRENCE ANALYSES DATA

Appendix A

Description of Data Sets Used in Co-occurrence Analyses

The data sets in which biological measures of effects and concentrations of chemicals in sediments were made with the same samples are described in this appendix, along with the description of how the data were manipulated and analyzed for use in this document.

Gilbert *et al.* (1976) sampled sediments at 37 stations in Massachusetts Bay and performed chemical analyses of portions of the samples that were also examined for benthic community composition. The samples were collected with a 0.1 m^2 Smith-McIntyre grab sampler and sieved with 2.0 and 0.5 mm screens. Data from quantification of trace metals and selected organic groups were reported. Their data suggested the occurrence of three modes in species richness among the stations: High (mean 93.6 ± 9.4 SD, range 81-106), intermediate (mean 58.1 ± 10.4 SD, range 40-78), and low (mean 31 ± 6.5 SD, range 22-37). The means and standard deviations in chemical concentrations that co-occurred with these modes were calculated.

McGreer (1979) observed burrowing time in the bivalve *Macoma balthica* exposed to five samples (one of which was used as a control) collected in the Fraser River estuary, British Columbia. The samples were also analyzed for the concentrations of various trace metals. The 95 percent confidence limits for effective burrowing time (ET50) for Sample C were outside the 95 percent confidence limits of the ET50 for the control. The chemical data for Sample C were used in this document. McGreer (1979) also examined avoidance behavior of *M. balthica* exposed to these sediment samples. A statistically significant avoidance response was found for Sample A, therefore, the data for Sample A were used in this document.

McGreer (1982) sampled 23 sites along the Strait of Georgia, British Columbia and determined the presence and abundance of *M. balthica* and the concentrations of various trace metals. The means and standard deviations of concentrations in samples devoid of *M. balthica* and in samples with *M. balthica* present were compared.

Yake, *et al.* (1986) sampled three sites in Lake Union, Washington and tested for toxicity with the amphipod *Hyalella azteca* and determined the concentrations of many chemicals in an area known to have high PAH concentrations. Undiluted sediment from one of the sites (GWP) caused an average of 95 percent mortality; the chemical data for that site were used in this document.

Anderson *et al.* (1988) sampled 12 sites in southern California and tested for toxicity with the amphipod *Grandidierella japonica* and for the concentration of hydrocarbons and trace metals. Half of the sites was significantly toxic (mean 48.3 ± 14.6 percent survival); and half were not significantly toxic (mean 76.8 ± 11.1 percent survival) relative to controls. The chemical concentrations were compared between toxic and non-toxic samples.

Kraft and Sypniewski (1981) sampled 15 sites each in the north and south regions of the Keweenaw Waterway, Michigan and determined macroinverterbrate taxa richness and copper content in the sediments in all 30 sites. The mean copper concentrations in the northern sites (average of 8.4 taxa per site) were compared with those in the southern sites (average of 19.8 taxa per site).

The Illinois Environmental Protection Agency (1983a) sampled 21 sites in the DuPage River Basin and determined benthic taxa abundance and concentrations of hydrocarbons and trace metals. Concentrations in 18 sites with relatively high abundance (mean 15.8 ± 2.0 SD taxa per Hester-Dendy artificial sampler) were compared with those in 3 sites (mean 6.7 ± 2.5 SD taxa) with relatively low abundance.

The Illinois Environmental Protection Agency (1983b) sampled 25 sites in the Kishwaukee River and determined the number of benthic taxa and concentrations of hydrocarbons and trace metals. The chemical concentrations in 20 sites associated with relatively high numbers of taxa (mean 16.3 ± 4.6 SD per site) were compared with concentration in 5 sites with relatively low numbers of taxa (8.4 ± 0.5 per site).

Tsai *et al.* (1979) sampled nine stations in Baltimore Harbor, Maryland and determined toxicity to mummichogs (*Fundulus heteroclitus*), spot (*Leiostomus xanthurus*), and soft-shell clams (*Mya arenaria*) and the concentrations of PCBs and trace metals. Five of the stations were relatively highly toxic (mean 48-h TLm of 5.1 ± 3.5) to mummichogs and four were relatively less toxic (mean TLm of 43.2 ± 31.3). The means and standard deviations of chemical concentrations among the most and least toxic samples were compared.

VanDolah *et al.* (1984) sampled 15 stations in and near a dredged material disposal site off Georgetown, South Carolina and determined benthic community composition and concentrations of PCBs and trace metals. The maximum sediment concentrations of chemicals at sites in which no demonstrable effects upon summer benthic community species richness and total abundance was observed were used in this document.

Tatem (1986) determined bioaccumulation of PCBs and trace metals in the prawn (*Macrobrachium rosenbergii*) exposed to Sheboygan River, Wisconsin sediments. He observed that the sediments were toxic to the prawns after 22 days' exposure. The concentrations of chemicals in the toxic sediments were used in this document.

Lee and Mariani (1977) reported results of sediment toxicity tests and chemical analyses for many prospective dredge areas throughout the United States. The chemical concentrations reported associated with the observations of relatively high toxicity to the grass shrimp *Palaemonetes pugio* were used in this document.

Zagatto *et al.* (1987) reported results of toxicity tests with *D. similis* and chemical concentrations in sediments from 18 stations in Cubatao River Basin, Brazil. Minimum chemical concentrations associated with samples that were reported as significantly toxic were used in this report.

Malueg *et al.* (1984a) sampled sediments from six sites in Phillips Chain of Lakes, Wisconsin, one site in Torch Lake, Michigan, and ten sites in the Little Grizzly Creek system, California and tested for toxicity to *Daphnia magna* and *Hexagenia limbata* and the concentrations of trace metals. The chemical concentrations in the one site in Phillips Chain of Lakes that was significantly toxic were compared with those in the five other samples that were reported as not significantly toxic. The chemical concentrations in the toxic Torch Lake sample also was listed and used in this document. The chemical concentrations in the eight samples from the Little Grizzly Creek system that were reported as significantly toxic were compared with those that were not toxic and used in this document.

Malueg *et al.* (1984b) sampled five sites each in the northern and southern reaches of the Keweenaw Waterway, Michigan and determined toxicity to *D. magna* and *Hexagenia limbata* and the concentrations of trace metals. The chemical concentrations in highly toxic northern sediments were compared with those in less toxic southern sediments.

Long and Buchman (1989) sampled 15 stations in San Francisco and Tomales bays and determined toxicity to the amphipod *Rhepoxynius abronius* and mussel embryos (*Mytilus edulis*) and concentrations of trace metals and organic compounds. U.S. Navy (1987) sampled 22 stations in San Francisco Bay and performed many of the same analyses, except they used the embryos of the oyster *C. gigas*. Chapman *et al.* (1987) sampled nine stations in San Francisco Bay and performed the same analyses as Long and Buchman (1989). Word *et al.* (1988) sampled 22 stations in the Oakland Inner Harbor of San Francisco Bay and performed the same analyses as U.S. Navy (1987). The data from these four studies were combined and three types of analyses were performed. First, AET values were calculated using SedQual software developed by PTI Environmental Services (1988) and a sorting routine on Microsoft Excel spreadsheets on a Macintosh computer. Second, the mean concentrations of chemicals associated with relatively highly toxic samples (mean 67 ± 11.8 percent mortality among *R. abronius*, mean 92.4 ± 4.5 percent abnormal bivalve embryos) were compared with those that were moderately toxic (33.8 ± 4.7 percent mortality among *R. abronius*, 59.4 ± 11.3 percent abnormal bivalve embryos) and least toxic (18 ± 6.6 percent mortality among *R. abronius*, 23.3 ± 7.3 percent abnormal bivalve embryos). Third, the chemical concentrations in samples reported as significantly toxic were compared with those that were reported as not significantly toxic, however, since most of the samples were significantly different from controls, this last approach appeared to be the least satisfactory of the three.

Tetra Tech (1985) sampled 55 sites in the Commencement Bay, Washington waterways and vicinity and determined toxicity to *R. abronius* and *C. gigas* embryos and concentrations of trace metals and organic compounds. The mean concentrations in samples that were most toxic (15.7 ± 3.9 dead *R. abronius* out of 20, 44.5 ± 19 percent abnormal *C. gigas* embryos) were compared with those in samples that were moderately toxic (5.2 ± 1.1 dead *R. abronius* out of 20, 23 ± 2.3 percent abnormal *C. gigas* embryos) and least toxic (2.5 ± 0.9 dead *R. abronius* out of 20, 15.1 ± 3.1 percent abnormal *C. gigas* embryos).

Word and Mearns (1979) sampled 71 sites along a 60-m depth contour off southern California and determined benthic community composition and concentrations of trace metals and selected hydrocarbons. The chemical concentrations associated with samples that had relatively high, intermediate, and low abundances of echinoderms and arthropod were compared. The chemical concentrations associated with relatively high, intermediate, and low species richness and total abundance were also compared. They were compared, for example, between sites with high echinoderm abundance (mean 191.3 ± 70.1/0.1 square meters), intermediate abundance (56.2 ± 23.0/0.1 square meters), and lowest abundance (6.1 ± 7.2/0.1 square meters).

Schiewe *et al.* (1984) sampled 18 sites in Puget Sound, Washington, and determined toxicity to *Photobacterium phosphoreum* in a Microtox™ test of organic extracts of sediments and concentrations of petroleum hydrocarbons. Chemical concentrations in highly toxic samples (mean EC50 0.31 ± 0.13), moderately toxic samples (mean EC50 2.14 ± 0.83), and least toxic samples (mean EC50 8.9 ± 3.3) were compared for use in this document.

Swartz *et al.* (1985 and 1986) sampled seven sites in 1980 and six sites in 1983 in the Southern California Bight off Palos Verdes and determined toxicity with a *R. abronius* bioassay, macroinvertebrate community composition, and concentrations of trace metals and selected organic compounds. The data from the two surveys were combined for use in this document. The chemical concentrations in samples that were significantly toxic to *R abronius* were compared with those that were not toxic. Also, the chemical concentrations in sites reported as having "major degradation" to the macrobenthos were listed and used in the present document.

Rygg (1985) reported the relationship between sediment copper concentrations in Norwegian fjords and benthic community composition sampled at 71 stations. He reported that a 50 percent reduction in Hurlbert's diversity index was correlated with 200 ppm copper in the sediments.

Johnson and Norton (1988) sampled 12 sites in ports along the lower Columbia River, Washington and determined toxicity to the amphipod *H. azteca* and concentrations of trace metals and organic compounds. PAH concentrations differed the most among sampling sites. No significant toxicity was observed, therefore, the maximum PAH concentration in which no toxicity was observed was listed and used in this document.

Armstrong *et al.*, (1979) sampled 15 stations in Trinity Bay, Texas in a grid associated with an oilfield brine effluent and determined benthic community composition and PAH concentration. The PAH concentrations in 10 stations with relatively high species richness (mean 33.3 per station) and total abundance (mean 5178 per station) were compared with those in 7 stations with relatively low species richness (mean 28.2 per station) and abundance (mean 1285 per station).

Qasim *et al.* (1980) sampled 13 sites in the Trinity River, Texas and tested for toxicity with *D. magna* and for the concentrations of hydrocarbons and trace metals. The chemical concentrations in five sites in which significant mortality (mean 92.5 ± 11.6 percent SD) was observed were compared with those from eight sites in which lower (nonsignificant) mortality (mean 16 ± 8.9 percent SD) was observed.

Ingersoll and Nelson (in press) sampled three sites and a control in Waukegan Harbor, Illinois and vicinity and determined toxicity to *H. azteca* and concentrations of trace metals and hydrocarbons. Chemical concentrations in the least contaminated of two samples that were significantly toxic (mean 13.8 percent survival) were compared to those with higher survival (mean 88.8 percent survival).

Simmers *et al.* (1984) reported 100 percent mortality in *N. virens* exposed for 14 days to Black Rock Harbor, Connecticut dredged material. The bioassays were performed with mixtures of 25 percent dredged material and 75 percent clean material and chemical analyses were performed with the diluted material. Therefore, the reported concentrations were multiplied by a factor of four for use in this document.

Salazar and Salazar (1985) and Salazar (1980) reported results of toxicity tests and chemical analyses of various numbers of samples in San Diego Bay, California. A variety of animals were used; all indicated relatively high survival (generally, over 82 percent survival). For this document, the highest concentrations in which these high degrees of survival were observed were listed and used.

Rogerson *et al.* (1985) reported the results of toxicity tests of Black Rock Harbor, Connecticut sediments performed with the amphipod *A. abdita* and chemical data for PAH. The projected concentrations of PAH in undiluted sediments that caused significant mortality were listed and used in this document.

Tietjen and Lee (1984) sampled 17 sites in the Hudson-Raritan Bay estuary and determined toxicity in 14-d tests of growth of the nematode *Chromadorina germanica* and concentrations of hydrocarbons and trace metals. The chemical concentrations in samples that caused a negative intrinsic rate of growth were compared with those that caused a positive rate of growth.

Long (1987) determined PAH concentrations in mudflat sediments and densities of meiofaunal organisms in 10 square centimeters cores at 28 stations in the Forth estuary, Scotland. The chemical concentrations associated with high meiofaunal densities (mean 3741 ± 1773) were compared with those that had intermediate densities (mean 1335 ± 396) and lowest densities (mean 112 ± 123).

CH^2M-Hill (1989) sampled 86 stations in Eagle Harbor, Washington during June 1988 and determined toxicity to *R. abronius* and concentrations of PAH in bulk sediments. Chemical concentrations in 49 least toxic samples (mean of 17.4 ± 1.4 survivors out of 20) were compared with those in 7 moderately toxic samples (mean of 11.8 ± 1.8 survivors out of 20) and 12 highly toxic samples (mean of 0.9 ± 1.7 survivors out of 20).

APPENDIX B

SEDIMENT EFFECTS DATA

Table B-1. Sediment effects data available for ANTIMONY arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm dw)	Biological Test	Remarks
0.9 ± 1	Commencement Bay least toxic--amphipod	No effect
1 ± 1.4	Commencement Bay least toxic--oyster	No effect
>1.9	San Francisco Bay AET--bivalve	Not definitive
2	**ER-L**	**10 percentile**
2 ± 5	Commencement Bay moderately toxic--amphipod	*
2 ± 5.5	Commencement Bay moderately toxic--oyster	*
2.3 ± 6.3	San Francisco Bay significantly toxic--amphipod	No concordance
2.6	PSDDA screening level	No effect
2.7 ± 6.7	San Francisco Bay moderately toxic--amphipod	No concordance
>2.9	San Francisco Bay AET--amphipod	No concordance
3.2	1986 Puget Sound AET--benthic	*
5 ± 11.2	San Francisco Bay least toxic--bivalve	No effect
5.3	1986 Puget Sound AET--amphipod	*
6.6 ± 1	San Francisco Bay moderately toxic--bivalve	*
6.7 ± 12.3	San Francisco Bay not toxic--bivalve	No effect
8.6 ± 11.9	San Francisco Bay significantly toxic--bivalve	*
9 ± 11.6	San Francisco Bay least toxic--amphipod	No effect
9.9 ± 11.8	San Francisco Bay not toxic--amphipod	No effect
25	**ER-M**	**50 percentile**
25 ± 0	San Francisco Bay highly toxic--bivalve	*
26	1986 Puget Sound AET--oyster	*
26	1986 Puget Sound AET--Microtox™	*
27.5 ± 101.5	Commencement Bay highly toxic--oyster	*
91.5 ± 184	Commencement Bay highly toxic--amphipod	*
150	1988 Puget Sound AET--Microtox™	*
200	1988 Puget Sound AET--amphipod	*
ND	San Francisco Bay highly toxic--amphipod	No concordance

* 13 concentrations used in ER-L and ER-M estimates.
ND = not detected

Table B-2. Sediment effects data available for ARSENIC arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
1	Stamford not toxic--shrimp	No effect
1.3	Duwamish River nontoxic--shrimp	No effect
1.36	Georgetown benthic community	No effect
1.9	Black Rock Harbor toxic--*Nereis*	Small gradient
2.2 ± 1.2	Trinity River not toxic--*Daphnia*	No effect
2.7 ± 0.2	Sheboygan River significantly toxic--prawn	Small gradient
2.8	Newport not toxic--shrimp	No effect
3.4 ± 1.8	Trinity River significant toxic--*Daphnia*	Small gradient
3.4	Norwalk not toxic--shrimp	No effect
3.7 ± 1	Kishwaukee River least taxa	No effect
5 ± 1.8	Kishwaukee River most taxa	Small gradient
5.8 ± 6.4	Southern California not toxic--amphipod	No effect
5.9 ± 1.1	DuPage River most taxa	Small gradient
7.4 ± 2.2	DuPage River least taxa	Small gradient
8.32 ± 5.2	Southern California significantly toxic--amphipod	Small gradient
10.4 ± 13.4	San Francisco Bay moderately toxic--amphipod	No concordance
12.8	Los Angeles Harbor toxic--shrimp	Small gradient
13.7 ± 14.8	San Francisco Bay least toxic--bivalve	No effect
14.6 ± 13.8	San Francisco Bay significantly toxic--amphipod	No concordance
17.5 ± 14.1	San Francisco Bay highly toxic--amphipod	No concordance
22 ± 18.7	San Francisco Bay not toxic--bivalve	No effect
22.1 ± 19.4	San Francisco Bay moderately toxic--bivalve	*
22.6 ± 28.1	Puget Sound non-toxic--amphipod	No effect
22.8 ± 22.1	San Francisco Bay significantly toxic--bivalve	No gradient
25.1 ± 23.1	Puget Sound moderately toxic--amphipod	Small gradient
27.8 ± 30.8	Commencement Bay least toxic--oyster	No effect
28 ± 21.5	San Francisco Bay least toxic--amphipod	No effect
28.? ± 26.6	Commencement Bay least toxic--amphipod	No effect
30.3 ± 22.4	San Francisco Bay not toxic--amphipod	No effect
32 ± 14.3	Baltimore Harbor least toxic--fish	No effect
33	**ER-L**	**10 percentile**
33	EP chronic marine	*
<47.2	Waukegan Harbor highly toxic--amphipod	Below detection
50.7 ± 29.3	San Francisco Bay highly toxic--bivalve	*
54	San Francisco Bay AET--bivalve	*
57	1988 Puget Sound AET--benthic	*
58.7 ± 148.1	Commencement Bay moderately toxic--oyster	*
63.2 ± 148	Commencement Bay moderately toxic--amphipod	*
64	EP acute marine	*
70	PSDDA screening level	No effect
70	San Francisco Bay AET--amphipod	No concordance
85	**ER-M**	**50 percentile**
85	1986 Puget Sound AET--benthic	*
91.9 ± 78.6	Baltimore Harbor most toxic--fish	*
93	1986 Puget Sound AET--amphipod	*
689.9 ± 2350.9	Commencement Bay highly toxic--oyster	*
700	1986 Puget Sound AET--oyster	*
700	1986 Puget Sound AET--Microtox™	*
1005 ± 2777	Puget Sound highly toxic--amphipod	*
2257.1 ± 4213.7	Commencement Bay highly toxic--amphipod	*

* 16 concentrations used to determine ER-L and ER-M values

Table B-3. Sediment effects data available for CADMIUM arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
<0.04	Fraser River feral clams present	no effects
0.05 ± 0	Kishwaukee River least taxa	Below detection
<0.1	Georgetown no benthic effects	No effects
0.2	Cubatao River highly toxic--*Daphnia*	Small gradient
0.3 ± 0.8	Kishwaukee River most taxa	Below detection
0.4	*Macoma* burrowing bioassay	Small gradient
0.4 ± 0.1	San Francisco Bay least toxic--bivalve	No effect
0.4 ± 0.3	Southern California high echinoderm abundance	No effect
0.4 ± 0.1	Massachusetts Bay high species richness	No effect
<0.5	Duwamish River low toxicity--shrimp	No effect
0.5 ± 0.3	San Francisco Bay moderately toxic amphipod	No gradient
0.5 ± 0.3	Southern California moderate echinoderm abundance	No gradient
0.5	Keweenaw Waterway least toxic--*Daphnia*	No effect
<0.5	Newport not toxic--shrimp	No effect
0.6 ± 0.3	San Francisco Bay least toxic--amphipod	No effect
0.6 ± 0.4	San Francisco Bay significantly toxic--amphipod	No gradient
0.6 ± 0.3	San Francisco Bay not toxic--amphipod	No effect
0.6 ± 0.4	San Francisco Bay significantly toxic--bivalve	No gradient
0.6 ± 0.3	San Francisco Bay not toxic--bivalve	No effect
0.6 ± 0.7	Southern California moderate species richness	No concordance
0.6 ± 0.3	Keweenaw Waterway not toxic--Daphnia	No effect
0.7 ± 0.3	San Francisco Bay highly toxic--bivalve	No gradient
0.7 ± 0.5	San Francisco Bay moderately toxic--bivalve	Small gradient
0.7 ± 0.7	Southern California moderate arthropod abundance	No concordance
0.7 ± 0.6	Massachusetts Bay moderate species richness	Small gradient
0.8 ± 0.5	San Francisco Bay highly toxic--amphipod	Small gradient
0.8 ± 1.1	Southern California moderate total abundance	No concordance
0.9 ± 1	Southern California high arthropod abundance	No effect
0.9	San Diego Bay low toxicity--various	No effect
0.9	San Diego Bay low toxicity--various	No effect
0.96	PSDDA screening level	No effect
1 ± 1.1	*R. abronius* LC50--spiked bioassay	Sand
1.1 ± 2	Southern California low total abundance	No concordance
1.1 ± 1.1	Massachusetts Bay least species richness	Small gradient
1.2 ± 1	Fraser River feral clams absent	Small gradient
1.2	San Francisco Bay AET--amphipod	No concordance
1.2 ± 0.3	Little Grizzly Creek high toxicity--*Daphnia*	Small gradient
1.3 ± 0.6	DuPage River least taxa	no concordance
1.4	*Macoma* avoidance bioassay	Small gradient
1.5 ± 4	Southern California high species richness	No effect
1.5 ± 0.9	DuPage River most taxa	No effect
1.5	Keweenaw Waterway most toxic--*Daphnia*	Small gradient
1.6	Black Rock Harbor highly toxic--Nereis	Small gradient
1.7	San Francisco Bay AET--bivalve	Small gradient
1.7 ± 0.3	Keweenaw Waterway significantly toxic--*Daphnia*	Small gradient
1.9 ± 1.1	Commencement Bay least toxic--oyster	No effect
1.98	Lake Union toxic--amphipod	Small gradient
2	Baltimore Harbor least toxic--fish	No effect
2.3 ± 1.3	Commencement Bay least toxic--amphipod	No effect
2.5	Waukegan Harbor high toxicity--amphipod	Small gradient
2.5	Torch Lake significantly toxic--*Daphnia*	Small gradient
2.7 ± 2	Commencement Bay moderately toxic--oyster	Small gradient

Table B-3. (continued)

Concentration (ppm)	Biological Test	Remarks
2.8 ± 0.5	Sheboygan River high toxicity–prawn	Small gradient
2.8	Stamford low toxicity–shrimp	No effect
2.9 ± 2.3	Commencement Bay moderately toxic–amphipod	Small gradient
3	Los Angeles Harbor high toxicity–shrimp	Small gradient
3.1 ± 0.6	Phillips Chain low toxicity–*Daphnia*	No effect
3.2 ± 6	Southern California not toxic–amphipod	No effect
4.1	Norwalk low toxicity–shrimp	No effect
4.3 ± 11.4	Southern California low arthropod abundance	*
4.7 ± 12.2	Southern California low species richness	*
4.8 ± 5.6	Trinity River not toxic–*Daphnia*	No effect
4.9	Phillips Chain high toxicity–*Daphnia*	Small gradient
5	**ER-L**	**10 percentile**
5.1	1988 Puget Sound AET–benthic	*
5.3 ± 11.4	Southern California significantly toxic–amphipod	*
5.6	*R. abronius*–spiked bioassay	*
5.8	1986 Puget Sound AET–benthic	*
5.8	*R. abronius*–spiked bioassay	*
6.2 ± 13.1	Southern California low echinoderm abundance	*
6.5	*R. abronius* EC50–spiked bioassay	*
6.7	1986 Puget Sound AET–amphipod	*
6.9	*R. abronius* LC50–spiked bioassay	*
8.2	*R. abronius* LC50–spiked bioassay	*
8.4	*E. sencillus* LC98- spiked bioassay	*
8.5	*R. abronius* LC76–spiked bioassay	*
8.7	*R. abronius* LC50–spiked bioassay	*
8.8	*R. abronius* LC50–spiked bioassay	*
8.9 ± 9.2	Palos Verdes not toxic–amphipod	No effect
8.9	*R. abronius* overall LC50–spiked bioassay	*
9.0	**ER-M**	**50 percentile**
9.1	*R. abronius* EC50–spiked bioassay	*
9.4 ± 17.3	Southern California high total abundance	No effect
9.6	1986 Puget Sound AET–oyster	*
9.6	1986 Puget Sound AET–Microtox™	*
9.7	*R. abronius* EC50–spiked bioassay	*
9.8	*R. abronius* LC50–spiked bioassay	*
10	*R. abronius* LC50–spiked bioassay	*
10.6 ± 8.7	Trinity River significantly toxic–*Daphnia*	*
11	*P. affinis* lethality -spiked bioassay	*
11.5	*R. abronius* LC50–spiked bioassay	*
11.8 ± 6.6	Hudson-Raritan least toxic–nematode	No effect
15.3 ± 45.1	Commencement Bay highly toxic–oyster	*
18.6 ± 8.9	Hudson-Raritan highly toxic–nematode	*
20.8	*R. abronius* EC50–spiked bioassay	*
22.7	San Diego Bay low toxicity–polychaete	No effect
22.8 ± 19.8	Baltimore Harbor most toxic–fish	*
25.9	*R. abronius* LC50–spiked bioassay	*
28	San Diego Bay low toxicity–mysid	No effect
28.7 ± 3.1	Palos Verdes significantly toxic–amphipod	*
28.7 ± 3.1	Palos Verdes major benthic degradation	*
31	EP chronic marine	*
32.5	San Diego Bay low toxicity–clam	No effect
32.5	San Diego Bay low toxicity–various	No effect
38.6	New York Harbor low toxicity–various	No effect
40	*N. virens*–spiked bioassay	No effect
41.6 ± 79.8	Commencement Bay highly toxic–amphipod	*
96	EP acute marine	*

* 36 concentrations used to determine ER-L and ER-M values

Table B-4. Sediment effects data available for CHROMIUM arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
2.5	Georgetown benthic community	No effect
11.8 ± 3.7	Commencement Bay least toxic--oyster	No effect
15.3	Duwamish River low toxicity	No effect
16.2 ± 8.1	Commencement Bay least toxic--amphipod	No effect
17.7 ± 7.3	Commencement Bay moderately toxic--amphipod	No gradient
17.7 ± 7.3	Commencement Bay moderately toxic--oyster	Small gradient
18.1 ± 16.8	Trinity River not toxic--*Daphnia*	No effect
19.7 ± 11.3	Commencement Bay highly toxic--amphipod	Small gradient
19.9	Newport low toxicity--shrimp	No effect
20	Lake Union highly toxic--amphipod	Small gradient
22.2 ± 9	Commencement Bay highly toxic--oyster	Small gradient
26	San Diego Bay low toxicity--various	No effect
26	San Diego Bay low toxicity--various	No effect
27 ± 11.1	Massachusetts Bay high species richness	No effect
29	Keweenaw Waterway least toxic--*Daphnia*	No effect
29.2 ± 9.1	Kishwaukee River most taxa	No effect
29.6 ± 15.6	Southern California high echinoderm abundance	No effect
32.3 ± 17.5	Southern California moderate echinoderm abundance	No gradient
34 ± 5.9	DuPage River most taxa	No effect
36.3 ± 21.9	Keweenaw Waterway not toxic--*Daphnia*	No effect
38.1 ± 36.3	Southern California moderate species richness	No concordance
38.5	Waukegan Harbor highly toxic--amphipod	Small gradient
40.7 ± 30.9	Southern California high arthropod abundance	No effect
42 ± 11	Fraser River *Macoma* present	No effect
42 ± 39.8	Southern California moderate total abundance	No concordance
43.4 ± 22.5	Kishwaukee River least taxa	Small gradient
46.3 ± 43.3	Southern California moderate arthropod abundance	Small gradient
47.6	Los Angeles Harbor high toxicity	Small gradient
54 ± 83.5	Southern California low total abundance	No concordance
59.7 ± 28.7	DuPage River least taxa	Weak concordance
60	*Macoma* burrowing bioassay	Small gradient
60.9 ± 27.5	Massachusetts Bay moderate species richness	*
62.3 ± 139.2	Southern California high species richness	No effect
67.5	Norwalk low toxicity--shrimp	No effect
72.6 ± 60.6	Trinity River significantly toxic--Daphnia	*
73 ± 124.4	Southern California not toxic--amphipod	No effect
80	**ER-L**	**10 percentile**
81 ± 29.3	Massachusetts Bay low species richness	*
81.4 ± 88.5	Southern California significantly toxic--amphipod	*
86	Stamford low toxicity--shrimp	No effect
87 ± 47	Little Grizzly Creek high toxicity--*Daphnia*	*
87.3 ± 22.1	Fraser River Macoma absent	*
88.2 ± 82.7	San Francisco Bay least toxic--bivalve	No effect
90	*Macoma* avoidance bioassay	*
97.5 ± 66.7	San Francisco Bay highly toxic--bivalve	No concordance
101.6	Keweenaw Waterway highly toxic--*Daphnia*	*
108.7 ± 19.6	Keweenaw Waterway significantly toxic--*Daphnia*	*
128 ± 4	Sheboygan River significant toxicity--prawn	*
133.7 ± 94.2	San Francisco Bay significantly toxic--bivalve	No effect
141.8 ± 86.5	San Francisco Bay highly toxic--amphipod	No concordance
144.6 ± 88.6	Hudson-Raritan least toxic--nematode	No effect
145	**ER-M**	**50 percentile**
145.8 ± 307.9	Southern California low arthropod abundance	*
150.2 ± 85.9	San Francisco Bay not toxic--bivalve	No effect
154.9 ± 102.1	San Francisco Bay significantly toxic --amphipod	No concordance
156.6 ± 320.9	Southern California low species richness	*
160.3 ± 85.4	Hudson-Raritan most toxic--nematode	*

Table B-4. (continued)

Concentration (ppm)	Biological Test	Remarks
163.3 ± 116.7	San Francisco Bay moderately toxic--amphipod	No concordance
164 ± 91.4	San Francisco Bay moderately toxic--bivalve	No concordance
180	Torch Lake significantly toxic--*Daphnia*	*
195 ± 93.9	San Francisco Bay least toxic--amphipod	No effect
201.3 ± 349	Southern California low echinoderm abundance	*
202.6 ± 97.3	San Francisco Bay not toxic--amphipod	No effect
254.8	San Diego Bay low toxicity--shrimp	No effect
260	1988 Puget Sound AET--benthic	*
270	1988 Puget Sound AET--amphipod	*
280	San Francisco Bay AET--bivalve	No concordance
292.6 ± 459.3	Southern California high total abundance	No effect
299.5	San Diego Bay low toxicity--clam	No effect
299.5	San Diego Bay low toxicity--polychaete	No effect
299.5	San Diego Bay low toxicity--fish	No effect
315.4 ± 236	Phillips Chain least toxic--*Daphnia*	No effect
335 ± 179.7	Baltimore Harbor least toxic--fish	No effect
369.2	Black Rock Harbor high toxicity	*
370	San Francisco Bay AET--amphipod	No concordance
669.3	Palos Verdes major benthic degradation	*
980	Phillips Chain significantly toxic--*Daphnia*	*
1646 ± 1628	Baltimore Harbor most toxic--fish	*

* 21 concentrations used to determine ER-L and EP '' values

Table B-5. Sediment effects data available for COPPER arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
1.02	Georgetown benthic community	No effect
4 ± 3	Mississippi River high toxicity--midge	No concordance
5 ± 2	Massachusetts Bay high species richness	No effect
7.9 ± 5	Mississippi River low toxicity	No effect
8.9 ± 4	Mississippi River low toxicity	No effect
12 ± 6	Southern California high echinoderm abundance	No effect
12.2	Newport low toxicity--shrimp	No effect
13.4 ± 14	Southern California moderate echinoderm abundance	No gradient
15 ± 7	Massachusetts Bay moderate species richness	*
16 ± 7	Massachusetts Bay low species richness	No gradient
17.8	Mississippi River low toxicity	No effect
17.8	ET50 burrowing time bioassay--clam	*
18 ± 15	Trinity River nontoxic--*Daphnia*	No effect
19.5	Waukegan Harbor highly toxic--amphipod	*
19.5 ± 6	Kishwaukee River high number of taxa	Small gradient
23.6	Keweenaw Waterway least toxicity	No effect
27.5 ± 16	Feral Fraser River *Macoma* present	No effect
33	Keweenaw Waterway high number of taxa	No effect
34.5 ± 17	San Francisco Bay least toxic--bivalve	No effect
42.8	Duwamish River nontoxic--shrimp	No effect
43 ± 49	Keweenaw Waterway nontoxic--*Daphnia*	No effect
45.4 ± 53	Kishwaukee River low number of taxa	*
46.9 ± 26	San Francisco Bay not toxic--bivalve	No effect
62.1 ± 25	DuPage River high number of taxa	No effect
62.3 ± 78	Southern California nontoxic--amphipod	No effect
64 ± 40	an Francisco Bay moderately toxic--amphipod	No concordance
67	*Macoma* burrowing bioassay	*
68.2 ± 48	San Francisco Bay significantly toxic--bivalve	*
68.4 ± 62	Trinity River significant toxicity--*Daphnia*	*
70	**ER-L**	**10 percentile**
70 ± 47	San Francisco Bay significantly toxic--amphipod	Small gradient
72.1 ± 41	San Francisco Bay least toxic--amphipod	No effect
72.6 ± 75	Commencement Bay least toxic--oyster	No effect
74.6 ± 43	San Francisco Bay not toxic--amphipod	No effect
76 ± 51	San Francisco Bay moderately toxic--bivalve	*
77.3 ± 39	DuPage River low number of taxa	Small gradient
81	PSDDA screening level	No effect
84.6 ± 63	San Francisco Bay highly toxic--amphipod	*
85.1 ± 69	Commencement Bay least toxic--amphipod	No effect
87.7 ± 33	San Francisco Bay highly toxic--bivalve	*
96.7 ± 177	Southern California low echinoderm abundance	*
98 ± 90	Puget Sound nontoxic--amphipod	No effect
106.3 ± 93	Commencement Bay moderately toxic--oyster	*
110	San Francisco Bay AET--bivalve	*
117.8 ± 98	Commencement Bay moderately toxic--amphipod	*
134.6 ± 57	Feral Fraser River *Macoma* absent	*
135.2 ± 118	Phillips Chain nontoxic--*Daphnia*	No effect
136	EP chronic marine @4% TOC	*
138 ± 124	Puget Sound moderately toxic--amphipod	*
145 ± 2	Sheboygan River toxic--prawn	*
147	Los Angeles Harbor toxic--shrimp	*

Table B-5. (continued)

Concentration (ppm)	Biological Test	Remarks
150	*Macoma* avoidance bioassay	*
156	Lake Union high toxicity--amphipod	*
157.5 ± 29	Baltimore Harbor least toxic--fish	No effect
180	San Francisco Bay AET--amphipod	*
181.3 ± 173	Southern California significant toxicity--amphipod	*
200	Norwegian benthos species diversity	*
210	San Diego Bay nontoxic--various	No effect
216	EP acute marine @4% TOC	*
217.8	Stamford nontoxic--shrimp	No effect
223.7	Norwalk nontoxic--shrimp	No effect
250.5 ± 232	Hudson-Raritan nontoxic--nematode	No effect
251 ± 227	Palos Verdes nontoxic--amphipod	No effect
310	1986 Puget Sound AET--benthic	*
312.3	San Diego Bay nontoxic--mysid	No effect
390	ER-M	50 percentile
390	1986 Puget Sound AET--oyster	*
390	1986 Puget Sound AET- Microtox™	*
453 ± 311	Hudson-Raritan highly toxic--nematode	*
530	1988 Puget Sound AET--benthic	*
540	Phillips Chain significant toxicity--*Daphnia*	*
589	Keweenaw Waterway least number of taxa	*
591.7 ± 126	Palos Verdes major benthic degradation	*
591.7 ± 126	Palos Verdes significant toxicity--amphipod	*
612	Black Rock Harbor highly toxic	*
612	Keweenaw Waterway highly toxic--*Daphnia*	*
681	LC50 *Daphnia* spiked bioassay--Soap Creek	*
730	Keweenaw Waterway significant toxicity--*Daphnia*	*
810	1986 Puget Sound AET--amphipod	*
857	LC50 midge spiked bioassay--Soap Creek	*
917.8 ± 2750	Commencement Bay highly toxic--oyster	*
937	LC50 *Daphnia* spiked bioassay--Tualatin River	*
964	LC50 amphipod spiked bioassay- Soap Creek	*
995	San Diego Bay nontoxic--clam	No effect
995	San Diego Bay nontoxic--polychaete	No effect
1071 ± 948	Baltimore Harbor most toxic-fish	*
1078	LC50 amphipod spiked bioassay--Soap Creek	*
1260 ± 3251	Puget Sound highly toxic--amphipod	*
1300	1988 Puget Sound AET--amphipod	*
1374 ± 809	Little Grizzly Creek toxic--*Daphnia*	*
1800	Torch Lake highly toxic--*Daphnia*	*
2296	LC50 midge spiked bioassay--Tualatin River	*
2820 ± 4881	Commencement Bay highly toxic--amphipod	*

* 51 concentrations used to determine ER-L and ER-M values

Table B-6. Sediment effects data available for LEAD arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
<0.5	Georgetown disposal site benthos	No effect
9.5 ± 9	Southern California moderate echinoderm abundance	No concordance
9.5	Keweenaw least toxic--*Daphnia*	No effect
10.7 ± 10	Keweenaw nontoxic--*Daphnia*	No effect
11.3 ± 8	Southern California moderate species richness	No concordance
11.7 ± 13	Southern California high echinoderm abundance	No effect
12.4 ± 9	Southern California high arthropod abundance	No effect
12.5 ± 4	Massachusetts Bay high benthhic species richness	No effect
12.5 ± 10	Southern California moderate arthropod abundance	No gradient
12.6 ± 10	Southern California moderate total abundance	No concordance
14 ± 9	Feral Fraser River *Macoma* present	No effect
16.6 ± 24	Southern California low total abundance	No concordance
18	Cubatao River Brazil high toxicity--*Daphnia*	Small gradient
19.8 ± 34	Southern California high species richness	No effect
21.2 ± 11	Kishwaukee River high number of taxa	No effect
25.2 ± 17	San Francisco Bay least toxic--bivalve	No effect
26.6	Keweenaw Waterway highly toxic--*Daphnia*	*
27.1	Duwamish River nontoxic--shrimp	No effect
29 ± 8	Keweenaw significantly toxic--*Daphnia*	*
30.6 ± 26	Kishwaukee River least number of taxa	*
32 ± 18	Little Grizzly Creek significant toxicity	No concordance
32	*Macoma* burrowing bioassay	*
<32.4	Waukegan Harbor highly toxic--amphipod	Detection limits
35	Norway benthos diversity	*
35	**ER-L**	**10 percentile**
35.1 ± 22	Trinity River least toxicity--*Daphnia*	No effect
41.3	Los Angeles Harbor >50% mortality--shrimp	*
42.1 ± 27	San Francisco Bay moderately toxic--amphipod	*
42.4 ± 26	Massachusetts Bay moderate species richness	*
43.1 ± 33	San Francisco Bay nontoxic--bivalve	No effect
45.6 ± 59	Southern California nontoxic--amphipod	No effect
46.7 ± 17	Massachusetts Bay low benthic species richness	*
46.9 ± 31	Puget Sound nontoxic--amphipod	No effect
47.8 ± 103	Southern California low arthropod abundance	*
≤50	San Francisco Bay triad minimum bioeffects	*
51 ± 34	San Francisco Bay least toxic--amphipod	No effect
51 ± 111	Southern California low species richness	*
53.7 ± 27	Trinity River significantly toxic--*Daphnia*	*
54.4 ± 36	San Francisco Bay nontoxic--amphipod	No effect
57.1 ± 20	DuPage River high number of taxa	No effect
58.3 ± 61	San Francisco Bay significantly toxic--amphipod	Small gradient
58.9 ± 63	San Francisco Bay significantly toxic--bivalve	*
>60	FWPCA heavy: benthos absent	*
63.4 ± 63	San Francisco Bay moderately toxic--bivalve	*
64.4 ± 118	Southern California low echinoderm abundance	*
66	PSDDA screening level	No effect
73.1 ± 42	Southern California significantly toxic--amphipod	*
74	*Macoma* avoidance bioassay	*
77.6 ± 75	Commencement Bay least toxic--amphipod	No effect
78.6 ± 34	Phillips Chain low toxicity--*Daphnia*	No effect
81.7 ± 49	Feral Fraser River *Macoma* absent	*

Table B-6. (continued)

Concentration (ppm)	Biological Test	Remarks
89.6	Black Rock Harbor 100% mortality–*Nereis*	*
94.9 ± 154	Southern California high total abundance	No effect
95.7 ± 93	San Francisco Bay highly toxic–amphipod	*
104.5 ± 87	San Francisco Bay highly toxic–bivalve	*
104.7 ± 173	Commencement Bay least toxic–oyster	No effect
110	**ER-M**	**50 percentile**
110	Torch Lake significantly toxic	*
113.1 ± 123	Commencement Bay moderately toxic–oyster	*
120	San Francisco Bay AET amphipod	*
122.9	Stamford nontoxic–shrimp	No effect
≥130	San Francisco Bay triad significant bioeffects	*
132	EP chronic marine @4% TOC	*
136.6 ± 140	Puget Sound moderately toxic–amphipod	*
140	San Francisco Bay AET–bivalve	*
143.7 ± 110	DuPage River low number of taxa	*
145.2 ± 132	Hudson-Raritan not toxic–nematode	No effect
160	Phillips Chain significantly toxic	*
170.8 ± 192	Commencement Bay moderately toxic–amphipod	*
213 ± 131	Baltimore Harbor least toxic–fish	No effect
253 ± 47	Sheboygan River significantly toxic	*
276.9	Norwalk nontoxic–shrimp	No effect
300	1986 Puget Sound AET–benthic	*
300	Lake Union 95% mortality–amphipod	*
312.3 ± 23	Palos Verdes major benthic degradation	*
320.9 ± 195	Hudson-Raritan highly toxic–nematode	*
450	1988 Puget Sound AET–benthic	*
512 ± 213	Baltimore Harbor most toxic–fish	*
530	1986 Puget Sound AET–Microtox™	*
570.1 ± 1489	Commencement Bay highly toxic–oyster	*
660	1986 Puget Sound AET–amphipod	*
660	1986 Puget Sound AET-oyster	*
750.2 ± 1763	Puget Sound highly toxic–amphipod	*
1613.2 ± 2628	Commencement Bay highly toxic–amphipod	*
3360	EP acute marine @ 4% TOC	*

* 47 concentrations used to determine ER-L and ER-M values

Table B-7. Sediment effects data available for MERCURY arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
0.026	Newport not toxic--shrimp	No effect
0.032	EP chronic marine @4% TOC	*
0.035	Mississippi River low toxicity	No effect
0.05	Duwamish River not toxic--shrimp	No effect
0.06	Massachusetts Bay high benthos species richness	No effect
0.08	Waukegan Harbor highly toxic--*Hyalella*	*
0.08 ± 0.1	Kishwaukee River high number of taxa	No effect
0.09 ± 0.1	Kishwaukee River low number of taxa	No gradient
<0.1	Sheboygan River significant toxicity--prawn	Below detection
0.1 ± 0.1	Feral Fraser River *Macoma* present	No effect
0.11 ± 0.02	Massachusetts Bay low benthos species richness	No gradient
0.13 ± 0.1	Keweenaw Waterway not toxic--*Daphnia*	No effect
0.13	Keweenaw Waterway least toxic--*Daphnia*	No effect
0.147	Los Angeles toxic (>50% mortality)--shrimp	*
0.15	**ER-L**	**10 percentile**
0.162	Stamford not toxic--shrimp	No effect
0.173	Lake Union 95% mortality--amphipod	*
0.18 ± 0.1	Massachusetts. Bay moderate benthos species richness	No gradient
0.18	*Macoma* burrowing time bioassay	*
0.18	Keweenaw Waterway most toxic--*Daphnia*	No gradient
0.2 ± 0.1	Commencement Bay least toxic--amphipod	No effect
0.2 ± 0.1	Commencement Bay moderately toxic--oyster	No gradient
0.2 ± 0.1	Commencement Bay least toxic--oyster	No effect
0.2 ± 0.1	Keweenaw Waterway significantly toxic--*Daphnia*	No gradient
0.21	PSDDA screening level	No effect
0.28 ± 0.2	DuPage River high number of taxa	No effect
0.29	Torch Lake significant mortality--*Daphnia*	*
0.3 ± 0.2	Commencement Bay moderately toxic--amphipod	No gradient
0.3 ± 0.2	San Francisco Bay least toxic--bivalve	No effect
0.3 ± 0.1	Trinity River significantly toxic--*Daphnia*	No concordance
0.3	Norwalk not toxic--shrimp	No effect
0.33 ± 0.1	Southern California significantly toxic--amphipod	No gradient
0.34 ± 0.02	Southern California not toxic--amphipod	No effect
0.38 ± 0.1	Baltimore Harbor least toxic--fish	No effect
0.41	1986 Puget Sound AET--Microtox™	*
0.42 ± 0.2	Feral Fraser River *Macoma* absent	*
0.47 ± 0.5	Puget Sound nontoxic--amphipod	No effect
0.48	*Macoma* avoidance bioassay	*
0.5 ± 0.4	San Francisco Bay least toxic--amphipod	No effect
0.5 ± 0.3	San Francisco Bay not toxic--bivalve	No effect
0.59	1986 Puget Sound AET--oyster	*
0.6 ± 0.4	San Francisco Bay not toxic--amphipod	No effect
0.6 ± 0.4	San Francisco Bay highly toxic--bivalve	No concordance
0.6 ± 0.7	Trinity River low toxicity--*Daphnia*	No effect
0.6	EP acute marine @4% TOC	*
0.61	Georgetown benthic community	No effect
0.65-1.15	*Pontoporeia* activity not significantly decreased	No effect
0.7 ± 0.8	San Francisco Bay moderately toxic--amphipod	No gradient
0.7 ± 0.8	San Francisco Bay significantly toxic--amphipod	No gradient)
0.7 ± 0.9	San Francisco Bay significantly toxic--bivalve	No gradient
0.88	1986 Puget Sound AET--benthic	*

Table B-7. (continued)

Concentration (ppm)	Biological Test	Remarks
0.9 ± 1	San Francisco Bay moderately toxic--bivalve	*
0.9	Cubatao River EC50 toxicity--*Daphnia*	*
0.96 ± 1	San Francisco Bay highly toxic--amphipod	*
1.02 ± 1.3	Phillips Chain not toxic--*Daphnia*	No effect
1.3	**ER-M**	**50 percentile**
1.3	San Francisco Bay AET-amphipod	*
1.38 ± 4.6	Puget Sound intermediate toxicity--amphipod	*
1.5	San Francisco Bay AET--bivalve	*
1.5 ± 0.9	L. Grizzly Creek significantly toxic--*Daphnia*	*
1.6 ± 1.1	Baltimore Harbor most toxic--fish	*
1.6 ± 2	DuPage River low number of taxa	*
2.1	1986 Puget Sound AET--amphipod	*
2.1	1988 Puget Sound AET--benthic	*
2.15-3.35	*Pontoporeia* activity sign decreased	*
2.7	San Diego Bay not toxic--various	No effect
3.5 ± 12.5	Commencement Bay highly toxic--oyster	*
5 ± 6.7	Hudson-Raritan not toxic--nematode	No effect
5.04 ± 14.8	Puget Sound highly toxic	*
8.9 ± 7.5	Hudson-Raritan highly toxic--nematode	*
9.4	Phillips Chain significantly toxic	*
11.2 ± 22.8	Commencement Bay highly toxic--amphipod	*
13.1	LC50 amphipod bioassay	*
34.9	New York nontoxic, 100-d, various species	No effect
58.2	San Diego Bay not toxic--mysid	No effect
66.5	San Diego Bay not toxic--clam	No effect
254.4	San Diego Bay not toxic--fish	No effect

* 30 concentrations used to determine ER-L and ER-M values

Table B-8. Sediment effects data available for NICKEL arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
3	Cubatao River toxicity–*Daphnia*	No concordance
6	Georgetown benthic community	No effect
10±3	Massachusetts Bay high species richness	No effect
10	Newport not toxic–shrimp	No effect
12±3	Commencement Bay least toxic–oyster	No effect
16±7	Commencement Bay least toxic–amphipod	No effect
17±8	Commencement Bay moderately toxic–oyster	Small gradient
17.5	Duwamish River nontoxic–shrimp	No effect
20±13	Commencement Bay moderately toxic–amphipod	Small gradient
20±15	Southern California not toxic–amphipod	No effect
21±11	Massachusetts Bay moderate species richness	*
24±22	Southern California significantly toxic–amphipod	Small gradient
28	1986 Puget Sound AET–Microtox™	*
28	PSDDA screening level	No effect
29	Keweenaw least toxic–*Daphnia*	No effect
29±26	Trinity River significantly toxic–*Daphnia*	No concordance
30	**ER-L**	**10 percentile**
30±22	Commencement Bay highly toxic–oyster	*
31	Los Angeles Harbor (>50% mortality)–shrimp	*
<31.8	Waukegan Harbor significantly toxic–amphipod	below detection
33±12	Massachusetts Bay low species richness	*
34±14	Feral Fraser River *Macoma* present	No effect
35±14	Keweenaw Waterway not toxic–*Daphnia*	No effect
36±29	Trinity River not toxic–*Daphnia*	No effect
38	Stamford not toxic	No effect
39	1986 Puget Sound AET–oyster	*
40±16	Little Grizzly Creek significantly toxic–*Daphnia*	*
41±32	Commencement Bay highly toxic–amphipod	*
43	Norwalk not toxic–shrimp	No effect
44±3	Feral Fraser River *Macoma* absent	Small gradient
49	1986 Puget Sound AET–benthic	*
50	**ER-M**	**50 percentile**
52	Black Rock Harbor 100% mortality–*Nereis*	*
70±14	Baltimore Harbor least toxic–fish	No effect
78±42	San Francisco Bay least toxic–bivalve	No effect
88	Lake Union highly toxic–amphipod	*
93±3	San Francisco Bay highly toxic–bivalve	Small gradient
94±5	Palos Verdes major benthic degradation	*
97±53	Baltimore Harbor most toxic–fish	*
99±35	San Francisco Bay moderately toxic–amphipod	No gradient
100±35	San Francisco Bay significantly toxic–bivalve	No gradient
100	Keweenaw Waterway highly toxic –*Daphnia*	*
102±44	San Francisco Bay not toxic–bivalve	No effect
105±36	San Francisco Bay significantly toxic–amphipod	No gradient
106±74	Phillips Chain least toxic –*Daphnia*	No effect
108±25	San Francisco Bay least toxic–amphipod	No effect
108±27	San Francisco Bay not toxic–amphipod	No effect
109±19	Keweenaw Waterway significantly toxic–*Daphnia*	*
110±0	Sheboygan River significant mortality–prawn	*
112±31	San Francisco Bay moderately toxic–bivalve	Poor concordance
113±43	San Francisco Bay highly toxic–amphipod	Small gradient
>120	1986 Puget Sound AET–amphipod	No definitive value
>140	1988 Puget Sound AET–amphipod	No definitive value
>140	1988 Puget Sound AET–benthic	No definitive value
150	Torch Lake significant toxicity–*Daphnia*	*
>170	San Francisco Bay AET–bivalve	Not definitive
>170	San Francisco Bay AET–amphipod	Not definitive
350	Phillips Chain significant toxicity–*Daphnia*	*

* 18 concentrations used to determine ER-L and ER-M values

Table B-9. **Sediment effects data available for SILVER arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.**

Concentration (ppm)	Biological Test	Remarks
0.2 ± 0.1	Commencement Bay highly toxic--amphipod	No gradient
0.3 ± 0.1	Commencement Bay moderately toxic--amphipod	No gradient
0.3 ± 0.1	Commencement Bay least toxic--amphipod	No gradient
0.3 ± 0.1	Commencement Bay highly toxic--oyster	No gradient
0.3 ± 0.1	Commencement Bay moderately toxic--oyster	No gradient
0.3 ± 0.1	Commencement Bay least toxic--oyster	No gradient
0.3 ± 0.1	Puget Sound least toxic--amphipod	No effect
0.5 ± 0.4	San Francisco Bay least toxic--bivalve	No effect
>0.6	1986 Puget Sound AET--oyster	No definitive value
>0.6	1986 Puget Sound AET--Microtox™	No definitive value
0.6 ± 1	Puget Sound highly toxic--amphipod	*
0.6 ± 0.5	San Francisco Bay not toxic--bivalve	No effect
0.6 ± 0.8	Southern California high echinoderm abundance	No effect
0.6 ± 0.7	Southern California moderate echinoderm abundance	No gradient
0.7 ± 1	Southern California moderate arthropod abundance	No concordance
0.7 ± 0.8	Southern California moderate species richness	No concordance
0.8 ± 0.6	Feral Fraser River *Macoma* present	No effect
0.8	San Diego Bay high survival--various	No effect
0.8	San Diego Bay high survival--various	No effect
0.9 ± 0.9	San Francisco Bay moderately toxic--amphipod	No concordance
0.9 ± 1.6	Southern California high arthropod abundance	No effect
0.9 ± 2.1	Southern California high species richness	No effect
1	*Macoma* avoidance bioassay	*
1	**ER-L**	**10 percentile**
1 ± 0.6	San Francisco Bay moderately toxic--bivalve	*
1 ± 2	Southern California moderate abundance	No concordance
1.1	San Francisco Bay AET--bivalve	*
1.1 ± 1.9	Southern California not toxic--amphipod	No effect
1.2	PSDDA screening level	No effect
1.2 ± 1.7	San Francisco Bay significantly toxic--amphipod	No concordance
1.3 ± 1.8	San Francisco Bay least toxic--amphipod	No effect
1.3 ± 1.4	Southern California significantly toxic--amphipod	No gradient
1.3 ± 1.8	Southern California low abundance	No concordance
1.4 ± 1.9	San Francisco Bay not toxic--amphipod	No effect
1.7 ± 2.6	San Francisco Bay highly toxic--amphipod	No concordance
1.7 ± 2.2	San Francisco Bay significantly toxic-- bivalve	*
2.1 ± 1.3	Feral Fraser River *Macoma* absent	*
2.2 ± 3.9	Southern California low arthropod abundance	*
2.2	**ER-M**	**50 percentile**
2.5 ± 4.1	Southern California low species richness	*
2.6	*Macoma* burrowing bioassay	*
3.1 ± 4.5	Southern California low echinoderm abundance	*
3.2 ± 5.6	Southern California high abundance	No effect
>3.7	1986 Puget Sound AET--amphipod	No definitive value
5.2	1986 Puget Sound AET--benthic	*
>6.1	1988 Puget Sound AET--benthic	No definitive value
6	1988 Puget Sound AET--amphipod	*
6.9 ± 2.5	San Francisco Bay highly toxic--bivalve	*
>8.6	San Francisco Bay AET--amphipod	Not definitive

* 13 concentrations used to determine ER-L and ER-M values

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Table B-10. Sediment effects data available for ZINC arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
11	Georgetown benthic community	No effect
20	Cubatao River highly toxic--*Daphnia*	No concordance
32 ± 7	Massachusetts Bay high species richness	No effect
50 ± 13	Southern California high echinoderm abundance	No effect
50 ± 22	Southern California moderate species richness	No concordance
51 ± 24	Southern California high arthropod abundance	No effect
51	Amphipod avoidance bioassay	*
52 ± 28	Southern California moderate arthropod abundance	No gradient
53 ± 28	Southern California moderate abundance	No concordance
55 ± 34	Southern California moderate echinoderm abundance	No gradient
55	Newport low toxicity--shrimp	No effect
58 ± 41	Trinity River low mortality--*Daphnia*	No effect
59 to 124	*Pontoporeia* bioassay	*
62	Keweenaw Waterway low toxicity--*Daphnia*	No effect
65 ± 19	Feral Fraser River *Macoma* present	No effect
69 ± 24	Keweenaw Waterway not toxic--*Daphnia*	No effect
71 ± 106	Southern California high species richness	No effect
73 ± 81	Southern California low abundance	No concordance
72	Duwamish River low toxicity--shrimp	No effect
76	LC08 amphipod bioassay	No effect
79	LC05 amphipod bioassay	No effect
80	Norwegian benthic species diversity	Poor concordance
89 ± 41	San Francisco least toxic--bivalve	No effect
96 ± 52	Kishwaukee River highest benthic species richness	No effect
98 ± 64	Massachusetts Bay moderate species richness	*
107 ± 122	Commencement Bay least toxic--oyster	No effect
107 ± 31	Kishwaukee River least benthic species richness	No gradient
108 ± 79	Commencement Bay least toxic--amphipod	No effect
109	*Macoma* burrowing time bioassay	No concordance
114 ± 52	Puget Sound nontoxic--amphipod	No effect
117 ± 42	Massachusetts Bay lowest species richness	*
120	**ER-L**	**10 percentile**
121 ± 100	Trinity River significant mortality--*Daphnia*	*
127	Waukegan Harbor high toxic--amphipod	*
130	San Francisco Bay AET--bivalve	*
136 ± 78	San Francisco Bay not toxic--bivalve	No effect
146 ± 73	San Francisco Bay moderately toxic--amphipod	No concordance
154 ± 91	San Francisco Bay significantly toxic--bivalve	Small gradient
154	Keweenaw highly toxic--*Daphnia*	*
158 ± 87	San Francisco Bay significantly toxic--amphipod	No concordance
160	PSDDA screening level	No effect
168 ± 52	Keweenaw Waterway significantly toxic--*Daphnia*	*
169 ± 53	Feral Fraser River *Macoma* absent	*
171 ± 91	San Francisco Bay least toxic--amphipod	No effect
172	*Macoma* avoidance bioassay	*
172 ± 92	San Francisco Bay moderately toxic--bivalve	*
177 ± 96	San Francisco Bay not toxic--amphipod	No effect
182 ± 384	Southern California low arthropod abundance	*
182 ± 56	DuPage River highest benthic species richness	No effect
185 ± 335	Commencement Bay moderately toxic--oyster	*
187 ± 115	San Francisco Bay highly toxic--amphipod	No gradient

Table B-10. (continued)

Concentration (ppb)	Biological Test	Remarks
188	Amphipod avoidance bioassay	*
195 ± 166	Puget Sound moderately toxic--amphipod	*
197 ± 415	Southern California low species richness	*
205 ± 90	San Francisco Bay highly toxic--bivalve	*
211 ± 342	Commencement Bay moderately toxic--amphipod	*
212 ± 243	Southern California not toxic--amphipod	No effect
216 ± 213	Phillips Chain low mortality--*Daphnia*	No effect
223	Los Angeles Harbor >50% mortality--shrimp	*
230	San Francisco Bay AET--amphipod	*
230 ± 444	Southern California low echinoderm abundance	*
245 ± 201	Hudson-Raritan positive growth--nematode	No effect
260	1986 Puget Sound AET--benthic	*
267 ± 298	Little Grizzly Creek significant mortality--*Daphnia*	*
270	ER-M	50 percentile
276	LC50 for amphipod bioassay	*
290 ± 10	Sheboygan River significant mortality--prawn	*
310	Torch Lake significant mortality--*Daphnia*	*
320	Lake Union high mortality--amphipod	*
327 ± 162	DuPage River least benthic species richness	*
334	Black Rock Harbor 100% mortality--*Nereis*	*
340	Stamford low mortality--shrimp	No effect
347 ± 592	Southern California high abundance	No concordance
348 ± 234	Southern California significantly toxic--amphipod	*
387 ± 783	Commencement Bay highly toxic--oyster	*
410	1988 Puget Sound AET--benthic	*
449 ± 252	Hudson-Raritan negative growth--nematode	*
570	Phillips Chain significant mortality	*
613	54.7% mortality--*Rhepoxynius* bioassay	*
636	Norwalk 0% mortality--shrimp	No effect
707 ± 955	Puget Sound highly toxic--amphipod	*
738 ± 394	Baltimore Harbor least toxic--fish	No effect
739 ± 139	Palos Verdes major benthic degradation	*
760	EP marine chronic @4% TOC	*
870	1986 Puget Sound AET--amphipod	*
941 ± 1373	Commencement Bay highly toxic--amphipod	*
960	1988 Puget Sound AET--amphipod	*
1600	1986 Puget Sound AET--oyster	*
1600	1986 Puget Sound AET--Microtox™	*
1804 ± 2098	Baltimore Harbor most toxic--fish	*
2240	EP marine acute @4% TOC	*

* 46 concentrations used to determine ER-L and ER-M values

Table B-11. Sediment effects data available for PCBs arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
0.005 ± 0	Trinity River significant mortality--*Daphnia*	No gradient
0.005 ± 0	Trinity River low mortality--*Daphnia*	No effect
0.7 ± 0.3	Mississippi River 55% survival--midges	No concordance
<1.13	Mississippi River 25% survival--mayfly	No concordance
2 ± 1	Massachusetts Bay high species richness	No effect
2.9	SLC freshwater	*
5 ± 5	Massachusetts Bay moderate species richness	No gradient
5 ± 5	Massachusetts Bay low species richness	No gradient
7 ± 6	Kishwaukee River highest species richness	No effect
12 ± 20	Mississippi River high survival--mayfly	No effect
15 ± 22	Mississippi River 90% survival--midges	No effect
20 ± 20	Southern California high echinoderm abundance	No effect
25	San Diego Bay high survival--various	No effect
25	San Diego Bay high survival--various	No effect
26 ± 16	San Francisco least toxic--bivalve	No effect
28 ± 27	Commencement Bay least toxic--oyster	No effect
30 ± 50	Southern California moderate echinoderm abundance	Small gradient
31 ± 19	DuPage River highest species richness	No effect
36.6	SLC marine	*
38 ± 32	Commencement Bay highly toxic--amphipod	No concordance
42.6	SLC marine	*
50	Georgetown benthic community	No effect
50	**ER-L**	**10 percentile**
54	San Francisco Bay AET--bivalve	*
60 ± 70	Southern California moderate arthropod abundance	No concordance
60	Mississippi River high survival	No effect
61 ± 88	Commencement Bay least toxic--amphipod	No effect
80 ± 100	Southern California high arthropod abundance	No effect
80 ± 140	Southern California moderate abundance	No concordance
94 ± 147	San Francisco Bay least toxic--amphipod	No effect
99 ± 120	Puget Sound nontoxic--amphipod	No effect
≤100	San Francisco Bay triad minimum bioeffects	*
101 ± 153	San Francisco Bay not toxic--amphipod	No effect
127 ± 171	San Francisco Bay significantly toxic--bivalve	No concordance
128 ± 264	Kishwaukee River least species richness	*
130	1986 Puget Sound AET--Microtox™	*
130	PSDDA screening level	No effect
140 ± 262	Commencement Bay moderately toxic--oyster	*
146 ± 218	San Francisco Bay significantly toxic--amphipod	*
151 ± 260	San Francisco Bay moderately toxic--amphipod	*
≥160	San Francisco Bay triad significant bioeffects.	*
160 ± 430	Southern California low abundance	No concordance
164 ± 100	San Francisco Bay highly toxic--bivalve	No gradient
165 ± 232	San Francisco Bay moderately toxic--bivalve	*
169 ± 171	San Francisco Bay highly toxic--amphipod	No gradient
ND-174	Waukegan Harbor least toxic--Microtox™	No effect
180 ± 160	Baltimore Harbor least toxic--fish	No effect
190 ± 214	DuPage River least species richness	*
216 ± 376	San Francisco not toxic--bivalve	No effect
220 ± 540	Southern California high species richness	No effect

Table B-11. (continued)

Concentration (ppb)	Biological Test	Remarks
251 ± 556	Commencement Bay moderately toxic--amphipod	No concordance
259 ± 407	Puget Sound moderately toxic--amphipod	*
260	San Francisco Bay AET--amphipod	*
272 ± 217	Southern California significantly toxic--amphipod	No concordance
276 ± 365	Puget Sound highly toxic--amphipod	Small gradient
280	EP chronic marine (hexa-PCB)	*
290 ± 502	Hudson-Raritan positive growth--nematode	No effect
368 ± 695	Commencement Bay highly toxic--oyster	*
400	**ER-M**	**50 percentile**
400 ± 600	Southern California moderate species richness	*
480 ± 724	Southern California not toxic--amphipod	No effect
638 ± 512	Hudson-Raritan negative growth--nematode	*
1000	1988 Puget Sound AET--benthic	*
1000 ± 2400	Southern California low arthropod abundance	*
1000 ± 300	Significant toxicity--*Rhepoxynius* in mixtures	*
1100	1986 Puget Sound AET--oyster	*
1100	1986 Puget Sound AET--benthic	*
1100 ± 800	Baltimore Harbor most toxic--fish	*
1110 ± 2600	Southern California low species richness	*
1300 ± 2610	Southern California low echinoderm abundance	*
1700	Black Rock Harbor significantly toxic--amphipod	*
2260 ± 3530	Southern California high abundance	No effect
2500	1986 Puget Sound AET--amphipod	*
3100	1988 Puget Sound AET--amphipod	*
4300	Lake Union significantly toxic--amphipod	*
7280	New York Harbor low mortality--various	No effect
10800	LC50 *Rhepoxynius* 10-d bioassay	*
355050 ± 6598300	Waukegan Harbor highly toxic--Microtox™	*
1141300 ± 2229700	Waukegan Harbor moderately toxic--Microtox™	*

* 34 concentrations used to determine ER-L and ER-M values

Table B-12. Sediment effects data available for p,p'-DDT arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
0.4	EP 99 percentile chronic marine	*
0.6	San Francisco Bay highly toxic--bivalve	No concordance
0.7	EP 95 percentile chronic marine	*
1	**ER-L**	**10 percentile**
1.22	San Francisco Bay not toxic--amphipod	No effect
1.3	San Francisco Bay least toxic--amphipod	No effect
1.6	EP chronic safe level @1% TOC	*
2.1	San Francisco Bay least toxic--bivalve	No effect
2.4	San Francisco Bay moderately toxic--amphipod	No gradient
3.2	San Francisco Bay not toxic-bivalve	No effect
3.9	1986 Puget Sound AET--amphipod	*
5.1	San Francisco Bay significantly toxic--bivalve	Small gradient
>6	1986 Puget Sound AET--oyster	No definitive value
6	EP chronic marine @4% TOC	*
6.4	EP chronic marine @4% TOC	*
6.6	San Francisco Bay moderately toxic--bivalve	*
7	**ER-M**	**50 percentile**
7.5	San Francisco Bay significantly toxic--amphipod	*
9.6	San Francisco Bay AET--bivalve	Poor concordance
9.6	San Francisco Bay AET--amphipod	*
11	1986 Puget Sound AET--benthic	*
12.2	San Francisco Bay highly toxic--amphipod	*
34	1988 Puget Sound AET--benthic	*
49.5	Overall LC50 *R. abronius* spiked bioassay @ 1% TOC	*
<50	Georgetown benthic communities	No effect
74	Palos Verdes not toxic--amphipod (n=1)	No effect
83	Palos Verdes significantly toxic--amphipod (n=2)	Small sample size
210	EP acute safe level @1% TOC	*
>270	1988 Puget Sound AET--amphipod	No definitive value
840	EP acute marine @4% TOC	*

* 15 concentrations used to determine ER-L and ER-M values

Table B-13. Sediment effects data available for p,p'-DDE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
0.1±0	Mississippi River 55% survival--midge	No gradient
0.12±0.1	Mississippi River 80 to100% survival--midge	No effect
0.13±0.1	Mississipi River 90% survival--midge	No effect
<0.2	Mississippi River 25% survival--mayfly (n=1)	Small sample size
0.28	Mississippi River 80 to100% survival--scud	No effect
0.6±0.7	San Francisco Bay least toxic--amphipod	No effect
0.7±0.7	San Francisco Bay not toxic--amphipod	No effect
0.7±1	San Francisco Bay least toxic--bivalve	No effect
1±0.5	San Francisco Bay highly toxic--bivalve	No gradient
1.2±1	San Francisco Bay not toxic--bivalve	No effect
1.2±1	San Francisco Bay moderately toxic--amphipod	No gradient
1.7±3.4	San Francisco Bay significantly toxic--bivalve	No gradient
2	**ER-L**	**10 percentile**
2.1±4	San Francisco Bay moderately toxic--bivalve	*
2.2	San Francisco Bay AET--bivalve	*
2.2±4	San Francisco Bay significantly toxic--amphipod	*
2.2	San Francisco Bay AET--amphipod	*
3.4±5.2	San Francisco Bay highly toxic--amphipod	*
9	1986 Puget Sound AET--benthic	*
15	**ER-M**	**50 percentile**
15	1986 Puget Sound AET--amphipod	*
27	EP 99 percentile chronic marine @1% TOC	*
<50	Georgetown benthic communities	No effect
60	EP 95 percentile chronic marine @1% TOC	*
3374±3153	Palos Verdes not toxic--amphipod	No effect
5157±1065	Palos Verdes significantly toxic--amphipod	*
5157±1065	Palos Verdes major benthic degradation	*
7000	EP safe acute @1% TOC	*
28000	EP acute marine @4% TOC	*

* 13 concentrations used to determine ER-L and ER-M values.

8550

Table B-14. Sediment effects data available for p,p'-DDD arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
0.6 ± 0.7	San Francisco Bay moderately toxic--amphipod	No gradient
0.9 ± 1.6	San Francisco Bay significantly toxic--amphipod	No gradient
2	**ER-L**	**10 percentile**
1.3 ± 0.3	San Francisco Bay highly toxic--bivalve	No concordance
1.3 ± 1.2	San Francisco Bay least toxic--amphipod	No effect
1.3 ± 2.1	San Francisco Bay highly toxic--amphipod	No gradient
2	1986 Puget Sound AET--benthic	*
2.3 ± 0.1	San Francisco Bay not toxic--amphipod	No effect
6	EP 99 percentile chronic marine	*
10 ± 7.4	San Francisco Bay least toxic--bivalve	No effect
12.5 ± 8.5	San Francisco Bay not toxic--bivalve	No effect
13.3 ± 21	San Francisco Bay significantly toxic--bivalve	Small gradient
16	San Francisco Bay AET--bivalve	No gradient
16	San Francisco Bay AET--amphipod	No gradient
16	1988 Puget Sound AET--benthic	*
16.1 ± 23.2	San Francisco Bay moderately toxic--bivalve	Small gradient
20	**ER-M**	**50 percentile**
22	EP 95 percentile chronic marine	*
43	1986 Puget Sound AET--amphipod	*
<50	Georgetown benthic communities	No effect
324 ± 387	Palos Verdes not significantly toxic--amphipod	No effect
1090.7 ± 573	Palos Verdes signficantly toxic--amphipod	Small sample size
3250	EP acute safe level @1% TOC	*
13000	EP acute marine @4% TOC	*

* 7 concentrations used to determine ER-L and ER-M values

Table B-15. Sediment effects data available for total DDT arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
1.58	EP saltwater chronic, assuming 1% TOC	*
1.9	Freshwater SLC, assuming 1% TOC	*
3	**ER-L**	**10 percentile**
3.29	EP saltwater chronic, assuming 1% TOC	*
6.9	PSDDA screening level	No effect
6.9 ± 9.8	Trinity River low mortality--*Daphnia*	No effect
8.28	Interim EP saltwater criteria, assuming 1% TOC	*
19.6 ± 18.4	DuPage River highest taxa richness	No effect
20	Lethal threshold-*Crangon* bioassay	*
28.6 ± 36.1	Southern California not toxic--amphipod (excludes Palos Verdes sample)	No effect
31	97-h LC50 *Crangon* spiked bioassay	*
31.4 ± 20.4	Trinity River significant mortality--*Daphnia*	*
45.9	Calculated EP threshold for freshwater	*
50 ± 60	Southern California high echinoderm abundance	No effect
68 ± 71.7	Southern California significantly toxic--amphipod	No concordance
90 ± 130	Southern California moderate echinoderm abundance	*
100 ± 150	Southern California high arthropod abundance	No effect
210 ± 490	Southern California moderate total abundance	No concordance
221.7 ± 281.6	DuPage River least taxa richness	*
250 ± 620	Southern California moderate species richness	No concordance
350	**ER-M**	**50 percentile**
350 ± 710	Southern California moderate arthropod abundance	*
428	Saltwater SLC, assuming 1% TOC	*
505	Saltwater SLC, assuming 1% TOC	*
1018.2 ± 2424	Southern California not toxic-amphipod (includes Palos Verdes sample)	No effect
1410 ± 5440	Southern California low total abundance	No concordance
2170 ± 7190	Southern California high species richness	No effect
4950	Overall LC50 for *Rhepoxynius* bioassay	*
11000	LC50 *H. azteca* bioassay @ 3% TOC	*
13420 ± 37670	Southern California low arthropod abundance	*
14190 ± 40200	Southern California low species richness	*
16500	No deaths *N. virens* spiked bioassay	No effect
18260 ± 43080	Southern California low echinoderm abundance	*
19600	LC50 *H. azteca* bioassay @ 7.2% TOC	*
35300 ± 59540	Southern California high total abundance	No effect
49700	LC50 *H. azteca* bioassay @ 10.5% TOC	*
67232	LD50 cricket nymph bioassay	*

* 21 concentrations used to determine ER-L and ER-M values

Table B-16. Sediment effects data available for CHLORDANE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
ND	San Francisco Bay moderately toxic--amphipod	No concordance
ND	San Francisco Bay least toxic--amphipod	No effect
ND	San Francisco Bay highly toxic--bivalve	No concordance
0.3	EP 99 percentile chronic marine	*
0.5 ± 1	San Francisco Bay least toxic--bivalve	No effect
0.5	**ER-L**	**10 percentile**
0.6	EP 95 percentile chronic marine	*
1 ± 1.4	San Francisco Bay not toxic--amphipod	No effect
1 ± 1.4	San Francisco Bay not toxic--bivalve	No effect
1.7 ± 2.3	Trinity River not toxic--*Daphnia*	No effect
2	San Francisco Bay AET--bivalve	Poor concordance
2	San Francisco Bay AET--amphipod	*
3.5 ± 6.3	San Francisco Bay significantly toxic--amphipod	*
3.5 ± 6.3	San Francisco Bay significantly toxic--bivalve	*
4.1 ± 6.6	San Francisco Bay moderately toxic--bivalve	*
6	**ER-M**	**50 percentile**
6.4 ± 7.5	San Francisco Bay highly toxic--amphipod	*
8.3 ± 4.3	DuPage River most benthic taxa	No effect
17.4	EP lethal threshold freshwater	*
25 ± 22.3	DuPage River least benthic taxa	*
31.3 ± 29.4	Trinity River significantly toxic--*Daphnia*	*
<50	Georgetown benthic communities	No effect
120	LC50 *Crangon* bioassay	*
≤5800	LC50 *N. virens* bioassay	*

* 12 concentrations used to determine ER-L and ER-M values

Table B-17. Sediment effects data available for DIELDRIN arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
ND	San Francisco Bay highly toxic--bivalve	No gradient
0.01	EP 99 percentile chronic marine	*
0.02	**ER-L**	**10 percenitle**
0.02	EP 95 percentile chronic marine	*
0.21	Freshwater SLC @1% TOC	*
4.1	LC50 Crangon spiked bioassay	*
4.3 ± 2.1	Kishwaukee River most benthic taxa	No effect
4.4 ± 2.3	San Francisco Bay moderately toxic--amphipod	No concordance
5.2 ± 1.2	San Francisco Bay least toxic--amphipod	No effect
5.2 ± 1.2	San Francisco Bay least toxic--bivalve	No effect
5.6 ± 2.2	DuPage River most benthic taxa	No effect
6.2 ± 0.6	San Francisco Bay not toxic--amphipod	No effect
6.2 ± 0.6	San Francisco Bay not toxic--bivalve	No effect
6.6	San Francisco Bay AET--bivalve	*
6.6	San Francisco Bay AET--amphipod	*
7.4 ± 4.8	Kishwaukee River least benthic taxa	*
7.6 ± 7.5	San Francisco Bay significantly toxic--amphipod	Small gradient
7.6 ± 7.5	San Francisco Bay significantly toxic--bivalve	Small gradient
8	**ER-M**	**50 percentile**
8.2 ± 8.1	San Francisco Bay moderately toxic--bivalve	*
10.3 ± 9.6	San Francisco Bay highly toxic--amphipod	*
11.9	EP lethal freshwater threshold	*
16 ± 12.1	DuPage River least benthic taxa	*
25.5 ± 33.2	Trinity River significantly toxic--*Daphnia*	No gradient
25.5 ± 61.1	Trinity River not toxic--*Daphnia*	No effect
<50	Georgetown disposal site benthic communities	No effect
57.7	EP interim marine criteria	*
199	EP interim freshwater criteria	*
13000	LC50 *Nereis* spiked bioassay	*

* 14 concentrations used to determine ER-L and ER-M values

Table B-18. Sediment effects data available for ENDRIN arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
0.01	EP 99 percentile chronic marine	*
0.02	ER-L	10 percentile
0.02	EP 95 percentile chronic marine	*
2.15	EP interim marine criteria @1% TOC	*
3.8 ± 3.1	Trinity River low mortality-*Daphnia*	No effect
10.4	EP interim freshwater criteria @1% TOC	*
15.4	EP freshwater lethal threshold	*
18.3 ± 2	Trinity River significant mortality–*Daphnia*	*
45	ER-M	50 percentile
47	LC50 *Crangon* spiked bioassay	*
<50	Georgetown benthic communities	No effect
174	EP chronic sediment/water marine @1% TOC	*
321	EP chronic sediment/biota marine @1% TOC	*
4400	LC50 *H. azteca* @3% TOC	*
4800	LC50 *H. azteca* @6.1% TOC	*
6000	LC50 *H. azteca* @11.2 % TOC	*
28000	LC50 *N. virens* spiked bioassay	*

* 13 concentrations used to determine ER-L and ER-M values

Table B-19. Sediment effects data available for ACENAPHTHENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
1.8 ± 4	San Francisco Bay least toxic--bivalve	No effect
3 ± 5.2	San Francisco Bay not toxic--bivalve	No effect
3.3 ± 5.9	San Francisco Bay moderately toxic--bivalve	Small gradient
4	Southern California highly toxic--amphipod	No concordance
5.4 ± 12.1	San Francisco Bay moderately toxic--amphipod	No concordance
5.9 ± 16.8	San Francisco Bay significantly toxic--amphipod	No concordance
7	Southern California not toxic--amphipod	No effect
7.6 ± 21.6	San Francisco Bay highly toxic--amphipod	No concordance
9	San Francisco Bay AET--bivalve	Small gradient
9.4 ± 17.9	San Francisco Bay significantly toxic--bivalve	Small gradient
9.8 ± 15.9	San Francisco Bay least toxic--amphipod	No effect
11.8 ± 16.8	San Francisco Bay not toxic--amphipod	No effect
30	Black Rock Harbor highly toxic--amphipod	Small gradient
48 ± 18.4	San Francisco Bay highly toxic--bivalve	Small gradient
56	San Francisco Bay AET--amphipod	No concordance
56.7 ± 70	Commencement Bay least toxic--oyster	No effect
86 ± 97	Commencement Bay least toxic--amphipod	No effect
118.5 ± 105	Commencement Bay moderately toxic--oyster	*
127 ± 117	Commencement Bay moderately toxic--amphipod	Small gradient
150	**ER-L**	**10 percentile**
150	Predicted LC50 amphipod bioassay-Eagle Harbor	*
306 ± 604	Commencement Bay highly toxic--oyster	*
500	1986 Puget Sound AET--oyster	*
500	1986 Puget Sound AET--benthic	*
500	1986 Puget Sound AET--Microtox™	*
630	1986 Puget Sound AET--amphipod	*
650	**ER-M**	**50 percentile**
654 ± 1049	Commencement Bay highly toxic--amphipod	*
730	1988 Puget Sound AET--benthic	*
2000	1988 Puget Sound AET--amphipod	*
5599 ± 24392	Eagle Harbor least toxic--amphipod	No effect
6522 ± 8915	Eagle Harbor moderately toxic--amphipod	Small gradient
7330	EP freshwater interim criteria @1% TOC	*
16500	EP chronic marine level @1% TOC	*
23000	EP acute marine level @1% TOC	*
39557 ± 48678	Eagle Harbor highly toxic--amphipod	*
66000	EP chronic marine @4% TOC	*

*15 concentrations used to determine ER-L and ER-M values.

Table B-20 Sediment effects data available for ANTHRACENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
15.4 ± 7.5	San Francisco Bay least toxic--bivalve	No effect
24	San Francisco Bay AET--bivalve	*
34.3 ± 41.2	San Francisco Bay not toxic--bivalve	No effect
35.9	Southern California not toxic--amphipod	No effect
63 ± 72	San Francisco Bay moderately toxic-amphipod	No concordance
70	Predicted LC50 Eagle Harbor-amphipod	*
85	ER-L	10 percentile
85.3 ± 119.3	San Francisco Bay moderately toxic--bivalve	*
110 ± 257	San Francisco Bay least toxic--amphipod	No effect
119.8 ± 276.7	San Francisco Bay significantly toxic--amphipod	No gradient
120.2 ± 269.2	San Francisco Bay not toxic--amphipod	No effect
130	PSDDA screening level	No effect
147.8 ± 148	Commencement Bay least toxic--oyster	No effect
163	Saltwater SLC @1% TOC	*
183.9 ± 347.2	San Francisco Bay significantly toxic--bivalve	*
190	99 percentile chronic marine @1% TOC	*
224.5	Southern California significantly toxic--amphipod	*
227.3 ± 197.6	Commencement Bay least toxic--amphipod	No effect
237 ± 455	San Francisco Bay highly toxic--amphipod	*
264.6 ± 227.8	Commencement Bay moderately toxic--amphipod	Small gradient
282.3 ± 206.9	Commencement Bay moderately toxic--oyster	*
363 ± 353.4	Commencement Bay highly toxic--oyster	*
380	95 percentile chronic marine @1% TOC	*
476.2 ± 549.2	Commencement Bay highly toxic--amphipod	*
922.7 ± 558.1	San Francisco Bay highly toxic--bivalve	*
960	1986 Puget Sound AET--oyster	*
960	ER-M	50 percentile
960	1986 Puget Sound AET--Microtox™	*
1100	San Francisco Bay AET--amphipod	*
1177 ± 1582	Eagle Harbor moderately toxic--amphipod	No concordance
1300	1986 Puget Sound AET--benthic	*
1490 ± 5389	Eagle Harbor least toxic--amphipod	No effect
1900	1986 Puget Sound AET--amphipod	*
4400	1988 Puget Sound AET--benthic	*
6600	28-d LC50 2.5% Elizabeth River--spot	*
7597 ± 7264	Eagle Harbor highly toxic--amphipod	*
13000	1988 Puget Sound AET--amphipod	*
44000	EP chronic marine @4% TOC	*
120000	Lake Union highly toxic--amphipod	*
147840	24-h LC50 58% Elizabeth River--spot	*
264000	LC100 100% Elizabeth River--spot	*

*26 concentrations used to determine ER-L and ER-M values.

Table B-21 Sediment effects data available for BENZO(A)ANTHRACENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
40.7 ± 20	San Francisco Bay not toxic--bivalve	No effect
56.4 ± 25.7	San Francisco Bay least toxic--bivalve	No effect
59.6 ± 129	Southern California not toxic--amphipod	No effect
60	San Francisco Bay AET--bivalve	*
80	Predicted LC50 Eagle Harbor--amphipod	*
122.1 ± 125.9	San Francisco Bay moderately toxic--bivalve	*
167.7 ± 324.2	San Francisco Bay least toxic--amphipod	No effect
187 ± 156.2	San Francisco Bay moderately toxic--amphipod	Small gradient
187.2 ± 359.2	San Francisco Bay not toxic--amphipod	No effect
230	**ER-L**	**10 percentile**
232 ± 336.8	San Francisco Bay significantly toxic--bivalve	*
234.7 ± 246.8	Commencement Bay least toxic--oyster	No effect
236.3 ± 313.2	San Francisco Bay significantly toxic--amphipod	Small gradient
261	Saltwater SLC @1 % TOC	*
300 ± 398.3	San Francisco Bay highly toxic--amphipod	*
310 ± 179.8	Southern California significantly toxic--amphipod	*
450	PSDDA screening level	No effect
475.6 ± 437.1	Commencement Bay least toxic--amphipod	No effect
520 ± 523.1	Commencement Bay moderately toxic--amphipod	Small gradient
548.5 ± 384	Commencement Bay moderately toxic--oyster	*
801 ± 866.2	Commencement Bay highly toxic--oyster	*
919.3 ± 432.7	San Francisco Bay highly toxic--bivalve	*
931 ± 1322.8	Commencement Bay highly toxic--amphipod	*
1100	San Francisco Bay AET--amphipod	*
1300	1986 Puget Sound AET--Microtox™	*
1600	1986 Puget Sound AET--amphipod	*
1600	**ER-M**	**50 percentile**
1600	1986 Puget Sound AET--oyster	*
1600	EP 99 percentile chronic marine @ 1% TOC	*
2200	Columbia River maximum--amphipod	No effect
2496 ± 4157	Eagle Harbor least toxic--amphipod	No effect
4500	1986 Puget Sound AET--benthic	*
5100	1988 Puget Sound AET--amphipod	*
5100	1988 Puget Sound AET--benthic	*
7370 ± 9984	Eagle Harbor moderately toxic--amphipod	*
8750	28-d LC50 2.5% Elizabeth River--spot	*
10000	Spiked bioassay with mixture--amphipod	*
11088 ± 8941	Eagle Harbor highly toxic--amphipod	*
13200	EP freshwater interim criteria @ 1% TOC	*
21000	EP 95 percentile chronic marine @ 1% TOC	*
55000	EP acute safe level @ 1% TOC	*
170000	Lake Union highly toxic--amphipod	*
196000	24-h LC50 56% Elizabeth River--spot	*
220000	EP acute marine @ 4% TOC	*
350000	LC100 100% Elizabeth River--spot	*

* 30 concentrations used to determine ER-L and ER-M values.

Table B-22 Sediment effects data available for BENZO(A)PYRENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
10	Eagle Harbor predicted LC50--amphipod	Small gradient
63 ± 96	Southern California not toxic--amphipod	No effect
129 ± 61	San Francisco Bay least toxic--bivalve	No Effect
210 ± 237	San Francisco Bay not toxic--bivalve	No effect
329 ± 385	Commencement Bay least toxic--oyster	No effect
396	Marine SLC @1% TOC	*
397	Marine SLC @1% TOC	*
400 ± 447	San Francisco Bay least toxic--amphipod	No effect
400	**ER-L**	**10 percentile**
404 ± 428	San Francisco Bay moderately toxic--bivalve	*
423 ± 465	San Francisco Bay not toxic--amphipod	No effect
429 ± 382	San Francisco Bay significantly toxic--amphipod	No gradient
432 ± 344	San Francisco Bay moderately toxic--amphipod	Small gradient
465 ± 471	San Francisco Bay significantly toxic--bivalve	*
486 ± 484	San Francisco Bay highly toxic--amphipod	Small gradient
509 ± 354	Southern California significantly toxic--amphipod	*
596 ± 593	Commencement Bay least toxic--amphipod	No effect
680	PSDDA screening level	No effect
684 ± 464	Commencement Bay moderately toxic--oyster	*
890 ± 1322	Commencement Bay moderately toxic--amphipod	*
1091 ± 338	San Francisco Bay highly toxic--bivalve	*
1192 ± 1643	Commencement Bay highly toxic--amphipod	*
1261 ± 1620	Commencement Bay highly toxic--oyster	*
1300	San Francisco Bay AET--amphipod	*
1600	1986 Puget Sound AET--oyster	*
1600	1986 Puget Sound AET--Microtox™	*
1800	San Francisco Bay AET--bivalve	Not definitive
1959 ± 1993	Eagle Harbor least toxic-amphipod	No effect
2400	1986 Puget Sound AET--amphipod	*
2462	LC50 2.5% Elizabeth River--spot	*
2500	**ER-M**	**50 percentile**
3000	1988 Puget Sound AET--amphipod	*
3485 ± 2475	Eagle Harbor highly toxic--amphipod	No concordance
3600	1988 Puget Sound AET--benthic	*
4100 ± 600	Significantly toxic mixtures--amphipod	*
5335 ± 6488	Eagle Harbor moderately toxic--amphipod	*
6800	1986 Puget Sound AET--benthic	*
10630	EP interim freshwater criteria @ 1% TOC	*
18000	99 percentile chronic marine @1% TOC	*
45000	95 percentile chronic marine @1% TOC	*
55160	LC50 56% Elizabeth River--spot	*
98500	LC100 100% Elizabeth River--spot	*
220000	Lake Union highly toxic-amphipod	*
450000	EP acute safe level	*
1800000	EP chronic marine @ 4% TOC	*

*28 concentrations used to determine ER-L and ER-M values.

Table B-23. Sediment effects data available for CHRYSENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
80	Eagle Harbor predicted LC50--amphipod	*
82 ± 37	San Francisco Bay least toxic--bivalve	No effect
127 ± 226	Southern California not toxic--amphipod	No effect
198 ± 276	San Francisco Bay not toxic--bivalve	No effect
358 ± 365	Commencement Bay least toxic--oyster	No effect
368 ± 466	San Francisco Bay moderately toxic--bivalve	*
378 ± 549	San Francisco Bay least toxic--amphipod	No effect
384	Marine SLC @1% TOC	*
400	**ER-L**	**10 percentile**
405 ± 571	San Francisco Bay not toxic--amphipod	No effect
413 ± 385	San Francisco Bay moderately toxic--amphipod	Small gradient
423 ± 512	San Francisco Bay significantly toxic--amphipod	Small gradient
500 ± 671	San Francisco Bay significantly toxic--bivalve	*
517 ± 729	San Francisco Bay highly toxic--amphipod	Small gradient
524 ± 284	Southern California significantly toxic--amphipod	*
670	PSDDA screening level	No effect
748 ± 773	Commencement Bay least toxic--amphipod	No effect
821 ± 732	Commencement Bay moderately toxic--amphipod	Small gradient
902 ± 691	Commencement Bay moderately toxic--oyster	*
1200	99 percentile chronic marine @1% TOC	*
1218 ± 1286	Commencement Bay highly toxic--oyster	*
1363 ± 1970	Commencement Bay highly toxic--amphipod	*
1400	1986 Puget Sound AET--Microtox™	*
1679 ± 847	San Francisco Bay highly toxic--bivalve	*
1700	San Francisco Bay AET--bivalve	*
2100	San Francisco Bay AET--amphipod	*
2800	1986 Puget Sound AET--amphipod	*
2800	1986 Puget Sound AET--oyster	*
2800	**ER-M**	**50 percentile**
3165 ± 4535	Eagle Harbor least toxic--amphipod	No effect
4100	Columbia River bioassay--amphipod	No effect
4400	95 percentile chronic marine @1% TOC	*
6700	1986 Puget Sound AET--benthic	*
7930	LC50 2.5% Elizabeth River--spot	*
9200	1988 Puget Sound AET--amphipod	*
9200	1988 Puget Sound AET--benthic	*
9203 ± 10972	Eagle Harbor moderately toxic--amphipod	*
10574 ± 7337	Eagle Harbor highly toxic--amphipod	*
115000	EP acute safe level	*
170000	Lake Union significantly toxic--amphipod	*
177520	LC50 56% Elizabeth River--spot	*
317000	LC100 100% Elizabeth River--spot	*
460000	EP chronic marine @4% TOC	*

* 27 concentrations used to determine ER-L and ER-M values.

Table B-24. Sediment effects data available for DIBENZ(A,H)ANTHRACENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
15 ± 15	San Francisco Bay least toxic--bivalve	No effect
21 ± 22	San Francisco Bay not toxic--bivalve	No effect
24 ± 36	Southern California not toxic--amphipod	No effect
42 ± 46	San Francisco Bay moderately toxic--bivalve	*
44 ± 32	San Francisco Bay moderately toxic--amphipod	No concordance
55 ± 41	Commencement Bay least toxic--bivalve	No effect
55 ± 58	San Francisco Bay significantly toxic--amphipod	No concordance
57 ± 77	San Francisco Bay least toxic--amphipod	No effect
60	**ER-L**	**10 percentile**
26 ± 80	San Francisco Bay not toxic--amphipod	No effect
63 ± 80	San Francisco Bay significantly toxic--bivalve	*
66 ± 46	Southern California significantly toxic--amphipod	*
72 ± 139	Commencement Bay highly toxic--amphipod	No gradient
73 ± 71	Commencement Bay least toxic--amphipod	No effect
80 ± 88	San Francisco Bay highly toxic--amphipod	Small gradient
101 ± 58	Commencement Bay moderately toxic--oyster	*
120	PSDDA screening level	No effect
183 ± 344	Commencement Bay moderately toxic--amphipod	*
217 ± 88	San Francisco Bay highly toxic--bivalve	*
230	1986 Puget Sound AET--oyster	*
230	1986 Puget Sount AET—Microtox™	*
260	1986 Puget Sound AET--amphipod	*
260	**ER-M**	**50 percentile**
260	San Francisco Bay AET--bivalve	*
263 ± 413	Commencement Bay highly toxic--bivalve	*
300	San Francisco Bay AET--amphipod	Poor concordance
360 ± 298	Eagle Harbor least toxic--amphipod	No effect
399 ± 252	Eagle Harbor highly toxic--amphipod	Small gradient
540	1988 Puget Sound AET--amphipod	*
797 ± 723	Eagle Harbor moderately toxic--amphipod	*
970	1988 Puget Sound AET--benthic	*
1200	1986 Puget Sound AET--benthic	*
12000	99 percentile EP chronic marine @ 1% TOC	*
35000	95 percentile EP chronic marine @ 1% TOC	*
240000	EP acute safe level	

* 18 concentrations used to determine ER-L and ER-M values.

Table B-25. Sediment effects data available for FLUORANTHENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
98	Palos Verdes not toxic–amphipod	No effect
136 ± 107	San Francisco Bay least toxic–bivalve	No effect
153 ± 307	Southern California not toxic–amphipod	No effect
193	Palos Verdes significantly toxic–amphipod	Small sample size
382 ± 617	San Francisco Bay not toxic–bivalve	No effect
382 ± 241	Southern California significantly toxic–amphipod	*
432	Marine SLC @ 1% TOC	*
451 ± 562	San Francisco Bay moderately toxic–bivalve	*
489 ± 492	Commencement Bay least toxic–oyster	No effect
509 ± 481	San Francisco Bay moderately toxic–amphipod	No gradient
539 ± 842	San Francisco Bay least toxic–amphipod	No effect
572 ± 880	San Francisco Bay not toxic–amphipod	No effect
584 ± 789	San Francisco Bay significantly toxic–amphipod	Small gradient
600	**ER-L**	**10 percentile**
600	Predicted LC50 Eagle Harbor–amphipod	*
630	PSDDA screening level	No effect
644	Marine SLC @ 1% TOC	*
682 ± 1043	San Francisco Bay significantly toxic–bivalve	*
794 ± 1210	San Francisco Bay highly toxic–amphipod	Small gradient
923 ± 865	Commencement Bay least toxic–amphipod	No effect
925 ± 864	Commencement Bay moderately toxic–amphipod	No gradient
1046 ± 655	Commencement Bay moderately toxic–oyster	*
1600	99 percentile EP chronic marine @ 1% TOC	*
1655 ± 2029	Commencement Bay highly toxic–oyster	*
1700	1986 Puget Sound AET–Microtox™	*
2000	San Francisco Bay AET–bivalve	*
2100	Columbia River bioassay–amphipod	No effect
2360 ± 3330	Commencement Bay highly toxic–amphipod	*
2500	1986 Puget Sound AET–oyster	*
2737 ± 1617	San Francisco Bay highly toxic–bivalve	*
3100	95 percentile EP chronic marine @ 1% TOC	*
3300	LC50 spiked bioassays @ 0.2% TOC–amphipod	*
3600	**ER-M**	**50 percentile**
3600	EP chronic safe level	*
>3700	San Francisco Bay AET–amphipod	Not definitive
3900	1986 Puget Sound AET–amphipod	*
4200	LC50 spiked bioassays–amphipod	*
6200	LC50 spiked bioassays @ 0.3% TOC–amphipod	*
6300	1986 Puget Sound AET–benthic	*
8895 ± 10337	Eagle Harbor moderately toxic–amphipod	No concordance
9000	EP acute safe level	*
10500	LC50 spiked bioassays @ 0.5% TOC–amphipod	*
12080 ± 51889	Eagle Harbor least toxic–amphipod	No effect
15000	Mixtures spiked bioassays–amphipod	*
18800	EP interim freshwater criteria @ 1% TOC	*
24000	1988 Puget Sound AET–benthic	*
30000	1988 Puget Sound AET–amphipod	*
36000	EP acute marine @ 4% TOC	*
59250	LC50 2.5% Elizabeth River–spot	*
71988 ± 95713	Eagle Harbor highly toxic–amphipod	*
327200	LC50 56% Elizabeth River–spot	*
570000	Lake Union significantly toxic–amphipod	*
2370000	LC500 100% Elizabeth River–spot	*

* 33 concentrations used to determine ER-L and ER-M values.

Table B-26. Sediment effects data available for FLUORENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
6 ± 5	San Francisco Bay least toxic--bivalve	No effect
8	San Francisco Bay not toxic--amphipod	No effect
11	San Francisco Bay AET--bivalve	*
16 ± 23	San Francisco Bay not toxic--bivalve	No effect
19 ± 30	San Francisco Bay moderately toxic--bivalve	*
29 ± 48	San Francisco Bay significantly toxic--amphipod	No concordance
30 ± 21	San Francisco Bay moderately toxic--amphipod	No concordance
33 ± 77	San Francisco Bay highly toxic--amphipod	No gradient
35	**ER-L**	**10 percentile**
35 ± 64	San Francisco Bay significantly toxic--bivalve	*
39 ± 49	San Francisco Bay least toxic--amphipod	No effect
4 ± 51	San Francisco Bay not toxic--amphipod	No effect
59	99 percentile EP chronic marine @ 1% TOC	*
64	PSDDA screening level	No effect
75 ± 76	Commencement Bay least toxic--oyster	No effect
93	Black Rock Harbor significant toxic--amphipod	*
101	Marine SLC @1% TOC	*
117 ± 113	Commencement Bay least toxic--amphipod	No effect
143 ± 119	Commencement Bay moderately toxic--oyster	*
147 ± 131	Commencement Bay moderately toxic--amphipod	Small gradient
160	95 percentile EP chronic marine @ 1% TOC	*
162 ± 105	San Francisco Bay highly toxic--bivalve	*
187 ± 234	Eagle Harbor moderatley toxic--amphipod	No concordance
210	Eagle Harbor predicted LC50--amphipod	*
210	San Francisco Bay AET--amphipod	No concordance
353 ± 746	Commencement Bay highly toxic--oyster	*
540	1986 Puget Sound AET--amphipod	*
540	1986 Puget Sound AET--oyster	*
540	1986 Puget Sound AET--Microtox™	*
640	**ER-M**	**50 percentile**
640	1986 Puget Sound AET--benthic	*
707 ± 1341	Commencement Bay highly toxic--amphipod	*
1000	1988 Puget Sound AET--benthic	*
1017 ± 4679	Eagle Harbor least toxic--amphipod	No effect
3600	1988 Puget Sound AET--amphipod	*
7000	EP acute safe level	*
17500	LC50 2.5% Elizabeth River--spot	*
22811 ± 65559	Eagle Harbor highly toxic--amphipod	*
28000	EP chronic marine @ 4% TOC	*
40000	Lake Union significantly toxic--amphipod	*
176510	Winter flounder liver--MFO	*
220550	Winter flounder liver--somatic condition	*
285290	Winter flounder kidney--MFO	*
700000	LC50 56% Elizabeth River--spot	*
1250000	Lc100 100% Elizabeth River--spot	*

* 28 concentrations used to determine ER-L and ER-M values.

Table B-27. Sediment effects data available for 2-METHYLNAPHTHALENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
16 ± 33	Southern California not toxic--amphipod	No effect
20 ± 7	San Francisco Bay least toxic--bivalve	No effect
24 ± 4	San Francisco Bay not toxic--bivalve	No effect
26 ± 23	San Francisco Bay moderately toxic--bivalve	Small gradient
27	San Francisco Bay AET--bivalve	*
31 ± 33	San Francisco Bay significantly toxic--amphipod	No concordance
32 ± 41	San Francisco Bay highly toxic--amphipod	No gradient
34 ± 27	San Francisco Bay moderately toxic--amphipod	No gradient
34 ± 33	San Francisco Bay least toxic--amphipod	No effect
35 ± 36	San Francisco Bay significantly toxic--bivalve	Small gradient
39 ± 35	San Francisco Bay not toxic--amphipod	No effect
65	**ER-L**	**10 percentile**
65 ± 154	Southern California significantly toxic--amphipod	*
67	PSDDA screening level	No effect
98 ± 41	San Francisco Bay highly toxic--bivalve	*
>130	San Francisco Bay AET--amphipod	Not definitive
165 ± 121	Commencement Bay least toxic--oyster	No effect
168 ± 169	Commencement Bay least toxic--amphipod	No effect
207 ± 169	Commencement Bay moderately toxic--oyster	Small gradient
213 ± 129	Commencement Bay moderately toxic--amphipod	Small gradient
326 ± 313	Commencement Bay highly toxic--oyster	*
500	Mixtures spiked bioassay--amphipod	*
546 ± 490	Commencement Bay highly toxic--amphipod	*
670	1986 Puget Sound AET--amphipod	*
670	1986 Puget Sound AET--oyster	*
670	**ER-M**	**50 percentile**
670	1986 Puget Sound AET--benthic	*
670	1986 Puget Sound AET--Microtox™	*
795	LC50 2.5% Elizabeth River--spot	*
1400	1988 Puget Sound AET--benthic	*
1788	LC50 56% Elizabeth River--spot	*
1900	1988 Puget Sound AET--amphipod	*
31800	LC100 100% Elizabeth River--spot	*

*15 concentrations used to determine ER-L and ER-M values.

Table B-28. Sediment effects data available for NAPHTHALENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
4.2	Black Rock Harbor projected highly toxic--amphipod	Small gradient
8.2 ± 16.1	Southern California not toxic--amphipod	No effect
30	Predicted Eagle Harbor--amphipod bioassay LC50	Small gradient
36 ± 50	Puget Sound least toxic--Microtox™ EC50	No effect
43.1 ± 26.2	San Francisco Bay moderately toxic--bivalve	No concordance
48 ± 24.7	San Francisco Bay moderately toxic--amphipod	No concordance
53.4 ± 40	San Francisco Bay significantly toxic--amphipod	No concordance
53.4 ± 37.6	San Francisco Bay significantly toxic--bivalve	No concordance
58 ± 50.6	San Francisco Bay least toxic--amphipod	No effect
63.2 ± 57.2	San Francisco Bay least toxic--bivalve	No effect
64 ± 45.8	San Francisco Bay highly toxic--amphipod	Small gradient
65.2 ± 53.5	San Francisco Bay not toxic--amphipod	No effect
77.3 ± 180.6	Southern California significantly toxic--amphipod	*
88.7	San Francisco Bay not toxic--bivalve	No effect
127.3 ± 32.4	San Francisco Bay highly toxic--bivalve	*
>160	San Francisco Bay AET--bivalve	Not definitive
>160	San Francisco Bay AET--amphipod	Not definitive
210	PSDDA screening level	No effect
288 ± 201	Eagle Harbor moderately toxic--amphipod	No concordance
340	**ER-L**	**10 percentile**
343 ± 388	Puget Sound moderately toxic--Microtox™EC50	*
358 ± 326	Commencement Bay least toxic--oyster	No effect
414	Saltwater SLC	*
456 ± 682	Eagle Harbor least toxic--amphipod	No effect
500	99 percentile EP chronic marine @1% TOC	*
510 ± 499	Commencement Bay least toxic--amphipod	No effect
593 ± 505	Commencement Bay moderately toxic--oyster	*
594 ± 424	Commencement Bay moderately toxic--amphipod	*
720	95 percentile EP chronic marine @1% TOC	*
973 ± 1041	Commencement Bay highly toxic--oyster	*
1501 ± 2064	Eagle Harbor highly toxic--amphipod	*
1564 ± 1735	Commencement Bay highly toxic--amphipod	*
2100	1986 Puget Sound AET--amphipod	*
2100	1986 Puget Sound AET--oyster	*
2100	1986 Puget Sound AET--benthic	*
2100	1986 Puget Sound AET--Microtox™	*
2100	**ER-M**	**50 percentile**
2375	28-d LC50 for spot-2.5% Elizabeth River sediments	*
2400	1988 Puget Sound AET--amphipod	*
2700	1988 Puget Sound AET--benthic	*
3670	Saltwater SLC	*
3934 ± 8864	Puget Sound highly toxic--Microtox™ EC50	*
5250 ± 1500	Trinity River high species richness	No effect
6200	Winter flounder spiked bioassays--hepatic MFO	*
7370	Winter flounder spiked bioassays--HSI	*
10710	Winter flounder spiked bioassays--kidney MFO	*
11500 ± 5600	Trinity River low species richness	*
40000	Lake Union highly toxic--*Hyalella*	*
42000	EP acute marine threshold @4% TOC	*
53200	24-h LC50 for spot-56% Elizabeth River	*
95000	LC100 for spot-100% Elizabeth River	*

*28 concentrations used to determine ER-L and ER-M values.

Table B-29. Sediment effects data available for PHENANTHRENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
65 ± 30	San Francisco Bay least toxic--bivalve	No effect
88	San Francisco Bay AET--bivalve	*
110	99 percentile chronic marine @1% TOC	*
119 ± 242	Southern California not toxic--amphipod	No effect
159 ± 216	San Francisco Bay not toxic--bivalve	No effect
188 ± 197	San Francisco Bay least toxic--amphipod	No effect
199 ± 205	San Francisco Bay not toxic--amphipod	No effect
220 ± 163	San Francisco Bay significantly toxic--amphipod	Small gradient
222 ± 136	Southern California significantly toxic--amphipod	*
224 ± 203	San Francisco Bay moderately toxic--bivalve	*
225	ER-L	10 percentile
228 ± 146	San Francisco Bay moderately toxic--amphipod	Small gradient
233 ± 208	San Francisco Bay significantly toxic--bivalve	Small gradient
240	95 percentile chronic marine @ 1% TOC	*
242 ± 203	San Francisco Bay highly toxic--amphipod	Small gradient
259	Marine SLC @1% TOC	*
270	Winter flounder liver--MFO induction	*
297 ± 263	Commencement Bay least toxic--oyster	No effect
320	PSDDA screening level	No effect
340	Winter flounder liver--somatic condition	*
368	Marine SLC @1% TOC	*
429	Winter flounder kidney--MFO induction	*
475 ± 160	San Francisco Bay highly toxic--bivalve	*
478 ± 367	Commencement Bay least toxic--amphipod	No effect
500	Mixtures bioassays--amphipod	*
510	San Francisco Bay AET--amphipod	*
580	Columbia River bioassays--amphipod	No effect
593 ± 365	Commencement Bay moderately toxic--oyster	*
597 ± 513	Commencement Bay moderately toxic--amphipod	*
950	Eagle Harbor predicted LC50--amphipod	*
1020	EP marine interim criteria @1% TOC	*
1379 ± 2546	Commencement Bay highly toxic--oyster	*
1380	ER-M	50 percentile
1390	EP freshwater interim criteria @1% TOC	*
1500	1986 Puget Sound AET--oyster	*
1500	1986 Puget Sound AET--Microtox™	*
2142 ± 2404	Eagle Harbor moderately toxic--amphipod	No concordance
2[illegible] ± 10009	Eagle Harbor least toxic--amphipod	No effect
2838 ± 4603	Commencement Bay highly toxic--amphipod	*
3200	1986 Puget Sound AET--benthic	*
3680	LC50 spiked bioassay--amphipod	*
5400	1986 Puget Sound AET--amphipod	*
5400	1988 Puget Sound AET--oyster	*
6900	1988 Puget Sound AET--amphipod	*
14000	EP acute safe level @1% TOC	*
33603 ± 84430	Eagle Harbor highly toxic--amphipod	*
56000	EP chronic marine @4% TOC	*
105500	LC50 2.5% Elizabeth River--spot	*
220000	LC100 100% Elizabeth River--spot	*
410000	Lake Union significantly toxic--amphipod	*
2363200	LC50 56% Elizabeth River--spot	*

*34 concentrations used to determine ER-L and ER-M values.

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Table B-30. Sediment effects data available for PYRENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
182	Kidney MFO induction--winter flounder	*
184 ± 318	Southern California not toxic--amphipod	No effect
216 ± 102	San Francisco Bay least toxic--bivalve	No effect
300	Liver MFO induction--winter flounder	*
350	Eagle Harbor predicted LC50--amphipod	*
350	**ER-L**	**10 percentile**
360	Liver somatic condition--winter flounder	*
430	PSDDA screening level	No effect
434 ± 442	Commencement Bay least toxic--oyster	No effect
434	Marine SLC @1% TOC	*
532 ± 372	Southern California significantly toxic--amphipod	*
665	Marine SLC @1% TOC	*
701 ± 866	San Francisco Bay least toxic--amphipod	No effect
719 ± 1123	San Francisco Bay not toxic--bivalve	No effect
724 ± 939	San Francisco Bay moderately toxic--bivalve	*
743 ± 902	San Francisco Bay not toxic--amphipod	No effect
777 ± 908	San Francisco Bay highly toxic--amphipod	Small gradient
806 ± 975	San Francisco Bay significantly toxic--bivalve	Small gradient
850	EP 99 percentile chronic marine @ 1% TOC	*
865 ± 719	Commencement Bay moderately toxic--amphipod	No concordance
896 ± 870	San Francisco Bay significantly toxic--amphipod	Small gradient
978 ± 996	Commencement Bay least toxic--amphipod	No effect
1078 ± 806	Commencement Bay moderately toxic--oyster	*
1110 ± 904	San Francisco Bay moderately toxic--amphipod	*
1538 ± 1501	Commencement Bay highly toxic--oyster	*
1820 ± 2252	Commencement Bay highly toxic--amphipod	*
1900	EP 95 percentile chronic marine @ 1% TOC	*
2188 ± 776	San Francisco Bay highly toxic--bivalve	*
2200	**ER-M**	**50 percentile**
2500	Columbia River bioassays--amphipod	No effect
2600	1986 Puget Sound AET--Microtox™	*
2600	San Francisco Bay AET--amphipod	*
3300	1986 Puget Sound AET--oyster	*
>3400	San Francisco Bay AET--bivalve	Not definitive
4300	1986 Puget Sound AET--amphipod	*
>7300	1986 Puget Sound AET--benthic	No definitive value
13100	EP interim freshwater criteria @ 1% TOC	*
16000	1988 Puget Sound AET--amphipod	*
16000	1988 Puget Sound AET--benthic	*
33750	LC50 2.5% Elizabeth River--spot	*
49500	EP acute safe level	*
198000	EP chronic marine @ 4% TOC	*
750000	Lake Union significantly toxic--amphipod	*
756000	LC50 56% Elizabeth River--spot	*
1350000	LC100 100% Elizabeth River--spot	*

*28 concentrations used to determine ER-L and ER-M values.

Table B-31. Sediment effects data available for total PAH arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values and the number of the PAHs that were quantified to determine the totals.

Concentrations (ppb)	Biological Test	Remarks	PAH Reported
763 ±727	Puget Sound least toxic--Microtox™	No effect	unspecified
870	San Francisco Bay AET--bivalve	*	**
941 ± 429	San Francisco Bay least toxic--bivalve	No effect	**
2242	Southern California not toxic--amphipod	No effect	18
2557 ± 3816	San Francisco Bay not toxic--bivalve	No effect	**
2590	Predicted LC50 Eagle Harbor--amphipod	*	13
3322 ± 4337	San Francisco Bay least toxic--amphipod	No effect	**
3343 ± 4039	San Francisco Bay moderately toxic--bivalve	*	**
3527 ± 4520	San Francisco Bay not toxic--amphipod	No effect	**
3705	Commencement Bay least toxic--oyster	No effect	16
3800	San Francisco Bay triad minimum bioeffects	*	9
3832 ± 3927	San Francisco Bay significantly toxic--amphipod	Small gradient	**
3966 ± 3524	San Francisco Bay moderately toxic--amphipod	Small gradient	**
4000	**ER-L**	**10 percentile**	
4022 ± 4908	San Francisco Bay significantly toxic--bivalve	*	**
4201 ± 4612	Puget Sound nontoxic--amphipod	No effect	unspecified
4227 ± 5025	San Francisco Bay highly toxic--amphipod	Small gradient	16
6467	Commencement Bay least toxic--amphipod	No effect	16
7627 ± 7065	Puget Sound moderately toxic--amphipod	*	unspecified
7841	Commencement Bay moderately toxic--oyster	*	16
8209	Commencement Bay moderately toxic--amphipod	Small gradient	16
8363	Southern California significantly toxic--amphipod	*	18
8550 ± 22990	Mississippi Sound not toxic--mysid	No effect	unspecified
8550 ± 23000	Mississippi Sount least toxic--mysid	No effect	unspecified
8700 ± 12600	Massachusetts Bay high species richness	No effect	unspecified
9500	San Francisco Bay triad significant bioeffects	*	18
9730 ± 22390	Mississippi Sound least toxic--amphipod	No effect	unspecified
10000	Petroleum product spiked bioassay--oyster larvae	No effect	unspecified
10200 ± 9950	Forth Estuary high meiofauna density	No effect	unspecified
11273	Black Rock Harbor significantly toxic--amphipod	*	20
11400 ± 14100	Mississippi Sound highly toxic--mysid	No concordance	unspecified
11735 ± 5499	San Francisco Bay highly toxic--bivalve	*	**
11752 ± 14548	Puget Sound highly toxic--amphipod	*	unspecified
11800 ± 9700	Forth Estuary moderate meiofauna density	Small gradient	unspecified
12325 ± 10425	Hampton Roads moderately toxic--shrimp	No concordance	16
12877	Commencement Bay highly toxic--oyster	*	16
13933 ± 17427	Puget Sound moderately toxic--Microtox™	*	unspecified
>15000	San Francisco Bay AET--amphipod	Not definitive	18 **
16771	Commencement Bay highly toxic--amphipod	*	16
16921 ± 20976	Hampton Roads least toxic--shrimp	No effect	16
18600 ± 47000	Mississippi Sound not toxic--amphipod	No effect	unspecified
19000	Lower Columbia River bioassays--amphipod	No effect	17
21467 ± 31160	Hudson-Raritan least toxic--nematode	No effect	unspecified
21600 ± 31000	Mississippi Sound significantly toxic--amphipod	No gradient	unspecified
23100 ± 15400	Massachusetts Bay moderate species richness	*	unspecified
35000± 2540	Massachusetts Bay low species richness	*	unspecified
35000	**ER-M**	**50 percentile**	
357000 ± 42181	Hampton Roads highly toxic--shrimp	*	16
41790 ± 66160	Mississippi Sound significantly toxic--mysid	*	unspecified
42769 ± 46084	Hudson-Raritan highly toxic--nematode	*	unspecified
47760 ± 74890	Mississippi Sound highly toxic--amphipod	*	unspecified
55630 ± 112530	Puget Sound highly toxic--Microtox™	*	unspecified
66100 ± 83300	Mississippi Sound moderately toxic--mysid	*	unspecified
83800 ± 57900	Forth Estuary low meiofauna density	*	unspecified

Table B-31 (Continued)

Concentrations (ppb)	Biological Test	Remarks	PAH Reported
99400	Mississippi Sound AET--mysid bioassay	*	unspecified
183060	Spiked bioassays--winter flounder liver MFO	*	4
>205000	Mississippi Sound AET--amphipod bioassay	Not definitive	unspecified
228722	Spiked bioassays--winter flounder liver condition	*	4
295860	Spiked bioassays--winter flounder kidney MFO	*	4
530000	LC50 2.5% Elizabeth River--spot	*	21
2240000	LC50 Bunker C oil spiked bioassay--amphipod	*	gravimetric
3900000	56% mortality Elizabeth River--spot	*	20
3900000	100% fin erosion Elizabeth River--spot	*	20
11872000	LC50 56% Elizabeth River--spot	*	21
21200000	LC100 100% Elizabeth River--spot	*	21

* 34 concentrations used to determine ER-L and ER-M values.

** Long and Buchman, 1989, 18 PAH ; Chapman *et al.*, 1986, 18 PAH; Word *et al*, 1988, 16 PAH; U. S. Navy, 1987, 6 or 7 PAH

GLOSSARY

NATIONAL STATUS AND TRENDS PROGRAM SITES

NS&T Program Mussel Watch Sites

Code	General Location	Specific Location	State
AIAC	Absecon Inlet	Atlantic City	New Jersey
ABWJ	Anaheim Bay	West Jetty	California
APCP	Apalachicola Bay	Cat Point Bar	Florida
APDB	Apalachicola Bay	Dry Bar	Florida
ABHI	Aransas Bay	Harbor Island	Texas
ABLR	Aransas Bay	Long Reef	Texas
ABOB	Atchafalaya Bay	Oyster Bayou	Louisiana
BBSD	Barataria Bay	Bayou Saint Denis	Louisiana
BBTB	Barataria Bay	Turtle Bay	Louisiana
BBMB	Barataria Bay	Middle Bank	Louisiana
BPBP	Barbers Point	Barbers Point	Hawaii
BIBL	Barnegat Inlet	Barnegat Light	New Jersey
BBSM	Bellingham Bay	Squalicum Marina	Washington
BBPC	Biscayne Bay	Princeton Canal	Florida
BIBI	Block Island	Block Island	Rhode Island
BBBE	Bodega Bay	Bodega Bay Entrance	California
BHDI	Boston Harbor	Deer Island	Massachusetts
BHDB	Boston Harbor	Dorchester Bay	Massachusetts
BHHB	Boston Harbor	Hingham Bay	Massachusetts
BHBI	Boston Harbor	Brewster Island	Massachusetts
BRFS	Brazos River	Ferrport Surfside	Texas
BSBG	Breton Sound	Bay Garderne	Louisiana
BSSI	Breton Sound	Sable Island	Louisiana
BBRH	Buzzards Bay	Round Hill	Massachusetts
BBAR	Buzzards Bay	Angelica Rock	Massachusetts
BBGN	Buzzards Bay	Goosebury Neck	Massachusetts
CLCL	Caillou Lake	Caillou Lake	Louisiana
CLLC	Calcasieu Lake	Lake Charles	Louisiana
CLSJ	Calcasieu Lake	Saint Johns Island	Louisiana
CAGH	Cape Ann	Gap Head	Massachusetts
CFBI	Cape Fear	Battery Island	North Carolina
CKBP	Cedar Key	Black Point	Florida
CHFJ	Charleston Harbor	Fort Johnson	South Carolina
CHSF	Charleston Harbor	Shutes Folly Island	South Carolina
CBBI	Charlotte Harbor	Bird Island	Florida
CBFM	Charlotte Harbor	Fort Meyers	Florida
CBMP	Chesapeake Bay	Mountain Point Bar	Maryland
CBHP	Chesapeake Bay	Hackett Point Bar	Maryland
CBHG	Chesapeake Bay	Hog Point	Maryland
CBIB	Chesapeake Bay	Ingram Bay	Virginia
CBCC	Chesapeake Bay	Cape Charles	Virginia
CBDP	Chesapeake Bay	Dandy Point	Virginia
CBCI	Chincot. Bay	Chincot. Inlet	Virginia
CBSP	Choctawatchee Bay	Shirk Point	Florida
CBSR	Choctawatchee Bay	Off Santa Rosa	Florida
CRSJ	Columbia River	South Jetty	Oregon
CBTP	Commencement Bay	Tahlequah Point	Washington
CBCH	Coos Bay	Coos Head	Oregon
CBRP	Coos Bay	Russell Point	Oregon
CBCR	Copano Bay	Copano Reef	Texas
CCBH	Corpus Christi	Boat Harbor	Texas
CCIC	Corpus Christi	Ingleside Cove	Texas
CCNB	Corpus Christi	Neuces Bay	Texas
DBFE	Delaware Bay	False Egg Island Point	Delaware

Code	General Location	Specific Location	State
DBBD	Delaware Bay	Ben Davis Point Shoal	Delaware
DBKI	Delaware Bay	Kelly Island	Delaware
EBFR	Elliott Bay	Four-Mile Rock	Washington
ESSP	Espiritu Santo	South Pass Reef	Texas
ESBD	Espiritu Santo	Bill Days Reef	Texas
EVFU	Everglades	Faka Union Bay	Florida
FIEL	Farallon Island	East Landing	California
GBHR	Galveston Bay	Hanna Reef	Texas
GBSC	Galveston Bay	Ship Channel	Texas
GBYC	Galveston Bay	Yacht Club	Texas
GBTD	Galveston Bay	Todd's Dump	Texas
GBCR	Galveston Bay	Confed.Reef	Texas
GBOB	Galveston Bay	Offats Bayou	Texas
GHWJ	Gray's Harbor	Westport Jetty	Washington
HHKL	Honolulu Harbor	Keehi Lagoon	Hawaii
HRJB	Hudson/Raritan Estuary	Jamaica Bay	New York
HRUB	Hudson/Raritan Estuary	Upper Bay	New York
HRLB	Hudson/Raritan Estuary	Lower Bay	New York
HMBJ	Humboldt Bay	Jetty	California
IBNJ	Imperial Beach	North Jetty	California
IRSR	Indian River	Sebastian River	Florida
JHJH	Joseph Harbor Bayou	Joseph Harbor Bay	Louisiana
KAUI	Kauai	Nawiliwili Harbor	Hawaii
LJLJ	La Jolla	Point La Jolla	California
LMSB	Laguna Madre	South Bay	Texas
LMPI	Laguna Madre	Port Isabell	Texas
LBNO	Lake Borgne	New Orleans	Louisiana
LBMP	Lake Borgne	Malheureux Point	Louisiana
LICR	Long Island Sound	Connecticut River	Connecticut
LINH	Long Island Sound	New Haven	Connecticut
LIHR	Long Island Sound	Housatonic River	Connecticut
LISI	Long Island Sound	Sheffield Island	Connecticut
LIHU	Long Island Sound	Huntington Harbor	New York
LIPJ	Long Island Sound	Port Jefferson	New York
LIMR	Long Island Sound	Mamaroneck	New York
LIHH	Long Island Sound	Hempstead Harbor	New York
LITN	Long Island Sound	Throgs Neck	New York
MDSJ	Marina Del Rey	South Jetty	California
MBEM	Matagorda Bay	East Matagorda	Texas
MBDI	Matagorda Bay	Dog Island	Texas
MBCB	Matagorda Bay	Carancahua Bay	Texas
MBTP	Matagorda Bay	Tres Palacios Bay	Texas
MBGP	Matagorda Bay	Gallinipper Point	Texas
MBLR	Matagorda Bay	Lavaca River Mouth	Texas
MRCB	Matanzas River	Cresent Beach	Florida
MSSP	Merriconeag Sound	Stover Point	Maine
MBAR	Mesquite Bay	Ayres Point	Texas
MRTP	Mississippi River	Tiger Pass	Louisiana
MRPL	Mississippi River	Pass a Loutre	Louisiana
MSPB	Mississippi Sound	Pascagoula Bay	Mississippi
MSBB	Mississippi Sound	Biloxi Bay	Mississippi
MSPC	Mississippi Sound	Pass Christian	Mississippi
MBVB	Mission Bay	Ventura Bridge	California
MBHI	Mobile Bay	Hollingers Island Channel	Alabama
MBCP	Mobile Bay	Cedar Point Reef	Alabama
MBSC	Monterey Bay	Point Santa Cruz	California

Code	General Location	Specific Location	State
MBTH	Moriches Bay	Tuthill Point	New York
NYLB	New York Bight	Long Branch	New Jersey
NYSH	Raritan Bay	Sandy Hook Bay	New Jersey
NYSR	New York Bight	Shark River	New Jersey
NBNB	Naples Bay	Naples Bay	Florida
NBDU	Narragansett Bay	Dutch Island	Rhode Island
NBDI	Narragansett Bay	Dyer Island	Rhode Island
NBWJ	Newport Beach	Wedge Jetty	California
NMML	North Miami	Maule Lake	Florida
OEIH	Oakland Estuary	Inner Harbor	California
OSBJ	Oceanside	Beach Jetty	California
PGLP	Pacific Grove	Lovers Point	California
PVRP	Palos Verdes	Royal Palms State Park	California
PSWB	Pamlico Sound	Wysoching Bay	North Carolina
PCMP	Panama City	Municipal Pier	Florida
PBSI	Penobscot Bay	Sears Island	Maine
PBPI	Penobscot Bay	Pickering Island	Maine
PBPH	Pensacola Bay	Public Harbor	Florida
PBIB	Pensacola Bay	Indian Bayou	Florida
PVMC	Port Valdez	Mineral Creek Flats	Alaska
PALH	Point Arena	Lighthouse	California
PCPC	Point Conception	Point Conception	California
PDSC	Point Delgada	Shelter Cove	California
PDPD	Point Dume	Point Dume	California
PLLH	Point Loma	Lighthouse	California
PRPR	Point Roberts	Point Roberts	Washington
SBSB	Point Santa Barbara	PointSanta Barbara	California
SGSG	Point Saint George	Point Saint George	California
QIUB	Quinby Inlet	Upshur Bay	Virginia
RSJC	Roanoke Sound	John Creek	North Carolina
RBHC	Rookery Bay	Henderson Creek	Florida
SCBR	South Catalina Island	Bird Rock	California
JFCF	South Juan de Fuca	Cape Flattery	Washington
SSBI	South Puget Sound	Budd Inlet	Washington
SLBB	Sabine Lake	Blue Buck Point	Texas
SHFP	Salem Harbor	Folger Point	Massachusetts
SAMP	San Antonio Bay	Mosquito Point	Texas
SAPP	San Antonio Bay	Panther Point Reef	Texas
SDHI	San Diego Bay	Harbor Island	California
SFDB	San Francisco Bay	Dumbarton Br.	California
SFSM	San Francisco Bay	San Mateo Bridge	California
SFEM	San Francisco Bay	Emeryville	California
SLSL	San Luis Obispo Bay	Point San Luis	California
SANM	San Miguel Island	Tyler Bight	California
SPFP	San Pedro Harbor	Fishing Pier	California
SPSP	San Francisco Bay	San Pablo Bay	California
SSSS	San Simeon Point	San Simeon Point	California
SCFP	Santa Cruz Island	Fraser Point	California
SSSI	Sapelo Sound	Sapelo Island	Georgia
SRTI	Savannah River Estuary	Tybee Island	Georgia
SIWP	Sinclair Inlet	Waterman Point	Washington
SAWB	Saint Andrew Bay	Watson Bayou	Florida
SJCB	Saint Johns River	Chicopit Bay	Florida
SRWP	Suwannee River	West Pass	Florida
TBMK	Tampa Bay	Mullet Key Bayou	Florida
TBCB	Tampa Bay	Cockroach Bay	Florida

Code	General Location	Specific Location	State
TBHB	Tampa Bay	Hillsborough Bay	Florida
TBPB	Tampa Bay	Papys Bayou	Florida
TBOT	Tampa Bay	Old Tampa Bay	Florida
TBLB	Terrebonne Bay	Lake Barre	Louisiana
TBHP	Tillamook Bay	Hobsonville Point	Oregon
TBSR	Tomales Bay	Spanger's Res.	California
UISB	Unakwit Inlet	Siwash Bay	Alaska
VBSP	Vermillion Bay	Southwest Pass	Louisiana
WIPP	Whidbey Island	Possession Point	Washington
YBOP	Yaquina Bay	Oneata Point	Oregon
YHSS	Yaquina Bay	Sally's Slough	Oregon
YHYH	Yaquina Head	Yaquina Head	Oregon

NS&T Program Benthic Surveillance Sites

Code	Location	State
APA	Apalachicola Bay	Florida
BAR	Barataria Bay	Louisiana
BOD	Bodega Bay	California
BOS	Boston Harbor	Massachusetts
BUZ	Buzzards Bay	Massachusetts
CAS	Casco Bay	Maine
CCB	Corpus Christi Bay	Texas
CHS	Charleston Harbor	South Carolina
COL	Columbia River	Oregon
COM	Commencement Bay	Washington
COO	Coos Bay	Oregon
DAN	Dana Point	California
DEL	Delaware Bay	Delaware
ELIE	Long Island Sound	Connecticut
ELL	Elliott Bay	Washington
END	Prudhoe Bay	Alaska
FRB	Frenchman Bay	Maine
GAL	Galveston Bay	Texas
GRB	Great Bay	New Jersey
HER	Heron Bay	Mississippi
HMB	Humboldt Bay	California
HUN	Hunters Point	California
LCB	Lower Chesapeake Bay	Virginia
LLM	Lower Laguna Madre	Texas
LNB	Long Beach	California
LOT	Charlotte Harbor	Florida
LUT	Lutak Inlet	Alaska
MAC	Machias Bay	Maine
MCB	Middle Chesapeake Bay	Virginia
MER	Merrimack River	Massachusetts
MOB	Mobile Bay	Alabama
MON	Monterey Bay	California
MRD	Mississippi Delta	Louisiana
NAH	Nahku Bay	Alaska
NAR	Narragansett Bay	Rhode Island
NIS	Nisqually Reach	Washington
OAK	Oakland Estuary	California

Code	Location	State
OLI	Oliktok Point	Alaska
PAB	San Pablo Bay	California
PAM	Pamlico Sound	North Carolina
PEN	Pensacola Bay	Florida
PNB	Penobscot Bay	Maine
RAR	Raritan Bay	New Jersey
ROU	Round Island	Mississippi
SAB	San Antonio Bay	Texas
SAL	Salem Harbor	Massachusetts
SAP	Sapelo Island	Georgia
SDA	San Diego Harbor	California
SDF	San Diego Bay	California
SEA	Seal Beach	California
SHS	Southhampton Shoal	California
SJR	Saint Johns River	Florida
SMB	Santa Monica Bay	California
SPB	San Pedro Bay	California
SPC	San Pedro Canyon	California
TAM	Tampa Bay	Florida
UCB	Upper Chesapeake Bay	Maryland
WLI	West Long Island Sound	New York

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