PNL-6794
UC-11

5.2

Confirmatory Sediment Analyses and Solid and Suspended Particulate Phase Bioassays on Sediment From Oakland Inner Harbor, San Francisco, California

J. Q. Word
J. A. Ward
C. W. Apts
D. L. Woodruff
M. E. Barrows
V. I. Cullinan
J. L. Hyland
J. F. Campbell

December 1988

Prepared for the
U.S. Army Corps of Engineers
San Francisco District
under a Related Services Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

PNL-6794

DISCLAIMER

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A10
226-250	A11
251-275	A12
276-300	A13

PNL-6794
UC-11

CONFIRMATORY SEDIMENT ANALYSES AND SOLID AND SUSPENDED PARTICULATE PHASE BIOASSAYS ON SEDIMENT FROM OAKLAND INNER HARBOR, SAN FRANCISCO, CALIFORNIA

J. Q. Word
J. A. Ward
C. W. Apts
D. L. Woodruff
M. E. Barrows[a]
V. I. Cullinan
J. L. Hyland[b]
J. F. Campbell[b]

Battelle/Marine Sciences Laboratory
Sequim, Washington

December 1988

Prepared for
the U.S. Army Corps of Engineers
San Francisco District
under a Related Services Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

(a) Ocean Sciences Department
Battelle Columbus Division
Duxbury, Massachusetts
(b) Ocean Sciences Department
Battelle Columbus Division
Ventura, California

SUMMARY

The U.S. Army Corps of Engineers (USACE), San Francisco District, was authorized by the U.S. Congress to deepen the navigation channels of Inner and Outer Oakland Harbor, California. During review of the environmental impact statement required for this dredging and disposal project, a panel of national experts approved the open-water disposal of dredged sediment from selected areas within the Inner Harbor, subject to results of confirmatory solid phase bioassays. The San Francisco District of the Corps requested the Battelle/ Marine Sciences Laboratory (MSL) to conduct these confirmatory studies. The studies provided technical data for an evaluation of the potential environmental impact of this project. Within extremely narrow time constraints, these studies provided chemical and biological information required by ocean dumping regulations to determine suitability of the Oakland Inner Harbor and turning basin sediment for ocean disposal.

Sediment core samples were collected to -38 ft mean lower low water (MLLW) plus 1-ft overdepth at 14 stations in the inner and outer portions of Oakland Inner Harbor, including the turning basin. At four of the turning basin stations, the cores were cut in half, resulting in a total of 18 Oakland Harbor sediment treatments. Sediment also was collected from reference sites offshore of Point Reyes, California, and in Sequim Bay, Washington. The MSL conducted solid-phase bioassays with these 20 sediment treatments on four species of organisms (polychaete, mollusc, and two species of amphipods). Suspended-phase bioassays were conducted using three species of organisms (mysid, fish, and oyster larvae) exposed to a subset of five sediment treatments. These 20 sediment treatments were chemically analyzed for 12 metals and metalloids, organotin compounds, 65 semivolatile organic compounds, 16 pesticides, 5 polychlorinated biphenyls, and 5 conventional contaminants. The sediment treatments also were physically analyzed for grain size. Bioaccumulation of chemical contaminants was then measured in the tissues of the mollusc exposed to the solid phase bioassay tests from turning basin sediment.

These confirmatory tests revealed elevated concentrations of chemical contaminants in some sediment treatments within the turning basin. The solid phase bioassay results revealed no statistically significant differences in survival for any of the 20 separate sediment treatments for three of the four species of test organisms. The amphipod Rhepoxynius abronius showed significant depressions in survival for Oakland Harbor Sediment Treatments 3-2, SN-3-L, 3-1, and TD-2-L. The suspended phase bioassay results revealed statistically significant differences in survival for some sediment treatments for the mysid (Acanthomysis sculpta) and fish (Citharicthys stigmaeus) bioassays, but none of these differences were large enough to calculate EC50 values. The suspended phase bioassays for survival and abnormal larval production using the oyster (Crassostrea gigas) revealed statistically significant depressions in survival and increased frequency of abnormal development for Oakland Harbor Sediment Treatments TD-2-U, TD-2-L, and SN-2-L. For the suspended particulate phase, two methods for determining the EC50 concentration provided ranges of 40-50% for Sediment Treatment TD-2-L, 62-67% for TD-2-U, and 42-47% for SN-2-L.

ACKNOWLEDGMENTS

The success of this project was the result of a closely integrated team effort incorporating scientists from Battelle's Marine Sciences Laboratory (MSL) in Sequim, Washington, and Battelle's Ocean Sciences Departments in Duxbury, Massachusetts, and Ventura, California; and from personnel from the U.S. Army Corps of Engineers, San Francisco District office, including Mr. Brian Walls, Ms. Sandy Lemlich, Mr. Lester Tong, Mr. Rod Chisholm, Mr. William C. Angeloni, and Ms. Irene Ulm. Mr. David Hayes of the Port of Oakland provided lead responsibility for contracting support vessels and collecting test sediment. In addition, we thank Dr. Brian Melzian and Mr. Pat Cotter of the U.S. Environmental Protection Agency for their part in the planning and technical design of these studies. Several key MSL scientists (not cited as authors) worked carefully and diligently to help generate the data critical to this report, including Dr. Eric Crecelius, Mr. Nicholas Bloom, Mr. Tim Fortman, Mr. Jeff Anderson, Ms. Virginia Broadhurst, Mr. James Coley, and Mr. Steve Kiesser. Battelle's senior management, who elevated the priority of this project and provided all the support necessary to accomplish it, are very much appreciated. They include Mr. Richard Ecker, Dr. Ray Wildung, and Dr. John Strand at Pacific Northwest Laboratory; Dr. Eiji Imamura at the Battelle-Ventura office and Drs. Sam Petrocelli and Richard Peddicord from the Battelle-Duxbury office. These individuals helped to resolve the processes required to mobilize personnel from the various offices and to identify key personnel who helped maintain cost tracking (Ms. Nancy Powell), provide formal QA/QC (Mr. Rob Cuello), and streamline contractual issues (Ms. Donna Anderson and Ms. Dianne Schroer). The editorial and word processing staff provided invaluable assistance not only in producing the document, but in guiding its delivery and ensuring the quality of report sections as they were produced. Ms. Georganne O'Connor led this effort with Ms. Judy Clark, Mr. Stan Crossman, Ms. Barbara Deak, and Ms. Judy McGuffey providing word processing support. The graphic art support provided by Ms. Laurel Black of Anaglyph and Mr. Mark Hutton, Mr. Rick Muir, and Mr. Gene Wattenburger of Pacific Northwest Laboratory are also acknowledged. None of the laboratory work could have been accomplished without the excellent support

provided by Sequim facilities staff (Mr. James Coley) under the direction of Mr. James Nimmo. When the scientific staff required modifications to laboratory facilities, Mr. Nimmo and his group provided that support, even when the timing was extremely short. Ms. Linda Franklin provided chemical analytical support while Dr. Michael Kent and Ms. Marilyn Wilkinson provided histopathology of the fish. We also would like to thank Drs. John Strand, Eric Crecelius, Betsy Brown, and Walter Pearson for their technical review of the report; their guidance improved the quality of the final product. As can be seen by this list of acknowledgements, the project was truly an extensive team approach to answering the needs of the program, and everyone involved was integral to its success.

CONTENTS

SUMMARY iii

ACKNOWLEDGMENTS v

1.0 INTRODUCTION 1.1

2.0 MATERIALS AND METHODS 2.1

2.1 STUDY AREA DESCRIPTION 2.1

2.2 SEDIMENT SAMPLE COLLECTION AND PRESERVATION 2.6

2.2.1 Vessels and Navigation. 2.6

2.2.2 Sampling Equipment and Methods. 2.8

2.2.3 Field Collections 2.8

2.2.4 Sample Shipment 2.10

2.3 SAMPLE PREPARATION PROCEDURES. 2.10

2.3.1 Labware Cleaning. 2.10

2.3.2 Suspended Particulate Phase Sample Preparation. . . . 2.11

2.3.3 Solid Phase Sample Preparation. 2.13

2.4 CHEMICAL ANALYTICAL PROCEDURES 2.14

2.4.1 Priority Pollutant Semivolatile Compounds Pesticides, and Polyclorinated Biphenyls. 2.14

2.4.2 Metals and Metalloids 2.14

2.4.3 Total Organic Carbons 2.16

2.4.4 Oil and Grease. 2.17

2.4.5 Petroleum Hydrocarbons. 2.17

2.4.6 Cyanide 2.18

2.4.7 Total and Dissolved Sulfides. 2.18

2.4.8 Grain Size. 2.19

2.5 TOXICOLOGICAL TESTING PROCEDURES 2.20
2.5.1 Suspended Particulate Phase Tests 2.20
2.5.2 Solid Phase Tests 2.32
2.5.3 Bioaccumulation Measurements. 2.36
2.6 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES 2.38
2.6.1 Sediment Sampling, Storage, and Tracking. 2.38
2.6.2 Biological Testing. 2.39
2.6.3 Chemical Testing. 2.40
2.7 STATISTICAL DESIGN, DATA ANALYSIS, AND INTERPRETATION. . . . 2.41
2.7.1 Statistical Methods 2.41
3.0 RESULTS AND DISCUSSION. 3.1
3.1 SUSPENDED PARTICULATE PHASE TESTS. 3.1
3.1.1 Mysids (A. sculpta) 3.1
3.1.2 Speckled Sand Dab (C. stigmaeus). 3.6
3.1.3 Oyster (C. gigas) Larvae 3.11
3.2 SOLID PHASE TESTS. 3.20
3.2.1 Polychaetes (N. caecoides) and Clams (M. nasuta) 3.20
3.2.2 Amphipods (R. abronius and G. japonica) 3.21
3.3 CHEMICAL ANALYSIS OF DREDGED-MATERIAL SAMPLES. 3.29
3.3.1 Priority Pollutant Semivolatile Compounds, Pesticides, and PCBs. 3.29
3.3.2 Metals and Metalloids 3.32
3.3.3 Organotins. 3.37
3.3.4 Total Organic Carbon 3.38
3.3.5 Oil and Grease 3.38

3.3.6 Conventionals/Petroleum Hydrocarbons 3.39
3.3.7 Cyanide 3.41
3.3.8 Total and Dissolved Sulfides. 3.41
3.3.9 Grain Size 3.41
3.4 BIOACCUMULATION POTENTIAL. 3.42
3.4.1 Metals. 3.42
3.4.2 Polynuclear Aromatic Hydrocarbons and Polychlorinated Biphenyls 3.46
3.4.3 Organotins. 3.49
4.0 CONCLUSIONS 4.1
4.1 SUSPENDED PARTICULATE PHASE BIOASSAYS. 4.1
4.2 SOLID-PHASE BIOASSAYS. 4.1
4.3 CHEMICAL TRENDS. 4.5
4.4 RELATION OF CHEMISTRY TO BIOLOGICAL DATA 4.5
4.5 BIOACCUMULATION. 4.7
4.5.1 Metals. 4.7
4.5.2 Polynuclear Aromatic Hydrocarbons 4.7
4.5.3 Organotins. 4.8
5.0 REFERENCES. 5.1
APPENDIX A - FIELD COLLECTION NOTES AND INFORMATION. A.1
APPENDIX B - SEDIMENT COMPOSITING INFORMATION. B.1
APPENDIX C - QA/QC EVALUATIONS C.1
APPENDIX D - EQUIPMENT LIST, CALIBRATION, AND MAINTENANCE RECORDS D.1
APPENDIX E - CITHARICHTHYS STIGMAEUS BIOASSAY TEST RESULTS E.1
APPENDIX F - ACANTHOMYSIS SCULPTA BIOASSAY F.1

APPENDIX G - *CRASSOSTREA GIGAS* BIOASSAY. G.1

APPENDIX H - *MACOMA NASUTA/NEPHTYS CAECOIDES* BIOASSAY. H.1

APPENDIX I - *RHEPOXYNIUS ABRONIUS/GRANDIDIERELLA JAPONICA* BIOASSAY I.1

APPENDIX J - CHEMISTRY DATA SUMMARY J.1

APPENDIX K - BIOACCUMULATION K.1

FIGURES

2.1 Sampling Stations for Oakland Inner Harbor. 2.2

2.2 Approximate Location of Point Reyes Reference Station 2.3

2.3 Approximate Location of Sequim Bay Reference Station. 2.4

2.4 Design of Gravity Corers Used for Oakland Inner Harbor. 2.9

2.5 MSL-Designed Centrifuge 2.12

2.6 MSL Wet Lab for Bioassays 2.21

2.7 Bioassay Test Equipment 2.22

2.8 Terminology for Characteristic Shapes of Oyster Larvae. 2.31

3.1 Mean Survival and 95% Confidence Intervals for 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments. 3.5

3.2 Mean Survival of Speckled Sand Dabs and 95% Confidence Intervals for 10, 50, and 100% SPP Concentrations Prepared for Six Sediment Treatments 3.9

3.3 Proportion of Normal D-Shaped Oyster Larvae for 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments Using an Arc Sine Square Root Transformation 3.15

3.4 Natural Logarithm of Oyster Larvae Recovered in a 30-mL Subsample in 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments. 3.18

3.5 95% Confidence Intervals of the Arc Sine Square Root of Proportion *R. abronius* Surviving. 3.24

3.6 95% Confidence Intervals of the Arc Sine Square Root of Proportion Amphipods (*G. japonica*) Surviving. 3.27

3.7 Natural Logarithm of Concentrations of Lead in Tissues of *M. nasuta* After 10-Day Exposure to Sediment Treatments 3.44

3.8 Natural Logarithm of Concentrations of Chromium in Tissues of *M. nasuta* After 10-Day Exposure to Sediment Treatments 3.46

3.9 Natural Logarithm of Concentrations of Mercury in Tissues of *M. nasuta* After 10-Day Exposure to Sediment Treatments 3.48

3.10 Natural Logarithm of Concentrations of PAHs in Tissues of *M. nasuta* After 10-Day Exposure to Sediment Treatments 3.50

TABLES

2.1 Analyses Performed on Sediment Treatments and Sediment Required, Volume of Sediment Required by Test 2.5

2.2 Experimental Design of Suspended Particulate Phase and Solid Phase Bioassays 2.7

2.3 Size Fractions of Sediment Grain Size Measured by Wet Sieving of Sediment or Through Pipette Techniques 2.19

2.4 Volumes of SPP Water Added to Sequim Bay Water to Achieve Desired Concentrations for Each of the Three Species Tested. 2.23

3.1 Numbers of Mysids (A. sculpta) Surviving After 96-h Exposure in Replicate Samples of 100% SPP and Sequim Bay Water 3.2

3.2 One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Sequim Bay Water Using the Arc Sine Square Root of the Proportion of Mysids Surviving a 96-h Exposure 3.3

3.3 Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine Square Root of the Proportion of Mysids Surviving a 96-h Exposure. 3.4

3.4 Numbers of Sand Dabs (C. stigmaeus) Surviving After 10-Day Exposure in Replicate Samples of 100% SPP and Sequim Bay Water 3.7

3.5 One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Sequim Bay Water Using the Arc Sine Square Root of the Proportion of Sand Dabs Surviving a 96-h Exposure. 3.7

3.6 Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine Square Root of the Proportion of Sand Dabs Surviving a 96-h Exposure. 3.8

3.7 Suspended Solid Concentrations in Speckled Sand Dab Containers. 3.10

3.8 Proportion of Normal D-Shaped Oyster Larvae Present in a 30-mL Subsample After 48-h Exposure to 100% SPP 3.13

3.9 One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Strait of Juan de Fuca Water Using the Arc Sine Square Root of the Proportion of Normal D-Shaped Oyster Larvae Surviving a 48-h Exposure 3.14

3.10 Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine Square Root of the Proportion of Normal D-Shaped Oyster Larvae Surviving a 48-h Exposure 3.14

3.11 Total Number of Oyster Larvae Recovered in a 30-mL Subsample After 48-h Exposure to 100% SPP Concentration 3.16

3.12 One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Strait of Juan de Fuca Water Using the Natural Logarithm of the Total Number of Oyster Larvae Surviving a 48-h Exposure 3.17

3.13 Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Natural Logarithm of the Total Number of Oyster Larvae Surviving a 48-h Exposure 3.18

3.14 Estimation of EC50 at Three Sediment Treatments Using the Litchfield and Wilcoxon Method. 3.19

3.15 Estimation of EC50 for Abnormal Production and Total Abundance of Larvae at Three Sediment Treatments Using the Least Squares Method. 3.20

3.16 Proportion of Polychaetes (N. caecoides) and Clams (M. nasuta) Surviving After 10-Day Exposure Expressed as the Total in Three Replicates 3.22

3.17 Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine Square Root of the Proportional of N. caecoides Surviving a 10-Day Solid Phase Exposure 3.22

3.18 Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine Square Root of the Proportion of R. abronius Surviving a 10-Day Solid-Phase Exposure 3.23

3.19 Comparison of Percent R. abronius Surviving for all Sediment Treatments 3.25

3.20 Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine Square Root of the Proportion of G. japonica Surviving a 10-Day Solid-Phase Exposure 3.26

3.21 Comparison of Percent Amphipods (G. japonica) Surviving for all Sediment Treatments 3.28

3.22 Pesticides and PCBs 3.30

3.23 Concentrations of Polynuclear Aromatic Hydrocarbons, Phthalates, and Percent Phthalates. 3.31

3.24 Concentrations of Metals in Each Sediment Treatment and Average Crustal Abundance of Metals in Shale Soils Throughout the World. 3.32

3.25 Comparison of Metal Concentrations for Each Station Relative to Metal Concentrations at Point Reyes. 3.33

3.26 Comparison of Metal Concentration for Each Station Relative to the Metal Concentration at Sequim Bay Reference Sediment Treatment. 3.34

3.27 Comparison of Metal Concentrations for Each Sediment Treatment Relative to the Average Crustal Abundance of Metals and Metalloids Found in Shale Soils Throughout the World. 3.35

3.28 Concentration of Butyltins in Oakland Inner Harbor, Point Reyes, and Sequim Bay Sediment. 3.37

3.29 Concentration and Enrichment Factors of TOC from Oakland Inner Harbor, Point Reyes, and Sequim Bay Sediment. 3.39

3.30 Conventionals/Petroleum Hydrocarbons 3.40

3.31 Percent Sediment Weight Used in Each Sediment Treatment by Major Size Category 3.41

3.32 Comparison of Concentrations of Lead Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.43

3.33 Balanced One-Way ANOVA of the Natural Logarithm of Lead Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments 3.43

3.34 Comparison of Concentrations of Chromium Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.45

3.35 Balanced One-Way ANOVA of the Natural Logarithm of Chromium Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.45

3.36 Comparison of Concentrations of Mercury Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.47

3.37 Balanced One-Way ANOVA of the Natural Logarithm of Mercury Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.47

3.38 Comparison of the Concentrations of Total PAHs Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. 3.49

3.39 Balanced One-Way ANOVA of the Natural Logarithm of PAH Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments 3.50

3.40 Comparison of the Concentrations of Butyltins Contained in Tissues of M. nasuta After 10-Day Exposure to Selected Sediment Treatments 3.51

4.1 Conclusions of Confirmatory Sediment Analyses, SPP, and Solid Phase Bioassays 4.2

INTRODUCTION

The Water Resources Development Act of 1986 (Public Law 99-662) authorized the San Francisco District of the U.S. Army Corps of Engineers (USACE) to deepen the navigation channels of the Oakland Inner and Outer Harbors to -42 ft measured from mean lower low water (MLLW). The recommended plan to deepen the channels includes widening them is several locations and constructing a turning basin in the Inner Harbor. The total amount of sediment to be dredged from the Inner and Outer Harbors is about 7 million cubic yards.

The original dredging plan called for the dredged material from the Inner and Outer Harbors to be discharged at the aquatic disposal site south of Alcatraz Island in San Francisco Bay. The Alcatraz Disposal Site receives the majority of sediment from maintenance dredging in the bay. Results of recent disposal studies at the Alcatraz Site indicate that the Oakland Harbor sediment could fill the Alcatraz Site to near capacity, thus jeopardizing continued maintenance dredging in San Francisco Bay. Consequently, the USACE is evaluating other alternative disposal sites, including other bay, ocean and upland sites.

Dredging to an interim depth of -38 ft MLLW has been contemplated for a portion of the Inner Harbor to better accommodate post-panamax container ships. These container ships are currently restricted to arriving and departing on high tides and with less than their design loads because of insufficient channel depth. Approximately 500,000 cubic yards of dredged material would be generated by dredging this portion of the Inner Harbor and the proposed turning basin to -38 ft MLLW. Ocean disposal of the dredged sediment from the initial phase of the project has been proposed.

Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (Public Law 92-532) mandates that all proposed operations involving the disposal of dredged materials into ocean waters be evaluated to determine potential environmental impacts. These evaluations, conducted by the USACE district engineer, must be performed according to criteria published in the Federal Register (1977), which emphasize using bioassays and other empirical techniques to provide direct measures of potential ecological effects. The regulations specifically require the USACE to address sediment quality issues

in these evaluations so that appropriate certifications from state agencies, where applicable, and the required concurrence with disposal site use from the U.S. Environmental Protection Agency (EPA) regional administrator can be obtained.

The EPA regional administrator and the USACE district engineer requested a panel of national experts to review existing sediment data from the Oakland Harbor Project. After reviewing these data, the panel determined that sediment from the Inner Harbor required supplemental confirmatory testing, specifically, solid phase bioassays.

As a result, the USACE asked Battelle/Marine Sciences Laboratory (MSL) to conduct studies to provide the technical data supporting an evaluation of the potential environmental impact of this dredging and disposal project. The purpose of the studies was to provide chemical and biological information required by ocean dumping regulations to determine the suitability of the Oakland Inner Harbor and turning basin sediment for ocean disposal. The studies included chemical analyses of selected contaminants in sediment and a series of confirmatory solid phase and suspended particulate phase bioassays performed on seven sensitive marine species. Bioaccumulation measurements were also made on surviving animals from selected solid phase bioassays.

This study builds on earlier chemical and biological evaluations conducted by Marine Bioassay Laboratory (MBL) and the Pacific Northwest Laboratory (PNL) as part of the Oakland Harbor Project.[(a)] To ensure that results of the current study comply with Federal Register requirements, the technical design and procedures were based on guidelines and recommendations provided in the Implementation Manual for Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters (EPA/USACE 1977).

Section 2.0 of this report describes field and laboratory methods, including quality assurance (QA) and quality control (QC) procedures. Results of chemical analyses, bioassays, and bioaccumulation measurements are provided in Section 3.0. Conclusions on the potential ecological impact of the proposed dredging and disposal operations are included in Section 4.0.

(a) Unpublished studies of Oakland Inner Harbor and Alcatraz Disposal Site by Word et al.

2.0 MATERIALS AND METHODS

Section 2.1 of this report describes the sediment collection areas in Oakland Inner Harbor, offshore of Point Reyes, California, and in Sequim Bay, Washington. The biological and chemical tests performed on the sediment are also described in this section. Sample collection and preservation methods are explained in Section 2.2. Section 2.3 describes the preparation of the solid and suspended particulate phase test materials. Chemical analytical procedures are presented in Section 2.4. The test objectives, overall experimental design, and collection and handling of organisms are included in Section 2.5. Section 2.5 also describes methods for the suspended particulate phase (SPP) bioassays performed on mysids (Acanthomysis sculpta), speckled sand dabs (Citharichthys stigmaeus), and oysters (Crassostrea gigas); solid phase bioassays performed on polychaetes (Nephtys caecoides), clams (Macoma nasuta), and amphipods (Grandidieralla japonica and Rhepoxynius abronius); and bioaccumulation measurements. Section 2.6 outlines the quality assurance (QA) and quality control (QC) procedures followed for each of the tests. The statistical design, analysis, and interpretation methods for the study are included in Section 2.7.

2.1 STUDY AREA DESCRIPTION

Oakland Inner Harbor, a 4.5-mile-long shipping channel, is located between the cities of Oakland and Alameda, California, which border the eastern shoreline of San Francisco Bay. Figure 2.1 shows the 14 stations in Oakland Inner Harbor designated by USACE for test sediment sample collection. Seven stations are located in the Inner Harbor Reach (1-1, 1-2, 1-3, 2-1, 2-2, 3-1, and 3-2), and seven are in the turning basin (SN-1, SN-2, SN-3, TD-1, TD-2, CH-1, and CH-2). For testing, sediment samples from Stations SN-2, SN-3, TD-1, and TD-2 were divided in half into upper and lower cores, which were then designated as Sediment Treatments SN-2-U, SN-2-L, SN-3-U, SN-3-L, TD-1-U, TD-1-L, TD-2-U, and TD-2-L.

The USACE also identified stations for reference sediment collection offshore of Point Reyes, California (Figure 2.2), and in Sequim Bay, Washington (Figure 2.3). In addition, for the bioaccumulation tests,

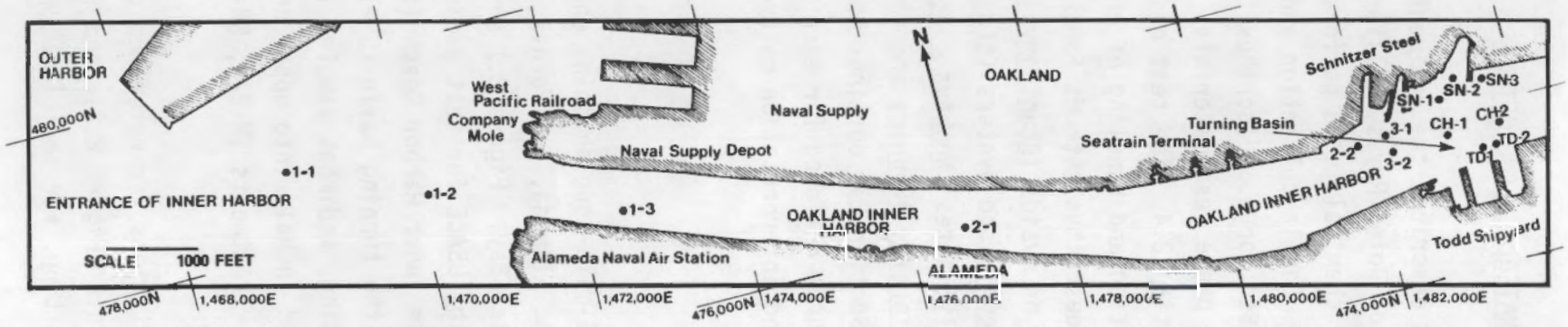


FIGURE 2.1. Sampling Stations for Oakland Inner Harbor

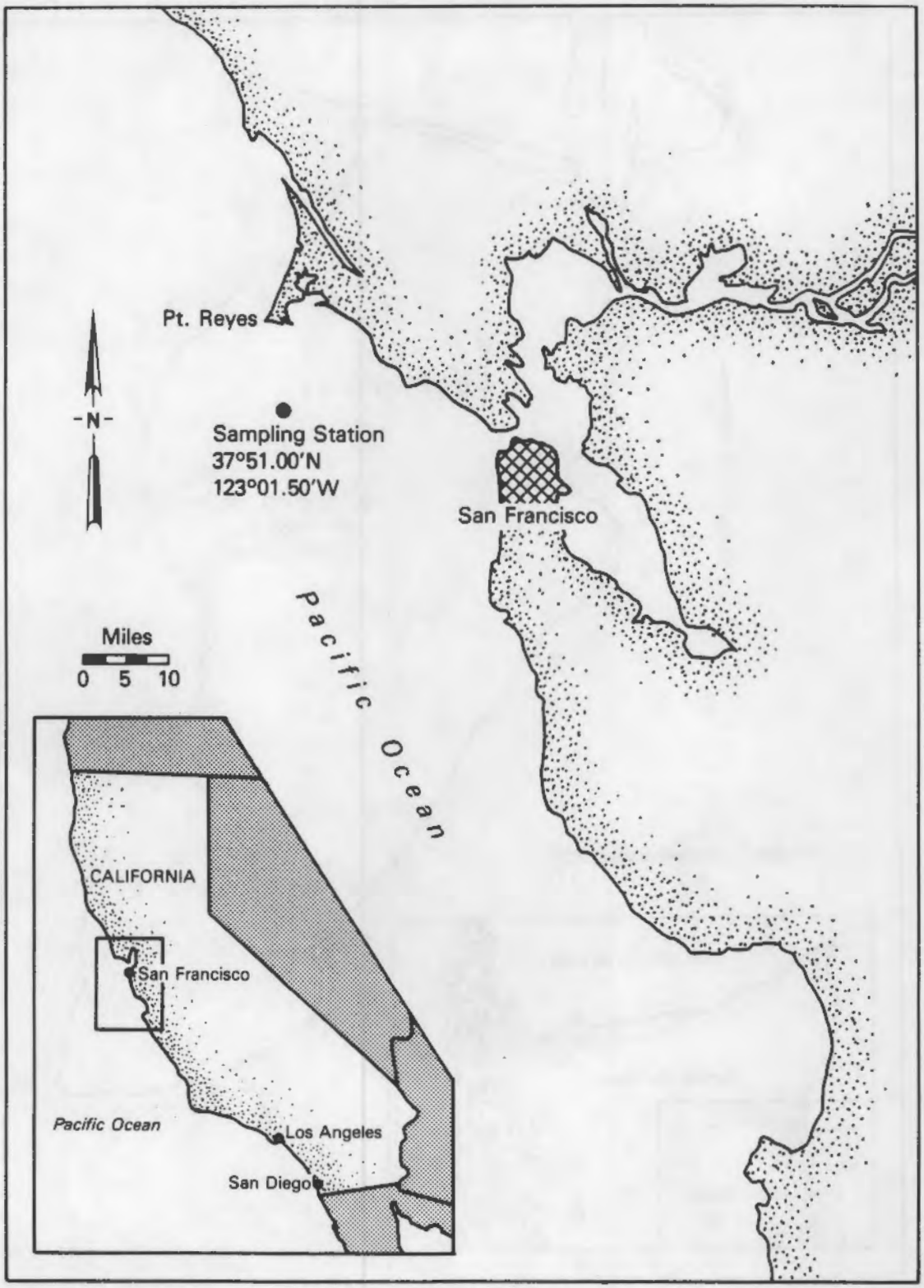


FIGURE 2.2. Approximate Location of Point Reyes Reference Station

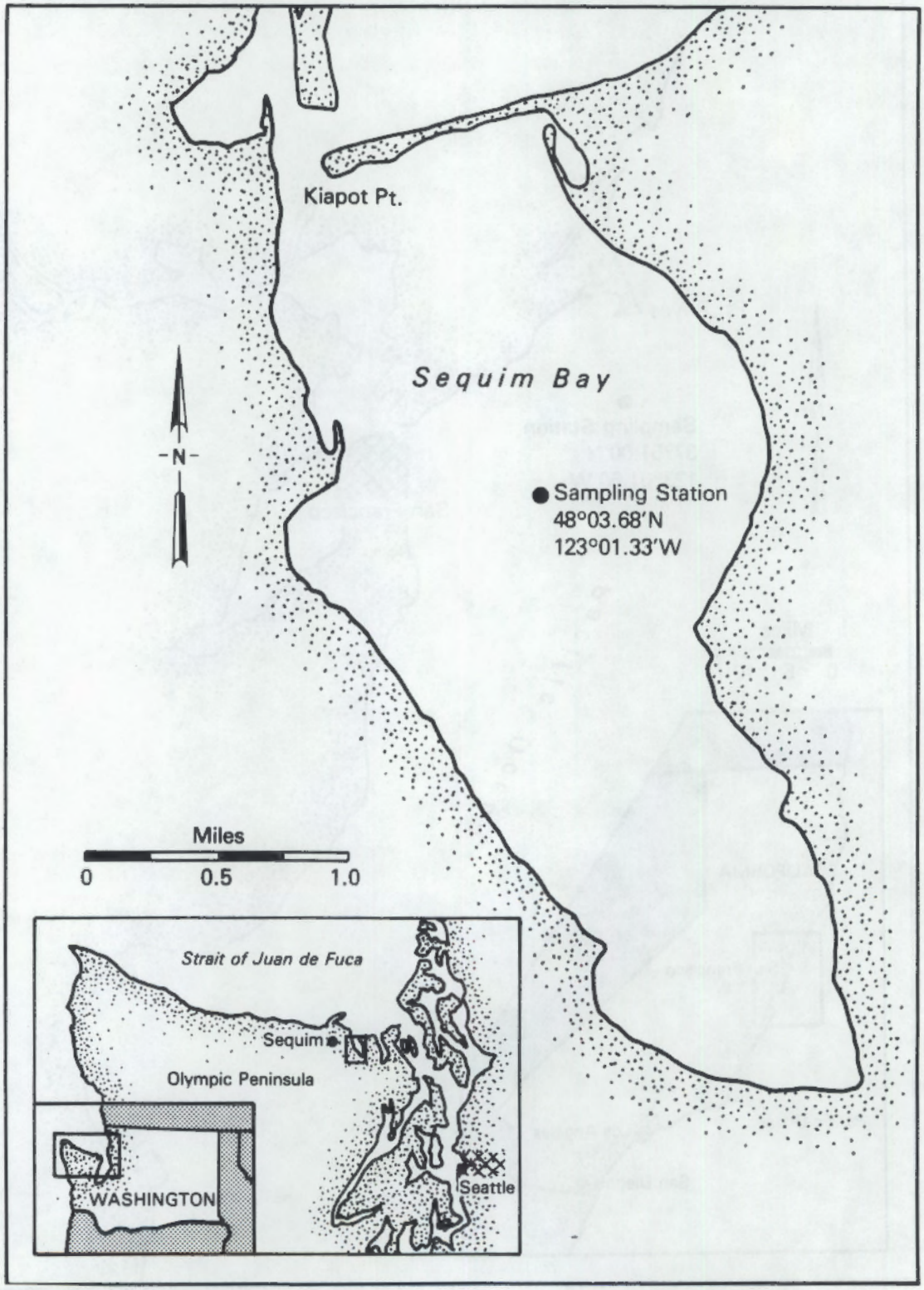


FIGURE 2.3. Approximate Location of Sequim Bay Reference Station

reference tissue samples from Elkhorn Slough, California, were analyzed as calibrated standards. The 18 test sediment treatments and 2 reference sediment treatments were used in various chemical analyses and solid and suspended particulate phase (SPP) bioassays. Specific analyses conducted on each treatment and the required sediment volume for the analyses are provided in Table 2.1. A summary of the experimental design for the SPP and solid phase

TABLE 2.1. Analyses Performed on Sediment Treatments and Sediment Required, Volume (L) of Sediment Required by Test

Sediment Treatment	Chemical (L)	Biological	
		Solid (L)	Suspended (L)
Oakland Inner Harbor Reaches			
1-1	2	13	
1-2	2	13	
1-3	2	13	
2-1	2	13	
2-2	2	13	
3-1	2	13	
3-1	2	13	
CH-1	2	13	55
CH-2	2	13	
CH-C[a]			
Oakland Inner Harbor Turning Basin			
SN-1	2	13	
SN-2U[b]	2	13	55
SN-2L[c]	2	13	55
SN-3U	2	13	
SN-3L	2	13	
TD-1U	2	13	
TD-1L	2	13	
TD-2U	2	13	55
TD-2L	2	13	55
Reference			
Point Reyes	2	400	
Sequim Bay	2	13	55

(a) Composite of samples CH-1 and CH-2 for suspended particulate phase tests.
(b) Upper core half.
(c) Lower core half.

bioassays is included in Table 2.2. Details of sampling procedures and individual sample characteristics are provided in Section 2.2 and in Appendices A and B.

2.2 SEDIMENT SAMPLE COLLECTION AND PRESERVATION

2.2.1 Vessels and Navigation

The R/V Prophecy, owned and operated by Kinnetic Laboratories, Inc., Santa Cruz, California, was the support vessel for the Oakland Inner Harbor cruise. Initially, the Point Reyes reference sediment also was to be collected using the R/V Prophecy. However, because the vessel was still being used to collect sediment in the Inner Harbor, the seatug Sea King, with a deck winch and davit, was used to collect the reference sediment. A 24-ft vessel owned by MSL was used to collect sediment in Sequim Bay.

Navigation services for the Oakland Inner Harbor cruise were provided by Sea Surveyor, Inc., Benicia, California, under contract to the Port of Oakland. Positioning was accomplished using an Electronic Survey Product (ESP) laser range/azimuth positioning system, referenced to the California State (Zone III) Coordinate System in the Oakland Harbor vicinity. The ESP laser system was established on either the Howard Terminal in Oakland or on Monument CHAN in Alameda. As stations were located with the laser system, a fix was logged and a station-marker buoy was deployed at the station site. Station water depths were recorded by a fathometer and corrected for MLLW using a surveyed MLLW reference marker or tide table. Details of sample collection locations and field observations are included in Appendix A.

The primary navigational aids for the Point Reyes reference sediment cruise were the Northstar 6000 LORAN receiver and a satellite navigation system. All LORAN time delays were in the 9940 group repetition interval (GRI) using the x and y secondary stations and the 27- and 43-K lines, respectively. Latitude and longitude coordinates were logged from the satellite navigation receiver. Sample times and positions were noted as the sampling gear haul-back commenced. A summary of sample positions for the Point Reyes sediment cruise is shown in Appendix A.

TABLE 2.2. Experimental Design of Suspended Particulate Phase (SPP) and Solid Phase (SP) Bioassays

Test Type	Test Time	Number Sample Treatments	Test Concentrations (% SPP)	Number Replicates	Sequim Bay Seawater Number Replicates	Total Number Containers	Number Organisms Per Container	Volume (liquid/ sediment)
Suspended Particulate Phase								
Oyster (Crassostrea gigas) larvae	48 h	6	10, 50, and 100	3	4[(a)]	58	24,800	800 mL/liquid only
Mysid (Acanthomysis sculpta)	96 h	6	10, 50, and 100	3	3	57	10	1 L/liquid only
Juvenile speckled sand dab (Citharichthys stigmaeus)	4 d	6	10, 50, and 100	3	3	57	10	20 L/liquid only
Solid Phase, Flow-Through								
Polychaete (Nephtys caecoides) and clams (Macoma nasuta)	10 d	20	N/A	3	N/A	60	20 (each species)	30 L/6 L
Solid Phase, Static								
Amphipods (Rhepoxynius abronius and Grandidierella japonica)	10 d	20	N/A	5	N/A	100	20 Rhepoxynius 10 Grandidierella	575 mL/225 mL

(a) Strait of Juan de Fuca water.
NA = Not applicable.

Station navigation in Sequim Bay was conducted by using range fixes to reference landmarks and water-depth confirmation. This station is routinely occupied by MSL staff. A summary of sample positions for the Sequim Bay sediment cruise is included in Appendix A.

2.2.2 Sampling Equipment and Methods

A Benthos Model 2171 (3-in. inner diameter x 8-ft-long barrel) gravity corer and a newly fabricated Sea Surveyor, Inc. (4-in. inner diameter x 8-ft-long barrel) gravity corer (Figure 2.4) were used to collect test sediment in Oakland Inner Harbor. The gravity corers were lined with steam-cleaned cellulose acetate buterate (CAB) core liners of 2.63- or 3.5-in. inner diameter. Core samples were labeled by station, measured for penetration depth and sample volume, and capped. Cores were then cut in lengths to fit coolers, open ends were capped, and the core sections stored in ice chests at approximately 4°C for shipment to MSL. Sediment chemistry samples for cyanide and sulfide analyses were obtained by collecting an additional core, extruding the sediment from the CAB core liner, and scraping the length of the core sample with a stainless steel spoon. The scraped samples were placed in 8-oz glass jars and preserved with 2 mL of sodium hydroxide or 2 mL of zinc acetate for cyanide and sulfide, respectively. These samples were stored in ice chests at approximately 4°C for shipment to MSL.

An 8-gal bucket dredge was used to collect reference sediment offshore of Point Reyes. Samples were placed in glass jars and stored in ice chests at approximately 4°C for shipment to MSL. Chemistry samples were collected, preserved, labeled, stored, and shipped as discussed above.

Sediment samples from Sequim Bay were collected using a 0.1-m^2 stainless steel modified van Veen grab. The collected sediment was stored in a 5-gal bucket for transport to MSL. Chemistry samples were subsampled at the time of collection from the modified van Veen grab using a stainless steel spoon, preserved, and transported to MSL.

2.2.3 Field Collections

Test sediment of the proposed dredged material was collected at Oakland Inner Harbor from March 21, 1988, to March 27, 1988. The Benthos corer

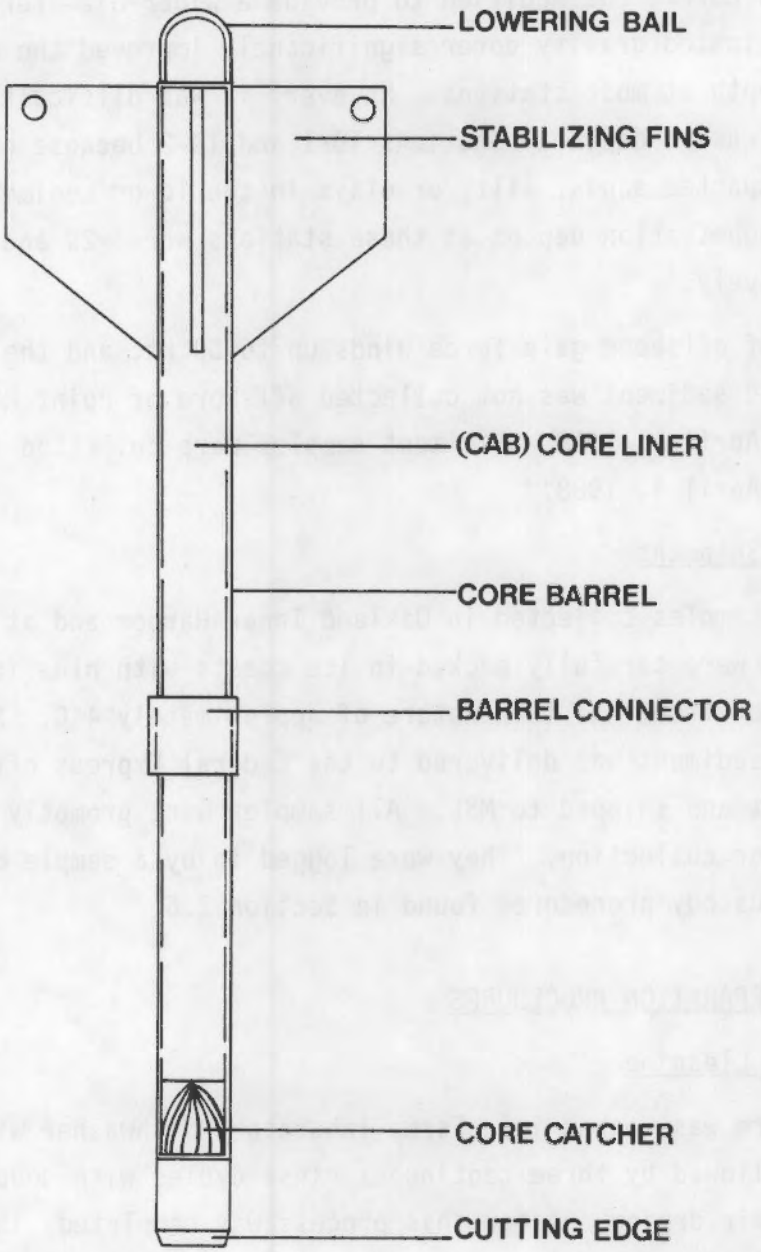


FIGURE 2.4. Design of Gravity Corers Used for Oakland Inner Harbor

retrieved 6-ft sediment cores at the Inner Harbor Reach stations and at the most northerly stations within the turning basin. However, the Benthos corer was unsuccessful at the mid-channel and southern stations of the turning basin and only collected sediment cores to a 3-ft penetration depth. To sample these areas more effectively, Sea Surveyor, Inc., fabricated a corer similar

to the Benthos corer, but modified to provide a wider-diameter core barrel. The newly fabricated gravity corer significantly improved the maximum core-penetration depth at most stations. However, it was difficult to reach maximum core-penetration depth at Stations TD-1 and TD-2 because of the resistance of densely compacted sands, silt, or clays in the lower sediment layers. Maximum core-penetration depths at these stations were -29 and -32 ft below MLLW, respectively.

Because of offshore gale force winds up to 50 kt, and the resultant high seas, reference sediment was not collected offshore of Point Reyes until March 31, and April 1, 1988. Sediment samples were collected in Sequim Bay on March 27, and April 4, 1988.

2.2.4 Sample Shipment

Sediment samples collected in Oakland Inner Harbor and at the Point Reyes reference site were carefully packed in ice chests with blue ice to ensure a chilled, but not freezing, temperature of approximately 4°C. Each day's collection of sediment was delivered to the Federal Express office at the Oakland Airport and shipped to MSL. All samples were promptly received at MSL on the day after collection. They were logged in by a sample custodian, according to custody procedures found in Section 2.6.

2.3 SAMPLE PREPARATION PROCEDURES

2.3.1 Labware Cleaning

All labware was washed in a Forma laboratory dishwasher with Forma Soap Solution 2, followed by three continuous rinse cycles with double-distilled water and hot air drying. After this process was completed, labware was soaked in a solution of 2% nitric acid (HNO_3, Baker Instra-analyzed grade) for at least 4 h. The labware was rinsed five times with double-distilled water, three times with methylene chloride, and then air dried under a laboratory hood.

The 10- and 55-gal, all-glass aquaria used in the bioassays or that contained sediment or suspended particulate phase (SPP) water, were too large to be cleaned in the dishwasher, so they were washed by hand with hot soapy

water and rinsed with tap water a minimum of five times. The containers were then partially filled with deionized water and an amount of concentrated HNO_3 added to provide a 2% acid bath. These containers were soaked in this acid bath mixture for a minimum of 4 h. Then the acid was removed, the aquaria were rinsed with deionized water a minimum of five times, and again with distilled water. After cleaning, the openings of these large containers were covered with aluminum foil that had been ashed in a kiln at 550°C for 2 h.

2.3.2 Suspended Particulate Phase Sample (SPP) Preparation

The SPP is the liquid supernatant that remains after mixing sediment with seawater and allowing heavier particles to settle out. Because the sample preparation does not involve filtration, this phase contains suspended particles as well as dissolved constituents. The process is intended to approximate exposure conditions created as a result of materials being discharged through the water column during dredge-disposal operations.

Oyster (C. gigas) bivalve larvae, juvenile speckled sand dabs (C. stigmaeus), and mysids (A. sculpta) were used in the SPP bioassays. Three shifts of personnel prepared all the SPP water within 2 days. The total volume of SPP water prepared from about 55 L of sediment was approximately 76 L for each of the six sampling stations. The SPP water was prepared by measuring 200 mL of Sequim Bay seawater into 1-L glass containers and adding approximately 200 mL of sediment followed by 600 mL of Sequim Bay seawater. The jars containing this mixture were then capped with Teflon® metal lids, placed on a shaking table for 30 min, and rocked back and forth at a rate of 120-150 cycles/min. After shaking, the suspended materials were allowed to settle for approximately 10 min. The overlying supernatant was poured into 500-mL Teflon® containers with Teflon® lids. These containers were placed into a specially designed centrifuge (Figure 2.5) and spun at low speed (1750 rpm, 740 g) for 10 min. This process provided approximately 4 or 8 L, respectively, of SPP water for each centrifugation run. The 10-min centrifugation ensured that the mysids (A. sculpta) and speckled sand dabs (C. stigmaeus) were visible when added to the SPP water.

After centrifugation, the SPP water was poured into 10-gal, all-glass aquaria. Five-gallon batches of the SPP water were prepared, transferred to

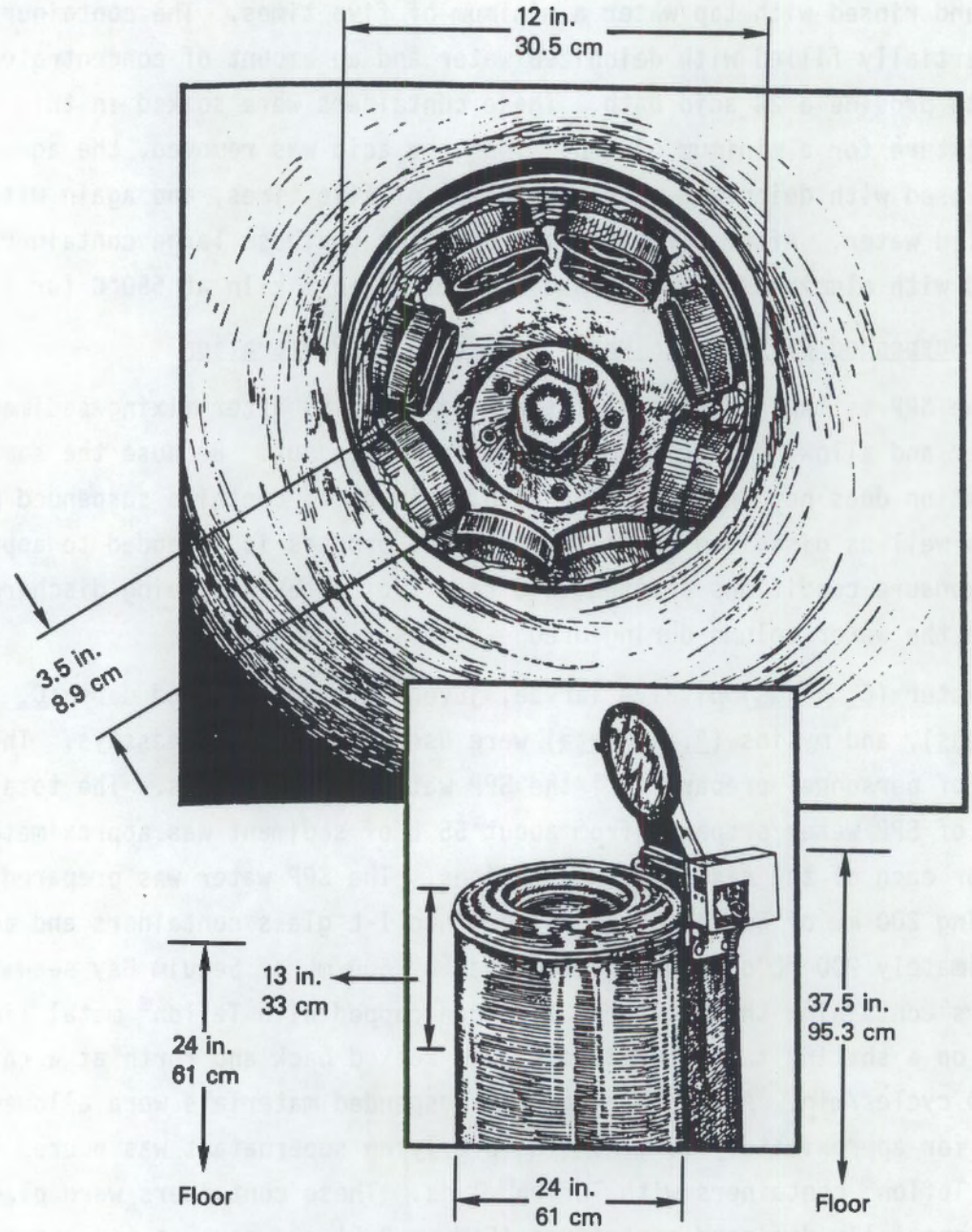


FIGURE 2.5. MSL-Designed Centrifuge

55-gal, all-glass aquaria, and gently aerated to ensure that all prepared test water was composited before use. This process produced approximately 120 L of SPP water per 8-h day. The bioassays were run immediately after all the SPP water was prepared.

Each sediment treatment required preparation of three replicates of 100, 50, 10, and 0% concentrations of SPP water. Concentrations were prepared using either reference Sequim Bay water for the speckled sand dab (C. stigmaeus) and mysid (A. sculpta) experiments or salinity-corrected Strait of Juan de Fuca water for the oyster (C. gigas) larvae test. The salinity was adjusted for the oyster larvae tests to 26 °/.. by diluting the reference Strait of Juan de Fuca water with deionized water. Sufficient test water was prepared at one time for all dilutions in each test. This composited water was then distributed to the test containers, as described in the individual bioassays.

2.3.3 Solid Phase Sample Preparation

Because of the large volume of sediment required for reference sediment layering in the solid phase bioassays, the preparation procedures for test sediment and reference sediment are discussed separately in this section.

The solid phase tests required approximately 100 gal of Point Reyes sediment, weighing nearly 2,000 lb. Upon arrival at MSL, the sediment containers were removed from the ice chests and stacked on the floor of the laboratory. Sediment from randomly selected containers was placed onto stacked mesh screens with 1.0- and 0.5-mm-diameter openings. Sediment that passed through these sieves was collected in 55-gal, all-glass aquaria. Water used during the sieving was recirculated from the aquaria to the screens to provide additional sieving water. Recirculation was provided by a Simms Geyser submersible water pump. Organisms collected on the sieves were discarded, and the small amount of remaining debris was added to the sieved sediment. This sieved sediment was then mixed with stainless steel spoons until it was judged that even consistency was obtained. Sediment was collected for the chemical analyses from this composited reference material.

Approximately 13 L of solid phase test sediment was prepared from each sediment treatment by extruding each section of the core into a stainless steel bowl and homogenizing the mixture (without adding water) using large stainless steel spoons. This process continued until similar consistency and color were visible throughout the bowl. After homogenization, chemical analyses samples were removed and either frozen, dried, or refrigerated, as

appropriate for chemical sample types. Samples of solid phase reference and test sediment were either used immediately (reference), or held in a cold room at 4°C (test). Sediment compositing information is presented in Appendix B.

2.4 CHEMICAL ANALYTICAL PROCEDURES

2.4.1 Priority Pollutant Semivolatile Compounds, Pesticides, and Polychlorinated Biphenyls (PCBs)

Sixty-five semivolatile compounds [polynuclear aromatic hydrocarbons (PAHs), phenols, phthalates] were measured by Analytical Resources Incorporated (ARI), Seattle, Washington, using EPA-approved control laboratory protocols (CLP) (Method 625), modified as follows (40 CFR Part 136 1984):

- Analyzed sample weight was increased to a minimum of 50 g (wet wt) to obtain lower detection limits.
- Gel permeation chromatography (GPC) cleanup using CLP protocol was performed on all samples.

Nineteen priority pollutant pesticides and five Aroclor PCBs also were analyzed in each sediment by ARI using approved EPA-CLP protocols (Method 8080), modified as follows (40 CFR Part 136 1984):

- Analyzed sample weight was increased to a minimum of 50 g (wet wt) to obtain lower detection limits.
- GPC and alumina cleanup using CLP protocols was performed on all samples.
- Final volumes were reduced to 1 mL, from the normal 10 mL, to provide lower detection limits for the pesticides and PCBs.

The QA/QC summaries of these data are found in Appendix C.

2.4.2 Metals and Metalloids

Metal and metalloid concentrations were determined through four procedures. Lead and zinc were measured by X-ray fluorescence (XRF). Mercury was analyzed with cold-vapor atomic absorption spectrophotometry. Antimony, arsenic, cadmium, chromium, copper, nickel, selenium, silver, and thallium

were analyzed by Zeeman graphite-furnace atomic absorption spectrophotometry. Organotin compounds were analyzed using gas chromatography-mass spectrometry (GCMS).

XRF Analysis

Energy diffusive XRF analysis was performed by Pacific Northwest Laboratory, Richland, Washington. Approximately 0.5-g of sediment was pressed into 2-cm-diameter pellets for the XRF analysis. Lead and zinc were analyzed by this technique. The XRF technique is recognized by the National Bureau of Standards (NBS) for analyzing metals in sediment matrices. Researchers at MSL provided NBS quantitation of samples to verify concentrations in standard reference materials (SRMs). The calibration techniques used in this analysis are described by Nielson and Sanders (1983).

Appendix C presents results of the XRF analyses. Blank values for XRF analysis were not included in Appendix C because X-rays are not produced unless a sample is analyzed. However, the detection limit in sediment is about 1 μg/g, based on a twofold standard deviation of mean counts for a sample that contains low concentrations of an element (Nielson and Sanders 1983). Spike recoveries were not conducted for the metals analyzed by XRF because it is not possible to mix solutions of metal homogeneously with dry sediment. Instead of conducting matrix spikes, two additional certified reference sediment were analyzed. The QA/QC results for these data are found in Appendix C.

Atomic Absorption Spectrophotometer Analysis

Atomic absorption spectroscopy was performed on sediment extracts to determine the concentrations of antimony, arsenic, cadmium, chromium, copper, mercury, nickel, selenium, silver, and thallium. Sediment was freeze-dried and blended in a Spex mixer-mill. Approximately 4 g of this mixed sediment was then ground in a Spex ceramic ball mill. Then, 0.2-g aliquots of this dried homogenate were digested with 4:1 nitric acid/perchloric acid in Teflon® digestion bombs. After these samples were allowed to cool, hydrofluoric acid was added, and the digestion bombs were placed in a 130°C oven for 8 to 12 h.

After cooling, solution volumes were determined, and the solutions were stored in polyethylene bottles until the analysis was performed.

Mercury concentrations were determined through cold-vapor atomic absorption using a Laboratory Data Control (LDC) mercury monitor with a 30-cm cell as a detector, as indicated in EPA Protocol 7471, and modified by Bloom and Crecelius (1983). The remaining metals (antimony, arsenic, cadmium, chromium, copper, nickel, selenium, silver, and thallium) were analyzed on a Zeeman graphite-furnace atomic absorption spectrometer using Methods 7041, 7060, 7131, 7191, 7210, 7520, 7740, 7760, and 7841 (EPA 1986).

Organotins

Sediment extraction for the organotin analysis followed the methods of Unger et al. (1986) consisted of weighing approximately 10-g wet sediment into a 125-mL solvent-cleaned glass jar. This sediment was mixed thoroughly with approximately 100 g of anhydrous sodium sulfate to remove the water within the sediment. Methylene chloride (110 mL) and 0.25 g of tropolone were then added to the container. This mixture was homogenized for 12 h and the liquid portion decanted through silanized glass wool to remove particles. The container was then rinsed three times with additional methylene chloride and the resulting fluid saved for further preparation.

The mono-, di-, and tri-butyltin compounds extracted from the sediment were derivatized with n-hexyl magnesium bromide to a less volatile and more thermally stable form than the organotin hydrides (Unger et al. 1986). This derivative was in the tetra-alkyltin form and was quantified by GCMs. The n-hexyl derivatives of butyltin species were separated, and the method was evaluated using tri-propyltin as a surrogate standard; recoveries were reported.

2.4.3 Total Organic Carbons

Total organic carbon in sediment was determined by AMTest, Redmond, Washington, using a non-dispersive infrared measurement of carbon dioxide released from the organic carbon during combustion of the sediment. Inorganic carbonates were released from the sediment sample before combustion using hydrochloride. A Dohrmann DC-180 was used to measure carbon dioxide.

Duplicate analysis was performed on sediment from Stations 2-1 and CH-1. This method is consistent with PSEP (1986) and Standard Method 505 (Standard Methods 1975).

2.4.4 Oil and Grease

Sediment for the total oil and grease analysis was extracted by weighing approximately 20 g of sediment into a solvent-rinsed, 250-mL jar. Approximately 40 to 50 g of anhydrous sodium sulfate was added to the sample and homogenized with the sediment to absorb any water from the sediment. Then 50 mL of carbon tetrachloride was added and stirred into this mixture. The sample was then immediately placed on a sample homogenizer for 16 h. After 16 h, the sample was removed from the homogenizer, and the carbon tetrachloride poured into a solvent-rinsed conical vial. An additional 50 mL of carbon tetrachloride then was added to the sediment, and the sample was rolled an additional 6 h. This second extraction has been shown to ensure 90% extraction efficiency for various sediment matrices (Word et al. 1987). These two extracts were combined and measured to the nearest milliliter. Two separate scintillation vials were filled for analysis on a Beckman Acculab 4 Infrared Spectrophotometer (IR).

The sample was scanned from 4000 to 600 cm^{-1}, and the peak height was measured at 2930 cm^{-1}. This wavelength represented the CH_2 configurations of hydrocarbons and is the standard used to determine oil and grease. Oil and grease may include hydrocarbons, fats, fatty acids, soaps, waxes, oils, and any other carbon-hydrogen material that is extracted by the carbon tetrachloride solvent. The relationship of peak height to the oil concentration was determined by regressing the peak height versus a known concentration of fuel oil (EPA-API Reference Oil WP 681). This method is consistent with Method 502 B (Standard Methods 1975).

2.4.5 Petroleum Hydrocarbons

The petroleum hydrocarbon analysis was performed on a portion of the oil and grease extract. Either 50 (for all but Sediment Treatments 1-1, 1-2, TD-2-U, and Point Reyes) or 25 mL of this extract was mixed with freon to provide 100 mL of sample in a solvent-rinsed glass jar. This mixture represents a 25 or 50% dilution, which is accounted for in the calculations of the

concentrations of the petroleum fraction of the oil and grease measurement. This solution was then mixed on a homogenizer for 5 min with 3 g of 200-mesh silica gel, Grade 922, to remove the polar materials (fatty acids) from the solution. The remaining materials were designated hydrocarbons for this test and were measured using the Beckman Acculab 4 Infrared Spectrophotometer.

As with the oil and grease measurement, the sample was scanned from 4000 to 600 cm^{-1}, and the peak height was measured at 2930 cm^{-1}. This wavelength represented the CH_2 configurations of hydrocarbons and was the standard used to determine oil and grease.

To ensure that the silica-gel extraction of fatty acids was effective, this extraction was performed on a sample of American Petroleum Institute (API) crude petroleum and also a sample of NuMade Pure Corn Oil. For the latter test, 1 mL of corn oil was dissolved in 100 mL of freon. This solution was diluted tenfold to obtain an appropriate reading on the infrared spectrophotometer. Thirty microliters of the API standard oil was dissolved in 100 mL of freon. Both of these samples were analyzed on the infrared spectrophotometer, as indicated in the above procedure. The samples were then exposed to the silica-gel extraction procedure and re-analyzed on the infrared spectrophotometer. The procedure was effective, and the corn oil was completely removed from the extract while the petroleum hydrocarbon sample remained essentially unaffected.

2.4.6 Cyanide

Cyanide measurements were conducted on a Schmadzo Spectrophotometer using EPA Method 335.3 protocols (EPA 1979). A method blank, two spiked samples (Sediment Treatments 2-1 and CH-1), and duplicate measurements of Sediment Treatment 2-1 and CH-1 also were run for QA/QC.

2.4.7 Total and Dissolved Sulfides

Total sulfide measurements followed the PSEP total sulfide distillation and calorimetric procedure, comparable to EPA Method 376.2 (PSEP 1986; EPA 1979). Dissolved sulfide measurements followed methodology set forth in Green and Schnitker (1974). Zinc acetate preservative solution recommended in PSEP

and EPA methodologies was added to samples during field collection (PSEP 1986; EPA 1979). Method blanks, two spiked recoveries (Sediment Treatments 2-1 and 2-2), and duplicate measurements from Sediment Treatments 2-1 and CH-1 were also evaluated for purposes of QA/QC.

2.4.8 Grain Size

Grain size was evaluated by measuring the mass of material collected on seven sieves and also the mass of material that had settled to 20, 10, or 7 cm in a 1-L graduated cylinder at specific time periods. The size of the material was either larger than the specified sieve size opening, or was determined for the pipette-collected material based on Stokes Law (Table 2.3).

TABLE 2.3. Size Fractions of Sediment Grain Size Measured by Wet Sieving of Sediment or Through Pipette Techniques

Grain Size (mm)	Phi	Screen Number	Pipette Depth (cm)	Time of Pipette Sampling		
				h	min	sec
3.35	-2.0	6	NA	NA		
2.0	-1.0	10	NA	NA		
1.0	0	18	NA	NA		
0.5	1.0	35	NA	NA		
0.25	2.0	60	NA	NA		
0.125	3.0	120	NA	NA		
0.0625	4.0	230	20	0	0	20
0.0480	4.5	NA	10	0	0	55
0.0312	5.0	NA	10	0	1	55
0.0230	5.5	NA	10	0	3	40
0.0156	6.0	NA	10	0	7	41
0.0078	7.0	NA	10	0	31	0
0.0039	8.0	NA	10	2	3	0
0.0019	9.0	NA	7	5	43	0
0.000976	10.0	NA	7	22	53	0
0.0004883	11.0	NA	5	65	25	0

NA = Not applicable.

Mass was determined after the samples had been dried by weighing the material weighing the material to the nearest 0.1 μg on a Metler AC-100 electronic balance. Salt content was then accounted for. This method is consistent with PSEP methodology (PSEP 1986).

2.5 TOXICOLOGICAL TESTING PROCEDURES

As part of the toxicological testing program, the laboratory at MSL was specifically set up to provide the facilities required for the SPP static bioassays and either flow-through or static solid phase bioassays. Eleven constant-temperature water baths were set up, as shown in Figure 2.6. These water baths contained the test equipment (Figure 2.7) for the following bioassays:

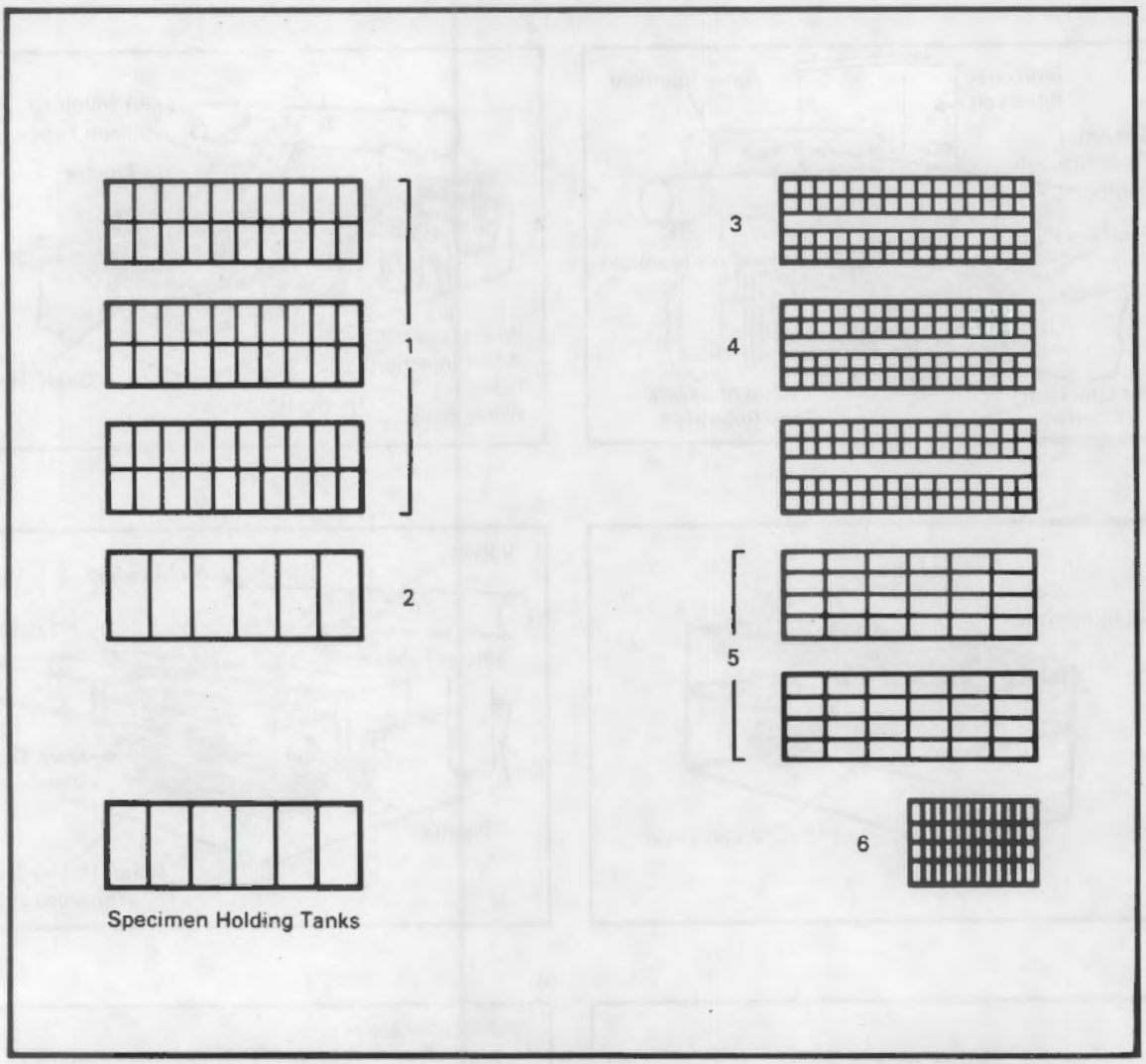
- flow-through, solid phase clam/polychaete (*M. nasuta*/*N. caecoides*)
- static, solid phase amphipods (*R. abronius*/*G. japonica*)
- static, SPP oyster larvae (*C. gigas*)
- static, SPP mysid (*A. sculpta*)
- static, SPP speckled sand dab (*C. stigmaeus*).

The facilities provided air, temperature control, lighting, and flow-through water supply as needed, as well as warning signals for potential equipment malfunctions.

2.5.1 Suspended Particulate Phase (SPP) Tests

Test Objectives

The primary objective of the SPP tests was to evaluate, through controlled laboratory experiments, potential biological effects of suspended particulate matter and dissolved chemical constituents released from dredged materials into the water column. The tests evaluated effects caused by both the physical presence of the suspended particles and the chemical toxicity of contaminants associated with the particles or dissolved fractions. These tests were conducted with three sensitive marine species, consisting of a fish, a crustacean, or mollusc, and a zooplanktonic organism, for the purpose of examining effects with a variety of test phyla.



1. Clam and Polychaete Solid-Phase Flow-Through Bioassay
2. Holding Tanks for Suspended-Particulate Phase
3. Amphipod Solid-Phase Static Bioassay
4. Oyster Larvae Suspended-Particulate-Phase Bioassay
5. Sanddab Suspended-Particulate-Phase Bioassay
6. Mysid Suspended-Particulate-Phase Bioassay

FIGURE 2.6. MSL Wet Lab for Bioassays

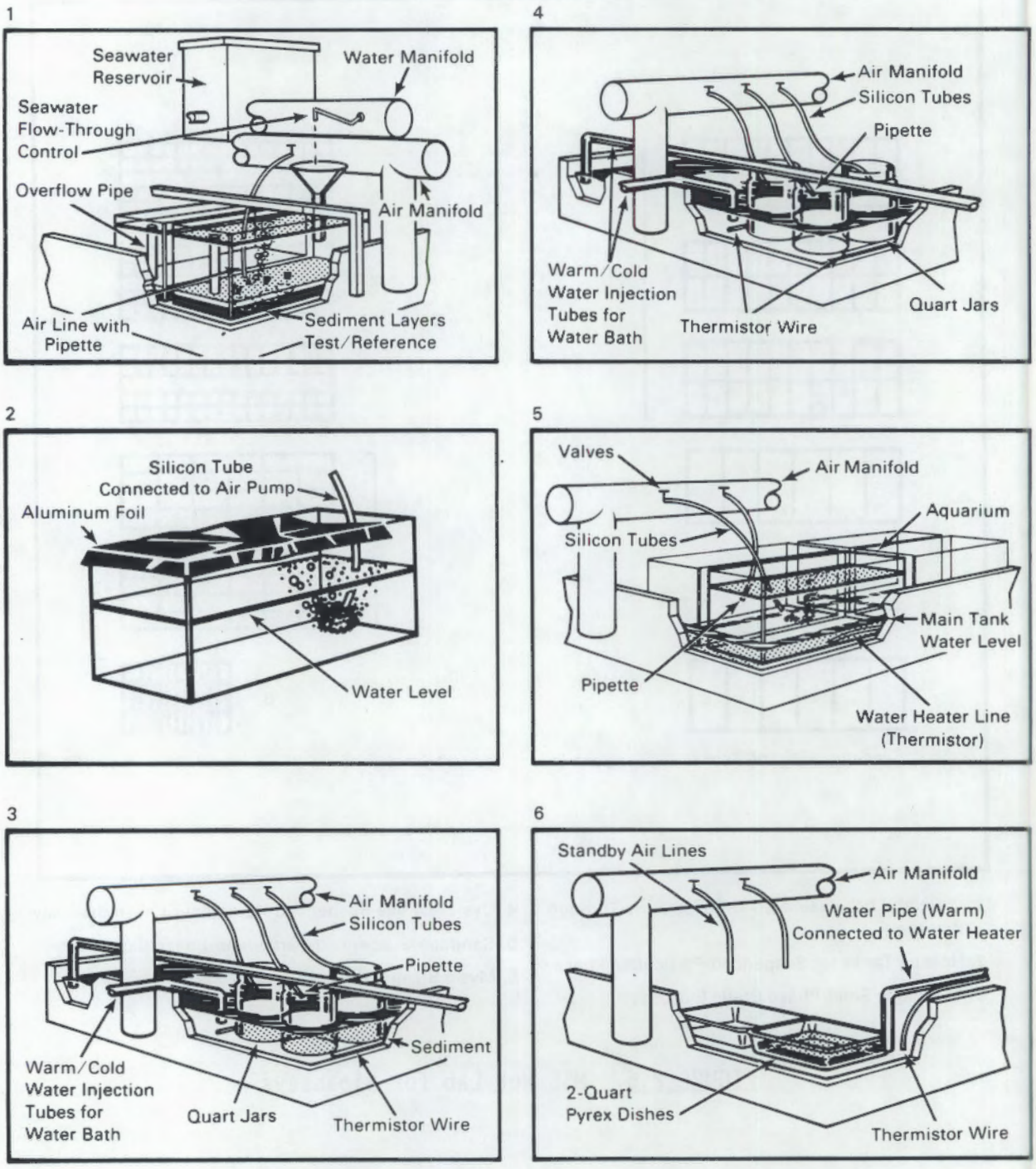


FIGURE 2.7. Bioassay Test Equipment (Numbers 1-6 above refer to the wet lab setup shown in Figure 2.6.)

Overall Experimental Design

The experimental design for the SPP tests were devised to fulfill requirements of the Federal Register (1977) and the implementation manual (EPA/USACE 1977). Guidelines for specific experimental procedures recommended in the implementation manual were followed wherever possible. Appropriate literature and/or protocols are also found in EPA (1976, 1978), APHA (1985), and ASTM (1980a and b).

The overall experimental design for the three SPP tests is summarized in Section 2.1, Table 2.2. As shown, six SPP preparations were tested. These preparations represented five dredge-site sediment from the turning basin (SN-2-U, SN-2-L, TD-2-U, TD-2-L, and CH-C) and Sequim Bay reference sediment. Each SPP test consisted of three treatments (100, 50, and 10% concentrations of the SPP) run in triplicate. Filtered Strait of Juan de Fuca water (for the oyster test), or Sequim Bay water samples (0% SPP) also were run as a treatment.

The SPP of each sediment sample was prepared as described in Section 2.3.1 above. Appropriate proportions of SPP and filtered Sequim Bay or Strait of Juan de Fuca water were added to exposure chambers to achieve the desired 100, 50, 10, and 0% concentrations for each of the species tested. Proportions of SPP concentration and sizes of various exposure chambers are summarized in Table 2.4. The test medium was not replaced in any of the exposure chambers throughout the experimental period.

TABLE 2.4. Volumes of SPP Water Added to Sequim Bay Water to Achieve Desired Concentrations For Each of the Three Species Tested

Species	Type of Container	% SPP (L)				Total Volume Per Container (L)
		100	50	10	0	
Speckled sand dab	10-gal aquaria	20	10	2	0	20
Mysid	1.5-qt rectangular Pyrex® dishes	1	0.50	0.1	0	1
Oyster larvae	1-qt Mason jars	0.8	0.4	0.08	0	0.8

Exposure chambers containing the test media were randomly positioned within a water table set up for each of the three test series (one table per species). A summary of the process of randomizing exposure chambers is provided in Section 2.7.

The following three species were tested against each of the six SPP concentrations and Sequim Bay seawater: mysid (A. sculpta) subadults, juvenile speckled sand dabs (C. stigmaeus), and oyster (C. gigas) larvae. These animals fulfilled the requirement to conduct tests with a crustacean or mollusc, a fish, and a planktonic organism, respectively.

All SPP bioassays were conducted under static conditions. Tests with mysids (A. sculpta) and speckled sand dabs (C. stigmaeus) were conducted for 96 h; tests with oyster (C. gigas) larvae were conducted for 48 h. Exposure chambers were aerated wherever necessary; aeration was required for speckled sand dabs and larval oyster, but not for mysids. The mysids (A. sculpta) were fed twice daily throughout the tests with brine shrimp nauplii (A. salina). The sand dabs (C. stigmaeus) and oyster (C. gigas) larvae were not fed.

Water-quality parameters were monitored daily to maintain temperature, salinity, dissolved oxygen (D.O.), and pH within narrow bounds. Temperature was maintained at 15 ± 1°C for mysids and speckled sand dabs and at 20 ± 1°C for oyster larvae. Salinity was maintained at 25 ± 2 °/₀₀ for oyster larvae; salinity was allowed to remain at ambient (approximately 31 °/₀₀) levels for mysids and speckled sand dabs, and was monitored to ensure that levels did not vary by more than ±2 °/₀₀. Dissolved oxygen was monitored to ensure that levels remained above 4 mg/L. The pH was allowed to remain at ambient levels for all species, and was monitored to ensure that levels did not vary by more than ±0.4. Parameters maintained at ambient levels reflected April conditions in Sequim Bay. These ranges of water quality parameters are consistent with allowable protocol variation.

Calibration procedures for the instruments used to measure these parameters are discussed in Appendix D. The thermometer and refractometer are calibrated monthly, and were calibrated again before the study began. Dissolved oxygen and pH meters were calibrated before each use. Calibration records are also presented in Appendix D.

The equipment used to measure and maintain the appropriate water quality parameters is discussed below. Temperature control was established using a Thermar (1500-W, 120-V) quick-recovery, water-heating system integrated to a Model 71A Thermistemp temperature controller. Temperature was recorded with ErTco thermometers, calibrated against an ErTco L-68397 laboratory standard thermometer at 20°C. The pH was measured with an Orion Research Model 701-A pH meter, calibrated against RICCA Chemical Co. buffer solutions of pH 4 and 7, and High Purity Chemical/Your Chemical source buffer solution of pH 10. Salinity was measured with an American Optical Corporation refractometer, calibrated against an International Association of Physical Oceanographers (IAPO) Standard Seawater Sample P46 (which has a salinity of 35.0 °/₀₀ and chlorinity of 19.38 °/₀₀). Dissolved oxygen was measured with a YSI dissolved-oxygen probe.

To ensure reliability of test results, all organisms were handled with care. Specific acclimation procedures and precautions for minimizing stress during collection, shipment, holding, and transferring of animals are discussed under individual tests. These procedures were based on guidelines provided in the implementation manual (EPA/USACE 1977) and other established protocols, including APHA (1985), ASTM (1980a and b), and EPA (1976).

Bioassay Protocols

Mysid (A. sculpta) Collection and Handling. Subadult mysids (A. sculpta) were collected near the water surface in Monterey Bay, California, over a water depth of 65 ft using a fine-mesh dip net. Approximately 2,000 mysids were shipped to MSL in collection water. Temperature of the collection water upon arrival was 14°C; salinity was 33 °/₀₀; D.O. was >19.9 mg/L; and pH was 7.14. A laboratory air line added to the shipping container reduced the oxygen to ambient levels, at which time the organisms were transferred to an 80-L fiberglass holding tank, and Sequim Bay filtered seawater was slowly added. Animals were maintained until testing in an 80-L tank with flow rate at 250 mL/min. Water quality of the holding tank included a temperature of 15°C; salinity of 31.0 °/₀₀; pH of 7.82; and D.O. of 8.0 mg/L. Animals were fed brine shrimp nauplii (Artemia salina), age 24-h, 100 to 150 mL of dense culture twice daily. The mortality of mysids during the 48-h holding/

acclimation period was less than 3%, and the animals appeared to be in excellent condition.

Mysid (A. sculpta) Test Preparation and Conduct. Testing was initiated immediately after the SPP was prepared and 0-h water quality measurements were completed. Mysids (A. sculpta) (10 animals per exposure chamber) were randomly dipped from the holding tank and transferred in petri dishes containing seawater to 57 exposure chambers. All exposure chambers containing test media were randomly positioned within a water table for the duration of the test.

Biological observations were made at 0, 4, 8, 24, 48, 72, and 96 h in each chamber. Mortality was considered the biological endpoint for this species. The number of live and dead organisms was recorded at each observation period. Death was considered lack of movement in response to touching the animal lightly with a clean probe, or to swirling the test dish gently to determine movement. Dead animals, molted exoskeletons, or excess food were removed at each observation period.

Temperature, salinity, dissolved oxygen, and pH were recorded daily at the same time (0, 24, 48, 72, and 96 h) in each test container. In addition, dissolved oxygen was recorded at 4 and 8 h in each chamber (see Appendix E).

Speckled Sand Dab (C. stigmaeus) Collection and Handling. Juvenile speckled sand dabs (C. stigmaeus) were collected near the mouth of Tomales Bay, California, in 12 to 15 ft of water using a small trawl with 1/4-in. mesh net. Approximately 650 fish were shipped to MSL and held 5 days for acclimation before use. Temperature and salinity of the collection water upon arrival were 14.0°C and 33 °/.., respectively; the dissolved oxygen was 19.9 mg/L; and pH was 6.86. Sequim Bay filtered water was added gradually over several hours and a temperature of 14.5°C maintained until test use. Fish were maintained in a flow-through fiberglass tank containing clean beach sand, and with an air supply. Speckled sand dabs were fed freeze-dried plankton and live Artemia nauplii several times daily. Feeding terminated 24 h before the test started.

Speckled Sand Dab (C. stigmaeus) Test Preparation and Conduct. After 2 days of SPP preparation, 54 test tanks (10-gal aquaria) were filled with

20 L of treatment water from 6 stations. In addition, 3 replicates of filtered Sequim Bay seawater were tested. Concentrations of SPP water were tested at 100, 50, 10, and 0%. Sequim Bay filtered seawater was used as dilution water in all tests. Aeration was provided in all tanks; however, fish were not fed during the test.

The day following SPP preparation, 10 speckled sand dabs were randomly selected from the holding tank and transferred with a fine-mesh dip net to each of the test tanks. The test was initiated immediately after transfer of the fish. Observations were made at 0, 4, 8, 24, 48, 72, and 96 h. The number of live fish was counted in each tank and numbers of fish swimming and resting in each tank also noted. Resting fish were touched gently with a probe to determine any movement before number of dead was counted. Dead animals were removed and examined at each observation period.

Temperature, salinity, dissolved oxygen, and pH measurements were recorded daily. All exposure tanks were examined at 0 and 96 h. One replicate of each exposure was examined at 24, 48, and 72 h. In addition, tanks with high mortalities received a complete water quality check.

All dead fish were removed and preserved in Davidson's fixative for histological analysis. At the termination of the bioassay, live fish from each of the SPP treatments were also preserved for histology. Fish were saved from each station's 100% SPP treatment, including Sequim Bay reference and the treatment. Fish were also preserved from the 10 and 50% concentrations of Sequim Bay reference and Sediment Treatment SN-2-L. All other fish were fixed in formalin. Histological samples are archived for potential analysis at a future date.

Total suspended solids were determined gravimetrically in water samples taken from the exposure tanks at the end of the exposure. All 100% treatments and the Sequim Bay seawater were analyzed. A 300-mL water sample was filtered under vacuum through a preweighed, 0.4-μm pore size, polycarbonate membrane filter. The inside of the filter was rinsed with distilled water and the filter vacuumed to dryness. The filter was dried at 50°C and weighed. Total

suspended solids were calculated after salt correction by dividing the dry weight by the volume filtered and reported as milligrams of dry weight per liter.

Oyster (C. gigas) Larvae Collection and Handling. Five-dozen oysters (C. gigas) obtained from a commercial oyster grower located in Quilcene, Washington, had been conditioned in 20°C seawater with a salinity of 26 °/.. for approximately 5 weeks. They were fed a special mixture of algae during this time to provide nutrition and hasten sexual maturity. The oysters were transported to MSL and placed in clean 10-gal, all-glass aquaria at a density of six animals per aquarium. Holding water was adjusted to 26 °/.. salinity and maintained at 20°C. Aeration was provided. Because the oysters for this experiment were held less than 1 week, they were not fed.

Actual test organisms in this bioassay were fertilized eggs (1 h) allowed to develop for 48 h. The procedure used to spawn the oysters and deliver known densities to individual test containers is described below.

Oyster (C. gigas) Test Preparation and Conduct. Fifty-eight test containers (1-qt Mason jars) were filled with 800 mL of SPP concentration at 100, 50, 10, or 0% concentrations. Strait of Juan de Fuca water diluted to 26 °/.. was used as dilution water for 10 and 50% treatments and as 0% concentration (reference water). Aeration was provided to all test jars, and a circulating water bath maintained the test system at 20 ± 1°C for the duration of the test.

The SPP was prepared using the procedure described in Section 2.3.1 except that SPP concentration was prepared using reference seawater (31.0 °/..) diluted with deionized water to a salinity of 26 °/... Temperature, salinity, D.O., and pH were recorded in all test containers initially and at 96-h termination. Water quality parameters were recorded at 24, 48, and 72 h from one replicate of each station treatment and exposure.

Testing was initiated on the same day the SPP was prepared and immediately following initial water quality observations. Initial preparation involved spawning conditioned oysters and determining larval stock densities, then inoculating each test container with the appropriate density.

Oyster (C. gigas) larvae used for the bioassay were spawned by a technique commonly called "strip spawning" (Dupuy et al. 1977). Using this technique, the oyster is opened by cutting the adductor muscles, and the mantle and gonad are sliced open with a series of shallow cuts, using a clean scalpel. The contents of the gonad are washed into a clean Pyrex® baking dish with a squeeze bottle of 26 °/₀₀ seawater, and the gametes are examined under a compound microscope to determine sex and state of development. Normal-appearing, pear-shaped eggs and motile viable sperm were saved and mixed in a 1.5-L Pyrex® beaker containing 1.2 L of 26 °/₀₀ seawater. They were incubated for 1 h at 20°C, aerated, and frequently stirred with a perforated plunger. After 1 h, fertilization success and egg density in the stock was determined by volumetric dilution and microscopic examination.

Each test jar was inoculated with approximately 30,500 fertilized eggs by adding 5 mL of this stock. The initial fertilized egg density in the 800-mL total volume of liquid in each test jar was estimated to be 38/mL. The egg density was determined by the following method. The fertilized egg stock was homogenized with a perforated plunger. A 1-mL aliquot was removed and placed in a 100-mL volumetric flask. The aliquot was diluted to a volume of 100 mL with a 5% formalin/seawater solution. This procedure was repeated twice, resulting in triplicate 10^{-2} substocks of the original oyster stock. Larval density was estimated by removing 1 mL of this substock, placing it in a Sedgewick-Rafter counting cell, and counting the number of fertilized and unfertilized eggs present under a microscope at 100x magnification. This counting was repeated twice for each 10^{-2} substock for a total of six observations. The density of fertilized eggs per milliliter of oyster stock was determined from these observations to be 6,100.

To check actual fertilized egg density, selected reference jars were subsampled 1 h after fertilization, and the number of fertilized eggs counted on a Sedgewick-Rafter cell. A homogeneous egg density was produced in each container before subsampling by slowly moving a perforation plunger up and down through the water column. This action evenly distributed the fertilized eggs/larvae throughout the container, allowing a representative subsample to be obtained. Immediately after this process, three, 10-mL samples were drawn from the test container with a calibrated 10-mL Eppendorf pipette and placed

in a labeled 50-mL plastic centrifuge tube containing 10 mL of 20% formalin. This resulted in a total liquid volume of 40 mL in each centrifuge tube: 30-mL test water and 10 mL formalin. Final formalin concentration was 5%. Examination of these samples yielded an observed fertilized egg density of 31 eggs/mL test water at the 1-h period, or 24,800 eggs exposed in each container.

At 48 h a 30-mL subsample was obtained from each test jar using procedures identical to those described for the 1-h subsampling. After collection and preservation, each sample was centrifuged for 10 min at 1750 rpm (740 g) to consolidate the larvae at the bottom of the centrifuge tube. Two milliliters of liquid/larvae were pipetted from the bottom of each tube. As a check of percent recovery, subsamples were also obtained from various levels within the centrifuge tube, from near surface to near bottom. No larvae were found in any of these subsamples. A second centrifugation after the first 2-mL subsample was removed again produced no larvae. The 2-mL subsamples collected near the centrifuge tube bottom were transferred to a Sedgewick-Rafter counting cell and examined under a compound microscope at 100x magnification.

Samples were scored for the appearance of normal D-shaped larvae, abnormally developed larvae, blastula-stage larvae, and total number larvae (in the 30-mL subsample). The following descriptions (Figure 2.8) explain the four categories used for quantification and data analysis.

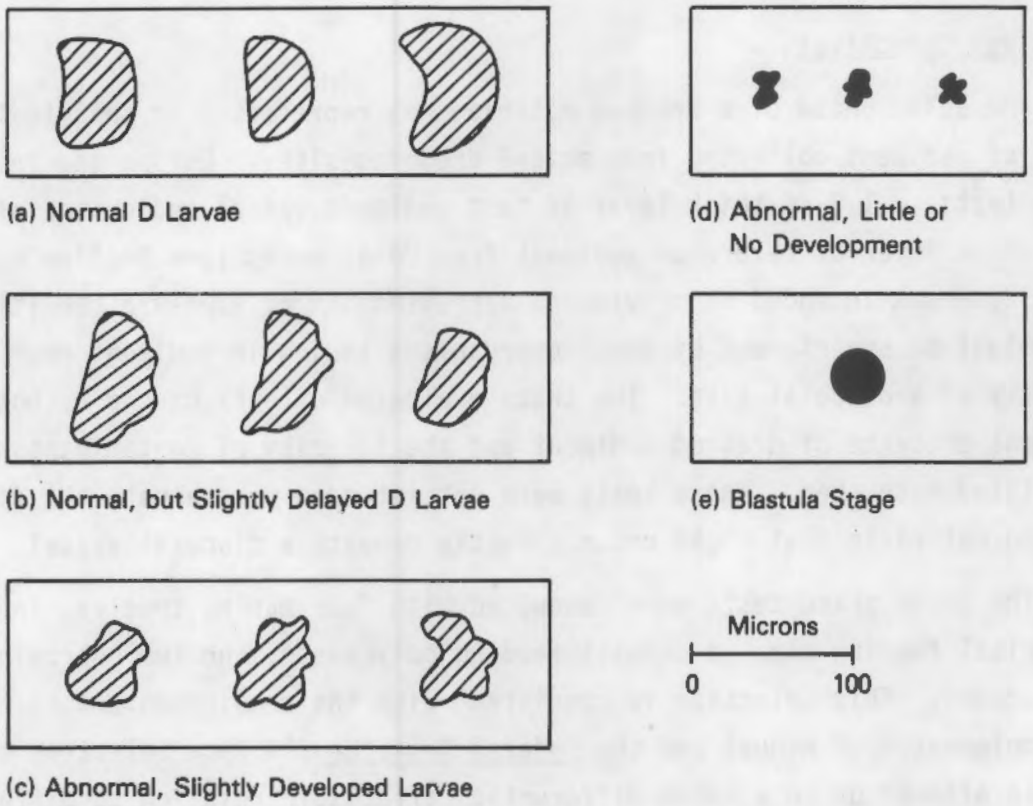


FIGURE 2.8. Terminology for Characteristic Shapes of Oyster Larvae

- Normal D-shaped larvae - Characterized by the presence of a straight or arched hinge. Larvae are relatively large and well developed.
- Normal, but slightly delayed D-shaped larvae - Exhibit a straight hinge, but do not have a well-developed, smooth shell.
- Abnormally developed larvae - Round, oblong, or irregularly shaped with no evidence of straight hinge formation, or small, crenulated masses that are approximately 1/3 the size of a normal D-shaped larvae.
- Blastula stage - Round spheres, approximately 1/2 to 2/3 the size of a normal D-shaped larvae.

2.5.2 Solid Phase Tests

Test Objectives

The solid phase of a dredged material was represented in this test by a layer of sediment collected from actual dredging sites. During the solid phase tests, a 1.5-cm-thick layer of test sediment was placed on top of a 3-cm-thick layer of reference sediment from Point Reyes (see Section 2.3.3). This layer was intended to provide an approximation of exposure conditions that might be experienced by benthic organisms living in sediment near the boundary of a disposal site. The tests evaluated effects caused by both the physical presence of dredged sediment and the toxicity of contaminants associated with them. These tests were not intended to evaluate the impact of dredged materials that might occur directly beneath a disposal vessel.

The solid phase tests were conducted with four marine species, including a detrital feeding clam, a deposit feeding polychaete, and two burrowing crustaceans. This selection is consistent with the requirements outlined in the implementation manual and the Federal Register (1977). Selection of these animals allowed us to examine differential effects in relation to differences in feeding and life habits.

Overall Experimental Design

This experimental design was devised to fulfill testing requirements of the Federal Register (1977) and the implementation manual (EPA/USACE 1977). Appropriate literature and/or protocols are also be found in EPA (1976, 1978), APHA (1985), and ASTM (1980a and b).

The experimental design for the solid phase tests is summarized in Section 2.1, Table 2.2. Eighteen sediment treatments from Oakland Inner Harbor, Point Reyes, and Sequim Bay were tested. Protocols for preparing these sediment samples for the solid phase tests are specified in Section 2.3.3. Two solid phase bioassays were conducted, a flow-through test and a static test. Both experiments lasted 10 days. The flow-through test, using the bent nose clam (M. nasuta) and the polychaete (N. caecoides) was conducted in individual 38-L aquaria connected to a temperature-regulated, flow-through seawater system. Twenty M. nasuta and 20 N. caecoides occupied each test aquarium.

The static test evaluated the response of two amphipods, G. japonica and R. abronius. Twenty R. abronius and 10 G. japonica shared each test container (1-L jars) during this study. Temperature was regulated by placing the containers in a temperature-controlled freshwater bath. For the flow-through test, three replicate exposure containers were used for each sediment treatment. Five replicate containers per sediment treatment were used for the static test. All test containers were first layered with clean reference sediment from the Point Reyes to a depth of 3 cm. The bent nose clam (M. nasuta) and the polychaete (N. caecoides) were randomly distributed among the aquaria and allowed to burrow into the reference sediment. Forty-eight hours after these animals were added to the containers, the test or reference sediment was deposited on the Point Reyes sediment to a depth of 1.5 cm. The amphipods (G. japonica and R. abronius) were added to the test container after this second deposit was added.

During both tests, water quality parameters were monitored daily. Temperature for both tests was held at 15 ± 1°C; salinity was maintained at Sequim Bay ambient levels for April (approximately 31 ± 1 °/₀₀). Dissolved oxygen was monitored to ensure that at least 4.0 mg/L was present during tests. The static test required aeration; the flow-through test did not. The pH was monitored, but not corrected, as it did not change more than 0.4 during either test.

Bioassay Protocols

Polychaete (N. caecoides) and Bent nose Clam (M. nasuta) Collection and Handling. Polychaetes (N. caecoides) were collected from a Tomales Bay, California, mudflat on March 28, 1988, using a shovel and 1.0-mm sieve. Approximately 2,000 adults were shipped to MSL on March 29, 1988. They arrived in a large waterproof box containing native sediment (fine sand) and water. Water-quality parameters at arrival consisted of a temperature of 11.5°C, D.O. of 19.9 mg/L, and pH of 7.01. The animals were kept in the shipping container approximately 6 h. During this time, the water temperature was gradually raised to 15°C, and MSL seawater was added (1-L/h) to gradually acclimatize the animals to MSL conditions. After the 6-h holding period, the sediment and polychaetes were transferred directly into a large holding

container with a temperature maintained through a regulated flow-through seawater system. The polychaetes were kept in this system until used. Water quality was checked daily.

The bent nose clams (M. nasuta) were collected from three sites on the Olympic Peninsula, Washington, near the MSL facility. About 1,300 clams were collected. The clams were transported immediately to MSL where the temperature was gradually increased from their natural ambient temperature of 12 to 15°C over 3 days. Clams (M. nasuta) were stored in large holding tubs with MSL beach sediment and a temperature-regulated, flow-through seawater system. Water quality was checked daily.

Test Preparation/Conduct

For the flow-through test using polychaetes (N. caecoides) and bent nose clams (M. nasuta), test aquaria were placed randomly on water tables and filled to a depth of 3 cm with sediment from the Point Reyes reference station. This sediment had been wet-sieved through a 1.0-mm-diameter Nytex screen the previous day and allowed to settle overnight. The flow-through system was initiated, and aquaria were allowed to fill to a total volume of approximately 36 L. During this time, the flow-through system was adjusted and calibrated to deliver 125-mL/min seawater flow to each aquaria.

After 4 h, 75% of the water was removed, 20 clams (M. nasuta) and 20 polychaetes (N. caecoides) were added to each aquaria, and a 48-h equilibration period initiated. During this period, water quality checks were made, and test organisms found at this stage were observed for abnormal behavior or mortality. The few dead organisms were removed and replaced. At the end of the 48-h, 75% of the water was removed from each aquarium, and a layer of test sediment 1.5-cm thick was placed on the Point Reyes sediment. The aquaria were allowed to fill again via the flow-through system, and the 10-day test period began. Daily observations included checks on animal behavior and water quality parameters of salinity, temperature, D.O., and pH. Test organisms were not fed during the 10-day bioassay.

At the end of the bioassay, contents of each aquarium were carefully passed through Nytex sieves with 1.0-mm mesh openings, and animals captured were counted and classified as alive or dead. They were then transferred to

either clean 38-L aquaria (M. nasuta) or 4-L Pyrex® baking dishes (N. caecoides). The aquaria and baking dishes were transferred to a water table containing a 15°C water bath, and aerated. The organisms were allowed to depurate for a period of 48 h. Fecal material was removed from each tank twice daily. At the end of the depuration period, the clams from selected sediment treatments were prepared for bioaccumulation analysis, and the polychaetes and remaining clams were frozen and archived.

Amphipod (G. japonica and R. abronius) Collection and Handling. Amphipods (R. abronius) were collected from West Beach, Whidbey Island, Washington, on April, 9, 1988, using an infaunal dredge constructed by MSL personnel. The animals were transported to MSL within 4 h of collection in large tubs containing native sediment (sand) and seawater. At MSL, they were transferred to holding vessels integrated into MSL's flow-through seawater system. The seawater was gradually increased from West Beach's ambient temperature (9°C) to 15°C over a period of 24 h. Water quality was checked daily in holding vessels. Animals were not fed before or during the test.

Amphipods (G. japonica) were collected in Southwest San Pablo Bay, California, in 14 to 18 ft of water using a bottom grab and a towed, weighted plankton net with mesh size of 215 μ. Material collected was sieved through a 0.5-mm mesh screen to collect the amphipods. The animals were shipped to MSL on April 5, 1988, in containers with native sediment. Water-quality parameters on arrival were as follows: temperature at 14.5°C, D.O. at >16.0 mg/L, pH at 7.51, and salinity at 30.5 °/₀₀. The amphipods and native sediment were held in a flow-through fiberglass tank after the water was exchanged for filtered Sequim Bay seawater, and parameters were slowly adjusted. The temperature was held at 15.0 ± 1°C until the amphipods were used.

Test Preparation/Conduct

For the amphipod (G. japonica and R. abronius) static test, 100, 1-L test containers were randomly arranged on a water table containing 15°C freshwater. Each container was layered with 3 cm (150 mL) of 0.5-mm sieved sediment from the Point Reyes reference station, then slowly filled to the 800-mL mark with filtered Sequim Bay seawater. The containers were allowed to equilibrate for 72 h at 15°C. At the end of this period, the test sediment was carefully

added to each container to a depth of 1.5 cm (75 mL), aeration supplied, and containers allowed to settle overnight. The following day, 75% of the overlying water was siphoned from each container, and slowly replaced with filtered Sequim Bay seawater to a volume of 800 mL. The amphipods (R. abronius and G. japonica) were carefully removed from the holding tanks, counted, and allocated to each exposure jar, again in random order. A total of 20 R. abronius and 10 G. japonica were placed in each jar. Daily animal observations included the number of R. abronius and G. japonica present on the sediment and water surface, and the number of dead individuals observed. For this test, death was defined as a lack of pleopod movement after stimulation with a glass probe. Dead animals were enumerated and removed without replacement. Test organisms were not fed during the bioassay. Water quality checks were performed daily, and included measurements of temperature, salinity, pH, and D.O. All containers were checked once at the beginning and once at the end of the bioassay. One replicate of each exposure and concentration was checked on all other days.

At the end of the 10-day bioassay, the contents of each exposure jar were carefully washed through a 0.5-mm-diameter sieve, and the animals were transferred to clean, labeled glass petri dishes containing 15°C seawater for observation and enumeration. Counts were performed on each dish to determine the number of R. abronius and G. japonica alive and dead at the end of the test, as well as total number recovered.

2.5.3 Bioaccumulation Measurements

At the end of the 10-day bioaccumulation test, living M. nasuta from each aquarium were placed in containers of clean seawater and allowed to depurate for 2 days. At the end of the 2-day period, clams were not producing additional fecal material; therefore, the contaminants bound to food and contained in the gut were assumed to have been excreted. Thus, the remaining contaminants were assumed to be those contained within and bioaccumulated by the tissues. The 2-day period is consistent with implementation manual requirements. At the end of this period, individuals within a replicate were randomly allocated for selected metal, organotins, and PAH analysis. Each individual was removed from its shell by dissection with titanium instruments,

and placed in labeled containers until analysis. Samples for metal and organotin analysis were placed in clean Teflon® jars and analyzed immediately at MSL. Samples for organic analysis were placed in solvent-rinsed glass containers and transported on ice to the analytical laboratory the day of dissection. A summary of analytical procedures used for tissue bioaccumulation analysis follows.

Metals. Tissue samples for metals analysis were first freeze-dried to remove moisture, then pulverized using a ball-mill apparatus. A 0.5-g sample of dried tissue material was weighed into a Teflon bomb, and 3-mL of 4:1 $HNO_3/HCLO_4$ was added. The bombs were placed on a warm hot plate for 2 to 3 h, allowing the nitric acid fumes to vent. The bombs were then placed in an oven at 130°C for 4 h. After cooling, 20-mL of deionized-distilled water was added to each bomb, and the solution weights were recorded. The solution was then transferred to an acid-rinsed 30-mL polybottle until analysis. Lead, mercury, and chromium were measured by atomic absorption spectrophotometry, described in Section 2.4.2.

Organotins. Tissue samples for organotin analysis were prepared by first homogenizing each sample with a Tekmar Tissumizer. Approximately 6-g of the homogenized material was placed in a solvent-rinsed glass jar with a Teflon®-lined cap. Then 50-g of sodium sulfate was added to each jar to dry the sample, and 300-mL methylene chloride was added to extract the organotin compounds. The sample was then sealed and placed on a sample roller and rolled overnight. After rolling, the sample was filtered through glass wool to remove solids, concentrated via evaporation, and the methylene chloride solvent was exchanged for hexane. Grignard reagent was added, and the sample was allowed to sit for approximately 30 minutes. The Grignard reagent was neutralized with concentrated hydrochloric acid. The organic layer was removed, run through a column containing 20-g of florisil, and washed with 300-mL of hexane. This liquid was evaporated to a volume of 1-mL, and injected into the Hewlett-Packard HP 5890 GC-MS. Procedures followed from this point were identical to those described for the sediment analysis.

Total Polynuclear Aromatic Hydrocarbons. Methods used for analysis of total PAHs were similar to those used for sediment analysis, with the following exceptions:

- tissue sample weight was increased to 50 g (wet wt)
- 1/10 of the effluent was run through alumina, concentrated to 1 mL, and run on the GC-ECD
- 9/10 of the effluent was concentrated to 0.9 mL for GC-MS analysis
- acid base neutrals were measured by GC-FID in two samples and GCMs in one.

2.6 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality assurance (QA)/quality control (QC) procedures followed for these studies were consistent with the implementation manual (EPA/USACE 1977) and the EPA protocols (PSEP 1986). The procedures followed were presented by Pacific Northwest Laboratory's (PNL) Quality Engineering Division as a QA Plan, Number EES-20, Revision 1. A member of PNL's quality engineering staff was present throughout these studies to ensure that accepted procedures were followed. The PNL Laboratory Record Books (LRBs) were used for all phases of this project. These LRBs were assigned to each portion of the study and served as records of day-to-day activities during the research. All entries in the LRBs were signed, dated, and reviewed by both the project manager, Jack Q. Word, and the quality assurance engineer, Rob Cuello. The following discussion summarizes QA/QC procedures followed for the three main portions of this study: sediment sampling, biological testing, and chemical testing. All QA/QC evaluations are contained in Appendix C.

2.6.1 Sediment Sampling, Storage, and Tracking

All sediment collected for these studies was stored in glass or cellulose acetate butyrate (CAB) containers before use. Sediment was stored at 4°C and never frozen. Tracking forms were developed and unique labels attached to each sample. A summary of field collection information is presented in Appendix A; sediment compositing information is included in Appendix B. These

procedures were consistent with Appendices B and D of the implementation manual and follow accepted EPA protocols (PSEP 1986).

2.6.2 Biological Testing

Care and Handling of Test Organisms

Test organisms were handled carefully during collection and transfer to test containers. Organisms shipped to MSL were gradually equilibrated to ambient surroundings, and kept in their native sediment whenever possible. Animals were fed, if required, before and during biological testing. Organisms were transferred to test containers by either pipetting, netting, or quantitative transfer. Animals were not touched by hand, or exposed to air during transfer. A short summary of collection and handling of each test species is included in Section 2.5.

Species Selection and Identification

Selection of species was consistent with the implementation manual (Appendix F.1) and included the use of juvenile forms, burrowing invertebrates, deposit feeding organisms, and a larval (planktonic) form. Representatives of all test organisms were taxonomically identified by qualified experts at MSL before use in bioassays.

Water Quality Checks

During all bioassay tests, water quality checks were performed to ensure that acceptable experimental conditions were maintained. These conditions included a stable temperature (±2.0°C), a lower dissolved oxygen limit, 4.0 mg/L, and 14 h of light per day. Salinity was allowed to vary ±2.0 °/₀₀, and pH was allowed to vary ±0.4 units within each container during the bioassay period. These limits and values are consistent with those outlined in the implementation manual. Actual water quality data for each biological test are presented in Appendices E through I. Water quality instruments were calibrated according to the manufacturer's specifications, or accepted Pacific Northwest Laboratory protocols. Information concerning equipment and calibration procedures are included in Appendix D.

2.6.3 Chemical Testing

Chemical testing protocols required by QA/QC and listed in PNL-MA-70 include the following:

- analysis of a reagent blank
- duplicate analysis on at least 10% of samples
- 20% of the samples be spiked (when possible) with an appropriate standard to address accuracy
- printouts from AA and GC analysis kept on file.

All these protocols were followed during this study, and are summarized below.

Measurements of Precision

Measurements of precision were obtained through duplicate analysis of selected sediment treatments (EPA 1988). Analysis of duplicates shows how precise or repeatable a result is. The QA/QC of duplicates included the use of the industrial statistic "I" and relative percent difference (RPD) measures. The "I" statistic is defined as the absolute value of the difference between duplicate measurements, divided by the sum of the duplicates. The RPD is defined as the absolute value of the difference between two duplicate measurements, divided by the mean of the duplicates, multiplied by 100. Both elucidate the precision of duplicate measurements. Sediment Treatments 2-1 and CH-1 were analyzed in duplicate for metals, organotins, TOC, oil and grease, cyanide and sulfides. The results, including the "I" statistic and RPD, are presented in (Tables C.1 and C.2). Values for pesticides, PCBs and polynuclear aromatic hydrocarbons, and Sediment Treatments 1-3 and 2-1 were analyzed in duplicate. The results of these duplicates are presented in (Tables C.3 and C.4).

Measurements of Accuracy

Measurements of accuracy are derived by using standard reference materials (SRM). For metals, SRMs included PACS-1, MESS, and 1646 (Table C.5). The organotin analysis was checked for accuracy against Moss Landing reference material and SQ-1 reference material (Table C.6). The PAH analytical accuracy was checked against SRM SQ-1 (Table C.7), and pesticides and PCBs were checked

against SRM SQI and also samples of Endosulfan II and Aroclor-1254 (Table C.8). Standard reference materials were not available for measurements of total sulfide, dissolved sulfide, total organic carbon, cyanide, oil and grease, petroleum hydrocarbons, or grain size (Table C.9).

Spikes and Recoveries

Percent of surrogate sample recoveries were calculated for eight sediment treatments and are reported for base/neutrals, acids, pesticides, and organotins in Table C.10. The recovery of chemical spikes is reported in Table C.11 (Metals), Table C.12 (Organotins), Table C.13 (PAHs), Table C.14 (Pesticides and PCBs), and in Table C.15 (total sulfide, dissolved sulfide, and cyanide). At least three sediment treatments were spiked and recovered for QA/QC purposes, consistent with the implementation manual.

Equipment Printouts and Data

All MSL analytical equipment printouts are filed for future reference. Procedures and related data were written into the appropriate laboratory record book. Offsite analysis (ARI/AmTest) original printouts are stored with the analytical equipment, but are available for inspection. Samples were tracked and tied to a particular device at all testing laboratories through chain of custody procedures.

2.7 STATISTICAL DESIGN, DATA ANALYSIS, AND INTERPRETATION

2.7.1 Statistical Methods

The purpose of the statistical analyses was to determine the statistical significance and magnitude of the toxicity of each sediment treatment from Oakland Inner Harbor and the turning basin and compare them with reference sediment from Point Reyes and Sequim Bay. The toxicity was ranked based either on the survival detected after 4-day exposure to varying percentages of SPP water, or 10-day exposure to sediment. In addition, the possible causes of the toxicity were examined by jointly analyzing the chemical composition of each station and the resultant toxicity ranking.

Randomization

Both the solid phase and SPP bioassays were conducted as completely random designs. Organisms were randomly allocated to treatments, and treatments were randomly allocated to positions within the water tables. Separate random number tables were generated for each of the bioassays for this purpose, using the discrete uniform random number generator available in STATGRAPHICS. For the SPP bioassays, mysids and oyster larvae were randomly allocated to SPP containers within a concentration. Because fish are highly mobile, and potential selection may occur as a result of different recapture times (because the more easily caught fish will occur earlier), we performed additional randomization based on each individual. Therefore, the speckled sand dabs were allocated randomly among all SPP containers rather than among containers with an SPP concentration. For the solid phase bioassays, organisms were randomly allocated to all treatments.

Suspended Particulate Phase Bioassays

For each concentration in the SPP bioassay, if the 96-h survival in the Sequim Bay reference water was higher than in the 100% SPP concentration, a one-sided t-test between the 96-h Sequim Bay reference water and 100% test SPP concentration was conducted, according to guidelines presented in the implementation manual (EPA/USACE 1977). Comparisons were made on angular-transformed data (arc sine, expressed in radians, of the square root of the proportion surviving) at 2 (n-1) degrees of freedom (if variances were homogeneous) or at degrees of freedom (d.f.) calculated by the following formula (if variances were not homogeneous):

$$d.f. = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} \right)}{\left[\frac{s_1^4}{n_1^2 (n_1-1)} + \frac{s_2^4}{n_2^2 (n_2-1)} \right]}$$

These tests were also performed on STATGRAPHICS. If significant differences existed, and at least 50% mortality occurred, the LC50 was calculated using either the method of Litchfield and Wilcoxon or the Spearman-Karber estimator (Finney 1971), as appropriate. The Spearman-Karber estimator is only appropriate if 100% mortality occurs at the greatest percent suspended particulate; the Litchfield and Wilcoxon method has no such restriction.

An alternative analysis was conducted for the SPP bioassay that combined the information from each concentration and, thus, protected against the compounding errors that result from conducting multiple t-tests. For this analysis, a two-way factorial ANOVA was conducted using the balanced data from each of the SPP concentrations. The two factors included the sediment treatment location and the percent of suspended particulate. To stabilize the within-class variances this analysis was conducted on the arc sine square root of the proportion of survivors using STATGRAPHICS.

The confidence intervals for the factorial analyses were generated by the same method as presented in the excerpts from Zar (1974). However, in this case, the estimate of the standard error of the mean is the square root of the quantity residual mean square from the ANOVA divided by the number of replicates. Further the t-value has the d.f. equal to the residual error's d.f. Thus, the confidence intervals are all the same width. If we had created confidence intervals for each mean independent of all other data, then the widths all would be different. However, these intervals would not reflect the hypotheses that are being tested by the ANOVA and would not be useful for evaluating the interaction between the sediment treatments and percent suspended particulate.

Solid Phase Bioassays

For the solid phase bioassays, sediment was compared by analysis of variance (ANOVA) tests on the arc sine square root of the proportion surviving to the tenth day. The transformation of arc sine square root was used to stabilize the within-class variances to meet the assumptions of the ANOVA. If the survival for at least one of the samples was significantly different, the samples were compared using the conservative Tukey's Honestly Significant Difference (HSD) test for all possible comparisons (Steel and Torrie 1980),

which uses an experiment-wide error rate. Tukey's HSD provides more information about how each sediment treatment compares with every other one, as opposed to comparisons with only a control as in Dunnet's test. So, by providing comparisons between Sequim Bay and Point Reyes sediment treatments, both can reasonably be viewed as controls. Thus, the type I error for the combined conclusions could be established at $\alpha = 0.05$. The ANOVAs were performed on survival data for individual species and for combined species (as recommended by the implementation manual).

3.0 RESULTS AND DISCUSSION

3.1 SUSPENDED PARTICULATE PHASE TESTS

3.1.1 Mysids (A. sculpta)

The results of SPP tests performed on subadult mysids (A. sculpta) indicate that all sediment treatments except TD-2-U produced significant mortality in comparison with Point Reyes and Sequim Bay reference sediment over the 96-h test period. However, as shown in Table 3.1, mortality did not reach 50% for any of the six sediment treatments tested (mortality ranged from 16.7 to 33.3%). Therefore, it was not possible to calculate LC50s or limiting permissible concentrations (LPCs) for any of these sediment treatments. (According to the implementation manual, LPCs for SPP are calculated as 0.01 of the lower 95% confidence limit of the LC50 value.) The percent mortality to organisms in the five 100% SPP concentrations from Oakland Inner Harbor, although significantly different from Sequim Bay water in most cases, was similar to the mortality level observed for Sequim Bay reference sediment. Thus, based solely on the results of these mysid toxicity tests, it appears that the 100% SPP concentrations of Sediment Treatments TD-2-U, TD-2-L, SN-2-U, SN-2-L, and CH-C would not cause significant adverse ecological effects in the water column. This conclusion confirms results of a previous related study (MBL 1987), which showed no significant mortality of mysids (A. sculpta) after 96-h exposure to SPP from any of the Oakland Inner Harbor sediment tested. These results are summarized in Appendix F. Survival data recorded in each replicate test chamber and on all required observation periods are presented in Table F.1. Water-quality data for these tests are presented in Table F.2.

All water-quality parameters remained within the acceptable ranges identified in Section 2.5.1. As shown in Table F.2, temperature ranged from 14.5 to 16°C, remaining within the required range of 15 ± 1°C; salinity ranged from ambient levels of 30.5 to 32 °/₀₀, remaining within the required range of ±2 °/₀₀; pH ranged from ambient values of 7.38 to 8.07, remaining within the required range of ±0.4; and dissolved oxygen (DO) ranged from 4.2 to 8.2 mg/L, always remaining above the lower acceptable limit of 4.0 mg/L. Dissolved

oxygen showed trends of decreasing levels with time (regardless of dose) and, during the first 8 h, decreasing levels with increasing % SPP for the earlier observation periods.

The potential toxicity of the SPP is compared by evaluating survival in replicate samples of the 100% SPP concentration. This is accomplished through Student t-test comparisons on each possible pair-wise combination of Sequim Bay water and the 100% SPP concentrations prepared from six sediment treatments (Table 3.1). The data shown in the table were transformed to the arc sine (expressed in radians) of the square root of the proportion surviving to reduce heterogeneity of within-class variances. The 100% SPP concentration variances of survival were nonhomogeneous (even after the data transformations) because of the complete absence of variance among reference replicates.

TABLE 3.1. Numbers of Mysids (A. sculpta) Surviving After 96-h Exposure in Replicate Samples of 100% SPP and Sequim Bay Water

		Sediment Treatment (100% SPP)					
Replicate	Sequim Bay Water	TD-2-U	TD-2-L	SN-2-U	SN-2-L	CH-C[(a)]	Sequim Bay Reference Sediment
1	10	7	7	7	7	8	8
2	10	8	7	8	7	8	8
3	10	10	6	9	7	8	9
Mean (expressed as % survival)	100	83.3	66.7	80.0	70.0	80.0	83.3
% Reduction relative to Sequim Bay water	--	16.7	33.3	20.0	30.0	20.0	16.7
% Reduction relative to Sequim Bay reference sediment	--	0	16.7	3.3	13.3	3.3	--

(a) An equal mixture of CH-1 and CH-2 sediment.

Therefore, only the approximate t-statistic (T) could be derived, and the degrees of freedom were calculated as presented in Section 2.7. Results of one-tailed, approximate t-tests performed on the transformed data are presented in Table 3.2.

Survival in the 100% SPP concentration was significantly lower ($\alpha = 0.05$) in comparison with reference survival for three of the four sediment treatments for which approximate t-values could be calculated (TD-2-L, SN-2-U, and Sequim Bay reference sediment). Survival was reduced by 33.3% for Sediment Treatment TD-2-L, by 20% for SN-2-U, and by 16.7% for the Sequim Bay reference sediment. Although survival in the 100% SPP concentration from Sediment Treatments SN-2-L and CH-C was reduced, compared with the Sequim Bay water (by 30 and 20%, respectively), statistical comparison of the differences by Student T-tests was not possible because variances for the Sequim Bay

TABLE 3.2. One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Sequim Bay Water Using the Arc Sine (expressed in radians) Square Root of the Proportion of Mysids Surviving a 96-h Exposure

Sequim Bay Water/ 100% SPP Comparison	Sample Mean	SD	Mean Difference	d.f.	T-Value	Approximate Probability	95% CI About Mean Difference
Sequim Bay water	1.5708	0	--	--	--	--	--
Sequim Bay water/TD-2-U	1.2230	0.31	0.3478	2	1.96	0.094	-0.4-1.11
Sequim Bay water/TD-2-L	0.9560	0.06	0.06	2	17.55*(a)	0.0016	0.46-0.77
Sequim Bay water/SN-2-U	1.1160	0.13	0.4548	2	6.10*	0.013	0.13-0.78
Sequim Bay water/SN-2-L	0.9910	0	0.5798	0	NC(b)	NC	NC
Sequim Bay water/CH-C(c)	1.1070	0	0.4638	0	NC	NC	NC
Sequim Bay water/Sequim Bay reference sediment	1.1540	0.08	0.4168	2	8.80*	0.0063	0.21-0.62

(a) Denotes significance at the 95% confidence interval.
(b) Approximate t-value was not possible to calculate because variances of both sediment treatments in the comparison were zero. Mean survival, therefore, is assumed to be different at an alpha value that approaches 0.
(c) An equal mixture of CH-1 and CH-2 sediment.

reference and the 100% SPP concentrations were zero. Because of this absence of within-class variance, it is assumed that the observed mean differences for these latter two comparisons are significant at an alpha value that approaches zero. Survival in Sediment Treatment TD-2-U was reduced to 83.3%, which was equivalent to the percent reduction observed for Sequim Bay reference sediment. However, the approximate t-value for the Sequim Bay water/TD-2-U comparison was not significant at the 95% confidence interval, because of the degree of variance associated with the TD-2-U replicate observations.

A more statistically appropriate way to evaluate these data is to examine differences in survival among the six sediment treatments and as a function of the three SPP concentrations (100, 50, and 10%). A balanced two-way ANOVA was performed on the arc sine transformed data. Sequim Bay water data were not included in this analysis because independent references were not run for each SPP concentration. Examination of the significance of differences among the sediment treatments is facilitated by this factorial approach, because the lack of variability among replicates for two of the sediment treatments is circumvented as a result of using joint within-class variabilities. The results of this analysis are summarized in Table 3.3. These data show that the means for the six sediment treatments averaged over the % SPP concentration are not significantly different ($\alpha = 0.05$), that the interaction of sediment treatment and % SPP concentration is not significant, and that

TABLE 3.3. Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine (expressed in radians) Square Root of the Proportion of Mysids Surviving a 96-h Exposure

Source	d.f.	Sum of Squares	F-Ratio	Conclusion (at $\alpha = 0.05$)
Sediment Treatment	5	0.1046	0.79	NS[(a)]
% SPP (concentration)	2	1.1324	21.39	S
Interaction	10	0.2098	0.79	NS
Residual	36	0.9528	--	--
Total	53	2.3997	--	--

(a) Not significant.

significant differences exist in survival in relation to concentration. Figure 3.1 illustrates these results with plots of mean survival and 95% confidence intervals for each sediment treatment and concentration. These plots indicate that no significant differences in survival ($\alpha = 0.05$) exist among 100% SPP concentrations, and that a trend of decreasing survival with increasing dose occurs (dose-related differences in survival are significant for Sediment Treatments TD-2-L and SN-2-L). Another possible trend indicated by the mysid data is that the lowest level of survival in the 100% SPP concentrations occurred in Sediment Treatments TD-2-L and SN-2-L.

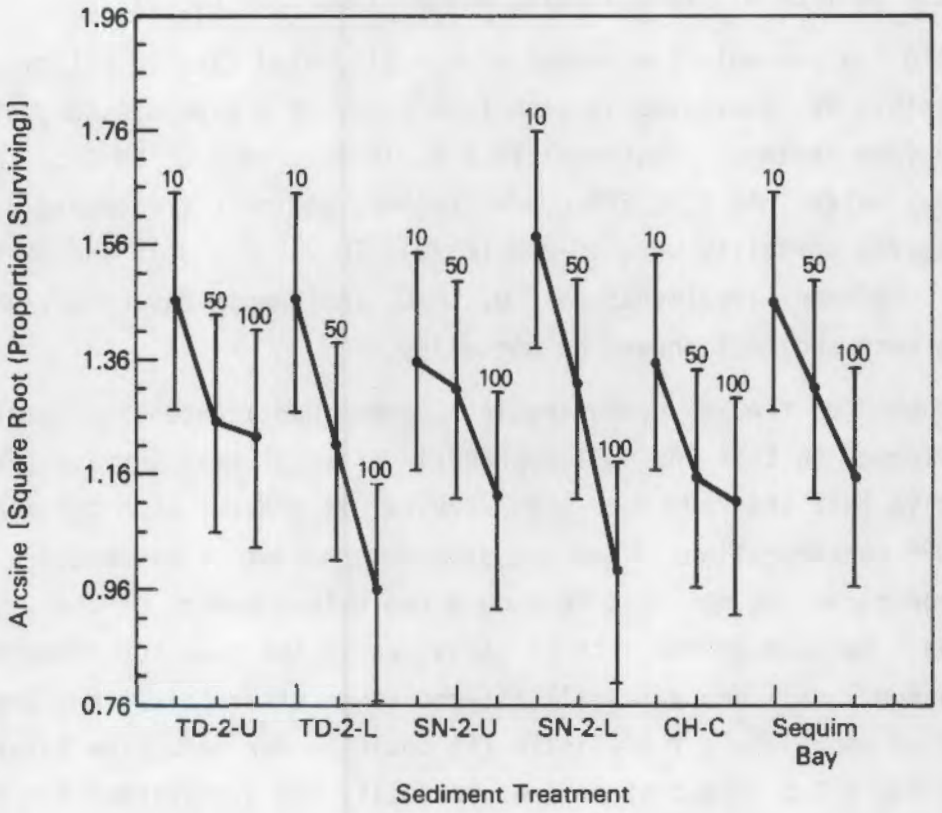


FIGURE 3.1. Mean Survival and 95% Confidence Intervals for 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments. (Mean reference survival was 1.5708, which is also expressed as an arc sine transformation. This value is included for visual comparison).

3.1.2 Speckled Sand Dab (C. stigmaeus)

Bioassay results of the 96-h, 100% SPP concentrations for speckled sand dabs (C. stigmaeus) indicate a statistically significant greater mortality of fish in Sediment Treatment TD-2-L than in the reference sediment (Appendix E). A trend toward greater mortality was indicated in Sediment Treatment SN-2-L that was not statistically significant because of high variability among replicates. No sediment treatment or % SPP concentration had high enough mortality to calculate an LC50. All water-quality parameters remained within the acceptable ranges stated in Section 2.5.1 (Appendix E). Temperature within the exposure tanks ranged from 14.2 to 15.6°C; salinity from 31.0 to 32.0 °/..; DO from 6.3 to 8.1 mg/L; and pH from 7.70 to 8.19.

Table 3.4 presents the number of speckled sand dabs (C. stigmaeus), out of a possible 10, surviving in each tank after 96-h exposure to 100% SPP prepared from Sediment Treatments TD-2-U, TD-2-L, SN-2-U, SN-2-L, CH-C, and Sequim Bay water. At 100% SPP concentration, sediment treatments producing some observed mortality were TD-2-U (6.7%), TD-2-L (23.3%), and SN-2-L (46.7%). Sediment Treatments SN-2-U, CH-C, and Sequim Bay water, and Sequim Bay reference sediment showed no mortality.

For each of the SPP concentrations, one-sided independent sample t-tests were performed to test the null hypothesis of equal mean survival versus the alternative that the reference mean survival is greater than the mean survival of the SPP concentrations. The arc sine square root transformation on the proportion surviving was used to reduce the heterogeneity of the within-class variances. Because of the lack of variation in the seawater reference replicates, unequal variance was still assumed (even after this transformation), and only an approximate t-statistic (T) could be derived. The t-tests presented in Table 3.5 show that percent mortality was significant for Sediment Treatment TD-2-L. They also show that, although percent mortality for Sediment Treatment SN-2-L was twice that of TD-2-L (46.7 vs 23.3%), the t-value for the reference seawater/SN-2-L comparison was not significant at the 95% confidence interval because of a large variance associated with the replicate observations for SN-2-L. Although Sediment Treatment SN-2-L does not show

TABLE 3.4. Numbers of Sand Dabs (C. stigmaeus) Surviving After 10-Day Exposure in Replicate Samples of 100% SPP and Sequim Bay Water

		Sediment Treatment Concentration (100% SPP)					
Replicate	Sequim Bay Water	TD-2-U	TD-2-L	SN-2-U	SN-2-L	CH-C[(a)]	Sequim Bay Reference Sediment
1	10	10	8	10	10	10	10
2	10	10	8	10	4	10	10
3	10	8	7	10	2	10	10
Mean (expressed as % survival)	100	93.7	76.7	100	53.3	100	100
% Reduction relative to Sequim Bay water or Sequim Bay reference sediment	0	6.3	23.3	0	46.7	0	0

(a) An equal mixture of CH-1 and CH-2 sediment.

TABLE 3.5. One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Sequim Bay Water Using the Arc Sine (expressed in radians) Square Root of the Proportion of Sand Dabs Surviving a 96-h Exposure

Seawater Reference vs Sediment Treatment	Mean	SD	T-Value	~Probability	95% CI About Mean Difference
TD-2-U	1.416	0.27	1.00	0.1869	(-0.51, 0.82)
TD-2-L	1.068	0.07	12.99	0.0001	(0.34, 0.67)
SN-2-L	0.906	0.59	1.96	0.0605	(-0.79, 2.12)

statistically significant mortality in relation to Sequim Bay water, SN-2-L and TD-2-L show a trend of greater mortality based on balanced two-way factorial analysis presented in Table 3.6.

The arc sine square root transformation of proportion surviving was used. The analysis shows that the interaction among sediment treatments and concentrations are highly significant (F-ratio 3.34); thus, testing the effects of the sediment and % SPP was not appropriate. Instead, each sediment treatment was examined individually. A plot of the 95% confidence intervals for each sediment treatment/% SPP is shown in Figure 3.2.

The bioassay results would suggest an apparent toxicity to juvenile sand dabs (C. stigmaeus) from 100% SPP prepared from Sediment Treatments SN-2-L and TD-L-2. Further supportive analyses were performed to examine possible causes. The first analysis was a histological examination of the gills in conjunction with a gravimetric analysis of the suspended-silt content present in the SPP concentration to access the potential effect of silt or suspended particles on gill irritations with enhanced mucous secretion and possible asphyxiation. The second was an examination of the livers to determine the presence of any histological changes related to chemical toxicity. It is, however, highly unlikely that 100% SPP would ever be present at a disposal site, especially for a period of hours or days.

TABLE 3.6. Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine (expressed in radians) Square Root of the Proportion of Sand Dabs Surviving a 96-h Exposure

Source	d.f.	Sum of Squares	F-Ratio
Sediment Treatment	5	0.2224	
% SPP (concentration)	2	0.3330	
Interaction	10	1.1611	3.34*(a)
Residual	36	1.2530	
Total (corrected)	53	2.9696	

(a) Statistically significant.

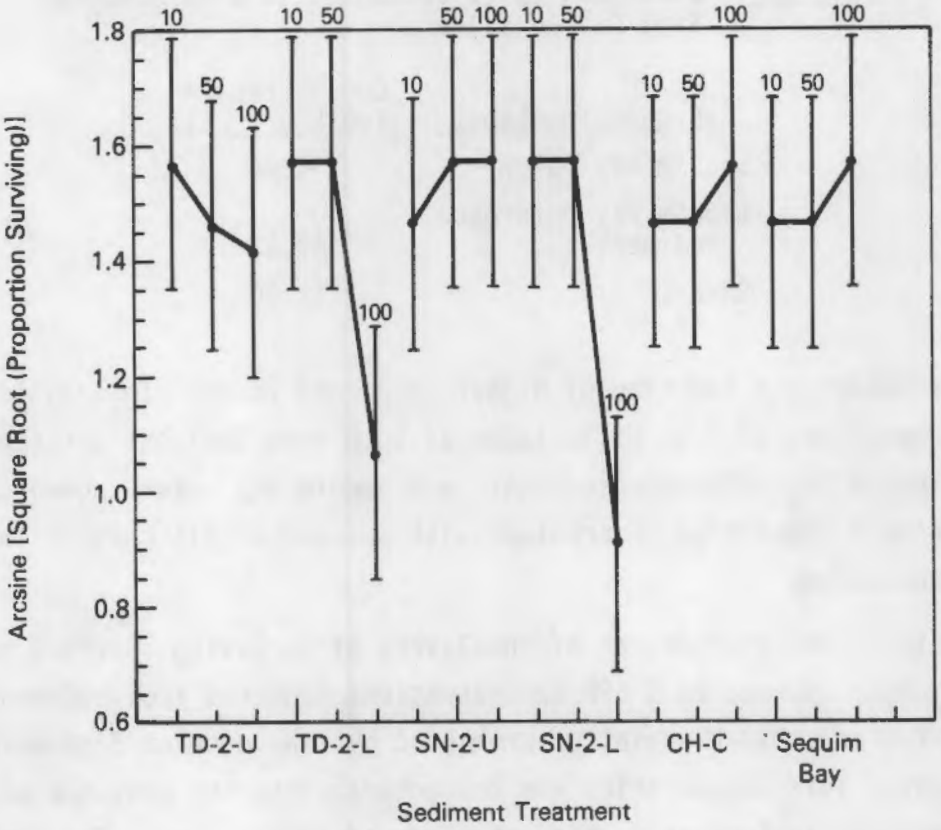


FIGURE 3.2. Mean Survival of Speckled Sand Dabs (C. stigmaeus) and 95% Confidence Intervals for 10, 50, and 100% SPP Concentrations Prepared for Six Sediment Treatments. (Mean reference survival was 1.5708--also expressed as arc sine transformation.)

Visual examination indicated that the 100% SPP concentration prepared from Sequim Bay sediment contained considerably more suspended material than did other tanks. Suspended-solid sample analysis confirmed that this concentration contained much more suspended-solid matter than did the SN-2-L or Sequim Bay reference water. Table 3.7 presents results from an analysis of speckled sand dab (C. stigmaeus) containers that were resuspended after termination of the exposure.

The Sequim Bay SPP contained 5.7 times as much suspended-solid matter as did the SN-2-L SPP concentration, yet mortality for Sequim Bay was 0%, and for SN-2-L was 46.7%. This result indicates that the higher mortality for SN-2-L

TABLE 3.7. Suspended Solid Concentrations in Speckled Sand Dab Containers

Sediment Treatment	Concentration (mg/L dry wt)
Sequim Bay water	1.00
Sequim Bay reference sediment	69.33
SN-2-L	12.00

is not necessarily a function of higher suspended loads. In addition, histologic examinations of fish gills taken at 96 h from Sediment Treatments SN-2-L, Sequim Bay reference sediment, and Sequim Bay water showed no toxicopathic lesions suggestive of problems with suspended-silt content in the 100% SPP concentration.

Histological examination of the livers of surviving speckled sand dabs (C. stigmaeus) exposed to % SPP concentrations prepared from Sediment Treatments SN-2-L and TD-2-L exhibited prominent hyaline droplet degeneration of hepatocytes. This degeneration was characterized by the presence of eosinophilic, hyaline inclusions in the cytoplasm of hepatocytes. The inclusions were large, and usually only one droplet occurred in each hepatocyte. Except for two fish, these inclusions were absent in reference fish taken at time 0 and Sequim Bay reference water fish taken at 96 h. Very few hepatocytes of these two fish contained the hyaline droplets. Prominent hyaline droplet accumulation occurred in several fish from SN-2-L and TD-2-L. A summary of the analysis of fish examined during this analysis follows.

- Seawater reference - time 0 (5 fish) - One of five fish exhibited very rare intensity of hyaline droplet accumulation in hepatocytes; others were normal.
- Seawater reference - 96 h (4 fish) - One of four fish exhibited rare intensity of hyaline droplet accumulation; others were normal.
- SN-2-U, 100% - 96 h (1 fish) - Fish exhibited occasional droplets in the hepatocytes.

- SN-2-L, 100% - 96 h (5 fish) - Two fish exhibited prominent, hyaline droplet accumulation in hepatocytes, and three fish exhibited moderate hyaline droplet accumulation in hepatocytes.
- SN-2-L, 50% - (4 fish) - One fish exhibited occasional hyaline droplets; three remained normal.
- TD-2-U, 100% - 96 h (2 fish) - Both fish remained normal.
- TD-2-L - 96 h (4 fish) - Two fish exhibited prominent hyaline droplet accumulation. Two other fish exhibited occasional droplets in the hepatocytes.

The presence of the hyaline droplets in a few hepatocytes from time 0 reference fish indicates that the droplets may occur occasionally in low numbers in presumably normal livers. However, although other pathological changes were not observed, the prominence of these droplets in hepatocytes in fish from some sediment treatments suggests that they are likely associated with early toxicopathic changes. Similar eosinophilic droplets have been reported in fishes exposed to pesticides and other compounds (Couch 1975). These changes were reported in fish exposed for several weeks and often co-occurred with other pathological changes, such as nuclear degeneration. Because this bioassay was terminated after 96 h, it likely accounts for the absence of the nuclear degeneration. The liver is a detoxification organ and evidence of the droplet degeneration of hepatocytes is an indication of possible chemical toxicity, particularly in SN-2-L and TD-2-L sediment. In addition, the results of this bioassay are similar to results observed with the mysid data where the lowest level of survival also occurred in Sediment Treatments SN-2-L and TD-2-L. Fish from each %SPP treatment were archived to perform histopathology for evaluation of potential effects.

3.1.3 Oyster (C. gigas) Larvae

The EC50 results of the SPP tests performed on oyster (C. gigas) larvae indicate that the effective concentration of SPP to produce 50% abnormality in oyster larvae is less than that required for 50% reduction in total abundance, and approximately 40% SPP in Sediment Treatments SN-2-L and TD-2-L, and about

62% in Sediment Treatment TD-2-U, using the Litchfield and Wilcoxon method. Using the least squares method, the results indicate a 40 to 70% concentration of SPP is necessary to reduce the percent of abnormal larvae to less than 50% abnormality. Based on these results, disposal of dredged material would require a minimum dilution of 40 to 50% to protect sensitive bivalve larvae.

Appendix G summarizes the results of these SPP tests, survival data, and daily water quality. In this bioassay, results from three of the five sediment treatments tested showed a significantly lower proportion of normal D-shaped oyster larvae when compared with the reference seawater treatment. Three of the five test sediment treatments showed a significant reduction in total survival when compared with the seawater treatment. The EC50 values were calculated for those sediment treatments where at least 50% of the recovered larvae were considered abnormal and where larval abundance was reduced by at least 50%. Sediment Treatments TD-2-L, TD-2-U, and SN-2-L were included in this calculation.

Throughout the test, water-quality parameters remained within acceptable ranges stated in Section 2.5.1. Water bath temperature ranged from 19.5 to 20.0°C, within the acceptable range of ±1.0°C. Salinity in all exposure jars ranged from 24.5 to 25.5 °/..., within the specified range of ±2 °/.... Dissolved oxygen levels in all containers ranged from 6.3 to 8.5 mg/L, remaining above the 4.0 mg/L minimum values stated in the protocols. The pH varied in all containers from 7.58 to 8.30, but the pH in each container did not change more than ±0.2 units throughout the experiment. Both pH variations were acceptable according to the protocol.

Proportion of Normal D-Shaped Larvae Surviving

The proportion of normal D-shaped oyster larvae (blastulas not included) present in a 30-mL subsample after 48-h exposure to 100% SPP concentration is summarized in Table 3.8. The table shows that the reference seawater and SPP prepared from CH-C had the highest proportions of normal D-shaped larvae, followed by the Sequim Bay SPP concentration. The SPP prepared from Sediment Treatment SN-2-U had 66% normal D-shaped larvae, while SPP from Sediment Treatments TD-2-U, TD-2-L, SN-2-U, and SN-2-L showed essentially no normal D-shaped larvae.

TABLE 3.8. Proportion of Normal D-Shaped Oyster Larvae Present in a 30-mL Subsample After 48-h Exposure to 100% SPP

		Sediment Treatment (100% SPP)					
Replicate	Sea-water[a]	TD-2-U	TD-2-L	SN-2-U	SN-2-L	CH-C[b]	Sequim Bay Reference Sediment
1	0.93	0.00	0.00	0.83	0.00	0.94	0.92
2	0.90	0.01	0.00	0.27	0.09	0.99	0.85
3	0.95	0.07	0.00	0.88	0.00	0.94	0.92
4	0.93						
Mean Proportion	0.93	0.03	0.00	0.66	0.03	0.96	0.90

(a) Strait of Juan de Fuca water.
(b) An equal mixture of CH-1 and CH-2 sediment.

For each of the 100% SPP concentrations, one-sided independent sample t-tests were performed to test the null hypothesis of equal mean proportions of normal D-shaped larvae among each test sediment treatment versus the alternative that the mean proportion of normal D-shaped larvae in the seawater sample was greater than that found in the test SPP concentration. The arc sine square root transformation on the proportion of normal D-shaped larvae surviving was used to reduce the heterogeneity of the within-class variances. Because of the lack of variation in several of the SPP concentrations, unequal variances were still assumed (even after this transformation) and only an approximate t-statistic (T) could be derived. Different degrees of freedom were used to test each comparison. The t-values, degrees of freedom, approximate probability of a greater value, and approximate 95% confidence interval of about $\bar{X}_1 - \bar{X}_2$ are expressed for this test in Table 3.9.

Table 3.9 shows that Sediment Treatments TD-2-U, TD-2-L, and SN-2-L have a significantly lower proportion ($\alpha = 0.05$) of normal D-shaped larvae compared with the seawater treatment.

Analysis of the entire data set as a balanced two-way factorial was also performed, using the proportion of normal D-shaped larvae as the criterion. For this analysis sediment treatments and % SPP were compared. Table 3.10 was

TABLE 3.9. One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Strait of Juan de Fuca Water Using the Arc Sine (expressed in radians) Square Root of the Proportion of Normal D-Shaped Oyster Larvae Surviving a 48-h Exposure

Seawater[a] vs Sediment Treatment	Mean	SD	T-Value	d.f.	Probability	95% CI About Mean Difference
TD-2-U	0.129	0.14	16.40	2.2	0.0001 *[b]	(0.85, 1.49)
TD-2-L	0.000	0.00	55.26	3.0	0.0001 *	(1.23, 1.36)
SN-2-U	0.846	0.59	1.58	2.0	0.0873	(-1.01, 1.91)
SN-2-L	0.099	0.17	13.89	2.2	0.0001 *	(0.79, 1.60)
CH-C[c]	1.376	0.09	-1.66	2.7	0.9211	(-0.26, 0.10)
Sequim Bay	1.246	0.07	1.28	3.0	0.1277	(-0.09, 0.19)

(a) Strait of Juan de Fuca water.
(b) Statistically significant.
(c) An equal mixture of CH-1 and CH-2 sediment.

TABLE 3.10. Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Arc Sine (expressed in radians) Square Root of the Proportion of Normal D-Shaped Oyster Larvae Surviving a 48-h Exposure

Source	d.f.	Sum of Squares	F-Ratio
Sediment Treatment	5	3.2633	
% SPP (concentration)	2	4.0220	
Interaction	10	3.6933	7.30 *[a]
Residual	36	1.8213	
Total (corrected)	53	12.7999	

(a) Statistically significant.

developed using the arc sine square root of the proportion of normal D-shaped larvae observed. Table 3.10 shows the interaction of sediment treatment * % SPP to be highly significant; thus, comparisons of the effects of the sediment

treatments and % SPP concentration were not appropriate. Instead, each sediment treatment was considered individually. A plot of the 95% confidence intervals for sediment treatment and % SPP combination is presented in Figure 3.3. This figure shows that the 100% SPP concentrations prepared from Sediment Treatments TD-2-U, TD-2-L, and SN-2-L produced fewer normal D-shaped larvae than did the 50 and 10% SPP concentrations. Little difference in the proportion of normal D-shaped larvae is apparent in the various SPP concentrations from CH-C and Sequim Bay sediment.

Total Number of Larvae Recovered

The total number of oyster larvae present (including normal D-shaped, abnormal, and blastula) in a 30-mL subsample after exposure to 100% SPP for

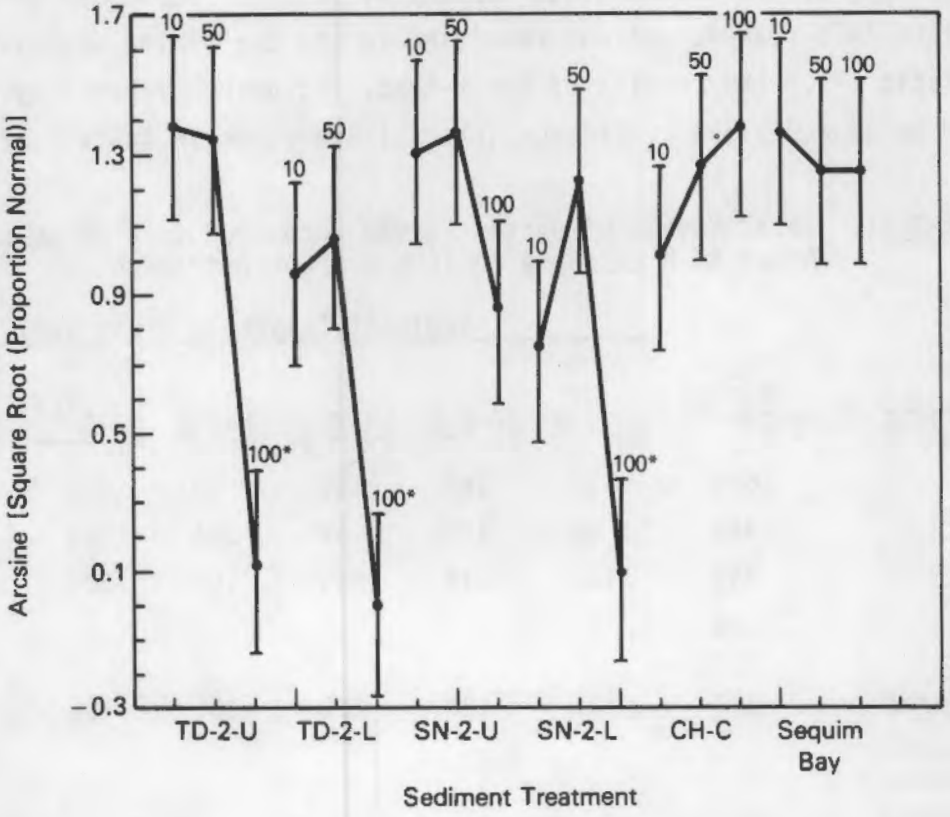


FIGURE 3.3. Proportion of Normal D-Shaped Oyster Larvae (including 95% confidence intervals) for 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments Using Arc Sine Square Root Transformation

48 h is summarized in Table 3.11. Table 3.11 shows that both the Strait of Juan de Fuca water and Sequim Bay sediment were similar in the number of larvae recovered, with 510 and 558, respectively. When expressing the number recovered as a percentage of the seawater treatment recovery, the percentage of larvae recovered from Sediment Treatments CH-C and Sequim Bay exceeded 95% of the seawater treatment recoveries. Sediment Treatments TD-2-U, TD-2-L, SN-2-U, and SN-2-L showed recoveries of less than 50% of seawater values.

For each of the test sediment treatments, one-sided independent sample t-tests were performed to test the null hypothesis of equal mean survival versus the alternative hypothesis that the seawater treatment mean survival was greater than the mean survival in the test SPP concentration. The natural log transformation of the total recovered oyster larvae was used to reduce the heterogeneity of the within-class variances. Unequal variances were assumed even after this transformation, resulting in the use of the approximate t-statistic (T). The results of the t-test, including probability of a greater value and a 95% confidence interval are shown in Table 3.12.

TABLE 3.11. Total Number of Oyster Larvae Recovered in a 30-mL Subsample After 48-h Exposure to 100% SPP Concentration

		Sediment Treatment (100% SPP)					
Replicate	Sea-water[a]	TD-2-U	TD-2-L	SN-2-U	SN-2-L	CH-C[b]	Sequim Bay Reference Sediment
1	674	75	162	157	39	528	614
2	444	86	106	42	356	351	582
3	354	143	115	463	104	584	479
4	569						
Mean recovered	510	101	128	221	166	488	558
% Reduction relative to seawater treatment	100	20	25	43	33	96	109

(a) Strait of Juan de Fuca water.
(b) An equal mixture of CH-1 and CH-2 sediment.

TABLE 3.12. One-Tailed Independent T-Tests of Various 100% SPP Concentrations from Six Sediment Treatments Versus Strait of Juan de Fuca Water Using the Natural Logarithm of the Total Number of Oyster Larvae Surviving a 48-h Exposure

Seawater[a] vs Sediment Treatment	Mean	SD	T-Value	d.f.	Probability	95% CI About Mean Difference
TD-2-U	4.578	0.34	6.95	5.0	0.0001 *[b]	(1.03, 2.23)
TD-2-L	4.832	0.23	6.89	5.0	0.0001 *	(0.86, 1.89)
SN-2-U	4.977	1.20	2.03	2.2	0.0900	(-1.61, 4.06)
SN-2-L	4.728	1.11	2.64	5.0	0.0231 *	(0.04, 2.92)
CH-C[c]	6.167	0.27	0.18	5.0	0.4306	(-0.51, 0.58)
Sequim Bay	6.319	0.13	-0.64	5.0	0.7241	(-0.57, 0.35)

(a) Strait of Juan de Fuca water.
(b) Statistically significant.
(c) An equal mixture of CH-1 and CH-2 sediment.

Table 3.12 shows the same pattern as Table 3.11 of proportion normal, revealing significantly less ($\alpha = 0.05$) recovery from Sediment Treatments TD-2-L, TD-2-U, and SN-2-L than from Sequim Bay.

Analysis of the entire data set as a balanced two-way factorial was also performed, using the total number of oyster larvae recovered as the criterion. For this analysis sediment treatments and % SPP concentrations were compared. Table 3.13 was developed using the natural log of the total number of larvae recovered. Table 3.13 shows that the interaction of sediment treatment * SPP is not significant; thus, comparison of the effects of the sediment and % SPP could be examined. Tukey's HSD showed that the mean survival for Sediment Treatments TD-2-L and SN-2-U was significantly reduced compared with the Sequim Bay sediment treatment. A plot of the 95% confidence intervals for each sediment treatment and % SPP combination is presented in Figure 3.4. This figure shows that fewer larvae were recovered in the 100% SPP than in the 10 and 50% concentrations prepared from Sediment Treatments TD-2-U, TD-2-L, SN-2-U, and SN-2-L. The low recovery rate for the 10% SPP from Sediment

TABLE 3.13. Balanced Two-Way ANOVA for Six Sediment Treatments and Three SPP Concentrations Using the Natural Logarithm of the Total Number of Oyster Larvae Surviving a 48-h Exposure

Source	d.f.	Sum of Squares	F-ratio
Sediment treatment	5	8.3704	4.65 *(a)
% SPP (concentration)	2	5.9322	8.23 *
Interaction	10	6.6916	1.86 NS(b)
Residual	36	12.9734	
Total (corrected)	53	33.9677	

(a) Statistically significant.
(b) Not significant.

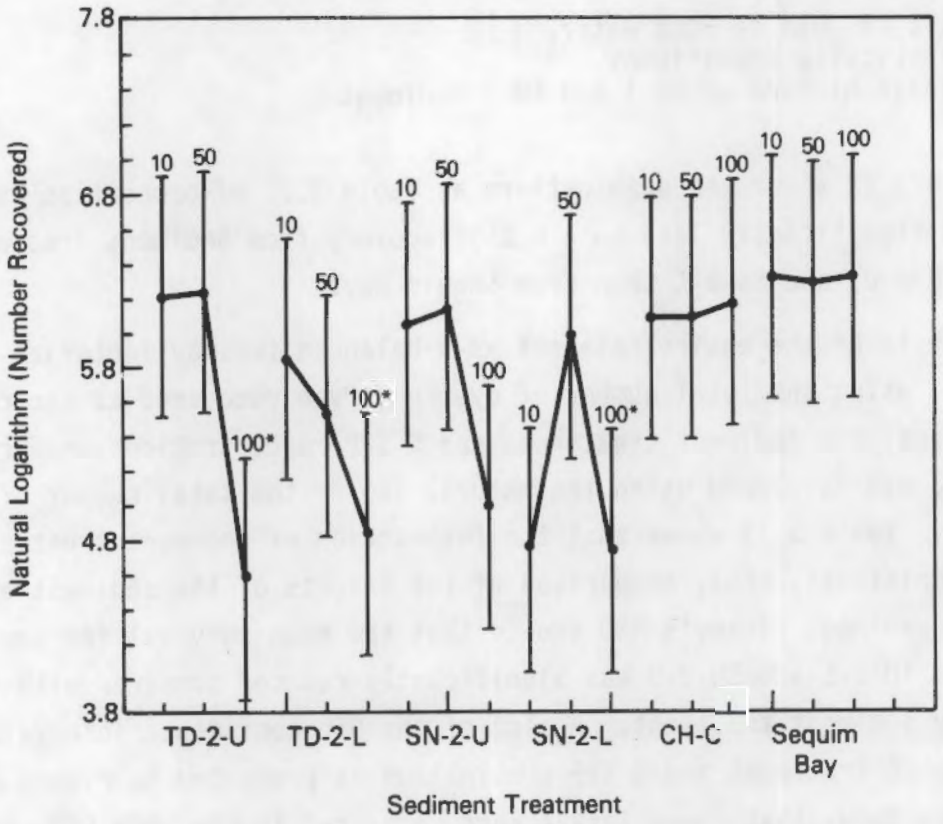


FIGURE 3.4. Natural Logarithm of Oyster Larvae Recovered in a 30-mL Subsample (including 95% confidence intervals) in 10, 50, and 100% SPP Concentrations Prepared from Six Sediment Treatments

Treatment SN-2-L is because of an absence of larvae in Replicate A (Appendix G). In this replicate, only 26 larvae were recovered (i.e., 1-% reduction), compared with 468 and 120 in Replicates B and C, respectively. We believe this low recovery may be due to nonhomogeneous conditions and resulting sampling error during the 30-mL subsampling at 48 h. The other two sediment treatments, CH-C and Sequim Bay reference sediment, showed little variation in oyster larvae recovery over the three SPP concentrations.

Calculation of EC50

The SPP concentration producing 50% abnormality in oyster larvae at 48 h (EC50) was calculated using the Litchfield and Wilcoxon method described in the implementation manual. Mean values of proportion normal and total abundance in three replicates for each SPP concentration were used for this calculation. The results of this analysis are presented in Table 3.14.

Sediment Treatments TD-2-U, TD-2-L, and SN-2-L produced approximately the same EC50 values. To check the Litchfield and Wilcoxon Method for estimating EC50, we also used a least squares regression technique, again on the mean values of proportion abnormal, but also on the total abundance of larvae for each sediment treatment and SPP concentration. The results are presented in Table 3.15.

The statistical analysis using the above two criteria--proportion of normal D-shaped larvae and total abundance--shows that the 100% SPP concentration from Sediment Treatments SN-2-L, TD-2-U, and TD-2-L resulted in significantly lower abundance and proportion of normal larvae than did the seawater

TABLE 3.14. Estimation of EC50 for Three Sediment Treatments Using the Litchfield and Wilcoxon Method

Sediment Treatment	% SPP
TD-2-L	40.0
TD-2-U	62.0
SN-2-L	42.0

TABLE 3.15. Estimation of EC50 for Abnormal Production and Total Abundance of Larvae for Three Sediment Treatments Using the Least Squares Method

Sediment Treatment	% SPP	
	Abnormal	Total Abundance
TD-2-L	50	88
TD-2-U	67	78
SN-2-L	47	72

treatment. In both analyses, Sediment Treatments CH-C and Sequim Bay reference sediment produced results not significantly different from those of the Strait of Juan de Fuca water.

3.2 SOLID PHASE TESTS

3.2.1 Polychaetes (N. caecoides) and Clams (M. nasuta)

The results of the 10-day solid phase bioassay using polychaetes (N. caecoides) and clams (M. nasuta) showed high proportion survival for all sediment treatments. The lowest recorded survival of either organism occurred among replicates of Sediment Treatment TD-2-L, where 46 of 60 polychaetes (N. caecoides) lived (a 0.77% survival rate). No significant differences were apparent based on survival among any of the sediment treatments.

Appendix H summarizes results of these solid phase tests including survival data. Because the polychaetes and clams were tested together, the results are reported together in this section. Most of the polychaetes (N. caecoides) and all except for two of the clams (M. nasuta) survived the 10-day solid phase flow-through series.

Water-quality parameters remained within acceptable ranges, as summarized in Section 2.5.1 and stated in the implementation manual. The flow-through system regulated temperature consistently, with a minimum water temperature of 14.4°C and a maximum of 15.5°C, well within the ±1°C target. Dissolved oxygen ranged from 6.1 to 8.4 mg/L; salinity ranged from 30.5 to 32.0 °/.., which is normal ambient salinity for Sequim Bay. The pH ranged from 7.69 to 8.02 and varied less than 0.4 units within each replicate container.

The proportion of each species surviving the 10-day bioassay are presented in Table 3.16. This table shows that only two of the clams (M. nasuta) died during the bioassay, one from Sediment Treatment 2-2, and one from Sediment Treatment CH-1. The proportion of polychaetes (N. caecoides) surviving the 10-day exposure varied from 0.77 (46 of 60) for Sediment Treatment TD-2-L to 1.00 for Sediment Treatment CH-2 (60 of 60). The ANOVA was run between and within groups on the arc sine square root of polychaete (N. caecoides) survival and showed no significant differences ($\alpha = 0.05$) between sediment treatments (Table 3.17). Because only 2 clams (M. nasuta) died during the test, it was not necessary to repeat the ANOVA for this data set.

3.2.2 Amphipods (R. Abronius and G. Japonica)

Results of the 10-day solid phase bioassay performed on amphipods (R. abronius and G. japonica), including daily water-quality data, are summarized in Appendix I.

Water-quality parameters for this experiment remained within acceptable ranges as stated in the implementation manual. Temperature ranged from 14.2 to 17.7°C (range of 3.5°C). The average temperature was 15.8 ± 1.7°C, which varying less than the allowable ±2°C. Salinity ranged from 31 to 33 °/₀₀, and varied less than 1.0 °/₀₀ within each jar. Dissolved oxygen levels remained above the minimum level of 4.0 mg/L, with a low of 4.9 mg/L and a high of 8.2 mg/L throughout the experiment. The pH in all containers varied 0.42 units, ranging from 7.64 to 8.06, but varied less than 0.2 units within each container over the 10-day test.

Comparison of Percent Survival: Amphipod (R. abronius)

One-way ANOVA among all stations using the angular transformed data was significant ($\alpha = 0.05$) (Table 3.18). Tukey's HSD method for multiple comparison produced two statistical groups separating the higher percent survival observed for the Point Reyes sediment from the lowest observed percent survival obtained from Sediment Treatments 3-1, 3-2, SN-3-L, and TD-2-L. The 95% confidence intervals about the true angular transformed means further support

TABLE 3.16. Proportion of Polychaetes (N. caecoides) and Clams (M. nasuta) Surviving After 10-Day Exposure Expressed as the Total in Three Replicates

Sediment Treatment	Number Alive		Proportion Surviving[a]	
	Nephtys	Macoma	Nephtys	Macoma
1-1	52	60	0.87	1.00
1-2	56	60	0.93	1.00
1-3	53	60	0.88	1.00
2-1	53	60	0.88	1.00
2-2	56	59	0.93	0.98
3-1	53	60	0.88	1.00
3-2	56	60	0.93	1.00
CH-1	57	59	0.95	0.98
CH-2	60	60	1.00	1.00
SN-1	49	60	0.82	1.00
SN-2-U	57	60	0.95	1.00
SN-2-L	56	60	0.93	1.00
SN-3-U	58	60	0.97	1.00
SN-3-L	47	60	0.78	1.00
TD-1-U	48	60	0.80	1.00
TD-1-L	54	60	0.90	1.00
TD-2-U	55	60	0.92	1.00
TD-2-L	46	60	0.77	1.00
Sequim Bay	56	60	0.93	1.00
Point Reyes	54	60	0.90	1.00

(a) Initial stocking density of 20 animals x 3 replicates = 60.

TABLE 3.17. Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine (expressed in radians) Square Root of the Proportion of N. caecoides Surviving a 10-Day Solid Phase Exposure

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	0.8275	19	0.0435	1.218	0.2914 NS[a]
Within groups	1.4299	40	0.0357	--	
Total (corrected)	2.2574	59			

(a) Not significant.

TABLE 3.18. Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine (expressed in radians) Square Root of the Proportion of R. abronius Surviving a 10-Day Solid Phase Exposure

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	0.93716	19	0.04932	2.051	0.0142 * (a)
Within groups	1.92357	80	0.02405	--	--
Total (corrected)	2.86072	99			

(a) Statistically significant.

the results obtained by the multiple comparison procedure (Figure 3.5). The percent of R. abronius surviving the 10-day bioassay for each sediment treatment is presented in Table 3.19. The sediment treatments are ordered by increasing percent survival and classified into statistical groups from the results of the multiple comparison analysis. Sediment treatments within the same statistical group are not significantly different ($\alpha = 0.05$) from each other. The change in percent survival also was compared by subtracting the mean percent survival for each sediment treatment from the mean percent survival for either Sequim Bay or Point Reyes reference sediment. A positive value in either column indicates that the mean percent survival for the test sediment treatment was less compared with the particular reference sediment. A negative value indicates greater survival.

When the mean percent survival for each sediment treatment was subtracted from the mean percent survival for Sequim Bay sediment, eight sediment treatments showed a trend toward statistical differences (i.e., an absolute change in survival greater than 10% was detected even though a statistical difference may not have been detected). The change in percent survival indicated that seven of these sediment treatments had a lower mean percent survival, and Point Reyes had a greater percent survival. Comparison of all sediment treatments with Point Reyes sediment showed that all sediment treatments except 1-1 had at least 10% lower mean percent survival. There is a general feeling among many scientists that both a statistically significant difference

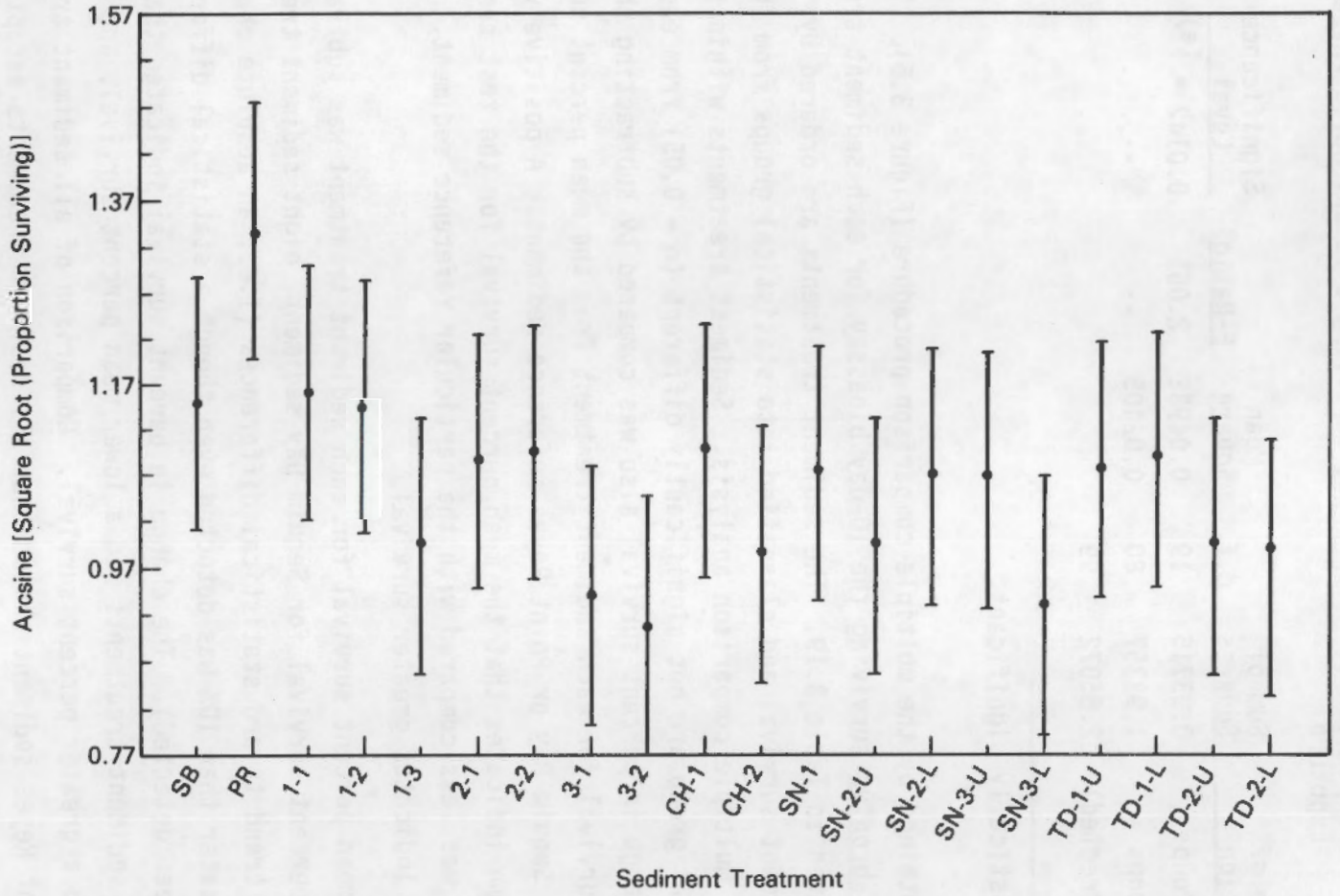


FIGURE 3.5. 95% Confidence Intervals of the Arc Sine Square Root of Proportion R. abronius Surviving

TABLE 3.19. Comparison of Percent R. abronius Surviving for all Sediment Treatments

Sediment Treatment	Percent Survival	Statistical Group[a]	Change in Percent When Compared with	
			Sequim Bay[b]	Point Reyes[c]
3-2	62	A	20*[d]	31*
SN-3-L	64	A	18*	29*
3-1	65	A	17*	28*
TD-2-L	68	A	14*	25*
CH-2	69	AB	13*	24*
1-3	70	AB	12*	23*
SN-2-U	70	AB	12*	23*
TD-2-U	70	AB	12*	23*
2-1	74	AB	8	19*
2-2	74	AB	8	19*
SN-2-L	76	AB	6	17*
SN-3-U	76	AB	6	17*
TD-1-U	77	AB	5	16*
SN-1	77	AB	5	16*
1-2	78	AB	4	15*
TD-1-L	78	AB	4	15*
CH-1	79	AB	3	14*
Sequim Bay	82	AB	0	11*
1-1	84	AB	-2	9
Point Reyes	93	B	-11*	0

(a) Sediment treatments with same statistical group are not significantly different from each other.
(b) Sequim Bay mean percent survival - sediment treatment mean percent survival.
(c) Point Reyes mean percent survival - sediment treatment mean percent survival.
(d) $\Delta \geq \pm 10\%$.

and at least a 10% decrease in survival is necessary before predictions of probable impact can be made. Thus, the greater toxicity of the sediment from Sediment Treatments 3-2, SN-3-L, 3-1, and TD-2-L to amphipod (R. abronius) were sufficiently different to allow prediction of a probable impact when compared with the Point Reyes sediment.

The relatively high percent survival in the Point Reyes reference sediment (<10% mortality) and the statistically comparable survival in the Sequim Bay sediment indicate the bioassay was successful, because both of these sediment are uncontaminated. The higher survival at Point Reyes may be due to a more suitable grain size (fine sand) than is present in the Sequim Bay sediment (silt).

Comparison of Percent Survival: Amphipod (G. japonica)

One-way ANOVA among all sediment treatments using the angular transformed data was not significant ($\alpha = 0.05$) (Table 3.20). Because this procedure, by design, does not contradict results of the one-way ANOVA, Tukey's HSD multiple comparison procedure classifies all sediment treatments into the same statistical groups. The 95% confidence intervals about the true angular transformed means further support the lack of significant differences (Figure 3.6).

The mean percent survival of G. japonica surviving the 10-day bioassay for each sediment treatment is presented in Table 3.21. The sediment treatments are ordered by increasing mean percent survival and are classified into statistical groups. The comparison of mean percent survival of test sediment

TABLE 3.20. Balanced One-Way ANOVA for 20 Sediment Treatments Using the Arc Sine (expressed in radians) Square Root of the Proportion of G. japonica Surviving a 10-Day Solid Phase Exposure

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	1.29404	19	0.06811	1.656	0.0627 NS(a)
Within groups	3.29106	80	0.04114	--	--
Total (corrected)	4.58510	99			

(a) Not significant.

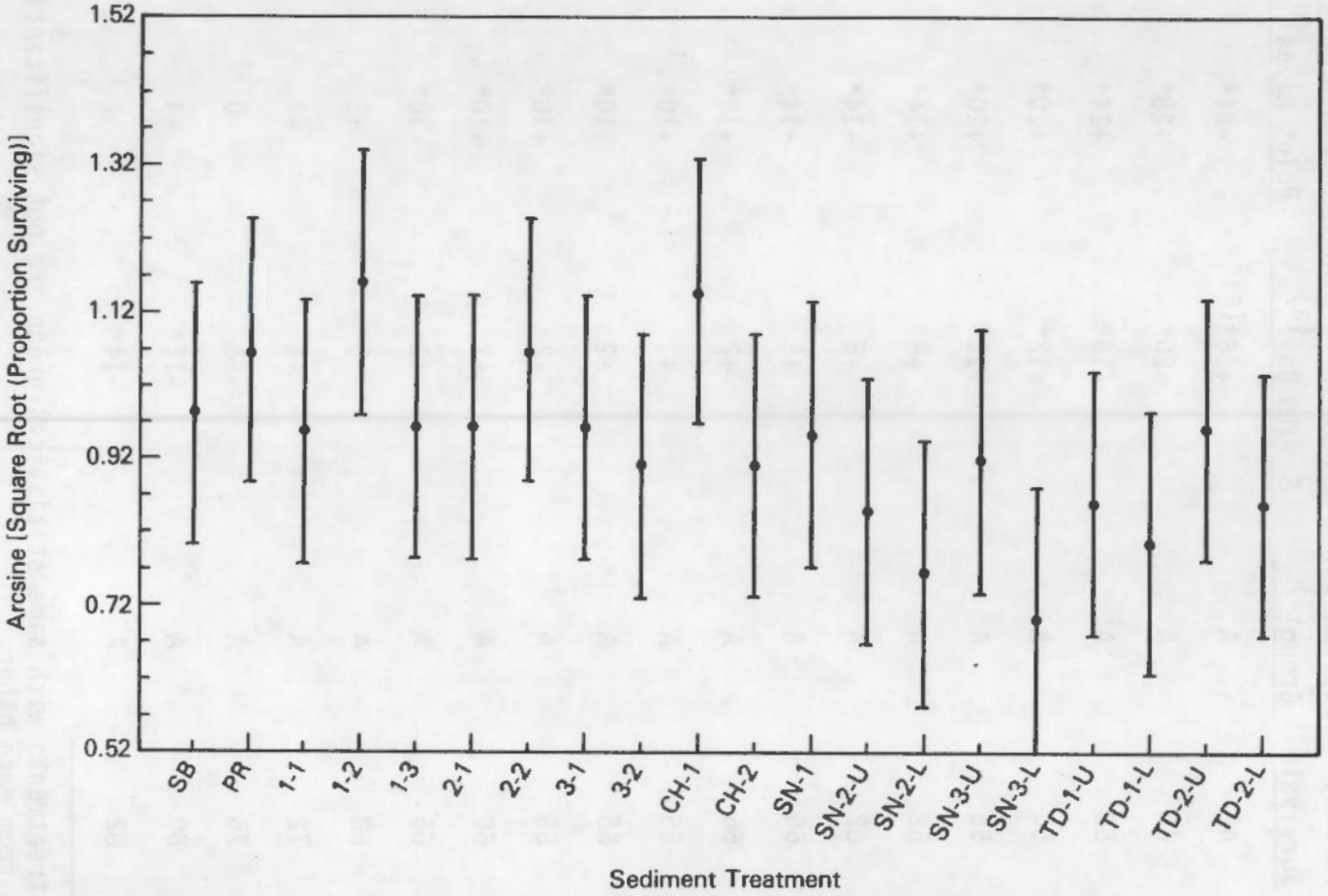


FIGURE 3.6. 95% Confidence Intervals of the Arc Sine Square Root of Proportion Amphipods (G. japonica) Surviving

TABLE 3.21. Comparison of Percent Amphipods (G. japonica) Surviving for all Sediment Treatments

Sediment Treatment	Percent Survival	Statistical Group[a]	Change in Percent When Compared with Sequim Bay[a]	Change in Percent When Compared with Point Reyes[b]
SN-3-L	42	A	+26*[c]	+34*
SN-2-L	48	A	+20*	+28*
SN-2-U	52	A	+16*	+24*
TD-2-L	56	A	+12*	+20*
3-2	56	A	+12	+20*
CH-2	62	A	+6	+14*
SN-3-U	62	A	+6	+14*
1-1	66	A	+6	+14*
1-3	66	A	+2	+10*
2-1	66	A	+2	+10*
3-1	66	A	+2	+10*
SN-1	66	A	+2	+10*
TD-1-U	66	A	+2	+10*
TD-2-U	66	A	+2	+10*
Sequim Bay	68	A	0	+8
2-2	72	A	-4	+4
Point Reyes	76	A	-8	0
1-2	80	A	-12*	-4
CH-1	82	A	-14*	-6

(a) Sediment treatments with same statistical group are not significantly different from each other.
(b) Sequim Bay mean percent survival - sediment treatment mean percent survival.
(c) Point Reyes mean percent survival - sediment treatment mean percent survival.
(d) $\Delta \geq \pm 10\%$.

treatment to survival in Sequim Bay sediment reveals that the percent survival decreased by more than 10% for Sediment Treatments SN-3-L, SN-2-L, TD-1-L, SN-2-U, and TD-2-L--which includes the same sediment treatments that produced the highest abnormality proportions in the oyster larvae test (Section 3.1.3). Mean survival in Sediment Treatments 1-2 and CH-1 exceeded Sequim Bay survival by more than 10%. Comparison of all sediment treatments with the Point Reyes percent survival showed that 15 sediment treatments showed at least a 10% decrease in mean percent survival. The lowest percent survivals again included the five sediment treatments noted above. No test sediment treatment exceeded the Point Reyes mean percent survival results by more than 6%.

Because of the low percent survival in the Sequim Bay and Point Reyes reference sediment, we conclude that the bioassay information for the amphipod (G. japonica) is not appropriate for estimating sediment toxicity. However, because no significant differences between sediment treatment means were detected, ranking sediment toxicity by percent survival only would have indicated trends that could be considered spurious. In contrast, the amphipod (R. abronius) bioassay delivered excellent survival in the reference sediment.

3.3 CHEMICAL ANALYSIS OF DREDGED-MATERIAL SAMPLES

3.3.1 Priority Pollutant Semivolatile Compounds, Pesticides, and Polychlorinated Biphenyls (PCBs)

One pesticide, three PCB Aroclors, and 16 PAHs were above the detection limits established for these studies (Table 3.22 and Appendix J). The pesticide 4,4′ DDE was found in the outer channel area of Oakland Inner Harbor at Sediment Treatment 1-1 at a concentration of 30 μg/kg dry wt.

Polychlorinated biphenyls were found in all turning basin sediment (SN-1, SN-2-U, SN-2-L, SN-3-U, SN-3-L, TD-1-U, TD-1-L, TD-2-U, TD-2-L) and in Oakland Inner Harbor Sediment Treatments 3-1 and CH-1. Total PCB concentrations in these sediment treatments ranged from 60 to 780 μg/kg dry wt. The Aroclor 1242 was found only in Sediment Treatment SN-2-L (220 μg/kg dry wt). SN-2-L also contained the Aroclors 1254 and 1260 at sufficiently high concentrations (370 and 190 μg/kg dry wt) to provide the maximum sum concentration of PCB in any sediment treatment. Sediment Treatments SN-2-U, SN-2-L, SN-3-L, TD-1-U, TD-1-L, TD-2-U, and TD-2-L had PCB concentrations that averaged 417 ± 258 SD

TABLE 3.22. Pesticides and PCBs

Sediment Treatment	Concentrations (μg/kg dry wt) 4,4′ DDE	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCBs
1-1	30	100U[a]	100U	100U	ND[b]
1-2	10U	100U	100U	100U	ND
1-3	10U	100U	100U	100U	ND
2-1	10U	100U	100U	100U	ND
2-2	10U	100U	100U	100U	ND
3-1	10U	100U	85J[c]	100U	85J
3-2	10U	100U	100U	100U	ND
CH-1	10U	100U	60J	100U	60J
CH-2	10U	100U	100U	100U	ND
SN-1	10U	100U	80J	100U	80J
SN-2-U	10U	100U	170	110	280
SN-2-L	10U	220	370	190	780
SN-3-U	10U	100U	90J	100U	90J
SN-3-L	10U	100U	110	100U	110
TD-1-U	10U	100U	330	120	450
TD-1-L	10U	100U	380	110	490
TD-2-U	10U	100U	140	100U	140
TD-2-L	10U	100U	500	170	670
Sequim Bay	10U	100U	100U	100U	ND
Point Reyes	10U	100U	100U	100U	ND

(a) Compound analyzed, but not detected at the given detection limit.
(b) Not detected.
(c) Estimated value when result is less than specified detection limit.

(n = 7), well above the concentrations seen in the outer channel of Oakland Inner Harbor (not detectable to 85 μg/kg dry wt) and in the Point Reyes and Sequim Bay reference sediment (not detectable).

Sixteen PAHs were detected in sediment treatments from Oakland Inner Harbor and in the reference sediment. Total measured PAHs (Table 3.23) ranged from non-detectable in Point Reyes and Sequim Bay reference sediment to

TABLE 3.23. Concentrations of Total Polynuclear Aromatic Hydrocarbons, and Total Phthalates

Sediment Treatment	Concentration (μg/kg) Total PAHs	Total Phthalates
1-1	794	240
1-2	833	340
1-3	873	480
2-1	1560	400
2-1	2750	370
3-1	2629	740
3-2	1756	265
CH-1	3570	660
CH-2	3310	1000
SN-1	2760	349
SN-2-U	8275	670
SN-2-L	15760	4890
SN-3-U	7610	1370
SN-3-L	10660	820
TD-1-U	5240	750
TD-1-L	3940	987
TD-2-U	8930	1330
TD-2-L	6107	1025
Sequim Bay	0	162
Point Reyes	0	40

15,760 μg/kg in Sediment Treatment SN-2-L. The outer portion of Oakland Inner Harbor had total PAH concentrations ranging from 794 to 3310 μg/kg. Sediment treatments from the southern portions of the turning basin showed concentrations ranging from 3940 to 8930 μg/kg while concentrations in sediment treatments from the northern part of the turning basin ranged from 2760 to 15760 μg/kg. The total polynuclear aromatic hydrocarbons observed were composed primarily of Fluoranthene, Pyrene, Benzo(a)Anthracene, Chrysene, Benzo(b,k)-Fluoranthene, and Benzo(a)Pyrene. The four phthalates [di-n butyl, butylbenzyl, bis(2-ethylhexyl) and di-n-octyl phthalate] expressed in Table 3.23 as total phthalates, ranged from a low of 40 μg/kg at the Point Reyes reference to a high of 4890 μg/kg at Sediment Treatment SN-2-L. The outer portions of Oakland Harbor had total phthalate concentrations ranging

from 240 to 1000 μg/kg, while the southern portion ranged from 750 to 1330 μg/kg. In the northern part of the turning basin, total phthalates ranged from 349 to 4890 μg/kg.

3.3.2 Metals and Metalloids

Table 3.24 shows the dry weight concentrations of 12 metal and metalloid contaminants in the Oakland Inner Harbor, Point Reyes, and Sequim Bay sediment. Chemical contaminant concentrations of reference and test sediment were compared by dividing the concentration in each test sediment treatment by the reference sediment concentration. Results of this process are presented in Table 3.25 for Point Reyes and for Sequim Bay in Table 3.26. Comparisons also

TABLE 3.24. Concentrations of Metals in Each Sediment Treatment and Average Crustal Abundance of Metals in Shale Soils Throughout the World

Sediment Treatment	Metal Concentrations (mg/kg dry wt)											
	Sb	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	As
1-1	1.02	0.34	226.2	65.1	34	0.354	125.8	0.68	0.522	0.4	141	14.7
1-2	0.90	0.35	232.2	68.4	28	0.326	121.8	0.59	0.492	0.3	139	14.1
1-3	0.84	0.33	231.6	77.9	25	0.351	117.9	0.65	0.581	0.3	149	13.8
2-1	0.96	0.52	289.1	62.7	42	0.472	108.0	0.43	0.674	0.5	147	12.6
2-2	0.72	0.50	296.9	66.5	46	0.513	91.5	0.50	0.561	0.3	158	11.6
3-1	0.96	0.63	264.9	77.9	59	0.575	115.2	0.68	0.674	0.2	175	13.9
3-2	0.84	0.50	264.1	63.2	43	0.437	131.2	0.54	0.557	0.3	166	13.0
CH-1	0.96	0.55	256.6	79.1	55	0.506	119.8	0.57	0.609	0.4	187	13.5
CH-2	0.96	0.49	259.9	80.1	55	0.568	124.4	0.54	0.615	0.4	188	12.7
SN-1	1.32	0.77	245.6	87.0	68	0.659	131.2	0.54	0.874	0.4	232	14.9
SN-2-L	1.92	1.67	279.6	111.4	141	1.484	132.4	0.59	1.117	0.3	347	14.1
SN-2-U	1.56	0.99	238.2	90.6	90	0.777	125.8	0.68	0.940	0.3	269	15.3
SN-3-L	1.68	1.09	277.0	77.6	86	1.111	124.5	0.68	0.813	0.3	234	14.9
SN-3-U	1.20	0.81	252.9	76.2	69	0.652	124.5	0.54	0.680	0.4	211	13.9
TD-1-L	1.92	1.16	352.5	178.5	109	1.060	135.0	0.54	0.837	0.4	471	13.5
TD-1-U	2.88	0.70	371.7	183.3	80	1.345	132.4	0.63	0.783	0.3	234	12.3
TD-2-L	1.80	0.82	425.0	178.5	90	1.823	153.5	0.45	0.857	0.3	287	14.1
TD-2-U	1.20	0.60	268.4	132.1	79	0.973	135.0	0.59	0.768	0.3	232	15.3
Sequim Bay	0.42	0.74	104.7	35.4	14	0.084	48.1	1.02	0.236	0.4	90	10.0
Point Reyes	0.48	1.36	259.8	9.2	10	0.059	34.6	0.45	0.034	0.6	10	7.0
Shale soil[(a)]	1.50	0.30	100.0	57.0	20	0.4	95	0.6	0.1	1	80	6.6

(a) Krauskopf (1967).

TABLE 3.25. Comparison of Metal Concentrations for Each Sediment Treatment Relative to Metal Concentrations at Point Reyes

Sediment Treatment	Metal Concentrations (mg/kg dry wt)											
	Sb	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	As
1-1	2.13	0.25	0.87	7.08	3.40	6.00	3.64	1.51	15.35	0.67	14.10	2.10
1-2	1.88	0.26	0.89	7.43	2.80	5.53	3.52	1.31	14.47	0.50	13.90	2.01
1-3	1.75	0.24	0.89	8.47	2.50	5.95	3.41	1.44	17.09	0.50	14.90	1.97
2-1	2.00	0.38	1.11	6.82	4.15	8.01	3.12	0.96	19.82	0.75	14.70	1.79
2-2	1.50	0.37	1.14	7.23	4.60	8.69	2.64	1.11	16.50	0.50	15.80	1.66
3-1	2.00	0.46	1.02	8.47	5.90	9.75	3.33	1.51	19.82	0.33	17.50	1.99
3-2	1.75	0.37	1.02	6.87	4.30	7.41	3.79	1.20	16.38	0.50	16.60	1.86
CH-1	2.00	0.40	0.99	8.60	5.50	8.57	3.46	1.26	17.90	0.58	18.65	1.92
CH-2	2.00	0.36	1.00	8.71	5.50	9.63	3.60	1.20	18.09	0.67	18.80	1.81
SN-1	2.75	0.57	0.95	9.46	6.80	11.17	3.79	1.20	25.71	0.67	23.20	2.13
SN-2-L	4.00	1.23	1.08	12.11	14.10	25.15	3.83	1.31	32.85	0.50	34.70	2.01
SN-2-U	3.25	0.73	0.92	9.85	9.00	13.17	3.64	1.51	27.65	0.50	26.90	2.19
SN-3-L	3.50	0.80	1.07	8.43	8.60	18.83	3.60	1.51	23.91	0.50	23.40	2.13
SN-3-U	2.50	0.60	0.97	8.28	6.90	11.05	3.60	1.20	20.00	0.67	21.10	1.99
TD-1-L	4.00	0.85	1.36	19.40	10.90	17.97	3.90	1.20	24.62	0.67	47.10	1.93
TD-1-U	6.00	0.51	1.43	19.92	8.00	22.80	3.83	1.40	23.03	0.50	23.40	1.76
TD-2-L	3.75	0.60	1.64	19.40	9.00	30.90	4.44	1.00	25.21	0.50	28.70	2.01
TD-2-U	2.50	0.44	1.03	14.36	7.90	16.49	3.90	1.31	22.59	0.50	23.20	2.19
Sequim Bay	0.86	0.54	0.4	3.84	1.7	1.42	1.39	2.25	6.96	0.75	9	1.42
Point Reyes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

were made between the average crustal abundance of the metals and metalloids found in shale soils throughout the world as a basis of reference to relative contaminant loads (Table 3.27).

Both Point Reyes and Sequim Bay reference sediment contained levels of metal enrichment consistent with and within one order of magnitude of the average concentrations seen in shale soils throughout the world. The relative enrichment values relative to shale soils at Point Reyes ranged from 0.06 for thallium (Tl) to 4.53 for cadmium (Cd) with an average enrichment of 0.96 ± 1.31 SD (n = 12). Sequim Bay reference sediment contained levels of metal enrichment that ranged from 0.21 for mercury (Hg) to 2.45 for cadmium (Cd) with an average enrichment of 1.10 ± 0.77 SD (n = 23). Cadmium showed the maximum enrichment in both the Point Reyes and Sequim Bay reference sediment. Chromium (Cr) and silver (Ag) also showed enrichments greater than

TABLE 3.26. Comparison of Metal Concentration for Each Sediment Treatment Relative to the Metal Concentration for Sequim Bay Reference Sediment Treatment

Sediment Treatment	Metal Concentrations (mg/kg dry wt)											
	Sb	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	As
1-1	2.43	0.46	2.16	1.84	2.43	4.21	2.62	0.67	2.21	1.00	1.57	1.47
1-2	2.14	0.47	2.22	1.93	2.00	3.88	2.53	0.58	2.08	0.75	1.54	1.41
1-3	2.00	0.45	2.21	2.20	1.79	4.18	2.45	0.64	2.46	0.75	1.54	1.38
2-1	2.29	0.70	2.76	1.77	3.00	5.62	2.25	0.42	2.86	1.25	1.66	1.26
2-2	1.71	0.68	2.84	1.88	3.29	6.11	1.90	0.49	2.38	0.75	1.63	1.16
3-1	2.29	0.85	2.53	2.20	4.21	6.85	2.40	0.67	2.86	0.50	1.76	1.39
3-2	2.00	0.68	2.52	1.79	3.07	5.20	2.73	0.53	2.36	0.75	1.94	1.30
CH-1	2.29	0.74	2.45	2.23	3.93	6.02	2.49	0.56	2.58	1.00	2.08	1.35
CH-2	2.29	0.66	2.48	2.26	3.93	6.76	2.59	0.53	2.61	1.00	2.09	1.27
SN-1	3.14	1.04	2.35	2.46	4.86	7.85	2.73	0.53	3.70	1.00	2.58	1.49
SN-2-L	4.57	2.26	2.67	3.15	10.07	17.67	2.75	0.58	4.73	0.75	3.86	1.41
SN-2-U	3.71	1.34	2.28	2.56	6.43	9.25	2.62	0.67	3.98	0.75	2.99	1.53
SN-3-L	4.00	1.47	2.65	2.19	6.14	13.23	2.59	0.67	3.44	0.75	2.60	1.49
SN-3-U	2.86	1.09	2.42	2.15	4.93	7.76	2.59	0.53	2.88	1.00	2.34	1.39
TD-1-L	4.57	1.57	3.37	5.04	7.79	12.62	2.81	0.53	3.55	1.00	5.23	1.35
TD-1-U	6.86	0.95	3.55	5.18	5.71	16.01	2.75	0.62	3.32	0.75	2.60	1.23
TD-2-L	4.29	1.11	4.06	5.04	6.43	21.70	3.19	0.44	3.63	0.75	3.19	1.41
TD-2-U	2.86	0.81	2.56	3.73	5.64	11.58	2.81	0.58	3.25	0.75	2.58	1.53
Point Reyes	1.14	1.84	2.48	0.26	0.71	0.70	0.72	0.44	0.14	1.50	0.11	0.70
Sequim Bay	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

twofold. Chromium was enriched to a level of 2.6-fold in the Point Reyes sediment, while Ag was enriched to 2.57-fold in the Sequim Bay sediment. These same three metals showed enrichments of 2.3 to 3.7-fold at the Alcatraz Island Dredged Material Disposal Site evaluated during previous sampling.(a)

The ratio of the concentration of metals and metalloids in Point Reyes reference sediment compared with the concentration of these same contaminants in the Sequim Bay reference averages 0.90 ± 0.72 SD (n = 12) (Table 3.25). These ratios are relatively close except for copper (Cu), silver (Ag), and

(a) Unpublished study of Oakland Inner Harbor and Alcatraz Island Disposal site by Word et al.

TABLE 3.27. Comparison of Metal Concentrations for Each Sediment Treatment Relative to the Average Crustal Abundance of Metals and Metalloids Found in Shale Soils Throughout the World

Sediment Treatment	Metal Concentration (mg/kg dry wt)											
	Sb	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	As
1-1	0.68	1.13	2.26	1.14	1.70	0.88	1.32	1.13	5.22	0.40	1.76	2.23
1-2	0.60	1.17	2.32	1.20	1.40	0.82	1.28	0.98	4.92	0.30	1.74	2.14
1-3	0.56	1.10	2.32	1.37	1.25	0.88	1.24	1.08	5.81	0.30	1.86	2.09
2-1	0.64	1.72	2.89	1.10	2.08	1.18	1.14	0.72	6.74	0.45	1.84	1.90
2-2	0.48	1.67	2.97	1.17	2.30	1.28	0.96	0.83	5.61	0.30	1.98	1.76
3-1	0.64	2.10	2.65	1.37	2.95	1.44	1.21	1.13	6.74	0.20	2.19	2.11
3-2	0.56	1.67	2.64	1.11	2.15	1.09	1.38	0.90	5.57	0.30	2.08	1.97
CH-1	0.64	1.82	2.57	1.39	2.75	1.26	1.26	0.94	6.09	0.35	2.33	2.04
CH-2	0.64	1.63	2.60	1.41	2.75	1.42	1.31	0.90	6.15	0.40	2.35	1.92
SN-1	0.88	2.57	2.46	1.53	3.40	1.65	1.38	0.90	8.74	0.40	2.90	2.26
SN-2-L	1.28	5.57	2.80	1.95	7.05	3.71	1.39	0.98	11.17	0.30	4.34	2.14
SN-2-U	1.04	3.30	2.38	1.59	4.50	1.94	1.32	1.13	9.40	0.30	3.36	2.32
SN-3-L	1.12	3.63	2.77	1.36	4.30	2.78	1.31	1.13	8.13	0.30	2.93	2.26
SN-3-U	0.80	2.70	2.53	1.34	3.45	1.63	1.31	0.90	6.80	0.40	2.64	2.11
TD-1-L	1.28	3.87	3.53	3.13	5.45	2.65	1.42	0.90	8.37	0.40	5.89	2.05
TD-1-U	1.92	2.33	3.72	3.22	4.00	3.36	1.39	1.05	7.83	0.30	2.93	1.86
TD-2-L	1.20	2.73	4.25	3.13	4.50	4.56	1.62	0.75	8.57	0.30	3.59	2.14
TD-2-U	0.80	2.00	2.68	2.32	3.95	2.43	1.42	0.98	7.68	0.30	2.90	2.32
Sequim Bay	0.28	2.45	1.05	0.62	0.68	0.21	0.51	1.69	2.37	0.45	1.13	1.51
Point Reyes	0.32	4.53	2.60	0.16	0.50	0.15	0.36	0.75	0.34	0.60	0.13	1.06

zinc (Zn). All three metals are higher in concentration in Sequim Bay reference sediment than in Point Reyes sediment by a factor averaging 6.74 ± 2.57 SD.

Most metals and metalloids contained in Oakland Inner Harbor sediment are divided into two geographical areas based on their concentrations: the turning basin stations (SN, TD, 2-2, 1-2, CH-2, 3-2) and the outer reaches of the channel (1-1, 2-1, 3-1, and 2-1). The sediment in the turning basin generally shows higher concentrations of metals and metalloids than sediment in the outer portion of the channel.

Compared with the Point Reyes reference sediment, cadmium and thallium are always lower in concentration while chromium averages about the same in the outer reaches of Oakland Inner Harbor. Selenium is either less than or

at 1.5-fold, while antimony and arsenic average about twofold higher than in the Point Reyes reference sediment. Nickel and lead range from 2.5- to 14.0-fold, while copper and mercury range from 3.00- to 30-fold, and silver and zinc range from 14- to 45-fold. Copper, silver, and zinc, while having relatively large enrichments compared with the Point Reyes sediment, range from 1.57- to 2.79-fold higher when compared with the concentrations of those metals in the finer-grained sediment in the Sequim Bay reference sediment.

Comparison of the concentrations of metals and metalloids in sediment from the turning basin area with reference sites provides information on some of the metals. Cadmium and thallium concentrations at the Point Reyes reference site exceed the concentrations in the turning basin in all sediment treatments except SN-2-L. Selenium and chromium show only slight enrichments ranging from less than the Point Reyes reference value to 1.6-fold. Arsenic ranges from 1.76- to 2.19-fold, while antimony and nickel range from 2.5- to 6-fold. Copper and lead range from 6.8- to 19.92-fold, while mercury, silver, and zinc range from 11.05- to 47.1-fold. Comparison of copper, silver, and zinc with the fine-grained reference sediment from Sequim Bay shows decreases in the average enrichments, ranging from 2.15- to 5.23-fold, while the relative concentration of lead compared with Sequim Bay shows little change (range of 4.9 to 10.1), and mercury shows large differences (7.76 to 21.70). This suggests that lead and mercury are showing enhanced concentrations beyond the ranges expected for shale sediment throughout the world and also for both of the reference sediment.

Whether or not the entire turning basin area is contaminated at the same level or whether certain locations or depths within the cores have vastly different concentrations of metals or metalloids should be considered. Maximum concentrations of lead, silver, and cadmium were found in Sediment Treatment SN-2-L; maximum levels of antimony, chromium, and copper were found in Sediment Treatment TD-1-U; and maximum levels of arsenic were found in Sediment Treatments SN-2-U and TD-2-U. Mercury and nickel were highest in Sediment Treatment TD-2-L. Zinc was at maximum concentration in Sediment Treatment TD-1-U. Maximum concentrations of thallium were found in Point Reyes sediment while maximum concentrations of selenium were found in Sequim Bay sediment. These findings indicate that maximum concentrations of at

least one metal were found for all sediment treatments except Sediment Treatment SN-3-U and SN-3-L. However, these sediment treatments had relatively high metal concentrations.

3.3.3 Organotins

Table 3.28 summarizes concentrations of mono-, di-, and tributyltins in Oakland Inner Harbor, Point Reyes, and Sequim Bay sediment. Total butyltins in the Sequim Bay and Point Reyes sediment were undetectable at the range of 2-10 μg/kg dry wt. Total butyltins ranged from 30 to 224 μg/kg dry wt in the outer channels and reaches of Oakland Inner Harbor (1-1, 1-2, 1-3, 2-1, 2-2, 3-1, 3-2, CH-1, CH-2), from 83 to 173 in northern turning basin sediment (SN-1, SN-2, SN-3), and from 318 to 3011 μg/kg in southern turning basin

TABLE 3.28. Concentration of Butyltins in Oakland Inner Harbor, Point Reyes, and Sequim Bay Sediment

Sediment Treatment	Butyltin Concentrations (μg/kg dry wt)				
	Tri	Di	Mono	Total	Percent Tri
1-1	36.8	16.4	16.4	70	53
1-2	26.0	11.6	3.5	41	63
1-3	18.7	11.5	<3.2	30	62
2-1	55.0	30.2	16.9	102	61
2-2	61.8	45.1	<2.4	107	58
3-1	168.0	46.5	9.5	224	75
3-2	82.1	41.8	6.8	131	63
CH-1	42.0	65.9	12.6	321	76
CH-2	179.0	42.6	8.6	230	78
SN-1	73.6	39.6	5.5	119	62
SN-2-U	96.3	67.8	9.3	173	56
SN-2-L	50.7	51.4	<3.0	102	50
SN-3-U	105.0	45.8	8.2	159	66
SN-3-L	37.1	35.2	10.5	83	45
TD-1-U	1601.0	422.0	69.1	2092	77
TD-1-L	2214.0	658.0	139.0	3011	74
TD-2-U	235.0	70.6	12.4	318	74
TD-2-L	603.0	156.0	51.1	810	74
Point Reyes	<5.0	<3.53	<2.2	NA	NA
Sequim Bay	<10.1	<4.44	<4.4	NA	NA

NA = Not applicable.

sediment (TD-1, TD-2). Maximum concentrations of tributyltins were found in Sediment Treatment TD-1-L. Sediment Treatment TD-1-U had the next highest tributyltin concentrations.

Sediment Treatments TD-1-U, TD-1-L, TD-2-U, TD-2-L, CH-1, and CH-2 contained an average of 75.3 ± 1.7% (n = 6) of the total measured butyltins in the more toxic tributyltin form. This percentage contrasts with Sediment Treatments SN-1, SN-2-U, SN-2-L, SN-3-U, and SN-3-L, and outer channel Sediment Treatments 1-1, 1-2, 1-3, 2-1, 2-2, 3-1, and 3-2, which averaged 59 ± 7.7% (n = 12) in the tributyltin form. Concentrations of tributyltin in outer channel sediment ranged from 19 to 168 μg/kg, from 42 to 179 μg/kg in the channel sediment, 37 to 105 μg/kg in the northern turning basin sediment, and 235 to 2214 μg/kg in the southern turning basin sediment.

3.3.4 Total Organic Carbon

Total organic carbon (TOC) concentrations were highest in Sequim Bay reference sediment (3.84% dry wt) and lowest in Point Reyes sediment (0.4% dry wt) (Table 3.29). Total organic carbon increased from the outer portion of the Oakland Inner Harbor channel (mean = 1.41% ± 0.33; n = 9) to higher levels in the southern turning basin sediment (mean = 1.65% ± 0.18; n = 4). The highest concentrations in Oakland Inner Harbor were found in the northern turning basin sediment (mean = 1.8% ± 0.27, n = 5). The maximum enrichment of TOC in any of the sediment proposed for dredging was 5.05-fold the concentration of organic carbon in the Point Reyes reference sediment. This sediment treatment was SN-2-U.

3.3.5 Oil and Grease

Table 3.30 presents the dry weight concentrations of total oil and grease in Oakland Inner Harbor test sediment and in Point Reyes and Sequim Bay reference sediment. Total oil and grease in sediment treatments from the outer channel sediment ranged from not detectable to 981 μg/g, averaging 444.4 μg/g, while turning basin sediment treatments showed levels of from 264 to 1040 μg/g, averaging 614.8 μg/g. The bottom 2.5 cm of the lower portion of core TD-2-L contained relatively low concentrations of total oil and grease, averaging 107 μg/g. The ANOVA showed that these differences were not

TABLE 3.29. Concentrations and Enrichment Factors of TOC from Oakland Inner Harbor, Point Reyes, and Sequim Bay Sediment

Sediment Treatment	Total Organic Carbon (% dry wt)	Enrichment Factors	
		Point Reyes	Sequim Bay
1-1	1.18	2.95	0.31
1-2	1.07	2.68	0.28
1-3	1.07	2.68	0.28
2-1	1.52	3.80	0.40
2-2	1.08	2.70	0.28
3-1	1.48	3.70	0.39
3-2	1.62	4.05	0.42
CH-1	1.77	4.43	0.46
CH-2	1.94	4.85	0.51
TD-1-U	1.46	3.65	0.38
TD-1-L	1.89	4.73	0.49
TD-2-U	1.65	4.12	0.43
TD-2-L	1.61	4.03	0.42
SN-1	1.76	4.40	0.46
SN-2-U	2.02	5.05	0.53
SN-2-L	2.13	5.33	0.55
SN-3-U	1.58	3.95	0.41
SN-3-L	1.51	3.78	0.39
Point Reyes	0.40	1.00	0.10
Sequim Bay	3.84	9.60	1.00

significantly different ($F = 0.92$ at d.f. = 2,16). These averages are also fairly consistent with the concentration of oil and grease observed within the Sequim Bay reference sediment.

3.3.6 Conventionals/Petroleum Hydrocarbons

Removal of the fatty acid portion of the oil and grease contaminants with silica gel provides information on the petroleum hydrocarbon fraction of oil and grease. Petroleum hydrocarbons ranged from not detectable to 507.8 μg/g dry wt (Table 3.30). A highly significant difference was detected with ANOVA between the the outer channel sediment and the northern and southern turning basin sediment ($F = 6.24$ at d.f. = 2,16). Higher concentrations of petroleum hydrocarbons (μg/g dry wt) were observed in the southern turning

TABLE 3.30. Conventionals/Petroleum Hydrocarbons (dry wt)

Sediment Treatment	Cyanide (µg/g)	TOC (%)	Total Sulfides (µg/g)	Water Soluble Sulfides (µg/g)	Oil and Grease (µg/g)	Petroleum Hydrocarbons (µg/g)	Total Solids (%)
1-1	<0.6	1.18	245.0	51.7	28.50	<10.0[a]	45.34
1-2	<0.6	1.07	83.7	53.5	<10.0	<10.0	46.28
1-3	<0.6	1.07	55.6	96.3	187.75	106.67	45.14
2-1	<0.6	1.52	152.5	53.5	981.74	73.20	53.04
2-2	<0.6	1.08	285.0	21.4	535.85	188.26	53.54
3-1	<0.6	1.48	128.0	85.6	676.18	189.67	50.26
3-2	<0.6	1.62	218.0	96.3	384.01	65.31	47.90
CH-1	<0.6	1.77	150.0	53.5	804.85	360.19	43.52
CH-2	<0.6	1.94	108.0	96.3	400.47	<10.0	43.08
SN-1	<0.6	1.76	56.3	160.0	264.98	86.72	41.61
SN-2-U	<0.6	2.02	437.0	107.0	751.05	263.53	38.84
SN-2-L	<0.6	2.13	399.0	535.0	739.74	507.81	45.84
SN-3-U	<0.6	1.58	82.0	107.0	755.35	239.43	41.46
SN-3-L	<0.6	1.51	252.0	107.0	308.02	244.27	46.68
TD-1-U	<0.6	1.46	226.0	482.0	503.80	399.84	47.96
TD-1-L	<0.6	1.89	394.0	374.0	1040.68	387.03	50.47
TD-2-U	<0.6	1.65	135.0	108.0	499.31	279.25	39.47
TD-2-L	<0.6	1.61	397.0	374.0	781.55	275.23	50.87
TD-2-L (Bottom)	NM[b]	NM	NM	NM	107.0[c]	7.8[c]	NM
Sequim Bay	<0.6	3.84	106.0	128.0	603.90	96.85	31.95
Point Reyes	<0.6	0.4	<5.0	5.4	<10.0	<10.0	75.6

(a) Not detected.
(b) NM - Not measured.
(c) Bottom 2.5 cm of extruded core analyzed for oil and grease and petroleum hydrocarbons, mean of two measurements.

basin sediment (mean = 326.7) than in the northern turning basin sediment (mean = 268.4), the outer channel (mean = 109.3), Sequim Bay (96.9), or Point Reyes (not detectable). The bottom portion of core TD-2-L had the lowest detectable concentrations of petroleum hydrocarbons, averaging 7.8 µg/g.

3.3.7 Cyanide

Cyanide was evaluated in all sediment treatments, but none was measured in any of the sediment at the detection limits of <0.6 μg/g dry wt.

3.3.8 Total and Dissolved Sulfides

Total and dissolved sulfides were determined from aliquots of preserved sediment (Table 3.30). Total sulfides ranged from <5.0 to 437 μg/g dry wt, while dissolved sulfides ranged from 5.4 to 535 μg/g dry wt.

3.3.9 Grain Size

A detailed grain size analysis was performed on each sediment treatment with size fractions divided into 16 phi-size categories (Appendix J). Percentages of major size fractions (gravel, sand, silt, and clay) are presented in Table 3.31. Point Reyes reference sediment contained only 5.44% silt and

TABLE 3.31. Percent Sediment Weight Used in Each Sediment Treatment by Major Size Category

Sediment Treatment	Sediment (% dry wt)			
	Gravel	Sand	Silt	Clay
1-1	0.10	7.37	37.82	54.76
1-2	0.00	9.93	40.96	49.20
1-3	0.00	6.84	45.88	47.22
2-1	0.00	32.47	33.22	34.37
2-2	0.25	37.81	25.50	36.53
3-1	0.00	22.12	30.74	47.16
3-2	0.00	17.77	36.11	46.13
CH-1	0.00	16.33	38.21	45.39
CH-2	0.00	18.26	32.56	49.14
SN-1	0.00	9.06	38.28	52.57
SN-2-U	0.00	4.65	39.78	55.58
SN-2-L	0.08	13.66	34.10	53.05
SN-3-U	0.00	21.63	30.63	47.80
SN-3-L	0.00	22.84	32.36	44.84
TD-1-U	0.71	27.17	30.62	41.47
TD-1-L	0.08	33.88	26.22	39.80
TD-2-U	0.06	10.24	36.55	53.25
TD-2-L	0.41	33.62	27.08	38.91
Point Reyes	0.00	94.52	3.24	2.20
Sequim Bay	0.00	27.84	42.75	29.44

clay, while all other treatment sediment contained between 62 and 90% silt and clay fractions. Sequim Bay reference sediment was 72% silt and clay, compared with other sediment treatments tested.

3.4 BIOACCUMULATION POTENTIAL

The analysis of bioaccumulated contaminants in clam tissues followed the guidelines provided in the implementation manual. Concentrations of contaminants in Sediment Treatments TD-1-U, TD-1-L, TD-2-U, TD-2-L, and CH-1 were compared with each other and a reference tissue from Elkhorn Slough (wet wt). To reduce variation from water content, one-way ANOVA on the natural logarithm of the dry weight concentration of the contaminants was performed. The variation between organisms within the same sediment treatment was used to test the equality of bioaccumulated contaminants between sediment treatments. When a significant difference was detected, Tukey's HSD multiple comparison test was used to compare sediment. For organotin comparisons, one-sample t-tests were used for the null hypothesis that the mean tissue concentrations from the TD and CH sediment treatments equaled that from the Elkhorn Slough sediment, versus the alternative that bioaccumulation was greater in tissues exposed to TD sediment. Appendix K summarizes contaminants associated with the tissues of M. nasuta after 10-day exposure to test sediment.

3.4.1. Metals

Mean concentrations of bioaccumulated lead ranged from a low of 0.38 μg/g (wet wt) in sediment treatments SN-1 and TD-2-U, to a high of 0.92 μg/g in Sediment Treatment TD-2-L. The Point Reyes concentration fell approximately in the middle of the distribution (Table 3.32). ANOVA results showed that there was a significant difference among sediment treatments (Table 3.33), and examination of statistical groupings shows that Sediment Treatments CH-1 and TD-2-L were statistically different and contained a higher concentration of lead than did Point Reyes. Figure 3.7 presents the 95% confidence intervals of the natural log of lead (μg/g dry wt) for these data. The table shows enhanced levels of lead at CH-1 and TD-2U, when compared with Point Reyes.

TABLE 3.32. Comparison of Concentrations of Lead Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. (Statistical analyses and sediment treatment groupings are performed on dry wt concentrations to reduce variation from water content.)

Sediment Treatment	Mean Concentration (µg/g wet wt)	Statistical Group[a]	Absolute Difference Compared with	
			Sequim Bay	Point Reyes
CH-2	0.40	A	0	-0.13
SN-1	0.38	AB	-0.02	-0.15
TD-2-U	0.38	ABC	-0.02	-0.15
SN-3-U	0.39	ABC	-0.01	-0.14
Sequim Bay	0.40	ABCD	0.0	-0.13
SN-2-L	0.53	BCDE	+0.13	0
TD-1-U	0.53	BCDE	+0.13	0
Point Reyes	0.53	CDE	+0.13	0
SN-2-U	0.58	DE	+0.18	+0.08
SN-3-L	0.67	DEF	+0.27	+0.14
TD-1-L	0.65	EF	+0.25	+0.12
CH-1	0.88	F	+0.35	+0.35
TD-2-L	0.92	F	+0.52	+0.39

(a) Sediment treatments with same statistical group are not significantly different from each other.

TABLE 3.33. Balanced One-Way ANOVA of the Natural Logarithm of Lead Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	3.6106	12	0.3009	17.858	0.0000
Within groups	0.4886	29	0.0168		
Total (corrected)	4.0993	41			

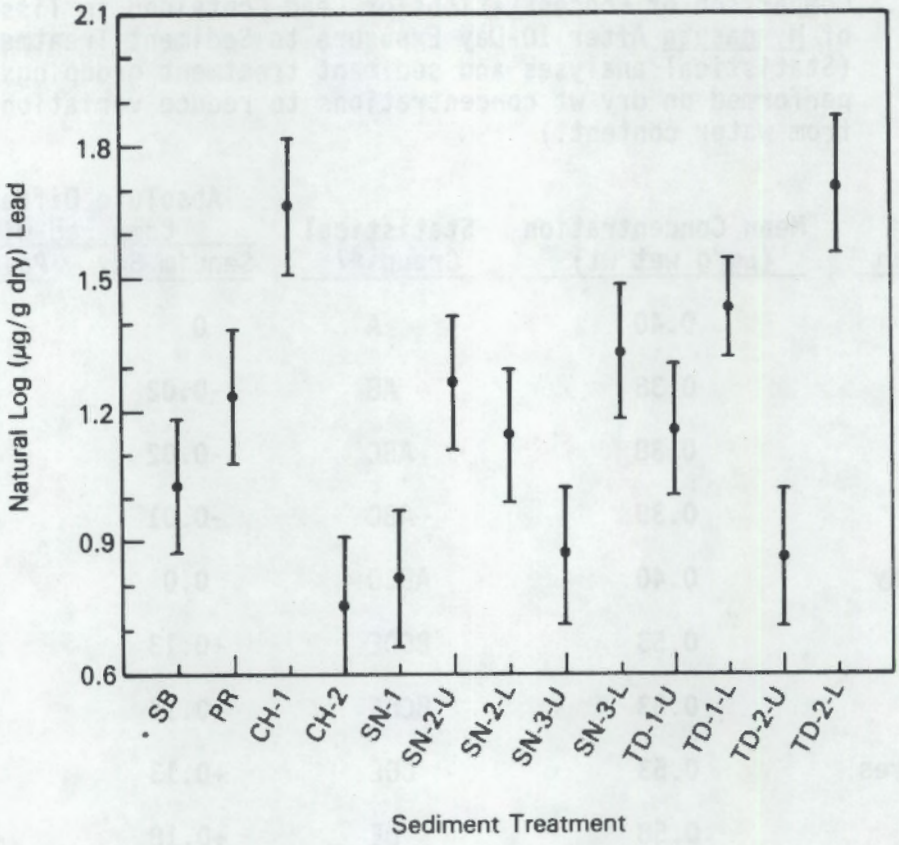


FIGURE 3.7. Natural Logarithm of Concentrations of Lead (µg/g dry wt) in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Mean concentrations of chromium contained in clam tissues (µg/g wet wt) ranged from 0.12 to 0.22 µg/g. Lowest concentrations occurred in Sediment Treatments CH-1, Point Reyes, Sequim Bay, CH-2, and SN-2-L. The highest concentration was present in the tissues of clams exposed to sediment from Sediment Treatment SN-3-L (Table 3.34). ANOVA showed significant differences between sediment treatments, and examination of the statistical groupings showed that bioaccumulation chromium levels at Sediment Treatment SN-3-L were higher than and statistically different from those at Point Reyes (Tables 3.34 and 3.35). Figure 3.8 presents the 95% confidence intervals of the natural logarithm of chromium concentration (µg/g dry wt) for these observations.

TABLE 3.34. Comparison of Concentrations of Chromium Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. (Statistical analyses and sediment treatment groupings are performed on dry wt concentrations to reduce variation from water content.)

Sediment Treatment	Mean Concentration (µg/g wet wt)	Statistical Group[a]	Absolute Difference Compared with	
			Sequim Bay	Point Reyes
CH-1	0.12	A	0	0
Point Reyes	0.12	AB	0	0
Sequim Bay	0.12	ABC	0	0
CH-2	0.13	ABC	+0.01	-0.01
SN-2-L	0.13	ABC	+0.01	+0.01
SN-1	0.15	ABC	+0.03	+0.03
TD-2-L	0.15	ABC	+0.03	+0.03
SN-2-U	0.16	ABC	+0.04	+0.04
SN-3-U	0.16	ABC	+0.04	+0.04
TD-1-U	0.17	ABC	+0.05	+0.05
TD-1-L	0.18	ABC	+0.06	+0.06
TD-2-U	0.18	BC	+0.06	+0.06
SN-3-L	0.22	C	+0.10	+0.10

(a) Sediment treatments with same statistical group are not significantly different from each other.

TABLE 3.35. Balanced One-Way ANOVA of the Natural Logarithm of Chromium Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	1.3879	12	0.1156	3.65	0.0021
Within groups	0.9194	29	0.0317		
Total (corrected)	2.3072	41			

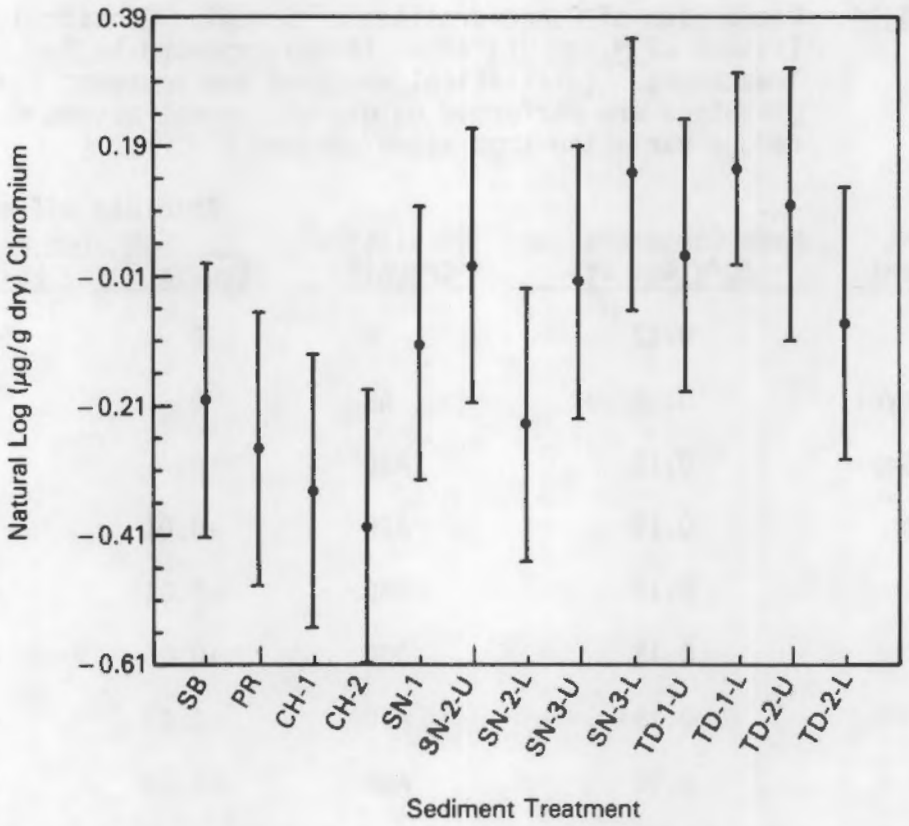


FIGURE 3.8. Natural Logarithm of Concentrations of Chromium (µg/g dry wt) in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Mercury contained in clam tissues (µg/g wet) had a very narrow range (0.01 to 0.02 µg/g) throughout the sediment treatments (Table 3.36). As a result, ANOVA showed no significant difference between sediment treatments (Table 3.37). Figure 3.9, shows the natural logarithm of mercury concentration in tissues (µg/g dry wt) for each sediment treatment.

3.4.2 Polynuclear Aromatic Hydrocarbons and Polychlorinated Biphenyls

Comparison of mean concentrations of total PAHs contained in tissues of M. nasuta showed non-detectable concentrations in Sediment Treatments Point Reyes, Sequim Bay, and TD-2-L, and a high of 353 µg/g (wet wt) in SN-3-L (Table 3.38).

TABLE 3.36. Comparison of Concentrations of Mercury Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. (Statistical analyses and sediment treatment groupings are performed on dry wt concentrations to reduce variation from water content.)

Sediment Treatment	Mean Concentration (µg/g wet wt)	Statistical Group[a]	Absolute Difference Compared with	
			Sequim Bay	Point Reyes
Sequim Bay	0.01	A	0	-0.01
CH-2	0.01	A	0	-0.01
SN-2-L	0.01	A	0	-0.01
SN-3-U	0.01	A	0	-0.01
SN-3-L	0.01	A	0	-0.01
TD-1-U	0.01	A	0	-0.01
TD-1-L	0.01	A	0	-0.01
Point Reyes	0.02	A	0.01	0
CH-1	0.02	A	0.01	0
SN-1	0.02	A	0.01	0
SN-2-U	0.02	A	0.01	0
TD-2-U	0.02	A	0.01	0
TD-2-L	0.02	A	0.01	0

(a) Sediment treatments with same statistical group are not significantly different from each other.

TABLE 3.37. Balanced One-Way ANOVA of the Natural Logarithm of Mercury Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	0.5407	12	0.4506	5.919	0.0000
Within groups	0.2208	29	0.0076		
Total (corrected)	0.7615	41			

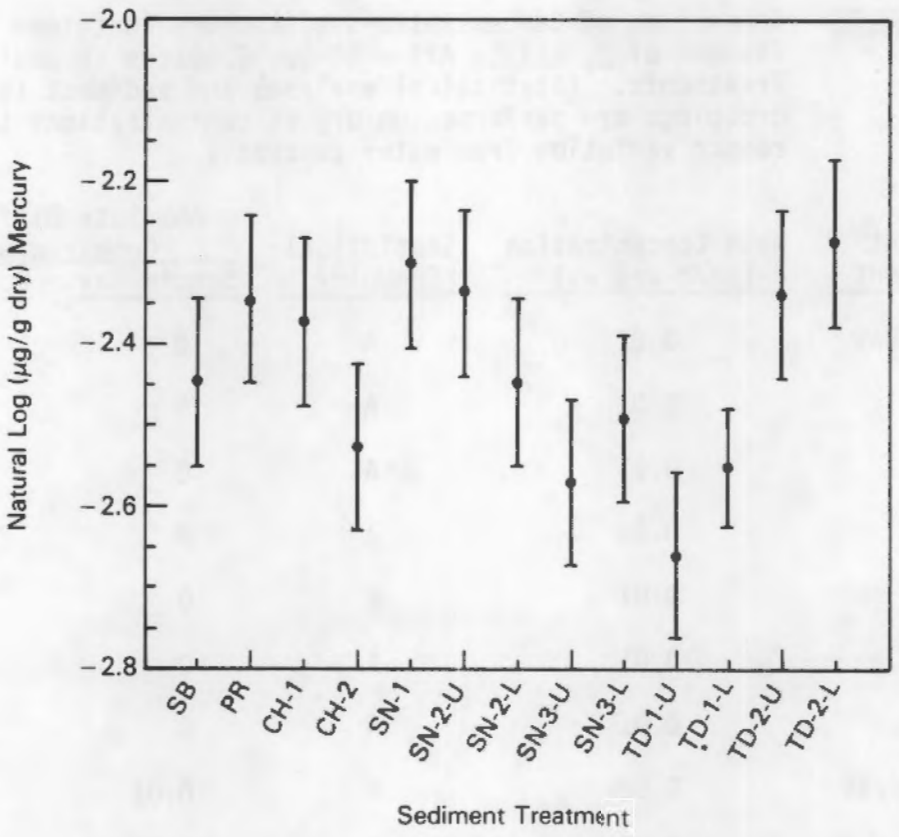


FIGURE 3.9. Natural Logarithm of Concentrations of Mercury (µg/g dry wt) in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

The only PCB detected in these tissues was Aroclor 1254. Aroclor concentrations were at detection limits in Sediment Treatments SN-2-L and TD-1-U, and slightly above detection limits in Sediment Treatments TD-1-Land TD-2-L (Appendix K). ANOVA of these data shows no significant differences among sediment treatments from high intra-replicate variation (Table 3.39 and Appendix K). Thus, all sediment treatments belong to the same statistical group. Figure 3.10 illustrates this lack of variation among sediment treatments.

The only pesticide detected in sediment was 4,4'DDE. Neither 4,4'DDE nor the other pesticides were found in tissue of M. nasuta.

TABLE 3.38. Comparison of the Concentrations of Total PAHs Contained in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments. (Statistical analyses and sediment treatment groupings are performed on dry wt concentrations to reduce variation from water content.)

Sediment Treatment	Mean Concentration (µg/g wet wt)	Statistical Group[a]	Absolute Difference Compared with	
			Sequim Bay	Point Reyes
Point Reyes	ND[b]	A	0	0
Sequim Bay	ND	A	0	0
TD-2-L	ND	A	0	0
CH-1	24.0	A	24.0	24.0
TD-1-U	29.3	A	29.3	29.3
CH-2	30.0	A	30.0	30.0
SN-3-U	36.6	A	36.6	36.6
TD-1-L	53.3	A	53.3	53.3
SN-1	76.6	A	76.6	76.6
TD-2-U	86.6	A	86.6	86.6
SN-2-L	103.1	A	103.1	103.1
SN-2-U	166.2	A	166.2	166.2
SN-3-L	353.0	A	353.0	353.0

(a) Sediment treatments with same statistical group are not significantly different from each other.
(b) Non-detectable concentration.

3.4.3 Organotins

Organotin concentrations were measured in M. nasuta tissues exposed to Sediment Treatments TD-1-U, TD-1-L, TD-2-U, TD-2-L, and CH-1. These concentrations were compared with those from Elkhorn Slough. Tissues from Elkhorn Slough are currently being analyzed by a number of laboratories as an intercalibration exercise. Analysis of organotin concentrations observed in

TABLE 3.39. Balanced One-Way ANOVA of the Natural Logarithm of PAH Concentrations in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

Source of Variation	Sum of Squares	d.f.	Mean Square	F-Ratio	Significance Level
Between groups	74.34220	12	6.1951837	1.004	0.4726
Within groups	160.46336	26	6.1716791		
Total (corrected)	234.80586	38			

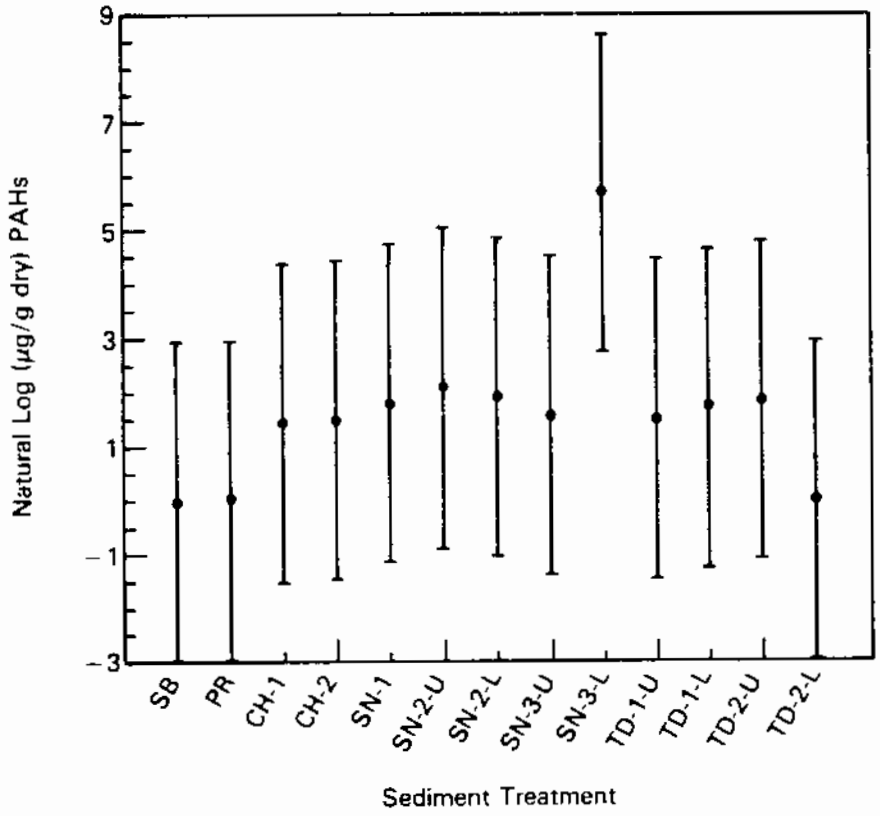


FIGURE 3.10. Natural Logarithm of Concentrations of PAHs (µg/kg dry wt) in Tissues of M. nasuta After 10-Day Exposure to Sediment Treatments

M. nasuta tissue after a 10-day exposure to test sediments shows that tributyltin concentrations ranged from 4.3 to 22.4 μg/kg (wet wt), dibutyltin concentrations ranged from 1.9 to 3.2 μg/kg (wet wt), and mono-butyltins ranged from non-detectable to 1.9 μg/kg (wet wt) in Oakland Inner Harbor sediment. Tri- and Di-butyltins were highest in tissues exposed to TD-1-U sediment, and lowest in tissues exposed to sediment from CH-1 (excluding the reference). Sediment Treatments TD-1-U, TD-1-L, TD-2-L and CH-1 were significantly different with respect to tributyltin concentrations when compared with the Elkhorn Slough reference. Sediment Treatments TD-1-U, TD-1-L, TD-2-U, and TD-2-L were statistically significantly different with respect to dibutyltin concentrations when compared with Sediment Treatment CH-1. No significant differences were noted for mono-butyltins (Table 3.40). This suggests that tri and di-butyltins are present and bioavailable at all five Oakland Harbor sediment treatments tested.

TABLE 3.40. Comparison of the Concentrations of Butyltins Contained in Tissues of M. nasuta After 10-Day Exposure to Selected Sediment Treatments

Sediment Treatment	Mean Concentrations (μg/kg wet wt) Tri	Di	Mono
TD-1-U	22.4[(a,b)] [(a,b)]	3.2[(a,b)]	ND[(c)]
TD-1-L	21.3	2.2[(a,b)]	0.06
TD-2-U	9.5[(a,b)]	2.6[(a,b)]	0.6
TD-2-L	10.6[(a,b)]	2.2[(a,b)]	1.9
CH-1	6.7[(a,b)]	1.9[(a,b)]	ND
Sequim Bay	4.3	1.0	ND
Significance level	0.013	4.5×10^{-3}	

(a) Sediment Treatments TD-1-U, TD-1-L, TD-2-U, TD-2-L, and CH-1 when compared with reference are significantly different.
(b) Sediment Treatments TD-1-U, TD-1-L, TD-2-U, TD-2-L when compared with CH-1 are significantly different.
(c) Non-detectable.

4.0 CONCLUSIONS

4.1 SUSPENDED PARTICULATE PHASE BIOASSAYS

The three species exposed to SPP concentrations prepared from test sediment showed different degrees of response to the five sediment treatments tested. The juvenile and larval forms [speckled sand dab (C. stigmaeus) and oyster (C. gigas)] were generally more sensitive indicators of contaminants than the more mature mysids. All three species showed some degree of response to Sediment Treatments SN-2-L, TD-2-U, and TD-2-L, although not all responses were statistically significant. The mass of suspended material present in water-only exposures and in 100% SPP from Sequim Bay and Sediment Treatment SN-2-L were 1.00, 69.33, and 12.00 mg/L, respectively. The mass of material did not influence the survival or development of the three species.

It was not possible to calculate EC50 concentrations for the speckled sand dab (C. stigmaeus) or mysid (A. sculpta) because 50% mortality was not observed for any sediment treatment. The EC50 concentrations were calculated from the oyster (C. gigas) larvae data, based on the proportion of abnormal larvae and the total abundance of larvae. The SPP concentration from Sediment Treatments TD-2-U, TD-2-L, and SN-2-L needed to produce 50% larval abnormality ranged from 42 to 62%, while the concentration of SPP needed to reduce the total abundance by 50% ranged from 72 to 88% (Table 4.1). These data indicate that sensitive bivalve larval forms may be affected if dredged-material disposal results in SPP concentrations in the water-column approaching these levels. These levels are not likely to occur, however, when the allowable mixing zone for dredged materials is considered.

4.2 SOLID PHASE BIOASSAYS

During the 10-day solid phase bioassays, four invertebrates were exposed to 18 test sediment treatments and two reference (uncontaminated) sediment treatments. The clams (M. nasuta), polychaetes (N. caecoides), and one species of amphipod (G. japonica) showed no statistical differences among test and reference sediment with respect to proportion surviving (Table 4.1).

TABLE 4.1 Conclusions of Confirmatory Sediment Analyses, SPP, and Solid Phase Bioassays

	Oakland Inner Harbor Channel Sediment Treatment										Turning Basin Sediment Treatment									
Test Type	1-1	1-2	1-3	2-1	2-2	3-1	3-2	CH-1	CH-2	CHC	SN-1	SN-2-U	SN-2-L	SN-3-U	SN-3-L	TD-1-U	TD-1-L	TD-2-U	TD-2-L	SB[a]
Supended Particulate Phase																				
A. sculpta survival(%)	--	--	--	--	--	--	--	--	--	80	--	80[c]	70[c]	--	--	--	--	83.3	67.7[c]	83.3
A. sculpta EC50	--	--	--	--	--	--	--	--	--	NA	--	NA	NA	--	--	--	--	NA	NA	NA
C. stigmaeus survival(%)	--	--	--	--	--	--	--	--	--	100	--	100	53.3	--	--	--	--	93.3	76.7[c]	100
C. stigmaeus EC50	--	--	--	--	--	--	--	--	--	NA	--	NA	NA	--	--	--	--	NA	NA	NA
C. gigas development(%)	--	--	--	--	--	--	--	--	--	95	--	66	3[c]	--	--	--	--	3[c]	0[c]	90
C. gigas EC50	--	--	--	--	--	--	--	--	--	NA	--	NA	42	--	--	--	--	62	40	NA
C. gigas survival(%)	--	--	--	--	--	--	--	--	--	96	--	43	33[c]	--	--	--	--	20[c]	25[c]	109
C. gigas EC50	--	--	--	--	--	--	--	--	--	NA	--	NA	72	--	--	--	--	78	88	NA
Solid Phase																				
M. nasuta survival	100	100	100	100	98	100	100	98	100	--	100	100	100	100	100	100	100	100	100	100
N. caecoides survival	87	93	88	88	93	88	93	95	100	--	82	95	93	97	78	80	90	92	77	93
R. abronius survival	84	78	70	74	74	65[c]	62[c]	79	69	--	77	70	76	76	64[c]	77	78	70	68[c]	82
G. japonica survival	66	80	66	66	72	66	62	82	62	--	66	56	48	62	42	66	52	66	56	68

TABLE 4.1 (contd)

Test Type	Oakland Inner Harbor Channel Sediment Treatment										Turning Basin Sediment Treatment									
	1-1	1-2	1-3	2-1	2-2	3-1	3-2	CH-1	CH-2	CHC	SN-1	SN-2-U	SN-2-L	SN-3-U	SN-3-L	TD-1-U	TD-1-L	TD-2-U	TD-2-L	SB[a]
Chemistry (dry wt)																				
DDE (µg/kg)	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1242 (µg/kg)	--	--	--	--	--	--	--	--	--	--	--	--	220[d]	--	--	--	--	--	--	--
Total Aroclor (µg/kg)	--	--	--	--	--	85J	--	60J	--	--	80J	280	780[d]	90J	110	450	490	140	670[d]	--
Total PAH (µg/kg)	794	833	873	1560	2750	2629	1756	3570	3310	--	2760	8275	15760[d]	7610	10660	5240	3940	8930	6107	ND
Total Phthalate (µg/kg)	240	340	480	400	370	740	265	660	1000	--	349	670	4890[d]	1370[d]	820	750	987	1330	1025	162
Fluoranthene (µg/kg)	140	160	170	300	510	450	280	450	500	--	450	1300[d]	2000[d]	750	1100	680	450	1200	690	ND
Tributlytin (µg/kg)	37	26	19	57	62	168	82	237	179	--	74	96	51	105	37	1601[d]	2214[d]	235	603	<10
Oil & Grease (µg/g)	29	ND	188	982[d]	536	676	384	805	400	--	265	751	740	755	308	504	1041[d]	499	782	604
Petroleum HC (µg/g)	ND	ND	107	73	188	190	65	360	ND	--	87	264	508[d]	239	244	400[d]	387	279	275	97
Water Soluble sulfides	52	54	96	54	21	86	96	53	96	--	160	107	535[d]	107	107	482[d]	374	108	374	128

TABLE 4.1 (contd)

Test Type	Oakland Inner Harbor Channel Sediment Treatment										Turning Basin Sediment Treatment									
	1-1	1-2	1-3	2-1	2-2	3-1	3-2	CH-1	CH-2	CHC	SN-1	SN-2-U	SN-2-L	SN-3-U	SN-3-L	TD-1-U	TD-1-L	TD-2-U	TD-2-L	SB[a]
Chemistry (dry wt) (contd)																				
Pb (µg/g)	34	28	25	42	46	59	43	55	55	--	68	90	141[d]	69	86	80	109[d]	79	90	17
Hg (µg/g)	0.35	0.33	0.35	0.47	0.51	0.58	0.44	0.51	0.57	--	0.66	0.78	1.48[d]	0.65	1.11	1.35[d]	1.06	0.97	1.8[c]	0.08
Cu (µg/g)	65	68	78	63	67	78	63	79	80	--	87	91	111	76	78	183[d]	179[d]	132	179	35
Bioaccumulation (wet wt)																				
Hg (µg/g)								0.01	0.01		0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.0
Cr (µg/g)								0.7			0.97	1.14	0.78	1.06	1.82	0.7	1.31	1.48	0.97	1.0
Pb (µg/g)								0.88[c]	0.40		0.38	0.58	0.53	0.39	0.67	0.53	0.65	0.38	0.92[c]	0.4
Tributyltin (µg/kg)								6.7								22.4[c]	21.3[c]	9.5[c]	10.6[c]	
Dibutyltin (µg/kg)								1.9								3.2[c]	2.2[c]	2.6[c]	2.2[c]	
Monobutyltin (µg/kg)								0								0	0.06	0.6	1.9	
PNA (µg/kg)								24	30		76	167	103	37	353	29	53	87	0	0
PCB (µg/g)								30U	30U		22J	23J	32	17J	25J	33	46	17	41	30U

(a) Sequim Bay reference sediment.
(b) Point Reyes reference sediment.
(c) Statistically significant.
(d) [max] + [next].
ND = Not detectable.
NA = Not applicable.

Only two clams died during the exposures, and the lowest percent survival of the polychaetes (N. caecoides) was 77% in Sediment Treatment TD-2-L.

The amphipod (G. japonica) did not meet the dual criteria of statistical significance and high reference survival. Therefore, these results must be regarded as data trends with less importance attached to the observations. The solid phase test involving the amphipod R. abronius was biologically valid (because of high survival in uncontaminated sediment) and demonstrated statistical and biological significance between the Point Reyes sediment and Sediment Treatments 3-2, SN-3-L, 3-1, and TD-2-L. Sediment Treatment TD-2-L was the only sediment that also had been tested in the SPP bioassay. No other sediment treatment was found to be significantly different in the solid phase tests. Of those sediment treatments found to be significantly different compared with Point Reyes or Sequim Bay, TD-2-L was the only sediment treatment common to both tests.

4.3 CHEMICAL TRENDS

Sediment Treatment SN-2-L contained the highest levels of Aroclors, PAHs, phthalates, petroleum hydrocarbons, water-soluble sulfides, lead, and mercury. Tributyltins were highest in Sediment Treatments TD-1-U and TD-1-L, and oil and grease attained maximum concentrations in Sediment Treatment 2-1. The pesticide DDE occurred in highest concentrations in sediment from Station 1-1, the outermost station in Oakland Inner Harbor (Table 4.1). General trends showed high organotin and copper concentrations in areas where ship-fitting and repair take place (TD-1 and TD-2). The highest PAH and related hydrocarbon concentrations occurred in Sediment Treatments SN-2-U, SN-3-U, and SN-3-L.

4.4 RELATIONSHIP OF CHEMISTRY TO BIOLOGICAL DATA

The lack of a simple relationship between measured chemical contamination and biological effects measured through the SPP and solid phase bioassays is not surprising. The biological effect of death or adverse response can be produced by a variety of mechanisms, and it is unlikely that an evaluation of sediment that may be contaminated by many different sources should reveal a

simple relationship. The biological observations made during these tests revealed that the SPP of the tested sediment has a relatively small effect. Significant mortalities were most obvious in the 100% SPP concentrations, and the only EC50s that could be calculated (for survival and abnormality of oyster larvae) revealed that diluting the SPP below concentrations of 40 to 70% (as would occur during disposal) did not result in acute population effects. The solid phase bioassays showed no significant differences between reference sediment for three of the four organisms tested. R. abronius, the interstitial-dwelling amphipod, was the only organism showing significant mortality in response to exposure to any of the sediment treatments. These four sediment treatments revealed, at most, a 30% increase in mortality compared with the Point Reyes reference sediment. Compared with the fine-grained sediment from Sequim Bay, a 20% increase, at most, was found in mortality. Significant effects were observed in Sediment Treatments 3-2, SN-3-L, 3-1, and TD-2-L. These results are statistically significant and, according to the implementation manual, are also biologically significant. However, the effects are relatively minor when compared with the results for the amphipod (R. abronius) at other locations in both California and Washington.

Initial statistical comparison of chemical concentrations to mortality or abnormality showed no obvious correlation of any one chemical contaminant with observed biological effects. Given spatial trends for chemicals present in Oakland Harbor, it appears that the biological effects seen in each of the SPP concentrations prepared from sediment treatments may be driven by different chemicals or mixes of chemicals. Sediment Treatment SN-2-L contained the highest concentrations of Aroclor, total PAHs, phthalates, petroleum hydrocarbons, and fluoranthene. Any or all of these substances could have been responsible for the minor biological effects seen in the SPP concentrations for this sediment treatment. Sediment Treatment SN-2-U contained much lower levels of the same chemicals, with the exception of comparable levels of fluoranthene. Elevated levels of Aroclor and copper were found in Sediment Treatments TD-2-U and TD-2-L compared with other sediment treatments. Both chemicals are toxic and may be responsible for the biological effects seen. Copper is also a component of anti-fouling paints used commonly in shipyards.

The high levels of organotins, also a component of anti-fouling paints, did not appear to have a major impact on any of the organisms exposed to Sediment Treatments TD-1-U and TD-1-L. Sediment Treatments SN-3-U and SN-3-L demonstrated a similar chemical pattern to that of SN-2-U and SN-2-L, in that both sediment treatments were high in total PAHs and phthalates. The reasons for amphipod toxicity in Sediment Treatments 3-1 and 3-2 are unclear because the chemical concentrations are similar to those of other sediment treatments. However, PAH levels in these areas seem to be elevated when compared with Sediment Treatments 1-1, 1-2, 1-3, and 2-1 (Table 4.1).

4.5 BIOACCUMULATION

4.5.1 Metals

Because some of the M. nasuta tissue samples in test sediment contained concentrations of metals above those observed in Point Reyes tissue, ANOVA was performed to determine statistical significance. Based on the results of ANOVA, lead and chromium were bioaccumulated in tissues of M. nasuta in statistically significant quantities when compared with tissues exposed to Point Reyes sediment. Lead was significantly elevated in Sediment Treatments CH-1 and TD-2-L, while chromium was significantly elevated in Sediment Treatment SN-3-L. Mercury concentrations in clam tissues were not significantly elevated above tissues exposed to Point Reyes sediment. Under implementation manual guidelines (Appendix G) we have concluded that a potential exists for bioaccumulation of lead in Sediment Treatments CH-1 and TD-2-L, and for bioaccumulation of chromium in Sediment Treatment SN-3-L. This conclusion is based on the 10-day exposure of clams to sediment collected from those sites during one field sampling.

4.5.2 Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbon concentrations in tissues of clams exposed to test sediment exceeded the concentrations found in tissues exposed to Point Reyes sediment. ANOVA was performed, as stated in the implementation manual, and the results showed no significant differences in the concentration

of PAHs in test tissues versus tissues from the Point Reyes exposure. This lack of statistical significance was the result of high intra-replicate variability, which is unexplained to date.

4.5.3 Organotins

Organotin concentrations in clam tissues were significantly elevated in all sediment tested. Two types of ANOVA were performed. The first compared the organotin concentrations in test sediment to an Elkhorn Slough reference, the second compared the organotin concentrations in Sediment Treatments TD-1-L, TD-1-U, TD-2-U, and TD-2-L to concentrations in CH-1. Tissue samples for Elkhorn Slough are currently being analyzed for organotins by several laboratories as an intercalibration exercise. Organotin concentrations for these tissues compared well with intercalibration values reported so far. The results of ANOVA showed that tri- and mono-butyltins in all sediment treatments were significantly bioaccumulated compared with the Elkhorn Slough reference, and tri- and di-butyltins were significantly bioaccumulated in Sediment Treatments TD-1 and TD-2 compared with CH-1. Monobutyltins in TD-1 and TD-2 were slightly higher than in the Elkhorn Slough and in CH-1, but were not statistically significant.

The results of these analysis indicate that, based on ANOVA, potential exists for bioaccumulation of tri- and di-butyltins in the tissues of M. nasuta. The potential for marine toxicity and human health effects is not known at this time, as few data concerning these phenomena are currently available.

5.0 REFERENCES

American Public Health Association (APHA). 1985. Standard Methods for the Examination of Water and Wastewater. 16th ed. American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF) Washington, D.C. p. 1268.

American Society for Testing and Materials (ASTM). 1980a. Standard Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians. E729-80, American Society for Testing and Materials, Philadelphia, Pennsylvania. pp. 272-295.

American Society for Testing and Materials (ASTM). 1980b. Standard Practice for Conducting Static Acute Toxicity Tests with Larvae of Four Species of Bivalve Molluscs. E724-80. American Society for Testing and Materials, Philadelphia, Pennsylvania.

Bloom, N. S., and E. A. Crecelius. 1983. "Determination of Mercury in Seawater at Nub-Nanogram per Liter Levels." Mar. Chem. 14:49-59.

Couch, J. A. 1975. "Histopathological Effects of Pesticides and Related Chemicals on the Livers of Fishes." In Pathology of Fishes. Eds. Ribelin and Migaki. University of Wisconsin Press. pp. 559-584.

Dupuy, J. L., N. T. Windsor, and C. E. Sutton. 1977. Manual for Design and Operation of an Oyster Seed Hatchery. Special Report No. 142 in Applied Marine Science and Ocean Engineering, Virginia Institute of Marine Science. Gloucester Point, Virginia.

Federal Register. 1977. "Ocean Dumping. Final Revisions of Regulations." Fed. Reg. Part VI, Vol. 42, No. 7.

Finney, D. J. 1971. Probit Analysis. Third ed., Cambridge University Press, Cambridge.

Green, E. J., and D. Schnitker. 1974. "The Direct Titration of Water-Soluble Sulfide in Estuarine Muds of Montsweag Bay, Maine." Marine Chem. 2:111-124.

Krauskopf, K. 1967. Introduction to Geochemistry. McGraw-Hill International Series in the Earth and Planetary Sciences, McGraw-Hill, New York. p. 721.

Marine Bioassay Laboratories (MBL). 1987. Bioassay/Bioaccumulation Assessment for Proposed Disposal of Dredged Material from Oakland Inner, Oakland Outer and Richmond Inner Harbors. Final Report. Prepared for the San Francisco District, U.S. Army Corps of Engineers, San Francisco, California.

Nielson, K. K., and R. W. Sanders. 1983. "Multielement Analysis of Unweighed Biological and Geological Samples Using Backscatter and Fundamental Parameters." Adv. in X-ray Anal. 26:385-390.

Puget Sound Estuary Program (PSEP). 1986. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Prepared by Tetra-Tech, Inc. for the Puget Sound Estuary Program. Volumes 1 and 2, Bellevue, Washington.

Standard Methods. 1975. Standard Methods for the Examination of Water and Wastewater. 14th ed. American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF). Washington, D.C. p. 1193.

Steel, R. G. D., and J. H. Torrie. 1980. Principles and Procedures of Statistics. A Biometrical Approach. McGraw-Hill, New York.

Unger, M. A., and W. G. MacIntyre, J. Greaves and R. J. Huggett. 1986. "GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation." Chemosphere 15(4):461-470.

U.S. Environmental Protection Agency (EPA). 1976. Bioassay Procedures for the Ocean Disposal Permit Program. EPA-600/9-76-010. Environmental Research Laboratory, Office of Research and Development, Gulf Breeze, Florida.

U.S. Environmental Protection Agency (EPA). 1978. Bioassay Procedures for the Ocean Disposal Permit Program. EPA-600/9-78-10. Environmental Research Laboratory, Office of Research and Development, Gulf Breeze, Florida.

U.S. Environmental Protection Agency (EPA). 1979. Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency. EPA-600 4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA-955-001-00000. U.S. Environmental Protection Agency, Government Printing Office, Washington, D.C.

U.S. Environmental Protection AGency (EPA). 1988. Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses. Prepared for the Hazardous Site Evaluation Oivision. USEPA Data Review Work Group. R-582-5-5-01. U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material (EPA/USACE). 1977. Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters: Implementation Manual for Section 103 of Public Law 92-532 (Marine Protection, Research, and Sanctuaries Act of 1972). Environmental Effects Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Word, J. Q., W. H. Pearson, J. R. Skalski, J. M. Gurtisen, R. B. Lucke and J. A. Strand. 1987. Reconnaissance of Petroleum Contamination from the ARCO ANCHORAGE Oil Spill at Port Angeles, Washington, and Its Influence on Selected Areas of the Strait of Juan de Fuca. Prepared for ARCO Marine, Inc., by Battelle/Marine Research Laboratory, Sequim, Washington.

Zar, J. H. 1974. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. 620 pp.

APPENDIX A

FIELD COLLECTION NOTES AND INFORMATION

TABLE A.1. Summary of Samples and Positions for Oakland Inner Harbor Dredged-Sediment Evaluation Cruise (R/V Prophecy 21-27 March 1988).

Sediment Treatment	Date Time (PST)	California State Coordinates	Water Depth[a] (ft)	Maximum Core Penetration Depth (ft)	Core Diameter (in.)	Reps	Comments
1-1	23 March 88 1205	N478921 E1469588	30.9	36.2	2.63	2	Oakland Outer Harbor, most westerly station. 9.8 L collected
1-1	24 March 88 0920	N478839 E1469576	32.0	37.7	2.63	2	Sediment; silty upper layer to 1 ft; compacted, black, lower layers. 9.7 L collected
1-2	23 March 88 1325	N478105 E1470283	33.3	38.1	2.63	2	10.25 L collected
1-2	24 March 88 0955	N478092 E1470038	32.3	37.5	2.63	2	Sediment; silty upper layers, dense clay lower layers. 9.8 L collected
1-3	23 March 88 1415	N477349 E1472590	37.0	42.8	2.63	2	10.8 L collected
1-3	24 March 88 1030	N477303 E1472548	36.0	42.0	2.63	2	Sediment; silty upper layers; compacted, black, lower layers. 11.7 L collected
2-1	23 March 88 1520	N476141 E1476690	35.9	38.2	2.63	4	Located in vicinity of sewer-line crossing on north shore. 7.5 L collected
2-1	24 March 88 1105	N476091 E1476794	37.2	39.2	2.63	5	Sediment; silty upper layers, dense lower layers. 8 L collected

TABLE A.1. (contd)

Sediment Treatment	Date Time (PST)	California State Coordinates	Water Depth[a] (ft)	Maximum Core Penetration Depth (ft)	Core Diameter (in.)	Reps	Comments
2-2	21 March 88 1045	N475868 E1481880	31.1	35.8	2.63	3	Located in vicinity of Moore's building on north side of harbor. 12.8 L collected
2-2	24 March 88 1500	N475852 E1481869	32.3	34.0	3.50	1	Sediment; silty upper layer, densely compacted clay, lower layer. 3.5 L collected
2-2	25 March 88 0925	N475860 E1481829	31.1	34.3	3.50	1	6.5 L collected
3-1	21 March 88 1206	N475919 E1482234	32.2	37.7	2.63	2	Directly off Moore's building; dense bottom sediments limiting corer penetration. 10.8 L collected
3-1	25 March 88 1035	N475892 E1482204	31.7	37.3	3.50	1	Sediment; silty upper layer, densely compacted lower layer. 11.1 L collected
3-2	21 March 88 1305	N475679 E1482432	35.8	40.6	2.63	3	Located in center of channel off Moore's building. 12.3 L collected
3-2	25 March 88 0955	N475670 E1482309	34.8	40.4	3.50	1	11 L collected
CH-1	22 March 88 1045	N475711 E1483182	36.8	39.1	2.63	5	8.1 L collected

TABLE A.1. (contd)

Sediment Treatment	Date Time (PST)	California State Coordinates	Water Depth[a] (ft)	Maximum Core Penetration Depth (ft)	Core Diameter (in.)	Reps	Comments
CH-1[b]	25 March 88 1500	N475646 E1483106	36.8	39.3 39.7	2.63 2.63	3 11	Densely compacted lower layer. 6.5 and 24.4 L collected
CH-1[b]	26 March 88 0920	N475593 E1483078	38.1	40.3	2.63	4	6 L collected
CH-2	22 March 88 1420	N475689 E1483707	36.6	38.8	2.63	5	Located south of center of channel, directly off western-most crane. 8 L collected
CH-2	25 March 88 1430	N475713 E1483748	37.6	39.3	2.63	4	Sediment; fine silty surface, dense lower layers. Patchy sediment density. 6.4 L collected. Patchy sediment density
CH-2[b]	27 March 88 1040	N475723 E1483694	36.8	39.6	2.63	19	Large diameter corer resulted in very poor penetration. 31.2 L collected
SN-1	21 March 88 1541	N476187 E1483037	29.4	36.0	2.63	2	Located on north side of channel, east of Moore's building. 12.9 L collected
SN-1	24 March 88 1615	N476168 E1483011	31.0	38.0	3.50	1	Sediment; silty upper layer, dense lower layer. 14 L collected
SN-2 (U and L)[c]	22 March 88 0910	N476368 E1483259	31.1	37.8	2.63	4	Located in center of channel. 19 L collected

TABLE A.1. (contd)

Sediment Treatment	Date Time (PST)	California State Coordinates	Water Depth[a] (ft)	Maximum Core Penetration Depth (ft)	Core Diameter (in.)	Reps	Comments
SN-2 (U and L)	24 March 88 1640	N476424 E1483259	31.9	39.1	3.50	1	Sediment; brown silty surface layer; black, dense lower layers. 14.5 L collected
SN-2 (U and L)	26 March 88 1415	N476380 E1483276	30.7	37.1	3.50	10	121 L collected
SN-2A[d]	22 March 88 1215	N476154 E1483373	37.2	39.7	2.63	1	Located on north side of harbor; sample is archived at Battelle-Northwest. 2.4 L collected
SN-3 (U and L)	21 March 88 1320	N476331 E1483613	35.8	41.1	2.63	2	10.3 L collected
SN-3 (U and L)	22 March 88 1325	N476240 E1483622	36.7	42.5	2.63	2	10.8 L collected
SN-3 (U and L)	25 March 88 0850	N476318 E1483601	35.7	41.3	3.50	2	Silty upper layers, densely compacted lower layers. 20.5 L collected
TD-1 (U and L)	22 March 88 1205	N475406 E1483287	26.5	29.3	2.63	6	South side of channel across from Schnitzer Steel dock; tug activity may have blown away upper sediment layers. 12 L collected
TD-1	25 March 88 1115	N475377 E1483273	25.1	27.3	3.50	3	Silty upper layers, (U and L) hard-packed clay lower layers. 12.5 L collected

TABLE A.1. (contd)

Sediment Treatment	Date Time (PST)	California State Coordinates	Water Depth[a] (ft)	Maximum Core Penetration Depth (ft)	Core Diameter (in.)	Reps	Comments
TD-1A	22 March 88 1205	N475510 E1483589	31.3	36.3	2.63	1	Located on south side of channel, west of third crane; archived sample. 5 L collected
TD-2 (U and L)	22 March 88 1535	N475446 E1483615	26.1	32.8	2.63	3	Located on south side of channel, across from western-most crane. 16.7 L collected
TD-2 (U and L)	25 March 88 1345	N475417 E1483608	25.2	31.3	3.50	1	12.2 L collected
TD-2 (U and L)	26 March 88 1010	N475471 E1483514	26.2	31.6	3.50	14	126 L collected

(a) Depth corrected for mean lower low water (MLLW).
(b) Denotes days when Sediment Treatments CH-1 and CH-2 were sampled to provide sediment for CH-C composite for the suspended-particulate-phase bioassays.
(c) (U and L) denotes cores split into equal halves for upper and lower sediment treatments.
(d) A denotes archived samples.

TABLE A.2. Summary of Samples and Positions for Point Reyes Reference Sediment Collection Cruise (M/V Sea King 31 March-1 April 1988)

Dredge Replicate	Date and Time (PST)	Latitude Longitude	LORAN Time Delays	Comments
1	31 March 88 1823	37°52.53'N 123°07.40'W	27100.9 43225.6	Discarded. Sampler one-third full
2	31 March 88 1852	37°52.60'N 123°04.36'W	27101.2 43225.0	Yield 1.5 qt. Fine sand and mud
3	31 March 88 1933	37°53.18'N 123°06.85'W	27101.3 43215.4	Yield 16 qt
4	31 March 88 2000	37°51.27'N 123°03.24'W	27100.9 43215.4	Yield 10 qt. Installed 1-ton Miller swivel on dredge between lead chain and bridle to eliminate twisting
5	31 March 88 2037	37°50.70'N 123°01.87'W	27101.2 43214.7	Yield 2.5 qt
6	31 March 88 2100	37°50.76'N 123°04.44'W	27101.4 43224.1	Moving astern while hauling back keeps sampler full
7	31 March 88 2116	37°50.70'N 123°01.30'W	27101.0 43224.9	
8	31 March 88 2131	37°50.64'N 123°01.16'W	27101.1 43224.2	Yield 24 qt
9	31 March 88 2145	37°52.05'N 123°59.86'W	27101.2 43215.0	
10	31 March 88 2201	37°52.29'N 123°59.48'W	27100.8 43225.0	
11	31 March 88 2218	37°52.55'N 123°59.07'W	27100.9 43224.5	
12	31 March 88 2235	37°51.19'N 123°02.34'W	27101.4 43225.3	Cumulative yield 40 gal
13	31 March 88 2334	37°50.57'N 123°02.45'W	27100.9 43224.8	
14	31 March 88 2350	37°50.44'N 123°02.66'W	27101.8 43223.8	

TABLE A.2. (contd)

Dredge Replicate	Date and Time (PST)	Latitude Longitude	LORAN Time Delays	Comments
15	1 April 88 0006	37°50.30'N 123°02.88'W	27100.9 43224.5	Swell 4-6 ft
16	1 April 88 0023	37°50.80'N 123°01.86'W	27100.7 43224.4	Wind direction changed; positioning difficult because of strong winds
17	1 April 88	37°49.73'N 123°03.27'W	27101.1 43224.8	Sampling gear "two-blocked" during last retrieval; davit destroyed. Towing pins used as fairlead and dredge hand-lifted aboard
18	1 April 88	37°51.05'N 122°59.47'W	27101.8 43226.4	Some sample loss during dredge recovery
19	1 April 88	37°51.16'N 122°59.47'W	27101.8 43224.4	Cable caught in port towing pin during pin retraction. Some sample loss
20	1 April 88	37°51.29'N 122°58.85'W	27100.6 43225.4	Final sample; some loss during retrieval. Total cumulative yield estimated at 90 gal.

TABLE A.3. Summary of Samples and Positions for Sequim Bay Sediment Collection Cruise (27 March and 4 April 1988)

Dredge Replicate	Date and Time (PST)	Latitude Longitude	Comments
1	27 March 1988 0800 to 1300	48°03.70'N 123°01.50'W	Yield 5 gal
2	4 April 1988 0900 to 1300	48°03.70'N 123°01.50'W	Yield 7.5 gal

TABLE A.4. Specimen Collection Information

Species	Location	Coordinates	
Nephtys caecoides[a]	Tomales Bay, California	38°13'50"N	122°57'40"W
Citharichthys stigmaeus[a]	Tomales Bay, California	38°13'40"N	122°58'15"W
Acanthomysis sculpta[a]	Monterey Bay, California	36°37'12"N	121°54'00"W
Grandidierella japonica[a]	San Francisco Bay, California	37°50'48"N	122°20'52"W
Rhepoxynius abronius	West Beach, Washington	48°23'50"N	122°40'00"W
Crassostrea gigas	Local hatchery, Washington		
Macoma nasuta	Discovery Bay, Washington	48°02'48"N	123°50'00"W
Macoma nasuta	Sequim Bay, Washington	48°03'48"N	123°00'15"W
		48°03'17"N	123°00'38"W
		48°02'37"N	123°01'35"W

(a) Collected and supplied to MSL by Brezina and Associates, P.O. Box 25, Dillon Beach, California 94929.

APPENDIX B

SEDIMENT COMPOSITING INFORMATION

TABLE B.1. Sediment Compositing Information

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-(3-1)	3-1	2 1/4	13.0	SILTY CLAY	DARK GRAY	MED/LOOSE PASTE	
870326-(3-1)	3-1	2 2/4	15.0	SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-1)	3-1	2 3/4	18.0	CLAY	DARK GRAY	FIRM/THICK PASTE	
870326-(3-1)	3-1	2 4/4	17.0	CLAY	MED/LT GRAY	SOLID PACK	
870326-(3-1)	3-1	3 1/4	12.0	SILTY CLAY	MED GRAY	MED PASTE	
870326-(3-1)	3-1	3 2/4	14.5	LT SAND/SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-1)	3-1	3 3/4	9.5	MED SAND/SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-1)	3-1	3 4/4	14.5	LT SAND/SILTY CLAY/CLAY	MED/DARK GRAY	THICK PASTE/SOLID PACK	
870326-(3-2)	3-2	1 1/3	11.0	SILTY CLAY	DARK GRAY	LOOSE PASTE	
870326-(3-2)	3-2	1 2/3	11.0	SILTY CLAY	DARK GRAY	LOOSE PASTE	
870326-(3-2)	3-2	1 3/3	14.5	SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-2)	3-2	2 1/3	17.0	SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-2)	3-2	2 2/3	15.0	SILTY CLAY	DARK GRAY	MED PASTE	
870326-(3-2)	3-2	2 3/3	17.0	SILTY CLAY	DARK GRAY	HEAVY PASTE	
870326-(3-2)	3-2	3 1/4	17.0	SILTY CLAY	DARK GRAY	LOOSE PASTE	
870326-(3-2)	3-2	3 2/4	15.5	LT SAND/SILTY CLAY	DARK GRAY	LOOSE PASTE	
870326-(3-2)	3-2	3 3/4	12.0	LT SAND/SILTY CLAY	DARK GRAY	MED/HEAVY PASTE	
870326-(3-2)	3-2	3 4/4	13.0	CLAY	DARK GRAY	HEAVY PASTE/SOLID PACK	
870326-(SN-1)	SN-1	1 1/5	15.0	SILTY CLAY	DK GRAY/BLUE-GREEN	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	1 2/5	15.5	SILTY CLAY	DK GRAY/BLUE-GREEN	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	1 3/5	15.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	1 4/5	15.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	1 5/5	16.0	SANDY SILT/CLAY	DK GRAY	MED PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	2 1/5	15.0	SILTY CLAY	DK GRAY	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	2 2/5	15.0	SILYY CLAY	DK GRAY/OLIVE-GREEN	LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	2 3/5	15.0	SILTY CLAY	DK GRAY	MED/LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	2 4/5	15.0	SILTY CLAY	DK GRAY	MED/LOOSE PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-1)	SN-1	2 5/5	16.5	SILTY CLAY	DK GRAY	THICK PASTE	SLIGHT PETROLEUM ODOR
870326-(SN-3-U)	SN-3A	1 1/5	15.0	LT SAND/SILTY CLAY	OLIVE GREEN/DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3A	1 2/5	15.0	LT SAND/SILTY CLAY	OLIVE GREEN/DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3A	2 1/4	15.0	SILTY CLAY	DK GRAY	LOOSE PASTE	

TABLE B.1. (contd)

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-(SN-3-U)	SN-3A	2 2/4	15.0	SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	1 1/4	15.0	SANDY SILT/CLAY	DK GRAY	LOOSE GRANULAR PASTE	
870326-(SN-3-U)	SN-3	1 2/4	15.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	2 1/4	15.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	2 2/4	15.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	4 1/3	13.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	4 2/3	10.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-3-U)	SN-3	4 3/3	10.0	LT SAND/SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(SN-2-L)	SN-2-L	1 1/3	14.0	CLAY	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	1 2/3	11.0	CLAY	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	1 3/3	13.0	CLAY	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	2 1/2	12.0	CLAY/SILT	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	2 2/2	11.0	CLAY/SILT	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	3 1/2	11.0	CLAY/SILT	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	3 2/2	13.5	CLAY/SILT	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	4 1/2	11.0	CLAY/SILT	GRAY	THICK PASTE	
870326-(SN-2-L)	SN-2-L	4 2/2	15.0	SILT/SILT SAND	GRAY	THICK PASTE	
870326-(SN-3-L)	SN3	1 3/4	16.0	CLAY	GRAY	THIN PASTE	
870326-(SN-3-L)	SN3	1 4/4	18.0	SAND, SOME SILT	GRAY/OLIVE	THIN PASTE	
870326-(SN-3-L)	SN3	2 3/4	16.0	CLAY (CHUNKS)	GRAY	MED PASTE	
870326-(SN-3-L)	SN3	2 4/4	17.0	CLAY/ SAND AT BOTTOM	GRAY	MED PASTE	
870326-(SN-3-L)	SN3-L	4 2/3	9.0	CLAY W/ SAND MIXED	GRAY	MED PASTE	
870326-(SN-3-L)	SN3-L	4 3/3	12.0	CLAY	GRAY	MED PASTE	
870326-(SN-3-L)	SN3-L	5 1/2	11.0	CLAY	GRAY	MED PASTE	
870326-(SN-3-L)	SN3-L	5 2/2	14.5	CLAY/MED SAND AT BOTTOM	GRAY	MED PASTE	
870326-(SN-2-U)	SN-2-U	1 1/3	14.5	SILT/SAND	LT GRAY	THIN PASTE	
870326-(SN-2-U)	SN-2-U	1 2/3	11.5	SILT	LT GRAY/OLIVE	MED PASTE	
870326-(SN-2-U)	SN-2-U	1 3/3	12.0	SILT	LT GRAY/OLIVE	MED PASTE	
870326-(SN-2-U)	SN-2-U	2 1/2	11.0	SILT/SAND	LT GRAY/OLIVE	MED PASTE	PETROLEUM ODOR
870326-(SN-2-U)	SN-2-U	2 2/2	10.5	SILT, LT SAND	LT GRAY/OLIVE	MED PASTE	
870326-(SN-2-U)	SN-2-U	3 1/2	12.0	SILT, LT SAND	DK GRAY/OLIVE	MED PASTE	

TABLE B.1. (contd)

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-(SW-2-U)	SW-2-U	3 2/2	11.0	SILT, LT SAND	LT GRAY/OLIVE	MED/HARD PASTE	PETROLEUM ODOR
870326-(SW-2-U)	SW-2-U	4 1/2	13.0	SILT, LT SAND	LT GRAY/OLIVE	MED PASTE	
870326-(SW-2-U)	SW-2-U	4 2/2	10.0	SILT, LT SAND	LT GRAY/OLIVE	MED PASTE	
870326-(TD-2-L)	TD-2-L	1 1/3	10.0	LT SAND/SILTY CLAY	DARK GRAY	LOOSE PASTE	
870326-(TD-2-L)	TD-2-L	1 2/3	9.5	SANDY SILT/CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	1 3/3	14.0	SANDY SILT/CLAY	DARK GRAY	THICK PASTE	
870326-(TD-2-L)	TD-2-L	2 1/3	14.0	LT SAND/SILTY CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	2 2/3	14.0	LT SAND/SILTY CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	2 3/3	13.0	LT SAND/SILTY CLAY	DARK GRAY	HEAVY PASTE	
870326-(TD-2-L)	TD-2-L	3 1/1	21.0	LT SAND/SILTY CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	4 1/3	15.0	SANDY SILT/CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	4 2/3	10.0	SANDY SILT/CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-L)	TD-2-L	4 3/3	13.0	SILTY CLAY	DARK GRAY	MED PASTE	
870326-(TD-2-U)	TD-2-U	1 1/3	11.5	SILT	LT GRAY/OLIVE	THIN PASTE	
870326-(TD-2-U)	TD-2-U	1 2/3	11.0	SILT	LT GRAY/OLIVE	MED PASTE	
870326-(TD-2-U)	TD-2-U	1 3/3	13.5	SAND SILT	LT GRAY/OLIVE	MED PASTE	
870326-(TD-2-U)	TD-2-U	2 1/3	15.0	SILT/LT SAND	GRAY/OLIVE	THIN PASTE	
870326-(TD-2-U)	TD-2-U	2 2/3	12.0	SILT/LT SAND	GRAY/OLIVE	MED PASTE	
870326-(TD-2-U)	TD-2-U	2 3/3	11.0	SILT/LT SAND	GRAY/OLIVE	MED PASTE	
870326-(TD-2-U)	TD-2-U	3 1/1	18.0	SILT/LT SAND	LT GRAY/OLIVE	THIN PASTE	H_2S ODOR
870326-(TD-2-U)	TD-2-U	4 1/3	12.0	SILT	LT GRAY/OLIVE	VERY RUNNY PASTE	
870326-(TD-2-U)	TD-2-U	4 2/3	13.0	SILT	LT GRAY	MED PASTE	
870326-(TD-2-U)	TD-2-U	4 3/3	12.0	SILT SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	1 1/2	7.5	SILT W/ SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	1 2/2	9.0	SILT W/ SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	2 1/1	9.5	LT SAND	GRAY	THICK PASTE	
870326-(TD-1-L)	TD-1-L	3 1/1	9.5	SILT W/ LT SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	4 1/1	11.0	SILT W/ LT SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	5 1/1	10.5	SILT/LT SAND	LT GRAY	MED PASTE	CHUNKS OF SHELL
870326-(TD-1-L)	TD-1-L	6 1/1	7.5	SILT/LT SAND	LT GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	7 1/1	5.5	ALL SAND	GOLDEN, PATCHES OF BLACK		H_2S ODOR

TABLE B.1. (contd)

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-(TD-1-L)	TD-1-L	8 1/1	12.5	SILT W/ SAND	GRAY	MED PASTE	
870326-(TD-1-L)	TD-1-L	9 1/1	14.5	SAND AND SILT (PATCHY)	GRAY	MED PASTE	
870326-(1-3)	1-3	1 1/4	15.0	SILT/LT SAND	LT GRAY/OLIVE	THIN PASTE	
870326-(1-3)	1-3	1 2/4	13.0	SILT	LT GRAY/OLIVE	THICK PASTE	BLACK ANAEROBIC PATCH
870326-(1-3)	1-3	1 3/4	15.0	SILTY	MED/LT GRAY/OLIVE	THICK PASTE	PETROLEUM AND SULFUR ODOR
870326-(1-3)	1-3	1 4/4	17.0	SILTY	LT GRAY/OLIVE	THICK PASTE	
870326-(1-3)	1-3	2 1/5	15.0	SILT/SAND	LT GRAY/OLIVE	THIN PASTE	
870326-(1-3)	1-3	2 2/5	14.0	SILT	LT GRAY/OLIVE	MED PASTE	
870326-(1-3)	1-3	2 3/5	14.5	SILT	LT GRAY/OLIVE	THICK PASTE	
870326-(1-3)	1-3	2 4/5	12.0	SILTY	LT-MED GRAY	THICK PASTE	
870326-(1-3)	1-3	2 5/5	14.0	SILT	LT-MED GRAY/OLIVE	THICK-THICK PASTE	
870326-(1-3)	1-3	3 1/5	15.0	SILT/SAND	LT GRAY/OLIVE	MED PASTE	
870326-(TD-1-U)	TD-1-U	1 1/2	8.0	SANDY/SILT CLAY	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	1 2/2	8.5	SANDY/SILT CLAY	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	2 1/1	7.0	SILTY CLAY	OLIVE/DRK GRAY	LOOSE PASTE	
870326-(TD-1-U)	TD-1-U	3 1/1	7.5	LT SAND/SILTY CLAY/ROCK	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	4 1/1	12.0	LT SAND/SILTY CLAY/ROCK	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	5 1/1	9.0	SILTY CLAY	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	6 1/1	6.0	LIGHT SAND/SILTY CLAY	DRK GRAY	MED PASTE	
870326-(TD-1-U)	TD-1-U	7 1/1	17.0	SILTY CLAY	DRK GRAY	LOOSE PASTE	
870326-(TD-1-U)	TD-1-U	8 1/1	10.5	SILTY CLAY	DRK GRAY	LOOSE PASTE	
870326-(TD-1-U)	TD-1-U	9 1/1	12.0	SILTY CLAY	DRK GRAY	LOOSE PASTE	
870326-CH-1	CH-1	1 1/2	8.0	FINE SAND AND SILT	GRAY	PASTE(GRAINY)	
870326-CH-1	CH-1	1 2/2	9.0	SILT/SLIGHT SAND	GRAY	PASTE	
870326-CH-1	CH-1	2 1/2	14.5	SILT/SLIGHT SAND	GRAY	PASTE	
870326-CH-1	CH-1	2 2/2	12.5	SILT/SLIGHT SAND	GRAY	PASTE	
870326-CH-1	CH-1	3 1/1	16.0	SILT/SLIGHT SAND	GRAY	THIN PASTE	
870326-CH-1	CH-1	4 1/2	9.5	SILT/SAND	GRAY	THIN PASTE	
870326-CH-1	CH-1	4 2/2	10.0	SILT/SAND	GRAY	MED PASTE	
870326-CH-1	CH-1	5 1/1	12.0	SILT/SAND	GRAY/OLIVE	THIN PASTE	
870326-CH-1	CH-1	6 1/2	16.0	SILT/LT SAND	GRAY	THICK PASTE	

TABLE B.1. (contd)

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-CH-1	CH-1	6 2/2	16.0	SILT/LT SAND	GRAY	MED PASTE	
870326-CH-1	CH-1	7 1/2	11.0	SILT/LT SAND	GRAY	THICK PASTE	
870326-CH-1	CH-1	7 2/2	12.0	SILT/LT SAND	GRAY	MED PASTE	
870326-(2-1)	2-1	1 1/2	10.5	SANDY SILT	LT GRAY/GREEN	THICK PASTE	(SLIGHT MUSTY ODOR IN
870326-(2-1)	2-1	1 2/2	11.5	SILT/SLIGHT SAND	LT GRAY/GREEN	THINNER PASTE	SEDIMENT TREATMENT 2-1)
870326-(2-1)	2-1	2 1/2	14.0	SILT/SLIGHT SAND	LT GRAY/GREEN	THICK PASTE	
870326-(2-1)	2-1	2 2/2	6.5	SILT	LT GRAY/GREEN	THICK PASTE	
870326-(2-1)	2-1	3 1/1	18.0	SILT/CLAY AT BOTTOM	GREENER	THICK PASTE	
870326-(2-1)	2-1	4 1/2	14.5	SILT	LT GRAY/OLIVE	THICK PASTE	
870326-(2-1)	2-1	4 2/2	13.0	SILT/SOME SAND AT BOTTOM	LT GRAY	THICK PASTE	
870326-(2-1)	2-1	5 1/2	14.5	SANDY SILT	LT GRAY/OLIVE	RUNNY PASTE	
870326-(2-1)	2-1	5 2/2	8.5	SILT/SLIGHT SAND	LT GRAY/OLIVE	THICK PASTE	
870326-(2-1)	2-1	6 1/1	11.5	SILT	LT GRAY/OLIVE	MED PASTE	
870326-(2-1)	2-1	7 1/2	12.0	SILT	LT GRAY/OLIVE	THICK PASTE	
870326-(2-1)	2-1	7 2/2	12.0	SILT	LT GRAY/OLIVE	THICK PASTE	
870326-(2-2)	2-2	1 1/4	15.0	LT SAND/SILTY CLAY	OLIVE/GRAY	LOOSE PASTE	
870326-(2-2)	2-2	1 2/4	8.0	SANDY CLAY	MED GRAY	MED PASTE	
870326-(2-2)	2-2	1 3/4	10.0	SANDY CLAY	MED GRAY	MED PASTE	
870326-(2-2)	2-2	1 4/4	11.0	LT SAND/CLAY	MED GRAY	MED PASTE	
870326-(2-2)	2-2	2 1/3	14.0	SILTY CLAY	MED GRAY	LOOSE PASTE	
870326-(2-2)	2-2	2 2/3	12.0	SILTY CLAY/LT SAND	MED GRAY	MED PASTE	
870326-(2-2)	2-2	2 3/3	14.5	LT SAND/CLAY	MED GRAY	MED THICK PASTE	
870326-(2-2)	2-2	3 1/4	12.0	SILTY CLAY	OLIVE/LT GRAY	LOOSE PASTE	
870326-(2-2)	2-2	3 2/4	12.0	SANDY CLAY	MED GRAY	MED PASTE	
870326-(2-2)	2-2	3 3/4	14.5	CLAY/LITTLE SILT	DK GRAY	THICK PASTE	
870326-(2-2)	2-2	3 4/4	16.0	SANDY SILT	DK GRAY	THICK PASTE	
870326-(CH-2)	CH-2	1 1/1	16.0	SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(CH-2)	CH-2	2 1/2	6.0	SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(CH-2)	CH-2	2 2/2	9.0	SILTY CLAY	DK GRAY	MED PASTE	
870326-(CH-2)	CH-2	3 1/2	11.0	SANDY CLAY	DK GRAY	MED PASTE	
870326-(CH-2)	CH-2	3 2/2	11.0	SILTY CLAY	DK GRAY	MED PASTE	

TABLE B.1. (contd)

Lab Number	Sediment Treatment	Rep	Length (in.)	Soil Texture	Color	Description	Comments
870326-(CH-2)	CH-2	4 1/1	12.0	SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(CH-2)	CH-2	5 1/2	12.0	SILTY CLAY	DK GRAY	LOOSE PASTE	
870326-(CH-2)	CH-2	5 2/2	14.0	SILTY CLAY	DK GRAY	MED PASTE	
870326-(CH-2)	CH-2	6 1/1	19.0	SILTY CLAY	DK GRAY	MED PASTE	
870326-(CH-2)	CH-2	7 1/1	18.0	SILTY CLAY	MED GRAY	MED PASTE	
870326-(CH-2)	CH-2	8 1/1	18.0	SILTY CLAY	DK GRAY	MED PASTE	
870326-(CH-2)	CH-2	9 1/1	18.0	SILTY CLAY/SM AMT SAND	DK GRAY	LOOSE-MED PASTE	
870326-(1-1)	1-1	1 1/5	14.5	CLAYEY SILT	LIGHT OLIVE DRAB	DOUGHY PASTE	
870326-(1-1)	1-1	1 2/5	14.0	CLAYEY SILT	DK GRAY	THICK PASTE	
870326-(1-1)	1-1	1 3/5	14.0	CLAY/SILT	DK GRAY	THICK PASTE	
870326-(1-1)	1-1	1 4/5	7.0	SILT/SLIGHT SAND	DARKER GRAY	THICK PASTE	
870326-(1-1)	1-1	1 5/5	10.0	SILT(NO SAND)	DARKER GRAY	THICK PASTE	
870326-(1-1)	1-1	2 1/4	14.5	SILT/CLAY	MED OLIVE DRAB	LOOSE PASTE	
870326-(1-1)	1-1	2 2/4	13.0	CLAY	MED GRAY	THICK PASTE-LIKE	
870326-(1-1)	1-1	2 3/4	10.0	CLAY	MED GRAY	THICK PASTE-LIKE	
870326-(1-1)	1-1	2 4/4	12.0	CLAY	MED GRAY	THICK PASTE-LIKE	
870326-(1-1)	1-1	3 1/4	14.0	CLAYEY SILT	LT GRAY	LOOSE PASTE	
870326-(1-1)	1-1	3 2/4	14.0	SANDY CLAY	MED GRAY	MED PASTE	
870326-(1-1)	1-1	3 3/4	7.5	CLAY/LT SAND	MED GRAY	PASTE	
870326-(1-1)	1-1	3 4/4	10.0	CLAY	DK GRAY	THICK PASTE	
870326-(1-2)	1-2	1 1/4	14.5	CLAY	LT GRAY	THICK PASTE	SLIGHT SAND FRACTION
870326-(1-2)	1-2	1 2/4	14.0	CLAY	LT GRAY	THICK PASTE	MID-6" W/DARKER BAND
870326-(1-2)	1-2	1 3/4	11.0	CLAY(SEMI-SAND)	LT GRAY	THICK PASTE	
870326-(1-2)	1-2	1 4/4	12.0	CLAY/THIN SAND	LT GRAY	THICK PASTE	
870326-(1-2)	1-2	2 1/3	14.5	CLAY	LT GRAY/OLIVE	THICK PASTE	
870326-(1-2)	1-2	2 2/3	10.5	SILT/CLAY	GRAY	THICK PASTE	
870326-(1-2)	1-2	2 3/3	13.0	SILT/CLAY	GRAY	THICK PASTE	MID-6" W/DARK GRAY
870326-(1-2)	1-2	3 1/2	14.0	CLAY	LT GRAY/OLIVE	THICK PASTE	SLIGHT FINE SAND FRACTION AT TOP
870326-(1-2)	1-2	3 2/2	15.0	CLAY	GRAY	THICK PASTE	
870326-(1-2)	1-2	4 1/4	14.5	CLAY	LT GRAY/OLIVE	THICK PASTE	SLIGHT FINE SAND FRACTION AT TOP
870326-(1-2)	1-2	4 2/4	14.0	CLAY	GRAY	THICK PASTE	NO SAND

APPENDIX C

QA/QC EVALUATIONS

List of Abbreviations

U	Compound analyzed, but not detected at the given detection limit.
ND	No data available.
J	Estimated value when result is less than specified detection limit.
M	Compound was present, but below detection. Estimated value of analyte found and confirmed by analyst, but with low spectral match parameter.
N/A	No analysis performed.
I Stat	Industrial Statistic "I" for Duplicates: $\frac{\lvert \text{Duplicate 1} - \text{Duplicate 2} \rvert}{\text{Duplicate 1} + \text{Duplicate 2}}$
RPD	Relative Percent Differnce in Duplicates: $\frac{\lvert \text{Duplicate 1} - \text{Duplicate 2} \rvert}{\text{Mean of Duplicates}}$

MEASUREMENTS OF PRECISION

TABLE C.1. Metals, Organotins

Compound (µg/g dry wt)	Sediment Treatment 2-1 Rep 1	Sediment Treatment 2-1 Rep 2	I Stat[a]	RPD[b]	Sediment Treatment CH-1 Rep 1	Sediment Treatment CH-1 Rep 2	I Stat	RPD
Antimony	0.96	0.96	0.00	0.00	1.08	0.84	0.13	25.00
Arsenic	11.80	13.30	0.06	11.95	13.70	13.20	0.02	3.72
Cadmium	0.52	0.51	0.01	1.94	0.55	0.54	0.01	1.83
Chromium	287.40	290.80	0.01	1.18	251.60	261.50	0.02	3.86
Copper	62.70	62.80	0.00	0.16	79.40	78.80	0.00	0.76
Lead	42.00	41.00	0.01	2.41	55.00	55.00	0.00	0.00
Mercury	0.481	0.464	0.018	12.06	0.483	0.528	0.045	8.90
Nickel	107.30	108.70	0.01	1.30	119.00	120.50	0.01	1.25
Selenium	0.45	0.41	0.05	9.30	0.54	0.59	0.04	8.85
Silver	0.680	0.668	0.009	1.78	0.621	0.596	0.021	4.11
Thallium	0.40	0.50	0.11	22.22	0.30	0.40	0.14	28.57
Zinc	145.00	149.00	0.01	2.72	185.00	188.00	0.01	1.61
Mono-butyltin	16.9	6.3	0.5	91.4	12.6	14.1	0.1	11.2
Di-butyltin	30.2	30.2	0.0	0.0	65.9	68.3	0.0	3.6
Tri-butyltin	55.0	58.1	0.0	5.5	242.0	231.0	0.0	4.7
Total Butyltins	102.1	94.6	0.0	7.6	320.5	313.4	0.0	2.2

(a) I Stat is the Industrial Statistic "I".

(b) RPD is relative percent difference.

TABLE C.2a. TOC, Cyanide, and Sulfides (dry wt)

Compound	Sediment Treatment 2-1 Rep 1	Sediment Treatment 2-1 Rep 2	I Stat[a]	RPD[b]	Sediment Treatment CH-1 Rep 1	Sediment Treatment CH-1 Rep 2	I Stat	RPD
Total Organic Carbon (% dry wt.)	1.58	1.45	0.04	8.58	2.02	1.51	0.14	28.90
Cyanide (ug/g)	<0.6	<0.6	N/A	N/A	<0.6	<0.6	N/A	N/A
Total Sulfides (ug/g dry wt.)	189.0	116.0	0.24	47.87	130.0	170.0	0.1	26.67
Dissolved Sulfides (ug/g dry wt.)	53.5	53.5	0.00	0.00	53.5	53.5	0.0	0.0

TABLE C.2b. Total Oil and Grease Petroleum Hydrocarbons and Percent Dry Weight

Compound	Sediment Treatment TD-2-U Rep 1	TD-2-U Rep 2	I Stat[a]	RPD[b]
Total Oil and Grease (μg/g dry wt.)	508.51	490.11	0.02	3.69
Petroleum Hydrocarbons (mg/kg dry wt)	508.19	250.31	0.10	20.73
Percent Dry Weight	39.47	39.47	0.00	0.00

(a) I Stat is the Industrial Statistic "I".
(b) RPD is relative percent difference.

TABLE C.3. Pesticides and PCBs

Compound (µ/kg dry wt)	Sediment Treatment 1-3 DQ Rep 1	1-3 DQ Rep 2	I Stat[b]	RPD[c]	Sediment Treatment 2-1 DQ[d] Rep 1	2-1 DQ Rep 2	I Stat	RPD
Alpha-BHC	5 U[a]	5 U	N/A[e]	N/A	5 U	5 U	N/A	N/A
Beta-BHC	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Delta-BHC	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Gamma-BHC (Lindane)	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Heptachlor	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Aldrin	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Heptachlor Epoxide	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Endosulfan I	5 U	5 U	N/A	N/A	5 U	5 U	N/A	N/A
Dieldrin	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
4,4'-DDE	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Endrin	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Endosulfan II	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
4,4'-DDD	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Endosulfan Sulfate	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
4,4'-DDT	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Methoxychlor	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Endrin Ketone	10 U	10 U	N/A	N/A	10 U	10 U	N/A	N/A
Chlordane	20 U	20 U	N/A	N/A	20 U	20 U	N/A	N/A
Toxaphene	1000 U	1000 U	N/A	N/A	1000 U	1000 U	N/A	N/A
Aroclor-1016	100 U	100 U	N/A	N/A	100 U	100 U	N/A	N/A
Aroclor-1242	100 U	100 U	N/A	N/A	100 U	100 U	N/A	N/A
Aroclor-1248	100 U	100 U	N/A	N/A	100 U	100 U	N/A	N/A
Aroclor-1254	100 U	100 U	N/A	N/A	100 U	100 U	N/A	N/A
Aroclor-1260	100 U	100 U	N/A	N/A	100 U	100 U	N/A	N/A

(a) Compound analyzed, but not detected at the given limit (see appendix for detection limits).

(b) I Stat is the Industrial Statistic "I".

(c) RPD is relative percent difference.

(d) DQ is the data qualifier.

(e) No analysis performed.

TABLE C.4. Polynuclear Aromatic Hydrocarbons

Compound (µg/kg dry wt)	Sediment Treatment 1-3 DQ[a] Rep 1	1-3 DQ Rep 2	I Stat[b]	RPD[c]	Sediment Treatment 2-1 DQ Rep 1	2-1 DQ Rep 2	I Stat	RPD
Phenol	83 U[d]	89 U	N/A	N/A	67 U	71 U	N/A	N/A
bis(2-Chloroethyl)Ether	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2-Chlorophenol	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
1,3-Dichlorobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
1,4-Dichlorobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Benzyl Alcohol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
1,2-Dichlorobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2-Methylphenol	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
bis(2-chloroisopropyl)Ether	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
4-Methylphenol	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
N-Nitroso-Di-n-Propylamine	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Hexachloroethane	170 U	180 U	N/A	N/A	130 U	140 U	N/A	N/A
Nitrobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Isophorone	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2-Nitrophenol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
2,4-Dimethylphenol	170 U	180 U	N/A	N/A	130 U	140 U	N/A	N/A
Benzoic Acid	830 U	890 U	N/A	N/A	670 U	710 U	N/A	N/A
bis(2-Chloroethoxy)Methane	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2,4-Dichlorophenol	250 U	270 U	N/A	N/A	200 U	210 U	N/A	N/A
1,2,4-Trichlorobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Naphthalene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
4-Chloroaniline	250 U	270 U	N/A	N/A	200 U	210 U	N/A	N/A
Hexachlorobutediene	170 U	180 U	N/A	N/A	130 U	140 U	N/A	N/A
4-Chloro-3-Methylphenol	170 U	180 U	N/A	N/A	130 U	140 U	N/A	N/A
2-Methylnaphthalene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Hexachlorocyclopentadiene	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
2,4,6-Trichlorophenol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
2,4,5-Trichlorophenol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
2-Chloronaphthalene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2-Nitroaniline	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
Dimethyl Phthalate	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Acenaphthylene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
3-Nitroaniline	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
Acenaphthene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2,4-Dinitrophenol	830 U	890 U	N/A	N/A	670 U	710 U	N/A	N/A
4-Nitrophenol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
Dibenzofuran	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
2,4-Dinitrotoluene	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
2,6-Dinitrotoluene	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
Diethylphthalate	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
4-Chlorophenol-phenylether	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Fluorene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
4-Nitroaniline	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
4,6-Dinotro-2-Methylphenol	830 U	890 U	N/A	N/A	670 U	710 U	N/A	N/A

TABLE C.4. (contd)

Compound (µg/kg dry wt)	Sediment Treatment 1-3 DQ[a] Rep 1	1-3 DQ Rep 2	I Stat[b]	RPD[c]	Sediment Treatment 2-1 DQ Rep 1	2-1 DQ Rep 2	I Stat	RPD
N-Nitrosodiphenylamine(1)	83 U[d]	89 U	N/A	N/A	67 U	71 U	N/A	N/A
4-Bromophenyl-phenylether	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Hexachlorobenzene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Pentachlorophenol	420 U	450 U	N/A	N/A	340 U	350 U	N/A	N/A
Phenanthrene	67.00 J	74.00 J	0.05	9.93	160.00	110.00	0.19	37.04
Anthracene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Di-n-Butylphthalate	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Fluoranthene	170.00	180.00	0.03	5.71	300.00	260.00	0.07	14.29
Pyrene	190.00	180.00	0.03	5.41	300.00	300.00	0.00	0.00
Butylbenzylphthalate	83.00 U	89.00 U	N/A	N/A	67.00 U	71.00 U	N/A	N/A
3,3'-Dichlorobenzidine	420.00 U	450.00 U	N/A	N/A	340.00 U	350.00 U	N/A	N/A
Benzo(a)Anthracene	76.00 M	75.00 M	0.01	1.32	130.00 M	120.00 M	0.04	8.00
bis(2-Ethylhexyl)Phthalate	480.00	420.00	0.07	13.33	400.00	310.00	0.13	25.35
Chrysene	110.00 M	95.00 M	0.07	14.63	140.00 M	150.00 M	0.03	6.90
Di-n-Octyl Phthalate	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Benzo(b)Fluoranthene and Benzo(k)Fluoranthene	150.00 M	150.00 M	0.00	0.00	250.00	280.00	0.03	11.32
Benzo(a)Pyrene	110.00 U	110.00 U	N/A	N/A	190.00	220.00	0.06	14.63
Indeno(1,2,3-cd)Pyrene	83 U	89 U	N/A	N/A	140 M	150 M	0.03	6.90
Dibenz(a,h)Anthracene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A
Benzo(ghi)Perylene	83 U	89 U	N/A	N/A	67 U	71 U	N/A	N/A

(a) DQ is the data qualifier.

(b) I Stat is the Industrial Statistic "I".

(c) RPD is relative percent difference.

(d) Compound analyzed, but not detected at the given limit (see appendix for detection limits).

MEASUREMENTS OF ACCURACY

TABLE C.5. Standard Reference Material Measurements (Metals μg/g dry wt)

	Standard Concentration			Laboratory Measurement					
					1646 Replicates			MESS Replicates	
Metal	PACS-1	Mess	1646	PACS -1	-1	-2	-3	1	2
Hg	4.57 ± 0.16	0.171 ± 0.014	0.063 ± 0.012	4.22	0.07	0.09	0.08	0.20	0.21
Ag	--	--	--	1.84	0.13	0.13	0.11	0.13	0.12
Cd	2.38 ± 0.2	0.59 ± 0.10	0.36 ± 0.07	2.19	0.36	0.40	0.30	0.64	0.68
Cu	452 ± 16	25.1 ± 3.8	18 ± 3.0	434.4	17.1	17.1	17.1	24.4	24.4
Pb	404 ± 20	34.0 ± 6.1	28.3 ± 1.0	356.0	29.0	29.0	--	34.0	33.0
Cr	113 ± 8	71.0 ± 11	76 ± 3.0	108.9	88.0	93.0	91.0	75.3	59.9
Ni	44.1 ± 2.0	29.5 ± 2.7	32 ± 3.0	47.8	35.0	34.0	36.0	29.8	24.4
As	211 ± 11	10.6 ± 1.2	11.6 ± 1.3	276.8	11.1	11.1	10.5	12.1	11.3
Se	1.09 ± 0.11	0.34 ± 0.6	-- 0.06	0.99	0.7	0.64	0.64	0.52	0.56
Sb	171 ± 14	0.73 ± 0.08	-- 0.4	180.6	0.3	0.44	0.36	0.72	0.60
Tl	--	--	-- 0.5	0.6	0.7	0.8	0.6	0.7	0.7
Zn	824 ± 22	191 ± 17.0	138 ± 6.0	681.0	134.0	138.0	--	185.0	187.0

TABLE C.6. Standard Reference Material Measurements (Organotins µg/kg dry wt)

Standard	Standard Concentration			Laboratory Measurement		
	Tri	Di	Mono	Tri	Di	Mono
Moss Landing	364	NM	NM	373	254	69.1
SQ-1	73	NM	NM	108	NM	NM

TABLE C.7. Standard Reference Material Measurements (Semivolatiles μg/kg dry wt)

Compound	Standard Concentration SQ-1	Laboratory Measurement SQ-1	Laboratory Measurement Percent Response (Measured/Standard) x 100
Phenol	330	320M	97
1,3-Dichlorobenzene	60	40M	67
1,4-Dichlorobenzene	30	14M	47
1,2-Dichlorobenzene	100	32J	32
4-Methylphenol	300	250M	83
Isophrone	100	95	95
Napthalene	100	85	85
2-Methylnapthalene	100	100	100
Acenaphthylene	100	79	79
Acenaphthene	100	120	120
4-Chlorophenyl-phenylether	100	96	96
Fluorene	100	110	110
4-Bromophenyl-phenylether	100	220	220
Pentachlorophenol	300	390M	130
Phenanthrene	100	170	170
Anthracene	100	140	140
Fluoranthene	100	140	120
Pyrene	100	120	120
Benzo(a)Anthracene	100	120	120
bis(2-ethylhexyl)Phthalate	100	220	220
Chyrsene	100	140	140
Benzo(b)Fluoranthene and Benzo(k)Fluoranthene	100	140	140
Benzo(a)pyrene	100	130	130
Indeno(1,2,3-cd)Pyrene	100	40M	40
Dibenz(a,h)Anthracene	100	160	160
Benzo(ghi)Perylene	100	30M	30

$\bar{X}$ = 107.42
SD = 50.68
N = 26

TABLE C.8. Standard Reference Material Measurements (Pesticides and PCBs μg/kg dry wt)

	Reference Material	Measured Concentrations
Compound	SQ-1	SQ-1
Endosulfan II	2	22
Aroclor 1254	100	130

(Other compunds in SQ-1 are spiked at 1-2 μg/kg (dry wt), which is below required detection limits.)

TABLE C.9. Standard Reference Material Measurements (Conventional Materials)

Compound	Standard Concentration
Total Sulfide	Standard Reference Materials Not Available - See Information on Spikes and Recoveries
Dissolved Sulfide	
Organic Carbon	
Cyanide	
Oil and Grease	
Petroleum Hydrocarbons	
Grain Size	

SPIKES AND RECOVERIES

TABLE C.10. Percent of Surrogate Recoveries for Analytical Chemistry QA/QC

	Sediment Treatment																
Surrogate Types	1-1 REP1	1-1 REP2	1-2 REP1	1-2 REP2	1-3 REP1	1-3 REP2	2-1 REP1	2-1 REP2	2-2 REP1	2-2 REP2	3-1 REP 1	3-1 REP 2	3-2 REP 1	3-2 REP 2	3-2 REP 3	CH-1 REP1	CH-1 REP2
Base/Neutrals																	
d5-Nitrobenzene	73.4	--	81.8	--	70.8	70.3	79.5	81.3	78.7	78.7	79.6	80	84.3	82.8	82.8	70.7	--
2-Fluorobiphenyl	73.9	--	83.7	--	76.9	77.5	83.2	91.3	81.6	80.7	82.7	83.7	86.7	79.7	80.3	67.1	--
d14-p-Terphenyl	85.4	--	101.0	--	93.2	86.6	88.8	96.1	87.4	88.9	82.6	90.0	95.8	83.6	83.4	75.5	--
Acids																	
d5-Phenol	83.1	--	90.5	--	76.6	76.2	85.0	92.3	87.9	91.5	89.1	90.7	89.7	94.5	95.1	77.8	--
2-Fluorophenol	80.7	--	95.4	--	84.7	78.8	87.4	96.8	92.3	95.5	89.6	92.9	92.3	96.3	95.3	84.78	--
2,4,6-Tribromo phenol	81.0	--	91.1	--	96.8	75.3	80.0	84.7	75.8	86.3	81.1	88.1	86.1	83.6	78.1	79.2	--
Pesticides																	
Dibutylchlorendate	90.0	--	108.0	--	86.0	95.0	91.0	90.0	108.0	102.0	150.0	150.0	155.0	120.0	142.0	172.0	--
Organotins																	
Propyl tin	100.0	94.3	143.0	122.0	112.0	80.6	119.0	98.9	85.8	--	139.0	--	114.0	--	--	154.0	130.0

TABLE C.10. (contd)

Surrogate Types	Sediment Treatment																	
	CH-2	SN-1	SN-2-U	SN-2-L	SN-3-U	SN-3-L	TD-1-U	TD-1-L	TD-2-U	TD-2-L	Point Reyes	Sequim Bay	SQ -1	BLANK	BLANK	MEAN	STD	% CV
Base/Neutrals																		
d5-Nitrobenzene	75.3	75.9	70.2	78.6	66.2	76.7	94.1	90.6	87.7	78.0	90.7	71.2	68.7	73.6	81.5	78.46	6.778	8.638
2-Fluorobiphenyl	78.3	66.4	73.4	95.2	78.1	83.5	77.1	79.2	71.8	66.1	95.3	70.6	71.4	77.3	94.2	79.54	7.778	9.777
d14-p-Terphenyl	81.6	80.1	80.4	97.6	82.6	76.3	79.6	79.1	80.1	67.6	83.9	83.9	73.5	66.2	123.0	85.30	10.93	12.81
Acids																		
d5-Phenol	83.6	79.1	79.6	96.7	63.0	76.0	91.1	91.7	87.8	76.2	92.0	66.9	69.8	74.9	91.9	84.14	8.850	10.51
2-Fluorophenol	88.1	77.2	84.5	96.9	80.1	89.0	85.8	84.9	82.2	75.3	102.0	73.1	75.0	80.4	100.0	87.48	7.765	8.875
2,4,6-Tribromo pheno	79.2	71.5	67.9	81.1	64.7	72.7	72.3	79.9	72.9	70.7	101.0	90.9	75.1	73.5	101.0	80.74	9.067	11.22
Pesticides																		
Dibutylchlorendate	169.0	146.0	173.0	265.0	159.0	126.0	177.0	162.0	146.0	194.0	113	115.0	136.0	98.0	93.0	135.6	40.27	29.70
Organotins																		
Propyl tin	103.0	90.3	115.0	98.5	145.0	114.0	147.0	134.0	54.1	99.4	98.2	125.0	86.4	140.0	89.1	111.8	24.05	21.51

See method 8250 for Surrogate Recovery Standards and Allowable Limits.

TABLE C.11. Recoveries of Chemical Spiked into Sediment (Metals)

Chemical	Spiked Concentration (µg/g dry wt)	Recovery in Sediment Treatment (%)				
		1-1	1-2	1-3	$\bar{X}$	SD
Hg	0.5	62	97	101	87	21.5
Ag	0.5	126	119	110	118	8.0
Cd	1.0	92	94	90	92	2.0
Cu	200.0	105	98	102	102	3.5
Pb	150.0	94	95	67	85	15.9
Cr	400.0	115	77	114	102	21.7
Ni	200.0	91	88	93	91	2.5
As	20.0	96	101	110	102	7.1
Se	1.0	93	123	115	110	15.5
Sb	1.9	74	79	83	78	4.5
Tl	1.0	70	80	80	77	5.8
Zn	400.0	NA	NA	NA	NA	NA

TABLE C.12. Recoveries of Chemical Spiked into Sediment (Organotins)

Chemicals	Recovery in Sediment Treatment (%)			Mean	SD
	1-1	1-2	1-3		
Tributyltin	84.4	106	76.6	89	15.2
Dibutyltin	96.7	102	88.2	95.6	7.0
Monobutyltin	43.1	61.1	72.7	59.0	14.9
Propyltin	79.5	116	94.3	96.6	18.4

TABLE C.13. Recoveries of Chemical Spiked into Sediment (Polynuclear Aromatic Hydrocarbons)

Chemical	QC Limits		Sediment Treatment				
	RPD	Recovery	3-1	3-2	3-2 Dup.	2-2	RPD[a]
1,2,4-trichlorobenzene	23	38-107	66.4	68.8	71	64.6	-3.2
Acenaphthene	19	31-137	78.0	74.9	74.2	73.1	1.0
2,4-Dinitrotoluene	47	28-89	77.7	85.9	88.7	80.0	-3.2
Pyrene	36	35-142	77.0	67.5	71.1	64.7	-4.5
N-nitioso-di-n-proplamine	38	41-126	83.0	83.8	88.2	80.0	-5.1
1,4 dichlorobenzene	27	28-104	68.1	70.3	70.9	65.5	-0.8
Pentachlorophenol	47	17-109	66.1	70.2	75.8	67.3	-7.6
Phenol	35	26- 90	78.4	79.2	82.6	75.5	-4.2
2-Chlorophenol	50	25-102	78.0	81.1	87.5	78.2	-1.7
4-chloro 3-methylphenol	33	26-103	77.7	84.5	81.0	77.8	4.2
4-Nitrophenol	50	11-114	84.6	84.9	92.9	87.1	-9.0

(a) RPD is relative percent difference.
All sediment treatments are within QA/QC limits.

TABLE C.14. Recoveries of Chemicals Spiked into Sediment (Pesticides and PCBs)

Compound	Recovery in Sediment Treatment %					
	3-1	3-2	3-2 Dup.	2-2	Mean	SD
Gamma-BHC	134	132	154	120	110.8	61.6
Heptachlor	92	91	105	83	92.8	9.1
Aldrin	114	114	134	102	116.0	13.3
Dieldrin	121	117	135	104	119.3	12.8
Endrin	118	114	133	117	120.5	8.5
4,4'DDT	140	134	157	120	137.8	15.3

TABLE C.15. Recoveries of Chemical Spiked into Sediment (Conventional Materials)

Compound	Recovery in Sediment Treatment (%)			
	2-1	2-2	CH-1	$\bar{X}$
Total Sulfide	37.9	194	NM	116
Dissolved Sulfide	107.0	107	NM	107
Cyanide	64.0	NM	65.9	65.0

APPENDIX D

EQUIPMENT LIST, CALIBRATION, AND MAINTENANCE RECORDS

Analysis:	Organics and Pesticides
Matrix:	Sediment and tissue
Performed at:	Analytical Resources, Inc. (ARI) Seattle, Washington
Equipment:	Hewlett-Packard 5890 Gas Chromatograph Hewlett-Packard 7673-A Autosampler Hewlett-Packard 3392-A Sample Integrator Hewlett-Packard 3393-A Sample Integrator Capillary column equipped with two electron capture detectors Finnigan Model 4000 Mass Spectrophotometer Finnigan INCOS Beta System Hewlett-Packard 5790 Gas Chromatograph
Calibration Information:	Daily calibration was performed by ARI personnel using U.S. EPA Contract Lab Protocol (CLP). Performance checks were conducted with standard reference materials (SRMs) by ARI personnel before the series was run.
Maintenance Information:	Maintenance by ARI or Hewlett-Packard personnel was performed routinely or when indicated by performance checks.
Sample Tracking:	All analysis were tied to specific machine and operator via sample tracking form used by ARI.
Responsible Person(s):	Dave Mitchell

Analysis:	Total Organic Carbon (TOC), Total and Dissolved Sulfides, Cyanide
Performed at:	AmTest, Inc. Redmond, Washington
Equipment:	Dohrmann DC-180 Carbon Analyzer (TOC)
	Schmadzo Spectrophotometer (cyanide)
	Titration Burette (sulfide)
Calibration Information:	For Dohrmann and Schmadzo devices, calibration was performed daily by AmTest personnel.
Maintenance Information:	Maintenance on Dohrmann and Schmadzo devices was performed monthly by AmTest personnel.
Sample Tracking:	All analyses were tied to specific machine and operator via laboratory book system approved by AmTest and verified by John Dailey.
Responsible Person:	John Dailey

Analysis:	Organotins
Matrix:	Sediment and tissue
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	Hewlett-Packard 5890 Gas Chromatograph (S/N 2728A 12901) Hewlett-Packard 5970 Mass Selective Detector (MSD)
Calibration Information:	The gas chromatograph was calibrated daily with tributyltin standards. The MSD was calibrated daily with the perflurotributyltin standard (internal standard).
Maintenance Information:	Maintenance was performed by either Battelle or Hewlett-Packard personnel. Schedule was dependent on use, but maintenance usually occurred monthly.
Sample Tracking:	All analyses were tied to specific machine and operator via Battelle's laboratory book system. All data were approved by E. A. Crecelius (Battelle/MSL).
Responsible Person(s):	E. A. Crecelius and T. A. Fortman

Analysis:	Arsenic, Copper, Chromium, Nickel, Mercury, Silver, Cadmium, Selenium, Thallium, and Antimony
Matrix:	Sediment and tissue
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	House Built Atomic Fluorescence Spectrophotometer (mercury) Perkin-Elmer 5000 Atomic Absorption Spectrophotometer (selenium, cadmium, arsenic, chromium, antimony, nickel, and silver) (S/N 5016) Perkin-Elmer 3030 Atomic Absorption Spectrophotometer (thallium) (S/N 3035) Instrumentation Laboratory 251 Flame Atomic Absorption Spectrophotometer (#1277) (copper)
Calibration Information:	All instruments were calibrated daily with SRMs.
Maintenance Information:	Maintenance was performed by Battelle or authorized technical representatives as needed, or when indicated by calibration results.
Sample Tracking:	All analyses were tied to specific machine and operator via Battelle's laboratory book system. All data were approved by E. A. Crecelius (Battelle/MSL).
Responsible Person(s):	E. A. Crecelius, C. W. Apts, and O. A. Cotter

Analysis:	Chromium, Lead, Nickel, Copper, Zinc, Arsenic
Matrix:	Sediment and tissue
Performed at:	Battelle/PNL Richland, Washington
Equipment:	Kevix 0810 A X-ray Fluorescence (XRF) Computer controlled with a Canberra Jupiter System (PDP 1134 A) Battelle Computer Codes: SAP-3, MCA, XRF
Calibration Information:	Equipment was calibrated at the beginning and end of each run with USGS Standard Andesite and NBS Standard 1646.
Maintenance Information:	Maintenance was performed as needed, or when specified by calibration results.
Sample Tracking:	All analyses were tied to specific machine and operator via Battelle's laboratory book system. All data were approved by R. Saunders.
Responsible Person(s):	R. Saunders

Analysis:	Oil and Grease
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	Beckman Acculab 4 Infrared Spectrophotometer (S/N 1000358)
Calibration Information:	Equipment was calibrated daily with API reference oil by Battelle/MSL personnel.
Maintenance Information:	Maintenance was performed by Battelle or Beckman personnel as needed, or when indicated by calibration results.
Sample Tracking:	All analyses were tied to specific machine and operator via Battelle's laboratory book system. All data were approved by J. Q. Word (Battelle/MSL).
Responsible Person(s):	J. Q. Word and L. M. Franklin

Analysis:	Petroleum Hydrocarbon
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	Beckman Acculab 4 Infrared Spectrophotometer (S/N 1000358) Silca gel
Calibration Information:	Equipment was Calibrated daily with API reference oil by Battelle/MSL personnel.
Maintenance Information:	Maintenance was performed by Battelle or Beckman personnel as needed, or when indicated by calibration results.
Sample Tracking:	All analyses were tied to specific machine and operator via Battelle's laboratory book system. All data were approved by J. Q. Word (Battelle/MSL).
Responsible Person(s):	J. Q. Word and L. M. Franklin

Analysis:	Grain Size
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	Tyler Standard Seives Mettler AC-100 Analytical Balance (S/N A89515)
Calibration Information:	The Mettler analytical balance is calibrated annually by Quality Control Services, Portland, Oregon.
Maintenance Information:	The Mettler analytical balance is maintained annually by Quality Control Services, Portland, Oregon.
Sample Tracking:	All analyses were tied to specific balance and analyst via Battelle's laboratory book system. All data were approved by E. A. Crecelius (Battelle/MSL).
Responsible Person(s):	E. A. Crecelius and O. A. Cotter

Analysis:	Bioassays
Performed at:	Battelle/MSL Sequim, Washington
Equipment:	Mettler AC100 Analytical Balance (S/N A89515) American Optical Corporation Refractometers (S/N AR605 and AR609) Reichert Refractometer (S/N 10054-7) ErTco 63602, 63673, and 63682 Thermometers ErTco L-68397 Thermometer (standard) Orion Research Model 601-A Digital Ionalyzer (S/N 75398) Orion Research Model 701-A Digital Ionalyzer (S/N 48912) Thermar (1500 W, 120 V) Temperature Controller YSI Model 58 Digital D.O. Meter (S/N 3095) YSI Model 57 D.O. Meter (S/N 15679) I.A.P.O. Standard Seawater (35 °/..) pH Buffers: RICCA Chemical Corp. pH 7.00, Lot Number C041 Expiration 6-2-88 pH 4.00, Lot Number C111 Expiration 6-9-88 High Purity Chemical/Your Chemical Source pH 10.00, Lot Number 02038 U.S. National Bureau of Standards-Certified Buffers
Calibration Information:	The Mettler balance is calibrated annually by Quality Control Services, Portland, Oregon. The refractometer and ErTco thermometers were calibrated by Battelle personnel before the bioassay test to standard seawater and ErTco thermometer, respectively. The Orion ionalyzers were calibrated before each use with the pH buffers, and the YSI D.O. meters were air calibrated (100% saturation) before each use by Battelle personnel.
Maintenance Information:	With the exception of the analytical balance, maintenance is performed as needed (determined by calibration results) by Battelle personnel.
Sample Tracking:	All measurements were tied to the specific instrument and analyst via Battelle's laboratory book system. All data were approved by J. Q. Word (Battelle/MSL).
Responsible Person(s):	J. Q. Word and J. A. Ward

APPENDIX E

CITHARICHTHYS STIGMAEUS BIOASSAY TEST RESULTS

TABLE E.1. Citharichthys stigmaeus Acute Toxicity Test

Sediment Treatment	% SPP[a]	Rep	Number Alive 0 h	4 h	8 h	24 h	48 h	72 h	96 h
TD-2-U	10	A	10	10	10	10	10	10	10
TD-2-U	10	B	10	10	10	10	10	10	10
TD-2-U	10	C	10	10	10	10	10	10	10
TD-2-U	50	A	10	10	10	10	10	10	10
TD-2-U	50	B	10	10	10	10	10	10	10
TD-2-U	50	C	10	10	10	10	10	10	9
TD-2-U	100	A	10	10	10	10	10	10	10
TD-2-U	100	B	10	10	10	10	10	10	10
TD-2-U	100	C	10	10	10	10	10	9	8
TD-2-L	10	A	10	10	10	10	10	10	10
TD-2-L	10	B	10	10	10	10	10	10	10
TD-2-L	10	C	10	10	10	10	10	10	10
TD-2-L	50	A	10	10	10	10	10	10	10
TD-2-L	50	B	10	10	10	10	10	10	10
TD-2-L	50	C	10	10	10	10	10	10	10
TD-2-L	100	A	10	10	9	8	8	8	8
TD-2-L	100	B	10	10	10	8	8	8	8
TD-2-L	100	C	10	10	9	7	7	7	7
SN-2-U	10	A	10	10	10	10	10	10	10
SN-2-U	10	B	10	10	10	10	10	10	10
SN-2-U	10	C	10	10	10	10	10	9	9
SN-2-U	50	A	10	10	10	10	10	10	10
SN-2-U	50	B	10	10	10	10	10	10	10
SN-2-U	50	C	10	10	10	10	10	10	10
SN-2-U	100	A	10	10	10	10	10	10	10
SN-2-U	100	B	10	10	10	10	10	10	10
SN-2-U	100	C	10	10	10	10	10	10	10
SN-2-L	10	A	10	10	10	10	10	10	10
SN-2-L	10	B	10	10	10	10	10	10	10
SN-2-L	10	C	10	10	10	10	10	10	10
SN-2-L	50	A	10	10	10	10	10	10	10
SN-2-L	50	B	10	10	10	10	10	10	10
SN-2-L	50	C	10	10	10	10	10	10	10
SN-2-L	100	A	10	10	10	10	10	10	10
SN-2-L	100	B	10	10	7	4	4	4	4
SN-2-L	100	C	10	8	6	4	2	2	2
CH-C[b]	10	A	10	10	10	10	10	10	10
CH-C	10	B	10	10	10	10	10	10	10
CH-C	10	C	10	10	10	10	10	10	9
CH-C	50	A	10	10	10	10	10	10	10
CH-C	50	B	10	10	10	10	10	10	10
CH-C	50	C	10	10	10	10	10	10	9
CH-C	100	A	10	10	10	10	10	10	10

TABLE E.1. (contd)

Sediment Treatment	% SPP[a]	Rep	Number Alive						
			0 h	4 h	8 h	24 h	48 h	72 h	96 h
CH-C	100	B	10	10	10	10	10	10	10
CH-C	100	C	10	10	10	10	10	10	10
SEQUIM BAY[c]	10	A	10	10	10	10	10	10	10
SEQUIM BAY	10	B	10	10	10	10	10	10	9
SEQUIM BAY	10	C	10	10	10	10	10	10	10
SEQUIM BAY	50	A	10	10	10	10	10	10	10
SEQUIM BAY	50	B	10	10	10	10	10	10	9
SEQUIM BAY	50	C	10	10	10	10	10	10	10
SEQUIM BAY	100	A	10	10	10	10	10	10	10
SEQUIM BAY	100	B	10	10	10	10	10	10	10
SEQUIM BAY	100	C	10	10	10	10	10	10	10
SB WATER[d]	0	A	10	10	10	10	10	10	10
SB WATER	0	B	10	10	10	10	10	10	10
SB WATER	0	C	10	10	10	10	10	10	10

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Sequim Bay reference sediment.
(d) Sequim Bay seawater.

TABLE E.2. Water Quality Monitoring (Citharichthys stigmaeus)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-U	0	10	A	15.6	31.5	7.7	7.85
TD-2-U	0	10	B	15.6	31.5	7.7	7.84
TD-2-U	0	10	C	15.6	31.5	7.6	7.76
TD-2-U	0	50	A	15.6	31.5	7.8	7.82
TD-2-U	0	50	B	15.6	31.5	7.7	7.89
TD-2-U	0	50	C	15.6	31.5	7.6	7.75
TD-2-U	0	100	A	15.6	31.5	7.7	7.81
TD-2-U	0	100	8	15.6	31.5	7.7	7.78
TD-2-U	0	100	C	15.6	31.5	7.7	7.86
TD-2-U	24	10	A	14.4	31.5	7.8	7.99
TD-2-U	24	10	B			7.8	7.99
TD-2-U	24	10	C			7.7	7.82
TD-2-U	24	50	A	14.4	31.5	7.9	7.98
TD-2-U	24	50	B			7.9	7.97
TD-2-U	24	50	C			7.8	7.84
TD-2-U	24	100	A	14.4	31.5	7.7	8.06
TD-2-U	24	100	B			7.9	7.92
TD-2-U	24	100	C			7.8	7.91
TD-2-U	48	10	A	15.4	31.5	7.5	8.07
TD-2-U	48	10	B				
TD-2-U	48	10	C				
TD-2-U	48	50	A	15.4	31.5	7.5	7.89
TD-2-U	48	50	B				
TD-2-U	48	50	C				
TD-2-U	48	100	A	15.4	31.5	7.5	7.95
TD-2-U	48	100	B				
TD-2-U	48	100	C				
TD-2-U	72	10	A	15.3	31.5	7.9	7.98
TD-2-U	72	10	B				
TD-2-U	72	10	C				
TD-2-U	72	50	A	15.0	31.5	8.0	7.96
TD-2-U	72	50	B				
TD-2-U	72	50	C				
TD-2-U	72	100	A	14.5	31.5	7.9	7.87
TD-2-U	72	100	B				
TD-2-U	72	100	C				
TD-2-U	96	10	A	15.4	31.5	7.6	7.79
TD-2-U	96	10	B	15.3	31.5	7.8	7.79
TD-2-U	96	10	C	15.1	31.5	7.8	7.87
TD-2-U	96	50	A	15.3	31.0	8.1	7.92
TD-2-U	96	50	B	15.2	31.0	7.6	7.93
TD-2-U	96	50	C	15.3	31.5	7.8	7.90

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-U	96	100	A	15.0	31.0	8.1	7.98
TD-2-U	96	100	B	15.4	31.5	7.8	7.97
TD-2-U	96	100	C	15.4	31.5	7.6	7.98
TD-2-L	0	10	A	15.6	31.5	7.7	7.76
TD-2-L	0	10	B	15.3	31.5	7.8	7.88
TD-2-L	0	10	C	15.6	31.5	7.7	7.78
TD-2-L	0	50	A	15.6	31.5	7.7	7.75
TD-2-L	0	50	B	15.6	31.5	7.7	7.82
TD-2-L	0	50	C	15.6	31.5	7.5	7.76
TD-2-L	0	100	A	15.6	31.5	7.6	7.95
TD-2-L	0	100	B	15.6	31.5	7.7	7.94
TD-2-L	0	100	C	15.6	31.5	7.7	7.96
TD-2-L	24	10	A	14.2	31.5	7.7	7.88
TD-2-L	24	10	B			7.9	8.00
TD-2-L	24	10	C			7.8	7.84
TD-2-L	24	50	A	14.4	31.5	7.8	7.92
TD-2-L	24	50	B			7.7	7.92
TD-2-L	24	50	C			7.9	7.96
TD-2-L	24	100	A	14.5	31.5	7.9	8.21
TD-2-L	24	100	B			7.8	8.19
TD-2-L	24	100	C			7.8	8.06
TD-2-L	48	10	A	15.4	31.5	7.4	7.90
TD-2-L	48	10	B				
TD-2-L	48	10	C				
TD-2-L	48	50	A	15.4	31.5	7.5	8.07
TD-2-L	48	50	B				
TD-2-L	48	50	C				
TD-2-L	48	100	A	15.4	31.5	7.5	8.25
TD-2-L	48	100	B	15.4	31.5	7.5	8.22
TD-2-L	48	100	C	15.4	31.5	7.5	8.26
TD-2-L	72	10	A	14.5	31.5	8.0	7.84
TD-2-L	72	10	B				
TD-2-L	72	10	C				
TD-2-L	72	50	A	15.1	31.5	8.0	8.02
TD-2-L	72	50	B				
TD-2-L	72	50	C				
TD-2-L	72	100	A	15.6	31.5	8.1	8.23
TD-2-L	72	100	B	15.4	31.5	8.0	8.19
TD-2-L	72	100	C	15.2	31.5	8.0	8.11
TD-2-L	96	10	A	15.1	31.0	7.5	7.81
TD-2-L	96	10	B	15.2	31.0	7.7	7.92

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-L	96	10	C	15.4	31.5	7.7	7.85
TD-2-L	96	50	A	14.9	31.5	7.9	7.94
TD-2-L	96	50	B	15.4	31.5	7.7	7.92
TD-2-L	96	50	C	15.2	31.5	7.8	7.98
TD-2-L	96	100	A	15.4	31.0	7.7	8.09
TD-2-L	96	100	B	15.4	31.0	7.8	8.07
TD-2-L	96	100	C	15.3	31.0	7.8	8.10
SN-2-U	0	10	A	15.6	31.5	7.7	7.85
SN-2-U	0	10	B	15.6	31.5	7.7	7.79
SN-2-U	0	10	C	15.6	31.5	7.7	7.79
SN-2-U	0	50	A	15.6	31.5	7.7	7.91
SN-2-U	0	50	B	15.6	31.5	7.7	7.83
SN-2-U	0	50	C	15.6	31.5	7.7	7.92
SN-2-U	0	100	A	15.6	31.5	7.6	7.99
SN-2-U	0	100	B	15.6	31.5	7.6	7.94
SN-2-U	0	100	C	15.6	31.5	7.6	7.88
SN-2-U	24	10	A	14.4	31.5	7.8	7.99
SN-2-U	24	10	B			7.6	7.81
SN-2-U	24	10	C			7.8	7.84
SN-2-U	24	50	A	14.4	31.5	7.7	8.04
SN-2-U	24	50	B			7.8	8.09
SN-2-U	24	50	C			7.9	8.06
SN-2-U	24	100	A	14.4	31.5	7.9	8.15
SN-2-U	24	100	B			7.6	7.95
SN-2-U	24	100	C			7.8	8.01
SN-2-U	48	10	A	15.4	31.5	7.4	8.05
SN-2-U	48	10	B				
SN-2-U	48	10	C				
SN-2-U	48	50	A	15.4	31.5	7.5	7.95
SN-2-U	48	50	B				
SN-2-U	48	50	C				
SN-2-U	48	100	A	15.4	31.5	7.5	8.12
SN-2-U	48	100	B				
SN-2-U	48	100	C				
SN-2-U	72	10	A	15.2	31.5	7.7	8.00
SN-2-U	72	10	B				
SN-2-U	72	10	C				
SN-2-U	72	50	A	15.0	31.5	8.1	8.00
SN-2-U	72	50	B				
SN-2-U	72	50	C				
SN-2-U	72	100	A	15.2	31.5	7.9	8.11

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-U	72	100	B				
SN-2-U	72	100	C				
SN-2-U	96	10	A	15.3	31.0	7.7	7.87
SN-2-U	96	10	B	15.4	31.0	7.8	7.86
SN-2-U	96	10	C	15.3	31.5	7.6	7.84
SN-2-U	96	50	A	15.2	31.0	7.8	7.97
SN-2-U	96	50	B	15.3	31.5	7.8	7.95
SN-2-U	96	50	C	15.3	31.0	6.3	7.81
SN-2-U	96	100	A	15.3	31.0	7.8	7.83
SN-2-U	96	100	B	15.2	31.5	7.6	8.02
SN-2-U	96	100	C	14.7	31.5	7.9	8.07
SN-2-L	0	10	A	15.6	31.5	7.8	7.79
SN-2-L	0	10	B	15.6	31.5	7.7	7.86
SN-2-L	0	10	C	15.6	31.5	7.6	7.85
SN-2-L	0	50	A	15.6	31.5	7.8	7.79
SN-2-L	0	50	B	15.6	31.5	7.7	7.79
SN-2-L	0	50	C	15.6	31.5	7.7	7.87
SN-2-L	0	100	A	15.6	31.5	7.7	7.93
SN-2-L	0	100	B	15.6	31.5	7.7	8.06
SN-2-L	0	100	C	15.6	31.5	7.8	8.06
SN-2-L	24	10	A	14.4	31.5	7.8	7.93
SN-2-L	24	10	B			7.8	7.99
SN-2-L	24	10	C			8.0	7.99
SN-2-L	24	50	A	14.2	31.5	7.3	7.75
SN-2-L	24	50	B			7.8	8.07
SN-2-L	24	50	C			7.8	7.96
SN-2-L	24	100	A	14.2	31.5	7.7	7.90
SN-2-L	24	100	B			7.9	8.19
SN-2-L	24	100	C			7.9	8.19
SN-2-L	48	10	A	15.4	31.5	7.5	7.79
SN-2-L	48	10	B				
SN-2-L	48	10	C				
SN-2-L	48	50	A	15.4	31.5	7.3	7.90
SN-2-L	48	50	B				
SN-2-L	48	50	C				
SN-2-L	48	100	A	15.4	31.5	7.5	8.11
SN-2-L	48	100	B	15.4	31.5	7.6	8.08
SN-2-L	48	100	C	15.4	31.5	7.6	8.16
SN-2-L	72	10	A	15.0	31.5	8.0	7.99
SN-2-L	72	10	B				
SN-2-L	72	10	C				

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
SN-2-L	72	50	A	14.4	31.5	7.8	7.94
SN-2-L	72	50	B				
SN-2-L	72	50	C				
SN-2-L	72	100	A	14.5	31.5	8.0	8.08
SN-2-L	72	100	B	14.8	31.5	8.0	8.23
SN-2-L	72	100	C	15.0	31.5	8.1	8.23
SN-2-L	96	10	A	15.4	31.5	8.0	7.86
SN-2-L	96	10	B	15.3	31.0	7.5	7.87
SN-2-L	96	10	C	15.4	31.5	7.8	7.84
SN-2-L	96	50	A	15.0	31.0	7.9	7.95
SN-2-L	96	50	B	15.3	32.0	7.8	7.97
SN-2-L	96	50	C	15.3	31.5	7.8	7.98
SN-2-L	96	100	A	15.1	31.0	8.0	8.09
SN-2-L	96	100	B	15.3	30.5	8.0	8.14
SN-2-L	96	100	C	15.3	31.0	7.7	8.16
CH-C[b]	0	10	A	15.6	31.5	7.7	7.76
CH-C	0	10	B	15.6	31.5	7.7	7.70
CH-C	0	10	C	15.6	31.5	7.6	7.66
CH-C	0	50	A	15.6	31.5	7.8	7.79
CH-C	0	50	B	15.6	31.5	7.7	7.92
CH-C	0	50	C	15.6	31.5	7.6	7.73
CH-C	0	100	A	15.6	31.5	7.1	7.83
CH-C	0	100	B	15.6	31.5	7.6	7.81
CH-C	0	100	C	15.6	31.5	7.6	7.74
CH-C	24	10	A	14.2	31.5	7.3	7.68
CH-C	24	10	B			7.8	7.83
CH-C	24	10	C			7.8	7.79
CH-C	24	50	A	14.2	31.5	7.7	7.78
CH-C	24	50	B			7.8	7.97
CH-C	24	50	C			7.2	7.74
CH-C	24	100	A	14.2	31.5	7.2	7.76
CH-C	24	100	B			7.6	8.03
CH-C	24	100	C			7.7	7.80
CH-C	48	10	A	15.4	31.5	7.2	7.79
CH-C	48	10	B				
CH-C	48	10	C				
CH-C	48	50	A	15.4	31.5	7.5	7.83
CH-C	48	50	B				
CH-C	48	50	C				
CH-C	48	100	A	15.4	31.5	7.2	7.86
CH-C	48	100	B				
CH-C	48	100	C				

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
CH-C	72	10	A	14.4	31.5	7.7	7.81
CH-C	72	10	B				
CH-C	72	10	C				
CH-C	72	50	A	14.5	31.5	8.0	7.89
CH-C	72	50	B				
CH-C	72	50	C				
CH-C	72	100	A	14.5	31.5	7.8	7.85
CH-C	72	100	B				
CH-C	72	100	C				
CH-C	96	10	A	15.1	31.5	7.9	7.71
CH-C	96	10	B	15.3	31.5	7.8	7.83
CH-C	96	10	C	15.3	31.5	7.8	7.85
CH-C	96	50	A	15.0	31.5	7.5	7.86
CH-C	96	50	B	15.3	31.0	7.9	8.17
CH-C	96	50	C	15.3	31.5	7.7	7.87
CH-C	96	100	A	15.1	31.0	7.4	7.82
CH-C	96	100	B	15.4	31.0	7.7	8.09
CH-C	96	100	C	15.1	31.0	7.9	7.87
SEQUIM BAY[c]	0	10	A	15.6	31.5	7.7	7.71
SEQUIM BAY	0	10	B	15.6	31.5	7.8	7.83
SEQUIM BAY	0	10	C	15.6	31.5	7.7	7.83
SEQUIM BAY	0	50	A	15.6	31.5	7.7	7.76
SEQUIM BAY	0	50	B	15.6	31.5	7.6	7.72
SEQUIM BAY	0	50	C	15.6	31.5	7.7	7.76
SEQUIM BAY	0	100	A	15.6	31.5	7.7	7.76
SEQUIM BAY	0	100	B	15.6	31.5	7.7	7.60
SEQUIM BAY	0	100	C	15.6	31.5	7.6	7.72
SEQUIM BAY	24	10	A	14.4	31.5	7.5	7.85
SEQUIM BAY	24	10	B			7.6	7.97
SEQUIM BAY	24	10	C			7.8	7.97
SEQUIM BAY	24	50	A	14.4	31.5	7.7	7.86
SEQUIM BAY	24	50	B			7.6	7.78
SEQUIM BAY	24	50	C			7.7	7.82
SEQUIM BAY	24	100	A	14.4	31.5	7.8	7.93
SEQUIM BAY	24	100	B			7.9	7.90
SEQUIM BAY	24	100	C			7.8	7.77
SEQUIM BAY	48	10	A	15.4	31.5	7.5	7.85
SEQUIM BAY	48	10	B				
SEQUIM BAY	48	10	C				
SEQUIM BAY	48	50	A	15.4	31.5	7.3	7.94
SEQUIM BAY	48	50	B				
SEQUIM BAY	48	50	C				

TABLE E.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SEQUIM BAY	100	A	48	15.4	31.5	7.3	7.91
SEQUIM BAY	100	B	48				
SEQUIM BAY	100	C	48				
SEQUIM BAY	10	A	72	15.1	31.5	8.0	7.94
SEQUIM BAY	10	B	72				
SEQUIM BAY	10	C	72				
SEQUIM BAY	50	A	72	15.1	31.5	7.9	7.93
SEQUIM BAY	50	B	72				
SEQUIM BAY	50	C	72				
SEQUIM BAY	100	A	72	15.2	31.5	7.9	7.96
SEQUIM 8AY	100	B	72				
SEQUIM BAY	100	C	72				
SEQUIM BAY	10	A	96	15.4	31.5	8.0	7.83
SEQUIM BAY	10	B	96	15.3	31.0	7.7	7.89
SEQUIM BAY	10	C	96	15.4	31.5	7.7	7.82
SEQUIM BAY	50	A	96	15.3	31.5	8.0	7.86
SEQUIM BAY	50	B	96	15.4	31.0	7.7	7.81
SEQUIM BAY	50	C	96	15.4	31.5	7.7	7.83
SEQUIM BAY	100	A	96	15.3	31.0	7.9	7.81
SEQUIM BAY	100	B	96	15.4	31.0	8.1	7.87
SEQUIM BAY	100	C	96	15.2	31.5	7.8	7.85
SB WATER[d]	0	A	0	15.6	31.5	7.8	7.82
SB WATER	0	B	0	15.6	31.5	7.7	7.83
SB WATER	0	C	0	15.6	31.5	7.7	7.83
SB WATER	0	A	24	14.4	31.5	7.9	7.96
SB WATER	0	B	24			7.9	7.97
SB WATER	0	C	24			7.8	7.98
SB WATER	0	A	48	15.4	31.5	7.5	8.00
SB WATER	0	B	48				
SB WATER	0	C	48				
SB WATER	0	A	72	15.1	31.5	7.8	8.03
SB WATER	0	B	72				
SB WATER	0	C	72				
SB WATER	0	A	96	15.3	31.5	7.7	7.84
SB WATER	0	B	96	15.3	31.0	7.7	7.87
SB WATER	0	C	96	15.3	31.5	6.5	7.76

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Sequim Bay reference sediment.
(d) Sequim Bay seawater.

APPENDIX F

ACANTHOMYSIS SCULPTA BIOASSAY

TABLE F.1. Mysid Acute Toxicity Test

Sediment Treatment	% SPP[a]	Rep	Number Alive						
			0 h	4 h	8 h	24 h	48 h	72 h	96 h
TD-2-U	10	A	10	10	10	9	9	9	9
TD-2-U	10	B	10	10	10	10	10	10	10
TD-2-U	10	C	10	10	10	10	10	10	10
TD-2-U	50	A	10	10	10	9	9	9	9
TD-2-U	50	B	10	10	10	10	10	9	9
TD-2-U	50	C	10	10	10	10	9	9	9
TD-2-U	100	A	10	10	10	10	8	7	7
TD-2-U	100	B	10	10	10	10	10	9	8
TD-2-U	100	C	10	10	10	10	10	10	10
TD-2-L	10	A	10	10	10	10	10	10	10
TD-2-L	10	B	10	10	10	10	10	10	10
TD-2-L	10	C	10	10	10	9	9	9	9
TD-2-L	50	A	10	10	10	10	10	9	8
TD-2-L	50	B	10	10	10	9	9	9	9
TD-2-L	50	C	10	10	10	10	10	10	9
TD-2-L	100	A	10	10	10	10	9	7	7
TD-2-L	100	B	10	10	10	9	8	7	7
TD-2-L	100	C	10	10	10	9	9	7	6
SN-2-U	10	A	10	10	10	10	10	10	9
SN-2-U	10	B	10	10	10	10	10	9	9
SN-2-U	10	C	10	10	10	10	10	10	10
SN-2-U	50	A	10	10	10	9	9	9	9
SN-2-U	50	B	10	10	10	10	9	9	8
SN-2-U	50	C	10	10	10	10	10	10	10
SN-2-U	100	A	10	10	10	9	8	8	7
SN-2-U	100	B	10	10	10	10	9	8	8
SN-2-U	100	C	10	10	10	9	9	9	9
SN-2-L	10	A	10	10	10	10	10	10	10
SN-2-L	10	B	10	10	10	10	10	10	10
SN-2-L	10	C	10	10	10	10	10	10	10
SN-2-L	50	A	10	10	10	10	9	9	8
SN-2-L	50	B	10	10	10	10	10	10	10
SN-2-L	50	C	10	10	10	10	10	9	9
SN-2-L	100	A	10	10	10	10	7	7	7
SN-2-L	100	B	10	10	10	10	9	8	7
SN-2-L	100	C	10	10	10	9	8	8	7
CH-C[b]	10	A	10	10	10	10	10	10	10
CH-C	10	B	10	10	10	10	10	9	9
CH-C	10	C	10	10	10	9	9	9	9
CH-C	50	A	10	10	10	10	9	8	8
CH-C	50	B	10	10	10	10	9	8	8
CH-C	50	C	10	10	10	10	10	9	9
CH-C	100	A	10	10	10	10	9	8	8

TABLE F.1. (contd)

Sediment Treatment	% SPP[a]	Rep	Number Alive 0 h	4 h	8 h	24 h	48 h	72 h	96 h
CH-C	100	B	10	10	10	10	9	8	8
CH-C	100	C	10	10	10	8	8	8	8
SEQUIM BAY[c]	10	A	10	10	10	10	10	10	10
SEQUIM BAY	10	B	10	10	10	10	10	10	10
SEQUIM BAY	10	C	10	10	10	9	9	9	9
SEQUIM BAY	50	A	10	10	10	9	9	9	B
SEQUIM BAY	50	B	10	10	10	10	10	10	10
SEQUIM BAY	50	C	10	10	10	10	10	10	9
SEQUIM BAY	100	A	10	10	10	10	10	8	8
SEQUIM BAY	100	B	10	10	10	10	9	8	8
SEQUIM BAY	100	C	10	10	10	10	10	9	9
SB WATER[d]	0	A	10	10	10	10	10	10	10
SB WATER	0	B	10	10	10	10	10	10	10
SB WATER	0	C	10	10	10	10	10	10	10

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Sequim Bay reference sediment.
(d) Sequim Bay seawater.

TABLE F.2. Water Quality Monitoring - Mysid Acute Toxicity Test

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-U	0	10	A	15.0	31.0	8.0	7.84
TD-2-U	0	10	B	15.0	31.0	8.0	7.83
TD-2-U	0	10	C	15.0	31.5	8.0	7.84
TD-2-U	0	50	A	15.5	31.0	7.6	7.82
TD-2-U	0	50	B	15.5	31.0	7.6	7.82
TD-2-U	0	50	C	15.5	31.5	7.6	7.82
TD-2-U	0	100	A	16.0	31.5	6.8	7.77
TD-2-U	0	100	8	16.0	31.5	6.8	7.76
TD-2-U	0	100	C	16.0	31.5	6.9	7.77
TD-2-U	4	10	A			7.2	
TD-2-U	4	10	B			7.4	
TD-2-U	4	10	C			7.2	
TD-2-U	4	50	A			6.9	
TD-2-U	4	50	B			6.9	
TD-2-U	4	50	C			7.0	
TD-2-U	4	100	A			6.7	
TD-2-U	4	100	B			6.5	
TD-2-U	4	100	C			6.6	
TD-2-U	8	10	A			7.2	
TD-2-U	8	10	B			7.1	
TD-2-U	8	10	C			7.2	
TD-2-U	8	50	A			6.8	
TD-2-U	8	50	B			6.6	
TD-2-U	8	50	C			6.9	
TD-2-U	8	100	A			6.5	
TD-2-U	8	100	B			6.6	
TD-2-U	8	100	C			6.5	
TD-2-U	24	10	A	15.0	31.5	6.0	7.84
TD-2-U	24	10	B	15.0	31.5	5.7	7.75
TD-2-U	24	10	C	15.5	32.0	6.5	7.84
TD-2-U	24	50	A	15.5	31.5	6.0	7.84
TD-2-U	24	50	8	15.5	31.0	6.2	7.85
TD-2-U	24	50	C	15.5	31.5	6.1	7.84
TD-2-U	24	100	A	15.5	31.5	6.5	7.92
TD-2-U	24	100	B	15.5	31.5	6.1	7.91
TD-2-U	24	100	C	15.5	31.5	6.1	7.88
TD-2-U	48	10	A	15.5	31.0	5.8	7.66
TD-2-U	48	10	B	15.D	31.0	5.2	7.56
TD-2-U	48	10	C	15.0	31.5	5.7	7.63
TD-2-U	48	50	A	15.5	31.5	5.4	7.68
TD-2-U	48	50	B	15.5	31.0	5.3	7.70
TD-2-U	48	50	C	15.0	31.5	5.4	7.67

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-U	48	100	A	15.0	31.0	5.5	7.78
TD-2-U	48	100	B	15.5	31.0	5.1	7.77
TD-2-U	48	100	C	15.5	31.5	5.0	7.75
TD-2-U	72	10	A	15.5	31.5	5.6	7.56
TD-2-U	72	10	B	15.5	31.0	5.0	7.48
TD-2-U	72	10	C	15.5	31.5	5.6	7.56
TD-2-U	72	50	A	15.5	31.5	5.1	7.54
TD-2-U	72	50	B	15.5	31.5	5.0	7.57
TD-2-U	72	50	C	15.5	31.5	5.3	7.58
TD-2-U	72	100	A	15.5	31.5	5.4	7.68
TD-2-U	72	100	B	15.5	31.5	4.9	7.55
TD-2-U	72	100	C	15.5	31.0	4.6	7.58
TD-2-U	96	10	A	15.0	32.0	4.9	7.49
TD-2-U	96	10	B	15.0	31.0	4.6	7.52
TD-2-U	96	10	C	15.0	31.0	5.0	7.51
TD-2-U	96	50	A	15.0	31.0	5.0	7.54
TD-2-U	96	50	B	15.0	31.5	4.6	7.55
TD-2-U	96	50	C	15.0	31.5	4.8	7.54
TD-2-U	96	100	A	15.0	31.0	4.9	7.68
TD-2-U	96	100	B	15.0	31.0	4.7	7.62
TD-2-U	96	100	C	15.0	31.5	4.7	7.61
TD-2-L	0	10	A	15.0	31.0	7.9	7.90
TD-2-L	0	10	B	15.0	30.5	8.0	7.91
TD-2-L	0	10	C	15.0	30.5	8.0	7.91
TD-2-L	0	50	A	15.5	31.5	7.6	7.87
TD-2-L	0	50	B	15.5	30.5	7.6	7.87
TD-2-L	0	50	C	16.0	31.5	7.6	7.87
TD-2-L	0	100	A	16.0	30.5	6.9	7.87
TD-2-L	0	100	B	16.0	30.5	6.9	7.87
TD-2-L	0	100	C	16.0	30.5	6.9	7.87
TD-2-L	4	10	A			7.3	
TD-2-L	4	10	B			7.3	
TD-2-L	4	10	C			7.2	
TD-2-L	4	50	A			7.0	
TD-2-L	4	50	B			7.2	
TD-2-L	4	50	C			6.9	
TD-2-L	4	100	A			6.6	
TD-2-L	4	100	B			6.5	
TD-2-L	4	100	C			6.6	

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-L	8	10	A			7.1	
TD-2-L	8	10	B			6.8	
TD-2-L	8	10	C			7.1	
TD-2-L	8	50	A			6.9	
TD-2-L	8	50	B			6.8	
TD-2-L	8	50	C			6.9	
TD-2-L	8	100	A			6.5	
TD-2-L	8	100	B			6.5	
TD-2-L	8	100	C			6.5	
TD-2-L	24	10	A	15.0	31.0	6.3	7.87
TD-2-L	24	10	B	15.0	31.0	6.3	7.85
TD-2-L	24	10	C	15.0	31.5	6.0	7.83
TD-2-L	24	50	A	15.0	31.0	6.4	7.91
TD-2-L	24	50	B	15.0	31.5	6.3	7.92
TD-2-L	24	50	C	15.0	31.5	6.4	7.94
TD-2-L	24	100	A	15.0	31.0	6.2	7.97
TD-2-L	24	100	B	15.0	31.0	6.1	7.98
TD-2-L	24	100	C	15.0	31.0	6.3	7.98
TD-2-L	48	10	A	15.0	31.0	5.7	7.55
TD-2-L	48	10	B	15.0	31.0	5.9	7.58
TD-2-L	48	10	C	15.0	31.0	5.4	7.55
TD-2-L	48	50	A	15.0	31.5	5.5	7.68
TD-2-L	48	50	B	15.0	31.5	5.3	7.68
TD-2-L	48	50	C	15.0	31.5	5.6	7.70
TD-2-L	48	100	A	15.0	30.5	5.3	7.78
TD-2-L	48	100	B	15.0	31.0	5.6	7.82
TD-2-L	48	100	C	15.0	31.0	5.4	7.82
TD-2-L	72	10	A	15.5	31.5	5.5	7.55
TD-2-L	72	10	B	15.5	31.5	5.4	7.54
TD-2-L	72	10	C	15.5	31.5	5.1	7.53
TD-2-L	72	50	A	15.5	31.0	5.2	7.68
TD-2-L	72	50	B	15.5	31.5	5.0	7.62
TD-2-L	72	50	C	15.5	32.0	5.3	7.66
TD-2-L	72	100	A	15.5	31.5	5.1	7.78
TD-2-L	72	100	B	15.5	31.5	4.9	7.77
TD-2-L	72	100	C	15.5	31.5	5.0	7.78
TD-2-L	96	10	A	14.5	31.5	4.9	7.56
TD-2-L	96	10	B	15.0	32.0	5.5	7.54
TD-2-L	96	10	C	15.0	32.0	4.9	7.53
TD-2-L	96	50	A	15.0	31.5	4.7	7.68
TD-2-L	96	50	B	15.0	31.5	4.8	7.63
TD-2-L	96	50	C	14.5	32.0	4.6	7.64

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-L	96	100	A	15.0	31.5	4.7	7.79
TD-2-L	96	100	B	15.0	31.5	4.6	7.77
TD-2-L	96	100	C	15.0	31.5	4.7	7.76
SN-2-U	0	10	A	16.0	31.5	8.1	7.86
SN-2-U	0	10	B	16.0	31.5	8.1	7.87
SN-2-U	0	10	C	16.0	31.5	8.1	7.87
SN-2-U	0	50	A	16.0	31.5	7.7	7.85
SN-2-U	0	50	B	16.0	31.5	7.7	7.85
SN-2-U	0	50	C	16.0	32.0	7.7	7.85
SN-2-U	0	100	A	16.0	32.0	7.0	7.80
SN-2-U	0	100	B	16.0	32.0	7.0	7.80
SN-2-U	0	100	C	16.0	32.0	7.0	7.80
SN-2-U	4	10	A			7.2	
SN-2-U	4	10	B			7.2	
SN-2-U	4	10	C			7.2	
SN-2-U	4	50	A			7.6	
SN-2-U	4	50	B			7.6	
SN-2-U	4	50	C			7.2	
SN-2-U	4	100	A			6.7	
SN-2-U	4	100	B			6.6	
SN-2-U	4	100	C			6.7	
SN-2-U	8	10	A			7.2	
SN-2-U	8	10	B			7.2	
SN-2-U	8	10	C			7.1	
SN-2-U	8	50	A			7.1	
SN-2-U	8	50	B			7.1	
SN-2-U	8	50	C			7.2	
SN-2-U	8	100	A			7.0	
SN-2-U	8	100	B			6.9	
SN-2-U	8	100	C			6.9	
SN-2-U	24	10	A	16.0	31.0	6.3	7.86
SN-2-U	24	10	B	16.0	31.5	6.5	7.84
SN-2-U	24	10	C	16.0	31.0	6.1	7.80
SN-2-U	24	50	A	16.0	31.5	6.4	7.92
SN-2-U	24	50	B	16.0	31.5	6.4	7.93
SN-2-U	24	50	C	16.0	31.5	6.6	7.96
SN-2-U	24	100	A	16.0	31.5	6.5	7.99
SN-2-U	24	100	B	16.0	31.5	6.6	7.98
SN-2-U	24	100	C	16.0	31.5	6.2	7.97

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-U	48	10	A	14.5	31.0	6.1	7.72
SN-2-U	48	10	B	15.0	31.0	6.3	7.62
SN-2-U	48	10	C	15.0	31.5	5.8	7.61
SN-2-U	48	50	A	15.0	31.5	6.0	7.82
SN-2-U	48	50	B	15.0	31.5	5.9	7.86
SN-2-U	48	50	C	15.0	31.5	6.2	7.84
SN-2-U	48	100	A	15.0	31.5	5.7	7.91
SN-2-U	48	100	B	14.5	31.5	5.9	7.93
SN-2-U	48	100	C	15.0	31.5	5.9	7.91
SN-2-U	72	10	A	15.5	31.5	5.5	7.56
SN-2-U	72	10	B	15.5	31.5	4.9	7.48
SN-2-U	72	10	C	15.0	31.5	5.4	7.55
SN-2-U	72	50	A	15.5	31.0	5.0	7.69
SN-2-U	72	50	B	15.5	31.5	5.3	7.72
SN-2-U	72	50	C	15.5	31.5	5.2	7.69
SN-2-U	72	100	A	15.5	31.5	5.3	7.77
SN-2-U	72	100	B	15.5	31.5	5.1	7.79
SN-2-U	72	100	C	15.5	32.0	5.0	7.78
SN-2-U	96	10	A	15.0	31.0	5.0	7.52
SN-2-U	96	10	B	15.5	31.0	4.7	7.52
SN-2-U	96	10	C	15.5	32.0	4.8	7.54
SN-2-U	96	50	A	15.0	31.5	4.7	7.68
SN-2-U	96	50	B	15.0	31.5	4.9	7.70
SN-2-U	96	50	C	15.0	31.0	4.9	7.67
SN-2-U	96	100	A	15.0	31.0	4.8	7.74
SN-2-U	96	100	B	15.0	31.0	4.7	7.79
SN-2-U	96	100	C	15.5	31.5	4.7	7.77
SN-2-L	0	10	A	15.5	31.0	8.2	7.90
SN-2-L	0	10	B	15.5	31.0	8.1	7.90
SN-2-L	0	10	C	15.5	31.0	8.1	7.90
SN-2-L	0	50	A	15.5	31.0	7.4	7.86
SN-2-L	0	50	B	15.5	31.0	7.4	7.86
SN-2-L	0	50	C	15.5	30.5	7.4	7.85
SN-2-L	0	100	A	15.5	30.5	6.2	7.82
SN-2-L	0	100	B	16.0	30.5	6.3	7.82
SN-2-L	0	100	C	16.0	30.5	6.3	7.82
SN-2-L	4	10	A			7.4	
SN-2-L	4	10	B			7.3	
SN-2-L	4	10	C			7.4	
SN-2-L	4	50	A			7.0	
SN-2-L	4	50	B			7.1	
SN-2-L	4	50	C			7.0	

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-L	4	100	A			6.5	
SN-2-L	4	100	B			6.4	
SN-2-L	4	100	C			6.4	
SN-2-L	8	10	A			7.6	
SN-2-L	8	10	B			7.2	
SN-2-L	8	10	C			7.0	
SN-2-L	8	50	A			7.0	
SN-2-L	8	50	B			7.0	
SN-2-L	8	50	C			7.1	
SN-2-L	8	100	A			6.8	
SN-2-L	8	100	B			6.8	
SN-2-L	8	100	C			6.9	
SN-2-L	24	10	A	16.0	31.5	6.1	7.86
SN-2-L	24	10	B	16.0	31.5	6.8	7.90
SN-2-L	24	10	C	16.0	31.5	6.6	7.89
SN-2-L	24	50	A	16.0	31.5	6.3	8.00
SN-2-L	24	50	B	16.0	32.0	6.3	7.97
SN-2-L	24	50	C	16.0	31.5	6.5	8.01
SN-2-L	24	100	A	16.0	31.0	6.2	8.07
SN-2-L	24	100	B	16.0	31.5	6.2	8.07
SN-2-L	24	100	C	16.0	31.5	6.3	8.06
SN-2-L	48	10	A	15.0	31.5	5.7	7.65
SN-2-L	48	10	B	15.0	31.5	6.0	7.71
SN-2-L	48	10	C	15.0	31.5	5.7	7.68
SN-2-L	48	50	A	15.0	31.5	5.8	7.89
SN-2-L	48	50	B	15.0	31.5	5.9	7.90
SN-2-L	48	50	C	15.0	31.0	5.7	7.92
SN-2-L	48	100	A	15.0	31.0	5.6	8.01
SN-2-L	48	100	B	15.0	31.0	5.5	8.04
SN-2-L	48	100	C	15.0	31.0	5.5	8.02
SN-2-L	72	10	A	15.0	31.0	5.1	7.51
SN-2-L	72	10	B	15.0	31.5	5.9	7.61
SN-2-L	72	10	C	15.0	31.5	5.7	7.59
SN-2-L	72	50	A	15.0	32.0	5.0	7.74
SN-2-L	72	50	B	15.0	31.5	4.9	7.76
SN-2-L	72	50	C	15.0	31.5	5.2	7.77
SN-2-L	72	100	A	15.0	31.5	5.2	7.91
SN-2-L	72	100	B	15.0	31.5	4.9	7.91
SN-2-L	72	100	C	15.0	31.0	5.0	7.90

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-L	96	10	A	15.0	31.0	5.0	7.54
SN-2-L	96	10	B	15.0	32.0	4.9	7.56
SN-2-L	96	10	C	15.0	32.0	4.9	7.56
SN-2-L	96	50	A	15.0	31.5	5.0	7.72
SN-2-L	96	50	B	15.0	32.0	4.8	7.73
SN-2-L	96	50	C	15.0	31.5	5.2	7.76
SN-2-L	96	100	A	15.0	31.5	4.7	7.90
SN-2-L	96	100	B	15.0	31.5	4.5	7.89
SN-2-L	96	100	C	15.0	31.5	5.0	7.89
CH-C[b]	0	10	A	15.5	30.5	7.7	7.91
CH-C	0	10	B	15.5	30.5	7.9	7.92
CH-C	0	10	C	15.5	31.0	7.8	7.93
CH-C	0	50	A	16.0	31.0	7.1	7.90
CH-C	0	50	B	16.0	30.5	7.3	7.90
CH-C	0	50	C	16.0	30.5	7.0	7.90
CH-C	0	100	A	16.0	30.5	6.4	7.87
CH-C	0	100	B	16.0	31.5	6.4	7.87
CH-C	0	100	C	16.0	31.5	6.6	7.88
CH-C	4	10	A			7.1	
CH-C	4	10	B			6.7	
CH-C	4	10	C			7.2	
CH-C	4	50	A			6.8	
CH-C	4	50	B			6.8	
CH-C	4	50	C			6.9	
CH-C	4	100	A			6.3	
CH-C	4	100	B			6.4	
CH-C	4	100	C			6.4	
CH-C	8	10	A			7.2	
CH-C	8	10	B			6.8	
CH-C	8	10	C			7.0	
CH-C	8	50	A			6.7	
CH-C	8	50	B			6.6	
CH-C	8	50	C			6.7	
CH-C	8	100	A			6.5	
CH-C	8	100	B			6.4	
CH-C	8	100	C			6.5	
CH-C	24	10	A	15.5	31.5	6.1	7.85
CH-C	24	10	B	15.5	31.5	5.6	7.82
CH-C	24	10	C	15.0	31.0	6.0	7.84
CH-C	24	50	A	15.0	31.0	5.7	7.86
CH-C	24	50	B	15.0	30.5	6.1	7.86
CH-C	24	50	C	15.0	31.0	6.0	7.89

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
CH-C	24	100	A	15.5	31.0	6.3	7.87
CH-C	24	100	B	15.5	31.0	5.7	7.95
CH-C	24	100	C	15.0	31.0	6.2	7.94
CH-C	48	10	A	15.0	31.5	5.6	7.58
CH-C	48	10	B	15.0	31.5	5.7	7.55
CH-C	48	10	C	15.0	31.5	5.7	7.58
CH-C	48	50	A	15.0	31.0	5.5	7.62
CH-C	48	50	B	15.0	30.5	5.7	7.65
CH-C	48	50	C	15.0	31.0	5.7	7.63
CH-C	48	100	A	15.0	31.0	5.5	7.65
CH-C	48	100	B	15.0	31.0	5.1	7.73
CH-C	48	100	C	15.0	31.0	5.4	7.68
CH-C	72	10	A	15.5	31.5	5.2	7.56
CH-C	72	10	8	15.5	32.0	5.1	7.54
CH-C	72	10	C	15.0	31.5	5.4	7.54
CH-C	72	50	A	15.5	31.0	5.4	7.65
CH-C	72	50	B	15.0	31.0	4.9	7.61
CH-C	72	50	C	15.5	31.5	5.5	7.63
CH-C	72	100	A	15.5	31.0	4.8	7.65
CH-C	72	100	B	15.5	31.0	5.3	7.69
CH-C	72	100	C	15.5	31.5	5.4	7.67
CH-C	96	10	A	14.5	31.5	4.7	7.53
CH-C	96	10	B	15.0	31.5	4.4	7.55
CH-C	96	10	C	14.5	31.5	4.9	7.52
CH-C	96	50	A	14.5	31.5	4.9	7.64
CH-C	96	50	B	15.0	31.0	4.6	7.61
CH-C	96	50	C	15.0	31.5	5.0	7.64
CH-C	96	100	A	15.0	31.5	4.6	7.66
CH-C	96	100	B	15.0	31.5	4.9	7.69
CH-C	96	100	C	15.0	32.0	4.9	7.68
SEQUIM BAY[c]	0	10	A	15.5	31.5	8.2	7.92
SEQUIM BAY	0	10	B	15.5	31.5	8.2	7.92
SEQUIM BAY	0	10	C	15.5	31.5	8.2	7.92
SEQUIM BAY	0	50	A	15.5	31.5	7.6	7.87
SEQUIM BAY	0	50	B	15.5	31.5	7.6	7.87
SEQUIM BAY	0	50	C	15.5	31.5	7.6	7.87
SEQUIM BAY	0	100	A	15.5	31.0	6.7	7.82
SEQUIM BAY	0	100	B	15.5	31.0	6.5	7.82
SEQUIM BAY	0	100	C	15.5	31.5	6.5	7.81

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SEQUIM BAY	4	10	A			7.0	
SEQUIM BAY	4	10	B			7.0	
SEQUIM BAY	4	10	C			7.1	
SEQUIM BAY	4	50	A			6.7	
SEQUIM BAY	4	50	B			6.7	
SEQUIM BAY	4	50	C			6.9	
SEQUIM BAY	4	100	A			6.6	
SEQUIM BAY	4	100	B			6.5	
SEQUIM BAY	4	100	C			6.5	
SEQUIM BAY	8	10	A			6.3	
SEQUIM BAY	8	10	B			6.5	
SEQUIM BAY	8	10	C			6.6	
SEQUIM BAY	8	50	A			6.2	
SEQUIM BAY	8	50	B			6.3	
SEQUIM BAY	8	50	C			6.2	
SEQUIM BAY	8	100	A			6.0	
SEQUIM BAY	8	100	B			6.1	
SEQUIM BAY	8	100	C			6.0	
SEQUIM BAY	24	10	A	16.0	31.5	5.5	7.68
SEQUIM BAY	24	10	B	16.0	31.5	6.2	7.77
SEQUIM BAY	24	10	C	16.0	31.5	6.6	7.76
SEQUIM BAY	24	50	A	16.0	32.0	5.9	7.75
SEQUIM BAY	24	50	B	16.0	32.0	6.1	7.77
SEQUIM BAY	24	50	C	16.0	32.0	6.0	7.81
SEQUIM BAY	24	100	A	16.0	31.5	5.8	7.78
SEQUIM BAY	24	100	B	16.0	31.5	5.8	7.76
SEQUIM BAY	24	100	C	16.0	32.0	5.9	7.80
SEQUIM BAY	48	10	A	15.0	30.5	5.3	7.52
SEQUIM BAY	48	10	B	15.0	31.0	5.8	7.58
SEQUIM BAY	48	10	C	15.0	31.0	5.6	7.64
SEQUIM BAY	48	50	A	15.0	31.5	5.7	7.59
SEQUIM BAY	48	50	B	15.0	31.0	5.5	7.54
SEQUIM BAY	48	50	C	15.0	32.0	5.7	7.57
SEQUIM BAY	48	100	A	15.5	31.5	5.4	7.58
SEQUIM BAY	48	100	B	15.0	32.0	5.6	7.58
SEQUIM BAY	48	100	C	15.0	32.0	5.7	7.61
SEQUIM BAY	72	10	A	15.0	31.5	4.9	7.42
SEQUIM BAY	72	10	B	15.0	32.0	5.4	7.48
SEQUIM BAY	72	10	C	15.0	31.5	5.5	7.57
SEQUIM BAY	72	50	A	15.0	31.5	4.8	7.49
SEQUIM BAY	72	50	B	14.5	32.0	4.7	7.46
SEQUIM BAY	72	50	C	15.0	31.5	4.7	7.50

TABLE F.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SEQUIM BAY	72	100	A	14.5	31.5	4.4	7.49
SEQUIM BAY	72	100	B	15.0	31.5	4.5	7.49
SEQUIM BAY	72	100	C	15.0	32.0	4.8	7.50
SEQUIM BAY	96	10	A	15.0	32.0	4.6	7.38
SEQUIM BAY	96	10	B	15.5	32.0	5.1	7.49
SEQUIM BAY	96	10	C	15.0	31.5	5.4	7.54
SEQUIM BAY	96	50	A	15.0	31.5	4.2	7.51
SEQUIM BAY	96	50	B	15.0	31.5	4.4	7.48
SEQUIM BAY	96	50	C	15.0	32.0	4.3	7.51
SEQUIM BAY	96	100	A	15.0	31.5	4.2	7.50
SEQUIM BAY	96	100	B	15.0	31.5	4.4	7.53
SEQUIM 8AY	96	100	C	15.0	32.0	4.5	7.53
SB WATER[d]	0	0	A	15.5	31.5	8.1	7.85
SB WATER	0	0	B	15.5	31.5	8.2	7.87
SB WATER	0	0	C	15.5	31.5	8.2	7.87
SB WATER	4	0	A			7.2	
SB WATER	4	0	B			7.1	
SB WATER	4	0	C			7.3	
SB WATER	8	0	A			6.9	
SB WATER	8	0	B			7.0	
SB WATER	8	0	C			7.0	
SB WATER	24	0	A	15.5	31.5	6.5	7.87
SB WATER	24	0	B	15.0	31.5	6.5	7.87
SB WATER	24	0	C	15.0	31.5	6.4	7.82
SB WATER	48	0	A	14.5	31.0	6.0	7.67
SB WATER	48	0	B	15.0	31.0	5.9	7.69
SB WATER	48	0	C	15.0	31.5	5.6	7.65
SB WATER	72	0	A	15.5	31.0	5.7	7.53
SB WATER	72	0	B	15.5	31.5	5.7	7.57
SB WATER	72	0	C	15.5	31.5	5.8	7.55
SB WATER	96	0	A	15.0	31.0	5.0	7.51
SB WATER	96	0	B	15.0	31.0	4.9	7.53
SB WATER	96	0	C	15.0	31.5	5.1	7.52

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Sequim Bay reference sediment.
(d) Sequim Bay seawater.

APPENDIX G

CRASSOSTREA GIGAS BIOASSAY

TABLE G.1. *Crassostrea gigas* Suspended-Particulate-Phase Toxicity Test 2

Sediment Treatment	% SPP[a]	Rep	Normal	Blastula	Abnormal	Total
TD-2-U	10	A	385	3	14	402
TD-2-U	10	B	565	0	32	597
TD-2-U	10	C	487	14	12	513
TD-2-U	50	A	497	21	33	551
TD-2-U	50	B1	413	13	34	460
TD-2-U	50	B2	421	14	25	460
TD-2-U	50	C	509	8	15	532
TD-2-U	100	A	0	0	75	75
TD-2-U	100	B	1	3	82	86
TD-2-U	100	C	10	9	124	143
TD-2-L	10	A	321	17	152	490
TD-2-L	10	B	105	2	60	167
TD-2-L	10	C	348	5	149	502
TD-2-L	50	B	160	1	32	192
TD-2-L	50	A	330	5	73	408
TD-2-L	50	C	116	11	74	201
TD-2-L	100	A	0	1	161	162
TD-2-L	100	B	0	4	102	106
TD-2-L	100	C1	0	13	95	108
TD-2-L	100	C2	0	16	106	122
SN-2-U	10	A	527	2	22	551
SN-2-U	10	B	253	1	26	280
SN-2-U	10	C1	438	5	46	489
SN-2-U	10	C2	452	10	32	494
SN-2-U	50	A	318	1	16	335
SN-2-U	50	B	481	2	26	509
SN-2-U	50	C	555	3	19	577
SN-2-U	100	A	130	2	25	157
SN-2-U	100	B1	1	5	37	43
SN-2-U	100	B2	1	6	34	41
SN-2-U	100	C	402	5	56	463
SN-2-L	10	A	0	6	20	26
SN-2-L	10	B	388	3	77	468
SN-2-L	10	C	89	0	31	120
SN-2-L	50	A	445	4	56	505
SN-2-L	50	B	269	3	30	302
SN-2-L	50	C	336	1	58	395
SN-2-L	100	A1	0	3	39	42
SN-2-L	100	A2	0	3	33	36
SN-2-L	100	B	30	7	319	356
SN-2-L	100	C	0	4	100	104

TABLE G.1. (contd)

Sediment Treatment	% SPP[a]	Rep	Normal	Blastula	Abnormal	Total
CH-C[b]	10	A	361	6	143	510
CH-C	10	B	219	14	181	414
CH-C	10	C	319	11	64	394
CH-C	50	A1	383	9	84	476
CH-C	50	A2	391	8	88	487
CH-C	50	B	202	2	16	220
CH-C	50	C	583	173	31	787
CH-C	100	A	479	18	31	528
CH-C	100	B	325	23	3	351
CH-C	100	C	525	28	31	584
SEQUIM BAY[c]	10	A	588	1	3	592
SEQUIM 8AY	10	B1	519	1	12	532
SEQUIM 8AY	10	B2	525	1	15	541
SEQUIM 8AY	10	C	438	12	81	531
SEQUIM 8AY	50	A	643	2	57	702
SEQUIM 8AY	50	8	308	4	43	355
SEQUIM BAY	50	C	545	5	64	614
SEQUIM BAY	100	A	566	2	46	614
SEQUIM BAY	100	B	490	3	89	582
SEQUIM BAY	100	C	434	5	40	479
SEAWATER[d]	0	A	620	7	47	674
SEAWATER	0	B	396	2	46	444
SEAWATER	0	C	334	1	19	354
SEAWATER	0	D	528	3	38	569

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Percent Sequim Bay reference sediment.
(d) Strait of Juan de Fuca seawater.

TABLE G.2. Water Quality Monitoring - *Crassostrea gigas* Suspended-Particulate-Phase Toxicity Test

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-U	0	10	A		25.0	7.20	7.60
TD-2-U	0	10	B				
TD-2-U	0	10	C				
TD-2-U	0	50	A	20.5	25.5	6.80	7.70
TD-2-U	0	50	B				
TD-2-U	0	50	C				
TD-2-U	0	100	A		25.0	6.30	7.72
TD-2-U	0	100	B				
TD-2-U	0	100	C				
TD-2-U	24	10	A		25.0	8.42	8.06
TD-2-U	24	10	B		25.0	8.48	8.26
TD-2-U	24	10	C		25.0	8.40	8.07
TD-2-U	24	50	A		25.0	8.43	8.05
TD-2-U	24	50	B		25.0	8.42	8.15
TD-2-U	24	50	C		25.0	8.48	8.13
TD-2-U	24	100	A		24.5	8.47	8.22
TD-2-U	24	100	B		25.0	8.26	8.23
TD-2-U	24	100	C		25.0	8.35	8.16
TD-2-U	48	10	A				
TD-2-U	48	10	B			7.46	8.06
TD-2-U	48	10	C			7.42	8.08
TD-2-U	48	50	A				
TD-2-U	48	50	B				
TD-2-U	48	50	C			7.43	8.14
TD-2-U	48	100	A				
TD-2-U	48	100	B		25.0	7.42	8.21
TD-2-U	48	100	C			7.20	8.18
TD-2-U	96	10	A		25.0	7.20	8.06
TD-2-U	96	10	B		25.5	7.20	8.07
TD-2-U	96	10	C		25.0	7.30	8.09
TD-2-U	96	50	A		25.5	7.15	8.04
TD-2-U	96	50	B		25.0	7.30	8.11
TD-2-U	96	50	C		25.0	7.30	8.13
TD-2-U	96	100	A		25.0	7.40	8.19
TD-2-U	96	100	B		25.0	7.30	8.20
TD-2-U	96	100	C		25.0	7.30	8.19
TD-2-L	0	10	A		25.5	7.40	7.58
TD-2-L	0	10	B				
TD-2-L	0	10	C				
TD-2-L	0	50	A		25.5	7.20	7.61
TD-2-L	0	50	B				

TABLE G.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-2-L	0	50	C				
TD-2-L	0	100	A	20.0	25.5	6.90	7.78
TD-2-L	0	100	B				
TD-2-L	0	100	C				
TD-2-L	24	10	A		25.0	8.43	8.08
TD-2-L	24	10	B		25.0	8.39	8.28
TD-2-L	24	10	C		25.0	8.47	8.05
TD-2-L	24	50	A		25.0	8.45	8.09
TD-2-L	24	50	B	20.0	24.5	8.40	8.18
TD-2-L	24	50	C		25.0	8.40	8.31
TD-2-L	24	100	A		24.5	8.45	8.30
TD-2-L	24	100	B		24.5	8.37	8.21
TD-2-L	24	100	C		24.5	8.37	8.33
TD-2-L	48	10	A				
TD-2-L	48	10	B				
TD-2-L	48	10	C		25.0	7.27	8.04
TD-2-L	48	50	A				
TD-2-L	48	50	B			7.45	8.23
TD-2-L	48	50	C			7.52	8.19
TD-2-L	48	100	A				
TD-2-L	48	100	B			7.40	8.32
TD-2-L	48	100	C		25.0	7.45	8.44
TD-2-L	96	10	A		25.0	7.10	8.07
TD-2-L	96	10	B		25.0	7.20	8.22
TD-2-L	96	10	C		25.0	7.20	8.01
TD-2-L	96	50	A		25.0	7.20	8.11
TD-2-L	96	50	B		25.0	7.30	8.17
TD-2-L	96	50	C		25.0	7.30	8.20
TD-2-L	96	100	A		25.5	7.22	8.24
TD-2-L	96	100	B		25.0	7.20	8.22
TD-2-L	96	100	C		25.0	7.20	8.30
SN-2-U	0	10	A		24.5	7.30	7.59
SN-2-U	0	10	B				
SN-2-U	0	10	C				
SN-2-U	0	50	A	19.5	25.5	7.10	7.65
SN-2-U	0	50	B				
SN-2-U	0	50	C				
SN-2-U	0	100	A		25.0	7.10	7.74
SN-2-U	0	100	B				
SN-2-U	0	100	C				

TABLE G.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-U	24	10	A		25.0	8.40	8.02
SN-2-U	24	10	B		25.0	8.48	8.08
SN-2-U	24	10	C		25.0	8.36	8.04
SN-2-U	24	50	A		25.0	8.35	8.15
SN-2-U	24	50	B		25.0	8.46	8.19
SN-2-U	24	50	C		25.0	8.43	8.19
SN-2-U	24	100	A		25.0	8.46	8.30
SN-2-U	24	100	B		25.0	8.44	8.29
SN-2-U	24	100	C		25.0	8.50	8.27
SN-2-U	48	10	A				
SN-2-U	48	10	B				
SN-2-U	48	10	C			7.18	8.05
SN-2-U	48	50	A				
SN-2-U	48	50	B				
SN-2-U	48	50	C			7.44	8.20
SN-2-U	48	100	A				
SN-2-U	48	100	B				
SN-2-U	48	100	C			7.44	8.27
SN-2-U	96	10	A		25.0	7.20	8.07
SN-2-U	96	10	B	20.0	25.0	7.30	8.05
SN-2-U	96	10	C		25.0	7.20	8.00
SN-2-U	96	50	A	20.0	25.5	7.12	8.06
SN-2-U	96	50	B		25.0	7.20	8.17
SN-2-U	96	50	C	20.0	25.0	7.30	8.19
SN-2-U	96	100	A		25.0	7.20	8.27
SN-2-U	96	100	B		25.0	7.20	8.27
SN-2-U	96	100	C		25.0	7.20	8.24
SN-2-L	0	10	A		25.5	7.20	7.59
SN-2-L	0	10	B				
SN-2-L	0	10	C				
SN-2-L	0	50	A		25.0	7.10	7.60
SN-2-L	0	50	B				
SN-2-L	0	50	C				
SN-2-L	0	100	A		25.0	7.00	7.65
SN-2-L	0	100	B				
SN-2-L	0	100	C				
SN-2-L	24	10	A		25.0	8.40	8.08
SN-2-L	24	10	B		25.0	8.46	8.06
SN-2-L	24	10	C	20.0	25.0	8.42	8.08
SN-2-L	24	50	A		25.0	8.49	8.17
SN-2-L	24	50	B		24.5	8.45	8.15
SN-2-L	24	50	C		25.0	8.37	8.10

TABLE G.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-L	24	100	A		25.0	8.50	8.29
SN-2-L	24	100	B		25.0	8.47	8.17
SN-2-L	24	100	C		24.5	8.34	8.25
SN-2-L	48	10	A				
SN-2-L	48	10	B			7.48	8.10
SN-2-L	48	10	C			7.43	8.08
SN-2-L	48	50	A				
SN-2-L	48	50	B				
SN-2-L	48	50	C			7.41	8.19
SN-2-L	48	100	A				
SN-2-L	48	100	B		25.0	7.39	8.21
SN-2-L	48	100	C			7.48	8.25
SN-2-L	96	10	A		25.0	7.30	8.11
SN-2-L	96	10	B		25.0	7.30	8.08
SN-2-L	96	10	C		25.0	7.30	8.12
SN-2-L	96	50	A		25.0	7.20	8.17
SN-2-L	96	50	B		25.0	7.20	8.16
SN-2-L	96	50	C		25.0	7.20	8.22
SN-2-L	96	100	A		25.0	7.20	8.26
SN-2-L	96	100	B	20.0	25.0	7.30	8.19
SN-2-L	96	100	C		25.0	7.30	8.21
CH-C[a]	0	10	A	20.5	25.5	7.60	7.60
CH-C	0	10	B				
CH-C	0	10	C				
CH-C	0	50	A		25.5	7.10	7.60
CH-C	0	50	B				
CH-C	0	50	C				
CH-C	0	100	A		25.0	6.80	7.67
CH-C	0	100	B				
CH-C	0	100	C				
CH-C	24	10	A	20.0	25.0	8.44	8.02
CH-C	24	10	B		25.0	8.46	8.02
CH-C	24	10	C		25.0	8.40	8.03
CH-C	24	50	A		25.0	8.40	8.09
CH-C	24	50	B		25.0	8.42	8.09
CH-C	24	50	C		24.5	8.54	8.04
CH-C	24	100	A		25.0	8.42	8.08
CH-C	24	100	B		24.5	8.39	8.08
CH-C	24	100	C		24.5	8.32	8.11
CH-C	48	10	A				
CH-C	48	10	B				

TABLE G.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
CH-C	48	10	C		25.0	7.39	8.08
CH-C	48	50	A				
CH-C	48	50	B			7.49	8.07
CH-C	48	50	C		25.0	7.23	8.04
CH-C	48	100	A				
CH-C	48	100	B				
CH-C	48	100	C			7.44	8.27
CH-C	96	10	A		25.0	7.30	8.03
CH-C	96	10	B		25.5	7.20	8.03
CH-C	96	10	C		25.0	7.20	8.04
CH-C	96	50	A		25.0	7.20	8.08
CH-C	96	50	B		25.0	7.30	8.09
CH-C	96	50	C		25.0	7.20	8.01
CH-C	96	100	A		25.0	7.20	8.09
CH-C	96	100	B		25.0	7.20	8.10
CH-C	96	100	C		25.0	7.30	8.16
SEQUIM BAY[c]	0	10	A		25.5	7.10	7.60
SEQUIM BAY	0	10	B				
SEQUIM BAY	0	10	C				
SEQUIM BAY	0	50	A		25.0	7.10	7.62
SEQUIM BAY	0	50	B				
SEQUIM BAY	0	50	C				
SEQUIM BAY	0	100	A		25.5	6.30	7.68
SEQUIM BAY	0	100	B				
SEQUIM BAY	0	100	C				
SEQUIM BAY	24	10	A		25.0	8.47	8.03
SEQUIM BAY	24	10	B		25.0	8.46	8.05
SEQUIM BAY	24	10	C		25.0	8.46	8.06
SEQUIM BAY	24	50	A		25.0	8.39	8.08
SEQUIM BAY	24	50	8		25.0	8.40	8.08
SEQUIM BAY	24	50	C		25.0	8.38	8.09
SEQUIM BAY	24	100	A		25.0	8.44	8.08
SEQUIM BAY	24	100	B		25.0	8.34	8.07
SEQUIM BAY	24	100	C		24.5	8.37	8.12
SEQUIM BAY	48	10	A				
SEQUIM BAY	48	10	B			7.48	8.06
SEQUIM BAY	48	10	C			7.51	8.07
SEQUIM BAY	48	50	A			7.45	8.13
SEQUIM BAY	48	50	B		25.0	7.41	8.12
SEQUIM BAY	48	50	C			7.40	8.06
SEQUIM BAY	48	100	A				

TABLE G.2. (contd)

Sediment Treatment	Hour	% SPP[a]	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
SEQUIM BAY	48	100	B			7.41	8.16
SEQUIM BAY	48	100	C		25.5	7.44	8.17
SEQUIM BAY	96	10	A		25.5	7.25	8.01
SEQUIM BAY	96	10	B		25.0	7.30	8.05
SEQUIM BAY	96	10	C		25.0	7.30	8.05
SEQUIM BAY	96	50	A		25.0	7.20	8.09
SEQUIM BAY	96	50	B		25.0	7.30	8.12
SEQUIM BAY	96	50	C	20.0	25.0	7.30	8.11
SEQUIM BAY	96	100	A		25.0	7.30	8.09
SEQUIM BAY	96	100	B		25.0	7.20	8.15
SEQUIM BAY	96	100	C		25.0	7.20	8.16
SEAWATER[d]	0	0	A		25.0	7.20	7.60
SEAWATER	0	0	B				
SEAWATER	0	0	C				
SEAWATER	0	0	D				
SEAWATER	24	0	A		25.0	8.44	8.00
SEAWATER	24	0	B		25.0	8.43	8.03
SEAWATER	24	0	C		25.0	8.40	8.03
SEAWATER	24	0	D		25.0	8.41	8.02
SEAWATER	48	0	A				
SEAWATER	48	0	B				
SEAWATER	48	0	C				
SEAWATER	48	0	D		25.5	7.43	8.06
SEAWATER	96	0	A		25.5	7.30	8.03
SEAWATER	96	0	B		25.5	7.30	8.04
SEAWATER	96	0	C		25.0	7.25	8.03
SEAWATER	96	0	D		25.0	7.25	8.04

(a) Percent suspended particulate phase.
(b) An equal mixture of CH-1 and CH-2 sediment.
(c) Sequim Bay reference sediment.
(d) Strait of Juan de Fuca seawater.

APPENDIX H

MACOMA NASUTA/NEPHTYS CAECOIDES BIOASSAY

TABLE H.1. Macoma Nasuta Solid Phase Toxicity Test

Sediment Treatment	Rep	Number Dead 240 h	Number on Sediment Surface									Number Siphons Exposed								
			24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
1-1	A										0	1	1	1	2	0	3	0	1	2
1-1	B		0	0	0	0	0	0		0	0	3	3	3	1	3	1	1	1	5
1-1	C		0	0	0	0	0	0		0	0	3	0	2	0	2	0	0	1	3
1-2	A										0	2	0	0	0	2	2	0	0	0
1-2	B				0			0			0	0	0	0	0	2	0	1	0	2
1-2	C		0	0	0	0	0	0		0	0	2	3	1	3	0	0	1	0	4
1-3	A										0	2	0	1	0	1	1	0	1	2
1-3	B										0	2	0	1	0	1	1	2	2	1
1-3	C		1PE[(a)]	1PE	1PE	1PE	1PE				0	3	5	2	4	3	3	3	2	3
2-1	A			1PE							0	3	2	5	0	0	2	1	3	0
2-1	B										0	5	5	3	1	1	5	0	0	3
2-1	C		0	0	0	0	0	0		0	0	7	1	3	0	2	0	2	0	4
2-2	A	1									0	8	6	3	1	1	0	2	0	5
2-2	B						0	0		0	0	8	9	5	3	4	3	1	1	2
2-2	C		0	0	0	0	0	0		0	0	14	7	4	1	5	3	5	1	6
3-1	A										0	0	0	1	0	1	1	0	1	1
3-1	B		1PE	0	0	0	0	0		0	0	0	1	1	1	1	1	1	0	3
3-1	C		0	0	0	0	0	0		0	0	2	3	0	0	2	2	2	0	4
3-2	A						1PE				0	0	2	2	0	3	4	1	1	7
3-2	B							0			0	0	1	1	0	1	1	2	1	3
3-2	C		0	0	0	0	0	0		0	0	2	3	1	1	1	5	1	2	1
CH-1	A			1PE	1PE	1PE					0	2	3	3	3	3	2	0	0	1
CH-1	B			0	0			0			0	2	1	0	0	0	0	0	1	0
CH-1	C	1	0	0	0	0	1PE	0		0	0	2	0	0	0	1	0	0	1	2

TABLE H.1. (contd)

Sediment Treatment	Rep	Number Dead 240 h	Number on Sediment Surface									Number Siphons Exposed								
			24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
CH-2	A										0	0	1	0	0	3	1	0	3	1
CH-2	B										0	1	2	2	0	3	4	1	3	4
CH-2	C		0	0	0	0	0	0		0	0	2	1	1	0	2	1	0	0	2
SN-1	A				0			0			0	3	0	2	0	0	0	0	1	0
SN-1	B				0			0			0	1	2	0	2	1	3	0	2	4
SN-1	C				0			0			0	2	2	3	0	2	1	0	4	1
SN-2-U	A										0	1	1	1	0	2	3	1	2	2
SN-2-U	B							0			0	3	1	1	1	2	1	1	2	4
SN-2-U	C		0	0	0	0	0	0		0	0	3	1	0	2	1	1	2	2	0
SN-2-L	A										0	3	6	4	0	3	1	1	2	9
SN-2-L	B										0	1	0	1	0	1	3	0	1	2
SN-2-L	C				0			0			0	0	1	2	1	1	0	1	2	0
SN-3-U	A										0	0	1	0	0	1	2	0	1	2
SN-3-U	B							0			0	0	0	1	1	0	0	1	1	4
SN-3-U	C		0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	1
SN-3-L	A				0			0			0	3	2	1	1	1	1	1	1	2
SN-3-L	B				0			0			0	1	2	0	0	1	2	0	0	3
SN-3-L	C				0			0			0	1	0	0	0	1	0	1	1	0
TD-1-U	A							0			0	2	3	1	2	1	2	1	1	4
TD-1-U	B				0			0			0	2	0	1	1	2	0	1	0	3
TD-1-U	C			0	0	0		0			0	3	3	1	1	1	1	0	1	2
TD-1-L	A							0			0	2	3	3	3	1	0	1	1	8
TD-1-L	B			0	0	0	0	0		0	0	2	0	0	0	0	0	1	0	0
TD-1-L	C			0	0	0	0	0		0	0	2	2	3	1	3	1	3	0	1

TABLE H.1. (contd)

Sediment Treatment	Rep	Number Dead 240 h	Number on Sediment Surface 24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	Number Siphons Exposed 24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
TD-2-U	A					0					0	0	2	0	1	0	2	0	1	3
TD-2-U	B					0					0	1	1	1	0	2	0	0	0	2
TD-2-U	C			0	0	0	0	0		0	0	0	1	1	0	0	0	0	0	2
TD-2-L	A					0					0	0	0	1	2	0	0	0	0	3
TD-2-L	B			0	0	0	0	0		0	0	4	5	2	4	2	0	1	1	9
TD-2-L	C			0	0	0	0	0		0	0	2	1	3	3	0	0	3	0	2
SEQUIM BAY	A										0	11	9	8	2	1	3	0	0	3
SEQUIM BAY	B					0				1PE	0	11	7	9	3	2	5	1	4	4
SEQUIM BAY	C				0	0					0	10	7	5	5	6	3	2	3	8
SB WATER[b]	A										0	6	6	6	1	6	5	2	3	2
SB WATER	B										0	10	7	3	1	7	3	4	2	0
SB WATER	C			0	0	0	0	0		0	0	7	7	1	6	5	3	3	3	8

(a) Partially exposed.

(b) Sequim Bay seawater.

TABLE H.2. *Nephtys caecoides* Solid Phase Toxicity Test

Sediment Treatment	Rep	Total Number Alive 240 h	Number on Sediment Surface									Number Heads Exposed								
			24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
1-1	A										0									0
1-1	B		0	0	0	0	0	0		0	0	1	1	0	0	0	0		0	0
1-1	C	52	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0
1-2	A										0									0
1-2	B				0			0			0	0		0			0			0
1-2	C	56	0	0	0	0	0	0		0	0		0	0	0	0	0		0	0
1-3	A										0	1								0
1-3	B		2								0									0
1-3	C	53									0									0
2-1	A										0			1						0
2-1	B					1					0						1			0
2-1	C	53	0		1	0	0	0		0	0	0	0	0	0	0	0		0	0
2-2	A										0	1		1						0
2-2	B		3	1	1	0	0	0		0	0	4	0	4	0	0	0		0	0
2-2	C	56	0	0	0	0	0	0		0	0	4	0	1	0	0	0		0	1 PE[a]
3-1	A										0	1				1				0
3-1	B		0	0	0	0	0	0		0	0	0	2	0	0	0	0		1 PE	0
3-1	C	53	0	1	0	0	0	0		0	0		0	0	0	0	0		0	0
3-2	A										0									0
3-2	B						0	0			0						0			0
3-2	C	56	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0
CH-1	A										0									0
CH-1	B			0	0			0			0		0	0			0			0
CH-1	C	57	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0

TABLE H.2. (contd)

Sediment Treatment	Rep	Total Number Alive 240 h	Number on Sediment Surface									Number Heads Exposed							
			24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
CH-2	A										0									0
CH-2	B										0									0
CH-2	C	60	0	0	0	0	0	0		0	0	2	1	1	0	0	0		0	0
SN-1	A				1			0			0			0			0			0
SN-1	B		1		0			1			0			0			0			0
SN-1	C	49			1			0			0			0			0			0
SN-2-U	A										0			1						0
SN-2-U	B						1 PE	0			0			1			0			0
SN-2-U	C	57	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0
SN-2-L	A										0	1			1					0
SN-2-L	B										0									0
SN-2-L	C	56			1			0		0	0		1	0			0			0
SN-3-U	A										0									0
SN-3-U	B							0			0						0			0
SN-3-U	C	58	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0
SN-3-L	A				0			0			0			0			0			0
SN-3-L	B				0			0			0			0			0			0
SN-3-L	C	47			0			0			0			1			0			0
TD-1-U	A							0			0						0			0
TD-1-U	B				0			0			0		1				0			0
TD-1-U	C	48		0	0			0			0		0				0			0
TD-1-L	A							0			0			1			0			0
TD-1-L	B		0	0	0	0	0	0		0	0	2	0	0	0	0	0		0	0
TD-1-L	C	54	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0

TABLE H.2. (contd)

Sediment Treatment	Rep	Total Number Alive 240 h	Number on Sediment Surface 24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h	Number Heads Exposed 24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
TD-2-U	A				0			0			0			0			0			0
TD-2-U	B				0			0			0			0		1	0			0
TD-2-U	C	55	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0	0
TD-2-L	A				0			0			0			0			0			0
TD-2-L	B				0	0	0	0		0	0	1	1	0	0	0	0		0	0
TD-2-L	C	46	0	1	0	0	0	0		0	0	0	0	0	0	0	0		0	0
SEQUIM BAY	A				1						0									0
SEQUIM BAY	B				0			0			0	1	1	0			0			0
SEQUIM BAY	C	56		0	0			0			0	5	1	1			0			0
SB WATER[b]	A										0	1								0
SB WATER	B										0									0
SB WATER	C	54	1	0	1	0	0	0		0	0	0	1	3	2	0	0		0	0

(a) Partially exposed.
(b) Sequim Bay seawater.

TABLE H.3. Water Quality Monitoring - Macoma nasuta/Nephtys caecoides Acute Toxicity Test

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
1-1	24	A	14.9	31.5	7.5	7.96	135
1-1	24	B	14.7	31.5	7.6	7.82	125
1-1	24	C	14.8	32.0	7.8	7.85	125
1-1	48	A	14.8	31.0	7.8	7.87	126
1-1	48	B			8.2		129
1-1	48	C			8.0		127
1-1	72	A			7.7		126
1-1	72	B	14.4	31.0	7.6	7.85	125
1-1	72	C			7.4		123
1-1	96	A			7.5		126
1-1	96	B			7.8		115
1-1	96	C	14.6	31.5	7.6	7.86	126
1-1	120	A	14.8	31.0	7.6	7.84	117
1-1	120	B			8.1		127
1-1	120	C			7.9		124
1-1	144	A			7.8		126
1-1	144	B	14.7	32.0	7.8	7.87	128
1-1	144	C			8.0		123
1-1	168	A					125
1-1	168	8					134
1-1	168	C	15.2	32.0	7.3	7.69	124
1-1	192	A	14.8	31.5	7.5	7.99	124
1-1	192	B			8.2		128
1-1	192	C			8.2		116
1-1	216	A			7.8		124
1-1	216	B	14.9	32.0	8.1	7.79	130
1-1	216	C			7.9		118
1-2	24	A	14.9	31.5	8.0	7.93	131
1-2	24	B	15.1	31.5	6.6	7.83	125
1-2	24	C	14.7	31.5	7.7	7.86	123
1-2	48	A	14.8	31.5	8.2	7.87	126
1-2	48	B			8.1		116
1-2	48	C			7.0		121
1-2	72	A			7.5		126
1-2	72	B	14.9	31.0	7.5	7.82	117
1-2	72	C			7.8		115
1-2	96	A			7.4		123
1-2	96	B			7.4		122
1-2	96	C	14.5	31.5	7.5	7.87	116
1-2	120	A	14.8	31.0	7.6	7.86	125
1-2	120	B			7.9		130
1-2	120	C			7.9		125
1-2	144	A			7.7		127
1-2	144	B	15.1	31.0	7.7	7.87	125

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
1-2	144	C			7.8		125
1-2	168	A					126
1-2	168	B					127
1-2	168	C	14.9	31.5	7.7	7.79	125
1-2	192	A	14.9	31.5	7.2	8.00	126
1-2	192	B			7.6		122
1-2	192	C			7.8		118
1-2	216	A			7.5		125
1-2	216	B	15.2	32.0	7.7	7.79	120
1-2	216	C			8.0		120
1-3	24	A	15.0	31.5	7.8	7.89	127
1-3	24	B	15.0	31.5	7.8	7.81	121
1-3	24	C	15.0	31.5	7.8	7.92	127
1-3	48	A	14.9	31.5	6.9	7.87	127
1-3	48	B			7.8		125
1-3	48	C			7.4		120
1-3	72	A			8.0		125
1-3	72	B	14.7	30.5	7.9	7.82	125
1-3	72	C			7.5		124
1-3	96	A			7.4		125
1-3	96	B			7.6		118
1-3	96	C	14.9	31.5	7.4	7.85	129
1-3	120	A	14.9	31.0	7.7	7.84	118
1-3	120	B			7.4		120
1-3	120	C			7.9		123
1-3	144	A			7.5		123
1-3	144	B	15.0	31.0	7.9	7.80	126
1-3	144	C			8.0		120
1-3	168	A					115
1-3	168	B					129
1-3	168	C	15.5	32.0	7.4	7.79	122
1-3	192	A	14.9	31.5	8.2	7.97	118
1-3	192	B			8.2		125
1-3	192	C			8.1		126
1-3	216	A			8.1		118
1-3	216	B	15.0	31.5	8.1	7.72	125
1-3	216	C			8.0		125
2-1	24	A	15.0	31.5	8.3	7.91	135
2-1	24	B	14.8	31.5	8.4	7.97	126
2-1	24	C	14.5	31.5	8.3	7.86	125
2-1	48	A	15.0	31.5	8.0	7.81	133
2-1	48	B			7.7		124
2-1	48	C			8.0		130
2-1	72	A			7.6		132

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
2-1	72	B	14.8	32.0	7.0	7.85	125
2-1	72	C			7.6		130
2-1	96	A			7.3		120
2-1	96	B			7.5		119
2-1	96	C	14.5	31.5	7.6	7.90	128
2-1	120	A	15.1	31.0	7.4	7.80	121
2-1	120	B			7.8		119
2-1	120	C			8.0		134
2-1	144	A			7.5		116
2-1	144	B	15.0	32.0	7.6	7.86	118
2-1	144	C			7.6		125
2-1	168	A					120
2-1	168	B					122
2-1	168	C	14.9	32.0	7.6	7.81	123
2-1	192	A	14.9	32.0	8.1	7.95	116
2-1	192	B			6.8		126
2-1	192	C			6.3		122
2-1	216	A			8.2		118
2-1	216	B	15.0	32.0	7.0	7.77	125
2-1	216	C			6.9		118
2-2	24	A	15.0	31.5	8.4	7.93	125
2-2	24	B	14.7	31.5	8.3	7.85	123
2-2	24	C	14.8	31.5	8.2	7.85	130
2-2	48	A	14.8	31.0	8.0	7.85	124
2-2	48	B			7.9		123
2-2	48	C			8.1		130
2-2	72	A			8.2		134
2-2	72	B	14.6	31.5	7.7	7.86	134
2-2	72	C			8.0		125
2-2	96	A			7.4		117
2-2	96	B			7.5		121
2-2	96	C	14.5	32.0	7.8	7.87	129
2-2	120	A	15.0	31.0	7.6	7.85	125
2-2	120	B			8.1		119
2-2	120	C			8.0		123
2-2	144	A			7.9		124
2-2	144	B	14.7	32.0	7.9	7.86	120
2-2	144	C			7.9		123
2-2	168	A					122
2-2	168	B					130
2-2	168	C	14.9	32.0	6.9	7.81	120
2-2	192	A	14.9	31.5	8.2	7.97	126
2-2	192	B			6.6		124
2-2	192	C			7.2		125
2-2	216	A			8.1		124

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
2-2	216	B	14.9	32.0	7.1	7.81	125
2-2	216	C			7.5		120
3-1	24	A	14.9	32.0	8.0	7.93	132
3-1	24	B	14.6	31.5	7.8	7.81	124
3-1	24	C	14.5	31.5	8.0	7.74	126
3-1	48	A	14.7	31.5	8.1	7.87	125
3-1	48	B			8.2		125
3-1	48	C			8.0		129
3-1	72	A			7.7		129
3-1	72	B	14.5	31.5	7.1	7.86	117
3-1	72	C			7.9		126
3-1	96	A			7.6		125
3-1	96	B			7.4		120
3-1	96	C	14.5	31.5	7.9	7.87	130
3-1	120	A	14.8	31.0	8.0	7.88	124
3-1	120	B			8.1		120
3-1	120	C			8.2		127
3-1	144	A			7.6		126
3-1	144	B	14.6	32.0	7.5	7.86	126
3-1	144	C			7.8		122
3-1	168	A					126
3-1	168	B					128
3-1	168	C	14.9	32.0	7.3	7.80	123
3-1	192	A	14.7	31.5	8.1	8.00	134
3-1	192	B			7.5		122
3-1	192	C			7.1		120
3-1	216	A			8.2		130
3-1	216	B	14.9	32.0	7.3	7.80	125
3-1	216	C			7.4		124
3-2	24	A	14.9	32.0	7.4	7.97	126
3-2	24	B	14.8	32.0	7.4	7.79	119
3-2	24	C	14.7	31.5	7.4	7.81	128
3-2	48	A	14.8	31.0	7.8	7.91	124
3-2	48	B			6.9		119
3-2	48	C			7.6		121
3-2	72	A			7.7		129
3-2	72	B	14.7	31.0	7.8	7.82	125
3-2	72	C			7.7		128
3-2	96	A			7.4		123
3-2	96	B			7.7		125
3-2	96	C	14.5	31.5	7.5	7.87	118
3-2	120	A	14.9	31.5	7.8	7.88	124
3-2	120	B			7.9		123
3-2	120	C			7.8		128

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
3-2	144	A			7.6		120
3-2	144	B	14.9	31.5	7.7	7.87	124
3-2	144	C			7.8		123
3-2	168	A					121
3-2	168	B					122
3-2	168	C	14.9	32.0	7.2	7.82	122
3-2	192	A	14.9	31.5	7.7	7.95	126
3-2	192	B			7.5		128
3-2	192	C			8.0		130
3-2	216	A			7.4		125
3-2	216	B	14.9	32.0	7.8	7.78	125
3-2	216	C			8.1		126
CH-1	24	A	14.8	31.5	7.8	7.92	134
CH-1	24	B	14.8	32.0	7.8	7.90	128
CH-1	24	C	14.7	32.0	7.8	7.84	126
CH-1	48	A	14.7	31.5	8.2	7.81	132
CH-1	48	B			7.2		134
CH-1	48	C			7.9		127
CH-1	72	A			7.9		125
CH-1	72	B	14.7	31.5	8.2	7.85	134
CH-1	72	C			8.0		125
CH-1	96	A			7.5		131
CH-1	96	B			7.6		128
CH-1	96	C	14.6	31.5	7.6	7.85	125
CH-1	120	A	14.9	31.0	7.8	7.88	127
CH-1	120	B			7.9		128
CH-1	120	C			7.9		124
CH-1	144	A			7.6		128
CH-1	144	B	14.8	32.0	7.8	7.89	120
CH-1	144	C			7.8		125
CH-1	168	A					120
CH-1	168	B					124
CH-1	168	C	14.9	31.5	7.5	7.71	121
CH-1	192	A	14.8	32.0	7.6	8.00	120
CH-1	192	B			7.1		116
CH-1	192	C			6.6		116
CH-1	216	A			7.8		122
CH-1	216	B	15.1	32.0	7.3	7.79	118
CH-1	216	C			6.9		116
CH-2	24	A	15.0	31.5	8.0	7.92	116
CH-2	24	B	14.8	31.5	8.1	7.95	130
CH-2	24	C	14.7	31.5	7.6	7.83	124
CH-2	48	A	14.8	31.0	7.1	7.89	116
CH-2	48	B			7.9		125

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
CH-2	48	C			8.2		125
CH-2	72	A			7.4		120
CH-2	72	B	14.8	31.0	7.8	7.76	120
CH-2	72	C			7.3		125
CH-2	96	A			7.5		122
CH-2	96	B			7.5		125
CH-2	96	C	14.6	31.5	7.7	7.88	123
CH-2	120	A	14.9	31.5	7.5	7.87	125
CH-2	120	B			7.6		125
CH-2	120	C			8.1		125
CH-2	144	A			7.0		119
CH-2	144	B	15.1	31.5	7.7	7.84	130
CH-2	144	C			7.7		120
CH-2	168	A					130
CH-2	168	B					130
CH-2	168	C	14.9	32.0	7.4	7.83	118
CH-2	192	A	14.9	31.5	8.1	7.98	130
CH-2	192	B			8.2		124
CH-2	192	C			7.1		116
CH-2	216	A			8.0		130
CH-2	216	B	15.1	32.0	8.1	7.77	120
CH-2	216	C			7.3		118
SN-1	24	A	14.8	31.5	8.1	7.81	128
SN-1	24	B	15.0	31.5	7.9	7.84	129
SN-1	24	C	14.9	32.0	7.3	7.84	120
SN-1	48	A	14.7	31.5	7.4	7.89	120
SN-1	48	B			7.4		130
SN-1	48	C			7.9		115
SN-1	72	A			7.3		125
SN-1	72	B	14.7	32.0	7.4	7.86	130
SN-1	72	C			7.7		123
SN-1	96	A			7.4		125
SN-1	96	B			7.6		125
SN-1	96	C	14.7	31.5	7.4	7.85	125
SN-1	120	A	14.7	32.0	7.7	7.85	120
SN-1	120	B			7.9		129
SN-1	120	C			8.0		122
SN-1	144	A			7.5		130
SN-1	144	B	14.9	31.5	7.6	7.89	120
SN-1	144	C			7.6		127
SN-1	168	A					128
SN-1	168	B					121
SN-1	168	C	15.2	32.0	7.5	7.81	118
SN-1	192	A	14.9	32.0	8.0	8.01	134
SN-1	192	B			7.9		120

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
SN-1	192	C			7.6		128
SN-1	216	A			8.1		130
SN-1	216	B	15.0	32.0	8.0	7.79	118
SN-1	216	C			7.8		125
SN-2-U	24	A	14.7	31.5	8.0	7.92	132
SN-2-U	24	B	14.7	31.5	7.5	7.84	129
SN-2-U	24	C	14.5	31.5	8.2	7.81	127
SN-2-U	48	A	14.8	31.5	7.4	7.90	130
SN-2-U	48	B			7.8		125
SN-2-U	48	C			7.6		131
SN-2-U	72	A			7.8		125
SN-2-U	72	B	14.8	31.5	7.7	7.82	135
SN-2-U	72	C			8.2		133
SN-2-U	96	A			7.6		130
SN-2-U	96	B			7.1		133
SN-2-U	96	C	14.4	31.5	7.9	7.86	125
SN-2-U	120	A	14.8	31.5	7.8	7.85	124
SN-2-U	120	B			7.4		122
SN-2-U	120	C			8.1		121
SN-2-U	144	A			7.8		125
SN-2-U	144	B	14.9	31.5	7.8	7.88	120
SN-2-U	144	C			8.0		127
SN-2-U	168	A					126
SN-2-U	168	B					128
SN-2-U	168	C	14.9	32.0	7.9	7.79	134
SN-2-U	192	A	14.7	31.5	7.1	8.00	130
SN-2-U	192	B			8.0		116
SN-2-U	192	C			7.4		134
SN-2-U	216	A			7.4		125
SN-2-U	216	B	15.0	31.5	8.0	7.78	118
SN-2-U	216	C			7.6		132
SN-2-L	24	A	15.0	31.5	7.4	7.93	131
SN-2-L	24	B	15.0	31.5	7.6	7.93	135
SN-2-L	24	C	14.8	32.0	7.9	7.87	133
SN-2-L	48	A	14.8	31.0	7.6	7.87	124
SN-2-L	48	B			7.6		135
SN-2-L	48	C			7.3		125
SN-2-L	72	A			7.9		125
SN-2-L	72	B	14.7	31.0	7.6	7.85	133
SN-2-L	72	C			7.6		128
SN-2-L	96	A			7.5		124
SN-2-L	96	B			7.5		127
SN-2-L	96	C	14.7	31.5	7.6	7.87	125
SN-2-L	120	A	14.8	31.0	7.9	7.88	122

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
SN-2-L	120	B			7.9		132
SN-2-L	120	C			7.9		129
SN-2-L	144	A			7.9		124
SN-2-L	144	B	14.9	31.5	7.8	7.85	130
SN-2-L	144	C			7.8		126
SN-2-L	168	A					120
SN-2-L	168	B					128
SN-2-L	168	C	15.2	32.0	7.5	7.83	128
SN-2-L	192	A	14.9	31.5	7.9	7.98	120
SN-2-L	192	B			7.5		126
SN-2-L	192	C			7.3		124
SN-2-L	216	A			8.0		123
SN-2-L	216	B	15.1	31.5	7.5	7.75	125
SN-2-L	216	C			7.5		125
SN-3-U	24	A	15.0	31.5	7.5	7.93	132
SN-3-U	24	B	14.7	32.0	7.5	7.84	135
SN-3-U	24	C	14.5	31.5	7.7	7.88	127
SN-3-U	48	A	14.9	31.5	7.3	7.86	128
SN-3-U	48	B			7.6		128
SN-3-U	48	C			8.2		126
SN-3-U	72	A			8.1		130
SN-3-U	72	B	14.9	31.0	7.5	7.85	131
SN-3-U	72	C			8.2		125
SN-3-U	96	A			7.7		132
SN-3-U	96	B			7.4		132
SN-3-U	96	C	14.5	31.5	7.7	7.91	131
SN-3-U	120	A	15.0	31.0	7.8	7.86	125
SN-3-U	120	B			7.8		132
SN-3-U	120	C			8.0		124
SN-3-U	144	A			7.8		128
SN-3-U	144	B	15.0	32.0	7.5	7.83	132
SN-3-U	144	C			7.6		120
SN-3-U	168	A					125
SN-3-U	168	B					126
SN-3-U	168	C	14.8	31.5	7.6	7.83	125
SN-3-U	192	A	14.9	32.0	8.1	7.95	118
SN-3-U	192	B			7.6		130
SN-3-U	192	C			6.1		118
SN-3-U	216	A			8.2		118
SN-3-U	216	B	15.1	32.0	7.8	7.78	132
SN-3-U	216	C			6.7		120
SN-3-L	24	A	14.7	32.0	7.6	7.86	128
SN-3-L	24	B	15.0	32.0	6.9	7.88	121
SN-3-L	24	C	14.8	32.0	7.8	7.82	126

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
SN-3-L	48	A	14.8	31.5	7.9	7.91	125
SN-3-L	48	B			6.9		123
SN-3-L	48	C			7.9		126
SN-3-L	72	A			7.6		116
SN-3-L	72	B	14.9	31.0	7.9	7.87	117
SN-3-L	72	C			7.7		129
SN-3-L	96	A			7.5		125
SN-3-L	96	B			7.4		121
SN-3-L	96	C	14.7	31.5	7.8	7.87	125
SN-3-L	120	A	14.7	31.5	8.1	7.91	125
SN-3-L	120	B			8.0		121
SN-3-L	120	C			7.9		130
SN-3-L	144	A			7.7		128
SN-3-L	144	B	15.1	31.5	7.8	7.87	125
SN-3-L	144	C			7.9		122
SN-3-L	168	A					128
SN-3-L	168	B					119
SN-3-L	168	C	14.9	31.5	7.2	7.81	119
SN-3-L	192	A	14.7	31.5	7.1	8.01	116
SN-3-L	192	B			6.7		125
SN-3-L	192	C			8.0		120
SN-3-L	216	A			7.5		118
SN-3-L	216	B	15.1	32.0	6.9	7.80	120
SN-3-L	216	C			8.1		118
TD-1-U	24	A	14.8	31.5	6.8	7.84	129
TD-1-U	24	B	14.8	31.5	7.5	7.82	123
TD-1-U	24	C	14.7	31.5	7.8	7.88	125
TD-1-U	48	A	14.7	31.5	7.4	7.91	134
TD-1-U	48	B			7.4		129
TD-1-U	48	C			7.2		125
TD-1-U	72	A			7.2		128
TD-1-U	72	B	14.6	31.5	7.6	7.85	125
TD-1-U	72	C			7.8		125
TD-1-U	96	A			7.4		123
TD-1-U	96	B			7.9		126
TD-1-U	96	C	14.7	31.5	7.6	7.87	130
TD-1-U	120	A	14.7	31.5	7.4	7.86	119
TD-1-U	120	B			7.9		121
TD-1-U	120	C			8.0		124
TD-1-U	144	A			7.6		119
TD-1-U	144	B	14.8	32.0	7.9	7.88	129
TD-1-U	144	C			7.8		120
TD-1-U	168	A					120
TD-1-U	168	B					135
TD-1-U	168	C	15.0	31.5	7.5	7.80	126

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
TD-1-U	192	A		31.5	7.9	8.01	122
TD-1-U	192	B			7.3		118
TD-1-U	192	C			6.7		120
TD-1-U	216	A			8.0		120
TD-1-U	216	B	15.0	32.0	7.6	7.79	120
TD-1-U	216	C			6.9		122
TD-1-L	24	A	14.8	31.5	7.1	7.83	133
TD-1-L	24	B	14.5	31.5	8.0	7.88	122
TD-1-L	24	C	14.5	31.5	8.1	7.84	130
TD-1-L	48	A	14.7	32.0	7.8	7.90	130
TD-1-L	48	B			7.6		129
TD-1-L	48	C			7.8		121
TD-1-L	72	A			7.7		125
TD-1-L	72	B	14.5	31.0	7.3	7.86	126
TD-1-L	72	C			7.7		116
TD-1-L	96	A			7.5		131
TD-1-L	96	B			7.9		126
TD-1-L	96	C	14.5	31.5	7.8	7.91	118
TD-1-L	120	A	14.7	32.0	7.6	7.89	125
TD-1-L	120	B			8.1		120
TD-1-L	120	C			7.8		115
TD-1-L	144	A			7.8		125
TD-1-L	144	B	14.7	32.0	7.6	7.88	123
TD-1-L	144	C			7.7		123
TD-1-L	168	A					120
TD-1-L	168	B					115
TD-1-L	168	C	15.0	32.0	7.7	7.83	126
TD-1-L	192	A	14.8	31.5	8.0	8.01	126
TD-1-L	192	B			7.0		125
TD-1-L	192	C			7.0		120
TD-1-L	216	A			8.1		125
TD-1-L	216	B	14.9	32.0	7.5	7.81	121
TD-1-L	216	C			7.2		120
TD-2-U	24	A	14.8	31.5	7.7	7.87	126
TD-2-U	24	B	15.0	32.0	7.3	7.87	123
TD-2-U	24	C	14.5	31.5	8.2	7.85	129
TD-2-U	48	A	14.9	31.5	7.1	7.91	124
TD-2-U	48	B			6.8		121
TD-2-U	48	C			8.1		130
TD-2-U	72	A			7.6		129
TD-2-U	72	B	14.9	31.0	7.7	7.86	120
TD-2-U	72	C			8.1		132
TD-2-U	96	A			7.4		121
TD-2-U	96	B			7.4		116

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
TD-2-U	96	C	14.5	31.5	7.5	7.92	127
TD-2-U	120	A	14.6	31.5	7.7	7.90	121
TD-2-U	120	B			7.8		117
TD-2-U	120	C			7.5		122
TD-2-U	144	A			7.8		119
TD-2-U	144	B	15.1	32.0	7.7	7.87	125
TD-2-U	144	C			7.9		125
TD-2-U	168	A					117
TD-2-U	168	B					132
TD-2-U	168	C	14.7	32.0	7.6	7.83	124
TD-2-U	192	A	14.7	31.5	6.8	8.02	116
TD-2-U	192	B			7.8		130
TD-2-U	192	C			6.8		122
TD-2-U	216	A			7.1		118
TD-2-U	216	8	15.1	31.5	8.0	7.80	126
TD-2-U	216	C			6.9		122
TD-2-L	24	A	14.7	32.0	7.9	7.86	127
TD-2-L	24	B	14.7	32.0	8.0	7.83	129
TD-2-L	24	C	14.5	31.5	7.9	7.83	124
TD-2-L	48	A	14.8	31.5	7.1	7.91	132
TD-2-L	48	B			8.2		129
TD-2-L	48	C			8.0		129
TD-2-L	72	A			7.5		127
TD-2-L	72	B	14.5	31.5	7.6	7.85	129
TD-2-L	72	C			7.2		125
TD-2-L	96	A			7.6		130
TD-2-L	96	B			7.6		127
TD-2-L	96	C	14.5	31.5	7.6	7.88	115
TD-2-L	120	A	14.7	31.5	7.6	7.90	124
TD-2-L	120	B			8.0		122
TD-2-L	120	C			8.1		128
TD-2-L	144	A			7.6		122
TD-2-L	144	B	14.6	32.0	7.8	7.87	125
TD-2-L	144	C			7.9		124
TD-2-L	168	A					125
TD-2-L	168	B					119
TD-2-L	168	C	14.9	32.0	7.8	7.80	115
TD-2-L	192	A	14.7	31.5	7.0	7.98	118
TD-2-L	192	B			6.4		116
TD-2-L	192	C			7.8		125
TD-2-L	216	A			7.2		120
TD-2-L	216	B	14.9	32.0	6.8	7.80	118
TD-2-L	216	C			8.0		122

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
SEQUIM BAY	24	A	14.8	31.5	8.4	7.97	128
SEQUIM BAY	24	B	15.0	32.0	8.1	7.88	121
SEQUIM BAY	24	C	14.8	31.5	8.4	7.86	127
SEQUIM BAY	48	A	14.8	31.0	7.7	7.88	125
SEQUIM BAY	48	B			7.5		125
SEQUIM BAY	48	C			7.9		125
SEQUIM BAY	72	A			6.8		122
SEQUIM BAY	72	B	14.8	31.5	7.0	7.85	125
SEQUIM BAY	72	C			7.8		126
SEQUIM BAY	96	A			6.9		125
SEQUIM BAY	96	B			7.7		125
SEQUIM 8AY	96	C	14.5	31.5	7.8	7.87	125
SEQUIM 8AY	120	A	14.7	31.0	7.7	7.85	121
SEQUIM 8AY	120	B			8.0		135
SEQUIM BAY	120	C			7.9		117
SEQUIM BAY	144	A			7.5		119
SEQUIM BAY	144	B	14.9	31.0	7.7	7.89	125
SEQUIM BAY	144	C			7.6		125
SEQUIM BAY	168	A					116
SEQUIM 8AY	168	8					131
SEQUIM 8AY	168	C	15.0	32.0	7.2	7.75	123
SEQUIM BAY	192	A	14.8	31.5	6.5	7.99	118
SEQUIM BAY	192	B			7.7		120
SEQUIM BAY	192	C			6.8		122
SEQUIM BAY	216	A			6.8		116
SEQUIM BAY	216	8	15.0	32.0	8.1	7.79	118
SEQUIM 8AY	216	C			7.0		125
SB WATER[a]	24	A	14.8	31.5	8.3	7.96	123
SB WATER	24	B	14.8	31.5	8.4	7.96	128
SB WATER	24	C	14.5	31.5	8.2	7.86	127
SB WATER	48	A	14.8	31.0	8.0	7.85	122
S8 WATER	48	8			7.9		125
S8 WATER	48	C			8.0		125
SB WATER	72	A			7.8		121
SB WATER	72	B	14.8	31.5	7.3	7.84	124
SB WATER	72	C			8.0		120
SB WATER	96	A			7.6		124
SB WATER	96	B			7.8		125
SB WATER	96	C	14.5	31.5	7.9	7.86	120
SB WATER	120	A	14.8	31.0	7.8	7.87	130
S8 WATER	120	B			7.9		128
SB WATER	120	C			8.0		118
SB WATER	144	A			7.9		122
SB WATER	144	B	15.1	31.5	7.8	7.85	126
SB WATER	144	C			8.1		122

TABLE H.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH	Flow Rate (mL/min)
SB WATER	168	A					120
SB WATER	168	B					128
SB WATER	168	C	14.9	32.0	7.7	7.81	124
SB WATER	192	A	14.8	31.5	7.3	7.99	116
SB WATER	192	B			7.3		130
SB WATER	192	C			7.2		118
SB WATER	216	A			7.5		118
SB WATER	216	B	15.0	31.5	7.6	7.77	126
SB WATER	216	C			7.5		120

(a) Sequim Bay seawater.

APPENDIX I

RHEPOXYNIUS ABRONIUS/GRANDIDIERELLA JAPONICA BIOASSAY

TABLE I.1. Rhepoxynius abronius Acute Toxicity Test

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
1-1	A	16	0	0	1	0	0	0	0	1	0	2	3	5	7	0	4	2	3	1
1-1	B	17	0	0	0	0	0	0	1D[a]	0	0	0	6	4	3	2	3	4	2	0
1-1	C	18	0	0	0	0	0	0	0	0	0	4	1	1	3	1	2	4	4	0
1-1	D	34	0	0	0	0	1D	0	0	0	1	0	3	7	8	8	7	18	9	11
1-1	E	16	0	0	0	0	0	U[b]	0	1	1	1	2	4	3	3	1	5	3	3
1-2	A	19	0	0	1	0	0	U	0	1	0	0	1	0	4	6	3	5	6	0
1-2	B	20	0	0	1	0	0	0	0	0	0	2	4	10	0	4	4	10	6	6
1-2	C	13	0	0	1	0	1	0	1D	0	0	3	5	4	3	4	6	5	4	1
1-2	D	12	0	0	0	0	0	0	0	2	1	6	4	0	2	4	1	6	2	2
1-2	E	14	0	0	0	0	0	0	0	1D	0	0	6	0	0	5	8	2	0	1
1-3	A	14	0	1	0	0	0	0	0	0	0	0	5	1	1	3	2	3	2	4
1-3	B	16	0	0	0	0	0	0	0	0	0	3	10	3	7	5	8	8	5	7
1-3	C	16	0	0	0	0	0	0	0	0	0	5	3	9	8	7	7	10	8	5
1-3	D	12	0	0	0	0	0	0	0	0	0	0	3	3	0	1	3	4	2	1
1-3	E	12	1	0	0	0	0	0	1D	1	0	4	7	2	7	5	7	5	4	5
2-1	A	13	0	0	0	0	0	1	1D	0	0	5	4	2	2	1	1	5	1	0

TABLE I.1. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
2-1	B	15	0	0	0	0	1D	0	0	1	0	1	4	0	2	2	2	3	3	1
2-1	C	11	0	1	1	0	0	0	0	0	1	0	5	2	3	2	5	2	3	6
2-1	D	15	0	0	1	0	0	0	0	0	0	3	5	0	1	4	2	3	4	2
2-1	E	20	0	0	0	0	0	0	0	1	1	0	1	0	0	3	0	4	1	2
2-2	A	10	0	0	0	0	0	0	0	0	0	3	1	1	0	0	1	4	1	3
2-2	B	14	0	0	0	0	1D	0	0	0	0		1	3	1	1	0	3	4	3
2-2	C	12	0	0	0	1D	0	0	0	0	0	1	3	3	2	1	2	5	2	6
2-2	D	18	0	1	0	0	0	0	0	0	0	7	3	0	1	2	3	2	1	1
2-2	E	20	0	0	0	0	0	0	0	0	1	5	4	0	3	3	2	2	4	6
3-1	A	12	0	0	0	0	0	0	0	0	0	1	5	2	0	3	7	6	4	0
3-1	B	9	0	1	0	0	0	0	0	0	0	0	2	4	2	1	2	4	3	4
3-1	C	15	0	0	0	0	0	0	1	0	0	6	0	1	0	3	1	6	4	3
3-1	D	14	0	0	0	0	0	0	0	0	0	0	7	2	8	4	5	7	1	2
3-1	E	15	0	0	0	0	0	U	0	1D	0	0	3	3	0	3	4	4	5	3
3-2	A	10	0	0	0	0	0	0	0	0	0	3	1	0	1	4	1	1	1	2
3-2	B	13	0	0	0	0	D	0	0	0	0	2	0	0	0	0	2	1	0	0
3-2	C	13	D	0	D	0	0	0	0	1D	0	4	2	2	1	3	4	4	6	2
3-2	D	11	0	0	0	0	0	0	0	0	0	0	3	0	0	4	5	5	1	6
3-2	E	15	0	0	0	0	0	U	0	0	0	1	2	0	1	4	5	4	6	4
CH-1	A	17	0	1	0	0	0	0	0	0	0	5	2	0	0	2	2	5	2	2
CH-1	B	15	0	0	0	0	0	0	0	0	0	0	2	0	1	3	3	2	4	5
CH-1	C	15	0	0	0	0	0	0	0	0	0	0	3	0	3	1	3	4	5	3
CH-1	D	17	0	0	0	0	0	0	1	0	0	0	2	0	0	0	2	2	5	4
CH-1	E	15	0	0	0	0	0	0	0	0	0	2	0	0	2	1	3	4	1	1
CH-2	A	15	0	0	0	0	0	0	1	0	1D	1	2	2	0	3	3	4	2	3
CH-2	B	14	0	0	0	1	1	0	0	0	0	0	3	0	5	5	2	1	3	3
CH-2	C	11	0	0	0	0	0	0	0	0	0	2	2	4	0	3	2	2	3	0
CH-2	D	12	0	0	0	0	0	0	0	1D	0	4	2	3	6	2	3	6	4	3
CH-2	E	17	0	0	0	0	0	0	0	0	0	3	0	4	1	6	6	6	7	B

TABLE I.1. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
SN-1	A	17	0	1	0	0	1D	0	0	0	0	3	3	0	3	2	3	8	2	2
SN-1	B	15	0	0	0	1	0	0	2D	0	0	4	6	2	1	5	7	3	0	0
SN-1	C	16	0	0	0	0	0	0	0	1	1D	5	5	2	6	6	3	3	5	6
SN-1	D	16	0	0	0	0	0	0	0	0	0	0	1	3	2	3	6	4	5	5
SN-1	E	13	0	0	2	0	0	0	0	0	0	1	4	1	2	2	2	1	1	6
SN-2-U	A	14	0	1	0	0	0	1	1D	1D	0	6	5	1	8	3	3	3	4	2
SN-2-U	B	13	0	0	0	0	0	0	0	0	0		7	0	1	3	1	3	2	3
SN-2-U	C	17	D	0	2	0	0	0	0	0	0	5	6	7	3	7	5	5	3	6
SN-2-U	D	14	0	1	1	0	0	U	0	1D	0	0	1	5	0	5	6	6	5	2
SN-2-U	E	12	0	0	0	0	0	U	0	0	0	8	6	3	2	4	5	6	0	0
SN-2-L	A	14	0	0	1	0	0	0	0	0	0	1	3	0	0	0	0	3	2	1
SN-2-L	B	12	0	0	0	0	0	0	0	0	0	0	5	0	3	3	4	0	0	3
SN-2-L	C	15	0	1	1	0	0	0	0	0	0	4	2	2	0	3	5	2	4	2
SN-2-L	D	18	0	1	0	0	0	0	1	0	0	3	10	1	6	8	8	9	6	5
SN-2-L	E	17	0	0	0	0	0	0	1D	0	1	8	4	5	1	0	4	0	2	0
SN-3-U	A	16	1	0	0	0	0	0	0	0	0		6	3	1	2	5	3	3	2
SN-3-U	B	15	0	0	0	0	0	0	0	0	1D	0	2	3	3	0	1	4	2	2
SN-3-U	C	13	0	0	0	0	0	0	1	0	0	0	2	2	0	1	0	4	2	3
SN-3-U	D	14	0	0	0	0	0	0	0	0	0	5	1	6	3	1	7	3	3	3
SN-3-U	E	18	0	0	0	0	0	0	1	0	0	0	3	0	1	3	5	6	6	7
SN-3-L	A	13	0	0	1	0	0	0	0	0	0	5	2	3	3	3	3	1	4	5
SN-3-L	B	14	0	1	0	0	0	0	0	0	0	6	6	3	3	4	6	7	3	4
SN-3-L	C	14	0	0	0	0	0	0	0	1	0	0	1	0	0	0	4	7	5	6
SN-3-L	D	14	0	0	0	0	1	1	1D	0	0	0	1	0	0	1	3	3	2	1
SN-3-L	E	9	0	0	1	0	0	0	0	0	0	2	5	3	1	3	1	3	3	4
TD-1-U	A	15	0	0	0	0	0	U	1D	1	0	0	6	0	0	2	5	7	8	4
TD-1-U	B	15	0	0	0	0	0	U	2D	2	0	3	2	0	0	3	1	5	7	3
TD-1-U	C	15	0	0	0	0	0	0	0	0	0	2	3	2	3	2	3	4	2	1
TD-1-U	D	18	0	0	0	0	0	U	0	0	0	0	5	3	6	7	4	8	7	2
TD-1-U	E	14	0	1	0	0	0	0	0	0	0	1	3	4	3	1	5	5	5	4

TABLE I.1. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface 24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	Number on Water Surface 24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
TD-1-L	A	17	0	0	0	0	0	0	0	1	0	1	2	4	3	0	4	3	6	1
TD-1-L	B	14	0	0	0	0	0	U	0	0	1	0	5	1	2	1	3	1	3	2
TD-1-L	C	14	0	0	0	1D	0	U	0	0	0	2	5	3	1	2	1	1	2	4
TD-1-L	D	17	0	0	0	0	0	U	0	1	0	4	5	0	1	0	0	6	2	4
TD-1-L	E	16	0	0	0	0	0	0	0	0	0	1	9	4	5	6	3	7	4	2
TD-2-U	A	12	0	0	0	0	0	0	2/1D	1D	0	4	2	0	0	1	2	6	4	2
TD-2-U	B	13	0	0	0	0	0	0	0	1D	1		3	2	5	3	4	4	3	9
TD-2-U	C	16	0	0	1	0	0	0	0	0	0	6	4	0	1	0	1	0	2	4
TD-2-U	D	15	0	0	0	0	0	U	2	0	0	1	5	0	0	0	4	3	6	3
TD-2-U	E	14	0	0	0	0	0	0	0	0	0	4	1	0	2	1	1	7	3	4
TD-2-L	A	12	0	0	0	0	0	0	0	0	0	3	7	0	0	2	3	4	2	2
TD-2-L	B	13	0	0	1	0	0	0	1	0	0	1	3	3	3	3	4	4	2	0
TD-2-L	C	15	0	0	0	0	0	U	0	0	1D	4	4	0	2	4	3	6	1	5
TD-2-L	D	14	0	0	0	0	0	U	0	0	0	3	4	2	3	3	4	7	5	4
TD-2-L	E	14	0	0	0	1D	0	0	0	0	0	1	0	0	3	3	3	6	3	2
Sequim Bay[c]	A	13	0	0	0	0	1D	0	0	1D	0	1	4	2	3	5	2	3	3	4
Sequim Bay	B	17	0	0	1	0	0	0	0	0	0	2	2	1	1	1	1	2	3	3
Sequim Bay	C	19	1	0	1	0	0	0	0	0	0	2	2	0	0	2	0	1	1	5
Sequim Bay	D	18	0	0	0	1	0	0	0	0	0	2	2	2	3	6	2	4	5	2
Sequim Bay	E	15	2	0	2	0	0	0	0	3	1	5	1	1	2	3	3	5	2	3
Point Reyes	A	17	0	1	0	0	0	0	0	0	0	1	3	0	0	0	0	2	1	1
Point Reyes	B	18	0	1	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0
Point Reyes	C	22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0
Point Reyes	D	19	0	0	0	1D	0	0	0	0	0		0	0	0	0	0	0	0	0
Point Reyes	E	19	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0

(a) Unknown because of turbidity.

(b) Dead.

(c) Sequim Bay reference sediment.

TABLE I.2. Grandidierella japonica Acute Toxicity Test

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
1-1	A	8	0	0	0	1D[a]	0	0	0	0	1D	0	0	0	0	0	0	0	0	0
1-1	B	6	0	0	0	0	0	0	0	0	2D	0	0	0	0	0	0	0	0	0
1-1	C	8	0	1	2	0	0	0	1D	1D	0	0	0	0	0	0	0	0	0	0
1-1	D	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-1	E	8	0	0	0	0	0	U[b]	0	0	0	0	0	0	0	0	0	0	0	0
1-2	A	10	0	0	0	0	0	U	0	0	0	0	0	0	0	0	0	0	0	0
1-2	B	6	D	1D	2	1D	1D	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	C	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-2	D	7	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
1-2	E	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-3	A	5	0	0	0	0	0	0	0	0	2D	0	0	0	0	0	0	0	0	0
1-3	B	7	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1-3	C	9	0	0	0	1	0	0	1D	0	1D	0	0	0	0	0	0	0	0	0
1-3	D	8	0	0	0	1/1D	0	0	1D	0	1D	0	0	0	0	0	0	0	0	0
1-3	E	4	0	1D	2	2D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-1	A	4	0	0	1	0	0	1	2D	1	0	0	0	0	0	0	0	0	0	0
2-1	B	5	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
2-1	C	8	0	1D	0	0	0	0	0	1	1D	0	0	0	0	0	0	0	0	0
2-1	D	14	0	0	0	1	1D	0	0	1D	1/1D	0	0	0	0	0	0	0	0	0
2-1	E	9	0	0	0	0	0	0	0	1	1D	0	0	0	0	0	0	0	0	0
2-2	A	7	0	0	0	0	1D	0	0	1D	0	0	0	0	0	0	0	0	0	0
2-2	B	6	0	0	2	0	1D	0	0	0	0	0	0	0	0	0	0	0	0	0
2-2	C	8	0	0	0	0	2/1D	2	2	0	0	0	0	0	0	0	0	0	0	0
2-2	D	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2-2	E	5	0	0	0	0	0	0	1D	1D	1D	0	0	0	0	0	0	0	0	0
3-1	A	4	0	1	0	0	1/1D	0	1D	0	0	0	0	0	0	0	0	0	0	0
3-1	B	8	0	0	1	1D	0	1	0	0	1	0	0	0	0	0	0	0	0	0
3-1	C	6	0	0	2	0	1D	0	1	0	1D	0	0	0	0	0	0	0	0	0

TABLE I.2. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
3-1	D	9	0	0	1	0	0	0	1D	0	1	0	0	0	0	0	0	0	0	0
3-1	E	6	0	0	0	1D	0	U	1	1D	0	0	0	0	0	0	0	0	0	0
3-2	A	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-2	B	6	0	0	0	1D	0	0	0	0	1D	0	0	0	0	0	0	0	0	0
3-2	C	4	0	1D	2	0	1/1D	1	1D	0	0	0	0	0	0	0	0	0	0	0
3-2	D	7	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
3-2	E	6	0	0	0	0	0	U	1D	1D	0	0	0	0	0	0	0	0	0	0
CH-1	A	9	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
CH-1	B	8	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH-1	C	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
CH-1	D	9	0	0	1	1D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH-1	E	9	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH-2	A	8	0	0	1	1	1D	0	1	0	0	0	0	0	0	0	0	0	0	0
CH-2	B	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH-2	C	4	0	1D	1	0	0	0	2D	1D	1D	0	0	0	0	0	0	0	0	0
CH-2	D	5	0	0	1	1/1D	0	1	2D	0	0	0	0	0	0	0	0	0	0	0
CH-2	E	7	0	0	1	2D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-1	A	7	0	0	0	0	0	1D	1D	0	0	0	0	0	0	0	0	0	0	0
SN-1	B	8	0	0	0	1	2D	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-1	C	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-1	D	7	0	1	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0
SN-1	E	7	0	1D	0	0	0	2	1D	0	2D	0	0	0	0	0	0	0	0	0
SN-2-U	A	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-2-U	B	4	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
SN-2-U	C	6	0	0	2	0	0	0	2D	0	0	0	0	0	0	0	0	0	0	0
SN-2-U	D	5	0	0	0	2	2	U	0	1/1D	1D	0	0	0	0	0	0	0	0	0
SN-2-U	E	5	0	0	1	0	1D	U	1D	1/1D	2/1D	0	0	0	0	0	0	0	0	0

TABLE I.2. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
SN-2-L	A	3	0	0	1	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0
SN-2-L	B	5	0	0	0	1D	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SN-2-L	C	3	0	0	0	0	1D	0	0	1D	0	0	0	0	0	0	0	0	0	0
SN-2-L	D	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-2-L	E	7	0	0	0	0	0	0	0	0	1D	0	0	0	0	0	1	0	0	0
SN-3-U	A	6	0	0	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0
SN-3-U	B	6	0	0	1	1	0	1	1D	0	0	0	0	0	0	0	0	0	0	0
SN-3-U	C	4	0	0	0	0	1D	0	0	0	2D	0	0	0	0	0	0	0	0	0
SN-3-U	D	6	0	0	1	1D	0	1	1D	0	0	0	0	0	0	0	0	0	0	0
SN-3-U	E	9	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SN-3-L	A	4	0	0	0	0	0	0	0	1	2D	0	0	0	0	0	0	0	0	0
SN-3-L	B	4	0	1D	2	1D	1D	0	0	0	0	0	0	0	0	0	0	0	0	0
SN-3-L	C	2	0	1	0	0	1D	0	0	1/1D	1D	0	1D	0	0	0	0	0	0	0
SN-3-L	D	6	0	0	0	0	1D	0	1D	2D	0	0	0	0	0	0	0	0	0	0
SN-3-L	E	5	0	0	0	1D	0	0	0	1D	1D	0	0	0	0	0	0	0	0	0
TD-1-U	A	3	0	0	1	0	2D	U	1D	1	1/1D	0	0	0	0	0	0	0	0	0
TD-1-U	B	7	0	0	1	0	0	U	0	1D	0	0	0	0	0	0	0	1	0	0
TD-1-U	C	11	0	0	2	0	0	D	0	0	0	0	0	0	0	0	0	0	0	0
TD-1-U	D	5	0	0	1	0	0	U	0	1D	1D	0	0	0	0	0	0	0	0	0
TD-1-U	E	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TD-1-L	A	5	0	0	0	1D	0	0	0	0	1D	0	0	0	0	0	0	0	0	0
TD-1-L	B	6	0	0	0	1D	1	U	1	2	1D	0	0	0	0	0	0	0	0	0
TD-1-L	C	3	0	1	0	0	0	U	2	1/2D	1D	0	0	0	0	0	0	0	0	1
TD-1-L	D	7	0	1	0	0	0	U	1	0	1D	0	0	0	0	0	0	0	0	0
TD-1-L	E	5	0	1	1/2D	1D	1	1	0	1D	0	0	0	0	0	0	0	0	0	0

TABLE I.2. (contd)

Sediment Treatment	Rep	Number Alive 240 h	Number on Sediment Surface									Number on Water Surface								
			24 h	48 h	72 h	96 h	120 h	144 h	168h	192 h	216 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	192 h	216 h
TD-2-U	A	7	0	0	1	2	2D	0	0	0	0	0	0	0	0	0	0	0	0	0
TD-2-U	B	6	0	D	0	0	0	0	2D	0	0	0	0	0	0	0	0	0	0	0
TD-2-U	C	4	0	0	2	0	0	0	0	1D	2D	0	0	0	0	0	0	0	0	0
TD-2-U	D	7	0	1D	0	1D	0	U	0	0	1D	0	0	0	0	0	0	0	0	0
TD-2-U	E	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TD-2-L	A	9	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0	0	0
TD-2-L	B	5	0	1D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TD-2-L	C	3	0	0	0	0	2	U	4/1D	3	1D	0	0	0	0	0	0	0	0	0
TD-2-L	D	6	0	1/1	0	1	1D	U	2/1D	1D	0	0	0	0	0	0	0	0	0	0
TD-2-L	E	5	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0	0	0
Sequim Bay[c]	A	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sequim Bay	B	6	0	0	1	0	0	0	1D	0	0	0	0	0	1D	0	0	0	0	0
Sequim Bay	C	5	0	1M[d]	1/1D	0	0	0	0	1D	0	0	0	0	0	0	0	0	0	0
Sequim Bay	D	6	0	0	0	2/1D	1D	1	0	0	0	0	0	0	0	0	0	0	0	0
Sequim Bay	E	8	0	0	0	1D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Point Reyes	A	8	0	0	0	0	1D	0	0	1D	0	0	0	0	0	0	0	0	0	0
Point Reyes	B	9	0	0	1/1D	1D	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Point Reyes	C	7	0	0	1	0	0	0	2D	0	0	0	0	0	0	0	0	0	0	0
Point Reyes	D	6	1	1M	1	1/1D	0	0	1/1D	1D	0	0	0	0	0	0	0	0	0	0
Point Reyes	E	8	0	1D/1M	1	1	1	1	1D	0	0	0	0	0	0	0	0	0	0	0

(a) Dead.
(b) Unknown because of turbidity.
(c) Sequim Bay reference sediment.
(d) Molt.

TABLE I.3. Rhepoxynius abronius and Grandidierella japonica Water Quality Monitoring - Acute Toxicity Test

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
1-1	24	A	15.7	32.0	7.6	7.95
1-1	24	B	15.7	32.0	7.5	8.04
1-1	72	A	16.0	31.5	6.7	7.87
1-1	72	B	14.7	32.0	7.3	7.91
1-1	72	C	15.2	32.0	7.9	7.89
1-1	72	D	15.5	32.0	6.9	7.84
1-1	72	E	15.0	31.5	8.1	7.90
1-1	96	A	15.0	32.0	7.2	7.82
1-1	120	B	14.5	32.0	7.4	7.88
1-1	144	C	14.5	32.0	7.4	7.75
1-1	168	D	15.5	31.5	8.2	7.92
1-1	192	E	15.0	32.0	6.9	7.81
1-1	216	A	14.5	31.5	7.9	7.89
1-1	240	B	15.0	31.5	7.1	7.84
1-2	24	A	15.5	32.0	7.5	8.01
1-2	24	B	16.0	31.5	7.4	7.97
1-2	72	A	15.0	31.5	8.1	7.93
1-2	72	B	15.8	31.5	6.8	7.83
1-2	72	C	15.2	31.0	7.1	7.90
1-2	72	D	15.5	32.0	7.2	7.91
1-2	72	E	15.7	32.0	7.3	7.99
1-2	96	A	15.1	32.0	5.6	7.76
1-2	120	B	14.5	31.5	7.0	7.80
1-2	144	C	14.4	32.0	7.4	7.69
1-2	168	D	15.5	31.5	8.1	7.90
1-2	192	E	15.0	31.5	8.0	7.94
1-2	216	A	15.0	31.5	6.1	7.86

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
1-2	240	B	14.5	31.5	7.8	7.81
1-3	24	A	15.0	32.0	7.5	8.04
1-3	24	B	14.6	32.0	7.6	8.02
1-3	72	A	15.6	31.5	7.2	7.95
1-3	72	B	15.6	32.0	7.2	7.94
1-3	72	C	15.3	32.0	8.0	7.93
1-3	72	D	16.4	32.0	6.7	7.86
1-3	72	E	15.8	32.0	6.3	7.73
1-3	96	A	15.1	32.0	7.4	7.95
1-3	120	B	14.4	32.0	7.5	7.89
1-3	144	C	14.5	32.0	7.7	7.84
1-3	168	D	16.0	31.5	8.1	7.90
1-3	192	E	15.0	32.0	7.7	7.95
1-3	216	A	15.0	31.5	7.7	7.91
1-3	240	B	14.5	31.5	7.9	7.82
2-1	24	A	15.2	32.0	7.3	7.92
2-1	24	B	17.2	32.0	6.0	7.92
2-1	72	A	15.5	32.0	8.0	7.84
2-1	72	B	15.1	32.0	8.1	7.94
2-1	72	C	15.0	32.0	8.1	7.90
2-1	72	O	15.8	32.0	7.8	7.86
2-1	72	E	14.8	31.5	8.1	7.90
2-1	120	B	14.7	31.5	7.5	7.93
2-1	144	C	14.5	32.0	7.5	7.75
2-1	168	D	15.5	31.5	7.7	7.80
2-1	192	E	14.5	31.5	7.8	7.82
2-1	216	A	15.5	32.0	6.8	7.86

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
2-1	240	B	15.5	32.0	5.1	7.67
2-2	24	A	15.7	32.0	7.4	7.99
2-2	24	B	15.5	31.5	7.1	7.90
2-2	72	A	16.1	31.5	7.2	7.89
2-2	72	B	15.4	32.0	7.3	7.93
2-2	72	C	15.9	31.5	6.7	7.82
2-2	72	D	16.2	32.0	6.8	7.83
2-2	72	E	15.0	32.0	8.0	7.98
2-2	96	A	15.5	32.0	6.8	7.93
2-2	120	B	14.4	32.0	7.7	7.98
2-2	144	C	14.5	33.0	6.7	7.64
2-2	168	D	15.0	31.5	7.9	7.91
2-2	192	E	15.0	31.5	7.5	7.88
2-2	216	A	15.0	31.5	7.8	7.87
2-2	240	B	14.5	31.5	8.1	7.83
3-1	24	A	15.3	31.5	7.3	8.02
3-1	24	B	16.2	31.5	6.9	7.97
3-1	72	A	14.9	32.0	7.2	7.96
3-1	72	B	16.5	32.0	7.1	7.94
3-1	72	C	14.9	31.5	7.3	8.01
3-1	72	D	14.8	31.5	8.0	7.93
3-1	72	E	14.7	32.0	7.2	7.94
3-1	96	A	15.1	32.0	7.5	7.97
3-1	120	B	14.8	31.5	7.4	7.91
3-1	144	C	15.0	32.0	7.6	7.81
3-1	168	D	15.0	31.5	7.8	7.89
3-1	192	E	15.0	32.0	7.6	7.84
3-1	216	A	15.0	31.5	6.8	7.86

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
3-1	240	B	15.0	31.5	7.7	7.82
3-2	24	A	15.8	32.0	7.1	7.95
3-2	24	B	17.7	32.0	5.8	7.76
3-2	72	A	15.0	32.0	8.2	7.99
3-2	72	B	15.4	31.5	7.9	7.99
3-2	72	C	15.0	32.0	7.7	7.89
3-2	72	D	16.1	32.0	7.6	7.91
3-2	72	E	14.9	32.0	8.2	8.05
3-2	96	A	14.5	32.0	7.7	7.99
3-2	120	B	14.9	31.5	7.5	8.02
3-2	144	C	14.5	31.5	7.7	7.78
3-2	168	D	15.5	31.5	7.6	7.93
3-2	192	E	15.0	31.5	7.7	7.88
3-2	216	A	15.0	32.0	7.4	7.96
3-2	240	B	15.0	32.0	7.8	7.95
CH-1	24	A	14.7	32.0	7.6	7.97
CH-1	24	B	15.4	32.0	7.1	7.89
CH-1	72	A	15.0	32.0	8.0	7.94
CH-1	72	B	14.9	32.0	7.3	7.91
CH-1	72	C	14.8	31.5	8.1	7.94
CH-1	72	D	14.7	31.5	7.9	7.85
CH-1	72	E	15.0	32.0	8.1	7.95
CH-1	96	A	15.8	32.0	7.3	7.94
CH-1	120	B	14.4	31.5	7.2	7.87
CH-1	144	C	14.4	32.0	7.3	7.71
CH-1	168	D	15.0	31.5	8.0	7.84
CH-1	192	E	15.0	31.5	7.7	7.84
CH-1	216	A	15.0	31.5	7.6	7.80

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
CH-1	240	B	14.5	31.5	7.7	7.77
CH-2	24	A	16.0	31.5	7.4	7.97
CH-2	24	B	15.7	32.5	7.3	7.94
CH-2	72	A	14.7	32.0	7.2	7.90
CH-2	72	B	15.1	32.0	7.2	7.83
CH-2	72	C	15.1	32.0	8.0	7.95
CH-2	72	D	14.7	32.0	7.2	7.90
CH-2	72	E	15.5	31.5	7.0	7.93
CH-2	96	A	14.9	32.0	7.4	7.87
CH-2	120	B	14.5	32.0	7.3	7.91
CH-2	144	C	14.5	31.5	7.7	7.86
CH-2	168	D	15.5	31.5	7.5	7.77
CH-2	192	E	14.5	31.5	7.7	7.77
CH-2	216	A	14.5	31.5	7.6	7.83
CH-2	240	B	14.5	32.0	7.7	7.79
SN-1	24	A	16.6	32.0	6.9	7.91
SN-1	24	B	16.2	32.0	6.5	7.81
SN-1	72	A	15.5	31.5	7.9	7.96
SN-1	72	B	14.7	32.0	6.7	7.87
SN-1	72	C	15.4	31.5	5.9	7.81
SN-1	72	D	15.0	31.5	7.4	8.04
SN-1	72	E	17.4	31.0	6.6	7.85
SN-1	96	A	15.3	32.0	7.4	7.91
SN-1	120	B	14.4	31.5	6.2	7.82
SN-1	144	C	15.0	33.0	7.6	7.80
SN-1	168	D	16.0	31.5	7.5	7.83
SN-1	192	E	15.0	31.5	7.5	7.84
SN-1	216	A	15.5	32.0	6.7	7.93

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-1	240	B	14.5	31.5	7.7	7.78
SN-2-U	24	A	16.5	32.0	6.4	7.85
SN-2-U	24	B	14.8	32.0	7.5	8.02
SN-2-U	72	A	15.5	32.0	7.3	7.83
SN-2-U	72	B	15.6	32.0	7.4	8.01
SN-2-U	72	C	15.6	32.0	7.3	7.89
SN-2-U	72	D	14.7	32.0	7.5	8.06
SN-2-U	72	E	15.6	32.0	6.3	7.85
SN-2-U	96	A	15.9	32.0	7.3	7.89
SN-2-U	120	B	14.3	32.0	7.6	7.96
SN-2-U	144	C	14.4	32.0	7.5	7.71
SN-2-U	168	D	16.0	32.0	7.2	7.91
SN-2-U	192	E	15.0	31.5	7.0	7.86
SN-2-U	216	A	14.5	31.5	7.9	7.98
SN-2-U	240	B	14.5	32.0	7.8	7.87
SN-2-L	24	A	16.0	32.0	7.2	7.98
SN-2-L	24	B	16.5	31.5	6.8	8.02
SN-2-L	72	A	14.8	32.0	8.2	8.04
SN-2-L	72	B	17.0	31.5	6.5	7.86
SN-2-L	72	C	15.3	32.0	8.2	7.99
SN-2-L	72	D	15.9	32.0	6.1	7.77
SN-2-L	72	E	15.5	32.0	7.8	7.84
SN-2-L	96	A	14.6	32.0	7.7	8.03
SN-2-L	120	B	14.9	32.0	5.8	7.84
SN-2-L	144	C	14.5	32.0	7.7	7.85
SN-2-L	168	D	15.5	32.0	8.0	7.96
SN-2-L	192	E	15.0	31.5	7.7	7.91
SN-2-L	216	A	15.0	32.0	7.6	8.00

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
SN-2-L	240	B	15.0	31.5	7.9	7.91
SN-3-U	24	A	16.0	32.0	7.4	7.95
SN-3-U	24	B	14.6	32.0	7.7	8.05
SN-3-U	72	A	16.0	31.5	7.1	7.88
SN-3-U	72	B	15.8	32.0	6.8	7.91
SN-3-U	72	C	14.8	32.0	8.1	8.00
SN-3-U	72	D	15.3	32.0	6.3	7.87
SN-3-U	72	E	14.8	31.5	8.0	7.91
SN-3-U	96	A	15.5	32.0	7.3	7.88
SN-3-U	120	B	14.9	32.0	7.5	7.99
SN-3-U	144	C	14.5	32.0	7.7	7.87
SN-3-U	168	D	16.0	31.5	7.5	7.90
SN-3-U	192	E	14.5	31.5	7.8	7.89
SN-3-U	216	A	15.0	31.5	7.6	7.85
SN-3-U	240	B	15.5	32.0	6.5	7.81
SN-3-L	24	A	15.9	32.0	7.3	7.94
SN-3-L	24	B	17.0	32.0	6.7	7.96
SN-3-L	72	A	14.8	31.5	8.0	7.91
SN-3-L	72	B	15.3	31.5	8.0	7.92
SN-3-L	72	C	14.8	32.0	8.1	7.98
SN-3-L	72	D	15.1	32.0	7.9	7.96
SN-3-L	72	E	15.1	32.0	7.2	7.95
SN-3-L	96	A	14.4	32.0	7.2	7.88
SN-3-L	120	B	14.6	32.0	7.2	7.86
SN-3-L	144	C	14.3	31.5	7.7	7.90
SN-3-L	168	D	16.0	31.5	7.2	7.85
SN-3-L	192	E	14.5	32.0	8.0	7.99
SN-3-L	216	A	14.5	31.5	6.8	7.95

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
SN-3-L	240	B	14.5	31.5	7.8	7.90
TD-1-U	24	A	15.4	32.0	7.6	7.97
TD-1-U	24	B	15.4	32.0	7.1	7.92
TD-1-U	72	A	15.0	32.0	8.1	7.91
TD-1-U	72	B	15.0	32.0	8.0	7.91
TD-1-U	72	C	15.1	31.5	7.8	7.88
TD-1-U	72	D	14.8	32.0	7.3	7.96
TD-1-U	72	E	15.4	31.5	7.0	7.86
TD-1-U	96	A	14.9	32.0	7.3	7.82
TD-1-U	120	B	14.3	32.0	7.5	7.88
TD-1-U	144	C	14.5	31.0	7.6	7.74
TD-1-U	168	D	16.0	32.0	7.6	7.82
TD-1-U	192	E	15.5	31.5	7.4	7.79
TD-1-U	216	A	14.5	31.5	7.4	7.94
TD-1-U	240	B	15.0	32.0	6.7	7.79
TD-1-L	24	A	15.1	31.5	7.7	8.02
TD-1-L	24	B	15.6	32.0	7.4	8.02
TD-1-L	72	A	15.8	31.5	7.4	7.98
TD-1-L	72	B	14.9	31.5	7.5	8.03
TD-1-L	72	C	14.8	31.5	7.4	7.94
TD-1-L	72	D	15.2	32.0	8.1	7.96
TD-1-L	72	E	15.9	31.5	6.4	7.85
TD-1-L	96	A	15.0	32.0	7.1	8.01
TD-1-L	120	B	14.5	32.0	7.6	7.99
TD-1-L	144	C	14.5	32.0	7.8	7.91
TD-1-L	168	D	16.0	32.0	8.1	7.96
TD-1-L	192	E	15.5	31.5	7.1	7.86
TD-1-L	216	A	15.0	31.5	7.4	7.99

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
TD-1-L	240	B	14.5	31.5	7.9	7.95
TD-2-U	24	A	17.4	32.0	6.6	7.96
TD-2-U	24	B	16.0	31.5	7.4	7.88
TD-2-U	72	A	15.3	31.5	8.0	7.98
TD-2-U	72	B	16.2	31.0	7.3	7.89
TD-2-U	72	C	14.7	31.5	8.1	7.92
TD-2-U	72	D	15.5	32.0	7.7	7.88
TD-2-U	72	E	14.8	31.5	8.2	7.97
TD-2-U	96	A	15.0	32.0	7.5	8.02
TD-2-U	120	B	15.2	32.0	7.2	7.91
TD-2-U	144	C	14.2	32.0	7.6	7.76
TD-2-U	168	D	15.5	31.5	7.9	7.84
TD-2-U	192	E	14.5	31.5	7.6	7.87
TD-2-U	216	A	15.5	31.5	7.3	7.94
TD-2-U	240	B	15.0	31.5	7.8	7.78
TD-2-L	24	A	15.5	31.5	7.5	8.00
TD-2-L	24	B	17.0	32.0	6.7	8.03
TD-2-L	72	A	15.6	32.0	7.3	7.96
TD-2-L	72	B	15.9	31.5	6.0	7.86
TD-2-L	72	C	15.0	32.0	7.3	7.99
TD-2-L	72	D	15.1	32.0	7.2	8.03
TD-2-L	72	E	14.7	32.0	7.3	7.99
TD-2-L	96	A	14.5	32.0	7.4	7.96
TD-2-L	120	B	15.2	32.0	7.2	7.97
TD-2-L	144	C	15.5	32.0	7.6	7.89
TD-2-L	168	D	15.5	31.5	8.0	7.97
TD-2-L	192	E	15.5	31.5	7.9	7.97
TD-2-L	216	A	14.5	32.0	7.1	7.89

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/₀₀)	Dissolved Oxygen (mg/L)	pH
TD-2-L	240	B	15.5	32.0	6.8	7.96
SEQUIM BAY[a]	24	A	15.8	31.5	7.3	7.91
SEQUIM BAY	24	B	16.2	32.0	7.0	7.86
SEQUIM BAY	72	A	15.5	31.5	6.8	7.84
SEQUIM BAY	72	B	15.2	31.5	8.0	7.95
SEQUIM BAY	72	C	14.9	31.5	7.2	7.88
SEQUIM BAY	72	D	15.7	31.0	7.4	7.89
SEQUIM BAY	72	E	14.7	32.0	7.1	7.87
SEQUIM BAY	96	A	14.5	32.0	7.3	7.82
SEQUIM BAY	120	B	14.8	32.0	7.0	7.83
SEQUIM BAY	144	C	14.4	32.0	7.8	7.71
SEQUIM BAY	168	D	15.5	31.5	8.1	7.85
SEQUIM BAY	192	E	15.0	31.5	5.7	7.73
SEQUIM BAY	216	A	14.5	31.5	4.9	7.67
SEQUIM BAY	240	B	15.0	31.5	7.3	7.92
POINT REYES	24	A	16.0	32.0	7.7	7.99
POINT REYES	24	B	15.6	32.5	7.5	8.01
POINT REYES	72	A	14.7	31.5	8.2	7.93
POINT REYES	72	B	15.2	32.0	8.1	7.96
POINT REYES	72	C	15.0	32.0	8.2	7.95
POINT REYES	72	D	16.0	31.0	7.5	7.90
POINT REYES	72	E	15.1	32.0	7.2	7.94
POINT REYES	96	A	14.2	32.0	7.7	7.92
POINT REYES	120	B	15.0	32.0	7.6	7.95
POINT REYES	144	C	14.5	32.0	7.7	7.82
PDINT REYES	168	D	15.0	31.5	8.2	7.87

TABLE I.3. (contd)

Sediment Treatment	Hour	Rep	Temperature (°C)	Salinity (°/..)	Dissolved Oxygen (mg/L)	pH
POINT REYES	192	E	15.0	31.5	7.9	7.89
POINT REYES	216	A	14.5	31.5	7.6	7.98
POINT REYES	240	B	15.5	32.0	7.4	7.92

(a) Sequim Bay reference sediment.

APPENDIX J

CHEMISTRY DATA SUMMARY

TABLE J.1. Metals, Metalloids, Organotins

Sediment Treatment	Concentrations (dry wt) mg/kg Sb	As	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn	µg/kg Tri-Butyl Sn	Di-Butyl Sn	Mono-Butyl Sn
1-1	1.02	14.7	0.34	226.2	65.1	34	0.354	125.8	0.68	0.522	0.4	141	36.8	16.4	16.40
1-2	0.90	14.1	0.35	232.2	68.4	28	0.326	121.8	0.59	0.492	0.3	139	26.0	11.6	3.51
1-3	0.84	13.8	0.33	231.6	77.9	25	0.351	117.9	0.65	0.581	0.3	149	18.7	11.5	3.22U[a]
2-1[b]	0.96	12.6	0.52	289.1	62.8	42	0.473	108.0	0.43	0.674	0.5	147	56.6	30.2	11.62[b]
2-2	0.72	11.6	0.50	296.9	66.5	46	0.513	91.5	0.50	0.561	0.3	158	61.8	45.1	2.39U
3-1	0.96	13.9	0.63	264.9	77.9	59	0.575	115.2	0.68	0.674	0.2	175	168.0	46.5	9.46
3-2	0.84	13.0	0.50	264.1	63.2	43	0.437	131.2	0.54	0.557	0.3	166	82.1	41.8	6.83
CH-1	0.96	13.5	0.55	256.6	79.1	55	0.506	119.8	0.57	0.609	0.4	187	236.5	67.1	13.35[b]
CH-2	0.96	12.7	0.49	259.9	80.1	55	0.568	124.4	0.54	0.615	0.4	188	179.0	42.6	8.56
SN-1	1.32	14.9	0.77	245.6	87.0	68	0.659	131.2	0.54	0.874	0.4	232	73.6	39.6	5.53
SN-2-U	1.56	15.3	0.99	238.2	90.6	90	0.777	125.8	0.68	0.940	0.3	269	96.3	67.8	9.28
SN-2-L	1.92	14.1	1.67	279.6	111.4	141	1.484	132.4	0.59	1.117	0.3	347	50.7	51.4	2.98U
SN-3-U	1.20	13.9	0.81	252.9	76.2	69	0.652	124.5	0.54	0.680	0.4	211	105.0	45.8	8.21
SN-3-L	1.68	14.9	1.09	277.0	77.6	86	1.111	124.5	0.68	0.813	0.3	234	37.1	35.2	10.45
TD-1-U	2.88	12.3	0.70	371.7	183.3	80	1.345	132.4	0.63	0.783	0.3	234	1601.0	422.0	69.10
TD-1-L	1.92	13.5	1.16	352.5	178.5	109	1.060	135.0	0.54	0.837	0.4	471	2214.0	658.0	139.00
TD-2-U	1.20	15.3	0.60	268.4	132.1	79	0.973	135.0	0.59	0.768	0.3	232	235.0	70.6	12.40
TD-2-L	1.80	14.1	0.82	425.0	178.5	90	1.823	153.5	0.45	0.857	0.3	287	603.0	156.0	51.10
SEQUIM BAY[b]	0.42	10.0	0.74	104.7	35.4	17	0.084	48.1	1.02	0.237	0.5	90	10.1U	7.2U	4.44U
POINT REYES	0.48	7.0	1.36	259.8	9.2	10	0.059	34.6	0.45	0.034	0.6	43	5.0U	3.5U	2.18U

(a) Compound analyzed, but not detected at the given detection limit.

(b) Indicates data are mean of duplicate measurements.

TABLE J.2. Conventionals/Petroleum Hydrocarbons (dry wt)

Sediment Treatment	Cyanide (µg/g)	TOC (%)	Total Sulfides (µg/g)	Water Soluble Sulfides (µg/g)	Oil and Grease (µg/g)	Petroleum Hydrocarbons (µg/g)	Total Solids (%)
1-1	<0.6	1.18	245.0	51.7	28.50	<10.0[a]	45.34
1-2	<0.6	1.07	83.7	53.5	<10.0	<10.0	46.28
1-3	<0.6[a]	1.07[a]	55.6[a]	96.3[a]	187.75	106.67	45.14
2-1	<0.6	1.52	152.5	53.5	981.74	73.20	53.04
2-2	<0.6	1.08	285.0	21.4	535.85	188.26	53.54
3-1	<0.6	1.48	128.0	85.6	676.18	189.67	50.26
3-2	<0.6[a]	1.62[a]	218.0[a]	96.3[a]	384.01	65.31	47.90
CH-1	<0.6	1.77	150.0	53.5	804.85	360.19	43.52
CH-2	<0.6	1.94	108.0	96.3	400.47	<10.0	43.08
SN-1	<0.6	1.76	56.3	160.0	264.98	86.72	41.61
SN-2-U	<0.6	2.02	437.0	107.0	751.05	263.53	38.84
SN-2-L	<0.6	2.13	399.0	535.0	739.74	507.81	45.84
SN-3-U	<0.6	1.58	82.0	107.0	755.35	239.43	41.46
SN-3-L	<0.6	1.51	252.0	107.0	308.02	244.27	46.68
TD-1-U	<0.6	1.46	226.0	482.0	503.80	399.84	47.96
TD-1-L	<0.6	1.89	394.0	374.0	1040.68	387.03	50.47
TD-2-U	<0.6	1.65	135.0	108.0	499.31[a]	279.25[a]	39.47[a]
TD-2-L	<0.6	1.61	397.0	374.0	781.55	275.23	50.87
TD-2-L BOTTOM[b]	NM[c]	NM	NM	NM	107.0[a]	7.8[a]	NM
SEQUIM BAY	<0.6	3.84	106.0	128.0	603.90	96.85	31.95
POINT REYES	<0.6	0.4	<5.0	5.4	<10.0	<10.0	75.6

(a) Average of duplicate measurements.
(b) Bottom inch of extruded core analyzed for oil and grease and petroleum hydrocarbons to determine levels of contamination.
(c) NM = not measured.

TABLE J.3. Pesticides and PCBs

Sediment Treatment	Concentrations (µg/kg dry wt) 4,4' DDE	PCB Aroclor 1242	PCB Aroclor 1254	PCB Aroclor 1260	Total PCBs
1-1	30	100U[a]	100U	100U	ND[b]
1-2	10U	100U	100U	100U	ND
1-3	10U	100U	100U	100U	ND
2-1	10U	100U	100U	100U	ND
2-2	10U	100U	100U	100U	ND
3-1	10U	100U	85J[c]	100U	85J
3-2	10U	100U	100U	100U	ND
CH-1	10U	100U	60J	100U	60J
CH-2	10U	100U	100U	100U	ND
SN-1	10U	100U	80J	100U	80J
SN-2-U	10U	100U	170	110	280
SN-2-L	10U	220	370	190	780
SN-3-U	10U	100U	90J	100U	90J
SN-3-L	10U	100U	110	100U	110
TD-1-U	10U	100U	330	120	450
TD-1-L	10U	100U	380	110	490
TD-2-U	10U	100U	140	100U	140
TD-2-L	10U	100U	500	170	670
SEQUIM BAY	10U	100U	100U	100U	ND
POINT REYES	10U	100U	100U	100U	ND

(a) Compound analyzed, but not detected at the given detection limit.
(b) Individual arochors not detected at specified limits.
(c) Estimated value when result is less than specified detection limit.

TABLE J.4. Semivolatiles

Sediment Treatment	Concentrations (µg/kg) Fluorene	Phenanthrene	Anthracene	Di-n-Butyl-Phthalate	Fluoranthene	Pyrene	Butylbenzyl-Phthalate	Benzo(a)-Anthracene	Bis(2-Ethylhexyl)-Phthalate
1-1	86U[a]	63J[b]	86U	86U	140	150	86U	91M[c]	240
1-2	73U	87	73U	73U	160	190	73U	92M	340
1-3	83U	67J	83U	83U	170	190	83U	76M	480
2-1	67U	160	67U	67U	300	300	67U	130M	400
2-2	69U	150	69U	69U	510	600	69U	210M	370
3-1	72U	180	72U	72U	450	570	100	170M	640
3-2	76U	96	76U	76U	280	390	45M	120M	220
CH-1	75U	150	75U	75U	450	730	75U	170	660
CH-2	99U	170	99U	99U	500	710	99U	220	1000
TD-1-U	79U	370	79U	79U	680	860	79U	350	750
TD-1-L	69U	240	69U	77M	450	680	69U	260	600
TD-2-U	88U	390	200J	340M	1200	1800	230	740	760
TD-2-L	72U	360	47M	72U	690	1100	65J	420	960
SN-1	86U	160	86U	86U	450	790	79J	190M	270
SN-2-U	98U	480	95M	98U	1300	2400	98U	630	670
SN-2-L	120M	870	500M	220U	2000	3400	990	930	3900
SN-3-U	180U	320	110M	180U	750	1800	270	420	1100
SN-3-L	160U	430	160U	160U	1100	2600	190M	410	630
SEQUIM BAY	210U	210U	210U	210U	210U	210U	210U	210U	162M
POINT REYES	45U	45U	45U	45U	45U	45U	45U	45U	40JB[d]

Sediment Treatment	Concentrations (µg/kg) Chrysene	Di-n-Octyl Phthalate	Benzo(b,k)-Fluoranthene	Benzo(a)-Pyrene	Indeno(1,2,3)-Pyrene	Dibenz(a,h)-Anthracene	Benzo(g,h,i)-Perylene
1-1	100M	86U	140	110M	86U	86U	86U
1-2	89M	73U	130M	85M	73U	73U	73U
1-3	110M	83U	150M	110M	83U	83U	83U
2-1	140M	67U	250	190	140M	67U	67U
2-2	400	69U	440	270	170	69U	69U
3-1	250	72U	440	290	220	72U	59M
3-2	160M	76U	320	220	170M	76U	76U
CH-1	270	75U	580	520	420	75U	280
CH-2	390	99U	630	410	280	99U	99U
TD-1-U	600M	79U	1100	590	520	230M	120M
TD-1-L	470	310	1000	500	480	69U	90M
TD-2-U	1400	88U	2100	620	880	88U	200M
TD-2-L	690	72U	1700	700	400	72U	72U
SN-1	300	86U	560	310	86U	86U	86U
SN-2-U	610	98U	2200	560	98U	98U	98U
SN-2-L	1700	220U	2800	1800	1500	260M	220U

TABLE J.4. (contd)

Sediment Treatment	Concentrations (µg/kg) Chrysene	Di-n-Octyl Phthalate	Benzo(b,k)-Fluoranthene	Benzo(a)-Pyrene	Indeno(1,2,3)-Pyrene	Dibenz(a,h)-Anthracene	Benzo(g,h,i)-Perylene
SN-3-U	730	180U	1600	1000	880	180U	180U
SN-3-L	620	160U	2300	1300	1400	160U	500M
SEQUIM BAY	210U	210U	210U	210U	210U	210U	210U
POINT REYES	45U	45U	45U	45U	45U	45U	45U

(a) Compound analyzed, but not detected at the given detection limit.
(b) Estimated value when result is less than specified detection limit.
(c) Compound was present, but below detection. Estimated value of analyte found and confirmed by analyst, but with low spectral match parameter.
(d) Compound was in the method blank.

TABLE J.5. Percent of Recovered Sediment (dry wt) Within Specified Sieve-Size Classes

Sediment Treatment	Sieve Size (mm)	Phi	Percent of Material Occurring in Each Sieve Size — Sediment Treatment: 1-1	1-2	1-3	2-1 Rep 1	2-1 Rep 2	2-2	3-1	3-2	CH-1 Rep 1	CH-1 Rep 2	CH-2
Gravel	>3.35	-2	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
	3.35 - 2.00	-1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand	2.00 - 1.00	0	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.13	0.01	0.04	0.03
	1.00 - 0.50	1	0.05	0.00	0.00	0.21	0.14	0.28	0.14	0.06	0.09	0.10	0.09
	0.50 - 0.25	2	1.45	0.43	0.67	8.00	6.35	15.89	4.74	2.54	5.01	5.31	5.41
	0.25 - 0.125	3	3.57	4.30	2.58	15.70	17.75	18.44	14.18	11.15	8.48	7.98	10.30
	0.125 - 0.062	4	2.30	5.20	3.59	8.80	7.95	3.20	3.03	3.89	2.80	2.83	2.43
Silt	0.062 - 0.048	4.5	2.33	3.31	0.00	1.34	2.46	2.09	1.30	2.68	2.17	3.50	0.46
	0.048 - 0.0312	5	3.64	5.03	7.07	4.95	6.93	2.20	3.01	3.15	0.49	4.43	3.11
	0.0312 - 0.023	5.5	5.79	15.08	6.40	6.29	3.20	2.13	5.13	4.45	5.07	3.01	4.08
	0.023 - 0.0156	6	6.35	0.00	6.87	4.59	5.20	3.35	3.79	4.97	6.35	6.47	5.61
	0.0156 - 0.0078	7	10.65	8.02	10.50	7.76	8.96	9.48	8.39	11.10	12.31	7.15	8.63
	0.0078 - 0.0039	8	9.06	9.52	15.04	8.65	6.10	6.25	9.12	9.76	13.79	11.68	10.67
Clay	0.0039 - 0.0019	9	11.52	9.95	7.45	4.47	6.49	6.51	6.76	10.28	5.66	9.97	11.75
	0.0019 - 0.000976	10	11.39	10.59	10.10	8.08	6.97	7.47	11.28	8.51	10.25	10.60	10.47
	< 0.000976	11	31.85	28.66	29.67	21.24	21.49	22.55	29.12	27.34	27.44	26.86	26.92
Total			99.96	100.09	99.94	100.08	100.02	100.09	100.02	100.10	99.92	99.93	99.60
% Dry Weight			45.30	46.10	45.10	52.90	53.30	53.10	50.50	48.81	43.57	43.49	42.09
Sample Weight (g dry)			9.26	9.35	9.24	9.86	10.89	10.96	10.10	9.85	8.80	8.78	8.47
% Recovery			94.60	99.04	96.43	90.87	93.85	95.80	97.22	94.01	92.27	93.62	92.44

TABLE J.5. (contd)

Sediment Treatment	Sieve Size (mm)	Phi	Percent of Material Occurring in Each Sieve Size — Sediment Treatment										
			SN-1	SN-2-U	SN-2-L	SN-3-U	SN-3-L	TD-1-U	TD-1-L	TD-2-U	TD-2-L	PR	SB
Gravel	>3.35	-2	0.00	0.00	0.07	0.00	0.00	0.64	0.00	0.04	0.15	0.00	0.00
	3.35 - 2.00	-1	0.00	0.00	0.01	0.00	0.00	0.07	0.08	0.02	0.26	0.00	0.00
Sand	2.00 - 1.00	0	0.02	0.00	0.06	0.00	0.04	0.42	0.72	0.03	0.47	0.00	0.25
	1.00 - 0.50	1	0.06	0.02	0.97	0.18	0.07	0.48	1.11	0.07	0.62	0.04	0.46
	0.50 - 0.25	2	1.57	0.65	2.53	4.48	5.41	5.68	12.55	1.96	9.09	0.22	3.45
	0.25 - 0.125	3	4.68	2.05	7.55	13.94	13.79	16.34	15.74	5.65	19.06	58.70	10.92
	0.125 - 0.062	4	2.73	1.93	2.55	3.03	3.53	4.25	3.76	2.53	4.38	35.56	12.76
Silt	0.062 - 0.048	4.5	1.79	0.00	1.32	4.68	0.00	5.68	0.00	1.98	3.02	0.00	3.43
	0.048 - 0.0312	5	2.95	2.33	2.90	0.00	3.95	4.83	3.28	2.60	2.38	1.90	3.36
	0.0312 - 0.023	5.5	4.74	4.03	5.67	2.93	2.35	4.63	6.15	5.09	3.15	0.00	7.73
	0.023 - 0.0156	6	6.15	8.49	3.07	3.71	7.60	0.00	2.87	4.42	5.37	1.25	4.17
	0.0156 - 0.0078	7	9.58	9.76	10.77	7.85	6.36	8.58	7.69	10.50	6.26	0.09	12.97
	0.0078 - 0.0039	8	13.07	15.17	10.37	11.46	12.10	6.90	6.23	11.96	6.90	0.00	11.09
Clay	0.0039 - 0.0019	9	8.95	8.27	10.72	12.34	9.25	8.37	9.76	13.00	7.71	0.48	9.54
	0.0019 - 0.000976	10	12.68	18.03	10.77	8.73	9.83	8.37	7.73	11.28	8.68	0.53	9.28
	< 0.000976	11	30.94	29.28	31.56	26.73	25.76	24.73	22.31	28.97	22.52	1.19	10.62
Total			99.91	100.01	100.80	100.06	100.04	99.97	99.98	100.10	100.02	99.96	100.03
% Dry Weight			41.90	38.93	45.19	41.73	46.41	48.32	50.88	39.72	51.14	72.43	32.38
Sample Weight (g dry)			8.55	7.88	9.18	8.42	9.35	9.66	10.25	8.05	10.23	14.58	6.56
% Recovery			96.60	95.68	99.10	97.38	96.14	98.45	96.39	95.53	96.87	92.18	90.70

APPENDIX K

BIOACCUMULATION

TABLE K.1. Concentrations of Metals in Tissues of *Macoma nasuta* After 10-day Exposure to Specified Sediment Treatment

Sediment Treatment	Dry Weight (%)	(µg/g dry wt)			(µg/g wet wt)		
		Mercury	Chromium	Lead	Mercury	Chromium	Lead
TD-1U	0.16	0.07	0.70	2.19	0.01	0.11	0.36
TD-1U	0.16	0.07	1.23	4.04	0.01	0.20	0.66
TD-1U	0.16	0.07	1.23	3.60	0.01	0.20	0.58
TD-1L	0.15	0.07	1.36	5.67	0.01	0.21	0.87
TD-1L	0.15	0.07	1.25	4.27	0.01	0.19	0.65
TD-1L	0.15	0.08	1.05	3.95	0.01	0.16	0.61
TD-1L	0.15	0.08	1.10	3.97	0.01	0.17	0.61
TD-1L	0.15	0.08	1.09	3.33	0.01	0.17	0.51
TD-1L	0.15	0.09	1.18	4.22	0.01	0.18	0.65
TD-2U	0.16	0.09	1.48	2.62	0.01	0.24	0.42
TD-2U	0.16	0.10	1.00	2.26	0.02	0.16	0.36
TD-2U	0.16	0.10	0.91	2.24	0.02	0.15	0.36
TD-2L	0.17	0.09	0.97	5.88	0.02	0.16	0.98
TD-2L	0.17	0.11	0.85	5.30	0.02	0.14	0.88
TD-2L	0.17	0.11	0.94	5.39	0.02	0.16	0.90
SN 1	0.17	0.10	0.97	2.42	0.02	0.16	0.41
SN 1	0.17	0.10	0.84	2.28	0.02	0.14	0.39
SN 1	0.17	0.10	0.87	2.09	0.02	0.15	0.35
SN-2U	0.16	0.09	1.14	3.48	0.01	0.19	0.57
SN-2U	0.16	0.10	1.07	4.10	0.02	0.17	0.67
SN-2U	0.16	0.10	0.83	3.09	0.02	0.13	0.50
SN-2L	0.17	0.08	0.78	3.16	0.01	0.13	0.53
SN-2L	0.17	0.09	0.83	3.17	0.01	0.14	0.54
SN-2L	0.17	0.09	0.75	3.06	0.01	0.13	0.52
SN-3U	0.16	0.07	1.06	2.44	0.01	0.17	0.40
SN-3U	0.16	0.08	0.93	2.36	0.01	0.15	0.39
SN-3U	0.16	0.08	0.95	2.35	0.01	0.16	0.39
SN-3L	0.18	0.07	1.82	4.09	0.01	0.32	0.72
SN-3L	0.18	0.09	1.01	3.70	0.02	0.18	0.65
SN-3L	0.18	0.09	0.84	3.58	0.02	0.15	0.63
CH-1	0.17	0.09	0.70	5.48	0.01	0.12	0.91
CH-1	0.17	0.09	0.69	5.27	0.01	0.12	0.88
CH-1	0.17	0.10	0.74	5.06	0.02	0.12	0.84
CH-2	0.19	0.08	0.70	2.19	0.01	0.13	0.41
CH-2	0.19	0.08	0.63	1.99	0.02	0.12	0.37
CH-2	0.19	0.08	0.69	2.21	0.01	0.13	0.41
Sequim Bay	0.14	0.08	1.04	3.15	0.01	0.15	0.45
Sequim Bay	0.14	0.09	0.72	2.53	0.01	0.10	0.36
Sequim Bay	0.14	0.09	0.73	2.75	0.01	0.10	0.39
Point Reyes	0.15	0.08	0.72	3.67	0.01	0.11	0.56
Point Reyes	0.15	0.10	0.73	3.27	0.02	0.11	0.50
Point Reyes	0.15	0.11	0.83	3.36	0.02	0.13	0.52
MEAN	0.16	0.08	0.96	3.47	0.01	0.16	0.57
STD	0.01	0.02	0.24	1.13	0.00	0.04	0.18
CV	0.06	0.19	0.25	0.33	0.21	0.26	0.33

TABLE K.2. Concentrations of Organotins in Tissues of Macoma nasuta After 10-day Exposure to Specified Sediment Treatment

Sediment Treatment	Dry Weight (%)	Butyltins (µg/kg dry wt)			Butyltins (µg/kg wet wt)		
		Tri	Di	Mono	Tri	Di	Mono
TD-1-U	0.16	132.40	21.00	0.4u	21.50	3.41	0.00
	0.16	138.50	18.40	2.2u	22.49	2.99	0.00
	0.16	142.10	19.40	2.2u	23.08	3.15	0.00
TD-1-L	0.15	136.60	15.00	1.10	20.94	2.30	0.17
	0.15	139.70	14.10	2.2u	21.42	2.16	0.00
	0.15	140.00	13.60	2.2u	21.46	2.08	0.00
TD-2-U	0.16	56.00	18.00	0.4u	9.01	2.90	0.00
	0.16	60.30	16.60	2.2u	9.70	2.67	0.00
	0.16	60.20	14.20	2.3u	9.69	2.28	1.85
TD-2-L	0.17	62.90	14.00	11.50	10.47	2.33	1.91
	0.17	63.60	12.50	10.90	10.58	2.08	1.81
	0.17	64.20	12.50	11.20	10.68	2.08	1.86
CH-1	0.17	36.70	8.90	0.3u	6.12	1.48	0.00
	0.17	41.20	12.40	1.9u	6.87	2.07	0.00
	0.17	42.40	13.30	1.9u	7.07	2.22	0.00
Reference[a]	0.15	28.20	7.30	0.4u	4.34	1.12	0.00
	0.15	27.00	5.70	2.0u	4.16	0.88	0.00
	0.15	27.80	6.00	2.0u	4.28	0.92	0.00

(a) Sequim Bay.

TABLE K.3. Concentrations of Polynuclear Aromatic Hydrocarbons and Aroclor in Tissues of *Macoma nasuta* After 10-Day Exposure to Selected Sediment Treatment

Sediment Treatment	µg/kg Wet Wt													
	A	B	C	D	E	F	G	H	I	K	L	M	N	O
CH-1	38U	113U	45N	40U		33U	33U	72	33U	150	30U	0	150	72
CH-1	38U	113U	48N	40U		25U	35U	160U	150U	150U	30U	0	0	0
CH-1	38U	113U	38U	33U				160U			30U	0	0	0
CH-2	32U	96U	89N	40U		33U	33U	90	33U	250	30U	0	250	90
CH-2	32U	96U	90N	40U		25U	35U	160U	150U	150U	30U	0	0	0
CH-2	32U	96U	32U	33U				160U			30U	0	0	0
SN-1	31U	62U	52N	40U		33U	33U	230	33U	190	22J	0	190	230
SN-1	31U	62U	70N	40U		25U	35U	160U	150U	150U	22J	0	0	0
SN-1	62U	62U	31U	33U				160U			23J	0	0	0
SN-2-U	440	560	250N	81N		26	33U	500	39U	260	23J	0	286	500
SN-2-U	31U	31N	370N	140N		39U	35U	160U	150U	150U	23J	0	0	0
SN-2-U	62U	62U	39U	39U		25U	160U				23J	0	0	0
SN-2-L	39U	77U	100N	40U		2200	520	310	630	810	30	0	4160	310
SN-2-L	39U	77U	110N	40U		25U	35U	160U	275	280	34	0	555	0
SN-2-L	39U	77U	39U	39U				160U			31	0	0	0
SN-3-U	32U	65U	32U	32U		32U	32U	110	32U	110	0	110	110	14J
SN-3-U	32U	65U	78N	40U		25U	35U	160U	150U	150U	0	0	0	19J
SN-3-U	32U	65U	76N	40U				160U			0	0	0	18J
SN-3-L	35U	71U	35U	35U		35U	35U	680	35U	360	0	360	680	25J
SN-3-L	35U	71U	180N	40U		25U	35U	190	150U	150U	0	0	190	24J
SN-3-L	35U	71U	140N	40U				200			0	0	200	26J

TABLE K.3. (contd)

Sediment Treatment	Concentrations µg/kg Wet Wt													
	A	B	C	D	E	F	G	H	I	K	L	M	N	O
TD-1-U	38U	76U	38U	38U		38U	38U	88	38U	250	0	250	88	35
TD-1-U	38U	76U	140N	40U		25U	35U	160U	150U	150U	0	0	0	34
TD-1-U	38U	76U	150N	40U				160U			0	0	0	31
TD-1-L	39U	78U	39U	39U		39U	39U	160	39U	280	0	280	160	44
TD-1-L	39U	78U	580N	40U		25U	35U	160U	150U	150U	0	0	0	46
TD-1-L	39U	78U	460N	40U				160U			0	0	0	48
TD-2-U	35U	70U	35U	35U		35U	35U	260	35U	240	0	240	260	17J
TD-2-U	35U	70U	180N	40U		25U	35U	160U	150U	150U	0	0	0	16J
TD-2-U	35U	70U	200N	40U				160U			0	0	0	18J
TD-2-L	38U	77U	38U	38U		38U	38U	170M	38U	210	0	210	0	41
TD-2-L	38U	77U	170N	40U		25U	35U	160U	150U	150U	0	0	0	40
TD-2-L	38U	77U	160N	40U				160U			0	0	0	42
Sequim Bay	33U	67U	170N	40U		33U	33U	33U	33U	240	30U	0	240	0
Sequim Bay	33U	67U	200N	40U		25U	35U	160U	150U	150U	30U	0	0	0
Sequim Bay	33U	67U	40U	33U				160U			30U	0	0	0
Point Reyes	33U	67U	33U	33U	31U	33U	33U	33U	33U	110	30U	0	110	0
Point Reyes	33U	67U	40U	40U		33U	33U	160U	33U	240	30U	0	240	0
Point Reyes	33U	67U	63N	40U		25U	35U	160U	150U	150U	30U	0	0	0
Point Reyes	33U	67U	58N	40U				160U			30U	0	0	0

A 2-methylphenol
B 2,4 dimethylphenol
C Acenaphthylene
D Acenaphthene
E Dimethylphthalate
F Diethylphthalate
G Di-n-Butlphthalate
H Pyrene
I Butylbenzylphthalate
K Bis(2-Ethylhexyl)phthalate

Total phenol J
Total phthalate K
Total PNA L
1254 M

APPENDIX L

STAFF RESPONSIBILITIES

CHEMISTRY ANALYSIS

Assignment	Person Responsible	Back-up Responsibility
Metals	Crecelius	Bloom
Tins	Crecelius	Fortman
Metals Bioaccumulation	Crecelius	Apts
Organics Bioaccumulation	Dave Mitchell (ARI)	Word
Organics	Dave Mitchell (ARI)	Word
Sulfides/Cyanide	John Dailey (AMTest)	Broadhurst
TOC	John Dailey (AMTest)	Broadhurst
Grain Size	Cotter	Crecelius
Oil and Grease	Ward	Franklin
Petroleum Hydrocarbons	Franklin	Ward

Person responsible ensures either receipt or delivery of sample to appropriate laboratory or contractor, and timely delivery of data and QA/QC information to individual responsible for data base management.

BIOASSAY TESTS

Assignment	Person Responsible	Back-up Responsibility
Macoma nasuta	Apts	Barrows
Nephtys caecoides	Apts	Barrows
Grandidierella japonica	Woodruff	Barrows
Citharichthys stigmaeus	Woodruff	Broadhurst
Acanthomysis sculpta	Barrows	Anderson
Crassostrea gigas	Ward	Anderson
Rhepoxynius abronius	Woodruff	Barrows

Responsible person ensures that specimens are available on the appropriate date; equipment for tests is available; and appropriate personnel are available to perform observations, set up, and breakdown tests on correct days. Person will also ensure entry of data into data base system.

DATA BASE MANAGEMENT SYSTEM

Assignment	Person Responsible	Back-up Responsibility
Data Base	Cullinan/Word	Ward

Cullinan is responsible for developing the data base management system, working with Word. Cullinan is responsible for ensuring that data is properly entered into the system in a timely fashion and that the QA/QC process occurs rapidly.

Assignment	Person Responsible	Back-up Responsibility
Statistics	Cullinan	

Cullinan is responsible for ensuring that appropriate randomization is performed and that the appropriate statistical design is incorporated and used in these tests.

REPORT PRODUCTION AND QA/QC

The responsible person for each of the following areas ensures that the report sections are completed by established dates.

Assignment	Person Responsible	Back-up Responsibility
Document Preparation	O'Connor/Word	Ward

This is the final put-together of all pieces of the draft document.

Assignment	Person Responsible	Back-up Responsibility
Editing	O'Connor	Weiss

O'Connor will be responsible for editing or providing the mechanism to ensure all portions of the document are being produced at the required rate. She will begin April 5, 1988.

Assignment	Person Responsible	Back-up Responsibility
QA/QC	Cuello	

Rob is responsible for establishing a QA/QC protocol for all of us to follow in each of these tests. All pieces for the draft document including all the appendices, will be completed by the 21st of April; bioaccumulation will be completed by the end of April.

Assignment	Person Responsible	Back-up Responsibility
Interpretation of results	The study team as a team	
Management	Word	Strand

SEDIMENT SAMPLING CRUISE PERSONNEL

Oakland Inner Harbor Cruise March 21-27, 1988

Battelle

Jeff A. Ward
James F. Campbell

Kinnetic Laboratories, Inc.

Mark Mertz
Sean Kinney

Sea Surveyor, Inc.

Mack Sullivan
Peter Jepson
Mike Bigelow
Clayton Hotson

Point Reyes Reference Sediment Cruise March 30-April 1, 1988

Battelle

Janet Kennedy
Steven Mellenthien
Heidi DeBra

Port of Oakland Environmental Division

David Hayes

Sea Surveyor, Inc.

Mike Bigelow

Sequim Bay Reference Sediment Cruise March 27-April 4, 1988

Battelle

Steve Kiesser
Jim Coley
Dave Erickson

PNL-6794
UC-11

DISTRIBUTION

No. of Copies

OFFSITE

10 DOE/Office of Scientific and Technical Information

S. Lemlich
U.S. Army Corps of Engineers
San Francisco District
211 Main Street
San Francisco, CA 94105

B. Walls
U.S. Army Corps of Engineers
San Francisco District
211 Main Street
San Francisco, CA 94105

R. Chisholm
U.S. Army Corps of Engineers
San Francisco District
211 Main Street
San Francisco, CA 94105

J. Anderson
58 Plain St.
Pembroke, MA 02359

M. E. Barrows
27 Compass Circle
Hyannis, MA 02601

J. F. Campbell
Battelle Ocean Sciences
1431 Spinnaker Dr.
Ventura, CA 93001

J. L. Hyland
Battelle Ocean Sciences
1431 Spinnaker Dr.
Ventura, CA 93001

No. of Copies

W. Steinhauer
Battelle Ocean Sciences
397 Washington St.
P.O. Box AH
Duxbury, MA 02332

D. L. Woodruff
49 Cedar Terrace
Chapel Hill, NC 27514

ONSITE

DOE Richland Operations Office

J. J. Sutey

42 Pacific Northwest Laboratory

C. W. Apts
B. B. Brown
J. A. Coley
V. I. Cullinan
E. A. Crecelius
R. M. Ecker
R. Cuello
J. W. Falco
P. C. Hayes
S. L. Kiesser
G. P. O'Connor
W. H. Pearson
J. A. Strand
J. A. Trelstad (2)
J. A. Ward (10)
J. Q. Word (10)
J. W. Weber
Publishing Coordination
Technical Report Files (5)