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Results of Bulk Sediment Analysis and Bioassay Testing on Selected Sediments from Oakland Inner Harbor and Alcatraz Disposal Site, San Francisco, California

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Battelle/Marine Sciences Laboratory
Sequim, Washington

September 1990

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

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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RESULTS OF BULK SEDIMENT ANALYSIS AND BIOASSAY TESTING ON SELECTED SEDIMENTS FROM OAKLAND INNER HARBOR AND ALCATRAZ DISPOSAL SITE, SAN FRANCISCO, CALIFORNIA

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Richland, Washington 99352

SUMMARY

The Battelle/Marine Sciences Laboratory (MSL) was contracted by the U.S. Army Corps of Engineers, San Francisco District, to perform bulk sediment analysis and oyster larvae bioassays (elutriate) on sediments from Inner Oakland Harbor, California. The sediment and water samples were collected by the consulting firms of Kennedy-Jenks-Chilton and Sea Surveyor under contract to and supervision of the Port of Oakland. Analysis of sediment characteristics by MSL indicated elevated priority pollutants, PAHs, pesticides, metals, organotins, and oil and grease concentrations, when compared to Alcatraz Island Dredged Material Disposal Site sediment concentrations.

Larvae of the Pacific oyster, *Crassostrea gigas*, were exposed to seawater collected from the Alcatraz Island Site, elutriates of the Oakland sediments with Alcatraz Island Site water, and a series of controls using water and sediments collected from Sequim Bay, Washington. Exposure of larvae to the Alcatraz seawater and the 50% and 100% elutriate concentrations from each Oakland sediment resulted in low survival and a high proportion of abnormal larvae compared to Sequim Bay control exposures. Evaluation of larvae survival and abnormalities in 10% elutriate concentrations revealed significant differences among the treatments. The analyses showed significantly lower survival and higher abnormalities at the Todd Shipyard stations than at Schnitzer Steel stations compared to Sequim controls.

MSL also identified that field sample collection, preservation, and storage protocols used by Port of Oakland contractors were inconsistent with standard accepted practices. These inconsistencies included storage of bioassay water in plastic containers (a possible reason for the Alcatraz Island reference water toxicity), freezing of collected sediments, and a lack of preservation of sediments for sulfide and cyanide analysis. These variations caused invalid cyanide and sulfide

results and probably influenced the results of bioassay tests. The inconsistencies are currently being discussed by MSL, the USACE, San Francisco District, and the California State Water Resources Control Board. The objective of these discussions was to develop a brief sampling guidance document that will minimize these types of problems in the future.

ACKNOWLEDGMENTS

We would like to thank the following individuals for their participation in this program: Dave Mitchell at Analytical Resources, Inc, for priority pollutant, pesticide, and PAH analyses; Dr. Eric A. Crecelius, Charles Apts, and Olga Cotter at MSL for analysis of metals and metalloids through atomic absorption spectroscopy; Dr. Eric Crecelius and Tim Fortman at MSL for GCMS analysis of organotins; Ron. W. Sanders at Pacific Northwest Laboratory for XRF analysis of metals; Linda Franklin at MSL for oil and grease determinations through Infra-red spectroscopy; Charles Apts at MSL for sediment grain-size analysis; and John Daily of AmTest Inc (AT) for analysis of total organic carbon, total and dissolved sulfides, and cyanide measurements.

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1.0 INTRODUCTION

The purpose of this study was to determine if sediments proposed for dredging from areas adjacent to Schnitzer Steel and Todd Shipyard in Inner Oakland Harbor of San Francisco Bay, California, were in compliance with state and federal regulations for open water disposal at the U.S. Army Corps of Engineers Alcatraz Island Dredged Material Disposal Site. This assessment was based on chemical analyses of selected contaminants in sediments and on bivalve larvae bioassays that determined the relative toxicity of chemicals and particulates eluted from the sediments.

This report describes the collection and navigational methods used by Kennedy/Jenks/Chilton, Pitcher Drilling, and Sea Surveyor; the results of the chemical analysis of the sediment and bioassay test; and QA/QC information on the chemistry and biological samples. It also assesses the potential influence of specified collection techniques on interpretation of this information. Appendices A-G provide field collection notes; chain of custody forms; information on equipment maintenance and calibration; and supporting data for bioassays, bulk sediment analysis, and chemical analysis.

2.0 MATERIALS AND METHODS

2.1 SEDIMENT AND WATER SAMPLING METHODOLOGY

2.1.1 Sampling Locations: Water and Sediment

Six, 5-gal water samples were collected by Sea Surveyor from a water depth of approximately 25 ft off of Alcatraz Island (Figure 2.1). The Sea Surveyor crew also collected sediment core samples at six locations within the Alcatraz Dredged Material Disposal Site in San Francisco Bay, California (Table 2.1). Sediment cores were also collected at three sites near Schnitzer Steel/Howard Terminal and at four sites near Todd Shipyard and Pitcher Drilling (Figure 2.2). The objective of Inner Harbor coring operations was to obtain sediment core samples equivalent to the proposed dredging depth of 44 ft below mean lower low water (MLLW). These cores were obtained on December 21, 1987 (Table 2.2). The water and sediment samples from the Alcatraz Dredged Material Disposal Site were collected on December 30, 1987.

TABLE 2.1. Alcatraz Dredged Disposal Site Sediment Sampling Locations on 30 December 1987. (Station identification number for the composite sample made from these cores is 878587.)

Station	California State Coordinates (Zone III)		Water Depth(a)
A3	N 487,105	E 1,444,388	48
A4	N 487,286	E 1,443,753	57
A5	N 486,699	E 1,443,840	51
B4	N 486,930	E 1,444,991	43
C1	N 486,615	E 1,444,789	48
D3	N 486,349	E 1,444,472	54

(a) Ft from MLLW.

TABLE 2.2. Station Information for Inner Oakland Harbor Sampling.

Area	Station	Date	Time	Sediment Core Depth (ft)	Battelle ID Number
Schnitzer Steel	S1	21 Dec 87	0820	36-39	878435
				39-42	
Schnitzer Steel	S2	21 Dec 87	0855	30-33	878436
				33-36	
				36-39	
				39-42	
Schnitzer Steel/ Howard Terminal	S3	21 Dec 87	0950	38.5-41.5	878437
				41.5-44	
Todd Shipyard	T4	21 Dec 87	1015	32-35	878438
				35-38	
				38-41	
				41-44	
Todd Shipyard	T5	21 Dec 87	1100	26-29	878439
				29-32	
				32-35	
				35-38	
				38-41	
				41-44	
Todd Shipyard	T6	21 Dec 87	1212	32-35	878440
				35-38	
Todd Shipyard	T7	21 Dec 87	1320	32-35	878441

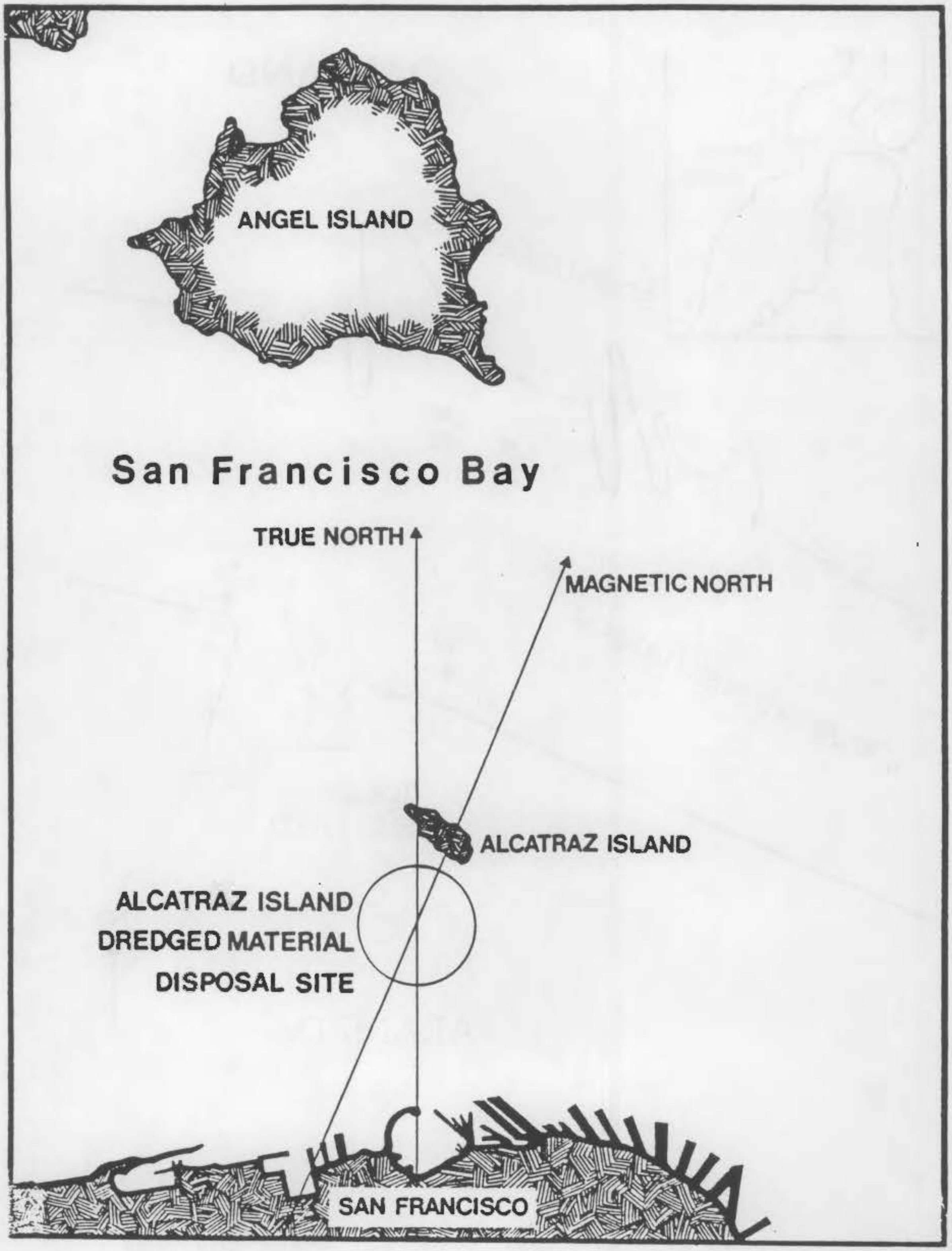

FIGURE 2.1. Sampling Location Near Alcatraz Island Dredged Material Disposal Site

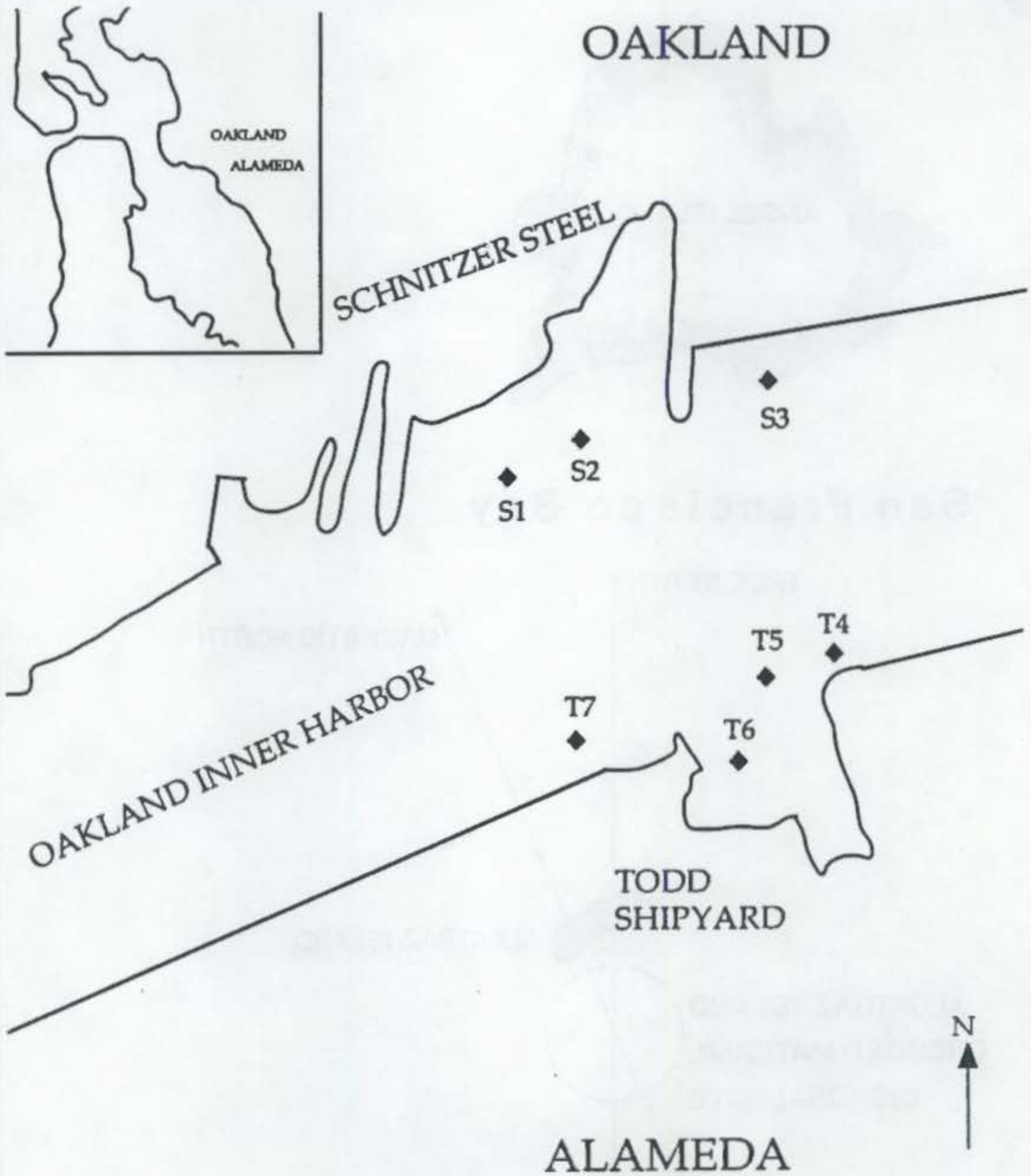

FIGURE 2.2. Sampling Locations Near Schnitzer Steel and Todd Shipyards in Inner Oakland Harbor, San Francisco, California

2.1.2 Station Location Techniques

The research vessel's position at the Alcatraz Island Dredged Material Disposal Site was determined using an E.S.P. Laser range/azimuth positioning system established at Monument 7 on the Municipal Pier. Sampling stations within Inner Oakland Harbor were located by measuring distances from existing structures with a rope marked at measured intervals.

Soundings for water depth at the Alcatraz Island Dredged Material Disposal Site were made with a Raytheon DE-719 survey-grade fathometer calibrated using a bar check method. Depths at the Inner Oakland Harbor sites were determined using a measured, weighted plumb line. All depths were corrected to MLLW using a tide table and tide board for reference.

2.1.3 Sampling Devices

Water samples were collected using a Teflon-lined Go-Flow discrete sampling water bottle. These water samples were placed in 5-gal plastic containers. They were held without refrigeration until delivered to MSL in Sequim, Washington.

Sediment samples from Inner Oakland Harbor were collected with a Shelby-tube piston sampler driven by water pressure. A new epoxy-coated Shelby-tube (2.5 ft x 4 in. diameter) was used each day. Before and between each use, these tubes were cleaned by scrubbing with brushes dipped in seawater collected from each site. The coring tool remained closed until the piston operation occurred. The core tube was opened at pre-specified depths within the sediment column. When the core barrel was opened, the water-driven piston was activated and a 2.5-ft section of cored sediment obtained at specific sediment depths.

Sediment samples from the Alcatraz Island Site were collected in Lexan liners, which were contained in a Benthos Model 2171 gravity corer. The sampler and the Lexan liners were steam cleaned prior to use.

2.1.4 Sediment and Water Sample Protocols

Water samples obtained at mid-depth (approximately 25 to 30 ft) near the Alcatraz Island Dredged Material Disposal Site were stored and shipped in 5-gal plastic containers to MSL. Sediment core samples obtained at the Alcatraz Island Dredged Material Disposal Site were retained in their Lexan core tube, capped with plastic lids, and sealed with duct tape. The tape, lids, and core liners were marked with station designation, sample number, and date of collection. These core liners were stored in coolers on "blue-ice." All sediment samples were then transferred to MSL where they were frozen and held from December 30, 1987 to January 5, 1988.

Sediment cores from the Inner Oakland Harbor area were extruded from a Shelby-tube into new plastic garbage bags. These bags were then placed into a second plastic garbage bag. Labels with station designation, sample number, sampling date, and depth within the sediment column were affixed on the outside and inside of the sample bags. These bags were placed in a cooler with "blue ice" and transported to MSL where they were frozen and held from December 21, 1987 to January 5, 1988. Appendix A includes the field notes and protocols for the sediment and water collections.

The collection and handling of sediment and water samples was not always consistent with accepted protocols:

- Sediment samples destined for sulfide and cyanide analysis were not preserved with zinc acetate or sodium hydroxide pellets, respectively. This was inconsistent with accepted protocols indicated in Standard Methods (APHA 1975).

- Freezing sediment after collection was not consistent with the requirements in the Implementation Manual or Standard Methods (Peddicord 1977; APHA 1975).

- Placing sediment samples and water samples in plastic bags or jugs was not consistent with the Implementation Manual (Peddicord 1977), Puget Sound Estuary Program (PSEP) protocols, Standard Methods or the U.S. Environmental Protection Agency (EPA) Handbook for Quality Control (Peddicord 1977; PSEP 1986; APHA 1975; Booth 1979).
- The Implementation Manual calls for collection of representative disposal site water by obtaining approximately 1/3 of the water from directly below the surface, 1/3 from mid-depth and 1/3 from 1-m above the sediment surface (Peddicord 1977); this was not the case.

All sediment and water samples were shipped to MSL on January 5th and were received on January 6, 1988. Inventories of the samples were conducted, and chain-of-custody sheets between the San Francisco-based laboratories and MSL checked for accuracy and signed (Appendix B).

2.1.5 Sample Inventory and Use

Copies of the chain-of-custody sheets delivered with the samples are contained in Appendix B. The inventory sheets prepared by MSL and additional chain-of-custody sheets for samples delivered to other laboratories are also contained in Appendix B.

2.2 SEDIMENT SAMPLE COMPOSITING

Samples were composited by placing equal volumes of sediments into a stainless steel mixing bowl. In the case of the Alcatraz Island sites, all the sediment from each core was placed into a single bowl. For the sediment collected in Inner Oakland Harbor, equal volumes of sediment were composited from each of the depth fractions from the cores. The sediments were then stirred with stainless steel spoons until the color and texture of the mixture appeared evenly distributed. Care was taken during the mixing process to avoid scraping the sides of the stainless steel container. Prior to mixing, each of these strata were qualitatively characterized for color, odor, sediment coarseness and any obvious characteristics (Tables 2.3a and b). The core length was also determined in the case of the Alcatraz sediment. This composite mixing strategy follows PSEP protocols, which are consistent with the intent of the Implementation Manual for preparation of uncontaminated sediment mixtures for use in chemical and biological testing (PSEP 1986; Peddicord, 1977). Notes on sediment compositing are presented in Appendix C.

2.3 BIOASSAY TEST ORGANISM INFORMATION

2.3.1 Test Organism Selection and Rationale

The organism selected for toxicity testing was the Pacific oyster, *Crassostrea gigas*. Mortality of larvae and the percentage of abnormal larvae produced by exposure to suspended particles or elutriates of sediments were selected as the criteria for evaluation of potential biological effects. This biological test of elutriate toxicity was requested by the USACE, San Francisco District, and is consistent with standard evaluations of contaminated sediments proposed for disposal. The technique has been described and modified in various documents (APHA 1985; ASTM 1985; PSEP 1986; Peddicord 1977).

TABLE 2.3a. Descriptive Characteristics of Alcatraz Dredged Disposal Site Sediment Fractions.

Station	Area	Sample Number	Core Length (in.)	Descriptive Characteristics	Odor(a)
A3	Alcatraz	878581	10.00	Dark gray silty sand	0
A4	Alcatraz	878582	9.25	Dark gray silt/clay	0
A5	Alcatraz	878583	8.75	Dark gray silty sand	2
B4	Alcatraz	878584	9.50	Dark gray silty sand	2
C1	Alcatraz	878585	9.25	Dark gray silty sand	0
D3	Alcatraz	878586	9.75	Black silt	0

(a) Odor Code: 0 = no odor, 1 = moderate petroleum, 2 = moderate chemical

TABLE 2.3b. Descriptive Characteristics of Oakland Inner Harbor Sediment Fractions.

Station	Area	Sample Number	Core Length (in.)	Descriptive Characteristics	Odor(a)
S1	Schnitzer	878435	36-39	Gray-green sandy silt	0
			39-42	Gray-green sandy silt	0
S2	Schnitzer	878436	30-33	Black-gray sandy silt	0
			33-36	Black sandy silt	0
			36-39	Black-gray sandy silt	0
			39-42	Gray-green fine sand	0
S3	Schnitzer	878437	38.5-41.5	Gray sandy silt	0
			41.5-44	Gray-black sandy silt	0
T4	Todd	878438	32-35	Black silt/sand	0
			35-38	Compacted black silt	0
			38-41	Compacted black silt	0
			41-44	Light brown fine sand	0
T5	Todd	878439	26-29	Brown-gray sand/silt	1
			29-32	Black silt	1
			32-35	Black silt	1
			35-38	Black silt, shell	1
			38-41	Black silt	1
			41-44	Black silt	1
T6	Todd	878440	32-35	Silt and coarse sand	0
			35-38	Silt and coarse sand	0
T7	Todd	878441	32-35	Black silt	0

(a) Odor Code: 0 = no odor, 1 = moderate petroleum, 2 = moderate chemical

2.3.2 Life History of Crassostrea gigas

Crassostrea gigas, the Pacific oyster, is a bivalve mollusc that typically lives in the intertidal and shallow subtidal of estuarine environments of the western Pacific Ocean. It is an ideal mariculture organism and has been transported and cultured throughout the world. It grows to lengths in excess of 14-in. in subtropical seas. It will grow in temperate seas, but does not reproduce well in these colder waters. Typically, the oysters become laden with spawn during July and August and release that spawn when surrounding water reaches temperatures of 67°F (20°C). Normal larval growth then requires a water temperature of 68°F or higher for a period of 3 weeks. At that point, the larval oysters settle to hard substrate (e.g., shells, rocks, etc) where they begin their sessile life (Quayle 1969).

The mariculture industry has produced an extensive body of information on the life history of this organism and the culture methods required to successfully maintain this industry (Quayle 1969). As a result, it was possible to adapt these well-developed procedures to the evaluation of contaminant toxicity contained in elutriates of dredged material. This test adaptation has been used by EPA, the USACE, and various state agencies (Peddicord 1977; PSEP 1986; APHA 1985; ASTM 1985). The portion of the mariculture procedures adopted for toxicity evaluation is the period from post-fertilization to fully shelled larvae (D-cells or prodissoconch I). This procedure occurs at 20°C during the first 48 h of embryonic life; failure to develop to this stage can result in mortality or abnormal development. Both of these characteristics were evaluated in the toxicity experiments.

2.4 BIOASSAY METHODOLOGY

2.4.1 Study Design

The design used was a completely randomized test involving seven test sediment elutriates from Inner Oakland Harbor, one reference sediment elutriate from the Alcatraz Island Dredged Material Disposal Site, and two control sediment elutriates from Sequim Bay, Washington. The sediment was mixed (diluted) with either Alcatraz Island Dredged Material Disposal Site reference water (ARW) or Sequim Bay seawater

(SBSW), and the resulting elutriate, referred to as the suspended particulate phase (SPP), was used in the bioassays. Each sediment treatment consisted of three replicate 1-L exposure jars containing 600 mL SPP, which was either undiluted (100%) or diluted to 50% or 10% concentration with reference water from the Alcatraz Island Dredged Material Disposal Site. One Sequim Bay control sediment elutriate was diluted with ARW, while the other was diluted with 0.45-µm filtered SBSW. Water-only controls were also run on the Alcatraz reference water and Sequim Bay seawater. The total number of exposure jars was 99. The number of exposure jars per dilution and treatment is depicted in Table 2.4.

Exposure jars were placed randomLy on a water table with dimensions of 1.5 m x 5 m x 0.1 m containing a freshwater bath deep enough to submerge the jars to the 600 mL water mark. Water-bath temperature was controlled at 20 ± 1°C. Light conditions controlled with a timer provided 8 h of daylight and 16 h of night. All exposure jars were aerated prior to and during the bioassay test. Bioassay test conditions and related equipment are discussed in Sections 2.4.6 and 2.4.7.

2.4.2 Preparation of Labware

Fulfilling the requirement that all glass or Pyrex labware was to be extremely clean (Peddicord 1977), all glassware was washed in a Forma Laboratory Dishwasher with Forma soap solution. This washer was set to rinse the labware three times with double-distilled water and dry with hot air. After this process, labware was rinsed with 10% nitric acid (HNO_3), placed back in the Forma Dishwasher, and run through the double-distilled rinse-only cycle again. This cycle rinsed the glassware an additional three times. Exposure jars were fitted with Teflon-lined lids that had been rinsed three times with methylene chloride and air dried under a laboratory hood.

Stainless steel utensils were washed before use with hot soapy water, rinsed, then rinsed three times with deionized water, and finally rinsed with methylene chloride and air dried under a laboratory hood. These procedures are consistent with glassware cleaning protocols outlined in the Implementation Manual (Peddicord 1977).

TABLE 2.4. Experimental Design for the Number of Exposure Jars Per Dilution and Treatment.

Treatment	Station	Suspended Particulate Phase 100%	50%	10%	Sea Water
878435 Sediment	S1	3	3	3	
878436 Sediment	S2	3	3	3	
878437 Sediment	S3	3			
878438 Sediment	T1	3	3	3	
878439 Sediment	T2	3	3	3	
878440 Sediment	T3	3	3	3	
878441 Sediment	T4	3	3	3	
878587 Sediment	Alcatraz	3	3	3	
Reference Water	Alcatraz	0	0	0	3
Sequim Bay Seawater		0	0	0	6
Sequim Bay Sediment (a)		3	3	3	
Sequim Bay Sediment (b)		3	3	3	

(a) SBRW, Sequim Bay sediment diluted with Alcatraz reference water.
(b) SBSW, Sequim Bay sediment diluted with Sequim Bay seawater.

2.4.3 Preparation of Suspended Particulate Phase (SPP)

The SPP is the liquid supernatant created by mixing water with the test, reference, or control sediment. This water contained the suspended particulate and dissolved phase of chemicals eluted from the sediments. The oyster larvae were exposed to three concentrations of the SPP. Standard SPP preparations used during the bioassay included 100%, 50%, and 10% concentrations. Procedures for preparing the SPP are found in the Implementation Manual (Peddicord 1977).

The SPP was prepared by volumetrically adding 720 mL (approximately 1300 g) of wet sediment and 2880 mL of reference water (Alcatraz or Sequim Bay seawater) to a clean 1-gal jar, resulting in a final volume of 3660 mL. The 4:1 water/sediment slurry was stirred continuously with a clean stainless steel spoon for 30 min to ensure that all the sediment was in suspension, then the slurry was allowed to settle for 1 h.

Because the test, reference, and control sediments were composed of fine material (primarily silt and clay), little material settled after the 1 h period. The slurries were transferred to a 4°C cold room for storage, and the amount of material settling out was measured daily. After 2 days, only a few of the slurries had settled enough to yield the required volume of SPP for bioassay purposes (2880 mL). Typically, the jars contained less than 1 L of relatively clear SPP, about 2.5 L of water/fine material suspension, and about 0.5 L of settled sediment. Low-speed centrifugation, as allowed by the Implementation Manual, was necessary to obtain sediment settlement that allowed the test organisms to be visible during the bioassay and to provide the required volume of SPP. This was accomplished by pouring off the clear SPP and water/fine material portions into clean 250 mL centrifuge jars and centrifuging for 15 min at 1750 rpm (740 g). After centrifugation, the overlying water (SPP) was poured off into a clean gallon jar and used in the bioassay.

For each sediment treatment, three exposure jars were filled with 600 mL SPP (100% concentration), three were filled with 300 mL SPP and 300 mL Alcatraz Reference or Sequim Bay seawater (50%), and three were filled with 60 mL SPP and 540 mL Alcatraz reference or Sequim Bay seawater (10%). The centrifugation and dilution process was repeated for each reference or control sediment.

2.4.4 Oyster Spawning Technique

One dozen conditioned oysters were obtained from a local hatchery on the day of the test. These animals had been held in 25‰ salinity water at 20°C for approximately 2 months and fed cultured algae maintained at the hatchery. At MSL, the animals were placed in individual Pyrex baking dishes (15 cm x 250 cm x 15 cm) containing 25‰ SBSW at 20°C, and attempts to induce them to spawn were made by gradually increasing and decreasing the water bath temperature surrounding them from 10 to 30°C. This procedure was not effective.

The alternative procedure employed for this test was to sever the adductor muscles and slice open the gonads. After this process, microscopic examination of the gametes was used to determine sex and state of egg development in the oysters. Eggs that were pear shaped and semen from individuals that had actively moving sperm were mixed in a Pyrex beaker containing 1.5 L of 25‰, 0.45-µm filtered SBSW and incubated at 20°C for 1 h. After 1 h, fertilization success and was determined by microscopic examination.

2.4.5 Estimation of Embryo Density

Larval density was determined by removing a 1-mL aliquot from the graduate cylinder and diluting this to a final volume of 10 mL with seawater (10x dilution). Three, 0.1-mL samples of this mixture were placed in a hemocytometer cell and examined under a microscope. Each exposure jar was inoculated with 20,000 oyster larvae, based on the density of developing eggs observed in this evaluation. Immediately after inoculation, two 10-mL subsamples were taken from each of the six MSL seawater control jars, fixed with formalin, and counted to determine the actual density per milliliter of the larvae at bioassay initiation.

2.4.6 Test Conditions and Duration

Test conditions during the bioassay were designed to mimic expected natural conditions. Water bath temperature (and exposure jar water temperature) were maintained at 20°C, varying less than 1°C during the bioassay test. Exposure jars were aerated before and during the tests, providing 80% to 100% oxygen saturation. Prior to SPP preparation, the salinity of ARW and SBSW was corrected to 25‰ by adding deionized water. Salinity in each exposure jar was initially corrected to 25‰, if necessary, and varied less than 1 ppt during the test. The pH was measured but not corrected. The duration of the test was 48 h.

2.4.7 Water Quality QA/QC and Instrumentation

All exposure jars were placed on the water table 1 day before the test was initiated. After approximately 4 h of equilibration and aeration, all jars from each treatment and dilution water jars were checked for dissovled oxygen (D.O.), pH, and salinity. Water bath temperature was controlled by a Thermar (1500 watt, 120 v) quick recovery water heating system integrated to a Thermistemp temperature controller Model 71A manufactured by Yellow Springs Instrument Company. Temperature was monitored at three locations on the water table before and during the bioassay. Just after test termination, water quality conditions were again recorded. The results of these observations are presented in Appendix B. Water bath temperatures were measured with a Kessler 0-30° thermometer, calibrated against an ErTco FC-36486 Laboratory Standard thermometer at 20°C. pH was measured with an Orion Research Model 701A pH meter, calibrated with Ricca Chemical Co. pH 4, 7, and 10 Buffer. Salinity was measured with an American Optical Corporation Refractometer, calibrated with I.A.P.O Standard Seawater P46 with a chlorinity of 19.377‰ (salinity of 35.0‰). Dissolved oxygen was measured with a YSI D.O. meter Model 57. The thermometer and refractometer are calibrated on a monthly basis and were calibrated prior to the beginning of the experiment, while the pH and D.O. meters were calibrated before each use. Calibration records are presented in Appendix G.

2.4.8 Determination of Relative Survival and Percent Abnormal

At the end of the bioassay, three 10-mL subsamples were obtained from each exposure jar. These 10-mL subsamples were collected in the following manner. A perforated plunger, whose large flat surface was placed parallel to the bottom of the test container, was moved up and down to swirl and evenly distribute the larvae into the water column. During this process, thre 10-mL subsamples were drawn from each container. Each of these 10-mL subsamples was placed into individual 50-mL centrifuge tubes containing 10 mL of seawater solution of 4% neutral formalin to fix the larvae.

Relative survival and percent abnormal were determined after centrifuging each 50-mL centrifuge tube for 5 min at 1750 rpm (approximately 740 g). This consolidated the larvae near the bottom of the tube. Pipetting off the larvae and water at the bottom of the tube (approximately 2 mL) ensured that over 99% of the larvae were captured. Each 1-mL sample was transferred to a Sedgewick-Rafter Cell and scored for total number, normal D-cell, blastula and abnormal larvae on a compound microscope at 100x magnification. Survival was estimated by comparing total observed larvae in each centrifuge tube to stocking density results from control containers at test initiation. Abnormality incidence was determined as percent of abnormals in relation to total observed larvae.

2.5 CHEMISTRY METHODS

2.5.1 Priority Pollutant Polynuclear Aromatic Hydrocarbons, Pesticides and PCBs

Sixty-five polynuclear aromatic hydrocarbons (PAHs) were measured by Analytical Resources, Inc. using EPA-CLP-approved protocols (Method 625), modified as follows (40 CFR Part 136 1984):

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

The quality assurance/quality control QA/QC of the measurements on these samples included analysis of a method blank, Standard Reference Material SQ-1 from the National Oceanic and Atmospheric Administration (NOAA), triplicate analysis of the Alcatraz Island reference sample, matrix spike and matrix spike duplicate for the Alcatraz Island reference sample, and a duplicate analysis of Todd Shipyard sample number 878439 (designated T5a and b). Confirmation of results on a second GC column was performed.

Nineteen priority pollutant pesticides and five Aroclor PCBs were analyzed in each sediment by Analytical Resources, Inc. using approved EPA-CLP protocols (Method 608) modified as follows (40 CFR Part 136):

- Analyzed sample weight was increased to a minimum of 50 g to obtain lower detection limits.
- GPC (gel permeation chromatography) cleanup using EPA-CLP protocol was performed on all samples.
- Final volumes were reduced to 1 mL, instead of the normal 10 mL, to provide lower detection limits for the pesticides and PCBs.

The QA/QC of the measurements on these samples were obtained through the analysis of a method blank, Standard Reference Material SQ-1 from NOAA, triplicate analysis of the Alcatraz Island reference sample, matrix spike and matrix spike duplicate for the Alcatraz Island reference sample, and a duplicate analysis of Todd Shipyard sample number 878439 (designated T5a and b). Confirmation of results were performed on a second column. Appendix F contains the results of the QA/QC measurements for the priority pollutant PAHs, pesticides, and PCBs.

2.5.2 Metal and Metalloid Analysis

Metal and metalloid concentrations were determined through four procedures. The majority of the metals (As, Cr, Cu, Pb, Ni, and Zn) were measured through X-ray Fluorescence. Mercury (Hg) was analyzed with cold vapor atomic absorption spectrophotometry. The Sb, Cd, Se, Ag, and Tl were analyzed by atomic absorption spectrophotometry. Organotin compounds were analyzed by Gas Chromatography-Mass Spectrometry (GCMS).

XRF Analysis

Energy diffusive x-ray fluorescence analysis (XRF) was performed at Pacific Northwest Laboratory (PNL), Richland, Washington. Approximately 0.5 g of sediment was pressed into 2 cm diameter pellets prior to analysis by XRF. This technique does not require dissolution of the sediment, and therefore, is not prone to the problem of underestimating the concentrations of Cr and Ni (difficult to recover from acid digestions). Therefore, the XRF technique is fast, accurate, precise, and cost effective. Several elements (As, Cr, Cu, Pb, Ni, and Zn) were quantified simultaneously. The calibration techniques are described by Nielson and Sanders (1983). This technique is recognized by the National Bureau of Standards (NBS) for the analysis of metals in sediment matrices, and the researchers at PNL provide NBS quantitation of samples to verify concentrations in standard reference materials.

Blank values for XRF analysis were not included in Appendix F 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 two-fold standard deviation of mean counts for a sample that contains a low concentration 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 sediments were analyzed.

Atomic Absorption Spectrophotometer Analysis

Atomic absorption spectroscopy was performed on sediment extracts to determine the concentrations of Sb, Cd, Se, Ag, and Tl. 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. The 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. Boric acid was then added the next day to these solutions, and the bombs were returned to the oven for 8 h. After cooling, solution volumes were determined, and the solutions were stored in polyethylene bottles until analysis was performed.

The QA/QC of metals analyses run under atomic absorption spectrometry were accomplished by performing spike/recovery analyses using sediments from Alcatraz Island and also Todd Shipyard sample number 878439 (designated T5a and b). Standard reference materials 1646 and PACS-1 were also run to determine the accuracy of the analyses. Todd Shipyard sample number 878439 was measured in duplicate (T5a and b) for determination of laboratory precision in methods. These data are available in Appendix F. Mercury concentrations were determined through cold vapor atomic absorption using, as a detector, a Laboratory Data Control (LDC) mercury monitor with a 3-cm cell as indicated in EPA Protocol 7471 and modified by Bloom and Crecelius (1983). The remaining metals (Sb, Cd, Se, Ag, and Tl) were analyzed on a Zeeman graphite-furnace atomic absorption spectrometer using Methods 7041, 7131, 7740, 7760, 7841 (EPA SW 846 1986).

Organotin Analysis

Sediment extraction for the organotin analysis consisted of weighing approximately 10 g wet sediment into a 125-mL solvent-cleaned glass jar. This sediment was mixed thoroughly with approximately 200 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 rolled 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 tributyltin 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 is in the tetra-alkyltin form and was quantified by GCMS. The n-hexyl derivatives of butyltin species were separated and quantified relative to the surrogate standard, tri-propyltin.

The QA/QC of the samples included internal surrogate standards spiked before extraction and internal standards spiked after extraction to evaluate the efficiency of the technique. Duplicate measurements were made on Schnitzer Steel sediment sample number 878435 (S1). Standard reference materials from Moss Landing Intercalibration Standards were also analyzed to determine the accuracy of the methodology (Tables D.3 and D.4).

2.5.3 Total Organic Carbon Analysis

Total organic carbon in sediment was determined by AMTest using a nondispersive infrared measurement of carbon dioxide released from the organic carbon during combustion of the sediment. Inorganic carbonates were released from the sediment sample prior to combustion through use of HCL. The apparatus used for the measurement of carbon dioxide was a Dohrmann DC-180. This method is consistent with PSEP (1986) and Standard Method 505 (APHA 1975).

2.5.4 Oil and Grease Analysis

Sediment extraction for total oil and grease was accomplished by weighing approximately 20 g of sediment into a solvent-rinsed 25-mL jar. Approximately 40 to 50 g of sodium sulfate was added to the sample and homogenized with the sediment to absorb any water from the sediments. Then 50 mL of carbon tetrachloride was added and stirred into this mixture. The sample was immediately placed on a sample roller for 16 h to completely mix the reagents with the sediments. After 16 h, the sample was removed from the roller and the carbon tetrachloride poured into a solvent-rinsed conical vial. An additional 50 mL of carbon tetrachloride was added to the sediments, and the sample was rolled an additional 6 h. This second extraction has been shown to assure 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 the IR instrument, a Beckman Acculab 4 Infrared Spectrophotometer.

The sample was scanned from 4000 cm-1 to 600 cm-1, and the peak height was measured at 2930 cm-1. This wavelength represents the CH_2 configurations of hydrocarbons and is the standard used for the determination of 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 concentration of Alaska North Slope (ANS) crude oil was determined by regressing the peak height versus a known concentration of crude oil (EPA-API Reference Oil WP 681). This method is consistent with Method 502 B (APHA 1975).

2.5.5 Cyanide Analysis

Cyanide measurements were conducted on a Schmadzo Spectrophotometer using EPA Method 335.3 protocols (EPA 1979). The results may be suspect, as collected sediment was not treated with sodium hydroxide pellets as a preservative at the time of collection. Lack of preservation can result in the destruction of cyanides, resulting in an underestimate of their concentrations.

2.5.6 Total and Dissolved Sulfide Analysis

Total sulfide measurements followed the PSEP total sulfide distillation and colorimetric procedure, comparable to EPA Method 376.2 (PSEP 1986; EPA 1979). Dissolved sulfide measurement followed methodology set forth in Green and Schnitker (1974). Again, established protocols were not followed in relation to sediment preservation, as the zinc acetate preservative solution recommended in PSEP and EPA methodologies was not added (PSEP 1986; EPA 1979). Lack of preservation can result in either the production or loss of sulfides prior to measurement.

2.5.7 Grain Size Analysis

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 is either larger than the specified sieve size opening or was determined for the pipette-collected material based on Stokes Law using the time and depth at which the samples were collected (Table 2.5). Mass was determined after the samples had been dried by weighing the material to the nearest 0.1 µg on a Metler AC-100 electronic balance. This method is consistent with PSEP methodology (PSEP 1986).

TABLE 2.5. 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 H	Min	Sec
3.35	-2	6	na	na		
2.0	-1	10	na	na		
1.0	0	18	na	na		
0.5	1	35	na	na		
0.25	2	60	na	na		
0.125	3	120	na	na		
0.0625	4	230	20	0	0	20
0.0480	4.5	na	10	0	0	55
0.0312	5	na	10	0	1	55
0.0230	5.5	na	10	0	3	40
0.0156	6	na	10	0	7	41
0.0078	7	na	10	0	31	0
0.0039	8	na	10	2	3	0
0.0019	9	na	7	5	43	0
0.000976	10	na	7	22	53	0
0.0004883	11	na	5	65	25	0

na = not applicable.

2.5.8 Statistical Analysis

Two-way fixed-effects cross-classified analysis of variance (ANOVA) was used to examine the sources of variation for both the total number of larvae observed in all treatments and the proportion of abnormal (non-D stage as number abnormal/larvae produced) in the treatments. For each variable, a separate analysis was conducted for: 1) comparison of the SBSW and ARW effects with Sequim Bay sediments, and 2) comparison of all station sediments with ARW.

The model used for the first ANOVA included the two main effects for diluent water source (Sequim Bay or Alcatraz Island), percent of elutriate in exposures, and the two-factor interaction--water source by percent elutriate in the exposure. The model used for the second ANOVA included the two main effects for sediment source, percent elutriate in exposures, and the two factor interaction--sediment source by percent elutriate exposure. Both ANOVAs used the residual mean sum of squares for testing the significance of the interactions and main effects.

To examine the Sequim Bay and Alcatraz sediments separately, a two-way cross classified ANOVA similar to those already mentioned was also performed for each variable. Finally, a one-way ANOVA was performed to examine only the 10% elutriates for each of the stations for each variable.

For all ANOVAs, the variable "total number of observed larvae" was transformed to the natural logarithm to stabilize the variances within sediment sources. (The variable "proportion of abnormal larvae produced" was transformed to the arcsine square root of the proportion of abnormals.) Examination of residual plots suggested that these transformations were adequate for meeting the assumptions of analysis of variance.

3.0 RESULTS

3.1 LARVAL BIOASSAY

The null hypotheses evaluated by ANOVA on the results of the bioassay experiments were as follows:

1. There are no significant differences in the number of larvae surviving in treatments using SBSW or ARW.

2. There are no significant differences in the percentage of abnormal larvae produced in treatments using SBRW or ARW.

3. There are no significant differences in the number of larvae surviving in treatments using ARW when mixed with Sequim Bay sediment or Alcatraz Island sediment.

4. There are no significant differences in the percentage of abnormal larvae produced in treatments using ARW when mixed with Sequim Bay sediment or Alcatraz Island sediment.

5. There are no significant differences in the number of larvae surviving in sediment treatments based on the concentration of the elutriate in the test water.

6. There are no significant differences in the percentage of abnormal larvae produced in sediment treatments based on the concentration of the elutriate in the test water.

7. There are no significant differences in the number of larvae surviving in sediment treatments with only 10% elutriate exposure.

8. There are no significant differences in the percentage of abnormal larvae produced in sediment treatments with only 10% elutriate concentration.

Null hypothesis 1 was rejected. There were significantly fewer larvae in treatments of water or sediment elutriates when the diluent was Alcatraz reference water rather than Sequim Bay seawater (Tables 3.1 a and b). The greatest difference in larval abundance (4.4-fold) occurred in treatments using only the different water sources. This difference decreased as increasing quantities of Sequim Bay sediment elutriate were added. This was evident in the higher number of larvae present in the Alcatraz Island reference water dilutions of Sequim Bay sediment at 50% and 100% (Figure 3.1 and Table 3.1a).

TABLE 3.1a. The Mean, Standard Error, and Relative Degree of Difference in the Number of Larvae Present in 30 mL of Test Water Using Various Concentrations of Sequim Bay Sediment Elutriate in Sequim Bay Seawater or Alcatraz Island Reference Water (Hypothesis 1).

	Water Source		
% Sediment Elutriate (Sequim Bay Sediment)	Sequim Bay Mean ± SE(a)	Alcatraz Island Mean ± SE	Relative Degree of Difference(b)
0	270 ± 73	61 ± 36	4.4
10	410 ± 95	135 ± 77	3.0
50	330 ± 116	268 ± 49	1.2
100	407 ± 17	287 ± 98	1.4
All Elutriates	354 ± 41	188 ± 41	1.9

(a) SE = Standard Error
(b) Relative Degree of Difference = number of larvae in Sequim Bay water source ÷ number of larvae in Alcatraz water source

TABLE 3.1b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation Using the Natural Logarithm of the Total Larvae Observed.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	11.27	4	2.8181858	3.078	0.412
Water	7.17	1	7.1749029	7.835	0.0114
Elutriate dilutions	5.51	3	1.8368079	2.006	0.1473
Interactions	3.53	3	1.1761713	1.284	0.3083
Residual	17.40	19	0.9156990		
Total	32.20	26			

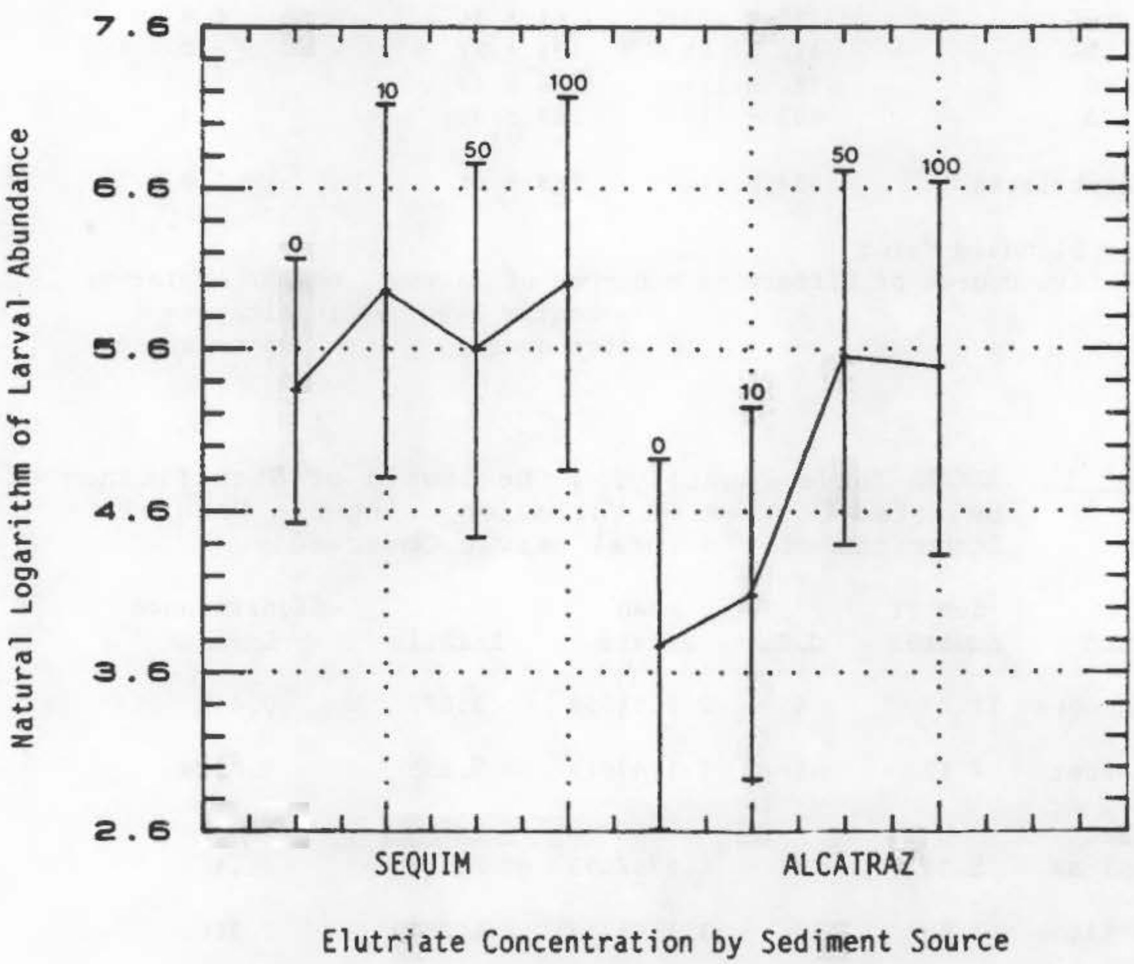

FIGURE 3.1. 95% Confidence Intervals on Natural Logarithm of the Survival of Larvae Exposed to Three Levels of Sediment Elutriate Concentrations Using Either Sequim Bay or Alcatraz Island Reference Water

Null hypothesis 2 was rejected. There was a significantly greater proportion of abnormal larvae in the ARW when compared to abnormality proportions in the SBRW (Tables 3.2a and b). The highest proportion of abnormal larvae occurred in the water treatment only. ARW averaged 66% abnormal, which was 1.9-fold the average abnormal percentage observed in the SBSW. The proportion of abnormal larvae decreased with additional Sequim Bay sediment elutriate in both sediment types. Average percentage of abnormal larvae in all Sequim Bay water and sediment elutriate was 19%, which was 1.9-fold less than the average in Alcatraz Bay water of 37% (Table 3.2a and b; Figure 3.2).

TABLE 3.2a. The Mean, Standard Error, and Relative Degree of Difference in the Proportion of Abnormal Larvae in 30 mL of Test Water Using Treatments of Various Concentrations of Sequim Bay Sediment Elutriate in Sequim Bay or Alcatraz Island Reference water (Hypothesis 2).

% Sediment Elutriate (Sequim Bay Sediment)	Water Source: Sequim Bay Mean ± SE(a)	Water Source: Alcatraz Island Mean ± SE	Relative Degree of Difference(b)
0	0.35 ± 0.17	0.66 ± 0.21	1.9
10	0.06 ± 0.02	0.38 ± 0.25	6.3
50	0.08 ± 0.01	0.20 ± 0.05	2.5
100	0.11 ± 0.01	0.24 ± 0.09	2.2
All Elutriates	0.19 ± 0.61	0.37 ± 0.10	1.9

(a) SE = Standard Error

(b) Relative Degree of Difference = number of larvae in Sequim Bay water source + number of larvae in Alcatraz water source

TABLE 3.2b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 2) Using the Arcsine Square Root of the Proportion Abnormal.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	1.37	4	0.3418994	2.407	0.0854
water	0.64	1	0.6444710	4.536	0.0465
elutriate	0.92	3	0.3103537	2.185	0.1232
Interactions	0.14	3	0.0457930	0.322	0.8091
Residual	2.70	19	0.1420647		
Total	4.20	26			

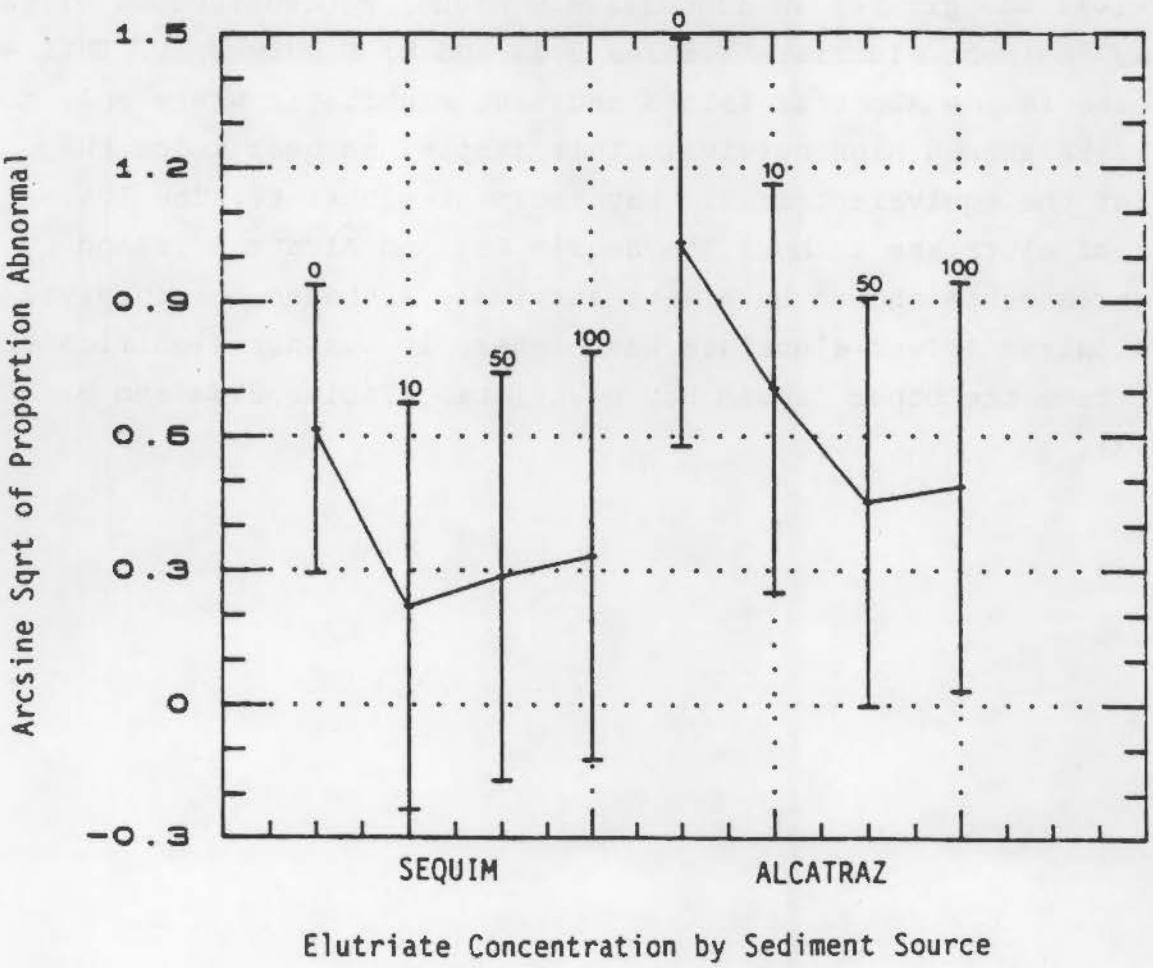

FIGURE 3.2. 95% Confidence Intervals on the Arcsine Square Root of Percentage of Abnormal Larvae Exposed to Three Levels of Sediment Elutriate Concentrations Using Sequim Bay or Alcatraz Island Reference Water as Diluent (Hypothesis 2)

Null hypothesis 3 was rejected. There were significantly more larvae in the Sequim Bay elutriates than in the Alcatraz Island elutriates when Alcatraz Island reference water was used as the diluent (Tables 3.3a and b). There was an average of 1.8-fold more larvae collected in treatments using Sequim Bay rather than Alcatraz Island elutriates. This effect was most obvious in the 50% and 100% sediment elutriate treatments where Sequim Bay sediments had 17- to 27-fold greater abundance than Alcatraz Island sediment.

Survival was greater in successively higher concentrations of the Sequim Bay sediment elutriate (Tables 3.3a and b; Figure 3.3). This was not the case in the Alcatraz Island sediment elutriate, where only the 10% elutriate showed high survival. This sample had over twice the survival of the equivalent Sequim Bay sediment elutriate. The 10% dilutions of elutriate in both the Sequim Bay and Alcatraz Island sediment treatments showed excellent survival. Although the survival in the 10% Alcatraz Island elutriate was higher, it was not significantly different from the other Sequim Bay elutriates (Tables 3.3a and b; Figure 3.3).

TABLE 3.3a. The Mean, Standard Error, and Degree of Difference in the Number of Larvae Present in 30 mL of Test Water Using Treatments of Various Concentrations of Sequim Bay Sediment Elutriate and Alcatraz Island Dredged Material Disposal Site Elutriates Mixed with Alcatraz Island Reference Water (Hypothesis 3).

% Sediment Elutriate (Alcatraz Island Reference Water)	Sediment Elutriate Source: Sequim Bay Mean ± SE	Alcatraz Island Mean ± SE	Relative Degree of Difference(a)
0(b)		61 ± 36	na
10	135 ± 77	358 ± 106	0.4
50	268 ± 49	10 ± 2	27
100	287 ± 98	18 ± 4	17
All Elutriates	230 ± 45	128 ± 65	1.8

(a) Relative Degree of Difference = number of larvae in Sequim Bay water source + number of larvae in Alcatraz water source

(b) Alcatraz Island Water Comparison only at the 0% sediment elutriate is appropriate.

TABLE 3.3b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 3). Using the Natural Logarithm of the Total Larvae Observed.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	12.35	3	4. 1151557	4.705	0.0215
sediment elutriate source	8.88	1	8.881901	10.156	0.0078
elutriate dilutions	3.46	2	1.7817828	1.980	0.1807
Interactions	22.23	2	11.113041	12.707	0.0011
Residual	10.49	12	0.8745755		
Total	45.07	17			

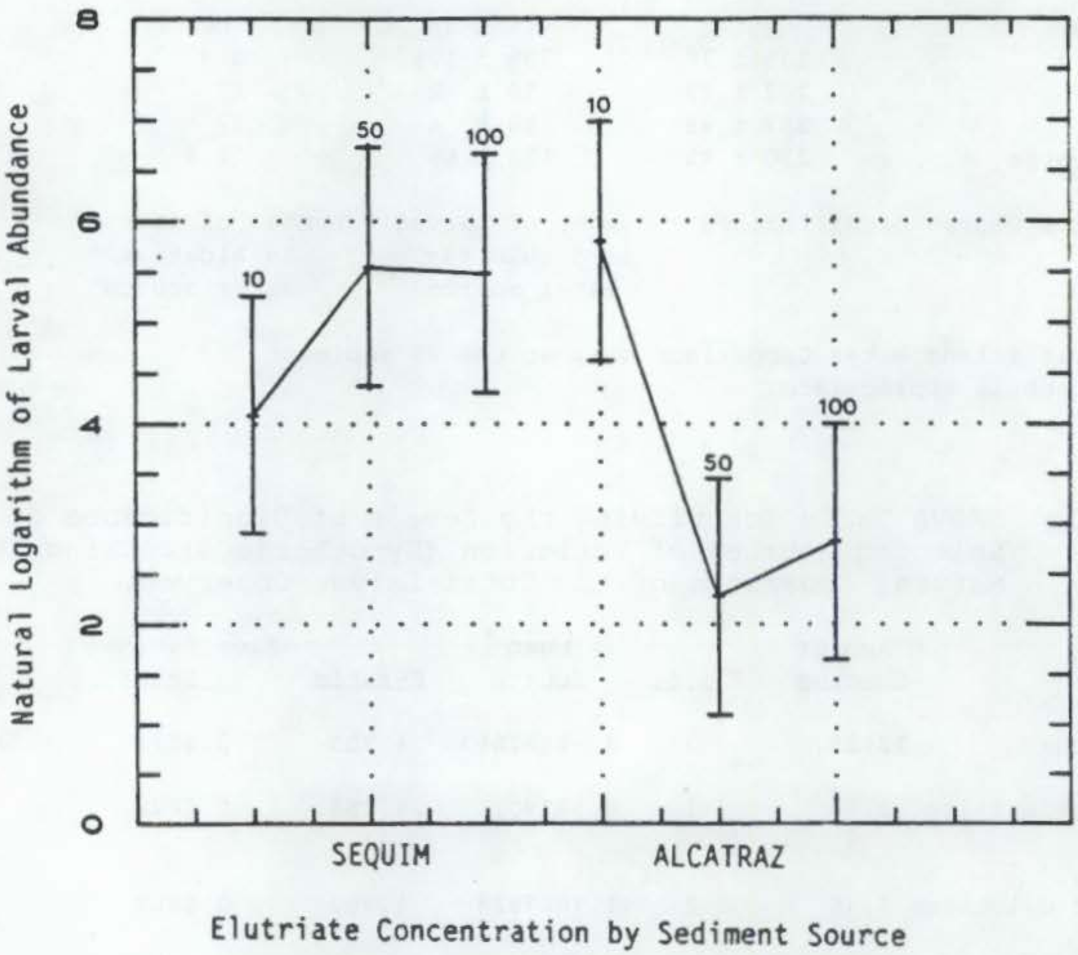

FIGURE 3.3. 95% Confidence Intervals on the Natural Logarithm of the Survival of Larvae Exposed to Sequim Bay or Alcatraz Island Sediment Elutriate Concentrations Using Alcatraz Island Reference Water as the Diluent (Hypothesis 3)

Null hypothesis 4 was rejected. There was a significantly greater proportion of abnormal larvae present in the Alcatraz Island sediment elutriates than in the Sequim Bay elutriate when Alcatraz Island Reference water was used as the diluent (Tables 3.4a and b; Figure 3.4). This difference averaged 2.4-fold over all the elutriate concentrations. It was most pronounced, however, in the 50% and 100% elutriate concentrations, which averaged approximately 7-fold difference in proportion of abnormal larvae. Low abnormality in the Alcatraz Island sediment elutriates when mixed with Alcatraz Island Reference water only occurred in the 10% dilution of the sediment elutriates.

TABLE 3.4a. The Mean, Standard Error and Relative Degree of Difference in the Proportion of Abnormal Larvae Present in 30 mL of Test Water Using Treatments of Various Concentrations of Sequim Bay Sediment Elutriate and Alcatraz Island Dredged Material Disposal Site Elutriates Mixed with Alcatraz Island Reference Water (Hypothesis 4).

% Sediment Elutriate (Alcatraz Island Reference Water)	Sediment Elutriate Source: Sequim Bay Mean ± SE	Sediment Elutriate Source: Alcatraz Island Mean ± SE	Relative Degree of Difference(a)
0(b)	NA	0.66 ± 0.26	NA(C)
10	0.38 ± 0.31	0.06 ± 0.02	0.2
50	0.20 ± 0.06	1.00 ± 0.00	5.0
100	0.24 ± 0.11	0.92 ± 0.02	8.4
All elutriates	0.27 ~ 0.10	0.66 ± 0.15	2.4

(a) Relative Degree of Difference = number of larvae in Sequim Bay water source ÷ number of larvae in Alcatraz water source

(b) Alcatraz Island Water Comparison only at the 0% sediment elutriate is appropriate.

(c) Not Applicable

TABLE 3.4b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 4) Using the Arcsine Square Root of the Proportion of Abnormals.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	2.25	8	0.7491076	6.212	0.0086
Sediment source	1.21	1	1.2141967	10.069	0.0080
Dilution	1.09	2	0.5165630	4.284	0.0394
Interactions	2.28	2	1.1153194	9.249	0.0037
Residual	1.45	12	0.125901		
Total	5.93	17			

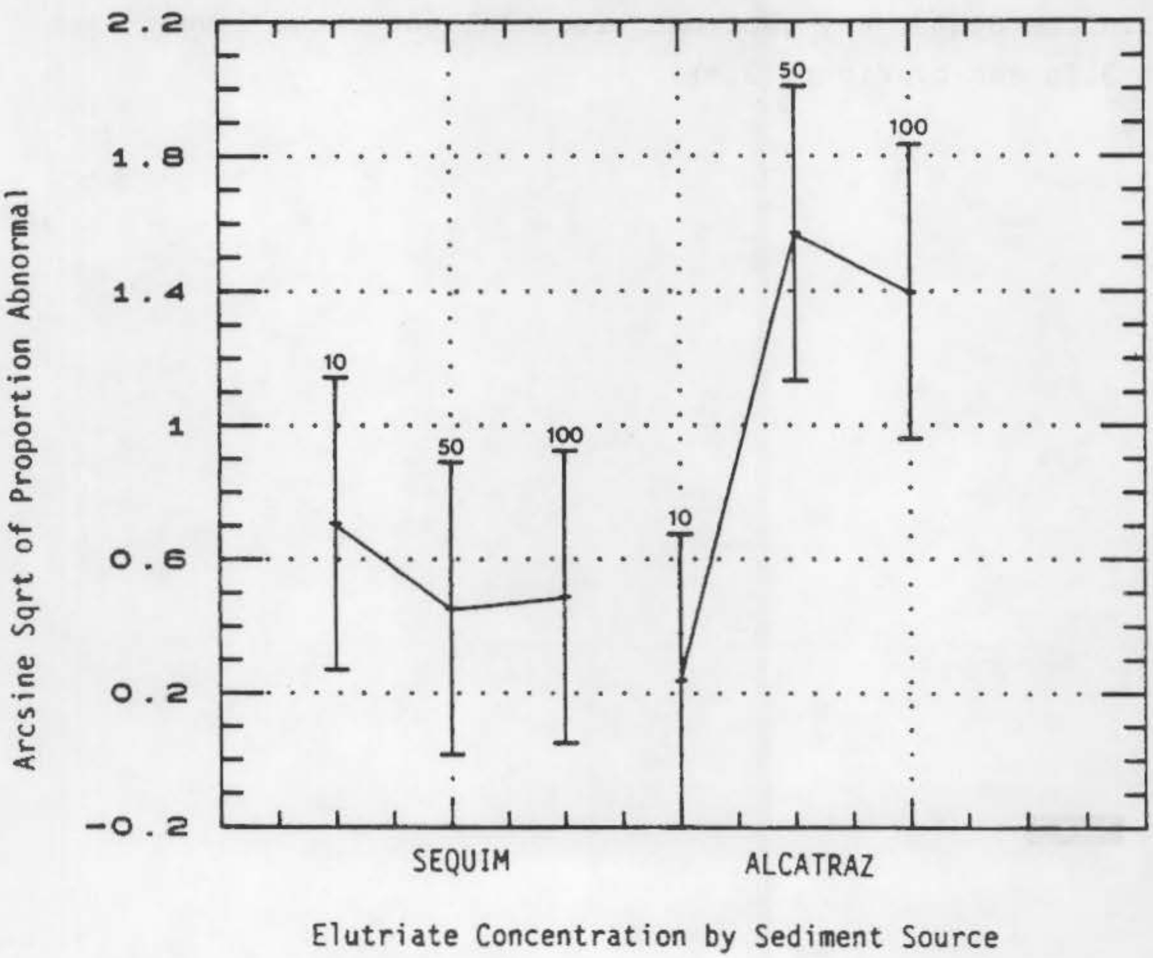

FIGURE 3.4. 95% Confidence Intervals on the Arcsine Square Root of Proportion of Abnormal Larvae Exposed to Sequim Bay or Alcatraz Island Sediment Elutriate Concentrations Using Alcatraz Island Reference Water as the Diluent (Hypothesis 4)

Hypothesis 5 was rejected. There was a significant difference in the quantity of larvae surviving in different concentrations of sediment elutriate (Tables 3.5a and b). Except in the case of the Sequim Bay sediment elutriate, there were significantly fewer larvae in the treatments of 50% and 100% than in the 10% elutriate concentration. There were no significant differences in number of larvae in any of the San Francisco sediment elutriate treatments at the 50% and 100% levels, but there were significantly more larvae in the Sequim Bay sediment treatments at these levels (Tables 3.5a and b; Figure 3.5).

TABLE 3.5a. Mean and Standard Error of Larval Survival at Various Stations and Sediment Elutriate Concentrations (Hypothesis 5) Using Alcatraz Island Reference Water.

	0%(a)	10%	50%	100%(b)
No Sediment	61 ± 36			
Sequim Bay		135 ± 77	68 ± 49	287 ± 98
Alcatraz		358 ± 106	10 ± 1.5	18 ± 4
Schnitzer Steel				
S1		269 ± 30	28 ± 8	17 ± 6
S2		162 ± 29	21 ± 6.5	25 ± 12
S3		49 ± 19	12 ± 5	26 ±8.5
Todd Shipyard				
T4		69 ± 46	15 ± 7	41 ±8.5
T5		14 ± 3.5	12 ± 1	32 ± 6
T6		190 ± 65	20 ± 7	42 ± 9
T7		94 ± 45	17 ± 7	26 ± 1

(a) Alcatraz Island Reference Water Only.
(b) Sediment Elutriate Only.

TABLE 3.5b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 5) Using the Natural Logarithm of the Total Larvae Observed.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	60.07	10	6.007233	10.322	<0.001
sediment elutriate source	30.51	8	3.813626	6.553	<0.001
elutriate dilutions	29.56	2	14.781663	25.399	<0.001
Interactions	38.03	16	2.3769603	4.084	<0.001
Residual	31.43	54	0.5819790		
Total	129.53	80			

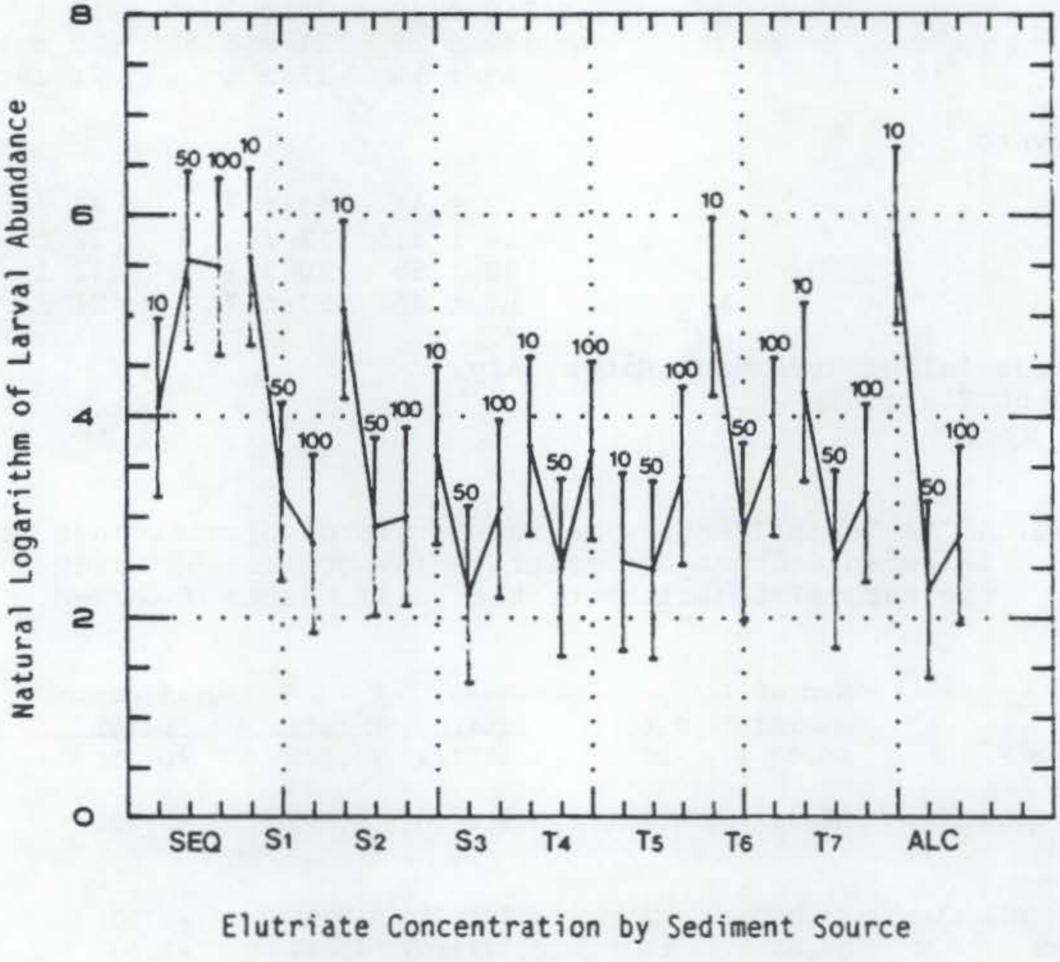

FIGURE 3.5. 95% Confidence Intervals on the Survival of Larvae Exposed to Three Sediment Elutriate Levels from Sequim Bay, Alcatraz Island, Schnitzer Steel, and Todd Shipyard sediments (Hypothesis 5)

Hypothesis 6 was rejected. There was a significantly greater proportion of abnormal larvae in the 50% and 100% sediment elutriate concentrations than in the 10% sediment elutriate concentration in all test sediments except Sequim Bay (Tables 3.6 a and b). In Sequim Bay sediments, the concentration of the elutriate did not influence the proportion of abnormal larvae (Tables 3.6 a and b; Figure 3.6).

TABLE 3.6a. Mean and Standard Error of the Proportion of Abnormal Larvae Survival at Various Stations and Sediment Elutriate Concentrations (Hypothesis 6) Using Alcatraz Island Reference Water.

	0%(a)	10%	50%	100%(b)
No Sediment	66 ± 0.26			
Sequim Bay		0.38 ± 0.31	0.20 ± 0.06	0.24 ± 0.11
Alcatraz		0.06 ± 0.02	1 ± 0	1.0 ± 0
Schnitzer Steel				
S1		0.30 ± 0.05	1.0 ± 0	1.0 ± 0
S2		0.21 ± 0.07	0.98 ± 0.02	0.91 ± 0.08
S3		0.035 ± 0.23	1.0 ± 0	0.88 ± 0.07
Todd Shipyard				
T4		0.76 ± 0.22	1.0 ± 0	0.99 ± 0.01
T5		1.0 ± 0	1.0 ± 0	1.0 ± 0
T6		0.40 ± 0.17	1.0 ± 0	1.0 ± 0
T7		0.66 ± 0.21	1.0 ± 0	1.0 ± 0

(a) Alcatraz Island Reference Water Only.
(b) Sediment Elutriate Only.

TABLE 3.6b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 6) Using the Arcsine Square Root of the Proportion of Abnormals.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Main Effects	13.33	10	1.9332892	21.493	<0.001
Station	6.00	8	0.7505798	12.100	<0.001
Dilution	7.33	2	3.6641266	59.068	<0.001
Interaction	4.04	16	0.2521624	4.065	0.001
Residual	3.35	54	0.0620325		
Total	20.72	80	0.0620325		

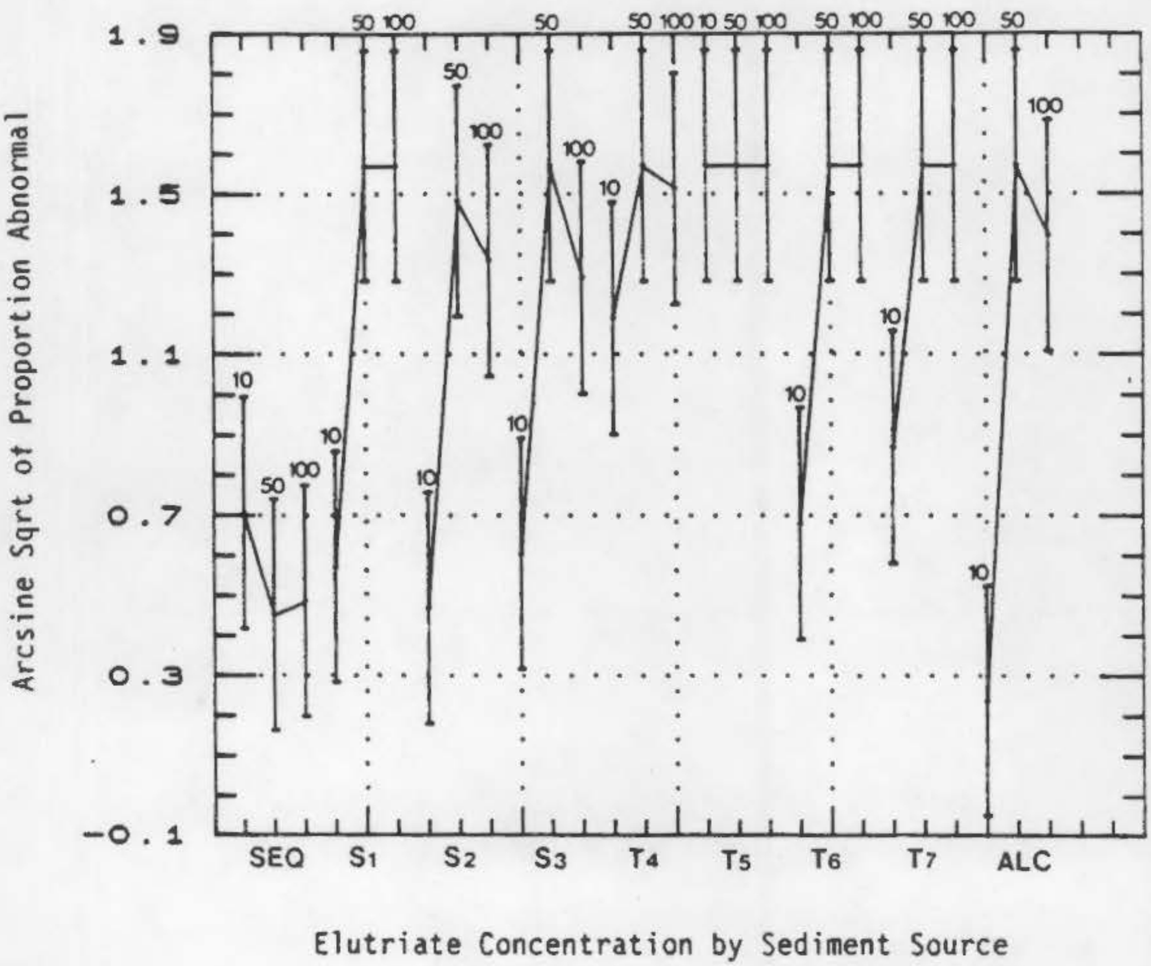

FIGURE 3.6. 95% Confidence Intervals on the Proportion of Abnormal Larvae Produced After Exposure to Three Sediment Elutriate Levels from Sequim Bay, Alcatraz Island, Schnitzer Steel, and Todd Shipyard sediments (Hypothesis 6)

Null hypothesis 7 was rejected. There were significant differences in the number of larvae observed in treatments of 10% elutriate concentrations from the test sediments (Tables 3.7a and b). Stations S2, S3, T4, T5, and T7 had significantly fewer larvae than the Alcatraz Island reference samples (Figure 3.7).

TABLE 3.7a. Mean and Standard Error for the Number of Larvae in the 10% Elutriates of the Various Sediments (Hypothesis 7) Using the Alcatraz Reference Water as the Diluent. Stations with Significantly Fewer Larvae Than Alcatraz Island Reference are Designated.

Station	Mean ± SE	Significance
Sequim Bay	135 ± 77	Not Significant
Alcatraz Island	358 ± 106	
Schnitzer Steel		
S1	269 ± 30	Not Significant
S2	162 ± 29	Significant
S3	49 ± 19	Significant
Todd Shipyard		
T4	69 ± 46	Significant
T5	14 ± 3.5	Significant
T6	190 ± 65	Not Significant
T7	94 ± 45	Significant

TABLE 3.7b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Variation (Hypothesis 7) Using the Natural Logarithm of the Total Larvae Observed.

Source of Variation	Sum of Squares	d.f.	Mean Square	F-ratio	Significance Level
Elutriate source	26.71	8	3.3388319	3.288	0.171
Error	18.28	18	1.0154114		
Total	44.99	26			

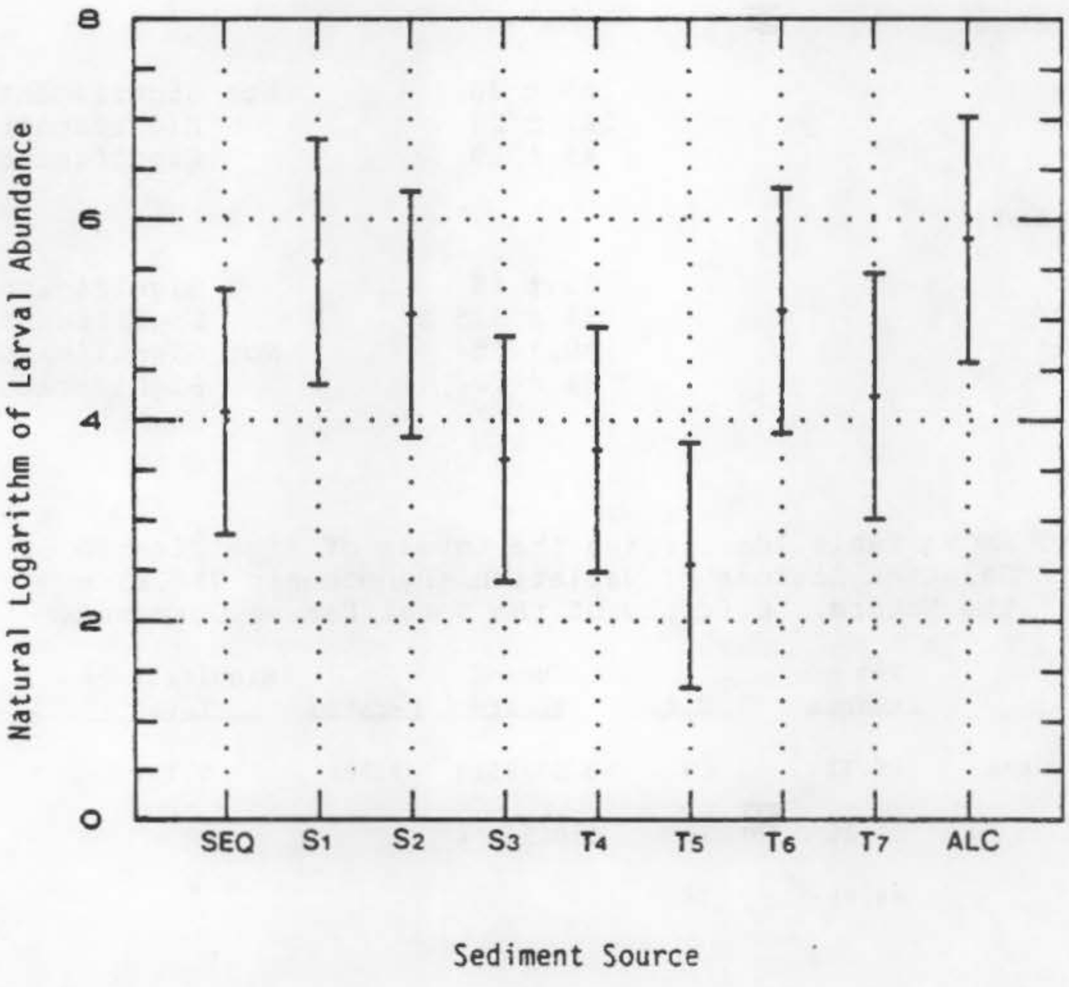

FIGURE 3.7. 95% Confidence Intervals for Larvae Survival in 10% Elutriate Concentrations Using Alcatraz Reference Water as a Diluent for each Sediment (Hypothesis 7)

Null hypothesis 8 was rejected. There were significantly lower proportions of abnormal larvae produced in 10% sediment elutriate concentrations from the various stations (Tables 3.8a and b). Alcatraz Island reference sediments had the lowest proportion of abnormal larvae. The proportion of abnormal larvae at the Schnitzer Steel sites was not significantly different from the proportion of abnormal larvae observed in the Alcatraz Island sites through all elutriate concentrations. All Todd Shipyard sediments showed significantly higher proportions of abnormal larvae than any of the other sites (Tables 3.8a and b; Figure 3.8).

TABLE 3.8a. Mean and Standard Error of the Proportion of Abnormal Larvae Present in 30 mL Aliquots of 10% Elutriate Concentration Treatment at Each Station (Hypothesis 8) Using the Alcatraz Reference Water as the Dilutant. Stations with Significantly Higher Proportions of Abnormal Larvae Versus Alcatraz Island Reference are Designated.

Station	Mean ± SE	Significance
Sequim Bay	0.38 ± 0.31	
Alcatraz Island	0.06 ± 0.03	
Schnitzer Steel		
S1	0.30 ± 0.05	Not Significant
S2	0.22 ± 0.07	Not Significant
S3	0.35 ± 0.23	Not Significant
Todd Shipyard		
T4	0.76 ± 0.22	Significant
T5	1.0 ± 0.00	Significant
T6	0.40 ± 0.17	Significant
T7	0.55 ± 0.20	Significant

TABLE 3.8b. ANOVA Table Identifying the Levels of Significance of Selected Sources of Potential Variation Using the Arcsine Square-Root of the Proportion of Abnormals.

Main Effect	Squares	d.f.	Square	F-ratio
Elutriate Source	3.842393	8	0.4802988	3.219
Error	2.686036	18	0.1492258	
Total	6.5284539	26		

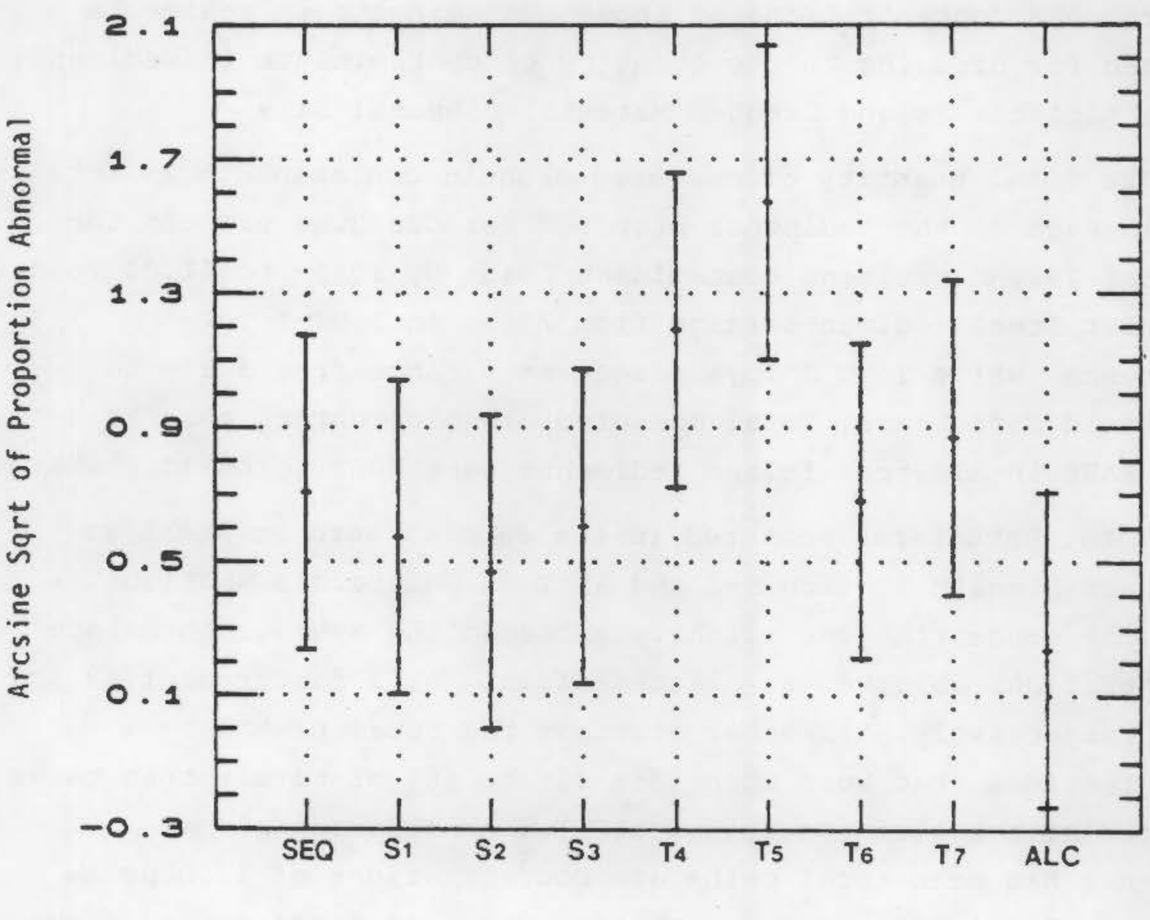

FIGURE 3.8. 95% Confidence Intervals on the Proportion of Abnormal Larvae Produced in 10% Elutriate Concentrations Using Alcatraz Island Reference Water as the Diluent for Each Sediment

3.2 BULK SEDIMENT ANALYSIS

3.2.1. Priority Pollutant Polynuclear Aromatic Hydrocarbons (PAHs), Pesticides, and PCBs

Twenty-one priority pollutant PAHs, pesticides, and PCBs were detected in sediments at Alcatraz Island, Schnitzer Steel, and Todd Shipyards. The wet and dry weight concentrations of these contaminants are presented in Tables 3.9a and b. Table 3.10 compares the concentrations of these contaminants in sediments proposed for dredging to the quantity of contaminants in sediments at the Alcatraz Island Dredged Material Disposal Site.

The total quantity of measured organic contaminants as total PAHs in each of the sediments proposed for dredging exceeds the Alcatraz Island sediment contaminant loads by 2.15- to 11.03-fold. Schnitzer Steel sediments range from 2.15- to 5.87-fold difference, while Todd Shipyard sediments range from 3.34- to 11.03-fold difference. Total measured organic contaminants as total PAHs in Alcatraz Island sediments were 3060 µg/kg (dry wt).

Total phthalates measured in the samples were greatest at Schnitzer Steel's station S-2 and at Todd Shipyard's station T-6 where the concentrations slightly exceeded the average phthalate concentrations observed at Alcatraz Island by a factor of 1.49 and 1.15, respectively. All other stations had total phthalate concentrations that were much less (0% to 66% of total) than those observed at the Alcatraz Island site. The Alcatraz Island sediments had mean total phthalate concentrations of 1280 µg/kg (dry wt). Total PCBs at the Schnitzer Steel stations ranged from 1.91- to 3.55-fold more than those observed at the Alcatraz Island site. The Todd Shipyard sites were more contaminated with 5.19 to 15.28 times the Alcatraz Island reference concentrations. Maximum concentration of total PCB as total Aroclor was found at Todd Shipyard station T-7 and was 1436 µg/kg (dry wt).

TABLE 3.9a. Priority Pollutants, Pesticides, and PCB Concentrations in Sediments. Values are Provided in Quantity of Contaminant Per Wet Weight of Sediment. Units Are in $\mu g/g$. Only Contaminants that Exceeded the Detection Level are Indicated.

Contaminant	Code Number	Alcatraz				Inner Oakland Harbor: Schnitzer Steel			Inner Oakland Harbor: Todd Shipyard				
		A1	A2	A3	MEAN	S1	S2	S3	T4	T6a	T6b	T6	T7
Acenaphthene	1	0	0	0	0.00	0	33	0	0	190	120	0	0
Diethylphthalate	2	61	0	0	20.33	61	0	0	0	0	0	0	0
Fluorene	3	0	0	0	0.00	0	0	0	0	190	110	49	0
Phenanthrene	4	58	62	130	86.67	140	330	230	170	950	1000	700	260
Anthracene	5	0	0	0	0.00	54	170	0	0	240	390	240	0
Di-n-Butylphthalate	6	21	0	0	7.00	23	110	0	0	0	0	140	170
Fluoranthene	7	131	140	180	150.33	270	680	610	330	2100	1100	1100	470
Pyrene	8	230	0	0	76.67	670	1900	2600	1600	3300	2400	3600	1100
Butylbenylphthalate	9	0	0	0	0.00	45	100	0	0	0	0	0	0
Benzo(a)Anthracene	10	55	81	95	77.00	150	330	250	250	1300	900	1500	300
bis(2-ethylhexyl)phthalate	11	1300	460	400	720.00	250	800	0	410	210	180	650	320
Chrysene	12	72	0	0	24.00	280	510	0	430	1700	1200	0	0
Benzo(b)Fluoranthene and	13	0	0	0	0.00	0	0	0	0	0	0	0	0
Benzo(k)Fluoranthene	14	177	190	230	199.00	450	1200	1200	1000	2500	2100	4500	1200
Benzo(a)Pyrene	15	120	140	160	140.00	300	670	860	670	1600	1200	2100	660
Indeno(1,2,3-cd)Pyrene	16	84	120	120	108.00	220	510	620	430	1100	1100	1500	0
Benzo(ghi)Perylene	17	110	150	140	133.33	260	620	690	490	1200	1200	1400	410
Aroclor 1016,1242,1248	18	0	0	0	0.00	0	50	0	0	0	0	0	0
Aroclor 1248	19	0	0	0	0.00	0	0	0	0	110	100	100	120
Aroclor 1254	20	0	0	0	0.00	90	90	40	190	160	190	600	590
Aroclor 1260	21	50	60	50	53.33	0	50	50	140	70	90	140	130
					0.00								
Dry Weight		0.586	0.586	0.586	0.59	0.499	0.571	0.41	0.675	0.549	0.549	0.539	0.585

TABLE 3.9b. Priority Pollutants, Pesticides, and PCB Concentrations in Sediments. Values are Provided in Quantity of Contaminant Per Dry Weight of Sediment. Units are in ug/g. Only Contaminants that Exceeded the Detection Level are Indicated.

						Inner Oakland Harbor							
Contaminant	Code Number	Alcatraz				Schnitzer Steel			Todd Shipyard				
		A1	A2	A3	MEAN	S1	S2	S3	T4	T5a	T5b	T6	T7
Acenaphthene	1	0	0	0	0	0	56	0	0	340	219	0	0
Diethylphthalate	2	104	0	0	35	102	0	0	0	0	0	0	0
Fluorene	3	0	0	0	0	0	0	0	0	348	200	91	0
Phenanthrene	4	65	105	222	130	201	570	561	252	1730	1021	1299	444
Anthracene	5	0	0	0	0	100	290	0	0	437	710	446	0
Di-n-Butylphthalate	6	36	0	0	12	40	193	0	0	0	0	200	291
Fluoranthene	7	224	230	307	257	541	1541	1400	489	3625	2004	2041	603
Pyrene	8	392	0	0	131	1343	3327	6341	2370	6011	4372	6079	1000
Butylbenylphthalate	9	0	0	0	0	90	315	0	0	0	0	0	0
Benzo(a)Anthracene	10	94	130	162	131	301	570	610	370	2300	1039	2783	650
bis(2-ethylhexyl)phthalate	11	2218	705	683	1220	601	1401	0	807	383	320	1200	547
Chrysene	12	123	0	0	41	561	693	0	637	3097	2100	0	0
Benzo(b)Fluoranthene and	13	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)Fluoranthene	14	302	324	392	340	922	2102	2027	2370	4554	3625	6349	2061
Benzo(a)Pyrene	15	206	239	273	239	601	1524	2146	1209	2914	2100	3896	1120
Indeno(1,2,3-cd)Pyrene	16	143	205	205	184	441	1000	1612	637	2004	2004	2783	0
Benzo(ghi)Perylene	17	186	256	230	228	601	1430	2171	726	2100	2100	2597	701
Aroclor 1016,1242,1248	18	0	0	0	0	0	80	0	0	0	0	0	0
Aroclor 1248	19	0	0	0	0	0	0	0	0	205	102	106	205
Aroclor 1254	20	0	0	0	0	100	160	90	201	320	340	920	1009
Aroclor 1260	21	65	102	65	91	0	80	122	207	120	104	200	222
Dry Weight		0.600	0.500	0.506	0.69	0.499	0.571	0.41	0.676	0.549	0.649	0.539	0.606

TABLE 3.10. Enrichment Levels for 21 Priority Pollutant PAH Hydrocarbons, Pesticides and PCB's in Sediments Proposed for Dredging. Enrichment Ratios are Determined by Dividing the Concentrations of the Contaminants at the Proposed Dredging Sites by the Corresponding Concentration of the Contaminant at the Alcatraz Site (Comparisons are made on Dry Weight Concentrations).

	Station Designation							
	Schnitzer Steel			Todd Shipyard				
Compound	S1	S2	S3	T4	T5A	T5B	T6	T7
acenaphthene	0	58	0	0	346	219	0	0
diethylphthalate	2.9	0	0	0	0	0	0	0
fluorene	0	0	0	0	346	200	91	0
phenanthrene	2.0	4.2	4.1	1.8	12.5	13.2	9.4	3.2
anthracene	108.0	298	0	0	437	710	445	0
di-n-butylphthalate	3.8	16.1	0	0	0	0	21.7	24
fluoranthene	2.1	6	5.8	1.9	14.8	7.8	7.9	3.1
pyrene	10.3	25.4	48.4	18.1	45.9	33.4	51	14
butylbenzylphthalate	90.0	315	0	0	0	0	0	0
benzo(a)anthracene	2.3	4.4	4.7	2.8	18.1	12.5	21.2	5
bis(2-ethylhexyl)phthalate	0.4	1.1	0	0.5	0.3	0.3	1.0	0.5
chrysene	13.7	21.8	0	15.5	75.5	53.3	0	0
benzo(b)fluoranthene and benzo(k)fluroanthene	2.7	6.2	8.6	7.0	13.4	11.3	24.6	6
benzo(a)pyrene	2.5	6.4	9.0	5.4	12.2	9.2	16.3	5
indeno(1,2,3-cd)pyrene	2.4	5.8	8.2	3.5	10.9	10.9	15.1	0
benzo(ghi)perylene	2.5	6.3	9.5	3.2	9.6	9.6	11.4	3
aroclor 1016,1242,1248	0	88.0	0	0	0	0	0	0
aroclor 1248	0	0	0	0	200	182	186	205
aroclor 1254	180.0	158.0	98.0	281.0	328	346	928	1009
aroclor 1260	0	1.0	1.3	2.3	1.4	1.8	2.9	2.4
Total PNA	2.2	5.1	5.9	3.3	10.1	8.0	11.0	3.2
Total Phthalates	0.6	1.5	0	0.5	0.3	0.3	1.2	0.7
Total Aroclor	1.9	3.6	2.3	5.2	7.0	7.4	14.6	15

The minimum concentration of total PCBs as total Aroclor observed at Todd Shipyard was approximately 0.488 while the concentrations at the Alcatraz Island site were 91 µg/kg (dry wt).

The remaining PAH hydrocarbons are the higher molecular weight forms larger than acenaphthene with fluoranthene, benzo(k and b) fluoranthenes, and pyrene and benzo(a) pyrene dominating the PAH mixtures. These materials may exist in a solid matrix form that may alter the bioavailability of the PAH contaminants.

3.2.2 Metals

The dry and wet weight concentrations of 12 metal and metalloid contaminants in sediments from composited core samples collected near the Alcatraz Island Dredged Material Disposal Site and in the composited core samples from Inner Oakland Harbor are included in Tables 3.11a and b. The concentrations of metals in Alcatraz sediments are considered reference contaminant levels by the USACE. Comparison of dry weight contaminant concentrations at proposed dredging sites to these reference concentrations is made by dividing the former by the latter (Table 3.12). Comparisons may also be made to the average crustal abundance of metals and metalloids found in shale soils throughout the world as a basis of reference to relative contaminant loads (Table 3.12).

Alcatraz Island sediments have concentrations of metals and metalloids that are fairly consistent with the concentrations of those metals observed in shale sediments throughout the world. Yet there is some indication of metal and metalloid enrichment at the Alcatraz disposal site. The levels of enrichment range from 0.6 to 3.7 with an average enrichment of 1.6 ± 0.9 SD. The metals that show the greatest enrichment above reference shale sediments are silver, chromium, and cadmium with 3.7, 2.46 and 2.3, respectively (Table 3.12).

The average enrichment of these twelve metals and metalloids in areas proposed for dredging ranged from 1.3 to 5.4 above the Alcatraz Island sediments. Schnitzer Steel sediments averaged 1.28-1.93 enrichment while sediments near Todd Shipyard ranged from 1.47

TABLE 3.11a. Metal and Metalloid Contaminant Concentrations in Sediment Samples from Alcatraz Island Dredge Disposal Site and Inner Oakland Harbor. Concentrations in ug/g(dry weight)

	Alcatraz	Inner Oakland Harbor							
		Schnitzer Steel				Todd Shipyard			
Contaminant	878587 A	878435 S1	878436 S2	878437 S3	878438 S4	878439 T5a	878439 T5b	878440 T6	878441 T7
Antimony (Sb)	2.82	2.58	7.37	3.78	3.09	13.12	13.03	18.83	11.39
Arsenic (As)	10.90	10.60	7.10	10.50	5.90	16.30	19.40	13.30	9.20
Cadmium (Cd)	0.69	1.42	1.97	1.05	0.67	2.02	2.03	1.16	1.33
Chromium (Cr)	246.00	230.00	343.00	217.00	416.00	390.00	419.00	930.00	437.00
Copper (Cu)	53.20	71.10	79.00	81.40	96.70	326.00	327.00	423.00	224.00
Lead (Pb)	29.00	48.40	100.00	87.60	78.30	177.00	175.00	246.00	174.00
Mercury (Hg)	0.26	0.41	1.30	0.76	1.30	8.30	8.40	4.20	2.70
Nickel (Ni)	118.00	129.00	101.00	130.00	85.70	146.00	155.00	212.00	155.00
Selenium (Se)	0.31	0.38	0.16	0.23	0.08	0.31	0.39	0.23	0.31
Silver (Ag)	0.37	0.45	0.57	0.63	0.33	1.00	0.99	0.62	0.70
Thallium (Tl)	0.64	0.64	0.52	0.65	0.39	0.52	0.59	0.45	0.65
Zinc (Zn)	131.00	179.00	260.00	208.00	183.00	428.00	415.00	549.00	287.00
Dry weight	0.57	0.50	0.56	0.42	0.68	0.55	0.55	0.53	0.58

TABLE 3.11b. Metal and Metalloid Contaminant Concentrations in Sediment Samples from Alcatraz Island Dredge Disposal Site and Inner Oakland Harbor. Concentrations in $\mu g/g$ (wet weight)

		Inner Oakland Harbor							
	Alcatraz	Schnitzer Steel				Todd Shipyard			
Contaminant	878587 A	878435 S1	878436 S2	878437 S3	878438 S4	878439 T5a	878439 T5b	878440 T6	878441 T7
Antimony (Sb)	1.61	1.28	4.09	1.58	2.09	7.16	7.11	9.96	6.63
Arsenic (As)	6.21	5.27	3.94	4.38	3.99	8.90	10.59	7.04	5.35
Cadmium (Cd)	0.39	0.71	1.09	0.44	0.45	1.10	1.11	0.61	0.77
Chromium (Cr)	140.22	114.31	190.37	90.49	281.63	212.94	228.77	491.97	254.33
Copper (Cu)	30.32	35.34	43.85	33.94	65.47	178.00	178.54	223.77	130.37
Lead (Pb)	16.53	24.05	55.50	36.53	53.01	96.64	95.55	130.13	101.27
Mercury (Hg)	0.15	0.20	0.72	0.32	0.88	4.53	4.59	2.22	1.57
Nickel (Ni)	67.26	64.11	56.06	54.21	58.02	79.72	84.63	112.15	90.21
Selenium (Se)	0.18	0.19	0.09	0.10	0.05	0.17	0.21	0.12	0.18
Silver (Ag)	0.21	0.22	0.32	0.26	0.22	0.55	0.54	0.33	0.40
Thallium (Tl)	0.36	0.32	0.29	0.27	0.26	0.28	0.32	0.24	0.38
Zinc (Zn)	74.67	88.96	144.30	86.74	123.89	233.69	226.59	290.42	167.03

TABLE 3.12. Enrichment Levels for 12 Sediment Bound Metals and Metalloids at Proposed Dredging Sites. Enrichment Ratio's are Determined by Dividing the Concentration of the Metal at the Proposed Dredging Site by the Alcatraz Island Site Concentration. Concentrations Ratio's are Determined Based on Dry Weight Values. Alcatraz Enrichment Ratio's are Referenced to Crustal Averages in Shale Soils.

Metal	Alcatraz	Station: Schnitzer Steel			Station: Todd Shipyard				
	A	S1	S2	S3	T4	T5A	T5B	T6	T7
Antimony	1.9	0.9	2.6	1.3	1.1	4.7	4.6	6.7	4.0
Arsenic	1.7	1.0	0.7	1.0	0.5	1.5	1.8	1.2	0.8
Cadmium	2.3	2.1	2.9	1.5	1.0	2.9	2.9	1.7	1.9
Chromium	2.5	0.9	1.4	0.9	1.7	1.6	1.7	3.8	1.8
Copper	0.9	1.3	1.5	1.5	1.8	6.1	6.2	8.0	4.2
Lead	1.5	1.7	3.5	3.0	2.7	6.1	6.0	8.5	6.0
Mercury	0.7	1.6	5.0	2.9	5.0	32	32	16.2	10.4
Nickel	1.2	1.1	0.9	1.1	0.7	1.2	1.3	1.8	1.3
Selenium	0.5	1.2	0.5	0.7	0.3	1.0	1.3	0.7	1.0
Silver	3.7	1.2	1.5	1.7	0.9	2.7	2.7	1.7	1.9
Thallium	0.6	1.0	0.8	1.0	0.6	0.8	0.9	0.7	1.0
Zinc	1.6	1.4	2.0	1.6	1.4	3.3	3.2	4.2	2.2

5.41. The metal concentrations in Schnitzer Steel sediments that always exceeded the Alcatraz Island disposal site concentrations were zinc, silver, mercury, lead, copper, and cadmium. Contaminant metals from at least four of the five samples at Todd Shipyards, whose concentrations exceeded Alcatraz Island reference levels, included those seen at Schnitzer Steel as well as nickel, chromium, and antimony. Maximum metal contamination at Schnitzer Steel occurred at station S-2 where mercury, lead, cadmium, and antimony were 5, 3.5, 2.9 and 2.6 times the sediment concentrations at the Alcatraz Island Site, respectively. All Todd Shipyard sites were at least as contaminated or exceeded the level of contamination at Schnitzer Steel's most contaminated site (S2). The least observed contamination of any of the Todd Shipyard samples was at station T-4, which generally equaled the maximum level of contamination observed at the Schnitzer Steel sites.

Todd Shipyard Stations T-5a, T-5b, T-6, and T-7 consistently had concentrations of antimony, copper, lead, mercury, and zinc that were more than three times those values at the Alcatraz sites. The Todd Shipyard sites had mercury contamination that exceeded the levels at Alcatraz by 5- to 32-fold, with concentrations approaching 10 µg/g (dry wt) at the most contaminated stations. Copper, antimony, and lead at these sites exceeded Alcatraz reference concentrations by 4.04- to 8.48-fold, with an average factor of 5.92 ± 1.4 ($n = 12$). Copper concentrations ranged from 224 to 423, while antimony ranged from 11.4 to 18.8, and lead ranged from 174 to 246 µg/g (dry wt). Zinc concentrations exceeded reference by an average factor of 3.21 ± 0.82 sd ($n = 4$) with concentrations ranging from 287 to 549 µg/g (dry wt).

3.2.3 Organotins

The wet and dry weight concentrations of mono-, di- and tri-butyltin in sediments at Alcatraz Island and Inner Oakland Harbor are summarized in Table 3.13. The concentrations of the sum of the

TABLE 3.13. Wet and Dry Weight Concentrations of Mono-, Di-, and Tributyltin Measured in Sediment Proposed for Dredging Near Schnitzer Steel and Todd Shipyards. The reference concentrations are from the composite cores from the Alcatraz Island Dredged Material Disposal Site. Application factors are for total butyltin and tributyltin comparisons of reference sediment concentrations to proposed dredging site concentrations. Concentrations are surrogate recovery corrected.

	Concentration of Contaminant							
	(dry wt) µg/kg				(wet wt) µg/kg			
Station	Tri	Di	Mono	Total	Tri	Di	Mono	Total
Alcatraz	30.4	32.8	15.4	78.6	19	20.5	9.6	49.1
Schnitzer Steel								
S1A	23.5	27.3	77.3	128.112	13.9	39.5	65.4	
S1B	37.5	38.6	89.3	165.4	19	19.7	45.6	84.5
S2	19.4	13.1	334.2	366.7	11	7.3	185.9	204
S3	16.6	15.6	43.4	75.6	6.7	6.3	17.5	30.5
Todd Shipyard								
T4	58.8	25.1	7.5	91.4	39.9	17	5.1	62
T5	<1.7	<2.4	<2.1	<6.2	<0.9	<1.3	<1.2	<3.4
T6	180	22.3	37.1	239.4	96	12	19.8	128
T7A	434.8	105.9	<10.2	550.9	292.8	71.3	<6.9	371
T7B	729.6	171.3	101.9	1002.8	491.3	115.4	68.6	675.3

	Application Factors - Dry Weight	
	Total Butyltins	Tributyltins
Schnitzer Steel		
S1A	1.6	0.8
S1B	2.1	1.2
S2	4.7	0.6
S3	1.0	0.6
Todd Shipyard		
T4	1.2	1.9
T5	0.1	0
T6	3.1	5.9
T7A	7.0	14.3
T7B	12.8	24

three butyltins at the reference site was 78.6 µg/kg (dry wt) while the concentrations at Schnitzer Steel sites ranged from 128 to 367 µg/kg (dry wt) and at Todd Shipyard sites from less than detectable to 1003 µg/kg (dry wt). Schnitzer Steel sediment showed dry weight enrichment factors of 0.96- to 4.7-fold while Todd Shipyard sediment measurements showed enrichment factors of 0.08- to 12.8-fold. Todd Shipyard sediments contained an average of 73% ±6 (n = 4) of the total measured butyltins in the more toxic tributyltin form while Schnitzer Steel sediments contained an average of 17% ± 8 (n = 4) and Alcatraz Island Dredged Material Disposal Site had 39%. The concentrations of tributyltin at the Schnitzer Steel sites ranged from 16.6 to 37.5 µg/kg (dry wt), which closely approximates the concentrations of this organotin in the Alcatraz Island Dredged Material Disposal Site sediment (30.4 µg/kg dry wt). Tributyltin in Todd Shipyard sediment samples ranges from less than detectable to 730 µg/kg (dry wt). Todd Shipyard station T-5 was the only Todd Station to have undetectable concentrations of butlytins. All other Todd Shipyard stations had from 2- to 24-fold greater tributyltin concentrations than the Alcatraz Island Dredged Material Disposal Site sediment.

3.2.4 Total Organic Carbon

Total organic carbon (wet and dry weight) in sediments at Schnitzer Steel were higher than the levels in reference sediments, while Todd Shipyard sediments were both lower and higher than the reference sediment values at Alcatraz Island Dredged Material Disposal Sites (Table 3.14). The concentrations exceeded the reference value (1.3%) at the Schnitzer Steel sites with ranges of 1.52 to 2.56% on a dry weight basis. Todd Shipyard sites had concentrations of total organic carbon, which ranged from 0.8 to 2.04%. The maximum enrichment of total organic carbon in sediment from the seven locations proposed for dredging is a factor of nearly 2 (Table 3.14).

TABLE 3.14. Wet and Dry Weight Concentrations of Total Organic Carbon from Inner Oakland Harbor and Alcatraz Island Sediments. Enrichment factors are based on comparison of the dry weight concentrations of organic carbon at proposed dredging sites to the reference Alcatraz Island sediments.

	% Total Organic Carbon		Enrichment Factor
Station	Wet	Dry	Dry
Alcatraz Island	0.76	1.3	1
Schnitzer Steel			
S1	0.96	1.9	1.5
S2	0.87	1.5	1.2
S3	1.05	2.6	2.0
Todd Shipyard			
T4	0.54	0.8	0.6
T5A	1.12	2.0	1.6
T5B	1.10	2.0	1.5
T6	0.87	1.6	1.2
T7	0.80	1.4	1.1

3.2.5 Oil and Grease

Wet and dry weight oil and grease concentrations from sediments collected at the seven sites proposed for dredging ranged from 138 to 734 µg/g (wet wt) and 271 to 1342 µg/g (dry wet) (Table 3.15). The Schnitzer Steel sediment samples contained oil and grease concentrations ranging from 271 to 1050 µg/g (dry wt) while the Todd Shipyard samples had concentrations ranging from 399 to 1342 µg/g (dry wt) (Table 3.15).

Enrichment factors (sample concentration/Alcatraz concentration) ranged from 0.72 to 3.82 (wet wt) to 0.88 to 4.37 (dry wt). The most enriched oil and grease measurement for the Schnitzer Steel samples was at station S-2, while Todd Shipyard samples were most enriched at Station T-5.

3.2.6 Cyanide

Cyanide concentrations were evaluated in sediments proposed for dredging. No cyanide was measured in any of the samples at the detection limits of <0.6 µg/g (wet wt). This may be due to lack of sediment preservation (See Section 2.2.5).

3.2.7 Total and Dissolved Sulfides

Total and dissolved sulfides were determined from aliquots of the unpreserved sediments. The wet and dry weight concentrations of these materials are included in Table 3.16. Total sulfides ranged from 225 to 578 µg/g, while dissolved sulfides ranged from 218 to 1521 µg/g (dry wt).

The quantity of total and dissolved sulfides at all proposed dredging sites exceeded the concentration at the Alcatraz Dredged Material Disposal Site (Table 3.17). Total sulfides at the Schnitzer Steel sites ranged from factors of 1.03 to 2.57 times

TABLE 3.15. Wet and Dry Weight Concentrations of Total Oil and Grease Concentrations from Inner Oakland Harbor and Alcatraz Island Sediments. Enrichment factors are based on comparisons of the dry weight concentrations of organic carbon at proposed dredging sites to the reference Alcatraz Island sediments.

	Total Oil and Grease (µg/g)		Enrichment Factor
Station	Wet	Dry	Dry
Alcatraz Island	192	307	1
Schnitzer Steel			
S1	138	271	0.9
S2	584	1056	3.4
S3	271	673	2.2
Todd Shipyard			
T4	271	399	1.3
T5A	734	1342	4.4
T5B	509	930	3.0
T6	551	1031	3.4
T7	279	414	1.4

TABLE 3.16. Wet and Dry Weight Concentrations of Total and Dissolved Sulfides in Sediments From Inner Oakland Harbor and Alcatraz Island

	Total Sulfides (µg/g)		Dissolved Sulfides (µg/g)	
Station	Wet	Dry	Wet	Dry
Alcatraz Island	132	225.3	128	218.4
Schnitzer Steel				
S1	117	234.5	417	835.7
S2	174	304.7	321	562.2
S3	237	578.1	161	392.7
Todd Shipyard				
T4	297	440	578	856.3
T5A	243	442.6	835	1521
T5B	165	300.6	NM	NM
T6	141	261.6	738	1369.2
T7A	232	396.6	610	1042.7
T7B	NM	NM	610	1042.7

TABLE 3.17. Enrichment Factors for Total and Dissolved Sulfides in Sediments are Based On Comparison of the Dry Weight Concentrations at Proposed Dredging Sites to the Reference Alcatraz Island Sediments

Station	Total Sulfides	Dissolved Sulfides
Alcatraz Island		
Schnitzer Steel		
S1	1	3.8
S2	1.4	2.6
S3	2.6	1.8
Todd Shipyard		
T4	1.95	3.9
T5A	1.96	7.0
T5B	1.33	NM
T6	1.16	6.3
T7A	1.76	4.8
T7B	NM	4.8

NM = not measured.

reference while Todd Shipyard sites ranged from 1.16 to 1.96 times. This is in contrast to the dissolved sulfide samples from Schnitzer Steel that ranged from 1.8- to 3.8-fold while the Todd Shipyard samples had larger enrichment with ranges of 3.92- to 6.96-fold.

3.2.8 Grain Size

Sediment grain size for composited samples was measured on a dry weight basis at each of the proposed dredging sites and at the Alcatraz Island Disposal site (Tables 3.18 and 3.19). The sediments at the Alcatraz site were composed of nearly equal percentages of silt and clay with a smaller percentage of sand. The Schnitzer Steel sediments were composed primarily of silt and clay, with Schnitzer station S2 containing the most sand (33%). The Todd Shipyard stations were variable, with Station T4 dominated by sand, Station T5 composed primarily of silt and clay in equal portions, and Stations T6 and T7 composed of nearly equal percentages of sand, silt, and clay.

Table 3.19 summarizes the above grain-size distributions and presents the relative enrichments of sand, silt, and clay in comparison to Alcatraz Island grain size data. Examination of this table shows that enrichment levels for sand ranged from a low of 0.2 (Schnitzer S1) to 3.5 (Todd T4); Station T5 was approximately equal to Alcatraz at 1.1. Enrichment levels for silt ranged from 0.3 (Todd T4) to 0.9 (Schnitzer S3); no test station exceeded the percent silt found at the Alcatraz Site. Clay enrichment ranged from a high of 1.6 at Schnitzer S1 to a low of 0.6 at Todd T4. Stations Schnitzer S2 and S3, and Todd T5 and T7 had slightly more percent clay than the Alcatraz Island sediments.

TABLE 3.18. Percent of Sediment (Dry Weight) Within Specified Seive Size Classes.

Battelle Id Number			870507	870435	870436	870437	870438	870439	870439	870440	870441
Station			A1	S1	S2	S3	T4	T5a	T5b	T6	T7
Sediment Type	Seive Size in mm	Phi	Percent of Material Occurring in Each Seive Size								
	> 3.35	-2	0.95	0.00	0.00	0.00	0.00	0.42	0.54	0.00	0.20
	3.35 - 2.00	-1	1.17	0.00	0.01	0.00	0.01	0.39	1.42	0.94	0.00
	2.00 - 1.00	0	0.97	0.20	0.24	0.00	0.35	1.49	0.91	2.19	0.52
-------------	1.00 - 0.50	1	1.06	0.09	0.53	0.03	1.00	0.60	0.65	2.12	1.71
Sand	0.50 - 0.25	2	4.81	0.51	16.05	0.98	33.74	4.53	4.96	11.31	7.92
	0.25 - 0.125	3	6.06	1.51	13.79	4.20	23.09	11.04	11.73	21.26	13.38
-------------	0.125 - 0.062	4	4.90	1.00	2.86	1.02	2.83	3.44	3.23	4.25	4.40
	0.062 - 0.040	4.5	2.19	1.08	4.13	3.02	1.27	3.89	0.21	1.01	1.03
	0.040 - 0.0312	5	6.64	3.36	2.67	3.61	1.56	0.15	4.73	1.84	1.07
Silt	0.0312 - 0.023	5.5	4.58	0.27	2.49	0.32	1.38	3.02	3.20	3.11	3.91
	0.023 - 0.0156	6	6.20	3.47	1.03	5.44	2.06	1.07	0.25	1.34	4.01
	0.0156 - 0.0078	7	8.95	11.42	7.45	9.87	2.53	8.04	5.30	6.10	10.00
-------------	0.0078 - 0.0039	8	8.36	10.50	9.12	12.43	4.40	6.98	8.93	6.72	6.02
Clay	0.0039 - 0.0019	9	8.36	12.45	7.59	11.39	4.42	11.38	9.16	7.69	7.44
	0.0019 - 0.000976	10	5.41	21.87	7.38	13.16	4.39	10.22	10.36	6.72	7.41
	< 0.000976	11	26.72	31.46	24.66	33.81	16.11	32.73	34.36	22.61	29.21
Total			100.01	99.99	100.00	100.08	100.02	99.99	99.97	100.01	99.99
Percent Dry Weight			58.19	61.90	56.63	42.37	69.65	55.99	56.00	54.47	58.41
Sample Weight (g Dry)			11.9290	10.4838	11.5422	8.8892	14.5847	11.4556	11.8327	11.1377	11.8886
Percent Recovery			96.66	98.66	97.26	98.49	93.15	98.01	94.97	99.43	97.28

TABLE 3.19. Relative Comparison of Grain Size Between Alcatraz Island Sediment and the Test Sediments From Inner Oakland Harbor

Station	Percent Grain Size			Relative Enrichment(a)		
	Sand	Silt	Clay	Sand	Silt	Clay
Alcatraz Island	17.43	39.00	40.49	1.0	1.0	1.0
Schnitzer Steel						
S1	3.91	30.10	65.78	0.2	0.8	1.6
S2	33.23	26.89	39.63	1.9	0.7	1.0
S3	7.03	43.69	58.36	0.4	0.9	1.4
Todd Shipyard						
T4	61.46	13.28	24.92	3.5	0.3	0.6
T5	19.61	23.75	54.33	1.1	0.6	1.3
T6	20.56	22.62	53.92	1.2	0.6	1.3
T7	27.41	24.67	44.06	1.6	0.6	1.1

(a) Test sediment result/Alcatraz sediment result.

4.0 DISCUSSION

The discussion of results includes a summary of the bioassay response (including possible Alcatraz Reference water toxicity) and the significance of the sediment contaminants derived from bulk sediment analysis.

4.1 BIOASSAY DISCUSSION

4.1.1 Oyster Larvae Response

Our estimates of the number of larvae exposed to various sediment elutriate and water treatments indicated an initial density of approximately 15 larvae per milliliter. The recovery of organisms in the Sequim Bay water and Sequim Bay sediment elutriate treatments indicated that approximately 350 organisms or an average of 80% of the fertilized eggs added to these test solutions survived the 48-h test. During that same period of time, in the same set of treatments, approximately 15% of the organisms were abnormal.

These observations are in contrast to the observations made about the Alcatraz Island Dredged Material Disposal Site reference water. The organisms in the Alcatraz reference water had an average of 4.4-fold lower survival and a 1.9-fold higher abnormal rate than organisms exposed to the Sequim Bay reference water. Other observations indicated that the addition of increasingly larger quantities of Sequim Bay sediment elutriate improved survival and reduced abnormal percentage rates in the treatments using ARW. In both cases, highly significant improvements in the survival and abnormal development rates were observed for the ARW sample.

Alcatraz Island reference sediment when mixed with ARW, had toxicity and abnormal development rates higher than those observed in treatments using SBRW. This may be due to increased contaminants in the Alcatraz Island reference sediment. The sediment may not scavenge the toxic components from the water column as effectively as Sequim Bay sediments. There was good survival at the 10% elutriate concentrations of both Alcatraz Island and Sequim Bay sediment. Therefore, the protective or scavenging potential for the contaminants in ARW was effective at low Alcatraz Island and Sequim Bay elutriate concentrations.

At higher Alcatraz Island elutriate concentrations there were greater mortalities but regular levels of abnormal production. This may be due to elevated levels of an increase in contaminants from the Alcatraz Island reference sediment or an as yet unidentified solids effect on the embryo bioassay. Both higher mortality and higher abnormal production at the higher sediment elutriate concentrations were observed at Todd Shipyard stations, but not at Sequim Bay or Schnitzer Steel stations.

Evaluation of the number of larvae and percent abnormals in the 10% elutriate concentrations revealed that Schnitzer Station S3 and Todd Shipyard Stations T4 and T5 had the lowest number of larvae while none of the Schnitzer Steel stations and all Todd Shipyard stations had significantly greater percentages of abnormal larvae. The decreased number of survivors at Schnitzer Steel occurred without a concomitant increase in abnormal larvae percentages while the number of larvae at Todd Shipyard, though greater, had decidedly greater percentages of abnormal larvae.

The cause of decreased survial and greater percentage of abnormal larvae in the bioassay at Schnitzer Steel cannot be shown to be either related to contaminant impacts or to the effects that increased particles may have had on developing oyster larvae. This is in contrast to the Todd Shipyard samples. The combination of increased abnormal development with increased developing larvae seems to indicate a contaminant is affecting the test. The contaminant(s) not only increase mortality of larvae in most samples but also affect normal development.

The percent of sediment elutriate that causes 50% abnormal development (EC50) is summarized in Table 4.1.

TABLE 4.1. Percent of Sediment Elutriate That Causes Abnormal Development in 50% (EC50) of Developing Larvae

Station	Water Source	% Elutriate	Deviation
Sequim Bay	Sequim Bay	1396	815
Sequim Bay	Alcatraz	234	69
Schnitzer Steel			
S1	Alcatraz	21.7	1.5
S2	Alcatraz	24.7	2.5
S3	Alcatraz	23.7	4.0
Todd Shipyard			
T4	Alcatraz	(a)	(a)
T5	Alcatraz	(a)	(a)
T6	Alcatraz	17.3	4.5
T7	Alcatraz	4.7	5.5
Alcatraz	Alcatraz	28.7	0.6

(a) Unable to calculate.

4.1.2 Alcatraz Reference Water Toxicity

The data presented in Section 4.1.1 concerning Alcatraz reference water bioassay results versus Sequim Bay seawater results suggest that the ARW was toxic to the oyster larvae and influenced normal development. The indication is that a contaminant is present in the reference water that is scavengable by sediment elutriates from Sequim Bay. Therefore, the likelihood that the contaminant might be a water quality parameter such as decreased D.O. or increased nutrients (ammonia, nitrates, or nitrites) is unlikely since increases in sediment elutriate should have the potential for raising nutrient levels and decreasing dissolved oxygen concentrations. The source of the contamination is not known. One possible explanation is that during water collection, handling, storage, transport or use, the water became contaminated to a level that was deleterious to the oyster larvae.

The possibilities of contamination of water during sampling or post-sample handling have been discussed with the USACE, San Francisco District, and a review of MSL procedures for handling the Alcatraz reference water. In a personal communication, USACE has indicated that ARW is not normally toxic in oyster larvae tests. Unfortunately, our data can neither confirm nor deny this statement.

Review of MSL bioassay procedures has shown that the ARW was treated in exactly the same way as the SBRW. This suggests that MSL storage and use of this water did not affect its toxicity or impart contamination.

The only other likely explanation for the Alcatraz water toxicity is that the samples of water became contaminated during collection or transport to MSL. The field collection information provided by Kennedy/Jenks/Chiton and Sea Surveyor (Appendix A) seems to indicate that a non-contaminating water sampler was used.

The water, however, was transported and then stored in plastic jugs for periods of more than 1 week. There is a possibility that the water became contaminated by these plastic containers. Phthalates esters are a potential contaminant in plastic products (Pierson et al. 1984) and they have been observed to occur in blood that has been stored in plastic bags (Guess et al. 1967). Phthalate esters are lipophilic, dissolving easily in organic solvents, but are generally described as being relatively insoluble in water. They can become apparently more soluble in water through three processes. First, they may adsorb to physical particles in the water column. Secondly, they may associate with fulvic or humic acids, and thirdly, they may be trapped on the outside of particles through processes other than adsorption (Pierson et al. 1984). All these processes may have occurred in the unfiltered seawater collected from the Alcatraz Island Disposal Site. The apparent solubility of phthalate esters in deionized water ranges from 0.34 to 4000 mg/L, which is higher than apparent toxicity thresholds observed in certain marine organisms. It appears that phthalate esters may be a potential contaminant resulting from the use of plastic jugs as storage containers for bioassay seawater.

4.2 DISCUSSION OF CONTAMINANT SIGNIFICANCE

4.2.1 Comparison of Alcatraz to Potential Dredge Sites

Forty contaminants were detected in the sediments from the Alcatraz Island Dredged Material Disposal Site, three stations near Schnitzer Steel, and the four stations near Todd Shipyard. The relative significance of these contaminants was determined by comparing them to the background concentrations of the same materials at the proposed dredged material disposal site near Alcatraz Island. Between 12 and 24 of these contaminants had concentrations that were at least twice the background levels observed at the Alcatraz Island Dredged Material Disposal Site (Table 4.2).

Schnitzer Steel sediments had metals concentrations that ranged from less than the Alcatraz Island reference sediment to a 5-fold enrichment. Cadmium, lead, and mercury had the largest elevations compared to the reference site. These sediments also had concentrations of PCBs in the 100-250 µg/kg (dry wt) range while the reference sediments had undetected levels of the types of PCBs that were present at Schnitzer Steel.(Reference samples

TABLE 4.2. Relative Level of Difference Between the Concentrations of a Chemical at a Proposed Dredging Site and the Alcatraz Island Dredged Material Disposal Reference Site

	Station						
	Schnitzer Steel			Todd Shipyard			
Contaminant	S1	S2	S3	T4	T5	T6	T7
acenaphthene	-	58	-	-	283	-	-
diethylphthalate	2.9	-	-	-	-	-	-
fluorene	-	-	-	-	273	91	-
phenanthrene	2.0	4.2	4.1	1.8	12.9	9.4	3.2
anthracene	108	298	-	-	574	445	-
di-n-butylphthalate	3.8	16	-	-	-	21.7	24.3
fluoranthene	2.1	6	5.8	1.9	11.3	7.9	3.1
pyrene	10.3	25	48.4	18.1	39.6	51	14.4
butylbenzylphthalate	90	315	-	-	-	-	-
benzo(a)anthracene	2.3	4.4	4.7	2.8	15.3	21.2	5
bis(2-ethylhexyl)-phthalate	0.4	1.1	-	0.5	0.3	1	0.5
chrysene	13.7	21.8	-	15.5	64.4	-	-
benzo(b)fluoranthene	-	-	-	-	-	-	-
benzo(k)fluoranthene	2.7	6.2	8.6	7	12.3	24.6	6
benzo(a)pyrene	2.5	6.4	9	5.4	10.7	16.3	4.7
indeno(1,2,3-cd)pyrene	2.4	5.8	8.2	3.5	10.9	15.1	-
benzo(ghi)perylene	2.5	6.3	9.5	3.2	9.6	11.4	3.1
aroclor 1016,1242,1248	-	88	-	-	-	-	-
aroclor 1248	-	-	-	-	191	186	205
aroclor 1254	180	158	98	281	337	928	1009
aroclor 1260	-	.97	1.3	2.3	1.6	2.9	2.4
Sb	0.9	2.6	1.3	1.1	4.6	6.7	4
As	1.0	0.7	1	0.5	1.6	1.2	0.8
Cd	2.1	2.9	1.5	1	2.9	1.7	1.9
Cr	0.9	1.4	0.9	1.7	1.6	3.8	1.8
Cu	1.3	1.5	1.5	1.8	6.1	8	4.2
Pb	1.7	3.5	3	2.7	6.1	8.5	6
Hg	1.6	5	2.9	5	32.1	16.2	10.4
Ni	1.1	0.9	1.1	0.7	1.3	1.8	1.3
Se	1.2	0.5	0.7	0.3	1.1	0.7	1
Ag	1.2	1.5	1.7	0.9	2.7	1.7	1.9
Tl	1.0	0.8	1	0.6	0.9	0.7	1
Zn	1.4	2	1.6	1.4	3.2	4.2	2.2
butyltins	1.9	4.7	1	1.2	0.1	3.1	9.9
tributyltin	1.0	0.6	0.6	1.9	0.05	5.9	19.2
organic carbon	1.5	1.2	2	0.6	1.6	1.2	1.1
oil and grease	0.9	3.4	2.2	1.3	3.7	3.4	1.4
CN	na	na	na	na	na	na	na
total sulfides	1.0	1.4	2.6	2	1.7	1.2	1.8
dissolved sulfides	3.8	2.6	1.8	3.9	7	6.3	4.8

had approximately 100 µg/kg (dry wt) aroclor 1260.) Polynuclear-araromatic hydrocarbons that exceeded reference levels were the higher molecular weight materials such as acenapthene, anthracene, pyrene, and chrysene, which are typically found in the more weathered petroleum products (Word et al. 1987). A phthalate, butylbenzylphthalate, was also found at enriched levels.

Todd Shipyard sediment samples had metals concentrations that ranged from less than the reference levels at the Alcatraz Island Dredged Material Disposal Site to more than 30 times the reference levels. Again, mercury and lead were elevated, along with copper and organotins. Mercury and organotins had the greatest enrichment relative to reference levels. PCBs were also high with concentrations ranging from approximately 280 to 1250 µg/kg (dry wt). Polynuclear aromatic hydrocarbons that exceeded reference levels were the higher molecular weight materials such as acenaphthene, fluorene, anthracene, pyrene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, and benzo(a)pyrene, which are typically found in more weathered petroleum products (Word et al. 1987). A phthalate, butylphthalate, was also found in these samples. The significance of these elevations in chemical contaminants is discussed below.

4.2.2 <u>Organotin Concentrations</u>

Organotin concentrations in three of the sediment samples near Todd Shipyard ranged from 91 to 1003 µg/kg (dry wt). The level of the more toxic tributyltin form ranged from 58.8 to 729.6 µg/kg (dry wt). Using a relationship developed by Velkins et al. (1986) water concentrations of the organotins can be estimated from the sediment concentration. Predicted organotin water concentrations based on Velkins et al. (1986) are provided in Table 4.3.

TABLE 4.3. Predicted Concentration of Organotins in Water Overlying the Contaminated Sediment near Todd Shipyards. Concentrations are in

	Station Concentrations (µg/L)			
Compound	T4	T5	T6	T7
monobutyltin	0.002	--	0.01	0.00-0.02
dibutyltin	0.03	--	0.03	0.14-0.23
tributyltin	0.04	--	0.11	0.27-0.46

Crassostrea gigas 48-h larvae tests showed an LC50 for tributyltin of 1.6 µg/L (Cardwell and Sheldon 1986). Thain (1986) has shown that concentrations of tributyltin averaging 0.24 µg/L over a 45-day period will cause significant growth depression in both the weight and length of the adult oyster *Crassostrea gigas*. These same oysters had contaminated tissue levels as high as 2.38 µg/kg (wet wt). Short and Thrower (1986) showed that water concentrations of 1.5 µg/L would kill 50% of exposed juvenile king salmon over a 96-h period. The acute salt water concentration of tributyltin that has been established for water quality criteria is 0.22 µg/L while the chronic sea water quality criteria is 0.069 µg/L. Stations T6 and T7 either approached or exceeded these levels of observed effects. The levels of organotins in these sediments were sufficiently high to be of concern.

4.2.3 Polychorinated Biphenyl (PCB) Concentrations

PCBs also appeared quite high in each of the Todd Shipyard samples. The total PCB concentrations at these stations ranged from 281 to 1214 µg/kg (dry wt). The acute marine water quality criteria is 10 µg/L, while the chronic marine criteria is 0.03 µg/L. The organic carbon partitioning coefficient and the equilibrium partitioning relationship described by Staples et al. (1985) allows prediction of the contamination level that would be observed in overlying water based upon these sediment concentrations (Table 4.4). Comparison of these predicted values

TABLE 4.4. Predicted Water Concentrations of PCBs in Water Overlying Contaminated Sediments near Todd Shipyards Using the Organic Carbon Partitioning Model Described in Staples et al. (1985)

Contamination Component	Station T4	T5	T6	T7
Sediment PCB concentration (µg/kg-dry)	281	528	1114	1214
Organic carbon concentration (mg/g-dry)	0.8	2.0	1.6	1.4
Predicted PCB concentration (µg/L)	0.01	0.004	0.01	0.01

to the water quality criteria allows an assessment of the significance of the levels observed in the sediment. In no case did the concentration of PCBs predicted to occur in overlying water exceed the chronic or acute water quality criteria for marine water. Three of the four stations did, however, approach the chronic level criteria for marine water. Since the method of prediction has several sources of potential variation (including the organic carbon partitioning relationship), this level should be viewed as a warning that there is a potential for concern regarding the concentration of PCBs in sediments at these sites.

4.2.4 Mercury Concentrations

Mercury concentrations are of concern at all Todd Shipyard stations and one of the Schnitzer Steel stations (S2). National standards for mercury established in 1972 permit a maximum concentration of total mercury of 1.0 mg/kg (dry wt) in sediments (OECD 1974). This level is exceeded at all these stations.

5.0 CONCLUSIONS

Significant mortality and abnormalities in developing oyster larvae were observed when the organisms were exposed to the Alcatraz Island reference water. However, these results have to be qualifed because of potential contamination of Alcatraz reference water during collection or transport. It may be possible to measure the concentrations of various contaminants in this reference water to determine if our suppositions are correct about contamination from the phthalates in the plastic jugs in which the water samples were stored. It is highly recommended that future water samples be stored in appropriately cleaned glass carboys rather than plastic jugs.

Sediment samples were collected for dissolved and total sulfides as well as cyanides without reference to appropriate sample preservation protocols. The data produced from these inappropriately preserved sediment samples should not be viewed as accurate. They may be too high in the case of the sulfides because of sulfide generation after the samples were collected, or they may even be too low as a result of sulfide losses to the atmosphere. If cyanide had been present in any of the samples, it was most likely lost through decomposition. In the future, sediment samples for these types of measurements must be preserved in the field with appropriate procedures.

Sediments were frozen during the original storage of the material. This is an inappropriate procedure for samples of sediment that will be analyzed for grain size or dissolved sulfides or that will be used for bioassays. The problem associated with freezing sediments is that during the freezing and defrosting cycles the sediment particles can be fractured because of expanding water. Upon fracturing, the particles can be changed in size. The particles can also release contaminants that might not be normally available to the organisms exposed through the bioassay tests. Freezing sediment samples probably would not affect the total quantity of metal or priority pollutant contaminants measured, because the extraction procedures are generally very destructive to ensure that the majority of the contaminants in a sediment sample are removed and made available for measurement.

In spite of the deviations observed from some of the sampling protocols, it is apparent that sediments from Todd Shipyard are significantly enriched with a number of chemical contaminants compared to concentrations at the Alcatraz Island Disposal Site. Of most concern are organotins, mercury, and PCBs. These chemical contaminants are at, near, or higher than the marine water quality criteria values and are also at levels that have been shown to affect marine organisms during water column exposure tests. Sediment elutriate tests not only showed significant mortality of oyster larvae during exposure, but also showed increased abnormal development. These results seem to indicate that contaminants in the sediments at Todd Shipyard can be expected to have an adverse impact on water column organisms during disposal operations.

The Schnitzer Steel sediment samples do not appear to have the same level of contamination problem nor do they show the same level of bioassay impacts observed with the Todd Shipyard sediment samples. There were significant larvae mortality, but the proportion of abnormally developed larvae was not significantly different than larvae exposed to uncontaminated Sequim Bay or Alcatraz Island sediments. Decreased survival because of exposure to Schnitzer Steel sediment may be a response to an as yet undocumented effect of fine-grained sediment on the development of oyster embryos. This effect needs to be evaluated in the future.

We do not know what the effects might be on organisms exposed to the actual solid phase of the sediment bound contaminants. There is a potential for organisms living in or near the sediment to accumulate contaminants in their tissues or to actually be affected by the sediment bound contaminants. It is recommended that the sediments be tested with an appropriate organism, in an attempt to demonstrate this effect.

Because the sediment at potential dredge sites is so fine, it may not be appropriate to use the infaunal dwelling amphipod Rhepoxynius abronius for a test organism. It is well known that this organism has variable survival when exposed to extremely fine sediments (Swartz et al. 1985). A more appropriate test might be a juvenile clam bioassay coupled with a bioaccumulation study of a filter feeding as well as a deposit feeding clam. These tests would indicate the potential for mortality and bioaccumulation from bulk sediment, as well as the potential for bioaccumulation of contaminants released from sediment into the water column.

One species that could be selected for these tests would be the California mussel, Mytilus californiensis, suspended above the sediments to evaluate the potential for bioaccumulation of contaminants released to the water column. Young native or japanese littleneck clams, Protothaca or Venerupis, could be used for evaluation of survival under exposure to the solid phase of the sediment. Relatively large clams that are deposit feeders could also be used to determine the potential for bioaccumulation resulting from ingesting and/or exposure to the sediments. Examples of these organisms would include certain species of the clam genera Macoma spp. and potentially Tellina spp. The most reasonable method of performing these tests would be to establish the organisms in a large flowing seawater system that would allow all organisms to be exposed at the same time over a specific period of time. The exposure would ideally be from 10 to 30 days. Contaminant measurements would be made at intervals to see if there was a change in the availability of the contaminants over this period of time.

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APPENDIX A

FIELD COLLECTION NOTES AND INFORMATION

Kennedy/Jenks/Chilton
Laboratory Division
657 Howard Street
San Francisco, California 94105
415-362-6065

January 14, 1988

Mr. Jeffrey Ward
Battelle Pacific Northwest Division
Marine Research Laboratory
439 West Sequim Bay Road
Sequim, WA 98382

Dear Mr. Ward:

Enclosed is the information regarding the samples collected for the Port of Oakland, which you requested in your letter of 6 January, 1988. Addressing your questions in the order of your letter:

- Attachments 1-A through 1-L include copies of site maps provided to us by the Port of Oakland. Annotations and additional site sketches were made by our field technician. Sea Surveyor provided coordinates of the sample locations at the Alcatraz disposal site. A map of the area is also enclosed.

- For all turning basin and berths 61-64 samples, a water pressure driven Shelby tube piston sampler was used to obtain the cores. A new epoxy coated 2.5 foot by 4 inch diameter Shelby tube was used each day. The tubes were cleaned prior to and between each use with surface site seawater and a brush. The devices used to collect Alcatraz disposal site samples are described in the letter from Sea Surveyor (attachment 1-k). In a follow-up conversation with Mack Sullivan of Sea Surveyor, he informed me that all sampling devices and lexan liners were steam-cleaned prior to use.

- Sediment samples from the turning basin and berths 61-64 were extruded from a Shelby tube into new plastic bags, which have proven to be practical and have not presented any contamination problems in our past experience. All samples were double-bagged and stored in a cooler with "blue ice" coolant immediately after collection. The alcatraz disposal site sediments were retained in their Lexan tubes which were capped with plastic and sealed with tape. These cores were also stored and transported to our laboratory in a cooler with "blue ice". The Alcatraz disposal site water was collected into 6 separate 5 gallon plastic jugs. These water samples were not refrigerated during transport or while being held in the laboratory.

(continued)

Kennedy/Jenks/Chilton

- All sediment samples were frozen while being held in the laboratory. They were shipped to you in coolers containing "blue ice". The Alcatraz disposal site water was shipped in the original containers without any cooling material.

- Sampling stations for sediments in the turning basin and berths 61-64 were located by measuring from landmarks using a measured rope. Distances along the length of berths 61-64 are clearly marked on the sides of the docks. Sea Surveyors' letter (attachment 1-k) described their navigation technique employing a laser positioning system.

- Attachments 2A through 2C list the core lengths and depths to bottom relative to MLLW for all sample stations. Soundings for the turning basin and berths 61-64 were taken, using a measured weighted plumb line. Corrections for the tide were applied using a tide table and tide board for reference. Soundings at the Alcatraz disposal site were taken using a Raytheon DE 719 Survey grade fathometer which was calibrated using the bar check method.

- A copy of the field notes from the turning basin and berths 61-64 sampling are included as attachments 3-A through 3-F. I questioned our field technician for the following additional information: The turning basin samples were collected December 21, 1987, in the morning while a nearly high tide peeked, and dropped again. The weather was overcast but not raining. Our technician, Joshua DeCarl, was accompanied by Pitcher Drilling's rig operator Sheldon Lovedahl and his assistant, Jeff Lance. The berth 61-64 samples were collected December 30, 1987, in the morning, while a high tide was dropping. The weather was overcast with some drizzle. The same persons listed above were present. I contacted Mack Sullivan of Sea Surveyor regarding the conditions under which the Alcatraz disposal site samples were collected. He informed me that the sampling was done in the morning of December 30, 1987, with an outgoing high tide. The weather was overcast and raining. Mr. Sullivan and his assistants Peter Jepsen and Clayton Hollson performed the sampling.

We trust that the enclosed information will be sufficient for your writing of your report. If however, you require any additional information or clarifications, do not hesitate to contact me.

Sincerely,

Gregg W. Bryden
Laboratory Field Services Supervisor

GWB/lhg

cc: David Hayes, Port of Oakland

Sea Surveyor, Inc.

Precision Marine Surveying
for the Engineering Community

8 January 1988

RECEIVED

JAN 11 1988

KENNEDY/JENKS/CHILTON
LABORATORY DIVISION

Kennedy/Jenks Engineers
657 Howard Streeet
San Francisco, CA 94105
ATTENTION: Mr. Ted Macamura

Dear Mr. Macamura:

Sea Surveyor, Inc. genuinely appreciates the opportunity to have collected six (6) 1' sediment samples and twenty-five (25) gallons of seawater from the Alcatraz Dredged Material Disposal Site in San Francisco Bay. The sediment samples were collected in Lexan liners that were contained within a *Benthos* Model 2171 gravity corer. The samples were collected at the following locations:

Station	California State Coordinates (Zone III)	
A3	N 487,105	E 1,444,388
A4	N 487,286	E 1,443,753
A5	N 486,699	E 1,443,840
B4	N 486,930	E 1,444,991
C1	N 486,615	E 1,444,789
D3	N 486,349	E 1,444,472

Location of the coring vessel was determined using a manned *E.S.P.* laser range/azimuth positioning system established at Monument 7 on the Municipal Pier.

Water samples were collected from mid-depth within the Alcatraz Dredged Material Disposal Site using a teflon-lined Go-Flow discrete sampling water bottle.

Again, thank you for giving Sea Surveyor the opportunity to be of service.

Sincerely,

S. M. Sullivan

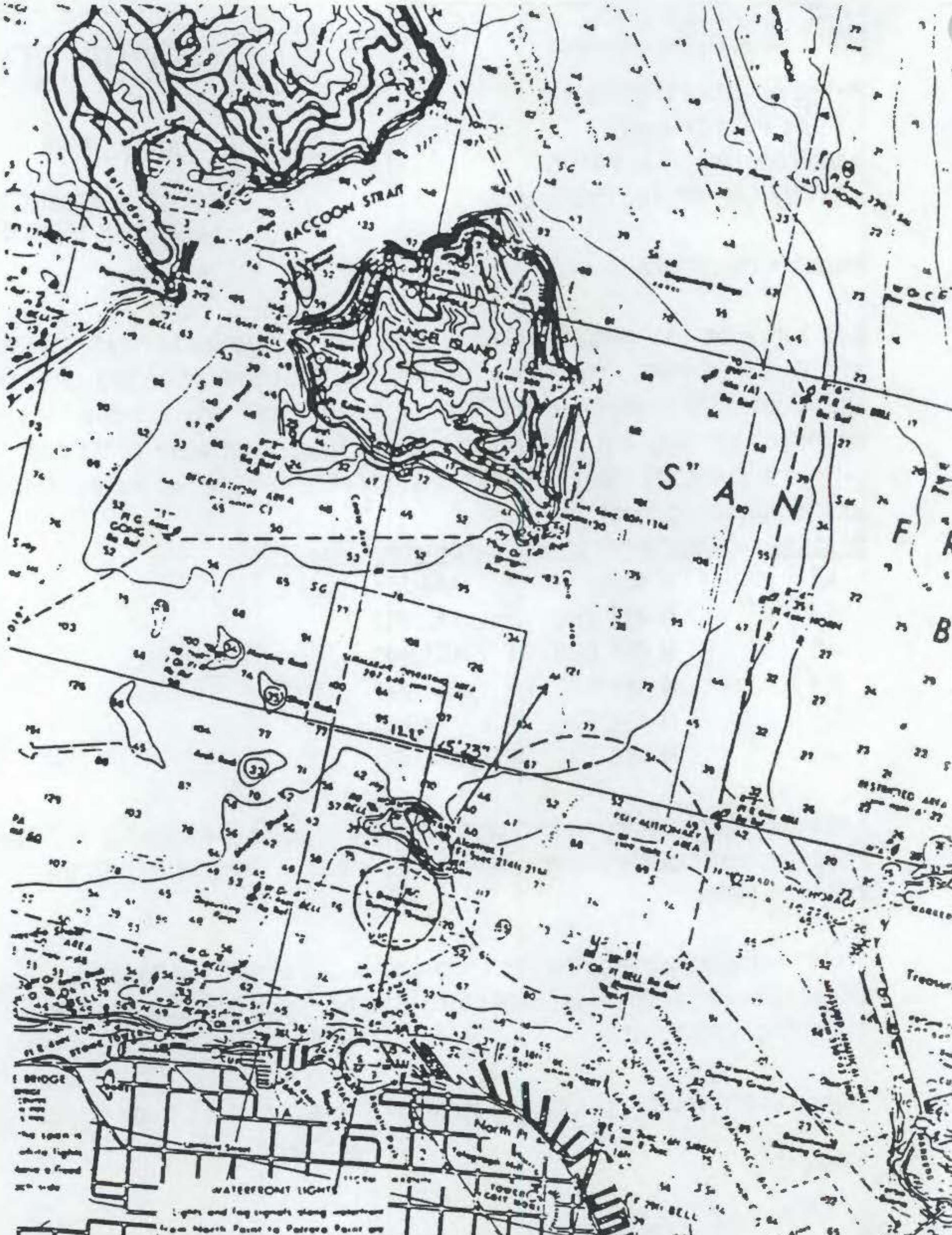
S. Mack Sullivan
President

△ 7713 Fay Ave., Ste. B
La Jolla, CA 92037
(619) 753-3643

△ 2646 Palma Dr., Ste. 400
Ventura, CA 93003
(805) 644-7722

△ 333 First St.
Benicia, CA 94510
(707) 746-1853

△ 15130 65th Ave. S., Ste. B-22
Tukwila, WA 98188
(206) 242-5100


Belvedere
RACCOON STRAIT
ANGEL ISLAND
S AN FR
B
RECREATION AREA
RESTRICTED AREA
North Pt
WATERFRONT LIGHTS
Lights and fog signals along waterfront
from North Point to Potrero Point are
privately maintained
AN FRANCISCO
Treasure

4x4 Grid Sheet 12/23/07 Kennedy/Jenks/Chilton

By Ze Carl Date 23/12/07 Subject Port of Oakland Job No.

Checked By Date Sheet 2 of 2

Were unable to continue drilling.

SAMPLE DEPTH SUMMARY

Station	Time	Depth w/Tide	MLLW Depth	Samples
①	8:20	41' (+5)	36'	36'-42'
②	8:45	36' (+6)	30'	30'-42' SAND
③	9:40	44.5' (+6)	38.5'	38.5'-44'
④	10:07	38' (+6)	32'	32'-44'
⑤	10:48	32' (+6)	26'	26'-44'
⑥	12:00	39' (+7)	32'	32'-41' SAND
⑦	13:12	37' (+5)	32'	32'-35' SAND

The drilling was done by Pitcher Drilling, and samples were taken with a 3' piston sampler.

Joshua Ze Carl

ATTACHMENT 2-A

By DeCarl Date 12/30/87 Subject Port of Oakland Job No 87001 ...
Checked By ________ Date ________ Sheet 2 of 2

Sample	Depth w/Tide	MLLW Depth	TIME	Depth Sampled
①	40'	34'	905	34'-37'
②	34'	32'	1240	32'-35'
			1250	34-37'
③	41'	36'	955	36'-37'
④	36'	35'	1305	35'-38'
⑤	40'	35'	1036	35'-38'
⑥	36'	35'	1317	35-38'

By G. Bryden Date 1/3/88 Subject Port of Oakland Sampling Data Job No ____
Checked By ____ Date ____ Sheet ___ of ___

I contacted Mack Sullivan of sea surveyor today regarding additional information needed for the Port of Oakland sampling project. Here is what he told me:

1) Depth from MLLW to bottom:

Station	Depth to bottom from MLLW (ft)
A-3	48'
A-4	57'
A-5	51'
B-4	43'
C-1	48'
D-3	54'

Soundings made using a Raytheon DE-719 survey grade fathometer calibrated using bar check method

2) Personnel:

Peter Jepsen
Mack Sullivan
Clayton Holtson

3) Weather: overcast and some rain. Sediments and water collected with an outgoing high tide during the morning.

4) Equipment Cleaning: All samplers and Lexan liners were steam cleaned prior to use

By DeCaul Date 23/Dec/87 Subject Port of Oakland Job No 87100.00
Checked By ________ Date ________ Sheet 1 of 2

21 December, 1987, I collected seven samples from the turning basin in the Port of Oakland. The samples were taken from the specified points on the map of the area. I numbered the sample points ① - ⑦ and these can seen on the included map. Also included are detailed descriptions of each sample point. It would be appreciated if a more detailed map were availible with better land references next time.

All samples were collected down to -49' MLLW, and any reference to depths in this report are at MLLW. Samples taken at stations ②, ⑥ and ⑦ were not taken from -49 MLLW because we hit sand at shallower depths and

By Ra Carl Date 23/12/87 Subject Port of Oakland Job No

Checked By Date Sheet 2 of 2

Were unable to continue drilling.

SAMPLE DEPTH SUMMARY

Station	Time	Depth w/Tide	MLLW Depth	Samples
①	8:20	41' (+5)	36'	36'-42'
②	8:45	36' (+6)	30'	30'-42' SAND
③	9:40	44.5' (+6)	38.5'	38.5'-44'
④	10:07	38' (+6)	32'	32'-44'
⑤	10:48	32' (+6)	26'	26'-44'
⑥	12:00	39' (+7)	32'	32'-41' SAND
⑦	13:12	37' (+5)	32'	32'-35' SAND

The drilling was done by Pitcher Drilling, and samples were taken with a 3' piston sampler.

Joshua Ra Carl

DAILY REPORT

Pitcher Drilling Co., Drilling Contractors

Job No. ______ Rig No. Raft Date 12-21-Mon. 19 87

FOR Kenning Jenke Location East m. [illegible]

FROM TO

Hole # 7 holes 22 sample

Materials:

Mud ______

Tubes 1G foreign tool

Pipe ______

Other ______

Other Expenses ______

Remarks: ______

Rig travel to and from Job Site 1 1/2 [illegible] Hrs. 3

On Site 7:00 Rig Hrs. 7 1/2

Helper Jeff Lamee Total Hrs. ______

Driller [illegible] Total Hrs. ______

From 5:30 a.m. to — From — p.m. to ______

Driller [signature] (Sign here) Client [signature] (Sign here)

Drilling as directed. It is understood and agreed that Pitcher Drilling Co., assumes no liability for subsurface conduits, cables, pipes or appurtenances.

ATTACHMENT 3-C

4x4 Grid Sheet Kennedy/Jenks/Chilton

By RC Carl Date 12/31/87 Subject Port of Oakland Job No E-[illegible]

Checked By ______ Date ______ Sheet 1 of 2

I sampled Port of Oakland with the Pitcher Drilling rig on 30 Dec 1987. Samples were taken adjacent to the President Lines shipping deck. The enclosed maps clearly marks the sample sites. Sample sites #2, #4 and #6 were changed due to water depths exceeding the dredging depth (-37' and -38' mllw). The new sample sites are also clearly marked on the maps. The new sites were chosen by Gregg Bryden and myself, upon authority of Port of Oakland officials.

Samples at Berths #60, #61 were taken at -37' mllw, and Berths #62, #63 at -38' mllw.

Joshua RcCarl

By DeCarl Date ______ Subject Port of Oakland Job No 870001.__ L.

Checked By ______ Date ______ Sheet 2 of 2

Sample	Depth w/Tide	MLLW Depth	TIME	Depth Sampled
①	40'	34'	9:05	34'-37'
②	34'	32'	1240	32'-35'
			1250	34'-37'
③	41'	36'	955	36'-37'
④	36'	35'	1305	35'-38'
⑤	40'	35'	1036	35'-38'
⑥	36'	35'	1317	35-38'

DAILY REPORT

Pitcher Drilling Co., Drilling Contractors

Job No. ______ Rig No. First Date 12-30-[illegible] 19__

FOR [illegible] Location [illegible]

FROM TO

Hole # [illegible]

Materials:

Mud ______

Tubes ______

Pipe ______

Other 1½ [illegible] Tube

Other Expenses ______

Remarks: ______

Rig travel to and from Job Site [illegible] Hrs. [illegible]

On Site 7:30 Rig Hrs. 1½

Helper [illegible] Total Hrs. ______

Driller [illegible] Total Hrs. ______

From 6:[illegible] a.m. to — From — p.m. to ______

Driller [illegible] Client [illegible]
(Sign here) (Sign here)

Drilling as directed. It is understood and agreed that Pitcher Drilling Co., assumes no liability for subsurface conduits, cables, pipes or appurtenances.

FIELD SAMPLING NOTES

(S1)

Project: PORT OF OAKLAND

Location: Schnitzer Steel Job No. ______

Date: 21 December Time: 8:20

Sampled by: DeCARL / PITCHER DRILLING

Field Sample No.: (1)

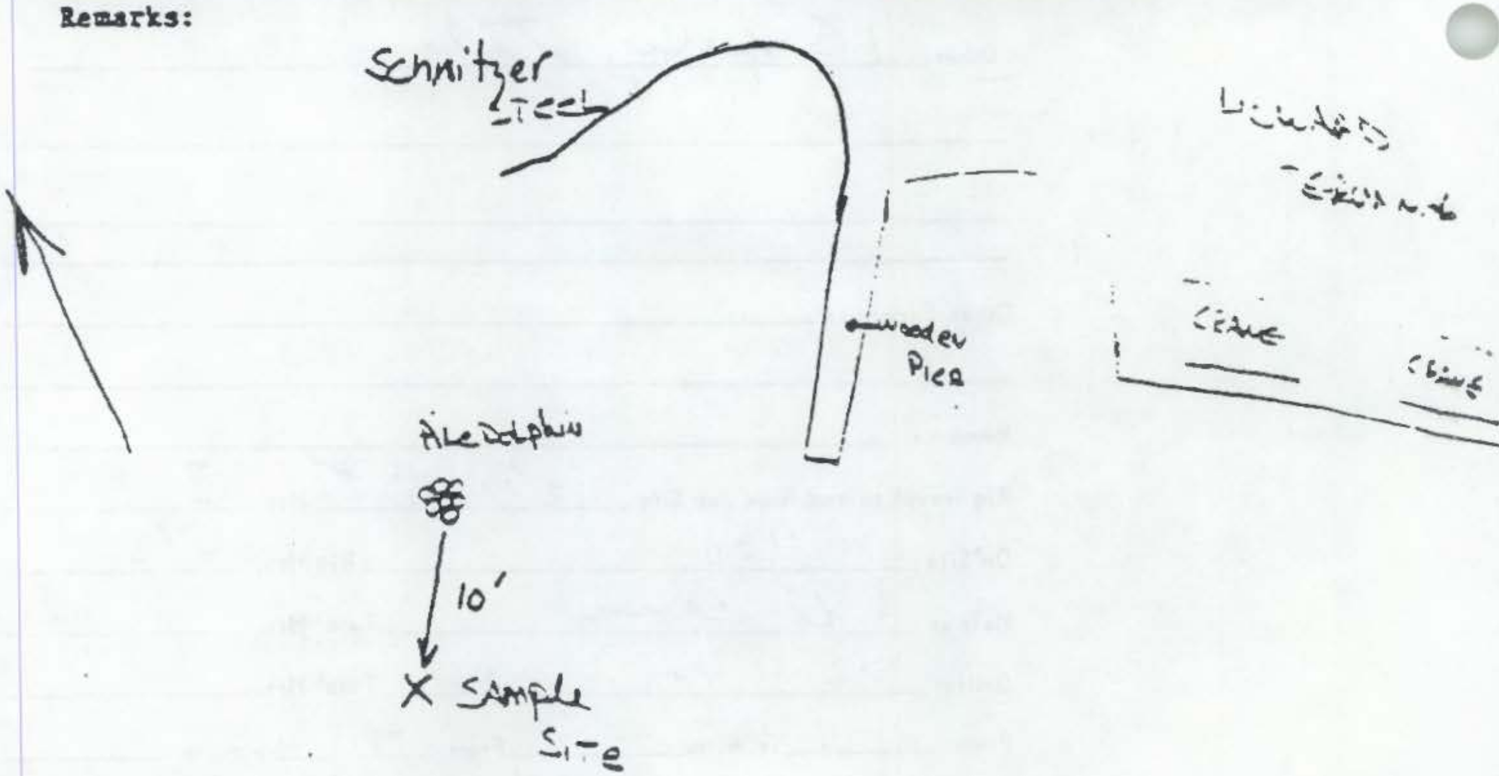
Type of Sample: SOIL
(Soil, Oil, Water, etc.)

Sampling Method: PISTON SAMPLER

Depth: 36' — 42'

Point of Collection: 10' off Pile Dolphin
(Near or direction from)

Remarks:



S2

FIELD SAMPLING NOTES

Project PORT OF OAKLAND

Location Schnitzer STEEL Job No.

Date 21 DeCember Time 855 - 910

Sampled by DeCarl / DITCHER DRILLING

Field Sample No. (2)

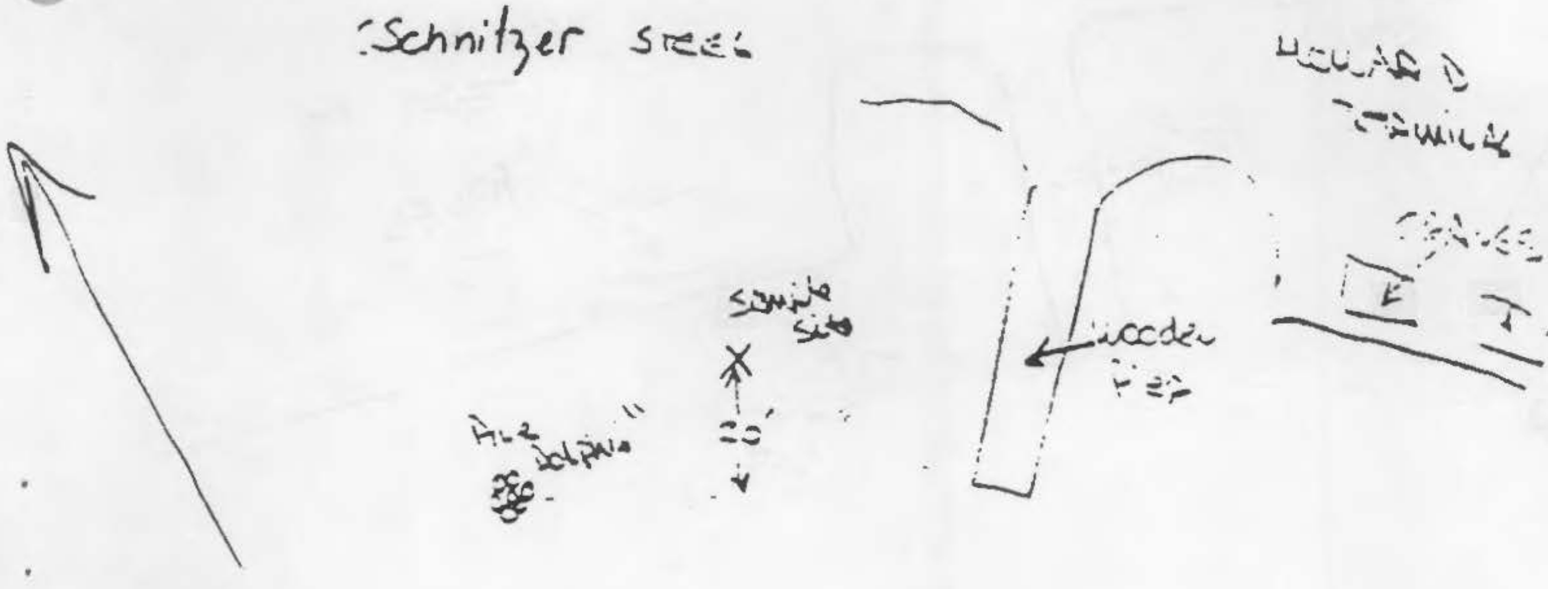
Type of Sample SOIL
(Soil, Oil, Water, etc.)

Sampling Method PISTON SAMPLER

Depth 30' - 42'

Point of Collection [illegible] 20'
(Near or direction from)

Remarks:



ATTACHMENT 1-C

FIELD SAMPLING NOTES

(S3)

Project: Port of Oakland

Location: Schnitzer Steel / Howard Terminal Job No. ______

Date: 21 December Time: 950 - 955

Sampled by: DeCarl / Pitcher Drilling

Field Sample No.: (3)

Type of Sample: Soil
(Soil, Oil, Water, etc.)

Sampling Method: Diston Sampler

Depth: 38.5' — 44'

Point of Collection: [illegible]
(Near or direction from)

40' off Cement dock

Remarks:

ATTACHMENT 1-D

(T4)

FIELD SAMPLING NOTES

Project PORT OF OAKLand

Location TODD ShipYARD Job No. ______

Date 21 December Time 1015 – 1040

Sampled by DeCARL / PITCHER DRILLING

Field Sample No. (4)

Type of Sample Soil
(Soil, Oil, Water, etc.)

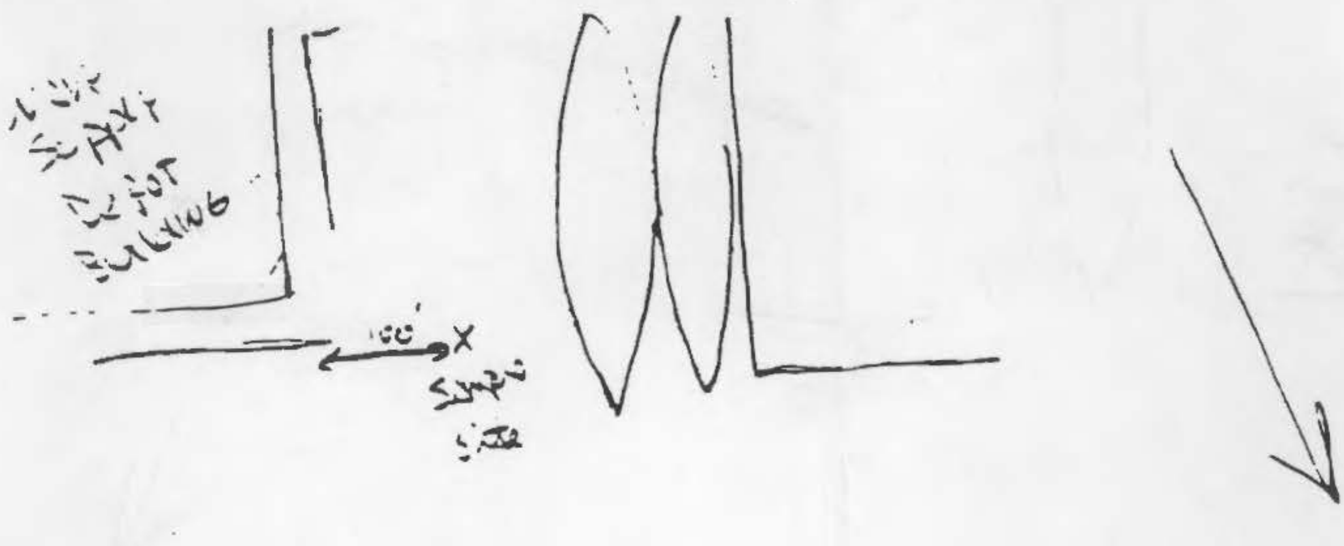
Sampling Method PISTON SAMPLER

Depth 32' – 44'

Point of Collection ABOUT 100' OFF NAVY SUPPLY DOCK lined up with the Dock
(Near or direction from)

Remarks:

TODD ShipYARD



FIELD SAMPLING NOTES

T5

Project PORT OF OAKLAND

Location TODD SHIPYARD Job No.

Date 21 DECEMBER Time 1100 - 1140

Sampled by DECARL / PITZHER DARLING

Field Sample No. (5)

Type of Sample Soil
(Soil, Oil, Water, etc.)

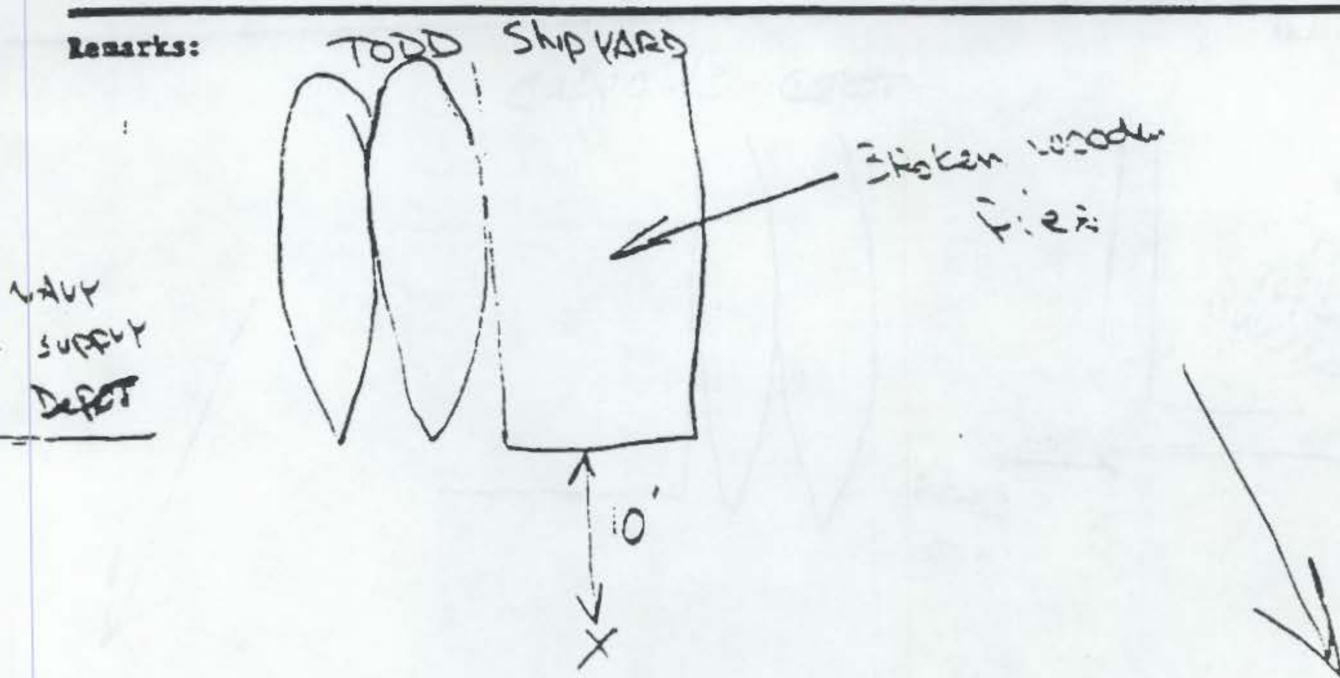
Sampling Method Piston Sampler

Depth 26' - 44'

Point of Collection 10' off the Broken wooden Pier opposite
(Near or direction from)

NAVY SUPPLY DEPOT

Remarks:



ATTACHMENT 1-F

FIELD SAMPLING NOTES

T6

Project: PORT OF OAKLAND

Location: TODD SHIPYARD — Job No.

Date: 21 December — Time: 1212 - 1228

Sampled by: DeCarl / Pitcher

Field Sample No.: (6)

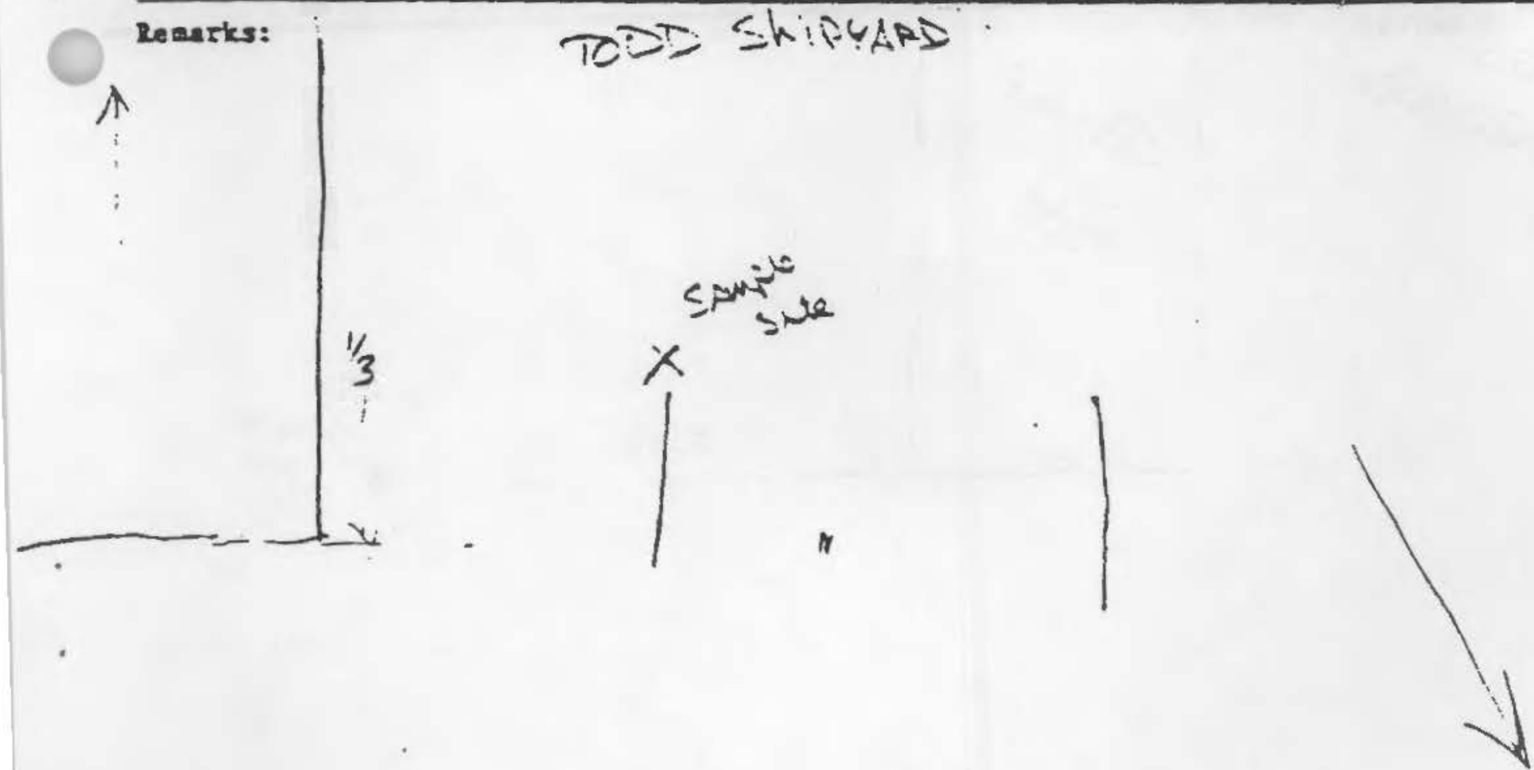
Type of Sample: Soil
(Soil, Oil, Water, etc.)

Sampling Method: Piston Sampler

Depth: 32' - 38'

Point of Collection: 1/2 way between piers about 1/3 way down the west pier
(Near or direction from)

Remarks:



(T7)

FIELD SAMPLING NOTES

Project PORT OF OAKland

Location TODD ShipYARD Job No. ___

Date 21 December Time 1320

Sampled by DeCARL / PIRCHER

Field Sample No. (7)

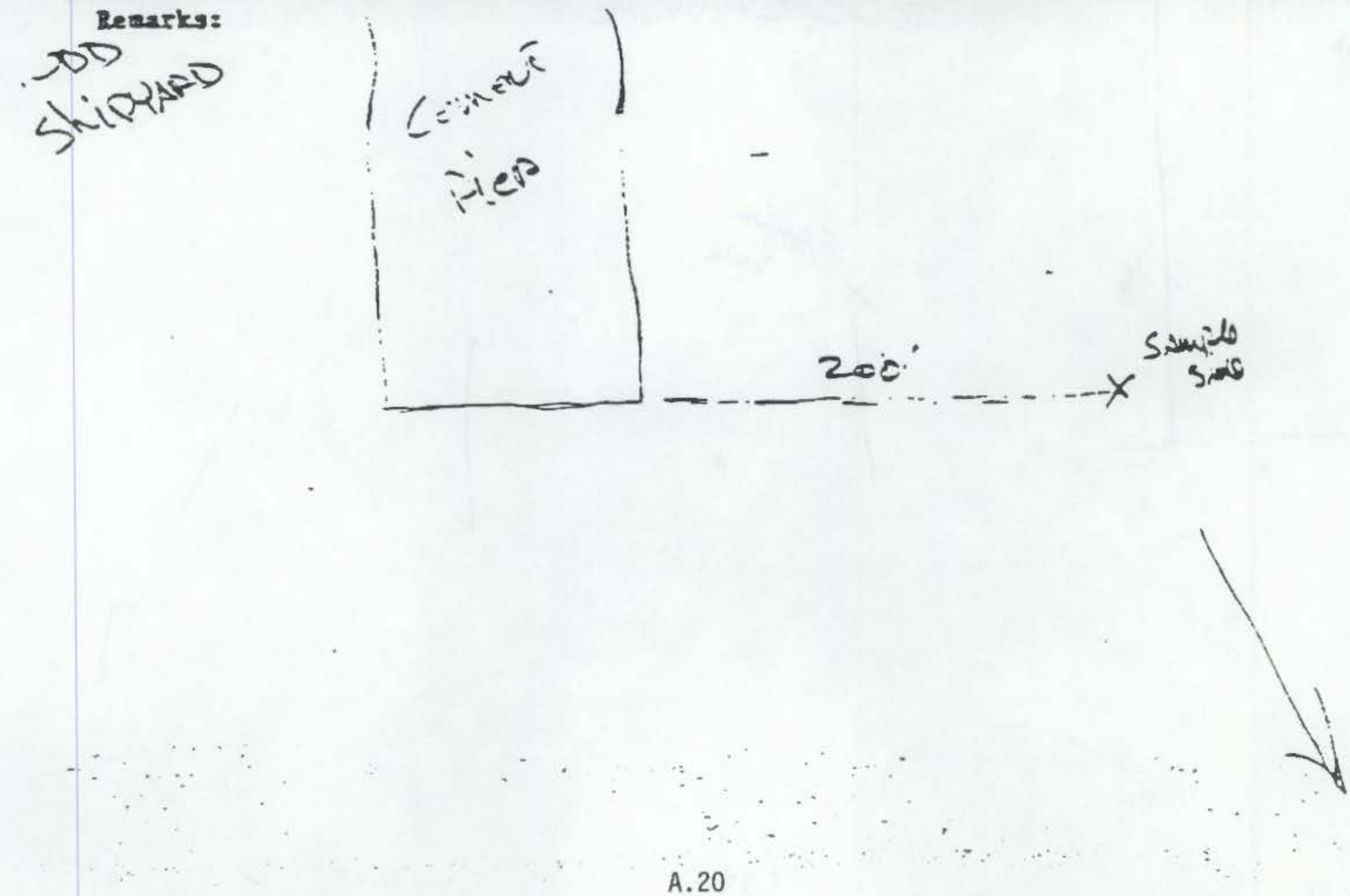
Type of Sample Soil
(Soil, Oil, Water, etc.)

Sampling Method Piston Sampler

Depth 32'-35'

Point of Collection 200' off Pier, in line with the end
(Near or direction from)

Remarks:



APPENDIX B

CHAIN-OF-CUSTODY INFORMATION

[illegible] Laboratory Division

Field Sample Chain of Custody Record

Source of Sample(s) OAKland Bay

Collector DeCoul

Address OAKland CA

Organization K/J/C

Address

Phone ( )

Report to (1) TED NAKAMURA

Phone ( )

Sample Information

K/J/C Job Number 87001.00-L-11

Lab No.	Field No.	Date	Time	Type (2)	Depth	Remarks (Suspected Contaminants, Field Conditions, etc.)
78435	①	12/21/87	820-830	S	36'-39', 39'-42'	10' off Dolphin Hit sand
8436	②	/ /	[illegible]		[illegible]	½ way Between Dolphin & Pier sand [illegible]
8437	③	/ /	950-955		38.5'-41.5', 41.5'-44'	off end of concrete pier
8438	④	/ /	1025-1040		[illegible]	left of ship off 20'
8439	⑤	/ /	1100-1140		[illegible]	10' off wooden Pier
8440	⑥	/ /	1212-1238		32-35, 35-38, 38-41	middle of bay hit sand at 41'
8441	⑦	/ /	1320		32-35	Hit sand, tried 3 different depths
		/ /				

Chain of Possession

	Relinquished by (Signature and affiliation)	Date	Time	Received by (3) (Signature and affiliation)	Date	Time
1.	Joshua DeCoul	12/21/87	15:20	[signature] K/J/C	12/21/87	15[20]
2.	[signature]	1/5/88	11[30]		/ /	[illegible]

Logged in at K/J/C by [signature] 12/21/87 16[illegible]

(1) There is a separate Request for Analysis form that should be filled out by the collector and given to the Laboratory when samples are delivered.

(2) e.g. water, sludge, soil, etc.

(3) If any samples are not intact at time of transfer, please describe on the back of this form.

Samples were put into a freezer upon receipt.

[signature]

Kennedy/Jenks/Chilton, Laboratory Division

Field Sample Chain of Custody Record

Source of Sample(s) OAKland Bay | Collector DeCoul
Address OAKland CA | Affiliation K/J/C
| Address
Phone ( ) |
Report to (1) TED NAKAMURA | Phone ( )

Sample Information | K/J/C Job Number 87001.00 – L-11

Lab No.	Field No.	Date	Time	Type (2)	Depth	Remarks (Suspected Contaminants, Field Conditions, etc.)
8435	①	12/21/87	820-830	S	36'-39', 39'-42'	10' off Dolphin Hit sand
8436	②	/ /	[illegible]		30'-33', 33'-36', 36'-39', 39'-42'	½ way Between Dolphin + Pier. sand in ≈ 20'
8437	③	/ /	950-955		38.5'-41.5', 41.5'-44'	off end of concrete Pier
8438	④	/ /	1015-1040		32-35', 35-38', 38-41', 41-44	left of ship off 20'
8439	⑤	/ /	1100-1140		26-29, 29-32, 32-35, 35-38, 38-41, 41-44	10' off wooden Pier
0440	⑥	/ /	1212-1228		32-35, 35-38, 38-41	middle of bay hit sand at 41'
8441	⑦	/ /	1320		32-35	Hit sand, tried 3 different depths
		/ /				

Chain of Possession

Relinquished by (Signature and affiliation)	Date	Time	Received by (3) (Signature and affiliation)	Date	Time
1. Joshua DeCoul	12/21/87	15:20	[signature] K/J/C	12/21/87	15[illegible]
2. [signature]	1/5/88	11:30		1/1	[illegible]

Logged in at K/J/C by [signature] 12/21/87 16[illegible]

(1) There is a separate Request for Analysis form that should be filled out by the collector and given to the Laboratory when samples are delivered.
(2) e.g. water, sludge, soil, etc.
(3) If any samples are not intact at time of transfer, please describe on the back of this form.

Samples were put into a freezer upon receipt. [signature]

(1) MIXING completed 1615 6 Jun -

Port of OAK

Kennedy/Jenks/Chilton, Laboratory Division

Field Sample Chain of Custody Record

Source of Sample(s) Alcatraz Site

Address

Phone ( )

Report to (1)

Collector Jim Cronin

Affiliation Sea Surveyor

Address

Phone ( )

K/J/C Job Number

Sample Information

Lab No.	Field No.	Date	Time	Type (2)	Depth	Remarks (Suspected Contaminants, Field Conditions, etc.)
78580	water	12/30/87		W	25'	5 gal plastic
8581	AC-1230-A3	/		S		reference mud.
8582	AC-1230-A4	/				
8583	AC-1230-A5	/				
8584	AC-1230-B4	/				
8585	AC-1230-C1	/				
8586	AC-1230-D3	/				
		/ /				

Chain of Possession

	Relinquished by (Signature and affiliation)	Date	Time	Received by (3) (Signature and affiliation)	Date	Time
1.	Clayton [signature]	/ /		[signature] KJC	12/31/87	10:30
2.	[signature]	1/15/88	11:30	[signature]	1/6/88	1520

Logged in at K/J/C by [signature] 12/31/87 10:40

(1) There is a separate Request for Analysis form that should be filled out by the collector and given to the Laboratory when samples are delivered.

(2) e.g. water, sludge, soil, etc.

(3) If any samples are not intact at time of transfer, please describe on the back of this form.

Port of OAK

Kennedy/Jenks/Chilton, Laboratory Division

Field Sample Chain of Custody Record

Source of Sample(s) Alcatraz Site   Collector Jim Cronin

Address ____   Affiliation Sea Surveyor

____   Address ____

Phone ( )   ____

Report to (1) ____   Phone ( )

Sample Information   K/J/C Job Number ____

Lab No.	Field No.	Date	Time	Type (2)	Depth	Remarks (Suspected Contaminants, Field Conditions, etc.)
878580	water	12/13/87	[illegible]	W	25'	5 gal plastic
8581	AC-1330-A3	1	↓	S		reference mud.
8582	AC-1330-A4	1				
8583	AC-1330-A5	1				
8584	AC-1330-B4	1				
8585	AC-1330-C1	1				
878586	AC-1330-D3	1	↓	↓		
		/ /				

Chain of Possession

	Relinquished by (Signature and affiliation)	Date	Time	Received by (3) (Signature and affiliation)	Date	Time
1.	Clayton [signature]	/ /		[signature] KJC	12/13/87	10:30
2.	[signature]	1/15/88	11:30		/ /	

Logged in at K/J/C by [signature] 1/3/88 10:40

(1) There is a separate Request for Analysis form that should be filled out by the collector and given to the laboratory when samples are delivered.

(2) e.g. water, sludge, soil, etc.

(3) If any samples are not intact at time of transfer, please describe on the back of this form.

Battelle Marine Research Laboratory

Chain of Custody Form

Laboratory: AmTest, Inc.
14603 N.E. 87th
Redmond, WA 98053
Contact: John Daily

Analysis Requested:

Analysis	Detection Limit (mg/kg)	
Total Organic Carbon	0.1 %	
Total Sulfides	0.1	5.0
Water Soluble Sulfides	0.1	5.0
* Inorganic Cyanide		

Results reported in wet weight and dry weight

Desired Method: EPA approved methodologies suitable for marine sediments and which yield the required detection limits.

QA/QC: See attached sheets

Date Requested: 15 January or ASAP

List of Samples to be Analyzed:

Sample Number	Type of Sample	Released By/Date Battelle MRL	Accepted By/Date AmTest, Inc
878435	Sediment	JWARD 1-8-88	K. Fugil 1/8/88
878436	Sediment	JWARD "	K. Fugil 1/8/88
878437	Sediment	JWARD "	K. Fugil 1/8/88
878438	Sediment	JWARD "	K. Fugil 1/8/88
878439	Sediment	JWARD "	K. Fugil 1/8/88
878440	Sediment	JWARD "	K. Fugil 1/8/88
878441	Sediment	JWARD "	K. Fugil 1/8/88
878587	Sediment	JWARD "	K. Fugil 1/8/88

1-11-88 1030am

* Informed John Daily to analyze for Cyanide. This was accidentally omitted from the above list.

JWard

Battelle Marine Research Laboratory

Chain of Custody Form

Laboratory: ARI, Inc.
333 9th Ave N.
Seattle, WA 98109-5187
Contact: Dave Mitchell

Analysis Requested:

See Attached Sheets

Results reported in wet weight and dry weight

Desired Method: See Attached Sheets

QA/QC: See Attached Sheets

Date Requested: 15 January or ASAP

List of Samples to be Analyzed:

Sample Number	Type of Sample	Released By/Date Battelle MRL	Accepted By/Date ARI, Inc
878435	Sediment	[signature] 1-8-87	[signature] 1/8/87 12:55
878436	Sediment	[signature] "	[signature]
878437	Sediment	[signature] "	[signature]
878438	Sediment	[signature] "	[signature]
878439	Sediment	[signature] "	[signature]
878440	Sediment	[signature] "	[signature]
878441	Sediment	[signature] "	[signature]
878587	Sediment	[signature] "	[signature]

APPENDIX C

SEDIMENT COMPOSITING INFORMATION

APPENDIX C Sediment Compositing Notes

Corps of Engineers, San Francisco District - Sample Log-in Sheets

Attached are copies of the original labels for the sediment collections (pages C.8 - C.10).

There are two sample numbers on these labels: 1)laboratory number and 2)field number. Samples taken near the Alcatraz Island Dredged Material Disposal Site.

Laboratory Number	Field Number	Sample Date	Sample Type	Depth (ft)	Remarks
878580	WATER	12/30/87	WATER	25	in plastic
878581	AL-1230-A3	12/30/87	SEDIMENT		10" core depth
878582	AL-1230-A4	12/30/87	SEDIMENT		9.25" core depth
878583	AL-1230-A5	12/30/87	SEDIMENT		8.75" core depth
878584	AL-1230-B4	12/30/87	SEDIMENT		9.5" core depth
878585	AL-1230-C1	12/30/87	SEDIMENT		9.25" core depth
878586	AL-1230-D3	12/30/87	SEDIMENT		9.75" core depth

Laboratory Number	Further Comments
878580	Water was stored in 5, 5-gallon plastic jugs.
878581	Dark gray color, not black; shell fragments, silty-sand texture.
878582	Dark gray color, silt-clay texture and hard packed no anaerobic odor.
878583	Dark gray color, silt, some sand and shell debris, chemical odor.
878584	Dark gray color, silt with sand (less than in 878583), chemical odor.
878585	Dark grey, not black, shell fragments, silty-sand texture.
878586	Black sediment, very fine texture and compacted. Texture similar to soft cheese, bottom of core black, upper 3/4" of core dark grey under fine green surface.

Oakland Inner Harbor Sampling
Field Summary

Laboratory Number	Field Number	Date	Sample Time	Core Depth (ft)	Comments
878435	1	12/21/87	0830	36-39	10 ft off dolphin
				39-42	
878436	2	12/21/87	0930	30-33	between dolphin and pier
				33-36	
				36-39	
				39-42	
878437	3	12/21/87	0955	38.5-41.5	off concrete pier
				41.5-44	
878438	4	12/21/87	1040	32-35	left of ship, 20 feet off
				35-38	
				38-41	
				41-44	
878439	5	12/21/87	1140	26-29	10 ft off pier
				29-32	
				32-35	
				35-38	
				38-41	
				41-44	
878440	B-6	12/21/87	1228	32-35	middle of bay
				35-38	
				38-41	
				41-44	
878441	7	12/21/87	1320	32-35	hit sand, tried 3 dif. spots

All of these sediments were mixed in a stainless steel bowl with stainless steel spoon. Sediment mixed until even color and texture observed.

This composite is called 878587.

The following quantity of sediment was prepared:

Purpose of Sample	Weight in grams (wet)
Metals (1 of 2)	115.8
Metals (2 of 2)	99.07
ARI Sample	382.0
AmTest Sample	412.7
Bioassay Sediments	1460.9
Reference (Archived)	1354.4
Additional Sediment	1480.7
Grain Size Analysis	122.88

The following presents sediment compositing information for the rest of the Oakland sediment samples.

COMPOSITE 878435

Laboratory Number	Bag Label	Comments
878435	36-39	sand/silt; green clay
	39-42	sandier sediment; green grey

Sample	Purpose	Sample weight
878435	Metals (1 of 2)	112.74
878435	Metals (2 of 2)	121.87
878435	ARI Sample	306.55
878435	AmTest Sample	314.04
878435	Bioassay Sample	1120.00
878435	Reference	986.50
878435	Extra 1	1004.30
878435	Extra 2	1133.50
878435	Grain Size	98.99

COMPOSITE 878436

Laboratory Number	Bag Label	Comments
878436	30-33	silt/sand, black-grey
	33-36	black silt/sand
	36-39	sand/silt black-grey
	39-42	fine sand; green grey

Sample	Purpose	Sample weight
878436	Metals (1 of 2)	142.75
878436	Metals (2 of 2)	106.55
878436	ARI Sample	381.83
878436	AmTest Sample	388.23
878436	Bioassay	1300.90
878436	Reference	1365.09
878436	Extra 1	1515.97
878436	Grain Size	123.23

COMPOSITE 878437

Laboratory Number	Bag Label	Comments
878437	38.5-41.5 41.5-44	watery silt with fine sand gray black, no odor

Sample	Purpose	Sample weight
878437	Metals (1 of 2)	112.13
878437	Metals (2 of 2)	121.06
878437	ARI Sample	365.29
878437	AmTest	349.46
878437	Bioassay	1318.45
878437	Reference	1261.95
878437	Extra 1	1256.24
878437	Grain Size	178.65

COMPOSITE 878438

Laboratory Number	Bag Label	Comments
878438	32-35 35-38 38-41 41-44	watery silt/sand compacted black silt compacted black silt fine sand-light brown in color with black streaks no odor - all fractions

Sample	Purpose	Sample weight
878438	Metals (1 of 2)	168.49
878438	Metals (2 of 2)	165.52
878438	ARI Sample	446.74
878438	AmTest Sample	450.03
878438	Bioassay	1572.76
878438	Reference	1551.26
878438	Extra 1	1373.12
878438	Extra 2	928.47
878438	Grain Size	306.64

COMPOSITE 878439

Laboratory Number	Bag Label	Comments
878439	26-29	light brown to black silt
	29-32	black silt
	32-35	black silt
	35-38	black silt
	38-41	black silt
	41-44	black silt

Sample	Purpose	Sample weight
878439	Metals (1 of 2)	89.73
878439	Metals (2 of 2)	111.93
878439	ARI Sample	336.89
878439	AmTest Sample	336.33
878439	Bioassay	1002.00
878439	Reference	1083.35
878439	Extra 1	121.45
878439	Extra 2	1057.59
878439	Grain Size	186.66

COMPOSITE 878440

Laboratory Number	Bag Label	Comments
878440	32-35	soupy mixture, some coarse
	35-38	same soupy mixture
	38-41	dry coarse silt
		color of sediment is black with some odor of hydrogen sulfide

Sample	Purpose	Sample weight
878440	Metals (1 of 2)	119.83
878440	Metals (2 of 2)	107.71
878440	ARI Sample	348.90
878440	AmTest Sample	318.60
878440	Bioassay	1440.30
878440	Reference	1097.80
878440	Grain Size	97.82

COMPOSITE 878441

Laboratory Number	Bag Label	Comments
878441	32-35	

Sample	Purpose	Sample weight
878441	Metals (1 of 2)	120.45
878441	Metals (2 of 2)	127.85
878441	ARI Sample	297.50
878441	AmTest	340.36
878441	Bioassay	780.34
878441	Reference	641.12
878441	Grain Size	98.74

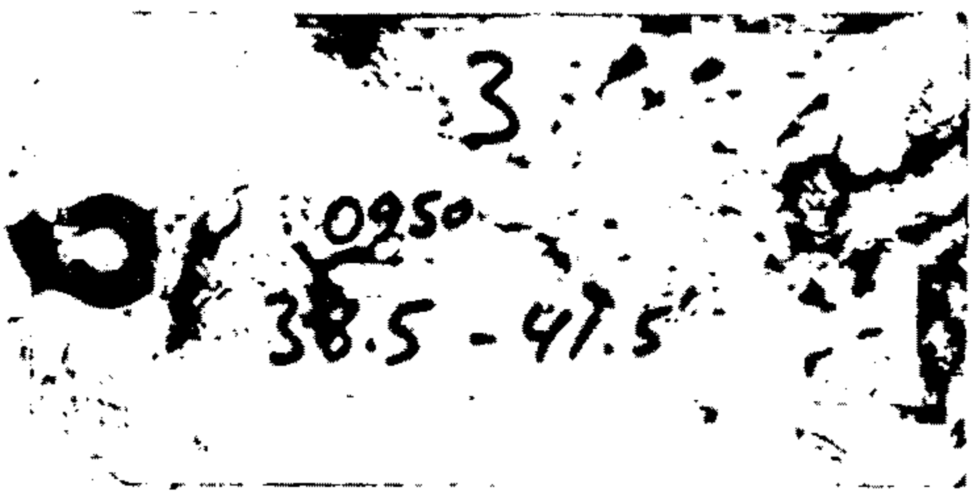
B-1 36-39 8:00
39-42'
8:30 878435

B-2 9'0 36-39'
9:00 33-36'
~~9:20~~
9:20 39-42'
855 30-33'
878436

878437
B-3
P of OAK

3

09:55
41.5'-44'



B-4

32-35' 10:15
35-38' 10:25
38-41' 10:30
41'-44' 10:40

878438

B-5

26-29' 11:00
29-32' 11:07
32-35' 11:15
35-38' 11:24
38-41' 11:30
41-44' 11:40

878439

B-6

32-35' 12:12
35-38 12:19
38-41' 12:28

878440

B-7

32-35' 13:20

878441

APPENDIX D

BIOASSAY TEST RESULTS AND WATER QUALITY INFORMATION

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Sequim Bay Water	1	1	NA	3	1	81	85
Sequim Bay Water	1	2	NA	59	1	39	99
Sequim Bay Water	1	3	NA	60	2	37	99
Sum of Replicates				122	4	157	283
Percent of Total				43.11	1.41	55.48	100.00
Sequim Bay Water	2	1	NA	23	1	16	40
Sequim Bay Water	2	2	NA	96	0	6	102
Sequim Bay Water	2	3	NA	163	1	16	180
Sum of Replicates				282	2	38	322
Percent of Total				87.58	0.62	11.80	100.00
Sequim Bay Water	3	1	NA	61	1	24	86
Sequim Bay Water	3	2	NA	64	1	18	83
Sequim Bay Water	3	3	NA	42	1	13	56
Sum of Replicates				167	3	55	225
Percent of Total				74.22	1.33	24.44	100.00
Sequim Bay Water	4	1	NA	163	1	14	178
Sequim Bay Water	4	2	NA	143	2	10	155
Sequim Bay Water	4	3	NA	223	1	19	243
Sum of Replicates				529	4	43	576
Percent of Total				91.84	0.69	7.47	100.00
Sequim Bay Water	5	1	NA	3	1	22	26
Sequim Bay Water	5	2	NA	1	1	10	12
Sequim Bay Water	5	3	NA	0	1	3	4
Sum of Replicates				4	3	35	42
Percent of Total				9.52	7.14	83.33	100.00
Sequim Bay Water	6	1	NA	30	0	8	38
Sequim Bay Water	6	2	NA	44	6	14	64
Sequim Bay Water	6	3	NA	58	1	9	68
Sum of Replicates				132	7	31	170
Percent of Total				77.65	4.12	18.24	100.00
Sequim Bay Water - Summary							
Total Abundance				1236	23	359	1618
Percent of Total				76.39	1.42	22.19	100.00
Average Abundance				206.00	3.83	59.83	269.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Site Reference Water	1	1	NA	44	1	3	48
		2	NA	30	1	11	42
		3	NA	40	0	4	44
Sum of Replicates				114	2	18	134
Percent of Total				85.07	1.49	13.43	100.00
Alcatraz Site Reference Water	2	1	NA	0	0	15	15
		2	NA	1	0	0	1
		3	NA	4	0	10	14
Sum of Replicates				5	0	25	30
Percent of Total				16.67	0.00	83.33	100.00
Alcatraz Site Reference Water	3	1	NA	0	1	3	4
		2	NA	0	0	8	8
		3	NA	0	7	1	8
Sum of Replicates				0	8	12	20
Percent of Total				0.00	40.00	60.00	100.00
Alcatraz Site Reference Water - Summary							
Total Abundance				119	10	55	184
Percent of Total				0.65	0.05	0.30	1.00
Average Abundance				39.67	3.33	18.33	61.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep	Dilution	Counts: Normal	Blastula	Abnormal	Total
Sequim Bay Water & Sequim Bay Sediment	1	1	100	58	2	6	66
		2	100	126	1	6	133
		3	100	148	2	36	186
Sum of Replicates				332	5	48	385
Percent of Total				86.23	1.30	12.47	100.00
Sequim Bay Water & Sequim Bay Sediment	2	1	100	134	0	17	151
		2	100	139	1	28	168
		3	100	112	4	6	122
Sum of Replicates				385	5	51	441
Percent of Total				87.30	1.13	11.56	100.00
Sequim Bay Water & Sequim Bay Sediment	3	1	100	112	4	6	118
		2	100	156	0	7	163
		3	100	95	2	18	115
Sum of Replicates				363	6	31	396
Percent of Total				91.67	1.52	7.83	100.00
Summary of 100% Dilution							
Sum of Replicates				1080	16	130	1222
Percent of Total				88.38	1.31	10.64	100.00
Average Abundance				360.00	5.33	43.33	407.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep	Dilution	Counts Normal	Blastula	Abnormal	Total
Sequim Bay Water &	1	1	50	24	0	1	25
Sequim Bay Sediment		2	50	20	2	4	26
		3	50	43	0	5	48
Sum of Replicates				87	2	10	99
Percent of Total				87.88	0.02	0.10	1.00
Sequim Bay Water &	2	1	50	137	5	4	146
Sequim Bay Sediment		2	50	142	1	8	151
		3	50	132	1	9	142
Sum of Replicates				411	7	21	439
Percent of Total				93.62	0.02	0.05	1.00
Sequim Bay Water &	3	1	50	126	0	20	146
Sequim Bay Sediment		2	50	153	1	14	167
		3	50	131	0	8	139
Sum of Replicates				410	1	42	452
Percent of Total				90.71	0.22	9.29	100.00
Summary of 50% Dilution							
Sum of Replicates				908	10	73	990
Percent of Total				91.72	1.01	7.37	100.00
Average Abundance				302.67	3.33	24.33	330.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Sequim Bay Water & Sequim Bay Sediment	1	1	10	195	4	2	201
		2	10	183	2	7	192
		3	10	200	0	4	204
Sum of Replicates				578	6	13	597
Percent of Total				96.82	1.01	2.18	100.00
Sequim Bay Water & Sequim Bay Sediment	2	1	10	117	5	1	123
		2	10	73	1	5	79
		3	10	144	0	1	145
Sum of Replicates				334	6	7	347
Percent of Total				96.25	1.73	2.02	100.00
Sequim Bay Water & Sequim Bay Sediment	3	1	10	90	3	18	111
		2	10	78	4	8	90
		3	10	72	3	9	84
Sum of Replicates				240	10	35	285
Percent of Total				84.21	3.51	12.28	100.00
Summary of 10% Dilution							
Sum of Replicates				1152	22	55	1229
Percent of Total				93.73	1.79	4.48	100.00
Average Abundance				384.00	7.33	18.33	409.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Site	1	1	100	119	7	10	136
Reference Water &		2	100	57	4	21	82
Sequim Bay Sediment		3	100	157	9	37	203
Sum of Replicates				333	20	68	421
Percent of Total				79.10	4.75	16.15	100.00
Alcatraz Site	2	1	100	16	2	5	23
Reference Water &		2	100	32	1	1	34
Sequim Bay Sediment		3	100	37	1	2	40
Sum of Replicates				85	4	8	97
Percent of Total				87.63	4.12	8.25	100.00
Alcatraz Site	3	1	100	65	5	78	148
Reference Water &		2	100	70	18	57	145
Sequim Bay Sediment		3	100	33	12	5	50
Sum of Replicates				168	35	140	343
Percent of Total				48.98	10.20	40.82	100.00
Summary of 100% Dilution							
Sum of Replicates				586	59	216	861
Percent of Total				68.06	6.85	25.09	100.00
Average Abundance				195.33	19.67	72.00	287.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Site	1	1	50	38	6	7	51
Reference Water &		2	50	27	0	9	36
Sequim Bay Sediment		3	50	75	0	18	93
Sum of Replicates				140	6	34	180
Percent of Total				77.78	3.33	18.89	100.00
Alcatraz Site	2	1	50	70	9	15	94
Reference Water &		2	50	52	0	29	81
Sequim Bay Sediment		3	50	115	3	56	174
Sum of Replicates				237	12	100	349
Percent of Total				67.91	3.44	28.65	100.00
Alcatraz Site	3	1	50	49	2	11	62
Reference Water &		2	50	97	5	6	108
Sequim Bay Sediment		3	50	94	0	10	104
Sum of Replicates				240	7	27	274
Percent of Total				87.59	2.55	9.85	100.00
Summary of 50% Dilution							
Sum of Replicates				617	25	161	803
Percent of Total				76.84	3.11	20.05	100.00
Average Abundance				205.67	8.33	53.67	267.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Site	1	1	10	0	0	4	4
Reference Water &		2	10	0	0	0	0
Sequim Bay Sediment		3	10	0	0	2	2
Sum of Replicates				0	0	6	6
Percent of Total				0.00	0.00	100.00	100.00
Alcatraz Site	2	1	10	83	0	5	88
Reference Water &		2	10	91	2	8	101
Sequim Bay Sediment		3	10	76	1	5	82
Sum of Replicates				250	3	18	271
Percent of Total				92.25	1.11	6.64	100.00
Alcatraz Site	3	1	10	37	0	2	39
Reference Water &		2	10	27	2	6	35
Sequim Bay Sediment		3	10	51	2	2	55
Sum of Replicates				115	4	10	129
Percent of Total				89.15	3.10	7.75	100.00
Summary of 10% Dilution							
Sum of Replicates				365	7	34	406
Percent of Total				89.90	1.72	8.37	100.00
Average Abundance				121.67	2.33	11.33	135.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	0	3	3
Water & 878435		2	100	0	0	4	4
Sediment		3	100	0	1	2	3
Sum of Replicates				0	1	9	10
Percent of Total				0.00	10.00	90.00	100.00
Alcatraz Reference	2	1	100	0	0	6	6
Water & 878435		2	100	0	0	11	11
Sediment		3	100	0	1	10	11
Sum of Replicates				0	1	27	28
Percent of Total				0.00	3.57	96.43	100.00
Alcatraz Reference	3	1	100	0	0	0	0
Water & 878435		2	100	0	0	6	6
Sediment		3	100	0	0	7	7
Sum of Replicates				0	0	13	13
Percent of Total				0.00	0.00	100.00	100.00
Summary of 100% Dilution							
Sum of Replicates				0	2	49	51
Percent of Total				0.00	3.92	96.08	100.00
Average Abundance				0.00	0.67	16.33	17.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	0	9	9
Water & 878435		2	50	0	1	5	6
Sediment		3	50	0	1	7	8
Sum of Replicates				0	2	21	23
Percent of Total				0.00	8.70	91.30	100.00
Alcatraz Reference	2	1	50	0	1	14	15
Water & 878435		2	50	0	0	24	24
Sediment		3	50	0	0	5	5
Sum of Replicates				0	1	43	44
Percent of Total				0.00	2.27	97.73	100.00
Alcatraz Reference	3	1	50	0	1	5	6
Water & 878435		2	50	0	0	7	7
Sediment		3	50	0	0	5	5
Sum of Replicates				0	1	17	17
Percent of Total				0.00	5.88	100.00	100.00
Summary of 50% Dilution							
Sum of Replicates				0	4	81	84
Percent of Total				0.00	4.76	96.43	100.00
Average Abundance				0.00	1.33	27.00	28.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	68	3	26	97
Water & 878435		2	10	95	3	28	126
Sediment		3	10	87	1	15	103
Sum of Replicates				250	7	69	326
Percent of Total				76.69	2.15	21.17	100.00
Alcatraz Reference	2	1	10	45	2	38	85
Water & 878435		2	10	34	3	22	60
Sediment		3	10	48	3	26	77
Sum of Replicates				127	8	86	222
Percent of Total				57.21	3.60	38.74	100.00
Alcatraz Reference	3	1	10	59	3	24	86
Water & 878435		2	10	72	2	20	94
Sediment		3	10	54	2	24	80
Sum of Replicates				185	7	68	260
Percent of Total				71.15	2.69	26.15	100.00
Summary of 10% Dilution							
Sum of Replicates				562	22	223	808
Percent of Total				69.55	2.72	27.60	100.00
Average Abundance				187.33	7.33	74.33	269.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	4	2	6
Water & 878438		2	100	0	2	0	2
Sediment		3	100	0	3	8	11
Sum of Replicates				0	9	10	19
Percent of Total				0.00	47.37	52.63	100.00
Alcatraz Reference	2	1	100	0	0	1	1
Water & 878438		2	100	0	2	2	4
Sediment		3	100	1	3	0	4
Sum of Replicates				1	5	3	9
Percent of Total				11.11	55.56	33.33	100.00
Alcatraz Reference	3	1	100	1	9	10	20
Water & 878438		2	100	0	4	7	11
Sediment		3	100	0	5	12	17
Sum of Replicates				1	18	29	48
Percent of Total				2.08	37.50	60.42	100.00
Summary of 100% Dilution							
Sum of Replicates				2	32	42	76
Percent of Total				2.63	42.11	55.26	100.00
Average Abundance				0.67	10.67	14.00	25.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	1	0	1
Water & 878436		2	50	0	1	0	1
Sediment		3	50	0	0	6	6
Sum of Replicates				0	2	6	8
Percent of Total				0.00	25.00	75 00	100.00
Alcatraz Reference	2	1	50	0	2	19	21
Water & 878436		2	50	0	1	2	3
Sediment		3	50	0	1	3	4
Sum of Replicates				0	4	24	28
Percent of Total				0.00	14.29	85.71	100.00
Alcatraz Reference	3	1	50	0	4	5	9
Water & 878436		2	50	0	5	4	9
Sediment		3	50	1	3	5	9
Sum of Replicates				1	12	14	27
Percent of Total				3.70	44.44	51.85	100.00
Summary of 50% Dilution							
Sum of Replicates				1	18	44	63
Percent of Total				1.59	28.57	69.84	100.00
Average Abundance				0.33	6.00	14.67	21 00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	10	3	6	19
Water & 878438		2	10	18	0	5	23
Sediment		3	10	43	3	23	69
Sum of Replicates				71	6	34	111
Percent of Total				63.96	5.41	30.63	100.00
Alcatraz Reference	2	1	10	42	0	7	49
Water & 878438		2	10	77	3	4	84
Sediment		3	10	70	3	4	77
Sum of Replicates				189	6	15	210
Percent of Total				90.00	2.86	7.14	100.00
Alcatraz Reference	3	1	10	29	0	17	46
Water & 878438		2	10	46	4	8	58
Sediment		3	10	45	2	16	63
Sum of Replicates				120	6	41	167
Percent of Total				71.86	3.59	24.55	100.00
Summary of 10% Dilution							
Sum of Replicates				380	18	90	488
Percent of Total				77.87	3.69	18.44	100.00
Average Abundance				126.67	6.00	30.00	162.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	7	3	17	27
Water & 878437		2	100	0	1	6	7
Sediment		3	100	1	1	1	3
Sum of Replicates				8	5	24	37
Percent of Total				21.62	13.51	64.86	100.00
Alcatraz Reference	2	1	100	0	0	5	5
Water & 878437		2	100	0	1	1	2
Sediment		3	100	0	0	2	2
Sum of Replicates				0	1	8	9
Percent of Total				0.00	11.11	88.89	100.00
Alcatraz Reference	3	1	100	0	4	6	10
Water & 878437		2	100	2	5	3	10
Sediment		3	100	0	1	10	11
Sum of Replicates				2	10	19	31
Percent of Total				6.45	32.26	61.29	100.00
Summary of 100% Dilution							
Sum of Replicates				10	16	51	77
Percent of Total				12.99	20.78	66.23	100.00
Average Abundance				3.33	5.33	17.00	25.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	1	3	4
Water & 878437		2	50	0	2	3	5
Sediment		3	50	0	1	9	10
Sum of Replicates				0	4	15	19
Percent of Total				0.00	21.05	78.95	100.00
Alcatraz Reference	2	1	50	0	0	1	1
Water & 878437		2	50	0	0	1	1
Sediment		3	50	0	0	1	1
Sum of Replicates				0	0	3	3
Percent of Total				0.00	0.00	100.00	100.00
Alcatraz Reference	3	1	50	0	4	0	4
Water & 878437		2	50	0	0	7	7
Sediment		3	50	0	0	3	3
Sum of Replicates				0	4	10	14
Percent of Total				0.00	28.57	71.43	100.00
Summary of 50% Dilution							
Sum of Replicates				0	8	28	36
Percent of Total				0.00	0.22	0.78	1.00
Average Abundance				0.00	2.67	9.33	12.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	88	0	4	92
Water & 878437		2	10	83	0	8	91
Sediment		3	10	57	1	11	69
Sum of Replicates				228	1	23	252
Percent of Total				90.48	0.40	9.13	100.00
Alcatraz Reference	2	1	10	0	1	2	3
Water & 878437		2	10	2	0	6	8
Sediment		3	10	0	0	0	0
Sum of Replicates				2	1	8	11
Percent of Total				18.18	9.09	72.73	100.00
Alcatraz Reference	3	1	10	22	1	6	29
Water & 878437		2	10	18	0	3	21
Sediment		3	10	16	0	1	17
Sum of Replicates				56	1	10	67
Percent of Total				83.58	1.49	14.93	100.00
Summary of 10% Dilution							
Sum of Replicates				286	3	41	330
Percent of Total				86.67	0.91	12.42	100.00
Average Abundance				95.33	1.00	13.67	110.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	1	8	12	21
Water & 078438		2	100	0	4	9	13
Sediment		3	100	0	4	12	16
Sum of Replicates				1	16	33	50
Percent of Total				2.00	32.00	66.00	100.00
Alcatraz Reference	2	1	100	0	11	6	17
Water & 078438		2	100	0	14	6	20
Sediment		3	100	0	9	3	12
Sum of Replicates				0	34	15	49
Percent of Total				0.00	69.39	30.61	100.00
Alcatraz Reference	2	1	100	0	2	1	3
Water & 878438		2	100	0	2	8	10
Sediment		3	100	0	1	10	11
Sum of Replicates				0	5	19	24
Percent of Total				0.00	20.83	79.17	100.00
Summary of 100% Dilution							
Sum of Replicates				1	55	67	123
Percent of Total				0.81	44.72	54.47	100.00
Average Abundance				0.33	18.33	22.33	41.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	0	1	1
Water & 870438		2	50	0	1	4	5
Sediment		3	50	0	0	2	0
Sum of Replicates				0	1	7	6
Percent of Total				0.00	0.17	1.17	1.00
Alcatraz Reference	2	1	50	0	0	7	7
Water & 870438		2	50	0	3	7	10
Sediment		3	50	0	1	12	13
Sum of Replicates				0	4	26	30
Percent of Total				0.00	0.13	0.87	1.00
Alcatraz Reference	3	1	50	0	2	3	6
Water & 870438		2	50	0	0	1	1
Sediment		3	50	0	0	4	4
Sum of Replicates				0	2	8	10
Percent of Total				0.00	0.20	0.80	1.00
Summary of 50% Dilutions							
Sum of Replicates				0	7	41	46
Percent of Total				0.00	15.22	89.13	100.00
Average Abundance				0.00	2.33	13.67	15.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	0	1	4	5
Water & 078438		2	10	0	0	1	1
Sediment		3	10	0	0	6	6
Sum of Replicates				0	1	11	12
Percent of Total				0.00	8.33	91.67	100.00
Alcatraz Reference	2	1	10	52	0	30	82
Water & 078438		2	10	40	1	15	56
Sediment		3	10	15	1	6	22
Sum of Replicates				107	2	51	160
Percent of Total				66.88	1.25	31.88	100.00
Alcatraz Reference	3	1	10	1	1	16	18
Water & 078438		2	10	1	1	18	20
Sediment		3	10	0	0	15	15
Sum of Replicates				2	2	49	53
Percent of Total				3.77	3.77	92.46	100.00
Summary of 10% Dilution							
Sum of Replicates				109	5	111	225
Percent of Total				48.44	2.22	49.33	100.00
Average Abundance				36.33	1.67	37.00	75.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	2	2	4
Water & 878439		2	100	0	2	6	8
Sediment		3	100	0	2	7	9
Sum of Replicates				0	6	15	21
Percent of Total				0.00	28.57	71.43	100.00
Alcatraz Reference	2	1	100	0	8	6	14
Water & 878439		2	100	0	8	6	14
Sediment		3	100	0	4	11	15
Sum of Replicates				0	20	23	43
Percent of Total				0.00	46.51	53.49	100.00
Alcatraz Reference	3	1	100	0	11	4	15
Water & 878439		2	100	0	3	3	6
Sediment		3	100	0	6	4	10
Sum of Replicates				0	20	11	31
Percent of Total				0.00	64.52	35.48	100.00
Summary of 100% Dilution							
Sum of Replicates				0	46	49	95
Percent of Total				0.00	48.42	51.58	100.00
Average Abundance				0.00	15.33	16.33	31.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	3	1	4
Water & 878439		2	50	0	0	3	3
Sediment		3	50	0	0	5	5
Sum of Replicates				0	3	9	12
Percent of Total				0.00	25.00	75.00	100.00
Alcatraz Reference	2	1	50	0	3	4	7
Water & 878439		2	50	0	2	2	4
Sediment		3	50	0	0	3	3
Sum of Replicates				0	5	9	14
Percent of Total				0.00	35.71	64.29	100.00
Alcatraz Reference	3	1	50	0	0	2	2
Water & 878439		2	50	0	0	2	2
Sediment		3	50	0	0	6	6
Sum of Replicates				0	0	10	10
Percent of Total				0.00	0.00	100.00	100.00
Summary of 50% Dilution							
Sum of Replicates				0	8	28	36
Percent of Total				0.00	22.22	77.78	100.00
Average Abundance				0.00	2.67	9.33	12.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	0	1	3	4
Water & 878439		2	10	0	0	2	2
Sediment		3	10	0	0	1	1
Sum of Replicates				0	1	6	7
Percent of Total				0.00	14.29	85.71	100.00
Alcatraz Reference	2	1	10	0	2	0	2
Water & 878439		2	10	0	2	9	11
Sediment		3	10	0	2	3	5
Sum of Replicates				0	6	12	18
Percent of Total				0.00	33.33	66.67	100.00
Alcatraz Reference	3	1	10	0	0	7	7
Water & 878439		2	10	0	0	7	7
Sediment		3	10	0	0	3	3
Sum of Replicates				0	0	17	17
Percent of Total				0.00	0.00	100.00	100.00
Summary of 10% Dilution							
Sum of Replicates				0	7	35	42
Percent of Total				0.00	16.67	83.33	100.00
Average Abundance				0.00	2.33	11.67	14.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	5	20	25
Water & 878440		2	100	0	2	10	12
Sediment		3	100.	0	4	4	8
Sum of Replicates				0	11	34	45
Percent of Total				0.00	24.44	75.56	100.00
Alcatraz Reference	2	1	100	0	4	2	6
Water & 878440		2	100	0	8	5	13
Sediment		3	100	0	1	6	7
Sum of Replicates				0	13	13	26
Percent of Total				0.00	50.00	50.00	100.00
Alcatraz Reference	3	1	100	0	9	13	22
Water & 878440		2	100	0	8	7	15
Sediment		3	100	0	16	3	19
Sum of Replicates				0	33	23	56
Percent of Total				0.00	58.93	41.07	100.00
Summary of 100% Dilution							
Sum of Replicates				0	57	70	127
Percent of Total				0.00	44.88	55.12	100.00
Average Abundance				0.00	19.00	23.33	42.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	0	2	2
Water & 078440		2	50	0	0	3	3
Sediment		3	50	0	0	6	6
Sum of Replicates				0	0	11	11
Percent of Total				0.00	0.00	1.00	1.00
Alcatraz Reference	2	1	50	0	0	3	3
Water & 078440		2	50	0	0	7	7
Sediment		3	50	0	0	4	4
Sum of Replicates				0	0	14	14
Percent of Total				0.00	0.00	1.00	1.00
Alcatraz Reference	3	1	50	0	0	6	6
Water & 078440		2	50	0	1	14	15
Sediment		3	50	0	3	10	13
Sum of Replicates				0	4	30	34
Percent of Total				0.00	0.12	0.88	1.00
Summary of 50% Dilution							
Sum of Replicates			50	0	4	55	59
Percent of Total				0.00	6.78	93.22	100.00
Average Abundance				0.00	1.33	18.33	19.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	81	0	15	96
Water & 878440		2	10	81	0	19	100
Sediment		3	10	85	0	13	98
Sum of Replicates				247	0	47	294
Percent of Total				84.01	0.00	15.99	100.00
Alcatraz Reference	2	1	10	8	0	23	31
Water & 878440		2	10	3	0	24	27
Sediment		3	10	8	0	5	13
Sum of Replicates				19	0	52	71
Percent of Total				26.76	0.00	73.24	100.00
Alcatraz Reference	3	1	10	47	0	21	68
Water & 878440		2	10	46	0	22	68
Sediment		3	10	47	0	23	70
Sum of Replicates				140	0	66	206
Percent of Total				67.96	0.00	32.04	100.00
Summary of 10% Dilution							
Sum of Replicates				406	0	165	571
Percent of Total				71.10	0.00	28.90	100.00
Average Abundance				135.33	0.00	55.00	190.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	2	7	9
Water & 878441		2	100	0	4	6	10
Sediment		3	100	0	1	4	5
Sum of Replicates				0	7	17	24
Percent of Total				0.00	29.17	70.83	100.00
Alcatraz Reference	2	1	100	0	4	6	10
Water & 878441		2	100	0	1	6	7
Sediment		3	100	0	1	10	11
Sum of Replicates				0	6	22	28
Percent of Total				0.00	21.43	78.57	100.00
Alcatraz Reference	3	1	100	0	3	6	9
Water & 878441		2	100	0	3	7	10
Sediment		3	100	0	3	3	6
Sum of Replicates				0	9	16	25
Percent of Total				0.00	36.00	64.00	100.00
Summary of 100% Dilution							
Sum of Replicates				0	22	55	77
Percent of Total				0.00	28.57	71.43	100.00
Average Abundance				0.00	7.33	18.33	25.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	0	0	0
Water & 878441		2	50	0	0	1	1
Sediment		3	50	0	1	3	4
Sum of Replicates				0	1	4	5
Percent of Total				0.00	20.00	80.00	100.00
Alcatraz Reference	2	1	50	0	1	7	8
Water & 878441		2	50	0	2	7	9
Sediment		3	50	0	0	12	12
Sum of Replicates				0	3	26	29
Percent of Total				0.00	10.34	89.66	100.00
Alcatraz Reference	3	1	50	0	2	3	5
Water & 878441		2	50	0	2	5	7
Sediment		3	50	0	1	3	4
Sum of Replicates				0	5	11	16
Percent of Total				0.00	31.25	68.75	100.00
Summary of 50% Dilution							
Sum of Replicates				0	9	41	50
Percent of Total				0.00	18.00	82.00	100.00
Average Abundance				0.00	3.00	13.67	16.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Counts: Blastula	Counts: Abnormal	Counts: Total
Alcatraz Reference	1	1	10	51	4	15	70
Water & 878441		2	10	32	2	18	52
Sediment		3	10	28	9	19	56
Sum of Replicates				111	15	52	178
Percent of Total				62.36	8.43	29.21	100.00
Alcatraz Reference	2	1	10	12	2	6	20
Water & 878441		2	10	11	2	8	21
Sediment		3	10	24	4	13	41
Sum of Replicates				47	8	27	82
Percent of Total				57.32	9.76	32.93	100.00
Alcatraz Reference	3	1	10	1	0	8	9
Water & 878441		2	10	0	0	7	7
Sediment		3	10	0	0	7	7
Sum of Replicates				1	0	22	23
Percent of Total				4.35	0.00	95.65	100.00
Summary of 10% Dilution							
Sum of Replicates				159	23	101	283
Percent of Total				56.18	8.13	35.69	100.00
Average Abundance				53.00	7.67	33.67	94.33

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts: Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	100	0	1	2	3
Water & 078567		2	100	0	7	1	8
Sediment		3	100	2	0	3	5
Sum of Replicates				2	8	6	16
Percent of Total				12.50	50.00	37.50	100.00
Alcatraz Reference	2	1	100	0	1	3	4
Water & 078567		2	100	0	2	2	4
Sediment		3	100	0	1	3	4
Sum of Replicates				0	4	8	12
Percent of Total				0.00	33.33	66.67	100.00
Alcatraz Reference	3	1	100	0	6	6	12
Water & 078567		2	100	0	3	2	5
Sediment		3	100	0	6	2	8
Sum of Replicates				0	15	10	25
Percent of Total				0.00	60.00	40.00	100.00
Summary of 100% Dilution							
Sum of Replicates				2	27	24	53
Percent of Total				3.77	50.94	45.28	100.00
Average Abundance				0.67	9.00	8.00	17.67

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

Treatment	Number	Rep.	Dilution	Counts			
				Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	50	0	0	1	1
Water & 870587		2	50	0	4	1	5
Sediment		3	50	0	2	1	3
Sum of Replicates				0	6	3	9
Percent of Total				0.00	66.67	33.33	100.00
Alcatraz Reference	2	1	50	0	1	3	4
Water & 870587		2	50	0	1	2	3
Sediment		3	50	0	0	1	1
Sum of Replicates				0	2	6	8
Percent of Total				0.00	25.00	75.00	100.00
Alcatraz Reference	3	1	50	0	4	4	8
Water & 870587		2	50	0	2	1	3
Sediment		3	50	0	1	1	2
Sum of Replicates				0	7	6	13
Percent of Total				0.00	53.85	46.15	100.00
Summary of 50% Dilution							
Sum of Replicates				0	15	15	30
Percent of Total				0.00	50.00	50.00	100.00
Average Abundance				0.00	5.00	5.00	10.00

Table 3. Number and percent of larvae within normal, blastula and abnormal classifications within various testing solutions

				Counts			
Treatment	Number	Rep.	Dilution	Normal	Blastula	Abnormal	Total
Alcatraz Reference	1	1	10	62	4	14	80
Water & 878587		2	10	107	5	2	114
Sediment		3	10	54	4	7	65
Sum of Replicates				223	13	23	259
Percent of Total				86.10	5.02	8.88	100.00
Alcatraz Reference	2	1	10	161	7	8	176
Water & 878587		2	10	193	3	10	206
Sediment		3	10	177	8	3	188
Sum of Replicates				531	18	21	570
Percent of Total				93.16	3.16	3.68	100.00
Alcatraz Reference	3	1	10	54	3	1	58
Water & 878587		2	10	101	4	4	109
Sediment		3	10	74	0	5	79
Sum of Replicates				229	7	10	246
Percent of Total				93.09	2.85	4.07	100.00
Summary of 10% Dilution							
Sum of Replicates				983	38	54	1075
Percent of Total				91.44	3.53	5.02	100.00
Average Abundance				327.67	12.67	18.00	358.33

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Bioassay Water Quality Data

Date of Observation 24 Jan 88
Time of Observation 0900 - 1200
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Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
878435	100	1 ✓	25.0	7.15	8.32
878435	100	2 ✓	25.0	7.18	8.41
878435	100	3 ✓	25.0	7.05	8.36
878435	50	1 ✓	25.0	7.18	8.19
878435	50	2 ✓	25.0	7.10	8.21
878435	50	3 ✓	25.0	7.16	8.17
878435	10	1 ✓	25.0	7.06	8.00
878435	10	2 ✓	25.0	7.36	8.05
878435	10	3 ✓	25.0	7.15	7.98
878436	100	1 ✓	25.0	7.10	8.42
878436	100	2 ✓	25.0	7.21	8.34
878436	100	3 ✓	25.0	7.23	7.41
878436	50	1 ✓	25.0	7.01	8.30
878436	50	2 ✓	25.0	7.14	8.27
878436	50	3 ✓	25.0	7.02	8.48
878436	10	1 ✓	25.0	7.24	7.29
878436	10	2 ✓	25.0	7.12	8.02
878436	10	3 ✓	25.0	7.16	8.04
878437	100	1 ✓	25.0	6.98	7.45
878437	100	2 ✓	25.0	7.17	8.38
878437	100	3 ✓	25.0	6.97	7.74
878437	50	1 ✓	25.0	7.21	8.25
878437	50	2 ✓	25.0	7.15	8.25
878437	50	3 ✓	25.0	7.21	8.19
878437	10	1 ✓	25.0	7.28	8.24
878437	10	2 ✓	25.0	7.18	8.01
878437	10	3 ✓	25.0	7.17	8.01
878438	100	1 ✓	25.0	7.27	~~8.07~~ 8.42
878438	100	2 ✓	25.0	7.28	8.41
878438	100	3 ✓	25.0	7.12	8.32
878438	50	1 ✓	25.0	7.04	8.20
878438	50	2 ✓	25.0	7.16	8.21
878438	50	3 ✓	25.0	6.98	7.98
878438	10	1 ✓	25.0	7.13	7.98
878438	10	2 ✓	25.0	7.12	7.70
878438	10	3 ✓	25.0	7.08	8.00

CDE - San Francisco
Bioassay Water Quality Data

Date of Observation 24 I-88
Time of Observation 0900 - 1200
Observer [illegible]

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Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
878439	100	1 ✓	25.0	7.19	8.38
878439	100	2 ✓	25.0	7.10	8.15
878439	100	3 ✓	25.0	7.39	8.48
878439	50	1 ✓	25.0	7.29	8.32
878439	50	2 ✓	25.0	7.18	8.22
878439	50	3 ✓	25.0	6.98	8.30
878439	10	1 ✓	25.0	7.15	8.04
878439	10	2 ✓	25.0	7.41	7.93
878439	10	3 ✓	25.0	7.18	8.06
878440	100	1 ✓	25.0	7.14	8.36
878440	100	2 ✓	25.0	7.12	8.27
878440	100	3 ✓	25.0	7.30	8.27
878440	50	1 ✓	25.0	7.21	8.17
878440	50	2 ✓	25.0	7.15	8.11
878440	50	3 ✓	25.0	6.99	8.05
878440	10	1 ✓	25.0	7.02	8.00
878440	10	2 ✓	25.0	7.99	8.10
878440	10	3 ✓	25.0	7.16	7.98
878441	100	1 ✓	25.0	7.15	8.26
878441	100	2 ✓	25.0	6.89	8.31
878441	100	3 ✓	25.0	6.95	8.34
878441	50	1 ✓	25.0	7.21	8.14
878441	50	2 ✓	25.0	6.96	8.25
878441	50	3 ✓	25.0	7.04	8.23
878441	10	1 ✓	25.0	7.20	8.01
878441	10	2 ✓	25.0	7.01	7.99
878441	10	3 ✓	25.0	7.05	7.99
878587	100	1 ✓	25.0	7.07	8.21
878587	100	2 ✓	25.0	7.12	8.16
878587	100	3 ✓	25.0	7.27	8.24
878587	50	1 ✓	25.0	7.12	8.12
878587	50	2 ✓	25.0	7.15	8.12
878587	50	3 ✓	25.0	7.19	8.13
878587	10	1 ✓	25.0	6.98	8.01
878587	10	2 ✓	25.0	6.99	8.02
878587	10	3 ✓	25.0	6.96	7.97
Reference H2O	---	1 ✓	25.0	7.15	7.92
Reference H2O	---	2 ✓	25.0	7.12	8.05
Reference H2O	---	3 ✓	25.0	7.07	8.00

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Bioassay Water Quality Data

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Time of Observation [illegible]
Observer [illegible]

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Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
Battelle H2O	---	1 ✓	25.0	7.10	7.90
Battelle H2O	---	2 ✓	25.0	6.50	8.07
Battelle H2O	---	3 ✓	25.0	7.05	7.98
Battelle H2O	---	4 ✓	25.0	6.65	8.06
Battelle H2O	---	5 ✓	25.0	7.16	7.32
Battelle H2O	---	6 ✓	25.0	6.53	8.03
Sequim Sed C1	100	1 ✓	25.0	7.10	8.24
Sequim Sed C1	100	2 ✓	25.0	7.24	8.29
Sequim Sed C1	100	3 ✓	25.0	7.18	8.29
Sequim Sed C1	50	1 ✓	25.0	7.11	8.20
Sequim Sed C1	50	2 ✓	25.0	7.19	8.17
Sequim Sed C1	50	3 ✓	25.0	7.15	8.14
Sequim Sed C1	10	1 ✓	25.0	7.25	8.22
Sequim Sed C1	10	2 ✓	25.0	7.17	8.20
Sequim Sed C1	10	3 ✓	25.0	7.15	8.02
Sequim Sed C2	100	1 ✓	25.0	6.95	8.28
Sequim Sed C2	100	2 ✓	25.0	7.19	8.27
Sequim Sed C2	100	3 ✓	25.0	7.07	8.14
Sequim Sed C2	50	1 ✓	25.0	7.21	8.11
Sequim Sed C2	50	2 ✓	25.0	7.09	8.18
Sequim Sed C2	50	3 ✓	25.0	7.24	8.24
Sequim Sed C2	10	1 ✓	25.0	7.02	8.31
Sequim Sed C2	10	2 ✓	25.0	7.05	8.25
Sequim Sed C2	10	3 ✓	25.0	7.05	8.24

SBSW (Sequim Sed C1 group); SBRW (Sequim Sed C2 group)

SBRW = Sequim Bay mud & [illegible] water

SBSW = Sequim Bay mud & Sequim Bay water

Water Table Temperature
Temperature within test jar °C

Drain End	Middle	Other End
20.0	20.1	20.0

[illegible]

pH 7.0 Buffer 7.04 → 7.00
D.O. [illegible] 101.0 → 100.0
See page [illegible] of [illegible]

COE - San Francisco
Bioassay Water Quality Data

Date of Observation 28 Jan 89
Time of Observation 1200 - 1330
Observer [illegible]

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Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
878435	100	1	26.0	7.65	8.21
878435	100	2			
878435	100	3			
878435	50	1			
878435	50	2	25.5	7.60	8.24
878435	50	3			
878435	10	1			
878435	10	2	26.0	7.38	7.77
878435	10	3			
878436	100	1			
878436	100	2	26.50	7.15	8.11
878436	100	3			
878436	50	1			
878436	50	2			
878436	50	3	26.0	6.79	7.98
878436	10	1			
878436	10	2			
878436	10	3	25.0	7.20	8.09
878437	100	1	25.0	7.19	8.10
878437	100	2			
878437	100	3			
878437	50	1			
878437	50	2	26.0	7.01	8.29
878437	50	3			
878437	10	1			
878437	10	2	25.0	7.20	7.99
878437	10	3			
878438	100	1			
878438	100	2	26.0	7.11	8.30
878438	100	3			
878438	50	1			
878438	50	2	26.0	7.19	8.15
878438	50	3			
878438	10	1			
878438	10	2			
878438	10	3	26.0	7.60	8.12

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Bioassay Water Quality Data

[illegible]

Date of Observation [illegible]
Time of Observation [illegible]
Observer [illegible]

Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
878439	100	1			
878439	100	2	26.0	7.11	8.26
878439	100	3			
878439	50	1			
878439	50	2			
878439	50	3	25.0	7.18	8.85
878439	10	1			
878439	10	2			
878439	10	3	25.0	7.21	7.99
878440	100	1			
878440	100	2	26.0	7.15	8.20
878440	100	3			
878440	50	1			
878440	50	2			
878440	50	3	26.0	7.18	8.00
878440	10	1			
878440	10	2			
878440	10	3	25.0	7.29	7.81
878441	100	1	26.0	7.17	8.21
878441	100	2			
878441	100	3			
878441	50	1	25.0	7.20	8.14
878441	50	2			
878441	50	3			
878441	10	1	26.0	7.15	7.88
878441	10	2			
878441	10	3			
878587	100	1			
878587	100	2	25.0	6.95	8.20
878587	100	3			
878587	50	1	25.5	7.19	8.00
878587	50	2			
878587	50	3			
878587	10	1			
878587	10	2	26.0	7.24	7.85
878587	10	3			
Reference H20	---	1			
Reference H20	---	2	25.5	7.19	7.98
Reference H20	---	3			

COE - San Francisco
Bioassay Water Quality Data

Date of Observation: 28 Jan 86
Time of Observation: 1200-1300
Observer: [illegible]

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Treatment	Dilution (%)	Jar No.	Salinity (o/oo)	D.O. (mg/l)	pH
Battelle H20	---	1	26.5	7.35	7.81
Battelle H20	---	2			
Battelle H20	---	3			
Battelle H20	---	4			
Battelle H20	---	5	26.0	7.50	7.85
Battelle H20	---	6			
Sequim Sed C1	100	1	25.5	7.15	8.10
Sequim Sed C1	100	2			
Sequim Sed C1	100	3			
Sequim Sed C1	50	1			
Sequim Sed C1	50	2	25.0	7.25	8.11
Sequim Sed C1	50	3			
Sequim Sed C1	10	1			
Sequim Sed C1	10	2			
Sequim Sed C1	10	3	25.0	7.[illegible]	7.95
Sequim Sed C2	100	1			
Sequim Sed C2	100	2			
Sequim Sed C2	100	3	26.0	7.05	[illegible]
Sequim Sed C2	50	1			
Sequim Sed C2	50	2			
Sequim Sed C2	50	3	26.0	7.15	8.25
Sequim Sed C2	10	1			
Sequim Sed C2	10	2			
Sequim Sed C2	10	3	26.0	7.15	[illegible]

Margin notes: Battelle H2O on Jar Label; SBRW Sequim Bay mud & Reference water; SBSW Sequim Bay mud & Sequim Bay water

Water Table Temperature
Temperature within test jar

Drain End	Middle	Other End
20.0	19.5	20.0

Calibration — initial / final
pH meter 7.05 → 7.10 pH 7 buffer
D.O. meter 101.5 → 100.0 % Air Calibration) See page 34

APPENDIX E

BULK SEDIMENT ANALYSIS RESULTS

TABLE E. Bulk Sediment Analysis Results in Wet Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		878587	878587	878587	878436	878436	878436	878437	878438	878439	878439	878440	878441	878441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T6	T7a	T7b
Compound	**Units**													
Phenol	ug/kg (wet)	14 U(a)	ND(b)	ND	15 U	ND	75 U	74 U	75 U	80 U	72 U	76U	70 U	ND
bis(2-Chloroethyl)Ether	ug/kg (wet)	15 U	16 U	16 U	16 U	ND	82 U	81 U	82 U	87 U	79 U	83 U	77 U	ND
2-Chlorophenol	ug/kg (wet)	17 U	ND	ND	18 U	ND	91 U	90 U	91 U	97 U	88 U	92 U	85 U	ND
1,3-Dichlorobenzene	ug/kg (wet)	6.9 U	6.5 U	6.5 U	6.6 U	ND	33 U	32 U	33 U	36 U	32 U	33 U	31 U	ND
1,4-Dichlorobenzene	ug/kg (wet)	16 U	ND	ND	17 U	ND	84 U	84 U	86 U	90 U	82 U	86 U	79 U	ND
Benzyl Alcohol	ug/kg (wet)	18 U	20 U	20 U	20 U	ND	98 U	98 U	99 U	100 U	95 U	99 U	92 U	ND
1,2-Dichlorobenzene	ug/kg (wet)	4.1 U	4.4 U	4.4 U	4.4 U	ND	22 U	22 U	22 U	24 U	22 U	23 U	21 U	ND
2-Methylphenol	ug/kg (wet)	20 U	22 U	22 U	22 U	ND	110 U	110 U	110 U	120 U	110 U	110 U	100 U	ND
bis(2-chloroisopropyl)Ether	ug/kg (wet)	44 U	49 U	48 U	48 U	ND	240 U	240 U	240 U	260 U	240 U	250 U	230 U	ND
4-Methylphenol	ug/kg (wet)	10 U	11 U	11 U	11 U	ND	58 U	58 U	58 U	60 U	54 U	57 U	52 U	ND
N-Nitroso-Di-n-Propylamine	ug/kg (wet)	27 U	ND	ND	29 U	ND	150 U	150 U	150 U	160 U	140 U	150 U	140 U	ND
Hexachloroethane	ug/kg (wet)	27 U	29 U	29 U	29 U	ND	160 U	160 U	160 U	160 U	140 U	160 U	140 U	ND
Nitrobenzene	ug/kg (wet)	18 U	20 U	20 U	20 U	ND	100 U	99 U	100 U	110 U	97 U	100 U	94 U	ND
Isophorone	ug/kg (wet)	41 U	45 U	44 U	45 U	ND	220 U	220 U	220 U	240 U	220 U	230 U	210 U	ND
2-Nitrophenol	ug/kg (wet)	54 U	59 U	59 U	59 U	ND	300 U	290 U	300 U	320 U	290 U	300 U	280 U	ND
2,4-Dimethylphenol	ug/kg (wet)	48 U	53 U	52 U	53 U	ND	260 U	260 U	270 U	280 U	260 U	270 U	250 U	ND
Benzoic Acid	ug/kg (wet)	57 U	63 U	62 U	62 U	ND	310 U	310 U	310 U	330 U	300 U	320 U	290 U	ND
bis(2-Chloroethoxy)Methane	ug/kg (wet)	41 U	45 U	44 U	45 U	ND	220 U	220 U	230 U	240 U	220 U	230 U	210 U	ND
2,4-Dichlorophenol	ug/kg (wet)	57 U	63 U	62 U	63 U	ND	310 U	310 U	320 U	330 U	300 U	320 U	290 U	ND
1,2,4-Trichlorobenzene	ug/kg (wet)	31 U	ND	ND	34 U	ND	170 U	170 U	170 U	180 U	170 U	170 U	160 U	ND

TABLE E. Bulk Sediment Analysis Results in Wet Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		878687	878687	878687	878436	878436	878438	878437	878438	878439	878439	878440	878441	878441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T6	T7a	T7b
Compound	Units													
Naphthalene	ug/kg (wet)	65 U(a)	60 U	60 U	60 U	ND(b)	300 U	300 U	300 U	320 U	290 U	310 U	250 U	ND
4-Chloroaniline	ug/kg (wet)	30 U	32 U	32 U	32 U	ND	160 U	160 U	160 U	170 U	160 U	160 U	150 U	ND
Hexachlorobutadiene	ug/kg (wet)	31 U	34 U	34 U	34 U	ND	170 U	170 U	170 U	180 U	160 U	170 U	160 U	ND
4-Chloro-3-Methylphenol	ug/kg (wet)	32 U	ND	ND	34 U	ND	170 U	170 U	170 U	180 U	170 U	180 U	160 U	ND
2-Methylnaphthalene	ug/kg (wet)	30 U	33 U	32 U	33 U	ND	160 U	160 U	160 U	170 U	160 U	170 U	150 U	ND
Hexachlorocyclopentadiene	ug/kg (wet)	29 U	32 U	32 U	32 U	ND	160 U	160 U	160 U	170 U	150 U	160 U	150 U	ND
2,4,6-Trichlorophenol	ug/kg (wet)	10 U	11 U	11 U	11 U	ND	57 U	56 U	57 U	60 U	55 U	57 U	53 U	ND
2,4,5-Trichlorophenol	ug/kg (wet)	12 U	14 U	14 U	14 U	ND	68 U	68 U	69 U	73 U	66 U	69 U	64 U	ND
2-Chloronaphthalene	ug/kg (wet)	2.5 U	2.7 U	2.7 U	2.7 U	ND	14 U	14 U	14 U	15 U	13 U	14 U	13 U	ND
2-Nitroaniline	ug/kg (wet)	54 U	59 U	59 U	59 U	ND	300 U	290 U	300 U	320 U	290 U	300 U	280 U	ND
Dimethyl Phthalate	ug/kg (wet)	17 U	18 U	18 U	18 U	ND	91 U	90 U	91 U	96 U	88 U	92 U	85 U	ND
Acenaphthylene	ug/kg (wet)	3.4 U	3.7 U	3.7 U	3.7 U	ND	19 U	19 U	19 U	20 U	18 U	19 U	18 U	ND
3-Nitroaniline	ug/kg (wet)	32 U	35 U	36 U	35 U	ND	170 U	170 U	180 U	190 U	170 U	180 U	160 U	ND
Acenaphthene	ug/kg (wet)	19 U	ND	ND	21 U	ND	33 M(c)	110 U	110 U	190 M	120 M	64 U	99 U	ND
2,4-Dinitrophenol	ug/kg (wet)	110 U	120 U	120 U	120 U	ND	600 U	690 U	600 U	630 U	580 U	600 U	560 U	ND
4-Nitrophenol	ug/kg (wet)	34 U	ND	ND	38 U	ND	190 U	190 U	190 U	200 U	180 U	190 U	180 U	ND
Dibenzofuran	ug/kg (wet)	28 U	31 U	31 U	31 U	ND	160 U	150 U	160 U	170 U	150 U	160 U	150 U	ND
2,4-Dinitrotoluene	ug/kg (wet)	17 U	ND	ND	18 U	ND	91 U	90 U	92 U	97 U	88 U	92 U	85 U	ND
2,6-Dinitrotoluene	ug/kg (wet)	46 U	50 U	50 U	60 U	ND	250 U	250 U	250 U	270 U	240 U	260 U	240 U	ND
Diethylphthalate	ug/kg (wet)	61 M	15 U	15 U	51 M	ND	74 U	73 U	74 U	79 U	72 U	75 U	69 U	ND

TABLE E. Bulk Sediment Analysis Results in Wet Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		078507	078507	078507	078435	078435	078436	078437	078438	078439	078439	078440	078441	078441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T6	T7a	T7b
Compound	Units													
4-Chlorophenol-phenylether	ug/kg (wet)	24 U	27 U	27 U	27 U	ND	130 U	130 U	130 U	140 U	130 U	140 U	130 U	ND
Fluorene	ug/kg (wet)	20 U	22 U	22 U	22 U	ND	110 U	110 U	110 U	190 M	110 M	49 M	100 U	ND
4-Nitroaniline	ug/kg (wet)	63 U	69 U	69 U	69 U	ND	350 U	340 U	350 U	370 U	340 U	350 U	320 U	ND
4,6-Dinotro-2-Methylphenol	ug/kg (wet)	110 U	120 U	120 U	120 U	ND	620 U	620 U	620 U	660 U	600 U	630 U	580 U	ND
N-Nitrosodiphenylamine(1)	ug/kg (wet)	55 U	60 U	59 U	60 U	ND	300 U	300 U	300 U	320 U	290 U	300 U	280 U	ND
4-Bromophenyl-phenylether	ug/kg (wet)	22 U	24 U	24 U	24 U	ND	120 U	120 U	120 U	130 U	120 U	120 U	110 U	ND
Hexachlorobenzene	ug/kg (wet)	30 U	32 U	32 U	32 U	ND	160 U	160 U	160 U	170 U	160 U	160 U	150 U	ND
Pentachlorophenol	ug/kg (wet)	22 U	ND	ND	24 U	ND	120 U	120 U	120 U	130 U	120 U	120 U	110 U	ND
Phenanthrene	ug/kg (wet)	60 M	62 M	130 M	140	ND	330	230	170	950	1000	700	200	ND
Anthracene	ug/kg (wet)	16 U	17 U	17 U	64	ND	170 M	64 U	60 U	240 M	390 M	240 M	60 U	ND
Di-n-Butylphthalate	ug/kg (wet)	21	29 U	28 U	23 J(c)	ND	110	140 U	140 U	150 U	140 U	140 M(d)	170 M	ND
Fluoranthene	ug/kg (wet)	130	140	100	270	ND	600	610	330	2100	1100	1100	470 M	ND
Pyrene	ug/kg (wet)	230	ND	ND	670	ND	1000	2600	1600	3300	2400	3600	1100	ND
Butylbenzylphthalate	ug/kg (wet)	69 U	75 U	76 U	45 J	ND	180 M	370 U	380 U	400 U	370 U	380 U	350 U	ND
3,3'-Dichlorobenzidine	ug/kg (wet)	28 U	30 U	30 U	50 U	ND	150 U	150 U	150 U	160 U	150 U	150 U	140 U	ND
Benzo(a)Anthracene	ug/kg (wet)	55	81	95	150	ND	330 M	250	250	1300	900	1600	380	ND
bis(2-Ethylhexyl)Phthalate	ug/kg (wet)	1300	460	400	250	ND	800	360 U	410	210	180 M	850	320	ND
Chrysene	ug/kg (wet)	72	12 U	12 U	280	ND	610	69 U	430	1700	1200	60 U	65 U	ND
Di-n-Octyl Phthalate	ug/kg (wet)	58 U	61 U	61 U	61 U	ND	310 U	300 U	310 U	330 U	300 U	310 U	290 U	ND
Benzo(b)Fluoranthene and Benzo(k)Fluoranthene	ug/kg (wet)	177	190	230	460	ND	1200	1200	1600	2500	2100	4500	1200	ND
Benzo(a)Pyrene	ug/kg (wet)	120 M	140 M	160 M	300	ND	670	600	670	1500	1200	2100	600	ND
Indeno(1,2,3-cd)Pyrene	ug/kg (wet)	64 M	120 M	120 M	220	ND	610	620 M	430	1100	1100	1500	150 U	ND
Dibenz(a,h)Anthracene	ug/kg (wet)	35 U	38 U	38 U	38 U	ND	190 U	190 U	190 U	200 U	180 U	190 U	160 U	ND
Benzo(ghi)Perylene	ug/kg (wet)	110 M	150 M	140 M	280	ND	820	690	490 M	1200	1200	1400	410 M	ND

TABLE E. Bulk Sediment Analysis Results in Wet Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		870587	870587	870587	870435	870435	870436	870437	870438	870439	870439	870440	870441	870441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T6a	T6b	T8	T7a	T7b
Compound	Units													
Alpha-BHC	ug/kg (wet)	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Beta-BHC	ug/kg (wet)	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Delta-BHC	ug/kg (wet)	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Gamma-BHC (Lindane)	ug/kg (wet)	2.0 U	ND	ND	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Heptachlor	ug/kg (wet)	2.0 U	ND	ND	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Aldrin	ug/kg (wet)	2.0 U	ND	ND	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Heptachlor Epoxide	ug/kg (wet)	2.0 U	0.7 U	0.9 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Endosulfan I	ug/kg (wet)	2.0 U	0.7 U	0.9 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	4.0 U	4.0 U	ND
Dieldrin	ug/kg (wet)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
4,4'-DDE	ug/kg (wet)	4.0 U	0.6 U	0.9 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Endrin	ug/kg (wet)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Endosulfan II	ug/kg (wet)	4.0 U	1.1 U	1.2 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
4,4'-DDD	ug/kg (wet)	4.0 U	1.1 U	1.2 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Endosulfan Sulfate	ug/kg (wet)	4.0 U	1.1 U	1.2 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
4,4'-DDT	ug/kg (wet)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Methoxychlor	ug/kg (wet)	4.0 U	0.6 U	0.6 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Endrin Ketone	ug/kg (wet)	4.0 U	0.6 U	0.6 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Chlordane	ug/kg (wet)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Toxaphene	ug/kg (wet)	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	400 U	800 U	800 U	ND
Aroclor-1016	ug/kg (wet)	40 U	40 U	40 U	40 U	40 U	50	40 U	40 U	40 U	40 U	80 U	80 U	ND
Aroclor-1242	ug/kg (wet)	40 U	40 U	40 U	40 U	40 U	50	40 U	40 U	40 U	40 U	80 U	80 U	ND
Aroclor-1248	ug/kg (wet)	40 U	40 U	40 U	40 U	40 U	50	40 U	40 U	110	100	150	120	ND
Aroclor-1254	ug/kg (wet)	40 U	40 U	40 U	90	90	90	40	190	180	190	500	590	ND
Aroclor-1260	ug/kg (wet)	50	50	50	40 U	40 U	50	50	140	70	90	140	150	ND

TABLE E. Bulk Sediment Analysis Results in Wet Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		878587	878587	878587	878435	878435	878436	878437	878438	878439	878439	878440	878441	878441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T6	T7a	T7b
Compound	Units													
Antimony	ug/g (wet)	1.01	ND	ND	1.20	ND	4.09	1.50	2.09	7.10	7.11	0.96	6.63	ND
Arsenic	ug/g (wet)	6.21	ND	ND	6.27	ND	5.94	4.36	3.99	8.90	10.69	7.04	6.56	ND
Cadmium	ug/g (wet)	0.39	ND	ND	0.71	ND	1.09	0.44	0.45	1.30	1.11	0.61	0.77	ND
Chromium	ug/g (wet)	140.22	ND	ND	114.81	ND	190.37	90.49	261.63	212.94	228.77	491.97	254.33	ND
Copper	ug/g (wet)	30.32	ND	ND	36.34	ND	43.85	33.94	65.47	178.00	178.64	223.77	130.57	ND
Lead	ug/g (wet)	18.53	ND	ND	24.05	ND	56.50	36.53	53.01	96.64	96.55	130.13	101.27	ND
Mercury	ug/g (wet)	0.16	ND	ND	0.20	ND	0.72	0.32	0.88	4.63	4.69	2.22	1.57	ND
Nickel	ug/g (wet)	67.26	ND	ND	64.11	ND	68.06	54.21	50.02	79.72	84.83	112.16	90.21	ND
Selenium	ug/g (wet)	0.18	ND	ND	0.19	ND	0.09	0.10	0.05	0.17	0.21	0.12	0.18	ND
Silver	ug/g (wet)	0.21	ND	ND	0.22	ND	0.32	0.20	0.22	0.55	0.54	0.33	0.40	ND
Thallium	ug/g (wet)	0.36	ND	ND	0.32	ND	0.29	0.27	0.20	0.20	0.32	0.24	0.38	ND
Zinc	ug/g (wet)	74.67	ND	ND	88.96	ND	144.30	86.74	123.89	233.89	226.69	290.42	167.03	ND
Mono-butyltin	ug/kg (wet)	9.6	ND	ND	39.5	46.6	185.9	17.5	6.1	1.2U	ND	19.8	8.9U	68.6
Di-butyltin	ug/kg (wet)	20.6	ND	ND	13.9	19.7	7.8	6.3	17.0	1.3U	ND	12.0	71.3	116.4
Tri-butyltin	ug/kg (wet)	19.0	ND	ND	12.0	19.0	11.0	6.7	39.9	0.9U	ND	96.0	292.8	491.3
Total Butyltins	ug/kg (wet)	49.1	ND	ND	65.4	84.6	204.0	30.6	62.0	3.4U	ND	128.0	371.0	676.3
Total Organic Carbon	% (wet)	0.76	ND	ND	0.96	ND	0.87	1.05	0.64	1.12	1.10	0.87	0.8	ND
Total Oil and Grease	ug/g (wet)	192	ND	ND	138	ND	584	271	371	734	609	661	279	ND
Cyanide	ug/g (wet)	0.6 U	ND	ND	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
Total Sulfides	ug/g (wet)	132	ND	ND	117	ND	174	237	297	243	166	141	232	ND
Dissolved Sulfides	ug/g (wet)	128	ND	ND	417	ND	321	181	678	835	ND	738	610	610

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

(b) ND = Data not determined.

(c) J = Estimated value when result is less than specificed detection limit.

(d) M = Compound is present, but below detection.
Estimated value of analyte found and confirmed by analyst, but with low spectral match parameter.

TABLE E. Bulk Sediment Analysis Results in Dry Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		078587	078587	078587	078435	078435	078436	078437	078438	078439	078439	078440	078441	078441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T8	T7a	T7b
Compound	Units													
Phenol	ug/kg (dry)	23 U	ND	ND	30 U	ND	130 U	180 U	110 U	150 U	130 U	140 U	120 U	ND
bis(2-Chloroethyl)Ether	ug/kg (dry)	25 U	28 U	28 U	33 U	ND	140 U	200 U	120 U	160 U	140 U	160 U	130 U	ND
2-Chlorophenol	ug/kg (dry)	28 U	ND	ND	38 U	ND	180 U	220 U	140 U	180 U	180 U	170 U	140 U	ND
1,3-Dichlorobenzene	ug/kg (dry)	10 U	11 U	11 U	13 U	ND	67 U	79 U	49 U	63 U	58 U	62 U	52 U	ND
1,4-Dichlorobenzene	ug/kg (dry)	28 U	ND	ND	34 U	ND	160 U	200 U	130 U	160 U	150 U	160 U	130 U	ND
Benzyl Alcohol	ug/kg (dry)	31 U	34 U	33 U	39 U	ND	170 U	240 U	150 U	190 U	170 U	190 U	160 U	ND
1,2-Dichlorobenzene	ug/kg (dry)	6.9 U	7.8 U	7.5 U	8.9 U	ND	39 U	54 U	33 U	43 U	39 U	42 U	38 U	ND
2-Methylphenol	ug/kg (dry)	35 U	38 U	38 U	44 U	ND	190 U	270 U	170 U	220 U	200 U	210 U	180 U	ND
bis(2-chloroisopropyl)Ether	ug/kg (dry)	76 U	83 U	82 U	97 U	ND	430 U	590 U	360 U	470 U	430 U	460 U	390 U	ND
4-Methylphenol	ug/kg (dry)	17 U	19 U	19 U	22 U	ND	98 U	140 U	83 U	110 U	99 U	110 U	90 U	ND
N-Nitroso-Di-n-Propylamine	ug/kg (dry)	46 U	ND	ND	59 U	ND	260 U	360 U	220 U	290 U	260 U	280 U	240 U	ND
Hexachloroethane	ug/kg (dry)	46 U	50 U	50 U	59 U	ND	260 U	360 U	220 U	290 U	260 U	280 U	240 U	ND
Nitrobenzene	ug/kg (dry)	31 U	34 U	34 U	40 U	ND	180 U	240 U	150 U	190 U	160 U	190 U	160 U	ND
Isophorone	ug/kg (dry)	69 U	76 U	75 U	89 U	ND	390 U	540 U	330 U	430 U	390 U	420 U	360 U	ND
2-Nitrophenol	ug/kg (dry)	92 U	100 U	100 U	120 U	ND	520 U	720 U	440 U	580 U	520 U	560 U	470 U	ND
2,4-Dimethylphenol	ug/kg (dry)	82 U	90 U	90 U	110 U	ND	460 U	640 U	390 U	510 U	470 U	500 U	420 U	ND
Benzoic Acid	ug/kg (dry)	97 U	110 U	110 U	120 U	ND	550 U	760 U	470 U	610 U	550 U	590 U	500 U	ND
bis(2-Chloroethoxy)Methane	ug/kg (dry)	70 U	76 U	76 U	89 U	ND	390 U	540 U	330 U	440 U	400 U	420 U	350 U	ND
2,4-Dichlorophenol	ug/kg (dry)	97 U	110 U	110 U	130 U	ND	550 U	760 U	470 U	610 U	550 U	590 U	500 U	ND
1,2,4-Trichlorobenzene	ug/kg (dry)	53 U	ND	ND	69 U	ND	300 U	420 U	260 U	330 U	300 U	330 U	270 U	ND

Table E. Bulk Sediment Analysis Results in Dry Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		878587	878587	878587	878435	878435	878436	878437	878438	878439	878439	878440	878441	878441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T5a	T5b	T6	T7a	T7b
Compound	**Units**													
Naphthalene	ug/kg (dry)	94 U	100 U	100 U	120 U	ND	630 U	730 U	450 U	590 U	630 U	570 U	400 U	ND
4-Chloroaniline	ug/kg (dry)	50 U	55 U	55 U	65 U	ND	280 U	390 U	240 U	320 U	290 U	310 U	200 U	ND
Hexachlorobutadiene	ug/kg (dry)	52 U	60 U	57 U	67 U	ND	300 U	410 U	250 U	330 U	300 U	320 U	270 U	ND
4-Chloro-3-Methylphenol	ug/kg (dry)	54 U	ND	ND	69 U	ND	300 U	420 U	260 U	340 U	310 U	330 U	250 U	ND
2-Methylnaphthalene	ug/kg (dry)	51 U	60 U	65 U	66 U	ND	290 U	400 U	240 U	320 U	290 U	310 U	200 U	ND
Hexachlorocyclopentadiene	ug/kg (dry)	50 U	54 U	54 U	64 U	ND	280 U	390 U	240 U	310 U	280 U	300 U	250 U	ND
2,4,6-Trichlorophenol	ug/kg (dry)	18 U	19 U	19 U	23 U	ND	100 U	140 U	85 U	110 U	100 U	110 U	91 U	ND
2,4,5-Trichlorophenol	ug/kg (dry)	21 U	23 U	23 U	27 U	ND	120 U	170 U	100 U	130 U	120 U	130 U	110 U	ND
2-Chloronaphthalene	ug/kg (dry)	4.2 U	4.6 U	4.6 U	5.4 U	ND	24 U	33 U	20 U	26 U	24 U	26 U	22 U	ND
2-Nitroaniline	ug/kg (dry)	92 U	100 U	100 U	120 U	ND	520 U	720 U	440 U	580 U	520 U	560 U	470 U	ND
Dimethyl Phthalate	ug/kg (dry)	28 U	31 U	31 U	36 U	ND	160 U	220 U	130 U	180 U	160 U	170 U	140 U	ND
Acenaphthylene	ug/kg (dry)	5.6 U	6.4 U	6.3 U	7.5 U	ND	33 U	45 U	28 U	36 U	33 U	35 U	30 U	ND
3-Nitroaniline	ug/kg (dry)	54 U	59 U	59 U	70 U	ND	310 U	420 U	260 U	340 U	310 U	330 U	260 U	ND
Acenaphthene	ug/kg (dry)	33 U	ND	ND	42 U	ND	57 M	260 U	160 U	340 M	220 M	120 U	170 U	ND
2,4-Dinitrophenol	ug/kg (dry)	190 U	200 U	200 U	240 U	ND	1000 U	1400 U	800 U	1200 U	1100 U	1100 U	950 U	ND
4-Nitrophenol	ug/kg (dry)	59 U	ND	ND	75 U	ND	330 U	460 U	280 U	370 U	330 U	360 U	300 U	ND
Dibenzofuran	ug/kg (dry)	48 U	53 U	53 U	62 U	ND	270 U	380 U	230 U	300 U	270 U	290 U	250 U	ND
2,4-Dinitrotoluene	ug/kg (dry)	28 U	ND	ND	36 U	ND	160 U	220 U	140 U	180 U	160 U	170 U	150 U	ND
2,6-Dinitrotoluene	ug/kg (dry)	70 U	86 U	85 U	100 U	ND	440 U	610 U	380 U	490 U	450 U	460 U	400 U	ND
Diethylphthalate	ug/kg (dry)	100 M	25 U	25 U	100 M	ND	130 U	180 U	110 U	140 U	130 U	140 U	120 U	ND

TABLE E. Bulk Sediment Analysis Results in Dry Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		078587	078587	078587	078435	078435	078436	078437	078438	078439	078439	078440	078441	078441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T6a	T6b	T8	T7a	T7b
Compound	**Units**													
4-Chlorophenol-phenylether	ug/kg (dry)	42 U	46 U	45 U	53 U	ND	230 U	320 U	200 U	260 U	240 U	250 U	210 U	ND
Fluorene	ug/kg (dry)	34 U	37 U	37 U	43 U	ND	190 U	260 U	166 U	340 M	200 M	92 M	170 U	ND
4-Nitroaniline	ug/kg (dry)	110 U	120 U	120 U	140 U	ND	810 U	840 U	620 U	670 U	810 U	860 U	660 U	ND
4,6-Dinitro-2-Methylphenol	ug/kg (dry)	190 U	200 U	210 U	250 U	ND	1100 U	1600 U	920 U	1200 U	1100 U	1200 U	900 U	ND
N-Nitrosodiphenylamine(1)	ug/kg (dry)	93 U	100 U	100 U	120 U	ND	530 U	730 U	450 U	580 U	530 U	570 U	480 U	ND
4-Bromophenyl-phenylether	ug/kg (dry)	38 U	41 U	41 U	48 U	ND	210 U	290 U	180 U	240 U	210 U	230 U	190 U	ND
Hexachlorobenzene	ug/kg (dry)	50 U	55 U	55 U	66 U	ND	280 U	390 U	240 U	310 U	290 U	310 U	260 U	ND
Pentachlorophenol	ug/kg (dry)	37 U	ND	ND	48 U	ND	200 U	290 U	170 U	230 U	210 U	230 U	190 U	ND
Phenanthrene	ug/kg (dry)	85 M	110 M	220 M	270	ND	670	560	250	1700	1900	1300	440	ND
Anthracene	ug/kg (dry)	26 U	29 U	29 U	110	ND	310 M	210 U	130 U	430 M	720 M	460 M	140 U	ND
Di-n-Butylphthalate	ug/kg (dry)	36	49 U	49 U	47 J	ND	200	360 U	210 U	280 U	250 U	270 M	290 M	ND
Fluroanthene	ug/kg (dry)	230	230	310	630	ND	1500	1500	400	3800	2100	2000	810 M	ND
Pyrene	ug/kg (dry)	390	ND	ND	1300	ND	3300	6400	2400	6100	4300	6700	1900	ND
Butylbenzylphthalate	ug/kg (dry)	120 U	130 U	130 U	90 J	ND	310 M	910 U	560 U	730 U	670 U	720 U	600 U	ND
3,3'-Dichlorobenzidine	ug/kg (dry)	47 U	52 U	52 U	61 U	ND	270 U	370 U	230 U	300 U	270 U	290 U	240 U	ND
Benzo(a)Anthracene	ug/kg (dry)	90	140	160	310	ND	580 M	820	350	2400	1600	2900	660	ND
bis(2-Ethylhexyl)Phthalate	ug/kg (dry)	2200	790	660	580	ND	1400	880 U	600	380	330 M	1200	550	ND
Chrysene	ug/kg (dry)	120	20 U	20 U	550	ND	890	140 U	830	3200	2300	110 U	95 U	ND
Di-n-Octyl Phthalate	ug/kg (dry)	95 U	100 U	100 U	120 U	ND	540 U	740 U	450 U	600 U	640 U	580 U	490 U	ND
Benzo(b)Fluoranthene and Benzo(k)Fluoranthene	ug/kg (dry)	300	320	390	930	ND	2100	3000	2300	4500	3900	6400	2100	ND
Benzo(a)Pyrene	ug/kg (dry)	210 M	230 M	200 M	590	ND	1600	2100	1300	2900	2200	4800	1100	ND
Indeno(1,2,3-cd)Pyrene	ug/kg (dry)	140 M	200 M	200 M	450	ND	1100	1600 M	840	1900	2000	2600	260 U	ND
Dibenz(a,h)Anthracene	ug/kg (dry)	59 U	65 U	64 U	76 U	ND	330 U	450 U	280 U	370 U	340 U	360 U	300 U	ND
Benzo(ghi)Perylene	ug/kg (dry)	260 M	250 M	250 M	570	ND	1400	2200	750 M	2200	2200	2600	690 M	ND

TABLE E. Bulk Sediment Analysis Results in Dry Weight, Including Detection Limits where Concentration was at or Below Detection

Area		Alcatraz			Schnitzer				Todd Shipyard					
Battelle Id Number		870587	870587	870587	870435	870435	870436	870437	870438	870439	870439	870440	870441	870441
Station		A1	A2	A3	S1a	S1b	S2	S3	T4	T6a	T6b	T6	T7a	T7b
Compound	Units													
Alpha-BHC	ug/kg (dry)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Beta-BHC	ug/kg (dry)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Delta-BHC	ug/kg (dry)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Gamma-BHC (Lindane)	ug/kg (dry)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Heptachlor	ug/kg (dry)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Aldrin	ug/kg (dry)	4.0 U	ND	ND	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Heptachlor Epoxide	ug/kg (dry)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Endosulfan I	ug/kg (dry)	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	4.0 U	4.0 U	8.0 U	8.0 U	ND
Dieldrin	ug/kg (dry)	8.0 U	ND	ND	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
4,4'-DDE	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Endrin	ug/kg (dry)	8.0 U	ND	ND	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Endosulfan II	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
4,4'-DDD	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Endosulfan Sulfate	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
4,4'-DDT	ug/kg (dry)	8.0 U	ND	ND	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Methoxychlor	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Endrin Ketone	ug/kg (dry)	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	10.0 U	8.0 U	8.0 U	8.0 U	16.0 U	16.0 U	ND
Chlordane	ug/kg (dry)	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	20.0 U	16.0 U	16.0 U	16.0 U	32.0 U	32.0 U	ND
Toxaphene	ug/kg (dry)	800 U	800 U	800 U	800 U	800 U	800 U	1000 U	800 U	800 U	800 U	1600 U	1600 U	ND
Aroclor-1016	ug/kg (dry)	80 U	80 U	80 U	80 U	80 U	50	100 U	80 U	80 U	80 U	160 U	160 U	ND
Aroclor-1242	ug/kg (dry)	80 U	80 U	80 U	80 U	80 U	50	100 U	80 U	80 U	80 U	160 U	160 U	ND
Aroclor-1248	ug/kg (dry)	80 U	80 U	80 U	80 U	80 U	50	100 U	80 U	200	180	190	210	ND
Aroclor-1254	ug/kg (dry)	80 U	80 U	80 U	190	190	150	110	260	330	340	940	1000	ND
Aroclor-1260	ug/kg (dry)	90	100	90	80 U	80 U	90	120	210	130	150	260	230	ND

GEA TBL

Table Percent of sediment (dry weight) within specified seive size classes.

Use this as Table 3.18

Sediment Type	Seive Size Class in mm	Phi	A1	S1	S2	S3	T4	T5a	T5b	T6	T7
Battelle Id Number			870507	870435	870436	870437	870438	870439	870439	870440	870441
			Percent of Material Occurring in Each Seive Size								
	> 3.35	-2	0.95	0.00	0.00	0.00	0.00	0.42	0.54	0.00	0.28
	3.35 - 2.00	-1	1.17	0.00	0.01	0.00	0.01	0.39	1.42	0.94	0.08
	2.00 - 1.00	0	0.07	0.20	0.24	0.00	0.35	1.49	0.91	2.19	0.52
Sand	1.00 - 0.50	1	1.06	0.09	0.53	0.03	1.00	0.50	0.65	2.12	1.71
Sand	0.50 - 0.25	2	4.01	0.51	10.05	0.98	33.74	4.53	4.95	11.31	7.92
Sand	0.25 - 0.125	3	6.66	1.61	13.79	4.20	23.69	11.04	11.73	21.26	13.38
Sand	0.125 - 0.062	4	4.90	1.80	2.86	1.02	2.83	3.44	3.23	4.25	4.40
Silt	0.062 - 0.040	4.5	2.19	1.05	4.13	3.02	1.27	3.80	0.21	1.01	1.03
Silt	0.040 - 0.0312	5	0.64	3.36	2.67	3.61	1.58	0.15	4.73	1.04	1.07
Silt	0.0312 - 0.023	5.5	4.66	0.27	2.49	0.32	1.38	5.02	3.20	3.11	3.91
Silt	0.023 - 0.0156	6	8.20	3.47	1.03	5.44	2.06	1.07	0.25	1.04	4.01
Silt	0.0156 - 0.0078	7	0.95	11.42	7.46	9.07	2.53	8.04	5.30	6.10	10.00
Silt	0.0078 - 0.0039	8	6.36	10.50	9.12	12.45	4.46	6.98	8.93	8.72	6.02
Clay	0.0039 - 0.0019	9	8.58	12.46	7.59	11.39	4.42	11.30	9.16	7.69	7.44
Clay	0.0019 - 0.000976	10	5.41	21.87	7.36	18.16	4.39	10.22	10.36	8.72	7.41
Clay	< 0.000976	11	26.72	31.46	24.86	33.81	16.11	32.73	34.38	22.81	29.21
Total			100.01	99.99	100.00	100.00	100.02	99.99	99.97	100.01	99.99
Percent Dry Weight			68.19	51.90	56.83	42.37	69.65	55.99	56.00	64.47	68.41
Sample Weight (g Dry)			11.0290	10.4838	11.5422	8.0892	14.5847	11.4558	11.0327	11.1377	11.8006
Percent Recovery			96.65	98.66	97.26	98.49	93.15	96.01	94.97	99.43	97.28

Table ___. Percent of sediment (dry weight) which passes through seives with specified diameters.

Battelle Id Number			078587	078435	078436	078437	078438	078439	078439	078440	078441
Station			A1	S1	S2	S3	T4	T5a	T5b	T6	T7
Sediment Type	**Seive Size in mm**	**Phi**	**Percent of Material Passing Through Each Seive Size**								
	3.35	-2	99.08	100.01	100.01	100.01	100.01	99.59	99.47	100.01	99.73
	2.00	-1	97.89	100.01	100.00	100.01	100.00	99.20	98.05	99.07	99.65
	1.00	0	96.92	99.81	99.76	100.01	99.06	97.71	97.14	96.88	99.13
-------------	0.50	1	95.00	99.72	99.23	99.98	98.06	97.11	96.49	94.76	97.42
Sand	0.25	2	91.05	99.21	83.18	99.00	84.91	92.60	91.64	83.45	89.50
	0.125	3	84.30	97.70	69.89	94.60	41.02	81.64	79.81	62.19	76.12
-------------	0.062	4	79.49	96.90	68.53	92.98	38.19	78.10	76.65	57.94	71.72
	0.044	4.5	77.30	94.82	62.40	89.96	38.92	74.21	76.37	56.13	69.89
	0.0312	5	68.66	91.48	59.73	88.36	36.36	74.06	71.84	54.29	68.02
Silt	0.022	5.5	64.00	91.19	57.24	86.03	33.98	71.04	68.44	51.18	64.11
	0.0156	6	57.80	87.72	56.21	80.59	31.92	69.37	65.19	49.84	60.10
	0.0078	7	48.85	76.30	48.76	70.72	29.39	61.33	62.69	43.74	50.16
-------------	0.0039	8	40.49	66.80	39.64	58.29	24.91	54.36	53.90	37.02	44.08
Clay	0.0019	9	32.13	63.35	32.05	46.90	20.49	42.97	44.78	29.33	38.04
	0.000976	10	26.72	51.48	24.67	33.74	18.10	32.76	34.42	22.81	29.23

F.1.1 Organics (Dry)

Battelle Id Number		878439	878439	878439	878439
Station		T5a	T5b	I Stat	RPD
Compound	Units				
Phenol	ug/kg (dry)	150 U	130 U	N/A	N/A
bis(2-Chloroethyl)Ether	ug/kg (dry)	160 U	140 U	N/A	N/A
2-Chlorophenol	ug/kg (dry)	180 U	160 U	N/A	N/A
1,3-Dichlorobenzene	ug/kg (dry)	63 U	58 U	N/A	N/A
1,4-Dichlorobenzene	ug/kg (dry)	160 U	150 U	N/A	N/A
Benzyl Alcohol	ug/kg (dry)	190 U	170 U	N/A	N/A
1,2-Dichlorobenzene	ug/kg (dry)	43 U	39 U	N/A	N/A
2-Methylphenol	ug/kg (dry)	220 U	200 U	N/A	N/A
bis(2-chloroisopropyl)Ether	ug/kg (dry)	470 U	430 U	N/A	N/A
4-Methylphenol	ug/kg (dry)	110 U	99 U	N/A	N/A
N-Nitroso-Di-n-Propylamine	ug/kg (dry)	290 U	260 U	N/A	N/A
Hexachloroethane	ug/kg (dry)	290 U	260 U	N/A	N/A
Nitrobenzene	ug/kg (dry)	190 U	180 U	N/A	N/A
Isophorone	ug/kg (dry)	430 U	390 U	N/A	N/A
2-Nitrophenol	ug/kg (dry)	580 U	520 U	N/A	N/A
2,4-Dimethylphenol	ug/kg (dry)	510 U	470 U	N/A	N/A
Benzoic Acid	ug/kg (dry)	610 U	550 U	N/A	N/A
bis(2-Chloroethoxy)Methane	ug/kg (dry)	440 U	400 U	N/A	N/A
2,4-Dichlorophenol	ug/kg (dry)	610 U	550 U	N/A	N/A
1,2,4-Trichlorobenzene	ug/kg (dry)	330 U	300 U	N/A	N/A
Naphthalene	ug/kg (dry)	590 U	530 U	N/A	N/A
4-Chloroaniline	ug/kg (dry)	320 U	290 U	N/A	N/A
Hexachlorobutadiene	ug/kg (dry)	330 U	300 U	N/A	N/A
4-Chloro-3-Methylphenol	ug/kg (dry)	340 U	310 U	N/A	N/A
2-Methylnaphthalene	ug/kg (dry)	320 U	290 U	N/A	N/A
Hexachlorocyclopentadiene	ug/kg (dry)	310 U	280 U	N/A	N/A
2,4,6-Trichlorophenol	ug/kg (dry)	110 U	100 U	N/A	N/A
2,4,5-Trichlorophenol	ug/kg (dry)	130 U	120 U	N/A	N/A
2-Chloronaphthalene	ug/kg (dry)	26 U	24 U	N/A	N/A
2-Nitroaniline	ug/kg (dry)	580 U	520 U	N/A	N/A
Dimethyl Phthalate	ug/kg (dry)	180 U	160 U	N/A	N/A
Acenaphthylene	ug/kg (dry)	36 U	33 U	N/A	N/A
3-Nitroaniline	ug/kg (dry)	340 U	310 U	N/A	N/A

F.1.1 Organics (Dry)

Battelle Id Number		878439	878439	878439	878439
Station		T5a	T5b	I Stat	RPD
Compound	Units				
Acenaphthene	ug/kg (dry)	340 M	220 M	N/A	N/A
2,4-Dinitrophenol	ug/kg (dry)	1200 U	1100 U	N/A	N/A
4-Nitrophenol	ug/kg (dry)	370 U	338 U	N/A	N/A
Dibenzofuran	ug/kg (dry)	300 U	270 U	N/A	N/A
2,4-Dinitrotoluene	ug/kg (dry)	180 U	160 U	N/A	N/A
2,6-Dinitrotoluene	ug/kg (dry)	490 U	450 U	N/A	N/A
Diethylphthalate	ug/kg (dry)	140 U	130 U	N/A	N/A
4-Chlorophenol-phenylether	ug/kg (dry)	260 U	240 U	N/A	N/A
Fluorene	ug/kg (dry)	340 M	200 M	N/A	N/A
4-Nitroaniline	ug/kg (dry)	670 U	610 U	N/A	N/A
4,6-Dinotro-2-Methylphenol	ug/kg (dry)	1200 U	1100 U	N/A	N/A
N-Nitrosodiphenylamine(1)	ug/kg (dry)	580 U	530 U	N/A	N/A
4-Bromophenyl-phenylether	ug/kg (dry)	240 U	210 U	N/A	N/A
Hexachlorobenzene	ug/kg (dry)	310 U	290 U	N/A	N/A
Pentachlorophenol	ug/kg (dry)	230 U	210 U	N/A	N/A
Phenanthrene	ug/kg (dry)	1700	1900	0.06	11.11
Anthracene	ug/kg (dry)	430 M	720 M	N/A	N/A
Di-n-Butylphthalate	ug/kg (dry)	280 U	260 U	N/A	N/A
Fluroanthene	ug/kg (dry)	3800	2100	0.29	57.63
Pyrene	ug/kg (dry)	6100	4300	0.17	34.62
Butylbenzylphthalate	ug/kg (dry)	730 U	670 U	N/A	N/A
3,3'-Dichlorobenzidine	ug/kg (dry)	300 U	270 U	N/A	N/A
Benzo(a)Anthracene	ug/kg (dry)	2400	1600	0.20	40.00
bis(2-Ethylhexyl)Phthalate	ug/kg (dry)	360	330 M	N/A	N/A
Chrysene	ug/kg (dry)	3200	2300	0.16	32.73
Di-n-Octyl Phthalate	ug/kg (dry)	600 U	540 U	N/A	N/A
Benzo(b)Fluoranthene and Benzo(k)Fluoranthene	ug/kg (dry)	4600	3900	0.08	16.47
Benzo(a)Pyrene	ug/kg (dry)	2900	2200	0.14	27.45
Indeno(1,2,3-cd)Pyrene	ug/kg (dry)	1900	2000	0.03	5.13
Dibenz(a,h)Anthracene	ug/kg (dry)	370 U	340 U	N/A	N/A
Benzo(ghi)Perylene	ug/kg (dry)	2200	2200	0.00	0.00

F.1.2 Pesticides (Dry)

Battelle Id Number		878435	878435	878435	878435	878439	878439	878439	878439
Station		S1a	S1b	I Stat	RPD	T5a	T5b	I Stat	RPD
Compound	Units								
Alpha-BHC	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Beta-BHC	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Delta-BHC	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Gamma-BHC (Lindane)	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Heptachlor	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Aldrin	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Heptachlor Epoxide	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Endosulfan I	ug/kg (dry)	4.0 U	4.0 U	N/A	N/A	4.0 U	4.0 U	N/A	N/A
Dieldrin	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
4,4'-DDE	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Endrin	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Endosulfan II	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
4,4'-DDD	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Endosulfan Sulfate	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
4,4'-DDT	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Methoxychlor	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Endrin Ketone	ug/kg (dry)	8.0 U	8.0 U	N/A	N/A	8.0 U	8.0 U	N/A	N/A
Chlordane	ug/kg (dry)	16.0 U	16.0 U	N/A	N/A	16.0 U	16.0 U	N/A	N/A
Toxaphene	ug/kg (dry)	800 U	800 U	N/A	N/A	800 U	800 U	N/A	N/A
Aroclor-1016	ug/kg (dry)	80 U	80 U	N/A	N/A	80 U	80 U	N/A	N/A
Aroclor-1242	ug/kg (dry)	80 U	80 U	N/A	N/A	80 U	80 U	N/A	N/A
Aroclor-1248	ug/kg (dry)	80 U	80 U	N/A	N/A	200	180	0.05	10.53
Aroclor-1254	ug/kg (dry)	190	190	0.00	0.00	330	340	0.01	2.99
Aroclor-1260	ug/kg (dry)	80 U	80 U	N/A	N/A	130	150	0.07	14.29

APPENDIX F

CHEMICAL ANALYSIS

F.1.3 Metals, Organotins, TOC, Oil and Grease, Cyanide, and Sulfides (Dry)

Battelle Id Number		870436	870436	870436	870436	870439	870439	870439	870439	870441	870441	870441	870441
Station		S1a	S1b	I Stat	RPD	T6a	T6b	I Stat	RPD	T7a	T7b	I Stat	RPD
Compound	Units												
Antimony	ug/g (dry)	2.50	ND	N/A	N/A	13.12	13.03	0.0	0.7	11.39	ND	N/A	N/A
Arsenic	ug/g (dry)	10.80	ND	N/A	N/A	16.30	19.40	0.1	17.4	9.20	ND	N/A	N/A
Cadmium	ug/g (dry)	1.42	ND	N/A	N/A	2.02	2.03	0.0	0.5	1.33	ND	N/A	N/A
Chromium	ug/g (dry)	230.00	ND	N/A	N/A	390.00	419.00	0.0	7.2	437.00	ND	N/A	N/A
Copper	ug/g (dry)	71.10	ND	N/A	N/A	326.00	327.00	0.0	0.3	224.00	ND	N/A	N/A
Lead	ug/g (dry)	48.40	ND	N/A	N/A	177.00	175.00	0.0	1.1	174.00	ND	N/A	N/A
Mercury	ug/g (dry)	0.41	ND	N/A	N/A	0.30	0.40	0.0	1.2	2.70	ND	N/A	N/A
Nickel	ug/g (dry)	120.00	ND	N/A	N/A	140.00	155.00	0.0	8.0	155.00	ND	N/A	N/A
Selenium	ug/g (dry)	0.38	ND	N/A	N/A	0.31	0.39	0.1	22.9	0.31	ND	N/A	N/A
Silver	ug/g (dry)	0.46	ND	N/A	N/A	1.00	0.99	0.0	1.0	0.70	ND	N/A	N/A
Thallium	ug/g (dry)	0.64	ND	N/A	N/A	0.62	0.59	0.1	12.8	0.65	ND	N/A	N/A
Zinc	ug/g (dry)	170.00	ND	N/A	N/A	420.00	415.00	0.0	3.1	287.00	ND	N/A	N/A
Mono-butyltin	ug/kg (dry)	77.3	39.3	0.1	14.4	2.1 U	ND	N/A	N/A	10.2 U	101.9	N/A	N/A
Di-butyltin	ug/kg (dry)	27.3	38.6	0.2	34.8	2.4 U	ND	N/A	N/A	105.9	171.3	0.2	47.2
Tri-butyltin	ug/kg (dry)	23.5	87.5	0.2	45.9	1.7 U	ND	N/A	N/A	434.8	729.6	0.3	50.6
Total Butyltins	ug/kg (dry)	128.1	165.4	0.1	25.4	6.2 U	ND	N/A	N/A	550.9	1002.8	0.3	50.2
Total Organic Carbon	% (dry)	1.9	ND	N/A	N/A	2.0	2.0	0.0	0.0	1.4	ND	N/A	N/A
Total Oil and Grease	ug/g (dry)	271	ND	N/A	N/A	1342	930	0.2	36.3	414.0	1.2 U	N/A	N/A
Cyanide	ug/g (dry)	1.2 U	1.2 U	N/A	N/A	1.2 U	1.2 U	N/A	N/A	1.2 U	1.2 U	N/A	N/A
Total Sulfides	ug/g (dry)	234.5	ND	N/A	N/A	442.6	300.6	0.2	38.2	396.8	ND	N/A	N/A
Dissolved Sulfides	ug/g (dry)	835.7	ND	N/A	N/A	1521.0	ND	N/A	N/A	1042.7	1042.7	0.0	0.0

F.1.4 Grain Size Analysis

Battelle Id Number			878439	878439	878439	878439
Station			T5a	T5b	I Stat	RPD
Sediment Type	Grain Size in mm	Phi				
	> 3.35	- 2	0.42	0.54	0.13	25.00
	3.35 - 2.00	- 1	0.39	1.42	0.57	114.00
	2.00 - 1.00	0	1.49	0.91	0.24	48.00
----------	1.00 - 0.50	1	0.60	0.85	0.34	6.00
Sand	0.50 - 0.25	2	4.63	4.95	0.34	9.00
	0.25 - 0.125	3	11.34	11.73	0.93	6.00
----------	0.125 - 0.062	4	3.44	3.23	0.03	8.00
	0.062 - 0.046	4.5	3.09	5.21	0.98	180.00
	0.046 - 0.0312	5	0.15	4.73	0.94	186.00
Silt	0.0312 - 0.023	5.5	3.02	3.20	0.05	6.00
	0.023 - 0.0156	6	1.67	8.25	0.74	148.00
	0.0156 - 0.0078	7	6.04	5.30	0.21	41.00
----------	0.0078 - 0.0039	8	6.98	6.93	0.12	26.00
	0.0039 - 0.0019	9	11.38	9.18	0.11	21.00
Clay	0.0019 - 0.000976	10	10.22	10.36	0.01	1.00
	< 0.000976	11	32.73	34.38	0.02	6.00

F.2 ANALYSIS OF ACCURACY (STANDARD REFERENCE MATERIALS)

F.2.1 Organics

Standard Reference Sediment (NOAA)

Compound	Units	Analyte Added	Analyte Detected	% Response (Detected/Added x 100)
Phenol	ug/kg (dry)	330	420	127.27
bis(2-Chloroethyl)Ether	ug/kg (dry)	None	21 U	N/A
2-Chlorophenol	ug/kg (dry)	None	23 U	N/A
1,3-Dichlorobenzene	ug/kg (dry)	60	51	85.00
1,4-Dichlorobenzene	ug/kg (dry)	30	19 M	N/A
Benzyl Alcohol	ug/kg (dry)	None	25 U	N/A
1,2-Dichlorobenzene	ug/kg (dry)	100	40	40.00
2-Methylphenol	ug/kg (dry)	None	28 U	N/A
bis(2-chloroisopropyl)Ether	ug/kg (dry)	None	62 U	N/A
4-Methylphenol	ug/kg (dry)	300	320	106.67
N-Nitroso-Di-n-Propylamine	ug/kg (dry)	None	37 U	N/A
Hexachloroethane	ug/kg (dry)	None	37 U	N/A
Nitrobenzene	ug/kg (dry)	None	25 U	N/A
Isophorone	ug/kg (dry)	100	140	140.00
2-Nitrophenol	ug/kg (dry)	None	75 U	N/A
2,4-Dimethylphenol	ug/kg (dry)	None	67 U	N/A
Benzoic Acid	ug/kg (dry)	None	79 U	N/A
bis(2-Chloroethoxy)Methane	ug/kg (dry)	None	57 U	N/A
2,4-Dichlorophenol	ug/kg (dry)	None	80 U	N/A
1,2,4-Trichlorobenzene	ug/kg (dry)	None	44 U	N/A
Naphthalene	ug/kg (dry)	100	130	130.00
4-Chloroaniline	ug/kg (dry)	None	41 U	N/A
Hexachlorobutadiene	ug/kg (dry)	None	43 U	N/A
4-Chloro-3-Methylphenol	ug/kg (dry)	None	44 U	N/A
2-Methylnaphthalene	ug/kg (dry)	100	110	110.00
Hexachlorocyclopentadiene	ug/kg (dry)	None	40 U	N/A
2,4,6-Trichlorophenol	ug/kg (dry)	None	14 U	N/A
2,4,5-Trichlorophenol	ug/kg (dry)	None	17 U	N/A
2-Chloronaphthalene	ug/kg (dry)	None	3 U	N/A
2-Nitroaniline	ug/kg (dry)	None	75 U	N/A
Dimethyl Phthalate	ug/kg (dry)	None	23 U	N/A
Acenaphthylene	ug/kg (dry)	100	95	95.00
3-Nitroaniline	ug/kg (dry)	None	44 U	N/A

F.2.1 Organics

Standard Reference Sediment (NOAA)

Compound	Units	Analyte Added	Analyte Detected	% Response (Detected/Added x 100)
Acenaphthene	ug/kg (dry)	100	150	150.00
2,4-Dinitrophenol	ug/kg (dry)	None	150 U	N/A
4-Nitrophenol	ug/kg (dry)	None	48 U	N/A
Dibenzofuran	ug/kg (dry)	None	5.3 M	N/A
2,4-Dinitrotoluene	ug/kg (dry)	None	23 U	N/A
2,6-Dinitrotoluene	ug/kg (dry)	None	64 U	N/A
Diethylphthalate	ug/kg (dry)	None	19 U	N/A
4-Chlorophenol-phenylether	ug/kg (dry)	100	130	130.00
Fluorene	ug/kg (dry)	100	140	140.00
4-Nitroaniline	ug/kg (dry)	None	88 U	N/A
4,6-Dinotro-2-Methylphenol	ug/kg (dry)	None	160 U	N/A
N-Nitrosodiphenylamine(1)	ug/kg (dry)	None	75 U	N/A
4-Bromophenyl-phenylether	ug/kg (dry)	100	280	280.00
Hexachlorobenzene	ug/kg (dry)	None	41 U	N/A
Pentachlorophenol	ug/kg (dry)	300	440	146.67
Phenanthrene	ug/kg (dry)	100	200	200.00
Anthracene	ug/kg (dry)	100	160	160.00
Di-n-Butylphthalate	ug/kg (dry)	None	22 M	N/A
Fluroanthene	ug/kg (dry)	100	190	190.00
Pyrene	ug/kg (dry)	100	160	160.00
Butylbenzylphthalate	ug/kg (dry)	None	96 U	N/A
3,3'-Dichlorobenzidine	ug/kg (dry)	None	39 U	N/A
Benzo(a)Anthracene	ug/kg (dry)	100	200	200.00
bis(2-Ethylhexyl)Phthalate	ug/kg (dry)	100	170	170.00
Chrysene	ug/kg (dry)	100	210	210.00
Di-n-Octyl Phthalate	ug/kg (dry)	None	78 U	N/A
Benzo(b)Fluoranthene and	ug/kg (dry)	100	170	170.00
Benzo(k)Fluoranthene	ug/kg (dry)	None	74 J	N/A
Benzo(a)Pyrene	ug/kg (dry)	100	200	200.00
Indeno(1,2,3-cd)Pyrene	ug/kg (dry)	100	120	120.00
Dibenz(a,h)Anthracene	ug/kg (dry)	100	220	220.00
Benzo(ghi)Perylene	ug/kg (dry)	100	240	240.00

F.2.2 Pesticides

Methods did not give detection limit for Pesticide/PCB analysis that would allow for detection of the SRMs

F.2.3 Metals, Organotins, TOC, Oil and Grease, Cyanide, And Sulfides (Wet)

		SRM 1646		SRM MESS-1		SRM PACS-1	
Compound	Units	Certified Conc. Range	Measured Conc.	Certified Conc. Range	Measured Conc.	Certified Conc. Range	Measured Conc.
Antimony	ug/g (dry)	None	None	None	None	None	None
Arsenic	ug/g (dry)	10.30-12.90	12.40	9.40-11.80	11.60	200.00-222.00	167.00
Cadmium	ug/g (dry)	0.29-0.43	0.37	None	None	None	None
Chromium	ug/g (dry)	73.00-79.00	86.00	60.00-82.00	72.00	105.00-121.00	111.00
Copper	ug/g (dry)	16.00-21.00	19.40	21.30-28.90	23.90	436.00-468.00	410.00
Lead	ug/g (dry)	26.40-30.00	26.50	27.90-40.10	31.90	384.00-424.00	409.00
Mercury	ug/g (dry)	0.06-0.08	0.08	None	None	4.41-4.73	4.52
Nickel	ug/g (dry)	29.00-35.00	32.00	26.80-32.20	26.00	42.10-46.10	46.90
Selenium	ug/g (dry)	None	None	None	None	0.98-1.20	1.03
Silver	ug/g (dry)	None	None	None	None	None	None
Thallium	ug/g (dry)	None	None	None	None	None	None
Zinc	ug/g (dry)	132.00-144.00	132.00	174.00-206.00	190.00	802.00-846.00	810.00

No Standard Reference Materials available for Organotins, TOC, Cyanide, or Sulfides.

F.2.4 Grain Size

No Data

F.3 ANALYSIS OF METHODS (SPIKES)

F.3.1 Organics

Alcatraz Island Sediment	Units	Matrix Spike Concentration Rep. 1	Percent Recovery Rep. 1	Matrix Spike Concentration Rep. 2	Percent Recovery Rep. 2
Base Neutrals					
1,2,4-Trichlorobenzene	ug/kg (dry)	5307	82.8	5069	79.1
Acenaphthene	ug/kg (dry)	5382	82.4	5369	83.8
2,4-Dinitrotoluene	ug/kg (dry)	6299	98.3	5910	92.2
Pyrene	ug/kg (dry)	5611	81.6	6536	96.0
N-Nitroso-Di-n-Propylamine	ug/kg (dry)	6550	102.0	6263	97.7
1,4-Dichlorobenzene	ug/kg (dry)	5077	79.2	5857	75.8
Acids					
Pentachlorophenol	ug/kg (dry)	8708	67.9	8264	64.4
Phenol	ug/kg (dry)	10665	83.2	10175	79.4
2-Chlorophenol	ug/kg (dry)	11231	87.3	10503	81.9
4-Chloro-3-Methylphenol	ug/kg (dry)	13028	102.0	12793	99.8
4-Nitrophenol	ug/kg (dry)	17192	134.0	15084	118.0

F.3.2 Pesticides

Gamma-BHC (Lindane)	ug/kg (dry)	1.0	78.0	Not Reported	93.0
Heptachlor	ug/kg (dry)	1.0	57.0	Not Reported	69.0
Aldrin	ug/kg (dry)	1.0	69.0	Not Reported	85.0
Dieldrin	ug/kg (dry)	1.0	76.0	Not Reported	91
Endrin	ug/kg (dry)	1.0	105.0	Not Reported	122
4,4'-DDT	ug/kg (dry)	1.0	76.0	Not Reported	78
Aroclor-1260	ug/kg (dry)	1.0	100.0	Not Reported	90

F.3.3 Metals, Organotins, TOC, Oil and Grease, Cyanide, and Sulfides

Metals	Units	878587 (A1) Matrix Spike Concentration Rep. 1	878587 (A1) Percent Recovery Rep. 1	878439 (T6) Matrix Spike Concentration Rep. 2	878439 (T6) Percent Recovery Rep. 2
Antimony	ug/g (dry)	5.00	89.0	5.00	96.0
* Arsenic	ug/g (dry)	N/A	N/A	N/A	N/A
Cadmium	ug/g (dry)	1.00	117.0	1.00	95.0
* Chromium	ug/g (dry)	N/A	N/A	N/A	N/A
* Copper	ug/g (dry)	N/A	N/A	N/A	N/A
* Lead	ug/g (dry)	N/A	N/A	N/A	N/A
Mercury	ug/g (dry)	0.50	106.0	0.50	**
* Nickel	ug/g (dry)	N/A	N/A	N/A	N/A
Selenium	ug/g (dry)	1.00	103.0	1.00	98.0
Silver	ug/g (dry)	0.50	91.0	0.50	83.0
Thallium	ug/g (dry)	1.00	115.0	1.00	116.0
Organotins					
Mono-butyltin	ng/g (dry)	1661.0	76.0	1806.0	76.0
Di-butyltin	ng/g (dry)	1661.0	78.0	1806.0	78.0
Tri-butyltin	ng/g (dry)	1661.0	88.0	1806.0	74.0
Total Organic Carbon	%	N/A	N/A	N/A	N/A
Cyanide	ug/g (dry)	2.0	74.10	N/A	N/A
Total Sulfides Dissolved Sulfides	ug/g (dry)	110.0	77.00	N/A	N/A

Oil and Grease Analysis		API Standard #1 Spike Conc.	API Standard #1 Measured Conc.	API Standard #2 Certified Conc.	API Standard #2 Measured Conc.
Oil and Grease	ug/g (dry)	38.45	48.00	192.00	228.00

F.3.4 Grain Size

No Data

* Samples were analyzed by XRF; No spikes can be used with this method

** Sample concentration was too high to see spike

F.4 PERCENT SURROGATE SAMPLE RECOVERIES BY STATION (Dry Weight)

F.4.1 Organics

	878435 S1	878436 S2	878437 S3	878438 T4	878439 T5a	878439 T5b	878440 T6	878441 T7	878587 A1
Base/Neutrals									
d5-Nitrobenzene	70.4	47.6	62.0	46.0	57.6	45.6	52.7	51.1	76.8
2-Fluorobiphenyl	84.5	83.7	102.0	83.1	96.2	76.6	89.7	87.7	88.2
d14-p-Terphenyl	92.3	109.0	160.0	147.0	126.0	92.6	117.0	124.0	98.5
Acids									
d5-Phenol	73.6	67.2	82.4	67.2	73.0	62.0	72.5	69.3	80.8
2-Fluorophenol	70.9	73.3	69.0	73.7	80.6	71.5	79.5	76.5	82.4
2,4,6-Tribromophenol	101.0	67.7	62.5	67.3	84.1	58.5	62.1	73.0	91.5

F.4.2 Pesticides

	878435 S1	878436 S2	878437 S3	878438 T4	878439 T5a	878439 T5b	878440 T6	878441 T7	878587 A1
Dibutylchlorebdate	92.0	116.0	106.0	97.0	65.0	97.0	106.0	76.0	149.0

F.4.3 Metals, Organotins, TOC, Oil and Grease, Cyanide, and Sulfides

	878435 S1	878436 S2	878437 S3	878438 T4	878439 T5a	878439 T5b	878440 T6	878441 T7	878587 A1
Metals	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Organotins									
Tripropyltin	130	82	140	116	203	194	70	104	160
Total Organic Carbon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Oil and Grease	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cyanide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Sulfides	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Sulfides	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

F.4.4 Grain Size

	878435 S1	878436 S2	878437 S3	878438 T4	878439 T5a	878439 T5b	878440 T6	878441 T7	878587 A1
Percent Recovery	98.66	97.26	98.49	93.15	96.01	94.97	99.43	97.28	96.65

APPENDIX G

EQUIPMENT LIST, CALIBRATION AND MAINTENANCE RECORDS

Appendix G. Equipment List, Calibration and Maintenance Records

Analysis:	Organics and Pesticides.
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 2 electron capture detectors. Finnigan Model 4000 Mass Spectrophotometer. Finnigan INCOS Beta System. Hewlett-Packard 5790 Gas Chromatograph.
Calibration Information:	Daily calibration by ARI personnel using US EPA Contract Lab Protocol (CLP). Performance checks with Standard Reference Materials (SRM's) by ARI personnel before run series.
Maintenance Information:	Maintenance by ARI or Hewlett-Packard personnel on routine basis or when indicated by performance checks.
Sample Tracking:	All analysis tied to specific machine and operator via sample tracking form utilized 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 Schmadzo Spectrophotometer (Cyanide Analysis). Titration Buret (Sulfide Analysis).
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 analysis tied to specific machine and operator via laboratory book system approved by AmTest and verified by John Daily.
Responsible Person:	John Daily

Analysis:	Organotins
Performed At:	Battelle MRL Sequim, Washington
Equipment:	Hewlett-Packard 5890 Gas Chromatograph Hewlett-Packard 5970 Mass Selective Detector (MSD)
Calibration Information:	Gas Chromatograph calibrated daily with tributyltin standards. MSD calibrated daily with perflurotributyltin standard (internal standard).
Maintenance Information:	Maintenance by either Battelle or Hewlett-Packard personnel. Schedule dependent upon use, but usually monthly.
Sample Tracking:	All analysis tied to specific machine and operator via Battelle's laboratory book system. All data approved by E.A. Crecelius (Battelle MRL).
Responsible Person(s):	E.A. Crecelius and T.A. Fortman.

Analysis: Mercury, Silver, Cadmium, Selenium, Thallium and Antimony.

Performed At: Battelle MRL
Sequim, Washington.

Equipment: Laboratory Data Control Cold Vapor Atomic Absorption Spectrophotometer for Mercury.

Perkin-Elmer 5000 Atomic Absorption Spectrophotometer for Selenium, Cadmium and Silver.

Perkin-Elmer 3030 Atomic Absorption Spectrophotometer for Thallium and Antimony.

Calibration Information: All instruments calibrated daily with Standard Reference Materials (SRM's).

Maintenance Information: Maintenance by Battelle or authorized technical representatives as needed or when indicated by calibration results.

Sample Tracking: All analysis tied to specific machine and operator via Battelle's laboratory book system. All data approved by E.A. Crecelius (Battelle MRL).

Responsible Person(s): E.A. Crecelius, C.W. Apts and O.A. Cotter.

Zeeman Graphite Furnace Atomic Absorption Spectrophotometer

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

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

Analysis:	Grain Size
Performed At:	Battelle MRL Sequim, Washington
Equipment:	Tyler Standard Seives Mettler AC-100 Analytical Balance
Calibration Information:	Mettler Analytical Balance calibrated every 12 months by Quality Control Services, Portland, Oregon.
Maintenance Information:	Mettler Analytical Balance maintenance every 12 months by Quality Control Services, Portland, Oregon.
Sample Tracking:	All analysis tied to specific balance and analyst via Battelle's laboratory book system. All data approved by E.A. Crecelius (Battelle MRL).
Responsible Person(s):	E.A. Crecelius and C.W. Apts.

Analysis:	Oyster Larvae Bioassay
Performed At:	Battelle MRL Sequim, Washington
Equipment:	Mettler PE-3600 Analytical Balance American Optical Corporation Refractometer Kessler Model 74A-136 Thermometer ERTCO FC-36486 Thromometer (Standard) Orion Research Model 701-A Digital Ionalyzer YSI Model 58 Digital D.O. Meter RICCA Buffers I.A.P.O. Standard Seawater (35 o/oo)
Calibration Information:	The Mettler balance is calibrated annually by Qulaity Control Services, Portland, Oregon. The Refractometer and Kessler Thermometer were calibrated by Battelle personnel before the bioassay test to Standard Seawater and ERTCO thermometer, respectively. The Orion Ionalyzer was calibrated before each use with the RICCA buffers, and the YSI D.O. Meter was air calibrated (100% saturation) before each use by Battelle personnel. Standard Stawater
Maintenance Information:	With the exception of the analytical balance, maintenance is performed on an "as needed" basis (determined by calibration results) by Battelle personnel.
Sample Tracking:	All measurements tied to specific instrument and analyst via Battelle's laboratory book system. All data approved by J.Q. Word (Battelle MRL).
Responsible Person(s):	J.Q. Word and J.A. Ward.

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