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Chemistry and Toxicity in Rhine Channel Sediments

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Final Report

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ABSTRACT

The spatial extent of sediment contamination and toxicity was examined for sediments collected from the Rhine Channel of Newport Bay. Concentrations of heavy metals, PAHs, PCBs, and pesticides were analyzed at 15 sites throughout the channel. The acute toxicity of Rhine Channel sediments was examined using a 10 day amphipod test, while sublethal effects of dissolved toxicants was examined with a sediment-water interface test using sea urchin embryos. Sediment contamination was prevalent in the Rhine Channel. Chemical-specific sediment quality guidelines (e.g., TEL) were exceeded for As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, and PCBs at most sites. Sediment toxicity was also prevalent in the Rhine Channel. Toxic sediments were identified at a majority of the 15 stations sampled. However, the cause of the sediment or seawater-interface toxicity reported in this study could not be determined with the available data. There were no statistically significant negative correlations among metals or organic contaminants and toxicity. It is possible that unmeasured contaminants or differences in contaminant bioavailability among stations may be responsible for the observed toxicity.

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INTRODUCTION

The USEPA is in the process of promulgating technical total maximum daily loads (TMDLs) for toxic loads in Lower Newport Bay including the Rhine Channel. The promulgated technical TMDLs will be a basis for the development of State TMDLs that will include an implementation plan. The implementation plan may require that the contaminated sediments be addressed to resolve water quality impairments. Thus an up to date understanding of the contamination and toxicity of sediments in Newport Bay, including the potential for impacts on the water column is necessary for the development of effective TMDLs.

Prior studies have identified the Rhine Channel as a high priority candidate Toxic Hot Spot (THS) based on sediment, water column, animal tissue residue, and benthic degradation data (SWRCB 1999; Phillips *et al*. 1998). Studies conducted in 1986 by the Santa Ana Regional Water Quality Control Board measured contaminants in 26 sediment samples from the Rhine Channel. These samples indicated the presence of elevated levels of metals and PCBs in locations scattered throughout the channel (T. Reeder, pers. comm.). Constituents of concern in the channel include heavy metals, polychlorinated biphenyls (PCBs), tributyl tin (TBT), and pesticides. Mercury concentrations in Rhine Channel sediments have been measured at concentrations ten to twelve times higher than the threshold value at which toxicity effects are expected to occur in organisms. Sediment and pore water toxicity has also been exhibited in a variety of toxicity tests (Phillips *et al*. 1998).

A comprehensive sampling of the Rhine Channel has not been conducted since 1986. Knowledge of the distribution and magnitude of contaminants and toxicity in the Rhine Channel is needed to guide potential remediation activities.

The goal of this study is to determine the spatial extent of sediment toxicity and contamination in the Rhine Channel. The study has two objectives. The first objective is to determine the spatial extent of the toxicity in surface sediments in the channel. The second objective is to determine the spatial extent of contamination in the Rhine Channel and determine the relationship between contamination and toxicity. Sediment samples were collected from throughout Rhine Channel and tested for toxicity and chemical contamination in both the bulk sediment and in samples from the sediment-water interface.

METHODS

STUDY DESIGN

Sediment samples were collected from 15 stations in Rhine Channel (Figure 1). These stations were distributed throughout the study area in order to identify contamination gradients related to known or suspected sources of contamination and to describe spatial patterns of toxicity. Many of the stations were located near areas sampled by the Regional Board in 1986 in order to facilitate temporal comparisons of the data.

Each sediment sample was analyzed for toxicity, chemical concentrations, and grain size. Two types of toxicity tests were conducted. The toxicity of the bulk sediment was measured using a 10-day amphipod survival test. This test measures the survival of the amphipod crustacean, *Eohaustorius estuarius,* after 10 days of exposure to whole sediment. The 10-day amphipod survival test is the benchmark indicator used to describe sediment toxicity in regional monitoring studies and dredged material investigations throughout the state of California and the nation. The second toxicity test measured the potential of the sediments to impact overlying water quality. In this test, known as the sediment-water interface (SWI) test, the toxicity of water in contact with the sediment surface is measured. This test determines whether sediment-associated toxicants are able to transfer into the water column in harmful quantities. Subsamples of bulk sediment and overlying water (from the SWI test) were also measured for trace metals and trace organics (sediment samples only) in order to determine the nature of the relationship between contamination and toxicity.

FIELD SAMPLING

Sediment samples were collected on May 14, 2002 from 15 sites in Rhine Channel, Newport Bay (Figure 1). Station locations are listed in the Appendix. Samples were collected using a 0.1 m^2 Van Veen grab. The top 2 cm of sediment from multiple grabs at each site were composited and then distributed to sample containers for chemistry analysis or toxicity testing. A separate grab was taken at each site for the collection of sediment subcores for the sediment-water interface test. The subcores consisted of plastic tubes that were inserted approximately 5 cm into the sediment and then carefully removed to minimize sample disturbance. Seawater was gently added to the core tube to prevent the sediment surface from drying out. Four replicate core samples were collected. All sediment samples were put on ice for transport to the laboratory.

CHEMICAL ANALYSIS

Sediment Metals and Organics

Samples for trace metal analysis were prepared using EPA Method 3015 and analyzed by Inductively Coupled Plasma Mass Spectrometry (ICPMS) using EPA Method 6020. Samples for organics analysis were extracted using EPA Method 3540 and analyzed by

Gas Chromatography/Mass Spectrometry (GC/MS) by EPA Method 8270. Total organic carbon concentrations were determined by EPA Method 415.1. Chemical analyses of the samples were conducted by CRG Labs, Torrance CA. The sample holding time before metals analysis was 35 days, and before sediment organics analysis was 62 days.

Sediment Grain Size

Sediment grain size analysis was performed by Aquatic Bioassay and Consulting Laboratories (Ventura, CA) using a single laser particle size analyzer. For this report, grain size is expressed as % fines (dry weight basis), which includes the silt and clay fractions (all particles $\leq$ 44 µm).

Overlying Water Metals

A composite sample composed of overlying water was collected from each of the replicate tubes from the sea urchin SWI toxicity test. Each sample was filtered through a 0.45 µm cellulose acetate filter to separate the dissolved fraction, then acidified with ultrapure nitric acid and stored under refrigeration until analyzed by ICPMS using EPA Method 1640. Only dissolved metals were measured in the overlying water samples. The sample holding time before metals analysis of the overlying water from the SWI test was four days.

TOXICITY TESTING

Bulk Sediment Toxicity

The 10-day amphipod survival test (U.S. EPA 1994) was used to evaluate toxicity of the whole sediment samples. The amphipods, *Eohaustorius estuarius*, were collected from Yaquina Bay near Newport, Oregon. The animals were held in the laboratory on their native (home) sediment for four days before testing began. Amphipod home sediment was tested as a negative control. The tests were conducted in 1 L glass jars containing 2 cm of sediment (approximately 150 ml) and 800 ml of water. Five replicates were used for each sample and the control. The overlying water was adjusted to a salinity of 20 g/kg, and the exposures conducted at 15°C. The sediment was added to the five replicate jars and overlying water added with aeration one day before the animals were added, in order to provide a 24 hr equilibration period. After equilibration, 20 amphipods were added to each beaker to start the test. The beakers were monitored daily for visible changes to the sediment or death of the animals. At the end of the exposure period, the sediment from the beakers was passed through a sieve to recover the animals, and the number of surviving animals counted. Water quality parameters (temperature, pH, dissolved oxygen, ammonia, and salinity) were measured on the pore water and overlying water of surrogate water quality beakers at both the beginning and end of the exposure period.

Sediment-Water Interface Toxicity

The preparation of the sediment-water interface (SWI) test samples was conducted according to the procedures described by Anderson *et al*. (1996). The toxicity of the SWI samples was tested using the purple sea urchin development test (U. S. EPA 1995). This test measures the ability of the sea urchin larvae to develop normally from a fertilized egg in test media. The purple sea urchins (*Strongylocentrotus purpuratus*) used in the tests were collected from the intertidal zone in northern Santa Monica Bay.

To test a SWI sample, the overlying water in each of the four core tube replicates was first replaced with clean seawater. Aeration was then applied to the core tubes. Four replicate cores were used for each sediment type. After equilibration for 24 h, a polycarbonate cylinder with a fine mesh screen bottom (screen tube) was placed on the sediment inside the core tube. Two controls were included in the test: a screen tube blank (screen tube placed in a beaker of seawater) and a core tube blank (core containing only seawater). Four replicates of each control were tested. Fertilized sea urchin eggs were then added to the screen tube and given 72 hr to develop at 15°C. After the exposure period, the screen tubes were removed from the core tube and the outside rinsed to remove any adhering sediment. The embryos were then rinsed into glass shell vials and preserved in formalin. Each sample was examined using a microscope to determine the percentage of normally developed embryos. Water quality parameters (temperature, pH, dissolved oxygen, ammonia, and salinity) were measured on the overlying water at both the beginning and end of the exposure period.

DATA ANALYSIS

Data from the amphipod survival and sea urchin development tests were tested for significant reductions in survival or percentage normal development using multiple t-tests, assuming unequal variances. Comparisons were made against the home sediment control for the amphipod test, and the screen tube blank for the sea urchin development test. The Spearman nonparametric correlation coefficient was calculated to describe the relationships among toxicity and sediment chemistry parameters.

The chemistry data were compared to three types of sediment quality guidelines, the Apparent Effects Threshold (AET) for amphipods (Puget Sound Estuary Program 1988) and the Effects Range-Low or Effects Range-Median (ERM), developed by NOAA (Long *et al*. 1995) and the Threshold Effects Level (TEL), developed by MacDonald (1994). The overall level of chemical contamination at each station was compared using the mean ERM quotient (ERMq), which was calculated as follows:

$$\text{Mean ERMq} = \frac{1}{N}\sum_{x=1}^{N}\left(\frac{C_x}{ERM_x}\right)$$

Where Cx and ERMx are the sediment concentration and ERM for contaminant x, respectively, and N is the total number of chemical parameters. The parameters used for calculating the ERMq included nine metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn), 13 PAH compounds (acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene), and total PCB (the sum of congeners 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201 and 206). Nondetects were treated as equal to half the detection limit.

Spatial patterns in the distribution of toxicity and contamination within Rhine Channel were described using contour plotting. The data were plotted using the advanced natural neighbor interpolation method in MapInfo and Vertical Mapper software.

RESULTS

SEDIMENT CHEMISTRY

The concentrations of all contaminants measured in this study can be found in Appendices A, B and C. A subset of contaminants, based on historical use patterns or particular constituents of concern, will be discussed in the following results section.

Concentrations of As varied by a factor of two, ranging from 8.8-19.6 mg/kg. The highest concentrations were found in the upper channel between the 29th Street drain and the cannery area (Figure 2). The lowest concentrations were found near the entrance to Rhine Channel.

Concentrations of Cu varied by a factor of four throughout the study area, ranging from 225-957 mg/kg. The highest concentrations were found in the central part of the channel (between Balboa Boatyards and South Coast Shipyards) and in the upper channel between the 29th Street drain and the cannery area (Figure 3). The lowest concentrations of Cu were found near the entrance to Rhine Channel.

Concentrations of Cr varied by a factor of three, ranging from 30-86 mg/kg. The highest concentrations were found in the central part of the channel (Figure 4). The lowest concentrations were found in the northern most part of the upper channel.

Concentrations of Cd varied by a factor of 3.5, ranging from 0.61-2.13 mg/kg. The highest concentration was found in the upper channel near the 29th Street drain (Figure 5). The lowest concentrations were found in the lower and central parts of the channel, and near the Lido Street drain in the upper channel.

Concentrations of Pb varied by a factor of four, ranging from 43.9-16.8 mg/kg. The highest concentration was found in the upper channel near the 29th Street drain (Figure 6). The lowest concentrations were found near the entrance to Rhine Channel.

Concentrations of Hg varied by a factor of six throughout Rhine Channel, ranging from 2.4-14.3 mg/kg. Concentrations were lowest at the entrance to Rhine Channel, with the highest concentrations present near the 29th Street drain and the cannery area (Figure 7).

Concentrations of Ni varied by a factor of three, ranging from 11.8-34.1 mg/kg. The highest concentrations were found in the central part of the channel (Figure 8). The lowest concentrations were found in the northern most part of the upper channel, near the Lido Street drain.

Concentrations of total PAHs varied by a factor of 4, ranging from 778-2831 ng/g. The highest concentrations were found in the upper part of the Channel near the 29th Street drain, while the lowest concentrations were found in the central part of the channel, between Balboa Boatyards and South Coast Shipyards (Figure 9).

Concentrations of total PCBs varied by a factor of eight, ranging from 51-401 ng/g. The highest concentration was found in the upper channel between the 29th Street drain and the cannery area (Figure 10). The lowest concentrations were found near the entrance to Rhine Channel.

Concentrations of total DDTs varied by a factor of three, ranging from 30-98 ng/g. The highest concentration was near the entrance to Rhine Channel.

Sediment grain size ranged from 71-95 % fines throughout Rhine Channel. Sediments in the lower part of the channel had the greatest proportion of fines and grain size tended to increase at stations closest to the upper end of the channel. (Figure 11).

SEDIMENT-WATER INTERFACE CHEMISTRY

The concentrations of dissolved metals in samples of overlying water from the SWI test were generally more variable than the sediment concentrations. The concentrations of Cu, Hg, Ni, Se and Zn in the SWI samples were generally greater than that of the blank sample of laboratory seawater used to start the SWI exposure, indicating that there was a net flux of these constituents out of the sediment and into the water column during the 72-hour test duration (Figures 12 and 13). Dissolved Cu concentrations ranged from 2-13 µg/L. The concentration of Zn at station RC1 was 140 µg/L, which was a 37 fold elevation relative to the blank. Nine of the SWI samples contained greater than 30 µg/L of Zn, which is greater than the median effect concentration (EC50) for toxicity to purple sea urchin embryos.

In contrast, the concentrations of As, Cd, Cr, Pb and Sn in the overlying water were generally lower than the the concentrations in the seawater blank, indicating that there was no net flux of these constituents out of the sediment (Figures 12 and 13). The concentration of dissolved Cr was below the blank value for all stations except station RC7.

TOXICITY

Bulk Sediment Toxicity

Most of the stations in the Rhine Channel (11 out of 15) had sediments that were toxic to amphipods (Table 1). Ten of these sites were highly toxic (significantly different and <80% of control survival), while one site had marginal toxicity (significantly different but ≥80% control survival). All of the stations in the lower part of Rhine Channel were toxic to amphipods (Figure 14), with the most toxic sediments found near the entrance of the channel (33% adjusted survival), and off the Lido Shipyard (40% adjusted survival). Station RC1 in the upper part of the channel had low amphipod survival (57% of control), but was not identified as being toxic due to the high variability in these data. Sediment from most of the stations in the upper portion Rhine Channel was not toxic to amphipods.

Sediment-Water Interface Toxicity

Samples of the sediment-water interface from 10 stations in the Rhine Channel were highly toxic to sea urchin embryos (Table 1). Three of the remaining five sites had low normal development (54-73% of control), but were not identified as being toxic due to high variability in these data. Two stations produced much greater toxicity (=3% normal development) than all other samples (32-92% normal development); these two stations were located in the upper part of the channel (Figure 15). Most stations in the lower part of the channel were also highly toxic. In the lower channel area, sediment from offshore of the Lido Shipyard produced the greatest toxicity to sea urchin embryos (32% normal development).

Some toxicity was measured in the core tube blank control sample, which had 81% normal development compared to the screen tube blank value of 97%. The results for the core tube blank were highly variable and thought to be unrepresentative of the condition of the sea urchin embryos. All statistical comparisons were conducted using only the screen tube blank results.

RELATIONSHIPS AMONG PARAMETERS

While both the amphipod survival test and the sea urchin development test detected toxicity at a majority of stations in Rhine Channel, the correlation between these indicators was not statistically significant (Table 2).

Amphipod survival was not significantly correlated with the concentrations of metals in the bulk sediment (Table 2). However, it was significantly correlated with the concentrations of total PAHs ($r = 0.66$, $p = 0.01$) and PCBs ($r = 0.78$, $p < 0.01$). The correlation coefficients had a positive sign, indicating that amphipod survival tended to increase with increasing levels of these contaminants (Figure 16). Amphipod survival was negatively correlated with sediment grain size ($r = -0.61$, $p = 0.02$); survival tended to decrease in finer grain sediments (Figure 17).

Sea urchin embryo development was not correlated with any of the bulk sediment parameters measured (Table 2). However, embryo development was negatively correlated with concentrations of dissolved Pb ($r = -0.56$, $p = 0.03$) and dissolved Sn ($r = -0.68$, $p = 0.01$) in the SWI samples (Figures 18 and 19). Concentrations of other metals in the SWI samples were not significantly correlated with embryo development (Table 3). Other than Pb and Sn, dissolved Cu concentration had one of the highest correlation with embryo development. Embryo toxicity was always present in water samples containing greater than 8 µg/L of dissolved Cu (Figure 20). A similar trend was evident for As, Hg, Cd ,Cr, Ni, and Zn; .toxicity was almost always present in the one or two samples having the highest dissolved concentrations for each metal. With the exception of zinc and copper, most metal concentrations in the SWI samples were below levels likely to be toxic to sea urchin embryos or other aquatic life.

Nonparametric correlation coefficients were calculated between sediment contaminants and three grain size fractions of the whole sediment: percent sand, percent silt, and percent clay. Relatively few statistically significant correlations were obtained for contaminants of concern (Table 4). Cr was significantly correlated with % sand (negative relationship) and % silt (positive), suggesting that this constituent was relatively more abundant in the silt fraction. Sn was significantly correlated with % sand (positive) and % clay (negative), suggesting that the distribution of this metal was most influenced by the sand content of the sediment. The distribution of trace organics showed variable relationships with grain size; PAHs were positively correlated with % sand, while DDTs were positively correlated with only the silt fraction and no association was evident for PCBs.

COMPARISON TO SEDIMENT QUALITY GUIDELINES

Concentrations of contaminants measured in Rhine Channel sediments were compared to sediment quality guidelines based on the NOAA effects range low (ERL) or median (ERM) approach and the State of Washington apparent effects threshold (AET) approach (Table 5). Concentrations of Hg exceeded the ERM and amphipod AET guidelines at all 15 stations (Table 6). Mercury concentrations exceeded the amphipod AET up to a factor of 6, while the Hg ERM value was exceeded by up to a factor of 20. Other contaminants exceeding ERM values included Cu (at 14 sites by up to a factor of four), total PCBs (at eleven sites by up to a factor of two), and Zn (at three sites by a factor of 1).

The mean ERM quotient (ERMq) among Rhine Channel sites ranged from 0.28-1.30, with values <1.00 at 12 of the stations (Table 6). Amphipod survival was not significantly correlated with mean ERMq values ($r = 0.45$, $p = 0.09$). Amphipod survival tended to be highest at mean ERMq values >1.0 (Figure 27), which was opposite of the expected trend.

Concentrations of Cu, Hg, Pb, Zn, and total PCBs exceeded the sediment TMDL targets established for Rhine Channel (equivalent to TEL) at all 15 stations. Concentrations of Cu were up to 51 times the sediment TMDL target value, while Hg concentrations were up 110 times the target value, Pb was up to 5.6 times the target value, Zn was up to 4.3 times the target value, and total PCBs were up to 13 times the target value. Concentrations of Cr also exceeded the sediment TMDL target value at stations RC3-RC14. Concentrations of Cr were up to 1.7 times the sediment TMDL target value. The sediment TMDL target values for these constituents are equivalent to the TEL values listed in Table 5.

Fourteen other constituents exceeded TEL values (Table 6). This included As (all 15 stations), Cd (at 12 stations), Ni (at 14 stations), acenaphthene (at two stations), acenaphthylene (at eight stations), anthracene (at one station), benzo(a)anthracene (at seven stations), benzo(a)pyrene (at 11 stations), chrysene (at eight stations), dibenz(a,h)anthracene (at all 15 stations), phenanthrene (at two stations), pyrene (at seven stations), high molecular weight PAHs (at seven stations), and total PAHs (at three stations). Concentrations of these constituents exceeded the TEL value by up to a factor of 2.7 for As, up to 3.1 for Cd, up to 2.1 for Ni, up to 1.2 for acenaphthene, up to 1.8 for acenaphthylene, up to 1.4 for anthracene, up to for 2.5 benzo(a)anthracene, up to 2.8 for benzo(a)pyrene, up to 2.9 for chrysene, up to 7.1 for dibenz(a,h)anthracene, up to 1.3 for phenanthrene, up to 2.6 for pyrene, up to 2.2 for high molecular weight PAHs, and up to 1.7 for total PAHs.

DISCUSSION

This study found sediment toxicity to be prevalent in the Rhine Channel. Two tests, an acute test of bulk sediment toxicity and a sublethal test of sediment-water transfer of toxicants detected toxicity at a majority of the 15 stations. Sediment contamination was also prevalent within Rhine Channel. The mean ERM quotient was above 0.1 at every station, indicating that all 15 stations contain elevated sediment contaminant concentrations. Chemical-specific sediment quality guidelines were exceeded for Cu, Hg, and PCBs at most stations, which is consistent with contamination patterns identified in previous studies by the Santa Ana Regional Water Quality Control Board.

An association between sediment contamination and toxicity could not be established in this study. There were no statistically significant negative correlations among metal or organic contaminants and toxicity. Statistically significant correlations were present among sediment PAHs or DDTs and amphipod survival, but these positive correlations do not indicate an adverse effect due to increasing chemical concentrations. Correlation analyses for amphipod toxicity and SWI metal concentration provide the only statistical evidence for an association between toxicity to amphipods and contamination (Appendix E). Significant negative correlations with amphipod survival were present for Se and Zn. The concentration of Se and Zn in the SWI samples are below those likely to cause toxicity, but, as the concentration of constituents in the SWI samples may correspond to variations in contaminant bioavailability or desorption into the pore water, these correlations may indicate that there were variations in pore water metal concentrations that may have been associated with toxic responses.

High percentages of fine sediments (silt and clay) have been associated with reduced amphipod survival in other studies and the correlation results suggest that grain size may have had an adverse effect on the amphipod test results in this study. There is no evidence to substantiate this inference, however. *Eohaustorius estuarius* is tolerant of a wide range of sediment grain sizes (U.S. EPA 1994) and the sediment grain size composition measured in the Rhine Channel are within the tolerance range of this species.

Data from the Bight'98 regional survey and other recent research in Newport Bay demonstrate good survival for *E. estuarius* in sediments of similar grain size composition to that present in Rhine Channel (Figures 28 and 29). In these studies, good survival was obtained in sediment containing higher percentages of silt and clay than those present in the Rhine Channel (=80% silt and =20% clay). *E. estuarius* has been reported to be sensitive to high concentrations of clay (Environment Canada 1998), but the effect is relatively small. A sediment sample containing 67% clay (much higher than the Rhine Channel clay content) produced a small reduction in survival of *E. estuarius* to 74%. There have been no controlled studies that demonstrate sediment grain size-related mortality to *E. estuarius* similar to the range of response obtained in this study.

The results of the SWI test with sea urchin embryos provide evidence that the toxicity measured for the Rhine Channel sediments is not due solely to physical effects from fine grain size. The SWI test measures the toxicity of water overlying an undisturbed sediment core. Toxicity to sea urchin embryos was present at 10 stations; significant negative correlations with toxicity were present for Pb and Sn. Elevated concentrations of dissolved trace metals were also observed for Cu, Ni, Hg, Se, and Zn, indicating that some contaminants were released from the sediment into the water column.

The cause of the sediment or SWI toxicity reported in this study cannot be determined with the data available. It is possible that unmeasured contaminants or differences in contaminant bioavailability among stations in Rhine Channel may be responsible for the observed toxicity. Additional studies, including toxicity identification evaluations (TIEs), are needed to determine the specific factors responsible for the toxicity measured in Rhine Channel.

Preliminary TIE studies at selected sites in Rhine Channel have produced inconsistent results to date. TIEs were conducted on a SWI sample from a station near RC7 in November 2001 (Bay 2003). SWI toxicity was reduced by treatments effective on both metals and nonpolar organics. The results indicated that metals were likely to be at least partially responsible for the SWI toxicity, with zinc the most likely cause. Sediment and pore water TIE experiments were also conducted on samples from Rhine Channel stations in March 2002 (Bay 2003). The experiments were unable to characterize the cause of pore water toxicity in one sample and produced variable results for three sediment samples, suggesting that there may be multiple types of toxicants present within the channel.

Chemistry data from the Newport Bay TIE studies show that dissolved concentrations of Cu and Zn are elevated in both water column and SWI samples from Rhine Channel, relative to other locations in Newport Bay. These data are consistent with the SWI chemistry results from this study and indicate that contaminated sediments in Rhine Channel are a probable source of increased metal concentrations in the water column. The sediment TIE chemistry results also indicate that metals in Rhine Channel sediments are unlikely to be a cause of acute toxicity to amphipods. Measured concentrations of sediment acid volatile sulfides (AVS) are approximately 30-fold greater than the simultaneously extracted metal concentrations, indicating that virtually all of the Cd, Cu, Ni, Pb, and Zn should be bound to sulfides and therefore of limited bioavailability to sediment-dwelling organisms. The AVS results are in apparent conflict with the water column and SWI chemistry results and indicate that more research is needed to discern the influence of metals on sediment toxicity in Rhine Channel.

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Table 1. Amphipod survival in exposures to Rhine Channel sediment, and sea urchin embryo development in sediment-water interface test.

	Amphipod 10 day survival Whole Sediment Test Initiated: 5/21/02 Test Ended: 5/31/02				Sea urchin development Sediment-water interface Test Initiated: 5/17/02 Test Ended: 5/20/02			
Sample	Mean	Std Dev	% Control	Significantly different from Home Sediment	Mean	Std Dev	% Control	Significantly different from screen tube blank
Home Sediment	88	6.7	100					
Screen Tube Blank					97	1.7	100	
RC1	50	46.4	57		1	0.8	1	**
RC2	89	12.4	101		48	6.6	49	**
RC3	78	19.2	89		3	3.2	3	**
RC4	79	15.2	90		52	44.5	54	
RC5	72	9.1	82	*	80	23.2	82	
RC6	67	13.0	76	**	89	9.4	92	
RC7	42	14.0	48	**	48	42.4	50	**
RC8	58	13.5	66	**	70	18.4	73	**
RC9	42	16.8	48	**	31	32.2	32	**
RC10	46	18.5	52	**	61	48.0	63	
RC11	56	24.1	64	**	40	34.4	41	**
RC12	35	25.0	40	**	39	39.4	40	**
RC13	44	18.2	50	**	62	17.7	65	**
RC14	59	8.9	67	**	52	15.3	53	**
RC15	29	25.1	33	**	70	28.7	73	

* = marginal toxicity (significantly different from control); ** = high toxicity (significantly different and <80% of control).

Table 2. Relationship between sediment constituents and toxicity. Non-detects were treated as equal to half the detection limit. The Spearman rank correlation procedure was used for all analyses. An r-value < 0 indicates a negative correlation, while r-values > 0 indicate a positive correlation. A p-value $\leq$ 0.05 is considered statistically significant.

	Amphipod survival		Sea urchin development	
	r	p	r	p
Sea urchin development	0.089	0.75		
Sediment Grain Size (% Fines)	-0.610	0.02	0.072	0.80
Metals/Metalloids				
Ag	0.31	0.27	-0.06	0.84
As	0.27	0.33	-0.01	0.98
Cd	0.32	0.25	0.12	0.67
Cr	-0.16	0.56	0.20	0.48
Cu	0.32	0.24	-0.31	0.26
Hg	0.38	0.17	-0.08	0.79
Ni	-0.23	0.41	0.19	0.51
Pb	0.36	0.19	0.07	0.81
Se	0.03	0.90	0.17	0.54
Sn	0.45	0.09	-0.11	0.70
Zn	0.19	0.51	0.08	0.77
Organics				
Total PAHs	0.66	0.01	0.22	0.43
Total PCBs	0.78	0.00	-0.08	0.77
Total DDTs	0.07	0.80	-0.02	0.93
ERMq	0.45	0.09		

Table 3. Relationship between concentrations of dissolved metals in overlying water from the sediment-water interface test and sea urchin embryo development. Non-detects were treated as equal to half the detection limit.

	Sea urchin embryo normal development	
	r	p
Al	-0.11	0.69
As	-0.22	0.43
Cd	-0.18	0.53
Co	-0.20	0.47
Cr	-0.01	0.97
Cu	-0.39	0.16
Fe	0.06	0.84
Hg	-0.19	0.51
Mn	-0.02	0.95
Mo	-0.05	0.85
Ni	-0.35	0.20
Pb	-0.56	0.03
Sb	-0.33	0.23
Se	-0.42	0.12
Ti	0.00	1.00
Tl	-0.32	0.24
Sn	-0.68	0.01
V	-0.02	0.94
Zn	-0.33	0.23

Table 4. Relationship between sediment contaminants and grain size.

	Sand		Silt		Clay	
	r	p	r	p	r	p
Metals/Metalloids						
Ag	0.530	0.042	-0.351	0.200	-0.689	0.004
Al	-0.737	0.002	0.791	0.000	0.528	0.043
As	0.175	0.532	-0.070	0.805	-0.216	0.439
Ba	-0.260	0.350	0.283	0.307	0.157	0.575
Be	-0.808	0.000	0.826	0.000	0.635	0.011
Cd	0.088	0.756	-0.091	0.746	-0.111	0.694
Cr	-0.520	0.047	0.568	0.027	0.318	0.248
Co	-0.569	0.027	0.611	0.015	0.370	0.175
Cu	0.347	0.205	-0.204	0.467	-0.336	0.221
Fe	-0.560	0.030	0.574	0.025	0.379	0.164
Hg	0.313	0.256	-0.186	0.508	-0.382	0.160
Mn	-0.453	0.090	0.456	0.088	0.300	0.277
Mo	0.534	0.040	-0.232	0.405	-0.668	0.007
Ni	-0.597	0.019	0.650	0.009	0.386	0.156
Pb	0.100	0.722	0.016	0.955	-0.204	0.466
Sb	0.479	0.071	-0.225	0.420	-0.464	0.081
Se	-0.138	0.625	0.314	0.254	0.000	1.000
Sn	0.526	0.044	-0.349	0.203	-0.542	0.037
Sr	0.550	0.033	-0.504	0.056	-0.454	0.089
Ti	-0.307	0.265	0.450	0.092	0.175	0.533
Tl	-0.494	0.061	0.530	0.042	0.329	0.231
V	-0.627	0.012	0.703	0.003	0.406	0.133
Zn	0.107	0.703	0.038	0.894	-0.177	0.528
Organics						
Total PAHs	0.624	0.013	-0.593	0.020	-0.696	0.004
Total PCBs	0.229	0.412	-0.289	0.296	-0.275	0.321
Total DDTs	-0.447	0.095	0.575	0.025	0.214	0.443

Table 5. Sediment quality guidelines used to evaluate contaminant concentrations in Rhine Channel sediments.

	ERL	ERM	Amphipod AET	TEL
Metals/Metalloids (mg/kg)				
As	8.2	70	450	7.24
Cd	1.2	9.6	14	0.68
Cr	81	370	>1,100	52.3
Cu	34	270	1,300	18.7
Hg	0.15	0.71	2.3	0.13
Pb	46.7	218	1,200	30.2
Ni	20.9	51.6	>370	15.9
Ag	1.0	3.7	6.1	0.73
Zn	150	410	3,800	124
Organics (ng/g)				
Low molecular weight PAHs	552	3,160	29,000	312
acenaphthene	16	500	2,000	6.71
acenaphthylene	44	640	1,300	5.87
anthracene	85.3	1,100	13,000	46.9
fluorene	19	540	3,600	21.2
2-methyl naphthalene	70	670	1,900	20.2
naphthalene	160	2,100	2,400	34.6
High molecular weight PAHs	1,700	9,600	69,000	655
phenanthrene	240	1,500	21,000	86.7
benzo(a)anthracene	261	1,600	5,100	74.8
benzo(a)pyrene	430	1,600	3,500	88.8
chrysene	384	2,800	21,000	108
dibenz(a,h)anthracene	63.4	260	1,900	6.22
fluoranthene	600	5,100	30,000	113
pyrene	665	2,600	16,000	153
Total PAHs	4,022	44,792	–	1684
Total PCBs	22.7	180	–	21.6

ERL = Effects Range-Low, from Long *et al.* 1995; ERM = Effects Range-Median, from Long *et al.* 1995; AET = Apparent Effects Threshold, from Puget Sound Estuary Program 1988; TEL = Threshold Effect Levels, from MacDonald 1994.

Table 6. Rhine Channel stations exceeding sediment quality guidelines. Non-detects were treated as equal to half the detection limit for calculating the ERM quotient (ERMq). HMW = high molecular weight.

Station	Mean ERMq	Contaminants exceeding ERL	Contaminants exceeding ERM	Contaminants exceeding amphipod AET	Contaminants exceeding TEL
RC1	0.679	As, Cu, Hg, Pb, Zn, total PCBs	Cu, Hg	Hg	As, Cu, Hg, Pb, Zn, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, HMW PAHs, total PCBs
RC2	0.884	As, Cu, Hg, Pb, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cu, Hg, Pb, Ni, Zn, acenaphthylene, anthracene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, total PAHs, HMW PAHs, total PCBs
RC3	1.152	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, HMW PAHs, total PCBs

Table 6 continued

Station	Mean ERMq	Contaminants exceeding ERL	Contaminants exceeding ERM	Contaminants exceeding amphipod AET	Contaminants exceeding TEL
RC4	1.297	As, Cd, Cu, Hg, Ni, Zn, total PCBs	Cu, Hg, Zn, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, total PAHs, HMW PAHs, total PCBs
RC5	0.972	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, benzo(a)pyrene, dibenz(a,h)anthracene, total PCBs
RC6	0.770	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthene, acenaphthylene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, total PAHs, HMW PAHs, total PCBs
RC7	0.859	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, Zn	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, dibenz(a,h)anthracene, total PCBs

Table 6 continued

Station	Mean ERMq	Contaminants exceeding ERL	Contaminants exceeding ERM	Contaminants exceeding amphipod AET	Contaminants exceeding TEL
RC8	0.817	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, total PCBs
RC9	0.960	As, Cr, Cu, Hg, Zn, total PCBs	Cu, Hg, Zn, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, benzo(a)pyrene, dibenz(a,h)anthracene, total PCBs
RC10	1.000	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, benzo(a)pyrene, dibenz(a,h)anthracene, total PCBs
RC11	0.654	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, dibenz(a,h)anthracene, total PCBs
RC12	0.700	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cr, Cu, Hg, Pb, Ni, Zn, dibenz(a,h)anthracene, total PCBs

Table 6 continued

Station	Mean ERMq	Contaminants exceeding ERL	Contaminants exceeding ERM	Contaminants exceeding amphipod AET	Contaminants exceeding TEL
RC13	0.839	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthylene, benzo(a)pyrene, dibenz(a,h)anthracene, total PCBs
RC14	0.638	As, Cu, Hg, Pb, Ni, Zn, total PCBs	Cu, Hg, total PCBs	Hg	As, Cd, Cr, Cu, Hg, Pb, Ni, Zn, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, pyrene, HMW PAHs, total PCBs
RC15	0.281	As, Cu, Hg, Zn, total PCBs	Hg	Hg	As, Cu, Hg, Pb, Ni, Zn, chrysene, dibenz(a,h)anthracene, pyrene, HMW PAHs, total PCBs

Parameters used for calculating ERM quotients included: As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, acenaphthene, acenaphthylene, anthracene, fluorene, 2-methylnaphthalene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, pyrene, total PCBs (sum of congeners 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, 206).

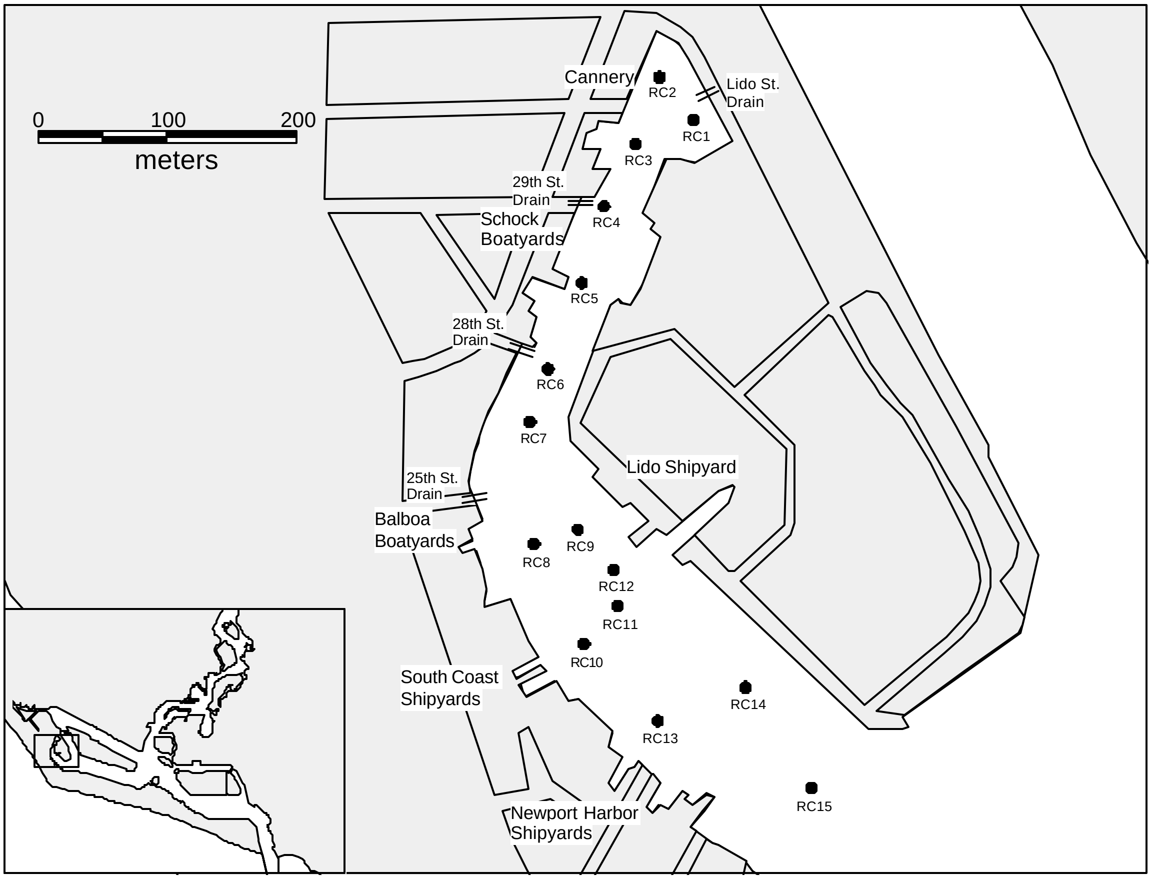


Figure 1. Sampling stations within the Rhine Channel of Newport Bay.

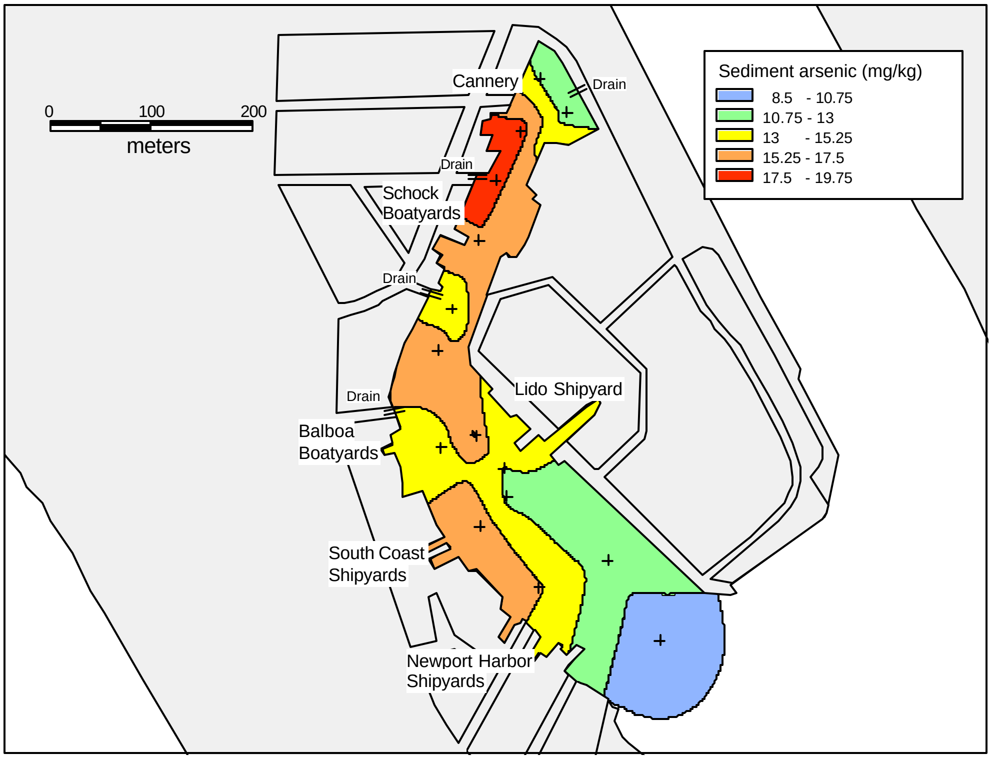


Figure 2. Pattern of arsenic concentrations in Rhine Channel sediments.

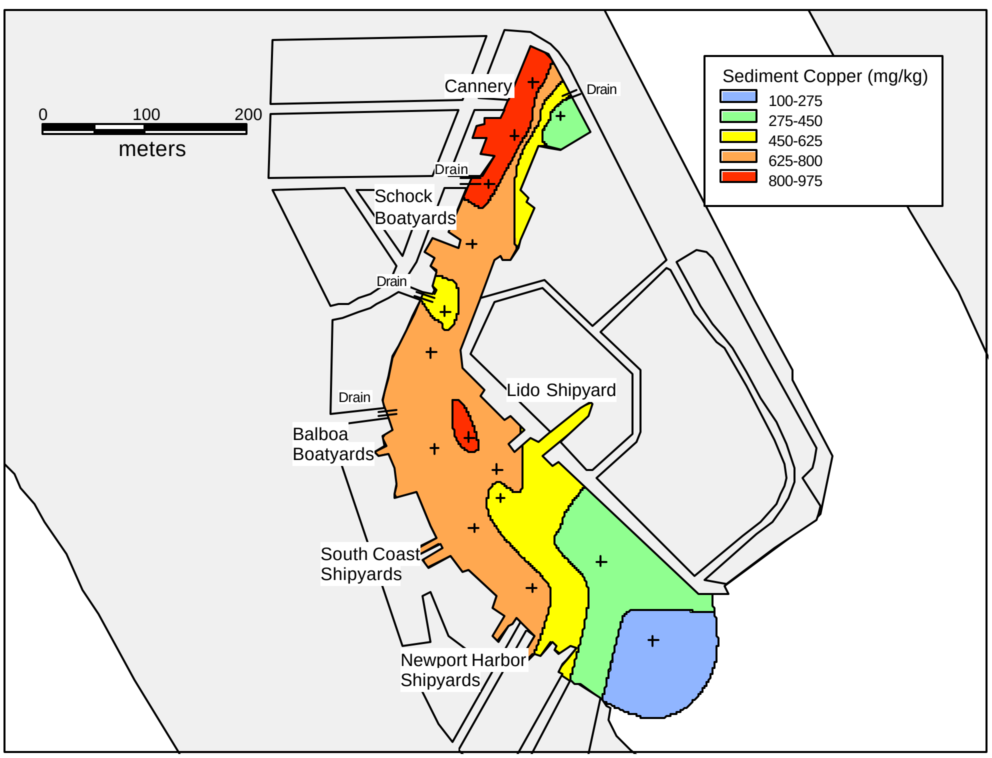


Figure 3. Pattern of copper concentrations in Rhine Channel sediments.

Figure 4. Pattern of chromium concentrations in Rhine Channel sediments.

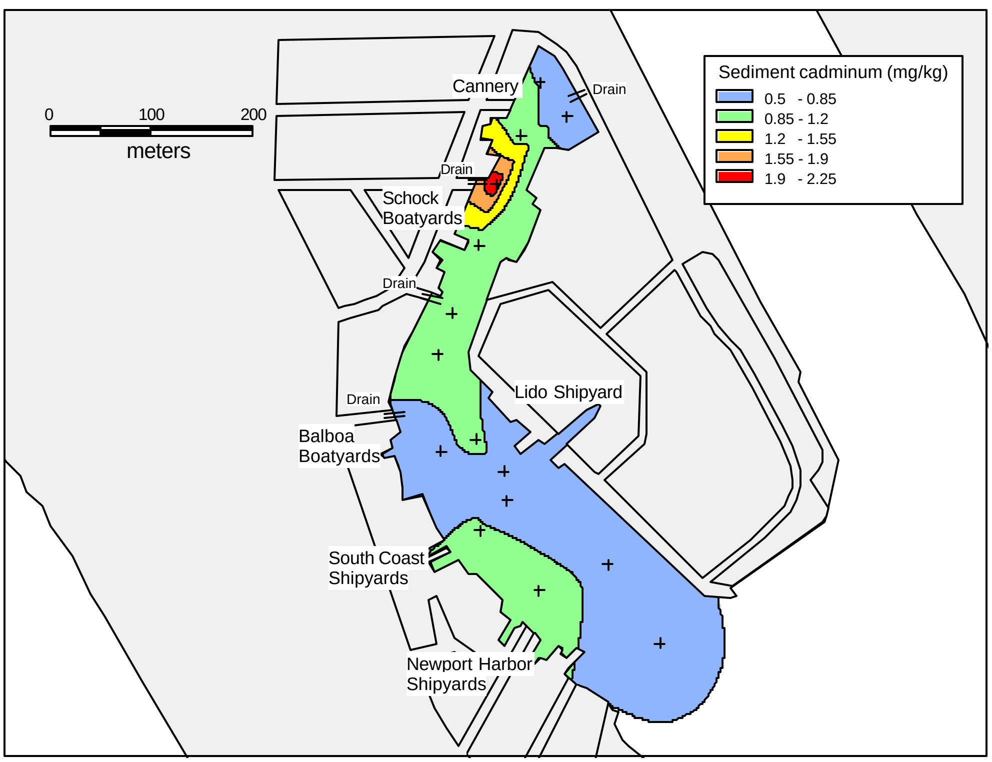


Figure 5. Pattern of cadmium concentrations in Rhine Channel sediments.

Figure 6. Pattern of lead concentrations in Rhine Channel sediments.

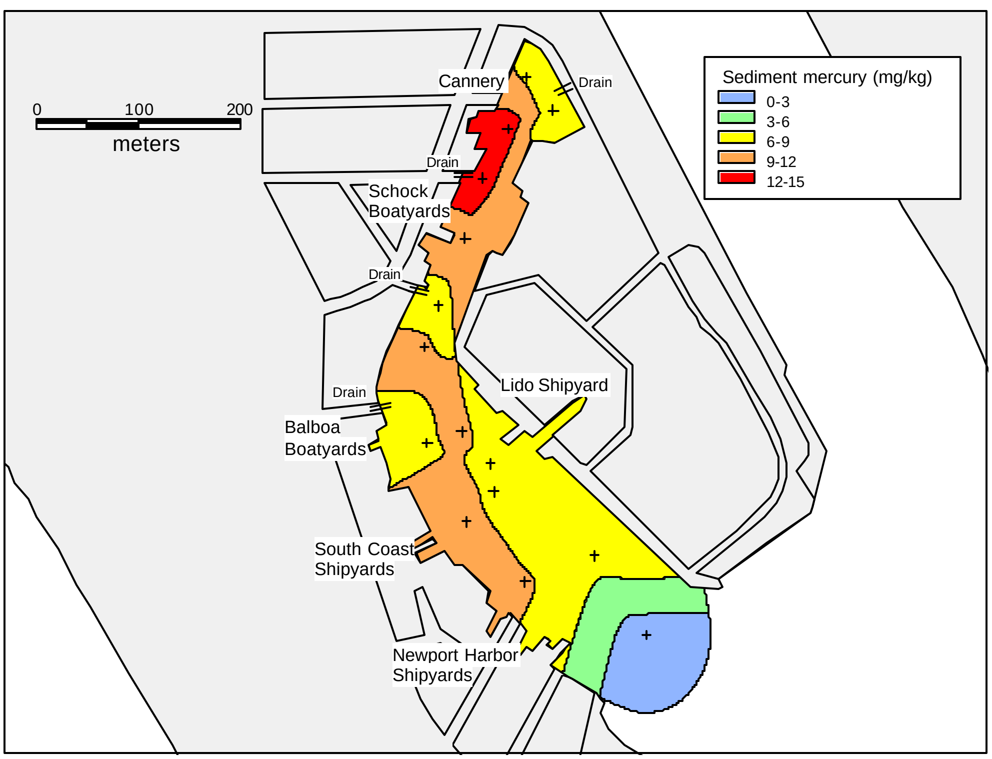


Figure 7. Pattern of mercury concentrations in Rhine Channel sediments.

Figure 8. Pattern of nickel concentrations in Rhine Channel sediments.

Figure 9. Pattern of total PAH concentrations in Rhine Channel sediments.

Figure 10. Pattern of total PBC concentrations in Rhine Channel sediments.

Figure 11. Distribution of grain size in Rhine Channel sediments.

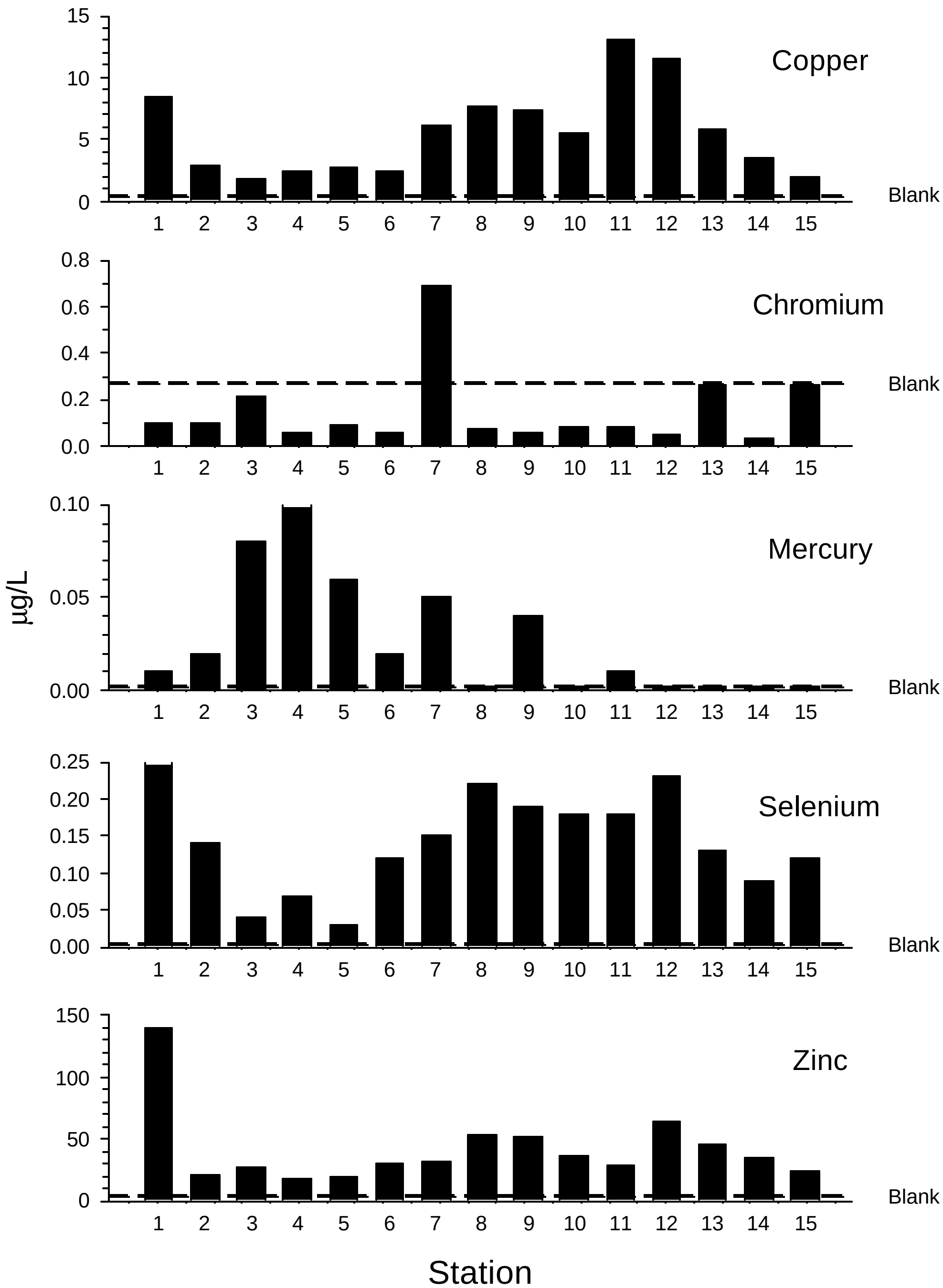


Figure 12. Concentration of dissolved metals in sediment-water interface samples. Dashed lines indicate the concentration in a blank sample of laboratory seawater.

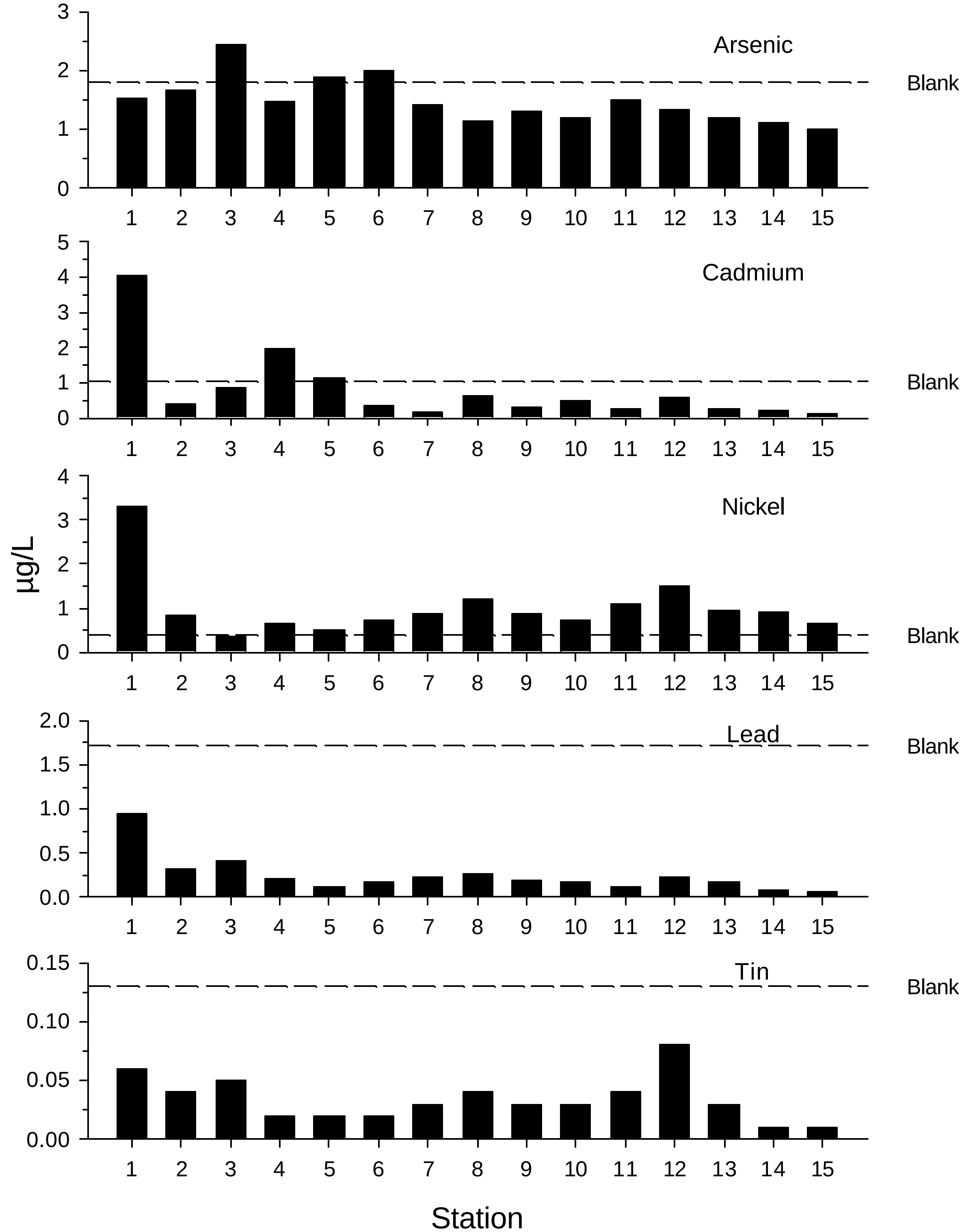


Figure 13. Concentration of dissolved metals in sediment-water interface samples. Dashed lines indicate the concentration in a blank sample of laboratory seawater.

Figure 14. Pattern of amphipod survival in sediments from the Rhine Channel.

Figure 15. Pattern of sea urchin embryo development in sediment-water interface test with Rhine Channel sediments.

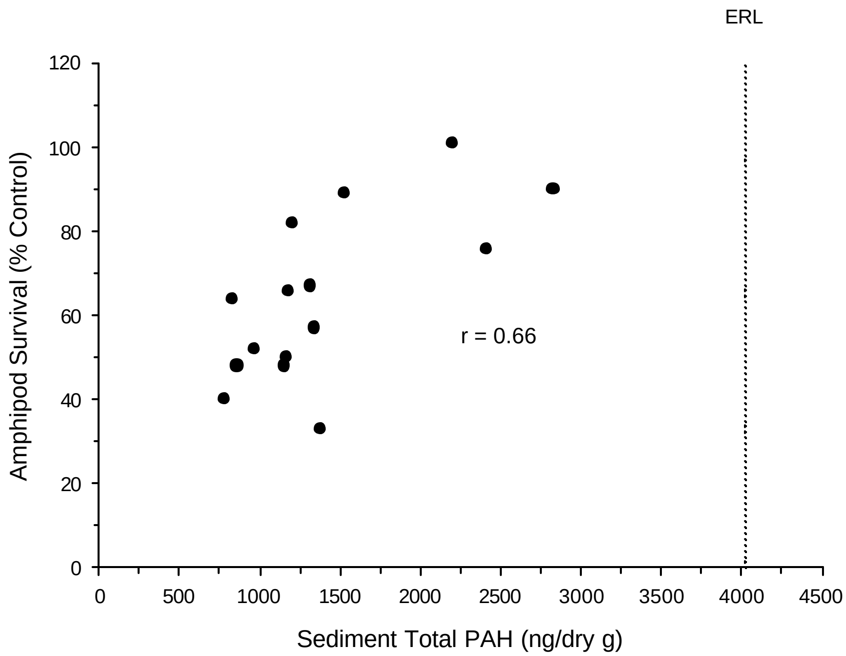


Figure 16. Relationship between amphipod survival and concentration of total PAHs in Rhine Channel sediments.

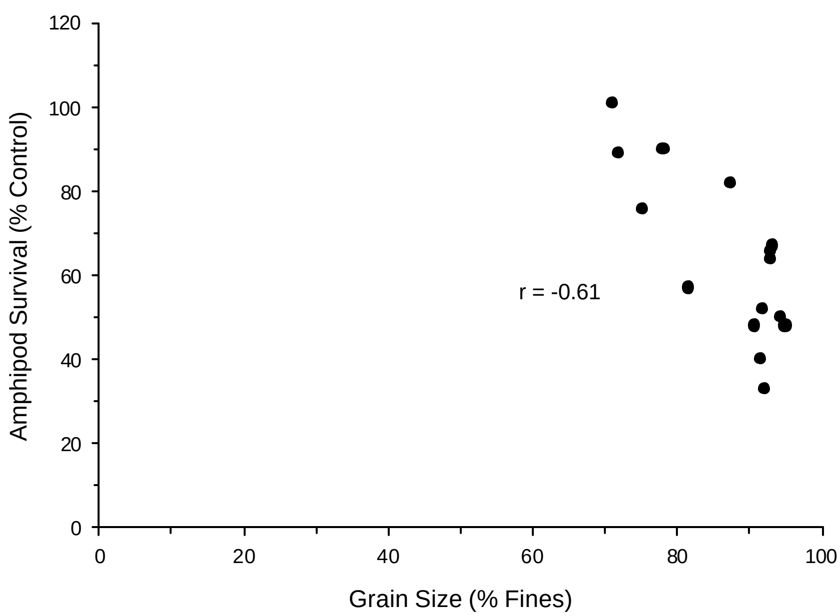


Figure 17. Relationship between amphipod survival and sediment grain size.

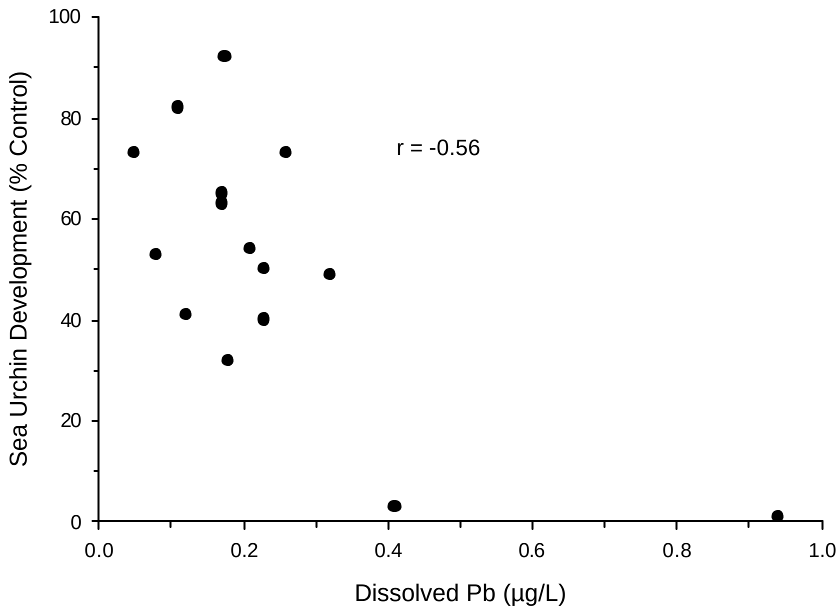


Figure 18. Relationship between sea urchin embryo development and concentration of dissolved lead in Rhine Channel sediment-water interface samples.

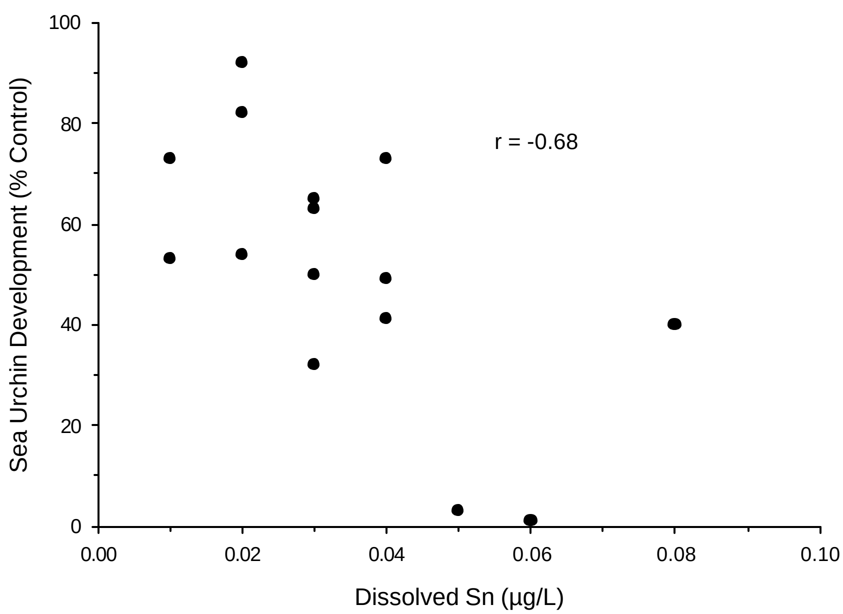


Figure 19. Relationship between sea urchin embryo development and concentration of dissolved tin in Rhine Channel sediment-water interface samples.

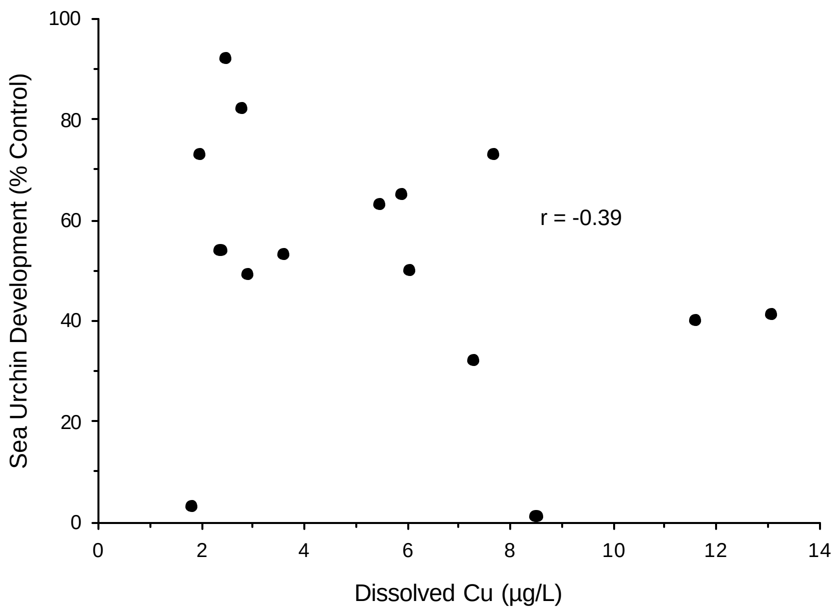


Figure 20. Relationship between sea urchin embryo development and concentration of dissolved copper in Rhine Channel sediment-water interface samples.

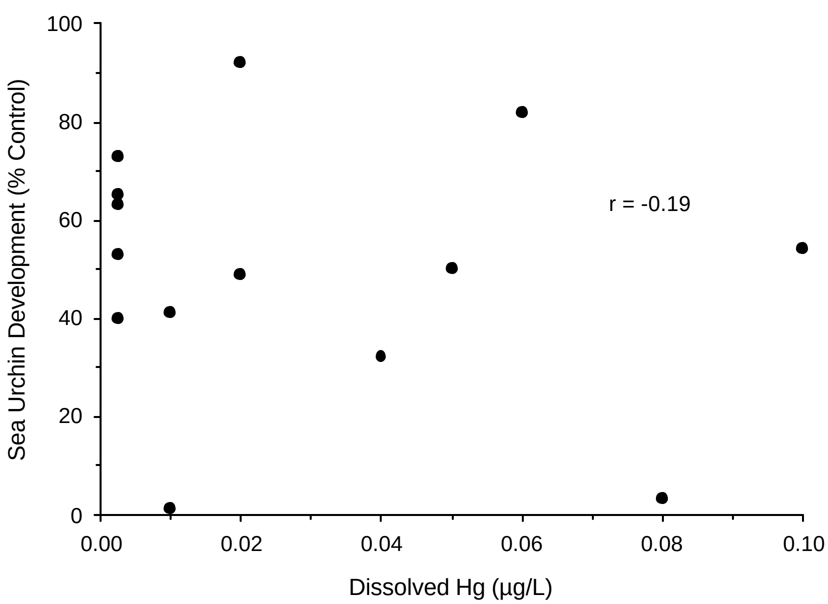


Figure 21. Relationship between sea urchin embryo development and concentration of dissolved mercury in Rhine Channel sediment-water interface samples.

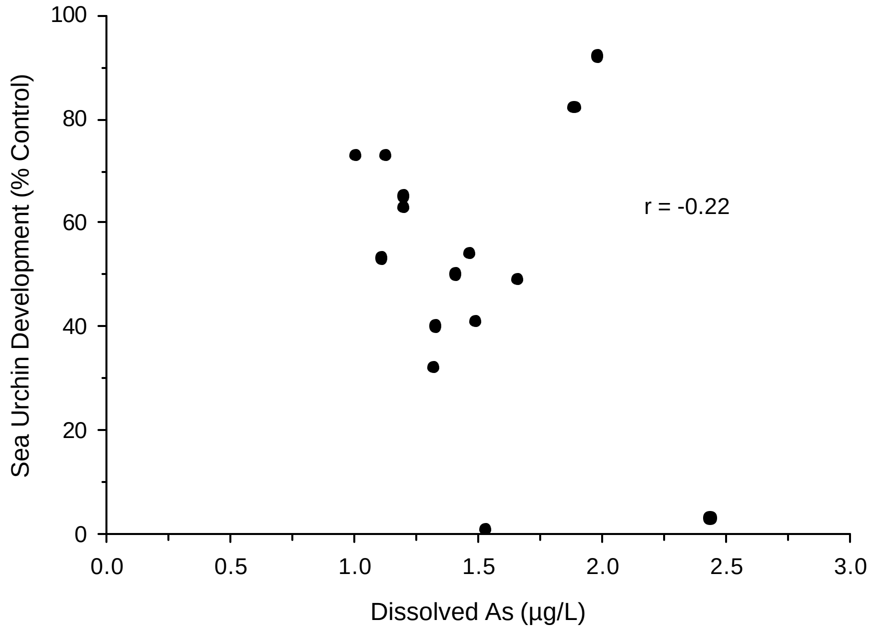


Figure 22. Relationship between sea urchin embryo development and concentration of dissolved arsenic in Rhine Channel sediment-water interface samples.

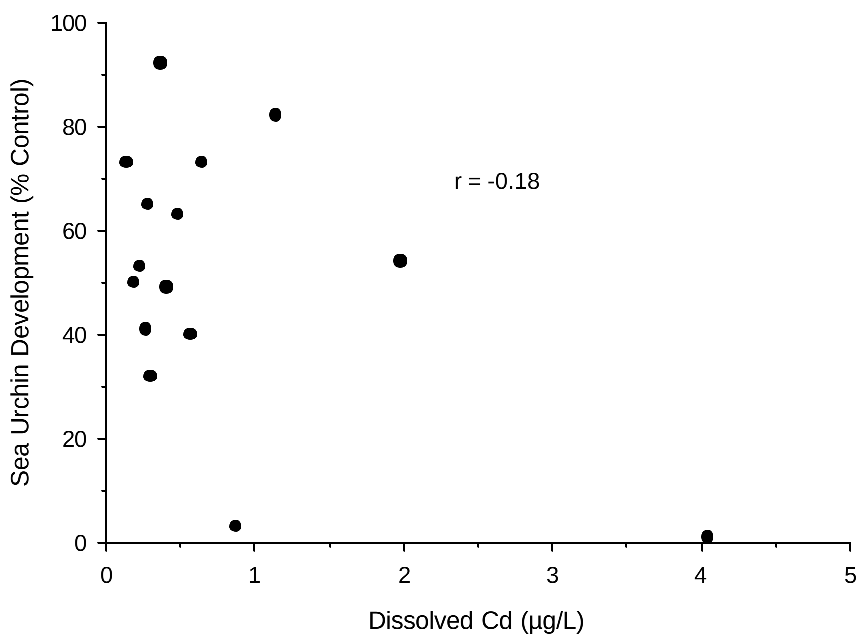


Figure 23. Relationship between sea urchin embryo development and concentration of dissolved cadmium in Rhine Channel sediment-water interface samples.

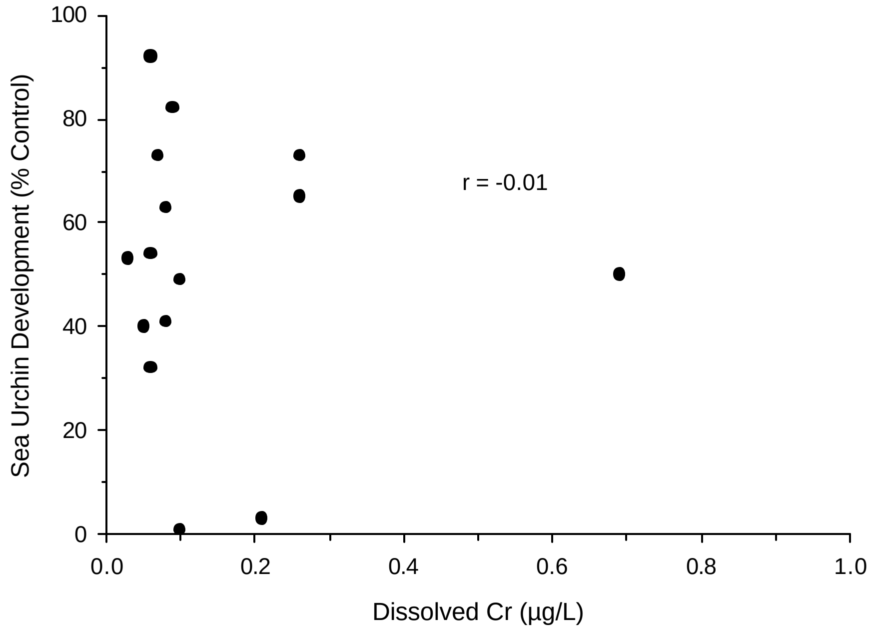


Figure 24. Relationship between sea urchin embryo development and concentration of dissolved chromium in Rhine Channel sediment-water interface samples.

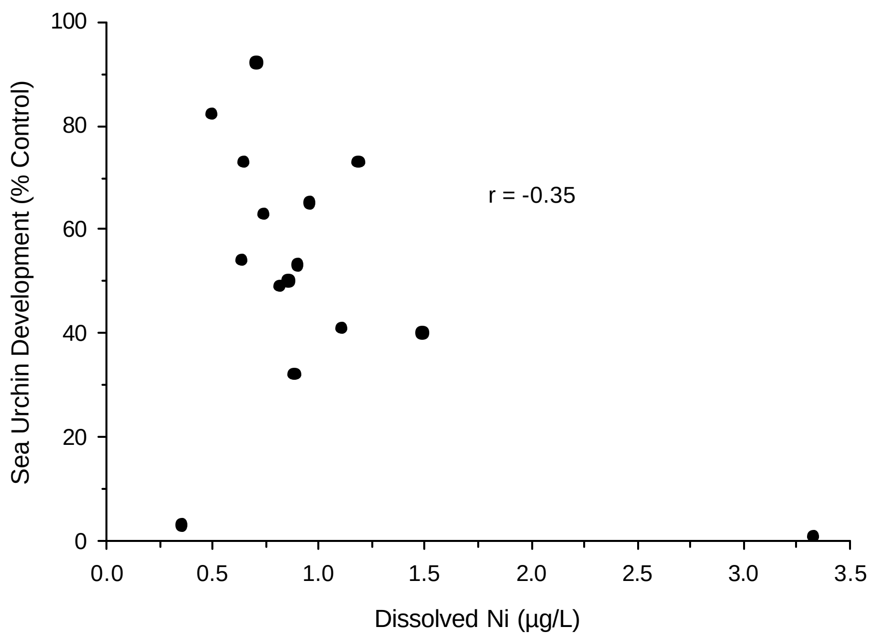


Figure 25. Relationship between sea urchin embryo development and concentration of dissolved nickle in Rhine Channel sediment-water interface samples.

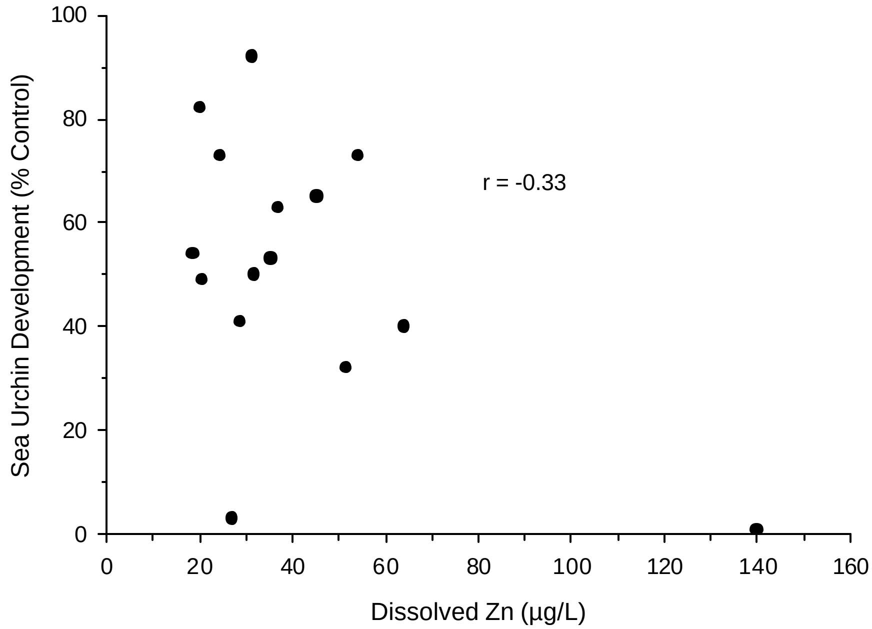


Figure 26. Relationship between sea urchin embryo development and concentration of dissolved zinc in Rhine Channel sediment-water interface samples

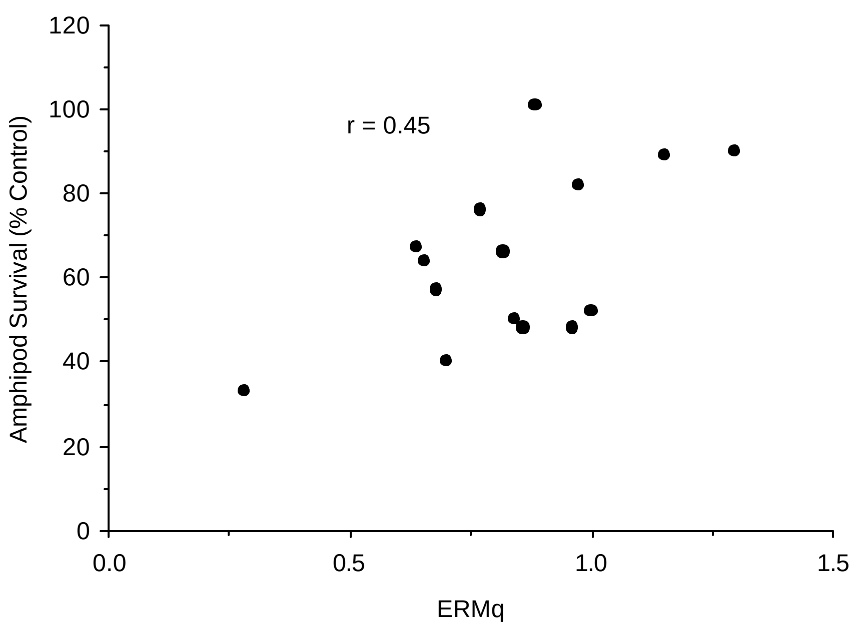


Figure 27. Relationship between amphipod survival and the mean ERM quotient (ERMq) values for Rhine Channel sediments. Amphipod survival was not significantly correlated with the ERMq values.

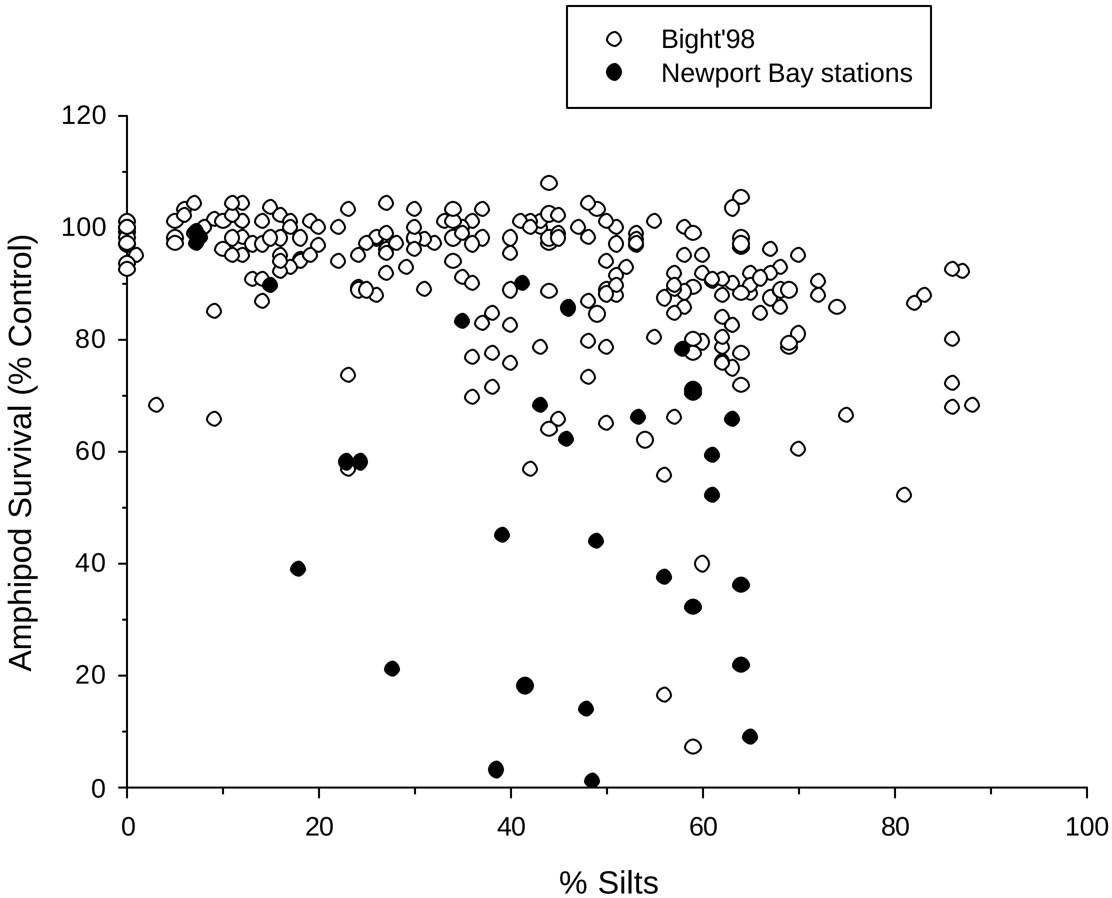


Figure 28. Relationship between amphipod survival and percent silts associated with sediments throughout the Southern California Bight. Sediments from Newport Bay, collected as part of Bight'98 (Bay *et al*. 2000) and other SCCWRP studies (Bay 2001) are indicated in black. None of the Newport Bay samples were from the Rhine Channel.

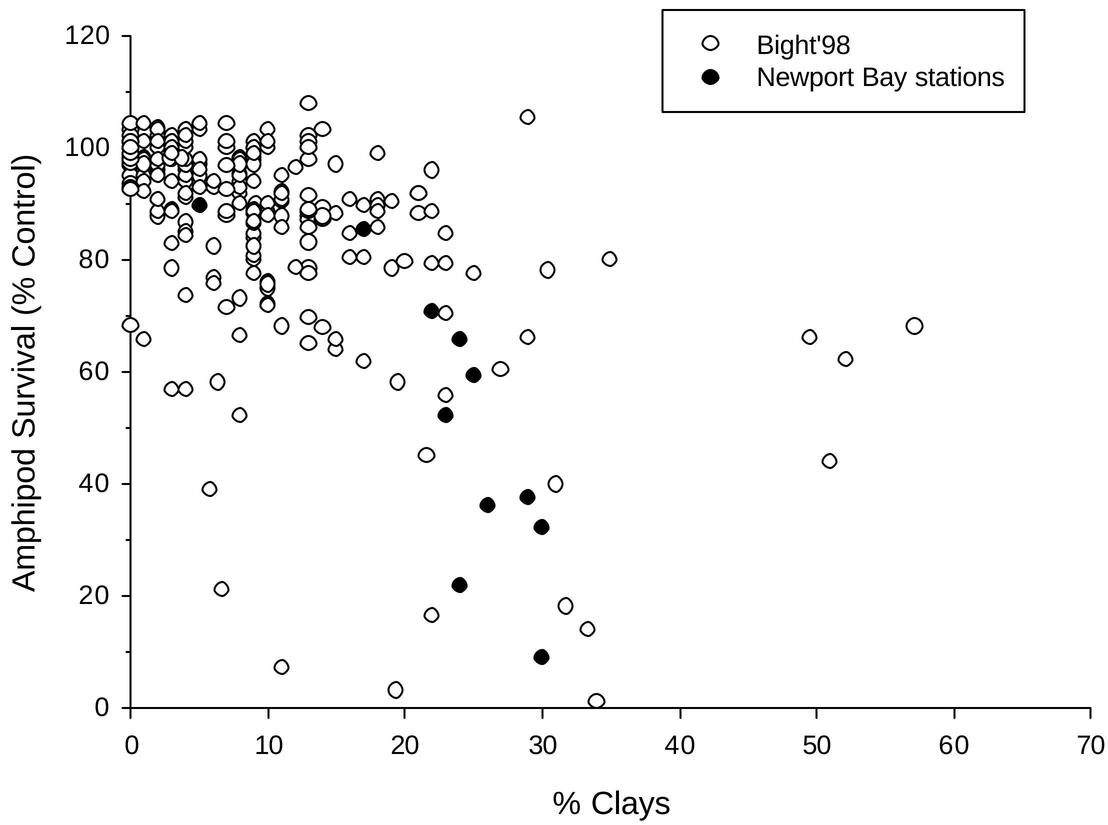


Figure 29. Relationship between amphipod survival and percent clay associated with sediments throughout the Southern California Bight. Sediments from Newport Bay, collected as part of Bight'98 (Bay *et al*. 2000) and other SCCWRP studies (Bay 2001) are indicated in black. None of the Newport Bay samples were from the Rhine Channel.

APPENDICES

Appendix A. General and metal constituents in Rhine Channel sediments. Bolded values indicate measurements that exceed the TMDL numeric target: Cu = 18.7 mg/kg, Cr = 52 mg/kg, Pb = 30.2 mg/kg, Zn = 124 mg/kg, Hg = 0.13 mg/kg.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
General															
% TOC	1.49	2.53	1.76	3.23	1.41	1.14	1.70	1.36	1.33	1.74	0.98	1.02	1.50	1.68	1.60
% Dry Wt.	54.6	50.5	42.6	33.4	39.8	40.0	35.6	32.9	31.3	36.0	38.9	38.0	34.3	35.9	42.6
% Fines	81.6	71.0	71.8	78.1	87.3	75.1	90.6	93.0	95.0	91.8	93.0	91.5	94.3	93.1	92.2
Metals/Metalloids (mg/ dry kg)															
Ag	0.43	0.24	0.23	0.25	0.21	0.18	0.21	0.19	0.17	0.20	0.14	0.17	0.18	0.22	0.35
Al	18500	26400	34700	45000	42900	35700	48800	46100	60100	45300	44350	42900	51600	45000	41120
As	12.0	12.7	18.5	19.6	17.0	13.7	16.6	14.2	17.7	16.6	12.5	12.9	15.5	11.9	8.8
Ba	78	100	145	163	145	161	146	152	192	161	136	142	167	140	99
Be	0.40	0.56	0.73	0.96	0.92	0.77	1.08	1.04	1.30	1.04	1.01	0.96	1.18	1.05	0.91
Cd	0.61	0.84	1.00	2.13	0.94	0.88	0.95	0.73	0.98	0.88	0.71	0.66	1.03	0.71	0.63
Cr	30.0	41.0	**53.4**	**75.9**	**64.4**	**55.3**	**73.4**	**68.7**	**86.2**	**68.9**	**63.4**	**63.1**	**74.5**	**64.3**	46.9
Co	4.0	5.9	7.4	10.1	9.3	7.8	10.1	9.4	11.7	9.4	8.7	8.4	10.3	8.8	7.4
Cu	**397**	**844**	**957**	**899**	**654**	**605**	**726**	**677**	**847**	**761**	**495**	**691**	**651**	**382**	**225**
Fe	19800	28000	36300	47300	43400	36500	47000	44900	56300	44900	42800	40100	48700	41300	32540
Hg	**8.2**	**8.9**	**12.8**	**14.3**	**11.1**	**8.0**	**9.2**	**8.7**	**10.2**	**11.7**	**6.9**	**7.2**	**9.1**	**6.7**	**2.4**
Mn	159	235	286	335	325	263	316	304	368	306	290	289	326	290	206
Mo	3.9	3.7	4.5	9.1	4.5	4.3	4.9	3.8	4.3	3.1	2.9	3.6	2.6	3.3	3.0
Ni	11.8	16.4	21.3	28.9	25.7	22.6	29.1	27.4	34.1	27.3	25.2	24.5	29.2	25.9	19.5
Pb	**72**	**105**	**136**	**168**	**128**	**117**	**126**	**127**	**138**	**127**	**98**	**94**	**122**	**81**	**44**

Appendix A continued.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
Sb	0.81	0.94	1.35	1.31	1.02	0.87	0.93	0.85	0.81	2.63	0.67	0.71	0.79	0.73	2.15
Se	1.33	1.83	2.39	3.12	2.63	2.28	2.97	2.47	3.03	2.50	2.12	2.30	2.45	2.21	1.74
Sn	9.3	13.0	23.0	16.7	12.5	12.5	12.6	11.3	13.9	11.6	8.3	9.1	10.8	7.1	8.7
Sr	66.3	120.0	125.0	110.0	107.0	109.0	104.0	89.9	105.0	83.4	81.4	79.9	103.0	76.9	62.0
Ti	1055	1660	1930	2190	2220	1810	2180	2100	2360	2120	1845	1970	2020	1950	1517
Tl	0.26	0.38	0.47	0.59	0.55	0.46	0.57	0.53	0.65	0.53	0.50	0.50	0.59	0.52	0.42
V	48.9	67.4	88.8	121.0	112.0	96.7	128.0	121.0	151.0	118.0	111.0	108.0	128.0	113.0	96.0
Zn	**237**	**290**	**403**	**534**	**397**	**397**	**454**	**372**	**440**	**378**	**301**	**337**	**386**	**303**	**228**

Appendix B. Organic contaminants in Rhine Channel sediments. u = non-detects were treated as equal to half the detection limit. The detection limit for toxaphene was 10 ng/g, while the detection limit for all other organics (PAHs, PCBs, other pesticides) was 1.0 ng/g. Bolded values indicate measurement exceeds TMDL numeric target: chlordane = 2.26 ng/g, dieldrin = 0.72 ng/g, total DDTs = 3.89 ng/g, total PCBs = 21.5 ng/g.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
PAHs (ng/g)															
1-Methylnaphthalene	1.0	1.6	2.5	3.9	1.1	3.8	1.3	1.5	1.4	0.5u	1.3	1.4	1.8	2.3	1.2
1-Methylphenanthrene	12.5	18.3	11	19.2	7.4	15	4.2	9.6	7	6.7	4	4.5	9.5	11.6	17.8
2,3,5-Trimethylnaphthalene	2.7	1.0	2.5	0.5u	2.1	2	3.1	2.9	4.1	0.5u	2.5	0.5u	3.9	3.4	2.7
2,6-Dimethylnaphthalene	1.8	2.9	3	4.5	3.1	3.3	0.5u	1.8	2.3	1.7	1.5	1.6	1.8	3.2	1.2
2-Methylnaphthalene	2.3	3.1	3.5	3.6	2.5	5.3	2.2	2.6	2.5	3.0	3.0	2.2	2.4	3.4	2.3
Acenaphthene	3.3	5.1	4.7	5.1	3.8	7.4	3.7	3.6	5.1	4.5	3.2	3.1	3.8	7.8	2.6
Acenaphthylene	3.6	7.1	6.4	10.8	7.1	9.7	4.1	6.3	5.6	4.3	4.4	3.6	6.1	5.5	3.2
Anthracene	39.1	67.6	24.5	43.7	16.4	31.9	13.1	25.6	14.5	19.3	11	12.7	16.7	21.1	9.1
Benz[a]anthracene	107	147	110	186	72.7	166	49.8	77.9	71.3	64.7	53.4	47.5	68.2	87.4	59.3
Benzo[a]pyrene	102	169	133	249	115	172	79.4	101	110	90.9	75.3	75.8	111	105	45.6
Benzo[b]fluoranthene	138	272	191	340	165	260	114	145	147	115	112	109	152	147	76.1
Benzo[e]pyrene	79.8	129	99.1	198	99.3	149	74.7	88.2	102	67.8	63.7	58.9	94.6	99.1	46.6
Benzo[g,h,i]perylene	35.3	88.7	72.0	144	66.6	83.4	51.9	52.7	72.7	51.6	37.7	43.8	73.4	66.2	24.9
Benzo[k]fluoranthene	74	132	82	169	62	117	55	68	70	52	53	51	68	69	32
Biphenyl	2.1	1.2	4.1	1.0	1.2	1.1	1.0	1.1	1.3	1.6	1.0	1.0	1.1	1.7	0.1
Chrysene	183	312	160	282	106	258	70.3	137	103	102	71.0	63.5	101	116	145
Dibenz[a,h]anthracene	12.6	35.6	23.4	43.9	24.5	31.9	17.4	18.2	21.7	20.1	19.4	19.9	29.0	25.3	10.6

Appendix B continued.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
Fluoranthene	185	254	186	331	129	380	85	120	114	106	92.7	74.8	115	157	458
Fluorene	3.9	10.1	2.3	5.0	3.3	6.1	0.5u	5.9	4.4	3.4	3.2	2.8	3.6	6.7	2.6
Indeno[1,2,3-c,d]pyrene	60.9	133	106	251	113	161	79.6	87.4	109	78.4	66.4	73.4	105	113	45.5
Naphthalene	2.9	3.4	4.8	5.3	3.6	6.3	3.3	4.7	4.5	4.3	3.9	3.1	4.7	4.2	3.1
Perylene	18.3	28.6	22.1	50	18.8	33.2	19.7	23.7	21.5	19.3	15.1	15.1	26.0	28.8	11.3
Phenanthrene	71.4	94.6	60.9	112	37.8	104	28.1	49.2	42.1	37.9	29.7	24	43.7	68.8	29.7
Pyrene	199	287	211	372	143	401	101	145	125	113	101	84.8	131	165	350
Total PAHs	1340	2200	1530	2831	1200	2410	864	1180	1160	969	829	778	1171	1320	1380
PCBs (ng/g)															
PCB018	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB028	0.5u	6.1	0.5u	4.8	0.5u	0.5u	0.5u	3.6	0.5u	0.5u	3.3	3.2	3.0	4.2	0.5u
PCB031	0.5u	4.1	5.1	3.4	0.5u	0.5u	0.5u	5.0	5.5	0.5u	2.6	3.4	6.0	6.4	0.5u
PCB033	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	2.0	5.1	3.6	4.0	0.5u	2.2	0.5u	0.5u
PCB037	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	2.8	0.5u	0.5u	8.3
PCB044	0.5u	12.4	12.3	13.6	3.6	13.0	8.0	14.4	11.8	5.9	8.4	8.8	11.0	13.5	2.2
PCB049	0.5u	13.5	15.2	16.5	8.3	9.0	15.8	10.7	14.3	7.0	9.7	11.5	11.4	15.5	3.2
PCB052	0.5u	15.7	10.7	13.1	6.5	10.0	10.6	12.7	11.6	7.3	9.2	8.9	10.3	9.9	1.0
PCB066	8.3	29.1	29.4	34.4	17.2	14.0	11.9	16.7	16.0	10.4	13.0	13.0	16.7	15.5	1.6
PCB070	5.6	19.1	21.0	25.3	13.2	8.6	8.1	13.4	13.1	8.8	9.4	9.3	9.1	9.7	1.9
PCB074	7.5	21.1	13.3	24.7	11.9	7.8	7.7	9.8	8.3	6.2	8.3	6.2	6.3	9.0	1.5
PCB077	0.5u	0.5u	0.5u	0.5u	6.1	0.5u	0.5u	1.8	1.3	1.4	1.9	1.9	1.0	3.3	0.5u
PCB081	0.5u	0.5u	0.5u	0.5u	6.4	0.5u	0.5u	0.5u	1.6	0.5u	0.5u	0.5u	0.5u	1.9	0.5u

Appendix B continued.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
PCB087	5.4	14.2	14.4	12.9	9.9	4.9	3.6	6.3	6.0	2.5	4.4	3.1	3.2	4.0	0.5u
PCB095	3.2	14.5	14.1	11.6	7.4	3.0	4.9	6.1	5.6	3.7	5.1	3.8	3.3	5.4	0.5u
PCB097	5.7	0.5u	14.5	13.4	8.1	3.7	4.1	5.3	4.3	2.6	3.5	4.5	2.1	7.2	0.5u
PCB099	6.9	23.2	16.3	20.4	11.5	7.6	9.4	9.3	10.4	7.0	6.1	7.2	8.0	9.1	1.0
PCB101	9.1	24.9	24.2	29.5	16.7	10.6	10.9	12.4	11.8	9.3	11.9	10.4	12.4	13.8	0.5u
PCB105	3.7	5.3	8.7	10.6	0.5u	10.1	3.8	12.3	8.7	4.8	7.6	6.0	7.4	9.5	1.5
PCB110	10.8	23.2	35.0	30.1	17.3	12.1	12.9	13.7	14.5	9.0	11.9	11.6	12.5	14.3	2.4
PCB114	2.4	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	3.5	1.9	3.7	0.5u	2.6	3.2	0.5u
PCB118	6.5	20.1	23.3	21.3	15.1	15.9	13.7	12.5	17.6	12.0	14.8	13.3	12.6	18.9	2.5
PCB119	1.0	0.5u	2.1	0.5u	0.5u	0.5u	0.5u	1.0	1.0	0.5u	0.5u	1.1	0.5u	0.5u	0.5u
PCB123	0.5u	0.5u	0.5u	0.5u	11.8	0.5u	3.8	4.3	3.5	1.3	3.6	3.2	3.2	3.7	0.5u
PCB126	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	9.0	0.5u	5.6	0.5u	5.3	0.5u	1.0
PCB128	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	1.9	3.0	1.1	1.1	1.9	0.5u	2.9	1.0
PCB138	8.9	29.4	20.7	27.6	19.1	10.9	12.3	13.4	11.4	9.1	11.6	11.2	11.0	14.1	2.5
PCB141	0.5u	4.1	3.2	3.5	2.4	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB149	4.5	13.0	9.7	9.8	11.0	5.8	6.0	6.0	7.3	5.6	6.6	4.2	5.3	8.4	0.5u
PCB151	0.5u	1.4	1.3	2.1	0.5u	0.5u	0.5u	1.1	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB153	7.5	18.9	15.8	25.1	15.1	12.3	9.3	14.3	11.2	8.1	9.0	9.4	9.7	14.5	3.1
PCB156	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	2.1	0.5u	3.1	6.0	0.5u
PCB157	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	1.2	0.5u	2.4	1.2	0.5u
PCB158	1.7	6.2	3.1	5.5	2.1	3.7	1.1	1.1	0.5u	1.5	1.4	2.1	1.2	1.0	0.5u
PCB167	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	1.6	2.7	1.0	0.5u	1.5	0.5u	3.8	1.0

Appendix B continued.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
PCB168+132	1.6	6.1	4.4	3.4	1.6	1.0	1.1	0.5u	0.5u	1.2	1.2	1.0	0.5u	0.5u	0.5u
PCB169	0.5u	24.5	18.3	12.4	0.5u	8.2	0.5u	6.5	4.7	3.2	10.8	5.4	5.2	13.0	0.5u
PCB170	0.5u	2.7	3.5	1.6	3.4	0.5u	0.5u	0.5u	0.5u	0.5u	1.4	0.5u	0.5u	0.5u	0.5u
PCB177	0.5u	0.5u	1.6	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB180	2.1	7.6	6.7	8.9	5.8	4.8	3.9	0.5u	3.4	0.5u	3.0	2.7	2.0	5.7	0.5u
PCB183	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB187	0.5u	4.6	5.3	5.2	2.5	1.5	4.0	2.0	0.5u	0.5u	3.0	3.2	1.2	2.6	0.5u
PCB189	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB194	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB200	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB201	0.5u	0.5u	1.8	0.5u	3.2	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
PCB206	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Total PCBs	**116**	**376**	**364**	**401**	**248**	**191**	**179**	**230**	**237**	**146**	**207**	**184**	**199**	**259**	**51**
Pesticides (ng/g)															
2,4'-DDD	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
2,4'-DDE	13.9	24.4	10.4	0.5u	8.9	12.6	32.4	13.7	16.4	19.1	23.6	12.8	14.0	32.2	9.3
2,4'-DDT	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
4,4'-DDD	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
4,4'-DDE	14.1	30.1	33.7	51.1	36.5	30.5	43.3	45.3	41.5	28.6	33.2	31.9	35.4	63.7	31.0
4,4'-DDT	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Total DDTs	**30.0**	**56.5**	**46.1**	**53.1**	**47.4**	**45.1**	**77.7**	**61.0**	**59.9**	**49.7**	**58.8**	**46.7**	**51.4**	**97.9**	**42.3**
Aldrin	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u

Appendix B continued.

	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
BHC-alpha	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
BHC-beta	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
BHC-delta	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
BHC-gamma	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Chlordane-alpha	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Chlordane-gamma	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Dieldrin	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Endosulfan Sulfate	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Endosulfan-I	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Endosulfan-II	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Endrin	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Endrin Aldehyde	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Heptachlor	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Heptachlor Epoxide	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Methoxychlor	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Mirex	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u
Toxaphene	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u	5u
trans-Nonachlor	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u	0.5u

Appendix C. Concentrations of dissolved metals and metalloids in overlying water from sediment-water interface test. Nondetects were treated as equal to half the detection limit and are indicated by a "u" suffix. The detection limit for Ag, Be, Cd, Cr, Co, Cu, Hg, Mn, Mo, Ni, Pb, Sn, Tl, Ti, V, and Zn was 0.005 µg/L. The detection limit for Al, As, Fe, Sb, and Se was 0.01 µg/L.

Metal (µg/L)	Lab seawater	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
Ag	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u
Al	0.005u	3.43	0.005u	0.005u	0.005u	1.03	0.005u	8.43	0.005u	0.005u	0.005u	0.005u	0.005u	0.005u	0.005u	0.005u
As	1.80	1.53	1.66	2.44	1.47	1.89	1.99	1.41	1.13	1.32	1.20	1.49	1.33	1.20	1.11	1.01
Be	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u	0.002u
Cd	1.04	4.05	0.41	0.87	1.98	1.14	0.37	0.19	0.64	0.30	0.48	0.27	0.57	0.28	0.23	0.14
Cr	0.27	0.10	0.10	0.21	0.06	0.09	0.06	0.69	0.07	0.06	0.08	0.08	0.05	0.26	0.03	0.26
Co	0.06	1.32	0.32	0.23	0.28	0.18	0.33	0.74	0.55	0.42	0.37	0.17	0.42	0.31	0.24	0.25
Cu	0.54	8.5	2.9	1.8	2.4	2.8	2.5	6.1	7.7	7.3	5.5	13.1	11.6	5.9	3.6	2.0
Fe	0.005u	0.005u	2.95	45.9	15.3	13.0	6.1	26.6	0.4	2.8	2.5	1.4	0.8	0.5	2.5	1.9
Hg	0.002u	0.01	0.02	0.08	0.10	0.06	0.02	0.05	0.002u	0.04	0.002u	0.01	0.002u	0.002u	0.002u	0.002u
Mo	9.59	24.6	10.6	5.2	9.8	7.6	17.8	17.3	13.5	12.6	11.4	12.7	15.8	11.7	19.2	14.4
Mn	0.61	5.9	17.5	37.0	45.0	14.8	13.8	26.9	5.45	9.69	10.6	6.92	4.28	6.5	7.6	5.85
Ni	0.38	3.33	0.82	0.36	0.64	0.5	0.71	0.86	1.19	0.89	0.74	1.11	1.49	0.96	0.9	0.65
Pb	1.72	0.94	0.32	0.41	0.21	0.11	0.18	0.23	0.26	0.18	0.17	0.12	0.23	0.17	0.08	0.05
Sb	0.14	1.62	0.61	0.16	0.21	0.17	0.36	0.32	0.56	0.48	0.65	0.40	0.67	0.47	0.37	0.29
Se	0.005u	0.25	0.14	0.04	0.07	0.03	0.12	0.15	0.22	0.19	0.18	0.18	0.23	0.13	0.09	0.12
Sn	0.13	0.06	0.04	0.05	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.04	0.08	0.03	0.01	0.01
Ti	0.05	0.002u	0.02	0.79	0.11	0.22	0.11	0.48	0.002u	0.01	0.12	0.10	0.05	0.01	0.002u	0.002u
Tl	0.01	0.03	0.002u	0.002u	0.002u	0.002u	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01
V	1.69	1.95	3.25	4.27	2.37	2.57	2.68	2.08	2.59	2.47	2.22	2.77	2.02	2.16	1.42	1.32
Zn	3.79	140.0	20.6	27.0	18.7	20.1	31.3	31.8	54.2	51.6	36.9	28.9	64.1	45.3	35.4	24.5

Appendix D. The relationship between sediment chemistry and toxicity for data at all 15 Rhine Channel stations. The top number in each box is the Spearman correlation coefficient, while the bottom number represents the level of significance (p value).

	Ag	Al	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo
Al	-0.51 0.05												
As	-0.13 0.65	0.38 0.16											
Ba	-0.46 0.09	0.72 0.00	0.75 0.00										
Be	-0.56 0.03	0.97 0.00	0.25 0.37	0.62 0.01									
Cd	-0.12 0.68	0.46 0.08	0.88 0.00	0.80 0.00	0.35 0.20								
Cr	-0.42 0.12	0.92 0.00	0.64 0.01	0.84 0.00	0.85 0.00	0.67 0.01							
Co	-0.46 0.08	0.95 0.00	0.60 0.02	0.83 0.00	0.89 0.00	0.66 0.01	0.99 0.00						
Cu	-0.04 0.88	0.18 0.52	0.82 0.00	0.50 0.06	0.07 0.80	0.69 0.00	0.38 0.16	0.33 0.23					
Fe	-0.48 0.07	0.94 0.00	0.62 0.01	0.84 0.00	0.87 0.00	0.67 0.01	0.99 0.00	0.99 0.00	0.35 0.20				
Hg	0.12 0.68	0.24 0.39	0.93 0.00	0.59 0.02	0.09 0.75	0.82 0.00	0.50 0.06	0.45 0.09	0.83 0.00	0.47 0.08			
Mn	-0.41 0.13	0.85 0.00	0.71 0.00	0.80 0.00	0.78 0.00	0.73 0.00	0.97 0.00	0.96 0.00	0.43 0.11	0.97 0.00	0.58 0.02		
Mo	0.28 0.32	-0.06 0.84	0.65 0.01	0.26 0.34	-0.16 0.56	0.47 0.08	0.20 0.47	0.17 0.55	0.55 0.03	0.15 0.59	0.61 0.02	0.27 0.34	
Ni	-0.46 0.08	0.97 0.00	0.56 0.03	0.82 0.00	0.92 0.00	0.63 0.01	0.98 0.00	1.00 0.00	0.31 0.27	0.98 0.00	0.40 0.14	0.94 0.00	0.14 0.63
Pb	-0.16 0.58	0.44 0.11	0.97 0.00	0.76 0.00	0.29 0.29	0.85 0.00	0.67 0.01	0.64 0.01	0.80 0.00	0.65 0.01	0.89 0.00	0.74 0.00	0.62 0.01

Appendix D continued.

	Ag	Al	As	Ba	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo
Sb	0.54 0.04	-0.17 0.55	0.40 0.14	0.11 0.69	-0.30 0.28	0.32 0.24	-0.02 0.94	-0.08 0.77	0.39 0.15	-0.07 0.80	0.54 0.04	-0.01 0.96	0.35 0.21
Se	-0.27 0.34	0.70 0.00	0.88 0.00	0.82 0.00	0.58 0.02	0.78 0.00	0.88 0.00	0.85 0.00	0.65 0.01	0.86 0.00	0.75 0.00	0.90 0.00	0.56 0.03
Sn	0.16 0.57	0.03 0.93	0.83 0.00	0.50 0.06	-0.11 0.69	0.76 0.00	0.27 0.33	0.23 0.40	0.87 0.00	0.25 0.38	0.84 0.00	0.33 0.22	0.75 0.00
Sr	0.00 1.00	-0.05 0.86	0.73 0.00	0.46 0.08	-0.15 0.59	0.77 0.00	0.20 0.48	0.18 0.53	0.75 0.00	0.19 0.50	0.71 0.00	0.30 0.28	0.61 0.02
Ti	-0.35 0.20	0.76 0.00	0.77 0.00	0.74 0.00	0.68 0.01	0.65 0.01	0.90 0.00	0.88 0.00	0.53 0.04	0.87 0.00	0.64 0.01	0.94 0.00	0.44 0.10
Tl	-0.39 0.15	0.89 0.00	0.68 0.01	0.81 0.00	0.83 0.00	0.70 0.00	0.98 0.00	0.98 0.00	0.40 0.14	0.97 0.00	0.53 0.04	0.98 0.00	0.26 0.35
V	-0.46 0.09	0.98 0.00	0.50 0.06	0.78 0.00	0.93 0.00	0.57 0.03	0.97 0.00	0.99 0.00	0.25 0.36	0.97 0.00	0.35 0.21	0.91 0.00	0.11 0.68
Zn	-0.21 0.46	0.48 0.07	0.91 0.00	0.80 0.00	0.39 0.15	0.88 0.00	0.71 0.00	0.68 0.01	0.66 0.01	0.68 0.01	0.76 0.00	0.73 0.00	0.71 0.00
Total PAHs	0.67 0.01	-0.53 0.04	0.05 0.86	-0.08 0.78	-0.61 0.02	0.17 0.54	-0.34 0.21	-0.39 0.16	0.07 0.81	-0.39 0.15	0.15 0.59	-0.32 0.25	0.35 0.21
Total PCBs	0.06 0.83	0.01 0.96	0.44 0.10	0.22 0.44	-0.01 0.96	0.51 0.05	0.21 0.46	0.18 0.52	0.52 0.05	0.18 0.53	0.42 0.12	0.33 0.23	0.38 0.16
Total DDTs	-0.31 0.26	0.68 0.01	0.13 0.65	0.28 0.31	0.71 0.00	0.24 0.39	0.59 0.02	0.61 0.02	0.19 0.51	0.58 0.02	0.05 0.85	0.55 0.03	0.04 0.89
Amphipod survival	0.31 0.27	-0.39 0.15	0.27 0.33	-0.01 0.97	-0.45 0.09	0.32 0.25	-0.16 0.56	-0.20 0.47	0.32 0.24	-0.20 0.48	0.38 0.17	-0.05 0.87	0.39 0.15
Sea urchin development	-0.06 0.84	0.18 0.52	-0.01 0.98	0.28 0.30	0.11 0.70	0.12 0.67	0.20 0.48	0.21 0.45	-0.31 0.26	0.20 0.48	-0.08 0.79	0.17 0.55	-0.09 0.76

Appendix D continued.

	Ni	Pb	Sb	Se	Sn	Sr	Ti	Tl	V	Zn	TPAHs	TPCBs	TDDTs
Pb	0.59 0.02												
Sb	-0.12 0.68	0.40 0.14											
Se	0.83 0.00	0.88 0.00	0.26 0.35										
Sn	0.20 0.48	0.81 0.00	0.55 0.03	0.59 0.02									
Sr	0.14 0.62	0.74 0.00	0.38 0.16	0.48 0.07	0.89 0.00								
Ti	0.85 0.00	0.78 0.00	0.12 0.67	0.96 0.00	0.42 0.12	0.33 0.24							
Tl	0.96 0.00	0.69 0.00	-0.03 0.92	0.90 0.00	0.30 0.28	0.23 0.41	0.93 0.00						
V	0.99 0.00	0.54 0.04	-0.11 0.68	0.80 0.00	0.15 0.59	0.08 0.78	0.84 0.00	0.95 0.00					
Zn	0.66 0.01	0.86 0.00	0.25 0.37	0.89 0.00	0.74 0.00	0.67 0.01	0.76 0.00	0.73 0.00	0.62 0.01				
Total PAHs	-0.40 0.14	0.09 0.75	0.47 0.08	-0.18 0.52	0.39 0.15	0.44 0.10	-0.34 0.22	-0.35 0.21	-0.43 0.11	0.04 0.89			
Total PCBs	0.16 0.56	0.54 0.04	0.03 0.92	0.31 0.25	0.50 0.06	0.69 0.00	0.30 0.27	0.25 0.36	0.11 0.71	0.37 0.17	0.41 0.13		
Total DDTs	0.65 0.01	0.26 0.35	-0.30 0.27	0.41 0.13	0.02 0.95	0.09 0.74	0.50 0.06	0.55 0.03	0.67 0.01	0.26 0.36	-0.34 0.22	0.42 0.12	
Amphipod survival	-0.23 0.41	0.36 0.19	0.23 0.42	0.03 0.90	0.45 0.09	0.68 0.01	-0.04 0.87	-0.16 0.58	-0.28 0.31	0.19 0.51	0.66 0.01	0.78 0.00	0.07 0.80
Sea urchin development	0.19 0.51	0.07 0.81	0.31 0.26	0.17 0.54	-0.11 0.70	0.05 0.87	0.16 0.57	0.18 0.53	0.22 0.42	0.08 0.77	0.22 0.43	-0.08 0.77	-0.02 0.93

Appendix E. The relationship among dissolved metals concentrations in overlying water from the sediment-water interface test for all 15 Rhine Channel stations. The top number in each box is the Spearman correlation coefficient, while the bottom number represents the level of significance (p value).

Variable	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb
As	0.28 0.31												
Cd	0.17 0.54	0.50 0.06											
Co	0.33 0.23	-0.17 0.54	0.14 0.62										
Cr	0.44 0.10	0.11 0.69	-0.19 0.50	0.00 0.99									
Cu	0.18 0.52	-0.21 0.45	-0.04 0.88	0.46 0.08	-0.19 0.49								
Fe	0.13 0.66	0.51 0.05	0.03 0.92	-0.30 0.28	0.11 0.69	-0.65 0.01							
Hg	0.33 0.23	0.73 0.00	0.36 0.18	-0.18 0.52	0.13 0.65	-0.40 0.14	0.80 0.00						
Mn	0.16 0.56	0.58 0.02	0.17 0.55	-0.27 0.34	0.16 0.58	-0.59 0.02	0.92 0.00	0.84 0.00					
Mo	0.24 0.38	-0.31 0.26	-0.35 0.20	0.49 0.06	-0.20 0.48	0.44 0.10	-0.48 0.07	-0.47 0.08	-0.53 0.04				
Ni	0.07 0.81	-0.35 0.20	-0.07 0.80	0.52 0.05	-0.21 0.46	0.90 0.00	-0.83 0.00	-0.59 0.02	-0.74 0.00	0.62 0.01			
Pb	0.21 0.45	0.45 0.09	0.56 0.03	0.57 0.03	0.13 0.64	0.18 0.52	0.04 0.89	0.31 0.26	0.15 0.58	-0.03 0.91	0.22 0.42		
Sb	-0.06 0.83	-0.25 0.36	0.12 0.68	0.64 0.01	-0.22 0.43	0.72 0.00	-0.71 0.00	-0.59 0.02	-0.58 0.02	0.39 0.15	0.79 0.00	0.33 0.23	

Appendix E continued.

Variable	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb
Se	0.08	-0.26	0.03	0.74	-0.12	0.85	-0.68	-0.46	-0.63	0.48	0.84	0.40	0.87
	0.78	0.34	0.91	0.00	0.68	0.00	0.01	0.08	0.01	0.07	0.00	0.14	0.00
Ti	0.22	0.61	0.20	-0.24	0.19	-0.31	0.79	0.66	0.74	-0.54	-0.61	0.11	-0.49
	0.44	0.02	0.47	0.39	0.50	0.25	0.00	0.01	0.00	0.04	0.02	0.69	0.07
Tl	0.07	-0.35	-0.10	0.54	-0.23	0.84	-0.76	-0.52	-0.77	0.67	0.86	0.11	0.67
	0.81	0.20	0.71	0.04	0.41	0.00	0.00	0.05	0.00	0.01	0.00	0.69	0.01
Sn	0.08	0.33	0.42	0.38	0.10	0.56	-0.31	-0.04	-0.24	-0.03	0.51	0.77	0.55
	0.79	0.23	0.12	0.17	0.73	0.03	0.26	0.90	0.39	0.92	0.05	0.00	0.03
V	-0.26	0.66	0.29	-0.29	0.00	-0.15	0.40	0.50	0.47	-0.59	-0.32	0.32	-0.20
	0.36	0.01	0.30	0.29	1.00	0.59	0.14	0.06	0.08	0.02	0.24	0.24	0.47
Zn	0.07	-0.36	0.03	0.70	-0.20	0.73	-0.69	-0.57	-0.68	0.58	0.82	0.30	0.75
	0.81	0.18	0.91	0.00	0.48	0.00	0.00	0.03	0.01	0.02	0.00	0.29	0.00
Amphipod survival	-0.10	0.60	0.50	-0.40	-0.16	-0.45	0.45	0.53	0.63	-0.46	-0.43	0.24	-0.32
	0.72	0.02	0.06	0.14	0.57	0.09	0.10	0.04	0.01	0.08	0.11	0.38	0.25
Sea urchin development	-0.11	-0.22	-0.18	-0.20	-0.01	-0.39	0.06	-0.19	-0.02	-0.05	-0.35	-0.56	-0.33
	0.69	0.43	0.53	0.47	0.97	0.16	0.84	0.51	0.95	0.85	0.20	0.03	0.23

Appendix E continued.

Variable	Se	Ti	Tl	Sn	V	Zn
Ti	-0.42 0.12					
Tl	0.87 0.00	-0.56 0.03				
Sn	0.63 0.01	0.05 0.85	0.41 0.13			
V	-0.20 0.48	0.47 0.08	-0.33 0.23	0.30 0.28		
Zn	0.81 0.00	-0.47 0.08	0.84 0.00	0.49 0.07	-0.37 0.18	
Amphipod survival	-0.53 0.04	0.30 0.28	-0.62 0.01	-0.04 0.88	0.65 0.01	-0.56 0.03
Sea urchin development	-0.42 0.12	0.00 1.00	-0.32 0.24	-0.68 0.01	-0.02 0.94	-0.33 0.23

Appendix F

Toxicity Test Laboratory Reports

Toxicity Data Summary

Project: Rhine Channel Sediment Toxicity
Sample Description: Rhine Channel SWI

Sample Collected: 5/14/02
Test Initiated: 5/17/02 Test Ended:5/20/02
Experiment Number: S596

Test Method: SWI Sea Urchin Development (EPA/600/R-95/136)
Species: *Strongylocentrotus purpuratus* Laboratory: SCCWRP
Supervising Technician: Ehren Doris

Sample Code	Sample	Mean %Developed	Standard Deviation	Number Counted
RCSW05170201	Screen Blank	97	1.7	4
RCSW05170202	Tube Blank	81	35.8	4
RCSI05170201	RC1 SWI	1	0.8	4
RCSI05170202	RC2 SWI	48	6.6	4
RCSI05170203	RC3 SWI	3	3.2	4
RCSI05170204	RC4 SWI	52	44.5	4
RCSI05170205	RC5 SWI	80	23.2	4
RCSI05170206	RC6 SWI	89	9.4	4
RCSI05170207	RC7 SWI	49	42.4	4
RCSI05170208	RC8 SWI	70	18.4	4
RCSI05170209	RC9 SWI	31	32.2	4
RCSI05170210	RC10 SWI	61	48.0	3
RCSI05170211	RC11 SWI	40	34.4	4
RCSI05170212	RC12 SWI	39	39.4	4
RCSI05170213	RC13 SWI	63	17.7	4
RCSI05170214	RC14 SWI	52	15.3	4
RCSI05170215	RC15 SWI	70	28.7	4

This test met the criterion for minimum control normal development (>80%).

Sample Characteristics (range among treatments during test):

Sample	pH	Dissolved Oxygen (mg/L)	Salinity (g/kg)	Temp (Celsius)	Total Ammonia (mg/L)
Test Min	7.52	2.5	33.0	13.9	0
Test Max	8.19	9.0	33.7	15.3	8.8

Toxicity Data Summary

Project: Rhine Channel Sediment Toxicity
Sample Description: Ammonia Reference Toxicant

Sample Collected: 5/17/02
Test Initiated: 5/17/02 Test Ended: 5/20/02
Experiment Number: S597

Test Method: Sea Urchin Development (EPA/600/R-95/136)
Species: *Strongylocentrotus purpuratus* Laboratory: SCCWRP
Supervising Technician: Ehren Doris

Sample Code	Sample	Mean %Developed	Standard Deviation	Number Counted	Significantly Reduced from Control
RCSW05170202	Seawater Control	97	1.6	5	
RCRT04170201	0.5 mg/L NH4+	97	0.8	5	
RCRT04170202	1.0 mg/L NH4+	96	0.8	5	
RCRT04170203	2.0 mg/L NH4+	97	1.2	5	
RCRT04170204	4.0 mg/L NH4+	87	2.3	5	*
RCRT04170205	8.0 mg/L NH4+	0	0.0	5	*

Total Ammonia (nominal)
NOEC = 2.0 mg/L
EC50 = 5.1 mg/L

This test met the criterion for minimum control normal development (>80%).

Sample Characteristics (range among treatments during test):

Sample	pH	Dissolved Oxygen (mg/L)	Salinity (g/kg)	Temp (Celsius)	Total Ammonia (mg/L)
Test Min	8.00		33.5	15.0	0.01
Test Max	8.16		34.0	15.0	9.00

Toxicity Data Summary

Project: Rhine Channel Sediment Toxicity
Sample Description: Rhine Channel Sediment

Sample Collected: 5/14/02
Test Initiated: 5/24/02 Test Ended:6/3/02
Experiment Number: EE46

Test Method: Amphipod Survival 10 day whole sediment
Species: *Eohaustorius estuarius* Laboratory: SCCWRP
Supervising Technician: Darrin Greenstein

Sample Code	Sample	Mean %Survival	Standard Deviation	Number Counted
RCHS05210201	Home Sediment	88	6.7	5
RCWS05140201	RC1 Whole Sediment	50	46.4	5
RCWS05140202	RC2 Whole Sediment	89	12.4	5
RCWS05140203	RC3 Whole Sediment	78	19.2	5
RCWS05140204	RC4 Whole Sediment	79	15.2	5
RCWS05140205	RC5 Whole Sediment	72	9.1	5
RCWS05140206	RC6 Whole Sediment	67	13.0	5
RCWS05140207	RC7 Whole Sediment	42	14.0	5
RCWS05140208	RC8 Whole Sediment	58	13.5	5
RCWS05140209	RC9 Whole Sediment	42	16.8	5
RCWS05140210	RC10 Whole Sediment	46	18.5	5
RCWS05140211	RC11 Whole Sediment	56	24.1	5
RCWS05140212	RC12 Whole Sediment	35	25.0	5
RCWS05140213	RC13 Whole Sediment	44	18.2	5
RCWS05140214	RC14 Whole Sediment	59	8.9	5
RCWS05140215	RC15 Whole Sediment	29	25.1	5

This test did not meet the criterion for minimum control survival (>90%).
The EC50 for the reference toxicant fell within control chart parameters.

Sample Characteristics (range among treatments during test):

Sample	pH	Dissolved Oxygen (mg/L)	Salinity (g/kg)	Temp (Celsius)	Total Ammonia (mg/L)
OW Test Min	7.87	7.3	20.2	14.5	0.03
OW Test Max	8.51	8.8	22.3	15.3	13.1
IW Test Min	7.06		22.1		1.3
IW Test Max	7.81		29.3		25.6

Toxicity Data Summary

Project: Rhine Channel Sediment Toxicity
Sample Description: Cadmium Reference Toxicant

Sample Collected: 5/14/02
Test Initiated: 5/21/02 Test Ended:5/28/02
Experiment Number: EE47

Test Method: Amphipod Survival 8 day whole sediment
Species: *Eohaustorius estuarius* Laboratory: SCCWRP
Supervising Technician: Darrin Greenstein

Sample Code	Sample	Mean %Survival	Standard Deviation	Number Counted
RCSW05210201	Seawater Control	100	0.0	3
RCRT05210201	Cadmium 1.0 mg/L	77	5.8	3
RCRT05210202	Cadmium 3.2 mg/L	73	5.8	3
RCRT05210203	Cadmium 5.6 mg/L	57	15.3	3
RCRT05210204	Cadmium 10.0 mg/L	7	5.8	3
RCRT05210205	Cadmium 15.0 mg/L	0	0.0	3

NOEC < 1.0 mg/L
EC50 = 5.3 mg/L

This test met the criterion for minimum control survival (>90%).
The EC50 fell within control chart parameters.

Sample Characteristics (range among treatments during test):

Sample	pH	Dissolved Oxygen (mg/L)	Salinity (g/kg)	Temp (Celsius)	Total Ammonia (mg/L)
Test Min	7.87	7.0	19.8	14.4	0
Test Max	8.14	8.3	20.5	22.5	0.07

Appendix G

Analytical Chemistry Laboratory Reports

Table G1. Laboratory report for sediment metal/metalloid chemistry analyses.

CRG PROJECT 2248																	
SCCWRP Rhine Channel Sediment Toxicity																	
	R1	R2	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1	R2	R1	R1	R1	R1
CRG ID#	6830	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839	6840	6840	6841	6842	6843	6844
SCCWRP ID#	RC1	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC11	RC12	RC13	RC14	RC15
	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g	µg/dry g
Aluminum (Al)	17900	19100	26400	34700	45000	42900	35700	48800	46100	60100	45300	44200	44500	42900	51600	45000	41120
Antimony (Sb)	0.83	0.78	0.94	1.35	1.31	1.02	0.87	0.93	0.85	0.81	2.63	0.71	0.62	0.71	0.79	0.73	2.15
Arsenic (As)	13.7	10.3	12.7	18.5	19.6	17	13.7	16.6	14.2	17.7	16.6	12.4	12.5	12.9	15.5	11.9	8.81
Barium (Ba)	86.7	69.5	100	145	163	145	161	146	152	192	161	133	139	142	167	140	99
Beryllium (Be)	0.41	0.39	0.56	0.73	0.96	0.92	0.77	1.08	1.04	1.3	1.04	1.02	1	0.96	1.18	1.05	0.91
Cadmium (Cd)	0.6	0.61	0.84	1	2.13	0.94	0.88	0.95	0.73	0.98	0.88	0.71	0.71	0.66	1.03	0.71	0.63
Chromium (Cr)	29.7	30.3	41	53.4	75.9	64.4	55.3	73.4	68.7	86.2	68.9	64.3	62.4	63.1	74.5	64.3	46.9
Cobalt (Co)	3.92	3.99	5.89	7.44	10.1	9.3	7.8	10.1	9.38	11.7	9.36	8.82	8.62	8.43	10.3	8.8	7.4
Copper (Cu)	444	350	844	957	899	654	605	726	677	847	761	501	489	691	651	382	225
Iron (Fe)	19400	20200	28000	36300	47300	43400	36500	47000	44900	56300	44900	43300	42300	40100	48700	41300	32540
Lead (Pb)	71.6	72.1	105	136	168	128	117	126	127	138	127	100	96.7	94.4	122	80.7	43.9
Manganese (Mn)	155	163	235	286	335	325	263	316	304	368	306	292	288	289	326	290	206
Mercury (Hg)	10.4	5.98	8.89	12.8	14.3	11.1	7.97	9.24	8.65	10.2	11.7	6.61	7.21	7.18	9.09	6.66	2.4
Molybdenum (Mo)	4.21	3.6	3.73	4.48	9.07	4.52	4.29	4.94	3.78	4.32	3.09	3.05	2.72	3.6	2.59	3.27	3
Nickel (Ni)	11.7	11.8	16.4	21.3	28.9	25.7	22.6	29.1	27.4	34.1	27.3	25.6	24.8	24.5	29.2	25.9	19.5
Selenium (Se)	1.27	1.39	1.83	2.39	3.12	2.63	2.28	2.97	2.47	3.03	2.5	2.17	2.07	2.3	2.45	2.21	1.74
Silver (Ag)	0.64	0.21	0.24	0.23	0.25	0.21	0.18	0.21	0.19	0.17	0.2	0.14	0.14	0.17	0.18	0.22	0.35
Strontium (Sr)	63.2	69.3	120	125	110	107	109	104	89.9	105	83.4	79.1	83.7	79.9	103	76.9	62
Thallium (Tl)	0.24	0.27	0.38	0.47	0.59	0.55	0.46	0.57	0.53	0.65	0.53	0.49	0.5	0.5	0.59	0.52	0.42
Tin (Sn)	9.86	8.69	13	23	16.7	12.5	12.5	12.6	11.3	13.9	11.6	8.33	8.31	9.07	10.8	7.14	8.7
Titanium (Ti)	1000	1110	1660	1930	2190	2220	1810	2180	2100	2360	2120	1950	1740	1970	2020	1950	1517
Vanadium (V)	47.4	50.4	67.4	88.8	121	112	96.7	128	121	151	118	112	110	108	128	113	96
Zinc (Zn)	249	225	290	403	534	397	397	454	372	440	378	312	290	337	386	303	228

Table G2. Laboratory report for the overlying water analysis in the seawater-interface test.

CRG PROJECT 2248
SCCWRP Rhine Channel Sediment Toxicity

	R1	R1	R1	R1	R1	R1	R1	R2	R1	R1	R1	R1	R1	R1	R1	R1	R1
CRG ID#	6800	6801	6802	6803	6804	6805	6806	6806	6807	6808	6809	6810	6811	6812	6813	6814	6815
SCCWRP ID#	Tube Blank	RC1	RC2	RC3	RC4	RC5	RC6	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13	RC14	RC15
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aluminum (Al)	ND	3.43	ND	ND	ND	1.03	ND	ND	8.43	ND	ND	ND	ND	ND	ND	ND	ND
Antimony (Sb)	0.14	1.62	0.61	0.16	0.21	0.17	0.35	0.36	0.32	0.56	0.48	0.65	0.4	0.67	0.47	0.37	0.29
Arsenic (As)	1.8	1.53	1.66	2.44	1.47	1.89	1.99	1.98	1.41	1.13	1.32	1.2	1.49	1.33	1.2	1.11	1.01
Beryllium (Be)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium (Cd)	1.04	4.05	0.41	0.87	1.98	1.14	0.38	0.36	0.19	0.64	0.3	0.48	0.27	0.57	0.28	0.23	0.14
Chromium (Cr)	0.27	0.1	0.1	0.21	0.06	0.09	0.06	0.06	0.69	0.07	0.06	0.08	0.08	0.05	0.26	0.03	0.26
Cobalt (Co)	0.06	1.32	0.32	0.23	0.28	0.18	0.33	0.33	0.74	0.55	0.42	0.37	0.17	0.42	0.31	0.24	0.25
Copper (Cu)	0.54	8.52	2.9	1.81	2.38	2.78	2.5	2.46	6.06	7.7	7.3	5.46	13.1	11.6	5.91	3.6	1.97
Iron (Fe)	ND	ND	2.95	45.9	15.3	13	6.41	5.84	26.6	0.43	2.75	2.51	1.39	0.84	0.52	2.49	1.91
Lead (Pb)	1.72	0.94	0.32	0.41	0.21	0.11	0.18	0.17	0.23	0.26	0.18	0.17	0.12	0.23	0.17	0.08	0.05
Manganese (Mn)	0.61	5.9	17.5	37	45	14.8	13.8	13.7	26.9	5.45	9.69	10.6	6.92	4.28	6.5	7.6	5.85
Mercury (Hg)	ND	0.01	0.02	0.08	0.1	0.06	ND	0.03	0.05	ND	0.04	ND	0.01	ND	ND	ND	ND
Molybdenum (Mo)	9.59	24.6	10.6	5.16	9.82	7.55	17.7	17.8	17.3	13.5	12.6	11.4	12.7	15.8	11.7	19.2	14.4
Nickel (Ni)	0.38	3.33	0.82	0.36	0.64	0.5	0.73	0.69	0.86	1.19	0.89	0.74	1.11	1.49	0.96	0.9	0.65
Selenium (Se)	ND	0.25	0.14	0.04	0.07	0.03	0.12	0.12	0.15	0.22	0.19	0.18	0.18	0.23	0.13	0.09	0.12
Silver (Ag)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium (Tl)	0.01	0.03	ND	ND	ND	ND	0.01	ND	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Tin (Sn)	0.13	0.06	0.04	0.05	0.02	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.04	0.08	0.03	0.01	0.01
Titanium (Ti)	0.05	ND	0.02	0.79	0.11	0.22	0.09	0.12	0.48	ND	0.01	0.12	0.1	0.05	0.01	ND	ND
Vanadium (V)	1.69	1.95	3.25	4.27	2.37	2.57	2.68	2.68	2.08	2.59	2.47	2.22	2.77	2.02	2.16	1.42	1.32
Zinc (Zn)	3.79	140	20.6	27	18.7	20.1	31.1	31.4	31.8	54.2	51.6	36.9	28.9	64.1	45.3	35.4	24.5

Table G3. Laboratory report for the sediment PAH analyses.

SCCWRP Rhine Channel Sediment Toxicity- Sediment Results

Sample ID	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839
Replicate	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Description	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
(d10-Acenaphthene)	74	76	64	73	78	67	75	81	73	76
(d10-Phenanthrene)	89	94	70	71	88	91	78	86	83	88
(d12-Chrysene)	89	93	98	87	92	100	86	90	90	97
(d12-Perylene)	91	76	100	85	81	95	77	80	81	88
(d8-Naphthalene)	53	55	64	63	59	57	65	54	58	61
1-Methylnaphthalene	1	1.6	2.5	3.9	1.1	3.8	1.3	1.5	1.4	<1.0
1-Methylphenanthrene	12.5	18.3	11	19.2	7.4	15	4.2	9.6	7	6.7
2,3,5-Trimethylnaphthalene	2.7	1	2.5	<1.0	2.1	2	3.1	2.9	4.1	<1.0
2,6-Dimethylnaphthalene	1.8	2.9	3	4.5	3.1	3.3	<1.0	1.8	2.3	1.7
2-Methylnaphthalene	2.3	3.1	3.5	3.6	2.5	5.3	2.2	2.6	2.5	3
Acenaphthene	3.3	5.1	4.7	5.1	3.8	7.4	3.7	3.6	5.1	4.5
Acenaphthylene	3.6	7.1	6.4	10.8	7.1	9.7	4.1	6.3	5.6	4.3
Anthracene	39.1	67.6	24.5	43.7	16.4	31.9	13.1	25.6	14.5	19.3
Benz[a]anthracene	107	147	110	186	72.7	166	49.8	77.9	71.3	64.7
Benzo[a]pyrene	102	169	133	249	115	172	79.4	101	110	90.9
Benzo[b]fluoranthene	138	272	191	340	165	260	114	145	147	115
Benzo[e]pyrene	79.8	129	99.1	198	99.3	149	74.7	88.2	102	67.8
Benzo[g,h,i]perylene	35.3	88.7	72	144	66.6	83.4	51.9	52.7	72.7	51.6
Benzo[k]fluoranthene	74.5	132	81.9	169	62	117	54.7	67.8	69.8	52
Biphenyl	2.1	1.2	4.1	1	1.2	1.1	1	1.1	1.3	1.6
Chrysene	183	312	160	282	106	258	70.3	137	103	102
Dibenz[a,h]anthracene	12.6	35.6	23.4	43.9	24.5	31.9	17.4	18.2	21.7	20.1
Fluoranthene	185	254	186	331	129	380	85	120	114	106
Fluorene	3.9	10.1	2.3	5	3.3	6.1	<1.0	5.9	4.4	3.4
Indeno[1,2,3-c,d]pyrene	60.9	133	106	251	113	161	79.6	87.4	109	78.4
Naphthalene	2.9	3.4	4.8	5.3	3.6	6.3	3.3	4.7	4.5	4.3
Perylene	18.3	28.6	22.1	50	18.8	33.2	19.7	23.7	21.5	19.3
Phenanthrene	71.4	94.6	60.9	112	37.8	104	28.1	49.2	42.1	37.9
Pyrene	199	287	211	372	143	401	101	145	125	113
Total Detectable PAHs	1340	2200	1530	2830	1200	2410	862	1180	1160	967

Table G3 continued.

Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
(d10-Acenaphthene)	63	74	76	80	76	81
(d10-Phenanthrene)	83	60	78	109	96	102
(d12-Chrysene)	90	60	90	117	100	104
(d12-Perylene)	91	102	83	94	84	85
(d8-Naphthalene)	63	60	70	55	53	51
1-Methylnaphthalene	1.3	1.4	1.7	1.8	2.3	1.2
1-Methylphenanthrene	4	4.5	6.5	12.4	11.6	17.8
2,3,5-Trimethylnaphthalene	2.5	<1.0	3.8	4	3.4	2.7
2,6-Dimethylnaphthalene	1.5	1.6	1.2	2.3	3.2	1.2
2-Methylnaphthalene	3	2.2	1.9	2.9	3.4	2.3
Acenaphthene	3.2	3.1	3.3	4.2	7.8	2.6
Acenaphthylene	4.4	3.6	5	7.2	5.5	3.2
Anthracene	11	12.7	11.2	22.2	21.1	9.1
Benz[a]anthracene	53.4	47.5	52.5	83.9	87.4	59.3
Benzo[a]pyrene	75.3	75.8	96.4	126	105	45.6
Benzo[b]fluoranthene	112	109	140	164	147	76.1
Benzo[e]pyrene	63.7	58.9	76.2	113	99.1	46.6
Benzo[g,h,i]perylene	37.7	43.8	71.2	75.5	66.2	24.9
Benzo[k]fluoranthene	52.9	50.8	62.6	72.6	68.6	32.5
Biphenyl	1	1	1	1.2	1.7	0.1
Chrysene	71	63.5	79.1	122	116	145
Dibenz[a,h]anthracene	19.4	19.9	29.6	28.4	25.3	10.6
Fluoranthene	92.7	74.8	88.5	142	157	458
Fluorene	3.2	2.8	2.4	4.7	6.7	2.6
Indeno[1,2,3-c,d]pyrene	66.4	73.4	101	109	113	45.5
Naphthalene	3.9	3.1	4.3	5.1	4.2	3.1
Perylene	15.1	15.1	21	31	28.8	11.3
Phenanthrene	29.7	24	29.5	57.9	68.8	29.7
Pyrene	101	84.8	101	161	165	350
Total Detectable PAHs	829	777	991	1350	1320	1380

Table G4. Laboratory report for the sediment PCB analyses.

SCCWRP Rhine Channel Sediment Toxicity- Sediment Results

Sample ID	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839
Replicate	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Description	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB018	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB028	<1.0	6.1	<1.0	4.8	<1.0	<1.0	<1.0	3.6	<1.0	<1.0
PCB031	<1.0	4.1	5.1	3.4	<1.0	<1.0	<1.0	5.0	5.5	<1.0
PCB033	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	5.1	3.6
PCB037	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB044	<1.0	12.4	12.3	13.6	3.6	13.0	8.0	14.4	11.8	5.9
PCB049	<1.0	13.5	15.2	16.5	8.3	9.0	15.8	10.7	14.3	7.0
PCB052	<1.0	15.7	10.7	13.1	6.5	10.0	10.6	12.7	11.6	7.3
PCB066	8.3	29.1	29.4	34.4	17.2	14.0	11.9	16.7	16.0	10.4
PCB070	5.6	19.1	21.0	25.3	13.2	8.6	8.1	13.4	13.1	8.8
PCB074	7.5	21.1	13.3	24.7	11.9	7.8	7.7	9.8	8.3	6.2
PCB077	<1.0	<1.0	<1.0	<1.0	6.1	<1.0	<1.0	1.8	1.3	1.4
PCB081	<1.0	<1.0	<1.0	<1.0	6.4	<1.0	<1.0	<1.0	1.6	<1.0
PCB087	5.4	14.2	14.4	12.9	9.9	4.9	3.6	6.3	6.0	2.5
PCB095	3.2	14.5	14.1	11.6	7.4	3.0	4.9	6.1	5.6	3.7
PCB097	5.7	<1.0	14.5	13.4	8.1	3.7	4.1	5.3	4.3	2.6
PCB099	6.9	23.2	16.3	20.4	11.5	7.6	9.4	9.3	10.4	7.0
PCB101	9.1	24.9	24.2	29.5	16.7	10.6	10.9	12.4	11.8	9.3
PCB105	3.7	5.3	8.7	10.6	<1.0	10.1	3.8	12.3	8.7	4.8
PCB110	10.8	23.2	35.0	30.1	17.3	12.1	12.9	13.7	14.5	9.0
PCB114	2.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.5	1.9
PCB118	6.5	20.1	23.3	21.3	15.1	15.9	13.7	12.5	17.6	12.0
PCB119	1.0	<1.0	2.1	<1.0	<1.0	<1.0	<1.0	1.0	1.0	<1.0
PCB123	<1.0	<1.0	<1.0	<1.0	11.8	<1.0	3.8	4.3	3.5	1.3
PCB126	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	9.0	<1.0
PCB128	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.9	3.0	1.1
PCB138	8.9	29.4	20.7	27.6	19.1	10.9	12.3	13.4	11.4	9.1
PCB141	<1.0	4.1	3.2	3.5	2.4	<1.0	<1.0	<1.0	<1.0	<1.0
PCB149	4.5	13.0	9.7	9.8	11.0	5.8	6.0	6.0	7.3	5.6
PCB151	<1.0	1.4	1.3	2.1	<1.0	<1.0	<1.0	1.1	<1.0	<1.0
PCB153	7.5	18.9	15.8	25.1	15.1	12.3	9.3	14.3	11.2	8.1

Table G4 continued.

Sample ID	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839
Replicate	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Description	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB156	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB157	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB158	1.7	6.2	3.1	5.5	2.1	3.7	1.1	1.1	<1.0	1.5
PCB167	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	2.7	1.0
PCB168+132	1.6	6.1	4.4	3.4	1.6	1.0	1.1	<1.0	<1.0	1.2
PCB169	<1.0	24.5	18.3	12.4	<1.0	8.2	<1.0	6.5	4.7	3.2
PCB170	<1.0	2.7	3.5	1.6	3.4	<1.0	<1.0	<1.0	<1.0	<1.0
PCB177	<1.0	<1.0	1.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB180	2.1	7.6	6.7	8.9	5.8	4.8	3.9	<1.0	3.4	<1.0
PCB183	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB187	<1.0	4.6	5.3	5.2	2.5	1.5	4.0	2.0	<1.0	<1.0
PCB189	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB194	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB200	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB201	<1.0	<1.0	1.8	<1.0	3.2	<1.0	<1.0	<1.0	<1.0	<1.0
PCB206	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB018	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB028	3.3	3.2	<1.0	5.5	4.2	<1.0
PCB031	2.6	3.4	5.1	6.8	6.4	<1.0
PCB033	4.0	<1.0	<1.0	3.9	<1.0	<1.0
PCB037	<1.0	2.8	<1.0	<1.0	<1.0	8.3
PCB044	8.4	8.8	8.7	13.3	13.5	2.2
PCB049	9.7	11.5	8.5	14.2	15.5	3.2
PCB052	9.2	8.9	7.2	13.4	9.9	1.0

Table G4 continued.

Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB066	13.0	13.0	13.2	20.1	15.5	1.6
PCB070	9.4	9.3	7.3	10.9	9.7	1.9
PCB074	8.3	6.2	4.5	8.1	9.0	1.5
PCB077	1.9	1.9	<1.0	1.6	3.3	<1.0
PCB081	<1.0	<1.0	<1.0	<1.0	1.9	<1.0
PCB087	4.4	3.1	2.1	4.2	4.0	<1.0
PCB095	5.1	3.8	2.7	3.9	5.4	<1.0
PCB097	3.5	4.5	2.4	1.8	7.2	<1.0
PCB099	6.1	7.2	6.5	9.5	9.1	1.0
PCB101	11.9	10.4	10.8	13.9	13.8	<1.0
PCB105	7.6	6.0	6.0	8.8	9.5	1.5
PCB110	11.9	11.6	10.3	14.6	14.3	2.4
PCB114	3.7	<1.0	<1.0	4.7	3.2	<1.0
PCB118	14.8	13.3	10.5	14.7	18.9	2.5
PCB119	<1.0	1.1	<1.0	<1.0	<1.0	<1.0
PCB123	3.6	3.2	1.9	4.5	3.7	<1.0
PCB126	5.6	<1.0	3.0	7.6	<1.0	1.0
PCB128	1.1	1.9	<1.0	1.0	2.9	1.0
PCB138	11.6	11.2	10.4	11.5	14.1	2.5
PCB141	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB149	6.6	4.2	5.6	5.0	8.4	<1.0
PCB151	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB153	9.0	9.4	7.1	12.2	14.5	3.1
PCB156	2.1	<1.0	3.1	3.0	6.0	<1.0
PCB157	1.2	<1.0	2.1	2.7	1.2	<1.0
PCB158	1.4	2.1	<1.0	1.8	1.0	<1.0
PCB167	<1.0	1.5	<1.0	<1.0	3.8	1.0
PCB168+132	1.2	1.0	<1.0	<1.0	<1.0	<1.0
PCB169	10.8	5.4	<1.0	9.8	13.0	<1.0
PCB170	1.4	<1.0	<1.0	<1.0	<1.0	<1.0
PCB177	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB180	3.0	2.7	<1.0	3.4	5.7	<1.0
PCB183	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table G4 continued.

Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
PCB187	3.0	3.2	<1.0	1.8	2.6	<1.0
PCB189	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB194	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB200	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB201	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
PCB206	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table G5. Laboratory report for the sediment pesticide analyses.

SCCWRP Rhine Channel Sediment Toxicity- Sediment Results

Sample ID	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839
Replicate	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Description	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
(PCB065)	91	95	75	76	76	78	82	93	89	85
(PCB198)	88	85	62	65	65	85	67	77	76	82
(TCMX)	79	78	57	52	60	69	61	73	70	71
[Total Detectable DDTs]	28	54.5	44.1	51.1	45.4	43.1	75.7	59	57.9	47.7
2,4'-DDD	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4'-DDE	13.9	24.4	10.4	<1.0	8.9	12.6	32.4	13.7	16.4	19.1
2,4'-DDT	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDD	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	14.1	30.1	33.7	51.1	36.5	30.5	43.3	45.3	41.5	28.6
4,4'-DDT	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-alpha	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-beta	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-delta	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-gamma	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlordane-alpha	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlordane-gamma	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan Sulfate	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan-I	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan-II	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin Aldehyde	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor Epoxide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mirex	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Toxaphene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
trans-Nonachlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table G5 continued.

Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g	ng/dry g
(PCB065)	86	50	78	85	92	108
(PCB198)	76	50	68	72	90	90
(TCMX)	62	39	51	72	82	84
[Total Detectable DDTs]	56.8	44.7	43.6	55.4	95.9	40.3
2,4'-DDD	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4'-DDE	23.6	12.8	10.2	17.9	32.2	9.3
2,4'-DDT	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDD	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4,4'-DDE	33.2	31.9	33.4	37.5	63.7	31
4,4'-DDT	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-alpha	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-beta	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-delta	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
BHC-gamma	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlordane-alpha	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlordane-gamma	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dieldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan Sulfate	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan-I	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan-II	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin Aldehyde	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor Epoxide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methoxychlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mirex	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Toxaphene	<10	<10	<10	<10	<10	<10
trans-Nonachlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table G6. Laboratory report for the sediment total organic carbon and total solids analyses.

SCCWRP Rhine Channel Sediment Toxicity- Sediment Results

Sample ID	6830	6831	6832	6833	6834	6835	6836	6837	6838	6839
Replicate	R1	R1	R1	R1	R1	R1	R1	R1	R1	R1
Description	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.
TOC	1.49	2.53	1.76	3.23	1.41	1.14	1.7	1.36	1.33	1.74
Total Solids	54.6	50.5	42.6	33.4	39.8	40	35.6	32.9	31.3	36

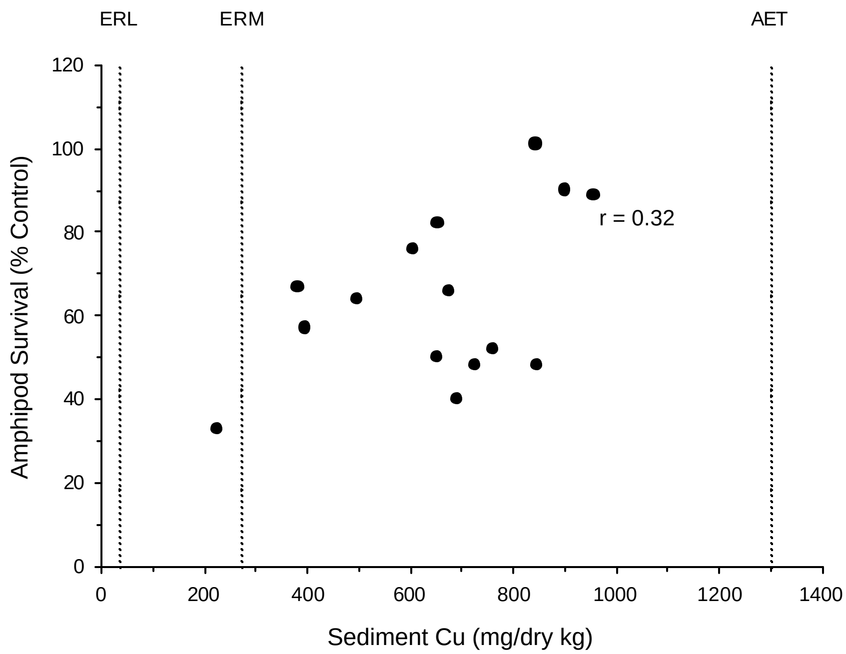
Sample ID	6840	6841	6842	6842	6843	6844
Replicate	R1	R1	R1	R2	R1	R1
Description	RC11	RC12	RC13	RC13	RC14	RC15
Sample Date	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02	14-May-02
Units	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.	% Dry Wt.
TOC	0.98	1.02	1.46	1.54	1.68	1.6
Total Solids	38.9	38	34.3	na	35.9	42.6

Appendix H. Rhine Channel station grab data.

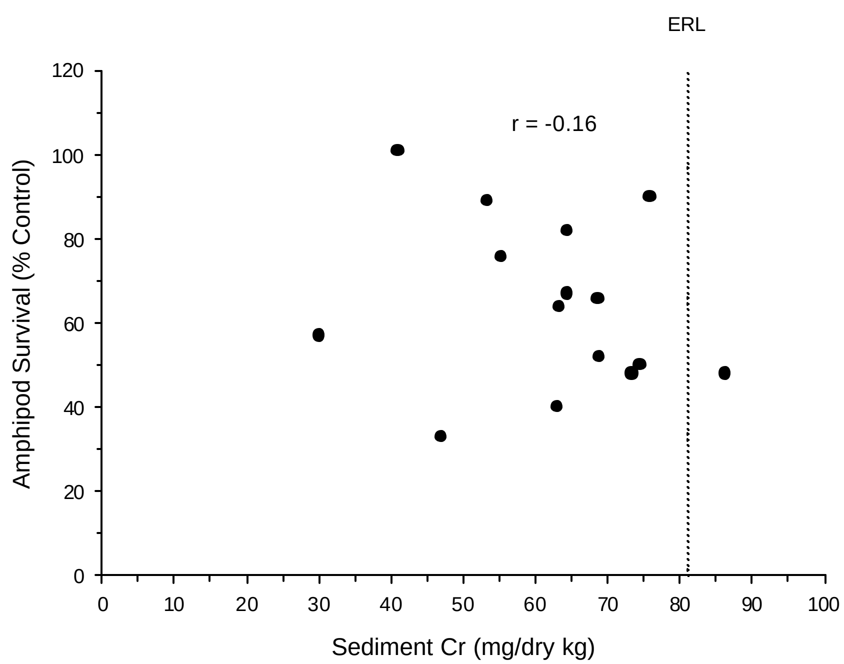
Station	Sampling Date	Sampling Time	Latitude	Longitude	Depth (m)	Grab Penetration (cm)
RC1	5/14/02	6:36	33.614600	-117.926483	2.6	14
RC2	5/14/02	7:10	33.614900	-117.926767	3.2	18
RC3	5/14/02	7:34	33.614433	-117.926967	3.9	18
RC4	5/14/02	7:54	33.614000	-117.927233	2.8	18
RC5	5/14/02	8:15	33.613467	-117.927417	3.0	18
RC6	5/14/02	8:33	33.612867	-117.927700	3.0	18
RC7	5/14/02	9:00	33.612500	-117.927850	3.2	18
RC8	5/14/02	9:19	33.611650	-117.927817	3.6	18
RC9	5/14/02	9:39	33.611750	-117.927450	3.6	18
RC10	5/14/02	10:00	33.610950	-117.927400	3.8	18
RC11	5/14/02	10:18	33.611217	-117.927117	4.4	18
RC12	5/14/02	10:37	33.611467	-117.927150	4.3	18
RC13	5/14/02	10:57	33.610417	-117.926783	4.0	18
RC14	5/14/02	11:28	33.610650	-117.926050	3.4	18
RC15	5/14/02	11:47	33.609950	-117.925500	3.6	18

Appendix I

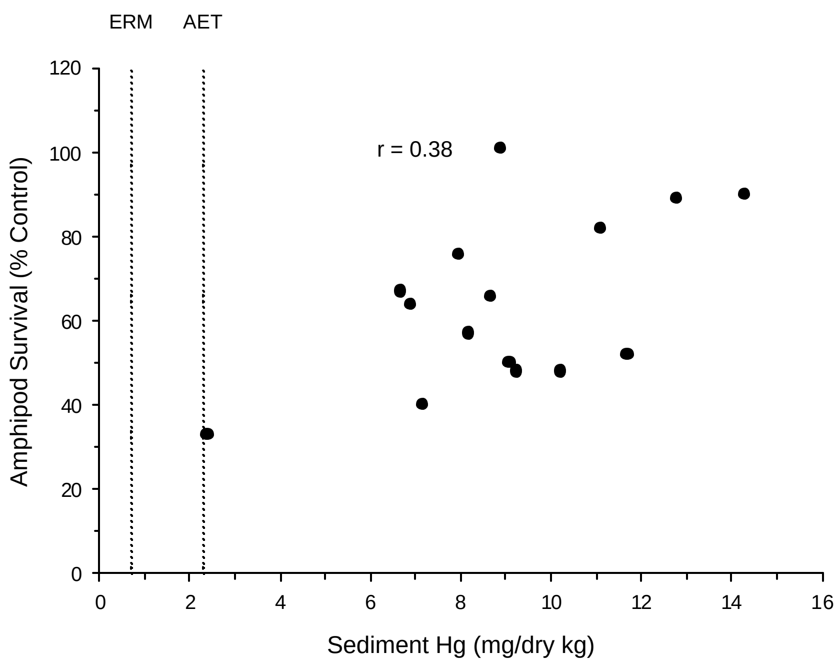
Scatterplots of Toxicity and Contamination Results



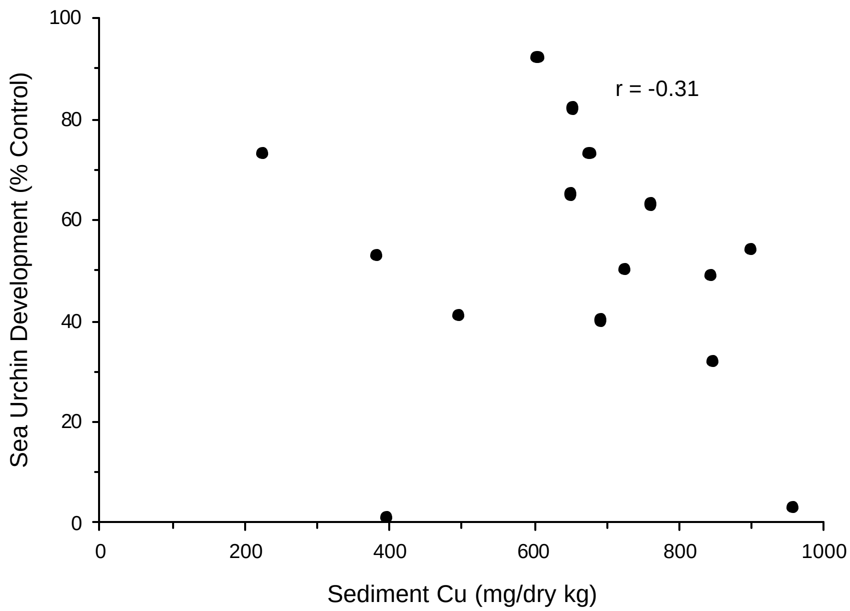
Relationship between amphipod survival and the concentration of copper in Rhine Channel sediments.



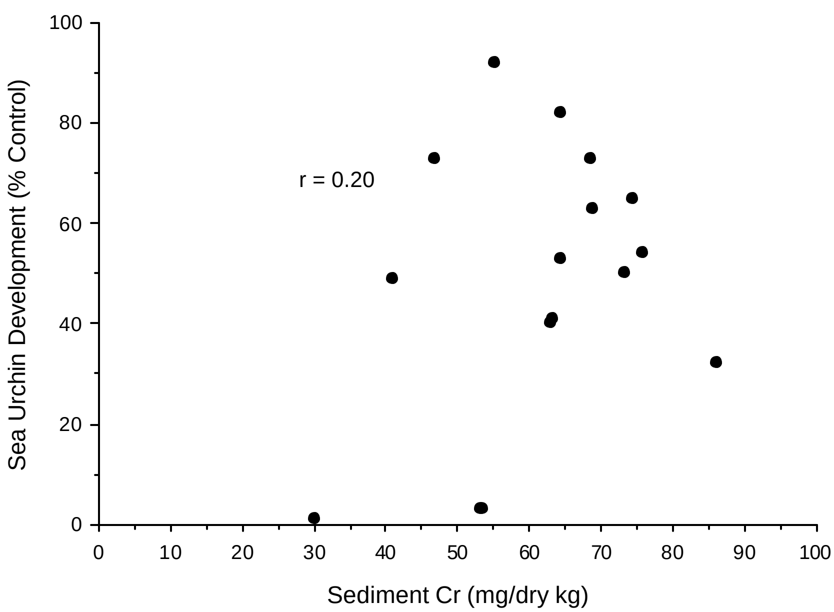
Relationship between amphipod survival and concentration of chromium in Rhine Channel sediments.



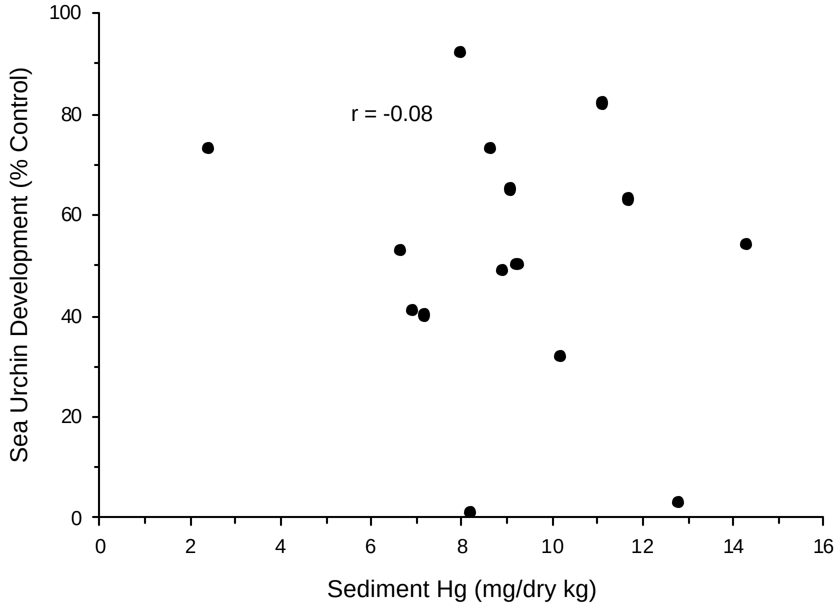
Relationship between amphipod survival and concentration of mercury in Rhine Channel sediments.



Relationship between sea urchin embryo development and concentration of copper in Rhine Channel sediments.



Relationship between sea urchin embryo development and concentration of chromium in Rhine Channel sediments.



Relationship between sea urchin embryo development and concentration of mercury in Rhine Channel sediments.

Appendix J

Sample Chain of Custodies

Southern California Coastal Water Research Project

7171 Fenwick Lane
Westminster, CA 92683
(714) 894-2222

Chain of Custody

Date May 20, 2002 Page 1 of 2

Sample Collection By: SCCWRP Tox Lab | Project Name: Rhine Channel Sed Tox | Project Number: T 3094

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
Tube Blank	5-20-02		water	Sealed Plastic	1	unfiltered	Dissolved metals
RC1	↓		↓	↓	1	↓	↓
RC2	↓		↓	↓	1	↓	↓
RC3	↓		↓	↓	1	↓	↓
RC4	↓		↓	↓	1	↓	↓
RC5	↓		↓	↓	1	↓	↓
RC6	↓		↓	↓	1	↓	↓
RC7	↓		↓	↓	1	↓	↓
RC8	↓		↓	↓	1	↓	↓
RC9	↓		↓	↓	1	↓	↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) Steven Bay	(Date) 5/21	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) Steven Bay	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [illegible]	(Date)	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) Rich Gossett	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) CRG		(Company)		(Company)	

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Chain of Custody

Date May 20, 2002 Page 2 of 2

Sample Collection By: SCCWRP Tox Lab | Project Name: Rhine Channel Sed Tox | Project Number: 73094

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC 10	5-20-02		water	500 ml Plastic	1	unfiltered	Dissolved metals
RC 11	↓		↓	↓	1	↓	↓
RC 12	↓		↓	↓	1	↓	↓
RC 13	↓		↓	↓	1	↓	↓
RC 14	↓		↓	↓	1	↓	↓
RC 15	↓		↓	↓	1	↓	↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) [signature]	(Date) 5/21	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) Steve Bay	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) /		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [signature]	(Date)	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) Rick Gossett	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) CRG		(Company)		(Company)	

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Chain of Custody

Date [illegible] Page 1 of 3

Sample Collection By: [illegible]			Project Name: [illegible]				Project Number: [illegible]
Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC1	5-[illegible]		[illegible]	25 [illegible]	1		[illegible]
RC2	↓		↓	↓	1		↓
RC3	↓		↓	↓	1		↓
RC4	↓		↓	↓	1		↓
RC5	↓		↓	↓	1		↓
RC6	↓		↓	↓	1		↓
RC7	↓		↓	↓	1		↓
RC8	↓		↓	↓	1		↓
RC9	↓		↓	↓	1		↓
RC10	↓		↓	↓	1		↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	

Southern California Coastal Water Research Project

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Chain of Custody

Date [illegible] Page 2 of 3

Sample Collection By: [illegible] Project Name: [illegible] Project Number: [illegible]

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC11	[illegible]		[illegible]	[illegible]	1		[illegible]
RC12	↓		↓	↓	1		↓
RC13	↓		↓	↓	1		↓
RC14	↓		↓	↓	1		↓
RC15	↓		↓	↓	1		↓
RC1	[illegible]		[illegible]	[illegible]	1		[illegible]
RC2	↓		↓	↓	1		↓
RC3	↓		↓	↓	1		↓
RC4	↓		↓	↓	1		↓
RC5	↓		↓	↓	1		↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) 1334	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) SCCWRP		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	

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Chain of Custody

Date [illegible] Page 3 of 3

Sample Collection By: [illegible]			Project Name: [illegible]				Project Number: [illegible]
Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
R66	[illegible]		[illegible]	[illegible]	1		[illegible]
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓
[illegible]	↓		↓	↓	1		↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	

Southern California Coastal Water Research Project

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Chain of Custody

Date [illegible] Page 1 of 3

Sample Collection By: SCCWRP

Project Name: [illegible]

Project Number: [illegible]

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
NB3	[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB10	[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB3	[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB11	[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB12	3/[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB1	[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB1 [illegible]	3/[illegible]	—	[illegible]	[illegible]	1		[illegible]
NB1 [illegible]	3/[illegible]	—	[illegible]	[illegible]	1		[illegible]
RC 1	3/[illegible]	—	[illegible]	[illegible]	1		[illegible]
RC 2	[illegible]	—	[illegible]	[illegible]	1		[illegible]

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) 1330	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) SCCWRP		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature)	(Date)	(Signature)	(Date)	(Signature)	(Date)
(Printed Name)	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	

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Chain of Custody

Date [illegible] Page 2 of 3

Sample Collection By: [illegible] Project Name: [illegible] Project Number: [illegible]

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
Rc3	[illegible]	—	[illegible]	[illegible]	1		[illegible]
Rc4		—			1		
Rc5		—			1		
Rc6		—			1		
Rc7		—			1		
Rc8		—			1		
Rc9		—			1		
Rc10		—			1		
Rc11		—			1		
Rc12		—			1		

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	
Received By		**Received By**		**Received By**	
(Signature)	(Date)	(Signature)	(Date)	(Signature)	(Date)
(Printed Name)	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	

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Chain of Custody

Date [illegible] Page 3 of [illegible]

Sample Collection By: SCCWRP

Project Name: [illegible]

Project Number: [illegible]

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC13	[illegible]	—	[illegible]	[illegible]	1		[illegible]
RC14	[illegible]	—	[illegible]	[illegible]	1		[illegible]
RC15	[illegible]	—	[illegible]	[illegible]	1		[illegible]

Relinquished By		Relinquished By		Relinquished By	
(Signature) [illegible]	(Date) [illegible]	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) [illegible]	(Time) [illegible]	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) [illegible]		(Company)		(Company)	

Received By		Received By		Received By	
(Signature)	(Date)	(Signature)	(Date)	(Signature)	(Date)
(Printed Name)	(Time)	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	

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Chain of Custody

Date Sept. 12, 2002 Page 1 of 3

Sample Collection By: SCCWRP

Project Name: Newport Bay & Rhine Channel Toxicity

Project Number: T3014 & T3094

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
NB3 ✓	11/27/01	—	Sediment	4 oz Plastic	1		Grain Size
NB10 ✓	11/27/01	—	Sediment	4 oz Plastic	1		Grain Size
NB3 ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
NB11 ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
NB12 ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
NB10 ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
NB10B ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
NB10C ✓	3/12/02	—	Sediment	4 oz Plastic	1		Grain Size
RC1 ✓	5/14/02	—	Sediment	4 oz Plastic	1		Grain Size
RC2 ✓	5/14/02	—	Sediment	4 oz Plastic	1		Grain Size

Relinquished By		Relinquished By		Relinquished By	
(Signature) [signature]	(Date) 9-12-02	(Signature) [signature]	(Date) 9/24/02	(Signature)	(Date)
(Printed Name) Darrin Greenstein	(Time) 1330	(Printed Name) Scott C. Johnson	(Time) 2:30 pm	(Printed Name)	(Time)
(Company) SCCWRP		(Company) ABC Labs		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [signature]	(Date) 9/12/02	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) F. Ramirez	(Time) 1030	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	

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Aquatic Bioassay
29 N. Olive St.
Ventura, CA 93001

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Chain of Custody

Date Sept. 12, 2002 Page 2 of 3

Sample Collection By: SCCWRP			Project Name: Rhine Channel Toxicity				Project Number: T3094
Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC3 ✓	5-14-02	—	Sediment	4 oz Plastic	1		Grain Size
RC4 ✓	↓	—	↓	↓	1		↓
RC5 ✓	↓	—	↓	↓	1		↓
RC6 ✓	↓	—	↓	↓	1		↓
RC7 ✓	↓	—	↓	↓	1		↓
RC8 ✓	↓	—	↓	↓	1		↓
RC9 ✓	↓	—	↓	↓	1		↓
RC10 ✓	↓	—	↓	↓	1		↓
RC11 ✓	↓	—	↓	↓	1		↓
RC12 ✓	↓	—	↓	↓	1		↓

Relinquished By		Relinquished By		Relinquished By	
(Signature) [signature]	(Date) 9-12-02	(Signature) [signature]	(Date) 9/24/02	(Signature)	(Date)
(Printed Name) Darrin J Greenstein	(Time) 1330	(Printed Name) Scott C Johnson	(Time) 2:30 pm	(Printed Name)	(Time)
(Company) SCCWRP		(Company) ABC Labs		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [signature]	(Date) 9/13/02	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) Phill Ramirez	(Time) 1130	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company)		(Company)		(Company)	

Aquatic Bioassay
29 N. Olive St.
Ventura, CA 93001

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Chain of Custody

Date Sept. 12, 2002 Page 3 of 3

Sample Collection By: SCCWRP | Project Name: ~~Newport~~ Rhine Channel Toxicity | Project Number: T3094

Sample ID	Date	Time	Matrix	Container Type	Number of Containers	Comments	Analysis
RC13 ✓	5/14/02	—	Sediment	4oz Plastic	1		Grain Size
RC14 ✓	5/14/02	—	Sediment	4oz Plastic	1		Grain Size
RC15 ✓	5/14/02	—	Sediment	4oz Plastic	1		Grain Size

Relinquished By		Relinquished By		Relinquished By	
(Signature) [signature]	(Date) 9-12-02	(Signature) [signature]	(Date) 9/24/02	(Signature)	(Date)
(Printed Name) Darrin Greenstein	(Time) 1330	(Printed Name) Scott C. Johnson	(Time) 2:30 pm	(Printed Name)	(Time)
(Company) SCCWRP		(Company) ABL Labs		(Company)	
Received By		**Received By**		**Received By**	
(Signature) [signature]	(Date) 9/13/02	(Signature)	(Date)	(Signature)	(Date)
(Printed Name) F. Ramirez	(Time) 1030	(Printed Name)	(Time)	(Printed Name)	(Time)
(Company) Aquatic Bioassay 29 N. Olive St. Ventura, CA 93001		(Company)		(Company)	

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