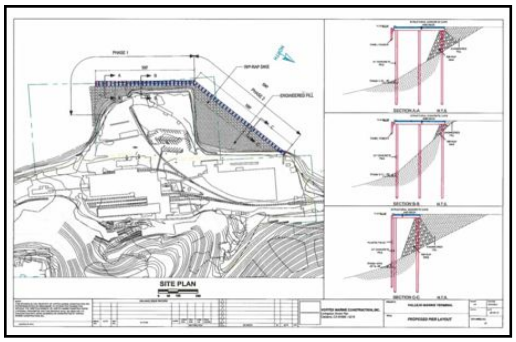
APPENDIX E-6

Benthic Survey of Vallejo Marine Terminal LLC Site

Benthic Survey
Of The
Vallejo Marine Terminal LLC Site
Vallejo, California



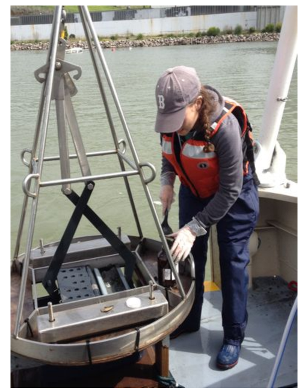


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Table of Contents

List of Tables

List of Figures

Executive Summary

Integral to the establishment of the Vallejo Marine Terminal (VMT), at the abandoned General Foods Flour Mill site in Vallejo California, is the reestablishment of the sites' former wharf and dock facilities and the eventual expansion of these facilities to accommodate the anticipated break-bulk ships and barges that would use the terminal. The reconstruction of the existing wharf site, as well as the creation of additional wharf area to accommodate smaller barges will require the burial of some intertidal and subtidal habitat, building new and/or repairing the protective riprap break walls along select segments of the shoreline, and the dredging of Napa River sediments adjacent to the marine terminal to provide adequate water depth for safe navigation.

Planned dredging and expansion of the existing wharf facilities will result in the temporary disturbance and potential loss of benthic habitat and associated biological communities. To assist in the assessment of the potential effect of this disturbance and loss of habitat on the ecosystem of the Napa River and the larger San Francisco Bay-Delta, a survey and assessment was conducted of the benthic infauna inhabiting the marine sediments adjacent to the VMT site. In addition, shallow sediment samples were collected to assess the presence of any organic or inorganic contaminants in the subtidal areas adjacent to the VMT project site.

Applied Marine Sciences, Inc. conducted field sampling on March 27-28, 2014. A total of eight (8) stations were sampled for benthic infauna, sediment grain size, and total organic carbon (TOC) concentration. An additional four (4) stations were sampled for organic and inorganic contaminants in surface sediments. Sampling sites were randomly selected before the survey and spatially distributed within the area that will encompass the proposed new Vallejo Marine Terminal.

Study findings were:

- Three benthic infaunal communities were observed inhabiting the study site with the first located immediately offshore in the northwest corner of the VMT project site in the predominantly silty sediments of a tidal mudflat. The second was located slightly farther offshore along the northern and central areas of the VMT project site in sediments consisting of some silt and clay but mostly characterized by sand, coarse sand and gravel. The third infaunal community occupied the natural deep-water river channel and consisted of sediments dominated by clay and silt.

- The first and shallowest infaunal community was composed of 15-16 taxa with a total mean density of 5,530 individuals per square meter. This community was dominated by the amphipods *Ampelisca abdita,* and *Grandidierella japonica*, the cumacean *Nippoleucon himunensis*, the polychaete *Streblospio benedicti*, tubificidae oligochaetes, and the bivalve clam *Potamocorbula amurensis*. *A abdita* and N. *himunensis* numerically dominated the community making up more than 67-82% of the total abundance observed at the two sampled sites. The dominant taxa observed in this community were fairly evenly distributed between suspension feeders and surface deposit feeders.

- The second benthic infaunal community consisted of 24-34 taxa with a total mean density of 4,289 individuals per square meter. This community was the most diverse infaunal community observed at the VMT study site. It was numerically dominated by the polychaetes *Polydora cornuta*, *Capitella capitata* (complex), and *Streblospio benedicti*, the nudibranch *Okenia plana*, the amphipods *Incisocalliope derzhavini*, *Monocorophium acherusicum*, *Corophium heteroceratum*, *C. alienense*, *C.* unidentified, *Ampelisca abdita,* and *Grandidierella japonica*, the horseshoe worm *Phoronopsis harmeri*, annelid tubificidae worms, the Asian clam *Potamocorbula*

amurensis, and the barnacles *Amphibalanus improvisus, Balanus crenatus* and *Balanomorpha* unidentified. The barnacles were observed attached to large gravel and pebbles located on the surface of most of the sample sites. The dominant taxa consisted of eight filter feeders, eight filter and deposit feeders, and one carnivore. The total abundance per meter square of seafloor for the second benthic infaunal community was slightly lower than observed at community 1 and was divided between more species.

- The third benthic community was represented by one site that was overwhelmingly dominated by the bivalve clam *Potamocorbula amurensis. Potamocorbula* accounted for 83% of the total individual abundance at this site. Infaunal community 3 consisted of 14 taxa with a total mean density of 4,413 individuals per square meter.

- Consideration of each observed taxon's potential sensitivity or tolerance to habitat degradation (Weisberg et al. 2008), suggests that the surface marine sediments at the VMT project site do not appear to be subject to either substantial physical or chemical disturbances. This conclusion is supported by the low to non-detectable concentrations of tested organic and inorganic contaminants measured at the project site.

- Finally, no protected species or species of special concern were observed. Many of the benthic taxa identified are common prey items for demersal fish including white and green sturgeon, especially the Asian clam, *Potamocorbula amurensis* and *the amphipod Corophium spp*.

1 Introduction

Integral to the establishment of the Vallejo Marine Terminal (VMT), at the former and abandoned General Foods Flour Mill site in Vallejo California, is the reestablishment of the sites' wharf and dock facilities, and the eventual expansion of these facilities to accommodate the break-bulk ships and barges utilizing the terminal. The reconstruction of the exiting wharf site (Figure 1-1), as well as the creation of additional wharf area to accommodate smaller barges, will require the burial of some intertidal and subtidal habitat, building new and/or repairing the protective riprap break walls along select segments of the shoreline, and the dredging of Napa River sediments adjacent to the marine terminal to provide adequate water depth for safe navigation (Figure 1-2).

Planned dredging and expansion of the existing wharf facilities will result in temporary disturbance to and potential loss of benthic habitat and associated biological communities. To more adequately assess the potential effect of this disturbance and loss of habitat on the ecosystem of the Napa River and the larger San Francisco Bay-Delta, a survey and assessment was conducted of the benthic fauna inhabiting the shallow subtidal sediments adjacent to the VMT site where the improved and expanded wharf facilities will occur. In addition to the biological assessment activities, shallow sediment samples were collected to assess the presence of any organic or inorganic contaminants in the subtidal areas adjacent to the VMT project site.

Accordingly, this study was designed to achieve the following objectives:

- Characterize the benthic infaunal community inhabiting the nearshore subtidal area of Napa River-San Francisco Bay-Delta where the proposed VMT marine terminal is to be constructed,
- Identify any physical environmental conditions that may be influencing benthic community composition,
- Assess whether the benthic infauna in the project area could be important prey for special status species,
- Determine if the benthic infaunal community reflects the presence of sediment contamination, and
- Determine if there are elevated contaminant levels in the shallow sediments where VMT wharf construction activities are projected to occur.

This report presents the results of sediment sampling and benthic analysis conducted in the shallow subtidal region immediately offshore of the Vallejo Marine Terminal project site.

Figure 1-1. Existing shoreline and nearshore areas along the Vallejo Marine Terminal Site waterfront, Vallejo, California. (Map source: Google Earth, 2014).

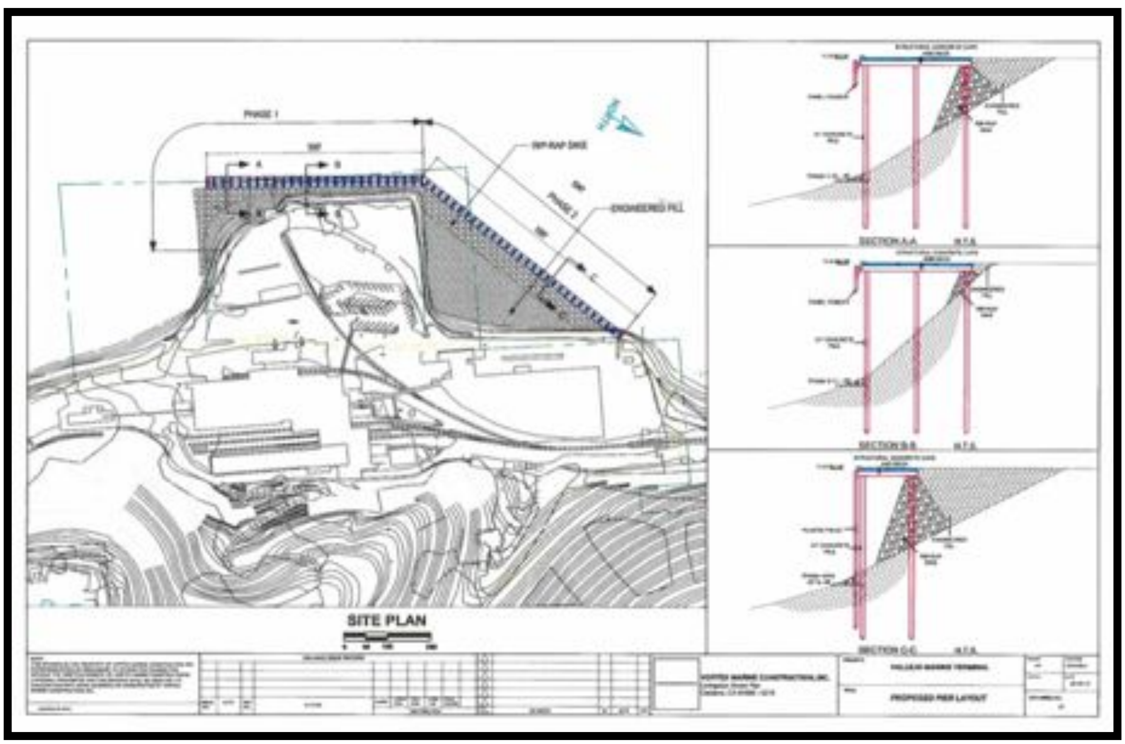


Figure 1-2. Proposed shoreline redevelopment plan for the Vallejo Marine Terminal Site, Vallejo California. (Map Source: Vallejo Marine Terminal, 2013).

2 Sampling and Analytical Methodologies

2.1 Field Sampling

AMS conducted field sampling on March 27-28, 2014. A total of eight (8) single-sample stations were sampled for benthic infauna, sediment grain size, and total organic carbon (TOC) concentration (Figure 2-1). In addition, four (4) more stations were sampled for organic and inorganic contaminants in the shallow surface sediments. All sampling sites were selected prior to field work for relative location along a stratified grid such that samples were collected both with increasing depth and from North to South within the area that will encompass the expanded marine terminal and where expected channel dredging is to occur (Figure 2-1). Some minor adjustments for site location occurred in the field to accommodate tidal currents, underwater obstructions, and vessel safety.

To provide additional physical environmental condition information for the survey site, water-column profiles for temperature, water depth, salinity, conductivity, pH, and dissolved oxygen were collected with an YSI 6600 EDS CTD profiler.

Table 2-1 provides details on each sample location, date and time of sampling and information on sediment characteristics; Table 2-2 provides sea and weather conditions during field work and Table 2-3 provides water quality conditions during sampling.

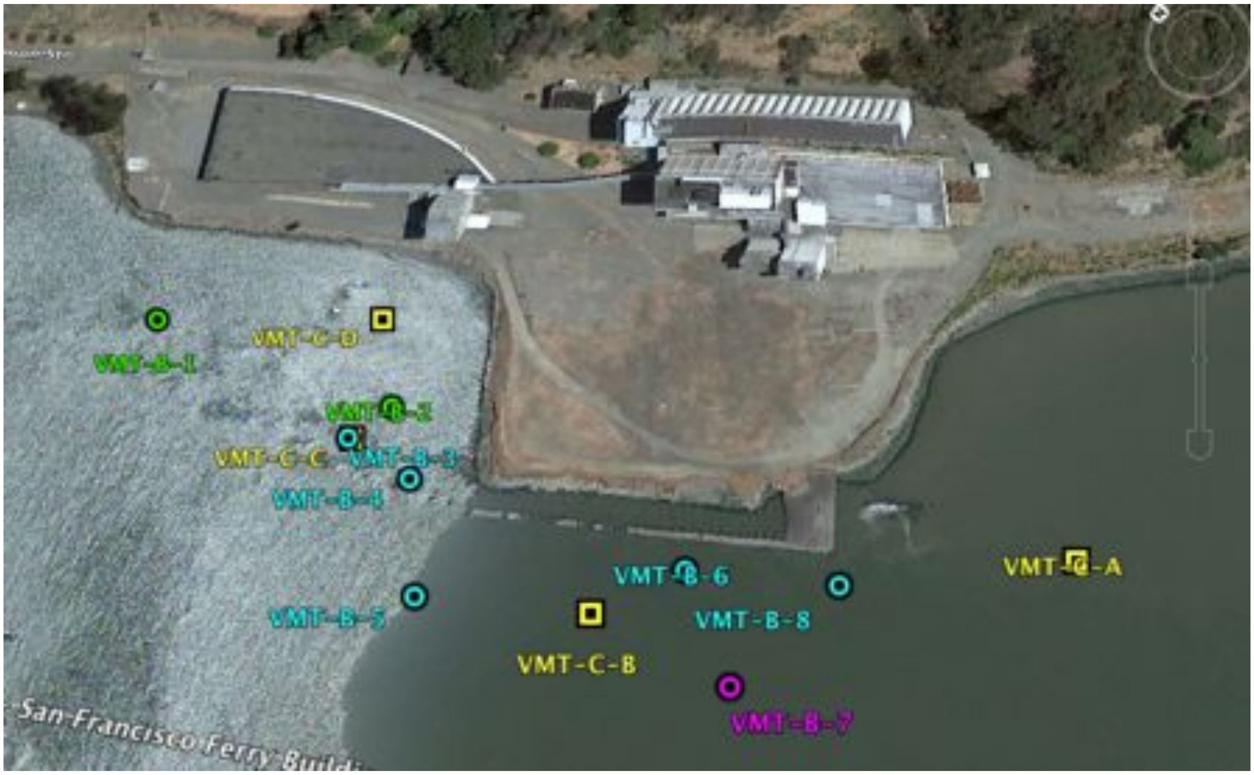
2.1.1 Sample Evaluation

Sediment samples were collected using a 0.1 m^2 modified Van Veen grab. In the field, the grab was split into two closely equal portions, with one side of the grab used for collecting physical and chemical analysis samples and the other half for benthic infauna.

Quality control procedures were used to ensure the collection of undisturbed samples of adequate volume. Upon retrieval of the grab, the acceptability of the sample was determined by evaluating the type of sediment, sample condition, and depth of penetration. Sample condition was judged using criteria for surface disturbance due to sediment leakage from the grab. An acceptable sample condition was characterized by an even surface with minimal disturbance and little or no leakage of the overlying water, which washes sediment from the grab surface. Samples with heavily canted surfaces were deemed unacceptable. Samples with a large amount of "humping" along the midline of the grab, which indicates washing from the sample periphery during retrieval, were also unacceptable. Although some humping will be evident in samples taken from firm sediment where penetration has been poor, this can be due to the closing action of the grab and is not necessarily evidence of unacceptable washing.

The following conditions led to sample rejection:

- There was a rock, shell fragment, or bivalve wedged between the jaws of the grab, allowing the sample to wash out,
- The sample surface was significantly disturbed,
- The sample was uneven from side to side, indicating that the grab was tilted when it penetrated the sediment,
- The surface of the sample was in contact with the top doors of the grab, indicating over-penetration of the grab and possible loss of material around the doors,
- The penetration depth of the grab was insufficient to provide enough sediment for analyses.



Legend: ⊙= Infaunal Community #1 Sampling Location, ⊙= Infaunal Community #2 Sampling Location ⊙= Infaunal Community #3 Sampling Location, ■= Sediment Chemistry Sampling Station

Figure 2-1. Sample locations for the Vallejo Marine Terminal benthic survey on March 27, 2014 (Map Source: Google Earth, 2014).

If sample condition was acceptable, then overlying water was carefully drained off into a sample tray and the depth of penetration was determined by inserting a plastic ruler into the sediment at the grab midline and measuring to the nearest 0.5 cm. Sediment penetration depth was required to be at least 5 cm. Overlying water in samples intended for infaunal analyses was drained by slightly opening the jaws of the grab and allowing the water to run off into the sample tray.

2.1.2 In-Field Processing of Benthic Infaunal Samples

One half of the grab sediment was used to collect the sediment grain size and TOC samples, and the other half of the grab was used to collect benthic infauna, resulting in a sampler area of approximately 0.05 m^2 for the benthic sample. With the grab jaws still closed, the grab sample was divided into two halves by inserting a thin metal plate vertically into the grab along the mid-line, directly above and in line with the jaw opening. This plate split the sediment sample into two equal subsamples.

With the dividing plate inserted and held in place, the subsample for grain size and TOC was removed from one side of the grab. After this, all sediment material on that half of the grab was removed with spoons or by hand, ensuring that the dividing plate remained in position. After all sediment material was removed from the first subsample, the dividing plate was removed, the grab jaws were opened, and the remaining subsample was washed from the grab into a plastic tub for processing of infauna.

Table 2-1. Sampling coordinates, depth, grab penetration, and sediment character of sampling sites for VMT benthic survey fieldwork.

Site Name[1]	Latitude	Longitude	Water Depth (m)	Grab Penetration Depth (cm)	Sediment Character
VMT-B-1	38.081778	-122.246817	2	11	Unconsolidated, brown silt and clay
VMT-B-2	38.080950	-122.246534	2.4	12.7	Semi-consolidated fines on surface with silt and clay underneath
VMT-B-3	38.080977	-122.246746	3.8	8.5	Loosely consolidated silty sand
VMT-B-4	38.080731	-122.246735	5.5	11.5	Unconsolidated silty sand, shell debris. Sandy surface with shell debris, consolidated fines underneath
VMT-B-5	38.080457	-122.247088	12.5	11.5	Semi-consolidated clay, heavily consolidated underneath
VMT-B-6	38.079908	-122.264396	10.9	9	Course cobble, sand, some fines
VMT-B-7	38.079605	-122.246647	13	14	Moderately consolidated clay, fine brown layer on top (1-2mm thick), shell hash, consolidated fines underneath
VMT-B-8	38.079537	-122.246099	11.8	10	Fine coating on top, shell hash, cobble, Consolidated fines underneath
VMT-C-A	38.079047	-122.245473	7.2	5	Semi-consolidated silty clay, very fine layer on surface
VMT-C-B	38.080035	-122.246746	12.8	5	Light gray silty clay with shell hash and pebbles, surface layer of fine sediments has brown coloration
VMT-C-C	38.080966	-122.246738	5.0	5	Brown silty clay with bits of metal and small pebbles, surface layer of fine sediments has brown coloration
VMT-C-D	38.081209	-122.246237	1.5	5	Unconsolidated semi-soft brown silty clay with no visible shell hash

Note [1] VMT-B-# = benthic infauna station; VMT-C-# = sediment chemistry stations.

Table 2-2. Sea and weather conditions at sampling sites during VMT benthic survey fieldwork.

Site Name[1]	Date & Sample Collection Time	Sea State	% Overcast	Current (speed) (Knots)
VMT-B-1	3/27/14; 10:42	Calm	50	0.1
VMT-B-2	3/27/14; 11:05	Calm	50	1.7
VMT-B-3	3/27/14; 11:13	Calm	50	1.0
VMT-B-4	3/27/14; 11:24	Calm	50	1.0
VMT-B-5	3/27/14; 11:46	Calm	50	0.4
VMT-B-6	3/27/14; 12:33	1 ft. chop	90	1.2
VMT-B-7	3/27/14; 12:49	Calm	90	0.8
VMT-B-8	3/27/14; 13:08	0.5 ft. slight wind chop	90	1.4
VMT-C-A	3/27/14; 9:03	Calm	100	2.5
VMT-C-B	3/27/14; 9:30	Calm	100	2.0
VMT-C-C	3/27/14; 9:56	Calm	50	1.6
VMT-C-D	3/27/14; 10:28	Calm	50	0.5

Note [1] VMT-B-# = benthic infauna station; VMT-C-# = sediment chemistry stations.

Table 2-3. Summary of physical water quality parameters during VMT benthic survey fieldwork.

Depth Group[1]	Analytes	VMT-B-01	VMT -B-03	VMT -B-08
Surface	Temperature (°C)	15.56	15.75	15.7.3
	Conductivity (S/m)	30.35	30.79	30.92
	Salinity (ppt)	18.88	19.16	19.27
	Oxygen (mg/L)	8.72	8.46	8.5 3
Mid-water	Temperature (°C)	15.81	15.71	15.42
	Conductivity (S/m)	30.43	30.91	32.47
	Salinity (ppt)	18.93	19.26	20.33
	Oxygen (mg/L)	9.21	8.43	8.51
Bottom	Temperature (°C)	15.89	15.44	15.40
	Conductivity (S/m)	30.37	32.60	33.65
	Salinity (ppt)	18.89	20.42	21.14
	Oxygen (mg/L)	8.85	8.44	8.6

Note [1] Surface, Mid-water, and Bottom refer to average values measured for the top, middle, and bottom 1/3 of depths sampled at a site, respectively.

All collected sediment was washed through a 2.0 mm screen to capture any large bivalves, worms, gastropods or other large benthic organisms, as well as to remove any shell fragments, or other large debris. Organisms captured on the 2.0 mm screen were placed into the 1.0 mm screen sample jar. Infauna samples were transferred to an infauna-processing chamber that gently washed and lifted coarse sediments, allowing benthic infauna to rise to the water surface and float through a sluice gate into nested 1.0 and 0.5 mm nylon mesh bags. The nested 0.5 and 1.0 mm mesh bags were placed into a full bucket of water while samples were being processed, to prevent impingement of organisms on the nets. After the sediment in the infauna-processing chamber was sufficiently washed to float all visible organisms, the remaining sediment was also carefully washed into a 1.0 mm screen and any organisms observed in the sediment were removed to the 1.0 mm jar.

At the conclusion of processing a sample, the nested nylon bags were removed and the contents of the 0.5 and 1.0 mm bags were washed and transferred onto separate 0.5 mm sieves for further screening, prior to placement into labeled sample jars. Once each sample was washed through the screen, the material (debris, coarse sediment, and organisms) retained on the screen was transferred to a sample container. All sample containers were labeled with an external label containing the station name, sample ID, date, time, and "split number" (*i.e.,* 1 of 1, 2 of 3, etc.) if required. A label bearing the same information was placed inside the jars containing infaunal samples. The sample containers had a screw-cap closure and were sufficiently large to accommodate the sample material with a headspace of at least 30% of the container volume. Because of the retained volume of material on some of the 1.0 or 0.5 mm screen, some samples required multiple containers that were labeled as one of a set of X containers. The sample containers were filled to approximately 50 to 70% of capacity with screened material. After the bulk of material had been transferred to the container, any organisms remaining on the screens were removed with forceps and added to the sample container. The screens were washed thoroughly between samples.

All infaunal samples were treated with an isotonic relaxant solution (Epsom salts, $MgSO_4$) for approximately 10-30 minutes prior to fixation to facilitate handling during taxonomic identification. After the relaxant treatment, the solution was decanted from the sample through a screen with a mesh size of 0.5 mm or less. Any animals adhering to the screen were carefully removed and placed back in the sample container. The container was then filled with sodium borate-buffered 10% formalin and stored for return to the laboratory. The samples were stored in formalin for no less than 72 hours, after which they were transferred to 70% isopropyl alcohol preservative.

2.1.3 Benthic and Sediment Chemistry Samples

In conjunction with the benthic infauna sampling, surficial sediment samples were collected at the eight-benthic infaunal sample locations and at four additional sediment chemistry sample locations. As discussed above, benthic infaunal grab samples had sediment removed for analysis of grain size and total organic carbon (TOC) from one half of each grab. The four sediment chemistry sample locations (Figure 2-1) were distributed spatially along the proposed VMT waterfront and sediment subsamples collected for assessing the potential presence of any heavy metals, pesticides, hydrocarbons, or legacy anti-fouling paints, at the project site.

Sediment chemistry samples were collected in accordance with established protocols for the Bay Regional Monitoring Program (RMP) to enable comparison of the analytical results from these samples with historic information on contaminants in the Bay-Delta collected by the RMP over the past 21-years. Given the VMT's location immediately downriver from to the Mare Island Naval Shipyard and at the mouth of the Napa River, the potential for the analyzed contaminants to be present in project area sediments that could be resuspended into the marine environment during construction and operation of the VMT was considered highly likely.

2.1.3.1 Grain Size, Total Organic Carbon (TOC) Samples

As mentioned above, each benthic infaunal sample was subsampled for sediment grain size and total organic carbon (TOC) analysis. Approximately 750-800 ml of sediment was collected from one half of each grab that was not used for infaunal taxonomic analysis at each of the benthic infaunal stations and placed into 1-litre wide mouth glass container, taking care to leave an air space at the top. Samples were stored on wet ice until they were returned to the laboratory.

2.1.3.2 Organic and Inorganic Contaminant Samples

Surface sediment samples were collected for the assessment of OC pesticides, PCBs, PAHs, total organic carbon (TOC), butyl tins, and total metals w/mercury. In accordance to RMP Sampling and Analysis Protocols, prior to collecting the four sediment chemistry samples, which were collected prior to all benthic infaunal sampling, sampling equipment (grab, compositing bucket, scoops, and spoons) were thoroughly cleaned by both washing and soaking for 24-hours in a Liquinox™ detergent and deionized water solution. Equipment was then rinsed three times with deionized water and allowed to dry prior to being further rinsed with a 1.0 % solution of hydrochloric acid, then petroleum ether, and finally three rinses with deionized water. Once dry, all cleaned equipment was wrapped in aluminum foil until used in the field.

Following sediment collection at each of the four sediment chemistry stations, the grab was re-cleaned as described above with a Liquinox™ detergent wash, deionized water rinse, 1.0 % hydrochloric acid rinse, and methanol rinse. Clean hands sampling and handling procedures were used while collecting all chemistry sediment samples.

In the field, each chemistry grab was initially processed by carefully removing any overlying water in the Van Veen grab without disturbing any sediment. Then the top 5 cm of sediment were collected with Teflon coated scoops and placed into a Teflon coated bucket for compositing. All sediment placed into the composting bucket was carefully mixed with a Teflon coated spoon to fully homogenize prior to filling sample jars. Once homogenized, two 500-ml wide-mouth glass bottles were filled and maintained at 4° C until returned to the laboratory.

2.2 Analytical Procedures

2.2.1 Benthic Infauna Samples

All benthic sorting and taxonomic analyses were performed or coordinated by Susan McCormick, Taxonomic Consultant. Upon receipt at the taxonomic lab, each sample was initially decanted of alcohol through a 0.5 mm screen, gently rinsed with water and then washed from the screen into a holding container. Small portions of each sample were spooned into a gridded Petri dish and sorted under 10x power of a dissecting microscope until all organisms had been removed from the petri dish. Removed organisms were placed into pre-labeled vials according to taxonomic group, *i.e.,* Polychaeta (polychaete worms), crustaceans (amphipods, isopods, crabs and other "shellfish"), Mollusca (snails and clams), Oligochaeta (round worms), Polychaete fragments (body pieces without heads), and Other. When multiple containers were required to preserve retained material in the field, all jars from the same station and screen size were combined during the sorting phase.

Each vial was labeled with taxonomic group name, station number, collection date, screen size, and sorter's initials using 100% rag paper or provided labels. Sample debris was placed back into the original sample container using recycled ETOH for preservation. Sorted taxa were then identified to the lowest taxon practicable. Reference specimens were kept for future use and validation, where required.

Ten percent of all samples (minimum one sample) from each sorter were re-sorted by a second sorter to verify quality control.

2.2.2 Sediment Chemistry Samples

ALS Environmental in Kelso, WA analyzed all samples for sediment particle size, total organic carbon (TOC), OC pesticides, PCBs, PAHs, butyl tins, and total metals w/mercury. Laboratory analysis methodologies for each of the criteria are listed in Table 2-4. Upon receipt of all analytical results, the data underwent QA/QC by AMS personnel.

Table 2-4. Laboratory Analytical Procedures

Analysis	Methodology
Grain Size	ASTM D422 (modified)
Total Organic Carbon (TOC)	EPA 9060
Polycyclic Aromatic Hydrocarbons (PAHs)	8270D SIM
OC Pesticides	EPA 8081B
Polychlorinated Biphenyl (PCBs)	EPA 8082A
Total Metals	EPA 6020
Mercury	EPA7471B
Butyl tins	Krone
Total Solids	EPA 160.3

2.2.3 Statistical Procedures

Several statistical procedures were used to analyze both biological and chemistry data in order to:

- Characterize the benthic infauna community adjacent to the Vallejo Marine Terminal site that might be affected by the building of break walls, groins and dredging,
- Compare community composition, species diversity and abundances to benthic infaunal communities reported for other areas of North Bay and the western Delta, and
- Examine the physical factors that could be responsible for the benthic community structure (*i.e.*, water depth, contamination, grain size, disturbance, currents, etc.).

Descriptive, agglomerative and parametric statistical procedures were applied sequentially to examine the data for broad patterns and then to determine the causes for those patterns. Agglomerative and parametric procedures were performed with Statistica and JMP statistical software (StatSoft, 2013; SAS Institute, 2000). First, the data were tabulated and examined for obvious patterns that might guide the following statistical procedures. Second, the biological data were used to produce site clusters using Ward's minimum variance method, in which the distance between two clusters is the analysis of variance (ANOVA) sum of squares between the two clusters added up over all the variables. The software was allowed to define clusters using the default algorithm that delineates clusters based upon the inflection point in the curve describing the distance between successive cluster nodes. The most frequently occurring taxa were used in an initial clustering that was followed by a second iteration of clustering that grouped the taxa occurrence according to similarities among stations. Third, ANOVA was performed to test for differences in benthic organisms and physical parameters among the identified clusters. ANOVA compares the amount of variation between samples within groups with the amount of variation between groups to determine whether the differences between groups are significant (i.e., the probability of achieving the result by chance is less than 5%). Consequently, it is possible that high variability among samples within one group would result in no significant difference between two groups, even if a species were absent from all samples in the second group.

Finally, stepwise linear regressions were performed to determine whether spatial patterns of benthic organism abundances (dependent variables) were associated with physical variables, such as depth and sediment grain size and TOC (independent variables). These tests enable determination of which independent variables are significantly correlated with the dependent variable when the effects of all other independent variables are considered. For example, bivariate correlations that appear to be positive might actually be negative when the effects of all other variables are taken into account. A mixed stepwise process was used, which alternates forward and backward steps, including the most significant term that satisfies the selected probability to enter, and removes the least significant term satisfying the selected probability to leave. It continues removing terms until the remaining terms are significant and then it changes to the forward direction until all significant terms have been added. The probabilities to enter and leave were set to the program default of 0.25 in each case. Finally, partial correlations were calculated between each dependent variable and each significant independent variable to determine which independent variables exerted the strongest influence on the dependent variables.

3 Data Results

3.1 Marine Biota

3.1.1 VMT Benthic Community

The benthic biota inhabiting the nearshore area adjacent to the Vallejo Marine Terminal, where the proposed redeveloped and expanded marine terminal is to be constructed, consists of a diverse community dominated by polychaetes, oligochaetes, bivalves, arthropods, and cnidarians (Table 3-1). Many of the samples included small surface rocks that were inhabited by barnacles (Cirripedia) and bryozoans. Between 2,689 and 5,433 individuals per m^2, representing 14 to 34 taxa, were reported from the eight samples collected in water depths ranging from 2.0 meters (6.7 feet) to 13.0 meters (42.7 feet) in water depth. Seafloor composition ranged from unconsolidated and consolidated silts and clays to coarse sand with cobble (Table 3-2). Nine of the fifteen most numerically dominant taxa were non-native species (Table 3-1).

The bivalve *Potamocorbula amurensis* was the most abundant organism observed over all sampling sites, accounting for 15.7% of the total number of organisms (abundance), followed by the amphipod *Ampelisca abdita* (13.4% of total abundance) and the cumacean *Nippoleucon himunensis* (12.2% of total abundance). The polychaetes *Polydora cornuta* and *Streblospio benedicti*, a group of very small gastropods that were combined together as Pyramidellidae unidentified, and the amphipod *Incisocalliope derzhavin* accounted for 6.3%, 5.6%, 5.8 % and 5.3% respectively of total abundance. These four taxa were followed by the phoronid *Phoronopsis harmeri*, the barnacle *Amphibalanus improvisus,* and the amphipods *Corophium heteroceratum* and *Grandidierella japonica* as the next most abundant species accounting for roughly 4.9%, 3.6%, 3.6% and 3.0% of total abundance, respectively. Finally, the amphipods *Corophium alienense* and *Monocorophium acherusicum,* Tubificidae oligochaete worms*,* and the barnacles *Balanus crenatu*s and Balanomorpha unidentified accounted for 2.0%, 2.2%, 2.3% and 2.4% of total abundance, respectively. These 16 taxa accounted for approximately 90.5% of the total organisms observed across all samples.

In all, amphipods accounted for the largest portion of the total abundance observed (32 %) and six of the 16 most dominant taxa. Mollusks were the second largest group of organisms accounting for approximately 23.9% of total infaunal abundance with two of the 15 most abundant species. Two species of polychaetes and one species of cumaceans then accounted for 15.2% and 12.2 %, respectively, of the total abundance. Barnacles accounted for 8.3% of the total abundance and three of the 16 most abundant taxa. Finally, phoronids and oligochaetes accounted for 4.9% and 2 % of the abundance with one each of the 16 most abundant taxa.

There were slight differences in the physical characteristics of the benthic sampling sites. Sampling depths ranged from 2.0–13 meters (6.7-42.7 feet) and averaged 7.7 meters (25.3 feet) (Table 3-2). The shallower sites were composed primarily of silts with high clay fractions whereas the mid-depth stations had high percentages of sand and gravel. The deepest station (VMT- B-7) was composed primarily of clay with a large silt fraction. Percent TOC showed no correlation with depth or grain size compositions or dominant fractions (Table 3-6).

Hierarchical cluster analysis of infaunal densities revealed three groupings of the sample sites. These groupings, which consisted of 26 taxa that included the 16 most abundant taxa as well as key occurrence taxa, clustered Sites VMT B-1 and VMT B-2 together, sites VMT B-3, VMT B-4 VMT B-5 VMT B-6, and VMT B-8 together, and site VMT B-7 by itself (Figure 3-1). Sampling site locations are shown in Figure 2-1 and are color-coded according to which cluster each station grouped with, with lime green showing Cluster 1, light blue showing Cluster 2, and purple showing Cluster 3.

Table 3-1. Abundances of all taxa (numbers/m²) found in samples at each of the sample sites.

Taxa	Cluster 1		Cluster 2					Cluster 3	Mean
	VMT B-1	VMT B-2	VMT B-3	VMT B-4	VMT B-5	VMT B-6	VMT B-8	VMT B-7	
Cnidaria									
Hydrozoa									
Hydrozoa unidentified		+	+	+	+		+		+
Anthozoa									
***Diadumene* spp[1]**	0	0	0	0	18.05	36.1	0	0	6.77
Platyhelminthes									
Turbellaria A	0	0	36.1	0	0	18.05	0	0	6.77
Nematoda									
Nematoda unidentified	0	0	0	0	0	0	0	18.05	2.26
Sipuncula									
Sipuncula unidentified	0	0	0	0	0	0	18.05	0	2.26
Annelida									
Oligochaeta									
Tubificidae unidentified	144.4	288.8	54.15	18.05	0	54.15	144.4	18.05	90.25
Polychaeta									
Polynoidae									
Harmothoe imbricata	0	0	0	18.05	0	18.05	54.15	0	11.28
Phyllodocidae									
Eteone californica	0	0	0	18.05	0	0	0	0	2.26
Syllidae									
Procerea nr. gigantea	0	0	0	0	36.1	18.05	0	0	6.77
Syllidae epitoke unidentified**	0	0	0	18.05	0	0	0	0	2.26
Nereidae									
Neanthes succinea	18.05	0	36.1	54.15	36.1	36.1	36.1	0	27.08
Nereidae unidentified[1]	0	0	0	0	0	18.05	0	0	2.26
Goniadidae									
Glycinde picta	72.2	54.15	0	0	0	36.1	36.1	0	24.82
Spionidae									
Dipolydora caulleryi	0	0	0	0	0	0	18.05	0	2.26
Dipolydora socialis	0	0	0	0	18.05	0	0	0	2.26
Polydora cornuta	0	0	72.2	1137.15	324.9	0	451.25	252.7	279.78
Pseudopolydora kempi	36.1	72.2	0	0	0	0	18.05	0	15.79
Streblospio benedicti	324.9	577.6	90.25	90.25	36.1	18.05	848.35	0	248.19
Capitellidae									
Capitella capitata complex	0	0	54.15	18.05	0	0	252.7	0	40.61
Heteromastus filiformis	0	0	0	0	18.05	0	18.05	0	4.51

Taxa	Cluster 1		Cluster 2					Cluster 3	Mean
	VMT B-1	VMT B-2	VMT B-3	VMT B-4	VMT B-5	VMT B-6	VMT B-8	VMT B-7	
Arthropoda									
Copepoda									
Harpacticoida unidentified	0	0	0	18.05	0	0	0	0	2.26
Ostracoda									
Eusarsiella zostericola	0	0	0	18.05	0	0	0	0	2.26
Cirripedia									
Amphibalanus improvisus	0	0	361	90.25	90.25	288.8	361	72.2	157.94
*Balanus crenatu*s	0	0	54.15	36.1	126.35	72.2	433.2	90.25	101.53
Balanomorpha unidentified[1]	0	0	126.35	72.2	90.25	469.3	90.25	0	106.04
Cumacea									
Nippoleucon himunensis	2527	1714.75	0	0	0	18.05	0	54.15	539.24
Isopoda									
Gnorimosphaeroma oregonense	0	0	18.05	0	126.35	0	18.05	0	20.31
Synedotea spp. [1]	0	0	0	0	18.05	0	0	0	2.26
Tanaidacea									
Sinolobus sp.	0	0	0	0	0	18.05	0	0	2.26
Amphipoda									
Gammaridea									
Ampelisca abdita	1967.45	2436.75	54.15	18.05	162.45	0	36.1	54.15	591.14
Corophiidae unidentified[1]	18.05	18.05	72.2	0	469.3	0	0	0	72.20
Corophium alienense	0	0	0	0	180.5	0	523.45	18.05	90.25
Corophium heteroceratum	90.25	18.05	0	433.2	361	0	361	18.05	160.19
Grandidierella japonica	108.3	722	18.05	18.05	144.4	0	54.15	0	133.12
Incisocalliope derzhavini	0	18.05	162.45	740.05	288.8	342.95	252.7	54.15	232.39
Monocorophium acherusicum	36.1	72.2	90.25	198.55	252.7	36.1	90.25	0	97.02
Monocorophium insidiosum	0	18.05	0	0	0	0	0	0	2.26
Monocorophium spp.	0	0	0	180.5	0	0	0	0	22.56
Caprellidae									
Caprellidae unidentified[1]	0	36.1	0	18.05	18.05	0	0	0	9.03
Decapoda									
Caridea									
Palaemon macrodactylus	0	0	18.05	0	0	18.05	0	0	4.51
Anomura									
Upogebia pugettensis	18.05	0	0	18.05	0	0	36.1	0	9.03
Mollusca									
Gastropoda									
Crepidula plana	0	0	18.05	0	0	0	0	0	2.26

Taxa	Cluster 1		Cluster 2					Cluster 3	Mean
	VMT B-1	VMT B-2	VMT B-3	VMT B-4	VMT B-5	VMT B-6	VMT B-8	VMT B-7	
Okenia plana	0	18.05	216.6	108.3	252.7	595.65	703.95	162.45	257.21
Pyramidellidae unidentified**	0	0	0	18.05	0	0	0	0	2.26
Bivalvia									
Potamocorbula amurensis	36.1	162.45	126.35	234.65	397.1	433.2	162.45	4007.1	694.93
Cryptomya californica	18.05	0	108.3	18.05	0	0	0	0	18.05
Gemma gemma	0	0	18.05	0	0	0	0	0	2.26
Musculista senhousia	0	0	18.05	18.05	54.15	0	0	36.1	15.79
Mya arenaria	0	0	72.2	18.05	0	0	18.05	0	13.54
Mytilus edulis complex	0	0	0	0	0	18.05	0	0	2.26
Venerupis philippanarum	0	0	90.25	108.3	0	0	18.05	0	27.08
Zirfaea pilsbryi	0	0	0	144.4	18.05	0	0	0	20.31
Phoronida									
Phoronopsis harmeri	18.05	0	685.9	848.35	0	0	180.5	0	216.60
Bryozoa									
Anascina A	0	0	+	+	+	+	+	+	0.00
Anascina B	0	0	+	+	0	+	+	0	0.00
Anascina C	0	0	+		0	+	0	0	0.00
Ascophora A	0	0	+	+	0	+	0	0	0.00
Chordata									
Ascidiacea									
Molgula manhattensis	0	0	18.05	0	0	0	18.05	0	4.51
Total Number of Individuals	**5433.1**	**6227.3**	**2689.5**	**4747.2**	**3537.8**	**2563.1**	**5252.6**	**4855.5**	**4413.2**
Number of Taxa[2]	**15**	**16**	**31**	**34**	**26**	**24**	**31**	**14**	**23.88**

Note [1] Too small to id to species, without characteristics necessary for identification, or in very poor shape
Note[2] Entries with family categories or spp. categories were included only if no other entry existed for those taxa;

"+" = Taxon present but not enumerated.

Species in **bold text** are non-native, introduced taxa.

Table 3-2 Sediment grain size compositions for VMT benthic samples.

Grain Size Analysis	Cluster 1		Cluster 2					Cluster 3	Mean
	VMT B-1	VMT B-2	VMT B-3	VMT B-4	VMT B-5	VMT B-6	VMT B-8	VMT B-7	
Clay (%)	38.50	42.26	21.64	18.67	57.03	3.67	39.64	62.53	35.49
Silt (%)	52.39	57.99	18.97	38.60	40.87	4.59	34.58	37.64	35.70
Sand, Fine (%)	7.58	4.09	9.65	16.31	0.53	1.41	2.30	0.30	5.27
Sand, Medium (%)	0.710	0.70	7.93	10.14	0.26	1.34	0.85	0.45	2.80
Sand, Coarse (%)	1.200	1.09	18.63	14.76	0.21	27.35	6.45	1.34	8.88
Gravel, Fine (%)	0.000	0.00	11.02	1.15	0.12	17.62	5.68	0.94	4.57
Gravel, Medium (%)	0.00	0.00	9.01	0.00	0.00	46.12	7.98	0.00	7.89
TOC (%)	1.72	1.56	2.09	1.680	1.800	0.90	1.71	1.72	1.65
Depth (m)	2.0	2.4	3.8	5.5	12.5	10.9	11.8	13.0	7.74

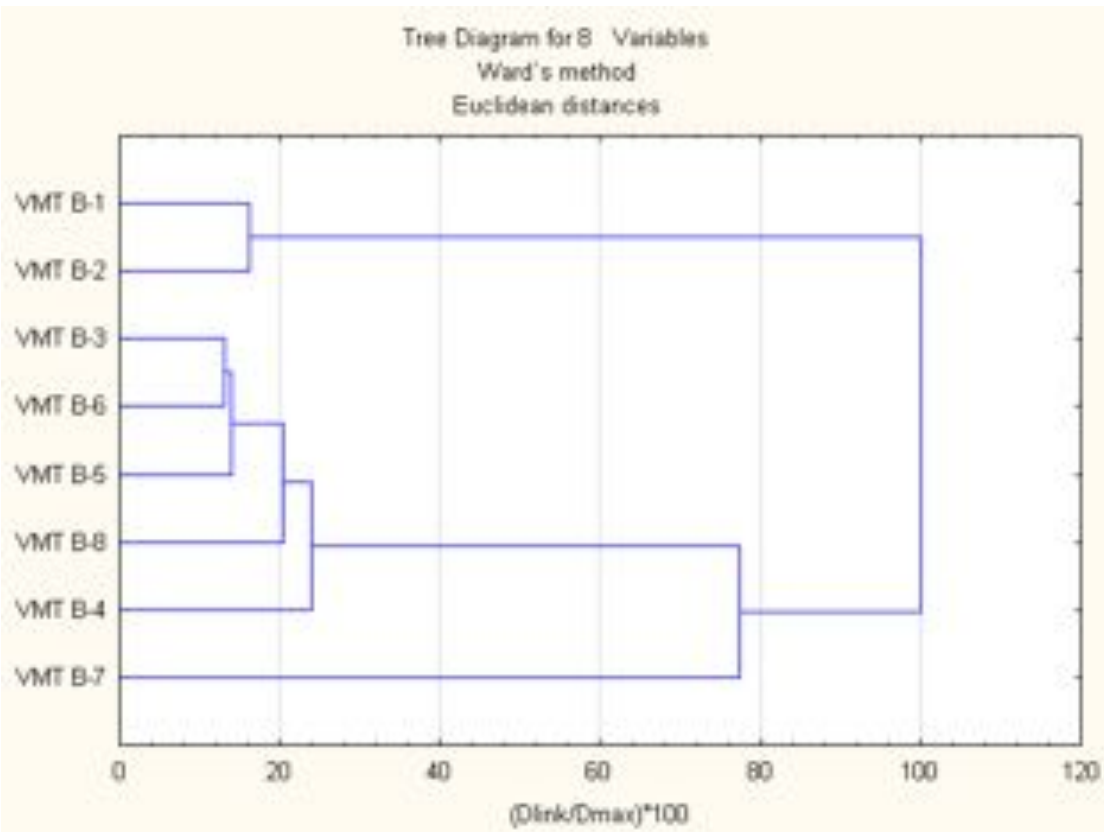


Figure 3-1. Clustering dendrogram based upon the 26 most common, abundant, or key taxa present at eight Vallejo Marine Terminal sample sites, sampled on March 27, 2014.

Cluster 1 includes sites VMT B-1 and VMT B-2, which are the two shallowest water sites, located closest to shore, (Table 3-2) and within the tidal mudflat area of the Study Site. The sediments at these two sites were predominantly silt with a high percentage of clay. The infaunal community at these two sites was dominated by the amphipods *Ampelisca abdita, Grandidierella japonica,* the cumacean *Nippoleucon himunensis,* the polychaete *Streblospio benedicti,* the oligochaete, tubificidae unidentified, and the bivalve clam *Potamocorbula amurensis*.

As discussed above, Cluster 2 represented the most diverse and abundant infaunal community when compared to Clusters 1 and 3. The sediment composition of the sites clustered in Cluster 2 (VMT B-3, VMT B-4, VMT B-5, VMT B-6, and VMT B-8) represent a diverse set of benthic microhabitats with sediments containing varying mixtures of silt, clay, sand, and gravel. Site VMT B-6 was composed primarily of gravel and sand, whereas the sediment at site VMT B-3 was pretty evenly composed of equal fractions of sand, gravel, clay and silts. Sites VMT B-5 and VMT B-8 were predominantly composed of silty clays, whereas site VMT B-4 was predominantly composed of silt with equal fractions of coarse sand, fine sand, and clay (Table 3-2).

As a result of the diversity in sediment composition among the five sites in Cluster 2, the infaunal community was equally diverse and abundant, with the sites being dominated by the polychaetes *Polydora cornuta*, *Capitella capitata* (complex), and *Streblospio benedicti*, the nudibranch *Okenia plana*, the amphipods *Incisorophium derzhavini*, *Monocorophium acherusicum*, *Corophium heteroceratum*, *C. alienense*, *C.* unidentified, *Ampelisca abdita,* and *Grandidierella japonica*, the horseshoe worm *Phoronopsis harmeri*, annelid tubificidae worms, the Asian clam *Potamocorbula amurensis,* and the barnacles *Amphibalanus improvisus , Balanus crenatus* and *Balanomorpha* unidentified (Table 3-1, Figure 3-2). The barnacles were observed attached to large gravel and pebbles located on the surface of the sites, suggesting the presence of high currents at some of these sites.

Cluster 3 contains one sample site, VMT B-7, which represents the deepest station (13.0 meters) and the site with the highest clay composition with a high silt secondary component (Table 3-2). The infaunal community at site VMT B-7 was overwhelmingly dominated by the bivalve clam *Corubula amuensis*, with the polychaete *Polydora cornuta* and the nudibranch *Okenia plana*, being the next two most abundant taxa (Figure 3-3). As with Cluster 2, small pebbles and rocks on the seafloor surface were covered with several species of barnacles (*Balanus crenatus* and *Amphibalanus improvisus*), which were the next most abundant taxa enumerated from this site (Table 3-1).

The total number of individuals per square meter of seafloor was slightly higher for the sample sites in Cluster 1 than for those in either Clusters 2 or 3 (Table 3-3). Cluster 2 showed the most variability in total number of individuals per square meter of seafloor, which is consistent with the highly variable physical conditions present at these station locations (Table 3-3).

An analysis of variance (ANOVA) comparing the number of individuals (density) of the twenty-six most abundant or common taxa among the three clusters indicated that the polychaetes *Glycinde picta* ($p<0.0001$) and *Pseudopolydora kempi.* ($p<0.006$), the clam *Potamocorbula amurensis* ($p =0.00$), the amphipod *Ampelisca abdita* ($p=0.00$) and the cumacean *Nippoleucon himunensis* ($p=0.00$) all differed significantly among clusters (0.05 significance level), but that the other twenty-one taxa were not (Table 3-4). A similar ANOVA conducted to assess differences in sediment grain size composition, TOC and total solids between the three clusters (Table 3-5), indicated that there did not appear to be any significant differences among the three clusters in physical conditions.

Table 3-3. Values for species abundance compared with % TOC and water depth.

Sample Station Number	Cluster	Number of taxa	Total Number of Organisms/m^2	Sediment Characterization	TOC %	Water Depth (m)
VMT B-1	1	15	5433.1	Clayey silt	1.72	2.0
VMT B-2		16	6227.3	Clayey silt	1.56	2.4
VMT B-3	2	31	2689.5	Gravelly mud	2.09	3.8
VMT B-4		34	4747.2	Sandy mud with some gravel	1.68	5.5
VMT B-5		26	3537.8	Silty clay	1.8	12.5
VMT B-6		24	2563.1	Muddy gravel	0.9	10.9
VMT B-8		31	5252.6	Gravelly mud	1.71	11.8
VMT B-7	3	14	4855.5	Silty clay	1.72	13.0

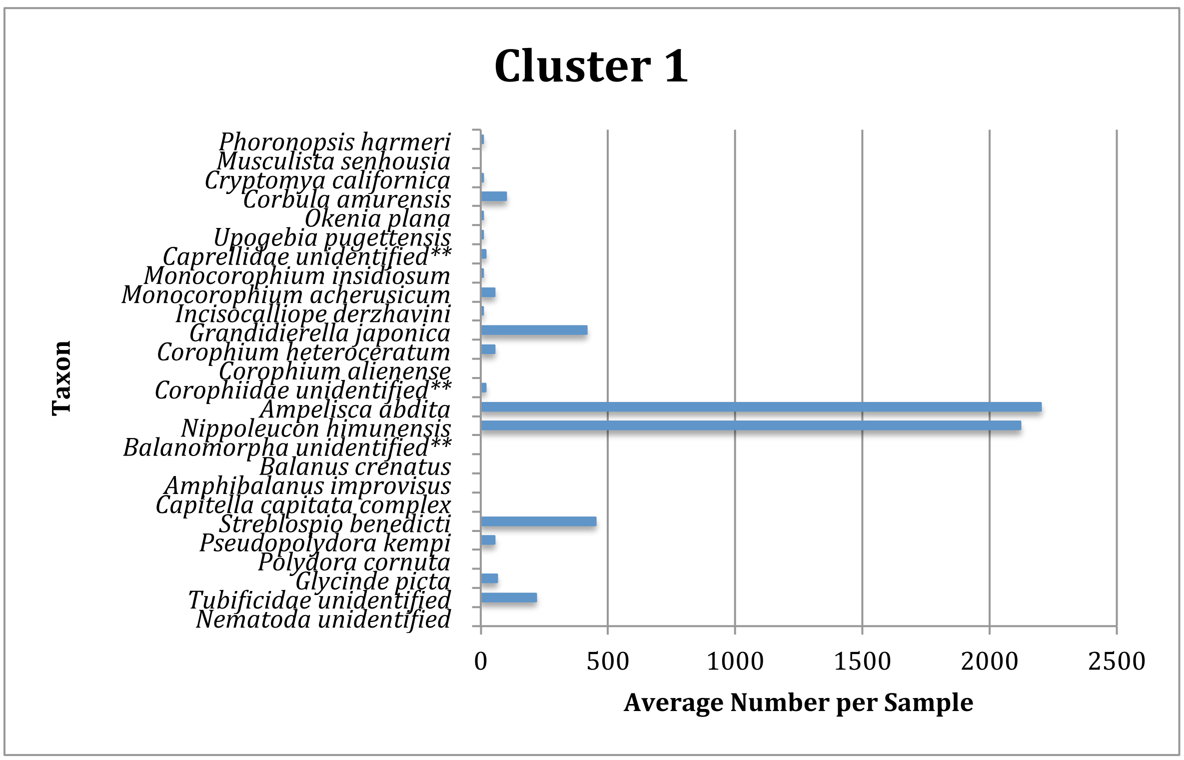


Figure 3-2. Cluster 1 and the 26 most abundant taxa.

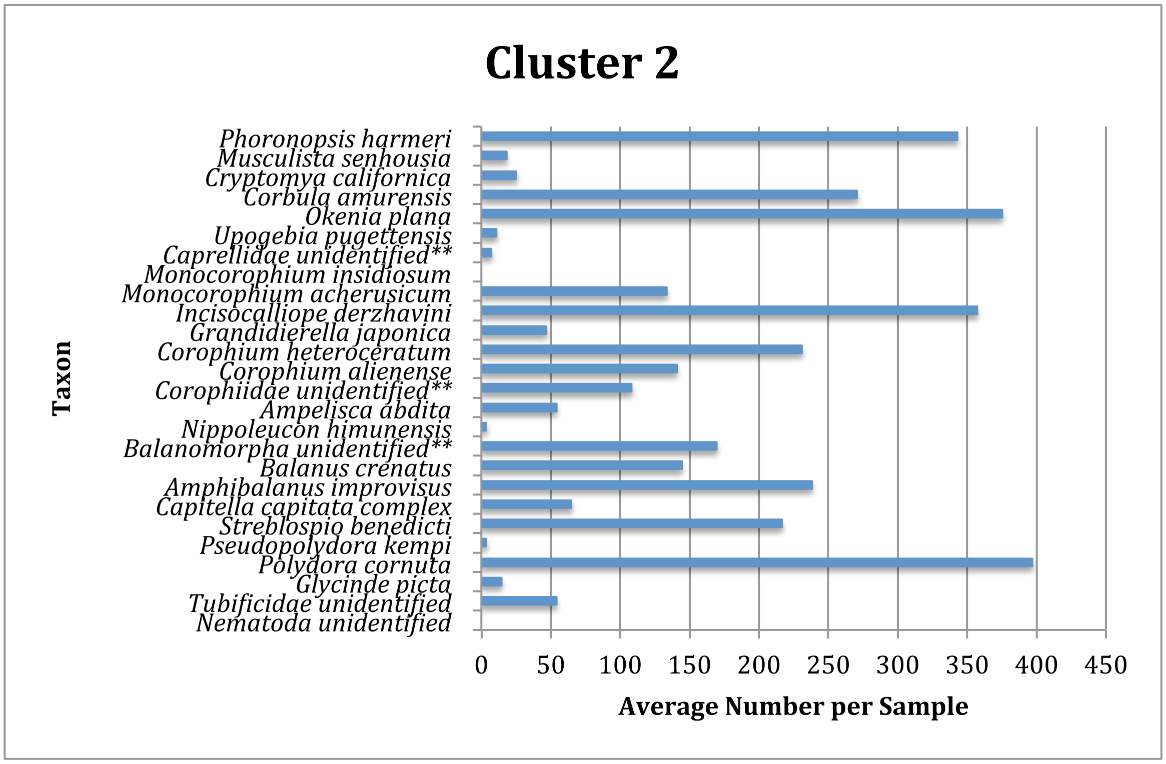


Figure 3-3. Cluster 2 and the 26 most abundant taxa.

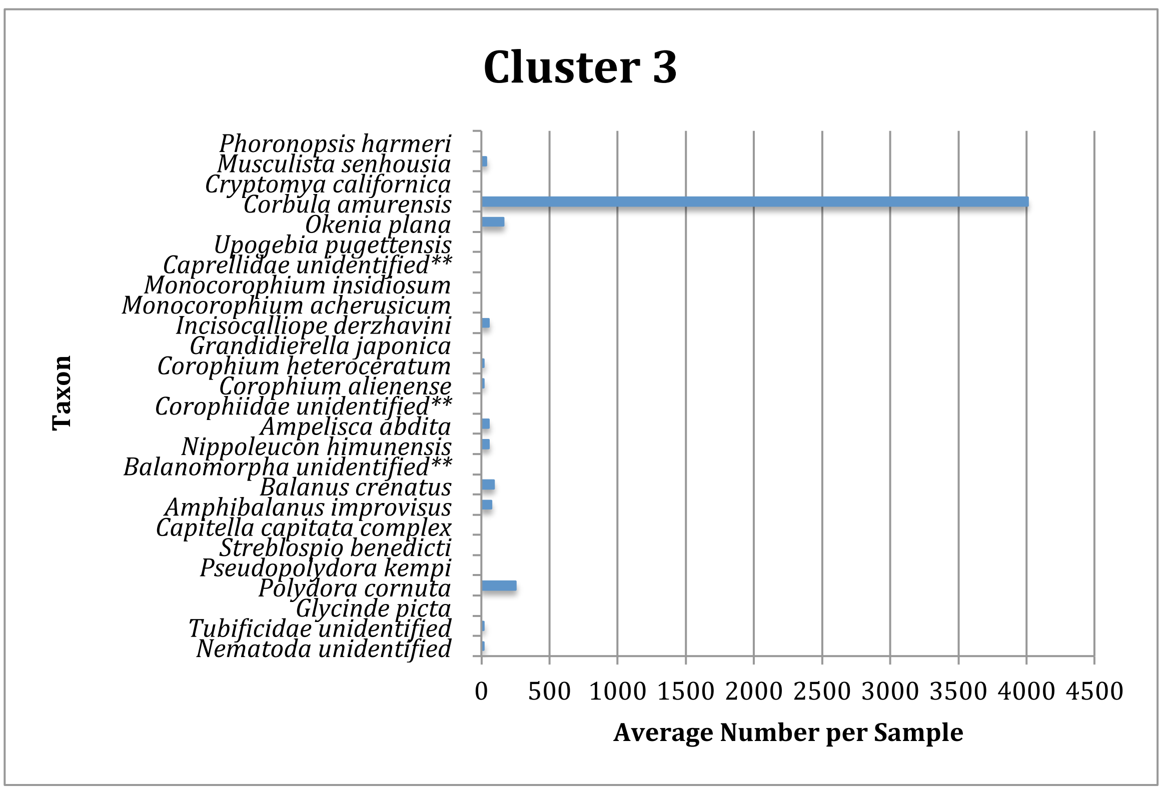


Figure 3-4. Cluster 3 and the 26 most abundant taxa.

Stepwise linear regressions revealed that taxonomic abundances for some of the twenty-six most abundant or key benthic species or taxonomic groups observed in the nearshore region of the Vallejo Marine Terminal site were strongly associated with physical parameters (Table 3-6).

Table 3-4. ANOVA results for differences in the density of the twenty-six most abundant or key taxa among the three clusters.

Species	F value	P value
Ampelisca abdita	**137.49**	**0.000**
Amphibalanus improvisus	2.92	0.145
Balanomorpha unidentified[2]	1.91	0.377
Balanus crenatus	0.684	0.546
Capitella capitata complex	0.431	0.672
Caprellidae unidentified[2]	1.869	0.248
Potamocorbula amurensis	**373.2**	**0.000**
Corophiidae unidentified[2]	0.262	0.779
Corophium alienense	0.415	0.681
Corophium heteroceratum	1.311	0.349
Cryptomya californica	4.188	0.085
Glycinde picta	**90.84**	**0.000**
Grandidierella japonica	2.648	0.164
Incisocalliope derzhavini	2.609	0.167
Monocorophium acherusicum	1.543	0.301
Monocorophium insidiosum	1.854	0.25
Musculista senhousia[1]	-	-
Nematoda unidentified[1]	-	-
Nippoleucon himunensis	**50.787**	**0.000**
Okenia plana	1.879	0.246
Phoronopsis harmeri	0.869	0.474
Polydora cornuta	0.668	0.553
Pseudopolydora kempi	**16.817**	**0.006**
Streblospio benedicti	0.695	0.542
Tubificidae unidentified	4.818	0.068
Upogebia pugettensis	1.854	0.25

Note [1] Only present in Cluster 3 (n = 1)
Note [2] Too small to identify to species, without characteristics necessary for identification, or in very poor condition

The amphipods *Ampelisca abdita*, *Grandidierella japonica*, *Monocorophium insidiosum*, caprellids, (Caprellidae unident.), the cumacean *Nippoleucon himunensis*, the polychaete *Pseudopolydora kempi*, and Tubificidae oligochaete worms were all positively correlated with silt and fine or medium gravel, suggesting that the physical stability added by a gravel covering over relatively unstable and easily mobilized silty sediment in an environment with potentially high currents is key to their abundance.

Similarly, the abundance of the nudibranch *Okenia plana* was positively correlated with the presence of fine gravel (partial correlation = 0.9998), fine sand (partial correlation = 0.9995), silt (partial correlation = 0.9996), depth (partial correlation = 0.9998), and negatively correlated to coarse sand (partial correlation = -0.9983), suggesting some similar stability relationship and the presence of foraging habitat. Similarly, the abundance of the polychaete *Glycinde picta* was positively correlated with the presence of fine sand (partial correlation = 0.9997) and to a lesser degree medium gravel (partial correlation = 0.4953) as well as being negatively correlated to medium sand and depth (partial correlations = 0.9999, suggesting that this polychaete prefers fine sand but avoids medium sand and prefers slightly deeper water depths (Figures 3-1, 3-2, and 3-3). Abundance of the amphipod *Incisocalliope derzhavini* was positively correlated with fine sand (partial correlation = 0.8938) and depth (partial correlation = 0.8522). Abundances of the mollusk *Potamocorbula amurensis* exhibited positive correlation to clay presence (partial correlation = 0.7595) and coarse sand (partial correlation = 0.6743) whereas abundance of the mollusk *Cryptomya californica* exhibited a partial correlation to fine sand (partial correlation = 0.8789) and a negative correlation to medium sand (partial correlation = -0.8849). Finally, it is not surprising that the abundance of unidentified barnacles (Balanomorpha unidentified) was positively correlated (partial correlation = 0.9745) with medium gravel and the barnacle *Amphibalanus improvisus* was negatively correlated with silt (partial correlation = -0.7870). Likewise the abundance of the horseshoe worm *Phoronopsis harmeri,* a suspension feeding tubeworm, was positively correlated to medium sand (partial correlation = 0.9830).

Table 3-5. ANOVA results for differences in the physical parameters (grain size, depth, TOC%) among clusters.

Sediment Composition Fraction	F value	P value
Clay (%)	1.543	0.301
Gravel, Fine (%)	0.996	0.433
Gravel, Medium (%)	0.537	0.615
Sand, Coarse (%)	1.485	0.312
Sand, Fine (%)	0.373	0.706
Sand, Medium (%)	0.572	0.597
Silt (%)	2.705	0.16
Total Organic Carbon (%)	0.218	0.811
Total Solids (%)	1.395	0.33

3.1.2 Comparison with other Benthic Studies

A literature review of available information on benthic infaunal communities near the Vallejo Marine Terminal site at the mouth of the Napa River revealed limited information. The best current source for a description of infaunal communities inhabiting the San Francisco Bay-Delta, including San Pablo Bay, is a report prepared by NOAA on the subtidal habitats and associated biological taxa in San Francisco Bay (NOAA 2007). This report describes habitat types according to salinity regimes including brackish water mesohaline environments, with salinities in the 5.0-18.0 ppt range and polyhaline environments, with salinities in the 18.0-30.0 ppt range, which characterizes the lower Napa River. This report bases its characterizations on multiple long-term monitoring programs and their data sets, including both the Regional Monitoring Program for San Francisco Bay and Delta as well as the Regional Effects Monitoring Program (REM), although none of the studies included sites in the current study area.

Table 3-6. Results of stepwise linear regression analysis to determine which physical factors had significant effects on taxa abundances.

Taxa	1st Most Important Variable		2nd Most Important Variable	
	Name	Partial Correlation	Name	Partial Correlation
Ampelisca abdita	Silt	0.9401	Gravel, Fine	0.8978
Amphibalanus improvisus	Silt	-0.7870		
Balanomorpha unidentified[1]	Medium Gravel	0.9745		
Balanus crenatus	Depth (m)	0.6780		
	-[1]	-	-	-
Caprellidae unidentified[1]	-	-	-	-
Potamocorbula amurensis	-	-	Sand, Coarse	0.6708
Corophiidae unidentified[2]	-	-	-	-
Corophium alienense	-	-	-	-
Corophium heteroceratum	-	-	-	-
Cryptomya californica	Sand, Medium	-0.8849	Sand, Fine	0.8789
Glycinde picta	Fine & Medium Sand, Depth	(+/-) 0.999	-	-
Grandidierella japonica	-	-	-	-
Incisocalliope derzhavini	Sand, Fine	0.8938	Depth (m)	0.8522
Monocorophium acherusicum	-	-	-	-
Monocorophium insidiosum	-	-	-	-
Musculista senhousia	-	-	-	-
Nematoda unidentified	-	-	-	-
Nippoleucon himunensis	Silt	0.9346	Gravel, Fine	0.8926
Okenia plana	Gravel, Fine	0.9998		
	Fine Gravel, Fine and Coarse Sand, Silt, Depth	(+/-) 0.999		
Phoronopsis harmeri	Sand, Medium	0.9830		
Polydora cornuta	-	-	-	-
Pseudopolydora kempi	Silt	0.9387	Gravel, Fine	0.9012
Streblospio benedicti	-	-	-	-
Tubificidae unidentified	Silt	0.9675	Gravel, Fine	0.9564
Upogebia pugettensis	-	-	-	-

Note [1] - indicates that no significant correlation was determined by the stepwise linear regression for any of the physical factors tested for that taxon.

Note[2] Too small to identify to species, without characteristics necessary for identification, or in very poor condition

The benthic sediment habitat types described for mesohaline environments include deep channels, shallow slough channels, channel edge, and shallow subtidal communities. For Polyhaline environments, only deep channel and shallow subtidal habitat types are present in the Bay-Delta according to NOAA (2007). The mesohaline shallow subtidal, and channel edge habitat conditions were present at the VMT survey site as were the polyhaline deep channel and shallow subtidal. Table 3-7 lists the taxa that are characteristic of each of the three mesohaline and two polyhaline infaunal community types as well as whether those taxa are present at the VMT site. In total, NOAA identified 14 of the 16 most dominant taxa observed at the VMT site as characteristic taxa that commonly occur in the two-polyhaline and three mesohaline infaunal communities. Four of the 7-mesohaline channel edge community taxa were observed at the VMT site.

Finally, a recent evaluation using best professional judgment to assess aquatic environmental condition, as employed by recognized benthic biologists in California (Weisberg et al., 2008), suggested the use of species that were either sensitive or tolerant to degraded benthic habitats. The evaluation was based on examination of datasets representing a range of organic enrichment, chemical contaminants and physical disturbances, and may be applicable to the general condition of benthic habitats adjacent to the VMT site.

Among the taxa found in the current study, the authors placed high value on *Capitella capitata*, oligochaetes, the polychaetes *Streblospio benedicti* and *Pseudopolydora spp.,* and the amphipods *Grandiderella japonica, and Monocorophium spp.* as taxa that were tolerant of degraded habitats, and amphipods, especially *Ampelisca abdita* and Corophiidae amphipods), mollusks, nemerteans (ribbon worms), cnidarians (anemones and corals), opisthobranches (sea slugs and nudibranchs), and sipunculids (sea squirts), and crustaceans (shrimp, crabs, lobsters) as taxa that were sensitive to degraded habitats (Table 3-8) (Weisberg *et al*. 2008).

When these taxa and groups are totaled for the current study, sensitive taxa (average of 13% of total organisms per site) were found in lower densities than tolerant taxa (average of 62% of total organisms per site) (Table 3-8). Sensitive taxa ranged from 0.4-28 % of total organisms and averaged 649.8/m^2 over all sites. Tolerant taxa ranged from 43-90 % of total organisms and averaged 2689.5/m^2. The very low occurrence (average of 13% of total organism per site) of sensitive taxa and the very high occurrence of tolerant organisms (average of 62% of total organism per site) suggests that the benthic habitats at the proposed Vallejo Marine Terminal site do not appear to be environmentally degraded.

3.2 Sediment Contaminants

Sediment samples were analyzed for metals, butyltins (TBTs), organochlorine (OC) and organophosphate (OP) pesticides and polynuclear aromatic hydrocarbons (PAH). Analytical results are provided in Table 3-10. Individual DDT, BHC and chlordane analyte results were summed for each sample site to generate total DDT, total BHC, and total chlordane. This was done in order to obtain values comparable to concentrations reported from other studies in the San Francisco Bay-Delta. In calculating these totals, all non-detect results, or results below the method detection limit (MDL), were included at one half of the MDL for each respective analyte.

Non-detect results for butlytins, and non-summed OC and OP pesticides are listed in Table 3-10 as less than the MDL, for each analyte.

3.2.1 Metals

All of the metals were detected at concentrations greater than the analytical method detection limits and at concentrations that are consistent and comparable with reported concentrations for San Pablo Bay (Table 3-10). Although some metal concentrations were observed above reported ambient concentrations, such

Table 3-7. Taxa found in the current study and NOAA (2007) in polyhaline and mesohaline environments.

Taxon	Taxonomic Group	Feeding Mode	Current Study[1]	NOAA 2007		
				Shallow Subtidal	Channels	Channel Edge
Grandidierella japonica	Amphipod	Filter & deposit feeder	**X**			M
Corophium acherusicum	Amphipod	Filter & deposit feeder	**X**		P	
Corophium heteroceratum	Amphipod	Filter & deposit feeder	**X**	P	P	
Corophium alienense	Amphipod	Filter & deposit feeder	**X**	M		
Monocorophium acherusicum	Amphipod	Filter & deposit feeder	**X**	P		
Ampelisca abdita	Amphipod	Filter feeder	**X**	P	P	M
Americorophium stimpsoni	Amphipod	Filter & deposit feeder		M		
Gammarus daiberi	Amphipod	Deposit & scraper		M		
Molgula manhattensis	Ascidian	Filter feeder			P	
Potamocorbula amurensis	Bivalve	Filter feeder	**X**	M, P	M, P	M
Corbicula fluminea	Bivalve	Filter & deposit feeder			M	
Gemma gemma	Bivalve	Filter & deposit feeder	X	P		
Theora lubrica	Bivalve	Surface deposit feeder			P	
Macoma petalum	Bivalve	Filter & deposit feeder		P	P	
Musculista senhousia	Bivalve	Filter feeder	X	P	P	
Mya arenaria	Bivalve	Filter feeder	X	P	P	
Venerupsis philippinarum	Bivalve	Filter feeder		P	P	
Theora lubrica	Bivalve	Surface deposit			P	
Anguinella palmata	Bryozoa	Filter feeder		P		
Sakuraeolis enosimensis	Gastropod	Carnivore-hydroids		P		
Ilyanassa obsoleta	Gastropod	Algae-scraper		P		
Pyromaia tuberculata	Decapod	Detritus & carnivore		P		
Sabaco elongatus	Polychaete	Subsurface deposit		P	P	
Heteromastus filiformis	Polychaete	Subsurface deposit		P	M, P	M
Euchone limnicola	Polychaete	Filter feeder		P		
Streblospio benedicti	Polychaete	Surface deposit	**X**		P	
Cirriformia spirabrancha	Polychaete	Surface deposit			P	
Exogone lourei	Polychaete	Carnivore			P	
Glycera armigera	Polychaete	Carnivore			P	
Marenzellaria viridis	Polychaete	Surface deposit		M	M, P	M
Neanthes succinea	Polychaete	Surface deposit & scavenger	X		P	
Polydora cornuta	Polychaete	Filter & deposit feeder	**X**		P	
Tubificidae - unidentified *(Tubificoides spp.)*	Oligochaete	Surface deposit	**X**		P	
Limnodrilus hoffmeisteri	Oligochaete	Surface & deposit feeder		M		
Nippoleucon hinumensis	Cumacean	Surface deposit	**X**	M, P	M, P	M
Pyromaia tuberculata	Decapod	Detritus & carnivore		P	P	
Synidotea laevidorsalis	Isopod	Carnivore				M

Note[1]: X=Observed; **X**= Dominant Taxa, M = Mesohaline; P= Polyhaline as copper and zinc at sites VMT-C-A, VMT-C-B and VMT-C-C, chromium and nickel at VMT-C-B, and arsenic at VMT-C-C, all of the reported concentrations are only slightly elevated or within the same order of magnitude as reported ambient concentrations for those metals in San Pablo Bay.

Table 3-8. Comparison of benthic taxa observed in the current study with potential indicator species of physically disturbed or chemical contaminated benthic habitat as identified in Weisberg et al. (2008).

Indicator Taxon		Importance[1]	Current Study[2]
Tolerant Taxa	*Capitella capitata* complex	1.0	X
	Oligochaeta	1.3	X
	Streblospio benedicti	2.0	X
	Dorvillea (Schistomeringos) spp.	2.2	
	Mediomastus spp.	2.3	
	Armandia brevis	2.6	
	Pseudopolydora spp.	3.0	X
	Exogone spp.	3.0	
	Grandiderella japonica	3.0	X
	Euphilomedes spp.	3.1	
	Monocorophium spp.	3.1	X
	Neanthes acuminata complex	3.2	
	Musculista senhousia	3.2	
	Notomastus spp.	3.4	
	Ophiura spp.	4.7	
Sensitive Taxa	Ophiuroidea	1.4	
	Amphipoda	1.8	X
	Gammaridea (most species)	1.9	
	Mollusca	2.2	X
	Ampelisca abdita	2.7	X
	Nemertea, Cnidaria, opistobranchia, and Sipuncula	3.0	X
	Corophiidae	3.2	X
	Spiophanes duplex and *S. berkeleyorum*	3.2	
	Crustacea	3.7	X
	Amphiuridae (long-arm brittle stars)	4.1	

Note[1]: Importance is the average importance for all experts, where: 1,very important; 2, important, but secondary; 3, marginally important; 4, useful, but only to interpret the other factors; 5, not used. N is the number of experts that identified the taxon as an indicator.

Note[2]: X=Observed;

3.2.2 Organochlorine (OC) and Organophosphate (OP) Pesticides

All of the OC and OP Pesticides concentrations were either non-detect or below ambient recorded concentrations (Table 3-10). Total PAHs, total BHCs and total DDT were all substantially below ambient reported concentrations for San Pablo Bay. The apparent high total chlordane concentration, relative to reported ambient chlordane concentrations, is an artifact of the methodology used to estimate the total concentration from individual chlordane analytes. All of the individual chlordane analytes were reported to be below method detection limits and therefore the nearshore sediments at the VMT project site do not contain any significant concentrations of chlordane.

Table 3-9. The numbers and percentages of organisms per sample from the Vallejo Marine Terminal sites judged to be sensitive or tolerant of degraded benthic habitat by Weisberg et al. (2007).

	Cluster 1		Cluster 2					Cluster 3	Average
	VMT B-1	VMT B-2	VMT B-3	VMT B-4	VMT B-5	VMT B-6	VMT B-8	VMT B-7	
# Tolerant Organisms (per m^{2})	649.8	1750.9	306.9	523.5	433.2	108.3	1407.9	18.1	649.8
# Sensitive Organisms (per m^{2})	2310	3483.7	1769	3122.7	2581.2	1444	2454.8	4350.1	2689.5
% Tolerant Organisms	12%	28%	11%	11%	12%	4%	27%	0.4%	13%
% Sensitive Organisms	43%	56%	66%	66%	73%	56%	47%	90%	62%

3.2.3 Tributyltins (TBTs)

TBT concentrations in collected sediments at the four VMT sediment sample sites were reported at either very low levels or below method detection limits. Although TBT concentrations in water, sediments, and biota have been a concern for decades, little information is known about ambient concentrations in sediments in San Francisco Bay. Available published TBT data for California coastal and Delta waters and Ontario Canada indicate the TBT concentrations observed at the VMT study site are very low. Data collected at Mare Island by the USGS (Pereira et. al, 1999) reported total tributyltin concentrations ranging between 1.8 and 8.1 ng/g for the Napa River and the Carquinez Straight, which are consistent with the observed concentrations at the VMT site.

3.2.4 Polynuclear Aromatic Hydrocarbons (PAHs)

All PAH concentrations in sediments were reported above method detection limits but below ambient recorded concentrations at all sites (Table 3-10). It is noteworthy that the concentrations of fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, perylene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene appeared to be slightly elevated at site VMT-C-C relative to the other three sediment chemistry sampling locations. The increased TOC concentrations present at the VMT-C-C site (as reported for the immediately adjacent VMT-B-3 location) would account for these reported differences in the four sites.

Table 3-10. Analytical results for metals, butyltins, organochlorine and organophosphate pesticides, and polynuclear aromatic hydrocarbons in marine sediment samples collected at the Vallejo Marine Terminal.

	VMT-C-A	VMT-C-B	VMT-C-C	VMT-C-D	RWQCB/SFBR[1]		SFEI Data[2]	
					<40% fines	<100% fines	Mean	Median
Metals (mg/kg dry weight)								
Antimony	0.34	0.38	0.39	0.19	ND	ND	ND	ND
Arsenic	15.70	15.70	29.30	13.30	13.50	15.30	11.22	10.90
Cadmium	0.52	0.46	0.58	0.22	0.25	0.33	0.23	0.21
Chromium	110.00	121.00	107.00	80.80	91.40	112.00	95.20	92.12
Copper	74.20	82.40	83.30	46.60	31.70	68.10	45.06	48.33
Lead	38.50	30.50	37.00	18.10	20.30	43.20	19.38	19.42
Mercury	0.49	0.36	0.81	0.29	0.25	0.43	0.26	0.27
Nickel	102.00	121.00	93.80	74.60	92.90	112.00	56.01	84.62
Silver	0.44	0.41	0.26	0.20	0.31	0.58	0.19	0.18
Zinc	177.00	182.00	187.00	110.00	97.80	158.00	110.68	111.82
Organochlorine and Organophosphate Pesticides (µg/kg dry weight)								
Hexachlorobenzene	0.10	0.11	0.11	0.10	ND	ND	0.15	0.10
Aldrin	<0.06	<0.07	<0.07	<0.06	ND	ND	0.04	0.00
Endosulfan I	<0.07	<0.07	<0.07	<0.07	ND	ND	0.05	0.01
Dieldrin	<0.091	<0.1	<0.18	<0.11	0.18	0.44	0.11	0.08
Endrin	<0.06	<0.07	<0.07	<0.06	ND	ND	0.04	0.01
Endosulfan II	<0.1	<0.11	<0.11	<0.16	ND	ND	ND	ND
Endosulfan Sulfate	<0.06	<0.06	<0.06	<0.12	ND	ND	ND	ND
Chlorpyrifos	0.37	0.39	0.39	0.37	ND	ND	ND	ND
Mirex	<0.69	<0.75	0.37	0.35	ND	ND	0.08	0.00
Total DDT	3.83	2.10	2.96	2.50	2.80	7.00	3.29	2.80
Total BHC	0.21	0.22	0.22	0.38	0.19	0.48	ND	ND
Total Chlordane	4.87[3]	3.16[3]	3.03[3]	2.88[3]	0.42	1.10	0.26	0.18
Total PCB	12.16	4.63	1.71	4.64	8.60	21.60	5.14	5.40
Polynuclear Aromatic Hydrocarbons (µg/kg dry weight)								
Naphthalene	4.80	5.80	17.00	9.20	8.80	55.80	21.87	20.40
2-Methylnaphthalene	3.60	4.60	4.70	4.80	9.40	19.40	9.31	9.38
1-Methylnaphthalene	2.00	2.60	2.80	3.60	6.80	12.10	5.77	5.97
Biphenyl	1.90	2.30	5.00	2.90	6.50	12.90	5.20	5.21

	VMT-C-A	VMT-C-B	VMT-C-C	VMT-C-D	RWQCB/SFBR[1]		SFEI Data[2]	
					<40% fines	<100% fines	Mean	Median
2,6-Dimethylnaphthalene	3.00	3.30	5.00	4.20	5.00	12.10	5.44	5.55
Acenaphthylene	2.10	1.80	10.00	7.20	2.20	31.70	7.95	5.07
Acenaphthene	1.60	2.10	3.80	3.20	11.30	26.60	5.45	3.63
2,3,5-Trimethylnaphthalene	1.70	2.50	3.80	2.70	3.30	9.80	4.65	3.59
Fluorene	3.10	5.20	7.20	6.40	4.00	25.30	8.32	7.37
Dibenzothiophene	1.70	2.00	5.10	3.20	ND	ND	5.01	3.93
Phenanthrene	14.00	16.00	57.00	37.00	17.80	237.00	57.82	46.10
Anthracene	5.10	4.10	16.00	16.00	9.30	88.00	17.85	12.65
1-Methylphenanthrene	2.50	3.30	7.10	6.40	4.50	31.70	9.22	6.91
Fluoranthene	38.00	36.00	190.00	87.00	78.70	514.00	144.71	110.00
Pyrene	57.00	49.00	300.00	120.00	64.60	665.00	194.27	151.00
Benz(a)anthracene	18.00	16.00	73.00	49.00	15.90	244.00	57.24	44.30
Chrysene	33.00	21.00	96.00	67.00	19.40	289.00	68.05	54.30
Benzo(b)fluoranthene	42.00	31.00	140.00	84.00	32.10	371.00	96.79	62.45
Benzo(k)fluoranthene	14.00	11.00	46.00	30.00	29.20	258.00	49.45	37.40
Benzo(e)pyrene	32.00	24.00	130.00	62.00	17.30	294.00	80.92	56.95
Benzo(a)pyrene	39.00	32.00	160.00	84.00	18.10	412.00	105.85	75.70
Perylene	40.00	110.00	97.00	44.00	24.00	145.00	90.66	74.70
Indeno(1,2,3-cd)pyrene	36.00	29.00	180.00	68.00	19.00	382.00	93.39	60.95
Dibenz(a,h)anthracene	4.70	4.20	16.00	10.00	3.00	32.70	12.11	8.18
Benzo(g,h,i)perylene	45.00	37.00	220.00	80.00	22.90	310.00	112.78	77.10
Butyltins (µg/kg dry weight)					**Calif. Coastal and Delta Waters[4]**		**Ontario Canada[4]**	
Tetra-n-butyltin	<0.97	<1.1	<1.1	<0.97	ND		ND	
Tri-n-butyltin Cation	6.90	1.20	<1	0.97	0.23-23		30-540	
Di-n-butyltin Cation	7.60	2.10	<0.44	0.80	0.26-27		9-350	
n-Butyltin Cation	3.60	0.72	<0.6	1.30	0.36-60		14-580	

ND= No Data

[1]Ambient concentrations of Toxic Chemicals in San Francisco Bay Sediment. Cal/EPA Regional Water Quality Control Board San Francisco Bay. Prepared by Tom Gandesbery, RWQCB-Basin Planning and Policy and Fred Hetzel, PhD, San Francisco Estuary Project. May 1998

[2]San Francisco Estuary Institute CD3 Contaminant Data Display and Download. 1993-2012. http://www.sfei.org/rmp/wqt. Accessed July 25, 2014.

[3]Individual chlordane compounds were reported as below method detection limits. The estimated high total chlordane concentration is an artifact of the method used to calculate the total concentration.

[4] California Department of Water Resources. 1995

4 Discussion

4.1 Physical Environment

The marine benthic environment immediately adjacent to the Vallejo Marine Terminal project site, where proposed reconstruction of the wharf and dock facilities is to occur, is physically composed of soft sediment habitat with varying clay, silt, sand and gravel composition. The area of the VMT study site located along the large embayment to the northeast of the existing wharf (northwest corner of the Project Site) would be characterized as a tidal mudflat and spends part of each day exposed to air and subject to limited current and wave action. This area is composed of clayey silts and is where benthic infauna community cluster 1 was observed. Farther offshore, where proposed dredging is expected to occur to maintain the Phase 1 wharf and support the Phase 2 wharf, bottom sediments appear to become more variable with higher occurrence of sand and gravels being present. The increased sand and gravel composition of seafloor sediments in this area of the project site suggests increased wind and wave energy resulting in a highly variable seafloor composition. This segment of the project site is where the benthic infaunal community cluster 2 was observed. In the deeper waters of the channel itself, bottom sediments appear to consist of silty clays, suggesting some physical disturbance by tidal and river currents. This is area of the project site where infaunal community cluster 3 was observed.

Assessment of potential organic (metals) and inorganic contaminants (PAHs, DDTs, OC and OP pesticides, and butyltins) in surface sediments indicate that overall the in-water portion of the Vallejo Marine Terminal project site does not contain any organic or inorganic contaminant concentrations that are above detection limits or inconsistent with reported ambient sediment concentrations for North San Francisco Bay, which includes San Pablo Bay and the Carquinez Straight. Although some metal (arsenic, chromium, copper, nickel and zinc) concentrations appear to be slightly elevated above reported ambient concentrations for the region, they are all the same order of magnitude and within the error of margin for reported mean ambient concentrations (SFEI, 2014, CDW, 1995, Gandesbery and Hetzel, 1998).

All of the OC and OP pesticides, including DDTs, BHCs, and chlordanes, as well as PCBs, PAHs and butyltins were either below method detection limits or less than reported ambient concentrations for the region. At site VMT-C-C, which consisted of fairly equal fractions of clay, silt and sand, higher concentrations of PAHs (fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, perylene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene) were observed. Although these PAH values are still below reported ambient concentrations, they are high in comparison to the other sites sampled. This increase in relative concentration can be accounted for by the higher TOC concentration in the sediments at this sample location relative to the other four sediment chemistry sample sites.

4.2 Benthic Community

Although located in a fairly small geographic area with depths ranging between 2 and 13 meters (6.7 and 43 feet), the eight benthic infaunal community sites sampled in the marine area of the VMT project site appeared to include three slightly different benthic infaunal communities. The first community was located immediately offshore the northwestern portion of the overall project site, in sediments containing predominantly silts and clays, in water depths less of than 2.4 meters (8 feet). This area of the project site includes a large tidal mud flat. The second community inhabited highly variable seafloor sediments with most sample locations containing sand, clay, silt, and gravel. To illustrate this variability in sediment composition, of the five sites, site VMT B-5 contained very low amounts of sand (<1%), less than 0.1% gravel, and was predominantly composed of clay (57%) and silt (41%), whereas site VMT B-4 also contained < 1% gravel, 41% sand and only 38.6% clay. Finally, site VMT B-6 consisted of 46% gravel, 43% sand and <9% silt and clay.

The second benthic infaunal community inhabited water depths between 3.8 and 12.5 meters (8 and 41 feet). The third community inhabited sediments predominantly composed of clay and silt with limited sand and no gravel. The one site representing this community (VMT B-7) was located in 13 meters (43 feet of water).

The first benthic infaunal community was dominated by the amphipods *Ampelisca abdita, Grandidierella japonica,* the cumacean *Nippoleucon himunensis,* the polychaete *Streblospio benedicti,* the oligochaete, tubificidae unidentified, and the bivalve clam *Potamocorbula amurensis*. *A abdita* and *N. himunensis* numerically dominated the community making up more than 67-82% of the total abundance observed at the two sites. Additionally, the dominant taxa observed in this community were fairly evenly distributed between suspension feeders and surface deposit feeders.

The second benthic community was dominated by the polychaetes *Polydora cornuta*, *Capitella capitata* (complex), and *Streblospio benedicti*, the nudibranch *Okenia plana*, the amphipods *Incisorophium derzhavini*, *Monocorophium acherusicum*, *Corophium heteroceratum*, *C. alienense*, *C*. unidentified, *Ampelisca abdita,* and *Grandidierella japonica*, the horseshoe worm *Phoronopsis harmeri*, annelid tubificidae worms, the Asian clam *Potamocorbula amurensis,* and the barnacles *Amphibalanus improvisus, Balanus crenatus* and Balanomorpha unidentified. The barnacles were observed attached to large gravel and pebbles located on the surface of some sites, suggesting the presence of high bottom currents at some of these sites. This community was the most species diverse community observed of the three identified at the study site. The most dominant seven species in this benthic community included a polychaete (*P. cornuta*), a nudibranch (O. *Plana*), two amphipods (*I. derzhavini* and *C. heteroceratum*), a horseshoe worm (*P. harmeri*), a clam (C. *amurensis*), and a barnacle (*A. improvisus*). Total abundance per meter square of seafloor remained comparable to benthic community 1, above, but divided between more species. Of these seven species, three are filter feeders and four are filter and deposit feeders.

Analysis of the sediment composition and the highly diverse species composition within each sample location suggests that the seafloor occupied by benthic community 2 contains multiple microhabitats, many of which appear subject to high current regimens based on the high concentrations of sand and gravel present.

The third benthic community was represented by one site that was overwhelmingly dominated by the bivalve clam *Corubula amurensis. Potamocorbula* accounted for 83% of the total individual abundance at this site. This benthic community occupied the deepest area of the study site and its sediments were composed of clays and silt with little sand or gravel.

The second infaunal community appears to occupy an area of the VMT project site that experiences a highly variable hydrographic regime resulting in multiple microhabitats with sediments that vary in their composition of silt, clay, sand, and gravel. The dominance of sand and gravel sediments in this area of the VMT project site, which occupies most of the offshore area proposed to be dredged, suggests regular disturbance and resuspension of sediment fines by wave action and tidal currents. The third infaunal community occupies the deepest area surveyed of the VMT offshore project site and is located in the natural river channel that fronts the VMT site. From the dominating percentage of clay and silt sediment observed at this location, this site is located in a low-energy depositional area of the natural river channel.

Consideration of each taxon's potential sensitivity or tolerance to habitat degradation (Weisberg *et al*. 2008), suggests that the infaunal communities occupying the offshore areas of the VMT project site, although subject to some physical disturbance by wave, river, and tidal currents do not appear to be inhabiting overtly physically or chemically stressed habitats. This observation is supported by the low concentrations of tested organic and inorganic contaminants at the project site.

The infaunal taxa inhabiting the Vallejo Marine Terminal project site are similar to infaunal communities observed in other polyhaline environments of San Francisco Bay-Delta as reported by NOAA (2007). Both deep channel and shallow subtidal habitats were present at the VMT survey site and 9 of the 16 most dominant taxa reported occurring at the VMT study site were reported by NOAA as being characteristic taxon for polyhaline soft sediment habitats in the Bay-Delta.

Finally, there are no marine special status or species of special concern in the infaunal community taxa observed at the VMT project site, some of the species, such as the Asian clam, *Potamocorbula amurensis,* assorted amphipods, and some polychaetes are prey items for many demersal fish species, including green sturgeon and are prey for smaller demersal fish that in turn are prey for salmonids.

5 References

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