2018 San Diego Regional Harbor Monitoring Program
Causal Assessment for Impaired Benthic Infaunal Communities - FINAL REPORT







Funded by and Submitted to:

PORT of SAN DIEGO

July 2022

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REGIONAL HARBOR MONITORING PROGRAM

CAUSAL ASSESSMENT FOR IMPAIRED BENTHIC INFAUNAL COMMUNITIES

FINAL REPORT

Prepared for the RHMP Agencies:

Port of San Diego **City of San Diego** **City of Oceanside** **County of Orange**

Submitted by:

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Prepared for:
Port of San Diego
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County of Orange

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

>	greater than
<	less than
≤	less than or equal to
µg/kg	microgram(s) per kilogram
%	percent
ADCP	acoustic doppler current profiler
ANOSIM	analysis of similarity
ANOVA	analysis of variance
Bight	Southern California Bight
Bight Program	Southern California Bight Regional Monitoring Program
BRI	Benthic Response Index
Cal-NEMO	California Non-native Estuarine and Marine Organisms
CA-LRM	California Linear Regression Model
CCS	Chemical Category Sum
CDFW	California Department of Fish and Wildlife
CSI	Chemical Score Index
DDT	dichlorodiphenyltrichloroethane
ERM	effects range median
IBI	Index of Biological Integrity
LOE	line(s) of evidence
mg/kg	milligram(s) per kilogram
MLOE	multiple lines of evidence
NBSD	Naval Base San Diego
nMDS	non-metric multidimensional scaling
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCA	principal components analysis
PCB	polychlorinated biphenyl
PEL	Probable Effects Level
RBI	Relative Benthic Index
RHMP	Regional Harbor Monitoring Program
RIVPACS	River Invertebrate Prediction and Classification System

ACRONYMS AND ABBREVIATIONS (continued)

San Diego Regional Harbors	Dana Point Harbor, Oceanside Harbor, Mission Bay, and San Diego Bay
SCCWRP	Southern California Coastal Water Research Project
SDRWQCB	San Diego Regional Water Quality Control Board
SIMPROF	similarity profile
SIYB	Shelter Island Yacht Basin
SQO	Sediment Quality Objective
TOC	total organic carbon
TWV	taxa weighted value
Wood	Wood Environment & Infrastructure Solutions, Inc.

1.0 INTRODUCTION

The Regional Harbor Monitoring Program (RHMP) was developed by the Port of San Diego, the City of San Diego, the City of Oceanside, and the County of Orange (collectively referred to as the "RHMP Agencies") in response to a July 24, 2003 request by the San Diego Regional Water Quality Control Board (SDRWQCB) under Section 13225 of the California Water Code. The RHMP is a thorough survey of the quality of water, sediments, and aquatic life to determine whether beneficial uses are attained and protected in Dana Point Harbor, Oceanside Harbor, Mission Bay, and San Diego Bay. These water bodies are collectively called the San Diego Regional Harbors. The RHMP is composed of a core monitoring program and supplemental focused special studies. The program was designed to address five major questions posed in the SDRWQCB's request:

1. What are the contributions and spatial distributions of inputs of pollutants to the harbors?
2. Do the waters and sediments in the harbors sustain healthy biota?
3. What are the long-term trends in water and sediment quality in the harbors?
4. Are the waters in the harbors safe for body contact activities?
5. Are fish in the harbors safe to eat?

To answer the core questions, the RHMP uses an iterative approach that has included extensive research of historical information for the four harbors, mapping of the harbors into strata, identification of indicators to be monitored to assess trends, comparison to reference values (i.e., threshold levels), and use of statistical methodologies to evaluate findings in a scientifically rigorous manner that also complements the larger Southern California Bight (Bight) Regional Monitoring Program (Bight Program). The RHMP uses a weight-of-evidence approach to assess the health and overall status of the harbors and compares findings to recent historical conditions to determine whether conditions are improving or deteriorating over time.

Central to both regional programs is the use of the State of California Sediment Quality Objective (SQO) approach which combines three independent lines of evidence (LOE) consisting of chemistry, toxicity, and benthic community conditions. These three lines of evidence are then combined into a final sediment quality score ranging from a "Reference" condition to "Clearly Impacted." An initial pilot monitoring effort was first conducted for RHMP in 2005 and since then the overall program, using consistent sediment quality assessment methods following the SQO approach at a total of 75 locations, has been conducted every 5 years in 2008, 2013, and 2018. The 2018 RHMP report is available at: https://pantheonstorage.blob.core.windows.net/environment/Regional-Harbor-Monitoring-Program-2018-Final-Report.pdf.

Using the SQO approach, sediment quality region-wide during the latest survey in 2018 was considered to be largely protective of healthy biota with 72% of RHMP stations classified as either "Unimpacted" or "Likely Unimpacted" based on all three LOE. Despite this, 31% of RHMP sites had "Moderately Disturbed" benthic communities and 12% of sites had "Highly Disturbed" benthic communities according to the SQO benthic community LOE. A majority of the moderately and highly disturbed benthic communities were located in freshwater-influenced and marina strata,

with 71% and 60% of sites in these strata in either the moderate or high disturbance categories, respectively.

1.1 Special Study Goal

The purpose of this special study evaluation is to provide an in-depth analysis of the likely causes of benthic community scores suggesting impairment at select stations evaluated during the 2018 RHMP monitoring effort. This assessment includes a suite of sites categorized as having "Moderately Disturbed" or "Highly Disturbed" benthic communities.

The benthic community disturbance LOE was a significant driver for final integrated SQO scores during the 2018 RHMP. Benthic infaunal communities are complex and are susceptible to a variety of stressors such as elevated chemistry, physical disturbance, temperature changes, freshwater exposure (i.e., low salinity), and physical substrate composition. In the final 2018 RHMP report, a cursory level causal assessment evaluation was included for a total of 8 sites: 5 sites with a final integrated SQO category of "Likely Impacted" (all considered to have moderately to highly disturbed benthic communities) and 3 additional sites with an integrated SQO score of "Possibly Impacted" with highly disturbed benthic communities. This initial desktop causal assessment evaluation focused solely on overall relationships with chemical concentrations and general geographic location related to potential stressors.

The assessment as presented within this report includes an evaluation of the specific metrics used by the four SQO benthic indices and how they influenced scores observed, as well as an analysis of individual species or groups of species driving the four individual benthic community indices. For some of these sites, considerable disagreement was observed among the four benthic indices that comprise the final SQO benthic community score. By examining these disagreements, additional insight can be made as to which factors (chemical, physical, or other) might be driving the benthic community disturbances. Additionally, benthic community scores in some cases were found to vary substantially among sites in very close proximity to each other. An evaluation of nearby "comparator" sites was included as part of the current causal assessment approach comparing their similarities and differences in metric scores, taxa observed, and chemical and physical characteristics with nearby targeted locations of interest with disturbed communities. These "comparator sites" provided additional insight to assist with better understanding the most likely causes of stress at the impaired locations.

2.0 MATERIALS AND METHODS

2.1 Project Location and Sampling Design

A total of 11 target stations classified as having "Moderately" or "Highly" disturbed benthic communities out of the total 75 RHMP stations were selected for this causal assessment evaluation as summarized in **Table 2-1**. For each target station, 1 to 2 comparator stations were also selected for analysis and comparison based on the following criteria: 1) spatial proximity to target station; 2) difference in integrated benthic and chemistry SQO category scores; and 3) similar strata when possible. Targeted locations (circled in red) and associated comparator sites (circled in blue) are shown on maps in **Figures 2-1 through 2-6,** including their integrated SQO benthic community score.

Table 2-1. Selected Target Causal Assessment Stations

RHMP Site ID	Harbor/ Location	Integrated SQO Score	Benthic Community SQO Score	Notes
B18-10066	Dana Point Harbor Marina	Possibly Impacted	Moderate Disturbance	Inconsistent benthic scores, non-toxic but elevated chemistry.
B18-10071	Oceanside Harbor Mouth	Likely Unimpacted	Moderate Disturbance	Inconsistent benthic scores, non-toxic, and low. chemistry. Likely physical disturbance.
B18-10015	Mission Bay – Eastern near Cudahy Cr.	Likely Unimpacted	High Disturbance	Inconsistent benthic scores, non-toxic, and low chemistry.
B18-10020	Mission Bay – Near Bay Mouth	Likely Unimpacted	Moderate Disturbance	Inconsistent benthic scores, non-toxic, and minimal chemistry.
B18-10084	N. San Diego Bay, Shelter Is.	Possibly Impacted	High Disturbance	Non-toxic but elevated chemistry. Neighboring site B18-10083 has a benthic community score of "Low Disturbance."
B18-10029	N. San Diego Bay near Paleta Cr. inlet	Likely Impacted	Moderate Disturbance	Non-toxic but elevated chemistry. Inconsistent benthic community scores. Nearby site B18-10114 has a benthic community score of "Reference." Influences from physical disturbance and freshwater likely at this site.
B18-10178	Central San Diego Bay, inner Chollas Cr. Channel	Likely Impacted	High Disturbance	Low toxicity, elevated chemistry. Inconsistent benthic community scores. Influences from physical disturbance and freshwater inputs likely at this location.
B18-10127	Central San Diego Bay, NBSD	Likely Impacted	High Disturbance	Non-toxic but elevated chemistry. Inconsistent benthic community scores. Influence from physical disturbance likely at this location.
B18-10180	South San Diego Bay, Sweetwater Channel	Likely Unimpacted	High Disturbance	Consistent benthic scores, non-toxic, and low chemistry Neighboring sites have moderate benthic community disturbance. Influences from physical disturbance and freshwater inputs likely at this location.

Table 2-1. Selected Target Causal Assessment Stations

RHMP Site ID	Harbor/ Location	Integrated SQO Score	Benthic Community SQO Score	Notes
B18-10200	South San Diego Bay, below Chula Vista Bayfront Park	Possibly Impacted	High Disturbance	Low toxicity and low chemistry Inconsistent benthic community scores. Shallow site near shore. Influences from physical disturbance, freshwater, and temperature fluctuations likely at this site.
B18-10044	South San Diego Bay, below Chula Vista Bayfront Park	Likely Unimpacted	High Disturbance	Non-toxic and low chemistry Consistent benthic community scores. Shallow site near shore. Influences from physical disturbance, freshwater inputs, and temperature fluctuations likely at this site.

Figure 2-1. Integrated Benthic SQO Scores for Causal Assessment Sites in Dana Point Harbor

Figure 2-2. Integrated Benthic SQO Scores for Causal Assessment Sites in Oceanside Harbor

Figure 2-3. Integrated Benthic SQO Scores for Causal Assessment Sites in Mission Bay

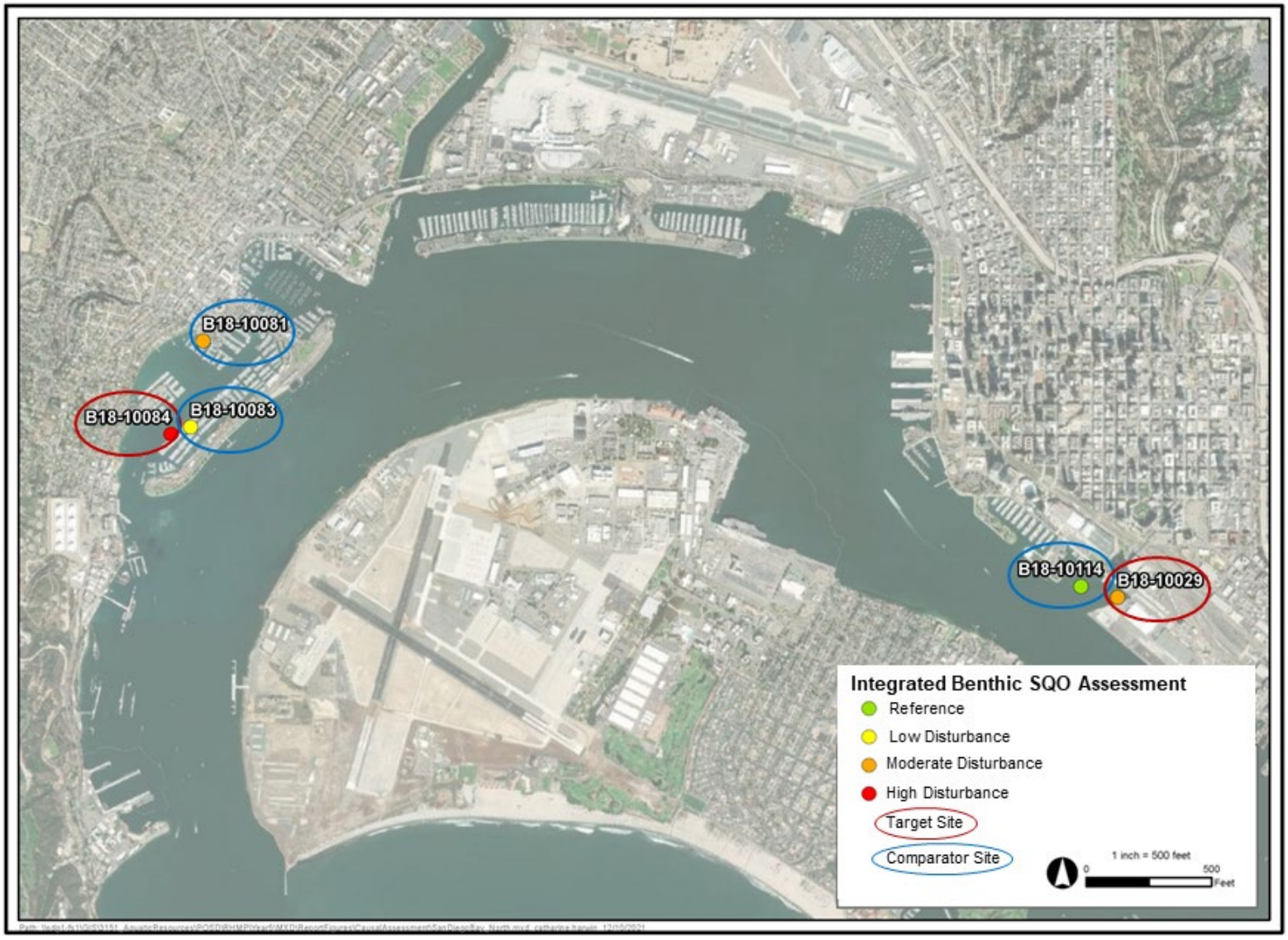

Figure 2-4. Integrated Benthic SQO Scores for Causal Assessment Sites in North San Diego Bay

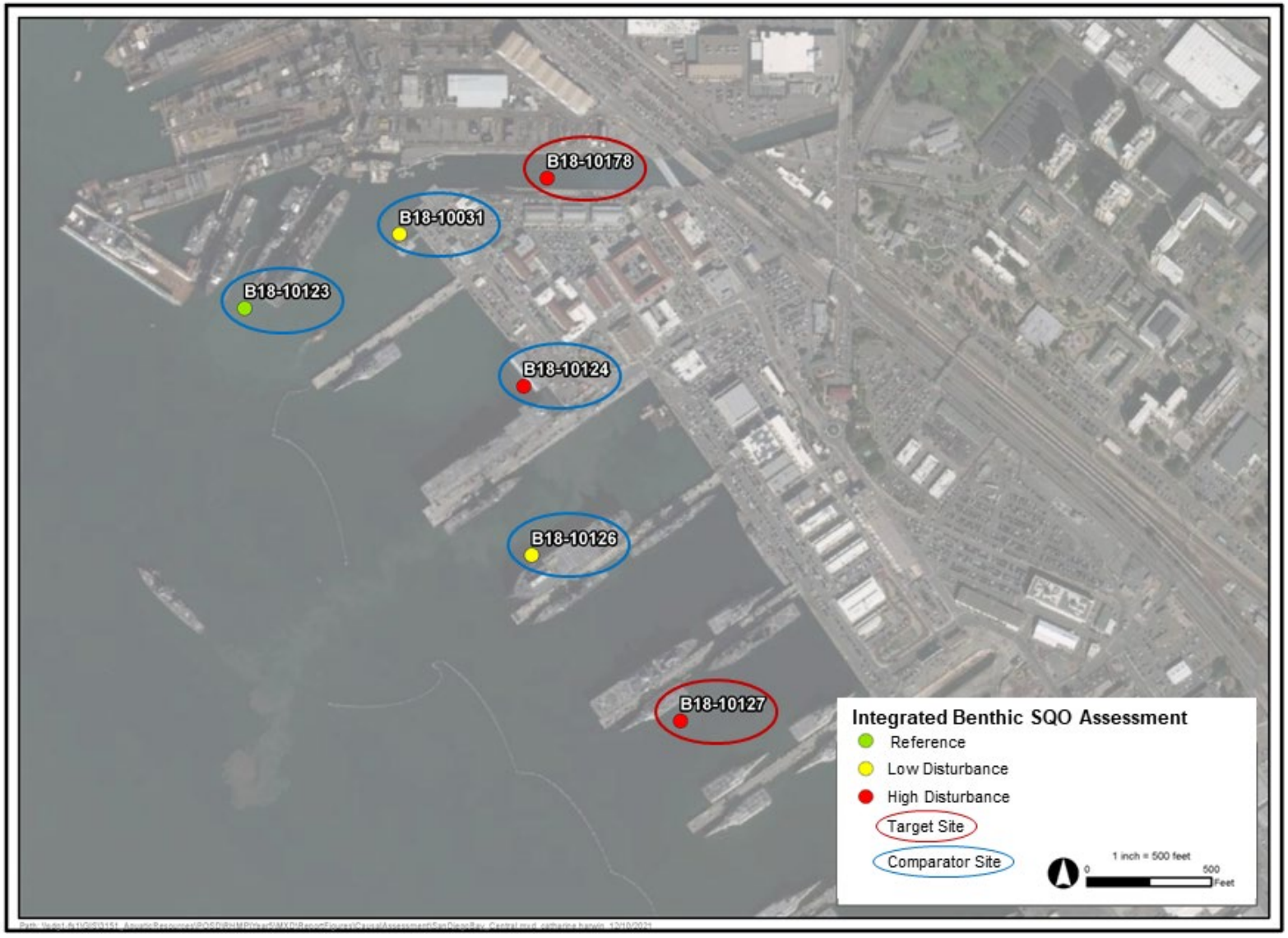

Figure 2-5. Integrated Benthic SQO Scores for Causal Assessment Sites in Central San Diego Bay

Figure 2-6. Integrated Benthic SQO Scores for Causal Assessment Sites in South San Diego Bay

2.2 Statistical Approach

A brief summary of data analysis methods is provided below.

Descriptive Analyses and Univariate Analysis

Target stations and nearby comparator stations were compared using descriptive statistical methods including linear regressions, box plots, and bar charts. Box plots were analyzed using a Kruskal-Wallis analysis of variance (ANOVA) to look for global statistically significant differences between benthic SQO groups for each chemical or benthic community parameter.

All general statistics and univariate comparisons were performed using GraphPad Prism® Version 8.0 statistical software.

Multivariate Analysis

A suite of multivariate analyses was also employed to help visualize and define relationships between benthic community populations (based on abundance and composition) among the harbors and strata, as well as benthic community measures and various associated key chemical and physical parameters. Patterns identified as driving a majority of the variability observed were then compared and used for subsequent directed analyses to help identify potential causes of impairment. Three primary multivariate techniques were employed for this evaluation as follows:

1. Multivariate cluster analysis was performed for benthic infauna abundance to identify similar station habitats and species communities grouped by station and by species. Clustering tested whether the similarities observed in the data were smaller and/or larger than those expected by chance. Paired station and species clusters were used to create a gradient heatmap, in which darker squares represented higher abundances than lighter squares. Additionally, the relationship of stations and species from the cluster analysis was preserved, whereby stations (or species) placement on their respective axis reflected how similar those stations are.
2. Principal components analysis (PCA) was performed as an exploratory multivariate tool to assess relationships between sediment chemistry and physical characteristics. This descriptive ordination analysis was used to visualize relationships and partition variance. Samples in an ordination space were represented by their location and their relationship to other samples visualized by their distance apart, where samples closer in space were more similar to one another. The two axes, PC1 and PC2, represented the direction in which the variance of sample points projected perpendicularly onto the axis was maximized (Clarke et al., 2014). Data analyzed in this report were log transformed for sediment data and arcsine square-root transformed for percent total organic carbon (TOC) and percent fines.
3. Non-metric multidimensional scaling (nMDS) was also performed to assess relationships between sediment chemistry and physical characteristics. nMDS is an ordination routine conceptually similar to PCA but can fit a model in fewer dimensions than PCA and does not assume linear relationships. Relationships using nMDS were reduced to a 2-dimensional representation of their similarity shown as relative distances between

samples. Sample variables (such as harbor, strata, SQO metric scores, etc.) in an ordination were analyzed for statistical significance by conducting an analysis of similarity (ANOSIM).

4. The strength of relationships between subsets of benthic community and sediment chemistry variables that best explain overall variance was evaluated using Spearman Rank correlations using RELATE and BEST/BIOENV analysis tool in Primer.

All multivariate analyses were performed using PRIMER-e version 7 statistical software and graphing program. Additional details regarding the statistical methods used for this assessment are provided in the RHMP 2018 report (Wood 2020).

2.3 Index Comparisons

2.3.1 Sediment Quality Objectives Overview

The SQO methodology uses a multiple lines of evidence (MLOE) approach to determine overall sediment quality at individual stations. The SQO framework is based on the integration of three LOEs: 1) sediment chemistry, 2) sediment toxicity, and 3) benthic infaunal community. Each of these three individual LOEs are comprised of multiple metrics.

After determining the condition class of each LOE, the three are then integrated into an overall station-level sediment quality assessment classification: Unimpacted, Likely Unimpacted, Possibly Impacted, Highly Impacted, or Clearly Impacted.

The chemistry LOE utilizes two sub-metrics: 1) the Chemical Score Index (CSI), and 2) the California Linear Regression Model (CA-LRM). In different ways, both of these metrics model the probability of toxicity based on the chemical concentration and predict the severity of community disturbance. The CSI calculates the relative toxicity of each chemical measured by multiplying the concentration of each chemical by its weighted toxicity value. These values are then summed into a Chemical Category Sum (CCS). This CSI-CCS is useful in shedding light on individual chemicals, or groups of chemicals, that might be driving benthic disturbance. Similarly, the CA-LRM does this in a slightly different way but bases its characterization of the chemical stress on the single chemical with the highest predicted toxicity.

The toxicity LOE bases its determination of sediment impact on two toxicity tests: at least one acute lethal test using amphipods and one sublethal test using mussel embryo development or polychaete growth/survival.

Determination of the benthic LOE condition is based on four established indices of benthic community condition as follows:

1. The Index of Biotic Integrity (IBI),
2. The Relative Benthic Index (RBI),
3. The Benthic Response Index (BRI), and
4. The River Invertebrate Prediction and Classification System (RIVPACS).

Research in California embayments has shown that by using a combination of benthic indices rather than a single index, a more accurate description of benthic invertebrate community condition can be generated (Ranasinghe *et al.,* 2009). Each index is explained further below.

2.3.1.1 *Index of Biotic Integrity*

The IBI uses four sub-metrics to determine the quality of the benthic community:

- Total number of taxa
- Number of mollusc taxa
- Abundance of *Notomastus* sp. (polychaete)
- Number of sensitive taxa

For each sub-metric that exhibits a numeric value falling outside of what has been determined to be the range of typical reference embayment sites in southern California, the condition class value increases by 1, with a final score of 0 equating to reference condition, and 4 to High Disturbance.

2.3.1.2 *Relative Benthic Index*

The RBI uses the weighted sum of three sub-metrics to determine the quality of the benthic community:

- Four community metrics related to biodiversity (in order of decreasing assigned weight) are combined into a Taxa Weighted Value (TWV). A higher TWV indicates better diversity:
    - Number of mollusc taxa
    - Number of crustacean taxa
    - Total number of taxa
    - Abundance of crustacean individuals
- Abundance of three positive indicator taxa (pollution intolerant)
- Presence of two negative indicator taxa (pollution tolerant)

2.3.1.3 *Benthic Response Index*

The BRI is the abundance weighted mean pollution tolerance score (p-code) of the organisms present in a sediment sample. The higher the mean BRI value is, the more disturbed the benthic community represented by the sample.

2.3.1.4 *River Invertebrate Prediction and Classification System*

The RIVPACS index compares the number of taxa observed (“O”) in the test sample to the number of taxa expected (“E”) to be present in a reference sample from the same habitat based on a predictive model approach. A ratio of observed to expected (O/E) taxa is then calculated. The RIVPACS utilizes a >50% capture probability when modelling what taxa are expected at a site. This means when determining how many reference taxa should be observed at a specific

site, only taxa that have a greater than 50% probability of being captured are included in the expected ("E") taxa.

After all four benthic indices are calculated, the numeric result of each is then compared to index-specific response ranges that are binned into categories corresponding to benthic infauna quality conditions of Reference, Low Disturbance, Moderate Disturbance, and High Disturbance. To determine the final integrated benthic LOE rating for a site, the high and low result categories are eliminated and the mean of the remaining two indices is used, rounding up to the more conservative category if the mean falls between categories.

2.3.2 Potential Limitations of the Benthic Community LOE Indices

Several of the benthic community LOEs have characteristics that can lead to potential bias in their rating of benthic infaunal community quality if unique site circumstances are encountered. Understanding and taking into account these potential biases and limitations is important to consider when assessing benthic conditions. A brief summary of known issues to consider and be aware of are provided below:

- Among the four indices used within the SQO benthic community LOE, three of them (IBI, RBI, and RIVPACS) rely on taxa richness as part of their assessment. While taxa richness (i.e., diversity) does play an important role in the health of the benthic infaunal community, this redundancy in sub-metrics can negatively bias the integrated SQO score in unique environments. As a result of this redundancy, there is a greater potential for a site to be categorized as disturbed in environments where you might expect naturally lower taxonomic diversity such as the upper edges of subtidal habitat, areas that receive regular scouring either through anthropogenic sources or natural bioturbation (e.g., bat ray or round ray feeding pits), areas of limited tidal exchange (back bay areas with increased temperatures), and/or areas that receive periodic salinity reduction. The SQO technical support manual (Bay et al., 2014) recognizes this and states that: "*A variety of environmental conditions exist within bays and estuaries that limit the scope of application of some of the tools, especially benthic community indices*." In these types of unique habitats, it might be expected that the benthic communities would look different and not conform to the parent SQO calibration models.
- RIVPACS was developed through documentation of taxonomic diversity in samples collected in southern California bays and harbors in order to establish a pool of reference site taxonomic data. Individual taxa were then assigned a percent probability of capture based on frequency of collection within the reference pool sites. The reference pool sites were then grouped into "habitat types" based on abiotic factors such as percent fine sediment, salinity, and latitude (RIVPACS defines four "habitat types" in the southern California region). In general, the greater the number of stations in a "habitat type", the more refined and accurate the expected taxa list will be. Additionally, the more precisely defined the reference pool "habitat types" are, the more accurate the expected taxa list should be if the test site habitat more closely matches the reference habitat.

  RIVPACS may be subject to a Type I statistical error (i.e., the determination of benthic disturbance where there is none). This may occur under several scenarios:

  - Unique habitat conditions are encountered that are dissimilar to the four southern California "habitat types" defined by the model and which may support unique benthic communities.
  - Rare taxa are collected but excluded from the observed taxa list because there is <50% probability of capture of those taxa, thereby disregarding a substantial portion of the benthic community. Many of these rare taxa could be stressor-sensitive taxa indicating healthy conditions.
  - RIVPACS was originally developed in 2008 and has not been updated since that time. The number of samples used to establish each "habitat type" reference group is somewhat limited. For example, the taxa assemblages for the four southern California "habitat types" used from 73 to 107 samples to develop each habitat model (Ranasinghe et al, 2009). The index could become more accurate if "habitat type"-specific capture probabilities were utilized to determine the expected taxa rather than a general 50% capture probability across all "habitat types".

- Within the RBI LOE, the abundance of three positive indicator (sensitive) taxa: *Monocorophium insidiosum* (amphipod), *Asthenothaerus diegensis* (mussel), and *Goniada littorea* (polychaete) have a large influence on the outcome of the RBI categorical rating. Of the 2018 RHMP sites with at least one individual of these positive taxa, an overwhelming majority of these sites were rated as "Reference" by the RBI (20 of 23), regardless of the status of other sub-metrics within the RBI. For example, Site B18-10081 (North San Diego Bay) had an RBI TWV score of 0.78 indicating high diversity, had no negative or positive indicator taxa, and was categorized as "Moderately Disturbed" by the RBI. Yet Site B18-10068 (Dana Point) had a lower TWV score of 0.60 (lower diversity), had five Oligochaeta individuals (a negative indicator taxa), but did contain one *Asthenothaerus diegensis* individual. This site was then categorized as "Reference" by the RBI. When negative indicator taxa (*Capitella capitata* complex and Oligochaeta) appear at a site, they do not have as much influence on the outcome of the RBI as does the presence of positive taxa. Additionally, more than any of the other three SQO indices, when the RBI categorized a site as "Reference", the remaining three metrics tended to score sites as higher quality as well.
- The SQO approach eliminates the single lowest and single highest scoring index (of the four indices) to determine the overall benthic integrated categorical rating. However, in some cases a more in-depth analysis of the benthic community composition might find that the highest or lowest scoring indices are actually the most accurate in describing benthic community conditions at a particular site where chemical impacts are of primary concern. Thus, an analysis of sites with questionable or degraded benthic community scores should review and consider results provided by all four benthic community indices, not just the two used to derive the final score.

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3.0 RESULTS

The results of the analyses described in Section 2 are discussed below. A summary of chemistry, benthic community, and overall SQO scores are presented in Section 3.1, overall observations based on univariate and multivariate techniques are presented in Sections 3.2 and 3.3, respectively, and individual detailed site-by-site evaluations are provided in Section 3.4.

3.1 Station Chemistry and Index Score Summary

This evaluation used sediment chemistry results from the 2018 RHMP collected in association with the benthic community. A summary of several primary chemicals of potential concern at target and comparator sites are provided for reference in **Table 3-1**. Full measured analytical results including individual PCB congener concentrations, pyrethroids, and chlordanes can be found in **Appendix F** of the Final 2018 RHMP report.

A summary of target and comparator station SQO line of evidence scores, as well as the integrated SQO station condition category, is provided in **Table 3-2**.

Benthic infauna abundance for target and comparator site stations evaluated herein is provided for reference in **Appendix A** of this document.

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Table 3-1. Chemistry Summary for Target and Comparator Stations

Station	Station Type	Harbor	Strata	Location	% Fines	% Sand	% TOC	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)	Total PAHs (µg/kg)	Total PCBs (µg/kg)	Total DDTs (µg/kg)[a]	Total Chlordanes (µg/kg)[b]	Total Pyrethroids (µg/kg)	Total PBDEs (µg/kg)
B18-10066	Target	Dana Point Harbor	Freshwater-Influenced	Dana Point Harbor	67.1	33.0	2.18	0.79	461	22.7	0.087	386	681	5.52	4.05	2.21	32.0	56.3
B18-10067	Comparator	Dana Point Harbor	Marina	Dana Point Harbor	67.3	32.7	2.26	0.45	664	30	0.084	616	381	4.57	1.88	<0.25	7.28	14.5
B18-10068	Comparator	Dana Point Harbor	Deep	Dana Point Harbor	52.6	47.2	1.07	0.52	93.6	10.2	0.027	162	266	1.15	1.95	<0.25	2.90	2.74
B18-10069	Comparator	Oceanside Harbor	Marina	Oceanside Harbor	52.9	46.8	1.42	0.23	489	24.4	0.373	331	182	5348	3.15	<0.25	0.41	20.4
B18-10070	Comparator	Oceanside Harbor	Freshwater-Influenced	Oceanside Harbor	62.3	37.7	1.75	0.32	156	14.2	0.073	202	132	1.51	1.89	<0.25	0.38	4.99
B18-10071	Target	Oceanside Harbor	Deep	Oceanside Harbor	50.0	50.0	1.55	0.38	55.9	8.8	0.025	127	196	0.41	3.14	<0.25	1.65	5.28
B18-10015	Target	Mission Bay	Freshwater-Influenced	Mission Bay	51.9	47.9	1.62	0.27	35.7	31.4	0.054	135	807	2.71	1.27	4.14	13.9	9.11
B18-10017	Comparator	Mission Bay	Shallow	Mission Bay	56.2	43.3	2.04	0.27	50.6	43.7	0.071	166	287	1.97	0.65	0.67	2.66	7.89
B18-10020	Target	Mission Bay	Deep	Mission Bay	8.9	90.8	0.21	0.09	4.08	2.41	0.010	21.4	31.7	<0.17	<0.27	<0.25	<0.28	0.75
B18-10029	Target	North San Diego Bay	Freshwater-Influenced	Switzer Creek	54.2	45.6	2.50	0.48	111	54.3	0.333	271	3289	43.9	10.6	22.7	57.4	13.3
B18-10114	Comparator	North San Diego Bay	Industrial/Port	Switzer Creek	68.5	30.9	1.75	0.24	133	48.8	0.472	218	4101	40.3	2.18	4.54	16.1	7.46
B18-10081	Comparator	North San Diego Bay	Marina	Shelter Island Yacht Basin	57.7	42.2	1.16	0.15	219	41.3	1.430	203	1235	34.0	3.20	4.27	3.07	2.11
B18-10083	Comparator	North San Diego Bay	Marina	Shelter Island Yacht Basin	53.4	46.7	1.22	0.16	173	27	0.616	169	736	11.9	0.69	<0.25	0.23	0.90
B18-10084	Target	North San Diego Bay	Marina	Shelter Island Yacht Basin	65.0	35.0	1.43	0.18	149	29.6	0.641	178	896	8.19	0.78	<0.25	<0.28	1.36
B18-10124	Comparator	Central San Diego Bay	Industrial/Port	Naval Base San Diego	87.5	12.4	2.05	0.42	228	62.3	0.711	313	2386	57.4	2.05	2.01	3.43	7.80
B18-10126	Comparator	Central San Diego Bay	Industrial/Port	Naval Base San Diego	68.3	31.7	1.34	0.23	162	41.9	0.506	206	1386	44.5	1.24	0.13	1.70	3.62
B18-10127	Target	Central San Diego Bay	Industrial/Port	Naval Base San Diego	74.7	25.4	1.45	0.52	196	367	0.661	255	2573	76.1	2.17	0.38	<0.28	5.11
B18-10178	Target	Central San Diego Bay	Freshwater-Influenced	Chollas Creek	67.0	33.0	3.50	0.76	108	54.6	0.137	294	3891	47.8	26.7	46.8	127	58.6
B18-10031	Comparator	Central San Diego Bay	Freshwater-Influenced	Chollas Creek	66.9	33.2	1.60	0.30	120	41.8	0.268	198	2278	42.7	5.42	10.69	24.2	9.00
B18-10123	Comparator	Central San Diego Bay	Industrial/Port	Chollas Creek	73.4	26.5	1.54	0.24	174	47.1	0.346	224	1796	99.4	6.22	4.44	15.0	6.62
B18-10043	Comparator	South San Diego Bay	Shallow	Chula Vista Bayfront Park	31.9	67.9	1.45	0.48	54.3	17	0.075	156	297	5.23	3.81	<0.25	3.81	1.89
B18-10200	Target	South San Diego Bay	Freshwater-Influenced	Chula Vista Bayfront Park	63.0	37.2	1.66	0.65	36.8	13.8	0.048	127	421	5.68	7.93	3.02	36.4	8.81
B18-10044	Target	South San Diego Bay	Freshwater-Influenced	Chula Vista Bayfront Park	60.6	39.3	1.73	0.69	85.2	24.4	0.131	220	300	5.63	1.56	<0.25	5.91	19.5
B18-10180	Target	South San Diego Bay	Freshwater-Influenced	Sweetwater Channel	34.0	65.5	0.76	0.18	70.3	14.8	0.106	125	253	5.88	2.17	<0.25	2.34	8.71
B18-10037	Comparator	South San Diego Bay	Freshwater-Influenced	Sweetwater Channel	52.1	47.5	1.14	0.14	91.6	18.9	0.145	160	303	9.28	0.58	<0.25	0.67	2.44

[a] Total detectable DDTs includes the sum of 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT, and 4,4'-DDT

[b] Total Chlordanes includes the sum of alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor and oxychlordane.

< Data reported to the method detection limit

Stations highlighted in yellow indicate target stations

Table 3-2 Target and Comparator Station SQO Index Line of Evidence Category Summary

Station	Station Type	Harbor	Strata	Location	BRI Score	BRI Category	RBI Score	RBI Category	IBI Score	IBI Category	RIVPACS Score	RIVPACS Category	Benthic SQO Category	Chem SQO Category	Tox SQO Category	Integrated SQO Category
B18-10066	Target	Dana Point Harbor	Freshwater-Influenced	Dana Point Harbor	56.0	Moderate Disturbance	0.06	High Disturbance	1	Low Disturbance	0.91	Reference	**Moderate Disturbance**	**Moderate Exposure**	**Nontoxic**	**Possibly impacted**
B18-10067	Comparator	Dana Point Harbor	Marina	Dana Point Harbor	59.5	Moderate Disturbance	0.05	High Disturbance	1	Low Disturbance	0.72	Moderate Disturbance	**Moderate Disturbance**	**Moderate Exposure**	**Nontoxic**	**Possibly impacted**
B18-10068	Comparator	Dana Point Harbor	Deep	Dana Point Harbor	37.4	Reference	0.29	Reference	1	Low Disturbance	0.60	Moderate Disturbance	**Low Disturbance**	**Low Exposure**	**Nontoxic**	**Unimpacted**
B18-10069	Comparator	Oceanside Harbor	Marina	Oceanside Harbor	37.1	Reference	0.07	High Disturbance	2	Moderate Disturbance	0.35	Moderate Disturbance	**Moderate Disturbance**	**Moderate Exposure**	**Nontoxic**	**Possibly impacted**
B18-10070	Comparator	Oceanside Harbor	Freshwater-Influenced	Oceanside Harbor	33.3	Reference	0.37	Reference	1	Low Disturbance	0.53	Moderate Disturbance	**Low Disturbance**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10071	Target	Oceanside Harbor	Deep	Oceanside Harbor	33.7	Reference	0.06	High Disturbance	1	Low Disturbance	0.36	Moderate Disturbance	**Moderate Disturbance**	**Low Exposure**	**Nontoxic**	**Likely unimpacted**
B18-10015	Target	Mission Bay	Freshwater-Influenced	Mission Bay	32.8	Reference	0.06	High Disturbance	2	Moderate Disturbance	0.11	High Disturbance	**High Disturbance**	**Low Exposure**	**Nontoxic**	**Likely unimpacted**
B18-10017	Comparator	Mission Bay	Shallow	Mission Bay	45.2	Low Disturbance	0.23	Low Disturbance	1	Low Disturbance	0.73	Moderate Disturbance	**Low Disturbance**	**Low Exposure**	**Low Toxicity**	**Likely unimpacted**
B18-10020	Target	Mission Bay	Deep	Mission Bay	21.0	Reference	0.08	High Disturbance	1	Low Disturbance	0.19	High Disturbance	**Moderate Disturbance**	**Minimal Exposure**	**Nontoxic**	**Likely unimpacted**
B18-10029	Target	North San Diego Bay	Freshwater-Influenced	Switzer Creek	43.7	Low Disturbance	0.07	High Disturbance	1	Low Disturbance	0.51	Moderate Disturbance	**Moderate Disturbance**	**High Exposure**	**Nontoxic**	**Likely impacted**
B18-10114	Comparator	North San Diego Bay	Industrial/Port	Switzer Creek	36.1	Reference	0.53	Reference	0	Reference	0.69	Moderate Disturbance	**Reference**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10081	Comparator	North San Diego Bay	Marina	Shelter Island Yacht Basin	52.0	Moderate Disturbance	0.16	Moderate Disturbance	0	Reference	0.48	Moderate Disturbance	**Moderate Disturbance**	**Moderate Exposure**	**Nontoxic**	**Possibly impacted**
B18-10083	Comparator	North San Diego Bay	Marina	Shelter Island Yacht Basin	47.8	Low Disturbance	0.18	Low Disturbance	0	Reference	0.70	Moderate Disturbance	**Low Disturbance**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10084	Target	North San Diego Bay	Marina	Shelter Island Yacht Basin	35.1	Reference	0.04	High Disturbance	3	High Disturbance	0.05	High Disturbance	**High Disturbance**	**Moderate Exposure**	**Nontoxic**	**Possibly impacted**
B18-10124	Comparator	Central San Diego Bay	Industrial/Port	Naval Base San Diego	57.3	Moderate Disturbance	0.06	High Disturbance	3	High Disturbance	0.10	High Disturbance	**High Disturbance**	**High Exposure**	**Nontoxic**	**Likely impacted**
B18-10126	Comparator	Central San Diego Bay	Industrial/Port	Naval Base San Diego	47.3	Low Disturbance	0.34	Reference	0	Reference	0.35	Moderate Disturbance	**Low Disturbance**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10127	Target	Central San Diego Bay	Industrial/Port	Naval Base San Diego	47.0	Low Disturbance	0.03	High Disturbance	2	Moderate Disturbance	0.20	High Disturbance	**High Disturbance**	**High Exposure**	**Nontoxic**	**Likely impacted**
B18-10178	Target	Central San Diego Bay	Freshwater-Influenced	Chollas Creek	43.9	Low Disturbance	0.05	High Disturbance	2	Moderate Disturbance	0.10	High Disturbance	**High Disturbance**	**High Exposure**	**Low Toxicity**	**Likely impacted**
B18-10031	Comparator	Central San Diego Bay	Freshwater-Influenced	Chollas Creek	41.4	Low Disturbance	0.20	Low Disturbance	1	Low Disturbance	0.76	Low Disturbance	**Low Disturbance**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10123	Comparator	Central San Diego Bay	Industrial/Port	Chollas Creek	46.0	Low Disturbance	0.49	Reference	0	Reference	1.01	Reference	**Reference**	**Moderate Exposure**	**Nontoxic**	**Unimpacted**
B18-10043	Comparator	South San Diego Bay	Shallow	Chula Vista Bayfront Park	30.7	Reference	0.21	Low Disturbance	1	Low Disturbance	0.69	Moderate Disturbance	**Low Disturbance**	**Low Exposure**	**Nontoxic**	**Unimpacted**
B18-10200	Target	South San Diego Bay	Freshwater-Influenced	Chula Vista Bayfront Park	59.8	Moderate Disturbance	0.03	High Disturbance	1	Low Disturbance	0.14	High Disturbance	**High Disturbance**	**Low Exposure**	**Low Toxicity**	**Possibly impacted**
B18-10044	Target	South San Diego Bay	Freshwater-Influenced	Chula Vista Bayfront Park	57.0	Moderate Disturbance	0.05	High Disturbance	2	Moderate Disturbance	0.24	High Disturbance	**High Disturbance**	**Low Exposure**	**Nontoxic**	**Likely unimpacted**
B18-10180	Target	South San Diego Bay	Freshwater-Influenced	Sweetwater Channel	56.5	Moderate Disturbance	0.08	High Disturbance	2	Moderate Disturbance	0.29	High Disturbance	**High Disturbance**	**Low Exposure**	**Nontoxic**	**Likely unimpacted**
B18-10037	Comparator	South San Diego Bay	Freshwater-Influenced	Sweetwater Channel	51.0	Moderate Disturbance	0.09	Moderate Disturbance	1	Low Disturbance	0.52	Moderate Disturbance	**Moderate Disturbance**	**Low Exposure**	**Nontoxic**	**Likely unimpacted**

Stations highlighted in yellow indicate target stations

3.2 Univariate Analysis

Target stations and comparator stations were analyzed using box plots grouped by benthic SQO category to identify patterns among benthic community SQO scores and additional community composition metrics in relation to sediment chemistry. Community composition metrics included total abundance, species richness, Shannon-Wiener diversity, percent sensitive taxa relative to total station taxa, percent sensitive species abundance relative to total station abundance, and non-native species as both abundance and percent of the total taxa at stations. Sensitive species were determined by their p-code being less than 39.96 (the BRI score threshold indicating a station is in reference-like condition), while non-native species were identified using the California Department of Fish and Wildlife (CDFW) California Non-native Estuarine and Marine Organisms (Cal-NEMO) database (https://wildlife.ca.gov/OSPR/Science/Cal-NEMO). Data was square-root transformed and then compared using a Kruskal-Wallis ANOVA to determine if medians between groups were statistically different from one another ($\alpha<0.05$).

Boxplots summarizing physical sediment characteristics (TOC and % fines) and select chemicals of potential concern[1] (**Figure 3-1**) did not show consistent patterns when grouped by benthic SQO categories. Lead and pyrethroid pesticides exhibited somewhat higher concentrations at stations with moderate or high disturbance; a less consistent pattern was evident for copper and total PCBs. A limiting factor was that there were only two stations classified as having a “reference” benthic community that were included in the analysis, but in general it would be expected that as the benthic community SQO category moves towards high disturbance there may be higher concentrations of target compounds in the sediment. Grain size and percent TOC were similar among those sites evaluated herein regardless of the benthic SQO category. No statistically significant relationships were observed between sediment chemistry and quality of the benthic community ($p\geq 0.05$; **Figure 3-1**).

[1] Multivariate analysis identified percent fines, percent total organic carbon (TOC), copper, lead, total pyrethroids and total PCBs as the most highly correlated to infauna community composition, so only those parameters for sediment chemistry are shown here.

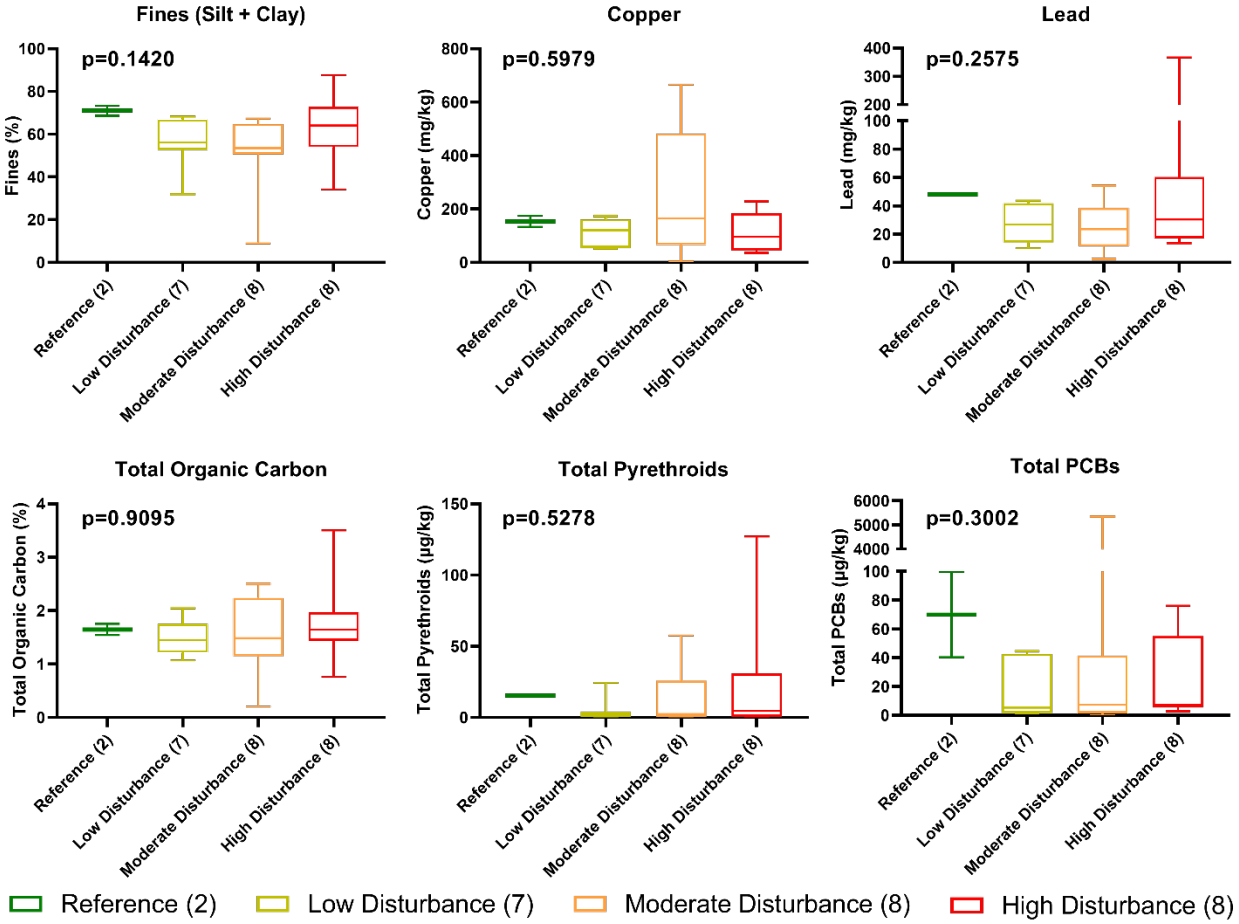

Figure 3-1. Boxplots of Sediment Chemistry Grouped by Benthic SQO Category

Boxplots include median values with the upper and lower 25th percentile ranges (boxes) and minimum and maximum values (whiskers) representing the upper and lower 75th percentile ranges. The number of stations represented by each box plot is denoted in parentheses.

Boxplots comparing several benthic infauna community metrics to integrated SQO scores (**Figure 3-2**) showed a more apparent pattern for abundance, species richness and Shannon-Wiener diversity, where more impacted stations had lower values for each metric compared to "Reference" and "Low Disturbance" stations. These relationships were all statistically significant ($p<0.05$); however, relationships to all other benthic infauna community SQO metrics were not significant. The percentage of sensitive species at a number of stations classified as having "Moderate" and "High Disturbance" was greater than at less disturbed sites although the median for all groups was similar. The percent abundance of sensitive species was generally lower at stations classified as "High Disturbance", although it also appeared that "Moderately Disturbed" stations had a higher proportion of sites with a greater percent abundance of sensitive species compared to sites classified as "Reference" or having "Low Disturbance." The percentage of stations with non-native species was greatest at sites classified as having "High Disturbance", although the median number of sites with non-natives was similar across station groups. There was no apparent pattern for the percent abundance of non-native species at each station.

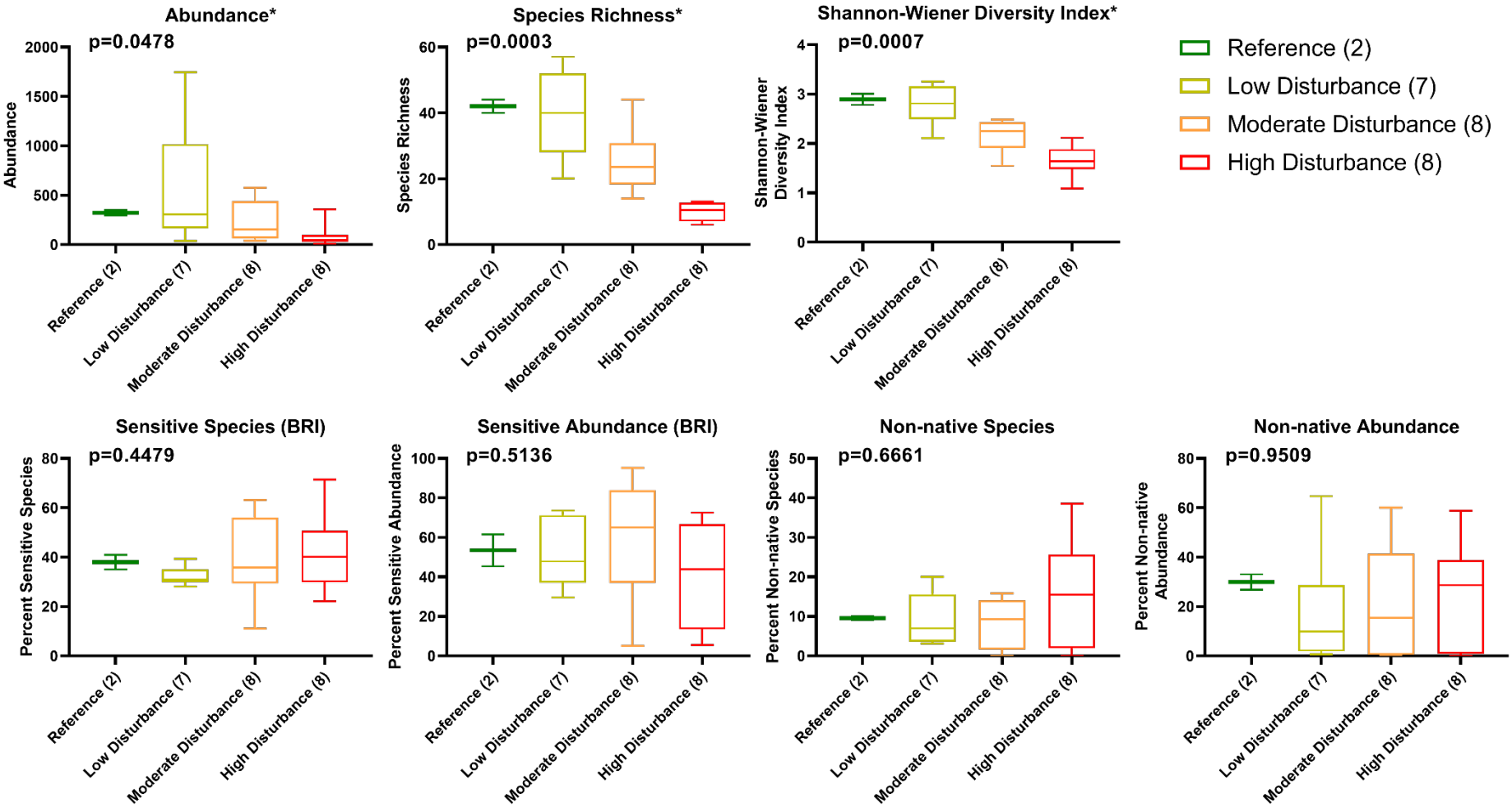

Figure 3-2. Boxplots of Infauna Community Metrics Grouped by Benthic SQO Category

**Asterisks represents significant differences among SQO disturbance categories based on Kruskal-Wallis ANOVA*
The number of stations represented by each box plot is denoted in parentheses.

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Linear regression analysis was performed to evaluate the correlation between select individual sediment chemistry and physical characteristic parameters and the proportion of sites with non-native species (number of non-native species and abundance of non-native species), as well as sensitive species (number of sensitive species and abundance of sensitive species). Statistically significant relationships ($p < 0.05$) were only observed between non-native species vs. percent fines; number of sensitive species vs. percent fines, percent TOC, and copper; and the abundance of sensitive species vs. percent fines (**Figure 3-3)**. While these relationships can help develop questions for further analysis, they are not definitive in assessing causation as far as factors that affect the number or abundance of sensitive and non-native species. However, a lack of a relationship can be used to infer no cause and effect collectively among the sites evaluated. Note also that some of the regressions are driven by only a few stations. For example, it would be expected that higher copper concentrations would result in less sensitive species, but a few stations with elevated copper had a number of sensitive species, which were strong drivers of an unexpected significant positive relationship. This relationship provided an opportunity to more critically assess how 'senstive species' are determined and where there may be limitations to including this measure in the index calculations. Such relationships and those described above also provide a strong indication among the samples included for this evaluation that other factors must be contributing to impacts on the benthic community measures as opposed to sediment chemistry and physical characteristics alone.

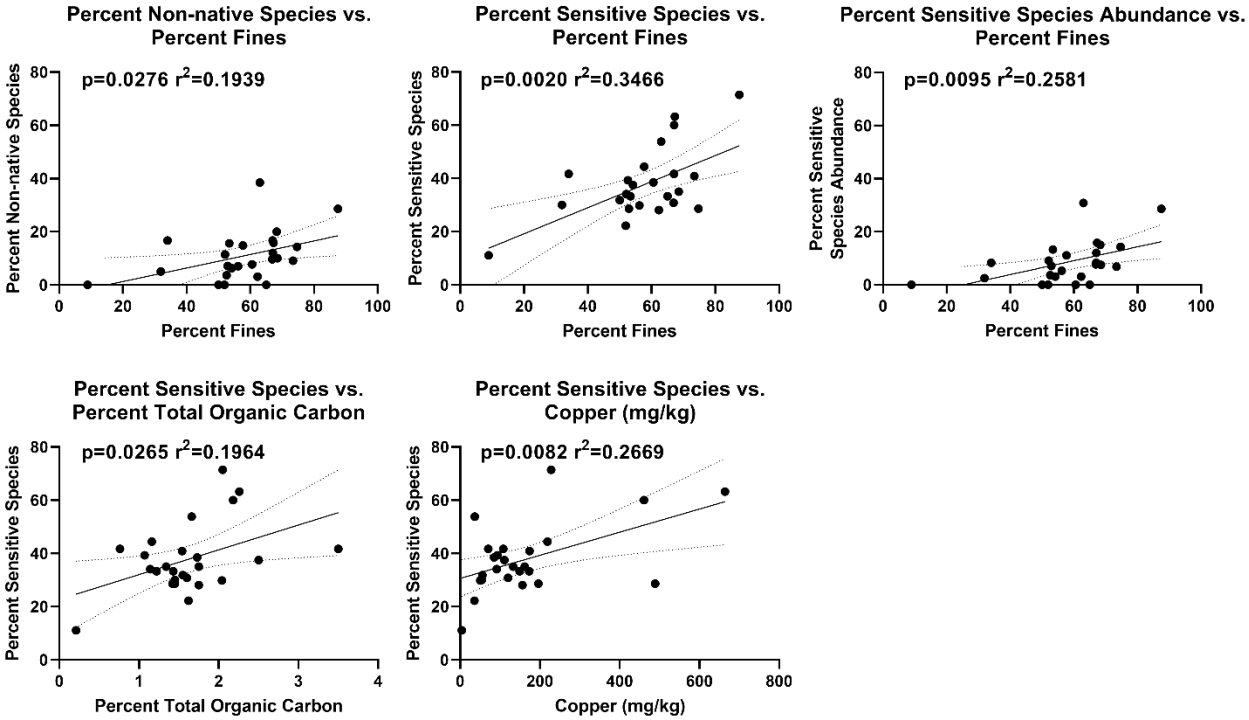

Figure 3-3. Significant Linear Regression Relationships Between Infauna Community Metrics and Select Sediment Physical and Chemical Parameters

3.3 Multivariate Analysis

3.3.1 Benthic Infauna Abundance

Results generated by nMDS were used to assess the relationships between benthic infauna abundance and the following four factors: location, strata, benthic SQO category, and chemistry SQO category (see **Figure 3-4)**. An ANOSIM for each factor group found that there were global statistically significant differences for stations grouped by each of the four factors despite not all pairwise comparisons showing significant differences. Results indicate that there are unique characteristics among these four groups that relate to infaunal abundance and composition and further justify keeping these categories distinct for additional analyses.

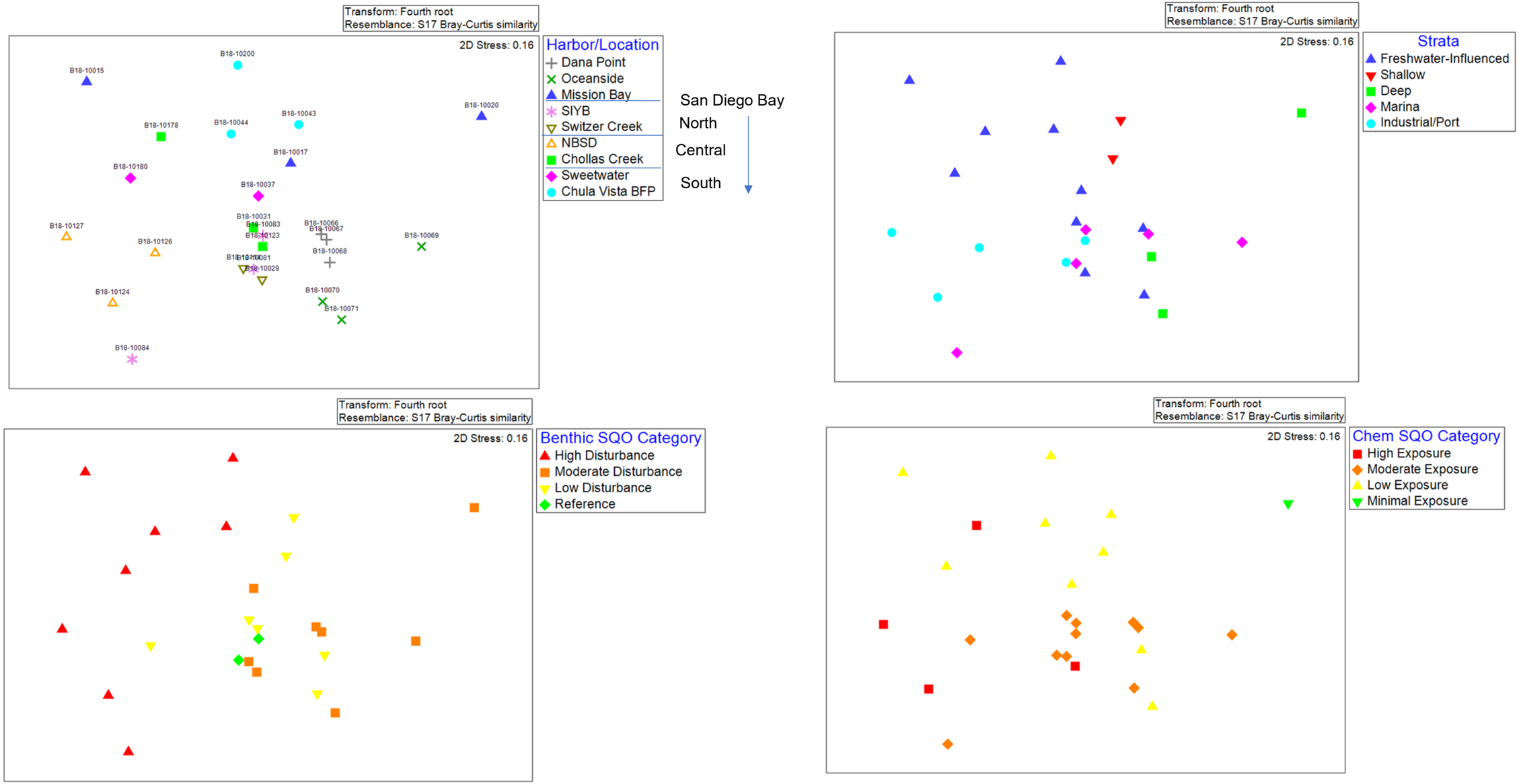

Figure 3-4. Non-Metric Multidimensional Scaling (nMDS) of Benthic Infauna Abundance

SIYB=Shelter Island Yacht Basin. NBSD=Naval Base San Diego. Chula Vista BFP=Chula Vista Bayfront Park. North San Diego Bay includes SIYB and Switzer Creek, Central San Diego Bay includes NBSD and Chollas Creek, South San Diego Bay includes Sweetwater and Chula Vista BFP.

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A more detailed look at how the infaunal communities related to each other based on location and the benthic community SQO category was performed by producing a shade plot dendrogram (**Figure 3-5)**. The shade plot of benthic infauna abundance was created using the 30 species that most differentiated stations according to a hierarchical clustering algorithm in which samples are fused at progressively decreasing similarity until a dendrogram is produced (left side of **Figure 3-5**). Stations were labeled by location and grouped by benthic SQO category, and the order of stations was also based on hierarchical clustering whereby stations that are closer together are more similar to one another than stations further away from one another. Interestingly, stations classified as having "High Disturbance" were observed on one end of the dendrogram and those classified as having "Moderate Disturbance" were observed on the other end. Stations considered to be "Reference" or classified as having "Low Disturbance" were observed in between stations classified as having "High Disturbance" and "Moderate Disturbance", with "Reference" stations closer to those with "Moderate Disturbance". While this suggests that from a purely mathematical standpoint the community composition and abundance gradient follows a different pattern than expected based on the benthic SQO categorization of that station, it does not account for several other factors that are incorporated in the integrated benthic SQO calculation (see Section 2.3.1) such as non-native and sensitive species. Using this visualization of the community composition can help interpret strengths and weaknesses of the benthic SQO category calculation by incorporating different metrics.

The shade plot is a useful tool to compare the relative abundance of species at each station and within the group of stations. The ordering of species and stations creates a gradient, where in this case stations classified as having "High Disturbance" had higher abundances of species at the bottom of the dendrogram, while stations considered to be "Reference" or having "Moderate Disturbance" had higher abundances of species at the top of the dendrogram. Species that fall in the middle of the dendrogram tend to be prevalent across more (or all) groups compared to those at either end. Shade plots are also useful to examine the presence/absence of species of interest in each group. For example, the non-native mollusc species *Musculista senhousia* (recently reclassified as *Arcuatula senhousia*) and *Theora lubrica* were present across all station groups, while the non-native annelid *Pseudopolydora paucibranchiata* and tube-dwelling amphipod *Monocorophium acherusicum* were present across stations identified as "Reference" or with "Low Disturbance" but were absent at sites classified as having "High Disturbance." Based on the BRI sensitivity scores *P. paucibranchiata* are considered to be relatively tolerant of pollution while *M. acherusicum* is considered a sensitive species.

Shade plots can also help identify species which may disappear from highly disturbed areas, such as the annelids *Cossura sp A* and *Leitoscoloplos pugettensis* despite being considered tolerant to pollution according to the BRI. Conversely, the non-native tube-dwelling annelid *Streblospio benedicti* was only found at a highly disturbed station along with native species such as the annelid *Neanthes acuminata* and the snail *Acteocina carinata* which were found in the highest densities at stations considered to have "Highly Disturbed" benthic communities. All three of these species are also considered to be relatively tolerant of pollution according to the BRI.

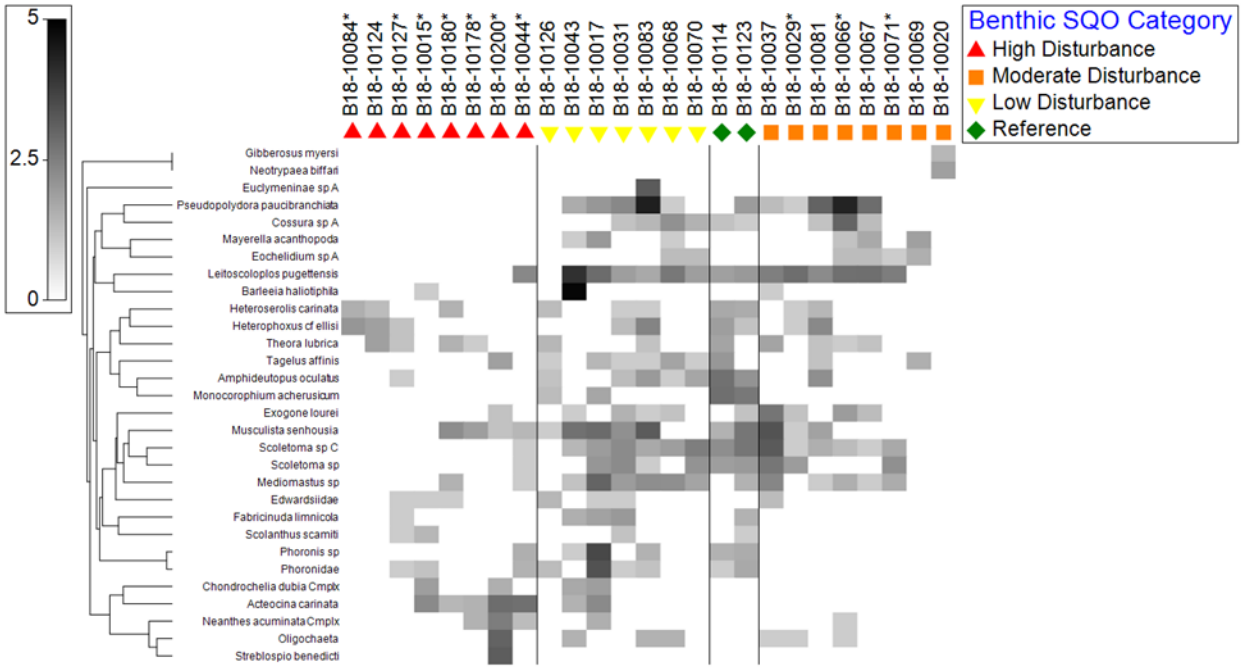

Figure 3-5. Shade Plot of Benthic Infauna Abundance (30 Species) with Stations Labeled by Location and Grouped by Benthic SQO Category

*Scale is 4th root-transformed abundance. Target stations indicated by **

3.3.2 Sediment Chemistry and Grain Size

PCA was performed to evaluate multivariate relationships between sediment chemistry, physical characteristics and the four factors: location, strata, benthic SQO category, and chemistry SQO category (**Figure 3-6**). PCA was performed on sediment chemistry and grain size data (square-root transformed) using Euclidean distance matrices. The results were plotted on the two principal component axes that accounted for the highest variability (i.e., axis that best separate the stations from one another), with PC1 representing 40.4% of the variation and PC2 representing 21.9% of the variation for a total of 62.3%. An ANOSIM for each factor group found that there were global statistically significant differences for stations grouped by location and chemistry SQO category, but strata and benthic SQO category were not significantly different from one another. The analysis, like nMDS, further indicates that there are unique characteristics among these four groups that relate in this case to sediment chemistry and physical characteristics and further justify keeping these categories distinct for additional analyses.

Based on the total variance explained and consistent with conclusions based on univariate relationships, this analysis also provides a strong indication among the samples included for this evaluation that other factors must be contributing to impacts on the benthic community measures as opposed to sediment chemistry and physical characteristics alone.

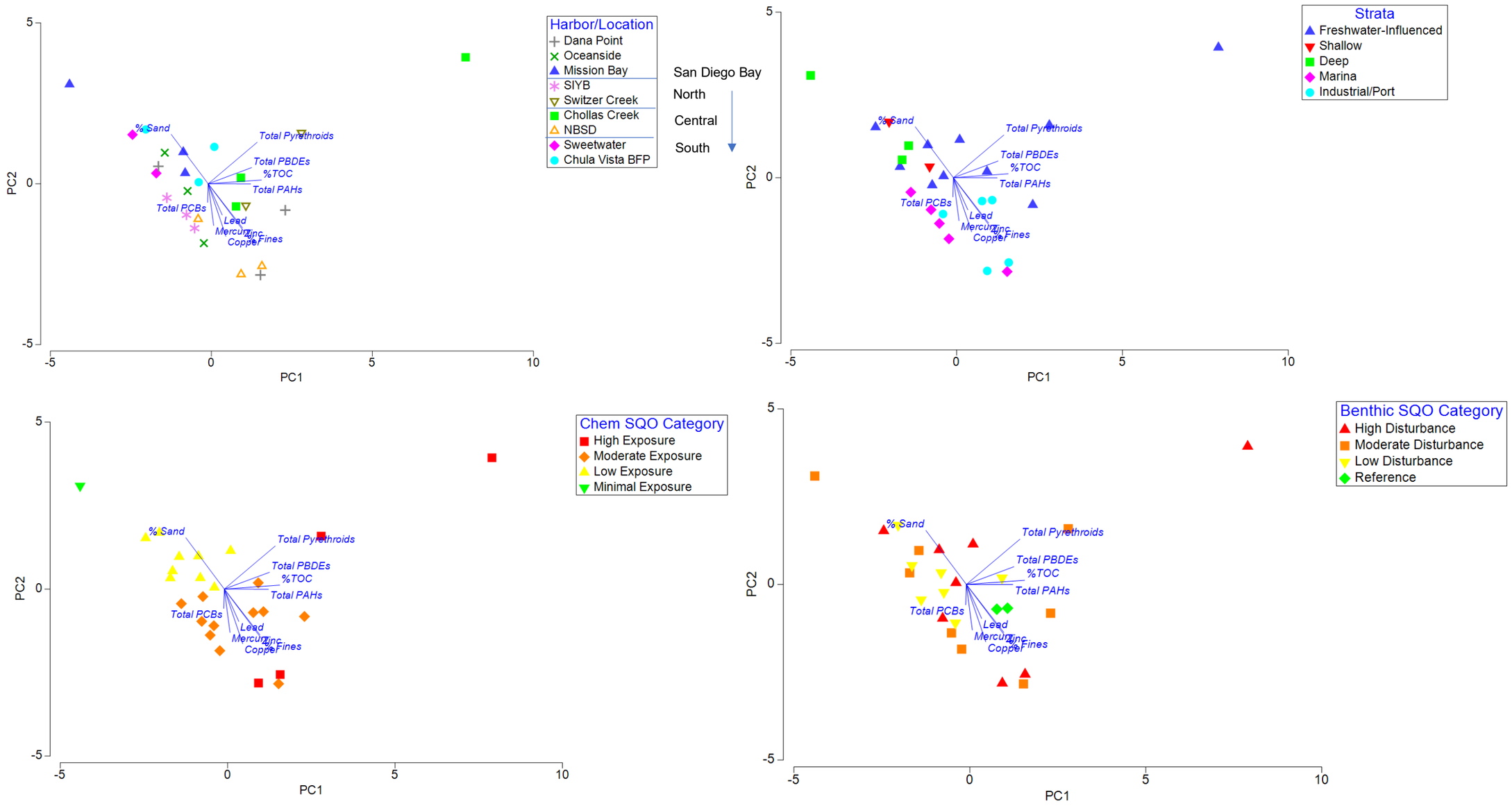

Figure 3-66. Principal Components Analysis (PCA) of Sediment Chemistry and Grain Size

SIYB=Shelter Island Yacht Basin. NBSD=Naval Base San Diego. Chula Vista BFP=Chula Vista Bayfront Park. North San Diego Bay includes SIYB and Switzer Creek, Central San Diego Bay includes NBSD and Chollas Creek, South San Diego Bay includes Sweetwater and Chula Vista BFP.

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3.3.3 Modeling Influence of Sediment Chemistry on Benthic Infauna Community

An assessment of the extent to which chemistry may explain benthic community composition using all input variables both combined and individually was performed using the RELATE permutational model and BEST/BIOENV analysis in PRIMER. The RELATE returned a statistically significant relationship for the target and comparison stations, which is similar to what was observed in the 2018 RHMP. This analysis showed that the highest correlation of chemistry to the benthic infauna (37.6%) combines percent fines, percent sand, lead, total PCBs, and total pyrethroids. Percent fines had the highest correlation (25.8%) out of any single constituent. These results further support conclusions from the other statistical and graphical analyses that all indicate multiple complex factors must be responsible for observed effects on the benthic infaunal communities in addition to sediment chemistry. Factors may include measures that were not included in this assessment such as the degree of physical disturbance and the frequency and magnitude of influence from freshwater.

3.4 Site by Site Comparisons

3.4.1 Station B18-10066 Dana Point Harbor, Freshwater-Influenced (Moderate Disturbance)

Target Station B18-10066 was located within the marina boat slips in Dana Point Harbor and near a storm drain outfall (see map on right and **Figure 2-1**). This location was classified as having a "Moderate Disturbance" benthic community with low-moderate taxa richness and high abundance (25 taxa collected and 577 individuals). The nearby comparator sites were Station B18-10067, also within the marina boat slips, and B18-10068 near the harbor mouth in the main navigation channel.

Integrated Benthic SQO Scores for Causal Assessment Sites in Dana Point Harbor

The comparator stations B18-10067 (Moderate Disturbance) and B18-10068 (Low Disturbance) had taxa richness values of 18 and 28, and abundances of 178 and 174, respectively. Invertebrate abundance was dominated by *Pseudopolydora paucibranchiata* (338 individuals, 59% of community) at target Station B18-10066, an invasive spionid polychaete which is relatively tolerant of generalized pollution (i.e., high individual p-code). This is in contrast to the two nearby

comparator stations which had 67 and a single *P. paucibranchiata* collected at B18-10067 and B18-10068, respectively.

Both target Station B18-10066 and comparator Station B18-10067 were rated as having "Moderate Exposure" based on the SQO chemistry LOE, while comparator Station B18-10068 was classified as having "Low Exposure". This differential in chemistry rating corresponds with both target Station B18-10066 and comparator Station B18-10067 that were classified as having "Moderate Disturbance" benthic communities, while comparator Station B18-10068 had "Low Disturbance." The CSI-CCS weighted mean chemistry score, an indicator of overall chemical exposure potential, for target Station B18-10066 and comparator Station B18-10067 were almost identical at 2.00 and 2.02, while comparator Station B18-10068 had a lower score of 1.38 (i.e., less chemical influence).

According to the BRI index, a mean pollution tolerance score of ≤39.96 for all taxa at a site (i.e., mean p-code) is the threshold below which a site would be considered in reference condition. For the purposes of this causal assessment report, this threshold was used to determine if an individual taxon was considered sensitive. Furthermore, p-code values below this threshold were further subdivided into moderately sensitive (p-codes <20) and very sensitive (p-codes <10). No very sensitive species (individual p-code value <10) or moderately sensitive species (individual p-code values <20) were observed at either target Station B18-10066 or comparator Station B18-10067, whereas 38% of the taxa at comparator Station B18-10068 had a p-code <20. Additionally, the mollusk *Asthenothaerus diegensis* was observed at comparator Station B18-10068, a positive marker within the RBI metric indicative of a good quality benthic community.

Both target Station B18-10066 and comparator Station B18-10067 had elevated copper and zinc concentrations, with copper concentrations at both stations falling into the CSI chemistry category of highest potential impact to benthic infauna (>406 milligrams per kilogram (mg/kg)). Zinc was in the second highest SQO chemical category at both the comparator Station B18-10067 and target Station B18-10066 (>201 - ≤629 mg/kg). Pyrethroid pesticides are not part of the SQO chemistry line of evidence; however, total concentrations observed were much higher at target Station B18-10066 (32 micrograms per kilogram (µg/kg)), than at either of the two comparator stations (2.9 and 7.3 µg/kg). Calculated toxic units for total pyrethroids (normalized for organic carbon content) was 1.74 for target Station B18-10066, approaching a threshold of 2.0 considered to be toxicologically relevant to the marine amphipod *Eohaustorius estuarius* (Lao et al., 2010). Target Station B18-10066 is a freshwater-influenced site near a storm drain, which was likely the source of the pyrethroid pesticides. This station also had greater concentrations of both total DDTs and chlordanes than either of the comparator stations, although the SQO CSI chemistry model had these chemicals rated as presenting minimal or low concern. Comparator Station B18-10068 did not exhibit any measured chemical concentrations above thresholds of concern.

In summary, multiple lines of evidence at target Station B18-10066, and at the nearby comparator Station B18-10067 indicate that elevated chemistry is likely the primary stressor to the benthic community at these locations. Copper, zinc, and pyrethroid pesticides all appear to have potential to cause both toxicity and benthic community impacts based on measured concentrations above levels documented to cause both toxicity in the laboratory and associated with impaired benthic communities (Swartz et al., 1988; Amweg et al., 2005; Anderson et al., 2008; Lao et al., 2010).

3.4.2 Station B18-10071 Oceanside Harbor, Deep (Moderate Disturbance)

Integrated Benthic SQO Scores for Causal Assessment Sites in Oceanside Harbor

Target Station B18-10071 just inside the mouth of Oceanside Harbor was classified as having a community indicative of "Moderate Disturbance" (see map on right and **Figure 2-2**). The "Moderate Disturbance" rating of this station was driven by the RBI and RIVPACS benthic indices, rating this station as having "High" and "Moderate" benthic disturbance, respectively. The RBI rated the site as having "High Disturbance" largely due to low numbers of mollusks and crustacea taxa, which are more highly weighted submetrics within the RBI. The RIVPACS metric classified this site as having "Moderate Disturbance", but this was likely because the species composition was unique, and the majority of the organisms present (81%) were below the capture probability required by RIVPACS model (>50% capture probability). In contrast, the BRI classified the benthic community at this site as being in "Reference" condition and the IBI indicated "Low Disturbance". Notably, 47% of the taxa collected at target Station B18-10071 were "very sensitive", pollution-intolerant organisms with individual p-codes of <10, which may indicate that pollutant stressors are less of a concern at this site. This contrasts with the other two comparator sites within Oceanside Harbor (B18-10069 and B18-10070) which had fewer "very sensitive" taxa. Chemical concentrations were generally low at target Station B18-10071 as indicated by the "Low Exposure" chemistry rating, while the other two comparator sites were rated as having "Moderate Exposure". Interestingly, despite the relative increased potential for chemical stressors at comparator Station B18-10070, the mollusk *Asthenothaerus diegensis* was observed at this location, one of three indicator species considered a positive sign of healthy conditions within the RBI index. Several other taxa considered pollution-intolerant (i.e., sensitive) were also found at comparator Station B18-10070, leading to the conclusion that if sensitive taxa are found at a nearby site with a higher level of chemical stress than target Station B18-10071, then it is likely that the "Moderate Disturbance" rating at B18-10071 is not driven by any of the chemical stressors measured. In addition, the CSI-CCS cumulative scores for these three stations increased in magnitude of chemical stress moving further back into the marina which corresponded with a decreasing percent of sensitive taxa along that same gradient. This further showed that chemical stress was not a likely cause of the stress at the target station.

One other line of evidence that suggests chemistry did not play a significant role in the "Moderate Disturbance" classification at target Station B18-10071 is the similarity in species composition to other sites relative to their SQO benthic community condition. Among all sites sampled for the 2018 RHMP, nMDS showed that the benthic community at target Station B18-10071 was most similar to B18-10117 (North San Diego Bay), B18-10070 (Oceanside Harbor), and B18-10023 (North San Diego Bay). All three of these sites were classified as being representative of "Reference" communities or having "Low Disturbance."

Furthermore, the entrance channel to Oceanside Harbor, as well as the outer channels leading to the Del Mar Boat Basin and Oceanside Harbor are dredged annually. While the entire footprint is not dredged every year, the area where B18-10070 is located is dredged regularly. No dredging was conducted in 2018 prior to the RHMP sampling effort, but the area was dredged in June 2017. It is highly likely that the regular dredging of the outer channels of Oceanside Harbor impacts the benthic community even with the 12-month recovery time between the summer 2018 RHMP sampling and the previous dredging in 2017.

Evidence appears to support the conclusion that the "Moderate Disturbance" rating of the benthic community at target Station B18-10071 is not being driven by chemistry, but rather a physical disturbance, likely due to regular dredging and tidal scouring in addition to the unique benthic community at this location that did not fit the RBI and RIVPACS models.

3.4.3 Station B18-10015, Freshwater-Influenced (High Benthic Disturbance) and Station B18-10020, Deep (Moderate Benthic Disturbance), Mission Bay

Target Station B18-10015 located in eastern Mission Bay (see map on right and in **Figure 2-3**) was classified as having a "High Disturbance" benthic community consisting of low taxa richness and abundance (9 taxa collected and 54 individuals). However, of the taxa present, 29% were considered "very sensitive" with an individual p-code of <10. The site was also characterized as having "Low Exposure" to chemical stressors according to the SQO methodology. This contrasts with the nearby comparator Station B18-10017 (~630 meters away), which, while also

Integrated Benthic SQO Scores for Causal Assessment Sites in Mission Bay

Bat and round ray feeding pits in the vicinity of Station B18-10015 in east Mission Bay

having a "Low Exposure" SQO rating to chemicals measured, had a "Low Disturbance" benthic community score despite having a lower percentage of "very sensitive" taxa (14% with p-code <10). The four SQO benthic indices for target Station B18-10015 were quite variable ranging from "Reference" to "High Disturbance", with the BRI rating the station as "Reference", RIVPACS/RBI rating it as "High Disturbance", while the IBI rated it as "Moderate Disturbance". All three indices that rated it as highly or moderately disturbed, heavily weight taxa richness, while the BRI only uses pollution tolerance of taxa present. The low ratings of the RIVPACS/RBI/IBI indices and nMDS plot (**Figure 3-4**) likely indicate a unique community structure rather than poor sediment quality, as the site had low overall chemical exposure. Target Station B18-10015 is located within the inner portion of Mission Bay with limited tidal exchange, and is close to being an intertidal location, becoming very shallow during the lowest tides of the year. These site characteristics may result in a unique benthic community relative to nearby stations at a lower tidal elevation. Additionally, with the exception of one taxon (Phoronida), and possibly the copepod *Euphilomedes carcharodonta* of which there was only one individual, all taxa observed at target Station B18-10015 were epibenthic (surface dwellers). This contrasts with the nearby comparator site B18-10017 which consisted primarily of burrowing infauna. This area of Mission Bay is known to be an area of high feeding activity for round rays (*Urobatis halleri*) and bat rays (*Myliobatis californica*) during which they disturb the sediment, removing the majority of organisms from the pit left behind as they do so (O'Shea, 2011). If the area sampled was recently disturbed in this way, it is highly likely that the benthic infauna community had not recovered yet and would appear altered. Given the "Low Exposure" rating for chemical stressors according to the SQO method, a significant portion of the benthic community considered to be "very sensitive" to pollution, and the fact that the nearby comparator station with the same level of chemical stress was observed to have a "Low Disturbance" benthic infaunal community, it would appear that the benthic community at target Station B18-10015 was considered "Highly Disturbed" as a result of physical disturbance, a tidal regime outside of the conditions the SQO was developed for, or both.

One other possibility considering that target Station B18-10015 is near the input of Cudahy Creek, is that a pollutant not measured could be influencing the benthic community. Pyrethroids are not included in the SQO chemistry score calculations but were detected at target Station B18-10015. However, it is unlikely that these were the cause of the benthic disturbance, because after normalizing for total organic carbon, the calculated pyrethroid toxic units were 0.75, well below a threshold of 2.0 considered to be toxicologically relevant to the marine amphipod *E. estuarius* (Lao et al., 2010). While alpha-chlordane, gamma-chlordane, and total DDE concentrations were slightly higher at target Station B18-10015 than observed at the comparator Station B18-10017, these concentrations were also unlikely high enough to explain the large difference in quality of the benthic community at these two stations (i.e., low vs. high disturbance).

A second Target location evaluated is Station B18-10020 near the mouth of Mission Bay. Despite the overall station condition rating of "Likely Unimpacted", the benthic community LOE was rated as being "Moderately Disturbed". The two other SQO LOEs were both in the best condition category possible, with the chemistry LOE exhibiting "Minimal Exposure" and the toxicity LOE at "Non-toxic". This location had 18 taxa, but a low abundance of 40 individuals. However, despite the "Moderately Disturbed" rating, a high percentage of the benthic taxa observed at the site (82%) were considered sensitive taxa (p-code <39.96), and 46% of the taxa were considered "very sensitive" (p-code <10). Given its proximity to the mouth of the bay, the relatively narrow channel, and the high percent sand substrate (90.8% sand), it is likely that in addition to the prevalence of sand at this location, strong tidal currents and sand movement have caused sediment scouring at this location resulting in a unique benthic community. This has been demonstrated in other studies that have shown benthic communities in areas of high coarse sand content are lower in total taxa richness, biomass, and abundance from those in areas of sand/silt mixtures or those dominated by silts/clays (McLachlan et al., 1993; McLachlan, 1996).

3.4.4 Station B18-10084 North San Diego Bay, Marina (High Disturbance)

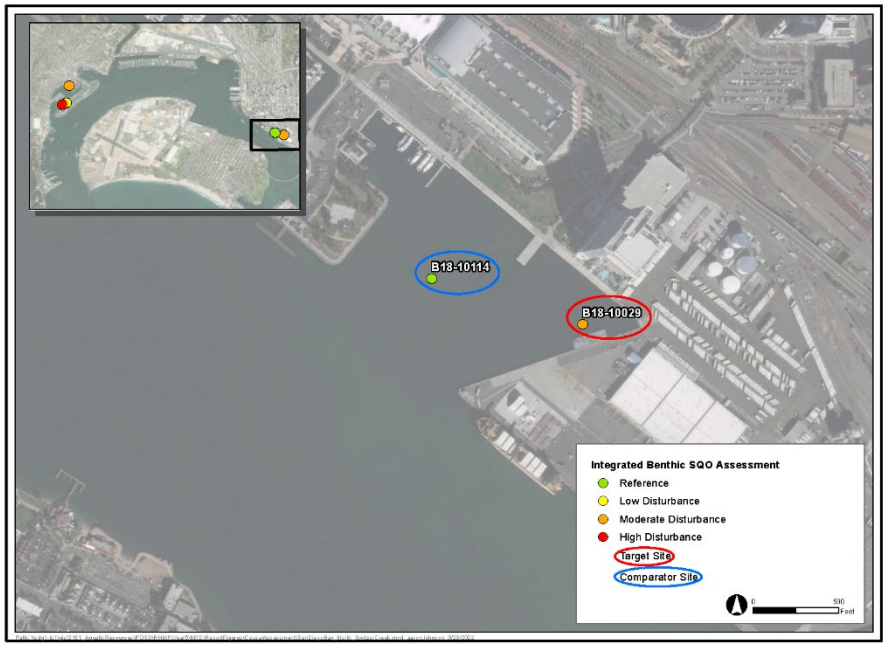
Target Station B18-10084 is located within Shelter Island Yacht Basin, approximately 750 meters from the entrance of the basin into San Diego Bay (see map below and **Figure 2-4**). The station had low taxa richness with a total of 6 taxa collected and only 28 individuals. This is in sharp contrast to a nearby comparator Station B18-10083 (~150 meters away) which had 43 taxa and 802 individuals, and comparator Station B18-10081 (near the innermost portion of Shelter Island Yacht Basin) which had 26 taxa and 244 individuals. While comparator Station B18-10083 and target Station B18-10084 were very close to each other, the two station locations differed in that target Station B18-10084 was in the main navigation channel adjacent to slips with large boats, while comparator Station B18-10083 was sheltered within smaller boat slips. It is very likely that scouring could be a stressor at B18-10084. This is based on location of the site within the main navigation channel and is further supported by the benthic community. All of the organisms collected at target Station B18-10084 were epibenthic (reside primarily on the surface of the sediment), with no exclusively burrowing infaunal organisms collected which normally would be

Integrated Benthic SQO Scores for Causal Assessment Sites
in North San Diego Bay – Shelter Island Yacht Basin (black box)

expected at a site in a shallow sheltered location with a substrate consisting of predominantly fine sediment. This could indicate that the area had been recently scoured and the organisms had not recovered yet. Additionally, the BRI index rated the station as representative of a "Reference" benthic community condition. Of the taxa collected at B18-10084, 50% had p-codes ≤39.96 indicating that the taxa present were generally more sensitive, pollution-intolerant organisms. All other indices rated the benthic community as "High Disturbance", which is likely a function of the low taxa richness. The remaining indices (IBI, RBI, and RIVPACS) all heavily weight overall taxa richness and/or presence of specific individual taxa or taxa categories (e.g., mollusks). All three sites evaluated in Shelter Island Yacht Basin for this assessment were considered to have "Moderate Exposure" based on the chemistry SQO LOE. While all three sites had some elevated levels of chemicals, target Station B18-10084 had the lowest CSI-CCS cumulative score, indicating a lower level of chemical stressor exposure than the two comparator stations. Given that the two comparator sites within Shelter Island Yacht Basin had higher CSI-CCS scores (and in the case of B18-10081, substantially higher), yet lower levels of benthic disturbance, these results suggest that chemical stressors were not the main driver of the "High Disturbance" rating of the benthic community at target Station B18-10084. Additionally, pyrethroids, which have been identified as a chemical class of concern at other RHMP locations evaluated, were not detected at target Station B18-10084. Based on this evaluation, chemical impacts at this site being the driver appear unlikely with sediment physical disturbance a more likely cause for impairment.

3.4.5 Station B18-10029 North San Diego Bay, Freshwater-Influenced (Moderate Disturbance)

Target Station B18-10029 (see map on right and **Figure 2-4**) is in proximity to the mouth of Switzer Creek and adjacent to the 10th Avenue Marine Terminal. The SQO methodology classified the benthic community at this location as "Moderately Disturbed", with an infaunal taxa richness of 31 taxa and an abundance of 125 individuals, dominated by the pollutant-tolerant (high p-code of 64.4) polychaete *Leitoscoloplos pugettensis* (64 individuals, 51% of the community). The Shannon-Wiener Diversity Index at the site was 1.94, with no other species beside *L. pugettensis* having more than 14 individuals. While organisms with high p-codes can be found at sites with good sediment and water quality, they tend to comprise a



Integrated Benthic SQO Scores for Causal Assessment Sites in North San Diego Bay – Switzer Creek (black box)

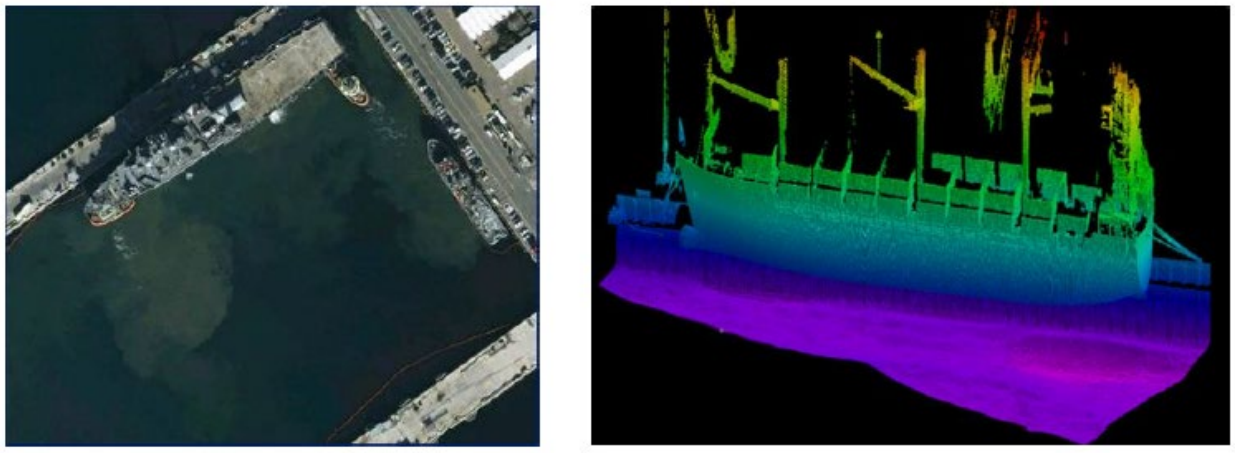
smaller proportion of the community. Conversely, these insensitive taxa tend to dominate sites with poor sediment or water quality. The nearby comparator Station B18-10114, approximately 310 meters away and just offshore of the Embarcadero Marina Park South, was classified as having a “Reference” benthic community. While having only a slightly higher taxa richness (39), the site had an abundance of 295 individuals, a higher Shannon-Wiener Diversity Index of 2.68, and a top dominant species that comprised only 21% of the community.

The benthic community at target Station B18-10029 was classified as having “Low Disturbance” by the BRI and IBI, but ”High Disturbance” by the RBI. Both “negative” taxa sub-metrics of the RBI were present at this site, while none of the three “positive” taxa sub-metrics were present. Conversely, seven individuals of the “positive” RBI taxon *Asthenothaerus diegensis* were observed at the comparator Station B18-10114.

Chemical concentrations overall were elevated resulting in the target Station B18-10029 being classified as having “High Exposure” to chemicals measured, with 8 of the 11 standard SQO analytes measured falling into the second highest CSI chemistry category of potential impact to benthic infauna. The CA-LRM chemistry sub-metric value indicated ”High Exposure” based on the SQO chemistry LOE. The CA-LRM identified zinc and chlordane as having the greatest potential impact, while the CSI sub-metric showed the trace metals copper, lead, and zinc as the strongest drivers of the SQO chemical exposure scores. The CSI also indicated that chlordanes were elevated and of potential concern. The chlordane concentration (22.7 µg/kg) at this station was the second highest among all RHMP stations and was more than 3 times the effects range median (ERM), which represents an estimated concentration above which adverse effects frequently occur based on a literature evaluation conducted by Long et al. (1995) to develop screening chemical guidelines for sediments. However, studies conducted by Phillips et al. (2008) and Stransky et al. (2006) found that concentrations of chlordane greater than 46 µg/kg did not cause toxicity to the burrowing amphipod *E. estuarius* in controlled laboratory studies.

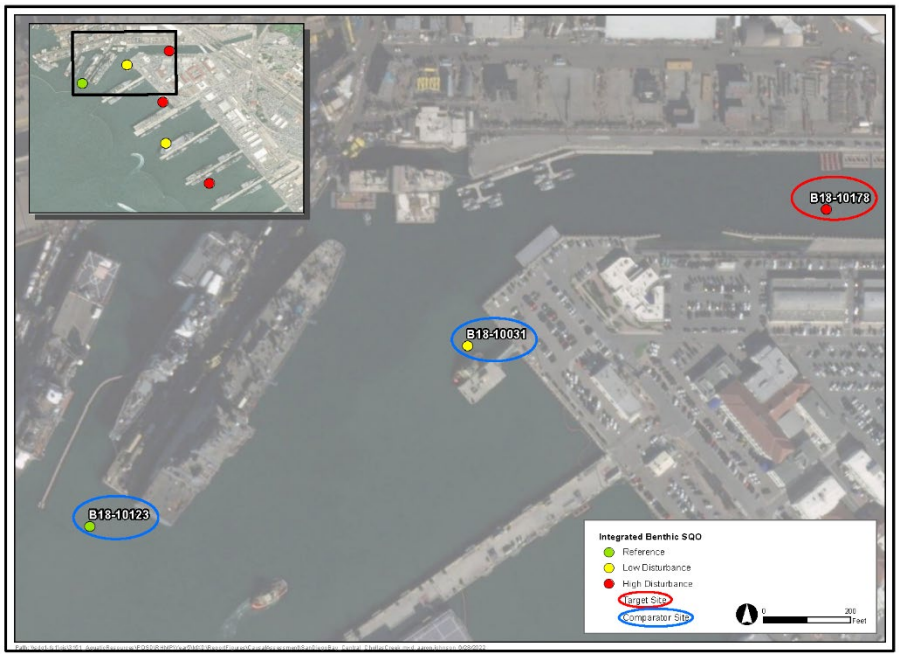
In addition, the pyrethroid concentration observed at target Station B18-10029 was the second highest among all RHMP stations at 57.4 µg/kg. An organic carbon normalized pyrethroid toxic unit value of 1.87 was calculated for this site, which approaches a toxicologically relevant toxic unit of 2.0 for the marine amphipod *E. estuarius.* The elevated chemistry in the sediment does appear to be a likely factor of potential concern for benthic communities at target Station B18-10029, but the sediments were also notably nontoxic according to the SQO toxicity line of evidence.

A few known potential confounding factors at this location include physical disturbance from scouring during large runoff events and prop wash related to tugboats docking ships at 10th Avenue Marine Terminal. An aerial photo below of tugboats docking a ship at Naval Base San Diego shows sediment plumes related to prop disturbance. Also notable at this location is the occasional accumulation of trash both in the surface waters and surrounding shoreline, as well as the sediment surface noted during diver surveys of the area.



Aerial photo of tugboats docking a ship at Naval Base San Diego (Google Earth) and a LIDAR picture of a ship at 10th Ave (Fugro). Terminal in San Diego showing a divot in the sediments related to prop disturbance.

3.4.6 Station B18-10178 Central Diego Bay, Freshwater-Influenced (High Disturbance)



Integrated Benthic SQO Scores for Causal Assessment Sites in Central San Diego Bay – Chollas Creek (black box)

Target Station B18-10178 is located within the mouth of Chollas Creek in an enclosed industrialized channel (see map on right and **Figure 2-5**). The station receives considerable freshwater runoff from the urbanized upstream watershed and was dredged in 2016. A total of 12 taxa consisting of 40 individuals were identified at this location. The sediment at the station had a moderate percent fines content (67%) and many infaunal/burrowing organisms (e.g., four polychaete taxa and three bivalve taxa). The four benthic indices of the SQO were somewhat variable; three of the four SQO metrics rated the site as having a benthic community representative of "Moderate" or "High Disturbance", while only the BRI rated the site as having "Low Disturbance". Two of the 12 taxa observed at the station were considered "very sensitive" (p-code <10), hence the "Low

Disturbance" BRI rating. However, the RIVPACS rating of "High Disturbance" may not have adequately characterized the station, as according to RIVPACS 58% of the taxa collected were not expected to occur at the site (i.e., a capture probability <50%), including the two "very sensitive" taxa. Two nearby comparator stations selected for evaluation (B18-10031 and B18-10123) were close to the mouth of Chollas Creek, with B18-10031 just outside the confined channel (but still categorized as a freshwater-influenced station), and B18-10123 in front of Chollas Creek but further out in the bay (see map above and **Figure 2-5**). A gradient in the SQO benthic community rating was observed among the three stations, with the benthic infaunal community improving as the station locations moved toward the bay. Target Station B18-10178 was rated as having "High Disturbance", while comparator stations B18-10031 and B18-10123 were considered to have "Low Disturbance" and "Reference" benthic communities, respectively. Both comparator stations contained much higher taxa richness (49 and 43 taxa), a greater fraction of sensitive taxa according to the BRI metric (38 and 49%, compared to 33% for target Station B18-10178), and higher number of crustacean taxa (10 and 13, versus 1 at B18-10178). Additionally, four *Asthenothaerus diegensis* individuals were observed at comparator Station B18-10123, a bivalve species considered to be a positive indicator of healthy conditions according to the RBI SQO metric.

Target Station B18-10178 was rated as having "High Exposure" to chemicals of concern based on the SQO approach. Of those chemicals measured as part of the SQO suite, concentrations of total chlordanes (46.8 µg/kg), total DDTs (26.7 µg/kg), copper (108 mg/kg), zinc (294 mg/kg), and high molecular weight PAHs (2329 µg/kg) were all considered elevated. Total chlordanes were measured at a concentration 4.5 times the ERM, the highest concentration at any RHMP station in 2018. Similarly, the total pyrethroid concentration at target Station B18-10178 was the highest of any RHMP station (127 µg/kg), 2.2 times the next highest concentration. A summed pyrethroid toxic unit of 3.76 (normalized for organic carbon) was well above the 2.0 threshold considered to be of toxicological concern for marine amphipods (Lao et al., 2010). The concentrations of both chlordanes and pyrethroids exhibited a decreasing gradient across the three sites as they moved away from the mouth of Chollas Creek. Total chlordanes dropped from 46.8 to 10.7 to 4.4 µg/kg across the three sites, while total pyrethroids decreased from 127 to 24.2 to 14.9 µg/kg (toxic units of 3.76, 0.97 and 0.60, respectively). While not a consistent gradient across the three sites, total DDTs also decreased significantly from 26.7 µg/kg at target Station B18-10178 to 5.4 and 6.2 µg/kg at the two comparator stations. Also of note, is that while the two comparator sites were "Nontoxic" according to SQO methodology, target Station B18-10178 exhibited "Low Toxicity".

The area near the mouth of Chollas Creek has been sampled during previous RHMP monitoring events (n=9 in RHMP 2008 and 2013 combined) and in each case received an integrated SQO benthic community rating of "Low Disturbance" or "Moderate Disturbance". However, since the initiation of RHMP in 2008, target Station B18-10178 is the first RHMP sample to be collected within the industrial channelized portion of the mouth of Chollas Creek. A study performed by the Southern California Coastal Water Research Project (SCCWRP) and Space and Naval Warfare Systems (SPAWAR) in 2001-2004 (SCCWRP and SPAWAR, 2005) sampled sediment in three locations within the industrial channelized portion of the mouth of Chollas Creek. All three of these samples were considered as having high concentrations of chemical stressors, and two of the three samples had highly disturbed benthic communities.

Other potential stressors at target Station B18-10178 could include the 2016 dredging event, low salinity due to freshwater flows from Chollas Creek during storm events, or scouring from boat activity, as large tugboats are typically docked within this channel. However, while other stressors are present within the channel and could have influenced the benthic community there, the presence of a correlated gradient of chemistry and benthic community condition suggests that elevated chemistry was the primary driver of the degraded benthos at target Station B18-10178.

3.4.7 Station B18-10127 Central San Diego Bay, Industrial/Port (High Disturbance)

Integrated Benthic SQO Scores for Causal Assessment Sites in Central San Diego Bay – NBSD (black box)

Target Station B18-10127 (see map on the right and **Figure 2-5**) is located within the naval shipyards on the eastern portion of San Diego Bay, just beside a ship berthing area. This station had very low taxa richness with a total of only 7 taxa collected and a total abundance of only 9 individuals, only one of which was considered sensitive (i.e., low p-code value). The majority of the organisms were infaunal (burrowing), and the substrate was 75% fines, both indicating that scouring was likely not an issue at this specific location. The BRI classified the site as having a benthic community representative of "Low Disturbance", while the other three SQO indices all classified the site as being representative of communities with "Moderate" or "High Disturbance". The nearby comparator Stations B18-10124 and B18-10126 were both located within the Naval Base San Diego (NBSD) berthing areas. The integrated benthic SQO metric also rated comparator Station B18-10124 as having "High Disturbance", while comparator Station B18-10126 was classified as having "Low Disturbance". Three of the four SQO benthic indices were rated as having "High Disturbance" for comparator Station B18-10124, whereas two of the four SQO indices at comparator Station B18-10126 considered this site to be representative of a "Reference" benthic community. The better scoring benthic community at comparator Station B18-10126 was primarily due to higher taxa richness, a greater number of crustacean taxa, and a greater proportion of sensitive taxa (p-code <39.96) relative to the other two sites classified as "Highly Disturbed." In addition, a positive indicator within the RBI metric, the bivalve *Asthenothaerus diegensis*, was found at comparator Station Site B18-10126.

Both comparator site B18-10124 and target Station B18-10127 were considered to have "High Exposure" based on the SQO chemistry LOE, which likely is the reason for the degraded benthic communities at these sites. Based on the SQO approach, the primary chemical stressors at target Station B18-10127 include lead (367 mg/kg), copper (196 mg/kg), zinc (255 mg/kg), and total PCBs (76.1 µg/kg). Lead had a considerably higher concentration than any of the other stations evaluated during the 2018 RHMP, with a concentration 1.7 times the ERM. The concentration of copper was near the ERM of 270 mg/kg. Comparator Station B18-10124 also had elevated concentrations of copper (228 mg/kg) and zinc (313 mg/kg). The CSI-CCS cumulative chemistry scores were very similar at 2.50 and 2.46, for comparator Station B18-10124 and target Station B18-10127, respectively, indicating similar levels of chemical stress to the biota. In contrast, comparator Station B18-10126 exhibited "Moderate Exposure" to chemicals measured with consistently lower levels of chemical concentrations and a CSI-CCS cumulative score of 2.17. Pyrethroids and chlordanes were all below the method detection limit at target Station B18-10127.

Based on the multiple lines of evidence evaluated it appears elevated chemistry is likely a primary stressor affecting benthic communities at target Station B18-10127 as well as nearby comparator Station B18-10124.

3.4.8 Station B18-10180 South San Diego Bay, Freshwater-Influenced (High Disturbance)

Target Station B18-10180 is located at the mouth of the Sweetwater River near the berthing offload area for automobile transport container ships (see map to right and **Figure 2-6**). The benthic community at this station was considered to have "High Disturbance", largely as a result of the low taxa richness (n=12) and abundance (n=51 individuals). All four SQO indices categorized the site as having either "Moderate Disturbance" or "High Disturbance". A nearby comparator Station B18-10037 located approximately 170 meters further toward the bay, contained 41 taxa and 504 individuals and was rated as having a benthic community representative of "Moderate Disturbance". Comparator Station B18-10037 had 3 taxa that were considered "very sensitive" (p-code ≤10) while target Station B18-10180 had no "very sensitive" taxa. However, when comparing less

Integrated Benthic SQO Scores for Causal Assessment Sites in South San Diego Bay – Sweetwater Channel (black box)

sensitive taxa with p-codes under 20 or under 40, very little difference was noted between the two sites.

Both sites were categorized as having "Low Exposure" chemistry potential based on the integrated SQO methodology and exhibited similar CSI-CCS scores (1.38 vs. 1.41). The total pyrethroid concentration was also low at target Station B18-10180 (2.34 µg/kg). Similarly, bioassay testing for both sites resulted in no toxicity. Given the low chemical concentrations and no toxicity, it is unlikely that chemistry is a primary driver of the "High Disturbance" benthic community classification at target Station B18-10180.

Notably, target Station B18-10180 happens to be in the vicinity of where large container ships berth at National City Marine Terminal. Sediment plumes resulting from prop wash scouring of the sediments due to tugboats berthing the container ships are routinely observed at this location, as evident in the LIDAR photograph and propwash image presented in Section 3.4.5 (see inset photo). This observation, along with the elevated sand content (18% more sand than the comparator Station B18-10037 (65% vs. 47%), and low chemical concentrations at target Station B18-10180 provides convincing evidence that physical disturbance from prop wash is likely a primary stressor for benthic communities at this location.

3.4.9 Station B18-10200 South San Diego Bay, Freshwater-Influenced (High Disturbance)

Target Station B18-10200 was located in a confined engineered tidal channel (~8 meters wide) in south San Diego Bay between the salt evaporation ponds and the Chula Vista Bayfront Park and Harbor (see map on right and **Figure 2-6**). The channel receives direct freshwater input from a subsurface concrete-lined storm water conveyance that emerges near the western end of L Street.

Integrated Benthic SQO Scores for Causal Assessment Sites in South San Diego Bay – Chula Vista Bayfront Park (black box)

Target Station B18-10200 had 13 total taxa and an abundance of 355 individuals, dominated by oligochaetes and the polychaete, *Streblospio benedicti* (53% of the community combined). Station B18-10200 was classified as having a benthic community indicative of "High Disturbance" according to SQO methodology, despite an SQO rating of "Low Exposure" based on chemical concentrations, and low toxicity. A nearby comparator station selected (B18-10043) for this

evaluation was located just outside of the same tidal channel in slightly deeper water and was classified as having a “Low Disturbance” benthic community. This comparator site had 39 taxa and a total of 1,745 individuals. Two “very sensitive” taxa (p-code ≤10) were collected at target Station B18-10200, whereas 8 “very sensitive” taxa were observed at comparator Station B18-10043. Two of the four SQO benthic indices classified the benthic community at target Station B18-10200 as having ”High Disturbance” (RBI and RIVPACS), the BRI classified it as having “Moderate Disturbance”, while the IBI considered the site to have a benthic community representative of “Low Disturbance.” While a total of 29 taxa were expected by the RIVPACS model, only 3 of the 13 taxa collected at target Station B18-10200 matched.

All but one of the metals measured at target Station B18-10200 were in the “Minimal Exposure” SQO category based on the CSI index (only zinc at 127 mg/kg was in the “Low Exposure” category). Of the pesticides measured as part of the SQO methods, total DDTs and total chlordanes were detected at concentrations of low concern according to the CSI model. An elevated concentration of total pyrethroids was observed at the site (36.4 µg/kg), the third highest concentration across all RHMP sites in 2018. The sum of toxic units based on total pyrethroid concentrations (normalized to organic carbon) was 2.29, above the 2.0 threshold considered to be of toxicological concern for marine amphipods (Lao et al., 2010). Dissolved oxygen near the surface of the sediment was adequate at 8.57 mg/L at the time of collection.

The location of this target station, within a shallow confined channel that receives considerable urban runoff makes it susceptible to physical stressors and the substrate may become exposed on very low tides (field data at the time of collection indicated a water depth of 6.0 feet on a tide of +5.9 feet). These conditions may not match the typical marine estuary habitat conditions defined by the SQO guidance, and the sampling station was unique compared to the other San Diego Bay stations (the only one being within a tidal channel). The influence of freshwater alone due to the proximity to the discharge channel combined with the shallow depth and possibly elevated temperatures are likely to be physical environmental factors that have some influence on benthic communities at this location.

In summary, pyrethroid concentrations are a likely primary stressor of concern at this site based on measured concentrations, but possible exposure at lower tides, direct freshwater influence, and elevated temperatures are all likely to be important factors as well influencing the benthic community at this location. More frequent measures of temperature and salinity would be required to better confirm the impact from these factors of potential concern.

3.4.10 Station B18-10044 South San Diego Bay, Freshwater-Influenced (High Disturbance)

Target Station B18-10044 is located in south San Diego Bay within the vicinity of the intake channel (approximately 200 meters from the intake point) of the decommissioned South Bay Power Plant (see map below and **Figure 2-6**). The site was classified as having a “Highly Disturbed” benthic community by SQO methodology, with two of the four benthic indices rating it as “Highly Disturbed” (RIVPACS and RBI) and two as “Moderately Disturbed” (IBI and BRI). The site was characterized as having low taxa richness (12 taxa) and abundance (115 individuals). No “very sensitive” taxa were observed based on p-codes, but two taxa (Subfamily *Euclymeninae* and Family *Hyalidae*) were considered “moderately sensitive” with p-codes between 10 and 20.

The same comparator site used for target Site B18-10200 was utilized here (B18-10043), approximately 540 meters from target Station B18-10044. Again, the comparator site contained much higher diversity and abundance of benthic infauna, with 3 times as many taxa and 15 times as many individuals compared to that observed at target Station B18-10044.

Target Station B18-10044 had a "Low Exposure" chemistry rating based on the SQO methodology, and exhibited no toxicity. The concentration of pyrethroids at target Station B18-10044 was low (0.46 toxic units organic carbon normalized), and at a concentration similar to that found at the comparator site (3.81 vs. 5.91 µg/kg). Dissolved oxygen near the surface of the sediment was adequate for benthic communities at 7.32 mg/L at the time of collection.

Integrated Benthic SQO Scores for Causal Assessment Sites
in South San Diego Bay – Chula Vista Bayfront Park (black box)

Target Station B18-10044 did have the highest mean water column temperature of any RHMP station in 2018 at 28.6˚C, however three other stations in the nearby area including the comparator Station B18-10043 were also above 28.0˚C.[2] The comparator station (B18-10043) was classified as having a benthic community representative of "Low Disturbance". The two other stations in south San Diego Bay with temperatures above 28.0˚C, B18-10040 and B18-10087, were considered to have benthic communities indicative of "Moderate Disturbance". These two sites are not considered comparator sites as defined in this report, in that they are further afield and in a different local environmental context, however being in south bay do provide some context for elevated temperatures. These two moderately disturbed stations are located in a freshwater influenced area and marina, respectively. Station B18-10087 was characterized as having "Moderate Exposure" to chemicals of concern based on the SQO methodology, however B18-10040 had lower chemical concentrations resulting in a "Minimal Exposure" SQO chemistry rating. Of all 2018 RHMP sites having mean water column temperatures above 27.0˚C, 7 of the 10 were rated as having benthic communities indicative of either "Moderate" or "High Disturbance", and all were in south San Diego Bay, with the exception of Site B18-10015 in Mission Bay. So, it is possible that elevated temperature played a role in the lower quality benthic community at target Station B18-10044, however the "Low Disturbance" benthic community at the

[2] Note that these temperatures represent only a single point in time when the sediment samples were collected, thus do not represent the actual average or range of temperatures experienced at these sites over longer time periods.

nearby comparator Station B18-10043 could counter this explanation unless the average temperature at B18-10043 might be lower as a result of currents at this more exposed location, relative to the protected, more enclosed location of target Station B18-10044. Depth of the sites would not account for the increased temperature at target Station B18-10044 relative to its comparator Station B18-10043 (i.e., might expect shallower sites equating to higher temperature), as the depth at the time of collection was 13.5 feet at target Station B18-10043 and considerable shallower at 5.5 feet at comparator Station B18-10043.

Based on the evidence available, it does not appear that chemicals measured played a role in the "Highly Disturbed" benthic community rating at target Station B18-10044. Elevated water temperatures and poor water circulation likely had some impact on the infauna at this site relative to the more open and exposed comparator Station B18-10043. More frequent measures of temperature and salinity would be required to better confirm the impact from these factors of potential concern.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Benthic communities are complex with many interwoven dynamic factors affecting their characteristics at any given point in time and space. Thus, a weight of evidence approach is required to derive a robust defensible assessment of the infaunal community at a given site. The approach reported herein included an in-depth assessment of specific individual species, community characteristics, and submetrics comprising the multiple SQO indices that ultimately resulted in an impaired community rating. Relationships to physical characteristics, sediment chemistry, toxicity, geographic location, and known activities in the vicinity that might influence the communities were all carefully considered for this evaluation.

4.1 Summary of Disturbances to the Benthic Communities

A mixture of stressors to the benthic communities were observed across the ten RHMP causal assessment sites evaluated, primarily consisting of heavy metals, pesticides, physical disturbance, and possibly elevated temperature/poor water circulation. At five of the ten sites evaluated, elevated chemistry appears to most likely be the primary factor responsible for observed impaired benthic communities including pyrethroid pesticides and chlordane, heavy metals (copper, lead, and zinc in particular), and secondarily, PCBs and DDT. Of the pyrethroid pesticides measured, bifenthrin and permethrin were the most frequently detected, with bifenthrin generally at higher concentrations than the other pyrethroids and most likely associated with potential toxic effects based on laboratory-based studies and calculated median lethal effect (LC_{50}) concentrations (Lao et al., 2010). This evaluation also suggested non-chemical influences in the form of physical disturbance as the primary source of benthic disturbance at four of the ten sites evaluated, with boat propwash scour, dredging activity, and bioturbation as the likely causes. Elevated temperature, poor water circulation, and direct influence from freshwater (low salinity) are additional factors of potential concern that would require more frequent field measurements to confirm further. The observation that sediment characteristics and select chemicals of potential concern did not show consistent patterns when grouped by benthic community SQO categories among the sites evaluated for this assessment, along with the limited variance explained by chemical and physical properties using multivariate statistical techniques, supports the conclusion that factors other than chemical impacts were influencing biological communities at many of the locations evaluated.

A site-by-site summary of the most likely causes of impairment to benthic communities at the RHMP sites selected for this evaluation is summarized in **Table 4-1** using a weight-of-evidence approach based on available data to date.

Table 4-1. Summary of Likely and Potential Stressors Causing Disturbance to the Benthic Communities Evaluated for Select RHMP Sites Sampled in 2018

Site Name	Location	Location Context	Likely Stressor(s)	Other Potential Stressor(s)
B18-10066	Dana Point Harbor	Freshwater-Influenced	Copper, Zinc	Pyrethroids
B18-10071	Oceanside Harbor	Deep	Physical disturbance, Dredging activity	Tidal Scouring
B18-10015	Mission Bay	Freshwater-Influenced	Physical disturbance, Bioturbation (ray feeding pits)	Possible exposure during low tides
B18-10020	Mission Bay	Deep	Tidal scouring	High % Sand
B18-10084	North San Diego Bay	Marina	Physical disturbance, Prop wash scouring	Copper
B18-10029	North San Diego Bay	Freshwater-Influenced	Chlordanes, Zinc	Copper, Lead, Pyrethroids
B18-10178	South-Central Diego Bay	Freshwater-Influenced	Pyrethroids, Chlordanes	DDT, Copper, Zinc
B18-10127	Central San Diego Bay	Industrial/port	Lead, Zinc	Copper, Prop Wash Scouring, PCBs
B18-10180	South San Diego Bay	Freshwater-Influenced	Physical disturbance, Prop wash scouring	Temperature
B18-10200	South San Diego Bay	Freshwater-Influenced	Pyrethroids, Exposure during low tides	Freshwater, Temperature
B18-10044	South San Diego Bay	Freshwater-Influenced	Constrained area with limited circulation and elevated temperature	Freshwater

4.2 Summary of Important Factors to Consider in When Using SQO Metrics for Causal Assessments

The in-depth evaluation of the four individual indices comprising the SQO benthic LOE during this exercise led to a number of valuable insights worth noting when evaluating the SQO benthic condition score of an individual site that may bias the results (more details are provided in **Section 2.3**). A summary of key lessons learned are provided below.

- Use of taxa richness in 3 of the 4 benthic indices of the SQO benthic LOE (IBI, RBI, RIVPACS) could lead to a greater potential for a site to be categorized as impacted in dynamic (physically disturbed) environments or unique environments where you might expect naturally lower taxonomic diversity.
- RIVPACS may falsely consider a site impaired in areas of unique habitats or where rare and sensitive taxa are observed but are excluded from the “observed” taxa list, thereby disregarding a substantial portion of the benthic community.

- Within the RBI LOE, the presence of any of three positive indicator taxa (even a single individual) has an overwhelming influence on the final outcome of the RBI quality rating of the benthic community.
- While the median categorical rating of the four SQO benthic indices is used to determine the overall benthic community condition according to SQO methodology, often valuable information can be gained by digging into the sub-metrics of all four indices and parsing the station's full taxa list to evaluate resident taxa at the species level. This is particularly important when non-chemical factors are suspected, for which the SQO benthic methodology does not differentiate from chemical impacts.

4.3 Recommendations for Additional Lines of Evidence to Support Benthic Infaunal Causal Assessment

This evaluation comprised of a desktop exercise using previously collected data, site and sediment sample photographs, knowledge of geography and known activities at the sites of interest, as well as supporting information from the literature. This assessment provided an opportunity to consider additional measurements that might further support and confirm conclusions reported herein, or to consider proactively at other sites of interest where impairment of benthic communities may be known or of potential concern.

Sample collections for benthic community analysis and associated documentation of field conditions generally happen on a single day at a single point in time. Confirmation of a site's benthic community condition is often best achieved by retesting the same location to determine if the communities are stable or changing. ***Prioritizing the sites evaluated herein for this assessment might be considered for the pool of revisit sites that will be drawn during the next RHMP/Bight Program in 2023.***

Environmental conditions and activities at all harbor and bay sites are dynamic; affected by factors such as tides, currents, winds, runoff, boating activity, dredging, biological activity and seasons. A better understanding of these dynamics would help further interpret how these non-chemical factors influence benthic infaunal communities, either positively or negatively. Many of these measures can be readily achieved with limited resources, though others will require more planning and expense. The following summary provides methods identified for consideration, recognizing that of the utilization of any specific measure would be site-specific.

- **Periodic photographs of the sediment surface and surrounding habitat**. Photographs/ video can be taken remotely with a camera suspended from the surface on a boat or dock, or directly by divers. At shallow sites photographs at low tide can document changes or impacts such as bat ray pits, changing sand bars, and evolving eelgrass beds.
- **Remote cameras**. To capture dynamics over time such as the impacts from large rainfall events at freshwater-influenced sites, ship propwash impacts, tidal exchange, and biological activity.
- **Periodic photographs of the vertical structure of the sediments in clear cores pulled from a Van Veen grab sampler.** A visual of the vertical characteristics can provide clues on stability, potential for disturbance, biological activity, and redox zones. At the same time subsamples of sediment can be collected and characterized for physical characteristics in

the field (color, odor, grain size, etc.) and subsampled if desired for analysis of any chemicals of potential concern or archived just in case. A separate grab for infauna could be collected and preserved as well.

- **Deployment of *in situ* sondes continuously or periodically recording salinity, temperature, and dissolved oxygen to capture dynamics and average conditions occurring over longer time periods.**
- **Sediment trap studies to assess sediment movement, deposition rates, and physical /chemical characteristics.** Pairing traps with an acoustic doppler current profiler (ADCP) can provide information on the predominant direction of sediment transport. A new sediment trap is currently being tested at the Naval Information Warfare Center in San Diego that can collect over a dozen discreet samples at intervals, on command, or programmed to coincide with specific environmental and chemical variables of interest.
- **Sediment transplant and recolonization studies.** Following this very powerful but more resource intensive approach, sediments from an impacted site of interest and an appropriate nearby unimpacted "reference location" are collected, defaunated (remove infauna by freezing), and then placed back in the environment at the opposite location (translocated) and where they originally came from. After a period of 6 months or more, the sediment chambers are retrieved, and benthic communities are evaluated. This preserves the chemical and physical characteristics of the sediment but changes the surrounding environmental conditions. If a healthy benthic community can be established in the impacted sediments translocated to the reference location, indications are that the physical characteristics and chemical composition of the sediment are not the cause for impairment, but rather the surrounding environmental conditions whether physical disturbance, temperature, DO, or other.

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APPENDIX A

RAW BENTHIC COMMUNITY DATA

Station ID	B18-10015	B18-10017	B18-10020	B18-10029	B18-10031	B18-10037	B18-10043	B18-10044	B18-10066	B18-10067
Harbor	Mission Bay	Mission Bay	Mission Bay	North San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay	South San Diego Bay	Dana Point Harbor	Dana Point Harbor
Strata	Freshwater-Influenced	Shallow	Deep	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced	Shallow	Freshwater-Influenced	Freshwater-Influenced	Marina
Tubificinae										4
Oligochaeta				1		1	5		1	
Pareurythoe californica										
Dorvillea (Dorvillea) sp										
Dorvillea (Schistomeringos) longicornis		11		1	4					
Dorvillea sp										
Ophryotrocha sp										
Protodorvillea gracilis										
Eunicidae										
Marphysa sp B			1							
Lumbrineridae										
Lumbrineris limicola										
Lumbrineris sp				3	7					
Lumbrineris sp E					4					
Scoletoma erecta										
Scoletoma sp		18		14	26	52		1		
Scoletoma sp A										
Scoletoma sp B										
Scoletoma sp C		14		1	26	107	4	1	3	1
Drilonereis sp										
Onuphidae										
Glycera americana		2		3		1				
Glycera macrobranchia										
Glycera nana					2					
Glycera sp										
Hemipodia borealis										
Glycinde armigera										
Goniada littorea										
Gyptis brunnea										
Hesionella mccullochae										
Micropodarke dubia										
Oxydromus pugettensis										
Bipalponephtys cornuta				1						
Nephtys caecoides					1				1	
Nephtys californiensis			3							
Nephtys simoni										
Nephtys sp										
Neanthes acuminata Cmplx		6						3	1	
Nereididae										
Platynereis bicanaliculata										
Eteone brigitteae						1				
Phyllodoce hartmanae										
Phyllodoce medipapillata										
Ancistrosyllis sp										
Halosydna sp										
Harmothoe fragilis						2				
Harmothoe imbricata Cmplx										
Malmgreniella macginitiei										
Malmgreniella sp										
Malmgreniella sp A										
Polynoidae										
Tenonia priops										
Pisione sp										
Epigamia-Myrianida Cmplx						3				
Exogone dwisula										
Exogone lourei				2	5	53	1		14	3
Exogone sp										
Exogone sp A		39				2				
Megasyllis nipponica		5								
Odontosyllis phosphorea		9					16			
Parexogone molesta										
Salvatoria sp										
Sphaerosyllis sp										
Syllinae										
Syllis gracilis Cmplx						1	12			
Syllis sp										
Fabricinuda limnicola		11			16		6			
Owenia collaris										
Owenia johnsoni										
Acromegalomma pigmentum		51			1		19			
Acromegalomma sp										
Bispira sp					2					
Euchone limnicola				3	5				23	1
Paradialychone ecaudata										
Paradialychone harrisae										
Paradialychone paramollis						1				
Sabellidae										
Serpulidae										
Spirorbidae							4			
Poecilochaetus martini										
Poecilochaetus sp										
Aonides sp SD1										
Dipolydora socialis										
Microspio sp DC1				1						
Paraprionospio alata										
Polydora heterochaeta										
Prionospio heterobranchia		7		1	13	5			5	1
Prionospio lighti										
Prionospio pygmaeus										
Pseudatherospio fauchaldi										
Pseudopolydora paucibranchiata		17		1	29	3	7		338	67
Pseudopolydora sp										
Rhynchospio arenincola									3	1
Scolelepis (Parascolelepis) texana		1							10	10
Spio maculata										
Spiophanes duplex			1		2					
Streblospio benedicti										
Ampharete labrops										
Amphicteis scaphobranchiata										
Melinna oculata										
Phyllochaetopterus prolifica										
Spiochaetopterus costarum Cmplx										
Aphelochaeta sp										
Caulleriella sp										
Chaetozone columbiana										
Chaetozone corona										
Cirratulidae						1				
Cirratulus sp					1					
Cirriformia sp						15				
Kirkegaardia cryptica				2						

Station ID	B18-10015	B18-10017	B18-10020	B18-10029	B18-10031	B18-10037	B18-10043	B18-10044	B18-10066	B18-10067
Harbor	Mission Bay	Mission Bay	Mission Bay	North San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay	South San Diego Bay	Dana Point Harbor	Dana Point Harbor
Strata	Freshwater-Influenced	Shallow	Deep	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced	Shallow	Freshwater-Influenced	Freshwater-Influenced	Marina
Kirkegaardia siblina										
Kirkegaardia sp										
Kirkegaardia sp 1										
Diplocirrus sp SD1		6		1	4	2				
Flabelligeridae										
Lamispina schmidtii		5								
Pherusa neopapillata										
Trophoniella harrisae						4				
Amaeana occidentalis										
Pista brevibranchiata										
Pista sp										
Pista wui										
Capitella capitata Cmplx		2		1		2				4
Decamastus gracilis										
Mediomastus sp		84			14	31	2	1	6	1
Notomastus hemipodus										
Notomastus lineatus										
Notomastus magnus		1								
Notomastus sp										
Cossura sp						5			1	
Cossura sp A					2				83	3
Euclymeninae				1	26		17	1		
Euclymeninae sp A										
Metasychis disparidentatus		2								
Notoproctus pacificus										
Petaloclymene pacifica					28		49			
Praxillella pacifica										
Armandia brevis		2	1				2			
Ophelia limacina			1							
Leitoscoloplos pugettensis		68		64	13	39	267	29	61	62
Naineris sp										
Scoloplos acmeceps										
Levinsenia gracilis										
Arachnida										
Harpacticoida										
Carabidae										
Ampelisca brachycladus										
Ampelisca cristata microdentata										
Amphilochidae										
Apolochus barnardi										
Hourstonius vilordes		1								
Ampithoe longimana										
Ampithoe plumulosa										
Ampithoidae										
Aoroides sp										
Bemlos concavus										
Bemlos macromanus							34			
Bemlos sp							9			
Grandidierella japonica					3				8	5
Paramicrodeutopus schmitti										
Caprella californica Cmplx		24								
Caprella equilibra										
Caprella penantis										
Caprella simia										
Caprella sp		2							1	
Caprella verrucosa										
Caprellinae										
Mayerella acanthopoda		16					1		2	8
Paracaprella sp SD1										
Phtisica marina										
Monocorophium acherusicum		9								
Monocorophium sp									2	
Monocorophium uenoi										
Sinocorophium alienense										
Paradexamine sp SD1		12								
Eohaustorius barnardi			1							
Hornellia occidentalis										
Hyalidae								1		
Protohyale frequens		26								
Protohyale sp							58			
Amphideutopus oculatus					3					
Ericthonius brasiliensis		1					6			
Leucothoe alata							28			
Listriella eriopisa										
Listriella melanica										
Aruga holmesi						1				
Elasmopus bampo		18					48			
Elasmopus sp										
Maera jerrica										
Gibberosus myersi			4							
Americhelidium sp										
Americhelidium sp SD4										
Eochelidium sp A									3	3
Hartmanodes hartmanae			2							
Hartmanodes sp SD1					1					
Eobrolgus chumashi										
Heterophoxus cf ellisi				1	3					
Heterophoxus sp										
Rhepoxynius heterocuspidatus										
Rhepoxynius lucubrans			3							
Rhepoxynius menziesi			2							
Podocerus fulanus		5				3	108			
Nasageneia quinsana							3			
Talitridae		2								
Hippomedon zetesimus										
Tryphosinae incertae sedis entalladurus			1							
Acuminodeutopus heteruropus		2								
Rudilemboides stenopropodus		10	1		2		2			
Corophioidea										
Oxyurostylis pacifica								1		
Nippoleucon hinumensis										
Campylaspis rubromaculata										
Cumacea										
Alpheus californiensis				1	3	2				
Alpheus sp										
Betaeus ensenadensis										
Betaeus sp				1						
Platymera gaudichaudii										
Neotrypaea biffari			12							
Neotrypaea gigas				2						

Station ID	B18-10015	B18-10017	B18-10020	B18-10029	B18-10031	B18-10037	B18-10043	B18-10044	B18-10066	B18-10067
Harbor	Mission Bay	Mission Bay	Mission Bay	North San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay	South San Diego Bay	Dana Point Harbor	Dana Point Harbor
Strata	Freshwater-Influenced	Shallow	Deep	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced	Shallow	Freshwater-Influenced	Freshwater-Influenced	Marina
Neotrypaea sp				2						
Romaleon branneri										
Crangon alaskensis										
Hippolyte californiensis							7			
Ericerodes hemphillii										
Pyromaia tuberculata										
Naushonia macginitiei										
Lophopanopeus frontalis										
Malacoplax californiensis										
Panopeidae					2	1				
Pinnixa franciscana										
Pinnotheridae										
Scleroplax granulata				4						
Ambidexter panamensis				3	1	1				
Upogebia lepta										
Xanthidae										
Brachyura										
Majoidea										
Xanthoidea										
Cyathura munda										
Neastacilla californica										
Erichsonella crenulata										
Paranthura japonica										
Heteroserolis carinata				1	1					
Paracerceis sculpta	2	41				1	149			
Sphaeromatidae										
Nebalia pugettensis Cmplx										
Amathimysis trigibba										
Deltamysis holmquistae										
Heteromysis odontops					1	1				
Mysidae										
Mysidopsis californica										
Siriella pacifica							1			
Schmittius politus							1			
Mesokalliapseudes crassus										
Chondrochelia dubia Cmplx	13	13					8			
Pseudotanais makrothrix										
Tanaididae										
Zeuxo normani Cmplx										
Asteropella slatteryi										
Leuroleberis sharpei										
Postasterope barnesi					1					
Vargula tsujii										
Euphilomedes carcharodonta	1						7			
Rutiderma judayi										
Rutiderma rotundum										
Rutidermatidae										
Eusarsiella thominx										
Podocopida										
Callipallene pacifica										
Nymphon pixellae										
Anoplodactylus erectus			1						1	
Anoplodactylus viridintestinalis										
Ciona robusta					1					
Eugyra glutinans										
Molgula ficus					4	1				
Molgula manhattensis										
Molgulidae										
Styela plicata						2				
Edwardsiidae	1	1			1	3				
Microcosmus squamiger										
Scolanthus scamiti	4				2					
Branchiostoma californiense										
Flosmaris grandis										
Edwardsia californica		6			1					
Edwardsia handi										
Edwardsia sp										
Nematostella vectensis										
Anemonactis sp A		1								
Zaolutus actius										
Metridium sp							51			
Actiniaria		20			1	4	118			
Actiniaria sp 1						2				
Actiniaria sp DC2		7								
Acanthoptilum sp										
Stylatula elongata										
Stylatula sp A										
Virgulariidae										
Cerianthidae										
Corymorpha bigelowi										
Strongylocentrotus sp										
Dendraster terminalis										
Chiridota										
Leptosynapta sp		22		2	3		2			
Molpadia arenicola			1							
Amphiodia digitata			1		1					
Amphiodia psara										
Amphiodia sp										
Amphiodia urtica										
Amphipholis pugetana										
Amphipholis squamata		5	1	2	2	2	2			
Amphiuridae						1				
Ophiactis simplex										
Limaria hemphilli										
Lucinisca nuttalli										
Musculista senhousia		69		1	22	128	60	4		
Nuculana taphria										
Ostrea lurida					1					
Leptopecten latiauratus										
Lyonsia californica		3							5	4
Asthenothaerus diegensis										
Laevicardium substriatum				1					1	
Trachycardium quadragenarium										
Caryocorbula luteola										
Kurtiella coani										
Kurtiella pedroana										
Theora lubrica						10			1	2
Kurtiella tumida										
Mactrotoma californica				1						
Cryptomya californica										

Station ID	B18-10015	B18-10017	B18-10020	B18-10029	B18-10031	B18-10037	B18-10043	B18-10044	B18-10066	B18-10067
Harbor	Mission Bay	Mission Bay	Mission Bay	North San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay	South San Diego Bay	Dana Point Harbor	Dana Point Harbor
Strata	Freshwater-Influenced	Shallow	Deep	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced	Shallow	Freshwater-Influenced	Freshwater-Influenced	Marina
Neolepton subtrigonum										
Cooperella subdiaphana										
Tagelus affinis		4			1					
Tagelus subteres										
Solen rostriformis										
Solen sp										
Macoma nasuta										
Macoma yoldiformis										
Psammotreta obesa										
Tellina cadieni										
Tellina meropsis		1					21	1		
Tellina modesta										
Tellina sp B										
Diplodonta sericata										
Leukoma laciniata				1						
Leukoma staminea										1
Pitar newcombianus										
Saxidomus nuttalli										
Venerinae										
Acteocina carinata	27	27					5	61		
Acteocina culcitella										
Acteocina sp										
Aglaja ocelligera										
Bulla gouldiana										
Haminoea vesicula		1								1
Philine auriformis										
Philine bakeri		1								
Philine ornatissima										
Sulcoretusa xystrum										
Volvulella panamica										
Barleeia haliotiphila	1					1	560			
Caecum californicum	3									
Calyptraea fastigiata										
Calyptraeidae										
Crepidula onyx					1	1				
Crepidula sp										
Crepipatella lingulata										
Crucibulum spinosum					6					
Alia tuberosa										
Astyris aurantiaca							44			
Mitrella variegata		1								
Plesiocystiscus politulus										
Epitonium hindsii										
Epitonium sp										
Polygireulima rutila										
Caesia fossatus										
Nassarius mendicus										
Nassarius tiarula										
Callianax biplicata			3							
Teinostoma sp										
Armina californica										
Aplysiopsis enteromorphae		6								
Iselica ovoidea										
Lottia depicta										
Murchisonella occidentalis										
Turbonilla almo										
Gadila aberrans										
Lineidae										
Baseodiscus delineatus		1			2	4				
Heteronemertea						1			1	
Carinoma mutabilis										
Carinomella lactea										
Tubulanus cingulatus										
Tubulanus polymorphus				1						
Tubulanus sp										
Tubulanus sp A										
Tubulanus sp SD1						1				
Palaeonemertea sp					1					
Amphiporidae						1				
Phoronidae	2	130			1			5		
Zygonemertes virescens										
Paranemertes californica		1			1	1			2	
Quasitetrastemma nigrifrons										
Tetrastemma candidum										
Monostilifera					1					
Enopla sp DC1										
Enopla sp DC2										
Phoronis sp		163					1	6		
Hoploplana californica		4								
Prosthiostomum latocelis										
Polycladida										
Apionsoma misakianum										
Thysanocardia nigra										
Sipunculidea										

# Non-Native Spp	0	3	0	1	4	4	1	0	3	3
# Sensitive Spp	1	6	2	2	5	2	3	1	3	2
Non-Native Abundance	0	31	0	1	37	16	7	0	347	74
Sensitive spp Abundance	3	18	3	3	17	68	28	1	20	7
Total Abundance	54	1017	40	125	305	504	1745	115	577	182
Species Richness	9	57	18	32	52	44	40	13	25	19
% NNS	0.0	5.3	0.0	3.1	7.7	9.1	2.5	0.0	12.0	15.8
%NNS Abundance	0.0	3.0	0.0	0.8	12.1	3.2	0.4	0.0	60.1	40.7
% Sensitive	11.1	10.5	11.1	6.3	9.6	4.5	7.5	7.7	12.0	10.5
%Sensitive Abundance	5.6	1.8	7.5	2.4	5.6	13.5	1.6	0.9	3.5	3.8

Station ID	B18-10068	B18-10069	B18-10070	B18-10071	B18-10081	B18-10083	B18-10084	B18-10114	B18-10123
Harbor	Dana Point Harbor	Oceanside Harbor	Oceanside Harbor	Oceanside Harbor	North San Diego Bay	North San Diego Bay	North San Diego Bay	North San Diego Bay	Central San Diego Bay
Strata	Deep	Marina	Freshwater-Influenced	Deep	Marina	Marina	Marina	Industrial/Port	Industrial/Port
Tubificinae									
Oligochaeta	5					5			
Pareurythoe californica									
Dorvillea (Dorvillea) sp									
Dorvillea (Schistomeringos) longicornis					1				
Dorvillea sp									
Ophryotrocha sp									
Protodorvillea gracilis									
Eunicidae									
Marphysa sp B									
Lumbrineridae									7
Lumbrineris limicola				1					
Lumbrineris sp									
Lumbrineris sp E			1						1
Scoletoma erecta									
Scoletoma sp			20	22		1		13	15
Scoletoma sp A									
Scoletoma sp B			1	1					
Scoletoma sp C	13		40	8	6	8		24	51
Drilonereis sp									
Onuphidae									
Glycera americana			1						1
Glycera macrobranchia									
Glycera nana									
Glycera sp									
Hemipodia borealis									
Glycinde armigera									
Goniada littorea									
Gyptis brunnea									
Hesionella mccullochae									
Micropodarke dubia									
Oxydromus pugettensis									
Bipalponephtys cornuta									
Nephtys caecoides									
Nephtys californiensis									
Nephtys simoni									
Nephtys sp									
Neanthes acuminata Cmplx									
Nereididae									
Platynereis bicanaliculata									
Eteone brigitteae									
Phyllodoce hartmanae									
Phyllodoce medipapillata									
Ancistrosyllis sp									
Halosydna sp									
Harmothoe fragilis									
Harmothoe imbricata Cmplx									
Malmgreniella macginitiei								1	
Malmgreniella sp									
Malmgreniella sp A									
Polynoidae									
Tenonia priops									
Pisione sp									
Epigamia-Myrianida Cmplx									
Exogone dwisula									
Exogone lourei	2					1			2
Exogone sp									
Exogone sp A									
Megasyllis nipponica								1	
Odontosyllis phosphorea									
Parexogone molesta									
Salvatoria sp									
Sphaerosyllis sp									
Syllinae									
Syllis gracilis Cmplx									
Syllis sp									
Fabricinuda limnicola									5
Owenia collaris			1					1	
Owenia johnsoni				1					
Acromegalomma pigmentum		3							
Acromegalomma sp									
Bispira sp									
Euchone limnicola		3		1	8	2		2	2
Paradialychone ecaudata									
Paradialychone harrisae									
Paradialychone paramollis									
Sabellidae								1	
Serpulidae						2			
Spirorbidae									
Poecilochaetus martini									
Poecilochaetus sp									
Aonides sp SD1									
Dipolydora socialis									
Microspio sp DC1				2					
Paraprionospio alata									
Polydora heterochaeta									
Prionospio heterobranchia	3		1		7	7		2	9
Prionospio lighti	6		1	2					
Prionospio pygmaeus									
Pseudatherospio fauchaldi									
Pseudopolydora paucibranchiata	1				86	367			14
Pseudopolydora sp									
Rhynchospio arenincola									
Scolelepis (Parascolelepis) texana	1								
Spio maculata									
Spiophanes duplex			2		1	6			
Streblospio benedicti									
Ampharete labrops				1					
Amphicteis scaphobranchiata				1					
Melinna oculata						1			
Phyllochaetopterus prolifica									
Spiochaetopterus costarum Cmplx			1						
Aphelochaeta sp									
Caulleriella sp									
Chaetozone columbiana									
Chaetozone corona									
Cirratulidae									
Cirratulus sp									
Cirriformia sp									
Kirkegaardia cryptica			1	1				1	

Station ID	B18-10068	B18-10069	B18-10070	B18-10071	B18-10081	B18-10083	B18-10084	B18-10114	B18-10123
Harbor	Dana Point Harbor	Oceanside Harbor	Oceanside Harbor	Oceanside Harbor	North San Diego Bay	North San Diego Bay	North San Diego Bay	North San Diego Bay	Central San Diego Bay
Strata	Deep	Marina	Freshwater-Influenced	Deep	Marina	Marina	Marina	Industrial/Port	Industrial/Port
Kirkegaardia siblina									
Kirkegaardia sp									
Kirkegaardia sp 1	2								
Diplocirrus sp SD1			4					1	4
Flabelligeridae									
Lamispina schmidtii								1	
Pherusa neopapillata									
Trophoniella harrisae						1			
Amaeana occidentalis									
Pista brevibranchiata									
Pista sp									
Pista wui									
Capitella capitata Cmplx									
Decamastus gracilis									
Mediomastus sp	23		10	7	1	24			5
Notomastus hemipodus									
Notomastus lineatus									
Notomastus magnus	2								
Notomastus sp									
Cossura sp	8					1			
Cossura sp A	21		5		2	4		2	1
Euclymeninae			1			6			
Euclymeninae sp A						106			
Metasychis disparidentatus	1		9	1				1	
Notoproctus pacificus									
Petaloclymene pacifica	1								2
Praxillella pacifica			2						
Armandia brevis									
Ophelia limacina									
Leitoscoloplos pugettensis	48		13	42	26	8		12	16
Naineris sp									
Scoloplos acmeceps									
Levinsenia gracilis									
Arachnida									
Harpacticoida									
Carabidae									
Ampelisca brachycladus									
Ampelisca cristata microdentata									
Amphilochidae									
Apolochus barnardi									
Hourstonius vilordes									
Ampithoe longimana									
Ampithoe plumulosa									
Ampithoidae									
Aoroides sp									
Bemlos concavus									
Bemlos macromanus									
Bemlos sp									
Grandidierella japonica					3	34			1
Paramicrodeutopus schmitti									
Caprella californica Cmplx									
Caprella equilibra									
Caprella penantis									
Caprella simia									
Caprella sp						3			
Caprella verrucosa									
Caprellinae									
Mayerella acanthopoda	1	12							
Paracaprella sp SD1									
Phtisica marina						10		6	2
Monocorophium acherusicum								63	49
Monocorophium sp									6
Monocorophium uenoi									
Sinocorophium alienense									
Paradexamine sp SD1									
Eohaustorius barnardi									
Hornellia occidentalis									
Hyalidae									
Protohyale frequens									
Protohyale sp									
Amphideutopus oculatus	1		9		23	15		59	20
Ericthonius brasiliensis									
Leucothoe alata									
Listriella eriopisa			3						
Listriella melanica			2	1					
Aruga holmesi									
Elasmopus bampo									
Elasmopus sp									
Maera jerrica									
Gibberosus myersi									
Americhelidium sp									
Americhelidium sp SD4									
Eochelidium sp A	3	6	3	1					
Hartmanodes hartmanae			1						
Hartmanodes sp SD1								2	3
Eobrolgus chumashi									
Heterophoxus cf ellisi					28	33	18	13	2
Heterophoxus sp									
Rhepoxynius heterocuspidatus									
Rhepoxynius lucubrans									
Rhepoxynius menziesi									
Podocerus fulanus						3			2
Nasageneia quinsana									
Talitridae									
Hippomedon zetesimus									
Tryphosinae incertae sedis entalladurus									
Acuminodeutopus heteruropus									
Rudilemboides stenopropodus		4				1		3	7
Corophioidea									
Oxyurostylis pacifica									
Nippoleucon hinumensis									
Campylaspis rubromaculata									
Cumacea									
Alpheus californiensis					2	1	1	1	1
Alpheus sp		2							
Betaeus ensenadensis									
Betaeus sp									
Platymera gaudichaudii									
Neotrypaea biffari									
Neotrypaea gigas					2				

Station ID	B18-10068	B18-10069	B18-10070	B18-10071	B18-10081	B18-10083	B18-10084	B18-10114	B18-10123
Harbor	Dana Point Harbor	Oceanside Harbor	Oceanside Harbor	Oceanside Harbor	North San Diego Bay	North San Diego Bay	North San Diego Bay	North San Diego Bay	Central San Diego Bay
Strata	Deep	Marina	Freshwater-Influenced	Deep	Marina	Marina	Marina	Industrial/Port	Industrial/Port
Neotrypaea sp					1				
Romaleon branneri									
Crangon alaskensis									
Hippolyte californiensis									
Ericerodes hemphillii						1		3	1
Pyromaia tuberculata									1
Naushonia macginitiei									
Lophopanopeus frontalis									
Malacoplax californiensis	1								
Panopeidae									
Pinnixa franciscana									
Pinnotheridae									
Scleroplax granulata									1
Ambidexter panamensis									
Upogebia lepta					1	1			
Xanthidae									
Brachyura									
Majoidea								1	1
Xanthoidea									
Cyathura munda									
Neastacilla californica									
Erichsonella crenulata									
Paranthura japonica						4			
Heteroserolis carinata					4	1	6	8	7
Paracerceis sculpta									
Sphaeromatidae									
Nebalia pugettensis Cmplx									
Amathimysis trigibba									
Deltamysis holmquistae		1							
Heteromysis odontops						4	1		
Mysidae									
Mysidopsis californica									
Siriella pacifica									
Schmittius politus								1	2
Mesokalliapseudes crassus									
Chondrochelia dubia Cmplx									
Pseudotanais makrothrix									
Tanaididae									
Zeuxo normani Cmplx					4				
Asteropella slatteryi									
Leuroleberis sharpei								1	
Postasterope barnesi									
Vargula tsujii									
Euphilomedes carcharodonta								1	
Rutiderma judayi									
Rutiderma rotundum									
Rutidermatidae									
Eusarsiella thominx									
Podocopida									
Callipallene pacifica									
Nymphon pixellae									
Anoplodactylus erectus		4							2
Anoplodactylus viridintestinalis									
Ciona robusta									
Eugyra glutinans									
Molgula ficus						1			
Molgula manhattensis						6			
Molgulidae									
Styela plicata									
Edwardsiidae									
Microcosmus squamiger									
Scolanthus scamiti									1
Branchiostoma californiense									
Flosmaris grandis									
Edwardsia californica									
Edwardsia handi									
Edwardsia sp									
Nematostella vectensis									
Anemonactis sp A		1			2	1			
Zaolutus actius									
Metridium sp									
Actiniaria									
Actiniaria sp 1									
Actiniaria sp DC2									
Acanthoptilum sp									
Stylatula elongata									
Stylatula sp A									
Virgulariidae									
Cerianthidae									
Corymorpha bigelowi						1			
Strongylocentrotus sp									
Dendraster terminalis									
Chiridota									
Leptosynapta sp						6	1	1	
Molpadia arenicola									
Amphiodia digitata									
Amphiodia psara									
Amphiodia sp									
Amphiodia urtica								1	
Amphipholis pugetana									
Amphipholis squamata						1			
Amphiuridae									
Ophiactis simplex									
Limaria hemphilli									
Lucinisca nuttalli									
Musculista senhousia					11	105		5	52
Nuculana taphria									
Ostrea lurida									
Leptopecten latiauratus									
Lyonsia californica	2				8	3		5	1
Asthenothaerus diegensis	1		3					7	4
Laevicardium substriatum	9	1	6	3	6	4		6	2
Trachycardium quadragenarium									
Caryocorbula luteola									
Kurtiella coani									
Kurtiella pedroana									
Theora lubrica					2	2		10	
Kurtiella tumida									
Mactrotoma californica	3							1	
Cryptomya californica					2				

Station ID	B18-10068	B18-10069	B18-10070	B18-10071	B18-10081	B18-10083	B18-10084	B18-10114	B18-10123
Harbor	Dana Point Harbor	Oceanside Harbor	Oceanside Harbor	Oceanside Harbor	North San Diego Bay	North San Diego Bay	North San Diego Bay	North San Diego Bay	Central San Diego Bay
Strata	Deep	Marina	Freshwater-Influenced	Deep	Marina	Marina	Marina	Industrial/Port	Industrial/Port
Neolepton subtrigonum									
Cooperella subdiaphana						1			
Tagelus affinis	10	6	1		2	1		17	
Tagelus subteres									20
Solen rostriformis		1			1			10	5
Solen sp									
Macoma nasuta									
Macoma yoldiformis	1								
Psammotreta obesa									
Tellina cadieni									
Tellina meropsis									
Tellina modesta				1					
Tellina sp B	2		8	2					
Diplodonta sericata									
Leukoma laciniata					4				
Leukoma staminea									
Pitar newcombianus									
Saxidomus nuttalli									
Venerinae									
Acteocina carinata									
Acteocina culcitella									
Acteocina sp									
Aglaja ocelligera									
Bulla gouldiana									
Haminoea vesicula		2					1		
Philine auriformis			3						
Philine bakeri									
Philine ornatissima									
Sulcoretusa xystrum									
Volvulella panamica								1	
Barleeia haliotiphila									
Caecum californicum									
Calyptraea fastigiata									
Calyptraeidae									
Crepidula onyx									
Crepidula sp									
Crepipatella lingulata									
Crucibulum spinosum									
Alia tuberosa									
Astyris aurantiaca									
Mitrella variegata									
Plesiocystiscus politulus									
Epitonium hindsii									
Epitonium sp									
Polygireulima rutila									
Caesia fossatus									
Nassarius mendicus									
Nassarius tiarula									6
Callianax biplicata									
Teinostoma sp									
Armina californica									
Aplysiopsis enteromorphae									
Iselica ovoidea									
Lottia depicta									
Murchisonella occidentalis									
Turbonilla almo									
Gadila aberrans									
Lineidae				1					
Baseodiscus delineatus									
Heteronemertea	2	1	4			2			
Carinoma mutabilis									
Carinomella lactea									
Tubulanus cingulatus									
Tubulanus polymorphus			5	7					
Tubulanus sp									
Tubulanus sp A	1		1	1					
Tubulanus sp SD1									1
Palaeonemertea sp									
Amphiporidae									
Phoronidae						2		1	8
Zygonemertes virescens									
Paranemertes californica									1
Quasitetrastemma nigrifrons									
Tetrastemma candidum									
Monostilifera									
Enopla sp DC1									
Enopla sp DC2									
Phoronis sp						5		5	7
Hoploplana californica									
Prosthiostomum latocelis			1						
Polycladida									
Apionsoma misakianum									
Thysanocardia nigra									
Sipunculidea									
# Non-Native Spp	**1**	**1**	**1**	**0**	**3**	**6**	**0**	**3**	**3**
# Sensitive Spp	**3**	**0**	**4**	**3**	**5**	**7**	**1**	**5**	**6**
Non-Native Abundance	**1**	**1**	**3**	**0**	**91**	**414**	**0**	**74**	**64**
Sensitive spp Abundance	**5**	**0**	**14**	**3**	**38**	**30**	**6**	**136**	**99**
Total Abundance	**174**	**47**	**164**	**108**	**244**	**802**	**28**	**295**	**351**
Species Richness	**28**	**14**	**32**	**22**	**27**	**45**	**6**	**40**	**44**
% NNS	**3.6**	**7.1**	**3.1**	**0.0**	**11.1**	**13.3**	**0.0**	**7.5**	**6.8**
%NNS Abundance	**0.6**	**2.1**	**1.8**	**0.0**	**37.3**	**51.6**	**0.0**	**25.1**	**18.2**
% Sensitive	**10.7**	**0.0**	**12.5**	**13.6**	**18.5**	**15.6**	**16.7**	**12.5**	**13.6**
%Sensitive Abundance	**2.9**	**0.0**	**8.5**	**2.8**	**15.6**	**3.7**	**21.4**	**46.1**	**28.2**

Station ID	B18-10124	B18-10126	B18-10127	B18-10178	B18-10180	B18-10200
Harbor	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay
Strata	Industrial/Port	Industrial/Port	Industrial/Port	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced
Tubificinae						
Oligochaeta						87
Pareurythoe californica						
Dorvillea (Dorvillea) sp						
Dorvillea (Schistomeringos) longicornis						
Dorvillea sp						
Ophryotrocha sp						
Protodorvillea gracilis						
Eunicidae						
Marphysa sp B						
Lumbrineridae						
Lumbrineris limicola						
Lumbrineris sp						
Lumbrineris sp E						
Scoletoma erecta				1		
Scoletoma sp						
Scoletoma sp A						
Scoletoma sp B						
Scoletoma sp C						
Drilonereis sp						
Onuphidae						
Glycera americana						
Glycera macrobranchia						
Glycera nana						
Glycera sp						
Hemipodia borealis						
Glycinde armigera						
Goniada littorea						
Gyptis brunnea						
Hesionella mccullochae						
Micropodarke dubia						
Oxydromus pugettensis						
Bipalponephtys cornuta						
Nephtys caecoides						
Nephtys californiensis						
Nephtys simoni						
Nephtys sp						
Neanthes acuminata Cmplx				5		42
Nereididae						
Platynereis bicanaliculata						
Eteone brigitteae						
Phyllodoce hartmanae						
Phyllodoce medipapillata						
Ancistrosyllis sp						
Halosydna sp				1		
Harmothoe fragilis						
Harmothoe imbricata Cmplx						
Malmgreniella macginitiei				2		
Malmgreniella sp						
Malmgreniella sp A						
Polynoidae						
Tenonia priops						
Pisione sp						
Epigamia-Myrianida Cmplx						
Exogone dwisula						
Exogone lourei						2
Exogone sp						
Exogone sp A						
Megasyllis nipponica						
Odontosyllis phosphorea						
Parexogone molesta						
Salvatoria sp						
Sphaerosyllis sp						
Syllinae						
Syllis gracilis Cmplx						
Syllis sp						
Fabricinuda limnicola			1			
Owenia collaris						
Owenia johnsoni						
Acromegalomma pigmentum						
Acromegalomma sp						
Bispira sp						
Euchone limnicola						
Paradialychone ecaudata						
Paradialychone harrisae						
Paradialychone paramollis						
Sabellidae						
Serpulidae						
Spirorbidae						
Poecilochaetus martini						
Poecilochaetus sp						
Aonides sp SD1						
Dipolydora socialis						
Microspio sp DC1						
Paraprionospio alata						
Polydora heterochaeta						
Prionospio heterobranchia						
Prionospio lighti						
Prionospio pygmaeus						
Pseudatherospio fauchaldi						
Pseudopolydora paucibranchiata						
Pseudopolydora sp						
Rhynchospio arenincola						
Scolelepis (Parascolelepis) texana						
Spio maculata						
Spiophanes duplex						
Streblospio benedicti						101
Ampharete labrops						
Amphicteis scaphobranchiata						
Melinna oculata						
Phyllochaetopterus prolifica						
Spiochaetopterus costarum Cmplx						
Aphelochaeta sp						
Caulleriella sp						
Chaetozone columbiana						
Chaetozone corona						
Cirratulidae						
Cirratulus sp						
Cirriformia sp						
Kirkegaardia cryptica						

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Harbor	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay
Strata	Industrial/Port	Industrial/Port	Industrial/Port	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced
Kirkegaardia siblina						
Kirkegaardia sp						
Kirkegaardia sp 1						
Diplocirrus sp SD1						
Flabelligeridae						
Lamispina schmidtii						
Pherusa neopapillata						
Trophoniella harrisae						
Amaeana occidentalis						
Pista brevibranchiata						
Pista sp						
Pista wui						
Capitella capitata Cmplx						8
Decamastus gracilis						
Mediomastus sp					5	
Notomastus hemipodus						
Notomastus lineatus						
Notomastus magnus						
Notomastus sp						
Cossura sp				3		
Cossura sp A						
Euclymeninae						
Euclymeninae sp A						
Metasychis disparidentatus						
Notoproctus pacificus						
Petaloclymene pacifica						
Praxillella pacifica						
Armandia brevis						1
Ophelia limacina						
Leitoscoloplos pugettensis						
Naineris sp						
Scoloplos acmeceps						
Levinsenia gracilis						
Arachnida						
Harpacticoida						
Carabidae						
Ampelisca brachycladus						
Ampelisca cristata microdentata						
Amphilochidae						
Apolochus barnardi						
Hourstonius vilordes						
Ampithoe longimana						
Ampithoe plumulosa						
Ampithoidae						
Aoroides sp						
Bemlos concavus						
Bemlos macromanus						
Bemlos sp						
Grandidierella japonica	1	2				6
Paramicrodeutopus schmitti						
Caprella californica Cmplx						
Caprella equilibra						
Caprella penantis						
Caprella simia						
Caprella sp						
Caprella verrucosa						
Caprellinae						
Mayerella acanthopoda						
Paracaprella sp SD1						
Phtisica marina						
Monocorophium acherusicum		3				
Monocorophium sp						
Monocorophium uenoi						17
Sinocorophium alienense						
Paradexamine sp SD1						
Eohaustorius barnardi						
Hornellia occidentalis						
Hyalidae						
Protohyale frequens						
Protohyale sp						
Amphideutopus oculatus		2	1			
Ericthonius brasiliensis						
Leucothoe alata						
Listriella eriopisa						
Listriella melanica						
Aruga holmesi		1				
Elasmopus bampo						
Elasmopus sp						
Maera jerrica						
Gibberosus myersi						
Americhelidium sp						
Americhelidium sp SD4						
Eochelidium sp A						
Hartmanodes hartmanae						
Hartmanodes sp SD1						
Eobrolgus chumashi						
Heterophoxus cf ellisi	12		2			
Heterophoxus sp		1				
Rhepoxynius heterocuspidatus						
Rhepoxynius lucubrans						
Rhepoxynius menziesi						
Podocerus fulanus						
Nasageneia quinsana						
Talitridae						
Hippomedon zetesimus		2				
Tryphosinae incertae sedis entalladurus						
Acuminodeutopus heteruropus						
Rudilemboides stenopropodus		1				
Corophioidea						
Oxyurostylis pacifica						
Nippoleucon hinumensis						5
Campylaspis rubromaculata						
Cumacea						
Alpheus californiensis	2	1				
Alpheus sp						
Betaeus ensenadensis						
Betaeus sp						
Platymera gaudichaudii						
Neotrypaea biffari						
Neotrypaea gigas						

Station ID	B18-10124	B18-10126	B18-10127	B18-10178	B18-10180	B18-10200
Harbor	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay
Strata	Industrial/Port	Industrial/Port	Industrial/Port	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced
Neotrypaea sp		1				
Romaleon branneri						
Crangon alaskensis						
Hippolyte californiensis						
Ericerodes hemphillii						
Pyromaia tuberculata		1				
Naushonia macginitiei	1					
Lophopanopeus frontalis						
Malacoplax californiensis						
Panopeidae						
Pinnixa franciscana						
Pinnotheridae						
Scleroplax granulata						
Ambidexter panamensis	2	1		3	1	
Upogebia lepta						
Xanthidae						
Brachyura						
Majoidea						
Xanthoidea						
Cyathura munda						
Neastacilla californica						
Erichsonella crenulata						
Paranthura japonica						
Heteroserolis carinata	3	3			5	
Paracerceis sculpta						
Sphaeromatidae						
Nebalia pugettensis Cmplx						
Amathimysis trigibba						
Deltamysis holmquistae						
Heteromysis odontops						
Mysidae						
Mysidopsis californica						
Siriella pacifica						
Schmittius politus						
Mesokalliapseudes crassus						
Chondrochelia dubia Cmplx						6
Pseudotanais makrothrix						
Tanaididae						
Zeuxo normani Cmplx						
Asteropella slatteryi						
Leuroleberis sharpei						
Postasterope barnesi						
Vargula tsujii						
Euphilomedes carcharodonta					1	
Rutiderma judayi						
Rutiderma rotundum						
Rutidermatidae						
Eusarsiella thominx						
Podocopida						
Callipallene pacifica						
Nymphon pixellae						
Anoplodactylus erectus						
Anoplodactylus viridintestinalis						
Ciona robusta						
Eugyra glutinans						
Molgula ficus						
Molgula manhattensis						
Molgulidae						
Styela plicata						
Edwardsiidae		4	1		1	
Microcosmus squamiger						
Scolanthus scamiti			1			
Branchiostoma californiense						
Flosmaris grandis						
Edwardsia californica						
Edwardsia handi						
Edwardsia sp						
Nematostella vectensis						
Anemonactis sp A						
Zaolutus actius						
Metridium sp						
Actiniaria		1				
Actiniaria sp 1						
Actiniaria sp DC2						
Acanthoptilum sp						
Stylatula elongata						
Stylatula sp A						
Virgulariidae						
Cerianthidae						
Corymorpha bigelowi						
Strongylocentrotus sp						
Dendraster terminalis						
Chiridota						
Leptosynapta sp				4		
Molpadia arenicola						
Amphiodia digitata						
Amphiodia psara						
Amphiodia sp						
Amphiodia urtica						
Amphipholis pugetana						
Amphipholis squamata						
Amphiuridae					1	
Ophiactis simplex						
Limaria hemphilli						
Lucinisca nuttalli						
Musculista senhousia		1		13	25	2
Nuculana taphria						
Ostrea lurida						
Leptopecten latiauratus						
Lyonsia californica						
Asthenothaerus diegensis		1				
Laevicardium substriatum				1		
Trachycardium quadragenarium						
Caryocorbula luteola						
Kurtiella coani						
Kurtiella pedroana						
Theora lubrica	12	4	2	1	5	
Kurtiella tumida						
Mactrotoma californica						
Cryptomya californica						

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Harbor	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	Central San Diego Bay	South San Diego Bay	South San Diego Bay
Strata	Industrial/Port	Industrial/Port	Industrial/Port	Freshwater-Influenced	Freshwater-Influenced	Freshwater-Influenced
Neolepton subtrigonum						
Cooperella subdiaphana						
Tagelus affinis		1				12
Tagelus subteres						
Solen rostriformis						
Solen sp						
Macoma nasuta						
Macoma yoldiformis						
Psammotreta obesa						
Tellina cadieni						
Tellina meropsis						
Tellina modesta						
Tellina sp B						
Diplodonta sericata						
Leukoma laciniata						
Leukoma staminea						
Pitar newcombianus						
Saxidomus nuttalli						
Venerinae						
Acteocina carinata				5	4	66
Acteocina culcitella						
Acteocina sp						
Aglaja ocelligera						
Bulla gouldiana						
Haminoea vesicula						
Philine auriformis						
Philine bakeri						
Philine ornatissima						
Sulcoretusa xystrum						
Volvulella panamica						
Barleeia haliotiphila						
Caecum californicum						
Calyptraea fastigiata						
Calyptraeidae						
Crepidula onyx					1	
Crepidula sp						
Crepipatella lingulata					1	
Crucibulum spinosum						
Alia tuberosa						
Astyris aurantiaca						
Mitrella variegata						
Plesiocystiscus politulus						
Epitonium hindsii						
Epitonium sp						
Polygireulima rutila						
Caesia fossatus						
Nassarius mendicus						
Nassarius tiarula		1				
Callianax biplicata						
Teinostoma sp						
Armina californica						
Aplysiopsis enteromorphae						
Iselica ovoidea						
Lottia depicta						
Murchisonella occidentalis						
Turbonilla almo						
Gadila aberrans						
Lineidae						
Baseodiscus delineatus						
Heteronemertea				1		
Carinoma mutabilis						
Carinomella lactea						
Tubulanus cingulatus						
Tubulanus polymorphus						
Tubulanus sp						
Tubulanus sp A						
Tubulanus sp SD1						
Palaeonemertea sp						
Amphiporidae						
Phoronidae		3	1			
Zygonemertes virescens						
Paranemertes californica					1	
Quasitetrastemma nigrifrons						
Tetrastemma candidum						
Monostilifera						
Enopla sp DC1						
Enopla sp DC2						
Phoronis sp						
Hoploplana californica						
Prosthiostomum latocelis						
Polycladida						
Apionsoma misakianum						
Thysanocardia nigra						
Sipunculidea						

# Non-Native Spp	2	3	1	1	1	4
# Sensitive Spp	1	3	1	0	1	1
Non-Native Abundance	13	9	2	1	5	129
Sensitive spp Abundance	3	8	1	0	5	2
Total Abundance	33	35	9	40	51	355
Species Richness	7	20	7	12	12	13
% NNS	28.6	15.0	14.3	8.3	8.3	30.8
%NNS Abundance	39.4	25.7	22.2	2.5	9.8	36.3
% Sensitive	14.3	15.0	14.3	0.0	8.3	7.7
%Sensitive Abundance	9.1	22.9	11.1	0.0	9.8	0.6