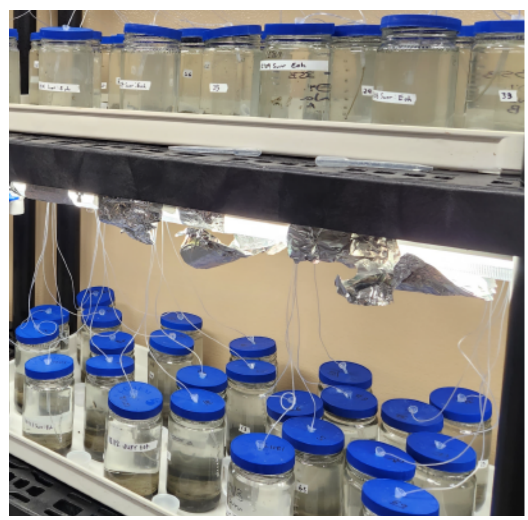
Sediment Toxicity

BIGHT '23



Southern California Bight 2023 Regional Monitoring Program Volume I

SCCWRP Technical Report 1433

Southern California Bight 2023 Regional Monitoring Program: Volume I. Sediment Toxicity

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FOREWORD

The 2023 Southern California Bight Regional Monitoring Survey (Bight ’23) is part of a collaborative effort to provide a large-scale, integrated assessment of the Southern California Bight (SCB). The Bight ’23 survey is a continuation of previous regional monitoring surveys conducted on a five-year cycle since 1994. This collaboration represents the joint efforts of over 100 organizations. Bight ’23 is organized into six elements: 1) Sediment Quality which includes Toxicity, Chemistry and Benthic Infauna, 2) Microbiology, 3) Shellfish Bioaccumulation 4) Trash and Microplastics, 5) Ocean Acidification, and 6) Estuarine Assessment. Copies of the sediment toxicity report, other Bight ’23 reports, as well as workplans and quality assurance plans, are available for download at www.sccwrp.org.

ACKNOWLEDGEMENTS

This report was achieved through the hard work and diligence of many individuals and organizations who share a common goal of improving our understanding of the environmental quality of the Southern California Bight. The authors wish to thank the members of the Bight ’23 Toxicology Committee for their assistance with study design, sample analysis, data analysis, and report review. We also thank the Bight ’23 Sediment Quality Planning Committee for their guidance and support of sediment toxicity testing in regional monitoring. This study would not have been possible without the knowledge and skills of the field sampling personnel from the following organizations: City of San Diego, Orange County Sanitation District, Sanitation Districts of Los Angeles County, City of Los Angeles- Environmental Monitoring Division, City of Los Angeles-Watershed Protection Division, Anchor QEA, Aquatic Bioassay and Consulting Laboratories, Weston Solutions, WSP, Inc., MBC Aquatic Sciences, and Naval Information Warfare Center Pacific. We also wish to thank Robert Butler, Abel Santana and Paul Smith (SCCWRP) for assistance with database management, data analysis and map preparation.

Toxicity testing was performed by eight laboratories: Aquatic Bioassay and Consulting Laboratories, City of Los Angeles- Environmental Monitoring Division, City of San Diego, Enthalpy Analytical, Naval Information Warfare Center Pacific, Orange County Sanitation District, Pacific EcoRisk, and WSP, Inc.

Acronyms and Abbreviations

CI	Confidence Interval
CV	Coefficient of variation
DQO	Data Quality Objective
EC_{50}	Median effect concentration
HDPE	High density polyethylene
LC_{50}	Median lethal concentration
NCCA	National Coastal Condition Assessment
NPDES	National Pollutant Discharge Elimination System
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
ppt	Parts per thousand
QA	Quality assurance
RMP	San Francisco Bay Regional Monitoring Program
SCB	Southern California Bight region
SCCWRP	Southern California Coastal Water Research Project
SD	Standard deviation
SQO	California's Sediment Quality Objectives
SWI	Sediment-water interface
TAC	Test acceptability criteria
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load

EXECUTIVE SUMMARY

Sediment toxicity is one of the three main lines of evidence for assessing overall sediment quality. However, most monitoring programs typically focus on sediment chemistry and limit toxicity assessment to areas with regulated discharges or specific sites where priority pollutants are detected. The Southern California Bight (SCB) Regional Marine Monitoring Program is a longstanding collaborative effort to characterize sediment quality based on toxicity, chemistry, and benthic community assessments for the entire 3,700 km^2 region. The surveys are designed to compare sediment quality among various strata over time, thus informing the effectiveness of management actions in improving aquatic health. For Bight ’23, the primary objectives for the sediment toxicity study were to:

1) Measure the extent and magnitude of sediment toxicity in the SCB using two standard toxicity tests
2) Compare the extent and magnitude of sediment toxicity among embayment and offshore strata
3) Evaluate changes in sediment toxicity over the past 25 years (1998-2023)

This report summarizes the toxicity test results and puts them into perspective using California’s sediment quality objectives (SQO) assessment framework. The chemistry and benthic community assessments will be reported separately, and all three lines of evidence will be subsequently combined in a final Bight ’23 integrated report to provide an overall evaluation of SCB sediment quality according to the SQO triad approach.

In the Bight ’23 survey, sediment for toxicity testing was collected at 219 stations across the SCB between Point Conception and the United States-Mexico border, between July and October 2023. The sampling scheme was based on a stratified random design to ensure spatial representativeness and minimize bias. Samples were collected from six strata in two general regions, offshore and embayments. The shelf stratum included the inner, mid, and outer shelf. Embayments included bays, ports, marinas, marine estuaries and freshwater estuaries (salinity less than 27 ppt). However, freshwater estuaries were not officially part of the Bight ’23 sampling design (i.e., not randomly selected) and this stratum was not included in the assessment of the areal extent of toxicity within the Bight region. Approximately one third of the stations (79) were sampled during previous Bight surveys. Surface sediments (upper 2 cm for offshore and upper 5 cm for embayments) were collected at each station by Van Veen grab and tested for toxicity within a month post collection.

Two established test methods described in the SQO program were used: the 10-day amphipod (*Eohaustorius estuarius*) survival test using whole sediment and the 48-hour mussel embryo (*Mytilus galloprovincialis*) sediment-water interface test. Since Bight ’98, all stations have been tested with the amphipod test. The mussel test was added for the embayment stations since Bight ’08. A rigorous quality assurance and quality control plan was implemented to ensure laboratory comparability and competency. This included a pre-survey interlaboratory calibration exercise, standardized test methods and data quality objectives (DQOs), laboratory audits, and split sample analysis. All established DQOs were met. Sampling and testing success were over 90% for all strata and tests. The samples were tested within the acceptable holding time of 28 days (over 98% within the optimal holding time of < 14 days) and met test acceptability criteria for both the amphipod and mussel tests. Results of the pre-survey intercalibration exercise showed high to very high comparability among most laboratories for both tests. Reference toxicant tests also showed comparable sensitivities with toxicity test point estimates (EC_{50} for mussel tests and LC_{50} for amphipod test) falling within two standardizations of the historical mean responses for all laboratories.

Bight-wide, toxicity was low based on the amphipod test results with 86% of the area considered not toxic (categorized as *nontoxic* or *low toxicity*). The greatest extent and magnitude of toxicity was measured in the estuaries followed by the marinas, with 24% and 14% of their areas considered toxic, respectively. On the continental shelf, 13% of the area was considered toxic (more specifically categorized as *moderate toxicity*). The mussel test results indicated that 99% of the total embayment area was not toxic. Once the amphipod and mussel toxicity scores were integrated, 97% of total embayments were considered not toxic.

The temporal assessment of toxicity extent and magnitude over the past 25 years indicated a trend towards decreased toxicity for most of the SCB region based on the integrated toxicity SQO scores. The areal extent of toxicity measured using the amphipod test remained comparable to those in Bight ’13 and ’18 surveys for the embayments, although variability at the stratum level was noted. The mussel embryo test results remained consistently in the downward trend for the embayments. In the offshore strata, 13% of the area was considered toxic (*moderate toxicity* category). The extent and magnitude of toxicity measured increased compared to Bight ’18 and reached levels comparable to those measured during Bight ’03. For the revisited sites, nearly 70% of them were consistently in the always not toxic category based on the amphipod only, mussel only and integrated toxicity data. None of the revisited sites were considered always toxic for either species.

Three recommendations are also formulated based on the results from the Bight ’23 survey. First, future surveys should identify and implement cost/time efficient stressor identification methods (e.g. effects-directed analysis, non-targeted chemistry) to explain the cause of persistent toxicity (e.g. in marinas and estuaries strata) or unexpected increase in toxicity (e.g. *moderate toxicity* observed in Bight ‘23 shelf stations). Second, documentation to justify the water quality DQO should be improved. The current limits were set based on best professional judgement and supporting datasets and references should be included for all critical water quality parameters. Finally, comparability evaluation scores used in the pre-survey intercalibration exercise should be reviewed to ensure that important metrics such as SQO score agreement are appropriately weighted in the final intercalibration score.

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I. Introduction

The Southern California Bight (SCB) is an ecologically diverse coastal region that spans from Point Conception in Santa Barbara County to Punta Colonet in Baja California, providing economic, cultural and recreational services to large populations. The region encompasses a range of habitats including estuaries, wetlands, kelp forests, deep sea and offshore environments, and supports numerous aquatic species (e.g., marine mammals, mollusks, crustaceans, fish, etc. It is also subject to various environmental stressors, including chemical pollution due to high urbanization and some of the most densely populated cities in the U.S. Thus, state and local agencies have made significant investments to monitor, improve and preserve SCB habitats.

Since 1994, approximately 100 regulated, regulatory, non-governmental and academic organizations have joined forces to assess the conditions of SCB every five years. The SCB Regional Marine Monitoring Program (i.e., the Bight program) has focused on sediment quality as many legacy and emerging contaminants (e.g., polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), pesticides, etc.) are known to bioaccumulate and affect aquatic health. Unlike routine monitoring programs that limit their assessment to areas nearest to regulated discharges associated with National Pollutant Discharge Elimination System (NPDES) permits, the Bight program implements a probabilistic design intended to assess regional condition of the various SCB habitats to provide much needed context for local NPDES and Total Maximum Daily Load (TMDL) monitoring (Schiff et al. 2019). During each Bight survey, a subset of sites is revisited to facilitate the characterization of site-specific trends in the region. Sediment quality within the SCB is assessed using multiple lines of evidence (i.e., sediment chemistry, benthic assemblages and sediment toxicity) that are analyzed and integrated using a framework largely based on the framework described in the California Sediment Quality Objectives Program (SQO). This standardized approach provides a robust assessment of sediment quality and allows for quantitative comparison of the Bight sediment quality results to other regions of the state. Long-term monitoring of the SCB region also serves as a vehicle to document the impact of management actions on regional sediment quality over time.

Sediment toxicity, described in this report, is a key component of the overall assessment of sediment quality. While chemical analysis provides much needed information on the magnitude of contamination, only a limited number of contaminants are routinely analyzed in monitoring programs. Furthermore, chemical occurrence data alone is not an indicator of adverse health effects as it does not account for bioavailability or the interactive effects of multiple contaminants on organisms. Thus, toxicity testing is used to complement chemical measurements by providing an integrated measure of the effects of all bioavailable contaminants present at a site. Two benthic marine species used in the SQO program are tested in the Bight program. The amphipod *Eohaustorius estuarius* that lives in marine and estuarine sediment, is used to assess whole sediment toxicity. The mussel *Mytilus galloprovincialis* that lives on top of the sediment, is used to assess the toxicity of dissolved contaminants at the sediment-water interface.

The sediment toxicity element of the Bight program was designed to address three questions:

1) What is the extent and magnitude of sediment toxicity in the SCB?
2) How does the extent and magnitude of sediment toxicity compare among habitats of interest?
3) How does the extent and magnitude of sediment toxicity compare to previous Bight surveys?

This report is organized into eight chapters and 3 appendices. Chapter I is the introduction for the toxicity element of SCB sediment quality assessment. Chapter II describes the methods used to prepare the samples and measure toxicity. Chapter III provides a description of the quality assurance plan used to evaluate laboratory performance, data reliability and comparability. Bight ’23 toxicity data and interpretation are presented in Chapters IV and V. Conclusions from the study are presented in Chapter VI, and recommendations for future studies are presented in Chapter VII. Appendices include electronic maps of results, a cross reference of station IDs for revisited sites for all previous Bight surveys, and a station-by-station summary of the toxicity results. Combined SQO scores for sites using the multiple lines of evidence: sediment toxicity, chemistry, and benthic community responses are not included in this report. Rather these results, and comparisons between indicators, will be addressed in the Bight ’23 Sediment Quality Synthesis Report.

II. METHODS

A. Sampling Design

Bight '23 stations were selected using a Generalized Random Tessellated Stratified design to create a random and spatially balanced selection process (Stevens 1997). A total of 280 stations evenly distributed among five embayment strata (bays, freshwater estuaries, marine estuaries, marinas, ports) and three offshore strata (inner, mid and outer shelf), were selected for sediment toxicity (Table 1 and Figure 1). Enhancement of the sampling design was achieved through intensified sampling in targeted areas of Los Angeles Harbor and San Diego Bay. To assess how site-specific toxicity varied over time, approximately 50% of the Bight '23 stations selected for sediment toxicity assessment were sites sampled in previous Bight surveys. All stations sampled were evaluated using the *E. estuarius* whole sediment toxicity test. The embayment samples (i.e., from ports, marinas, bays and estuaries) were also evaluated using a sediment-water interface test with *M. galloprovincialis* embryos.

Table 1. Distribution of new and revisited stations for toxicity testing during Bight '23 survey.

Stratum	New Stations	Revisit Stations	Total Number of Stations
Bays	28	18	46
Marinas	30	16	46
Ports	38	18	56
Marine Estuaries	22	11	33
Freshwater Estuaries	7	1	8
Inner Shelf	5	5	10
Mid Shelf	5	5	10
Outer Shelf	5	5	10
Total	140	79	219

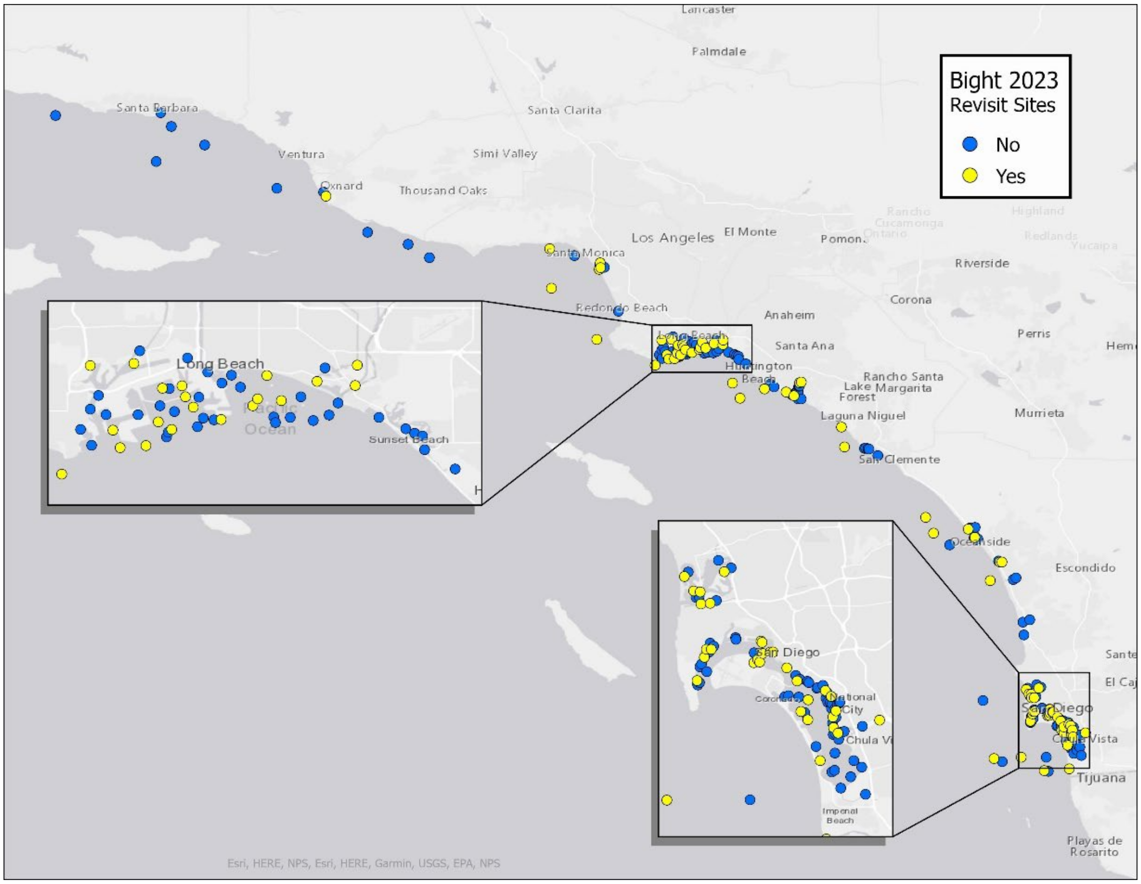

Figure 1. Locations of all Bight '23 stations targeted for toxicity testing. Sites sampled at least once during previous Bight surveys are in yellow.

B. Sample Collection

Sediment sampling was conducted between July 1 and October 31, 2023. The field sampling window was extended beyond the usual end of September timeframe due to the passage of Hurricane Hilary in August 2023. Sediment samples were collected for toxicity and chemical measurements with a 0.1 m^2 modified Van Veen grab. The top 2 cm (shelf sites) or top 5 cm (embayment sites) of the undisturbed sediment surface was collected using a plastic (high-density polyethylene [HDPE], polycarbonate, or Teflon) scoop and placed in Teflon bag or HDPE 1- liter jars. Sediment within 1 cm of the edges of the Van Veen grab was avoided to minimize cross-contamination. Sediment from all embayment stations were thoroughly homogenized using a clean plastic spoon or by kneading the sample within the bag. After homogenization, the samples were aliquoted for chemistry and toxicity measurements. Homogenization was not required for sediment samples collected from the shelf stratum even if multiple grabs were needed. All sediment samples for toxicity testing (~ 6 L per sample) were kept in their original containers and stored in the dark at 4°C up to four weeks prior to testing.

C. Laboratory Methods

Whole Sediment Toxicity

The toxicity of whole sediment-associated contaminants was determined using a 10-day amphipod (*E. estuarius*) survival test (USEPA 1994, ASTM 2010) under static conditions. Amphipods and negative control sediment were collected from a non-contaminated estuarine site in Yaquina Bay (Oregon) by Northwest Amphipod (Newport, OR). The field-collected amphipods were acclimated to laboratory conditions for a minimum of 2 days and not longer than 10 days prior to test initiation. The amphipods were only fed once with saltwater fish food (0.25 g TetraMarin® in 100 mL seawater per 1000 amphipods) at receipt.

Upon arrival of all the field-collected sediment samples at the testing laboratory, porewater ammonia and salinity were measured. Sediment samples were press sieved through a 1 mm mesh screen, homogenized and added to 1 L glass chambers to form a sediment layer approximately 2 cm deep. Filtered (≤ 20 µm) natural seawater (800 mL at 32 ppt salinity) was then added slowly. Pipettes or microtubing connected to an air source provided continuous, gentle aeration. Sediments were allowed to equilibrate overnight under these conditions and the following day, 20 amphipods were added to each test chamber. For each B'23 sample, five replicate chambers were prepared along with two surrogate containers for measurements of overlying water (temperature, dissolved oxygen, pH, total ammonia and salinity) and pore water (pH, total ammonia, and salinity). A negative control, with sediment from the amphipod collection site, was included with each batch of samples tested. Based on the water quality data measured at sample receipt, additional low salinity control samples were set up for test batches that included samples with salinity < 30 ppt. The salinity of the secondary controls was dependent on the porewater salinity of samples in the test batch and in some cases multiple controls were needed (Table 2). The amphipod toxicity tests were conducted for 10 days at 15 ± 2°C under constant illumination with daily examination of the test chambers to verify that adequate test conditions were maintained (e.g. aeration, temperature) and to record emergence of the animals or changes in sediment appearance.

Table 2. Secondary control salinities based on sample porewater salinities.

Sample Porewater Salinity Range (ppt)	Additional Control Salinity (ppt)
0 - 4	2 ± 2
5 - 9	7 ± 2
10 - 14	12 ± 2
15 - 19	17 ± 2
20 - 24	22 ± 2
25 - 29	27 ± 2

Overlying water quality measurements of temperature, pH, dissolved oxygen, and salinity were made on day 0 and at least every other day for the duration of the exposure. Ammonia measurements in the overlying water were made at a minimum on day 0 and day 10. Temperature of overlying water was measured daily throughout the test. The amphipods were exposed to sediment samples for 10 days. At the end of the exposure period, the sediment was screened through a 0.5 mm mesh screen and the number of surviving amphipods was recorded.

Each test batch also included a concurrent reference toxicant consisting of four replicates of five concentrations of ammonia (15.6, 31.2, 62.5, 125, and 250 mg/L total ammonia) dissolved in seawater without any sediment added, plus a seawater control. Some laboratories added an optional concentration of 500 mg/L ammonia. Ten amphipods were added to each replicate and exposed to the reference toxicant for 4 days in the dark. Water quality was measured using a similar methodology to the sediment phase of the test. At the end of 4 days, the total number of surviving animals was recorded.

Sediment-Water Interface Toxicity

The mussel (*M. galloprovincialis*) embryos 48 h sediment-water interface (SWI) tests were performed following the methodology of USEPA (1995) and Anderson et al. (1996). Multiple sources in southern California and Washington states were used to obtain mussels in spawning conditions. Because mussels can have difficulties spawning in the warmer summer months, some laboratories held mussels for extended periods under conditions optimized to keep them in spawning conditions.

Sediment was passed through a 1 mm sieve, homogenized and added to tall 600 mL glass test chambers (~7.5 x 15 cm) to a depth of 5 cm. Approximately 300 mL of filtered (≤ 1 µm) natural seawater (32 ppt) was carefully added over the sediment. The overlying water was gently aerated, and exposure chambers placed at 15°C with a 16-hour light, 8-hour dark cycle. The sediment and overlying water equilibrated overnight before addition of a screen tube made of polycarbonate tubing with a 25 to 30 µm Nylon mesh or polyethylene screen (Figure 2). A negative control consisting of the screen tube in seawater without sediment, was tested with each batch to verify that the test system was not a source of adverse effects to the mussel embryos. A second control consisting of approximately 250 embryos in 10 mL laboratory seawater in 20 mL glass shell vial was tested to verify organism health. The controls from the concurrent reference toxicant test were often used for this purpose.

On the day of test initiation, spawning was induced, gametes were collected, and fertilization was initiated in a controlled environment. Approximately 250 fertilized mussel eggs from a stock solution were added to the screen tube. The same volume of embryo stock was also added to five replicate glass vials which were immediately preserved for determination of the initial number of embryos added. Water quality parameters (temperature, dissolved oxygen, salinity, and pH) were measured daily in the overlying water. Ammonia was analyzed in the overlying water at test initiation and termination. After 48 hours of exposure to the test samples, the embryos were washed from the screen tube into another vessel for preservation and storage. The embryos were then counted and examined for normal development under a microscope. The number of normal embryos divided by the average initial number of embryos inoculated determined the endpoint, termed percent normal-alive.

A concurrent reference toxicant test was conducted with each test batch, consisting of six concentrations of ammonia (2, 4, 6, 8, 10, and 20 mg/L total ammonia) dissolved in seawater and a control, all testing five replicate chambers. For these tests, embryos were directly added to the solutions in 20 mL glass shell vials and exposed for 48 hours. At the end of the exposure period, embryos were preserved and stored for microscopic analysis. Water quality for the reference toxicant tests was measured using methods similar to the sediment test. Samples were examined microscopically as described above to determine the percent normal-alive.

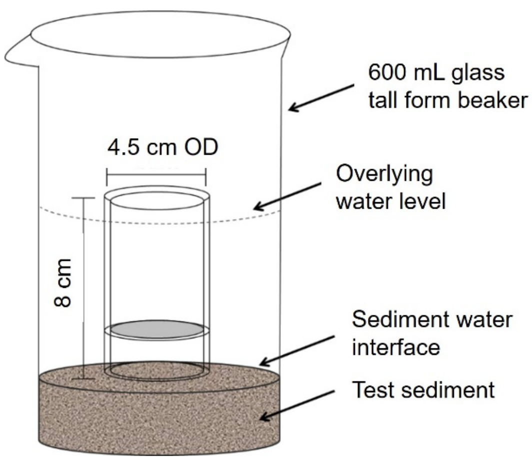

Figure 2. Schematic diagram of sediment-water interface exposure system.

D. Data analysis

Test validity was first assessed based on a set of established test acceptability criteria. For the amphipod toxicity test, results were deemed acceptable when the mean survival in controls was ≥ 90% and the coefficient of variation (CV) for the controls was ≤ 11.9%. If the control CV was greater than 11.9%, any test samples with a mean survival ≥ 90% were deemed acceptable and not retested. Test samples with a mean survival < 90% were retested. For the mussel test, a test batch was deemed acceptable when the mean control percent normal-alive was ≥ 80%.

Reference toxicant data was analyzed using linear interpretation methods (USEPA 1995) to calculate the median lethal un-ionized ammonia concentration (LC_{50}) for the amphipod test, and the median effective concentration for percent normal-alive (EC_{50}) for the mussel test. LC_{50} and EC_{50} values were then compared to the control chart of past reference toxicant data by the testing laboratory. Test results within two standard deviations of the mean LC_{50} or EC_{50} in the control chart of the laboratory were considered acceptable. A test falling outside two standard deviations was not considered invalid, but a thorough review of all data and test procedures was triggered to ensure that the data were of high quality.

Bight '23 sediment toxicity data were analyzed in four ways: 1) mean control-normalized responses; 2) SQO toxicity category for each station using the SQO assessment framework; 3) areal extent of toxicity as percent stations and percentage area weight classified into each SQO toxicity category; and 4) temporal analysis of toxicity compared to previous Bight data.

Control-Normalized Responses

Control-normalized data is more amenable to comparisons across time and between laboratories to account for variable control performance. For all Bight '23 samples, data was expressed as mean control-normalized response and calculated as the mean sample response divided by the mean response of the associated control for that batch multiplied by 100.

SQO Toxicity Category

The SQO framework was applied to derive SQO toxicity category for each Bight station (Bay et al. 2014). There are four toxicity categories, and associated scores based on the severity of toxicity and the confidence that the toxicity data is reproducible: *nontoxic*, *low toxicity*, *moderate toxicity*, or *high toxicity*.

- ***Nontoxic* (score 1)**: Sample response is not substantially different from that in control sediments that have optimum characteristics for the test species.
- ***Low toxicity* (score 2)**: Sample response is of relatively low magnitude; the response may not be greater than test variability.
- ***Moderate toxicity* (score 3)**: High confidence that a statistically significant toxic effect is present. Also referred to as *moderately toxic* in this report.
- ***High toxicity* (score 4)**: High confidence that a toxic effect is present, and the magnitude of response includes the strongest effects observed for the test. Also referred to as *highly toxic* in this report.

The toxicity thresholds for each category are test method-specific (Table 3). These thresholds described were initially developed for application in embayments based on analysis of toxicity data from bays and estuaries only (Greenstein and Bay 2012). However, the thresholds are also being used herein for interpretation of the amphipod test results for Bight offshore samples, even though the thresholds were not designed for that stratum. It should be noted that the thresholds applied for Bight sample analysis are nearly identical to those used throughout the US for regional sediment quality assessment of nearshore and offshore marine sediment (USEPA 2014). For stations where both amphipod and mussel tests were conducted, a final toxicity category was determined by averaging the SQO category scores and rounding up. All SQO toxicity scores were generated using a custom R-script developed by SCCWRP for the Bight Program specifically. As part of the quality control process, the codes and outputs were evaluated by other Bight participating agencies and compared to the output of the Excel SQO toxicity tool available on the SCCWRP website. More information about the codes is available in the Bight ‘23 data portal.

For descriptive purposes in the results and discussion, toxicity is often characterized in a simplified manner using “not toxic” or “toxic”. The term “not toxic” is used for stations or areas classified as *nontoxic* or *low toxicity*, and the term “toxic” is used for stations and areas classified as *moderate* or *high toxicity* based on the SQO approach.

Table 3. Thresholds for calculating toxicity categories.

Test Species/ Endpoint	***Nontoxic* (Percent)**	***Low Toxicity* (Percent of control)**	***Moderate* Toxicity (Percent of control)**	***High Toxicity* (Percent of control)**
E. estuarius Survival	90 to 100	82 to 89[a]	59 to 81[b]	< 59
M. galloprovincialis Percent Normal-alive	80 to 100	77 to 79[a]	42 to 76[b]	< 42

[a]If the response is not significantly different from the negative control, then the category becomes *nontoxic*.

[b]If the response is not significantly different from the negative control, then the category becomes *low toxicity*.

Areal Extent of Toxicity

The study design implemented for the Bight program provides unbiased probability-based areal estimates of the proportion that each site represents within a stratum. Specifically, the estimates are a weighted average where the weights are determined by the size of each disjoint sampling area divided by the number of samples falling into that area. These “area weights” are the same as the inverse of the inclusion probabilities for that sample. The area weighted proportions were computed as a ratio of the sum of the area weights for all sites which fell within an SQO toxicity category and the sum of the area weights for the entire stratum. The local neighborhood variance estimator, which takes advantage of any spatial proximity with the data set, was used to compute standard errors for constructing 95% confidence limits (Stevens and Olsen 2003). Freshwater estuaries stations were not assigned area weights because they were targeted (i.e., not randomly assigned). Therefore, these stations were not included in areal assessment including regional assessment and temporal analysis.

Prior to any statistical analysis, area weights were adjusted to account for missing data due to inability to access sites or minor inaccuracies in the initial sample frame. The study design included oversampling of stations to account for sampling failures in the field. A complete description of the statistical tools used and scripts for probability-based estimation can be found in the following website http://archive.epa.gov/nheerl/arm/web/html/monit_intro.html.

The representativeness of the randomly selected Bight sample locations in some of the more spatially and physically diverse habitats (i.e., bays and estuaries) may have more uncertainty when extrapolating results over a larger area. To address this concern, an additional analysis was conducted to evaluate the percentage of stations tested that fell within each SQO toxicity category.

Temporal Analysis

Bight' 23 data were compared to the results from the five previous toxicity surveys of the SCB to assess temporal changes in toxicity over the past ~25 years (Bay et al. 2000, 2005, 2011, and 2014; Parks et al. 2020). Comparisons of the SQO toxicity scores were made on a percent area basis using the individual test methods results as well as the integrated SQO category results for the embayment strata. To ensure that temporal trends were evaluated appropriately, two steps were taken. First, Bight '98 and '03 toxicity results re-calculated using the current SQO toxicity thresholds and described in the Bight' 13 report were used. This step was needed because SQO toxicity thresholds were not available during Bight '98 and '03. Second, the temporal analysis was limited to the strata for which data was consistently available among the different Bight surveys. As such, the freshwater estuaries were not included in the temporal comparisons, and offshore strata only included mid shelf, inner shelf and outer shelf. Data for the revisited sites were analyzed using two statistical tests. Pearson's chi-square tests were used to assess the frequency of distribution of categorical data over time. The analysis was only performed for sample size $n > 5$ (i.e., > 5 survey data per stratum). Significance was determined at $p \leq 0.05$. The non-parametric Wilcoxon Signed Rank test was also performed to evaluate the significance in toxicity magnitude between the initial and final surveys. This non-parametric test was used because the toxicity test results (percent survival or normal-alive) did not fit the assumptions of the parametric test. Significance was determined using an alpha = 0.05, and the two-tailed hypothesis was used to determine if any significant differences exist.

III. Quality Assurance Evaluation

To ensure good data quality and comparability between laboratories, the Toxicology Committee developed and implemented a Quality Assurance (QA) plan for the Bight ’23 survey. This QA plan is included in the toxicology laboratory manual. Five data quality objectives (DQO) were used to ensure data robustness: sampling success and holding times for sediment samples and organisms, reference toxicant tests run concurrently with every test batch, test performance including water quality measures and testing completeness, evaluation of the interlaboratory agreement, and laboratory audits. More details on each of the five DQOs for Bight ’23 are provided below.

A. Sampling Success and Holding Times

The target sampling success of 90% was achieved with an estimated 99% of the Bight ’23 assigned stations successfully collected. The optimal sediment holding time prior to toxicity testing was within 14 days. Holding time between 15 and 28 days was allowed but data were flagged. All Bight ’23 samples collected were tested within the acceptable holding time of 28 days. For the amphipod test, 99% of the samples were tested within the optimal holding time of 14 days and 1% (i.e., two stations) were tested within 15 to 28 days (Table 4). For the mussel test, 100% of the samples were tested within 14 days post collection.

The recommended organism holding time for amphipods acclimation was between two and 10 days. In this survey, all organisms were held in accordance with the protocols set forth in the toxicology laboratory manual. No unusual occurrences were noted regarding the transport, holding or acclimation of the organisms.

Table 4. Toxicity sample holding times (from sample collection to animal addition) for Bight ’23 samples.

	E. estuarius		*M. galloprovincialis*	
Time Interval (days)	**# Stations**	**Total (%)**	**# Stations**	**Total (%)**
0-14 (acceptable)	217	99	183	100
15-28 (acceptable w/ qualifier)	2	1	0	0
> 28 (unacceptable)	0	0	0	0

B. Reference Toxicant Testing

Each toxicity test batch for both methods was accompanied by a concurrent reference toxicant test to monitor organism health and relative sensitivity within a laboratory throughout the testing period.

There were 33 amphipods and 21 mussel embryos reference toxicant batches. The EC_{50}/LC_{50} data were computed for the un-ionized ammonia measured at time zero using by linear interpolation using an R-script written by SCCWRP. Test data for the amphipod and mussels were compared to the standard deviation of a large set of historical reference toxicant data submitted by the participating laboratories over the years. All LC_{50} values derived from the amphipod reference toxicant tests fell within two standard deviations of the historical grand mean (Figure 3. Similarly, all mussel embryo reference toxicant tests had EC_{50} within the two standard deviations of the test's historical grand mean (Figure 4).

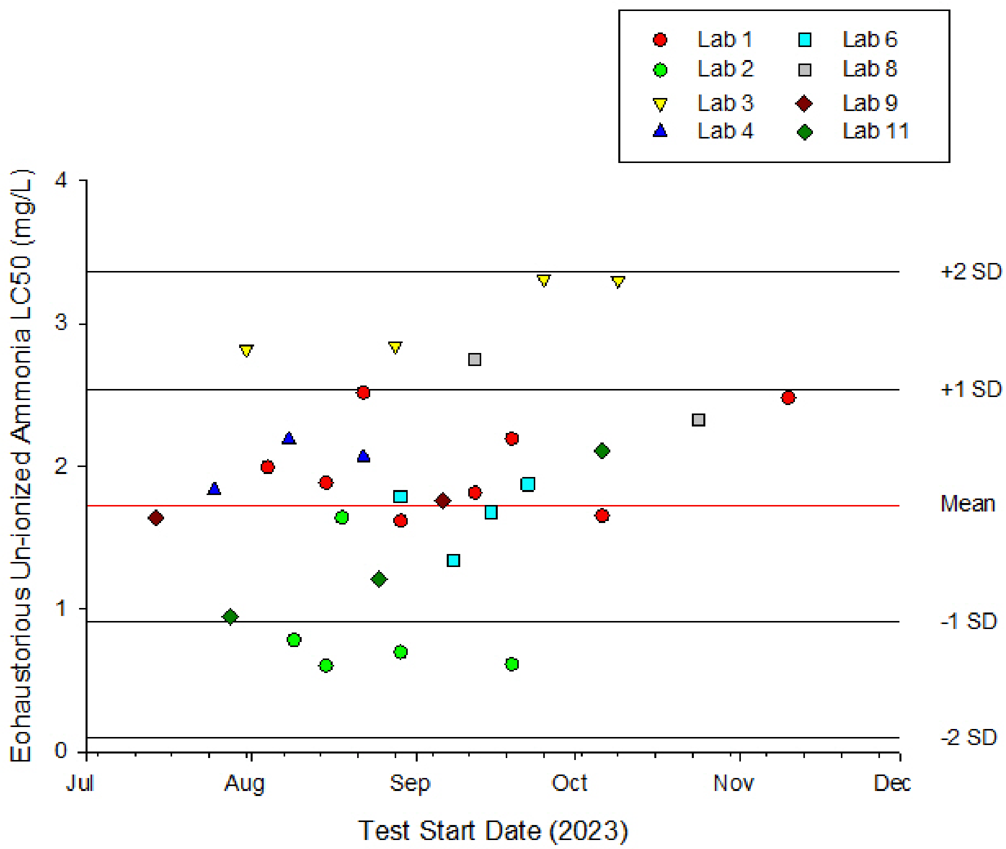

Figure 3. Results of amphipod 96 h reference toxicant tests with ammonia.

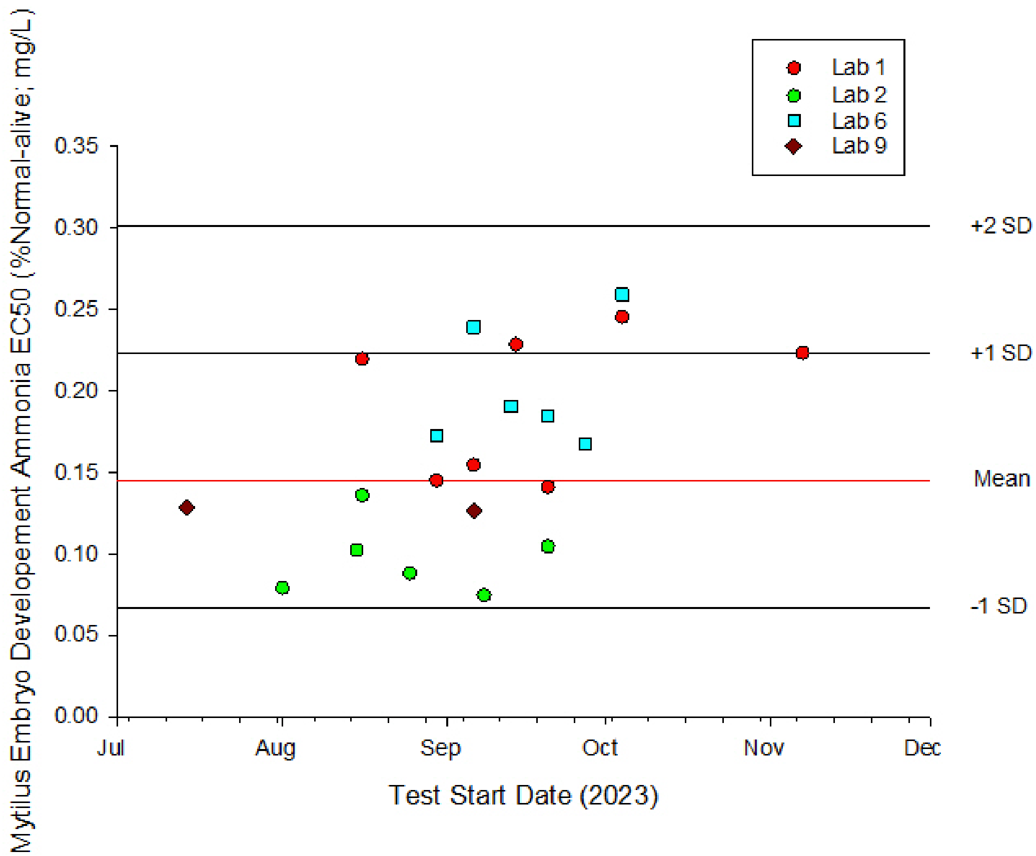

Figure 4. Results of mussel embryo reference toxicant tests with ammonia.

C. Test Performance and Testing Success

The test acceptability criteria (TAC) for the amphipod tests were ≥ 90% mean control survival and CV ≤ 11.9 for control survival. For the first time, the mussel embryo TAC was set as ≥ 80% mean control percent normal-alive which is consistent with the TAC used in the California state SQO program. Overall, all test batches for the amphipod and mussel test met the established TAC. The target 90% testing completion was also exceeded with 100% of the amphipod tests and 97% of the mussel tests successfully performed (Table 5).

Water quality measurements were within the predefined ranges for most of the tests (Table 6). Any out-of-range data were flagged in the database. Additional analysis was performed to examine the relationship between water quality and test outcomes (data not shown). Results showed no correlation between any of the water quality excursions and the sample's toxicity levels. This was also the case for dissolved oxygen which was found to often be below the desired threshold (Table 6). Therefore, all the exceedances were deemed minor, and the data were considered acceptable for analysis.

Table 5. Testing success of Bight ’23 toxicity samples.

	E. estuarius				*M. galloprovincialis*			
Stratum	**Assigned**	**Collected**	**Tested**	**Testing Success (%)**	**Assigned**	**Collected**	**Tested**	**Testing Success (%)**
Bay	46	46	46	100	46	46	46	100
Freshwater estuary	8	8	8	100	8	8	8	100
Marine estuary	33	33	33	100	33	33	31	94
Marina	46	46	46	100	46	46	44	96
Port	56	56	56	100	56	56	55	98
Shelf	31	30	30	97	0	0	0	-
Total	220	219	219	100	189	189	184	97

Table 6. Summary of data quality objectives (DQO) for water quality measurements.

Metric	Amphipod DQO	Success (%)	Mussel DQO	Success (%)
Temperature	15 ± 2°C	100	15 ± 2°C	100
Dissolved oxygen	≥ 90% saturation	66	≥ 4 mg/L	100
pH	7.7 – 8.3	92	7.6 – 8.3	90
Salinity	32 ± 2 ppt	95*	32 ± 2 ppt	100
Un-ionized ammonia	< 0.8 mg/L	100	Not available	-

*Salinity controls were included for test batches with samples below 30 ppt.

D. Evaluation of Interlaboratory Agreement Before Testing of Bight Samples

Prior to testing Bight ’23 samples, all toxicity testing laboratories were required to participate in an interlaboratory study to ensure comparability of data produced. Nine laboratories participated in the amphipod intercalibration, and five laboratories participated in the mussel embryo intercalibration. Laboratories that did not participate in the mussel embryo intercalibration did not analyze any of the Bight ’23 samples. The participating laboratories tested four split field samples, including one duplicate sample, and ran concurrent reference toxicant tests. Details for evaluating and scoring each category are described in Appendix E. The final score was broken down into four categories: low, moderate, high, and very high comparability. A laboratory passed the intercalibration test if they received a score of moderate or above.

For the amphipod test, the average survival between laboratories was similar, except for Laboratory 2 for Samples A and B (Figure 5). Note that samples C and D were duplicates. There was a considerable spread in the SQO categories between laboratories within each sample. This was somewhat of an artifact caused by the mean values for each sample being close to the threshold between *low* and *moderate toxicity*. Therefore, a small difference in the percentage survival could lead to a category or two difference for the SQO assignment. The labs did very well for the duplicate samples. For the amphipod test, all laboratories were found to be comparable during the intercalibration exercise (Table 7).

For the mussel test, there was again a little more spread in the results for Samples A and B (Figure 6). For Samples C and D, the results were comparable between laboratories except for Laboratory 9. For Sample C, Laboratory 9's data was found to be a statistical outlier from the others and therefore was not included in the grand mean for the calculation of comparative metrics. The SQO categories were found to be more similar between labs for the sediment-water interface test than for the amphipod test. Again, all laboratories scored well for the duplicate samples. All laboratories participating in the mussel test were also found to be comparable during the intercalibration exercise except for Laboratory 10 whose test did not meet the acceptability criterion of 80% normal/alive embryos in their controls. The final intercalibration results ranged from high to very high comparability for the amphipod test and moderate to very high comparability for the mussel test (Table 7). In past surveys, laboratories not receiving acceptable scores were given a second chance at achieving comparability through repeat testing. However, since no survey samples were assigned to Laboratory 10, a second intercalibration was not performed.

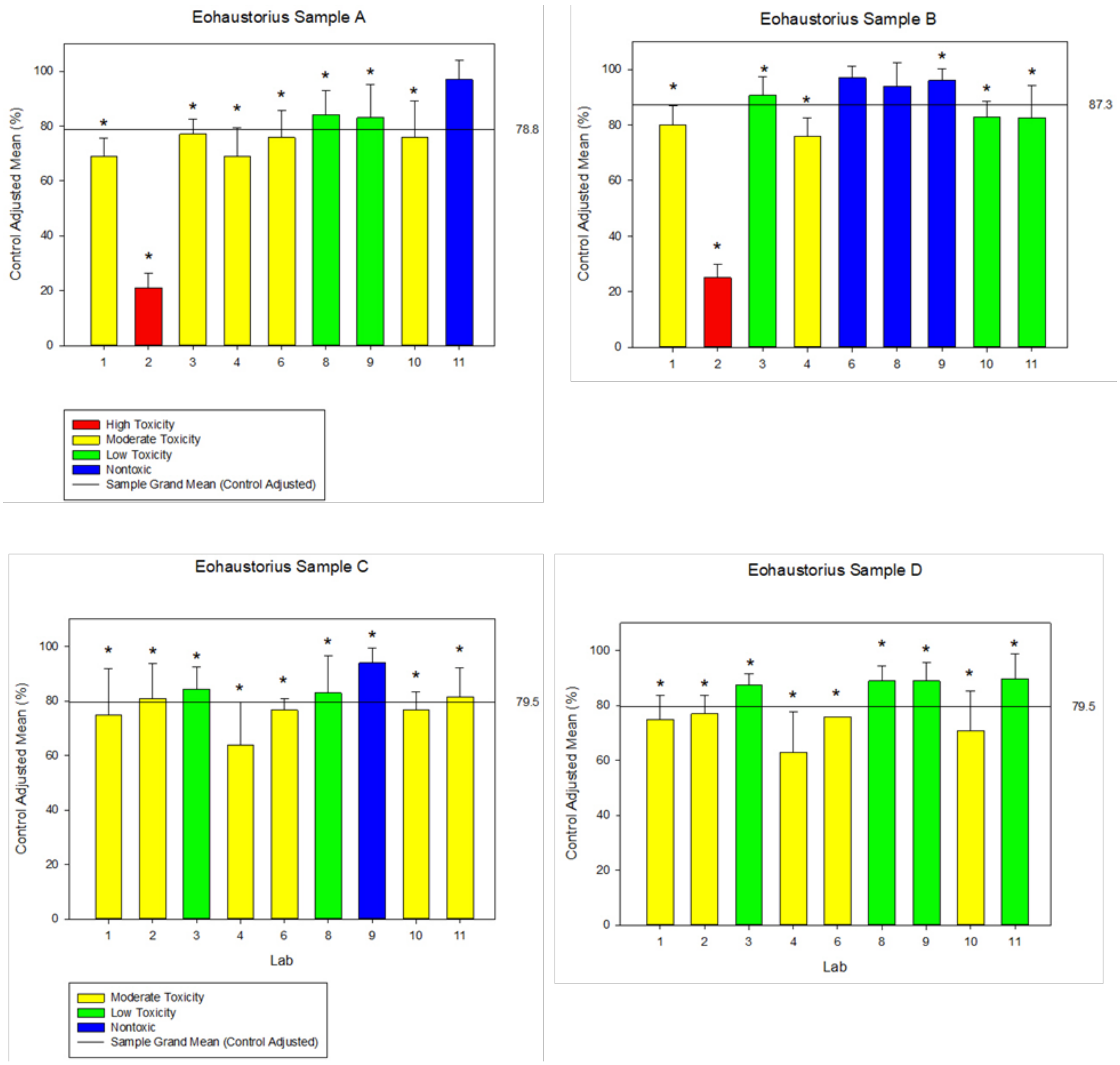

Figure 5. Intercalibration results using the amphipod whole sediment toxicity test. Asterisks* indicate a significant difference from the laboratory's control. Samples C and D were duplicates.

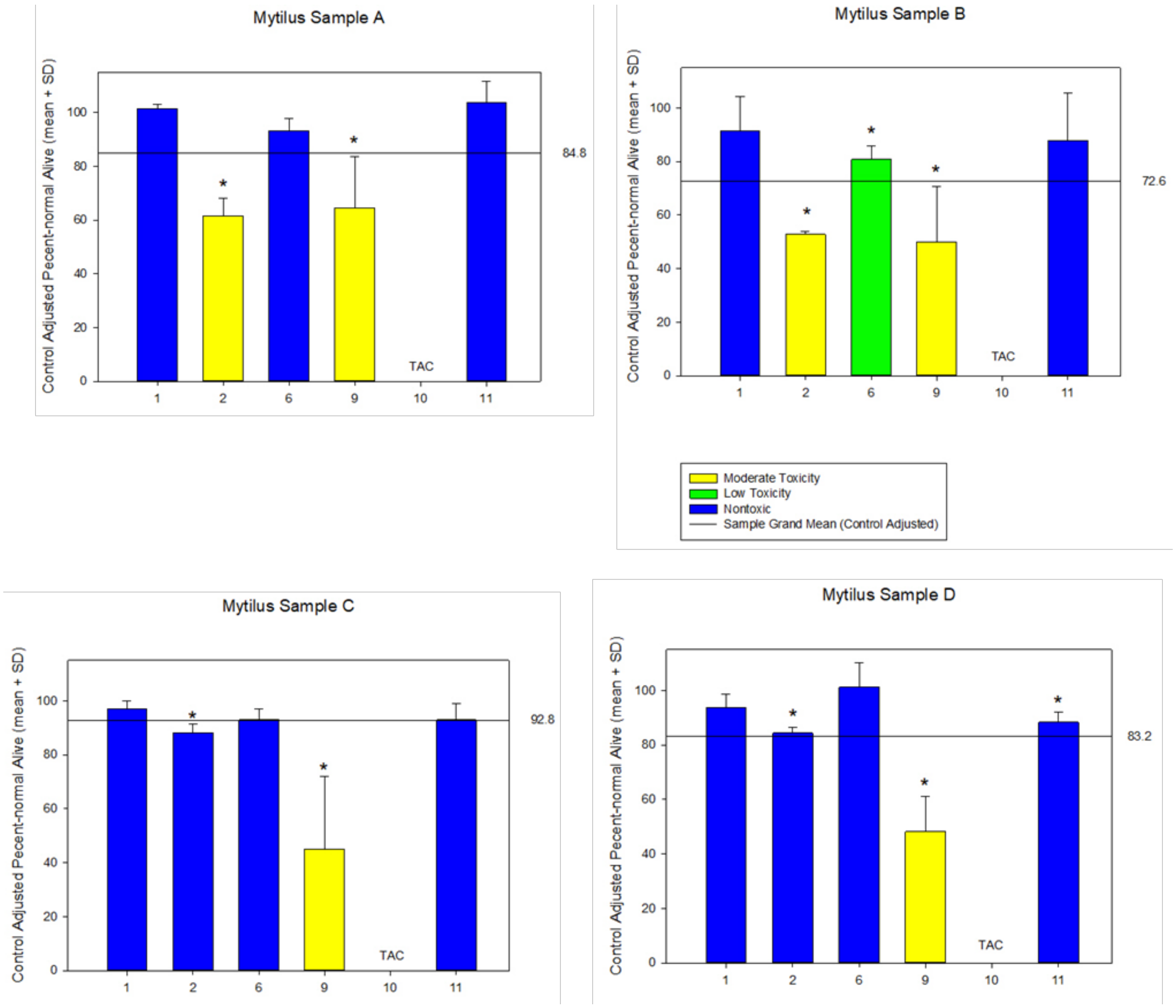

Figure 6. Intercalibration results using the mussel embryo sediment-water interface test. Asterisks* indicates a significant difference from the laboratory's control. Note that for Sample C, the mean for Laboratory 9 was found to be an outlier and therefore their data was not included in the sample grand mean. Samples C and D were duplicates.

Table 7. Laboratory comparability based on results of the intercalibration exercise.

Laboratory	Amphipod Test	Mussel Embryo Test
1	Very high	Very high
2	High	High
3	Very high	DNP
4	Very high	DNP
6	Very high	Very high
8	Very high	DNP
9	Very high	Moderate
10	Very high	Did not meet TAC
11	Very high	Very high

DNP-Laboratory did not participate in this test.

Five laboratories conducted a third toxicity test with an alternate species, the 72-hour sediment-water interface test with purple sea urchin embryos (*Strongylocentrotus purpuratus*). This test used methods similar to those for the mussel embryo test and a longer exposure period. The sea urchin test results could not be compared like those from the amphipod and mussel tests because: 1) there are no established SQO toxicity thresholds for the sea urchins; and 2) there is not a body of ammonia reference toxicant data for comparisons. Laboratories had very good results in their controls except for laboratory 10 which did not meet the test acceptability criterion of 80% percent normal-alive (Figure 7). There was considerable variability in the results for the split samples between the laboratories (Figure 8). Laboratory 9 observed 0% normal-alive in all four samples. Sample A exhibited the full range of results from 100 to 0% among the laboratories. Even the two duplicate samples (C and D) had variable results. The results indicate that laboratories may need more experience performing this test that has previously been found to have considerable variability (Greenstein et al. 2008).

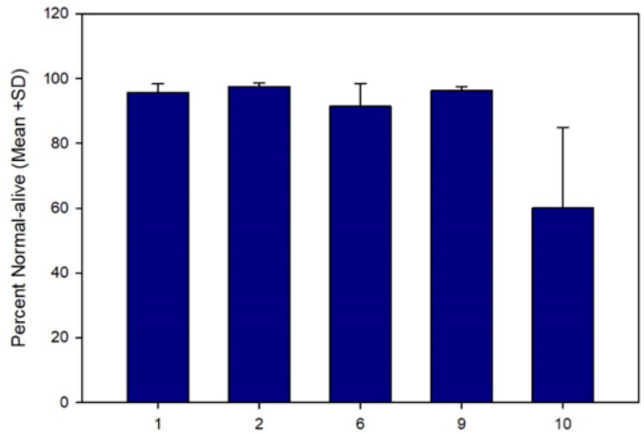

Figure 7. Laboratory control results for the sea urchin sediment-water interface test.

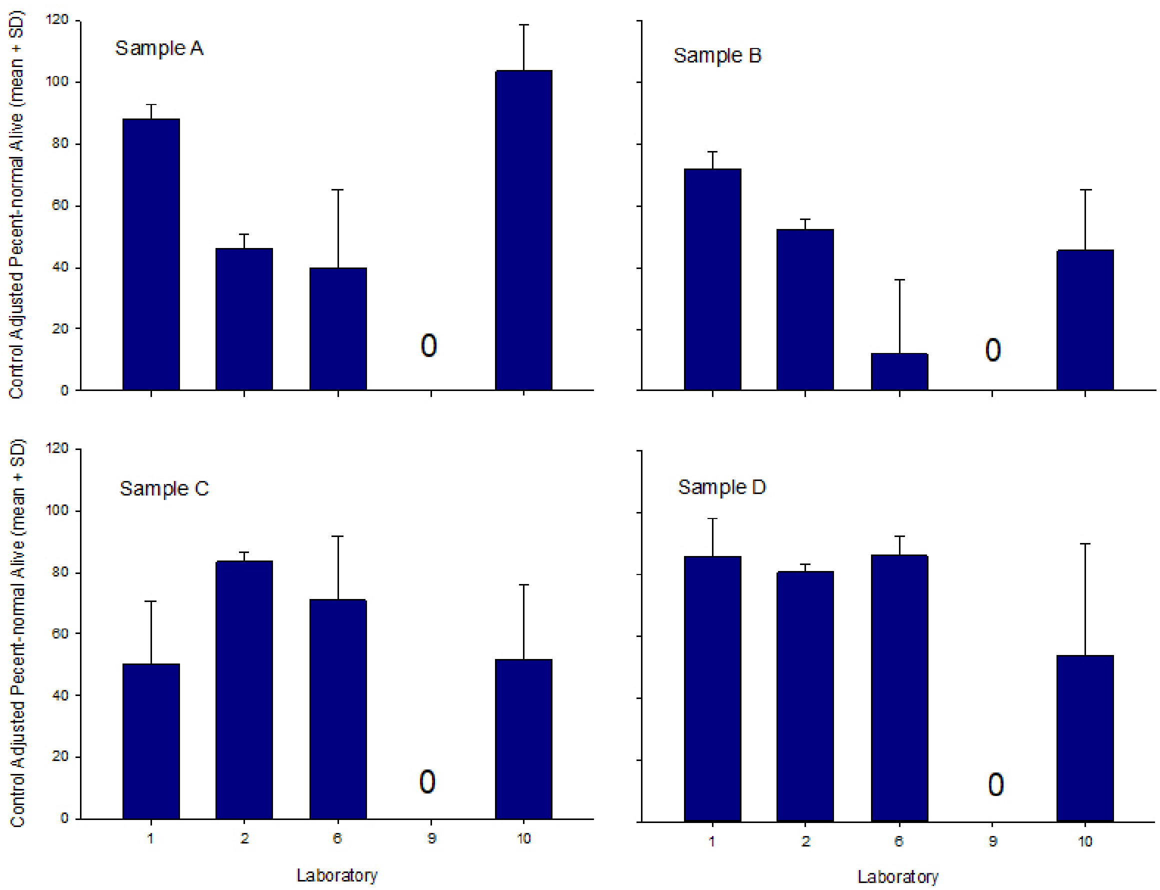

Figure 8. Results of intercalibration exercise using the purple sea urchin embryo sediment-water interface test.

E. Split Sample Testing During Bight '23 Survey

During the Bight '23 sample testing period, additional samples were collected at two stations, B23-12060 and B23-12065, and split samples were tested by all participating laboratories to assess interlaboratory variability. Due to the timing of split samples collection and laboratory testing schedules, there was a wide span of holding times, ranging from the ideal holding time of less than 14 days up to 53 days. Laboratory 3 had the longest holding time, but it did not seem to cause data variability. The comparison criteria used to evaluate laboratory performance were similar to those used for the pre-survey interlaboratory comparison; however, no duplicate samples were included, and no evaluation of reference toxicant results were made. The maximum point score for overall comparability was 9. The ranges used for assessment were: 90% or greater of the points, very high comparability; 80-90%, high comparability; 70-80%, moderate comparability; and < 70%, low comparability. Details of the assessment methods can be found in Appendix E. Due to the nature of the split samples used in this exercise compared to the interlaboratory study (i.e., expanded holding times and less rigorous homogenization), the results were only used for information purposes. There were no actions taken if a laboratory's comparability was determined to be low. for this comparability assessment.

For the amphipod testing, all the laboratories fell within an acceptable range of agreement based on the intercalibration scoring method. For station B23-12060, five laboratories classified the sample as *nontoxic* and three as *low toxicity* (Figure 9). For B23-12065, there was somewhat less agreement with three of the laboratories identifying it as *nontoxic*, three in the *low* category, and two in the *moderate toxicity* category. While there were differences in the SQO category identified, the range in survival percentages was narrow; 86-98% for B23-12060 and 80-95% for B23-12065. Additionally, for two of the laboratories that were in the *moderate toxicity* category for B23-12065, the survival was within two percentage points of the threshold between the *moderate* and *low toxicity* categories. All eight of the laboratories were found to have very high comparability (Table 8).

Results of the mussel tests showed acceptable agreement between the laboratories for both stations (Figure 9). Three of the four laboratories found B23-12060 to be in the *nontoxic* category with the remaining laboratory in the *moderate toxicity* category. The agreement was similar for B23-12065, with three laboratories finding the sample to be in the *nontoxic* category and one in the *low* category. The remaining four laboratories which tested Bight '23 samples did not conduct the mussel test for the survey. Three of the four laboratories had very high comparability scores and the fourth laboratory had high comparability (Table 9).

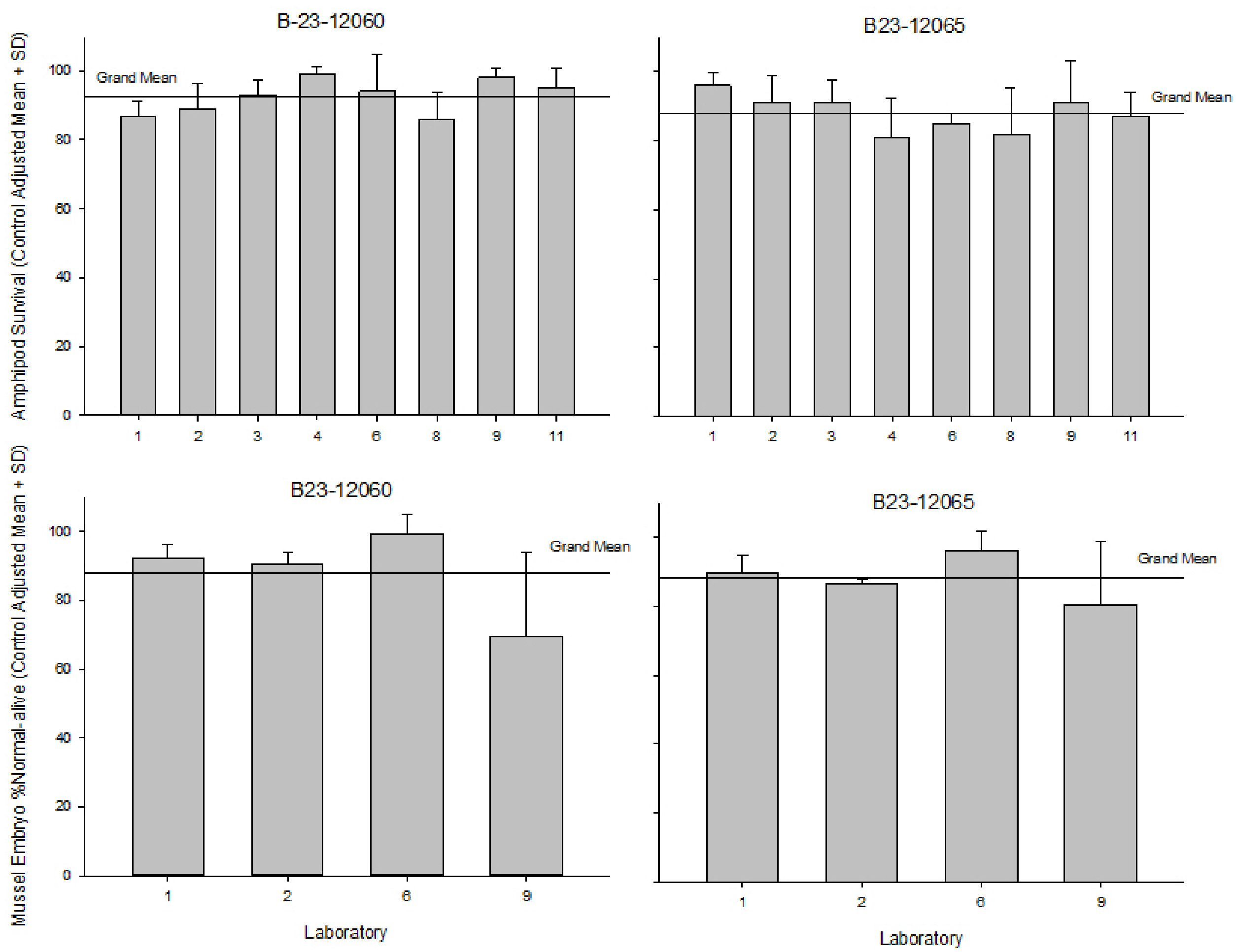

Figure 9. Results of split sample testing of two Bight' 23 stations for the amphipod and mussel embryo tests.

Table 8. Split sample comparability scores using the amphipod whole sediment toxicity test.

Laboratory	12060 Difference[1]	12060 Category[2]	12065 Difference[1]	12065 Category[2]	Total	Comparability Category
1	3	1	3	1	8.0	Very high
2	3	1	3	1.5	8.5	Very high
3	3	1.5	3	1.5	9.0	Very high
4	3	1.5	3	1	8.5	Very high
6	3	1.5	3	1.5	9.0	Very high
8	3	1	3	1	8.0	Very high
9	3	1.5	3	1	8.5	Very high
11	3	1.5	3	1.5	9.0	Very high

[1]Assessment based on the difference between the laboratories' percentage survival and the grand mean for all participating laboratories. [2]Assessment based on the difference between the laboratories' identification of SQO category versus the category calculated from the grand mean of all participating laboratories.

Table 9. Split sample comparability scores using the mussel embryo sediment-water interface toxicity test.

Laboratory	12060 Difference[1]	12060 Category[2]	12065 Difference[1]	12065 Category[2]	Total	Comparability Category
1	3	1.5	3	1.5	9.0	Very high
2	3	1.5	3	1.5	9.0	Very high
6	2	1.5	3	1.5	8.0	Very high
9	2	0.5	3	1	6.5	High

[1]Assessment based on the difference between the laboratories' percentage survival and the grand mean for all participating laboratories.

[2]Assessment based on the difference between the laboratories' identification of SQO category versus the category calculated from the grand mean of all participating laboratories.

F. Laboratory Audit

Onsite audits of each laboratory were conducted as early as possible during the testing period, so that laboratories could implement corrective actions promptly. Laboratory 6 tested their samples late in the survey and the samples arrived on short notice. Therefore, an audit of this laboratory did not occur. There were no significant deviations from the test protocols. One laboratory did not do water quality on porewater at test receipt, and one took the sample by decanting off an aliquot of overlying water instead of centrifuging sediment. Another laboratory had poor records for the calibration of the instruments used to measure water quality on all their samples. These minor discrepancies were noted but were unlikely to have substantial impacts on test results.

IV. Results

A. Frequency and Magnitude of Toxicity

Among the 219 stations tested using the amphipod survival test, 188 stations (86%) were considered not toxic including 148 stations in the *nontoxic* category and 40 stations in the *low toxicity* category (Table 10 and Figure 10). At the stratum level, over 50% of the stations in any given stratum were *nontoxic*. The highest percentage of toxic stations was found in the marine estuaries where 12% of stations were *moderately* toxic, and 12% (4 out of 33) of stations were *highly* toxic. These four stations were the only ones classified as *highly* toxic and had the greatest magnitude of toxicity among all the Bight ’23 samples tested using the amphipod test (Table 11). The second highest percentage of toxic stations was detected in the ports with 20% of the stations (11 out of 55) classified as *moderately* toxic. The bays had the lowest percentage of toxic stations with only 4% of stations (2 out of 47) deemed *moderately* toxic. Additionally, there was one station in the shelf stratum that was not sampled and therefore its toxicity category is designated as unknown.

Results of the mussel embryo test revealed that 99% of stations (182 out of 184) were not toxic (Table 12, Figure 11). Toxicity, more specifically *moderate toxicity*, was only observed at two stations in the marine estuaries and marinas. No stations were found to be in the *high toxicity* category. There were five stations among the ports, marinas, and marine estuaries strata that were sampled but not tested due to logistical errors. The toxicity of these stations was classified as unknown. Overall, there was a good agreement between the two tests for stations deemed *nontoxic* or with *low toxicity*. In contrast, no stations consistently showed *moderate* or *high toxicity* using both the amphipod and mussel embryo tests (Figure 12).

For the embayment stations where both the amphipod and mussel tests were conducted, the integrated toxicity SQO scores indicated that 97% of the stations (178 out of 184) were not toxic (Table 13, Figure 13). There were no stations deemed *highly* toxic. The 8 stations deemed *moderately* toxic were in the marine estuaries, ports and marinas strata. Stations in the bays and freshwater estuaries were all deemed not toxic and over 70% of the stations in both strata were in the *nontoxic* category. For the integrated assessment, 5 (3%) stations were in the unknown category because they were not tested using the mussel embryos. A map summarizing the Bight ’23 toxicity results based on their integrated toxicity SQO categories is provided in Figure 14. Newport Bay and San Diego Bay were identified as areas with the highest frequency of *low* and *moderate toxicity*. More information on the toxicity test results and SQO category for all Bight ’23 stations tested are provided in Appendix A.

Table 10. Number of stations per SQO toxicity category based on the amphipod test results for the embayments (bay, marina, port, marine estuary, and freshwater estuary) and total Bight region (all embayments and the shelf).

Stratum	***Nontoxic***	***Low Toxicity***	***Moderate Toxicity***	***High Toxicity***	***Unknown***
Bay	38	7	2	0	0
Marina	29	12	5	0	0
Port	35	9	11	0	0
Marine Estuary	17	8	4	4	0
Freshwater Estuary	6	1	1	0	0
Shelf	23	3	4	0	1
Total Embayment	125	37	23	4	0
Total Bight	148	40	27	4	1

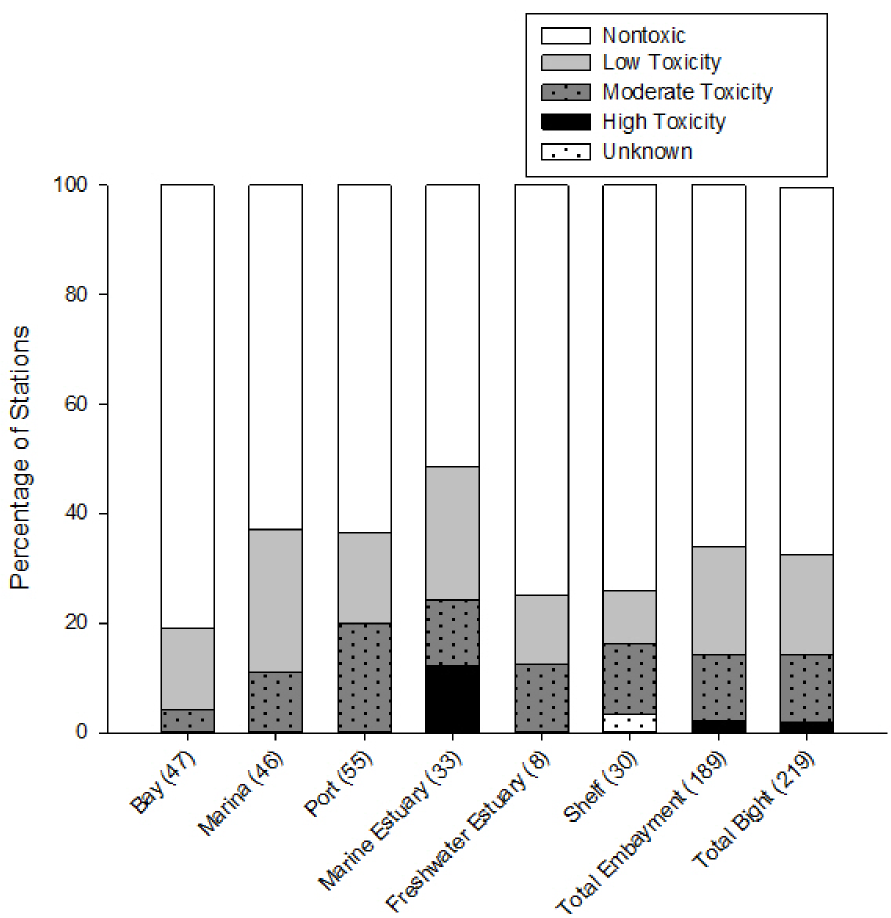

Figure 10. The percentage of stations in each sediment quality objective category for the amphipod toxicity test. The number of stations in each stratum is shown in parentheses.

Table 11. Control-adjusted mean survival of amphipods in the *moderate* and *high toxicity* categories.

	Moderate Toxicity			*High Toxicity*		
Stratum	**Mean**	**Range**	**n**	**Mean**	**Range**	**n**
Bay	74	67-81	2	NA	NA	0
Marina	72	69-77	5	NA	NA	0
Port	73	62-80	11	NA	NA	0
Marine Estuary	70	62-78	4	8	5-30	4
Freshwater Estuary	82	NA	1	NA	NA	0
Shelf	70	66-76	4	NA	NA	0

NA = not applicable. No stations in this category.

Table 12. Number of stations per SQO toxicity category based on the mussel embryo test results.

Stratum	***Nontoxic***	***Low Toxicity***	***Moderate Toxicity***	***High Toxicity***	**Unknown**
Bay	43	4	0	0	0
Marina	38	5	1	0	2
Port	43	11	0	0	1
Marine Estuary	29	1	1	0	2
Freshwater Estuary	8	0	0	0	0
Total Embayment	161	21	2	0	5

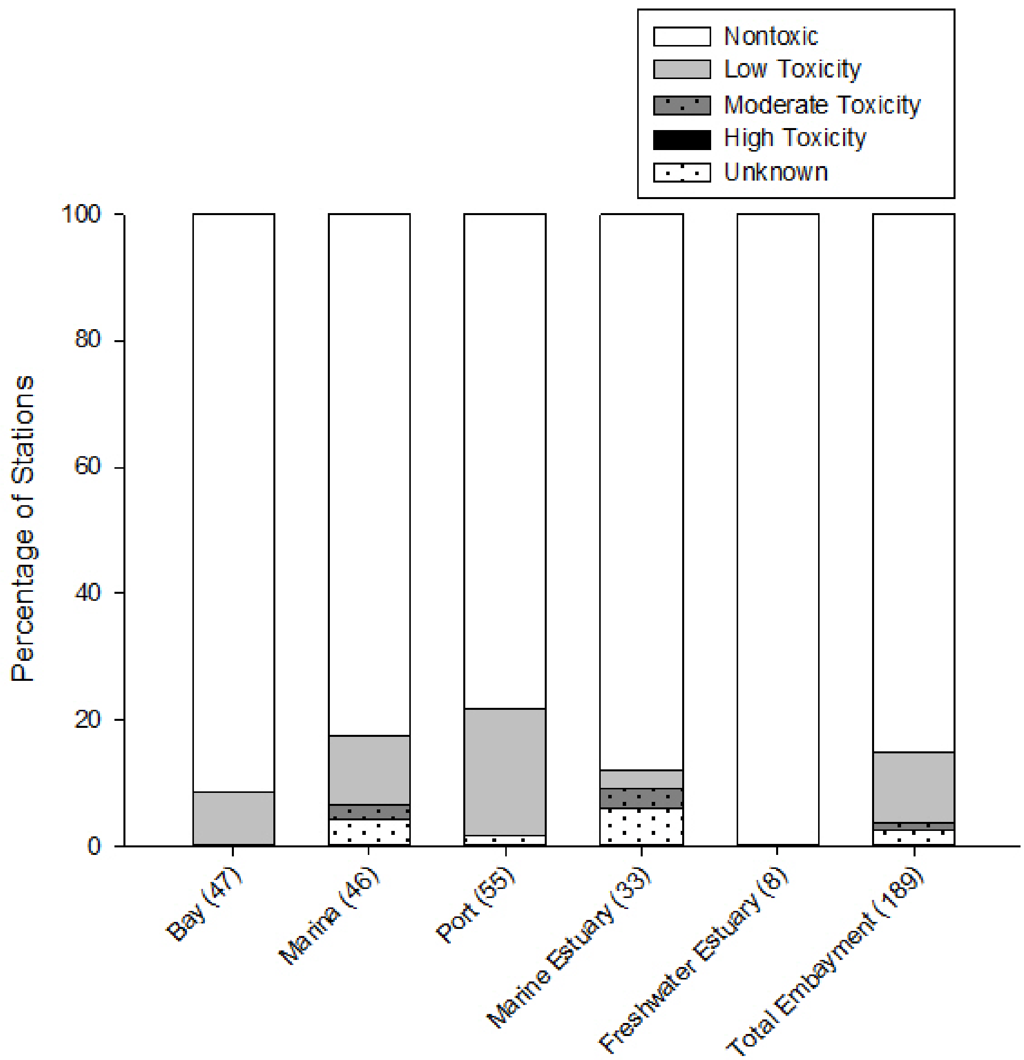

Figure 11. The percentage of stations in each sediment quality objective category for mussel embryo sediment-water interface test by embayment strata. The number of stations in each stratum is shown in parentheses.

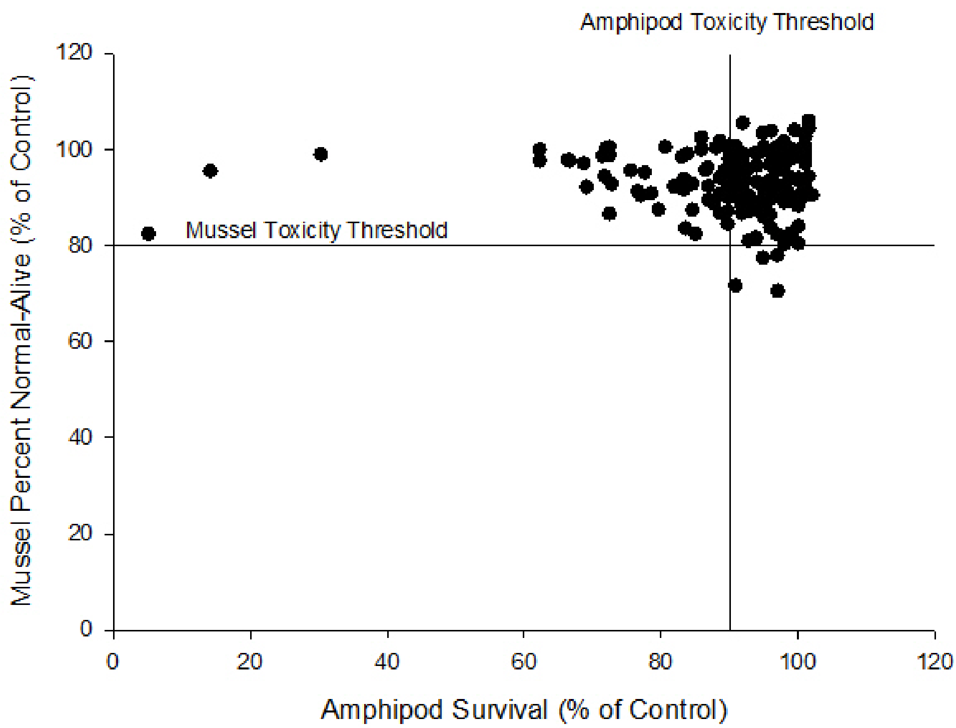

Figure 12. Comparison of the results between the amphipod and mussel embryo toxicity test methods. Note that samples falling below the thresholds indicated may not be identified as toxic because a statistical difference from the control is also necessary to indicate toxicity.

Table 13. Number of stations falling in each integrated toxicity SQO category, organized by stratum.

Stratum	***Nontoxic***	***Low Toxicity***	***Moderate Toxicity***	***High Toxicity***	**Unknown**
Bay	34	13	0	0	0
Marina	24	19	1	0	2
Port	28	24	2	0	1
Marine Estuary	16	12	3	0	2
Freshwater Estuary	6	2	0	0	0
Total Embayment	108	70	8	0	5

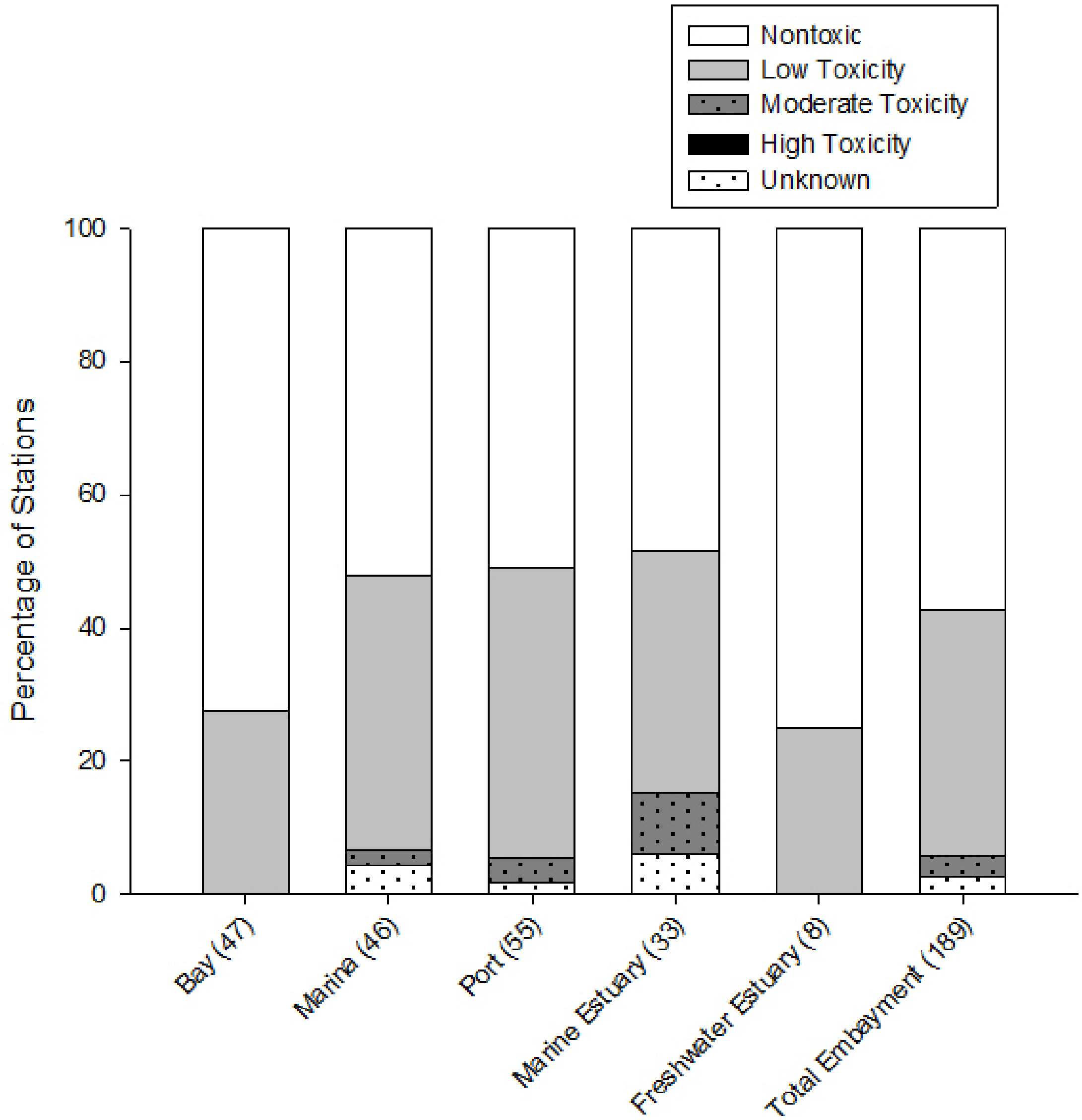

Figure 13. Percentage of stations in each sediment quality objective category after integration of the amphipod and embryo tests results. Data are organized by stratum for the embayments. The number of stations in each stratum is shown in parentheses.

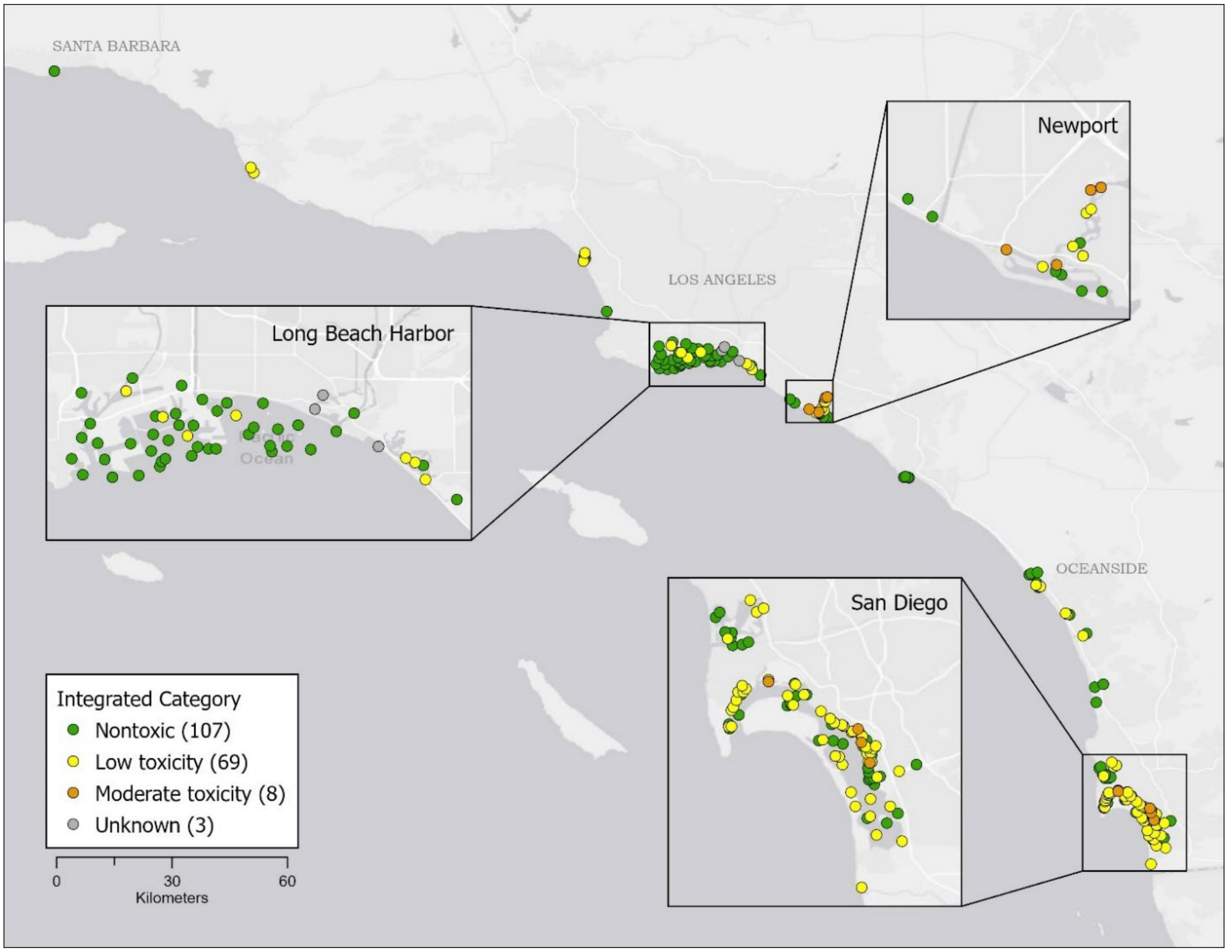

Figure 14. Map of Bight '23 stations and corresponding integrated toxicity SQO category in the embayments.

B. Regional Extent of Toxicity

The area data presented in this section should be evaluated with a few key points in mind. First, the embayment stations that did not get tested using the mussel SWI leave a total of 2.52 km^2 for which complete assessments cannot be made. This represented 2% of the total embayments and affected the marinas, ports, and marine estuaries but not the bays. Freshwater estuaries were not assigned area weights because they were targeted rather than randomly assigned, so they are not included in the areal assessment. Second, all area estimates within any toxicity category that are made up of only a few stations have high uncertainty around those estimates. This is a consideration for any statistical analysis with low sample size. The lower bounds of the 95% confidence limit for these estimates may include zero. Thirdly, presentation of the data as percentage of area allows for evaluation of the toxicity in each stratum as a whole and does not represent site-specific toxicity results.

The total area of the Bight surveyed in 2023 for sediment toxicity was 3924 km^2. The amphipod survival test indicated 72.6% (or 2849 km^2) of the SCB region was in the *nontoxic* category and 9.6% (or 377 km^2) was categorized as *low toxicity* (Table 14 and Figure 15). Thus, 82.2% (3227 km^2) of the SCB was not toxic (*nontoxic* and *low toxicity*). The area classified as toxic (*moderate* and *high toxicity*) was 13.1% (or 513 km^2) of the SCB region surveyed. For the embayment strata (bays, marine estuaries, marinas, and ports), the total area surveyed was 126 km^2, of which 75.1% (or 94 km^2) was *nontoxic* and 15.8% (or 20 km^2) was in the *low toxicity* category based on the amphipod test (Figure 16). Therefore, the total area categorized as not toxic was 90.9% (or 114 km^2). The amphipod test identified 9.1% (or 11 km^2) of embayments as toxic. Marine estuaries and marinas had the largest percentage of area (24% and 21%, respectively) identified as toxic, bays and ports had the smallest percentage of area considered toxic at 4.4 and 7.3%, respectively. Offshore (inner-, mid-, and outer-shelf) was categorized as *nontoxic* for 72.5% of the area (or 2755 km^2) and *low toxicity* category for 9.4% (357 km^2). There was 13.2% (502 km^2) of the area in the *moderate toxicity* category. Due to one station not being sampled, 4.8% (184 km^2) of the shelf was categorized as unknown.

The mussel embryo SWI test was only conducted in embayment strata samples. The embayment area found to be *nontoxic* by the mussel embryo test was 89.8% (or 113 km^2) of the total area (Table 15 and Figure 17). An additional 7.7% (or 9.7 km^2) was categorized as *low toxicity*, bringing the total area identified as not toxic to 97.5% (or 123 km^2). The area identified as toxic was 0.5% (or 0.7 km^2). The entirety of the area considered to be toxic was due to results from two stations, one in the marine estuary stratum and one in the marina stratum. Due to sample distribution issues that prevented five stations from being tested, 2.0% of the embayment area (or 2.5 km^2) was categorized as having unknown toxicity.

Integrated toxicity results are only presented for the embayment strata, where both tests were performed (Table 16 and Figure 18). The area categorized as *nontoxic* was reduced to 67.3% of the area (or 85 km^2). The integrated toxicity estimate of percentage area in the *nontoxic* category is slightly reduced from the amphipod-only test results and greatly reduced from the mussel-only test results. This reduction is caused by the effect of averaging the category results and rounding up if the mean was between two categories. The *low toxicity* category percentage area (28.6% or 36 km^2) was greatly increased from the individual test results (7.7% and 15.8% for mussels and amphipods, respectively). The total percentage area categorized as not toxic was 95.9% (or 121 km^2), which is similar to the mussel embryo test results. The integrated area classified as toxic was 2.0% (or 2.6 km^2). Due to the sample distribution issues, the toxicity of 2.0% (or 2.5 km^2) of the area was characterized as unknown. The integrated data indicated that the largest area of toxic sediment was in the marine estuary stratum with 1.1 km^2 representing 9.1% of that stratum. The lowest toxicity was observed in the bays and ports strata, with 100% and 99% of each area (70.6 km^2 and 25.9 km^2, respectively) identified as not toxic.

Table 14. Estimated area (in km^2) of SCB sediment classified by toxicity category using the amphipod survival test.

	Nontoxic		***Low Toxicity***		***Moderate Toxicity***		***High Toxicity***		***Unknown***	
Stratum	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**
Bay	57.4	6.2	10.1	5.1	3.1	3.8	0	-	0	-
Marine Estuary	6.0	1.7	2.8	1.4	1.4	1.0	1.4	1.1	0	-
Marina	9.7	2.4	4.6	2.0	2.3	1.6	0	-	0	-
Ports	21.8	2.6	3.3	2.6	2.0	0.8	0	-	0	-
Shelf	2755	627	357	375	502	421	0	-	184	287
Total Bight	2850	881	378	367	511	452	1.4	1.0	184	256

Table 15. Estimated area (in km^2) of SCB sediment classified by toxicity category using the sediment-water interface test with mussels.

	Nontoxic		***Low Toxicity***		***Moderate Toxicity***		***High Toxicity***		***Unknown***	
Stratum	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**
Bay	64.7	4.9	5.8	4.4	0	-	0	-	0	-
Marine Estuary	10.2	1.2	0.4	0.6	0.4	0.6	0	-	0.7	0.8
Marina	13.7	1.4	1.5	0.9	0.3	0.5	0	-	1.0	1.1
Port	24.3	1.8	2.0	0.8	0	0	0	-	0.8	1.3
Total Embayment	113	8.7	9.7	4.8	0.7	0.8	0	-	2.5	1.7

Table 16. Estimated area (in km2) of SCB sediment classified by SQO toxicity category using the integrated toxicity results.

	Nontoxic		***Low Toxicity***		***Moderate Toxicity***		***High Toxicity***		**Unknown**	
Stratum	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**	**Area**	**95% CI**
Bay	51.6	7.0	19.0	6.8	0	-	0	-	0	-
Marine Estuary	5.6	1.7	4.2	1.7	1.1	0.9	0	-	0.7	0.8
Marina	8.0	2.3	7.2	2.3	0.3	0.5	0	-	1.0	1.1
Port	19.9	3.0	6.0	2.7	0.4	0.4	0	-	0.8	1.3
Total Embayment	85.1	9.8	36.4	7.7	1.7	1.1	0	-	2.5	1.7

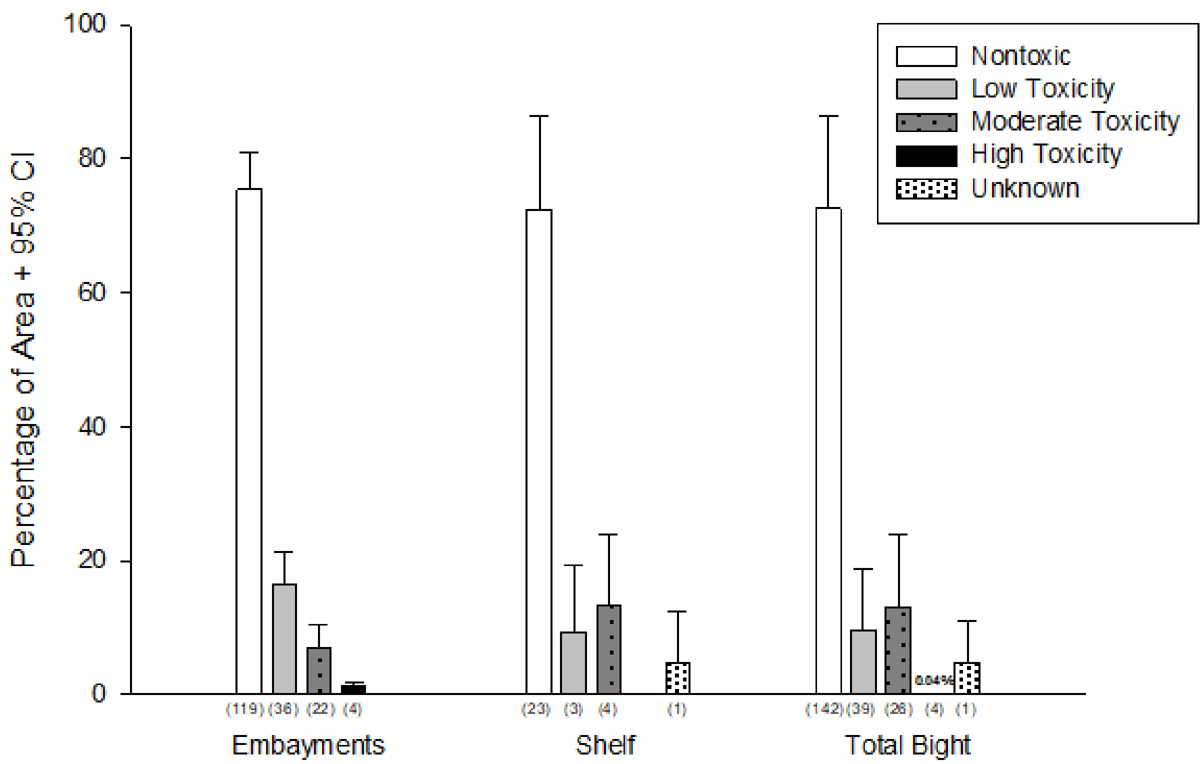

Figure 15. Percentage of area falling into each of the sediment quality objective categories by major strata groups using the amphipod survival test. The number of stations representing the data (n) is listed for each bar.

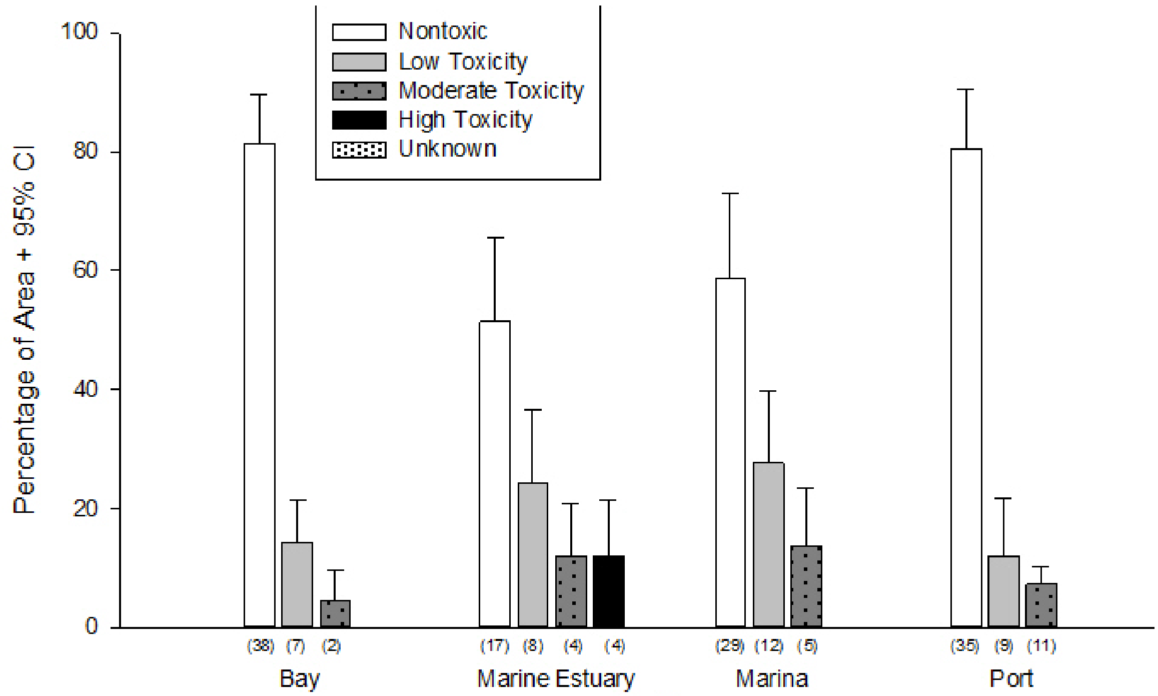

Figure 16. Percentage of area falling into each of the sediment quality objective categories using the amphipod survival test for embayment strata. The number of stations representing the data (n) is listed for each bar.

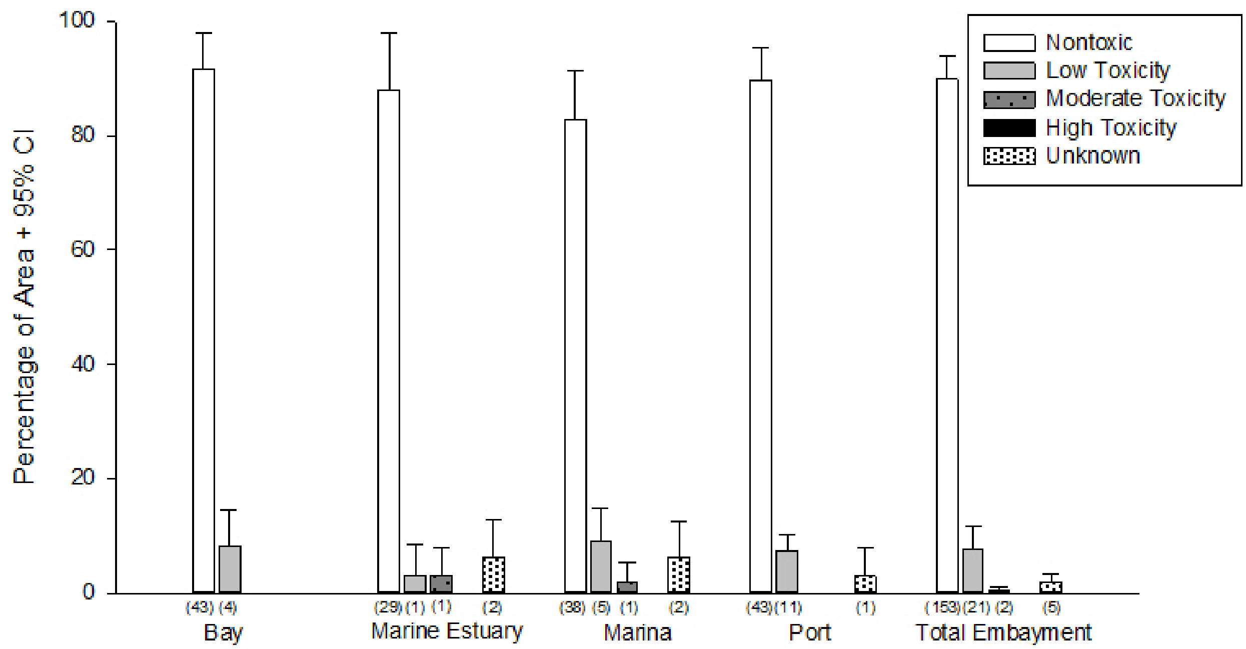

Figure 17. Percentage of area falling into each of the sediment quality objective categories by stratum using the mussel embryo sediment-water interface test. The number of stations representing the data (n) is listed for each bar.

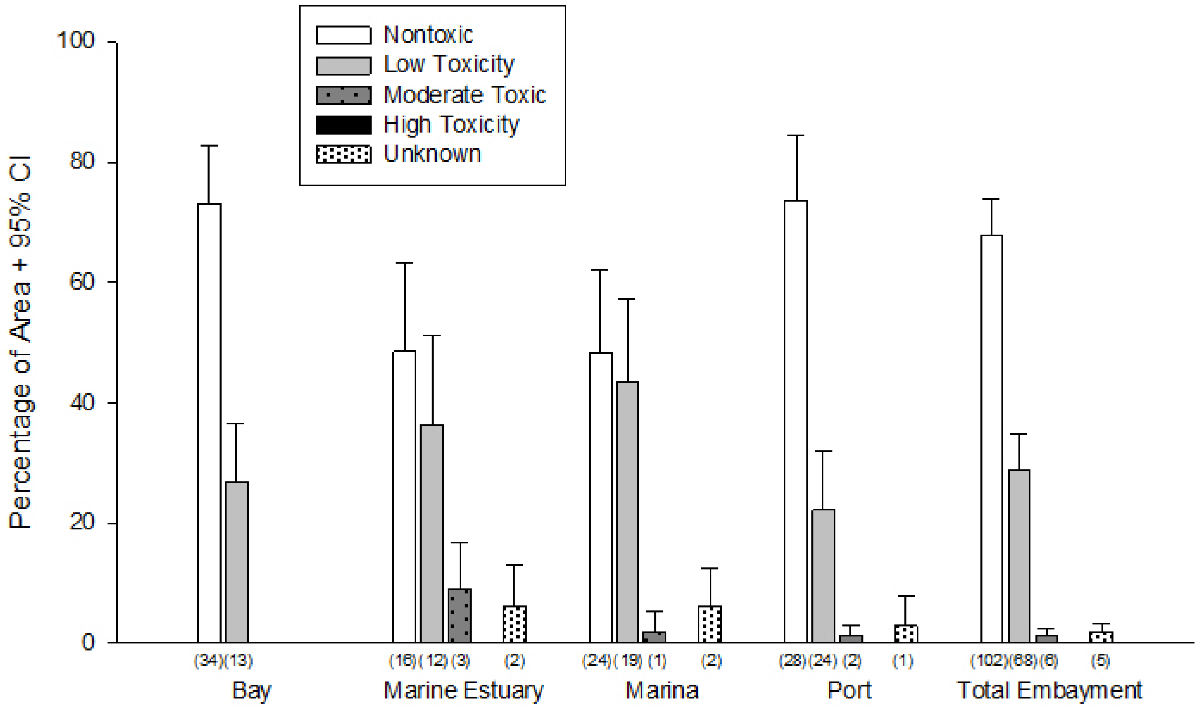

Figure 18. Percentage of area falling into each of the sediment quality objective categories by stratum using the integrated toxicity results of the amphipod and mussel embryo tests. The number of stations for each bar is listed as (n).

C. Temporal Assessment

Changes in toxicity within the SCB were evaluated for the embayment strata and the shelf using survey data from Bight' 98 through Bight' 23. The area weight for strata that were not consistently assessed over time, including the Channel Islands, brackish estuary and freshwater estuary, were not included in any of the temporal comparisons. For each stratum, a general trend towards decreased toxicity was observed based on the integrated toxicity SQO scores (Figure 19). However, when looking at the individual test species, the percentage area designated as toxic by the amphipod test appeared variable over time, while the mussel embryo test results remained in the downward trend. For the first time since Bight '03, results of the amphipod tests indicated that 13% of the SCB region was in the *moderate toxicity* category (Figure 20). This was a considerable increase compared to the last three Bight surveys (i.e., Bight '08, '13 and '18) where less than 5% of the area was in the *moderate toxicity* category. This was largely driven by an increase in the extent of *moderate toxicity* in the shelf stratum. In contrast, the amphipod test results for total embayments showed no significant changes compared to the results from Bight '13 and '18 surveys. There was a slight increase in the percentage area of ports/bays in the *low* and *moderate toxicity* categories compared to the previous two surveys. There was also a small reduction in the percentage area of marinas and marine estuaries deemed *moderately* toxic (Figure 21).

Temporal changes in toxicity were further evaluated in the embayments using the results of the mussel test and the integrated SQO scores. Results of the mussel tests indicated an increase in the percentage area of estuaries in the *moderate toxicity* category compared to Bight ’18 where all stations were deemed not toxic (Figure 22). The bays, ports and total embayments, however remained not toxic with only a small increase in the percentage area classified as *low toxicity* within these strata. Due to the markedly different effects measured with the amphipod and mussel tests, the integration of these two datasets indicated no significant changes in the areal extent of toxicity since Bight ’13 (Figure 23). Approximately 68% of the total embayments were in the *nontoxic* category, which is a small reduction compared to Bight ’18 results but consistent with the results of Bight ‘13. When looking at individual strata, the percentage area of ports in the *moderate* and *low toxicity* increased slightly and the percentage area of marinas in the *moderate toxicity* category was 6% lower than in Bight ‘18.

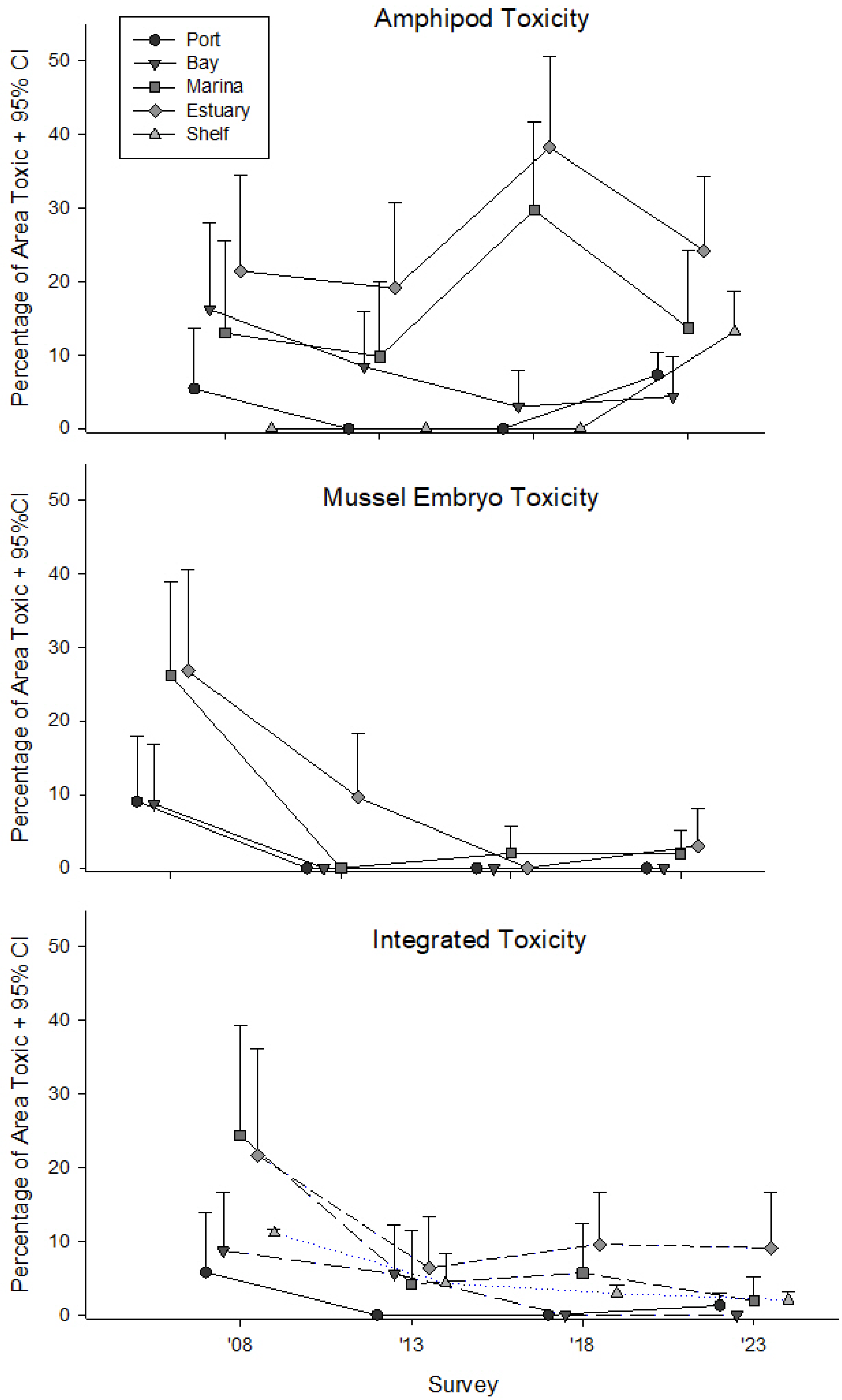

Figure 19. Percentage area found to be toxic (*moderate* and *high* toxicity SQO categories) for the last four Bight surveys where both amphipod and mussel embryo sediment-water interface tests were performed.

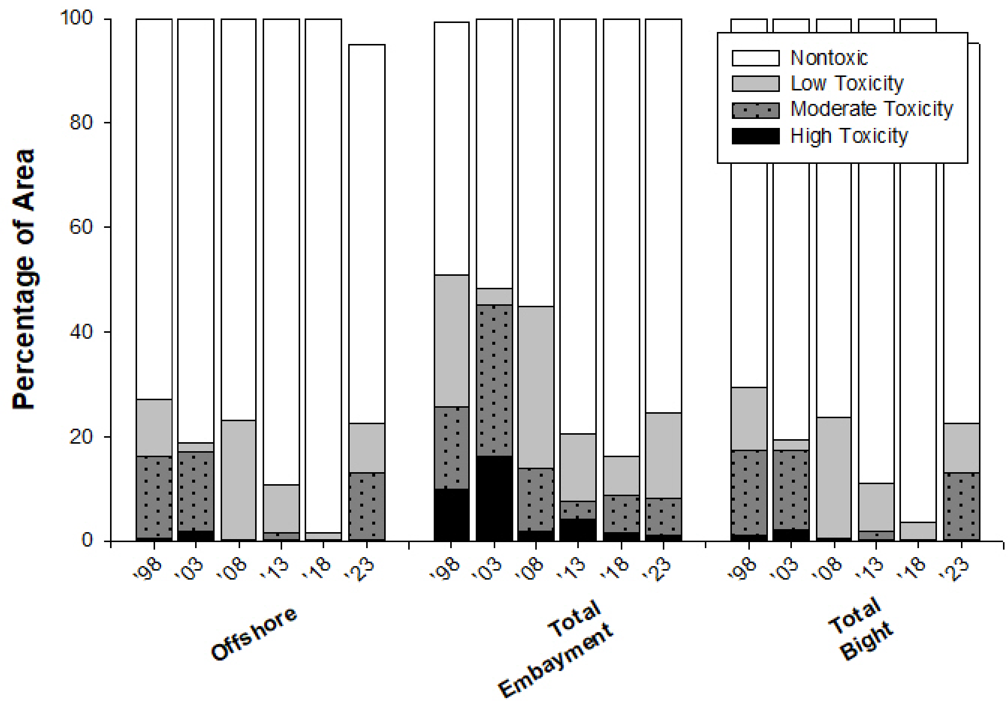

Figure 20. Comparisons of SQO toxicity categories for the amphipod test over time, expressed as percentage area for the combined Bight strata. Note that offshore strata only included shelf stations and total bight was based on the same strata over time (i.e. Channel Islands and brackish estuaries were not included in B'18 total bight area)

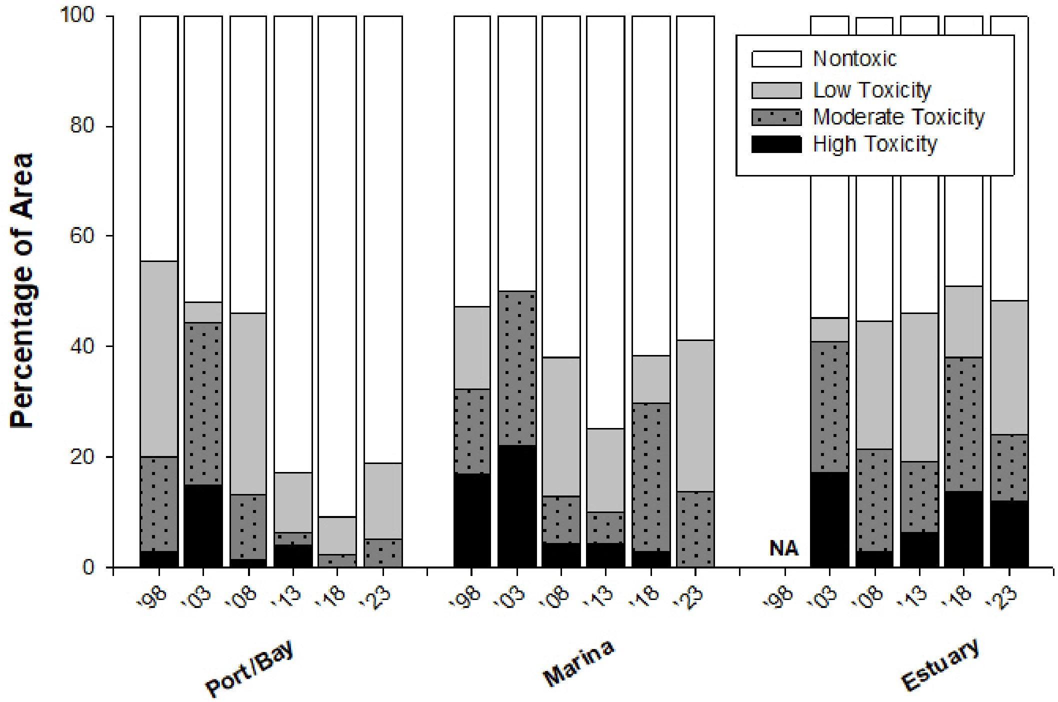

Figure 21. Comparisons of SQO toxicity categories for the amphipod test over time, expressed as percentage area for the embayment strata.

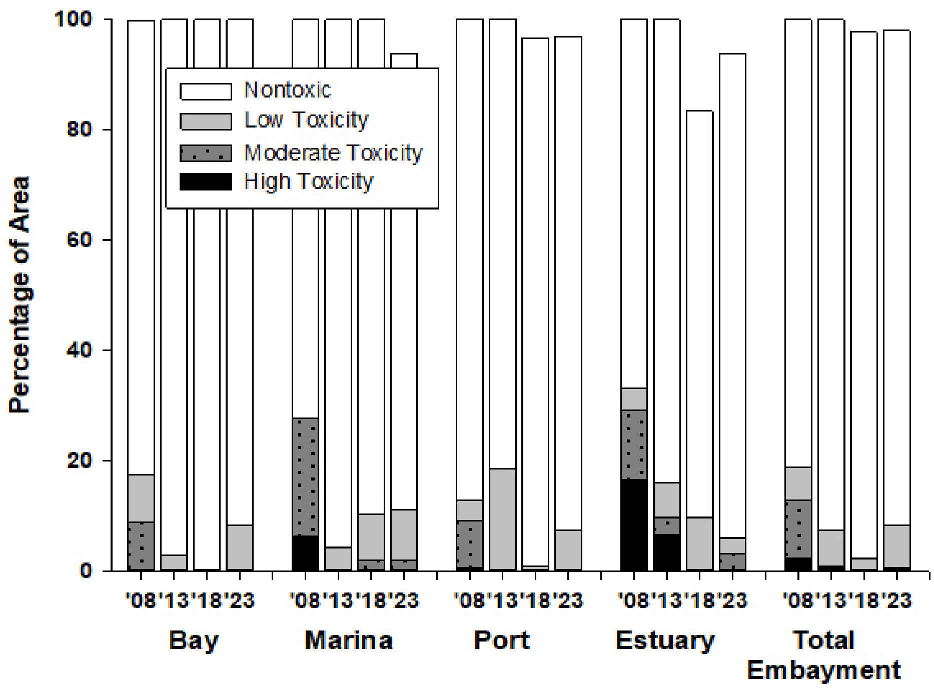

Figure 22. Comparison of percentage areas by sediment quality objective categories for the mussel test, shown by stratum over multiple surveys.

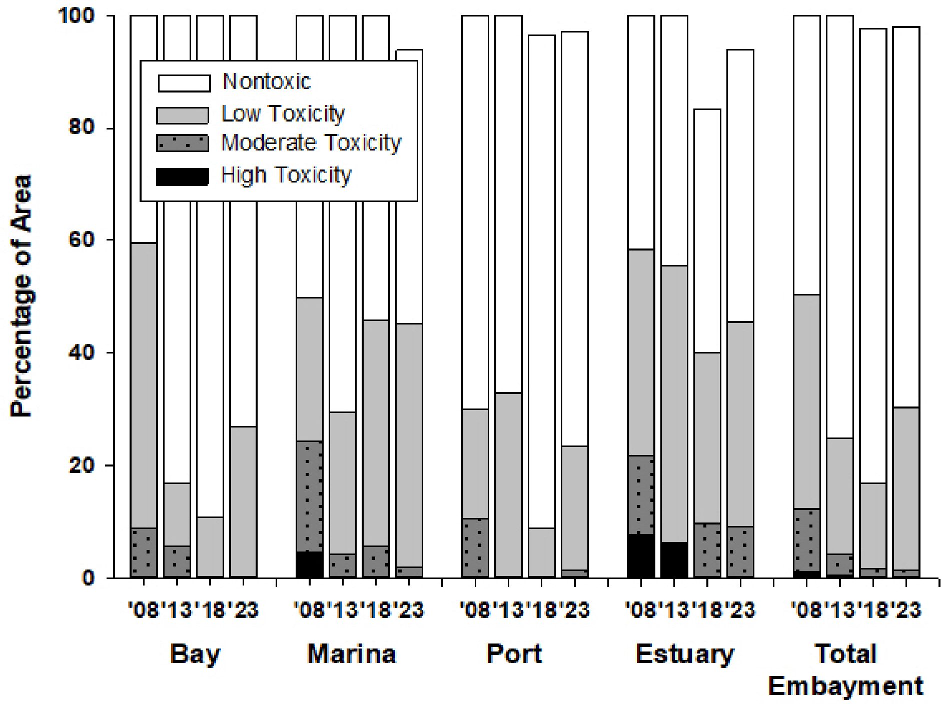

Figure 23. Comparison of percentage areas by sediment quality objective categories for the integrated SQO score, shown by stratum over multiple surveys.

Bight '23 survey included 77 stations sampled at least once in previous Bight cycles. Appendix B provides a list of the stations revisited and their IDs in previous Bight surveys. Temporal analysis of the changes in amphipod toxicity at these stations revealed that 67.5% of the stations remained always not toxic (i.e., *nontoxic* or *low toxicity* categories) (Figure 24). This assessment was based on three or more data points for 44 out of the 52 stations. The other 8 stations in the "always not toxic" category only had two data points. None of the stations revisited over time were considered always toxic (i.e., *moderate* or *high toxicity*). Approximately 18% of the stations were considered as trending not toxic indicating a change to a lower SQO category in previous surveys. Only 8% of stations were trending toxic. The five stations with increased toxicity included San Diego Bay and Marina Del Rey in the marinas, Los Cerritos in the estuaries and a Bight mid-shelf station (Table 17). It should be noted that the trends towards increased or decreased toxicity described here were all based on three or more datapoints. Finally, 6.5% of the stations with no set patterns over 3 or more surveys were considered inconsistent.

There were 60 revisited stations tested using the mussel test. Results indicated that 88% of the stations remained not toxic and 12% were trending not toxic (Figure 25). Analysis of the mussel test data did not identify any stations as always toxic, trending toxic or with inconsistent results. Like the observations made for the amphipod test, all the stations trending not toxic were identified as such using a minimum of 3 data points, while 8 of the stations in the always not toxic category only had two data points. Overall, the integration of the two toxicity tests indicated that only 3% (2 stations) of the embayment stations revisited were trending toxic (Table 17), 87% were always not toxic, and 8% were trending towards not toxic (Figure 26). Noteworthy, the two stations trending toxic were in Newport Bay. The five stations trending not toxic were in Los Angeles/Long Beach (bays), Newport Bay (marinas) and San Diego Bay (ports). More information on the locations of the revisited sites and the temporal changes are provided in the interactive maps in Appendices C and D. Additional statistical analysis was performed using a Pearson's chi-squared test to evaluate the relationship between categorical variables, such as toxicity (i.e., toxic or not toxic) in relation to time (i.e., initial survey versus final survey). Since the initial and final survey year may have differed among stations, the analysis allowed the assessment of the overall change over time. For amphipod test results, the total Bight, total embayment, marinas, and estuaries were the only strata with enough categorical replicates to perform the statistical analysis, and all of them resulted in a non-significant trend ($p > 0.05$) in classification from the initial survey to Bight '23 survey. Mussel test and integrated SQO category data could not be evaluated due to low sample size. Another point of comparison is the toxicity magnitude over time, represented by either percent survival or percent normal-alive for amphipods and mussel embryos, respectively. Results of the non-parametric Wilcoxon Signed Rank test revealed a statistically significant increase in percent amphipod survival between the initial survey and Bight '23 in the total bight, total embayment, bays, and ports strata. The p-values were 0.037, 0.019, 0.041 and 0.005, respectively although the average differences between the initial sampling period and B'23 were all less than 10%. For the mussel test results, the changes in percent normal-alive from the initial to Bight '23 survey were not significantly different in any stratum or combined area. This is explained by the lack of toxicity measured with this test throughout the different Bight surveys.

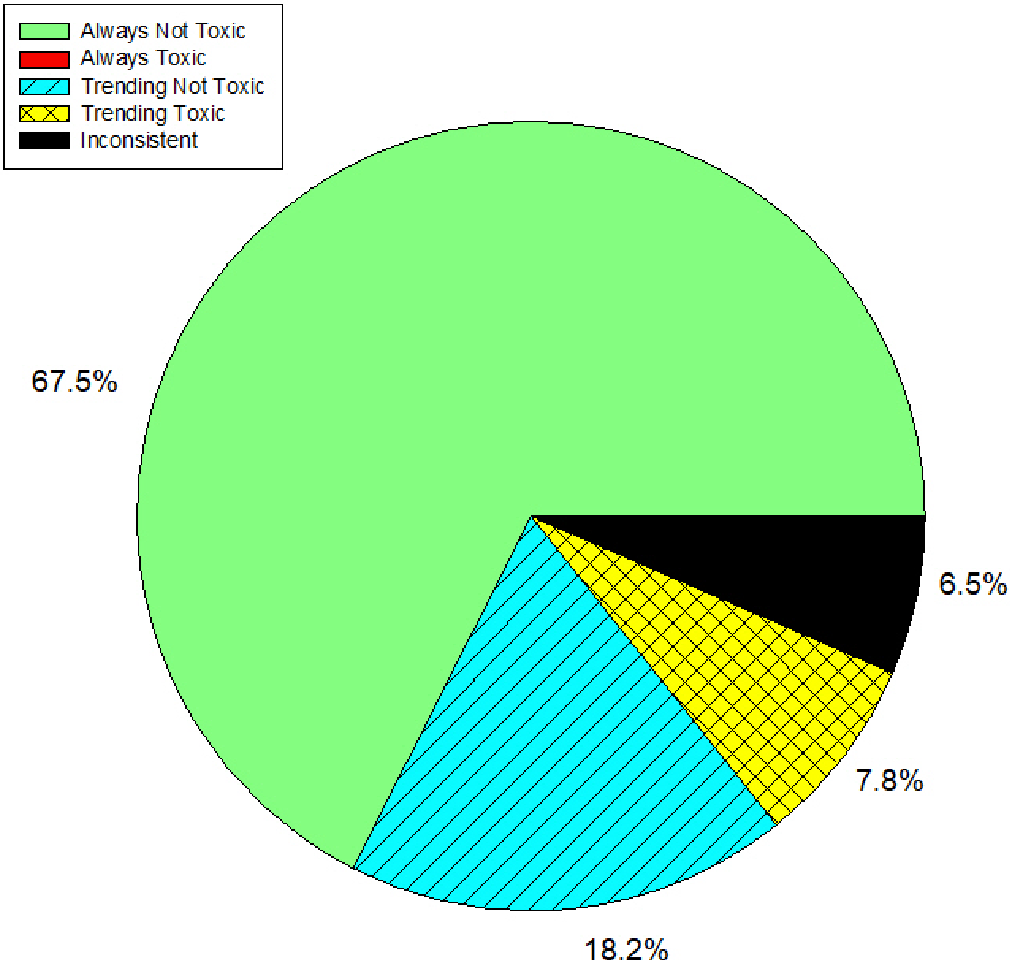

Figure 24. Trends in amphipod toxicity responses for the revisited sites, presented as proportion of sites in each category. No stations were found to always be toxic.

Table 17. Locations of revisit stations trending toxic over time.

Stratum	Region	Station ID	Test	B '23 SQO Category
Marina	San Diego Bay	B23-12047	Amphipod	*Moderate toxicity*
Marina	Marina Del Rey	B23-12086	Amphipod	*Moderate toxicity*
Marine Estuary	Los Cerritos	B23-12182	Amphipod	*High toxicity*
Marine Estuary	Newport Bay	B23-12174	Integrated	*Moderate toxicity*
Marine Estuary	Newport Bay	B23-12175	Integrated	*Moderate toxicity*
Shelf	Bight (Mid Shelf)	B23-12221	Amphipod	*Moderate toxicity*

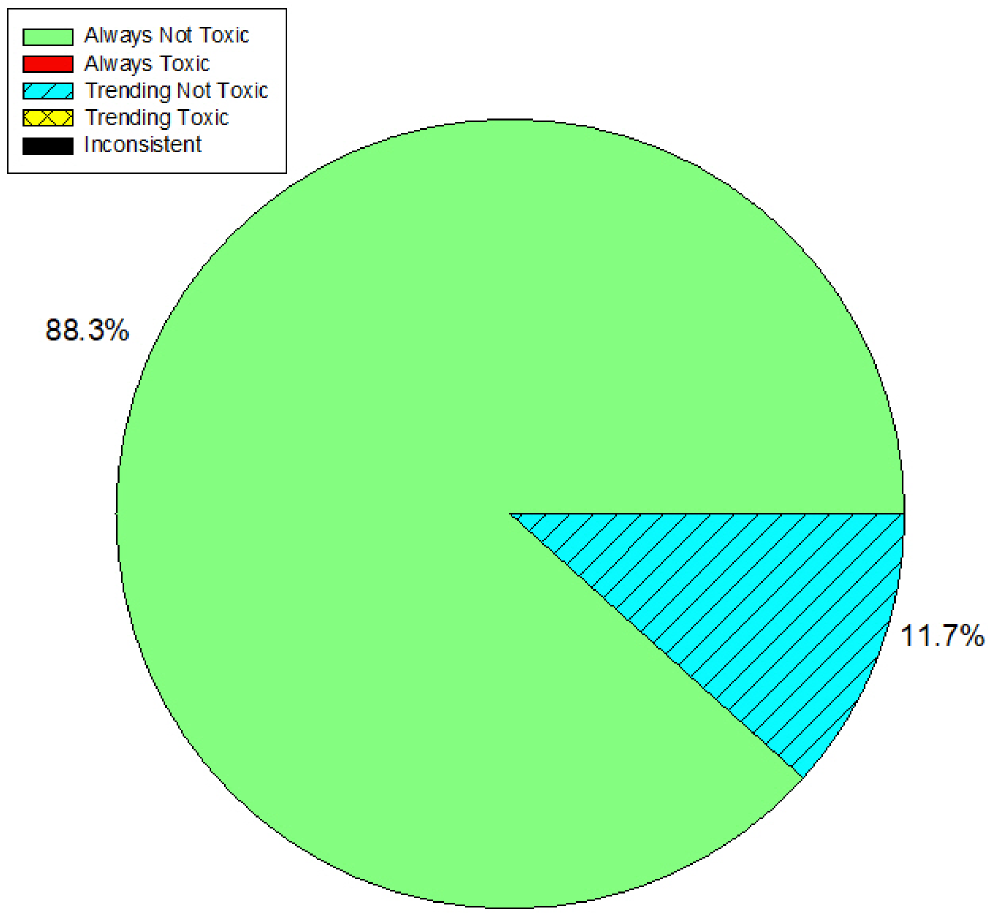

Figure 25. Trends in mussel embryo toxicity responses for the revisited sites, presented as proportion of sites in each category.

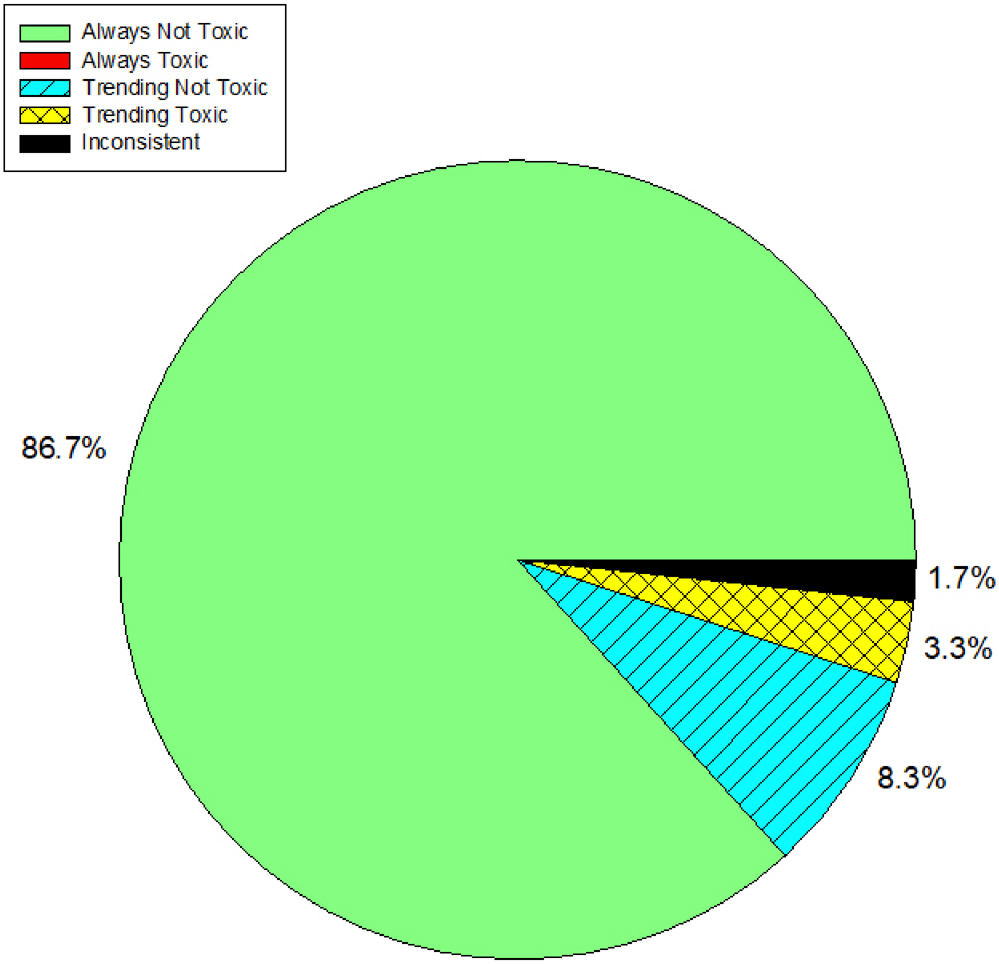

Figure 26. Trends in integrated toxicity responses for the revisited sites, presented as proportion of sites in each trend.

V. Discussion

Overall, the Bight ’23 sediment toxicity survey indicated no changes in sediment quality throughout the SCB since the last survey. The greatest extent and magnitude of toxicity was measured in the embayments, specifically the marine estuaries and marinas, while ports and bays remained largely not toxic based on the integrated toxicity SQO scores. However, the toxicity patterns were very different when comparing the amphipod and mussel tests. Consistent with previous Bight surveys, the 10-day amphipod survival test proved to be a more sensitive indicator of sediment-associated toxicity than the mussel embryo sediment-water interface test (Bay et al. 2005, 2011, and 2015, Parks et al. 2020). Previous studies have shown that amphipods are more sensitive to organic contaminants and mussel embryos are more sensitive to metals (Thompson et al. 1999). Although chemical analysis of Bight ’23 sediments are ongoing, results from Bight ’18 showed that the highest chemical exposure levels were in the estuaries and marinas where pyrethroids, fipronils and chlordane levels were the highest (Du et al. 2018). The relationships between Bight ’23 toxicity and chemistry results will be further discussed as part of the Bight ‘23 integrated sediment quality report.

Bight ’23 was the fourth survey to apply the toxicity test methods to embayments as detailed in the California Sediment Quality Objectives Program (SWRCB 2009). This was also the first survey where the test acceptability criteria for the two test species, amphipod and mussel embryos, were consistent with the SQO program. The use of two different test methods (i.e., different exposure mode, duration and endpoints) and species with differing sensitivities provided a more representative evaluation of sediment quality. Consistent with the previous surveys, *moderate* to *high toxicity* was detected at a higher frequency using the amphipod test than the mussel test. By integrating the results of both tests, these stations often fell in the *low toxicity* category. SQO toxicity thresholds were applied to the offshore strata for the amphipod toxicity test alone. Although these thresholds are not calibrated to offshore strata, this application within the Bight program specifically is intended to facilitate comparison of amphipod toxicity results within the SCB region. In the past 15 years (i.e. Bight ’08 to ’23), offshore stations were largely considered not toxic based on the amphipod test results. However, Bight’23 showed an increase in the areal extent of *moderate toxicity*. In the absence of a follow-up TIE study, the specific causes of such increase cannot be explained.

Bight Regional Marine Monitoring Program is one of the longest standing sediment quality monitoring programs that uses a triad approach to assess chemical exposure and impacts on sentinel species and benthic communities. Toxicity data collected over the years for a subset of revisited stations have shown that most stations were consistently not toxic or trending from toxic to not toxic. The reduction in toxicity Bight-wide is an indication of the effectiveness of management actions to reduce contaminant loads and impacts. Other programs such as the National Coastal Condition Assessment (NCCA) and the San Francisco Bay Regional Monitoring Program (RMP) have conducted sediment quality assessments that include laboratory-based toxicity testing of bottom-dwelling organisms. In the 2015 NCCA survey, approximately 12% of the estuaries sampled on the West Coast (124 sites from Puget Sound in Washington State to the California-Mexico border) were considered poor based on their combined toxicity and chemistry index (USEPA 2021). Despite the differences in spatial scales, the percentage area deemed toxic is comparable to the results of the Bight survey. Like the Bight program, the RMP has used the SQO triad approach and the same amphipod species for sediment quality assessment. In their last published toxicity assessment, the RMP reported that 70 to 80% of stations monitored between 2008 and 2012 were considered toxic (SFEI 2013). These results indicated much higher frequency of toxicity in San Francisco Bay stations compared to the toxicity in the larger urban watersheds of the SCB region.

The toxicity test results described here are one of the three elements of the sediment quality triad. Sediment toxicity data provides information on the biological response to natural and anthropogenic characteristics of the sediment but does not identify the specific toxicants. Moreover, sediment toxicity tests are performed under controlled laboratory conditions and may not represent the true condition of the sediment which may impact benthic community health. As described in California's SQO policy, chemical exposure and benthic community health are needed to provide a more complete assessment of sediment quality (SWRCB 2009). Once these three lines are evaluated, the sediment quality triad approach will be used to calculate overall SQO scores and assess sediment quality. This integrated assessment will be reported in the main sediment quality summary report for Bight '23.

VI. Conclusions

The Bight ’23 monitoring survey provided a regional assessment of the toxicity of sediment-associated chemicals in the SCB. Based on the results of two standard marine toxicity tests, the 10-day whole sediment amphipod test and the 48-hour mussel embryo sediment-water interface test, the Bight ’23 Toxicology Technical Committee concluded that:

- **Most of the sediment in the SCB region was not toxic.**
  Integrated results from the two toxicity tests showed that 68% of the total embayments were *nontoxic* and 29% were in the *low toxicity* category. Less than 2% of the total embayments were in the *moderate toxicity* category. In the continental shelf stratum, where only the amphipod test was conducted, 72.5% was *nontoxic*, 9.5% was in the *low toxicity* category and 13% was in the *moderate toxicity* category. Like the integrated scores for the total embayments, there was no evidence of *high toxicity* offshore.

- **The greatest extent and magnitude of toxicity observed was in the marine estuaries**.
  Approximately 9% of the marine estuaries were classified as *moderately* toxic based on the integrated assessment with the two toxicity test species. The most impacted estuarine stations were in large urban watersheds.

- **Temporal analysis showed that toxicity in the embayments was comparable to the past two surveys but increased slightly in the continental shelf stratum.**
  The areal extent of *moderate toxicity* measured in the shelf stratum using the amphipod test (13% of the shelf) was the highest recorded since Bight ’03 when 15% of the shelf was deemed *moderately toxic* and 2% was deemed *highly toxic*. In the embayments, minimal temporal changes in toxicity were observed using the integrated toxicity SQO categories. However, the percentage area designated as toxic using the amphipod test alone has varied over time.

- **Most of the revisited sites remained classified as always not toxic.**
  Nearly 70% of the revisited sites were consistently in the always not toxic category based on the amphipod only, mussel only and integrated toxicity data. None of the revisited sites were considered always toxic.

VII. RECOMMENDATIONS

A. Bight 2023

Based on the efforts from Bight ’23, the Sediment Quality Planning and Toxicology Technical Committees agree on the following recommendations to implement in Bight surveys.

- **Devote additional resources for stressor identification.**
  As discussed in previous Bight surveys, the significance of some toxicity measurements can be limited due to the inability to explain the cause of toxicity. In Bight ’23, an unexpected increase in toxicity was observed in shelf stations compared to previous surveys. The persistent detection of toxic sediments over time in estuaries and marinas was also noted. In both cases, the specific causes of toxicity could not be determined with the data available at the time. While chemistry data will offer some insights, the analysis will be limited to correlations and not causation. Therefore, stressor identification is recommended to improve the interpretation of toxicity data. Because traditional TIE methods may be cost prohibitive, future Bight surveys should review the literature and identify available cost-effective methods to improve toxicant identification.

- **Review and refine water quality thresholds.**
  There is no documentation of the data used to set water quality acceptance limits used as part of the data quality objectives for the amphipod and mussel toxicity tests. Although the current thresholds are reasonable, minor inconsistencies were noted in the range of pH and ammonia for the amphipod and mussel tests. Citable references should be added to future toxicity data quality assurance plans to ensure that data are flagged appropriately.

- **Revisit the basis for the current intercalibration scoring criteria.**
  Current scoring criteria for the interlaboratory agreement evaluation are not equally weighted. Although SQO categories are the main point of comparison for Bight toxicity data, the comparability of reference toxicant and duplicate sample responses largely outweighs the comparability of the split samples SQO category results. The modification of the scoring criteria and the implications should be discussed and documented before implementation of the next intercalibration exercise.

B. Bight 2018

To ensure the Bight Program continues to progress and improve over time, this section addresses the Program's ability to follow through on previous recommendations. Here, we list the recommendations from Bight '18 and hold ourselves accountable for improving the Bight Program's effectiveness and efficiency.

- **Further investigate increased toxicity in Estuaries and Marinas between 2013 and 2018.**
  No additional analysis was performed on historical data collected during Bight '13 and '18. However, this recommendation resulted in continued intensified sampling and testing in Los Angeles Harbor and San Diego Bay in Bight '23. In marinas and estuaries, approximately 30% of the sites were sampled in previous surveys to investigate temporal trends.

- **Confirm the extent and magnitude of toxicity in Brackish Estuaries.**
  This recommendation could not be implemented as the estuary stratum was redefined as marine and freshwater estuaries and only a small number of freshwater stations were sampled. Although the estuary stratum continued to show *moderate* to *high toxicity*, no additional resources were available to conduct TIEs.

- **Evaluate the comparability of alternative test species and include it in the pre-Bight intercalibration exercise.**
  This recommendation resulted in the inclusion of the purple sea urchin embryo sediment-water interface test during the intercalibration exercise. Limited data analyses were performed due to the lack of SQO toxicity thresholds and reference toxicant data for this species. Results showed a good interlaboratory agreement for the controls but high variability in the percent normal-alive embryos for the split field samples.

- **Investigate the impact of sediment homogenization on the comparability between chemistry and toxicity results.**
  Bight '18 was the first survey to require homogenization of the sediment grabs collected for each station prior to distribution to the respective chemistry and toxicity sample containers. The purpose of this change was to improve the potential relationships between the chemistry and toxicity test results. The Toxicology Committee did not conduct any analysis because there was no chemistry data available at the time to make the comparisons.

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APPENDIX A: TOXICITY RESULTS BY STATION

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12000	32.60976	117.10740	Bay	1.4	San Diego Bay	97	97	Nontoxic
B23-12001	32.61372	117.12371	Bay	1.7	San Diego Bay	97	97	Nontoxic
B23-12002	32.61523	117.12130	Bay	1.9	San Diego Bay	90	98	Low toxicity
B23-12003	32.62985	117.12100	Bay	5.1	San Diego Bay	81	101	Low toxicity
B23-12004	32.63540	117.13701	Bay	2.1	San Diego Bay	83	92	Low toxicity
B23-12005	32.64168	117.11777	Bay	0.35	San Diego Bay	94	97	Nontoxic
B23-12006	32.64564	117.12250	Bay	12.3	San Diego Bay	89	94	Nontoxic
B23-12007	32.64664	117.12076	Bay	14.4	San Diego Bay	100	94	Nontoxic
B23-12008	32.64690	117.11829	Bay	10.4	San Diego Bay	96	93	Nontoxic
B23-12009	32.65831	117.14413	Bay	5.6	San Diego Bay	94	88	Low toxicity
B23-12010	32.66457	117.14689	Bay	5.2	San Diego Bay	89	91	Low toxicity
B23-12011	32.66524	117.14994	Bay	4.9	San Diego Bay	92	98	Low toxicity
B23-12012	32.67535	117.14382	Bay	4.7	San Diego Bay	102	91	Nontoxic
B23-12013	32.67780	117.15169	Bay	3.7	San Diego Bay	95	92	Nontoxic
B23-12014	32.69930	117.23015	Bay	16.5	San Diego Bay	101	90	Nontoxic
B23-12015	32.70702	117.18998	Bay	15.1	San Diego Bay	100	88	Nontoxic
B23-12016	32.70747	117.18502	Bay	15.8	San Diego Bay	96	84	Low toxicity
B23-12017	32.70790	117.18670	Bay	15.0	San Diego Bay	100	94	Nontoxic
B23-12018	32.70957	117.18695	Bay	15.1	San Diego Bay	101	99	Nontoxic
B23-12019	32.71500	117.18258	Bay	12.9	San Diego Bay	95	90	Nontoxic
B23-12020	32.71539	117.18968	Bay	16.5	San Diego Bay	97	82	Low toxicity
B23-12021	32.72436	117.18300	Bay	5.7	San Diego Bay	96	90	Low toxicity
B23-12022	32.76808	117.24147	Bay	6.2	Mission Bay	96	91	Nontoxic
B23-12023	32.78420	117.24600	Bay	3.6	Mission Bay	92	87	Nontoxic

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12024	32.78448	117.21521	Bay	3.9	Mission Bay	88	89	Low toxicity
B23-12025	32.78771	117.20945	Bay	3.0	Mission Bay	89	91	Low toxicity
B23-12026	32.79435	117.22037	Bay	1.6	Mission Bay	85	87	Low toxicity
B23-12027	33.71240	118.25796	Bay	26	Los Angeles/Long Beach	101	97	Nontoxic
B23-12028	33.71369	118.24135	Bay	24.5	Los Angeles/Long Beach	98	89	Nontoxic
B23-12029	33.71400	118.27665	Bay	17	Los Angeles/Long Beach	101	100	Nontoxic
B23-12030	33.72243	118.22679	Bay	14	Los Angeles/Long Beach	95	101	Nontoxic
B23-12031	33.72413	118.22447	Bay	18	Los Angeles/Long Beach	98	99	Nontoxic
B23-12032	33.72602	118.20771	Bay	19	Los Angeles/Long Beach	98	101	Nontoxic
B23-12033	33.72862	118.15708	Bay	16	Los Angeles/Long Beach	101	101	Nontoxic
B23-12034	33.72995	118.13247	Bay	12	Los Angeles/Long Beach	98	100	Nontoxic
B23-12035	33.73153	118.20404	Bay	21	Los Angeles/Long Beach	96	97	Nontoxic
B23-12036	33.73210	118.14736	Bay	13	Los Angeles/Long Beach	99	99	Nontoxic
B23-12037	33.73223	118.15822	Bay	14	Los Angeles/Long Beach	96	93	Nontoxic
B23-12038	33.73575	118.22262	Bay	12	Los Angeles/Long Beach	98	98	Nontoxic
B23-12039	33.73952	118.17170	Bay	13	Los Angeles/Long Beach	97	100	Nontoxic

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12040	33.74287	118.15330	Bay	10	Los Angeles/Long Beach	94	99	Nontoxic
B23-12041	33.74405	118.16854	Bay	11	Los Angeles/Long Beach	95	100	Nontoxic
B23-12042	33.74550	118.14053	Bay	8	Los Angeles/Long Beach	99	98	Nontoxic
B23-12043	33.75157	118.17970	Bay	8.0	Los Angeles/Long Beach	67	98	Low toxicity
B23-12044	33.75930	118.16265	Bay	7.0	Los Angeles/Long Beach	101	100	Nontoxic
B23-12045	32.62362	117.10477	Marina	4.8	San Diego Bay	89	87	Low toxicity
B23-12046	32.62355	117.13348	Marina	4.0	San Diego Bay	86	96	Low toxicity
B23-12047	32.71158	117.23229	Marina	6.7	San Diego Bay	77	91	Low toxicity
B23-12048	32.71605	117.22828	Marina	4.7	San Diego Bay	91	96	Nontoxic
B23-12049	32.71826	117.23062	Marina	4.5	San Diego Bay	94	81	Low toxicity
B23-12050	32.71847	117.22634	Marina	6.5	San Diego Bay	90	92	Low toxicity
B23-12051	32.72101	117.22430	Marina	5.8	San Diego Bay	90	90	Low toxicity
B23-12052	32.72546	117.18384	Marina	5.1	San Diego Bay	96	94	Nontoxic
B23-12053	32.72701	117.20544	Marina	3.7	San Diego Bay	91	72	Moderate toxicity
B23-12054	32.72843	117.20552	Marina	3.7	San Diego Bay	96	86	Low toxicity
B23-12055	32.76254	117.23920	Marina	8.2	Mission Bay	93	81	Low toxicity
B23-12056	32.76322	117.23679	Marina	6.9	Mission Bay	94	82	Nontoxic
B23-12057	32.76728	117.23569	Marina	3.5	Mission Bay	93	90	Nontoxic
B23-12058	32.78040	117.24927	Marina	3.5	Mission Bay	95	77	Nontoxic
B23-12059	33.20429	117.39138	Marina	3.8	Oceanside	98	98	Nontoxic
B23-12060	33.20842	117.39673	Marina	7.6	Oceanside	87	92	Low toxicity
B23-12061	33.20939	117.39531	Marina	6.2	Oceanside	91	92	Nontoxic
B23-12062	33.21293	117.39509	Marina	4.0	Oceanside	92	95	Nontoxic

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12063	33.45850	117.69353	Marina	4.6	Dana Point	96	92	Nontoxic
B23-12064	33.46013	117.70581	Marina	5.1	Dana Point	97	93	Nontoxic
B23-12065	33.45989	117.69628	Marina	4.3	Dana Point	96	90	Nontoxic
B23-12066	33.46120	117.70190	Marina	3.8	Dana Point	97	92	Nontoxic
B23-12067	33.60017	117.88378	Marina	7.0	Newport Bay	98	114	Nontoxic
B23-12068	33.60030	117.89291	Marina	4.0	Newport Bay	97	94	Nontoxic
B23-12069	33.60757	117.90213	Marina	5.0	Newport Bay	97	104	Nontoxic
B23-12070	33.60910	117.90470	Marina	7.0	Newport Bay	97	105	Nontoxic
B23-12071	33.61128	117.91065	Marina	4	Newport Bay	64	95	Low toxicity
B23-12072	33.61207	117.90428	Marina	4	Newport Bay	56	108	Moderate toxicity
B23-12073	33.61615	117.89246	Marina	2.8	Newport Bay	72	94	Low toxicity
B23-12074	33.61893	117.92693	Marina	8	Newport Bay	55	82	Moderate toxicity
B23-12075	33.71989	118.06125	Marina	4	Huntington Harbor	92	106	Nontoxic
B23-12076	33.72177	118.06648	Marina	4.9	Huntington Harbor	90	93	Low toxicity
B23-12077	33.72407	118.28363	Marina	4	Los Angeles/Long Beach	101	99	Nontoxic
B23-12078	33.75552	118.12994	Marina	5.8	Alamitos Bay	98	NA	NA
B23-12079	33.75949	118.18557	Marina	10	Long Beach	91	101	Nontoxic
B23-12080	33.76429	118.12474	Marina	6.1	Alamitos Bay	69	NA	NA
B23-12081	33.76708	118.24917	Marina	5	Los Angeles/Long Beach	84	99	Low toxicity
B23-12082	33.84701	118.39945	Marina	7	Redondo Beach Harbor	97	96	Nontoxic
B23-12083	33.96473	118.45338	Marina	6.95	Marina del Rey	85	83	Low toxicity
B23-12084	33.97028	118.44969	Marina	7	Marina del Rey	90	90	Nontoxic
B23-12085	33.97506	118.45184	Marina	5.1	Marina del Rey	95	86	Nontoxic
B23-12086	33.98306	118.45057	Marina	4.45	Marina del Rey	77	90	Low toxicity

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12087	34.17105	119.22348	Marina	1.99	Oxnard/Channel I. Harbor	72	100	Low toxicity
B23-12088	34.40715	119.68896	Marina	4.5	Santa Barbara	100	100	Nontoxic
B23-12089	32.65175	117.12226	Port	12.2	San Diego Bay	97	99	Nontoxic
B23-12090	32.65548	117.12316	Port	13.1	San Diego Bay	98	102	Nontoxic
B23-12091	32.65982	117.12134	Port	6.9	San Diego Bay	80	88	Moderate toxicity
B23-12092	32.66030	117.12000	Port	2.6	San Diego Bay	99	83	Low toxicity
B23-12093	32.66065	117.12273	Port	11	San Diego Bay	79	91	Low toxicity
B23-12094	32.66600	117.12000	Port	11.16	San Diego Bay	95	88	Nontoxic
B23-12095	32.66788	117.12384	Port	11.9	San Diego Bay	76	96	Low toxicity
B23-12096	32.66810	117.12079	Port	16.9	San Diego Bay	62	98	Low toxicity
B23-12097	32.67136	117.11880	Port	8.3	San Diego Bay	90	95	Low toxicity
B23-12098	32.67211	117.12344	Port	13.2	San Diego Bay	72	101	Low toxicity
B23-12099	32.67304	117.12497	Port	14.2	San Diego Bay	78	95	Low toxicity
B23-12100	32.67280	117.11720	Port	7.06	San Diego Bay	94	93	Nontoxic
B23-12101	32.67320	117.12710	Port	11.7	San Diego Bay	96	93	Nontoxic
B23-12102	32.67354	117.11650	Port	8.1	San Diego Bay	66	98	Low toxicity
B23-12103	32.67679	117.12856	Port	12.1	San Diego Bay	72	87	Moderate toxicity
B23-12104	32.67840	117.12430	Port	9.4	San Diego Bay	93	90	Nontoxic
B23-12105	32.67889	117.16046	Port	3.9	San Diego Bay	100	81	Low toxicity
B23-12107	32.68142	117.12766	Port	11.4	San Diego Bay	71	99	Low toxicity
B23-12108	32.68320	117.12920	Port	11.4	San Diego Bay	98	96	Nontoxic
B23-12109	32.68527	117.13643	Port	11.3	San Diego Bay	87	96	Low toxicity
B23-12110	32.68598	117.13558	Port	12.2	San Diego Bay	72	99	Low toxicity
B23-12111	32.68802	117.23780	Port	10.7	San Diego Bay	100	94	Nontoxic
B23-12112	32.68997	117.23628	Port	13.5	San Diego Bay	97	78	Low toxicity
B23-12113	32.68952	117.23837	Port	10.5	San Diego Bay	93	87	Low toxicity

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12114	32.69010	117.14317	Port	9.9	San Diego Bay	84	84	Low toxicity
B23-12115	32.69117	117.14439	Port	20.6	San Diego Bay	69	92	Low toxicity
B23-12116	32.69177	117.23840	Port	14.8	San Diego Bay	96	97	Nontoxic
B23-12117	32.69156	117.15307	Port	13.7	San Diego Bay	96	91	Nontoxic
B23-12118	32.69281	117.15085	Port	13.7	San Diego Bay	90	85	Low toxicity
B23-12119	32.69617	117.15440	Port	15.3	San Diego Bay	92	88	Low toxicity
B23-12120	32.70253	117.16190	Port	9.1	San Diego Bay	85	93	Low toxicity
B23-12121	32.70333	117.23612	Port	4.9	San Diego Bay	99	83	Low toxicity
B23-12122	32.70583	117.23457	Port	6.1	San Diego Bay	98	80	Low toxicity
B23-12123	32.71617	117.17384	Port	9.8	San Diego Bay	92	92	Nontoxic
B23-12124	32.71615	117.17619	Port	11.5	San Diego Bay	91	90	Low toxicity
B23-12125	33.71935	118.22786	Port	14	Los Angeles/Long Beach	100	84	Nontoxic
B23-12126	33.72363	118.26274	Port	26	Los Angeles/Long Beach	99	89	Nontoxic
B23-12127	33.72912	118.23330	Port	10	Los Angeles/Long Beach	98	90	Nontoxic
B23-12128	33.73037	118.19701	Port	24	Los Angeles/Long Beach	99	100	Nontoxic
B23-12129	33.73058	118.19233	Port	17	Los Angeles/Long Beach	101	100	Nontoxic
B23-12130	33.73199	118.08967	Port	7.32	Anaheim Bay	99	NA	NA
B23-12131	33.73378	118.24635	Port	18	Los Angeles/Long Beach	101	99	Nontoxic
B23-12132	33.73387	118.26720	Port	8	Los Angeles/Long Beach	101	99	Nontoxic
B23-12133	33.73742	118.27740	Port	18	Los Angeles/Long Beach	101	99	Nontoxic

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12134	33.73868	118.21043	Port	27	Los Angeles/Long Beach	83	94	Low toxicity
B23-12135	33.73953	118.23210	Port	14	Los Angeles/Long Beach	93	96	Nontoxic
B23-12136	33.74540	118.21566	Port	20	Los Angeles/Long Beach	96	94	Nontoxic
B23-12137	33.74628	118.27200	Port	18	Los Angeles/Long Beach	101	99	Nontoxic
B23-12138	33.74522	118.20673	Port	21	Los Angeles/Long Beach	101	100	Nontoxic
B23-12139	33.75068	118.22603	Port	19	Los Angeles/Long Beach	92	98	Low toxicity
B23-12140	33.75107	118.23060	Port	19	Los Angeles/Long Beach	99	98	Nontoxic
B23-12141	33.75267	118.21777	Port	24.5	Los Angeles/Long Beach	101	100	Nontoxic
B23-12142	33.75442	118.19178	Port	7	Los Angeles/Long Beach	101	98	Nontoxic
B23-12143	33.76585	118.27755	Port	18	Los Angeles/Long Beach	101	99	Nontoxic
B23-12144	33.77057	118.21422	Port	15	Los Angeles/Long Beach	100	99	Nontoxic
B23-12145	33.77526	118.24531	Port	9	Los Angeles/Long Beach	101	98	Nontoxic
B23-12146	32.55662	117.12821	Estuary	1.2	Tijuana River Estuary	82	92	Low toxicity
B23-12148	32.59995	117.11598	Freshwater Estuary	1.6	Otay	82	92	Low toxicity
B23-12150	32.61784	117.09824	Freshwater Estuary	1.5	San Diego Bay	98	99	Nontoxic
B23-12151	32.64769	117.11545	Estuary	8.8	Sweetwater Marsh	92	95	Low toxicity

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12152	32.64833	117.11301	Estuary	4.6	Sweetwater Marsh	101	103	Nontoxic
B23-12154	32.65264	117.09741	Estuary	1.95	Sweetwater Marsh	83	99	Low toxicity
B23-12155	32.68775	117.13136	Estuary	7.2	San Diego Bay	5	82	Moderate toxicity
B23-12156	32.75697	117.23527	Estuary	1.27	San Diego River	102	106	Nontoxic
B23-12157	32.75755	117.22719	Estuary	0.9	San Diego River	99	104	Nontoxic
B23-12158	32.93425	117.25665	Estuary	4.2	Los Penasquitos Lagoon	96	104	Nontoxic
B23-12159	32.97029	117.25941	Estuary	1.1	San Dieguito Lagoon	98	97	Nontoxic
B23-12160	33.09033	117.28693	Estuary	1.35	Batiquitos Lagoon	89	96	Low toxicity
B23-12161	33.09520	117.27860	Estuary	0.8	Batiquitos Lagoon	98	101	Nontoxic
B23-12163	33.13948	117.31869	Estuary	1.2	Agua Hedionda	101	92	Nontoxic
B23-12164	33.14009	117.32445	Estuary	2.6	Agua Hedionda	90	90	Low toxicity
B23-12165	33.23262	117.41289	Estuary	1.16	Santa Margarita Estuary	102	94	Nontoxic
B23-12166	33.62044	117.89695	Estuary	3.8	Newport Bay	90	96	Low toxicity
B23-12167	33.62203	117.89364	Estuary	3.7	Newport Bay	92	94	Nontoxic
B23-12169	33.63379	117.96027	Estuary	1.7	Talbert/Huntington Beach	98	93	Nontoxic
B23-12170	33.63554	117.89089	Estuary	4.9	Newport Bay	69	97	Low toxicity
B23-12172	33.63713	117.88868	Estuary	3.1	Newport Bay	73	93	Low toxicity
B23-12173	33.64190	117.97134	Estuary	1.3	Talbert/Huntington Beach	97	100	Nontoxic
B23-12174	33.64579	117.88890	Estuary	3.7	Newport Bay	30	99	Moderate toxicity
B23-12175	33.64705	117.88421	Estuary	6.4	Newport Bay	14	96	Moderate toxicity
B23-12176	33.69839	118.04010	Estuary	3.1	Bolsa Chica Lagoon	95	103	Nontoxic
B23-12177	33.71098	118.05995	Estuary	4.9	Bolsa Chica	89	102	Low toxicity
B23-12179	33.74141	118.11625	Estuary	2.5	San Gabriel River	91	98	Nontoxic
B23-12180	33.75286	118.10510	Estuary	4	San Gabriel River	90	87	Nontoxic

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12181	33.76148	118.20092	Estuary	3	Los Angeles River	101	98	Nontoxic
B23-12182	33.76603	118.10371	Estuary	3.7	Los Cerritos	21	NA	NA
B23-12184	33.97108	118.43923	Estuary	1.75	Ballona Creek	78	NA	NA
B23-12186	34.18297	119.23051	Estuary	2.53	Channel Islands Harbor	62	100	Low toxicity
B23-12187	32.54961	117.18772	Inner Shelf	30	Bight	81	NA	NA
B23-12192	33.43965	117.66772	Inner Shelf	11	Bight	100	NA	NA
B23-12193	33.52095	117.77025	Inner Shelf	18	Bight	99	NA	NA
B23-12194	33.62792	117.98773	Inner Shelf	14	Bight	100	NA	NA
B23-12195	33.64408	118.07816	Inner Shelf	28	Bight	101	NA	NA
B23-12199	33.69518	118.29597	Inner Shelf	28	Bight	94	NA	NA
B23-12201	33.73347	118.12205	Inner Shelf	8	Bight	101	NA	NA
B23-12203	34.00360	118.52310	Inner Shelf	18	Bight	98	NA	NA
B23-12204	34.02309	118.59329	Inner Shelf	22	Bight	95	NA	NA
B23-12210	34.19377	119.36196	Inner Shelf	28.1	Bight	99	NA	NA
B23-12217	32.55166	117.19942	Mid Shelf	35	Bight	83	NA	NA
B23-12218	32.57673	117.31743	Mid Shelf	120	Bight	76	NA	NA
B23-12219	32.58970	117.26425	Mid Shelf	57	Bight	101	NA	NA
B23-12221	33.08766	117.35088	Mid Shelf	72	Bight	70	NA	NA
B23-12224	33.26548	117.53338	Mid Shelf	63	Bight	97	NA	NA
B23-12228	33.60210	118.05646	Mid Shelf	39	Bight	100	NA	NA
B23-12237	34.03558	118.99247	Mid Shelf	56	Bight	102	NA	NA
B23-12239	34.31583	119.56562	Mid Shelf	67.1	Bight	91	NA	NA
B23-12241	34.36797	119.65957	Mid Shelf	53.9	Bight	97	NA	NA
B23-12247	32.58566	117.34060	Outer Shelf	182	Bight	88	NA	NA
B23-12248	32.74984	117.37160	Outer Shelf	195	Bight	66	NA	NA
B23-12250	33.18809	117.46553	Outer Shelf	128	Bight	84	NA	NA

StationID	Latitude (North)	Longitude (West)	Stratum	Depth (m)	Region	Amphipod Survival (%Control)	Mussel Embryo Percent Normal Alive (%Control)	Integrated Toxicity Category
B23-12251	33.22099	117.51147	Outer Shelf	186	Bight	98	NA	NA
B23-12253	33.46437	117.76178	Outer Shelf	147	Bight	97	NA	NA
B23-12258	33.76707	118.45999	Mid Shelf	119	Bight	89	NA	NA
B23-12261	33.91228	118.58847	Outer Shelf	173	Bight	98	NA	NA
B23-12262	33.99767	118.93197	Outer Shelf	180	Bight	101	NA	NA
B23-12266	34.06988	119.10607	Outer Shelf	156	Bight	94	NA	NA
B23-12280	34.26956	119.70212	Outer Shelf	197	Bight	68	NA	NA
B23-12360	32.59475	117.09495	Freshwater Estuary	1	Otay	88	100	Low toxicity
B23-12363	32.65817	117.08298	Freshwater Estuary	1.2	Sweetwater River	90	100	Nontoxic
B23-12364	32.75987	117.22216	Freshwater Estuary	0.55	San Diego River	102	104	Nontoxic
B23-12366	32.97715	117.23955	Freshwater Estuary	0.5	San Dieguito Lagoon	92	95	Nontoxic
B23-12368	33.20347	117.39084	Freshwater Estuary	0.31	San Luis Rey River	100	99	Nontoxic
B23-12369	33.23767	117.39390	Freshwater Estuary	0.56	Santa Margarita River	101	91	Nontoxic
B23-12545	33.14236	117.32822	Estuary	4	Agua Hedionda	86	103	Low toxicity
B23-12591	32.59000	117.19328	Inner Shelf	27	Bight	92	NA	NA
B23-12709	32.67810	117.16370	Bay	4.6	San Diego Bay	99	94	Nontoxic
B23-12811	33.72460	118.07237	Marina	4.5	Huntington Harbor	87	90	Low toxicity
B23-12841	32.72367	117.22719	Marina	3.2	San Diego Bay	95	88	Low toxicity
B23-12976	33.23530	117.40871	Estuary	0.95	Santa Margarita estuary	98	91	Nontoxic
B23-12979	33.20475	117.38651	Estuary	0.85	SLR	97	71	Low toxicity

NA= Not analyzed.

APPENDIX B: STATION ID CROSS REFERENCE

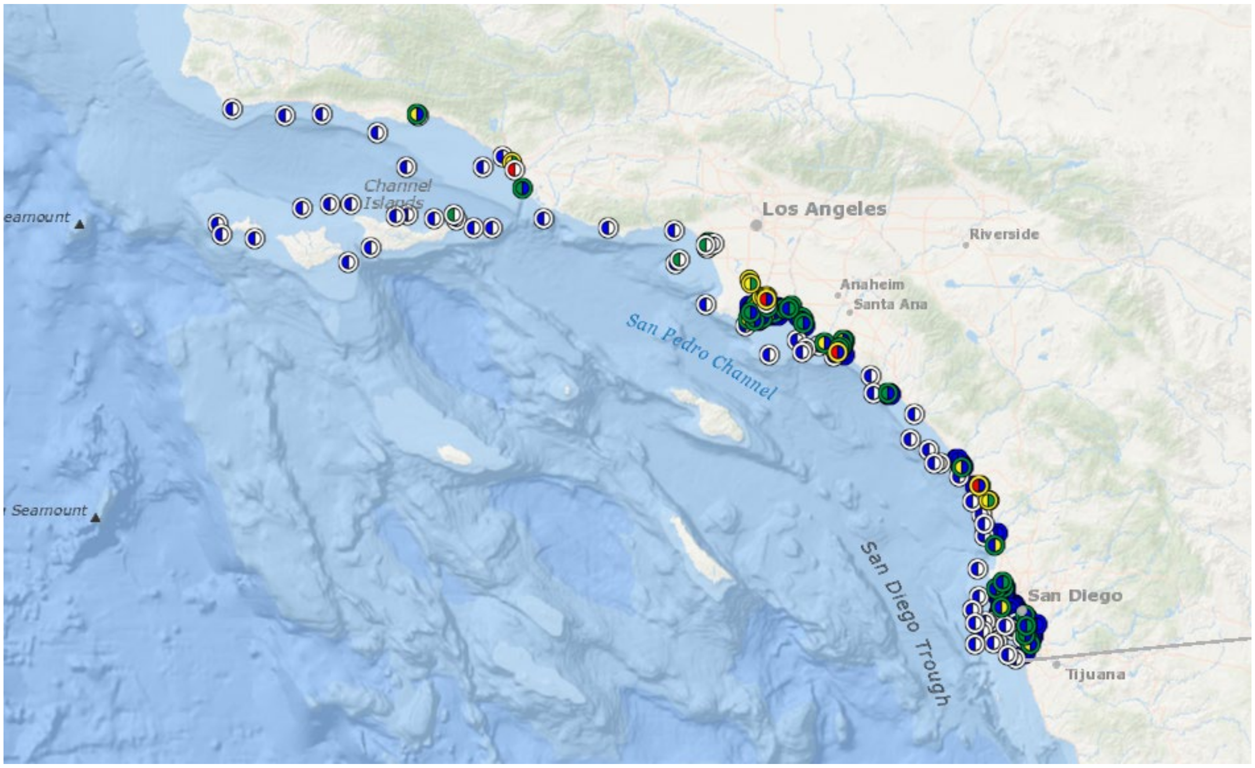
Cross reference of station IDs for revisit stations sampled in Bight ’23 and in at least one previous Bight survey.

Bight’23	Bight ’18	Bight ’13	Bight ’08	Bight ’03	Bight ’98
12008	10037	8029	6040	4148	-
12009	10036	8052	6071	4116	-
12011	10034	8060	6080	-	2242
12012	10032	8068	6093	4028	-
12015	10028	-	-	-	-
12016	10027	-	-	-	-
12018	10026	-	-	-	-
12019	10024	8109	6152	-	2436
12021	10022	8122	6172	4092	-
12022	10019	8152	6212	4020	-
12024	10017	8159	6217	4228	-
12027	10013	8302	6386	4178	-
12028	10012	8304	6387	-	2162
12031	10011	8319	6404	4242	-
12039	10006	8350	6437	-	2156
12040	10004	8355	6444	-	2157
12041	10002	8358	6448	4098	-
12044	10000	8388	6478	-	2152
12046	10086	8013	6025	4052	-
12047	10084	8102	6145	-	2226
12049	10081	8116	6159	4076	-
12050	10080	8117	6161	-	2222
12052	10077	8123	6173	-	2434
12057	10075	8151	6211	-	2425
12058	10073	8156	6216	-	2423
12061	10070	-	-	-	-
12070	10062	8273	6343	4065	-
12074	10059	8280	6350	-	2136
12078	10055	8383	6472	4018	-
12081	10053	8397	6489	4010	-
12083	10051	8407	6513	4085	-
12084	10050	8409	6518	-	2448
12086	10047	8417	6530	-	2443
12087	10046	8425	6549	-	2130
12089	10144	8045	6054	-	2262
12093	10140	8056	6075	4084	-
12094	10138	-	-	-	-

Bight’23	Bight ’18	Bight ’13	Bight ’08	Bight ’03	Bight ’98
12104	10128	-	-	--	-
12108	10125	-	-	-	-
12116	10117	8085	6128	-	2441
12117	10116	8087	6129	-	2252
12120	10114	8100	6140	-	2251
12123	10113	-	-	-	-
12124	10112	8112	6155	-	2263
12126	10108	8316	6402	-	2182
12127	10107	8326	6413	-	2298
12129	10106	8333	6419	4162	-
12134	10101	8347	6435	-	2179
12136	10096	8360	6450	4146	-
12140	10095	8371	6463	-	2432
12141	10094	8374	6466	4210	-
12143	10090	8396	6487	4266	-
12146	10182	8002	6001	4695	-
12156	10177	8129	6181	4264	-
12157	10176	8136	6192	4033	-
12163	10169	8219	6270	4087	-
12164	10168	8222	6271	4304	-
12165	10167	8248	6303	4209	-
12174	10159	8290	6362	4017	-
12175	10158	8292	6363	4075	-
12180	10151	8378	6468	4194	-
12182	10149	8394	6485	4118	-
12193	10229	9171	7231	-	2304
12194	10227	9204	7293	-	2325
12195	10226	9214	7300	4058	-
12199	10224	9229	7321	4042	-
12204	10218	9341	7517	-	2382
12217	10278	9007	7002	4000	-
12219	10277	9012	7009	-	2419
12221	10269	9105	7122	4048	-
12224	10266	9129	7166	4080	-
12228	10260	9199	7269	-	2208
12247	10320	9011	7008	4068	-
12251	10317	9125	7158	4144	-
12253	10315	9150	7208	4110	-
12258	10311	9251	7395	4038	-
12261	10308	-	-	-	-
12363	10199	-	-	-	-

APPENDIX C: INTERACTIVE MAP OF BIGHT '23, '18,'13, AND '08 TOXICITY RESULTS

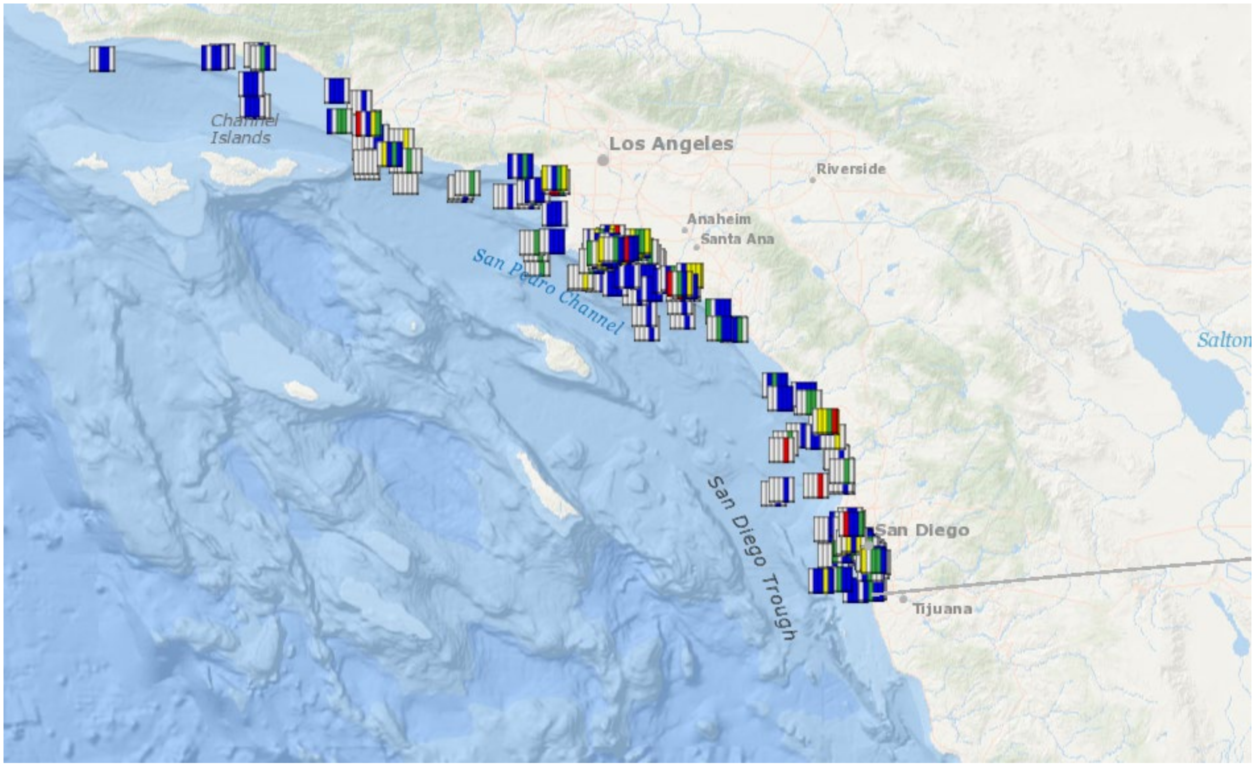
[Bight' 23 Sediment Toxicity Report (Appendix C)]



The link above is for a scalable map of the Bight region. Symbols represent SQO categorization of the amphipod, mussel, and integrated results from Bight '08, Bight '13, Bight '18, and Bight '23. Note that the results from each survey are on different layers that cannot be properly viewed simultaneously. Click on the layer icon in the upper left of the map and a table of the possible layers to view will open; make sure only one survey is chosen. The information icon contains a legend for the symbols. At the bottom center of the map is an upward arrow icon. Clicking on this icon opens a table of information for all the stations. This table can be sorted by any of the columns by clicking in the column header. Clicking on any station in the table zooms and centers the map to that station. Clicking any station symbol on the map opens a table containing the toxicity information for all three surveys. The table also contains station information from Bight '23 (e.g., latitude and longitude).

APPENDIX D: INTERACTIVE MAP OF HISTORICAL SEDIMENT TOXICITY TO AMPHIPODS

[Bight ’23 Sediment Toxicity Report (Appendix D)]



The link above is for a scalable map of the Bight region with symbols representing SQO categorization of the amphipod test results from Bight ’98, Bight ’03, Bight ’08, Bight ’13, Bight ’18 and Bight ‘23. The information icon contains a legend for the symbols. At the bottom center of the map is an upward arrow icon. Clicking on this icon opens a table of information for all the stations. This table can be sorted by any of the columns by clicking in the column header. Clicking on any station in the table zooms and centers the map to that station. Clicking any station symbol on the map opens a table containing the toxicity information for all the surveys represented. The table also contains station information from Bight ’23 (e.g., latitude and longitude).

APPENDIX E: LABORATORY INTERCALIBRATION AND SPLIT SAMPLE ASSESSMENT METHODS

Comparability of the laboratories for the intercalibration was based on four factors: the percentage difference from the mean for each sample, a comparison of the toxicity category for each sample, the relative percent difference (RPD) of the duplicate sample and results from the reference toxicant test. For the split samples tested during the survey, there were no duplicate samples and no standardized reference toxicant materials were sent to the laboratories. Therefore, the split sample comparability during the survey was assessed using just the percentage difference from the grand mean for each sample and the comparison of the mean toxicity category for each sample.

For the percentage difference from the mean, the following procedure was used:

1. The data was pooled from all labs, treating each sample separately.
2. Removed outlier laboratory's data (if any) for each sample, which was not included in the grand mean (Grubb's test).
3. Calculate grand mean.
4. Assigned points to each laboratory based on the percentage difference between their mean and the grand mean (Table E1).
5. Sum the points assigned from each sample.

Given that there were four samples for comparison, the maximum attainable score for this evaluation factor was 12.

Table E1. Summary of scoring system for percent survival or normal alive data and toxicity category.

% Survival or Normal-alive (absolute difference from grand mean)		Toxicity Category Agreement	
Result	Pts	Result	Pts
0 – 10 %	3	Same cat.	1.5
> 10 – 20 %	2	1 cat. difference	1.0
> 20 – 30 %	1	2 cat. difference	0.5
> 30 %	0	3 cat. difference	0

The second comparison factor was based on the sediment toxicity category. For each sample, the grand mean was used to place the sample into a toxicity category based on California AQO thresholds (Table E2). The results for each laboratory were also assigned to a category. The category from the grand mean and for the individual samples was then compared. The number of categories difference was then used to assign point values (Table E1). For example, if the grand mean placed the sample in the nontoxic category and an individual laboratory was in the *moderate toxicity* category, then the difference would be 2 categories, and 0.5 points would be assigned. Since there were four samples, the maximum points awarded for this category was 6.

Table E2. Threshold values for sediment toxicity test response.

Test species/endpoint	Statistical Significance	*Nontoxic* (%)	*Low Toxicity* (% Control)	*Moderate Toxicity* (% Control)	*High Toxicity* (% Control)
E. estuarius	Significant	90 – 100	82 – 89	59 – 81	< 59
Survival	Not Sig.	82 – 100	59 – 81		< 59
M. galloprovincialis	Significant	80 to 100	77 – 79	42 – 76	< 42
Normal Development	Not Sig.	77 – 79	42 – 76		< 42

For the duplicate sample the following procedure was used:

1. The relative percent difference of the percent mortality of the two duplicate samples was calculated for each laboratory.
2. Assigned points to each laboratory based on their calculated RPD when compared to the thresholds shown in Table E3.

The maximum attainable score for this evaluation factor was 12.

Table 3. Scoring system for duplicate sample results based on the relative percent difference between the duplicates.

Result	Pts.
0 – 10 %	12
>10 – 20 %	9
> 20 – 30 %	6
> 30 %	0

The final factor to be considered was the reference toxicant. The evaluation method involved the following steps:

1. Collected ammonia reference toxicant data from all laboratories for both *Eohaustorius* and *Mytilus* tests (historical data). Data was formatted as mg/L un-ionized ammonia.
2. Calculated the standard deviation (SD) for all of the historical EC50/LC50 data for each species.
3. Pooled intercalibration reference toxicant EC50/LC50 data from all labs.

4. Removed outlier laboratory's data for each sample, which was not included in the grand mean (Grubb's test).
5. Calculated grand mean.
6. Calculated the difference from the grand mean for each laboratory.
7. Compared the difference from the grand mean to the standard deviation from the historical data and assign points as shown in Table E4.

As an example, we will say that the SD for all historical data for one of the methods is 0.1. The mean value for the labs participating in the intercalibration we will say is 0.124 mg/L un-ionized ammonia. If Lab A found the LC50 to be 0.263, then the difference would be 0.139 which is greater than 1 SD, but less than 2, so would therefore get a score of 2 points. The maximum achievable score for the reference toxicant evaluation factor was 12.

Table E4. Scoring system for reference toxicant results, based on the standard deviation from the grand mean.

Result	Pts.
Within 1 SD	12
Within 2 SD	9
Within 3 SD	6
> 3 SD	0

For integration of the three comparison factors, the points were summed for each laboratory. The "grading" system for the total score is shown in Table E5.

Table E5. Scoring system for the sum of all factors

Description	% of maximum possible score	Number of points
Very High comparability	90	38 – 42
High comparability	80	34 – 37.5
Moderate comparability	70	29.5 – 33.5
Low comparability	< 70	< 29.5