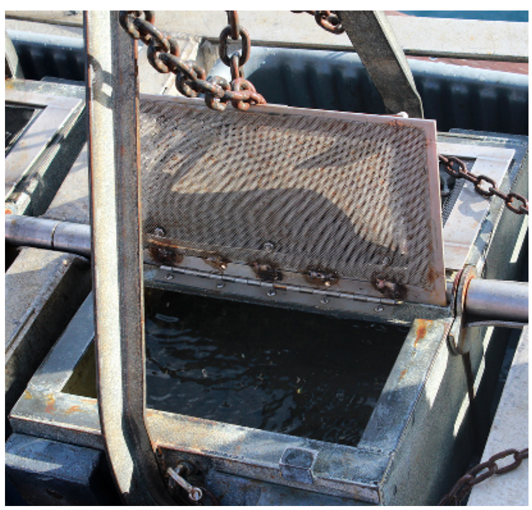
Southern California Bight 2013
Regional Monitoring Program

Sediment Chemistry

BIGHT '13


Southern California Bight
2013 Regional Monitoring
Program
Volume IV

SCCWRP Technical Report 922

Southern California Bight 2013 Regional Monitoring Program: Volume IV. Sediment Chemistry

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FOREWORD

The Southern California Bight 2013 Regional Monitoring Program (Bight'13) is an integrated, collaborative effort to provide large-scale assessments of the Southern California Bight (SCB). The Bight'13 survey is an extension of previous regional assessments conducted every five years dating back to 1994. The collaboration represents the combined efforts of nearly 100 organizations. Bight'13 is organized into five elements: 1) Contaminant Impact Assessment (formerly Coastal Ecology), 2) Shoreline Microbiology, 3) Nutrients, 4) Marine Protected Areas, and 5) Trash and Debris. This assessment report presents the results of the sediment chemistry portion of the survey, which is one component of the Contaminant Impact Assessment element. Copies of this and other Bight'13 reports, as well as work plans and quality assurance plans, are available for download at www.sccwrp.org.

Acknowledgements

This report is a result of the dedication and hard work of many individuals 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'13 Chemistry Committee for their assistance with study design, sample analysis, data analysis and report review. We also thank the Bight'13 Executive Advisory Committee and Contaminant Impact Assessment Committee for their guidance and support of sediment chemistry measurements in regional monitoring. This study would not have been possible without the remarkable expertise of the field sampling personnel from the following organizations: City of San Diego, Weston Solutions, Orange County Sanitation District, Sanitation Districts of Los Angeles County, City of Los Angeles, Southern California Coastal Water Research Project, Aquatic Bioassay and Consulting Laboratories, and AMEC Foster Wheeler. We also wish to express our gratitude to Abel Santana and Dario Diehl (SCCWRP) for map preparation; Wayne Lao and David Tsukada (SCCWRP) for preparation of field reference materials; and Ed Wirth and Mike Fulton for chemical analysis (National Oceanic Atmospheric Administration).

Sediment chemistry measurements were provided by the following laboratories: City of Los Angeles Environmental Monitoring Division; City of San Diego; Eurofins Calscience; Institute for Integrated Research in Materials, Environments and Societies; Sanitation Districts of Los Angeles County; National Oceanic Atmospheric Administration; Orange County Sanitation District; and Physis Laboratories.

EXECUTIVE SUMMARY

Regional monitoring has become an important component of assessing the status of our coastal resources in the Southern California Bight (SCB). The Southern California Bight 2013 Regional Monitoring Program (Bight'13) is the fifth in a series of regional marine monitoring efforts beginning in 1994 and repeated again in 1998, 2003, and 2008. More than 90 different organizations encompassing regulatory, regulated, academic, and non-governmental agencies collaborated to create Bight'13. Collectively, these organizations asked three primary questions:

1. What is the extent and magnitude of impact in the SCB?
2. Does the extent and magnitude of impact vary among different habitats of interest?
3. What are the temporal trends in impacts?

Bight'13 had five components: Contaminant Impact Assessment, Water Column Nutrients, Shoreline Microbiology, Marine Protected Areas, and Trash and Debris. The Contaminant Impact Assessment component included sediment chemistry and toxicity, benthic infauna, fish assemblages, and bioaccumulation. The focus of this report is on sediment chemistry.

A stratified random sampling design was selected to ensure an unbiased sampling approach to provide areal assessments of environmental condition. There were 11 strata selected for this study including three continental shelf strata (5-30 m, 30-120 m, 120-200 m), upper slope (200-500 m), lower slope and basin (500-1000m), and embayment strata (marinas, ports, open bays and harbors, estuaries). Two new strata, submarine canyon bottoms and marine protected areas, were introduced in Bight'13.

A total of 346 stations were sampled between July and September 2013, and analyzed for grain size, total organic carbon, total nitrogen, 15 trace metals, total PAH (sum of 24 individual polynuclear aromatic hydrocarbons), total PCB (sum of 41 polychlorinated biphenyl congeners), total DDT (sum of two dichlorodiphenyltrichloroethane isomers and 5 degradation products), and total chlordane (sum of 5 forms). Oxychlordane is a new analyte to Bight'13. Two groups of emerging contaminants were measured in Bight'13 including 13 polybrominated diphenyl ether (PBDE) flame retardants and 8 pyrethroid pesticides.

Based on the chemistry indices of California's Sediment Quality Objectives (SQO) assessment framework, 68% of the Bight sediments have minimal or low exposure to sediment contamination. Less than one percent of the Bight sediments have high exposure to sediment contamination, the worst category of contamination according to the Chemical Scoring Index. The relative extent of sediment contamination was generally greater in embayments than offshore strata, and the distribution of many sediment contaminants was a function of their sources.

The extent of acceptable sediment condition (defined as minimal or low chemical exposure) has remained steady over the last 10 years and ranged from 65% to 75% during the three surveys from 2003 to 2013. Over the same period, the extent of high exposure to sediment contamination has remained low (<3% of SCB).

While Bight-wide trends have been stable since 2003, there were varying trends in sediment condition of individual habitats. For example, the extent of acceptable sediment condition in SCB's ports/bays/marinas has steadily improved, increasing from 40% in 1998 to 72% in 2013.

Reductions in sediment concentrations of some contaminants of emerging concern were observed, concomitant with source control measures. PBDEs have the potential to accumulate in sediment and in tissues of fish. This is one reason why regulations restricting the production and use of PBDEs were implemented beginning in 2010. This may also be part of the reason Bight'13 results indicated a 10-fold reduction of average PBDE concentrations in embayments between 2008 and 2013.

The two new strata introduced in Bight'13, Submarine Canyon Bottoms and Marine Protected Areas, reflected the contaminant concentrations in surrounding areas. Submarine canyons were introduced with the hypothesis that contaminant transport from surrounding areas may lead to higher canyon concentrations. Bight'13 indicated this transport was taking place; continental shelf locations with the highest concentrations also had nearby submarine canyons with the highest concentrations. Similarly, MPAs near continental shelf locations with the highest concentrations were also the MPAs with the highest concentrations. The extent that this sediment contamination impacts MPA goals such as fishery production is unclear.

A number of recommendations are provided to help spur improvements in future Bight surveys. These recommendations fall into two categories. The first addresses the survey's ability to reveal new information including using biological and toxicity data to interpret the extent and magnitude of anthropogenic effects using a weight-of-evidence approach, to continue to assess constituents of emerging concern, and to calibrate and validate an SQO chemistry index specifically for offshore sediments. The second category of recommendations is to invest in monitoring infrastructure to improve comparability and efficiency. The areas of specific concern were compliance with Bight performance-based quality assurance requirements, and information management.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

Overview

The Southern California Bight is an important and unique resource that is influenced by the large population centers along the coast. The region extends from Point Conception, California, to Cabo Colnett, Baja California. The SCB has a complex topography with offshore islands, submarine canyons, ridges, and basins, which provide a variety of habitats. The mixing of cold and warm currents and the diverse habitats in the SCB allow for the coexistence of a broad spectrum of species, including more than 500 species of fish and 1,500 species of invertebrates (Dailey et al. 1993). The SCB is also a major migration route, with diverse marine bird and mammal populations.

The coastal areas that form the SCB are some of the most densely populated regions in the country, which in turn creates stresses upon the adjacent marine environment. The population of the five coastal counties that border the SCB was 15 million in 2013 (State of California, 2015). The SCB is also a substantial economic resource; for example, commercial fishery landings in the SCB generated an estimated $45 billion in 2002 and recreational fishing generated more than $500 million that same year (Kildow and Colgan 2005). Population growth and economic activity has resulted in conversion of open land into urban and largely non-permeable surfaces, and 48% of historical estuarine habitat has been lost since 1850 (Stein et al. 2014). This “hardening of the coast” increases the rate of runoff and can impact water quality through the addition of sediment, toxic chemicals, pathogens, and nutrients to the ocean. Besides the impacts of land conversion, the SCB is already home to 15 municipal wastewater treatment facilities, 8 power-generating stations, 10 industrial treatment facilities, and 18 oil platforms that discharge to the open coast (Schiff et al. 2001).

A majority of the annual monitoring effort is associated with National Pollutant Discharge Elimination System (NPDES) permits and is primarily intended to assess regulatory compliance. While these monitoring programs have answered important questions regarding the health of coastal waters, they were specifically designed to evaluate impacts of individual discharges, and only cover approximately 5% of the total SCB area.

To inform management strategies for the entire SCB, the regionally-based Bight Program was initiated to gather information for assessing cumulative impacts of multiple and often diffuse sources of contaminant inputs and to evaluate relative risk among these different sources and their associated stresses. Regional monitoring also provides an opportunity to assess large-scale reference conditions that cover the entire range of natural variability observed in the SCB, in contrast to comparing an individual discharge to a small number of local reference sites.

Previous Regional Monitoring Studies

The first regional sediment chemistry monitoring program occurred in 1994 (Pilot Project) and consisted of 12 collaborating agencies (Schiff and Gossett 1998). The second occurred in 1998 (Bight ‘98) and consisted of more than 60 collaborating agencies (Noblet et al. 2002). The third occurred in 2003 (Bight ‘03) and also consisted of more than 60 agencies. The fourth occurred in 2008 (Bight ’08) and consisted of more than 90 collaborating agencies. There were 264 sites sampled in 1994, 404 sampled in 1998, 359 sampled in 2003, and 383 sampled in 2008. Each survey focused on differing habitats from the mainland continental shelf, offshore Channel Islands, and several types of embayment habitats (open bays, enclosed estuaries, ports, etc.). Every survey assessed the extent and magnitude of impacts for a number of indicators including sediment chemistry, benthic infauna, sediment toxicity, fish assemblages and bioaccumulation.

Previous surveys invested substantial effort in developing analytical comparability (Gossett et al. 2003). Since all of the regional programs were conducted in a collaborative fashion with multiple analytical laboratories participating, inter-calibration studies were a focal point for trace metal and trace organic constituents. Although all participating laboratories were certified by the State of California, there was significant discrepancy at times for specific constituents. Therefore, iterative inter-comparison and inter-calibration exercises were performed until all of the laboratories could meet prescribed data quality objectives for inter-laboratory precision. These inter-calibrations remain one of the foundational elements of the regional monitoring quality assurance/quality control program.

Objectives of the 2013 Regional Monitoring Program

The purpose of the Southern California Bight 2013 Regional Monitoring Program (Bight'13) is to address three specific management questions:

1. What is the extent and magnitude of impact in the SCB?
2. Does the extent and magnitude of impact vary among different habitats of interest?
3. What are the temporal trends in impacts?

Answering these questions addresses the management needs for assessing the overall environmental health of the SCB, describing regional reference conditions, and developing regional assessment tools. Like the earlier surveys, the Bight'13 program was a multi-faceted program. It had five components: Contaminant Impact Assessment, Water Column Nutrients, Shoreline Microbiology, Marine Protected Areas, and Trash and Debris. The Contaminant Impact Assessment component included sediment chemistry and toxicity, benthic infauna, fish assemblages, and bioaccumulation. The focus of this report is sediment chemistry and includes sections on Methods (Section II), Quality Assurance/Quality Control (Section III), Descriptive Results (Section IV), Assessment Results (Section V), Discussion (Section Vi), Conclusions (Section VII), and Recommendations (Section VIII).

II. METHODS

Sampling Design

A stratified random sampling design was selected to ensure an unbiased sampling approach to provide areal assessments of environmental condition (Stevens 1997). There were 11 strata selected for this study including three continental shelf strata (5-30 m, 30-120 m, 120-200 m), upper slope (200-500 m), lower slope and basin (500-1000m), and embayment strata (marinas, ports, open bays and harbors, estuaries) (Figure II-1). Two new strata, submarine canyon bottoms (Figure II-2) and marine protected areas (MPAs) (Figure II-3), were introduced in Bight'13. The number of stations in each stratum is shown in Table II-1. Oceanic/coastal MPAs were sampled; estuarine MPAs were not included in the survey design. The Bight '08 Channel Islands National Marine Sanctuary stratum was not included in Bight'13. Stratification ensured that an appropriate number of samples were allocated to characterize each stratum with adequate precision. The goal was to allocate approximately 30 sites to each stratum, yielding a 90% confidence interval of about ± 10% around estimates of areal extent (assuming a binomial probability distribution and p = 0.2).

Table II-1. Station frequency by stratum in Bight'13. The MPA stratum contained 28 stations overlapping other strata.

Stratum	Number of Stations
Bay	31
Port	30
Estuaries	40
Marina	35
Canyon Bottom	30
Inner Shelf	38
Mid Shelf	42
Outer Shelf	32
Upper Slope	44
Lower Slope	24

Figure II-1. Stratum Boundaries in Bight'13.

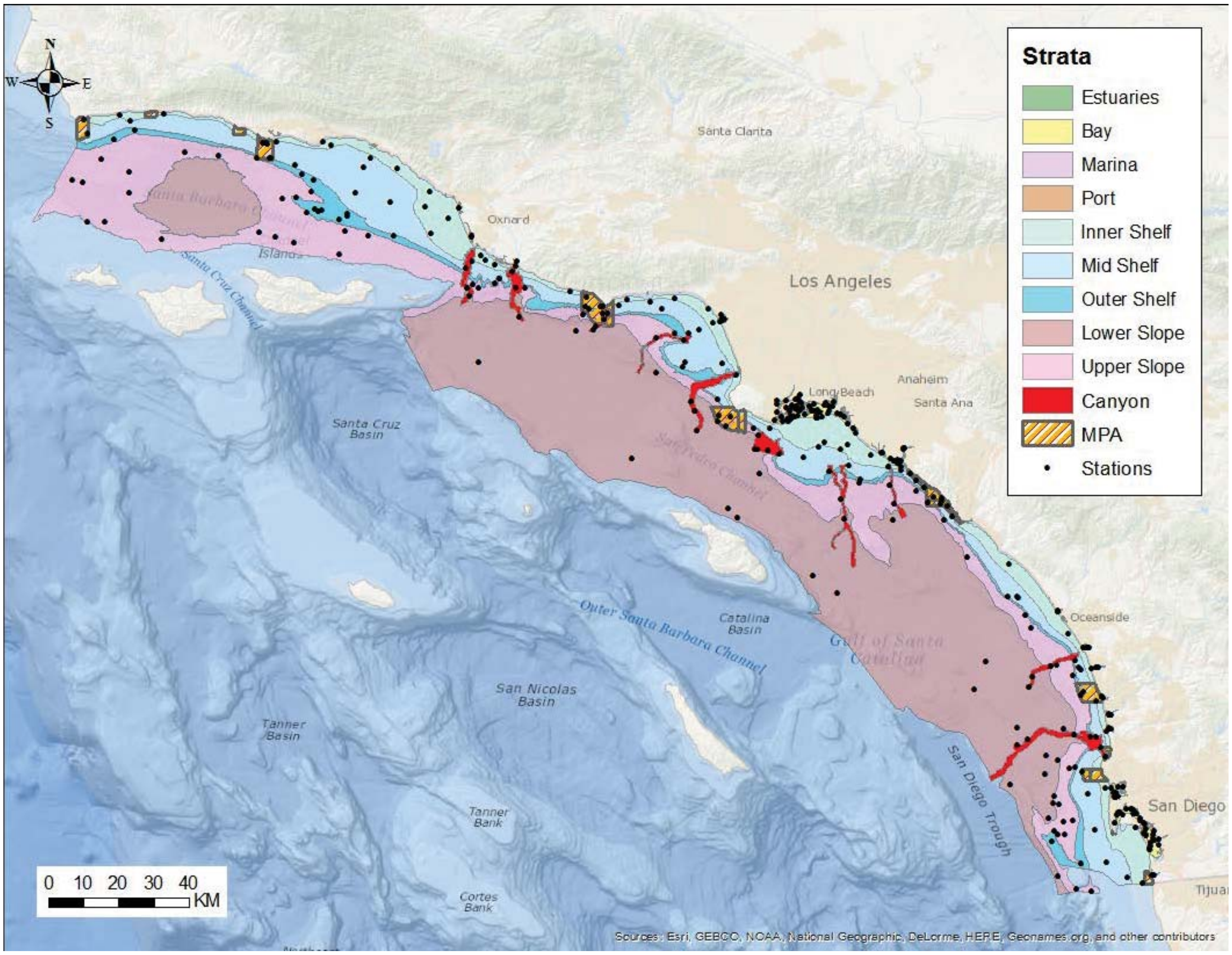


Figure II-2. Boundaries of the Submarine Canyon stratum in Bight'13.

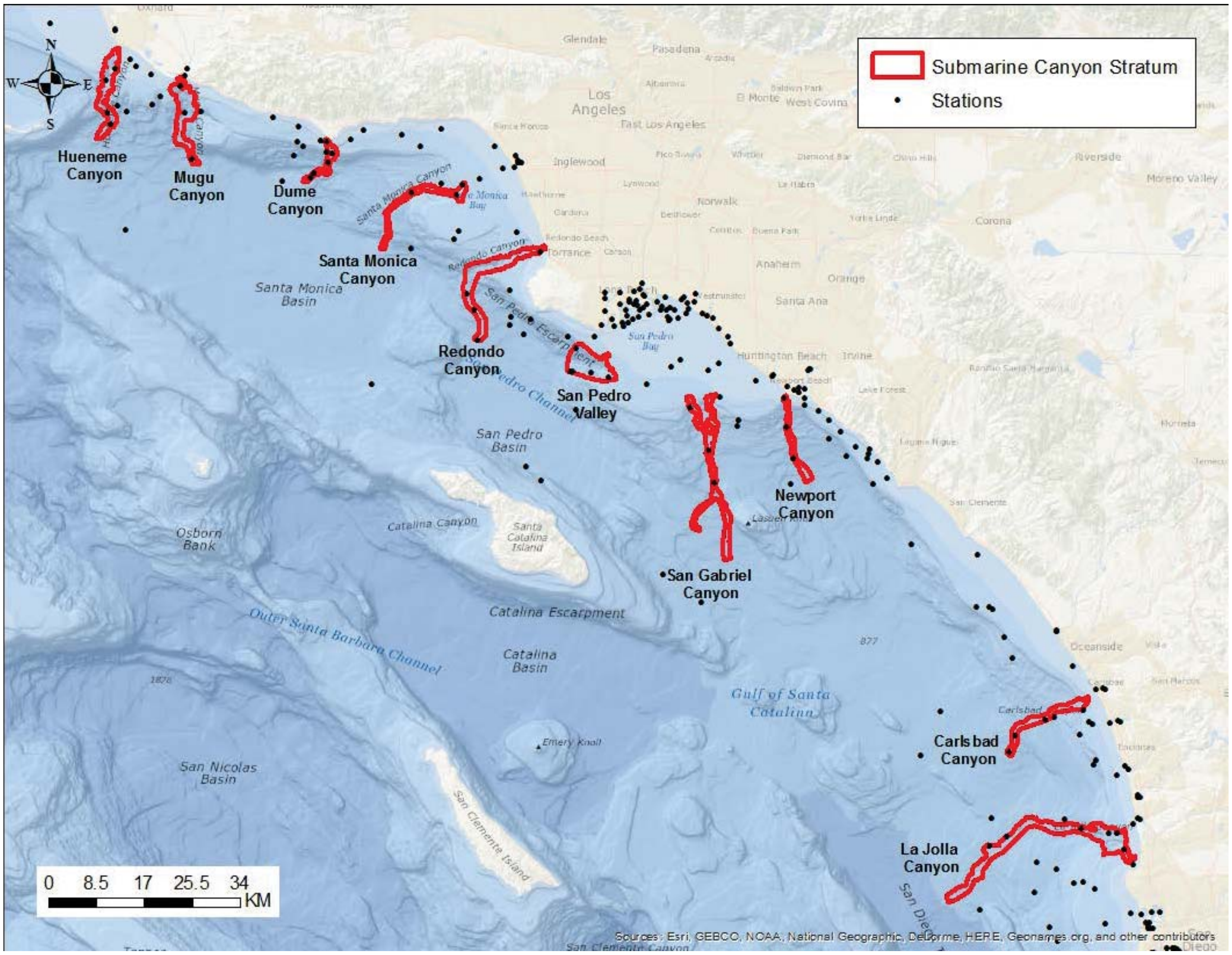
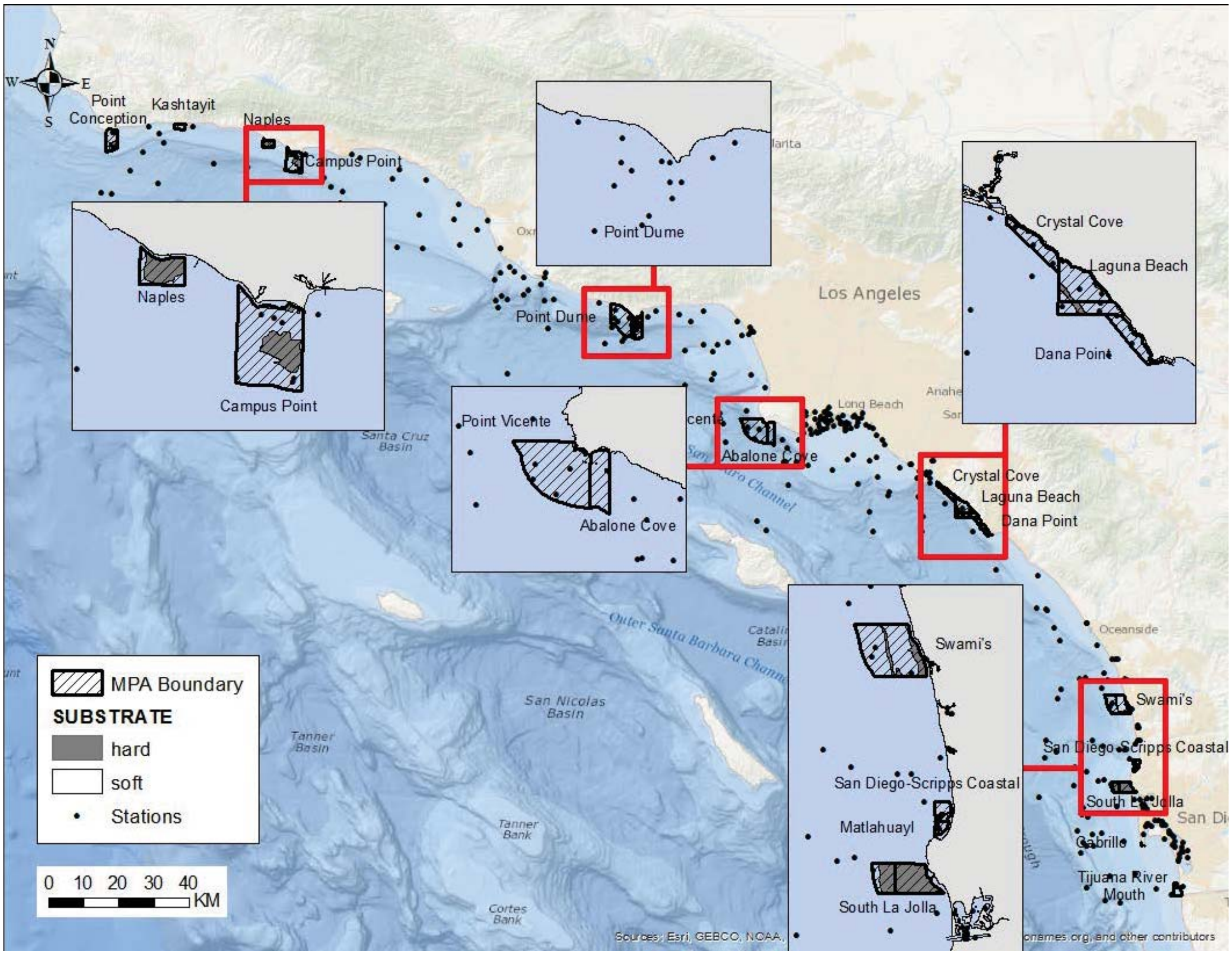


Figure II-3. Boundaries of the Marine Protected Areas stratum in Bight'13.



Sample Collection

Sediment samples were collected using a 0.1 m^2 modified Van Veen grab sampler (Stubbs et al. 1987). Grab samples were required to be within 100 m and 10% of water depth of the location specified by the sampling design. Sediment samples were taken from the top 2 cm in coastal shelf, slope and basin strata, the top 5 cm from embayment strata, and placed in appropriate containers for the subsequent analysis. All sample containers were purchased pre-cleaned glass with Teflon®-lined closures, and were certified to meet Environmental Protection Agency (EPA) standards. All samples except those for grain size analysis were stored frozen (-20 °C) until analyzed. Samples for grain size were stored at 4 °C until analyzed. Further details on the sample collection procedures used in this study can be found in the Bight'13 Field Operations Manual (Bight'13 Contaminant Impact Assessment Committee 2013). As soon as possible after collection, samples were distributed to the appropriate laboratories for analysis. A summary of the division of effort for the Bight'13 chemistry component as a function of parameter and laboratory is given in Table II-2.

Analytical Methods and Target Analytes

Analytical methods employed were at the discretion of the participating laboratories, contingent upon their ability to demonstrate acceptable analytical performance. Acceptable analytical performance required strict adherence to common quality assurance/quality control (QA/QC) practices, and each laboratory was required to demonstrate its capability to meet the stated measurement quality objectives (MQOs) for each of the target analytes. Initially, each laboratory established a method detection limit (MDL) for each target analyte following the MDL protocol cited in EPA 40 CFR Part 136, and laboratories were required to meet the study's stated reporting levels (RLs). Laboratories participated in an inter-calibration exercise and were required to meet specified performance criteria prior to any analysis of the survey samples. Analytical performance criteria and the data quality objective (DQO) for each quality control sample type can be found in the Bight'13 Survey Quality Assurance Plan. See Section III for an assessment of these Bight'13 Chemistry Committee quality assurance activities.

The target analytes for the Bight'13 Survey are listed in Table II-3, and are similar to the analytes measured in Bight '08. The 15 metal analytes were selected from those metals normally monitored by the participating agencies. The 24 PAHs include 16 PAHs on the EPA's priority pollutant list, as well as 8 additional compounds, including 5 methylated PAHs. The 41 polychlorinated biphenyl congeners (PCBs) were selected based on their potential toxicity and occurrence in the commonly used (and subsequently discharged) Aroclors 1242, 1248, 1254, and 1260. The 12 chlorinated pesticides were selected based on known abundance and impacts in previous Bight surveys. Oxychlordane is a new analyte to Bight'13. Two groups of emerging contaminants were measured in Bight'13 including 13 polybrominated diphenyl ether (PBDE) flame retardants and 8 pyrethroid pesticides. The PBDEs and pyrethroids were first measured in Bight '08 as part of special studies.

The following are brief descriptions of the analytical methods.

Grain Size

All of the samples were analyzed using a Horiba LA920 instrument. This instrument utilizes light-scattering technology to measure particles in 85 size categories ranging from 0.04-1019 µm. All samples were screened through 1000 and 2000 µm sieve prior to analysis to remove methodological interferences and bias. The sample fraction greater than 2000 µm was designated as gravel. All categories <63 µm were considered fine-grained material (silts + clays) and are referenced herein as percent fines.

Total Organic Carbon and Total Nitrogen

Total organic carbon (TOC) and total nitrogen (TN) analyses were performed using an elemental analyzer, in which samples are combusted at high temperature (>1000 °C) and separated by gas chromatography. Frozen sediments were thawed to room temperature and homogenized before being dried in an air oven at 60 °C overnight. The dried samples were then exposed to concentrated hydrochloric acid vapors in a closed container to remove inorganic carbon. The acid-treated samples were again dried and weighed, and crimped in a tin or silver capsule prior to analysis.

Metals

Metals, except for mercury, were digested in strong acid according to the procedures described in EPA Method 3050B (formerly 3055). The resulting digestates were diluted to a specific volume with de-ionized water and subsequently analyzed by one or more of the following instrumental methods, depending on the laboratory: inductively coupled plasma mass spectrometry, inductively coupled plasma emission spectroscopy, flame atomic absorption, or graphite furnace atomic absorption. Some laboratories analyzed arsenic and selenium by hydride generation atomic absorption spectroscopy. All laboratories analyzed mercury using cold vapor atomic absorption spectroscopy.

Trace Organics

Samples requiring trace organic chemistry analysis were solvent extracted using one of the following methods: accelerated solvent extraction, soxhlet, or sonication. The extracts obtained were subjected to each laboratory's own clean-up procedures and were analyzed by an appropriate gas chromatographic method. PCB congeners and organochlorine pesticides were analyzed using either dual-column GC-ECD or GC-MS in the selected ion monitoring (SIM) mode. All laboratories analyzed PAHs, PBDE, and pyrethroids by GC-MS.

Table II-2. Sediment chemistry laboratory effort in Bight'13[1].

Parameter	CLAEMD	CSD	Eurofins CalScience	LACSD	NOAA	OCSD	Physis	IIRMES	Total Number of Samples
Grain Size[2]	0	395	0	0	0	0	0	0	395
Total Organic Carbon (TOC)	39	173	0	0	0	39	73	22	346
Total Nitrogen (TN)	0	180	0	0	0	0	73	22	275
Metals	58	126	0	27	0	37	97	0	345
Polycyclic Aromatic Hydrocarbons (PAH)	0	124	0	28	0	38	156	0	346
Polychlorinated Biphenyls (PCB)	0	124	0	28	0	38	156	0	346
Chlorinated hydrocarbons	0	62[3]	0	28	0	38	156	0	284
Polybrominated Diphenyl Ethers (PBDE)	0	0	0	0	79	0	97	0	176
Pyrethroid Pesticides	0	0	18	0	0	0	118	0	136
Total Number of Sample Analyses per Laboratory	97	1184	18	111	79	190	926	44	2649

[1]CLAEMD = City of Los Angeles Environmental Monitoring Division, CSD = City of San Diego, LACSD = Sanitation Districts of Los Angeles County, NOAA = National Oceanic Atmospheric Administration, OCSD = Orange County Sanitation District, IIRMES = Institute for Integrated Research in Materials, Environments and Societies.
[2]Grain size sample count include non-sediment chemistry stations.
[3]Does not include 62 rejected samples, see Section III.

Table II-3. Sediment chemistry target analytes in Bight'13[1].

Trace Metals	PAHs	PCBs	Pesticides	PBDEs
Aluminum	1,6,7-Trimethylnaphthalene	PCB-18	Chlorinated Pesticides[2]	BDE-17
Antimony	1-Methylnapthalene	PCB-28	4,4'-DDT	BDE-28
Arsenic	1-Methylphenanthrene	PCB-37	2,4'-DDT	BDE-47
Barium	2,6-Dimethylnaphthalene	PCB-44	4,4'-DDD	BDE-49
Beryllium	2-Methylnapthalene	PCB-49	2,4'-DDD	BDE-66
Cadmium	Acenaphthene	PCB-52	4,4'-DDE	BDE-85
Chromium	Acenaphthylene	PCB-66	2,4'-DDE	BDE-99
Copper	Anthracene	PCB-70	4,4'-DDMU	BDE-100
Iron	Benz[a]anthracene	PCB-74	alpha-Chlordane	BDE-138
Lead	Benzo[a]pyrene	PCB-77	gamma-Chlordane	BDE-153
Mercury	Benzo[b]fluoranthene	PCB-81	cis-nonachlor	BDE-154
Nickel	Benzo[e]pyrene	PCB-87	trans-nonachlor	BDE-183
Selenium	Benzo[g,h,i]perylene	PCB-99	oxychlordane	BDE-209
Silver	Benzo[k]fluoranthene	PCB-101		
Zinc	Biphenyl	PCB-105	Pyrethroid Pesticides	
	Chrysene	PCB-110	Bifenthrin	
	Dibenz[a,h]anthracene	PCB-114	Cyfluthrin (total)	
	Fluoranthene	PCB-118	Cypermethrin (total)	
	Fluorene	PCB-119	lambda-Cyhalothrin (total)	
	Indeno[1,2,3-c,d]pyrene	PCB-123	cis-Permethrin	
	Naphthalene	PCB-126	trans-Permethrin	
	Perylene	PCB-128	Deltamethrin	
	Phenanthrene	PCB-138	Esfenvalerate	
	Pyrene	PCB-149		
		PCB-151		
		PCB-153		
		PCB-156		
		PCB-157		
		PCB-158		
		PCB-167		
		PCB-168		
		PCB-169		
		PCB-170		
		PCB-177		
		PCB-180		
		PCB-183		
		PCB-187		
		PCB-189		
		PCB-194		
		PCB-201		
		PCB-206		

[1]Measured general constituents were grain size, total organic carbon, and total nitrogen.
[2]DDT = dichlorodiphenyltrichloroethane, DDD = dichlorodiphenyldichloroethane, DDE = dichlorodiphenyldichloroethylene, and DDMU = di(p-chlorophenyl)-2-chloroethylene.

Data Analysis

The sediment chemistry data from Bight'13 were analyzed to determine descriptive statistics of sediment contamination and to assess the extent and magnitude of sediment contamination. Descriptive statistics focused on two types of analyses: 1) distributions and central tendencies of parameter values including the area-weighted mean (AWM) and confidence interval for each of the strata of interest and the SCB as a whole; and 2) geographical distributions including thematic maps of sediment concentrations by parameter. Assessment of extent and magnitude focused on three types of analyses: 1) estimating the proportion of contaminant mass for each constituent relative to the amount of area occupied for individual strata, 2) evaluation of sediment concentrations using chemistry indices, and 3) comparison of sediment contamination extent to results from previous surveys. The chemistry indices are part of the Sediment Quality Objectives (SQO) assessment framework established by the State of California (SWRCB 2009). Data below the method detection limit were treated as zero for all calculations.

Quantitative spatial analysis was performed using R (R Development Core Team, 2015) and the *cont.analysis* function within the spsurvey package (Diaz-Ramos et al., 1996 and Kincaid et al., 2015). This function estimated the area weighted mean concentrations, area weighted chemical index scores, and the corresponding confidence intervals. The 95% confidence intervals about the mean were calculated as 1.96 times the standard error.

Evaluation of Chemical Exposure

Following the procedure first used in Bight '08, the SQO chemistry indices for bays and estuaries were used to assess chemical exposure. The objective for benthic community protection requires three lines of evidence for evaluation; benthic infauna, sediment toxicity, and sediment chemistry. For each line of evidence, an evaluation of condition is made, then the three lines of evidence are combined for a final site assessment. In the case of sediment chemistry, concentrations of selected constituents were evaluated using two chemistry indices: the Chemical Scoring Index (CSI) and California Logistic Regression Model (CA LRM). Results from the two indices were combined to determine the chemical exposure category. The four chemistry exposure categories are:

1. Minimal Exposure - Sediment-associated contamination may be present, but exposure is unlikely to result in effects.
2. Low Exposure - Small increase in contaminant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.
3. Moderate Exposure - Clear evidence of sediment contaminant exposure at concentrations that are likely to result in biological effects.
4. High Exposure - Contaminant exposure is highly likely to result in substantial biological effects.

The threshold for determining if a site is "acceptable" or "impacted" lies between low and moderate exposure.

The analytes required to calculate the chemical indices are a subset of those measured in the Bight survey: cadmium, copper, lead, mercury, zinc, alpha-chlordane, gamma-chlordane, trans-nonachlor, 4,4'-DDT, ΣHPAH (high molecular weight), ΣLPAH (low molecular weight), ΣDDD, ΣDDE, ΣDDT, and ΣPCB. Dieldrin is a required analyte, but was not analyzed in the survey. The methods for determining the compound class sums, handling non-detects, and calculating the indices are described in Bay et al., 2014.

There are two assumptions in evaluating sediment condition based on chemical exposure. First, we only apply the sediment chemistry line of evidence portion of the SQO assessment framework because sediment toxicity and benthic infaunal data are not yet available. In order to comply with the complete protocol, these two remaining lines of evidence must be applied. Our second assumption was applying the SQO chemistry indices to sediments on the continental shelf, slope and basin. The SQO chemistry indices were developed specifically for bays and estuaries of the state, and this is the only habitat in which the full SQO assessment is appropriate. However, no other California-specific sediment chemistry assessment tool currently exists for these offshore habitats.

III. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

The primary goal of the quality assurance/quality control (QA/QC) effort was to ensure the sediment chemistry data generated among the many study participants were comparable and complete. Therefore, a performance-based approach to QA/QC was adopted, allowing each participating laboratory the flexibility to utilize their own protocols, while meeting common data quality objectives (DQOs) for criteria pertaining to sensitivity, accuracy, and precision. This is the same approach used in previous regional surveys (Gossett et al., 2003), and was carried out in accordance with the Bight'13 Quality Assurance Manual.

Reporting Limits

Minimum target reporting limits (RL) for each analyte were set in the Bight'13 Quality Assurance Manual based on requirements of the Sediment Quality Objectives Chemical Scoring Index used to assess contamination impacts. Overall, participant-specific minimum RLs were lower than the targets, therefore the analyses were performed with adequate sensitivity. Exceptions are as follows. The 98% success in meeting the required organochlorine pesticide RL was due to one laboratory's oxychlordane measurements, which exceeded the requirement in 20% of the laboratory's measurements. The 98% success in meeting the required PBDE reporting level was due to one laboratory exceeding the requirement in 4% of the laboratory's PBDE measurements.

The RLs among the laboratories generally varied by two orders of magnitude (Table III-1). Some laboratories elected to use the required RL, even if they were capable of improved sensitivity. Other laboratories, however, elected to use the lowest RL they could achieve. Since the laboratories' data are combined, there should ideally be a narrower range of RLs. One future option is to require laboratories to report data only using the current RL (to not utilize lower RLs). This has the advantage of straightforward comparison to historical data acquired with similar RLs. Alternatively, in a coordinated effort all laboratories could utilize lower RLs. This has the advantage of keeping methods state-of-the-art and continuing to detect and quantify legacy contaminants as they decrease in environmental concentration.

Inter-Laboratory Comparison Exercises

Prior to analysis of field samples, reference sediment samples were selected, prepared, and analyzed by all participating labs to assess the inter-laboratory comparability of analytical results. Metals and organic measurements were each evaluated using two types of reference materials: a certified reference materials with assigned certified or reference values, and reference materials generated from Bight sediment with regionally relevant matrices and ranges of expected target analyte concentrations. The reference materials were measured in triplicate, and at least two of the replicates must have passed to achieve passing results. Laboratories were required to pass the inter-calibration before analyzing field samples. As noted below, some analytes were measured for information value only and were not assessed on a pass/fail basis. A summary of inter-calibration results is in Table III-2. The full set of results is provided in Appendix B. The full set of participating laboratories in Appendix B included some that did not analyze field samples; they participated on a volunteer basis. NOAA, which analyzed PBDEs in Bight'13, did not participate in the inter-calibration exercise.

Trace Metals

ERA Certified Reference Material 540 Metals in Soil, Lot D074-540 or Lot D079-540, tested method accuracy. Laboratories are required to obtain concentrations within 30% of the certified value for 12 of 15 analytes. The field reference material provided by the City of San Diego from monitoring station E25 tested method performance when analyzing a sample with potential interferences not present in ERA 540.

Pass/fail criteria for the metals field reference material was not set; instead, values obtained by the laboratories were for informational purposes only.

Organics

National Institute of Standards and Technology Standard Reference Material (NIST SRM) 1944 New York/New Jersey Waterway Sediment tested method accuracy. Laboratories were required to obtain concentrations within 40% of the certified or reference value for 70% of the compounds within each class, except PAHs. PAHs were required to be within 40% of the certified or reference value for 80% of the criteria compounds. Pass/fail criteria for PBDEs were not set, PBDE values were for information value only.

The organics field reference material from the Palos Verdes Superfund Site, Marine Sediment SR0326 from US EPA Region 9, tested method performance when analyzing a sample with high levels of DDT and potential interferences not present in NIST SRM 1944. Laboratories were required to obtain a total compound class concentration within 40% of the mean value. Pass/fail criteria for PBDEs were not set, PBDE values are for information value only. A separate field reference material from Ballona Creek was used to assess pyrethroids. Pyrethroid values were used for information values only.

Performance-Based Quality Control Goals and Success

Quality Control (QC) goals are described in detail in the Bight'13 Quality Assurance Manual (Bight'13 Contaminant Impact Assessment Committee, 2013), and summarized along with the results in Table III-3. The completeness, the proportion of the expected data that is actually collected in the measurement process, was 100%, except for chlorinated pesticides due to the rejected stations described below. The frequency success of running QC samples was 80% to 100%. The accuracy and precision success of the QC samples was 79% to 100%. Overall, the majority of QC criteria were met, however, deviations from the criteria were noted in the study database for users to make their own decisions regarding data quality.

Holding Times

Holding time results are shown in Table III-4. The 99% trace metal holding time success was due to one laboratory submitting 45% of its mercury data with a holding time of 561 to 610 days, exceeding the 1 year holding time by approximately 8 months. These data were 84% of the total number of mercury measurements. The organic contaminant holding time success ranged from 57% to 87%, and up to 5 months outside the required holding time. The majority of organic contaminant measurements performed outside the required holding time were expected, due to (1) a required reanalysis of a set of samples, and (2) one laboratory joining the program late.

Ninety-eight percent of the grain size measurements, performed by a single laboratory, were made between six to ten months after sampling and outside of the 6 month holding time. There is no evidence this contributed to measurement bias, since other monitoring programs, such as the Surface Water Ambient Monitoring Program (SWAMP), utilize one year holding times for grain size. Furthermore, a subset of Bight'13 grain size samples were re-analyzed after approximately 1 year of subsequent storage and minimal differences were observed; i.e., < 3 µm change in the mean grain size. Table III-5 shows the results of three example repeated analyses, each performed approximately 15 months apart. The relative percent difference among percent fines was < 5% and without a consistent upwards or downwards trend, indicating the grain size was stable over the time period.

Rejected Stations

Chlorinated pesticide data from 62 stations, or 18% of the total 346 stations, was rejected by the Sediment Chemistry Technical Committee. The rejected data was not used in the subsequent data analysis, calculation of area weighted mean concentration, or calculation of the Chemical Scoring Index. All rejected stations were measured by one laboratory, where it was determined the pressurized liquid extractor was faulty during the sample preparation leading to poor and irreproducible extraction efficiency. Data was rejected for all twelve DDT and chlordane related compounds listed in Table II-3, which were analyzed together in a single method. The rejected stations fell primarily in the northern regions of the Bight (Figure III-1 and Table III-6). A sensitivity analysis was performed to determine if there was a significant bias when rejecting the data. Most changes in the area weighted mean concentrations within a given stratum were less than 5%, indicating the bias was minimal. The largest change when rejecting the data was a 41% and 45% increase in the DDT outer shelf and upper slope area weighted mean concentrations, respectively. However, this change would not have influenced the survey’s major findings or conclusions.

Table III-1. Achieved reporting levels. Percent success is based on the number of samples meeting the required reporting level.

Parameter	Required Reporting Level	Reporting Level Range Achieved	Percent Success
Aluminum (µg/g dw)	NA[1]	2.0 - 500	
Antimony (µg/g dw)	10	0.05 – 1	100%
Arsenic (µg/g dw)	1.6	0.05 – 1	100%
Barium (µg/g dw)	NA	0.02 - 10	
Beryllium (µg/g dw)	0.20	0.01 – 0.2	100%
Cadmium (µg/g dw)	90	0.005 – 1	100%
Chromium (µg/g dw)	16	0.005 – 2	100%
Copper (µg/g dw)	7.0	0.005 – 1	100%
Iron (µg/g dw)	NA	5 - 205	
Lead (µg/g dw)	9.3	0.005 – 2	100%
Mercury (µg/g dw)	0.030	2e-5 – 0.03	100%
Nickel (µg/g dw)	4.2	0.020 – 2	100%
Selenium (µg/g dw)	1.0	0.05 – 1	100%
Silver (µg/g dw)	0.20	0.020 – 0.2	100%
Zinc (µg/g dw)	30	0.05 – 5	100%
Organochlorine Pesticides (ng/g dw)	0.5	0.025 – 1.2	98%
PAH (ng/g dw)	50-100	0.02 – 100	100%
PCB (ng/g dw)	7.5	0.03 – 7.5	100%
PBDE[1] (ng/g dw)	0.1	0.01 – 2.3	98%
Pyrethroids (ng/g dw)	NA	0.5 – 1.1	

[1]NA indicates a required reporting level was not set.
[2]Excluding congener BDE-209, which did not have a required reporting level. The range of BDE-209 reporting levels was 0.1 to 3.5 ng/g dw.

Table III-2. Sediment chemistry inter-calibration results summary. Percentages refer to the number of parameter analyses that passed the acceptance criteria. The table includes required parameters only, results for other measured parameters are provided in Appendix C.

Reference Material	Parameter	Criteria	LACSD	OCSD	CLAEMD	CSD	Physis	Calscience	Summary
SRM 1944	Individual PAHs	Within 40% of target value for 80% of the analytes	100%	87%	80%	87%	93%	93%	All Passed (≥ 80%)
SRM 1944	Individual PCB Congeners	Within 40% of target value for 70% of the analytes	92%	88%	96%	100%	100%	100%	All Passed (≥ 70%)
SRM 1944	Individual OC Pesticides	Within 40% of target value for 70% of the analytes	78%	78%	89%	78%	89%	100%	All Passed (≥ 70%)
Organics Field Reference	Total PAH	40% of the mean value	100%	100%	100%	100%	100%	NA	All Passed (is 100%)
Organics Field Reference	Total PCB	40% of the mean value	100%	100%	100%	100%	100%	100%	All Passed (is 100%)
Organics Field Reference	Total OC Pesticides	40% of the mean value	100%	100%	100%	100%	100%	100%	All Passed (is 100%)
ERA 540	Individual Metals	30% of the certified value for 80% analytes	100%	100%	100%	80%	80%	100%	All Passed (≥ 80%)

Table III-3. Summary of performance-based QC criteria and project success in performing within those criteria.

Quality Control Parameter	Metals		PAH		TOC	
	DQO	**Success**	**DQO**	**Success**	**DQO**	**Success**
Completeness	100%	100%	100%	100%	100%	100%
Method Blank						
Frequency Success	1 / batch	100%	1 / batch	100%	1 / batch	100%
Accuracy Success	< MDL or < 5% of result	98%	< 10 times MDL	100%	< 10 times MDL	100%
Blank Spike						
Frequency Success	1 / batch	100%	Not Required	NA	Not Required	NA
Accuracy Success	15% of true value	99%				
Reference Material						
Frequency Success	1 / batch	100%	1 / batch	100%	1 / batch	95%
Accuracy Success		92%	± 40% of specified value for ≥ 80% of selected analytes	97%	± 20% of specified value	99%
Matrix Spike						
Frequency Success	10% of samples	100%	Not Required	NA	Not Required	NA
Accuracy Success		88%				
Sample Duplicate						
Frequency Success	10% of samples	80%	Not Required	NA	1 / batch	91%
Precision Success	RPD < 30%	98%			RPD < 30%	96%

Table III-3 (cont.)

Quality Control Parameter	Common DQO	OC Pesticides	PCB	PBDE	Pyrethroid Pesticides
Completeness	100%	82%	100%	100%	100%
Method Blank					
Frequency Success	1 / batch	100%	100%	100%	100%
Accuracy Success	< 10 times MDL	100%	100%	99%	96%
Blank Spike					
Frequency Success	Not Required	NA	NA	NA	NA
Accuracy Success					
Reference Material					
Frequency Success	1 / batch	100%	100%	100%	NA
Accuracy Success	± 40% of specified value for ≥ 70% of selected analytes	82%	100%	100%	
Matrix Spike					
Frequency Success	1 / batch	100%	100%	100%	100%
Accuracy Success	70-130% recovery for > 70% of analytes	79%	84%	93%	93%
Sample Duplicate					
Frequency Success	1 / batch	100%	100%	87%	96%
Precision Success	RPD < 30%	89%	89%	93%	93%

Table III-4. Achieved sample holding times. Percent success is based on the number of samples meeting the required holding time.

Parameter	Required Holding Time	Holding Time Range (days)	Percent Success
Grain Size	6 months	158 – 318	2%
TOC/TN	1 year	14 - 206	100%
Trace Metals	1 year	24 - 610	99%
Organochlorine Pesticides	1 year	14 – 488	74%
PAH	1 year	33 – 493	83%
PCB	1 year	14 – 488	79%
PBDE	1 year	43 – 454	57%
Pyrethroids	1 year	17 – 527	87%

Table III-5. Repeated grain size measurements to test stability over time.

Sample	B13-8177		B13-8355		B13-8417	
Analysis Date	3/27/2014	7/6/2015	4/15/2014	7/6/2015	4/15/2014	7/6/2015
Measured Percent Fines	84.0%	83.9%	83.2%	85.4%	97.4%	93.0%
Relative Percent Difference	0.12%		2.6%		4.5%	

Figure III-1. Rejected station locations.

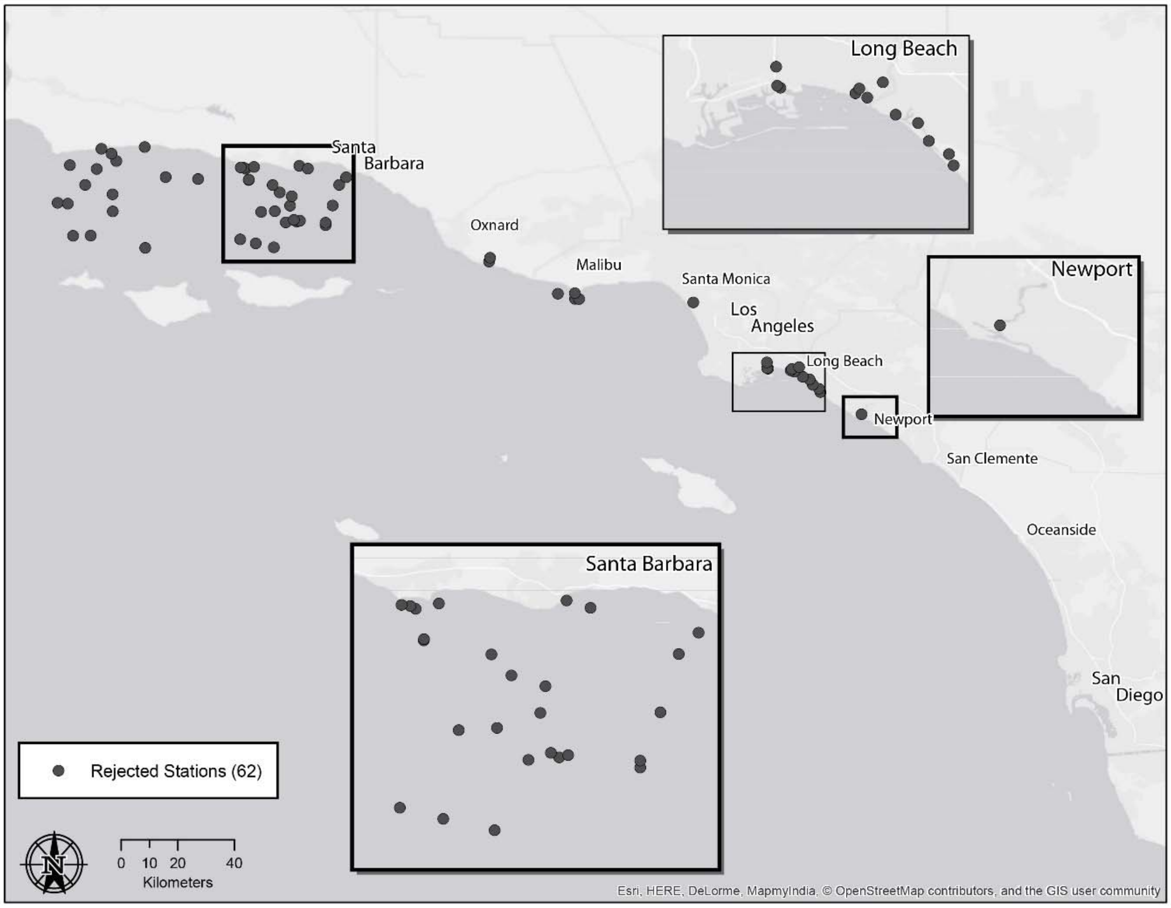


Table III-6. Locations of the rejected stations. Parenthesis indicate the number of stations in each stratum or region.

Stratum	Bight Region	DDT AWM concentration including all stations	DDT AWM concentration excluding rejected stations	Chlordane AWM concentration including all stations	Chlordane AWM concentration excluding rejected stations
Estuaries (10)	Bolsa Chica Lagoon (2) Bolsa Chica (1) Los Angeles River (3) Los Cerritos (1) Ballona Creek (1) Mugu Lagoon-south (2)	3.7 ± 1.4	3.2 ± 1.3	1.2±0.7	0.48 ± 0.17
Marina (6)	Alamitos Bay (3) Santa Barbara (1) Newport Bay (1) Huntington Harbor (1)	19 ± 8	22 ± 9	3.1 ± 1.8	3.7±2.5
Port (1)	Anaheim Bay (1)	1.2 ± 0.2	1.2 ± 0.2	0.038±0.066	0.040 ± 0.070
Inner Shelf (6)		11 ± 13	12 ± 15	0.031±0.042	0.036 ± 0.050
Mid Shelf (11)		14 ± 8	18 ± 10	0.019±0.017	0.024 ± 0.021
Outer Shelf (13)		47 ± 63	79 ± 110	0.038±0.047	0.066 ± 0.079
Upper Slope (15)		270 ± 330	490 ± 440	0.57±0.869	1.1 ± 1.2

IV. DESCRIPTIVE RESULTS

Bight-Wide Results

The area weighted mean and 95% confidence interval (CI), along with the minimum, 10th percentile, median, 90th percentile, and maximum concentrations for each analyte is summarized in Table IV-1. Grain size very coarse (0% fines) to very fine (99% silt and clay), averaging 68 ± 4% fines overall. The TOC measurements varied from non-detect to 6.4 % TOC, with a median of 1.1 % TOC and an 11:1 TOC/TN ratio. Six of fifteen trace metals were detectable in 100% of the samples (Al, Ba, Cr, Fe, Pb, and Zn). Area weighted average (± 95% CI) concentrations (dry weight basis) among the different metals varied from a low of 0.089 ± 0.02 µg/g for nickel to a high of 25,000 ± 1,100 µg/g for iron. Organic constituents were detectable in 22%, 53%, 76%, and 93% of the samples for total chlordanes, total PCB, total DDT, and total PAH, respectively. Area weighted averages for the organic analyte classes ranged from a low of 0.15 ± 0.17 ng/g for chlordanes to a high of 130 ± 68 ng/g for total DDT. Total PCB was two orders of magnitude lower than total DDT, at 5.2 ± 3 ng/g. The area weighted mean for total PBDE was 2.8 ± 0.5 ng/g, and was detected in 83% of the samples in which it was measured. The area weighted mean concentration for pyrethroid pesticides was 11 ± 7 ng/g, and was detected in 35% of the samples in which it was measured.

Subpopulation Comparisons

Area weighted mean (AWM) concentrations and corresponding 95% CIs for 10 of the 11 strata of interest are presented in Table IV-2 (marine protected areas are discussed separately below). Generally, the embayment strata (marinas, ports, bays, estuaries) exhibited higher concentrations for metals and organic contaminants compared to the shelf and slope strata. For example, zinc ranged from 29 ± 4 ug/g to 100 ± 7 ug/g offshore and from 100 ± 20 ug/g to 190 ± 20 ug/g in embayments. However, there was an enrichment in sediment fines and TOC as the shelf and slope depth increased; for example, from 22 ± 5% fines on the inner shelf (5-30 m) to 89 ± 2% fines on the lower slope (500-1000 m). This led to concomitant increases in contaminants with depth, and to contaminant concentrations on the lower slope that were in some cases similar to those in embayments. An exception to this general trend was DDT in sediments on continental shelf and slope (maximum of 490 ± 440 ng/g), which had higher concentrations of DDT compared to embayments (maximum of 22 ± 9 ng/g). Canyons had percent fines, TOC, and contaminant concentrations similar to those found on the upper and lower slope. A comparison to SCB Publicly Owned Treatment Works (POTW) monitoring data is presented in Appendix E.

Geographic Distribution of Sediment Parameters

The geographic distribution and magnitude of sediment concentrations in Bight'13 illustrate that not all constituents have the same source and may differ in their ultimate fate within the SCB (maps of all parameters can be found in Appendix A). Generally, the geographic distribution in Bight'13 was similar to previous Bight surveys. For example, total DDT sediment concentrations were greatest near Palos Verdes and Los Angeles Harbor due to historical discharges at the LACSD ocean outfall, then declined moving northward through Santa Monica Bay in the net current direction (Figure IV-1). The spatial distribution of copper was different than DDT, with sediment concentrations generally greater in embayments, particularly marinas, than offshore due to its use in anti-fouling paints on recreational and commercial vessels (Figure IV-2). PAHs were also higher in embayments, but likely due to land-based runoff (Table IV-2). As in Bight '08, total pyrethroids were highest in marinas and in particular estuaries (7.8 ± 3.6 and 100 ± 80 ng/g, respectively) compared to ports and bays (0.057 ± 0.068 and 2.3 ± 0.7 ng/g, respectively) (Figure IV-3). An exception to the similarity with Bight '08 was total PBDE. When previously measured, total PBDE was found at approximately 10 times higher concentrations in embayments compared to offshore strata. In Bight'13, the concentrations inshore and offshore were approximately the same (0.42 ± 0.40 to 3.6 ± 2.6 ng/g in embayments and 0.99 ± 0.84 to 4.2 ± 5.4 ng/g offshore; Figure IV-4).

Submarine Canyon Bottoms

Submarine canyons, a stratum new to Bight'13, showed a spatial distribution of contaminant concentrations that were concomitant with the distribution outside the canyons. Canyons transverse the full range of offshore strata (the shelf and slope) and have concentrations within the ranges of those strata (Table IV-2). For example, DDT had a canyon concentration of 140 ± 60 ng/g and the offshore strata had a range of 12 ± 15 to 490 ± 440 ng/g. PAH had a canyon concentration of 130 ± 24 ng/g and the offshore strata had a range of 24 ± 6 to 160 ± 60 ng/g. PBDE had a canyon concentration of 4.1 ± 1.5 ng/g and the offshore strata had a range of 0.99 ± 0.84 to 4.2 ± 5.4 ng/g. A spatial illustration of DDT concentrations in and near canyons is given in Figures IV-5 and IV-6. For all contaminants, it was not observed that contaminant concentrations were higher in canyon bottoms compared to nearby regions outside the canyons.

Marine Protected Areas

MPAs are also a stratum new to Bight'13. Unlike the other strata, MPAs are not defined by geographic features or suspected contaminant sources; their boundaries were set aside to protect commercially important species and enhance ecosystem function, and overlap the other strata. Therefore, the MPA data analysis was treated separately, with the above analysis placing MPA stations into the appropriate non-MPA stratum based on depth, and the following analysis placing MPA stations into their own stratum to examine the extent and magnitude of contamination in MPAs specifically. Area weighted mean (AWM) concentrations and corresponding 95% CIs for the MPA stratum are in Table IV-3. Generally, the contaminant concentrations, percent fines, and TOC/TN levels were within the range of values in the shelf and slope that the MPA boundaries traverse. The exceptions were total DDT (790 ± 700 ng/g) and total PCB (23 ± 33 ng/g), which averaged higher than the offshore averages of total DDT (12 ± 15 ng/g to 490 ± 440 ng/g) and total PCB (0.62 ± 0.31 ng/g to 15 ± 13 ng/g). This was due to high concentrations in the Point Vicente MPA that is situated off Palos Verdes and overlaps with the region of high DDT and PCB contamination from the historical LACSD ocean outfall discharges.

Table IV-1. Bight-wide area weighted mean concentrations and selected ranges of the sediment contaminants. Metal concentrations are in ug/g dry weight and organic contaminant concentrations are in ng/g dry weight.

Chemical Group	Area Weighted Mean	95% CI	Min	10th Percentile	Median	90th Percentile	Max
Fines%	68	4	<RL	15	61	89	99
TOC%	2.1	0.3	<RL	0.24	1.1	2.5	6.4
TN%	0.21	0.02	<RL	<RL	0.10	0.30	0.56
Aluminum	20000	1800	890	5900	18000	37000	67000
Antimony	0.90	0.15	<RL	<RL	0.52	1.7	3.1
Arsenic	4.0	0.5	<RL	1.0	4.1	12	28
Barium	250	35	6.3	40	100	264	660
Beryllium	0.35	0.05	<RL	<RL	0.34	0.82	2.3
Cadmium	1.3	0.3	<RL	0.11	0.50	2.1	14
Chromium	57	5	2.9	14	38	73	160
Copper	25	3	<RL	3.2	21	88	380
Iron	25000	1100	1600	9500	23000	37000	130000
Lead	11	1	0.73	3.7	12	36	140
Mercury	0.089	0.02	<RL	0.010	0.064	0.32	7.2
Nickel	33	2.9	<RL	6.5	18	38	56
Selenium	1.3	0.4	<RL	<RL	0.18	1.4	5.4
Silver	0.41	0.11	<RL	<RL	0.080	0.87	6.1
Zinc	86	6	5.4	27	76	170	480
PAH	120	29	<RL	14	84	580	2900
PCB	5.2	3	<RL	<RL	0.17	16	350
DDT	130	68	<RL	<RL	2.0	57	5500
Chlordanes	0.15	0.17	<RL	<RL	<RL	0.56	28
PBDE	2.8	0.5	<RL	<RL	1.3	8.9	27
Pyrethroids	11	7	<RL	<RL	<RL	12	1500

Table IV-2. Area weighted mean concentrations and associated 95% confidence intervals (CIs) of the sediment contaminants in geographic subpopulations of the Bight. Metal concentrations are in ug/g dry weight and organic contaminant concentrations are in ng/g dry weight. Off-shore PBDEs were measured at < 15 stations per stratum, increasing the uncertainty in the result.

	SHELF						SLOPE AND BASIN			
	Inner (5-30m)		Mid (30-120m)		Outer (120-200m)		Upper (200-500m)		Lower (500-1000m)	
Parameter	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Fines%	22	5	48	4	49	5	75	5	89	2
TOC%	0.25	0.04	0.70	0.08	0.93	0.14	1.9	0.2	2.9	0.4
TN%	0.034	0.005	0.069	0.008	0.10	0.01	0.25	0.02	0.26	0.02
Aluminum	7000	1000	13000	1000	13000	2000	20000	2000	20000	3000
Antimony	0.43	0.11	0.92	0.13	1.1	0.2	1.4	0.1	0.76	0.29
Arsenic	2.4	0.3	2.7	0.5	5.3	1.6	5.4	1.0	3.9	0.9
Barium	75	18	130	40	130	20	160	10	360	50
Beryllium	0.13	0.02	0.21	0.05	0.36	0.15	0.27	0.06	0.45	0.08
Cadmium	0.66	0.11	0.68	0.14	0.82	0.22	1.5	0.28	1.5	0.49
Chromium	17	2	30	3	37	6	57	5	72	9
Copper	3.7	0.5	7.9	1.1	11	4	21	3	35	3
Iron	11000	1000	18000	2000	28000	7000	29000	2000	28000	1000
Lead	4.3	0.5	7.0	0.6	10	2	12	2	12	2
Mercury	0.041	0.022	0.051	0.008	0.067	0.041	0.083	0.021	0.11	0.03
Nickel	9.7	1.2	15	1	18	1	30	2	43	4

Selenium	0.068	0.020	0.096	0.032	0.21	0.06	0.89	0.16	2.1	0.7
Silver	0.22	0.31	0.29	0.20	0.39	0.32	0.24	0.09	0.53	0.19
Zinc	29	4	48	3	57	5	88	7	100	7
PAH	24	6	55	14	92	32	160	60	130	50
PCB	0.62	0.31	2.7	1.7	4.5	3.5	15	13	2.7	2.4
DDT	12	15	18	10	79	110	490	440	97	36
Chlordanes	0.036	0.050	0.024	0.021	0.066	0.079	1.1	1.2	<RL	
Pyrethroids	NA		NA		NA		NA		NA	
PBDE	0.99	0.84	2.8	1.2	4.2	5.4	3.5	0.7	2.5	0.7

Table IV-2 (cont.)

	EMBAYMENTS									
	Marinas		**Estuaries**		**Ports**		**Bays**		**Canyons**	
Parameter	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Fines%	71	6	49	8	69	6	60	5	78	4
TOC%	1.6	0.2	1.5	0.3	1.4	0.18	1.2	0.2	2.0	0.2
TN%	0.15	0.03	0.12	0.03	0.051	0.028	0.16	0.03	0.22	0.03
Aluminum	25000	3000	24000	3000	26000	3000	27000	4000	27000	3000
Antimony	0.56	0.18	0.66	0.13	0.76	0.10	0.44	0.06	0.61	0.25
Arsenic	7.1	1.1	5.9	0.9	12	1	8.5	1.0	4.5	0.7

Barium	100	20	100	10	190	20	120	20	190	40
Beryllium	0.54	0.11	0.49	0.09	0.69	0.08	0.57	0.08	0.45	0.08
Cadmium	1.3	0.3	0.60	0.22	0.49	0.17	0.41	0.04	2.0	1.6
Chromium	49	8	37	4	56	6	45	5	52	4
Copper	120	30	33	9	75	13	55	9	28	2
Iron	28000	3000	27000	3000	32000	3000	27000	3000	27000	2000
Lead	38	7	17	4	30	6	32	4	14	2
Mercury	0.30	0.07	0.058	0.022	0.53	0.40	0.22	0.04	0.096	0.022
Nickel	22	2	18	3	28	3	19	2	27	3
Selenium	0.23	0.08	0.34	0.11	0.55	0.10	0.34	0.07	0.74	0.26
Silver	0.38	0.09	0.060	0.021	0.44	0.19	0.92	0.32	0.44	0.18
Zinc	190	20	100	20	150	20	130	20	84	5
PAH	660	160	380	150	420	140	300	69	130	24
PCB	15	4	5.4	4.8	6.2	3.1	10	7	3.5	1.4
DDT	22	9	3.2	1.3	1.2	0.2	4.4	2.5	140	60
Chlordanes	3.7	2.5	0.48	0.17	0.040	0.070	0.31	0.23	0.041	0.027
Pyrethroids	7.8	3.6	100	80	0.057	0.068	2.3	0.7	NA	
PBDE	3.6	2.6	0.42	0.40	3.5	0.8	2.5	2.5	4.1	1.5

Table IV-3. Area weighted mean concentrations and associated 95% confidence intervals (CIs) of the sediment contaminants in Marine Protected Areas. Metal concentrations are in ug/g dry weight and organic contaminant concentrations are in ng/g dry weight.

	MPA	
Parameter	Mean	95% CI
Fines%	60	11
TOC%	1.1	0.2
TN%	0.13	0.02
Aluminum	22000	9000
Antimony	1.0	0.4
Arsenic	3.9	1.2
Barium	150	20
Beryllium	0.15	0.08
Cadmium	0.91	0.34
Chromium	47	5
Copper	17	3
Iron	22000	5000
Lead	11	2
Mercury	0.11	0.02
Nickel	21	2
Selenium	0.42	0.25
Silver	0.24	0.16
Zinc	73	11
PAH	100	50
PCB	23	33
DDT	790	700
Chlordanes	0.029	0.028
Pyrethroids	NA	
PBDE	NA	

Figure IV-1. Geographic distribution of total DDT sediment concentrations during the 2013 Southern California Bight regional monitoring survey. Cut-points are the 95th, 75th, 50th, 25th, and 5th percentiles. The legend shows the concentration range and number of samples for each bin.

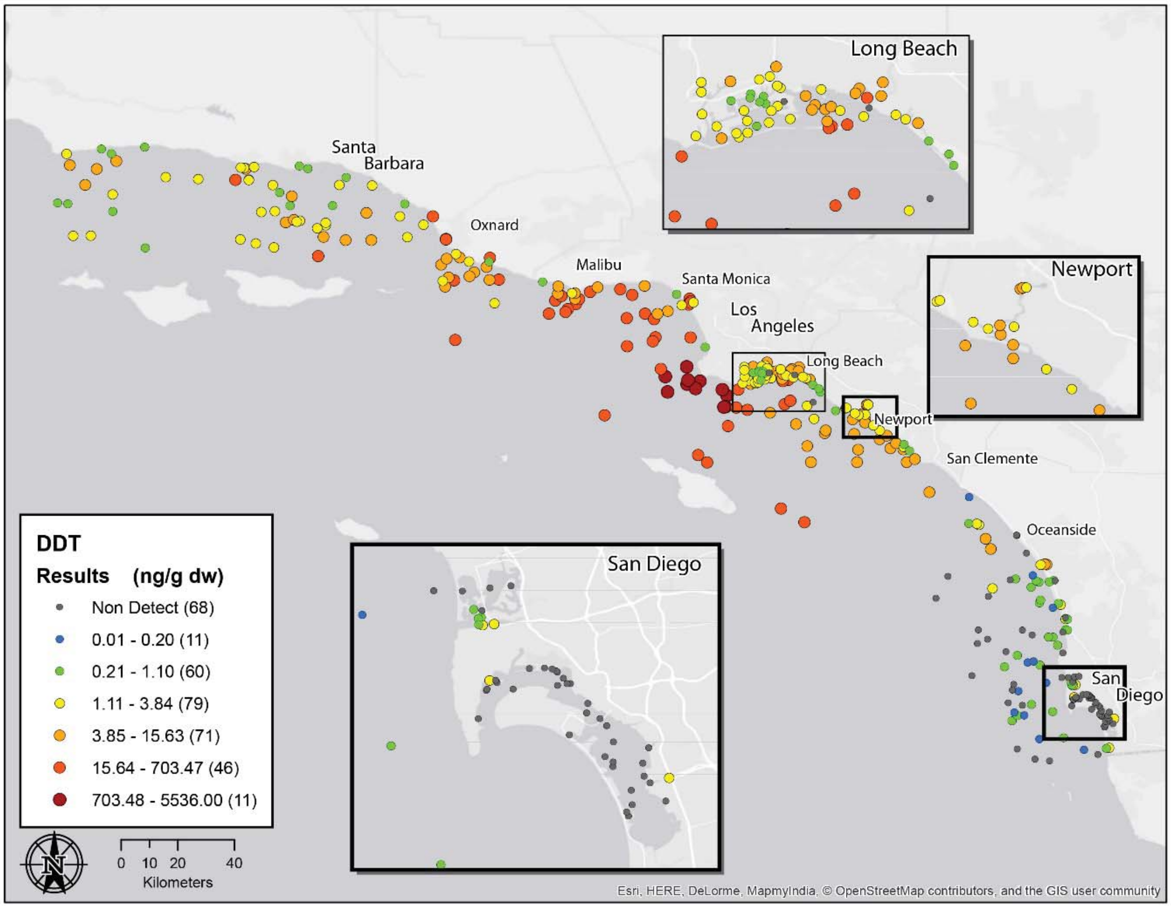


Figure IV-2. Geographic distribution of total copper sediment concentrations during the 2013 Southern California Bight regional monitoring survey. Cut-points are the 95th, 75th, 50th, 25th, and 5th percentiles. The legend shows the concentration range and number of samples for each bin.

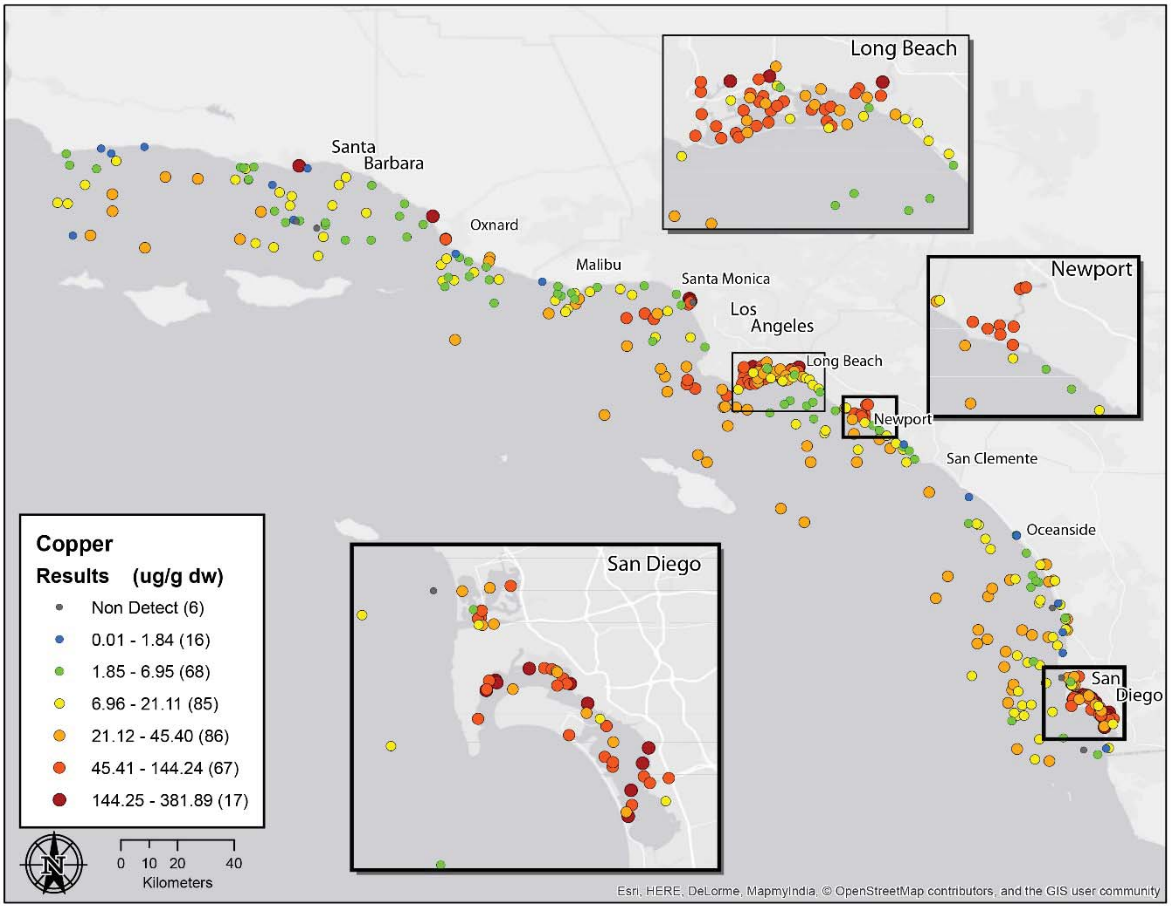


Figure IV-3. Geographic distribution of total pyrethroid sediment concentrations during the 2013 Southern California Bight regional monitoring survey. Cut-points are the 95th, 75th, 50th, 25th, and 5th percentiles. The legend shows the concentration range and number of samples for each bin.

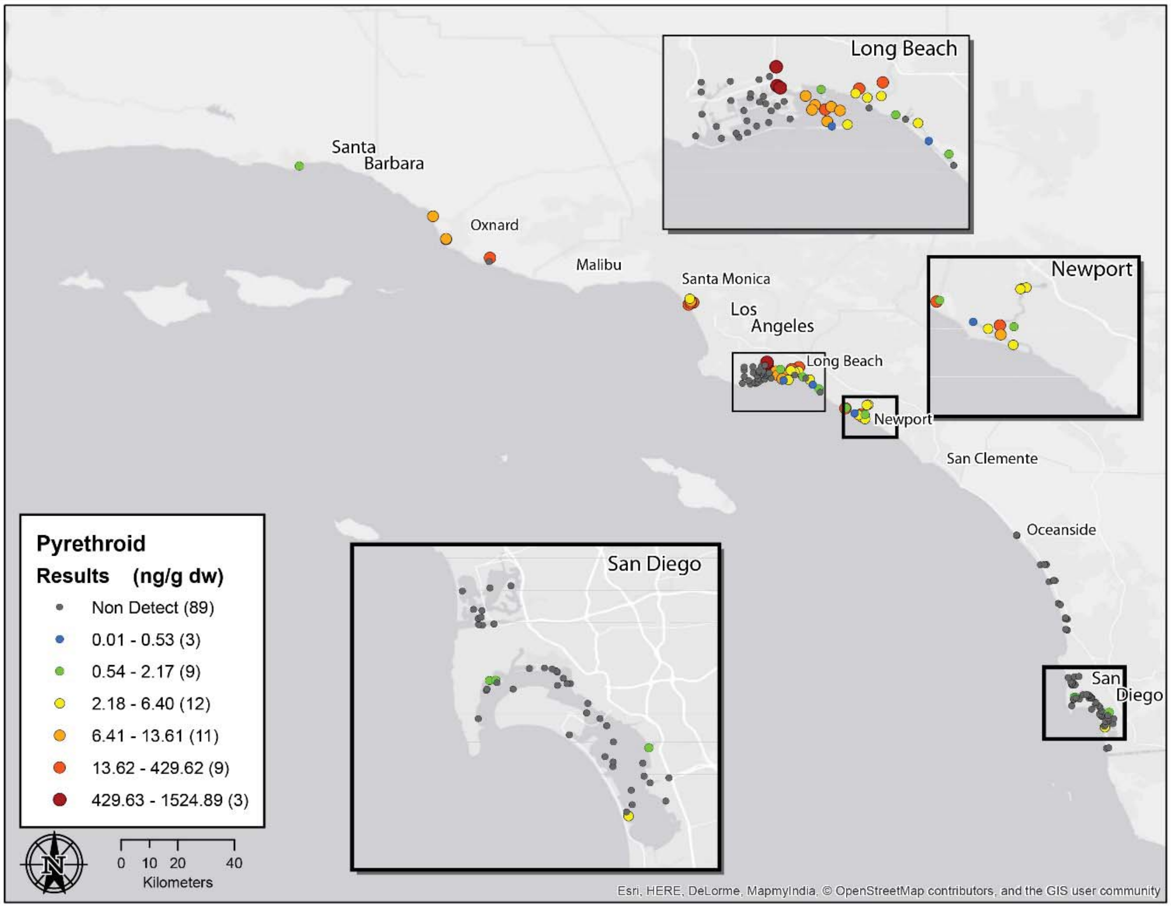


Figure IV-4. Geographic distribution of total PBDE sediment concentrations during the 2013 Southern California Bight regional monitoring survey. Cut-points are the 95th, 75th, 50th, 25th, and 5th percentiles. The legend shows the concentration range and number of samples for each bin.

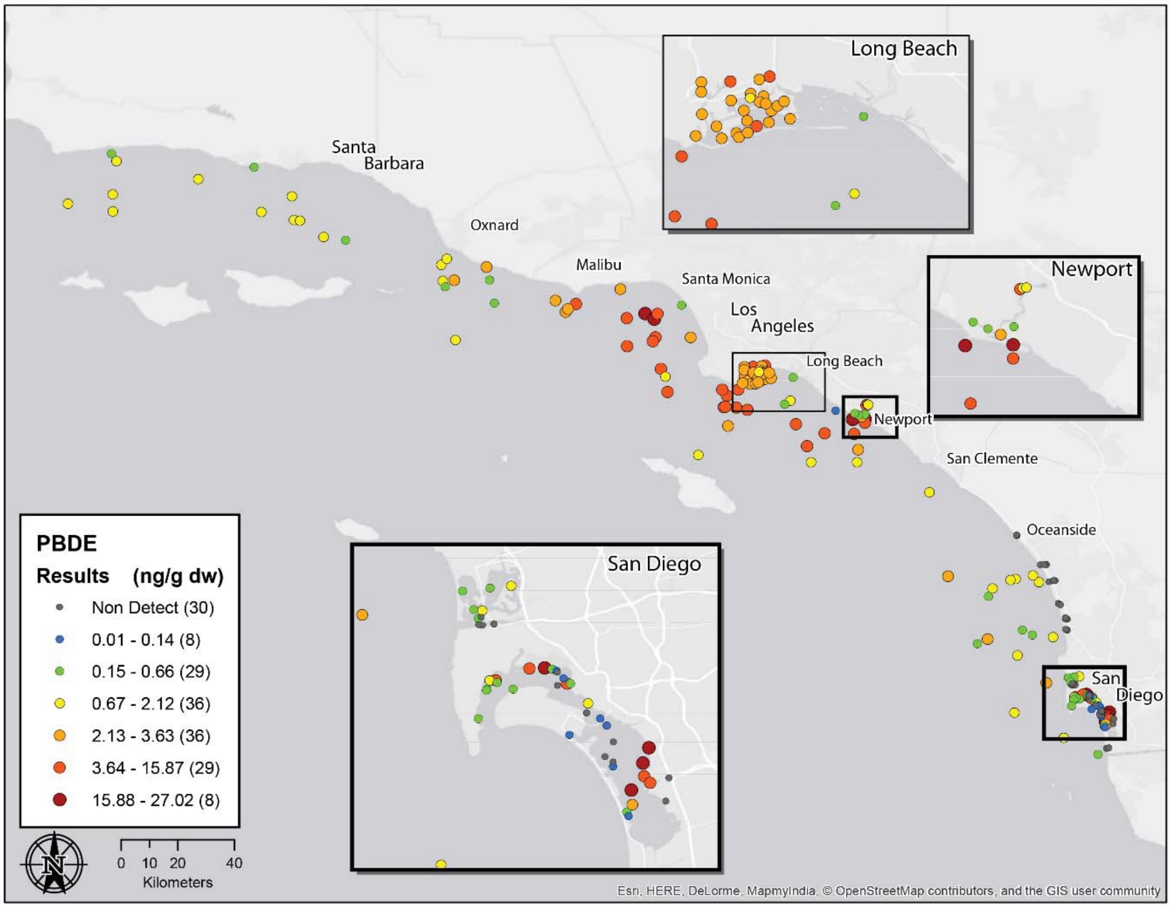


Figure IV-5. Geographic distribution of DDT sediment concentrations inside and outside of northern Bight canyons.

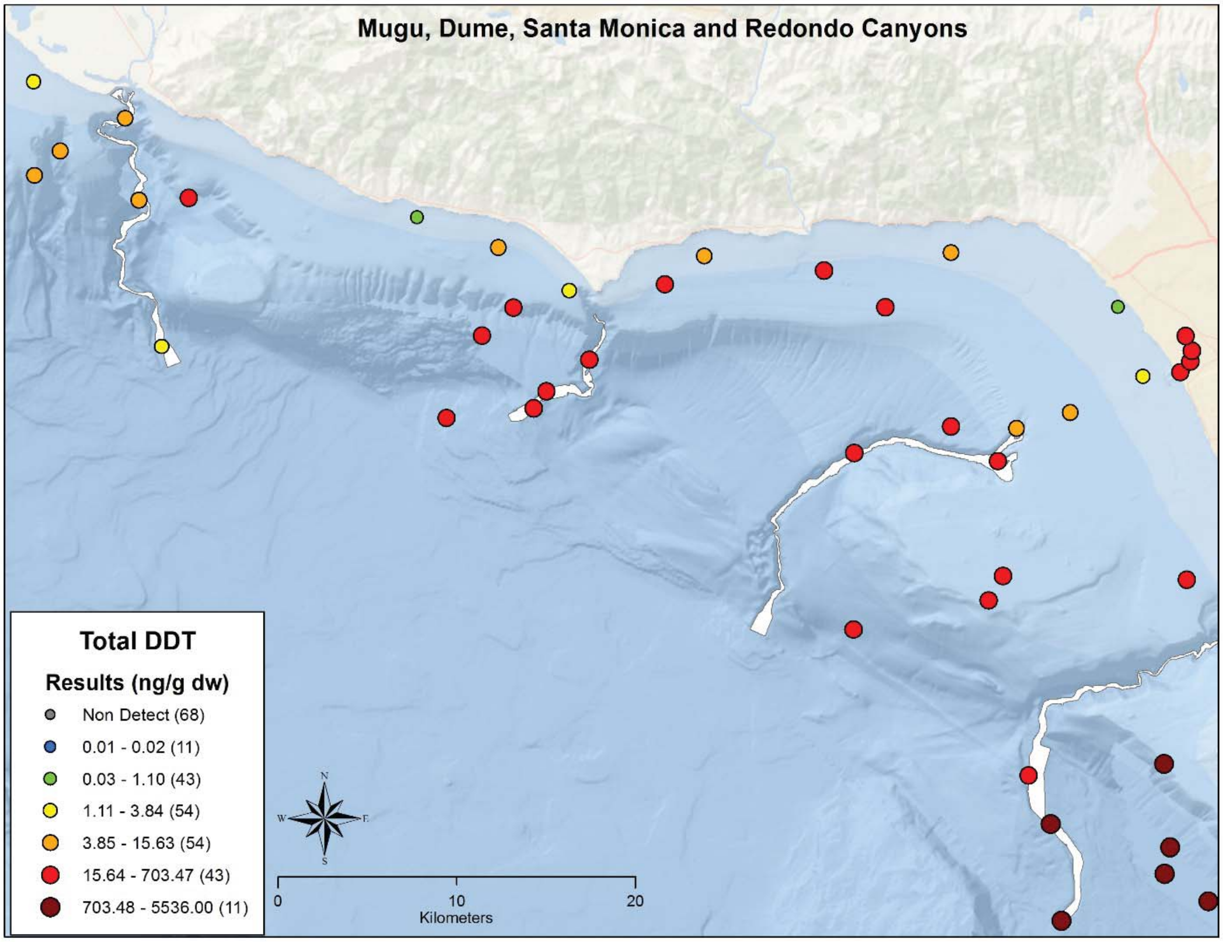
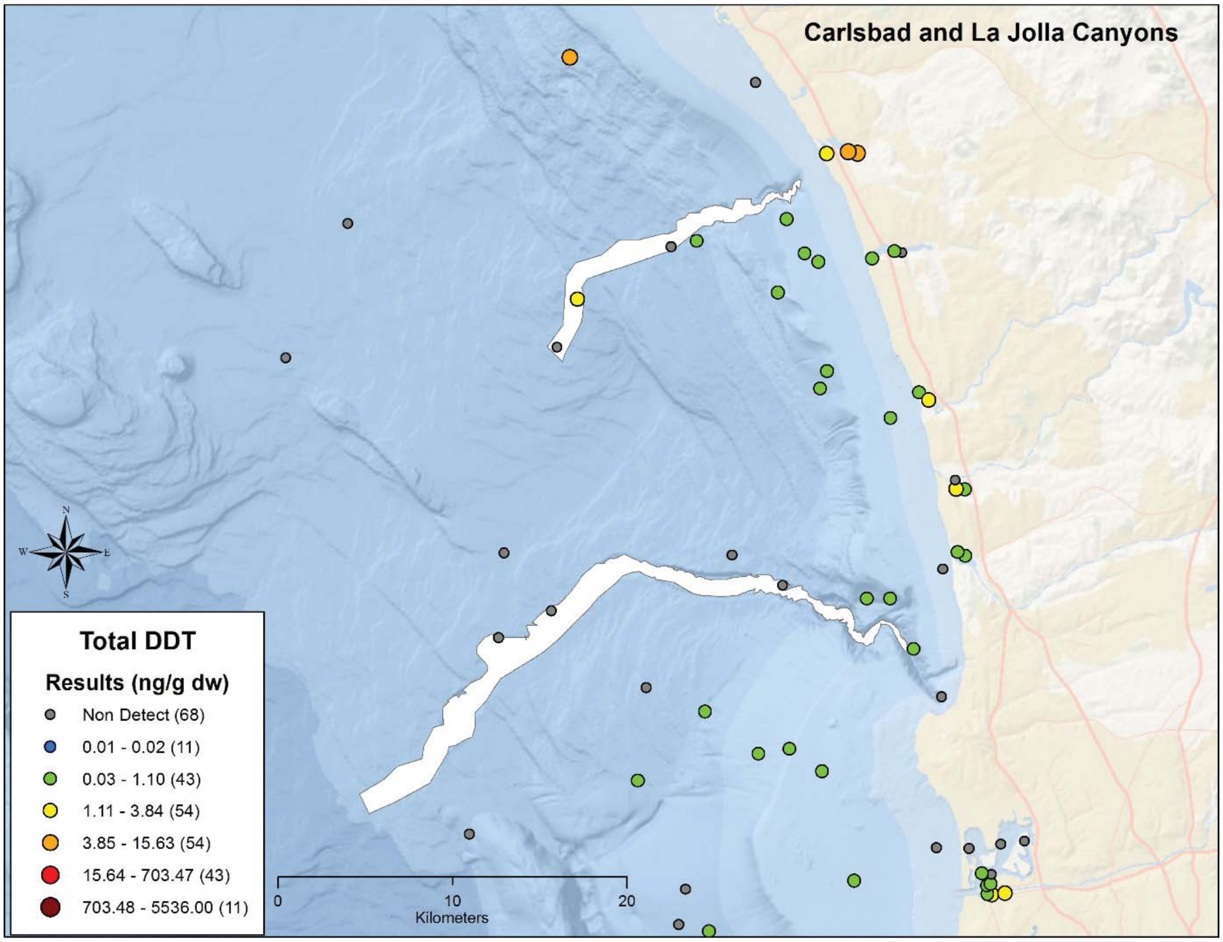


Figure IV-6. Geographic distribution of total DDT sediment concentrations inside and outside of southern Bight canyons.



V. Assessment Results

Comparison to Chemical Index Scores

The proportion of the SCB that falls within each of the four sediment chemistry categories of increasing concern is presented in Figure V-1. The four categories are derived from the State's sediment quality objectives framework (SWRCB 2009; Bay and Weisberg 2008): Category 1 minimal exposure; Category 2 is low exposure; Category 3 is moderate exposure; and Category 4 is high exposure. Categories 1 and 2 are considered acceptable condition for this evaluation. Three important aspects of this assessment are that: 1) this assessment is based on the use of composite scoring indices that aggregate many chemicals so that individual chemical assessments are unknown; 2) in addition to the sediment chemistry line of evidence, the SQO site assessment relies on biological and toxicological lines of evidence; and 3) the SQO framework only applies to marine embayments, but for comparison purposes we use the tool for offshore strata. .

Approximately 68 ± 8% of SCB sediments were in acceptable condition based on sediment contamination (Figure V-1). Approximately 31 ± 5% of SCB sediments were in the moderate exposure category. The remaining 0.7 ± 0.6% of the SCB had high chemistry exposure. The areal extent of acceptable condition among strata varied from 34% to 90% depending upon the habitat (Figure V-2). Most strata had similar extents of acceptable condition, between 69% and 78%. Exceptions were marinas and the upper slope with lower extents of acceptable condition at 34% and 50%, respectively. The inner shelf had the highest levels of acceptable conditions at 90%. Appendix Figures C-1 and C-2 show expanded versions of Figure V-2 with 95% confidence intervals. Figure V-3 shows the spatial distribution of the exposure categories.

Temporal Trends

Detailed comparisons between this study and the results from previous Bight surveys in 1998, 2003, and 2008 were hindered because of the differences in the study frame. Therefore, temporal comparisons were limited to those strata sampled during all three surveys. These strata included combined embayments (inclusive of ports, bays, and marinas), estuaries, mainland continental shelf, and the continental slope and basin.

The areal extent of acceptable condition in the SCB based on sediment contamination decreased from 91 ± 8% in 1998 to 68 ± 15% in 2013 (Figure V-4). The areal extents of acceptable condition in 2003 (65 ± 6%), 2008 (75 ± 6%), and 2013 were similar. While the areal extent of unacceptable sediment contamination increased between 1998 and 2008, the areal extent of high exposure to sediment contamination (the worst condition) was small regardless of survey year (between 0.050% and 2.2% of the SCB area). Appendix Figure D-1 shows the Bight-wide temporal trends with 95% confidence intervals. The range of reporting levels did not vary significantly between the 1998 and 2013 surveys. Generally, the minimum and maximum reporting levels for each compound were within the same order of magnitude between surveys, indicating this was not a factor in the observed changes in the extent of acceptable condition.

The change in extent of acceptable sediment condition from Bight'13 relative to previous surveys was inconsistent among the four examined strata (Figure V-5). Based on sediment contamination, the greatest and most consistent increase in the areal extent of acceptable sediment condition occurred in the ports/bays/harbors composite stratum, with 40 ± 5% of the area acceptable in 1998 compared to 72 ± 11% in 2013. The areal extent of acceptable sediment condition in the estuaries and the slope & basin were relatively static over time. The shelf stratum had a decrease in the areal extent of acceptable sediment condition to 80% in 2013, from an earlier range of 94% to 99%. Appendix Figures D-2 to E-5 show the strata temporal trends with 95% confidence intervals.

Marine Protected Areas

As in the previous section, the analysis of the new MPA stratum was treated separately. When placed into their own stratum, the areal extent of acceptable sediment condition in the MPAs was 80 ± 43% (Figure V-6), higher than the Bight as a whole (68 ± 8%). The areal extent of high exposure to sediment contamination in MPAs was zero.

Figure V-1. Areal extent of SQO chemistry exposure categories across the SCB.

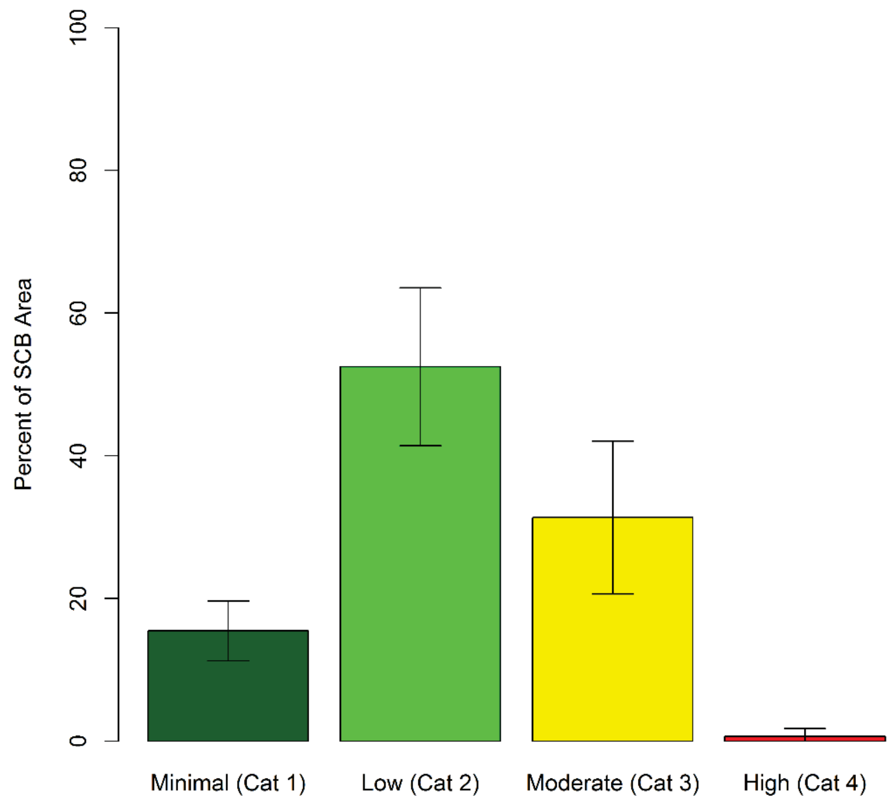


Figure V-2. Areal extent of SQO chemistry exposure categories by SCB strata.

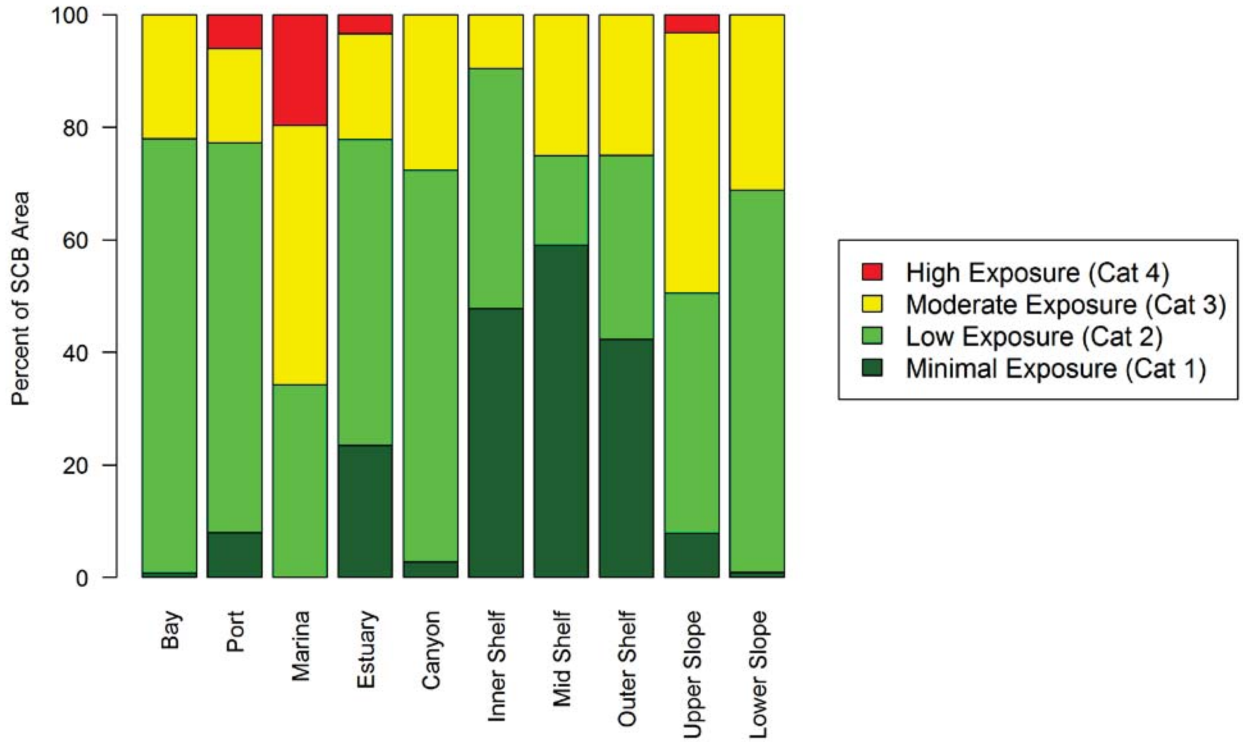


Figure V-3. Spatial distribution SQO chemistry exposure categories.

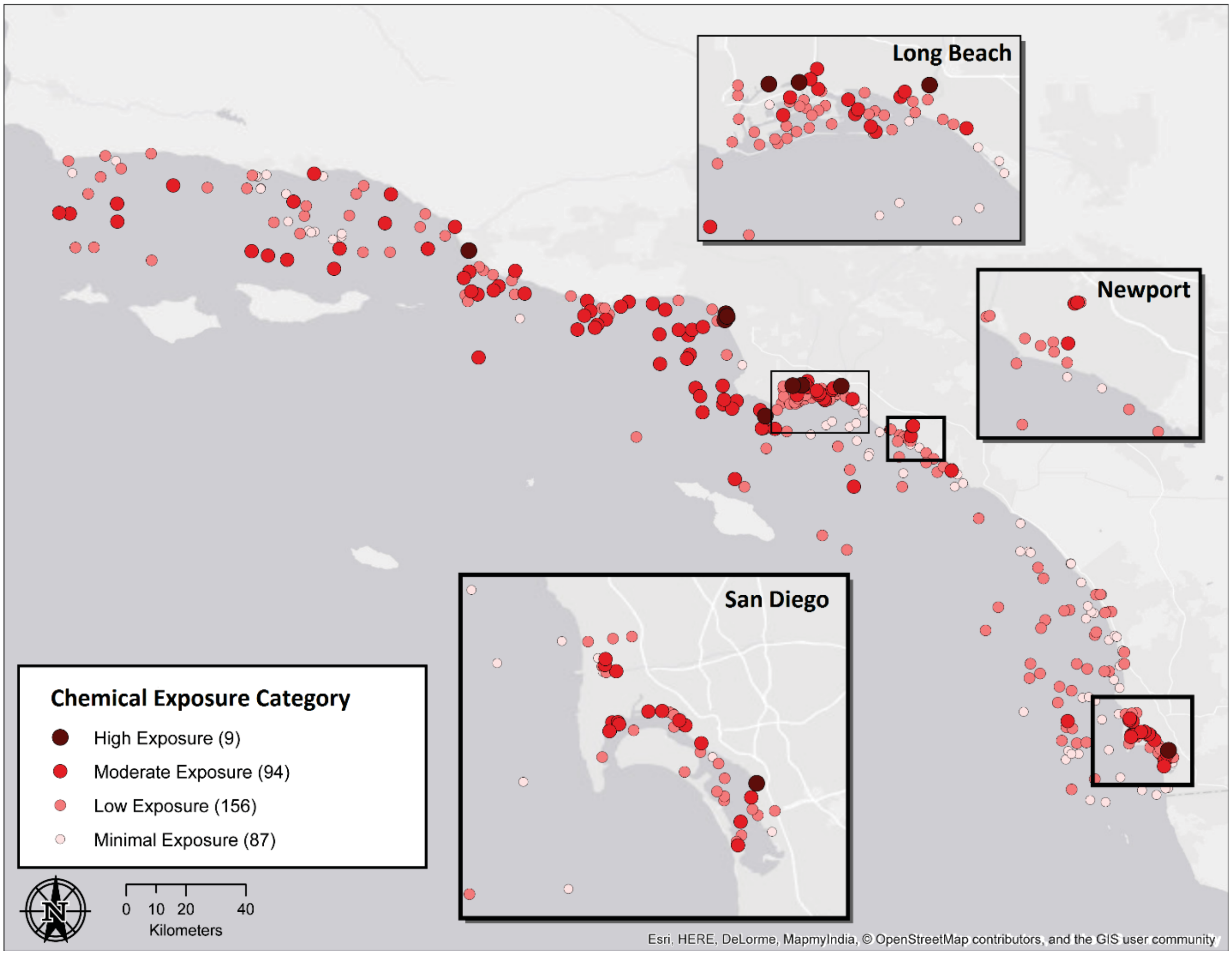


Figure V-4. Areal extent of SCB sediments by survey year in varying categories of exposure to contamination.

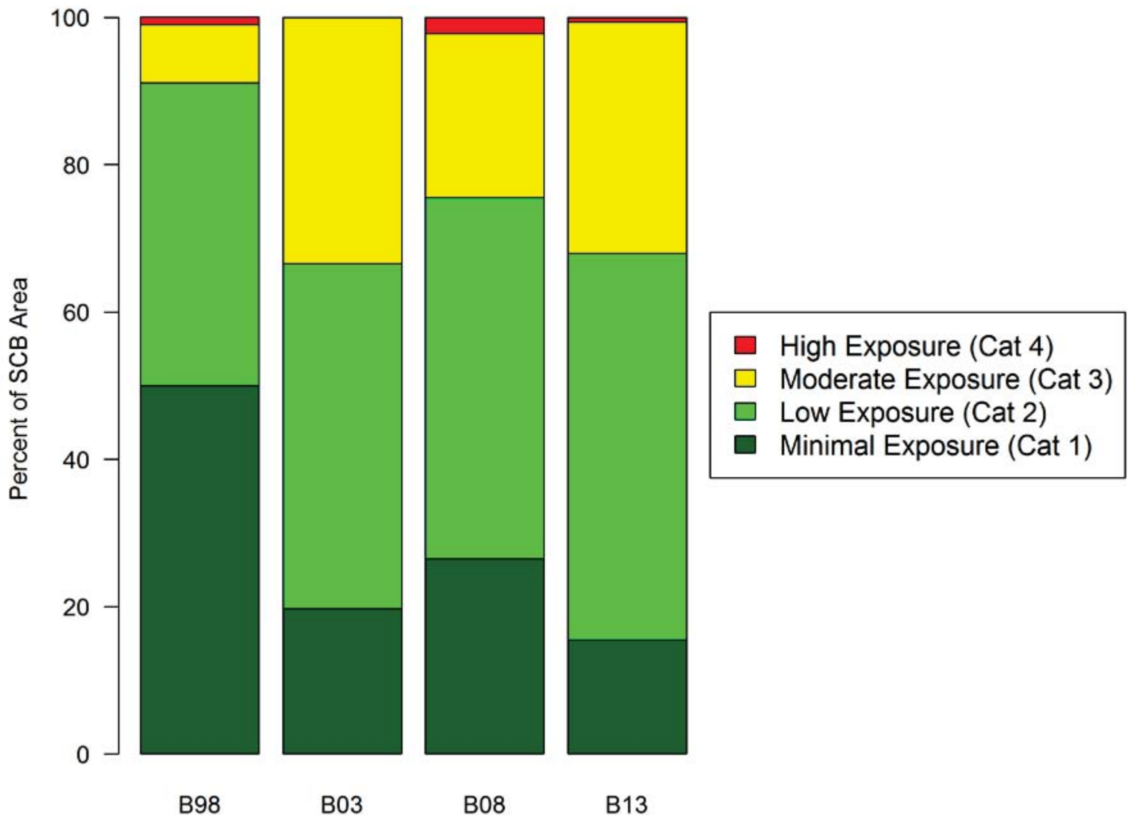


Figure V-5. Areal extent of SCB sediments by stratum and survey year in varying categories of exposure to contamination.

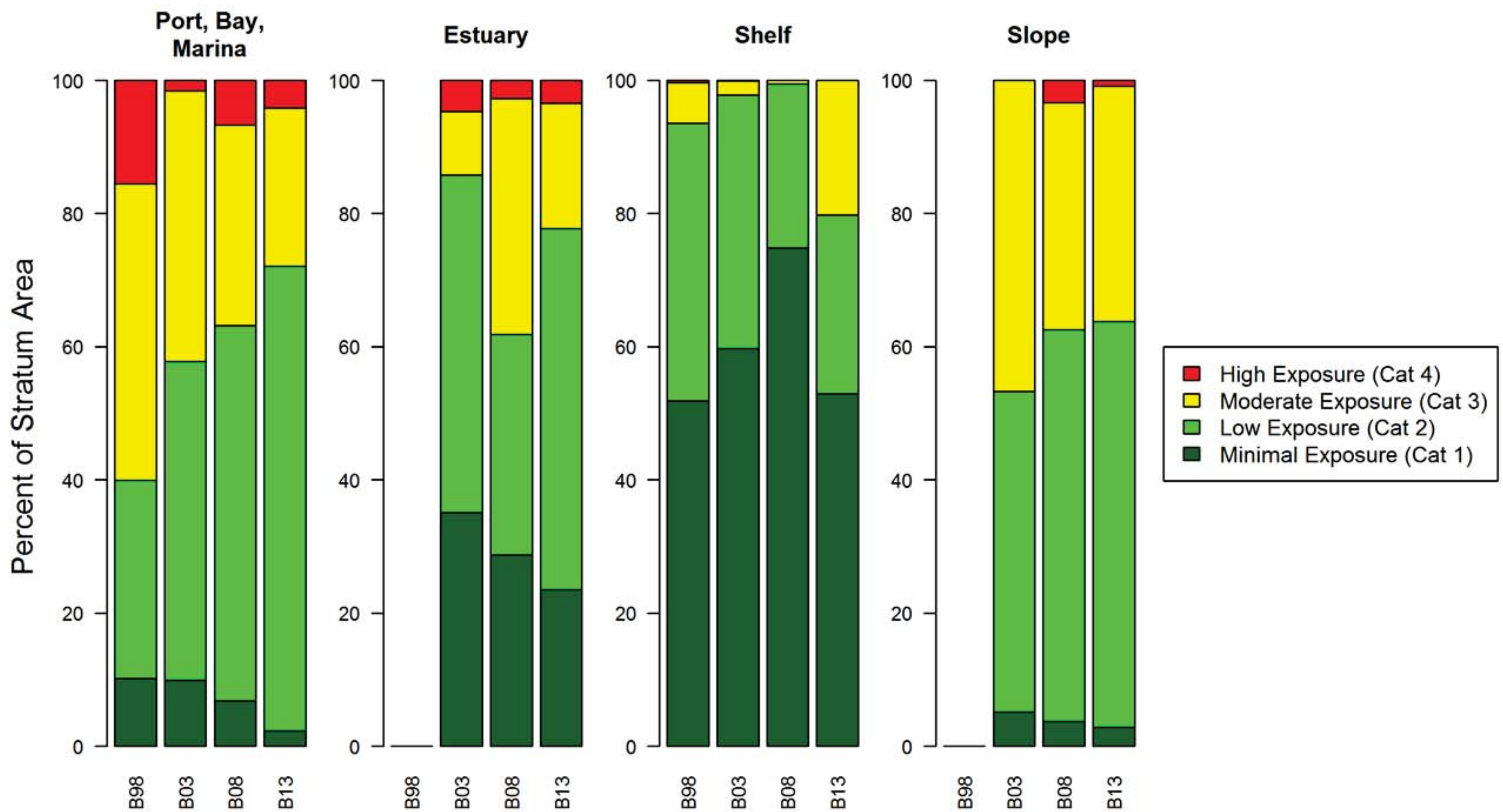
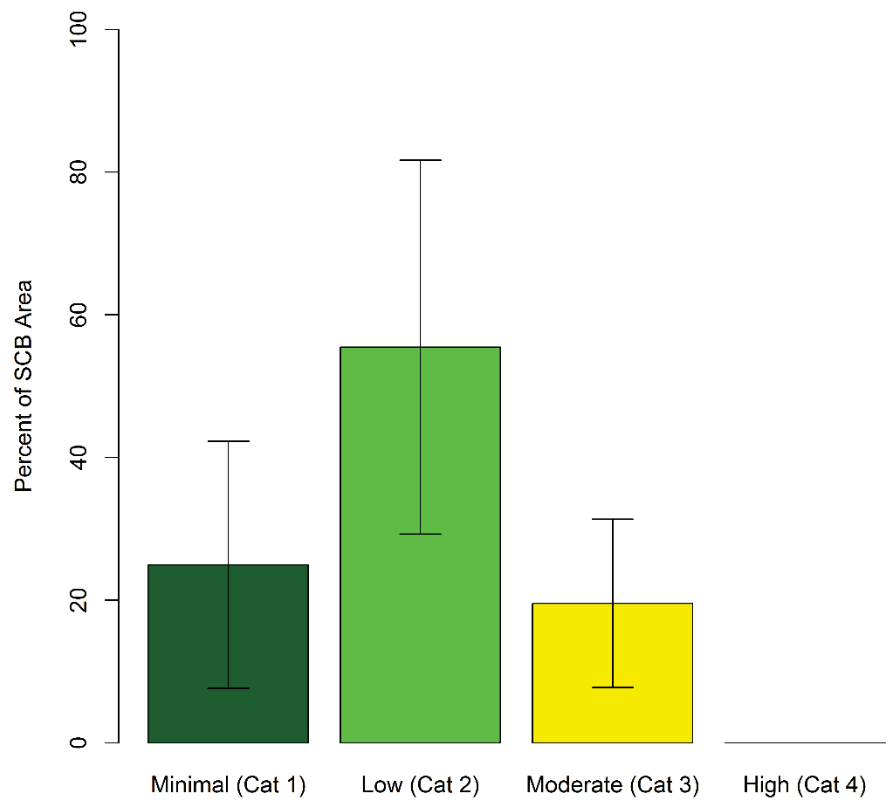


Figure V-6. Areal extent of sediments in Marine Protected Areas in varying categories of exposure to contamination.



VI. DISCUSSION

Overall, the Bight'13 survey design was similar to those of Bight '08, Bight '03, and to some extent Bight '98. Similar results were obtained in terms of the extent and magnitude of sediment contamination, the spatial distribution, and temporal trends. Notable exceptions and the additional new strata are discussed below.

Embayment Decline in Polybrominated Diphenyl Ether Concentrations

The AWM concentration of PBDE flame retardants decreased AWM concentration from Bight '08 to Bight'13. The 2013 concentration of the 4 predominant PBDE congeners (BDE-47, BDE-99, BDE-183, and BDE-209) was 2.0 ± 1.6 ng/g dw in embayments and 1.9 ± 0.6 ng/g dw offshore. In 2008, the concentrations were 25 ± 10 ng/g dw in embayments and 3.8 ± 2.0 ng/g dw offshore. Although difficult to make strong conclusions based on two time points (e.g., legacy contaminant AWM concentrations fluctuated between 1998 and 2013), this observation matches generally decreasing PBDE trends observed in the Bight (Maruya et al., 2015) and elsewhere in California (Sutton et al., 2015) since the implementation of regulations restricting the production and use of these flame retardants (Dodder et al., 2012). The decline was primarily observed in the embayment strata and was primarily due to a decrease in the concentration of BDE-209, generally the most abundant congener in products and observed in sediment, but also the most susceptible to degradation (Dodder et al., 2012) (Figure VI-1).

PBDE congener concentrations at Bight '08 stations that were revisited again in Bight'13 were investigated to determine if the decline was reproducibly observed at the same locations over time (Figure VI-2). Results for the predominant congeners BDE-47, BDE-99, and BDE-209 indicated station fidelity over time, but with a slope of less than one showing a relative decrease in Bight'13 concentrations compared to Bight '08.

Changes in Highest Pyrethroid and Mercury Concentrations

The three stations with the highest pyrethroid concentrations at 430, 540, and 1500 ng/g dw were located in the Los Angeles River. Eighty-nine percent of the total pyrethroid concentration at these three stations was made up of bifenthrin and permethrin. This location was not analyzed for pyrethroids in 2008, when the highest measured concentration was 250 ng/g dw. The station with the highest abundance of mercury, 7.2 ug/g dw, was located in the Los Angeles/Long Beach port. In 2008, the highest mercury concentrations, with a maximum of 5.7 ug/g dw, were located in San Diego Bay.

New Canyon Bottom and Marine Protected Area Strata

Submarine canyons may act as conduit for contaminant transport from inshore sources, such as storm water discharge from urbanized rivers, out to the continental slope (Hartwell, 2008 and Koenig et al., 2013). Canyons may also accumulate fine sediments that are suspended from the seabed and transported to canyons through cross-shelf currents. Fine sediments tend to have higher TOC and contaminant concentrations. The hypothesis for Bight'13 was this transport could result in relatively high contaminant concentrations in the canyons compared to the surrounding region, and this may cause adverse health effects in the canyons' benthic communities. Results indicated there was no evidence the canyons had significantly elevated concentrations of the measured targets compared to their surrounding regions.

MPAs are geographic areas designed to preserve biodiversity and/or to manage fisheries. This is accomplished through restrictions on extractive activities that vary depending on the type of MPA (Botsford et al., 2003 and Sala et al., 2002). Chemical contamination is among the possible human impacts on the marine environment in MPAs; therefore, a goal within Bight'13 was to assess the extent and magnitude of sediment contaminants in the southern California MPAs in relation to the broader SCB region. It was found that neither the measured contaminant concentrations nor the Chemical Scoring Index within MPAs was significantly different from the SCB, when excluding the influence of high DDT and PCB contamination off Palos Verdes on the overlapping MPA.

Figure VI-1. Profile distribution of the four predominant PBDE congeners in Bight '08 compared to Bight'13. AWM concentrations were calculated for the combined embayment strata (port, bay, marina, and estuary) and combined offshore strata (shelf and slope).

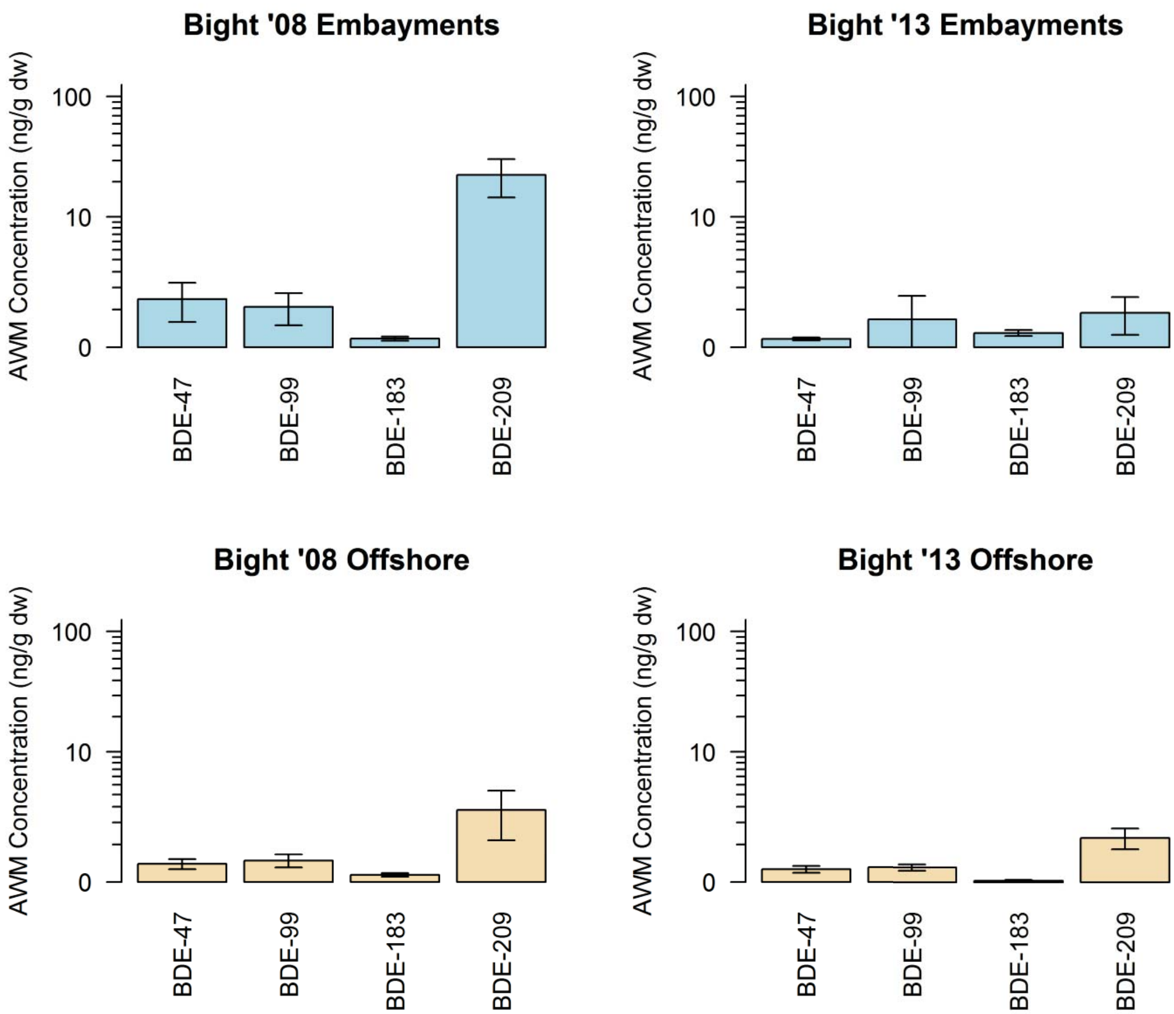
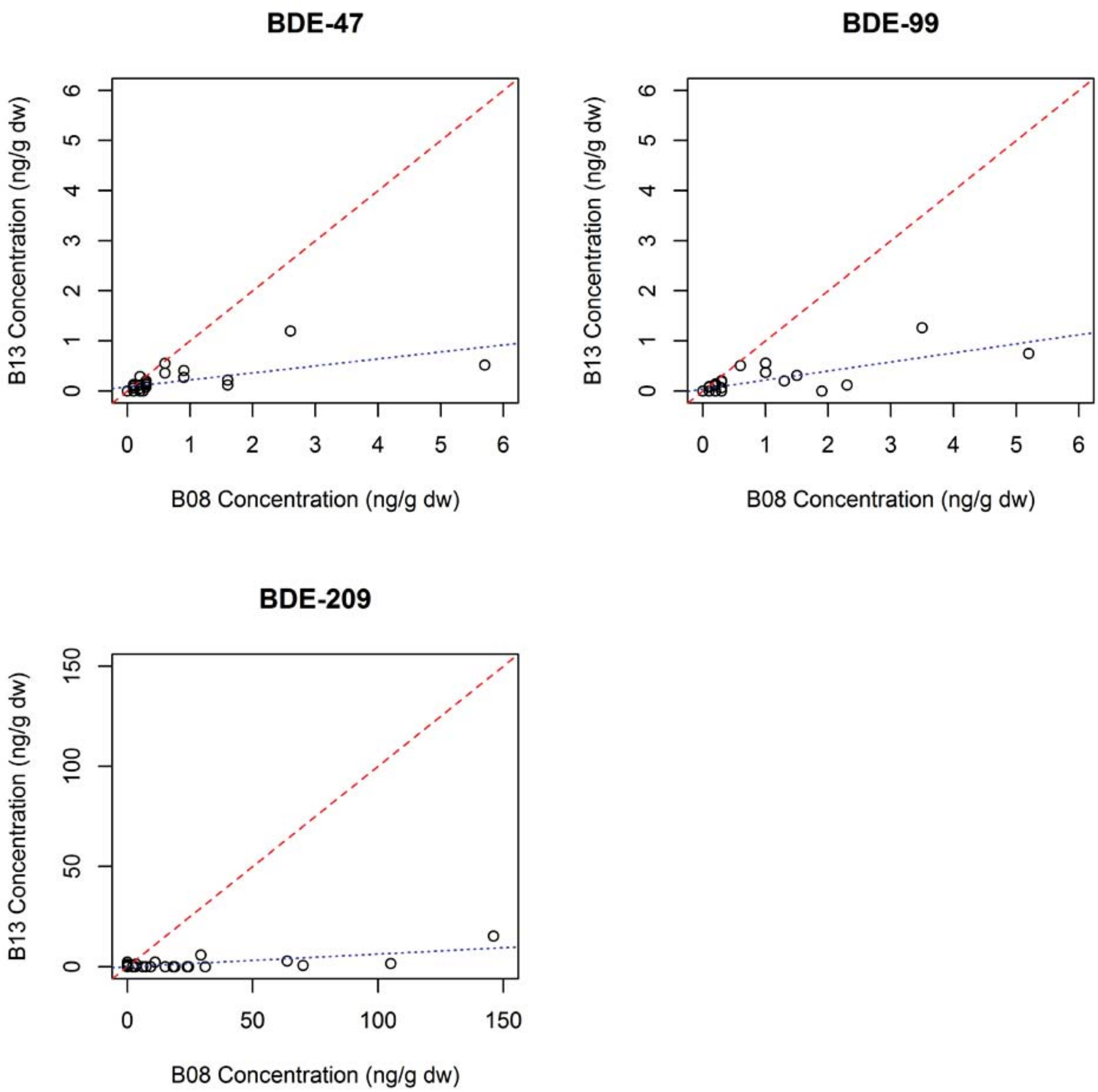


Figure VI-2. Correlation between PBDE congener concentrations at Bight ’08 stations revisited again in Bight’13. The dashed red line indicates a slope of 1 and the dotted blue line is the linear best fit.



VII. Conclusions

- **Approximately three-quarters of the SCB has acceptable condition for sediment contamination.**

  Based on the SQO chemistry indices, a sediment chemistry assessment tool, 68% of the Bight sediments have contamination levels representing minimal or low exposure. Less than one percent of the Bight sediments have high chemistry exposure, the worst category of contamination according to the SQO assessment tool. This assessment tool integrates sediment concentrations of multiple contaminants; therefore, the contaminant of greatest concern cannot be determined. The chemistry indices were calibrated and validated for embayments, not for the offshore environment. However, they are the best of the available assessment tools and were applied to the offshore sediments for continuity with the embayment assessments.

- **The relative extent of sediment contamination was generally greater in embayments than offshore.**

  Acceptable sediment condition per the SQO chemistry indices was found in 34% to 78% of the area in embayment strata, compared to 50% to 90% of the offshore strata. Up to 20% of the embayment strata had high exposure to sediment contamination, compared to 3% of the offshore strata. The greatest sediment concentrations of contaminants such as copper, zinc, and PAHs occurred near embayment sources such as marinas with vessel antifouling paints and estuaries that receive land-based runoff. In contrast, the greatest concentrations of DDT were located on the continental shelf near the Palos Verdes shelf resulting from historical inputs.

- **The extent of acceptable sediment contamination in the SCB has remained steady over the last 10 years.**

  The range of acceptable sediment contamination ranged from 65% to 75% during the three surveys from 2003 to 2013. In addition, the range of high exposure to sediment contamination has remained low over the same time period. The extent of acceptable sediment contamination was greater in the 1998 Bight survey (90% of SCB).

- **While Bight-wide trends have been stable since 2003, there has been both a positive long term trend and a negative recent decline in the sediment condition of individual habitats.**

  The extent of acceptable sediment chemistry condition in the SCB's ports/bays/marinas has steadily improved, increasing from 40% in 1998 to 72% in 2013. In contrast, the extent of acceptable sediment chemistry condition in the SCB's continental shelf declined in Bight'13, from 93% in 1998 to 80% in 2013.

- **Reductions in sediment concentrations of some measured contaminants of emerging concern were observed, concomitant with source control regulations.**

  Polybrominated diphenyl ether flame retardants, (PBDEs), have the potential to accumulate in sediment and biomagnify in tissues of fish. This is one reason regulations restricting the production and use of PBDEs were implemented starting in 2010. This may also be part of the reason Bight'13 results indicated a 10-fold reduction of average PBDE concentrations in embayments between 2008 and 2013.

- **The two new strata introduced in Bight'13, Submarine Canyon Bottoms and Marine Protected Areas, reflected the contaminant concentrations in surrounding areas.**

  Submarine canyons were introduced with the hypothesis that contaminant transport from surrounding areas may lead to higher canyon concentrations. Bight'13 results indicated this transport was taking place; continental shelf locations with the highest concentrations also had nearby submarine canyons with the highest concentrations. However, canyon bottoms did not have higher concentrations than nearby locations. Similarly, concentrations within MPAs were similar to the surrounding regions. When MPAs were collocated or adjacent to regions of the continental shelf with high contaminant concentrations, the sediments within the MPAs were also elevated. The extent to which this sediment contamination impacts MPA goals such as fishery production is unclear.

VIII. RECOMMENDATIONS

Future recommendations are ordered based on the Committee's priorities.

1. **Compare Bight'13 sediment chemistry results with that of the Bight'13 sediment toxicity and infauna surveys.**

   Sediment chemistry, while a useful indicator of potential effects, does not address bioavailability or automatically predict impacts to biota. Therefore, measures of biological response such as sediment toxicity and infaunal biological community health need to be examined. This weight-of-evidence approach is consistent with the State Water Board's sediment quality objectives framework for bays and estuaries.

2. **Improve the information management for sediment chemistry data.**

   Improving information management is the single greatest step to reducing the time to produce the final sediment chemistry technical report. Specific recommendations are to first have the Sediment Chemistry Technical Committee, rather than the Information Management Committee, specify the data submission format and the rules for the online data checker. The data checker should be evaluated during the pre-survey inter-calibration exercise, which will also serve to train laboratories in data submission. Second, the online data checker should evaluate the sample inventory and quality control results expected from the laboratories. It may not be possible to completely automate this process, but early feedback is more efficient for both the data submitter and data user.

3. **Analyze new constituents of emerging concern to assess the occurrence of these largely un-investigated compounds.**

   Two constituents of emerging concern (CECs), the polybrominated diphenyl ether (PBDE) flame retardants and pyrethroid pesticides, were measured in Bight'13 after initial findings indicated widespread extent during special studies in Bight '08. However, based on limited site-specific studies, other CECs likely exist in the Bight including pharmaceuticals, alternate flame retardants (those used to replace PBDEs), and alkylphenols, but their spatial extent and magnitude is currently unknown. The Bight program is one of the best platforms for effectively investigating the occurrence of these potentially harmful contaminants, and where they are accumulating to their greatest concentrations.

4. **Apply an integrated biological and chemical monitoring framework for contaminants of emerging concern to address unknown contaminants.**

   Targeted analyses of a defined list of contaminants does not address potential impacts of unexpected or completely unknown compounds. To address this issue, a tiered framework that incorporates bioanalytical screening tools and diagnostic non-targeted chemical analysis to more effectively monitor for these compounds has been developed through the State's Expert Panel on CECs. The framework is based on a comprehensive battery of *in vitro* bioassays to screen for a broad spectrum of contaminants and non-targeted analytical methods to identify bioactive compounds missed by targeted analyses. This framework is currently being applied in regional and statewide pilot studies on waterbodies that receive discharge from municipal wastewater treatment plants and stormwater runoff. This framework should be applied to the Bight program.

5. **Provide additional time and/or resources to laboratories for improving data comparability.**

   In Bight'13, multiple laboratories made attempts to develop methods for PBDEs. This was unsuccessful, primarily due to an inability to reach the required reporting level. In response, only two laboratories could reach the required reporting level for measuring PBDEs, which resulted in an uneven burden on these facilities. Similar concerns for other targeted contaminants were observed, which can hinder data comparability. Capability and comparability are fundamental to a collaborative, performance-based monitoring program like Bight'13. Underperforming laboratories need additional time and/or resources to achieve the necessary performance goals required of Bight. Alternatively, participating agencies may consider outsourcing these analyses to those laboratories that can achieve these performance goals. Efforts should also be made to harmonize reporting levels among laboratories to ensure that holding times are met.

6. **A calibrated and validated assessment tool for sediment chemistry is needed for offshore sediments.**

   The sediment chemistry assessment indices used for the Bight'13 assessment, the Chemical Scoring Index (CSI) and California Logistic Regression Model (CA LRM), were calibrated and validated for embayment sediments. However, these indices were also applied to offshore sediments for this report because no comparable tool currently exists for this habitat. As a result, there are important limitations and assumptions in our offshore habitat assessment. The best alternative for future surveys is to calibrate and validate a sediment chemistry assessment tool for offshore sediments.

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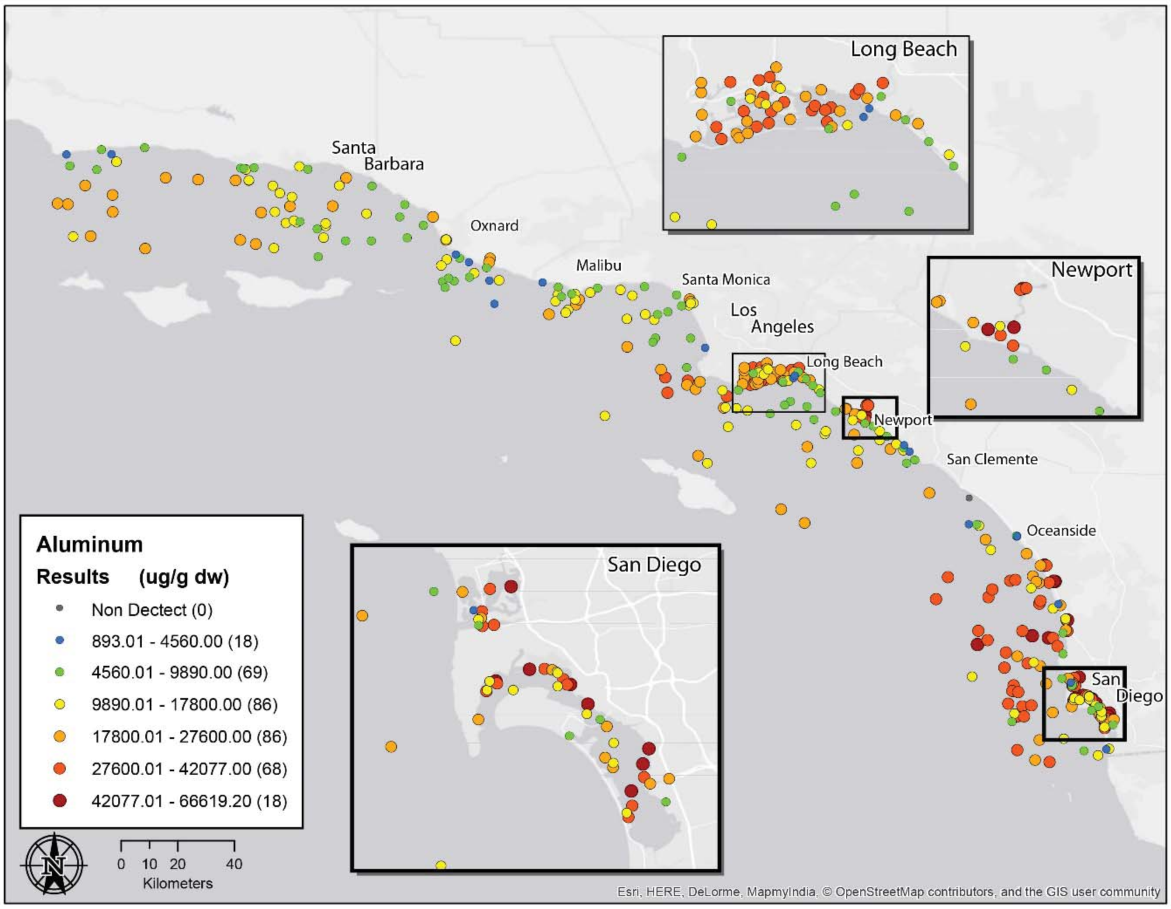
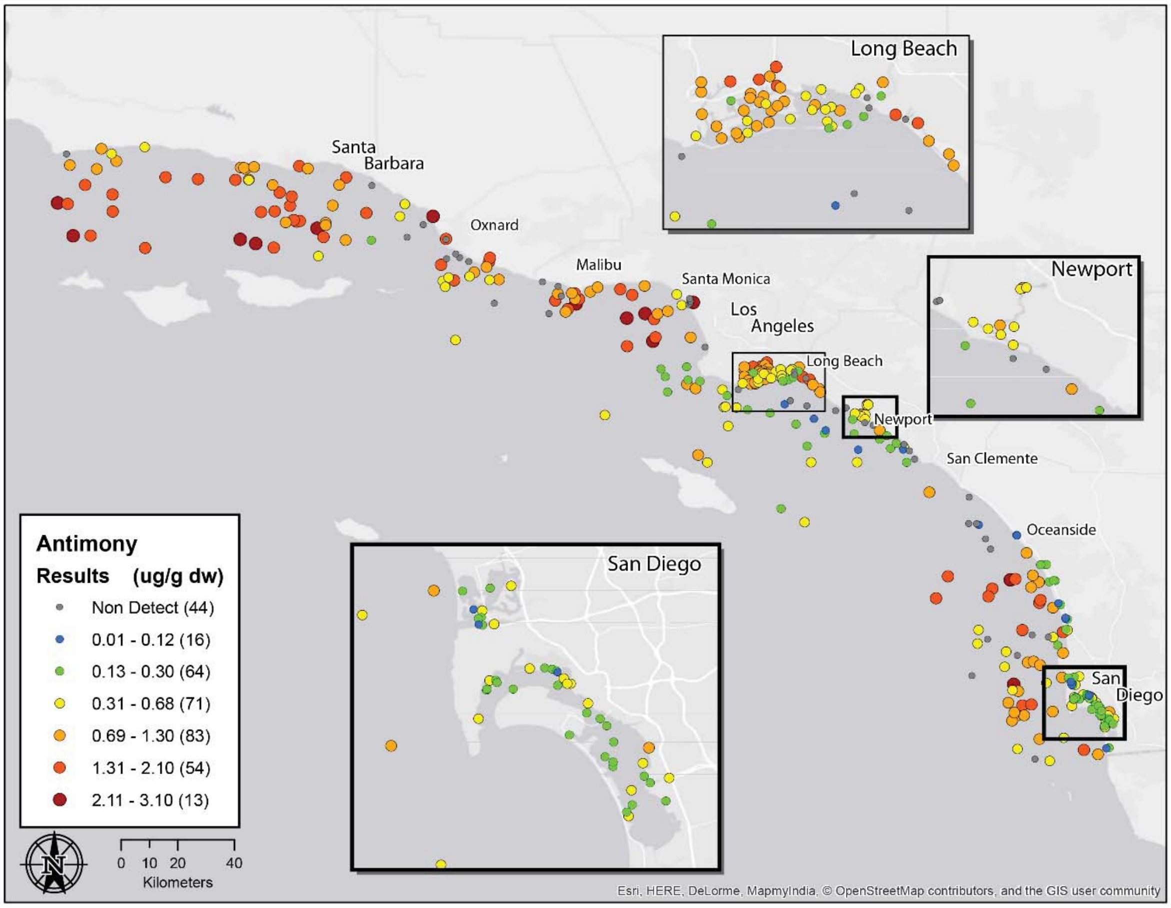
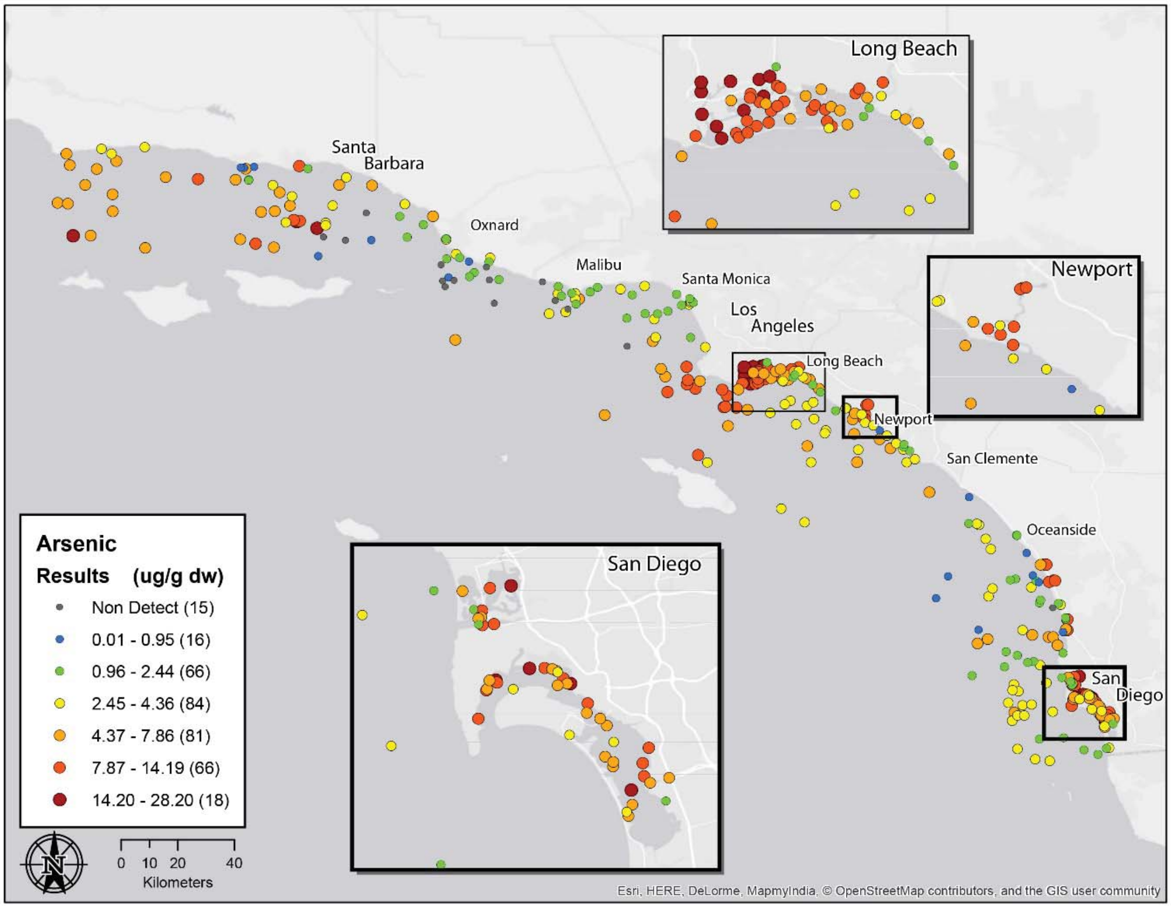
APPENDIX A. GEOGRAPHIC DISTRIBUTION AND MAGNITUDE OF ANALYTES

The following plots show the geographic distribution of sediment contaminant concentrations during the 2013 Southern California Bight regional monitoring survey. Cut-points are the 95th, 75th, 50th, 25th, and 5th percentiles. The legend shows the concentration range and number of samples for each bin.

Maps with a zooming user interface may be viewed online at https://gis.sccwrp.org/arcgis/apps/Viewer/index.html?appid=6e071a9a65b84823af914d4a768bcf16.




Long Beach
Newport
Santa
Barbara
Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Antimony
Results (ug/g dw)
Non Detect (44)
0.01 - 0.12 (16)
0.13 - 0.30 (64)
0.31 - 0.68 (71)
0.69 - 1.30 (83)
1.31 - 2.10 (54)
2.11 - 3.10 (13)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



Long Beach
Newport
Santa
Barbara
Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Arsenic
Results (ug/g dw)
Non Detect (15)
0.01 - 0.95 (16)
0.96 - 2.44 (66)
2.45 - 4.36 (84)
4.37 - 7.86 (81)
7.87 - 14.19 (66)
14.20 - 28.20 (18)
0 10 20 40
Kilometers
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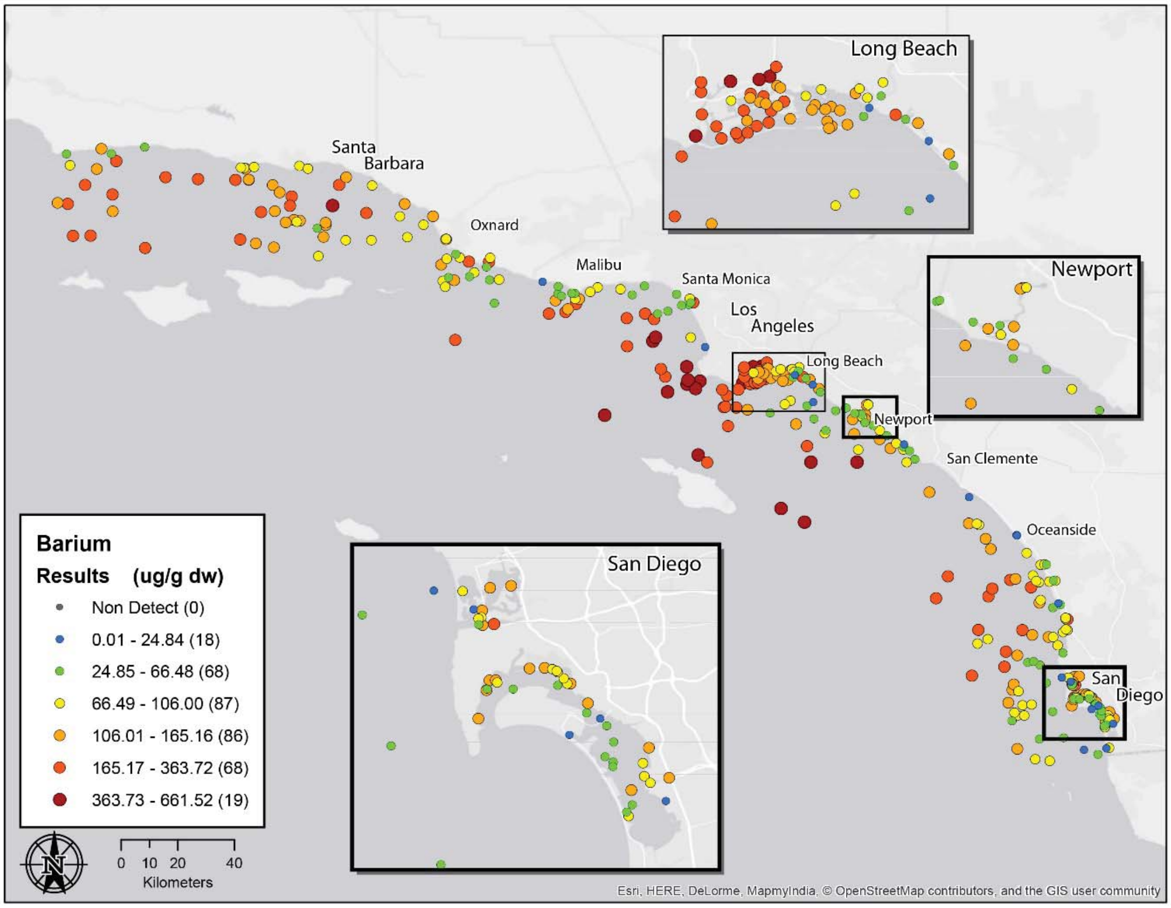
Long Beach
Newport
San Diego
Santa
Barbara
Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
Barium
Results (ug/g dw)
Non Detect (0)
0.01 - 24.84 (18)
24.85 - 66.48 (68)
66.49 - 106.00 (87)
106.01 - 165.16 (86)
165.17 - 363.72 (68)
363.73 - 661.52 (19)
0 10 20 40
Kilometers
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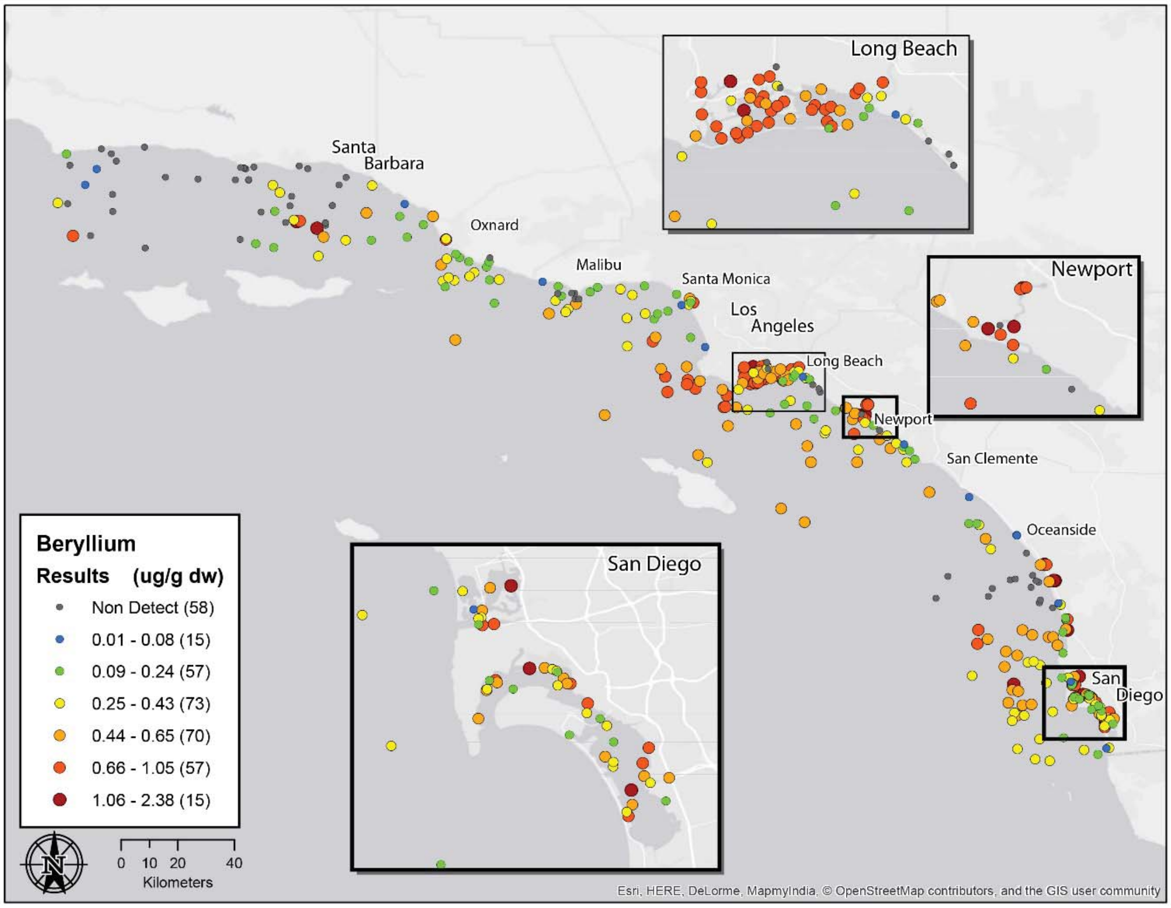
Long Beach
Newport
Santa Barbara
Oxnard
Malibu
Santa Monica
Los Angeles
Long Beach
Newport
San Clemente
Oceanside
San Diego
San Diego
Beryllium
Results (ug/g dw)
Non Detect (58)
0.01 - 0.08 (15)
0.09 - 0.24 (57)
0.25 - 0.43 (73)
0.44 - 0.65 (70)
0.66 - 1.05 (57)
1.06 - 2.38 (15)
0 10 20 40
Kilometers
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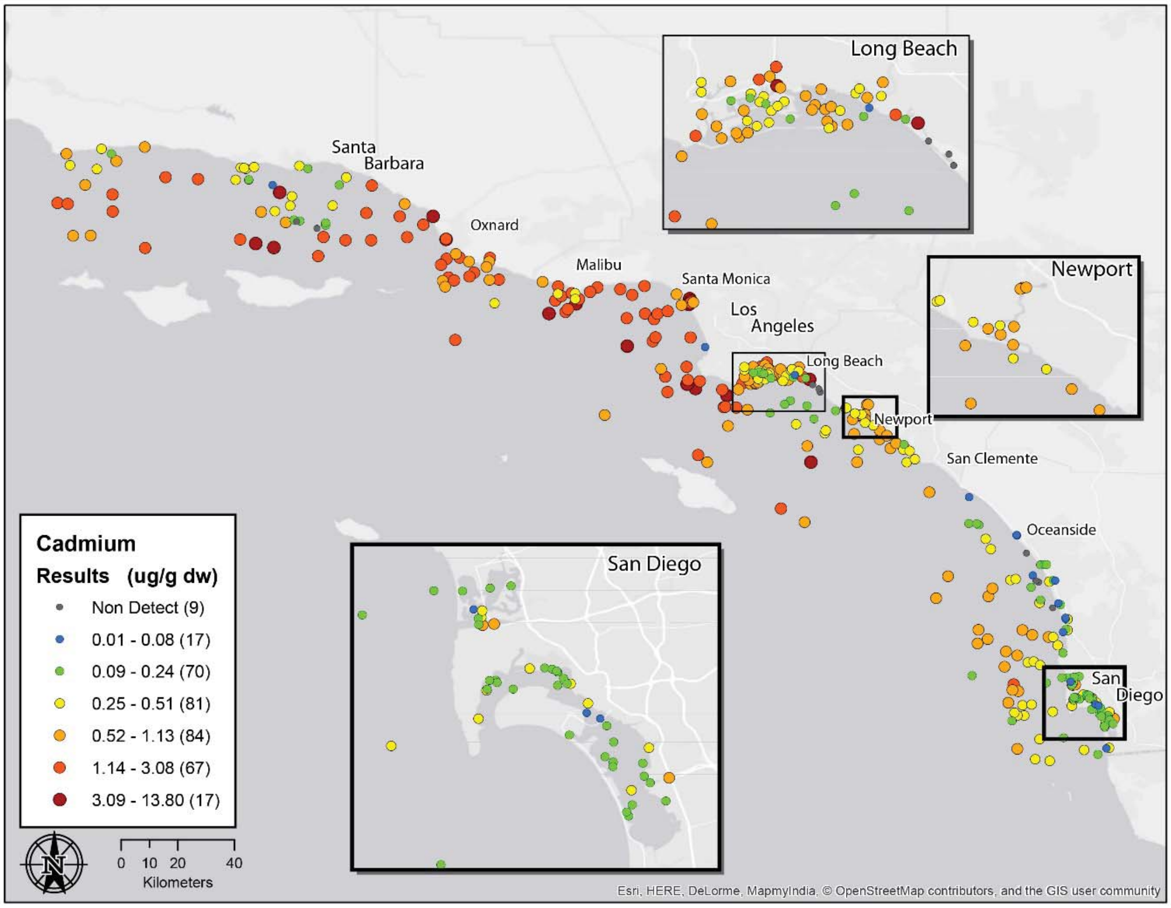
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Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Cadmium
Results (ug/g dw)
Non Detect (9)
0.01 - 0.08 (17)
0.09 - 0.24 (70)
0.25 - 0.51 (81)
0.52 - 1.13 (84)
1.14 - 3.08 (67)
3.09 - 13.80 (17)
0 10 20 40
Kilometers
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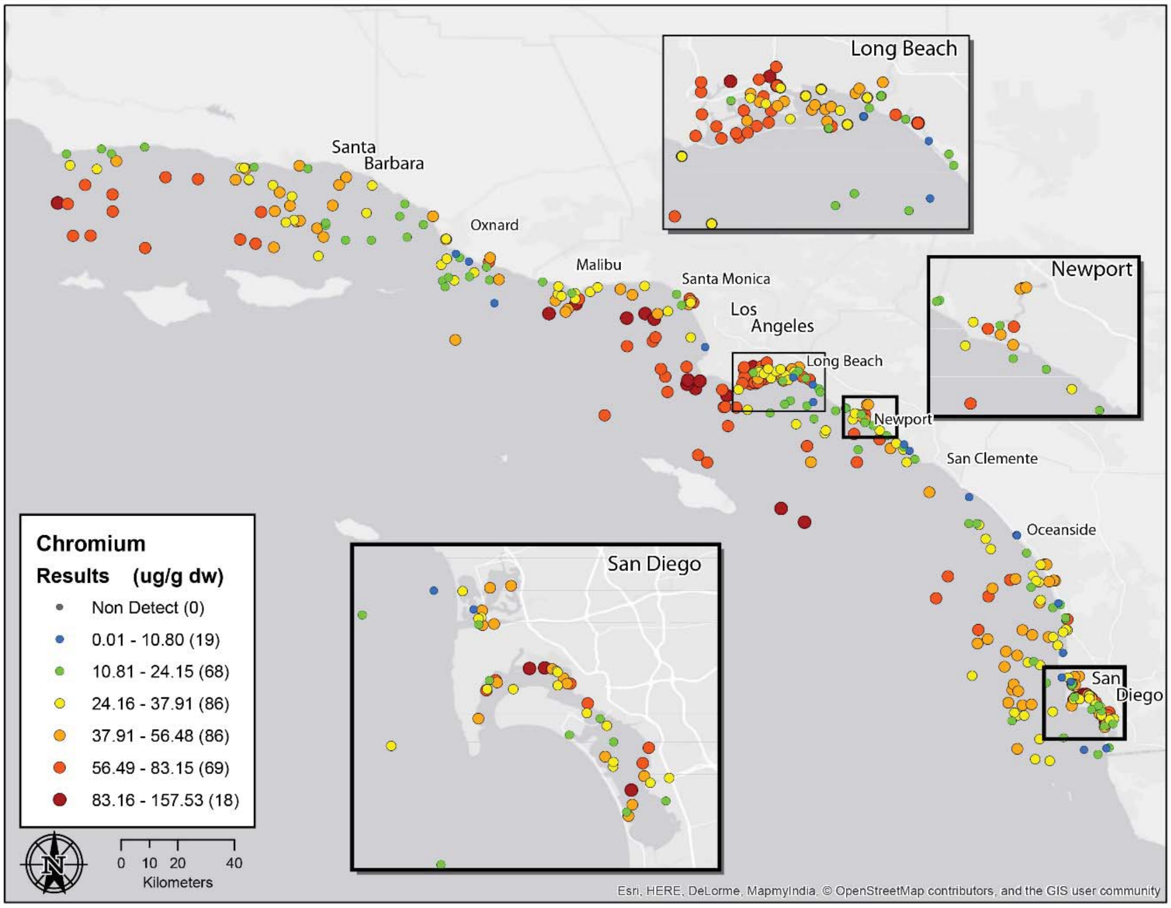

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Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Chromium
Results (ug/g dw)
Non Detect (0)
0.01 - 10.80 (19)
10.81 - 24.15 (68)
24.16 - 37.91 (86)
37.91 - 56.48 (86)
56.49 - 83.15 (69)
83.16 - 157.53 (18)
0 10 20 40
Kilometers
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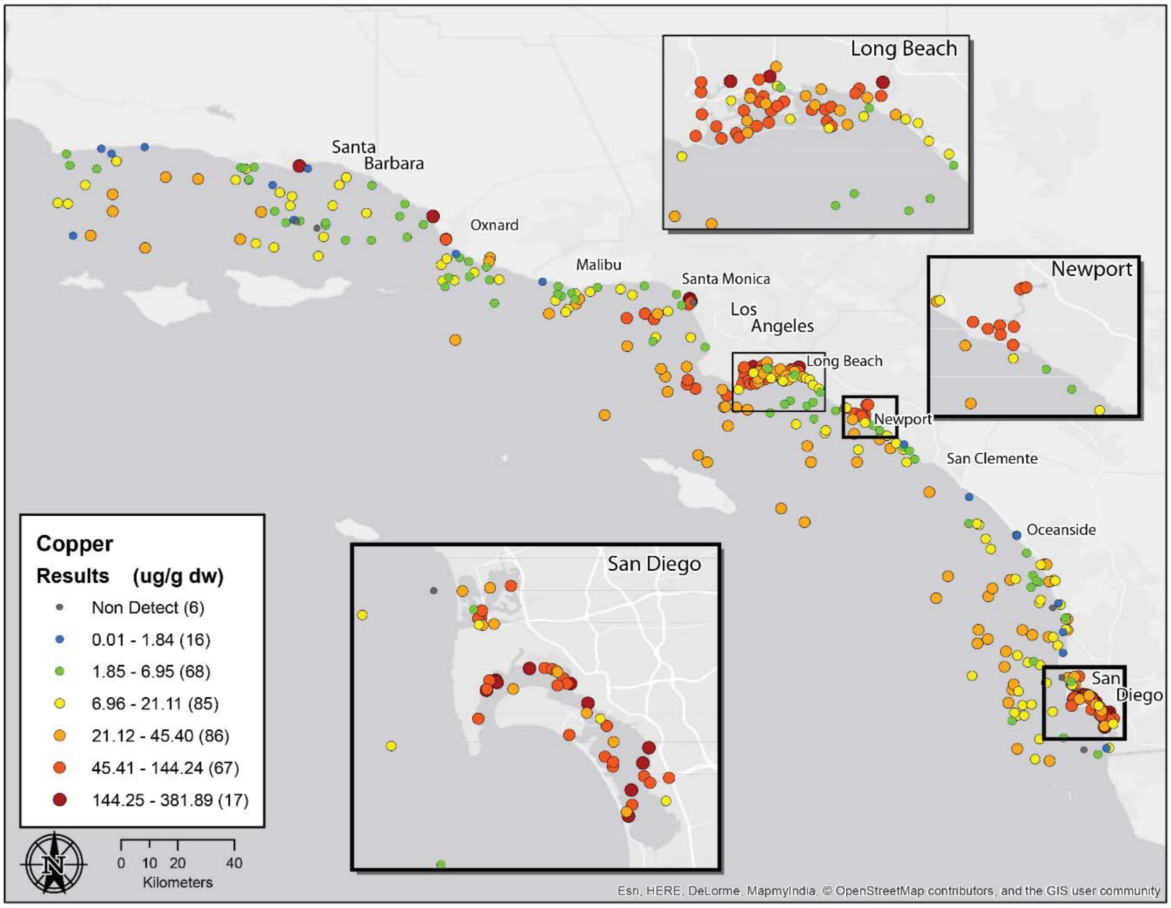

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Long Beach
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San Clemente
Oceanside
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Diego
Copper
Results (ug/g dw)
Non Detect (6)
0.01 - 1.84 (16)
1.85 - 6.95 (68)
6.96 - 21.11 (85)
21.12 - 45.40 (86)
45.41 - 144.24 (67)
144.25 - 381.89 (17)
0 10 20 40
Kilometers
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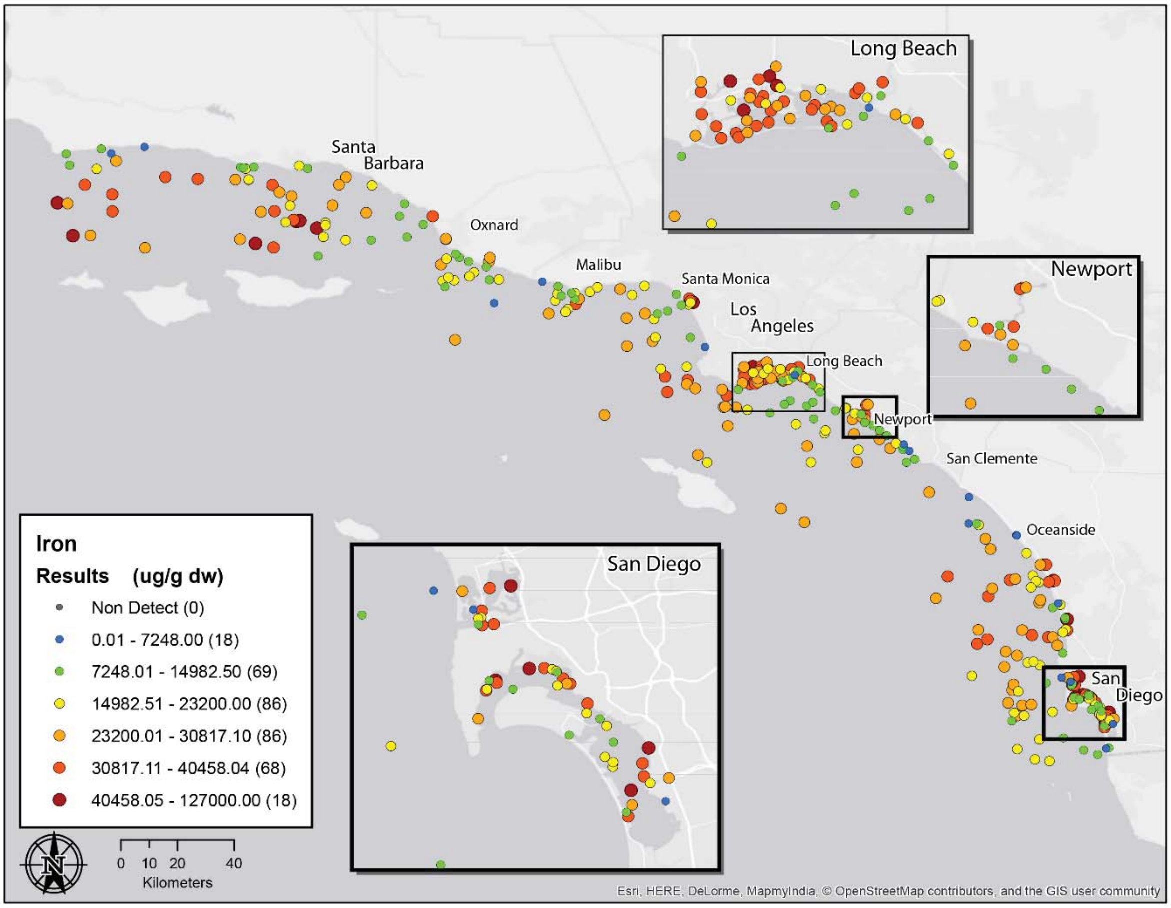

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Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Iron
Results (ug/g dw)
Non Detect (0)
0.01 - 7248.00 (18)
7248.01 - 14982.50 (69)
14982.51 - 23200.00 (86)
23200.01 - 30817.10 (86)
30817.11 - 40458.04 (68)
40458.05 - 127000.00 (18)
N
0 10 20 40
Kilometers
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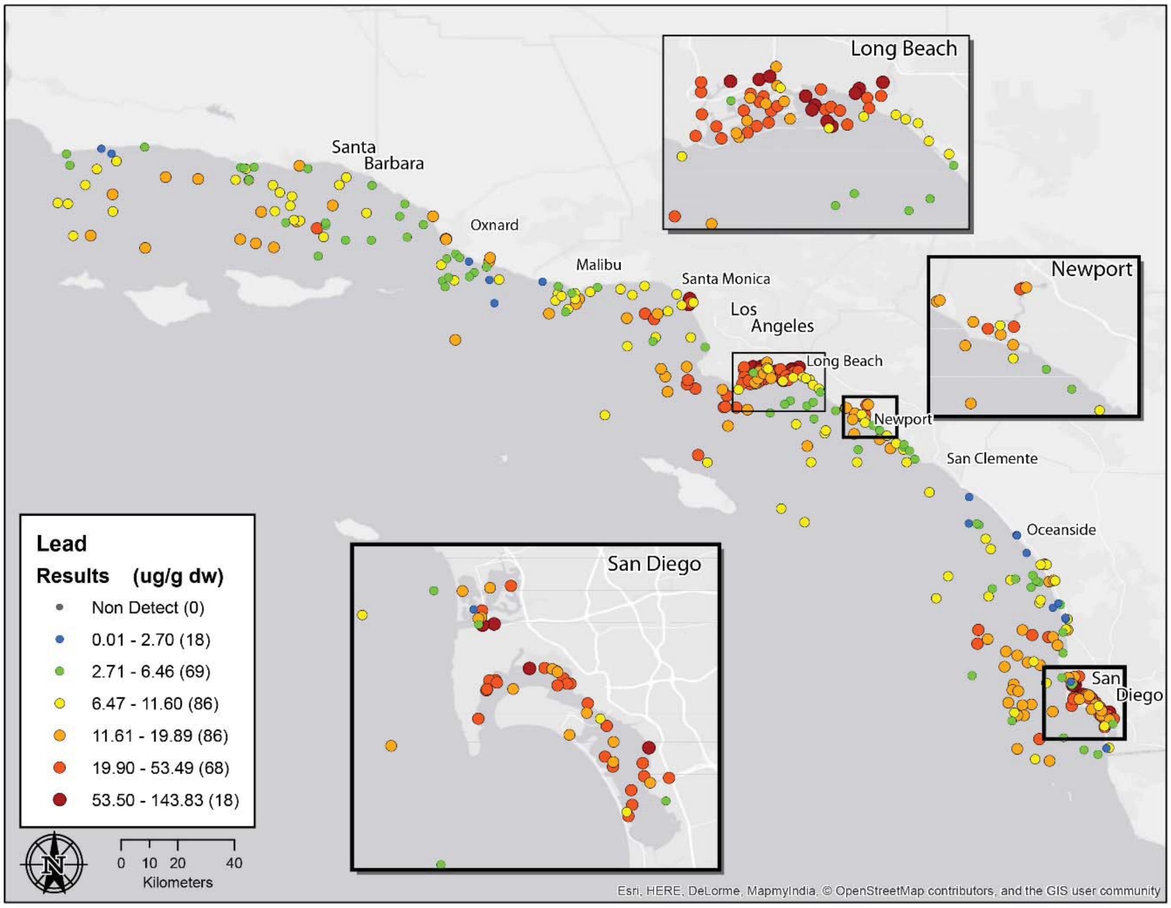
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Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Lead
Results (ug/g dw)
Non Detect (0)
0.01 - 2.70 (18)
2.71 - 6.46 (69)
6.47 - 11.60 (86)
11.61 - 19.89 (86)
19.90 - 53.49 (68)
53.50 - 143.83 (18)
0 10 20 40
Kilometers
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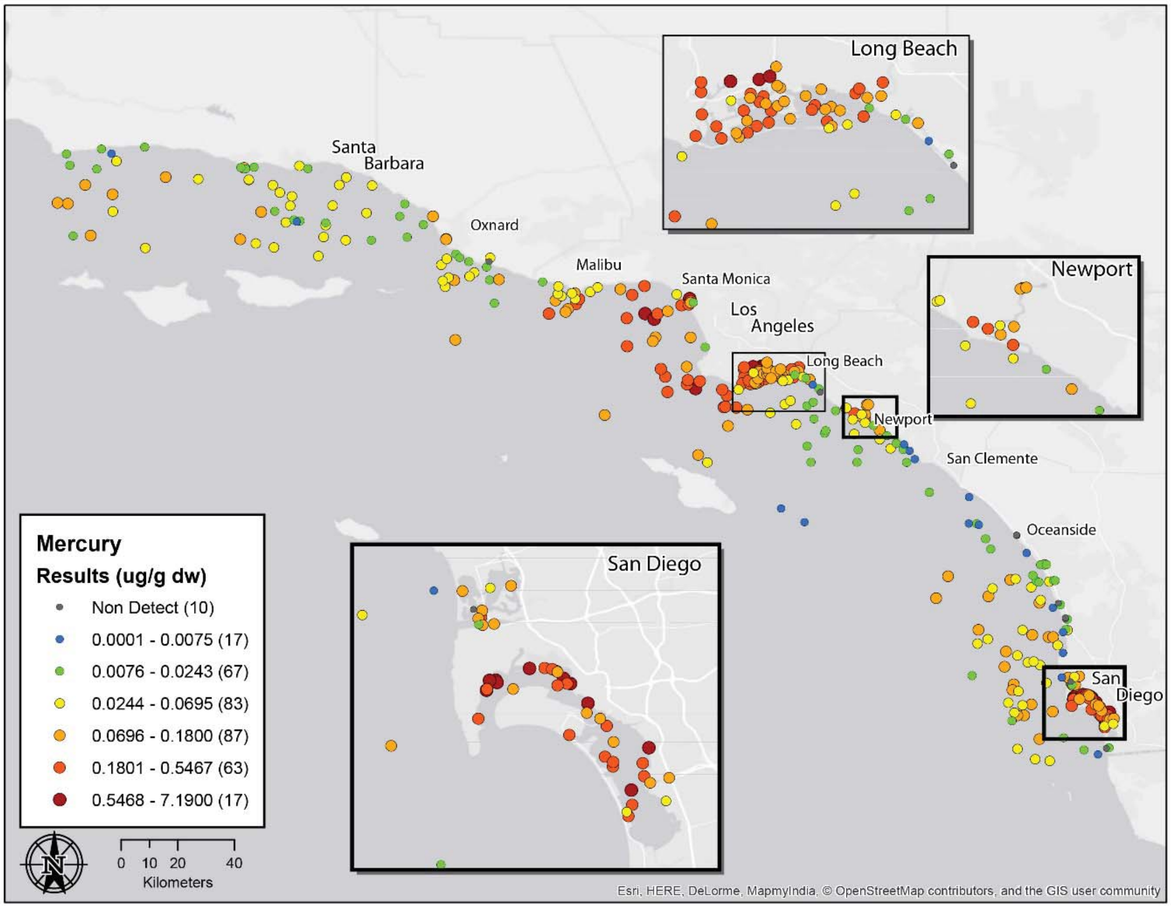
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Long Beach
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San Clemente
Oceanside
San Diego
San
Diego
Mercury
Results (ug/g dw)
Non Detect (10)
0.0001 - 0.0075 (17)
0.0076 - 0.0243 (67)
0.0244 - 0.0695 (83)
0.0696 - 0.1800 (87)
0.1801 - 0.5467 (63)
0.5468 - 7.1900 (17)
0 10 20 40
Kilometers
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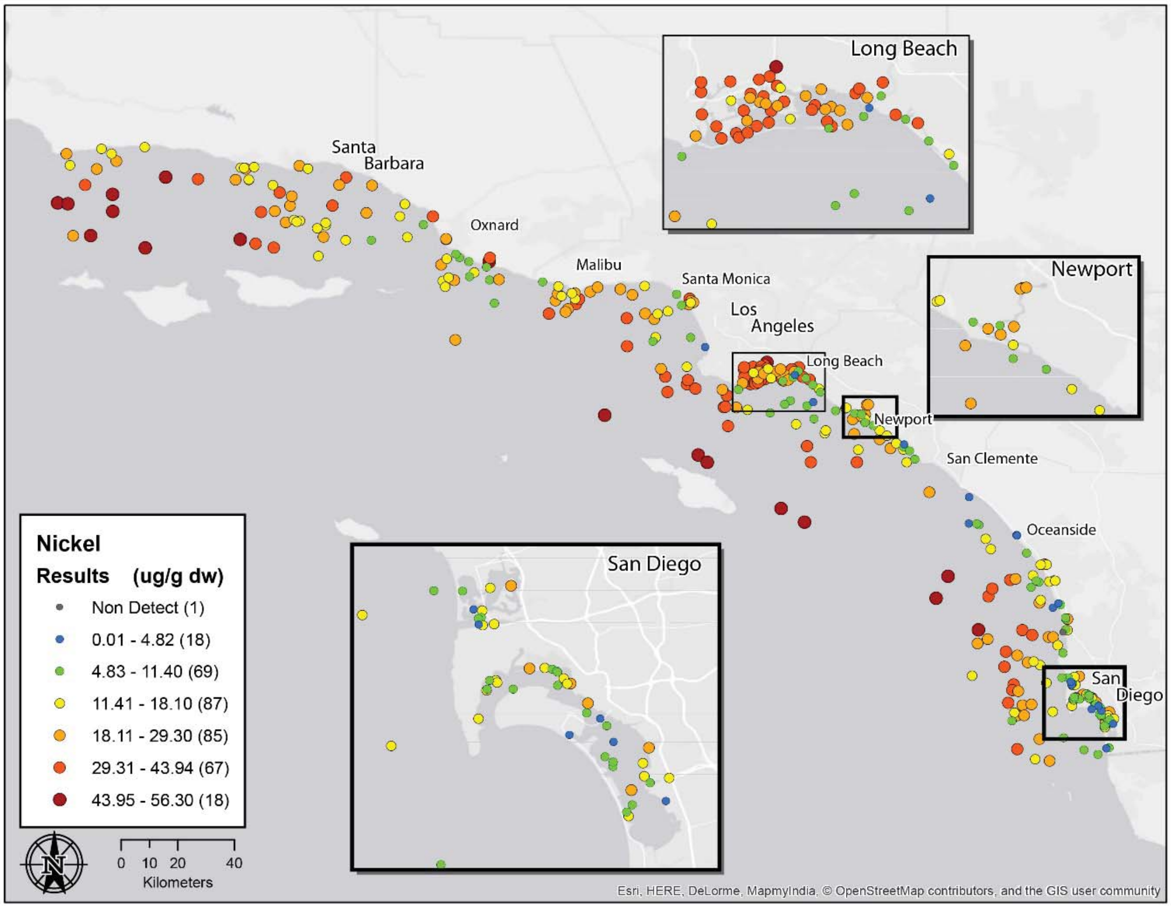
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San Clemente
Oceanside
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Diego
San Diego
Nickel
Results (ug/g dw)
Non Detect (1)
0.01 - 4.82 (18)
4.83 - 11.40 (69)
11.41 - 18.10 (87)
18.11 - 29.30 (85)
29.31 - 43.94 (67)
43.95 - 56.30 (18)
0 10 20 40
Kilometers
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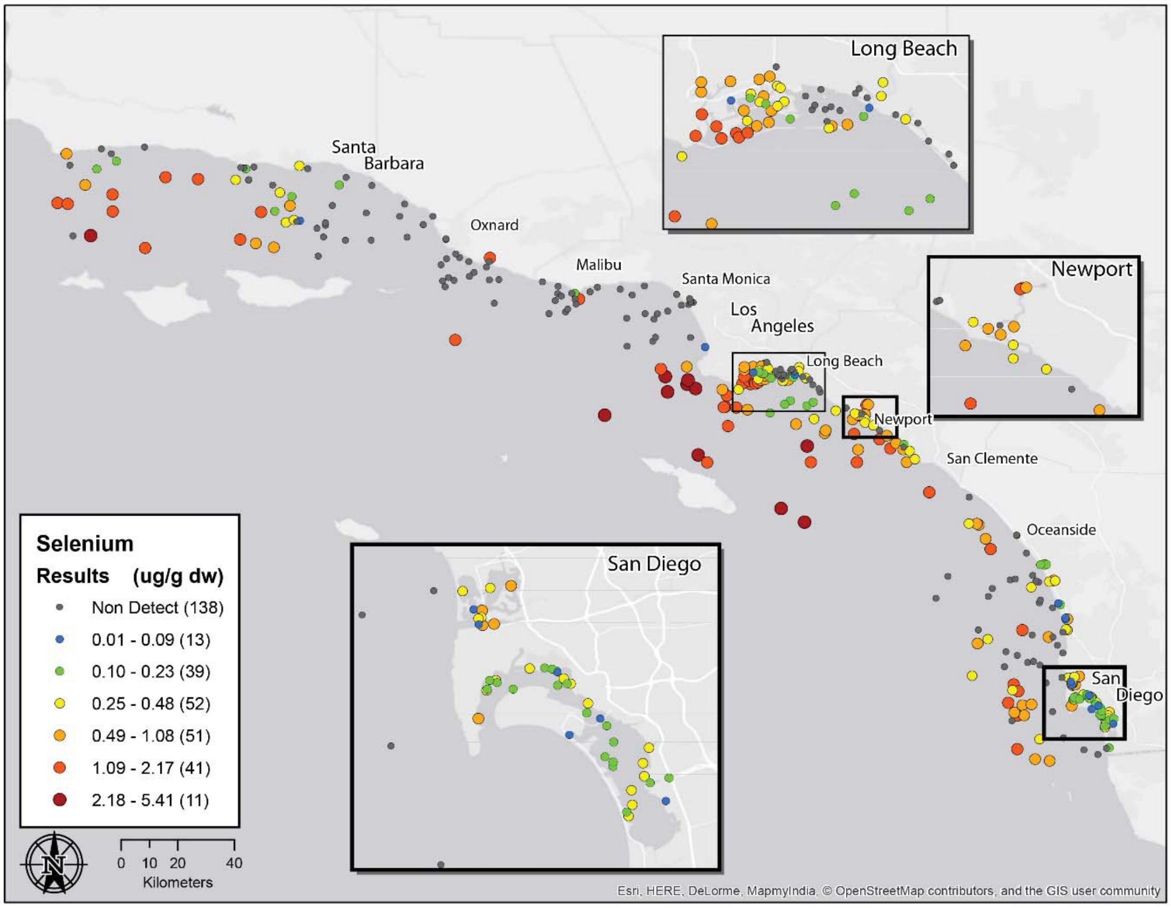

Long Beach
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Oceanside
San Diego
San Diego
Selenium Results (ug/g dw)
Non Detect (138)
0.01 - 0.09 (13)
0.10 - 0.23 (39)
0.25 - 0.48 (52)
0.49 - 1.08 (51)
1.09 - 2.17 (41)
2.18 - 5.41 (11)
0 10 20 40
Kilometers
N
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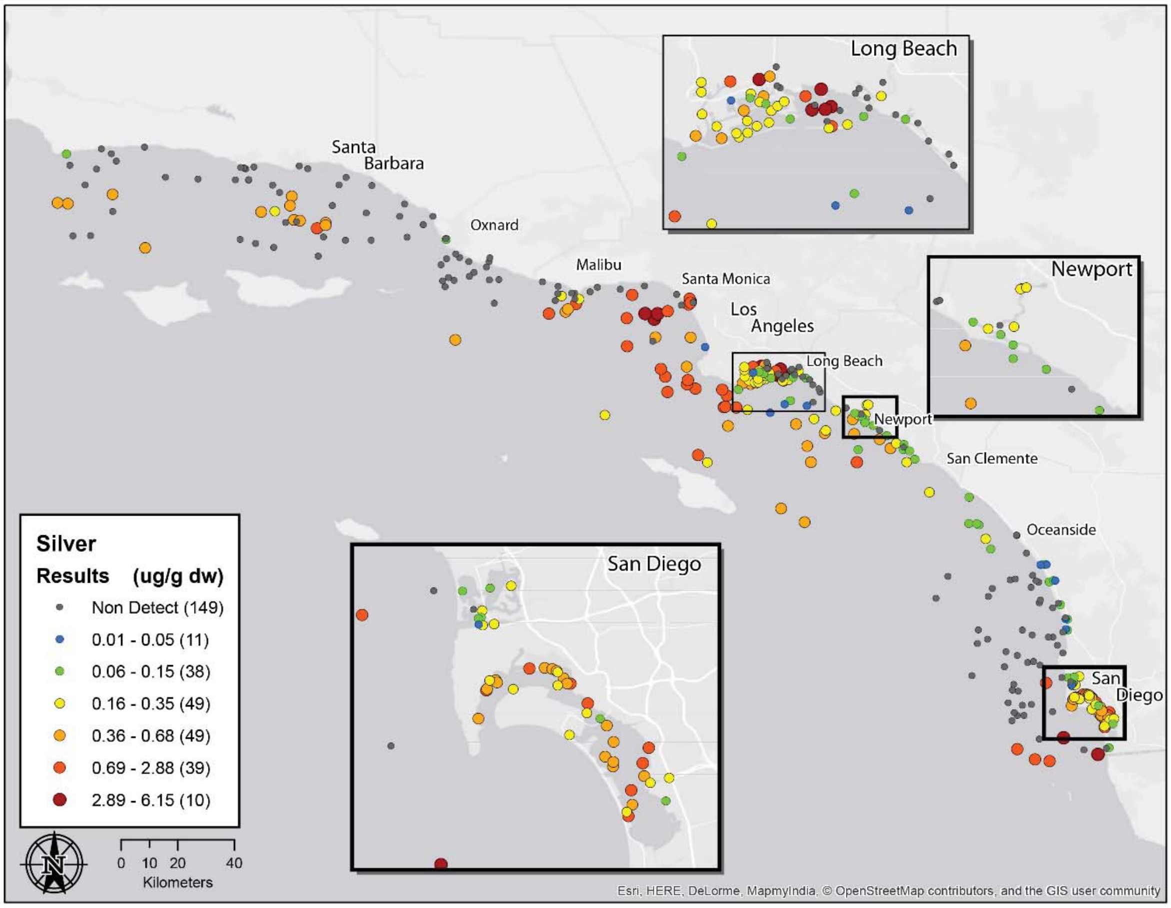

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Diego
San Diego
Silver
Results (ug/g dw)
Non Detect (149)
0.01 - 0.05 (11)
0.06 - 0.15 (38)
0.16 - 0.35 (49)
0.36 - 0.68 (49)
0.69 - 2.88 (39)
2.89 - 6.15 (10)
0 10 20 40
Kilometers
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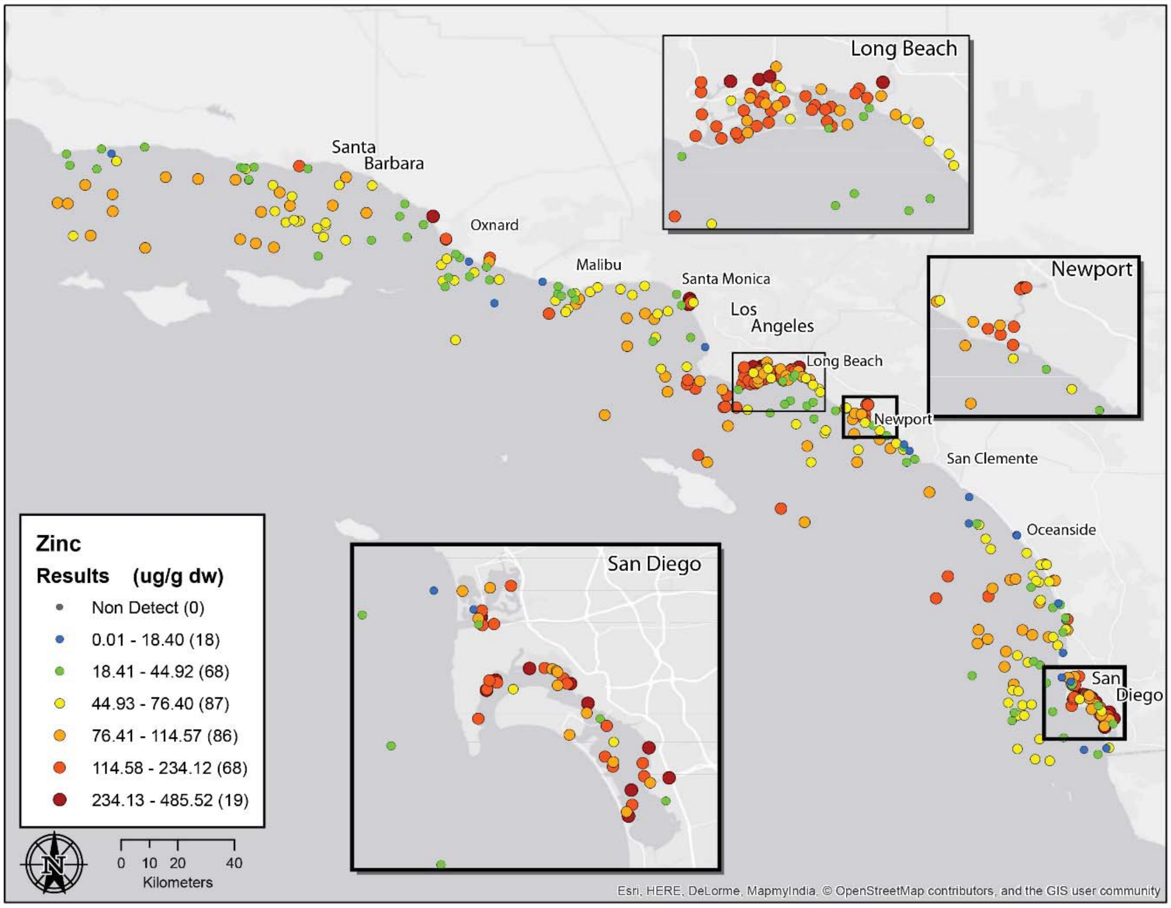
Long Beach
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Oceanside
San
Diego
San Diego
Zinc
Results (ug/g dw)
Non Detect (0)
0.01 - 18.40 (18)
18.41 - 44.92 (68)
44.93 - 76.40 (87)
76.41 - 114.57 (86)
114.58 - 234.12 (68)
234.13 - 485.52 (19)
0 10 20 40
Kilometers
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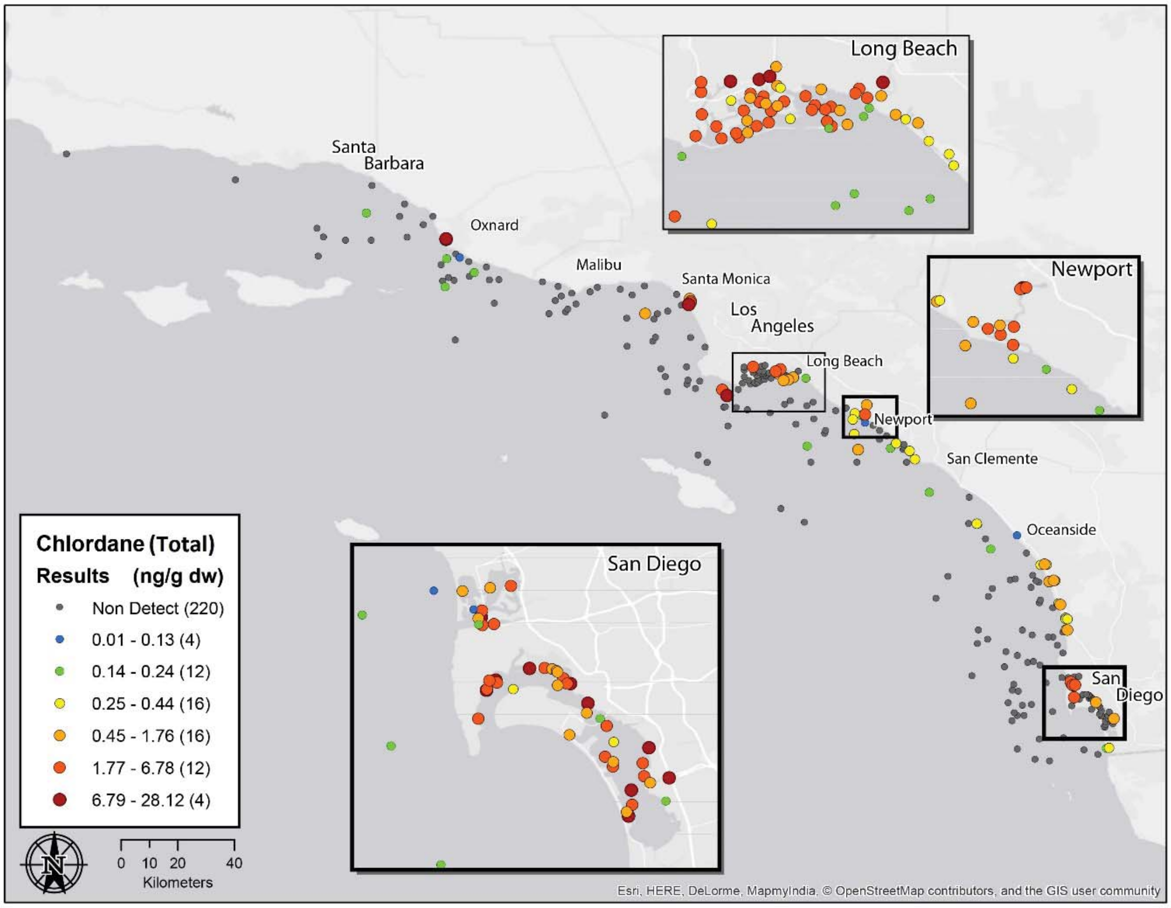
Long Beach
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Long Beach
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San Clemente
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San
Diego
San Diego
Chlordane (Total)
Results (ng/g dw)
Non Detect (220)
0.01 - 0.13 (4)
0.14 - 0.24 (12)
0.25 - 0.44 (16)
0.45 - 1.76 (16)
1.77 - 6.78 (12)
6.79 - 28.12 (4)
0 10 20 40
Kilometers
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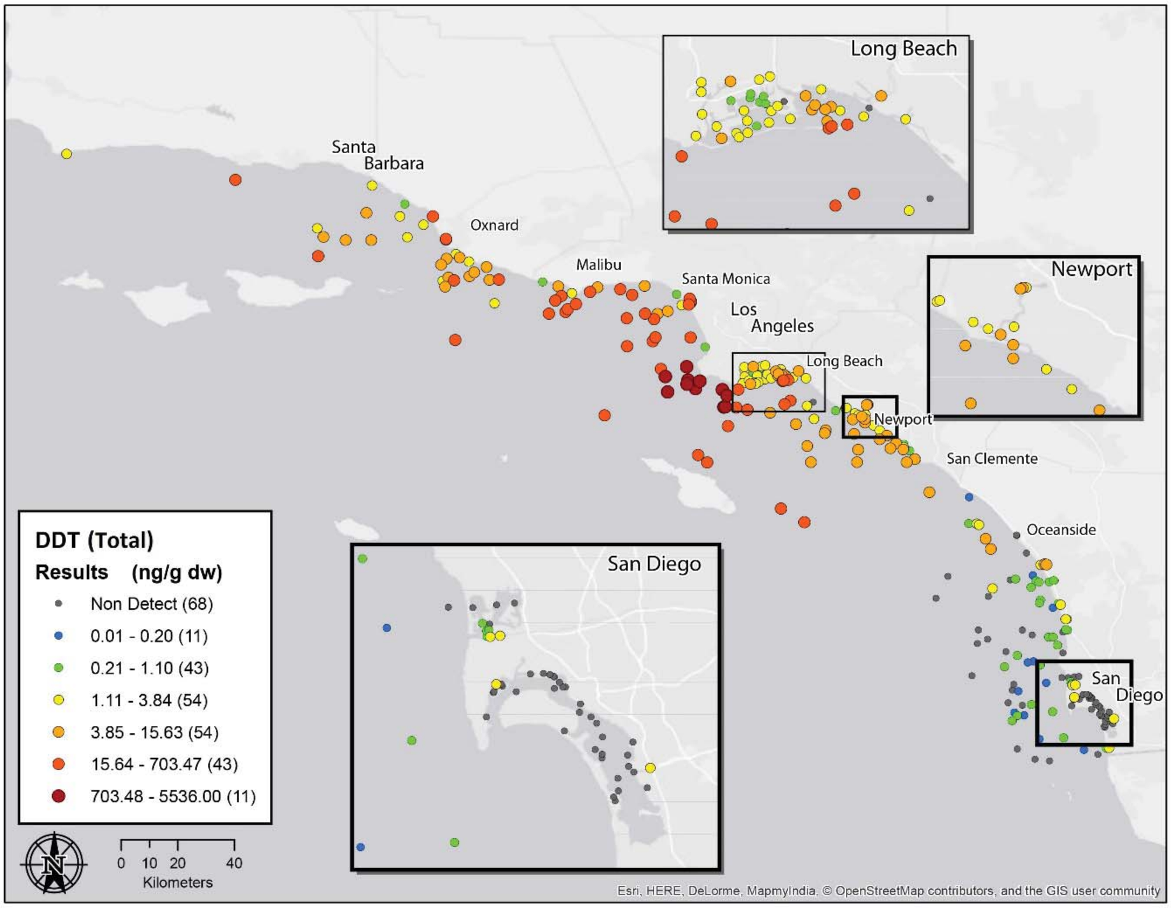
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Long Beach
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San Clemente
Oceanside
San
Diego
San Diego
DDT (Total)
Results (ng/g dw)
Non Detect (68)
0.01 - 0.20 (11)
0.21 - 1.10 (43)
1.11 - 3.84 (54)
3.85 - 15.63 (54)
15.64 - 703.47 (43)
703.48 - 5536.00 (11)
0 10 20 40
Kilometers
N
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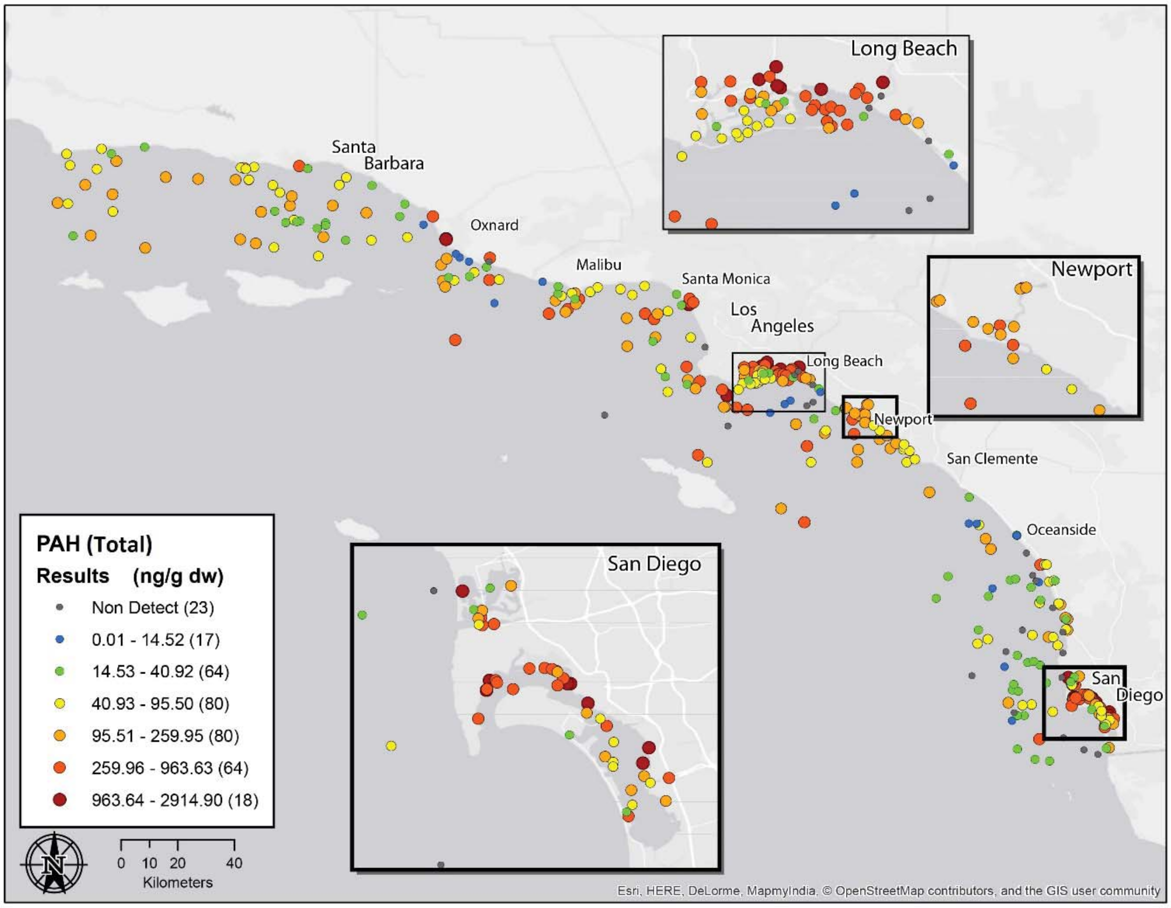
Long Beach
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Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
PAH (Total)
Results (ng/g dw)
Non Detect (23)
0.01 - 14.52 (17)
14.53 - 40.92 (64)
40.93 - 95.50 (80)
95.51 - 259.95 (80)
259.96 - 963.63 (64)
963.64 - 2914.90 (18)
0 10 20 40
Kilometers
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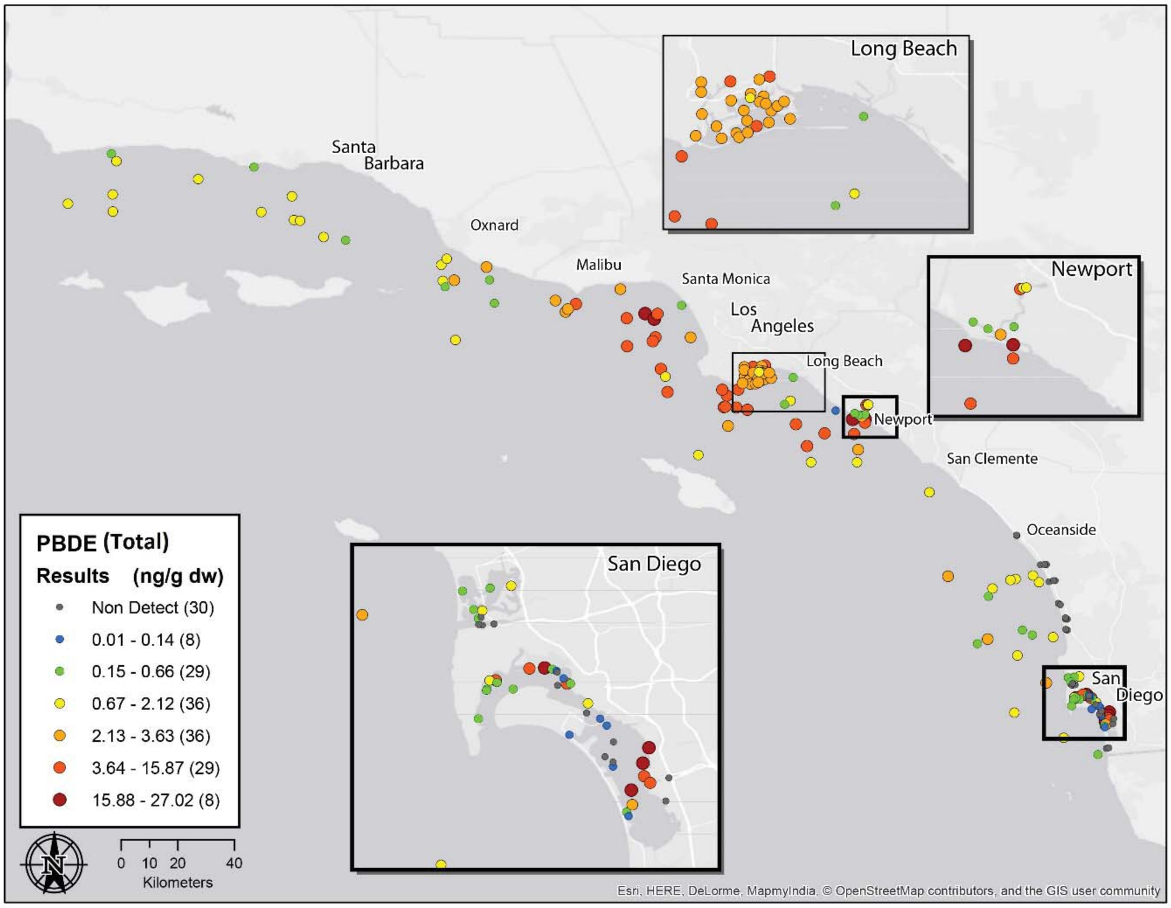

Long Beach
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Oxnard
Malibu
Santa Monica
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Angeles
Long Beach
Newport
San Clemente
Oceanside
San Diego
San
Diego
PBDE (Total)
Results (ng/g dw)
Non Detect (30)
0.01 - 0.14 (8)
0.15 - 0.66 (29)
0.67 - 2.12 (36)
2.13 - 3.63 (36)
3.64 - 15.87 (29)
15.88 - 27.02 (8)
0 10 20 40
Kilometers
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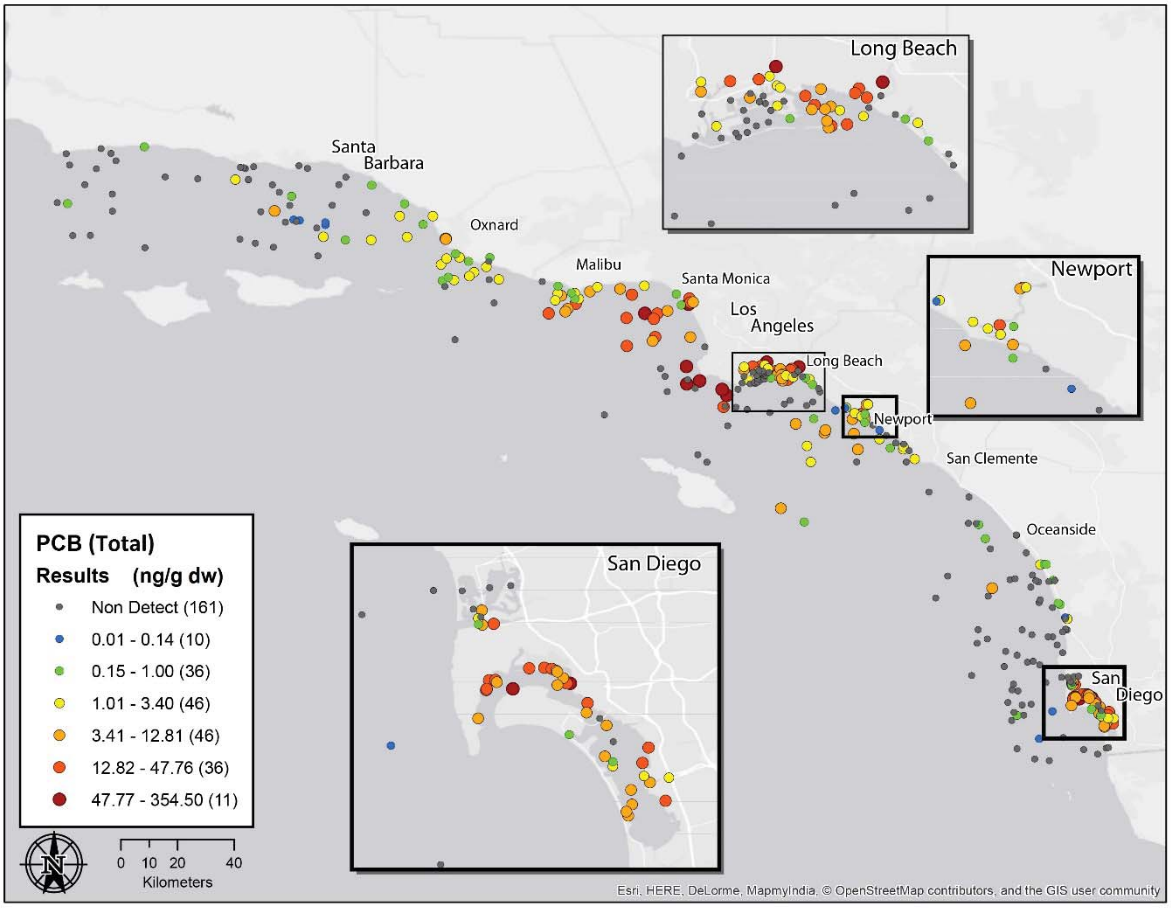

Long Beach
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Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
PCB (Total)
Results (ng/g dw)
Non Detect (161)
0.01 - 0.14 (10)
0.15 - 1.00 (36)
1.01 - 3.40 (46)
3.41 - 12.81 (46)
12.82 - 47.76 (36)
47.77 - 354.50 (11)
0 10 20 40
Kilometers
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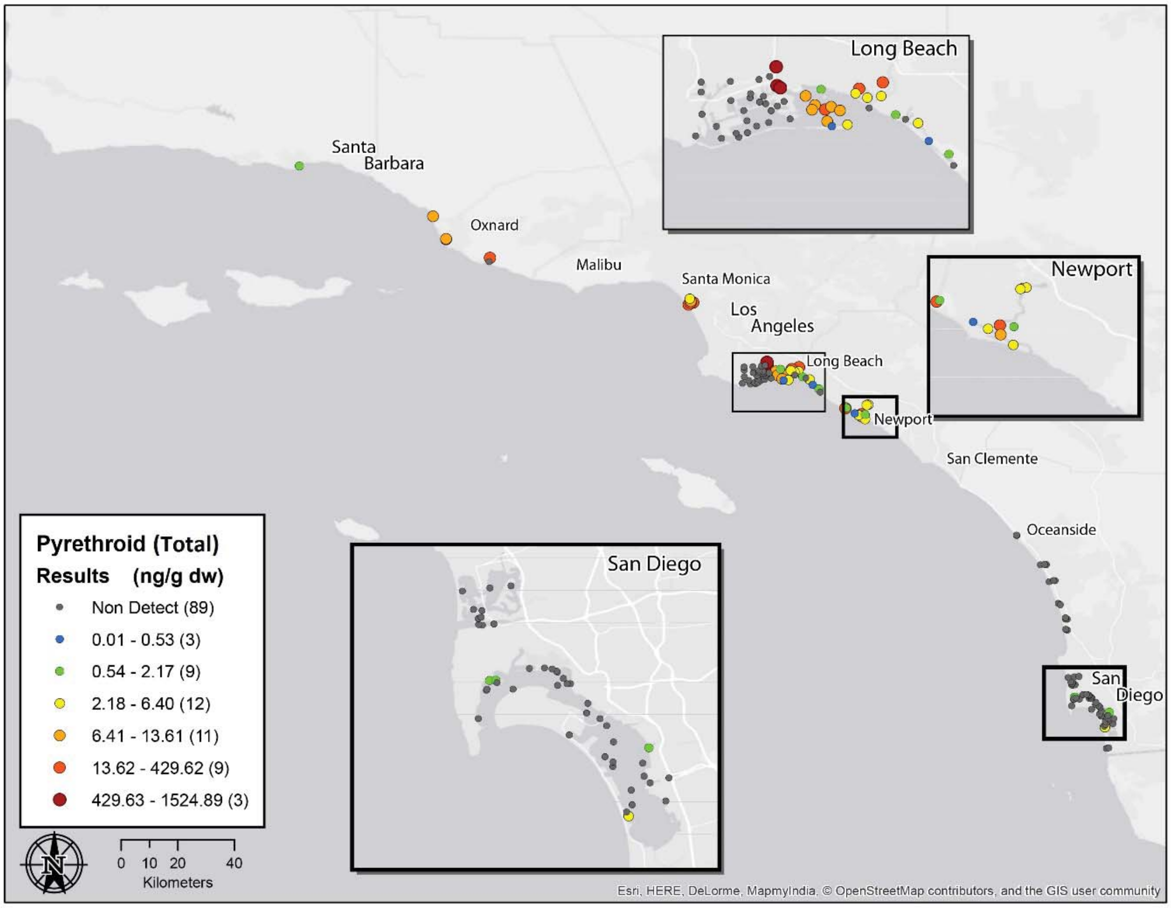
Long Beach
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Barbara
Oxnard
Malibu
Santa Monica
Los
Angeles
Long Beach
Newport
San Clemente
Oceanside
San
Diego
San Diego
Pyrethroid (Total)
Results (ng/g dw)
Non Detect (89)
0.01 - 0.53 (3)
0.54 - 2.17 (9)
2.18 - 6.40 (12)
6.41 - 13.61 (11)
13.62 - 429.62 (9)
429.63 - 1524.89 (3)
0 10 20 40
Kilometers
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Appendix B. Laboratory Quality Assurance Information

Bight 2013 Sediment Chemistry Inter-Calibration Exercise

The following five reference materials were measured by participating laboratories in triplicate. To achieve passing results for a given material and analyte class, at least 2 of replicates must have individually passed.

Blue control charts indicate compounds with pass/fail criteria. Green control charts indicate compounds without pass/fail criteria, and are presented for information value only.

Organics

1. NIST SRM 1944 New York/New Jersey Waterway Sediment

SRM 1944 tests method accuracy. Laboratories are required to obtain concentrations within 40% of the certified or reference value for 70% of the compounds within each class except PAHs. PAHs are required to be within 40% of the certified or reference value for 80% of the criteria compounds. The website for the material is https://www-s.nist.gov/srmors/view_detail.cfm?srm=1944

Pass/fail criteria for PBDEs were not set. PBDE values are for information value only.

2. Field Reference Material from Palos Verdes Superfund Site (Marine Sediment SR0326 from US EPA Region 9)

The organics field reference material tests method performance when analyzing a sample with high levels of DDT and potential interferences not present in SRM 1944. Laboratories are required to obtain a total class concentration within 40% of the mean value. This material is new to Bight'13.

Pass/fail criteria for PBDEs were not set. PBDE values are for information value only.

Metals

3. ERA 540 Metals in Soil. Lot D074-540.

ERA 540 tests method accuracy. Laboratories are required to obtain concentrations within 30% of the certified value for 12 of 15 analytes. The website for the material is http://www.eraqc.com/

4. Field Reference Material (Sediment) from City of San Diego (SD-E25)

Pass/fail criteria for this material were not set. It is for information value only.

Pyrethroids/Fipronils

5. Field Reference Material (Sediment) from Ballona Creek PyIC-BC

Pass/fail criteria for this material were not set. It is for information value only.

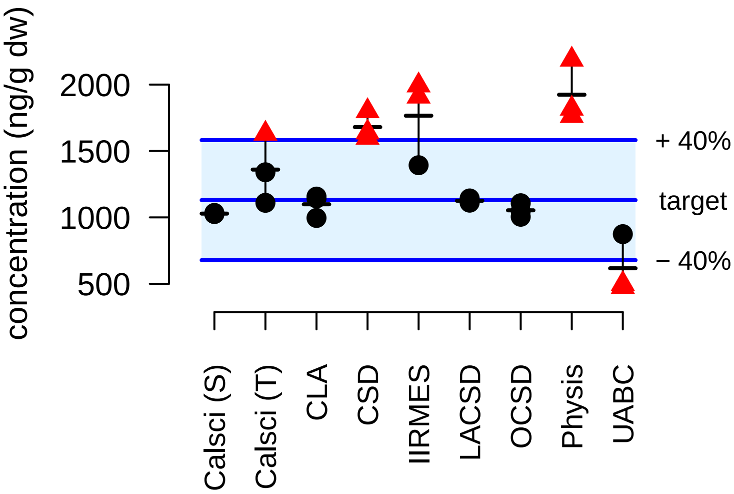
Number of passing replicates, out of three

Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC
Anthracene	3	2	3	0	1	3	3	0	1
Benz[a]anthracene	3	3	3	3	3	3	3	3	3
Benzo[a]pyrene	0	3	3	3	3	3	3	3	2
Benzo[b]fluoranthene	3	3	2	3	3	3	0	3	3
Benzo[e]pyrene	3	3	3	3	3	3	3	3	3
Benzo[g,h,i]perylene	3	3	3	3	3	3	3	3	3
Benzo[k]fluoranthene	3	3	3	2	3	3	3	3	3
Chrysene	3	3	3	3	3	3	3	3	3
Dibenz[a,h]anthracene	3	0	2	0	3	3	0	3	1
Fluoranthene	3	3	3	3	3	3	3	3	3
Indeno[1,2,3−c,d]pyrene	3	3	3	2	3	3	3	3	3
Naphthalene	3	2	1	3	2	3	3	2	0
Perylene	1	2	0	3	3	3	3	3	3
Phenanthrene	3	3	0	3	3	3	3	3	2
Pyrene	3	3	3	3	3	3	3	3	2

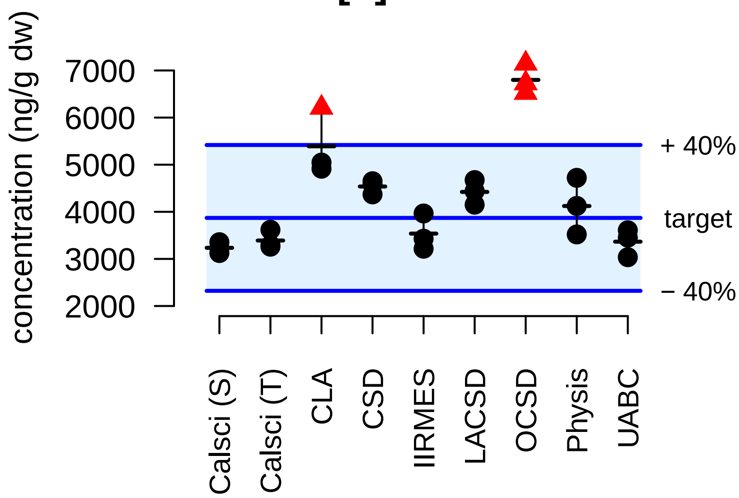
Percent passing and final result

Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC
Percent	87	93	80	87	93	100	87	93	80
Result	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

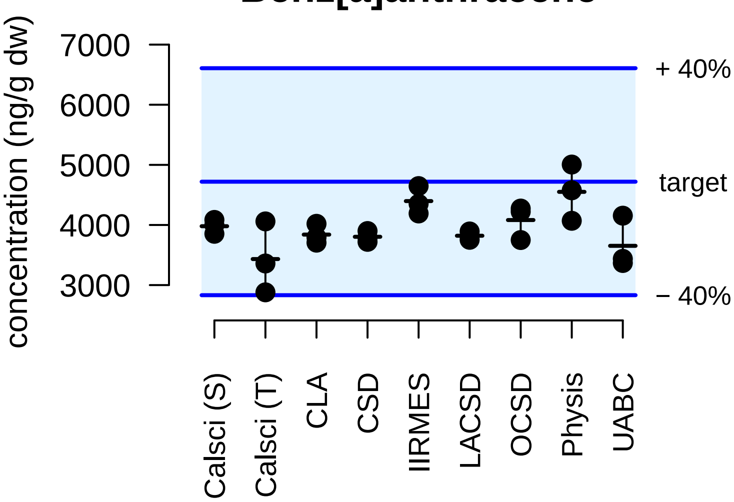
Anthracene



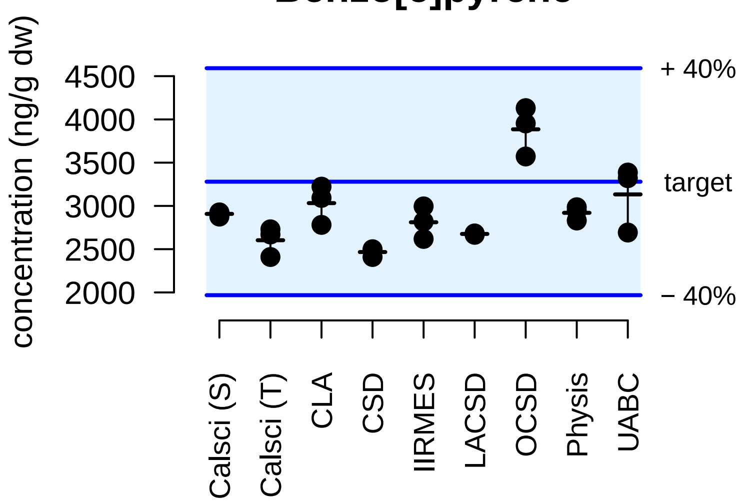
Benzo[b]fluoranthene



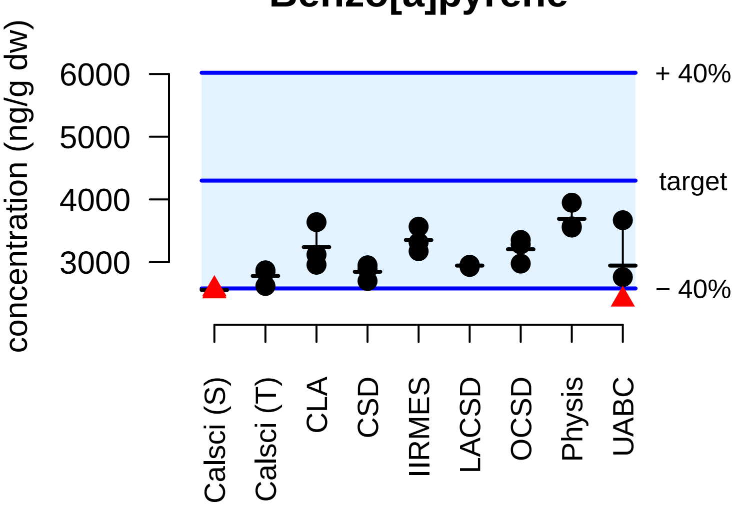
Benz[a]anthracene



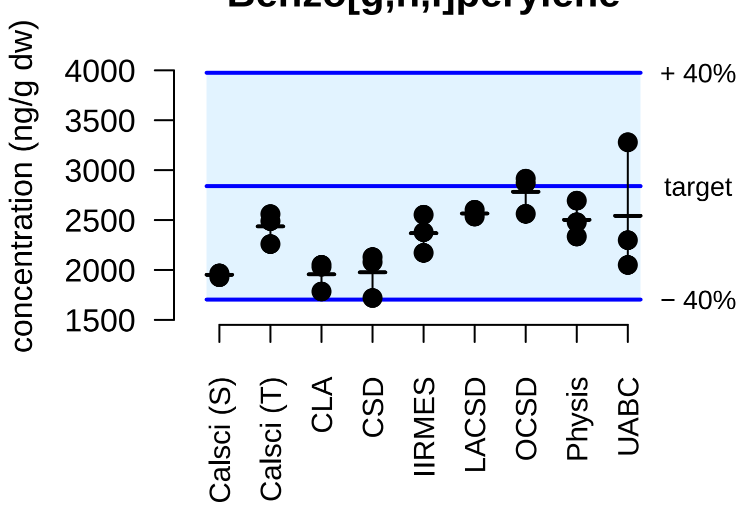
Benzo[e]pyrene

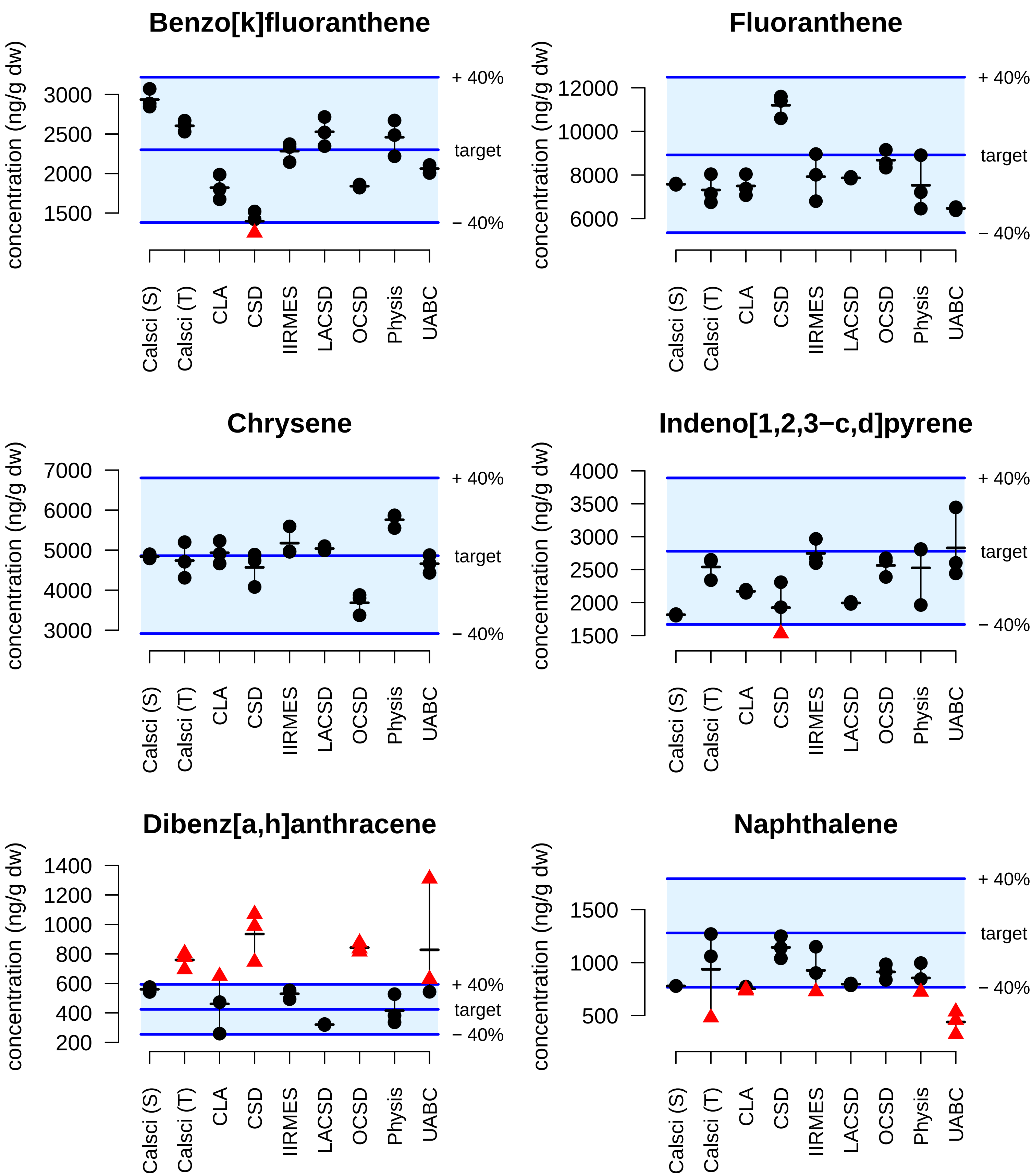


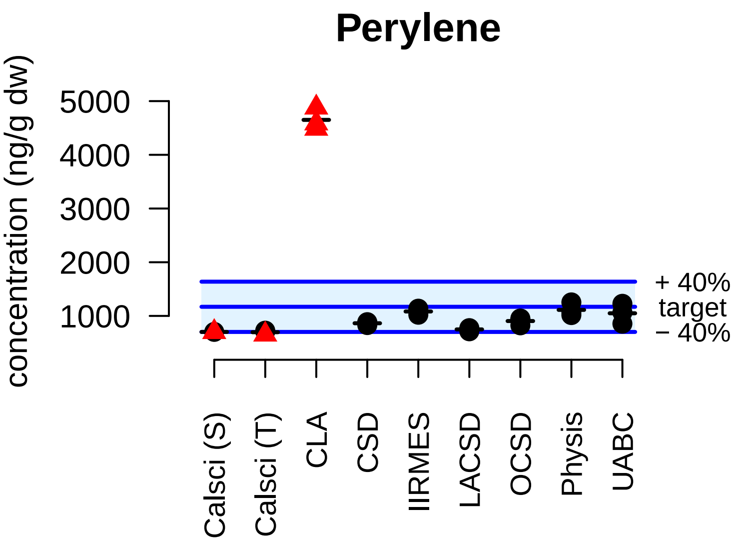
Benzo[a]pyrene

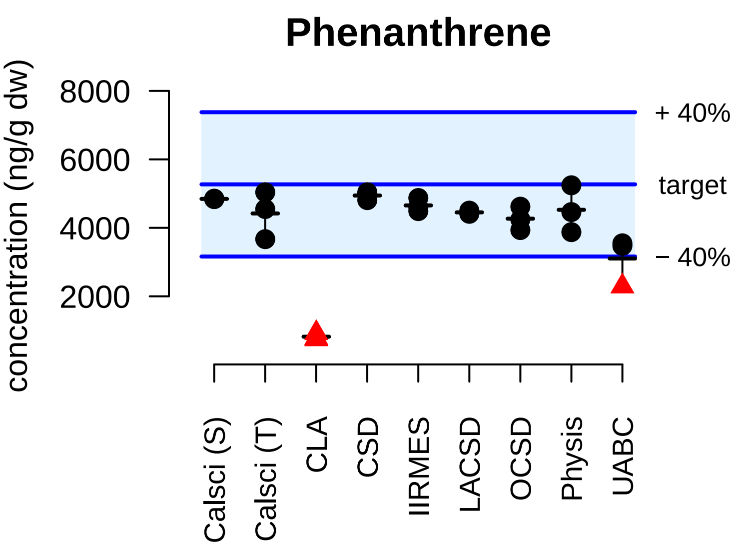


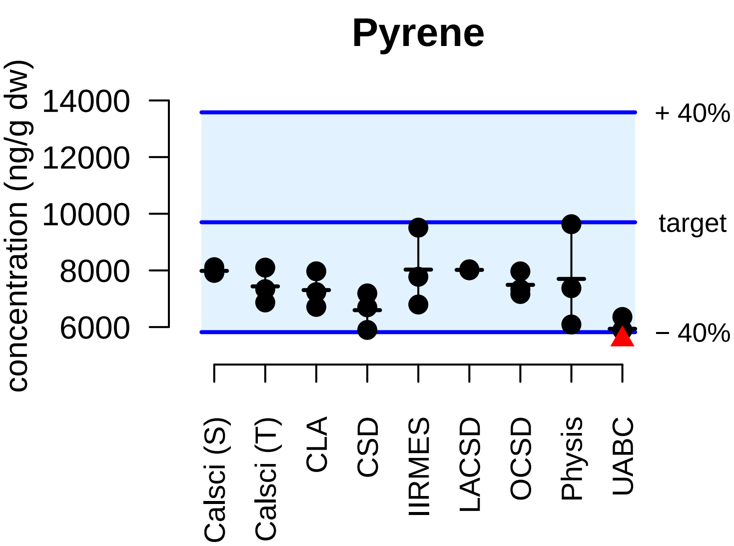
Benzo[g,h,i]perylene




Benzo[k]fluoranthene
Fluoranthene
Chrysene
Indeno[1,2,3−c,d]pyrene
Dibenz[a,h]anthracene
Naphthalene
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC


Perylene
concentration (ng/g dw)
5000
4000
3000
2000
1000
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC


Phenanthrene
concentration (ng/g dw)
8000
6000
4000
2000
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC

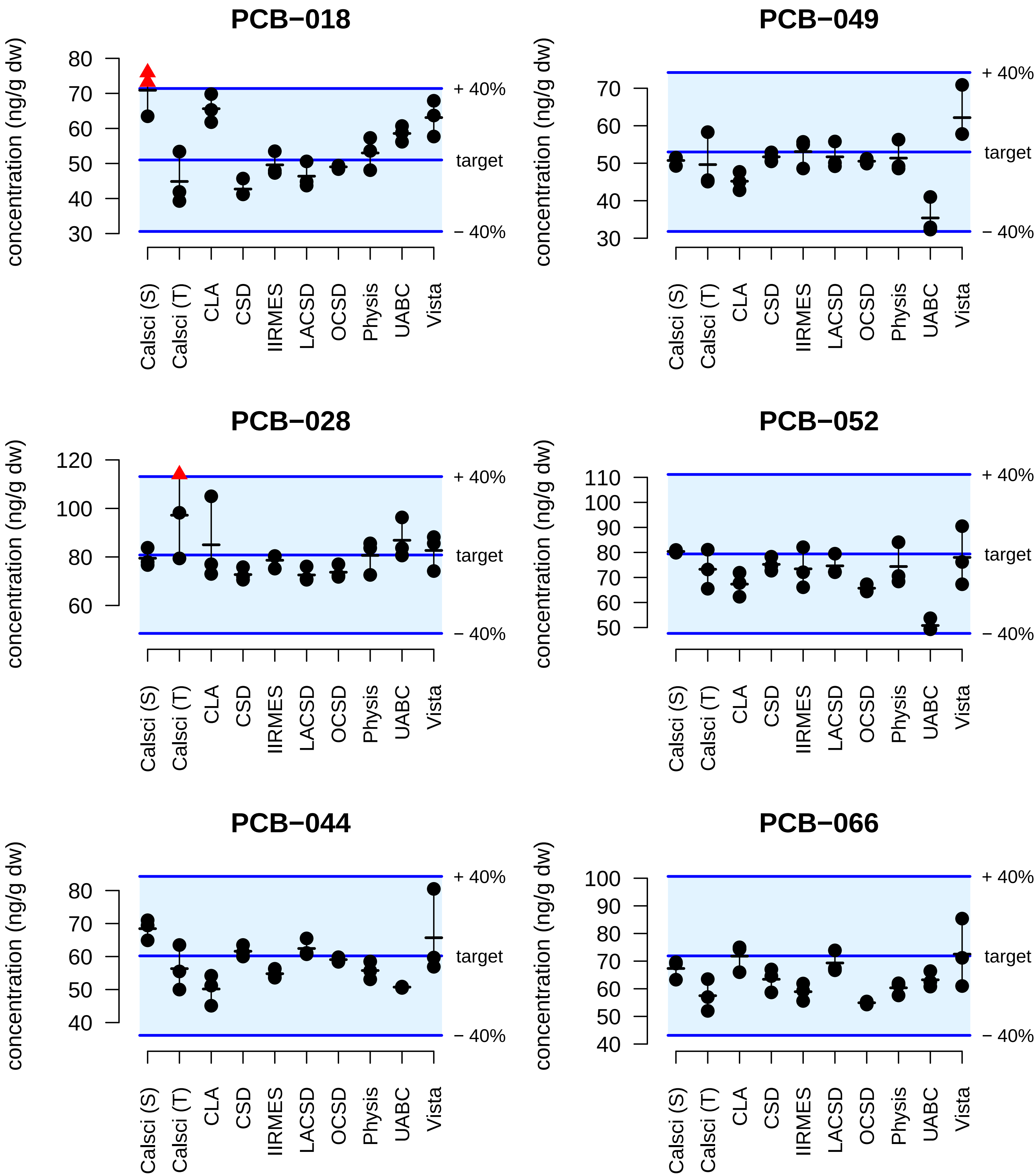

Pyrene
concentration (ng/g dw)
14000
12000
10000
8000
6000
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC

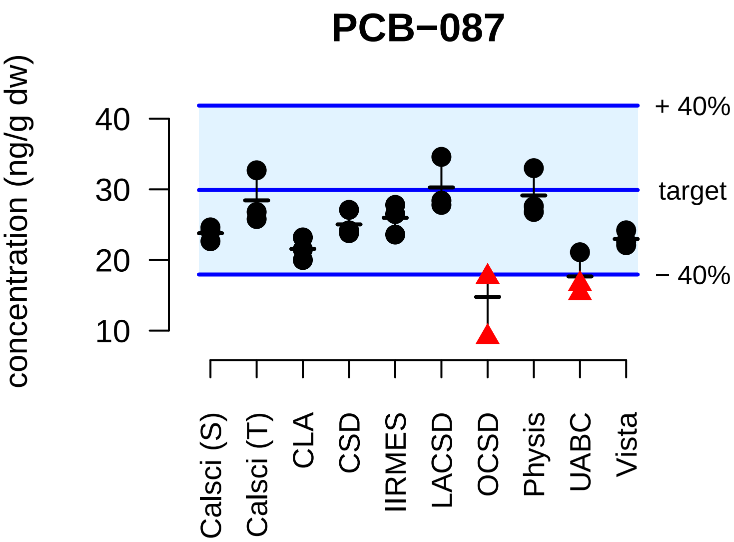
Number of passing replicates, out of three

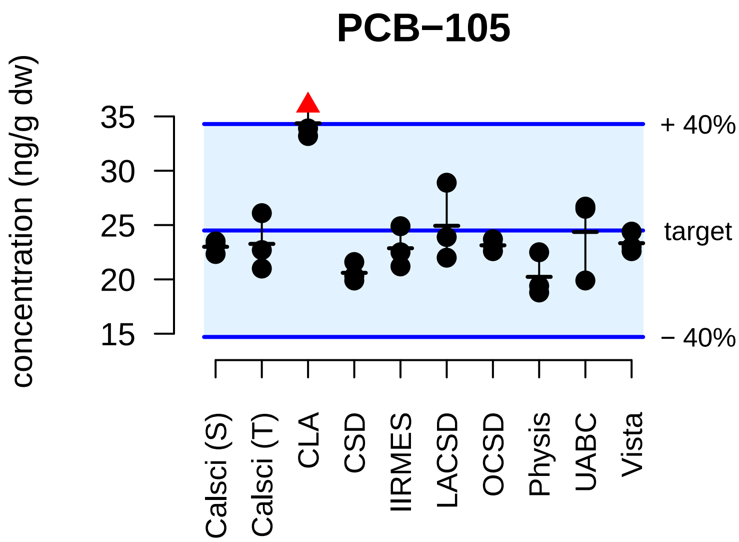
Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista
PCB−018	1	3	3	3	3	3	3	3	3	3
PCB−028	3	2	3	3	3	3	3	3	3	3
PCB−044	3	3	3	3	3	3	3	3	3	3
PCB−049	3	3	3	3	3	3	3	3	3	3
PCB−052	3	3	3	3	3	3	3	3	3	3
PCB−066	3	3	3	3	3	3	3	3	3	3
PCB−087	3	3	3	3	3	3	0	3	1	3
PCB−099	3	3	3	3	3	3	3	3	3	3
PCB−101	3	3	2	3	3	3	3	3	3	3
PCB−105	3	3	2	3	3	3	3	3	3	3
PCB−110	3	3	3	3	3	3	3	3	3	3
PCB−118	3	3	3	3	3	3	3	3	3	3
PCB−128	3	2	2	3	3	3	3	3	3	3
PCB−138	3	3	2	3	3	3	3	3	0	3
PCB−149	3	3	3	3	3	3	3	3	3	3
PCB−151	3	3	1	3	3	3	3	3	2	3
PCB−153	3	3	2	3	3	3	0	3	3	3
PCB−156	3	3	3	3	3	3	3	3	3	3
PCB−170	2	3	3	3	3	3	3	3	1	3
PCB−180	3	3	3	3	3	3	3	3	3	3
PCB−183	3	3	2	3	3	3	3	3	3	3
PCB−187	3	3	3	3	3	3	3	3	2	3
PCB−194	3	3	3	3	3	0	3	3	3	3
PCB−206	3	3	3	3	3	0	1	3	3	3

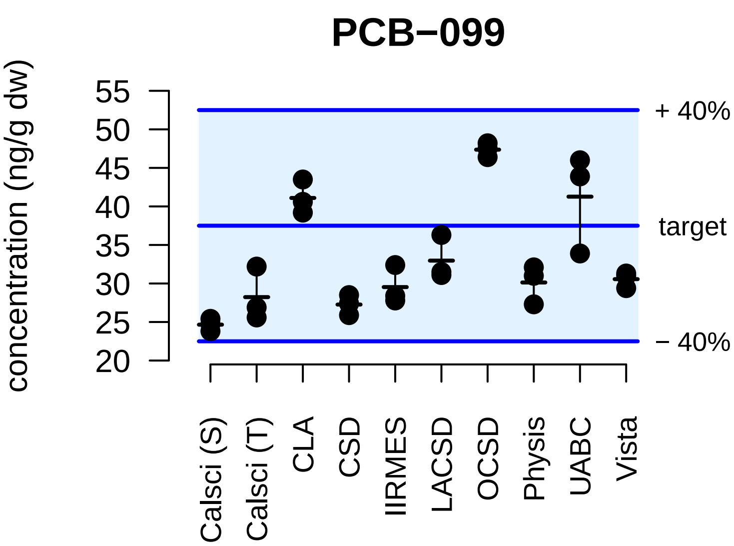
Percent passing and final result

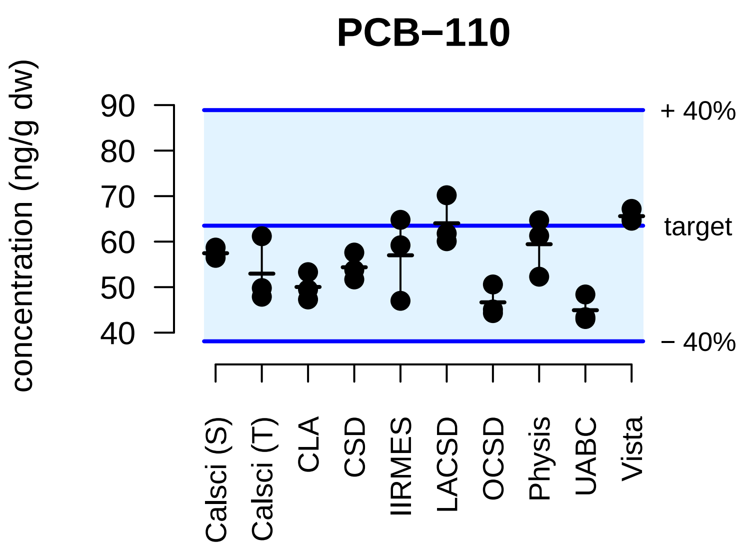
Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista
Percent	96	100	96	100	100	92	88	100	88	100
Result	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

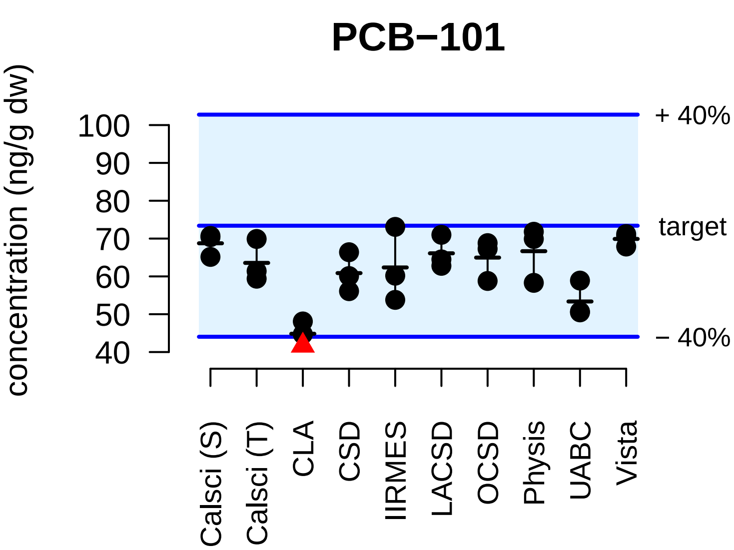

PCB−018
PCB−049
PCB−028
PCB−052
PCB−044
PCB−066
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

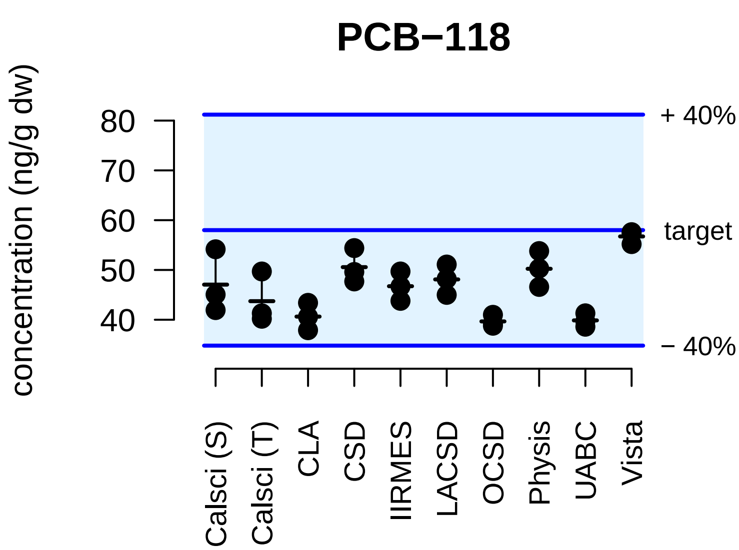

PCB−087
concentration (ng/g dw)
10
20
30
40
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

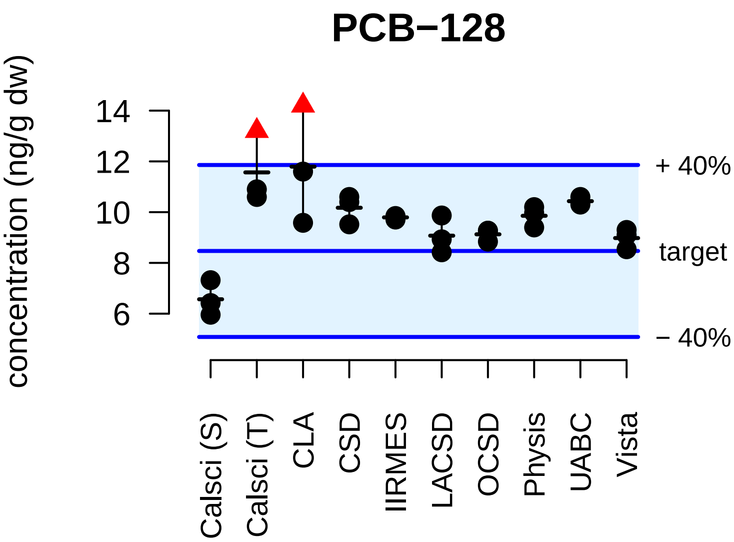

PCB−105
concentration (ng/g dw)
15
20
25
30
35
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

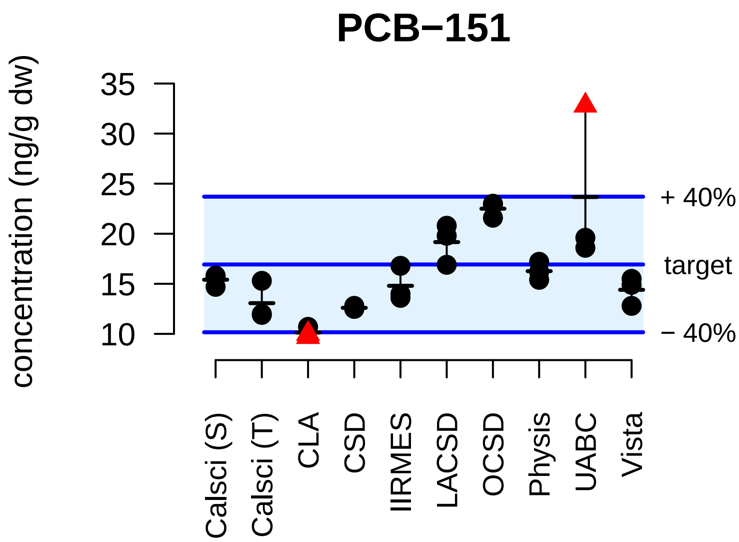

PCB−099
concentration (ng/g dw)
20
25
30
35
40
45
50
55
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

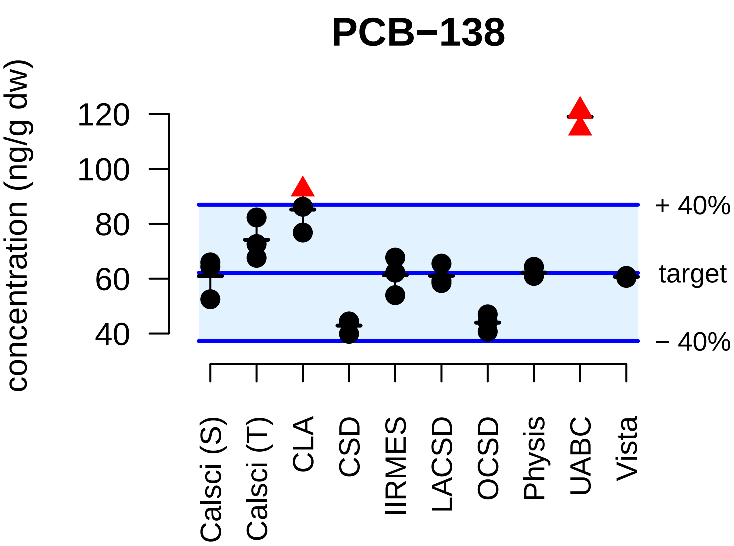

PCB−110
concentration (ng/g dw)
40
50
60
70
80
90
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

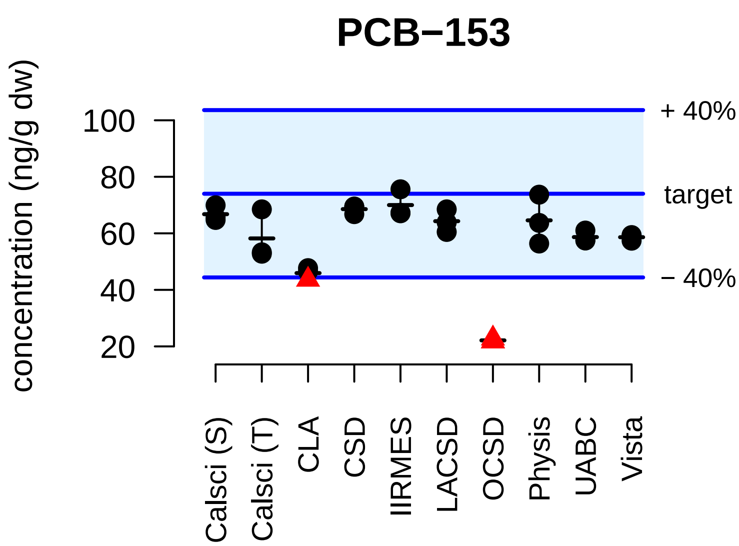

PCB−101
concentration (ng/g dw)
40
50
60
70
80
90
100
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

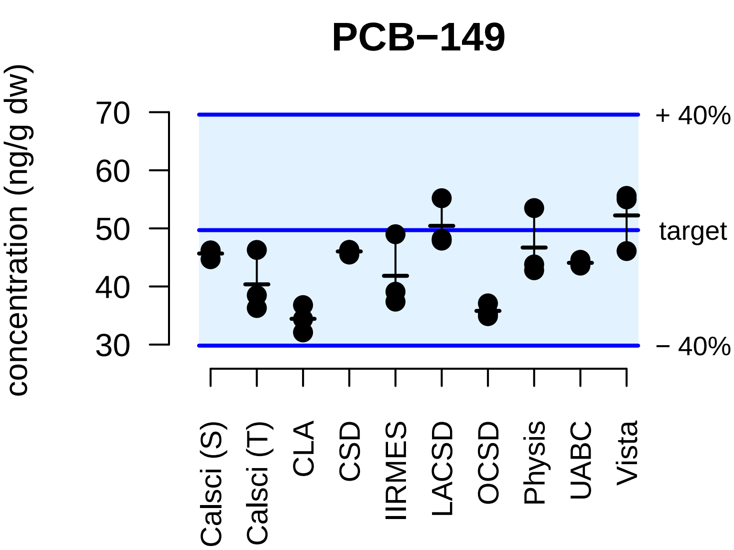

PCB−118
concentration (ng/g dw)
40
50
60
70
80
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

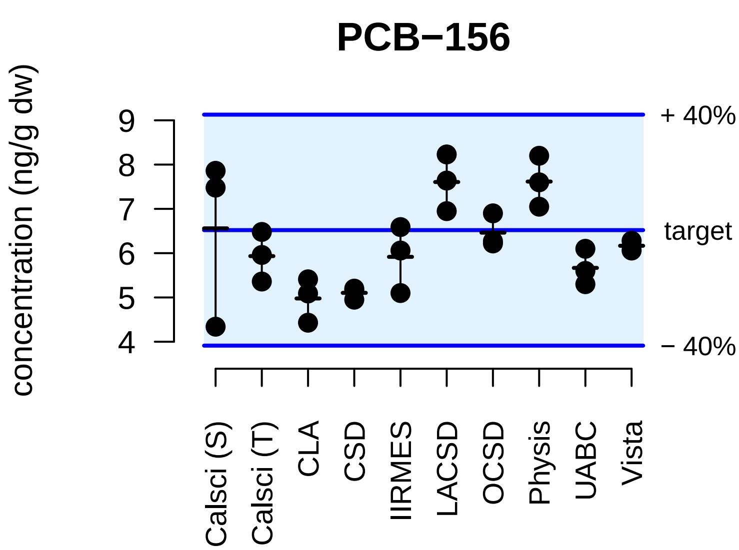

PCB−128
concentration (ng/g dw)
14
12
10
8
6
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

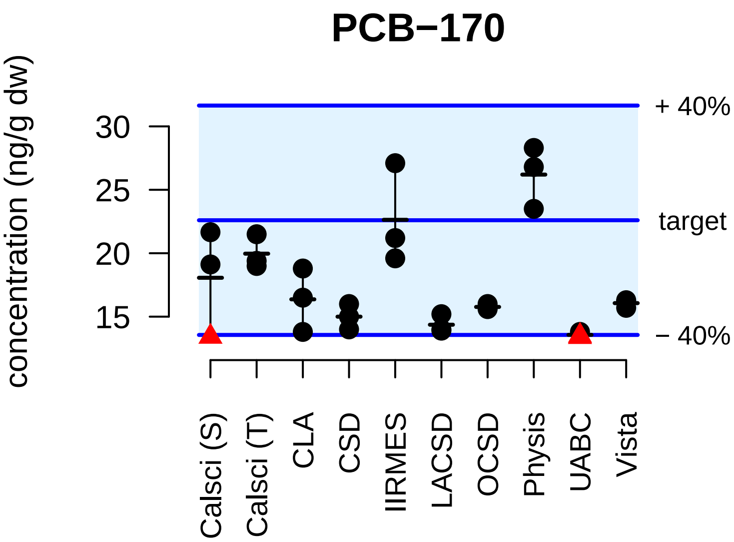

PCB−151
concentration (ng/g dw)
35
30
25
20
15
10
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

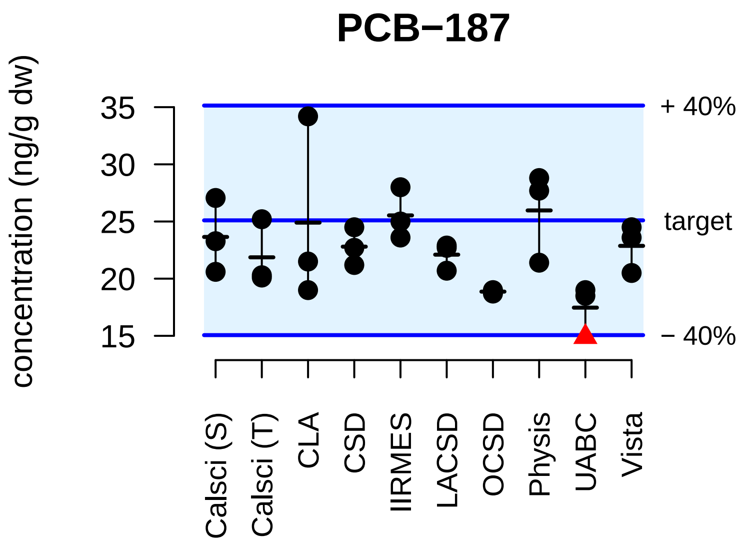

PCB−138
concentration (ng/g dw)
120
100
80
60
40
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

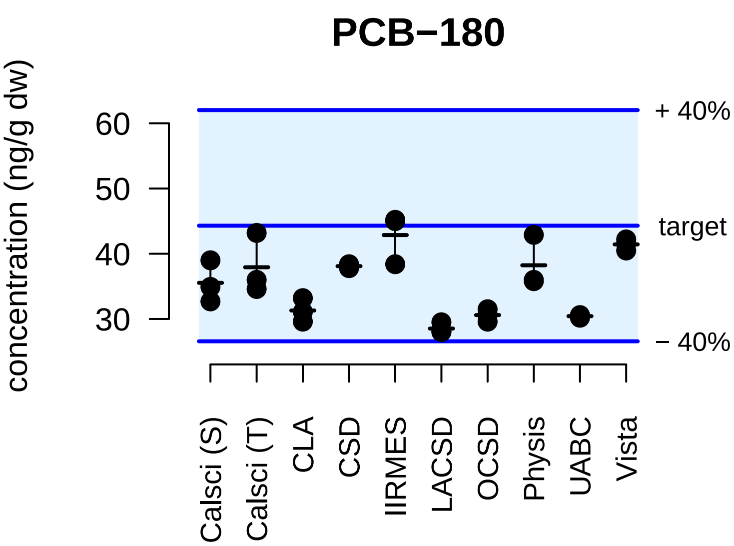

PCB−153
concentration (ng/g dw)
100
80
60
40
20
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

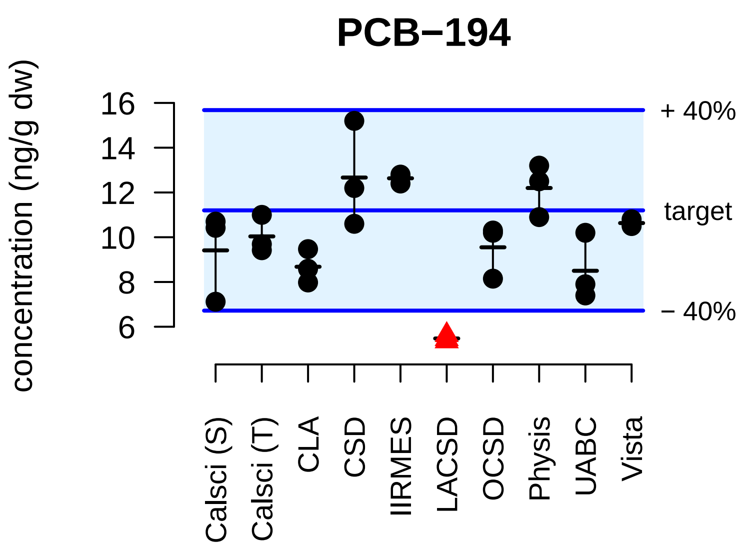

PCB−149
concentration (ng/g dw)
70
60
50
40
30
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

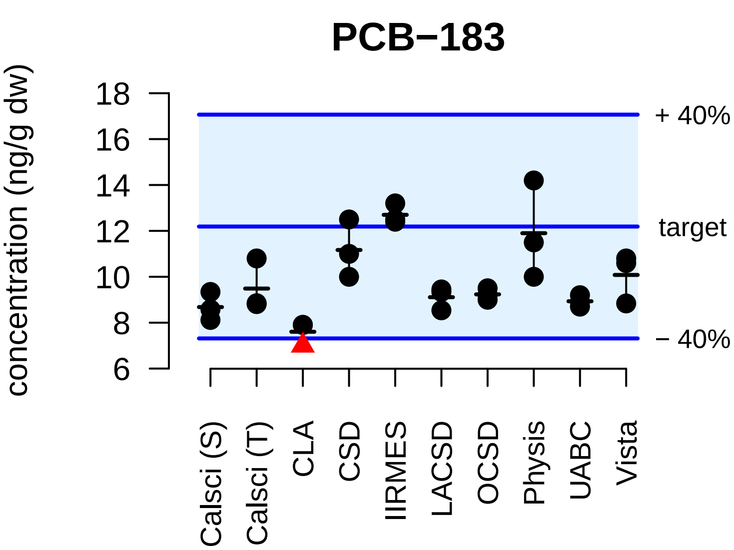

PCB−156
concentration (ng/g dw)
9
8
7
6
5
4
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

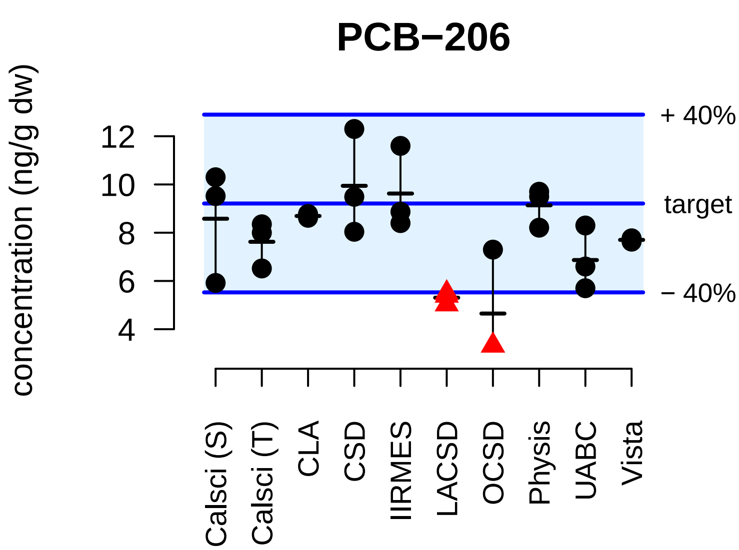

PCB−170
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


PCB−187
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


PCB−180
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


PCB−194
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


PCB−183
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


PCB−206
concentration (ng/g dw)
+ 40%
target
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

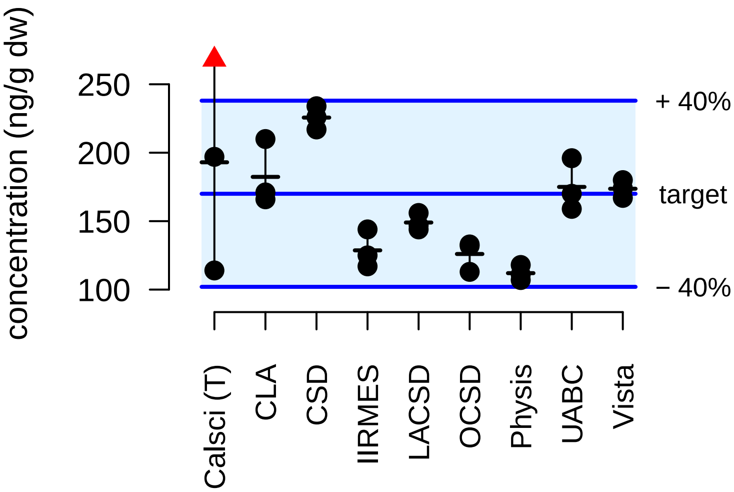
Number of passing replicates, out of three

Parameter	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista
2,4'−DDD	3	3	3	3	3	3	3	3	3
2,4'−DDE	3	2	3	2	3	3	2	3	3
4,4'−DDD	3	3	3	3	3	3	3	3	3
4,4'−DDE	3	1	3	3	3	0	3	3	3
4,4'−DDT	2	3	3	3	3	3	3	3	3
alpha−Chlordane	3	2	0	3	3	3	3	0	2
cis−nonachlor	2	3	2	3	0	2	3	3	2
gamma−Chlordane	2	3	3	3	0	2	0	3	3
trans−nonachlor	2	3	1	3	3	0	3	3	1

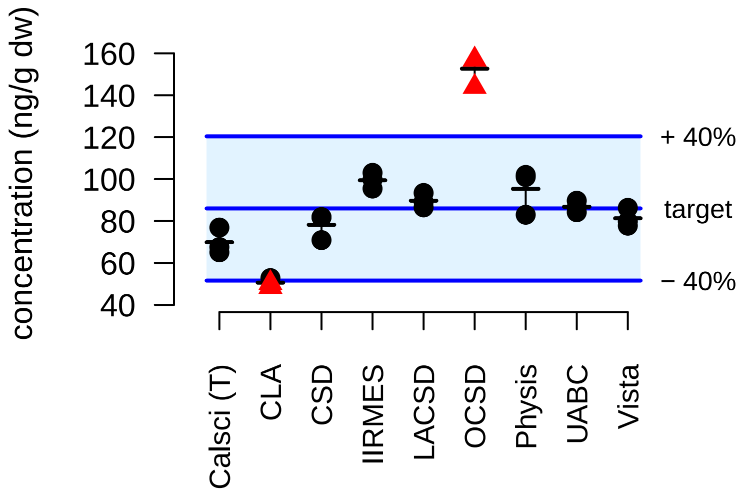
Percent passing and final result

Parameter	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista
Percent	100	89	78	100	78	78	89	89	89
Result	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

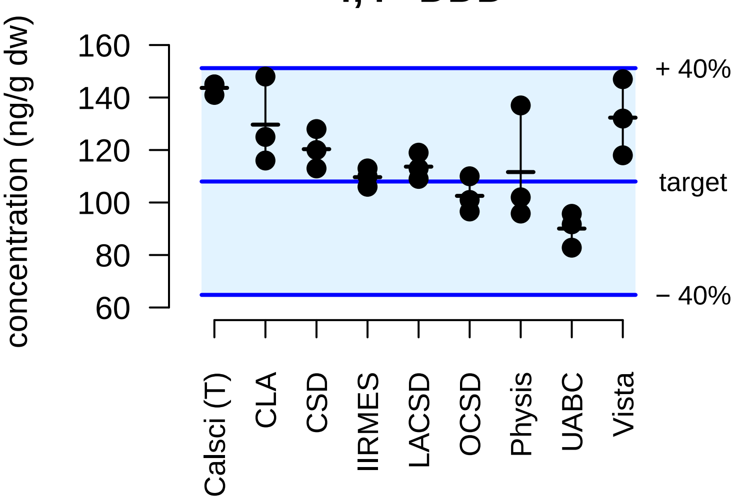
4,4'−DDT



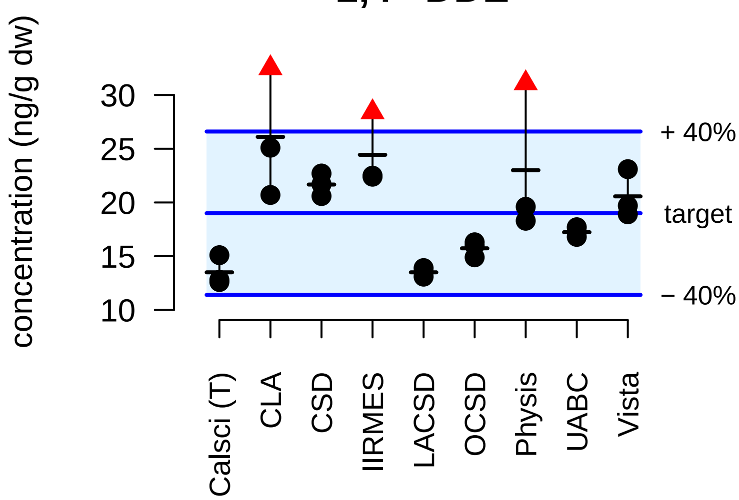
4,4'−DDE



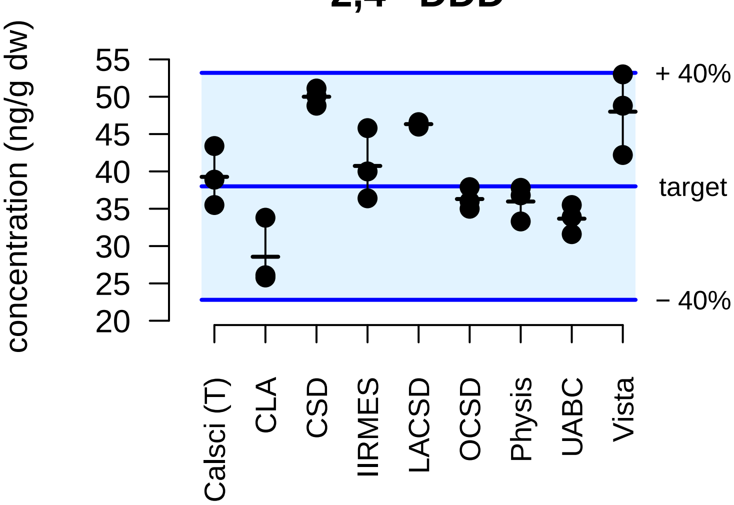
4,4'−DDD



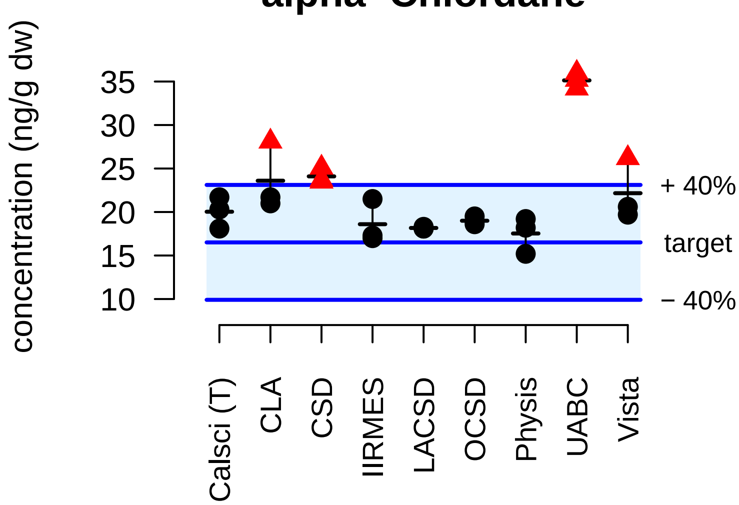
2,4'−DDE

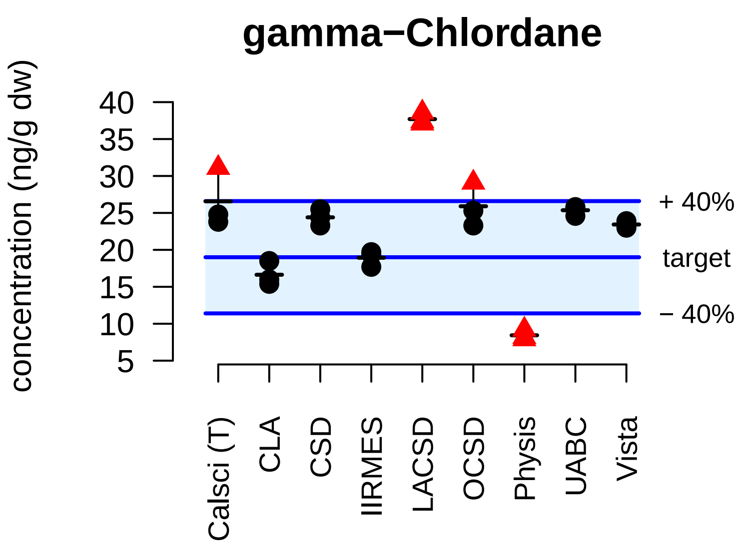


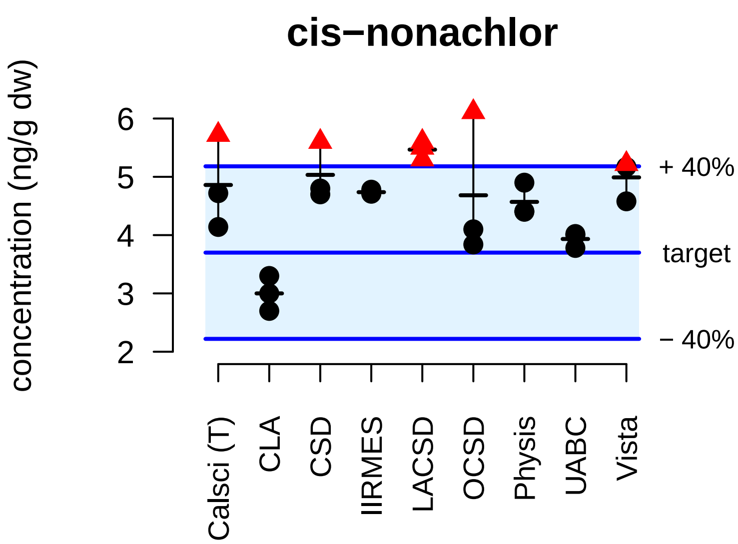
2,4'−DDD

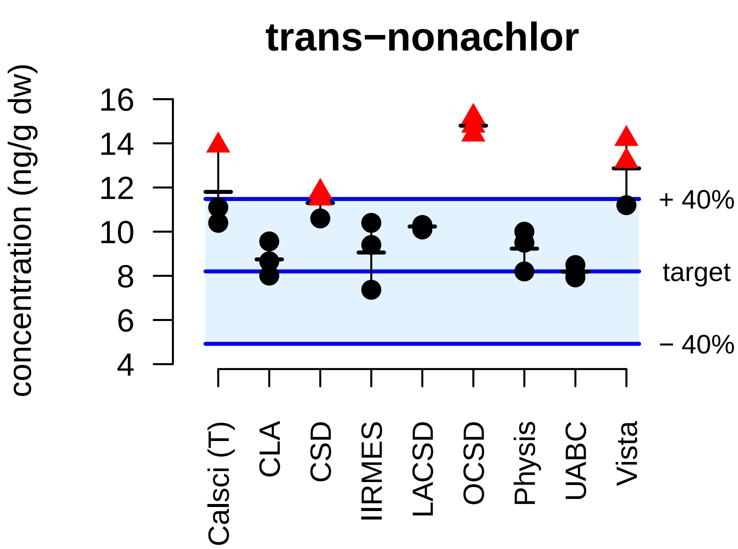


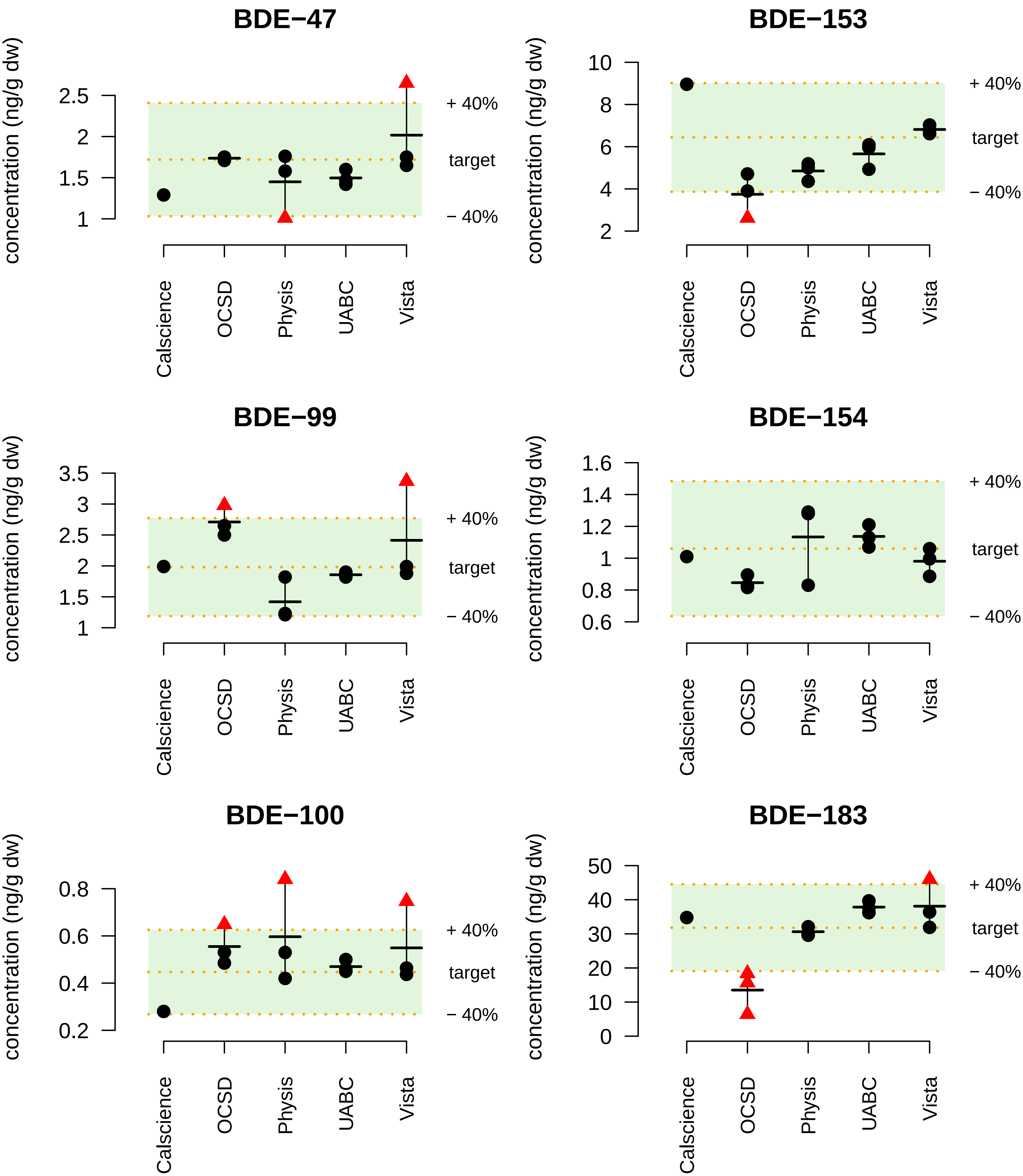
alpha−Chlordane




gamma−Chlordane
concentration (ng/g dw)
40
35
30
25
20
15
10
5
+ 40%
target
− 40%
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


cis−nonachlor
concentration (ng/g dw)
6
5
4
3
2
+ 40%
target
− 40%
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista


trans−nonachlor
concentration (ng/g dw)
16
14
12
10
8
6
4
+ 40%
target
− 40%
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

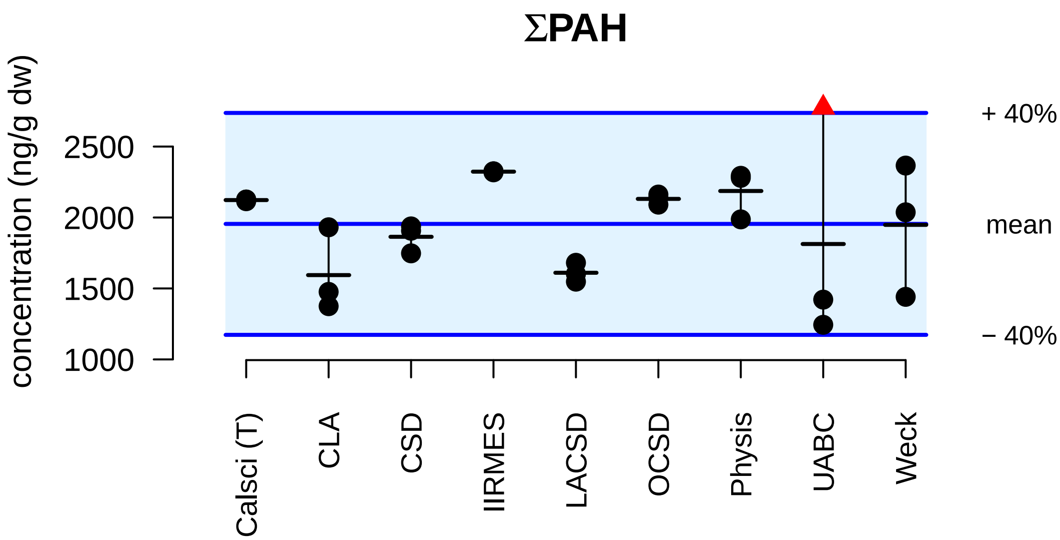

BDE−47
BDE−153
BDE−99
BDE−154
BDE−100
BDE−183
concentration (ng/g dw)
+ 40%
target
− 40%
Calscience
OCSD
Physis
UABC
Vista

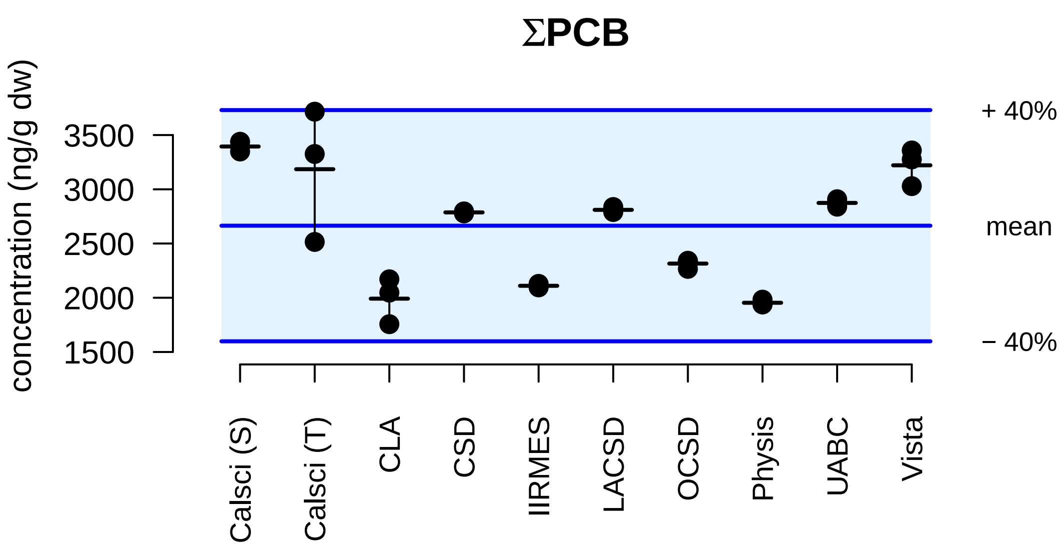
Number of passing replicates, out of three

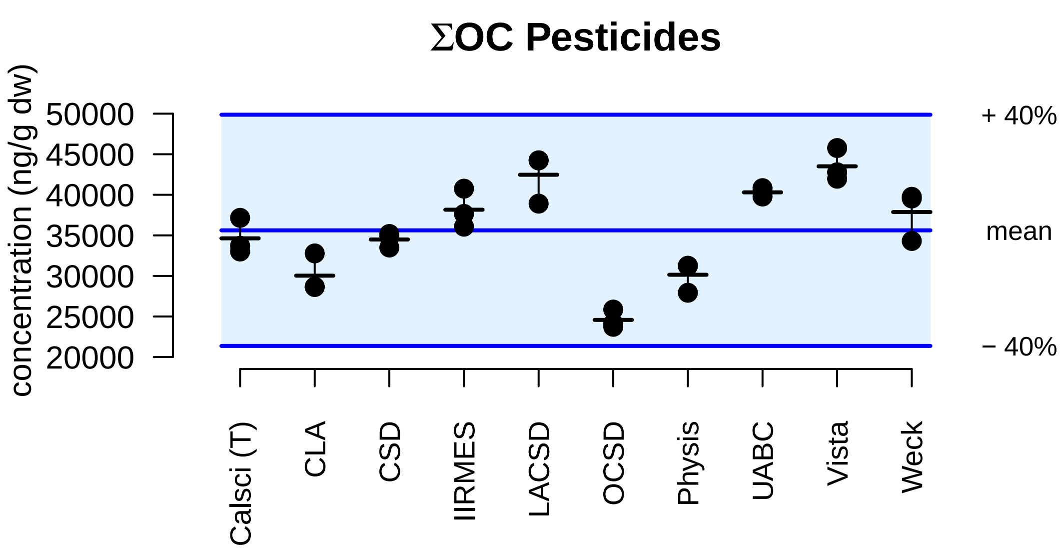
Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista	Weck
PCB	3	3	3	3	3	3	3	3	3	3	NA
OC Pesticides	NA	3	3	3	3	3	3	3	3	3	3
PAH	NA	3	3	3	3	3	3	3	2	NA	3

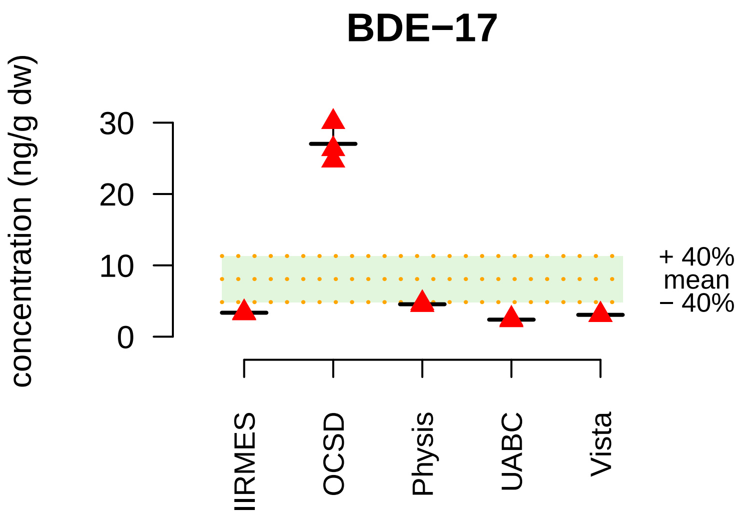
Final result

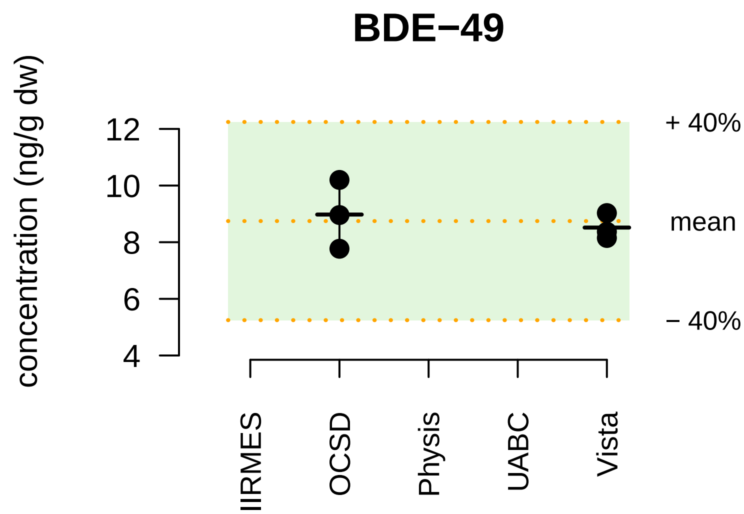
Parameter	Calsci (S)	Calsci (T)	CLA	CSD	IIRMES	LACSD	OCSD	Physis	UABC	Vista	Weck
PCB	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	NA
OC Pesticides	NA	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
PAH	NA	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	NA	PASS

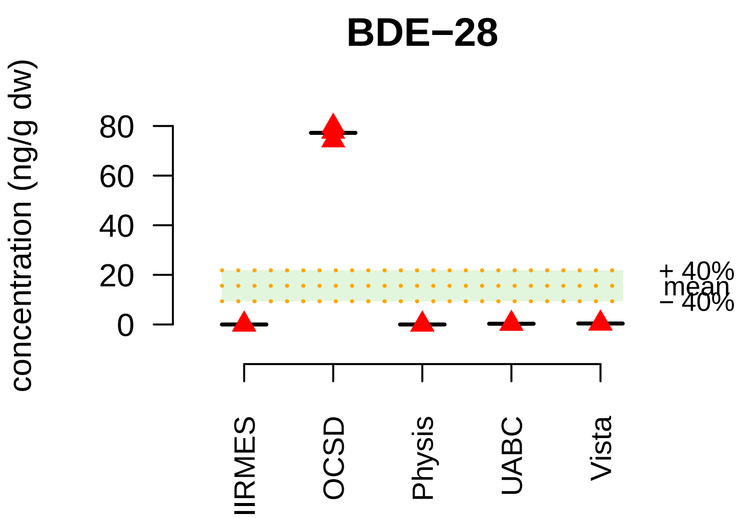

ΣPAH
concentration (ng/g dw)
2500
2000
1500
1000
+ 40%
mean
− 40%
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

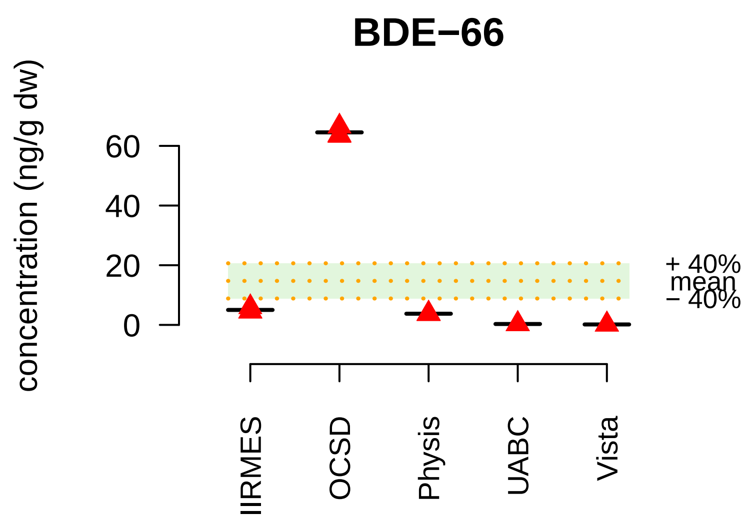

ΣPCB
concentration (ng/g dw)
3500
3000
2500
2000
1500
+ 40%
mean
− 40%
Calsci (S)
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista

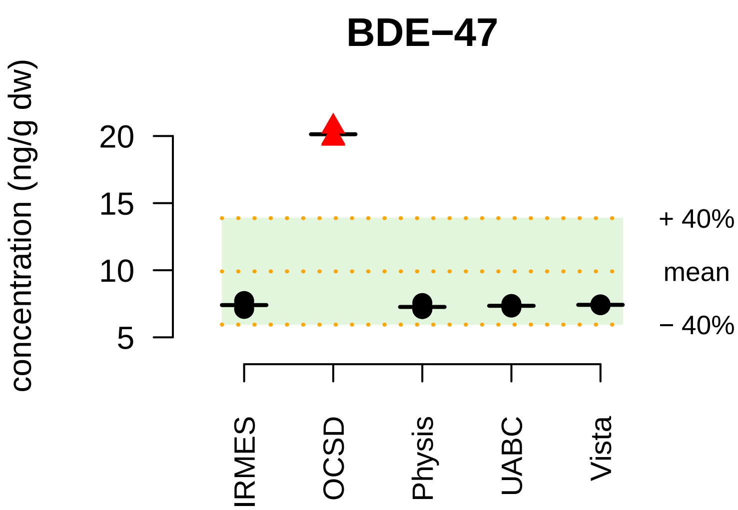

ΣOC Pesticides
concentration (ng/g dw)
50000
45000
40000
35000
30000
25000
20000
+ 40%
mean
− 40%
Calsci (T)
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Vista
Weck

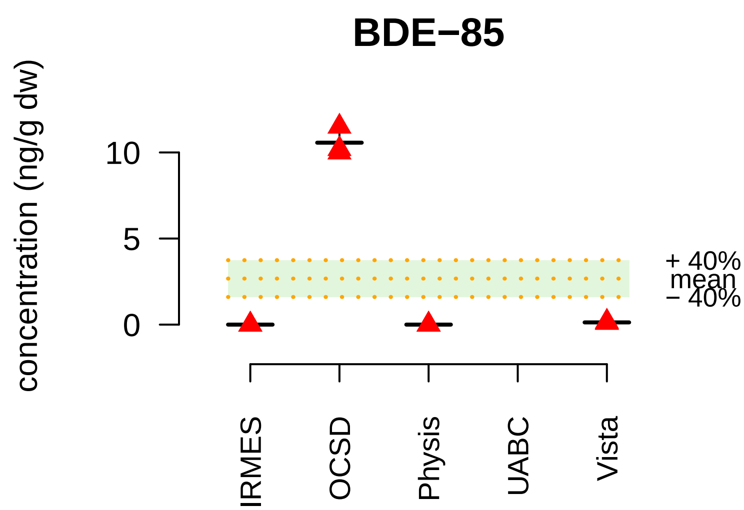

BDE−17
concentration (ng/g dw)
0
10
20
30
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

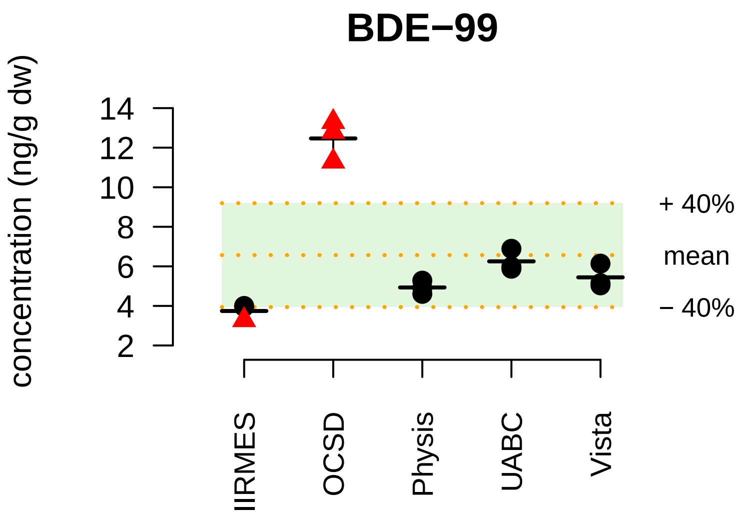

BDE−49
concentration (ng/g dw)
4
6
8
10
12
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

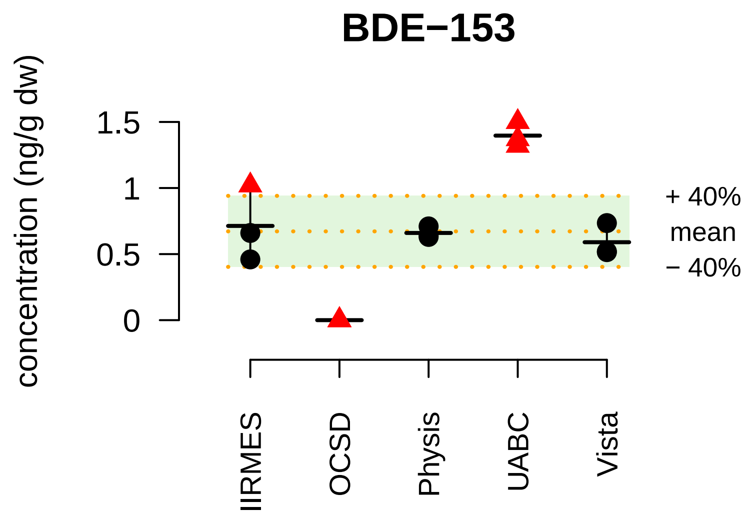

BDE−28
concentration (ng/g dw)
0
20
40
60
80
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

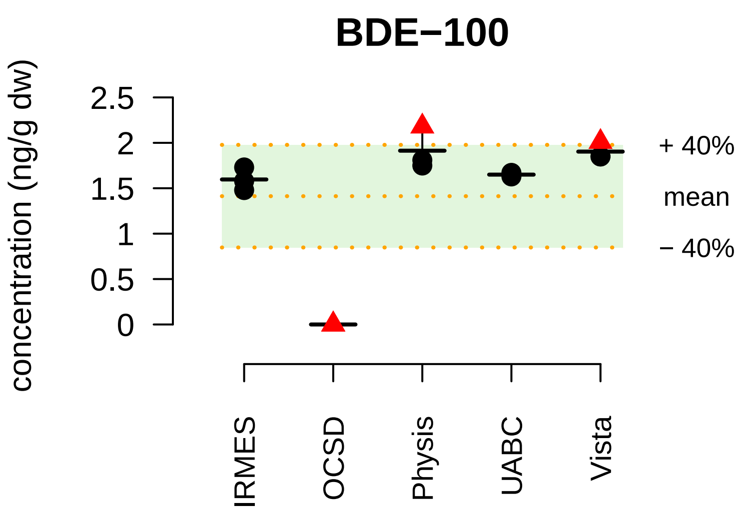

BDE−66
concentration (ng/g dw)
0
20
40
60
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

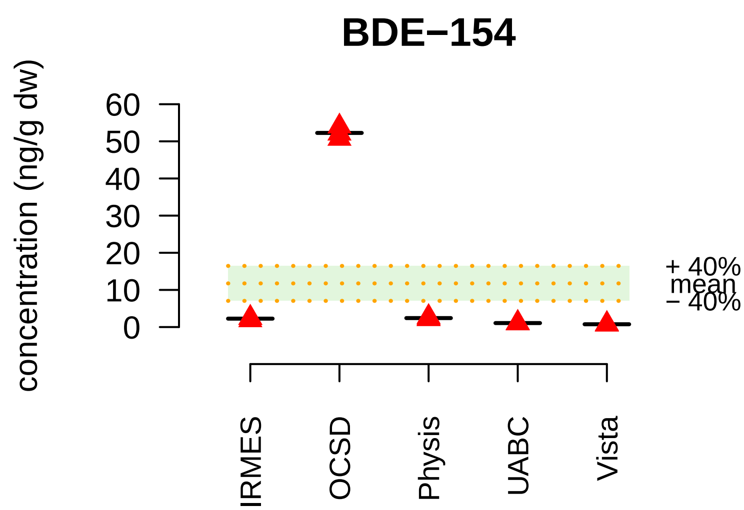

BDE−47
concentration (ng/g dw)
5
10
15
20
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

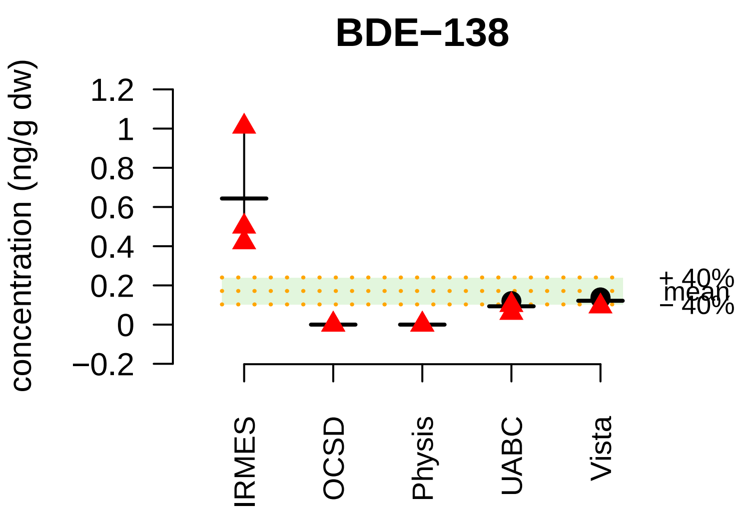

BDE−85
concentration (ng/g dw)
0
5
10
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

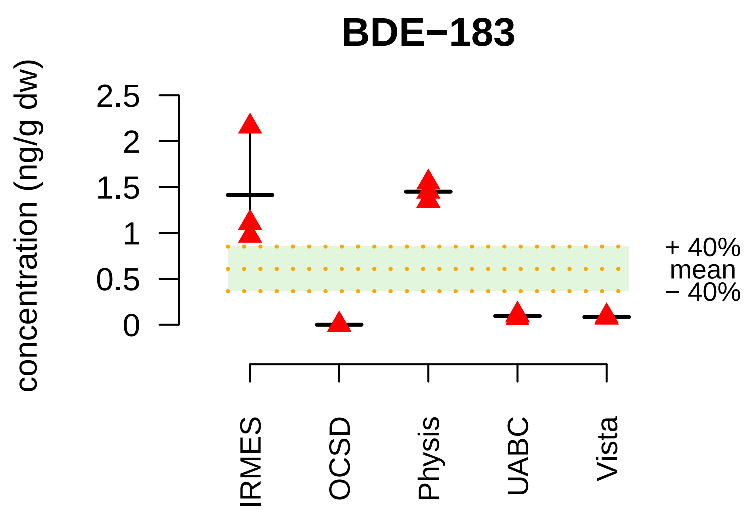

BDE−99
concentration (ng/g dw)
14
12
10
8
6
4
2
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

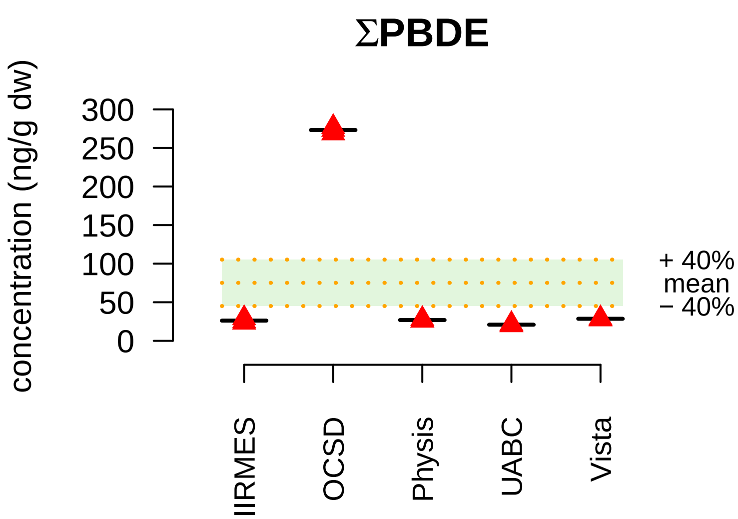

BDE−153
concentration (ng/g dw)
1.5
1
0.5
0
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista


BDE−100
concentration (ng/g dw)
2.5
2
1.5
1
0.5
0
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista


BDE−154
concentration (ng/g dw)
60
50
40
30
20
10
0
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista


BDE−138
concentration (ng/g dw)
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista


BDE−183
concentration (ng/g dw)
2.5
2
1.5
1
0.5
0
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista


ΣPBDE
concentration (ng/g dw)
300
250
200
150
100
50
0
+ 40%
mean
− 40%
IIRMES
OCSD
Physis
UABC
Vista

Number of passing replicates, out of three

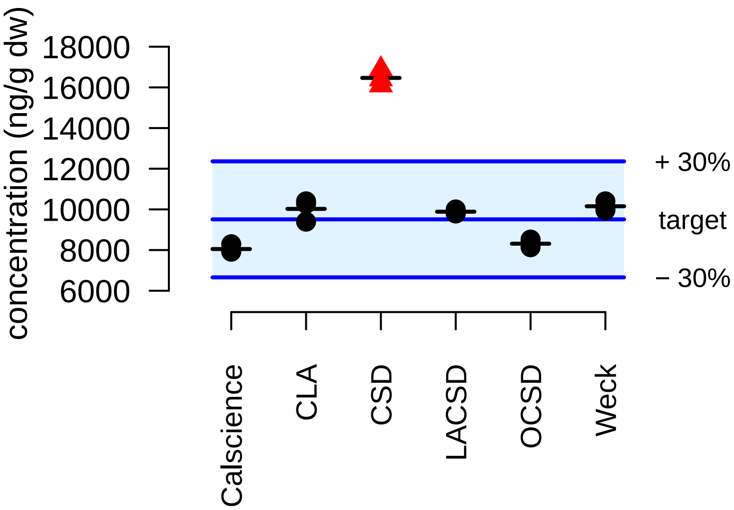
UABC did not measure all 15 metals and is not included in the summary.
UABC data is shown in the control charts.

Parameter	Calscience	CLA	CSD	IIRMES	LACSD	OCSD	Physis	Weck
Aluminum	3	3	0	0	3	3	0	3
Antimony	3	3	0	0	3	3	0	0
Arsenic	3	3	3	3	3	3	3	3
Barium	3	3	3	3	3	3	3	3
Beryllium	3	3	3	3	3	3	3	3
Cadmium	3	3	3	3	3	3	3	3
Chromium	3	3	3	3	3	3	3	3
Copper	3	3	3	3	3	3	3	3
Iron	3	3	0	3	3	3	0	3
Lead	3	3	3	3	3	3	3	3
Mercury	3	3	3	3	3	2	3	3
Nickel	3	3	3	3	3	3	3	3
Selenium	3	3	3	3	3	3	3	3
Silver	3	3	3	3	3	3	3	2
Zinc	3	3	3	3	3	3	3	3

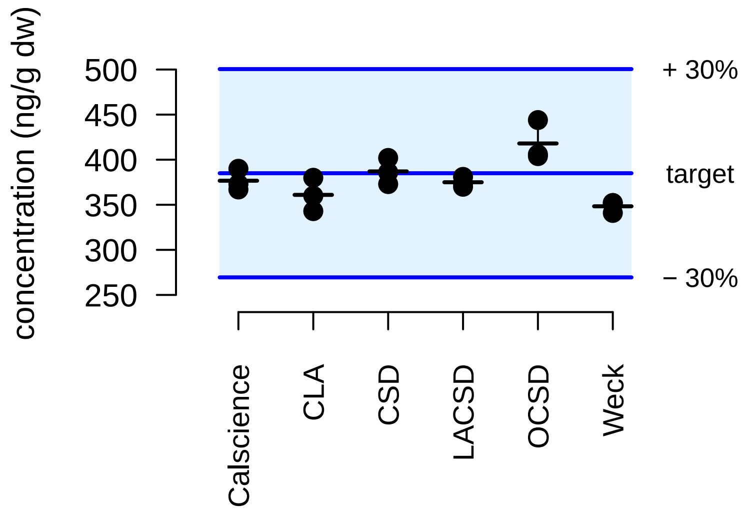
Percent passing and final result

Parameter	Calscience	CLA	CSD	IIRMES	LACSD	OCSD	Physis	Weck
Percent	100	100	80	87	100	100	80	93
Result	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

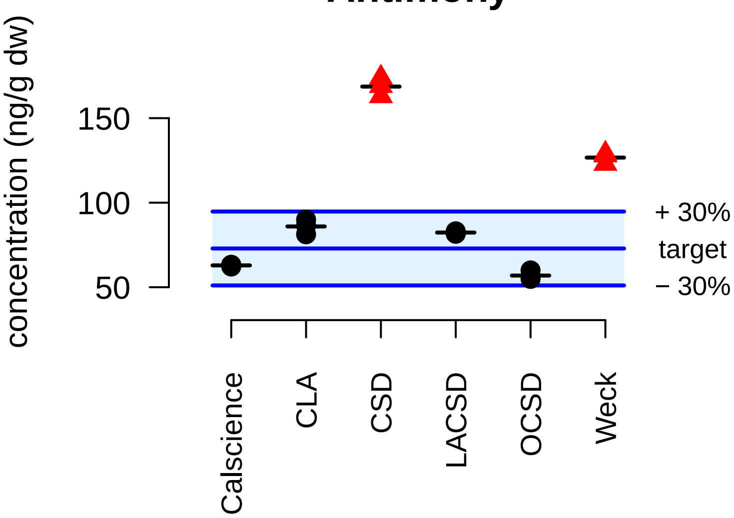
Aluminum



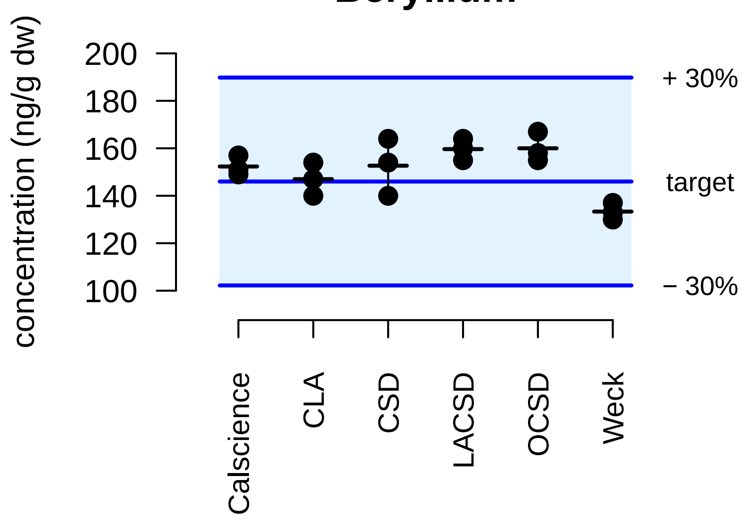
Barium



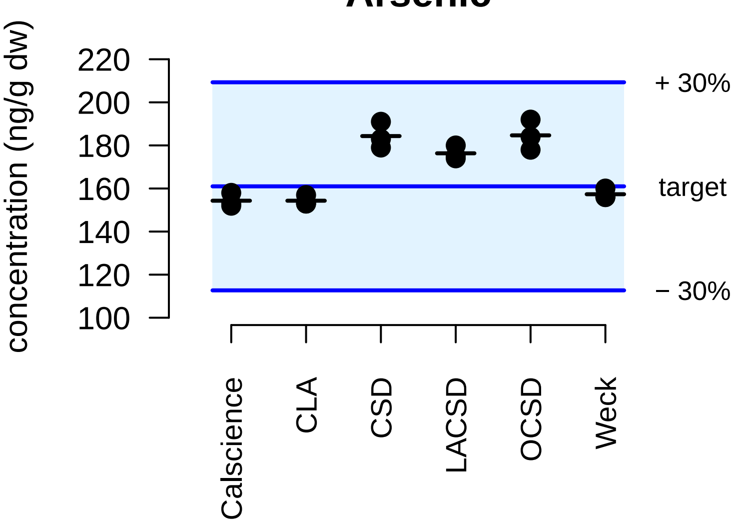
Antimony



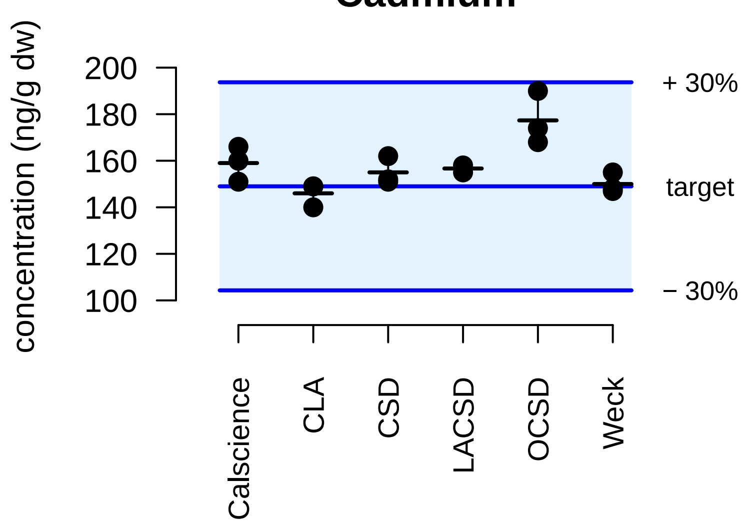
Beryllium

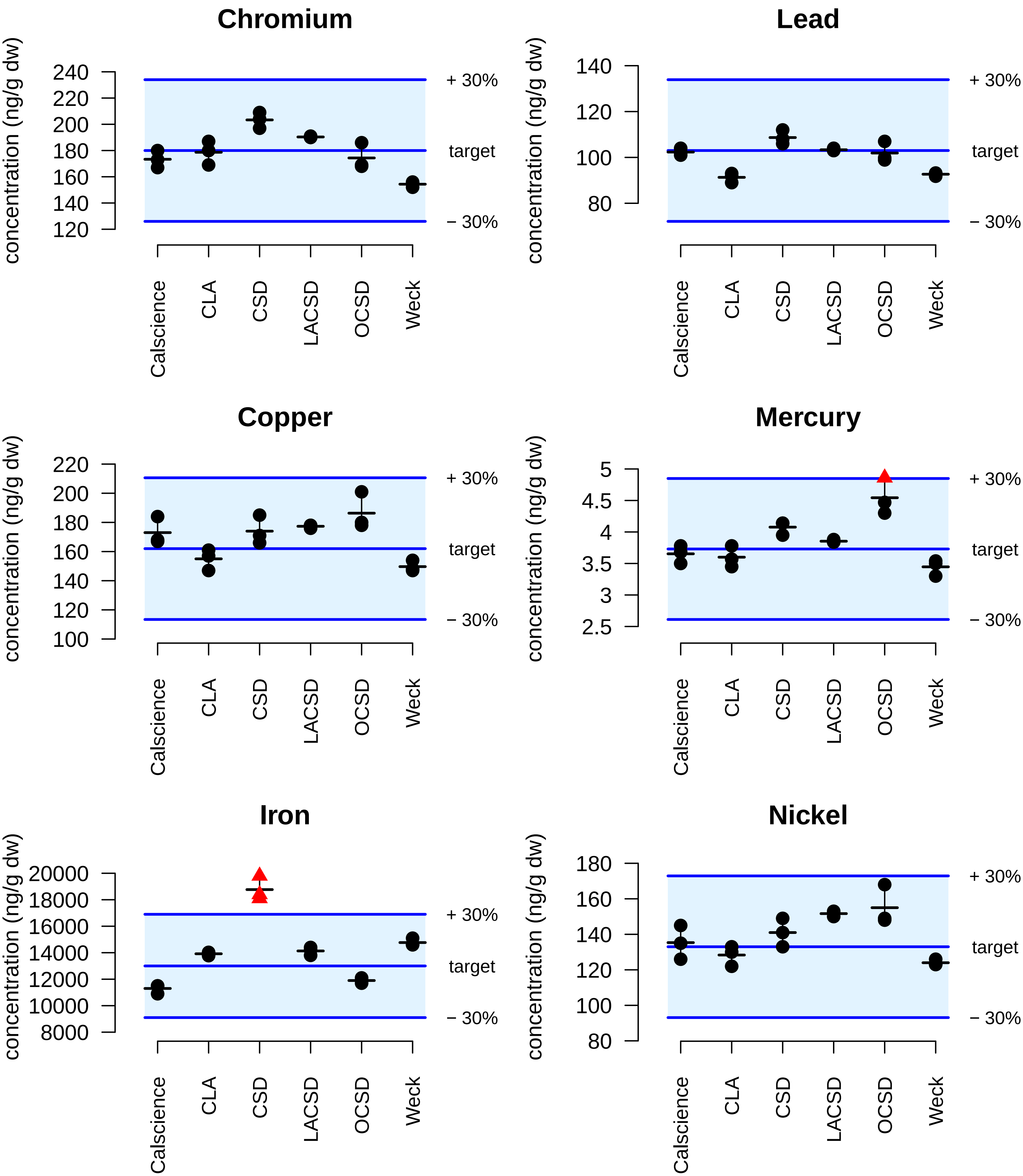


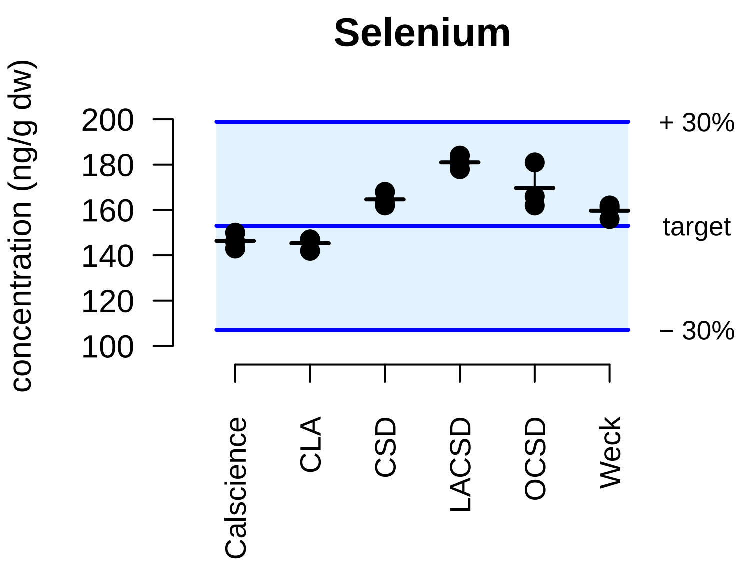
Arsenic

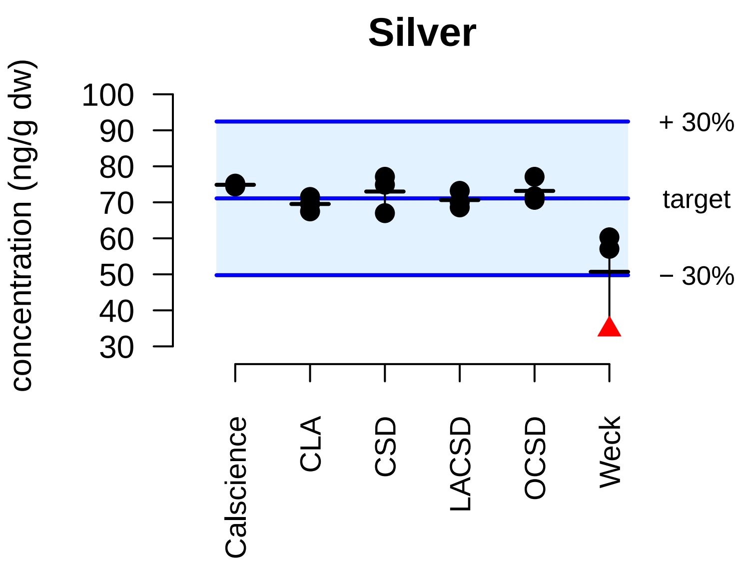


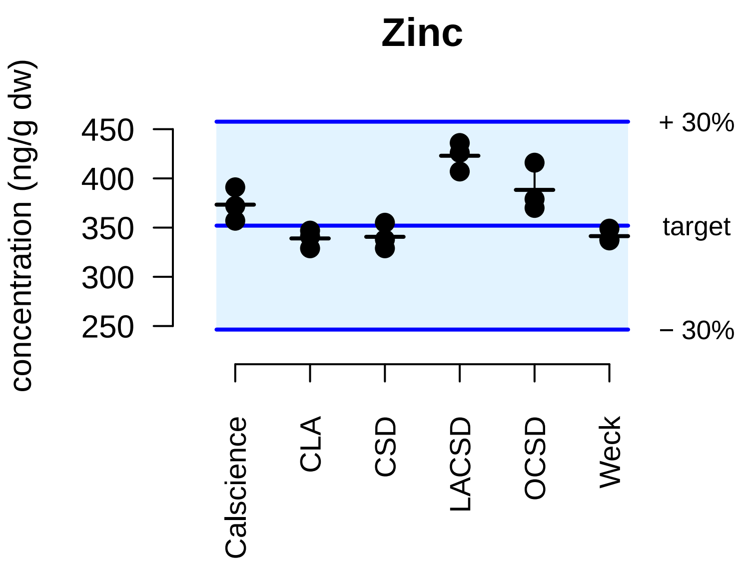
Cadmium

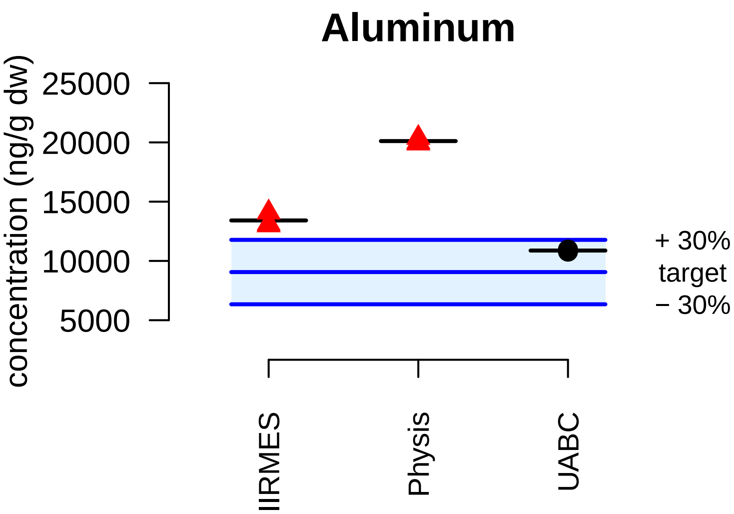


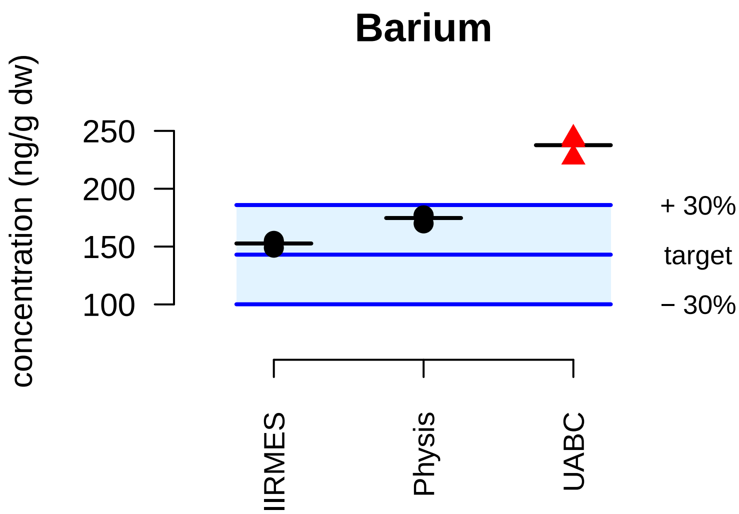

Chromium
concentration (ng/g dw)
240
220
200
180
160
140
120
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck
Lead
concentration (ng/g dw)
140
120
100
80
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck
Copper
concentration (ng/g dw)
220
200
180
160
140
120
100
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck
Mercury
concentration (ng/g dw)
5
4.5
4
3.5
3
2.5
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck
Iron
concentration (ng/g dw)
20000
18000
16000
14000
12000
10000
8000
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck
Nickel
concentration (ng/g dw)
180
160
140
120
100
80
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck

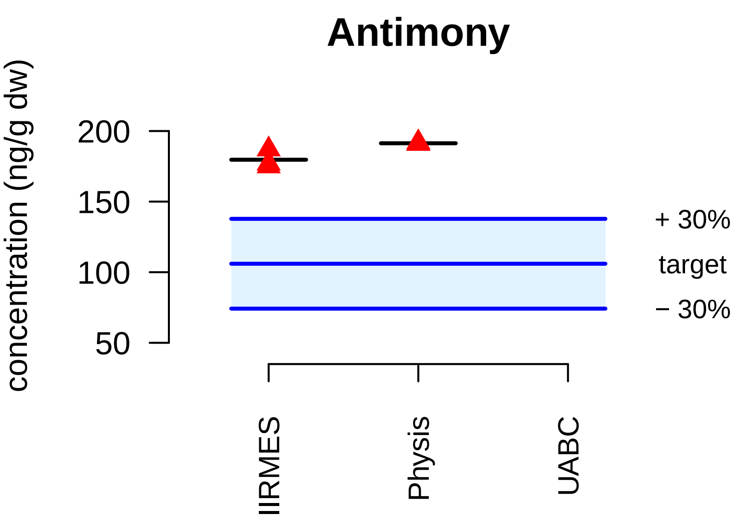

Selenium
concentration (ng/g dw)
200
180
160
140
120
100
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck

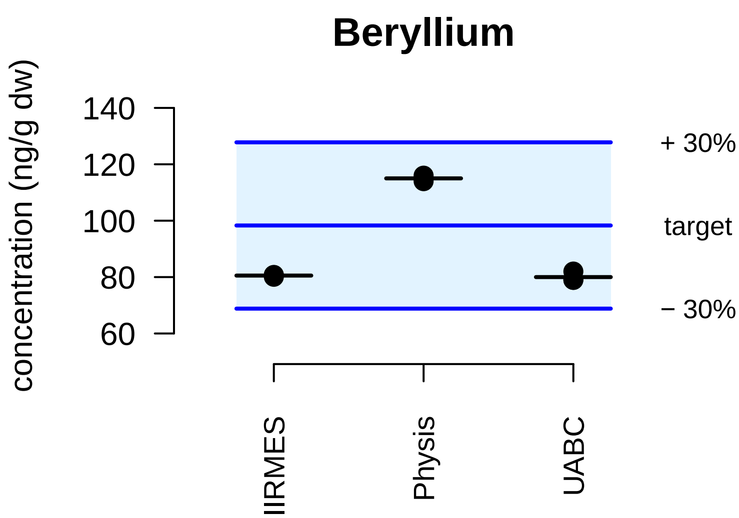

Silver
concentration (ng/g dw)
100
90
80
70
60
50
40
30
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck

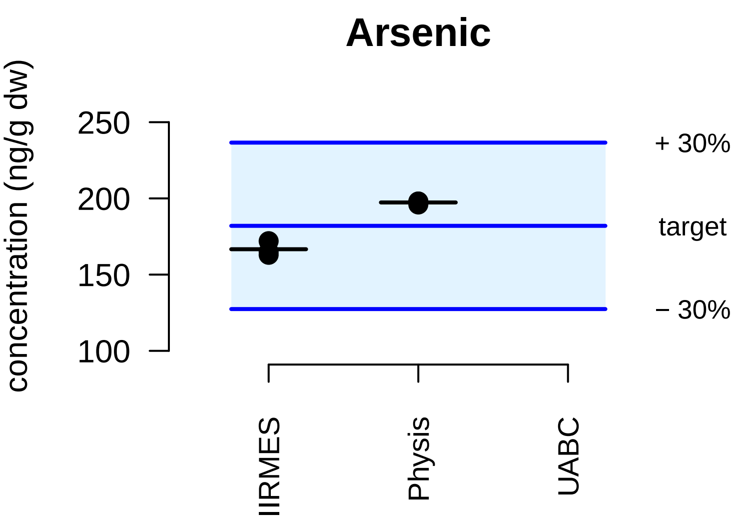

Zinc
concentration (ng/g dw)
450
400
350
300
250
+ 30%
target
− 30%
Calscience
CLA
CSD
LACSD
OCSD
Weck

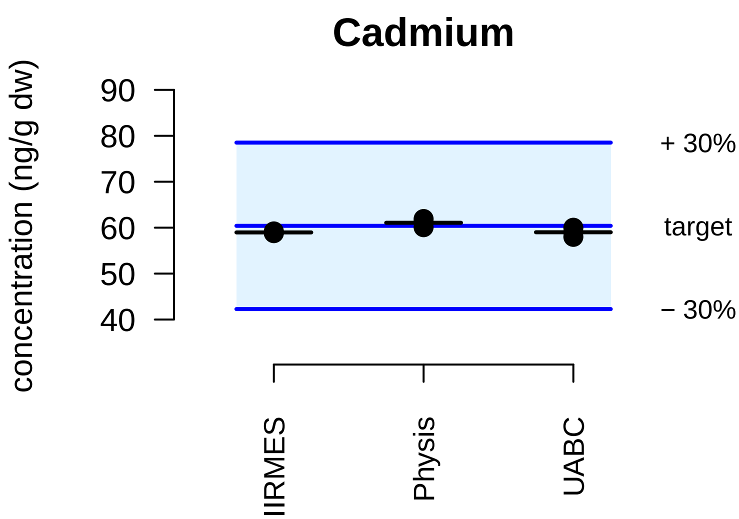

Aluminum
concentration (ng/g dw)
25000
20000
15000
10000
5000
+ 30%
target
− 30%
IIRMES
Physis
UABC

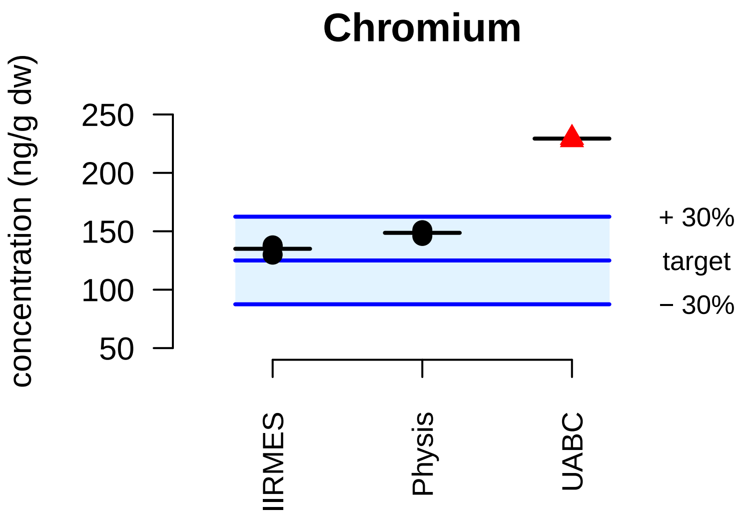

Barium
concentration (ng/g dw)
250
200
150
100
+ 30%
target
− 30%
IIRMES
Physis
UABC

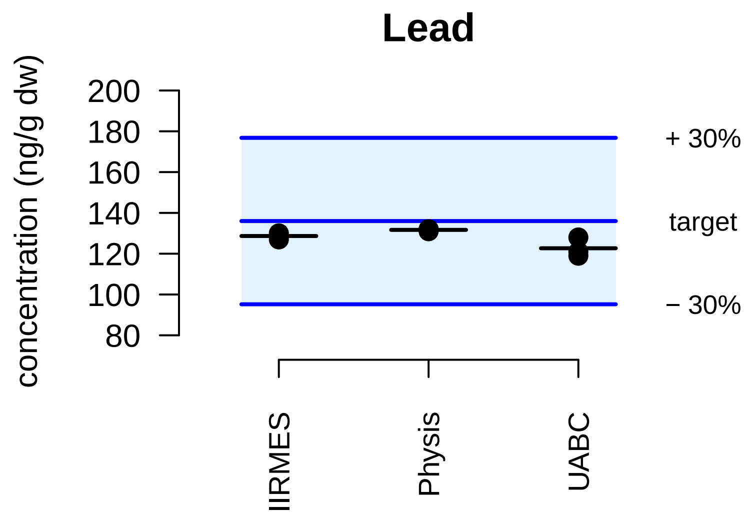

Antimony
concentration (ng/g dw)
200
150
100
50
+ 30%
target
− 30%
IIRMES
Physis
UABC

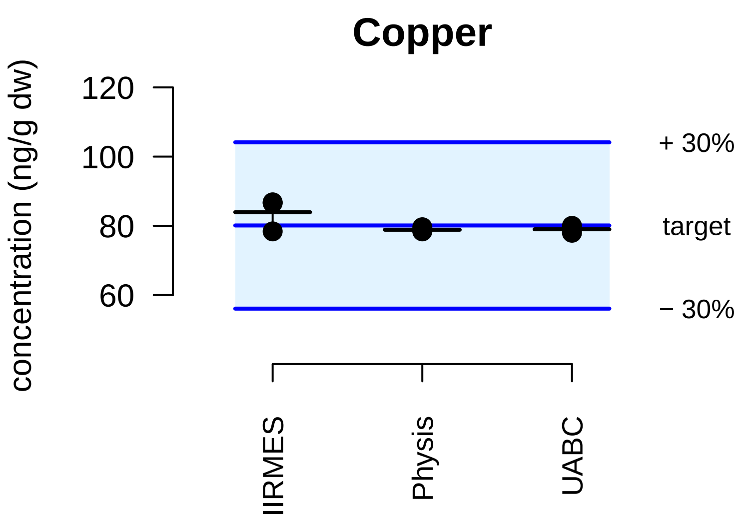

Beryllium
concentration (ng/g dw)
140
120
100
80
60
+ 30%
target
− 30%
IIRMES
Physis
UABC

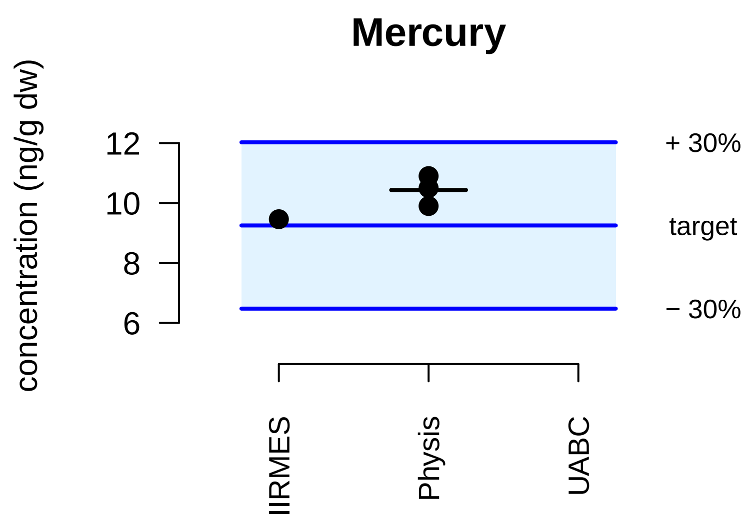

Arsenic
concentration (ng/g dw)
250
200
150
100
+ 30%
target
− 30%
IIRMES
Physis
UABC

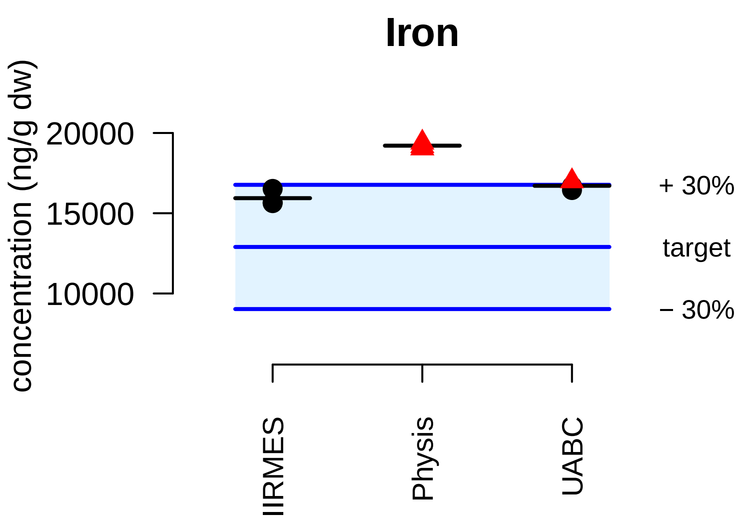

Cadmium
concentration (ng/g dw)
90
80
70
60
50
40
+ 30%
target
− 30%
IIRMES
Physis
UABC

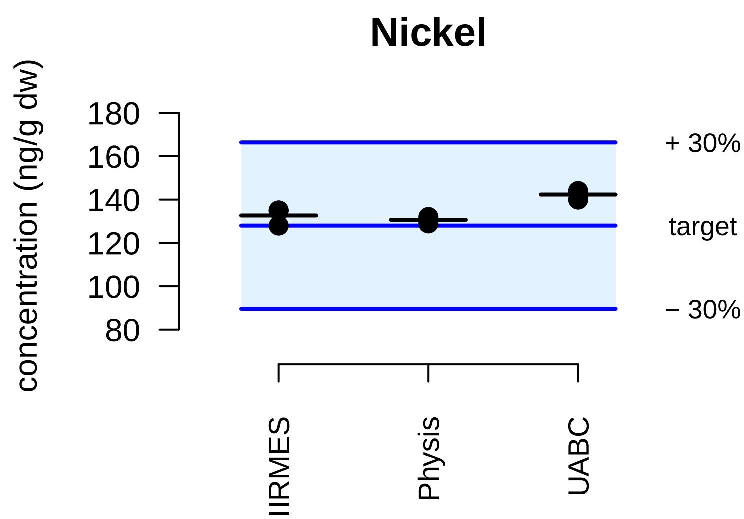

Chromium
concentration (ng/g dw)
250
200
150
100
50
+ 30%
target
− 30%
IIRMES
Physis
UABC

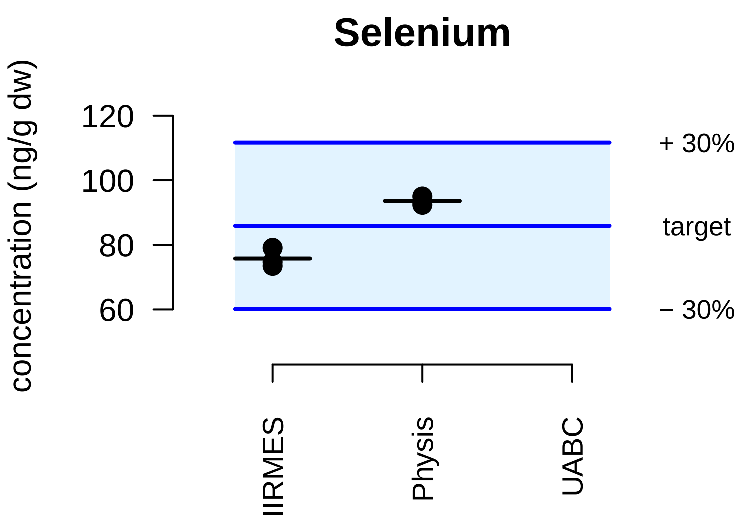

Lead
concentration (ng/g dw)
200
180
160
140
120
100
80
+ 30%
target
− 30%
IIRMES
Physis
UABC

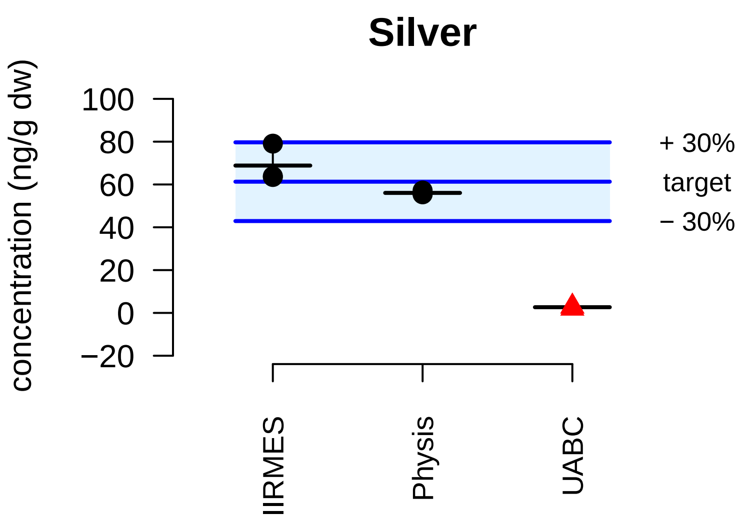

Copper
concentration (ng/g dw)
120
100
80
60
+ 30%
target
− 30%
IIRMES
Physis
UABC

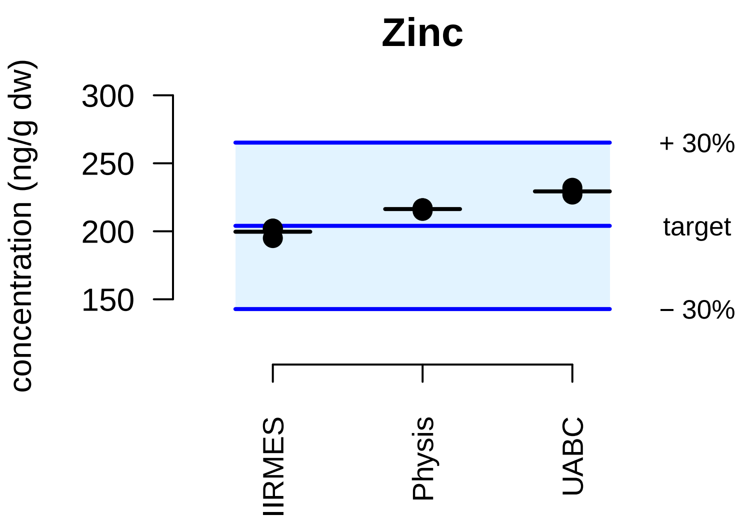

Mercury
concentration (ng/g dw)
12
10
8
6
+ 30%
target
− 30%
IIRMES
Physis
UABC

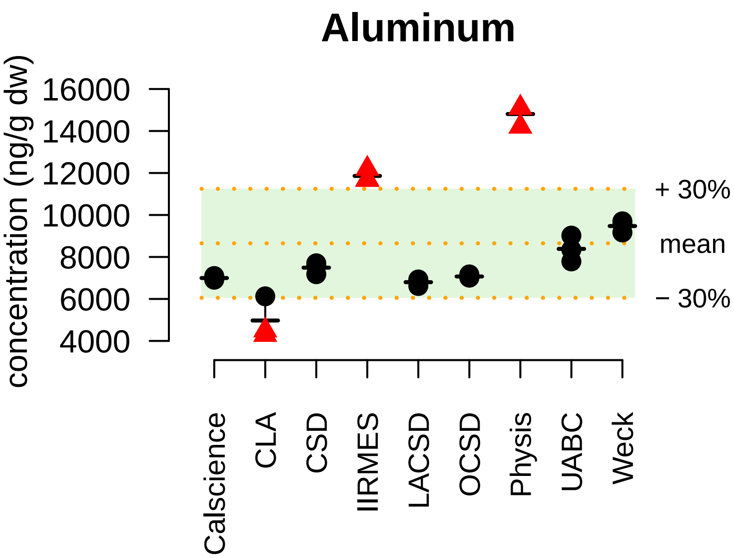

Iron
concentration (ng/g dw)
20000
15000
10000
+ 30%
target
− 30%
IIRMES
Physis
UABC

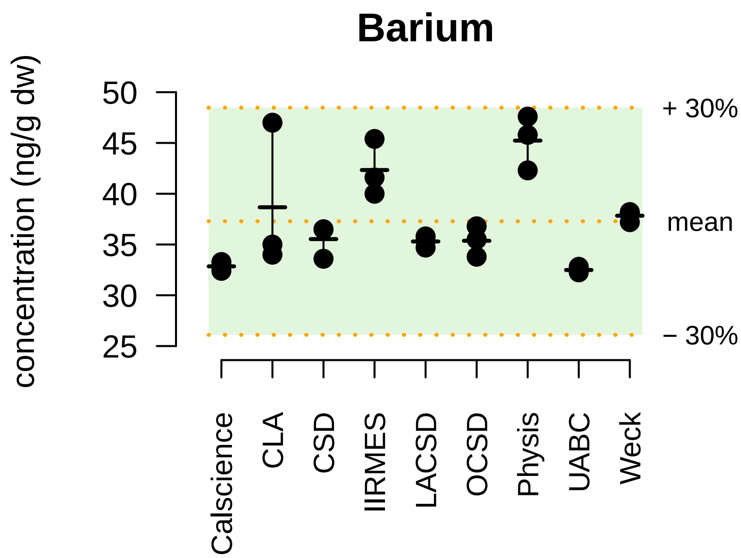

Nickel
concentration (ng/g dw)
180
160
140
120
100
80
+ 30%
target
− 30%
IIRMES
Physis
UABC

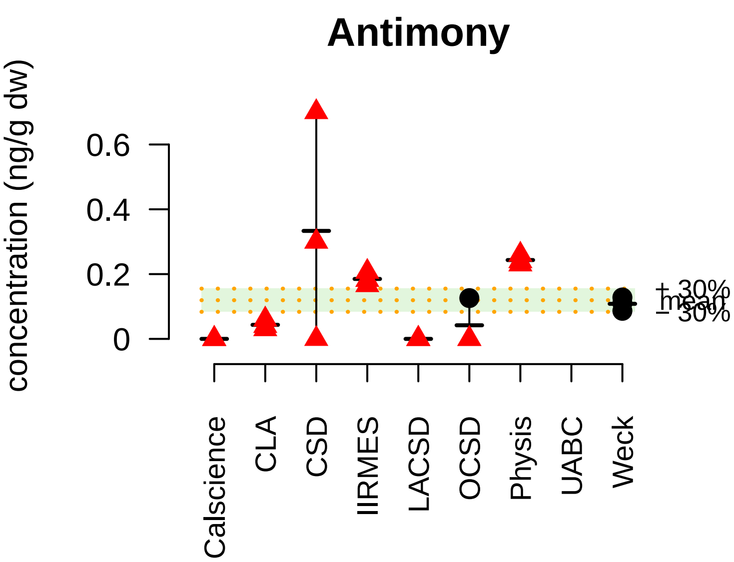

Selenium
concentration (ng/g dw)
120
100
80
60
+ 30%
target
− 30%
IIRMES
Physis
UABC

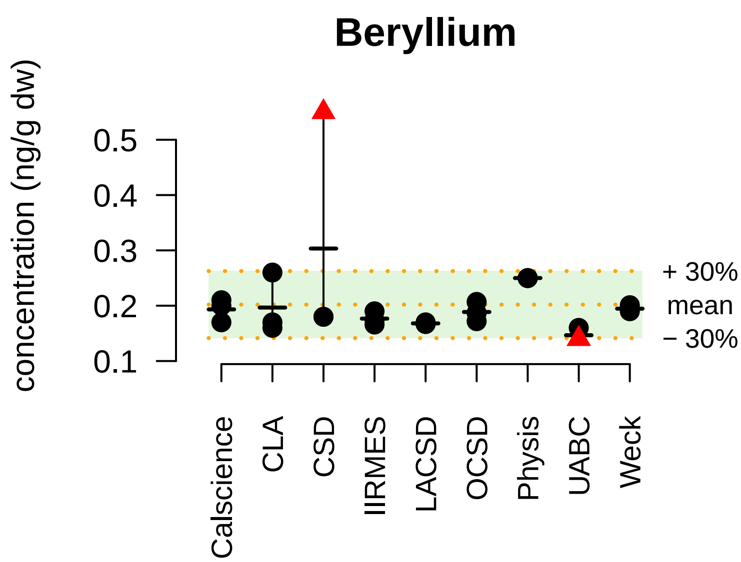

Silver
concentration (ng/g dw)
100
80
60
40
20
0
−20
+ 30%
target
− 30%
IIRMES
Physis
UABC

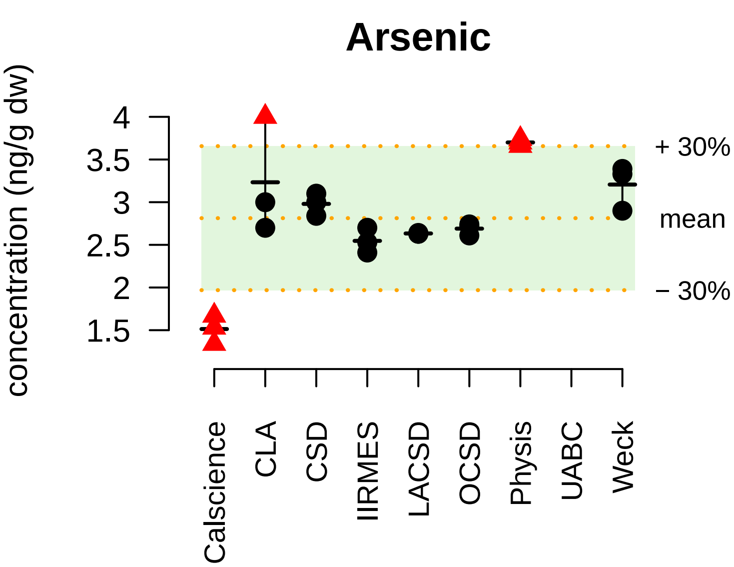

Zinc
concentration (ng/g dw)
300
250
200
150
+ 30%
target
− 30%
IIRMES
Physis
UABC

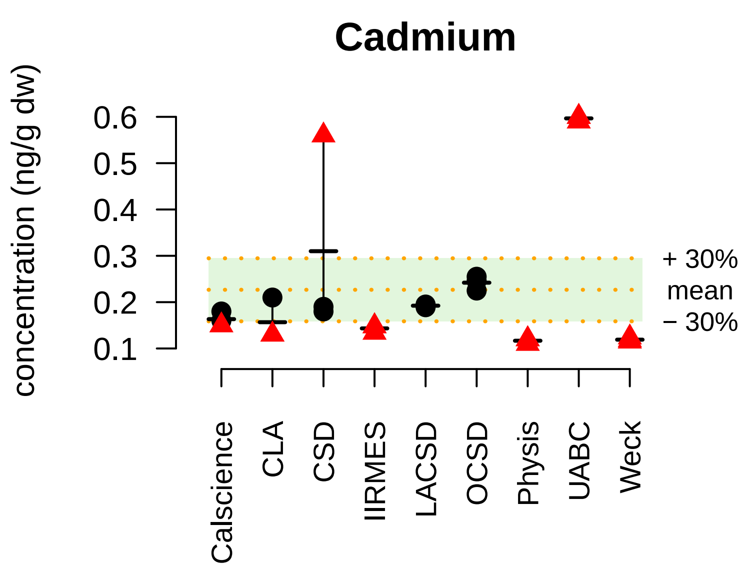

Aluminum
concentration (ng/g dw)
16000
14000
12000
10000
8000
6000
4000
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

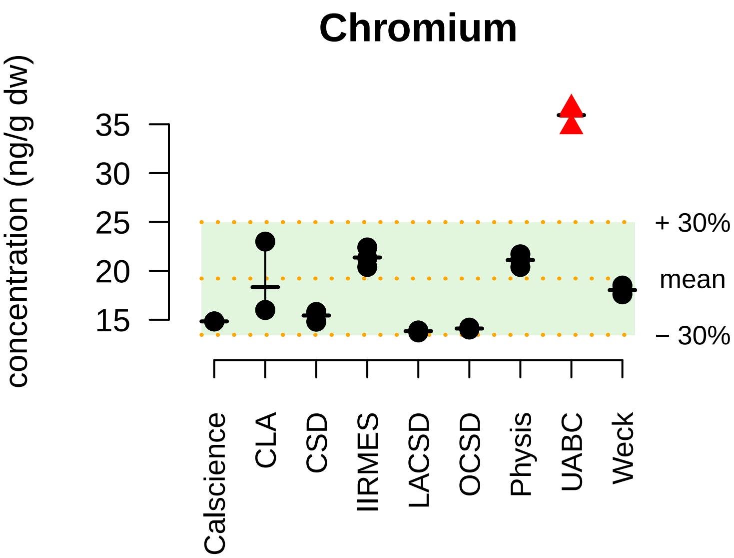

Barium
concentration (ng/g dw)
50
45
40
35
30
25
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

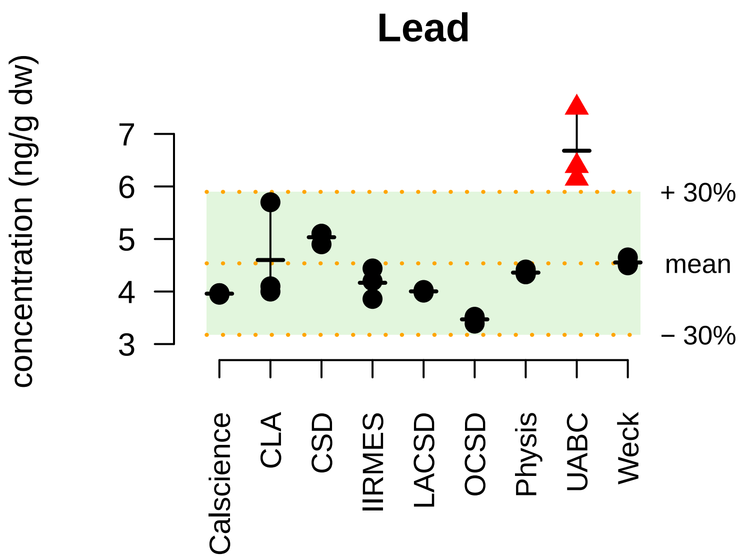

Antimony
concentration (ng/g dw)
0.6
0.4
0.2
0
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

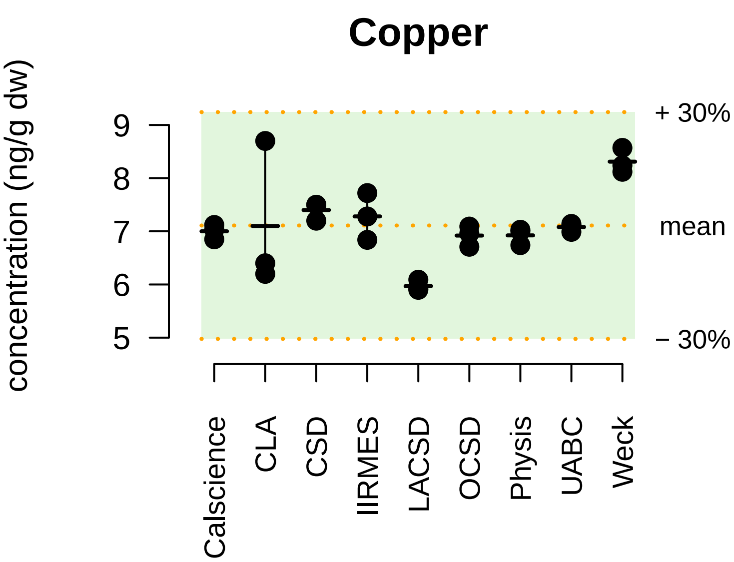

Beryllium
concentration (ng/g dw)
0.5
0.4
0.3
0.2
0.1
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

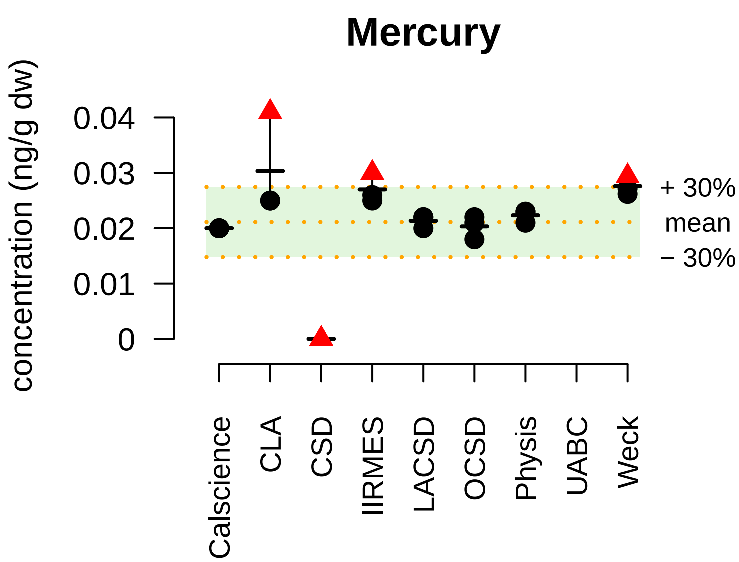

Arsenic
concentration (ng/g dw)
4
3.5
3
2.5
2
1.5
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

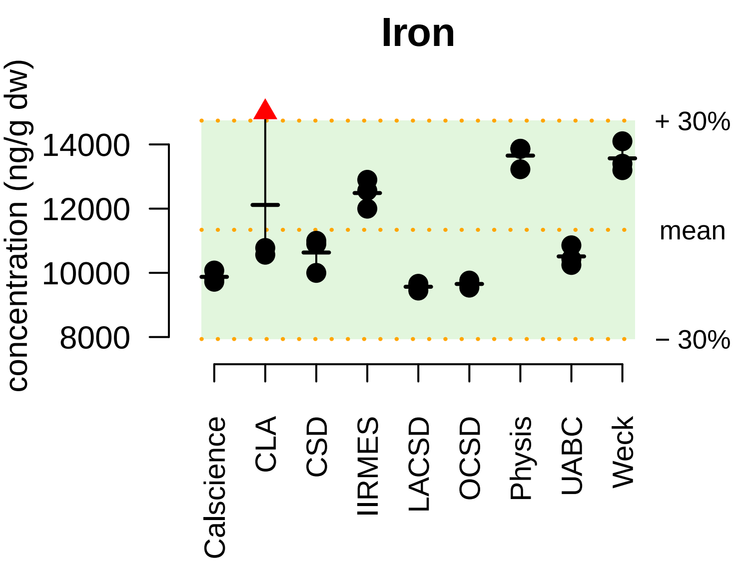

Cadmium
concentration (ng/g dw)
0.6
0.5
0.4
0.3
0.2
0.1
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

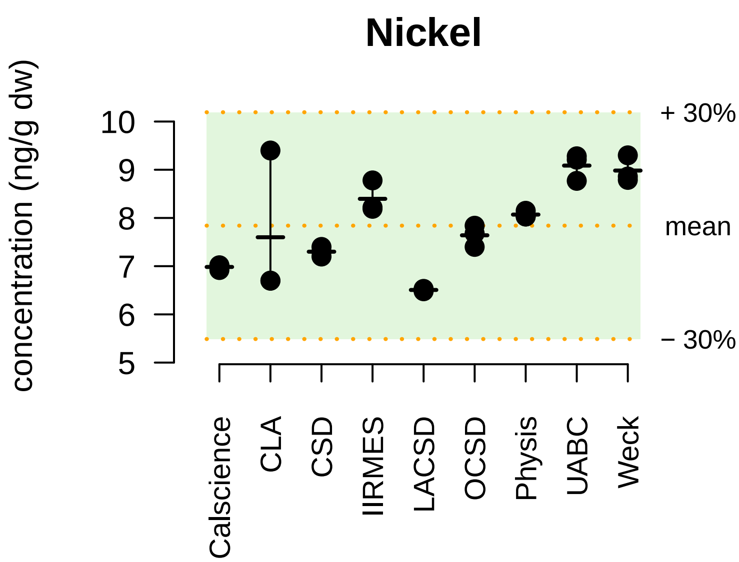

Chromium
concentration (ng/g dw)
35
30
25
20
15
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

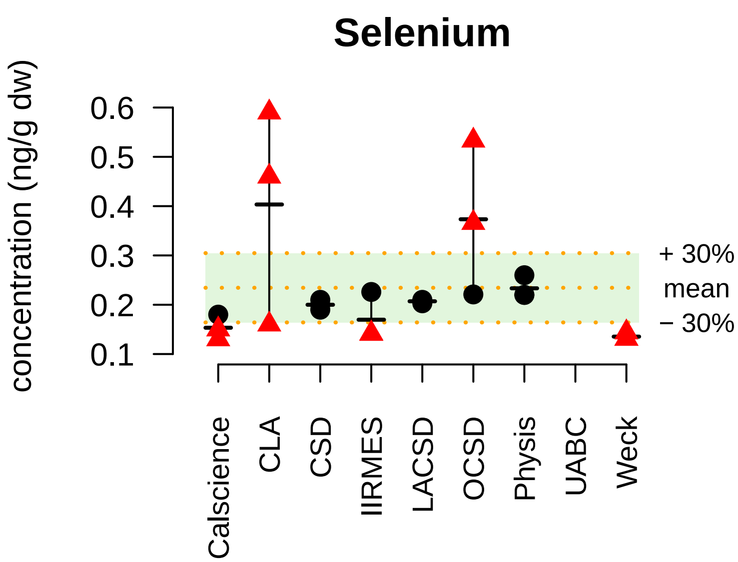

Lead
concentration (ng/g dw)
7
6
5
4
3
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

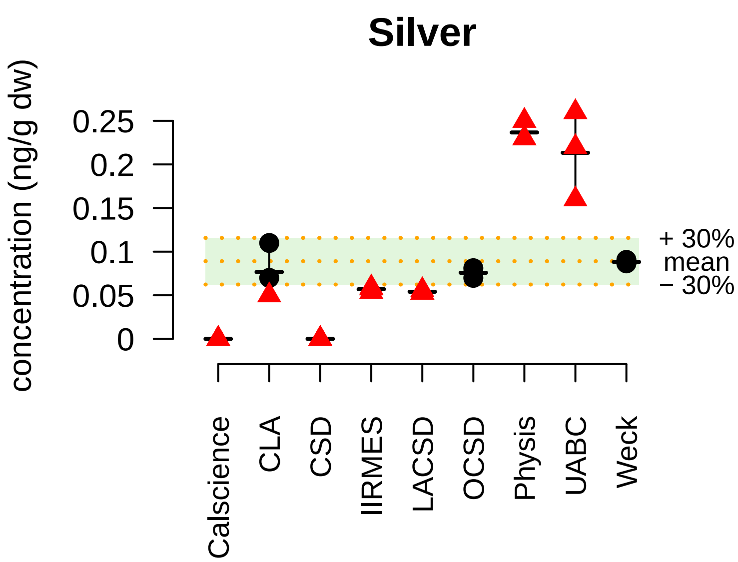

Copper
concentration (ng/g dw)
9
8
7
6
5
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

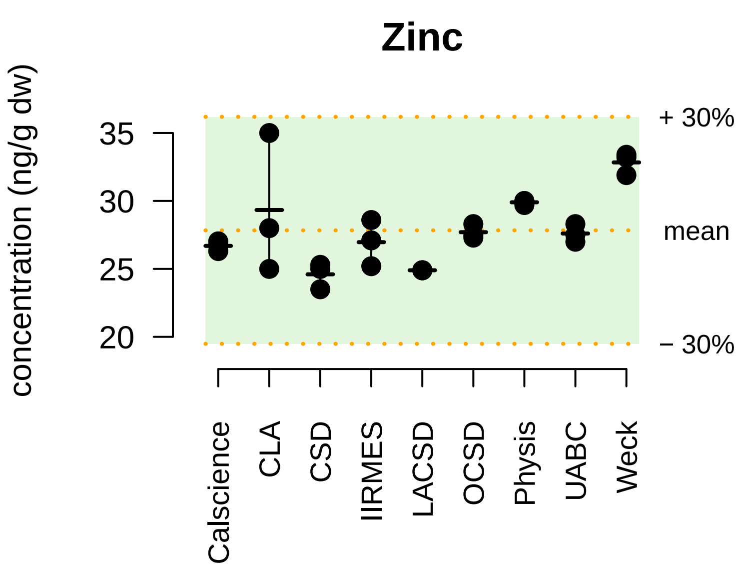

Mercury
concentration (ng/g dw)
0.04
0.03
0.02
0.01
0
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

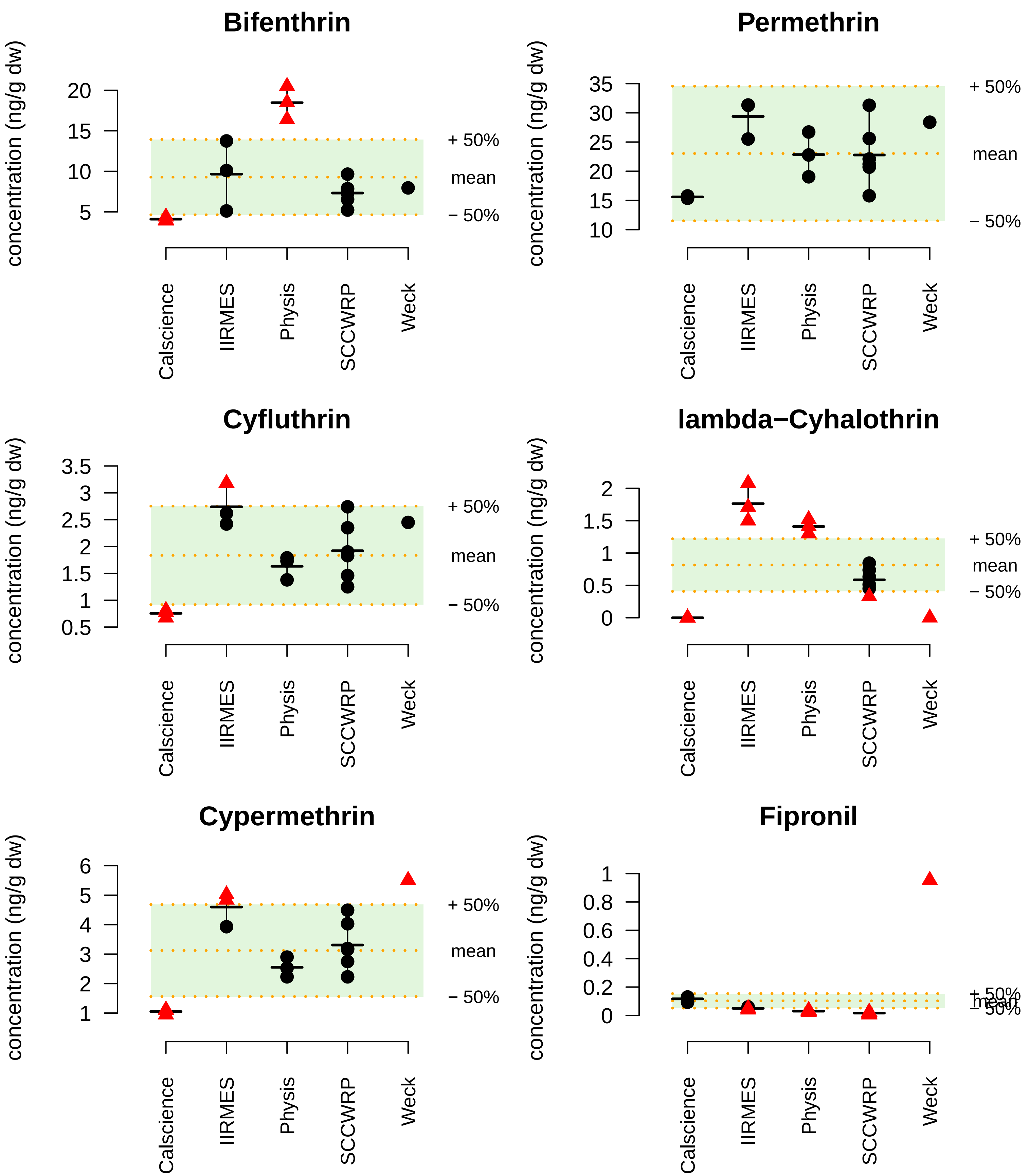

Iron
concentration (ng/g dw)
14000
12000
10000
8000
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

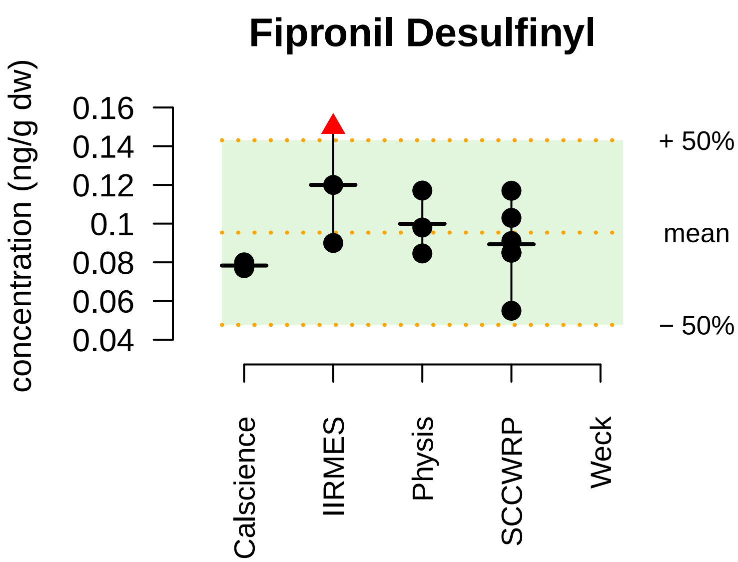

Nickel
concentration (ng/g dw)
10
9
8
7
6
5
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

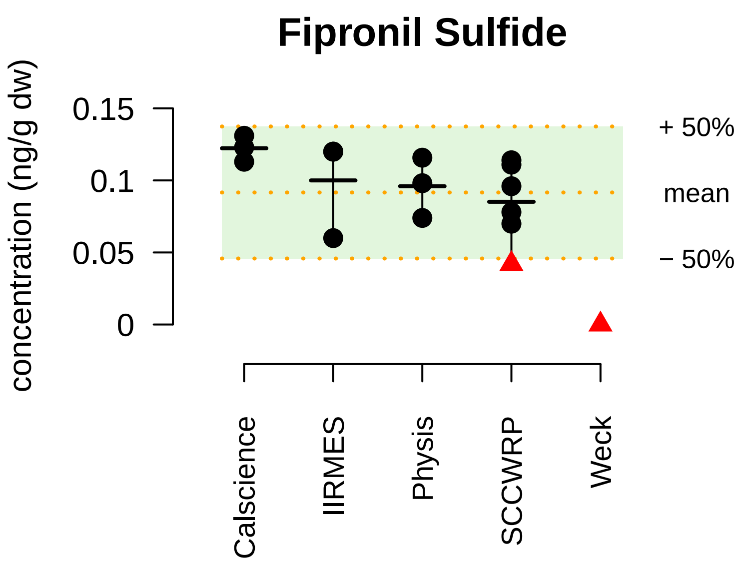

Selenium
concentration (ng/g dw)
0.6
0.5
0.4
0.3
0.2
0.1
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck

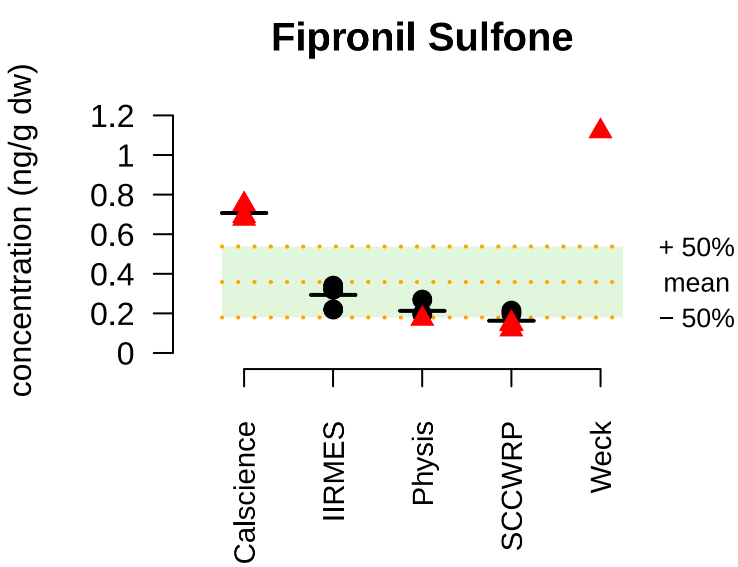

Silver
concentration (ng/g dw)
0.25
0.2
0.15
0.1
0.05
0
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck


Zinc
concentration (ng/g dw)
35
30
25
20
+ 30%
mean
− 30%
Calscience
CLA
CSD
IIRMES
LACSD
OCSD
Physis
UABC
Weck


Bifenthrin
concentration (ng/g dw)
20
15
10
5
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck
Permethrin
concentration (ng/g dw)
35
30
25
20
15
10
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck
Cyfluthrin
concentration (ng/g dw)
3.5
3
2.5
2
1.5
1
0.5
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck
lambda−Cyhalothrin
concentration (ng/g dw)
2
1.5
1
0.5
0
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck
Cypermethrin
concentration (ng/g dw)
6
5
4
3
2
1
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck
Fipronil
concentration (ng/g dw)
1
0.8
0.6
0.4
0.2
0
Calscience
IIRMES
Physis
SCCWRP
Weck


Fipronil Desulfinyl
concentration (ng/g dw)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck


Fipronil Sulfide
concentration (ng/g dw)
0.15
0.1
0.05
0
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck


Fipronil Sulfone
concentration (ng/g dw)
1.2
1
0.8
0.6
0.4
0.2
0
+ 50%
mean
− 50%
Calscience
IIRMES
Physis
SCCWRP
Weck

Appendix C. Bight'13 Areal Extent of Chemical Index Scores

Figure C-1. Areal extent of Chemical Index Score categories by embayment SCB strata. Error bars are 95% confidence intervals.

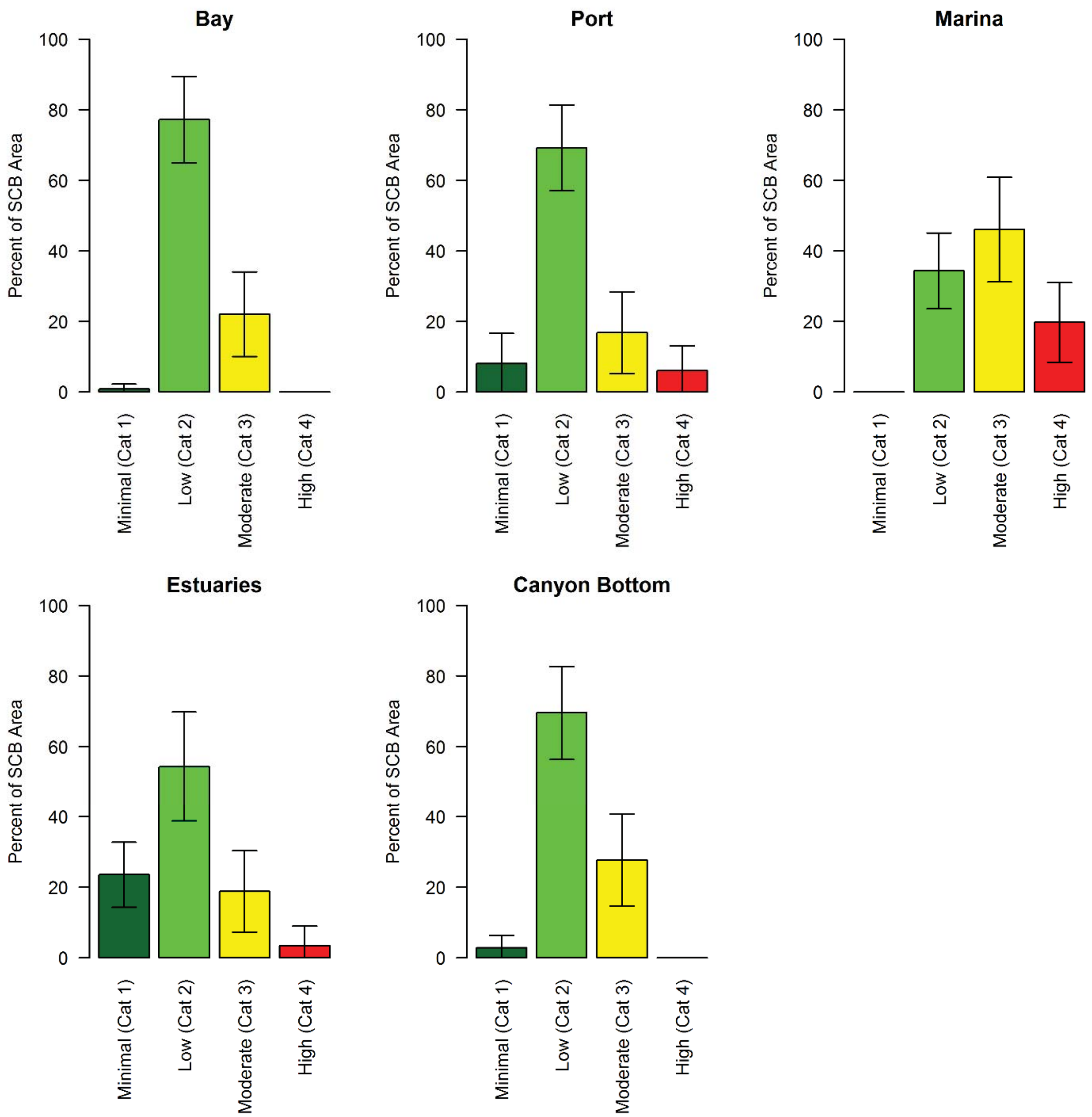
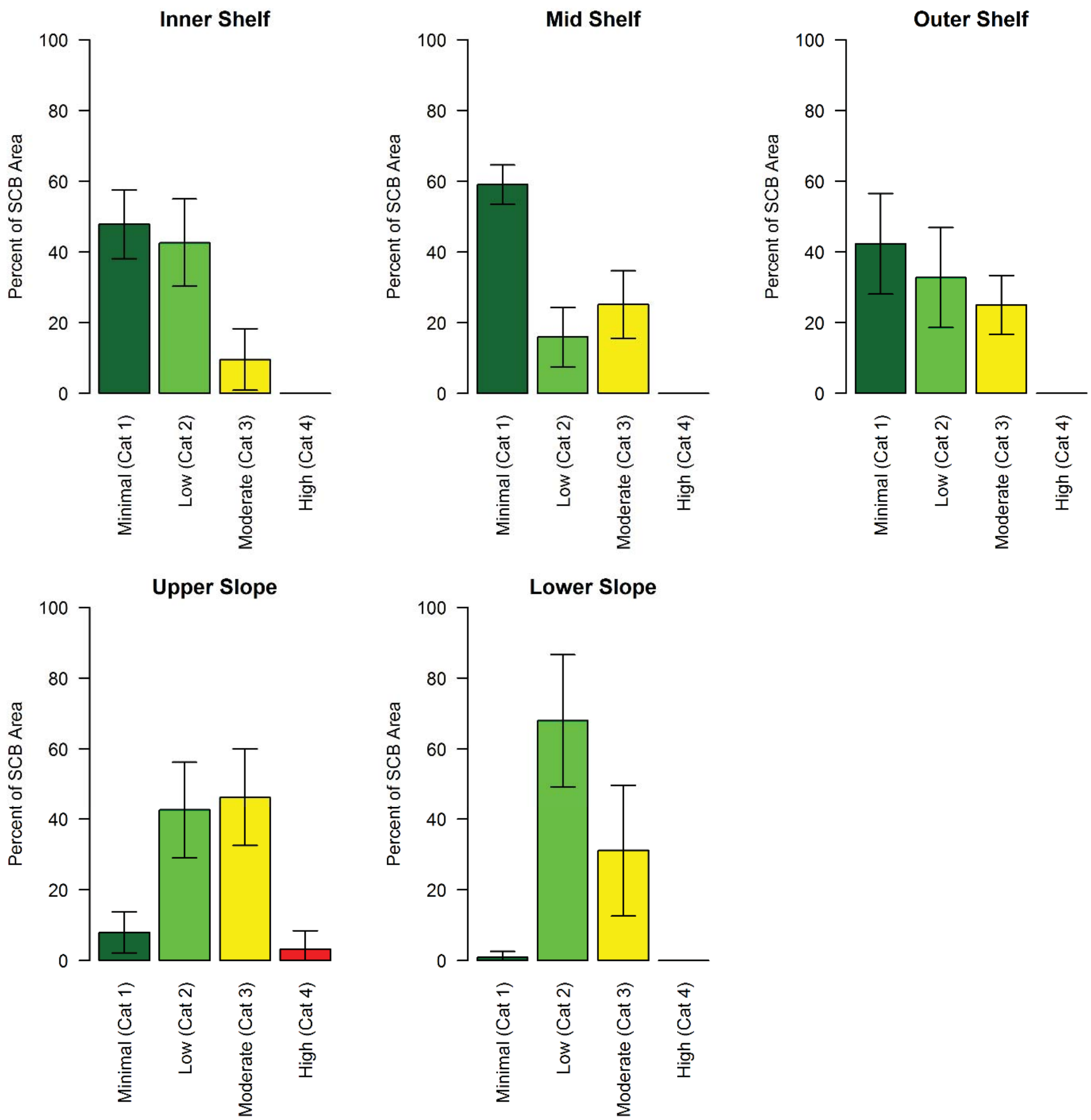
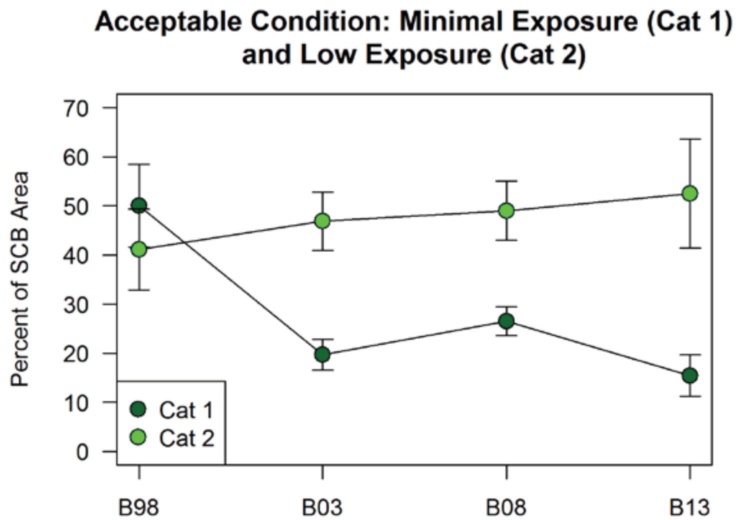


Figure C-2. Areal extent of Chemical Index Score categories by offshore SCB strata. Error bars are 95% confidence intervals.



APPENDIX D. TEMPORAL TREND OF AREAL EXTENT OF CHEMICAL INDEX SCORES

Figure D-1. Bight-Wide Chemical Index Scores across four Bight surveys. Error bars are 95% confidence intervals.



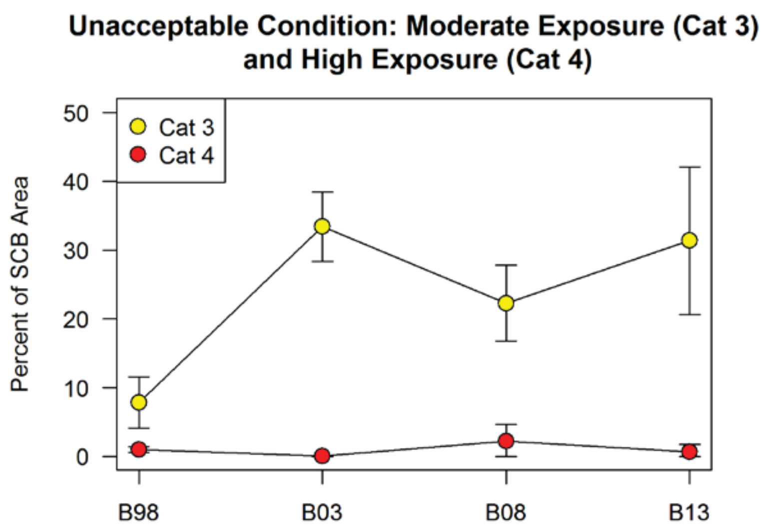


Figure D-2. Combined port, bay, and harbor strata Chemical Index Scores across four Bight surveys. Error bars are 95% confidence intervals.

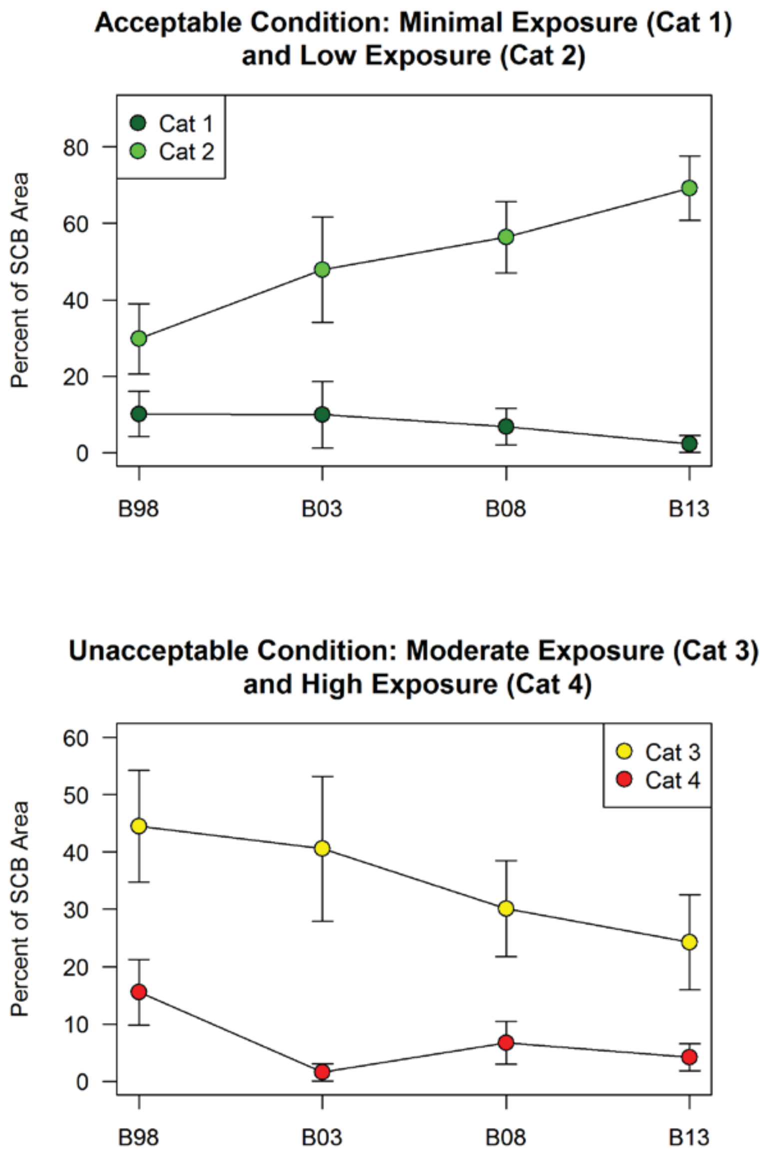
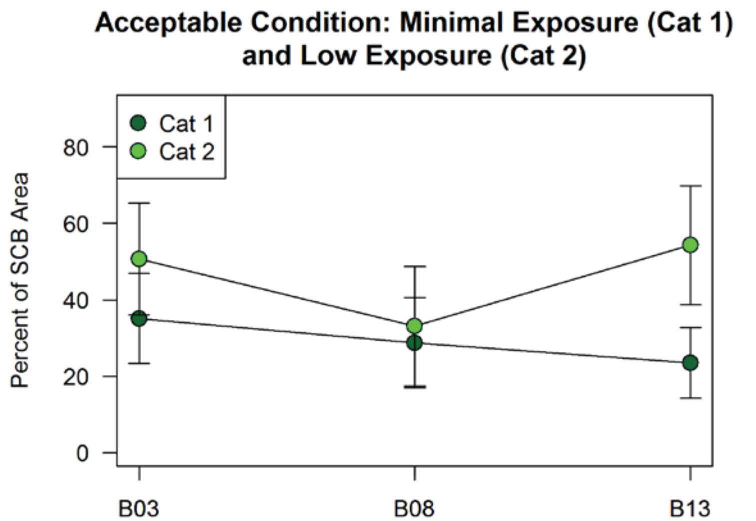


Figure D-3. Estuary stratum Chemical Index Scores across three Bight surveys. Error bars are 95% confidence intervals.



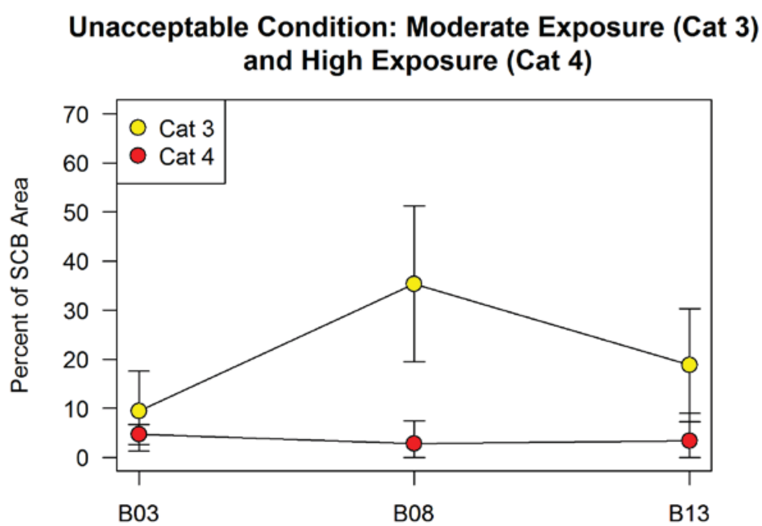
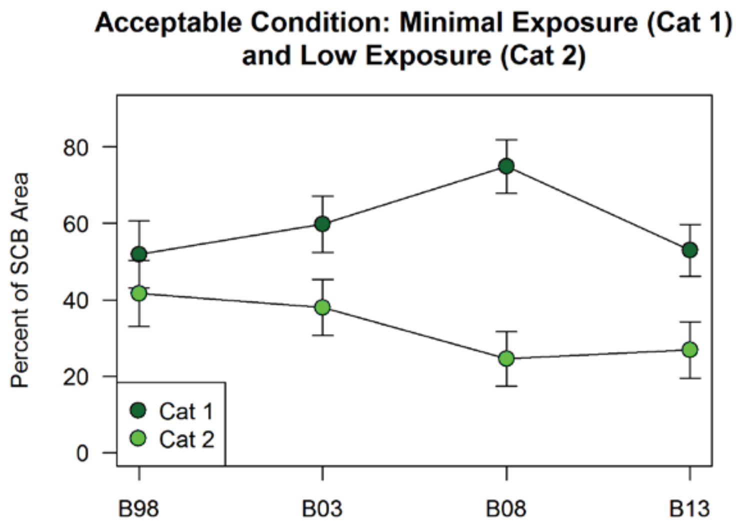


Figure D-4. Shelf stratum Chemical Index Scores across four Bight surveys. Error bars are 95% confidence intervals.



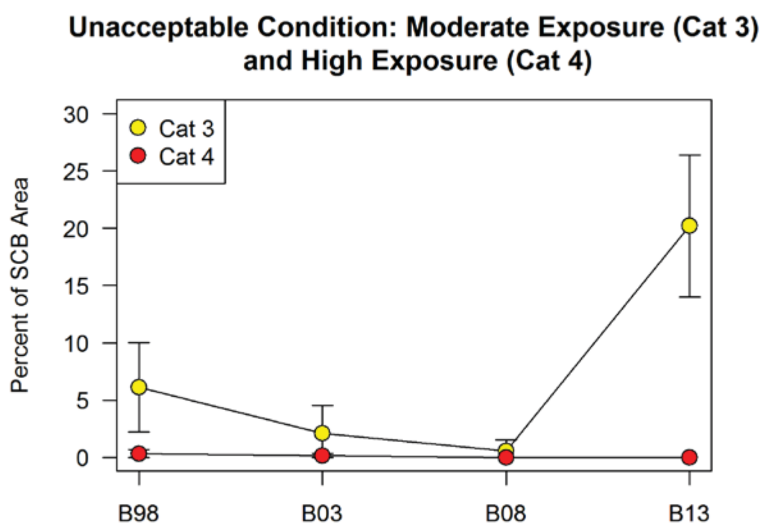
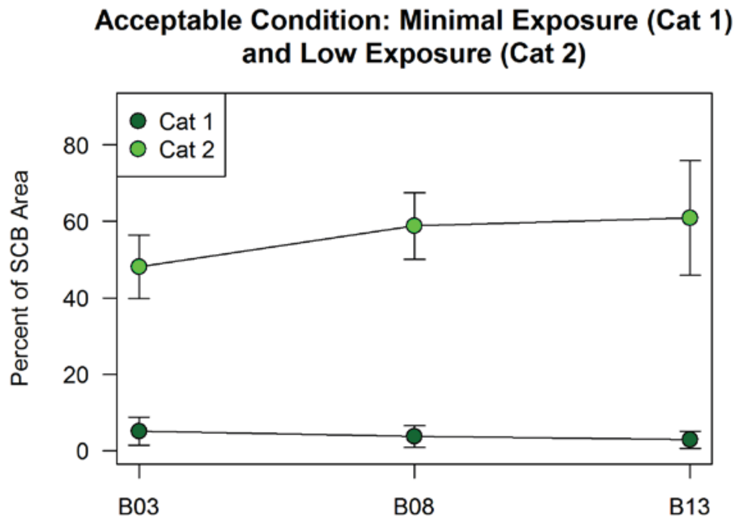
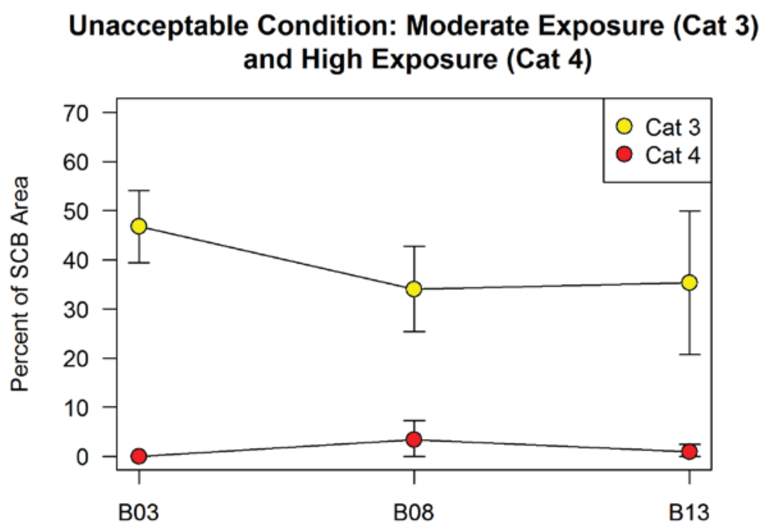


Figure D-5. Slope and Basin stratum Chemical Index Scores across three Bight surveys. Error bars are 95% confidence intervals.





APPENDIX E. POTW OUTFALL COMPARISON

Contaminant concentrations in sediments collected from Bight'13 stations located within the mid-shelf stratum (30-120 m; see Methods section) were compared to concentrations found in sediments collected from Publicly Owned Treatment Works (POTWs) monitoring stations located within the Southern California Bight (SCB) to evaluate contaminant levels within the monitoring regions against conditions present throughout the SCB. POTW data used for this comparison were provided by the Sanitation Districts of Los Angeles County (LACSD), the City of Los Angeles (CLAEMD), Aquatic Bioassay Consulting Laboratories, Inc. on behalf of the City of Oxnard (Oxnard), Orange County Sanitation District (OCSD), and the City of San Diego's Ocean Monitoring Program for the Point Loma Ocean Outfall (PLOO) and the South Bay Ocean Outfall (SBOO). This comparison was limited to five commonly detected metals (copper, lead, mercury, silver, zinc), total PCB congeners, total DDT, and percent fines (particle sizes ≤ 63 microns). With the exception of Oxnard, POTW sediment samples were collected during the same time period as the Bight'13 survey (July-August 2013). Oxnard samples were collected during September 2012 and August 2014. The City of Los Angeles provided data for two outfalls, one discharging effluent (CLAEMD-E) and one that previously discharged sludge (CLAEMD-S).

Table E-1 provides the location information for each of the POTW monitoring stations, and Figure E-1 shows these on a map. Table E-2 lists the summary statistics for contaminant concentrations at the POTW monitoring stations, and Figure E-2 shows this information in boxplots by depth stratum. Data considerations were as follows: 1) since all stations are in the mid-shelf Bight'13 stratum, the concentrations shown are equivalent to area weighted concentrations; 2) PCB and DDT constituents submitted by the POTWs were compared to those required for Bight'13 analyses, with the exceptions that total PCB values from PLOO and SBOO samples were not analyzed for PCB 168, and total DDT values from CLAEMD and LACSD samples were missing p,p'-DDMU; 3) for the summary statistics (Table E-1), metal non-detects were set to zero; 4) for the boxplots (Figure E-1), all metal non-detects were set to the MDL; 5) each agency submitted data for all of their monitoring stations..

Table E-1. List of POTW monitoring stations from which data were provided for this comparison. CLAEMD-E = City of Los Angeles effluent station, CLAEMD-S = City of Los Angeles sludge station, LACSD = Sanitation Districts of Los Angeles County, OCSD = Orange County Sanitation District, Oxnard = City of Oxnard, PLOO = Point Loma Ocean Outfall, and SBOO = South Bay Ocean Outfall.

Outfall	Station I.D.	Depth (m)	Latitude	Longitude
CLAEMD	C1	61	33.9972	-118.7175
(August 2013)	C3	62	33.9897	-118.6006
	C6	57	33.9281	-118.5347
	E6	158	33.9283	-118.5569
	Z2	60	33.9075	-118.5244
LACSD	0B	152	33.8117	-118.4417
(July 2013)	0C	61	33.8072	-118.4305
	0D	30	33.8028	-118.4227
	1B	152	33.7495	-118.4468
	1C	61	33.7573	-118.4410
	1D	30	33.7650	-118.4353
	3B	152	33.7238	-118.4073
	3C	61	33.7300	-118.4025
	3D	30	33.7332	-118.4005
	5B	152	33.7090	-118.3680
	5C	61	33.7147	-118.3660
	5D	30	33.7223	-118.3632
	6B	152	33.7030	-118.3558
	6C	61	33.7078	-118.3540
	6D	30	33.7163	-118.3485
	7B	152	33.7008	-118.3515
	7C	61	33.7052	-118.3487
	7D	30	33.7127	-118.3435
	8B	152	33.6922	-118.3373
	8C	61	33.6985	-118.3357
	8D	30	33.7070	-118.3298
	9B	152	33.6815	-118.3218
	9C	61	33.6887	-118.3183
	9D	30	33.6995	-118.3130

Table E-1 (cont.)

Outfall	Station I.D.	Depth (m)	Latitude	Longitude
OCSD (July 2013)	0	56	33.5762	-118.0100
	1	56	33.5776	-118.0161
	3	60	33.5739	-118.0110
	4	56	33.5750	-117.9960
	5	59	33.5792	-118.0269
	9	59	33.5727	-117.9918
	12	58	33.5731	-117.9842
	68	52	33.5808	-118.0116
	69	52	33.5799	-118.0077
	70	52	33.5789	-118.0030
	71	52	33.5781	-117.9990
	72	55	33.5779	-118.0191
	73	55	33.5766	-118.0118
	74	57	33.5769	-118.0038
	75	60	33.5760	-117.9996
	76	58	33.5743	-118.0050
	77	60	33.5729	-117.9955
	78	63	33.5722	-118.0006
	79	65	33.5731	-118.0146
	80	65	33.5721	-118.0110
	81	65	33.5711	-118.0060
	82	65	33.5701	-118.0013
	84	54	33.5775	-118.0091
	85	57	33.5755	-118.0113
	86	57	33.5760	-118.0134
	87	60	33.5733	-118.0063
	C	56	33.5967	-118.0643
	CON	59	33.6006	-118.0898
	ZB	56	33.5758	-118.0046
Oxnard (September 2012, August 2014)	RWS-001	15	34.1305	-119.2089
	RWS-002	15	34.1266	-119.2003
	RWS-003	15	34.1257	-119.1983
	RWS-004	15	34.1258	-119.1979
	RWS-005	15	34.1250	-119.1964
	RWS-006	15	34.1233	-119.1934
	RWS-007	15	34.1075	-119.1702

Table E-1 (cont.)

Outfall	Station I.D.	Depth (m)	Latitude	Longitude
PLOO	B-10	116	32.7537	-117.3693
(July 2013)	B-11	88	32.7762	-117.3558
	B-12	98	32.7727	-117.3717
	B-8	88	32.7583	-117.3462
	B-9	98	32.7555	-117.3617
	E-1	88	32.6255	-117.3058
	E-11	98	32.6567	-117.3237
	E-14	98	32.6657	-117.3248
	E-15	116	32.6647	-117.3318
	E-17	98	32.6747	-117.3257
	E-19	88	32.6840	-117.3197
	E-2	98	32.6242	-117.3182
	E-20	98	32.6827	-117.3278
	E-21	116	32.6815	-117.3333
	E-23	98	32.6912	-117.3295
	E-25	98	32.7063	-117.3345
	E-26	98	32.7303	-117.3428
	E-3	116	32.6215	-117.3348
	E-5	98	32.6397	-117.3213
	E-7	88	32.6500	-117.3108
	E-8	98	32.6485	-117.3223
	E-9	116	32.6458	-117.3343

Table E-1 (cont.)

Outfall	Station I.D.	Depth (m)	Latitude	Longitude
SBOO (July 2013)	I-1	60	32.4733	-117.2770
	I-10	19	32.5167	-117.1560
	I-12	28	32.5328	-117.1830
	I-13	38	32.5375	-117.2120
	I-14	28	32.5430	-117.1840
	I-15	31	32.5378	-117.1890
	I-16	28	32.5378	-117.1830
	I-18	19	32.5362	-117.1610
	I-2	32	32.4733	-117.1990
	I-20	55	32.5570	-117.2570
	I-21	41	32.5607	-117.2270
	I-22	28	32.5533	-117.1850
	I-23	21	32.5508	-117.1650
	I-27	28	32.5742	-117.1910
	I-28	55	32.5938	-117.2640
	I-29	38	32.5945	-117.2230
	I-3	27	32.4670	-117.1680
	I-30	28	32.5953	-117.1970
	I-31	19	32.5955	-117.1720
	I-33	30	32.6238	-117.2370
	I-34	19	32.6300	-117.2160
	I-35	19	32.6367	-117.1820
	I-4	18	32.4717	-117.1400
	I-6	26	32.4935	-117.1630
	I-7	52	32.5167	-117.2530
	I-8	36	32.5167	-117.2020
	I-9	29	32.5117	-117.1790

Figure E-1. Maps of Bight'13 and POTW monitoring stations. Dates are the POTW sampling periods.

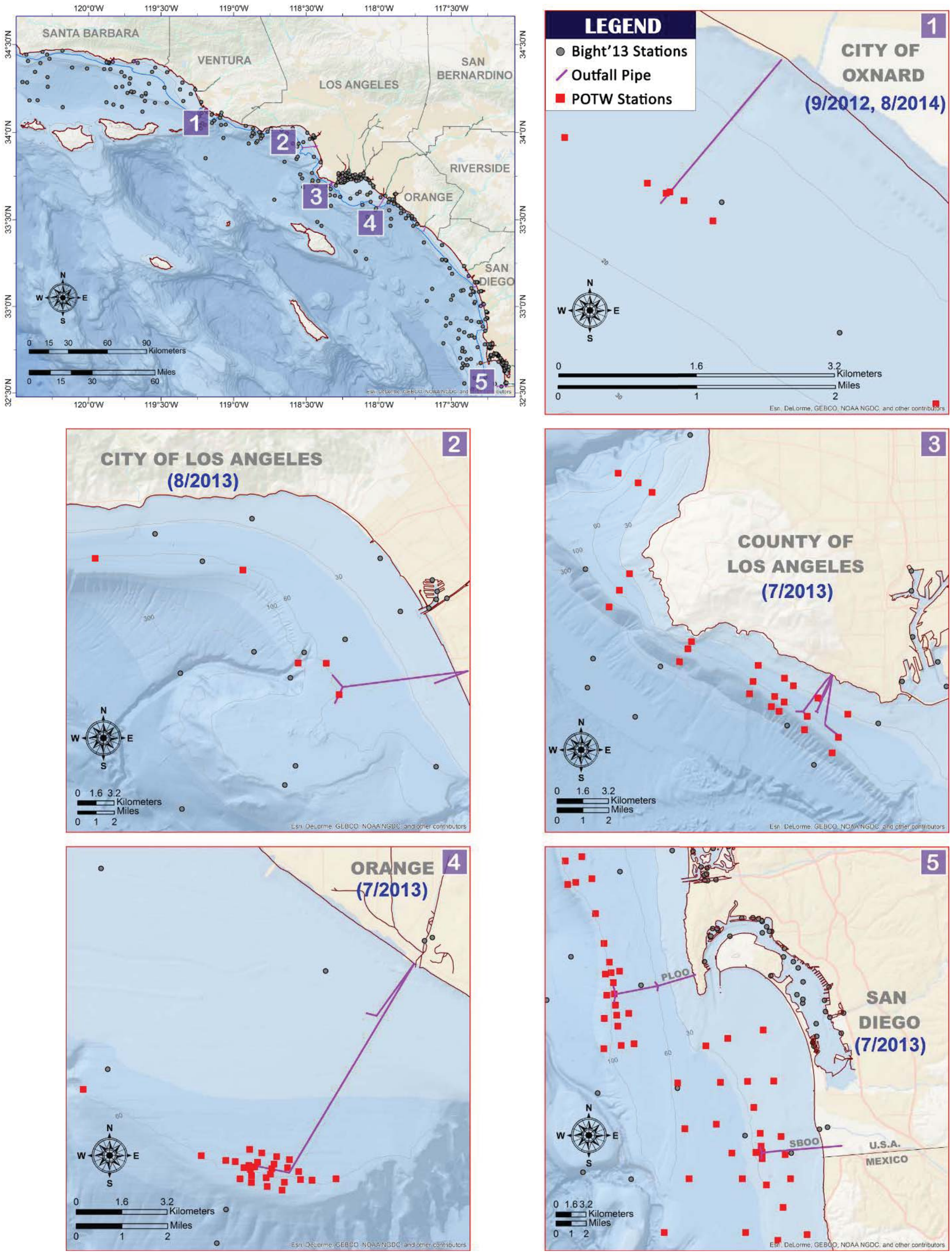


Table E-2. Summary statistics of Bight'13 and POTW monitoring grid sediment contaminant concentrations. N = number of stations, DR = detection rate percentage, and CI = confidence interval. Oxnard = City of Oxnard, CLAEMD-E = City of Los Angeles effluent station, CLAEMD-S = City of Los Angeles sludge station, LACSD = Sanitation Districts of Los Angeles County, OCSD = Orange County Sanitation District, PLOO = Point Loma Ocean Outfall, and SBOO = South Bay Ocean Outfall.

Outfall	Stratum	N	DR	Min	Median	Max	Mean	95% CI
Copper (μg/g dw)								
Bight'13	Inner Shelf	38	97	0.00	3.46	9.57	3.69	0.78
Bight'13	Mid Shelf	42	95	0.00	6.81	15.66	7.45	1.26
Bight'13	Outer Shelf	32	94	0.00	7.00	79.13	10.56	5.03
CLAEMD-E	Mid Shelf	4	100	10.30	15.50	16.70	14.50	4.61
CLAEMD-S	Outer Shelf	1	100	216.80	216.80	216.80	216.80	—
LACSD	Inner Shelf	8	100	5.93	9.99	15.00	10.19	2.52
LACSD	Mid Shelf	8	100	17.00	34.10	179.00	52.28	44.10
LACSD	Outer Shelf	8	100	21.40	72.90	234.00	93.31	61.47
OCSD	Mid Shelf	29	100	8.40	10.70	42.60	12.16	2.37
Oxnard	Inner Shelf	14	100	1.68	3.11	4.13	3.05	0.33
PLOO	Mid Shelf	22	100	4.44	9.10	20.00	9.84	1.64
SBOO	Inner Shelf	17	100	0.50	3.60	7.80	3.41	0.94
SBOO	Mid Shelf	10	100	0.50	1.15	6.60	2.21	1.63
Lead (μg/g dw)								
Bight'13	Inner Shelf	38	100	0.84	3.79	11.40	4.20	0.69
Bight'13	Mid Shelf	42	100	1.30	6.58	13.20	6.95	0.88
Bight'13	Outer Shelf	32	100	3.80	7.56	24.21	9.61	1.96
CLAEMD-E	Mid Shelf	4	100	7.30	11.85	13.20	11.05	4.19
CLAEMD-S	Outer Shelf	1	100	64.40	64.40	64.40	64.40	—
LACSD	Inner Shelf	8	100	7.93	8.68	14.70	9.33	1.84
LACSD	Mid Shelf	8	100	14.70	23.00	83.50	30.70	18.78
LACSD	Outer Shelf	8	100	18.90	46.00	144.00	60.09	36.74
OCSD	Mid Shelf	29	100	4.42	6.38	12.10	6.51	0.67
Oxnard	Inner Shelf	14	100	2.45	3.35	3.56	3.22	0.20
PLOO	Mid Shelf	22	100	4.53	7.05	11.90	7.33	0.90
SBOO	Inner Shelf	17	94	0.00	4.50	6.74	4.00	0.97
SBOO	Mid Shelf	10	100	1.10	3.50	5.94	3.50	1.12

Table E-2 (cont.)

Outfall	Stratum	N	DR	Min	Median	Max	Mean	95% CI
Mercury (µg/g dw)								
Bight'13	Inner Shelf	38	100	0.001	0.015	0.325	0.038	0.024
Bight'13	Mid Shelf	42	100	0.005	0.030	0.201	0.047	0.014
Bight'13	Outer Shelf	30	100	0.004	0.032	0.776	0.066	0.052
CLAEMD-E	Mid Shelf	4	100	0.100	0.150	0.200	0.150	0.092
CLAEMD-S	Outer Shelf	1	100	2.300	2.300	2.300	2.300	—
LACSD	Inner Shelf	8	100	0.040	0.060	0.090	0.063	0.012
LACSD	Mid Shelf	8	100	0.110	0.220	0.730	0.329	0.194
LACSD	Outer Shelf	8	100	0.160	0.610	1.340	0.675	0.394
OCSD	Mid Shelf	29	100	0.012	0.023	1.229	0.105	0.114
Oxnard	Inner Shelf	14	100	0.008	0.010	0.014	0.010	0.001
PLOO	Mid Shelf	22	100	0.017	0.028	0.052	0.031	0.004
SBOO	Inner Shelf	17	53	0.000	0.004	0.135	0.012	0.017
SBOO	Mid Shelf	10	30	0.000	0.000	0.016	0.003	0.004
Silver (µg/g dw)								
Bight'13	Inner Shelf	38	37	0.00	0.00	6.15	0.19	0.33
Bight'13	Mid Shelf	42	38	0.00	0.00	3.05	0.21	0.18
Bight'13	Outer Shelf	32	44	0.00	0.00	5.79	0.35	0.37
CLAEMD-E	Mid Shelf	4	50	0.00	0.30	1.30	0.48	0.98
CLAEMD-S	Outer Shelf	1	100	18.40	18.40	18.40	18.40	—
LACSD	Inner Shelf	8	100	0.20	0.21	0.26	0.22	0.02
LACSD	Mid Shelf	8	100	0.36	0.82	2.42	1.06	0.55
LACSD	Outer Shelf	8	100	0.54	1.98	6.36	2.52	1.60
OCSD	Mid Shelf	29	100	0.13	0.23	0.39	0.23	0.02
Oxnard	Inner Shelf	14	50	0.00	0.01	0.02	0.01	0.01
PLOO	Mid Shelf	22	86	0.00	1.43	3.77	1.48	0.50
SBOO	Inner Shelf	17	59	0.00	0.35	11.20	2.04	1.76
SBOO	Mid Shelf	10	40	0.00	0.00	5.62	0.97	1.40

Table E-2 (cont.)

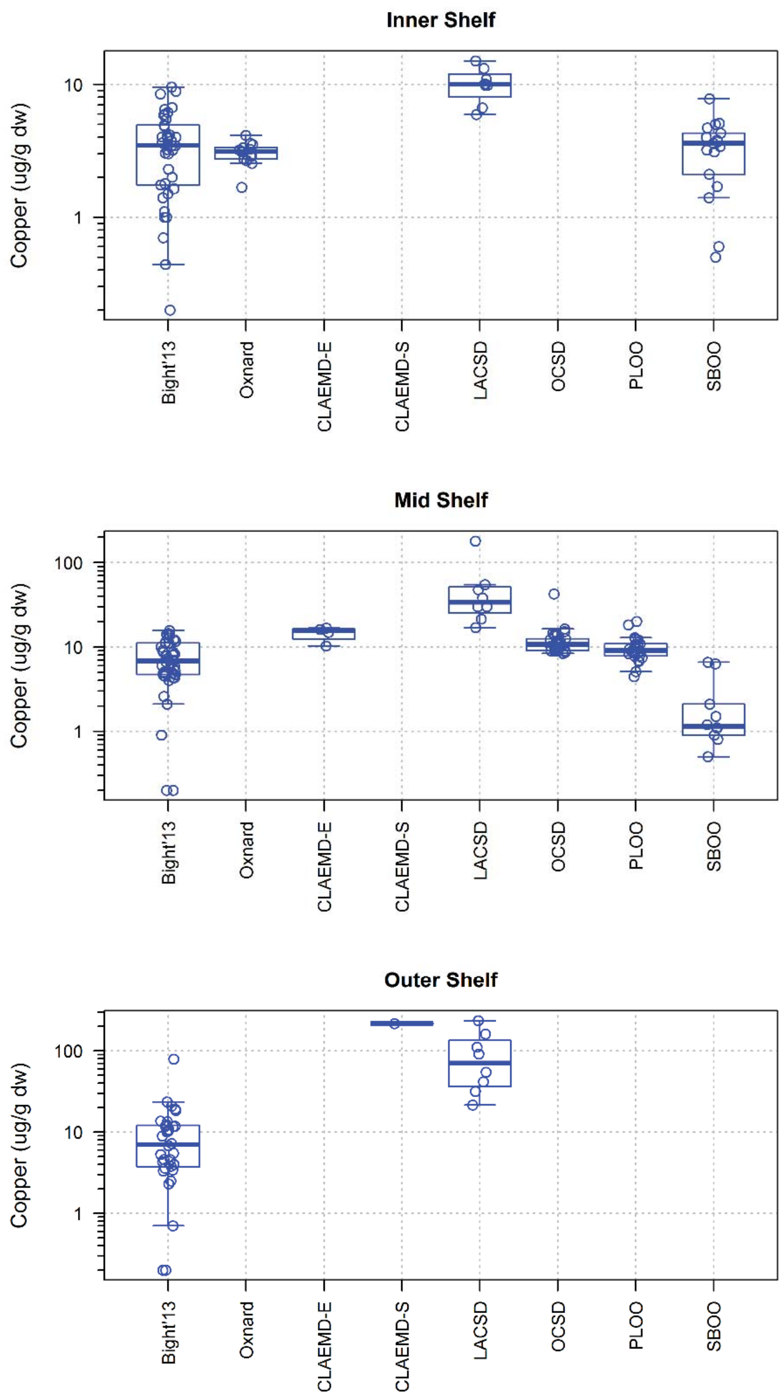
Outfall	Stratum	N	DR	Min	Median	Max	Mean	95% CI
Zinc (µg/g dw)								
Bight'13	Inner Shelf	38	100	5.36	28.34	60.61	27.86	4.06
Bight'13	Mid Shelf	42	100	15.20	44.45	94.50	45.91	5.44
Bight'13	Outer Shelf	32	100	21.80	56.54	104.33	56.50	6.52
CLAEMD-E	Mid Shelf	4	100	41.30	63.40	183.80	87.98	103.23
CLAEMD-S	Outer Shelf	1	100	249.70	249.70	249.70	249.70	—
LACSD	Inner Shelf	8	100	37.40	50.55	56.30	48.71	6.23
LACSD	Mid Shelf	8	100	54.90	102.30	270.00	118.64	57.78
LACSD	Outer Shelf	8	100	81.40	166.00	621.00	228.40	150.67
OCSD	Mid Shelf	29	100	38.90	44.90	56.40	45.79	1.41
Oxnard	Inner Shelf	14	100	10.56	20.40	25.47	20.54	2.14
PLOO	Mid Shelf	22	100	28.60	34.65	43.80	35.85	2.36
SBOO	Inner Shelf	17	100	2.61	22.70	36.20	20.40	4.54
SBOO	Mid Shelf	10	100	3.37	9.78	27.80	12.47	5.71
Total DDT (ng/g dw)								
Bight'13	Inner Shelf	32	81	0.0	1.7	251.5	10.9	15.9
Bight'13	Mid Shelf	31	100	0.1	3.4	150.7	14.0	10.5
Bight'13	Outer Shelf	19	100	0.1	6.3	1141.5	71.6	125.2
CLAEMD-E	Mid Shelf	4	100	16.3	37.8	59.3	37.8	31.2
CLAEMD-S	Outer Shelf	1	100	195.6	195.6	195.6	195.6	—
LACSD	Inner Shelf	8	100	188.0	261.5	304.0	260.6	34.8
LACSD	Mid Shelf	8	100	538.0	1750.0	42900.0	6853.6	12202.0
LACSD	Outer Shelf	8	100	828.0	4810.0	15900.0	6032.3	4240.7
OCSD	Mid Shelf	29	100	1.0	2.0	52.9	4.3	3.7
Oxnard	Inner Shelf	14	7	0.0	0.0	1.0	0.1	0.2
PLOO	Mid Shelf	22	100	0.1	0.3	0.5	0.3	0.0
SBOO	Inner Shelf	17	65	0.0	0.1	0.6	0.2	0.1
SBOO	Mid Shelf	10	30	0.0	0.0	0.8	0.2	0.2

Table E-2 (cont.)

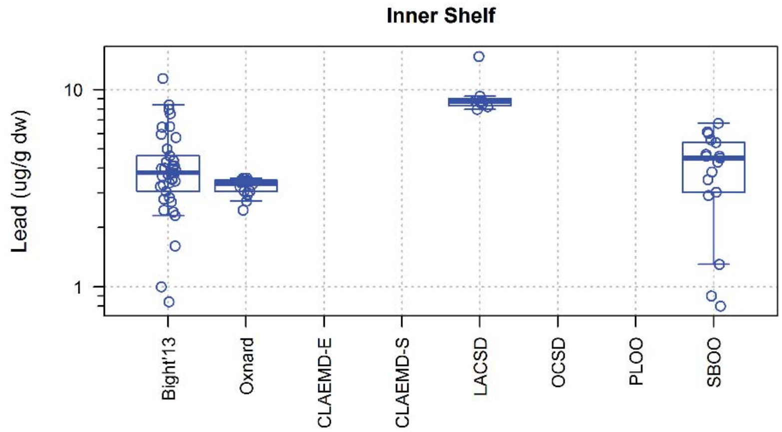
Outfall	Stratum	N	DR	Min	Median	Max	Mean	95% CI
Total PCB (ng/g dw)								
Bight'13	Inner Shelf	38	45	0.0	0.0	5.4	0.5	0.3
Bight'13	Mid Shelf	42	43	0.0	0.0	31.7	2.0	1.7
Bight'13	Outer Shelf	32	59	0.0	0.1	58.2	4.3	4.8
CLAEMD-E	Mid Shelf	4	100	6.5	14.6	21.9	14.4	10.1
CLAEMD-S	Outer Shelf	1	100	288.6	288.6	288.6	288.6	—
LACSD	Inner Shelf	8	38	0.0	0.0	32.3	6.3	9.4
LACSD	Mid Shelf	8	100	32.6	181.5	1870.0	386.7	508.9
LACSD	Outer Shelf	8	100	68.4	591.0	2340.0	871.1	660.6
OCSD	Mid Shelf	29	100	0.4	2.6	19.6	3.7	1.5
Oxnard	Inner Shelf	14	0	0.0	0.0	0.0	0.0	0.0
PLOO	Mid Shelf	22	41	0.0	0.0	5.2	0.5	0.6
SBOO	Inner Shelf	17	6	0.0	0.0	0.4	0.0	0.0
SBOO	Mid Shelf	10	20	0.0	0.0	1.4	0.2	0.4
Percent Fines (%)								
Bight'13	Inner Shelf	38	100	1.57	18.00	87.86	22.24	5.95
Bight'13	Mid Shelf	42	100	14.07	50.52	88.37	48.47	6.50
Bight'13	Outer Shelf	32	100	6.09	46.68	77.04	49.21	7.31
CLAEMD-E	Mid Shelf	4	100	19.40	28.45	71.80	37.03	38.2
CLAEMD-S	Outer Shelf	1	100	33.85	33.85	33.85	33.85	—
LACSD	Inner Shelf	8	100	11.12	26.25	41.48	25.03	8.12
LACSD	Mid Shelf	8	100	46.15	62.13	78.79	64.38	9.59
LACSD	Outer Shelf	8	100	47.06	69.11	89.35	69.13	10.8
OCSD	Mid Shelf	29	100	19.17	33.98	54.07	35.36	3.17
Oxnard	Inner Shelf	14	93	0.00	5.86	30.91	8.87	4.64
PLOO	Mid Shelf	22	100	19.40	50.00	70.88	49.06	4.46
SBOO	Inner Shelf	17	100	1.00	19.00	42.00	18.88	5.21
SBOO	Mid Shelf	10	100	4.00	15.00	55.00	22.30	12.98

Figure E-2. Bight'13 and POTW monitoring grid sediment contaminant concentrations by depth strata. Outfall abbreviations follow those of Table E-2.

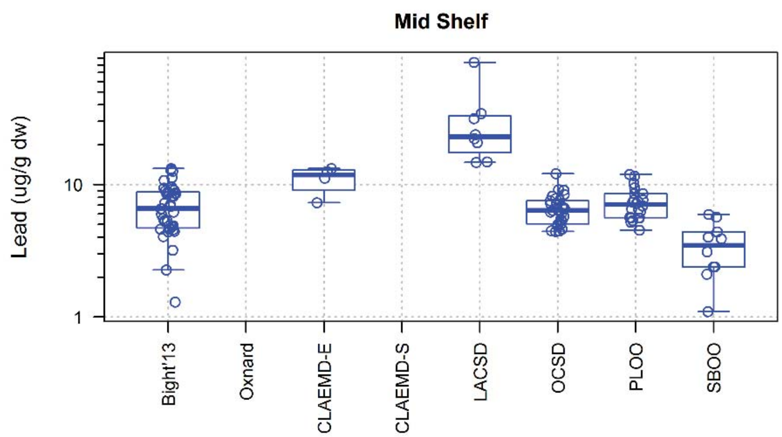
Copper



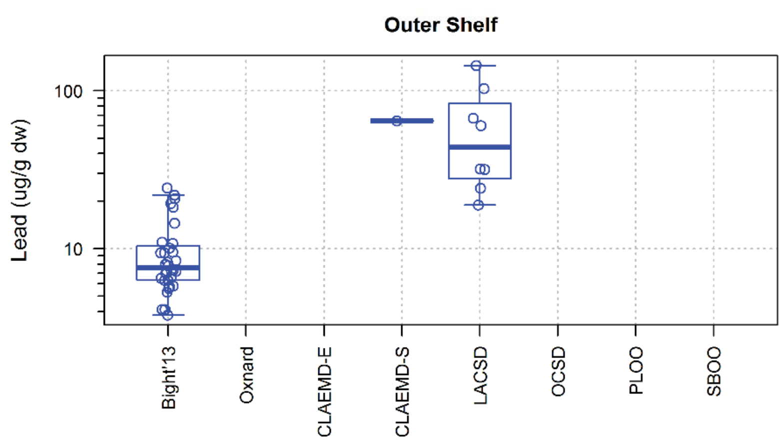
Lead



Inner Shelf
Lead (ug/g dw)
10
1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

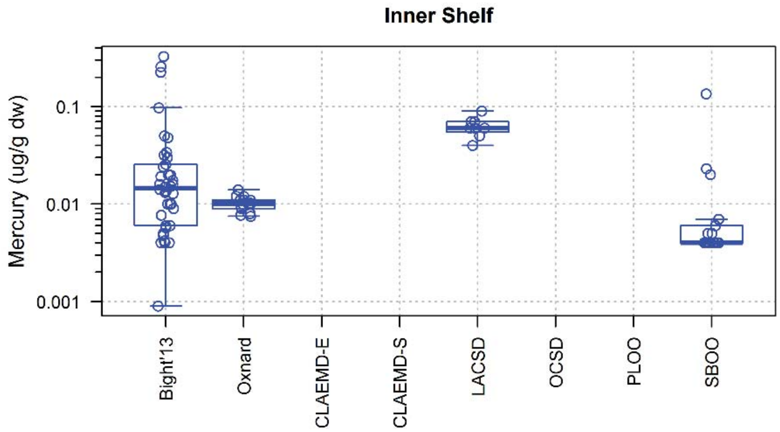


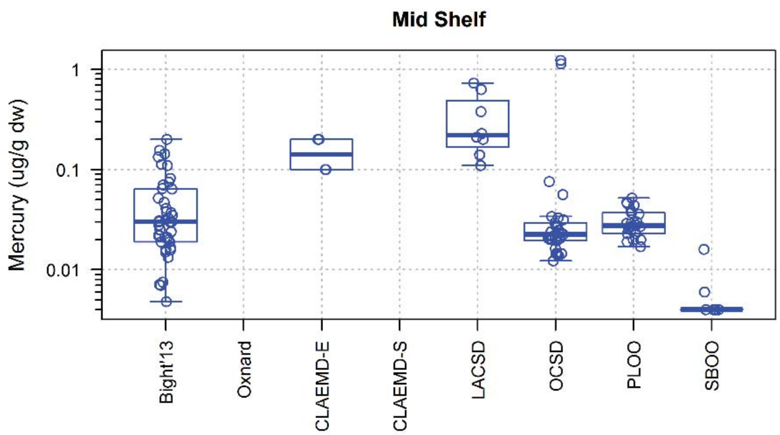
Mid Shelf
Lead (ug/g dw)
10
1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

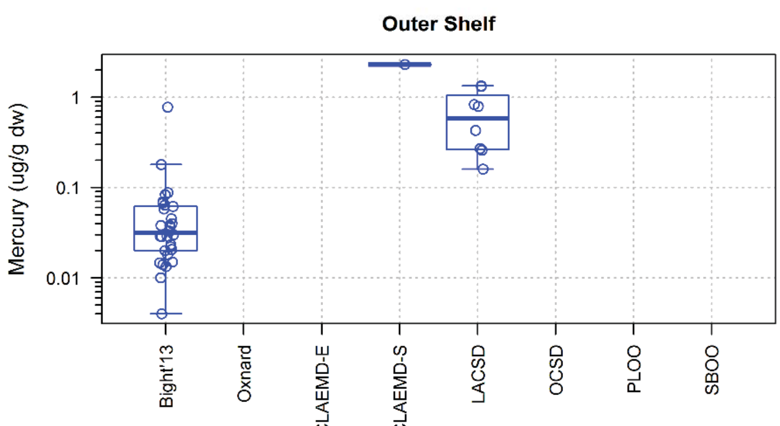


Outer Shelf
Lead (ug/g dw)
100
10
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

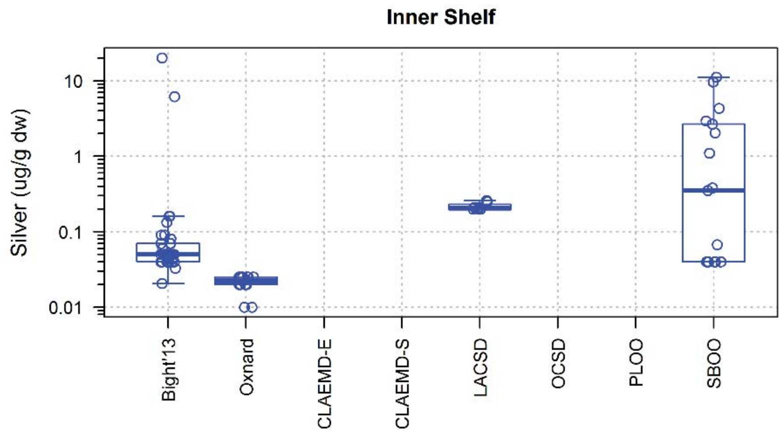
Mercury

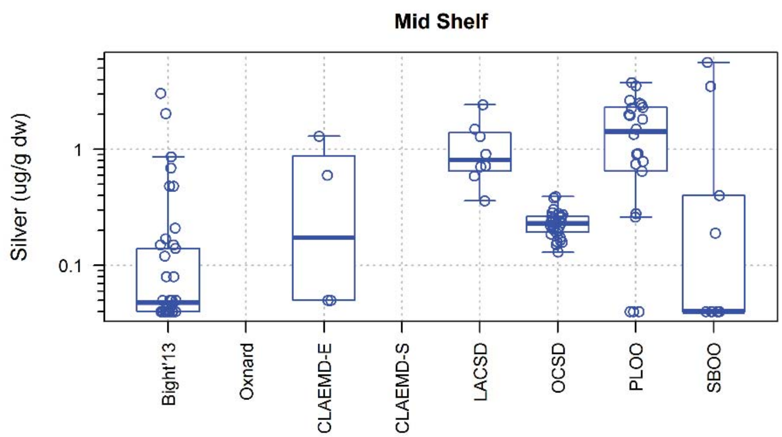

Inner Shelf
Mercury (ug/g dw)
0.1
0.01
0.001
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

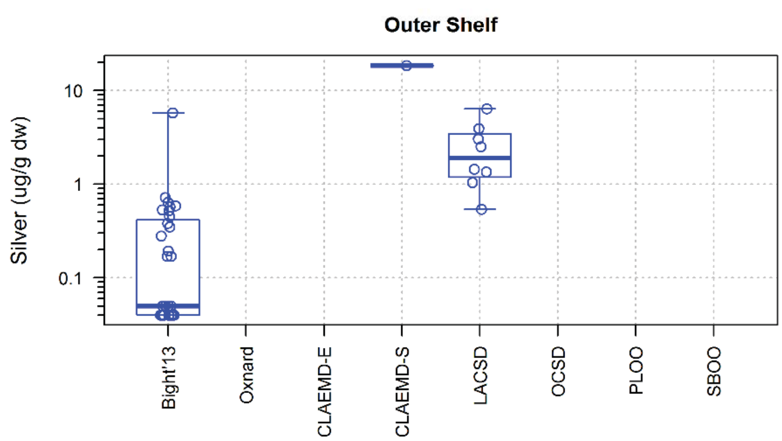

Mid Shelf
Mercury (ug/g dw)
1
0.1
0.01
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO


Outer Shelf
Mercury (ug/g dw)
1
0.1
0.01
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

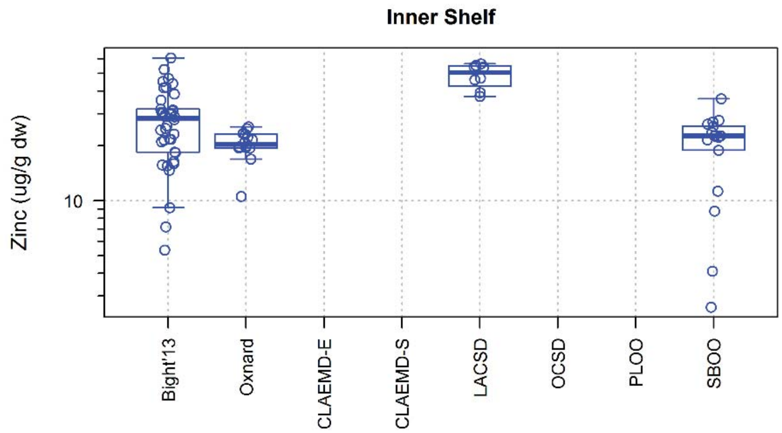
Silver

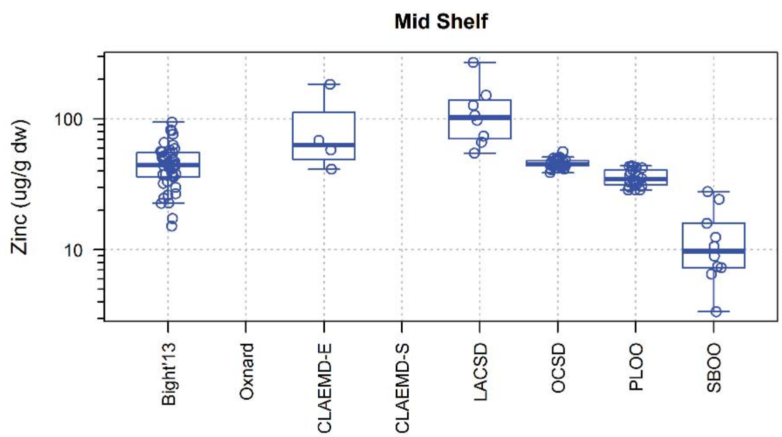

Inner Shelf
Silver (ug/g dw)
10
1
0.1
0.01
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

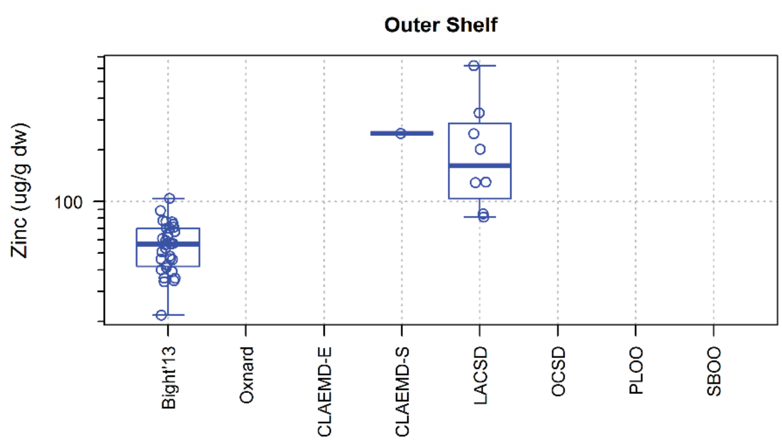

Mid Shelf
Silver (ug/g dw)
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO


Outer Shelf
Silver (ug/g dw)
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

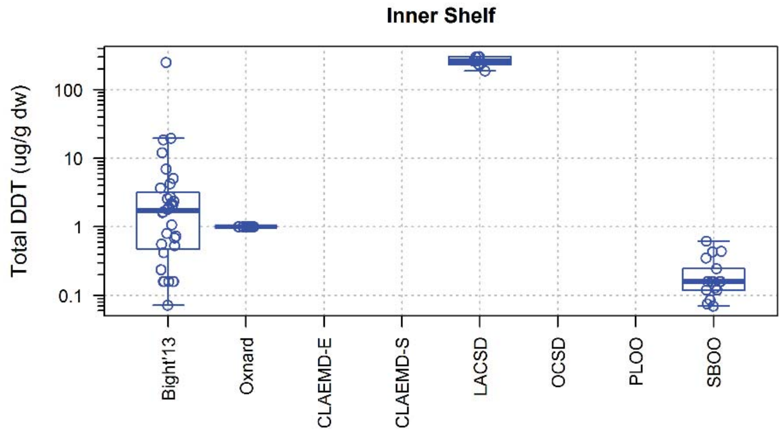
Zinc


Inner Shelf
Zinc (ug/g dw)
10
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

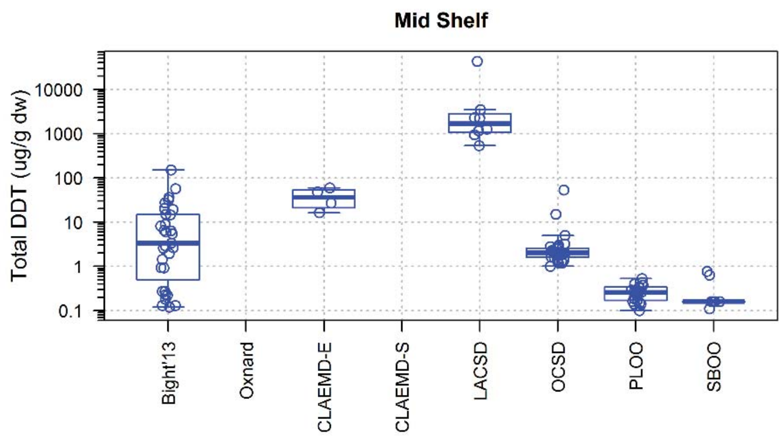

Mid Shelf
Zinc (ug/g dw)
100
10
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO


Outer Shelf
Zinc (ug/g dw)
100
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

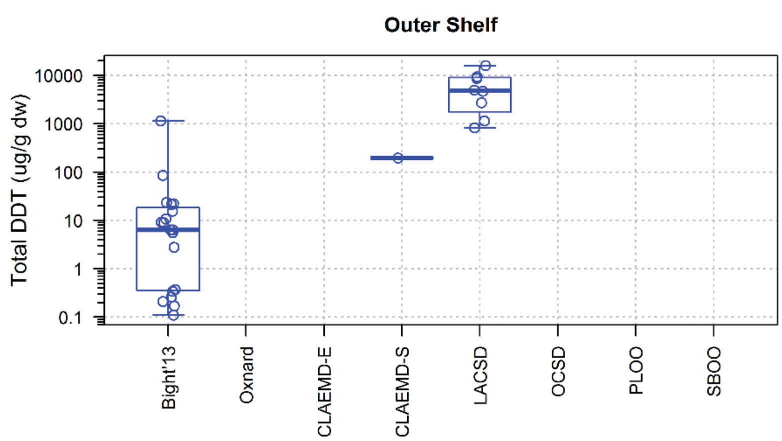
Total DDT



Inner Shelf
Total DDT (ug/g dw)
100
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

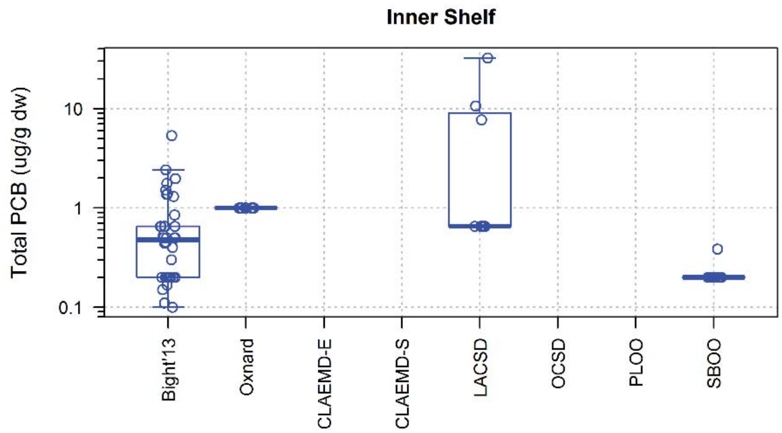


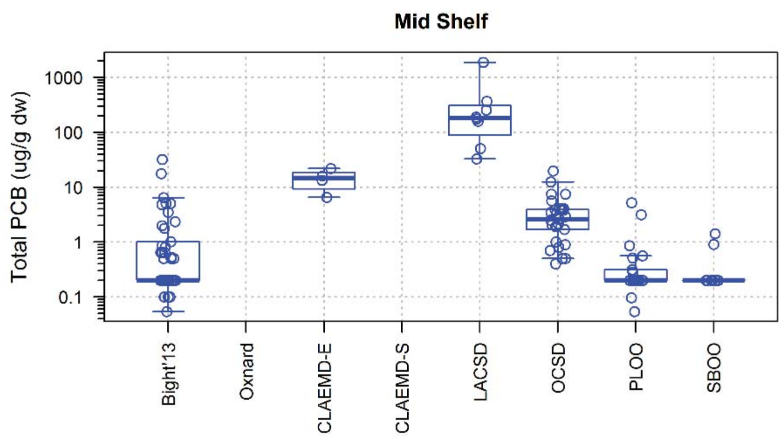
Mid Shelf
Total DDT (ug/g dw)
10000
1000
100
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

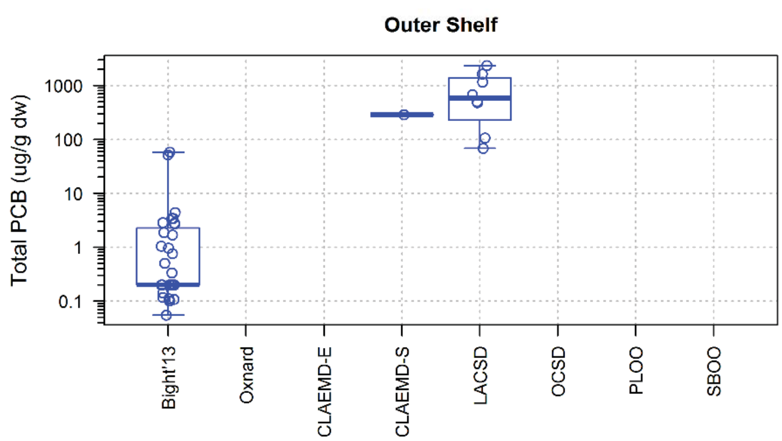


Outer Shelf
Total DDT (ug/g dw)
10000
1000
100
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

Total PCB


Inner Shelf
Total PCB (ug/g dw)
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO


Mid Shelf
Total PCB (ug/g dw)
1000
100
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO


Outer Shelf
Total PCB (ug/g dw)
1000
100
10
1
0.1
Bight'13
Oxnard
CLAEMD-E
CLAEMD-S
LACSD
OCSD
PLOO
SBOO

Percent Fines