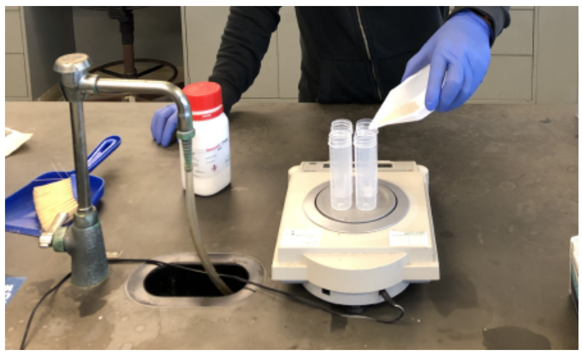
Sediment Chemistry

BIGHT '18



Southern California Bight
2018 Regional Monitoring Program
Volume II

SCCWRP Technical Report 1130

Southern California Bight 2018 Regional Monitoring Program: Volume II. Sediment Chemistry

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FOREWORD

The 2018 Southern California Bight Regional Monitoring Program (Bight '18) is a collaborative effort to provide an integrated large-scale assessment of the Southern California Bight (SCB). The Bight '18 survey is a continuation of previous regional assessments conducted in 1994, 1998, 2003, 2008, and 2013. The collaboration represents the joint efforts of 46 organizations. Bight '18 is organized into five elements: 1) Sediment Quality (formerly Contaminant Impact Assessment/ Coastal Ecology); 2) Microbiology; 3) Ocean Acidification; 4) Harmful Algal Blooms; and 5) Trash. This assessment report presents the results of the sediment chemistry portion of the survey, which is one component of the Sediment Quality element. Other Sediment Quality components include sediment toxicity and benthic infauna. Copies of this and other Bight '18 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 '18 Chemistry Technical Committee for their assistance with study design, sample analysis, data analysis, and report review. We also thank the Bight '18 Sediment Quality Planning Committee for their guidance and support of the application of sediment chemistry in regional monitoring. This study would not have been possible without the exceptional expertise of the field sampling personnel from the following organizations: City of San Diego, Weston Solutions, Orange County Sanitation District, Los Angeles County Sanitation Districts, City of Los Angeles, Southern California Coastal Water Research Project, Aquatic Bioassay and Consulting Laboratories, Wood Environment and Infrastructure Solutions, and Regional Harbor Monitoring Program. We also wish to express our gratitude to Rich Gossett (Physis Laboratories) for data interpretation and discussion; Jordan Golemo, Robert Butler, and Paul Smith (SCCWRP) for data submission; Abel Santana and Anne Holt (SCCWRP) for map preparation; and Amber Jolly and Jamie Hayward (SCCWRP) for preparation of field reference materials.

Sediment chemistry measurements were provided by the following laboratories: City of Los Angeles Environmental Monitoring Division; City of San Diego; Eurofins Calscience; Los Angeles County Sanitation Districts; National Oceanic Atmospheric Administration; Orange County Sanitation District; Weck Laboratories; and Physis Laboratories.

EXECUTIVE SUMMARY

Regional monitoring is an important mechanism to assess status and trends in human influences of coastal habitats in the Southern California Bight (SCB). The Southern California Bight 2018 Regional Monitoring Program (Bight '18) is the sixth in a series of regional marine monitoring efforts beginning in 1994 and repeated in 1998, 2003, 2008, and 2013. Forty-six different organizations encompassing regulatory, regulated, academic, and non-governmental agencies collaborated in the Bight '18 Program. The Sediment Chemistry element sought to address two primary questions:

1. What is the extent and magnitude of sediment chemistry exposure in the SCB?
2. How does the extent and magnitude of sediment chemistry exposure vary over time in the SCB?

Assessment of the toxicity, infauna, algal toxin (domoic acid), and extent and magnitude of bioaccumulation are reported elsewhere (https://www.sccwrp.org/about/research-areas/regional-monitoring/southern-california-bight-regional-monitoring-program/bight-program-documents/bight-18/).

Sampling Approach. A stratified random sampling design was selected to ensure an unbiased sampling approach to areal assessments of environmental condition. There were 11 strata selected for this study including three continental shelf strata (inner: 5-30 m, middle: 30-120 m, outer: 120-200 m), upper slope (200-500 m), lower slope (500-1000 m), Channel Islands, and five embayment strata (marinas, ports, bays, estuaries, and brackish estuaries). These strata were selected to represent a range of natural and potentially affected habitats and are inclusive of most of the habitats sampled in previous Bight surveys. This is the first survey in which the brackish estuaries stratum has been sampled (salinities less than 27 ppt). A total of 376 stations were sampled between July and September 2018.

Chemical Analytes. Sediment samples were 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 43 polychlorinated biphenyl congeners), total DDT (sum of two dichlorodiphenyltrichloroethane isomers and 5 degradation products), and total chlordane (sum of 5 forms). PCBs 8 and 195 are new analytes to Bight '18. Three groups of emerging contaminants were measured in Bight '18 including 13 polybrominated diphenyl ether (PBDE) flame retardant congeners, 4 fipronil pesticides, and 8 pyrethroids.

Extent and Magnitude of Sediment Chemistry Exposure. Applying the chemistry indices of California's Sediment Quality Objectives (SQO) assessment framework to sediment chemistry results, 79% of Bight sediments fall into minimal or low chemical exposure categories, which is considered acceptable by the SQO framework. Less than one percent of Bight sediments fall into high exposure category, the worst category of contamination according to the SQO framework. The relative extent of sediment contamination was generally greater in embayments than offshore strata, and the spatial distribution of many sediment contaminants was related to proximity to their sources.

Trends in Sediment Chemistry Exposure. The extent of acceptable sediment condition (defined as minimal or low chemical exposure) has remained relatively consistent over the last 15 years and ranged from 65% to 79% over the four surveys from 2003 to 2018. Over the same period, the extent of high exposure to sediment contamination has remained low (< 3% of SCB). While Bight-wide trends have been consistent since 2003, there were varying trends in sediment condition within different strata. The extent of acceptable sediment condition in the embayment habitats from Bight '18 relative to previous surveys was unchanged or decreased. Based on sediment contamination, the combined port, bay, marina strata had shown little improvement between 1998 and 2008 (40% to 63%), then a significant improvement to 72% in 2013, then decreased to 53% in 2018. This same analysis of trends in the areal extent of acceptable sediment condition using only revisited sites from 2003 and 2018 indicated that the sediment condition was relatively unchanged over time, with no clear trends in either increasing or decreasing chemical exposure. The extent of acceptable sediment chemistry condition in the estuaries stratum was relatively unchanged from 2003 to 2018, but the high exposure sediment contamination increased. The extent of acceptable sediment chemistry in the combined continental shelf strata was relatively unchanged between 1998 and 2018. The extent of acceptable sediment chemistry in the combined slope strata increased between 2003 and 2018.

New Analyte. Fipronil and its degradation products – a relatively new pesticide used to control insects – were investigated for the first time in the Bight '18 Program. Fipronil pesticides were not widely detected in any of the embayment strata. The highest concentrations of fipronil and its degradation products were in brackish estuaries wherein the concentrations of fipronil sulfone observed at some sites exceeded the LC50 (lethal concentration 50; 0.83 ng/g) for *Chironomus dilutus* (midge).

New Stratum. The brackish estuary stratum was introduced during this survey with the hypothesis that this habitat may be subject to higher contaminant exposure relative to other embayment strata due to closer proximity to urban and agricultural runoff. The highest concentrations of PBDEs, pyrethroids, and fipronils in Bight '18 were observed in brackish estuaries. However, concentrations of metals and other organic compounds detected in brackish estuaries were similar to those in the other embayment habitats. While the areal extent of acceptable sediment condition in brackish estuaries mirrored other embayment strata, brackish estuaries had the greatest extent of sediments in the high exposure category. However, this stratum had a low number of stations (12), generating increased uncertainty in the areal assessment.

Recommendations. As a result of the analyses included in this report, several recommendations are provided to improve future Bight surveys. These recommendations fall into two categories. The first recommends the continued monitoring of new and existing embayment habitats to assess the extent and magnitude of anthropogenic effects and the spatial and temporal variability in these effects. The second category of recommendations is to invest in monitoring infrastructure to improve comparability and efficiency of laboratory analysis. Since a small amount of data was not used due to failure of one lab to meet data quality objectives, the area of greatest concern was compliance with Bight performance-based quality assurance requirements.

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I. INTRODUCTION

Overview

The Southern California Bight (SCB) is an important ecological resource between Point Conception, California and Cabo Colnett, Baja California. The SCB is situated within an eastern boundary upwelling system, wherein seasonal upwelling of nutrient-rich waters supports large-scale primary productivity along the coastline (Capone and Hutchins 2013; Chavez and Messié 2009). The SCB also has a complex topography with offshore islands, submarine canyons, ridges, and basins (Dailey et al. 1993). This diversity of habitats, coupled with high productivity, sustains a biological diverse coastal ocean environment (Dailey et al. 1993; Dawson 2001). The SCB is also a major migration route, with marine bird and mammal populations ranking among the most diverse in north temperate waters.

The State of California has the nation's largest ocean-based economy, valued at approximately $45 billion annually, $28 billion from the SCB 5 coastal counties, and employing over half a million people (NOAA 2020). Los Angeles/Long Beach (LA/LB) Harbor is the largest commercial port in the United States and San Diego Bay is home to one of the largest U.S. Naval facilities in the country. In 2013, commercial fishermen landed more than 228 million pounds of seafood in the SCB with an ex-vessel value (amount paid to fishermen) of nearly $96 million (SeaGrant 2020). Tourism and recreation accounted for approximately $9 billion of GDP in the SCB's 5 coastal counties (NOAA 2015).

The coastal areas that form the SCB are also 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 18 million in 2018 (State of California 2019). 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). Non-permeable surfaces increase the rate of runoff and can impact water quality through the addition of sediment, toxic chemicals, pathogens, and nutrients to the ocean. There are 17 major watersheds that discharge largely untreated surface runoff from urban and agricultural land uses to the SCB (Schiff and Tiefenthaler 2011). In addition, there are 17 wastewater treatment plants that discharge a cumulative 4×10^9 L day^{-1} of treated effluent (Lyon and Stein 2008).

Historically, monitoring for sediment quality had been focused on areas nearest to regulated discharges associated with National Pollutant Discharge Elimination System (NPDES) permits and is primarily intended to assess regulatory compliance (Schiff et al. 2002). 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, providing a potentially biased perspective of the health of coastal habitats.

Beginning in 1994 and conducted every five years since, nearly 100 regulated, regulatory, non-governmental, and academic organizations have combined resources to implement the SCB Regional Marine Monitoring Program (the Bight Program), a probabilistic survey intended to assess regional condition of SCB habitats to provide much needed context for NPDES and Total Maximum Daily Load (TMDL) monitoring (Schiff et al. 2019). Regional monitoring allows assessment of large-scale reference conditions that cover a greater range of natural variability observed in the SCB, in contrast to comparing an individual discharge to a small number of local reference sites.

Beginning with the 2008 survey, the Sediment Quality component of the Bight Program evaluates potential impacts on marine benthic communities through multiple lines of evidence: sediment chemistry, biological assemblages, and sediment toxicity, compatible with the California Sediment Quality Objectives Program (SQO). Using the standardized SQO assessment methods allows for quantitative comparison of the Bight Sediment Quality results to other regions of the state and provides a mechanism to detect and monitor changes through time.

Sediment chemistry, which is the focus of this report, is a key component of the overall assessment of sediment quality using the SQO tool. Chemical measurements provide much needed information on magnitude of contamination by specific chemical contaminants region wide. Substantial effort in developing analytical comparability was invested in the previous surveys (Gossett et al. 2003). Since all the regional programs were conducted in a collaborative fashion with multiple analytical laboratories participating, intercalibration studies were a focal point for trace metal and trace organic constituents. Despite all the laboratories being certified by the State of California, there was significant discrepancy at times for specific constituents. Therefore, iterative intercalibration exercises were performed until all the laboratories could meet prescribed data quality objectives for interlaboratory accuracy and precision. These intercalibrations remain one of the foundational elements of the regional monitoring quality assurance/quality control program and ensure a robust regional monitoring program.

Objectives of the 2018 Regional Monitoring Program

The sediment chemistry portion of Bight '18 Sediment Quality Element aimed to address two questions:

1. What is the extent and magnitude of sediment chemistry exposure in the SCB?
2. How does the extent and magnitude of sediment chemistry exposure vary over time in the SCB?

The probabilistic design of the Bight Program allows for characterization of the breadth and depth of variability in sediment chemistry exposure for multiple habitats and the region overall, providing much needed context for local NPDES monitoring. Furthermore, because sediment chemistry exposure was evaluated in seven habitats, or strata, during Bight '18, relative habitat quality between habitats can also be described. Six strata representing the offshore region: Inner, Middle and Outer Shelf, Upper and Lower Slope and Channel Islands, and five embayment strata: Bays, Marinas, Ports, Estuaries (salinity > 27 ppt) and Brackish Estuaries (salinity < 27 ppt), the latter of which was assessed for the first time during this survey.

The strategy to revisit a subset of sites during each Bight survey allows for characterization of site-specific trends in sediment chemistry exposure for the region. State and local agencies have made significant investments in improving water quality and treatment. Long-term monitoring, like the Bight Program, provides a means to document the impact of these management actions on regional sediment quality and the relative rate of those impacts.

This report is structured in eight chapters 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).

Table I-1. Summary of Regional Survey Monitoring Programs.

Year	# participants	# strata	# stations
1994	12	4	264
1998	60	10	404
2003	60	11	359
2008	90	10	383
2013	34	12	397
2018	46	11	376

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 3 continental shelf strata (5-30 m, 30-120 m, 120-200 m), upper slope (200-500 m), lower slope and basin (500-1000 m), Channel Islands, and embayment strata (marinas, ports, bays, and estuaries) (Figure II-1). Brackish estuaries (Figure II-2) was introduced in Bight '18. The number of stations in each stratum is shown in Table II-1. The Bight '13 Marine Protected Areas and Submarine Canyon Bottom strata were not included in Bight '18. Stratification ensured that an appropriate number of samples was 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). Enhancement of the sampling design was achieved through intensified sampling in targeted areas (driven by stakeholder needs) and area-weights were adjusted to account for intensification in certain areas (e.g., San Diego Bay, Newport Bay, Ports of Los Angeles and Long Beach). Two strata did not meet the target 30 sites per stratum, Channel Islands and brackish estuaries, where sediments were collected from 15 (all revisits) and 12 (all new) stations, respectively. We targeted 20 sites for the brackish estuaries stratum, but at the time of sampling, 8 of those stations (both target sites and overdraw locations) did not meet the salinity requirement and were reclassified to the estuaries stratum. To assess how extent and magnitude of site-specific sediment quality vary over time, approximately 50% of the Bight '18 sample sites were sampled in the previous surveys.

Table II-1. Sample size by stratum in Bight '18.

Stratum	New Stations	Revisit Stations	Total Number of Stations
Inner Shelf	21	15	36
Mid Shelf	22	14	36
Outer Shelf	17	15	32
Upper Slope	15	15	30
Lower Slope	12	15	27
Channel Islands	0	15	15
Bay	28	15	43
Port	41	15	56
Marina	29	15	44
Estuaries	34	11	45
Brackish Estuaries	12	0	12
Total	231	145	376

Figure II-1. Stratum boundaries in Bight '18.

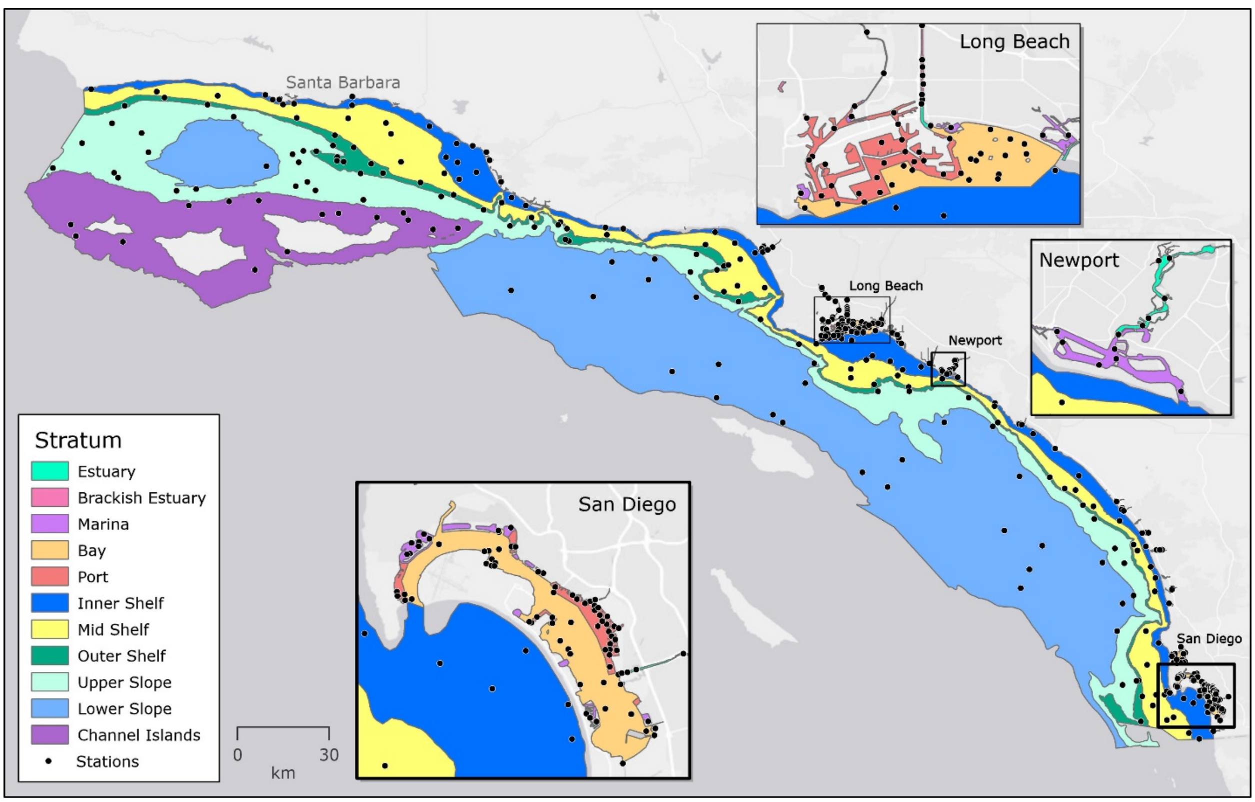
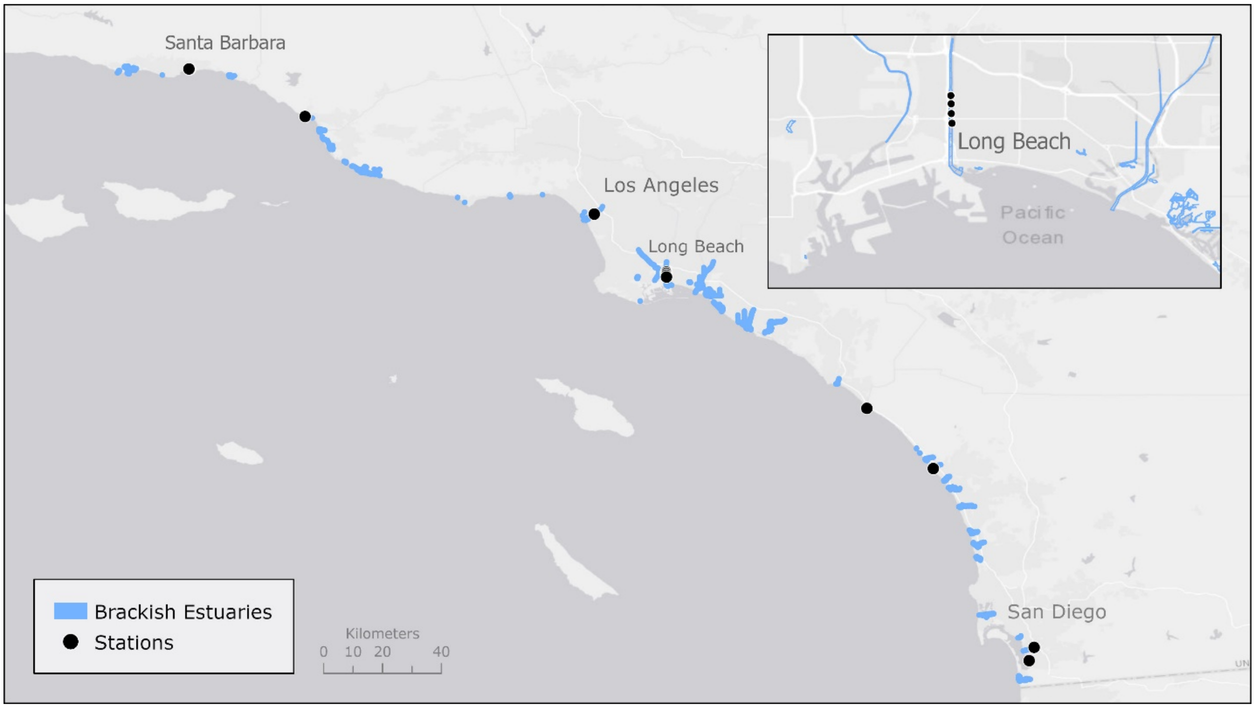


Figure II-2. Brackish estuary stations sampled in Bight '18.



Sample Collection

Sediment samples were collected using a 0.1 m^2 modified Van Veen grab sampler (Stubbs et al. 1987) or a 6-inch sediment push core in wadable depths (brackish estuaries) within 100 m and 10% of water depth of the location specified by the sampling design. Up to 6.0 L of sediment were collected for measurement of both sediment toxicity and sediment chemistry. A plastic (high-density polyethylene [HDPE], polycarbonate, or Teflon) scoop was used to collect sediment from the top 2 cm (offshore stations) or top 5 cm (embayment stations) of the undisturbed surface material in the grab. Contact with sediment within 1 cm of the sides of the grab was avoided in order to minimize cross-contamination. In most cases, multiple grabs were required to obtain enough sediment for toxicity testing and chemical analysis. If more than one grab was required, sediment from each grab was added to the Teflon bag and homogenized thoroughly using either a clean Teflon or plastic spoon, or by kneading the sample within the bag. After homogenization, sub-samples were aliquoted for chemical analysis and the remaining contents of the bag was saved for toxicity testing. Homogenization of sediments prior to subsampling for chemistry and toxicity was required for all embayment stations. For offshore sites, the contents of multiple grabs could be homogenized as was done for the embayment sites, or samples could be distributed directly to containers (HDPE jars) for toxicity and chemistry (glass jars) by placing approximately equal aliquots of sediment from the surface of a grab sample into each container type.

Subsamples for chemical analysis were placed in appropriate containers for the subsequent analysis. Glass containers with Teflon®-lined closures (250 mL) were used for all samples and were certified to meet Environmental Protection Agency (EPA) standards. Except for grain size, samples were stored frozen (-20°C) until analyzed; 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'18 Field Operations Manual (Bight '18 Sediment Quality Committee 2018). 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 '18 chemistry component as a function of parameter and laboratory is given in Table II-2.

Analytical Methods

Analytical methods employed were at the discretion of the participating laboratories, contingent upon their ability to demonstrate acceptable analytical performance determined by strict adherence to common quality assurance/quality control (QA/QC) practices, routine analysis of certified standard reference materials (SRMs) and participation in an inter-laboratory calibration study. Each laboratory was required to demonstrate its capability to meet the stated data quality objectives (DQOs) 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 intercalibration exercise and were required to meet specified performance criteria prior to any analysis of the survey samples. Analytical performance criteria and the DQOs for each quality control sample type can be found in the Bight '18 Survey Quality Assurance Plan. See Section III for an assessment of these Bight '18 Chemistry Committee quality assurance activities.

Target Analytes

Analytes for the Bight'18 survey are listed in Table II-3, and are similar to those measured in Bight '13. The 15 metal analytes were selected from 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. Due to the cost and capability constraints, not all polychlorinated biphenyl congeners (PCBs) were targeted. The 43 congeners were selected based on their potential toxicity and occurrence in the commonly used (and subsequently discharged) Aroclors 1242, 1248, 1254, and 1260. These congeners represent most prevalent and toxic congeners among the total 209 PCB congeners. Many of these targeted congeners are also associated Sediment Quality Objectives (SQO) assessment. PCBs 8 and 195 are new analytes to Bight '18 (on CA SWAMP list). The 12 chlorinated pesticides were selected based on known abundance and impacts in previous Bight surveys. Four groups of emerging contaminants were measured in Bight '18 including 13 polybrominated diphenyl ether (PBDE) flame retardants (PBDE 190 added to the list used in Bight' 13), 4 fipronil pesticides, 8 pyrethroid pesticides, and domoic acid (DA). Results on domoic acid are reported in the Bight '18 Harmful Algal Bloom final report. The PBDEs and pyrethroids were first measured in Bight '08 special studies. Bight'18 is the first regional monitoring program to include fipronils and DA in the regional program of SCB.

Table II-2. Sediment chemistry laboratory effort in Bight '18[1].

	Agency								
Parameter	**CLAEMD**	**CSD**	**LACSD**	**OCSD**	**Physis**	**NOAA**	**Eurofins CalScience**	**Weck**	**Total Number of Samples**
Grain Size	0	218	0	0	113	0	43	0	374
Total Organic Carbon (TOC)	32	137	33	34	111	0	27	0	374
Total Nitrogen (TN)	32	137	33	34	111	0	27	0	374
Metals	32	100	33	40	111	15	43	0	374
Polycyclic Aromatic Hydrocarbons (PAH)	33	66	35	42	140	15	43	0	374
Polychlorinated Biphenyls (PCB)	33	66	35	42	139	15	43	0	373
Chlorinated hydrocarbons	31	66	35	42	140	15	43	0	372
Polybrominated Diphenyl Ethers (PBDE)	0	0	0	0	110	15	41	24	190
Pyrethroids	0	0	28	0	110	15	41	0	194
Fipronils	0	0	0	41	110	15	0	24	190
Total Number of Sample Analyses per Laboratory	193	790	232	275	1195	105	351	48	3189

[1]CLAEMD = City of Los Angeles Environmental Monitoring Division, CSD = City of San Diego, LACSD = Los Angeles County Sanitation Districts, NOAA = National Oceanic Atmospheric Administration, OCSD = Orange County Sanitation District.

The following are brief descriptions of the analytical methods.

Grain Size

Samples were analyzed by 3 laboratories, including Physis Environmental Laboratories (113), City of San Diego (218), and Eurofins Calscience (43). 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. The sample fraction less than 1000 µm were analyzed using a Horiba or Micromeritics Saturn II Digisizer. The size distribution was computed by summarizing the set of numbers for each size classification which are represented by each channel detector. All categories < 63 µm were considered fine-grained material (silts + clays) and are referenced herein as percent fines.

Table II-3. Sediment chemistry target analytes in Bight '18[1].

Trace Metals	PAHs	PCBs		Pesticides	PBDEs
Aluminum	1,6,7-Trimethylnaphthalene	PCB-8	PCB-158	<u>Chlorinated Pesticides[2]</u>	BDE-17
Antimony	1-Methylnapthalene	PCB-18	PCB-167	4,4'-DDT	BDE-28
Arsenic	1-Methylphenanthrene	PCB-28	PCB-168	2,4'-DDT	BDE-47
Barium	2,6-Dimethylnaphthalene	PCB-37	PCB-169	4,4'-DDD	BDE-49
Beryllium	2-Methylnapthalene	PCB-44	PCB-170	2,4'-DDD	BDE-66
Cadmium	Acenaphthene	PCB-49	PCB-177	4,4'-DDE	BDE-85
Chromium	Acenaphthylene	PCB-52	PCB-180	2,4'-DDE	BDE-99
Copper	Anthracene	PCB-66	PCB-183	4,4'-DDMU	BDE-100
Iron	Benz[*a*]anthracene	PCB-70	PCB-187	alpha-chlordane	BDE-138
Lead	Benzo[*a*]pyrene	PCB-74	PCB-189	gamma-chlordane	BDE-153
Mercury	Benzo[*b*]fluoranthene	PCB-77	PCB-194	*cis*-nonachlor	BDE-154
Nickel	Benzo[*e*]pyrene	PCB-81	PCB-195	*trans*-nonachlor	BDE-183
Selenium	Benzo[*g,h,i*]perylene	PCB-87	PCB-201	oxychlordane	BDE-190
Silver	Benzo[*k*]fluoranthene	PCB-99	PCB-206		
Zinc	Biphenyl	PCB-101		<u>Pyrethroid Pesticides</u>	
	Chrysene	PCB-105		Bifenthrin	
	Dibenz[*a,h*]anthracene	PCB-110		Cyfluthrin (total)	
	Fluoranthene	PCB-114		Cypermethrin (total)	
	Fluorene	PCB-118		lambda-Cyhalothrin (total)	
	Indeno[1,2,3-*c,d*]pyrene	PCB-119		*cis*-Permethrin	
	Naphthalene	PCB-123		*trans*-Permethrin	
	Perylene	PCB-126		Deltamethrin	
	Phenanthrene	PCB-128		Esfenvalerate	
	Pyrene	PCB-138			
		PCB-149		<u>Fipronil Pesticides</u>	
		PCB-151		Fipronil	
		PCB-153		Fipronil Desulfinyl	
		PCB-156		Fipronil Sulfide	
		PCB-157		Fipronil Sulfone	

[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.

Total Organic Carbon and Total Nitrogen

Freeze-dried sediment sample was grinded with mortar and pestle into a fine homogeneous powder prior to being loaded on a ceramic boat. Inorganic carbon was removed by exposing to hydrochloric acid at 60°C for 24 h. Total organic carbon (TOC) and total nitrogen (TN) analyses were performed using a Shimadzu TOC-VCPH/CPN analyzer, in which samples are combusted at high temperature (680°C for TOC, 720°C for TN), dehumidified, and analyzed by a non-dispersive infrared (NDIR) gas analyzer.

Metals

Samples, not including those 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 deionized 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. Samples for mercury were prepared according to the procedures described in EPA Method 245.5. All laboratories analyzed mercury using cold vapor atomic absorption spectroscopy.

Trace Organics

Trace organic chemistry samples 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 and PBDE by GC-MS. Pyrethroids and fipronils were analyzed by using either LC-MS/MS or GC-MS.

Data Analysis

The sediment chemistry data from Bight '18 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 SQO assessment framework established by the State of California (SWRCB 2009).

Data below the method detection limit were treated as zero when data were reported. The same approach was adopted for determination of descriptive statistics. A sensitivity analysis was performed in Section V where data below method detection limits were treated as either one-half the method detection limit or the full method detection limit to evaluate how method detection limit discrepancies affected chemistry indices. The fact that limited changes were observed in the method limit discrepancy exercise suggests that the data set is robust enough that arbitrary selection of less-than values did not much change the key points from the study. For determination of chemical indices, the unique way of data preparation followed the California Sediment Quality Objectives Technical Manual (Bay et al. 2014). For example, if all components of a sum are non-detected, then the highest reporting level of any one compound in the group should be used to represent the sum value.

Quantitative spatial analysis was performed using R (R Development Core Team 2015) and the Spatial Survey package (Diaz-Ramos et al. 1996; Kincaid and Olsen 2015). This function estimated the AWM 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 not 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 for SQO chemical index but has not been analyzed since Bight '08 because it was rarely detected. We assume non detectable quantities of dieldrin would not increase chemical exposure category. 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 benthic infaunal data are not yet available. In order to comply with the complete protocol, the 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 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 its own protocols, while meeting common 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 '18 Quality Assurance Manual.

Reporting Limits

To achieve study goals, minimum target reporting limits (RL) for each analyte were set forth in the Bight '18 Quality Assurance Manual based on requirements of the SQO CSI used to assess contamination impacts. Overall, participant-specific minimum RLs were lower than or comparable to the targets, therefore the analyses were performed with adequate sensitivity. Exceptions are as follows. The 64%-97% success in meeting the required trace metal RLs was due to three laboratories' trace metal measurements, which exceeded the requirement in 55%-100% of the laboratory's measurements. The 93%, 79%, and 80% successes in meeting the required RLs for PAHs, PBDEs, and pyrethroids, respectively, were due to two laboratories' RLs exceeding the target RLs; however, MDLs were below the target RLs when non-detect values were reported, indicating there was no measurement bias.

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.

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 material 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 intercalibration before analyzing field samples. As noted below, pyrethroids and fipronils were measured and assessed only using Bight sediment due to unavailability of certified reference materials. A summary of intercalibration results is in Table III-2. The full set of participating laboratories in Appendix A included some that did not analyze field samples; they participated on a volunteer basis. Weck Laboratories, which voluntarily analyzed PBDEs and fipronils in Bight '18, did not fully participate in the intercalibration exercise for these two chemical classes.

Performance-Based Quality Control Goals and Success

Organics

National Institute of Standards and Technology Standard Reference Material (NIST SRM) 1944 New York/New Jersey Waterway Sediment was used to test 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.

Trace Metals in Sediment

ERA Certified Reference Material 540 Metals in Soil, Lot D099-540 was used to test method accuracy. Laboratories are required to obtain concentrations within PT performance acceptance limits of certified value for all of 15 analytes.

The field reference material provided by the Los Angeles County Sanitation District from Palos Verdes Shelf was used to test both inter- and intra-laboratory precision when analyzing a sample with high levels of DDT and potential interferences not present in SRM 1944 and ERA 540. Laboratories are required to obtain a total class concentration within 40% of the grand mean value for PCBs, PAHs, OC pesticides, and PBDEs. Laboratories were also required to obtain a concentration within 30% of the grand mean value for 12 of 15 trace metals. A separate field reference material from Port of Los Angeles Consolidated Slip Site was used to assess pyrethroids and fipronils. Values for pyrethroids and fipronils are used for informational purposes only.

Quality Control (QC) goals are described in detail in the Bight ’18 Quality Assurance Manual (Bight ’18 Sediment Quality Committee 2018) and summarized along with the results in Table III-3. The completeness, defined as the proportion of the expected data that was collected in the measurement process, was 96% due to the rejected stations described below. The frequency success of running QC samples was 100%, except for PBDEs due to a lack of running SRMs. The accuracy and precision success of the QC samples was typically 83% to 100%, except for trace metals due to the matrix interferences on matrix spike recoveries. In the preparation batches that were affected by matrix spike failures, the Sediment Chemistry Technical Committee decided to use QC performances of CRM and blank spike records to evaluate the data quality. These data were accepted for sediment quality assessment upon the success of passing CRM and blank spike criteria. Overall, most 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 93.9% holding time success for trace metals, TOC, and organic contaminants was because a required reanalysis of a set of samples was completed 6 weeks outside the targeted 1-year holding times. In addition, 3.1% of the grain size measurements, performed by one laboratory, were made 2 weeks outside of the 6-month holding time. There is no evidence that 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. A 100% holding time success rate was achieved for the remaining measurements.

Rejected Stations

All chemistry data from 16 stations (4.4%) was rejected and not used in the data analysis. Samples from all rejected stations were measured by one laboratory, where a required reanalysis of a set of samples was delayed and data for those samples was not received. The rejected stations fell primarily in the southern regions of the Bight, particularly in San Diego Bay and were stakeholder intensification sites (Table III-5), thus this will not impact the assessment results (even with the 16 rejected stations there were 33 sites remaining in the Port stratum and 22 sites remaining in all San Diego Bay strata). Thus, the San Diego Bay and the Port stratum remained well represented. The total area of these 16 rejected stations accounted for 0.1% of area in the Bight ’18 survey. Thus, the removal of these stations will not have a meaningful impact on the final Bight-wide or embayment-wide conclusions of this project.

Repeated Analysis

Chemical analyses, including metals, TOC, PAHs, PCBs, and chlorinated pesticides, from 27 stations (7.5%) were repeated according to the suggestions from the Sediment Chemistry Technical Committee. The samples from these stations were measured by one laboratory where various QC discrepancies (e.g. missing target analytes, missing CRM records, and lack of complete analyte list for matrix spikes) were found. Data (all parameters) from repeated analysis were in agreement with the data from the original analysis (Figure III-1, Reanalysis = 9.9 + 0.41*Original, $R^2 = 0.74$, red line is in 1:1 ratio) and would not produce a meaningful impact to the results. Therefore, the Technical Committee decided to use these data from the repeated analysis in the subsequent data analysis, calculation of AWM concentration, and calculation of the Chemical Index scores.

Figure III-1. Comparison of results between the original and repeated analyses.

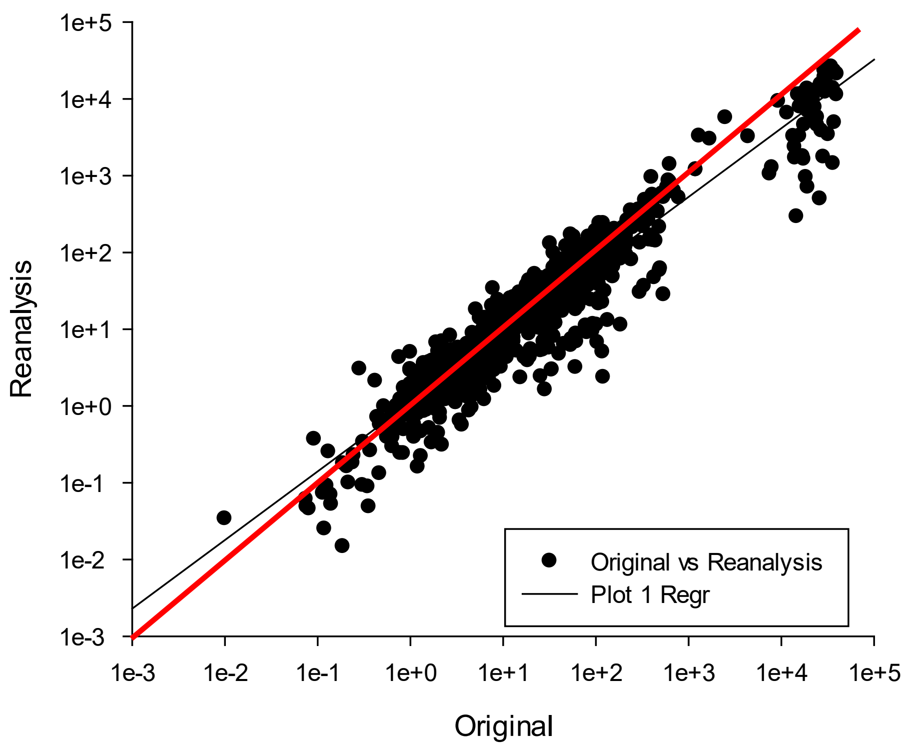


Table III-1. Achieved reporting levels in sediment. Percent success is based on the number of samples meeting the required reporting level.

Parameter	Required Reporting Level	Reporting Level Range Achieved	Percent Success
Aluminum (µg/g dw)	NA[1]	5.0-1990	
Antimony (µg/g dw)	10	0.05-27.1	93%
Arsenic (µg/g dw)	1.6	0.05-13.6	93%
Barium (µg/g dw)	NA	0.05-13.6	
Beryllium (µg/g dw)	0.2	0.05-13.6	93%
Cadmium (µg/g dw)	0.09	0.005-13.6	93%
Chromium (µg/g dw)	16	0.005-27.1	95%
Copper (µg/g dw)	7	0.005-13.6	93%
Iron (µg/g dw)	NA	5-996	
Lead (µg/g dw)	9.3	0.005-13.6	97%
Mercury (µg/g dw)	0.03	0.00002-0.219	88%
Nickel (µg/g dw)	4.2	0.02-13.6	93%
Selenium (µg/g dw)	1	0.05-13.6	93%
Silver (µg/g dw)	0.2	0.02-13.6	64%
Zinc (µg/g dw)	30	0.05-67.8	93%
Organochlorine Pesticides (ng/g dw)	0.5	0.24-8.7	74%
PAH (ng/g dw)	20-80	0.5-210	93%
PCB (ng/g dw)	3	0.2-3	100%
PBDE (ng/g dw)	0.1	0.097-1	79%
Pyrethroids (ng/g dw)	0.5	0.05-27	80%
Fipronils (ng/g dw)	0.5	0.05-0.5	100%

[1]NA indicates a required reporting level was not set.

Table III-2. Sediment chemistry intercalibration 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	CLA	CSD	NOAA	Physis	Eurofins Calscience	Summary
SRM 1944	Individual PAHs	Within 40% of target value for 80% of the analytes	93%	86%	86%	100%	86%	86%	93%	All passed (≥86%)
SRM 1944	Individual PCBs	Within 40% of target value for 70% of the analytes	96%	100%	96%	92%	100%	100%	77%	All passed (≥77%)
SRM 1944	Individual OC Pesticides	Within 40% of target value for 70% of the analytes	89%	100%	89%	100%	100%	100%	89%	All passed (≥89%)
SRM 1944	Individual PBDEs	Within 40% of target value for 70% of the analytes	NA	NA	NA	NA	100%	100%	83%	All passed (≥83%)
Organics Field Reference	Total PAH	40% of the mean value	100%	100%	100%	100%	100%	100%	100%	All passed (is 100%)
Organics Field Reference	Total PCB	40% of the mean value	100%	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%	100%	All passed (is 100%)
Organics Field Reference	Total PBDEs	40% of the mean value	NA	NA	NA	NA	100%	100%	100%	All passed (is 100%)
ERA 540	Individual Metals	Within PT performance acceptance limits for all analytes	100%	100%	100%	100%	100%	100%	100%	All passed (is 100%)
Metals Field Reference	Individual Metals	30% of the mean value for 80% of the analytes	93%	80%	93%	80%	80%	80%	87%	All passed (≥80%)

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

Quality Control Parameter	Metals		PAH		TOC	
	DQO	**Success**	**DQO**	**Success**	**DQO**	**Success**
Completeness	100%	96%	100%	96%	100%	96%
Method Blank Frequency Success Accuracy Success	 1/batch < MDL or < 5% of result	 100% 99%	 1/batch < 10 times MDL	 100% 100%	 1/batch < 10 times MDL	 100% 100%
Blank Spike Frequency Success Accuracy Success	 1/batch 15% of true value	 100% 100%	Not Required	NA	Not Required	NA
Reference Material Frequency Success Accuracy Success	 1/batch Within PT performance acceptance limits of certified values for all 15 analytes	 100% 100%	 1/batch ± 40% of specified value for ≥ 80% of selected analytes	 100% 100%	 1/batch ± 20% of specified value	 100% 98%
Matrix Spike Frequency Success Accuracy Success	 10% of samples	 100% 40%	 1/batch 60-140% recovery of spiked mass for > 80% of analytes	 100% 87%	Not Required	NA
Sample or MS Duplicate Frequency Success Accuracy Success	 10% of samples RPD < 30%	 100% 97%	 1/batch RPD < 40% for > 70% of analyte	 100% 100%	 1/batch RPD < 30%	 100% 100%

Table III-3 (cont.)

Quality Control Parameter	Common DQO	OC Pesticides	PCB	PBDE	Pyrethroid Pesticides	Fipronils
Completeness	100%	96%	96%	100%	100%	100%
Method Blank Frequency Success Accuracy Success	 1/batch < 10 times MDL & <RL	 100% 100%	 100% 100%	 100% 100%	 100% 89%	 100% 100%
Blank Spike Frequency Success Accuracy Success	 Not Required	 NA	 NA	 NA	 NA	 NA
Reference Material Frequency Success Accuracy Success	 1/batch ± 40% of specified value for ≥ 70% of selected analytes	 100% 100%	 100% 100%	 66% 94%	 NA	 NA
Matrix Spike Frequency Success Accuracy Success	 10% of samples 60-140% recovery of spiked mass for > 80% of analytes	 100% 93%	 100% 93%	 100% 83%	 100% 90%	 100% 87%
Sample or MS Duplicate Frequency Success Accuracy Success	 1/batch RPD < 40% for > 70% of analyte	 100% 99%	 100% 100%	 100% 100%	 100% 100%	 100% 100%

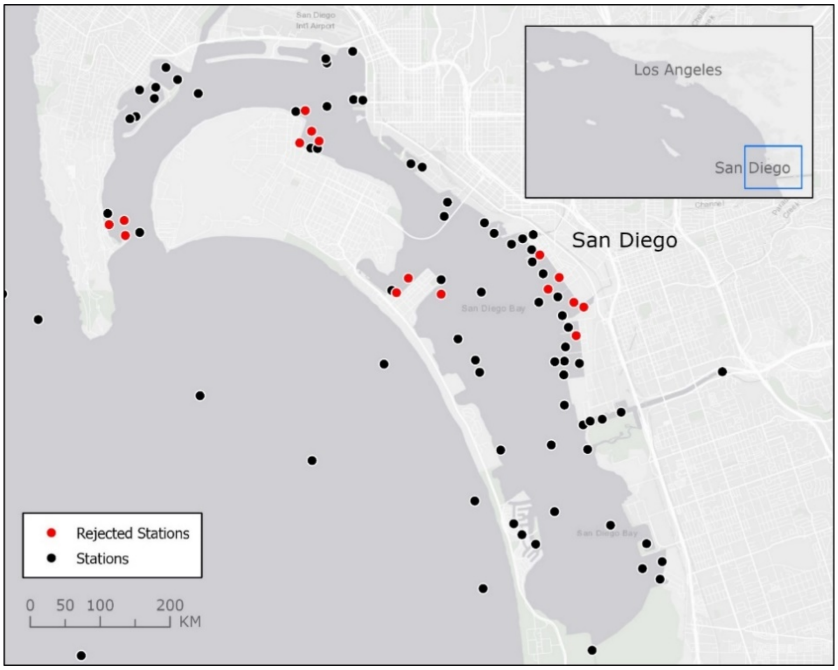
Table III-4. Achieved sample holding times. Percent success is based on the number of samples meeting the required holding time.

Parameter	Required Holding Time	Holding Time Range (days)	Percent Success
Grain Size	6 months	1-199	96.9%
TOC	1 year	2-407	93.9%
TN	1 year	15-365	100%
Trace Metals	1 year	5-407	93.9%
Organochlorine Pesticides	1 year	1-407	93.9%
PAH	1 year	3-407	93.9%
PCB	1 year	1-407	93.9%
PBDE	1 year	20-176	100%
Pyrethroids	1 year	20-176	100%
Fipronils	1 year	20-214	100%

Table III-5. Locations of the rejected stations. Parenthesis indicate the number of stations in each region.

Stratum	Bight Region	Type
Bays	San Diego Bay (2)	Overdraw
Bays	San Diego Bay-NBC (3)	New Site
Ports	San Diego Bay-NAB (2)	New Site
Ports	San Diego Bay-NBPL (3)	New Site
Ports	San Diego Bay-NBSD (6)	New Site

Figure III-2. Sampled station locations in San Diego Bay.



IV. Descriptive Results

Bight-wide Results

The AWM 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 was very coarse (0% fines) to very fine (99% silt and clay), averaging 62 ± 4.9% fines overall. The TOC measurements varied from non-detect to 7.9% TOC and a 13:1 TOC/TN ratio. Five of fifteen trace metals were detectable in 100% of the samples (Al, Ba, Cr, Fe, and Zn). AWM (± 95% CI) concentrations (dry weight basis) among the different metals varied from a low of 0.068 ± 0.01 µg/g for mercury to a high of 22,000 ± 1,600 µg/g for iron. Organic constituents were detectable in 21%, 61%, 90%, and 85% 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 0.08 ± 0.06 ng/g for chlordanes to a high of 101 ± 24 ng/g for total PAH. Total PBDE had an AWM for of 0.99 ± 0.39 ng/g and was detected in 46% of the samples in which it was measured. Total pyrethroid had an AWM concentration of 5.0 ± 2.2 ng/g and was detected in 70% of the samples in which it was measured. Total fipronil had an AWM concentration of 0.20 ± 0.15 ng/g and was detected in 7% of the samples in which it was measured.

Subpopulation Comparisons

AWM concentrations and corresponding 95% CIs for all strata of interest are presented in Table IV-2. Generally, the embayment strata (marinas, ports, bays, estuaries, and brackish estuaries) exhibited higher concentrations for metals and organic contaminants compared to the shelf and slope strata. For example, copper ranged from 3.2 ± 0.82 µg/g to 27 ± 2.9 ug/g offshore and from 34 ± 9.6 µg/g to 110 ± 24 µg/g in embayments. However, there was an enrichment in sediment fines and TOC as the water depth increased with AWM fines on the inner shelf (5-30 m) being 12 ± 2.6% versus 83 ± 2.1% on the lower slope (500-1000 m). This led to similar increases in contaminants with depth with concentrations on the lower slope in some cases similar to those in embayments. A different trend was present for DDT in sediments on continental shelf and slope (maximum of 120 ± 190 ng/g), which had higher concentrations of DDT compared to embayments (maximum of 41 ± 14 ng/g). Marinas consistently exhibited the highest AWM concentrations for trace metals and legacy organic contaminants. For example, copper and mercury were the highest in marinas followed by ports, bays, brackish estuaries, and estuaries. Other metals with a history of anthropogenic inputs (i.e. zinc and lead) followed similar trends. The new brackish estuaries stratum had percent fines, TOC, and trace metals and legacy organic contaminant concentrations similar to those found in other embayment habitats. Zinc concentrations, as an example, were 140 ± 87 µg/g in brackish estuaries while embayments ranged from 110 ± 29 to 170 ± 31 µg/g. For total PAHs, brackish estuaries AWM was 730 ± 490 ng/g with embayment ranging from 570 ± 230 to 2400 ± 2300 ng/g. In contrast, brackish estuaries exhibited the highest AWM concentrations for pyrethroids, PBDEs, and fipronils. Sediments from the Channel Islands consistently had the lowest concentrations of most trace metals and organics constituents.

Geographic Distribution of Sediment Parameters

The geographic distribution and magnitude of sediment concentrations in Bight '18 illustrate that not all constituents have the same sources and may differ in their ultimate fate within the SCB (maps of all parameters can be found in Appendix B). Generally, the geographic distribution in Bight'18 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 from the LACSD ocean outfall, then declined moving northward through Santa Monica Bay and the Santa Barbara Channel in the net current direction (Figure IV-1). The spatial distribution of copper (Figure IV-2) 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 (Schiff et al. 2004). Total PAHs were also higher in embayments, but likely due to land-based runoff (Table IV-2). Total pyrethroids were highest in brackish estuaries and in estuaries (29 ± 22 and 15 ± 10 ng/g, respectively) compared to ports and bays (1.3 ± 0.75 and 3.3 ± 3.1 ng/g, respectively) (Figure IV-3). Total PBDEs were also highest in brackish estuaries compared to the rest of embayment strata ranging from 0.15 ± 0.12 to 2.2 ± 1.5 ng/g., PBDEs (Figure IV-4), pyrethroids, and fipronils were not measured in offshore strata, except in Channel Islands with minimal detections. Total fipronils (Figure IV-5), investigated for the first time in Bight, were highest in brackish estuaries (3.2 ± 3.4 ng/g) compared to the rest of embayment strata (up to 0.58 ± 0.56 ng/g).

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

Chemical Group	Area Weighted Mean	95% CI	Min	10th percentile	Median	90th Percentile	Max	Percent of stations detected
Fines%	62	4.9	0.56	11	47	84	99	
TOC%	2.2	0.24	0.05	0.26	1.1	3.2	7.9	100
TN%	0.22	0.03	< MDL	0.03	0.09	0.28	0.77	96
Aluminum	15000	1400	290	4000	14000	35000	58000	100
Antimony	0.96	0.21	<MDL	<MDL	0.28	2.4	6.7	85
Arsenic	5.3	0.54	<MDL	1.8	5.0	10	16	96
Barium	240	38	2.4	31	96	260	1800	100
Beryllium	0.46	0.04	<MDL	0.05	0.39	0.79	1.9	91
Cadmium	0.87	0.13	<MDL	0.02	0.27	1.7	6.1	91
Chromium	45	5.2	3.0	10	30	62	180	100
Copper	19	2.4	<MDL	3.0	21	120	660	98
Iron	22000	1600	500	7300	21000	35000	67000	100
Lead	9.4	1.4	<MDL	2.8	11	41	370	99
Mercury	0.07	0.01	<MDL	0.01	0.06	0.33	2.8	98
Nickel	26	3.1	<MDL	3.8	15	30	70	99
Selenium	2.3	0.39	<MDL	<MDL	0.51	2.4	7.1	79
Silver	0.23	0.08	<MDL	<MDL	<MDL	0.50	5.4	49
Zinc	72	6.2	3.3	23	79	220	700	100
PAH	100	24	<MDL	8.7	130	1600	33000	85
PCB	13	8.8	<MDL	<MDL	2.9	36	4600	61
DDT	70	47	<MDL	0.04	4.3	49	2900	90
Chlordanes	0.08	0.06	<MDL	<MDL	<MDL	3.0	72	21
PBDE	0.99	0.39	<MDL	<MDL	0.22	3.2	23	46
Pyrethroids	5.0	2.2	<MDL	<MDL	0.93	20	160	70
Fipronils	0.20	0.15	<MDL	<MDL	<MDL	<MDL	18	6.7

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. (NA – not applicable; MDL – method detection limit).

	Shelf						Slope and Basin				Channel Islands	
	Inner (5-30 m)		Mid (30-120 m)		Outer (120-200 m)		Upper (200-500 m)		Lower (500-1000 m)			
Parameter	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Fines%	12	2.6	35	6.2	39	5.0	69	5.5	83	2.1	26	6.6
TOC%	0.35	0.08	0.74	0.13	1.0	0.19	2.2	0.32	3.1	0.29	2.1	0.72
TN%	0.03	0.004	0.06	0.01	0.09	0.02	0.23	0.04	0.33	0.04	0.09	0.02
Aluminum	5800	610	9600	1100	11000	1500	19000	3600	20000	860	3500	530
Antimony	0.57	0.17	1.2	0.34	0.98	0.28	1.3	0.40	0.98	0.40	0.39	0.28
Arsenic	3.8	0.58	4.4	1.0	4.1	0.84	7.3	1.3	5.8	0.87	2.5	0.20
Barium	77	21	170	120	150	59	180	31	360	53	66	28
Beryllium	0.18	0.03	0.38	0.10	0.37	0.07	0.62	0.08	0.55	0.04	0.14	0.03
Cadmium	0.20	0.08	0.56	0.31	0.62	0.27	1.4	0.45	0.96	0.18	0.56	0.18
Chromium	14	1.8	28	7.1	33	7.1	56	12	59	7.3	16	2.6
Copper	3.2	0.82	6.8	1.8	10	3.5	21	5.2	27	2.9	5.0	0.69
Iron	10000	970	19000	3800	21000	3500	27000	2500	27000	1200	7600	1000
Lead	4.6	1.6	6.4	0.97	7.5	1.7	11	3.1	12	2.4	3.2	0.44
Mercury	0.02	0.005	0.05	0.02	0.06	0.04	0.10	0.03	0.08	0.02	0.03	0.02
Nickel	8.1	1.6	12	2.0	15	1.9	29	4.5	36	5.0	14	1.7
Selenium	0.85	0.37	0.75	0.19	0.63	0.19	1.8	0.24	3.9	0.54	0.52	0.09
Silver	0.004	0.01	0.08	0.09	0.18	0.29	0.24	0.17	0.37	0.13	<MDL	<MDL
Zinc	26	3.4	45	6.4	50	5.3	82	12	95	6.3	30	3.3
PAH	44	21	67	22	88	33	120	45	120	46	12	3.6
PCB	1.2	1.3	4.3	4.0	120	200	16	17	11	6.1	0.55	0.25
DDT	6.6	8.8	13	8.9	41	45	120	190	96	67	3.9	1.5
Chlordanes	<MDL		<MDL		<MDL		0.19	0.24	0.08	0.09	0.001	0.001
PBDE	NA		NA		NA		NA		NA		0.04	0.02
Pyrethroids	NA		NA		NA		NA		NA		0.15	0.28
Fipronils	NA		NA		NA		NA		NA		<MDL	<MDL

Table IV-2 (cont.)

	Embayments									
	Marinas		Ports		Bays		Estuaries		Brackish Estuaries	
Parameter	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Fines%	58	7.9	62	6.7	49	7.9	43	8.1	39	9.8
TOC%	1.7	0.37	1.5	0.27	1.2	0.23	1.4	0.41	3.1	1.6
TN%	0.14	0.02	0.09	0.02	0.08	0.01	0.09	0.03	0.27	0.15
Aluminum	20000	4300	16000	3000	22000	4000	20000	4700	9800	2900
Antimony	0.71	0.39	0.32	0.28	0.35	0.23	0.98	0.43	1.8	0.87
Arsenic	6.7	1.3	6.6	1.5	6.0	1.1	5.3	1.0	5.17	2.1
Barium	79	14	110	21	120	34	78	15	91	34
Beryllium	0.49	0.13	0.26	0.11	0.48	0.10	0.44	0.09	0.30	0.10
Cadmium	0.30	0.09	0.49	0.33	1.0	0.39	0.37	0.11	0.67	0.31
Chromium	35	6.3	33	5.0	37	5.4	25	4.3	20	6.3
Copper	110	24	66	24	47	9.8	34	9.6	37	18
Iron	23000	4300	22000	3300	25000	3600	20000	3400	14000	3700
Lead	31	7.1	27	7.9	23	4.5	23	9.4	17	9.5
Mercury	0.32	0.11	0.28	0.19	0.14	0.03	0.05	0.02	0.05	0.03
Nickel	14	2.8	18	3.4	16	2.9	11	2.2	13	5.5
Selenium	1.0	0.37	0.16	0.10	0.29	0.12	0.44	0.12	0.80	0.32
Silver	0.20	0.06	0.10	0.05	0.19	0.08	0.14	0.10	0.03	0.03
Zinc	170	31	120	23	130	20	110	29	140	87
PAH	930	400	2400	2300	630	220	570	230	730	490
PCB	110	140	37	31	15	5.8	13	7.7	7.9	5.7
DDT	22	12	41	14	26	20	11	4.2	9.4	5.6
Chlordanes	1.9	1.1	1.4	1.0	1.0	1.1	5.2	3.1	8.3	6.1
PBDE	0.88	0.39	0.15	0.12	0.89	0.59	2.2	1.5	4.9	3.5
Pyrethroids	4.9	1.9	1.3	0.75	3.3	3.1	15	10	29	22
Fipronils	0.005	0.01	<MDL		0.07	0.10	0.58	0.56	3.2	3.4

Figure IV-1. Geographic distribution of total DDT sediment concentrations (ng/g dw) during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range and number of samples for each bin.

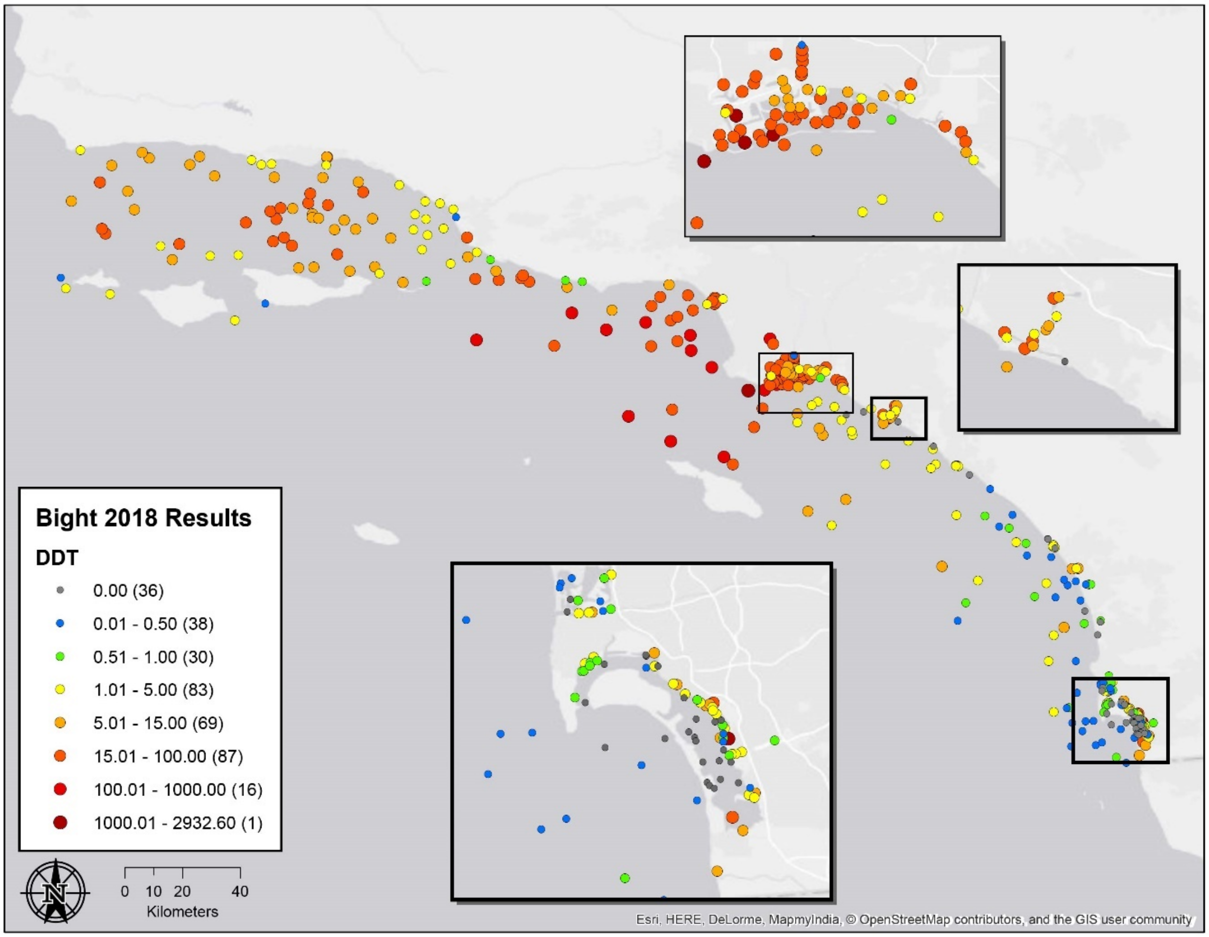


Figure IV-2. Geographic distribution of copper sediment concentrations (µg/g dw) during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range and number of samples for each bin.

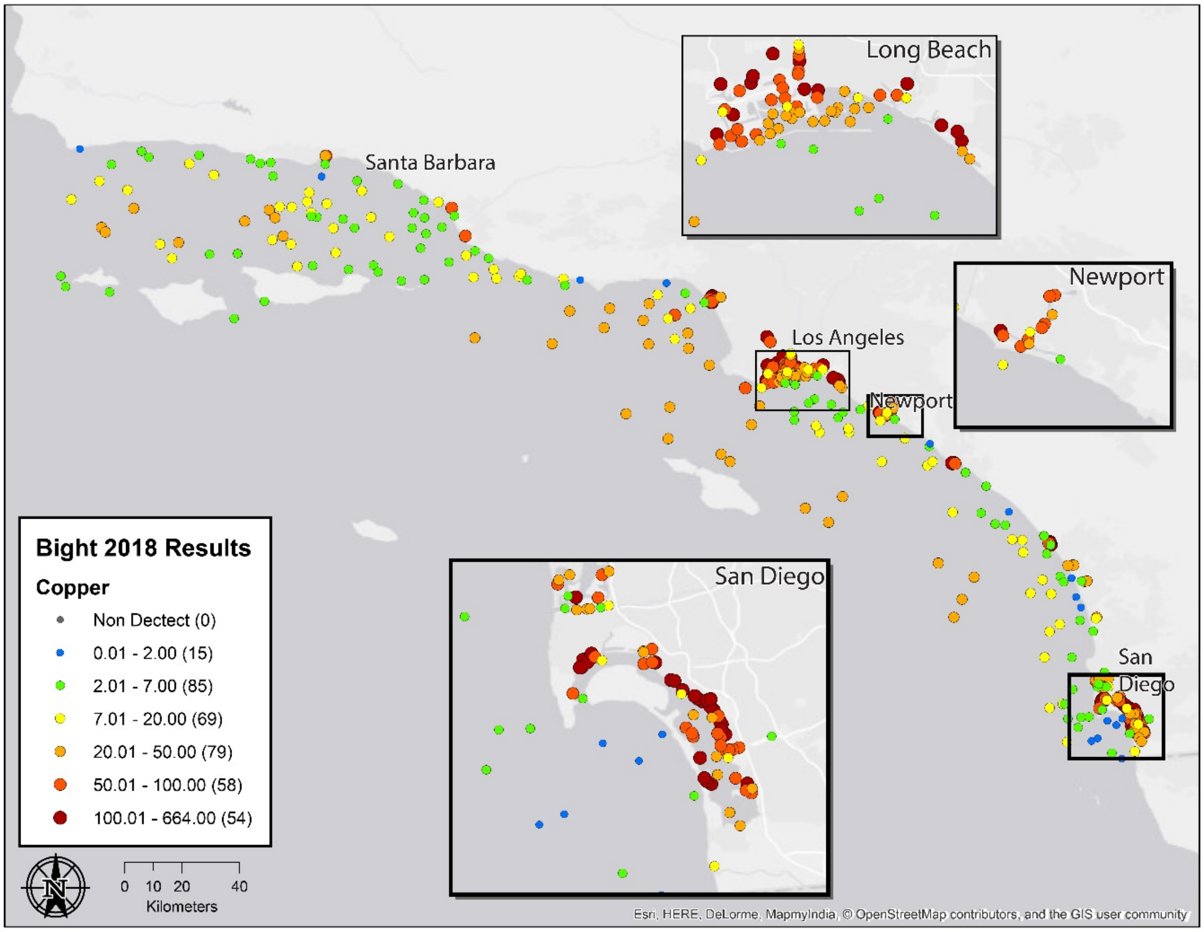


Figure IV-3. Geographic distribution of pyrethroid sediment concentrations (ng/g dw) during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range and number of samples for each bin.

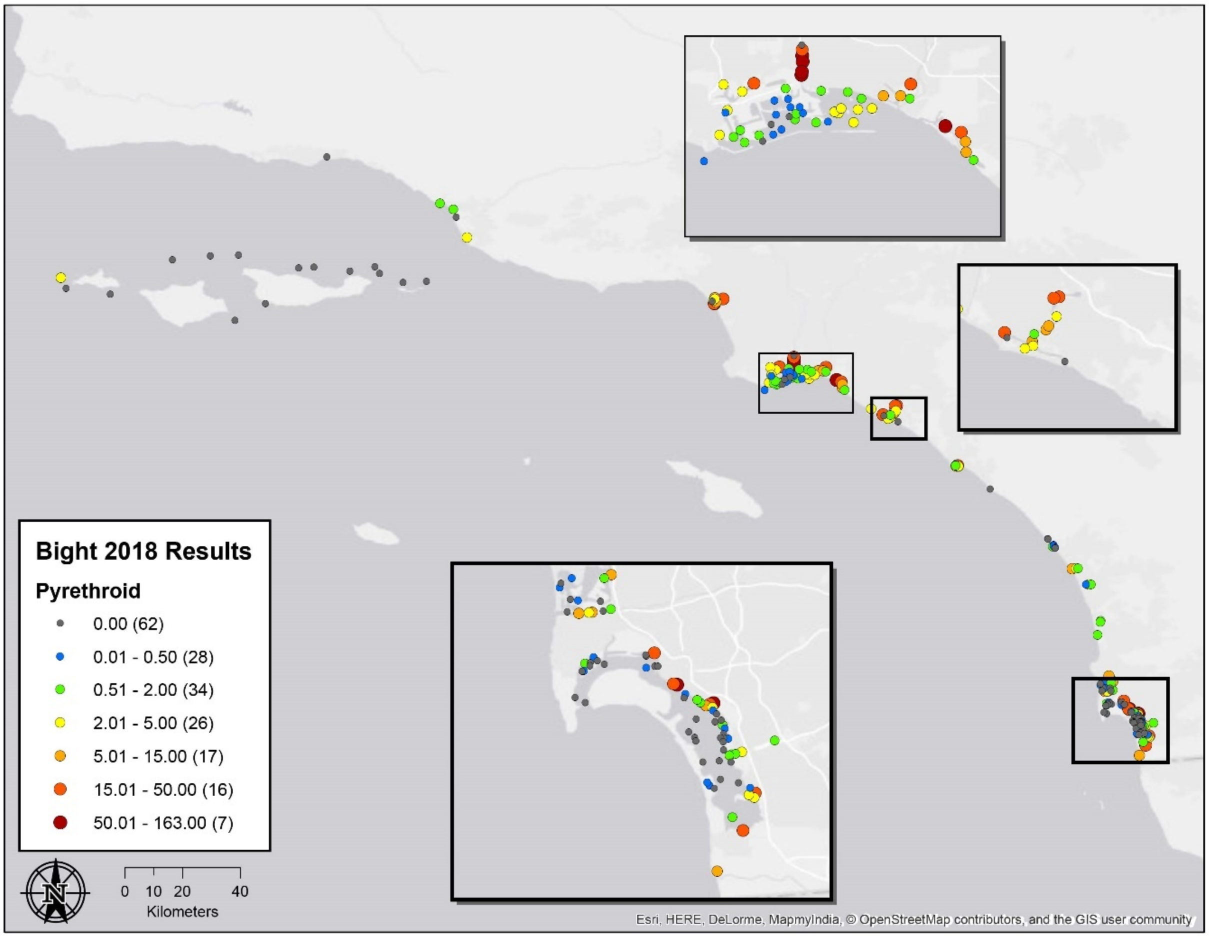


Figure IV-4. Geographic distribution of PBDE sediment concentrations (ng/g dw) during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range and number of samples for each bin.

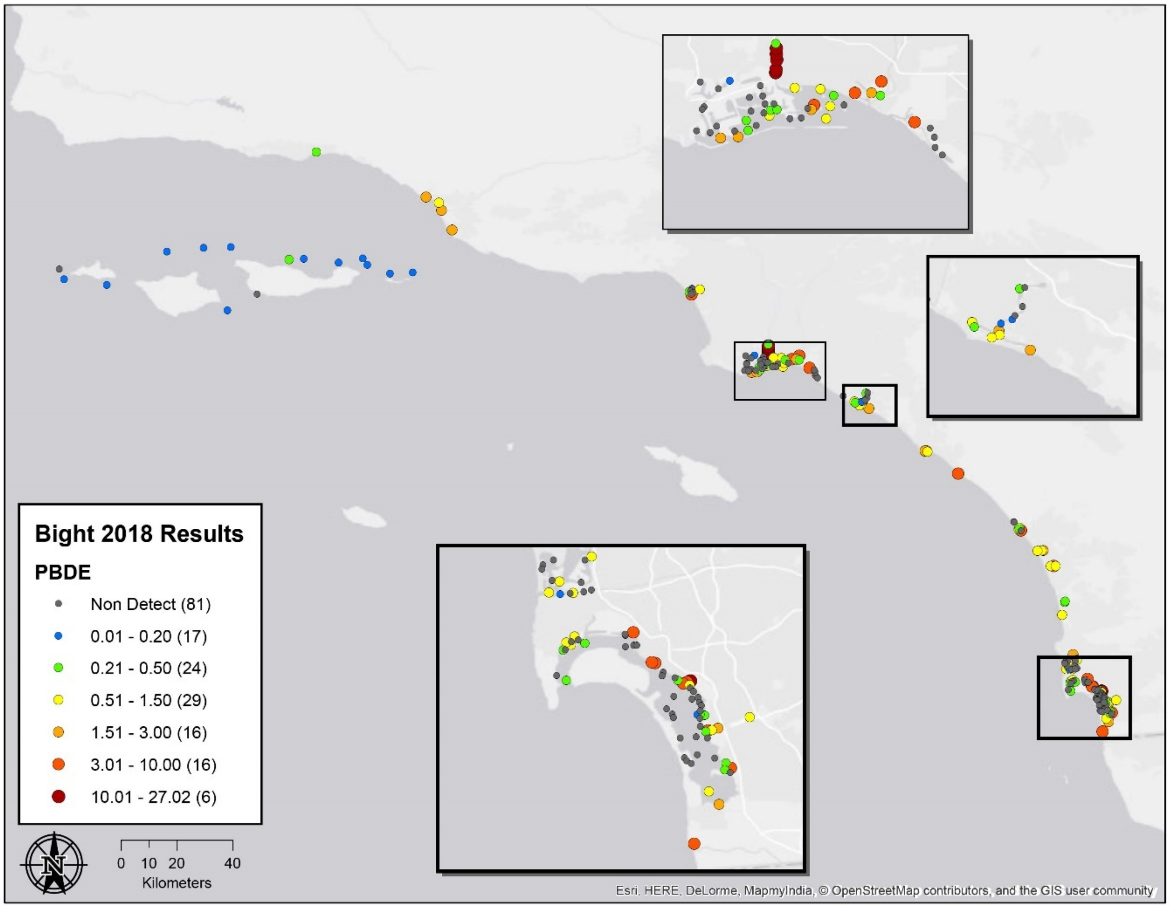
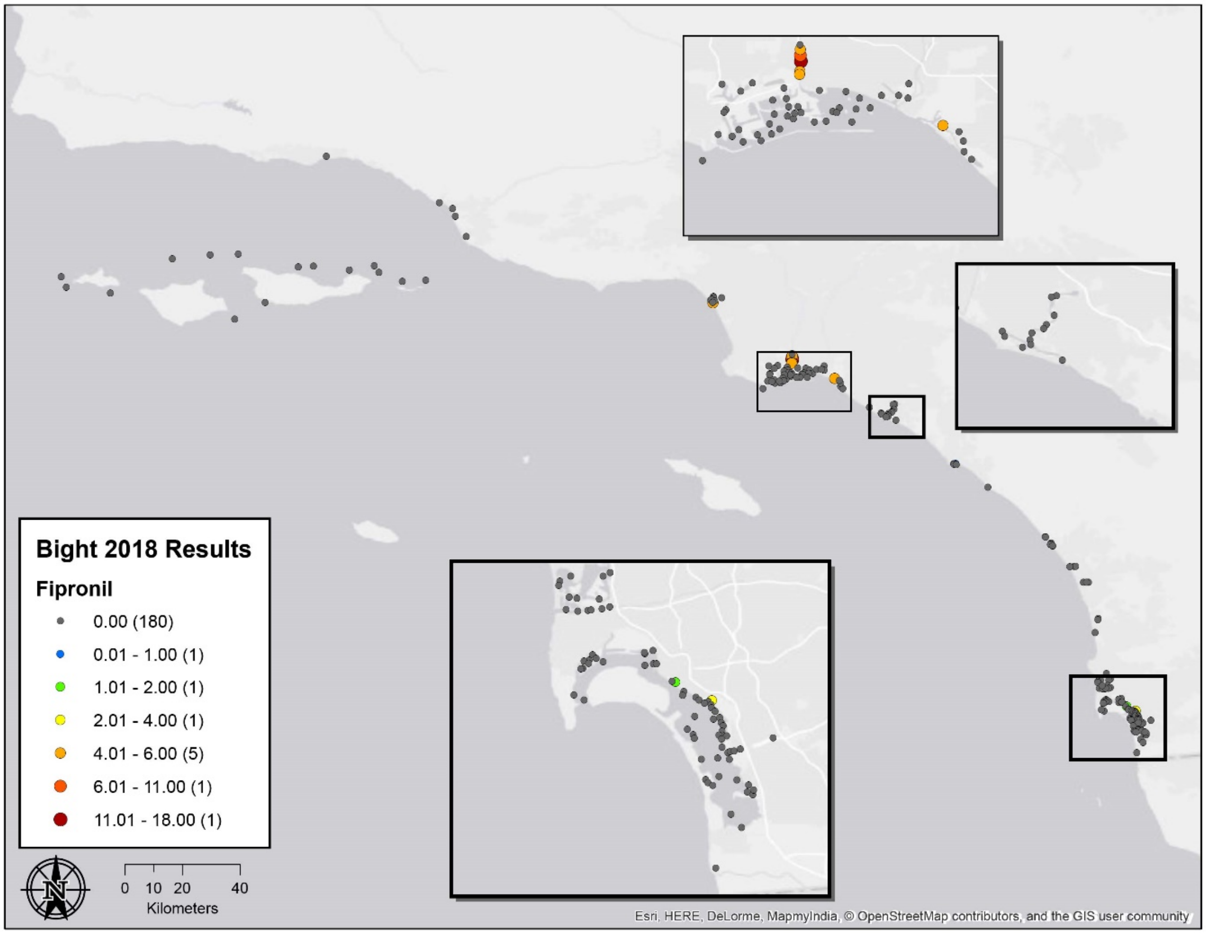


Figure IV-5. Geographic distribution of fipronils sediment concentrations (ng/g dw) during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range and number of samples for each bin.



V. Assessment Results

Spatial Extent of Chemical Index Scores

A summary of the SCB percent area that falls within each of the four SQO Chemical Index Score categories of increasing concern is presented in Figure V-1. The four categories are derived from the State's sediment quality objectives framework (Bay and Weisberg 2008; SWRCB 2009): Category 1 is 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 conditions for this evaluation. Three important aspects of this assessment are: 1) this assessment is based on composite scoring indices that aggregate many chemicals so that individual chemical assessments are unknown; 2) the SQO site assessment also relies on biological and toxicological lines of evidence; and 3) while the SQO framework only applies to marine embayments, for comparison purposes we use the tool for offshore strata.

Approximately 79 ± 6.6% of SCB sediments were in acceptable condition based on SQO Chemical Index Scores (Figure V-1). Approximately 21 ± 6.5% of SCB sediments were in the moderate exposure category. The remaining 0.66 ± 1.1% of the SCB had high chemistry exposure. The areal extent of acceptable condition among strata varied from 42% to 100% depending upon the stratum (Figure V-2). Most strata had similar extents of acceptable condition, between 63% and 86%. Exceptions were marinas, ports, and bays with lower extents of acceptable condition from 42% and 56%. The inner shelf had the highest levels of acceptable conditions at 100%. 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. The areal extent of acceptable sediment condition in the new brackish estuaries stratum was 75 ± 16% (Figure C-1), lower than the Bight as a whole (79 ± 6.6%). The areal extent of high exposure to sediment contamination in brackish estuaries was 17 ± 16%.

Temporal Trends of Chemical Index Scores

The areal extent of acceptable condition in the SCB based on SQO Chemical Index Scores decreased from 91 ± 8.0% in 1998 to 79 ± 6.6% in 2018 (Figure V-4). The areal extent of acceptable condition in 2003 (65 ±6.0%), 2008 (75 ± 6.0%), 2013 (68 ± 8.0%), and 2018 (79 ± 6.6%) were similar. While the areal extent of unacceptable sediment contamination increased between 1998 and 2018, the areal extent of high exposure to sediment contamination was small regardless of survey year (between 0.05% 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 2018 surveys. Generally, the 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 extent of acceptable sediment condition in the embayment habitats from Bight '18 relative to previous surveys was at best unchanged or decreasing (Figures V-5 and V-6). Based on SQO Chemical Index Scores, the combined port, bay, and marina strata had shown improvement between 1998 and 2008 (40% to 63%), then a significant improvement to 72% in 2013, but decreased to 53% in 2018. This suggests that the results from the 2013 survey may be anomalous, relative to the other survey years. This same analysis of trends in the areal extent of acceptable sediment condition using revisited sites only from 2003 and 2018 indicated that the sediment condition was relatively static over time, with no clear trends in chemical exposure. However, focusing assessment on revisited site results does not represent an equal spatial resolution of the stratum as the former analysis which employs all sites, and consequently, the conclusion based on revisited site results has lower statistical confidence. The areal extent of acceptable sediment condition in the slope and basin composite stratum and shelf composite stratum has been relatively unchanged over time.

The areal extent of acceptable sediment condition in individual stratum presented different temporal patterns. The areal extent of acceptable sediment condition in the estuaries, marina, upper slope, and lower slope strata were relatively similar over time. The areal extent of acceptable sediment condition in both the port and bay strata had increased to ~80% in 2013 but were otherwise similar for all other Bight Surveys including 2018. The areal extent of high exposure to sediment contamination increased from 3.4% in 2013 to 13% in 2018 in estuaries. The areal extent of high exposure also increased in the ports stratum from 0% in 2003 to 6.8% in 2018, while the areal extent of moderate sediment decreased. The areal extent of acceptable sediment condition in the inner shelf, mid shelf, and outer shelf strata decreased in 2013, but improved slightly in 2018. Appendix Figures D-2 and D-3 show the strata temporal trends with 95% confidence intervals. The areal extent of acceptable sediment condition in Channel Island National Marine Sanctuary increased from 88% in 2003 to 100% in 2018 (not surveyed in 2013).

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

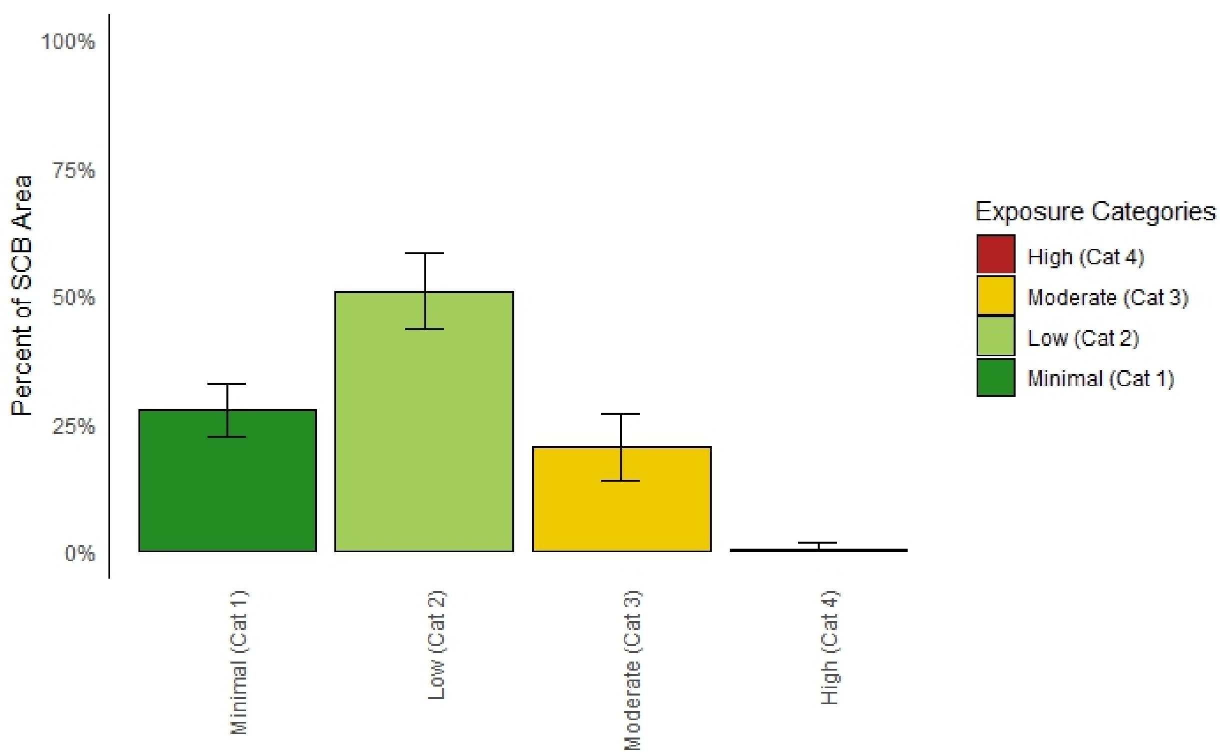


Figure V-2. Areal extent of SQO chemistry exposure categories by SCB strata.

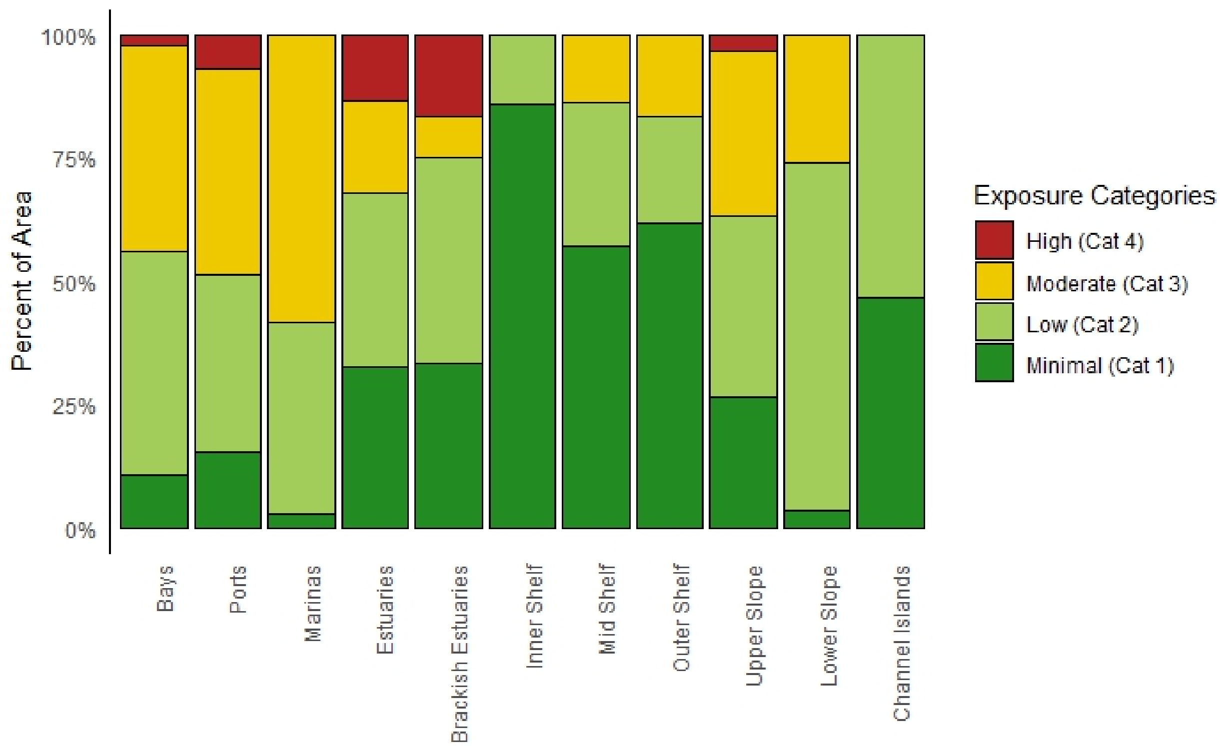


Figure V-3. Spatial distribution SQO chemistry exposure categories. The legend shows number of samples for each category in parentheses.

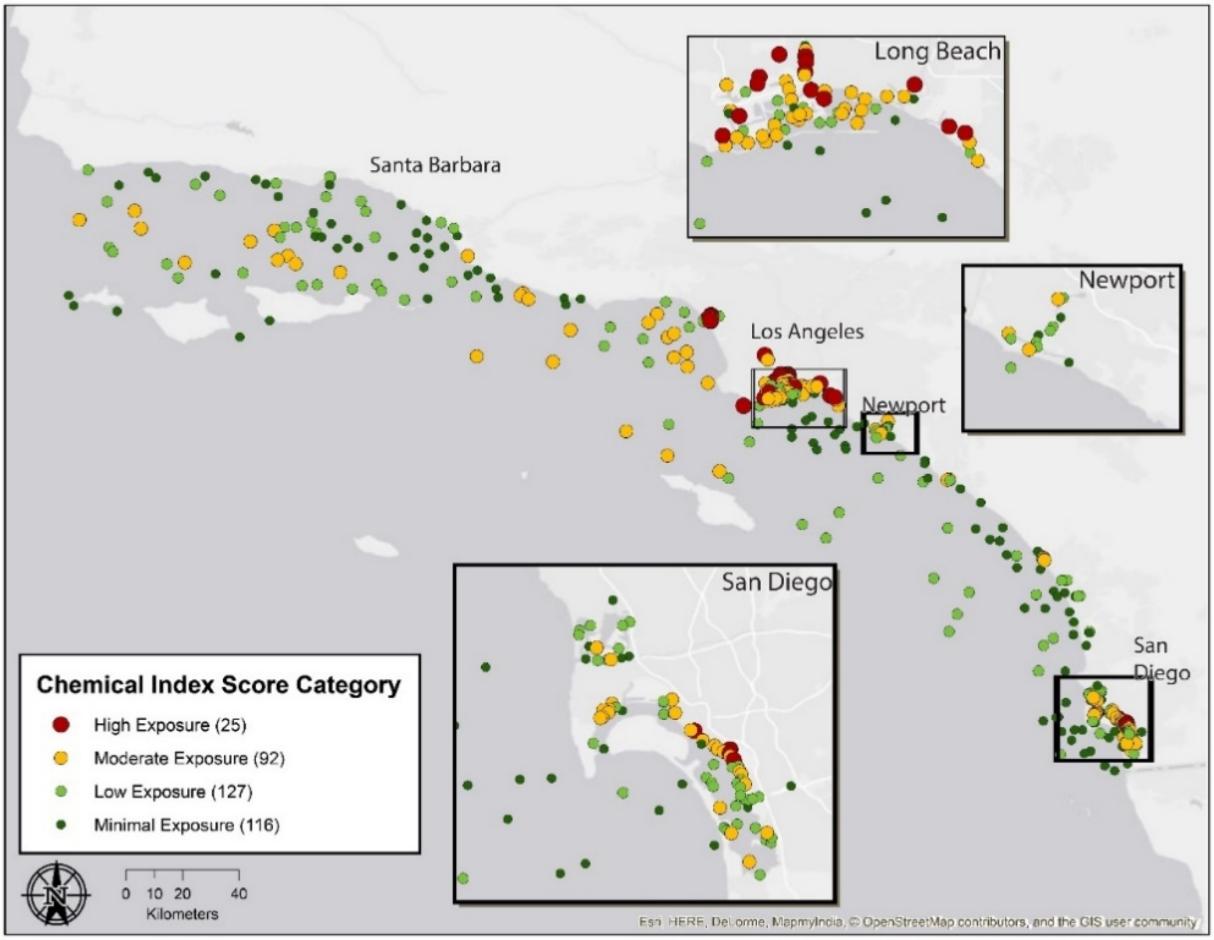


Figure V-4. Areal extent of SCB sediments by survey year in varying categories of exposure to contamination.

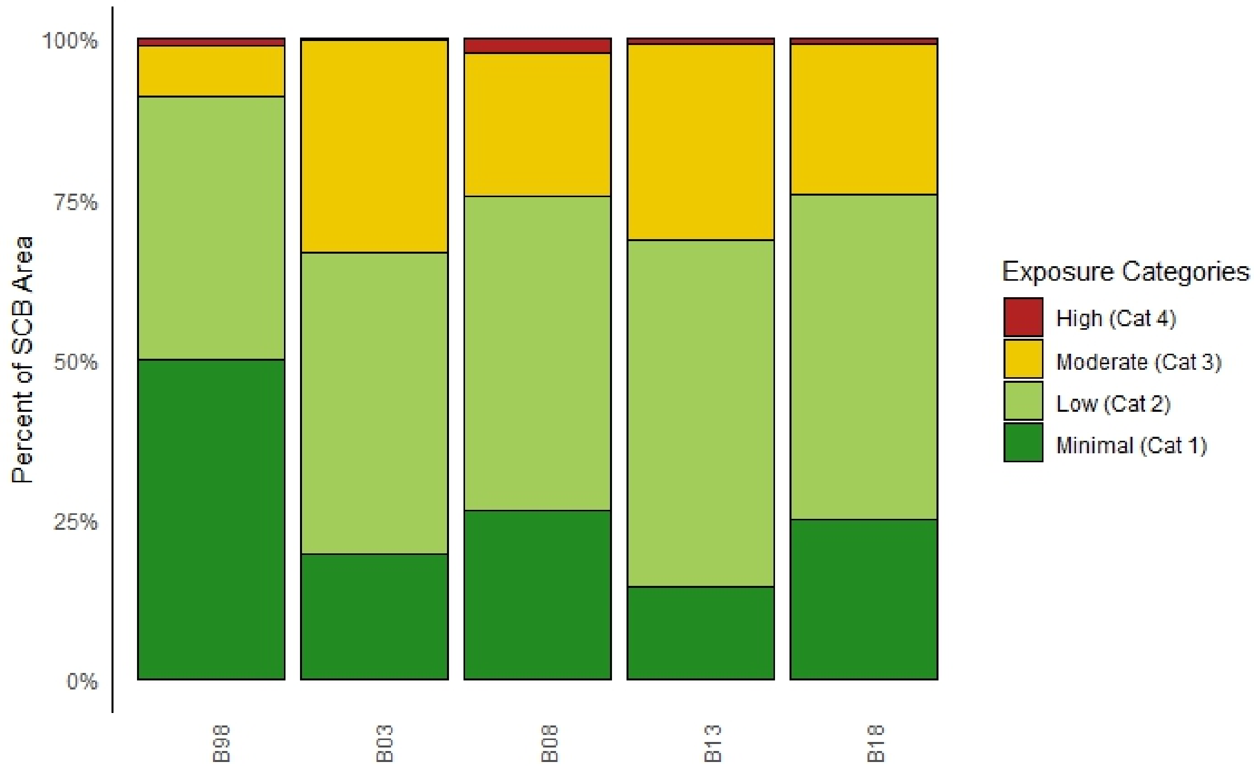


Figure V-5. Areal extent of SCB sediments by composite stratum and survey year in varying categories of exposure to contamination.

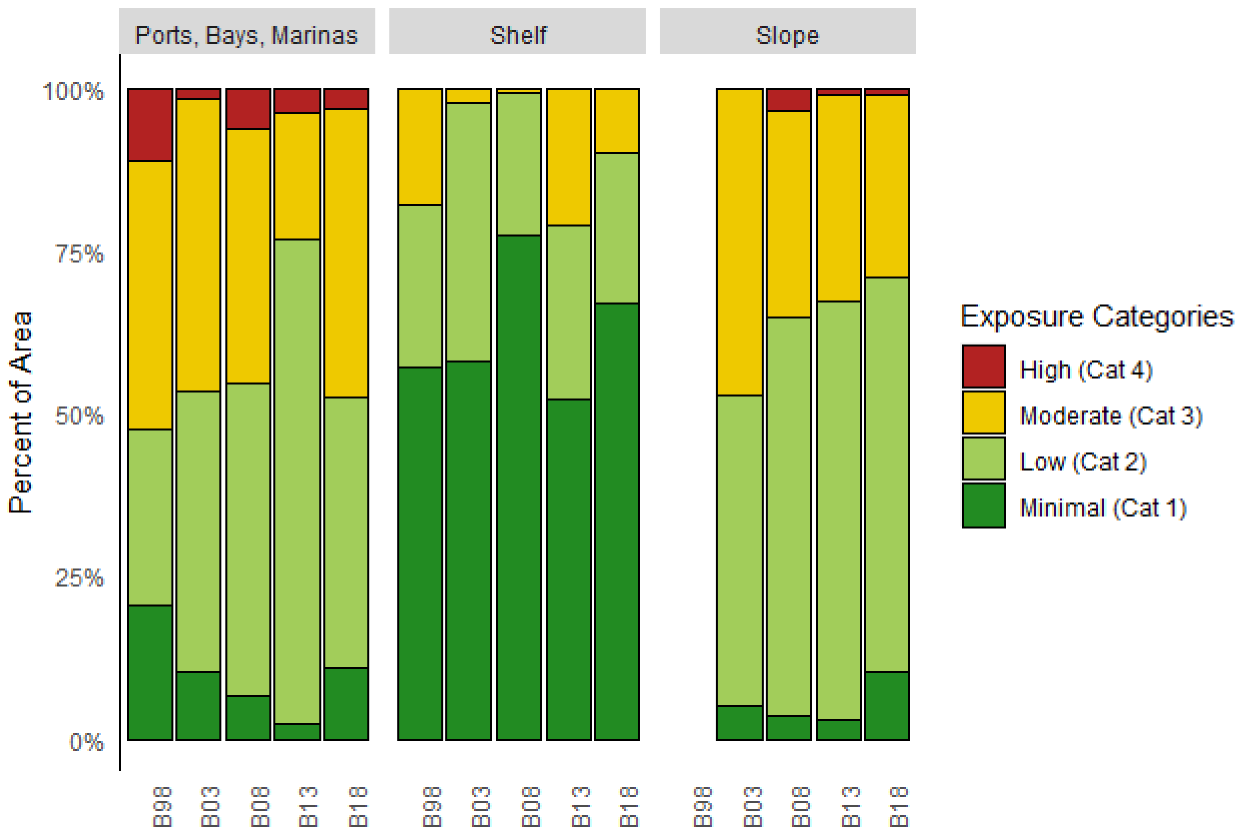
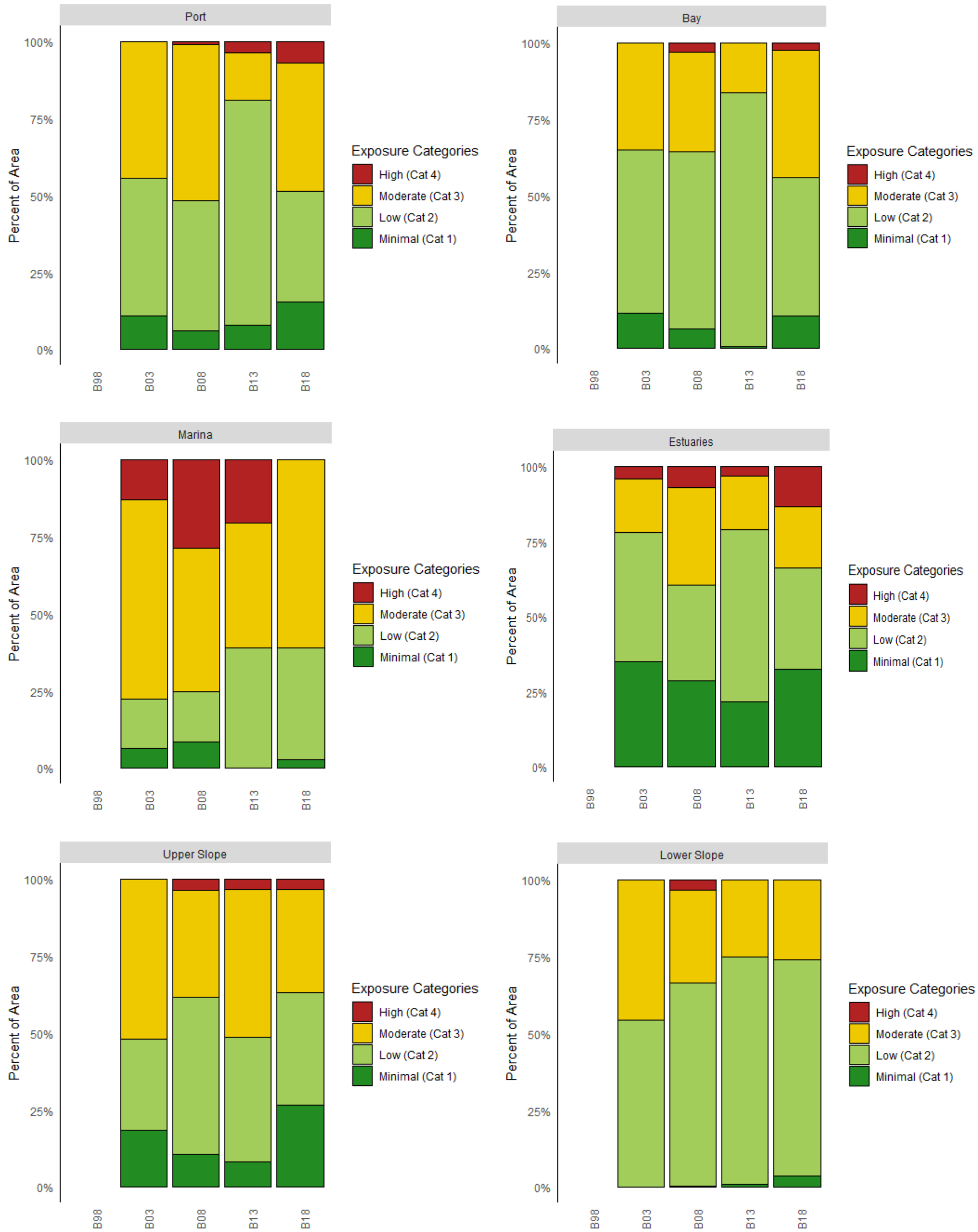
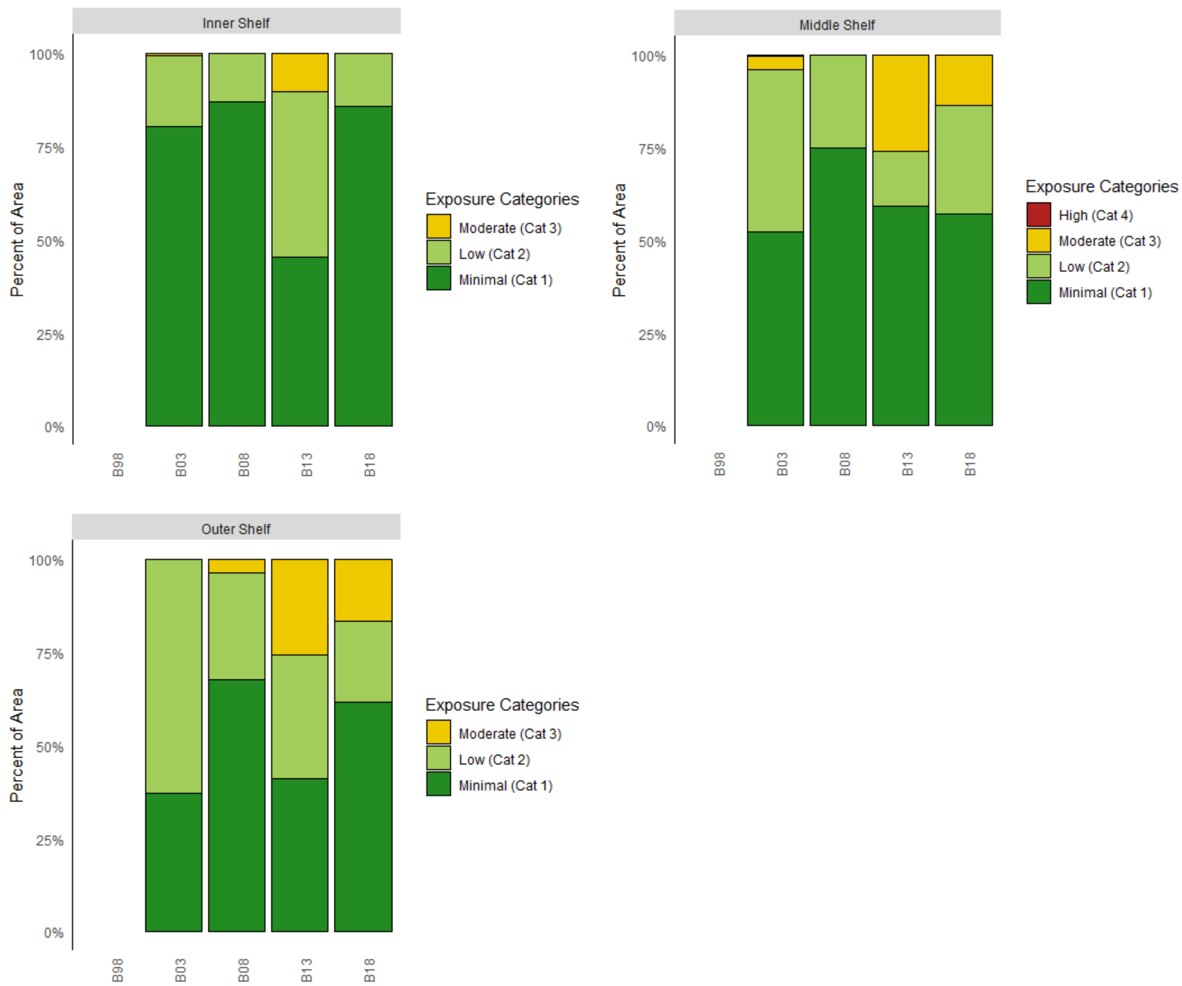


Figure V-6. Areal extent of SCB sediments by individual stratum and survey year in varying categories of exposure to contamination.




Inner Shelf
Middle Shelf
Outer Shelf
Percent of Area
100%
75%
50%
25%
0%
B98
B03
B08
B13
B18
Exposure Categories
High (Cat 4)
Moderate (Cat 3)
Low (Cat 2)
Minimal (Cat 1)

VI. DISCUSSION

Overall, the Bight ’18 survey design sampled similar habitats in Bight ’13, Bight ’08, Bight ’03, and Bight ’98. Similar results were obtained in terms of the extent and magnitude of sediment contamination, spatial distribution, and temporal trends. Notable exceptions, new target analytes, and the new strata are discussed below.

Changes in Organics Concentrations

The 2018 AWM concentration of organics decreased from 2013, except for an increase in PCB AWM concentration in 2018 (6.1 ng/g dw) compared to 2013 (5.2 ng/g dw). One possible explanation is the higher total PCB concentration due to the addition of two PCB congeners (PCB 008 and PCB 195) in Bight ’18, which are routinely monitored in other regional and statewide programs in California and utilized in SQO Chemical Index Scores. However, these two congeners were not frequently detected in Bight ’18 and, when quantified, found in low concentrations. A second explanation of increasing concentrations between Bight ’13 and Bight ’18 is a reduction of reporting levels. The reporting level of PCBs was lowered from 7.5 ng/g dw in 2013 to 3.0 ng/g dw in 2018. In Bight ’13, samples below the RL are assigned a value of zero, which would decrease concentrations at sites where RLs are high. Up to 46% of detections of PCB congeners were reported between 3.0 and 7.5 ng/g dw in Bight ’18. To assess this potential bias, a sensitivity analysis was performed comparing the adjusted AWM using the results above 7.5 ng/g dw. The similarity in the adjusted AWM of total PCB concentrations between Bight ’13 (5.2 ± 3.0 ng/g dw) to Bight ’18 (5.4 ± 8.0 ng/g dw) indicates that the increased concentration between the two surveys may have been the result of changes in reporting limits. This difference illustrates the necessity for increased sensitivity among all laboratories to characterize the actual chemical exposure and subsequent environmental risk. Also note that 43 of 209 PCB congeners are targeted for analysis in Bight ’18. Although the 43 congeners selected for Bight ’18 comprise the vast majority of the PCB mass, the total PCB concentration of all 209 congeners may be higher than the AWM concentration reported herein.

Further Embayment Decline in Polybrominated Diphenyl Ether Concentrations

In Bight ’18, PBDE flame retardants were only investigated in embayments because previous surveys indicated that PBDE in offshore sediments were non-detectable to uniformly low. The AWM concentration of PBDE flame retardants in embayments substantially decreased (~10 times) from Bight ’08 to Bight ’13. Based on the current survey results, PBDE concentrations further decreased from Bight ’13 (2.0 ± 1.6 ng/g dw) to Bight ’18 (0.99 ± 0.39 ng/g dw). 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). PBDEs were detected in Channel Islands stratum, but the concentration is very low.

Extent and Magnitude of Fipronils in SCB Embayments

The Bight program provides a venue for testing new compounds that were not previously measured in any monitoring program. Bight ’18 enabled the analysis of contaminants of emerging concern (CECs) including current use pesticides, such as fipronil. Fipronil and its degradation products have been detected in freshwater, estuarine, and marine environments and are toxic to non-target aquatic organisms at part per billion levels (Schlenk et al. 2001). The environmental occurrence of fipronils in coastal sediments has been under reported (Lao et al. 2010; Taylor et al. 2019). Fipronils are not widely detected in SCB embayments and mostly detected in brackish estuaries. The AWM concentrations of fipronils were greatest in brackish estuaries and estuaries, particularly those brackish estuaries that received inputs from the most urbanized watersheds. This indicates that urban runoff is likely a primary source of fipronils to SCB embayments. The single active ingredient of the pesticides cannot capture all the impacts to the receiving systems due to more toxicity of the degradation products (Phillips et al. 2014). Fipronil sulfone and fipronil sulfide are found to be more toxic than the parent compound (Weston and Lydy 2014). The concentrations of fipronil sulfone observed at specific sites exceeded the LC50 for *Chironomus dilutus* (midge) (Anderson et al. 2018). Fipronils were not detected in Channel Islands stratum.

New Brackish Estuaries Stratum

Estuaries are a critical ecological habitat in southern California with enhanced primary productivity, nursery grounds for many fish species, and feeding and nesting areas for migrating waterfowl (Dailey et al. 1993). Hence, it is critical that sediment contamination in estuaries and its biological and ecological significance be assessed (Chapman and Wang 2001). The Bight Program has assessed sediment quality in high salinity (> 27 ppt) estuaries since 1998 (Schiff et al. 2019). In Bight ’18, brackish estuaries (salinity 0 - 27 ppt) were assessed for the first time. Urban runoff that drains directly to brackish estuaries could result in relatively high contaminant exposure in this stratum compared to the other embayment strata.

Results indicated that brackish estuaries had elevated concentrations of PBDEs, pyrethroids, and fipronils compared to other embayment strata. The highest concentrations of these contaminants occurred at the mouths of urban rivers, illustrating a pattern consistent with terrestrial sources. PBDEs can enter the environment from the manufacturing and disposal of products containing PBDEs; pyrethroids and fipronils can enter the environment from residential and commercial pest control in the urban landscape. During storm events, these contaminants can be mobilized and transported by urban creeks and storm drains to embayments including brackish estuaries. However, these results should be interpreted cautiously. Brackish estuaries had the smallest sample size (n=12), which leads to less confidence in the AWM concentrations and areal extent estimates compared to other strata which had larger sample sizes (n=30).

Inability to Reach the Required RL

Capability and comparability are critical to a collaborative, performance-based monitoring program such as Bight ’18. One element of comparability is sensitivity, defined in the sediment chemistry portion of Bight ’18 by RL. It is essential that labs have similar sensitivity because differing RL can result in bias when one lab cannot detect contaminants that other labs can. 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. In Bight ’18, samples below the MDL are assigned a value of zero, which would artificially decrease concentrations at sites where the MDL is higher than targeted RL. Therefore, all participating labs agreed to attempt to achieve the RL targeted in the Bight ’18 Quality Assurance Project Plan.

Several participating laboratories failed to achieve the Bight ’18 required RL for specific target analytes. Noticeably, one laboratory documented substantially higher RL for trace metals. The reason cited for the increased reporting levels was compliance to an EPA method update rule. The specific Bight samples with higher RL were diluted due to an internal standard accuracy failure. The internal standard is used primarily to detect and correct for the effect of physical interferences created by the sample matrix. Pursuant to the EPA method update rule, a 5X dilution and re-analysis is required when the accuracy of internal standard recovery fails during the initial analysis. Inaccurate internal standard recovery in the initial analysis typically indicates that the sample matrix was interfering with the analytical process.

There were four laboratories generating 313 sample analyses which had RLs greater than the targeted RLs in the Bight ’18 Quality Assurance Plan. The greatest frequency of RL exceedances occurred for trace metals (36% of sample analyses), organochlorine pesticides (26% of sample analyses), and PBDEs (21% of sample analyses). The majority of all sample analyses (84%) were within the data quality objectives for RL sensitivity.

Some laboratories exceeding targeted RLs reported non-detects while the corresponding MDLs also exceed targeted RLs. To account for the bias potentially introduced by high MDLs, sensitivity analysis was performed to determine if there were changes in the chemical exposure category when replacing zero (reported as -88 in the Bight database) for non-detects with either half the MDL values or the full MDL values for non-detects. Nine of the 376 sites in Bight ‘18 changed chemical exposure category using this sensitivity analysis (Table VI-1). One site changed from low exposure to moderate exposure when replacing zero with half the MDL values in the estuary stratum. Six sites changed from low exposure to moderate exposure when replacing zero with the full MDL values with four sites in the marina stratum, one site in the estuary stratum, and one site in the port stratum. Additionally, three sites changed from minimum exposure to low exposure when replacing zero with the full MDL values in the port stratum. This sensitivity analysis changed assessment of acceptable sediment exposure from 41.85% to 30.52% in marina stratum, from 52.99% to 49.35% in port stratum, and from 55.35% to 53.13% in the embayment strata. This sensitivity analysis changed our Bight-wide overall assessment of acceptable sediment exposure from 78.82% to 78.80%. Ultimately, the Planning Committee decided that this minimal bias that did not meaningfully influence the survey’s major findings or conclusions.

Table VI-1. Sensitivity analysis replacing zero with half the MDL or full MDL to test changes of chemical exposure category.

Stratum	Bight Region	Exposure category original	Exposure category zero–half the MDL	Exposure category zero-full MDL
Estuary	Newport Bay (B18-10158)	low	moderate	moderate
Port	LA/Long Beach (B18-10097)	minimum	minimum	low
Port	LA/Long Beach (B18-10099)	minimum	minimum	low
Port	LA/Long Beach (B18-10106)	minimum	minimum	low
Port	LA/Long Beach (B18-10090)	low	low	moderate
Marina	LA/Long Beach (B18-10052)	low	low	moderate
Marina	LA/Long Beach (B18-10057)	low	low	moderate
Marina	Marina del Rey (B18-10050)	low	low	moderate
Marina	Newport Bay (B18-10061)	low	low	moderate

VII. Conclusions

The Bight '18 Program provided a regional assessment of sediment chemistry in the SCB through analysis of multiple chemical constituents. Based on the results of this survey, the Chemistry Technical Committee concluded that:

- **The majority of the SCB has minimal to low exposure to sediment contamination.**

  The SQO sediment chemistry assessment tool integrates sediment chemistry data from several key constituents into a single assessment for exposure to sediment contamination. While the tool is calibrated and validated for embayments, it is the best available tool for offshore sediments as well. Therefore, it is applied to all Bight strata to generate a regional assessment of contaminant exposure for the SCB. Applying this tool to the sediment chemistry dataset, 79% of SCB sediments have minimal to low exposure to contamination, which is deemed acceptable by the SQO assessment tool. Less than 1% of SCB sediments have high exposure, the worst category of contamination.

- **The extent of sediment contamination was greater in embayments compared to offshore.**
  While over three-quarters of the SCB had acceptable sediment contamination, not all strata were in equally good condition. Embayments had a smaller percent area falling into acceptable condition (42% to 75% depending upon stratum) compared to offshore area (63% to 100% depending upon stratum). Up to 17% of the embayment area had high exposure to sediment contamination, compared to 3.3% of the offshore strata.

- **Concentrations of several contaminants had clear spatial patterns based on sources.**
  The highest sediment concentrations of copper occurred near embayment sources such as marinas, likely attributable to vessel antifouling paints. Fipronils had highest concentrations in brackish estuaries and estuaries, likely attributable to land-based runoff from pesticide applications in urbanized watersheds. The highest concentrations of DDT were located on the continental shelf in the vicinity of Palos Verdes, the location of a superfund site for this legacy contaminant.

- **100% of the area of Channel Islands National Marine Sanctuary is in acceptable condition per the SQO chemistry indices.**

  The areal extent of acceptable sediment condition at the Channel Islands has steadily improved, increasing from 88% in 2003 to 100% in 2018 (chemistry was not assessed in 2013). However, Channel Islands National Marine Sanctuary had a smaller sample size (n=15), and thus less confidence in the areal extent estimates compared to the other embayment and offshore habitats, which typically had larger sample sizes (n>30). In addition, PBDEs and pyrethroids were detected in the sediment at the Channel Islands, but concentrations were very low. Fipronils were not detected.

- **Bight-wide sediment conditions have remained relatively consistent over the last fifteen years.**
  The range of acceptable sediment contamination ranged from 66% to 79%, showing inconsistent changes in acceptable and unacceptable sediment contaminant exposure

during the four surveys from 2003 to 2018. 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 highest in the 1998 Bight survey (more than 90% of SCB).

- **There are both positive long-term trends and a negative recent decline in the sediment condition of specific Bight habitats.**
  The extent of acceptable sediment condition in the embayment habitats from Bight'18 was unchanged or decreased relative to previous surveys (see Figures V-5 and V-6). Based on SQO sediment contamination indices, the combined port, bay, and marina strata had shown improvement between 1998 and 2008 (40% to 63%), then a substantial improvement to 72% in 2013, then decreased to 53% in 2018. This same analysis of trends in the areal extent of acceptable sediment condition using only revisited sites from 2003 to 2018 indicated that the extent of sediment condition was relatively unchanged over time, with no clear trends in either increasing or decreasing extent of chemical exposure. The extent of acceptable sediment chemistry condition in the estuary stratum was relatively unchanged from 2003 to 2018, but the high exposure to sediment contamination increased. The extent of acceptable sediment chemistry in the combined continental shelf strata was relatively unchanged between 1998 and 2018. The extent of acceptable sediment chemistry in the combined slope strata increased between 2003 and 2018.

- **The new stratum introduced in Bight '18, brackish estuaries, had the greatest extent of high sediment contaminant exposure of any habitat assessed.**

  Brackish estuaries were adopted as a stratum for Bight '18 with the hypothesis that contaminant exposure would be higher in closer proximity to sources of urban runoff. Results indicated that brackish estuaries had the highest sediment concentrations of PBDEs, pyrethroids, and fipronils relative to other embayment strata, but similar concentrations of other target contaminants compared to other embayment habitats. The areal extent of high exposure to sediment contamination in brackish estuaries was 17 ± 16%, which was the greatest among any assessed habitats. However, this stratum had the smallest sample size (n=12), and thus less confidence in the areal extent estimates compared to the other embayment and offshore habitats, which typically had larger sample sizes (n>30).

- **The new pesticide measured in Bight '18, Fipronils, were not widely detected in SCB embayments**

  Fipronil and its degradation products were investigated for the first-time during Bight '18. In many site-specific studies, fipronils have typically had lower concentrations than other pesticide measured previously in the Bight Program such as pyrethroids, but fipronil's potential for toxicity is high compared to pyrethroids. The results from Bight '18 indicated that fipronils were not widely detected in the embayment habitats. The greatest concentrations of fipronil and its degradation products were detected in brackish estuaries and the concentrations of fipronil sulfone observed at specific sites exceeded the LC50 (0.83 ng/g) for *Chironomus dilutus* (midge).

VIII. Recommendations

A. Bight 2018

Based on the efforts from Bight '18, the Sediment Quality Planning and Chemistry Technical Committee agree on the following recommendations to follow up on current survey results or to improve the next regional survey implementation.

- **Expand investigations at brackish estuaries in future surveys.**

  Bight '18 results indicated that brackish estuaries had elevated concentrations of PBDEs, pyrethroids, and fipronils compared to other embayment habitats. However, this stratum had the smallest sample size (n=12) due to reclassification of several sites based on the salinity at the time of sampling. Consequently, the areal extent estimates have lower confidence compared to the other strata (n>30). Thus, the committee recommends improving the sample frame for brackish estuaries to ensure greater sampling success and higher confidence in areal extent estimates of chemical exposure in this stratum.

- **Continue to evaluate high chemical exposure in embayment habitats.**

  The areal extent of acceptable sediment chemistry condition in SCB's embayment habitats has decreased in Bight '18 relative to Bight '13 and an investigation of the revisited sites indicated that there has been little change in the extent of acceptable sediment chemistry from 2003 and 2018. Furthermore, the extent of high sediment contaminant exposure in estuaries has increased. The cause of the increase in high exposure should be better understood and the sources of contamination in estuaries and embayments should continue to be explored.

- **Ensure participating laboratories enforce Bight data quality objectives to improve data quality and comparability.**

  In Bight '18, multiple laboratories were unable to meet all of Bight's strict data quality objectives primarily due to lack of required quality control records and inconsistencies in quality assurance practices. Similarly, some labs were unable to reach the required reporting levels required by Bight. Because of insufficient QA records, 16 stations were rejected and 0.1% of area in the Bight '18 survey cannot be assessed. The removal of these stations will not have a meaningful impact on the final conclusions of this survey, but are an unfortunate consequence of non-compliance with Bight's standards. Capability and comparability are fundamental to a collaborative, performance-based monitoring program such as Bight '18. Greater efforts should be made to apply uniform practices to harmonize quality assurance and quality control across laboratories.

B. Bight 2013

To ensure the Bight program continues to improve over time, Bight ’18 followed through on the recommendations from Bight ’13.

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

  This recommendation resulted from the need to compare sediment chemistry, toxicity, and infauna results to better understand the sediment quality. This weight-of-evidence approach is consistent with the State Water Board’s sediment quality objectives framework for bays and estuaries. In order to provide a more comprehensive understanding of sediment quality in the Southern California Bight, three primary indicators (lines of evidence) of sediment quality were integrated in the B’13 Contaminant Impact Assessment Synthesis Report. The relationship between each line of evidence combination and site condition was established using a conceptual model that related the severity of biological effects (i.e., sediment toxicity and benthic community disturbance) to the level of chemical exposure (sediment chemistry and toxicity). For Bight ’18, the same efforts will be made to synthesize three primary indicators into a comprehensive assessment report. Furthermore, to increase comparability with the toxicity results, sediment samples were homogenized before subsampling into toxicity and chemistry jars. Results of the homogenization will be addressed in the synthesis document.

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

  This recommendation resulted from a desire to minimize the time from sample collection to reporting. An improved information management system was expected to expedite the quality assurance and quality control of submitted data, allowing the technical committee to get to data analysis and interpretation faster. The Sediment Chemistry Technical Committee worked directly with SCCWRP IT specialists to implement the suggestions from previous surveys into a series of automated data checkers for Bight ’18. This online data checker was capable of evaluating the sample inventory and quality control results expected from the laboratories, which was an improvement to the data submission process relative to the previous surveys.

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

  This recommendation resulted from the need to understand the occurrence of uninvestigated constituents of emerging concern (CECs) in the Bight sediments. The Bight Program is one of the best platforms for investigating the occurrence of these potentially harmful contaminants and determining if they are localized or widespread, and assess the magnitude of contaminant concentrations accumulating in Bight sediments. Fipronil and three degradation products were investigated for the first time in the Bight ‘18 survey. The results indicated that fipronils were not widely detected in the embayment habitats and that the highest concentrations were in brackish estuaries where the concentrations of fipronil sulfone exceeded toxicological thresholds.

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

  This recommendation resulted from the need to address potential impacts of non-targeted compounds. The State Water Board's CEC 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 has been applied in regional and statewide pilot studies on waterbodies that receive discharge from municipal wastewater treatment plants and stormwater runoff. The Bight program represents an excellent opportunity to leverage similar studies and pilot research not routinely conducted in ongoing monitoring programs. A leveraged study using bioanalytical screening tools coupled with diagnostic non-targeted chemical analysis was implemented in Bight '18 to explore new contaminants and serve as a tool to link contaminants to toxicity in the Bight sediments and fish tissues. The *in vitro* bioassays and non-targeted analysis results will appear in the Bight Synthesis report.

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

  This recommendation resulted from the need to improve data comparability among all participating agencies or laboratories. Capability and comparability are fundamental to a collaborative, performance-based monitoring program like Bight '18. In Bight '18, participating laboratories recognized the challenges of expanding target analyte lists and improving analytical sensitivity. Many laboratories invested time and resources to achieve the updated performance goals. In the meantime, laboratories that underachieved the performance goals needed additional time to reanalyze a subset of samples with a full QA protocol for data comparability. In future Bight surveys, participating agencies may consider outsourcing these analyses to those laboratories that can achieve these performance goals to improve data comparability.

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

  This recommendation resulted from the need to calibrate and validate a sediment chemistry assessment tool for offshore sediments. Since the last Bight survey, no progress has been made towards development of a sediment chemistry assessment tool for offshore sediments. Like Bight '13, Bight '18 applied the State Water Board's SQO chemistry assessment indices, which were calibrated and validated for embayment sediments, to offshore sediments for comparison. The best alternative for future surveys is to calibrate and validate a sediment chemistry assessment tool for offshore sediments before the next survey.

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Appendix A. Laboratory Quality Assurance Information

Bight 2018 Sediment Chemistry Intercalibration Exercise

Previous surveys invested substantial effort in developing analytical comparability. Since all of the regional programs were conducted in a collaborative fashion with multiple analytical laboratories participating, intercalibration studies were critical for analyses of 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 intercalibration exercises were performed until all laboratories could meet prescribed data quality objectives for inter-laboratory precision. These intercalibrations remain one of the foundational elements of the regional monitoring quality assurance/quality control program.

The following seven reference materials were measured by participating laboratories in triplicate. Assessing laboratory performance for comparability in the intercalibration study follows a three-step process. First, for each analyte, the laboratory average was computed as the mean of the triplicate samples. Second, a grand mean was calculated as the average across all laboratories. Potential outlier results were identified using the Grubbs Test. Outlier results were excluded when calculating the grand mean. Third, to achieve passing results for a given analyte, the results of at least two of three replicates must be within the defined variability of certified value or grand mean. Fourth, 70 to 80% of the target analytes in a compound class must achieve passing results to qualify for Bight ’18 participation for that compound class.

Laboratories that participated in the intercalibration exercise were required to meet specified performance criteria, which can be found in the Bight ’18 Survey Quality Assurance Plan. Prior to any analysis of the survey samples, laboratories analyzing Bight samples were required to pass the assessment for both certified reference materials (CRM) and field reference materials (FRM).

Overall, all of Bight ’18 participating laboratories passed in both CRM and FRM for the designated analyses (Tables A1 and A2). Note that some laboratories only submitted one CRM data to result in incomplete performance evaluation. The performance of these laboratories was labeled as “Insufficient”. If laboratories did not participate in the specified compound class or laboratories failed to submit complete data, performance of these laboratories was listed as “NA”.

Pass/Fail Criteria

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.

2. Field Reference Material from Palos Verdes Shelf

The organics include PCBs, PAHs, OC pesticides, and PBDEs. Field reference material tests inter- and intra-laboratory precision 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 grand mean value.

Metals

3. ERA 540 Metals in Soil. Lot D099-540.

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 from Palos Verdes Shelf (the same material to Reference Material 2)

The individual metals field reference material tests inter- and intra-laboratory precision when analyzing a sample with potential interferences not present in ERA 540. Laboratories are required to obtain a concentration within 30% of the grand mean value for 12 of 15 analytes.

Pyrethroids/Fipronils

5. Field Reference Material from Port of Los Angeles Consolidated Slip Site

The intercalibration exercise of pyrethroids and fipronil using certified reference materials (CRM) is not feasible due to the current unavailability of the CRM. Pass/fail criteria for this material were not set. It is for information value only.

Table A-1. Sediment chemistry intercalibration results summary.

		Parameter				
Lab	**Participating Bight Lab**	**Metals**	**PAH**	**PCB**	**OC Pesticides**	**PBDE**
CLA	Yes	**Pass**	**Pass**	**Pass**	**Pass**	NA
LACSD	Yes	**Pass**	**Pass**	**Pass**	**Pass**	NA
OCSD	Yes	**Pass**	**Pass**	**Pass**	**Pass**	NA
CSD	Yes	**Pass**	**Pass**	**Pass**	**Pass**	NA
Physis	Yes	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**
NB[a] lab 1	No	Fail	NA	Fail	Insufficient	Insufficient
NOAA-Charl	Yes	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**
NB lab 2	No	NA	Insufficient	Insufficient	Insufficient	Insufficient
NB lab 3	No	Pass	NA	NA	NA	NA
NB lab 4	No	NA	Insufficient	Insufficient	Insufficient	Pass
NB lab 5	No	Insufficient	Fail	NA	NA	NA
Eurofins	Yes	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**
NB lab 6	No	Insufficient	NA	NA	NA	NA
NB lab 7	No	NA	NA	Insufficient	NA	NA
NB lab 8	No	NA	NA	Insufficient	NA	NA
NB lab 9	No	Insufficient	NA	NA	NA	NA

a. NB means non-bight

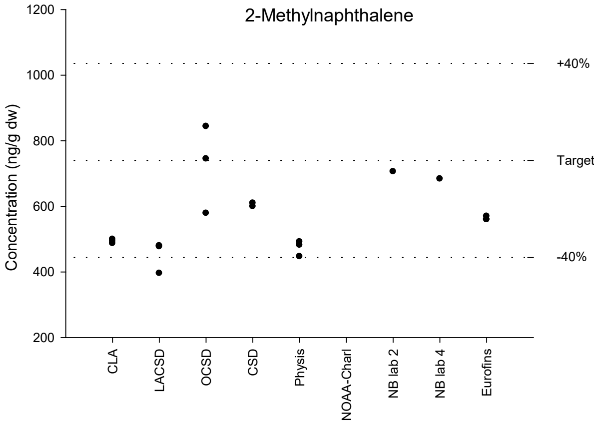
Number of passing replicates, out of three

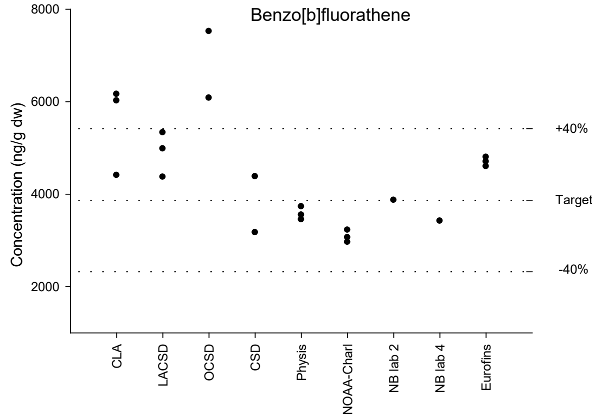
Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2[a]	NB lab 4[a]	Eurofins
2-Methylnaphthalene	3	2	3	2	3	NA	1	1	3
Benz[a]anthracene	3	3	3	2	3	3	1	1	3
Benzo[a]pyrene	3	3	3	2	3	3	1	1	3
Benzo[b]fluoranthene	1	3	0	2	3	3	1	1	3
Benzo[e]pyrene	3	3	3	2	3	3	1	1	3
Benzo[g,h,i]perylene	3	3	3	2	3	3	1	1	0
Benzo[k]fluoranthene	3	0	3	2	0	3	0	0	3
Chrysene	3	3	3	2	3	3	1	1	3
Dibenz[a,h]anthracene	0	3	0	2	0	3	0	0	3
Fluoranthene	3	3	3	2	3	3	1	1	3
Indeno[1,2,3-c,d]pyrene	3	3	3	2	3	3	1	1	3
Perylene	3	2	3	2	3	3	1	1	3
Phenanthrene	3	3	3	2	3	3	1	1	3
Pyrene	3	3	3	2	3	3	1	1	3

a. Only one replicate was submitted.

Percent passing and final result

Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2	NB lab 4	Eurofins
Percent	86	93	86	100	86	86	NA	NA	93
Result	Pass	Pass	Pass	Pass	Pass	Pass	Insufficient	Insufficient	Pass


2-Methylnaphthalene
Concentration (ng/g dw)
1200
1000
800
600
400
200
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Benzo[b]fluorathene
Concentration (ng/g dw)
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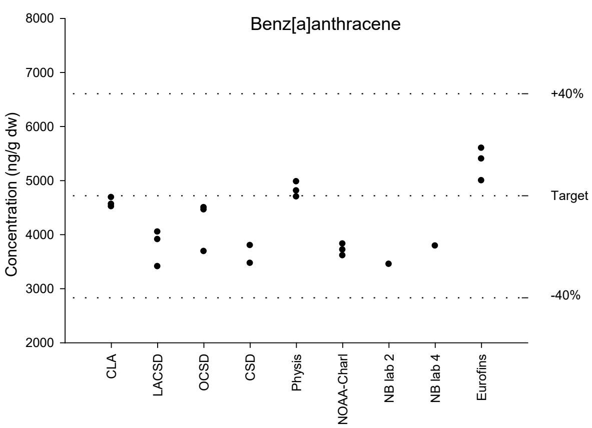
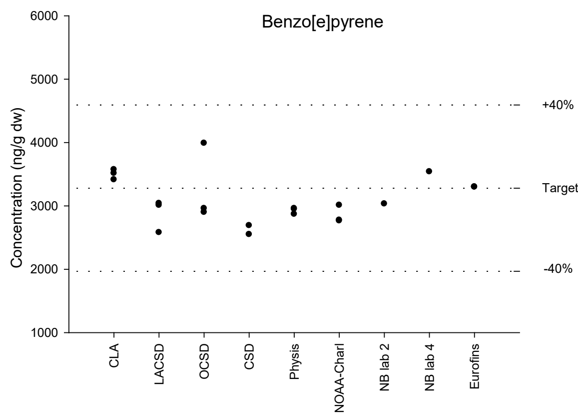
6000
4000
2000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Benz[a]anthracene
Concentration (ng/g dw)
8000
7000
6000
5000
4000
3000
2000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins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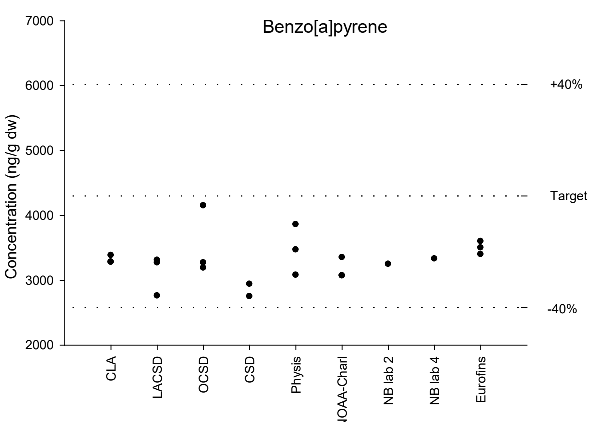
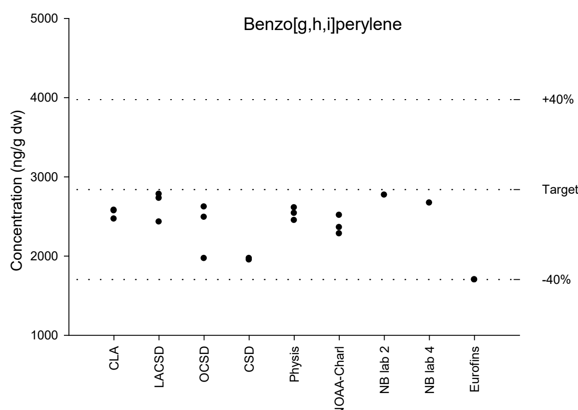
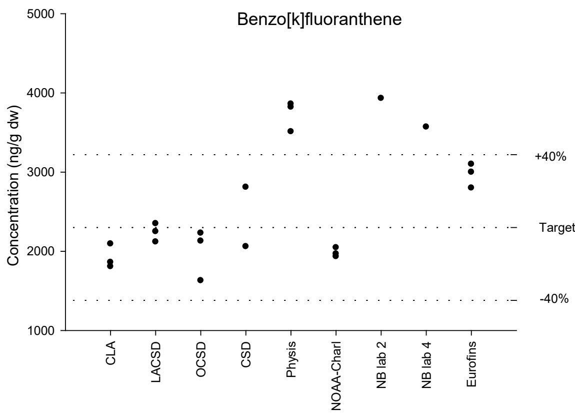
Concentration (ng/g dw)
6000
5000
4000
3000
2000
1000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Benzo[a]pyrene
Concentration (ng/g dw)
7000
6000
5000
4000
3000
2000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Benzo[g,h,i]perylene
Concentration (ng/g dw)
5000
4000
3000
2000
1000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Benzo[k]fluoranthene
Concentration (ng/g dw)
5000
4000
3000
2000
1000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
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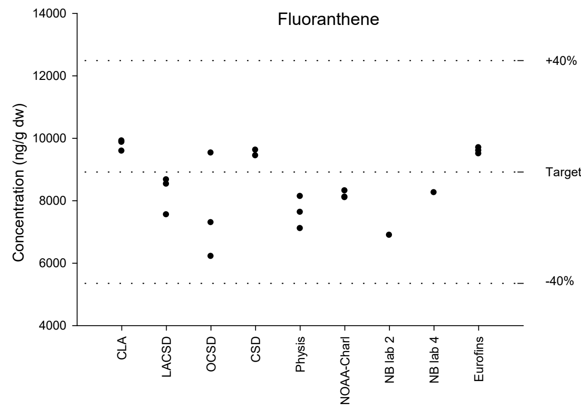
NB lab 2
NB lab 4
Eurofins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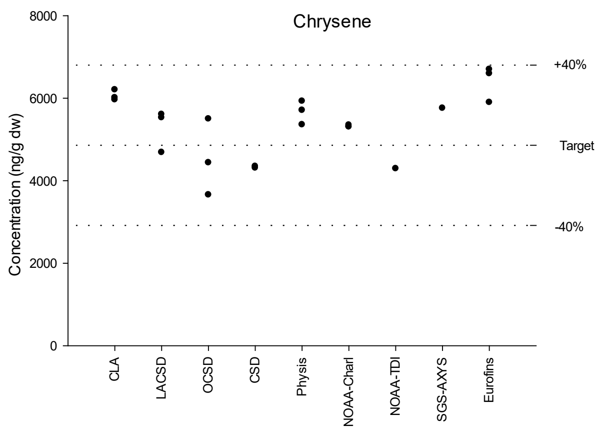
Concentration (ng/g dw)
14000
12000
10000
8000
6000
4000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Chrysene
Concentration (ng/g dw)
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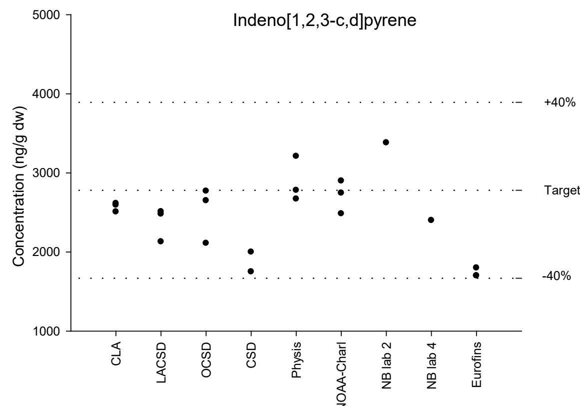
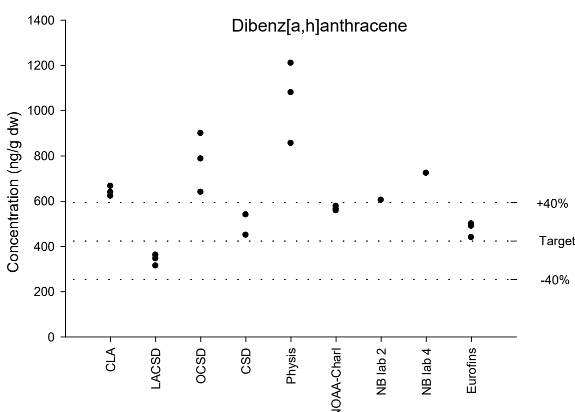
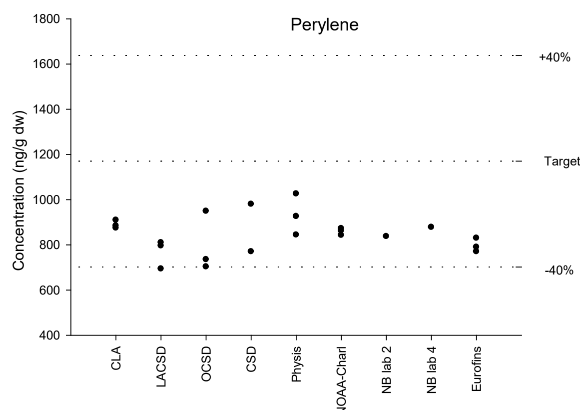
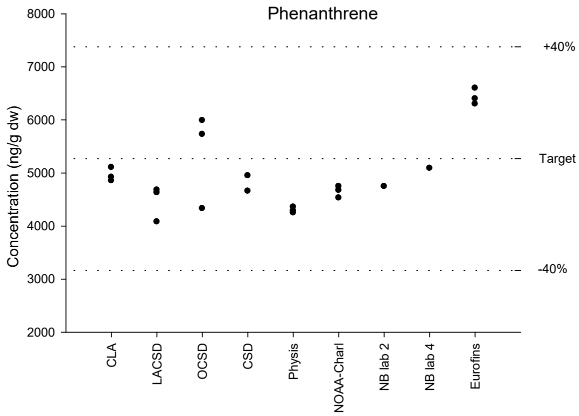
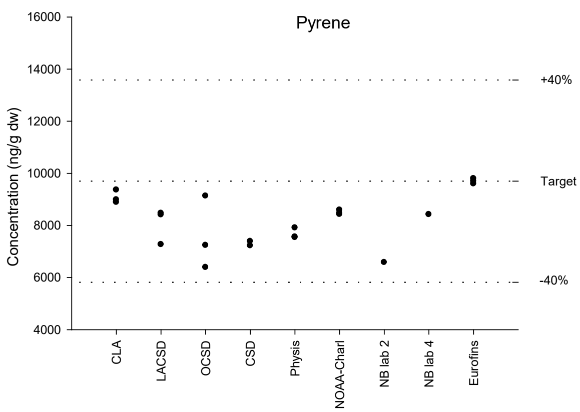
6000
4000
2000
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NOAA-TDI
SGS-AXYS
Eurofins


Indeno[1,2,3-c,d]pyrene
Concentration (ng/g dw)
5000
4000
3000
2000
1000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Dibenz[a,h]anthracene
Concentration (ng/g dw)
1400
1200
1000
800
600
400
200
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Perylene
Concentration (ng/g dw)
1800
1600
1400
1200
1000
800
600
400
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Phenanthrene
Concentration (ng/g dw)
8000
7000
6000
5000
4000
3000
2000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


Pyrene
Concentration (ng/g dw)
16000
14000
12000
10000
8000
6000
4000
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

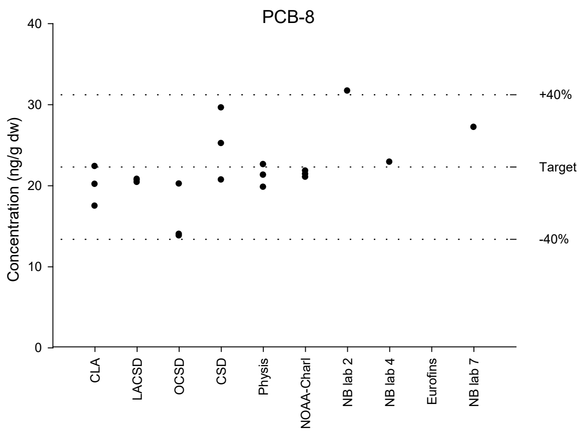
Number of passing replicates, out of three

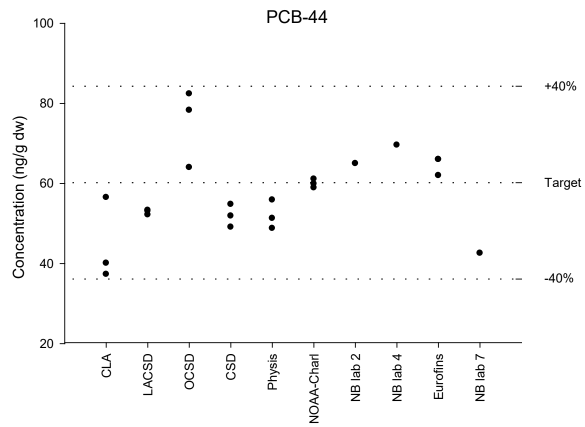
Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2[a]	NB lab 4[a]	Eurofins	NB lab 7[a]
PCB-8	3	3	3	3	3	3	0	1	NA	1
PCB-18	2	3	2	3	3	3	1	1	0	1
PCB-28	3	3	3	3	3	3	1	1	3	1
PCB-44	3	3	3	3	3	3	1	1	3	1
PCB-49	2	3	3	3	3	3	1	1	3	1
PCB-52	2	3	3	3	3	3	1	1	3	1
PCB-66	2	3	3	3	3	3	1	1	3	1
PCB-87	3	3	3	3	3	3	1	0	3	1
PCB-99	2	3	3	3	3	3	1	1	3	1
PCB-101	2	3	3	3	3	3	1	1	3	1
PCB-105	2	3	3	3	3	3	1	1	2	1
PCB-110	3	3	3	3	3	2	1	1	3	1
PCB-118	3	3	3	3	3	3	1	1	3	1
PCB-128	3	3	2	3	3	3	1	1	3	1
PCB-138	3	3	3	3	3	3	1	1	NA	1
PCB-149	2	3	3	3	3	3	1	1	3	1
PCB-151	3	3	3	3	3	3	1	NA	3	1
PCB-153	1	3	3	3	3	3	1	1	NA	1
PCB-156	3	3	3	1	3	3	1	1	3	1
PCB-170	2	3	3	3	3	3	0	1	3	1
PCB-180	2	3	3	3	3	3	1	1	1	1
PCB-183	2	3	3	3	3	3	1	1	3	1
PCB-187	3	3	3	1	3	3	1	1	3	1
PCB-194	3	3	3	3	3	3	1	1	3	1
PCB-195	3	0	2	2	3	3	1	1	2	1
PCB-206	3	3	2	2	3	3	1	1	1	1

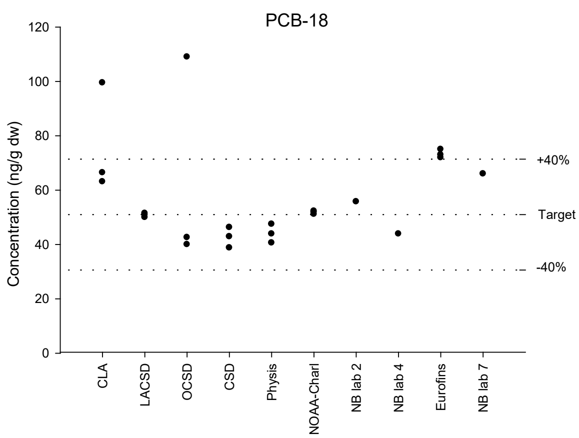
a. Only one replicate was submitted

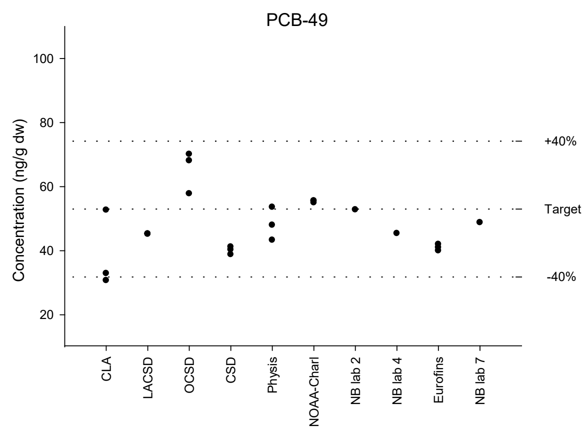
Percent passing and final result

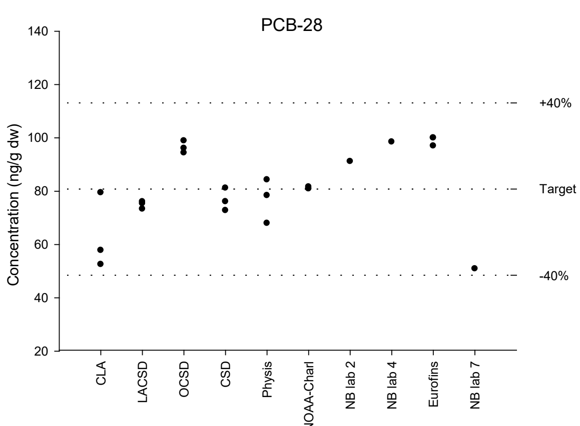
Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2	NB lab 4	Eurofins	NB lab 7
Percent	96	96	100	92	100	100	NA	NA	77	NA
Result	Pass	Pass	Pass	Pass	Pass	Pass	Insufficient	Insufficient	Pass	Insufficient

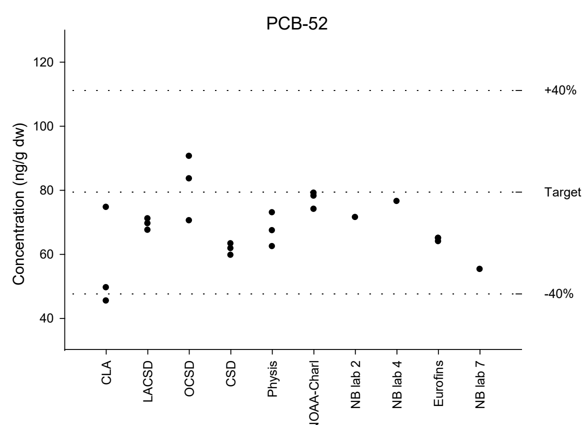

PCB-8
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

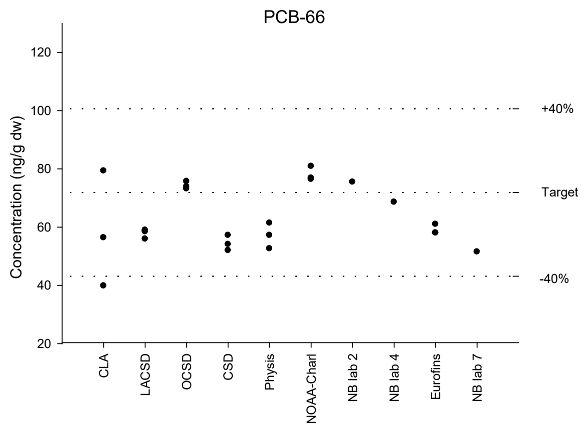

PCB-44
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

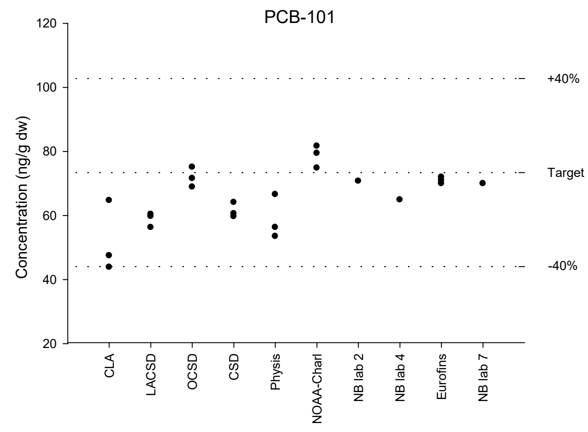

PCB-18
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

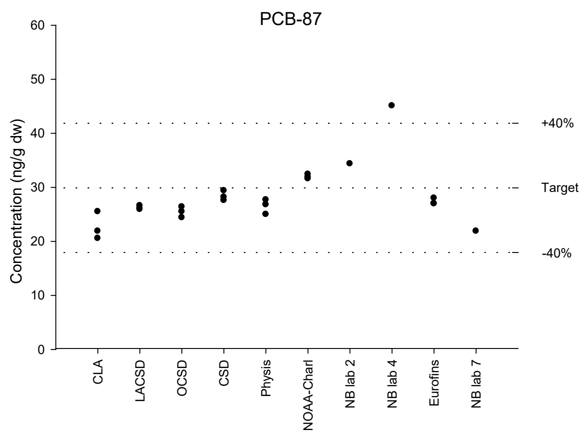

PCB-49
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

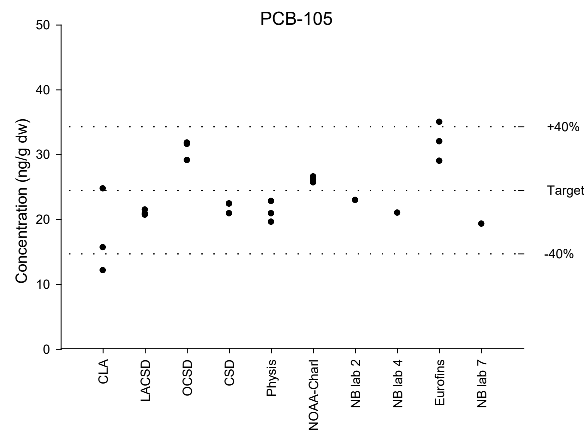

PCB-28
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

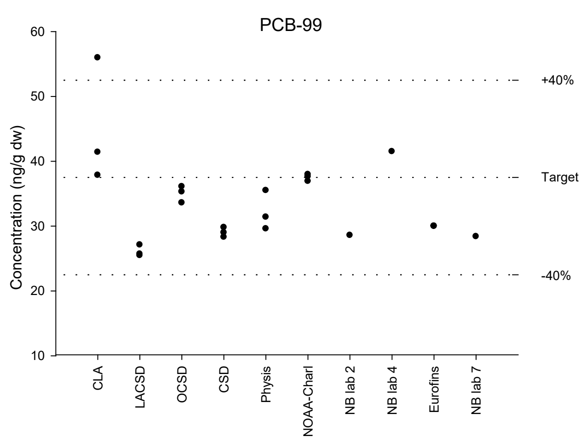

PCB-52
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

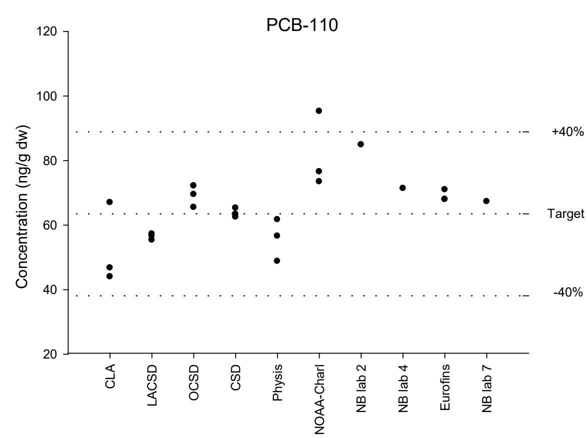

PCB-66
Concentration (ng/g dw)
120
100
80
60
40
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

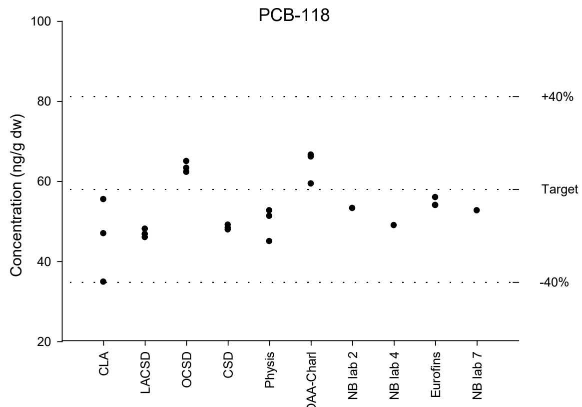

PCB-101
Concentration (ng/g dw)
120
100
80
60
40
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

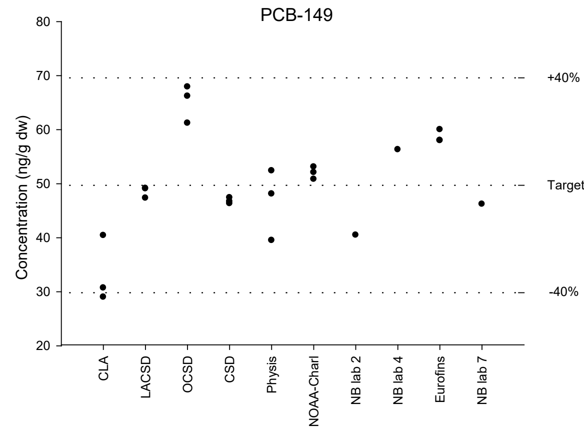

PCB-87
Concentration (ng/g dw)
60
50
40
30
20
10
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

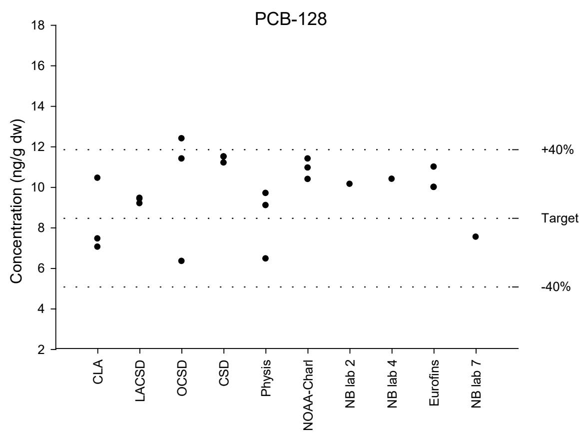

PCB-105
Concentration (ng/g dw)
50
40
30
20
10
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

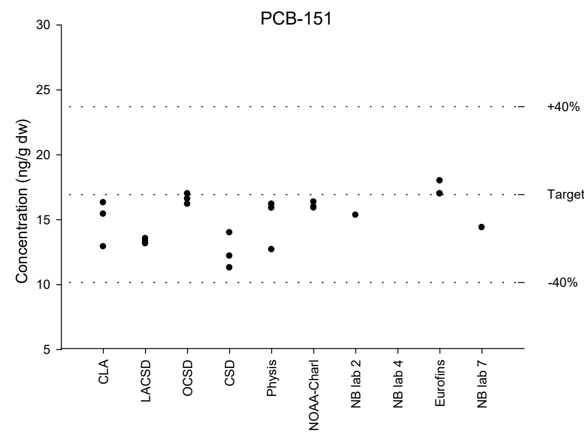

PCB-99
Concentration (ng/g dw)
60
50
40
30
20
10
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

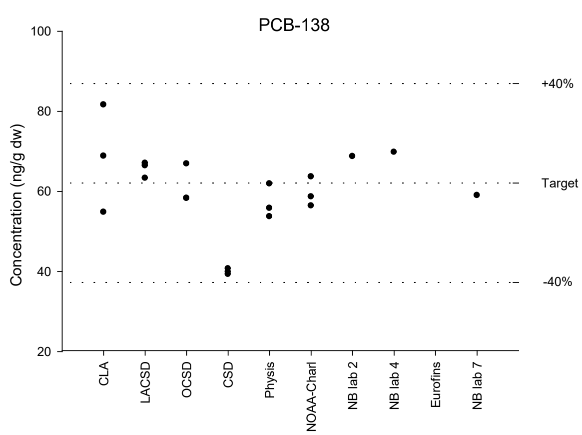

PCB-110
Concentration (ng/g dw)
120
100
80
60
40
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

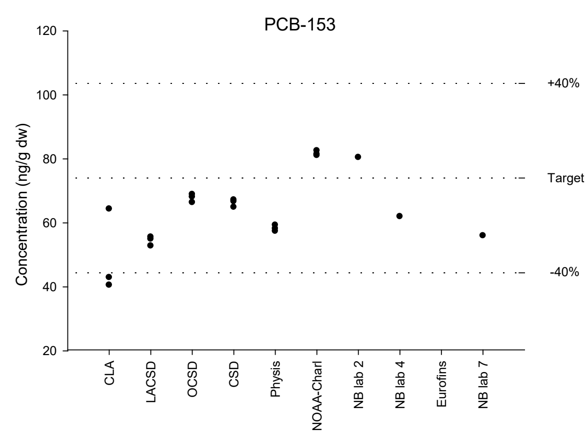

PCB-118
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

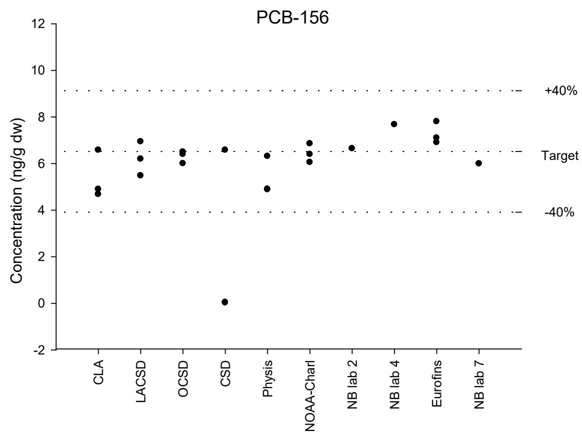

PCB-149
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

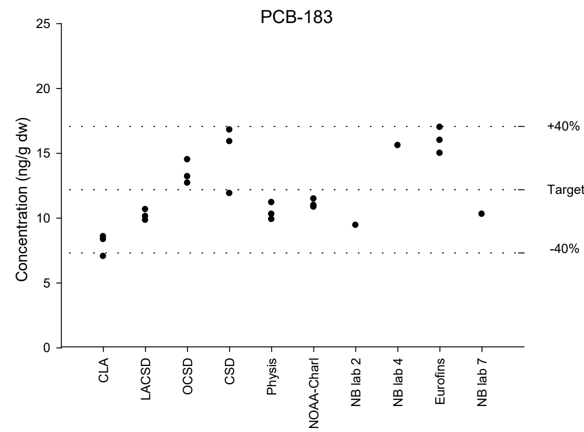

PCB-128
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

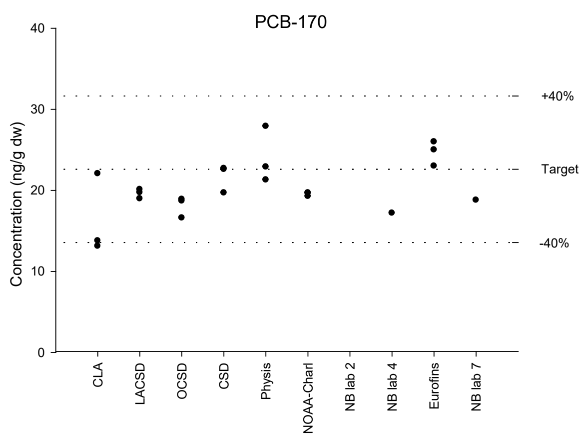

PCB-151
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

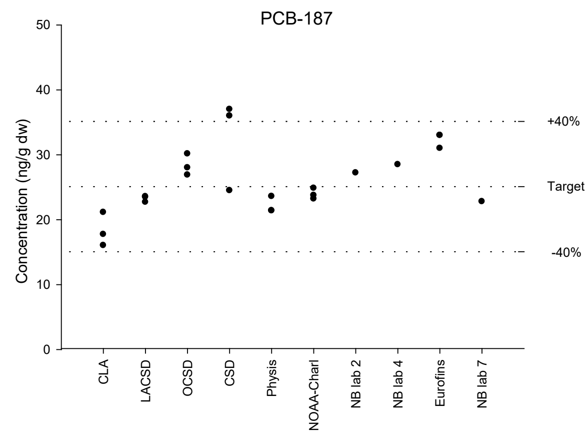

PCB-138
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

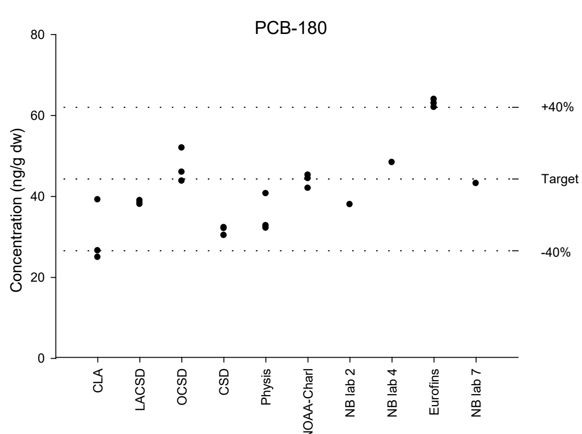

PCB-153
Concentration (ng/g dw)
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

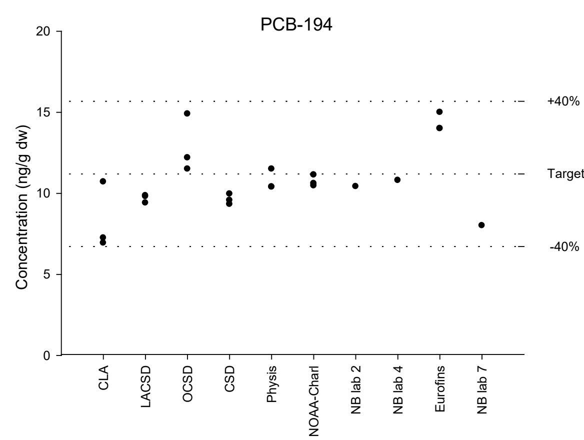

PCB-156
Concentration (ng/g dw)
12
10
8
6
4
2
0
-2
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

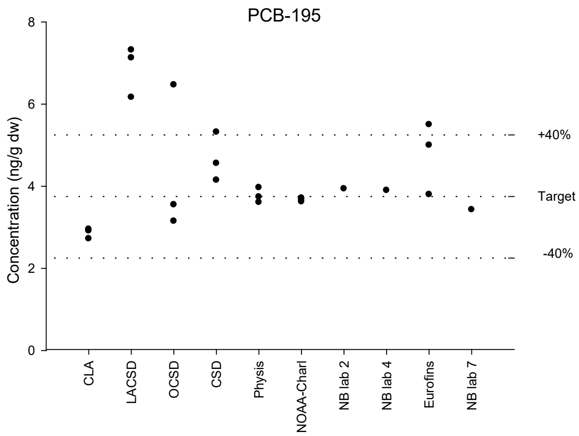

PCB-183
Concentration (ng/g dw)
25
20
15
10
5
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

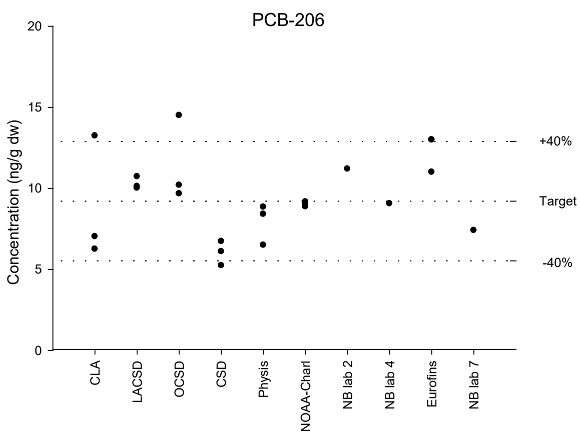

PCB-170
Concentration (ng/g dw)
40
30
20
10
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7


PCB-187
Concentration (ng/g dw)
50
40
30
20
10
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7


PCB-180
Concentration (ng/g dw)
80
60
40
20
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7


PCB-194
Concentration (ng/g dw)
20
15
10
5
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7


PCB-195
Concentration (ng/g dw)
0
2
4
6
8
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7


PCB-206
Concentration (ng/g dw)
0
5
10
15
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins
NB lab 7

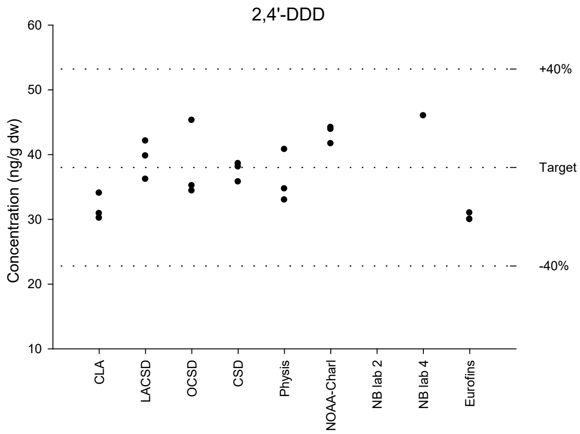
Number of passing replicates, out of three

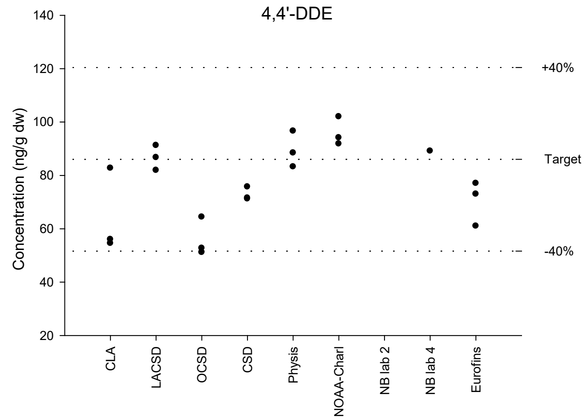
Parameters	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2 [a]	NB lab 4 [a]	Eurofins
4,4'-DDT	3	0	2	3	3	3	1	0	3
4,4'-DDD	3	3	3	3	3	3	NA	1	3
2,4'-DDD	3	3	3	3	3	3	NA	1	3
4,4'-DDE	3	3	2	3	3	3	NA	1	3
2,4'-DDE	2	3	3	3	3	3	NA	1	3
alpha-Chlordane	3	3	3	3	3	3	1	1	3
gamma-Chlordane	2	3	3	3	3	3	NA	1	3
cis-nonachlor	0	3	3	3	3	3	NA	0	3
trans-nonachlor	3	2	3	3	3	3	1	0	0

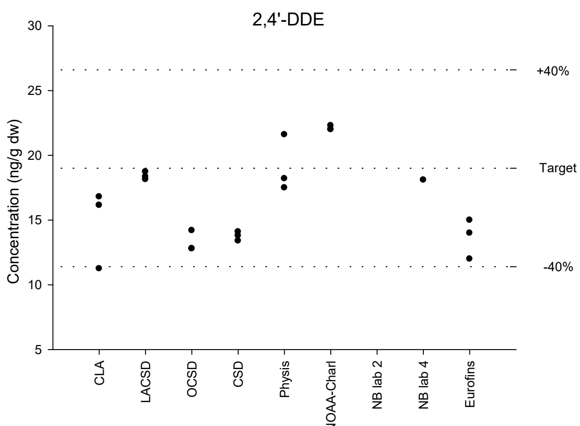
a. Only one replicate was submitted

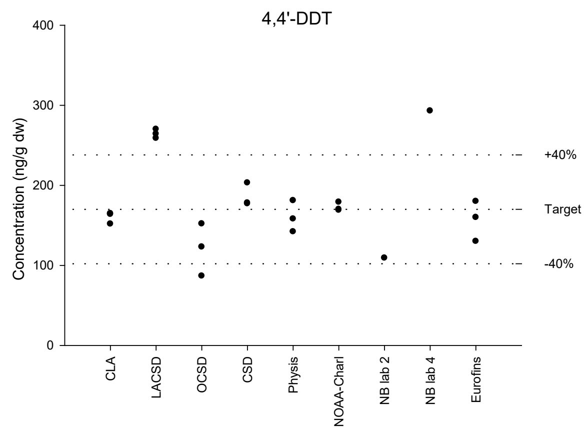
Percent passing and final result

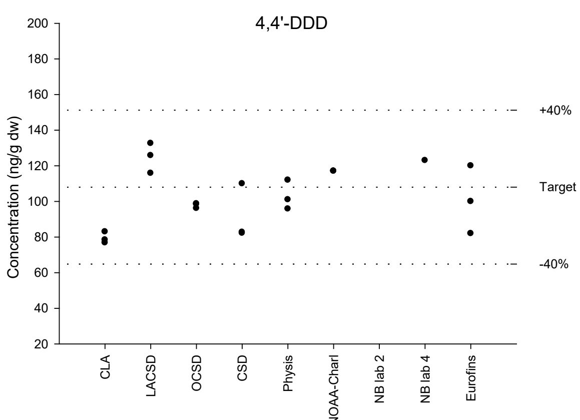
Parameters	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 2	NB lab 4	Eurofins
Percent	89	89	100	100	100	100	NA	NA	89
Result	Pass	Pass	Pass	Pass	Pass	Pass	Insufficient	Insufficient	Pass

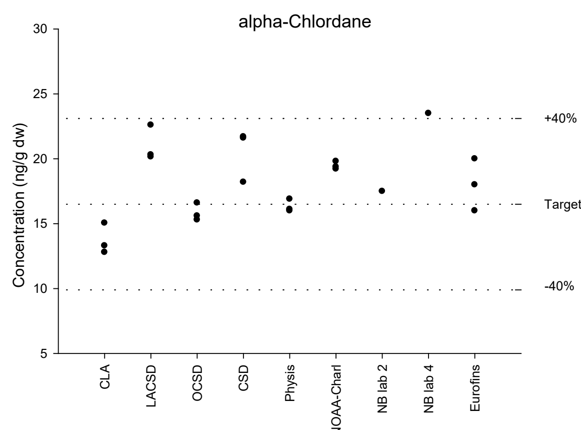

2,4'-DDD
Concentration (ng/g dw)
60
50
40
30
20
10
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

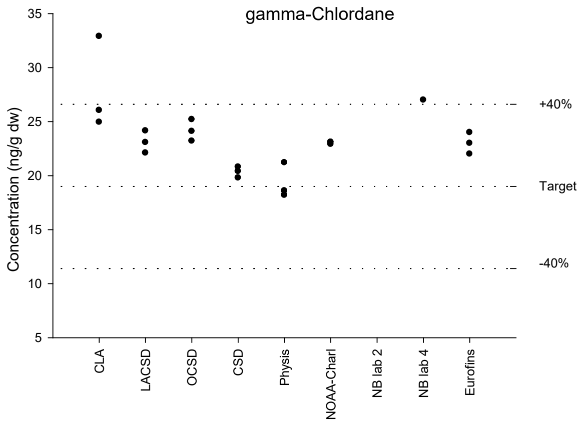

4,4'-DDE
Concentration (ng/g dw)
140
120
100
80
60
40
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

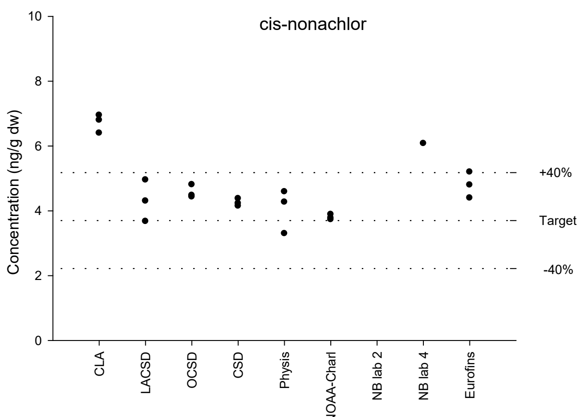

2,4'-DDE
Concentration (ng/g dw)
30
25
20
15
10
5
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

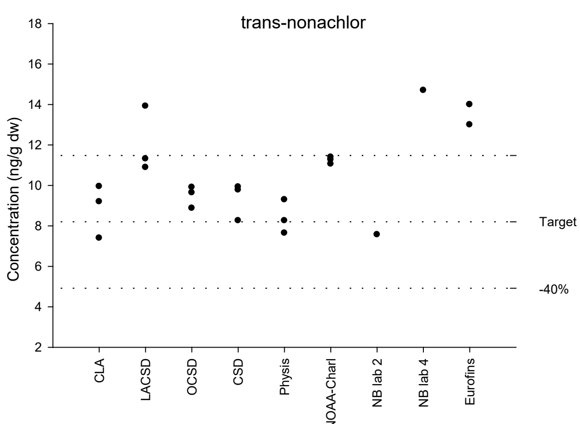

4,4'-DDT
Concentration (ng/g dw)
400
300
200
100
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


4,4'-DDD
Concentration (ng/g dw)
200
180
160
140
120
100
80
60
40
20
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


alpha-Chlordane
Concentration (ng/g dw)
30
25
20
15
10
5
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


gamma-Chlordane
Concentration (ng/g dw)
35
30
25
20
15
10
5
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


cis-nonachlor
Concentration (ng/g dw)
10
8
6
4
2
0
+40%
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


trans-nonachlor
Concentration (ng/g dw)
18
16
14
12
10
8
6
4
2
Target
-40%
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

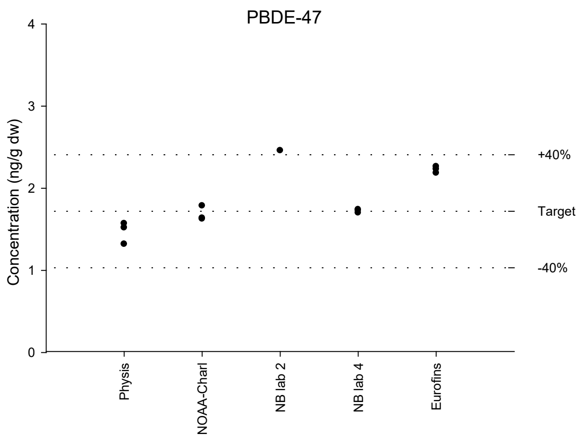
Number of passing replicates, out of three

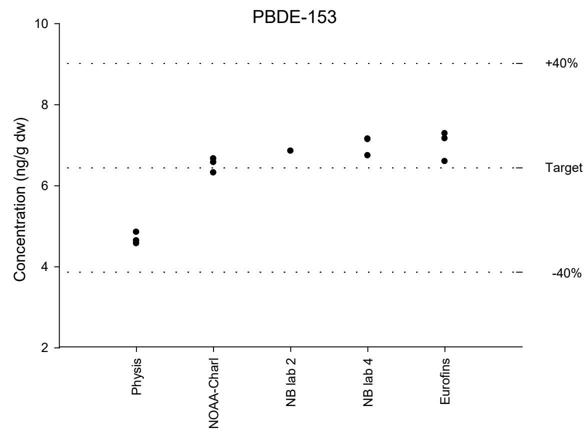
Parameters	Physis	NOAA-Charl	NB lab 2 [a]	NB lab 4	Eurofins
PBDE-47	3	3	0	3	3
PBDE-99	3	3	1	3	2
PBDE-100	3	3	0	3	0
PBDE-153	3	3	1	3	3
PBDE-154	3	3	1	3	3
PBDE-183	3	3	1	3	3

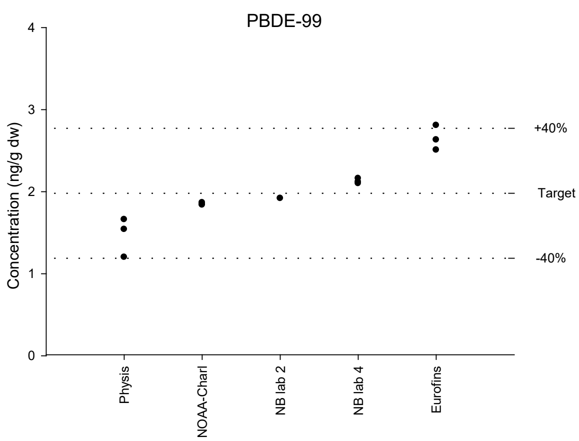
a. Only one replicate was submitted.

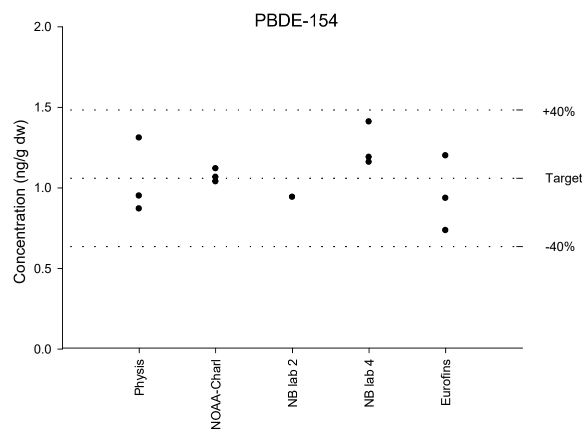
Percent passing and final result

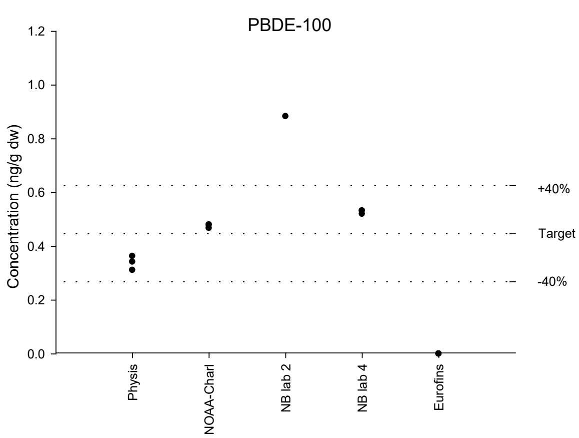
Parameters	Physis	NOAA-Charl	NB lab 2	NB lab 4	Eurofins
Percent	100%	100%	NA	100%	83%
Pass or fail	Pass	Pass	Insufficient	Pass	Pass

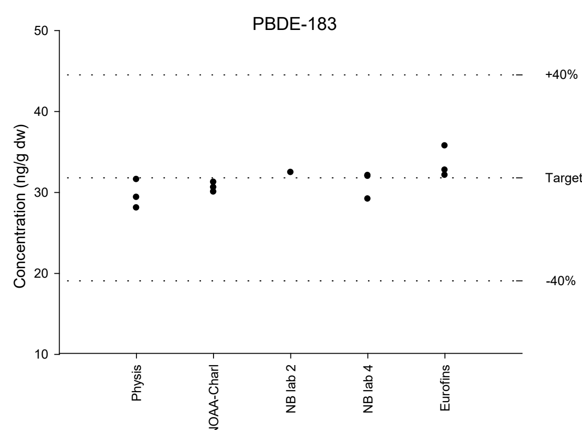

PBDE-47
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


PBDE-153
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


PBDE-99
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


PBDE-154
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


PBDE-100
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins


PBDE-183
Concentration (ng/g dw)
+40%
Target
-40%
Physis
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

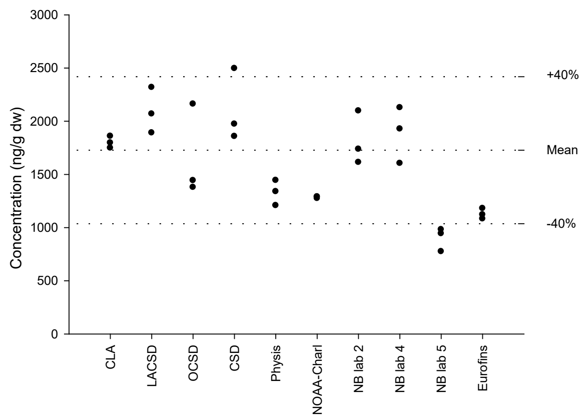
Number of passing replicates, out of three

Parameter	CLA	LACSD	OCSD	CSD	Physis	NB lab 1	NOAA-Charl	NB lab 2	NB lab 4	NB lab 5	Eurofins	NB lab 7	NB lab 8
PAH	3	3	3	2	3	NA	3	3	3	0	3	NA	NA
OC Pesticides	3	2	3	3	3	3	3	3	3	NA	3	NA	NA
PCB	3	2	3	3	3	0	3	3	2	NA	3	3	3
PBDE	NA	NA	NA	NA	2	3	3	3	0	NA	3	NA	NA

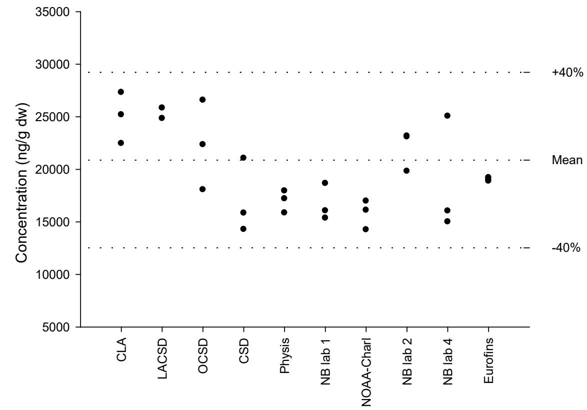
Final result

Parameter	CLA	LACSD	OCSD	CSD	Physis	NB lab 1	NOAA-Charl	NB lab 2	NB lab 4	NB lab 5	Eurofins	NB lab 7	NB lab 8
PAH	Pass	Pass	Pass	Pass	Pass	NA	Pass	Pass	Pass	Fail	Pass	NA	NA
OC Pesticides	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	NA	Pass	NA	NA
PCB	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	NA	Pass	Pass	Pass
PBDE	NA	NA	NA	NA	Pass	Pass	Pass	Pass	Fail	NA	Pass	NA	NA

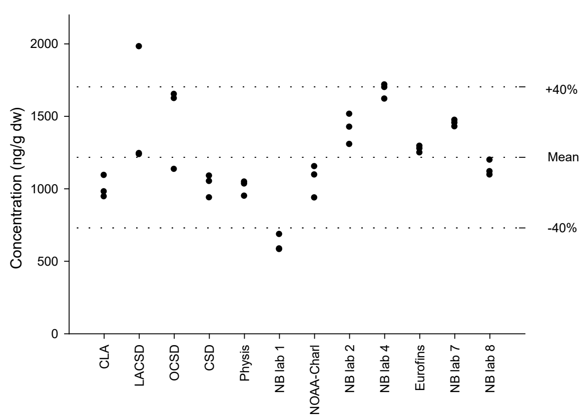
ΣPAH



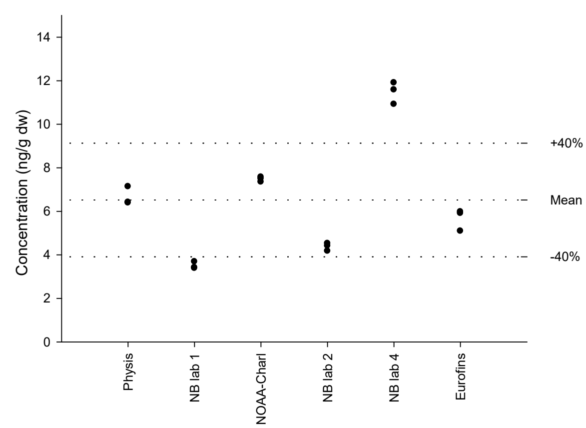
ΣOC Pesticides



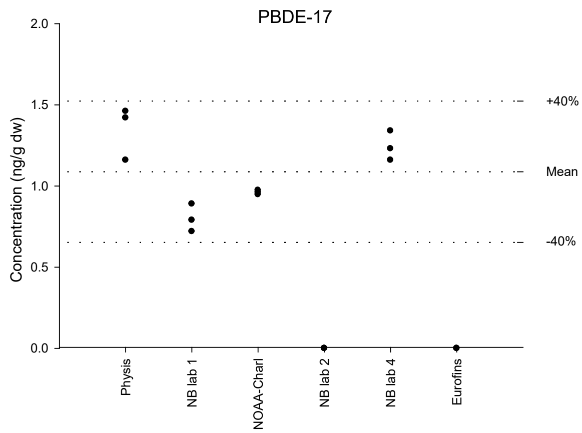
ΣPCB

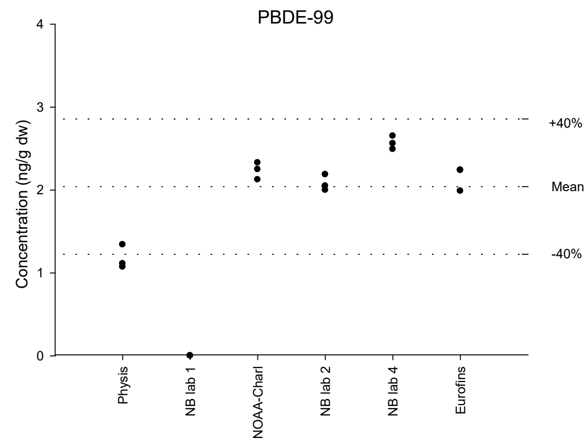


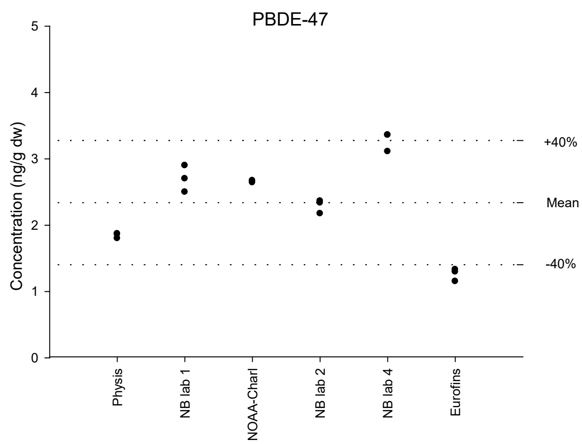
ΣPBDE

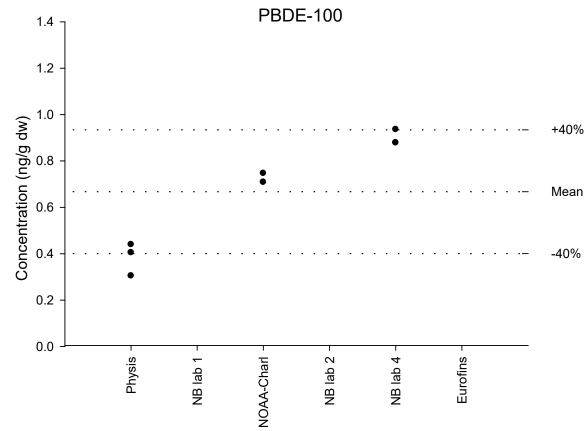


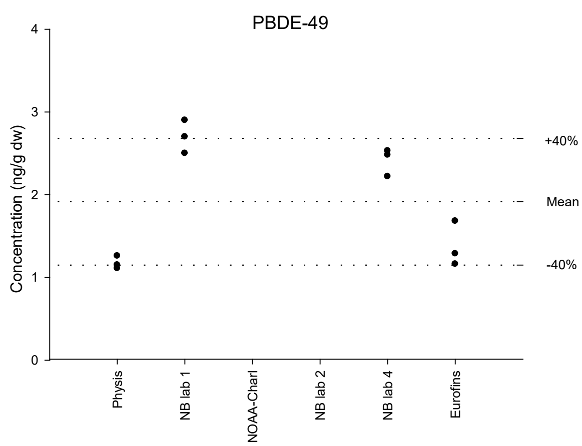
B'18 Chemistry Intercalibration
Material: Palos Verdes Shelf Sediment
Analytes: Individual PBDEs

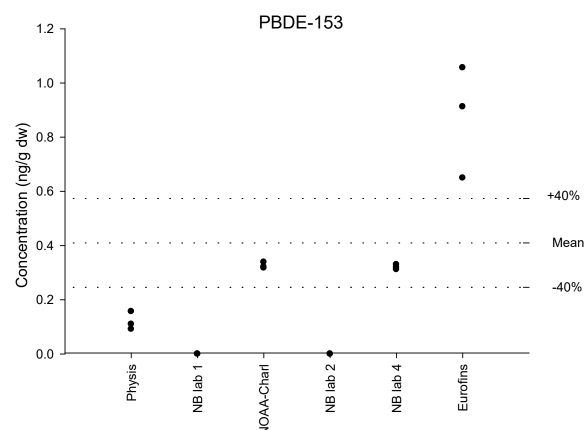


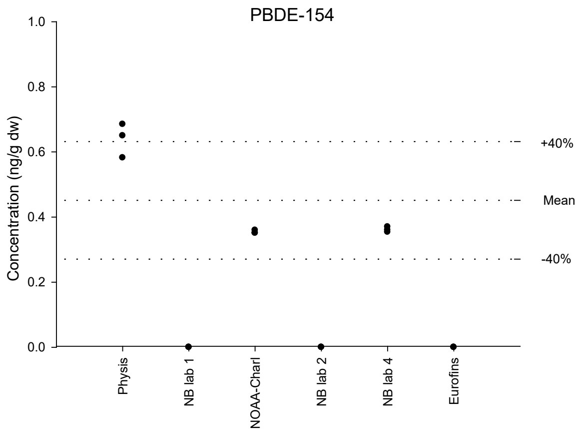











PBDE-154
Concentration (ng/g dw)
1.0
0.8
0.6
0.4
0.2
0.0
+40%
Mean
-40%
Physis
NB lab 1
NOAA-Charl
NB lab 2
NB lab 4
Eurofins

Number of passing replicates, out of three

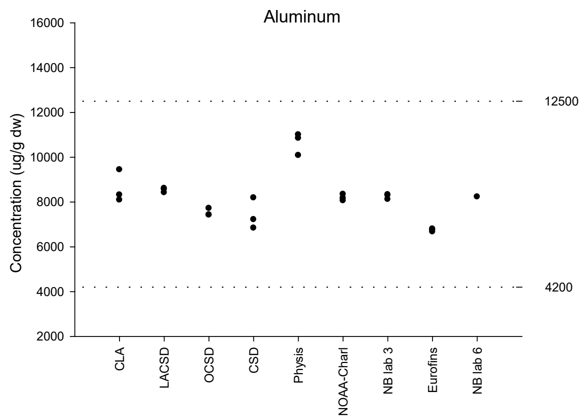
Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 3	Eurofins	NB lab 6 [a]
Aluminum	3	3	3	3	3	3	3	3	1
Antimony	3	3	3	3	3	3	3	3	1
Arsenic	3	3	3	3	3	3	3	3	1
Barium	3	3	3	3	3	3	3	3	1
Beryllium	3	3	3	3	3	3	3	3	1
Cadmium	3	3	3	3	3	3	3	3	1
Chromium	3	3	3	3	3	3	3	3	1
Copper	3	3	3	3	3	3	3	3	1
Iron	3	3	3	3	3	3	3	3	1
Lead	3	3	3	3	3	3	3	3	0
Mercury	3	3	3	3	3	3	3	3	1
Nickel	3	3	3	3	3	3	3	3	1
Selenium	3	3	3	3	3	3	3	3	1
Silver	3	3	3	3	3	3	3	3	1
Zinc	3	3	3	3	3	3	3	3	1

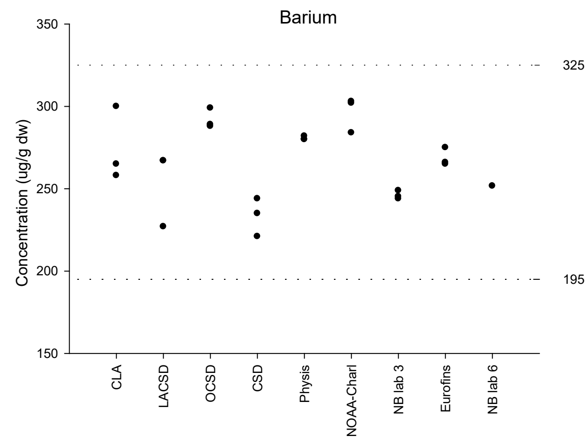
a. Only one replicate was submitted.

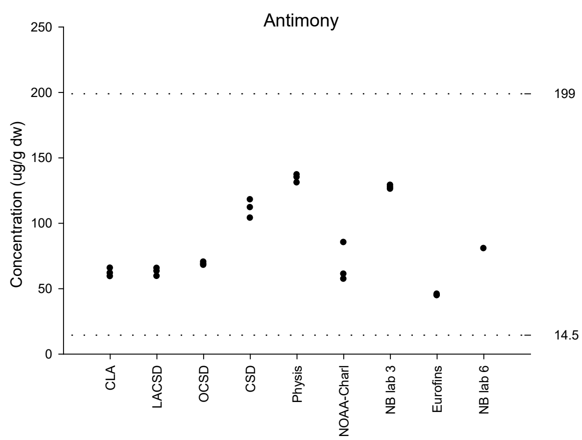
Percent passing and final result

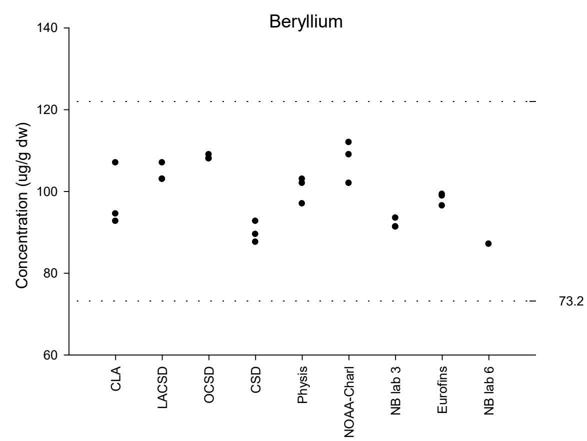
Parameter	CLA	LACSD	OCSD	CSD	Physis	NOAA-Charl	NB lab 3	Eurofins	NB lab 6
Percent	100	100	100	100	100	100	100	100	NA
Result	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Insufficient

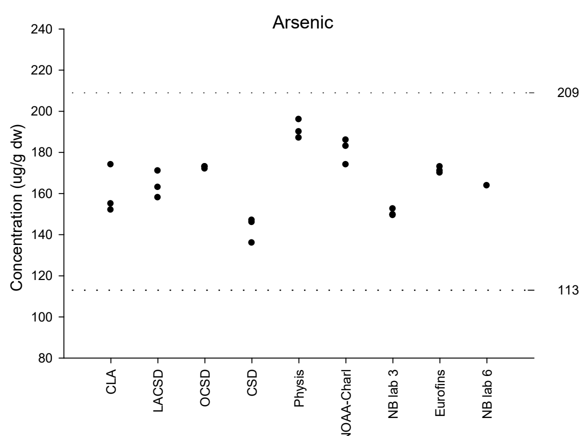
B'18 Chemistry Intercalibration
Material: ERA 540 Lot 099
Analytes: Metals

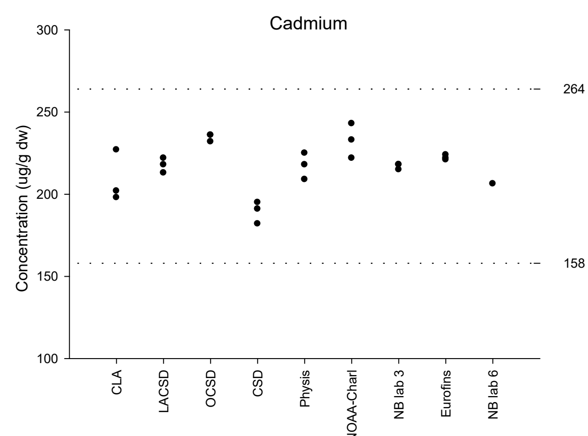




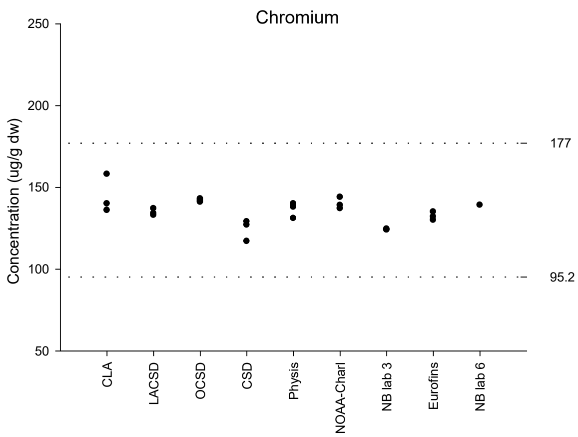


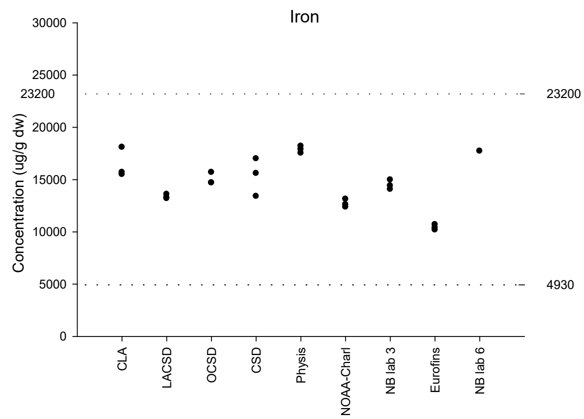


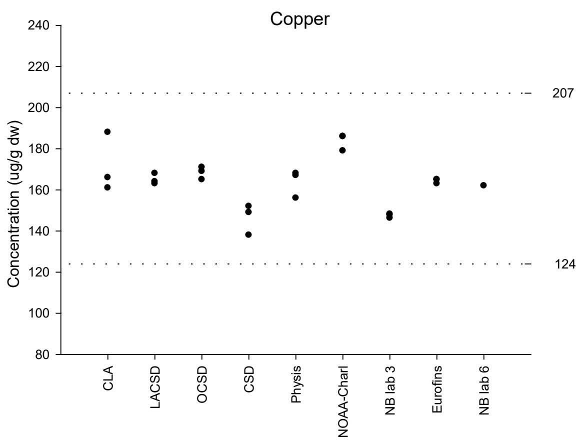


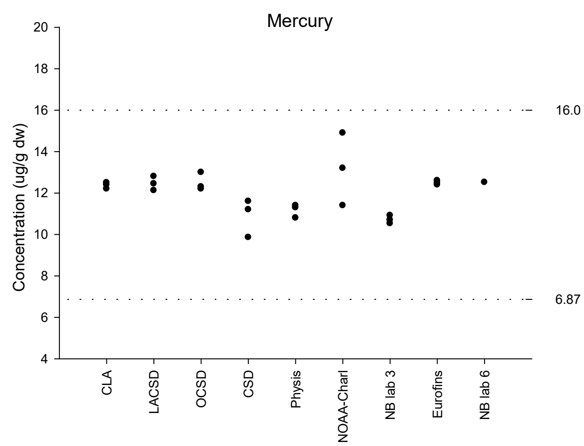


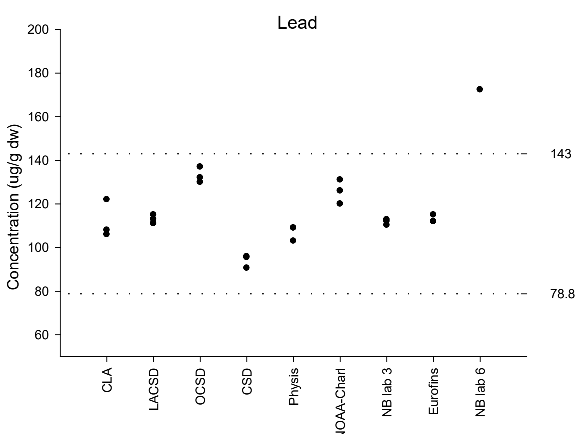
B'18 Chemistry Intercalibration
Material: ERA 540 Lot 099
Analytes: Metals

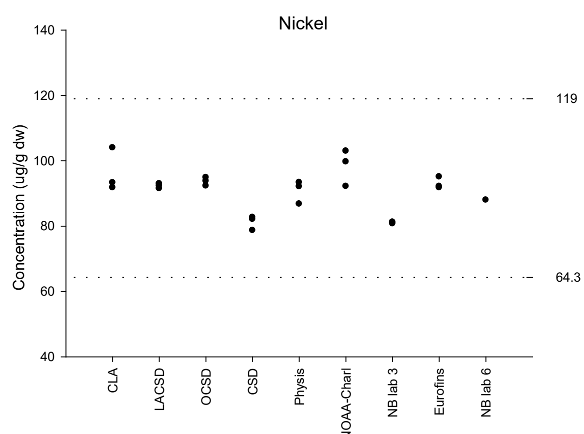


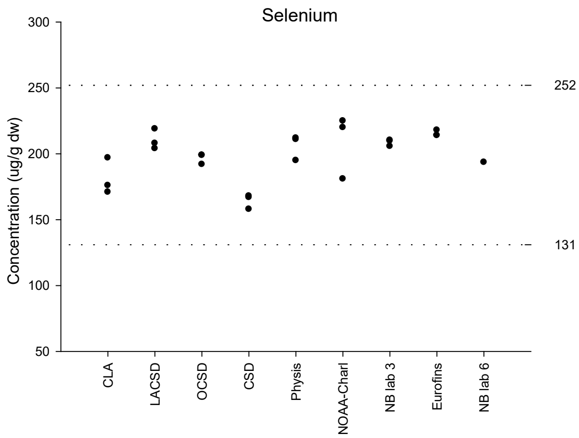


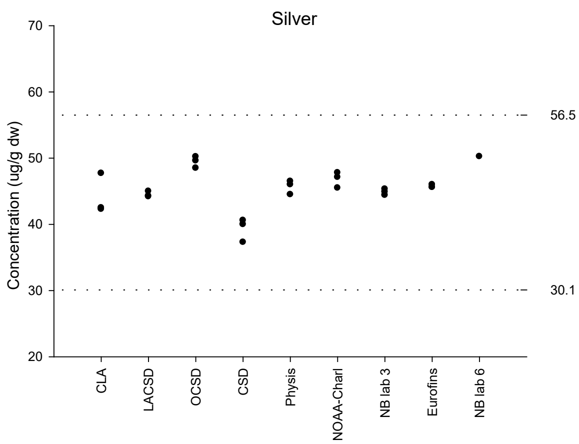


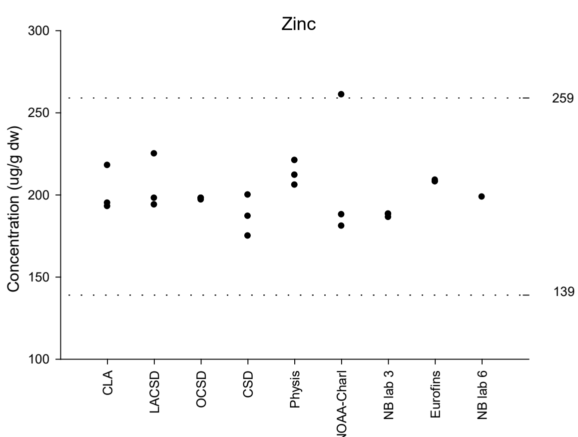







Selenium
Concentration (ug/g dw)
300
250
200
150
100
50
252
131
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 3
Eurofins
NB lab 6


Silver
Concentration (ug/g dw)
70
60
50
40
30
20
56.5
30.1
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 3
Eurofins
NB lab 6

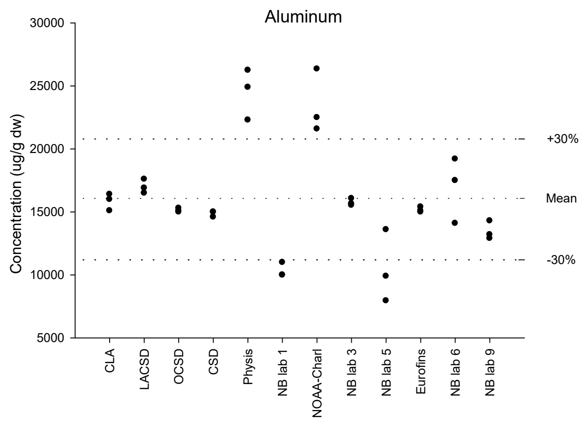

Zinc
Concentration (ug/g dw)
300
250
200
150
100
259
139
CLA
LACSD
OCSD
CSD
Physis
NOAA-Charl
NB lab 3
Eurofins
NB lab 6

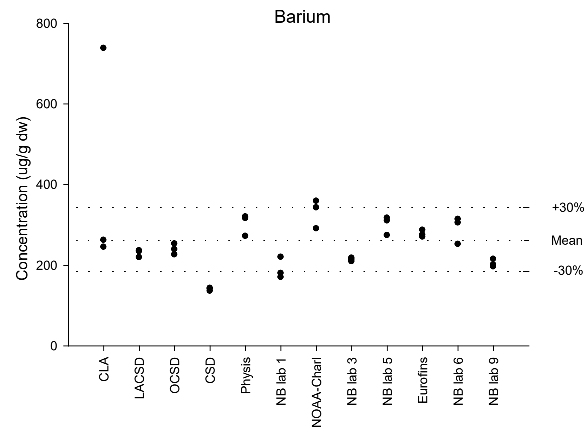
Number of passing replicates, out of three

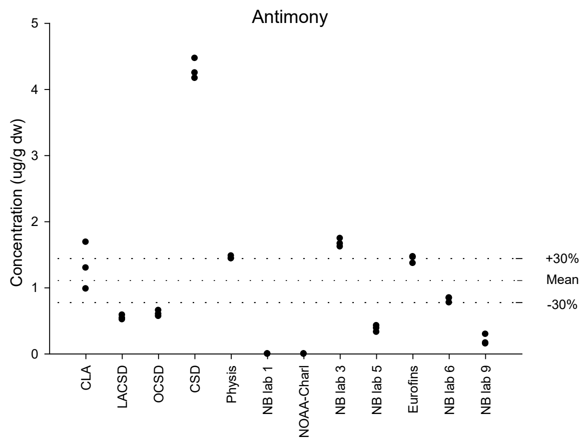
Parameter	CLA	LACSD	OCSD	CSD	Physis	NB lab 1	NOAA-Charl	NB lab 3	NB lab 5	Eurofins	NB lab 6	NB lab 9
Aluminum	3	3	3	3	0	0	0	3	1	3	3	3
Antimony	0	1	3	0	0	0	0	0	0	0	3	0
Arsenic	3	3	3	3	3	0	3	3	3	3	3	3
Barium	2	3	3	0	3	1	2	3	3	3	3	3
Beryllium	3	3	3	0	1	0	3	3	3	2	3	3
Cadmium	3	3	3	3	3	0	3	3	3	3	3	3
Chromium	3	3	3	3	3	0	3	3	3	3	3	3
Copper	3	3	3	2	3	1	2	3	3	2	2	3
Iron	3	3	3	3	3	0	3	3	2	3	3	3
Lead	3	3	1	3	3	0	3	3	3	3	3	3
Mercury	3	3	1	3	3	0	0	2	3	2	3	3
Nickel	3	3	3	3	3	0	3	3	3	3	3	3
Selenium	2	3	0	3	3	0	3	3	3	0	3	0
Silver	3	3	3	3	3	0	3	3	3	3	3	3
Zinc	3	3	3	3	2	0	2	3	3	3	3	3

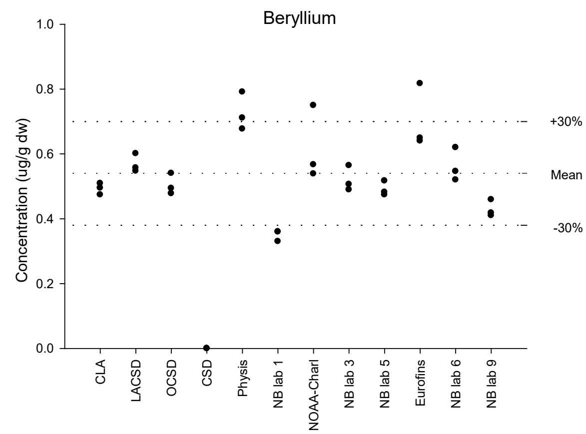
Percent passing and final result

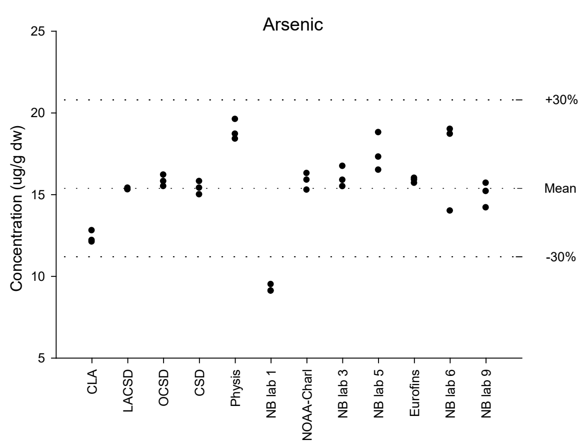
Parameter	CLA	LACSD	OCSD	CSD	Physis	NB lab 1	NOAA-Charl	NB lab 3	NB lab 5	Eurofins	NB lab 6	NB lab 9
Percent	93	93	80	80	80	0	80	93	87	87	100	87
Result	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass

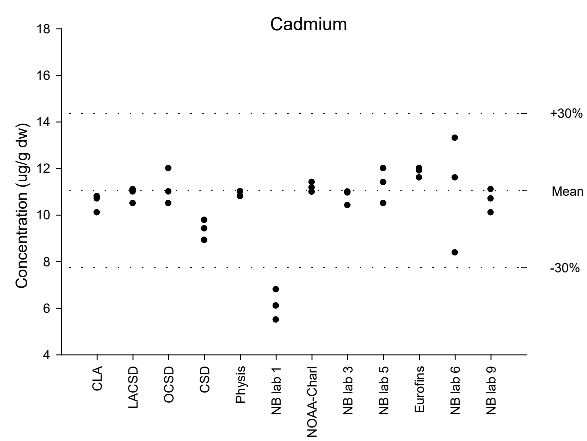

Aluminum
Concentration (ug/g dw)
30000
25000
20000
15000
10000
5000
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

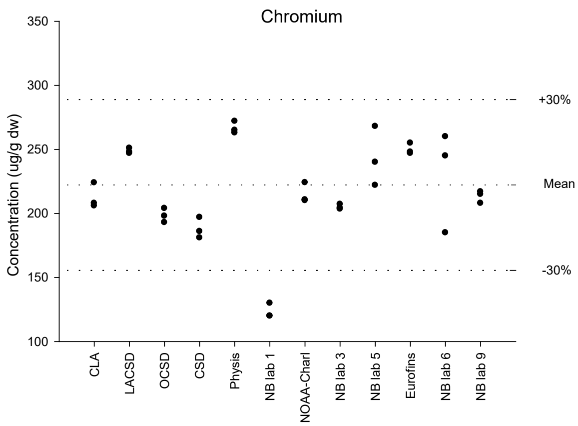

Barium
Concentration (ug/g dw)
800
600
400
200
0
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

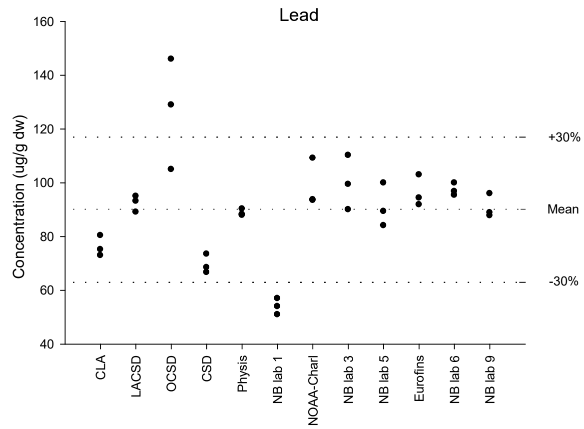

Antimony
Concentration (ug/g dw)
5
4
3
2
1
0
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

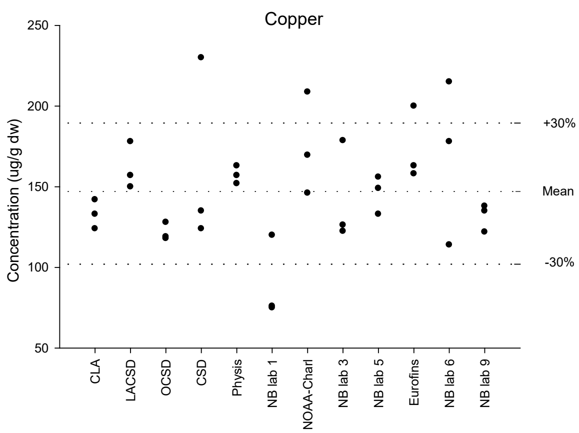

Beryllium
Concentration (ug/g dw)
1.0
0.8
0.6
0.4
0.2
0.0
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

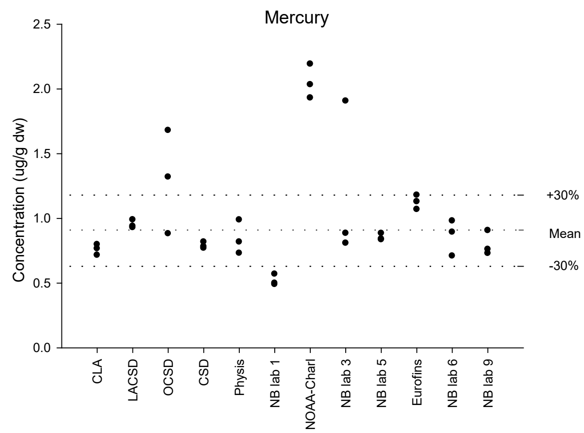

Arsenic
Concentration (ug/g dw)
25
20
15
10
5
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

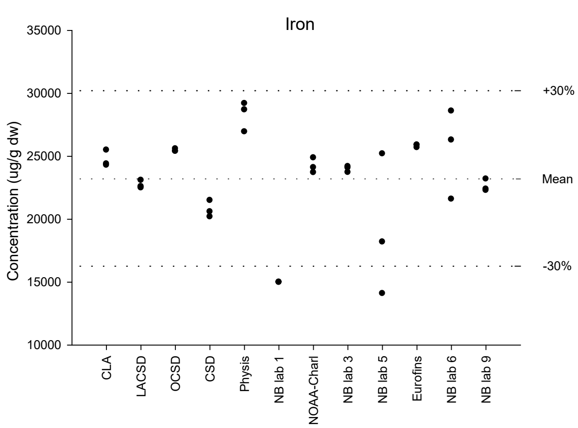

Cadmium
Concentration (ug/g dw)
18
16
14
12
10
8
6
4
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

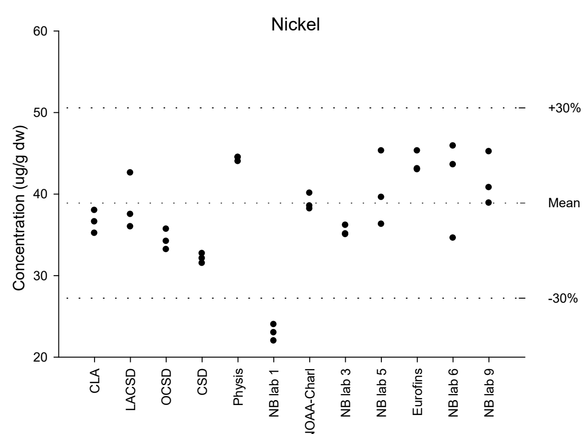

Chromium
Concentration (ug/g dw)
350
300
250
200
150
100
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

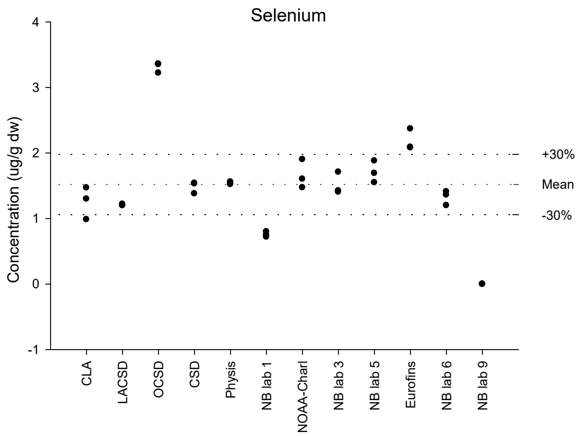

Lead
Concentration (ug/g dw)
160
140
120
100
80
60
40
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

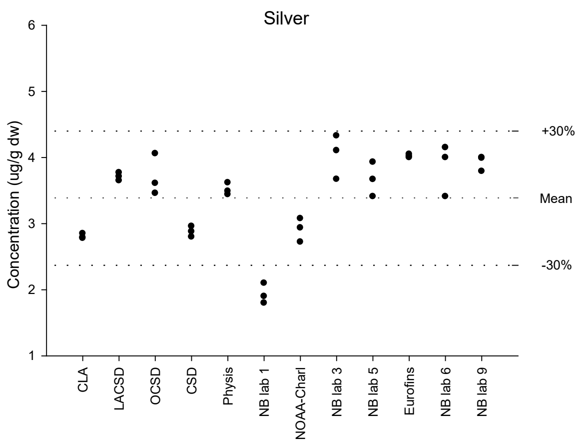

Copper
Concentration (ug/g dw)
250
200
150
100
50
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

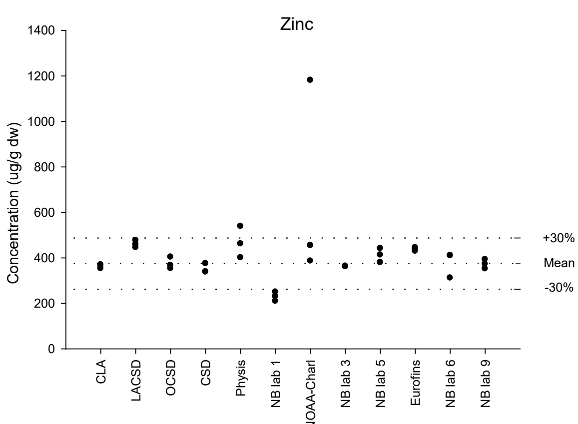

Mercury
Concentration (ug/g dw)
2.5
2.0
1.5
1.0
0.5
0.0
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9


Iron
Concentration (ug/g dw)
35000
30000
25000
20000
15000
10000
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

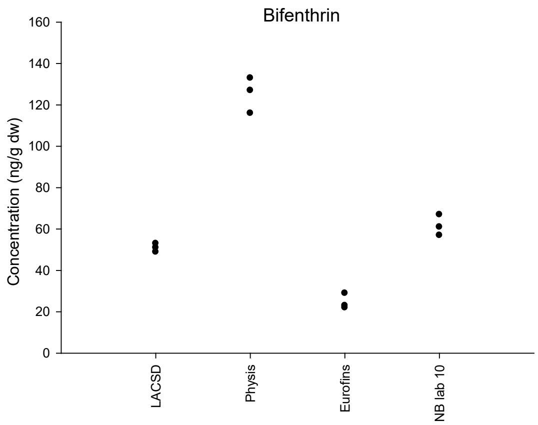

Nickel
Concentration (ug/g dw)
60
50
40
30
20
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

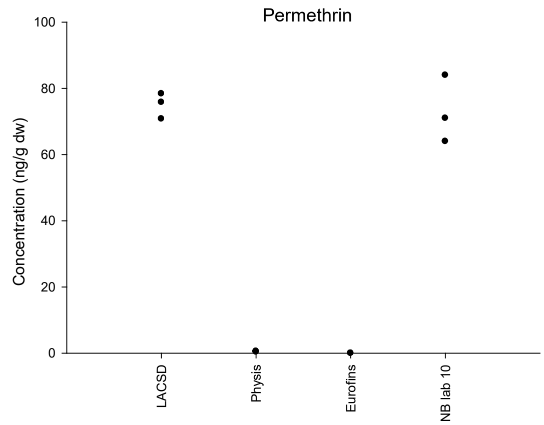

Selenium
Concentration (ug/g dw)
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

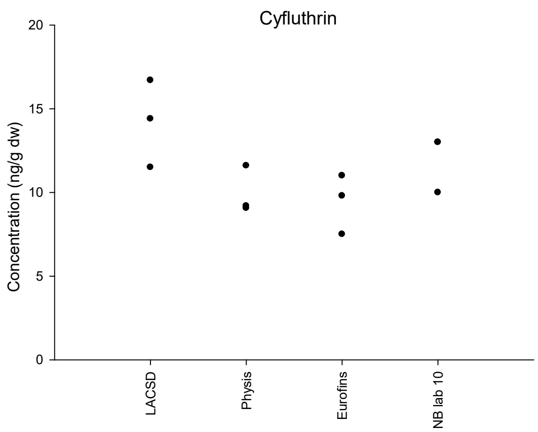

Silver
Concentration (ug/g dw)
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

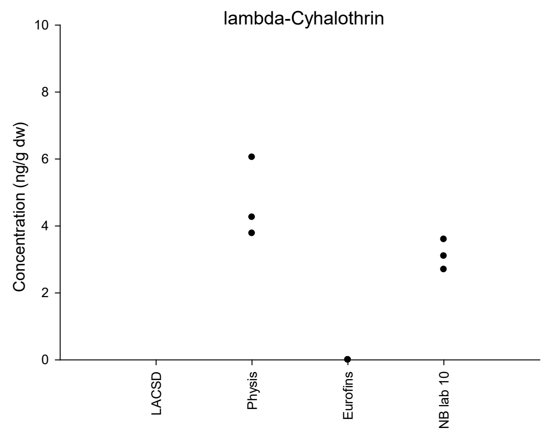

Zinc
Concentration (ug/g dw)
+30%
Mean
-30%
CLA
LACSD
OCSD
CSD
Physis
NB lab 1
NOAA-Charl
NB lab 3
NB lab 5
Eurofins
NB lab 6
NB lab 9

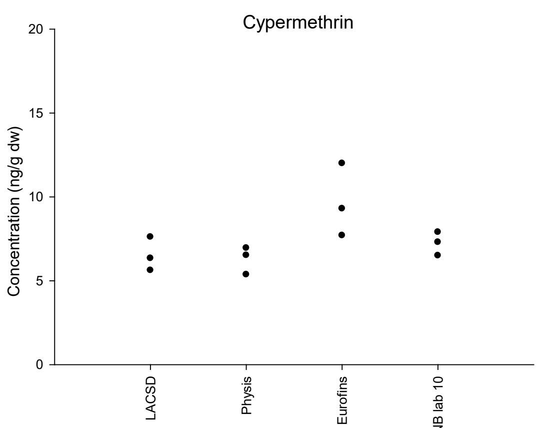
B’18 Chemistry Intercalibration
Material: Port of Los Angeles Consolidated Slip Sediment
Analytes: Pyrethroids and Fipronils

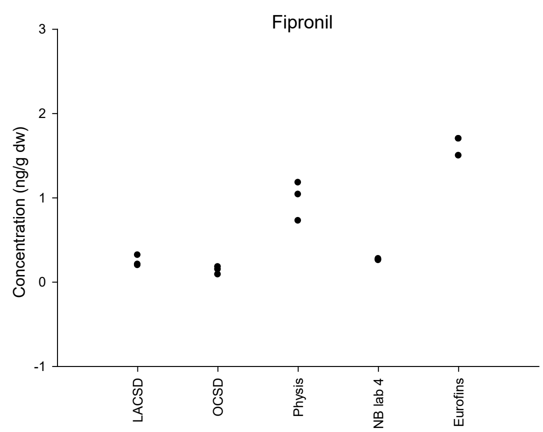


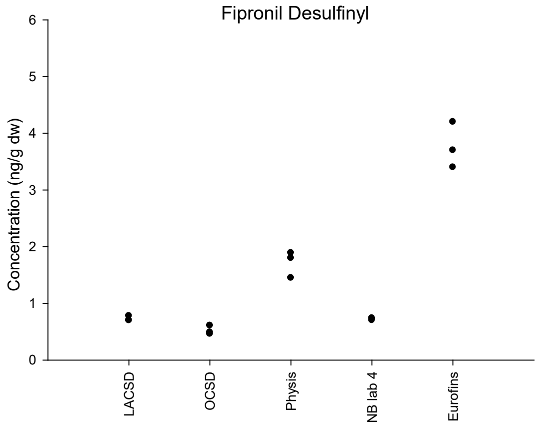


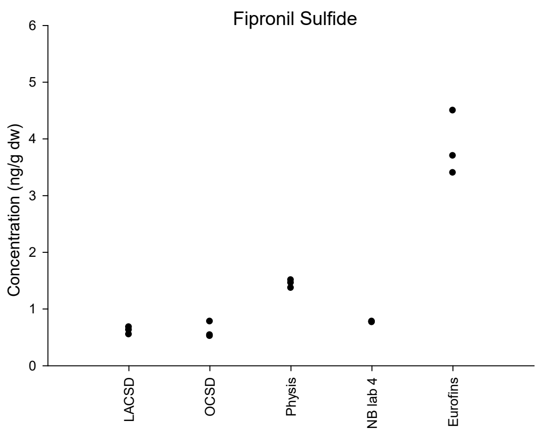


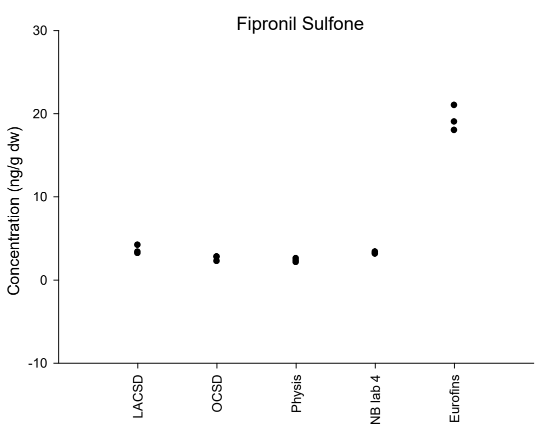






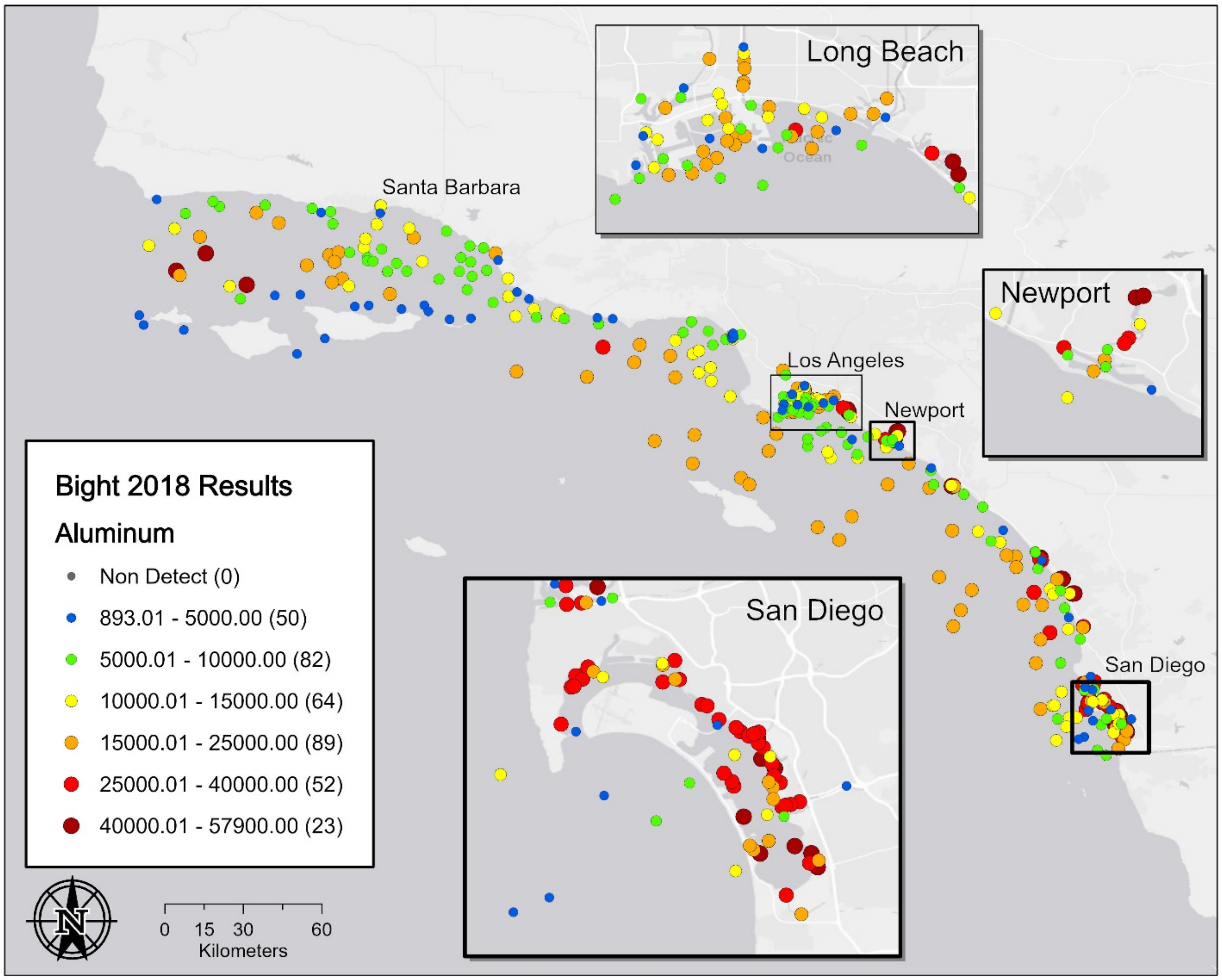

Fipronil Desulfinyl
Concentration (ng/g dw)
0
1
2
3
4
5
6
LACSD
OCSD
Physis
NB lab 4
Eurofins

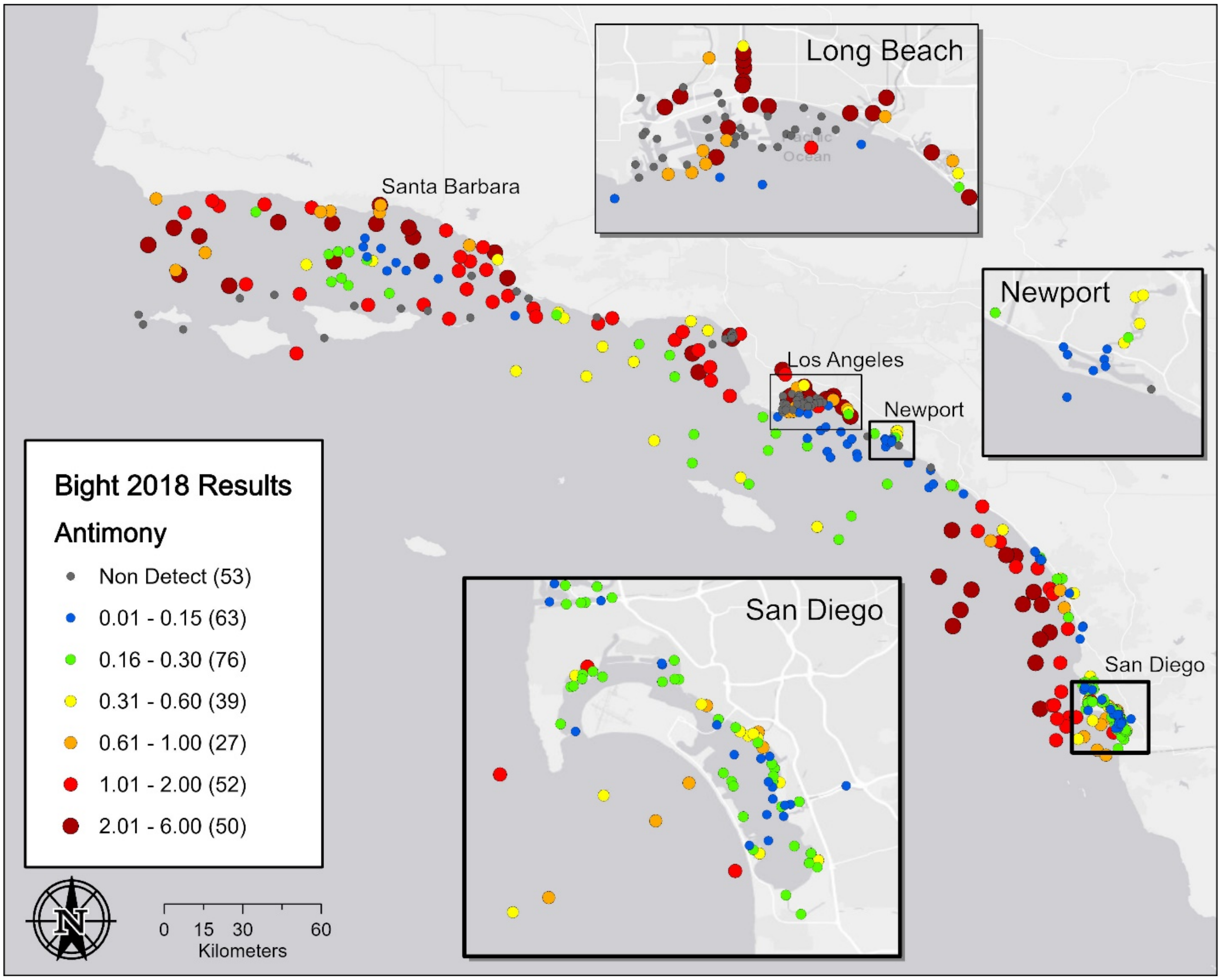

Fipronil Sulfide
Concentration (ng/g dw)
0
1
2
3
4
5
6
LACSD
OCSD
Physis
NB lab 4
Eurofins


Fipronil Sulfone
Concentration (ng/g dw)
-10
0
10
20
30
LACSD
OCSD
Physis
NB lab 4
Eurofins

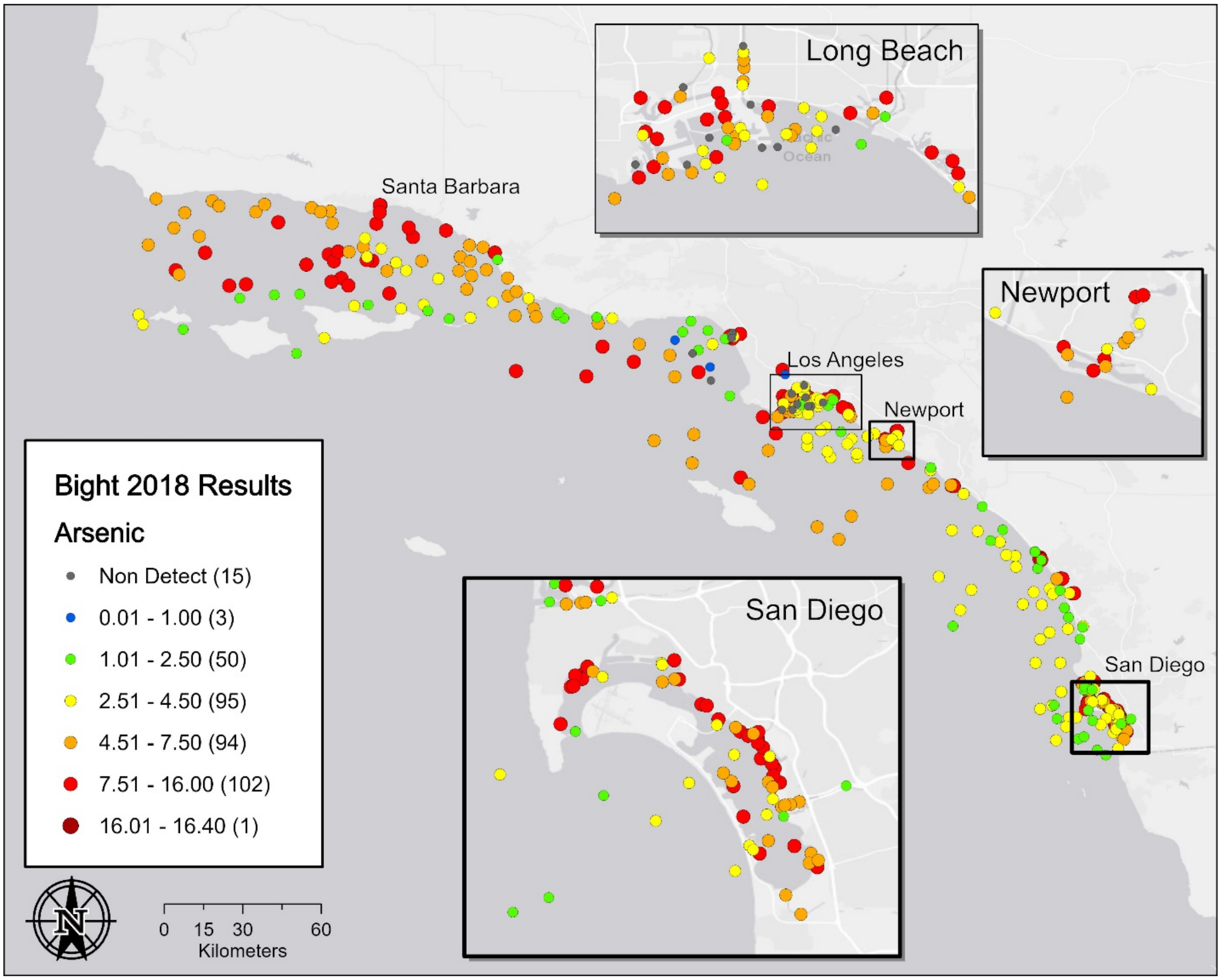
APPENDIX B. GEOGRAPHIC DISTRIBUTION AND MAGNITUDE OF ANALYTES

The following plots show the geographic distribution of sediment contaminant concentrations during the 2018 Southern California Bight regional monitoring survey. The legend shows the concentration range (metals in µg/g dw and organics in ng/g dw) and number of samples for each bin.

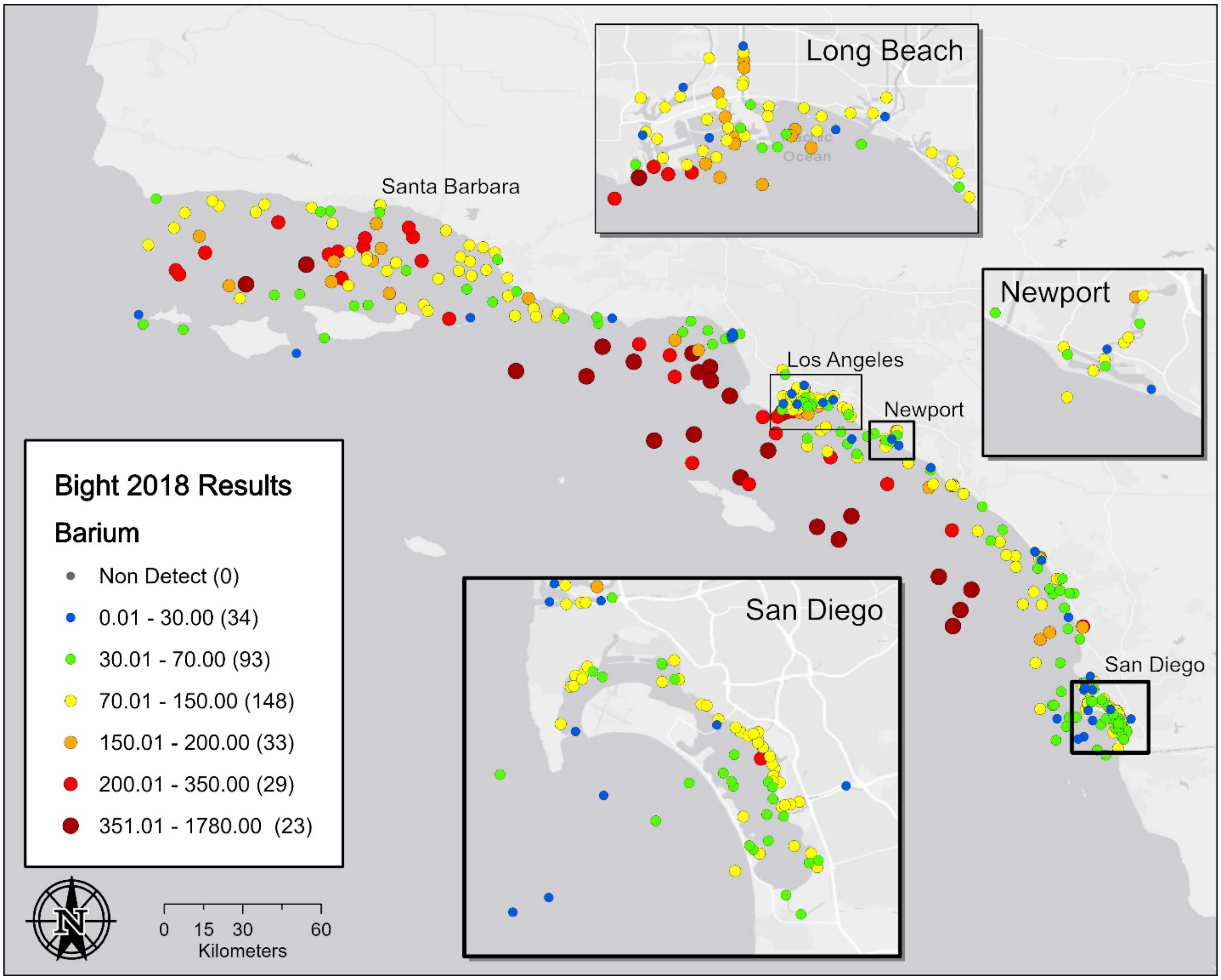




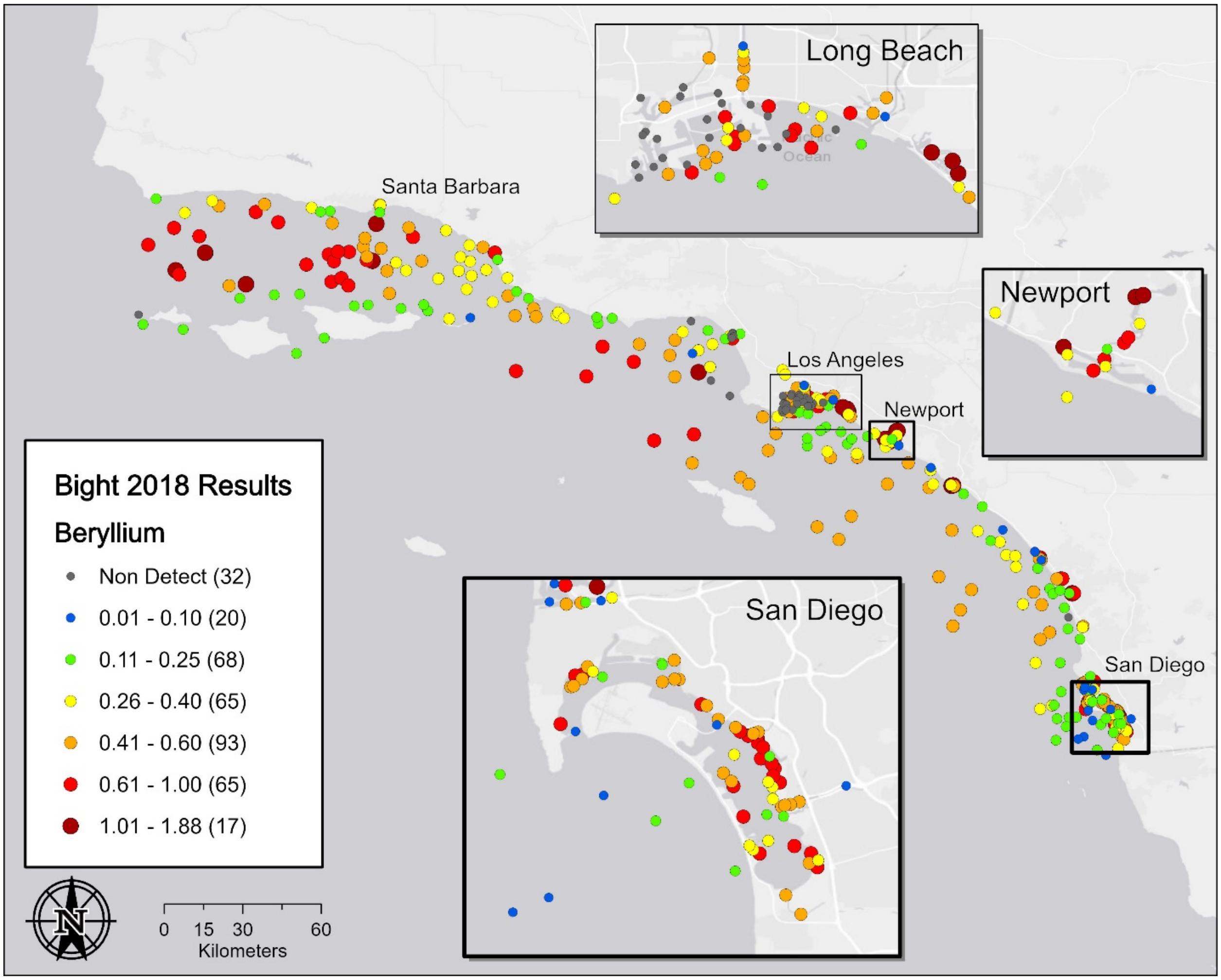
Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Antimony
Non Detect (53)
0.01 - 0.15 (63)
0.16 - 0.30 (76)
0.31 - 0.60 (39)
0.61 - 1.00 (27)
1.01 - 2.00 (52)
2.01 - 6.00 (50)
N
0 15 30 60
Kilometers



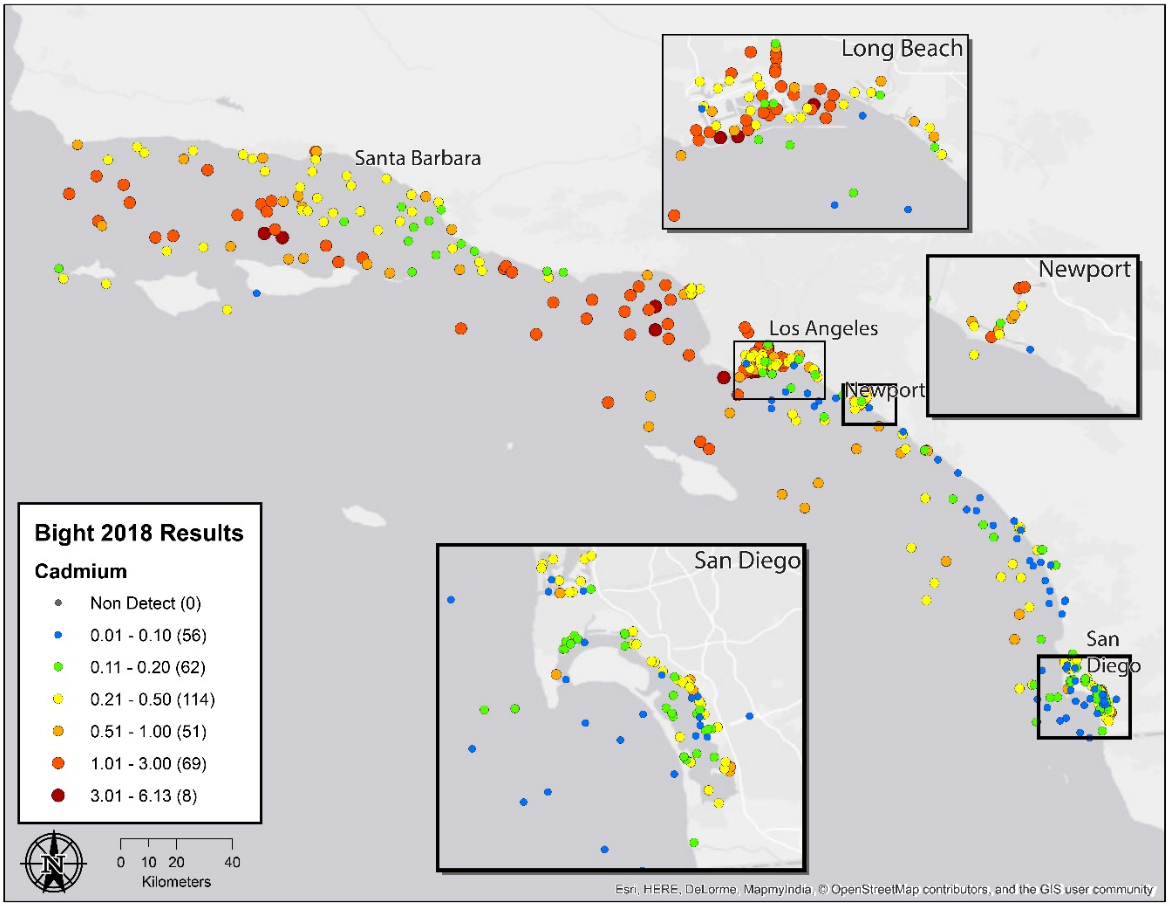
Long Beach
Pacific Ocean
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Arsenic
Non Detect (15)
0.01 - 1.00 (3)
1.01 - 2.50 (50)
2.51 - 4.50 (95)
4.51 - 7.50 (94)
7.51 - 16.00 (102)
16.01 - 16.40 (1)
0 15 30 60
Kilometers

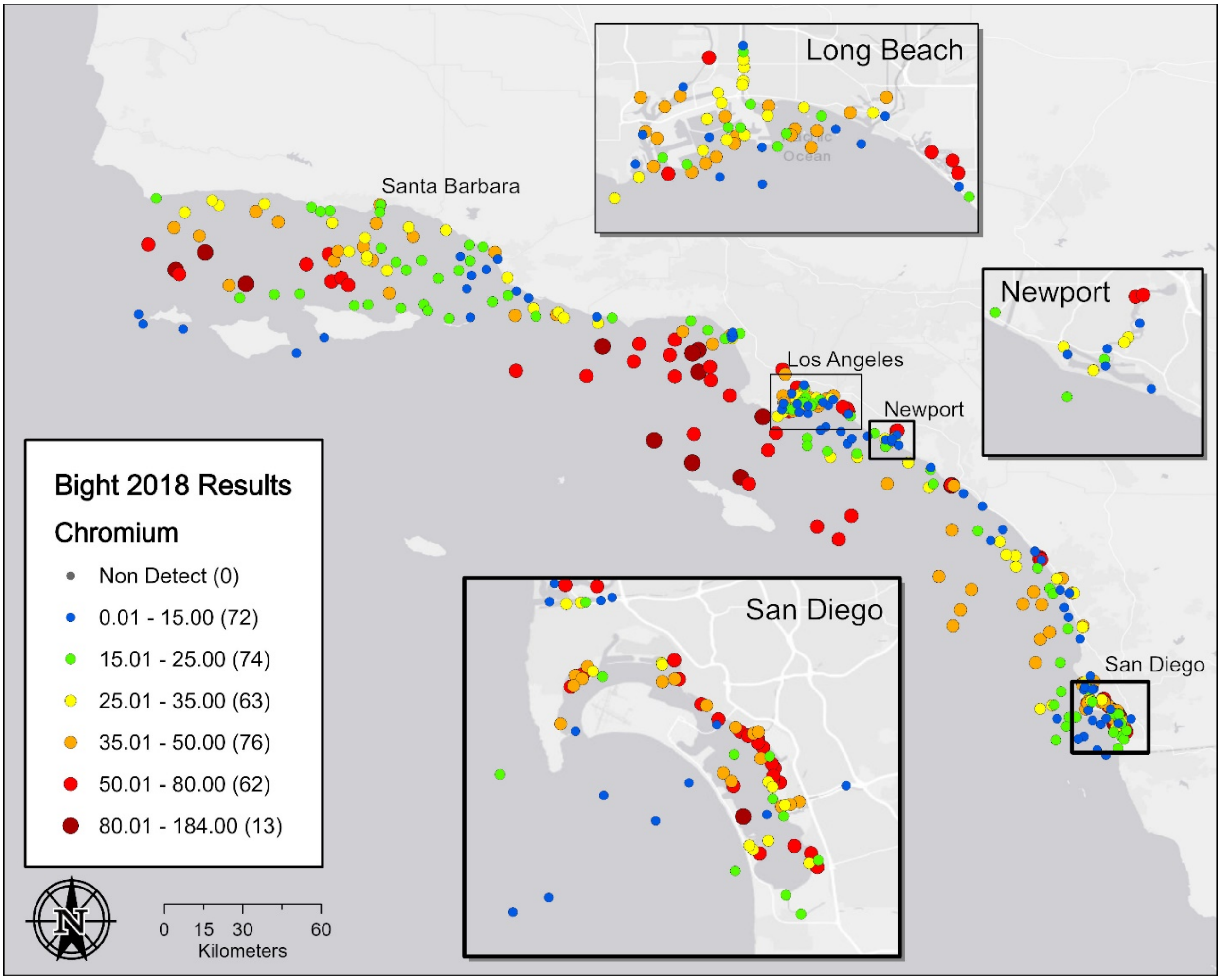


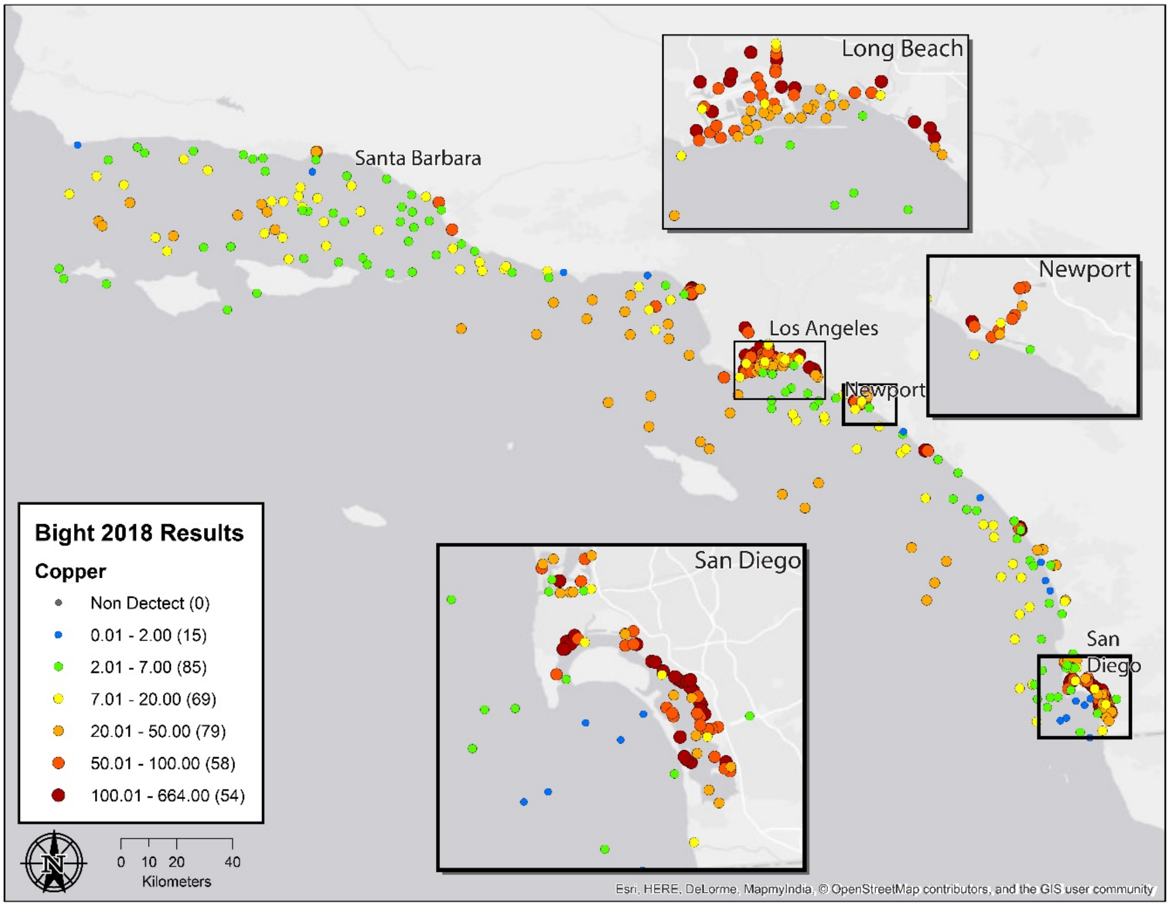
Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Barium
Non Detect (0)
0.01 - 30.00 (34)
30.01 - 70.00 (93)
70.01 - 150.00 (148)
150.01 - 200.00 (33)
200.01 - 350.00 (29)
351.01 - 1780.00 (23)
N
0 15 30 60
Kilometers



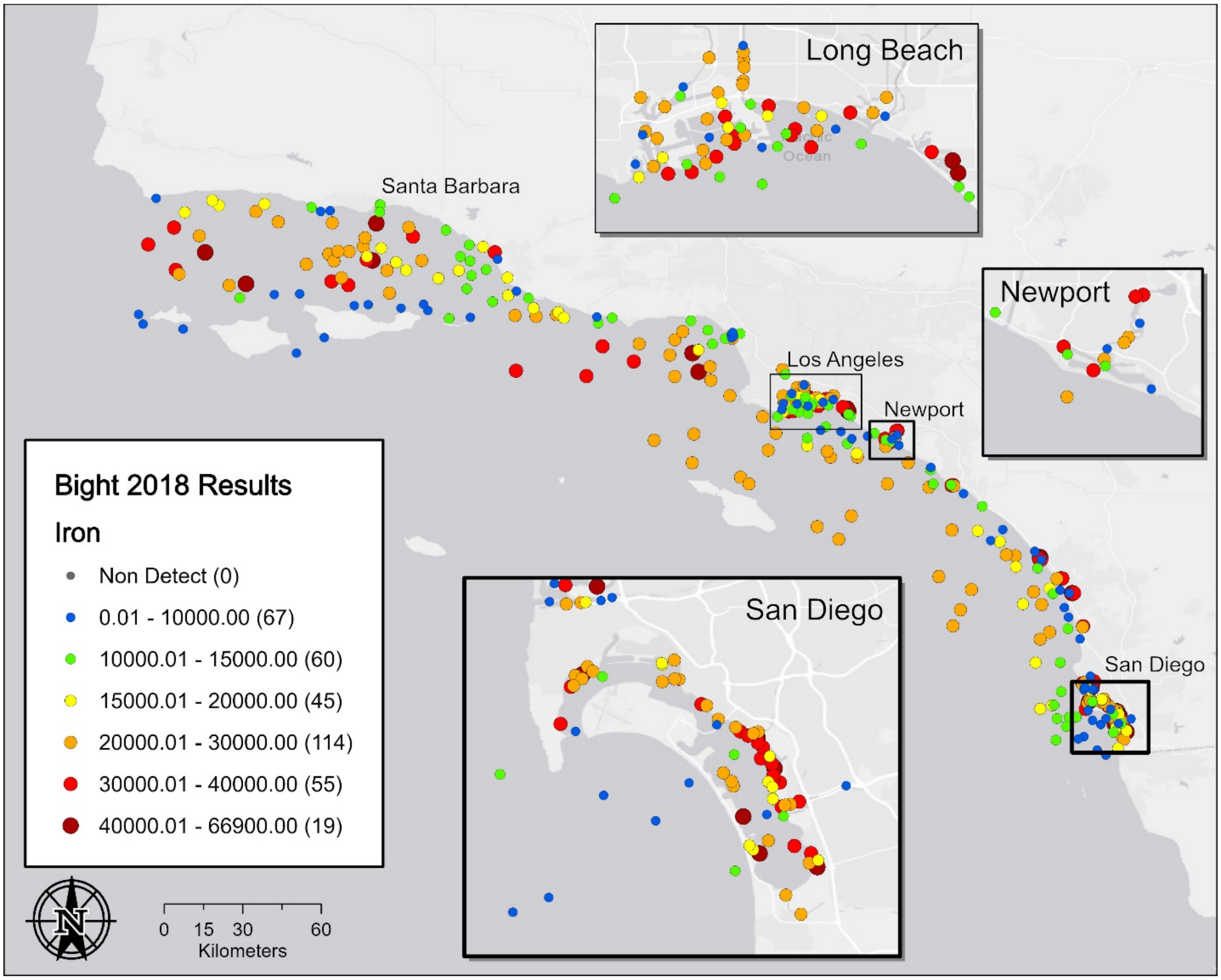
Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Beryllium
Non Detect (32)
0.01 - 0.10 (20)
0.11 - 0.25 (68)
0.26 - 0.40 (65)
0.41 - 0.60 (93)
0.61 - 1.00 (65)
1.01 - 1.88 (17)
0 15 30 60
Kilometers

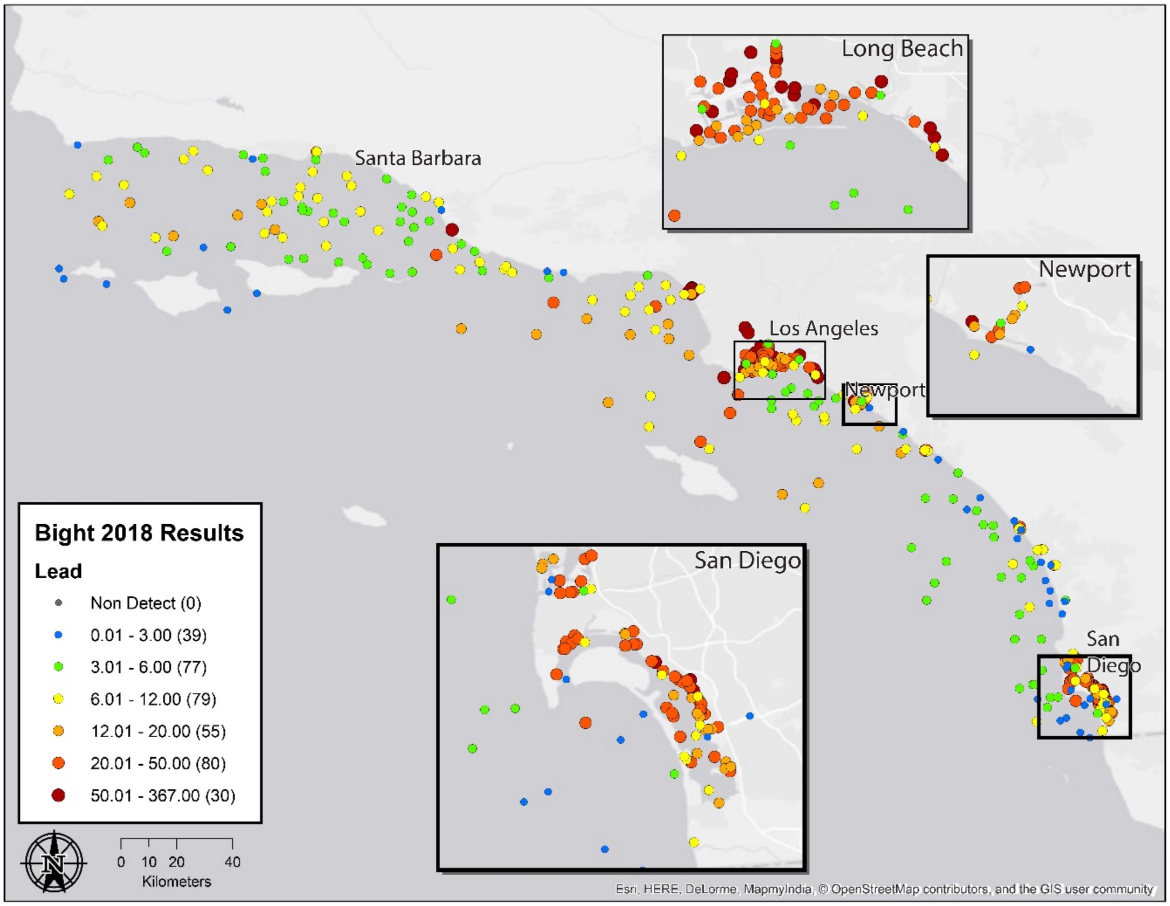

Long Beach
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Cadmium
Non Detect (0)
0.01 - 0.10 (56)
0.11 - 0.20 (62)
0.21 - 0.50 (114)
0.51 - 1.00 (51)
1.01 - 3.00 (69)
3.01 - 6.13 (8)
N
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

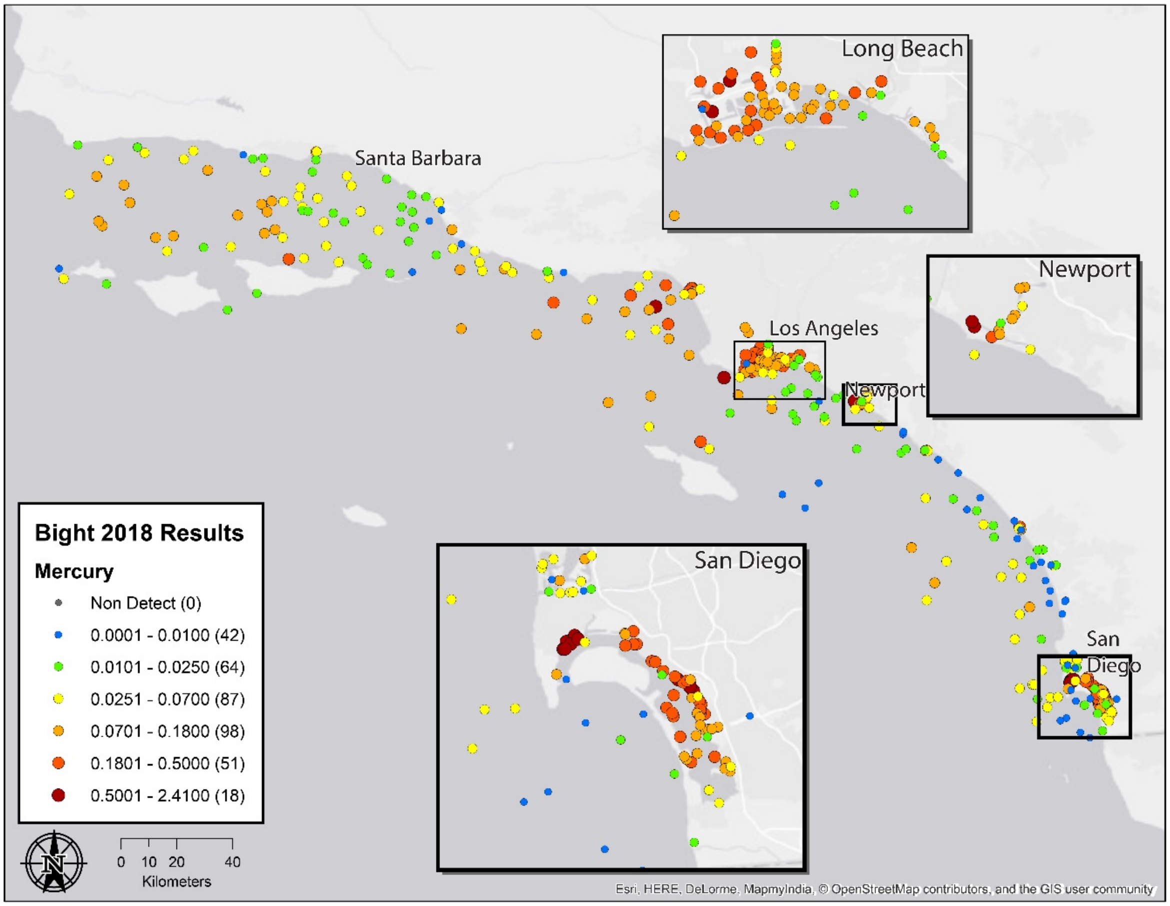

Long Beach
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Chromium
Non Detect (0)
0.01 - 15.00 (72)
15.01 - 25.00 (74)
25.01 - 35.00 (63)
35.01 - 50.00 (76)
50.01 - 80.00 (62)
80.01 - 184.00 (13)
0 15 30 60
Kilometers

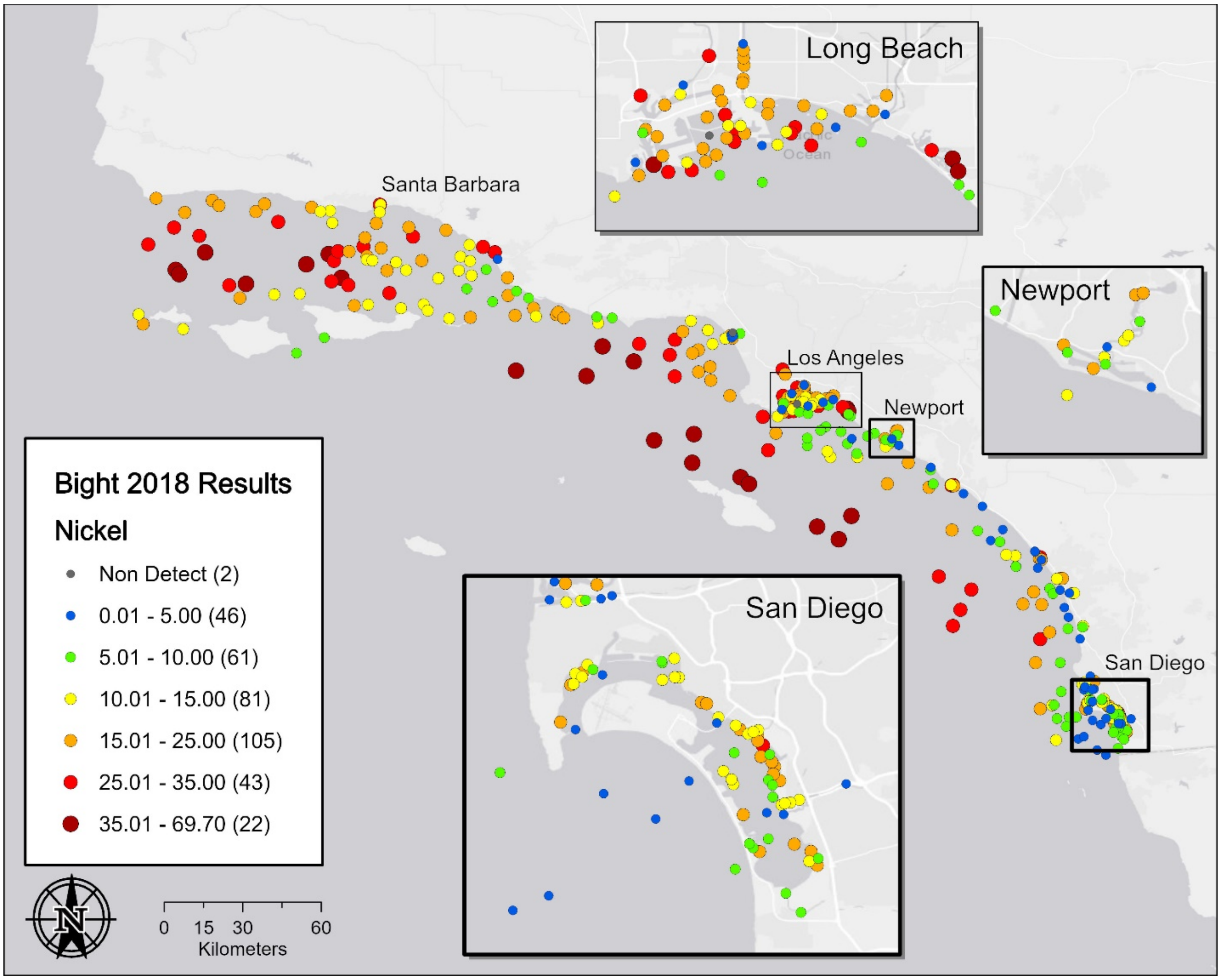


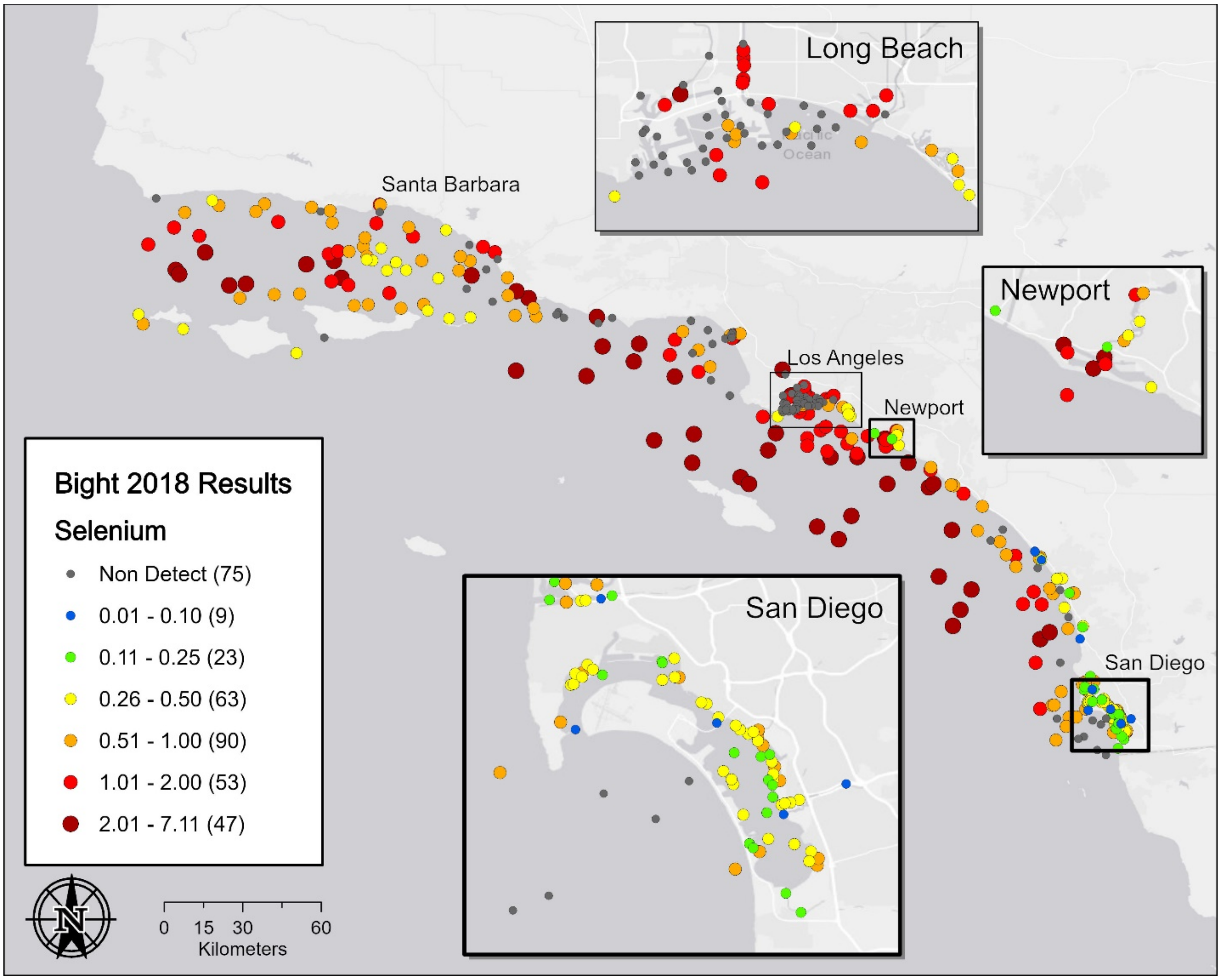
Long Beach
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Copper
Non Dectect (0)
0.01 - 2.00 (15)
2.01 - 7.00 (85)
7.01 - 20.00 (69)
20.01 - 50.00 (79)
50.01 - 100.00 (58)
100.01 - 664.00 (54)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

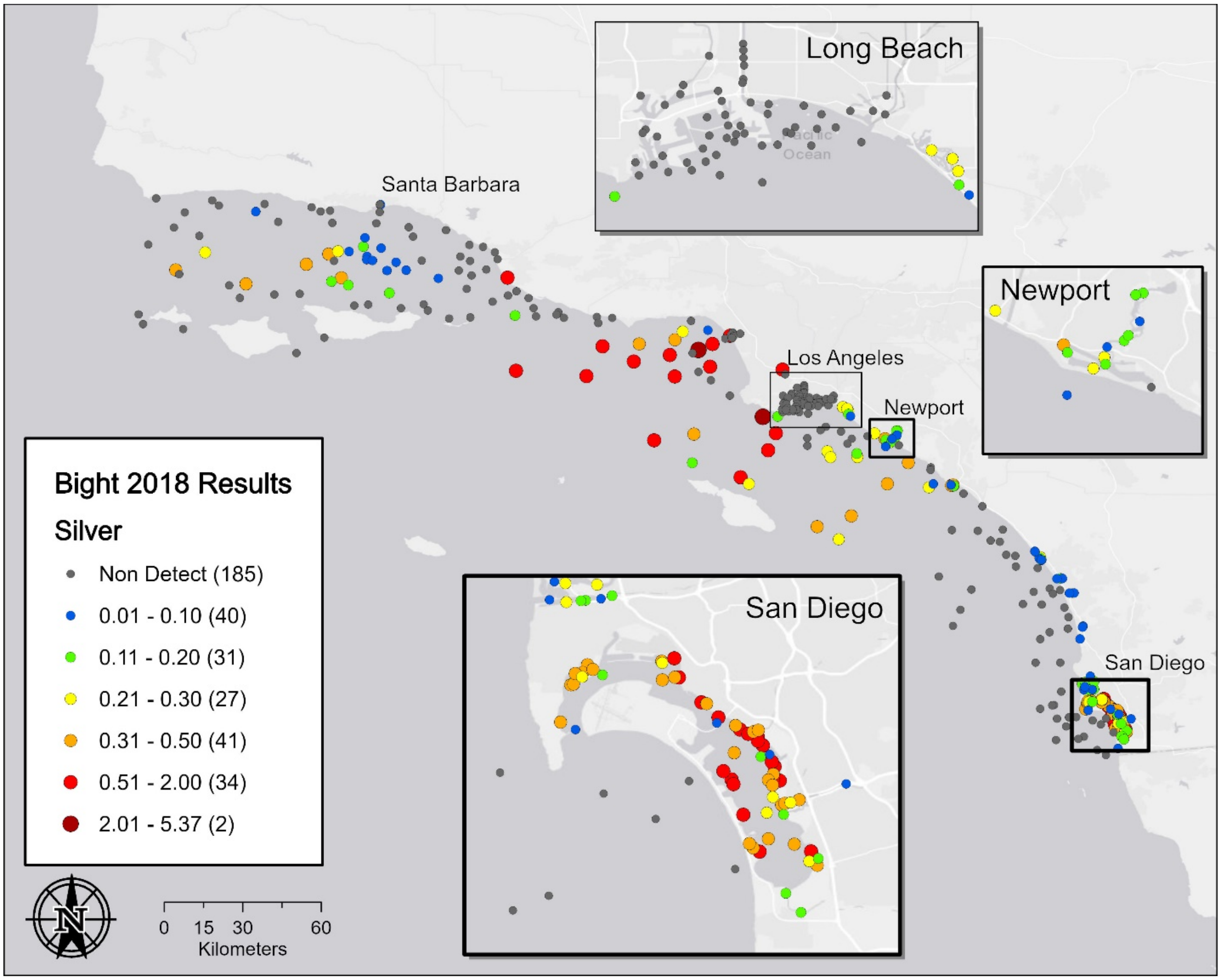

Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Iron
Non Detect (0)
0.01 - 10000.00 (67)
10000.01 - 15000.00 (60)
15000.01 - 20000.00 (45)
20000.01 - 30000.00 (114)
30000.01 - 40000.00 (55)
40000.01 - 66900.00 (19)
N
0 15 30 60
Kilometers

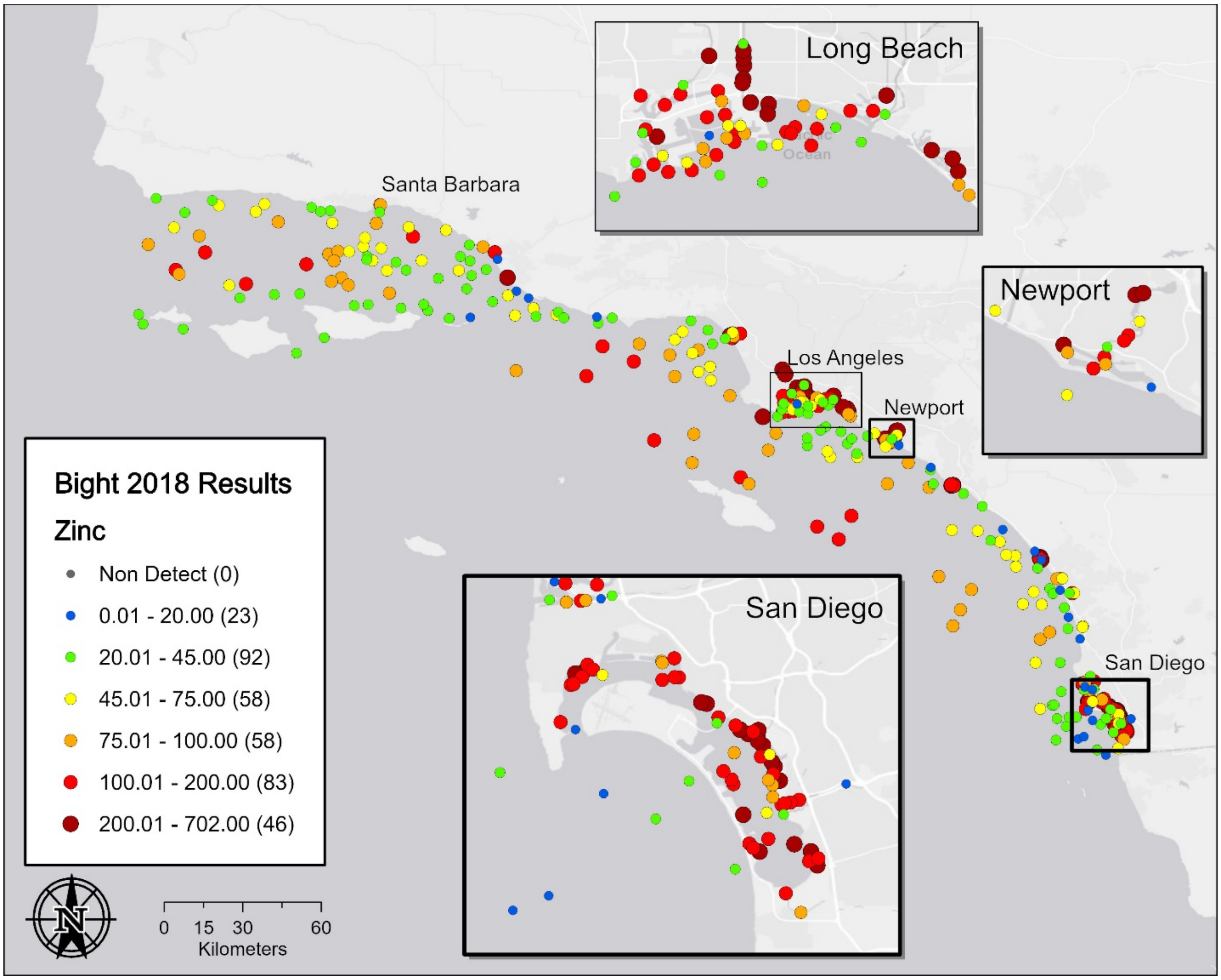

Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Lead
Non Detect (0)
0.01 - 3.00 (39)
3.01 - 6.00 (77)
6.01 - 12.00 (79)
12.01 - 20.00 (55)
20.01 - 50.00 (80)
50.01 - 367.00 (30)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

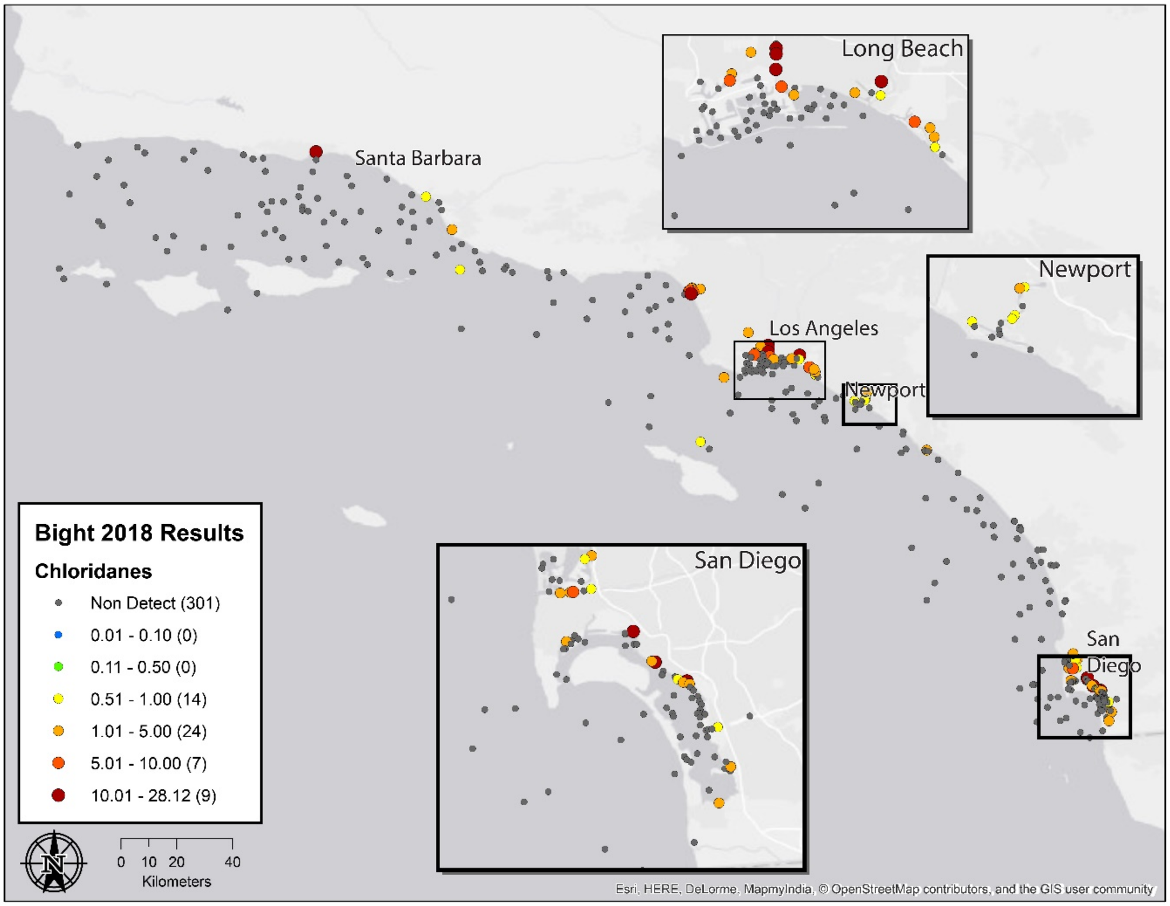

Long Beach
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Mercury
Non Detect (0)
0.0001 - 0.0100 (42)
0.0101 - 0.0250 (64)
0.0251 - 0.0700 (87)
0.0701 - 0.1800 (98)
0.1801 - 0.5000 (51)
0.5001 - 2.4100 (18)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

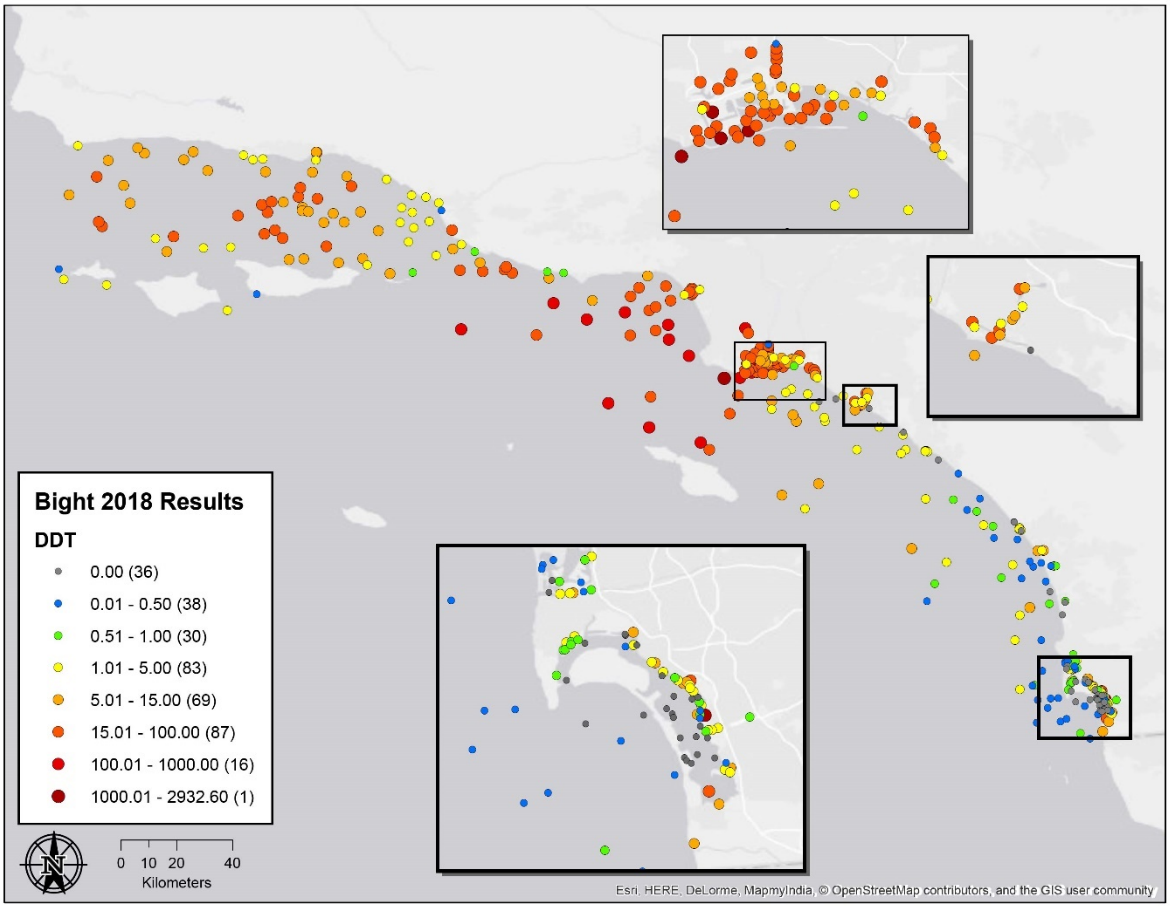

Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Nickel
Non Detect (2)
0.01 - 5.00 (46)
5.01 - 10.00 (61)
10.01 - 15.00 (81)
15.01 - 25.00 (105)
25.01 - 35.00 (43)
35.01 - 69.70 (22)
0 15 30 60
Kilometers


Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Selenium
Non Detect (75)
0.01 - 0.10 (9)
0.11 - 0.25 (23)
0.26 - 0.50 (63)
0.51 - 1.00 (90)
1.01 - 2.00 (53)
2.01 - 7.11 (47)
0 15 30 60
Kilometers

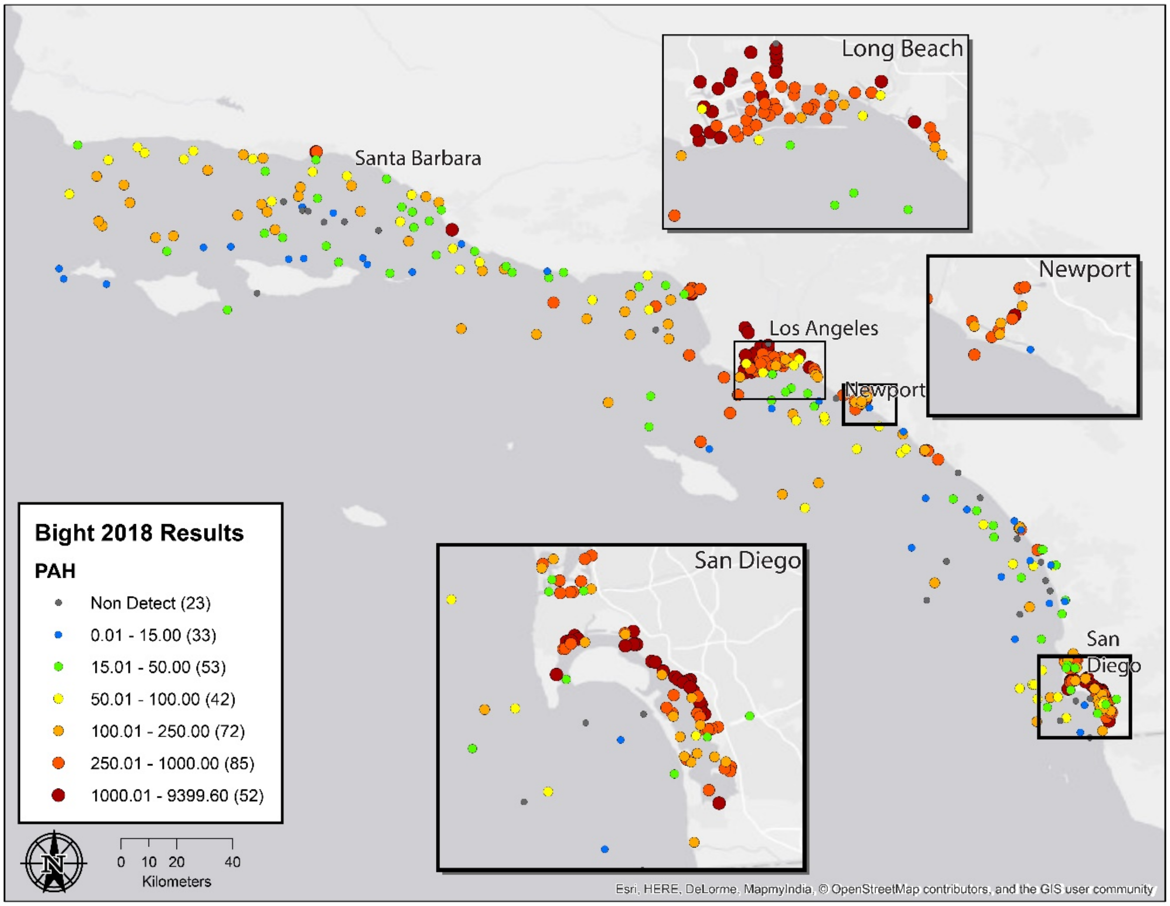

Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Silver
Non Detect (185)
0.01 - 0.10 (40)
0.11 - 0.20 (31)
0.21 - 0.30 (27)
0.31 - 0.50 (41)
0.51 - 2.00 (34)
2.01 - 5.37 (2)
0 15 30 60
Kilometers

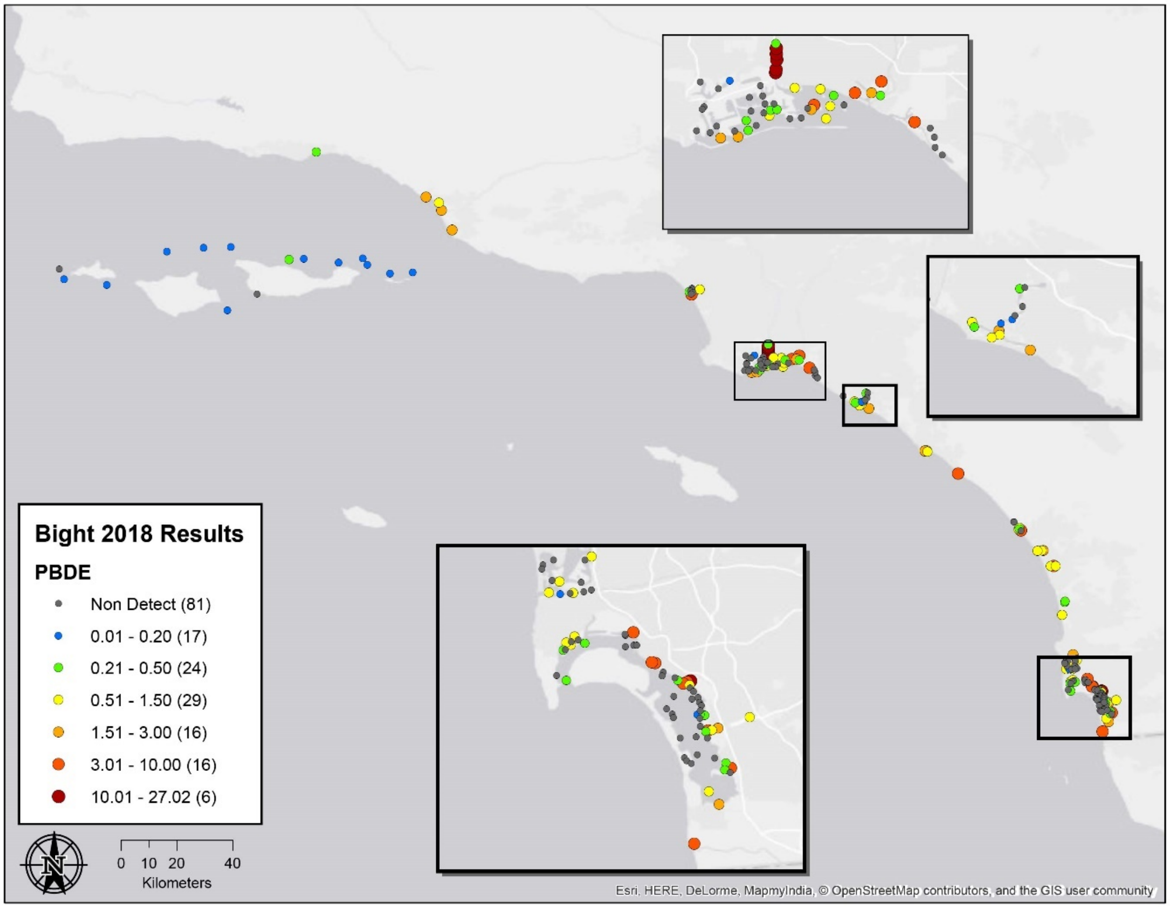

Long Beach
Newport
Santa Barbara
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
Zinc
Non Detect (0)
0.01 - 20.00 (23)
20.01 - 45.00 (92)
45.01 - 75.00 (58)
75.01 - 100.00 (58)
100.01 - 200.00 (83)
200.01 - 702.00 (46)
0 15 30 60
Kilometers

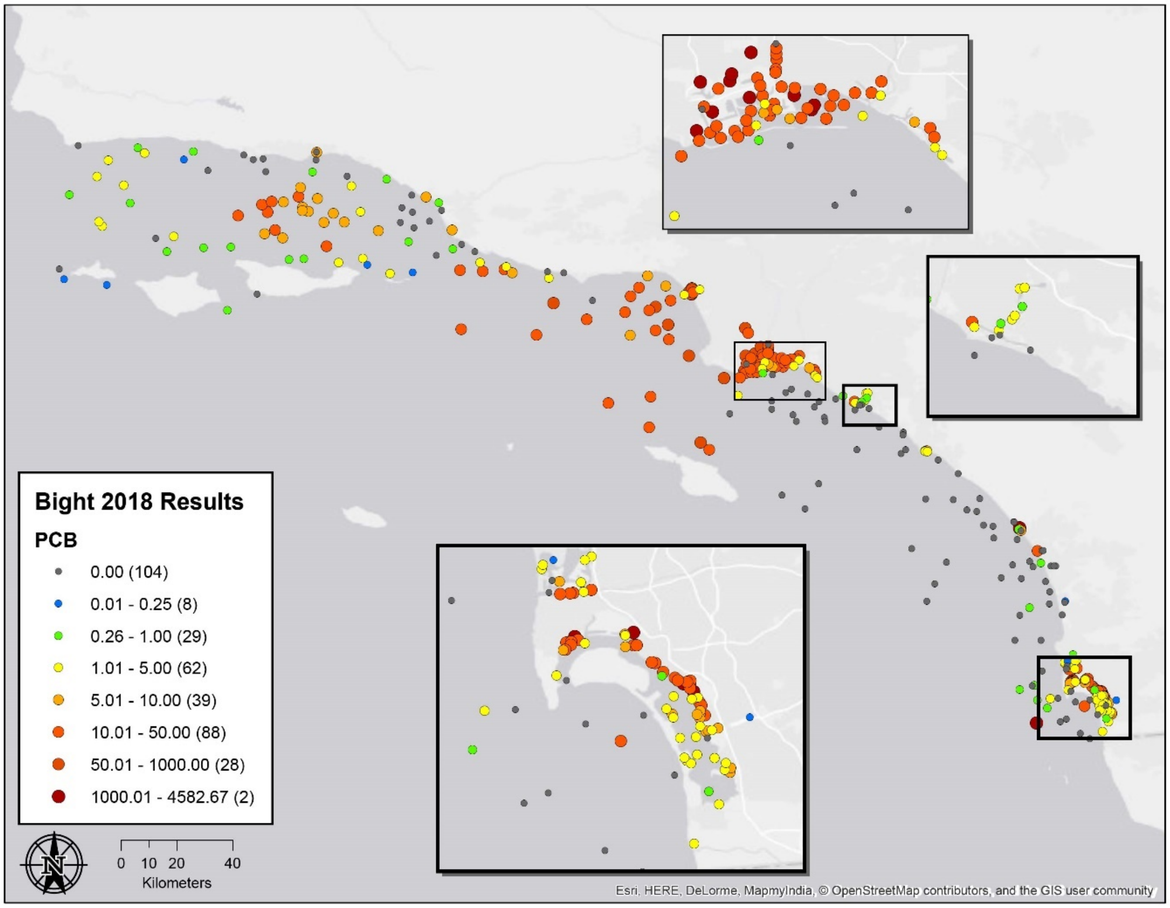

Long Beach
Santa Barbara
Newport
Los Angeles
Newport
Bight 2018 Results
Chloridanes
Non Detect (301)
0.01 - 0.10 (0)
0.11 - 0.50 (0)
0.51 - 1.00 (14)
1.01 - 5.00 (24)
5.01 - 10.00 (7)
10.01 - 28.12 (9)
San Diego
San
Diego
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



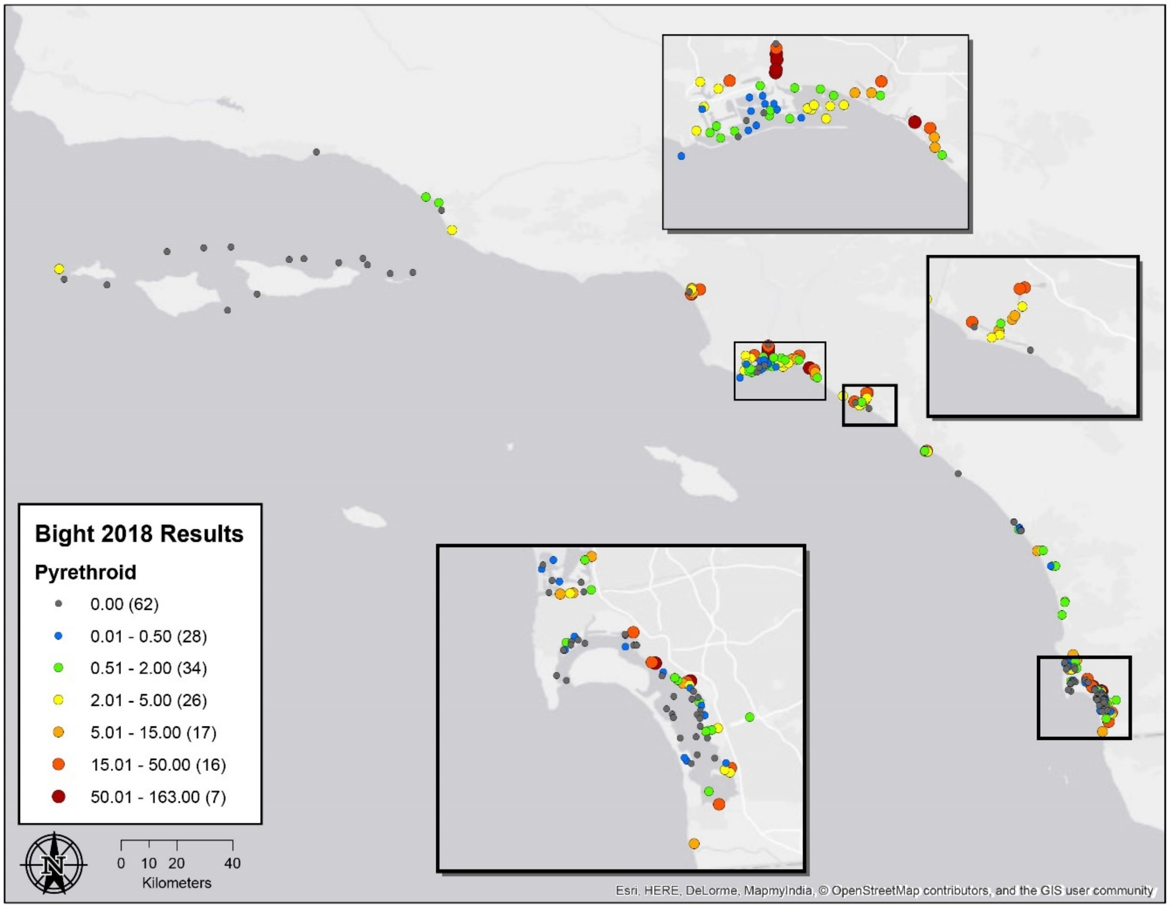
Bight 2018 Results
DDT
0.00 (36)
0.01 - 0.50 (38)
0.51 - 1.00 (30)
1.01 - 5.00 (83)
5.01 - 15.00 (69)
15.01 - 100.00 (87)
100.01 - 1000.00 (16)
1000.01 - 2932.60 (1)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

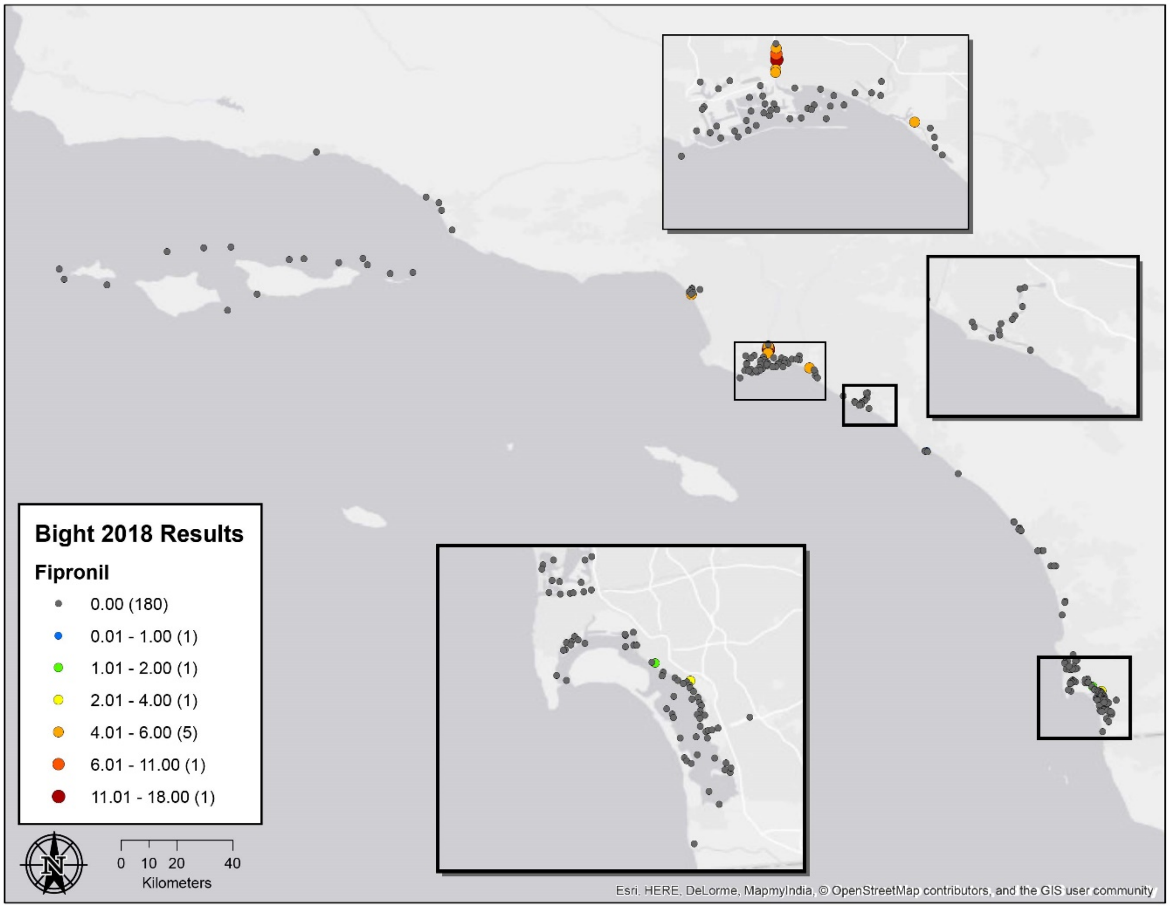

Long Beach
Santa Barbara
Newport
Los Angeles
Newport
San Diego
San Diego
Bight 2018 Results
PAH
Non Detect (23)
0.01 - 15.00 (33)
15.01 - 50.00 (53)
50.01 - 100.00 (42)
100.01 - 250.00 (72)
250.01 - 1000.00 (85)
1000.01 - 9399.60 (52)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


Bight 2018 Results
PBDE
Non Detect (81)
0.01 - 0.20 (17)
0.21 - 0.50 (24)
0.51 - 1.50 (29)
1.51 - 3.00 (16)
3.01 - 10.00 (16)
10.01 - 27.02 (6)
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



(43 congeners were targeted in Bight '18)


Bight 2018 Results
Pyrethroid
0.00 (62)
0.01 - 0.50 (28)
0.51 - 2.00 (34)
2.01 - 5.00 (26)
5.01 - 15.00 (17)
15.01 - 50.00 (16)
50.01 - 163.00 (7)
N
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


Bight 2018 Results
Fipronil
0.00 (180)
0.01 - 1.00 (1)
1.01 - 2.00 (1)
2.01 - 4.00 (1)
4.01 - 6.00 (5)
6.01 - 11.00 (1)
11.01 - 18.00 (1)
N
0 10 20 40
Kilometers
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

APPENDIX C. BIGHT '18 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.

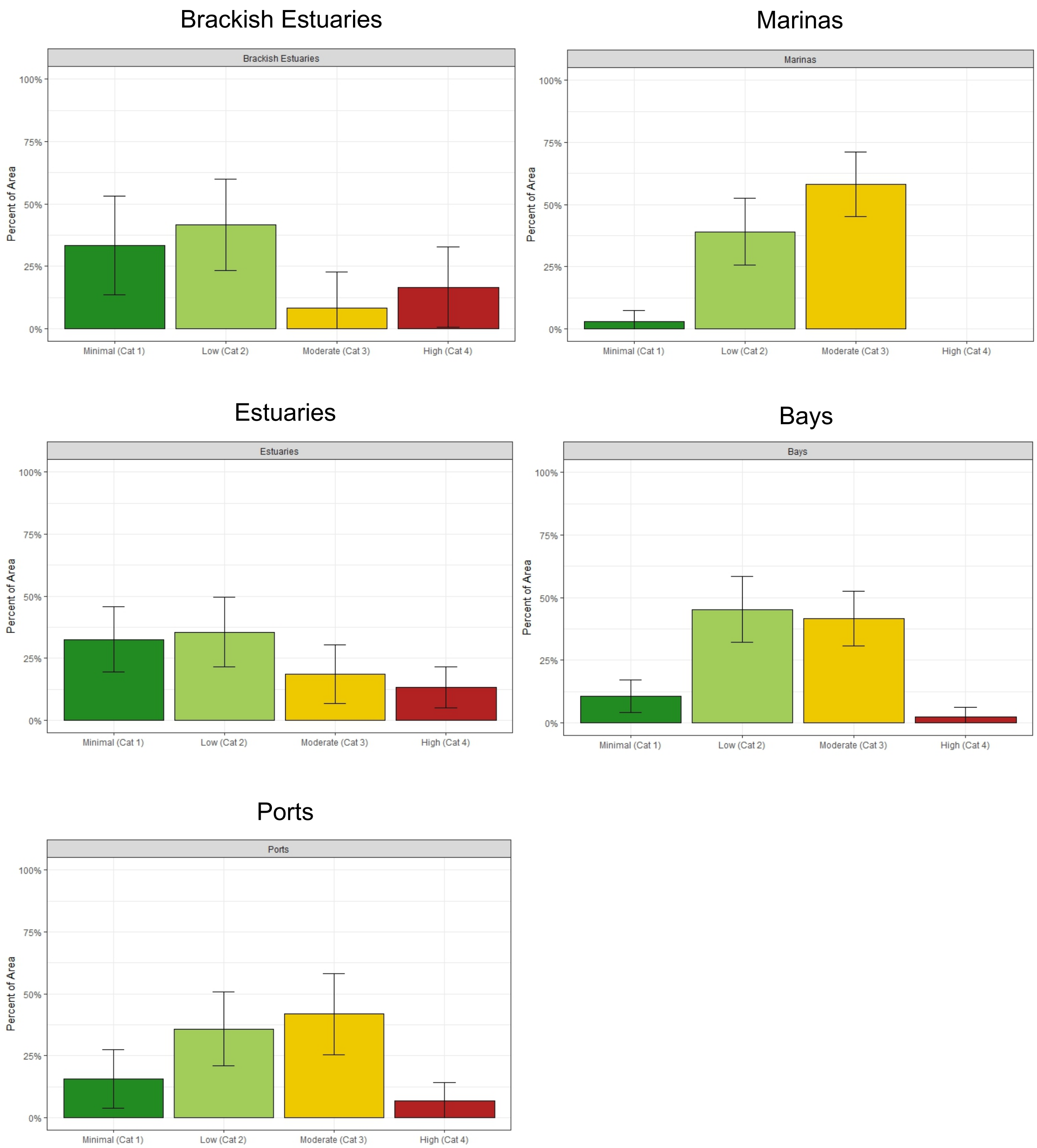
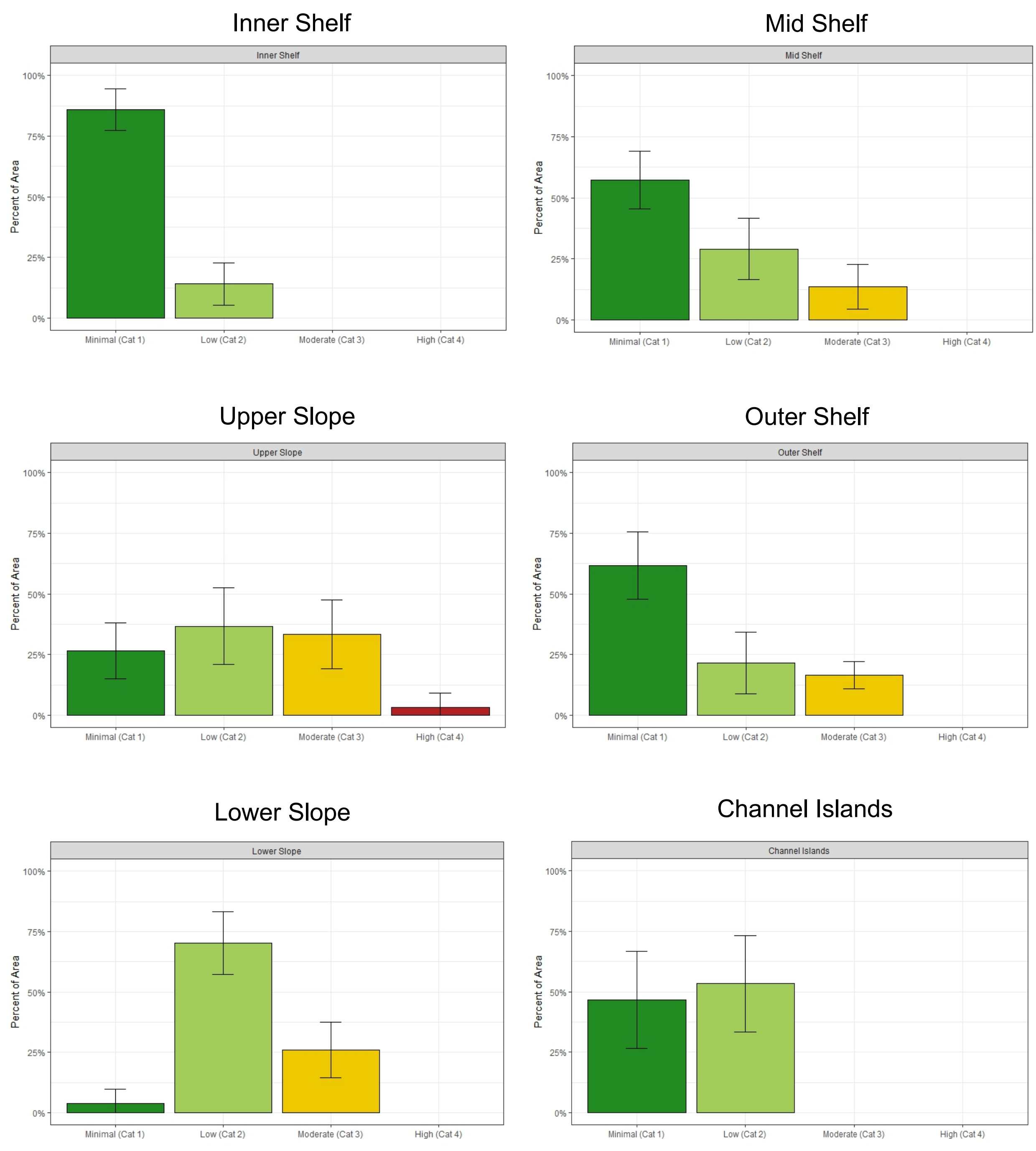


Figure C-2. Areal extent of Chemical Index Score categories by offshore SCB strata and Channel Islands. Error bars are 95% confidence intervals.



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

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

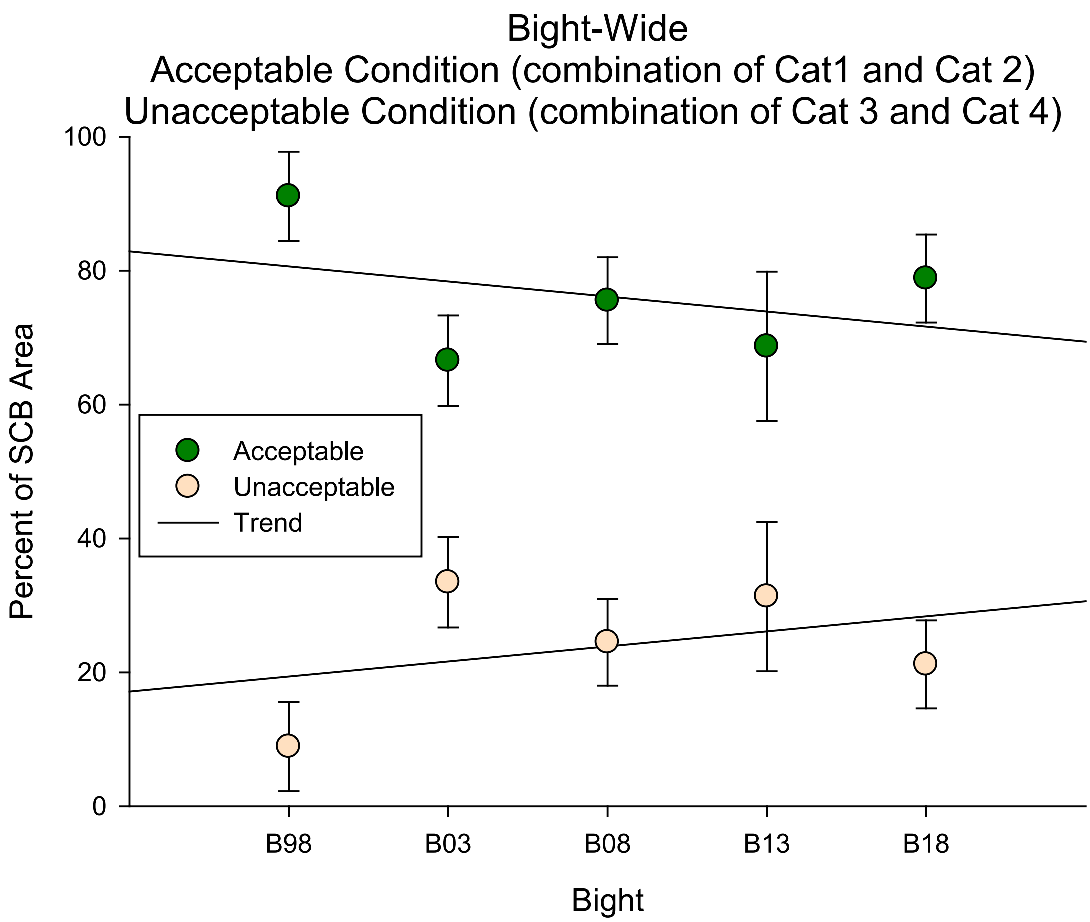


Figure D- 2. Composite stratum Chemical Index Scores for across Bight surveys. Error bars are 95% confidence intervals.

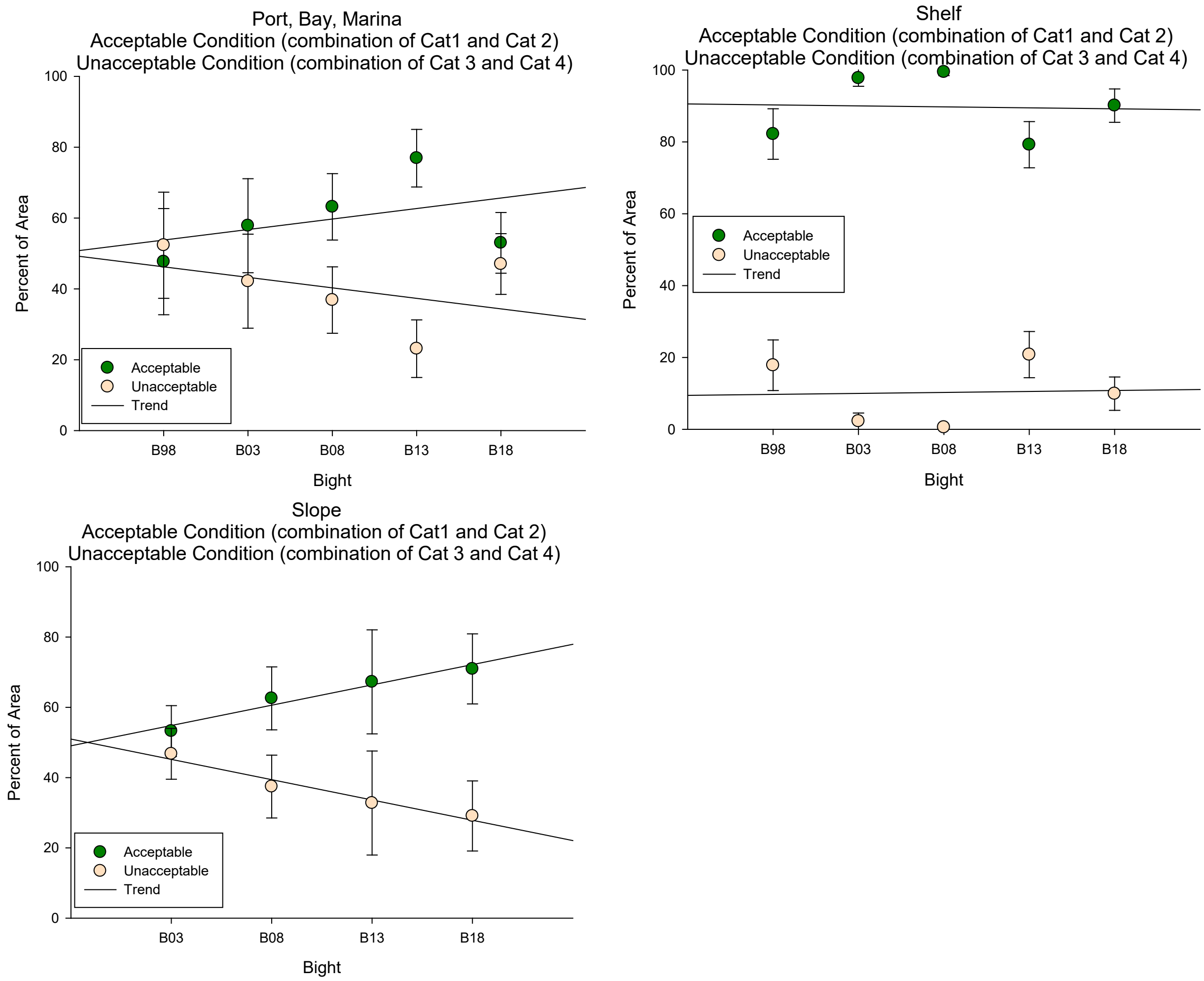
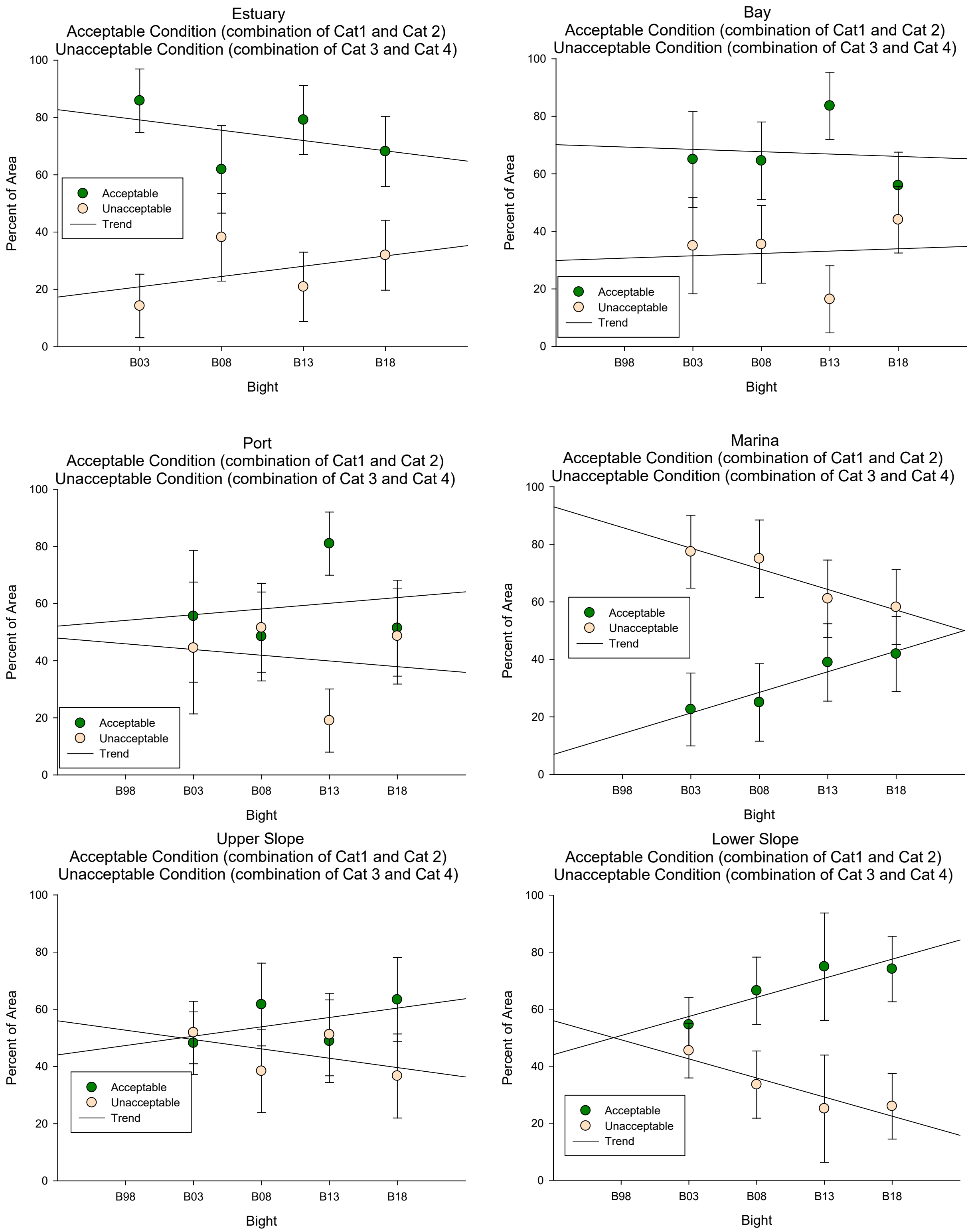
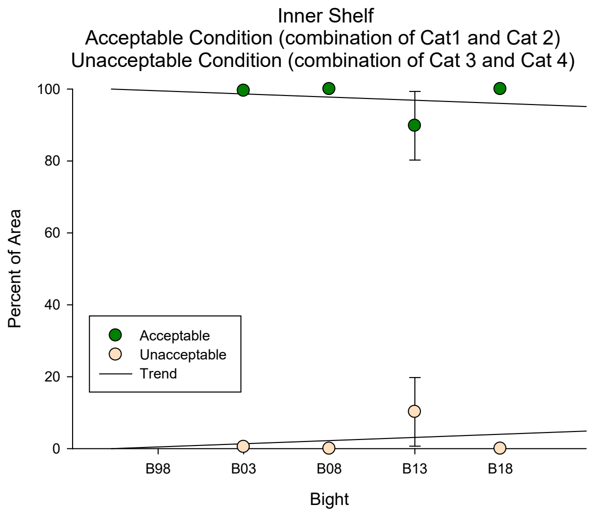
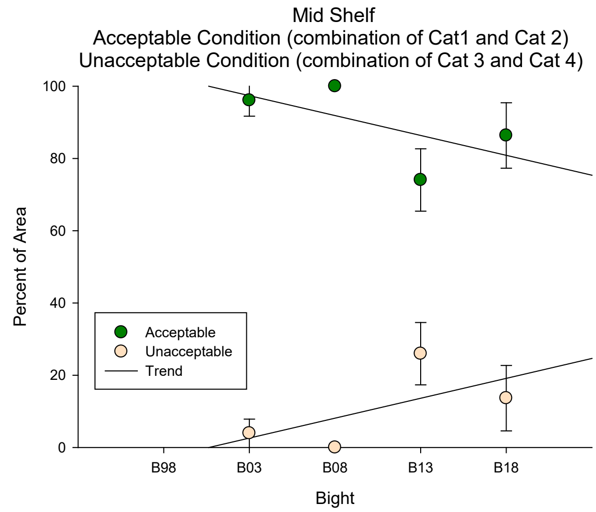
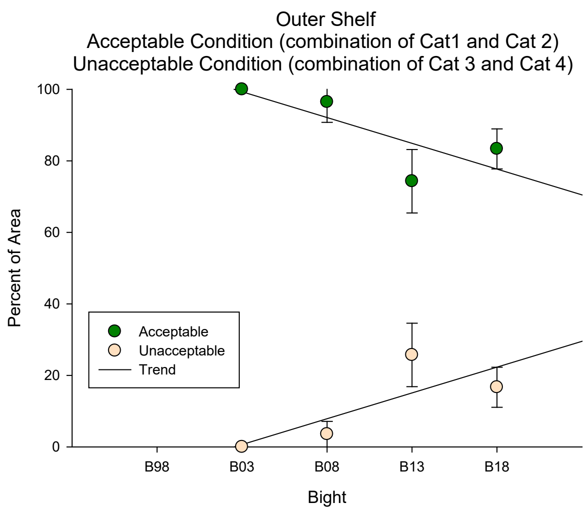


Figure D- 3. Individual stratum Chemical Index Scores for across Bight surveys. Error bars are 95% confidence intervals.




Inner Shelf
Acceptable Condition (combination of Cat1 and Cat 2)
Unacceptable Condition (combination of Cat 3 and Cat 4)
Percent of Area
Bight
B98
B03
B08
B13
B18
Acceptable
Unacceptable
Trend


Mid Shelf
Acceptable Condition (combination of Cat1 and Cat 2)
Unacceptable Condition (combination of Cat 3 and Cat 4)
Percent of Area
Bight
B98
B03
B08
B13
B18
Acceptable
Unacceptable
Trend


Outer Shelf
Acceptable Condition (combination of Cat1 and Cat 2)
Unacceptable Condition (combination of Cat 3 and Cat 4)
Percent of Area
Bight
B98
B03
B08
B13
B18
Acceptable
Unacceptable
Trend