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SAN DIEGO BAY SEDIMENT POLLUTANTS: EVALUATION OF CONTEMPORARY AMBIENT CONCENTRATIONS TO INFORM WATER QUALITY MANAGEMENT

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San Diego Bay Sediment Pollutants: Evaluation of Contemporary Ambient Concentrations to Inform Water Quality Management

Staff Technical Report, January 2024

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ACRONYMS

a (when used in an equation)	Acceleration or Skew Correction Parameter
BCa	Bias Corrected and Accelerated Bootstrap
CALRM	California Logistic Regression Model
CASQO	California Sediment Quality Objectives
Cd	Cadmium
CSI	Chemical Score Index
Cu	Copper
CWA	Clean Water Act
EDD	Electronic Data Deliverable
EPA	Environmental Protection Agency
ERL	Effects Range Low
ERM	Effects Range Medium
ESRI	Environmental Systems Research Incorporated
GIS	Geographical Information System
Hg	Mercury
MDL	Method Detection Limit
MS	Microsoft
MS4	Municipal Separate Storm Sewer System
ND	Non-Detect
OEHHA	Office of Environmental Health Hazard Assessment
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PCB	Polychlorinated Biphenyl
QA	Quality Assurance
QC	Quality Control
RHMP	Regional Harbor Monitoring Program
TCHL	Total Chlordanes (Sum of congeners)
TDDT	Sum of congeners of dichlorodiphenyltrichloroethanes
TPAH	Total Polycyclic Aromatic Hydrocarbon (Sum of congeners)
TPCB	Total Polychlorinated Biphenyl (Sum of Congeners)
SCCWRP	Southern California Coastal Waters Research Project
SQO	Sediment Quality Objective
SWRCB	State Water Resources Control Board
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
z_0	Bias Correction Parameter
Zn	Zinc

INTRODUCTION

San Diego Bay (referred to throughout as “the Bay” or “Bay”) is the largest natural enclosed bay in southern California. The Bay provides important habitat for fish and wildlife and is a valuable food source for recreational and subsistence anglers. The Bay and its shoreline have been used for maritime, commercial, industrial, and military purposes for many decades. Discharges of various pollutants due to these uses, as well as Municipal Separate Storm Sewer System (MS4) discharges from the Pueblo, Sweetwater, and Otay watersheds, have contaminated Bay sediments (Fairey et al. 1996). Prior to implementation of the Clean Water Act (CWA), raw sewage and industrial wastes were discharged directly into portions of the Bay, and pre-discharge data for the Bay is non-existent.[1] The purpose of this report, therefore, was to evaluate the contemporary ambient concentrations of pollutants in surficial Bay sediments away from known or suspected pollutant sources, such as remediation sites, boat slips, and storm drain outfalls.

Pollutants accumulated in Bay sediments pose a potential health risk to ecological and human receptors. Exposure to contaminated sediments can have adverse effects on (1) the health, diversity, and abundance of invertebrates living in the sediments, such as clams and worms, (2) foraging fish and birds that ingest contaminated invertebrates and/or sediments, and (3) humans who consume contaminated fish and/or shellfish caught from the Bay.

Some of the pollutants found in Bay sediments, such as polychlorinated biphenyls (PCBs) and mercury, are of particular concern because these chemicals can bioaccumulate and biomagnify in the food web and can exhibit synergistic toxic effects (Beyer and Biziuk 2009; Komoroske et al. 2012; Pellicani et al. 2012, see Figure 1).[2]

Exposure to elevated concentrations of PCBs and mercury in vertebrates (e.g., birds, marine mammals, and humans) can cause cancer as well as immunological, neurological, and reproductive harm. This has prompted the Office of Environmental Health Hazard Assessment (OEHHA) to post a fish consumption health advisory for the Bay for potential exposure to high concentrations of PCBs and mercury (OEHHA 2018) (Figure 2).

[1] It may be feasible to determine pre-discharge data for San Diego Bay in the future by conducting a Bay-wide evaluation of sediment concentrations using sediment cores, elemental fingerprinting, or other scientific methods beyond the scope of this project.

[2] Bioaccumulation is the process by which pollutants are stored and accumulate in animal tissues, whereas biomagnification describes increasing levels of exposure to a pollutant observed at higher trophic levels. These natural processes can lead to some receptor organisms having tissue concentrations of pollutants several orders of magnitude higher than those observed in sediments, as well as significant adverse health effects.

Numerous investigations have confirmed the presence of elevated pollutant concentrations in sediments within certain areas in San Diego Bay, such as marinas, estuaries, and near current or former industrial facilities (Weston 2008; Amec 2016a and 2016b; Neira et al. 2018; Wood 2020). Several areas of the Bay are included in the Clean Water Act (CWA) section 303(d) list of impaired waterbodies based on elevated concentrations of toxic and bioaccumulative pollutants in sediments, tissue, and the water column (SWRCB 2017, 2021). Pollutants responsible for the impairments include cadmium, copper, lead, mercury, polycyclic aromatic hydrocarbons (PAHs), PCBs, pesticides, and zinc. Remediation of sediments polluted with these compounds is therefore a high priority. Please note that, in the State of California regulations the word, “level” is used interchangeably with the word, “concentration”.

Figure 1. San Diego Bay Bioaccumulation Conceptual Model.

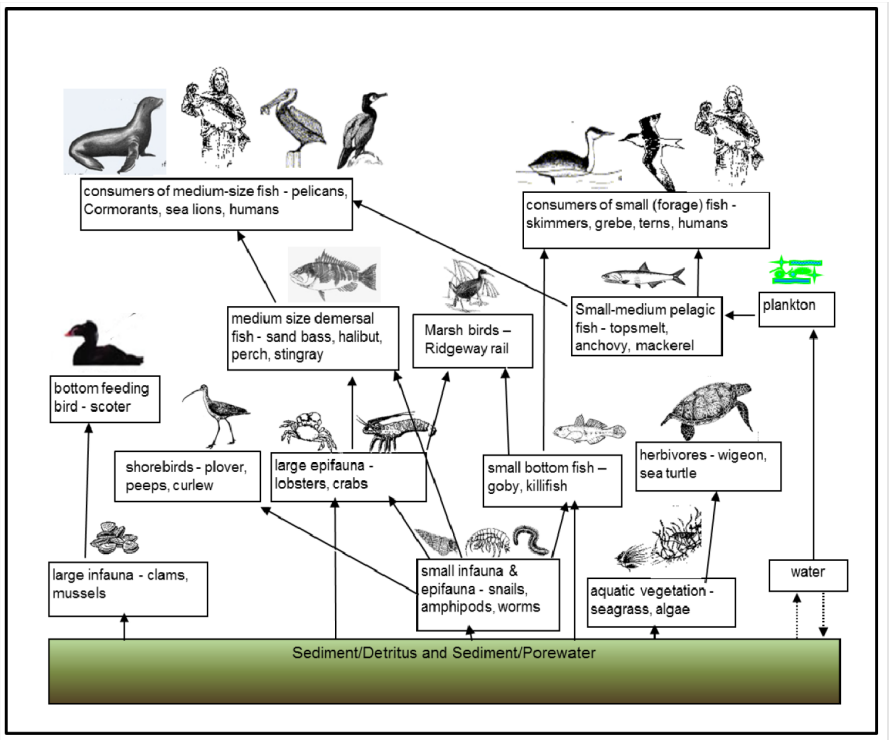
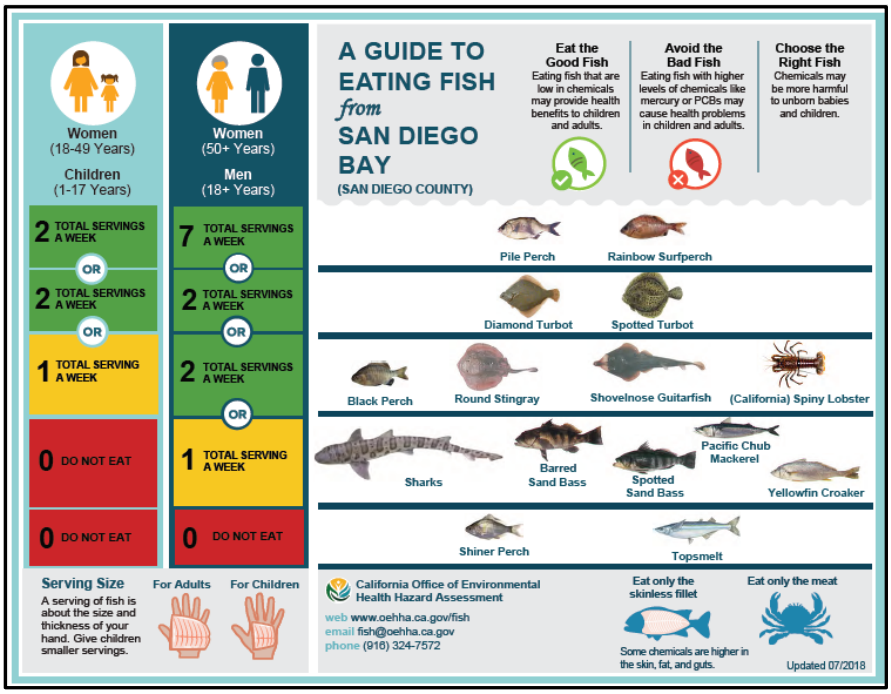


Figure 1-1. Conceptual Food Web Model for San Diego Bay

Courtesy of Southern California Coastal Water Research Project (SCCWRP)
(*San Diego Bay Bioaccumulation Report – Food Web Bioaccumulation Study; Bay et al., 2016 Draft Report*)

Figure 2. Fish Consumption Advisory Guide for San Diego Bay.



Investigations are currently being conducted within the Bay to collect data to determine if sediments meet the following State of California narrative sediment quality objectives (SQOs)[3] that protect the beneficial uses designated for the Bay (Table 1):

- **Aquatic Life – Benthic Community Protection.** Pollutants must not be present in sediments in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California.
- **Human Health.** Pollutants must not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health in bays and estuaries of California.
- **Wildlife and Resident Finfish.** Pollutants must not be present in sediments at levels that alone or in combination are toxic to wildlife and resident finfish by direct exposure or that bioaccumulate in aquatic life at levels that are harmful to wildlife or resident finfish by indirect exposure in bays and estuaries of California.

[3] The Sediment Quality Provisions, which include specifications for the SQOs, integrate chemical, toxicological, and biological measures to determine if sediment-dependent biota are protected or degraded as a result of exposure to toxic pollutants* in sediment in order to protect benthic* communities in enclosed bays* and estuaries*, human health, wildlife, and resident finfish. Water Quality Control Plan for Enclosed Bays and Estuaries of California Sediment Quality Provisions

Table 1. Beneficial Uses and Target Receptors of San Diego Bay.

Beneficial Use	Target Receptor(s)
Commercial and Sport Fishing	Human Health
Shellfish Harvesting	Human Health
Estuarine Habitat	Benthic Community, Wildlife, Finfish
Marine Habitat	Benthic Community, Wildlife, Finfish
Wildlife Habitat	Wildlife
Rare, Threatened, or Endangered Species	Wildlife, Finfish
Preservation of Biological Habitats of Special Significance	Wildlife, Finfish
Spawning, Reproduction, and/or Early Development	Finfish

If field data for sediments do not meet the narrative SQOs, cleanup levels must be established under the California Water Code pursuant to State Water Resources Control Board Resolution No. 92-49.[4] According to Resolution No. 92-49, contaminated sediments must be cleaned up to background sediment quality conditions (emphasis added) (i.e., the water quality that existed before the discharge) unless it is technologically or economically infeasible to do so. If attainment of background sediment quality conditions is infeasible, Resolution No. 92-49 requires the development of alternative cleanup levels. The alternative cleanup levels must (1) be consistent with maximum benefit to the people of the state; (2) not unreasonably affect present and anticipated beneficial uses of such water; and (3) not result in water quality less than that prescribed in the Water Quality Control Plans and policies adopted by the State and Regional Water Boards.

The identification of “background” by Resolution No. 92-49 as the level of pollutants present prior to discharge provides multiple challenges from a regulatory perspective. First, many pollutants (e.g., PCBs) are anthropogenically created and do not exist in the natural environment, making true “background” concentrations prior to discharges effectively zero. Second, for those pollutants that naturally occur, distinguishing between anthropogenic sources and non-anthropogenic sources can be difficult.

As a result, site cleanups in the Bay thus far have been based on inconsistent sediment cleanup goals. This is largely because the evaluation of “background” sediment quality conditions and the development of alternative sediment cleanup levels has been done on a site-specific basis.

[4] SWRCB Resolution No. 92-49

Implementing cleanups on a site-specific basis often results in the use of different criteria to identify pollutants of concern, use of different datasets, and application of different statistical methods for evaluating sediment background concentrations and calculating alternative cleanup levels. This approach results in inconsistency in the degree of cleanup achieved across sites in terms of the final sediment quality achieved. Further, this approach does not guarantee that post-remedial conditions at impacted sites will be consistent with those observed at other less impacted parts of the Bay.

This problem, however, is not unique to San Diego. In fact, this issue is a problem nationally. Specific guidance from the U.S. Environmental Protection Agency (EPA) for the determination of sediment pollutant background concentrations has yet to be released (Geiselbrecht et al. 2018).

The analysis of sediment chemistry data provided in this report represents the first attempt to develop a consistent Bay-wide set of contemporary ambient sediment concentrations to be considered for areas within the Bay outside of known or suspected pollutant sources (hereinafter referred to as contemporary ambient concentrations). This data can be used as a tool for water quality management, such as remedial actions due to site sediments not meeting the narrative SQOs. The study goals were:

1. To identify pollutants of concern in sediments that have the potential to pose a risk to benthic organisms, human health, wildlife, and resident fish.
2. To develop a robust Bay-wide dataset using sediment samples collected by various regional monitoring programs from areas located away from point source discharges and known contaminated sediment sites.
3. To use rigorous and modern statistical methods to compute reliable estimates of population parameters[5] for development of the contemporary ambient sediment concentrations.

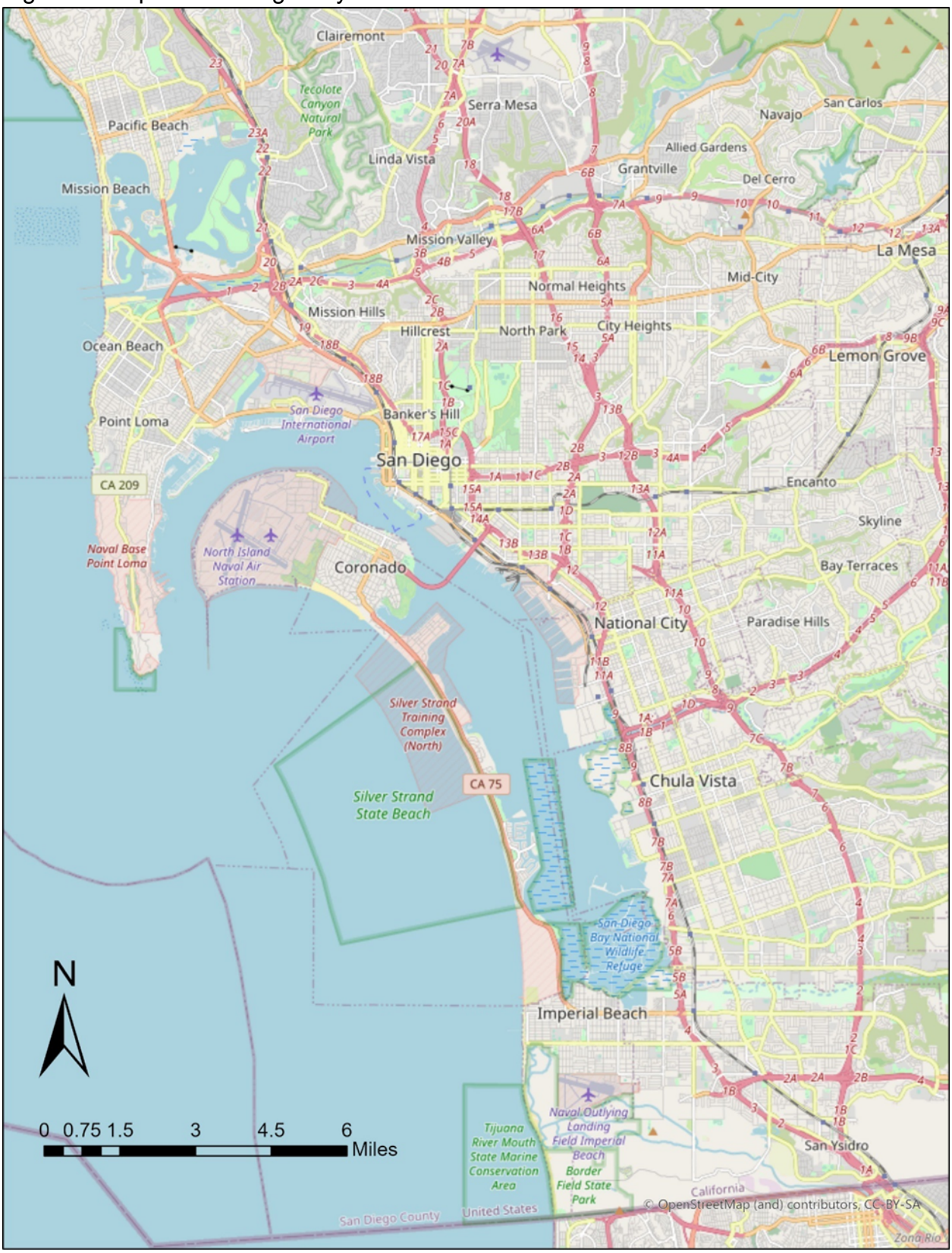
[5] A parameter is a number describing a whole population (e.g., population mean), while a statistic is a number describing a sample (e.g., sample mean).

STUDY AREA

This study focused on San Diego Bay, which is located within the cities of San Diego, National City, Chula Vista, Coronado, and Imperial Beach (Figure 3). The Bay is a natural, crescent-shaped embayment extending approximately 14 miles along a curved axis from where it connects to the Pacific Ocean at Point Loma in the north, to its innermost reaches at the mouth of the Otay River in the south. The Bay has been extensively modified by dredging and filling since the late 1800s. The Bay in its current form is narrower and deeper than in its un-dredged, unfilled state. The surface area of the Bay is approximately 19 square miles. The width of the bay ranges from 0.25 to 2.5 miles. The depth of the Bay ranges from more than 60 feet in some northern areas to only a few feet in much of the southern portion. Depths average less than 40 feet.

Freshwater inflow to the Bay has been reduced by rerouting the San Diego River so that it no longer periodically enters the Bay, and by construction of dams for water supply reservoirs on the Sweetwater and Otay Rivers. The salinity of the Bay is generally similar to that of the ocean. In summer and early fall, the salinity of the southern part of the Bay may be somewhat higher than that of the ocean due to elevated temperatures, evaporation, and limited tidal pumping (Largier 1995). Immediately following storm events, the salinity of the Bay in the vicinity of the mouths of rivers and creeks and storm drain outfalls may be lower than that of the ocean.

Figure 3. Map of San Diego Bay.



METHODOLOGY

Pollutants of Concern

Pollutants of concern were selected because they meet all of the following criteria: 1) pollutants must be monitored in sediment per regulatory requirements, 2) pollutants are known to be the cause of impairments in the Bay, and 3) pollutant data is available that been collected and analyzed in accordance to the methodology outlined in the State of California Sediment Quality Assessment Technical Support Manual (Bay et al. 2021, SWRCB 2005, 2017, 2018).

The *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Sediment Quality Provisions* (Sediment Quality Provisions) lists chemicals used to characterize the exposure to and effect on the benthic community, human health, wildlife, and resident finfish. To be consistent with the Sediment Quality Provisions, as well as the pollutants of concern identified in the San Diego Bay fish consumption advisory (OEHHA 2018) and CWA section 303(d) list (SWRCB 2017,2018, 2021), this study selected the following chemicals for which to derive contemporary ambient sediment concentrations for the Bay:

- Persistent Organic Chemicals (excluding pesticides): total polycyclic aromatic hydrocarbons (PAHs) and total PCB congeners
- Metals: cadmium, copper, lead, mercury, and zinc
- Organochlorine Pesticides: dieldrin, total chlordanes, and total dichlorodiphenyltrichloroethanes (DDTs)

Datasets Used

To estimate contemporary ambient concentrations of pollutants in San Diego Bay surficial sediments[6], this study used data from the 2008, 2013, and 2018 Regional Harbor Monitoring Program (RHMP) and the 2014 Aquatic Food Web Bioaccumulation Study of San Diego Bay (Bioaccumulation Study) (Weston 2008; Amec 2016, Amec 2016a and 2016b; Wood 2020). These studies were chosen because they contain the most up-to-date data and therefore are most representative of contemporary conditions. In addition, the studies used a stratified random (emphasis added) sampling design that includes areas of the Bay not associated with site-specific investigation or cleanups, as opposed to site cleanup or discharge sampling, which typically targets only areas associated with a cleanup project or active permitted discharges. These studies also used consistent field sample collection and laboratory analysis methodologies, allowing for individual datasets to be compiled into a single larger dataset. The Port of San Diego and the City of San Diego, the agencies that led the studies, provided the following data products for use in this study:

[6] Surficial sediments are defined as the upper 5 cm of surface sediment collected by a grab sampler (Bay et al. 2021).

- Digital records of project final reports
- Field sampling sheets
- Laboratory quality assurance/quality control (QA/QC) data
- Electronic data deliverable (EDD) sheets
- Analytical results in tabular MS Excel format
- Geographic information systems (GIS) data
- Other supporting materials

Identification of Contemporary Ambient Sites

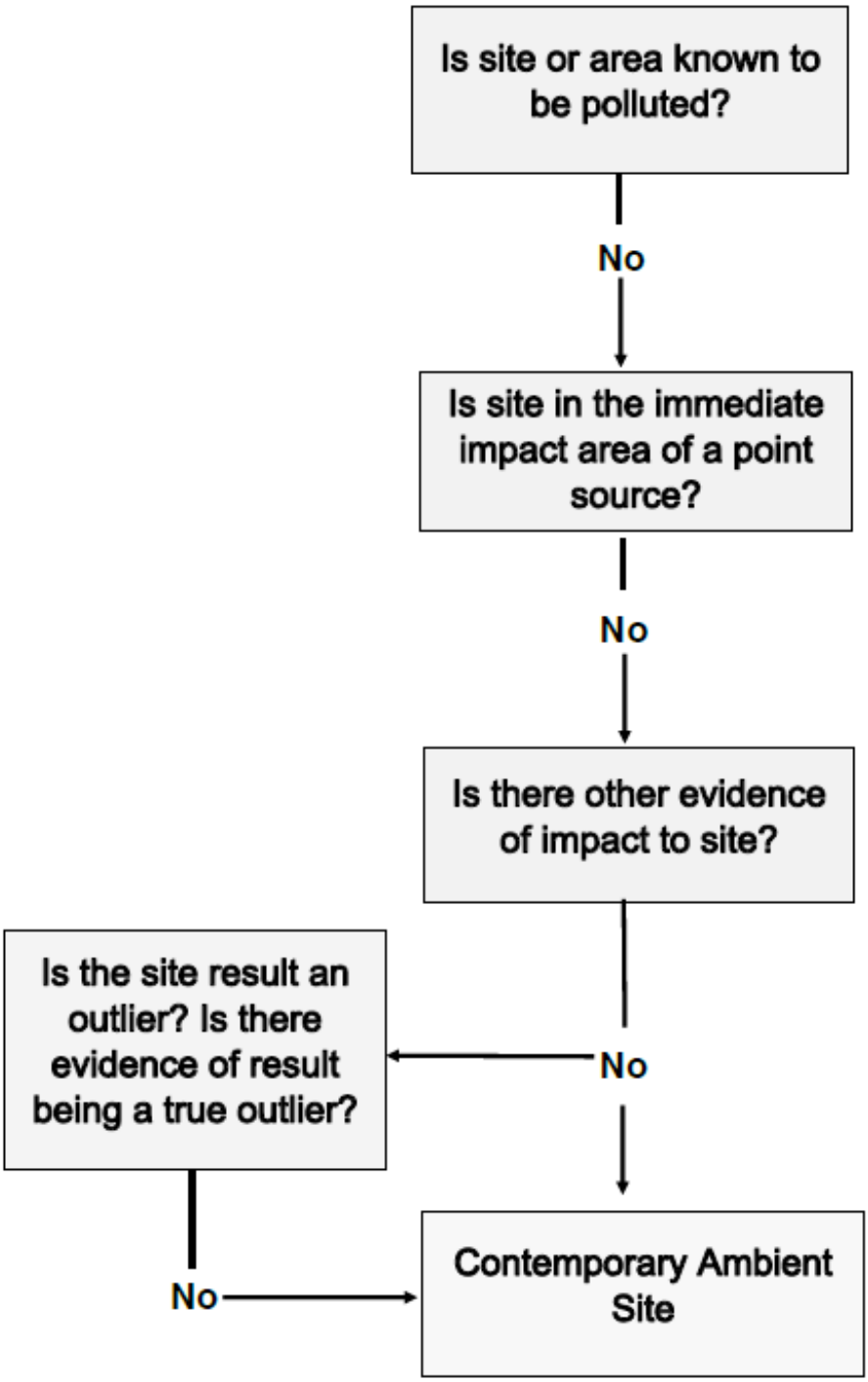
The methodology used to identify contemporary ambient sites for this study is shown on Figure 4. Contemporary ambient sites were defined as sampling sites meeting the following criteria:

1) Locations outside the boundaries of known contaminated sites,

2) Sites not directly impacted by significant point sources of pollution (e.g., large municipal storm drains), and

3) Sites not located in the marina, port, industrial, or estuary sampling strata as defined by the RHMP.

Figure 4. Approach for Selection of Contemporary Ambient Sites.



This approach assumes that sediment transport and deposition was/is not a major contributor of pollutants to identified contemporary ambient sites.

To identify contemporary ambient sites for this study, sites were first mapped using ESRI's ArcGIS Pro (version 2.6.1) to determine their spatial association with one of five strata in San Diego Bay (i.e., marina, port, industrial, deep, and shallow) used for probabilistic sampling by the RHMP (Weston 2008; Amec 2016a and 2016b; Wood 2020). All sites located in industrial, port, or marina areas of San Diego Bay were excluded since these strata are known to be the most anthropogenically influenced and generally exhibit the highest pollutant concentrations (Weston 2008; Amec 2016a and 2016b; Wood 2020). These are also areas identified as impaired for beneficial uses under the CWA due to sediment contamination (State Water Board 2016, 2021).

After the initial strata-based filtering step, the remaining sites in the deep and shallow strata were mapped along with areas that are known to historically or currently have contaminated sediments or significant point source discharges of pollution. Sites outside of the boundaries of contaminated areas and not located immediately adjacent to known point discharge sources of pollution were selected as contemporary ambient sites (Figure 5).

Data Preparation and Statistical Analysis

All raw data were screened for QA/QC compliance purposes, and pollutant method detection limits (MDLs) and reporting limits (RLs) were compared across survey years to ensure consistency in analysis. R statistical programing language (R version 4.0.2) and R Studio (version 1.2.5042) were used to transform raw datasets into a consistent long data format, visualize data, and complete all statistical analysis. The primary R packages used for data wrangling and visualization were "tidyverse," "ggplot2," and "ggpubr."

To complete the analysis, data were first separated into two groups (one including older 2008 data and one excluding the 2008 data), followed by two categories: uncensored and censored (See

Figure 6, for a diagram summarizing statistical analysis). Censored data consist of measurements for which an exact result is not known. In this study these data include both left-censored (below MDL) and interval-censored data (results between MDL and RL, sometimes referred to as "estimated values"). All censored data were tagged as such prior to running any analysis.

Figure 5. Map of San Diego Bay Depicting Final Contemporary Ambient Sites, Known Contaminated Areas, and Excluded Sites.

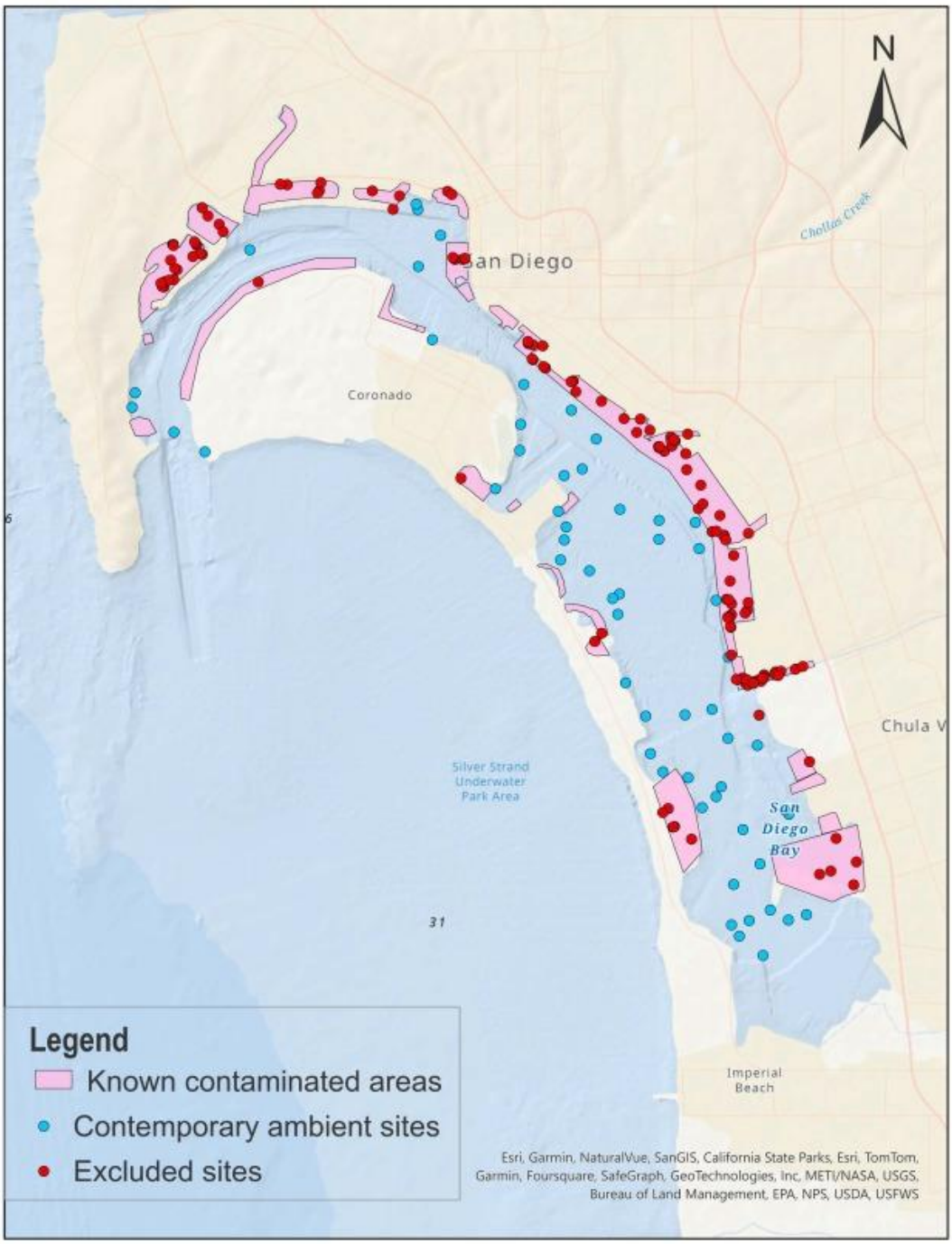
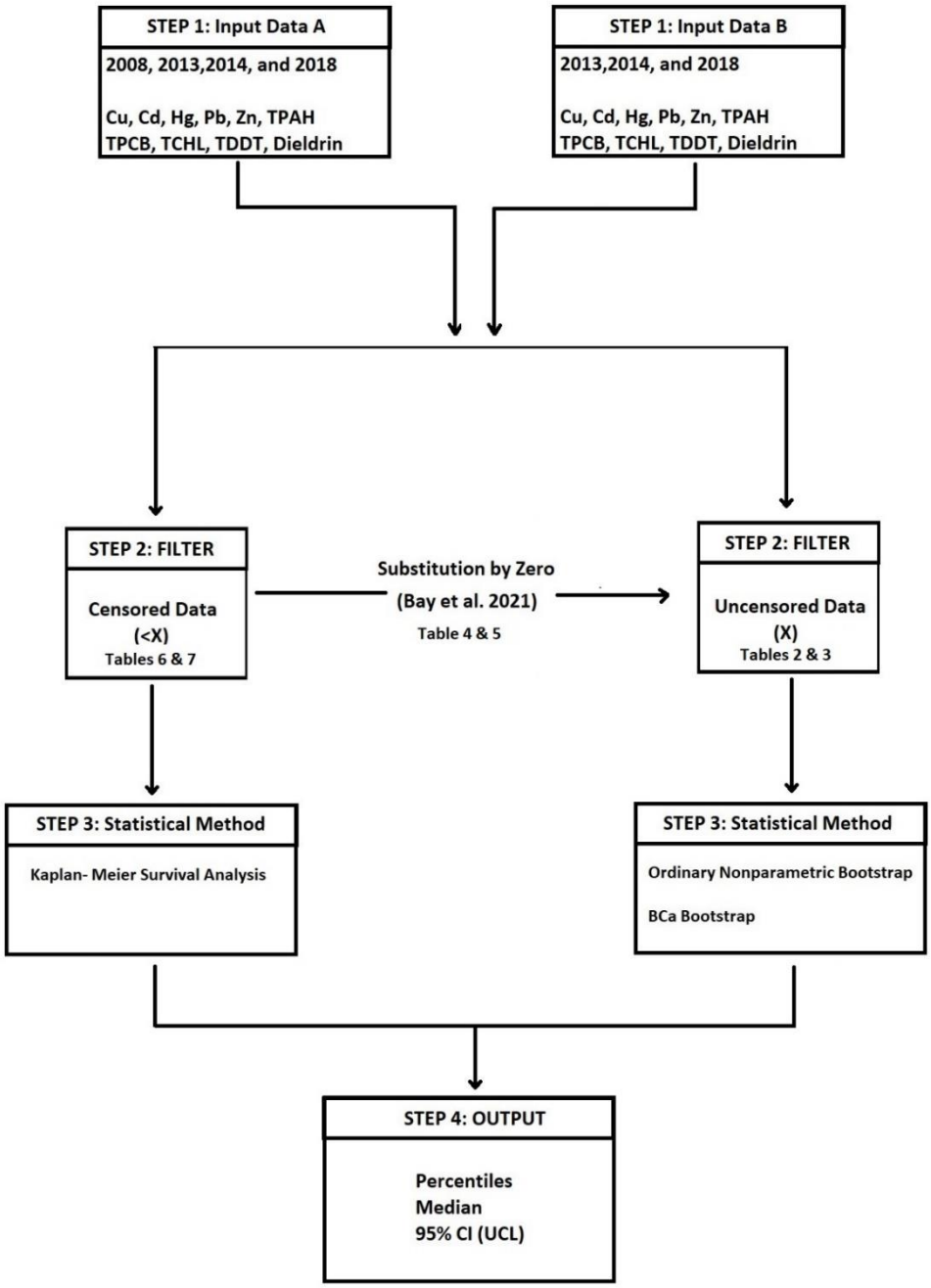


Figure 6. Statistical Analysis Flowchart.



Note that we do not advocate for substitution of censored data, but rather for the use of appropriate statistical methods for working with censored data (e.g., Kaplan-Meier). However, it is still important to recognize that substitution of left-censored data with zero has been the recommended practice in the State of California (Bay et al 2021). We present the results of substitution of left-censored data with zero in the Report for comparison purposes and not as a recommended practice (Tables 4 & 5). Therefore, non-detects were replaced with zero per State of California SQO Technical Manual recommendations (Bay et al. 2021) prior to using non-parametric bootstrap procedures. To summarize, left-censored data values were set as zero, or as the estimated value for interval-censored data. This includes individual species (e.g., congeners) for those pollutants reported as totals (PAHs, PCBs, and chlordanes).

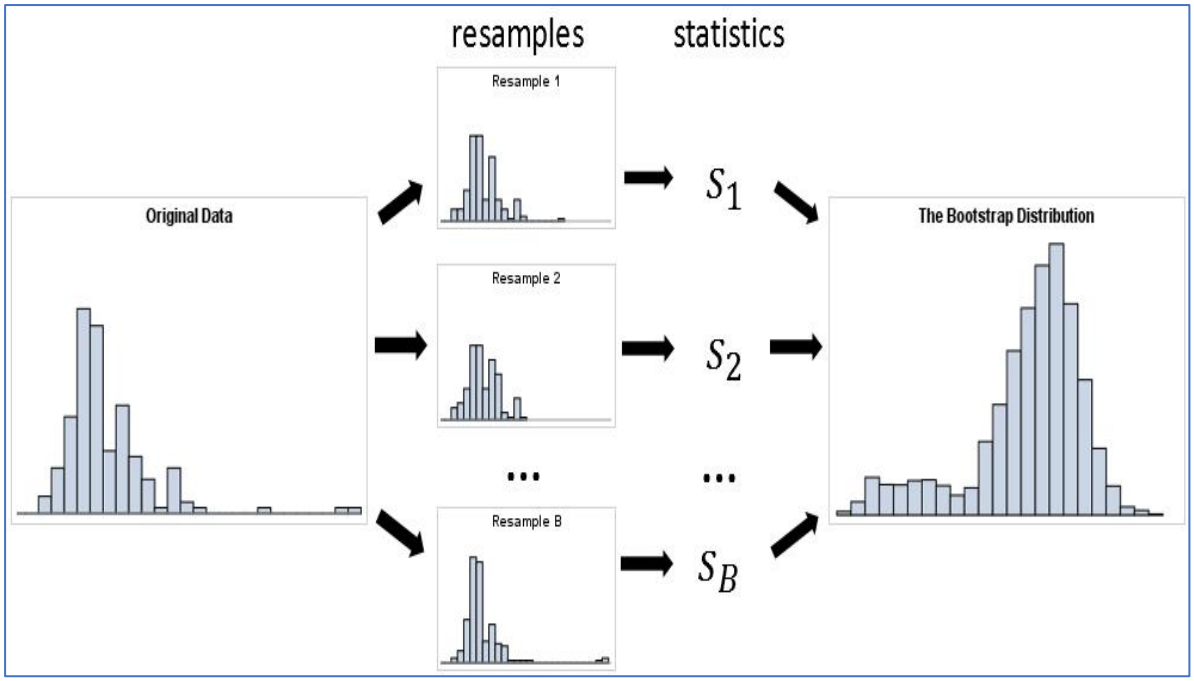
For uncensored data, statistical estimates of population parameters (mean, median, quantiles, and confidence limits) were obtained using the nonparametric Bootstrap methods with the Bootstrap Resampling package (“boot”) in R (Efron 1979, Davidson and Hinkley 1997, Canty and Ripley 2021). Bootstrapping provides a superior means of estimating population parameters, given that the data used as an input meet the independent identically distributed (iid) assumption. Rather than being constrained by sample size when estimating population parameters, Bootstrapping simulates sampling the population with a high level of replication (i.e., k=10,000) or the equivalent of conducting the same field studies 10,000 times. The output is a bootstrap distribution made up 10,000 simulated sampling events for the parameter of interest.

The generalized steps to the bootstrap procedure are as follows:

1. Calculate the statistic of interest from the original dataset (sample).
2. Resample the original dataset (matching the number of observations in the original sample) randomly and with replacement a large number of times (k=10,000).
3. Calculate the statistic of interest from each bootstrap sample. Pool all results to create the bootstrap distribution that approximates the sampling distribution of the statistic of interest.
4. Calculate estimates for the statistics of interest from bootstrap distribution.

An illustration of the bootstrap resampling procedure is provided below (Figure 7):

Figure 7. Illustration of the bootstrap resampling procedure. Samples are drawn randomly with replacement from the original or sample dataset in such a way that the value of n for an individual bootstrap resample matches that of the original sample.



Since its introduction in 1979 by Efron, the original bootstrap procedure has seen many improvements (Efron 1979, Efron and Tibshirani 1986, 1994). This study used two different nonparametric bootstrapping procedures to calculate measures of central tendency and confidence intervals, the percentile bootstrap and bias corrected and accelerated bootstrap.

Percentile bootstrap estimates are based on quantiles of the output bootstrap distribution. A limitation of the percentile bootstrap is that it only uses bootstrap samples to estimate the statistic of interest and not the estimate calculated from the original sample data. Furthermore, percentile bootstrap estimates are not adjusted for any skew in the output bootstrap distribution.

To address these shortcomings, we used an improvement on the percentile bootstrap introduced by Efron (1986) called the bias-corrected and accelerated (BCa) bootstrap. The BCa bootstrap corrects for both bias and skewness in the distribution of bootstrap estimates. The BCa bootstrap requires the calculation of a bias-correction parameter (z_0) and an acceleration parameter (a). The bias-correction parameter (z_0) is the proportion of bootstrap estimates that are less than the estimate for the statistic calculated from the original sample data. The acceleration parameter (a) is calculated using the jacknife method and is proportional to the skewness of the output bootstrap distribution. Both of these parameters are used to adjust the bootstrap estimate. For example, if the bootstrap distribution has a right or positive skew then the estimate is adjusted to the right and vice versa.

For censored data, summary statistics (i.e., mean, median, quantiles, and confidence limits) were computed using the Kaplan-Meier method using the Data Analysis for Censored Environmental Data package ("NADA2") in R (Helsel 2011 and 2021, Julian and Helsel 2021). For any datasets with censoring levels above 60 percent (not including individual pollutant species for total counts), no further calculations were completed because results become unreliable except for those percentiles where detected values are available (Helsel et al. 2011, Shoari and Dube 2018). When levels of censoring were above 60 percent, contemporary ambient concentrations were set according to the following:

1) When the percentage of censored data in the contemporary ambient concentration dataset equals or exceeds 60 percent: Match the percentage of non-detects in the contemporary ambient concentration dataset using the lowest or minimum detection limit for the parameter of interest (see Appendix II of Technical Report) and do not exceed the estimated 90th percentile value.

2) When percentage of censored data in the contemporary ambient concentration dataset equals 100%: Set contemporary ambient concentration to match 100 percent censored data using the lowest or minimum detection limit for the parameter of interest (see Appendix II of Technical Report).

Data used were not normally distributed (Shapiro-Wilk test, $p \leq 0.05$) and no prior data transformation was conducted because the statistical methods used (Ordinary Nonparametric Bootstrap and Kaplan-Meier) are distribution-free or non-parametric methods, which do not require transformation.

Still, it is important to note that for both the Percentile Bootstrap and BCa Bootstrap, both require that monotonic function exists that can transform the original data into a normally distributed dataset (Gomez-Hernandez pers comm. 2022, Efron and Tibshirani 1986). A more detailed discussion of the Bootstrap procedure is provided in Appendix IV.

While the studies employed used a stratified random sampling design, Spearman correlation analysis were still carried out to confirm the independence portion of the iid assumption required for Bootstrap analysis.

Outliers (Rosner, $p \leq 0.05$) were not eliminated because no evidence of error in measurement or reporting was identified (e.g., exceeding sample holding time, data entry error, some other quality control issue that would invalidate a particular data point). These data points are assumed to be extreme manifestations of naturally occurring random variability in the data used (Grubbs 1969). This approach is appropriate also because the median (chosen here as the recommended measure of central tendency) is resilient to the presence of outliers.

To compare our methods and calculations carried out in R, total PCB data was used to calculate statistics using EPA's ProUCL software (Singe and Maichle 2015). See

comparison of mean UCL, using ProUCL in Tables 4 and 6. The full dataset (all years) was formatted and entered into ProUCL, and analysis was carried out using the software's suggested UCL method and corrections, with non-detect values (NDs) in the results column set to the MDLs, as recommended in the PRO UCL user guide (Singh and Maichle 2015).

Lastly, calculated values were qualitatively compared to scientifically published effects ranges and reference values from the State SQO Chemical Score Index (CSI) (Bay et al. 2021) to evaluate protectiveness of contemporary ambient concentrations.

RESULTS

Contemporary Ambient Sites

Site screening yielded 57 sites across all studies whose sediment pollutant concentrations could be used to estimate contemporary ambient concentrations (Figure 5, Appendix 1). Person and Spearman correlations comparing different sampling years for each parameter showed significant correlations ($p \leq 0.05$) in approximately 12 percent of cases when data from all years are included (2008-2018). When data from 2008 are excluded, no significant correlations are observed.

MDLs and RLs

Due to improvements in laboratory detection limits over time (2008-2018), MDLs and RLs decreased by over an order of magnitude across studies, with the exception of zinc in the 2014 Bioaccumulation Study and DDTs, dieldrin, total chlordanes, and zinc in the 2018 RHMP study (Appendix 1). Subsequent analysis was conducted on 1) the entire dataset and 2) excluding those data from 2008 with elevated MDLs and RLs as described below.

Analysis Results

Tabulated results are presented first for uncensored data (Bootstrap only) and then for censored data (Bootstrap and Kaplan-Meier) for the dataset including all years (Tables 2, 4, and 6) and in the same fashion for the dataset excluding the older 2008 RHMP data (Tables 3, 5, and 7). The exclusion of the older 2008 data resulted in all uncensored data for total PCB samples, hence total PCB results are missing from Table 7.

Summary statistics were successfully calculated for all uncensored data, with median 95 percent upper confidence limits (“median 95 percent UCLs”) falling below the Effects Range-Low (ERL) and SQO reference values for lead, cadmium, and total PAHs (Tables 2 and 3; Long and Morgan 1990). In contrast, the median 95 percent UCLs were above multiple thresholds for mercury, copper, and zinc (Table 2). The same pattern was observed using all data years and when 2008 RHMP data are excluded. When 2008 RHMP data are excluded from the analysis, all median 95 percent UCLs decrease (Tables 2 through 7).

Censored data were present only in the datasets for total PCBs (0 to 3.5 percent), total DDTs (79.6 to 80.7 percent), total chlordanes (93.9 to 94.7 percent), and dieldrin (100 percent) (Tables 4 through 7). The ranges represent percent censored data when all data years are included versus when 2008 RHMP data are excluded.

Because of the high level of censored data for total DDTs, total chlordanes, and dieldrin, no summary statistics could be calculated for quantiles below the respective censoring level.

For total PCBs, the median 95 percent UCL ranged from 5.27 to 5.67 nanograms per gram (ng/g) dry weight (dw) for the analysis including all data years and 5.00 ng/g dw excluding RHMP 2008 data, for ordinary nonparametric Bootstrap (k=10,000, BCa) and nonparametric Kaplan-Meier, respectively (Tables 4, 6 and 5, in that order).

The total PCB mean 95 percent UCL for all data years ranged from 9.63 to 8.26 ng/g dw for ordinary nonparametric Bootstrap (k=10,000, BCa) and nonparametric Kaplan-Meier, respectively (Table 4). Using ProUCL 5.1, the Kaplan-Meier approximate Gamma total PCB mean 95 percent UCL was 8.45 ng/g dw (Table 4).

These results are well below both the ERL (22.7 ng/g dw) and SQO reference value (≤11.9 ng/g dw), while the 95th percentiles (16.4 and 16.7 ng/kg dw, Tables 4 and 6 respectively), were below the ERL and above the SQO reference value.

A sample dataset and R code is provided in Appendix 3.

Table 2. 2008, 2013, and 2018 RHMP and 2014 Bioaccumulation Study uncensored data results of ordinary non-parametric Bootstrap (k=10,000) of quantiles and bias-corrected and accelerated median 95% confidence intervals for metals and total PAHs (n=57).

Estimated Parameter/ Reference Concentration	Mercury (mg/kg dw)	Lead (mg/kg dw)	Copper (mg/kg dw)	Cadmium (mg/kg dw)	Zinc (mg/kg dw)	Total PAHs (ng/g dw)
10th Percentile	0.06	7.1	15.4	0.06	47.2	63.6
20th Percentile	0.08	9.3	25.5	0.08	77.4	89.2
30th Percentile	0.10	12.4	37.2	0.13	88.5	119.6
40th Percentile	0.11	13.9	44.2	0.16	101.9	156.4
50th Percentile (Median)	0.15	15.1	49.8	0.17	124.5	176.0
Median 95% LCL (Bca)	0.10	13.4	42.4	0.14	94.7	130.0
Median 95% UCL (Bca)	0.17	17.7	54.0	0.20	150.0	227.0
90th Percentile	0.38	33.9	95.8	0.35	212.8	578.0
95th Percentile	0.59	40.4	123.6	0.39	244.16	1335.4
Effects Range-Low (ERL)	0.15	46.7	34	1.2	150	4,022
Effects Range-Median (ERM)	0.71	218	270	9.6	410	44,792
SQO Chemical Score Index (CSI) Reference Condition	≤0.090	≤26.4	≤52.8	CALRM*	≤ 113	≤398.4

*CALRM = California Linear Regression Model

Table 3. 2013 and 2018 RHMP and 2014 Bioaccumulation Study uncensored data results of ordinary non-parametric Bootstrap (k=10,000) of quantiles and bias-corrected and accelerated median 95% confidence intervals for metals and total PAHs (n=49).

Estimated Parameter/ Reference Concentration	Mercury (mg/kg dw)	Lead (mg/kg dw)	Copper (mg/kg dw)	Cadmium (mg/kg dw)	Zinc (mg/kg dw)	Total PAHs (ng/g dw)	Total PCBs (ng/g dw)
10th Percentile	0.05	7.0	15.2	0.05	44.9	61.2	1.06
20th Percentile	0.07	8.4	25.0	0.08	63.1	85.8	1.65
30th Percentile	0.09	11.9	34.9	0.11	86.5	113.8	2.19
40th Percentile	0.11	13.5	42.7	0.15	97.8	132.4	3.45
50th Percentile (Median)	0.13	14.5	49.6	0.17	121.0	161.0	4.34
Median 95% LCL (Bca)	0.10	11.8	37.3	0.14	88.7	120	2.62
Median 95% UCL (Bca)	0.17	16.1	53.5	0.19	153.0	208	5.00
90th Percentile	0.35	30.2	94.7	0.30	203.0	463.0	9.91
95th Percentile	0.45	37.1	113.6	0.35	250.4	624.0	11.15
Effects Range-Low (ERL)	0.15	46.7	34	1.2	150	4,022	22.7
Effects Range-Median (ERM)	0.71	218	270	9.6	410	44,792	180
SQO Chemical Score Index (CSI) Reference Condition	≤0.090	≤26.4	≤52.8	CALRM*	≤113	≤398.4	≤11.9

* CALRM = California Linear Regression Model

Table 4. 2008, 2013, and 2018 RHMP and 2014 Bioaccumulation Study censored data results of ordinary non-parametric Bootstrap (k=10,000) of quantiles and bias-corrected and accelerated median 95% confidence intervals for total PCBs, total DDTs, total chlordanes, and dieldrin (n=57).

Estimated Parameter/ Reference Value/ Censoring Level	Total PCBs (ng/g dw)	Total DDTs (ng/g dw)	Total Chlordanes (ng/g dw)	Dieldrin (ng/g dw)
10th Percentile	0.94	NA	NA	NA
20th Percentile	1.64	NA	NA	NA
30th Percentile	2.18	NA	NA	NA
40th Percentile	3.55	NA	NA	NA
50th Percentile (Median)	4.44	NA	NA	NA
Median 95% LCL (Bca)	2.83	NA	NA	NA
Median 95% UCL (Bca)	5.27	NA	NA	NA
Mean (95% UCL), R Ordinary Nonparametric Bootstrap BCa	6.09 (9.63)	NA	NA	NA
Mean (95% UCL), R KM Nonparametric	6.11 (8.26)	NA	NA	NA
Mean (95% UCL), ProUCL KM Approximate Gamma	6.11 (8.45)	NA	NA	NA
90th Percentile	10.8	0.34	NA	NA
95th Percentile	16.4	1.0	NA	NA
ERL	22.7	1.58	2.0	NA
ERM	180	46.1	6.0	NA
SQO CSI Reference Condition	≤11.9	≤0.061	≤1.04	CALRM*

*CALRM = California Linear Regression Model
NA = not available

Table 5. 2013 and 2018 RHMP and 2014 Bioaccumulation Study censored data results of ordinary non-parametric Bootstrap (k=10,000) estimation of quantiles and bias-corrected and accelerated median 95% confidence intervals for total PCBs, total DDTs, total chlordanes, and dieldrin (n=49).

Estimated Parameter/ Reference Value/ Censoring Level	Total PCBs (ng/g dw)	Total DDTs (ng/g dw)	Total Chlordanes (ng/g dw)	Dieldrin (ng/g dw)
10th Percentile	0.94	NA	NA	NA
20th Percentile	1.64	NA	NA	NA
30th Percentile	2.18	NA	NA	NA
40th Percentile	3.55	NA	NA	NA
50th Percentile (Median)	4.44	NA	NA	NA
Median 95% LCL (Bca)	2.83	NA	NA	NA
Median 95% UCL (Bca)	5.27	NA	NA	NA
90th Percentile	10.8	0.32	NA	NA
95th Percentile	16.4	0.83	NA	NA
ERL	22.7	1.58	2.0	NA
ERM	180	46.1	6.0	NA
SQO CSI Reference Condition	≤11.9	≤0.061	≤1.04	CALRM*

* CALRM = California Linear Regression Model
NA = not available

Table 6. 2008, 2013, and 2018 RHMP and 2014 Bioaccumulation Study censored data results of Kaplan-Meier estimation of quantiles and bias-corrected and accelerated median 95% confidence intervals for total PCBs, total DDTs, total chlordanes, and dieldrin.

Estimated Parameter/ Reference Value/ Censoring Level	Total PCBs (ng/g dw)	Total DDTs (ng/g dw)	Total Chlordanes (ng/g dw)	Dieldrin (ng/g dw)
10th Percentile	<1	NA	NA	NA
20th Percentile	1.64	NA	NA	NA
30th Percentile	2.2	NA	NA	NA
40th Percentile	3.855	NA	NA	NA
50th Percentile (Median)	4.44	NA	NA	NA
Median 95% LCL (Bca)	3.038	NA	NA	NA
Median 95% UCL (Bca)	5.67	NA	NA	NA
Mean (95% UCL), R Ordinary Nonparametric Bootstrap BCa	4.75 (5.86)	NA	NA	NA
Mean (95% UCL), ProUCL Gamma Adjusted (n<50) UCL	4.75 (5.84)	NA	NA	NA
90th Percentile	11.85	0.67	NA	NA
95th Percentile	16.7	<1.0	NA	NA
ERL	22.7	1.58	2.0	NA
ERM	180	46.1	6.0	NA
SQO CSI Reference Condition	≤11.9	≤0.061	≤1.04	CALRM*
n	57	57	57	57
Non-detects	2	46	54	57
Percent Censoring	3.5	80.7	94.7	100.0

* CALRM = California Linear Regression Model
NA = not available

Table 7. 2013 RHMP and 2014 Bioaccumulation Study, and 2018 RHMP censored data results of Kaplan-Meier estimation of quantiles and bias-corrected and accelerated estimates of confidence intervals for total PCBs, total DDTs, total chlordanes, and dieldrin.

Estimated Parameter/ Reference Value/ Censoring Level	Total DDTs (ng/g dw)	Total Chlordanes (ng/g dw)	Dieldrin (ng/g dw)
10th Percentile	NA	NA	NA
20th Percentile	NA	NA	NA
30th Percentile	NA	NA	NA
40th Percentile	NA	NA	NA
50th Percentile (Median)	NA	NA	NA
Median 95% LCL (Bca)	NA	NA	NA
Median 95% UCL (Bca)	NA	NA	NA
90th Percentile	0.39	NA	NA
95th Percentile	1.72	NA	NA
ERL	1.58	2.0	NA
ERM	46.1	6.0	NA
SQO CSI Reference Condition	≤0.061	≤1.04	CALRM**
n	49	49	49
Non-detects	39	46	49
Percent Censoring	79.6	93.9	100.0

* All values are detects, see Table 5 for Ordinary Non-Parametric Bootstrap results
** CALRM = California Linear Regression Model
NA = not available

CONCLUSIONS AND RECOMMENDATIONS

General Study Conclusions Associated with Study Goals

The purpose of this study was to develop a consistent Bay-wide set of contemporary ambient sediment concentrations outside of known or suspected pollutant sources. This data can be used as a tool for water quality management, such as for remedial actions when the sediments do not meet the narrative SQOs. The specific study goals were:

1. To identify pollutants of concern in sediments that have the potential to pose a risk to benthic organisms, human health, wildlife, and resident fish.
2. To develop a robust Bay-wide dataset using sediment samples collected from various regional monitoring programs and from areas located away from point source discharges and known contaminated sediment sites.
3. To use rigorous and modern statistical methods to compute reliable estimates of population parameters for development of the contemporary ambient sediment concentrations.

For study goal 1, sediment pollutants of concern in the Bay were identified by including as many of the compounds for which data were available that are required by pertinent regulations to conduct ecological and human health risk assessments. The final list of compounds analyzed matches those responsible for the CWA section 303(d) impairments in the Bay. Many of these are persistent organic pollutants and/or bioaccumulate and biomagnify in the food web, posing a risk to both ecological and human receptors. Additional pollutants could be added as data allows.

For study goal 2, sufficient quality-controlled data was available (n ranging from 49 to 57) across a representative time period for the San Diego Water Board to evaluate contemporary ambient concentrations for pollutants of concern in San Diego Bay. Also, unlike other approaches, this approach represents a synoptic evaluation of all regions of the entire Bay while ensuring that sites located immediately next to point discharges, in strata known to exhibit high anthropogenic influence (i.e., marina, port, industrial, and estuary), are excluded from the final list of contemporary ambient sites (Figure 5).

For study goal 3, we used Ordinary Nonparametric Bootstrap, Bias-Corrected and Accelerated Bootstrap and Kaplan-Meier statistical methods to estimate potential pollutant thresholds and confidence intervals that could serve as contemporary ambient (Kaplan Meier, Kaplan and Meier 1958, and Bootstrap, Efron 1979).

These statistical methods are well supported in the scientific literature and advancements in open-source statistical computing over the last decade has expanded the ability for the methods to be used (e.g. Helsel 2011).

Historic methods used in sediment assessment often call for introducing replacement values for non-detects that can adversely affect the ability to correctly identify differences or detect trends in data. Here we demonstrated that the Kaplan-Meier method can produce comparable, consistent, and reliable results, while avoiding the introduction of un-natural patterns into the original dataset.

Assumptions and Considerations

Specific assumptions and decisions were made in data assessment that make the resultant contemporary ambient concentrations more or less conservative. These assumptions and considerations should be considered in developing regulatory actions and selecting the appropriate calculated threshold(s) for use.

First, all left-censored data was set to zero (excluding Kaplan Meier), which is a conservative assumption that none of the pollutant was present. This approach is consistent with state sediment objectives for assessment, with the SQOs setting all left-censored data to zero (Bay et al. 2021). For anthropogenically created pollutants not naturally found in the environment (e.g., PCBs), this assumption reflects true "background" or reference conditions since these pollutants are not naturally found in the environment.

Note that while setting left-censored data to zero might be a more protective approach for determining contemporary ambient concentrations, the inverse is true when conducting ecological and human health risk assessment as the sediment pollutant concentrations would be underestimated.

Second, the identification of what constitutes pollutant contemporary ambient concentration has been done on a waterbody-specific basis for San Diego Bay. Another approach would be to calculate contemporary ambient concentrations on a regional basis for all enclosed bays and estuaries in the San Diego Region. This Bay-only approach is less conservative because San Diego Bay has been subject to extensive industrial activity for over 100 years and is documented to have higher pollutant concentrations than other enclosed bays and estuaries in the region (Weston 2008; Amec 2016a and 2016b; Du et al. 2020, Wood 2020). A more conservative approach would be to develop a region-wide contemporary ambient concentration threshold that includes data from waterbodies with less anthropogenic impacts.

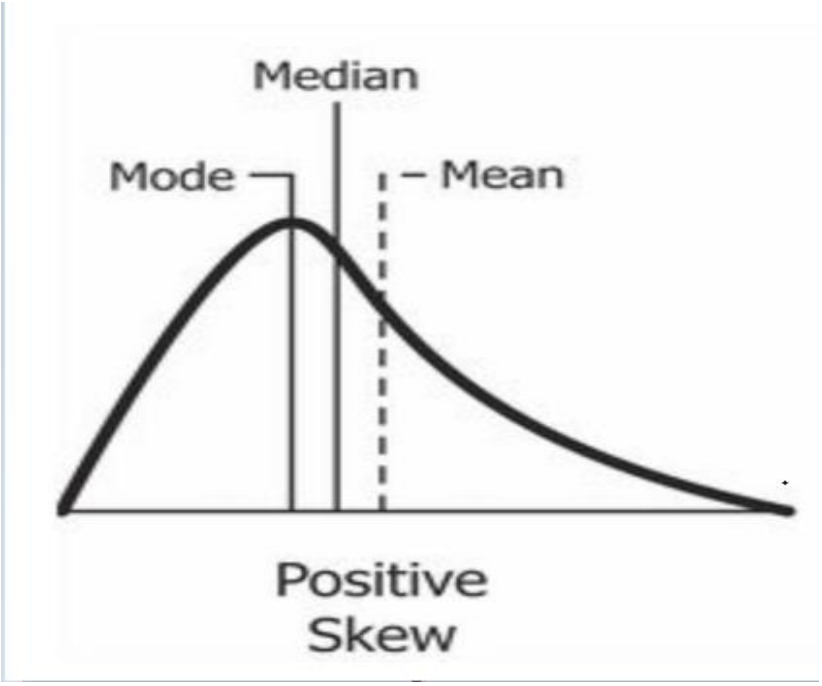
Third, the selection of sites representative of contemporary ambient conditions within San Diego Bay was conducted based on sampling stations occurring outside known active-use footprints for anthropogenic activities and active sediment investigation and remediation sites. This assumes that there is no impact from these areas to other portions of the Bay through mechanisms such as tidal sediment transport, prop wash, or dredging. This assumption is less conservative, as some sediment transport is expected to result in low level movement of pollutants to these areas of the Bay, as evidenced by the ubiquitous detection of low concentrations of anthropogenically created PCBs across contemporary stations in the Bay. Furthermore, some stations could be falsely screened as contemporary ambient but have unknown anthropogenic impacts that result in elevated pollutant concentrations. For these reasons, the uncertainty around the selection of contemporary ambient sites is expected to be less conservative.

Selection of Contemporary Ambient Concentrations

The proposed contemporary ambient concentration thresholds take into consideration the above assumptions, which are expected to make the concentrations observed less conservative through inclusion of sites that are not entirely free of anthropogenic impacts.

While EPA sampling to set cleanup targets recommends the use of the mean and its 95 percent UCL (Singh and Maichle 2015), this approach is not recommended for identifying contemporary ambient concentrations. Using the mean and its 95 percent UCL would result in contemporary ambient concentrations that are less conservative due to upward bias, as those data used here are non-normally distributed (Shapiro-Wilk test, $p \leq 0.05$) and right-skewed (positive skewness) (Figure 8). This right-skewed distribution results in a mean with a higher value than the median as the mean can be highly influenced by the presence of high values and/or outliers.

Figure 8. Measures of Central Tendency in a Right-Skewed Distribution.



Therefore, the median in this case is a more representative measure of central tendency and one that will be more protective of beneficial uses. An added advantage of using the median over the mean is that if highly anthropogenically influenced sites were included in the contemporary ambient category, despite the filters used in this study, the pollutant concentrations from those sites will have less of an influence on the median.

As a result, the median 95th percentile upper confidence limit is recommended for all pollutants assessed by this study when evaluating sediment cleanup sites within San Diego Bay.

Other summary statistics resulting from analysis are presented in Tables 2 through 7. As sediment cleanups throughout the Bay progress over time, these numbers may be revisited as factors such as contaminated sediment resuspension and transport are expected to be reduced, and as the dataset for potentially low-impact sites/areas of the Bay is expected to increase in size.

For total DDTs, total chlordanes, and dieldrin, it is recommended that contemporary ambient pollutant concentrations be set to the non-detect level using the same MDLs/RLs and testing methods as those for those data analyzed here. This approach is consistent with requirements for setting background water column concentrations for pollutants in the State of California Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SWRCB 2005), which recommends use of detection limits if all of the samples are below reported detection limits. While this same policy recommends use of the arithmetic mean for datasets with detections, we did not elect to follow these guidelines due to the high preponderance of NDs in the dataset (82-100 percent), as well as the anthropogenic nature of these pollutants, which effectively sets a natural “background” or reference expectation as zero.

Future Direction

This study used existing data on surficial sediments collected in San Diego Bay as part of ongoing Bay-wide sampling programs. As additional sediment quality data will be collected in the future by these programs, the approach taken here is reproducible, and the results presented here can be updated as new data become available from additional sites and as the chemical analysis is improved upon as more precise methods are developed. To that end, the R code (and input files) used in this study are provided for transparency and to facilitate the recalculation of contemporary ambient concentrations in the future (Appendix 3).

Lastly, the methods and results identified here are not the only method to evaluate sediment concentrations in the absence of pollution. While anthropogenic pollutant pre-discharge concentrations were zero, other pollutants were expected to be naturally present in the environment prior to discharges of waste to the Bay. Other methods for evaluating concentrations of these pollutants could be pursued on a Bay-wide or region-wide basis, such as by using sediment cores, elemental fingerprinting, or other scientific methods as they are developed.

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Appendix I: Site List

Table A1-1. San Diego Bay RHMP and Bioaccumulation Study sampling sites used.

Site	Latitude	Longitude	Stratum	Date Sampled	Project
B08-6015	32.60756	-117.12241	Shallow	8/22/2008	RHMP 2008
B08-6017	32.60837	-117.11141	Shallow	8/22/2008	RHMP 2008
B08-6031	32.63249	-117.13566	Shallow	8/22/2008	RHMP 2008
B08-6083	32.67028	-117.15477	Shallow	8/21/2008	RHMP 2008
B08-6084	32.67039	-117.13647	Deep	8/19/2008	RHMP 2008
B08-6090	32.67347	-117.13643	Shallow	8/19/2008	RHMP 2008
B08-6130	32.69424	-117.23779	Deep	8/20/2008	RHMP 2008
B08-6572	32.66888	-117.12869	Deep	8/18/2008	RHMP 2008
B13-8017	32.63157	-117.1308	Shallow	8/11/2013	RHMP 2013
B13-8020	32.64179	-117.1314	Shallow	8/11/2013	RHMP 2013
B13-8058	32.66147	-117.1441	Shallow	8/30/2013	RHMP 2013
B13-8078	32.68672	-117.1486	Deep	8/27/2013	RHMP 2013
B13-8093	32.6956	-117.1626	Deep	8/29/2013	RHMP 2013
B13-8118	32.71988	-117.1787	Deep	8/28/2013	RHMP 2013
B18-10022	32.72408	-117.1831	Deep	7/18/2018	RHMP 2018
B18-10023	32.7175	-117.2156	Deep	7/16/2018	RHMP 2018
B18-10024	32.7148	-117.183	Deep	7/19/2018	RHMP 2018
B18-10030	32.68784	-117.2303	Deep	7/16/2018	RHMP 2018
B18-10032	32.67526	-117.144	Shallow	7/20/2018	RHMP 2018
B18-10034	32.66526	-117.1499	Shallow	7/30/2018	RHMP 2018
B18-10035	32.66075	-117.1454	Shallow	7/30/2018	RHMP 2018
B18-10036	32.65816	-117.1444	Shallow	7/30/2018	RHMP 2018
B18-10038	32.64268	-117.1262	Shallow	7/31/2018	RHMP 2018
B18-10039	32.64158	-117.139	Shallow	7/30/2018	RHMP 2018
B18-10041	32.62848	-117.1254	Shallow	8/1/2018	RHMP 2018
B18-10042	32.62559	-117.1113	Shallow	8/1/2018	RHMP 2018
B18-10077	32.72496	-117.1834	Shallow	7/18/2018	RHMP 2018
B18-10116	32.6914	-117.1534	Deep	7/19/2018	RHMP 2018
B18-10117	32.69188	-117.2384	Deep	7/16/2018	RHMP 2018
B18-10133	32.67313	-117.1294	Deep	7/26/2018	RHMP 2018
B18-10141	32.66045	-117.1254	Deep	7/27/2018	RHMP 2018
B18-10144	32.65118	-117.123	Deep	7/30/2018	RHMP 2018
SWHB-01	32.6724	-117.1544	Shallow	4/16/2014	2014 Bioaccumulation Study
SWHB-02	32.67494	-117.1559	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-06	32.68185	-117.1513	Shallow	4/7/2014	2014 Bioaccumulation Study

SWHB-07	32.64702	-117.1429	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-09	32.68077	-117.1548	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-10	32.68487	-117.1634	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-11	32.60259	-117.1163	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-13	32.63547	-117.1381	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-14	32.61416	-117.122	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-15	32.60923	-117.1079	Shallow	4/15/2014	2014 Bioaccumulation Study
SWHB-16	32.6175	-117.1169	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-18	32.60573	-117.1209	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-19	32.60828	-117.119	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-20	32.62629	-117.1121	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-21	32.63798	-117.1231	Shallow	4/15/2014	2014 Bioaccumulation Study
SWHB-22	32.6231	-117.1202	Shallow	4/15/2014	2014 Bioaccumulation Study
SWHB-23	32.61	-117.1149	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-24	32.63681	-117.1174	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-25	32.63007	-117.1244	Shallow	4/8/2014	2014 Bioaccumulation Study
SWHB-26	32.68911	-117.1632	Shallow	4/17/2014	2014 Bioaccumulation Study
SWHB-28	32.70289	-117.1803	Shallow	4/17/2014	2014 Bioaccumulation Study
SWHB-30	32.68464	-117.2243	Shallow	4/18/2014	2014 Bioaccumulation Study
SWHB-33	32.66704	-117.1555	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-36	32.67863	-117.1681	Shallow	4/9/2014	2014 Bioaccumulation Study
SWHB-41	32.62669	-117.1281	Shallow	4/9/2014	2014 Bioaccumulation Study

Appendix II: Analytical Methods, Method Detection Limits, and Reporting Limits

Table 2-1. 2008 RHMP study. Metals with corresponding analytical method, method detection limit, and reporting limit. All masses are in micromoles per gram of dry weight (Source: CRG Marine Laboratories Electronic Data Format (EDF) report).

Metal	Method	Method Detection Limit (µg/g)	Reporting Limit (µg/g)
Cadmium	EPA 200.8m	0.025	0.05
Copper	EPA 200.8m	0.025	0.05
Lead	EPA 200.8m	0.025	0.05
Mercury	EPA 245.7	0.01	0.02
Zinc	EPA 200.8m	0.025	0.05

Table A2-2. 2013 RHMP study. Metals with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: PHYSIS Environmental Laboratories Electronic Data Format (EDF) report).

Metal	Method	Method Detection Limit (µg/g)	Reporting Limit (µg/g)
Cadmium	EPA 6020	0.0025	0.005
Copper	EPA 6020	0.0025	0.005
Lead	EPA 6020	0.0025	0.005
Mercury	EPA 245.7	0.00001	0.00002
Zinc	EPA 6020	0.0025	0.005

Table II-3. 2014 Bioaccumulation Study, metals with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: PHYSIS Environmental Laboratories Electronic Data Format (EDF) report).

Metal	Method	Method Detection Limit (µg/g)	Reporting Limit (µg/g)
Cadmium	EPA 6020	0.0025	0.005
Copper	EPA 6020	0.0025	0.005
Lead	EPA 6020	0.0025	0.005
Mercury	EPA 245.7	0.00001	0.00002
Zinc	EPA 6020	0.025	0.05

Table A2-4. 2018 RHMP study. Metals with corresponding analytical method, method detection level, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: Wood Environment & Infrastructure MS Excel Electronic Data Format (EDF) spreadsheet).

Metal	Method	Method Detection Limit (µg/g)	Reporting Limit (µg/g)
Cadmium	EPA 6020	0.0025	0.005
Copper	EPA 6020	0.0025	0.005
Lead	EPA 6020	0.0025	0.005
Mercury	EPA 245.7	0.00001	0.00002
Zinc	EPA 6020	0.025	0.05

Table A2-5. 2008 RHMP study. Polynuclear aromatic hydrocarbon (PAH) species used to calculate total PAHs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PAH Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
1-Methylnaphthalene	EPA 8270C	1	5
1-Methylphenanthrene	EPA 8270C	1	5
2,3,5-Trimethylnaphthalene	EPA 8270C	1	5
2,6-Dimethylnaphthalene	EPA 8270C	1	5
2-Methylnaphthalene	EPA 8270C	1	5
Acenaphthene	EPA 8270C	1	5
Acenaphthylene	EPA 8270C	1	5
Anthracene	EPA 8270C	1	5
Benz[a]anthracene	EPA 8270C	1	5
Benzo[a]pyrene	EPA 8270C	1	5
Benzo[b]fluoranthene	EPA 8270C	1	5
Benzo[e]pyrene	EPA 8270C	1	5
Benzo[g,h,i]perylene	EPA 8270C	1	5
Benzo[k]fluoranthene	EPA 8270C	1	5
Biphenyl	EPA 8270C	1	5
Chrysene	EPA 8270C	1	5
Dibenz[a,h]anthracene	EPA 8270C	1	5
Dibenzothiophene	EPA 8270C	1	5
Fluoranthene	EPA 8270C	1	5
Fluorene	EPA 8270C	1	5
Indeno[1,2,3-c,d]pyrene	EPA 8270C	1	5
Naphthalene	EPA 8270C	1	5
Perylene	EPA 8270C	1	5
Phenanthrene	EPA 8270C	1	5
Pyrene	EPA 8270C	1	5

Table A2-6. 2013 RHMP study. Polynuclear aromatic hydrocarbon (PAH) species used to calculate total PAHs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PAH Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
1-Methylnaphthalene	EPA 8270C	1	5
1-Methylphenanthrene	EPA 8270C	1	5
2,3,5-Trimethylnaphthalene	EPA 8270C	1	5
2,6-Dimethylnaphthalene	EPA 8270C	1	5
2-Methylnaphthalene	EPA 8270C	1	5
Acenaphthene	EPA 8270C	1	5
Acenaphthylene	EPA 8270C	1	5
Anthracene	EPA 8270C	1	5
Benz[a]anthracene	EPA 8270C	1	5
Benzo[a]pyrene	EPA 8270C	1	5
Benzo[b]fluoranthene	EPA 8270C	1	5
Benzo[e]pyrene	EPA 8270C	1	5
Benzo[g,h,i]perylene	EPA 8270C	1	5
Benzo[k]fluoranthene	EPA 8270C	1	5
Biphenyl	EPA 8270C	1	5
Chrysene	EPA 8270C	1	5
Dibenz[a,h]anthracene	EPA 8270C	1	5
Dibenzothiophene	EPA 8270C	1	5
Fluoranthene	EPA 8270C	1	5
Fluorene	EPA 8270C	1	5
Indeno[1,2,3-c,d]pyrene	EPA 8270C	1	5
Naphthalene	EPA 8270C	1	5
Perylene	EPA 8270C	1	5
Phenanthrene	EPA 8270C	1	5
Pyrene	EPA 8270C	1	5

Table A2-7. 2014 Bioaccumulation Study. Polynuclear aromatic hydrocarbon species (PAH) used to calculate total PAHs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PAH Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
(d10-Acenaphthene)	EPA 8270D	1	5
(d10-Phenanthrene)	EPA 8270D	1	5
(d12-Chrysene)	EPA 8270D	1	5
(d8-Naphthalene)	EPA 8270D	1	5
1-Methylnaphthalene	EPA 8270D	1	5
1-Methylphenanthrene	EPA 8270D	1	5
2,3,5-Trimethylnaphthalene	EPA 8270D	1	5
2,6-Dimethylnaphthalene	EPA 8270D	1	5
2-Methylnaphthalene	EPA 8270D	1	5
Acenaphthene	EPA 8270D	1	5
Acenaphthylene	EPA 8270D	1	5
Anthracene	EPA 8270D	1	5
Benz[a]anthracene	EPA 8270D	1	5
Benzo[a]pyrene	EPA 8270D	1	5
Benzo[b]fluoranthene	EPA 8270D	1	5
Benzo[e]pyrene	EPA 8270D	1	5
Benzo[g,h,i]perylene	EPA 8270D	1	5
Benzo[k]fluoranthene	EPA 8270D	1	5
Biphenyl	EPA 8270D	1	5
Chrysene	EPA 8270D	1	5
Dibenz[a,h]anthracene	EPA 8270D	1	5
Dibenzothiophene	EPA 8270D	1	5
Fluoranthene	EPA 8270D	1	5
Fluorene	EPA 8270D	1	5
Indeno[1,2,3-c,d]pyrene	EPA 8270D	1	5
Naphthalene	EPA 8270D	1	5
Perylene	EPA 8270D	1	5
Phenanthrene	EPA 8270D	1	5
Pyrene	EPA 8270D	1	5

Table A2-8. 2018 RHMP study. Polynuclear aromatic hydrocarbon (PAH) species used to calculate total PAHs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PAH Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
1,6,7-Trimethylnaphthalene	EPA 8270Cm	0.059	0.5
1-Methylnaphthalene	EPA 8270Cm	0.084	0.5
1-Methylphenanthrene	EPA 8270Cm	0.076	0.5
2,3,5-Trimethylnaphthalene	EPA 8270Cm	NA	NA
2,6-Dimethylnaphthalene	EPA 8270Cm	0.065	0.5
2-Methylnaphthalene	EPA 8270Cm	0.106	0.5
Acenaphthene	EPA 8270Cm	0.078	0.5
Acenaphthylene	EPA 8270Cm	0.058	0.5
Anthracene	EPA 8270Cm	0.046	0.5
Benz[a]anthracene	EPA 8270Cm	0.107	0.5
Benzo[a]pyrene	EPA 8270Cm	0.106	0.5
Benzo[b]fluoranthene	EPA 8270Cm	0.063	0.5
Benzo[e]pyrene	EPA 8270Cm	0.098	0.5
Benzo[g,h,i]perylene	EPA 8270Cm	0.093	0.5
Benzo[k]fluoranthene	EPA 8270Cm	0.111	0.5
Biphenyl	EPA 8270Cm	0.092	0.5
Chrysene	EPA 8270Cm	0.067	0.5
Dibenz[a,h]anthracene	EPA 8270Cm	0.106	0.5
Dibenzothiophene	EPA 8270Cm	0.2	0.5
Fluoranthene	EPA 8270Cm	0.035	0.5
Fluorene	EPA 8270Cm	0.068	0.5
Indeno[1,2,3-c,d]pyrene	EPA 8270Cm	0.087	0.5
Naphthalene	EPA 8270Cm	0.187	0.5
Perylene	EPA 8270Cm	0.11	0.5
Phenanthrene	EPA 8270Cm	0.074	0.5
Pyrene	EPA 8270Cm	0.048	0.5

Table A2-9. 2008 RHMP study. Polychlorinated biphenyl (PCB) congeners used to calculate total PCBs with corresponding analytical chemistry method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PCB Congener	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
PCB008, PCB018, PCB028, PCB031, PCB033, PCB044, PCB049, PCB052, PCB066, PCB070, PCB074, PCB077, PCB087, PCB095, PCB097, PCB099, PCB101, PCB105, PCB110, PCB114, PCB118, PCB126, PCB128, PCB138, PCB141, PCB149, PCB151, PCB153, PCB156, PCB157, PCB158, PCB169, PCB170, PCB174, PCB177, PCB180, PCB183, PCB187, PCB189, PCB194, PCB195, PCB201, PCB203, PCB206, PCB209	EPA 8270C	1	5

Table A2-10. 2013 RHMP study. Polychlorinated biphenyl (PCB) congeners used to calculate total PCBs with corresponding analytical chemistry method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PCB Congener	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
PCB008, PCB018, PCB028, PCB031, PCB033, PCB044, PCB049, PCB052, PCB066, PCB070, PCB074, PCB077, PCB087, PCB095, PCB097, PCB099, PCB101, PCB105, PCB110, PCB114, PCB118, PCB126, PCB128, PCB138, PCB141, PCB149, PCB151, PCB153, PCB156, PCB157, PCB158, PCB169, PCB170, PCB174, PCB177, PCB180, PCB183, PCB187, PCB189, PCB194, PCB195, PCB201, PCB203, PCB206, PCB209	EPA 8270C	0.05	0.1

Table A2-11. 2014 Bioaccumulation Study. Polychlorinated biphenyl (PCB) congeners used to calculate total PCBs with corresponding analytical chemistry method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PCB Congener	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
PCB008, PCB018, PCB028, PCB031, PCB033, PCB044, PCB049, PCB052, PCB066, PCB070, PCB074, PCB077, PCB087, PCB095, PCB097, PCB099, PCB101, PCB105, PCB110, PCB114, PCB118, PCB126, PCB128, PCB138, PCB141, PCB149, PCB151, PCB153, PCB156, PCB157, PCB158, PCB169, PCB170, PCB174, PCB177, PCB180, PCB183, PCB187, PCB189, PCB194, PCB195, PCB201, PCB203, PCB206, PCB209	EPA 8270C	0.05	0.1

Table A2-12. 2018 RHMP study. Polychlorinated biphenyl (PCB) congeners used to calculate total PCBs with corresponding analytical chemistry method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight.

PCB Congener	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
PCB008	EPA 8270Cm	0.017	0.25
PCB018	EPA 8270Cm	0.029	0.25
PCB028	EPA 8270Cm	0.023	0.25
PCB031	EPA 8270Cm	0.1	0.25
PCB033	EPA 8270Cm	0.1	0.25
PCB044	EPA 8270Cm	0.028	0.25
PCB049	EPA 8270Cm	0.036	0.25
PCB052	EPA 8270Cm	0.012	0.25
PCB066	EPA 8270Cm	0.027	0.25
PCB070	EPA 8270Cm	0.023	0.25
PCB074	EPA 8270Cm	0.021	0.25
PCB077	EPA 8270Cm	0.018	0.25
PCB087	EPA 8270Cm	0.081	0.25
PCB095	EPA 8270Cm	0.1	0.25
PCB097	EPA 8270Cm	0.1	0.25
PCB099	EPA 8270Cm	0.028	0.25
PCB101	EPA 8270Cm	0.027	0.25
PCB105	EPA 8270Cm	0.047	0.25
PCB110	EPA 8270Cm	0.074	0.25
PCB114	EPA 8270Cm	0.072	0.25
PCB118	EPA 8270Cm	0.069	0.25
PCB126	EPA 8270Cm	0.086	0.25
PCB128	EPA 8270Cm	0.081	0.25
PCB138	EPA 8270Cm	0.057	0.25
PCB141	EPA 8270Cm	0.1	0.25
PCB149	EPA 8270Cm	0.092	0.25
PCB151	EPA 8270Cm	0.073	0.25
PCB153	EPA 8270Cm	0.065	0.25
PCB156	EPA 8270Cm	0.089	0.25
PCB157	EPA 8270Cm	0.103	0.25
PCB158	EPA 8270Cm	0.074	0.25
PCB169	EPA 8270Cm	0.116	0.25
PCB170	EPA 8270Cm	0.118	0.25
PCB174	EPA 8270Cm	0.12	0.25
PCB177	EPA 8270Cm	0.085	0.25

PCB180	EPA 8270Cm	0.154	0.25
PCB183	EPA 8270Cm	0.056	0.25
PCB187	EPA 8270Cm	0.168	0.25
PCB189	EPA 8270Cm	0.109	0.25
PCB194	EPA 8270Cm	0.164	0.25
PCB195	EPA 8270Cm	0.093	0.25
PCB201	EPA 8270Cm	0.104	0.25
PCB203	EPA 8270Cm	0.12	0.25
PCB206	EPA 8270Cm	0.155	0.25
PCB209	EPA 8270Cm	0.12	0.25

Table A2-13. 2008 RHMP study. Dieldrin and chlordanes with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: CRG Marine Laboratories EDDs).

Chlorinated Pesticide Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
Dieldrin	EPA 8270Cm	1	5
Chlordane-alpha	EPA 8270Cm	1	5
Chlordane-gamma	EPA 8270Cm	1	5
cis-Nonachlor	EPA 8270Cm	1	5
Oxychlordane	EPA 8270Cm	1	5
trans-Nonachlor	EPA 8270Cm	1	5

Table A2-14. 2013 RHMP study. Dieldrin and chlordanes with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: CRG Marine Laboratories EDDs).

Chlorinated Pesticide Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
Dieldrin	EPA 8270Cm	0.05	0.1
Chlordane-alpha	EPA 8270Cm	0.05	0.1
Chlordane-gamma	EPA 8270Cm	0.05	0.1
cis-Nonachlor	EPA 8270Cm	0.05	0.1
Oxychlordane	EPA 8270Cm	0.05	0.1
trans-Nonachlor	EPA 8270Cm	0.05	0.1

Table A2-15. 2014 Bioaccumulation Study. Dieldrin and chlordanes with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: CRG Marine Laboratories EDDs).

Chlorinated Pesticide Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
Dieldrin	EPA 8270D	0.05	0.1
Chlordane-alpha	EPA 8270D	0.05	0.1
Chlordane-gamma	EPA 8270D	0.05	0.1
cis-Nonachlor	EPA 8270D	0.05	0.1
Oxychlordane	EPA 8270D	0.05	0.1
trans-Nonachlor	EPA 8270D	0.05	0.1

Table A2-16. 2018 RHMP study. Dieldrin and chlordanes with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: CRG Marine Laboratories EDDs).

Chlorinated Pesticide Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
Dieldrin	EPA 8270Cm	0.1	0.2
Chlordane-alpha	EPA 8270Cm	0.187	0.5
Chlordane-gamma	EPA 8270Cm	0.179	0.5
cis-Nonachlor	EPA 8270Cm	0.192	0.5
Oxychlordane	EPA 8270Cm	0.25	0.5
trans-Nonachlor	EPA 8270Cm	0.186	0.5

Table A2-17. 2008 RHMP study. Dichlorodiphenyltrichloroethane (DDT) species used to calculate total DDTs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: CRG Marine Laboratories EDDs).

DDT Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
2,4’ DDD	EPA 8270Cm	1	5
2,4’ DDE	EPA 8270Cm	1	5
2,4’ DDT	EPA 8270Cm	1	5
4,4’ DDD	EPA 8270Cm	1	5
4,4’ DDE	EPA 8270Cm	1	5
4,4’ DDMU	EPA 8270Cm	1	5
4,4’ DDT	EPA 8270Cm	1	5

Table A2-18. 2013 RHMP study. Dichlorodiphenyltrichloroethane (DDT) species used to calculate total DDTs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: Physis EDDs).

DDT Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
2,4’ DDD	EPA 8270Cm	0.05	0.1
2,4’ DDE	EPA 8270Cm	0.05	0.1
2,4’ DDT	EPA 8270Cm	0.05	0.1
4,4’ DDD	EPA 8270Cm	0.05	0.1
4,4’ DDE	EPA 8270Cm	0.05	0.1
4,4’ DDMU	EPA 8270Cm	0.05	0.1
4,4’ DDT	EPA 8270Cm	0.05	0.1

Table A2-19. 2014 Bioaccumulation Study. Dichlorodiphenyltrichloroethane (DDT) species used to calculate total DDTs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: Physis EDDs).

DDT Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
2,4’ DDD	EPA 8270Cm	0.05	0.1
2,4’ DDE	EPA 8270Cm	0.05	0.1
2,4’ DDT	EPA 8270Cm	0.05	0.1
4,4’ DDD	EPA 8270Cm	0.05	0.1
4,4’ DDE	EPA 8270Cm	0.05	0.1
4,4’ DDMU	EPA 8270Cm	0.05	0.1
4,4’ DDT	EPA 8270Cm	0.05	0.1

Table A2-20. 2018 RHMP study. Dichlorodiphenyltrichloroethane (DDT) species used to calculate total DDTs with corresponding analytical method, method detection limit, and reporting limit. All masses are in nanograms per gram and represent dry weight (Source: Report Tables No Copy of Physis EDD).

DDT Species	Method	Method Detection Limit (ng/g)	Reporting Limit (ng/g)
2,4’ DDD	EPA 8270Cm	0.267	0.5
2,4’ DDE	EPA 8270Cm	0.2	0.5
2,4’ DDT	EPA 8270Cm	0.194	0.5
4,4’ DDD	EPA 8270Cm	0.198	0.5
4,4’ DDE	EPA 8270Cm	0.193	0.5
4,4’ DDMU	EPA 8270Cm	0.223	0.5
4,4’ DDT	EPA 8270Cm	0.128	0.5

Appendix III: Sample Input Data

The full dataset and R programming code is available upon request.

Table A3-1. Sample polychlorinated biphenyl input data for calculation of Total PCBs. * MDL = Method Detection Limit, RL = Reporting Limit, ND = Non-Detect

Site	Stratum	Sampled	Matrix	Parameter	Qualifier	Result	Unit	MDL	RL
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 008	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 018	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 028	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 031	None	0.33	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 033	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 044	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 049	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 052	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 066	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 070	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 074	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 077	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 087	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 095	None	0.44	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 097	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 099	None	0.32	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 101	None	0.48	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 105	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 110	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 114	None	0.18	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 118	None	0.64	ng/g dw	0.05	0.1

SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 126	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 128	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 138	None	0.85	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 141	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 149	None	0.52	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 151	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 153	None	0.89	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 156	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 157	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 158	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 169	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 170	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 174	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 177	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 180	None	0.65	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 183	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 187	None	0.37	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 189	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 194	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 195	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 201	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 203	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 206	ND	0.00	ng/g dw	0.05	0.1
SWHB-01	Shallow-SWHB	4/16/2014	Sediment	PCB 209	ND	0.00	ng/g dw	0.05	0.1