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April 8, 2013

VIA EMAIL

Ms. Lisa Honma
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, California 92123

Re: Tentative Resolution R9-2013-0003

Dear Ms. Honma:

On behalf of National Steel and Shipbuilding Company ("NASSCO"), please find enclosed technical comments regarding Tentative Resolution R9-2013-0003 for the mouth of Chollas Creek TMDL, prepared by Rick Bodishbaugh, Gary Bigham, and Thomas Ginn of Exponent. The enclosed comments supplement the comment letter prepared by my office that is being submitted concurrently.

Very truly yours,

Jeffrey P. Carlin
of LATHAM & WATKINS LLP

cc: Kelly Richardson
Matthew Luxton
Michael Askew
T. Michael Chee

Exponent®

E X T E R N A L   M E M O R A N D U M

TO: Michael Chee, NASSCO

FROM: Rick Bodishbaugh, Ph.D., Gary Bigham, Thomas Ginn, Ph.D.

DATE: April 8, 2013

PROJECT: PH10719.001 1004

SUBJECT: Review of Chollas Creek TMDLs

We have reviewed the Draft Technical Report authored by the San Diego Region Water Quality Control Board (the Board) to support TMDL values developed for Paleta, Chollas, and Switzer Creeks (TMDL report; RWQCB 2013), together with appendices and supporting documents posted for public review on the Board website[1]. We have also reviewed additional information obtained through NASSCO's Public Records Act request and provided to us by counsel. As requested, our comments focus specifically on Chollas Creek and the scientific validity and applicability of the TMDL values for that watershed, though many comments may also be relevant to Paleta and Switzer Creeks.

Overview of TMDL Approach

The draft TMDL report asserts that chlordane, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) are pollutants causing impairment of beneficial uses in all three creek mouths in San Diego Bay, and TMDLs are proposed, in accordance with Clean Water Act section 303(d) requirements. The report includes mass-based TMDLs to control watershed discharges and concentration-based TMDL target levels for the sediment, fish, and waters that occur at the mouths of the creeks. The report states that these TMDLs are intended to provide sediment quality that supports healthy benthic communities and protects aquatic-

1 http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/sediment_toxicity.shtml

dependent wildlife from bioaccumulation of toxic pollutants in the food web, as well as to protect human health from ingestion of contaminated fish from the bay.

Target concentrations for total chlordane, benzo[a]pyrene, and total PCBs in creek mouth water are taken directly from the California Toxics Rule (CTR) human health targets for consumption of organisms. As such, these targets solely reflect a value deemed to be protective of humans who consume seafood from San Diego Bay. A fish tissue target concentration for total PCBs is taken directly from the OEHHA Fish Contaminant Goal for PCB cancer risk to humans (OEHHA 2008). Sediment target concentrations for total chlordane, total priority pollutant PAHs and total PCBs are derived using a novel method that employs sediment quality triad data and the California Sediment Quality Objective (SQO) assessment process. Sediment target concentrations therefore solely reflect a value deemed to be protective of the benthic macroinvertebrate community at the TMDL sites.

While the sediment TMDLs described in the report are stated to be specific to the three central San Diego Bay creek mouths identified in the title, the values are actually derived from a pool of sediment and biological data that includes samples collected at 303(d) listed impaired locations elsewhere in San Diego Bay, including the Downtown Anchorage, B Street, and Broadway Pier sites in the northern portion of the Bay. Furthermore, the sediment TMDLs are numerically identical to preliminary values recently proposed by the Board for the Downtown Anchorage and B Street TMDL area at a recent stakeholder outreach workshop (Cheng 2013). In effect, these values are actually being developed by the Board as Bay-wide TMDLs, though the various TMDL sites are on different completion schedules. This aspect of the approach has important technical ramifications in that it implicitly presumes that all sites share common chemical and biological conditions, degrees of impairment, and causes of impairment, and that the same limits and target concentrations are appropriate and justified at each location.

Summary of Comments

Our review finds that the fundamental approach and many of the quantitative results and target concentrations for sediments developed in the TMDL report are technically flawed and scientifically unjustified. Because of these flaws, any TMDL developed using the approach described in the subject document will not enable the stated objective of protecting beneficial uses or mitigating impairment. The following is a summary of major deficiencies and technically unsupported conclusions we have identified. Detailed descriptions of each technical deficiency follow.

- Impairment of the Chollas Creek mouth due to PCB contamination has not been demonstrated, and is not apparent from available data. The Chollas Creek sediment Toxicity Identification Evaluation (TIE), conducted by the Southern California Coastal Water Research Project (SCCWRP), concluded that PCBs were not a source of toxicity. Analysis of available data indicates that Chollas Creek is not currently a source of PCBs and no TMDL for PCBs is warranted.

- The TMDL sample pool, used to develop numeric target criteria for sediments are not necessarily representative of any single watershed, and the Board has made no attempt to justify their use on a Bay wide basis or control for site-specific differences between the various TMDL assessment areas. They have furthermore failed to consider known differences between watersheds in their development of target criteria.

- The SQO assessment process used by the Board to set sediment target levels is incomplete, is not compliant with State Water Board guidance on interpretation of SQO data, and fails to demonstrate any evidence of a causal exposure-response relationship in the underlying data.

- A simple evaluation of the SQO chemical and biological data (performed by us) reveals that there is no causal relationship between sediment concentrations of chlordane, PAH or PCBs and toxicity or benthic community disturbance. In other words, the very SQO analysis used by the Board to derive the target concentrations in sediments indicates that these chemicals are not causing toxicity or community disturbance in the TMDL sample pool. The SQO station score result of "unimpacted" or "likely unimpacted" within this pool of samples is not driven by the sediment concentrations of chlordane, PAH or PCBs. Thus the target sediment concentrations which are solely based on this outcome have no causal basis or validity.

- Even given the flawed and erroneous assumptions made by the Board in their use of SQO station scores to set sediment target concentrations, their calculations misrepresent the actual concentrations of chlordane, PAHs and PCBs associated with "unimpacted" and "likely unimpacted" stations from their selected pool of data. Rather than the upper confidence limit on the mean concentration from these reference categories, the Board should have chosen a value more representative of the upper end of the distribution, such as a upper confidence limit of the entire distribution, as recommended by regulatory guidance on characterization of background or reference concentrations.

- In general, the quantitative derivation of sediment target concentrations in the TMDL report is poorly documented, inadequately explained or justified, misuses or fails to properly interpret data distributions (e.g., method of calculating sediment targets from existing data), and cannot be replicated from the information provided in the report and attachments. The report and conclusions reached lack transparency.

Comment #1 - No TMDL for PCBs is warranted at Chollas Creek.

Summary

The Board's determination that PCBs are a source of significant impairment in the mouth of Chollas Creek, and their requirement for a TMDL for PCBs in creek sediment and water cannot be supported by the data upon which the report relies. On the contrary, an evaluation of available data, including data cited in the TMDL report, clearly indicates that sediment and water column PCBs are not a source of impairment in the mouth of Chollas Creek.

The Chollas Creek watershed is not a significant current source of PCBs to the creek-mouth sediment or to San Diego Bay. Furthermore, PCBs in sediments at the mouth of Chollas Creek are not causing sediment toxicity or benthic community disturbance. The draft TMDL report provides no justification, within the TMDL regulatory framework, for including PCBs as a compound of concern. The sole justification provided for inclusion of PCBs at Chollas Creek is a quantitative finding that sediment PCBs bioaccumulate in clam tissue in laboratory bioassays. There is no quantitative linkage between Chollas Creek mouth PCBs and impairment.

The draft TMDL report was developed using the prescribed seven components:

1. Problem statement
2. Identification of numeric targets
3. Source analysis
4. Linkage analysis to calculate the loading capacity
5. Determine a margin of safety to account for uncertainties
6. Allocation of the allowable load
7. Consideration of seasonal variation and critical conditions.

A detailed review of each component for PCBs in Chollas Creek, with identification of major deficiencies follows.

Problem Statement

Although reduction of sediment toxicity is the primary focus of the draft TMDL report, PCBs in Chollas Creek sediment have not been linked to any measured adverse effect (benthic community disturbance, direct toxicity to amphipods, or to effects on survival, growth, or development of sea urchin embryos; SCCWRP 2011). As stated in the Chollas Creek TIE study (SCCWRP 2011), "Data from other laboratory and field studies indicate that the measured concentrations of DDTs and PCBs at the study sites are several orders of magnitude lower that (sic) the levels associated with direct toxicity from sediment exposure."

The only allegation that PCBs in Chollas Creek are linked to impairment, as stated on page 8 of the draft TMDL report, is that PCBs were found to bioaccumulate in clam tissue during laboratory tests of field collected sediments (data from Anderson et al. 2005), and are a "potential source contributing to elevated fish tissue concentrations found in San Diego Bay". This qualitative allegation falls well short of demonstration of any causal or quantitative link between Chollas Creek sediment chemicals and impairment. Also, laboratory bioaccumulation results are not relevant to impairment of the three beneficial uses of Chollas Creek that are listed in Table 2 – 4 of the TMDL report; non-contact water recreation, warm freshwater habitat, and wildlife habitat. Furthermore, the laboratory bioassay used, which measures accumulation of sediment contaminants in the filter-feeding clam *Macoma nasuta*, is an inappropriate surrogate for fish bioaccumulation. *Macoma* clams directly ingest sediment particles and carry large gutloads of sediment. The *Macoma* test, which involves incubation of clams over sediment samples in the laboratory, is therefore a highly conservative indicator of bioaccumulation potential. Such a test does not incorporate any of the complex trophic, behavioral, and spatial factors that determine bioaccumulation of sediment chemicals in fish, which typically move and integrate their exposure over large areas. Use of measured tissue concentrations from the *Macoma* test for exposure modeling or any quantitative purpose would be inappropriate and excessively conservative. The Board has not demonstrated causality between Chollas Creek mouth PCBs and impairment, and has not quantitatively linked bioaccumulation potential of Chollas Creek mouth PCBs to human health or wildlife food-web exposure elsewhere in the Bay. The sole evidence relied upon (*Macoma* bioaccumulation data) does not constitute a causal linkage between PCBs in sediments and impairment of human health or wildlife beneficial uses.

Identification of Numeric Targets

The numeric target listed in Table 4-1 of the Draft TMDL report for PCBs in Chollas Creek mouth sediments, 168 µg/kg, is derived from a flawed and inappropriate use of the California SQO assessment methodology (see comments 3, 4, and 5 below). This value is not risk-based, and has no relevance or relationship to sediment toxicity, bioaccumulation, or impairment in the mouth of Chollas Creek. It does not represent the upper range of PCBs in unimpacted sediments, is not an effect threshold, and cannot be reliably linked to the presence or absence of ecological effects.

Even if this inappropriate target value is accepted for purposes of discussion, the available data indicate that no action is required in the mouth of Chollas Creek to attain the target. The Chollas Creek sediment TIE (SCCWRP 2011), analyzed surface sediments (0 – 2.5 cm) at three stations in the mouth of Chollas Creek for sediment toxicity in three separate surveys. The concentrations measured at stations C10 and C14 in 2001 (189.49 µg/kg and 211.57 µg/kg, respectively) exceeded the numeric target of 168 µg/kg. The concentrations of PCBs measured in 2002 at the same stations were less than the numeric target at 112.94 µg/kg at C10 and 54.58 µg/kg at C14. PCBs were not detected in 2004 at station C13. All congeners were below the detection limit of 1 µg/kg. While the number of samples was limited, it clearly suggests a decreasing trend in the concentration of PCBs in the surface sediment of the Chollas Creek mouth and compliance with the numeric target. As noted above, the TIE study concluded that PCBs levels were far too low to cause sediment toxicity.

Additional sediment PCB concentrations were reported by Brown and Bay (2011) for stations C10 and C14. These samples were collected in July and November of 2001 and February, June, and October 2002. The July 2001 and October 2002 results are the same data reported by SCCWRP (2011). The PCB concentrations in the top 2 cm of sediment at station C10 ranged from 109 – 202 µg/kg with a mean of 138 µg/kg. The concentrations reported for station C14 ranged from 77 – 212 µg/kg with a mean of 136 µg/kg. In both cases the mean values were less than the TMDL target sediment concentration.

The numeric target for PCBs in water at the Chollas Creek mouth is 0.00017 µg/L (0.17 ng/L or parts per trillion). Two wet-weather sampling events were conducted by Tetra Tech/Mactec (2010) in the Chollas Creek drainage basin. In the first event, no PCB congeners or Aroclors were detected. In the second event, seven congeners[2] were detected at temporary wet weather station MAC15 at concentrations ranging from approximately 4.0 to 9.5 ng/L (Figure 6-41). None of the detected PCB congeners are considered to exhibit dioxin-like toxicity (Van Den Berg, et al. 2006). As seen in Figure 1, Station MAC15 is located well upstream in the drainage basin and upstream of the Chollas Creek mouth. No PCBs were reported at the stations (MAC11 and MAC17) nearest the mouth of Chollas Creek. Taken together, the results of the two stormwater sampling events indicate that the Chollas Creek drainage basin is currently an insignificant source of PCBs to the mouth of Chollas Creek and to San Diego Bay.

Source Analysis

The draft TMDL report states in section 5.2 that potential pollutant sources were identified based on wet-weather stormwater data collected in Chollas Creek; whereas sediment data were used to confirm impairment and to relate pollutant loading with pollutant deposition and impairment. The only wet-weather source attributed to NASSCO is stormwater runoff from the employee parking lots, which are stated to contain oil and grease and PAHs that are deposited on the parking lot surfaces by motor vehicles (dismissed as a “negligible” source in the TMDL

[2] PCB congeners 031, 044, 049, 052, 066, 095, and 101.

Order). Section 5.4.2 of the draft TMDL report notes PCBs have generally not been detected in stormwater and storm drain studies in the Chollas Creek drainage basin.

The draft TMDL report notes that NASSCO operates and maintains a stormwater diversion system that has eliminated the discharge of industrial stormwater to San Diego Bay. In spite of the fact that NASSCO's facilities do not contribute PCBs to the mouth of Chollas Creek, NASSCO is listed in Table 5-4 as a "primary source" contributing PCBs to the mouth of Chollas Creek. The inclusion of NASSCO as a source of PCBs to surface water or impairment due to PCBs in sediment of Chollas Creek is clearly not supported by the data presented in the draft TMDL report. Given the rate of sedimentation for this part of San Diego Bay, estimated at 1 to 2 cm/year (RWQCB 2012), and the fact that NASSCO stopped discharging stormwater to Chollas Creek in 1997, it is highly unlikely that any contaminants present today in surface sediments at the mouth of Chollas Creek originated at the NASSCO shipyard.

Linkage Analysis

The linkage of contaminant sources to the water column and sediments in the mouth of Chollas Creek is based on modeling contaminant loading by stormwater runoff from the Chollas Creek drainage basin. The fate of the contaminant loading to the mouth of Chollas Creek and San Diego Bay is based on a separate circulation and sediment transport model. The results of the modeling analysis are stated in section 7.6.2, which states "Model results suggest that under existing loading, total PCBs meet the numeric target; therefore, no additional reduction of total PCBs is needed from the watershed." It should be noted that the analysis is additionally conservative because the numerous non-detected results were replaced by one-half the detection limit (0.05 ng/L) instead of zero. The detection limits of all PCB data used in the analysis are not stated in the TMDL report. So it is not clear if values greater than 0.05 ng/L were substituted for zero for non- detected values at higher detection limits.

Margin of Safety

A margin of safety of 5% was applied to the TMDL for PCBs. This means that 5% of the total allowable load is reserved to account for uncertainty in the analysis.

Allocation of the Allowable Load

The draft TMDL report sets the total maximum allowable load on a daily basis for Chollas Creek at 0.00331 g/d, which is equal to the existing calculated load in a high flow year. No reduction is, therefore, required. Section 8.1.1 of the draft TMDL report states the wasteload allocation for NASSCO:

> NASSCO is not permitted to discharge facility-related wastewater directly to the mouth of Chollas Creek (RWQCB 2009a); however, storm water runoff from the facility's employee parking lots discharges into Chollas Creek and is considered negligible for TMDL allocation. No other individual NPDES permits for point sources have been issued in these watersheds for total PCBs, total PAHs, or chlordane.

Given that no loading reduction is required to meet the allowable load, the justification for a PCB TMDL in Chollas Creek is unclear.

Consideration of Seasonal Variation and Critical Conditions

To be conservative, a critical period associated with extreme wet conditions (October 2004 to September 2005) was selected for loading analysis and TMDL calculations.

Comment #2 – The Bay-wide approach for setting individual watershed sediment target levels is not justified.

Summary

The Board has elected to use a pool of sediment data from TMDL candidate sites in northern and central San Diego Bay as the basis for determining sediment target concentrations. These appear to have been drawn from any source of available sediment quality Triad data that would permit an SQO analysis, though the data selection criteria for inclusion in their analysis is both unclear and complicated by discrepancies and poor documentation in the draft TMDL report itself (see discussion below and comment 6). The representativeness of the data pool used has not been demonstrated for any TMDL site. There is also no apparent attempt to control for or even identify differences between the level of beneficial use impairment, causes of impairment, environmental conditions, or other baseline factors that may influence beneficial uses at individual TMDL sites. Non-chemical stressors that can affect community structure, such as altered sediment grain size distribution and freshwater influences in the mouths of creeks are not considered, nor are known physical stressors, such as the proximity of the Chollas Creek mouth to NASSCO berths V and VI that are routinely used for engine testing (see discussion in Exponent 2003, section 4.1). There is no consideration of temporal trends, even though the data may be influenced by them. The data included were collected over a 7-year period (1998-2005), and include both known impaired areas and designated reference areas. In summary, the Board have employed a one-size-fits-all approach, which ignores important site-specific information and would require a technical justification that is not found in the draft TMDL report.

Sediment Data Selection

The data sources for derivation of sediment target values include the Southern California Bight 1998 Regional Monitoring Program (Bight ’98), the Phase 1 TMDL study of Chollas and Paleta Creeks (SCCWRP 2005), and the Phase 1 TMDL study of B Street, Broadway Piers, Downtown Anchorage and Switzer Creek (Anderson et al. 2004). The data selection and management process used by the Board in preparing their sediment data pool is poorly and inconsistently documented, to the point of being opaque. According to the report, “there were a total of 161 stations, with 190 samples collected from 1998 through 2003” (Appendix I, p. 2). However, examination of the data tables in Appendix I of the report reveals only 134 records from 69 unique sediment stations (only 10 of which are in the Chollas Creek mouth TMDL area). The data include multiple samples from many stations, which appear to be field replicates collected at the same time in some cases and time series samples collected in different seasons or years in other cases. It is unclear from the incomplete process description how or if replicate samples were combined by the Board or how time series data were handled, though it appears from the data tables that all samples were evaluated as independent stations. Replicate samples are tabulated separately with identical chemistry results. There is also reference in the report to exclusion of "statistical outliers" from the analysis (Appendix I, p. 4), though this exclusion process is neither explained nor documented.

In the information produced by the Board in response to NASSCO's Public Records Act request, we did find working files that document the data used by the Board to calculate sediment target concentrations (output files from the ProUCL program). The sample and station count match those cited above from the text, but the source of much of the data is unclear. As a result of the inadequate documentation, it is impossible to fully evaluate the quality or representativeness of the data pool used and the data selection process employed by the Board.

Comment #3 – The SQO analysis performed by the Board is incomplete, and the use of SQO station scores to set TMDL target sediment limits is inappropriate.

Summary

The sediment target concentrations set by the Board are calculated as the 95 percent upper confidence limit of the mean (95% UCL) of sediment concentrations in samples which score as "unimpacted" or "likely unimpacted" in a SQO analysis. In selection of this approach, the Board has inappropriately presumed that SQO station scores reflect some causal impairment that can be linked to sediment concentrations of chlordane, PAH, and PCBs. The Board has performed no causal analysis of their selected sediment data pool, even though such an analysis is both straight-forward technically and is required by State Board guidance on interpretation of SQOs. The Board has also failed to evaluate or even acknowledge the possibility that SQO station scores can reflect the effects of non-chemical stressors.

SQO Guidance Requirements for Causal Analysis

The Part 1 SQO assessment method is a tool for determining whether or not sediment chemicals are causing benthic macroinvertebrate community disturbance. The State Board guidance document defines the overall objective of the process as follows:

> Part 1 integrates chemical and biological measures to determine if the sediment dependent biota are protected or degraded as a result of exposure to toxic pollutants in sediment and to protect human health. (SWRCB 2008, p. 4)

The Part 1 SQO method is an adaptation of sediment Triad analysis, where three independent lines of evidence (LOEs) are evaluated at each assessment station: sediment chemistry, sediment toxicity, and benthic community. Sediment samples are collected synoptically, assessed in the laboratory, and used to evaluate each LOE independently. A decision framework is then applied to the individual LOE findings to integrate them into a multiple line of evidence (MLOE) station score, which is a characterization of the likelihood that sediment contamination is causing adverse impacts to the benthic community. With respect to the overall objectives of the Part 1 SQOs, this would seem an appropriate tool for derivation of target concentration of sediment chemicals.

However, completion of the initial SQO MLOE analysis does not establish causality between community effects and sediment chemistry or any sediment chemical. Establishment of causality requires an additional step: stressor identification. When an SQO investigation concludes that benthic community impacts are likely or clear, stressor identification is the required next step to determine the cause of the apparent disturbance. The stressor identification approach consists of the development and implementation of a work plan focused on confirmation and characterization of pollutant-related impacts, pollutant identification and source identification as described in Section VII.F of the SQO guidance document:

> The MLOE assessment establishes a linkage to sediment pollutants; however, the lack of confounding factors (e.g., physical disturbance, non-pollutant constituents) must be confirmed. (SWRCB 2008, p. 17)

The guidance goes on to describe in detail the types of confounding factors that can lead to false indications of a chemical-mediated benthic impact, which include physical disturbance, sediment characteristics (e.g., grain size distribution, organic carbon content), freshwater influences (particularly likely in creek mouths), and uncharacterized chemical constituents. SQO guidance and method recommendations are also provided in a technical support manual developed by the technical team at SCCWRP, who developed the SQOs for the State Board (Bay et al. 2009). The SCCWRP Assessment Manual provides a more detailed discussion on recommended methods for stressor identification, which includes the following:

> Three types of additional information are needed to assist in the planning of actions to improve sediment quality: 1) confirmation that pollutants are indeed the basis for the impact; 2) establishment of what specific chemical(s) is the cause of impact; 3) identification of the source of the chemical(s). (Bay et al. 2009, p. 103)

The U.S. Environmental Protection Agency (EPA) has published more extensive guidance on stressor identification, which is acknowledged and recommended by the SCCWRP Assessment Manual (Bay et al. 2009). This federal guidance summarizes the process this way:

> The first step in the SI process is to develop a list of candidate causes, or stressors, that will be evaluated. This is accomplished by carefully describing the effect that is prompting the analysis (e.g., unexplained absence of brook trout) and gathering available information on the situation and potential causes. Evidence may come from the case at hand, other similar situations, or knowledge of biological processes or mechanisms. The outputs of this initial step are a list of candidate causes and a conceptual model that shows cause and effect relationships. (U.S. EPA 2000, p. 1-3)

Stressor identification is a second tier of the SQO assessment that is designed to identify specific drivers of apparent benthic impairment and establish causality of the sediment chemical or other stressor that is leading to a finding of impaired stations. The type of analysis required for stressor identification is determined by the outcome of the initial SQO Triad assessment, and should be tailored to the site and data.

Examples of the types of activities involved in the chemical linkage confirmation phase of stressor identification are described in the SCCWRP Assessment Manual and include:

- Assessment of confounding factors and other non-chemical stressors. Examples at Chollas Creek would be presence of physical disturbance from deposition and nearby shipyard activities, episodic salinity disturbance from storm events, and physical characteristics of creek mouth sediments.

- Comparison of site chemistry data to appropriate chemical-specific benchmarks. Examples at Chollas Creek would be site-specific sediment chemistry levels determined to be protective of the benthic community at the adjacent Shipyards Site, where lowest apparent effect thresholds (LAETs) were developed for total PCBs and high molecular weight PAHs (HPAH).

- Statistical analysis of data to test correlations between chemistry and biological endpoints (i.e., evaluation of an exposure-response relationship). This exercise could easily have been performed for Chollas Creek or the entire TMDL sample pool (see discussion under comment 4).

Only after confirmation that observed benthic impacts have a chemical cause does the SQO process move to the second phase that focuses on which specific chemicals are causing degradation, establishment of sediment concentrations associated with degradation, and beyond into mitigation of impacts. The presumptive approach of the Board in their incomplete application of the SQO method is that the causative agents of benthic community disturbance are known *a priori*, and that they are limited to the three TMDL target chemicals. In fact, an objective evaluation of the sediment data pool used to calculate the target concentrations clearly shows that these chemicals are not causally related to either toxicity or community disturbance (see comment 4 discussion below). Had the Board applied the principles of stressor identification, as required by the SQO guidance, they would have demonstrated a lack of chemical causality.

Comment #4 – Analysis of the sediment data pool used to set target concentrations provides strong evidence against chemical causality of impairment

Summary

The Board approach in selecting sediment chemical target concentrations presumes both chemical causation for the three TMDL target chemicals (which they have not demonstrated) and the existence of an exposure-response relationship. In other words, the method presumes that the degree of impairment is exposure dependent, and that the data can be interpreted to select a target concentration that reflects a “safe” exposure threshold for benthic macroinvertebrates. This assumption is readily testable using the Board’s selected data pool.

Correlation analysis provides a simple but powerful tool to assess the existence of an apparent exposure-response relationship between sediment concentrations and biological effects (either toxicity or community disturbance). A strong correlation does not necessarily demonstrate causation, but it demonstrates potential for causation, and can be interpreted to support a hypothesis of chemical causation. Absence of a strong correlation between exposure and effect is a clear indication that stressors other than the chemical being evaluated are responsible for any apparent adverse effects.

We have performed a simple series of regressions to evaluate the relationship between sediment chlordane, PAH, and PCB concentrations and biological effects that are included in the Board’s SQO analysis. These biological effects include two toxicity test responses: amphipod survival and bivalve larval development, as well as four benthic community metrics: BRI, RBI, IBI, and RIVPACs. None of the three target chemicals correlates well with any indicator of adverse biological effect that is incorporated into the SQO analysis. The very data used to derive the target sediment concentrations disprove the assumptions that underlie the derivation method selected. The data strongly indicate a lack of causation for the three TMDL target chemicals. Benthic community disturbance and toxicity are not a function of sediment concentrations of chlordane, PAH, or PCBs in these data. The underlying basic assumption of the derivation method is disproven by the data. The Board’s use of the data to set target levels is therefore

without technical justification, and the values themselves have no technical validity. Any action, such as sediment remediation or even development of wasteload allocations, that is based on these invalid targets is unlikely to result in any reduction of impairment or protection of beneficial uses. Only through a thorough stressor identification could actual sources of benthic community be confirmed and identified.

With regard to Chollas Creek, the recent Chollas Creek and Paleta Creek storm drain characterization study (Tetra Tech/Mactech, 2010) noted “Pyrethroid pesticides, copper, chlordane, DDT and malathion were the predominant causes of observed toxicity throughout the Chollas and Paleta Creek watersheds during wet weather events”. This further suggests that the Board has evaluated the wrong chemical stressors (with the possible exception of chlordane) to explain adverse biological effects on benthic communities.

Analysis of Data

We have tabulated the sediment data selected by the Board for their SQO-based target level derivation, as described in Appendix I-1 of the draft TMDL report (Table 1). As noted above, this appears to actually be a smaller data set than they ultimately used to derive their 95% UCL values, but it is the only pool of data provided in the draft TMDL report attachments for which we have complete Triad data (chemistry, toxicity, and benthic community). In our analysis, unique station locations were identified, and all replicate samples were averaged for a given location, to prevent bias in the data set from locations with multiple replicates or repeat samples.

The regressions of the three TMDL target chemicals on toxicity endpoints are shown in Figures 2 through 7. Positive correlations between TMDL chemical concentrations in sediment and toxicity are weak to non-existent for both amphipod mortality and bivalve larval development endpoints. The highest R-squared value is 0.27 for chlordane on amphipod toxicity, indicating that at least 73 percent of observed variability in amphipod survival is due to other factors. The R-squared value for PCBs on amphipod toxicity is only 0.11, indicating that 89 percent of observed variability is due to other factors. The PAH concentration in sediments can explain less than 1 percent of the observed variability in amphipod survival. The correlation coefficients for bivalve larval development endpoints are even lower for all three chemicals. This is a clear indication that the TMDL target chemical levels in sediment are poorly predictive of toxicity and cannot therefore be used to infer “safe” levels for benthic invertebrates.

Regressions for the three TMDL target chemicals on benthic community metrics are shown in Figures 8 through 19. Few and only very weak positive correlations exist between exposure and benthic community disturbance, the highest with an R-squared value of only 0.16 (chlordane on BRI). The regression of PCBs on BRI has an R-squared value of only 0.10. For all PAH correlations, and for all RBI, IBI, and RIVPACS correlations, sediment concentrations explain less than 4 percent of the observed variability. As a whole, these data clearly indicate that these three chemicals are not causally related to benthic community disturbance in the Board’s selected pool of samples, and cannot be used to infer “safe” sediment concentrations for benthic invertebrates.

Comment #5 –The Board’s 95% UCL calculations misrepresent the actual concentrations of chlordane, PAHs and PCBs associated with “unimpacted” and “likely unimpacted” stations from their selected pool of data.

Summary

If the lack of causal evidence, lack of an exposure-response relationship, and the contradiction between the underlying method assumptions made by the Board and the data themselves are ignored, their mathematical derivation method is still severely flawed. The Board’s selection of the 95% UCL of the mean concentration to characterize exposure at “unimpacted” and “likely unimpacted” stations is inappropriate and without scientific or logical basis. The ostensible purpose of using these low disturbance categories to set sediment target concentrations is to characterize an exposure threshold below which the likelihood of impairment is negligible. In other words, the Board is defining a reference condition, and has defined SQO category 1 and 2 stations as their reference pool. The appropriate threshold to select from a reference pool is a point that represents the upper end of the reference concentration range, such as a 95th percentile of the entire distribution. The central tendency, including the mean or 95% UCL of the mean, has no significance as a threshold, and is an arbitrary value from a risk perspective. This approach is also inconsistent with the Board's stated definition of a TMDL: "A TMDL represents the maximum amount of a pollutant that the waterbody can receive and still attain applicable water quality standards" (RWQCB 2013, p. 1). Based on this definition, it is clear that the thresholds derived from the reference pools should be based on statistical upper limits and NOT on an estimation of a mean value. In addition, the Board incorrectly assumed that all data were normally distributed and inappropriately removed high concentration data from their reference pool on the basis of an outlier test that presumes normality in the data, further skewing their target concentration estimates, and the range sediment concentrations at "likely unimpacted" stations .

The Board's 95% UCL Calculations

The Board used the U.S. EPA statistical program ProUCL to calculate 95% UCLs of the mean concentrations in the SQO category 1 and 2 reference pool. Based on the ProUCL output files found in the Board's response to NASSCO's Public Records Act request (Attachment 1), we have deduced that they used ProUCL to apply Rosner's test for outliers and on this basis eliminated as statistical outliers the stations with the highest chlordane, PAH, and PCB concentrations. However, this outlier test requires normal data. Concerning Rosner's test, the EPA ProUCL guidance specifically says: " This test also assumes that the data are normally distributed; therefore, it is necessary to perform a test for normality before applying this test" (USEPA 2010, p. 73). The Board ignored the fact that none of the concentration distributions are normal, even though ProUCL clearly identified this fact in the program output (see Attachment 1). Use of Rosner's test or other distribution-dependent outlier tests in the case of non-normal data distributions is inappropriate and likely to lead to misinterpretation of data. National Institutes of Standards and Technology guidance says "If the normality assumption for the data being tested is not valid, then a determination that there is an outlier may in fact be due to the non-normality of the data rather than the presence of an outlier" (NIST 2012). The chlordane, PAH, and PCB concentrations that were thrown out by the Board as putative outliers

(16.2 ppb, 17,383 ppb, and 2,381 ppb respectively) were 6 to 14 times higher than the arbitrary 95% UCL of the mean selected by the Board to characterize their reference concentrations, but provide the true upper limit of sediment concentrations associated with SQO scores of "likely unimpacted" in this data pool.

Appropriate Estimates of "Likely Unimpacted" Sediment Concentrations

Use of measures of the central tendency in a distribution, including the 95% UCL of the mean, is recognized by U.S. EPA guidance on statistical comparison of data as an inappropriate basis for comparison of a reference or background condition (commonly called a background threshold value or BTV) to individual sample concentrations. In fact, the ProUCL user's manual, the very software package used by the Board for this purpose cautions against this practice in several portions of the document:

> It should be noted that it is not appropriate to compare individual point-by-point site observations with the background mean concentration level. (USEPA 2010, p.1)

> A UCL95 should not be used to estimate a background threshold value (a value in the upper tail of the background data distribution) to be compared with individual site observations. There are many instances in background evaluations and background versus site comparison studies, when it is not appropriate to use a 95% UCL. Specifically, when point-by-point site observations are to be compared with a BTV, then that BTV should be estimated (or represented) by a limit from the upper tail of the reference set (background) data distribution. (USEPA 2010, p.21)

The ProUCL guidance goes on to recommend several acceptable options for comparison of reference ranges to site data:

> When individual point-by-point site observations are compared with a threshold value (pre-determined or estimated) of a background population or some other threshold and compliance limit value, such as a PRG, MLC, or ACL, then that threshold value should represent a not-to-exceed value. Such BTVs or not-to-exceed values are often estimated by a 95% UPL, UTL 95%-95%, or by an upper percentile. (USEPA, p. 21)

The ProUCL output files generated by the Board's analysis (Attachment 1) actually do contain calculation of an appropriate BTV concentration: the 95th percentile of the reference data pool (i.e., the SQO category 1 and 2 stations). The 95th percentile concentrations for "likely unimpacted" or better stations are: chlordane = 5.7 ppb, PAHs = 11,548 ppb, PCBs = 663.4 ppb. While not technically well-founded, due to the absence of an apparent exposure-response relationship or evidence of causality, these higher values are at least closer to the magnitude of site-specific LAET values demonstrated to be protective of the benthic community at the adjacent Shipyards Site, where the total PCB LAET was determined to be 5,450 ppb and the HPAH LAET was determined to be 25,500 ppb (RWQCB 2012). In the recently promulgated Cleanup and Abatement Order for the Shipyard Site (RWQCB 2012), the final protective value specified was 60 percent of the LAET (60%LAET), a value deemed to be both scientifically supportable and incorporating a sufficient safety factor to assure beneficial use protection. The 60%LAET values were 3,270 ppb for total PCBs and 15,300 ppb for HPAHs. It should be noted that total HPAH makes up only a portion of the total PP-PAH assessed in the draft TMDL report, indicating how conservative the upper 95th percentile values from the Board's selected TMDL reference pool is likely to be. Indeed, the upper range of sediment concentrations for total PCBs and total PAHs in the reference pool of "unimpacted" and "likely unimpacted" SQO stations is much closer to the Shipyard 60%LAET values (see discussion of "outlier" removal above).

If the flawed sediment target derivation approach used by the Board were accepted for purposes of discussion, the 95th percentile values above would be far more appropriate BTV estimates than the 95% UCL values of the means, as proposed by the Board. While the use of the SQO station scores does not support any target sediment concentration for the purposes of setting a TMDL, the use of 95th percentiles would at least be a statistically meaningful comparison point for the selected reference pool of stations, and would still be highly protective. It should be noted that the highest average total PCB concentration among the 14 Chollas Creek mouth TMDL area stations (C01 through C14) is only 422 ppb, well below the 95th percentile value of SQO category 1 and 2 stations, further underscoring that Chollas Creek sediment PCBs are not a cause of impairment. Only two of the 14 Chollas Creek mouth TMDL stations would exceed the PP-PAH 95th percentile value for SQO category 1 and 2 stations (see Table 1).

Comment #6 – The Board's derivation process for setting numerical targets is poorly documented, inadequately explained and justified, and lacks transparency.

General Comment

As detailed above, we find that the Board has inadequately documented and justified every aspect of their derivation of numerical sediment targets –demonstration of impairment, selection of chemicals, establishment of causation and exposure-response relationships, selection of data used for calculation of target concentrations, and numerical calculation of target values. As a result, their calculations are very difficult to follow, let alone reproduce or evaluate for accuracy. In its current form, the draft TMDL report lacks transparency and falls short of documenting, let alone justifying many critical assumptions and decisions that went into development of their method and calculation of target sediment concentrations. Only by reviewing additional information obtained by NASSCO though a Public Records Act request, including raw data files and program output files that require specialty software to review, have we been able to partially reconstruct calculation of the sediment target concentrations.

References

Anderson, B., P. Nicely, B. Phillips, and J. Hunt. 2005. Sediment Quality Assessment Study at the B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek, San Diego Bay, Phase I Final Report. Marine Pollution Studies Laboratory, University of California – Davis in cooperation with San Diego Regional Water Quality Control Board, Port of San Diego, and City of San Diego. Davis, CA.

Bay, S.M., D.J. Greenstein, J.A. Ranasinghe, D.W. Diehl, and A.E. Fetscher. 2009. Sediment quality assessment draft technical support manual. Technical Report 582. Southern California Coastal Water Research Project. May 2009. 114 pp.

Brown, J., and S. Bay. 2011. Temporal Assessment of Chemistry, Toxicity, and Benthic Communities in Sediments at the Mouths of Chollas Creek and Paleta Creek, San Diego Bay. Southern California Coastal Water Research Project. Costa Mesa, CA. January 2005.

Cheng, C. 2013. Powerpoint Presentation: Public Workshop and CEQA Scoping Meeting. Downtown Anchorage and B Street/Broadway Piers (DAB) TMDLs for Toxic Pollutants in Sediments. January 10, 2013.

Exponent. 2003. NASSCO and Southwest Marine Detailed Sediment Investigation Volumes I - III. Prepared for NASSCO and Southwest Marine, San Diego, CA. Exponent Inc., Bellevue, WA. October 2003.

NIST. 2012. Engineering Statistics Handbook, Section 1.3.5.17. Detection of Outliers. U.S. Commerce Department, National Institute of Standards and Technology, Washington, DC. Available at: http://www.itl.nist.gov/div898/handbook/eda/section3/eda35h.htm

OEHHA. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency, Sacramento, CA. June 2008.

RWQCB. 2009a. Waste Discharge Requirements for General Dynamics, National Steel and Shipbuilding Company (NASSCO) Discharge to the San Diego Bay. Order No. R9-2009-0099. NPDES No. CA0109134. August 12, 2009.

RWQCB. 2012. Technical Report for Tentative Cleanup and Abatement Order No. R9-2012-0024 for the Shipyard Sediment Site, San Diego Bay, San Diego, CA – Volumes I, II, and III. California Regional Water Quality Control Board, San Diego Region. San Diego, CA. March 14, 2012.

RWQCB. 2013. Total Maximum Daily Loads for Toxic Pollutants in Sediment at San Diego Bay Shorelines – Mouths of Paleta, Chollas, and Switzer Creeks. Draft Technical Report. California Regional Water Quality Control Board, San Diego Region, San Diego, CA. February 19, 2013.

SCCWRP 2005. Sediment Assessment Study for the Mouths of Chollas and Paleta Creek, San Diego, Phase I Report. Prepared by Southern California Coastal Water Research Project, Westminster, CA and Space and Naval Warfare Systems Center, San Diego, CA for the San Diego Regional Water Quality Control Board and Commander Navy Region Southwest, San Diego, CA.

SCCWRP. 2011. Greenstein, D., S. Bay, and D. Young. Sediment Toxicity Identification Evaluation for the mouths of Chollas and Paleta Creek, San Diego, CA. Southern California Coastal Water Research Project, Costa Mesa, CA. Technical Report 669. November 2011.

SWRCB. 2008. Draft Staff Report – Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1 Sediment Quality, Appendix D – Toxic Hot Spots. CA Environmental Protection Agency, State Water Resources Control Board, Sacramento, CA. July 18, 2008.

Tetra Tech/MACTEC. 2010. Chollas Creek and Paleta Creek Storm Drain Characterization Study. Submitted to the City of San Diego by Tetra Tech. Final Report. July 16, 2010.

U.S. EPA. 2000. Stressor identification guidance document. EPA-822-B-00-025. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

U.S. EPA. 2010. ProUCL Version 4.1 User Guide (Draft). Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. EPA/600/R-07/041. May 2010.

Van Den Berg, M., L. S. Birnbaum, M. Denison, M. De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, and R. E. Peterson. 2006. The 2005 World Health Organization's re-evaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol. Sci. 39(2): 223–241.

Figures

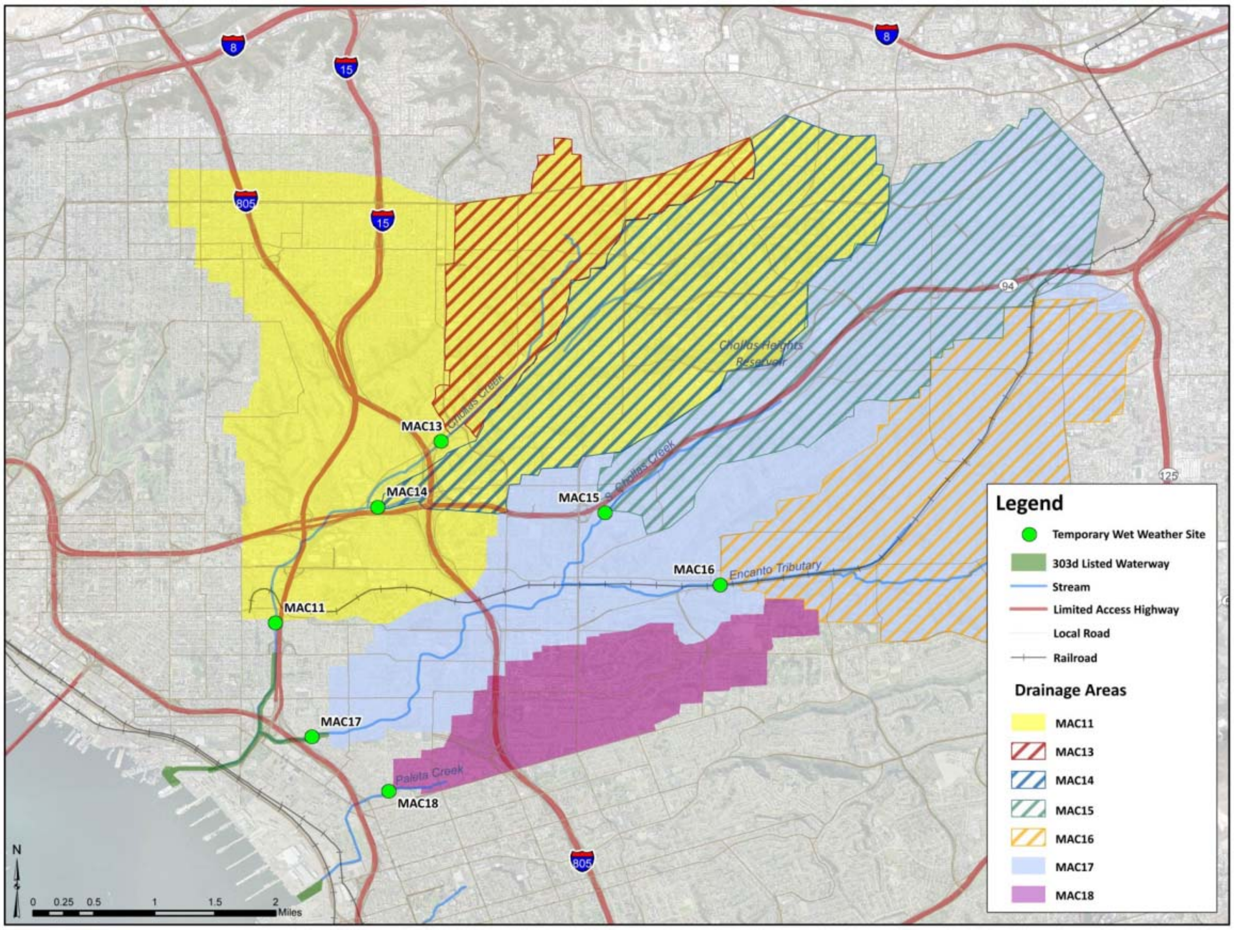

Figure 1. Chollas Creek temporary wet weather monitoring stations (green circles) and contributing drainage area (from Figure 2-2, TetraTech/Mactec 2010)

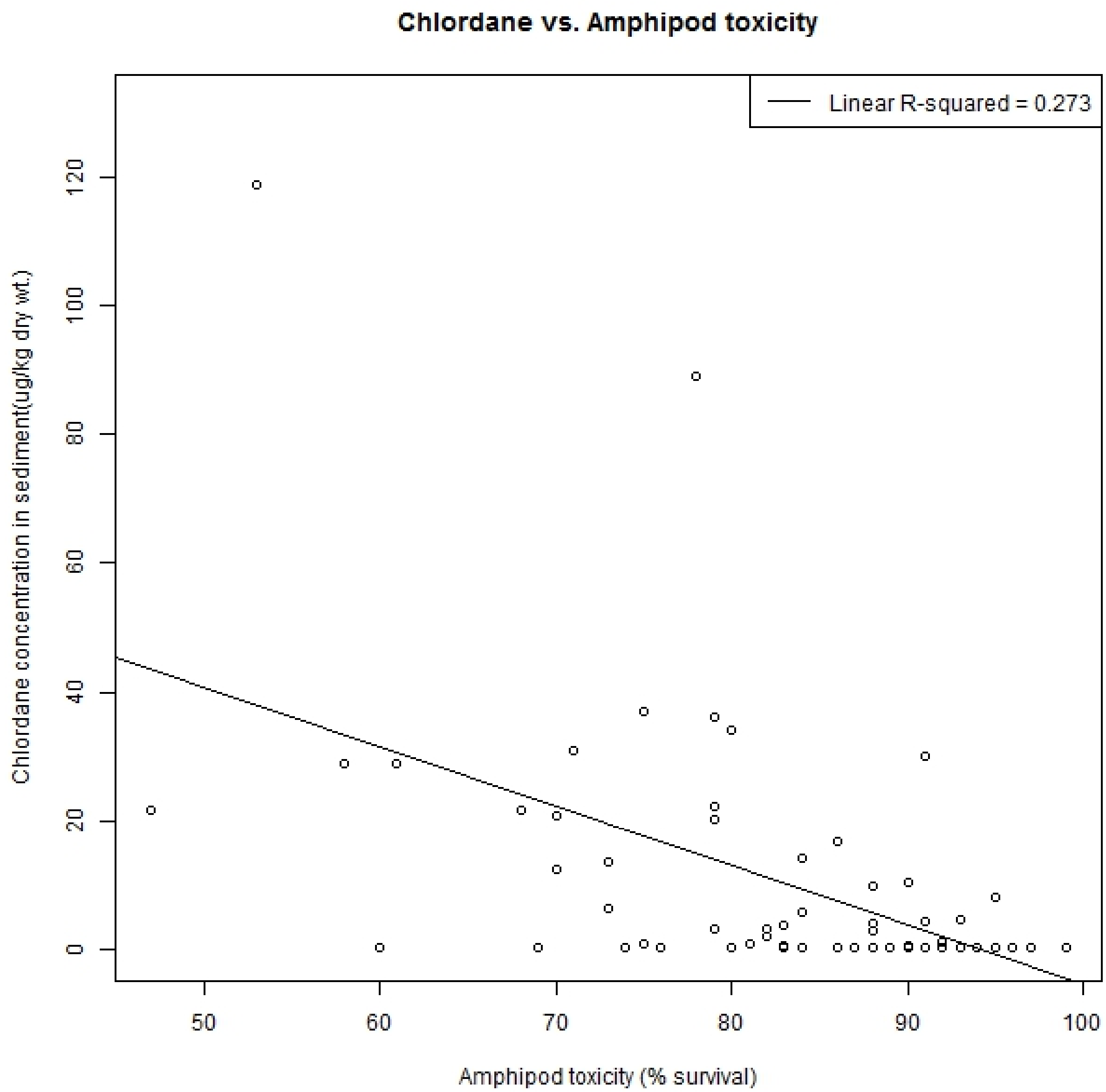

Figure 2. Chlordane vs. amphipod toxicity

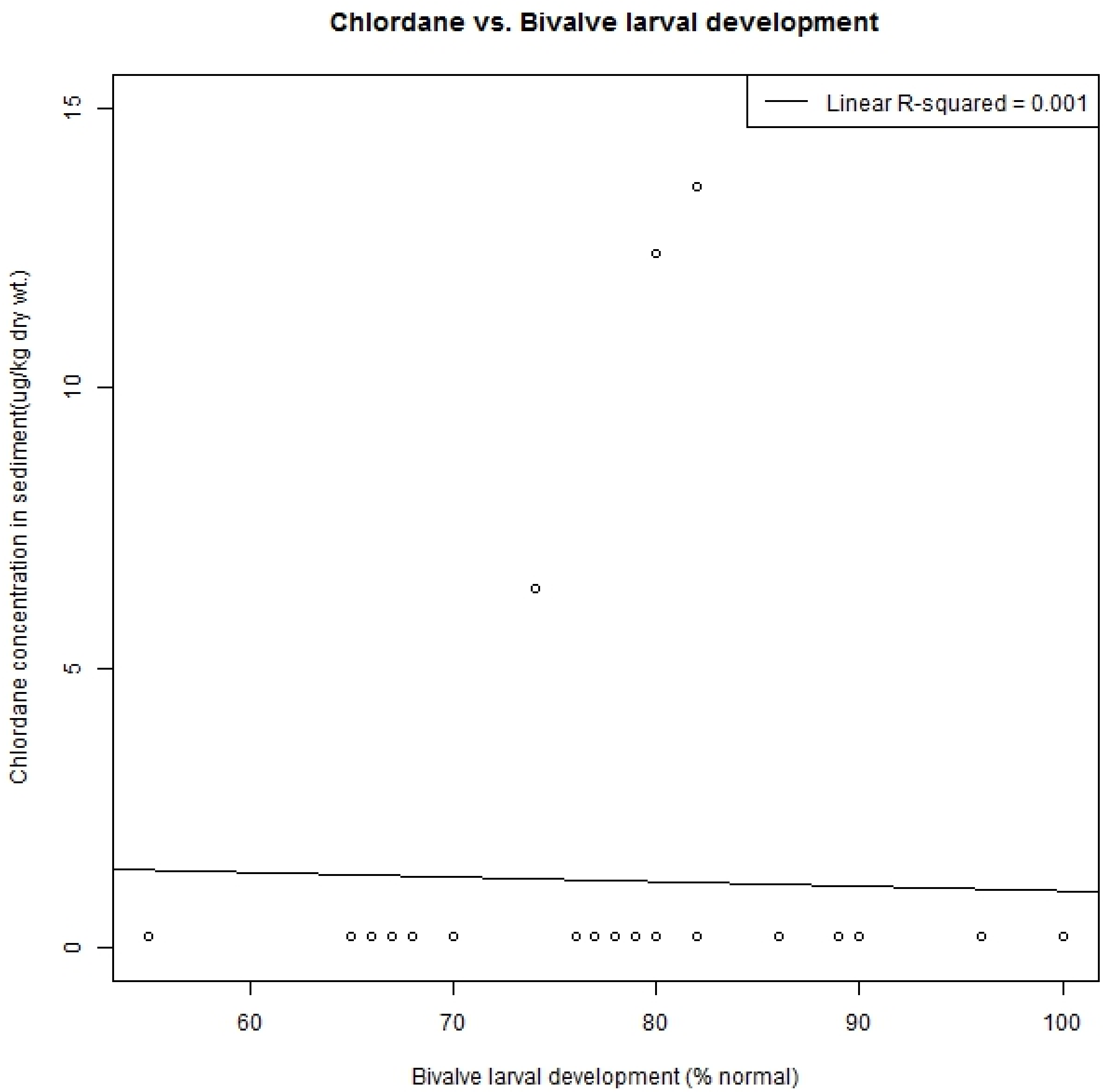

Figure 3. Chlordane vs. bivalve larval development

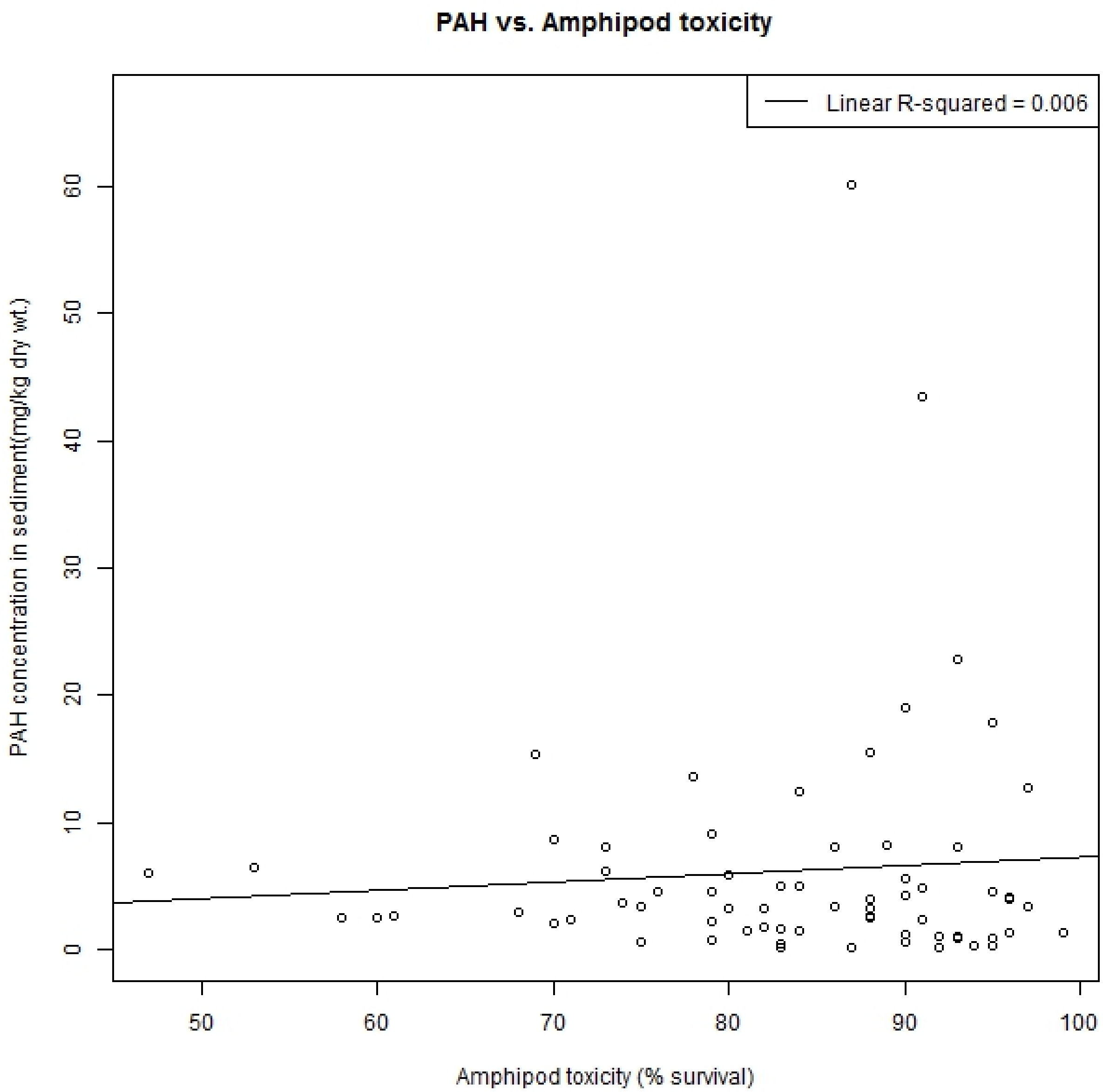

Figure 4. PAH vs. amphipod toxicity

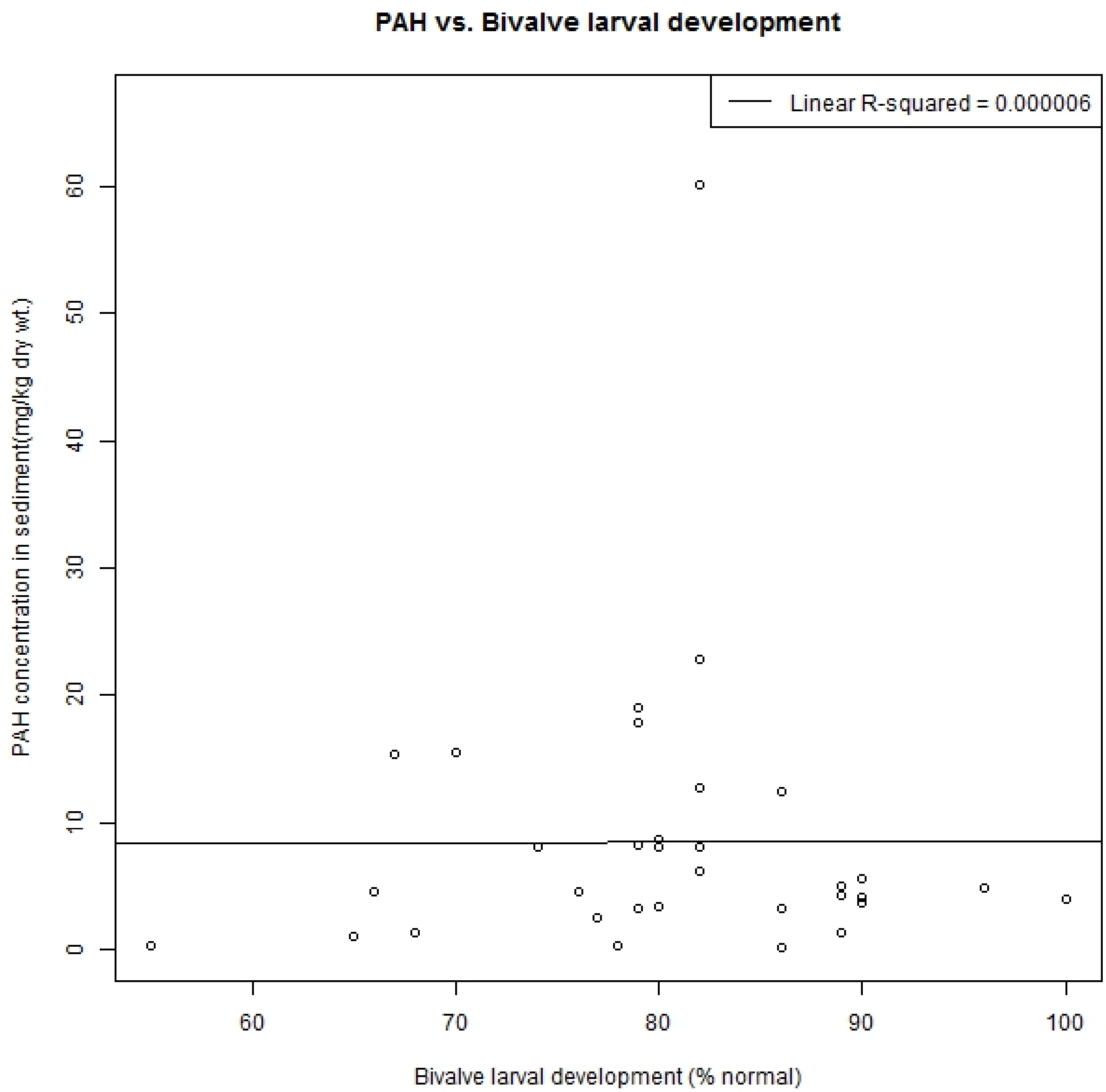

Figure 5. PAH vs. bivalve larval development

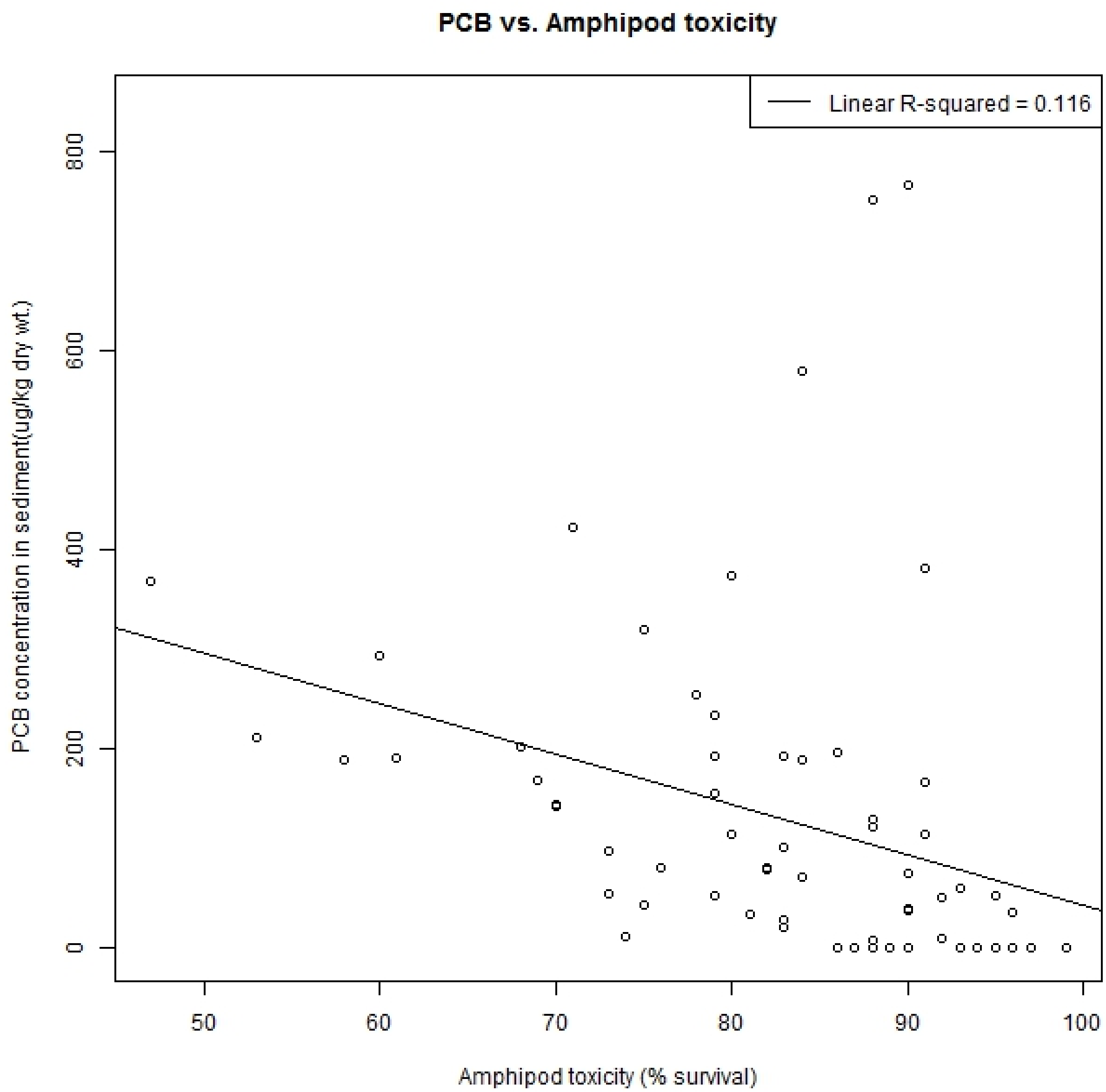

Figure 6. PCB vs. amphipod toxicity

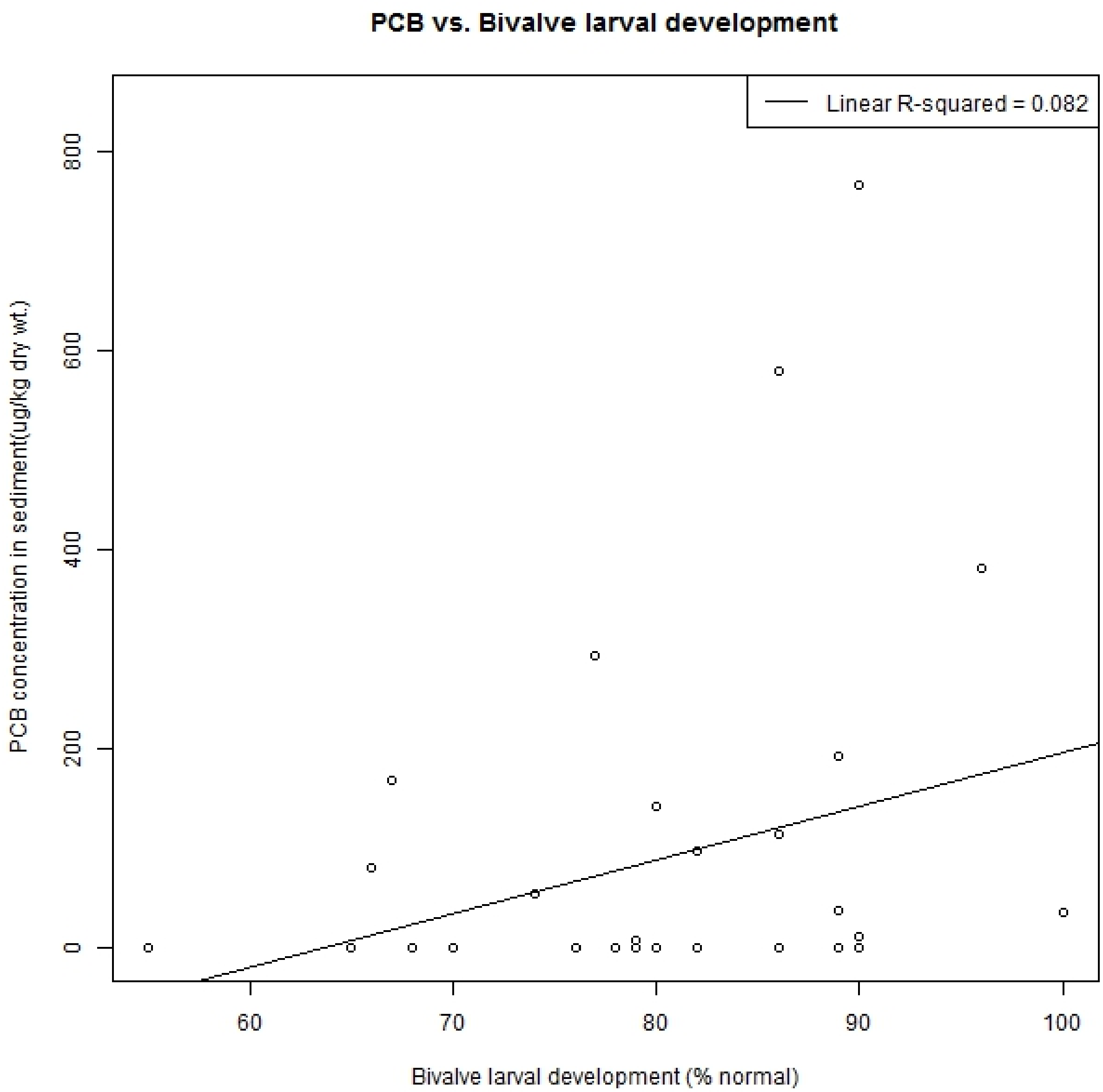

Figure 7. PCB vs. bivalve larval development

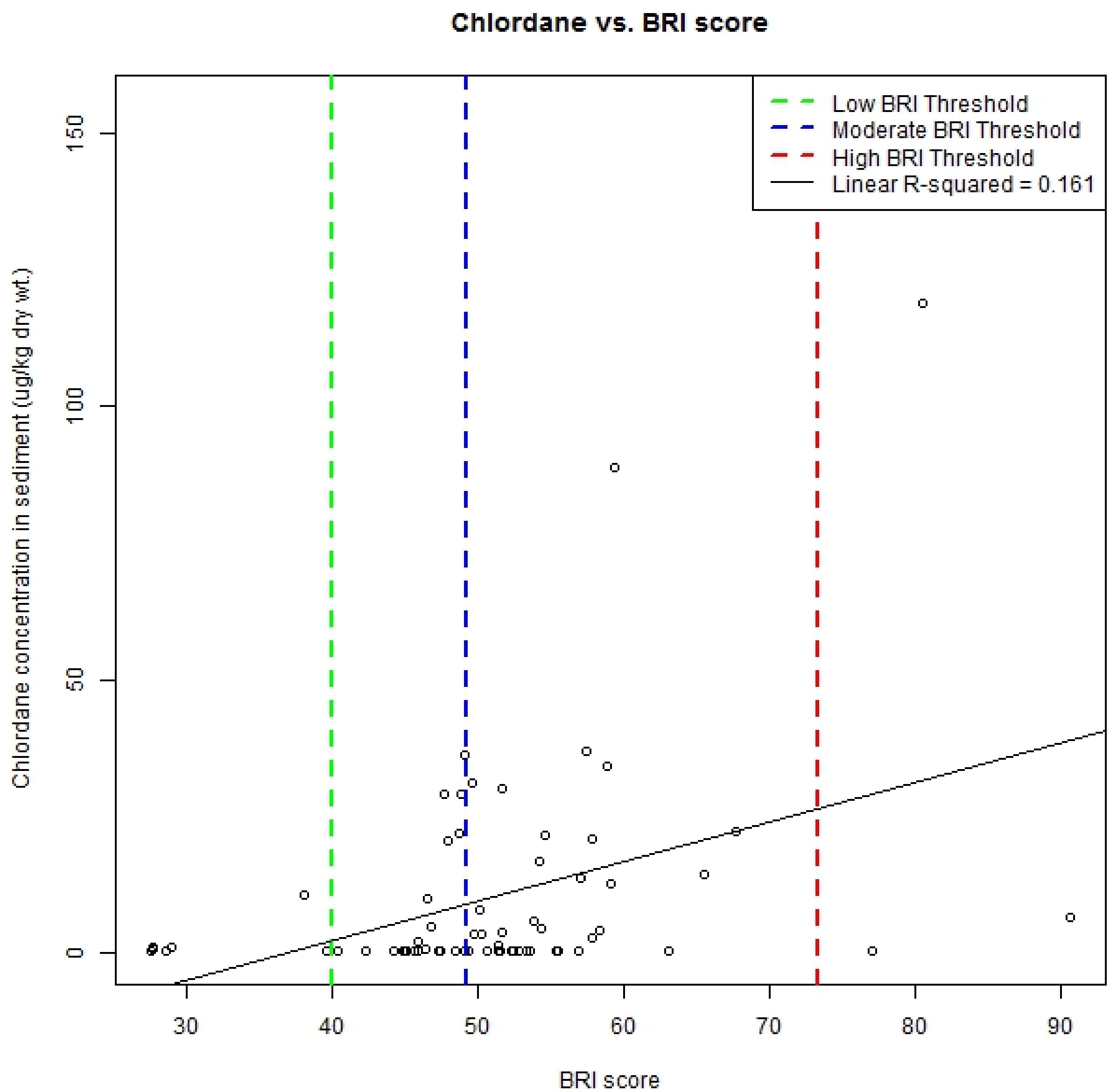

Figure 8. Chlordane vs. BRI score

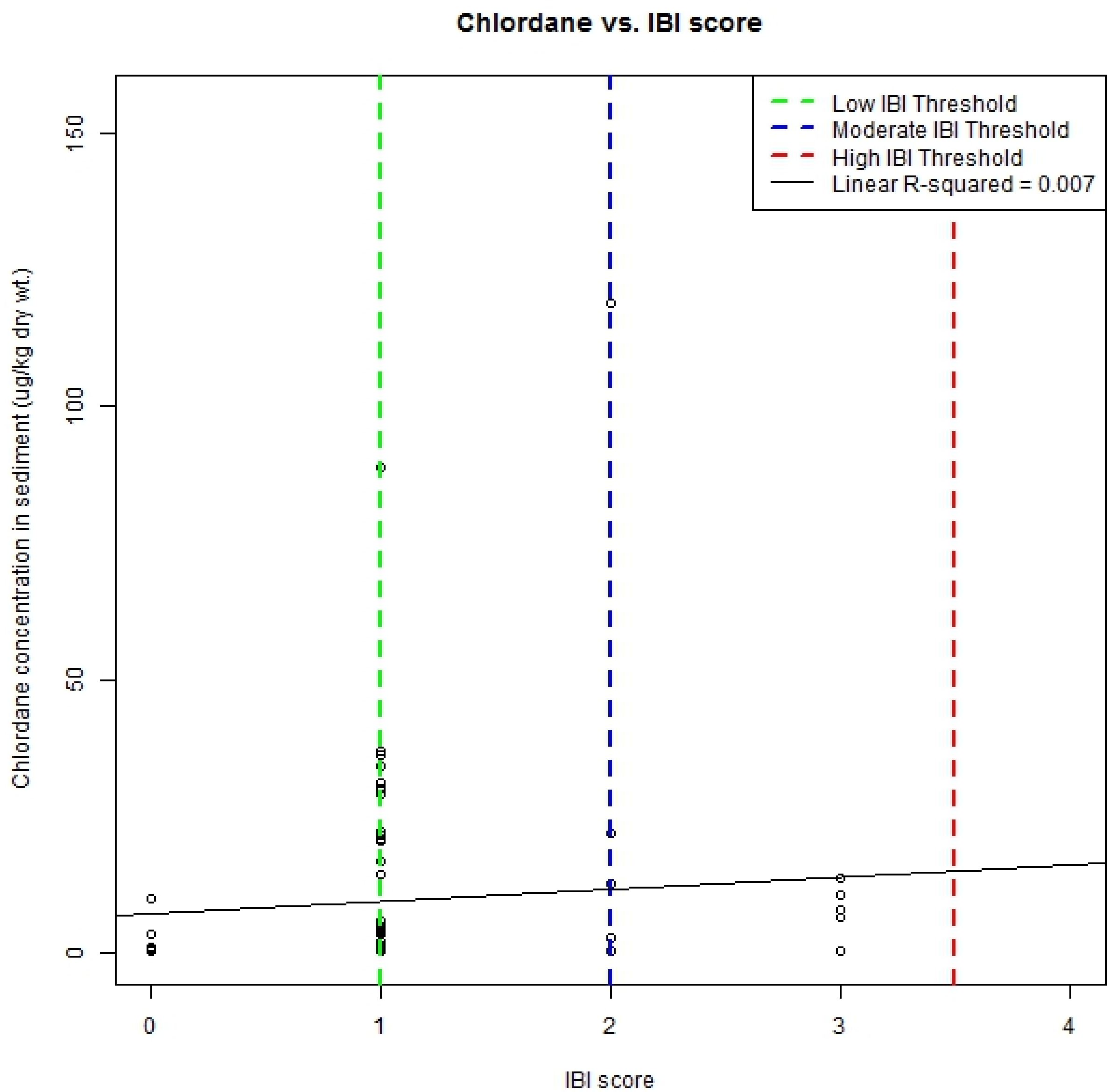

Figure 9. Chlordane vs. IBI score

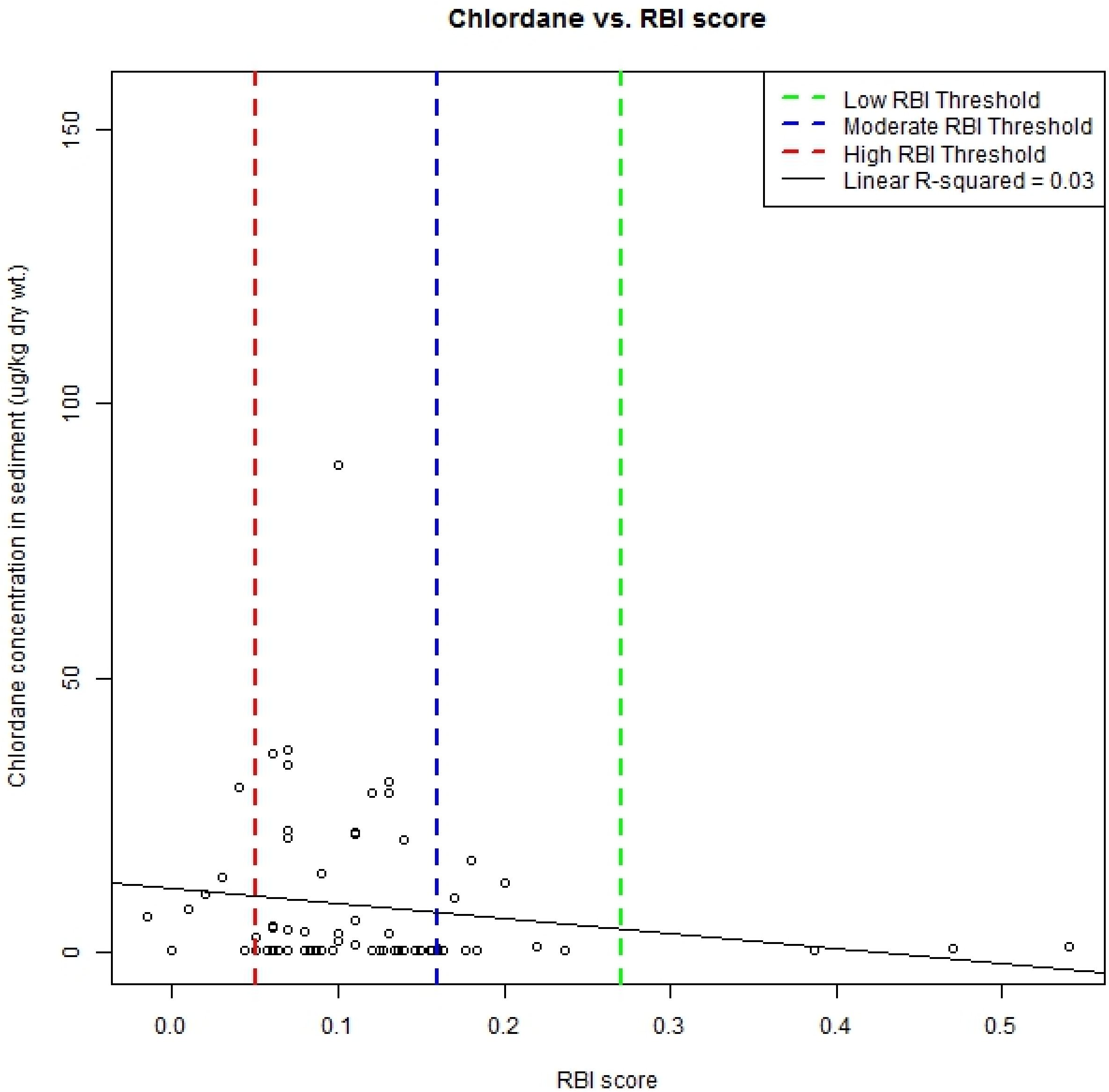

Figure 10. Chlordane vs. RBI score

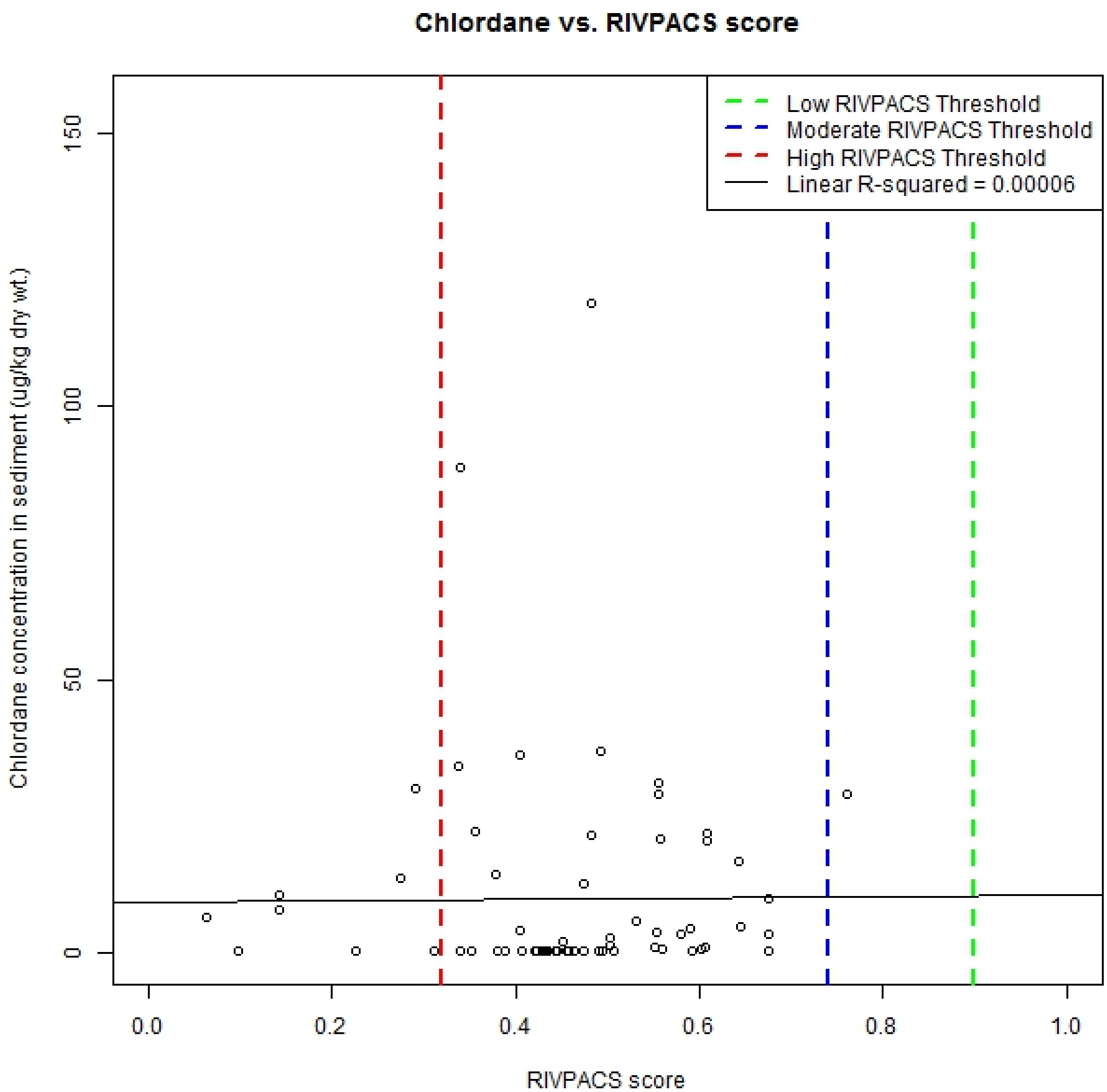

Figure 11. Chlordane vs. RIVPACS score

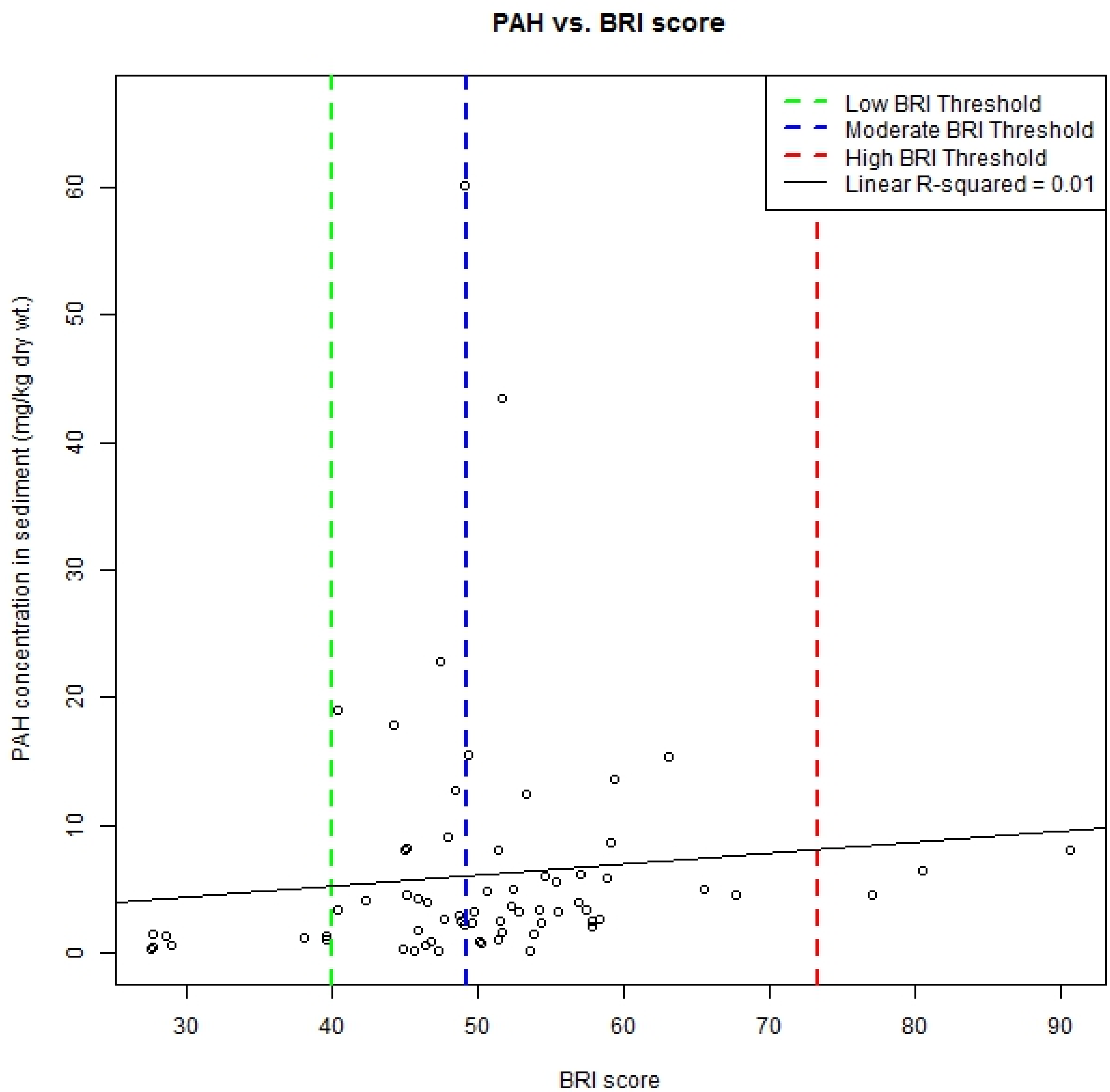

Figure 12. PAH vs. BRI score

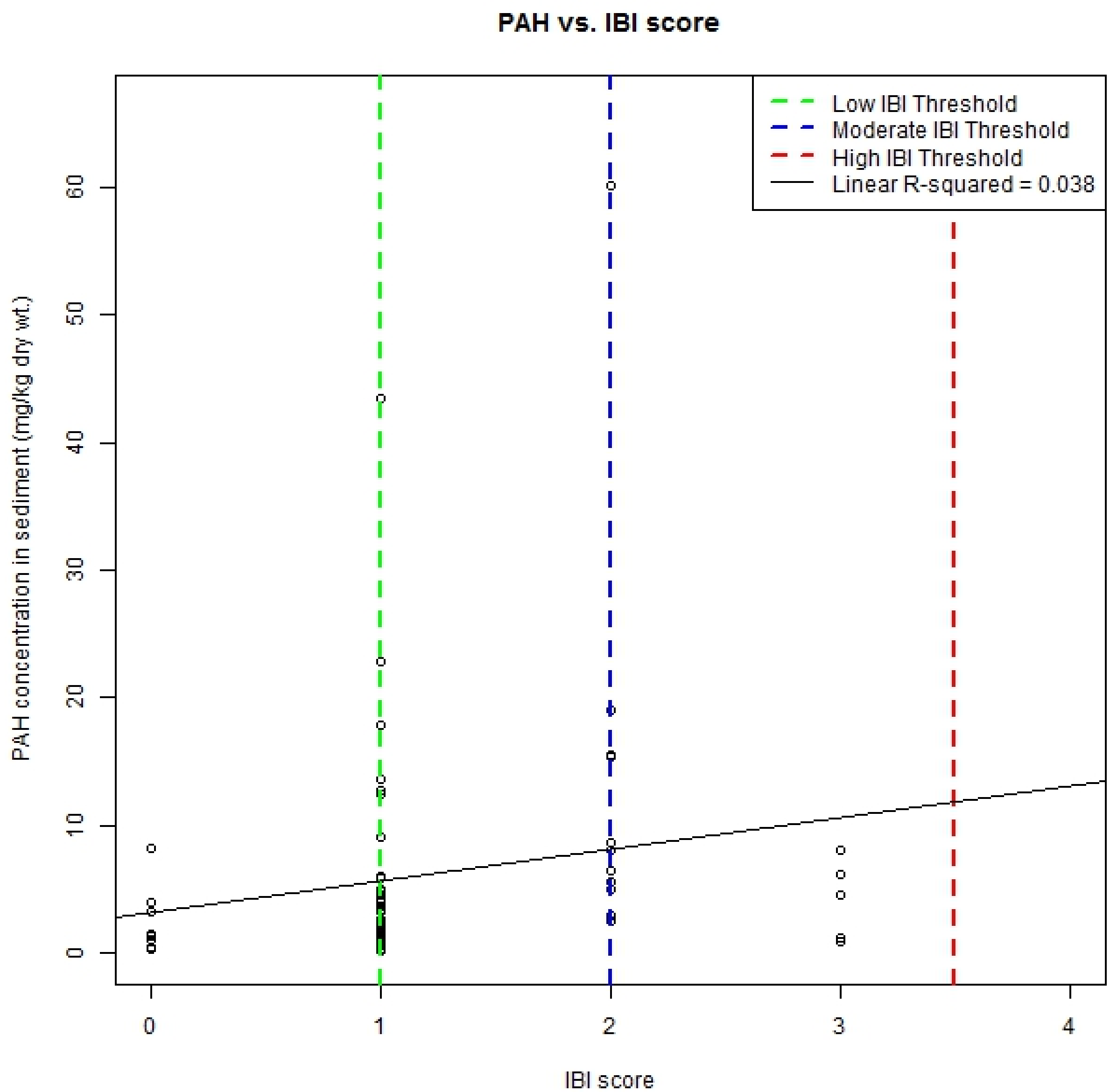

Figure 13. PAH vs. IBI score

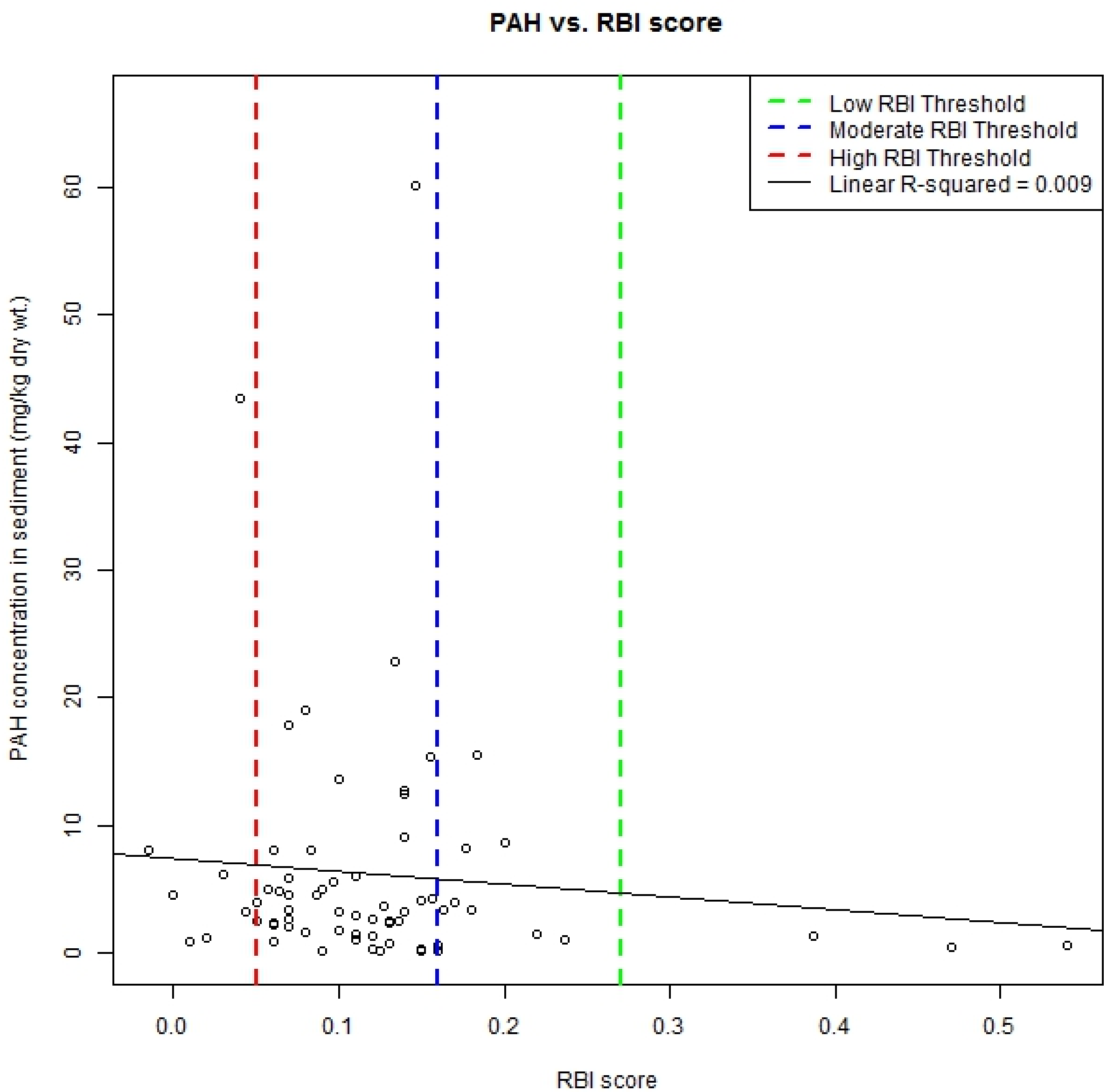

Figure 14. PAH vs. RBI score

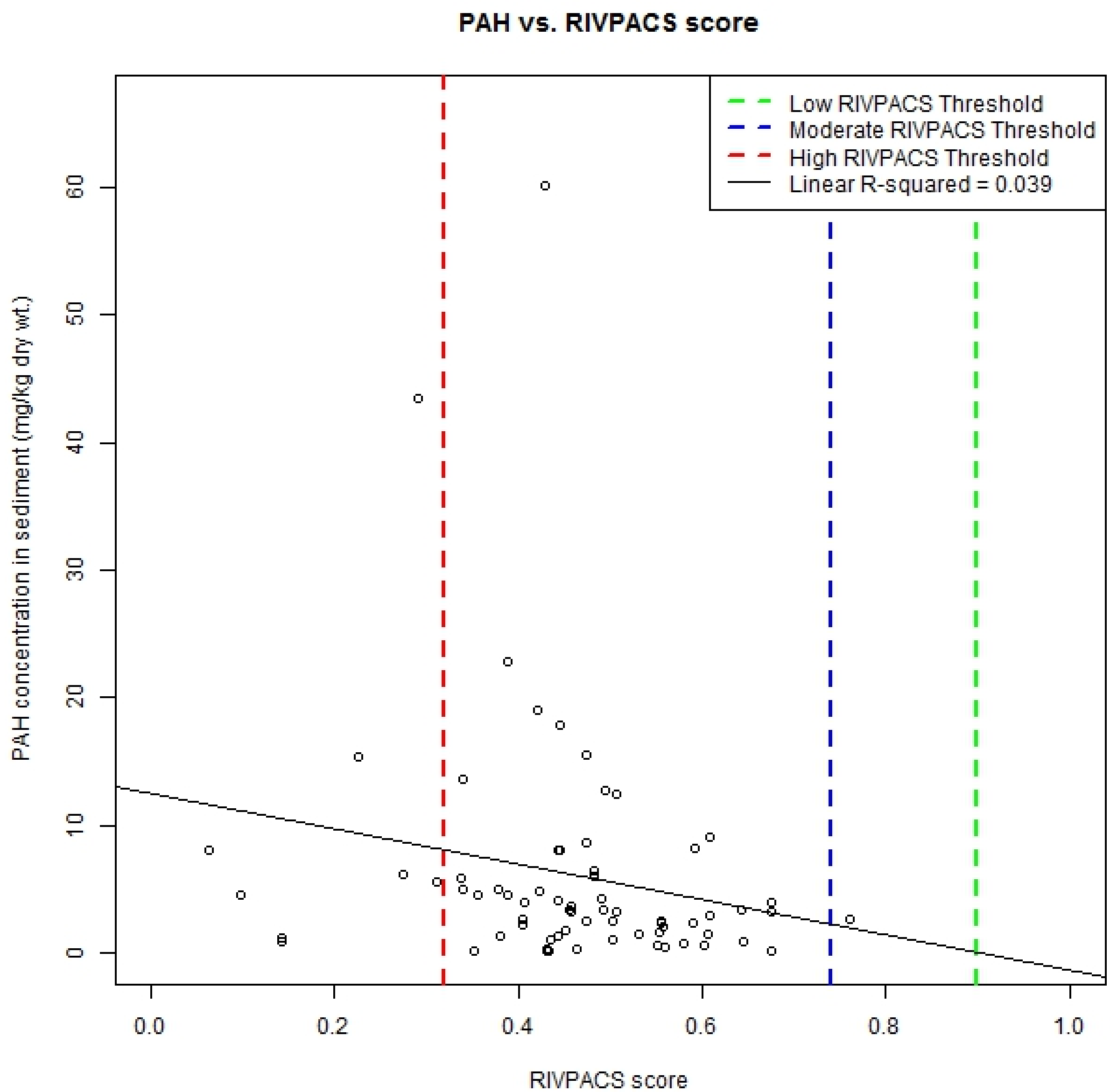

Figure 15. PAH vs. RIVPACS score

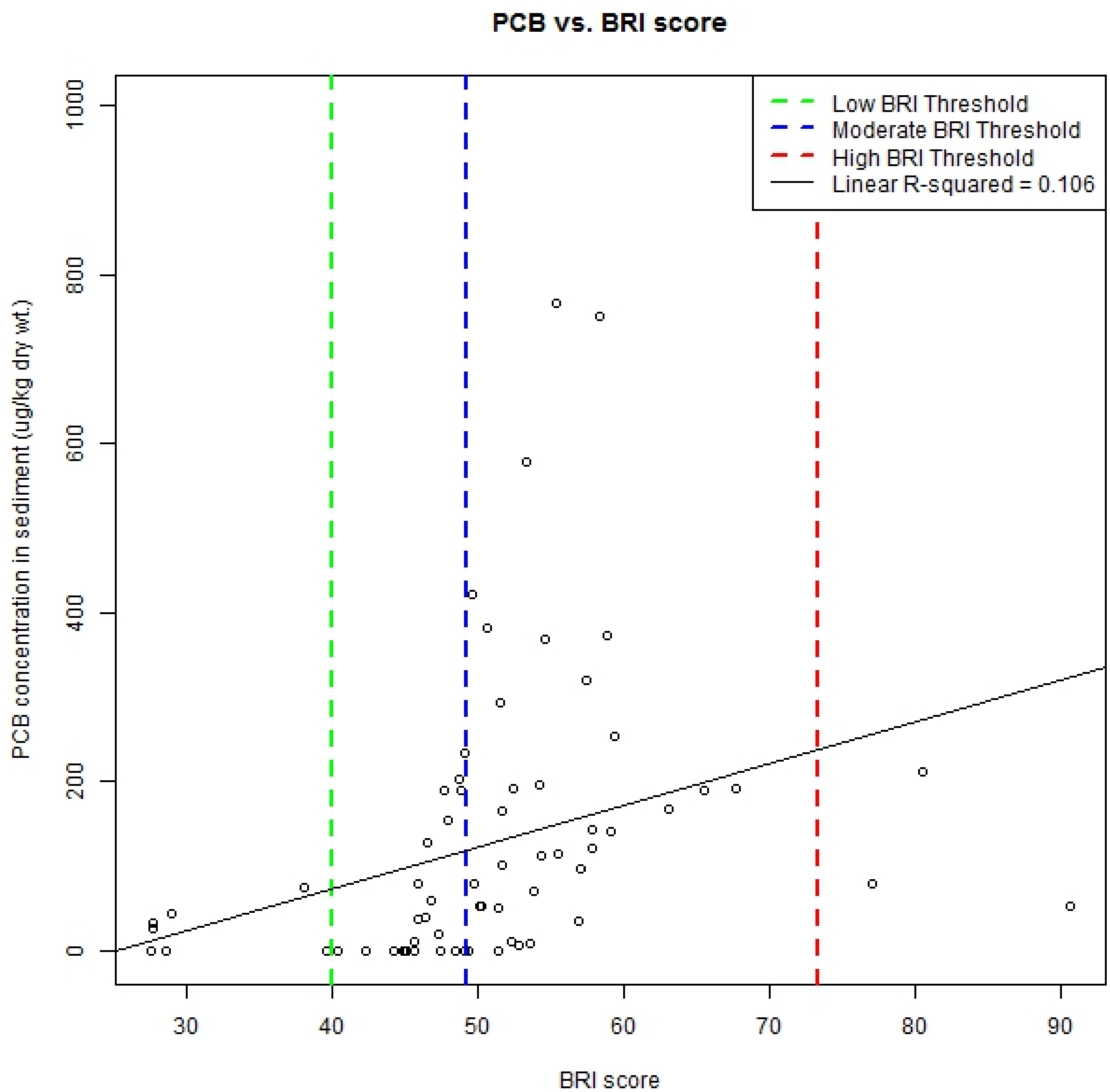

Figure 16. PCB vs. BRI score

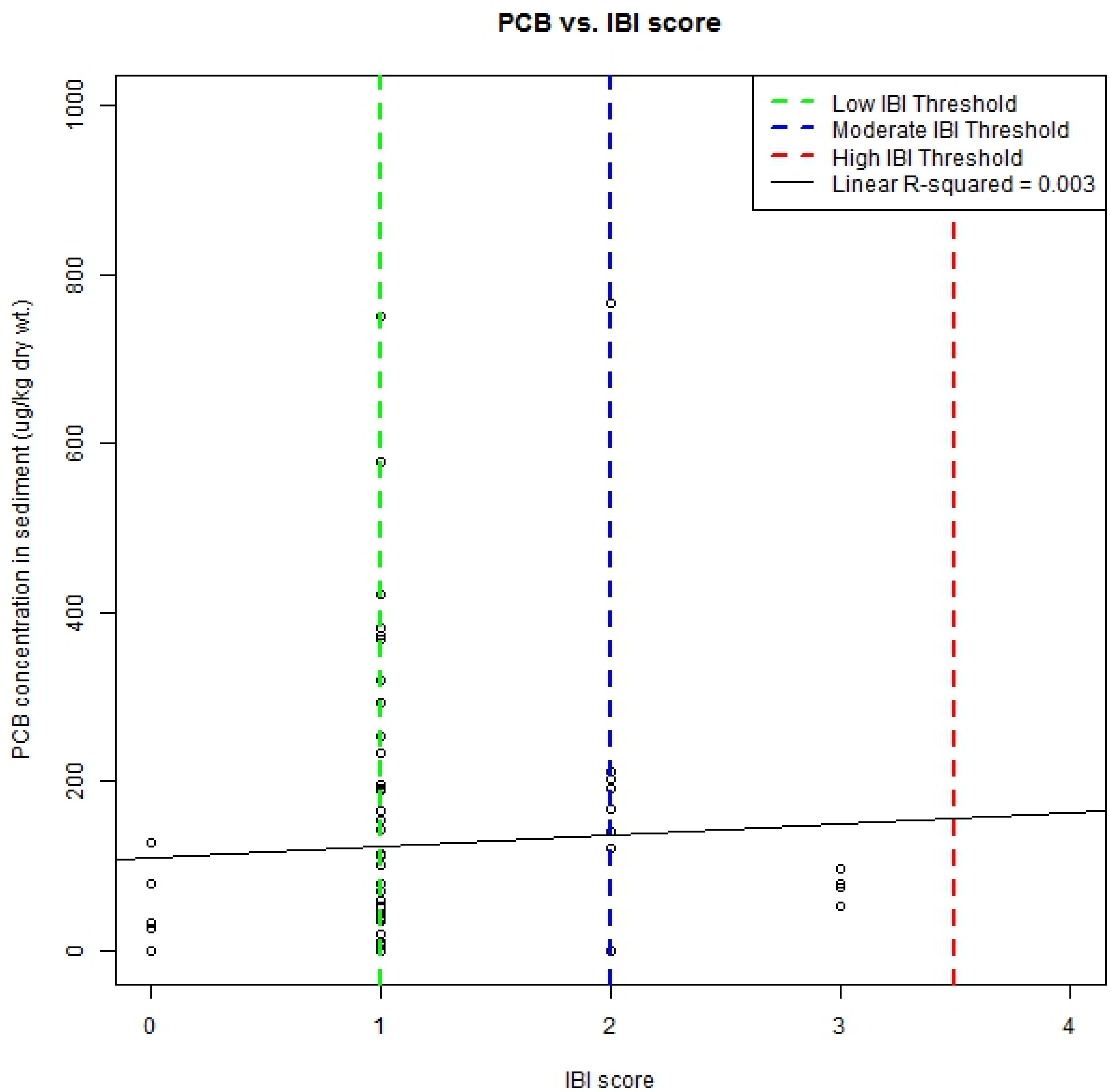

Figure 17. PCB vs. IBI score

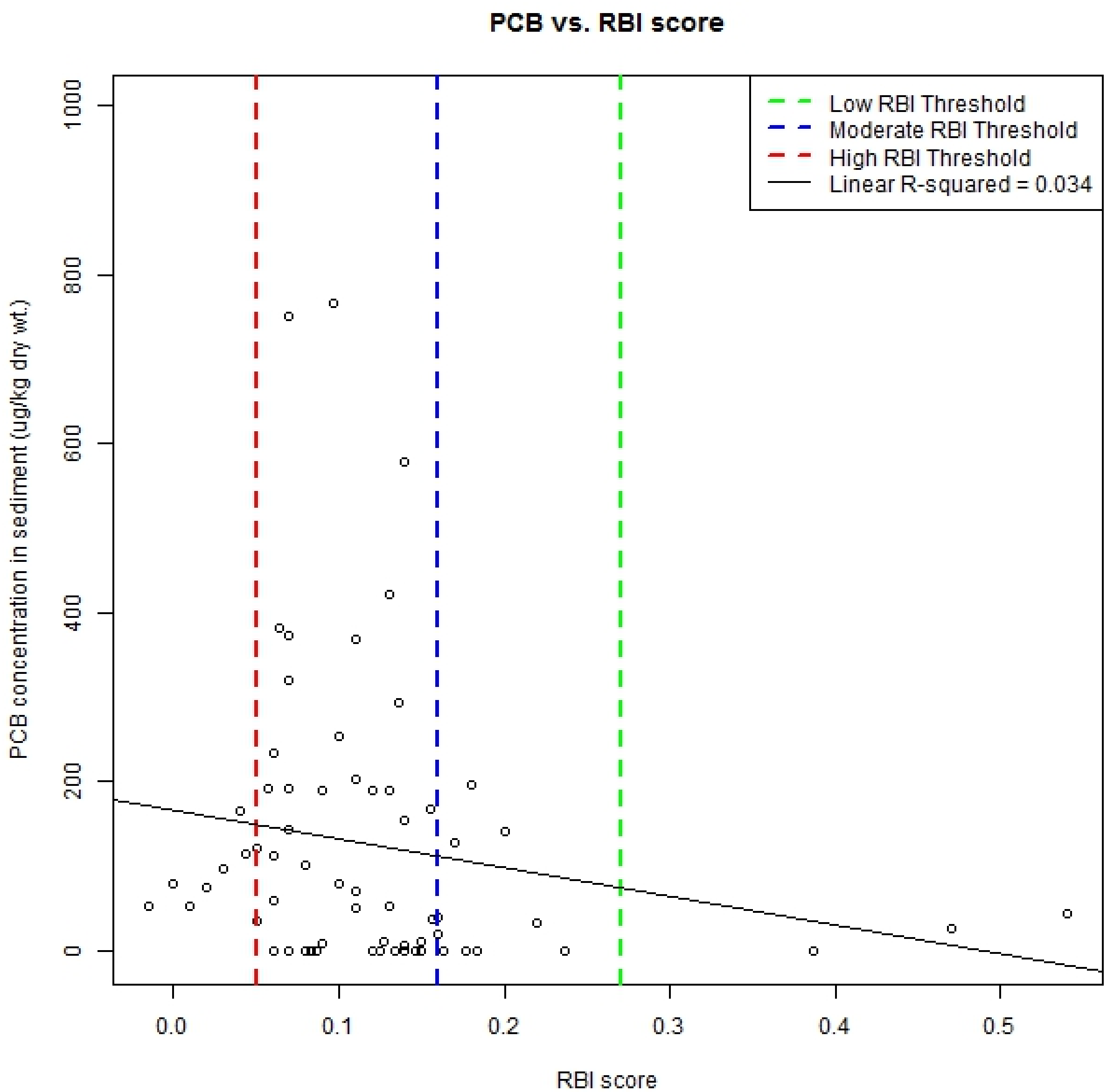

Figure 18. PCB vs. RBI score

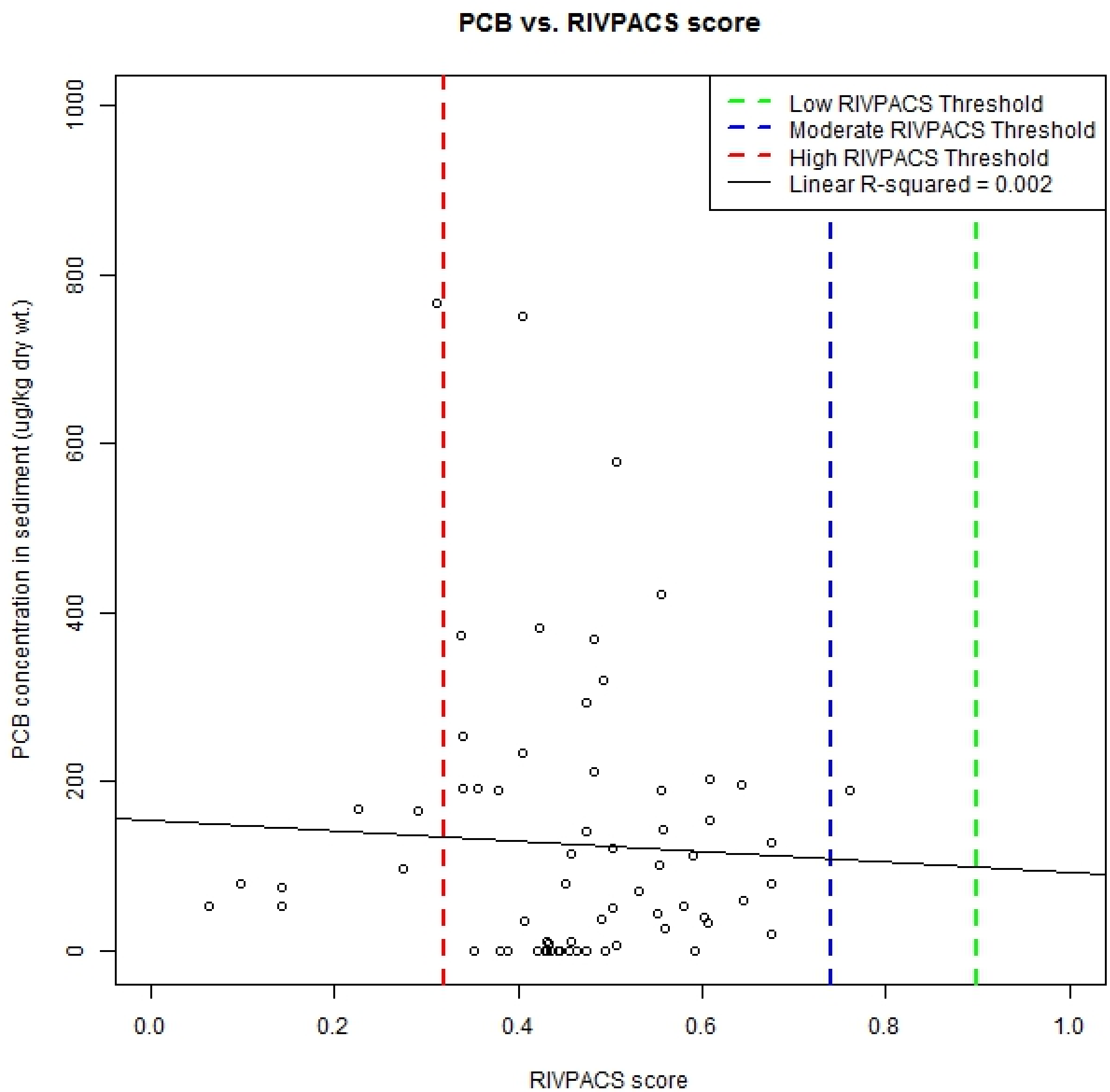

Figure 19. PCB vs. RIVPACS score

Table

Table 1. Sediment chemistry, toxicity results, and benthic scores from draft TMDL report, Appendix I-1

Station ID	HPAH (mg/kg)	LPAH (mg/kg)	PAH (mg/kg)	Alpha Chlordane (µg/kg)	Gamma Chlordane (µg/kg)	Chlordane (µg/kg)	PCBs (µg/kg)	Amphipod Toxicity Test Raw Station Result (% survival)	Bivalve Larval Development Test Raw Station Result (% normal)	BRI Score	IBI Score	RBI Score	RIVPACS Score
C01	2.184	0.326	2.51	12	17	29	189.73	58	NA	48.87	1	0.13	0.556
C02	2.05	0.341	2.391	13	18	31	421.58	71	NA	49.62	1	0.13	0.556
C03	2.66	0.623	3.283	14	23	37	319.86	75	NA	57.35	1	0.07	0.493
C04	1.787	0.266	2.053	8.9	12	20.9	144.66	70	NA	57.80	1	0.07	0.557
C05	1.913	0.298	2.211	16	20	36	233.55	79	NA	49.10	1	0.06	0.405
C06	2.306	0.367	2.673	12	17	29	189.76	61	NA	47.67	1	0.12	0.761
C07	0.772	0.13	0.902	1.8	2.8	4.6	59.56	93	NA	46.70	1	0.06	0.644
C08	0.775	0.116	0.891	3.4	4.5	7.9	52.852	95	NA	50.11	3	0.01	0.142
C09	6.02	3.048	9.068	8.3	12	20.3	154.42	79	NA	47.86	1	0.14	0.609
C10	2.56	0.332	2.892	8.7	13	21.7	202.34	68	NA	48.73	2	0.11	0.608
C11	1.013	0.12	1.133	4.2	6.2	10.4	74.245	90	NA	38.02	3	0.02	0.142
C12	36.06	7.475	43.535	11	19	30	166.57	91	NA	51.57	1	0.04	0.291
C13	11.6	2.007	13.607	39	50	89	255.07	78	NA	59.27	1	0.10	0.339
C14	5.194	1.212	6.406	54	65	119	212.12	53	NA	80.46	2	NA	0.482
2231	0.536	0.086	0.622	0.27	0.64	0.91	43.426	75	NA	28.90	1	0.54	0.552
2243	0.118	0.02	0.138	0.095	0.11	0.205	21.06	83	NA	47.34	1	0.16	0.675
2433	0.415	0.056	0.471	0.18	0.39	0.57	27.37	83	NA	27.65	0	0.47	0.560
2441	1.21	0.236	1.446	0.11	0.72	0.83	33.943	81	NA	27.72	0	0.22	0.606
2238	0.103	0.017	0.12	0.043	0.14	0.183	11.69	NA	NA	45.55	1	0.15	0.430
P01	0.432	0.108	0.54	0.17	0.45	0.62	40.097	90	NA	46.34	1	0.16	0.602
P02	1.504	0.258	1.762	0.62	1.2	1.82	78.612	82	NA	45.86	1	0.10	0.452
P03	0.808	0.177	0.985	0.42	0.75	1.17	50.74	92	NA	51.38	1	0.11	0.502
P04	1.329	0.311	1.64	1.2	2.5	3.7	101.38	83	NA	51.67	1	0.08	0.553
P05	2.17	0.464	2.634	1.4	2.5	3.9	751.27	88	NA	58.25	1	0.07	0.405
P06	2.11	0.428	2.538	1	1.8	2.8	121.77	88	NA	57.79	2	0.05	0.503
P07	1.87	0.401	2.271	1.5	2.7	4.2	113.79	91	NA	54.34	1	0.06	0.590
P08	2.87	0.342	3.212	0.94	2.3	3.24	80.297	82	NA	49.67	0	0.10	0.676
P09	0.108	0.024	0.132	0.1	0.16	0.26	9.993	92	NA	53.54	1	0.09	0.434
P10	1.326	0.196	1.522	2.2	3.6	5.8	71.729	84	NA	53.85	1	0.11	0.531
P11	5.54	0.417	5.957	7.5	14	21.5	368.75	47	NA	54.54	1	0.11	0.482
P12	3.47	0.444	3.914	3.6	6.2	9.8	128.84	88	NA	46.50	0	0.17	0.675
P13	0.645	0.099	0.744	1.1	2.1	3.2	52.773	79	NA	50.21	1	0.13	0.580
P14	2.81	0.514	3.324	5.6	11	16.6	195.71	86	NA	54.18	1	0.18	0.643
P15	5.44	0.4	5.84	11	23	34	374.29	80	NA	58.80	1	0.07	0.338
P16	3.94	0.539	4.479	9.1	13	22.1	192.27	79	NA	67.64	1	0.07	0.355
P17	4.44	0.556	4.996	7.8	6.4	14.2	188.98	84	NA	65.52	1	0.09	0.378

Table 1. (cont.)

Station ID	HPAH (mg/kg)	LPAH (mg/kg)	PAH (mg/kg)	Alpha Chlordane (µg/kg)	Gamma Chlordane (µg/kg)	Chlordane (µg/kg)	PCBs (µg/kg)	Amphipod Toxicity Test Raw Station Result (% survival)	Bivalve Larval Development Test Raw Station Result (% normal)	BRI Score	IBI Score	RBI Score	RIVPACS Score
2229a	1.35322	0.01935	1.37257	0.1	0.1	0.2	0.1	99	89	35.26	0	0.49	0.365
2229b	1.35322	0.01935	1.37257	0.1	0.1	0.2	0.1	99	89	43.97	0	0.31	0.365
2229c	1.35322	0.01935	1.37257	0.1	0.1	0.2	0.1	99	89	39.67	0	0.36	0.411
2229avg	1.35322	0.01935	1.37257	0.1	0.1	0.2	0.1	99	89	38.98	0	0.55	0.351
2229AV										**39.63**	**0**	**0.39**	**0.380**
2238a	0.13886	0.01555	0.15441	0.1	0.1	0.2	0.1	87	86	44.58	1	0.12	0.351
2238b	0.13886	0.01555	0.15441	0.1	0.1	0.2	0.1	87	86	46.76	1	0.13	251[a]
2238AV										**45.67**	**1**	**0.13**	**0.351**
2243a	0.32392	0.01344	0.33736	0.1	0.1	0.2	0.1	94	78	43.91	0	0.13	0.430
2243b	0.32392	0.01344	0.33736	0.1	0.1	0.2	0.1	94	78	42.42	1	0.12	0.430
2243c	0.32392	0.01344	0.33736	0.1	0.1	0.2	0.1	94	78	48.30	0	0.11	0.531
2243AV										**44.88**	**1**	**0.12**	**0.464**
2433a	1.05251	0.02842	1.08093	0.1	0.1	0.2	0.1	93	65	38.91	0	0.13	0.531
2433b	1.05251	0.02842	1.08093	0.1	0.1	0.2	0.1	93	65	39.29	0	0.29	0.386
2433c	1.05251	0.02842	1.08093	0.1	0.1	0.2	0.1	93	65	40.37	0	0.29	0.386
2433AV										**39.52**	**0**	**0.24**	**0.434**
2435b	0.32052	0.00945	0.32997	0.1	0.1	0.2	0.1	95	55	25.75	0	0.15	0.362
2435c	0.32052	0.00945	0.32997	0.1	0.1	0.2	0.1	95	55	29.38	0	0.15	0.498
2435AV										**27.57**	**0**	**0.15**	**0.430**
2441a	1.31152	0.06041	1.37193	0.1	0.1	0.2	0.1	96	68	25.62	0	0.14	0.542
2441b	1.31152	0.06041	1.37193	0.1	0.1	0.2	0.1	96	68	29.41	0	0.14	0.493
2441c	1.31152	0.06041	1.37193	0.1	0.1	0.2	0.1	96	68	30.65	1	0.08	0.296
2441AV										**28.56**	**1**	**0.12**	**0.444**
SWZ01a	7.9107	0.1284	8.0391	3.4	3	6.4	53.8	73	74	130.84	3	-0.03	0.000
SWZ01b	7.9107	0.1284	8.0391	3.4	3	6.4	53.8	73	74	71.40	3	NA	0.095
SWZ01c	7.9107	0.1284	8.0391	3.4	3	6.4	53.8	73	74	69.39	3	0.00	0.095
SWZ01AV	0	0	0							**90.54**	**3**	**-0.02**	**0.063**
SWZ02a	4.3516	0.1463	4.4979	0.1	0.1	0.2	80.1	76	66	61.11	2	NA	0.097
SWZ02b	4.3516	0.1463	4.4979	0.1	0.1	0.2	80.1	76	66	64.04	3	0.00	0.194
SWZ02c	4.3516	0.1463	4.4979	0.1	0.1	0.2	80.1	76	66	105.98	3	0.00	0.000
SWZ02AV										**77.04**	**3**	**0.00**	**0.097**
SWZ03a	12.192	0.3043	12.4963	0.1	0.1	0.2	579.3	84	86	54.70	1	0.07	0.608
SWZ03b	12.192	0.3043	12.4963	0.1	0.1	0.2	579.3	84	86	51.10	1	0.27	0.405
SWZ03c	12.192	0.3043	12.4963	0.1	0.1	0.2	579.3	84	86	54.21	1	0.08	0.507
SWZ03AV										**53.34**	**1**	**0.14**	**0.507**

Table 1. (cont.)

Station ID	HPAH (mg/kg)	LPAH (mg/kg)	PAH (mg/kg)	Alpha Chlordane (µg/kg)	Gamma Chlordane (µg/kg)	Chlordane (µg/kg)	PCBs (µg/kg)	Amphipod Toxicity Test Raw Station Result (% survival)	Bivalve Larval Development Test Raw Station Result (% normal)	BRI Score	IBI Score	RBI Score	RIVPACS Score
SWZ04a	15.0717	0.2565	15.3282	0.1	0.1	0.2	168	69	67	66.10	2	0.00	0.145
SWZ04b	15.0717	0.2565	15.3282	0.1	0.1	0.2	168	69	67	71.11	2	NA	0.097
SWZ04c	15.0717	0.2565	15.3282	0.1	0.1	0.2	168	69	67	51.74	1	0.31	0.436
SWZ04AV										**62.98**	**2**	**0.16**	**0.226**
SWZ05a	5.968	0.165	6.133	3.2	10.4	13.6	98	73	82	65.89	3	NA	0.145
SWZ05b	5.968	0.165	6.133	3.2	10.4	13.6	98	73	82	45.74	3	0.04	0.387
SWZ05c	5.968	0.165	6.133	3.2	10.4	13.6	98	73	82	59.38	3	0.02	0.290
SWZ05AV										**57.00**	**3**	**0.03**	**0.274**
SWZ06a	8.3461	0.285	8.6311	4.1	8.3	12.4	142.3	70	80	51.15	0	0.26	0.608
SWZ06b	8.3461	0.285	8.6311	4.1	8.3	12.4	142.3	70	80	73.08	3	0.00	0.304
SWZ06c	8.3461	0.285	8.6311	4.1	8.3	12.4	142.3	70	80	53.01	1	0.34	0.507
SWZ06AV										**59.08**	**2**	**0.20**	**0.473**
DAC01a	4.9302	0.0864	5.0166	0.1	0.1	0.2	192.9	83	89	49.84	1	0.08	0.390
DAC01b	4.9302	0.0864	5.0166	0.1	0.1	0.2	192.9	83	89	55.15	2	0.04	0.290
DAC01c	4.9302	0.0864	5.0166	0.1	0.1	0.2	192.9	83	89	52.30	2	0.05	0.340
DAC01AV										**52.43**	**2**	**0.06**	**0.340**
DAC02a	4.7365	0.0914	4.8279	0.1	0.1	0.2	381.1	91	96	51.63	0	0.08	0.490
DAC02b	4.7365	0.0914	4.8279	0.1	0.1	0.2	381.1	91	96	50.13	0	0.08	0.440
DAC02c	4.7365	0.0914	4.8279	0.1	0.1	0.2	381.1	91	96	50.03	3	0.03	0.340
DAC02AV										**50.60**	**1**	**0.06**	**0.423**
DAC03a	5.4114	0.0901	5.5015	0.1	0.1	0.2	766.8	90	90	49.50	2	0.22	0.440
DAC03b	5.4114	0.0901	5.5015	0.1	0.1	0.2	766.8	90	90	61.82	2	0.02	0.340
DAC03c	5.4114	0.0901	5.5015	0.1	0.1	0.2	766.8	90	90	54.66	2	0.05	0.150
DAC03AV										**55.33**	**2**	**0.10**	**0.310**
DAC04a	2.4152	0.0579	2.4731	0.1	0.1	0.2	293.65	60	77	55.74	1	0.03	0.440
DAC04b	2.4152	0.0579	2.4731	0.1	0.1	0.2	293.65	60	77	50.43	1	0.10	0.490
DAC04c	2.4152	0.0579	2.4731	0.1	0.1	0.2	293.65	60	77	48.30	0	0.28	0.490
DAC04AV										**51.49**	**1**	**0.14**	**0.473**
DAC05a	4.1183	0.0807	4.199	0.1	0.1	0.2	37.4	90	89	46.79	1	0.08	0.590
DAC05b	4.1183	0.0807	4.199	0.1	0.1	0.2	37.4	90	89	44.19	0	0.09	0.440
DAC05c	4.1183	0.0807	4.199	0.1	0.1	0.2	37.4	90	89	46.81	0	0.30	0.440
DAC05AV										**45.93**	**1**	**0.16**	**0.490**
DAC06a	3.8924	0.0854	3.9778	0.1	0.1	0.2	36.1	96	100	51.42	0	0.07	0.440
DAC06b	3.8924	0.0854	3.9778	0.1	0.1	0.2	36.1	96	100	59.37	0	0.05	0.440
DAC06c	3.8924	0.0854	3.9778	0.1	0.1	0.2	36.1	96	100	59.91	3	0.03	0.340
DAC06AV										**56.90**	**1**	**0.05**	**0.407**

Table 1. (cont.)

Station ID	HPAH (mg/kg)	LPAH (mg/kg)	PAH (mg/kg)	Alpha Chlordane (µg/kg)	Gamma Chlordane (µg/kg)	Chlordane (µg/kg)	PCBs (µg/kg)	Amphipod Toxicity Test Raw Station Result (% survival)	Bivalve Larval Development Test Raw Station Result (% normal)	BRI Score	IBI Score	RBI Score	RIVPACS Score
DAC07a	3.111	0.06031	3.17131	0.1	0.1	0.2	114	80	86	53.97	1	0.04	0.390
DAC07b	3.111	0.06031	3.17131	0.1	0.1	0.2	114	80	86	57.60	1	0.04	0.440
DAC07c	3.111	0.06031	3.17131	0.1	0.1	0.2	114	80	86	54.99	1	0.05	0.540
DAC07AV										**55.52**	**1**	**0.04**	**0.457**
DAC08a	3.5729	0.06601	3.63891	0.1	0.1	0.2	11.5	74	90	51.38	0	0.07	0.540
DAC08b	3.5729	0.06601	3.63891	0.1	0.1	0.2	11.5	74	90	49.63	0	0.08	0.490
DAC08c	3.5729	0.06601	3.63891	0.1	0.1	0.2	11.5	74	90	55.79	1	0.23	0.340
DAC08AV										**52.27**	**1**	**0.13**	**0.457**
DAC09a	3.0825	0.0546	3.1371	0.1	0.1	0.2	6.7	88	79	52.96	1	0.05	0.440
DAC09b	3.0825	0.0546	3.1371	0.1	0.1	0.2	6.7	88	79	49.12	0	0.11	0.590
DAC09c	3.0825	0.0546	3.1371	0.1	0.1	0.2	6.7	88	79	56.47	1	0.26	0.490
DAC09AV										**52.85**	**1**	**0.14**	**0.507**
BST01a	22.5533	0.2394	22.7927	0.1	0.1	0.2	0.1	93	82	49.67	1	0.26	0.406
BST01b	22.5533	0.2394	22.7927	0.1	0.1	0.2	0.1	93	82	47.12	0	0.06	0.457
BST01c	22.5533	0.2394	22.7927	0.1	0.1	0.2	0.1	93	82	45.56	1	0.08	0.304
BST01AV	0	0	0							**47.45**	**1**	**0.13**	**0.389**
BST02a	14.8999	0.54911	15.44901	0.1	0.1	0.2	0.1	88	70	48.78	1	0.26	0.406
BST02b	14.8999	0.54911	15.44901	0.1	0.1	0.2	0.1	88	70	50.90	2	0.03	0.507
BST02c	14.8999	0.54911	15.44901	0.1	0.1	0.2	0.1	88	70	48.45	1	0.26	0.507
BST02AV										**49.38**	**2**	**0.18**	**0.473**
BST03a	7.9411	0.2189	8.16	0.1	0.1	0.2	0.1	89	79	49.14	0	0.10	0.494
BST03b	7.9411	0.2189	8.16	0.1	0.1	0.2	0.1	89	79	45.73	0	0.11	0.642
BST03c	7.9411	0.2189	8.16	0.1	0.1	0.2	0.1	89	79	40.45	0	0.32	0.642
BST03AV										**45.11**	**0**	**0.18**	**0.593**
BST04a	17.4832	0.2971	17.7803	0.1	0.1	0.2	0.1	95	79	42.42	0	0.09	0.445
BST04b	17.4832	0.2971	17.7803	0.1	0.1	0.2	0.1	95	79	40.00	0	0.10	0.545
BST04c	17.4832	0.2971	17.7803	0.1	0.1	0.2	0.1	95	79	50.27	3	0.02	0.346
BST04AV										**44.23**	**1**	**0.07**	**0.445**
BST05a	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	86	80	47.84	2	0.05	0.395
BST05b	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	86	80	49.52	1	0.08	0.493
BST05c	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	86	80	56.86	1	0.05	0.444
BST05AV										**51.41**	**2**	**0.06**	**0.444**
BST06a	3.9522	0.08541	4.03761	0.1	0.1	0.2	0.1	96	90	43.64	1	0.29	0.444
BST06b	3.9522	0.08541	4.03761	0.1	0.1	0.2	0.1	96	90	42.48	0	0.08	0.444
BST06c	3.9522	0.08541	4.03761	0.1	0.1	0.2	0.1	96	90	40.78	1	0.08	0.444
BST06AV										**42.30**	**1**	**0.15**	**0.444**

Table 1. (cont.)

Station ID	HPAH (mg/kg)	LPAH (mg/kg)	PAH (mg/kg)	Alpha Chlordane (µg/kg)	Gamma Chlordane (µg/kg)	Chlordane (µg/kg)	PCBs (µg/kg)	Amphipod Toxicity Test Raw Station Result (% survival)	Bivalve Larval Development Test Raw Station Result (% normal)	BRI Score	IBI Score	RBI Score	RIVPACS Score
BST07a	59.268	0.94221	60.21021	0.1	0.1	0.2	0.1	87	82	52.47	3	0.01	0.247
BST07b	59.268	0.94221	60.21021	0.1	0.1	0.2	0.1	87	82	49.53	1	0.05	0.494
BST07c	59.268	0.94221	60.21021	0.1	0.1	0.2	0.1	87	82	45.35	1	0.38	0.543
BST07AV										**49.12**	**2**	**0.15**	**0.428**
BST08a	12.3968	0.27591	12.67271	0.1	0.1	0.2	0.1	97	82	49.13	1	0.28	0.543
BST08b	12.3968	0.27591	12.67271	0.1	0.1	0.2	0.1	97	82	52.05	1	0.06	0.444
BST08c	12.3968	0.27591	12.67271	0.1	0.1	0.2	0.1	97	82	44.06	1	0.08	0.494
BST08AV										**48.41**	**1**	**0.14**	**0.494**
BST09a	16.66	2.37231	19.03231	0.1	0.1	0.2	0.1	90	79	36.80	0	0.12	0.505
BST09b	16.66	2.37231	19.03231	0.1	0.1	0.2	0.1	90	79	41.28	1	0.07	0.404
BST09c	16.66	2.37231	19.03231	0.1	0.1	0.2	0.1	90	79	42.88	3	0.05	0.354
BST09AV										**40.32**	**2**	**0.08**	**0.421**
BST10a	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	93	82	48.52	0	0.10	0.543
BST10b	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	93	82	39.96	2	0.10	0.395
BST10c	7.6816	0.3744	8.056	0.1	0.1	0.2	0.1	93	82	46.55	2	0.05	0.395
BST10AV										**45.01**	**2**	**0.08**	**0.444**
BST11a	3.3409	0.04923	3.39013	0.1	0.1	0.2	0.1	97	80	44.32	0	0.28	0.304
BST11b	3.3409	0.04923	3.39013	0.1	0.1	0.2	0.1	97	80	38.29	1	0.08	0.557
BST11c	3.3409	0.04923	3.39013	0.1	0.1	0.2	0.1	97	80	38.41	0	0.13	0.507
BST11AV										**40.34**	**1**	**0.16**	**0.456**
BST12a	4.4086	0.08503	4.49363	0.1	0.1	0.2	0.1	95	76	50.81	0	0.10	0.355
BST12b	4.4086	0.08503	4.49363	0.1	0.1	0.2	0.1	95	76	41.01	1	0.07	0.406
BST12c	4.4086	0.08503	4.49363	0.1	0.1	0.2	0.1	95	76	43.39	0	0.09	0.406
BST12AV										**45.07**	**1**	**0.09**	**0.389**

Notes: Bolded stations are the average of replicate benthic scores. The average was used in the correlation analyses and plots.

BRI -
HPAH - high-molecular-weight polycyclic aromatic hydrocarbon
IBI
LPAH - low-molecular-weight polycyclic aromatic hydrocarbon
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
RBI -
RIVPACs -
UCL - upper confidence limit

[a] Outlier was removed for this RIVPACS score.

Attachment 1

Key ProUCL Output Files from NASSCO Public Records Act Request

	Lognormal UCL Statistics for Full Data Sets	
User Selected Options		
From File	C:\My Documents\ChollasCrk\SQO Analysis All\SQOstats12final.wst	
Full Precision	OFF	
Confidence Coefficient	95%	
Number of Bootstrap Operations	2000	

tPCBs

Number of Valid Observations	75
Number of Distinct Observations	30
Minimum of log data	-2.303
Maximum of log data	7.655
Mean of log data	2.215
SD of log data	2.45
Variance of log data	6.004
Coefficient of Variation of raw data	2.824
Skewness of raw data	4.549
Lilliefors Test Statistic	0.228
Lilliefors 5% Critical Value	0.102
Data not Lognormal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
95% Student's-t UCL	168.3
ML Estimates Assuming Lognormal Distribution	
Mean	184.4
SD	3706
Coefficient of Variation	20.1
Skewness	8179
Median	9.164
80% Quantile	72.06
90% Quantile	211.8
95% Quantile	515.7
99% Quantile	2739
MVU Estimate of Median	8.804
MVU Estimate of Mean	159.5
MVU Estimate of SD	1734
MVU Estimate of Standard Error of Mean	74.76
Non-Parametric UCLs	
95% Adjusted-CLT UCL (Adjusted for Skewness, Chen-1995)	187.5
95% Modified-t UCL (Adjusted for Skewness, Johnson-1978))	171.4
95% Hall's Bootstrap UCL	263.4
95% Bootstrap t UCL	213.5
95% BCA Bootstrap UCL	193.6
95% Chebyshev (Mean, Sd) UCL	264.1
97.5% Chebyshev (Mean, Sd) UCL	331.2
99% Chebyshev (Mean, Sd) UCL	462.9

UCLs (Assuming Lognormal Distribution)	
95% H-UCL	578.5
95% Chebyshev (MVUE) UCL	485.4
97.5% Chebyshev (MVUE) UCL	626.4
99% Chebyshev (MVUE) UCL	903.4
Data do not follow a Discernable Distribution (0.05)	
May want to try Non-Parametric UCLs	
tChlordane	
Number of Valid Observations	60
Number of Distinct Observations	9
Minimum of log data	-1.609
Maximum of log data	2.282
Mean of log data	-0.264
SD of log data	1.134
Variance of log data	1.287
Coefficient of Variation of raw data	1.412
Skewness of raw data	1.792
Lilliefors Test Statistic	0.347
Lilliefors 5% Critical Value	0.114
Data not Lognormal at 5% Significance Level	
95% UCL (Assuming Normal Distribution)	
95% Student's-t UCL	2.101
ML Estimates Assuming Lognormal Distribution	
Mean	1.461
SD	2.366
Coefficient of Variation	1.619
Skewness	9.103
Median	0.768
80% Quantile	1.995
90% Quantile	3.285
95% Quantile	4.961
99% Quantile	10.75
MVU Estimate of Median	0.759
MVU Estimate of Mean	1.436
MVU Estimate of SD	2.177
MVU Estimate of Standard Error of Mean	0.258
Non-Parametric UCLs	
95% Adjusted-CLT UCL (Adjusted for Skewness, Chen-1995)	2.166
95% Modified-t UCL (Adjusted for Skewness, Johnson-1978))	2.112
95% Hall's Bootstrap UCL	2.159

	A	B	C	D	E	F	G	H	I	J	K	L
105	95% Bootstrap t UCL					2.156						
106	95% BCA Bootstrap UCL					2.147						
107	95% Chebyshev (Mean, Sd) UCL					2.89						
108	97.5% Chebyshev (Mean, Sd) UCL					3.444						
109	99% Chebyshev (Mean, Sd) UCL					4.532						
110												
111	UCLs (Assuming Lognormal Distribution)											
112	95% H-UCL					2.142						
113	95% Chebyshev (MVUE) UCL					2.56						
114	97.5% Chebyshev (MVUE) UCL					3.047						
115	99% Chebyshev (MVUE) UCL					4.003						
116												
117	**Data do not follow a Discernable Distribution (0.05)**											
118												
119	**May want to try Non-Parametric UCLs**											
120												
121												
122	PPPAHs											
123												
124	Number of Valid Observations					75						
125	Number of Distinct Observations					67						
126	Minimum of log data					4.927						
127	Maximum of log data					9.461						
128	Mean of log data					7.028						
129	SD of log data					1.173						
130	Variance of log data					1.377						
131	Coefficient of Variation of raw data					1.387						
132	Skewness of raw data					2.087						
133												
134	Lilliefors Test Statistic					0.158						
135	Lilliefors 5% Critical Value					0.102						
136	Data not Lognormal at 5% Significance Level											
137												
138	95% UCL (Assuming Normal Distribution)											
139	95% Student's-t UCL					2965						
140												
141	ML Estimates Assuming Lognormal Distribution											
142	Mean					2245						
143	SD					3864						
144	Coefficient of Variation					1.721						
145	Skewness					10.26						
146	Median					1128						
147	80% Quantile					3028						
148	90% Quantile					5073						
149	95% Quantile					7770						
150	99% Quantile					17287						
151												
152	MVU Estimate of Median					1117						
153	MVU Estimate of Mean					2211						
154	MVU Estimate of SD					3586						
155	MVU Estimate of Standard Error of Mean					374.5						
156												

	A	B	C	D	E	F	G	H	I	J	K	L
157	Non-Parametric UCLs											
158	95% Adjusted-CLT UCL (Adjusted for Skewness, Chen-1995)					3053						
159	95% Modified-t UCL (Adjusted for Skewness, Johnson-1978))					2980						
160	95% Hall's Bootstrap UCL					3030						
161	95% Bootstrap t UCL					3078						
162	95% BCA Bootstrap UCL					3089						
163	95% Chebyshev (Mean, Sd) UCL					3974						
164	97.5% Chebyshev (Mean, Sd) UCL					4681						
165	99% Chebyshev (Mean, Sd) UCL					6070						
166												
167	UCLs (Assuming Lognormal Distribution)											
168	95% H-UCL					3129						
169	95% Chebyshev (MVUE) UCL					3844						
170	97.5% Chebyshev (MVUE) UCL					4550						
171	99% Chebyshev (MVUE) UCL					5937						
172												
173	**Data do not follow a Discernable Distribution (0.05)**											
174												
175	**May want to try Non-Parametric UCLs**											
176												

Outlier Tests for Selected Variables

User Selected Options	
From File	C:\My Documents\ChollasCrk\SQO Analysis All\SQOstats12final.wst
Full Precision	OFF
Test for Suspected Outliers with Dixon test	1
Test for Suspected Outliers with Rosner test	1

Rosner's Outlier Test for tPCBs

Mean	**139**
Standard Deviation	**401.9**
Number of data	**76**
Number of suspected outliers	**1**

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	139	399.2	2381	73	5.616	3.29	3.65

For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 2381 is a Potential Statistical Outlier

For 1% Significance Level, there is 1 Potential Outlier

Therefore, Observation 2381 is a Potential Statistical Outlier

Rosner's Outlier Test for tChlordane

Mean	**1.485**
Standard Deviation	**2.722**
Number of data	**76**
Number of suspected outliers	**1**

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	1.485	2.704	16.2	64	5.442	3.29	3.65

For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 16.2 is a Potential Statistical Outlier

For 1% Significance Level, there is 1 Potential Outlier

Therefore, Observation 16.2 is a Potential Statistical Outlier

Rosner's Outlier Test for PPPAHs

Mean	**2538**

	A	B	C	D	E	F	G	H	I	J	K	L
51			**Standard Deviation**	**3657**								
52			**Number of data**	**76**								
53			**Number of suspected outliers**	**1**								
54												
55				Potential	Obs.	Test	Critical	Critical				
56	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)				
57	1	2538	3633	17383	60	4.086	3.29	3.65				
58												
59	For 5% Significance Level, there is 1 Potential Outlier											
60	Therefore, Observation 17383 is a Potential Statistical Outlier											
61												
62	For 1% Significance Level, there is 1 Potential Outlier											
63	Therefore, Observation 17383 is a Potential Statistical Outlier											
64												

Attachment 2

Resumes of Memorandum Authors

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Gary N. Bigham, L.G.
Principal

Professional Profile

Mr. Gary Bigham is a Principal in Exponent's Environmental and Earth Sciences practice who specializes in the evaluation of transport, fate, and effects of contaminants in the environment. He has managed and been the principal investigator of field, laboratory, and theoretical assessments of a wide variety of contaminants in lakes, rivers, estuarine waters, ocean waters, groundwater, and air. Mr. Bigham has also directed RI/FSs, human health and ecological risk assessments, cost allocation studies, and NRDAs for sites involving soils, sediments, and waters contaminated with arsenic, chlorinated benzenes, dioxins/furans, mercury, metals, PAHs, PCBs, petroleum hydrocarbons, and solvents. He has also completed several evaluations of mercury in indoor air. Examples of contaminant transport and fate analyses include the development of a numerical model of mercury cycling and bioaccumulation for Onondaga Lake; a detailed evaluation and modification of sediment transport and PCB bioaccumulation models for the Fox River and Green Bay, Wisconsin; and an evaluation of the effects of eutrophication on mercury bioaccumulation in the Florida Everglades. Mr. Bigham is the author of numerous publications on the behavior of mercury in the environment.

Mr. Bigham has been designated an expert witness in class action and individual tort claims on the issue of PCB and PAH transport in streams and rivers, and dioxins/furans in a lake; in litigation involving mercury bioaccumulation in the Florida Everglades; and assessments of exposure to mercury vapor, crude oil, and produced water. He has also evaluated and testified on the effects of atmospheric deposition of mercury and sulfate (acid rain) on drainage basins. Mr. Bigham has also completed environmental forensic investigations of mercury-contaminated sediments and soil, groundwater contaminated with chlorinated solvents and petroleum hydrocarbons, and for allocation of remediation costs of a PAH-contaminated sediment site in Boston Harbor. He has also had a lead role in NRDAs related to mercury contamination in surface waters and involving solvents in groundwater. He has also served as a consulting expert on a major NRD claim involving confined animal feeding operations (CAFOs) in Oklahoma and Arkansas.

Mr. Bigham's international experience includes serving as resident manager for a multi-year air quality and marine environmental monitoring program in Saudi Arabia. He led the technical development of a natural resource damage claim for the Kingdom of Jordan to the United Nations Compensation Commission for damages arising from the first Gulf War. He recently completed an environmental assessment for a major oil export facility in Abu Dhabi and evaluated potential human exposure to spilled oil and produced-water discharges in the Amazon basin of Ecuador. He applied a water quality model to predict conditions in and downstream of a proposed reservoir in Bolivia and assessed water quality and greenhouse gas emissions for a proposed reservoir in Guyana. He has also completed an assessment of potential human exposure to mercury vapor from a spill in the Peruvian highlands.

Academic Credentials and Professional Honors

Post-graduate course work in Environmental Engineering, University of Southern California, 1975–1976
M.S., Geophysical Sciences, Georgia Institute of Technology, 1972
B.S., Geology, Oregon State University, 1968

Licenses and Certifications

Licensed Geologist, Washington, #1303
Hazardous Waste Operations Management and Supervisor 8-hour training program

Publications

Bigham G, Feng X (guest editors). Mercury biogeochemical cycling in mercury contaminated environments. Applied Geochemistry 2011; 26(2).

Bigham G, Law S. Agriculture meets Natural Resource Damage claims. Agricultural Management Committee Newsletter, American Bar Association, August 2009.

Bigham G, Chan W, Dekermenjian M, Reza A. Indoor concentrations of mercury vapor following various spill scenarios. Environmental Forensics 2008; 9(2):187–196.

Chan W, Bigham G, Dekermenjian M. Exposure to elemental mercury from a spill. In: Abstracts—11th International Conference on Indoor Air Quality and Climate, Copenhagen, Denmark, August 17–22, 2008.

Bigham G, Gard N, Drury D. Assessment of natural resource damages at the New Almaden mercury mining district, California. In: Abstracts—8th International Conference on Mercury as a Global Pollutant, Madison, WI, August 6–11, 2006.

Bigham GN, Henry B, Bessinger B. Mercury. In: Environmental Forensics, Contaminant Specific Guide. Morrison RD and Murphy BL (eds), Academic Press, 2006.

Bigham G, Henry B, Bessinger B. Mercury—A tale of two toxins. Natural Resources & Environment, American Bar Association 2005; 19(4).

Mackay CE, Colton JE, Bigham G. Structuring population-based ecological risk assessments in a dynamic landscape. In: Coastal and Estuarine Risk Assessment. Newman MC, Roberts Jr. MH, and Hale RC (eds), Lewis Publishers, Boca Raton, FL, 2002.

Bigham GN, Vandal GM. A drainage basin perspective of mercury transport and bioaccumulation: Onondaga Lake, New York. Neurotoxicology 1996; 17(1):279–290.

Becker DS, Bigham GN. Distribution of mercury in the aquatic food web of Onondaga Lake. Water Air and Soil Pollution 1995; 80:563–571.

Becker DS, Rose CD, Bigham GN. Comparison of the 10-day freshwater sediment toxicity tests using *Hyalella azteca* and *Chironomus tentans*. Environmental Toxicology and Chemistry 1995; 4(12):2089–2094.

Henry EA, Dodge-Murphy LJ, Bigham GN, Klein SM. Modeling the transport and fate of mercury in an urban lake (Onondaga Lake, NY). Water Air and Soil Pollution 1995; 80:489–498.

Henry EA, Dodge-Murphy LJ, Bigham GN, Klein SM, Gilmour CC. Total mercury and methylmercury mass balance in an alkaline, hypereutrophic urban lake (Onondaga Lake, NY). Water Air and Soil Pollution 1995; 80:509–518.

Bigham GN. Oceanic disposal of waste from manganese nodule processing. In: Oceanic Processes in Marine Pollution, Volume 3, Marine Waste Management—Science and Policy. Champ MA and Park DK (eds), Robert E. Krieger Publishing Company, Malabar, FL, 1989.

Bigham GN. Zone of influence, inner continental shelf of Georgia. Journal of Sediment Petrol 1973; 31(1):207–21.

Prior Experience

Vice President, PTI Environmental Services, 1987–1997
Senior Scientist, Tetra Tech, Inc., 1974–1987
Environmental Scientist, U.S. Army Corps of Engineers, 1972–1974

Project Experience

Contaminant Transport and Fate

Technical lead on behalf of the U.S. Department of State for evaluation of the potential transport and fate of crude oil (diluted bitumen or dilbit) in the event of a spill from the Keystone XL pipeline project. The project included review of information in the DOS final environmental impact statement and supplementary analysis of the impacts of dilbit on groundwater from a very small and a large spill, as well as impacts of a spill to surface waters.

Evaluated the transport and fate of spilled oil and produced water alleged in a toxic tort claim related to oil exploration and production from the Sacha field in the Amazon basin region of Ecuador and provided an expert report for ChevronTexaco.

Evaluated the transport and deposition of PCB-contaminated sediment in a Kentucky river system and provided expert jury-trial testimony for Rockwell International.

Prepared an expert report in a property damage case in Brunswick, Georgia, regarding deposition of mercury and PCBs on intertidal and riparian properties.

Prepared an expert report and provided expert hearing testimony in a class-action property damage case regarding the transport of PCB-contaminated sediment in a stream system at Rome, Georgia, for General Electric.

Prepared an expert report in a property damage case regarding transport of PCB-contaminated stormwater runoff onto a property in Rome, Georgia, for General Electric.

Selected by SERDP (U.S. Department of Defense's Strategic Environmental Research and Development Program) in 2005 to review research grant proposals on "Assessment and Measurement of Processes Impacting the Fate and Transport of Contaminants in Sediments," and in 2006, to review proposals on "Ecosystem Risk and Recovery Assessment for Contaminated Sediments."

Managed an ecological risk assessment and potential natural resource assessment for Honeywell at a tidal marsh in Georgia contaminated by mercury, PCBs, and other substances. The project included a detailed evaluation of mercury species and PCB congeners in sediment, water, and biota, as well as food-web modeling of ecological effects.

Assisted in the design and implementation of field data collection and field experimentation to predict water quality for an open-pit mine in Indonesia.

Provided an analysis of the long-term effects of drilling-mud deposits from offshore oil exploration and production platforms in southern California.

Conducted a program for measuring sediment oxygen demand in Great South Bay, New York, and developed input for a numerical water quality model.

Developed a simple leach-test procedure to evaluate the water quality effects of dredged material disposal. Procedure was adopted as a standard test by the U.S. Army Corps of Engineers and EPA.

Assisted in developing a laboratory selective leaching procedure for the U.S. Army Corps of Engineers to determine how metals are bound to contaminated sediments.

Served as project manager to provide technical support regarding transport, fate, and effects of PCBs for a contractor at a dredging site on the St. Lawrence River at Massena, New York.

Served as project manager to develop a method to predict concentrations of bacteria and suspended sediments at a site within Grays Harbor, Washington, resulting from dredged material disposal at the Point Chehalis disposal site for the U.S. Army Corps of Engineers.

Served as project manager for a critical review of projected risks of spilled oil to the southern sea otter population in California for an oil and gas company.

Managed an analysis of the wave propagation and flushing characteristics of a marina in Puget Sound, Washington. Project included physical modeling and field verification.

Performed stream gauging, determined river-aquifer exchange, and collected historical surface and groundwater data along the Rockaway River, New Jersey.

Cost Allocation

Prepared an expert report for an arbitration panel on the allocation of costs for remediation of elemental mercury spilled at a municipal sewage treatment plant in Dubuque, Iowa.

Prepared a historical sedimentation and fate analysis in allocation mediation among three companies for remediation costs of PAH-contaminated sediments at a site in Boston Harbor. Conducted an environmental forensics investigation of the timing and nature of transport and deposition of wastes from coke, coal tar, and manufactured gas plants.

Prepared an expert report for arbitration on a risk-based approach for allocation of remediation costs at a commercial landfill site in the New Jersey Pine Barrens. Also conducted an environmental forensics investigation to determine the sources of onsite contaminants.

Environmental Assessment

Performed an evaluation of potential impacts of dredging and related modifications to a container port facility in Buenos Aires, Argentina.

Project manager for an environmental impact assessment for modifications of oil storage facilities at the major oil export terminal at Abu Dhabi, UAE.

Project manager for the investigation of potential dredged material disposal sites within San Francisco Bay, California.

Developed approach and managed the preparation of a draft and final EIS for the National Science Foundation–funded Deep Ocean Drilling Program.

Served as project manager to provide shipboard and technical support to EPA's ocean dumping program. Prepared ocean dumping site designation reports, and developed a QA/QC program for marine sample collection and shipboard and shore-based analyses.

Served as project manager for planning, design, and construction supervision of a marina and related facilities in Tulalip Bay, Washington. Prepared an environmental assessment, and provided permitting support.

Served as project manager for a precision bathymetric survey and the production of bathymetric maps of Boca de Quadra Fjord near Ketchikan, Alaska.

Served as resident manager in Jubail, Saudi Arabia, for an extensive environmental baseline survey. Program included air quality monitoring, marine biological and physical oceanographic surveys, and sediment transport studies.

Performed a preliminary siting survey for a single-point mooring oil terminal on the southern coast of Oman.

Evaluated effluent characteristics and water quality effects of a major oil and gas gathering project in the Arabian Gulf.

Served as assistant project manager of an EIS for a major beach restoration project along the south shore of Long Island, New York. Project involved placing sand dredged from offshore onto the beach.

Performed an analysis of the potential impacts of a proposed single-point mooring oil terminal facility off Morro Bay, California.

Served as contract manager for a marine environmental investigation of the effects of major improvements to the Los Angeles/Long Beach Harbor, California.

Environmental Forensics

Prepared an expert report and provided deposition testimony regarding the extent of contamination and need for remediation at a former chemical manufacturing site near Tacoma, Washington. The project involved review of past manufacturing and waste disposal practices and evaluation of chemical analyses of soil and groundwater data. Degradation of chlorinated and petroleum hydrocarbons in groundwater and groundwater velocities were also evaluated.

Prepared a report on behalf of BP/ARCO and provided deposition testimony in support of a motion to dismiss in a toxic tort claim. The claim involved alleged damages related to vapor intrusion from comingled PCE, TCE, and petroleum hydrocarbon groundwater plumes. The objective of the report was to determine the timing of a release of petroleum hydrocarbons from a wholesale distribution site and whether the plume had reached the plaintiffs' property.

Prepared an expert report and provided deposition testimony in opposition to class certification regarding the sources, transport, and deposition of sediment and associated dioxins and furans in Lake Sam Rayburn, Texas, on behalf of defendants International Paper and Abitibi.

Prepared an expert report regarding the sources, transport, and deposition of contaminated sediments and the chemical fate of associated PCB, PAH, and metals in a small stream in Brockport, New York, for General Electric.

Prepared an expert report on behalf of BP/ARCO regarding the nature of contamination at a former bulk fuel distribution site in Pomona, California. Weathered gasoline and diesel fuel were present on the site along with PCE. One source of PCE to the vadose zone was determined to be a nearby solvent wholesaler site.

Prepared an expert report on behalf of BP/ARCO evaluating the potential contamination of a municipal supply well in Norwalk, California, with 1,1-DCA by near-surface releases from a service station.

Performed field research of circulation patterns on the inner continental shelf of Georgia by using suspended and deposited clay minerals as tracers.

Mercury

Evaluated the environmental impact of mercury and sulfate deposition (acid rain) related to emissions from a coal-burning industrial boiler in Maryland on federal lands in northern Virginia and West Virginia. Provided deposition and trial testimony.

Developed estimates of mercury vapor emission rate associated with the ordered removal of brine mud landfills at a former mercury-cell chlor-alkali plant on the Penobscot River in Maine. The emission rates were back-calculated, using AERMOD, from measured vapor emissions from similar material during remediation at another chlor-alkali plant. Provided regulatory hearing testimony.

Performed a survey of mercury concentrations in indoor air and soil vapor at a chemical facility in Canton, Ohio.

Evaluated potential exposure to mercury vapor related to a spill of elemental mercury over 40 km of highway in the Peruvian highlands. Exposure occurred when residents took the mercury home. The project included construction of a room similar to a rural Peruvian home and measuring mercury vapor concentrations in the room following a controlled mercury release. The results were used to verify a mathematical mercury evaporation and exposure model. Also evaluated mercury in urine data to corroborate model results.

Performed a reconnaissance of the Almaden Quicksilver County Park on behalf of the Santa Clara County Parks and Recreation Department to identify sites of soil erosion. The areas were prioritized according to their potential contribution of sediment and mercury to the Guadalupe River system.

Prepared comments on behalf of the Santa Clara Parks and Recreation Department on the Guadalupe River Mercury TMDL report.

Prepared an expert report in defense of a class action claim against a natural gas utility for mercury exposure related to removal of gas pressure regulators. The work included evaluation of regulator removal procedures and estimation of the potential short- and long-term mercury exposure in indoor air.

Prepared and submitted comments on the TMDL report for mercury in San Francisco Bay on behalf of the Santa Clara Valley Water District.

Provided review and comment of a TMDL for mercury in the Guadalupe River prepared by a contractor for the Santa Clara Valley Water District.

Project manager for a cooperative Natural Resource Damage Assessment for the Guadalupe River Basin that drains the former Almaden Mercury Mining District near San Jose, California.

Work also included additional sampling, analyses, and interpretation of mercury data for various media.

Project manager for evaluation of factors that influence bioaccumulation of mercury and other contaminants in fishes for the Michigan DEQ. Also recommended parameters to include in fish monitoring programs. The objective was to ensure that all appropriate parameters needed to identify the cause of long-term trends are measured.

Provided comments for Westinghouse Savannah River Laboratory on the draft TMDL for mercury in the Savannah River developed by U.S. EPA Region 4.

Designated as an expert witness in standard-of-care litigation involving a consulting engineering firm's clean up of a mercury-contaminated building.

Member of a panel of mercury experts to evaluate mercury behavior, bioaccumulation, and remedies at South River, a tributary of the Shenandoah River, Virginia, for DuPont and the VADEQ.

Project manager for evaluation of the behavior, effects, and remediation of elemental mercury spilled in homes from gas pressure regulators in Detroit, Michigan.

Project manager for evaluation of mercury toxicity and treatability in petroleum industry effluents for the American Petroleum Institute. Project also included a separate evaluation of reported mercury concentration data in crude oil.

Managed a project designed to evaluate mercury cycling and bioaccumulation in fresh and estuarine waters to help guide future investigations for the Aluminum Company of America.

Expert witness on the issue of the relationship between mercury bioaccumulation in aquatic food webs and the degree of eutrophication in the south Florida Water Conservation Areas and the Everglades.

Natural Resource Damage Assessment

Provided technical support to an analysis of damages to groundwater from a bauxite processing facility and oil refinery complex on St. Croix, U.S. Virgin Islands.

Served as a consulting expert for a first-of-its-kind NRD claim involving confined animal feeding operations (CAFOs) in Oklahoma and Arkansas. Evaluated animal waste and soil chemical data along with information in nutrient management plans. Evaluated transport of contaminants by stormwater runoff and potential water quality effects on downstream surface waters and a reservoir. Developed a comprehensive web-based compilation of reports and data linked to a GIS map of relevant locations.

Prepared a preliminary estimate of potential natural resources damage liability for a chemical facility in Delaware. Potential damages were related to solvents in groundwater, surface water, and tidal wetlands.

Prepared an expert report and provided deposition testimony regarding delineation of a PCE groundwater plume and associated natural resource damages at a former manufacturing facility in North Brunswick, New Jersey.

Project manager for a cooperative Natural Resource Damage Assessment for the Guadalupe River Basin that drains the former Almaden Mercury Mining District near San Jose, California. Project included development of a Habitat Equivalency Analysis and negotiation of restoration with resource trustees.

Performed a preliminary Habitat Equivalency Analysis of natural resource damages related to mercury contamination of Onondaga Lake, New York.

Project manager to provide an evaluation of a Natural Resource Damage Assessment prepared by the State of New Jersey for a landfill site. Evaluated injuries to fisheries, groundwater, and wetlands and prepared alternative assessment. Project also included development of restoration alternatives.

Developed the technical claim to the United Nations Compensation Commission on behalf of the Kingdom of Jordan for environmental damages to water resources incurred during the Gulf War. Also developed a claim and work plan for monitoring and assessment to further quantify damages.

Directed a preliminary natural resource damage evaluation for a complex aquatic system in Montana affected by mining wastes.

NPDES Permitting

Evaluated the source of metals in water discharged from the NASSCO graving dock in San Diego Harbor. Performed field leach testing of likely sources of copper, nickel, and zinc and prepared a model to predict concentrations in water from initial flooding through ship launching. Also performed field sampling of flood waters over several launch cycles to verify the model.

Prepared an expert report regarding compliance of the City and County of Honolulu's Sand Island and Honouliuli municipal sewage treatment plants with terms of their NPDES discharge permits and Section 301(h) waivers from the requirements of secondary treatment. Also addressed the appropriateness of the City and County's applications for NPDES permit and Section 301(h) waiver renewals.

Served as resident manager for a numerical water quality modeling study of the effects of municipal wastewater discharges to all the bays around Long Island, New York.

Served as project manager and technical director to evaluate the fate and effects of submarine tailings disposal to a fjord in southeastern Alaska, for EPA's evaluation of an NPDES discharge permit.

Managed and performed an EPA field evaluation of the effects of fish processing waste disposal on marine waters and sediment at a site in the Aleutian Islands, Alaska.

Managed an investigation for two fish processing companies to support a request to EPA and the State of Alaska for continued discharge of fish processing waste at a site in the Aleutian Islands, Alaska.

Remedial Investigations/Feasibility Studies

Performed an evaluation of potential liability for a multinational manufacturing company related to past offsite disposal of hazardous wastes at facilities worldwide.

Managed a major RI/FS and natural resource damage investigation at Onondaga Lake, New York, for AlliedSignal Inc., to evaluate impacts of historical discharges from soda ash and mercury cell chlor-alkali plants. Project includes modeling mercury cycling and bioaccumulation in the lake and assessing the toxicity of a variety of contaminants in sediments. Results of the modeling and human health and ecological risk assessments will be used to select effective remedies.

Directed an evaluation of human health and ecological risks at the Butte and Anaconda, Montana, mining and smelting sites. Project included preparing risk assessment scoping documents for several operable units where arsenic, cadmium, and lead were the primary contaminants of concern. Also conducted in-depth research on the bioavailability of soil contaminants to demonstrate the reduced risk posed by mining-waste-related soils.

Provided deposition testimony for Shell Oil Company regarding the identification of wastes disposed of at Lowry Landfill (Colorado) as hazardous.

Project director of an RI/FS for the Smelter Hill operable unit of the Anaconda Smelter site in Anaconda, Montana. Investigations involved collecting more than 10,000 soil samples and evaluating soil phytotoxicity, human health risks, and contaminant transport in air and groundwater.

Project manager for technical litigation support related to a Superfund site near Kent, Washington. Project included evaluating organic and inorganic contaminant migration from the site to adjacent property via groundwater and air for a law firm representing two PRPs.

Managed an investigation of the extent of contamination at an industrial site near Grays Harbor, Washington, for a party interested in acquiring the site. Investigation included assessing soil, surface water, and groundwater contamination related to an abandoned municipal landfill, a truck maintenance shop, a wood waste landfill, and a log sort yard. Estimated cleanup costs and initiated soil removal.

Managed development of the work plan of a major historical mining district for the Butte, Montana, Superfund site RI/FS.

Project director to develop a work plan for the Bunker Hill, Idaho, Superfund site RI/FS. The 21-mi^2 site contains mill tailings and lead and zinc processing wastes.

Managed a Phase I RI/FS at a Superfund site in Anaconda, Montana. This complex site contains a wide variety of copper smelting and sulfide ore processing wastes, including approximately 7 mi^2 of impounded mill tailings.

Managed a remedial investigation examining the human health effects of arsenic-contaminated soils and potential remedial actions for Mill Creek, Montana, a small community adjacent to a Montana Superfund site.

Water Quality Modeling

Prepared a water quality evaluation of the proposed Amaila Falls Reservoir in Guyana on behalf of the project developer. Applied the water quality model CE Qual W2 to simulate water quality in the reservoir and downstream. A particular focus of the study was evaluation of greenhouse gases emitted by the pre-reservoir tropical river compared to emission from the reservoir.

Performed a modeling study to evaluate the behavior of discharge plumes from methane extraction facility on the stability of Lake Kivu, Rwanda. Utilized the Computational Fluid Dynamics code to determine the depth of plume stratification. Also evaluated water quality impacts of the wash water discharge on near surface waters.

Prepared a water quality evaluation for the proposed Misicuni Reservoir in Bolivia on behalf of the Inter-American Development Bank. Applied the coupled DYRESM-CAEDYM hydrodynamic and water quality models to predict water quality in the reservoir. Also applied the biogeochemical model PHREEQC to evaluate the release of contaminants from sediments under anaerobic conditions.

Prepared a risk evaluation of mineral oil spilled from a transformer at a hydroelectric dam in western Montana for submittal to EPA Region 8. The evaluation included estimation of the spill rate and transport and dilution, which were compared to anecdotal observations of oil sheen. Special attention was given to the fate of the PCBs contained in the mineral oil.

Managed an evaluation for NCR of sediment transport, water quality, and food-web models applied to PCB-contaminated sediments in the Fox River and Green Bay, Wisconsin, for a potential natural resource damage claim. Also participated on a state-industry work group to evaluate and modify applicable models.

Developed a method to allocate costs to remediate PCB-contaminated sediments in the Fox River, Wisconsin. The method was based on results of a sediment transport model.

Managed and directed technical analysis of legal, technological, and environmental factors related to future ocean disposal of manganese nodule processing wastes for NOAA. Project included development of a simplified waste dispersion model for screening of potential ocean dump sites.

Performed an analysis of oil spill trajectories in the Santa Barbara Channel, California, for an oil company.

Served as project manager and technical director for portions of EPA's evaluation of the fate and effects of drilling muds and cuttings in Alaska's marine waters. Applied the Offshore Operators Committee model to simulate dispersion of the plume.

Served as project manager for an analysis of the fate of drilling mud and cuttings discharges to the Beaufort Sea for two oil companies. Applied the Offshore Operators Committee model to simulate dispersion of the plume.

Served as project manager and technical director for portions of EPA's evaluation of the fate and effects of drilling muds and cuttings in Alaska's marine waters.

Served as project manager for an analysis of the fate of drilling mud and cuttings discharges to the Beaufort Sea for two oil companies.

Performed analyses of the fate and effects on water quality of municipal sewage discharge plumes to marine waters of the U.S. West Coast and Puerto Rico and evaluated compliance with water quality criteria as part of EPA's evaluation of applications, nationwide, for Section 30l(h) waivers from the requirement of secondary treatment.

Managed a numerical water quality evaluation and field verification study for a harbor development project in Saudi Arabia. Performed bathymetric surveys and dye dispersion tests. Measured tides, currents, and alongshore sediment transport.

Served a resident manager of water quality modeling studies of all of the bays around Long Island, New York. The purpose of the studies was to determine the optimum location for municipal sewage outfalls as part of a long-term regional (Section 208) planning program.

Professional Affiliations

- American Chemical Society
- Geological Society of America
- International Society of Environmental Forensics
- Society of Environmental Toxicology and Chemistry
- Associate Member, American Bar Association

Deposition/Trial Testimony

United States v. Westvaco Corporation, et al., U.S. District Court of Maryland, Case No. MGJ 00-cv-2602, January 16, 2013. Trial and deposition testimony.

Maine Department of Environmental Protection v Mallinckrodt, Maine Board of Environmental Protection, Penobscot County, Maine, January 25–February 4, 2010. Hearing testimony.

Middlesex Corporation v Phelps, Superior Court of Washington, Pierce County, Case No. 08-2-05524-3, September 9, 2009. Deposition testimony.

Huddleston et al., v. Union Pacific Railroad et al., Superior Court of the State of California, Contra Costa County, Case NO. C 05 – 02394, March 19, 2009. Deposition testimony.

New Jersey Department of Environmental Protection (NJDEP) and the Administrator of the New Jersey spill compensation Fund v Parker-Hannifin Corporation, State Court of New Jersey Docket No.: MID-L-286-06, March 13, 2008. Deposition testimony.

City of Pomona v ARCO et al., U.S. District Court Central District of California, Case No. CV 05 2353 RGK (JTLx), March 27, 2006. Deposition testimony.

Donald Brophy v Philadelphia Gas Works, Court of Common Pleas of Philadelphia County, First Judicial District of Pennsylvania, Civil Trial Division, Case No. 07MR05J1, March 7, 2005. Class certification hearing testimony.

Anderson v. Donahue Industries, Inc., et al., 1st Judicial District Court, Jasper County, Texas, Case No. 24516, April 13, 2004, Deposition testimony.

Richard L. Muller Jr. v. General Electric Company, U.S. District Court Northern District of Georgia, Rome Division, Case No. No. 4:99-CV-294-HLM, May 2002 and March 2004. Affidavit testimony.

Edwin Watters et al. v. General Electric Company, U.S. District Court Northern District of Georgia, Rome Division, Case No. 4:98-CV-0195-HLM, July 8, 1999. Class certification hearing testimony.

Mercer et al. v. Rockwell International, U.S. District Court, Western District of Kentucky at Bowling Green, Case No. 1:87CV-106-H, September 1997. Jury trial testimony.

Sugar Cane Growers v. South Florida Water Management District, U.S. District Court, Southern District of Florida, Case No. 88-1886-CIV-Hoeveler, November 1995. Deposition and Trial testimony.

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D. Frederick Bodishbaugh, Ph.D.

Managing Ecotoxicologist

Professional Profile

Dr. Rick Bodishbaugh is a Managing Ecotoxicologist in Exponent's EcoSciences practice. He has 19 years of diverse experience in aquatic toxicology research, chemical and site assessment, ecological risk assessment (ERA) in aquatic and terrestrial systems, and natural resource damage assessment (NRDA). His specific areas of technical expertise include fish and wildlife toxicity assessment, resource/habitat equivalency analysis (REA/HEA), bioavailability of chemical contaminants in aquatic and terrestrial ecosystems, and chemical structure-activity relationships. Dr. Bodishbaugh's graduate research focused on the aquatic toxicology of synthetic surfactant and other organic pollutants. Originally trained as a chemical engineer, he also has 4 years of experience as a geophysical and geochemical engineer in the international offshore oil and gas industry, and is trained and experienced in geophysical surveying and reservoir geology. Dr. Bodishbaugh also has formal training in marine biochemistry, molecular biology, and bioremediation principles.

Dr. Bodishbaugh is experienced in evaluating the effects of contaminated soil, groundwater, surface water, and sediments on ecological receptors. He has conducted assessments of chemical risk at dozens of sites for energy, petrochemical, pulp and paper, manufacturing, and mining industry clients. He is intimately familiar with federal, regional, and various state guidance and standards or practice for ERA under common regulatory frameworks, and has extensive face-to-face negotiation experience with federal and state regulatory agency technical staff across the U.S. He is also experienced in evaluating and interpreting field bioaccumulation and laboratory toxicity bioassay data for use in assessing ecological risk. He is well versed in the environmental toxicology and assessment of metals and persistent organic pollutants, especially PCBs and PAHs.

Dr. Bodishbaugh is experienced in providing technical support in a litigation context. He has extensive NRDA experience, and has helped clients develop defensive and settlement strategies for NRDA claims by federal, state, and tribal trustees at sites in Alaska, California, Indiana, Missouri, New Jersey, New York, Texas, and Washington. He is an expert in the application of REA and HEA, including applications for assessment of groundwater injury. He has worked closely with client legal teams to assess and critically evaluate the technical merits and costs of natural resource liability and settlement options, and has represented industry clients in both formal and informal trustee negotiations to arrive at rational injury assessments and cost effective, restoration-based compensation options. He has provided deposition testimony on NRD liability for east and west coast clients, and has contributed to numerous expert reports for NRD cases.

Academic Credentials and Professional Honors

Ph.D., Aquatic Toxicology, Duke University, 1995
B.S., Chemical Engineering, University of Tulsa (*cum laude*), 1985

Publications

Pastorok RA, Noftsker C, Iannuzzi TJ, Ludwig DF, Barrick RC, Ruby MV, Bodishbaugh DF. Natural remediation of polynuclear aromatic hydrocarbons and other petroleum hydrocarbons. In: Natural Remediation of Environmental Contaminants: Its Role in Ecological Risk Assessment and Management. Swindoll M, Stahl Jr RG, Ells SJ (eds), SETAC General Publications Series, Society of Environmental Toxicology and Chemistry, SETAC Press, Pensacola, FL, pp. 159–198, 2000.

Bodishbaugh DF. Acute toxicity mechanisms and quantitative structure-activity relationships of alkylphenol polyethoxylate surfactants in fish. Dissertation. Duke University, Durham, NC, 1995.

Bonaventura C, Bonaventura J, Bodishbaugh DF. Environmental bioremediation: Approaches and processes. In: Ecotoxicity and Human Health: A Biological Approach to Environmental Remediation. Bloom AD and de Serres FJ (eds) CRC Press, Boca Raton, FL, 1995.

Bonaventura C, Bonaventura J, Bodishbaugh DF. Environmental bioremediation: Applications and new horizons. In: Ecotoxicity and Human Health: A Biological Approach to Environmental Remediation. Bloom AD and de Serres FJ (eds) CRC Press, Boca Raton, FL, 1995.

Selected Presentations

Ginn T, Bodishbaugh DF. Key issues for use of habitat equivalency analysis in scaling compensatory restoration projects. Presentation at SETAC Annual Meeting, Portland, OR, November 2004.

Bodishbaugh DF, Moore ML, Godtfredsen KL. Congener composition of environmental PCB mixtures: An empirical analysis. Presentation at SETAC Annual Meeting, Austin, TX, November 2003.

Bodishbaugh DF. Toxicity endpoint extrapolation for characterization of ecological risk: Which method is right? Invited presentation at SETAC Annual Meeting, San Francisco, CA, November 1997.

Bodishbaugh DF. Toxicity assessment for calculation of ecological risk: The deterministic vs. probabilistic approaches to endpoint extrapolation. Presentation at SETAC Annual Meeting, Washington, DC, November 1996.

Bodishbaugh DF. *In vitro* studies of acute toxicity mechanisms and structure-activity relationships of nonionic surfactants in fish. Presentation at SETAC Annual Meeting, Denver, CO, November 1994.

Project Experience

Natural Resource Damage Assessment

Performed injury assessments and developed restoration alternatives for more than a dozen NRDA sites, involving PCBs, mining wastes, pulp mill effluent, chemical plant discharges and other hazardous releases. Habitats assessed include freshwater rivers and lakes, estuaries, and marine systems, as well as terrestrial habitats.

Familiar with NOAA, DOI, and various state trustee guidance and standard NRDA methods. Experienced in emerging NRDA issues, such as evaluation of groundwater resource damages, resource scaling in sensitive habitats, allocation at complex industrial sites, and allegations involving wood waste.

Developed client-customizable HEA computational tools for real-time evaluation of injury and restoration alternatives. Provided technical support and strategy in preparation for and during legal negotiations between industry clients and trustees on NRD settlements.

Developed and provided scientific rationale for cost-effective HEA-based restoration alternatives to avoid an expensive and arbitrary cash settlement. Presented and defended NRDA alternatives and technical justifications to trustees during face-to-face settlement negotiations.

Ecological Risk Assessment

Conducted or supervised ERAs for numerous industrial facilities where a combination of organic and inorganic contaminants were risk drivers. Sites have included pipelines, foundries, refineries, petrochemical plants, wood preservative sites, manufactured gas plant sites, shooting ranges, pulp mills, landfills, shipyards, mining sites, research facilities, and munitions plants. State-of-the-art approaches for ecological screening assessments, receptor exposure modeling, toxicity assessment, and chemical hazard characterization were integrated to form rational, science-based site assessments.

Conducted extensive bioavailability and bioaccumulation assessments for organic and inorganic contaminants in aquatic systems to provide higher tiers of assessment at complex sites where conventional bulk sediment assessment failed to produce feasible remedial alternatives. Successfully implemented habitat assessment and bioavailability analysis as tools to focus the scope of ecological risk assessments and make site assessment manageable.

Conducted ERAs of PCB contamination for numerous industrial clients. Contamination scenarios evaluated include direct product discharges and indirect transport of product to soil, groundwater, and surface water, including sensitive habitats. Industrial sites evaluated include pipeline facilities, heavy manufacturing facilities, and landfills. Developed site-specific food web modeling approaches to the assessment of risk from PCBs, and negotiated technical approaches to assessment with state and federal regulatory agencies. Reviewed and critiqued recent research developments and helped design original research into environmental toxicity of PCBs.

Developed, supported, and negotiated site-specific approaches to the assessment of metals toxicity at mining sites where natural mineralization and physical disturbance make bulk concentration a poor indicator of exposure and risk from site activities.

Litigation Support

Testified in deposition on general and site-specific NRDA issues on liability insurance case for a pulp and paper industry client in Alaska.

Testified in deposition on potential groundwater injuries at an industrial facility in New Jersey.

Authored and contributed to expert reports on NRDA issues submitted to state and federal courts on several NRD cases across the country.

Reviewed literature and served as an expert technical consultant for client legal teams, and authored affidavits on aquatic toxicity and biodegradation issues in support of active litigation concerning client product liability.

Conducted ERA and NRDA training for client legal staff.

Aquatic Toxicology Research and Consulting

Designed and conducted aquatic toxicity investigations using a variety of *in vivo* and *in vitro* techniques and test species, including studies on the toxicity mechanisms and structure-activity relationships of surfactant chemicals, detergents, and oil spill dispersants to fish.

Provided oversight for client-supported independent research used to establish the value of potential restoration projects.

Participated in the design of chronic dietary exposure studies to assess risk of endangered salmon species to PCBs and PAHs in estuarine sediments.

Served as technical consultant on potential endocrine disruptor effects of chemicals and client operations. Conducted training for client technical staff.

Professional Affiliations

- American Chemical Society
- Society of Environmental Toxicology and Chemistry

Exponent®

Thomas C. Ginn, Ph.D.
Principal

Professional Profile

Dr. Thomas Ginn is a Principal Scientist in Exponent's EcoSciences practice. He specializes in natural resource damage assessment and ecological risk assessment. He has conducted studies of the effects of inorganic and organic chemicals on aquatic and terrestrial organisms at sites nationwide. Dr. Ginn has specialized expertise in assessing the fate, exposure, and effects of substances such as PCBs, PAHs, dioxins, arsenic, cadmium, copper, lead, and mercury. He has provided scientific consultation regarding the design of remedial investigations and development of overall strategy, and he has provided technical support during negotiations with state and federal agencies. Dr. Ginn has provided support to industrial clients for natural resource damage assessments in Alaska, Arizona, California, Idaho, Indiana, Missouri, Montana, Massachusetts, Michigan, Minnesota, New Jersey, New York, Ohio, Oklahoma, South Carolina, Texas, Washington and West Virginia. In these projects, he has worked closely with legal counsel during strategy development and settlement negotiations with state, federal, and tribal trustees. Dr. Ginn has performed detailed technical assessments of injuries to terrestrial and aquatic resources, including fishes, birds, and mammals, and has also developed innovative and cost-effective restoration alternatives. He has provided deposition and trial testimony concerning injury to aquatic and terrestrial resources. Dr. Ginn has evaluated remedial alternative at contaminated sediment sites and has conducted state-of-the-art studies of the sources and distribution of trace metals. He has also developed site-specific sediment quality values based on the empirical relationships of chemical concentrations to biological effects.

Dr. Ginn has authored many publications in the area of applied ecology. He has given numerous presentations and CLE seminars on risk assessment and natural resource damage assessment. Since 1983, he has co-authored the annual literature review of marine pollution studies published by the Research Journal of the Water Environment Federation. Dr. Ginn has served as an expert witness concerning the effects of waste discharges and chemicals in sediments on aquatic organisms. He has also served on scientific advisory committees concerning management of contaminated sediments for Puget Sound, San Francisco Bay, and New York/New Jersey Harbor. Dr. Ginn testified to the U.S. House of Representatives, Commerce Committee, concerning the natural resource damage provision of Superfund reauthorization.

Academic Credentials and Professional Honors

Ph.D., Biology, New York University, 1977
M.S., Biological Sciences, Oregon State University, 1971
B.S., Fisheries Science, Oregon State University, 1968

Licenses and Certifications

Certified Fisheries Professional, American Fisheries Society, Certificate No. 2844

Publications

Mearns AJ, Reish DJ, Oshida PS, Ginn T, Rempel-Hester MA. Effects of pollution on marine organisms. Water Environ Res 2011; 83(10):1789–1852.

Mearns AJ, Reish DJ, Oshida PS, Buchman M, Ginn T, Donnelly R. Effects of pollution on marine organisms. Water Environ Res 2009; 81(10):2070–2125.

Gala W, Lipton J, Cernera P, Ginn TC, Haddad R, Henning MH, Jahn K, Landis WG, Mancini E, Nicoll J, Peters V, Peterson J. Ecological Risk Assessment (ERA) and Natural Resource Damage Assessment (NRDA): Synthesis of assessment procedures. Integrated Environ Assess Manage 2009; 5(4):515–522.

Mearns AJ, Reish DJ, Oshida PS, Buchman M, Ginn T, Donnelly R. Effects of pollution on marine organisms. Water Environ Res 2008; 80(10):1918–1979.

Becker DS, Ginn TC. Critical evaluation of the sediment effect concentrations for polychlorinated biphenyls. Integrated Environ Assess Manage 2008; 4(2):156–170.

Mearns AJ, Reish DJ, Oshida PS, Buchman M, Ginn TC, Donnelly R. Effects of pollution on marine organisms. Water Environ Res 2007; 79(10):2102–2160.

Becker DS, Long ER, Proctor DM, Ginn TC. Evaluation of potential toxicity and bioavailability of chromium in sediments associated with Chromite ore processing residue. Environ Toxicol Chem 2006; 25(10):2576–2583.

Mearns AJ, Reish DJ, Oshida PS, Buchman M, Ginn TC. Effects of pollution on marine organisms. Water Environ Res 2006; 78(10):2033–2086.

Sampson JR, Sexton JE, Ginn TC, Pastorok RA, Spielman A, Young DR, Taganov I. Content of metals and some organic contaminants in environmental media of Lake Baikal. Proc Russ Geogr Soc 2006; 1:52–58 (in Russian).

Nielsen D, Ginn T, Ziccardi L, Boehm P. Study: Proposed offshore gulf LNG terminals will have minor effects on fish populations. Oil Gas J 2006; 104(28), July 28.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2005; 77(7):2733–2919.

Dunford RW, Ginn TC, Desvousges WH. The use of habitat equivalency analysis in natural resource damage assessments. Ecol Econ 2004; 48(1):49–70.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2004; 76(7):2443.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2003; 75, 63 pp.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2002; 74, 78 pp.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2001; 73, 77 pp.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 2000; 72, 59 pp.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on marine organisms. Water Environ Res 1999; 71(5):1100–1115.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Buchman M. Effects of pollution on saltwater organisms. Water Environ Res 1998; 70(4):931–949.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Godwin-Saad EM, Buchman M. Effects of pollution on saltwater organisms. Water Environ Res 1997; 69(4):877–892.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects of pollution on saltwater organisms. Water Environ Res 1996; 68(4):784–796.

Becker DS, Ginn TC. Effects of storage time on toxicity of sediments from Puget Sound, Washington. Environ Toxicol Chem 1995; 14(5):829–835.

La Tier AJ, Mulligan PI, Pastorok RA, Ginn TC. Bioaccumulation of trace elements and reproductive effects in deer mice *(Peromyscus maniculatus)*. Proceedings, 12th Annual National Meeting of the American Society for Surface Mining and Reclamation, Gillette, WY, pp. 3–14, 1995.

Pastorok RA, La Tier AJ, Butcher MK, Ginn TC. Mining-related trace elements in riparian food webs of the Upper Clark Fork River Basin. Proceedings, 12th Annual National Meeting of the American Society for Surface Mining and Reclamation, Gillette, WY, pp. 31–51, 1995.

Pastorok RA, Butcher MK, Ginn TC. 1995. Thresholds for potential effects of mining-related trace elements on riparian plant communities. Proceedings, 12th Annual National Meeting of the American Society for Surface Mining and Reclamation, Gillette, WY, pp. 15–30, 1995.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects of pollution on saltwater organisms. Water Environ Res 1995; 67(4):718–731.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects of pollution on saltwater organisms. Water Environ Res 1994; 66(4):623–635.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects of pollution on saltwater organisms. Res J Water Pollut Control Fed 1993; 65(4):573–585.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects of pollution on saltwater organisms. Res J Water Pollut Control Fed 1992; 64(4):599–610.

Ginn TC, Pastorok RA. Assessment and management of contaminated sediments in Puget Sound. In: Sediment Toxicity Assessment. Burton GA (ed), Lewis Publishers, Inc., Boca Raton, FL, 1992.

Johns DM, Pastorok RA, Ginn TC. A sublethal sediment toxicity test using juvenile Neanthes sp. (Polychaeta: Nereidae). In: Aquatic Toxicology and Risk Assessment: Fourteenth Volume. Mays MA, Barron MG (eds), ASTM STP 1124, American Society for Testing and Materials, Philadelphia, PA, pp. 280–283, 1992.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Fate and effects of pollutants: Effects on saltwater organisms. Res J Water Pollut Control Fed 1992; 62(4):577–593.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. Res J Water Pollut Control Fed 1991; 63(4):696–709.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. Res J Water Pollut Control Fed 1990; 62(4):577–593.

Becker DS, Bilyard GR, Ginn TC. Comparisons between sediment bioassays and alterations of benthic macroinvertebrate assemblages at a marine Superfund site: Commencement Bay, Washington. Environ Toxicol Chem 1990; 9(5):669–685.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. J Water Pollut Control Fed 1989; 61(6):1042–1054.

Ginn TC. Assessment of contaminated sediments in Commencement Bay (Puget Sound, Washington). In: Contaminated Marine Sediments—Assessment and Remediation. National Academy Press, Washington, DC, pp. 425–439, 1989.

Barrick RC, Beller H, Becker DS, Ginn TC. Use of the apparent effects threshold approach (AET) in classifying contaminated sediments. In: Contaminated Marine Sediments—Assessment and Remediation. National Academy Press, Washington, DC, pp. 64–77, 1989.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. J Water Pollut Control Fed 1988; 60(6):1065–1077.

Ginn TC, Barrick RC. Bioaccumulation of toxic substances in Puget Sound organisms. In: Oceanic Processes in Marine Pollution, Volume 5. Wolfe DA and O'Connor TP (eds). Robert E. Krieger Pub. Co, Malabar, FL, pp. 157–168, 1988.

Barrick RC, Pastorok R, Beller H, Ginn T. Use of sediment quality values to assess sediment contamination and potential remedial actions in Puget Sound. Proceedings, 1st Annual Meeting on Puget Sound Research, Volume 2. Puget Sound Water Quality Authority, Seattle, WA, pp. 667–675, 1988.

Becker DS, Ginn TC, Bilyard GR. Field validation of sediment bioassays at a marine Superfund site: Commencement Bay, Washington. In: Superfund '88, Proceedings, 9th National Conference, Hazardous Materials Control Research Institute, Silver Spring, MD, pp. 323–328, 1988.

Jacobs LA, Barrick R, Ginn T. Application of a mathematical model (SEDCAM) to evaluate the effects of source control or sediment coordination in Commencement Bay. Proceedings, 1st Annual Meeting on Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA, pp. 677–684, 1988.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. J Water Pollut Control Fed 1987; 59(6):572–586.

Becker DS, Ginn TC, Landolt ML. Powell DB. Hepatic lesions in English sole (*Parophrys vetulus*) from Commencement Bay, Washington (USA). Mar Env Res 1987; 23:153–173.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC. Effects on saltwater organisms. J Water Pollut Control Fed 1986; 58(6):671–680.

Williams LG, Chapman PM, Ginn TC. A comparative evaluation of marine sediment toxicity using bacterial luminescence, oyster embryo and amphipod sediment bioassays. Mar Env Res 1986; 19:225–249.

Reish DJ, Oshida PS, Mearns AJ, Ginn TC, Carr RS, Wilkes FG, Butowski N. Effects on saltwater organisms. J Water Pollut Control Fed 1985; 57(6):699–712.

Reish DJ, Oshida PS, Wilkes FG, Mearns AJ, Ginn TC, Carr RS. Effects on saltwater organisms. J Water Pollut Control Fed 1984; 56(6):759–774.

Reish DJ, Geesey GG, Wilkes FG, Oshida PS, Mearns AJ, Rossi SS, Ginn TC. Marine and estuarine pollution. J Water Pollut Control Fed 1983; 55(6):767–787.

Reish DJ, Geesey GG, Wilkes FG, Oshida PS, Mearns AJ, Rossi SS, Ginn TC. Marine and estuarine pollution. J Water Pollut Control Fed 1982; 54(6):786–812.

Poje GV, O'Connor JM, Ginn TC. Physical simulation of power plant condenser tube passage. Water Res 1982; 16(6):921–928.

Reish DJ, Geesey GG, Oshida PS, Wilkes FG, Mearns AJ, Rossi SS, Ginn TC. Marine and estuarine pollution. J Water Pollut Control Fed 1981; 53(6):925–949.

Grieb TM, Porcella DB, Ginn TC, Lorenzen MW. Classification and analysis of cooling impoundments: an assessment methodology using fish standing crop data. Proceedings, Symposium on Surface Water Impoundments. American Society of Civil Engineering, Washington, DC, pp. 482–494, 1981.

Pastorok RA, Lorenzen MW, Ginn TC. Aeration/circulation as a control of algal production. Proceedings, Workshop on Algal Management and Control. Technical Report E-817. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, pp. 57–97, 1981.

Pastorok RA, Ginn TC, Lorenzen MW. Evaluation of aeration/circulation as a lake restoration technique. Ecological Research Series, EPA-600/3-81/014. U.S. Environmental Protection Agency, Corvallis, OR, 1981.

Pastorok RA, Ginn TC, Lorenzen MW. Review of aeration/circulation for lake management. In: Restoration of Lakes and Inland Waters. EPA-440/5-81/010. U.S. Environmental Protection Agency, Washington, DC, pp. 124–133, 1980.

Ginn TC, O'Connor JM. Response of the estuarine amphipod *Gammarus daiberi* to chlorinated power plant effluent. Estuarine Coastal Mar Sci 1978; 6(5):459–469.

Haven KF, Ginn TC. A mathematical model of the interactions of an aquatic ecosystem and a thermal power station cooling system. Proceedings, 4th National Workshop on Entrainment and Impingement. Jensen LD (ed). E.A. Communications, Melville, NY, pp. 321–344, 1978.

Poje GV, Ginn TC, O'Connor JM. Responses of ichthyoplankton to stresses simulating passage through a power plant condenser tube. In: Energy and Environmental Stress in Aquatic Systems. J.H. Thorp and J.W. Gibbons (eds.). U.S. Department of Energy, Technical Information Center, Washington, DC, pp. 794–808, 1978.

Ginn TC, Waller WT, Lauer GL. Survival and reproduction of *Gammarus* spp. (Amphipoda) following short-term exposure to elevated temperature. Chesapeake Sci 1976; 17(1):8–14.

Ginn TC, Waller WT, Lauer GL. The effects of power plant condenser cooling water entrainment on the amphipod, *Gammarus* sp. Water Res 1974; 8(11):937–945.

Ginn TC, Bond CE. Occurrence of the cutfin poacher, *Xeneretmus leiops*, on the continental shelf off the Columbia River mouth. Copeia 1973; 4:814–815.

Selected Project Experience

Natural Resource Damage Assessments

St. Croix Alumina Site. (U.S. Virgin Islands). Expert witness concerning alleged injuries to terrestrial resources from upland disposal of bauxite ore processing wastes for the case: *Commissioner of the Department of Planning and Natural Resources, Alicia V. Barnes, et al. v. Virgin Islands Alumina Company et al.* District Court of the Virgin Islands, Division of St. Croix, Civil Case No. 2005-0062.

Tar Creek Superfund Site (Oklahoma). Expert witness concerning alleged injuries to terrestrial plant communities resulting from mining wastes for the case: *The Quapaw Tribe of Oklahoma et al. v. Blue Tee Corp, et al.* United States District Court, Northern District of Oklahoma, Case No. 03-CV-0846-CVE-PJC.

Illinois River and Lake Tenkiller (Oklahoma). Assessment of the status of benthic macroinvertebrates and fishes in the aquatic environment and relationships of biotic characteristics to habitat factors and potential effects of poultry operations.

Bayway and Bayonne Refineries (New Jersey). Evaluation of marine, wetland, and terrestrial communities at the refinery sites. Expert witness in the case: *New Jersey Department of Environmental Protection and Administrator, New Jersey Spill Compensation Fund v. Exxon Mobil Corporation,* Superior Court of New Jersey, Law Division/Union County.

Tittabawassee and Saginaw River/Bay (Michigan). Assessment of potential injuries to aquatic and terrestrial resources caused by releases of dioxins/furans and other substances. Negotiations with state, tribal, and federal trustees.

Pine Bend Refinery (Minnesota). Key issues involve injuries to groundwater, surface water, and wetland resources resulting from releases of petroleum products. Negotiations with state and federal trustees.

FAG Bearing site (Missouri). The claim focused on potential injuries to groundwater resources and federally-listed aquatic species resulting from releases of trichloroethene. Negotiation with trustees and successful settlement.

Ohio River (Ohio and West Virginia). Claim related to alleged releases of carbamate-metal complexes from a manganese smelter at Marrietta. Key issues involve the causes of mortalities in populations of freshwater mussels and fishes and restoration alternatives for important species. Negotiations with state and federal trustees and deposition.

Ashtabula River/Harbor site (Ohio). Key issues include potential effects of PCBs and PAH on fishes and invertebrates in the harbor ecosystem.

White River (Indiana). Alleged injuries included a major fish kill associated with releases of carbamate-metal complexes from an industrial facility. Participant in technical negotiations with state and federal trustees.

Koppers site in Charleston Harbor (South Carolina). Assessment of PAH and metals in the estuarine environment and development of restoration alternatives. Negotiations with state and federal trustees.

Coeur d'Alene River (Idaho). Provided expert testimony concerning potential injuries caused by metals at deposition and trial (U.S. v. Asarco et al).

Saginaw River/Bay (Michigan). Key issues involve bioaccumulation and effects of PCBs in fishes, aquatic birds, and terrestrial wildlife. Participated in settlement negotiations with state and federal trustees.

Three industrial sites on the St. Lawrence River (New York). Negotiations with federal, state, and tribal trustees on injuries related to PCBs and PAH and identification of restoration alternatives.

Duwamish River (Washington). Claim related to releases of PCBs in the estuarine environment and potential injuries to fish, benthic, and bird resources. Participated in settlement negotiations with state, federal, and tribal trustees.

Clark Fork Basin Superfund complex (Montana). Served as technical lead for PRP negotiations with the trustee and developed supporting scientific reports. Provided testimony at trial in areas of water quality, sediments, and ecosystem-level effects of metals for terrestrial environments.

SMC Cambridge site (Ohio). Technical review and response to a natural resource damage claim associated with metals injuries to wetland resources. Participated in settlement negotiations with state and federal trustees.

Pools Prairie Superfund site (Missouri). Key issues include groundwater injuries and potential effects on a federally listed species.

Koppers site in Texarkana (Texas). Assessment of aquatic injuries and developed restoration settlement package for client. Leader of technical negotiations with state and federal trustees.

SMC Newfield site (New Jersey). Conducted technical review and response to a natural resource damage claim for groundwater resources at the. Participated in settlement negotiations with the state trustee.

Ecological Risk Assessments

NASSCO Shipyard (California). Expert and mediation support to resolve sediment remediation issues in response to a cleanup and abatement order. Issues involved the amount of dredging and other remediation required to reduce aquatic and human health risks at the site and the scope of post-remedial monitoring.

San Diego Bay Shipyard sites (California). Studies of sediment contamination and ecological risks of metals (e.g., copper, zinc, and butyltins) and organic substances (PAH and PCBs) at two major shipyards. Site-specific studies included sediment triad assessment and sampling of resident biota for bioaccumulation and histopathology analyses.

Hudson River (New York). Studies and agency presentations to support ecological risk assessment for the upper Hudson River. Technical leader for studies of the effects of PCBs on fishes, invertebrates, mammals, and birds of the upper Hudson River.

National Zinc site (Oklahoma). Participated in agency negotiations on RI/FS implementation. Assessed effects of metals on aquatic and terrestrial biota.

Lake Apopka (Florida). Ecotoxicological investigation of large-scale avian mortality at restored wetland habitats near the lake. The specific objective is to determine whether organochlorine pesticides or some other environmental factor was the causal agent of the mortalities.

Shelter Island Boatyard (California). Principal investigator for field and laboratory studies and an assessment of sediment cleanup levels for copper, mercury, and butyltin near a commercial marine maintenance operation in San Diego Bay, California.

PCB sites in Southeast. Principal-in-charge for ecological risk assessments conducted at several natural gas pipeline compressor stations located throughout the southeastern U.S. Led technical negotiations with EPA concerning the scope and interpretation of studies assessing risk of PCBs to aquatic and terrestrial biota.

Clark Fork River (Montana). Managed integrated ecological risk assessment studies at the Clark Fork River, Montana, Superfund site. Assessed the bioavailability and effects of metals in aquatic and terrestrial food chains.

Chikaskia River (Oklahoma). Managed field and laboratory studies of the effects of cadmium and the development of site-specific water quality criteria using the water effect ratio approach.

Campbell Shipyard (California). Directed an investigation of sediment chemical levels, biological effects, and human health risks at a major shipyard facility in San Diego Bay, California.

Commencement Bay Superfund Site (Washington). Managed RI/FS that included extensive field sampling of sediments and biota, assessing effects of toxic substances, assessing health risks, and identifying pollutant sources.

Puget Sound Estuary Program (Washington). Managed a multiyear, comprehensive field and laboratory investigation of the effects of chemicals in various sub-areas of Puget Sound. The study included numerous projects involving field and laboratory analyses, assessment of pollutant sources, assessments of human health and ecological risks, and development of sampling and analytical protocols.

Sewage Discharges (Alaska). Managed field and laboratory studies of benthic macroinvertebrates, bioaccumulation, and water quality at three sewage outfalls in southeastern Alaska.

Bering Sea (Alaska). Conducted study design, statistical analysis, and interpretation of results for a field study investigating the effects of commercial harvesting operations on surf clams and other invertebrates.

Poplar River (Montana). Managed a risk assessment for water quality, air quality, and socioeconomic impacts of a coal-fired power plant in the Poplar River basin in Montana. Managed an EIS for river flow apportionment alternatives and atmospheric emissions from the plant.

Klamath Lake (Oregon). Managed a project to evaluate water quality effects on fish populations in the Klamath River basin and to develop a modeling approach to assess the effects of flow apportionment alternatives on water quality and fish habitat.

Puget Sound (Washington). Project manager for an assessment of potential biological effects caused by the release of dichloromethane from an industrial facility. Prepared expert report for use in litigation.

Regulatory Programs

Project manager for technical support activities for EPA's Office of Marine and Estuarine Protection. Supervised data management, development of technical guidance, estuarine program support, monitoring program design, bioaccumulation analyses, and quality assurance reviews.

Served as one member of the five-member Technical Review Panel for the Long-Term Management Strategy for San Francisco Bay. The panel provided critical outside technical review of the program's conceptual approach, scientific rigor, and technical findings. Specifically assigned to sediment toxicology aspects.

Manager for a comprehensive review by EPA of sediment toxicity test methods and development of a resource document that is used to select appropriate test methods for use in NPDES monitoring programs at industrial facilities.

Served as a member of a six-member Biological Resource Assessment Group for New York Harbor. Specifically assigned as an expert in chemical contaminants in sediments and bioaccumulation.

For EPA multi-year project, served as chief biologist for technical evaluation of Clean Water Act Section 301(h) applications for permit modifications at marine sewage discharge sites throughout the United States.

Provided technical support to the Oklahoma Water Resources Board for the development of site-specific water quality criteria for metals.

For the Army Corps of Engineers, served as principal-in-charge for Puget Sound Dredged Disposal Analysis Phase I and II baseline biological surveys at dredged material disposal sites in Puget Sound, Washington.

Served on the Technical Advisory Committee for the Puget Sound Estuary Program. The committee provided technical review and program guidance to the various sponsoring agencies.

Other Water Quality Studies

Served as principal investigator and expert witness for an assessment of benthic biological effects and sediment chemical levels near the Pt. Loma, California, sewage discharge.

Assessment of the effects of offshore LNG terminals in the Gulf of Mexico on fish populations. Evaluated effects of fish egg and larvae entrainment of key species in proposed facilities at various locations.

Conducted a comprehensive assessment of bioaccumulation of inorganic and organic substances in marine organisms in the Southern California Bight.

Directed a comprehensive review and evaluation of the biological impacts of oil spill cleanup operations on marine ecosystems.

Conducted an evaluation of the role of soil and water bioassays for assessing biological effects of hazardous waste sites.

Principal investigator to evaluate the biological impacts of ocean disposal of manganese nodule processing wastes.

Managed a project to evaluate available cause and effect data and models to predict water quality and biological impacts for Puget Sound, Washington.

Developed the biological components of an ecosystem model to evaluate effects of multiple power plant discharges on a single water body.

Managed statistical analyses of benthic infauna data collected near the Waterflood Causeway in the Beaufort Sea.

Project co-manager and principal investigator for a review and analysis of biological impact data for all currently operating coastal power plants in the United States.

Principal scientist to evaluate responses of benthic invertebrates and fishes to lake aeration and circulation projects.

Principal scientist for a comprehensive limnological evaluation of the Lafayette Reservoir in California.

Evaluated the responses of benthic invertebrates and fishes to lake aeration and circulation programs and developed recommendations for applicable lake restoration techniques.

Principal investigator in analyzing water quality conditions at a hypereutrophic lake and conducting public workshops on alternative restoration measures.

Developed a method of predicting biological responses of new cooling lakes based on a deterministic ecosystem model and empirical fish production models.

Conducted field and laboratory investigations of the effects of power plant entrainment on macroinvertebrates in the Hudson River estuary. Determined relationship of entrainment effects to populations in the lower estuary.

Managed laboratory bioassay studies evaluating the combined effects of temperature, chlorine, and physical stress on estuarine ichthyoplankton and zooplankton.

Professional Affiliations

- Society of Environmental Toxicology and Chemistry
- American Chemical Society
- American Institute of Fishery Research Biologists

Depositions

Commissioner of the Department of Planning and Natural Resources, Alicia V. Barnes, et al. v. Virgin Islands Alumina Company et al. District Court of the Virgin Islands, Division of St. Croix, Civil Case No. 2005-0062, deposition 2012.

The Quapaw Tribe of Oklahoma et al. v. Blue Tee Corp, et al., United States District Court, Northern District of Oklahoma, Case No. 03-CV-0846-CVE-PJC, deposition 2010.

Moraine Properties, LLC v. Ethyl Corporation, United States District Court, Southern District of Ohio, Civil Action No. 3:07-cv-00229, deposition 2010.

State of Oklahoma et al. v. Tyson Foods, Inc, et al., United States District Court for the Northern District of Oklahoma, Civil Action Number 4:05-CV-00329-TCK-SAJ, deposition 2009.

New Jersey Department of Environmental Protection and Administrator, New Jersey Spill Compensation Fund v. Exxon Mobil Corporation, Superior Court of New Jersey, Law Division/Union County, DOCKET NO. L-3026-04, deposition 2008.

United States of America, The State of West Virginia, and The State of Ohio v. Elkem Metals Co. L.P., Ferro Invest III Inc., Ferro Invest II Inc., and Eramet Marietta Inc, United States District Court, Southern District of Ohio, Eastern Division, Case No. 2:03 CV 528, deposition 2005.

United States of America v. Asarco Incorporated et al., United States District Court for the District of Idaho, Case No. CV-96-0122-N-EVL, deposition, 2000.

State of Montana v. Atlantic Richfield Company, United States District Court for the District of Montana, Case No. CV-83-317-HLN-PGH, deposition, 1996.

Aluminum Company of America and Northwest Alloys, Inc. v. Accident and Casualty Insurance Company, et al, Superior Court of the State of Washington, King County, Case No. 92-2-28065-5, depositions 1995, 1996.

Asarco v. American Home Insurance Company, et al., Superior Court of the State of Washington, King County, Case No. 90-2-23560-2, deposition 1993.

U.S. v. City of San Diego, United States District Court, Southern District of California, Case No. 88-1101-B, depositions 1991, 1993.

Trials and Hearings

California Regional Water Quality Control Board – San Diego Region. Testimony at public hearing for consideration of Resolution No. R9-2011-0072, certification pursuant to the California Environmental Quality Act, of the Final Environmental Impact Report, for the San Diego Bay Shipyard Remediation Project, November 14, 2011.

United States of America v. Asarco Incorporated et al., United States District Court for the District of Idaho, Case No. CV-96-0122-N-EVL, testimony at trial, 2001.

State of Montana v. Atlantic Richfield Company, United States District Court for the District of Montana, Case No. CV-83-317-HLN-PGH, testimony at trial 1997 (aquatic and terrestrial phases of the trial).

U.S. v. City of San Diego, United States District Court, Southern District of California, Case No. 88-1101-B, deposition, testimony at trial 1991, testimony at motion hearing 1994.