

APPENDIX K

BENTHIC INVERTEBRATE COMMUNITY METRICS



ERM

In association and consultation with: HDR Engineering, Inc. and
Exponent, Inc.

Appendix K: Benthic Invertebrate Community Metrics

Final Aquatic Baseline Ecological Risk
Assessment—Upper Columbia River

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ACRONYMS AND ABBREVIATIONS

μmol/g	micromole per gram
AOI	area of interest
BAP	Biological Assessment Profile
BERA	baseline ecological risk assessment
B-IBI	benthic index of biotic integrity
BLM	biotic ligand model
BMI	benthic macroinvertebrate
CS50	medium, coarse, and very coarse sand > 50 percent of substrate
CWA	Clean Water Act
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
HBI	Hilsenhoff Biotic Index
IDEQ	Idaho Department of Environmental Quality
km	kilometer(s)
LOE	line of evidence
MMI	multi-metric index
MTI	metals tolerance index
NYSDEC	New York State Department of Environmental Conservation
OU	operable unit
PCA	principal components analysis
QAPP	Quality Assurance Project Plan
RBP	Rapid Bioassessment Protocol
RM	river mile
SEM	simultaneously extracted metal(s)
Site	Upper Columbia River site
TAI	Teck American Incorporated
TU	toxic unit
UCR	Upper Columbia River

1. INTRODUCTION

This appendix addresses several components of the benthic invertebrate community analysis used in the Aquatic Baseline Ecological Risk Assessment (BERA) for the Upper Columbia River Site (UCR; hereafter, the Site),¹ which extends from the U.S.-Canada border (River Mile [RM] 745) to Grand Coulee Dam (RM 596). The components are:

- Selection of a priority list of benthic invertebrate community metrics to assess whether communities may be adversely affected by metals associated with slag in depositional sediments in the Operable Unit 1 (OU 1) of the Site;
- Review of the literature to determine whether suitable benchmarks can be developed for assessing possible impairment to the benthic invertebrate community at individual locations; and
- Supplemental detail regarding contextual analyses for benthic invertebrate communities in OU 1.

Section 2 of this appendix describes how the full list of benthic invertebrate community metrics tabulated for each community sample in the Final 2019 Phase 3 Sediment Study Data Summary Report (hereafter, 2019 Phase 3 Sediment Study) (TAI 2022)² data set was refined into a set of metrics that are informative and ecologically relevant in the Site. These metrics were previously summarized in Appendix E to the 2019 Phase 3 Sediment Study (TAI 2022). This section provides additional detail regarding the process for selecting the metrics used to assess risks to benthic invertebrates in the main text of the Aquatic BERA. Through this process, over 100 benthic invertebrate metrics tabulated by the taxonomic laboratory were focused down to the 11 most informative and ecologically relevant metrics for assessing metal contamination in the sandy sediments collected from the Site during the 2019 Phase 3 Sediment Study.

Section 3 of this appendix summarizes the available literature for developing suitable benchmarks to assess potential impairment to the benthic invertebrate community at individual locations in OU 1. This evaluation supports the assessment of the benthic invertebrate community metrics line of evidence (LOE) in the Aquatic BERA. The literature review demonstrates that the use of benthic invertebrate community data for making determinations regarding environmental health is dependent on the study design and the type of stressors and habitat. Given these substantial complexities, it is not possible to identify benchmarks that would be an appropriate point of comparison for benthic invertebrate communities from individual sediment grab locations in the Site.

¹ The Site as defined within the June 2, 2006, Settlement Agreement is the areal extent of hazardous substances contamination within the United States in or adjacent to the Site, including the Franklin D. Roosevelt Lake, from the U.S.-Canada border to Grand Coulee Dam, and those areas in proximity to the contamination that are suitable and necessary for implementation of response actions (USEPA 2006).

² Sediment, porewater, and benthic invertebrate community sampling in the 2019 Phase 3 Sediment Study (TAI 2022) focused on three areas of interest (AOIs) in the OU 1 portion of the Site and upstream reference areas from the Columbia River north of Trail, British Columbia. The three AOIs include Deadman's Eddy, China Bend, and Evans.

Section 4 provides a brief assessment of whether the abundance of the chironomid *Robackia demeijerei* can be used to control for habitat when comparing benthic invertebrate community abundance and composition between OU 1 and upstream reference areas. This is additional detail beyond what is discussed in the contextual analyses for the benthic invertebrate community metric LOE in the main text of the Aquatic BERA (Section 4.1.3.4 of Volume 2).

Finally, this appendix includes the following two attachments:

- Attachment K1 contains the taxa-specific tolerance values for the taxa identified in the Phase 3 sediment study in OU 1.
- Attachment K2 contains results for the correlation analyses between the in situ benthic invertebrate community metrics developed in Section 2 of this appendix and exposure to concentrations of individual metals in bulk sediment and porewater. The analyses in the main text of the Aquatic BERA (Section 4.1.5 of Volume 2) focus on multiple metal exposure metrics in bulk sediment (e.g., mean potential effect concentration quotients, excess simultaneously extracted metals (SEM), and estimated slag content) as well as porewater exposure metrics that account for bioavailability of individual metals. The raw results from the correlation analyses based on individual metals, without accounting for bioavailability, are included as tables within this attachment. Attachment K2 also includes the weight of evidence scoring tables for these correlations, which are consistent with the weight of evidence scoring tables for LOE 5 in the main body of the Aquatic BERA. Results from these analyses are incorporated into the risk characterization section for each chemical of potential concern in Section 4.3 of Volume 2.

2. SELECTION OF THE BENTHIC INVERTEBRATE COMMUNITY METRICS

Following identification and enumeration of the organisms found in each sediment sample collected for the benthic invertebrate community evaluation, the taxonomic laboratory (EcoAnalysts, Inc.) tabulated more than 100 community metrics for each sample. Because many of the metrics tabulated were not directly relevant to the assessment of risks to the benthic invertebrate community in the Aquatic BERA, a short-list of priority benthic invertebrate community metrics was developed. This section describes how the list of 11 benthic invertebrate community metrics used in the analyses presented in the Aquatic BERA was developed. First, the list of 107 metrics tabulated by the taxonomic laboratory was narrowed to a candidate list of approximately 20 community metrics. This was based on a review of the available literature for freshwater sites with known or potential impacts from metals contamination, augmented with best professional judgment to develop a starting list that broadly addressed the abundance, diversity, and metals pollution tolerance of the benthic invertebrate community (Section 2.1). Second, the candidate list was further refined based on the ecological relevance of each metric to the Site and the suitability of the data available to calculate the metric to reduce redundancy among metrics (Section 2.2). Finally, the final list of benthic invertebrate community metrics was reviewed to identify in which direction potential impairment is indicated (Section 2.3).

2.1 DEVELOPMENT OF INITIAL CANDIDATE LIST

EcoAnalysts, Inc. tabulated 107 community metrics that included common abundance, diversity, and richness metrics as well as diagnostic indices (e.g., metals tolerance index [MTI], fine sediment biotic index, and Hilsenhoff Biotic Index [HBI]), functional groupings based on diet, habit, and generation length, relative abundance metrics of various taxonomic groups, and various regional biotic indices (Table K-1). The complete list of tabulated metrics was narrowed to a list of candidate metrics for further consideration based on initial screening of the metrics. Teck American Incorporated's (TAI's) benthic invertebrate technical team reviewed the complete list and assessed each tabulated metric for its potential utility in identifying possible impairments to benthic invertebrate communities in depositional habitats due to potential exposures to metals in OU 1. Thirty-two metrics were initially short-listed for this purpose (Table K-1). The findings from the technical team review were supplemented with a literature review of assessments of benthic invertebrate communities at other freshwater lentic sites in the western United States and Canada to ensure that commonly identified community metrics were included for consideration.

Benthic invertebrates are commonly used as indicators of aquatic ecosystem health in studies of mining impacts (Byrne et al. 2012; Mebane et al. 2015; Schmidt et al. 2002). In their compilation of studies on impacts to benthic invertebrate communities from common metals stressors (copper, cadmium, iron, lead, and zinc), Byrne et al. (2012) noted that frequently reported impacts include reductions in overall abundance of benthic invertebrates and decreases in taxonomic richness and diversity; these are primarily due to losses of metal-sensitive species. In wadeable streams with riffle habitats, sensitive species include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), collectively called EPT taxa (Barbour et al. 1999; Byrne et al. 2012; Clements et al. 2000). In depositional habitats, however, EPT are less common, suggesting that

commonly used EPT metrics may not be as reliable for indicating metals impacts in the sandy habitats that were sampled in the 2019 Phase 3 Sediment Study.

Functional feeding guild metrics describe how organisms obtain their food. In large rivers like the UCR where fine particulate matter is expected to be the dominant source of organic inputs to the system, the benthic macroinvertebrate community is expected to be dominated by gatherers and filterers and, to a lesser extent, predators that feed on those lower trophic level organisms (Vannote et al. 1980). Scrapers and shredders rely on coarse organic matter inputs such as leaf litter and tend to dominate benthic macroinvertebrate communities in smaller streams (Jones and Smol 2023) and are not common in the UCR. The only functional feeding guild metric retained following the initial screening of community metrics is predator richness, which is retained because it is an indicator of trophic complexity of the benthic invertebrate community. Filterers were also tentatively considered for inclusion into the list of candidate metrics. While individual filterer taxa have been used to assess impacts to benthic invertebrate communities from exposure to metals in freshwater, lotic systems (e.g., freshwater mussels; Roberts et al. 2023)³, the use of the filterer functional feeding guild as a metric to assess those impacts could not be identified in the literature. Without a clear indication of the directionality of the response of the percent filterers metric to metals exposure, it was not retained as a candidate community metric.

Studies from locations in the Columbia River in British Columbia (Teck Metals Ltd. 2007, 2014, 2019),⁴ north of the U.S.-Canada border, the Clark Fork River in Montana (Jacobs 2020; McGuire 1993; Canfield et al. 1994; Poulton et al. 1995), Blackbird Mine in Idaho (Mebane et al. 2015; Beltman et al. 1999), and the South Fork of the Coeur d'Alene River in Idaho (Hoiland and Rabe 1992) were reviewed to ensure that the Aquatic BERA incorporated benthic invertebrate metrics that are relevant for riverine, depositional habitats in the region. Table K-2 summarizes the benthic invertebrate community metrics that were used to detect potential impacts associated with exposure to metals in sediment, porewater, and/or surface water in each of these studies. All metrics identified from the literature review had been identified by TAI's technical team.

Based on the findings from the literature review of benthic invertebrate community investigations from rivers in the region, the short-list of 32 metrics was further refined to identify those metrics that have been found to be useful in identifying metals impacts to benthic invertebrate communities and to screen out redundant metrics. Best professional practices were applied to narrow the list of metrics identified by the technical team from 32 to 17 candidate metrics (Table K-1). The list of 17 candidate metrics was further refined to the list of 11 priority benthic invertebrate community metrics as described in the next section.

³ The presence and abundance of individual, sensitive taxa are evaluated in the Aquatic BERA via contextual analyses as described in Volume 1.

⁴ Teck Metals Ltd.'s 2007 study was reviewed by a technical advisory committee that included participants from the B.C. Ministry of the Environment, Western Washington University, and EPA. The later 2014 and 2019 studies were prepared as a requirement of the Trail facility effluent discharge permit and were reviewed by B.C. Ministry of the Environment before they were finalized.

2.2 REFINEMENT OF PRIORITY METRICS LIST

Based on the findings discussed above and considering that the 2019 Phase 3 Sediment Study targeted depositional habitats, the candidate list of 17 benthic invertebrate metrics was further refined to develop a set of metrics that are both informative and ecologically relevant to the Site.

The starting list of 17 candidate metrics identified in Table K-1 included:

- Measures of abundance: total corrected abundance (henceforth called total abundance), density (number per square meter), and counted blotted mass (biomass);⁵
- Measures of diversity and richness: taxonomic richness, Shannon-Weaver diversity ($\log_{10}$), percent dominant taxon, percent 2nd dominant taxon, and percent 3rd dominant taxon;
- Measures of pollution tolerance: MTI, HBI, percent Chironomidae, and Chironomidae richness;
- Measures of pollution sensitivity: EPT Richness, EPT Abundance, percent EPT, and percent Intolerant;
- Measures of trophic complexity: predator richness; and
- Measures of generation length, or voltinism: percent semivoltine.

This candidate list was then refined based on the following considerations:

- The ecological relevance of each metric to the Site;
- The suitability of the data available to calculate the metric; and
- Redundancy among metrics.

2.2.1 APPLICABILITY TO THE SITE

Applicability was assessed based on confirmation that the metrics have been commonly used to assess benthic invertebrate community abundance and diversity and that there is a clear connection to the ecosystem function or service of the benthic invertebrate community in OU 1. Applicability to the Site, therefore, was assessed based on a review of benthic invertebrate community assessment guidance documents and literature, as well as a more detailed review of two specific diagnostic metrics to the benthic invertebrate communities observed in the Site OU 1.

2.2.1.1 LITERATURE CONFIRMATION

Measures of abundance, taxonomic richness, and diversity are common metrics for assessing the quality of benthic invertebrate communities (Blocksom and Flotemersch 2005; Byrne et al. 2012; Ecology 2019; King County 2014; Llansó and Dauer 2002; USEPA 2019). The Washington State Department of Ecology (Ecology) standard operating procedure for collecting benthic invertebrates from rivers specifically requires the reporting of benthic invertebrate density per square meter (Ecology 2019). Biomass can also be informative for assessing the condition of a benthic invertebrate community (Llansó and Dauer 2002) and is a proxy measure for benthic invertebrates as a food resource to higher trophic level organisms. Measures of dominance commonly include the proportion of the sample composed of the most abundant taxa (Blocksom and Flotemersch 2005; King County 2014; Ecology 2019). Predator richness and voltinism are

⁵ Note that biomass estimates do not include oligochaetes and are, therefore, not representative of total benthic invertebrate biomass.

used less commonly (Blocksom and Flotemersch 2005; King County 2014; Ecology 2019) but are indicators of the complexity and stability of the benthic invertebrate community food web.

Among measures of pollution tolerance or sensitivity, metrics related to EPT and chironomids, as well as HBI, are used frequently (Blocksom and Flotemersch 2005; King County 2014; Ecology 2019; Teck Metals Ltd. 2014). EPT metrics are included in this assessment because they are so commonly used for assessment of potential metals impacts on benthic invertebrate communities (Byrne et al. 2012). Tolerance indices such as HBI and MTI can be informative if the observed taxa have been assigned tolerance values (Ecology 2019; Llansó and Dauer 2002). HBI was developed to indicate the level of tolerance of the benthic invertebrate community to organic enrichment (Hilsenhoff 1987) while MTI was originally developed for the Clark Fork River to indicate the level of tolerance of the benthic invertebrate community to metals in surface water (McGuire 1993). Like the HBI, it is calculated using tolerance values developed for each individual taxon in each sample where the tolerance values range from 0 (no tolerance) to 10 (high tolerance). Additional detail regarding the basis for and calculation of MTI and HBI is provided below.

2.2.1.2 DEVELOPMENT OF TOLERANCE INDICES

As discussed above, the MTI was developed for the Clark Fork River to provide an indication of the benthic invertebrate community's tolerance of metals present at that site (McGuire 1993). It is calculated using metals tolerance values determined for individual taxa based on their presence or absence from Montana streams with known concentrations of metals in surface water or sediment. Tolerance values range from 0 to 10 where higher values indicate greater tolerance of metals. The MTI is calculated as the weighted average of tolerance values; weighted based on taxon abundance in the sample for all taxa for which metals tolerance values are available. Most of the taxa observed in the 2019 Phase 3 Sediment Study samples have tolerance values assigned, but some do not.

The HBI is a widely used index for assessing water quality with respect to organic enrichment and nutrient pollution. For example, HBI was used at the Clark Fork River as a diagnostic index for distinguishing causes of impairment in the benthic invertebrate community relative to minimally disturbed reference sites (McGuire 1993; Jacobs 2020). Similar to the calculation of MTI, the HBI is calculated using pollution tolerance values that have been determined for individual taxa based on their presence or absence in aquatic systems with varying levels of organic enrichment. Tolerance values for individual taxa range from 0 to 10, and higher values indicate greater tolerance of organically enriched conditions (Hilsenhoff 1987). The HBI is calculated as the weighted average of tolerance values for all of the taxa present, weighted based on each taxon's relative abundance in the sample. Some of the taxa observed in the 2019 Phase 3 Sediment Study (TAI 2022) samples did not have HBI values assigned.

There is more than one database assigning tolerance values to benthic invertebrate taxa. Different databases do not necessarily include all the same taxa, nor do they always agree on the tolerance value assigned to a particular taxon that is common to multiple databases. This is the case for both MTI and HBI. Accordingly, TAI's technical team examined two possible versions of the MTI and two possible versions of the HBI using different databases of tolerance values.

As described in detail in Appendix E of the 2019 Phase 3 Sediment Study (TAI 2022), one version of each index was calculated by EcoAnalysts, Inc. using their in-house database of tolerance values, and TAI's technical team calculated two additional versions of each index. One version was calculated using a database of metals tolerance values and pollution tolerance values received from Ecology⁶ (hereafter referred to as the Washington tolerance values) and a second, or hybrid, version was calculated based on a combination of the tolerance values from the EcoAnalysts, Inc. database and the Washington tolerance values. To calculate the hybrid indices, applying the Washington tolerance values was prioritized where available and using the tolerance values from EcoAnalysts, Inc. when no Washington tolerance values were available. Because the database of Washington tolerance values contains metals tolerance values for the majority of taxa identified in the 2019 Phase 3 Sediment Study, the MTI calculated using solely the Washington tolerance values is not substantially different from the MTI calculated using the combination of tolerance values from EcoAnalysts, Inc. and the Washington tolerance values. Both versions of MTI and HBI were provided in the 2019 Phase 3 Sediment Study (TAI 2022).

Upon inspection, the Washington MTI and HBI tolerance values were found to be more reliable for the 2019 Phase 3 Sediment Study than those from the EcoAnalysts, Inc. database (Attachment K1). The metadata in the Washington tolerance values database includes citations for each taxon's tolerance value. The analysis of the benthic invertebrate community in the Aquatic BERA solely used the Washington MTI and HBI tolerance values for two reasons: 1) the bases for the Washington tolerance values are clearly documented and 2) they provide metals tolerance values for most of the taxa found in the 2019 Phase 3 Sediment Study and benthic invertebrate community response to metals exposure is the basis for the Aquatic BERA.

Some benthic invertebrate taxa identified in the Site during the 2019 Phase 3 Sediment Study do not have metals tolerance or HBI tolerance values assigned to them in any of the databases that were described above. The percent of organisms with tolerance values differed between the two metrics and differed between the areas of interest (AOIs). For MTI, the majority of organisms from most of the samples from reference areas and Deadman's Eddy AOI had tolerance values while the majority of organisms from most of the samples from China Bend and Evans AOIs did not have metals tolerance values (Figure K-1). For HBI, the pattern is reversed. In most samples from reference and Deadman's Eddy AOI, fewer than half of the benthic invertebrate organisms had HBI tolerance values while greater percentages of the organisms in China Bend and Evans AOIs had HBI tolerance values (Figure K-2). The uncertainty associated with the lack of tolerance values for taxa observed in the 2019 Phase 3 Sediment Study on the interpretability of the MTI and HBI metrics used in the Aquatic BERA is addressed in the Uncertainty Assessment in the main body of the Aquatic BERA (Section 4.2 of Volume 2).

⁶ A data file of tolerance values was obtained from Ecology's Environmental Assessment Program on February 8, 2021 (Ecology 2021).

2.2.2 SUITABILITY OF THE DATA AVAILABLE TO CALCULATE BENTHIC INVERTEBRATE METRICS

When selecting the metrics used to address the primary and secondary questions from the Final Quality Assurance Project Plan for the 2019 Phase 3 Sediment Study (hereafter, 2019 Phase 3 QAPP) (TAI 2019), consideration was made for the usability of the available data. Metrics with high proportions of zero values are not suitable for the majority of parametric statistical tests because their data are not normally distributed and tend to cause unequal variances among groups. Pervasive zero counts for some taxa rendered the metrics related to EPT and semivoltinism difficult to incorporate into statistical analyses. Approximately half of the samples contained zeros for EPT abundance, EPT richness, and percent EPT. Similarly, approximately 50 percent of samples had zeros for percent intolerant across the data set. Because the EPT measures are among the most common indicators of metals impacts in benthic invertebrate communities (Byrne et al. 2012), the EPT and percent intolerant metrics were retained for consideration despite the abundance of zeros. However, percent semivoltine, the only measure of voltinism indicative of longer generation times, had zero values in 97 percent of samples and was, thus, removed from consideration prior to assessing redundancy among the remaining metrics.

2.2.3 REDUNDANCY AMONG METRICS

Two methods were used to consolidate duplicative metrics: correlation analysis and principal components analysis (PCA). The specific details regarding the approach for both statistical methods are provided in Appendix L.

PCA was performed on the list of candidate benthic invertebrate metrics to identify those that were similar to one another. The goal of the PCA is to identify a subset of the non-redundant community metrics that represent as much information about the benthic invertebrate community as possible. All PCAs were performed in R as described in Appendix L. Scree plots, loadings plots, and PCA biplots were used to inform metric selection because metrics with similar loadings (Figure K-3a) and vectors in the biplots (Figure K-3b) may contain redundant information.

A correlation matrix using Kendall's tau showed that numerous benthic invertebrate community metrics were significantly correlated with one another (Figure K-4). In particular, the various measures of dominance were correlated, as were certain measures of tolerance related to EPT and percent intolerant. The PCA biplots corroborated the findings of the correlation analysis (Figure K-3b). For example, the PCA biplot vectors for percent dominant taxon, percent 2nd dominant taxon, and percent 3rd dominant taxon overlapped strongly (Kendall's tau > 0.7). Since these provide redundant measures of dominance, percent dominant taxon was selected and the remaining measures of dominance were eliminated from the final list of priority metrics. Percent EPT was significantly correlated with both EPT abundance and EPT richness (tau > 0.8). Based on the PCA, its information content was also similar to that of percent intolerant. Percent EPT was selected as the preferred metric for sensitivity because it was associated with EPT abundance and richness and it had fewer zero values than percent intolerant. Chironomidae richness was correlated with species and predator richness and was eliminated. Because it was calculated based on abundance, density was strongly correlated with total abundance. The other benthic invertebrate metrics were not as closely correlated with other metrics and provide non-redundant

information; they were, therefore, retained for analyses as priority benthic invertebrate community metrics in the Aquatic BERA.

2.3 SUMMARY OF PRIORITY BENTHIC INVERTEBRATE METRICS

Based on the analyses above, the following 11 priority benthic invertebrate community metrics were selected for further analysis of benthic invertebrate community data in the Aquatic BERA. Note that each metric is associated with one of the attributes identified for the benthic invertebrate ecological assessment endpoints (EAEs) in the main body of the Aquatic BERA (Section 2 of Volume 1):

Benthic Invertebrate Metric	EAE Attribute	Relative Direction of Impairment
Total Abundance	Abundance	Impaired = Low
Density	Abundance	Impaired = Low
Biomass (as Counted Blotted Mass)	Production	Impaired = Low
Diversity (as Shannon-Weaver $H' [\log_{10}]$)	Composition	Impaired = Low
Taxonomic Richness	Composition	Impaired = Low
Predator Richness	Composition	Impaired = Low
% Dominant Taxon	Composition	Impaired = High
MTI	Composition	Impaired = High
HBI	Composition	Impaired = High
% Chironomidae	Composition	Impaired = High
% EPT	Composition	Impaired = Low

Notes: EPT = Ephemeroptera, Plecoptera, and Trichoptera; HBI = Hilsenhoff Biotic Index; MTI = metals tolerance index

To assess whether differences in benthic invertebrate communities in OU 1 of the Site might be indications of impairment due to metals stress, the directionality of each metric with respect to impairment must be specified. Decreases in abundance, biomass, and/or density are sometimes, but not always, an indicator of impairment. The relationship is not always linear and can, at times, invert, as was demonstrated in Panther Creek, a stream impacted by mining in Idaho (Mebane et al. 2015). When richness declined, it resulted in a large number of a few dominant species which, in turn, influenced the biomass estimates; in this case, higher abundance was not necessarily indicative of the absence of a stressor (Mebane et al. 2015). To evaluate how abundance is likely to respond to the presence of a stressor in the Site, total abundance in the 2019 Phase 3 Sediment Study samples was examined relative to the presence of pollution-intolerant species. If the Site exhibits a similar biological response to that observed in Panther Creek (Mebane et al. 2015), then there would be a nonlinear relationship between total abundance and the presence of intolerant species. Specifically, higher abundance would be observed in samples where intolerant

organisms are abundant. In addition, there would also likely be evidence of a nonlinear relationship between total abundance and species richness such that abundance would be relatively high in samples with low richness. In fact, no significant correlation was found between total abundance and percent intolerant organisms, and species richness and abundance were positively correlated with each other (Figure K-5). For this analysis, therefore, reduced abundance, density, and biomass are assumed to be indications of reduced benthic invertebrate community quality. This is consistent with the approach employed at the Clark Fork River in Montana, where an optimal benthic invertebrate community abundance has been identified. Benthic invertebrate community abundance below that optimum is assumed to be indicative of metals stress, while community abundance above that optimum is assumed to be indicative of organic enrichment stress (Jacobs 2020).

Reduced taxonomic richness or diversity is broadly acknowledged as a potential indicator of community impairment (Barbour et al. 1999; Byrne et al. 2012; NYSDEC 2019). Predator richness varies across aquatic ecosystems (Barbour et al. 1999), but this metric is assumed to exhibit the same directionality as taxonomic richness (King County 2014; Ecology 2003). The metric of percent dominant taxon is oriented in the opposite direction of diversity.

Among tolerance/sensitivity metrics, decreases in percent EPT and increases in percent Chironomidae are common indicators of impairment (Barbour et al. 1999; Byrne et al. 2012; Canfield et al. 1994). Increases in the pollution tolerance indices of MTI and HBI are seen as indicative of impairment (Hilsenhoff 1987; McGuire 1993; Jacobs 2020).

2.4 DEVELOPMENT OF COMPOSITE BENTHIC INVERTEBRATE COMMUNITY METRICS FOR CONCENTRATION-RESPONSE MODELING

As described in the Aquatic BERA (Section 4.3.1.5 of Volume 1), analyses conducted to evaluate the community + chemistry LOE for the benthic invertebrate ecological assessment endpoint (LOE 5) were focused on a subset of the benthic invertebrate community data collected during the 2019 Phase 3 Sediment Study. To focus the analyses on samples from substrate most likely to contain slag, the 2019 Phase 3 Sediment Study data set was filtered to include samples that were more than 50 percent medium sand, coarse sand, and very coarse sand (i.e., the CS50 data set). As part of that analysis, the U.S. Environmental Protection Agency (EPA) requested that principal component (PC) scores should be used to represent benthic invertebrate communities rather than individual metrics (USEPA 2023, pers. comm.). Therefore, the 11 priority benthic invertebrate community metrics in OU 1 and reference samples from the CS50 data set were combined using PCA (Figures K-6a and K-6b; Table K-3).

PC1 accounts for 46 percent of the variation in the data set of the 11 priority community metrics from the CS50 locations. Richness, diversity, biomass, density, and abundance metrics load in the positive direction while percent Chironomidae and percent dominant taxon load in the negative direction. Therefore, high PC1 values indicate relatively rich, abundant, diverse communities while low PC1 values indicate communities with lower abundance with fewer species that tend to be dominated by chironomids. Interpretation of PC1 scores with respect to impairment is relatively straightforward; low PC1 scores would be indicative of potential impairment consistent with the interpretation rules identified above (Section 2.3).

PC2 accounts for 18 percent of the variation in the same data set of 11 priority community metrics. Abundance loads in the positive direction while percent EPT and diversity load, weakly, in the negative direction. High PC2 values indicate communities with relatively high abundance while low PC2 values may indicate more diverse communities with greater percentage of sensitive organisms. Interpretation of PC2 scores with respect to impairment is less certain than with PC1. As described in Section 2.3 above, reduced abundance is assumed to be an indication of reduced benthic invertebrate community quality. However, for the purposes of interpreting the bivariate and multivariate models of community metrics and metals exposure, high PC2 values are assumed to be indicative of potential impairment.

3. BENTHIC INVERTEBRATE COMMUNITY METRIC BENCHMARKS

This section summarizes the available literature with the goal of determining whether *a priori* benchmarks could be used to address the analysis questions for LOE 3 in the Aquatic BERA, which are similar to the 2019 Phase 3 QAPP Question 1C, “Do benthic macroinvertebrate community metrics indicate reduced species diversity, richness, or increased pollution tolerance (i.e., prevalence of pollution tolerant species) in UCR Upper Reach OU locations?” To address this question, the 2019 Phase 3 QAPP [page A-16] indicates that “tolerance values or indices may also be useful for comparing species composition with respect to general or specific stressor tolerance” and subsequent clarification from EPA during a July 28, 2020, conference call indicated that “literature comparisons and/or benchmarks, if available should be used to answer Study Question 1C.” This section investigates such potentially relevant literature comparisons and benchmarks and discusses their relevance to the Site.

3.1 RAPID BIOASSESSMENT PROTOCOLS

EPA developed the Rapid Bioassessment Protocols (RBP) (Barbour et al. 1999) as “...a practical technical reference for conducting cost-effective biological assessments of lotic systems.” This guidance is intended to provide programmatic and technical guidance to states and tribes for development of their biological assessment programs. The RBP does not provide calibrated metrics for any given region or data set. Rather, the RBP provides methods and national benthic invertebrate metadata that were the best available science for benthic invertebrate bioassessment at that time (i.e., in 1999). Relevant sections of the RBPs include an introduction to the application of bioassessment in different parts of the Clean Water Act (CWA) (including ecological risk assessment), elements of biomonitoring, methods for sampling benthic invertebrates, laboratory processing, potential metrics and metric groups, and multi-metric index (MMI) development methods. The sampling methods described in the RBP only cover methods in multiple wadeable habitat types using a kick-net. Large river and non-wadeable methods are not part of the RBP. Sampling sand deposits with a clamshell dredge (e.g., van Veen or similar equipment) or with a freeze grab sampler as were used to collect samples for the 2019 Phase 3 Sediment Study is not described in the RBP.

The RBP summarizes the elements of developing biocriteria, including the development of a regional reference condition, selection of community metrics, and aggregation into MMIs. Community metrics include categories such as richness, composition, tolerance, feeding, and habit. The process of developing an MMI includes data collection, site classification, assignment of test sites to reference classes, development of a reference condition, and assessment of sites based on that reference condition. The RBP also describes how to define thresholds for the MMI.

The applicability of the RBP to the Site benthic invertebrate data analysis is limited for several reasons. First, the RBP focuses on sampling riffles and multiple habitat samples in wadeable streams. Sampling sand is briefly discussed in terms of qualitative sampling with a traveling kick-net, but large river methods (e.g., van Veen grab samples) are not discussed. The RBP does not offer guidance for development of a project-based or ad hoc reference condition. The guidance is intended to be used for development of regional biological expectations that require a long-term programmatic level of effort.

In summary, while the RBP (Barbour et al. 1999) is a commonly used guidance document in the development of biological monitoring programs, it is not useful for identifying benthic invertebrate community metric benchmarks that can be used to determine whether benthic invertebrate communities at individual locations in OU 1 show evidence of impairment. The RBP was developed to provide information about overall stream quality/integrity but was not intended to be diagnostic as to the cause of any potential impairments. Based on the approaches described in the RBP, assessment of community metric values relies on the availability of suitable regional or local reference area data. Unlike the 2019 Phase 3 Sediment Study (TAI 2022), which focuses solely on benthic invertebrate communities in depositional habitats, the RBP focuses on multiple habitat assessments at the reach scale.

3.2 MULTI-METRIC INDEX DEVELOPMENT FOR BIOLOGICAL MONITORING IN WASHINGTON STATE STREAMS

The *Multi-Metric Index Development for Biological Monitoring in Washington State Streams* (Ecology 2003) document provides a standard programmatic approach for MMI development for streams in the State of Washington. The methods were intended to be iterative and to include periodic re-evaluation of ambient monitoring data over time. The document provides classification and MMI calibration approaches for biological criteria development in Washington using benthic invertebrates. It also presents biological classification results for western Washington and proposed MMIs for the Puget Lowland and Cascades regions.

The Ecology (2003) document was developed to inform the state's biological monitoring program. Like the RBP (Barbour et al. 1999), this program focuses on reach-wide assessments of water quality, and, thus, relies on systematic sampling of four representative riffles with a D-frame net. Depositional environments are not sampled. Determinations of benthic invertebrate community health are not made without consideration of reference conditions. Screening criteria for reference sites vary by ecoregion and are defined by a "least disturbed" condition. Candidate metrics are defined and selected for each ecoregion based on discrimination efficiency between reference and test sites. Calibration of metrics (i.e., a definition of what is "good, fair, and poor") is based on the applicable reference distribution. Finally, the calibrated metric scores are aggregated into MMIs, but only for those ecoregions where there are sufficient reference sites. For example, Ecology (2003) derived a calibrated MMI for the Puget Lowland and Cascades ecoregions, but not for the Site.

The applicability of the Ecology (2003) approach to the Site benthic invertebrate data evaluation is limited by the field methods, target habitat strata, and regions evaluated. The field methods are limited to wadeable kick-sampled methods because the target habitat stratum is limited to riffle habitat. The regions evaluated are limited to the Puget Lowlands and Cascades ecoregions. Therefore, calibration of the metrics presented in that document are not applicable to the Site benthic invertebrate analysis. Similar to the RBP, the Ecology (2003) approach to the Site benthic invertebrate data evaluation was designed to provide information about overall stream health and was not developed to identify potential causes of benthic invertebrate community impairments. It is not a source for benthic invertebrate community metric benchmarks to make location-specific determinations of benthic invertebrate community health in sandy habitats on the Site.

3.3 BIOLOGICAL ASSESSMENT FRAMEWORKS AND INDEX DEVELOPMENT FOR RIVERS AND STREAMS IN IDAHO

The Idaho Department of Environmental Quality (IDEQ) developed a biological framework and index (IDEQ 2011) to evaluate biological and habitat integrity in streams and rivers throughout Idaho. These efforts included definition of reference conditions and assessment of macroinvertebrates, fish, and habitat, for use in CWA assessments of state waterbodies. CWA aquatic life use designations are made independently of stressor assessment, and as such are not indicative of degradation from a particular stressor, but only of a deviation from natural reference conditions. A total of 10 ecoregions were identified: the Columbia Plateau, the Blue Mountains, the Snake River Plain, the Central Basin and Range, the Northern Rockies, the Idaho Batholith, the Middle Rockies, the Wyoming Basin, the Wasatch and Uinta Mountains, and the Northern Basin and Range.

Benthic invertebrate community data were collected by IDEQ using Hess samplers in shallow riffle habitats. The protocol directed sampling teams to composite benthic invertebrates collected from three samples of a wadeable riffle at each site. Therefore, the metrics identified by IDEQ (2011) reflect benthic invertebrate communities from riffle areas and not depositional/sandy areas similar to the sandy areas in OU 1 of the Site that were targeted for sampling in the 2019 Phase 3 Sediment Study (TAI 2022).

Because of the focus on riffle habitats, the benthic invertebrate MMI developed by the State of Idaho for rivers of the state in non-mountain regions (i.e., regions most similar to that of the Site) was driven by community metrics associated with epibenthic benthic invertebrates rather than those found in depositional areas, namely insect taxa richness, percent non-insect taxa, percent Ephemeroptera, percent scrapers, sprawler taxa richness, percent tolerant benthic invertebrates, and percent multivoltine benthic invertebrates. Determinations regarding degradation of the benthic invertebrate community at given sites were made based on comparisons to suitable reference sites, where identified reference sites were representative of least disturbed conditions. IDEQ reported difficulties in identifying appropriate non-mountain reference sites utilizing the concept of “best available reference” because “[a]lmost all reference sites were in mountainous regions and almost all stressed sites were in plains regions.” Ultimately, reference sites located in the non-mountain regions of rivers were characterized by:

- Road densities of less than 0.6 kilometer (km)/km²;
- Less than 0.2 km of roads close to channels per km of river;
- Landscape disturbance index less than 0.05; and
- Population density equal or less than one person per square mile.

The use of Hess samplers and reliance on riffle benthic invertebrate community metrics to discern impacted sites from natural reference areas invalidates the use of this approach for soft-sediment depositional areas. Moreover, application of the approach to CWA aquatic life use designations means that identification of impairment is made independently of specific stressors. Therefore, use of this approach on the Site would mean that areas impacted by sedimentation or pooling by dams (but not by chemicals of potential concern, or slag-related metals) would be identified as impaired.

3.4 RECALIBRATION OF THE PUGET LOWLAND BENTHIC INDEX OF BIOTIC INTEGRITY

The benthic index of biotic integrity (B-IBI) for Puget Sound Lowland streams is used to support CWA requirements and is a general indicator of stream health in the Puget Sound region. The B-IBI was developed to reflect the ecological health of wadeable streams in the Puget Sound region and is, thus, not directly transferrable to benthic invertebrate communities from sampleable sand habitats on the Site. First developed in the 1990s (King County 2014), the B-IBI incorporates 10 different benthic invertebrate community metrics into a single index; these include metrics such as EPT taxa richness and clinger taxa that are most applicable to coarse-bottomed riffle habitats. The remaining metrics were taxa richness, long-lived taxa, intolerant taxa, number of intolerant individuals, number of predator individuals, and percent dominance. This index is highly correlated to watershed urbanization.

For the recent recalibration of the B-IBI (King County 2014), the Puget Sound Stream Benthos database was queried for benthic invertebrate community data from sites that met the following criteria:

- Puget Sound basin
- Elevations below 500 meters
- Surface area between 3 and 9 square feet
- Collected in late summer or fall

The resulting data set was made up of samples collected from wadeable riffles or other non-depositional areas using a variety of methods (King County 2014). This approach cannot be appropriately used for determining whether benthic invertebrate communities in depositional habitats (i.e., sand) in OU 1 of the Site show evidence of impairment. Of the 10 metrics used as part of the B-IBI, 8 are negative indicators of disturbance (i.e., the metrics decrease with increasing disturbance); these include taxa richness, EPT taxa richness, clinger abundance, predator abundance, and intolerant taxa richness. The remaining two metrics, percent dominance and abundance of tolerant individuals, are positive indicators of disturbance. As indicated in the King County (2014) descriptions of the component metrics, they are predominantly associated with rocky or riffle substrates.

3.5 ADDITIONAL BENCHMARK LITERATURE REVIEW

While the examples above describe common uses of benthic invertebrate community indices in bioassessments, the conditions for which they were developed differ from those on the Site in several important aspects. The most common and significant difference relates to the differences in habitats targeted in the bioassessment approaches described above and the sampleable sand habitats targeted in the 2019 Phase 3 Sediment Study. Hydraulic condition (e.g., surface water velocities) and substrate have a direct influence on the food resources and successful feeding strategies that help structure benthic invertebrate communities (Vannote et al. 1980). For example, species that indicate potential impairment in riffle habitats (e.g., percent chironomids as described at several sites in the studies mentioned above) may be more common in depositional habitats and would, therefore, be less likely to be a reliable indication of impairment in

depositional habitats than in riffle habitats. This subsection summarizes bioassessments from other sites that may be more representative of conditions faced by benthic invertebrate communities in sandy habitats on the Site to document the relevant metrics and determine whether they provide candidate benchmarks for use in answering the relevant analysis questions for the benthic invertebrate community LOE in the Aquatic BERA.

3.5.1 LARGE RIVER MONITORING PROGRAMS

Some state and federal monitoring programs include biocriteria development and assessment specific to non-wadeable streams and large rivers. The USEPA (2016) provided overall guidance for non-wadeable rivers, in terms of sampling methods and sampling design considerations. The field protocol accommodates large non-wadeable rivers, but is shoreline-oriented, with sampling constrained to the shallow margin (less than 1 meter in depth). Unlike the 2019 Phase 3 Sediment Study, these large river bioassessments employ systematic designs for representing the variety of habitats encountered over a given reach. Forty-two potential community metrics for use in large rivers were defined by Blocksom and Flotemersch (2005). The metrics identified by USEPA (2016) were intended to be responsive to disturbance gradients in large rivers and differ for each ecoregion in the continental United States.

The National Rivers and Streams Program samples non-wadable streams and rivers with a systematic design (USEPA 2019). The reach length is 40 times the average wetted width, but no longer than 4 km. Within that reach, 11 transects are defined and sampling occurs only on the wadeable margins. Sampling of the left bank versus the right bank at any given transect is randomly determined. Benthic invertebrate samples have been collected across the country in large rivers using this methodology. Regional MMIs have been developed based on estimating “floor” and “ceiling” benthic invertebrate metric values, and then scaling a metric value at a given site to a 1 to 10 point scale, based on the difference between the regional floor and ceiling values (USEPA 2016).

While these regional expectations could be relevant for the Site ecosystem, they are not relevant to the 2019 Phase 3 Sediment Study because the sampling protocol was not comparable (e.g., sampling deep water from boats for the Site study versus shoreline wadeable sampling in the National Rivers and Streams study). It is, therefore, not possible to derive relevant benthic invertebrate community metric benchmarks from the National Rivers and Streams data set.

The same is also true for Washington State’s data set for rivers and non-wadeable streams (Ecology 2019). Washington State employs a similar methodology for assessing large river reaches as that developed by USEPA (2019). It uses a river reach length that is 20 times the average wetted width and collects benthic invertebrate community samples from wadeable margins of 11 systematic transects along the reach length (Ecology 2019). Washington State samples large streams and rivers but does not sample the Columbia River or the Snake River. Similar to the EPA, Washington State has interpreted benthic invertebrate data collected with this protocol in terms of community metrics (Larson et al. 2019), but these regional expectations cannot be applied to data collected from the Site for the 2019 Phase 3 Sediment Study because the sampling protocols are not comparable.

3.5.2 OTHER SOFT SEDIMENT MONITORING PROGRAMS

In addition to the large systematic design biomonitoring programs described above, more site-specific approaches for using benthic invertebrate data to evaluate community health have been developed by a variety of entities. Two programs that have been specifically developed for depositional, freshwater habitats are described below to provide context on the types of community metrics that have been used for assessing community health.

3.5.2.1 CHESAPEAKE B-IBI

The Maryland Department of Natural Resources developed a B-IBI to assess the health of benthic communities in Chesapeake Bay. Communities are scored on a scale from 1 to 5, with communities scoring 3 or higher determined to have “good benthic condition indicative of good habitat quality.” These evaluations are made independently of stressors so they are not diagnostic of impacts associated with metals rather than habitat degradation or organic enrichment. A series of optimizations was conducted to improve the metric, and it was concluded that, overall, this B-IBI is “sensitive, stable, robust, and statistically sound.” This method incorporates a variety of approaches for different salinity regimes, ranging from tidal freshwater to marine sediments. The Chesapeake Bay B-IBI approach has been used in coastal rivers along the eastern coast of the United States (Diaz 1989; Hyland et al. 1999; McGee et al. 2001).

The methodology notes that the Chesapeake Bay B-IBI approach should be applied to benthic invertebrate samples collected from unvegetated soft-sediment substrates using a modified van Veen sampler (specified as a Young grab). Benthic invertebrates retained on a 500-micrometer (0.5-millimeter) screen are incorporated in the Chesapeake Bay B-IBI; smaller taxa (e.g., nematodes, copepods, and ostracods) (NYSDEC 2019) are removed from the assessment. Additional taxa removed from the metric calculations are listed in a table appended to Llansó and Dauer (2002). Of the five different B-IBIs developed for the Chesapeake Bay, only the B-IBI developed for tidal freshwater habitats (bottom salinity between 0 and 0.5 parts per thousand) would be potentially applicable to OU 1 of the Site. The metrics used to calculate the tidal freshwater index include total abundance, percent abundance of pollution-indicative taxa, percent of deep-deposit feeders, and site-specific tolerance scores. Because the Chesapeake Bay B-IBIs were developed specifically for the types of habitat in the bay, using regional reference data, they are not suitable for “off-the-shelf” benchmarks that can be applied to the 2019 Phase 3 Sediment Study benthic invertebrate community data.

3.5.2.2 NEW YORK STATE BIOMONITORING PROGRAM

The New York State Department of Environmental Conservation (NYSDEC) has developed multiple metric benthic invertebrate community indices for a variety of aquatic habitats. NYSDDEC developed its Biological Assessment Profile Score (BAP) methodology for monitoring water quality in waters of New York. NYSDDEC developed separate BAP indices depending on the sampling methodology—kick-net samples from shallow riffles, multiplate artificial substrate samplers for navigable water, and Ponar grab samples from soft-bottom rivers (NYSDEC 2019). The BAP MMI for Ponar samples is based on species richness, diversity (Shannon-Weaver, H' , calculated with $\log_{10}$), HBI, percent dominant 3 taxa, and relative abundance of common taxa including chironomids, oligochaetes, molluscs, crustaceans, and non-chironomid insects. Although

NYSDEC's Ponar benthic invertebrate community samples are relatively comparable to the van Veen benthic invertebrate community samples collected from the Site for the 2019 Phase 3 Sediment Study, the community metrics and cutoff values that provide the basis for the Ponar BAP were designed and calibrated using data from New York State. NYSDEC (2019) emphasizes that they were not designed for use with community data from outside of New York or outside their June through September sampling season. Use of NYSDEC's BAP approach for assessing benthic invertebrate community impairment at individual sample locations in the Site would require calibration with relevant regional reference data that are not presently available.

3.6 SUMMARY OF BENCHMARK LITERATURE REVIEW

The use of benthic invertebrate community data for making determinations regarding environmental health is dependent on the geographic location, type of substrate, study design, and type of stressors. A variety of factors can influence benthic invertebrate community composition (e.g., hydraulic setting, sediment grain size, reservoir age, organic enrichment, and water depth).

TAI's benthic invertebrate technical team did not identify any set of established benchmarks that would be an appropriate point of comparison for benthic invertebrate communities from individual sediment grab locations on the Site *without* attempting to account for representative reference conditions. Representative reference conditions are required for development of benthic invertebrate community benchmarks for sandy depositional areas of the Site.

4. USE OF *ROBACKIA DEMEIJEREI* PRESENCE TO CONTROL FOR HABITAT FACTORS

As discussed in Section 4.1.3.4 of Volume 2, the chironomid *Robackia demeijerei* was locally abundant in all but one of the benthic invertebrate community samples from OU 1 that were outside of the reference envelope. Samples from these locations had relatively low abundance, richness, and diversity as well as high percent Chironomidae. The literature on this species indicates that they are specialists adapted to shifting sand habitats. Because this species was also locally abundant in benthic invertebrate communities from several of the free-flowing upstream reference locations, this analysis was conducted to determine whether the abundance of *R. demeijerei* can be used to identify samples with similar habitats as a way to control for habitat when comparing OU 1 communities with reference area communities.

Benthic invertebrate communities where *R. demeijerei* account for at least 5 percent of the individuals were collected from 15 locations in the Deadman's Eddy sand bar, 2 locations at the downstream end of China Bend, and 7 locations in the free-flowing reference areas (Table K-4). The analyses presented below focus on those locations to answer the following questions:

- Do physical habitat metrics in reference and OU 1 samples vary consistently with the relative abundance of *R. demeijerei* suggesting physical habitat factors are comparable at the reference and OU 1 locations? That is, can relative abundance of *R. demeijerei* in reference and OU 1 locations be used to control for physical habitat factors when comparing community metrics between reference and OU 1 locations?
- Are metals exposure metrics in reference and OU 1 samples correlated with the relative abundance of *R. demeijerei*? If they are found to be correlated, this could suggest that dominance of benthic invertebrate communities by *R. demeijerei* could be influenced, in part, by exposure to metals.

Because of the limited number of samples where *R. demeijerei* are abundant, this is a qualitative analysis based on assessment of patterns in the available data.

To answer the first question, physical habitat metrics are represented by the first two PC scores from the PCA of the physical habitat parameters from the Phase 3 study locations (Figures 4-12a,b from Volume 2). These PCs account for 53 percent of the variability in the physical habitat data where PC1 is negatively correlated with coarse sand content and positively correlated with fines, TOC, and very fine sand. PC2 is negatively correlated with fine gravel and positively correlated with medium and total sand. For confirmation, one of the individual sand size categories (specifically, medium sand) is included in the assessment of physical habitat metrics (Figure K-7) because medium sand dominates the grain size distribution in the samples from the sand bar downstream of Deadman's Eddy. These figures show that among these samples, the relative abundance of *R. demeijerei* does not reliably vary with physical habitat substrate. In addition, the figures suggest that substrates across the OU 1 samples where *R. demeijerei* are abundant tend to differ from the substrates in the reference samples where *R. demeijerei* are abundant. Most of the reference area samples have low medium sand and low PC1 and PC2 scores while most OU 1 samples have high medium sand and high PC1 and PC2 scores suggesting that samples from reference that are dominated by *R. demeijerei* tend to be from samples with

different sand grain size distributions. The lack of relationship between relative abundance of *R. demeijerei* and physical substrate suggests that the measured physical habitat metrics do not capture all factors influencing benthic invertebrate community composition in these samples. One possible explanation for these differences in the Deadman's Eddy locations relates to their physical location in the sand bar. The samples where *R. demeijerei* are more than 50 percent of the benthic invertebrate community (identified in Table K-4 and mapped in Map 3-1 of Volume 1) tend to be those located closest to the channel's edge, which, based on the water velocity measurements taken in 2018 (TAI 2020), is where hydrodynamic forces are likely to be highest. This is consistent with the observations that *R. demeijerei* are adapted to harsh conditions (Rempel et al. 2000; Bij De Vaate et al. 2007).

Both of the metals exposure metrics used to address the second question attempt to account for bioavailability. They include excess SEM to represent bioavailability of solid-phase metals and toxic units associated with bioavailable copper in porewater (Figure K-7). Excess SEM is significantly higher in all OU 1 locations but the relative abundance of *R. demeijerei* in the OU 1 samples does not show any obvious relationships with solid-phase metals. Bioavailable copper in porewater is more comparable in the OU 1 and upstream reference samples but, consistent with the solid-phase comparisons, relative abundance of *R. demeijerei* does not show any obvious relationship with bioavailable copper in porewater.

Overall, the data suggest that the physical substrate in the reference samples is not directly comparable to the substrate in OU 1 samples. Therefore, it is not possible to use presence of *R. demeijerei* as a way to control for habitat when discerning what factors may be responsible for differences in community composition in the Deadman's Eddy sand bar. In addition, these data do not provide evidence that dominance of *R. demeijerei* in benthic invertebrate communities in sandy areas of OU 1 and reference areas is associated with exposure to metals.

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TABLES

Table K-1
Initial Screen of 107 Benthic Invertebrate Community Metrics for Use in 2019 Phase 3 Sediment Study Analyses
Upper Columbia River
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BMI Metric Category	BMI Community Metric	Retained after Initial SME Screen	Retained as Candidate Metric	Basis for Selection of Candidate Metrics
Corrected Abundance	Total Abundance	Yes	Yes	Commonly used metric
Corrected Abundance	Invertebrate Density	Yes	Yes	Commonly used metric
Corrected Abundance	EPT Abundance	Yes	Yes	Commonly used metric
Biotic Indices	Fine Sediment Biotic Index	No	No	Unrelated stressor
Biotic Indices	FSBI - average	No	No	Unrelated stressor
Biotic Indices	FSBI - weighted average	No	No	Unrelated stressor
Biotic Indices	% Individ. w/ FSBI Value	No	No	Unrelated stressor
Biotic Indices	Hilsenhoff Biotic Index	Yes	Yes	Common metric though unrelated stressor
Biotic Indices	% Individ. w/ HBI Value	No	No	Data quality metric for HBI
Biotic Indices	Metals Tolerance Index	Yes	Yes	Diagnostic metric for metals
Biotic Indices	% Individ. w/ MTI Value	No	No	Data quality metric for MTI
Biotic Indices	Temp. Pref. Metric - average	No	No	Unrelated stressor
Biotic Indices	TPM - weighted average	No	No	Unrelated stressor
Biotic Indices	% Individ. w/ TPM Value	No	No	Unrelated stressor
Community Composition	% Baetidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Brachycentridae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Chironomidae	Yes	Yes	Commonly used tolerant taxa
Community Composition	% Coleoptera	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Diptera	Yes	No	Represented by Chironomid metric
Community Composition	% Ephemerellidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Ephemeroptera	Yes	No	Represented by EPT metrics
Community Composition	% EPT	Yes	Yes	Commonly used metric of metals sensitivity
Community Composition	% Hydropsychidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Odonata	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Oligochaeta	Yes	No	Link to metals stress not widely documented
Community Composition	% Perlidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Plecoptera	No	No	Represented by EPT metrics
Community Composition	% Pteronarcyidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Simuliidae	No	No	Compositional, Link to metals stress not well documented
Community Composition	% Trichoptera	Yes	No	Represented by EPT metrics
Counted organisms blotted biomass	CountedBlottedMass	Yes	Yes	Commonly used metric, relevant for BERA
Diversity/Evenness Measures	Margalef's Richness	Yes	No	Represented by Shannon-Weaver
Diversity/Evenness Measures	Pielou's J'	Yes	No	Represented by Shannon-Weaver
Diversity/Evenness Measures	Shannon-Weaver H' (log 10)	Yes	Yes	Commonly used metric
Diversity/Evenness Measures	Shannon-Weaver H' (log 2)	No	No	Redundant with other Shannon-Weaver metric
Diversity/Evenness Measures	Shannon-Weaver H' (log e)	No	No	Redundant with other Shannon-Weaver metric
Diversity/Evenness Measures	Simpson's Heterogeneity	Yes	No	Represented by Shannon-Weaver
Dominance Measures	Dominant Taxon	No	No	Represented by dominance metrics
Dominance Measures	Dominant Abundance	No	No	Represented by dominance metrics

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BMI Metric Category	BMI Community Metric	Retained after Initial SME Screen	Retained as Candidate Metric	Basis for Selection of Candidate Metrics
Dominance Measures	% Dominant Taxon	Yes	Yes	Dominance commonly used metric
Dominance Measures	2nd Dominant Taxa	No	No	Represented by dominance metrics
Dominance Measures	2nd Dominant Abundance	No	No	Represented by dominance metrics
Dominance Measures	% 2 Dominant Taxa	Yes	Yes	Dominance commonly used metric
Dominance Measures	3rd Dominant Taxa	No	No	Represented by dominance metrics
Dominance Measures	3rd Dominant Abundance	No	No	Represented by dominance metrics
Dominance Measures	% 3 Dominant Taxa	Yes	Yes	Dominance commonly used metric
Functional Group Composition	Filterer Richness	No	No	Link to metals stress not widely documented
Functional Group Composition	% Filterers	No	No	Link to metals stress not widely documented
Functional Group Composition	Gatherer Richness	No	No	Link to metals stress not widely documented
Functional Group Composition	% Gatherers	No	No	Link to metals stress not widely documented
Functional Group Composition	Piercer-Herbivore Richness	No	No	Link to metals stress not widely documented
Functional Group Composition	% Piercer-Herbivores	No	No	Link to metals stress not widely documented
Functional Group Composition	Predator Richness	Yes	Yes	Related to trophic complexity
Functional Group Composition	% Predators	No	No	Related to predator richness metric
Functional Group Composition	Scraper Richness	No	No	Link to metals stress not widely documented
Functional Group Composition	% Scrapers	No	No	Link to metals stress not widely documented
Functional Group Composition	Shredder Richness	No	No	Link to metals stress not widely documented
Functional Group Composition	% Shredders	No	No	Link to metals stress not widely documented
Functional Group Composition	Unclassified	No	No	Link to metals stress not widely documented
Functional Group Composition	% Unclassified	No	No	Link to metals stress not widely documented
Karr BIBI Metrics	Clinger Richness	No	No	Link to metals stress not widely documented
Karr BIBI Metrics	% Clingers	No	No	Link to metals stress not widely documented
Karr BIBI Metrics	Coleoptera Richness	No	No	Link to metals stress not widely documented
Karr BIBI Metrics	Intolerant Taxa Richness	No	No	Related to retained intolerance metric
Karr BIBI Metrics	Long-Lived Taxa Richness	No	No	Related to semivoltine metric
Karr BIBI Metrics	% Tolerant Individuals	No	No	Related to intolerance/tolerance metrics
Karr BIBI Metrics	% Tolerant Taxa	No	No	Related to intolerance/tolerance metrics
Lake Metrics	Average Abundance (per Taxon)	No	No	Represented by abundance, richness metrics
Lake Metrics	Chironomini Richness	No	No	Related to chironomid metrics
Lake Metrics	Orthocladinae Richness	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Chironomini	Yes	No	Redundant with chironomid metrics
Lake Metrics	% Chironomus	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Corbicula	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Crustacea + Mollusca	Yes	No	Link to metals stress not widely documented
Lake Metrics	% Dicrotendipes	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Dicrotendipes + Chironomus	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Individuals w/ CAHBI value	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Intolerant	Yes	Yes	Potentially relevant to metals tolerance
Lake Metrics	% Intolerant Indiv. (CAHBI)	No	No	Compositional, Link to metals stress not well documented

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Initial Screen of 107 Benthic Invertebrate Community Metrics for Use in 2019 Phase 3 Sediment Study Analyses
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BMI Metric Category	BMI Community Metric	Retained after Initial SME Screen	Retained as Candidate Metric	Basis for Selection of Candidate Metrics
Lake Metrics	% Intolerant Individ. (S.CA)	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Manayunkia speciosa	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Non-Insect Individuals (S.CA)	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Non-Insect Taxa	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Orthocladinae	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Sensitive EPT (CAHBI)	No	No	Different region
Lake Metrics	% Tanytarsini	No	No	Compositional, Link to metals stress not well documented
Lake Metrics	% Tanytarsus	No	No	Compositional, Link to metals stress not well documented
Montana DEQ Metrics	MT Biotic Index	Yes	No	Redundant with original HBI, applicable to unrelated stressor.
Montana DEQ Metrics	Community Tolerance Quotient	No	No	Link to metals stress not widely documented
Montana DEQ Metrics	C-Gatherers + C-Filterers	No	No	Link to metals stress not widely documented
Montana DEQ Metrics	% Hydropsychinae	No	No	Compositional, Link to metals stress not well documented
Montana DEQ Metrics	% Multivoltine	No	No	Link to metals stress not widely documented
Montana DEQ Metrics	% Scraper + % Shredder	No	No	Link to metals stress not widely documented
Montana DEQ Metrics	% Semivoltine	Yes	No	Presence of long-lived taxa but data quality insufficient
Montana DEQ Metrics	% Univoltine	No	No	Link to metals stress not widely documented
NYSDEC PMA Metrics	% Crustacea	Yes	No	Link to metals stress not widely documented
NYSDEC PMA Metrics	% Mollusca	Yes	No	Link to metals stress not widely documented
NYSDEC PMA Metrics	% Non-Chironomidae	No	No	Inverse of chironomid metrics
Richness Measures	Species Richness	Yes	Yes	Common community metric
Richness Measures	Chironomidae Richness	Yes	Yes	Tolerant taxa, used at Clark Fork site
Richness Measures	Ephemeroptera Richness	Yes	No	Represented by EPT metrics
Richness Measures	EPT Richness	Yes	Yes	Metals-sensitive taxa
Richness Measures	Non-Chiro. Non-Olig. Richness	No	No	Link to metals stress not widely documented
Richness Measures	Oligochaeta Richness	Yes	No	Link to metals stress not widely documented
Richness Measures	Plecoptera Richness	No	No	Represented by EPT metrics
Richness Measures	Rhyacophila Richness	No	No	Link to metals stress not widely documented
Richness Measures	Trichoptera Richness	Yes	No	Represented by EPT metrics

Notes:

BERA = baseline ecological risk assessment

BMI = benthic macroinvertebrate

DEQ = Department of Environmental Quality

EPT = Ephemeroptera, Plecoptera, Trichoptera

NYSDEC PMA = New York State Department of Environmental Conservation Percent Model Affinity

SME = subject matter expert

Table K-2
Benthic Invertebrate Community Metrics Used to Identify Metals Stress in Freshwater Rivers and Streams in the Western United States
Upper Columbia River
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Site	Habitat (method)	Total Abundance / Density	Biomass	Diversity	Total Richness	EPT Richness	% Dominant	Chironomid Richness	MTI	HBI	% Chironomidae	EPT Abundance	EPT Relative Abundance	Metals-sensitive Taxa Abundance	Citation
Columbia River, BC	Depositional (grab)	X		X	X	X				X	X		X		Teck Metals Ltd. (2014)
Columbia River, BC	Depositional (grab)	X			X									X	Teck Metals Ltd. (2007)
Columbia River, BC	Depositional (grab)	X		X	X	X				X	X		X		Teck Metals Ltd. (2019)
Clark Fork River, MT	Depositional (grab)							X							Canfield et al. (1994)
Columbia River, BC	Erosional (surface disturbance)	X		X	X	X				X	X		X		Teck Metals Ltd. (2014)
Columbia River, BC	Erosional (surface disturbance)	X		X	X	X				X	X		X		Teck Metals Ltd. (2019)
Clark Fork River, MT	Riffles (surface disturbance)	X			X	X	X	X		X			X		Poulton et al. (1995)
Clark Fork River, MT	Riffles (surface disturbance)	X		X	X	X			X						Jacobs (2020)
Blackbird Mine, ID	Riffles (surface disturbance)	X	X		X						X	X			Beltman et al. (1999)
Blackbird Mine, ID	Riffles (surface disturbance)		X		X							X			Mebane et al. (2015)
South Fork Coeur d'Alene River, ID	Riffles (surface disturbance)			X	X	X	X			X			X		Hoiland and Rabe (1992)

Notes:
BC = British Columbia
EPT = Ephemeroptera, Plecoptera, Trichoptera
HBI = Hilsenhoff Biotic Index
ID = Idaho
MT = Montana
MTI = Metals Tolerance Index

Table K-3
 PC Scores for the Primary Benthic Invertebrate Community Metrics from Locations with > 50% Medium, Coarse, and Very Coarse Sand
 Upper Columbia River
 Final Aquatic Baseline Ecological Risk Assessment
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Study Location ID	Site	Target Stratum	Hydraulic Condition	Latitude	Longitude	PC1	PC2	PC3	PC4	PC5
1-B6-NRT-2019	Deadman's Eddy	undefined	free-flowing	48.93979	-117.7328	0.4223	-0.8481	0.2012	0.9107	1.233
3-R7-2019	China Bend	undefined	backwater	48.81342	-117.9494	-0.6052	-0.8876	0.7676	-2.1957	-1.6896
3-R8-2019	China Bend	undefined	backwater	48.81456	-117.9611	-2.8574	-3.1002	-3.3415	-0.1934	-1.4707
4-B1-2019	Evans	undefined	backwater	48.69012	-118.0259	1.0937	0.1797	-1.3812	0.3534	-0.4878
4-B6-2019	Evans	undefined	backwater	48.67397	-118.0446	0.3478	-0.3857	-1.4238	-0.4691	-0.3963
CB006	China Bend	sampleable sand	backwater	48.81571	-117.9598	0.4982	-0.4272	-0.121	-0.1209	0.5434
CB009	China Bend	sampleable sand	backwater	48.8159	-117.9589	1.5413	0.3021	-0.0976	-0.4037	0.6801
CB012	China Bend	sampleable sand	backwater	48.81548	-117.959	-1.5154	-0.2158	-1.1285	0.8817	0.5324
CB014	China Bend	sampleable sand	backwater	48.81505	-117.9588	-3.2827	-0.7628	-0.3806	0.2735	0.3706
CB016	China Bend	sampleable sand	backwater	48.81563	-117.958	2.3595	0.1373	-0.35	0.229	0.7009
CB018	China Bend	sampleable sand	backwater	48.8154309	-117.9575195	2.0047	0.3467	-0.1551	-0.2813	0.5876
CB020	China Bend	sampleable sand	backwater	48.81528	-117.9571	2.6864	1.2722	0.0985	-0.0881	0.3588
CB039	China Bend	sampleable sand	backwater	48.81398	-117.9446	0.1089	-1.3559	-0.1369	-1.5428	-0.7006
CB047	China Bend	sampleable sand	backwater	48.81593	-117.9396	0.2322	-1.6647	-0.6051	0.0169	-0.7902
DM002	Deadman's Eddy	sampleable sand	free-flowing	48.94162	-117.7377	-4.3232	2.1884	1.4135	-0.218	-0.116
DM007	Deadman's Eddy	sampleable sand	free-flowing	48.94127	-117.7363	-3.7592	2.5896	1.2202	-0.4134	-0.0262
DM008	Deadman's Eddy	sampleable sand	free-flowing	48.94141	-117.7364	0.9434	-2.8186	4.2885	0.6669	-0.4218
DM010	Deadman's Eddy	sampleable sand	free-flowing	48.94149	-117.7359	-0.766	-0.6075	-0.001	1.4624	-0.399
DM015	Deadman's Eddy	sampleable sand	free-flowing	48.94164	-117.7352	0.1628	-0.614	1.1244	0.4226	0.4585
DM018	Deadman's Eddy	sampleable sand	free-flowing	48.94082	-117.7346	-5.5132	4.0164	1.5681	-1.0715	-0.513
DM020	Deadman's Eddy	sampleable sand	free-flowing	48.94149	-117.7343	-3.7114	-0.8978	0.7314	1.1996	-0.1774
DM022	Deadman's Eddy	sampleable sand	free-flowing	48.94098	-117.7342	-3.3396	0.331	-0.7443	-0.0107	0.4562
DM023	Deadman's Eddy	sampleable sand	free-flowing	48.94107	-117.7339	-6.6659	1.0977	0.9988	-0.1416	0.2439
DM024	Deadman's Eddy	sampleable sand	free-flowing	48.94054	-117.7339	-4.9148	-0.5633	1.8066	1.4775	-0.2269
DM025	Deadman's Eddy	sampleable sand	free-flowing	48.94047	-117.7331	-2.5744	-0.1764	0.0931	0.2808	0.3339
DM026	Deadman's Eddy	sampleable sand	free-flowing	48.94023364	-117.7334189	-4.0314	-0.347	-1.573	0.0334	1.1152
DM027	Deadman's Eddy	sampleable sand	free-flowing	48.94011	-117.7331	-0.0135	-1.2855	-0.1689	0.4051	0.5941
EV001	Evans	sampleable sand	backwater	48.67204	-118.0532	0.4559	-1.0059	-1.0153	0.2905	-0.0903
EV002	Evans	sampleable sand	backwater	48.67329	-118.0528	1.6898	0.1229	-1.0659	0.4563	-0.2512
EV005	Evans	sampleable sand	backwater	48.67359	-118.0513	0.5061	0.1385	-0.6238	-1.0302	0.3532
EV008	Evans	sampleable sand	backwater	48.67316	-118.0498	2.3246	1.6723	-0.9409	1.2227	0.2152
EV010	Evans	sampleable sand	backwater	48.67201	-118.0506	-0.2213	-0.4936	-1.3017	2.6238	-0.095
EV012	Evans	sampleable sand	backwater	48.67246	-118.0484	1.4704	-0.4768	-0.3281	-0.3888	-0.0144
EV013	Evans	sampleable sand	backwater	48.67261	-118.0471	0.1161	-0.8442	-0.2864	0.2632	-0.7063
EV026	Evans	sampleable sand	backwater	48.67784	-118.0346	0.3944	-1.0978	-0.8561	-0.3967	1.1149
EV027	Evans	sampleable sand	backwater	48.67665	-118.0342	-0.4753	-0.6337	-1.1571	-0.7745	-0.5972
EV037	Evans	sampleable sand	backwater	48.67932	-118.0288	0.0832	-0.5284	-0.7253	-0.3362	-0.3423
EV048	Evans	sampleable sand	backwater	48.68486	-118.0239	2.465	2.9362	0.7336	0.1443	0.4426
EV049	Evans	mixed coarse	backwater	48.68498	-118.0232	0.8528	1.2033	-0.2475	0.1897	0.7272
EV051	Evans	sampleable sand	backwater	48.68608	-118.0236	2.5609	0.3444	-0.0881	-0.2185	0.491
EV052	Evans	sampleable sand	backwater	48.68698	-118.0242	1.7037	0.7474	-0.4781	-0.5643	-0.0864

Table K-3
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Study Location ID	Site	Target Stratum	Hydraulic Condition	Latitude	Longitude	PC1	PC2	PC3	PC4	PC5
EV060	Evans	sampleable sand	backwater	48.69162	-118.025	1.1135	-0.1758	-0.4762	0.6763	0.5716
EV065	Evans	sampleable sand	backwater	48.69369	-118.0265	0.7198	-1.0832	-0.5706	-1.7586	0.3316
EV066	Evans	sampleable sand	backwater	48.6944	-118.0263	1.4929	2.1239	0.4588	0.9062	0.0579
EV069	Evans	sampleable sand	backwater	48.69553	-118.027	-0.2526	-1.2722	-0.6942	2.4853	-0.3035
EV071	Evans	sampleable sand	backwater	48.69682	-118.0269	1.5524	1.9505	0.1834	1.1447	-0.1505
EV072	Evans	sampleable sand	backwater	48.69718	-118.0277	1.366	1.8688	0.6325	-0.1034	0.053
EV075	Evans	sampleable sand	backwater	48.69852	-118.0277	-0.041	-0.5337	-0.6783	1.0044	0.0971
JS001	China Bend	sampleable sand	backwater	48.81676	-117.9404	1.8628	1.5582	0.004	-0.2963	-1.2231
JS002	China Bend	sampleable sand	backwater	48.81734	-117.939	2.7383	1.729	-0.9744	0.9737	-1.2759
REF001	Reference	sampleable sand	free-flowing	49.16457	-117.7208	-0.8075	-1.6536	1.2016	-0.645	0.4878
REF002	Reference	sampleable sand	free-flowing	49.1652	-117.7203	-1.5058	-1.5348	-1.3214	-2.839	0.9188
REF003	Reference	sampleable sand	free-flowing	49.17253	-117.7152	0.6877	0.5838	-0.842	0.4232	-0.267
REF004	Reference	sampleable sand	free-flowing	49.173	-117.7154	2.4276	1.8752	-0.2361	-0.0812	-0.871
REF005	Reference	sampleable sand	free-flowing	49.20207	-117.7057	2.4728	-0.7999	2.5766	-0.8131	0.4535
REF006	Reference	sampleable sand	free-flowing	49.20198	-117.7049	1.8727	-1.3393	0.9834	-0.5251	1.1594
REF007	Reference	sampleable sand	free-flowing	49.20249	-117.7039	2.534	0.8964	0.276	-1.8494	0.1761
REF008	Reference	sampleable sand	free-flowing	49.20278	-117.7054	1.0631	-1.1071	1.7523	-0.2877	-1.5132
REF009A	Reference	sampleable sand	free-flowing	49.20404	-117.7049	0.3663	1.0427	-0.4999	-0.8199	-1.0893
REF010	Reference	sampleable sand	free-flowing	49.20512	-117.7044	2.5343	-2.476	4.3785	0.5612	-0.1972
REF011	Reference	sampleable sand	free-flowing	49.23028	-117.6695	-0.6515	0.7597	-0.4763	-1.1007	0.6296

Note:
 PC = principal component

Table K-4
Percent Abundance of *Robackia demeijerei* Where Encountered in the
Benthic Invertebrate Community at All Phase 3 Sediment Study Locations
Upper Columbia River
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Appendix K

Area	Location ID	Sand (%)	Abundance (%)
Deadman's Eddy	DM018	99.7	98.2
Deadman's Eddy	DM023	99.6	95.5
Deadman's Eddy	DM002	64.3	92.8
Deadman's Eddy	DM007	99.9	91.1
Deadman's Eddy	DM016	99.5	86
Deadman's Eddy	DM024	99.3	77.6
China Bend	CB014	99.8	71.2
Deadman's Eddy	DM020	98.5	70.3
Deadman's Eddy	DM025	99.8	69.7
Deadman's Eddy	DM022	98.6	68.9
Deadman's Eddy	DM026	99.7	61.2
Reference	REF011	99.5	48.2
China Bend	CB012	98.6	40.2
Reference	REF001	76.4	39.3
Deadman's Eddy	DM019	98.4	33.3
Deadman's Eddy	DM010	99.8	30.2
Reference	REF002	99.9	30.1
Deadman's Eddy	DM015	99.4	24.3
Deadman's Eddy	DM027	99.8	19.9
Reference	REF009A	99.3	17.2
Reference	REF010	39.7	16.8
Deadman's Eddy	DM008	99.1	11.7
Reference	REF005	37.9	7.5
Reference	REF006	54.3	5.8
Reference	REF007	95.0	2.3
China Bend	CB006	99.1	2.3
Reference	REF008	93.8	1.7
China Bend	3-R7-2019	68.1	1
Reference	REF012	60.6	0.5
China Bend	CB044	95.7	0.3
Reference	REF003	99.3	0.2
Reference	REF004	19.8	0.1
Evans	EV051	95.2	0.1
China Bend	JS002	96.4	0.1
China Bend	CB020	98.5	0

Notes:

AOI - area of interest

NA - not applicable

REF - reference area



FIGURES

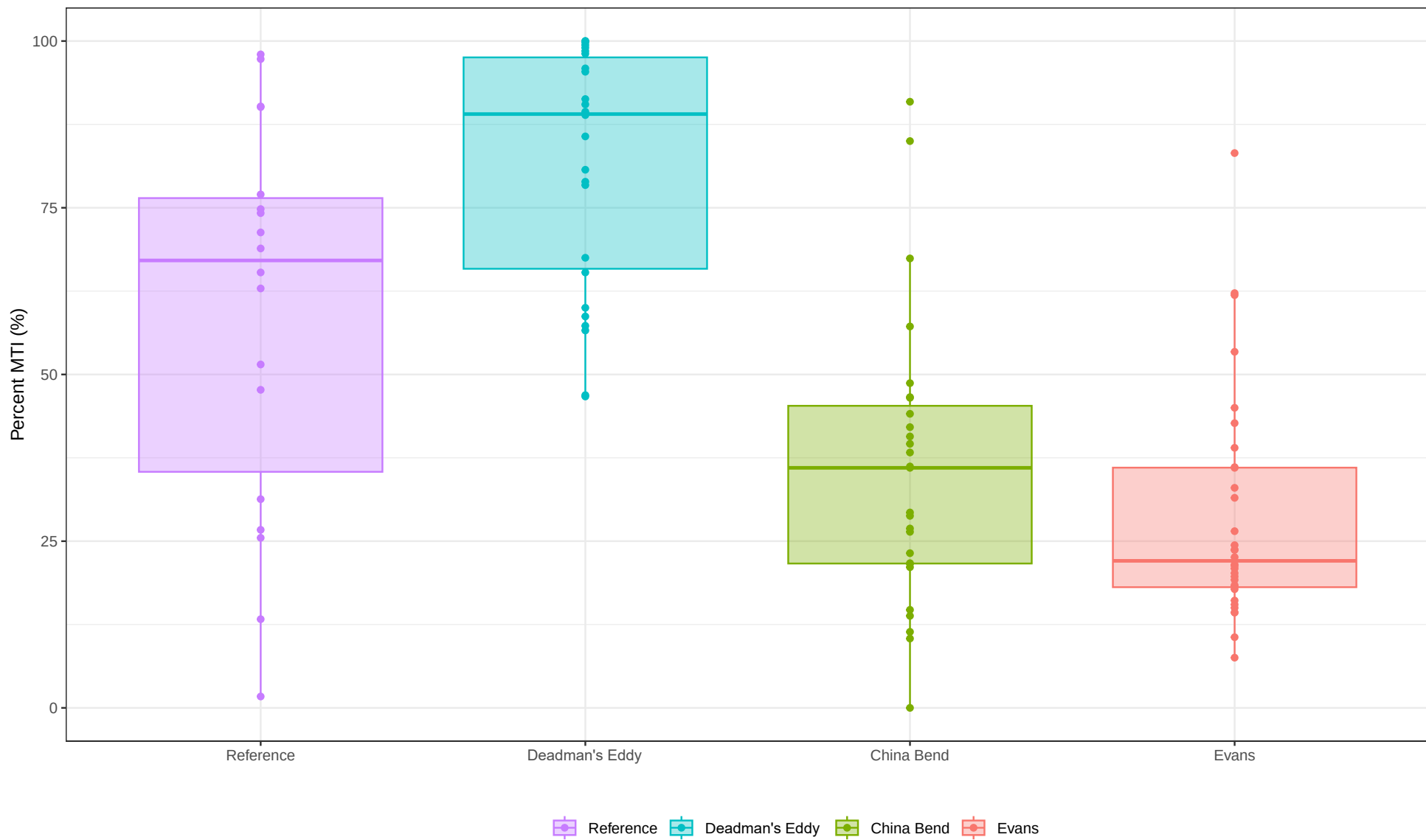


Figure K-1
Percent of Individuals with Metals Tolerance
Values in AOIs and Reference Areas

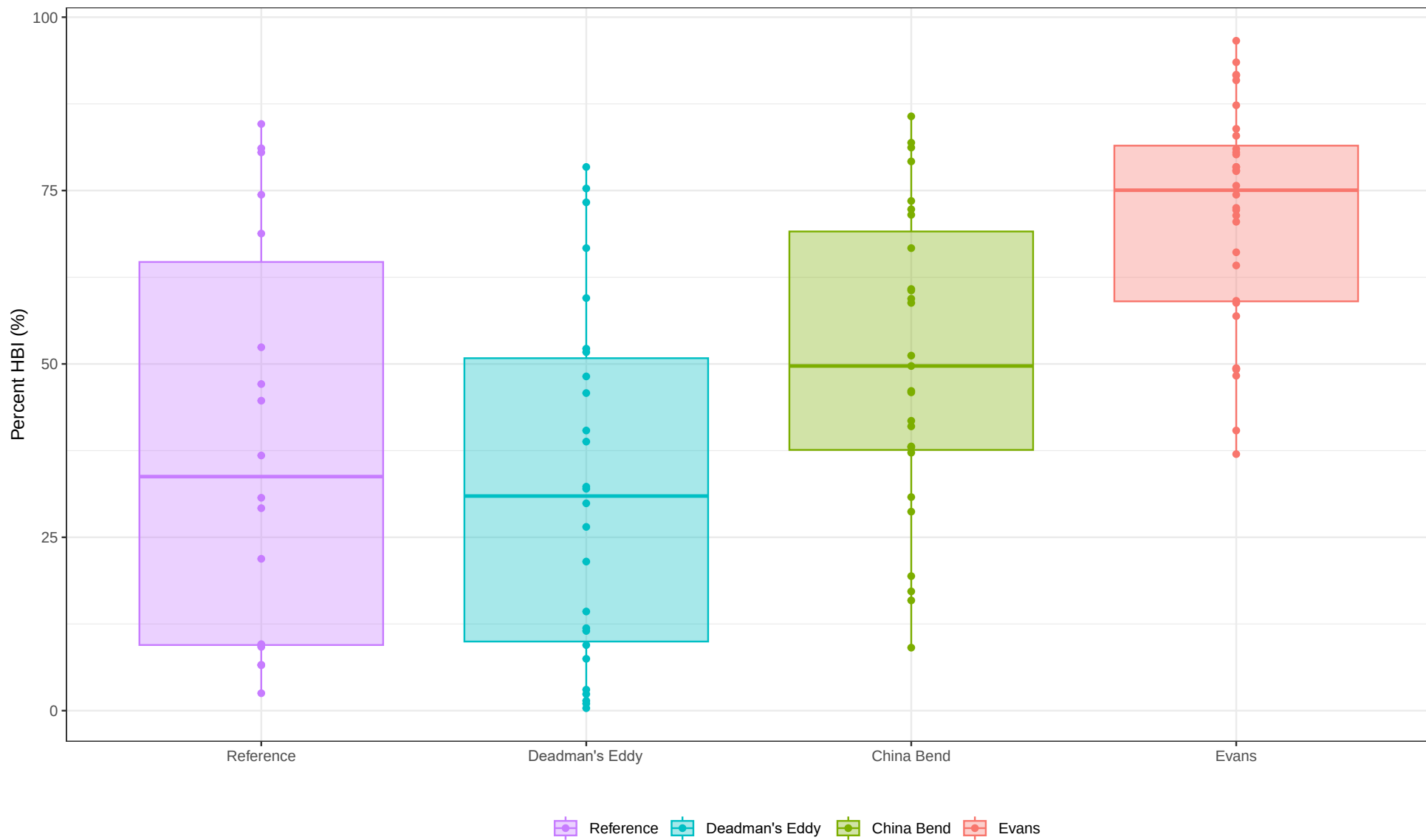


Figure K-2
Percent of Individuals with Hilsenhoff Biotic
Index Values in AOIs and Reference Areas

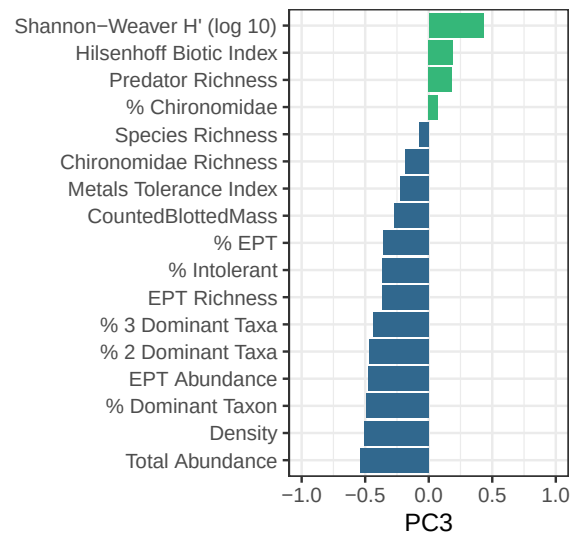
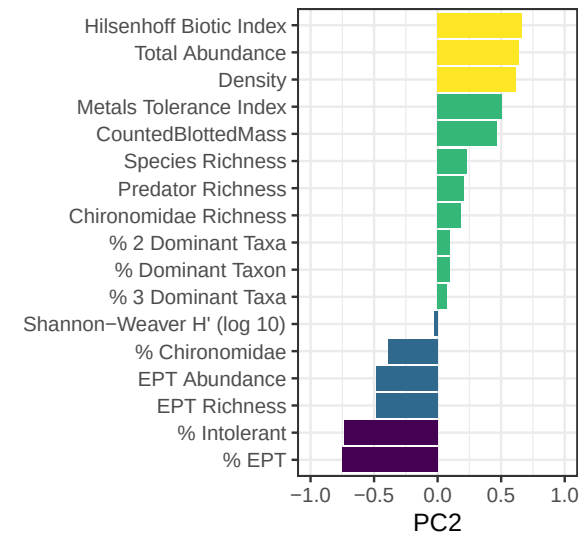
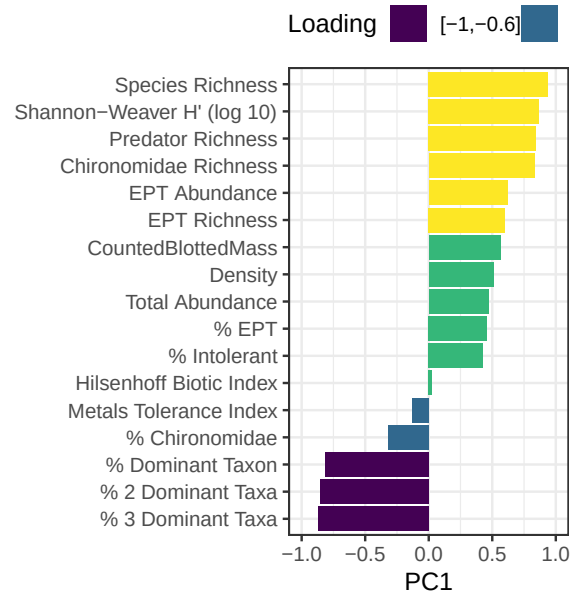
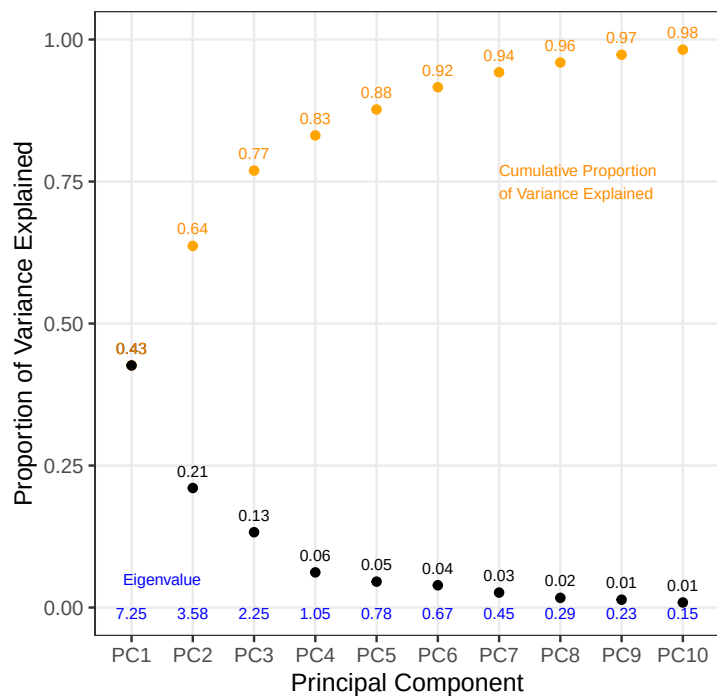


Figure K-3a
PCA Scree and Loadings Plots for Candidate
Benthic Invertebrate Metrics

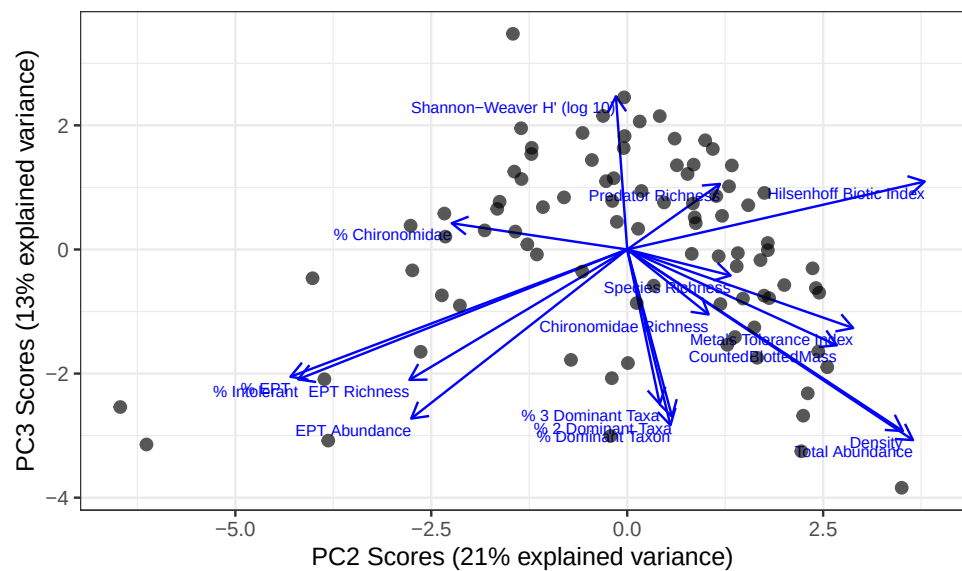
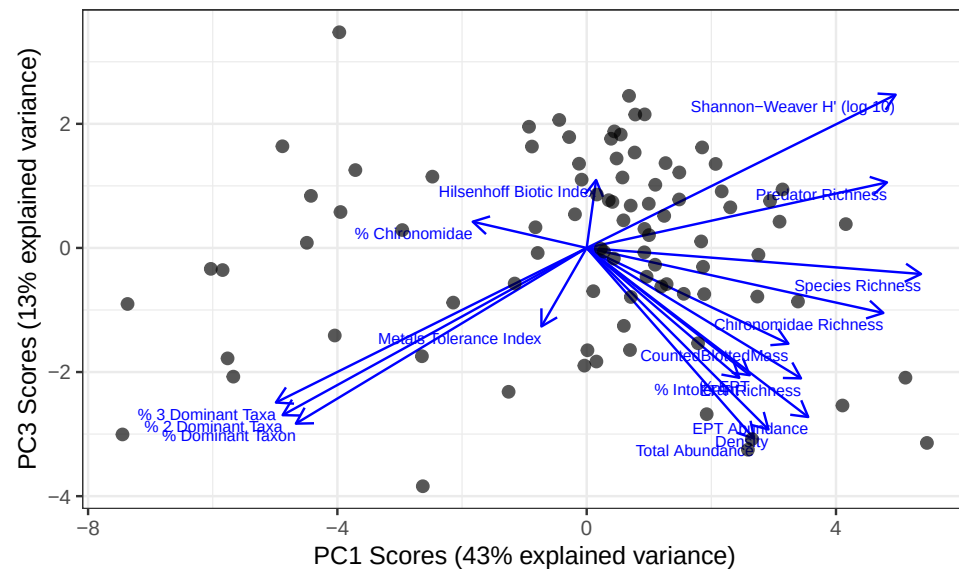
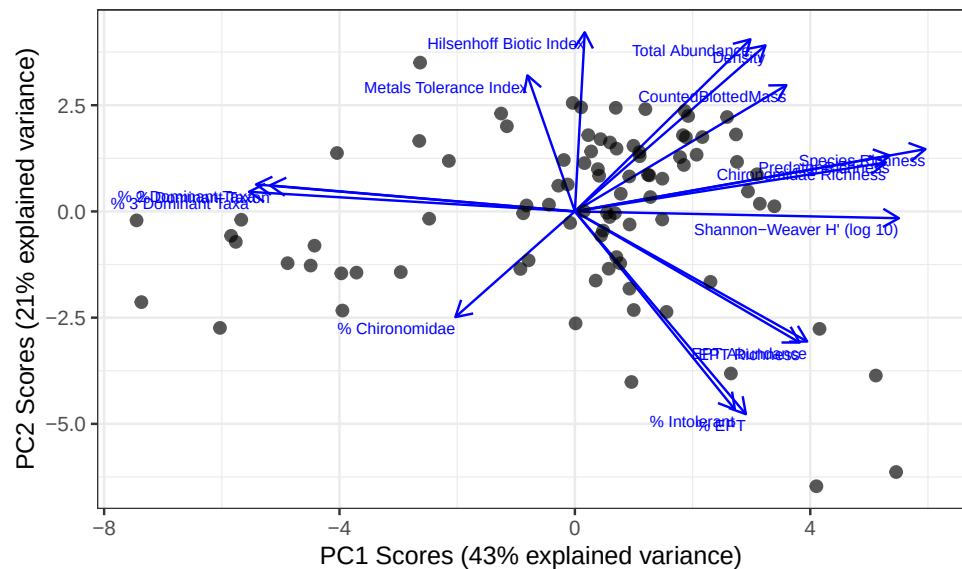


Figure K-3b
PCA Biplots for Candidate Benthic
Invertebrate Metrics

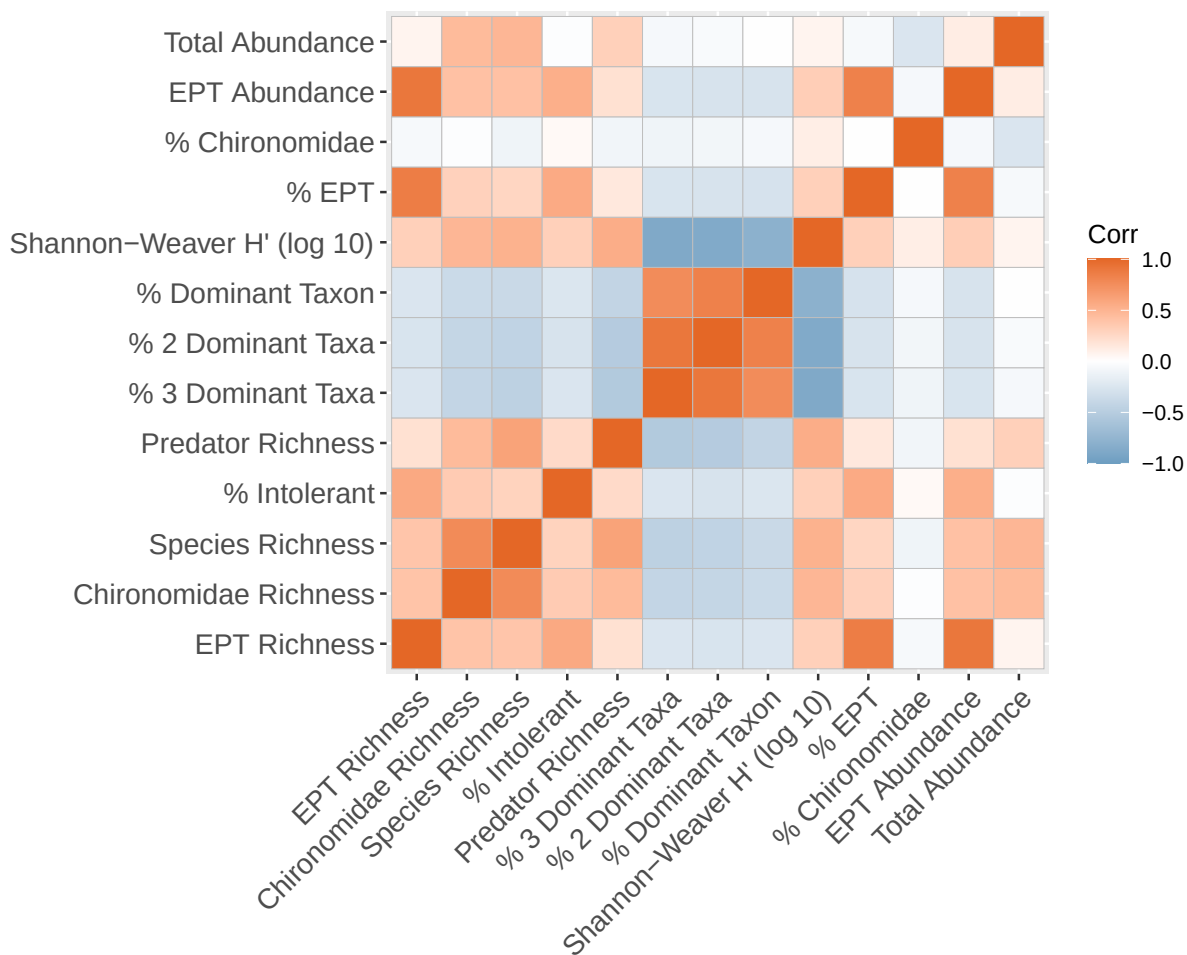
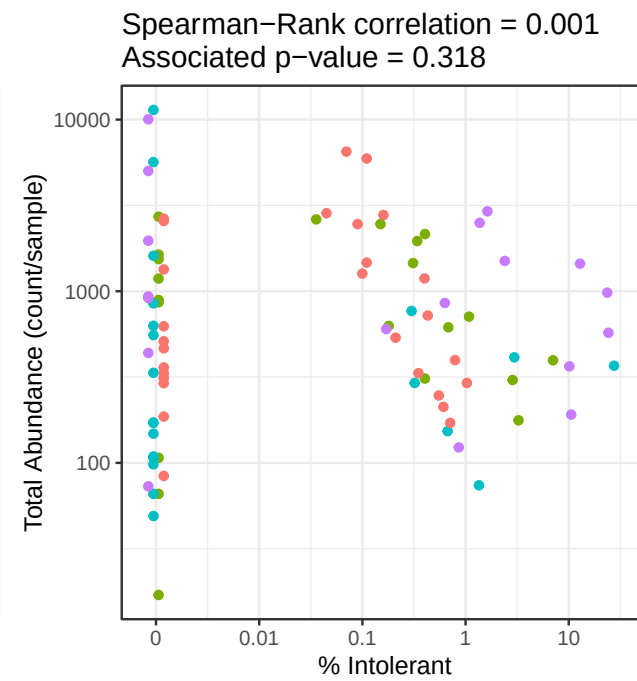
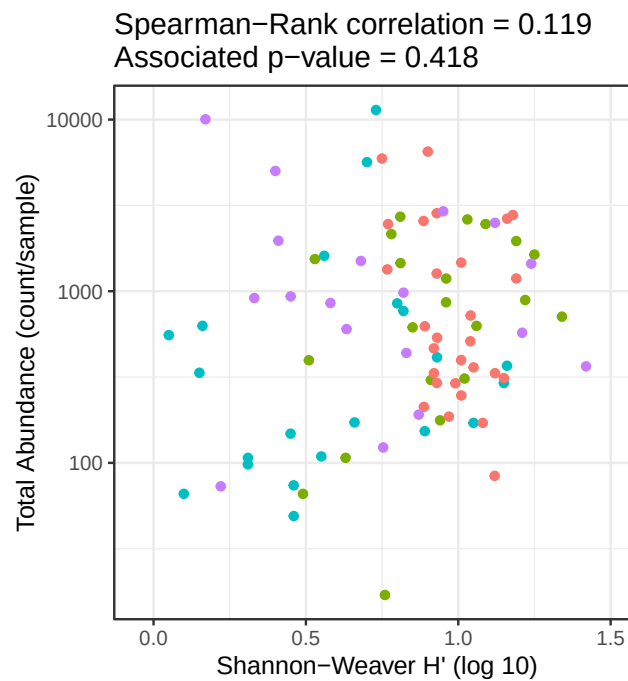
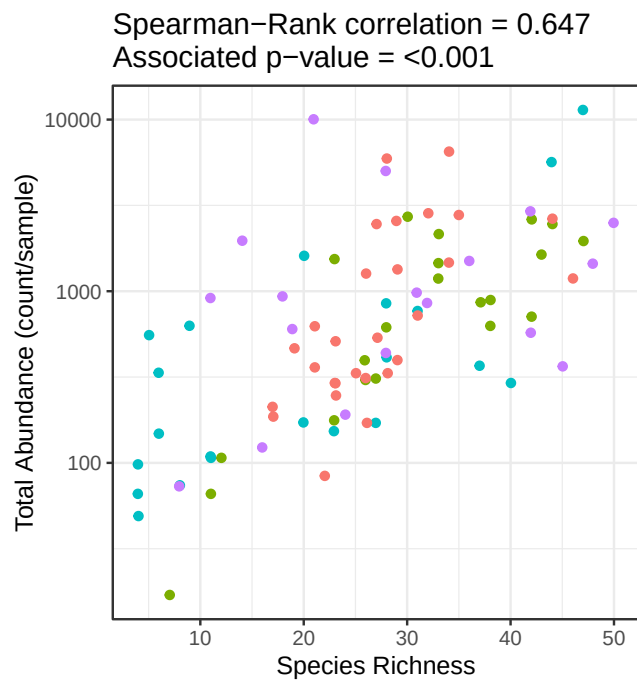


Figure K-4
Correlation Matrix (Kendall's Tau) of
Potential Benthic Invertebrate Metrics



● Reference ● Deadman's Eddy ● China Bend ● Evans

Figure K-5
Scatterplots of Percent Intolerant versus Total Abundance
and Species Richness versus Total Abundance

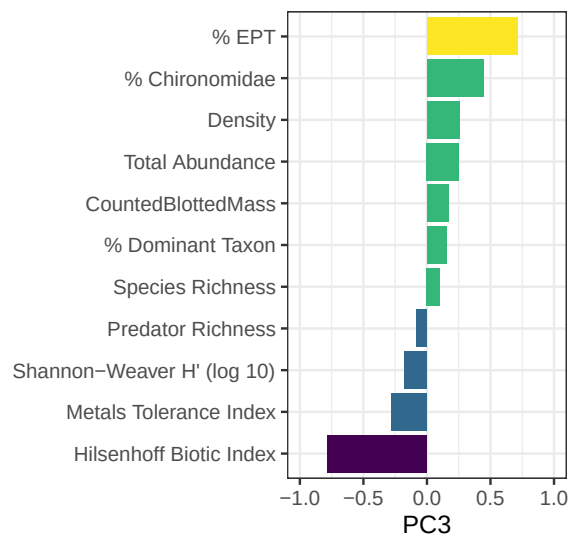
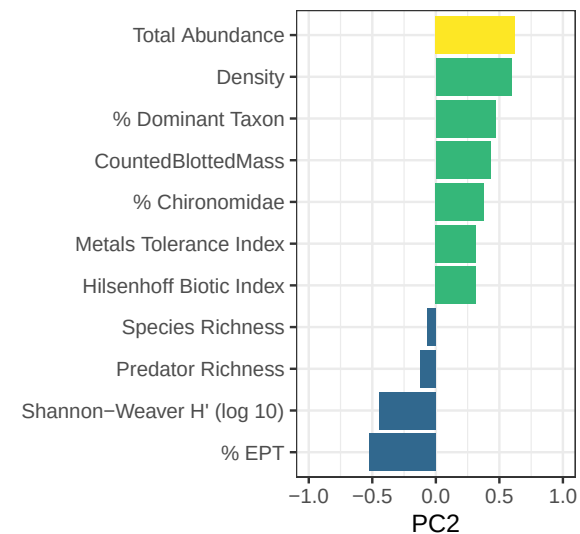
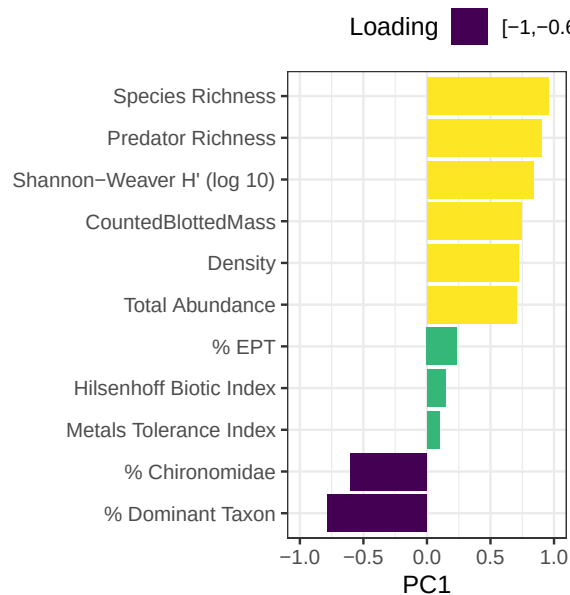
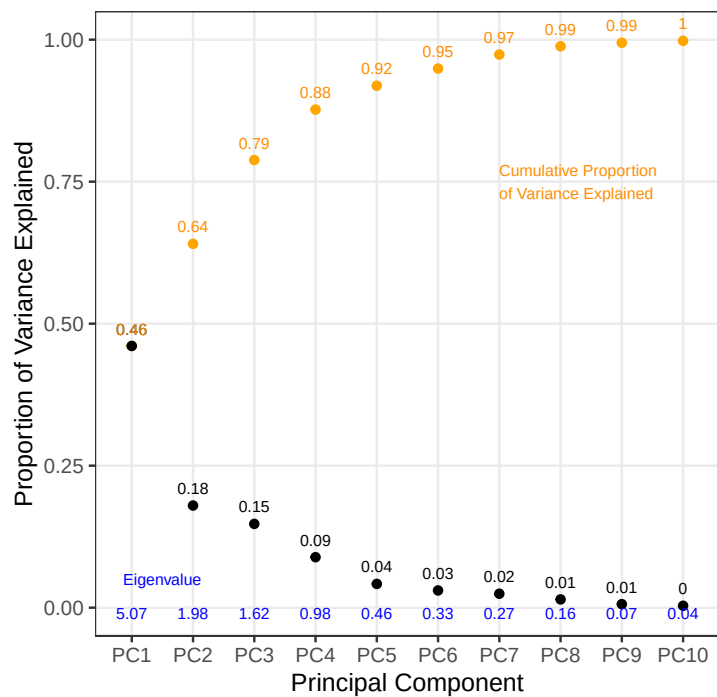


Figure K-6a
PCA Scree and Loadings Plots for Priority Benthic Invertebrate Metrics
from Samples with > 50% Medium, Coarse, and Very Coarse Sand

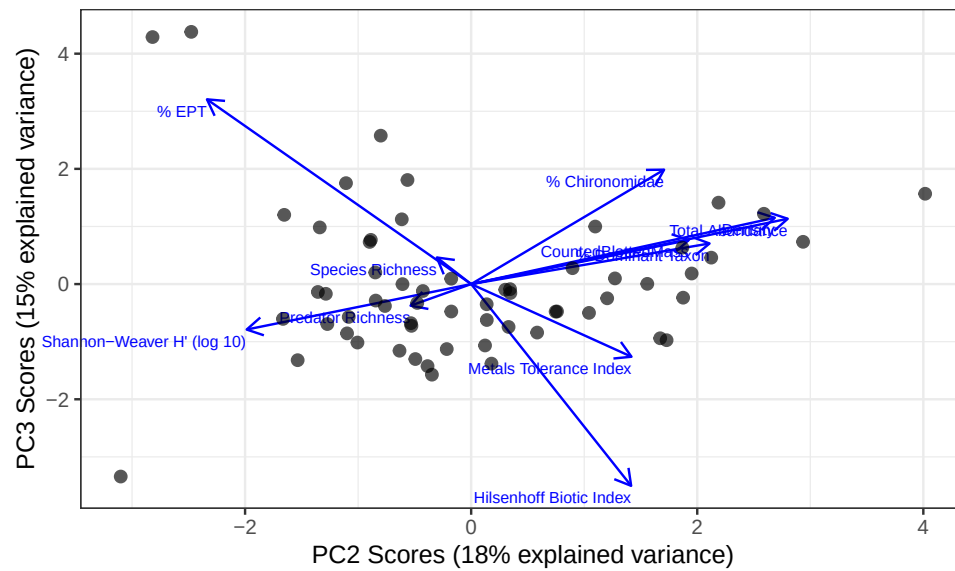
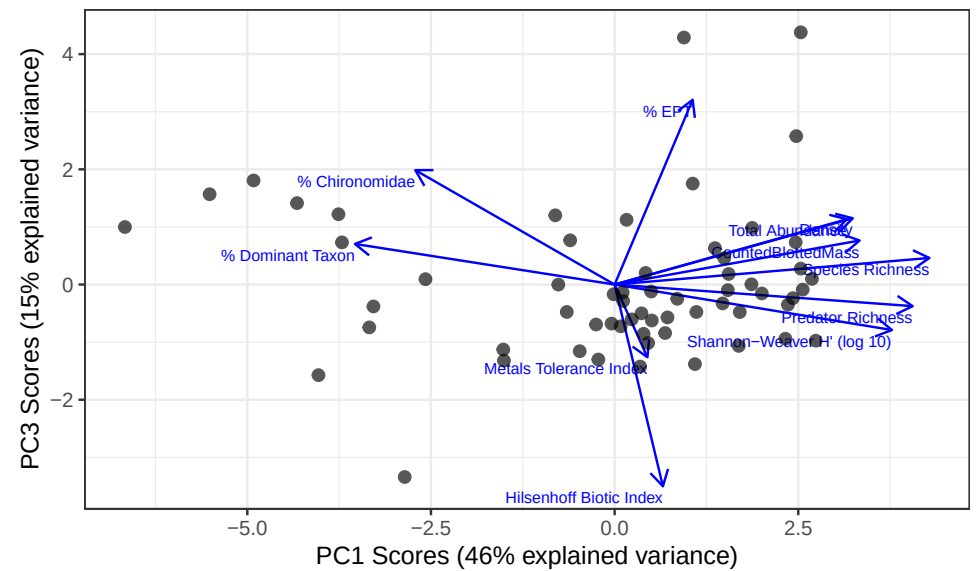
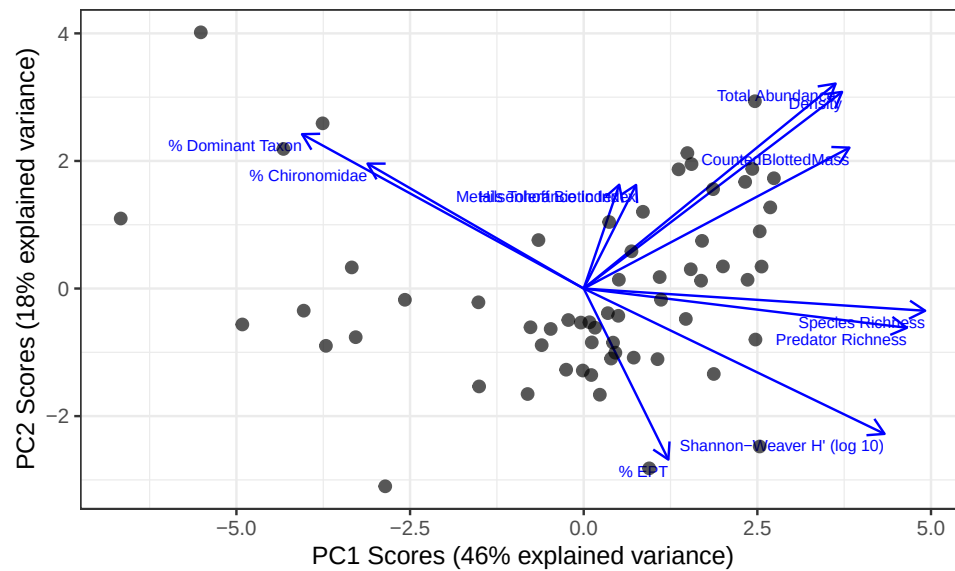


Figure K-6b
PCA Biplots for Priority Benthic Invertebrate Metrics from Samples
with > 50% Medium, Coarse, and Very Coarse Sand

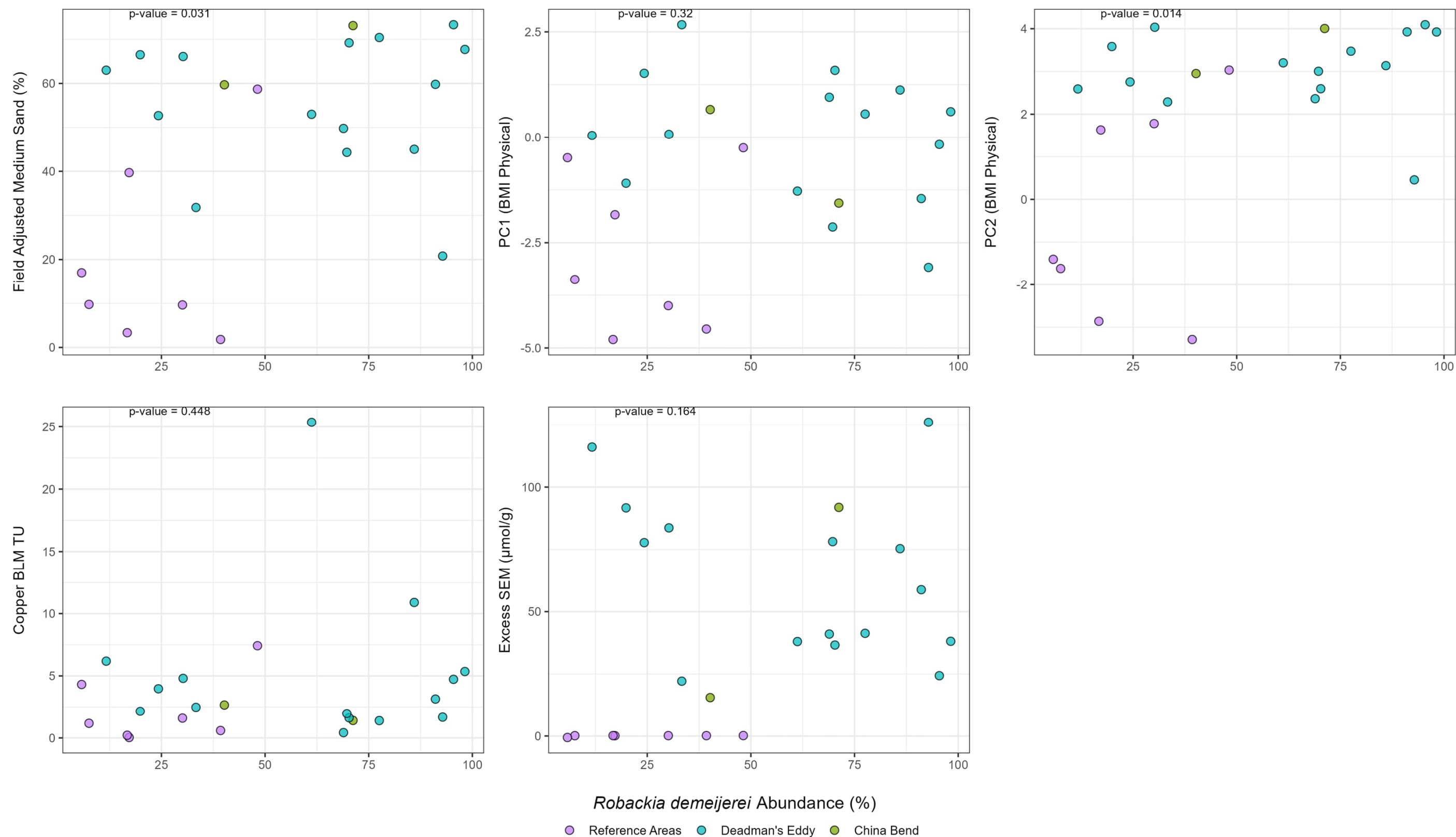


Figure K-7
Differences in Substrate and Metals Exposure in Samples
Dominated by *Robackia demeijerei*



ATTACHMENT K1 SPECIES-SPECIFIC TOLERANCE VALUES
FOR CALCULATING METALS TOLERANCE
INDEX AND HILSENHOFF BIOTIC INDEX

Attachment K1
Species-Specific Tolerance Values for Calculating Metals Tolerance Index and Hilsenhoff Biotic Index
Upper Columbia River
Final Aquatic Baseline Ecological Risk Assessment
Appendix K

Taxon Code	Kingdom	Phylum	Subphylum	Tax Class	Subclass	Infraclass	Superorder	Tax Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Species	Serial	Taxon Name	EA HBI		WA HBI		EA MTI		WA MTI	
																			Value	Reference ^a	Value	Reference ^a	Tolerance Value	Reference	Tolerance Value	Reference ^a
ErpobdellaSp	Animalia	Annelida		Clitellata	Hirudinida	Euhirudinea		Arhyncho bdellida	Erpobdelli formes			Erpobdellidae			<i>Erpobdella</i>	sp.	69444	<i>Erpobdella</i> sp.	NR		NR		NR	Montana DEQ	4	McGuire (1992); Erpobdellidae
HelobElongata	Animalia	Annelida		Clitellata	Hirudinida	Euhirudinea		Rhyncho bdellida				Glossiphoniidae			<i>Helobdella</i>	<i>Helobdella elongata</i>	69397	<i>Helobdella elongata</i>	7		8	Bode et al. (2002)	NR	Montana DEQ	4	McGuire (1992); Glossophoniidae
HelobStagnalis	Animalia	Annelida		Clitellata	Hirudinida	Euhirudinea		Rhyncho bdellida				Glossiphoniidae			<i>Helobdella</i>	<i>Helobdella stagnalis</i>	69398	<i>Helobdella stagnalis</i>	7		8	Bode et al. (2002)	4	Montana DEQ	4	McGuire (1992)
HelobdellaSp	Animalia	Annelida		Clitellata	Hirudinida	Euhirudinea		Rhyncho bdellida				Glossiphoniidae			<i>Helobdella</i>	sp.	69396	<i>Helobdella</i> sp.	NR		6	Barbour et al. (1999)	NR	Montana DEQ	4	McGuire (1992)
TheromyzonSp	Animalia	Annelida		Clitellata	Hirudinida	Euhirudinea		Rhyncho bdellida				Glossiphoniidae			<i>Theromyzon</i>	sp.	69375	<i>Theromyzon</i> sp.	NR		NR		NR	Montana DEQ	NR	
Enchytraeidae	Animalia	Annelida		Clitellata	Oligochaeta			Enchytraeida				Enchytraeidae					68510	<i>Enchytraeidae</i>	10	NYSDEC	10		1	Montana DEQ	1	McGuire (1992)
Lumbriculidae	Animalia	Annelida		Clitellata	Oligochaeta			Lumbriculida				Lumbriculidae					68440	<i>Lumbriculidae</i>	8		5		1	Montana DEQ	1	McGuire (1992)
Lumbricina	Animalia	Annelida		Clitellata	Oligochaeta			Opisthopora	Lumbricina								69069	<i>Lumbricina</i>	8		6		1	Montana DEQ	NR	
AmphiAmericana	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Amphichaeta</i>	<i>Amphichaeta americana</i>	68981	<i>Amphichaeta americana</i>	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
ArcteLomondi	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Arcteonais</i>	<i>Arcteonais lomondi</i>	68976	<i>Arcteonais lomondi</i>	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
AulodAmericanus	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Aulodrilus</i>	<i>Aulodrilus americanus</i>	68683	<i>Aulodrilus americanus</i>	8		7	Bode et al. (2002)	NR	Montana DEQ	5	McGuire (1992); Naididae
AulodLimnobius	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Aulodrilus</i>	<i>Aulodrilus limnobius</i>	68682	<i>Aulodrilus limnobius</i>	8		7	Bode et al. (2002)	NR	Montana DEQ	5	McGuire (1992); Naididae
AulodPigueti	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Aulodrilus</i>	<i>Aulodrilus pigueti</i>	68680	<i>Aulodrilus pigueti</i>	8		7	Bode et al. (2002)	NR	Montana DEQ	5	McGuire (1992); Naididae
AulodPluriseta	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Aulodrilus</i>	<i>Aulodrilus pluriseta</i>	68684	<i>Aulodrilus pluriseta</i>	8		7	Bode et al. (2002)	NR	Montana DEQ	NR	
ChaetDiaphanus	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Chaetogaster</i>	<i>Chaetogaster diaphanus</i>	68935	<i>Chaetogaster diaphanus</i>	6		7	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
ChaetDiastrophus	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Chaetogaster</i>	<i>Chaetogaster diastrophus</i>	68938	<i>Chaetogaster diastrophus</i>	6		7	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
DeroDigitata	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Dero</i>	<i>Dero digitata</i>	68904	<i>Dero digitata</i>	10		10	Bode et al. (1996)	NR	Montana DEQ	NR	
DeroSp	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Dero</i>	sp.	68898	<i>Dero</i> sp.	10		10	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
LimnoHoffmeister	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Limnodrilus</i>	<i>Limnodrilus hoffmeisteri</i>	68639	<i>Limnodrilus hoffmeisteri</i>	10		10	Bode et al. (1996)	NR	Montana DEQ	NR	
NaisBehningi	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Nais</i>	<i>Nais behningi</i>	68949	<i>Nais behningi</i>	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
NaisSp	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Nais</i>	sp.	68946	<i>Nais</i> sp.	8		8	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
PristinaSp	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Pristina</i>	sp.	68876	<i>Pristina</i> sp.	8		8	Bode et al. (1996)	NR	Montana DEQ	NR	
QuistMultisetosu	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Quistadrilus</i>	<i>Quistadrilus multisetosus</i>		<i>Quistadrilus multisetosus</i>	10		10	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
RhyacSodalis	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Rhyacodrilus</i>	<i>Rhyacodrilus sodalis</i>		<i>Rhyacodrilus sodalis</i>	NR		NR	Bode et al. (1996)	NR		5	McGuire (1992); Naididae
RipisParasita	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Ripistes</i>	<i>Ripistes parasita</i>	68964	<i>Ripistes parasita</i>	8		8	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
SlaviAppendicula	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Slavina</i>	<i>Slavina appendiculata</i>	68856	<i>Slavina appendiculata</i>	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
SpecaJosinae	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Specaria</i>	<i>Specaria josinae</i>	68985	<i>Specaria josinae</i>	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
TubiTubifex	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Tubifex</i>	<i>Tubifex tubifex</i>	68623	<i>Tubifex tubifex</i>	10		10	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992); Naididae
UncinUncinata	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Uncinais</i>	<i>Uncinais uncinata</i>	68990	<i>Uncinais uncinata</i>	NR		NR		NR		5	McGuire (1992); Naididae
VejdoComata	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae			<i>Vejdovskyella</i>	<i>Vejdovskyella comata</i>	69010	<i>Vejdovskyella comata tubificoid</i>	4		6	Bode et al. (2002)	NR	Montana DEQ	5	McGuire (1992); Naididae
Naididae-wcap	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae	tubificoid Naididae w/ cap setae				68585	<i>Naididae w/ cap setae tubificoid</i>	10		10	Barbour et al. (1999)	NR	Montana DEQ	5	McGuire (1992); Naididae
Naididae-wocap	Animalia	Annelida		Clitellata	Oligochaeta			Tubificida				Naididae	Naididae w/o cap setae				68585	<i>Naididae w/o cap setae</i>	10		10	Barbour et al. (1999)	NR	Montana DEQ	5	McGuire (1992)
AeolosomaSp	Animalia	Annelida	Ac litellata	Polychaeta				Aeolosomatida				Aeolosomatidae			<i>Aeolosoma</i>	sp.	68424	<i>Aeolosoma</i> sp.	8		8		NR	Montana DEQ	NR	
Acari	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes										733321	<i>Acari</i>	6		NR		5	Montana DEQ	NR	
Oribatei	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes										83544	<i>Oribatei</i>	NR		NR		NR		NR	
ArrenurusSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes	Trombidiformes				Arrenuridae			<i>Arrenurus</i>	sp.	82862	<i>Arrenurus</i> sp.	NR		NR		NR		NR	
Aturidae	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes	Trombidiformes				Aturidae					82973	<i>Aturidae</i>	NR		NR		NR		NR	
FeltriaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes	Trombidiformes				Feltriidae			<i>Feltria</i>	sp.	83314	<i>Feltria</i> sp.	NR	Not found in EA references	NR		NR	unknown	NR	
Halacaridae	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes	Trombidiformes				Halacaridae					82771	<i>Halacaridae</i>	NR		NR		NR		NR	
AttractidesSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acari formes	Trombidiformes				Hygrobatidae			<i>Attractides</i>	sp.	83282	<i>Atractides</i> sp.	NR		6	Bode et al. (1996)	NR		NR	

Attachment K1
Species-Specific Tolerance Values for Calculating Metals Tolerance Index and Hilsenhoff Biotic Index
Upper Columbia River
Final Aquatic Baseline Ecological Risk Assessment
Appendix K

Taxon Code	Kingdom	Phylum	Subphylum	Tax Class	Subclass	Infraclass	Superorder	Tax Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Species	Serial	Taxon Name	EA HBI		WA HBI		EA MTI		WA MTI	
																			Value	Reference ^a	Value	Reference ^a	Tolerance Value	Reference	Tolerance Value	Reference ^a
HygrobatesSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Hygrobatidae			<i>Hygrobates</i>	sp.	83297	<i>Hygrobates</i> sp.	NR		NR		NR		NR	
EstelloxusSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Lebertiidae			<i>Estelloxus</i>	sp.	83048	<i>Estelloxus</i> sp.	NR		NR		NR		NR	
LebertiaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Lebertiidae			<i>Lebertia</i>	sp.	83034	<i>Lebertia</i> sp.	NR		6	Bode et al. (1996)	NR		NR	
LimnesiaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Limnesiidae			<i>Limnesia</i>	sp.	83051	<i>Limnesia</i> sp.	NR		6	Bode et al. (1996)	NR		NR	
MideopsisSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Mideopsidae			<i>Mideopsis</i>	sp.	83479	<i>Mideopsis</i> sp.	NR		6	Bode et al. (1996)	NR		NR	
FrontipodaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Oxidae			<i>Frontipoda</i>	sp.	83240	<i>Frontipoda</i> sp.	NR		NR		NR		NR	
Pionidae	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Pionidae					83330	<i>Pionidae</i>	NR		NR		NR		NR	
ForeliaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Pionidae			<i>Forelia</i>	sp.	83331	<i>Forelia</i> sp.	NR		NR		NR		NR	
SperchonSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Sperchontidae			<i>Sperchon</i>	sp.	83006	<i>Sperchon</i> sp.	NR		6	Bode et al. (1996)	NR		NR	
Torrenticolidae	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Torrenticolidae					83249	<i>Torrenticolidae</i>	NR		NR		NR		NR	
TorrenticolaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Torrenticolidae			<i>Torrenticola</i>	sp.	83254	<i>Torrenticola</i> sp.	NR		NR		NR		NR	
NeumaniaSp	Animalia	Arthropoda	Chelicerata	Arachnida	Acari		Acariformes	Trombidiformes				Unionicolidae			<i>Neumania</i>	sp.	83103	<i>Neumania</i> sp.	NR		NR		NR		NR	
Cladocera	Animalia	Arthropoda	Crustacea	Branchiopoda	Phyllopoda			Diplostraca	Cladocera								83832	<i>Cladocera</i>	8		8	Barbour et al. (1999)	NR	Montana DEQ	NR	
PacifLeniusculus	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Eucarida	Decapoda	Pleocyemata	Astacidea	Astacoidea	Astacidae			<i>Pacifastacus</i>	<i>Pacifastacus leniusculus</i>	97326		6		NR		NR	Montana DEQ	3	McGuire (1992)
Amphipoda	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Peracarida	Amphipoda									93294	<i>Amphipoda</i>	4		4	Barbour et al. (1999)	NR	Montana DEQ	NR	
CrangonyxSp	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Peracarida	Amphipoda	Gammaridea			Crangonyctidae			<i>Crangonyx</i>	sp.	95081	<i>Crangonyx</i> sp.	6		6	Bode et al. (1996)	NR	Montana DEQ	NR	
GammarusSp	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Peracarida	Amphipoda	Gammaridea			Gammaridae			<i>Gammarus</i>	sp.	93773	<i>Gammarus</i> sp.	6		6	Bode et al. (1996)	1	Montana DEQ	1	McGuire (1992)
HyaellaSp	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Peracarida	Amphipoda	Gammaridea			Hyaellidae			<i>Hyaella</i>	sp.	94025					Barbour et al. 1996;				
															<i>Hyaella</i> sp.		8		8		Barbour et al. (1999)	NR	Montana DEQ	3	McGuire (1992)	
CaecidoteaSp	Animalia	Arthropoda	Crustacea	Malacostraca	Eumalacostraca		Peracarida	Isopoda	Asellota		Aselloidea	Asellidae			<i>Caecidotea</i>	sp.	92686	<i>Caecidotea</i> sp.	8		8	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)
Calanoida	Animalia	Arthropoda	Crustacea	Maxillopoda	Copepoda			Calanoida									85258	<i>Calanoida</i>	NR		NR		NR		NR	
Cyclopoida	Animalia	Arthropoda	Crustacea	Maxillopoda	Copepoda			Cyclopoida									88530	<i>Cyclopoida</i>	NR		8	Barbour et al. (1999)	NR	Montana DEQ	NR	
Cyclopidae	Animalia	Arthropoda	Crustacea	Maxillopoda	Copepoda			Cyclopidae				Cyclopidae					88634	<i>Cyclopidae</i>	NR		NR		NR		NR	
Harpacticoida	Animalia	Arthropoda	Crustacea	Maxillopoda	Copepoda			Harpacticoida									86110	<i>Harpacticoida</i>	NR		NR		NR		NR	
Ostracoda	Animalia	Arthropoda	Crustacea	Ostracoda													84195	<i>Ostracoda</i>	8		8	Barbour et al. (1999)	NR	Montana DEQ	NR	
Diptera	Animalia	Arthropoda	Hexapoda	Insecta				Diptera									118831	<i>Diptera</i>	NR		NR		NR	Montana DEQ	NR	
Empididae	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Brachycera			Empididae					135830		6		6	Hauer and Lamberti 1996	4	Montana DEQ	4	McGuire (1992)
HemerodromiaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Brachycera			Empididae			<i>Hemerodromia</i>	sp.	136327	<i>Hemerodromia</i> sp.	6		6	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)
Ceratopogoninae	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Ceratopogonidae	Ceratopogoninae				127338	<i>Ceratopogoninae</i>	6		NR		4	Montana DEQ	4	McGuire (1992)
Chironomini	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini			129229		6		6	Bode et al. (1996)	NR	Montana DEQ	NR	Multiple species, TVs 0-7
ChironomusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Chironomus</i>	sp.	129254	<i>Chironomus</i> sp.	10		10	Bode et al. (1996)	4	Montana DEQ	7	McGuire (1992)
CladopelmaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Cladopelma</i>	sp.	129350	<i>Cladopelma</i> sp.	9		9	Bode et al. (1996)	NR	Montana DEQ	NR	
CryptochironomSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Cryptochironomus</i>	sp.	129368	<i>Cryptochironomus</i> sp.	8		8	Bode et al. (1996)	4	Montana DEQ	5	McGuire (1992)
CryptotendipesSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Cryptotendipes</i>	sp.	129394	<i>Cryptotendipes</i> sp.	6		6	Bode et al. (1996)	NR	Montana DEQ	NR	
DemicryptochirSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Demicryptochironomus</i>	sp.	129421	<i>Demicryptochironomus</i> sp.	8		8	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)
DicrotendipesSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Dicrotendipes</i>	sp.	129428	<i>Dicrotendipes</i> sp.	8		8	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)
HarnischiaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Harnischia</i>	sp.	129516	<i>Harnischia</i> sp.	8		8	Bode et al. (1996)	NR	Montana DEQ	NR	
MicroPedellus	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Microtendipes</i>	<i>Microtendipes pedellus</i> gr.		<i>Microtendipes pedellus</i> gr.	6		6	Bode et al. (1996)	NR	Montana DEQ	4	McGuire (1992); Microtendipes
PagastiellaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Pagastiella</i>	sp.	129561	<i>Pagastiella</i> sp.	NR		7	Bode et al. (1996)	NR	Montana DEQ	NR	
ParachironomusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Parachironomus</i>	sp.	129564	<i>Parachironomus</i> sp.	10		10	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)
ParacladopelmaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Paracladopelma</i>	sp.	129597	<i>Paracladopelma</i> sp.	7		7	Bode et al. (1996)	NR	Montana DEQ	4	McGuire (1992)
ParalNigrohalter	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Paralauterborniella</i>	<i>Paralauterborniella nigrohalteralis</i>	129619	<i>Paralauterborniella nigrohalteralis</i>	8	Bode et al. (1991)	8	Bode et al. (1996)	NR	Montana DEQ	NR	
ParatendipesSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Paratendipes</i>	sp.	129623	<i>Paratendipes</i> sp.	8		6	Bode et al. (1996)	NR	Montana DEQ	NR	
PhaenopsectraSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Phaenopsectra</i>	sp.	129637	<i>Phaenopsectra</i> sp.	7		7	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)
PolypedilumSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Polypedilum</i>	sp.	129657	<i>Polypedilum</i> sp.	6		6	Bode et al. (2002)	4	Montana DEQ	4	McGuire (1992)
RobacDemeijerei	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Robackia</i>	<i>Robackia demeijerei</i>	129733	<i>Robackia demeijerei</i>	4		NR		NR	Montana DEQ	4	McGuire (1992)
StenochironomusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Stenochironomus</i>	sp.	129746	<i>Stenochironomus</i> sp.	5		5	Bode et al. (1996)	NR	Montana DEQ	4	McGuire (1992)
StictochironomSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	<i>Stictochironomus</i>	sp.	129785	<i>Stictochironomus</i> sp.	9</							

Attachment K1
Species-Specific Tolerance Values for Calculating Metals Tolerance Index and Hilsenhoff Biotic Index
Upper Columbia River
Final Aquatic Baseline Ecological Risk Assessment
Appendix K

Taxon Code	Kingdom	Phylum	Subphylum	Tax Class	Subclass	Infraclass	Superorder	Tax Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Species	Serial	Taxon Name	EA HBI		WA HBI		EA MTI		WA MTI		
																			Value	Reference ^a	Value	Reference ^a	Tolerance Value	Reference	Tolerance Value	Reference ^a	
XenocXenolabis	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Chironomini	Xenochironomus	Xenochironomus xenolabis	129838	Xenochironomus xenolabis	0	Bode et al. (1991)	4	Bode et al. (2002)	NR	Montana DEQ	0	McGuire (1992)	
PseudochironomSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Pseudochironomini	Pseudochironomus	sp.	129851	Pseudochironomus sp.	5		5	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)	
Tanytarsini	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini			129872		6		6	Bode et al. (1996)	NR	Montana DEQ	NR	Multiple species, TVs 0-3	
CladotanytarsuSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Cladotanytarsus	sp.	129873	Tanytarsini Cladotanytarsus sp.	7		5	Bode et al. (1996)	3	Montana DEQ	3		McGuire (1992)
ConstempellinaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Constempellina	sp.	129884	Constempellina sp.	6		4	Bode et al. (1996)	NR	Montana DEQ	NR		
MicropsectraSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Micropsectra	sp.	129890	Micropsectra sp.	7		7	Bode et al. (2002)	1	Montana DEQ	1		McGuire (1992)
ParatanytarsusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Paratanytarsus	sp.	129935	Paratanytarsus sp.	6		6	Bode et al. (1996)	2	Montana DEQ	3	McGuire (1992)	
RheotanytarsusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Rheotanytarsus	sp.	129952	Rheotanytarsus sp.	6		6	Bode et al. (1996)	1	Montana DEQ	1	McGuire (1992)	
StempellinaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Stempellina	sp.	129962	Stempellina sp.	2		2	Bode et al. (1996)	0	Montana DEQ	0	McGuire (1992)	
StempellinellaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Stempellinella	sp.	129969	Stempellinella sp.	4		4	Bode et al. (1996)	NR	Montana DEQ	0	McGuire (1992)	
SubletteaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Sublettea	sp.	129975	Sublettea sp.	6		NR		NR	Montana DEQ	0	McGuire (1992)	
TanytarsusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Chironominae	Tanytarsini	Tanytarsus	sp.	129978	Tanytarsus sp.	6		6	Bode et al. (1996)	3	Montana DEQ	3	McGuire (1992)	
PagastiaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Diamesinae	Diamesini	Pagastia	sp.	128401	Pagastia sp.	1		1	Bode et al. (2002)	9	Montana DEQ	9	McGuire (1992)	
PotthGaedii	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Diamesinae	Diamesini	Potthastia	Potthastia gaedii gr.		Potthastia gaedii gr.	2		2	Bode et al. (2002)	5	Montana DEQ	5	McGuire (1992)	
PotthLongimana	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Diamesinae	Diamesini	Potthastia	Potthastia longimana gr.		Potthastia longimana gr.	2		2	Bode et al. (2002)	5	Montana DEQ	NR		
ProtanypusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Diamesinae	Protanypodini	Protanypus	sp.	128431	Protanypus sp.	NR		NR		NR	Montana DEQ	NR		
Orthoclaadiinae	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae				128457	Orthoclaadiinae	6		5	Bode et al. (2002)	NR	Montana DEQ	NR	Multiple species, TVs 1-10	
BrilliaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Brillia	sp.	128477	Brillia sp.	5		5	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)	
CorynoneuraSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Corynoneura	sp.	128563	Corynoneura sp.	4		4	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)	
CricoNostocicola	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Cricotopus	Cricotopus (Nostococladius) nostocicola	128575	Cricotopus (Nostococladius) nostocicola	7		7	Bode et al. (2002)	5	Montana DEQ	10	McGuire (1992)	
CricotopusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Cricotopus	sp.	128575	Cricotopus sp.	7		7	Bode et al. (2002)	9	Montana DEQ	10	McGuire (1992)	
CricotopusOrthSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Cricotopus/Orthocladius	sp.		Cricotopus sp. Cricotopus/Orthocladius sp.	NR		NR		NR		10	McGuire (1992); Cricotopus	
EukieClaripennis	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Eukiefferiella	Eukiefferiella claripennis gr.		Eukiefferiella claripennis gr.	8		8	Bode et al. (1996)	NR	Montana DEQ	9	McGuire (1992)	
EukiefferiellaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Eukiefferiella	sp.	128689	Eukiefferiella sp.	4		NR		9	Montana DEQ	9	McGuire (1992)	
HeterMarcidus	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Heterotrissocladius	Heterotrissocladius marcidus gr.		Heterotrissocladius marcidus gr.	4		4	Bode et al. (1996)	NR	Montana DEQ	NR		
HydrosmittiaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Hydrosmittia	sp.		Hydrosmittia sp.	NR		NR		NR		NR		
NanocladiusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Nanocladius	sp.	128844	Nanocladius sp.	3		3	Bode et al. (2002)	4	Montana DEQ	4	McGuire (1992)	
OrthocladiusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Orthocladius	sp.	128874	Orthocladius sp.	6		6	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)	
OrthoEuorthoSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Orthocladius	sp.	568520	Orthocladius (Euorthocladius) sp.	6		6	Bode et al. (1996)	NR	Montana DEQ	5	McGuire (1992)	
ParacladiusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Paracladius	sp.	128956	Paracladius sp.	8		NR		NR	Montana DEQ	NR		
ParakiefferielSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Parakiefferiella	sp.	128968	Parakiefferiella sp.	6		4	Bode et al. (1996)	NR	Montana DEQ	NR		
PsectrocladiusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Psectrocladius	sp.	129018	Psectrocladius sp.	9		8	Bode et al. (1996)	NR	Montana DEQ	NR		
RheocricotopusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Rheocricotopus	sp.	129086	Rheocricotopus sp.	4		6	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)	
SynorthocladiuSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Synorthocladius	sp.	129161	Synorthocladius sp.	2		6	Bode et al. (1996)	1	Montana DEQ	1	McGuire (1992)	
ThienemanniellSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Thienemanniella	sp.	129182	Thienemanniella sp.	6		6	Bode et al. (1996)	4	Montana DEQ	4	McGuire (1992)	
TveteDiscoloripe	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Orthoclaadiinae		Tvetenia	Tvetenia discoloripes gr.		Tvetenia discoloripes gr.	5		5	Bode et al. (2002)	4	Montana DEQ	4	McGuire (1992)	
MonodiamesaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Prodiamesinae		Monodiamesa	sp.	128440	Monodiamesa sp.	7		7	Bode et al. (2002)	5	Montana DEQ	5	McGuire (1992)	
Tanypodinae	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae				127994		7		7	Bode et al. (1996)	NR	Montana DEQ	NR	Multiple species, TVs 2-8	
Pentaneurini	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae	Pentaneurini			128078	Tanypodinae Pentaneurini	6		NR		NR	Montana DEQ	2	McGuire (1992)	
AblabesmyiaSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae	Pentaneurini	Ablabesmyia	sp.	128079	Ablabesmyia sp.	8		8	Bode et al. (1996)	3	Montana DEQ	3	McGuire (1992)	
PentaneuraSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae	Pentaneurini	Pentaneura	sp.	128215	Pentaneura sp.	6		6	Bode et al. (1996)	2	Montana DEQ	2	McGuire (1992)	
ThienemannimySp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae	Pentaneurini	Thienemannimyia gr.	sp.		Thienemannimyia gr. sp.	5		6	Bode et al. (1996)	3	Montana DEQ	3	McGuire (1992)	
ProcladiusSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Chironomidae	Tanypodinae	Procladiini	Procladius	sp.	128277	Procladius sp.	9		9	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)	
Simuliidae	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Simuliidae					126640	Simuliidae	6		6	Hauer and Lamberti (1996)	4	Montana DEQ	NR	Multiple species, TVs 5-7	

Attachment K1
Species-Specific Tolerance Values for Calculating Metals Tolerance Index and Hilsenhoff Biotic Index
Upper Columbia River
Final Aquatic Baseline Ecological Risk Assessment
Appendix K

Taxon Code	Kingdom	Phylum	Subphylum	Tax Class	Subclass	Infraclass	Superorder	Tax Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Species	Serial	Taxon Name	EA HBI		WA HBI		EA MTI		WA MTI	
																			Value	Reference ^a	Value	Reference ^a	Tolerance Value	Reference	Tolerance Value	Reference ^a
SimuliumSp	Animalia	Arthropoda	Hexapoda	Insecta				Diptera	Nematocera			Simuliidae			Simulium	sp.	126774	Simulium sp.	5		5	Bode et al. (1996) Hauer and Lambert 1996;	5	Montana DEQ	6	McGuire (1992)
Baetidae	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Baetidae					100755				Barbour et al. (1999)	NR	Montana DEQ	NR	Multiple species, TVs 1-5	
BaetiTricaudatus	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Baetidae	Baetis tricaudatus		Baetis		100817	Baetis tricaudatus	4		6	Bode et al. (1996) Bode et al. (1996);	5	Montana DEQ	5	McGuire (1992)
BaetisSp	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Baetidae			Baetis	sp.	100800				6	Barbour et al. (1999) Bode et al. (1996)	4	Montana DEQ	NR	Multiple species, TVs 4-5
CaeniLatipennis	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Caenidae	Caenis latipennis		Caenis		101488	Caenis latipennis	NR		6	Bode et al. (1996)	NR	Montana DEQ	3	McGuire (1992)
CaenisSp	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Caenidae	Caenis sp.		Caenis		101478	Caenis sp.	7		7	Barbour et al. (1999) Hauer and Lambert 1996)	3	Montana DEQ	3	McGuire (1992)
Ephemerellidae	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Ephemerellidae					101232	Ephemerellidae	1		1		NR	Montana DEQ	NR	Multiple species, TVs 0-3
DruneGrandis	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Ephemerellidae	Drunella grandis		Drunella		101370	Drunella grandis	2		NR		1	Montana DEQ	1	McGuire (1992)
EphemerellaSp	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Ephemerellidae	Ephemerella sp.		Ephemerella		101233	Ephemerella sp.	1		1	Bode et al. (1996)	NR	Montana DEQ	3	McGuire (1992)
RhithrogenaSp	Animalia	Arthropoda	Hexapoda	Insecta				Ephemeroptera				Heptageniidae	Rhithrogena sp.		Rhithrogena		100572	Rhithrogena sp.	0		0	Bode et al. (1996) Hauer and Lambert 1996)	2	Montana DEQ	2	McGuire (1992)
Gomphidae	Animalia	Arthropoda	Hexapoda	Insecta				Odonata	Anisoptera			Gomphidae					101664	Gomphidae	1		1	Bode et al. (1996)	NR	Montana DEQ	4	McGuire (1992)
HaliplusSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Coleoptera	Adephaga			Haliplidae	Haliplus sp.		Haliplus		111858	Haliplus sp.	8		5	Bode et al. (1996)	NR	Montana DEQ	NR	
ZaitzeviaSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Coleoptera	Polyphaga			Elmidae	Zaitzevia sp.		Zaitzevia		114205	Zaitzevia sp.	5		NR		NR	Montana DEQ	3	McGuire (1992)
Plecoptera	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Plecoptera									102467	Plecoptera	NR		NR		NR	Montana DEQ	NR	Multiple species, TVs 0-4
Chloroperlidae	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Plecoptera				Chloroperlidae					103202	Chloroperlidae	1		1	Hauer and Lambert 1996)	NR	Montana DEQ	2	McGuire (1992)
Trichoptera	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera									115095	Trichoptera	NR		NR		NR	Montana DEQ	NR	Multiple species, TVs 1-6
ApataniaSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Apataniidae	Apatania sp.		Apatania		115935	Apatania sp.	1		3	Bode et al. (2002)	2	Montana DEQ	NR	
AmiocAspilus	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Brachycentridae	Amiocentrus aspilus		Amiocentrus		116934	Amiocentrus aspilus	2		NR		NR	Montana DEQ	1	McGuire (1992)
BrachOccidentali	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Brachycentridae	Brachycentrus occidentalis		Brachycentrus		116918	Brachycentrus occidentalis	2		NR		3	Montana DEQ	3	McGuire (1992)
Glossosomatidae	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Glossosomatidae					117120	Glossosomatidae	0		0	Hauer and Lambert 1996)	2	Montana DEQ	2	McGuire (1992)
GlossosomaSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Glossosomatidae	Glossosoma sp.		Glossosoma		117159	Glossosoma sp.	0		0	Bode et al. (1996)	2	Montana DEQ	2	McGuire (1992)
ProtoptilaSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Glossosomatidae	Protoptila sp.		Protoptila		115221	Protoptila sp.	1		1	Bode et al. (1996)	2	Montana DEQ	2	McGuire (1992)
CheumatopsycheSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Hydropsychidae	Hydropsychinae		Cheumatopsyche sp.		115408	Cheumatopsyche sp.	5		5	Bode et al. (1996)	5	Montana DEQ	5	McGuire (1992)
HydropsycheSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Hydropsychidae	Hydropsychinae		Hydropsyche sp.		115453	Hydropsyche sp.	5		4	Bode et al. (1996) Hauer and Lambert 1996)	5	Montana DEQ	5	McGuire (1992)
Leptoceridae	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Leptoceridae					116547	Leptoceridae	4		4	Bode et al. (1996)	NR	Montana DEQ	NR	
CeracleaSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Leptoceridae	Ceraclea sp.		Ceraclea		116684	Ceraclea sp.	8		3	Bode et al. (1996)	1	Montana DEQ	1	McGuire (1992)
MystaAlafimbriat	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Leptoceridae	Mystacides alafimbriata		Mystacides		116603	Mystacides alafimbriata	4		4	Bode et al. (1996)	NR	Montana DEQ	NR	
MystacidesSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Leptoceridae	Mystacides sp.		Mystacides		116598	Mystacides sp.	4		4	Bode et al. (1996)	3	Montana DEQ	NR	
OecetisSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Leptoceridae	Oecetis sp.		Oecetis		116607	Oecetis sp.	8		5	Bode et al. (1996) Hauer and Lambert 1996)	3	Montana DEQ	3	McGuire (1992); Oecetis avara gr.
Polycentropodida	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera		Trichoptera				Polycentropodidae					117043	Polycentropodidae	6		6	Bode et al. (1996) Bode et al. (1996);	NR	Montana DEQ	1	McGuire (1992)
SialisSp	Animalia	Arthropoda	Hexapoda	Insecta	Pterygota	Neoptera	Neuropterida	Megaloptera				Sialidae	Sialis sp.		Sialis		115002					4	Montana DEQ	4	McGuire (1992)	
HydraSp	Animalia	Cnidaria		Hydrozoa				Anthoathecatae				Hydriidae	Hydra sp.		Hydra		50845	Hydra sp.	5		5	Bode et al. (1996)	3	Montana DEQ	3	McGuire (1992)
Unionacea	Animalia	Mollusca		Bivalvia				Schizodonta			Unionacea						566875	Unionacea	NR		NR		NR	Montana DEQ	NR	
Corbiculoidea	Animalia	Mollusca		Bivalvia	Heterodonta			Veneroida			Corbiculoidea						81385	Corbiculoidea	NR		NR		NR	Montana DEQ	NR	
CorbiculaSp	Animalia	Mollusca		Bivalvia	Heterodonta			Veneroida			Corbiculoidea	Corbiculidae	Corbicula sp.		Corbicula			Corbicula sp.	NR		NR		NR	Montana DEQ	NR	
Sphaeriidae	Animalia	Mollusca		Bivalvia	Heterodonta			Veneroida			Corbiculoidea	Sphaeriidae					81390	Sphaeriidae	6		8	Barbour et al. (1999)	3	Montana DEQ	3	McGuire (1992)
MusculiumSp	Animalia	Mollusca		Bivalvia	Heterodonta			Veneroida			Corbiculoidea	Sphaeriidae			Musculium		81427	Musculium sp.	4		6	Bode et al. (1996)	NR	Montana DEQ	NR	
PisidiumSp	Animalia	Mollusca		Bivalvia	Heterodonta			Veneroida			Corbiculoidea	Sphaeriidae			Pisidium		81400	Pisidium sp.	6		6	Bode et al. (1996)	NR	Montana DEQ	3	McGuire (1992)
AnodontaSp	Animalia	Mollusca		Bivalvia	Palaeoheterodonta			Unionoida				Unionidae	Anodonta sp.		Anodonta		79930	Anodonta sp.	6		6	Bode et al. (1996)	NR	Montana DEQ	NR	
Gastropoda	Animalia	Mollusca		Gastropoda													69459	Gastropoda	7	2010 R.Biggam Uofl	7	Barbour et al. (1999)	NR	Montana DEQ	NR	Multiple species, TVs 1-4
FluminicolaSp	Animalia	Mollusca		Gastropoda	Caenogastropoda			Littoridinomorpha			Truncatelloidea	Lithoglyphidae	Fluminicola sp.		Fluminicola		70778	Fluminicola sp.	5		NR		NR	Montana DEQ	NR	

Attachment K1
Species-Specific Tolerance Values for Calculating Metals Tolerance Index and Hilsenhoff Biotic Index
Upper Columbia River
Final Aquatic Baseline Ecological Risk Assessment
Appendix K

Taxon Code	Kingdom	Phylum	Subphylum	Tax Class	Subclass	Infraclass	Superorder	Tax Order	Suborder	Infraorder	Superfamily	Family	Subfamily	Tribe	Genus	Species	Serial	Taxon Name	EA HBI		WA HBI		EA MTI		WA MTI	
																			Value	Reference ^a	Value	Reference ^a	Tolerance Value	Reference	Tolerance Value	Reference ^a
Lymnaeidae	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Lymneioidea	Lymnaeidae					76483	Lymnaeidae	6		6	Barbour et al. (1999)	3	Montana DEQ	NR	Multiple species, TVs 1,3
GalbaSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Lymneioidea	Lymnaeidae			Galba	sp.		Galba sp.	6		6	Barbour et al. (1999)	3	Montana DEQ	NR	
StagnicolaSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Lymneioidea	Lymnaeidae			Stagnicola	sp.	76534	Stagnicola sp.	6		6	Bode et al. (1996)	3	Montana DEQ	3	
PhysaSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Lymneioidea	Physidae			Physa	sp.	76677	Physa sp.	8		8	Barbour et al. (1999)	NR	Montana DEQ	NR	McGuire (1992)
PhysellaSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Lymneioidea	Physidae			Physella	sp.	76698	Physella sp.	NR		8	Bode et al. (1996)	NR		4	
Planorbidae	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Planorboidea	Planorbidae					76591	Planorbidae	6		7	Barbour et al. (1999)	3	Montana DEQ	3	
GyraulusSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Planorboidea	Planorbidae			Gyraulus	sp.	76592	Gyraulus sp.	8		8	Bode et al. (1996)	3	Montana DEQ	3	McGuire (1992)
HelisAnceps	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Planorboidea	Planorbidae			Helisoma	Helisoma anceps	76600	Helisoma anceps	NR		6	Bode et al. (1996)	NR	Montana DEQ	3	McGuire (1992)
MenetOpercularis	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Planorboidea	Planorbidae			Menetus	Menetus opercularis	76628	Menetus opercularis	6		NR		NR		NR	
ValvataSp	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Valvatoidea	Valvatidae			Valvata	sp.	70346	Valvata sp.	8		8	Bode et al. (1996)	1	Montana DEQ	1	McGuire (1992)
ValvaHumeralis	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Valvatoidea	Valvatidae			Valvata	Valvata humeralis	70358	Valvata humeralis	NR		NR		NR		1	McGuire (1992)
ValvaTricarinata	Animalia	Mollusca		Gastropoda	Heterobranchia			Hygrophila			Valvatoidea	Valvatidae			Valvata	Valvata tricarinata	70354	Valvata tricarinata	NR		8	Bode et al. (1996)	NR	Montana DEQ	NR	McGuire (1992)
Nematoda	Animalia	Nematoda														59490	Nematoda	5		NR		5	Montana DEQ	5		
ProstomaSp	Animalia	Nemertea		Enopla				Hoplonemertea	Monostilifera			Tetrastemmatidae			Prostoma	sp.	57577	Prostoma sp.	8	Bode et al. (1991)	8	Bode et al. (1996)	NR	Montana DEQ	NR	
Turbellaria	Animalia	Platyhelminthes		Turbellaria													53964	Turbellaria	4		4	Barbour et al. (1999)	4	Montana DEQ	5	McGuire (1992)
Tardigrada	Animalia	Tardigrada															155166	Tardigrada	NR		NR		NR		NR	

Notes:
^a References as cited in Ecology (2021). Full reference information for Ecology (2021) is included in Appendix K main text.
DEQ = Department of Environmental Quality
EA = EcoAnalysts
HBI = Hilsenhoff Biotic Index
MTI = Metals Tolerance Index
NR = None reported
NYSDEC = New York State Department of Environmental Conservation
WA = Washington State



ATTACHMENT K2 CORRELATION ANALYSES AND WEIGHT OF
EVIDENCE SCORING TABLES FOR IN SITU
COMMUNITY METRICS AND
CONCENTRATIONS OF INDIVIDUAL
METALS IN SEDIMENT AND POREWATER
ON THE PHASE 3 SEDIMENT STUDY



Appendix K, Attachment K2: Assessment of COI Correlations with In Situ Benthic Invertebrate Community Metrics

Final Aquatic Baseline Ecological Risk
Assessment—Upper Columbia River

PREPARED FOR
Teck American Incorporated

DATE
July 2026

REFERENCE
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ACRONYMS AND ABBREVIATIONS

Acronym	Description
µg/L	microgram(s) per liter
BERA	baseline ecological risk assessment
COI	chemical of interest
COPC	chemical of potential concern
CS50	medium, coarse, and very coarse sand > 50 percent of substrate
EPT	Ephemeroptera, Plecoptera, and Trichoptera
g	gram(s)
HBI	Hilsenhoff Biotic Index
HQ	hazard quotient
LOE	line of evidence
LOESS	locally estimated scatterplot smoothing
log10	base 10 logarithm
m ²	meter(s) squared
mg/kg	milligram(s) per kilogram
MTI	Metals Tolerance Index
OU	operable unit
PC	principal component
TU	toxic unit
UCR	Upper Columbia River

1. OVERVIEW

This attachment summarizes the results from the correlation analyses of individual metal chemicals of potential concern (COPCs) and chemicals of interest (COIs) and benthic invertebrate community metrics from the Final 2019 Phase 3 Sediment Study Data Summary Report (Phase 3; TAI 2022) in Operable Unit 1 (OU 1) of the Upper Columbia River (UCR) Site. As discussed in Volumes 1 (Section 4.2.3) and 2 (Section 4.1.5) of the Aquatic Baseline Ecological Risk Assessment (BERA), due to the high correlation among individual metals concentrations in OU 1, the primary analysis for the integrative lines of evidence (LOEs) in the main body of the Aquatic BERA for the UCR Site focus on multiple metal sediment metrics and bioavailability-adjusted porewater exposure metrics. This attachment, therefore, presents the raw results for the rank correlations of concentrations of individual metals in sediment and porewater with in situ benthic invertebrate community metrics as part of LOE 5 for the assessment of risks to benthic invertebrate communities in OU 1.

2. LINE OF EVIDENCE ESTIMATION

LOE estimation analyses for LOE 5 include assessment of rank correlations between exposure to metals in sediment and porewater and the in situ benthic invertebrate community metrics developed in this attachment (Section 2). As discussed in Volumes 1 and 2 of the Aquatic BERA, these analyses are presented separately depending on the physical characteristics of the sediment substrate. Samples that are more than 50 percent medium, coarse, and very coarse sand (or CS50) are evaluated separately from samples where that is not true (i.e., non-CS50).

The rank correlation results for CS50 substrate are presented in Table K2-1 and Figures K2-1 and K2-3, and scatterplots for each pair of COPC and community metrics are presented in Figures K2-2 and K2-4. The same results for non-CS50 substrate are presented in Table K2-2 and Figures K2-5, K2-7, and K2-9, and scatterplots for each pair of COPC and community metrics are presented in Figures K2-6, K2-8, and K2-10.

Sodium, calcium, magnesium, and potassium are typically considered essential nutrients and are unlikely to be contributing to adverse effects on the benthic invertebrate community.

2.1 CS50 SUBSTRATE

The rank correlation results are presented separately for abundance metrics (i.e., total abundance and density), production metrics (i.e., counted blotted mass), and composition metrics (i.e., species richness, predator richness, diversity, percent dominant taxon, Metals Tolerance Index [MTI], Hilsenhoff Biotic Index [HBI], percent Chironomidae, and presence of Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa).

2.1.1 ABUNDANCE METRICS

None of the individual sediment or porewater metals metrics show significant relationships with either of the abundance metrics (Table K2-1; Figure K2-1 and Figure K2-3).

2.1.2 PRODUCTION METRICS

None of the individual sediment or porewater metals metrics show significant relationships with the production metric, counted blotted mass (Table K2-1; Figure K2-1 and Figure K2-3).

2.1.3 COMPOSITION METRICS

Of the possible relationships evaluated among the seven benthic invertebrate community composition metrics and individual bulk sediment metals metrics in CS50 substrate, a single relationship is identified. Concentrations of total mercury in sediment are weakly, positively correlated with percent Chironomidae ($r = 0.309$) (Table K2-1; Figure K2-1). Among the individual porewater metals metrics, at least one of the community composition metrics is correlated with dissolved concentrations of antimony, arsenic, and copper. MTI is positively correlated with porewater antimony, the composite community metrics principal component (PC)2 is positively correlated with porewater arsenic, and percent Chironomidae is positively correlated with porewater copper concentrations (Table K2-1; Figure K2-3).

2.2 NON-CS50 SUBSTRATE

Consistent with the CS50 discussion, the rank correlation results are presented separately for abundance metrics (i.e., total abundance and density), production metrics (i.e., counted blotted mass), and composition metrics (i.e., species richness, predator richness, diversity, percent dominant taxon, MTI, HBI, percent Chironomidae, and presence of EPT taxa).

2.2.1 ABUNDANCE METRICS

None of the individual sediment or porewater metals metrics show significant relationships with either of the abundance metrics (Table K2-2; Figure K2-5 and Figure K2-7).

2.2.2 PRODUCTION METRICS

None of the individual sediment metals metrics show significant relationships with the production metric, counted blotted mass (Table K2-2; Figure K2-5). For porewater, there is a significant rank correlation between dissolved concentrations of aluminum and counted blotted mass (Table K2-2; Figure K2-7).

2.2.3 COMPOSITION METRICS

Several significant correlations are identified among the seven benthic invertebrate community composition metrics and individual metals concentrations in bulk sediment in non-CS50 substrate. Concentrations of nickel in sediment are negatively correlated with predator richness and positively correlated with MTI (Table K2-2; Figure K2-5 and Figure K2-7). There are 7 individual metals that are positively correlated with percent Chironomidae and 10 individual metals that are positively correlated with HBI.

Of the porewater metals metrics evaluated, predatory richness is negatively correlated with dissolved concentrations of nickel. MTI is positively correlated with dissolved concentrations of iron, magnesium, manganese, and nickel; HBI is correlated with dissolved concentrations of arsenic, barium, calcium, and magnesium; and percent Chironomidae is positively correlated with

dissolved concentrations of eight porewater metals and metalloids. Finally, dissolved aluminum concentrations are significantly higher in samples where EPT are absent than where they are present.

3. STRENGTH SCORING AND WEIGHT OF EVIDENCE

As discussed in Volumes 1 (Section 4.3.3) and 2 (Section 4.4.5) of the Aquatic BERA, correlations identified in the LOE estimation are first categorized as “possible” rather than “uncertain” based on the strength of the relationship in the direction specified in Volume 2 Table 4-48. Each “possible” relationship is further evaluated to assess its relevance and reliability based on comparisons to threshold values or benchmarks from the literature as well as consideration of the patterns and magnitude of response in the underlying data as illustrated in the scatterplots.

3.1 CS50 SUBSTRATE

There are no significant rank correlations between the abundance and production metrics and any of the individual metals metrics for bulk sediment and porewater in CS50 substrate. This section, therefore, addresses the strength, relevance, and reliability of the rank correlations with the composition metrics:

- Bulk Sediment
 - **Mercury.** There is a statistically significant relationship with percent Chironomidae. Mercury exceeded the benchmark in 2 percent of samples in OU 1. Due to the limited frequency of exceedance, it is unlikely that mercury is contributing to adverse effects on benthic invertebrate community composition.
- Porewater
 - **Antimony.** There is a statistically significant relationship with MTI. However, none of the Phase 3 field-collected porewater samples exceed the refined porewater screening benchmark for antimony (Volume 2 Table 4-4; Volume 2 Figure 4-2a). Therefore, exposure to antimony in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
 - **Arsenic.** There is a statistically significant relationship with the composite community metrics PC2. However, arsenic in porewater is not identified as a COPC or a COI in porewater for benthic invertebrates (Volume 1 Table 2-8a), suggesting that exposure to arsenic in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
 - **Barium.** There is a statistically significant relationship with the composite community metrics PC2. However, barium is not identified as a COPC or a COI in porewater for benthic invertebrates (Volume 1 Table 2-8a), suggesting that exposure to barium in porewater is unlikely to be contributing to differences in benthic invertebrate community composition in locations with CS50 substrates.
 - **Copper.** There is a statistically significant relationship with percent Chironomidae. However, exposure to copper in porewater is addressed using a more relevant exposure metric that accounts for bioavailability (Volume 2 Section 4.1.5).

- **Vanadium.** There is a statistically significant relationship with the composite community metrics PC2. However, vanadium in porewater is not identified as a COPC or a COI for benthic invertebrates (Volume 1 Table 2-8a), suggesting that exposure to vanadium in porewater is unlikely to be contributing to differences in benthic invertebrate community composition locations with CS50 substrate.

Overall, no additional relevant or reliable correlations between individual metals exposures with benthic invertebrate community metrics beyond those discussed in Volumes 1 through 4 of the Aquatic BERA are identified for the CS50 substrate.

3.2 NON-CS50 SUBSTRATE

There are no significant rank correlations between the abundance metrics and any of the individual metals metrics for bulk sediment and porewater in non-CS50 substrate. This section, therefore, addresses the strength, relevance, and reliability of the rank correlations with the production and composition metrics.

3.2.1 PRODUCTION METRICS

While there is a relationship between dissolved concentrations of aluminum in porewater and counted blotted mass, examination of the scatterplot (Figure K2-8) shows that the highest concentrations and lowest counted blotted mass values occur in the upstream reference area samples. Therefore, any relationship between benthic invertebrate community biomass and dissolved concentrations of aluminum in porewater in the non-CS50 substrate is not related to the risk question.¹

3.2.2 COMPOSITION METRICS

The strength of the relationships are considered in Table K2-5, and the relevance and reliability of the following COPCs or COIs are discussed below:

- Bulk Sediment
 - **Antimony.** There is a statistically significant relationship with percent Chironomidae. However, as a COI, there is no benchmark for assessing the likelihood that exposure to antimony in bulk sediment is contributing to adverse effects on benthic invertebrate community composition. However, porewater is a more reliable exposure metric, and relationships with dissolved concentrations of antimony in porewater are discussed below.
 - **Arsenic.** There is a statistically significant relationship with HBI. However, HBI is not a diagnostic metric for metals stress; exposure to arsenic in bulk sediment is unlikely to be contributing to an increase in HBI.
 - **Barium.** There is a statistically significant relationship with HBI. However, as a COI, there is no benchmark for assessing the likelihood that exposure to barium in bulk sediment is

¹ As noted in Volume 1 Table 2-14c, the risk question for the production metric in LOE 5 is: Is there a statistically significant, biologically meaningful, negative relationship between COPC concentrations and production (i.e., biomass) in OU 1?

contributing to adverse effects. In addition, HBI is not a diagnostic metric for metals stress, suggesting that barium is unlikely to be contributing to an increase in HBI.

- **Cadmium.** There is a statistically significant relationship with HBI. However, HBI is not a diagnostic metric for metals stress; exposure to cadmium in bulk sediment is unlikely to be contributing to an increase in HBI.
- **Chromium.** There is a statistically significant relationship with percent Chironomidae, but all chromium concentrations in the non-CS50 data set are less than the probable effect concentration of 110 mg/kg (as evident by all hazard quotients [HQs] < 1 for chromium in sediment in Volume 2 Table 4-62), suggesting that exposure to chromium in bulk sediment is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
- **Copper.** There is a statistically significant relationship with percent Chironomidae. However, exposure to copper in sediment is addressed using a more relevant exposure metric that accounts for bioavailability in Volume 2 Section 4.1.5.
- **Iron.** There is a statistically significant relationship with percent Chironomidae. However, as a COI, there is no benchmark for assessing the likelihood that exposure to iron in bulk sediment is contributing to adverse effects on benthic invertebrate community composition.
- **Lead.** There is a statistically significant relationship with HBI. However, HBI is not a diagnostic metric for metals stress; exposure to lead in bulk sediment is unlikely to be contributing to an increase in HBI.
- **Manganese.** There is a statistically significant relationship with percent Chironomidae. However, as a COI, there is no benchmark for assessing the likelihood that exposure to manganese in bulk sediment is contributing to adverse effects on benthic invertebrate community composition. However, porewater is a more reliable exposure metric, and relationships with dissolved concentrations of manganese in porewater are discussed below.
- **Mercury.** There is a statistically significant relationship with HBI. However, there are no relationships between mercury and any of the other composition metrics that are more diagnostic of metals stress than HBI, suggesting that exposure to mercury in bulk sediment is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
- **Nickel.** There are statistically significant relationships with predator richness and MTI. However, all concentrations in the non-CS50 data set are less than the probable effect concentration of 49 mg/kg (as evident by all HQs < 1 for nickel in sediment in Volume 2 Table 4-62), which suggests exposure to nickel in bulk sediment is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
- **Selenium.** There is a statistically significant relationship with HBI. However, as a COI, there is no benchmark for assessing the likelihood that exposure to selenium in bulk sediment is contributing to adverse effects. As discussed above, because HBI is not a

diagnostic metric for metals stress, exposure to selenium is unlikely to be contributing to an increase in HBI.

- **Silver.** There is a statistically significant relationship with percent Chironomidae. Silver in sediment is a COI due to the lack of sufficient sediment benchmarks. However, the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables for sediment identify a screening value for silver in sediment of > 0.5 mg/kg (Buchman 2008), which generally distinguishes samples collected in the upstream reference areas in the non-CS50 from samples collected in the areas of interest (Volume 2 Figure 4-55s). Therefore, exposure to silver in sediment cannot be ruled out as a potential factor influencing the composition of the benthic invertebrate community in samples in the non-CS50 data set.
- **Thallium.** There is a statistically significant relationship with HBI. However, as a COI, there is no benchmark for assessing the likelihood that exposure to thallium in bulk sediment is contributing to adverse effects. As discussed above, because HBI is not a diagnostic metric for metals stress, exposure to thallium is unlikely to be contributing to an increase in HBI.
- **Vanadium.** There is a statistically significant relationship with HBI and MTI. However, as a COI, there is no benchmark for assessing the likelihood that exposure to vanadium in bulk sediment is contributing to adverse effects. As discussed above, because HBI is not a diagnostic metric for metals stress, exposure to vanadium is unlikely to be contributing to an increase in HBI.
- **Porewater**
 - **Aluminum.** There is a statistically significant relationship between counted blotted mass and dissolved concentrations of aluminum in porewater. Aluminum had no exceedances of the benchmark in OU 1 samples. Due to the lack of exceedances, it is unlikely that aluminum is contributing to adverse effects on benthic invertebrate community composition.
 - **Antimony.** There is a statistically significant relationship between percent Chironomidae and total abundance with dissolved concentrations of antimony in porewater from non-CS50 substrate. However, none of the Phase 3 field-collected porewater samples exceed the refined porewater screening benchmark for antimony (Volume 2 Table 4-4; Volume 2 Figure 4-2a). Therefore, exposure to antimony in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
 - **Arsenic.** There is a statistically significant relationship between percent Chironomidae and HBI with dissolved concentrations of arsenic in porewater. However, arsenic in porewater is not identified as a COPC or a COI in porewater for benthic invertebrates (Volume 1 Table 2-8a), suggesting that exposure to arsenic in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
 - **Barium.** There is a statistically significant relationship between HBI and dissolved concentrations of barium in porewater. However, barium is not identified as a COPC or a COI in porewater for benthic invertebrates (Volume 1 Table 2-8a), suggesting that

exposure to barium in porewater is unlikely to be contributing to differences in benthic invertebrate community composition in locations with non-CS50 substrates. In addition, HBI is not a diagnostic metric for metals stress.

- **Cadmium.** There is a statistically significant relationship between percent Chironomidae and dissolved concentrations of cadmium in porewater from non-CS50 substrate. However, exposure to cadmium in porewater is addressed using a more relevant exposure metric that accounts for bioavailability (Volume 2 Section 4.1.5).
- **Manganese.** There is a statistically significant relationship with MTI and dissolved concentrations of manganese in porewater. However, none of the Phase 3 field-collected porewater samples exceed the porewater screening benchmark for manganese (Volume 2 Table 4-3). Therefore, exposure to manganese in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition at locations with non-CS50 substrate.
- **Nickel.** There is a statistically significant relationship between MTI and dissolved concentrations of nickel in porewater. However, nickel in porewater is not identified as a COPC or a COI for benthic invertebrates (Volume 1 Table 2-8a) because it did not exceed porewater benchmarks (TAI 2020). Therefore, exposure to nickel in porewater is unlikely to be contributing to adverse effects on benthic invertebrate community composition.
- **Vanadium.** There is a statistically significant relationship with percent Chironomidae and dissolved concentrations of vanadium in porewater. However, vanadium in porewater is not identified as a COPC or a COI for benthic invertebrates (Volume 1 Table 2-8a), suggesting that exposure to vanadium in porewater is unlikely to be contributing to differences in benthic invertebrate community composition locations with non-CS50 substrate.

4. SUMMARY

After scoring the relationships for strength, and qualitatively assessing the relevance and reliability of the relationships, the relationships between community metrics and the following bulk sediment and porewater metals are scored for each data set:

CS50 data set:

- Unlikely—antimony, arsenic, barium, copper, mercury, and vanadium
- Uncertain—barium (porewater)

Non-CS50 data set:

- Unlikely—aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, and vanadium
- Uncertain—silver (bulk sediment) as well as antimony and arsenic (porewater)

Finally, as discussed in Section 1 of this attachment, there is additional uncertainty as to whether these relationships between community metrics and individual metals exposure metrics are reliable or relevant. Their relevance is uncertain because they do not account for bioavailability, and their reliability is low because individual metals concentrations covary with each other in OU 1. It is for these reasons that the primary analyses for this LOE focus on multiple metal and bioavailability-adjusted exposure metrics, as presented in Volume 2 (Section 4).

5. REFERENCES

- Buchman, M.F. 2008. Screening Quick Reference Tables (SQuiRTs). NOAA OR&R Report 08-1, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, Seattle, WA. <https://repository.library.noaa.gov/view/noaa/9327>.
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- TAI. 2022. *Final 2019 Phase 3 Sediment Study Data Summary Report*. Prepared for TAI by ERM, Seattle, WA. <https://www.ucr-rifs.com/assets/Docs/New/01-25-22-Final-Phase3Sediment-DSR-Volume-I.pdf>.



TABLES

Table K2-1
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
with CS50 Substrate
Upper Columbia River
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Total Abundance	Sediment	Aluminum, Sediment (mg/kg)	0.052	0.689	No
Total Abundance	Sediment	Antimony, Sediment (mg/kg)	-0.021	0.871	No
Total Abundance	Sediment	Arsenic, Sediment (mg/kg)	0.01	0.937	No
Total Abundance	Sediment	Barium, Sediment (mg/kg)	0.063	0.632	No
Total Abundance	Sediment	Beryllium, Sediment (mg/kg)	0.041	0.757	No
Total Abundance	Sediment	Cadmium, Sediment (mg/kg)	-0.101	0.439	No
Total Abundance	Sediment	Calcium, Sediment (mg/kg)	0.069	0.596	No
Total Abundance	Sediment	Chromium, Sediment (mg/kg)	0.029	0.824	No
Total Abundance	Sediment	Cobalt, Sediment (mg/kg)	-0.042	0.75	No
Total Abundance	Sediment	Copper, Sediment (mg/kg)	0.045	0.73	No
Total Abundance	Sediment	Iron, Sediment (mg/kg)	0.081	0.533	No
Total Abundance	Sediment	Lead, Sediment (mg/kg)	0.107	0.41	No
Total Abundance	Sediment	Magnesium, Sediment (mg/kg)	0.131	0.315	No
Total Abundance	Sediment	Manganese, Sediment (mg/kg)	0.074	0.57	No
Total Abundance	Sediment	Mercury, Sediment (mg/kg)	-0.238	0.065	No
Total Abundance	Sediment	Nickel, Sediment (mg/kg)	0.007	0.955	No
Total Abundance	Sediment	Potassium, Sediment (mg/kg)	0.039	0.765	No
Total Abundance	Sediment	Selenium, Sediment (mg/kg)	0.022	0.864	No
Total Abundance	Sediment	Silver, Sediment (mg/kg)	-0.152	0.243	No
Total Abundance	Sediment	Sodium, Sediment (mg/kg)	-0.002	0.989	No
Total Abundance	Sediment	Thallium, Sediment (mg/kg)	-0.052	0.689	No
Total Abundance	Sediment	Vanadium, Sediment (mg/kg)	0.051	0.695	No
Total Abundance	Sediment	Zinc, Sediment (mg/kg)	0.075	0.568	No
Density	Sediment	Aluminum, Sediment (mg/kg)	0.005	0.968	No
Density	Sediment	Antimony, Sediment (mg/kg)	-0.038	0.773	No

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Density	Sediment	Arsenic, Sediment (mg/kg)	-0.021	0.872	No
Density	Sediment	Barium, Sediment (mg/kg)	0.023	0.862	No
Density	Sediment	Beryllium, Sediment (mg/kg)	0.009	0.945	No
Density	Sediment	Cadmium, Sediment (mg/kg)	-0.066	0.613	No
Density	Sediment	Calcium, Sediment (mg/kg)	0.026	0.843	No
Density	Sediment	Chromium, Sediment (mg/kg)	-0.003	0.979	No
Density	Sediment	Cobalt, Sediment (mg/kg)	-0.075	0.567	No
Density	Sediment	Copper, Sediment (mg/kg)	0.012	0.926	No
Density	Sediment	Iron, Sediment (mg/kg)	0.04	0.757	No
Density	Sediment	Lead, Sediment (mg/kg)	0.091	0.486	No
Density	Sediment	Magnesium, Sediment (mg/kg)	0.129	0.321	No
Density	Sediment	Manganese, Sediment (mg/kg)	0.03	0.816	No
Density	Sediment	Mercury, Sediment (mg/kg)	-0.195	0.133	No
Density	Sediment	Nickel, Sediment (mg/kg)	-0.008	0.95	No
Density	Sediment	Potassium, Sediment (mg/kg)	-0.003	0.982	No
Density	Sediment	Selenium, Sediment (mg/kg)	-0.01	0.939	No
Density	Sediment	Silver, Sediment (mg/kg)	-0.181	0.163	No
Density	Sediment	Sodium, Sediment (mg/kg)	-0.045	0.731	No
Density	Sediment	Thallium, Sediment (mg/kg)	0.002	0.99	No
Density	Sediment	Vanadium, Sediment (mg/kg)	0.01	0.941	No
Density	Sediment	Zinc, Sediment (mg/kg)	0.033	0.801	No
Counted Blotted Mass	Sediment	Aluminum, Sediment (mg/kg)	0.004	0.974	No
Counted Blotted Mass	Sediment	Antimony, Sediment (mg/kg)	-0.067	0.608	No
Counted Blotted Mass	Sediment	Arsenic, Sediment (mg/kg)	-0.034	0.797	No
Counted Blotted Mass	Sediment	Barium, Sediment (mg/kg)	0.04	0.757	No

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Counted Blotted Mass	Sediment	Beryllium, Sediment (mg/kg)	-0.006	0.962	No
Counted Blotted Mass	Sediment	Cadmium, Sediment (mg/kg)	0.041	0.754	No
Counted Blotted Mass	Sediment	Calcium, Sediment (mg/kg)	0.052	0.692	No
Counted Blotted Mass	Sediment	Chromium, Sediment (mg/kg)	0.019	0.887	No
Counted Blotted Mass	Sediment	Cobalt, Sediment (mg/kg)	-0.067	0.608	No
Counted Blotted Mass	Sediment	Copper, Sediment (mg/kg)	0.026	0.845	No
Counted Blotted Mass	Sediment	Iron, Sediment (mg/kg)	0.062	0.637	No
Counted Blotted Mass	Sediment	Lead, Sediment (mg/kg)	0.097	0.455	No
Counted Blotted Mass	Sediment	Magnesium, Sediment (mg/kg)	0.18	0.164	No
Counted Blotted Mass	Sediment	Manganese, Sediment (mg/kg)	0.052	0.688	No
Counted Blotted Mass	Sediment	Mercury, Sediment (mg/kg)	-0.082	0.532	No
Counted Blotted Mass	Sediment	Nickel, Sediment (mg/kg)	0.002	0.989	No
Counted Blotted Mass	Sediment	Potassium, Sediment (mg/kg)	-0.002	0.985	No
Counted Blotted Mass	Sediment	Selenium, Sediment (mg/kg)	-0.005	0.969	No
Counted Blotted Mass	Sediment	Silver, Sediment (mg/kg)	-0.198	0.126	No
Counted Blotted Mass	Sediment	Sodium, Sediment (mg/kg)	-0.059	0.65	No
Counted Blotted Mass	Sediment	Thallium, Sediment (mg/kg)	0.035	0.788	No
Counted Blotted Mass	Sediment	Vanadium, Sediment (mg/kg)	0.003	0.979	No
Counted Blotted Mass	Sediment	Zinc, Sediment (mg/kg)	0.042	0.747	No
Species Richness	Sediment	Aluminum, Sediment (mg/kg)	0.009	0.944	No
Species Richness	Sediment	Antimony, Sediment (mg/kg)	-0.071	0.587	No
Species Richness	Sediment	Arsenic, Sediment (mg/kg)	0.003	0.979	No
Species Richness	Sediment	Barium, Sediment (mg/kg)	0.021	0.872	No
Species Richness	Sediment	Beryllium, Sediment (mg/kg)	0.009	0.946	No
Species Richness	Sediment	Cadmium, Sediment (mg/kg)	0.028	0.83	No

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Species Richness	Sediment	Calcium, Sediment (mg/kg)	0.058	0.658	No
Species Richness	Sediment	Chromium, Sediment (mg/kg)	-0.004	0.977	No
Species Richness	Sediment	Cobalt, Sediment (mg/kg)	-0.065	0.617	No
Species Richness	Sediment	Copper, Sediment (mg/kg)	0.043	0.74	No
Species Richness	Sediment	Iron, Sediment (mg/kg)	0.038	0.773	No
Species Richness	Sediment	Lead, Sediment (mg/kg)	0.093	0.478	No
Species Richness	Sediment	Magnesium, Sediment (mg/kg)	0.18	0.165	No
Species Richness	Sediment	Manganese, Sediment (mg/kg)	0.061	0.641	No
Species Richness	Sediment	Mercury, Sediment (mg/kg)	-0.208	0.108	No
Species Richness	Sediment	Nickel, Sediment (mg/kg)	-0.063	0.63	No
Species Richness	Sediment	Potassium, Sediment (mg/kg)	-0.009	0.947	No
Species Richness	Sediment	Selenium, Sediment (mg/kg)	0.008	0.952	No
Species Richness	Sediment	Silver, Sediment (mg/kg)	-0.157	0.227	No
Species Richness	Sediment	Sodium, Sediment (mg/kg)	-0.026	0.844	No
Species Richness	Sediment	Thallium, Sediment (mg/kg)	-0.127	0.329	No
Species Richness	Sediment	Vanadium, Sediment (mg/kg)	0.044	0.734	No
Species Richness	Sediment	Zinc, Sediment (mg/kg)	0.039	0.768	No
Predator Richness	Sediment	Aluminum, Sediment (mg/kg)	0.344	0.007	No
Predator Richness	Sediment	Antimony, Sediment (mg/kg)	0.129	0.323	No
Predator Richness	Sediment	Arsenic, Sediment (mg/kg)	0.286	0.025	No
Predator Richness	Sediment	Barium, Sediment (mg/kg)	0.314	0.014	No
Predator Richness	Sediment	Beryllium, Sediment (mg/kg)	0.312	0.015	No
Predator Richness	Sediment	Cadmium, Sediment (mg/kg)	0.091	0.487	No
Predator Richness	Sediment	Calcium, Sediment (mg/kg)	0.383	0.002	No
Predator Richness	Sediment	Chromium, Sediment (mg/kg)	0.296	0.021	No

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Predator Richness	Sediment	Cobalt, Sediment (mg/kg)	0.23	0.074	No
Predator Richness	Sediment	Copper, Sediment (mg/kg)	0.323	0.011	No
Predator Richness	Sediment	Iron, Sediment (mg/kg)	0.381	0.002	No
Predator Richness	Sediment	Lead, Sediment (mg/kg)	0.398	0.001	No
Predator Richness	Sediment	Magnesium, Sediment (mg/kg)	0.364	0.004	No
Predator Richness	Sediment	Manganese, Sediment (mg/kg)	0.368	0.004	No
Predator Richness	Sediment	Mercury, Sediment (mg/kg)	-0.22	0.089	No
Predator Richness	Sediment	Nickel, Sediment (mg/kg)	0.196	0.129	No
Predator Richness	Sediment	Potassium, Sediment (mg/kg)	0.339	0.008	No
Predator Richness	Sediment	Selenium, Sediment (mg/kg)	0.334	0.008	No
Predator Richness	Sediment	Silver, Sediment (mg/kg)	0.054	0.681	No
Predator Richness	Sediment	Sodium, Sediment (mg/kg)	0.276	0.031	No
Predator Richness	Sediment	Thallium, Sediment (mg/kg)	-0.081	0.536	No
Predator Richness	Sediment	Vanadium, Sediment (mg/kg)	0.359	0.005	No
Predator Richness	Sediment	Zinc, Sediment (mg/kg)	0.359	0.004	No
Shannon-Weaver H' (log 10)	Sediment	Aluminum, Sediment (mg/kg)	0.091	0.486	No
Shannon-Weaver H' (log 10)	Sediment	Antimony, Sediment (mg/kg)	-0.002	0.987	No
Shannon-Weaver H' (log 10)	Sediment	Arsenic, Sediment (mg/kg)	0.11	0.4	No
Shannon-Weaver H' (log 10)	Sediment	Barium, Sediment (mg/kg)	0.117	0.367	No
Shannon-Weaver H' (log 10)	Sediment	Beryllium, Sediment (mg/kg)	0.111	0.395	No
Shannon-Weaver H' (log 10)	Sediment	Cadmium, Sediment (mg/kg)	0.162	0.211	No
Shannon-Weaver H' (log 10)	Sediment	Calcium, Sediment (mg/kg)	0.162	0.213	No
Shannon-Weaver H' (log 10)	Sediment	Chromium, Sediment (mg/kg)	0.117	0.369	No
Shannon-Weaver H' (log 10)	Sediment	Cobalt, Sediment (mg/kg)	0.069	0.597	No
Shannon-Weaver H' (log 10)	Sediment	Copper, Sediment (mg/kg)	0.166	0.202	No

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Shannon-Weaver H' (log 10)	Sediment	Iron, Sediment (mg/kg)	0.158	0.223	No
Shannon-Weaver H' (log 10)	Sediment	Lead, Sediment (mg/kg)	0.163	0.209	No
Shannon-Weaver H' (log 10)	Sediment	Magnesium, Sediment (mg/kg)	0.24	0.063	No
Shannon-Weaver H' (log 10)	Sediment	Manganese, Sediment (mg/kg)	0.171	0.188	No
Shannon-Weaver H' (log 10)	Sediment	Mercury, Sediment (mg/kg)	-0.089	0.493	No
Shannon-Weaver H' (log 10)	Sediment	Nickel, Sediment (mg/kg)	0.049	0.709	No
Shannon-Weaver H' (log 10)	Sediment	Potassium, Sediment (mg/kg)	0.105	0.419	No
Shannon-Weaver H' (log 10)	Sediment	Selenium, Sediment (mg/kg)	0.129	0.32	No
Shannon-Weaver H' (log 10)	Sediment	Silver, Sediment (mg/kg)	-0.066	0.614	No
Shannon-Weaver H' (log 10)	Sediment	Sodium, Sediment (mg/kg)	0.082	0.532	No
Shannon-Weaver H' (log 10)	Sediment	Thallium, Sediment (mg/kg)	-0.061	0.64	No
Shannon-Weaver H' (log 10)	Sediment	Vanadium, Sediment (mg/kg)	0.133	0.309	No
Shannon-Weaver H' (log 10)	Sediment	Zinc, Sediment (mg/kg)	0.14	0.282	No
% Dominant Taxon	Sediment	Aluminum, Sediment (mg/kg)	-0.058	0.658	No
% Dominant Taxon	Sediment	Antimony, Sediment (mg/kg)	0.008	0.951	No
% Dominant Taxon	Sediment	Arsenic, Sediment (mg/kg)	-0.083	0.523	No
% Dominant Taxon	Sediment	Barium, Sediment (mg/kg)	-0.077	0.558	No
% Dominant Taxon	Sediment	Beryllium, Sediment (mg/kg)	-0.079	0.544	No
% Dominant Taxon	Sediment	Cadmium, Sediment (mg/kg)	-0.187	0.149	No
% Dominant Taxon	Sediment	Calcium, Sediment (mg/kg)	-0.128	0.327	No
% Dominant Taxon	Sediment	Chromium, Sediment (mg/kg)	-0.082	0.531	No
% Dominant Taxon	Sediment	Cobalt, Sediment (mg/kg)	-0.045	0.728	No
% Dominant Taxon	Sediment	Copper, Sediment (mg/kg)	-0.127	0.329	No
% Dominant Taxon	Sediment	Iron, Sediment (mg/kg)	-0.116	0.374	No
% Dominant Taxon	Sediment	Lead, Sediment (mg/kg)	-0.121	0.355	No

Table K2-1
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Dominant Taxon	Sediment	Magnesium, Sediment (mg/kg)	-0.263	0.04	No
% Dominant Taxon	Sediment	Manganese, Sediment (mg/kg)	-0.114	0.383	No
% Dominant Taxon	Sediment	Mercury, Sediment (mg/kg)	0.069	0.597	No
% Dominant Taxon	Sediment	Nickel, Sediment (mg/kg)	-0.073	0.575	No
% Dominant Taxon	Sediment	Potassium, Sediment (mg/kg)	-0.083	0.523	No
% Dominant Taxon	Sediment	Selenium, Sediment (mg/kg)	-0.114	0.383	No
% Dominant Taxon	Sediment	Silver, Sediment (mg/kg)	0.051	0.696	No
% Dominant Taxon	Sediment	Sodium, Sediment (mg/kg)	-0.065	0.62	No
% Dominant Taxon	Sediment	Thallium, Sediment (mg/kg)	0.019	0.882	No
% Dominant Taxon	Sediment	Vanadium, Sediment (mg/kg)	-0.094	0.472	No
% Dominant Taxon	Sediment	Zinc, Sediment (mg/kg)	-0.1	0.441	No
Metals Tolerance Index	Sediment	Aluminum, Sediment (mg/kg)	0.283	0.029	No
Metals Tolerance Index	Sediment	Antimony, Sediment (mg/kg)	0.201	0.124	No
Metals Tolerance Index	Sediment	Arsenic, Sediment (mg/kg)	0.12	0.361	No
Metals Tolerance Index	Sediment	Barium, Sediment (mg/kg)	0.197	0.131	No
Metals Tolerance Index	Sediment	Beryllium, Sediment (mg/kg)	0.229	0.078	No
Metals Tolerance Index	Sediment	Cadmium, Sediment (mg/kg)	0.241	0.063	No
Metals Tolerance Index	Sediment	Calcium, Sediment (mg/kg)	0.282	0.029	No
Metals Tolerance Index	Sediment	Chromium, Sediment (mg/kg)	0.253	0.051	No
Metals Tolerance Index	Sediment	Cobalt, Sediment (mg/kg)	0.216	0.098	No
Metals Tolerance Index	Sediment	Copper, Sediment (mg/kg)	0.233	0.073	No
Metals Tolerance Index	Sediment	Iron, Sediment (mg/kg)	0.29	0.025	No
Metals Tolerance Index	Sediment	Lead, Sediment (mg/kg)	0.241	0.064	No
Metals Tolerance Index	Sediment	Magnesium, Sediment (mg/kg)	0.289	0.025	No
Metals Tolerance Index	Sediment	Manganese, Sediment (mg/kg)	0.246	0.058	No

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Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Metals Tolerance Index	Sediment	Mercury, Sediment (mg/kg)	0.285	0.027	No
Metals Tolerance Index	Sediment	Nickel, Sediment (mg/kg)	0.17	0.195	No
Metals Tolerance Index	Sediment	Potassium, Sediment (mg/kg)	0.281	0.03	No
Metals Tolerance Index	Sediment	Selenium, Sediment (mg/kg)	0.254	0.05	No
Metals Tolerance Index	Sediment	Silver, Sediment (mg/kg)	0.177	0.175	No
Metals Tolerance Index	Sediment	Sodium, Sediment (mg/kg)	0.23	0.077	No
Metals Tolerance Index	Sediment	Thallium, Sediment (mg/kg)	0.114	0.384	No
Metals Tolerance Index	Sediment	Vanadium, Sediment (mg/kg)	0.245	0.059	No
Metals Tolerance Index	Sediment	Zinc, Sediment (mg/kg)	0.279	0.031	No
Hilsenhoff Biotic Index	Sediment	Aluminum, Sediment (mg/kg)	0.127	0.329	No
Hilsenhoff Biotic Index	Sediment	Antimony, Sediment (mg/kg)	-0.268	0.037	No
Hilsenhoff Biotic Index	Sediment	Arsenic, Sediment (mg/kg)	-0.063	0.63	No
Hilsenhoff Biotic Index	Sediment	Barium, Sediment (mg/kg)	-0.081	0.536	No
Hilsenhoff Biotic Index	Sediment	Beryllium, Sediment (mg/kg)	-0.003	0.981	No
Hilsenhoff Biotic Index	Sediment	Cadmium, Sediment (mg/kg)	-0.017	0.897	No
Hilsenhoff Biotic Index	Sediment	Calcium, Sediment (mg/kg)	0.031	0.815	No
Hilsenhoff Biotic Index	Sediment	Chromium, Sediment (mg/kg)	-0.055	0.676	No
Hilsenhoff Biotic Index	Sediment	Cobalt, Sediment (mg/kg)	-0.05	0.701	No
Hilsenhoff Biotic Index	Sediment	Copper, Sediment (mg/kg)	-0.068	0.604	No
Hilsenhoff Biotic Index	Sediment	Iron, Sediment (mg/kg)	0.043	0.74	No
Hilsenhoff Biotic Index	Sediment	Lead, Sediment (mg/kg)	0.14	0.284	No
Hilsenhoff Biotic Index	Sediment	Magnesium, Sediment (mg/kg)	0.049	0.705	No
Hilsenhoff Biotic Index	Sediment	Manganese, Sediment (mg/kg)	0.016	0.905	No
Hilsenhoff Biotic Index	Sediment	Mercury, Sediment (mg/kg)	-0.234	0.069	No
Hilsenhoff Biotic Index	Sediment	Nickel, Sediment (mg/kg)	-0.064	0.623	No

Table K2-1
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Hilsenhoff Biotic Index	Sediment	Potassium, Sediment (mg/kg)	0.08	0.539	No
Hilsenhoff Biotic Index	Sediment	Selenium, Sediment (mg/kg)	0.059	0.653	No
Hilsenhoff Biotic Index	Sediment	Silver, Sediment (mg/kg)	-0.207	0.109	No
Hilsenhoff Biotic Index	Sediment	Sodium, Sediment (mg/kg)	0.009	0.945	No
Hilsenhoff Biotic Index	Sediment	Thallium, Sediment (mg/kg)	-0.001	0.991	No
Hilsenhoff Biotic Index	Sediment	Vanadium, Sediment (mg/kg)	0.109	0.404	No
Hilsenhoff Biotic Index	Sediment	Zinc, Sediment (mg/kg)	0.097	0.458	No
% Chironomidae	Sediment	Aluminum, Sediment (mg/kg)	-0.303	0.017	No
% Chironomidae	Sediment	Antimony, Sediment (mg/kg)	0.088	0.501	No
% Chironomidae	Sediment	Arsenic, Sediment (mg/kg)	-0.184	0.156	No
% Chironomidae	Sediment	Barium, Sediment (mg/kg)	-0.106	0.417	No
% Chironomidae	Sediment	Beryllium, Sediment (mg/kg)	-0.211	0.102	No
% Chironomidae	Sediment	Cadmium, Sediment (mg/kg)	-0.052	0.692	No
% Chironomidae	Sediment	Calcium, Sediment (mg/kg)	-0.245	0.057	No
% Chironomidae	Sediment	Chromium, Sediment (mg/kg)	-0.094	0.473	No
% Chironomidae	Sediment	Cobalt, Sediment (mg/kg)	-0.113	0.387	No
% Chironomidae	Sediment	Copper, Sediment (mg/kg)	-0.164	0.206	No
% Chironomidae	Sediment	Iron, Sediment (mg/kg)	-0.242	0.06	No
% Chironomidae	Sediment	Lead, Sediment (mg/kg)	-0.364	0.004	No
% Chironomidae	Sediment	Magnesium, Sediment (mg/kg)	-0.288	0.025	No
% Chironomidae	Sediment	Manganese, Sediment (mg/kg)	-0.211	0.102	No
% Chironomidae	Sediment	Mercury, Sediment (mg/kg)	0.309	0.016	Yes
% Chironomidae	Sediment	Nickel, Sediment (mg/kg)	-0.108	0.407	No
% Chironomidae	Sediment	Potassium, Sediment (mg/kg)	-0.293	0.022	No
% Chironomidae	Sediment	Selenium, Sediment (mg/kg)	-0.278	0.03	No

Table K2-1
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Chironomidae	Sediment	Silver, Sediment (mg/kg)	0.062	0.637	No
% Chironomidae	Sediment	Sodium, Sediment (mg/kg)	-0.264	0.04	No
% Chironomidae	Sediment	Thallium, Sediment (mg/kg)	0.17	0.191	No
% Chironomidae	Sediment	Vanadium, Sediment (mg/kg)	-0.325	0.011	No
% Chironomidae	Sediment	Zinc, Sediment (mg/kg)	-0.276	0.032	No
Community Metrics PC1	Sediment	Aluminum, Sediment (mg/kg)	0.124	0.342	No
Community Metrics PC1	Sediment	Antimony, Sediment (mg/kg)	-0.031	0.815	No
Community Metrics PC1	Sediment	Arsenic, Sediment (mg/kg)	0.09	0.488	No
Community Metrics PC1	Sediment	Barium, Sediment (mg/kg)	0.104	0.423	No
Community Metrics PC1	Sediment	Beryllium, Sediment (mg/kg)	0.102	0.434	No
Community Metrics PC1	Sediment	Cadmium, Sediment (mg/kg)	0.054	0.681	No
Community Metrics PC1	Sediment	Calcium, Sediment (mg/kg)	0.16	0.218	No
Community Metrics PC1	Sediment	Chromium, Sediment (mg/kg)	0.083	0.524	No
Community Metrics PC1	Sediment	Cobalt, Sediment (mg/kg)	0.013	0.923	No
Community Metrics PC1	Sediment	Copper, Sediment (mg/kg)	0.127	0.328	No
Community Metrics PC1	Sediment	Iron, Sediment (mg/kg)	0.161	0.216	No
Community Metrics PC1	Sediment	Lead, Sediment (mg/kg)	0.222	0.086	No
Community Metrics PC1	Sediment	Magnesium, Sediment (mg/kg)	0.253	0.049	No
Community Metrics PC1	Sediment	Manganese, Sediment (mg/kg)	0.16	0.218	No
Community Metrics PC1	Sediment	Mercury, Sediment (mg/kg)	-0.209	0.107	No
Community Metrics PC1	Sediment	Nickel, Sediment (mg/kg)	0.043	0.742	No
Community Metrics PC1	Sediment	Potassium, Sediment (mg/kg)	0.11	0.397	No
Community Metrics PC1	Sediment	Selenium, Sediment (mg/kg)	0.112	0.39	No
Community Metrics PC1	Sediment	Silver, Sediment (mg/kg)	-0.141	0.278	No
Community Metrics PC1	Sediment	Sodium, Sediment (mg/kg)	0.055	0.676	No

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Community Metrics PC1	Sediment	Thallium, Sediment (mg/kg)	-0.032	0.809	No
Community Metrics PC1	Sediment	Vanadium, Sediment (mg/kg)	0.138	0.288	No
Community Metrics PC1	Sediment	Zinc, Sediment (mg/kg)	0.153	0.238	No
Community Metrics PC2	Sediment	Aluminum, Sediment (mg/kg)	0.033	0.8	No
Community Metrics PC2	Sediment	Antimony, Sediment (mg/kg)	0.038	0.773	No
Community Metrics PC2	Sediment	Arsenic, Sediment (mg/kg)	-0.032	0.808	No
Community Metrics PC2	Sediment	Barium, Sediment (mg/kg)	0.034	0.796	No
Community Metrics PC2	Sediment	Beryllium, Sediment (mg/kg)	0	0.997	No
Community Metrics PC2	Sediment	Cadmium, Sediment (mg/kg)	-0.021	0.87	No
Community Metrics PC2	Sediment	Calcium, Sediment (mg/kg)	0.015	0.908	No
Community Metrics PC2	Sediment	Chromium, Sediment (mg/kg)	0.037	0.779	No
Community Metrics PC2	Sediment	Cobalt, Sediment (mg/kg)	-0.03	0.818	No
Community Metrics PC2	Sediment	Copper, Sediment (mg/kg)	-0.024	0.852	No
Community Metrics PC2	Sediment	Iron, Sediment (mg/kg)	0.057	0.661	No
Community Metrics PC2	Sediment	Lead, Sediment (mg/kg)	0.076	0.562	No
Community Metrics PC2	Sediment	Magnesium, Sediment (mg/kg)	0.081	0.537	No
Community Metrics PC2	Sediment	Manganese, Sediment (mg/kg)	0.016	0.9	No
Community Metrics PC2	Sediment	Mercury, Sediment (mg/kg)	0.126	0.334	No
Community Metrics PC2	Sediment	Nickel, Sediment (mg/kg)	-0.009	0.942	No
Community Metrics PC2	Sediment	Potassium, Sediment (mg/kg)	0.014	0.917	No
Community Metrics PC2	Sediment	Selenium, Sediment (mg/kg)	-0.02	0.875	No
Community Metrics PC2	Sediment	Silver, Sediment (mg/kg)	-0.045	0.733	No
Community Metrics PC2	Sediment	Sodium, Sediment (mg/kg)	-0.049	0.705	No
Community Metrics PC2	Sediment	Thallium, Sediment (mg/kg)	0.172	0.184	No
Community Metrics PC2	Sediment	Vanadium, Sediment (mg/kg)	-0.009	0.947	No

Table K2-1

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Community Metrics PC2	Sediment	Zinc, Sediment (mg/kg)	0.04	0.76	No
Total Abundance	Porewater	Aluminum	0.036	0.781	No
Total Abundance	Porewater	Antimony	-0.096	0.462	No
Total Abundance	Porewater	Arsenic	0.172	0.185	No
Total Abundance	Porewater	Barium	0.391	0.002	No
Total Abundance	Porewater	Cadmium	0.046	0.725	No
Total Abundance	Porewater	Calcium	0.139	0.285	No
Total Abundance	Porewater	Chromium	-0.033	0.799	No
Total Abundance	Porewater	Cobalt	0.297	0.02	No
Total Abundance	Porewater	Copper	-0.169	0.194	No
Total Abundance	Porewater	Iron	0.131	0.316	No
Total Abundance	Porewater	Lead	0.02	0.879	No
Total Abundance	Porewater	Magnesium	-0.085	0.515	No
Total Abundance	Porewater	Manganese	0.368	0.003	No
Total Abundance	Porewater	Nickel	-0.004	0.975	No
Total Abundance	Porewater	Potassium	0.427	0.001	No
Total Abundance	Porewater	Sodium	0.067	0.61	No
Total Abundance	Porewater	Vanadium	0.229	0.076	No
Total Abundance	Porewater	Zinc	-0.033	0.803	No
Density	Porewater	Aluminum	0.083	0.522	No
Density	Porewater	Antimony	-0.079	0.544	No
Density	Porewater	Arsenic	0.2	0.123	No
Density	Porewater	Barium	0.378	0.003	No
Density	Porewater	Cadmium	0.033	0.803	No
Density	Porewater	Calcium	0.133	0.305	No
Density	Porewater	Chromium	-0.035	0.787	No
Density	Porewater	Cobalt	0.344	0.007	No
Density	Porewater	Copper	-0.185	0.154	No
Density	Porewater	Iron	0.146	0.26	No
Density	Porewater	Lead	0.061	0.642	No
Density	Porewater	Magnesium	-0.058	0.657	No
Density	Porewater	Manganese	0.406	0.001	No
Density	Porewater	Nickel	-0.031	0.812	No
Density	Porewater	Potassium	0.44	0	No
Density	Porewater	Sodium	0.072	0.58	No
Density	Porewater	Vanadium	0.241	0.061	No
Density	Porewater	Zinc	-0.05	0.7	No
Counted Blotted Mass	Porewater	Aluminum	0.118	0.365	No
Counted Blotted Mass	Porewater	Antimony	-0.039	0.768	No
Counted Blotted Mass	Porewater	Arsenic	0.226	0.079	No
Counted Blotted Mass	Porewater	Barium	0.376	0.003	No
Counted Blotted Mass	Porewater	Cadmium	0.108	0.409	No
Counted Blotted Mass	Porewater	Calcium	0.168	0.194	No
Counted Blotted Mass	Porewater	Chromium	-0.06	0.648	No
Counted Blotted Mass	Porewater	Cobalt	0.219	0.09	No
Counted Blotted Mass	Porewater	Copper	-0.105	0.42	No
Counted Blotted Mass	Porewater	Iron	0.114	0.382	No
Counted Blotted Mass	Porewater	Lead	0.094	0.472	No
Counted Blotted Mass	Porewater	Magnesium	-0.014	0.916	No

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Counted Blotted Mass	Porewater	Manganese	0.393	0.002	No
Counted Blotted Mass	Porewater	Nickel	-0.112	0.392	No
Counted Blotted Mass	Porewater	Potassium	0.388	0.002	No
Counted Blotted Mass	Porewater	Sodium	0.155	0.232	No
Counted Blotted Mass	Porewater	Vanadium	0.215	0.095	No
Counted Blotted Mass	Porewater	Zinc	-0.056	0.667	No
Species Richness	Porewater	Aluminum	0.095	0.466	No
Species Richness	Porewater	Antimony	-0.087	0.504	No
Species Richness	Porewater	Arsenic	0.081	0.537	No
Species Richness	Porewater	Barium	0.39	0.002	No
Species Richness	Porewater	Cadmium	0.126	0.333	No
Species Richness	Porewater	Calcium	0.132	0.31	No
Species Richness	Porewater	Chromium	-0.022	0.867	No
Species Richness	Porewater	Cobalt	0.419	0.001	No
Species Richness	Porewater	Copper	-0.253	0.049	No
Species Richness	Porewater	Iron	0.222	0.086	No
Species Richness	Porewater	Lead	0.003	0.982	No
Species Richness	Porewater	Magnesium	-0.024	0.856	No
Species Richness	Porewater	Manganese	0.373	0.003	No
Species Richness	Porewater	Nickel	0.151	0.244	No
Species Richness	Porewater	Potassium	0.326	0.01	No
Species Richness	Porewater	Sodium	-0.124	0.342	No
Species Richness	Porewater	Vanadium	0.202	0.118	No
Species Richness	Porewater	Zinc	0	0.999	No
Predator Richness	Porewater	Aluminum	0.037	0.78	No
Predator Richness	Porewater	Antimony	0.121	0.353	No
Predator Richness	Porewater	Arsenic	0.04	0.762	No
Predator Richness	Porewater	Barium	0.319	0.012	No
Predator Richness	Porewater	Cadmium	-0.04	0.761	No
Predator Richness	Porewater	Calcium	0.223	0.084	No
Predator Richness	Porewater	Chromium	-0.014	0.916	No
Predator Richness	Porewater	Cobalt	0.304	0.017	No
Predator Richness	Porewater	Copper	-0.211	0.102	No
Predator Richness	Porewater	Iron	-0.052	0.692	No
Predator Richness	Porewater	Lead	-0.07	0.59	No
Predator Richness	Porewater	Magnesium	-0.001	0.994	No
Predator Richness	Porewater	Manganese	0.344	0.007	No
Predator Richness	Porewater	Nickel	-0.087	0.505	No
Predator Richness	Porewater	Potassium	0.168	0.195	No
Predator Richness	Porewater	Sodium	-0.024	0.853	No
Predator Richness	Porewater	Vanadium	0.032	0.805	No
Predator Richness	Porewater	Zinc	-0.187	0.148	No
Shannon-Weaver H' (log 10)	Porewater	Aluminum	0.114	0.383	No
Shannon-Weaver H' (log 10)	Porewater	Antimony	0.037	0.775	No
Shannon-Weaver H' (log 10)	Porewater	Arsenic	0.058	0.656	No
Shannon-Weaver H' (log 10)	Porewater	Barium	0.227	0.078	No
Shannon-Weaver H' (log 10)	Porewater	Cadmium	0.078	0.548	No
Shannon-Weaver H' (log 10)	Porewater	Calcium	0.175	0.178	No
Shannon-Weaver H' (log 10)	Porewater	Chromium	0.075	0.567	No
Shannon-Weaver H' (log 10)	Porewater	Cobalt	0.293	0.022	No

Table K2-1

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Shannon-Weaver H' (log 10)	Porewater	Copper	-0.169	0.194	No
Shannon-Weaver H' (log 10)	Porewater	Iron	0.053	0.684	No
Shannon-Weaver H' (log 10)	Porewater	Lead	-0.008	0.95	No
Shannon-Weaver H' (log 10)	Porewater	Magnesium	0.055	0.676	No
Shannon-Weaver H' (log 10)	Porewater	Manganese	0.293	0.022	No
Shannon-Weaver H' (log 10)	Porewater	Nickel	-0.042	0.748	No
Shannon-Weaver H' (log 10)	Porewater	Potassium	0.204	0.115	No
Shannon-Weaver H' (log 10)	Porewater	Sodium	-0.04	0.762	No
Shannon-Weaver H' (log 10)	Porewater	Vanadium	0.074	0.571	No
Shannon-Weaver H' (log 10)	Porewater	Zinc	-0.169	0.194	No
% Dominant Taxon	Porewater	Aluminum	-0.157	0.226	No
% Dominant Taxon	Porewater	Antimony	-0.023	0.857	No
% Dominant Taxon	Porewater	Arsenic	-0.056	0.668	No
% Dominant Taxon	Porewater	Barium	-0.174	0.179	No
% Dominant Taxon	Porewater	Cadmium	-0.113	0.386	No
% Dominant Taxon	Porewater	Calcium	-0.162	0.213	No
% Dominant Taxon	Porewater	Chromium	-0.161	0.214	No
% Dominant Taxon	Porewater	Cobalt	-0.261	0.042	No
% Dominant Taxon	Porewater	Copper	0.082	0.53	No
% Dominant Taxon	Porewater	Iron	0.021	0.871	No
% Dominant Taxon	Porewater	Lead	0.013	0.921	No
% Dominant Taxon	Porewater	Magnesium	-0.015	0.908	No
% Dominant Taxon	Porewater	Manganese	-0.265	0.039	No
% Dominant Taxon	Porewater	Nickel	0.076	0.561	No
% Dominant Taxon	Porewater	Potassium	-0.23	0.075	No
% Dominant Taxon	Porewater	Sodium	-0.035	0.787	No
% Dominant Taxon	Porewater	Vanadium	-0.014	0.913	No
% Dominant Taxon	Porewater	Zinc	0.195	0.132	No
Metals Tolerance Index	Porewater	Aluminum	-0.02	0.876	No
Metals Tolerance Index	Porewater	Antimony	0.348	0.006	Yes
Metals Tolerance Index	Porewater	Arsenic	0.084	0.521	No
Metals Tolerance Index	Porewater	Barium	0.214	0.1	No
Metals Tolerance Index	Porewater	Cadmium	-0.215	0.099	No
Metals Tolerance Index	Porewater	Calcium	0.078	0.552	No
Metals Tolerance Index	Porewater	Chromium	-0.266	0.04	No
Metals Tolerance Index	Porewater	Cobalt	0.087	0.507	No
Metals Tolerance Index	Porewater	Copper	0.062	0.639	No
Metals Tolerance Index	Porewater	Iron	-0.122	0.354	No
Metals Tolerance Index	Porewater	Lead	0.051	0.698	No
Metals Tolerance Index	Porewater	Magnesium	-0.073	0.578	No
Metals Tolerance Index	Porewater	Manganese	0.028	0.829	No
Metals Tolerance Index	Porewater	Nickel	-0.201	0.124	No
Metals Tolerance Index	Porewater	Potassium	-0.001	0.996	No
Metals Tolerance Index	Porewater	Sodium	-0.003	0.98	No
Metals Tolerance Index	Porewater	Vanadium	-0.041	0.758	No
Metals Tolerance Index	Porewater	Zinc	0.01	0.942	No
Hilsenhoff Biotic Index	Porewater	Aluminum	-0.14	0.281	No
Hilsenhoff Biotic Index	Porewater	Antimony	-0.047	0.721	No
Hilsenhoff Biotic Index	Porewater	Arsenic	-0.084	0.519	No
Hilsenhoff Biotic Index	Porewater	Barium	0.004	0.976	No

Table K2-1

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Hilsenhoff Biotic Index	Porewater	Cadmium	-0.096	0.463	No
Hilsenhoff Biotic Index	Porewater	Calcium	0.085	0.516	No
Hilsenhoff Biotic Index	Porewater	Chromium	0.199	0.124	No
Hilsenhoff Biotic Index	Porewater	Cobalt	0.081	0.534	No
Hilsenhoff Biotic Index	Porewater	Copper	-0.236	0.067	No
Hilsenhoff Biotic Index	Porewater	Iron	-0.213	0.099	No
Hilsenhoff Biotic Index	Porewater	Lead	-0.178	0.171	No
Hilsenhoff Biotic Index	Porewater	Magnesium	0.002	0.985	No
Hilsenhoff Biotic Index	Porewater	Manganese	0.012	0.926	No
Hilsenhoff Biotic Index	Porewater	Nickel	0.041	0.752	No
Hilsenhoff Biotic Index	Porewater	Potassium	0.06	0.648	No
Hilsenhoff Biotic Index	Porewater	Sodium	0.01	0.939	No
Hilsenhoff Biotic Index	Porewater	Vanadium	0.062	0.634	No
Hilsenhoff Biotic Index	Porewater	Zinc	-0.018	0.892	No
% Chironomidae	Porewater	Aluminum	-0.021	0.874	No
% Chironomidae	Porewater	Antimony	0.18	0.166	No
% Chironomidae	Porewater	Arsenic	0.14	0.282	No
% Chironomidae	Porewater	Barium	-0.2	0.123	No
% Chironomidae	Porewater	Cadmium	0	0.997	No
% Chironomidae	Porewater	Calcium	-0.136	0.295	No
% Chironomidae	Porewater	Chromium	-0.219	0.09	No
% Chironomidae	Porewater	Cobalt	-0.353	0.005	No
% Chironomidae	Porewater	Copper	0.334	0.008	Yes
% Chironomidae	Porewater	Iron	0.016	0.905	No
% Chironomidae	Porewater	Lead	0.122	0.347	No
% Chironomidae	Porewater	Magnesium	-0.141	0.278	No
% Chironomidae	Porewater	Manganese	-0.36	0.004	No
% Chironomidae	Porewater	Nickel	-0.128	0.327	No
% Chironomidae	Porewater	Potassium	-0.049	0.707	No
% Chironomidae	Porewater	Sodium	0.169	0.192	No
% Chironomidae	Porewater	Vanadium	0.029	0.823	No
% Chironomidae	Porewater	Zinc	-0.025	0.849	No
Community Metrics PC1	Porewater	Aluminum	0.096	0.464	No
Community Metrics PC1	Porewater	Antimony	-0.02	0.877	No
Community Metrics PC1	Porewater	Arsenic	0.143	0.272	No
Community Metrics PC1	Porewater	Barium	0.41	0.001	No
Community Metrics PC1	Porewater	Cadmium	0.031	0.814	No
Community Metrics PC1	Porewater	Calcium	0.203	0.116	No
Community Metrics PC1	Porewater	Chromium	-0.005	0.967	No
Community Metrics PC1	Porewater	Cobalt	0.416	0.001	No
Community Metrics PC1	Porewater	Copper	-0.243	0.059	No
Community Metrics PC1	Porewater	Iron	0.115	0.378	No
Community Metrics PC1	Porewater	Lead	0.001	0.993	No
Community Metrics PC1	Porewater	Magnesium	-0.03	0.817	No
Community Metrics PC1	Porewater	Manganese	0.455	0	No
Community Metrics PC1	Porewater	Nickel	-0.004	0.976	No
Community Metrics PC1	Porewater	Potassium	0.376	0.003	No
Community Metrics PC1	Porewater	Sodium	0.004	0.977	No
Community Metrics PC1	Porewater	Vanadium	0.188	0.146	No
Community Metrics PC1	Porewater	Zinc	-0.124	0.341	No

Table K2-1
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Community Metrics PC2	Porewater	Aluminum	0.07	0.591	No
Community Metrics PC2	Porewater	Antimony	0.123	0.344	No
Community Metrics PC2	Porewater	Arsenic	0.306	0.016	Yes
Community Metrics PC2	Porewater	Barium	0.138	0.288	No
Community Metrics PC2	Porewater	Cadmium	-0.009	0.943	No

Table K2-1

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Community Metrics PC2	Porewater	Calcium	0.029	0.825	No
Community Metrics PC2	Porewater	Chromium	-0.128	0.326	No
Community Metrics PC2	Porewater	Cobalt	-0.079	0.545	No
Community Metrics PC2	Porewater	Copper	0.15	0.25	No
Community Metrics PC2	Porewater	Iron	0.029	0.822	No
Community Metrics PC2	Porewater	Lead	0.241	0.062	No
Community Metrics PC2	Porewater	Magnesium	-0.157	0.226	No
Community Metrics PC2	Porewater	Manganese	0.051	0.696	No
Community Metrics PC2	Porewater	Nickel	-0.25	0.052	No
Community Metrics PC2	Porewater	Potassium	0.297	0.02	No
Community Metrics PC2	Porewater	Sodium	0.227	0.079	No
Community Metrics PC2	Porewater	Vanadium	0.27	0.036	No
Community Metrics PC2	Porewater	Zinc	0.059	0.651	No

Notes:

CS50 - medium, coarse, and very coarse sand greater than 50 percent of substrate

log10 - base 10 logarithm

mg/kg - milligram per kilogram

PC - principal component

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
with Non-CS50 Substrate
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Total Abundance	Sediment	Aluminum, Sediment (mg/kg)	0.096	0.639	No
Total Abundance	Sediment	Antimony, Sediment (mg/kg)	-0.356	0.075	No
Total Abundance	Sediment	Arsenic, Sediment (mg/kg)	0.1	0.627	No
Total Abundance	Sediment	Barium, Sediment (mg/kg)	-0.097	0.637	No
Total Abundance	Sediment	Beryllium, Sediment (mg/kg)	0.069	0.736	No
Total Abundance	Sediment	Cadmium, Sediment (mg/kg)	0.2	0.326	No
Total Abundance	Sediment	Calcium, Sediment (mg/kg)	-0.197	0.334	No
Total Abundance	Sediment	Chromium, Sediment (mg/kg)	-0.086	0.673	No
Total Abundance	Sediment	Cobalt, Sediment (mg/kg)	-0.087	0.673	No
Total Abundance	Sediment	Copper, Sediment (mg/kg)	-0.291	0.149	No
Total Abundance	Sediment	Iron, Sediment (mg/kg)	-0.178	0.385	No
Total Abundance	Sediment	Lead, Sediment (mg/kg)	0.103	0.618	No
Total Abundance	Sediment	Magnesium, Sediment (mg/kg)	0.104	0.612	No
Total Abundance	Sediment	Manganese, Sediment (mg/kg)	-0.311	0.122	No
Total Abundance	Sediment	Mercury, Sediment (mg/kg)	0.143	0.485	No
Total Abundance	Sediment	Nickel, Sediment (mg/kg)	0.399	0.043	No
Total Abundance	Sediment	Potassium, Sediment (mg/kg)	0.086	0.673	No
Total Abundance	Sediment	Selenium, Sediment (mg/kg)	-0.031	0.882	No
Total Abundance	Sediment	Silver, Sediment (mg/kg)	-0.045	0.828	No
Total Abundance	Sediment	Sodium, Sediment (mg/kg)	-0.375	0.059	No
Total Abundance	Sediment	Thallium, Sediment (mg/kg)	0.27	0.182	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Total Abundance	Sediment	Vanadium, Sediment (mg/kg)	0.129	0.531	No
Total Abundance	Sediment	Zinc, Sediment (mg/kg)	-0.35	0.08	No
Density	Sediment	Aluminum, Sediment (mg/kg)	-0.003	0.989	No
Density	Sediment	Antimony, Sediment (mg/kg)	-0.324	0.106	No
Density	Sediment	Arsenic, Sediment (mg/kg)	0.059	0.773	No
Density	Sediment	Barium, Sediment (mg/kg)	-0.135	0.509	No
Density	Sediment	Beryllium, Sediment (mg/kg)	-0.029	0.888	No
Density	Sediment	Cadmium, Sediment (mg/kg)	0.147	0.471	No
Density	Sediment	Calcium, Sediment (mg/kg)	-0.18	0.377	No
Density	Sediment	Chromium, Sediment (mg/kg)	-0.19	0.35	No
Density	Sediment	Cobalt, Sediment (mg/kg)	-0.179	0.383	No
Density	Sediment	Copper, Sediment (mg/kg)	-0.276	0.173	No
Density	Sediment	Iron, Sediment (mg/kg)	-0.146	0.476	No
Density	Sediment	Lead, Sediment (mg/kg)	0.094	0.649	No
Density	Sediment	Magnesium, Sediment (mg/kg)	0.039	0.85	No
Density	Sediment	Manganese, Sediment (mg/kg)	-0.278	0.169	No
Density	Sediment	Mercury, Sediment (mg/kg)	0.09	0.662	No
Density	Sediment	Nickel, Sediment (mg/kg)	0.221	0.278	No
Density	Sediment	Potassium, Sediment (mg/kg)	-0.015	0.944	No
Density	Sediment	Selenium, Sediment (mg/kg)	-0.066	0.747	No
Density	Sediment	Silver, Sediment (mg/kg)	-0.075	0.715	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Density	Sediment	Sodium, Sediment (mg/kg)	-0.38	0.056	No
Density	Sediment	Thallium, Sediment (mg/kg)	0.119	0.56	No
Density	Sediment	Vanadium, Sediment (mg/kg)	0.006	0.975	No
Density	Sediment	Zinc, Sediment (mg/kg)	-0.306	0.128	No
Counted Blotted Mass	Sediment	Aluminum, Sediment (mg/kg)	-0.102	0.618	No
Counted Blotted Mass	Sediment	Antimony, Sediment (mg/kg)	0.138	0.501	No
Counted Blotted Mass	Sediment	Arsenic, Sediment (mg/kg)	0.439	0.025	No
Counted Blotted Mass	Sediment	Barium, Sediment (mg/kg)	0.584	0.002	No
Counted Blotted Mass	Sediment	Beryllium, Sediment (mg/kg)	0.034	0.87	No
Counted Blotted Mass	Sediment	Cadmium, Sediment (mg/kg)	0.689	0	No
Counted Blotted Mass	Sediment	Calcium, Sediment (mg/kg)	0.449	0.022	No
Counted Blotted Mass	Sediment	Chromium, Sediment (mg/kg)	0.024	0.91	No
Counted Blotted Mass	Sediment	Cobalt, Sediment (mg/kg)	-0.135	0.509	No
Counted Blotted Mass	Sediment	Copper, Sediment (mg/kg)	0.102	0.622	No
Counted Blotted Mass	Sediment	Iron, Sediment (mg/kg)	0.314	0.118	No
Counted Blotted Mass	Sediment	Lead, Sediment (mg/kg)	0.616	0.001	No
Counted Blotted Mass	Sediment	Magnesium, Sediment (mg/kg)	0.686	0	No
Counted Blotted Mass	Sediment	Manganese, Sediment (mg/kg)	0.185	0.365	No
Counted Blotted Mass	Sediment	Mercury, Sediment (mg/kg)	0.614	0.001	No
Counted Blotted Mass	Sediment	Nickel, Sediment (mg/kg)	0.109	0.596	No
Counted Blotted Mass	Sediment	Potassium, Sediment (mg/kg)	-0.166	0.415	No

Table K2-2
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Counted Blotted Mass	Sediment	Selenium, Sediment (mg/kg)	0.403	0.041	No
Counted Blotted Mass	Sediment	Silver, Sediment (mg/kg)	0.303	0.133	No
Counted Blotted Mass	Sediment	Sodium, Sediment (mg/kg)	-0.248	0.222	No
Counted Blotted Mass	Sediment	Thallium, Sediment (mg/kg)	0.506	0.009	No
Counted Blotted Mass	Sediment	Vanadium, Sediment (mg/kg)	0.188	0.357	No
Counted Blotted Mass	Sediment	Zinc, Sediment (mg/kg)	0.23	0.257	No
Species Richness	Sediment	Aluminum, Sediment (mg/kg)	-0.029	0.889	No
Species Richness	Sediment	Antimony, Sediment (mg/kg)	0.161	0.431	No
Species Richness	Sediment	Arsenic, Sediment (mg/kg)	0.101	0.625	No
Species Richness	Sediment	Barium, Sediment (mg/kg)	0.203	0.321	No
Species Richness	Sediment	Beryllium, Sediment (mg/kg)	-0.069	0.738	No
Species Richness	Sediment	Cadmium, Sediment (mg/kg)	0.37	0.063	No
Species Richness	Sediment	Calcium, Sediment (mg/kg)	0.275	0.174	No
Species Richness	Sediment	Chromium, Sediment (mg/kg)	-0.009	0.964	No
Species Richness	Sediment	Cobalt, Sediment (mg/kg)	-0.103	0.615	No
Species Richness	Sediment	Copper, Sediment (mg/kg)	0.166	0.417	No
Species Richness	Sediment	Iron, Sediment (mg/kg)	0.212	0.298	No
Species Richness	Sediment	Lead, Sediment (mg/kg)	0.304	0.131	No
Species Richness	Sediment	Magnesium, Sediment (mg/kg)	0.384	0.053	No
Species Richness	Sediment	Manganese, Sediment (mg/kg)	0.198	0.332	No
Species Richness	Sediment	Mercury, Sediment (mg/kg)	0.337	0.093	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Species Richness	Sediment	Nickel, Sediment (mg/kg)	-0.155	0.45	No
Species Richness	Sediment	Potassium, Sediment (mg/kg)	-0.038	0.855	No
Species Richness	Sediment	Selenium, Sediment (mg/kg)	0.105	0.609	No
Species Richness	Sediment	Silver, Sediment (mg/kg)	0.242	0.233	No
Species Richness	Sediment	Sodium, Sediment (mg/kg)	-0.051	0.805	No
Species Richness	Sediment	Thallium, Sediment (mg/kg)	0.088	0.669	No
Species Richness	Sediment	Vanadium, Sediment (mg/kg)	0.026	0.899	No
Species Richness	Sediment	Zinc, Sediment (mg/kg)	0.15	0.464	No
Predator Richness	Sediment	Aluminum, Sediment (mg/kg)	-0.111	0.59	No
Predator Richness	Sediment	Antimony, Sediment (mg/kg)	0.372	0.061	No
Predator Richness	Sediment	Arsenic, Sediment (mg/kg)	0.014	0.946	No
Predator Richness	Sediment	Barium, Sediment (mg/kg)	0.182	0.373	No
Predator Richness	Sediment	Beryllium, Sediment (mg/kg)	-0.211	0.302	No
Predator Richness	Sediment	Cadmium, Sediment (mg/kg)	0.174	0.395	No
Predator Richness	Sediment	Calcium, Sediment (mg/kg)	0.441	0.024	No
Predator Richness	Sediment	Chromium, Sediment (mg/kg)	-0.056	0.786	No
Predator Richness	Sediment	Cobalt, Sediment (mg/kg)	-0.104	0.612	No
Predator Richness	Sediment	Copper, Sediment (mg/kg)	0.361	0.07	No
Predator Richness	Sediment	Iron, Sediment (mg/kg)	0.33	0.1	No
Predator Richness	Sediment	Lead, Sediment (mg/kg)	0.204	0.319	No
Predator Richness	Sediment	Magnesium, Sediment (mg/kg)	0.32	0.111	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Predator Richness	Sediment	Manganese, Sediment (mg/kg)	0.442	0.024	No
Predator Richness	Sediment	Mercury, Sediment (mg/kg)	0.165	0.422	No
Predator Richness	Sediment	Nickel, Sediment (mg/kg)	-0.423	0.031	Yes
Predator Richness	Sediment	Potassium, Sediment (mg/kg)	-0.117	0.57	No
Predator Richness	Sediment	Selenium, Sediment (mg/kg)	0.011	0.959	No
Predator Richness	Sediment	Silver, Sediment (mg/kg)	0.156	0.447	No
Predator Richness	Sediment	Sodium, Sediment (mg/kg)	0.116	0.571	No
Predator Richness	Sediment	Thallium, Sediment (mg/kg)	-0.164	0.423	No
Predator Richness	Sediment	Vanadium, Sediment (mg/kg)	-0.126	0.539	No
Predator Richness	Sediment	Zinc, Sediment (mg/kg)	0.388	0.05	No
Shannon-Weaver H' (log 10)	Sediment	Aluminum, Sediment (mg/kg)	0.224	0.271	No
Shannon-Weaver H' (log 10)	Sediment	Antimony, Sediment (mg/kg)	0.446	0.022	No
Shannon-Weaver H' (log 10)	Sediment	Arsenic, Sediment (mg/kg)	0.353	0.077	No
Shannon-Weaver H' (log 10)	Sediment	Barium, Sediment (mg/kg)	0.431	0.028	No
Shannon-Weaver H' (log 10)	Sediment	Beryllium, Sediment (mg/kg)	0.176	0.391	No
Shannon-Weaver H' (log 10)	Sediment	Cadmium, Sediment (mg/kg)	0.38	0.055	No
Shannon-Weaver H' (log 10)	Sediment	Calcium, Sediment (mg/kg)	0.376	0.058	No
Shannon-Weaver H' (log 10)	Sediment	Chromium, Sediment (mg/kg)	0.275	0.173	No
Shannon-Weaver H' (log 10)	Sediment	Cobalt, Sediment (mg/kg)	0.229	0.261	No
Shannon-Weaver H' (log 10)	Sediment	Copper, Sediment (mg/kg)	0.466	0.016	No
Shannon-Weaver H' (log 10)	Sediment	Iron, Sediment (mg/kg)	0.475	0.014	No

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Shannon-Weaver H' (log 10)	Sediment	Lead, Sediment (mg/kg)	0.477	0.014	No
Shannon-Weaver H' (log 10)	Sediment	Magnesium, Sediment (mg/kg)	0.278	0.169	No
Shannon-Weaver H' (log 10)	Sediment	Manganese, Sediment (mg/kg)	0.49	0.011	No
Shannon-Weaver H' (log 10)	Sediment	Mercury, Sediment (mg/kg)	0.394	0.046	No
Shannon-Weaver H' (log 10)	Sediment	Nickel, Sediment (mg/kg)	-0.236	0.246	No
Shannon-Weaver H' (log 10)	Sediment	Potassium, Sediment (mg/kg)	0.158	0.44	No
Shannon-Weaver H' (log 10)	Sediment	Selenium, Sediment (mg/kg)	0.37	0.063	No
Shannon-Weaver H' (log 10)	Sediment	Silver, Sediment (mg/kg)	0.532	0.005	No
Shannon-Weaver H' (log 10)	Sediment	Sodium, Sediment (mg/kg)	0.428	0.029	No
Shannon-Weaver H' (log 10)	Sediment	Thallium, Sediment (mg/kg)	0.076	0.711	No
Shannon-Weaver H' (log 10)	Sediment	Vanadium, Sediment (mg/kg)	0.215	0.291	No
Shannon-Weaver H' (log 10)	Sediment	Zinc, Sediment (mg/kg)	0.441	0.024	No
% Dominant Taxon	Sediment	Aluminum, Sediment (mg/kg)	-0.287	0.155	No
% Dominant Taxon	Sediment	Antimony, Sediment (mg/kg)	-0.368	0.064	No
% Dominant Taxon	Sediment	Arsenic, Sediment (mg/kg)	-0.419	0.033	No
% Dominant Taxon	Sediment	Barium, Sediment (mg/kg)	-0.502	0.01	No
% Dominant Taxon	Sediment	Beryllium, Sediment (mg/kg)	-0.267	0.187	No
% Dominant Taxon	Sediment	Cadmium, Sediment (mg/kg)	-0.409	0.039	No
% Dominant Taxon	Sediment	Calcium, Sediment (mg/kg)	-0.352	0.079	No
% Dominant Taxon	Sediment	Chromium, Sediment (mg/kg)	-0.289	0.152	No
% Dominant Taxon	Sediment	Cobalt, Sediment (mg/kg)	-0.242	0.234	No

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Dominant Taxon	Sediment	Copper, Sediment (mg/kg)	-0.377	0.058	No
% Dominant Taxon	Sediment	Iron, Sediment (mg/kg)	-0.422	0.032	No
% Dominant Taxon	Sediment	Lead, Sediment (mg/kg)	-0.515	0.007	No
% Dominant Taxon	Sediment	Magnesium, Sediment (mg/kg)	-0.271	0.181	No
% Dominant Taxon	Sediment	Manganese, Sediment (mg/kg)	-0.414	0.035	No
% Dominant Taxon	Sediment	Mercury, Sediment (mg/kg)	-0.444	0.023	No
% Dominant Taxon	Sediment	Nickel, Sediment (mg/kg)	0.126	0.541	No
% Dominant Taxon	Sediment	Potassium, Sediment (mg/kg)	-0.218	0.284	No
% Dominant Taxon	Sediment	Selenium, Sediment (mg/kg)	-0.455	0.019	No
% Dominant Taxon	Sediment	Silver, Sediment (mg/kg)	-0.523	0.007	No
% Dominant Taxon	Sediment	Sodium, Sediment (mg/kg)	-0.437	0.026	No
% Dominant Taxon	Sediment	Thallium, Sediment (mg/kg)	-0.17	0.405	No
% Dominant Taxon	Sediment	Vanadium, Sediment (mg/kg)	-0.332	0.097	No
% Dominant Taxon	Sediment	Zinc, Sediment (mg/kg)	-0.394	0.048	No
Metals Tolerance Index	Sediment	Aluminum, Sediment (mg/kg)	0.253	0.211	No
Metals Tolerance Index	Sediment	Antimony, Sediment (mg/kg)	-0.684	0	No
Metals Tolerance Index	Sediment	Arsenic, Sediment (mg/kg)	0.047	0.819	No
Metals Tolerance Index	Sediment	Barium, Sediment (mg/kg)	-0.027	0.896	No
Metals Tolerance Index	Sediment	Beryllium, Sediment (mg/kg)	0.297	0.14	No
Metals Tolerance Index	Sediment	Cadmium, Sediment (mg/kg)	-0.067	0.743	No
Metals Tolerance Index	Sediment	Calcium, Sediment (mg/kg)	-0.307	0.127	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Metals Tolerance Index	Sediment	Chromium, Sediment (mg/kg)	-0.112	0.583	No
Metals Tolerance Index	Sediment	Cobalt, Sediment (mg/kg)	-0.14	0.494	No
Metals Tolerance Index	Sediment	Copper, Sediment (mg/kg)	-0.649	0	No
Metals Tolerance Index	Sediment	Iron, Sediment (mg/kg)	-0.561	0.003	No
Metals Tolerance Index	Sediment	Lead, Sediment (mg/kg)	-0.143	0.487	No
Metals Tolerance Index	Sediment	Magnesium, Sediment (mg/kg)	-0.036	0.862	No
Metals Tolerance Index	Sediment	Manganese, Sediment (mg/kg)	-0.636	0	No
Metals Tolerance Index	Sediment	Mercury, Sediment (mg/kg)	-0.025	0.904	No
Metals Tolerance Index	Sediment	Nickel, Sediment (mg/kg)	0.71	0	Yes
Metals Tolerance Index	Sediment	Potassium, Sediment (mg/kg)	0.275	0.173	No
Metals Tolerance Index	Sediment	Selenium, Sediment (mg/kg)	0.05	0.808	No
Metals Tolerance Index	Sediment	Silver, Sediment (mg/kg)	-0.266	0.188	No
Metals Tolerance Index	Sediment	Sodium, Sediment (mg/kg)	-0.448	0.022	No
Metals Tolerance Index	Sediment	Thallium, Sediment (mg/kg)	0.372	0.062	No
Metals Tolerance Index	Sediment	Vanadium, Sediment (mg/kg)	0.434	0.027	Yes
Metals Tolerance Index	Sediment	Zinc, Sediment (mg/kg)	-0.602	0.001	No
Hilsenhoff Biotic Index	Sediment	Aluminum, Sediment (mg/kg)	0.121	0.556	No
Hilsenhoff Biotic Index	Sediment	Antimony, Sediment (mg/kg)	-0.121	0.557	No
Hilsenhoff Biotic Index	Sediment	Arsenic, Sediment (mg/kg)	0.417	0.034	Yes
Hilsenhoff Biotic Index	Sediment	Barium, Sediment (mg/kg)	0.616	0.001	Yes
Hilsenhoff Biotic Index	Sediment	Beryllium, Sediment (mg/kg)	0.303	0.133	No

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Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Hilsenhoff Biotic Index	Sediment	Cadmium, Sediment (mg/kg)	0.51	0.008	Yes
Hilsenhoff Biotic Index	Sediment	Calcium, Sediment (mg/kg)	0.182	0.371	No
Hilsenhoff Biotic Index	Sediment	Chromium, Sediment (mg/kg)	0.112	0.585	No
Hilsenhoff Biotic Index	Sediment	Cobalt, Sediment (mg/kg)	-0.109	0.597	No
Hilsenhoff Biotic Index	Sediment	Copper, Sediment (mg/kg)	-0.087	0.672	No
Hilsenhoff Biotic Index	Sediment	Iron, Sediment (mg/kg)	0.019	0.926	No
Hilsenhoff Biotic Index	Sediment	Lead, Sediment (mg/kg)	0.476	0.014	Yes
Hilsenhoff Biotic Index	Sediment	Magnesium, Sediment (mg/kg)	0.484	0.012	Yes
Hilsenhoff Biotic Index	Sediment	Manganese, Sediment (mg/kg)	-0.14	0.495	No
Hilsenhoff Biotic Index	Sediment	Mercury, Sediment (mg/kg)	0.51	0.008	Yes
Hilsenhoff Biotic Index	Sediment	Nickel, Sediment (mg/kg)	0.317	0.115	No
Hilsenhoff Biotic Index	Sediment	Potassium, Sediment (mg/kg)	0.056	0.787	No
Hilsenhoff Biotic Index	Sediment	Selenium, Sediment (mg/kg)	0.544	0.004	Yes
Hilsenhoff Biotic Index	Sediment	Silver, Sediment (mg/kg)	0.4	0.044	Yes
Hilsenhoff Biotic Index	Sediment	Sodium, Sediment (mg/kg)	-0.306	0.128	No
Hilsenhoff Biotic Index	Sediment	Thallium, Sediment (mg/kg)	0.549	0.004	Yes
Hilsenhoff Biotic Index	Sediment	Vanadium, Sediment (mg/kg)	0.463	0.017	Yes
Hilsenhoff Biotic Index	Sediment	Zinc, Sediment (mg/kg)	-0.081	0.693	No
% Chironomidae	Sediment	Aluminum, Sediment (mg/kg)	0.307	0.127	No
% Chironomidae	Sediment	Antimony, Sediment (mg/kg)	0.517	0.007	Yes
% Chironomidae	Sediment	Arsenic, Sediment (mg/kg)	0.077	0.709	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Chironomidae	Sediment	Barium, Sediment (mg/kg)	0.181	0.376	No
% Chironomidae	Sediment	Beryllium, Sediment (mg/kg)	0.213	0.297	No
% Chironomidae	Sediment	Cadmium, Sediment (mg/kg)	0.199	0.33	No
% Chironomidae	Sediment	Calcium, Sediment (mg/kg)	0.057	0.783	No
% Chironomidae	Sediment	Chromium, Sediment (mg/kg)	0.526	0.006	Yes
% Chironomidae	Sediment	Cobalt, Sediment (mg/kg)	0.366	0.066	No
% Chironomidae	Sediment	Copper, Sediment (mg/kg)	0.582	0.002	Yes
% Chironomidae	Sediment	Iron, Sediment (mg/kg)	0.473	0.015	Yes
% Chironomidae	Sediment	Lead, Sediment (mg/kg)	0.185	0.366	No
% Chironomidae	Sediment	Magnesium, Sediment (mg/kg)	0.05	0.81	No
% Chironomidae	Sediment	Manganese, Sediment (mg/kg)	0.512	0.007	Yes
% Chironomidae	Sediment	Mercury, Sediment (mg/kg)	0.189	0.356	No
% Chironomidae	Sediment	Nickel, Sediment (mg/kg)	-0.275	0.174	No
% Chironomidae	Sediment	Potassium, Sediment (mg/kg)	0.29	0.15	No
% Chironomidae	Sediment	Selenium, Sediment (mg/kg)	0.215	0.292	No
% Chironomidae	Sediment	Silver, Sediment (mg/kg)	0.618	0.001	Yes
% Chironomidae	Sediment	Sodium, Sediment (mg/kg)	0.532	0.005	Yes
% Chironomidae	Sediment	Thallium, Sediment (mg/kg)	-0.011	0.956	No
% Chironomidae	Sediment	Vanadium, Sediment (mg/kg)	0.036	0.86	No
% Chironomidae	Sediment	Zinc, Sediment (mg/kg)	0.384	0.053	No
Total Abundance	Porewater	Aluminum	-0.112	0.585	No
Total Abundance	Porewater	Antimony	-0.399	0.044	Yes
Total Abundance	Porewater	Arsenic	0.049	0.812	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Total Abundance	Porewater	Barium	0.137	0.505	No
Total Abundance	Porewater	Cadmium	0.14	0.496	No
Total Abundance	Porewater	Calcium	0.212	0.298	No
Total Abundance	Porewater	Chromium	0.127	0.537	No
Total Abundance	Porewater	Cobalt	0.345	0.084	No
Total Abundance	Porewater	Copper	-0.281	0.164	No
Total Abundance	Porewater	Iron	0.18	0.379	No
Total Abundance	Porewater	Lead	-0.188	0.357	No
Total Abundance	Porewater	Magnesium	0.319	0.112	No
Total Abundance	Porewater	Manganese	0.441	0.024	No
Total Abundance	Porewater	Nickel	0.254	0.21	No
Total Abundance	Porewater	Potassium	-0.085	0.679	No
Total Abundance	Porewater	Sodium	-0.324	0.107	No
Total Abundance	Porewater	Vanadium	-0.146	0.476	No
Total Abundance	Porewater	Zinc	0.032	0.877	No
Density	Porewater	Aluminum	-0.17	0.405	No
Density	Porewater	Antimony	-0.357	0.074	No
Density	Porewater	Arsenic	-0.018	0.931	No
Density	Porewater	Barium	0.139	0.498	No
Density	Porewater	Cadmium	0.034	0.869	No
Density	Porewater	Calcium	0.221	0.276	No
Density	Porewater	Chromium	0.066	0.747	No
Density	Porewater	Cobalt	0.205	0.315	No
Density	Porewater	Copper	-0.308	0.125	No
Density	Porewater	Iron	0.037	0.859	No
Density	Porewater	Lead	-0.24	0.236	No
Density	Porewater	Magnesium	0.312	0.121	No
Density	Porewater	Manganese	0.341	0.089	No
Density	Porewater	Nickel	0.154	0.453	No
Density	Porewater	Potassium	0.016	0.937	No
Density	Porewater	Sodium	-0.26	0.199	No
Density	Porewater	Vanadium	-0.15	0.464	No
Density	Porewater	Zinc	-0.056	0.785	No
Counted Blotted Mass	Porewater	Aluminum	-0.625	0.001	Yes
Counted Blotted Mass	Porewater	Antimony	-0.039	0.852	No
Counted Blotted Mass	Porewater	Arsenic	0.472	0.016	No
Counted Blotted Mass	Porewater	Barium	0.619	0.001	No
Counted Blotted Mass	Porewater	Cadmium	-0.08	0.697	No
Counted Blotted Mass	Porewater	Calcium	0.593	0.002	No
Counted Blotted Mass	Porewater	Chromium	-0.377	0.058	No
Counted Blotted Mass	Porewater	Cobalt	0.273	0.177	No
Counted Blotted Mass	Porewater	Copper	-0.244	0.229	No
Counted Blotted Mass	Porewater	Iron	0.303	0.132	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Counted Blotted Mass	Porewater	Lead	-0.184	0.368	No
Counted Blotted Mass	Porewater	Magnesium	0.479	0.014	No
Counted Blotted Mass	Porewater	Manganese	0.364	0.068	No
Counted Blotted Mass	Porewater	Nickel	-0.008	0.968	No
Counted Blotted Mass	Porewater	Potassium	0.35	0.079	No
Counted Blotted Mass	Porewater	Sodium	0.117	0.571	No
Counted Blotted Mass	Porewater	Vanadium	-0.068	0.74	No
Counted Blotted Mass	Porewater	Zinc	0.044	0.83	No
Species Richness	Porewater	Aluminum	-0.35	0.08	No
Species Richness	Porewater	Antimony	0.21	0.303	No
Species Richness	Porewater	Arsenic	0.337	0.093	No
Species Richness	Porewater	Barium	0.367	0.065	No
Species Richness	Porewater	Cadmium	0.105	0.611	No
Species Richness	Porewater	Calcium	0.342	0.087	No
Species Richness	Porewater	Chromium	-0.256	0.207	No
Species Richness	Porewater	Cobalt	0.178	0.386	No
Species Richness	Porewater	Copper	0.03	0.884	No
Species Richness	Porewater	Iron	-0.011	0.959	No
Species Richness	Porewater	Lead	0.078	0.704	No
Species Richness	Porewater	Magnesium	0.156	0.447	No
Species Richness	Porewater	Manganese	0.196	0.338	No
Species Richness	Porewater	Nickel	-0.22	0.28	No
Species Richness	Porewater	Potassium	0.203	0.319	No
Species Richness	Porewater	Sodium	-0.092	0.655	No
Species Richness	Porewater	Vanadium	0.181	0.376	No
Species Richness	Porewater	Zinc	0.129	0.531	No
Predator Richness	Porewater	Aluminum	-0.151	0.462	No
Predator Richness	Porewater	Antimony	0.51	0.008	No
Predator Richness	Porewater	Arsenic	0.26	0.2	No
Predator Richness	Porewater	Barium	0.204	0.317	No
Predator Richness	Porewater	Cadmium	0.025	0.902	No
Predator Richness	Porewater	Calcium	0.161	0.433	No
Predator Richness	Porewater	Chromium	-0.322	0.108	No
Predator Richness	Porewater	Cobalt	-0.059	0.776	No
Predator Richness	Porewater	Copper	0.189	0.356	No
Predator Richness	Porewater	Iron	-0.274	0.175	No
Predator Richness	Porewater	Lead	0.318	0.113	No
Predator Richness	Porewater	Magnesium	-0.076	0.711	No
Predator Richness	Porewater	Manganese	-0.078	0.706	No
Predator Richness	Porewater	Nickel	-0.475	0.014	Yes
Predator Richness	Porewater	Potassium	0.26	0.199	No
Predator Richness	Porewater	Sodium	-0.04	0.847	No
Predator Richness	Porewater	Vanadium	0.332	0.098	No

Table K2-2
Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
Predator Richness	Porewater	Zinc	0.101	0.624	No
Shannon-Weaver H' (log 10)	Porewater	Aluminum	-0.248	0.223	No
Shannon-Weaver H' (log 10)	Porewater	Antimony	0.565	0.003	No
Shannon-Weaver H' (log 10)	Porewater	Arsenic	0.434	0.027	No
Shannon-Weaver H' (log 10)	Porewater	Barium	0.336	0.094	No
Shannon-Weaver H' (log 10)	Porewater	Cadmium	0.339	0.09	No
Shannon-Weaver H' (log 10)	Porewater	Calcium	0.266	0.189	No
Shannon-Weaver H' (log 10)	Porewater	Chromium	-0.092	0.656	No
Shannon-Weaver H' (log 10)	Porewater	Cobalt	0.099	0.629	No
Shannon-Weaver H' (log 10)	Porewater	Copper	0.369	0.064	No
Shannon-Weaver H' (log 10)	Porewater	Iron	-0.037	0.856	No
Shannon-Weaver H' (log 10)	Porewater	Lead	0.31	0.124	No
Shannon-Weaver H' (log 10)	Porewater	Magnesium	0.045	0.828	No
Shannon-Weaver H' (log 10)	Porewater	Manganese	0.075	0.716	No
Shannon-Weaver H' (log 10)	Porewater	Nickel	-0.368	0.065	No
Shannon-Weaver H' (log 10)	Porewater	Potassium	0.081	0.696	No
Shannon-Weaver H' (log 10)	Porewater	Sodium	-0.129	0.531	No
Shannon-Weaver H' (log 10)	Porewater	Vanadium	0.289	0.153	No
Shannon-Weaver H' (log 10)	Porewater	Zinc	0.119	0.563	No
% Dominant Taxon	Porewater	Aluminum	0.283	0.16	No
% Dominant Taxon	Porewater	Antimony	-0.491	0.012	No
% Dominant Taxon	Porewater	Arsenic	-0.413	0.037	No
% Dominant Taxon	Porewater	Barium	-0.321	0.11	No
% Dominant Taxon	Porewater	Cadmium	-0.282	0.163	No
% Dominant Taxon	Porewater	Calcium	-0.278	0.169	No
% Dominant Taxon	Porewater	Chromium	0.006	0.975	No
% Dominant Taxon	Porewater	Cobalt	-0.138	0.502	No
% Dominant Taxon	Porewater	Copper	-0.272	0.179	No
% Dominant Taxon	Porewater	Iron	-0.082	0.691	No
% Dominant Taxon	Porewater	Lead	-0.216	0.288	No
% Dominant Taxon	Porewater	Magnesium	-0.138	0.498	No

Table K2-2

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations with Non-CS50 Substrate

Upper Columbia River

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Dominant Taxon	Porewater	Manganese	-0.147	0.474	No
% Dominant Taxon	Porewater	Nickel	0.241	0.235	No
% Dominant Taxon	Porewater	Potassium	-0.029	0.888	No
% Dominant Taxon	Porewater	Sodium	0.171	0.404	No
% Dominant Taxon	Porewater	Vanadium	-0.21	0.304	No
% Dominant Taxon	Porewater	Zinc	-0.077	0.707	No
Metals Tolerance Index	Porewater	Aluminum	-0.102	0.618	No
Metals Tolerance Index	Porewater	Antimony	-0.644	0.001	No
Metals Tolerance Index	Porewater	Arsenic	-0.231	0.256	No
Metals Tolerance Index	Porewater	Barium	-0.179	0.381	No
Metals Tolerance Index	Porewater	Cadmium	-0.336	0.093	No
Metals Tolerance Index	Porewater	Calcium	0.168	0.411	No
Metals Tolerance Index	Porewater	Chromium	0.353	0.077	No
Metals Tolerance Index	Porewater	Cobalt	0.347	0.083	No
Metals Tolerance Index	Porewater	Copper	-0.65	0	No
Metals Tolerance Index	Porewater	Iron	0.414	0.035	Yes
Metals Tolerance Index	Porewater	Lead	-0.575	0.003	No
Metals Tolerance Index	Porewater	Magnesium	0.486	0.013	Yes
Metals Tolerance Index	Porewater	Manganese	0.543	0.004	Yes
Metals Tolerance Index	Porewater	Nickel	0.734	0	Yes
Metals Tolerance Index	Porewater	Potassium	-0.207	0.311	No
Metals Tolerance Index	Porewater	Sodium	-0.286	0.157	No
Metals Tolerance Index	Porewater	Vanadium	-0.238	0.242	No
Metals Tolerance Index	Porewater	Zinc	-0.101	0.622	No
Hilsenhoff Biotic Index	Porewater	Aluminum	-0.559	0.003	No
Hilsenhoff Biotic Index	Porewater	Antimony	-0.169	0.409	No
Hilsenhoff Biotic Index	Porewater	Arsenic	0.394	0.048	Yes
Hilsenhoff Biotic Index	Porewater	Barium	0.515	0.007	Yes
Hilsenhoff Biotic Index	Porewater	Cadmium	-0.064	0.756	No
Hilsenhoff Biotic Index	Porewater	Calcium	0.64	0.001	Yes
Hilsenhoff Biotic Index	Porewater	Chromium	0.09	0.663	No
Hilsenhoff Biotic Index	Porewater	Cobalt	0.238	0.241	No
Hilsenhoff Biotic Index	Porewater	Copper	-0.296	0.141	No
Hilsenhoff Biotic Index	Porewater	Iron	0.277	0.171	No
Hilsenhoff Biotic Index	Porewater	Lead	-0.339	0.09	No
Hilsenhoff Biotic Index	Porewater	Magnesium	0.586	0.002	Yes
Hilsenhoff Biotic Index	Porewater	Manganese	0.35	0.079	No
Hilsenhoff Biotic Index	Porewater	Nickel	0.206	0.313	No
Hilsenhoff Biotic Index	Porewater	Potassium	0.268	0.186	No
Hilsenhoff Biotic Index	Porewater	Sodium	-0.088	0.669	No
Hilsenhoff Biotic Index	Porewater	Vanadium	0.096	0.64	No
Hilsenhoff Biotic Index	Porewater	Zinc	-0.011	0.958	No
% Chironomidae	Porewater	Aluminum	-0.019	0.925	No

Table K2-2

Spearman Rank Correlations of Bulk Sediment and Porewater Metals Metrics
with Benthic Invertebrate Community Metrics at OU 1 and Reference Locations
with Non-CS50 Substrate

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Community Metric	Matrix	Analyte	Spearman Correlation	Spearman Correlation p-Value	Meets Criteria
% Chironomidae	Porewater	Antimony	0.554	0.003	Yes
% Chironomidae	Porewater	Arsenic	0.539	0.005	Yes
% Chironomidae	Porewater	Barium	0.079	0.7	No
% Chironomidae	Porewater	Cadmium	0.656	0	Yes
% Chironomidae	Porewater	Calcium	0.044	0.832	No
% Chironomidae	Porewater	Chromium	0.082	0.692	No
% Chironomidae	Porewater	Cobalt	0.152	0.46	No
% Chironomidae	Porewater	Copper	0.686	0	Yes
% Chironomidae	Porewater	Iron	-0.034	0.869	No
% Chironomidae	Porewater	Lead	0.533	0.005	Yes
% Chironomidae	Porewater	Magnesium	-0.173	0.398	No
% Chironomidae	Porewater	Manganese	0.039	0.851	No
% Chironomidae	Porewater	Nickel	-0.271	0.181	No
% Chironomidae	Porewater	Potassium	-0.07	0.732	No
% Chironomidae	Porewater	Sodium	-0.082	0.69	No
% Chironomidae	Porewater	Vanadium	0.544	0.004	Yes
% Chironomidae	Porewater	Zinc	0.231	0.256	No

Notes:

log10 - base 10 logarithm

mg/kg - milligram per kilogram

Non-CS50 - medium, coarse, and very coarse sand less than 50 percent of substrate

Table K2-3

Spearman Rank Correlations for Bulk Sediment and Porewater Metals Metrics with Adjusted Counted Blotted Mass of Benthic Invertebrates at OU 1 and Reference Locations with Non-CS50 Substrate
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Matrix	Parameter	Slope	Standard Error	p-Value	R	R ²	Meets Criteria?
Sediment	Aluminum	0.06216	0.83	0.9409	0.01529	0.0002337	no
Sediment	Antimony	0.2024	0.147	0.1813	0.2705	0.07319	no
Sediment	Arsenic	0.485	0.4291	0.2696	0.2248	0.05053	no
Sediment	Barium	0.6967	0.3398	0.05144	0.386	0.149	no
Sediment	Beryllium	0.3189	0.7606	0.6787	0.08528	0.007272	no
Sediment	Cadmium	0.6887	0.212	0.003411	0.5527	0.3055	no
Sediment	Calcium	0.5493	0.2953	0.07513	0.355	0.126	no
Sediment	Chromium	-0.05951	0.7438	0.9369	-0.01633	0.0002667	no
Sediment	Cobalt	-0.3678	0.5789	0.5312	-0.1286	0.01654	no
Sediment	Copper	0.1917	0.2149	0.3813	0.1791	0.03209	no
Sediment	Iron	0.1305	0.5455	0.813	0.04876	0.002378	no
Sediment	Lead	0.5476	0.2228	0.02158	0.4484	0.2011	no
Sediment	Magnesium	1.13	0.3969	0.008924	0.5023	0.2523	no
Sediment	Manganese	0.1751	0.4197	0.6802	0.08486	0.007201	no
Sediment	Mercury	0.3639	0.1419	0.01699	0.4639	0.2152	no
Sediment	Nickel	0.2925	0.7136	0.6855	0.08338	0.006951	no
Sediment	Potassium	-0.4341	0.7832	0.5845	-0.1124	0.01264	no
Sediment	Selenium	0.6425	0.4503	0.1665	0.2796	0.0782	no
Sediment	Silver	0.4315	0.2145	0.05567	0.3798	0.1442	no
Sediment	Sodium	-0.6289	0.5707	0.2814	-0.2195	0.04816	no
Sediment	Thallium	1.021	0.41	0.02004	0.4533	0.2055	no
Sediment	Vanadium	1.39	0.9932	0.1745	0.2747	0.07545	no
Sediment	Zinc	0.2576	0.176	0.1562	0.2863	0.08197	no

Table K2-3

Spearman Rank Correlations for Bulk Sediment and Porewater Metals Metrics with Adjusted Counted Blotted Mass of Benthic Invertebrates at OU 1 and Reference Locations with Non-CS50 Substrate
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Matrix	Parameter	Slope	Standard Error	p-Value	R	R ²	Meets Criteria?
Porewater	Aluminum	-0.724	0.1984	0.001271	-0.5974	0.3569	yes
Porewater	Antimony	-0.1426	0.2156	0.5148	-0.1338	0.01789	no
Porewater	Barium	1.368	0.343	0.0005428	0.6313	0.3986	no
Porewater	Cadmium	-0.04443	0.2787	0.8747	-0.03252	0.001058	no
Porewater	Calcium	2.118	0.46	0.0001139	0.6848	0.4689	no
Porewater	Chromium	-0.4587	0.3393	0.1891	-0.266	0.07075	no
Porewater	Cobalt	1.009	0.4642	0.03988	0.4055	0.1644	no
Porewater	Copper	-0.1926	0.2169	0.3835	-0.1783	0.0318	no
Porewater	Iron	0.2982	0.1421	0.04658	0.3937	0.155	no
Porewater	Lead	-0.1727	0.201	0.3985	-0.1728	0.02987	no
Porewater	Magnesium	0.8642	0.3937	0.03807	0.4089	0.1672	no
Porewater	Manganese	0.2925	0.1368	0.04293	0.3999	0.1599	no
Porewater	Nickel	-0.04159	0.3508	0.9066	-0.02419	0.0005853	no
Porewater	Potassium	1.055	0.5321	0.05891	0.3752	0.1408	no
Porewater	Sodium	0.5411	0.4886	0.279	0.2205	0.04863	no
Porewater	Vanadium	0.03923	0.3868	0.9201	0.0207	0.0004283	no
Porewater	Zinc	-0.1246	0.2838	0.6647	-0.08923	0.007962	no

Note:

Non-CS50 - medium, coarse, and very coarse sand less than 50 percent of substrate

Table K2-4
 WOE Scoring Tables for Rank Correlations of Benthic Invertebrate Community
 Metrics and Sediment and Porewater Metals Concentrations from All Phase 3
 Locations with CS50 Substrate
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Community Metric	Matrix	Parameter	Spearman Correlation	Spearman Correlation p-Value	WOE Score
Metals tolerance index	porewater	antimony	0.348	0.006	uncertain
Community metrics PC2	porewater	arsenic	0.391	0.007	uncertain
Community metrics PC2	porewater	barium	0.425	0.003	possible
Percent Chironomidae	porewater	copper	0.334	0.008	uncertain
Percent Chironomidae	sediment	mercury	0.309	0.016	uncertain
Community metrics PC2	porewater	vanadium	0.305	0.037	uncertain

Notes:

CS50 - medium, coarse, and very coarse sand greater than 50 percent of substrate

PC - principal component

WOE - weight of evidence

Table K2-5
 WOE Scoring Tables for Rank Correlations of Benthic Invertebrate Community
 Metrics and Sediment and Porewater Metals Concentrations from All Phase 3
 Locations with Non-CS50 Substrate
 Upper Columbia River
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Community Metric	Matrix	Parameter	Spearman Correlation	Spearman Correlation p-Value	WOE Score
Counted blotted mass (g)	porewater	aluminum	-0.625	0.001	possible
Total abundance	porewater	antimony	-0.399	0.044	uncertain
Percent Chironomidae	porewater	antimony	0.554	0.003	possible
Hilsenhoff Biotic Index	porewater	arsenic	0.394	0.048	uncertain
Percent Chironomidae	porewater	arsenic	0.539	0.005	possible
Hilsenhoff Biotic Index	porewater	barium	0.515	0.007	possible
Percent Chironomidae	porewater	cadmium	0.656	0	possible
Hilsenhoff Biotic Index	porewater	calcium	0.64	0.001	possible
Percent Chironomidae	porewater	copper	0.686	0	possible
Metals tolerance index	porewater	iron	0.414	0.035	possible
Percent Chironomidae	porewater	lead	0.533	0.005	possible
Metals tolerance index	porewater	magnesium	0.486	0.013	possible
Hilsenhoff Biotic Index	porewater	magnesium	0.586	0.002	possible
Metals tolerance index	porewater	manganese	0.543	0.004	possible
Predator richness	porewater	nickel	-0.475	0.014	possible
Metals tolerance index	porewater	nickel	0.734	0	possible
Percent Chironomidae	porewater	vanadium	0.544	0.004	possible

Table K2-5
 WOE Scoring Tables for Rank Correlations of Benthic Invertebrate Community Metrics and Sediment and Porewater Metals Concentrations from All Phase 3 Locations with Non-CS50 Substrate
 Upper Columbia River
 Final Aquatic Baseline Ecological Risk Assessment
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Community Metric	Matrix	Parameter	Spearman Correlation	Spearman Correlation p-Value	WOE Score
Percent Chironomidae	sediment	antimony	0.517	0.007	possible
Hilsenhoff Biotic Index	sediment	arsenic	0.417	0.034	possible
Hilsenhoff Biotic Index	sediment	barium	0.616	0.001	possible
Hilsenhoff Biotic Index	sediment	cadmium	0.51	0.008	possible
Percent Chironomidae	sediment	chromium	0.526	0.006	possible
Percent Chironomidae	sediment	copper	0.582	0.002	possible
Percent Chironomidae	sediment	iron	0.473	0.015	possible
Hilsenhoff Biotic Index	sediment	lead	0.476	0.014	possible
Hilsenhoff Biotic Index	sediment	magnesium	0.484	0.012	possible
Percent Chironomidae	sediment	manganese	0.512	0.007	possible
Hilsenhoff Biotic Index	sediment	mercury	0.51	0.008	possible
Predator richness	sediment	nickel	-0.423	0.031	possible
Metals tolerance index	sediment	nickel	0.71	0	possible
Hilsenhoff Biotic Index	sediment	selenium	0.544	0.004	possible
Hilsenhoff Biotic Index	sediment	silver	0.4	0.044	uncertain
Percent Chironomidae	sediment	silver	0.618	0.001	possible
Percent Chironomidae	sediment	sodium	0.532	0.005	possible
Hilsenhoff Biotic Index	sediment	thallium	0.549	0.004	possible
Metals tolerance index	sediment	vanadium	0.434	0.027	possible
Hilsenhoff Biotic Index	sediment	vanadium	0.463	0.017	possible

Notes:

g - gram(s)

Non-CS50 - medium, coarse, and very coarse sand less than 50 percent of substrate

WOE - weight of evidence



FIGURES

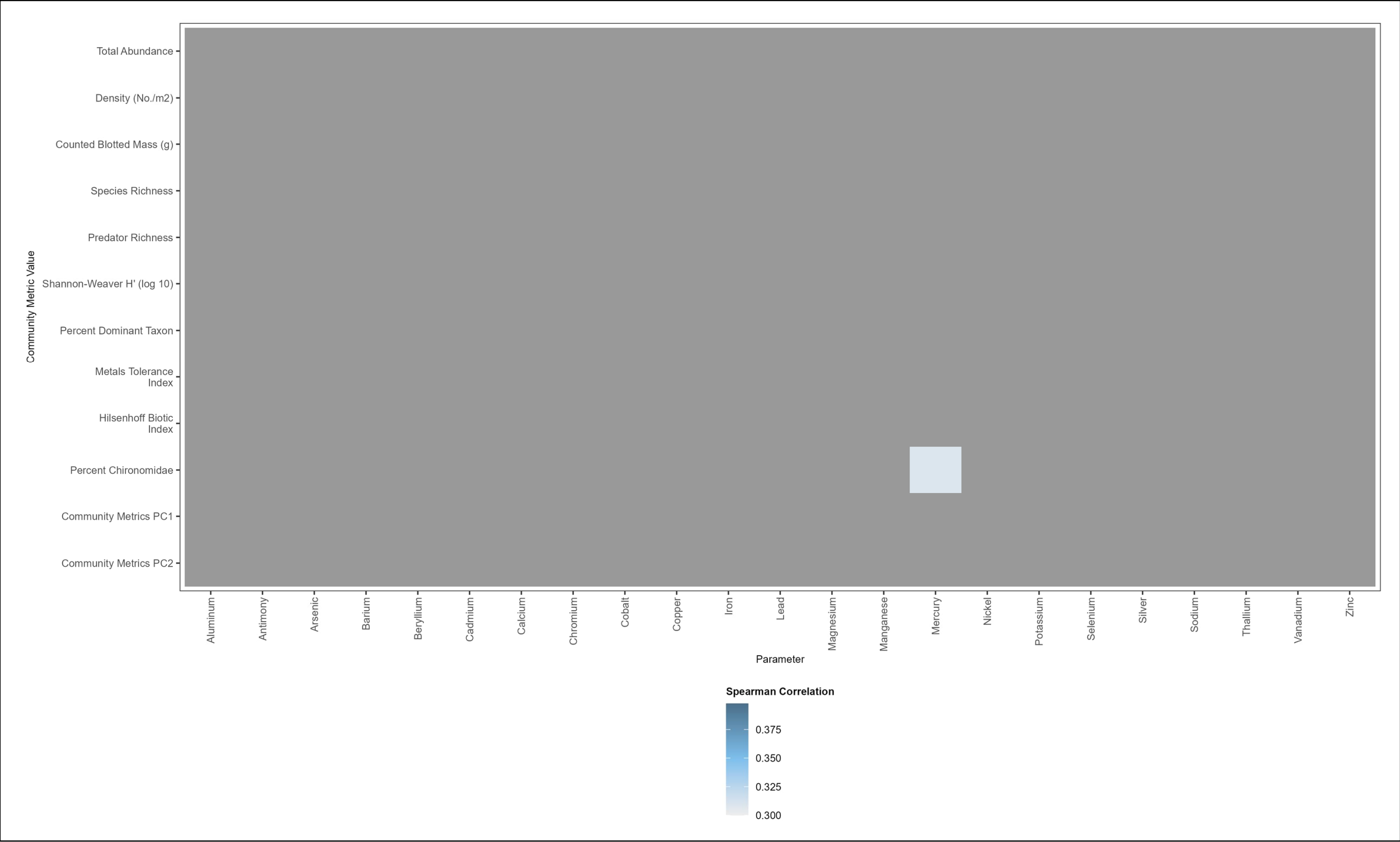


Figure K2-1. Mosaic of Rank Correlation Results for Benthic Invertebrate Community Metrics versus Bulk Sediment Metals Concentrations at Phase 3 Locations with CS50 Substrate

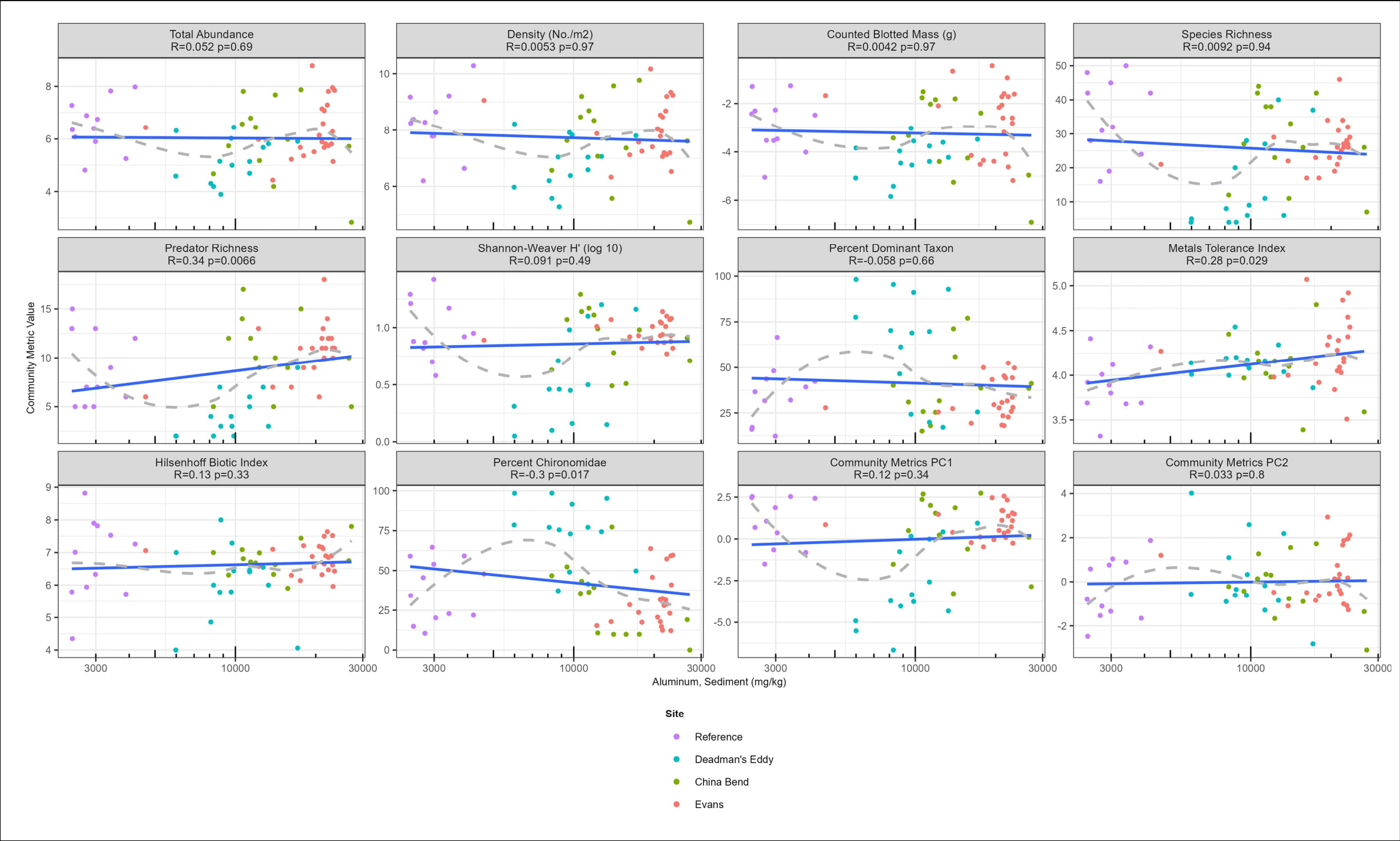


Figure K2-2a. Scatterplots of Benthic Invertebrate Metrics Against Bulk Sediment Aluminum Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

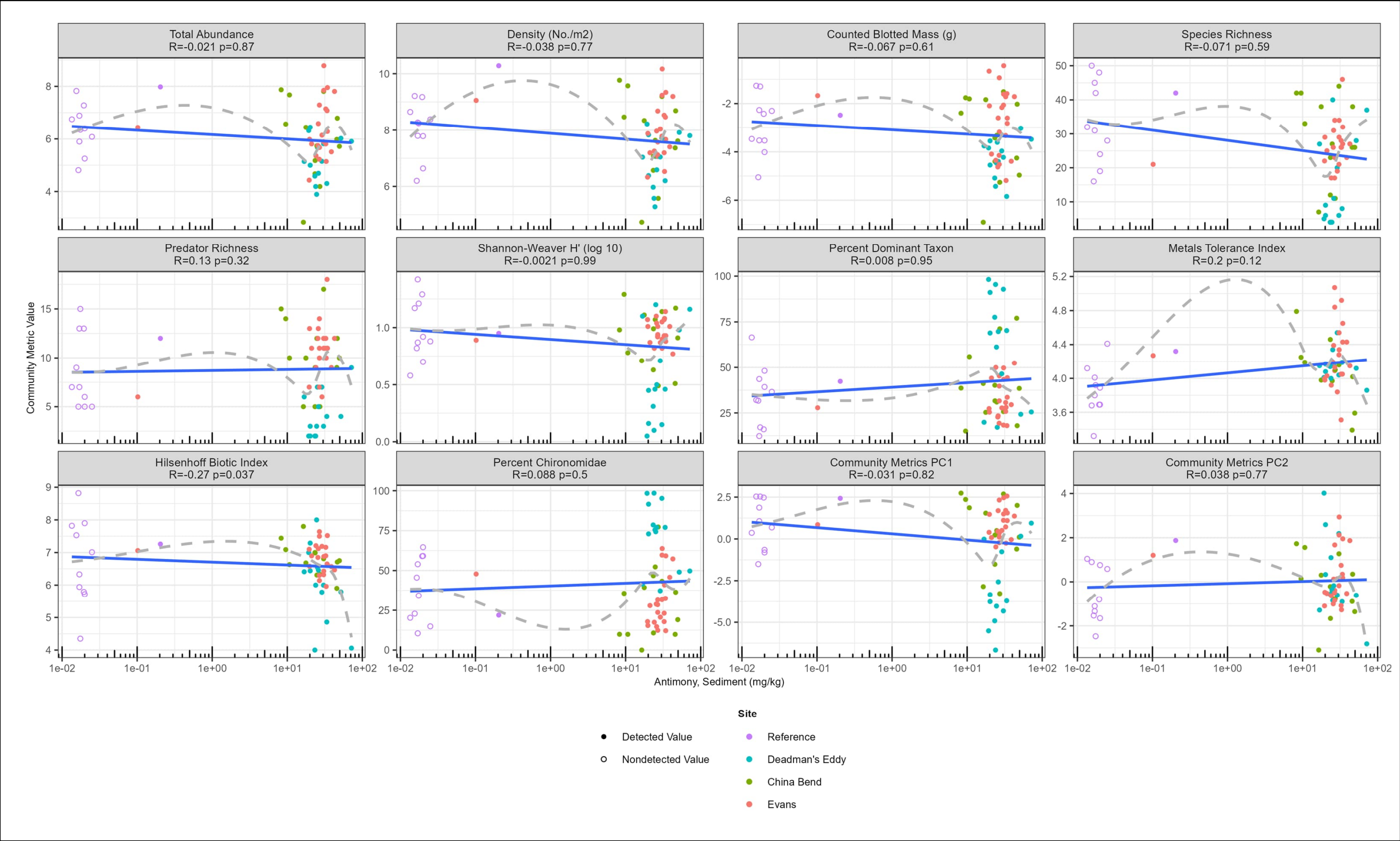


Figure K2-2b. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Antimony Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

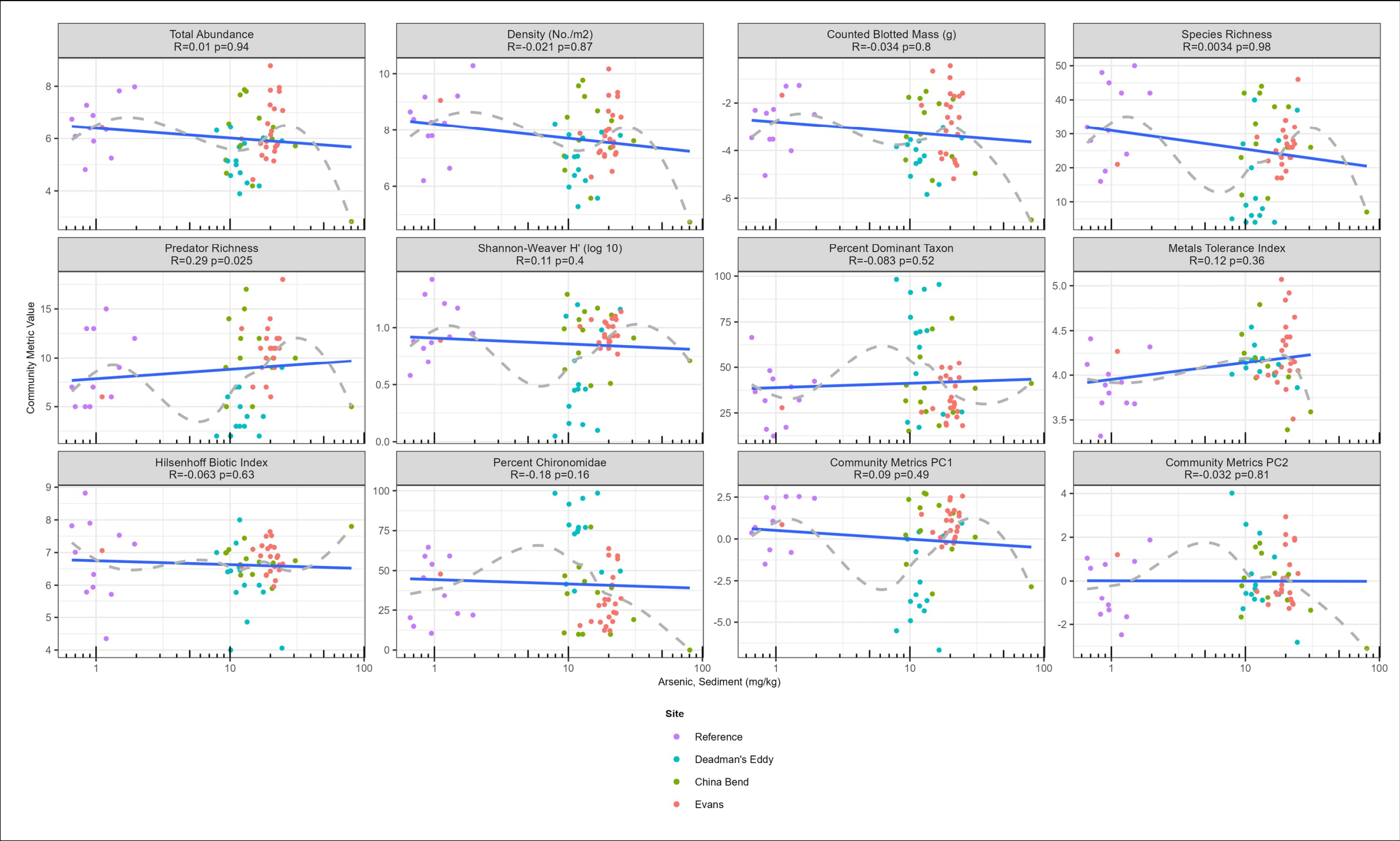


Figure K2-2c. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Arsenic Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

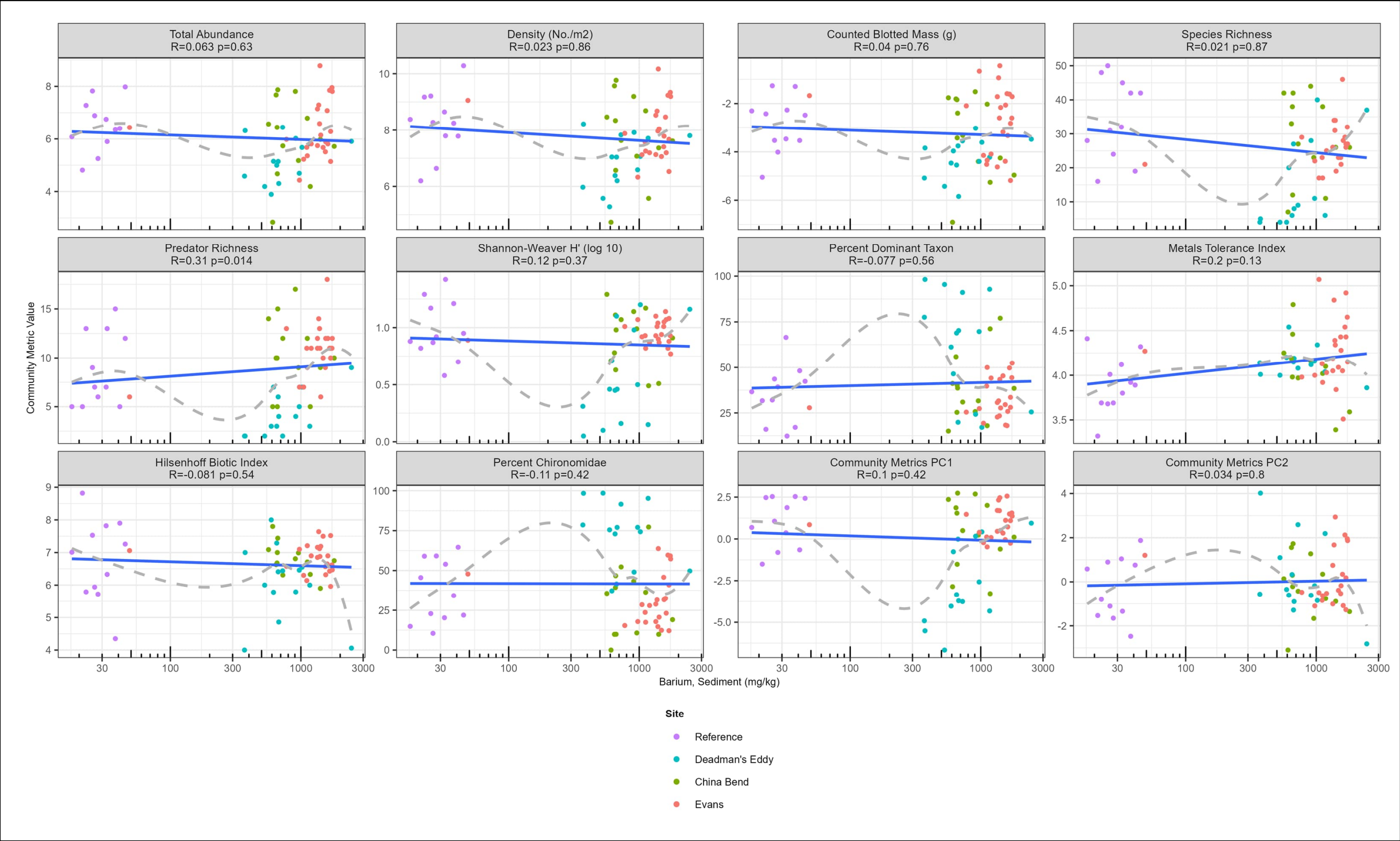


Figure K2-2d. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Barium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

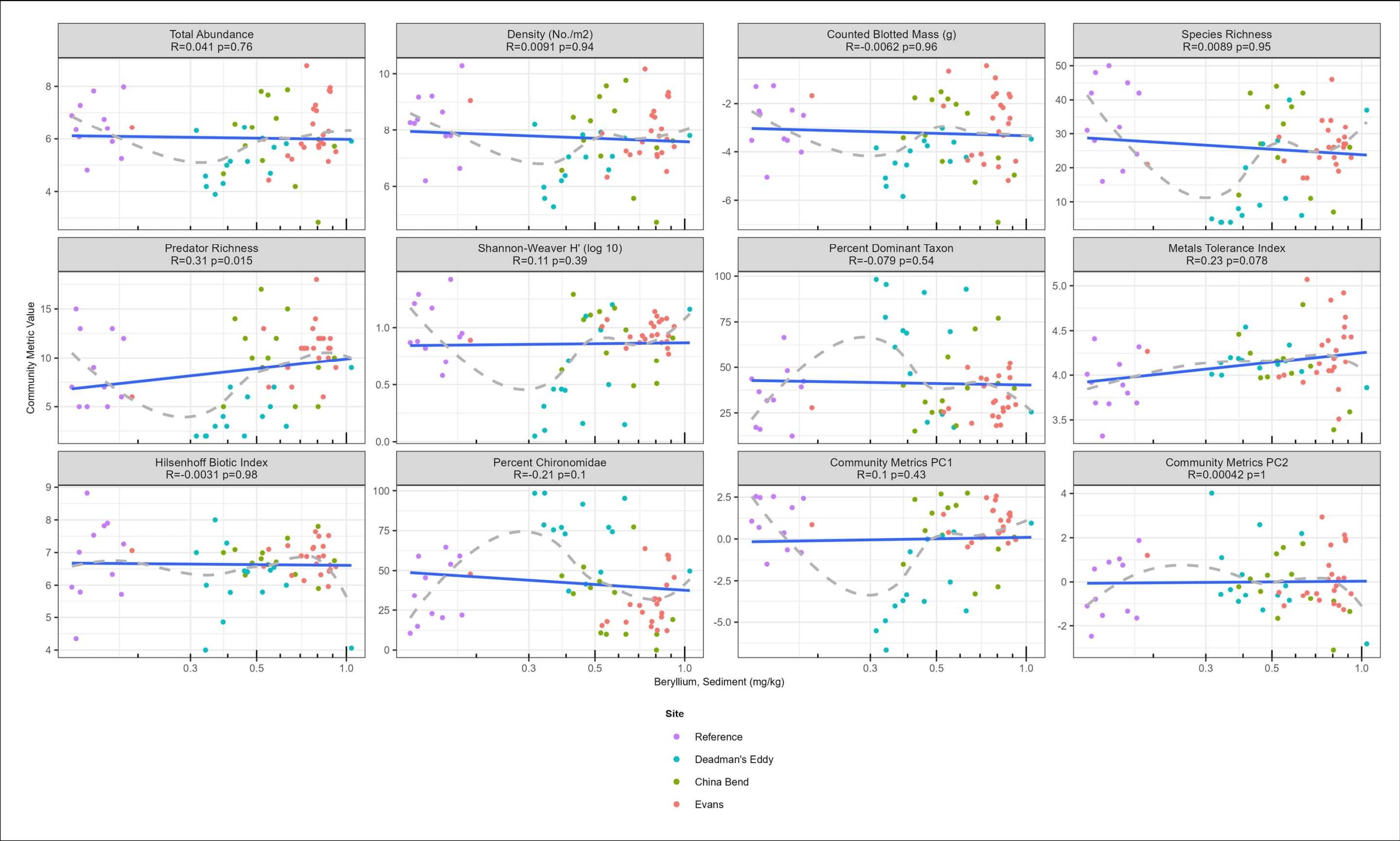


Figure K2-2e. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Beryllium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

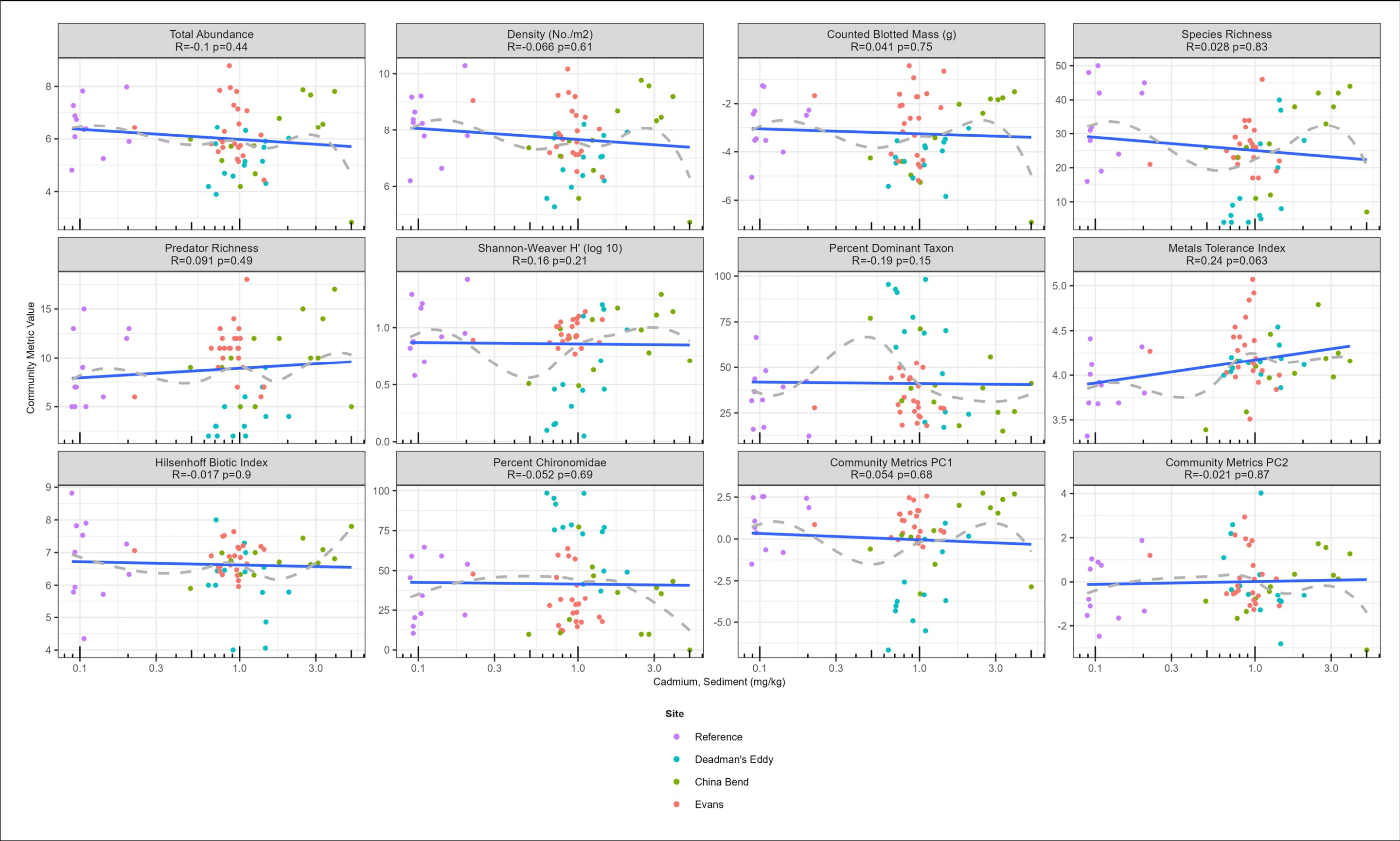


Figure K2-2f. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Cadmium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

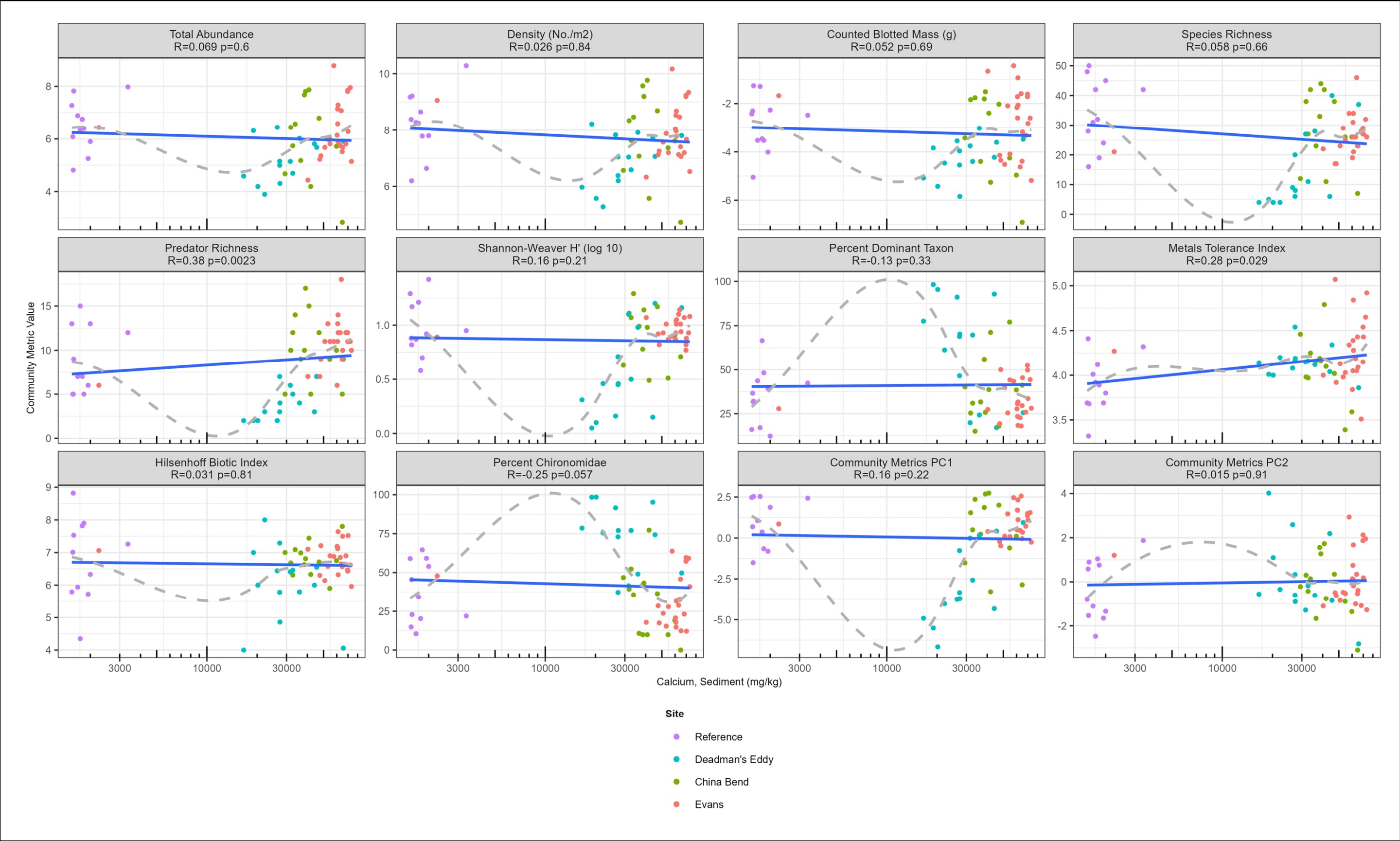


Figure K2-2g. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Calcium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

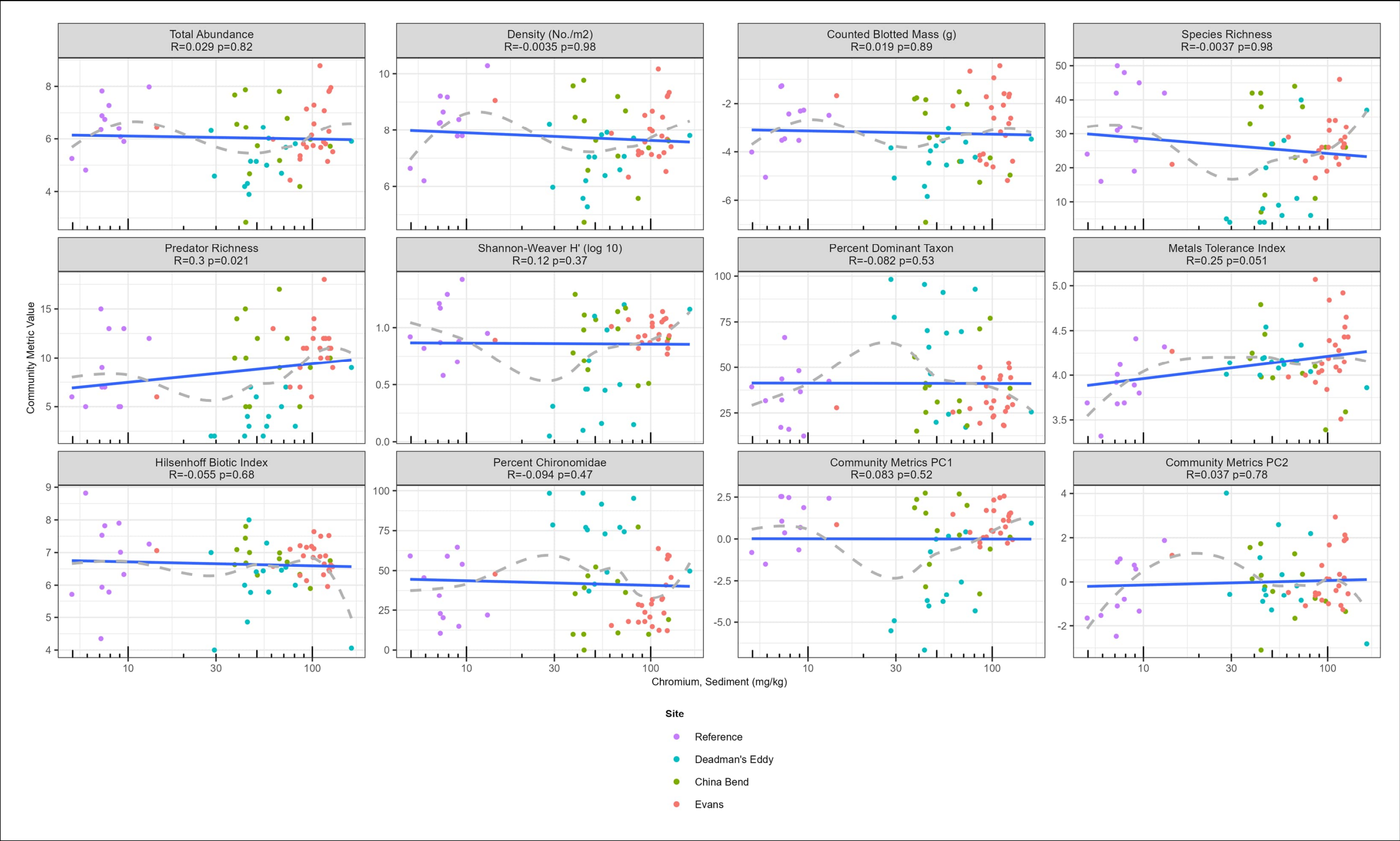


Figure K2-2h. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Chromium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

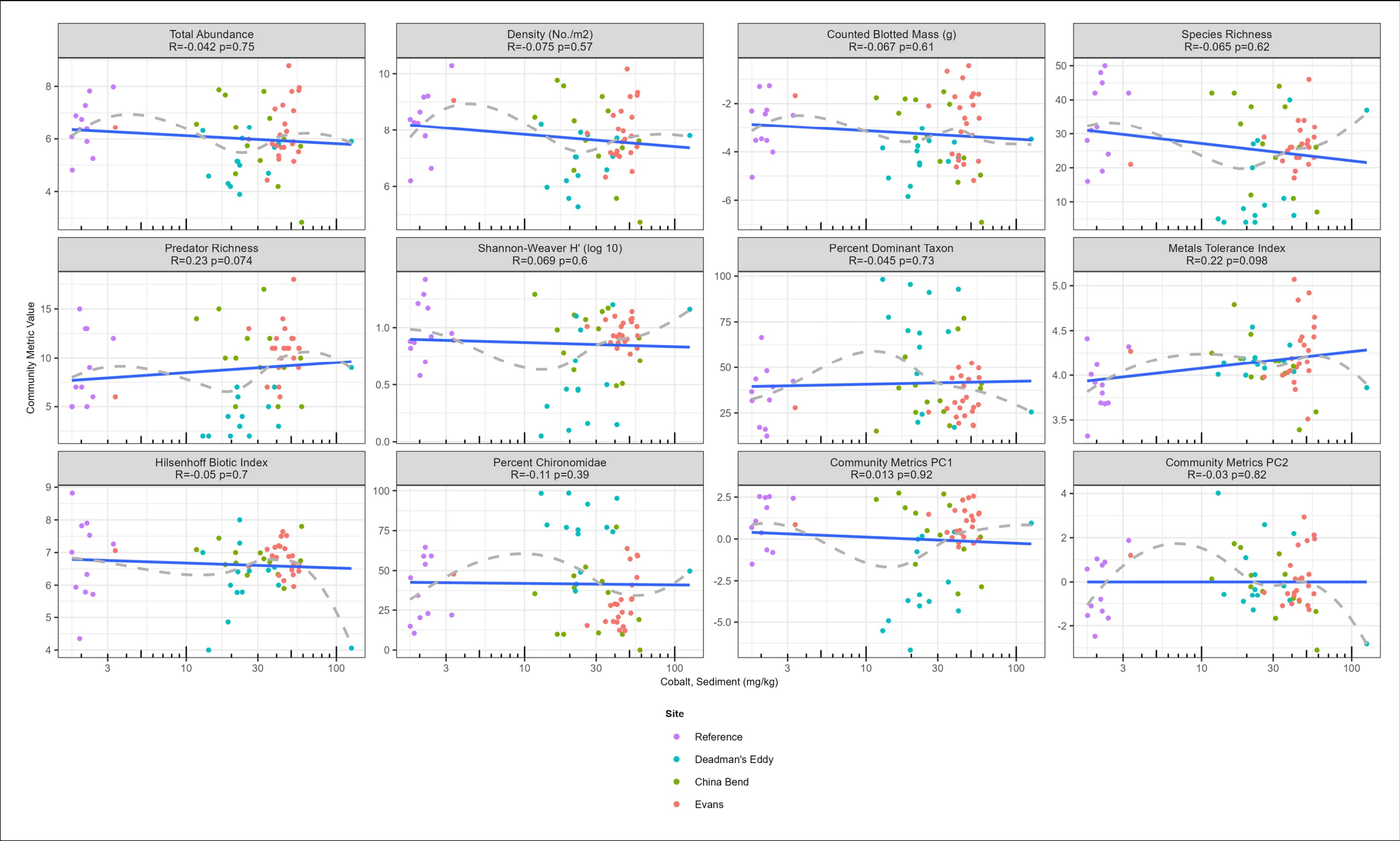


Figure K2-2i. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Cobalt Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

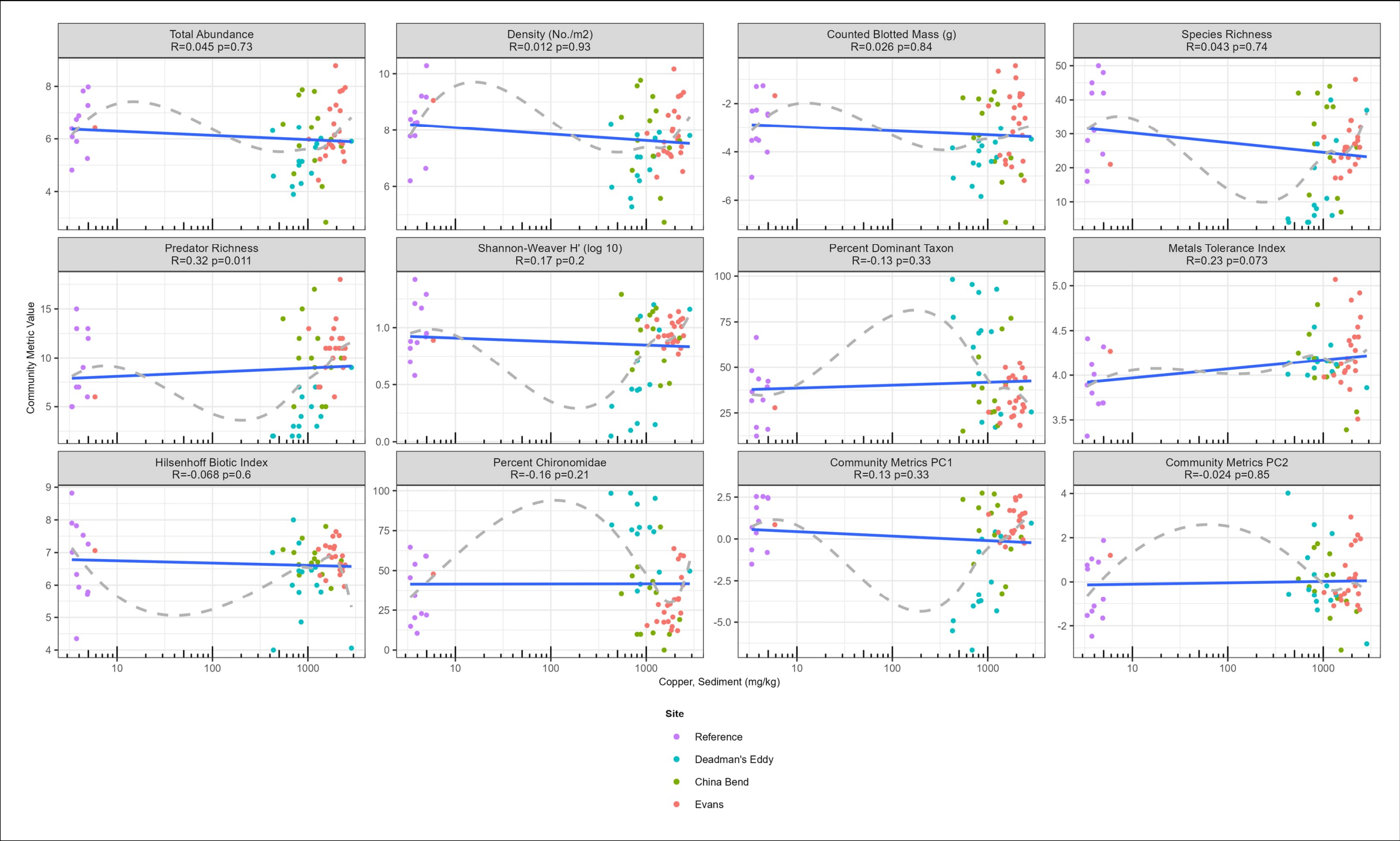


Figure K2-2j. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Copper Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

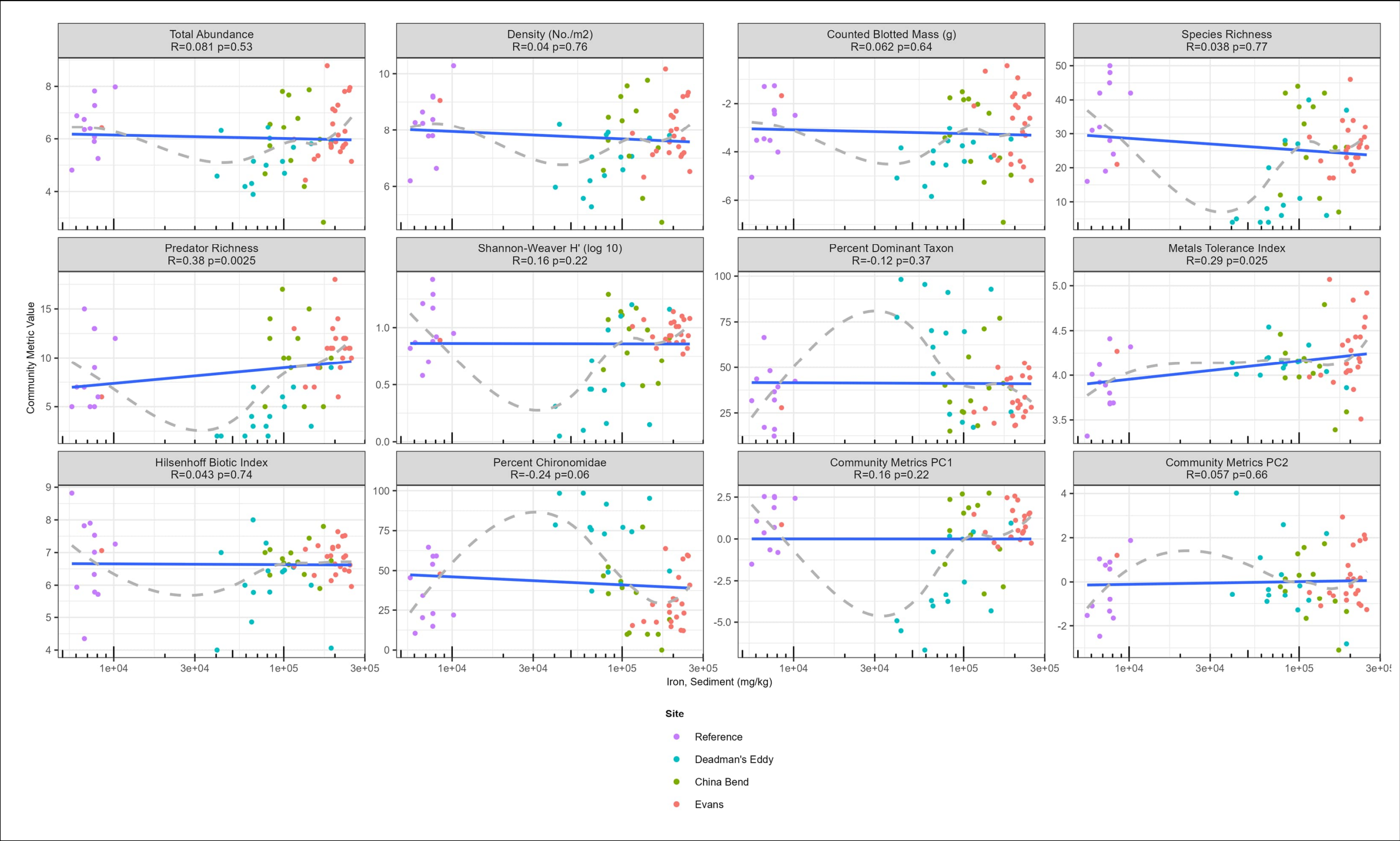


Figure K2-2k. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Iron Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

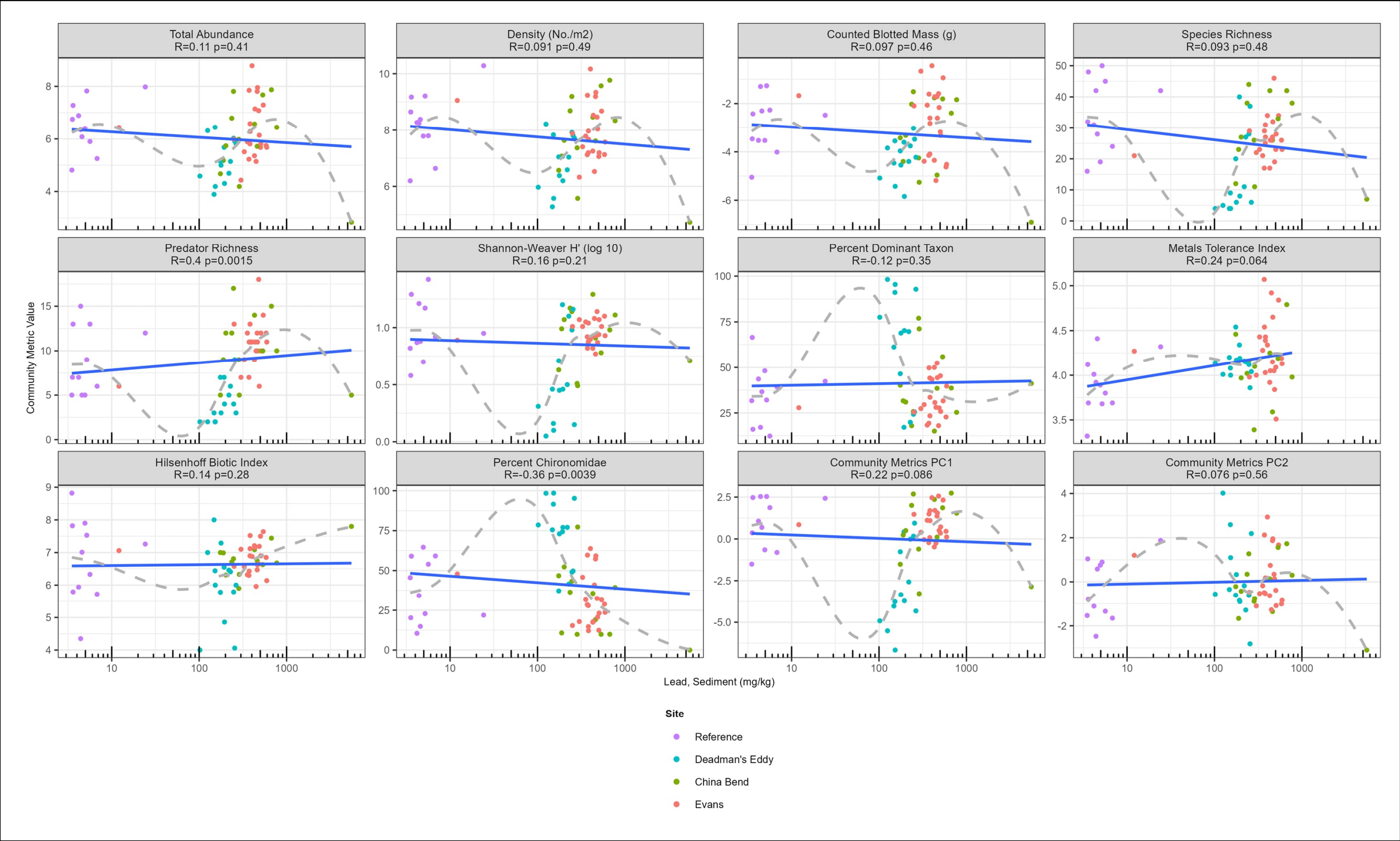


Figure K2-21. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Lead Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

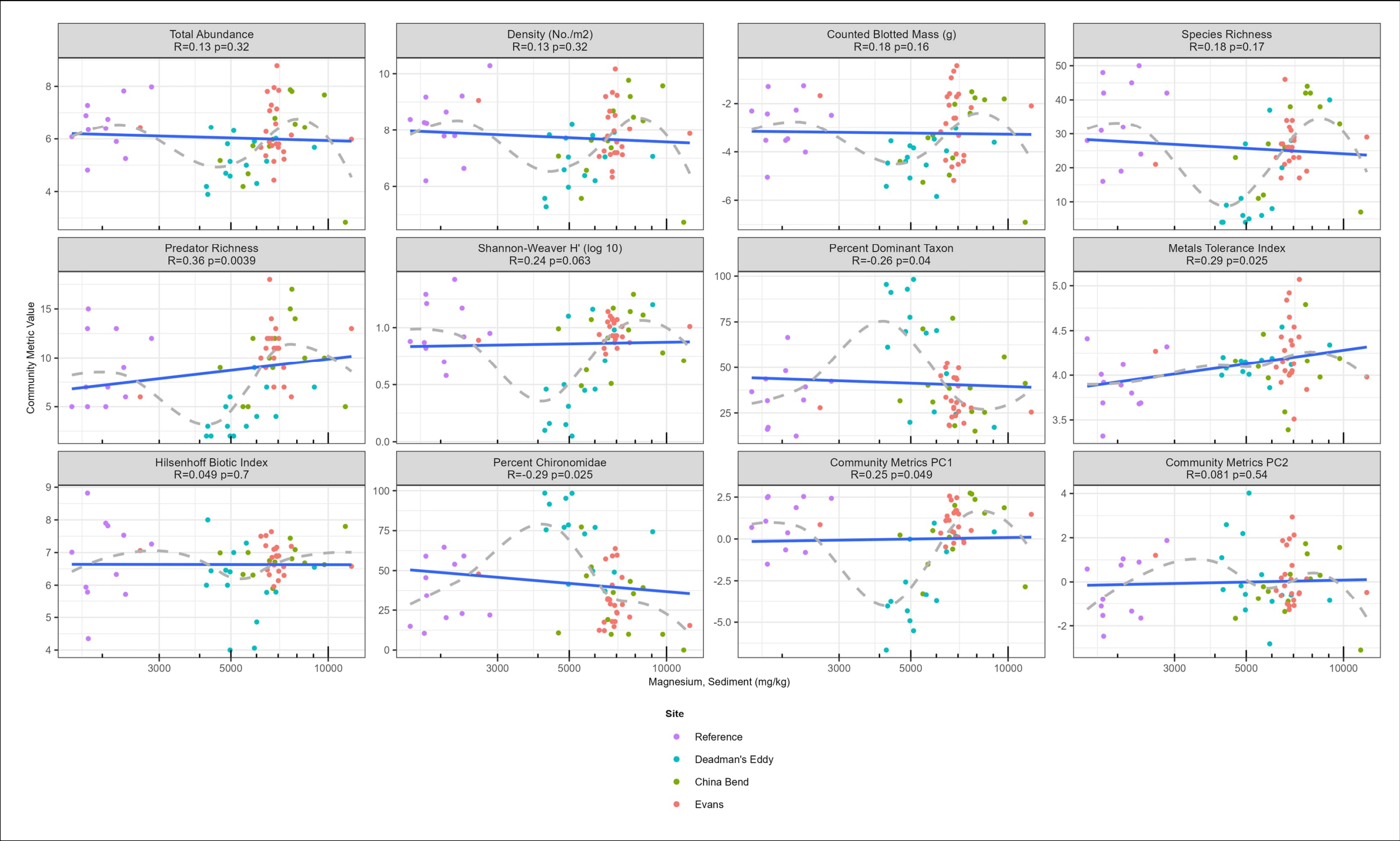


Figure K2-2m. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Magnesium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

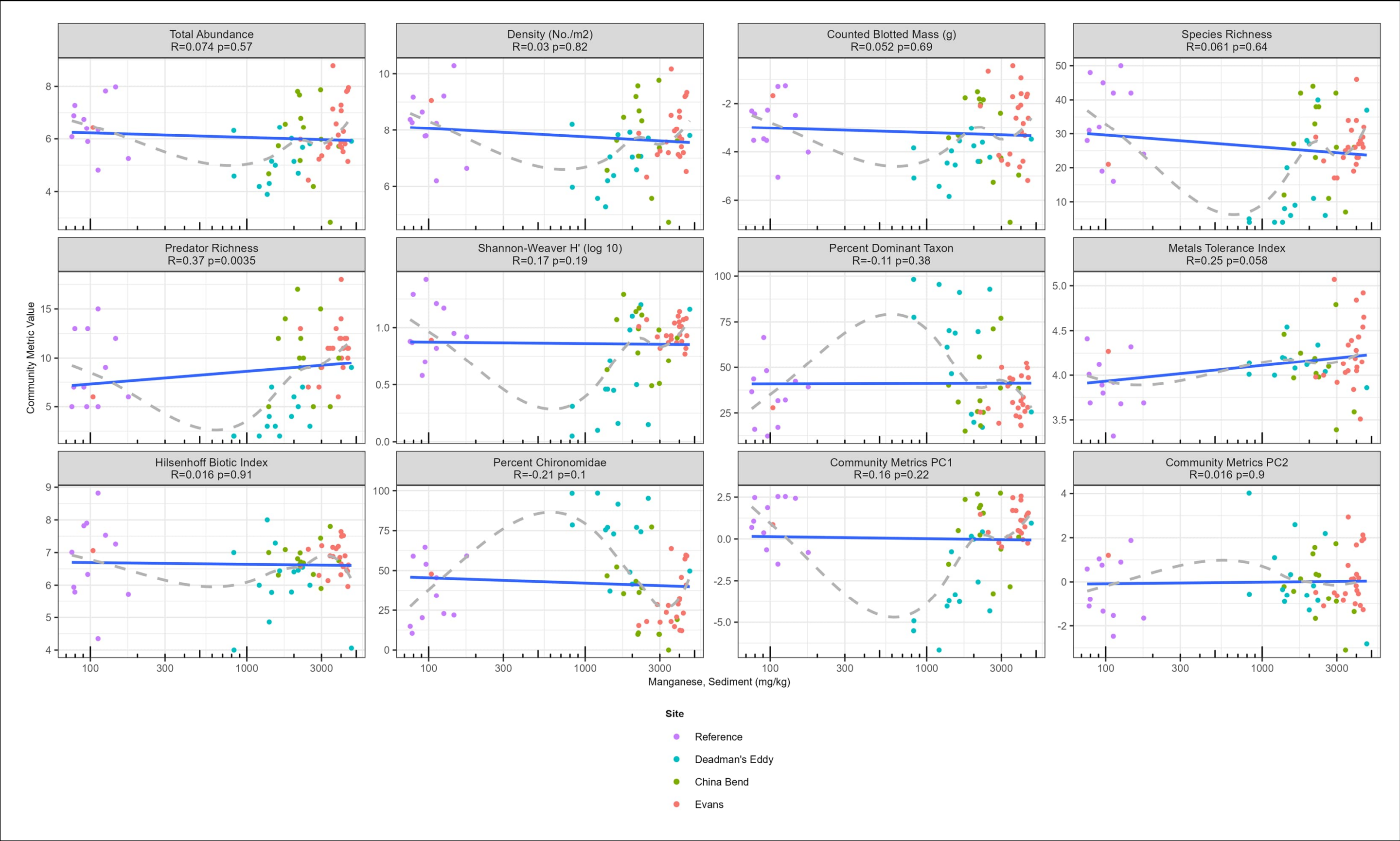


Figure K2-2n. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Manganese Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

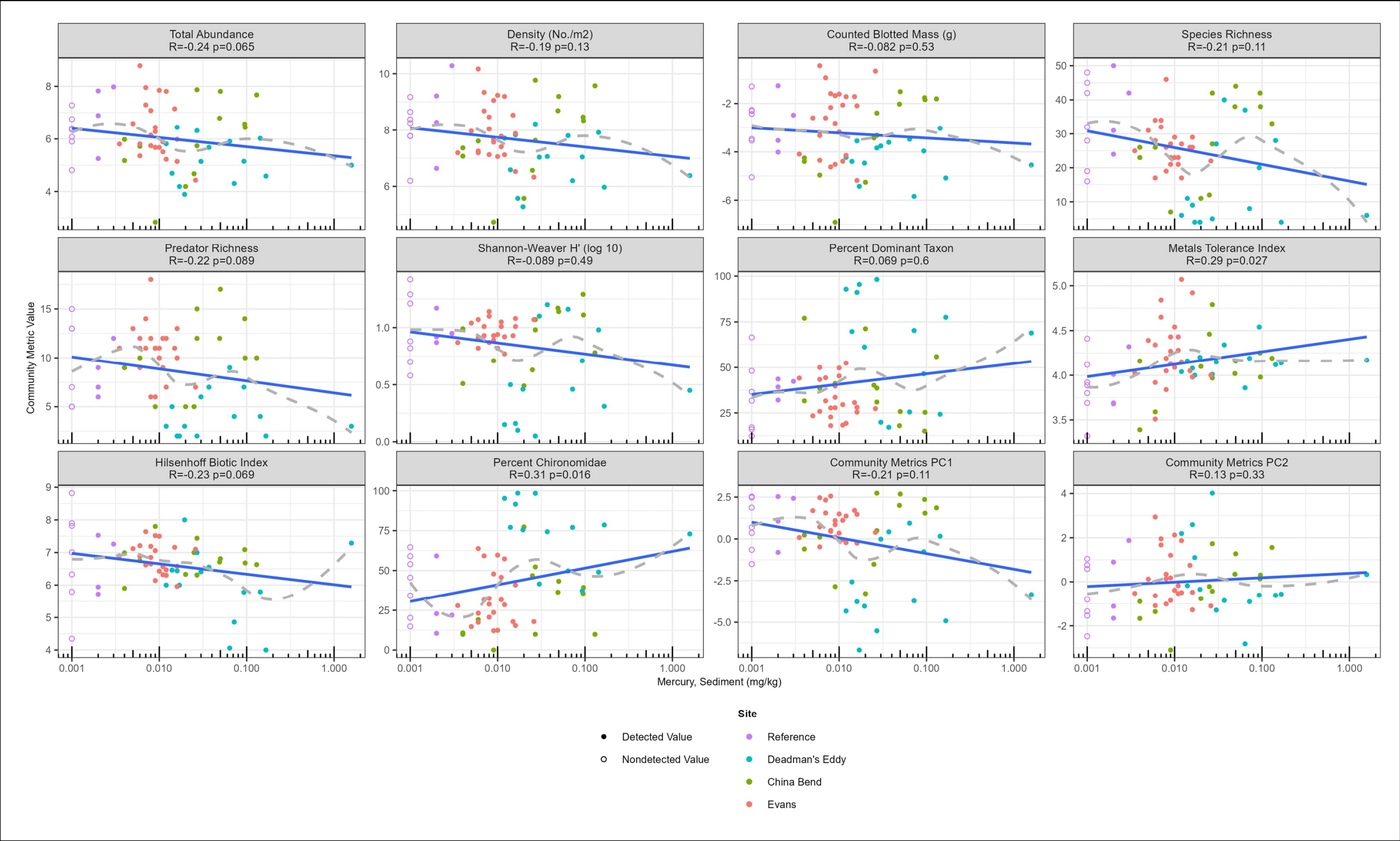


Figure K2-2o. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Mercury Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

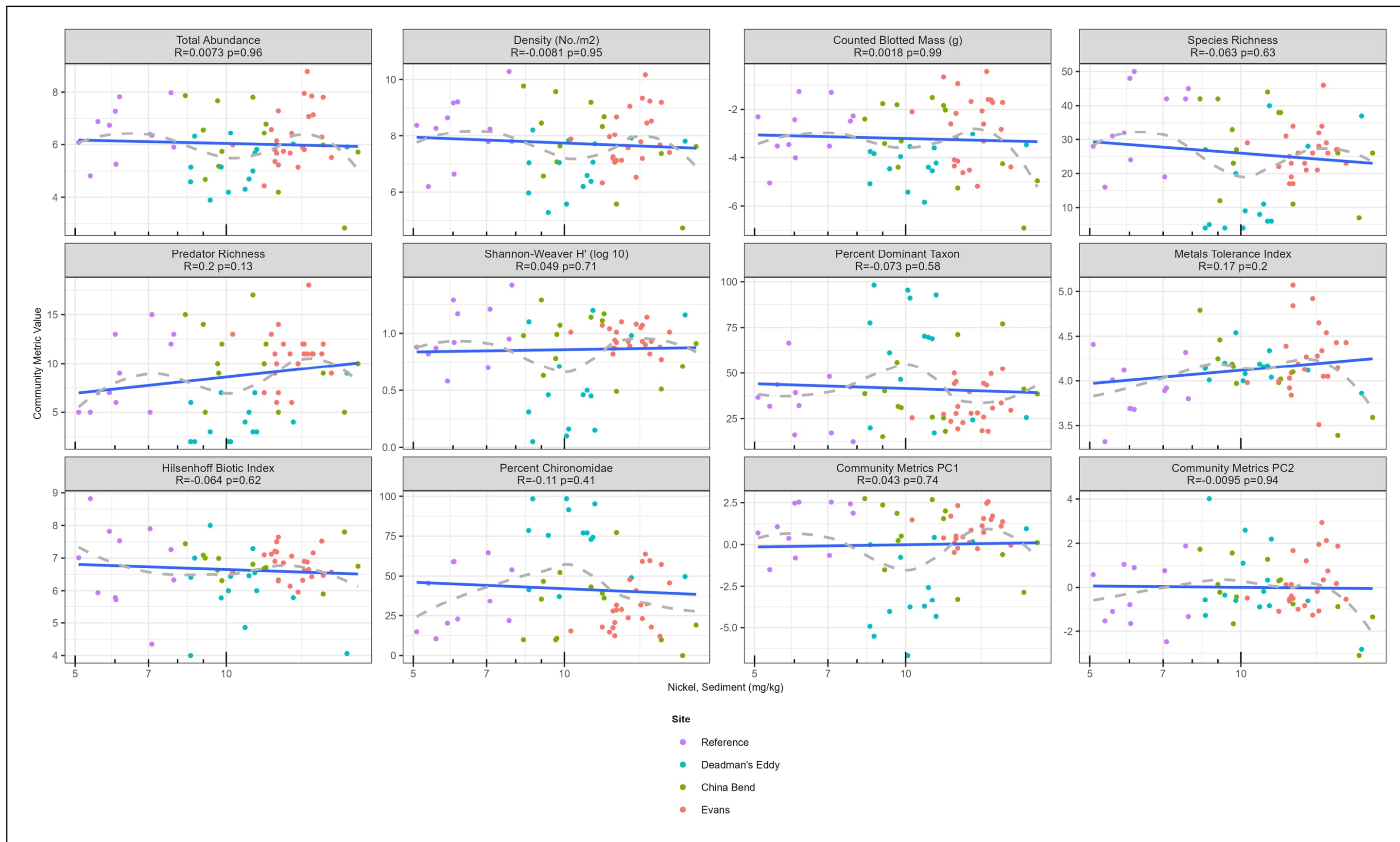


Figure K2-2p. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Nickel Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

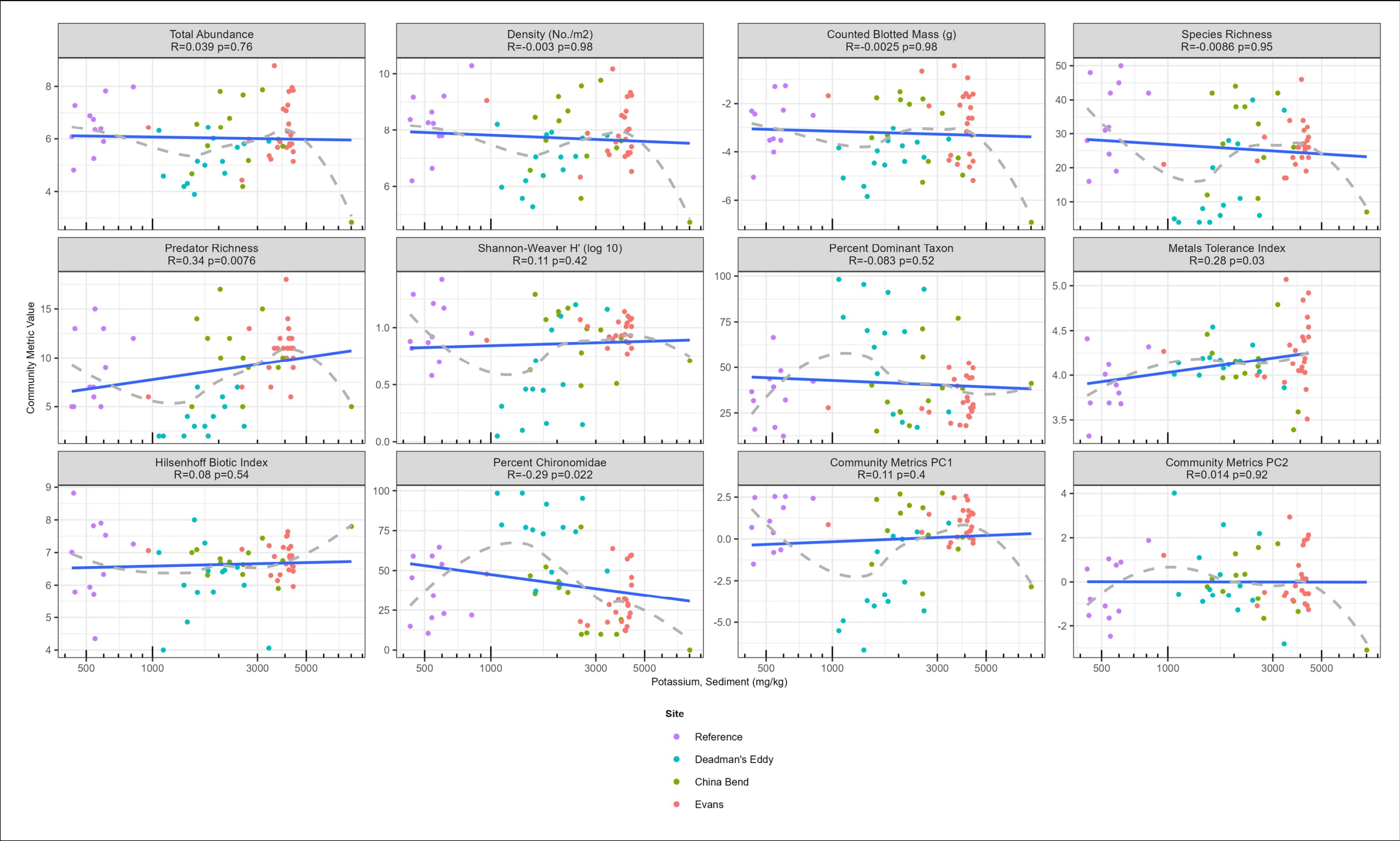


Figure K2-2q. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Potassium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

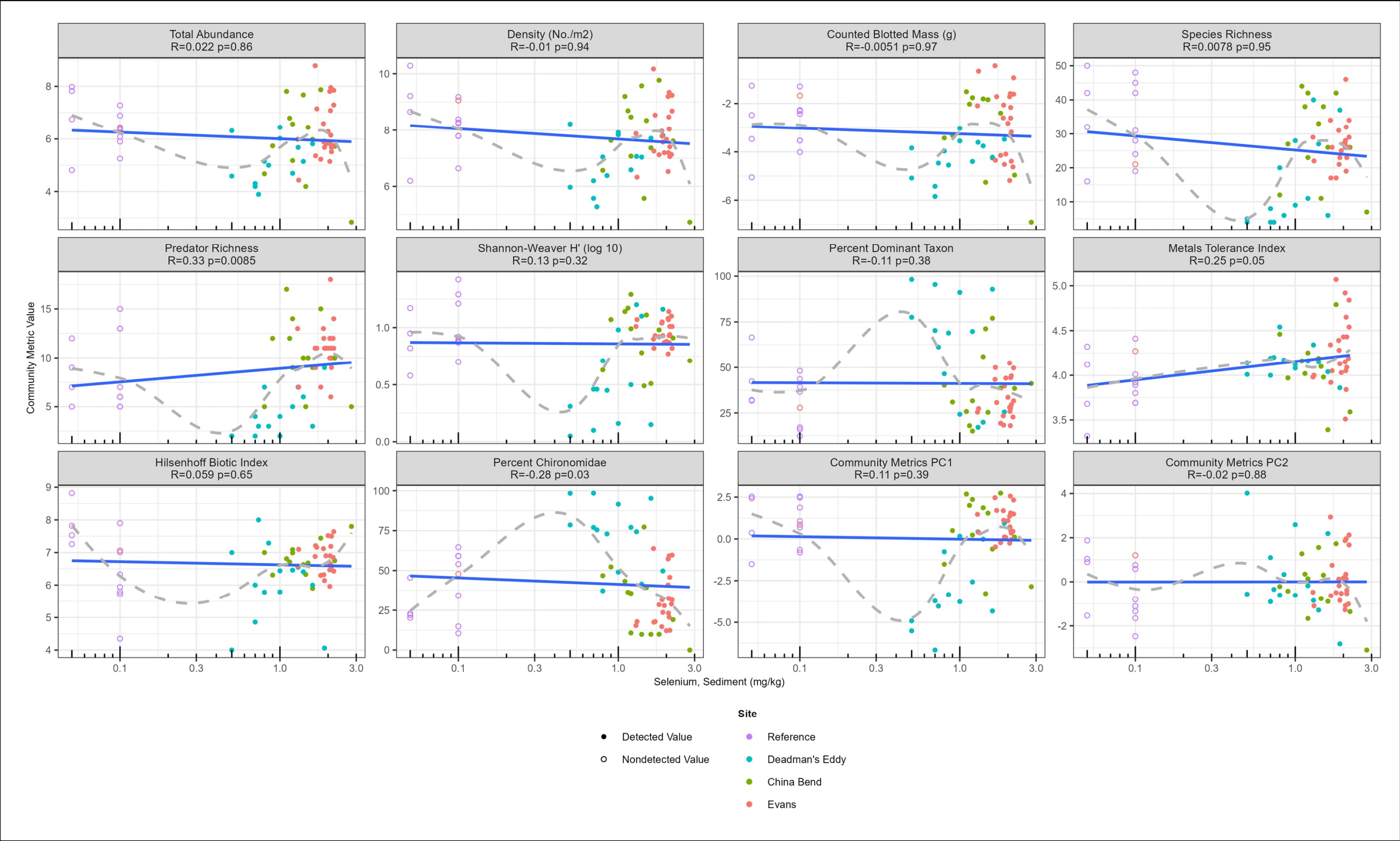


Figure K2-2r. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Selenium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

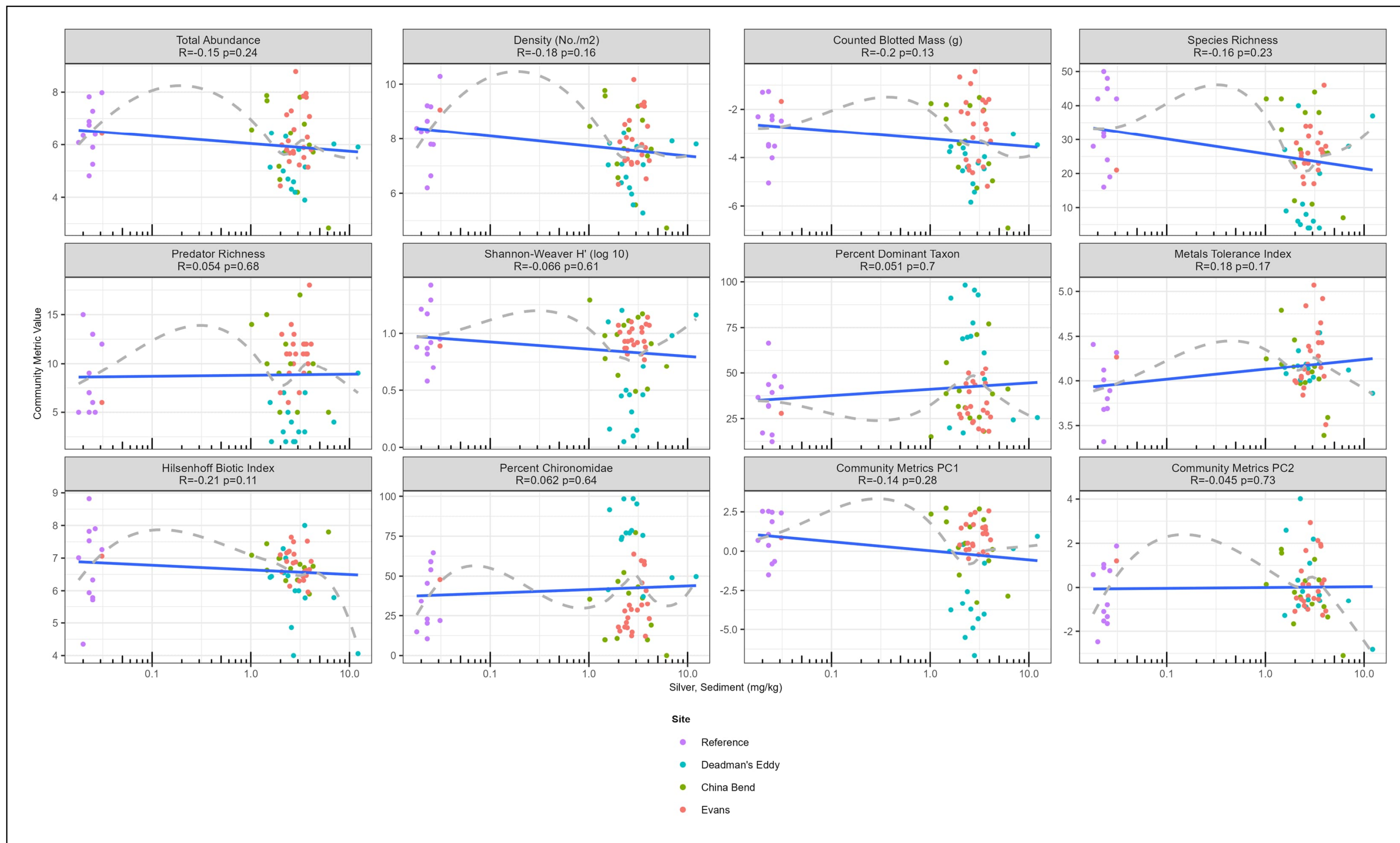


Figure K2-2s. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Silver Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

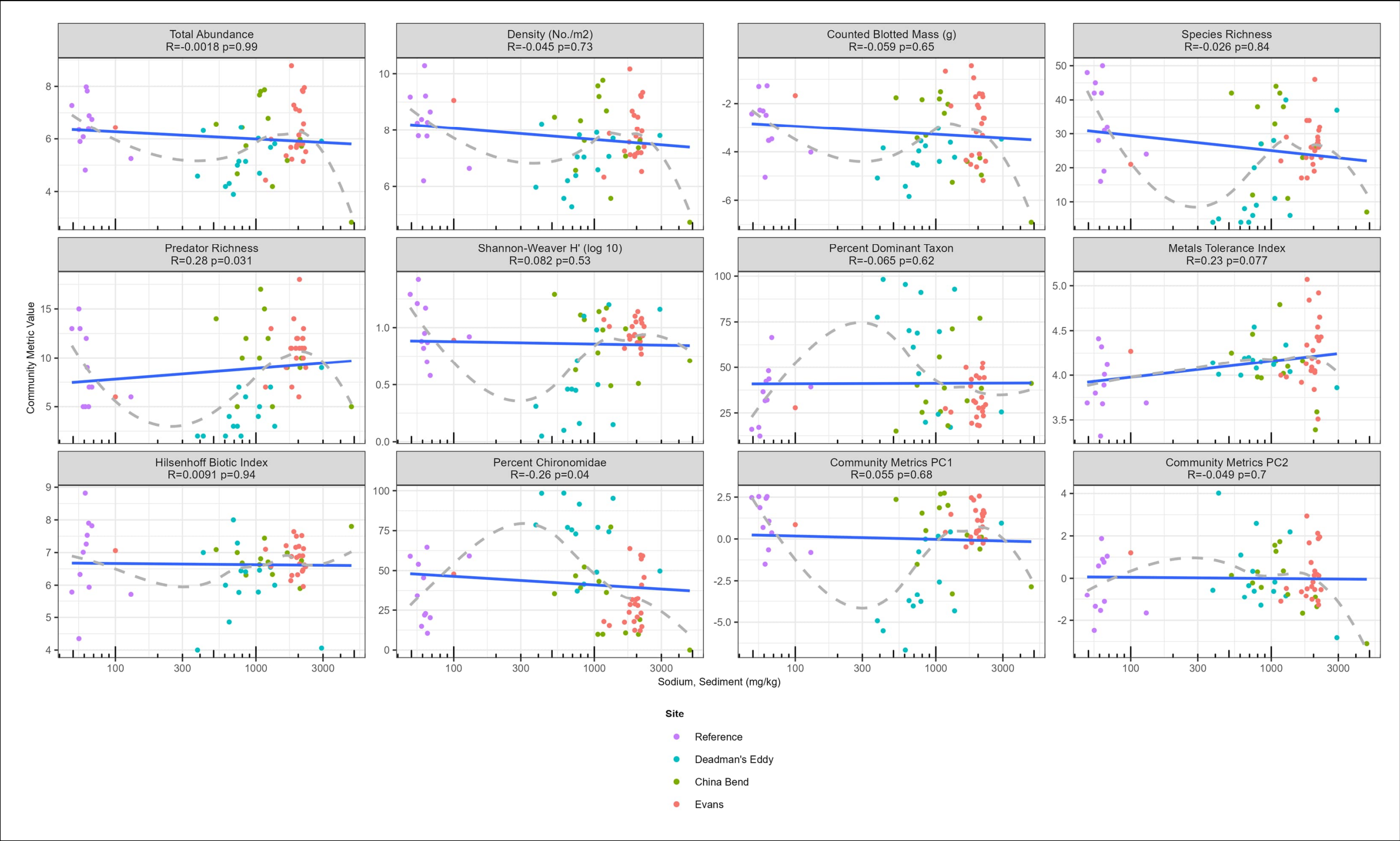


Figure K2-2t. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Sodium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

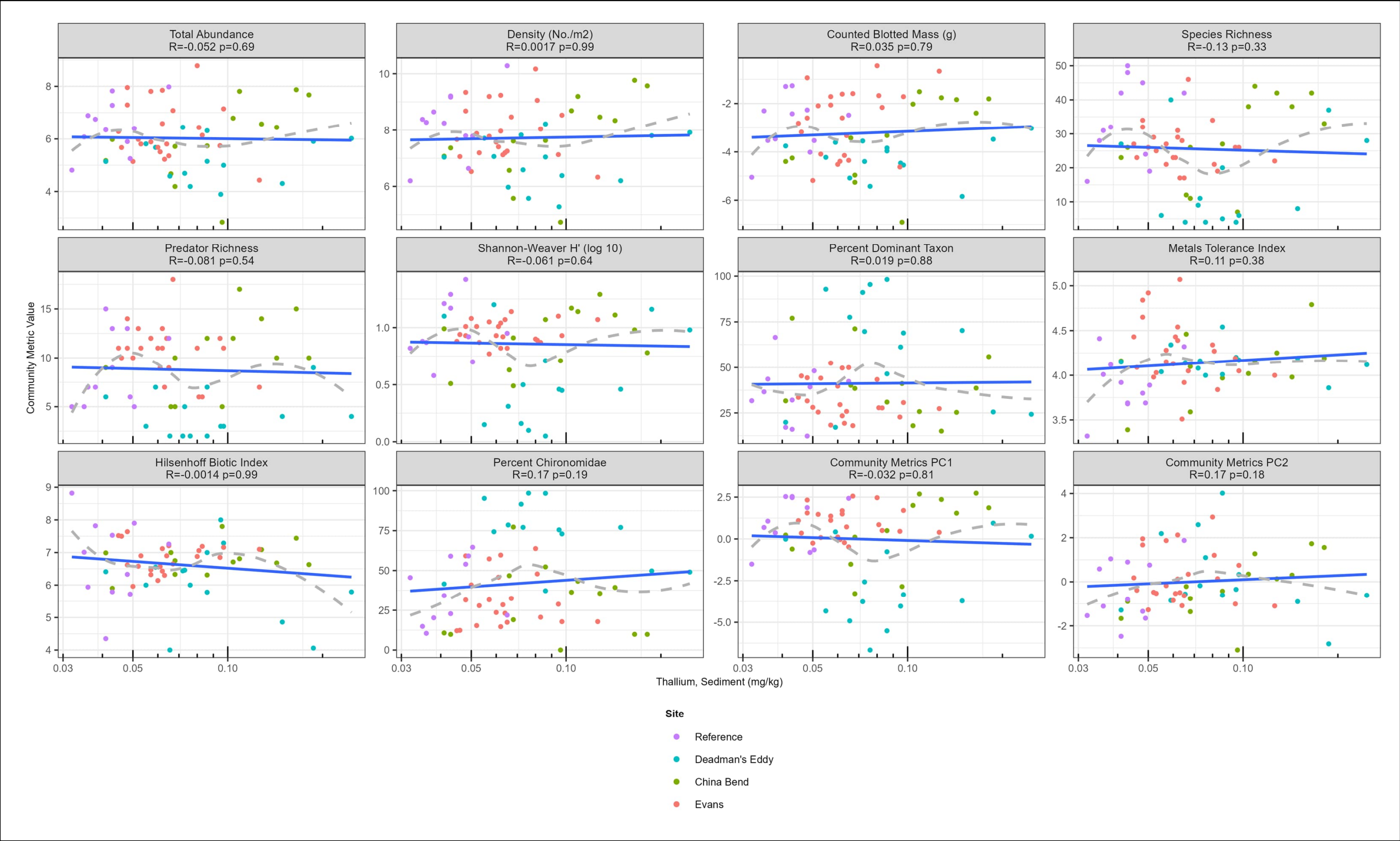


Figure K2-2u. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Thallium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

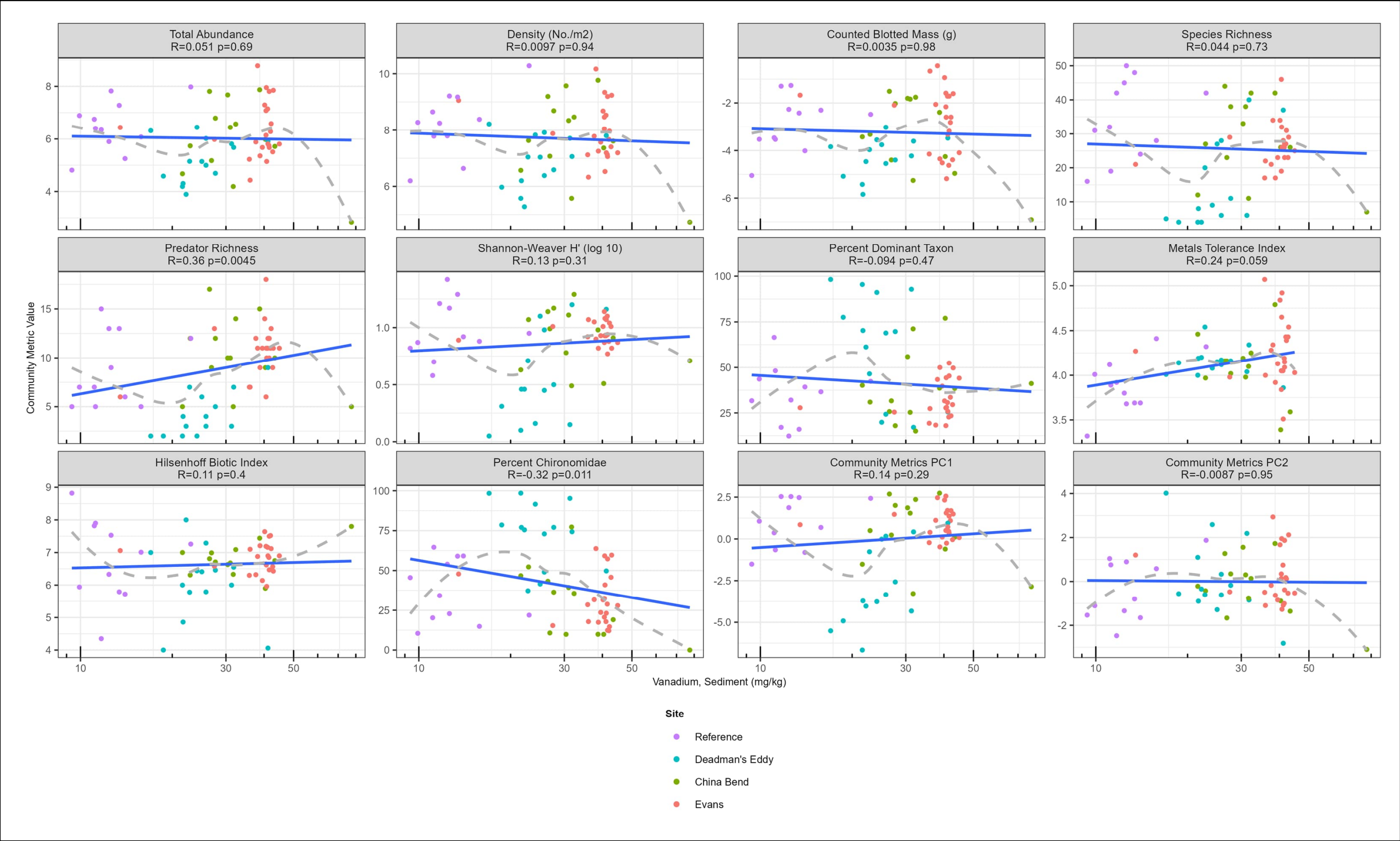


Figure K2-2v. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Vanadium Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

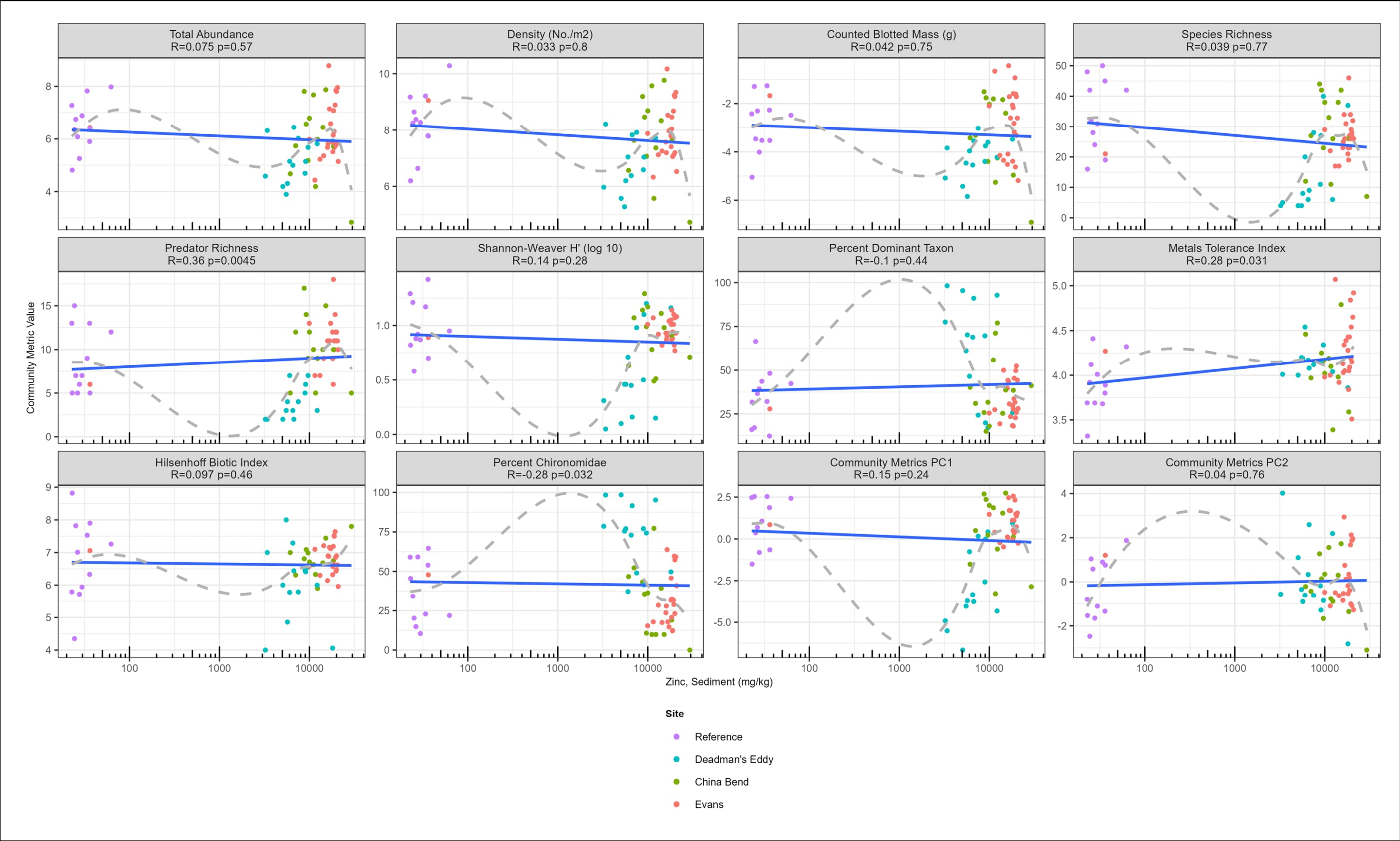


Figure K2-2w. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Zinc Concentrations from Phase 3 Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

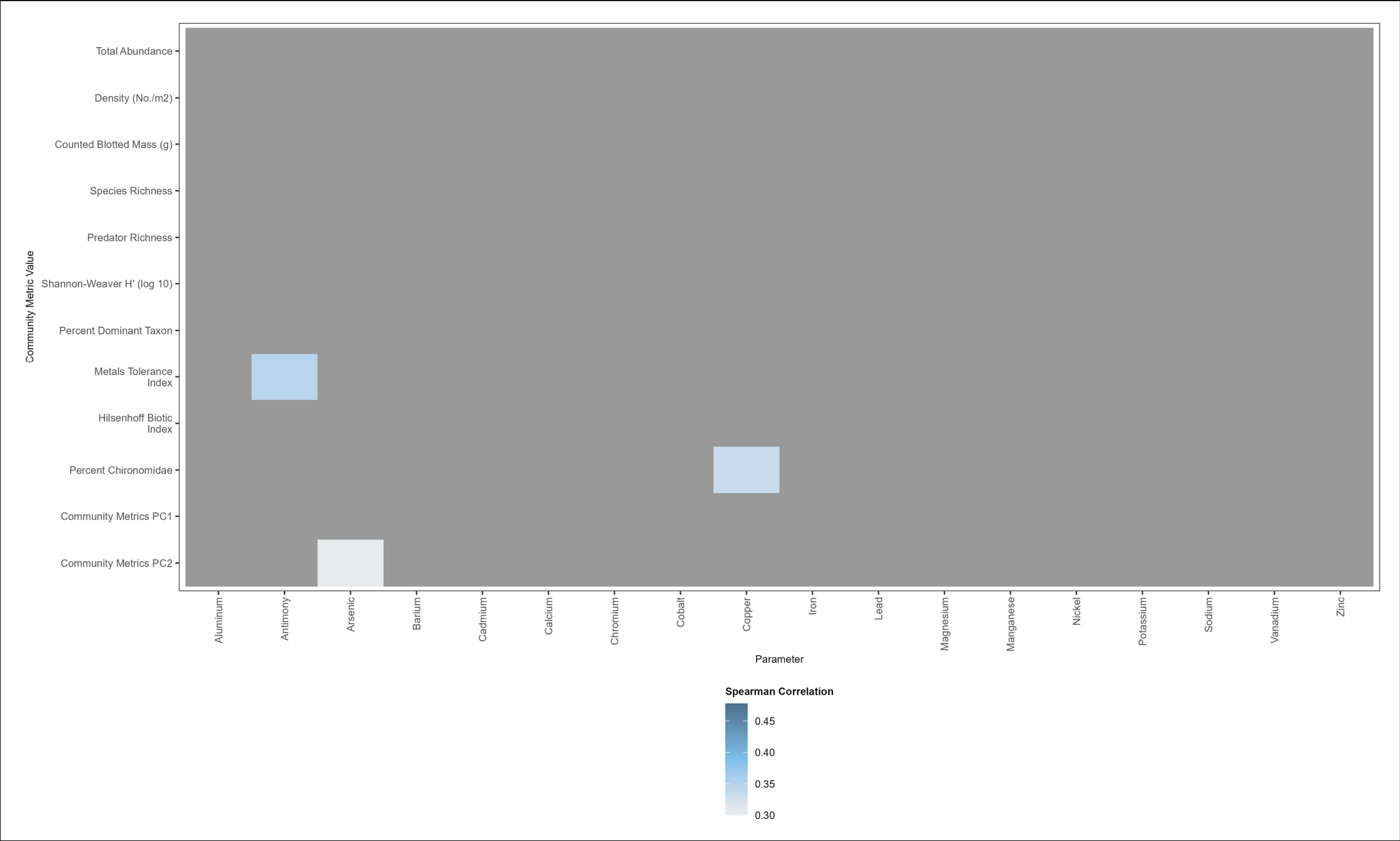


Figure K2-3. Mosaic of Rank Correlation Results for Benthic Invertebrate Community Metrics versus Dissolved Concentrations of Analytes in Porewater at Phase 3 Locations with CS50 Substrate

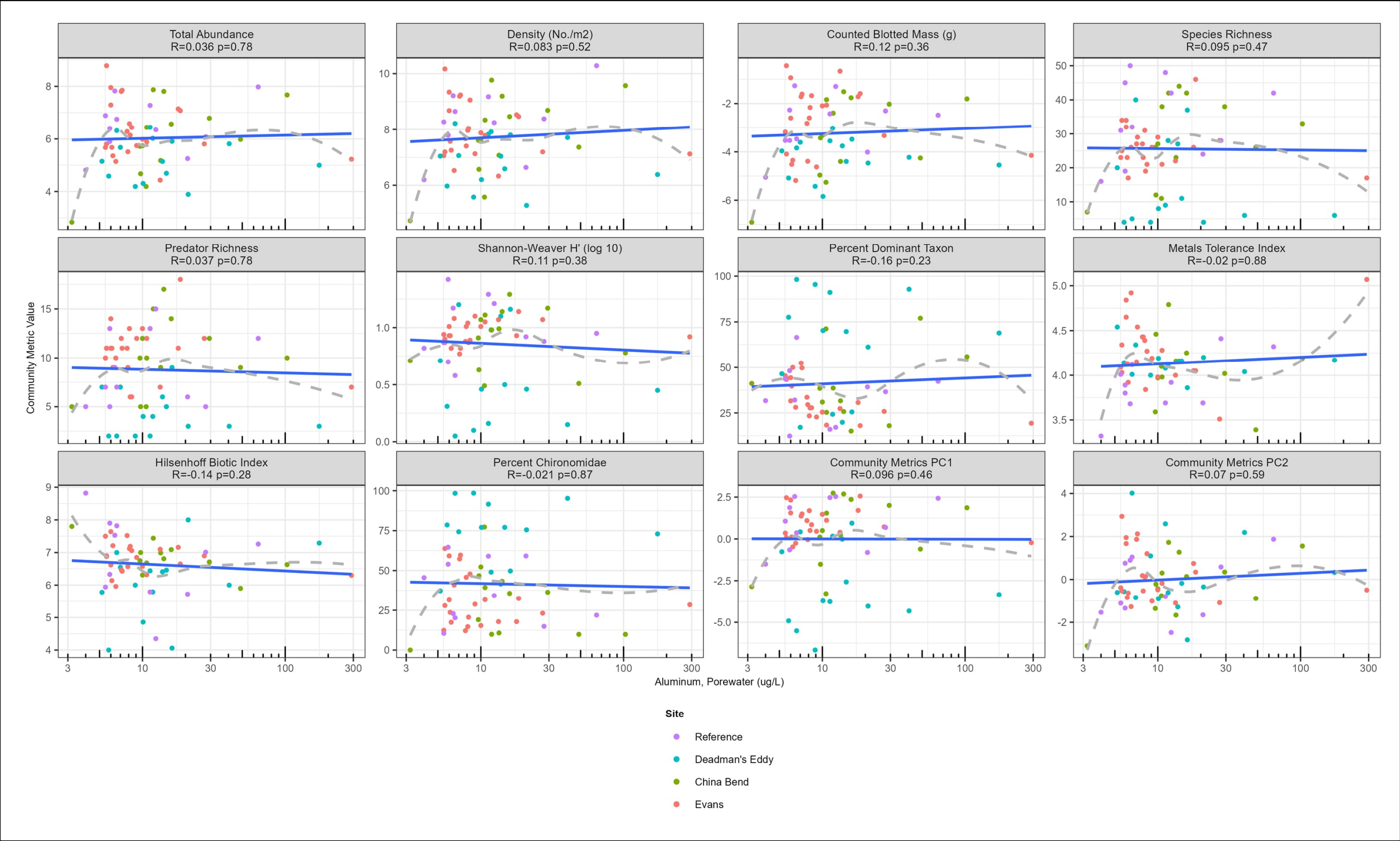


Figure K2-4a. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Aluminum in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

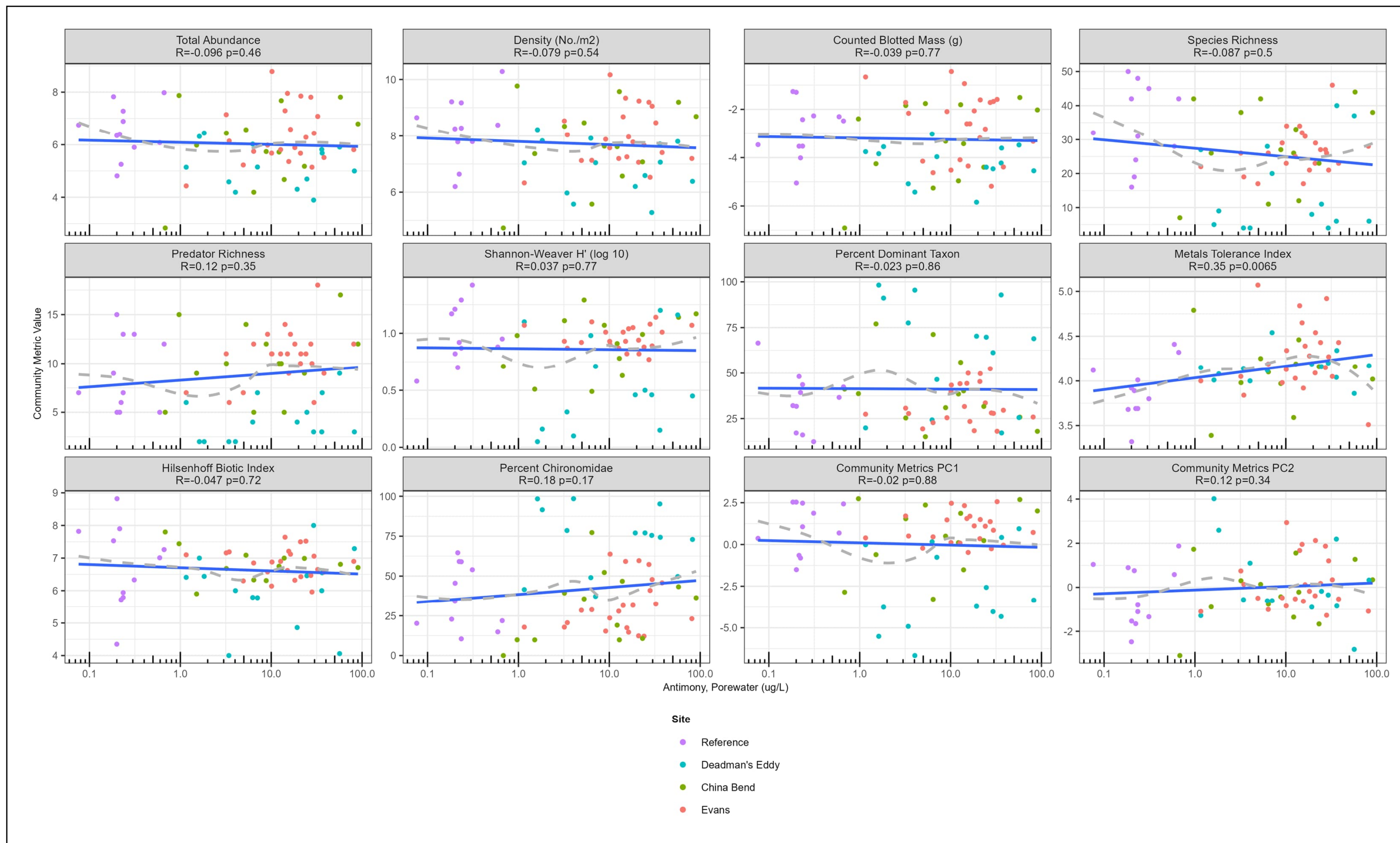


Figure K2-4b. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Antimony in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

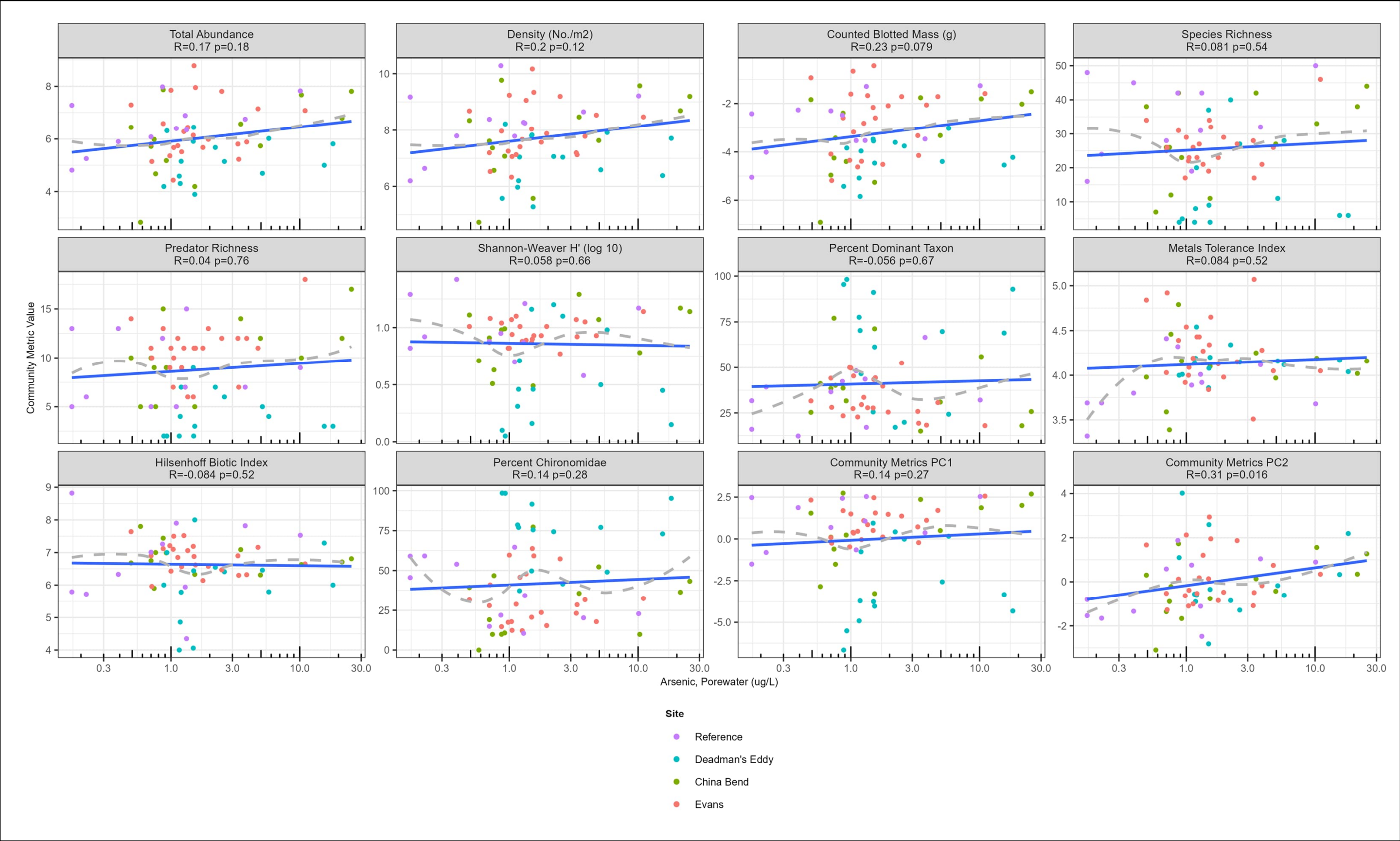


Figure K2-4c. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Arsenic in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

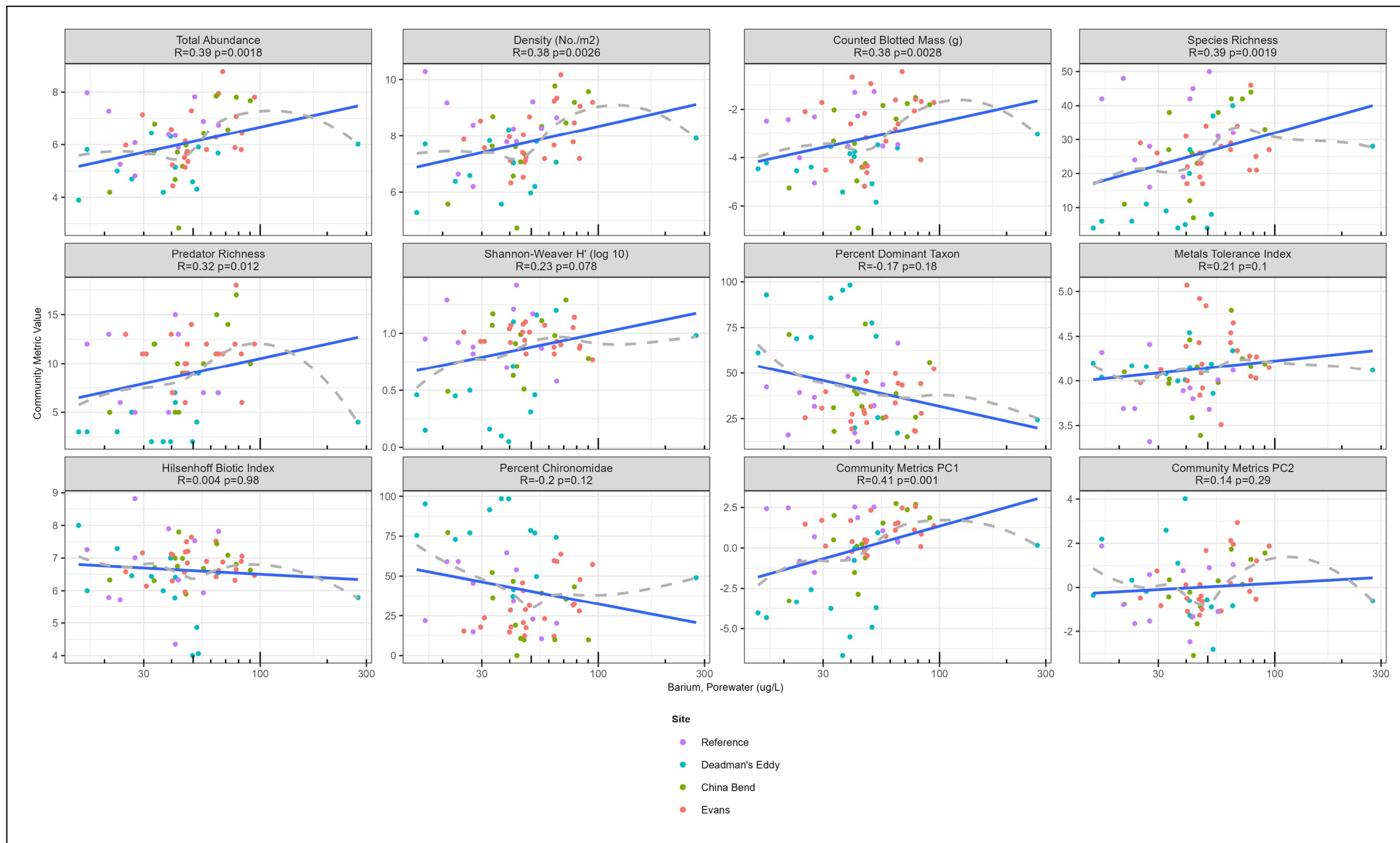


Figure K2-4d. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Barium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

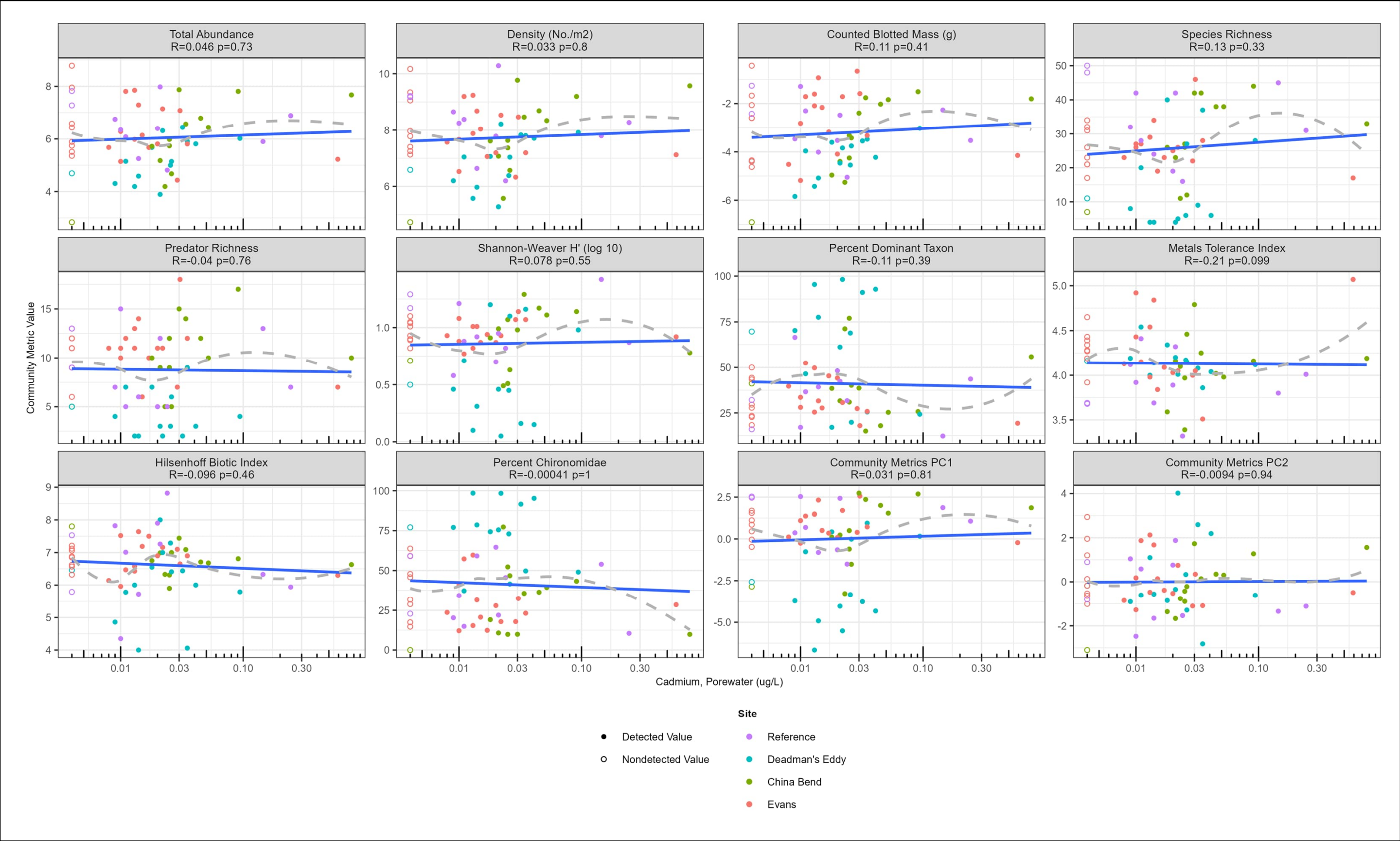


Figure K2-4e. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cadmium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

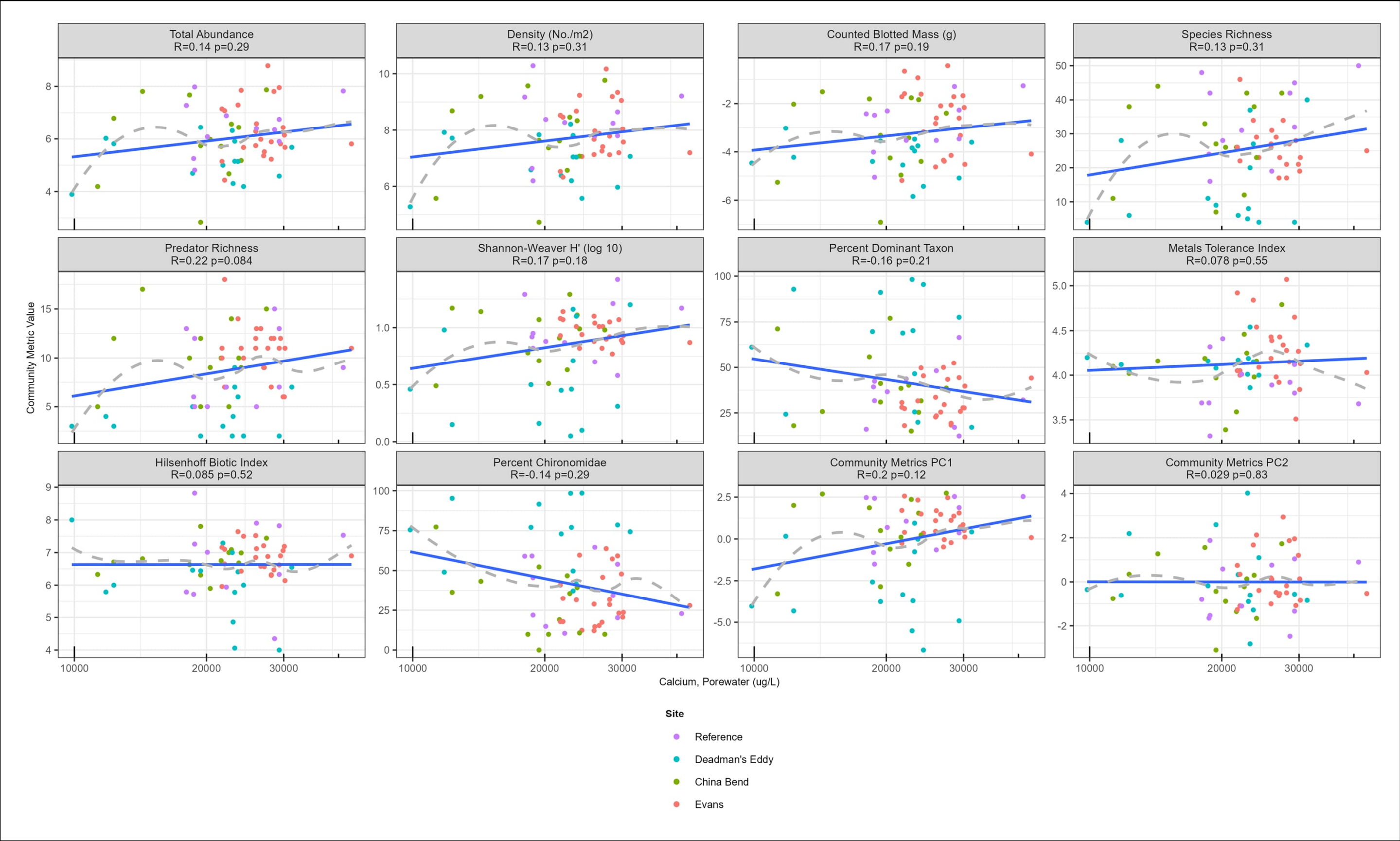


Figure K2-4f. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Calcium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

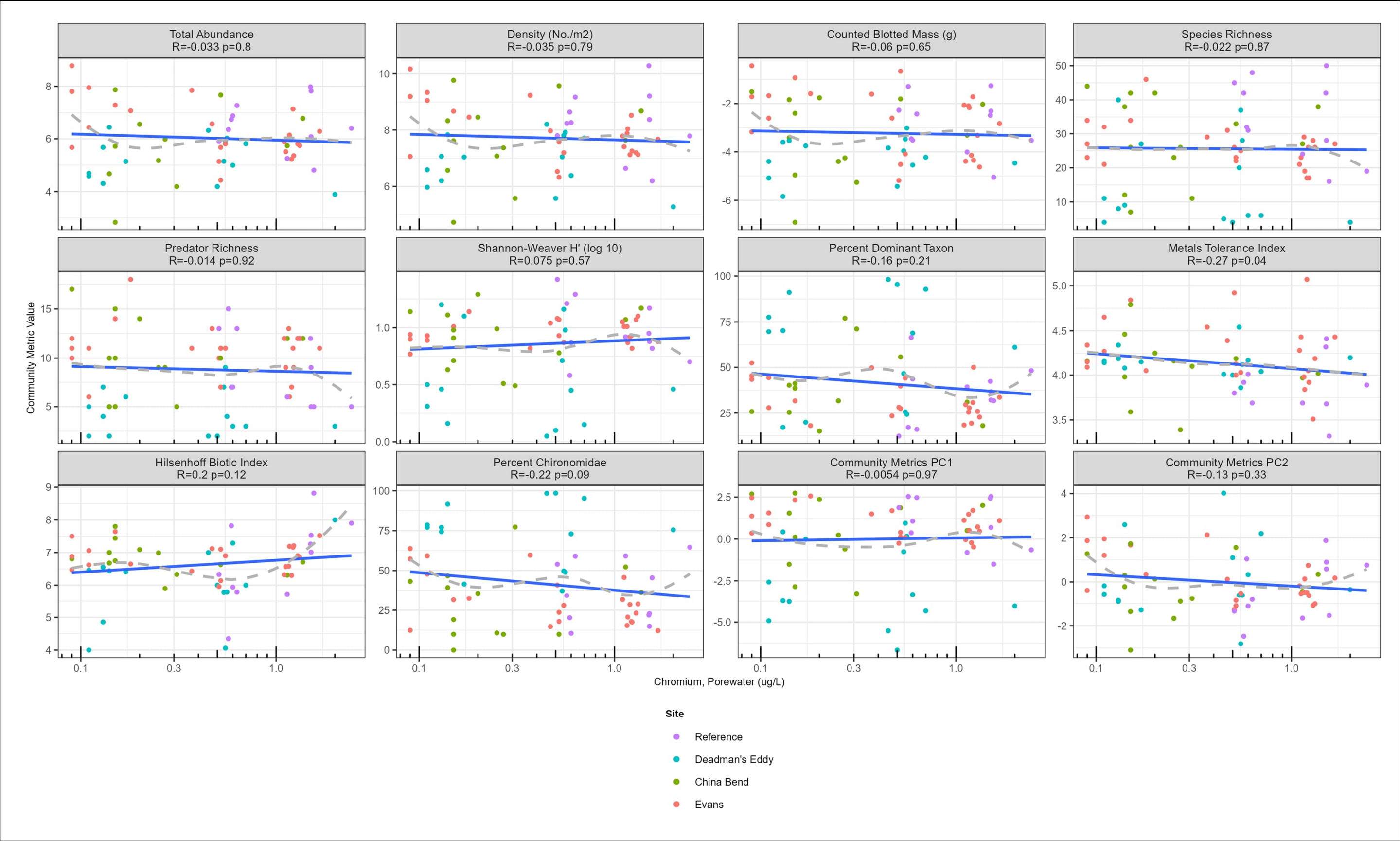


Figure K2-4g. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Chromium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

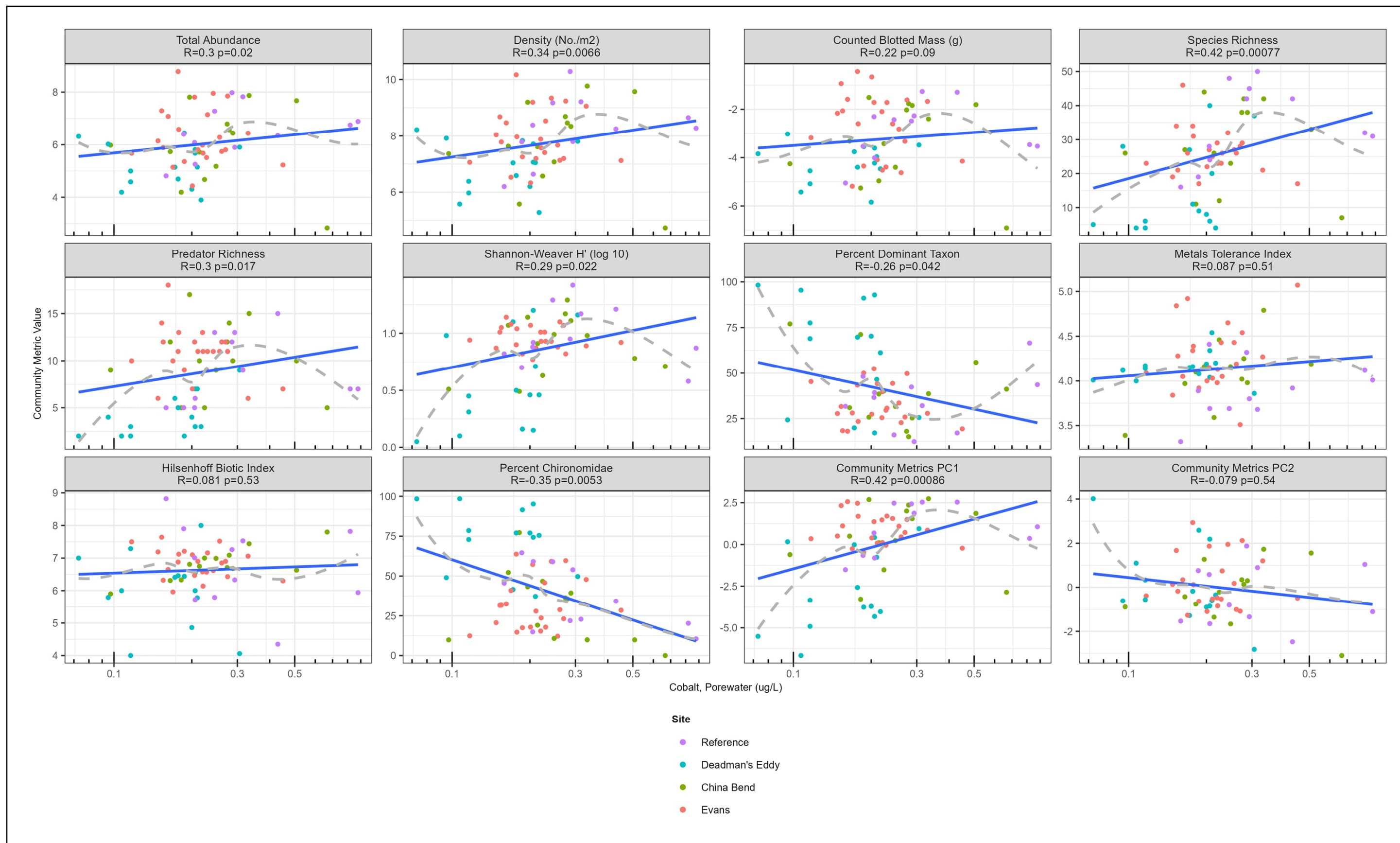


Figure K2-4h. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cobalt in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

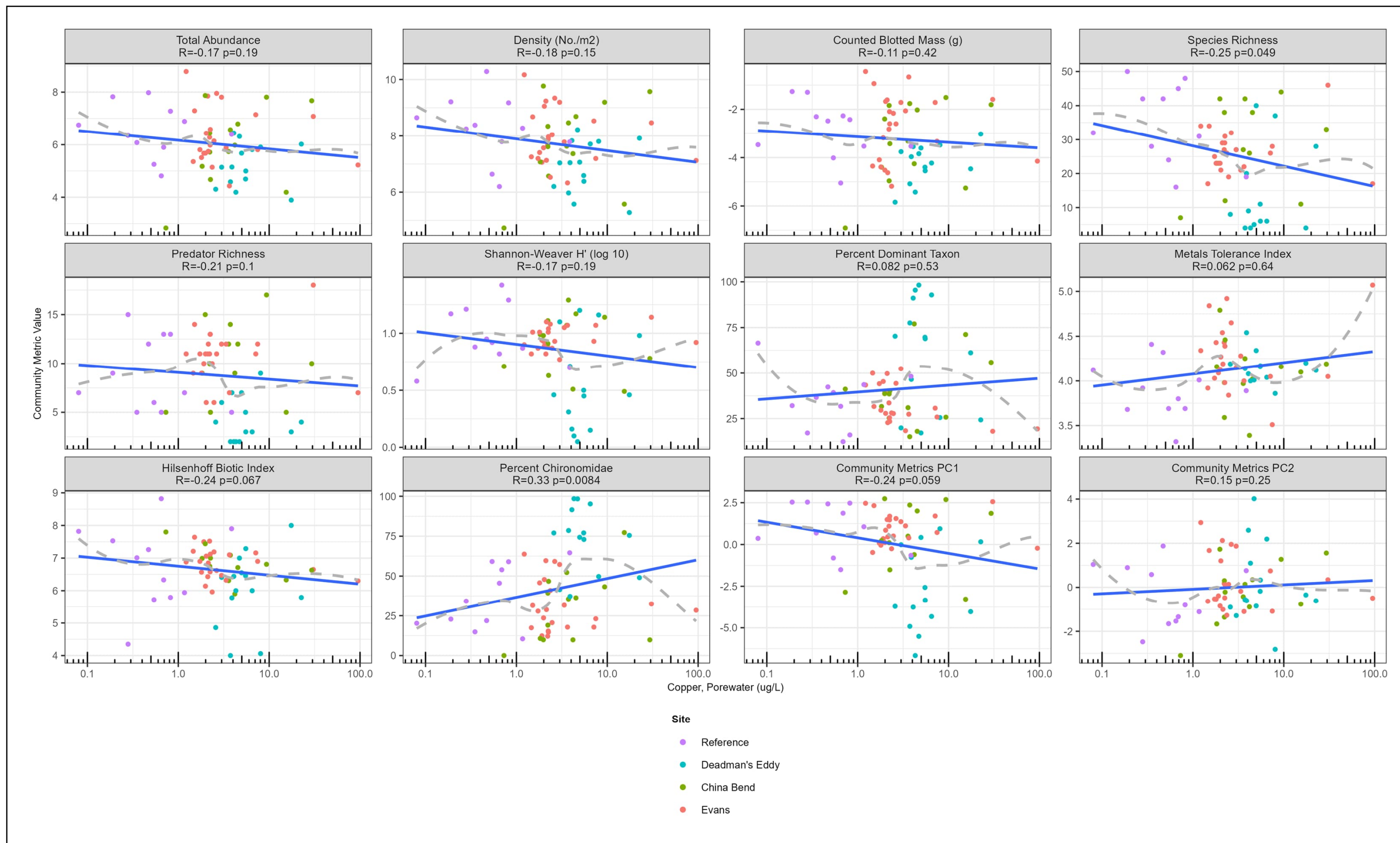


Figure K2-4i. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Copper in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

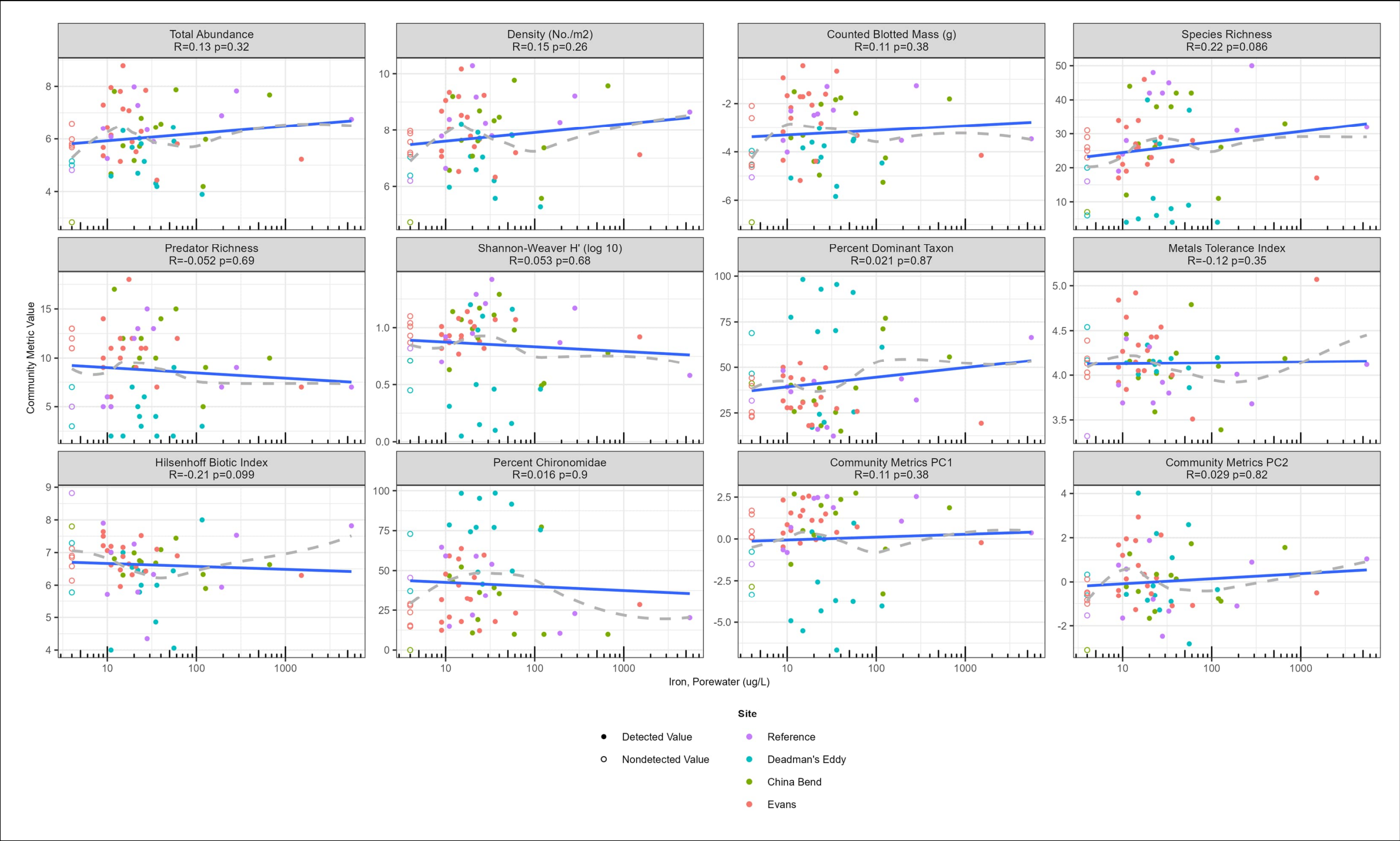


Figure K2-4j. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Iron in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

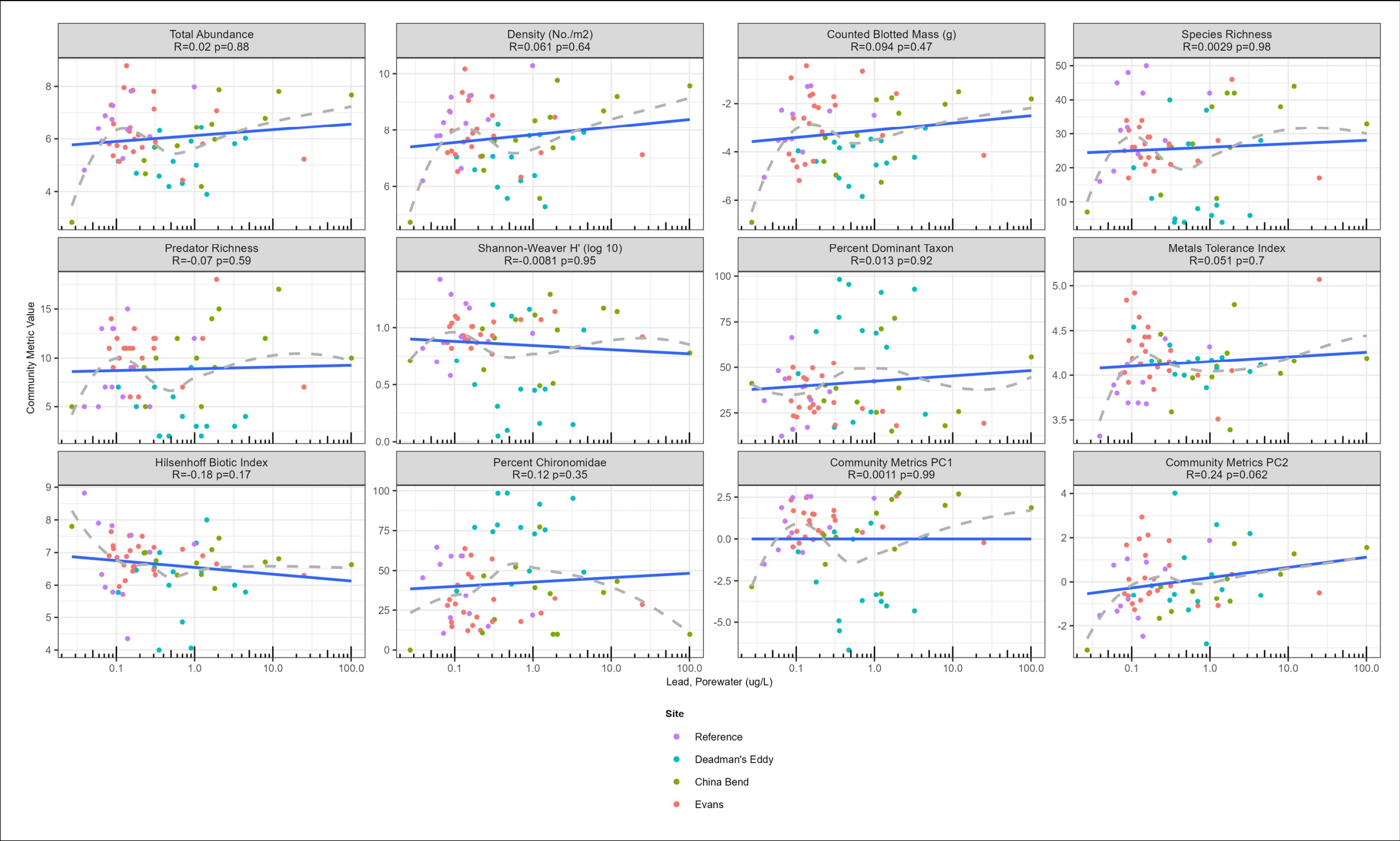


Figure K2-4k. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Lead in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

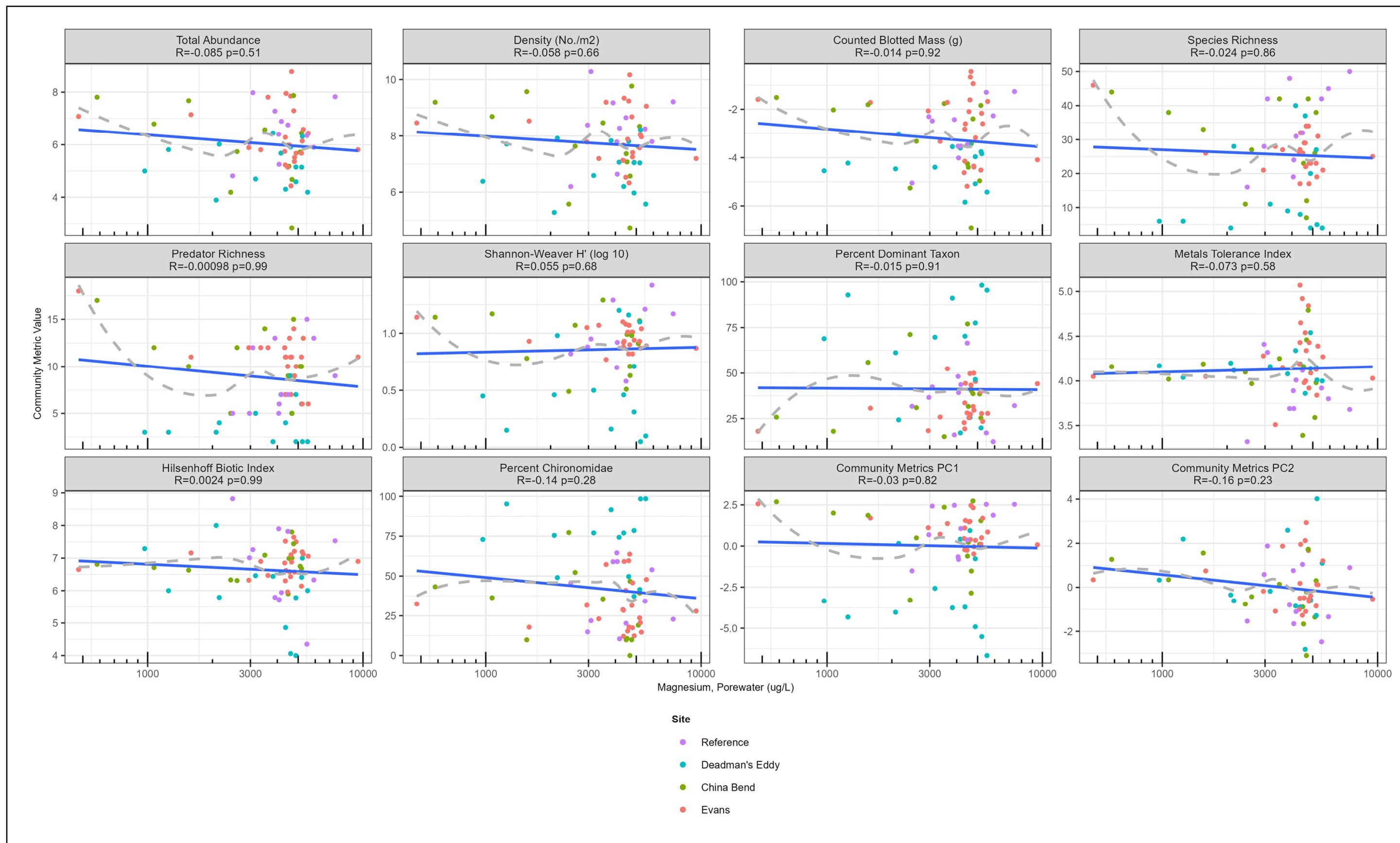


Figure K2-41. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Magnesium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

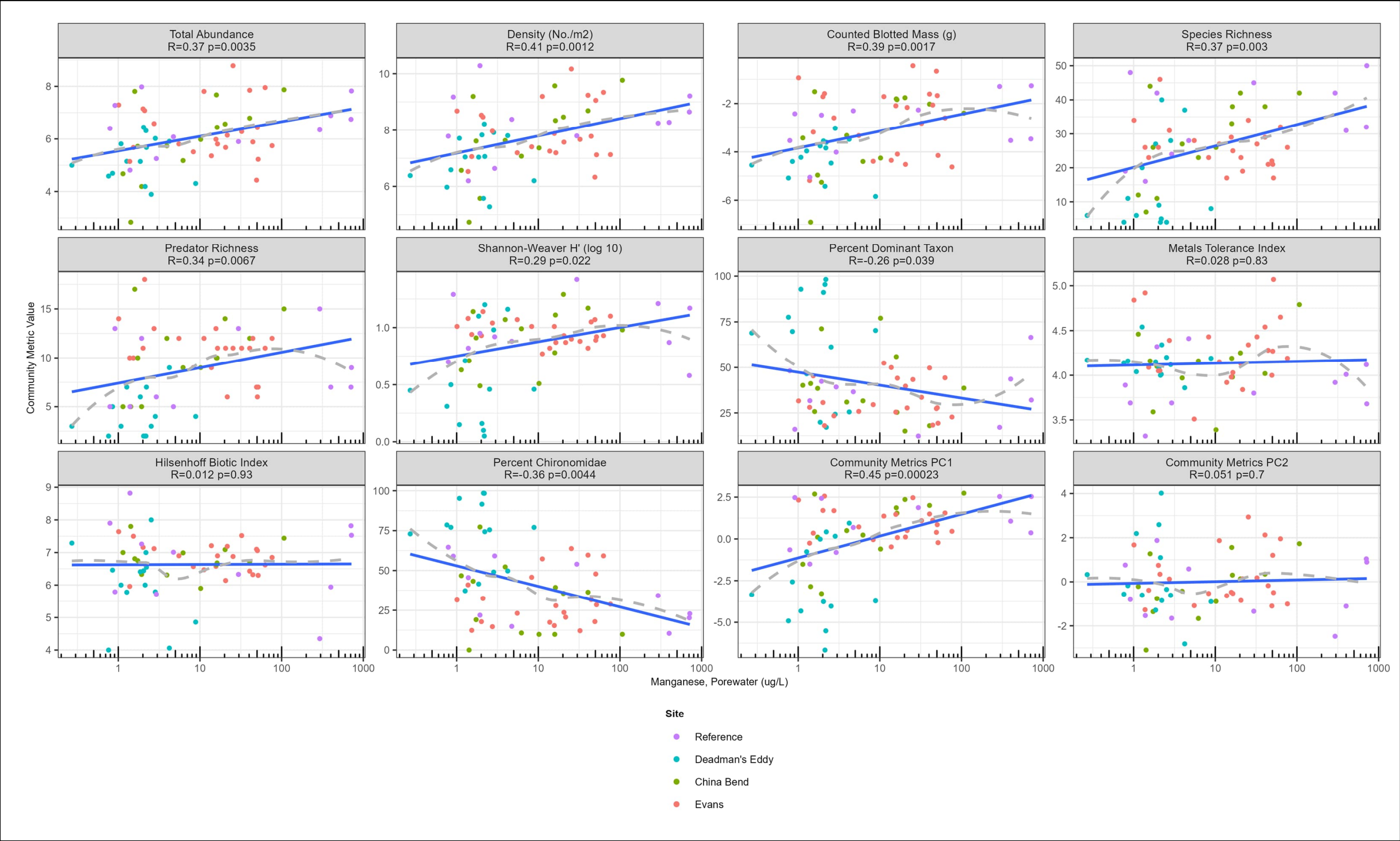


Figure K2-4m. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Manganese in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

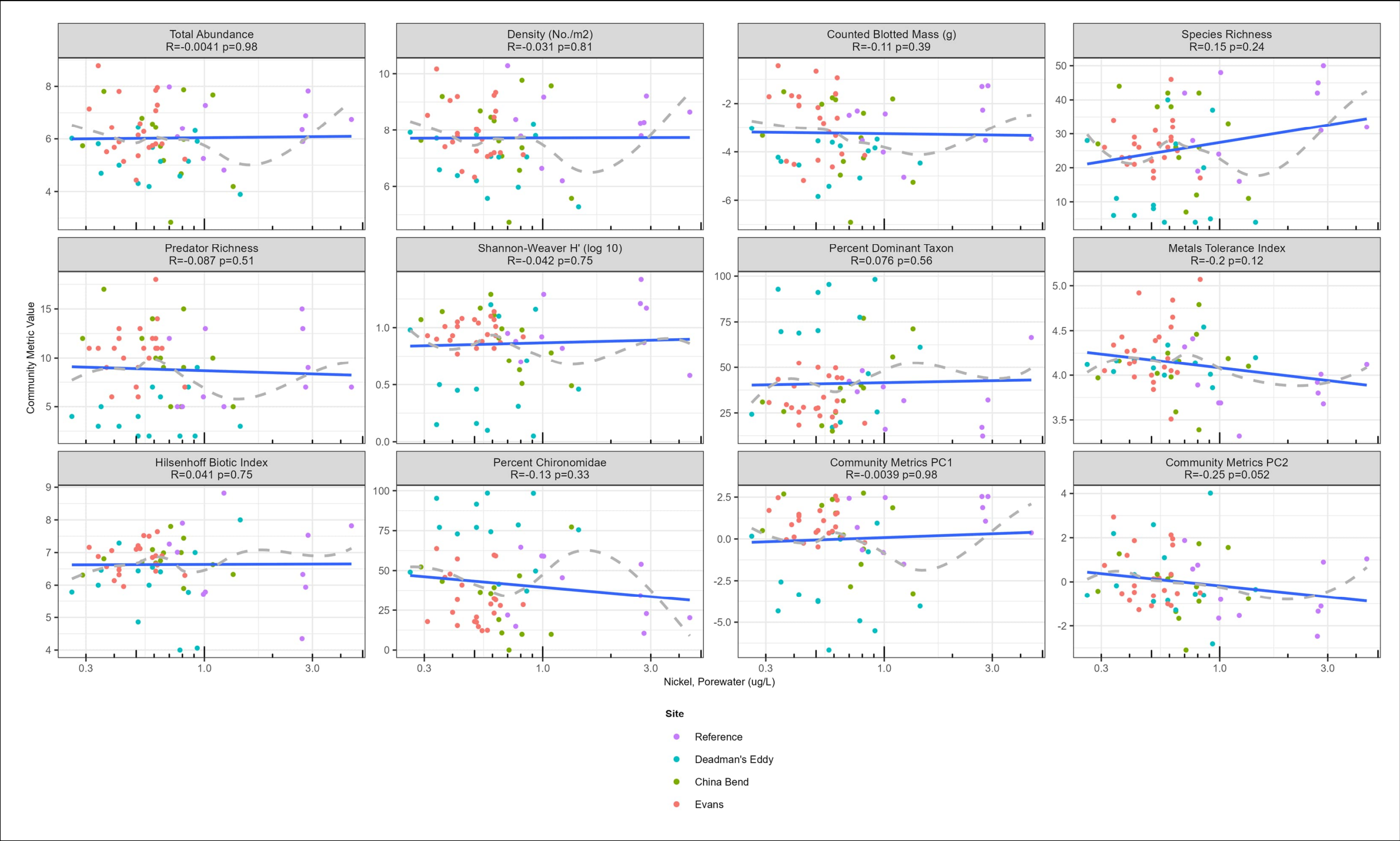


Figure K2-4n. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Nickel in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

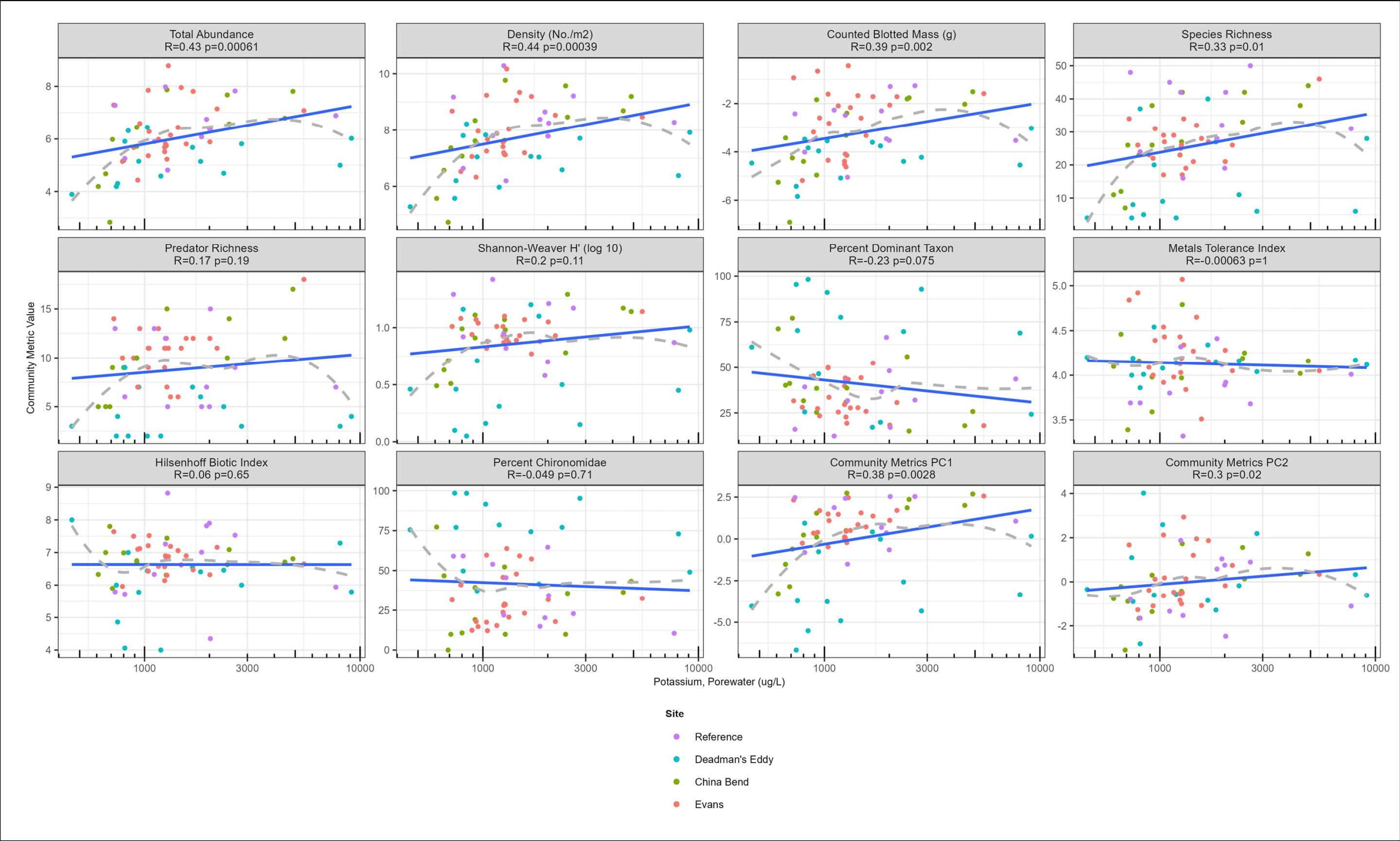


Figure K2-4o. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Potassium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

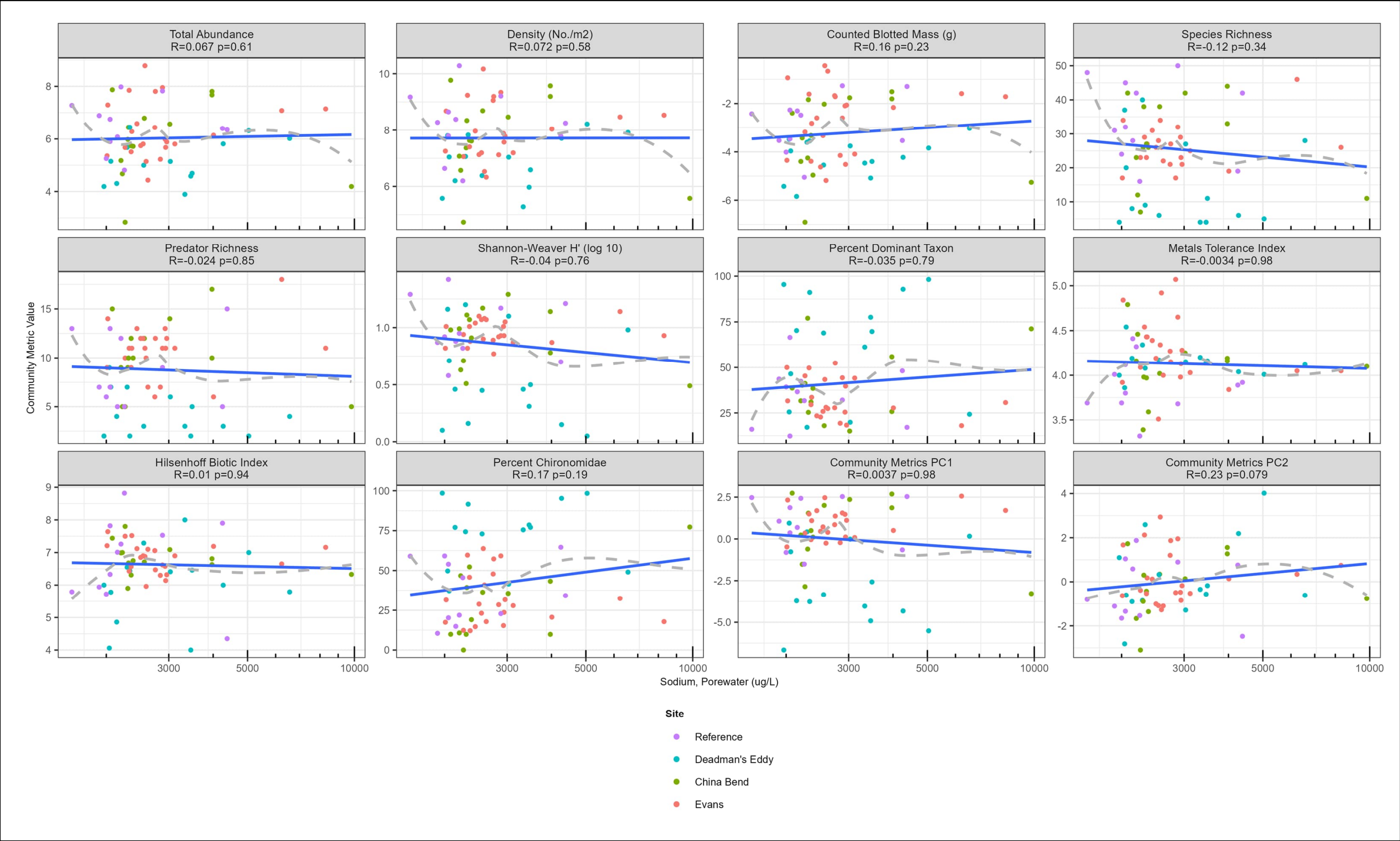


Figure K2-4p. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Sodium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

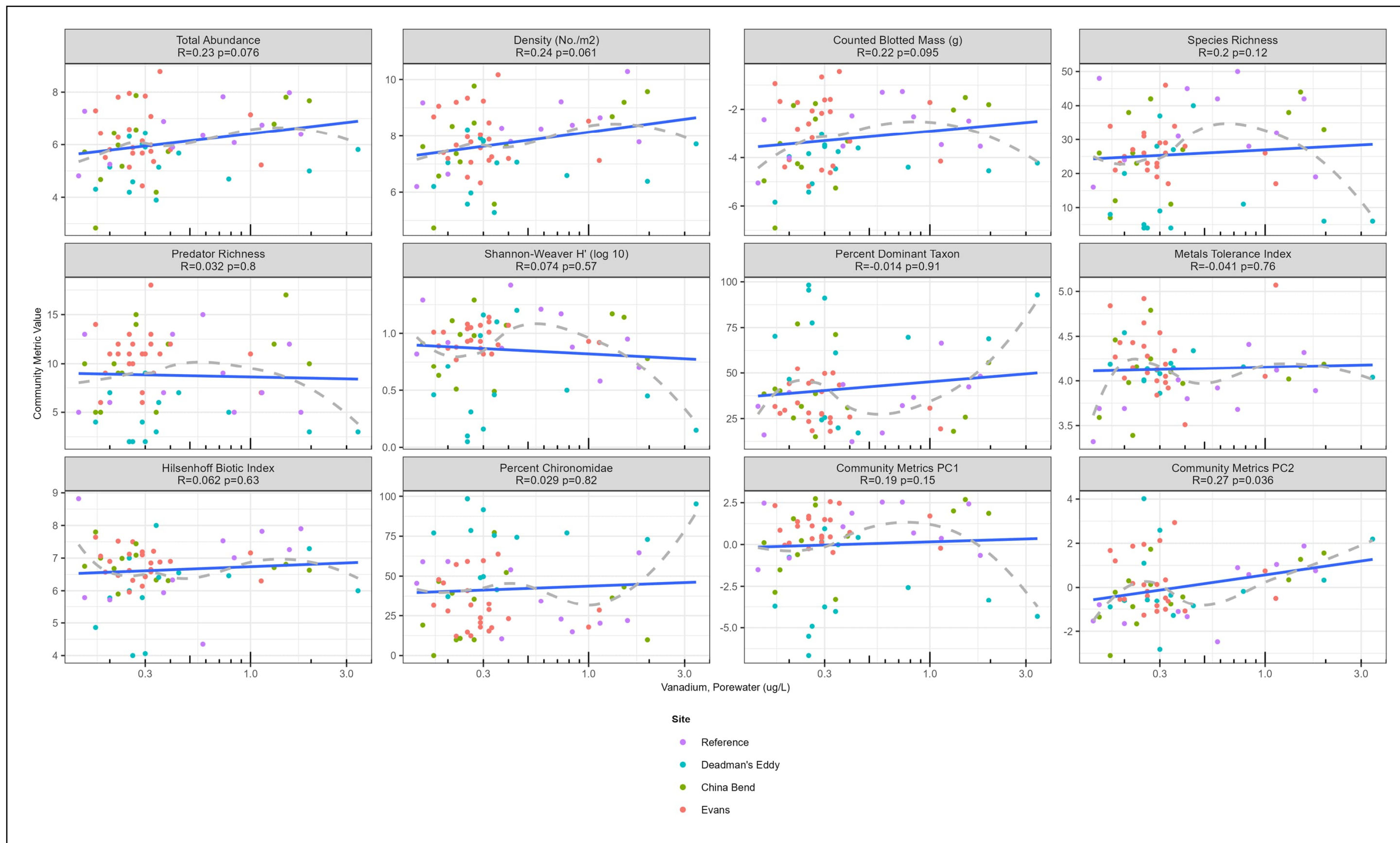


Figure K2-4q. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Vanadium in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

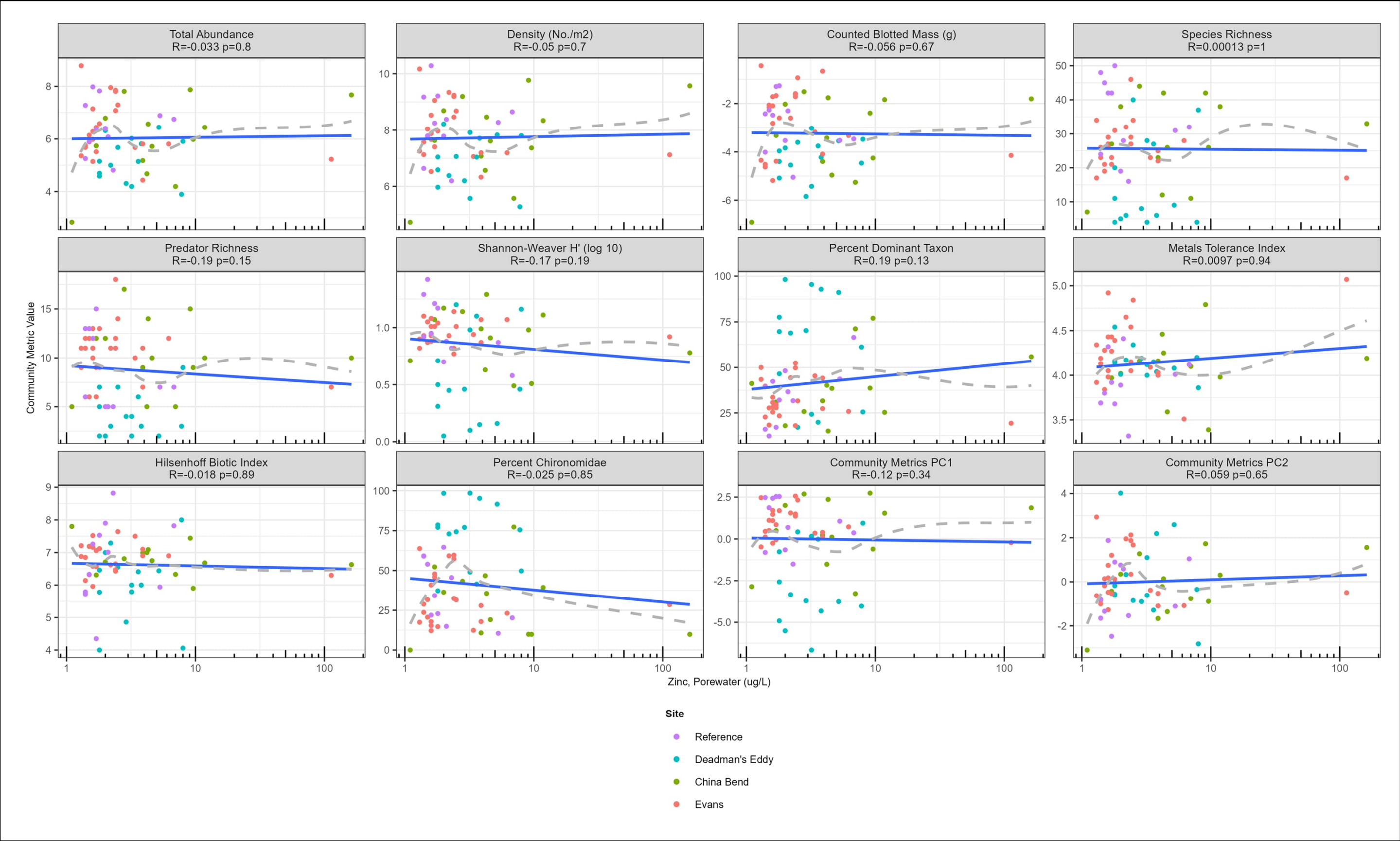


Figure K2-4r. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Zinc in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

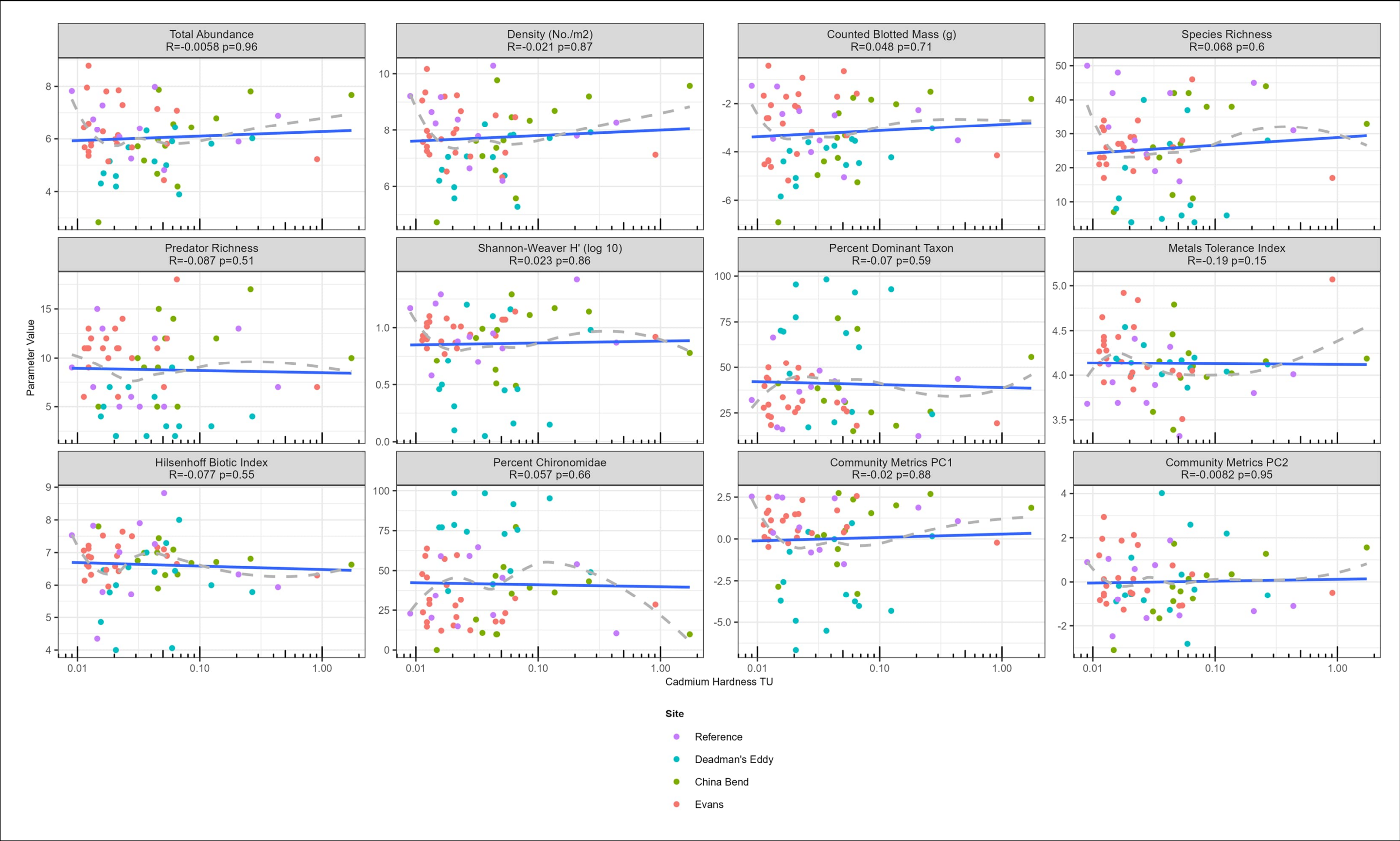


Figure K2-4s. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cadmium Hardness TU in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

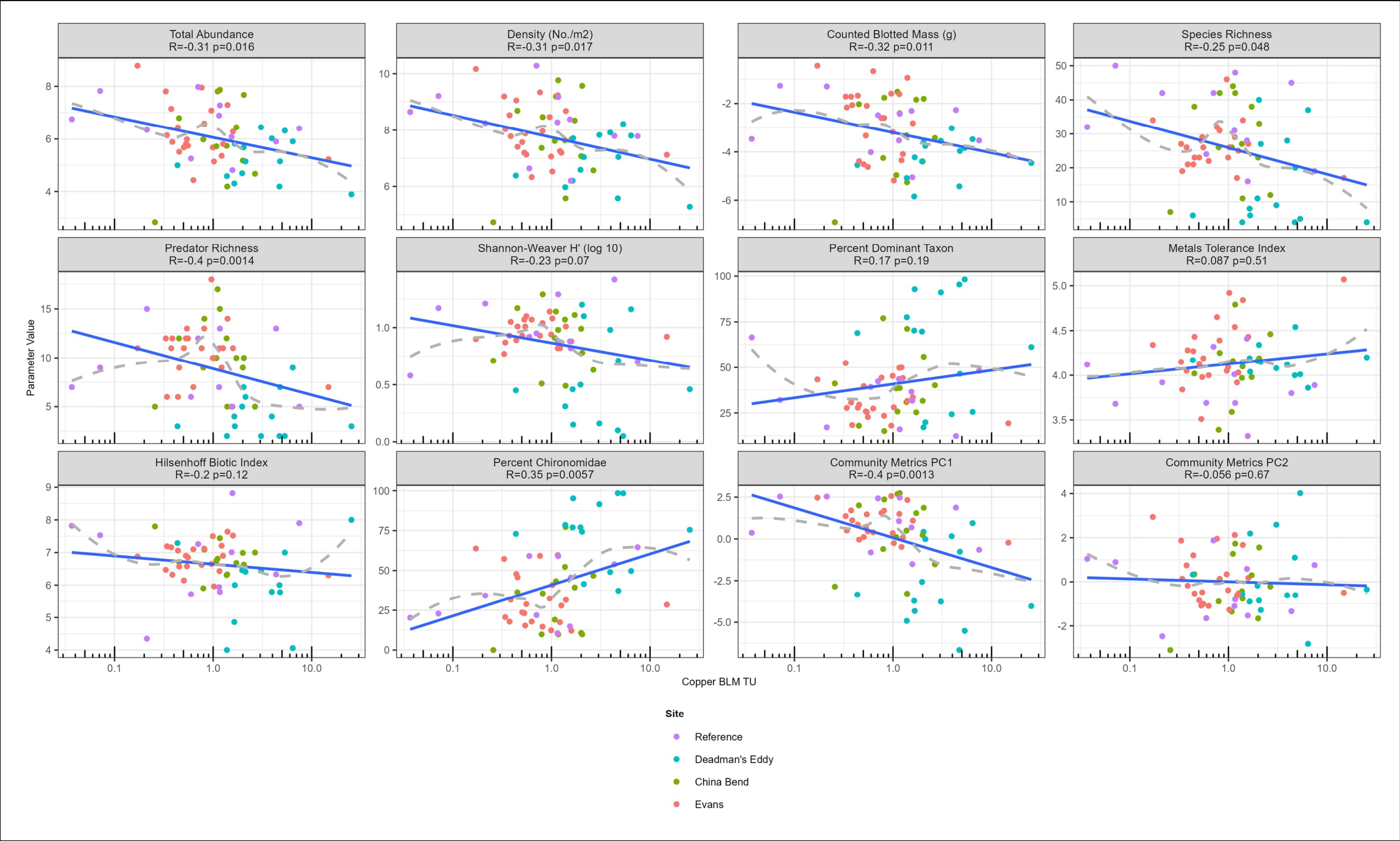


Figure K2-4t. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Copper BLM TU in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

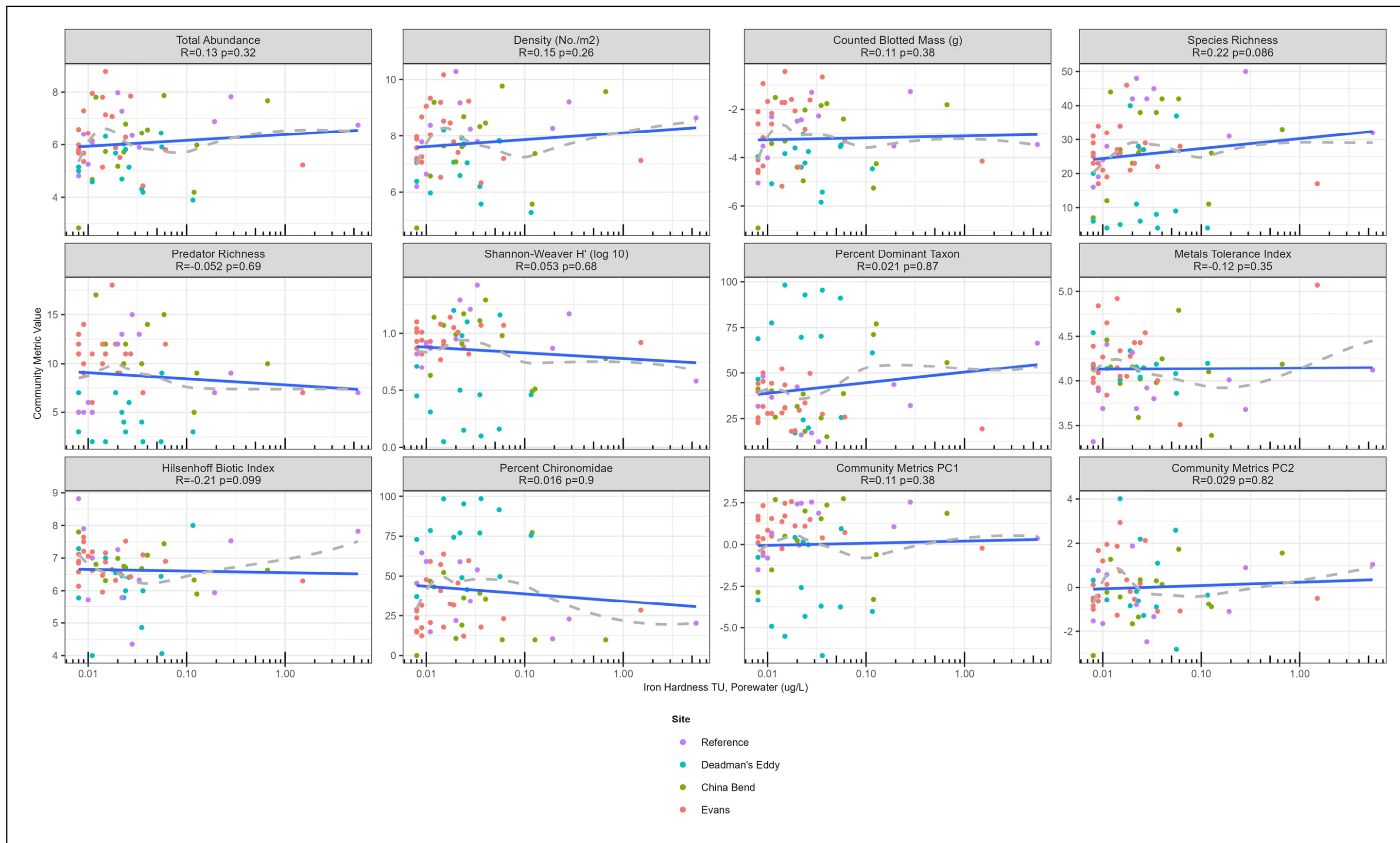


Figure K2-4u. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Iron Hardness TU in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

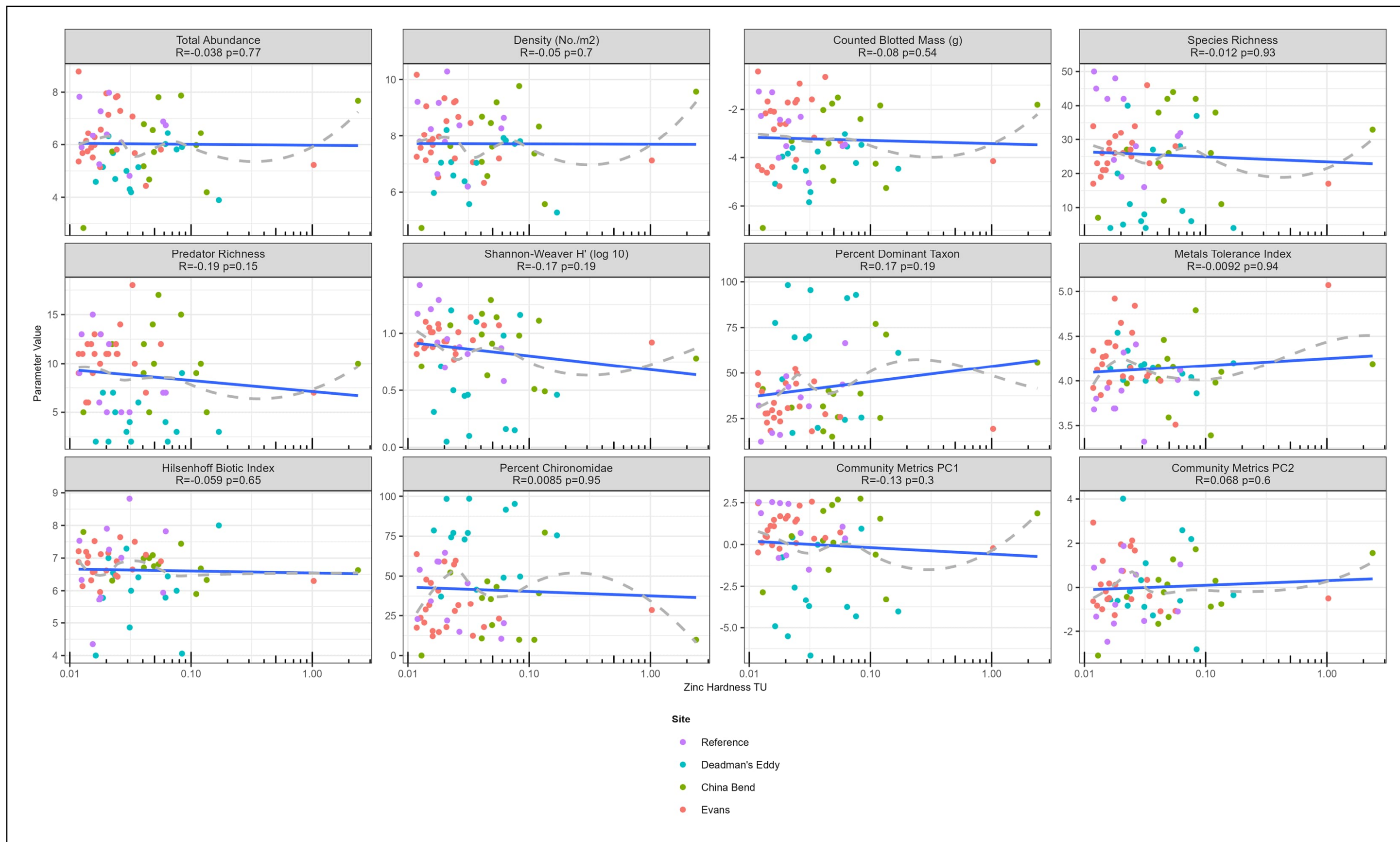


Figure K2-4v. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Zinc Hardness TU in Porewater at Locations with Greater than 50 Percent Medium, Coarse, and Very Coarse Sand

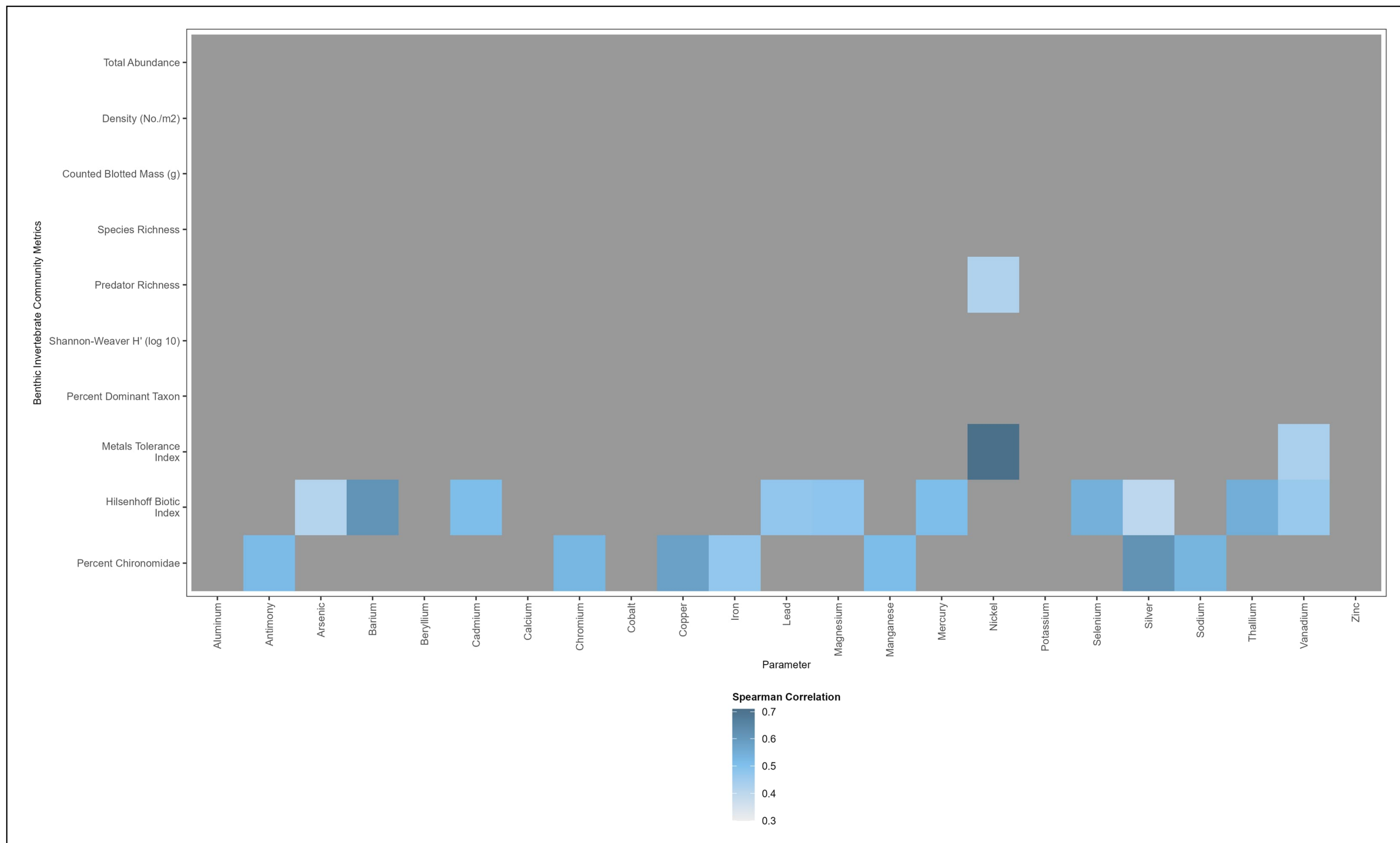


Figure K2-5. Mosaic of Rank Correlation Results for Benthic Invertebrate Community Metrics versus Bulk Sediment Metals Concentrations at Phase 3 Locations with Non-CS50 Substrate

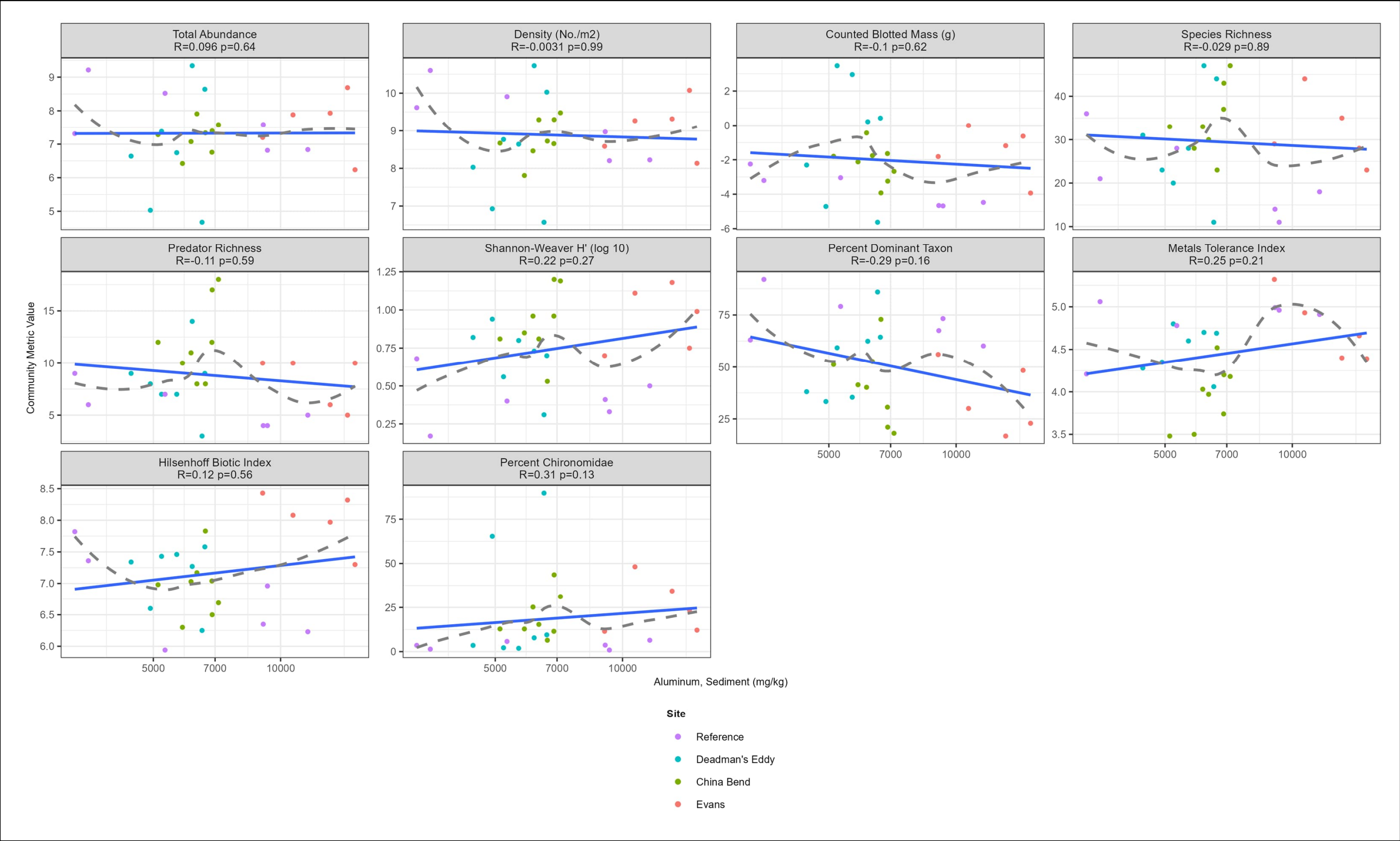


Figure K2-6a. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Aluminum Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

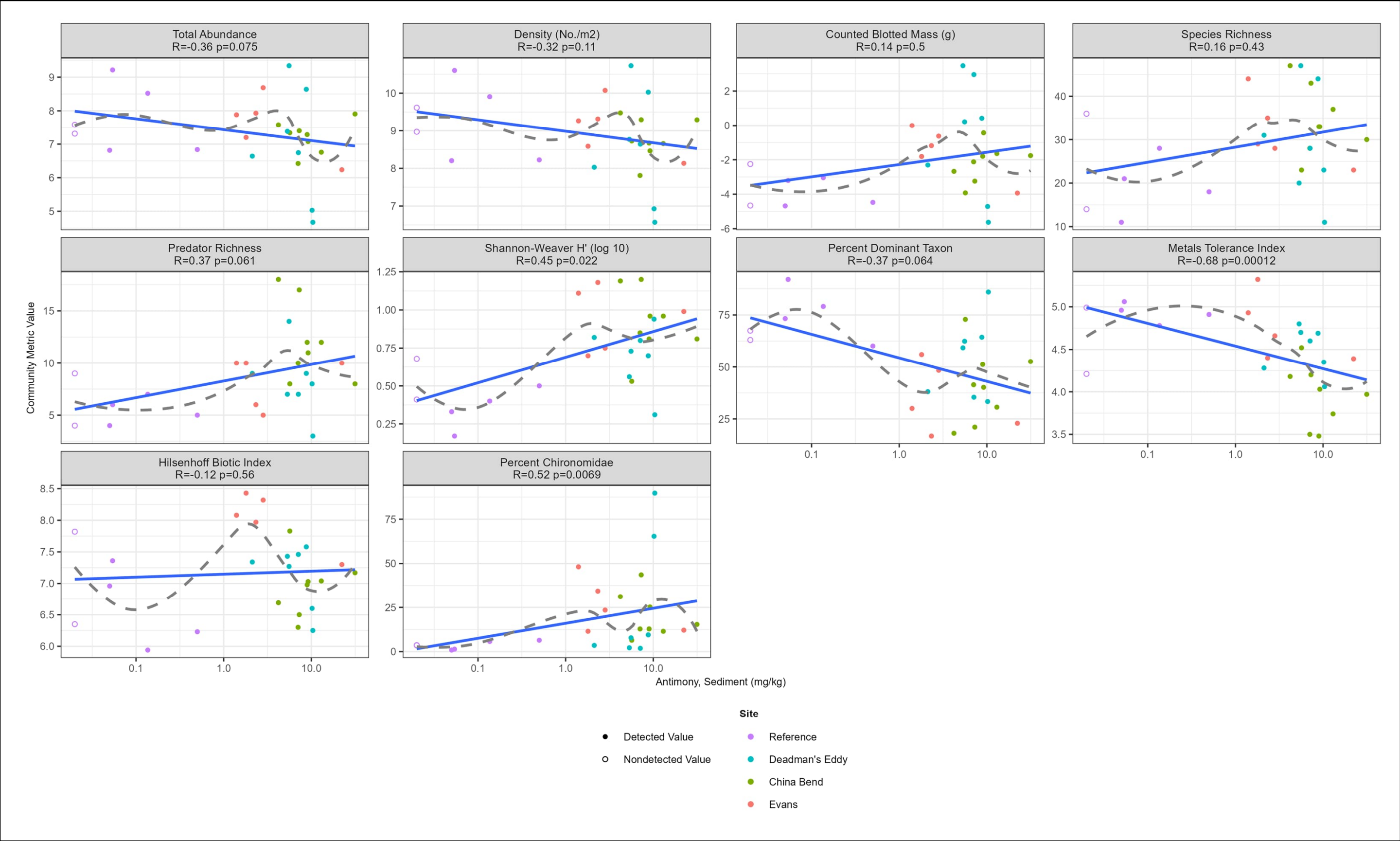


Figure K2-6b. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Antimony Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

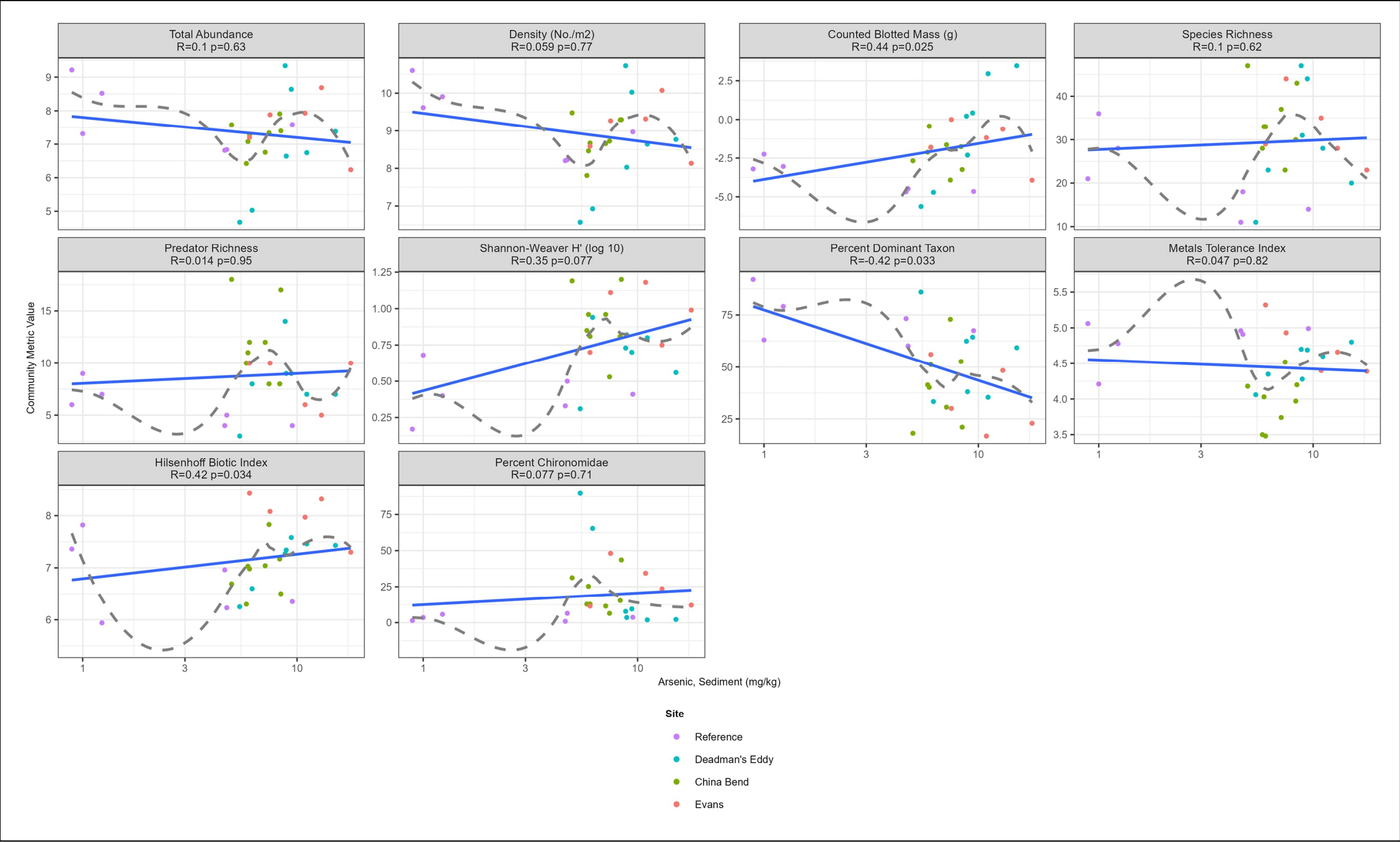


Figure K2-6c. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Arsenic Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

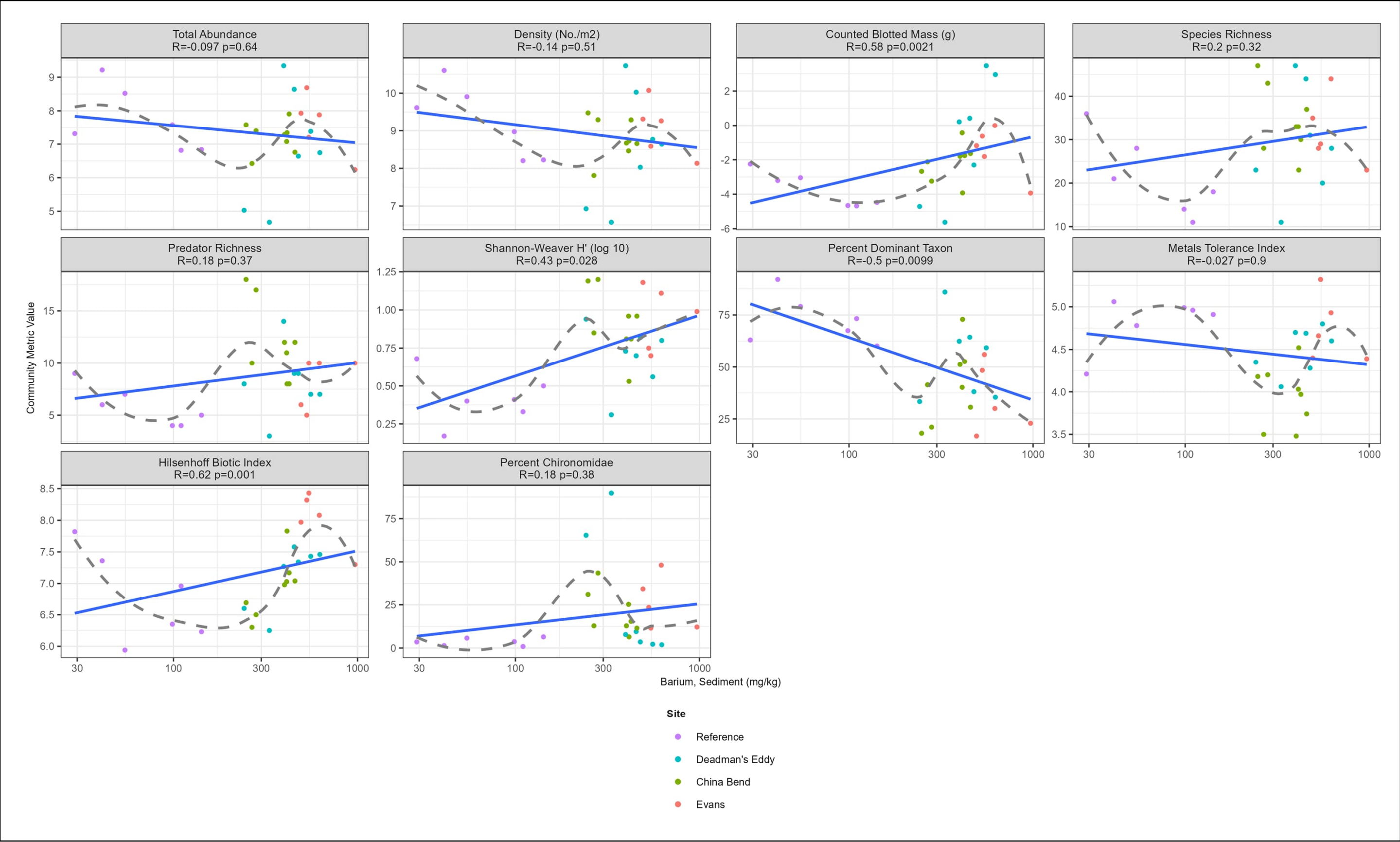


Figure K2-6d. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Barium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

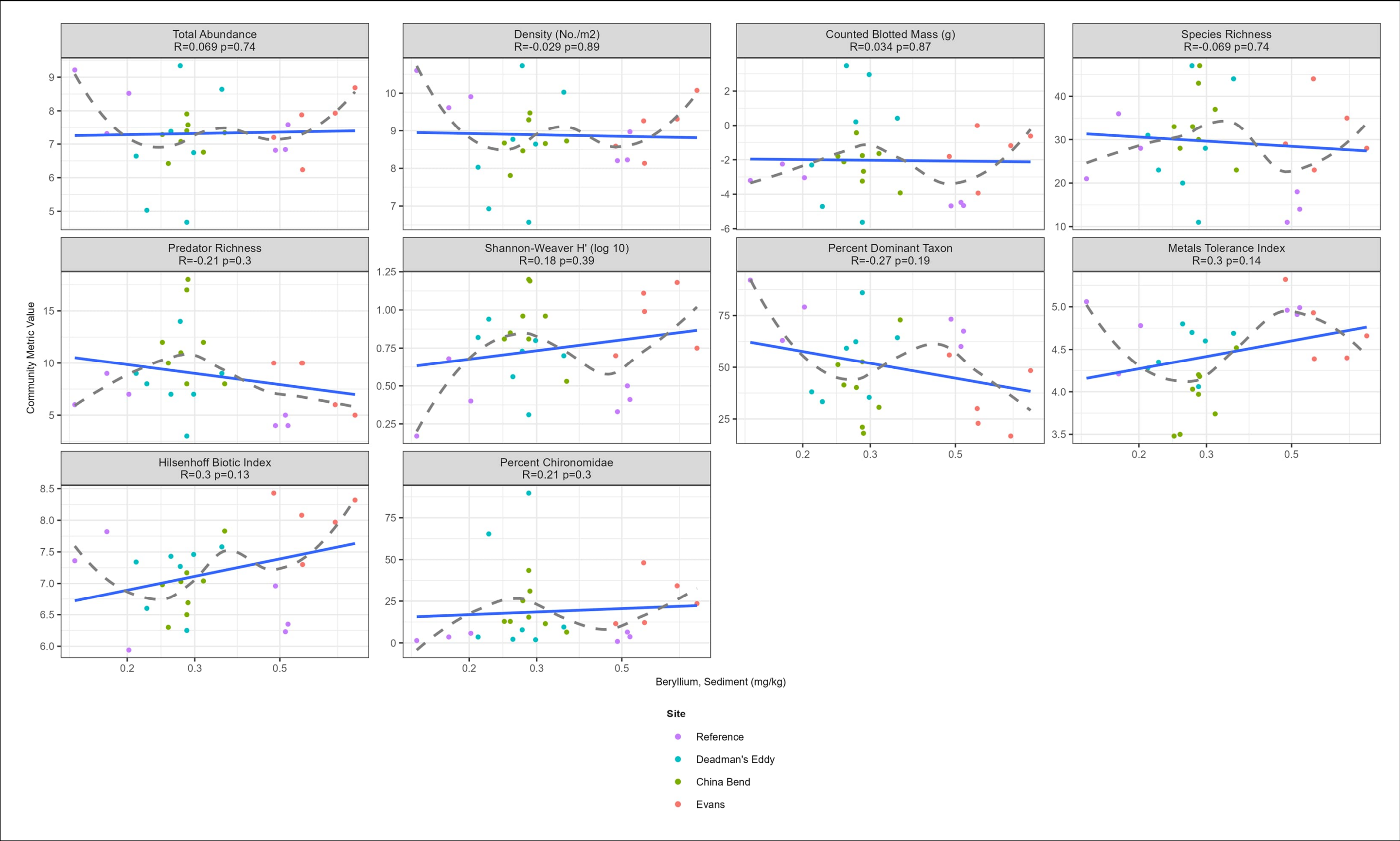


Figure K2-6e. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Beryllium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

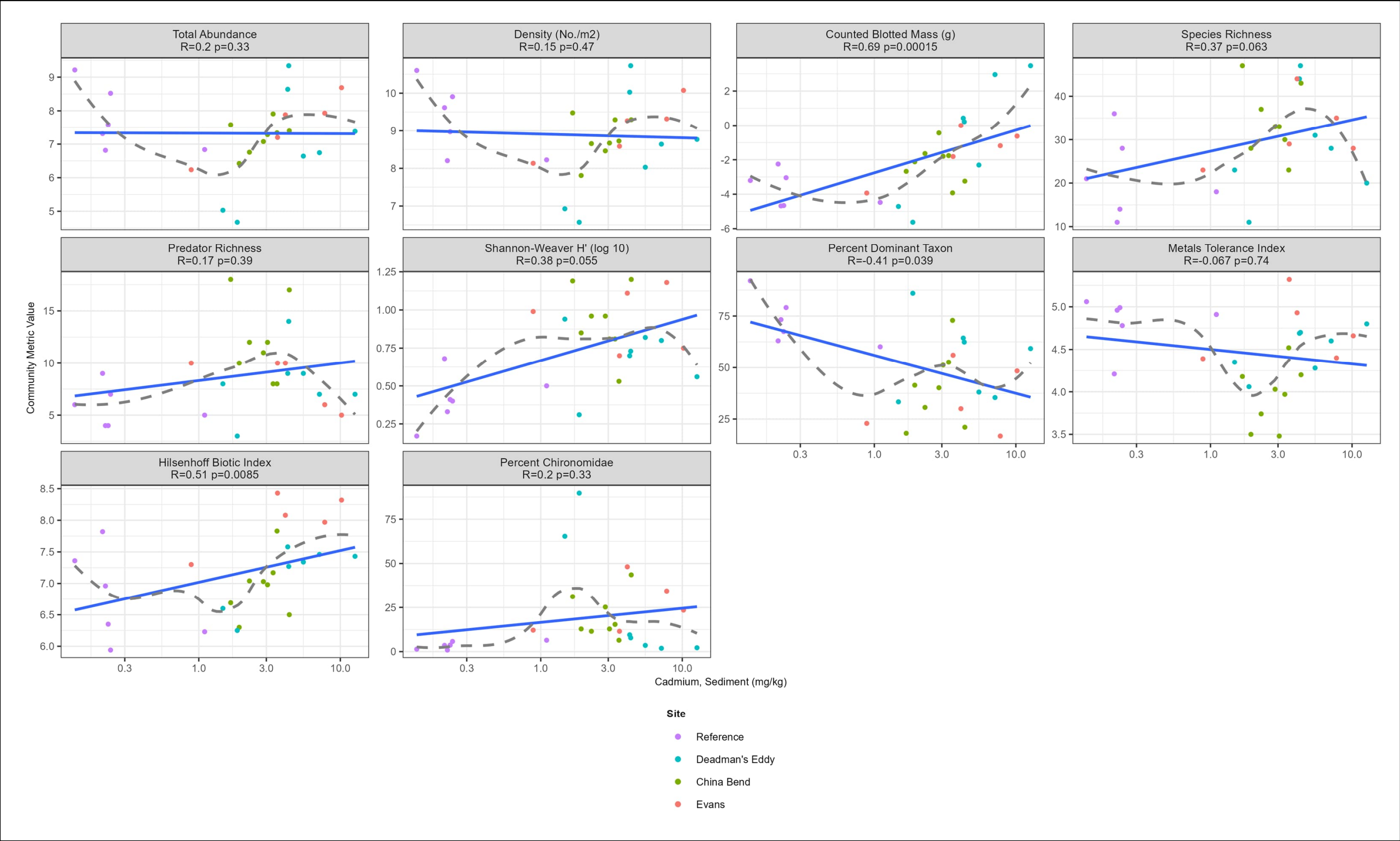


Figure K2-6f. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Cadmium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

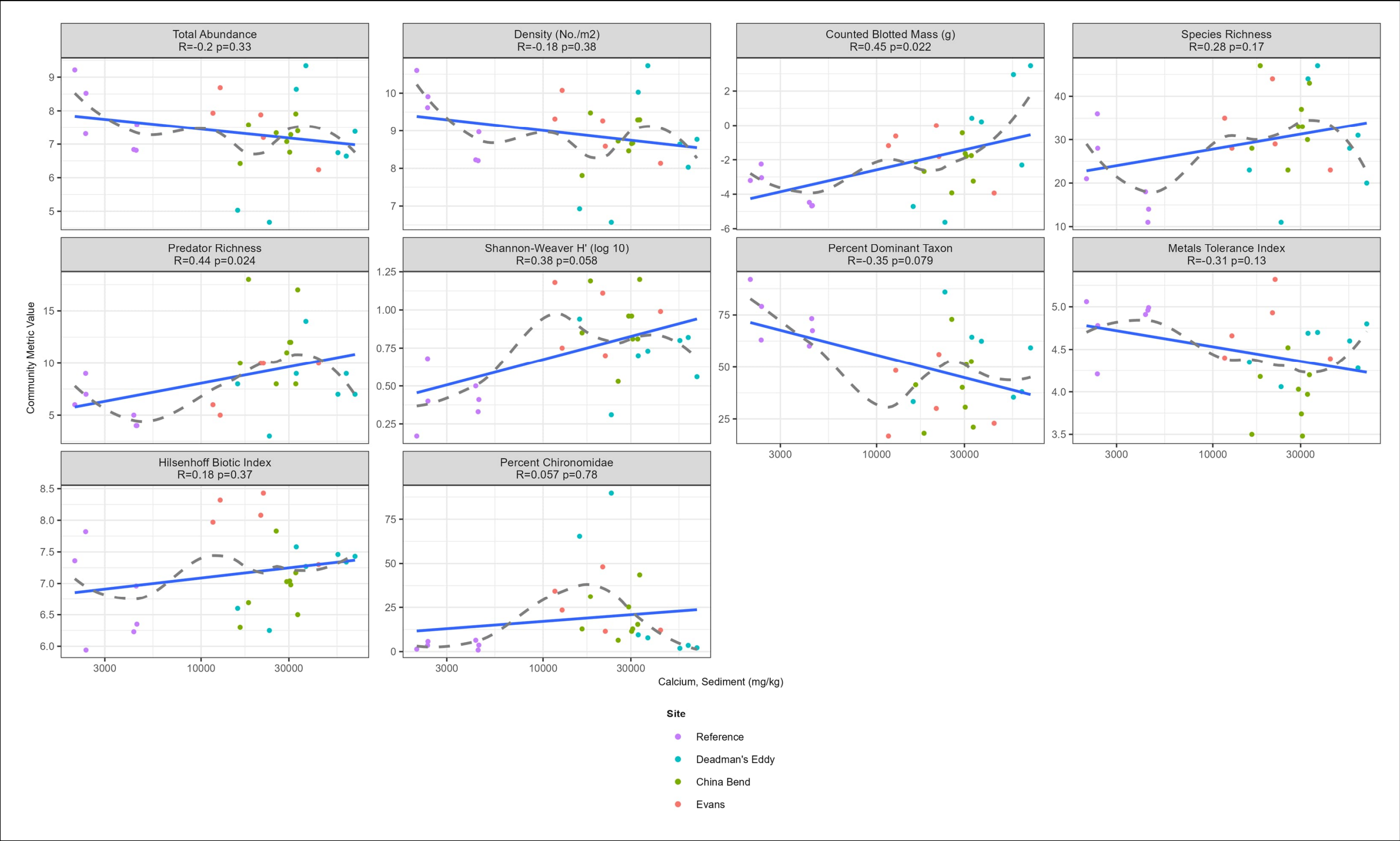


Figure K2-6g. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Calcium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

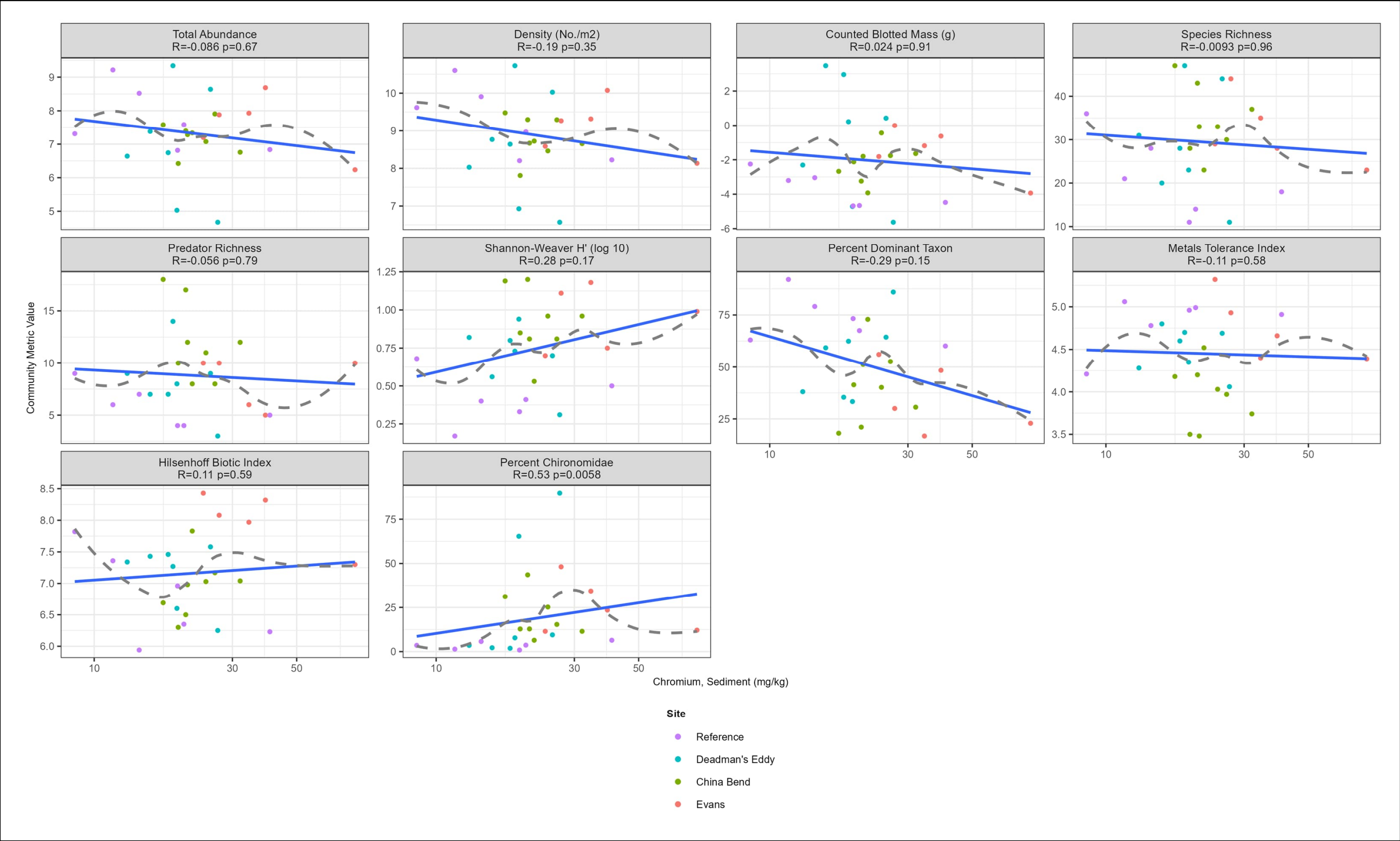


Figure K2-6h. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Chromium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

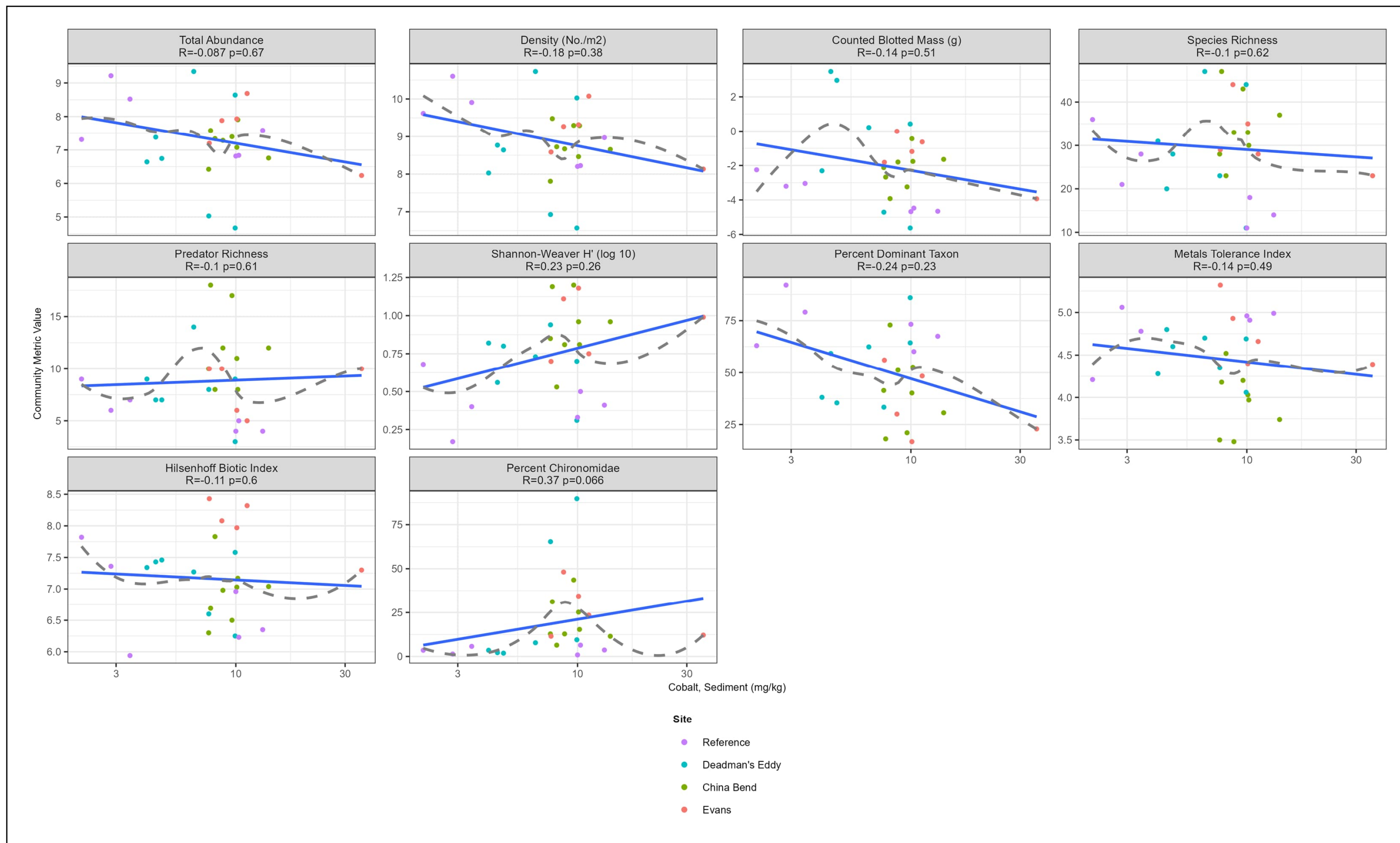


Figure K2-6i. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Cobalt Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

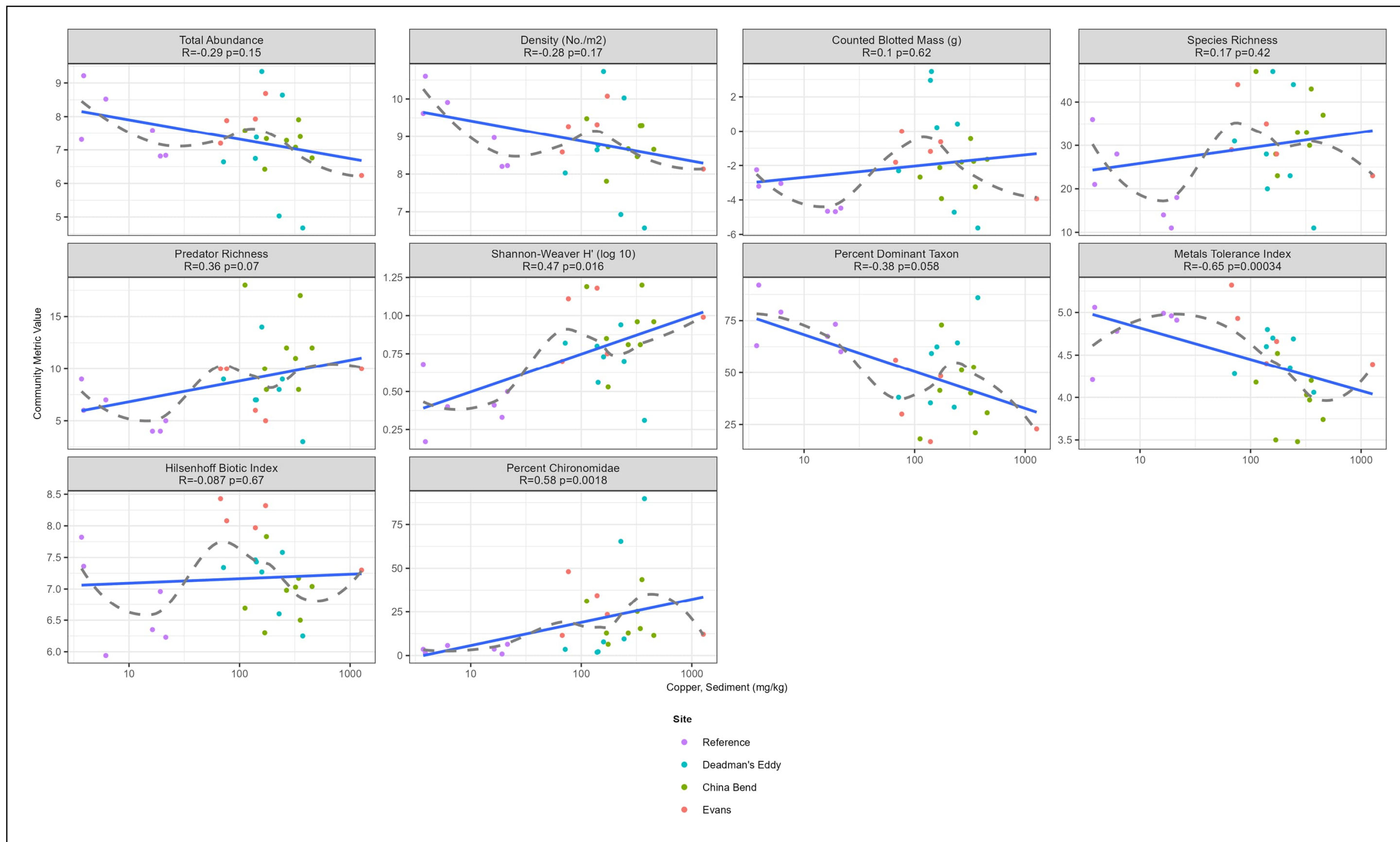


Figure K2-6j. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Copper Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

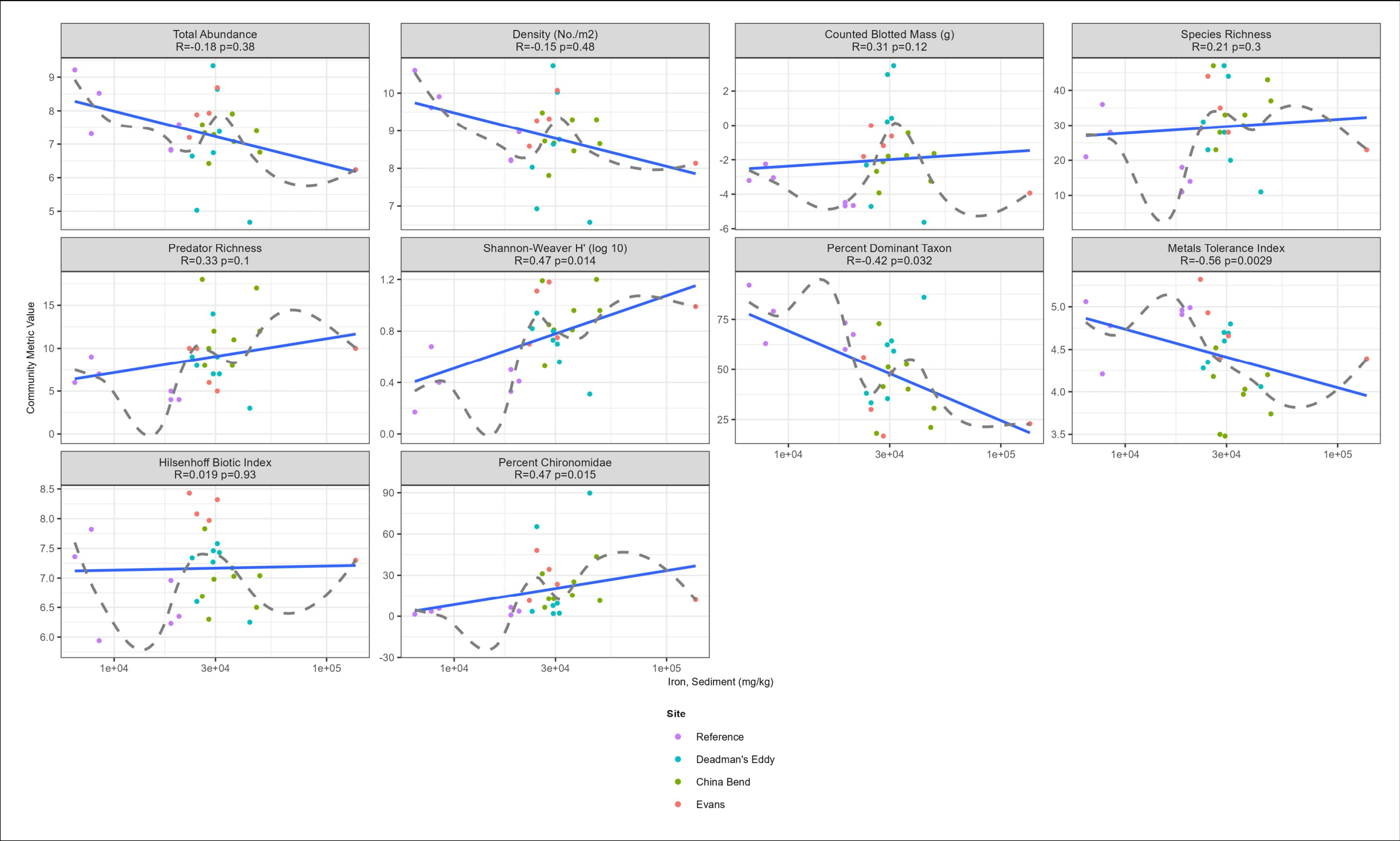


Figure K2-6k. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Iron Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

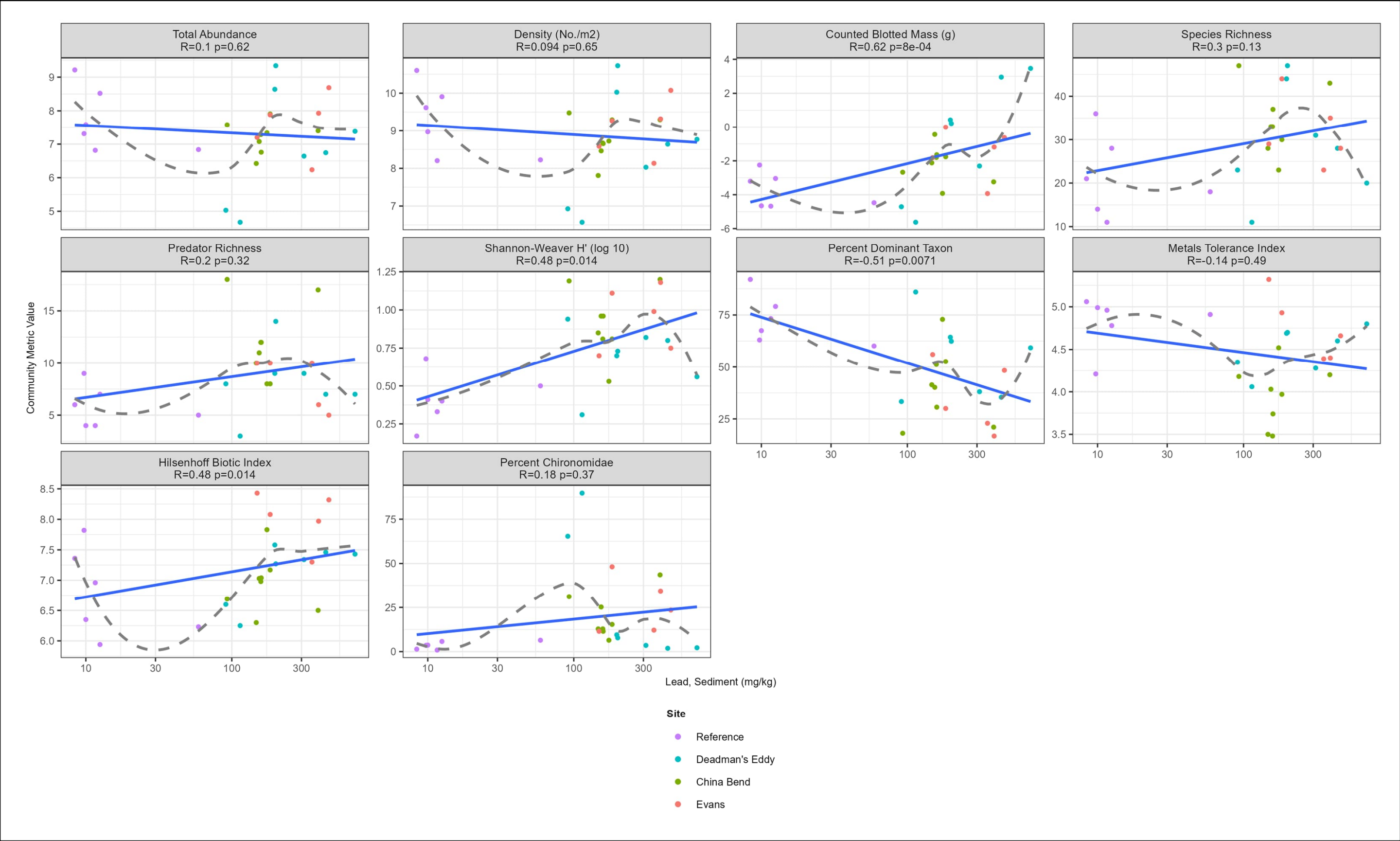


Figure K2-6I. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Lead Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

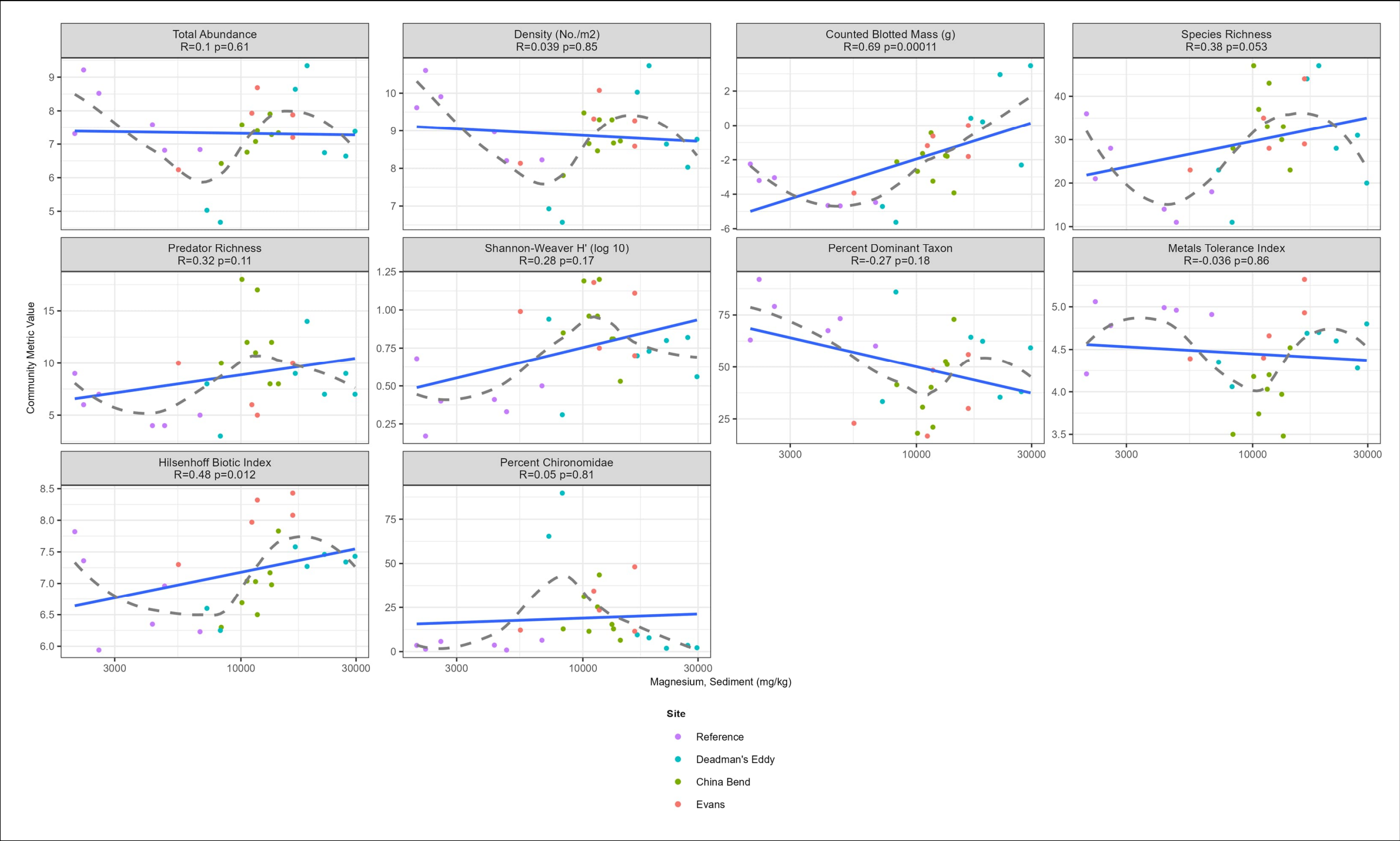


Figure K2-6m. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Magnesium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

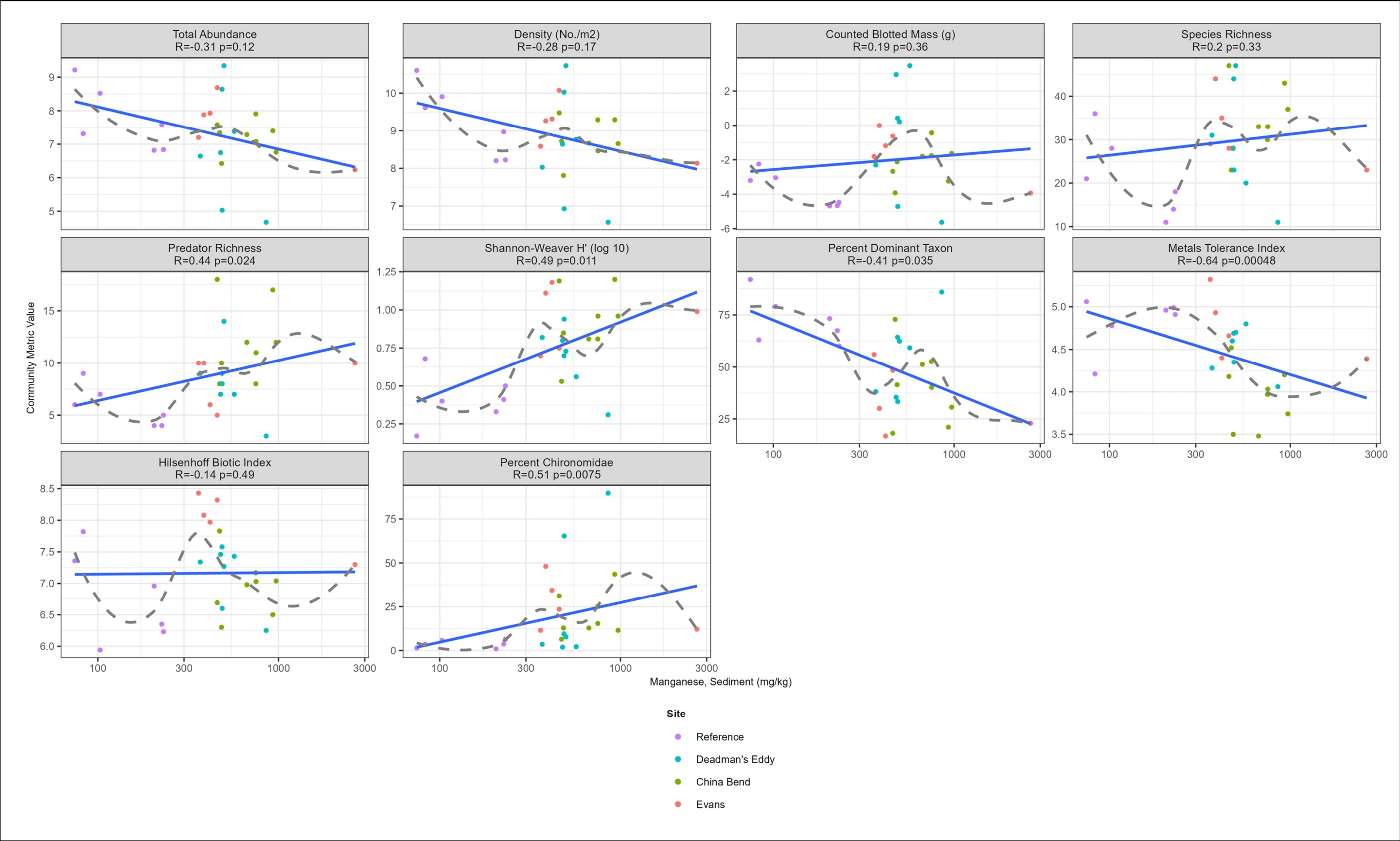


Figure K2-6n. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Manganese Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

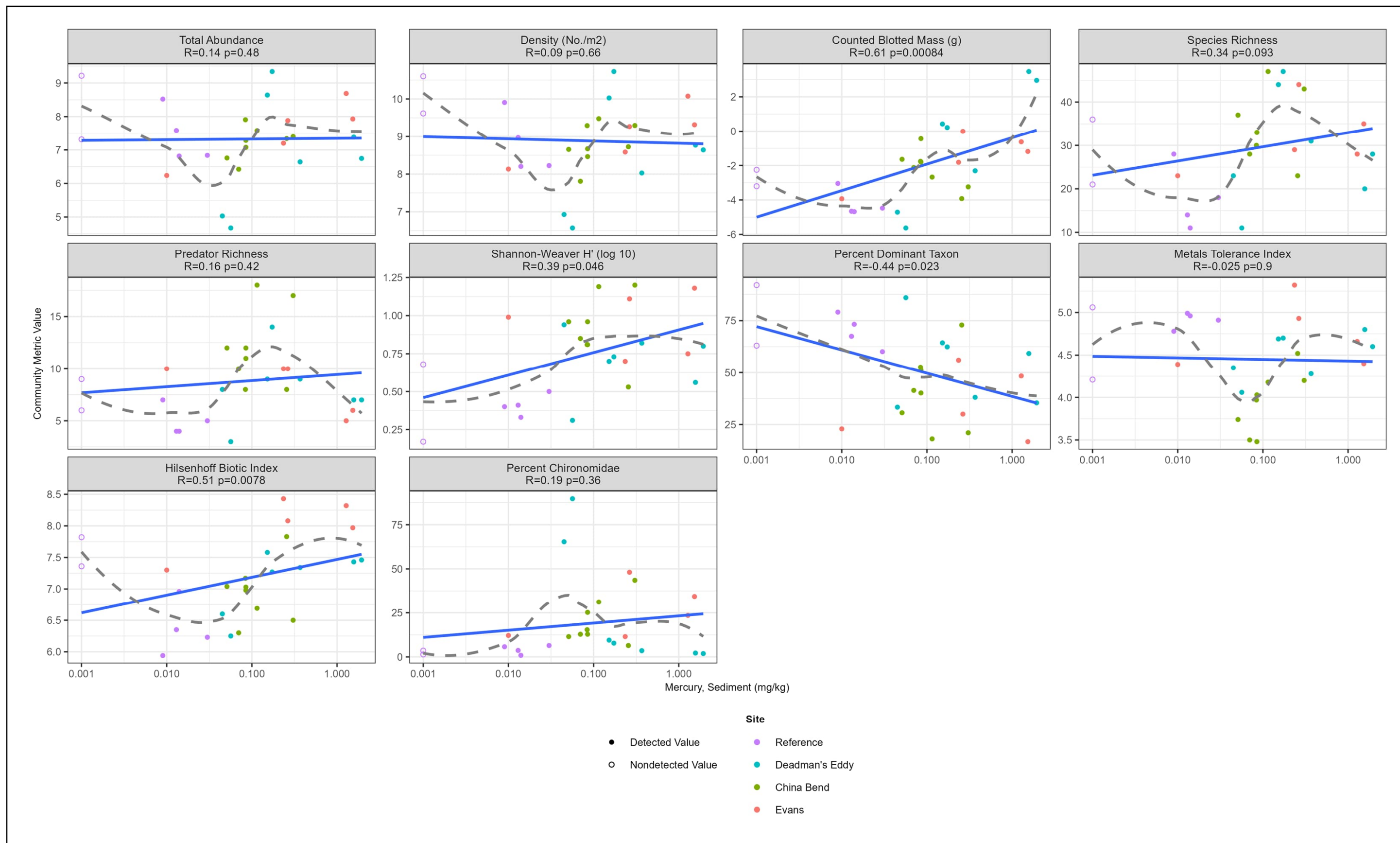


Figure K2-6o. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Mercury Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

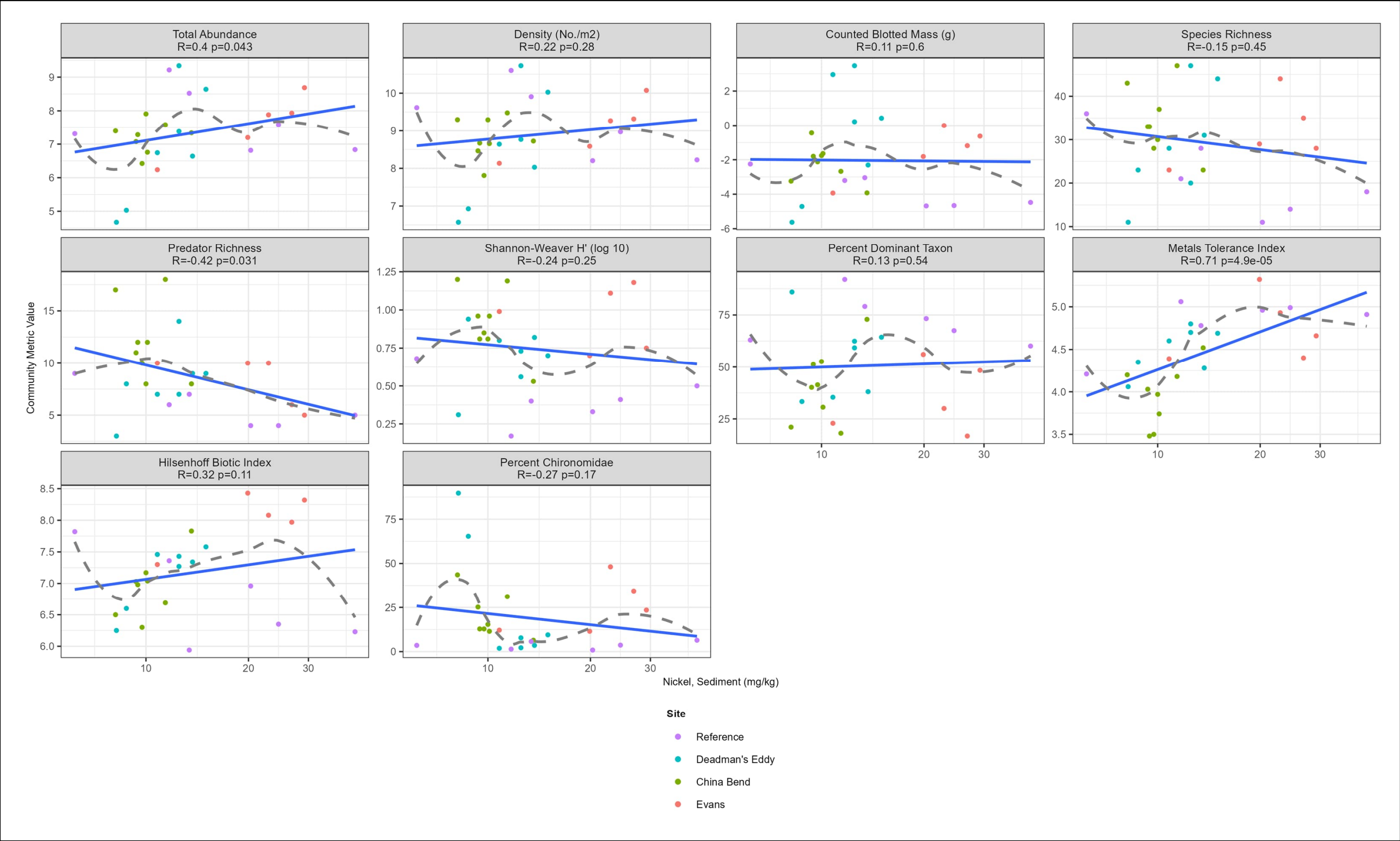


Figure K2-6p. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Nickel Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

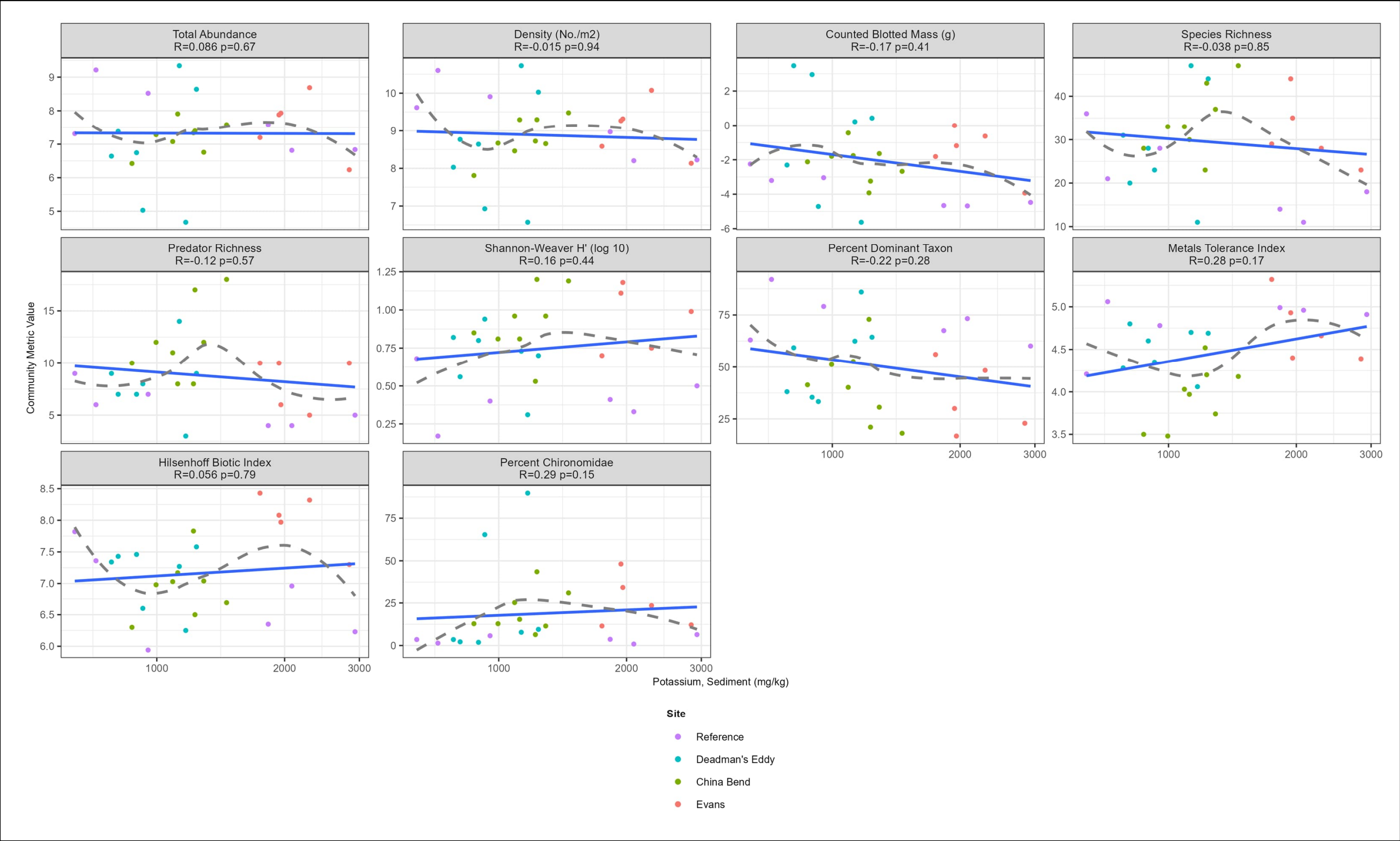


Figure K2-6q. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Potassium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

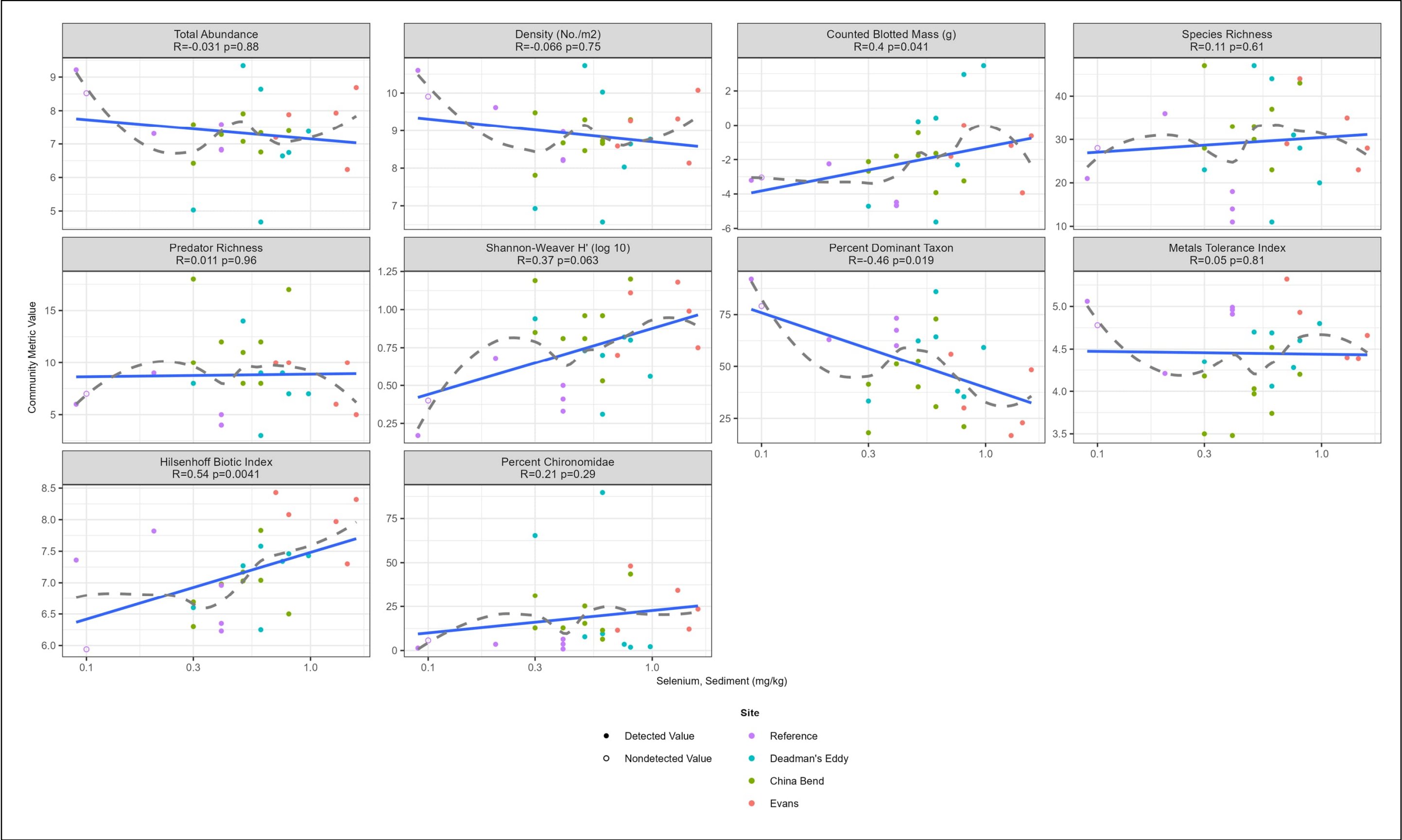


Figure K2-6r. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Selenium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

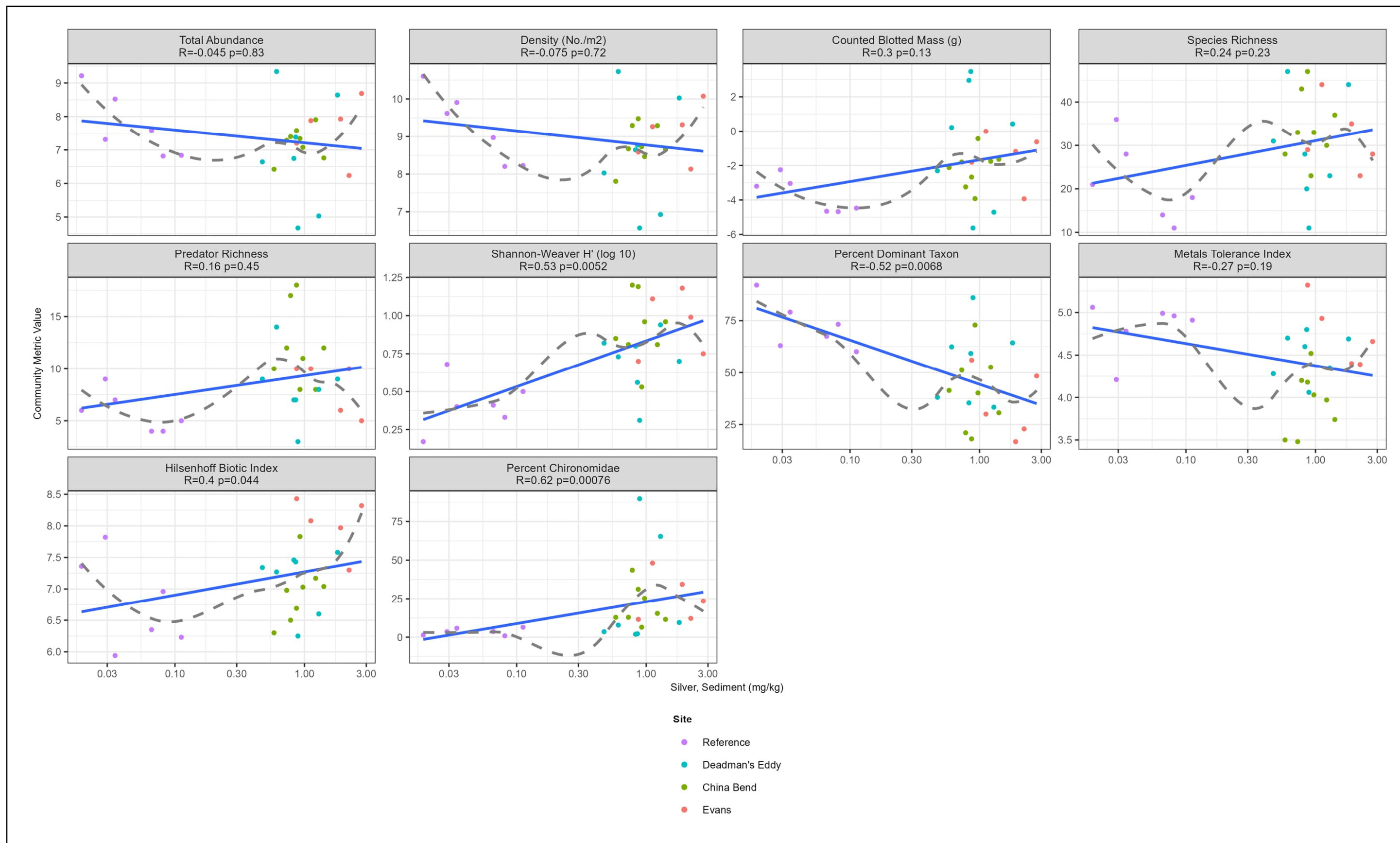


Figure K2-6s. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Silver Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

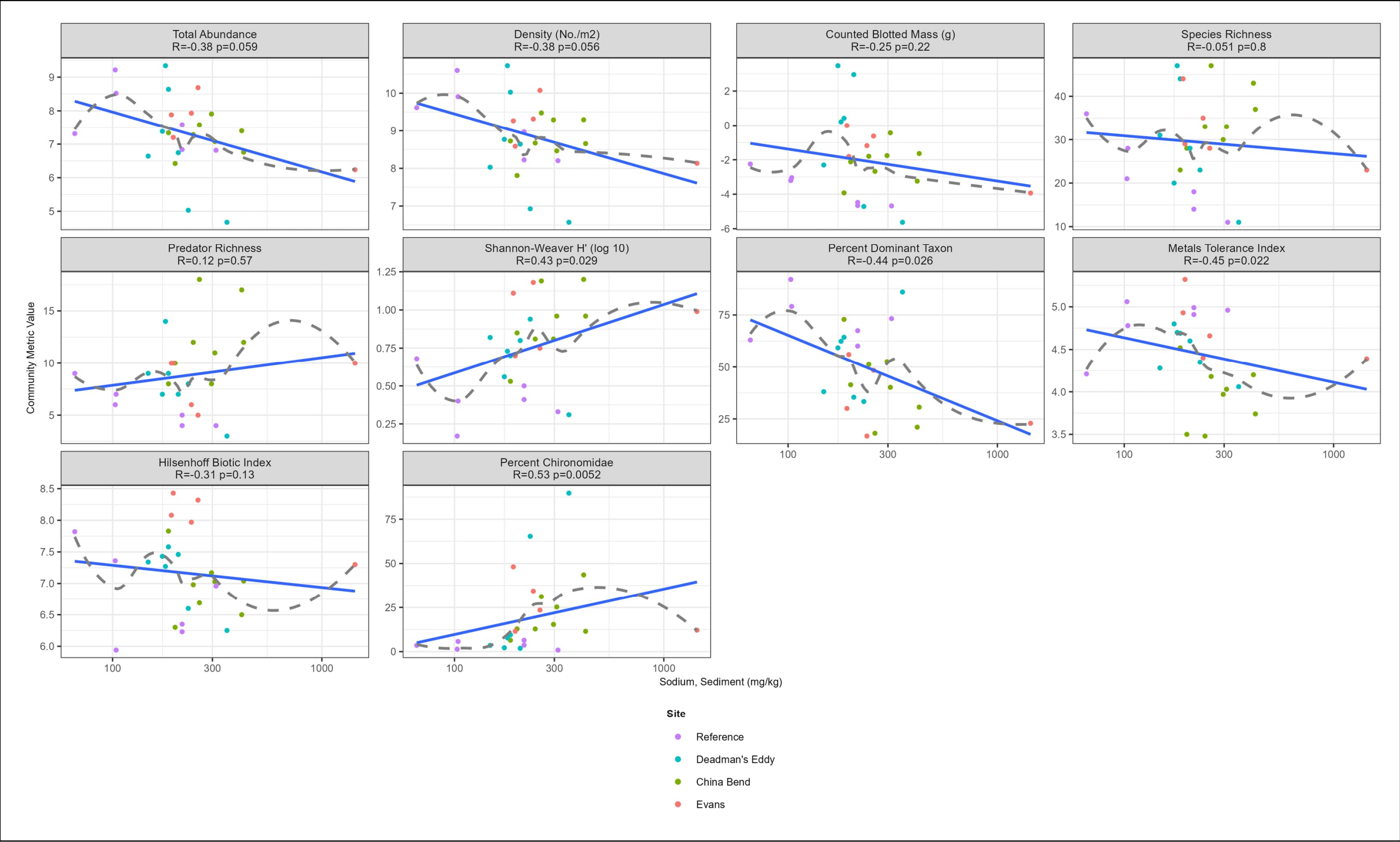


Figure K2-6t. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Sodium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

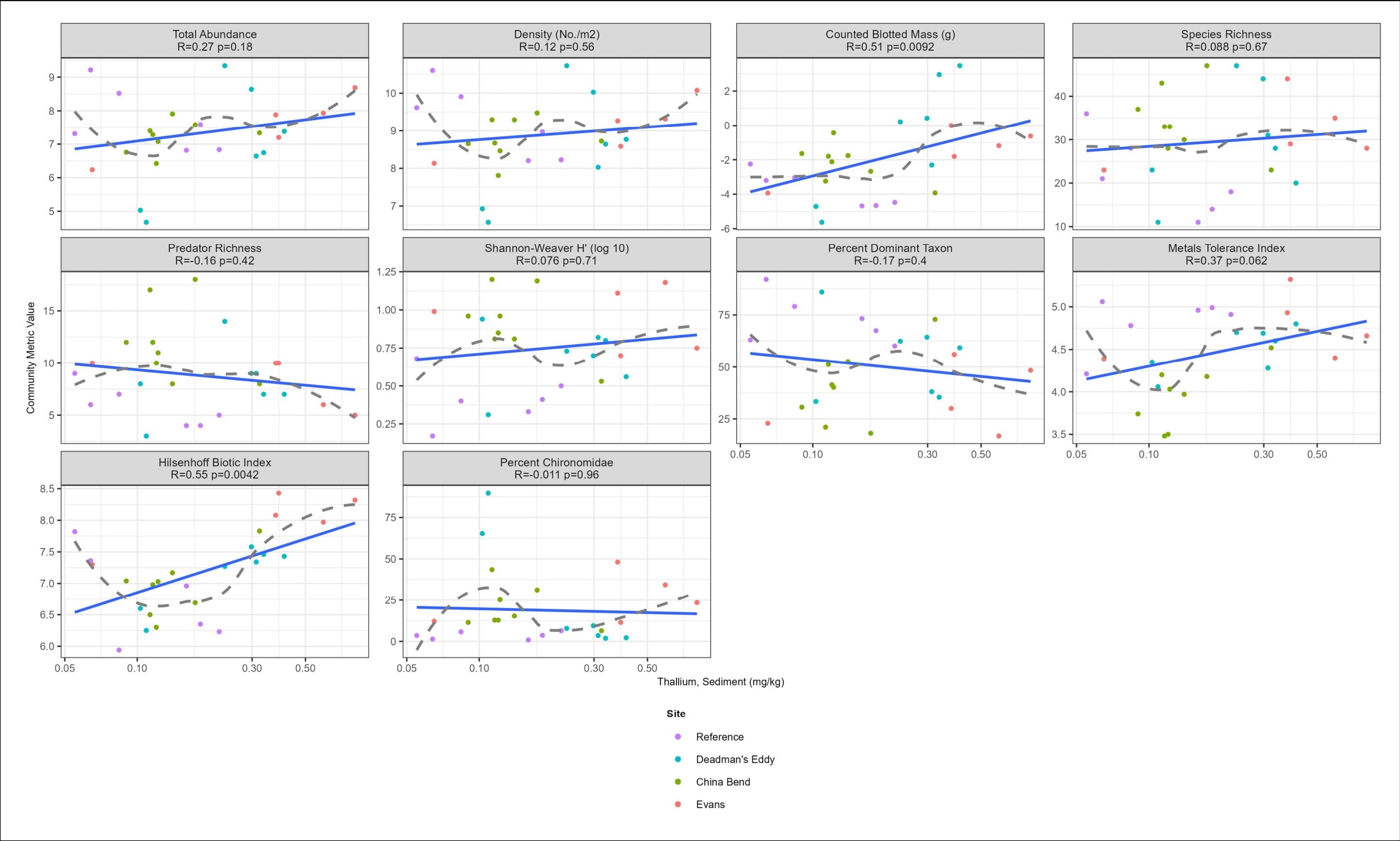


Figure K2-6u. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Thallium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

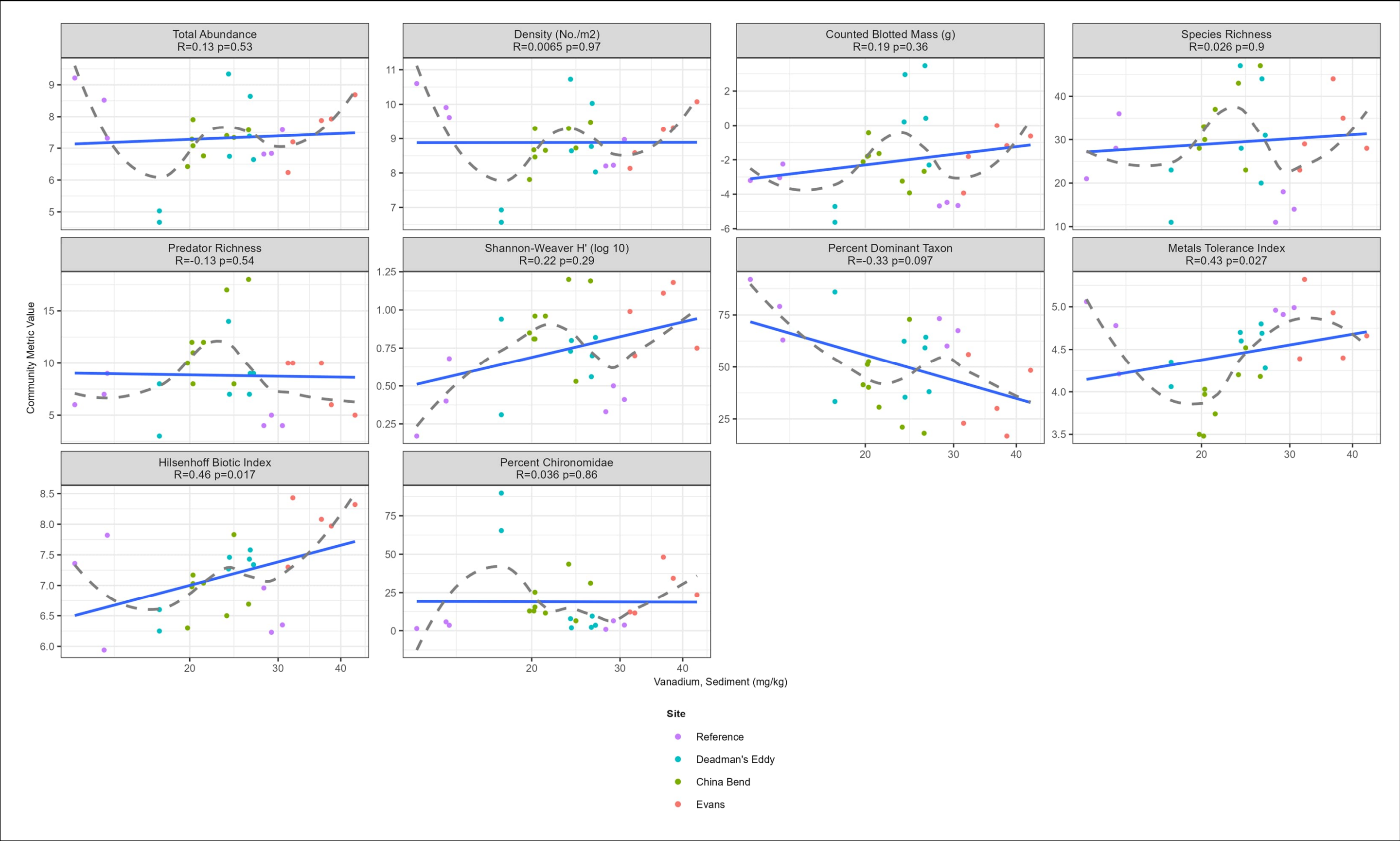


Figure K2-6v. Scatterplots of Benthic Invertebrate Metrics against Bulk Sediment Vanadium Concentrations from Phase 3 Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

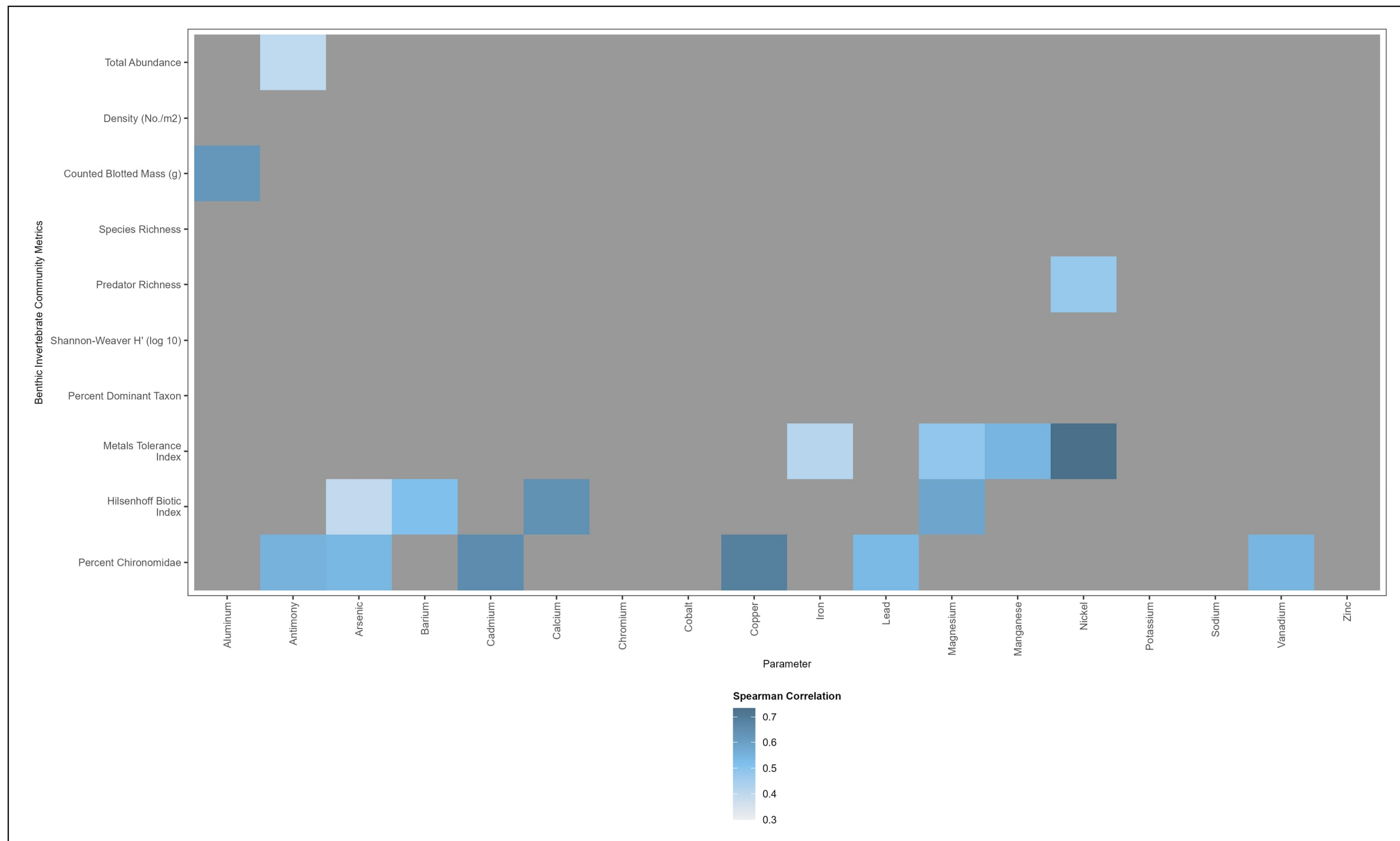


Figure K2-7. Mosaic of Rank Correlation Results for Benthic Invertebrate Community Metrics versus Dissolved Metals Concentrations in Porewater at Phase 3 Locations with Non-CS50 Substrate

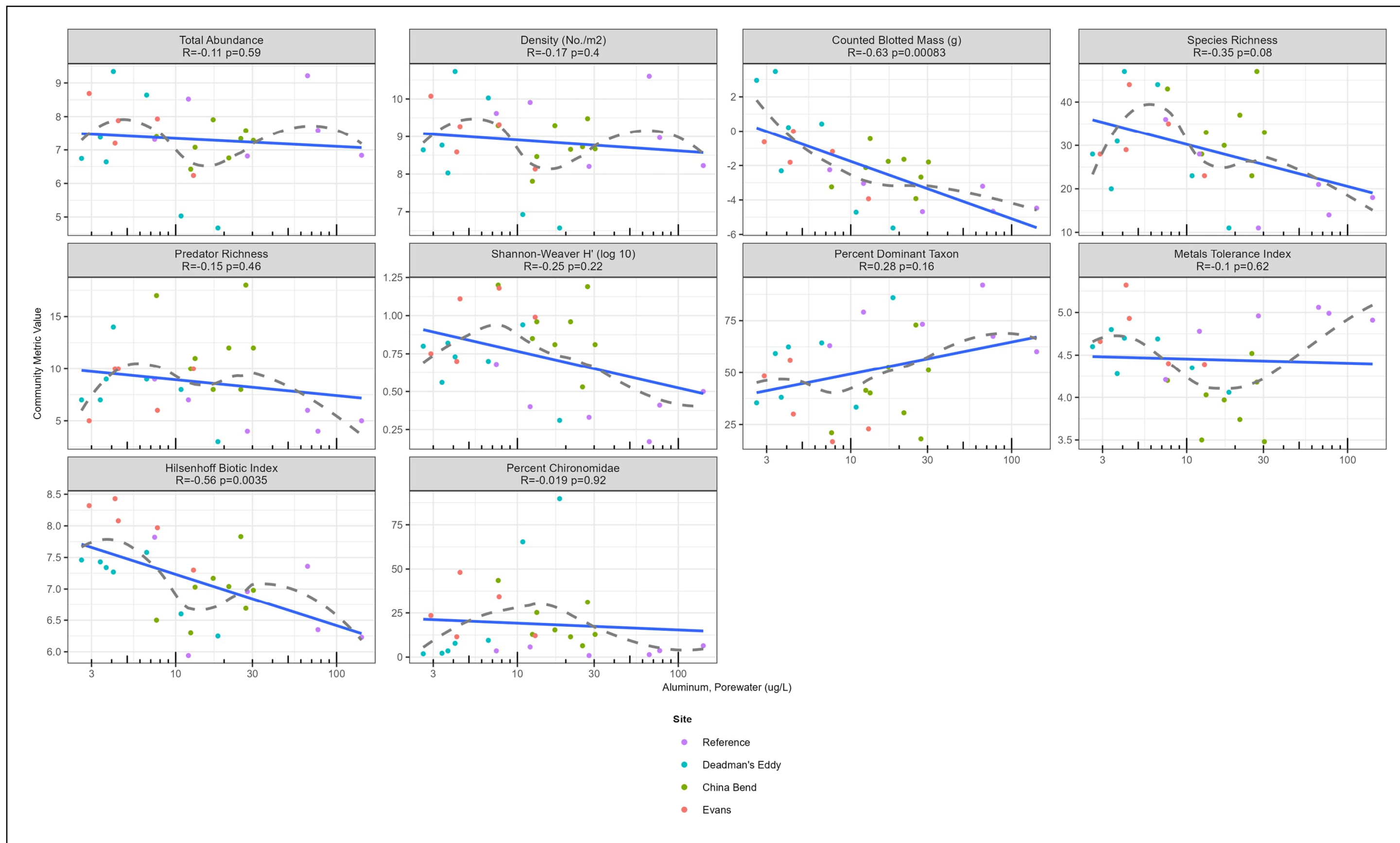


Figure K2-8a. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Aluminum in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

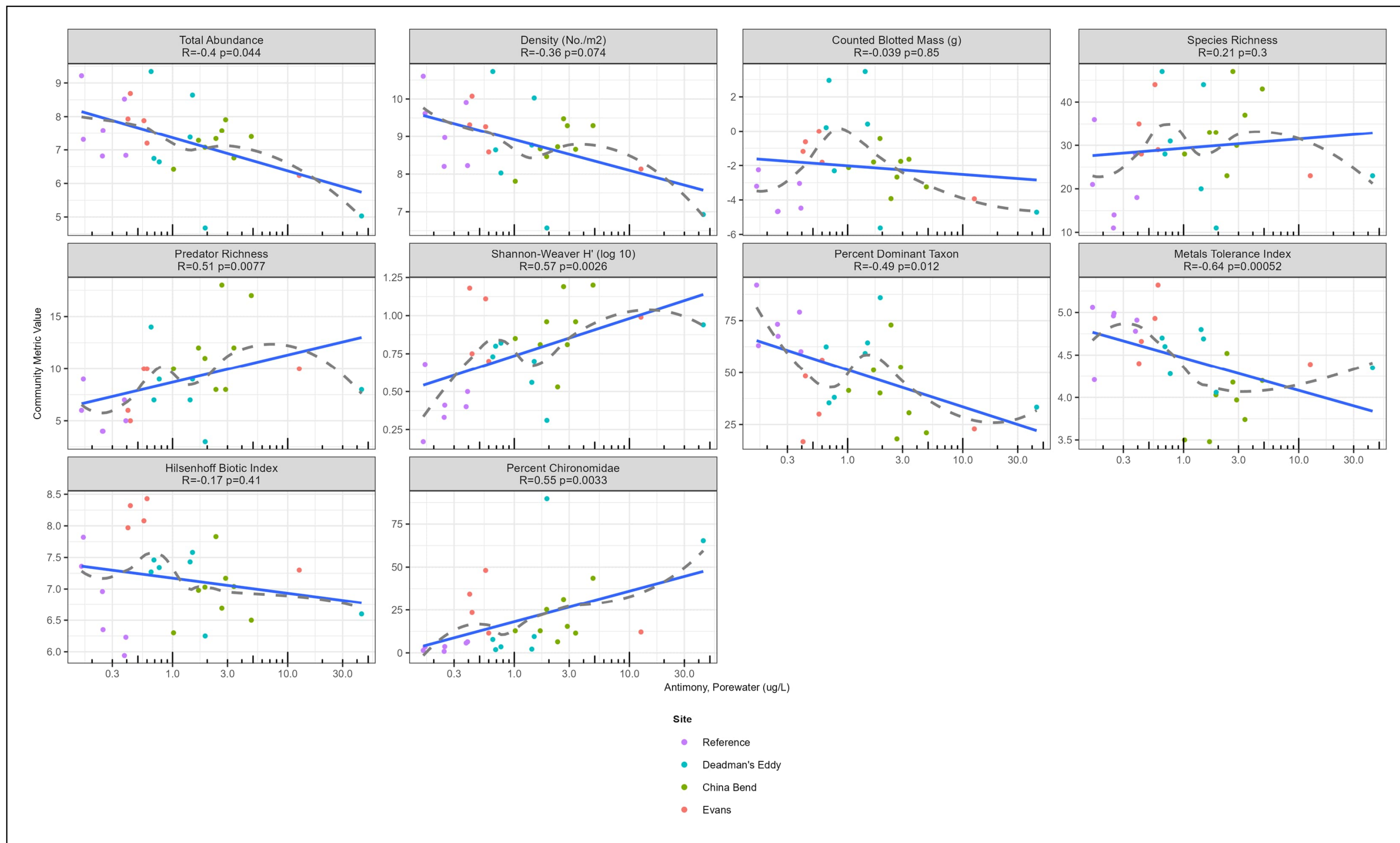


Figure K2-8b. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Antimony in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

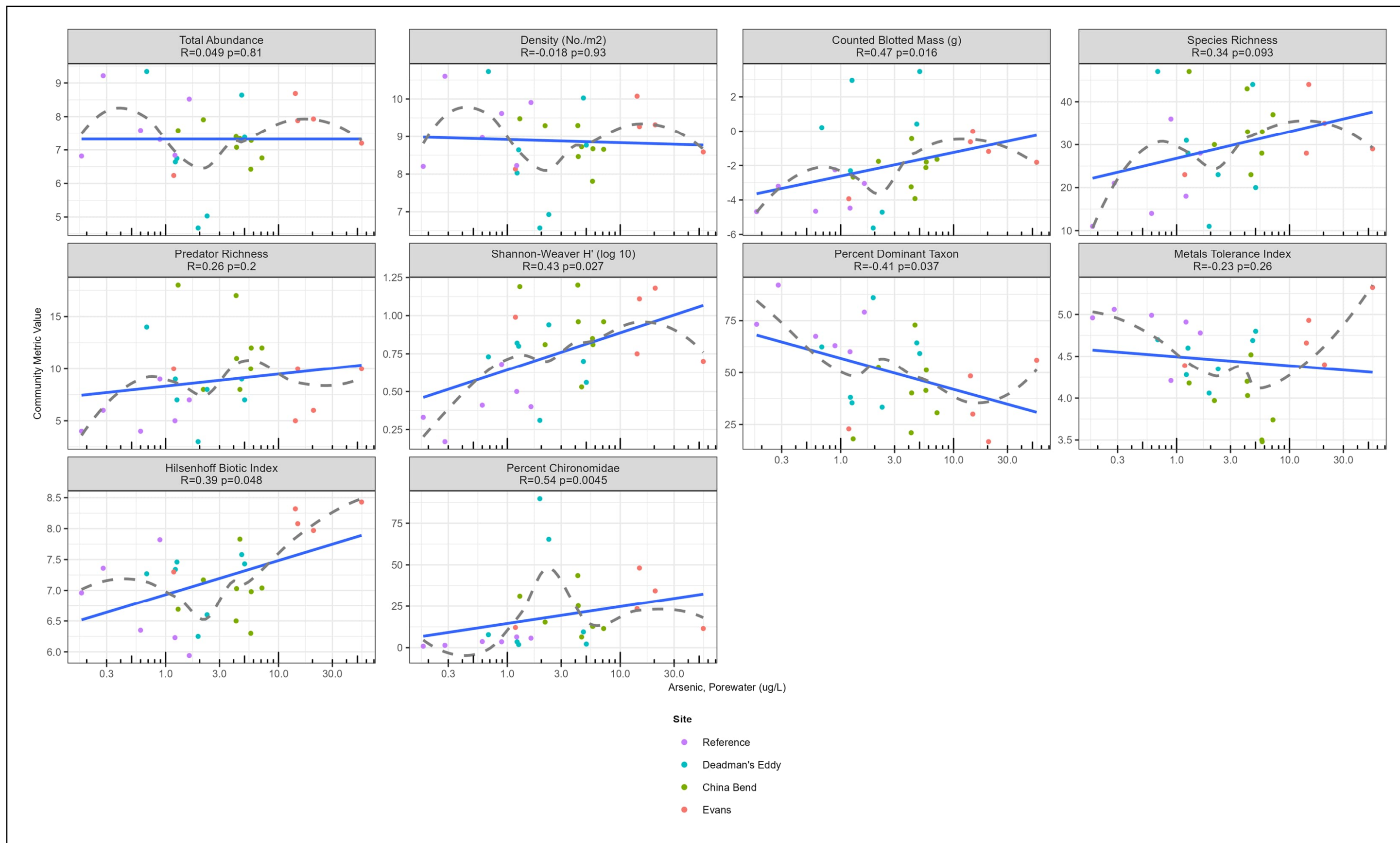


Figure K2-8c. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Arsenic in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

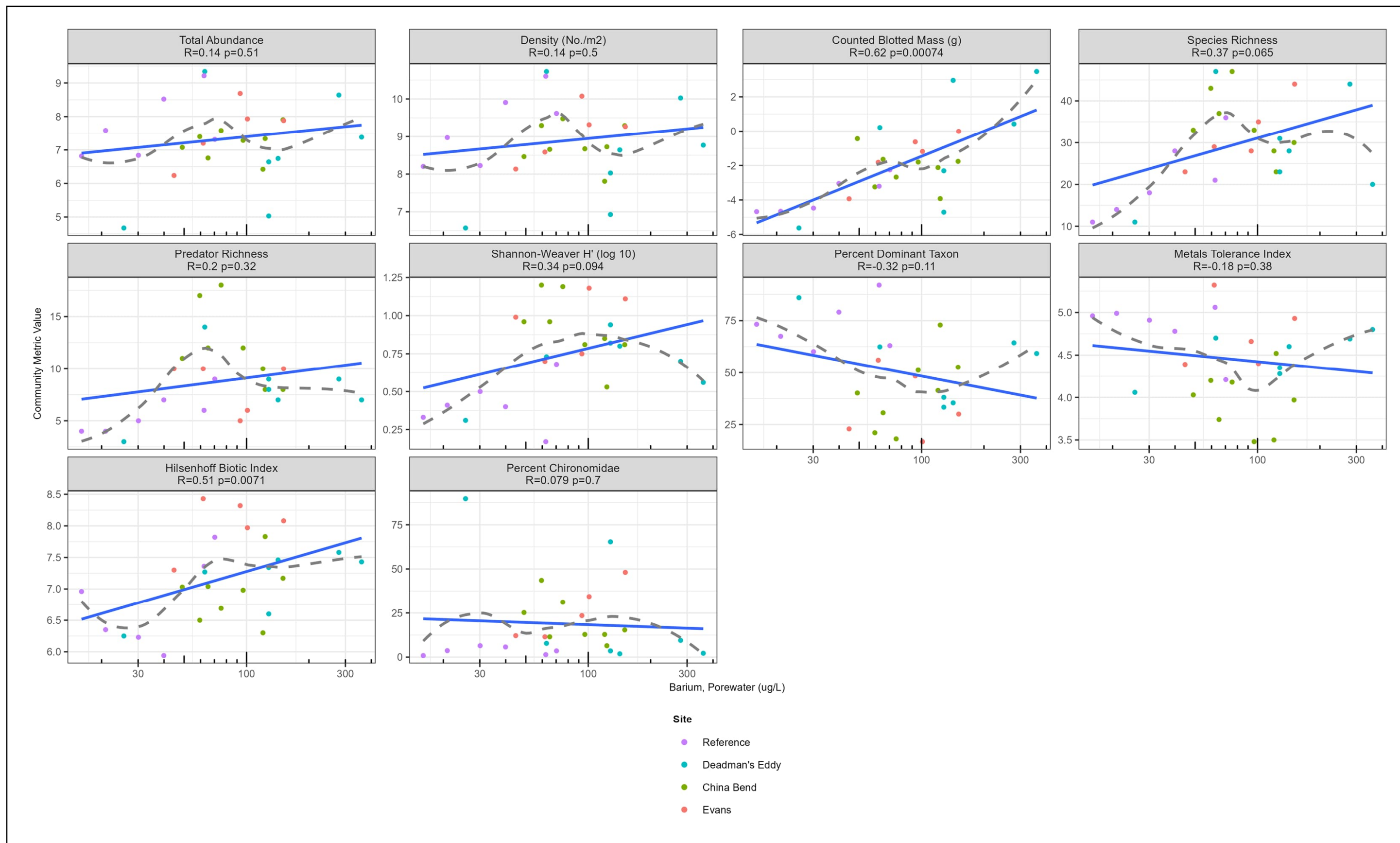


Figure K2-8d. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Barium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

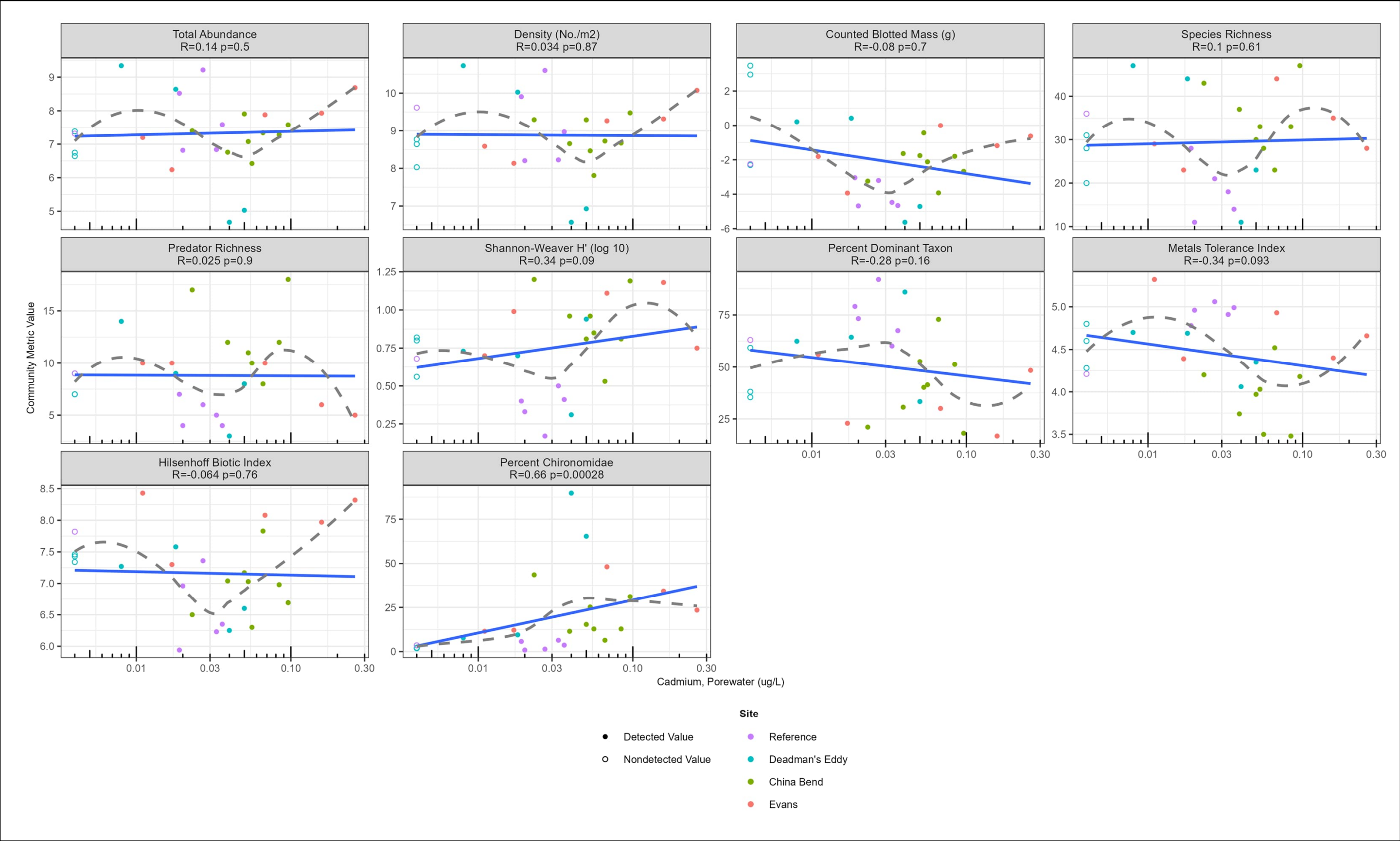


Figure K2-8e. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cadmium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

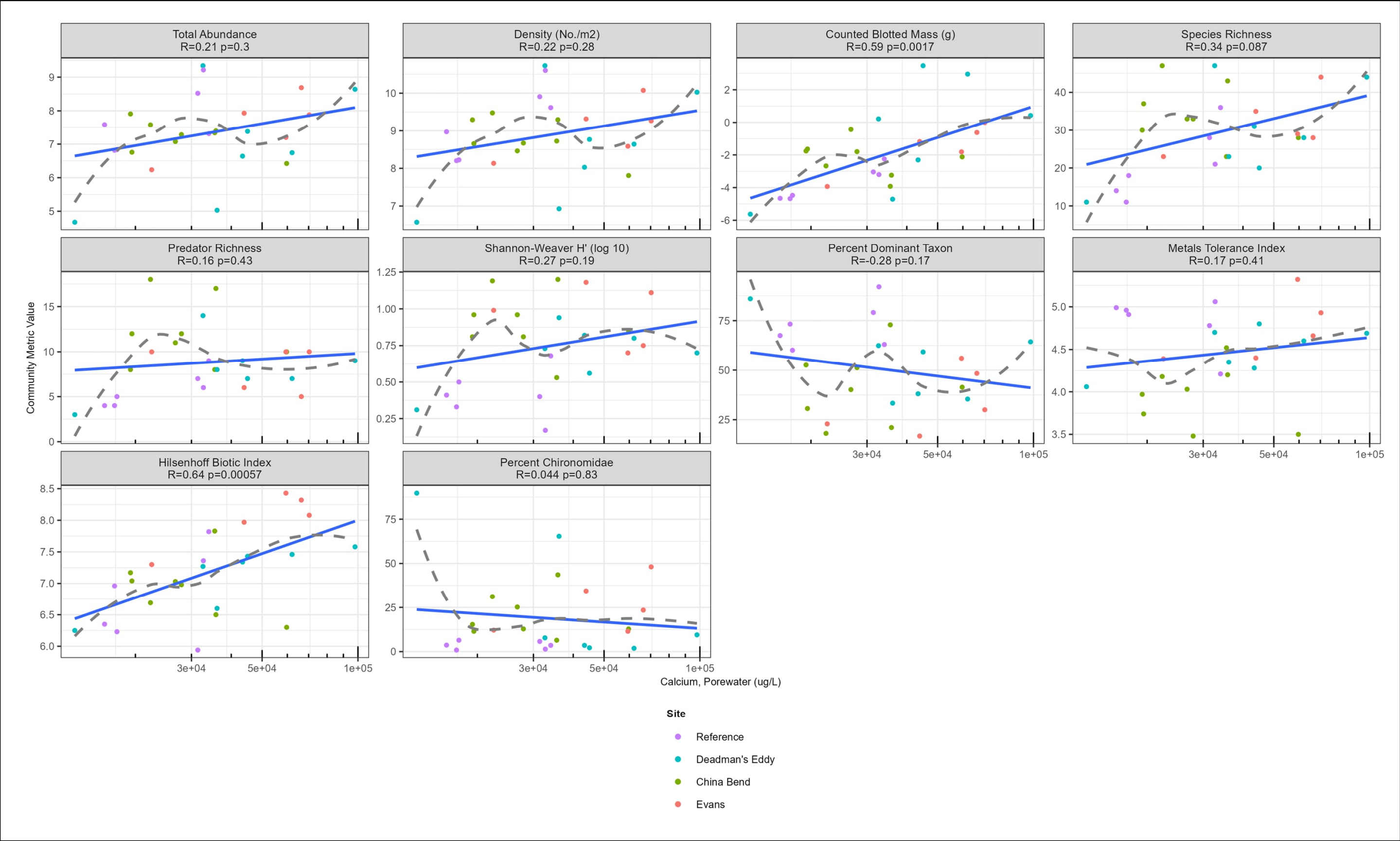


Figure K2-8f. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Calcium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

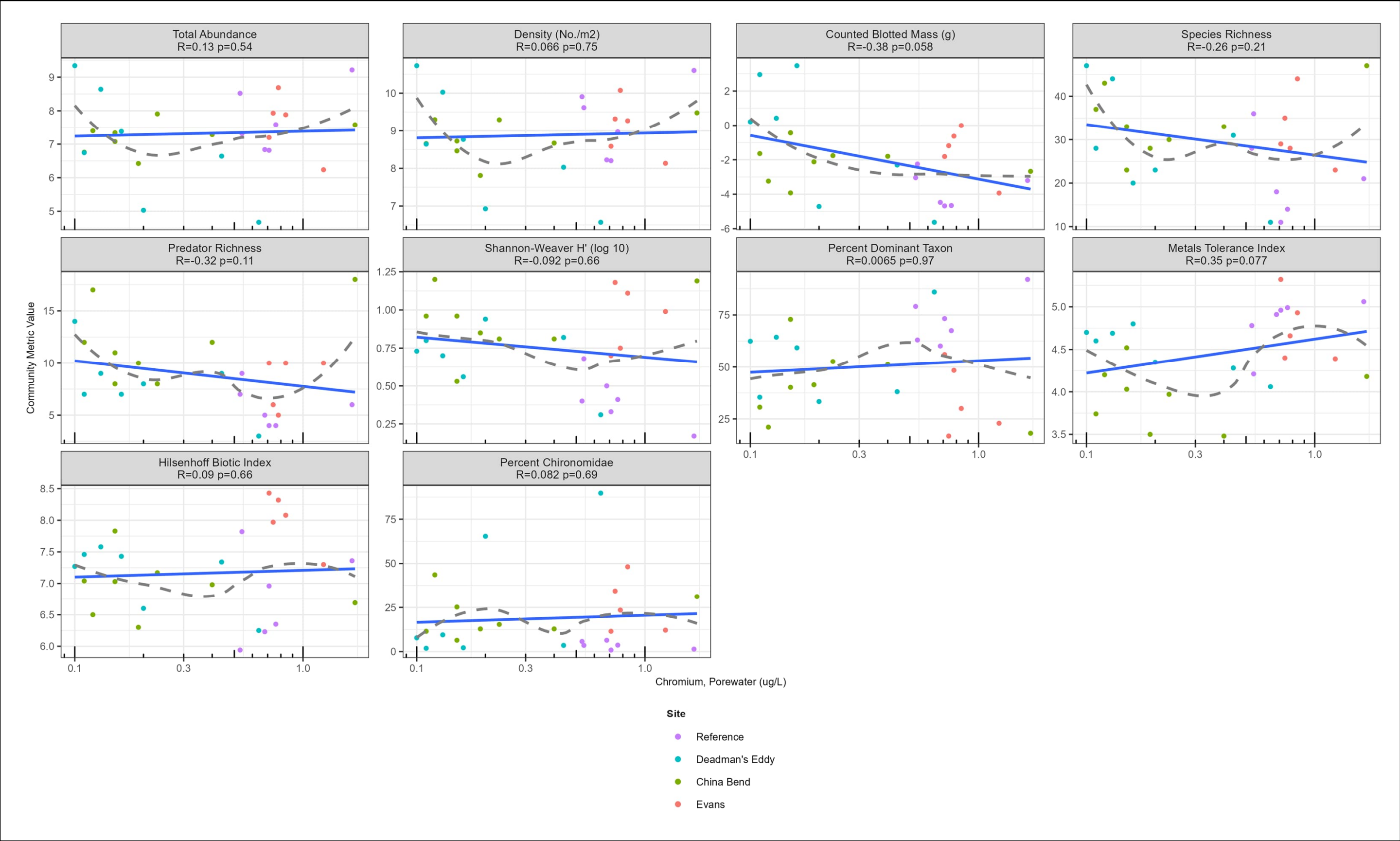


Figure K2-8g. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Chromium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

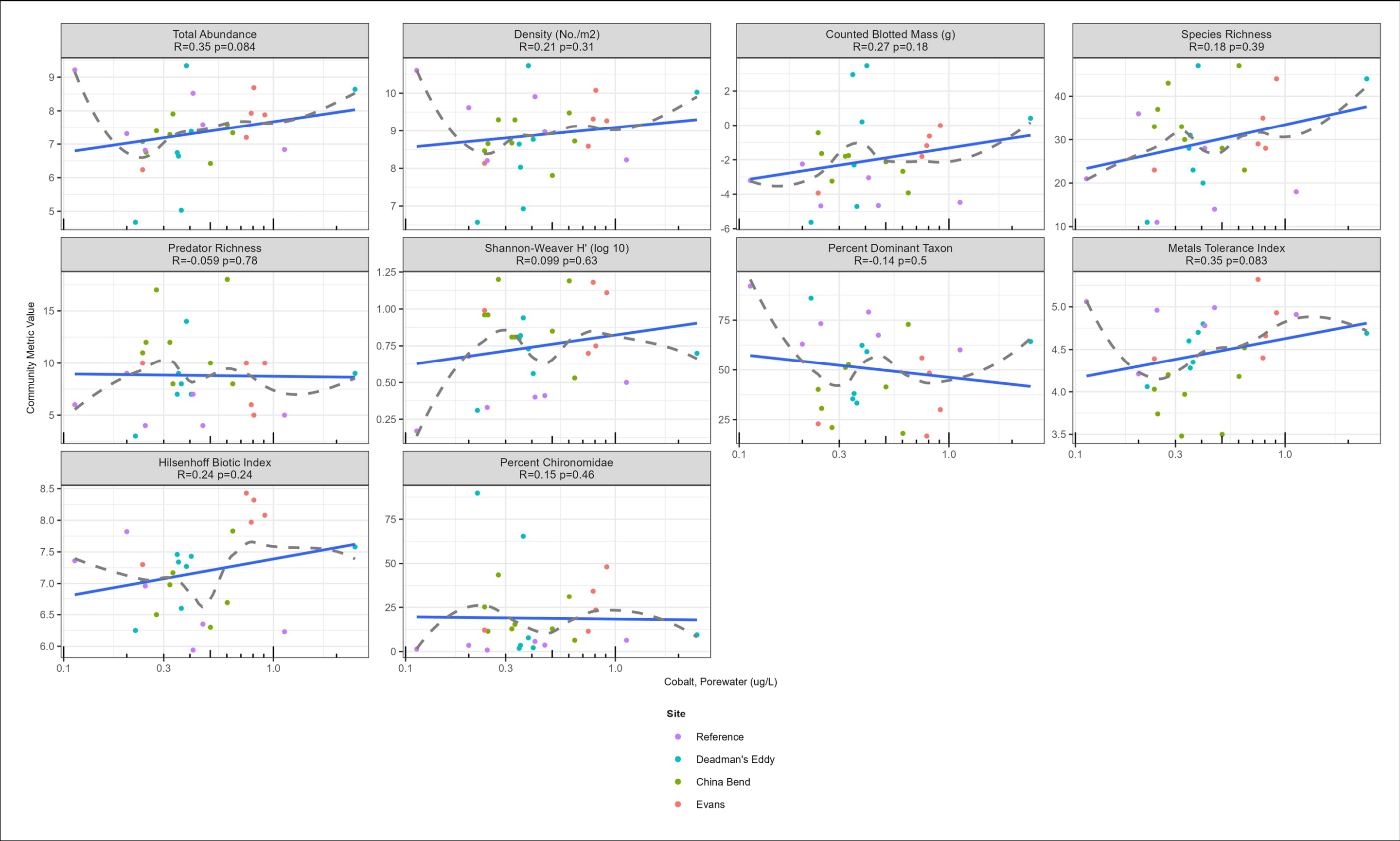


Figure K2-8h. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cobalt in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

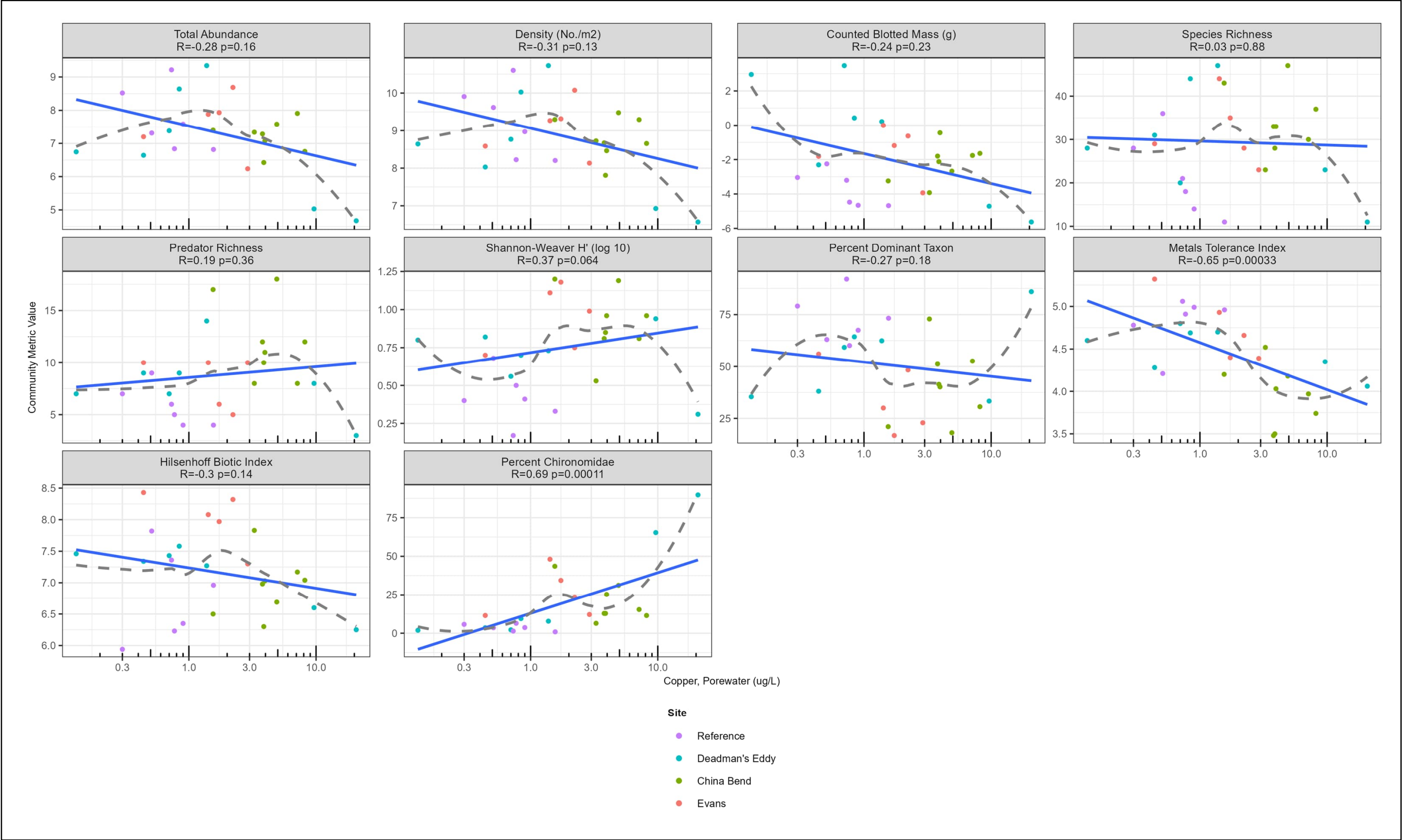


Figure K2-8i. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Copper in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

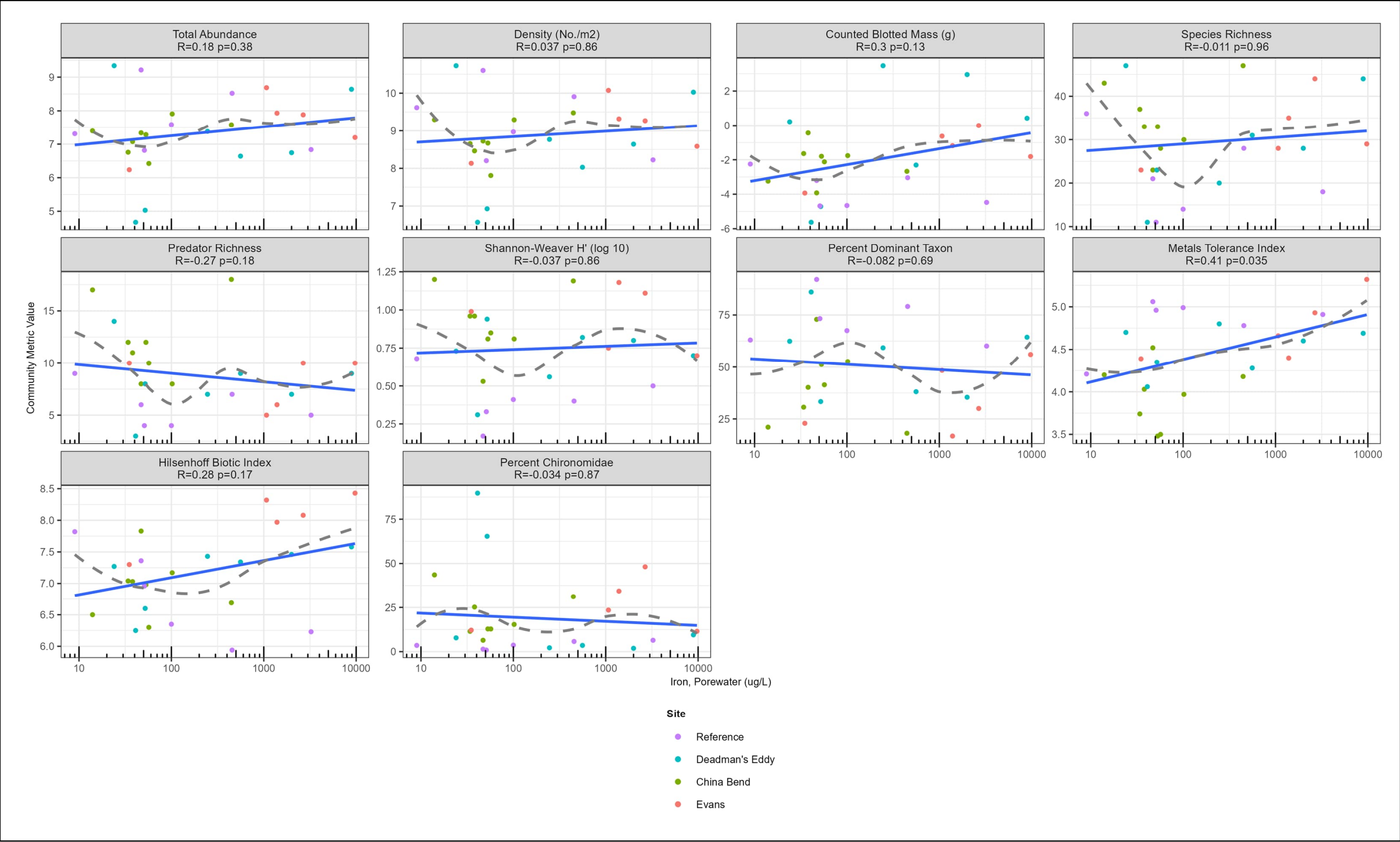


Figure K2-8j. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Iron in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

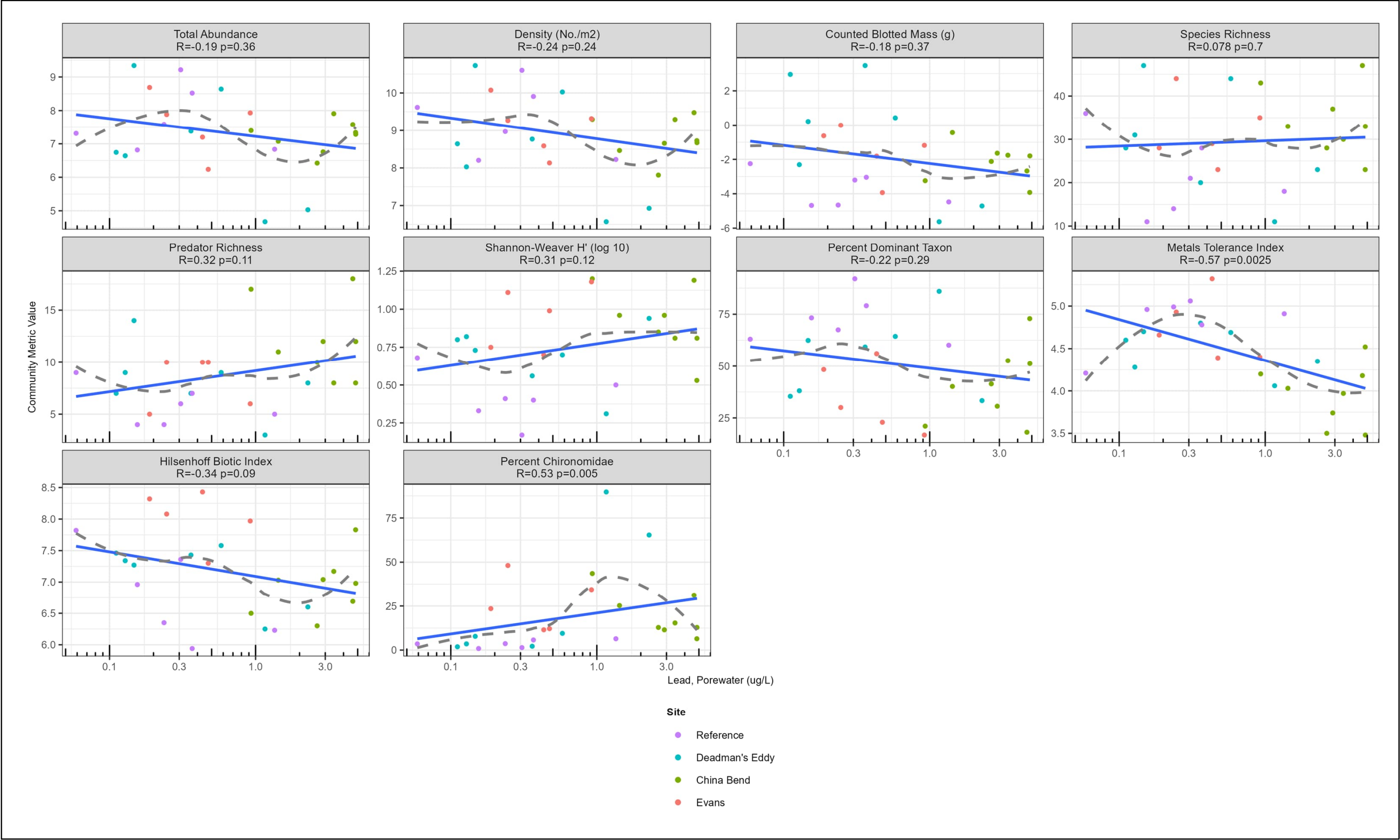


Figure K2-8k. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Lead in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

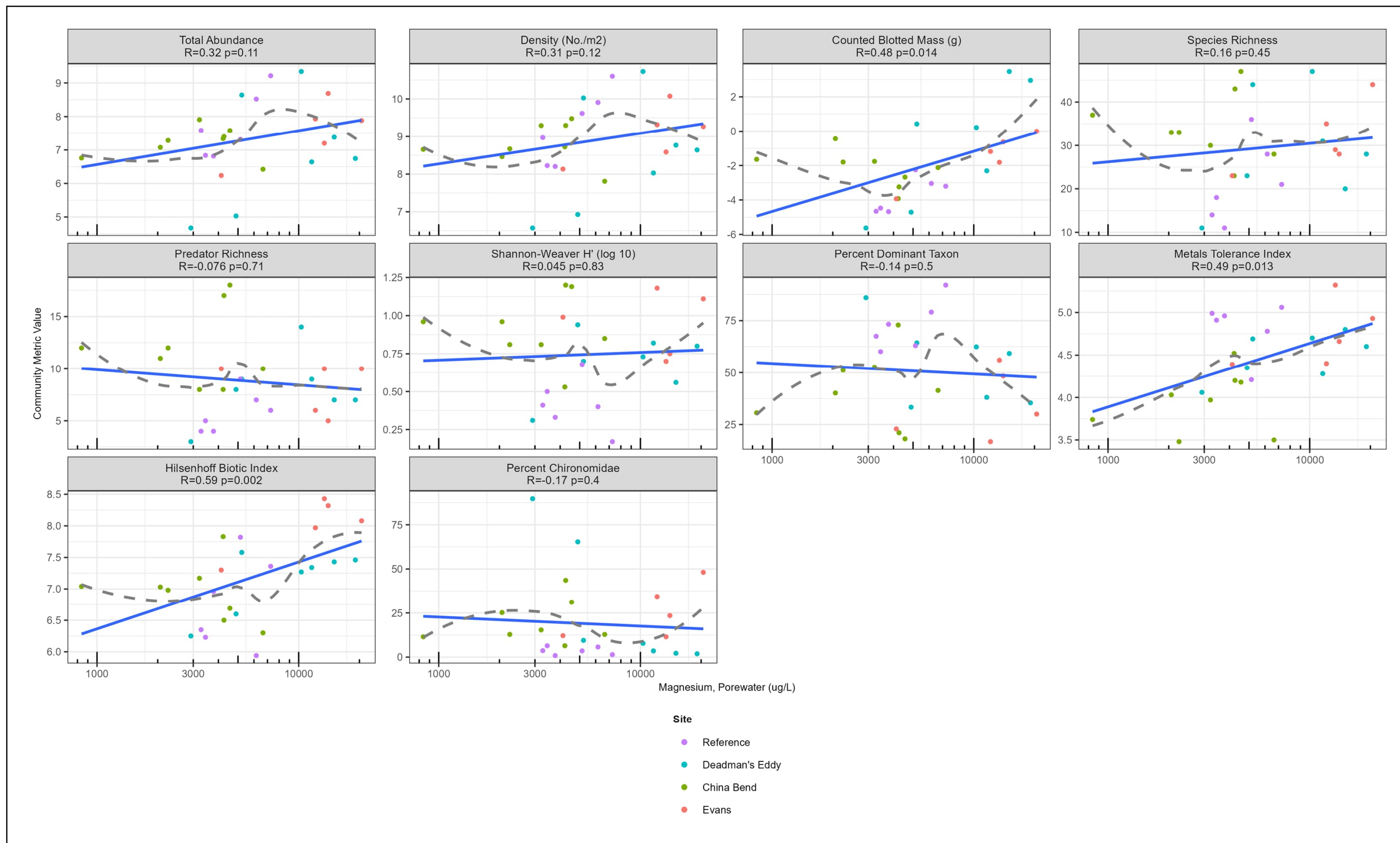


Figure K2-8I. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Magnesium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

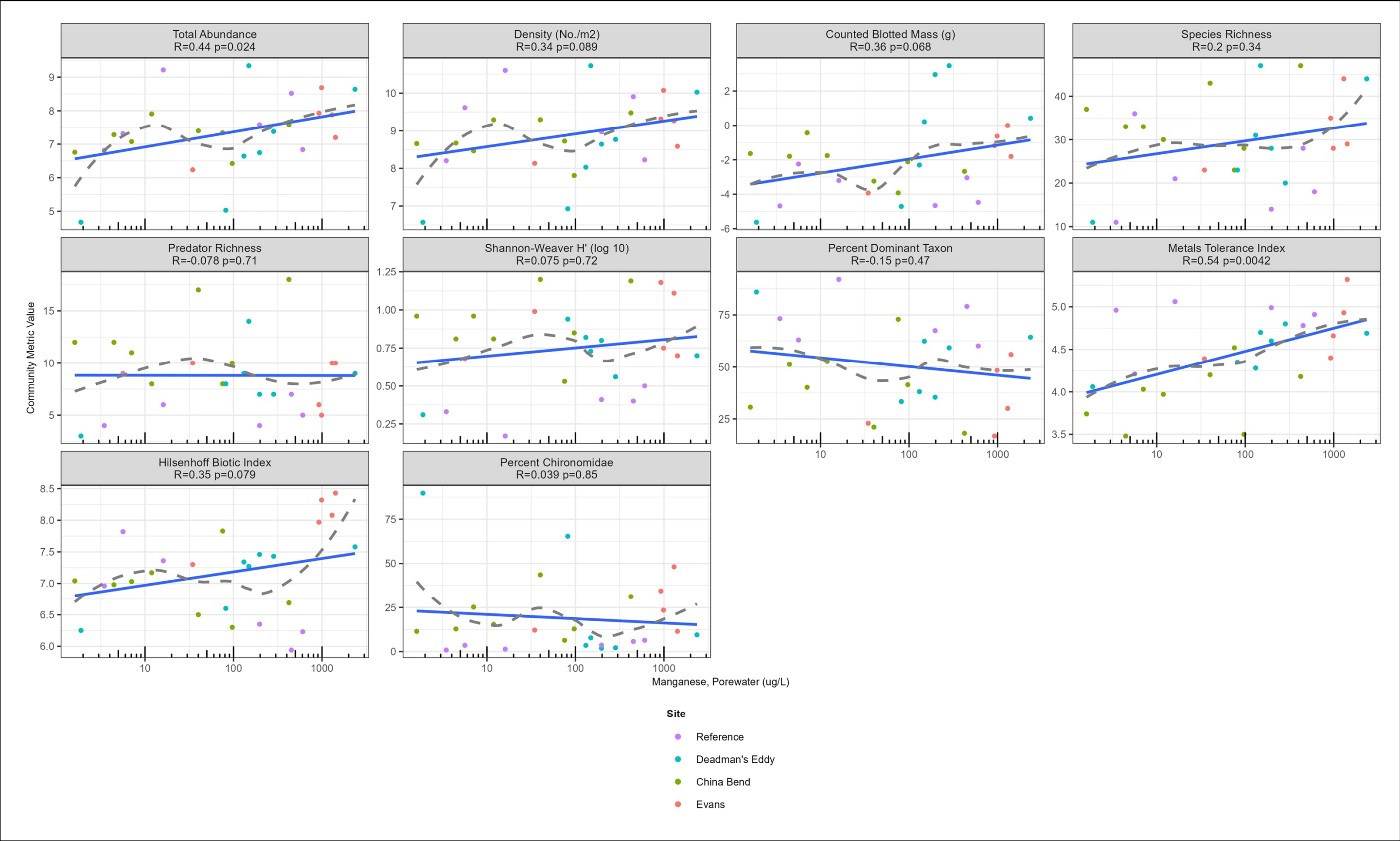


Figure K2-8m. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Manganese in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

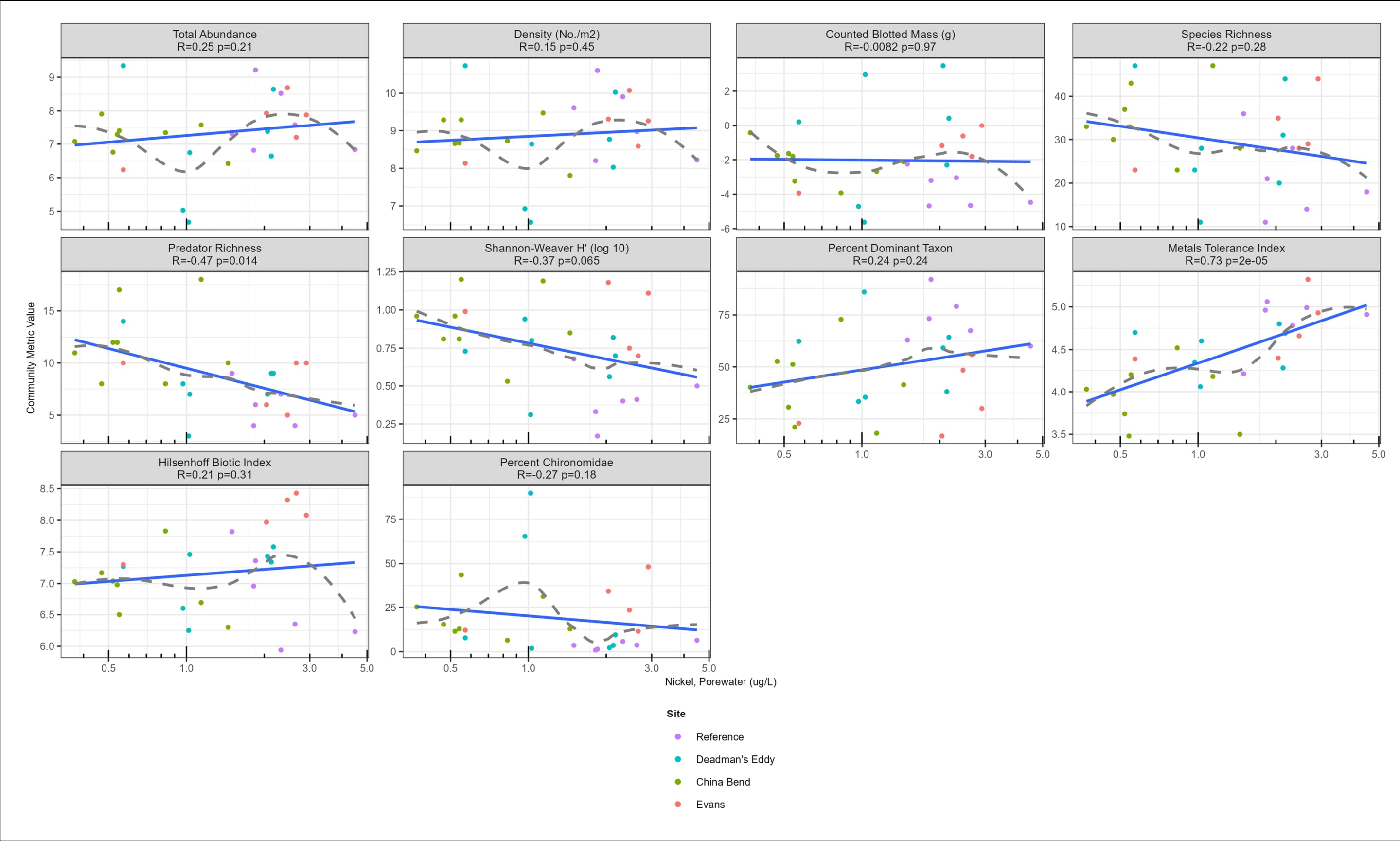


Figure K2-8n. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Nickel in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

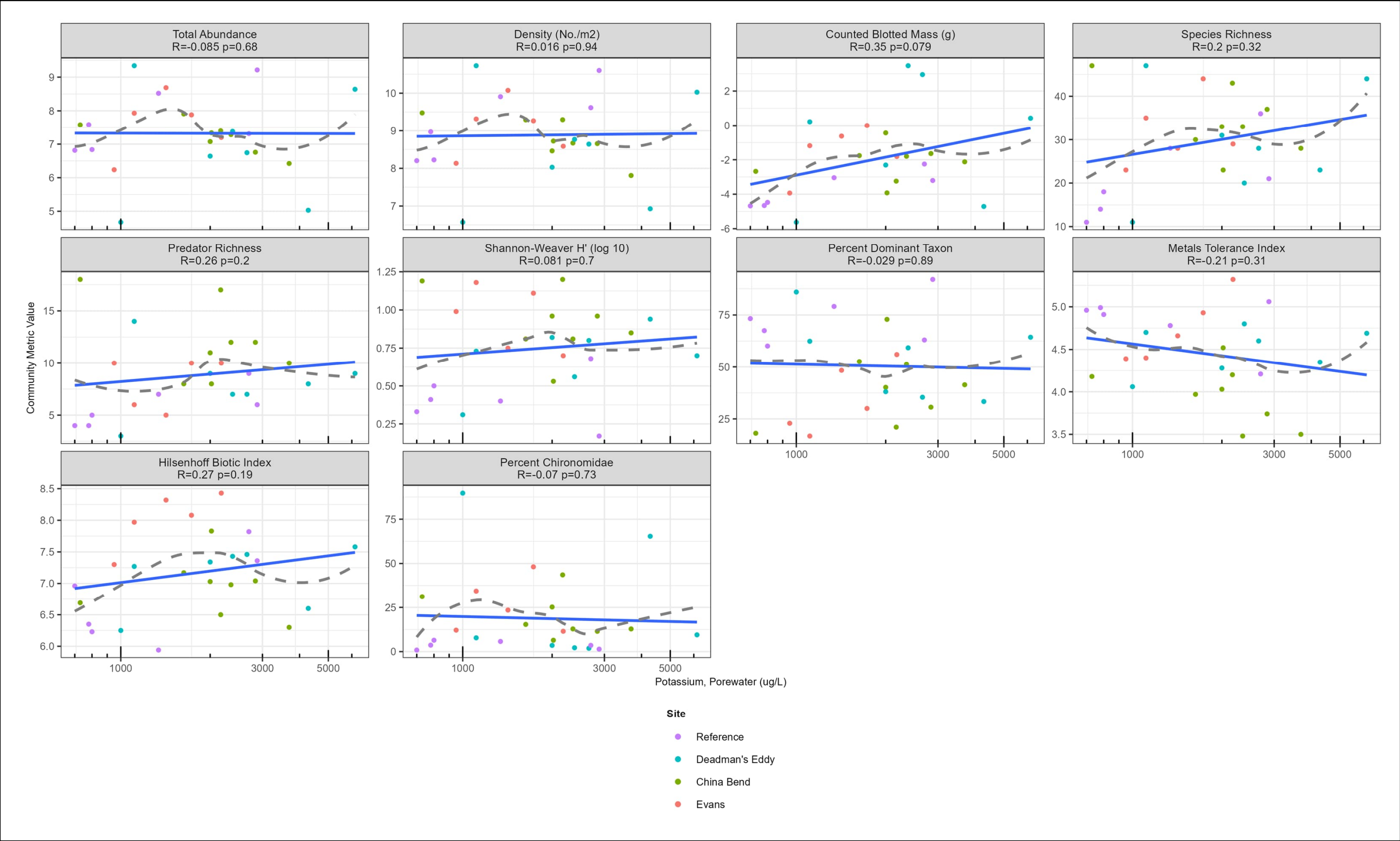


Figure K2-80. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Potassium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

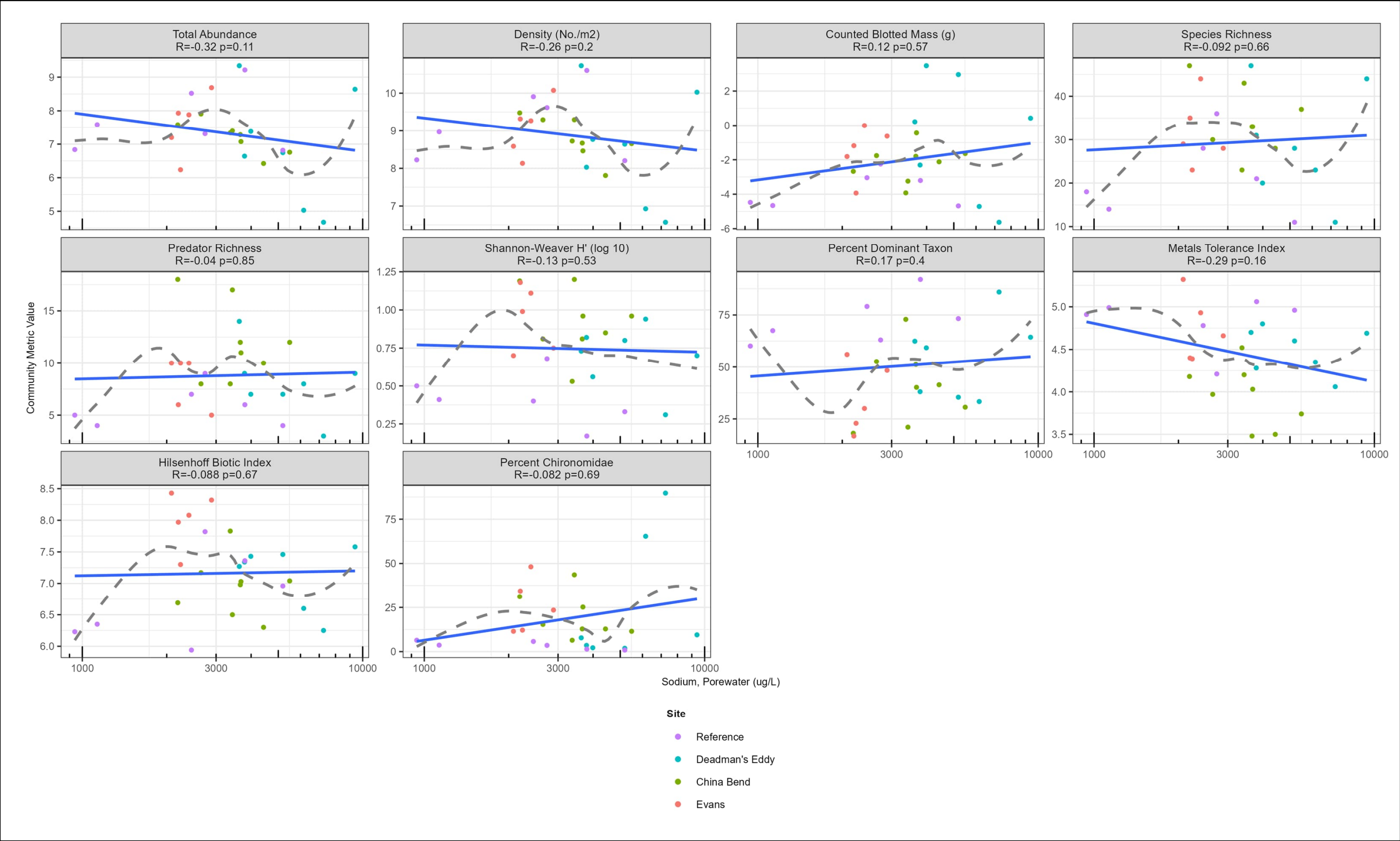


Figure K2-8p. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Sodium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

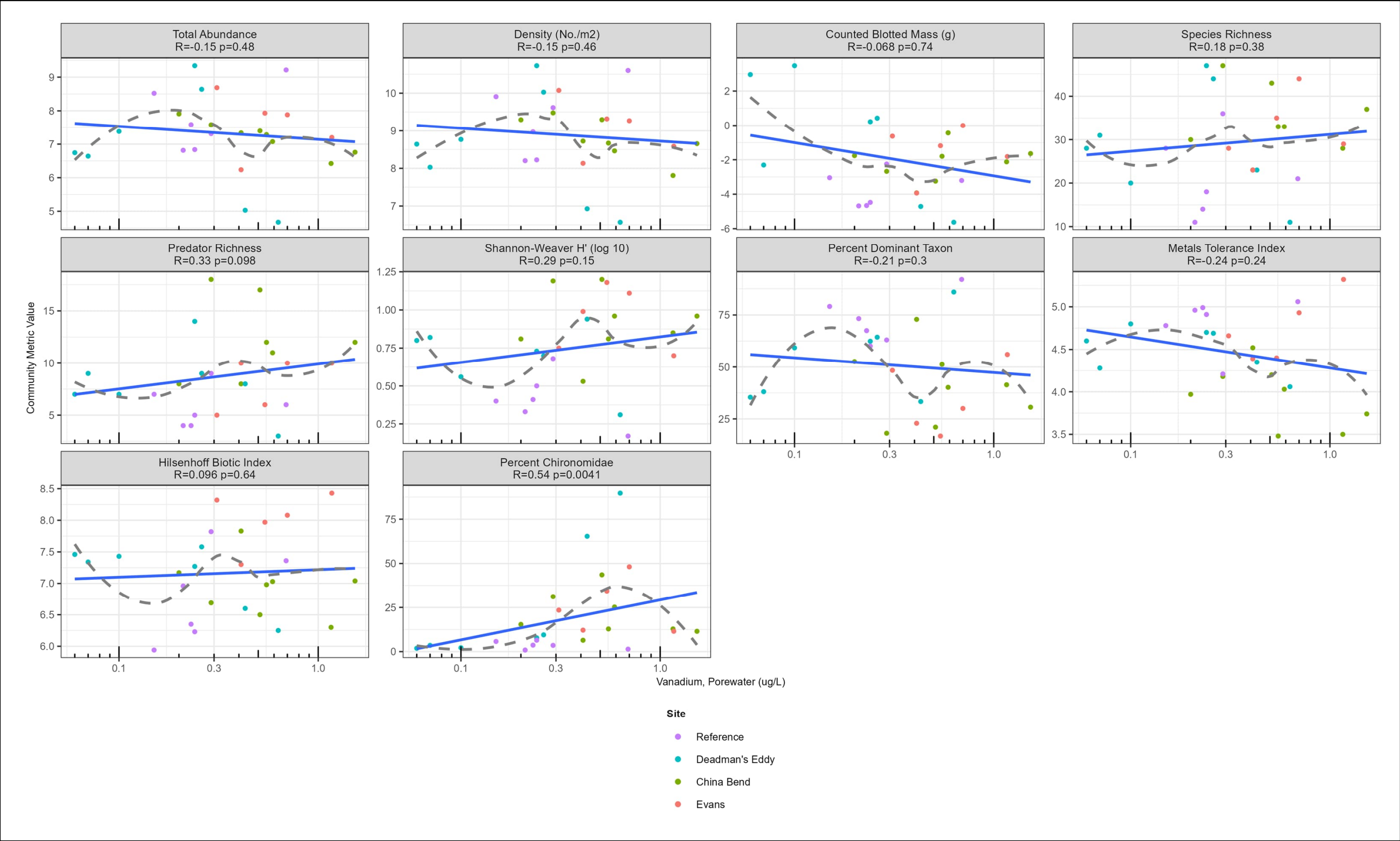


Figure K2-8q. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Vanadium in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

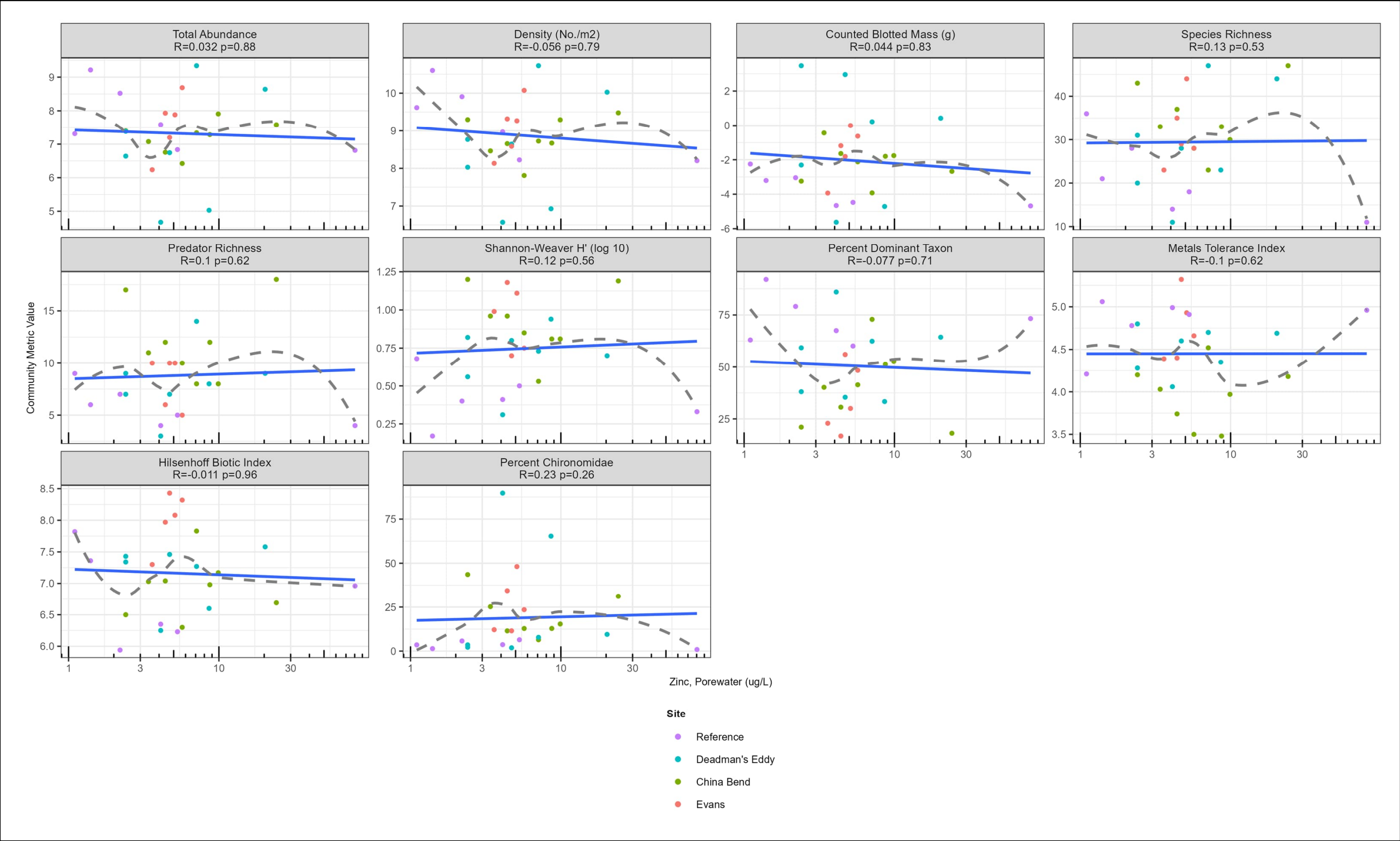


Figure K2-8r. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Zinc in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

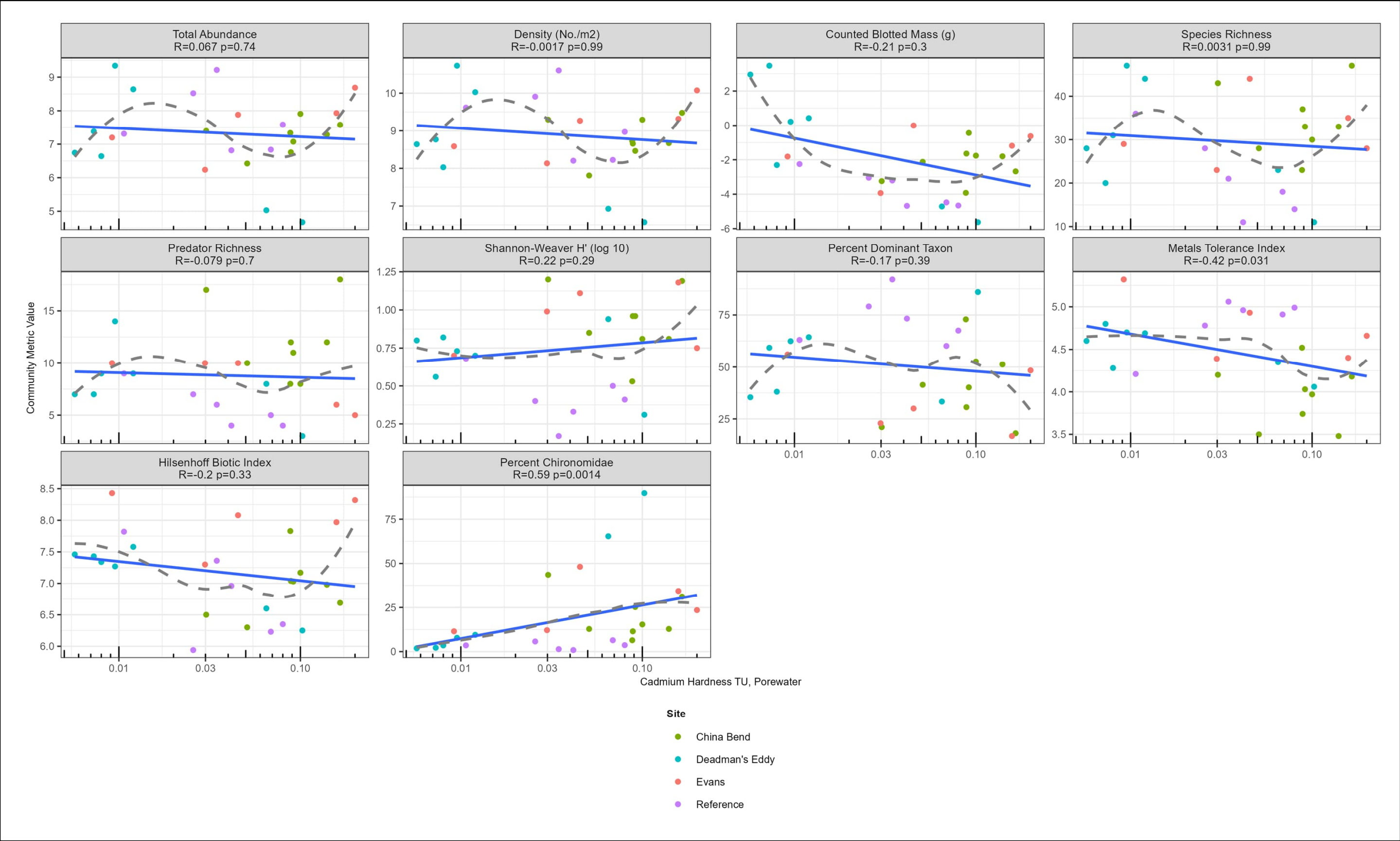


Figure K2-8s. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Cadmium Hardness TU in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

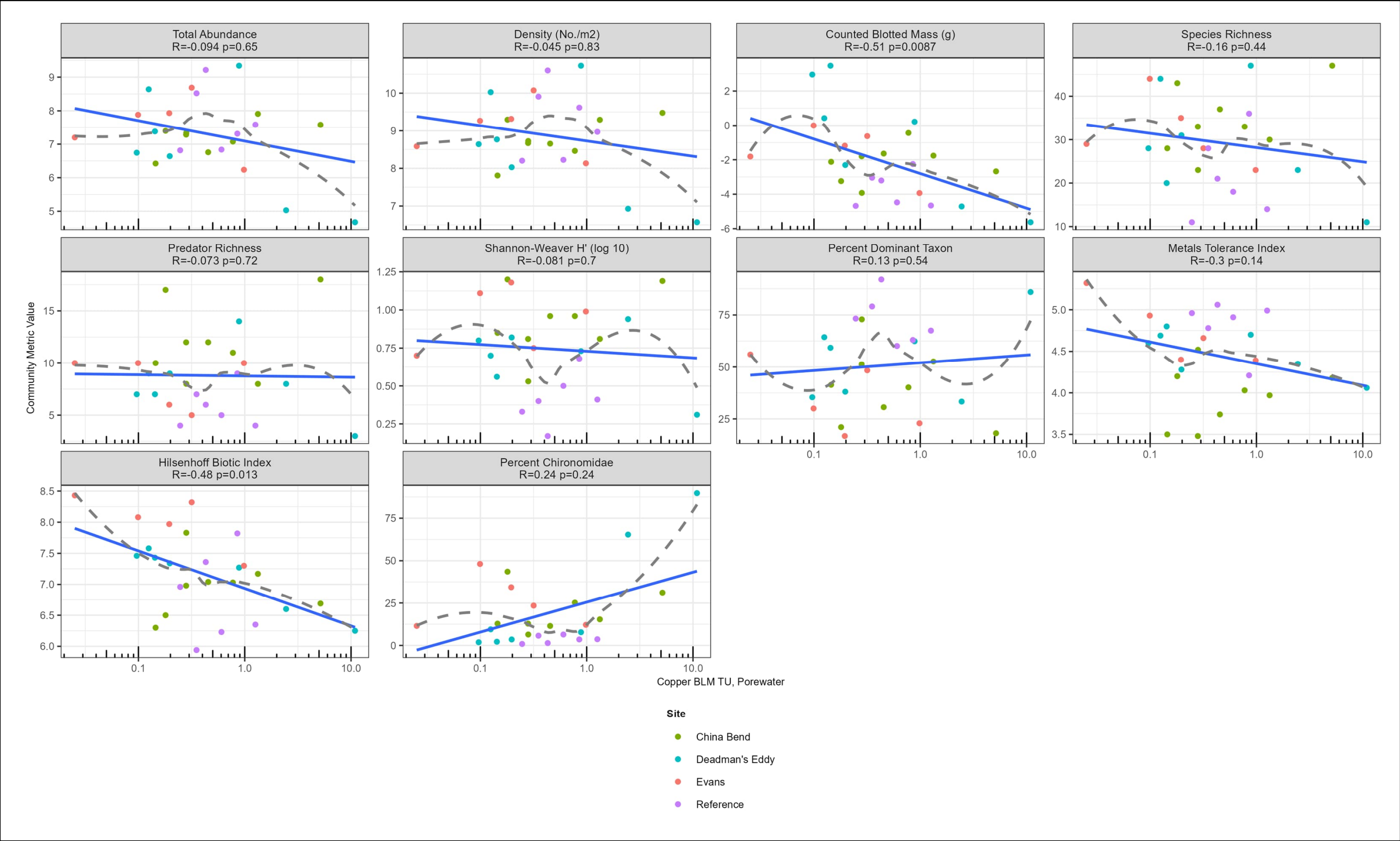


Figure K2-8t. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Copper BLM TU in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

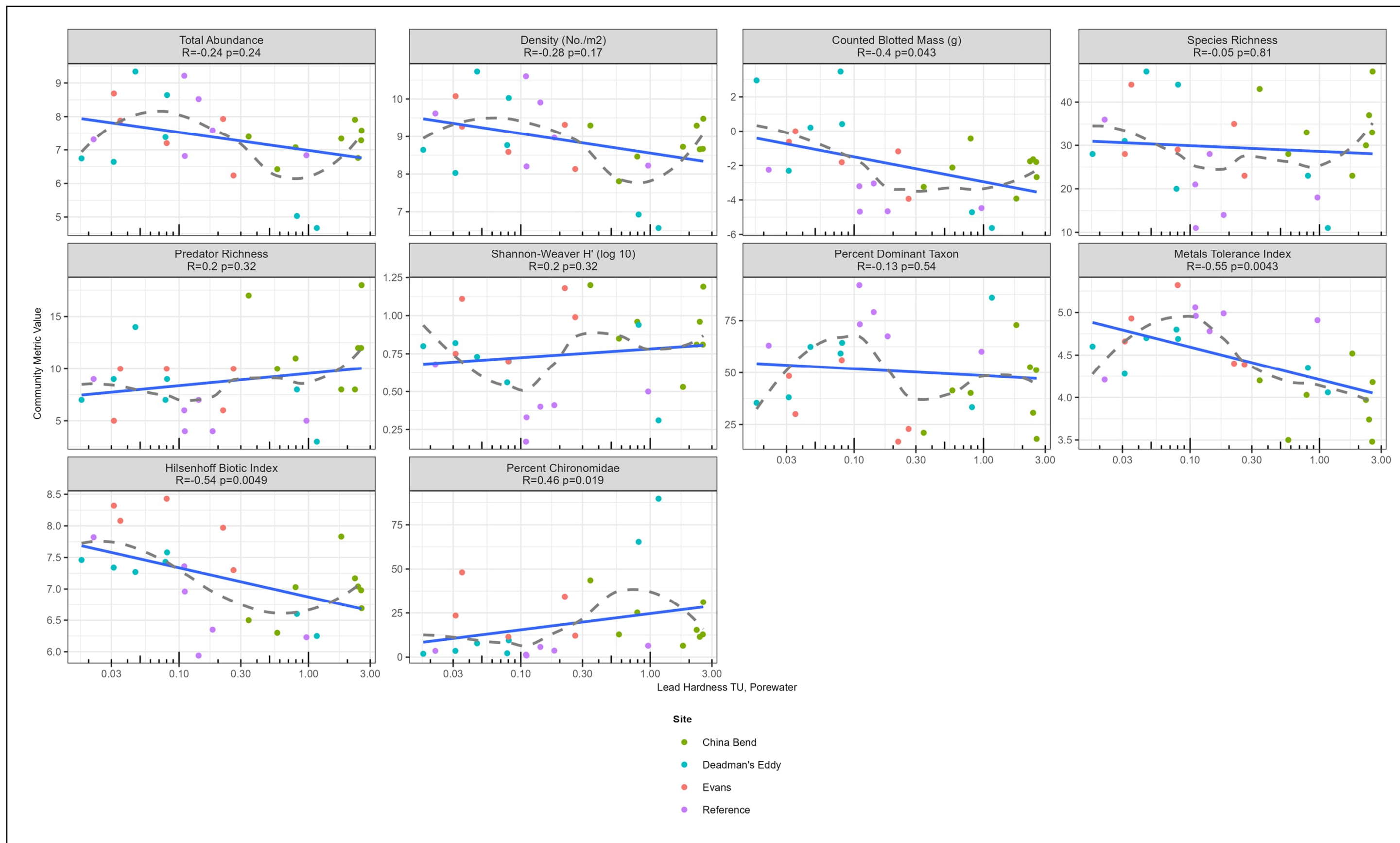


Figure K2-8u. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Lead Hardness TU in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

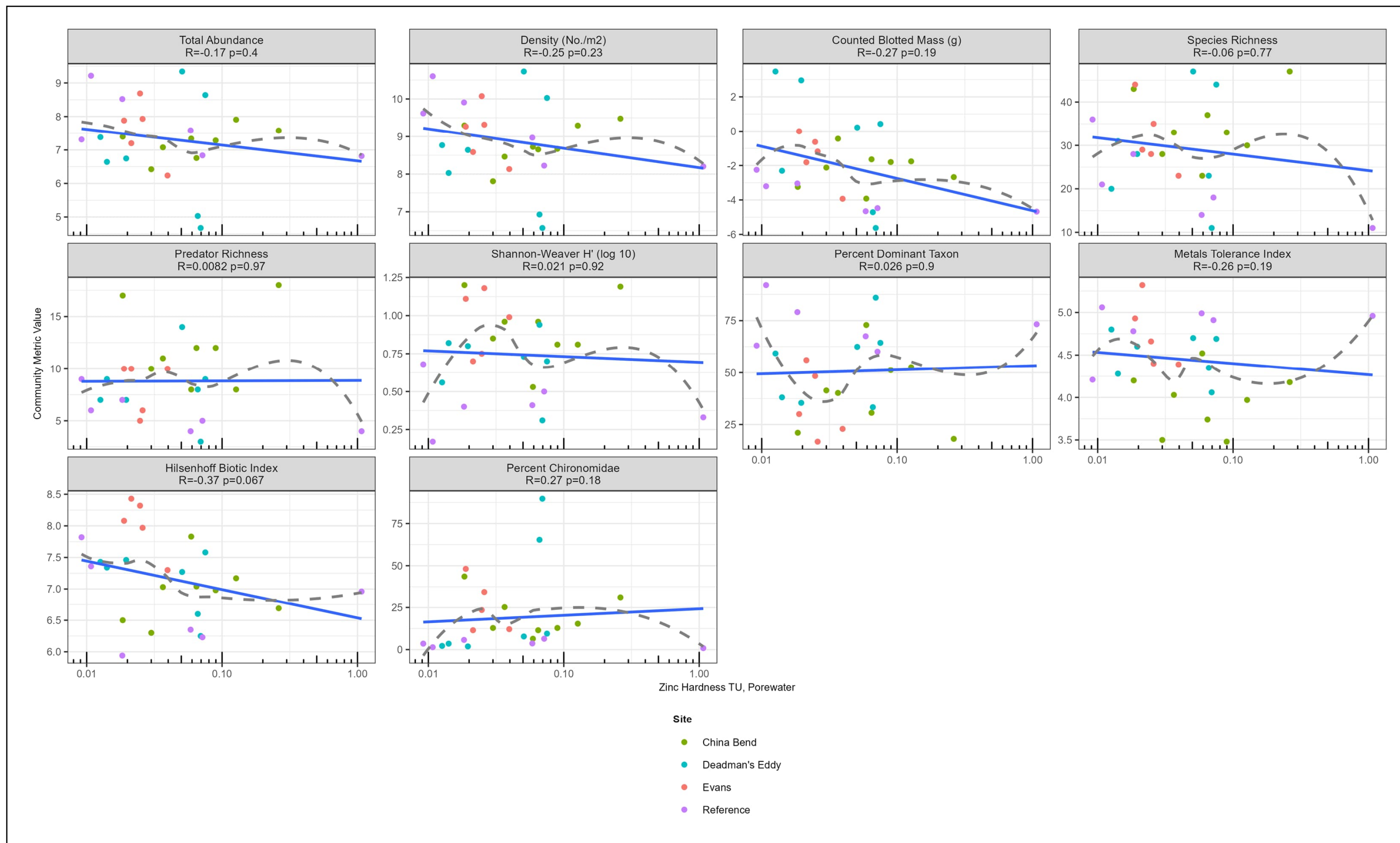


Figure K2-8v. Scatterplots of Benthic Invertebrate Community Metrics Against Dissolved Concentrations of Zinc Hardness TU in Porewater at Locations with Less than 50 Percent Medium, Coarse, and Very Coarse Sand

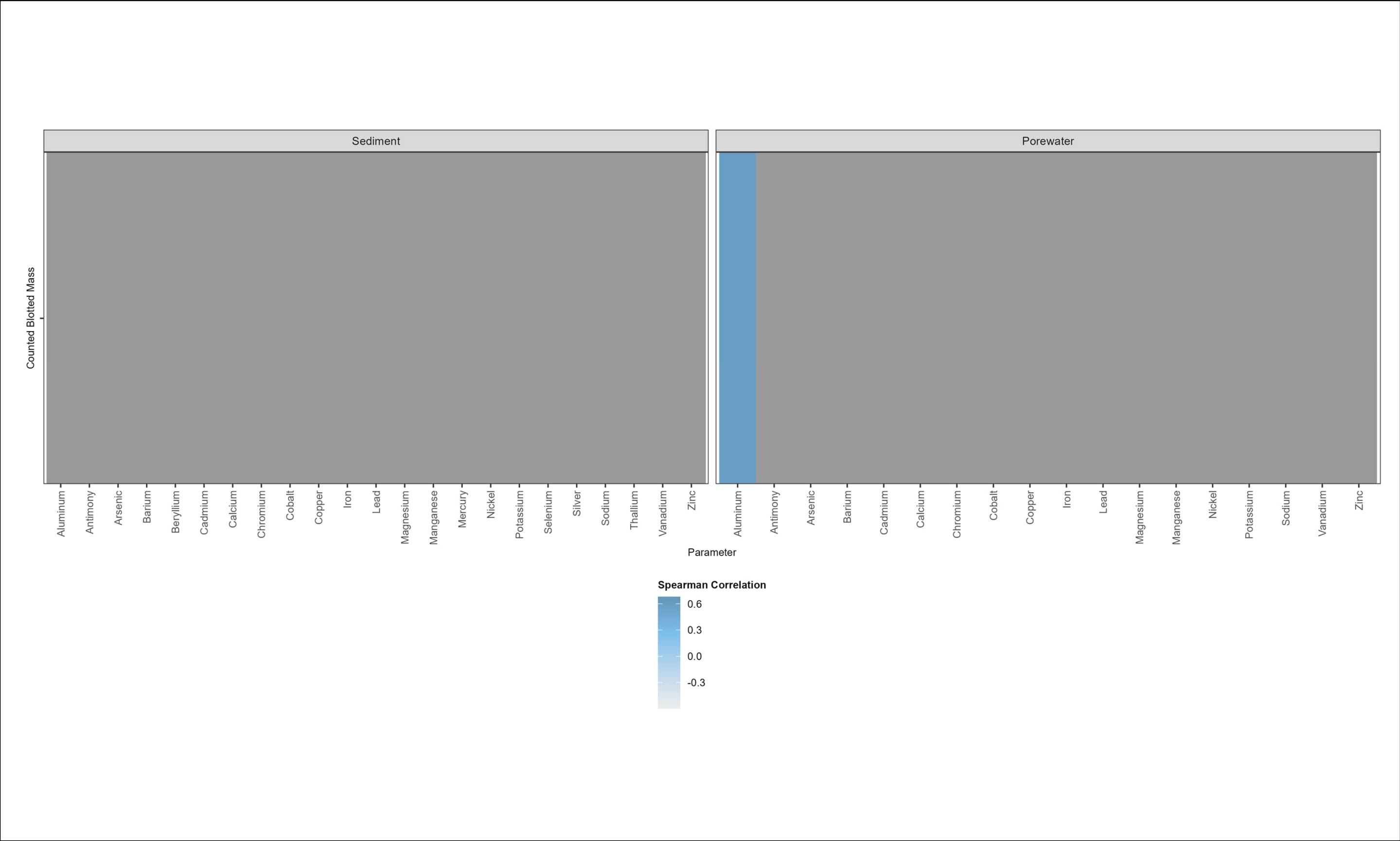


Figure K2-9. Mosaic of Rank Correlation Results for Adjusted Counted Blotted Mass of Benthic Invertebrates versus Bulk Sediment and Porewater Metals Concentrations at Phase 3 Locations with Non-CS50 Substrate

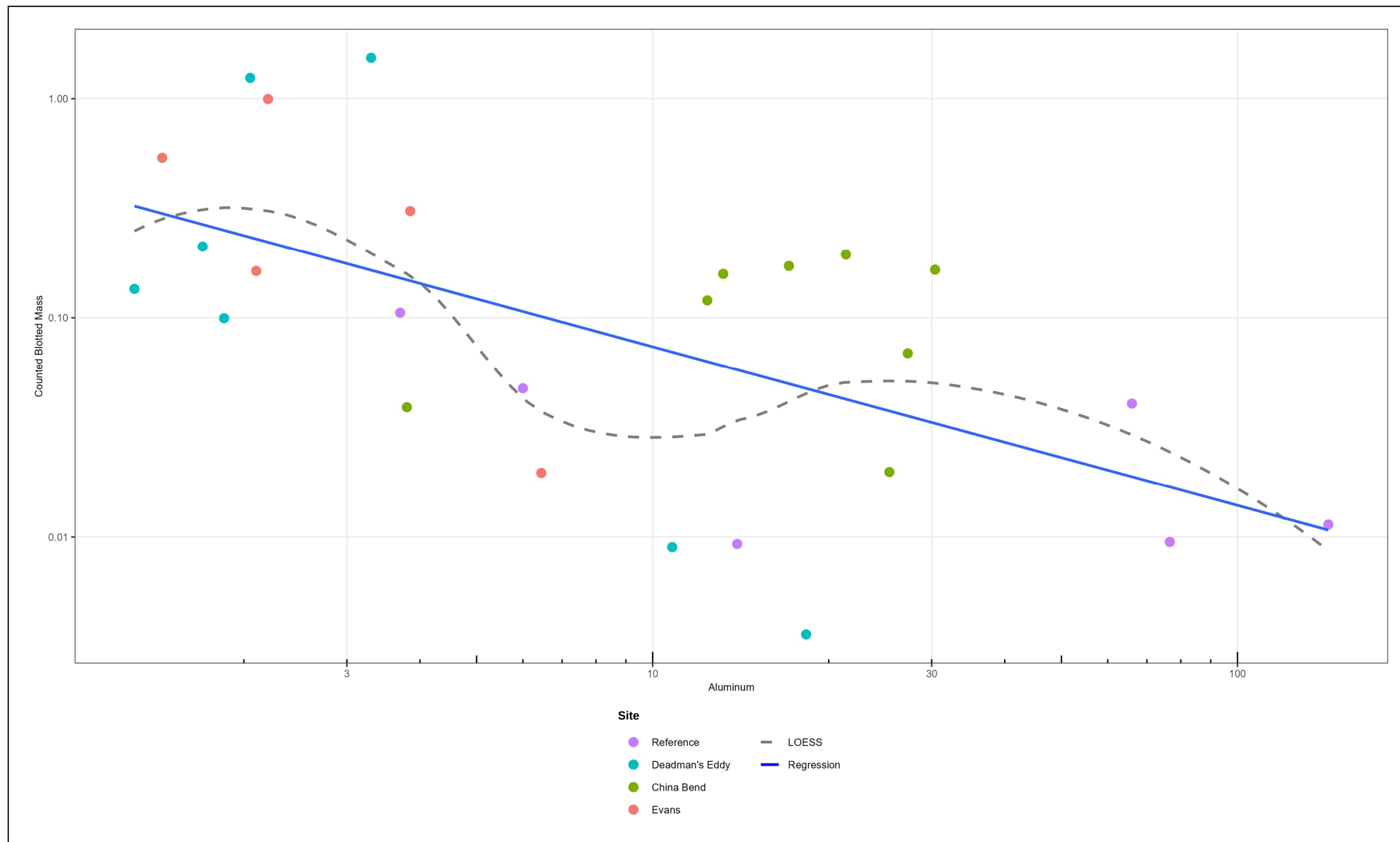


Figure K2-10. Scatterplots of Adjusted Counted Blotted Mass of Benthic Invertebrates Significantly Related to Metals Metrics at Phase 3 Locations with Non-CS50 Substrate



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ERM's Carpinteria Office

1180 Eugenia Place
Suite 204
Carpinteria, CA 93013

T: +1 805 684 2801
F: +1 805 684 1978

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