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TECHNICAL MEMORANDUM

Date: February 26, 2016

To: Brian Ross, USEPA Region 9, Dredging & Sediment Management Team
Beth Christian, San Francisco Bay Regional Water Quality Control Board

From: Don Yee and Phil Trowbridge, SFEI

Re: Updated ambient concentrations of toxic chemicals in San Francisco Bay area sediments

Introduction

The purpose of this memo is to communicate the most recent results for the ambient concentrations of mercury, Total PAHs and Total PCBs in San Francisco Bay area sediments.

Regulation of dredging and dredged material disposal or reuse under the San Francisco Bay Long Term Management Strategy for Dredging (LTMS) involves, in part, evaluation of sediment chemistry characteristics. For dredged material in California, for most chemicals, there are no numeric sediment quality standards or objectives that define chemical suitability for disposal or reuse at particular placement sites.[1] Consequently, Bay dredged sediments are compared to various published screening values and other guidelines, to reference site chemistry, and where available and appropriate, to ambient sediment contaminant concentrations for the Bay as a whole. Therefore, starting in 2011, the LTMS agencies have asked SFEI to calculate the ambient concentrations for a small subset of sediment contaminants that are either subject to TMDL limits for in-Bay dredged material disposal or are relevant for bioaccumulation testing for dredging (DMMO, n.d.).

It is important to note that even if contaminant concentrations in a dredged material project are below ambient values, this alone does not indicate that the dredged material is suitable for placement at any particular site. Ambient levels may be higher than environmentally desirable for some placement sites, while at other sites ambient concentrations may be far below levels of concern that need to be regulated. Ambient concentrations by themselves are not sediment screening values, and should not be used directly as guidelines for any particular regulatory use. However, understanding how potential regulatory goals or limits under consideration may relate

[1] Pursuant to the Water Quality Control Plan for Enclosed Bays and Estuaries - Part 1 Sediment Quality, California's Sediment Quality Objectives (SQOs) do not apply to dredged material suitability determinations. However, strict sediment chemistry limits may be established for individual compounds or locations under Bay-wide TMDLs, site-specific remediation decisions, etc.

to existing Bay ambient sediment concentrations can be important in informing regulatory decisions that are both effective and feasible to implement.

Methods

For this report, RMP staff calculated updated the ambient concentrations for mercury, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) using data through 2014. Ambient concentrations were calculated for individual PAH compounds and PCB congeners routinely reported by the RMP, as well as the Total PAHs and Total PCBs.

The previous report on ambient sediment concentrations (SFEI, 2015) was based on data through 2012. Another round of sediment data were collected in 2014, but not 2013. Therefore, to update the ambient concentrations, the 2014 dataset was added to the data considered for the last report and then the combined dataset was reanalyzed. Specifically, for PAHs and PCBs, the dataset included the years from 2002-2014 (excluding data from 2004-2006 that was censored due to QA issues). For mercury, the previous calculations were based on data from 2003-2012, so the current update used mercury data from 2003-2014.

The approach taken for this update was consistent with the recommendations from SFEI (2015) that calculations of ambient concentrations use data from the most recent 13-year period, instead of the 10-year period that had been used previously. The frequency of RMP sediment sampling has been changed to every 4 years. A 13-year time window is needed so that the calculations for each update would be based on at least 4 sediment sampling events. The 13-year trailing window from the most recent RMP data is 2002-2014. The data for PAHs and PCBs used for this update exactly matched this window. For mercury, data used for the update were from 2003-2014, which falls within this window.

The ambient values calculated are the 90% upper tolerance limit of the 90th percentile concentrations (U.S. Army Corps of Engineers and US Environmental Protection Agency, 2011). To avoid skewing the results, data from historical fixed sampling stations that are not part of the RMP randomized sampling design, including all pre-2002 data, have been excluded. Outliers were removed to exclude any highly contaminated samples, using an updated methodology previously described in the 2015 report (and summarized in Appendix A). The RMP visually selects for fine-grained sediments during field sampling; thus the ambient concentrations are representative of sediments with greater than 40% fines (which is typical of most sediments dredged in the Bay area).

The updated results for mercury, Total PAHs and Total PCBs are summarized in a simple table for the RMP website (Table 1). For comparison, the concentrations for these parameters from the 2015 report are shown in Table 2.

The updated concentrations for mercury, Total PAHs, and Total PCBs plus updated concentrations for individual PAH and PCB congeners are shown in a master table in Appendix B. Appendix B also includes the ambient concentrations for all other analytes updated in the last report (SFEI, 2015) but are unchanged here. Appendix C contains histograms of the latest results for all analytes.

Results

Table 1. Ambient contaminant concentrations in San Francisco Bay area sediments calculated from data between 2002 and 2014 for Mercury, Total PAHs (and HPAH/LPAH subtotals), and Total PCBs.

	1998 Ambient Sediment Values	90th Percentile 90% UTL (2015 Ambient Value)	99th Percentile 90% UTL[1]
MERCURY (2003-2014) (mg/kg dw)			
Mercury	0.43	0.332	0.47
PAH (2002-2003, 2007-2014) (ug/kg dw)			
Total PAH	3390	4520	9090
Total HPAH	3060	3640	5830
Total LPAH	434	568	746
PCB (2002-2003, 2007-2014) (ug/kg dw)			
Total PCB (sum of 40 congeners)	21.6	18.2	29.5

[1] 99th percentile required only for Mercury and PCBs. Indicates approximate (non-outlier) upper limit for other contaminants.

Table 2. Ambient contaminant concentrations in San Francisco Bay area sediments calculated from data between 2002 and 2012 for Mercury, Total PAHs (and HPAH/LPAH subtotals), and Total PCBs as reported in SFEI (2015).

	1998 Ambient Sediment Values	90th Percentile 90% UTL (2014 Ambient Value)	99th Percentile 90% UTL[1]
METALS (2003-2012) (mg/kg dw)			
Mercury	0.43	0.332	0.47
PAH (2002-2003, 2007-2012) (ug/kg dw)			
Total PAH	3390	4540	9100
Total HPAH	3060	3870	5830
Total LPAH	434	574	946
PCB (2002-2003, 2007-2012) (ug/kg dw)			
Total PCB (sum of 40 congeners)	21.6	18.3	29.6

[1] 99th percentile required only for Mercury and PCBs. Indicates approximate (non-outlier) upper limit for other contaminants.

As would be expected based on the calculation algorithm (which includes multiple years to provide some stability), only small changes to each of the ambient concentrations were observed from the last report.

After receiving your approval, RMP staff will add the updated concentrations in Table 1 to the RMP's Dredged Material Testing Thresholds website: http://www.sfei.org/projects/dmmo-ambient-sediment-conditions.

The next RMP sediment sampling event will occur in 2018. Once the data are finalized, the ambient concentrations for mercury, PAHs and PCBs will be updated using data from the 13-year window between 2006 and 2018.

References

Dredged Material Management Office (n.d.). Retrieved from http://www.spn.usace.army.mil/Missions/DredgingWorkPermits/DredgedMaterialManagementOffice(DMMO).aspx

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) staff. May 1998. Staff Report: Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments. Oakland, CA.

SFEI. 2015. Updated Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments. San Francisco Estuary Institute, Richmond, CA. Contribution # 749. Published online: http://www.sfei.org/documents/updated-ambient-concentrations-toxic-chemicals-san-francisco-bay-sediments.

U.S. Army Corps of Engineers, U.S. EPA Region 9. Memo to: Robert S. Hoffmann, National Marine Fisheries Service, Long Beach, CA. 9 June 2011.

Appendix A: Addendum on Auto-Outlier Detection Function

Using the original coding of the R script for identifying outliers, addition of RMP PCB data from 2011 to the previous data set (2002-2010) resulted in a statistical artifact that caused a large percentage of the data (~11%) to be regarded as outliers; previous years' analyses had most of these same points not as outliers (1% or less of the data as outliers). This arose due to a randomly occurring tight cluster of values in one portion of the distribution. The outlier function used a moderately small percentage of the total data set (2.5%, with a minimum of 12 values) to determine a local average difference expected between points; this very tight cluster thus resulted in a gap to the next higher value (between 15.9 and 16.7 ppb) previously considered unremarkable (<10x the local average difference) in previous years' data, being labeled as the gap to a set of outliers when the 2011 data were included.

To prevent future flagging of such chance statistical anomalies as outlier gaps, the following modifications to the outlier auto-detection function have been made:

1. A larger percentage of the nearest lower values (5% of the total data) are used to calculate a local average difference. Increasing from 2.5 % to 5% of the population decreases the influence of any small cluster of tightly spaced points (the anomaly seen in the 2002-2011 set). However, in the upper tail of the data distribution where we usually expect sparser spacing, using a larger % of the population decreases the apparent local difference by averaging in some more tightly spaced points in the main body of the distribution, potentially flagging more gaps. This change stabilizes the local average difference, decreasing the probability of finding gaps in the main body of the distribution, but increasing the likelihood in sparse areas of the upper tail.
2. Any outlier has to be at least 25% greater than the mean of its nearest lower neighbors (a running average 10% of the total data) to be considered "meaningful". In many laboratory chemical analyses, a 25% difference in replicate measurements is acceptable, so the difference between a possible outlier and its nearest lower neighbors should be at least as large to account for measurement uncertainty. The difference to a running average of nearest lower neighbors rather than a single nearest lower neighbor is used, as otherwise a few values between low and high concentration groups could bridge apparent gaps, causing no outliers to be found. The use of 10% of the data for the running average further ensures that a small set of sparse values cannot bridge the zone between low and high concentration groups.
3. Since our concern is about high outlier values, any outlier has to occur above the upper quartile value. This avoids a case where a minority of very low values (e.g., clean sites near Golden Gate) would create an apparent gap to the main population of results, causing all of the latter to be called outliers. Using the upper quartile as the threshold, a bimodal distribution where a slight majority of the data is in the lower group would still result the upper portion labeled as outliers.

Imposing all three of the modifications above makes the detection of outlier groups more stable and resistant to chance anomalies in the data distribution. The current data set now has 10 years of data, and future calculations will only include the most recent 10 sets of data. Existing outlier groups are therefore unlikely to change just by the filling in of gaps using new data with similar concentration distributions; only larger and real shifts in distribution (e.g., 5% or more of the total data bridging the gaps) will cause appreciable shifts in the subset of points being identified as outliers.

Appendix B
Full List of Ambient Values (including previous updates)

Table B-1. Ambient contaminant concentrations in San Francisco Bay area sediments calculated using data through 2014 for mercury, PAHs, and PCBs.

	1998 Ambient Sediment Values	90th Percentile 90% UTL (2015 Ambient Value)	99th Percentile 90% UTL[2]
MERCURY (2003-2014) (mg/kg dw)			
Mercury	0.43	0.332	0.469
PAH (2002-2003, 2007-2014) (ug/kg dw)			
Total PAH	3390	4520	9090
Total HPAH	3060	3640	5830
Total LPAH	434	568	746
Acenaphthene	26.6	13.6	20.3
Acenaphthylene	31.7	34.0	52.2
Anthracene	88	80.5	110
Benz(a)anthracene	244	212	252
Benzo(a)pyrene	412	395	746
Benzo(b)fluoranthene	371	225	280
Benzo(e)pyrene	294	244	467
Benzo(g,h,i)perylene	310	408	654
Benzo(k)fluoranthene	258	229	452
Biphenyl	12.9	11.8	17.0
Chrysene	289	243	481
Dibenz(a,h)anthracene	32.7	47.8	106
Dibenzothiophene	NA	16.3	28.4
Dimethylnaphthalene, 2,6-	12.1	12.9	17.6
Fluoranthene	514	562	791
Fluorene	25.3	27.2	57.3
Indeno(1,2,3-c,d)pyrene	382	336	490
Methylnaphthalene, 1-	12.1	13.8	20.1
Methylnaphthalene, 2-	19.4	20.8	29.8
Methylphenanthrene, 1-	31.7	37.8	70.2
Naphthalene	55.8	56.2	70.6
Perylene	145	213	319
Phenanthrene	237	173	253
Pyrene	665	783	1115
Trimethylnaphthalene, 2,3,5-	9.8	7.31	9.77

PCB (2002-2003, 2007-2014) (ug/kg dw)			
Total PCB (sum of 40 congeners)	21.6	18.2	29.5
PCB 8	NA	0.143	0.291
PCB 18	NA	0.0668	0.0946
PCB 28	NA	0.284	0.438
PCB 31	NA	0.134	0.223
PCB 33	NA	0.0819	0.146
PCB 44	NA	0.333	0.465
PCB 49	NA	0.249	0.301
PCB 52	NA	0.39	0.717
PCB 56	NA	0.135	0.238
PCB 60	NA	0.0661	0.134
PCB 66	NA	0.467	0.802
PCB 70	NA	0.58	0.944
PCB 87	NA	0.462	0.602
PCB 95	NA	0.6	1.28
PCB 99	NA	0.648	1.25
PCB 101	NA	1.11	2.25
PCB 105	NA	0.364	0.487
PCB 110	NA	1.04	1.93
PCB 118	NA	0.979	1.32
PCB 128	NA	0.276	0.508
PCB 132	NA	0.37	0.441
PCB 138	NA	1.84	2.62
PCB 141	NA	0.207	0.309
PCB 149	NA	1.26	2.55
PCB 151	NA	0.562	1.28
PCB 153	NA	1.82	2.61
PCB 156	NA	0.164	0.217
PCB 158	NA	0.147	0.216
PCB 170	NA	0.459	0.561
PCB 174	NA	0.468	0.678
PCB 177	NA	0.359	0.532
PCB 180	NA	1.02	2.16
PCB 183	NA	0.356	0.479
PCB 187	NA	0.852	1.11
PCB 194	NA	0.328	0.405
PCB 195	NA	0.112	0.136
PCB 201	NA	0.0551	0.116
PCB 203	NA	0.181	0.398

Table B-2. Ambient contaminant concentrations in San Francisco Bay area sediments for other analytes calculated using data through 2012 and reported in SFEI (2015).

	1998 Ambient Sediment Values	90th Percentile 90% UTL (2014 Ambient Value)	99th Percentile 90% UTL[2]
METALS (2003-2012) (mg/kg dw)			
Arsenic	15.3	13.9	19
Cadmium	0.33	0.329	0.483
Chromium[1]	112	NA	NA
Copper	68.1	53.9	71.2
Lead	43.2	25.1	33.2
Nickel	112	98.3	118
Selenium	0.64	0.359	0.493
Silver	0.58	0.315	0.496
Zinc	158	136	162
PESTICIDES (2002-2003, 2007-2012) (ug/kg dw)			
Aldrin	NA	0.0335	0.0585
Total Chlordane	1.1	0.342	0.599
Dieldrin	0.44	0.157	0.203
Endrin	NA	0.00897	0.0177
Total DDT (total of 6 isomers)	7	4.68	6.29
DDD(o,p')	NA	0.509	0.742
DDD(p,p')	NA	1.98	2.74
DDE(o,p')	NA	0.109	0.221
DDE(p,p')	NA	1.98	2.92
DDT(o,p')	NA	0.0371	0.0593
DDT(p,p')	NA	0.265	0.599
Total HCH	0.78	0.0512	0.115
Hexachlorobenzene	0.48	0.196	0.416
PBDE (2002-2003, 2007-2012) (ug/kg dw)			
Total PBDE	NA	5.47	21.4
DIOXIN (2008-2010) (ug TEQ/kg dw)			
Sum of Dioxins TEQ	NA	0.00183	0.00269
Sum of Furans TEQ	NA	0.00107	0.00135

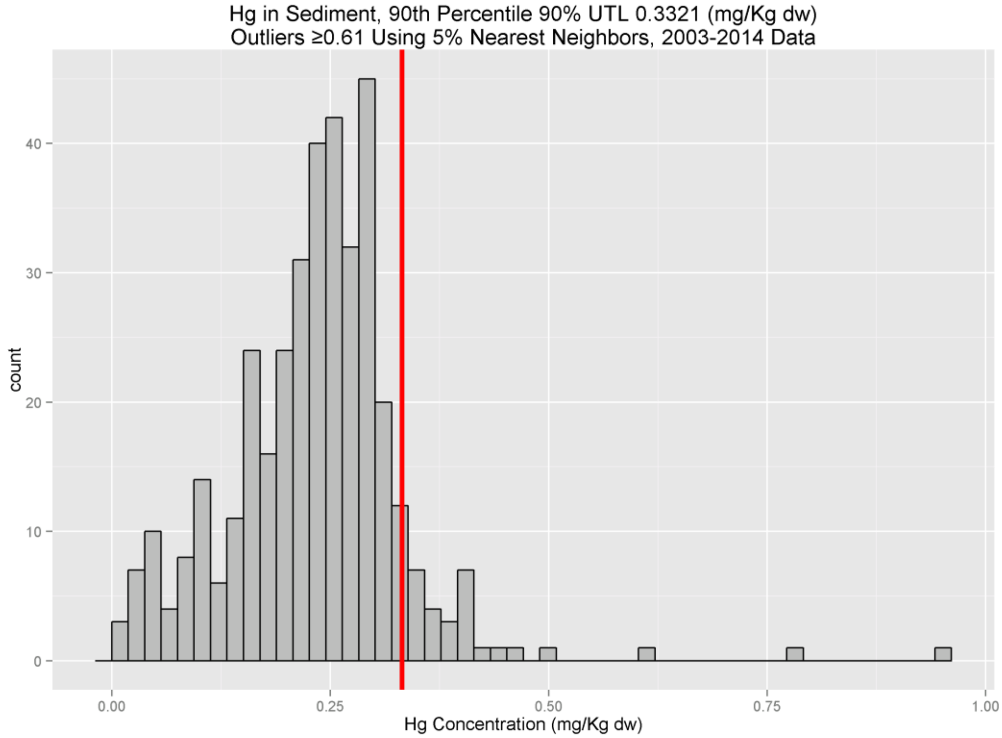
NA = Data Not Available

[1]RMP stopped monitoring Cr in 2002 because it was not a concern for water quality in the Bay.

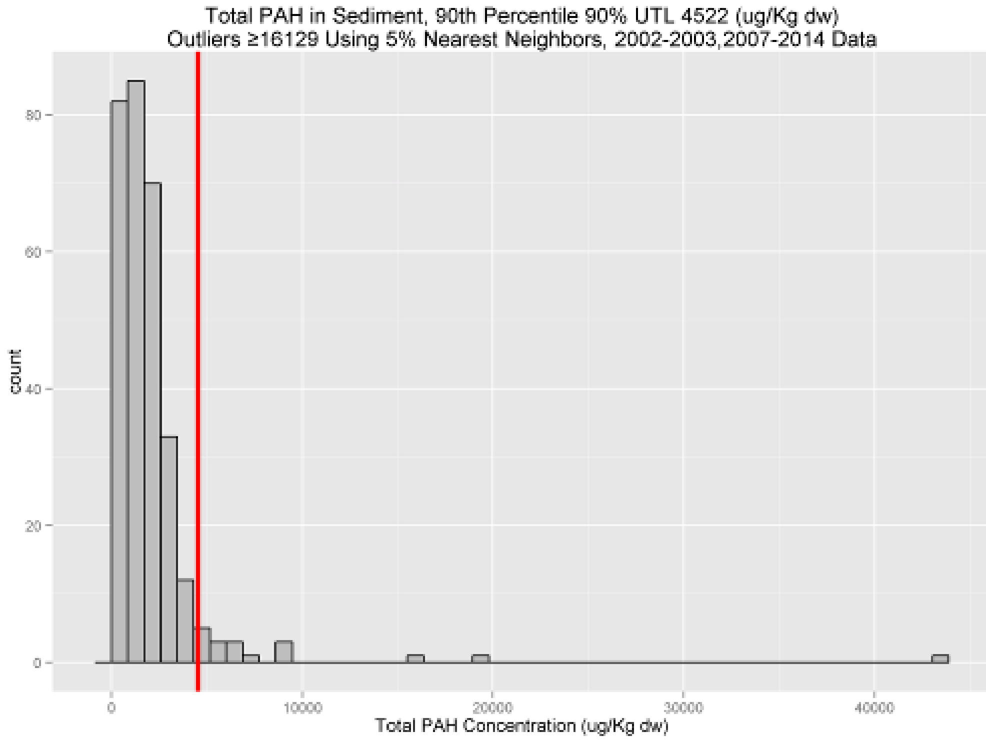
[2]99th percentile required only for Mercury and PCBs. Indicates approximate (non-outlier) upper limit for other contaminants.

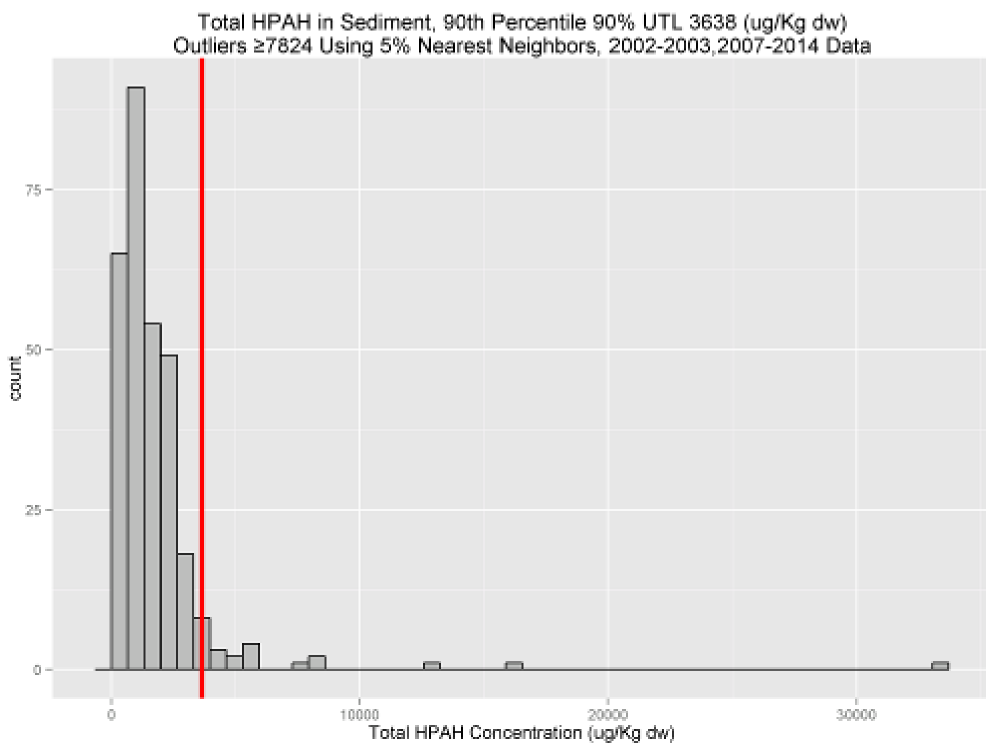
Appendix C
Histograms for Individual Analytes

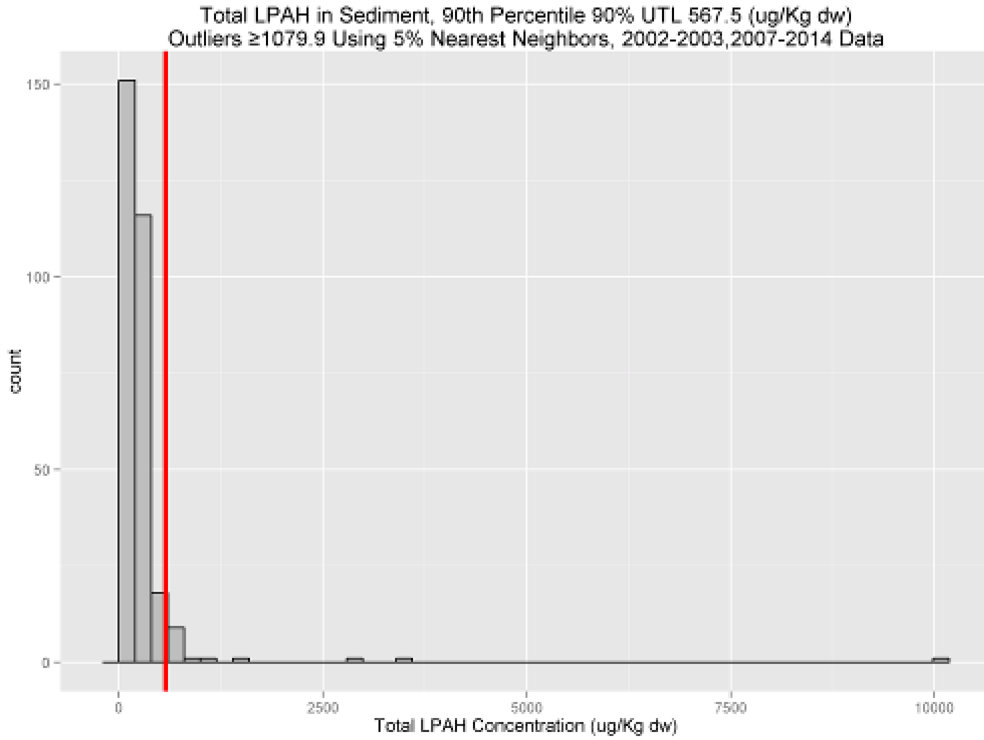
C-1 Short List Contaminants (changed since 2014 update)
Mercury

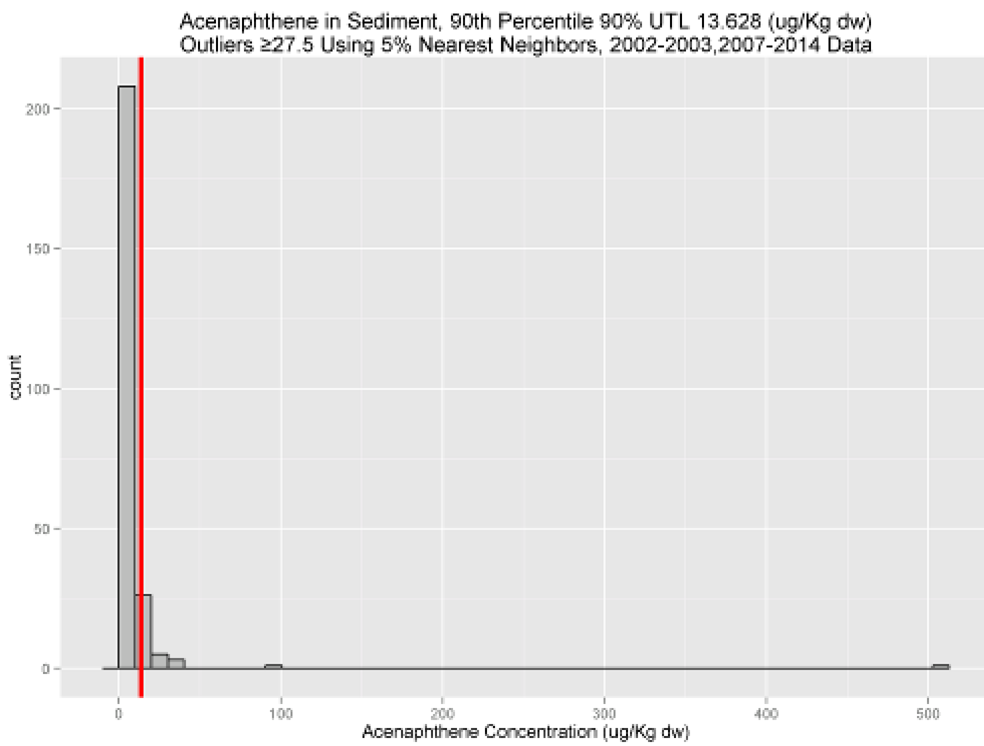


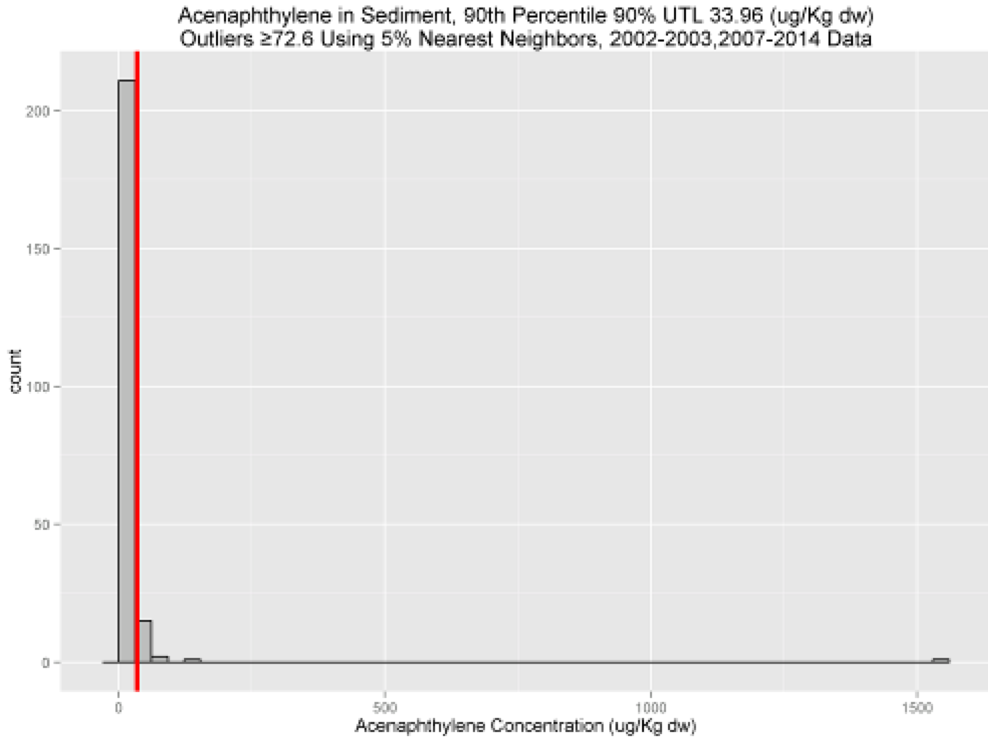
PAHs

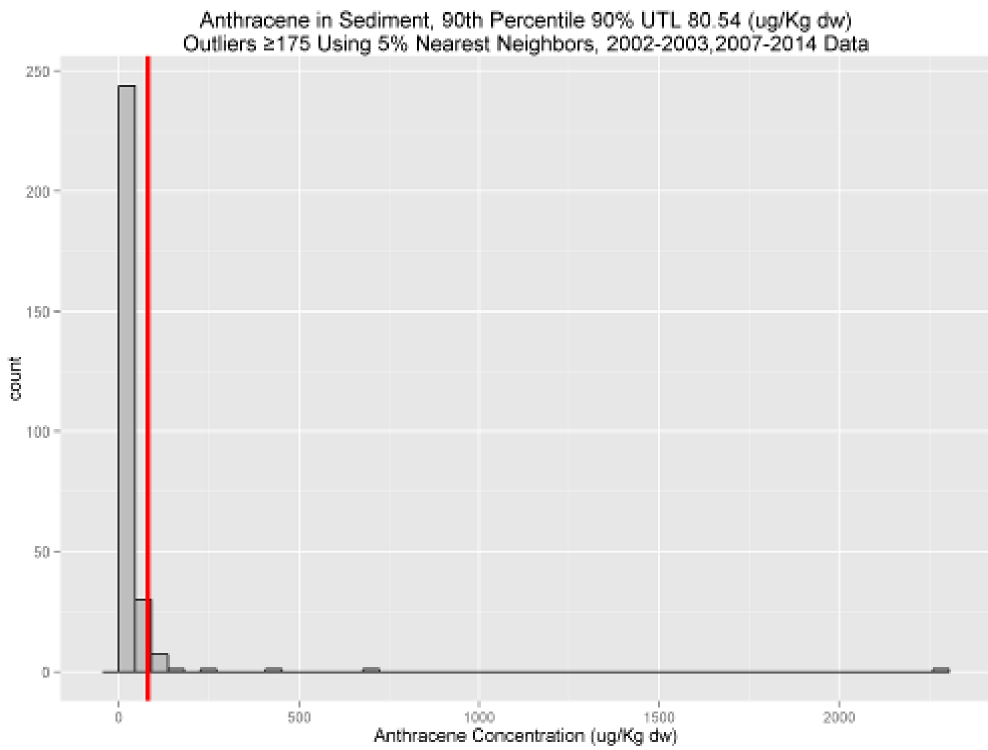

Total PAH in Sediment, 90th Percentile 90% UTL 4522 (ug/Kg dw)
Outliers ≥16129 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
80
60
40
20
0
0
10000
20000
30000
40000
Total PAH Concentration (ug/Kg dw)


Total HPAH in Sediment, 90th Percentile 90% UTL 3638 (ug/Kg dw)
Outliers ≥7824 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
75
50
25
0
0
10000
20000
30000
Total HPAH Concentration (ug/Kg dw)

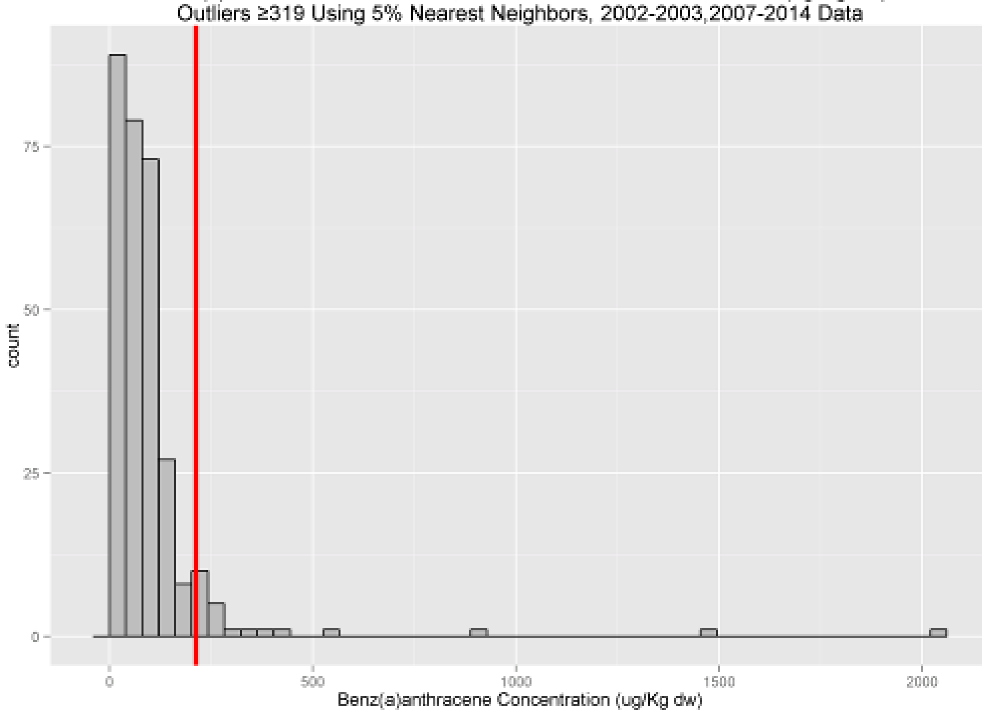

Total LPAH in Sediment, 90th Percentile 90% UTL 567.5 (ug/Kg dw)
Outliers ≥1079.9 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
150
100
50
0
0
2500
5000
7500
10000
Total LPAH Concentration (ug/Kg dw)


Acenaphthene in Sediment, 90th Percentile 90% UTL 13.628 (ug/Kg dw)
Outliers ≥27.5 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
200
150
100
50
0
0
100
200
300
400
500
Acenaphthene Concentration (ug/Kg dw)

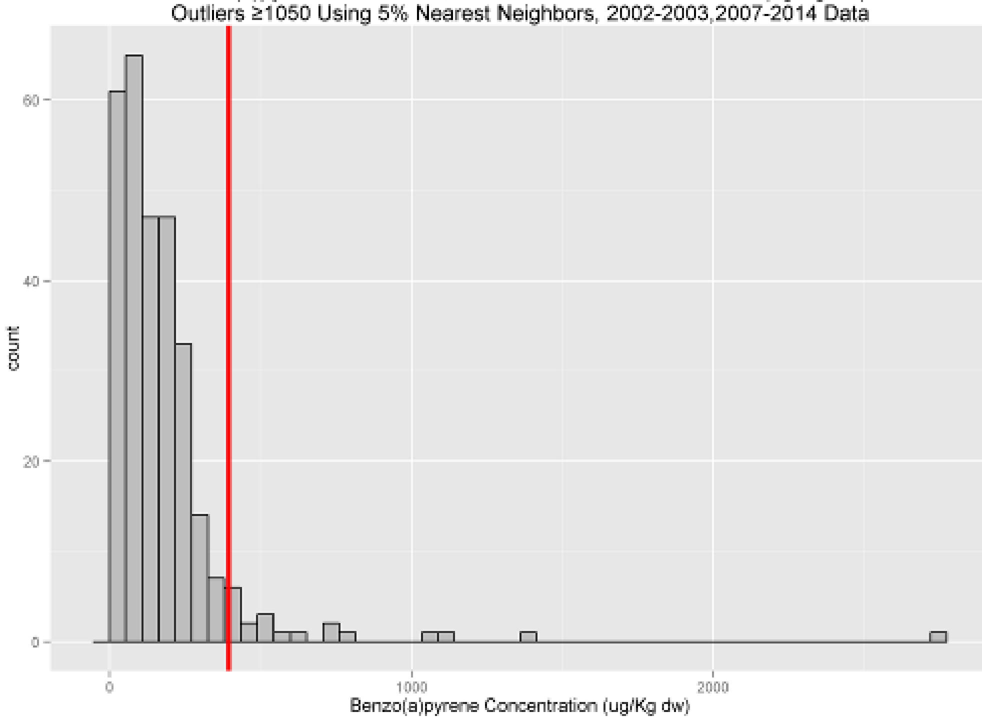

Acenaphthylene in Sediment, 90th Percentile 90% UTL 33.96 (ug/Kg dw)
Outliers ≥72.6 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
200
150
100
50
0
0
500
1000
1500
Acenaphthylene Concentration (ug/Kg dw)

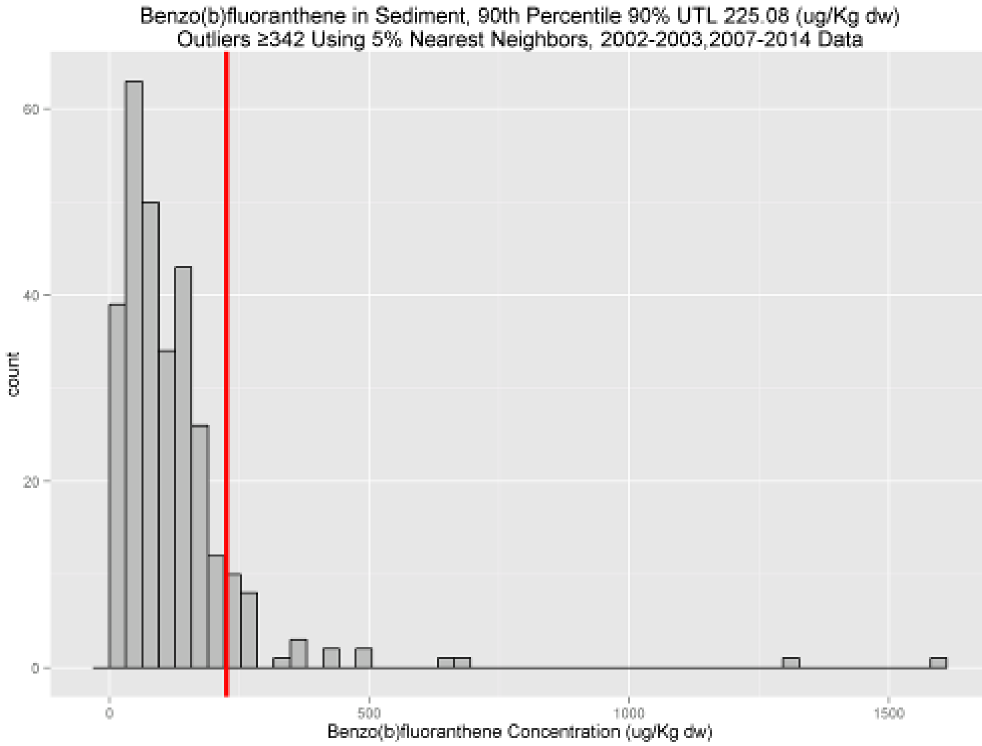

Anthracene in Sediment, 90th Percentile 90% UTL 80.54 (ug/Kg dw)
Outliers ≥175 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
250
200
150
100
50
0
0
500
1000
1500
2000
Anthracene Concentration (ug/Kg dw)

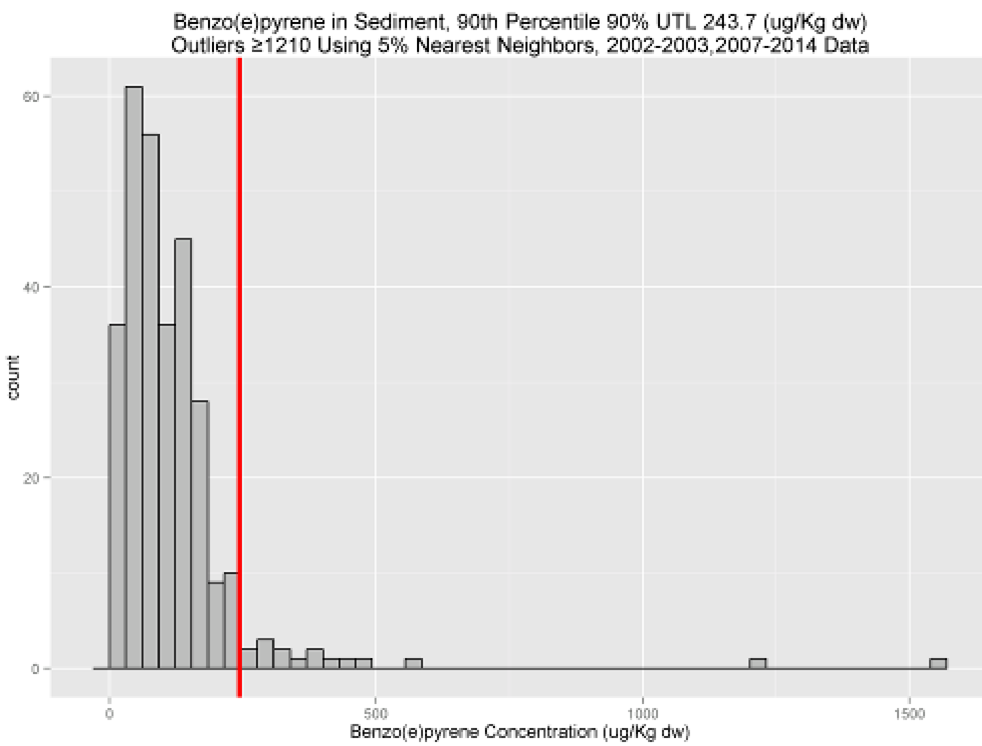
Benz(a)anthracene in Sediment, 90th Percentile 90% UTL 211.97 (ug/Kg dw)
Outliers ≥319 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

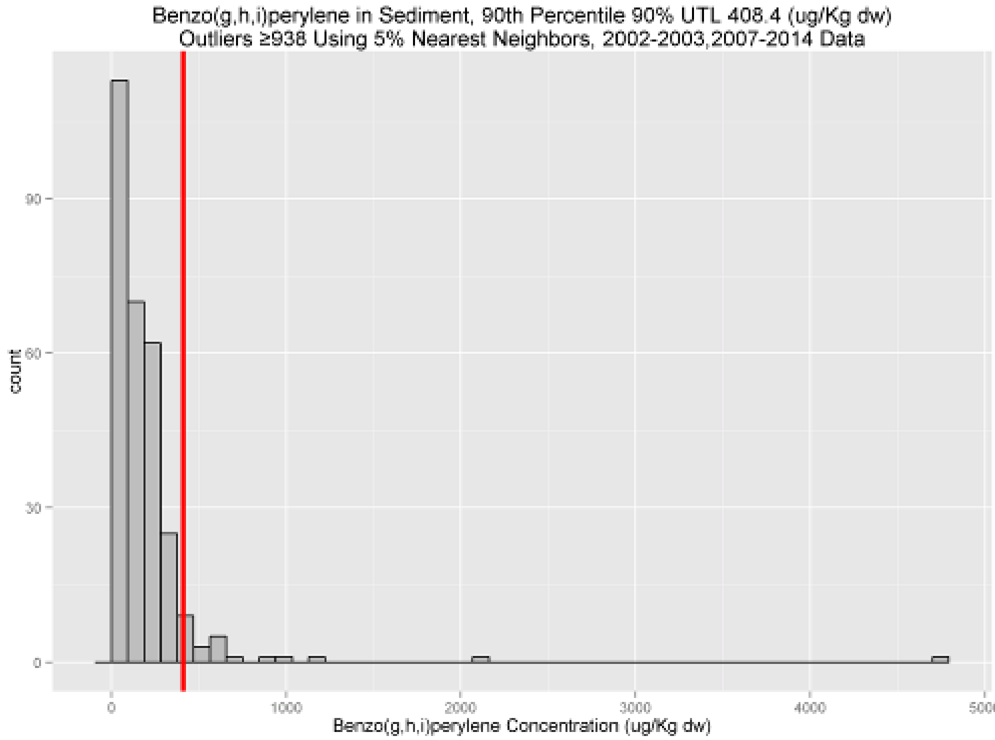


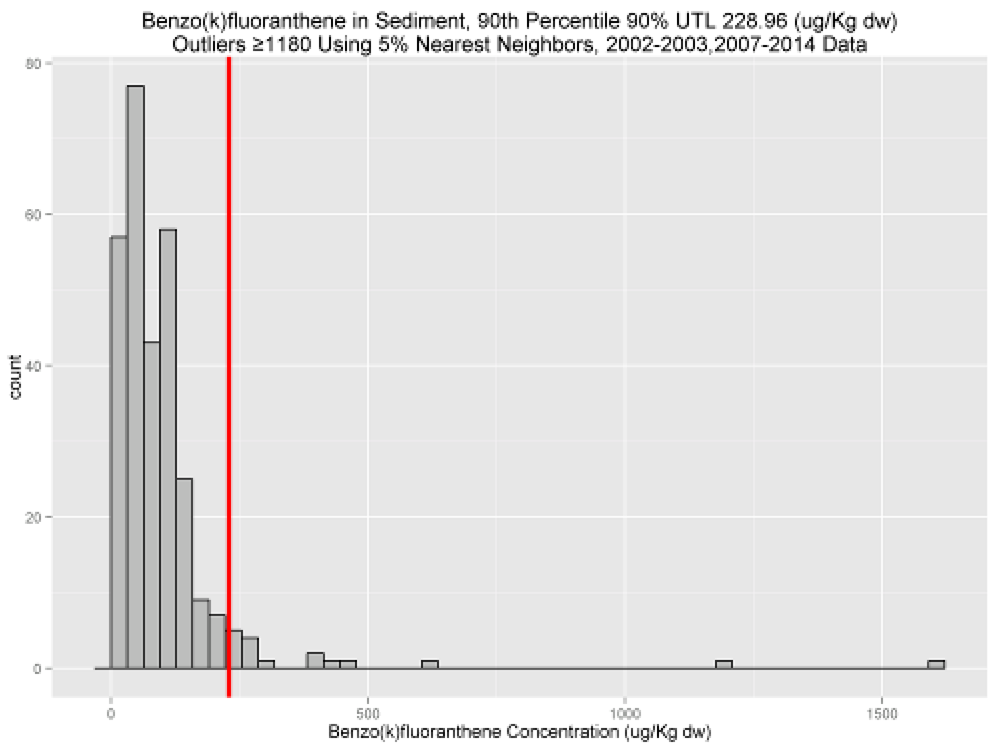
Benzo(a)pyrene in Sediment, 90th Percentile 90% UTL 394.6 (ug/Kg dw)
Outliers ≥1050 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

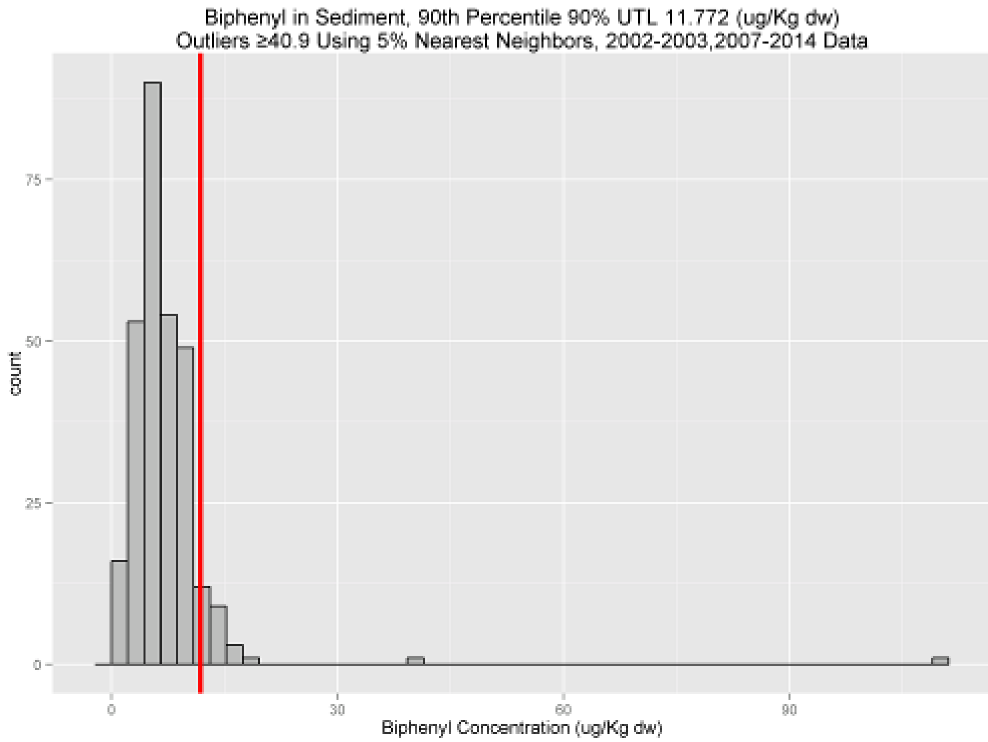


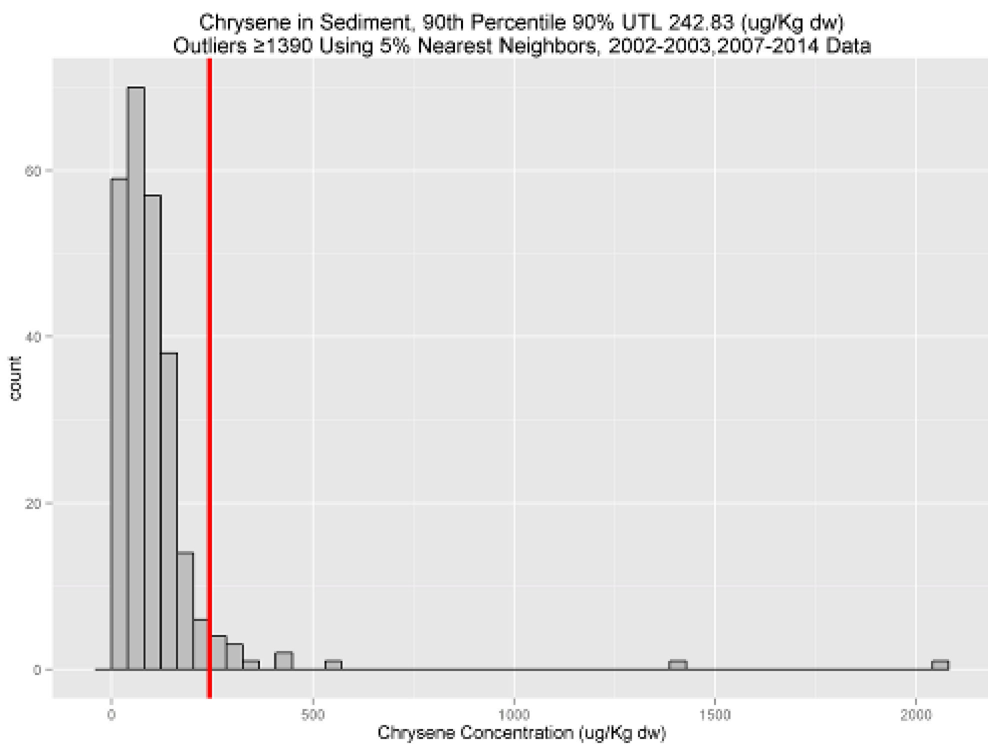

Benzo(b)fluoranthene in Sediment, 90th Percentile 90% UTL 225.08 (ug/Kg dw)
Outliers ≥342 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
500
1000
1500
Benzo(b)fluoranthene Concentration (ug/Kg dw)


Benzo(e)pyrene in Sediment, 90th Percentile 90% UTL 243.7 (ug/Kg dw)
Outliers ≥1210 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
500
1000
1500
Benzo(e)pyrene Concentration (ug/Kg dw)

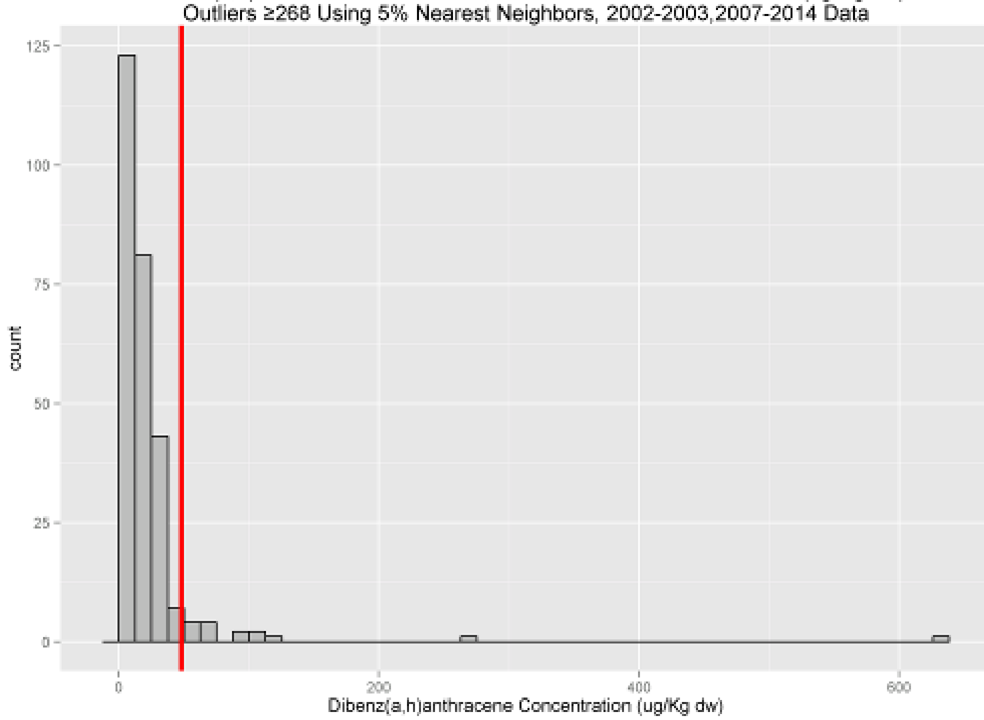

Benzo(g,h,i)perylene in Sediment, 90th Percentile 90% UTL 408.4 (ug/Kg dw)
Outliers ≥938 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
30
60
90
0
1000
2000
3000
4000
5000
Benzo(g,h,i)perylene Concentration (ug/Kg dw)


Benzo(k)fluoranthene in Sediment, 90th Percentile 90% UTL 228.96 (ug/Kg dw)
Outliers ≥1180 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
20
40
60
80
0
500
1000
1500
Benzo(k)fluoranthene Concentration (ug/Kg dw)

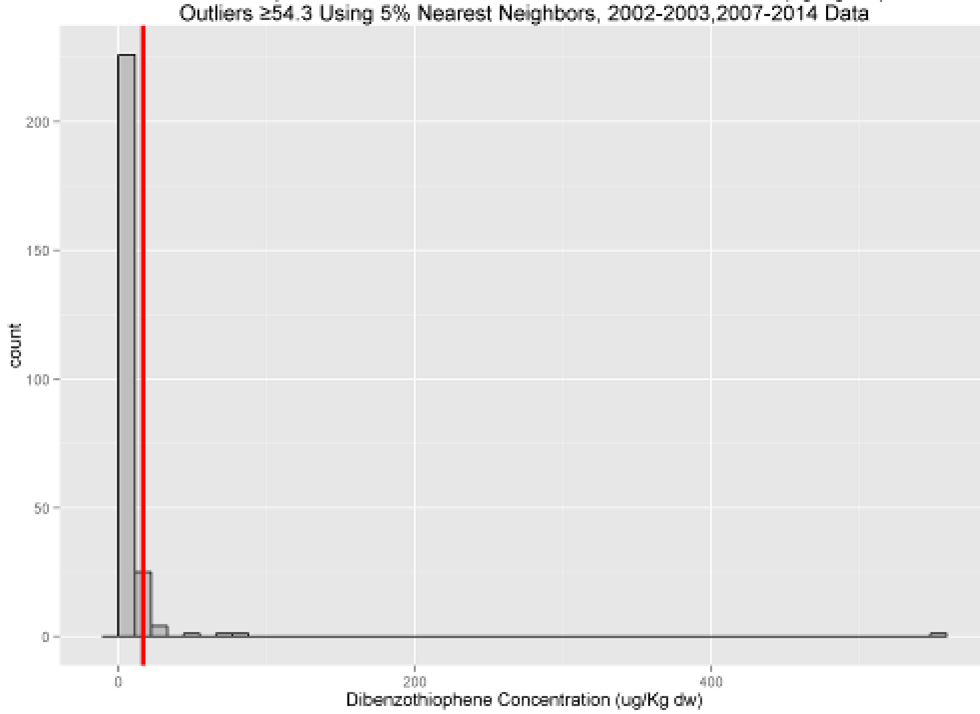

Biphenyl in Sediment, 90th Percentile 90% UTL 11.772 (ug/Kg dw)
Outliers ≥40.9 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
75
50
25
0
0
30
60
90
Biphenyl Concentration (ug/Kg dw)

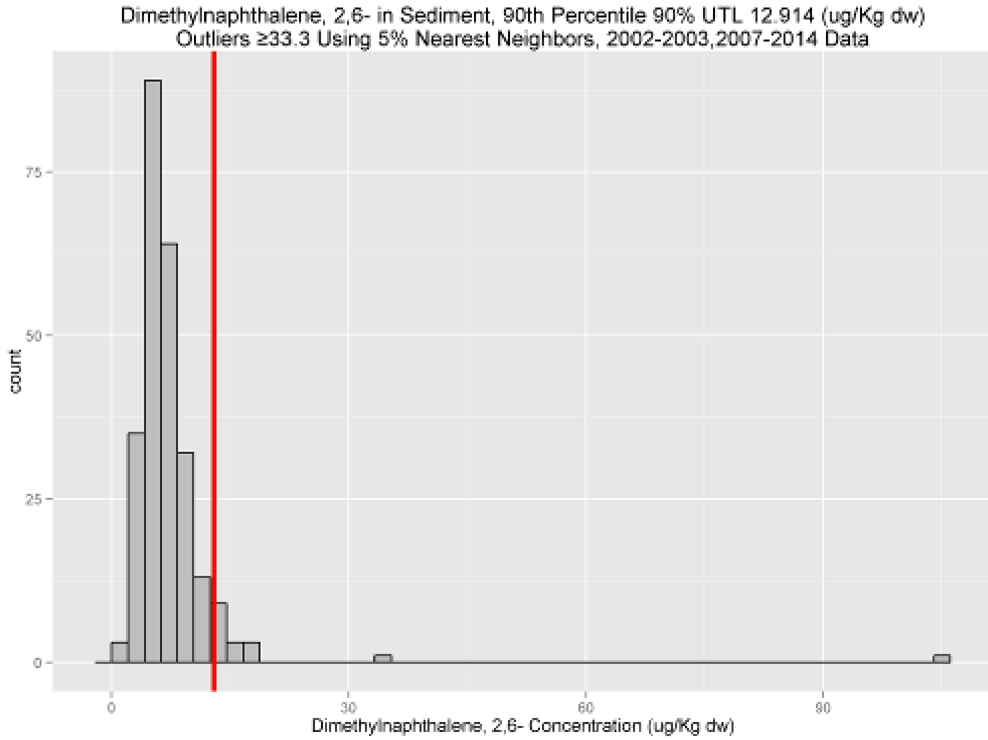

Chrysene in Sediment, 90th Percentile 90% UTL 242.83 (ug/Kg dw)
Outliers ≥1390 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
500
1000
1500
2000
Chrysene Concentration (ug/Kg dw)

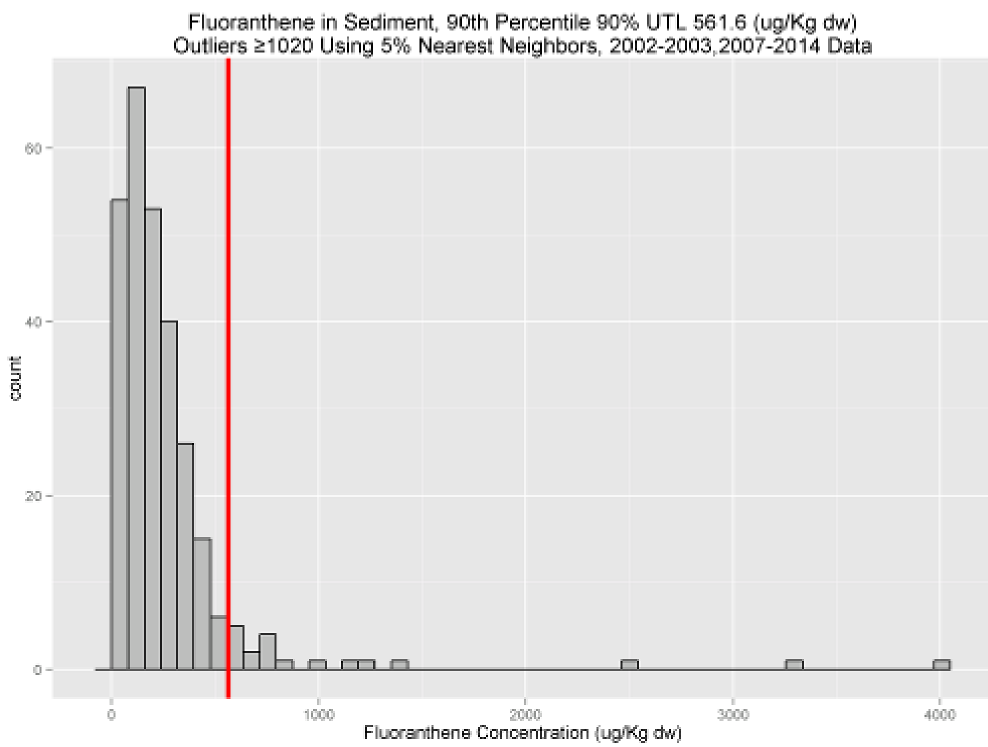
Dibenz(a,h)anthracene in Sediment, 90th Percentile 90% UTL 47.78 (ug/Kg dw)
Outliers ≥268 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

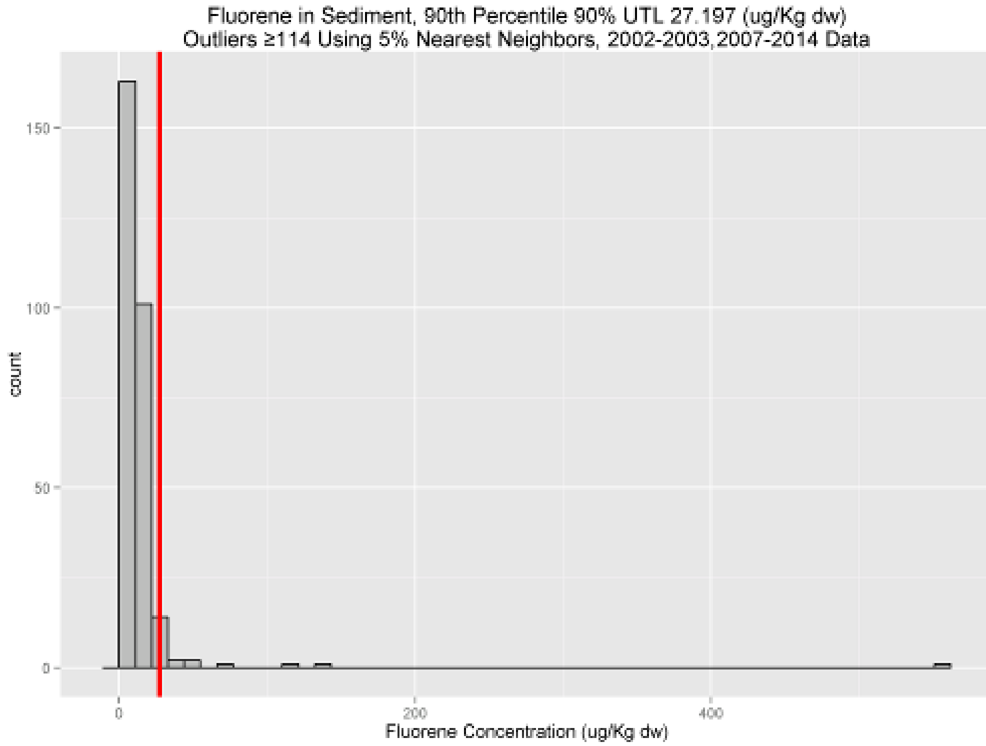


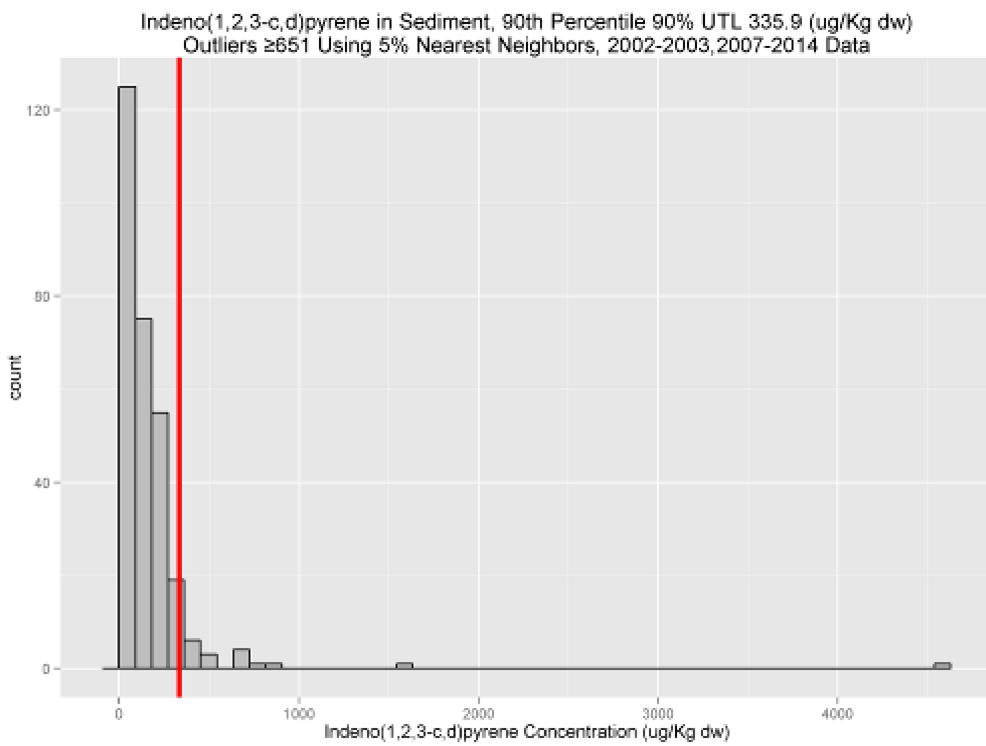
Dibenzothiophene in Sediment, 90th Percentile 90% UTL 16.324 (ug/Kg dw)
Outliers ≥54.3 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

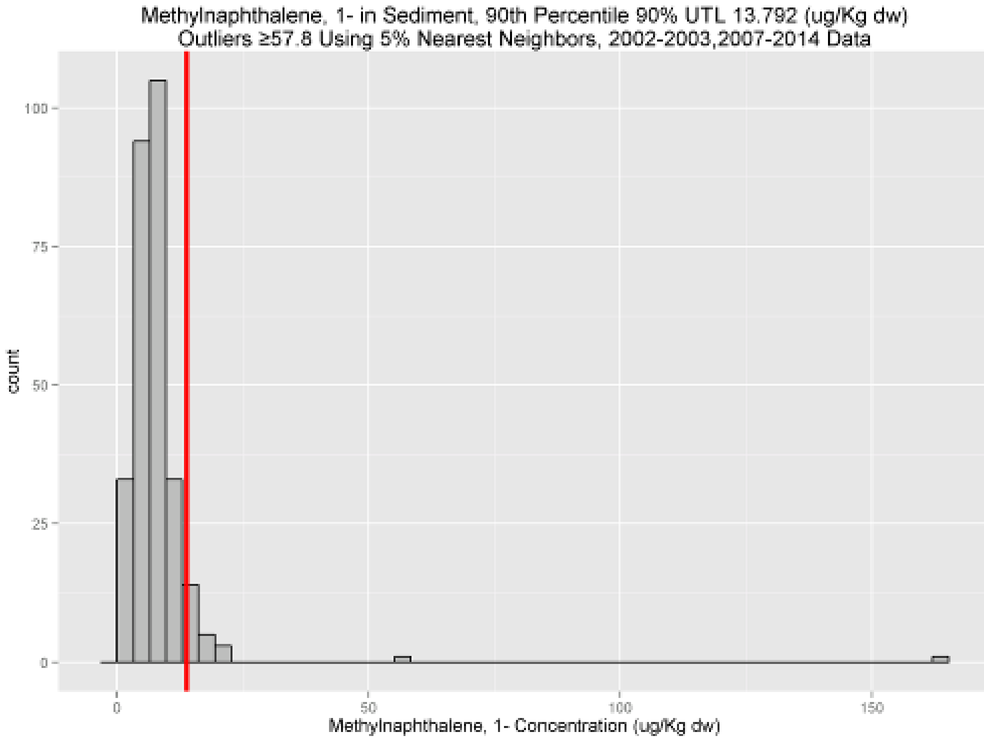


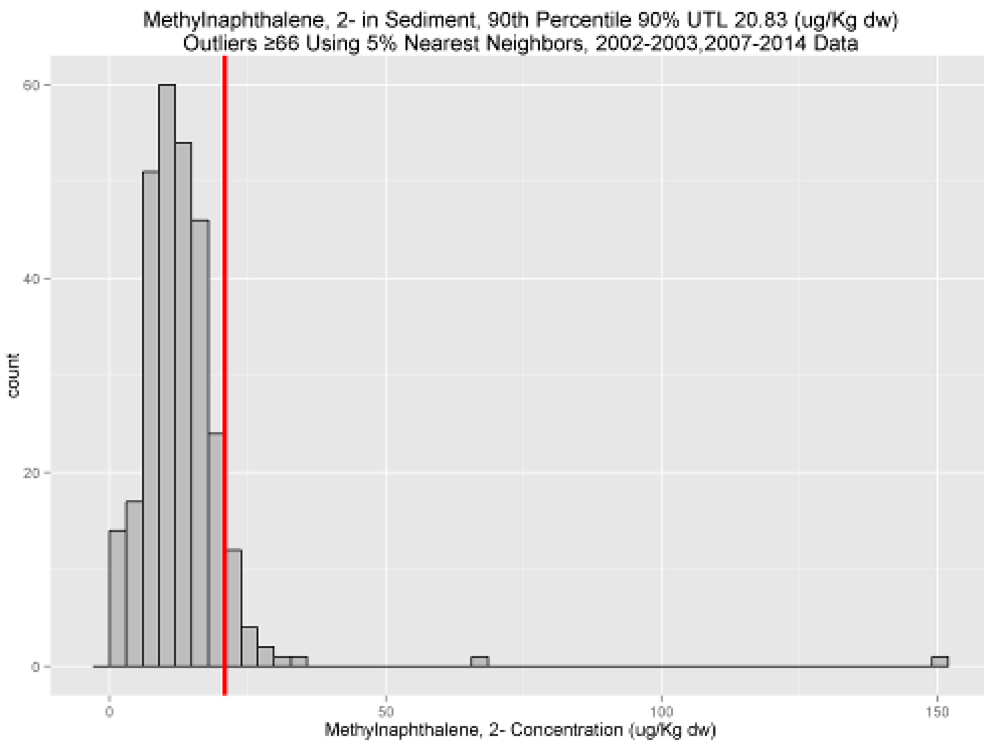

Dimethylnaphthalene, 2,6- in Sediment, 90th Percentile 90% UTL 12.914 (ug/Kg dw)
Outliers ≥33.3 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
75
50
25
0
0
30
60
90
Dimethylnaphthalene, 2,6- Concentration (ug/Kg dw)

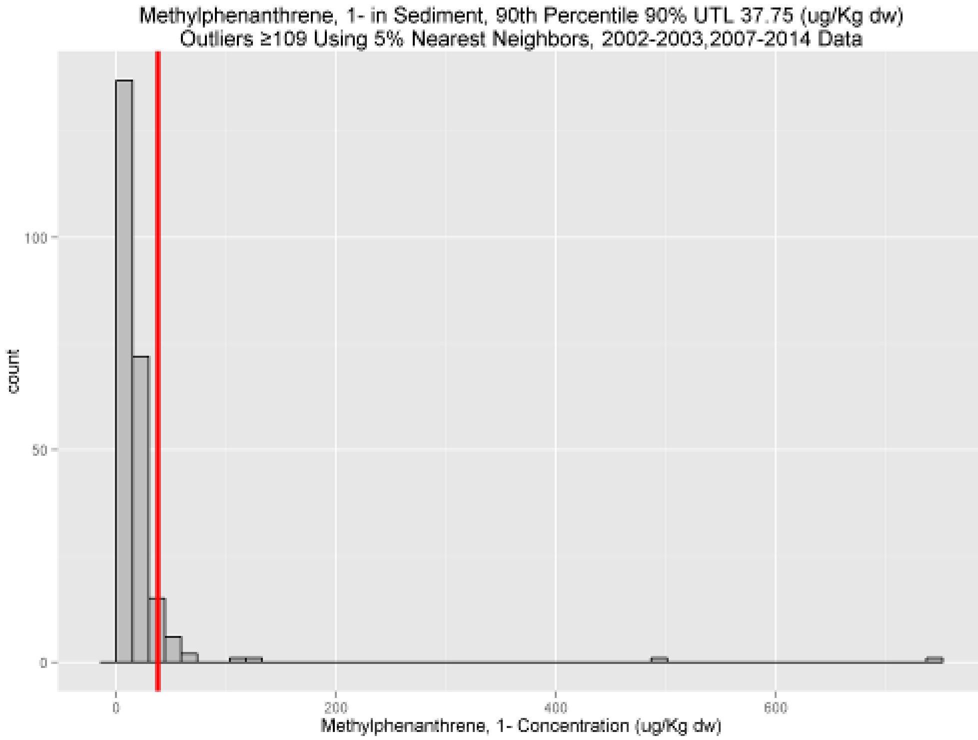

Fluoranthene in Sediment, 90th Percentile 90% UTL 561.6 (ug/Kg dw)
Outliers ≥1020 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
1000
2000
3000
4000
Fluoranthene Concentration (ug/Kg dw)

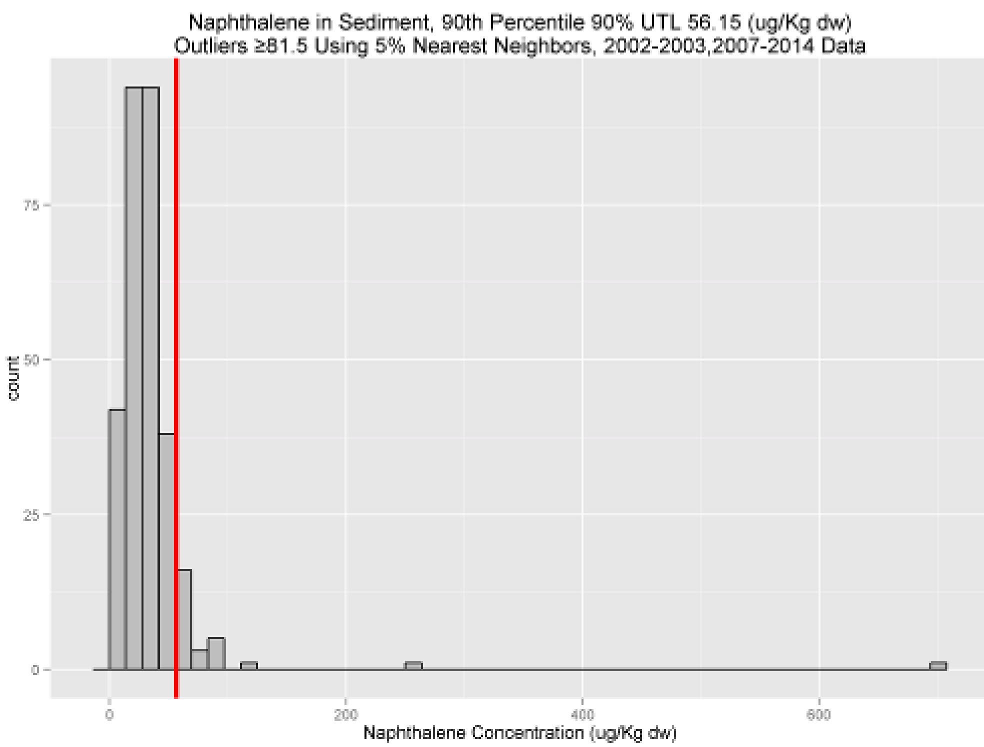

Fluorene in Sediment, 90th Percentile 90% UTL 27.197 (ug/Kg dw)
Outliers ≥114 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
150
100
50
0
0
200
400
Fluorene Concentration (ug/Kg dw)

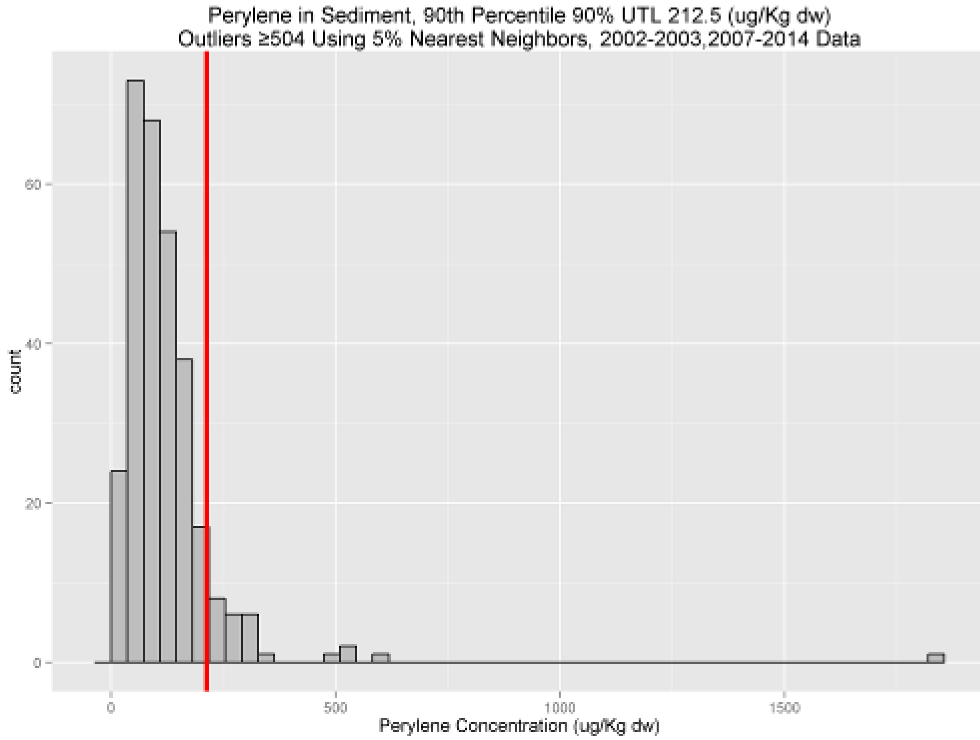

Indeno(1,2,3-c,d)pyrene in Sediment, 90th Percentile 90% UTL 335.9 (ug/Kg dw)
Outliers ≥651 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
120
80
40
0
0
1000
2000
3000
4000
Indeno(1,2,3-c,d)pyrene Concentration (ug/Kg dw)

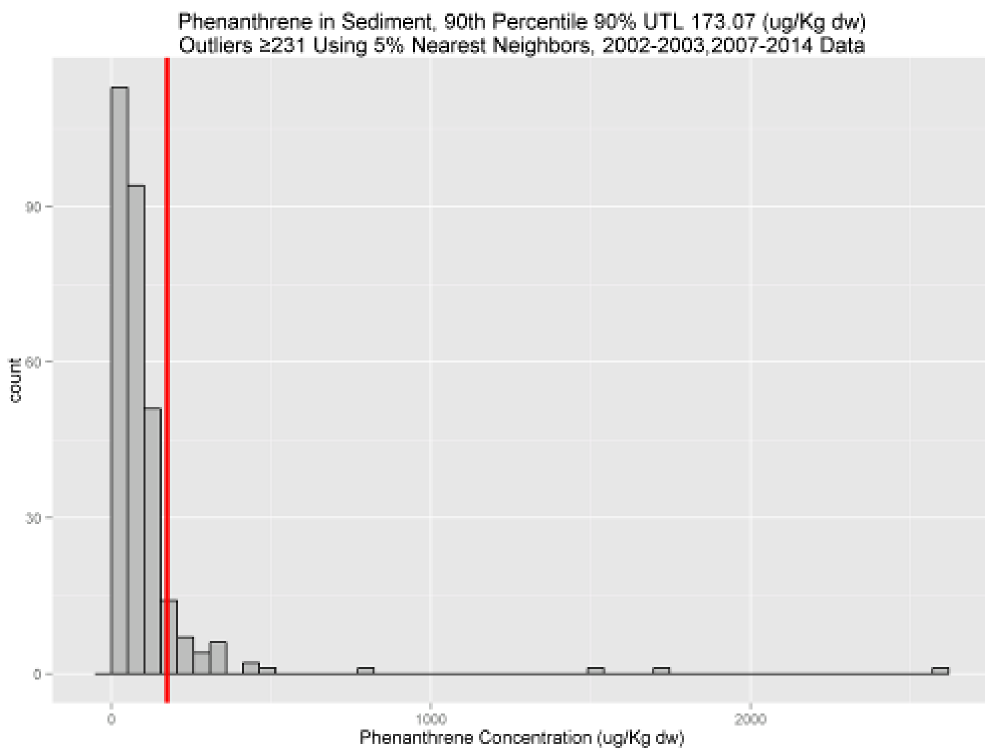

Methylnaphthalene, 1- in Sediment, 90th Percentile 90% UTL 13.792 (ug/Kg dw)
Outliers ≥57.8 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
100
75
50
25
0
0
50
100
150
Methylnaphthalene, 1- Concentration (ug/Kg dw)

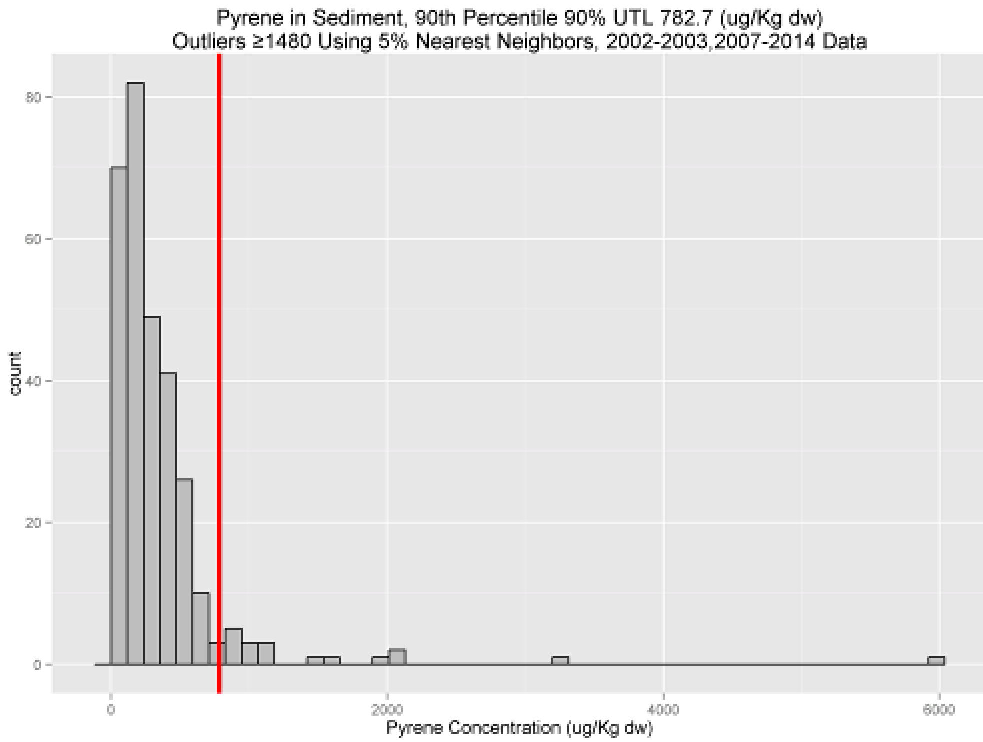

Methylnaphthalene, 2- in Sediment, 90th Percentile 90% UTL 20.83 (ug/Kg dw)
Outliers ≥66 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
50
100
150
Methylnaphthalene, 2- Concentration (ug/Kg dw)


Methylphenanthrene, 1- in Sediment, 90th Percentile 90% UTL 37.75 (ug/Kg dw)
Outliers ≥109 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
100
50
0
0
200
400
600
Methylphenanthrene, 1- Concentration (ug/Kg dw)

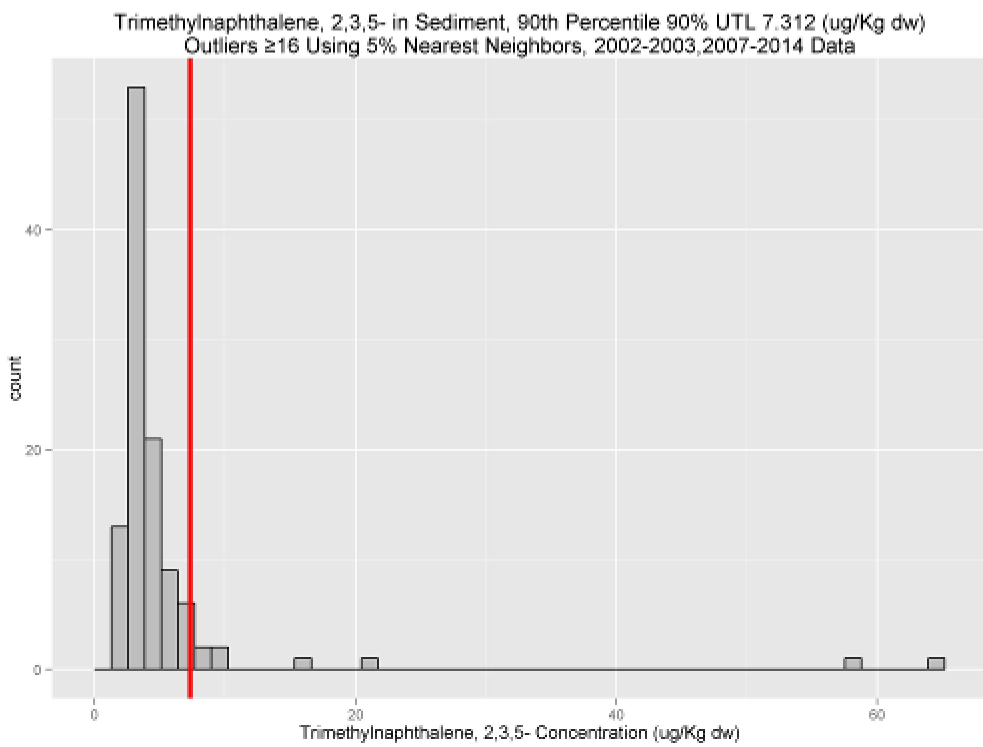

Naphthalene in Sediment, 90th Percentile 90% UTL 56.15 (ug/Kg dw)
Outliers ≥81.5 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
75
50
25
0
0
200
400
600
Naphthalene Concentration (ug/Kg dw)


Perylene in Sediment, 90th Percentile 90% UTL 212.5 (ug/Kg dw)
Outliers ≥504 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
60
40
20
0
0
500
1000
1500
Perylene Concentration (ug/Kg dw)


Phenanthrene in Sediment, 90th Percentile 90% UTL 173.07 (ug/Kg dw)
Outliers ≥231 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
90
60
30
0
0
1000
2000
Phenanthrene Concentration (ug/Kg dw)

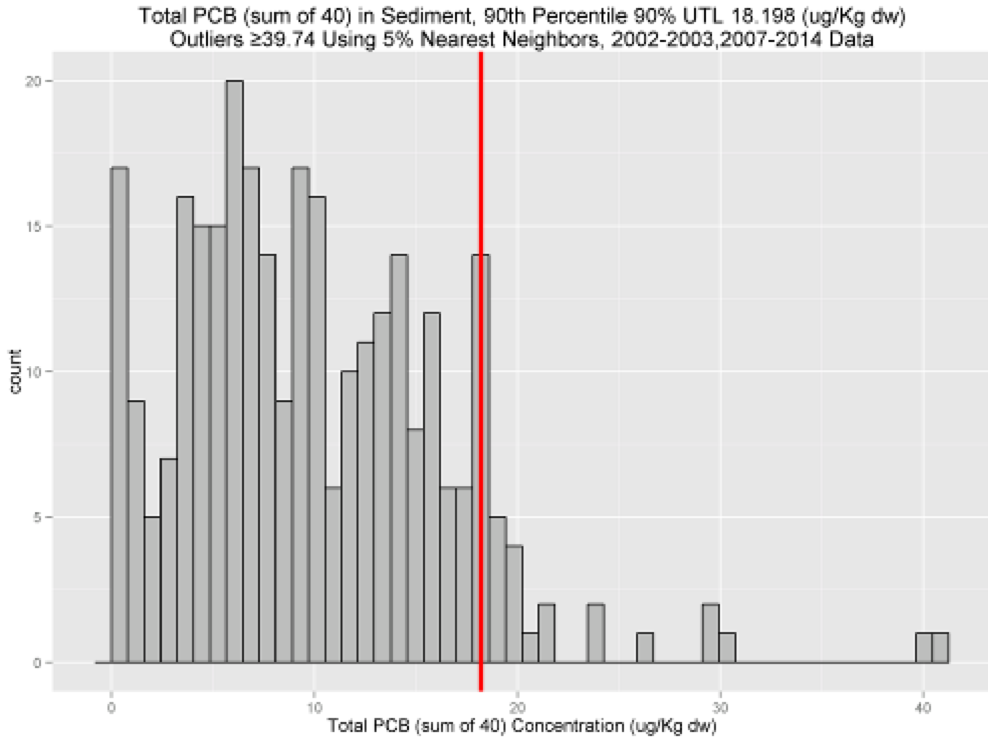


Pyrene in Sediment, 90th Percentile 90% UTL 782.7 (ug/Kg dw)
Outliers ≥1480 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
80
60
40
20
0
0
2000
4000
6000
Pyrene Concentration (ug/Kg dw)

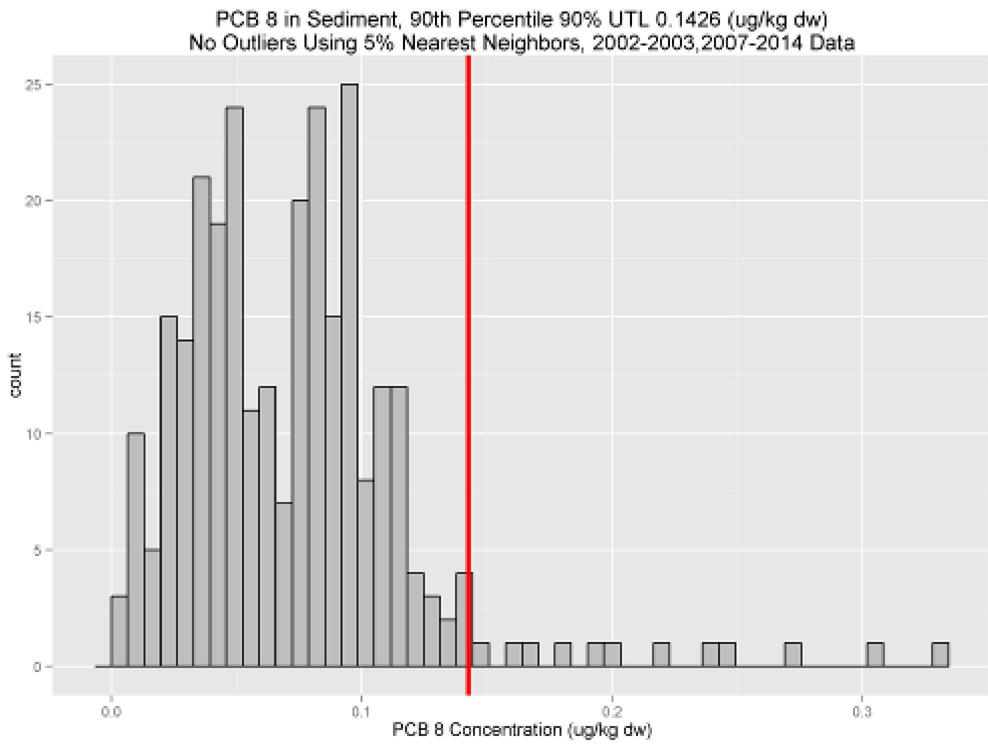


Trimethylnaphthalene, 2,3,5- in Sediment, 90th Percentile 90% UTL 7.312 (ug/Kg dw)
Outliers ≥16 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
40
20
0
0
20
40
60
Trimethylnaphthalene, 2,3,5- Concentration (ug/Kg dw)

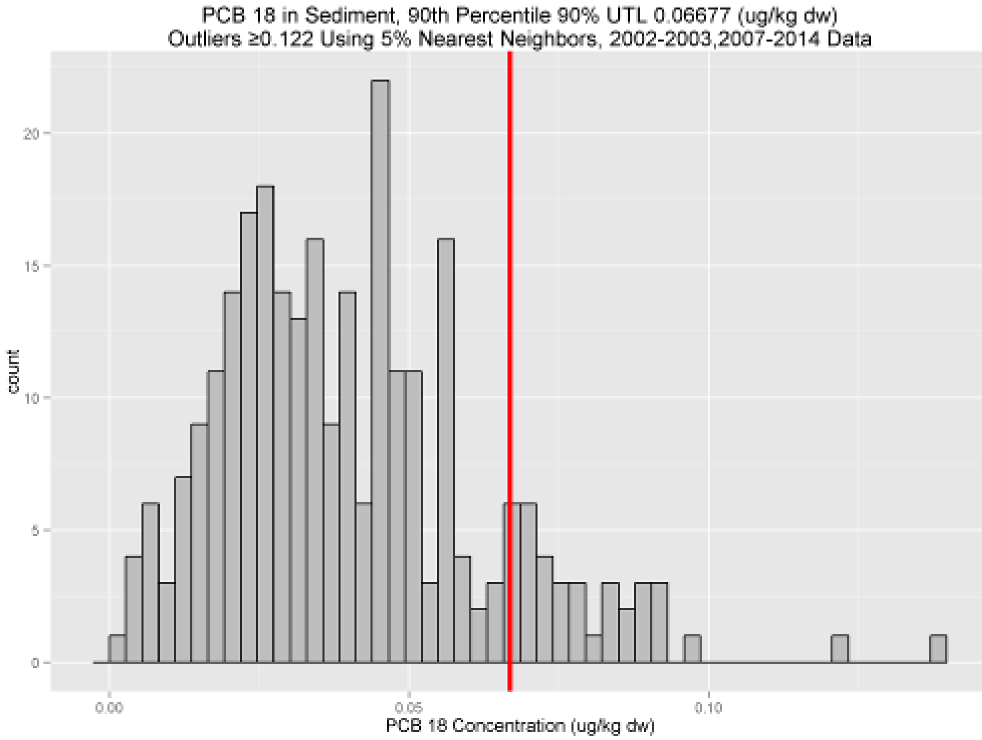
PCBs

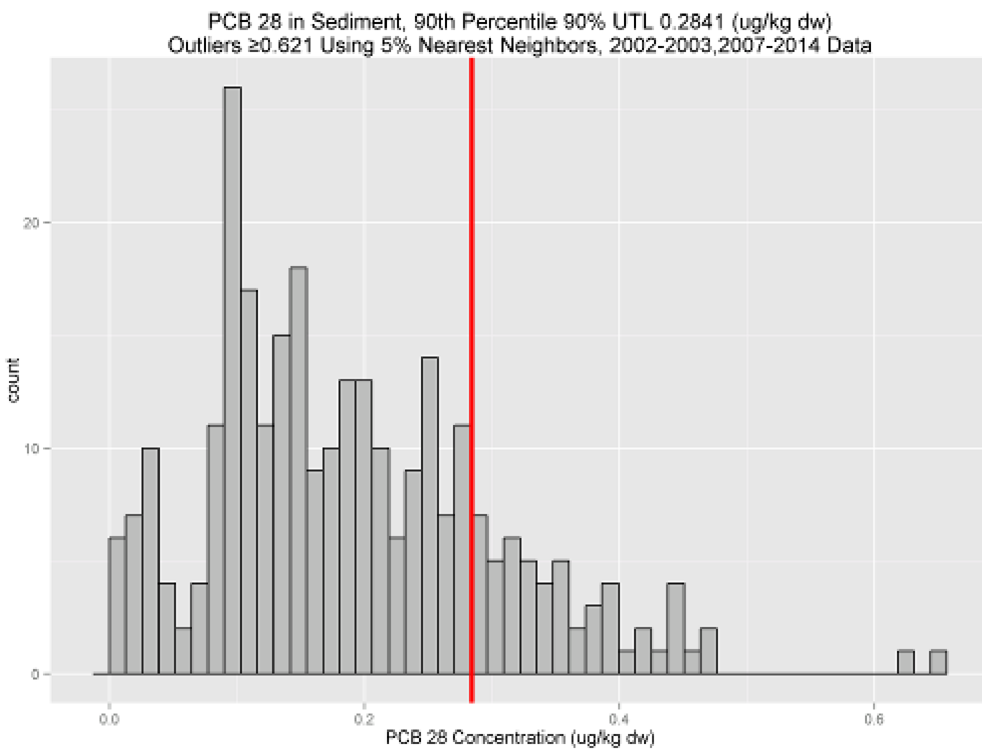


Total PCB (sum of 40) in Sediment, 90th Percentile 90% UTL 18.198 (ug/Kg dw)
Outliers ≥39.74 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
Total PCB (sum of 40) Concentration (ug/Kg dw)

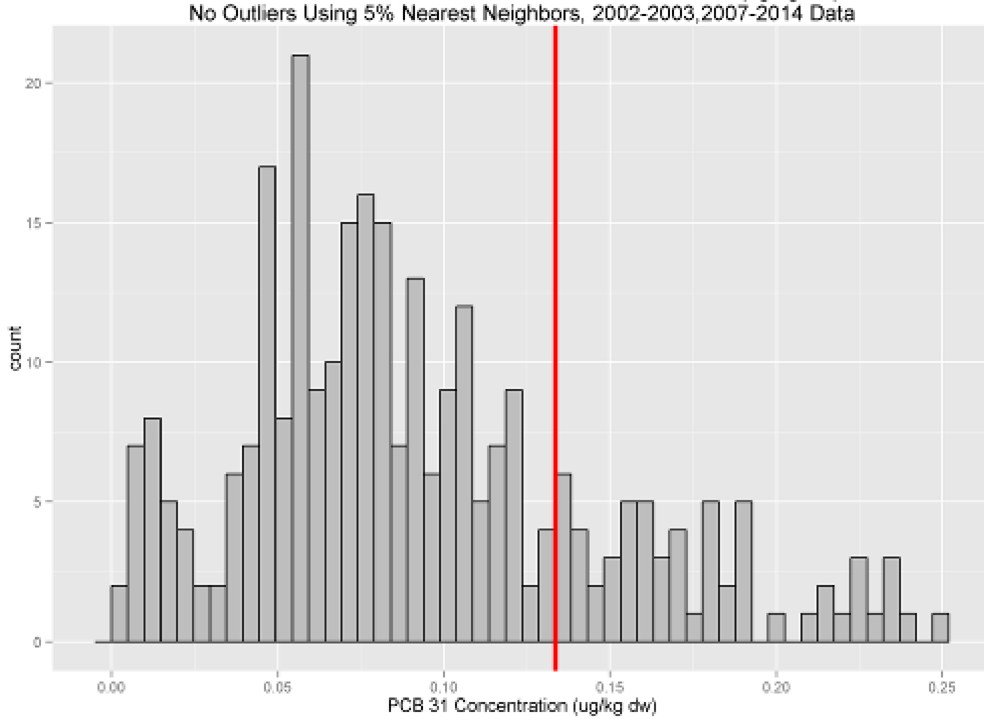


PCB 8 in Sediment, 90th Percentile 90% UTL 0.1426 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 8 Concentration (ug/kg dw)

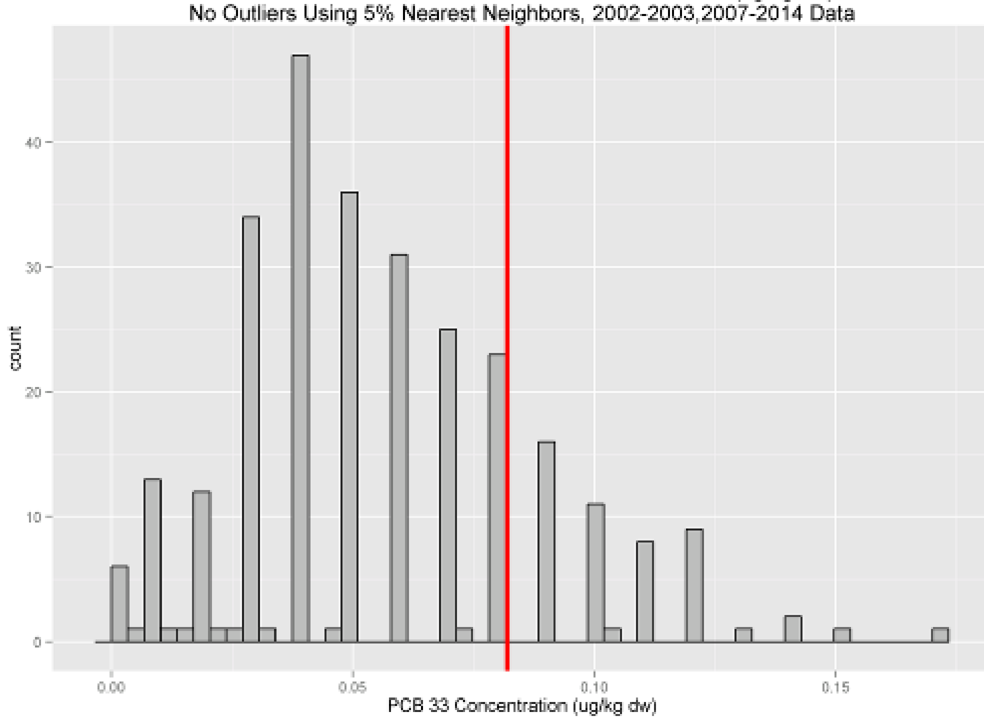

PCB 18 in Sediment, 90th Percentile 90% UTL 0.06677 (ug/kg dw)
Outliers ≥0.122 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 18 Concentration (ug/kg dw)


PCB 28 in Sediment, 90th Percentile 90% UTL 0.2841 (ug/kg dw)
Outliers ≥0.621 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 28 Concentration (ug/kg dw)

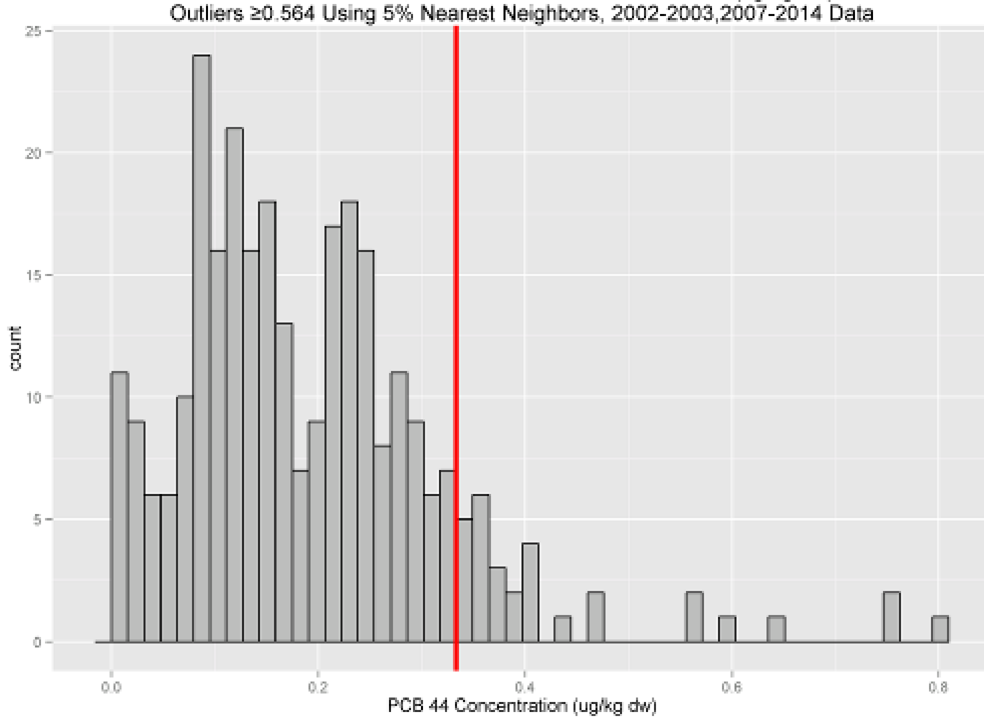
PCB 31 in Sediment, 90th Percentile 90% UTL 0.13352 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



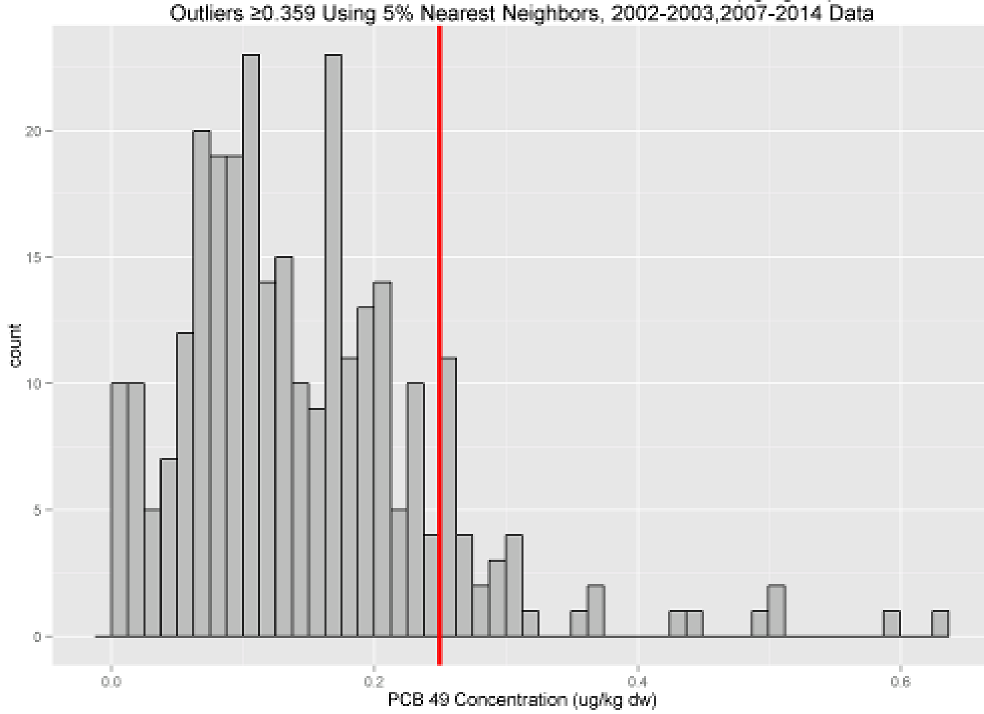
PCB 33 in Sediment, 90th Percentile 90% UTL 0.0819 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



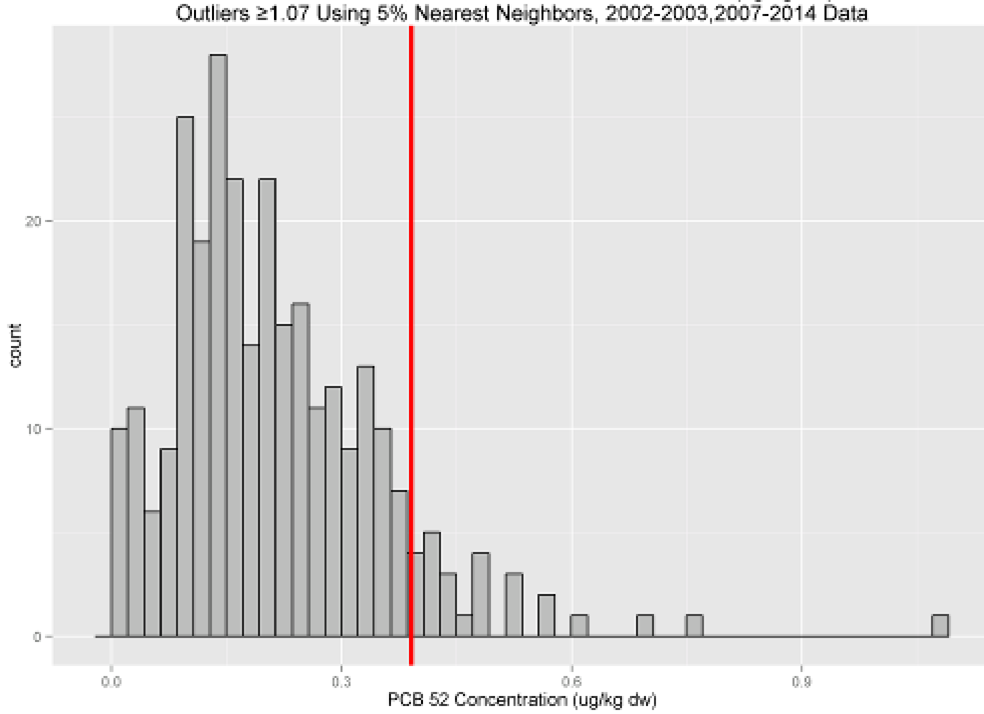
PCB 44 in Sediment, 90th Percentile 90% UTL 0.3331 (ug/kg dw)
Outliers ≥0.564 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



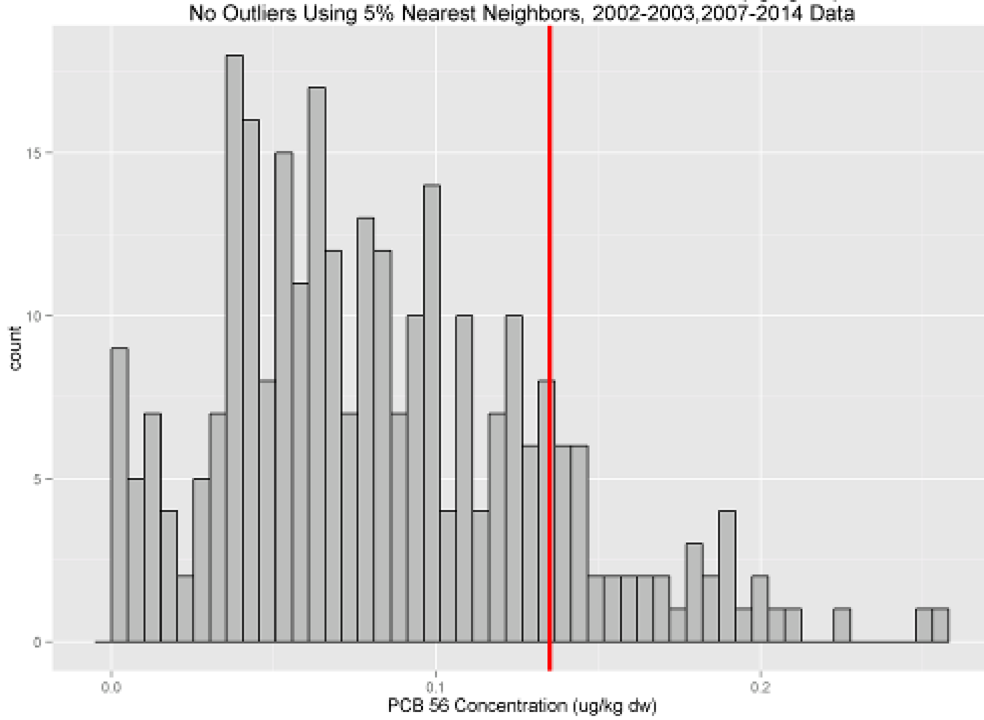
PCB 49 in Sediment, 90th Percentile 90% UTL 0.2492 (ug/kg dw)
Outliers ≥0.359 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

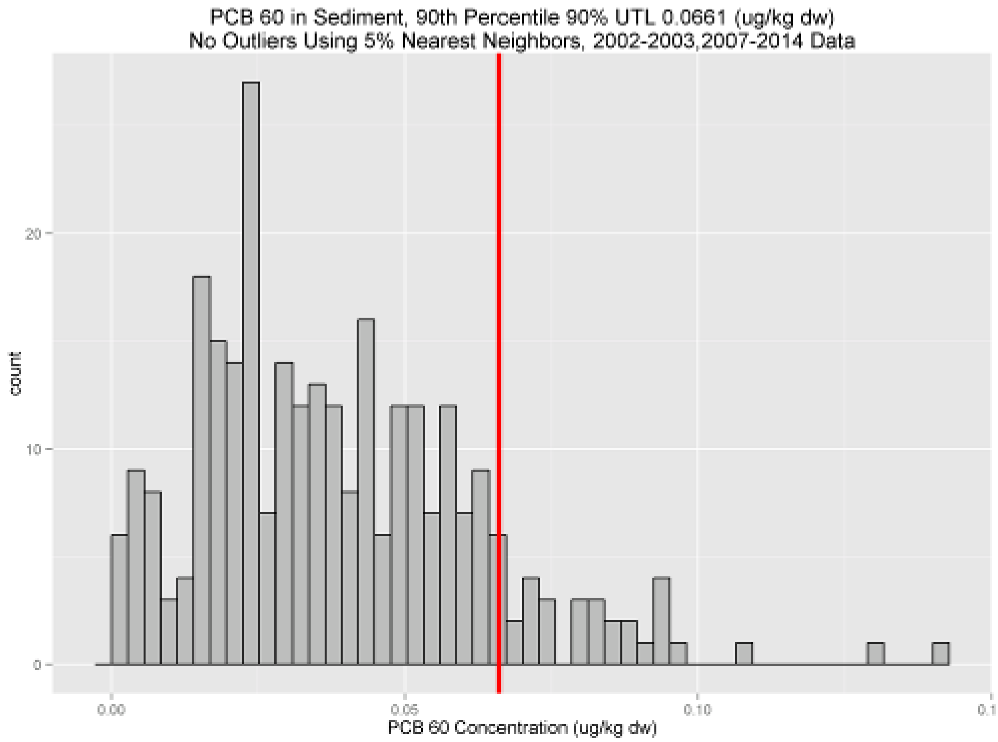


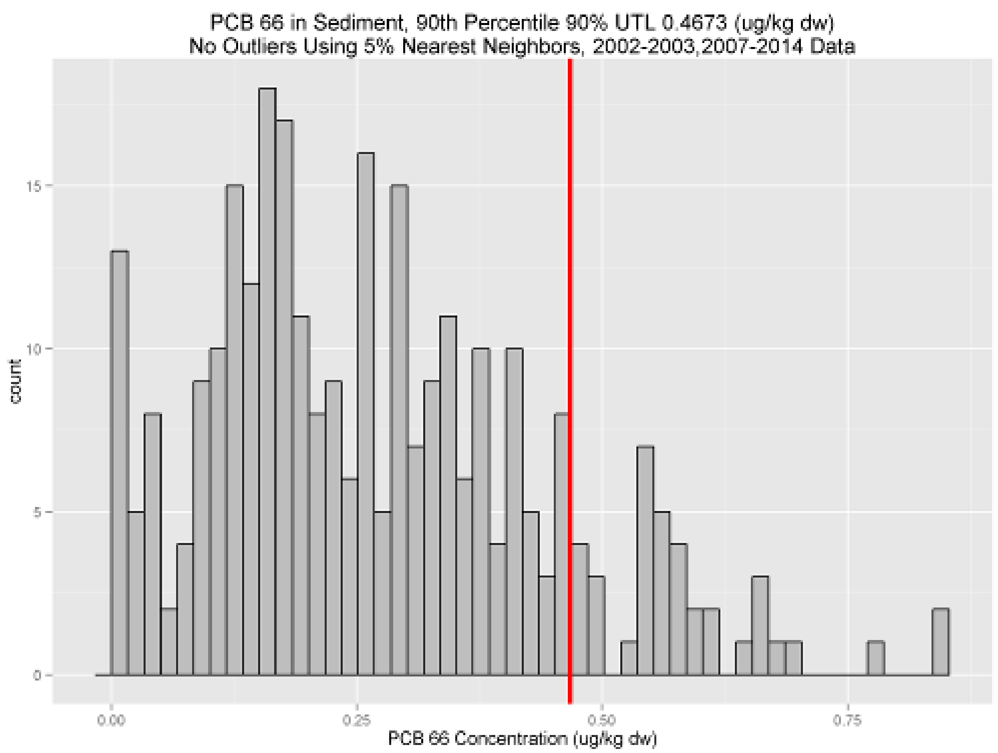
PCB 52 in Sediment, 90th Percentile 90% UTL 0.3904 (ug/kg dw)
Outliers ≥1.07 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

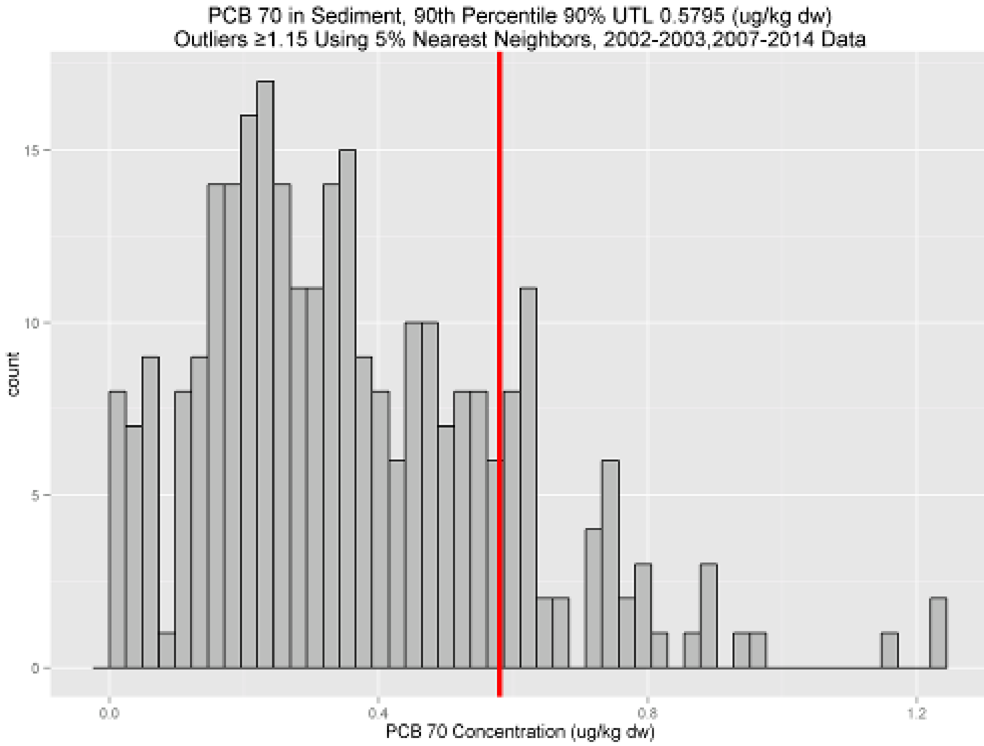


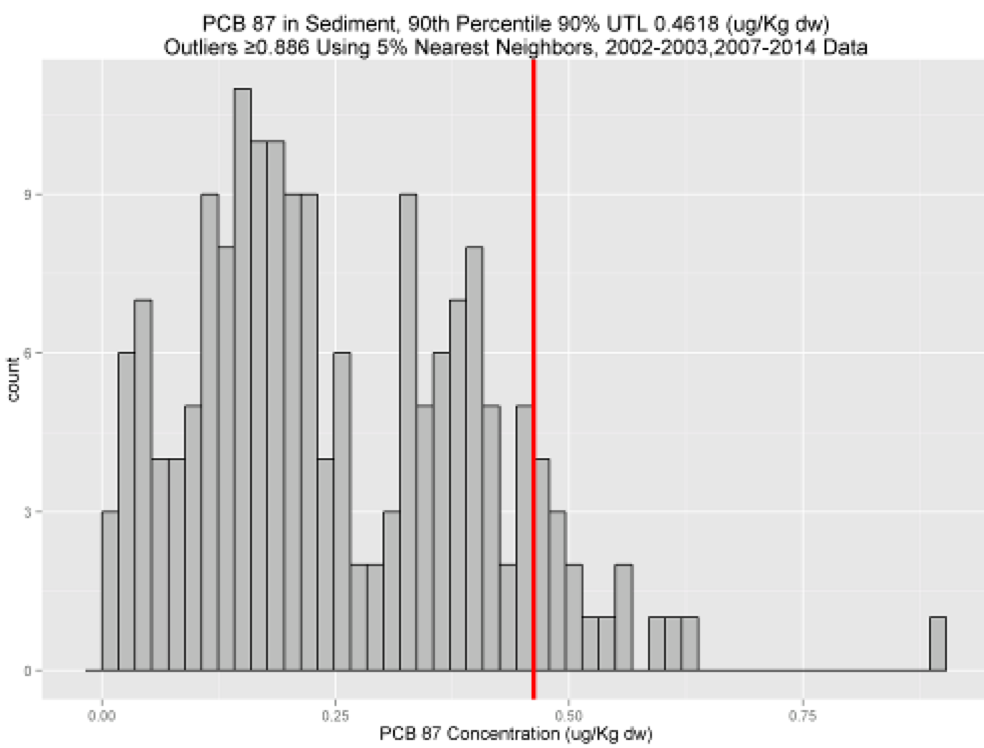
PCB 56 in Sediment, 90th Percentile 90% UTL 0.13496 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



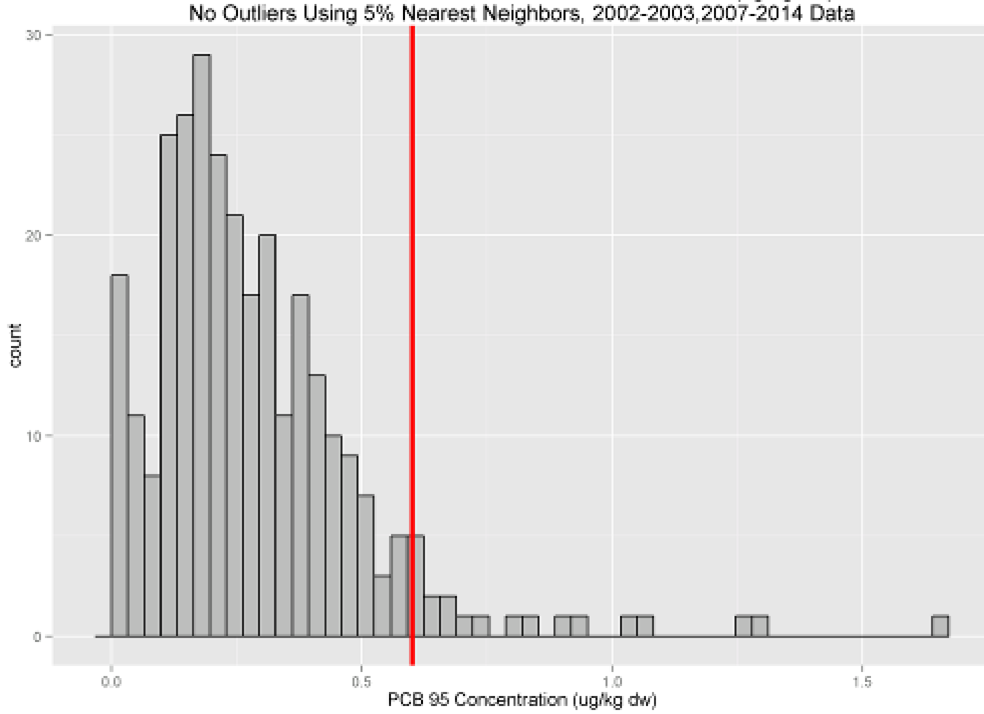

PCB 60 in Sediment, 90th Percentile 90% UTL 0.0661 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 60 Concentration (ug/kg dw)


PCB 66 in Sediment, 90th Percentile 90% UTL 0.4673 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 66 Concentration (ug/kg dw)

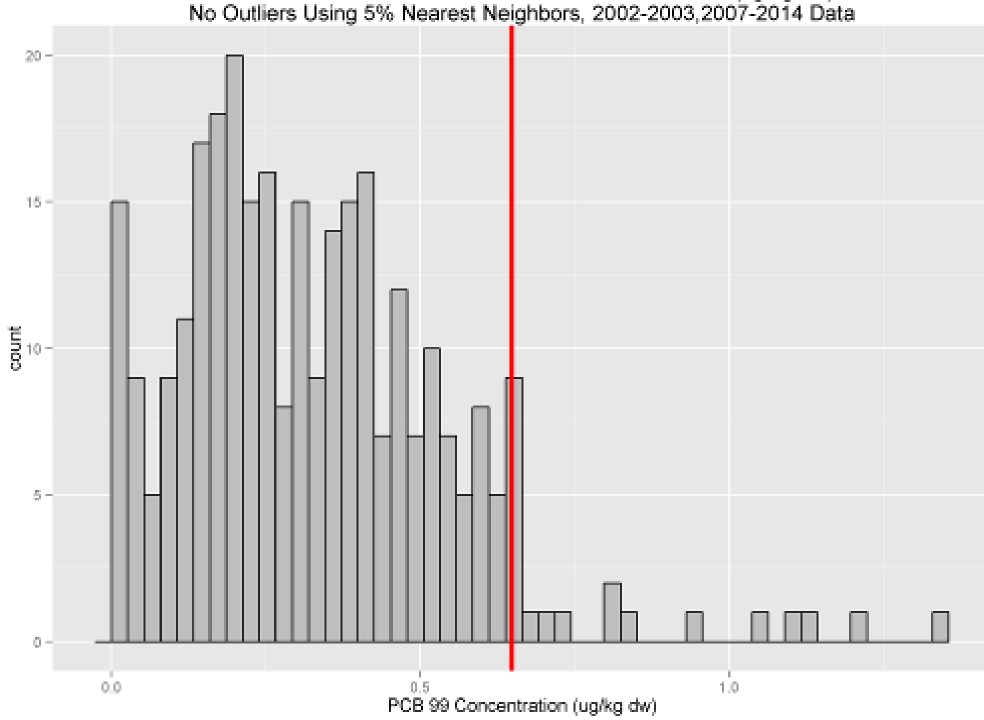

PCB 70 in Sediment, 90th Percentile 90% UTL 0.5795 (ug/kg dw)
Outliers ≥1.15 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
5
10
15
0.0
0.4
0.8
1.2
PCB 70 Concentration (ug/kg dw)

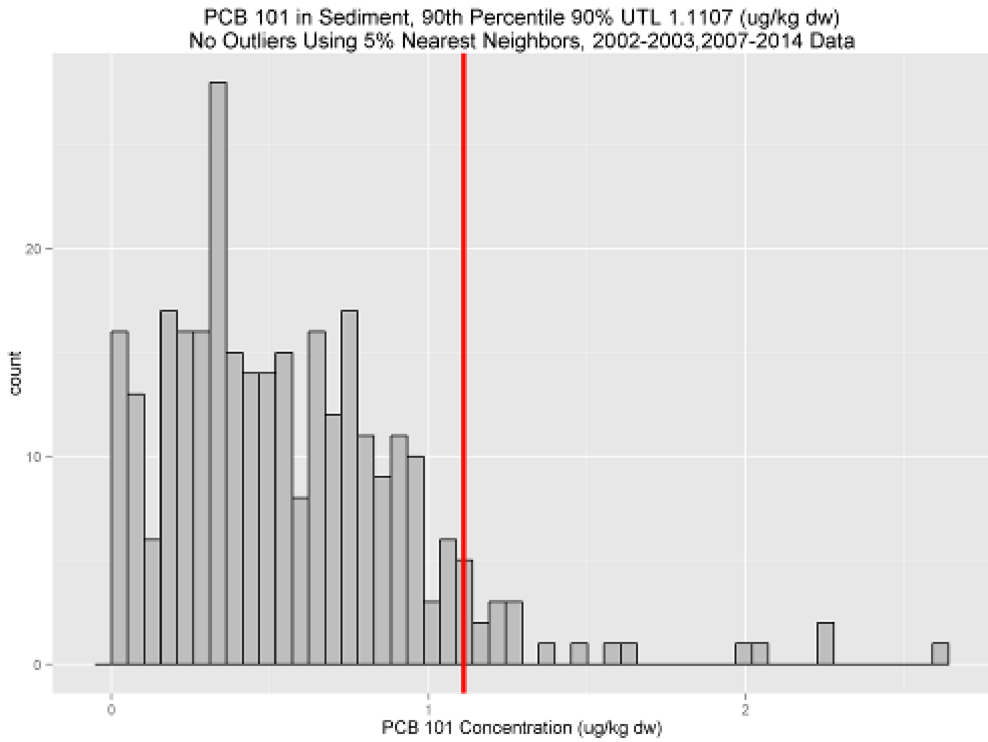

PCB 87 in Sediment, 90th Percentile 90% UTL 0.4618 (ug/Kg dw)
Outliers ≥0.886 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
3
6
9
0.00
0.25
0.50
0.75
PCB 87 Concentration (ug/Kg dw)

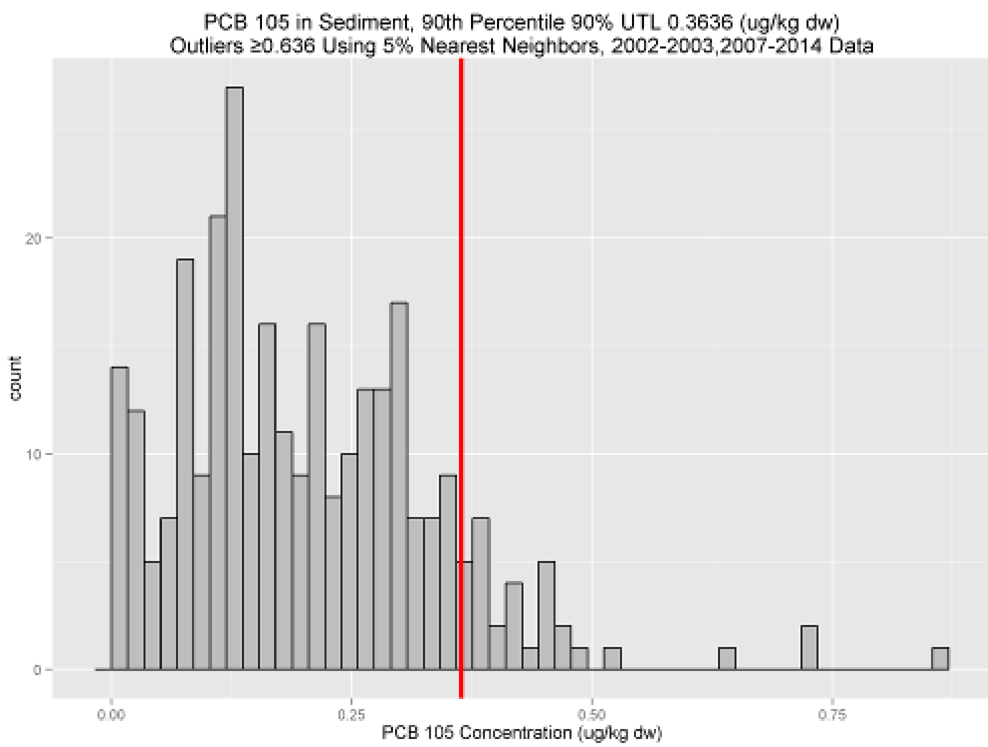
PCB 95 in Sediment, 90th Percentile 90% UTL 0.6001 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



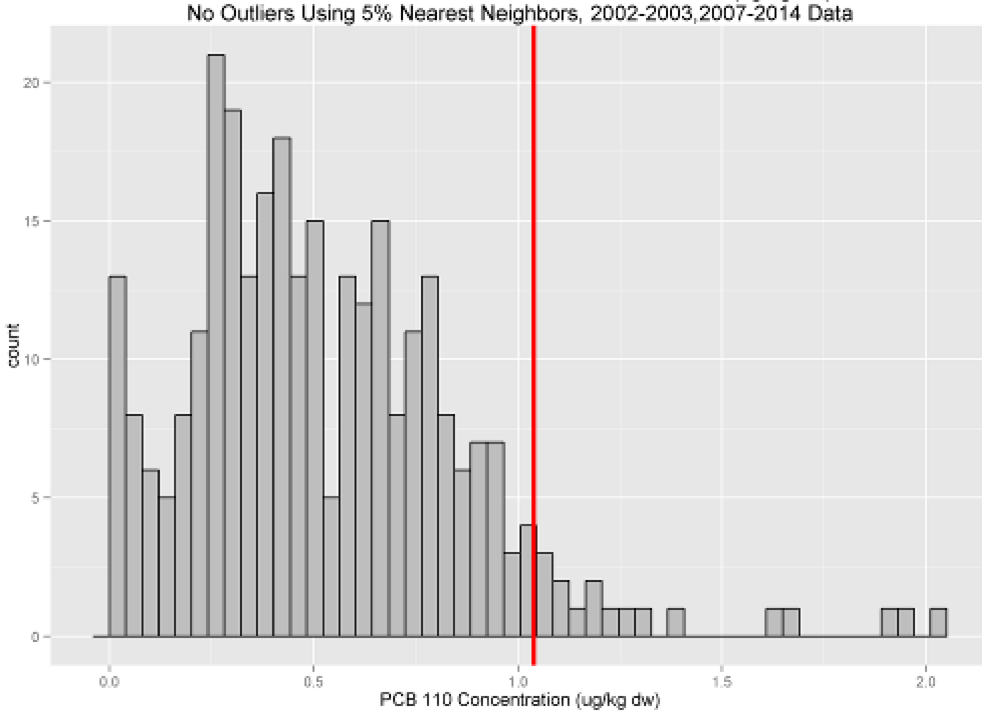
PCB 99 in Sediment, 90th Percentile 90% UTL 0.6477 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



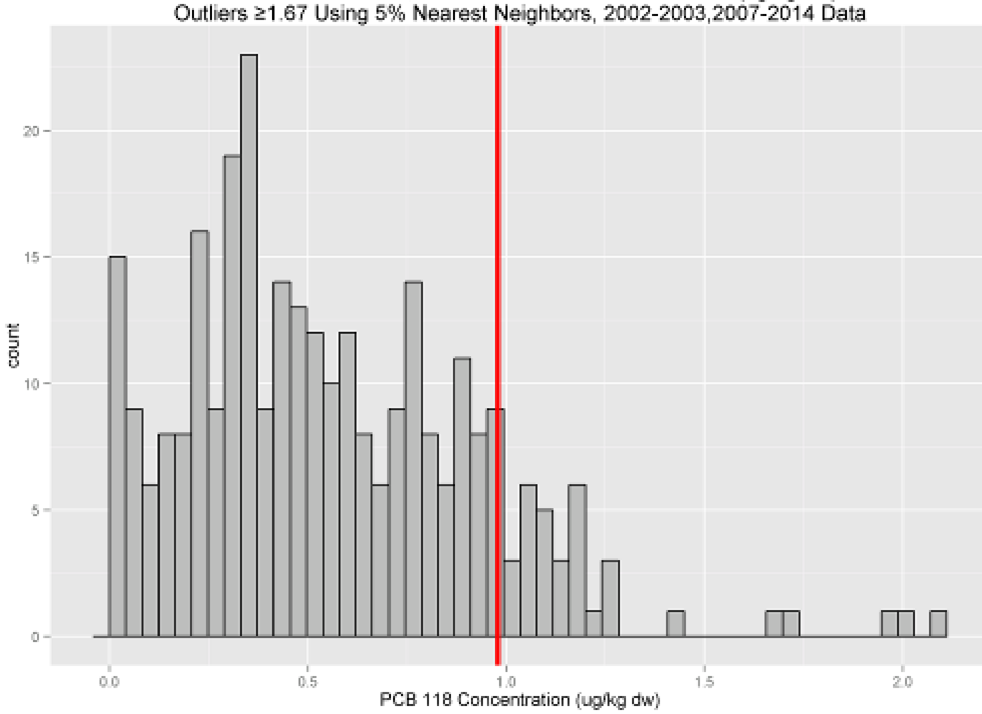

PCB 101 in Sediment, 90th Percentile 90% UTL 1.1107 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 101 Concentration (ug/kg dw)

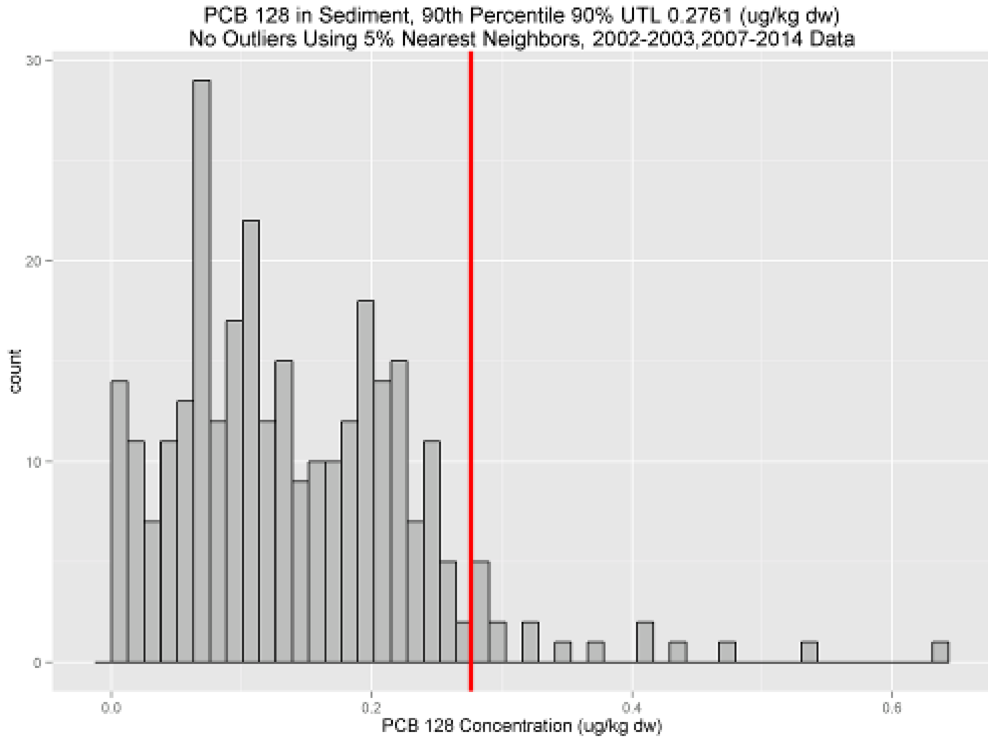

PCB 105 in Sediment, 90th Percentile 90% UTL 0.3636 (ug/kg dw)
Outliers ≥0.636 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 105 Concentration (ug/kg dw)

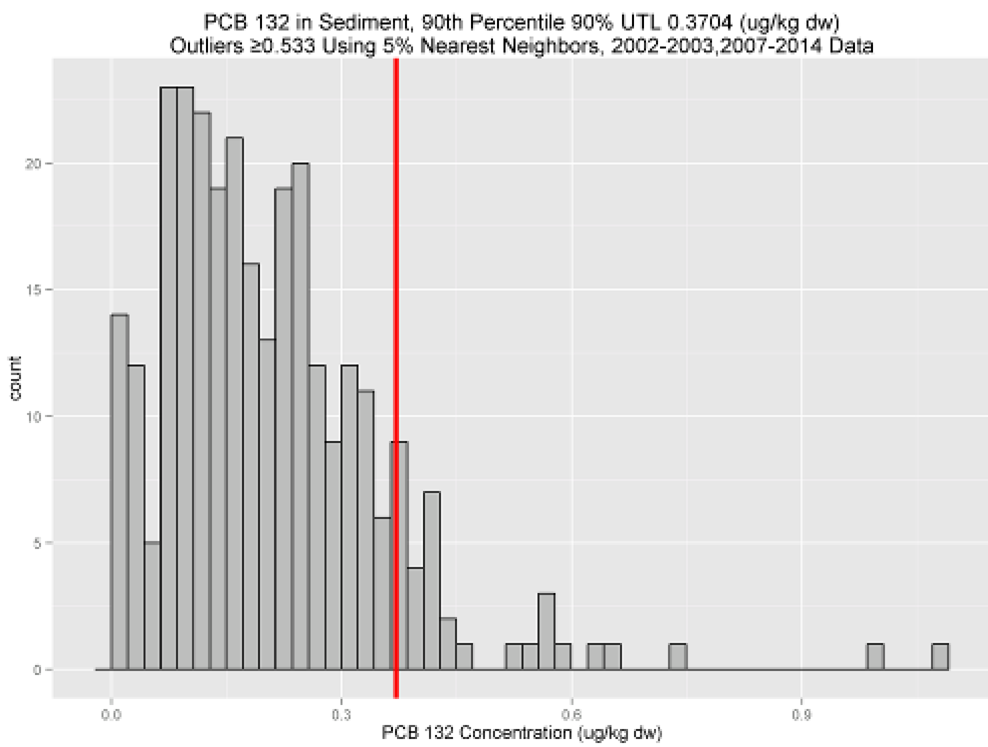
PCB 110 in Sediment, 90th Percentile 90% UTL 1.038 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

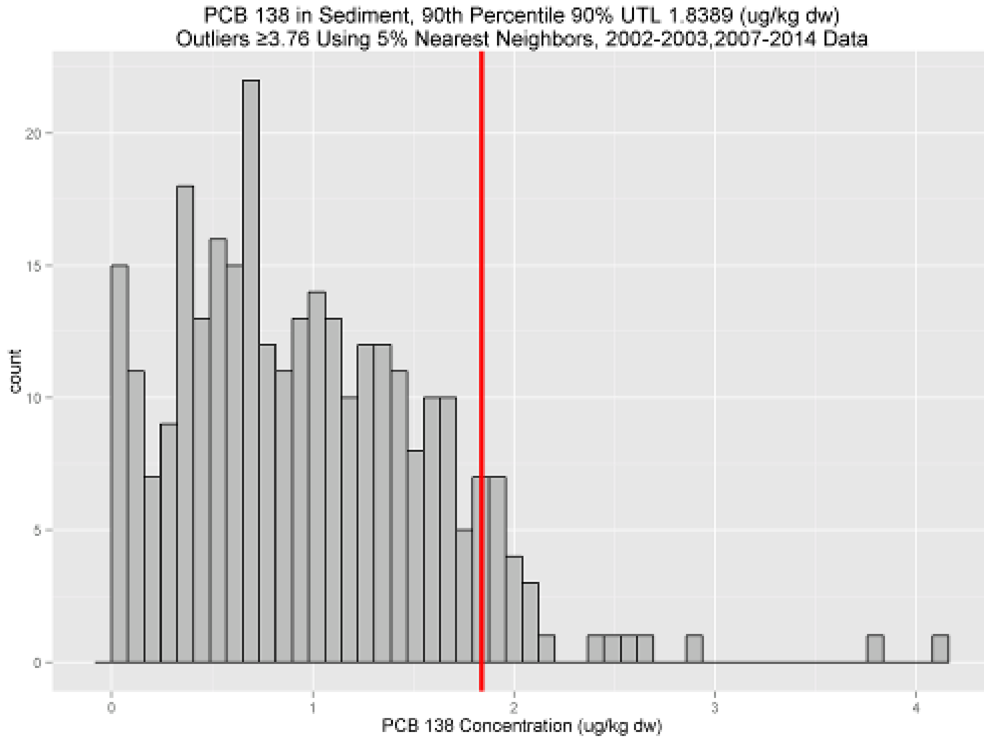


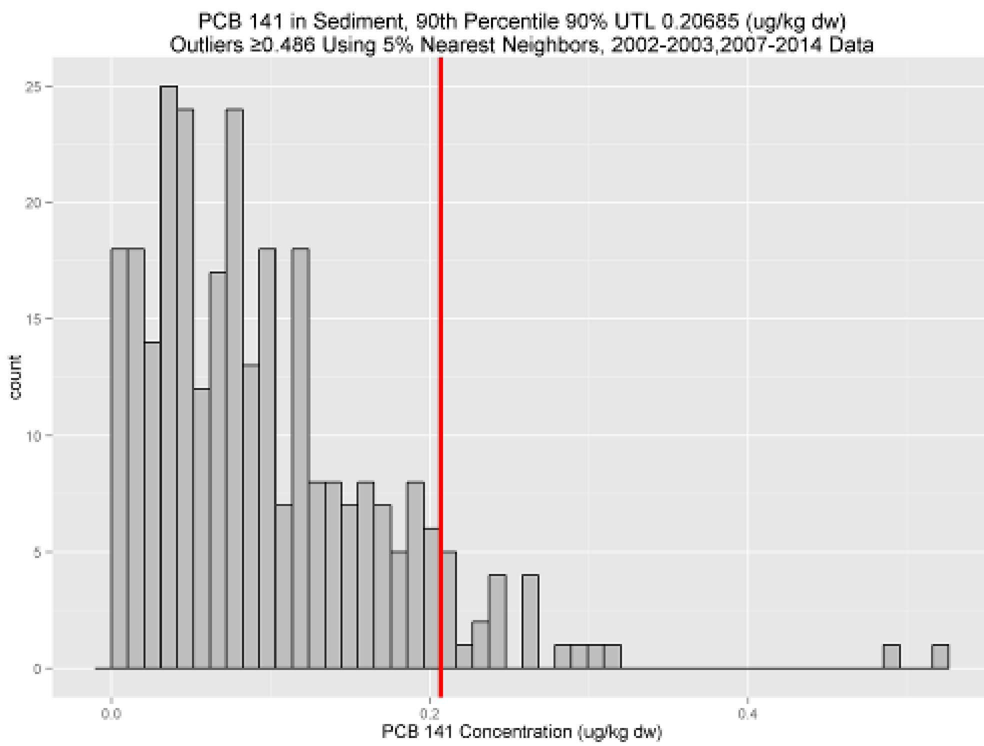
PCB 118 in Sediment, 90th Percentile 90% UTL 0.9785 (ug/kg dw)
Outliers ≥1.67 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data



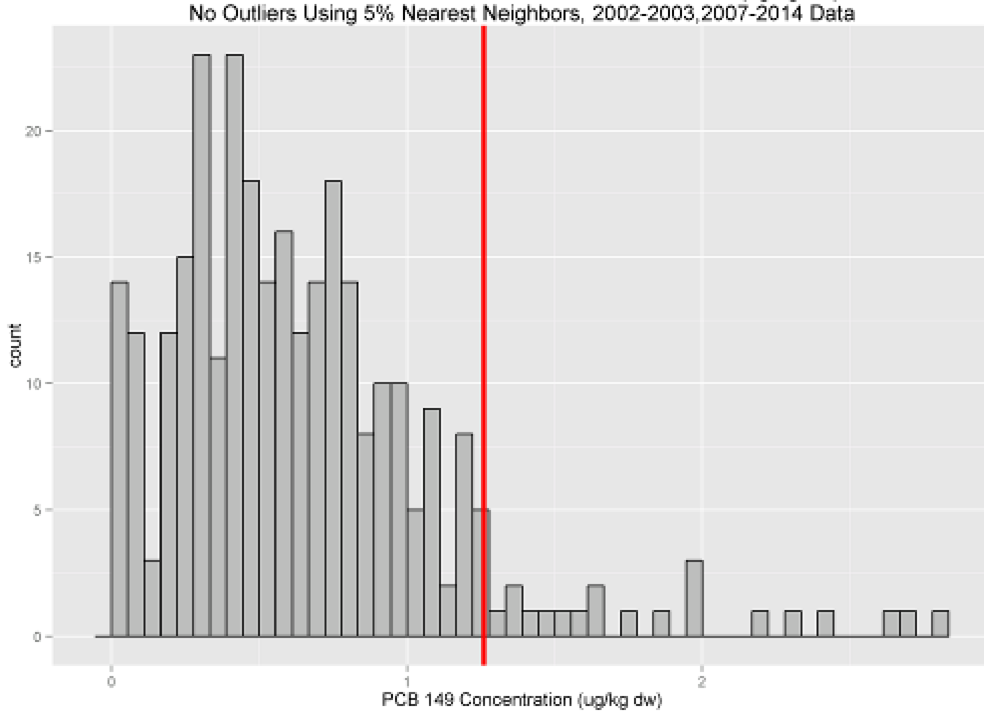

PCB 128 in Sediment, 90th Percentile 90% UTL 0.2761 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
10
20
30
0.0
0.2
0.4
0.6
PCB 128 Concentration (ug/kg dw)


PCB 132 in Sediment, 90th Percentile 90% UTL 0.3704 (ug/kg dw)
Outliers ≥0.533 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
5
10
15
20
0.0
0.3
0.6
0.9
PCB 132 Concentration (ug/kg dw)

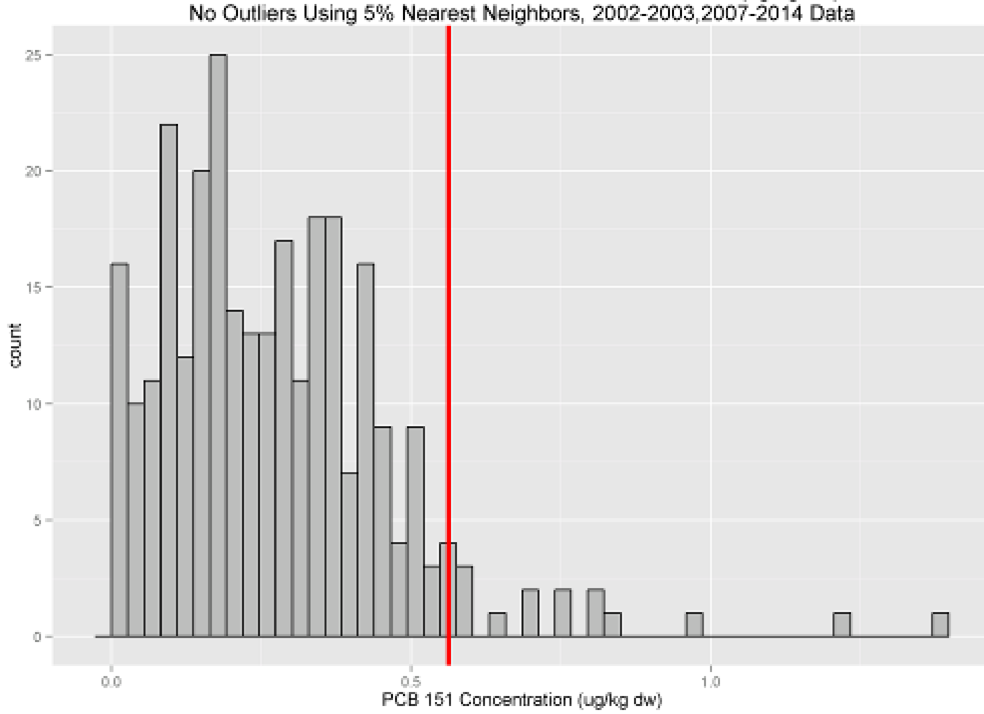

PCB 138 in Sediment, 90th Percentile 90% UTL 1.8389 (ug/kg dw)
Outliers ≥3.76 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 138 Concentration (ug/kg dw)

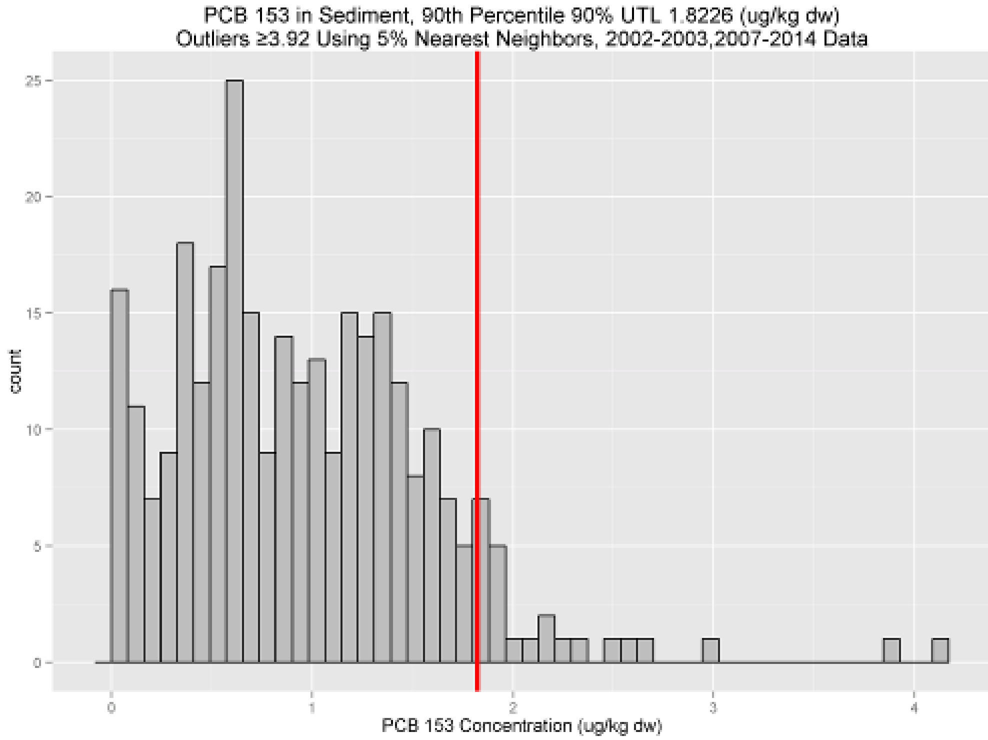

PCB 141 in Sediment, 90th Percentile 90% UTL 0.20685 (ug/kg dw)
Outliers ≥0.486 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 141 Concentration (ug/kg dw)

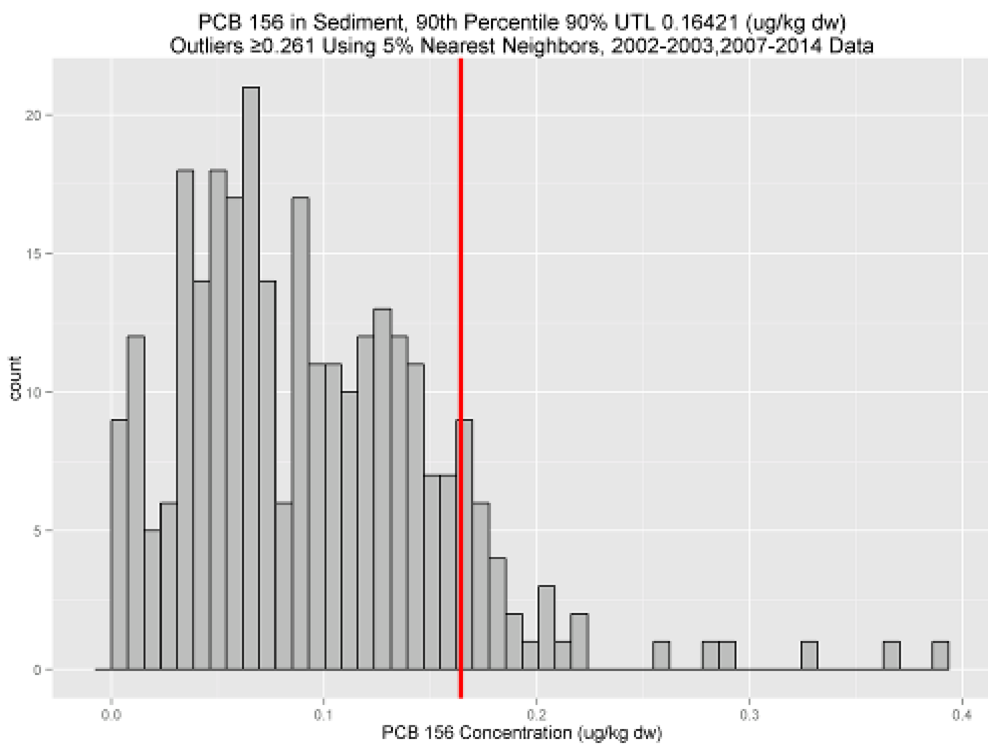
PCB 149 in Sediment, 90th Percentile 90% UTL 1.2611 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

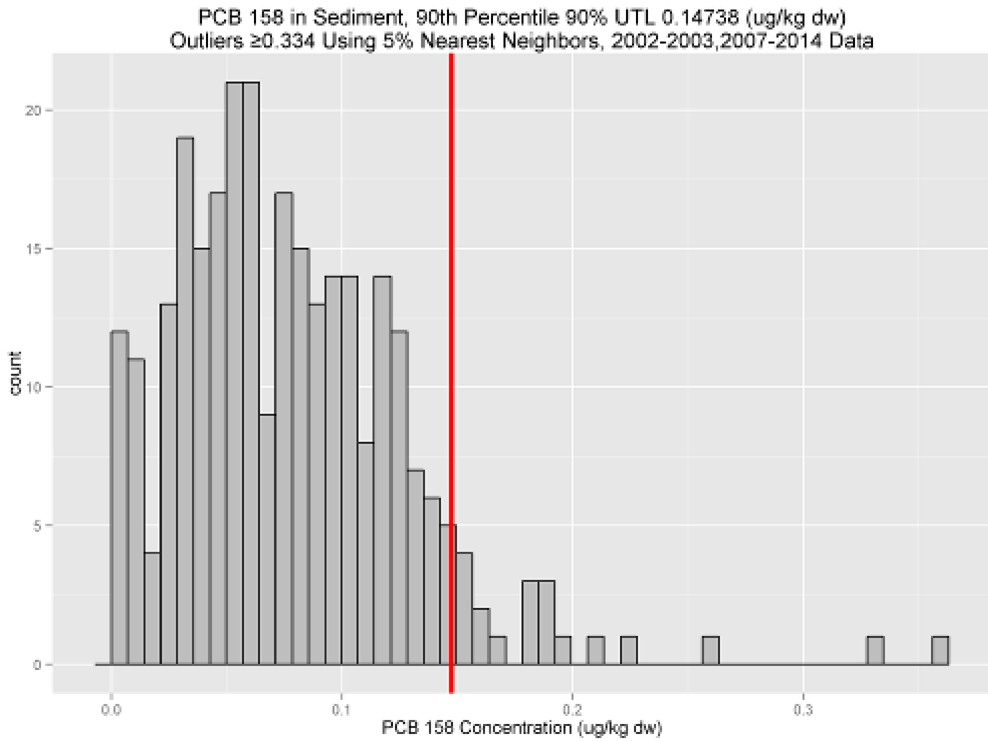


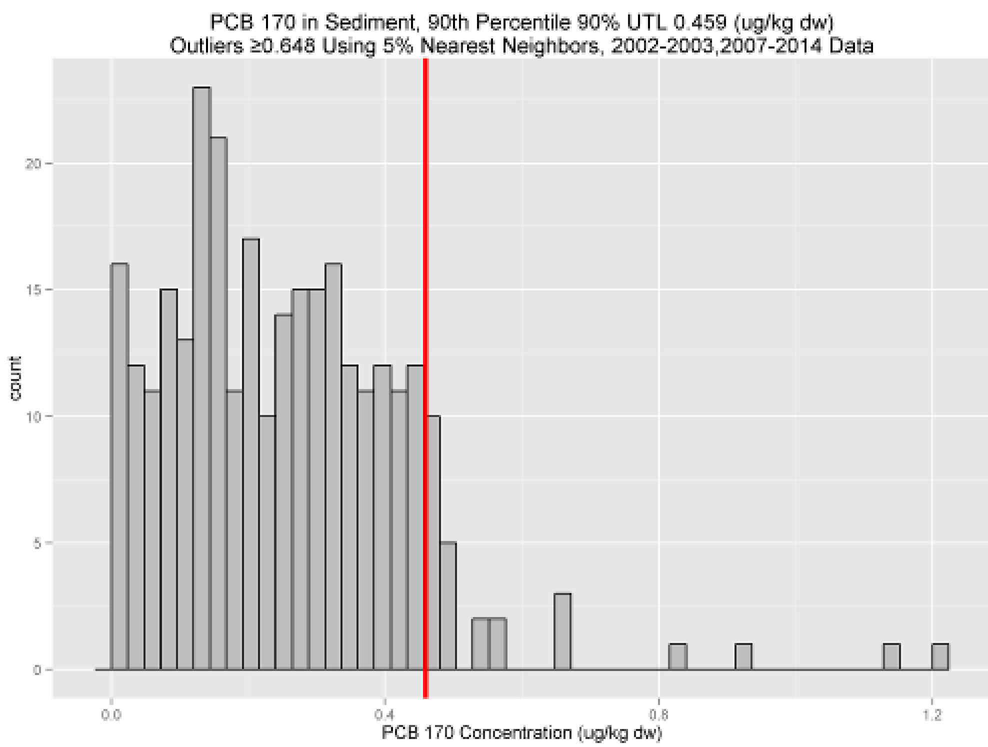
PCB 151 in Sediment, 90th Percentile 90% UTL 0.5621 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data

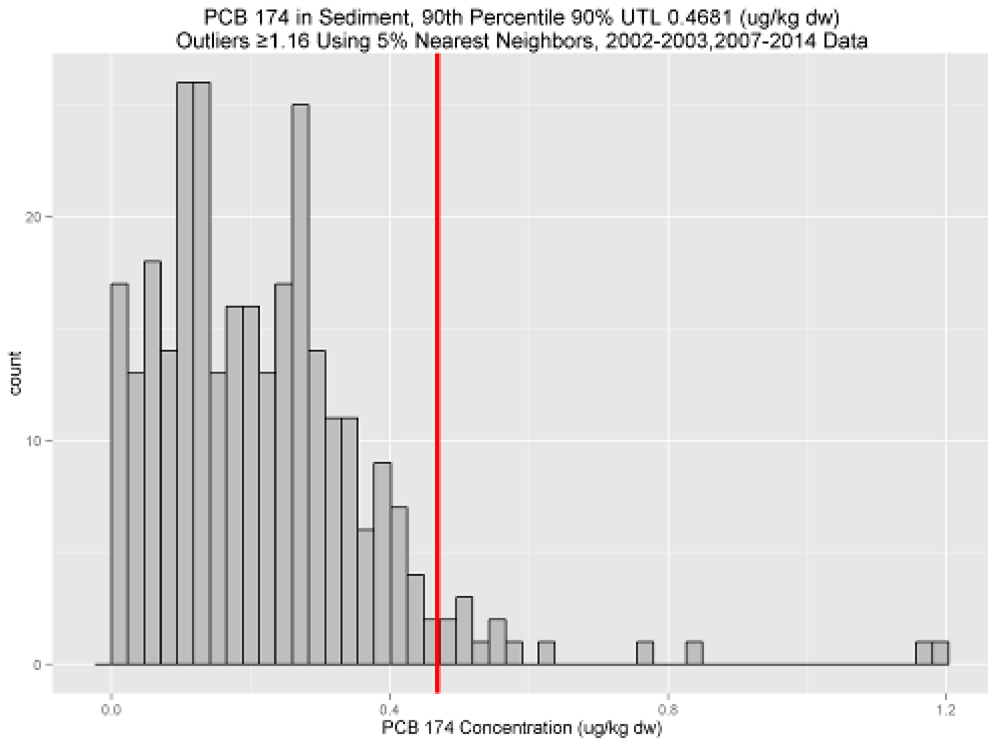


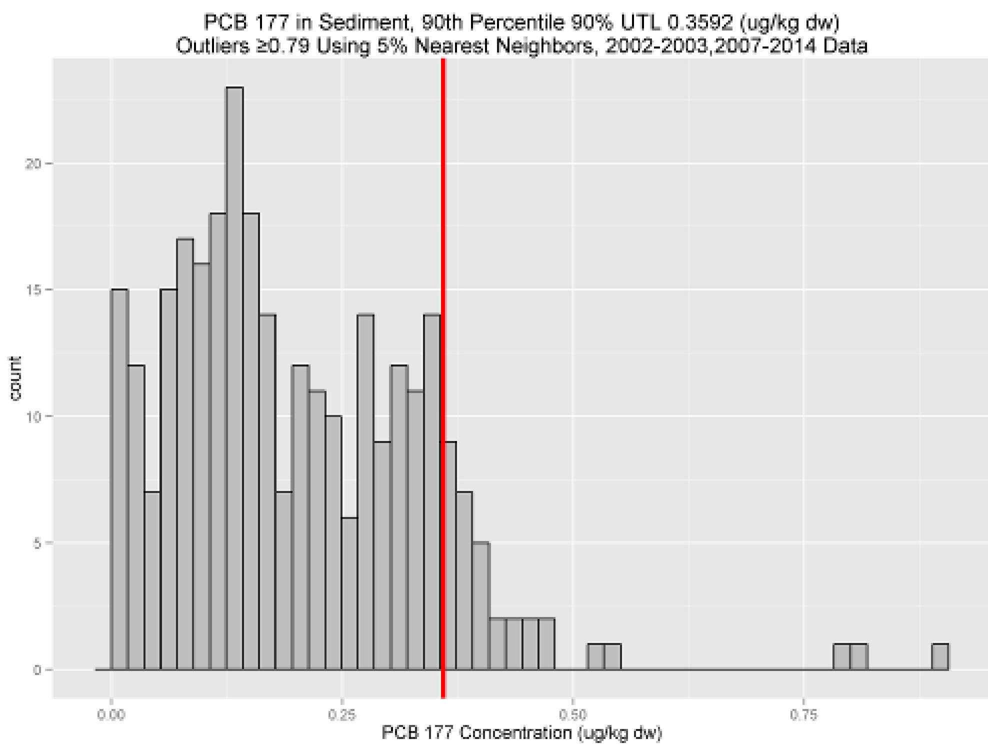

PCB 153 in Sediment, 90th Percentile 90% UTL 1.8226 (ug/kg dw)
Outliers ≥3.92 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 153 Concentration (ug/kg dw)

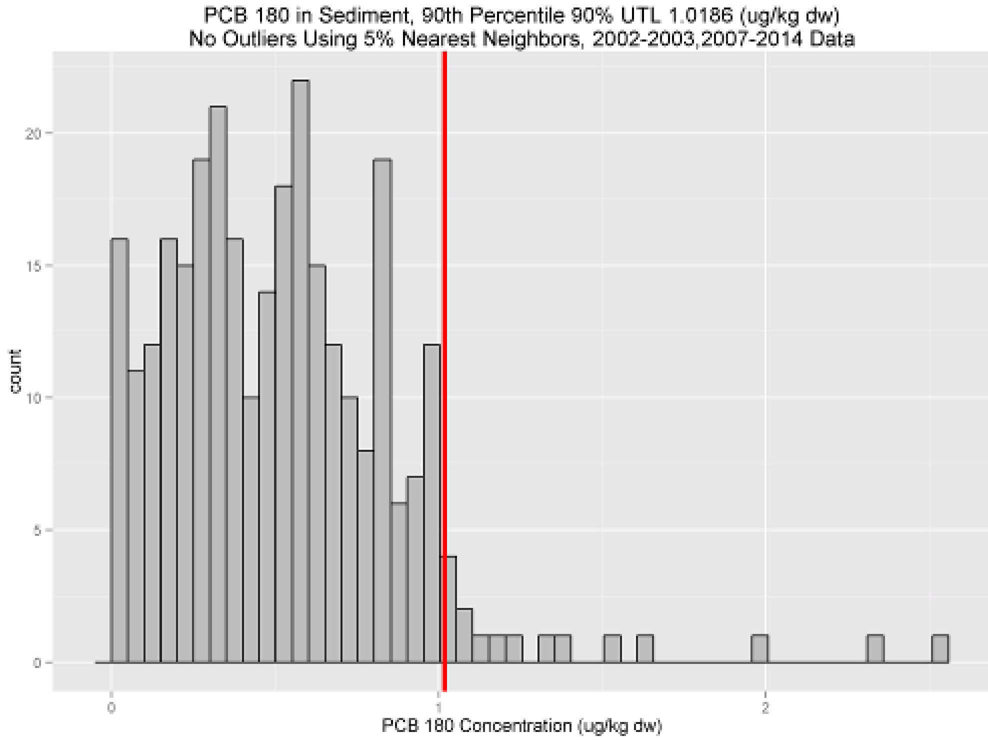

PCB 156 in Sediment, 90th Percentile 90% UTL 0.16421 (ug/kg dw)
Outliers ≥0.261 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 156 Concentration (ug/kg dw)

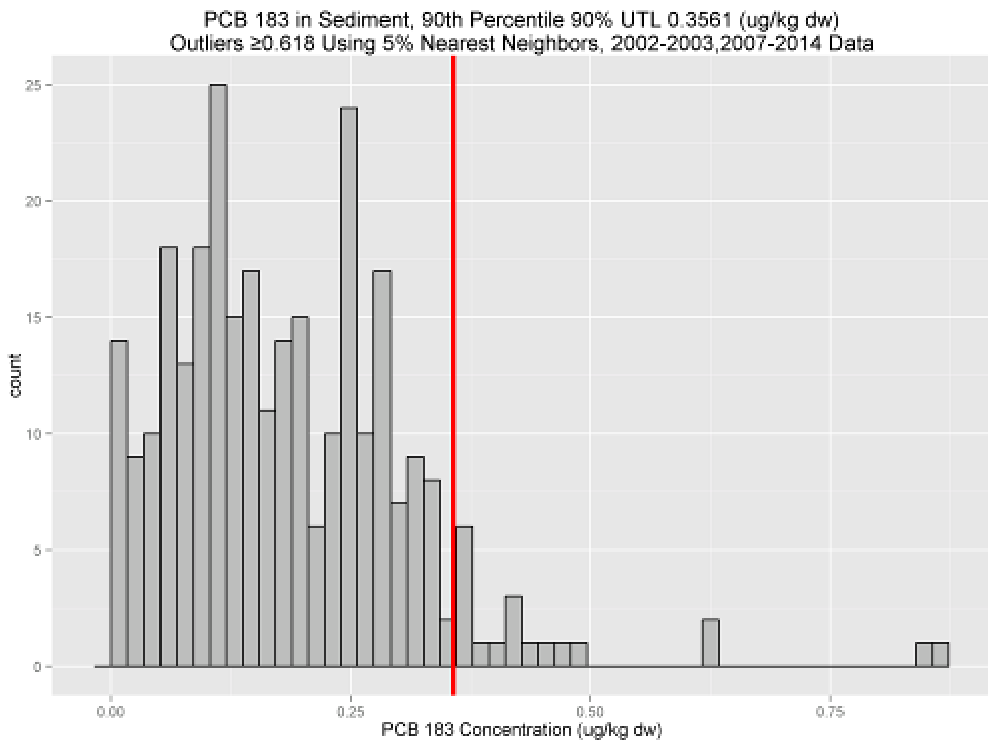

PCB 158 in Sediment, 90th Percentile 90% UTL 0.14738 (ug/kg dw)
Outliers ≥0.334 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 158 Concentration (ug/kg dw)

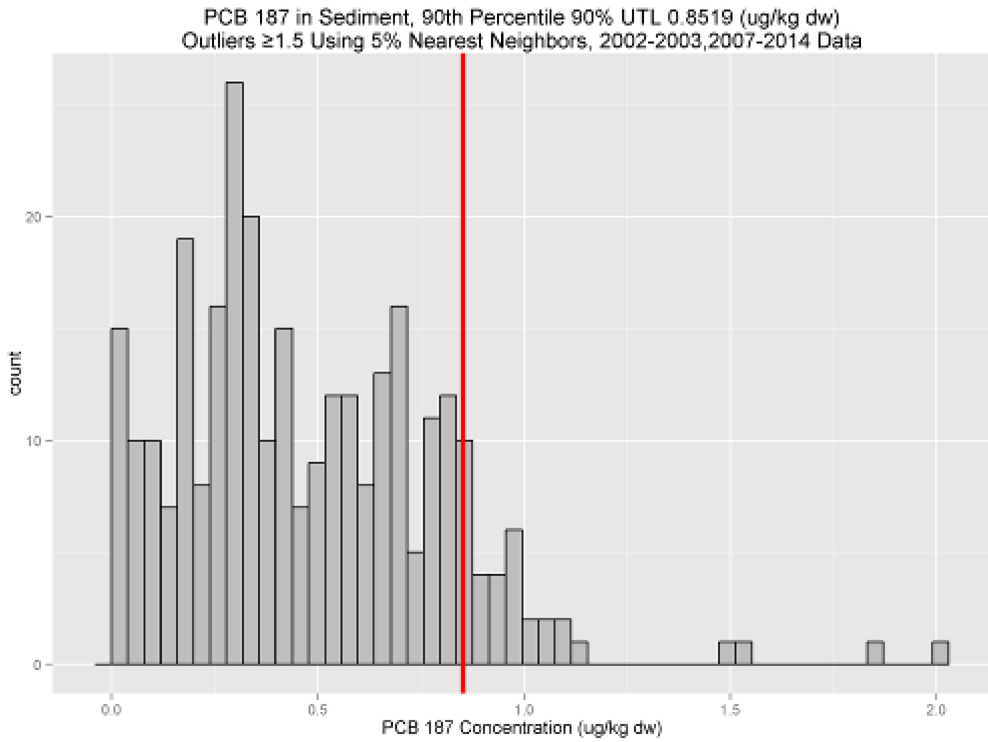

PCB 170 in Sediment, 90th Percentile 90% UTL 0.459 (ug/kg dw)
Outliers ≥0.648 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 170 Concentration (ug/kg dw)

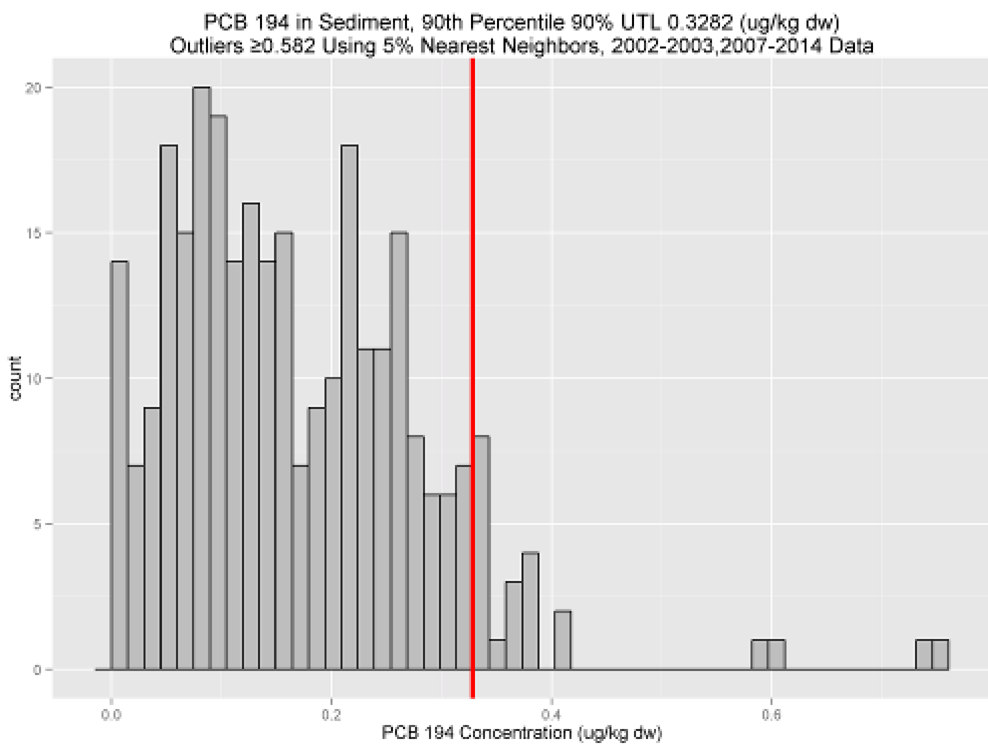

PCB 174 in Sediment, 90th Percentile 90% UTL 0.4681 (ug/kg dw)
Outliers ≥1.16 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
20
10
0
0.0
0.4
0.8
1.2
PCB 174 Concentration (ug/kg dw)

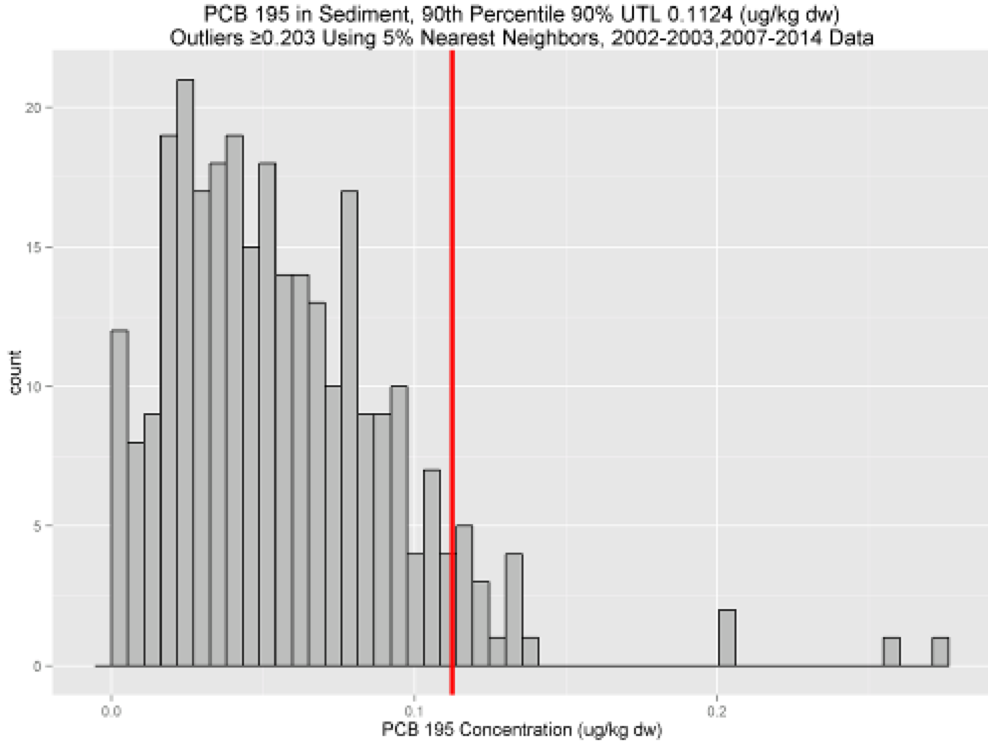

PCB 177 in Sediment, 90th Percentile 90% UTL 0.3592 (ug/kg dw)
Outliers ≥0.79 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
20
15
10
5
0
0.00
0.25
0.50
0.75
PCB 177 Concentration (ug/kg dw)

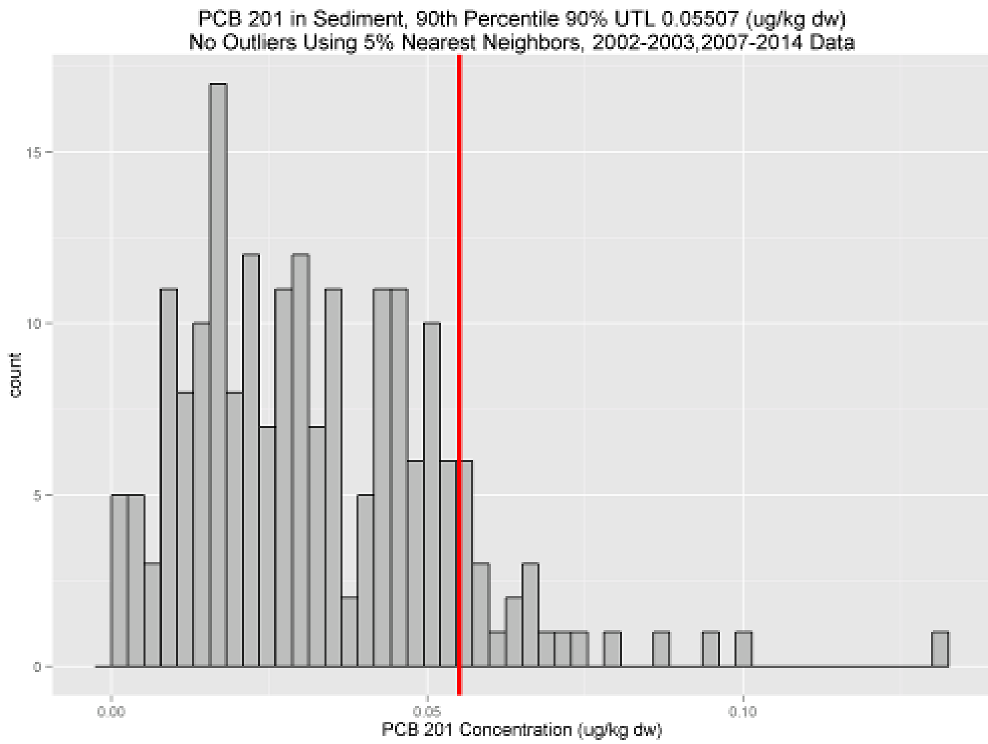

PCB 180 in Sediment, 90th Percentile 90% UTL 1.0186 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 180 Concentration (ug/kg dw)

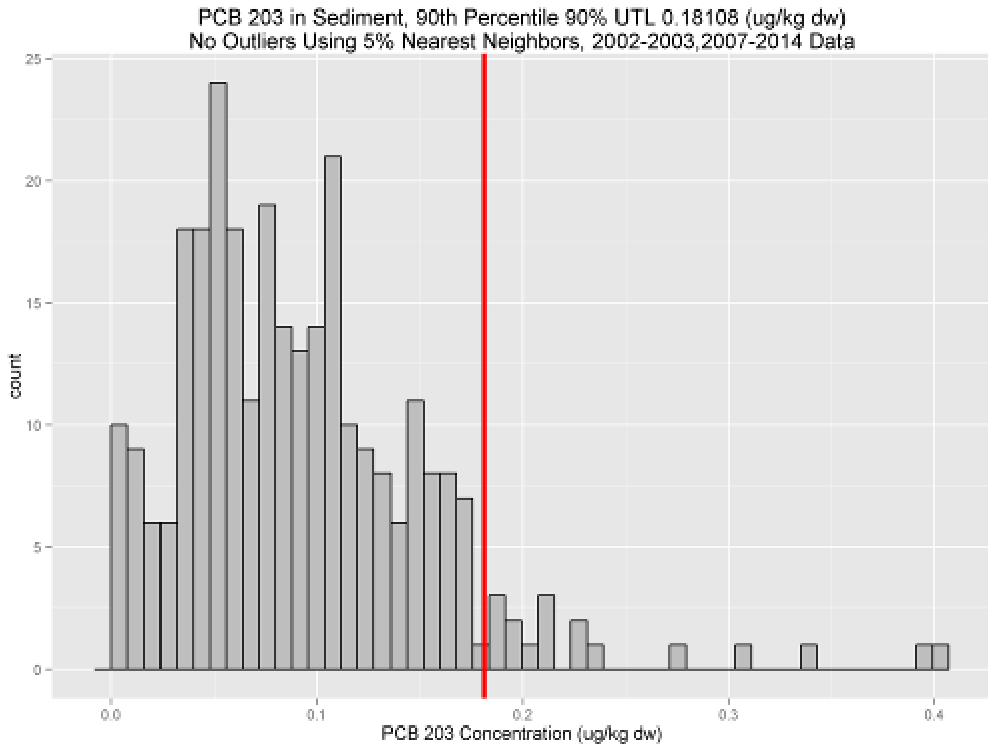

PCB 183 in Sediment, 90th Percentile 90% UTL 0.3561 (ug/kg dw)
Outliers ≥0.618 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 183 Concentration (ug/kg dw)


PCB 187 in Sediment, 90th Percentile 90% UTL 0.8519 (ug/kg dw)
Outliers ≥1.5 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
10
20
0.0
0.5
1.0
1.5
2.0
PCB 187 Concentration (ug/kg dw)

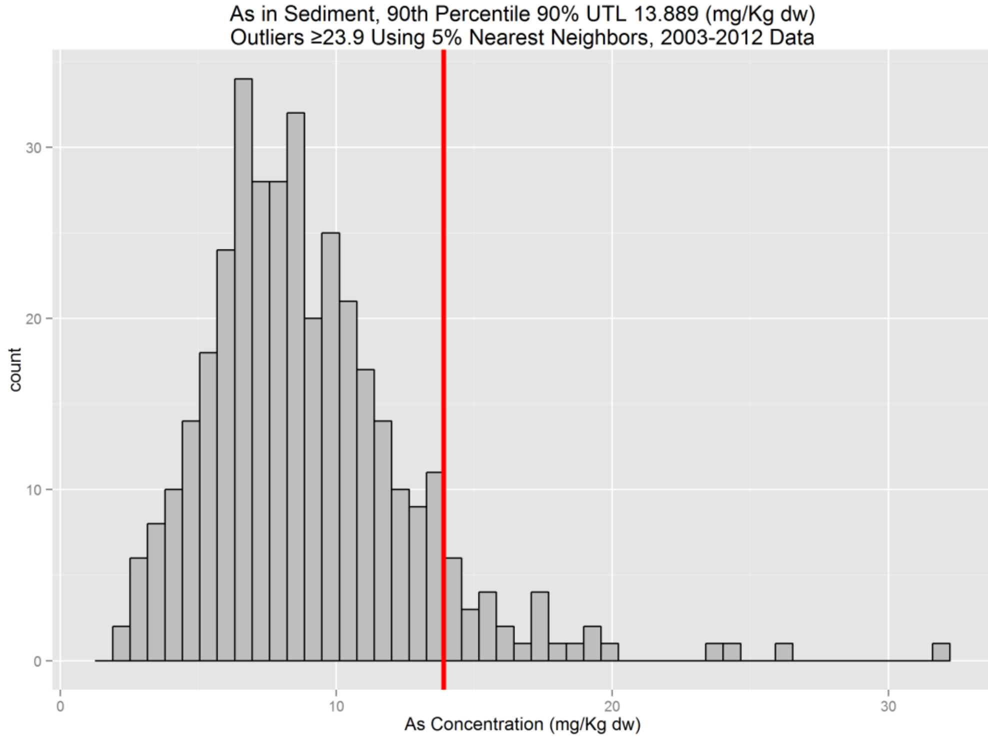

PCB 194 in Sediment, 90th Percentile 90% UTL 0.3282 (ug/kg dw)
Outliers ≥0.582 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
0
5
10
15
20
0.0
0.2
0.4
0.6
PCB 194 Concentration (ug/kg dw)

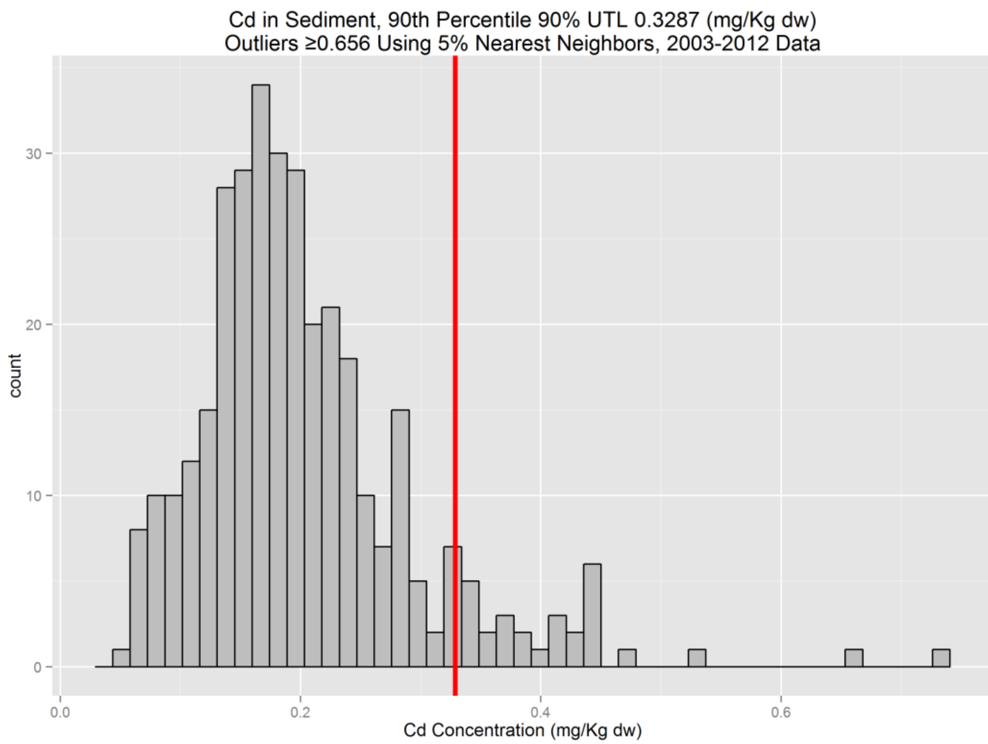

PCB 195 in Sediment, 90th Percentile 90% UTL 0.1124 (ug/kg dw)
Outliers ≥0.203 Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 195 Concentration (ug/kg dw)

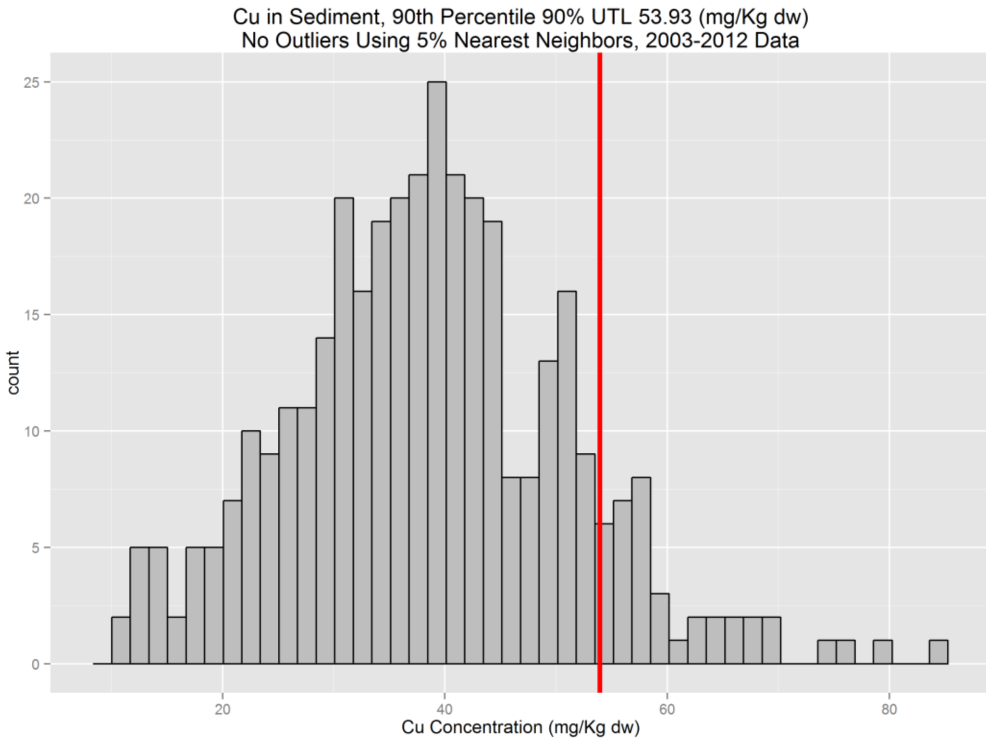

PCB 201 in Sediment, 90th Percentile 90% UTL 0.05507 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
PCB 201 Concentration (ug/kg dw)

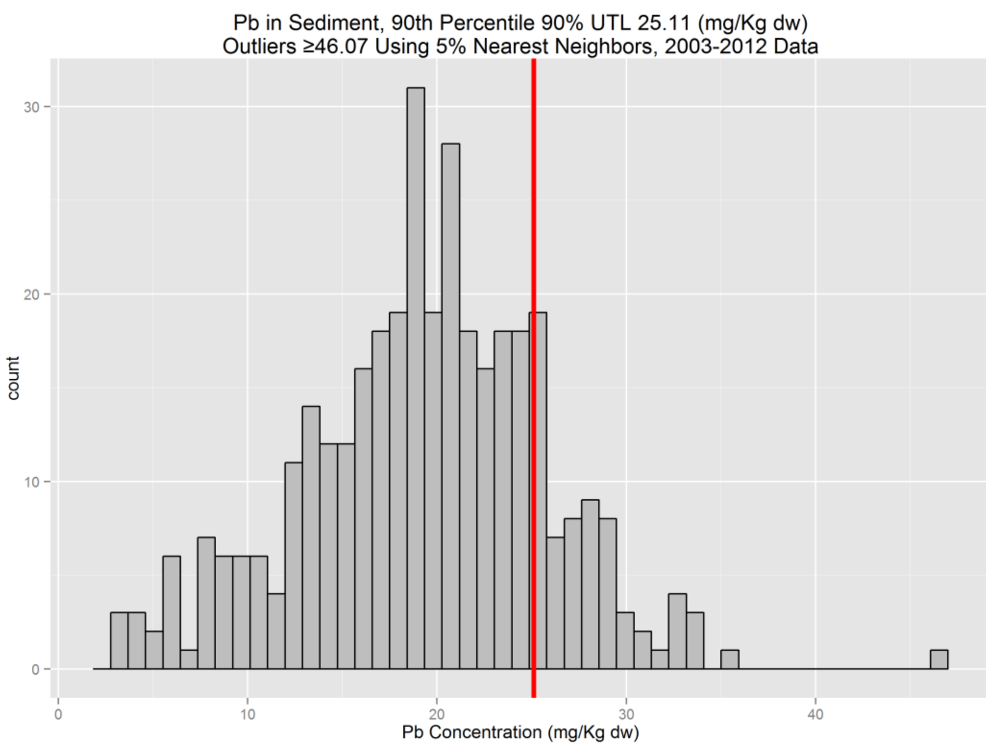

PCB 203 in Sediment, 90th Percentile 90% UTL 0.18108 (ug/kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2014 Data
count
25
20
15
10
5
0
0.0
0.1
0.2
0.3
0.4
PCB 203 Concentration (ug/kg dw)

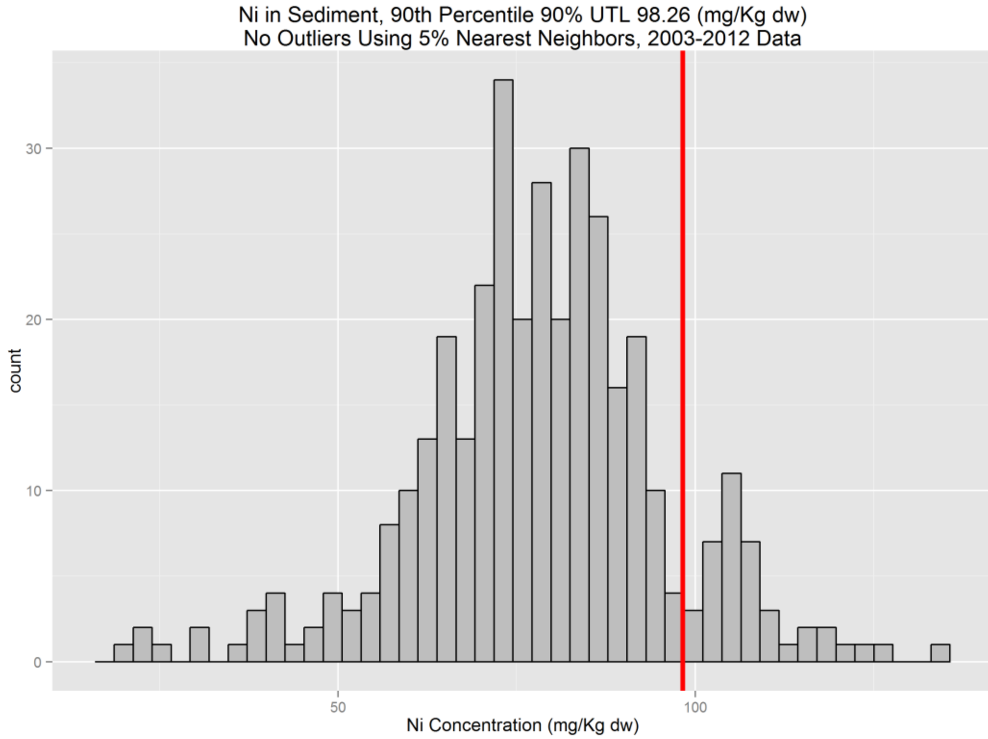
C-2 Remaining Full List Contaminants (unchanged from 2014 update)
Trace Metals

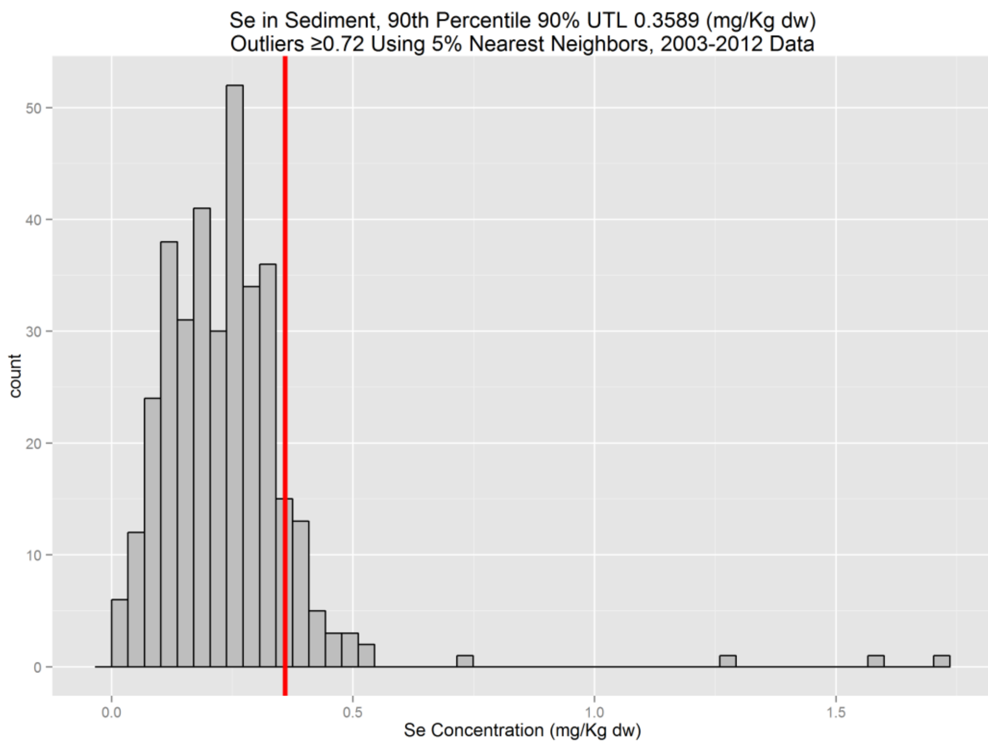


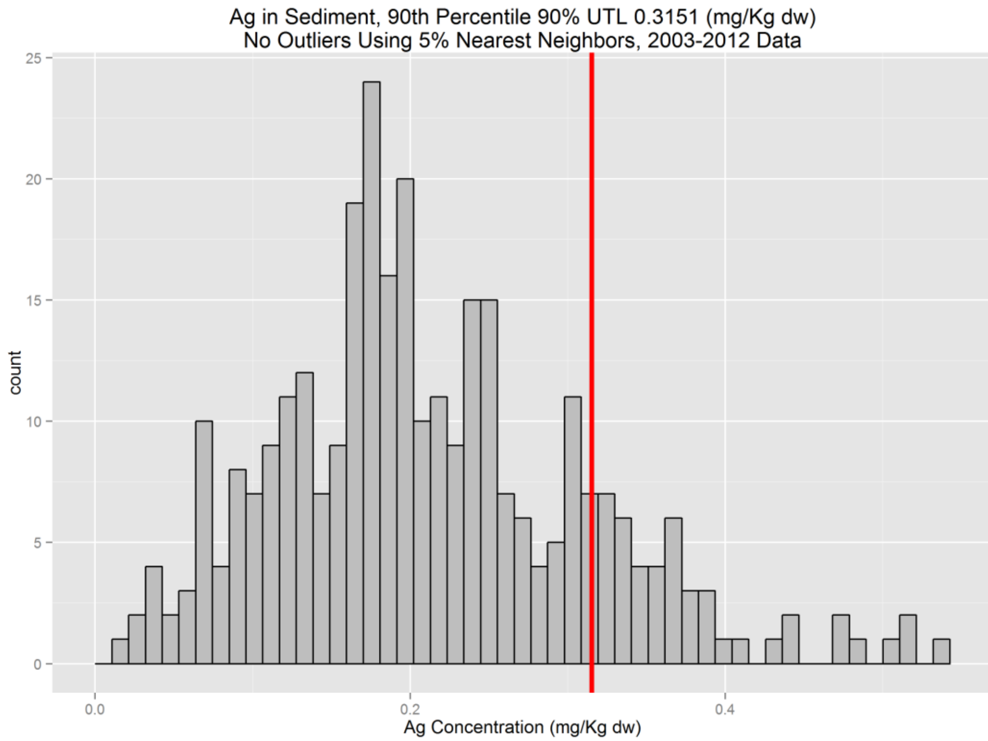



Cu in Sediment, 90th Percentile 90% UTL 53.93 (mg/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2003-2012 Data
count
0
5
10
15
20
25
20
40
60
80
Cu Concentration (mg/Kg dw)

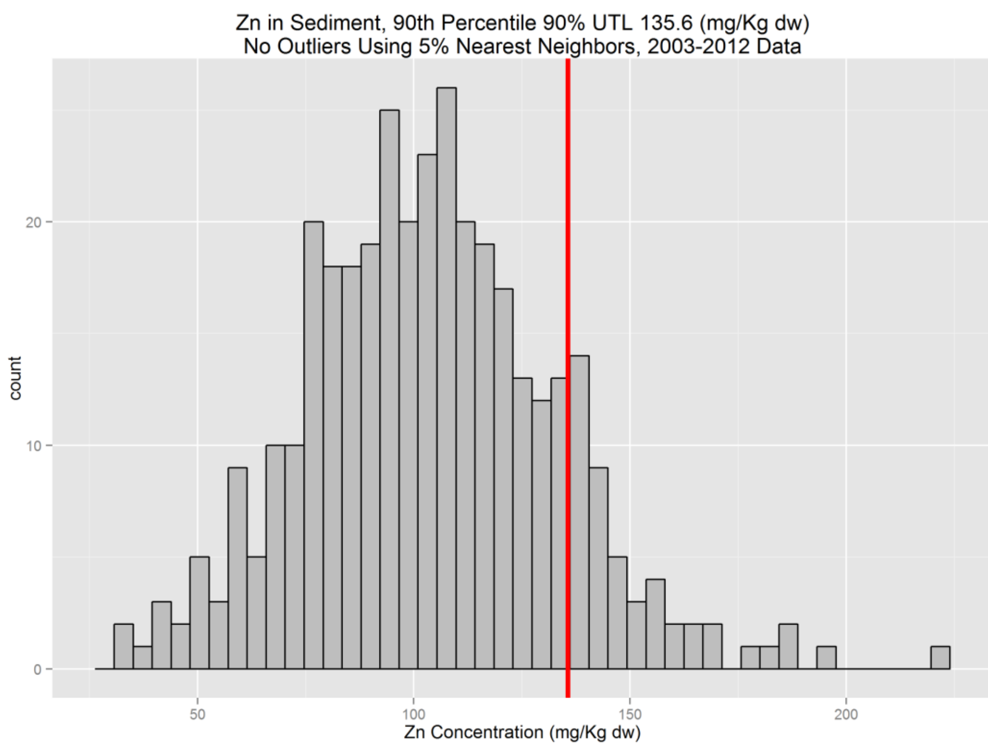

Pb in Sediment, 90th Percentile 90% UTL 25.11 (mg/Kg dw)
Outliers ≥46.07 Using 5% Nearest Neighbors, 2003-2012 Data
count
0
10
20
30
0
10
20
30
40
Pb Concentration (mg/Kg dw)


Ni in Sediment, 90th Percentile 90% UTL 98.26 (mg/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2003-2012 Data
count
30
20
10
0
50
100
Ni Concentration (mg/Kg dw)


Se in Sediment, 90th Percentile 90% UTL 0.3589 (mg/Kg dw)
Outliers ≥0.72 Using 5% Nearest Neighbors, 2003-2012 Data
count
50
40
30
20
10
0
0.0
0.5
1.0
1.5
Se Concentration (mg/Kg dw)

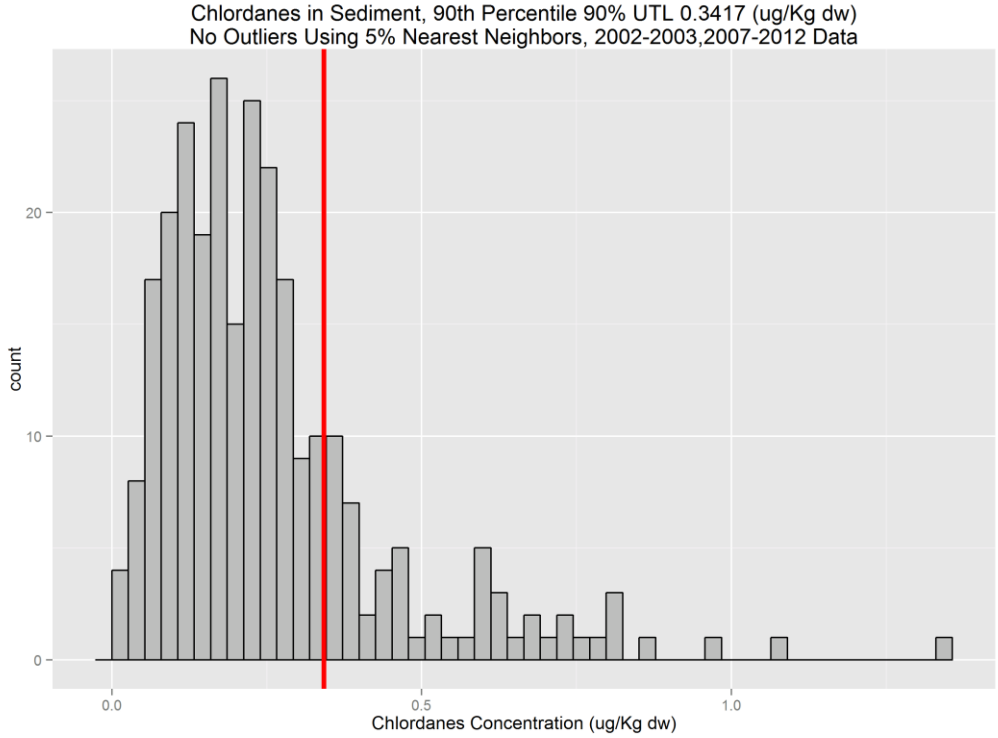


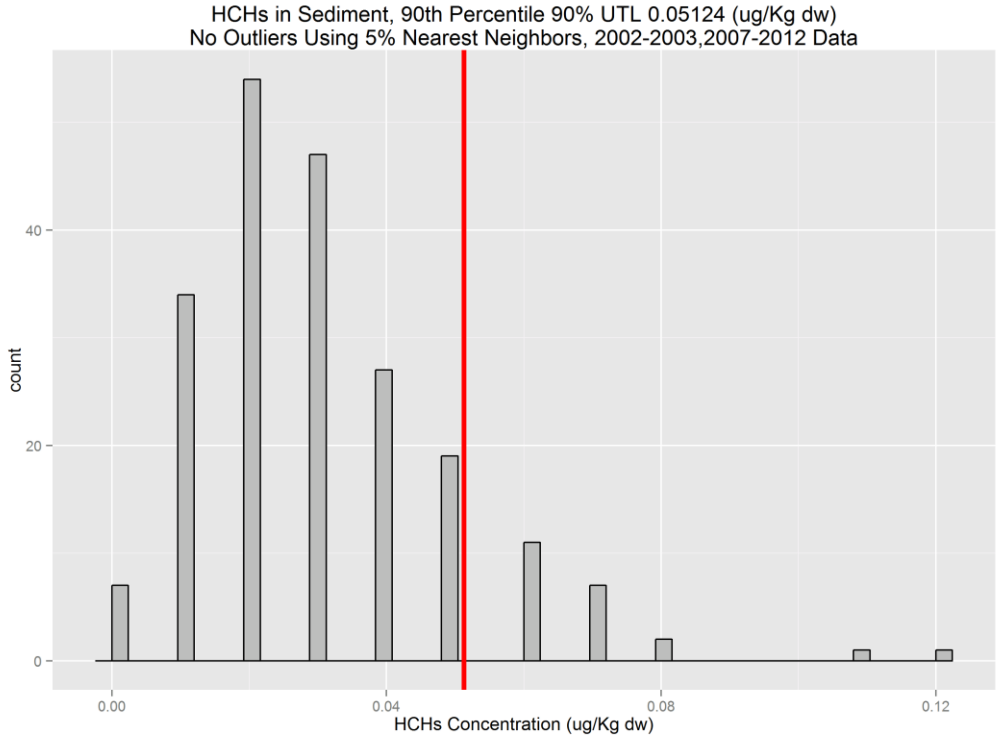
Ag in Sediment, 90th Percentile 90% UTL 0.3151 (mg/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2003-2012 Data
count
25
20
15
10
5
0
0.0
0.2
0.4
Ag Concentration (mg/Kg dw)

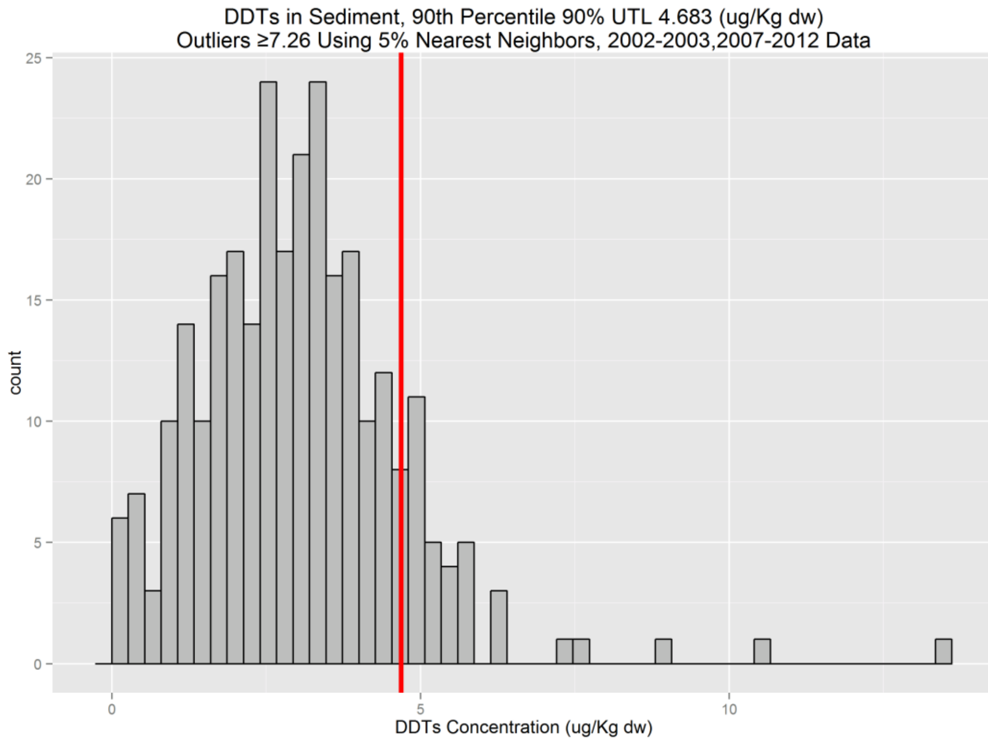


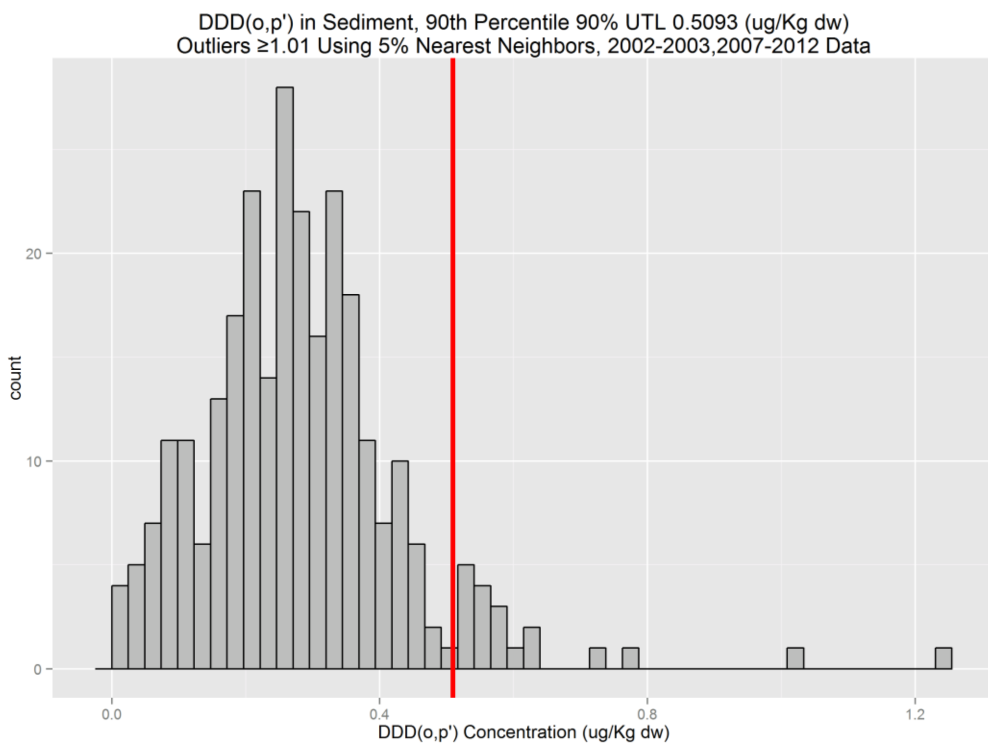
Zn in Sediment, 90th Percentile 90% UTL 135.6 (mg/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2003-2012 Data
count
20
10
0
50
100
150
200
Zn Concentration (mg/Kg dw)

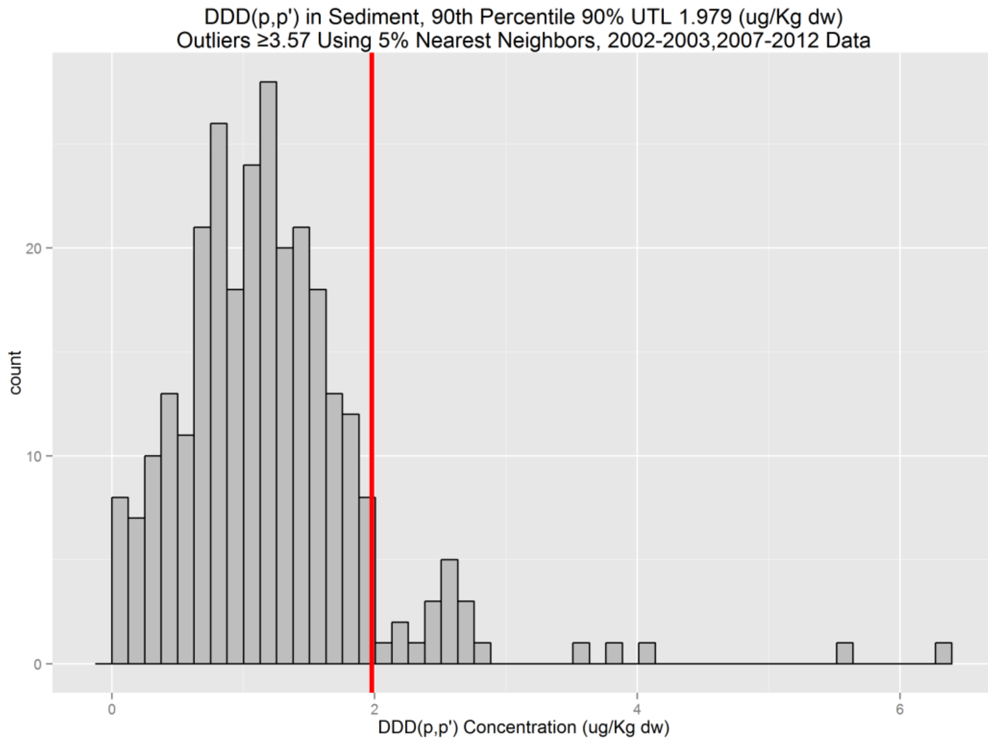
Pesticides

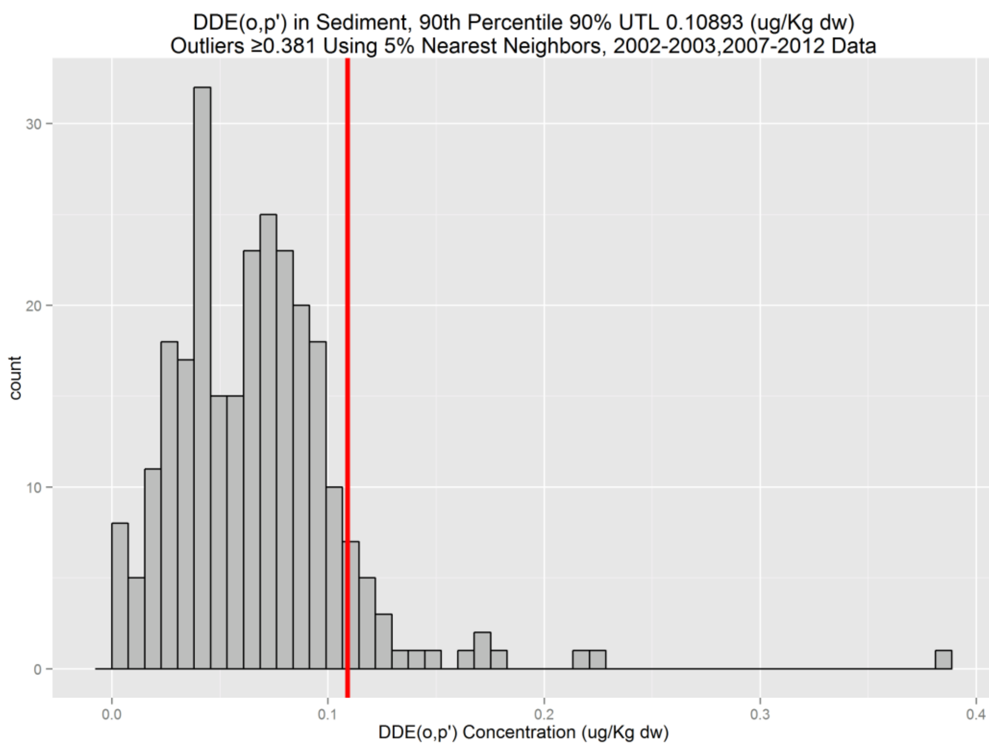

Chlordanes in Sediment, 90th Percentile 90% UTL 0.3417 (ug/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
20
10
0
0.0
0.5
1.0
Chlordanes Concentration (ug/Kg dw)


HCHs in Sediment, 90th Percentile 90% UTL 0.05124 (ug/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
40
20
0
0.00
0.04
0.08
0.12
HCHs Concentration (ug/Kg dw)

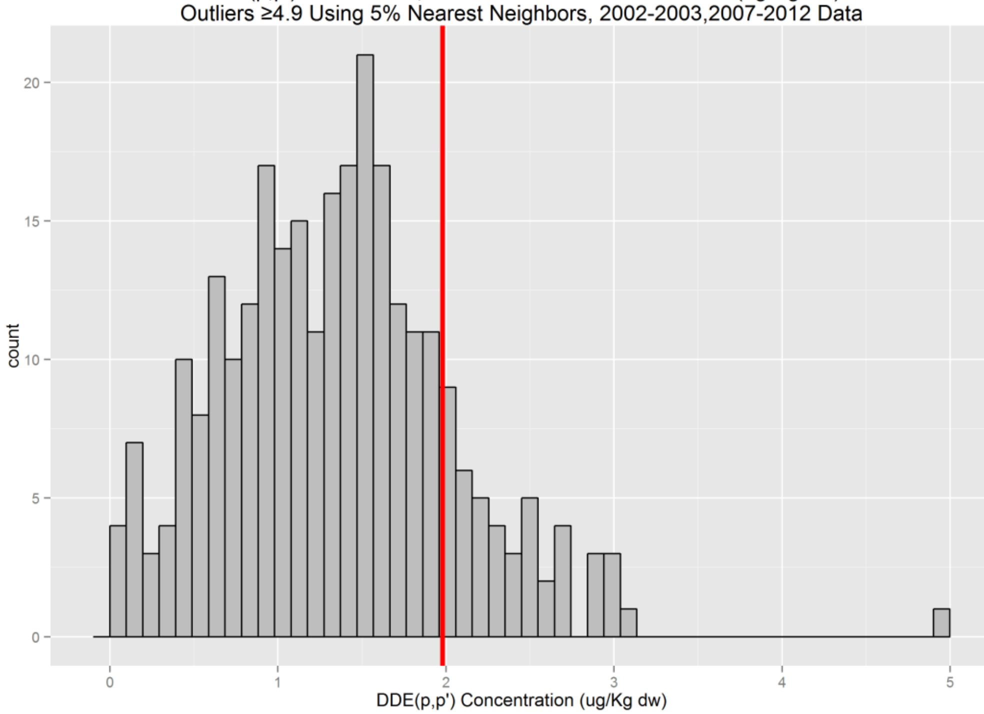

DDTs in Sediment, 90th Percentile 90% UTL 4.683 (ug/Kg dw)
Outliers ≥7.26 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
DDTs Concentration (ug/Kg dw)


DDD(o,p') in Sediment, 90th Percentile 90% UTL 0.5093 (ug/Kg dw)
Outliers ≥1.01 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
DDD(o,p') Concentration (ug/Kg dw)

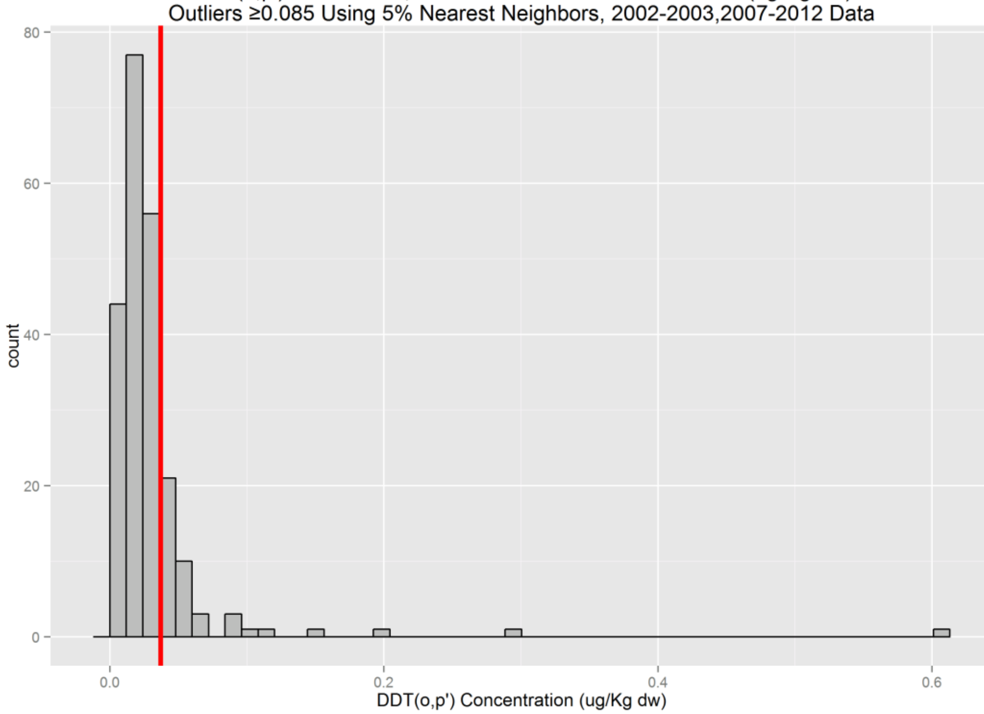

DDD(p,p') in Sediment, 90th Percentile 90% UTL 1.979 (ug/Kg dw)
Outliers ≥3.57 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
0
10
20
0
2
4
6
DDD(p,p') Concentration (ug/Kg dw)

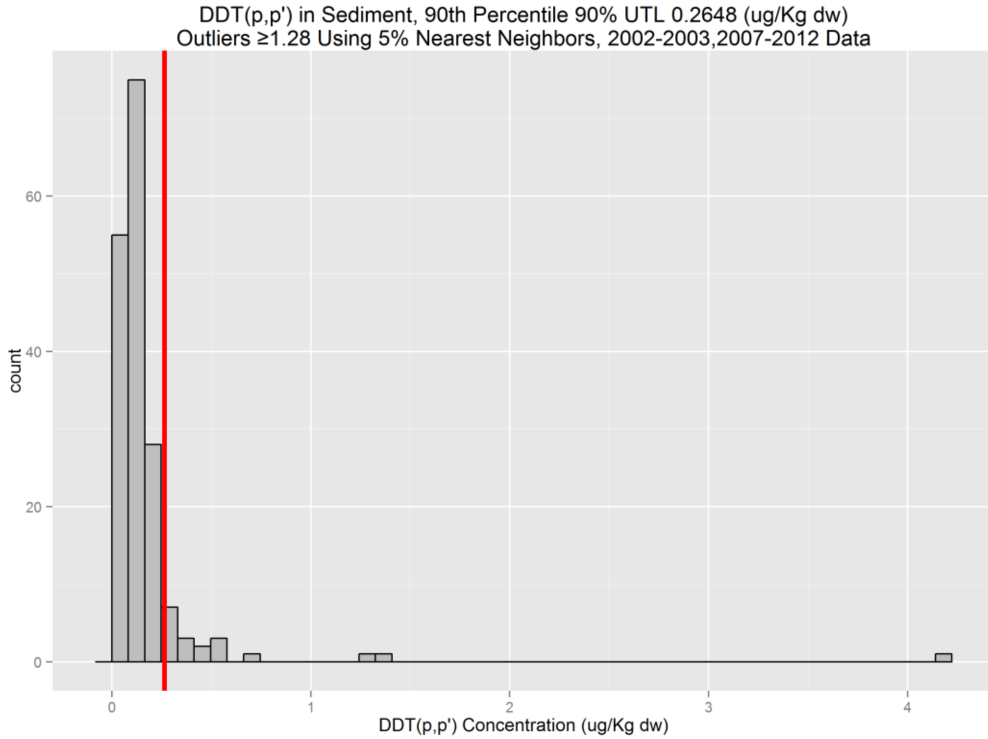

DDE(o,p') in Sediment, 90th Percentile 90% UTL 0.10893 (ug/Kg dw)
Outliers ≥0.381 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
0
10
20
30
0.0
0.1
0.2
0.3
0.4
DDE(o,p') Concentration (ug/Kg dw)

DDE(p,p') in Sediment, 90th Percentile 90% UTL 1.979 (ug/Kg dw)
Outliers ≥4.9 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data

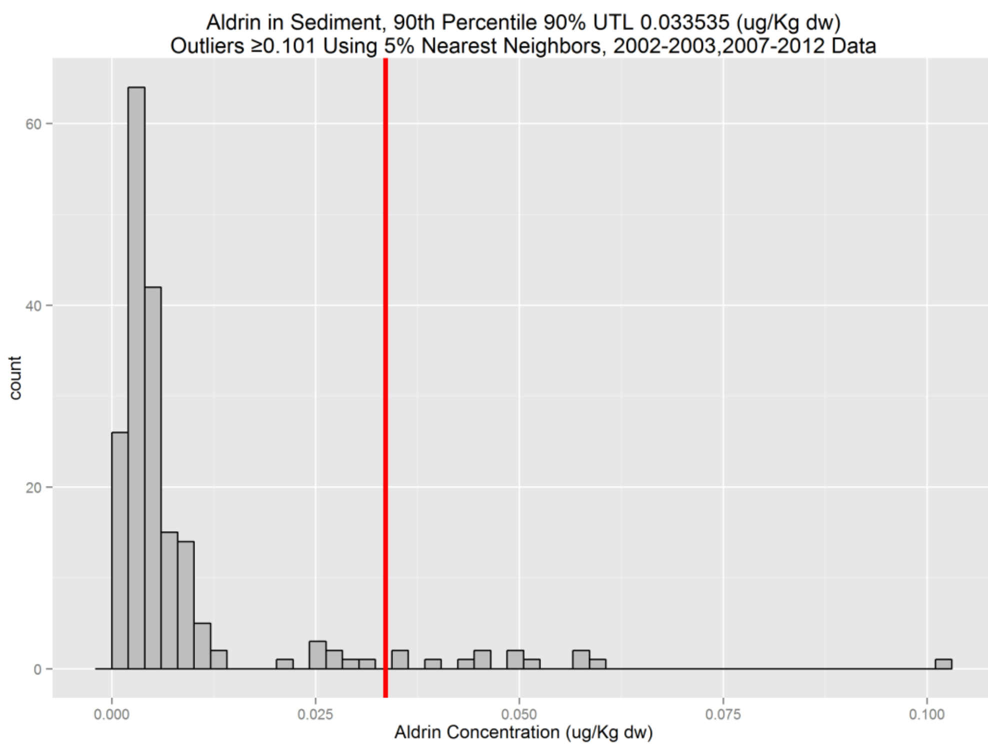


DDT(o,p') in Sediment, 90th Percentile 90% UTL 0.03708 (ug/Kg dw)
Outliers ≥0.085 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data

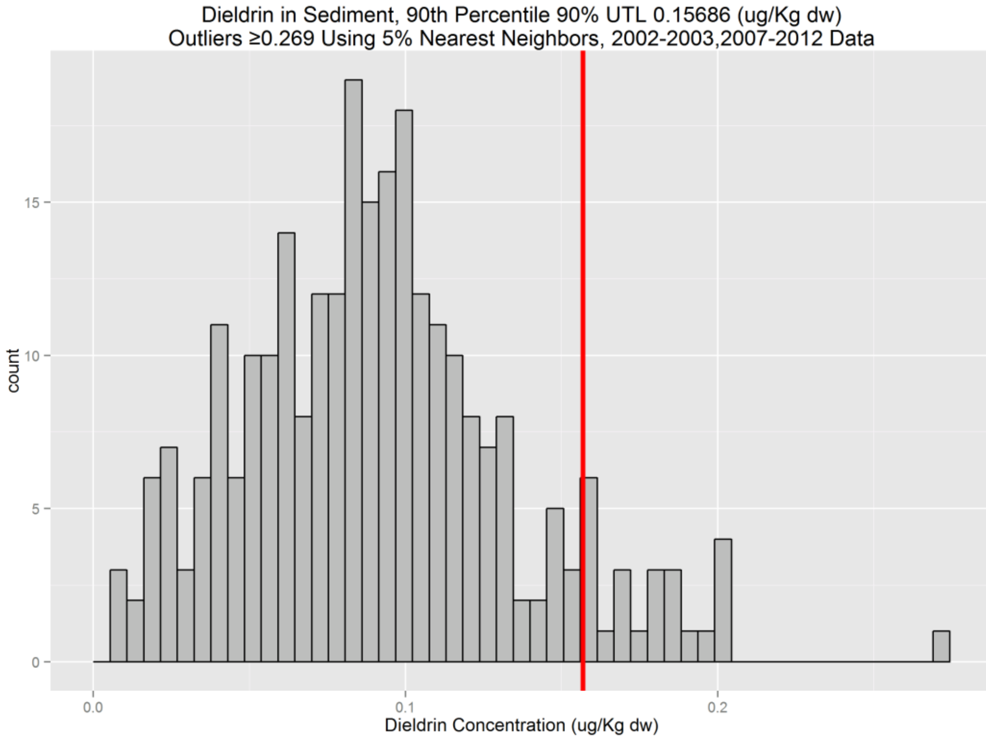


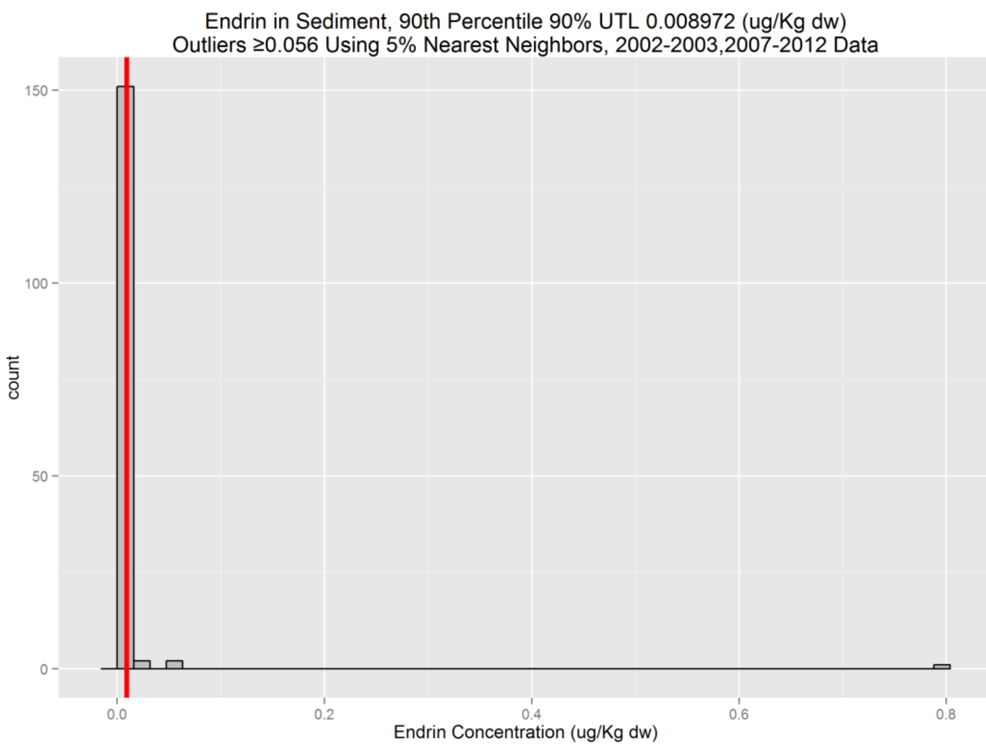


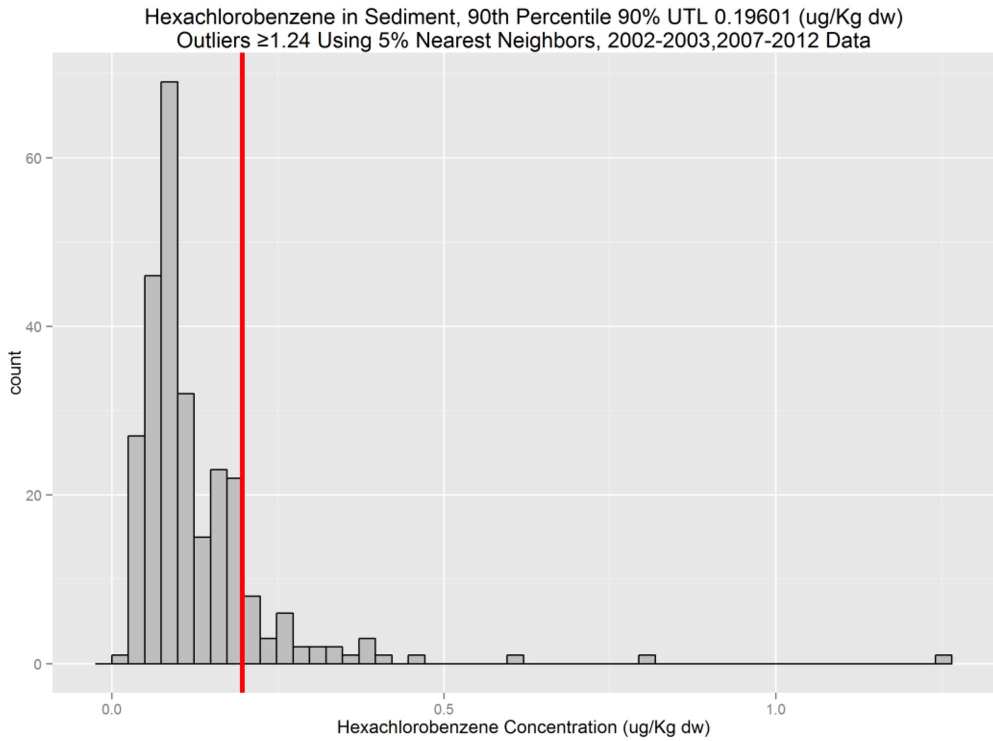
DDT(p,p') in Sediment, 90th Percentile 90% UTL 0.2648 (ug/Kg dw)
Outliers ≥1.28 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
0
20
40
60
0
1
2
3
4
DDT(p,p') Concentration (ug/Kg dw)



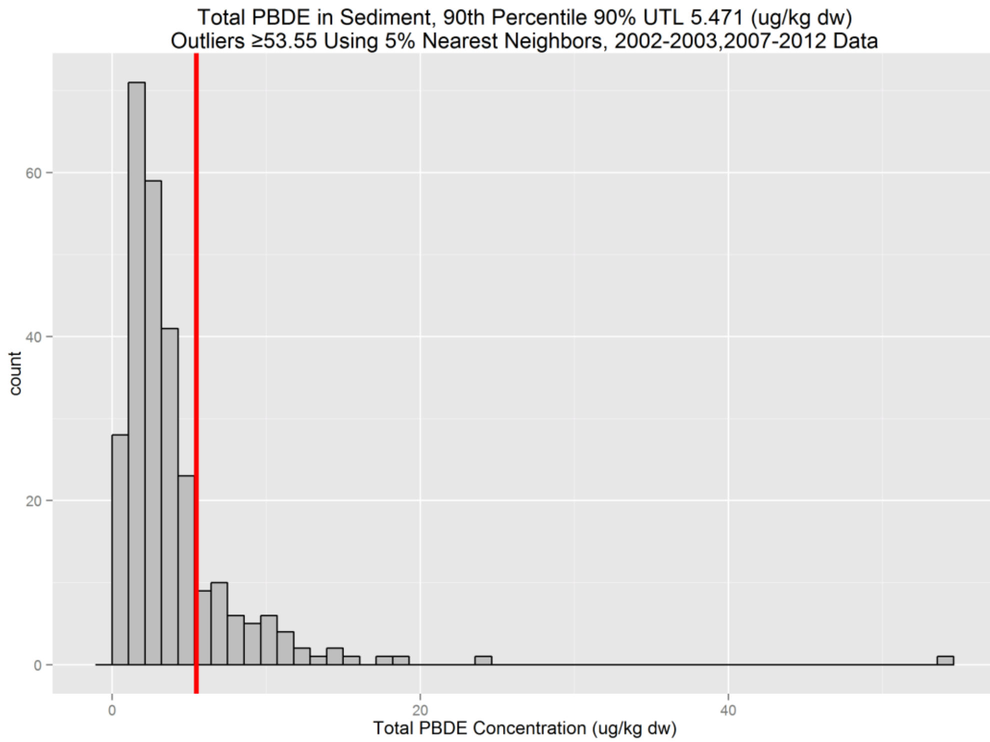
Aldrin in Sediment, 90th Percentile 90% UTL 0.033535 (ug/Kg dw)
Outliers ≥0.101 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
0
20
40
60
0.000
0.025
0.050
0.075
0.100
Aldrin Concentration (ug/Kg dw)


Dieldrin in Sediment, 90th Percentile 90% UTL 0.15686 (ug/Kg dw)
Outliers ≥0.269 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
Dieldrin Concentration (ug/Kg dw)

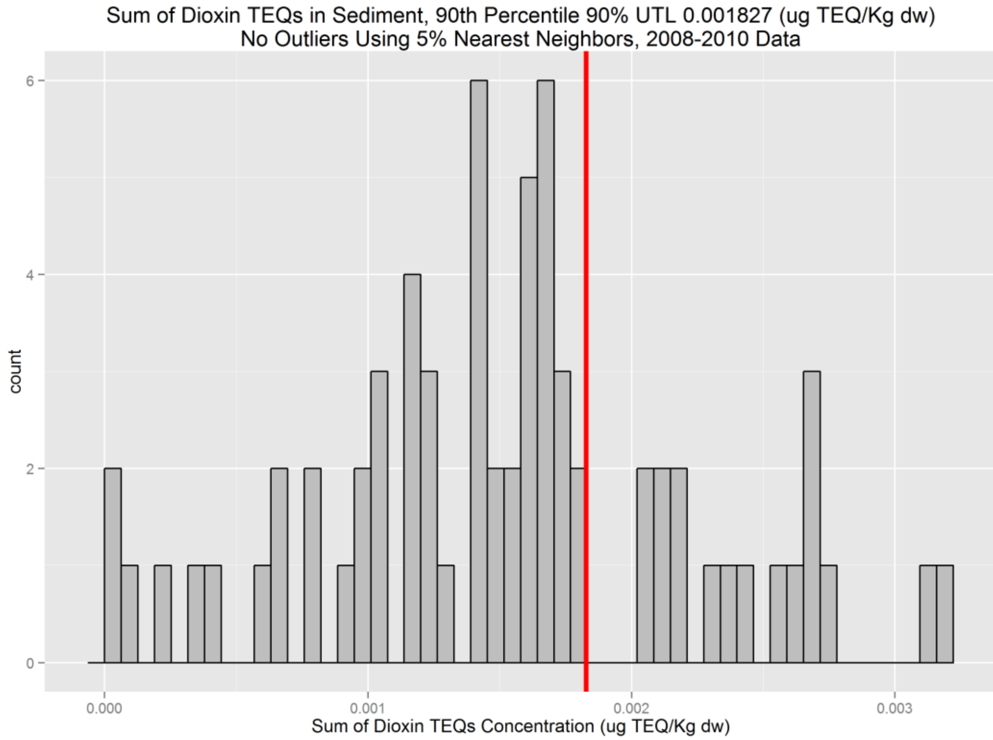

Endrin in Sediment, 90th Percentile 90% UTL 0.008972 (ug/Kg dw)
Outliers ≥0.056 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
Endrin Concentration (ug/Kg dw)

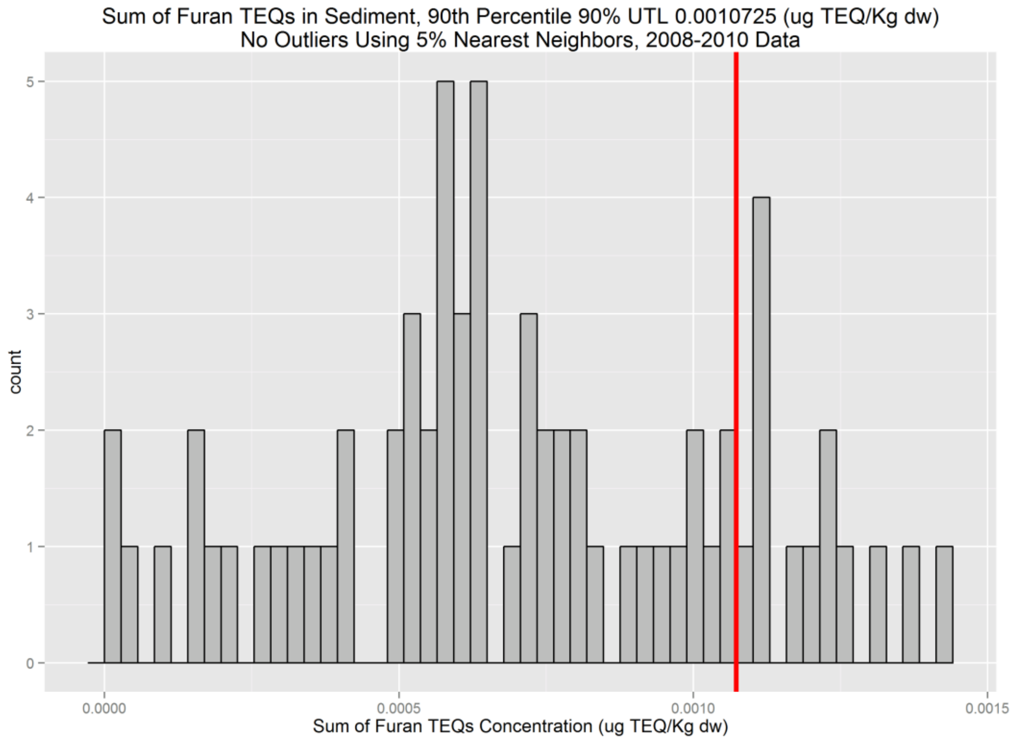

Hexachlorobenzene in Sediment, 90th Percentile 90% UTL 0.19601 (ug/Kg dw)
Outliers ≥1.24 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
60
40
20
0
0.0
0.5
1.0
Hexachlorobenzene Concentration (ug/Kg dw)

PBDEs


Total PBDE in Sediment, 90th Percentile 90% UTL 5.471 (ug/kg dw)
Outliers ≥53.55 Using 5% Nearest Neighbors, 2002-2003,2007-2012 Data
count
60
40
20
0
0
20
40
Total PBDE Concentration (ug/kg dw)

Dioxin TEQs


Sum of Dioxin TEQs in Sediment, 90th Percentile 90% UTL 0.001827 (ug TEQ/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2008-2010 Data
count
0
2
4
6
0.000
0.001
0.002
0.003
Sum of Dioxin TEQs Concentration (ug TEQ/Kg dw)


Sum of Furan TEQs in Sediment, 90th Percentile 90% UTL 0.0010725 (ug TEQ/Kg dw)
No Outliers Using 5% Nearest Neighbors, 2008-2010 Data
count
0
1
2
3
4
5
0.0000
0.0005
0.0010
0.0015
Sum of Furan TEQs Concentration (ug TEQ/Kg dw)