2012 San Juan Islands Marine Sediment Monitoring

Sediment Chemistry Data Summary

Table of Contents

Results and Statistical Summaries 3

Concentrations of contaminants in the sediment samples are displayed graphically in this linked file. Qualified (estimated) and undetected results are indicated. Stations are ordered approximately north to south and east to west... 3

Summary statistics for concentrations of metals and organic compounds from sediments collected for the 2012 survey of the San Juan Islands. 1

Chemical Contamination 5

No chemicals exceeded (did not meet) the Washington State Sediment Management Standards criteria in the 2012 San Juan Islands monitoring region.5

Spatial patterns for mean SQS quotients (SQSQ) in the 2012 survey of the San Juan Islands. *The numbers on the map are the station identifications.* 6

Spatial patterns in Sediment Chemistry Index in the 2012 survey of the San Juan Islands. *The numbers on the map are the station identifications.* 7

Incidence and spatial extent of chemical contamination in the 2012 survey of the San Juan Islands, as measured with the Sediment Chemistry Index. 8

Comparisons with Baseline 9

Changes in contaminant concentrations and Sediment Chemistry Index results (unweighted[1] and weighted[2] by area) from 2002-2003 to 2012. 9

Comparison of contaminant concentrations in sediments sampled in the 2002-2003 and 2012 surveys of the San Juan Islands. Graphical displays are given below for the Sediment Chemistry Index (SCI), metals, BNAs, and PAHs. The graphical displays include two types of graphs: 11

Comparison of Sediment Chemistry Index Categories by Year 34

Comparisons with Other Regions 35

Incidence and spatial extent of chemical contamination among eight PSEMP Sediment Component regions and all of Puget Sound, as measured by chemical concentrations exceeding applicable Washington State Sediment Cleanup Objective (SCO) benthic chemical criteria. 35

Incidence and spatial extent of chemical contamination in eight sediment monitoring regions and all of Puget Sound as measured with the Sediment Chemistry Index..... 36

Chemistry Case Narratives 38

2012 TOC Case Narrative.pdf 38

Results and Statistical Summaries

Laboratory chemistry results (data) for the 2012 survey of the San Juan Islands.

Concentrations of contaminants in the sediment samples are displayed graphically in this linked file. Qualified (estimated) and undetected results are indicated. Stations are ordered approximately north to south and east to west.

Summary statistics for concentrations of metals and organic compounds from sediments collected for the 2012 survey of the San Juan Islands**.**

Parameter	N	# Detects	# ND	# ND > highest detect	Mean*	Std. Dev.*	Median*	Minimum*	Maximum (detected)	Max RL (ND)	Notes (see bottom)
Total Organic Carbon	40	40	0	n.a.	1.43	0.80	1.40	0.14	3.30	3.30	1
Total Organic Carbon (M)	40	40	0	n.a.	1.44	0.81	1.41	0.14	3.35	3.35	1
Metals (mg/kg dry weight)											
Arsenic	40	40	0	n.a.	5.87	2.34	5.50	1.69	12.10	12.10	1
Cadmium	40	40	0	n.a.	0.64	0.54	0.42	0.11	2.82	2.82	1
Chromium	40	40	0	n.a.	32.38	11.63	33.05	12.10	52.50	52.50	1
Copper	40	40	0	n.a.	16.59	7.55	16.40	4.02	32.70	32.70	1
Lead	40	40	0	n.a.	7.93	3.33	8.85	1.70	0.00	14.10	1
Mercury	40	40	0	n.a.	0.06	0.03	0.05	0.01	0.11	0.11	1
Nickel	40	40	0	n.a.	20.77	6.77	22.00	7.52	32.10	32.10	1
Selenium	40	27	13	0	0.55	0.39	0.44	0.13	1.71	0.50	
Silver	40	25	15	0	0.10	0.06	0.08	0.03	0.24	0.10	
Tin	40	39	1	0	0.63	0.28	0.58	0.18	1.09	0.20	
Zinc	40	40	0	n.a.	58.03	20.71	59.65	19.60	103.00	103.00	1
Organic Compounds (µg/kg dry weight)											
Polycyclic Aromatic Hydrocarbons (PAH)											
LPAH											
1,6,7-Trimethylnaphthalene	40	40	0	n.a.	10.70	4.60	12.35	1.21	16.90	16.90	1
1-Methylnaphthalene	40	40	0	n.a.	33.82	16.26	39.25	1.40	63.20	63.20	1
1-Methylphenanthrene	40	37	3	0	18.02	6.95	17.35	7.42	31.20	5.15	
2,6-Dimethylnaphthalene	40	40	0	n.a.	78.58	62.48	65.05	12.30	243.00	243.00	1
2-Methylnaphthalene	40	40	0	n.a.	41.51	19.62	46.65	2.06	77.90	77.90	1

Parameter	N	# Detects	# ND	# ND > highest detect	Mean*	Std. Dev.*	Median*	Minimum*	Maximum (detected)	Max RL (ND)	Notes (see bottom)
2-Methylphenanthrene	40	39	1	0	29.08	12.78	30.95	1.68	48.90	1.03	
Acenaphthene	40	34	6	0	3.57	1.19	3.79	1.80	5.92	2.07	
Acenaphthylene	40	34	6	0	3.65	1.63	4.03	0.92	6.02	1.03	
Anthracene	40	38	2	0	10.14	5.34	10.95	2.17	20.70	1.03	
Biphenyl	40	37	3	0	11.09	4.24	12.40	4.12	18.70	5.15	
Dibenzothiophene	40	37	3	0	4.83	2.11	5.43	0.88	8.84	1.03	
Fluorene	40	40	0	n.a.	12.80	5.67	14.60	0.84	21.50	21.50	1
Naphthalene	40	39	1	0	26.84	14.27	28.95	2.58	57.10	2.04	
Phenanthrene	40	40	0	n.a.	56.65	24.36	68.45	3.52	83.30	83.30	1
Retene	40	39	1	0	29.04	11.97	32.25	2.83	44.30	5.10	
1,6,7-Trimethylnaphthalene	40	40	0	n.a.	10.70	4.60	12.35	1.21	16.90	16.90	1
HPAH											
Benzo(a)anthracene	40	40	0	n.a.	13.35	7.09	13.65	1.09	27.20	27.20	1
Benzo(a)pyrene	40	40	0	n.a.	15.65	8.55	16.05	1.17	32.60	32.60	1
Benzo(b)fluoranthene	40	40	0	n.a.	29.60	17.87	28.15	2.12	70.30	70.30	1
Benzo(g,h,i)perylene	40	40	0	n.a.	18.54	11.51	17.10	1.58	44.70	44.70	1
Benzo(k)fluoranthene	40	38	2	0	10.17	6.54	8.88	1.68	27.80	2.06	
Benzo[e]pyrene	40	40	0	n.a.	18.46	10.86	17.95	1.27	43.60	43.60	1
Chrysene	40	40	0	n.a.	31.62	15.16	34.55	2.41	54.50	54.50	1
Dibenzo(a,h)anthracene	40	38	2	0	3.26	1.76	3.29	0.63	7.56	1.03	
Fluoranthene	40	40	0	n.a.	45.63	25.76	46.80	3.04	91.20	91.20	1
Indeno(1,2,3-c,d)pyrene	40	40	0	n.a.	19.21	12.67	17.10	1.17	49.90	49.90	1
Perylene	40	40	0	n.a.	54.55	26.88	64.50	3.44	99.70	99.70	1
Pyrene	40	40	0	n.a.	38.62	19.92	41.70	2.86	69.90	69.90	1
Total Benfluoranthenes	40	40	0	n.a.	39.67	24.44	36.81	2.12	98.10	98.10	1

Parameter	N	# Detects	# ND	# ND > highest detect	Mean*	Std. Dev.*	Median*	Minimum*	Maximum (detected)	Max RL (ND)	Notes (see bottom)
Base/Neutral/Acid (BNA)											
Semivolatile Compounds											
Chlorinated Alkenes – all undetected											
Chlorinated and Nitro substituted Phenols – all undetected											
Chlorinated Aromatic Compounds – all undetected											
Miscellaneous Extractable Compounds											
Beta-Coprostanol	22	11	11	0	843.00	875.00	381.00	167.00	3400.00	1100.00	
Carbazole	40	37	3	0	5.95	1.51	5.56	3.38	8.48	5.16	
Cholesterol	40	38	2	0	2149.00	1023.00	1950.00	581.00	4600.00	1000.00	
Isophorone	40	19	21	21						390.00	3,4
Triclosan	40	40	0	n.a.						120.00	2
Bisphenol A	5	3	2	0	78.60	24.90	77.00	54.60	110.00	35.00	
Organonitrogen Compounds – all undetected											
Phenols											
Phenol	40	5	35	26	145.69	29.80	138.22	110.00	210.00	600.00	3
Phthalate Esters – all undetected											
Pesticides and Herbicides - all others undetected											
Gamma-BHC (Lindane)	40	3	37	0	0.11	0.31	0.03	0.00	1.90	0.58	
Hexachlorobenzene (method 8081/8082)	40	1	39	0						0.58	5
Polychlorinated Biphenyls (PCB)											
PCB Congeners - all undetected											
PCB Aroclors - all others undetected											
PCB Aroclor 1254	40	1	39	0						5.80	5
Polybrominated Diphenylethers (PBDE)											
PBDE- 47	40	12	28	28						0.46	3,4

Parameter	N	# Detects	# ND	# ND > highest detect	Mean*	Std. Dev.*	Median*	Minimum*	Maximum (detected)	Max RL (ND)	Notes (see bottom)
PBDE-153	40	2	38	38						0.92	3,4
PBDE-154	40	1	39	39						0.92	3,4
PBDE-183	40	2	38	38						0.92	3,4
PBDE-184	40	2	38	38						0.92	3,4
PBDE-209	40	15	25	0	1.38	0.41	1.30	0.81	2.80	2.30	

Notes

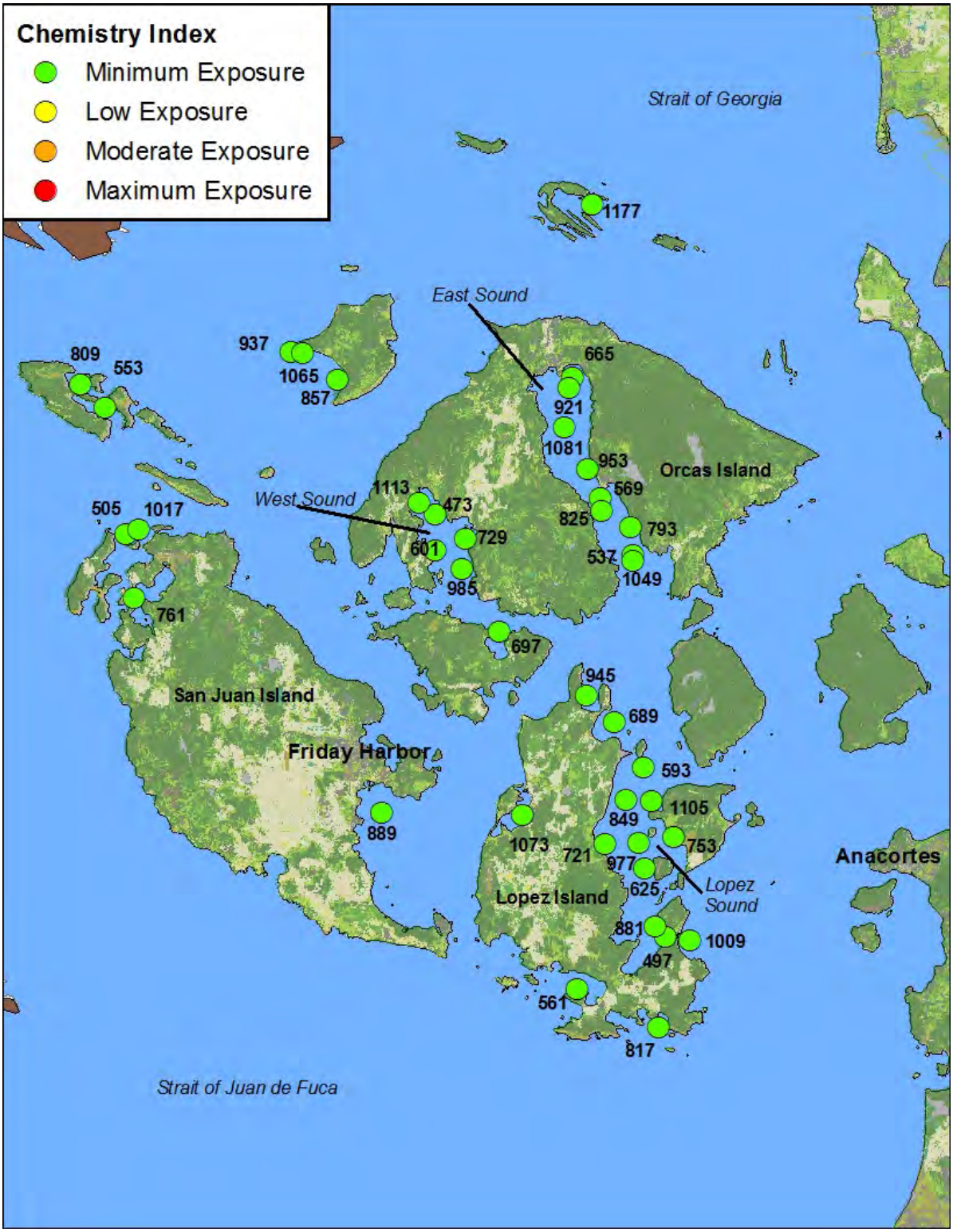
RL = reporting limit; ND = nondetect; CDF = cumulative distribution function
*: Estimated by regression on order statistics (ROS) when nondetects present.
1: All values detected (no nondetects).
2: All nondetect.
3: Nondetects higher than the maximum detect are set to missing values.
4: All nondetects are higher than the maximum detect.
5: Too few detected observations for regression.

Chemical Contamination

No chemicals exceeded (did not meet) the Washington State Sediment Management Standards criteria in the 2012 San Juan Islands monitoring region.

Spatial patterns for mean SQS[1] quotients (SQSQ) in the 2012 survey of the San Juan Islands. *The numbers on the map are the station identifications.*

[1] now called Sediment Cleanup Objective (SCO) instead of Sediment Quality Standard (SQS)



Spatial patterns in Sediment Chemistry Index in the 2012 survey of the San Juan Islands.
The numbers on the map are the station identifications.

Incidence and spatial extent of chemical contamination in the 2012 survey of the San Juan Islands, as measured with the Sediment Chemistry Index.

Sediment Chemistry Index Category	Stations		Area	
	No.	(%)	km^2	(%)
San Juan Islands	40	(100.0)	79.46	(100.0)
Minimum exposure	40	(100.0)	79.46	(100.0)
Low exposure	0	(0.0)	0.0	(0.0)
Moderate exposure	0	(0.0)	0.0	(0.0)
Maximum exposure	0	(0.0)	0.0	(0.0)

Comparisons with Baseline

Changes in contaminant concentrations and Sediment Chemistry Index results (unweighted[1] and weighted[2] by area) from 2002-2003 to 2012.

↑ = increase, ↓ = decrease, -- = no change, ? = significant only at α = 0.10

Parameter	Change from 2002-2003 to 2012
Metals	
Arsenic	--
Cadmium	↓
Chromium	↑
Copper	--
Lead	--
Mercury	--
Nickel	--
Selenium	↓
Silver	--
Tin	--
Zinc	--
Organics	
BNAs	
Carbazole	↑
Cholesterol	↓
Dibenzofuran	↑
All other BNAs	too few detected values to test
PAHs	
1,6,7-Trimethylnaphthalene	↑
1-Methylnaphthalene	↑
1-Methylphenanthrene	mixed
2,6-Dimethylnaphthalene	↑
2-Methylnaphthalene	↑
2-Methylphenanthrene	--
Acenaphthene	↑
Acenaphthylene	↑?
Anthracene	↑
Benzo(a)anthracene	--
Benzo(a)pyrene	--
Benzo(b)fluoranthene	↑
Benzo[e]pyrene	--
Benzo(g,h,i)perylene	--
Benzo(k)fluoranthene	↓
Biphenyl	↑
Chrysene	↑
Dibenzo(a,h)anthracene	--

Parameter	Change from 2002-2003 to 2012
Dibenzothiophene	↑?
Fluoranthene	--
Fluorene	↑
Indeno(1,2,3-c,d)pyrene	↑
Naphthalene	↑
Perylene	--
Phenanthrene	--
Pyrene	mixed
Retene	↑?
Total Benzofluoranthenes	--
PCBs	
Individual Aroclors	too few detected values to test
Individual PCB congeners	too few detected values to test
Pesticides	
Individual pesticides	too few detected values to test

[1] Medians (unweighted) compared by Kruskal-Wallis test when nonnondetects are present, or by the Generalized Wilcoxon test when nondetects are present ($\alpha = 0.05$).

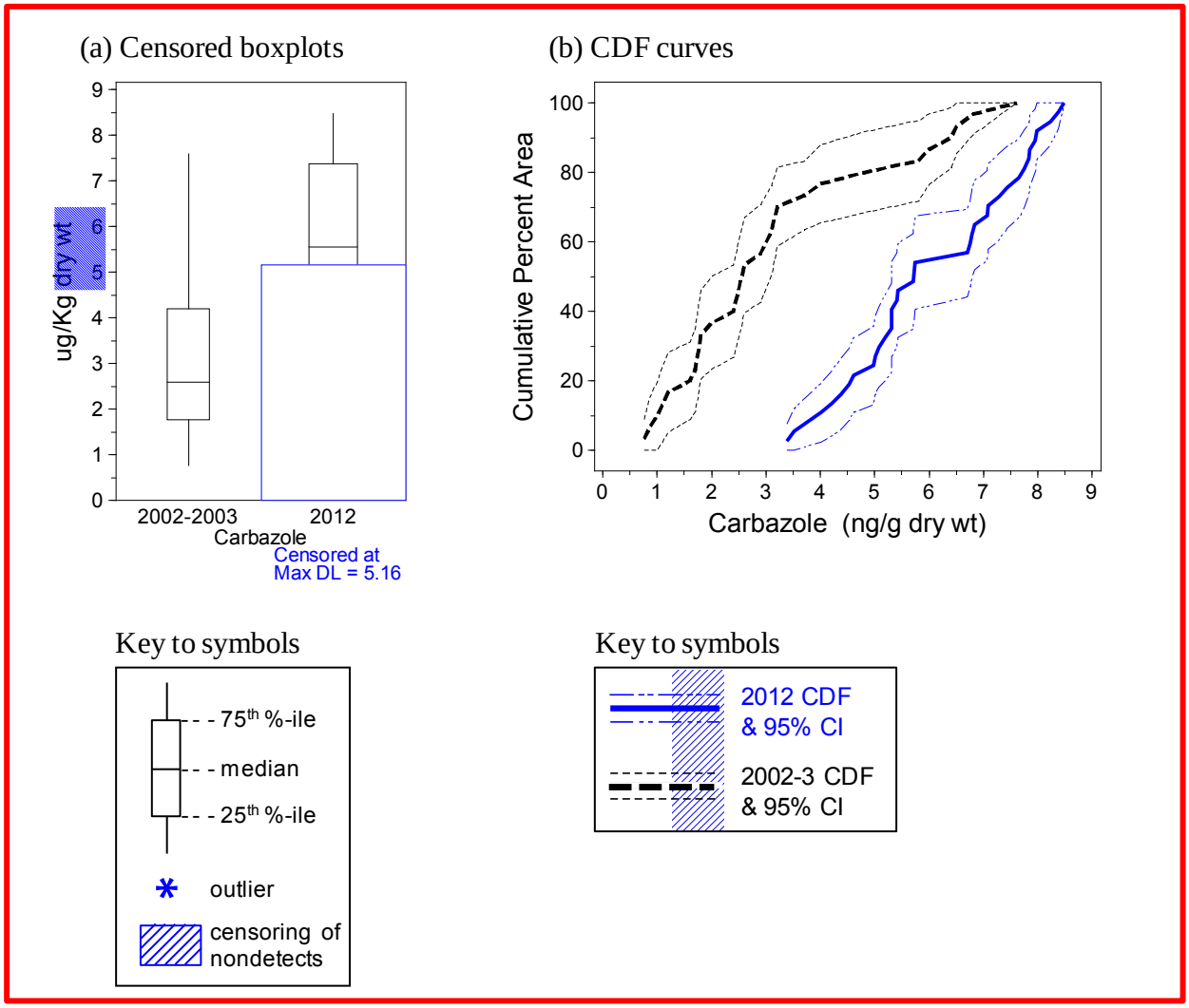
[2] CDFs (weighted) compared by Wald F test ($\alpha = 0.05$).

Comparison of contaminant concentrations in sediments sampled in the 2002-2003 and 2012 surveys of the San Juan Islands. Graphical displays are given below for the Sediment Chemistry Index (SCI), metals, BNAs, and PAHs. The graphical displays include two types of graphs:

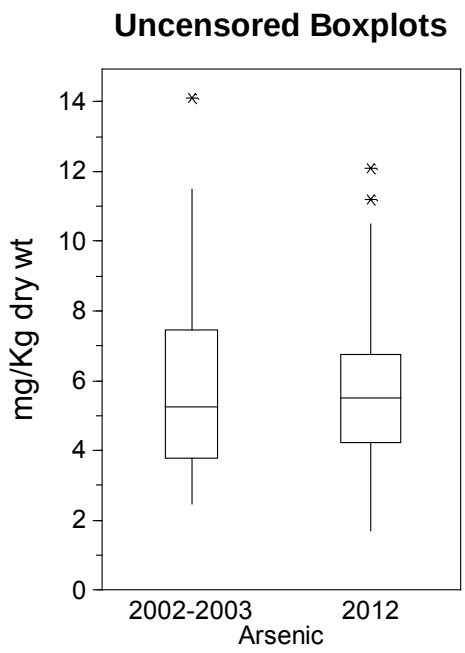
(a) Censored boxplots display the distributions of the data unweighted by sample area.
(b) Cumulative distribution function (CDF) curves display the cumulative distributions of the data weighted by sample area. CDFs are not given when there were too few detected values.

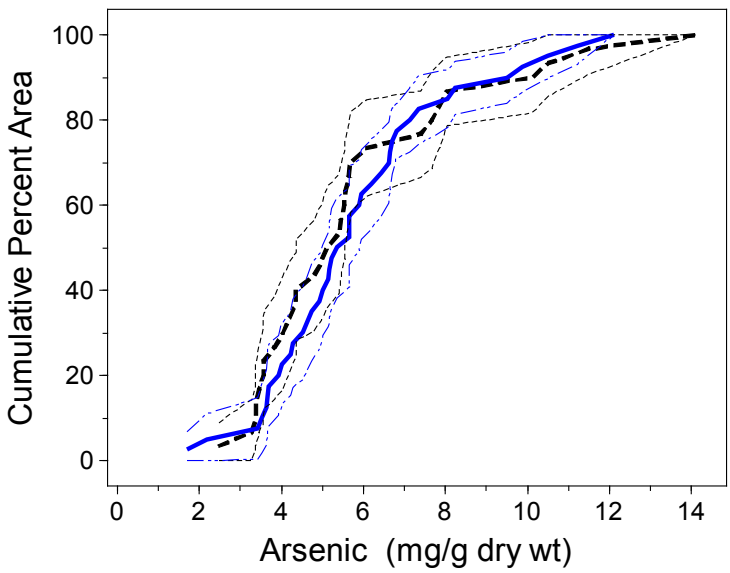
Note 1: 95% confidence intervals (CI) are shown in both graph types. Non-overlapping confidence intervals indicate statistically significant differences. P-values from the Wald F test that are ≤0.05 indicate that CDFs are statistically significantly different.

Note 2: Missing CDF curves indicate insufficient detected values to calculate curves and CIs.

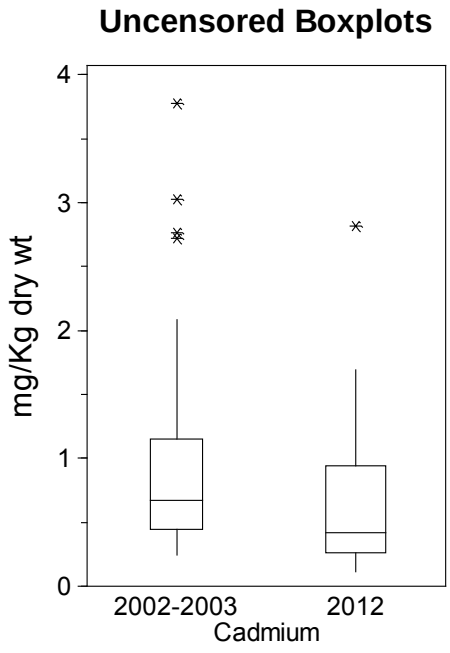


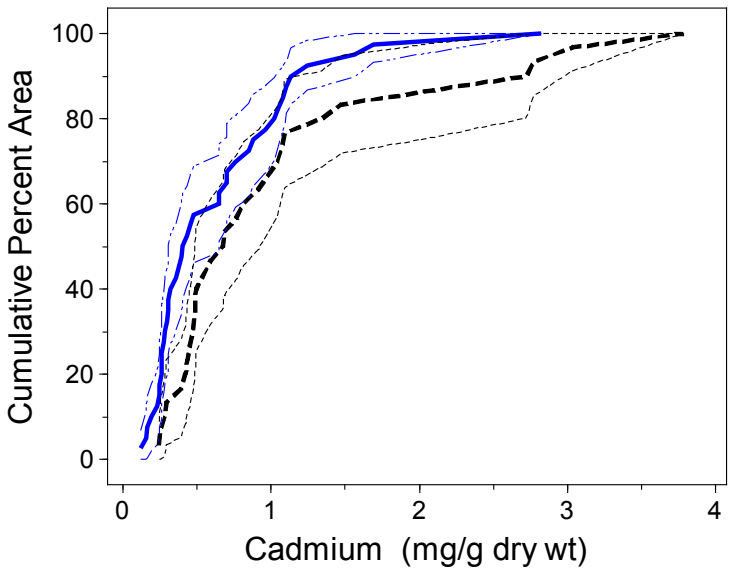
Arsenic



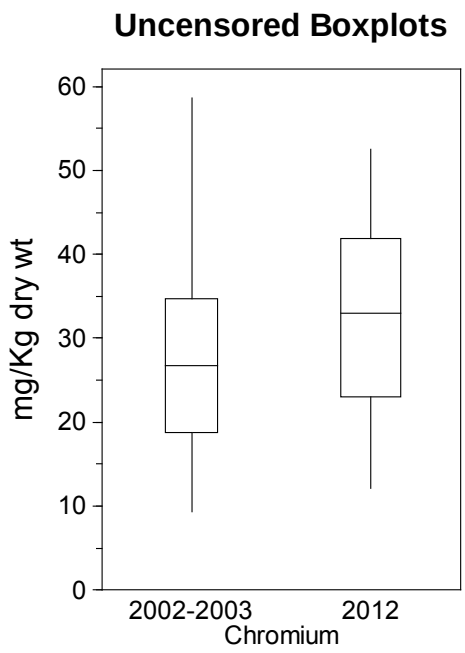


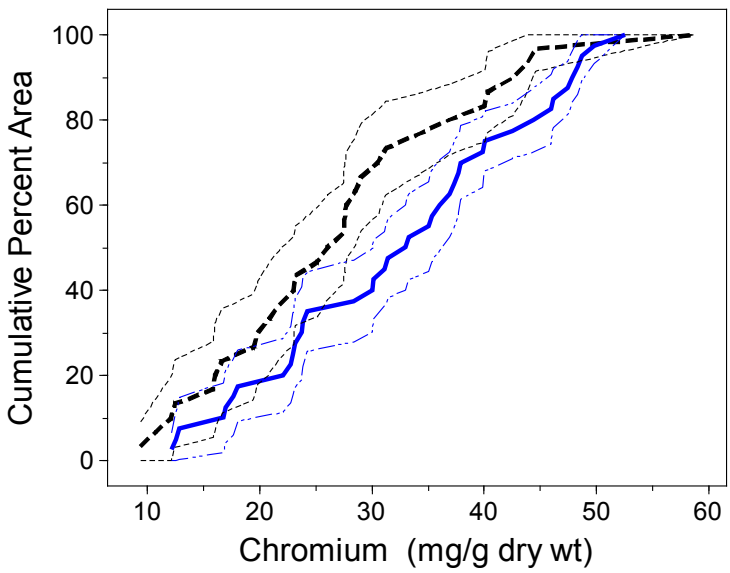
Cadmium



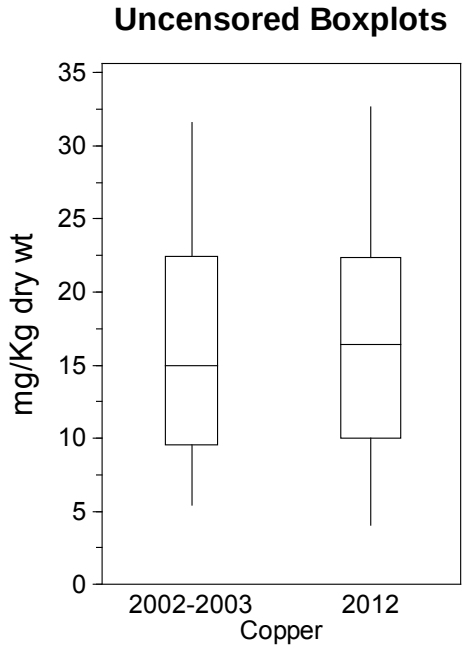


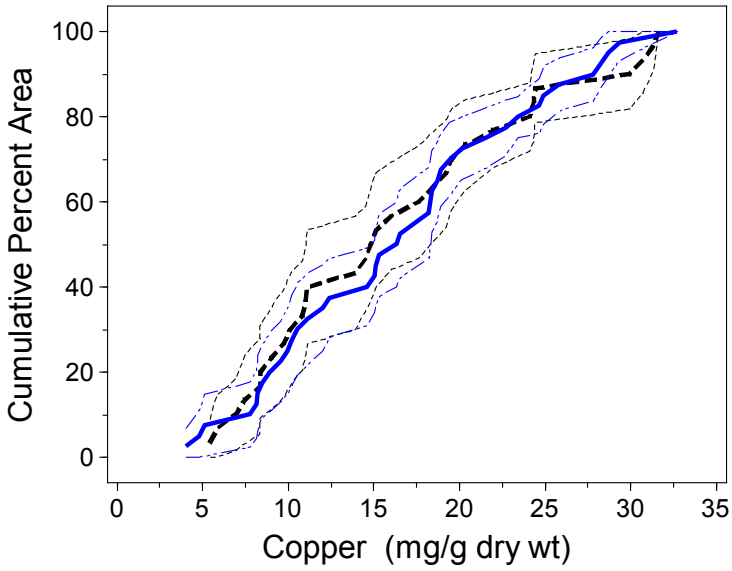
Chromium



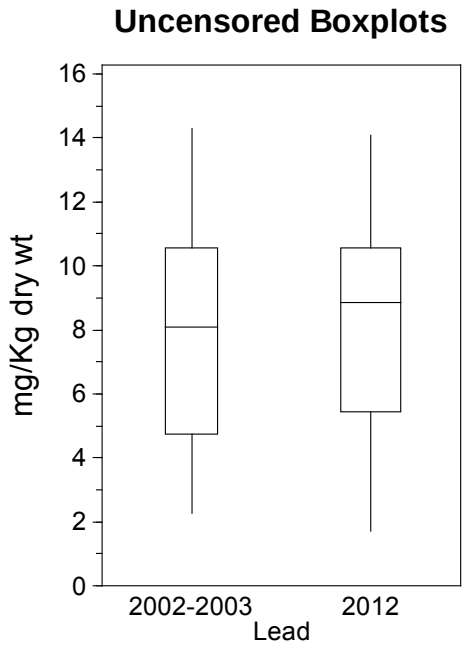


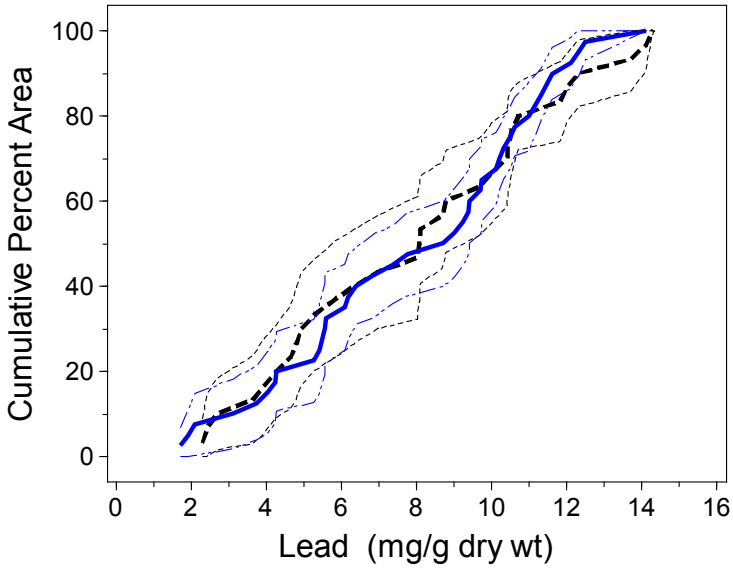
Copper



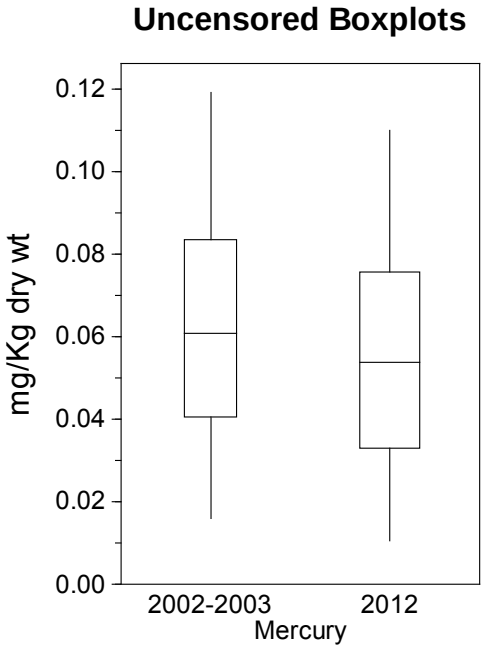


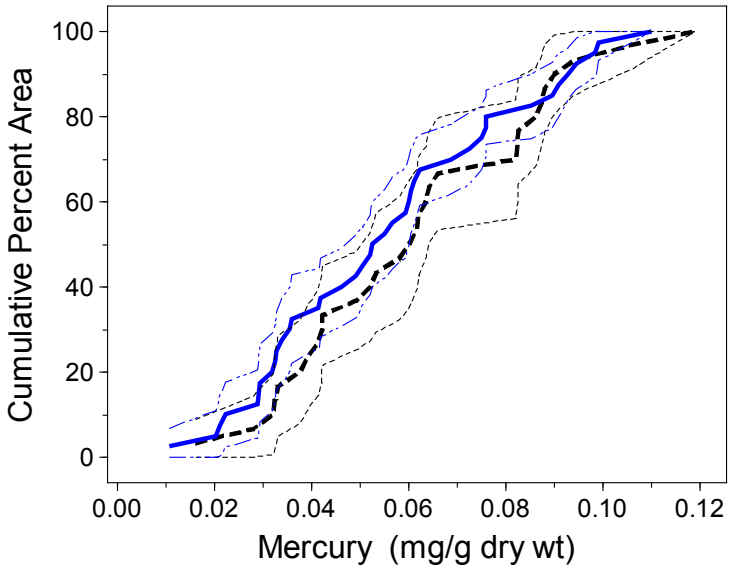
Lead



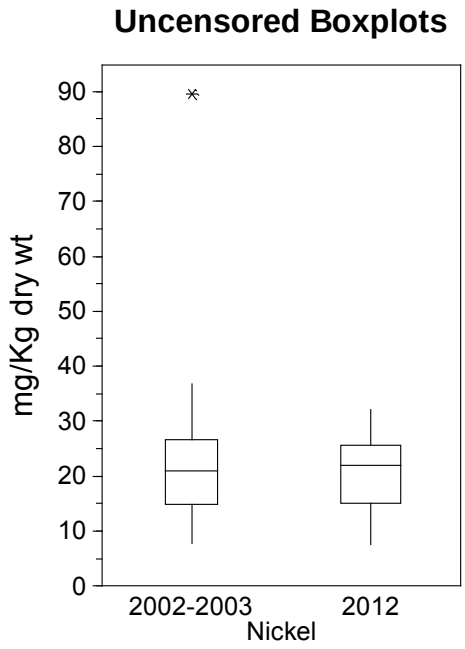


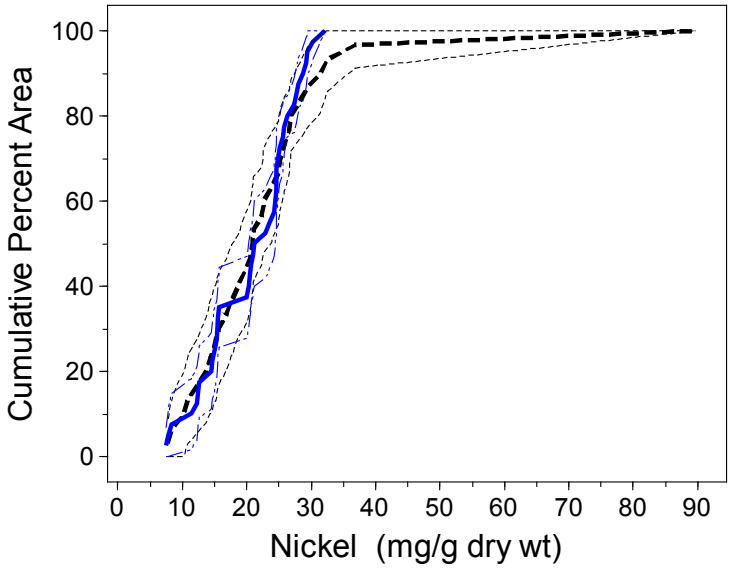
Mercury



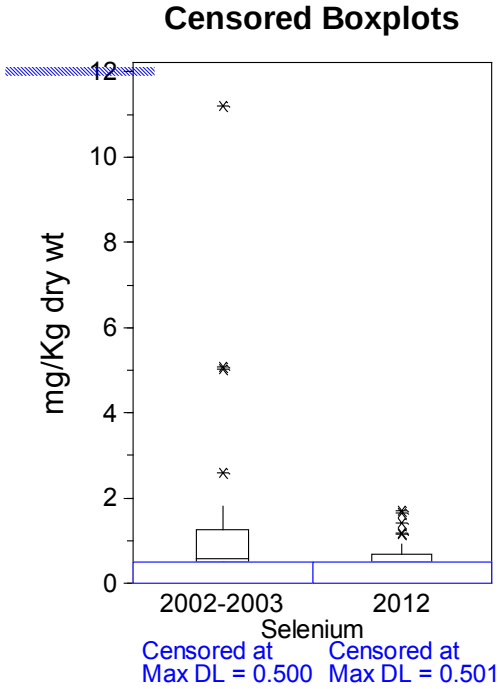


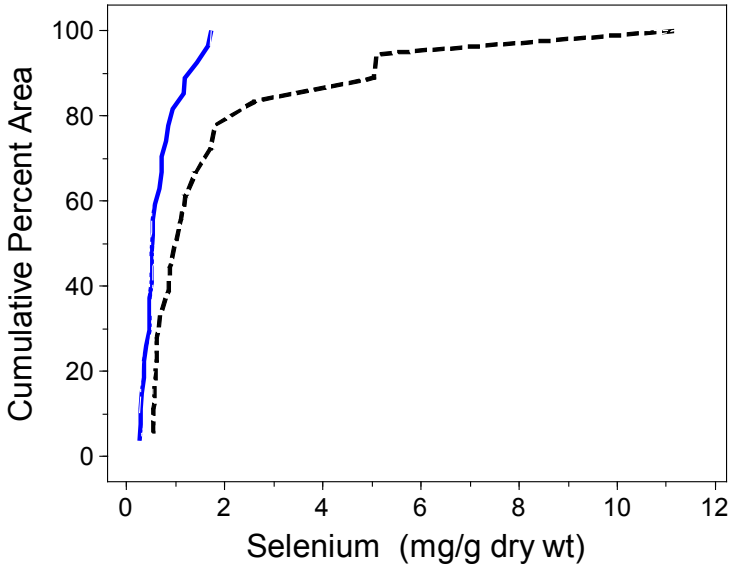
Nickel



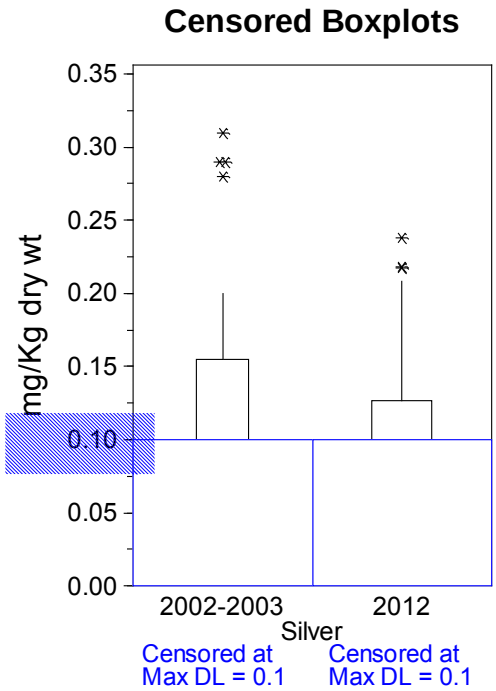


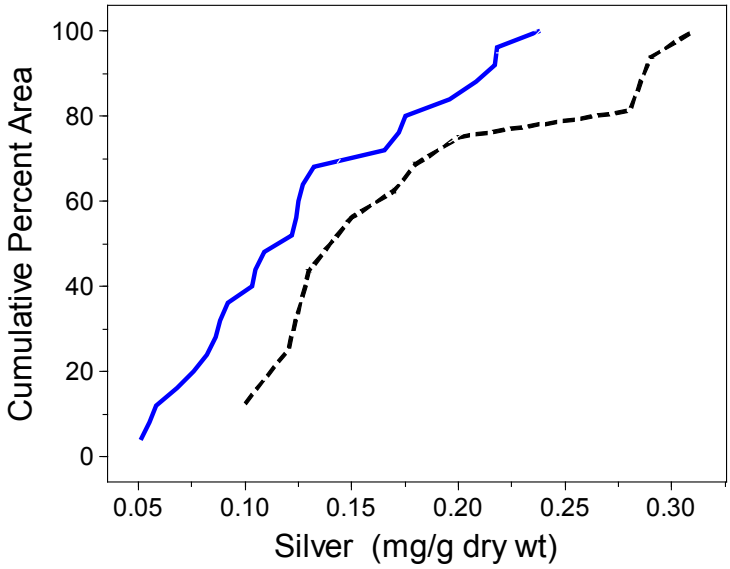
Selenium



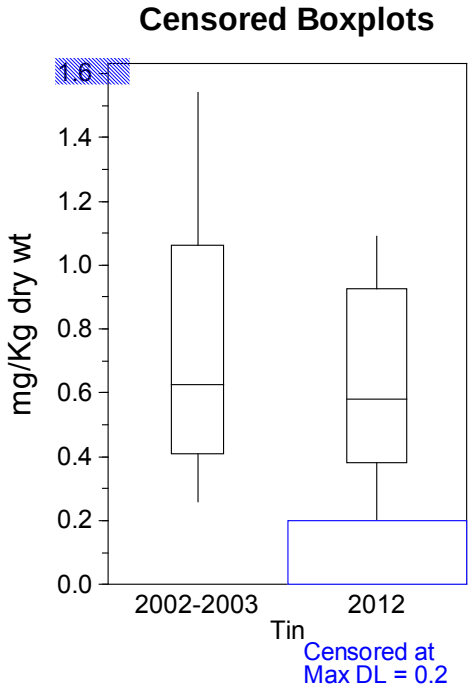


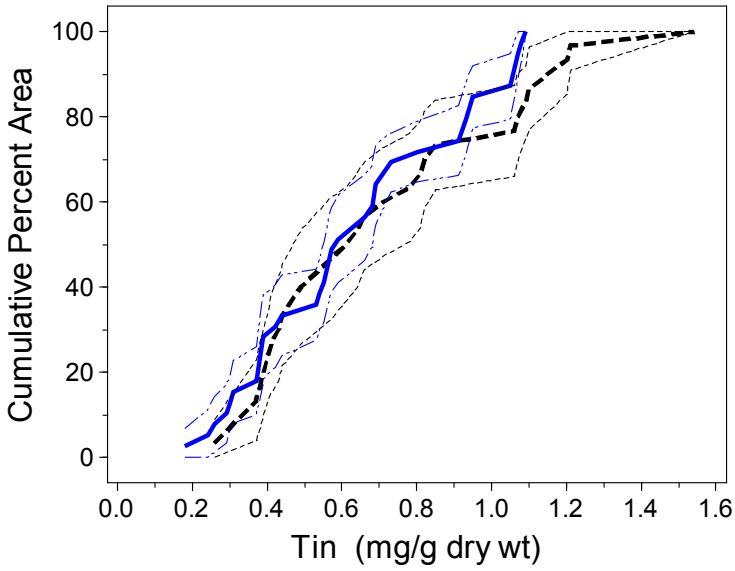
Silver


Censored Boxplots
mg/Kg dry wt
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2002-2003
2012
Silver
Censored at
Max DL = 0.1
Censored at
Max DL = 0.1

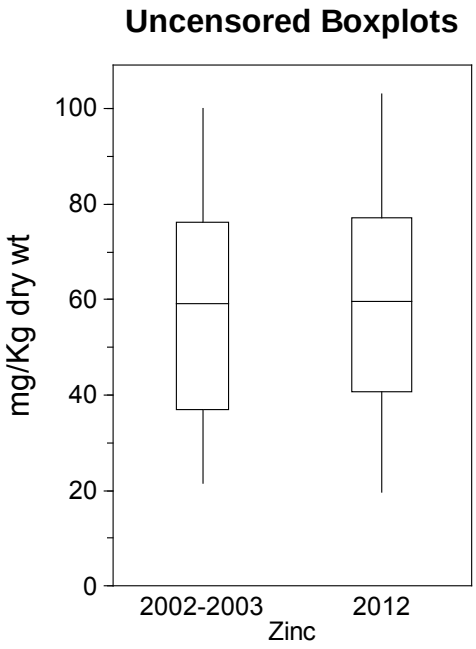

Cumulative Percent Area
100
80
60
40
20
0
0.05
0.10
0.15
0.20
0.25
0.30
Silver (mg/g dry wt)

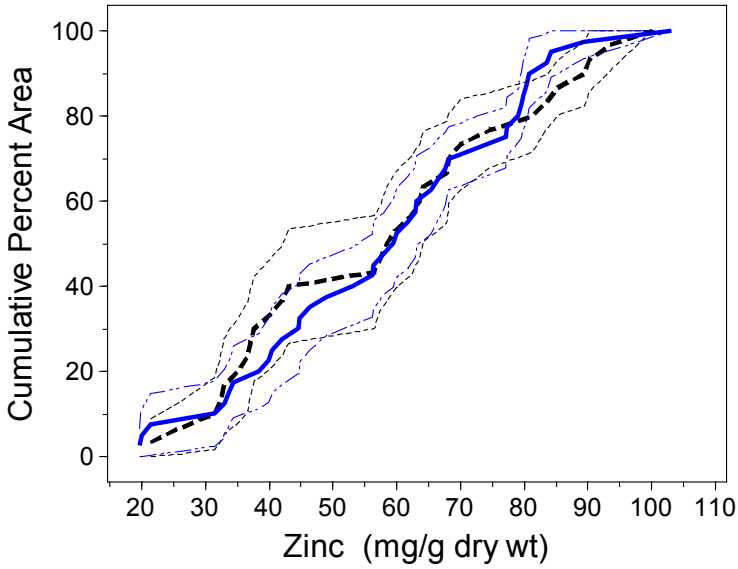
Tin


Censored Boxplots
mg/Kg dry wt
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2002-2003
2012
Tin
Censored at
Max DL = 0.2

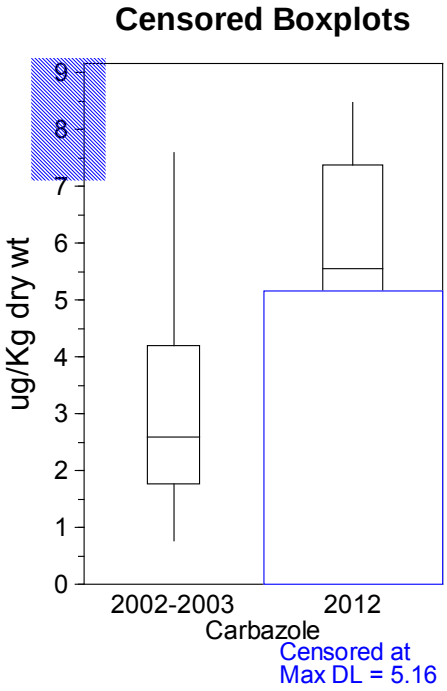

Cumulative Percent Area
100
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Tin (mg/g dry wt)

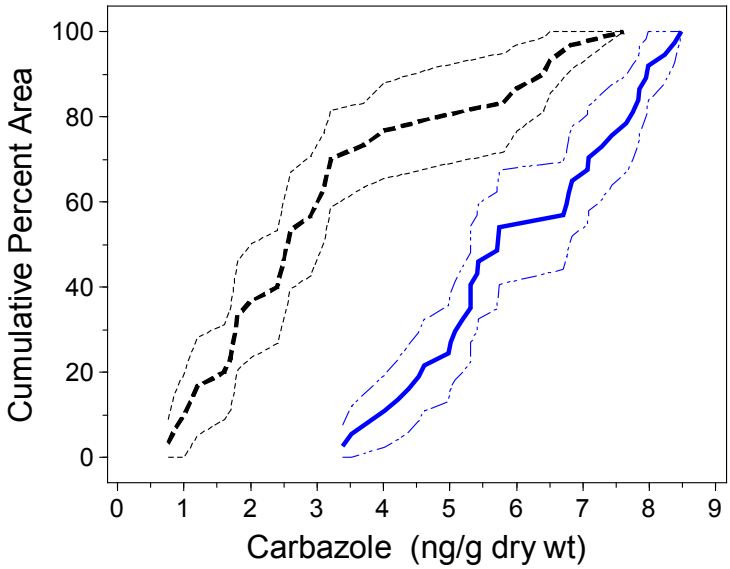
Zinc



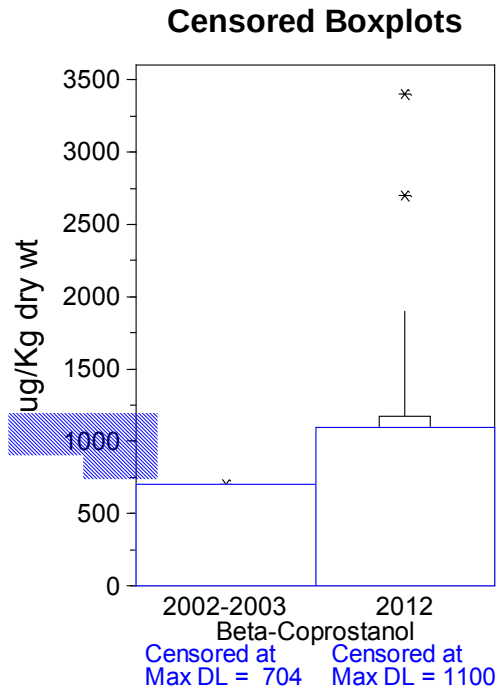


Carbazole

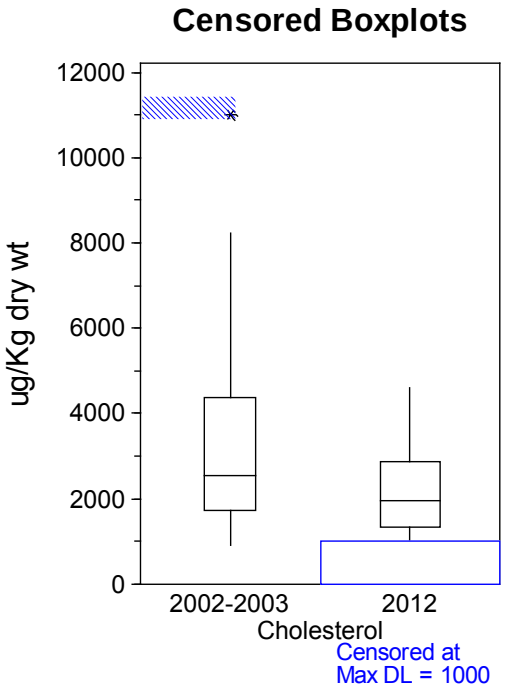


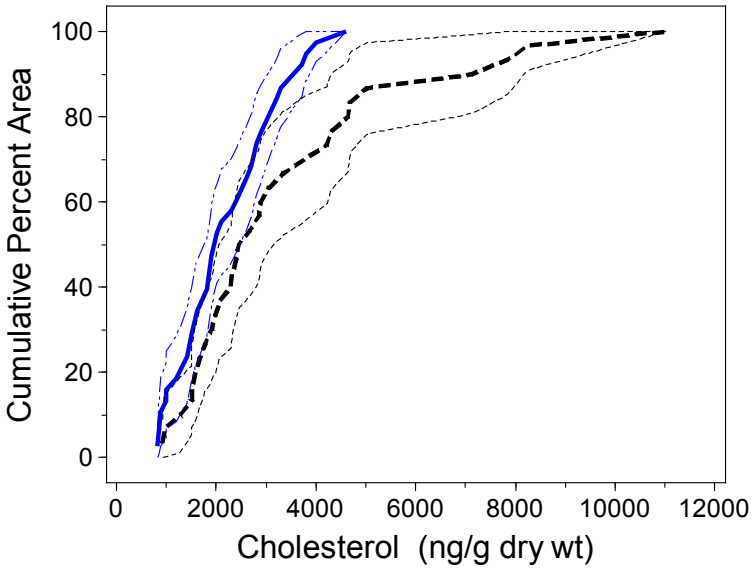


Beta-Coprostanol

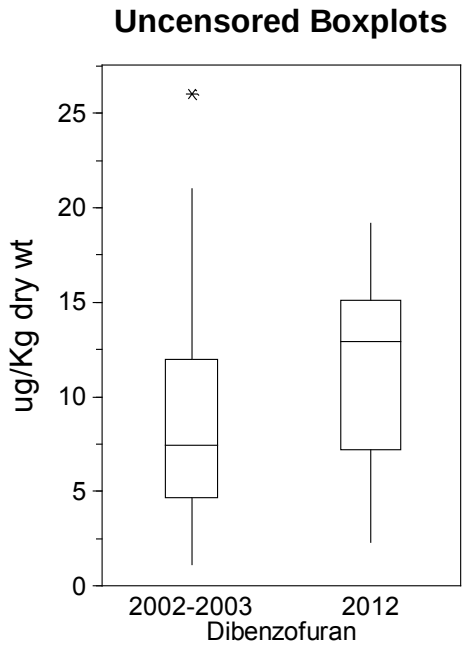


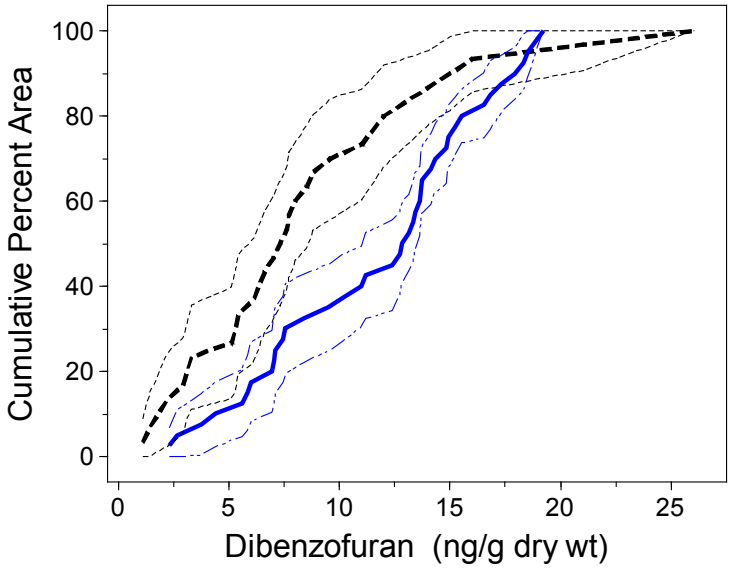
Cholesterol



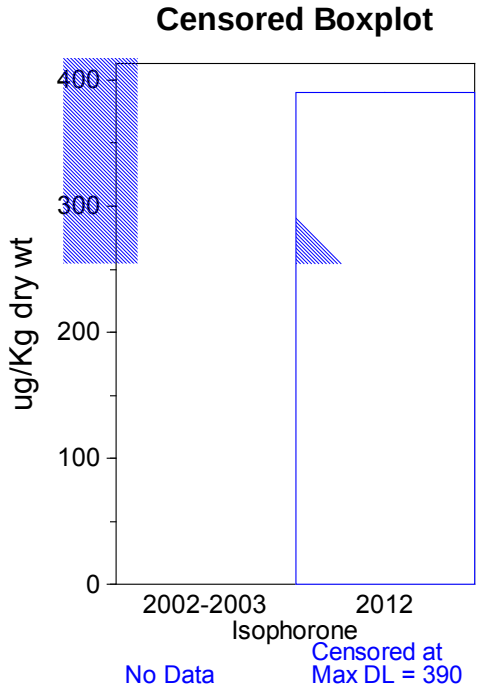


Dibenzofuran

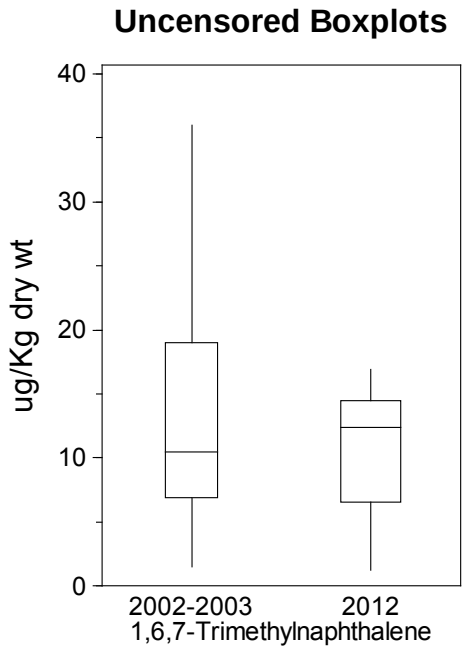


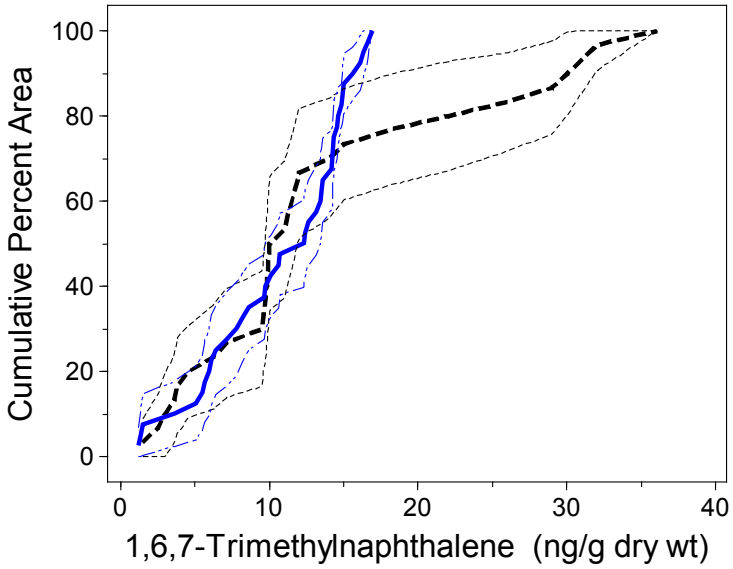


Isophorone

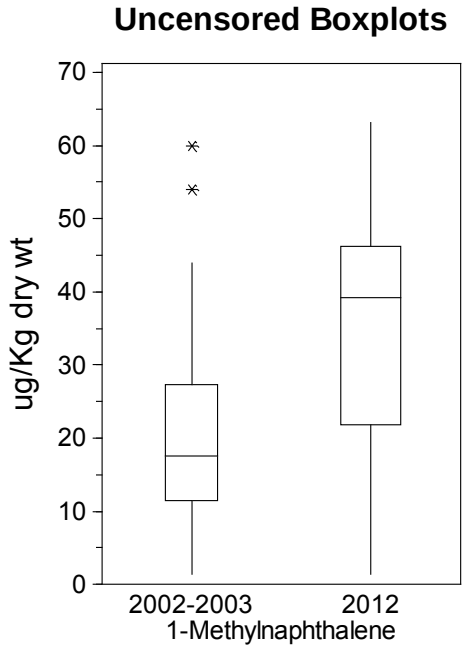


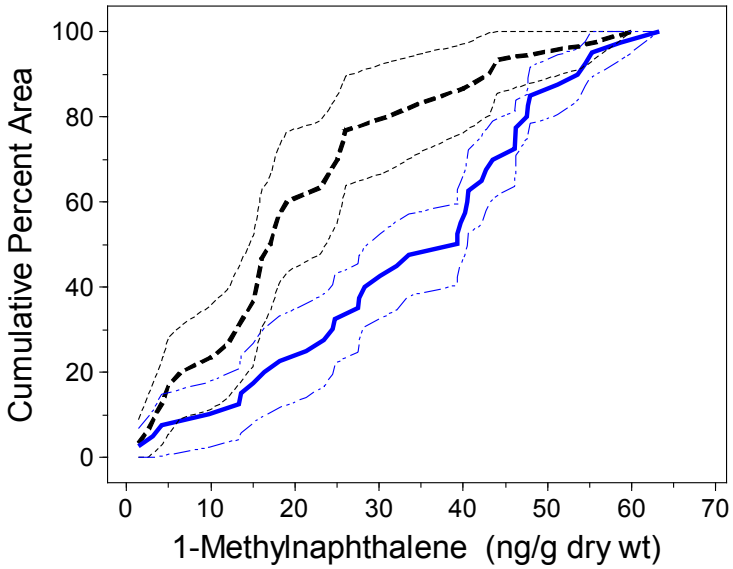
1,6,7-Trimethylnaphthalene



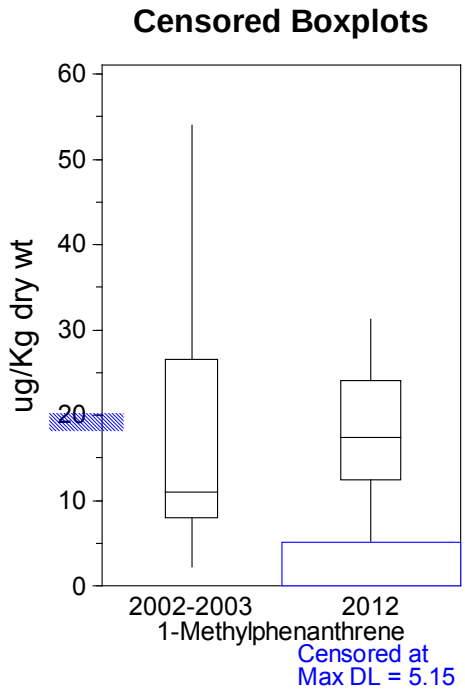


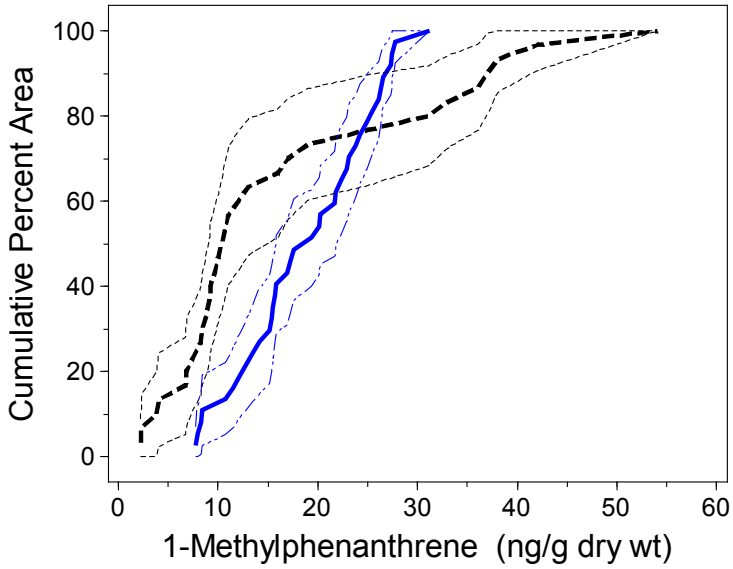
1-Methylnaphthalene



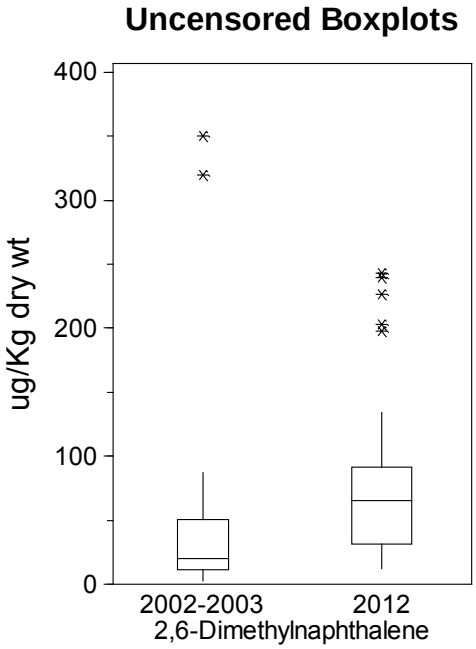


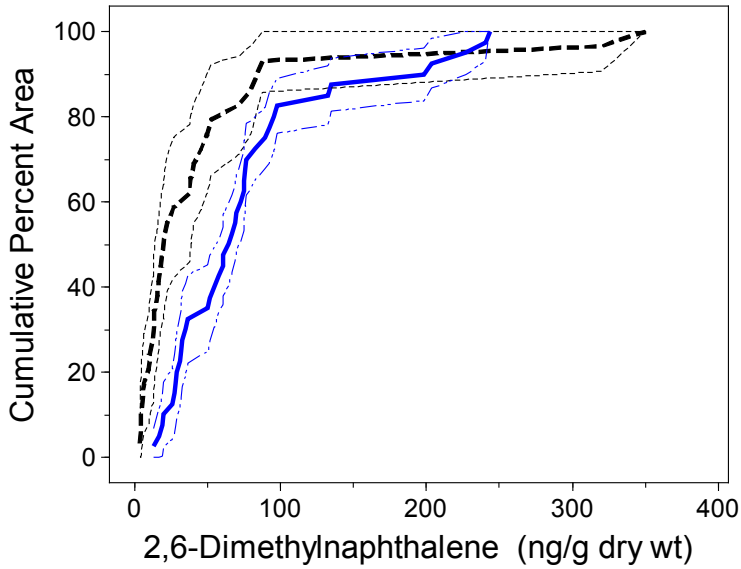
1-Methylphenanthrene





2,6-Dimethylnaphthalene





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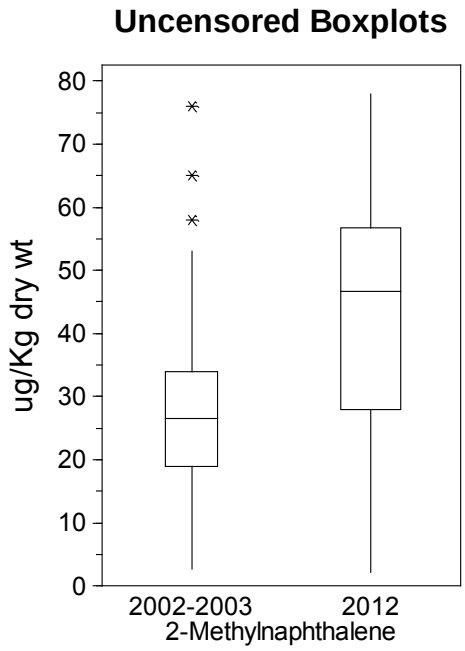

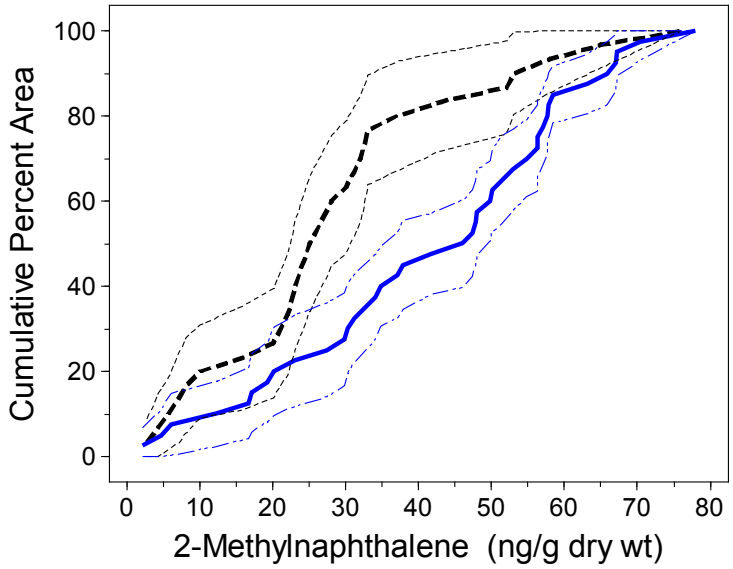

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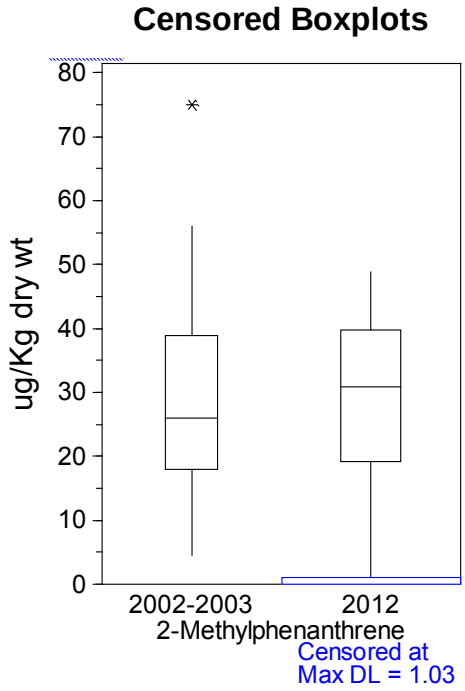
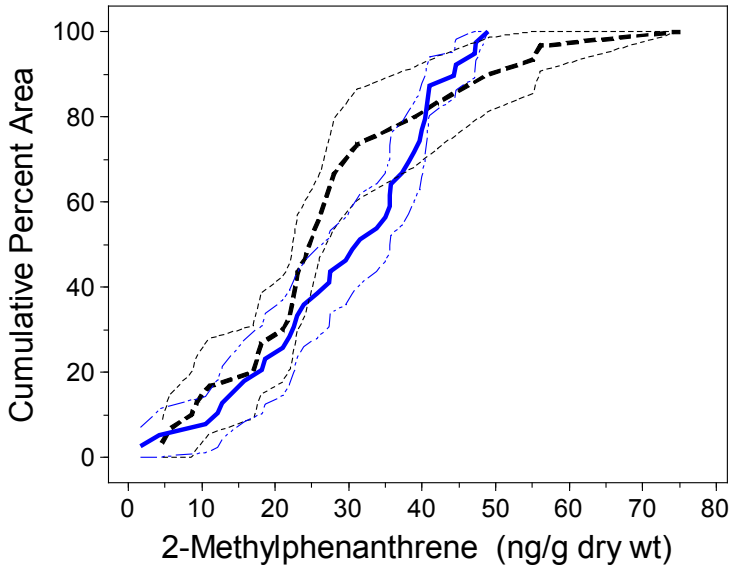
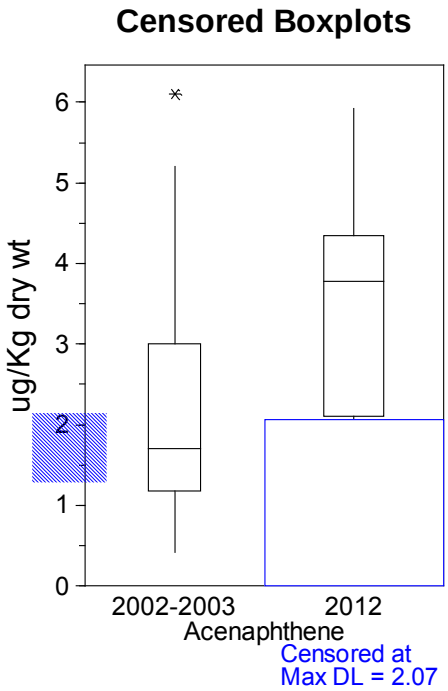
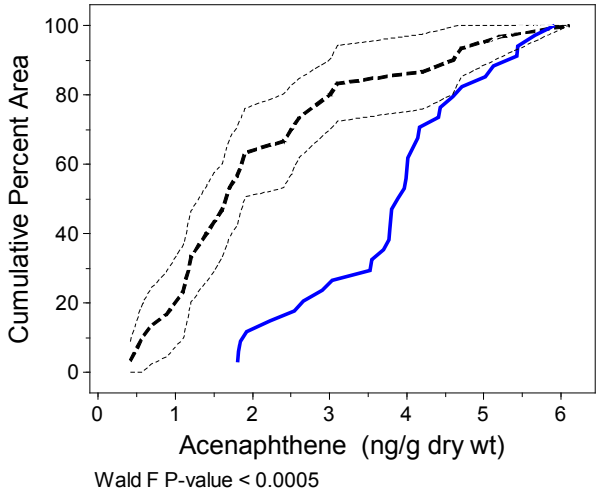


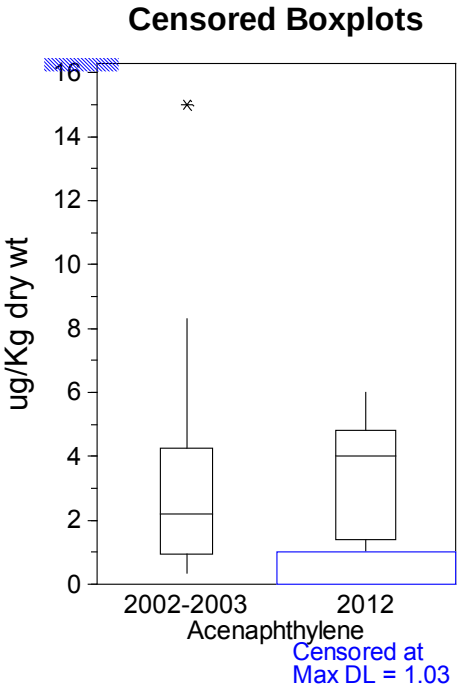


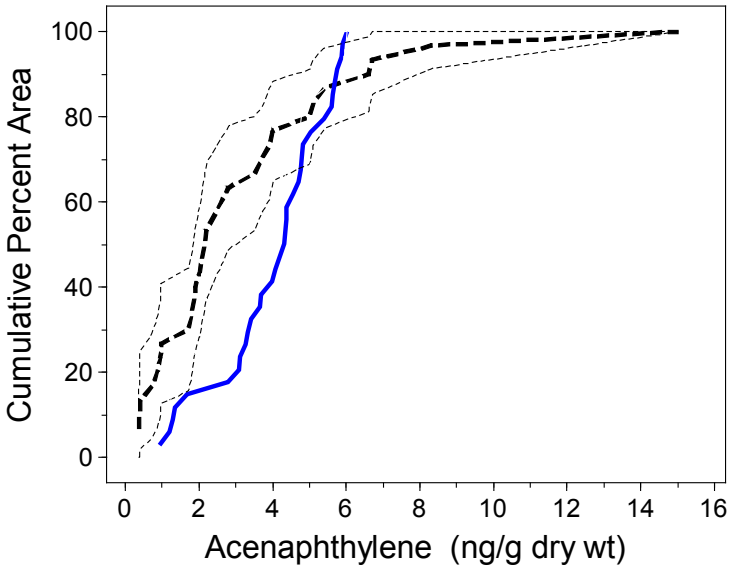
Acenaphthene



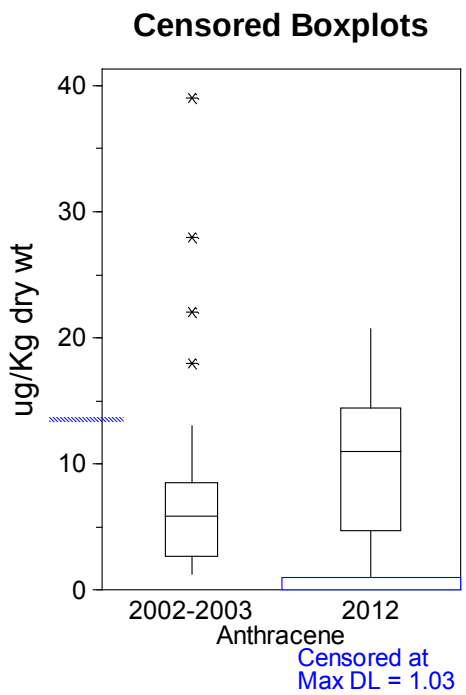


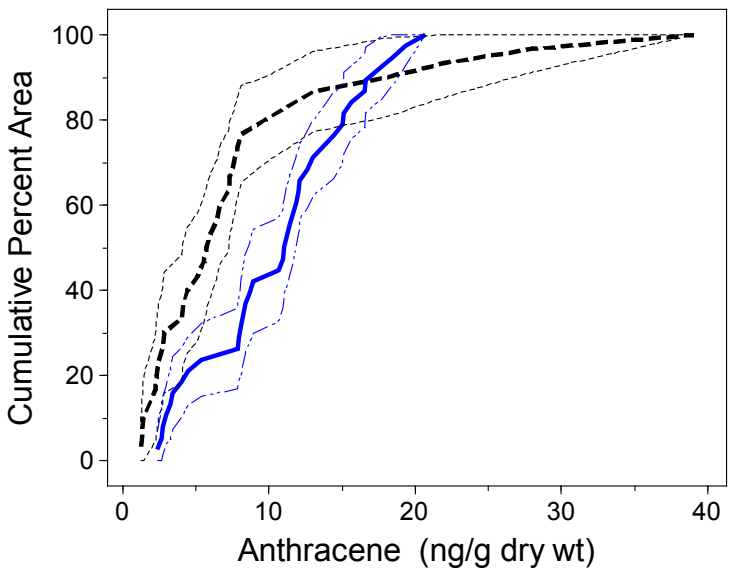
Acenaphthylene



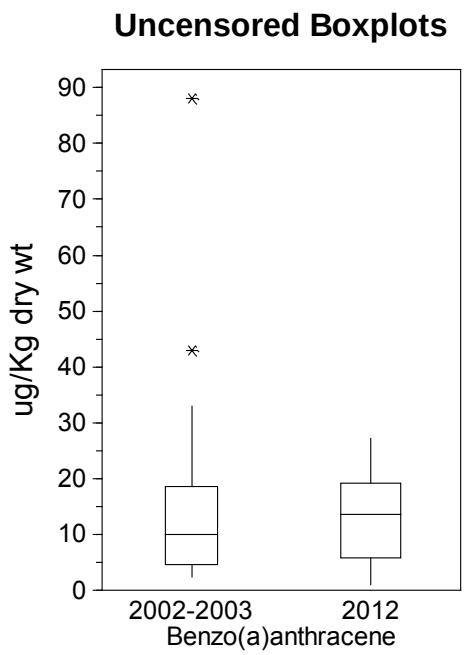


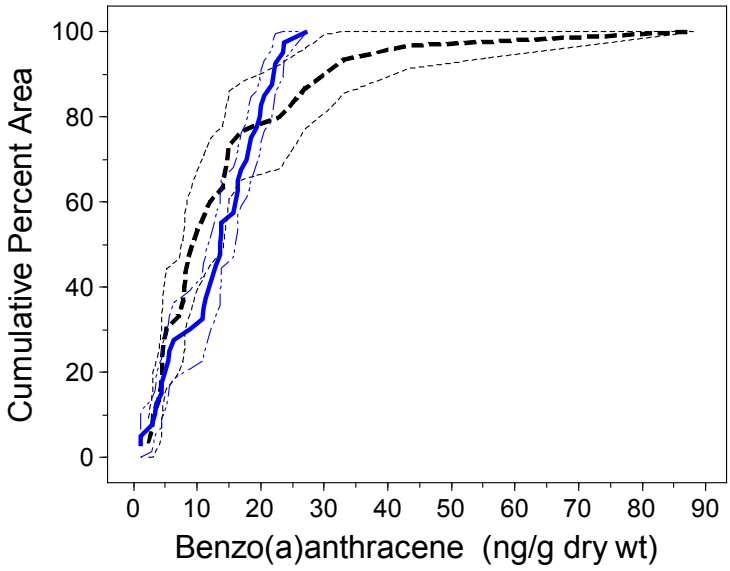
Anthracene



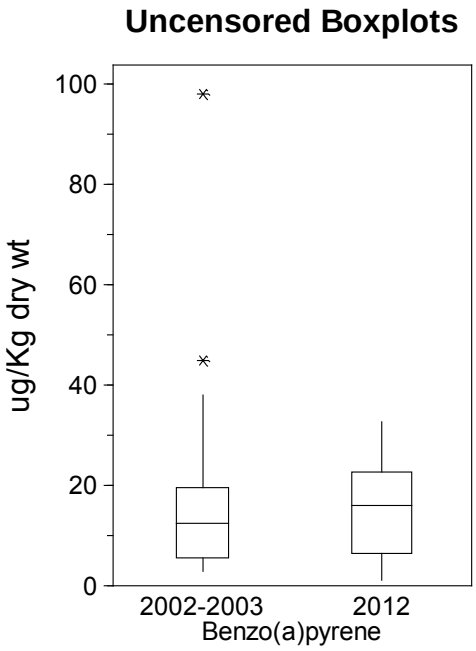


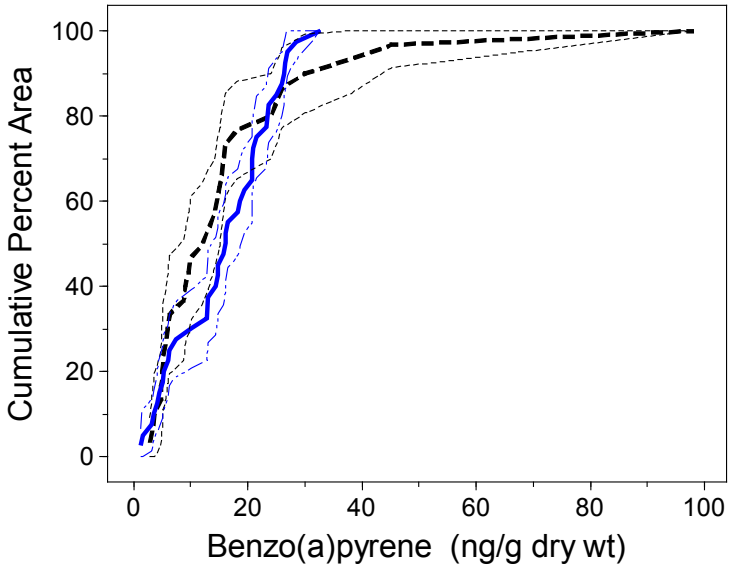
Benzo(a)anthracene



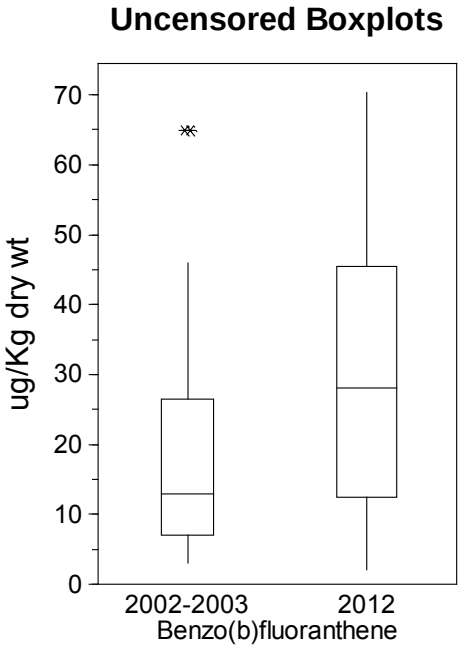


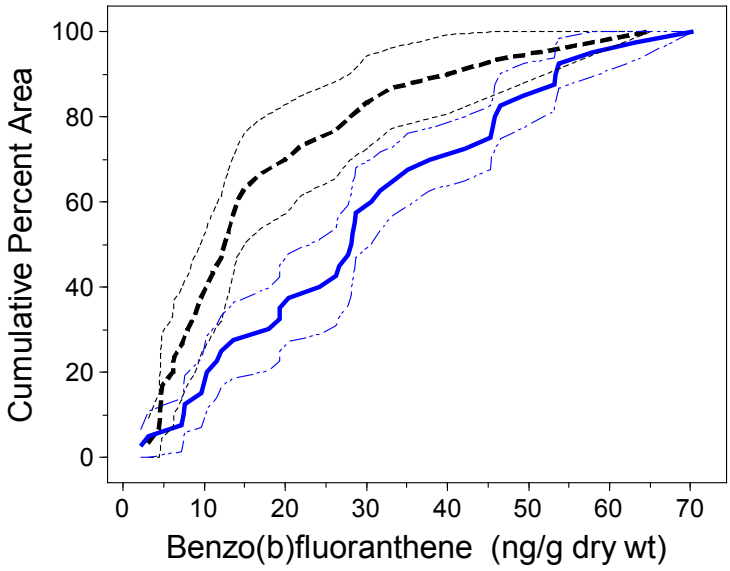
Benzo(a)pyrene



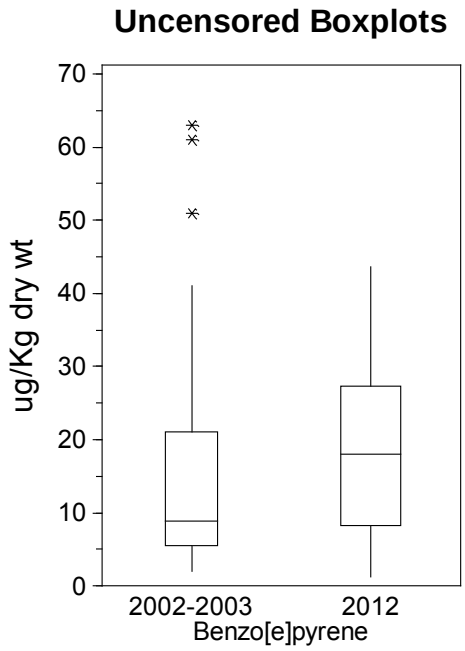


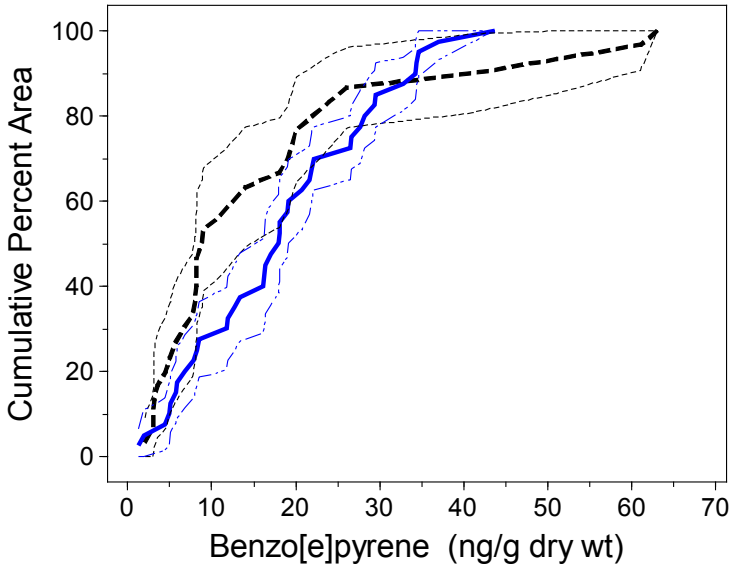
Benzo(b)fluoranthene



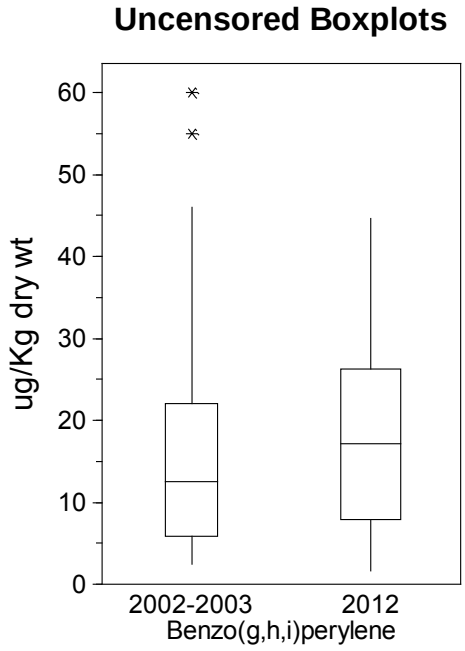


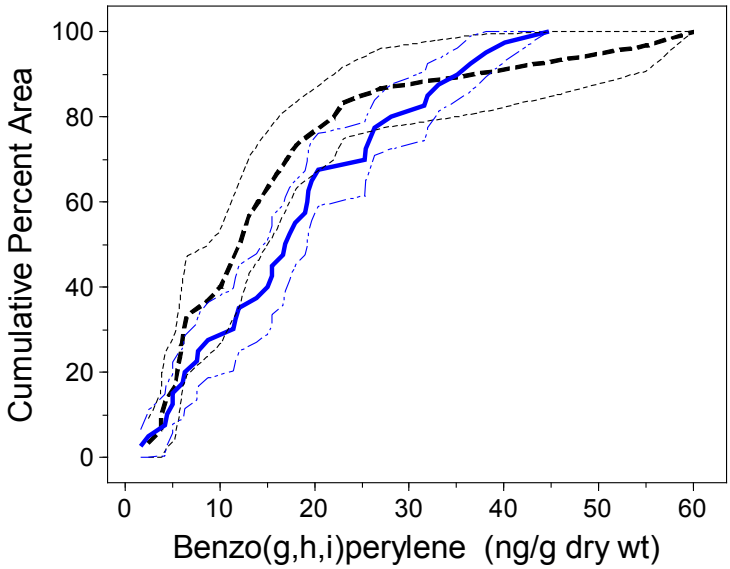
Benzo[e]pyrene



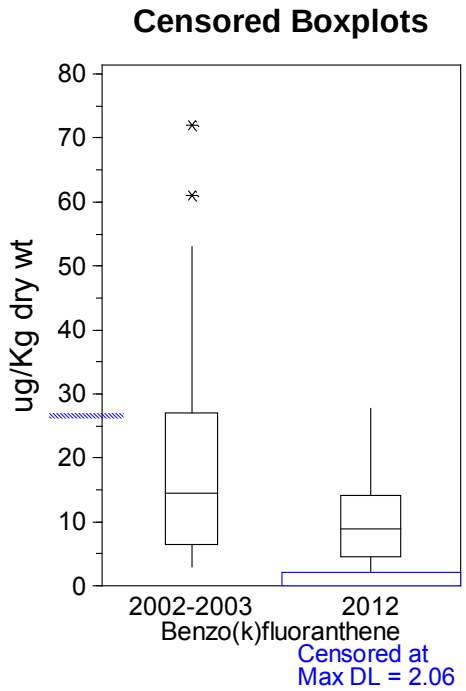


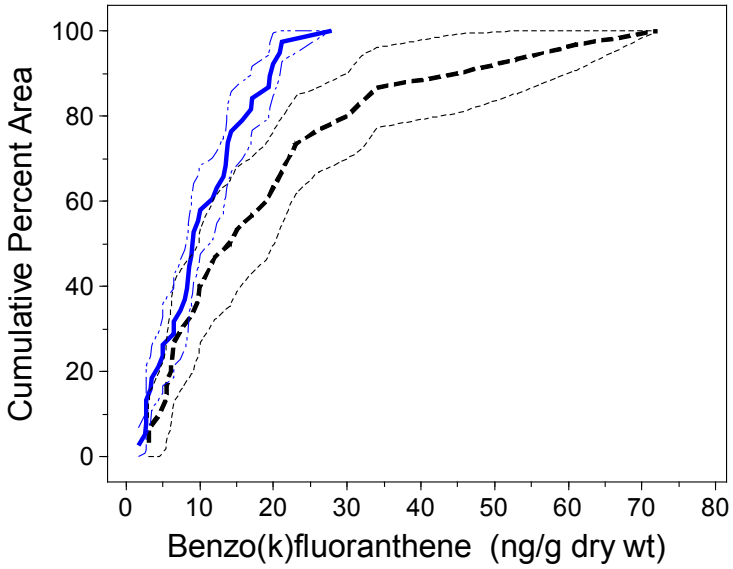
Benzo(g,h,i)perylene



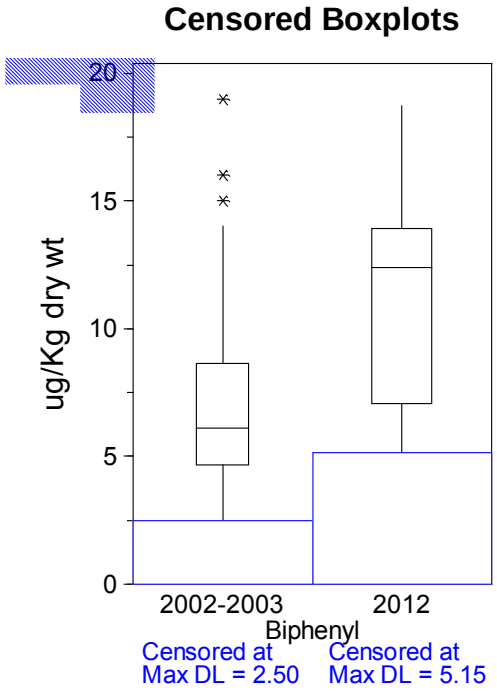


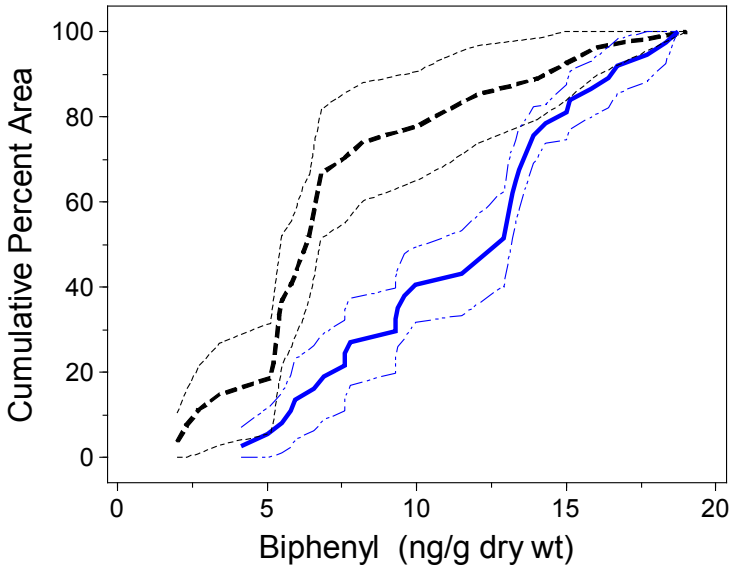
Benzo(k)fluoranthene



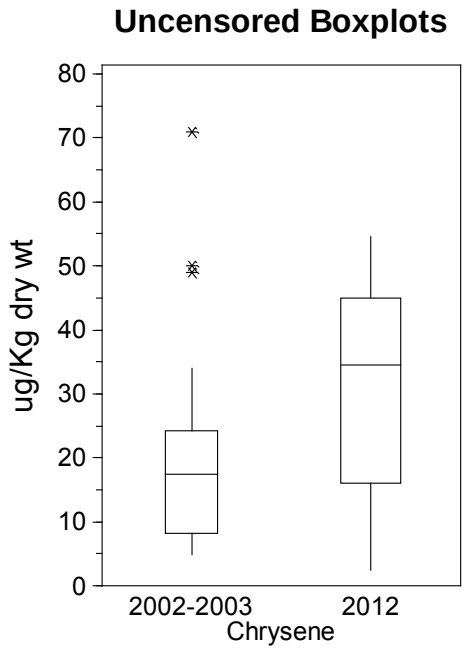


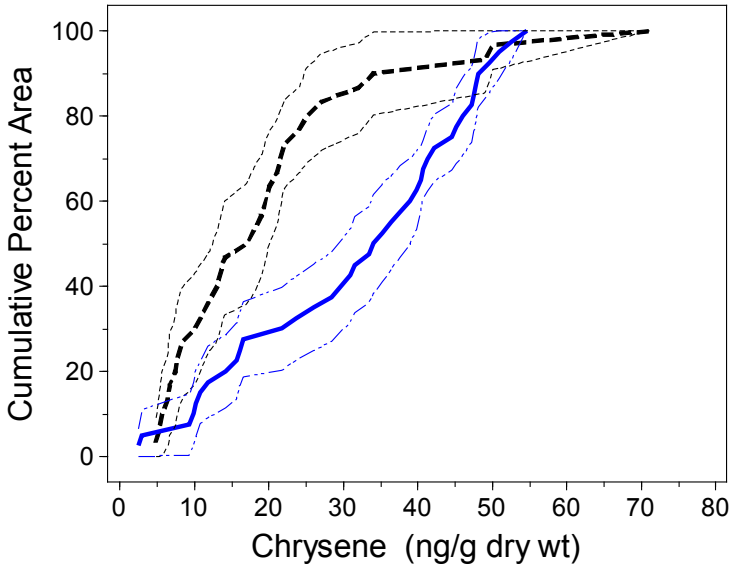
Biphenyl



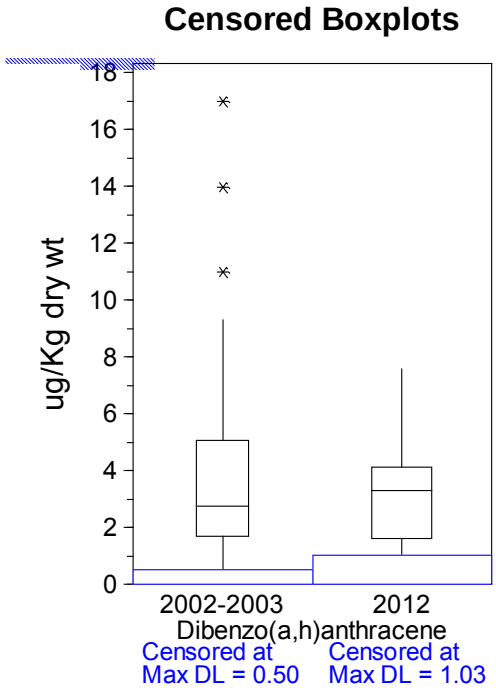


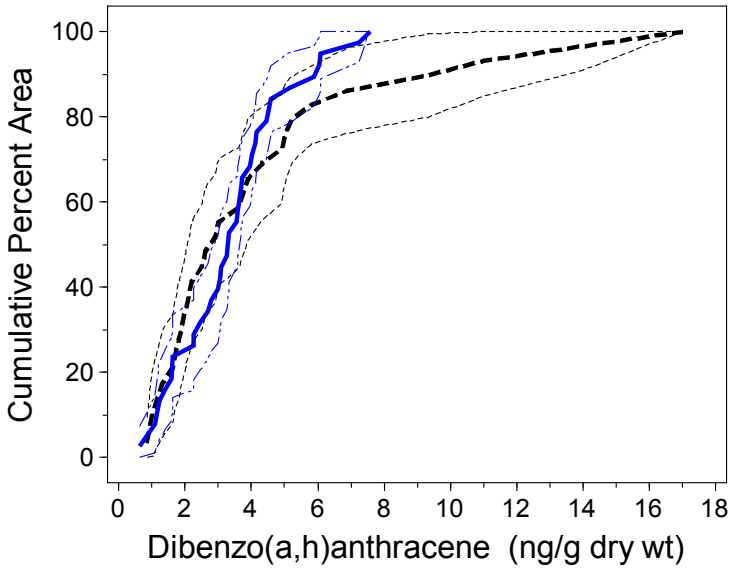
Chrysene



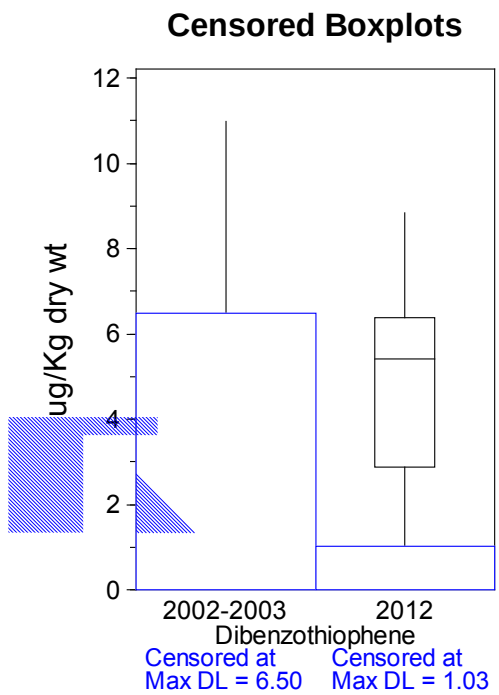


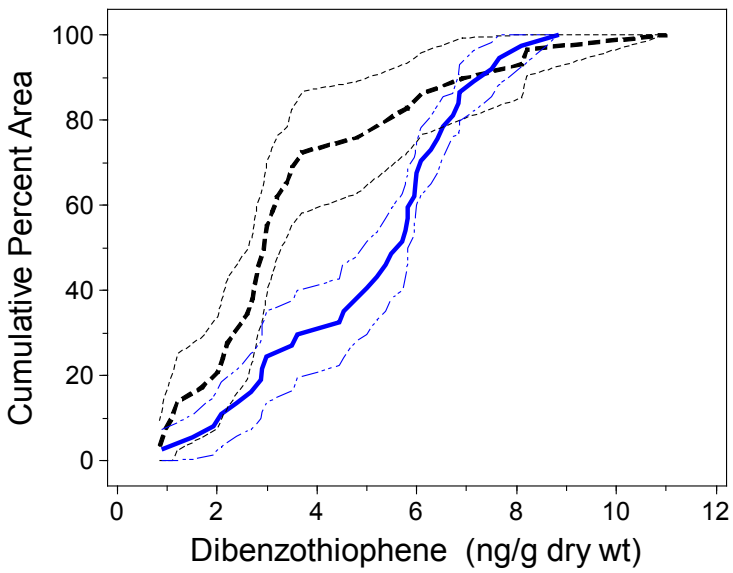
Dibenzo(a,h)anthracene



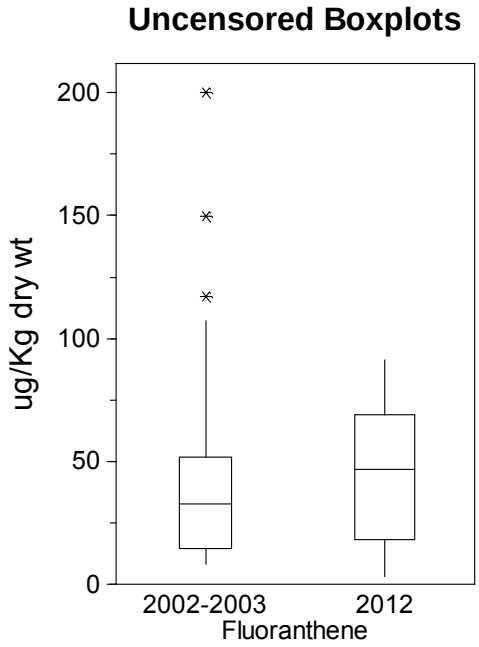


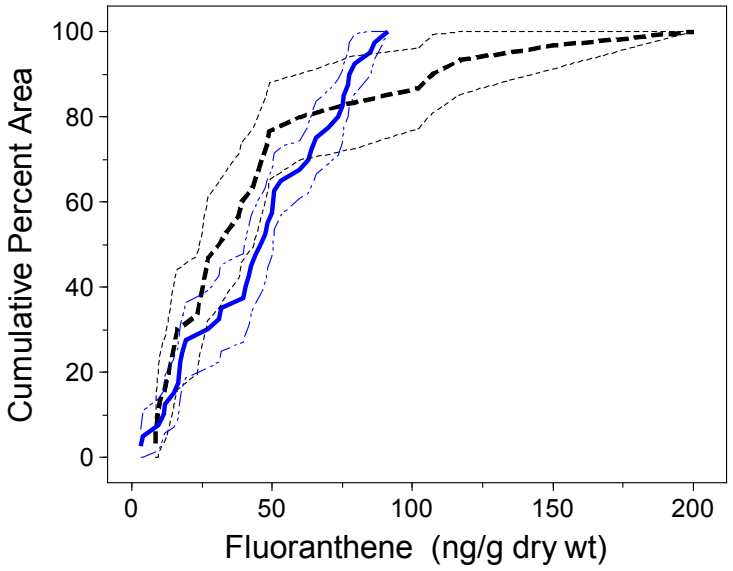
Dibenzothiophene





Fluoranthene





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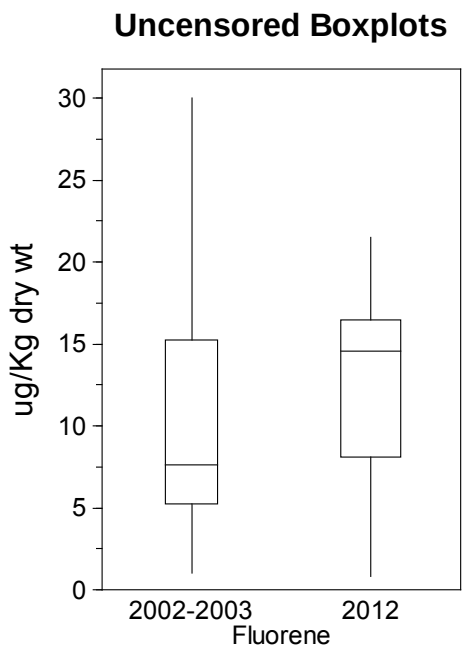
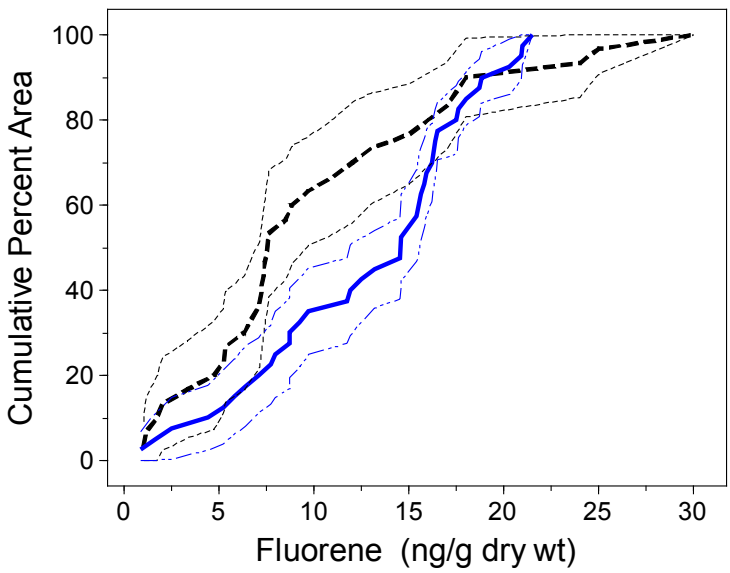
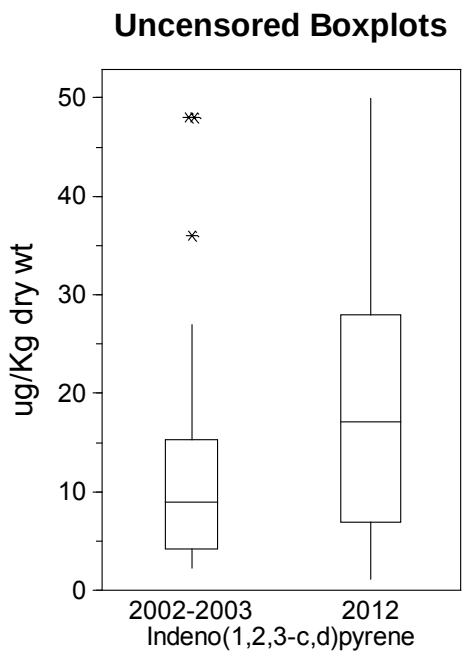
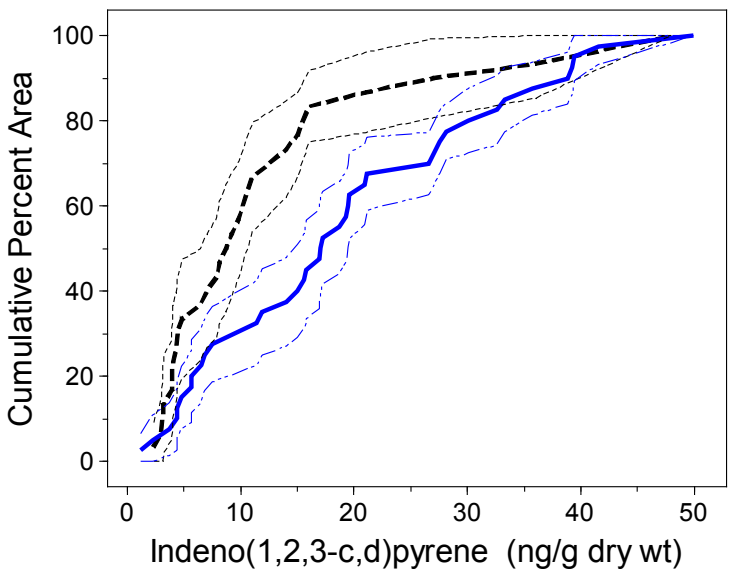


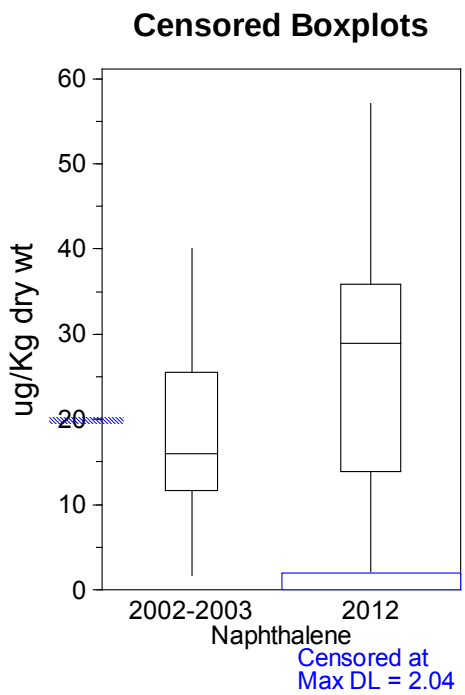


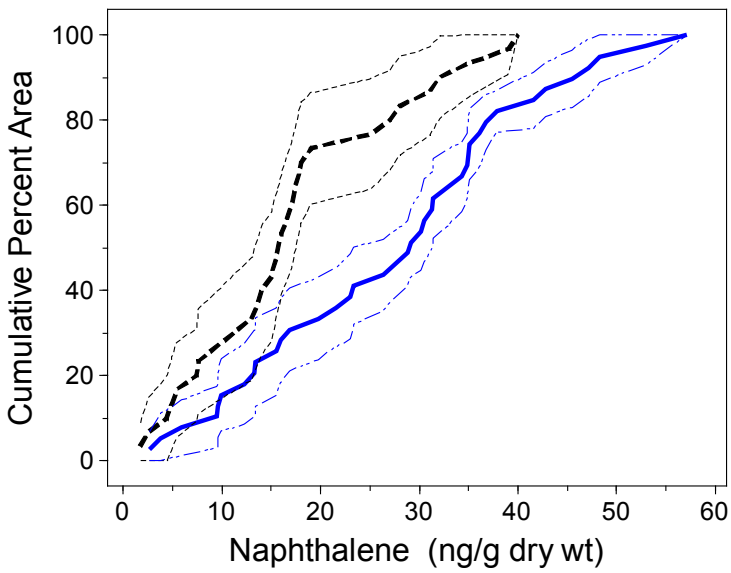
Indeno(1,2,3-c,d)pyrene



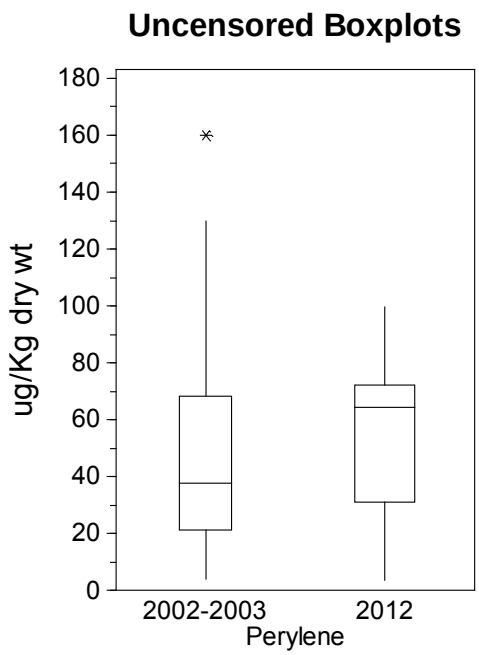


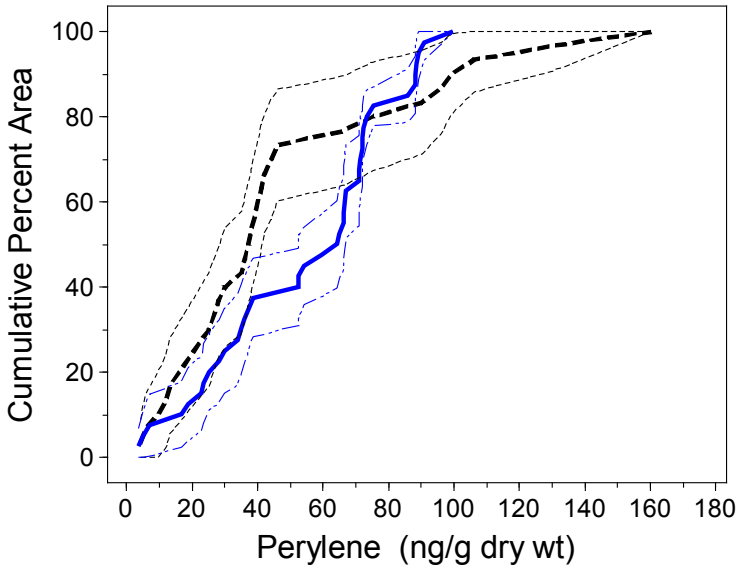
Naphthalene



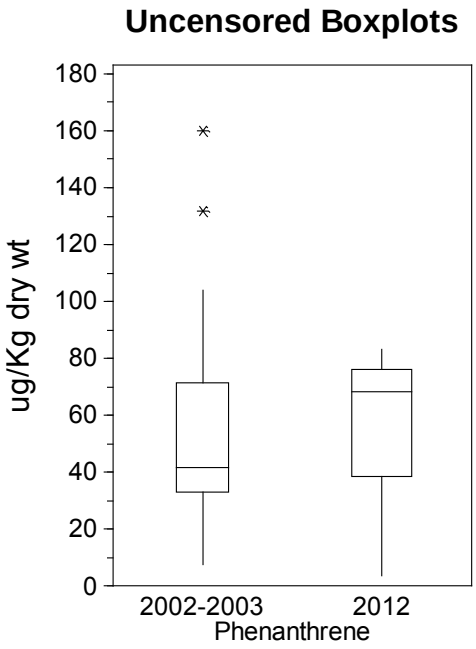


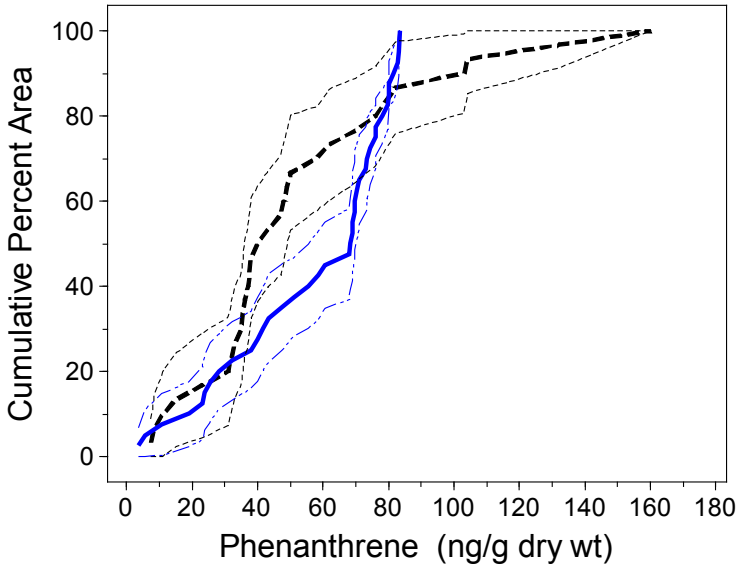
Perylene



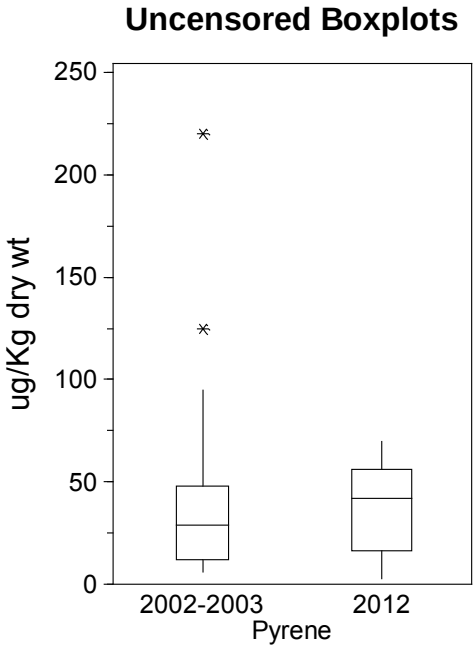


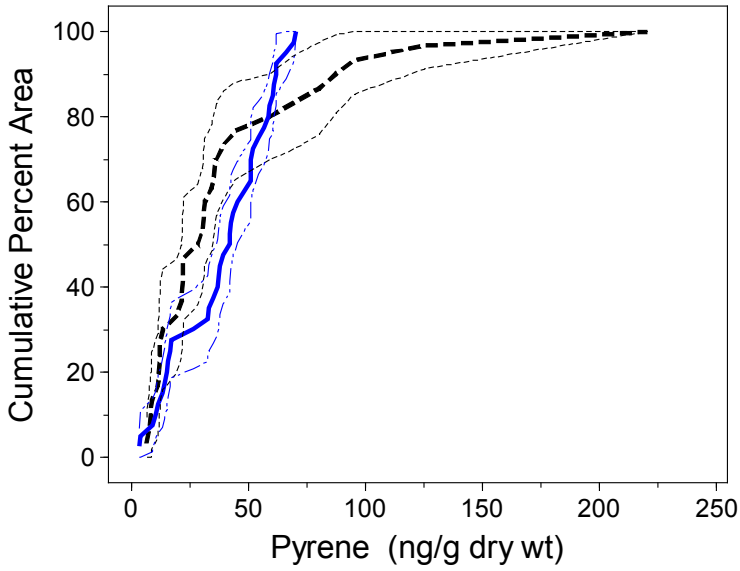
Phenanthrene





Pyrene





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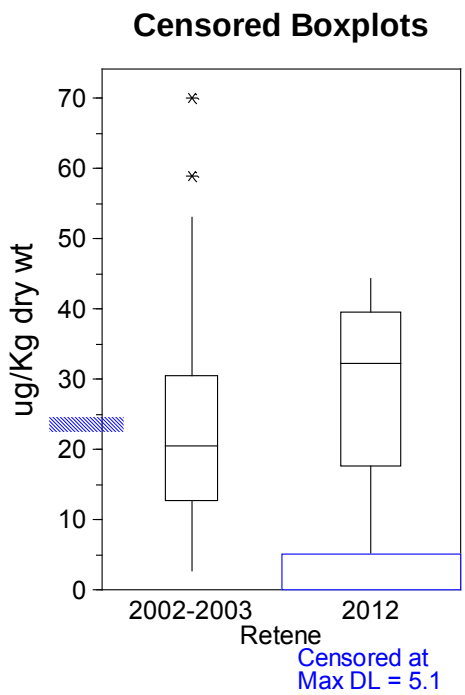
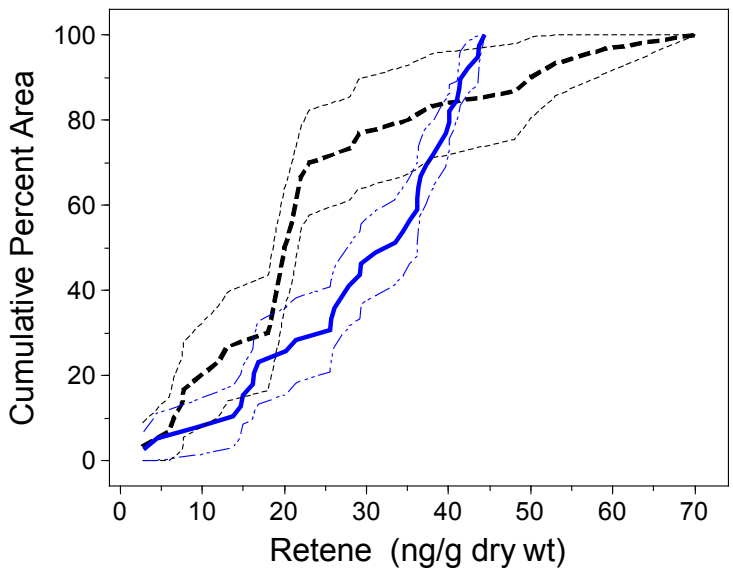
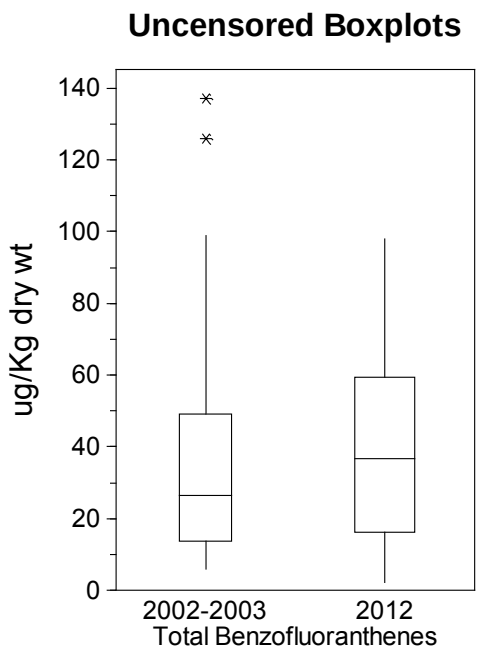
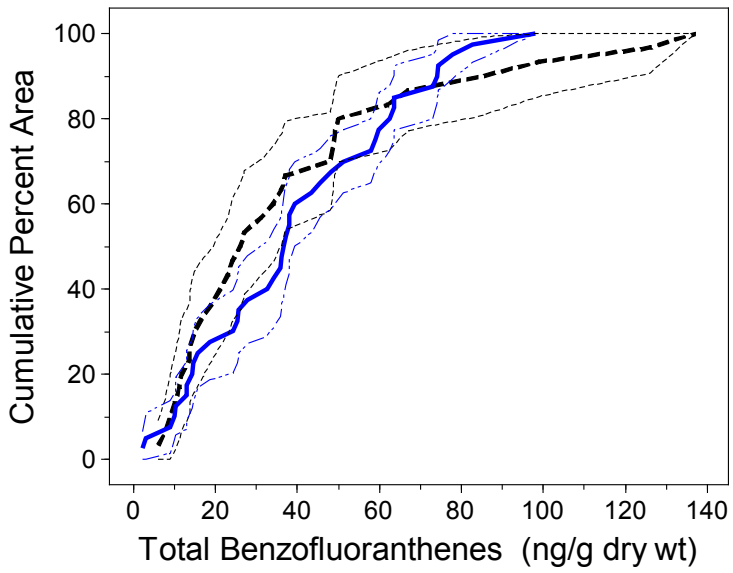




Total Benzofluoranthenes

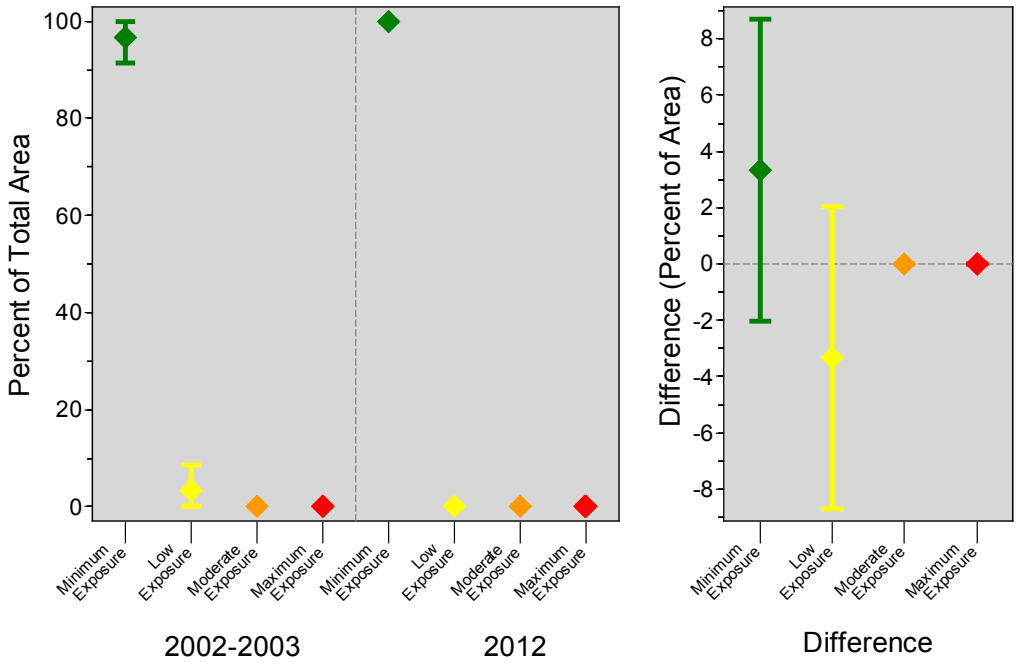




Comparison of Sediment Chemistry Index Categories by Year

Estimated spatial extent (percent of area) and 95% confidence intervals for each of the SCI categories for the San Juan Islands in 2012, compared to 2002-2003. The differences between the years are *not* statistically significant, as indicated by the difference confidence intervals containing the value zero.

Sediment Chemistry Index Category	Baseline (2002-2003)			2012			Difference (2012-Baseline)			* = significantly different (alpha=0.05)
		Confidence Limit			Confidence Limit			Confidence Limit		
	Estimate	Lower	Upper	Estimate	Lower	Upper	Estimate	Lower	Upper	
Minimum exposure	96.67	91.29	100.00	100.00	100.00	100.00	3.33	-2.04	8.71	
Low exposure	3.33	0.00	8.71	0.00	n.a.	n.a.	-3.33	n.a.	n.a.	
Moderate exposure	0.00	n.a.	n.a.	0.00	n.a.	n.a.	0.00	n.a.	n.a.	
Maximum exposure	0.00	n.a.	n.a.	0.00	n.a.	n.a.	0.00	n.a.	n.a.	



Comparisons with Other Regions

Incidence and spatial extent of chemical contamination among eight PSEMP Sediment Component regions and all of Puget Sound, as measured by chemical concentrations exceeding applicable Washington State Sediment Cleanup Objective (SCO[2]) benthic chemical criteria.

Monitoring Region	Year(s) sampled	Numbers of Samples	Percent of samples > SCO	Percent of area > SCO
Strait of Georgia	1997	61	13.1	9.7
	2006	40	0.0	0.0
Whidbey Basin	1997	39	12.8	9.1
	2007	40	5.0	2.4
Central Puget Sound	1998-1999	128	32.0	4.0
	2008-2009	80	21.3	1.2
South Puget Sound	1999	42	2.4	1.7
	2011	55	0.0	0.0
Hood Canal	1999	21	4.8	0.5
	2004	30	0.0	0.0
San Juan Islands	2002-2003	30	3.3	3.3
	2012	40	0.0	0.0
Eastern Strait of Juan de Fuca	2002-2003	30	6.7	3.3
	2013	40	Results in preparation	
Admiralty Inlet	1998-2003	30	3.3	2.2
	2014	43	Available after 2014	
All of Puget Sound	1997-2003	381	15.7	4.8
	2004-2014	368	Available after 2014	

[2] formerly called Sediment Quality Standard (SQS)

Incidence and spatial extent of chemical contamination in eight sediment monitoring regions and all of Puget Sound as measured with the Sediment Chemistry Index.

Sediment Chemistry Index Category	Regional Baseline				Second Baseline			
	Stations		Area		Stations		Area	
	No.	(%)	km^2	(%)	No.	(%)	km^2	(%)
San Juan Islands	30	(100.0)	80.7	(100.0)	40	(100.)	79.46	(100.0)
Minimum exposure	29	(96.7)	78.0	(96.7)	40	(100.)	79.46	(100.0)
Low exposure	1	(3.3)	2.7	(3.3)	0	(0.0)	0.0	(0.0)
Moderate exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Maximum exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Hood Canal	21	(100.0)	331.7	(100.0)	30	(100.0)	294.8	(100.0)
Minimum exposure	16	(76.2)	324.4	(97.8)	29	(96.7)	285.6	(96.9)
Low exposure	5	(23.8)	7.3	(2.2)	1	(3.3)	9.2	(3.1)
Moderate exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Maximum exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Strait of Georgia	61	(100.0)	386.9	(100.0)	40	(100.0)	360.6	(100.0)
Minimum exposure	46	(75.4)	345.1	(89.2)	36	(90.0)	352.3	(97.7)
Low exposure	15	(24.6)	41.8	(10.8)	4	(10.0)	8.3	(2.3)
Moderate exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Maximum exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Whidbey Basin	39	(100.0)	338.1	(100.0)	40	(100.0)	353.3	(100.0)
Minimum exposure	29	(74.4)	307.0	(90.8)	36	(90.0)	344.4	(97.5)
Low exposure	6	(15.4)	20.7	(6.1)	4	(10.0)	8.9	(2.5)
Moderate exposure	3	(7.7)	10.4	(3.1)	0	(0.0)	0.0	(0.0)
Maximum exposure	1	(2.6)	0.1	(0.0)	0	(0.0)	0.0	(0.0)
Central Sound	128	(100.0)	683.9	(100.0)	80	(100.0)	667.4	(100.0)
Minimum exposure	54	(42.2)	569.5	(83.3)	58	(72.5)	583.2	(87.4)
Low exposure	46	(35.9)	105.1	(15.4)	21	(26.3)	68.6	(10.3)
Moderate exposure	19	(14.8)	7.8	(1.1)	1	(1.3)	15.6	(2.3)
Maximum exposure	9	(7.0)	1.5	(0.2)	0	(0.0)	0.0	(0.0)
South Sound	42	(100.0)	341.6	(100.0)	55	(100.0)	317.7	(100.0)
Minimum exposure	36	(85.7)	332.7	(97.4)	53	(96.4)	317.4	(99.9)
Low exposure	6	(14.3)	8.9	(2.6)	2	(3.6)	0.3	(0.1)
Moderate exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
Maximum exposure	0	(0.0)	0.0	(0.0)	0	(0.0)	0.0	(0.0)
E. Strait of Juan de Fuca	30	(100.0)	61.8	(100.0)	Results in preparation			
Minimum exposure	29	(96.7)	61.0	(98.6)				
Low exposure	1	(3.3)	0.9	(1.4)				
Moderate exposure	0	(0.0)	0.0	(0.0)				
Maximum exposure	0	(0.0)	0.0	(0.0)				
Admiralty Inlet	30	(100.0)	69.2	(100.0)	Available after 2014			
Minimum exposure	30	(100.0)	69.2	(100.0)				
Low exposure	0	(0.0)	0.0	(0.0)				

Sediment Chemistry Index Category	Regional Baseline				Second Baseline			
	Stations		Area		Stations		Area	
	No.	(%)	km^2	(%)	No.	(%)	km^2	(%)
Moderate exposure	0	(0.0)	0.0	(0.0)				
Maximum exposure	0	(0.0)	0.0	(0.0)				
Total Study Area	381	(100.0)	2294.1	(100.0)	Available after 2014			
Minimum exposure	269	(70.6)	2087.0	(91.0)				
Low exposure	80	(21.0)	187.36	(8.2)				
Moderate exposure	22	(5.8)	18.15	(0.8)				
Maximum exposure	10	(2.6)	1.57	(0.1)				

Chemistry Case Narratives

General Chemistry

2012 TOC Case Narrative.pdf

Metals

PSAMP_Metals-1206024.pdf

BNAs

PSAMP&UW 2012_BNASQS- Batch 1-1206024.pdf

PSAMP&UW 2012_BNASQS- Batch 2-1206024.pdf

PSAMP&UW 2012_BNASQS- Batch 3-1206024.pdf

PSAMP&UW 2012_BNASQS- Batch 4-1206024.pdf

PAHs

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PSAMP&UW_PAHNOAA_BATCH 5-1206024.pdf

PBDEs

PSAMP & Urban Waters_PBDE1-1206024-01-21.pdf

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PSAMP & Urban Waters_PBDE3-1206024-01-21.pdf

PSAMP & Urban Waters_PBDE4-1206024-01-21.pdf

PCBs and Pesticides

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PSAMP-UW_PestPCB-1206024-68-83.pdf