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Volume 2 of 3

Figures and Tables

Sheboygan River and Harbor

Aquatic Ecological Risk Assessment

Prepared for:

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Chicago, Illinois

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Sheboygan River and Harbor

AQUATIC ECOLOGICAL RISK ASSESSMENT

Volume 2 of 3
Figures and Tables

Prepared for

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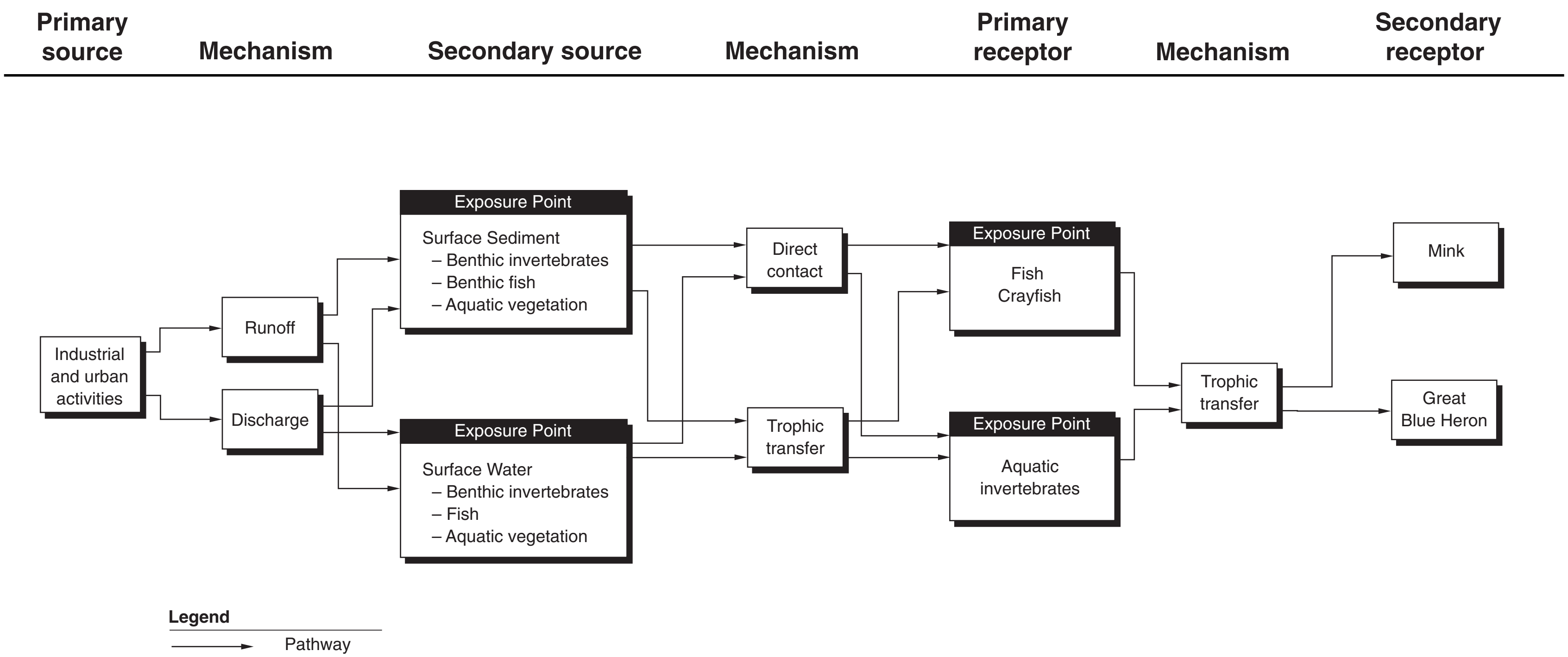


Figure 2-2. Potential exposure pathways for ecological receptors

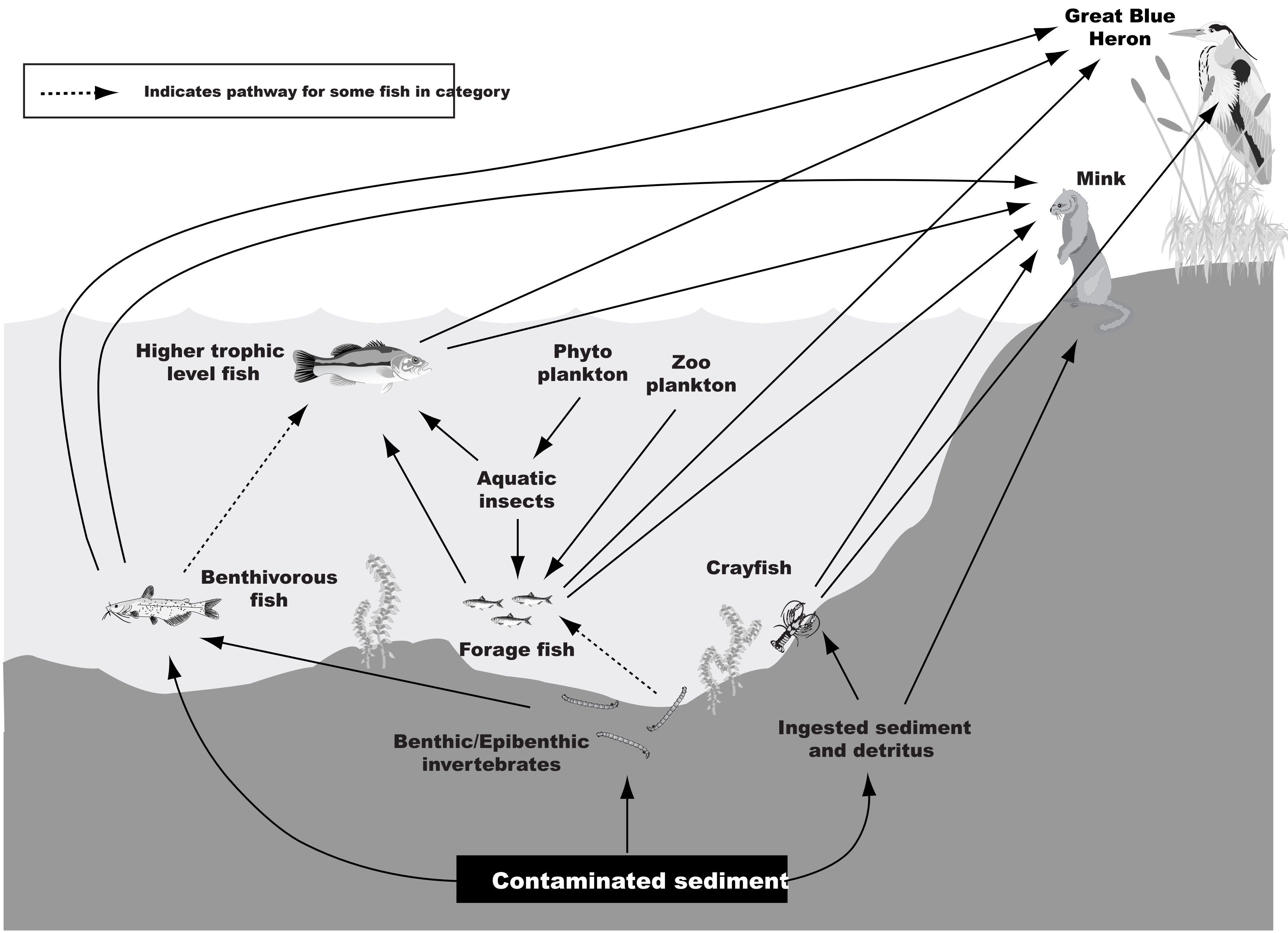
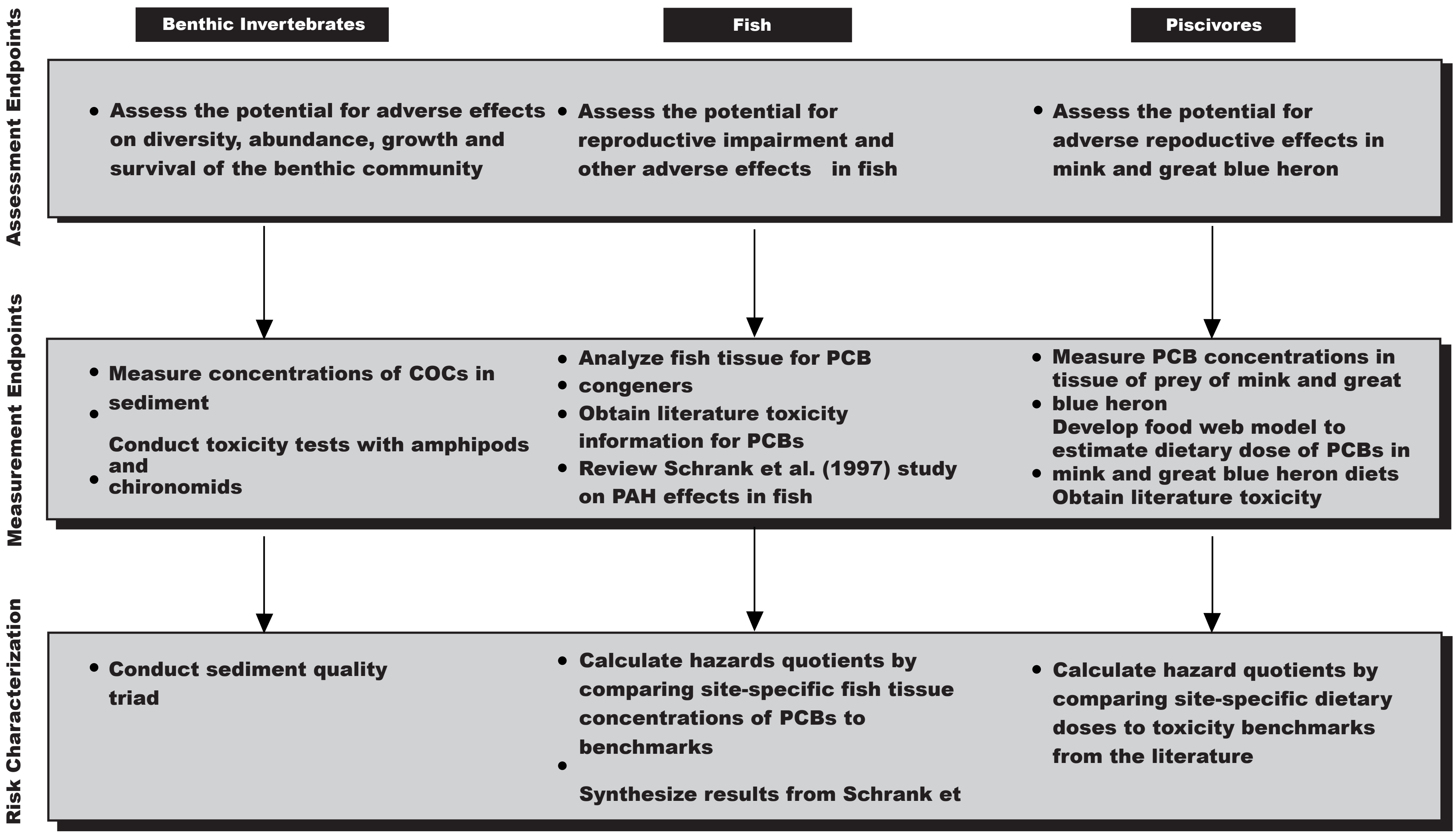


Figure 2-3. Aquatic food web exposure pathways



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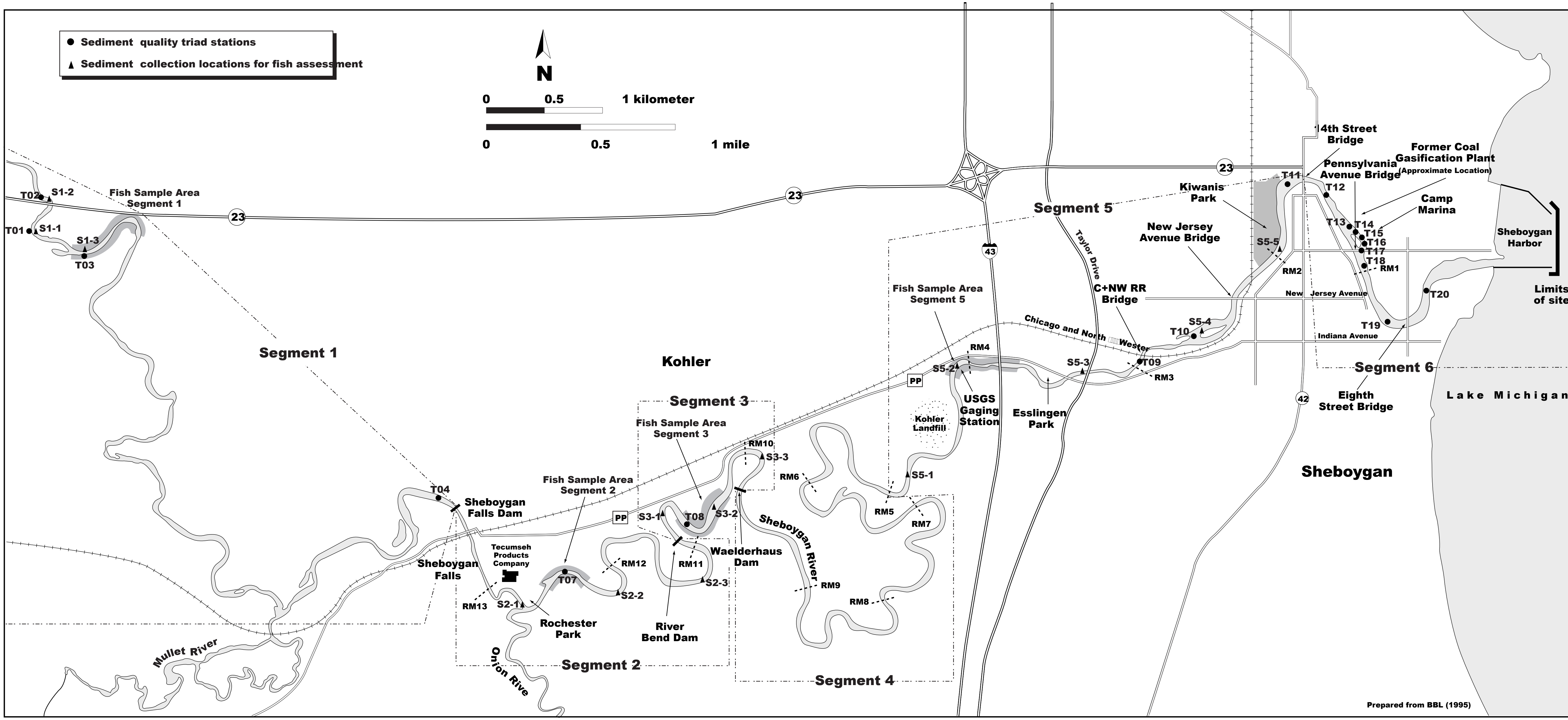

Figure 3-1. Sampling locations for ERA sampling conducted in August 1997

Note: In text and tables sediment samples for the fish assessment are designated by an S as in S2-1 (sediment sample 1 from Segment 2); fish tissue samples are designated by an F as in F2-1 (fish tissue sample 1 from Segment 2).

2/575-37\DELIVER/ERA/GRAPHICS/FINAL/FIG.3-2
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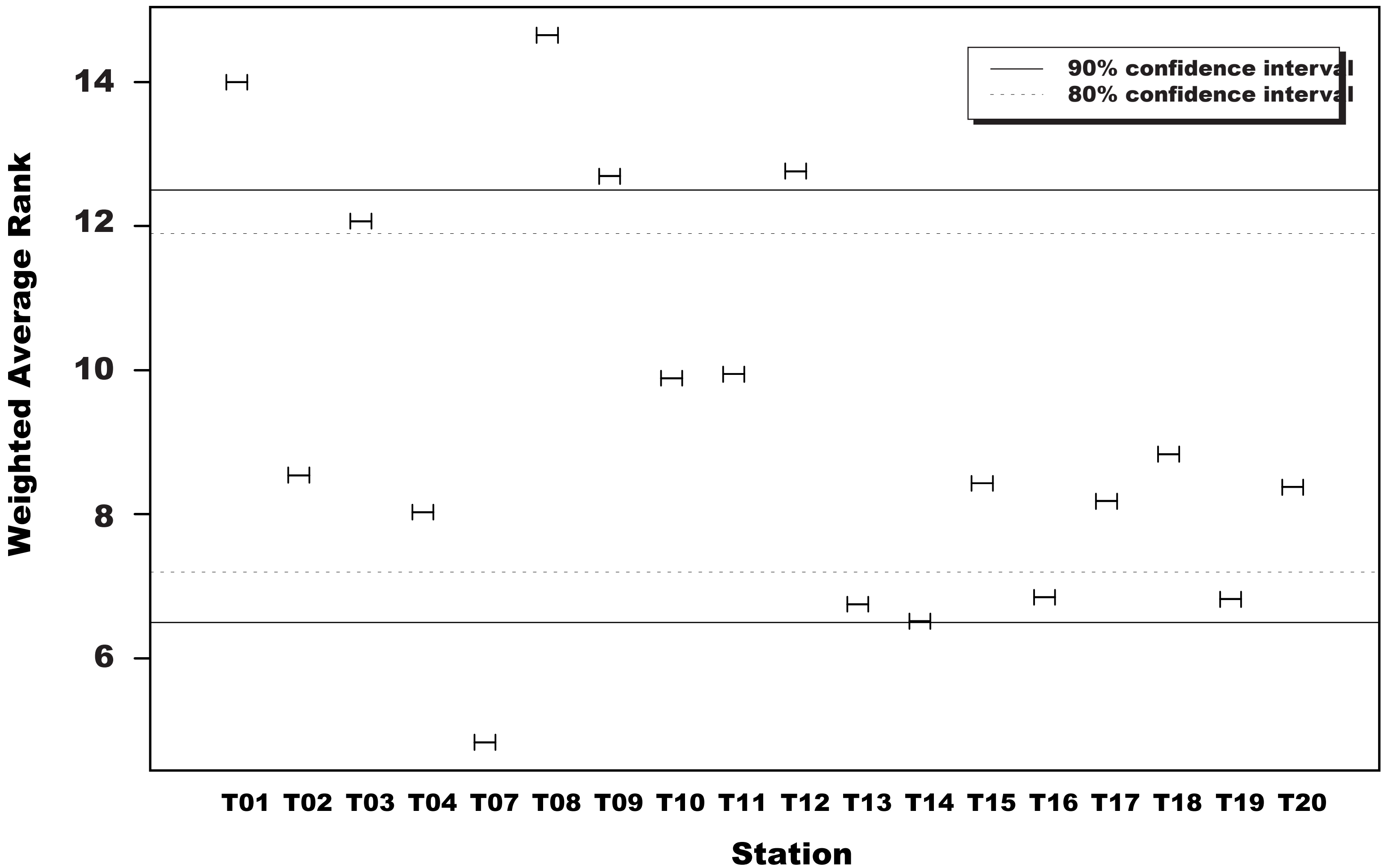
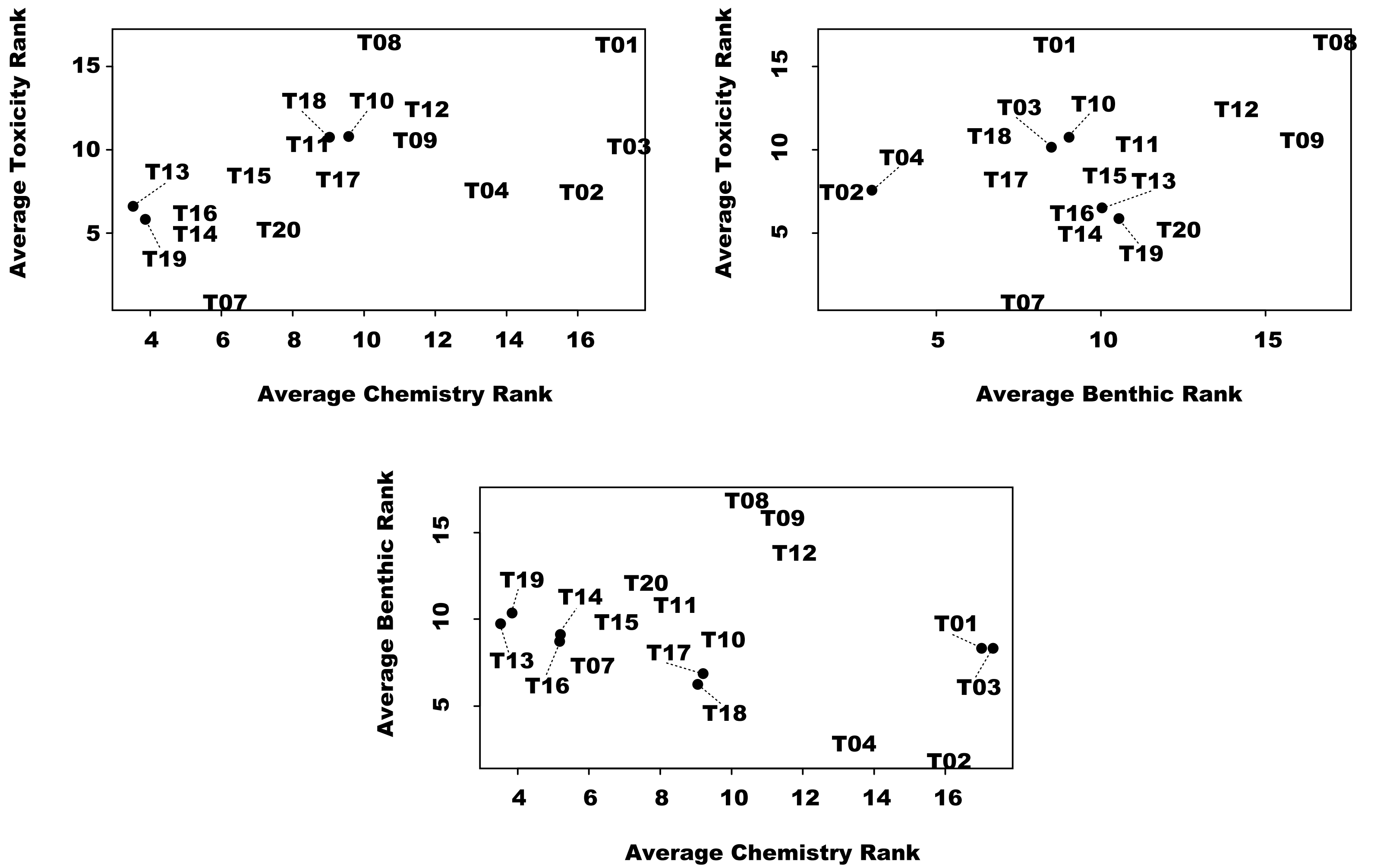


Figure 3-2. Average Triad ranks for each station, weighted so that each leg of the Triad is equally represented



Note: The highest ranks indicate the best performers for each leg

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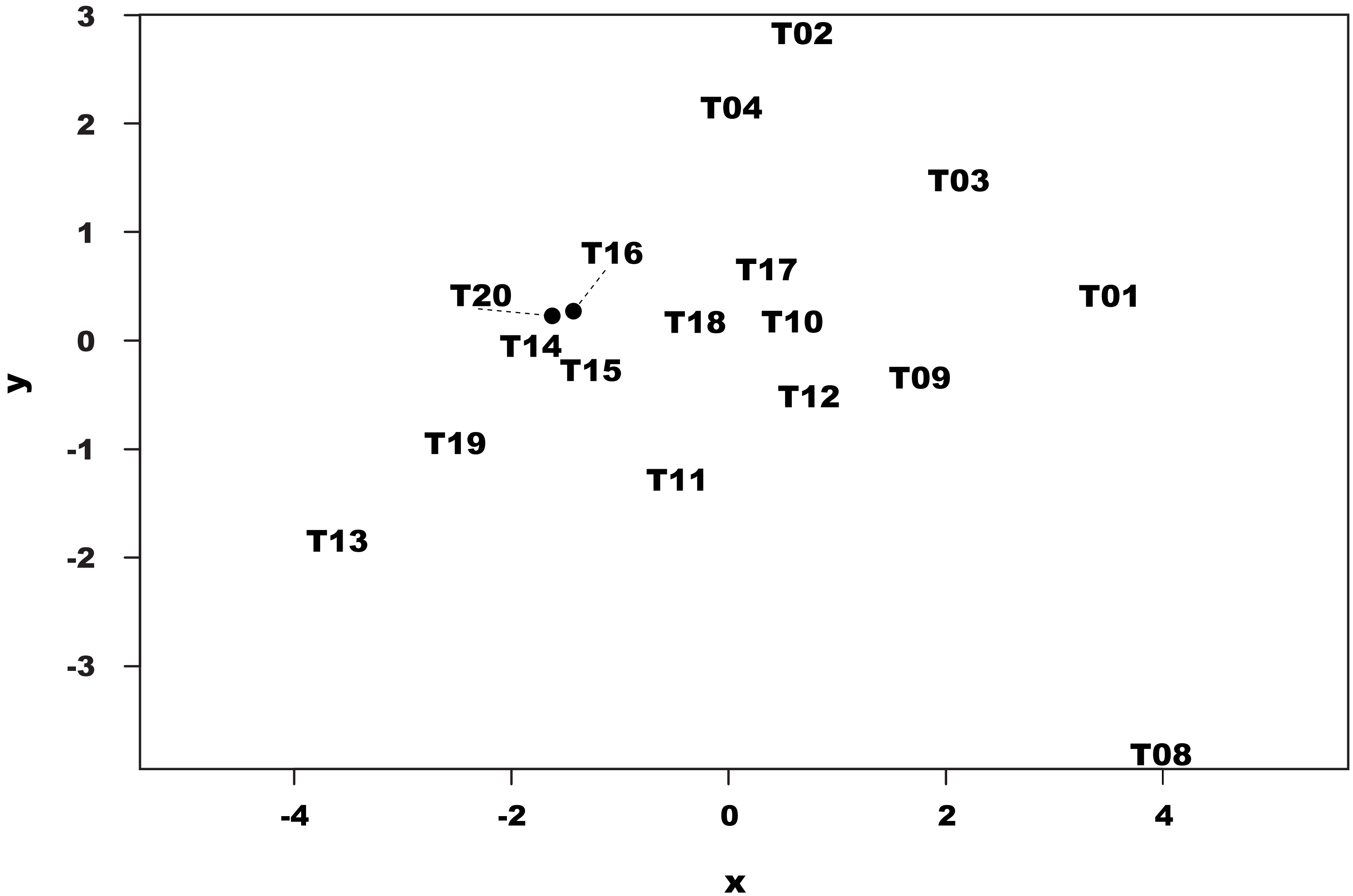
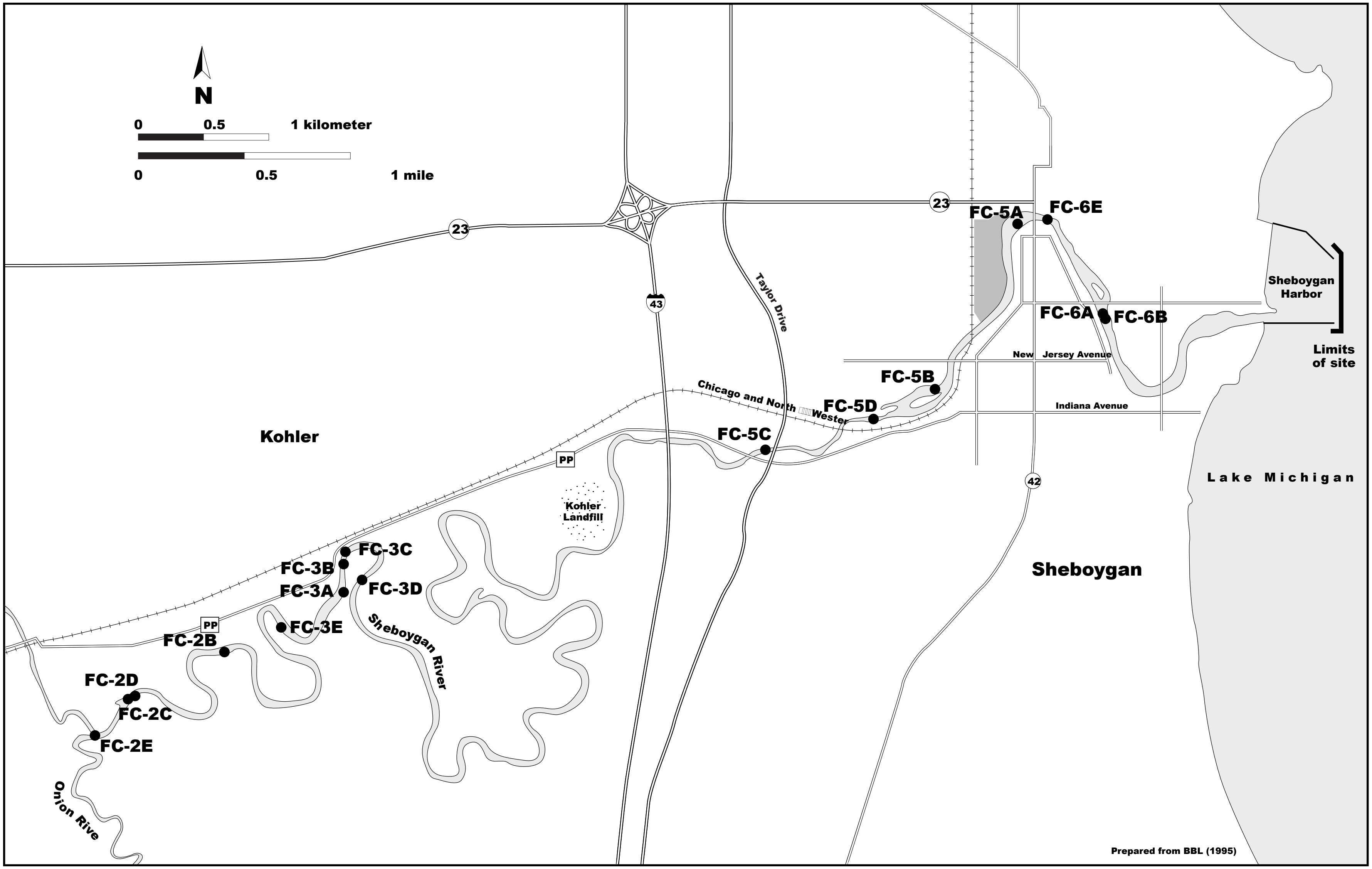


Note: Station T07 was removed from this distance calculation to aviod distortion of the axes.
Stations located outside of the main cluster are considered to be different.

Figure 3-4. Two-dimensional representation of distances between stations for all Triad endpoints



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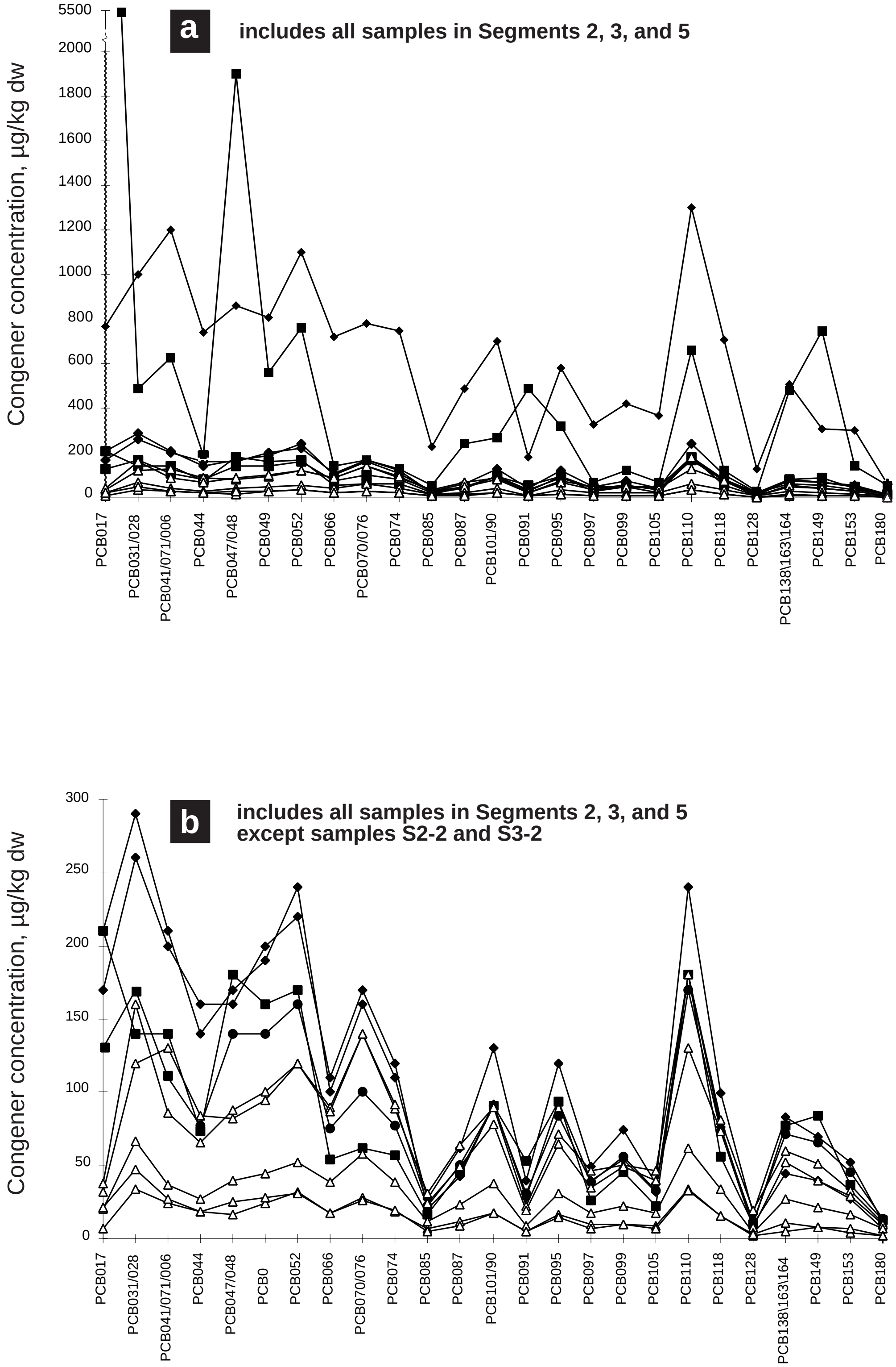


Figure 4-2. PCB congener pattern in 1997 sediment samples collected for the ERA fish assessment

Segment 2 | Segment 3 | Segment 5

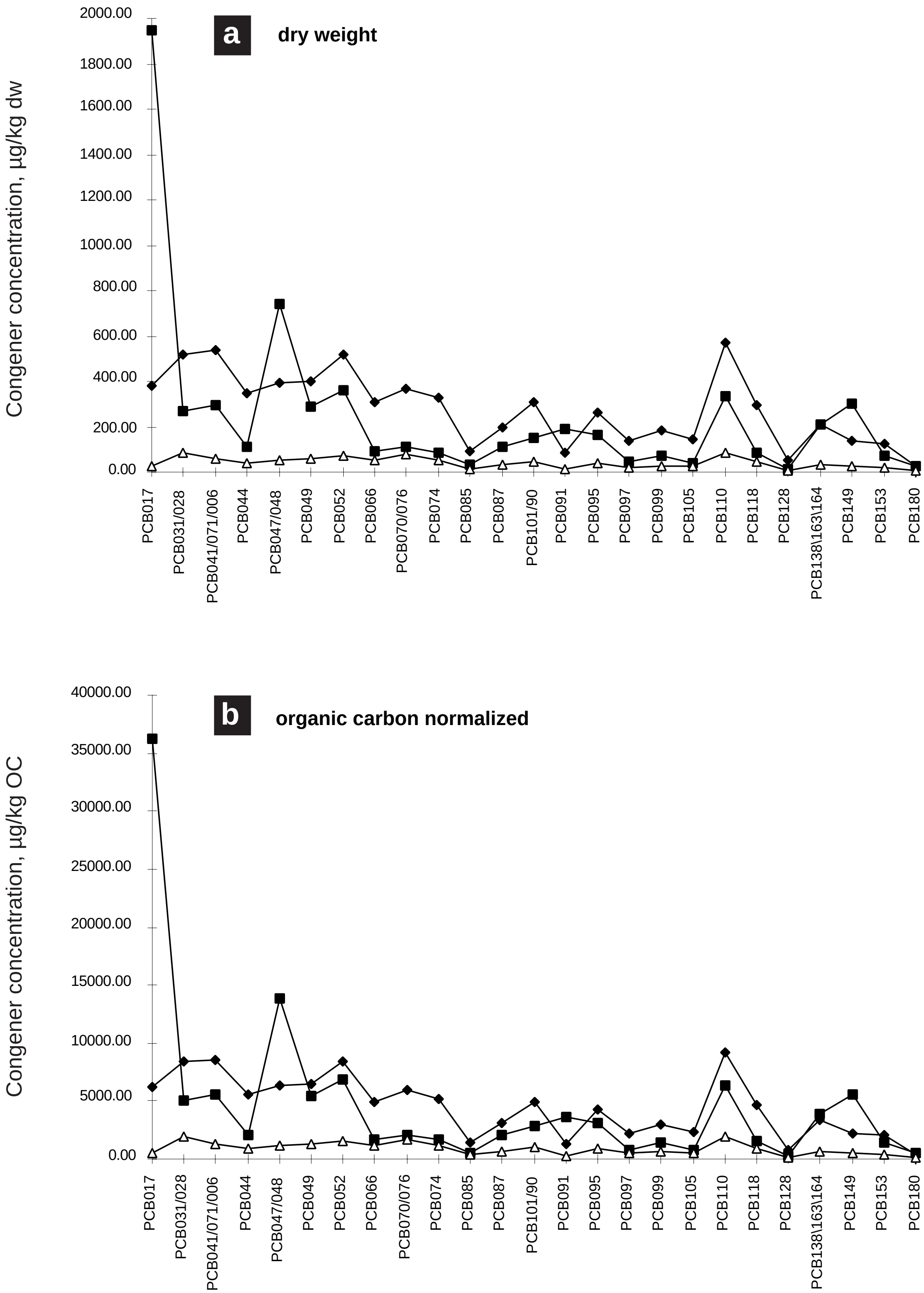
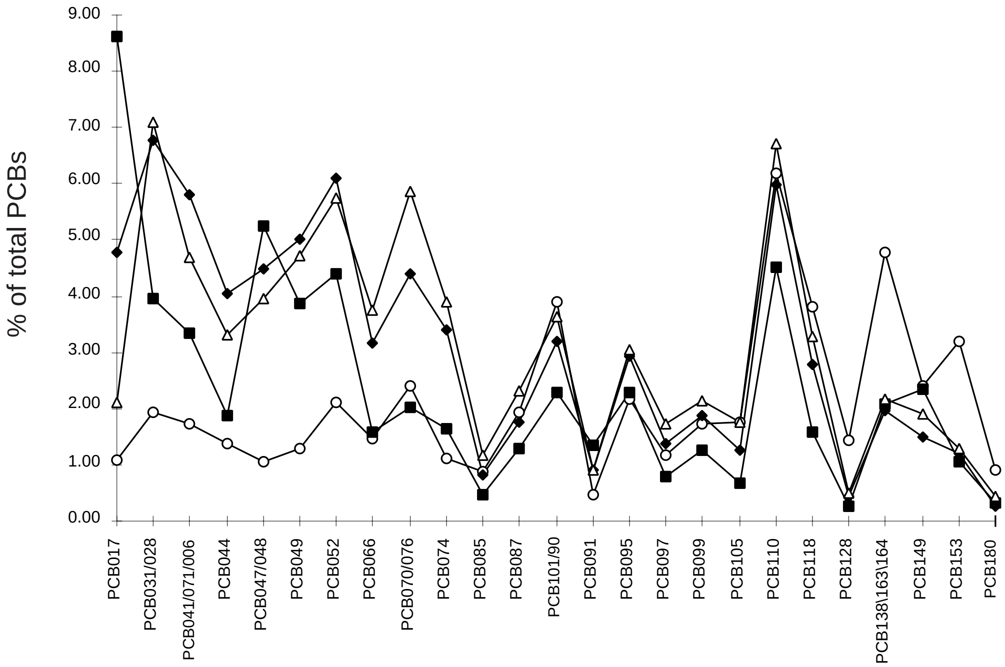


Figure 4-3. Average congener concentrations in 1997 sediment samples

Segment 2 Segment 3 Segment 5



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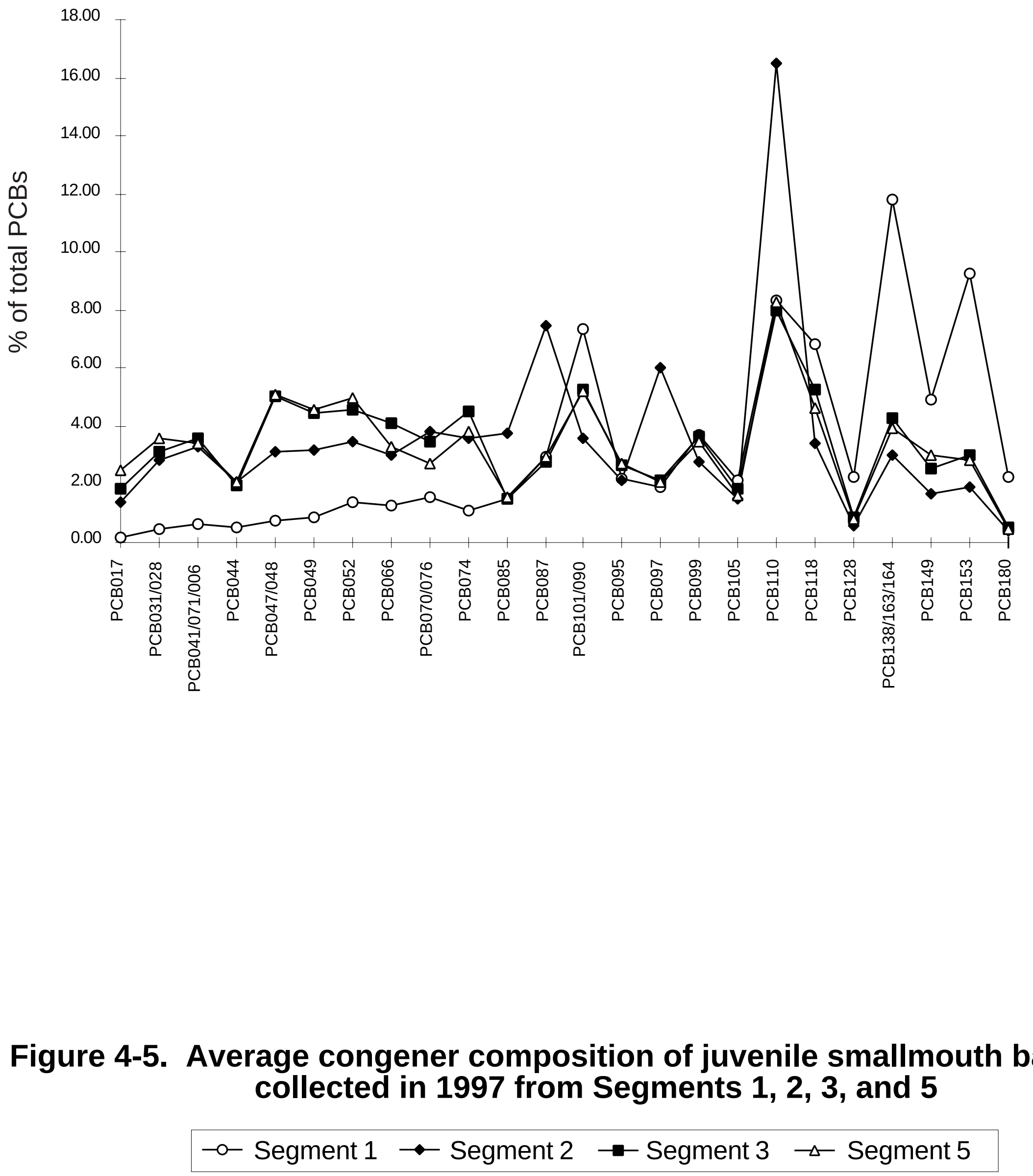

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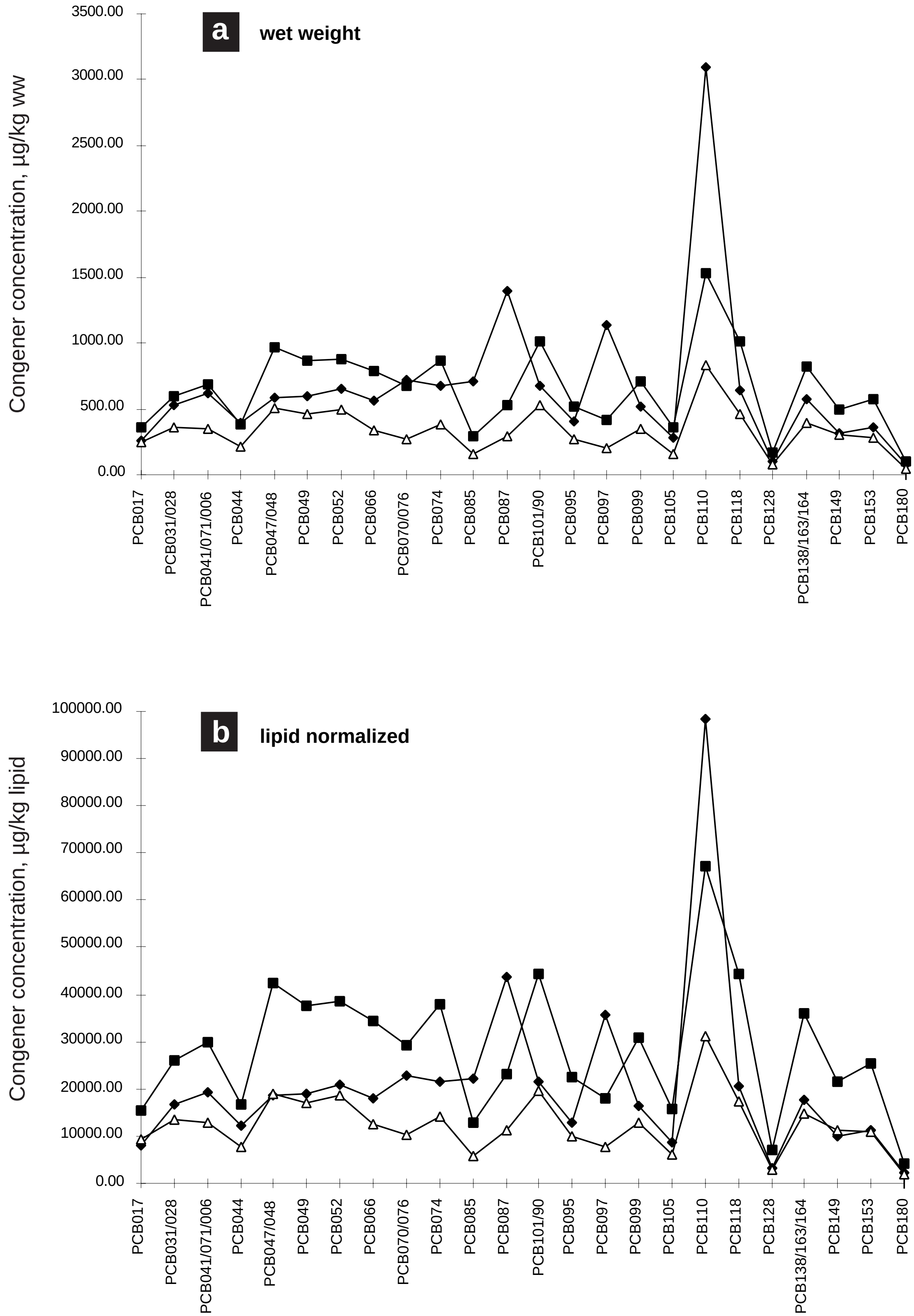

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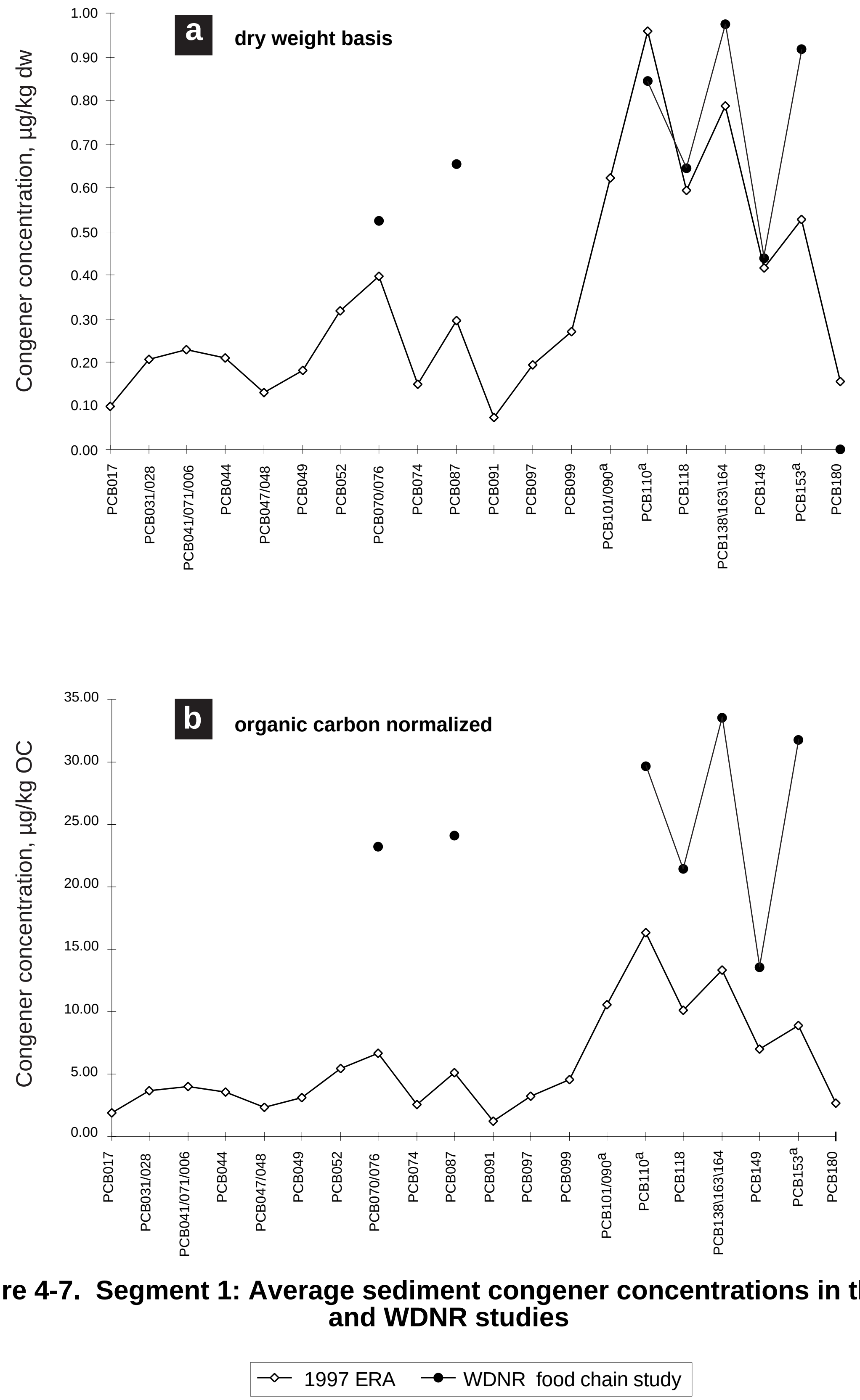

Figure 4-7. Segment 1: Average sediment congener concentrations in the ERA and WDNR studies

[a] These congener concentrations are as reported in the 1997 ERA. In the WDNR food chain study PCB 110 was reported as PCB 110/077, PCB101/90 was reported as PCB101, and PCB153 was reported as PCB153/132.

F:\HAZMAT.575\575-37\DELIVER\ERA\GRAPHICS\FIG.4.7

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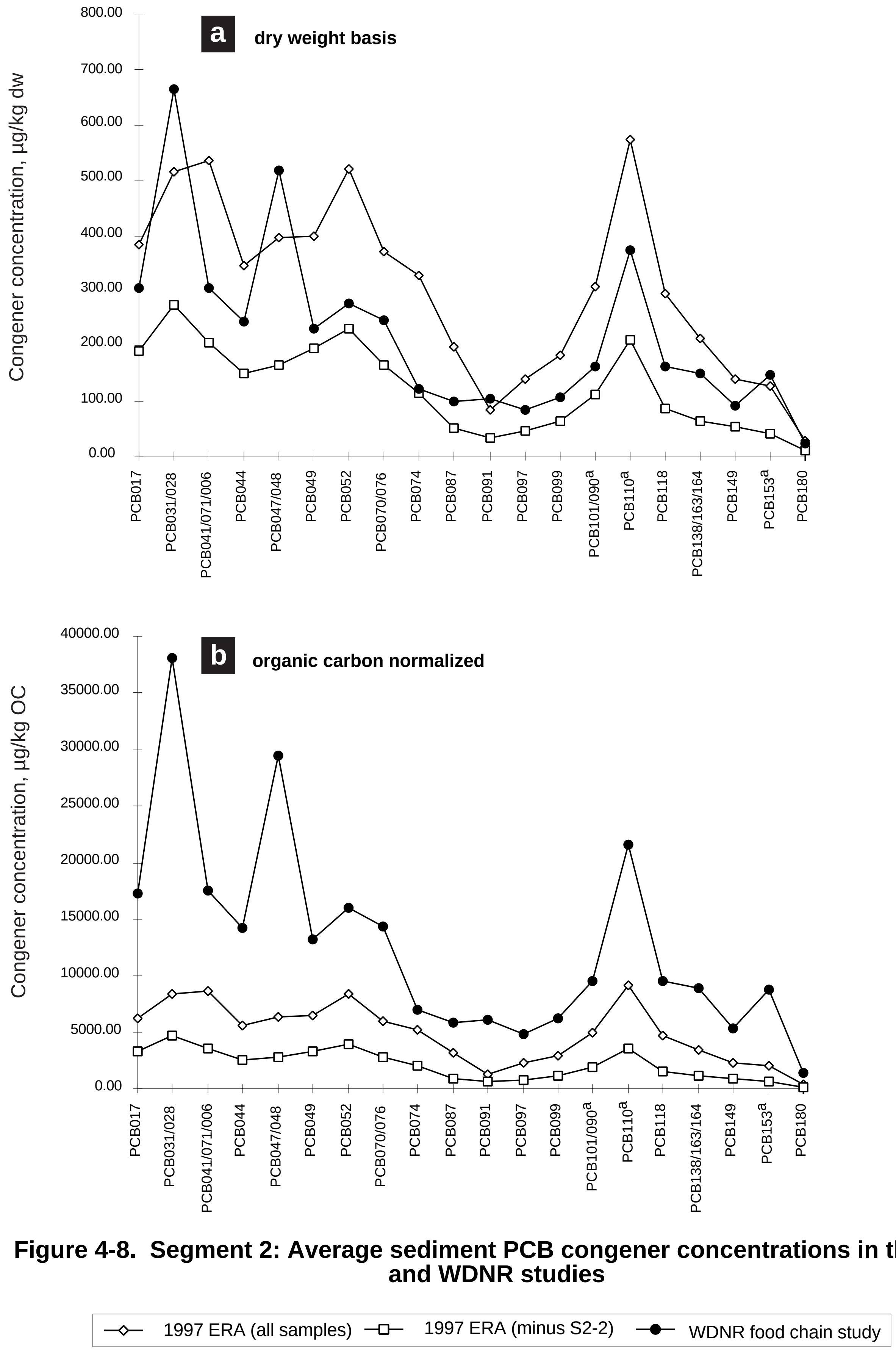


Figure 4-8. Segment 2: Average sediment PCB congener concentrations in the ERA and WDNR studies

[a] These congener concentrations are as reported in the 1997 ERA. In the WDNR food chain study PCB 110 was reported as PCB 110/077, PCB101/90 was reported as PCB101, and PCB153 was reported as PCB153/132.

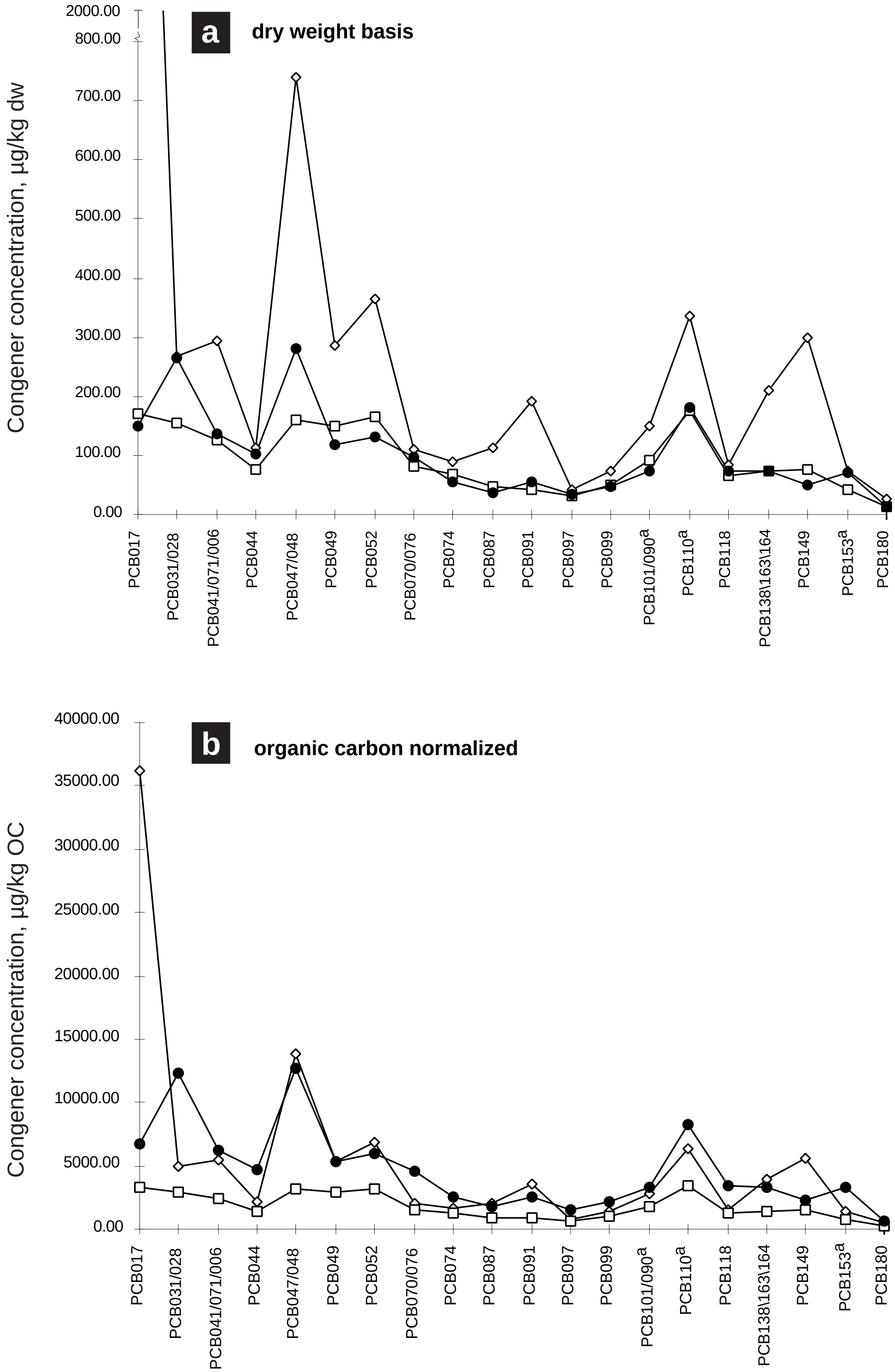


Figure 4-9. Segment 3: Average sediment congener concentrations in the ERA and WDNR studies

1997 ERA (all samples) | 1997 ERA (minus S3-2) | WDNR food chain study

[a] These congener concentrations are as reported in the 1997 ERA. In the WDNR food chain study PCB 110 was reported as PCB 110/077, PCB101/90 was reported as PCB101, and PCB153 was reported as PCB153/132.

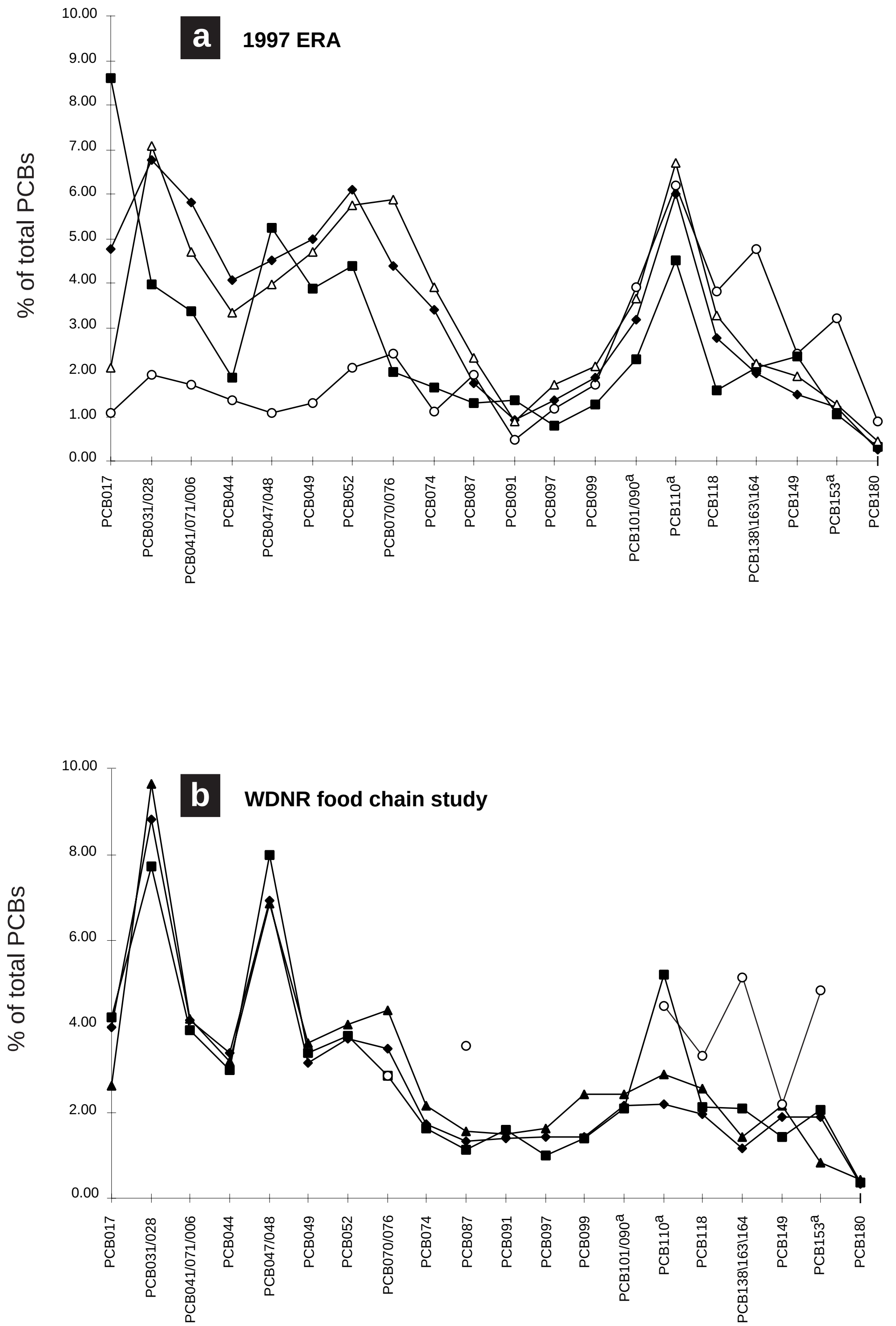


Figure 4-11. Average congener composition in sediments collected for the 1997 ERA and the WDNR food chain study

[a] These congener concentrations are as reported in the 1997 ERA. In the WDNR food chain study PCB 110 was reported as PCB 110/077, PCB101/90 was reported as PCB101, and PCB153 was reported as PCB153/132.

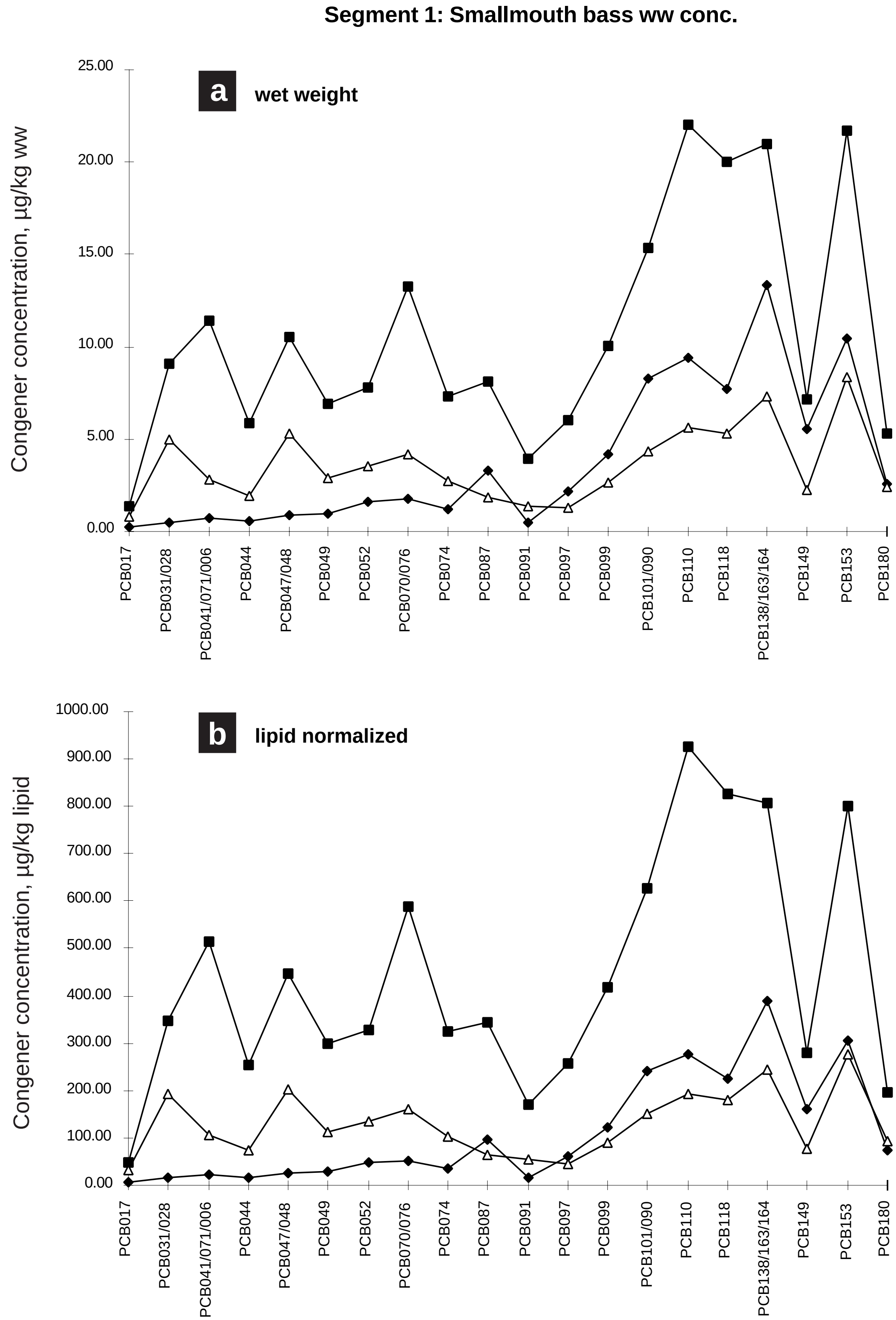
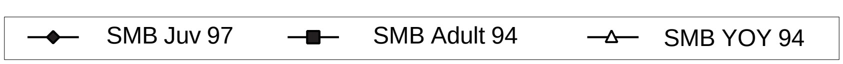


Figure 4-12. Segment 1: Tissue congener concentrations from ERA (juvenile smallmouth bass) and WDNR (adult and young-of-year smallmouth bass) studies



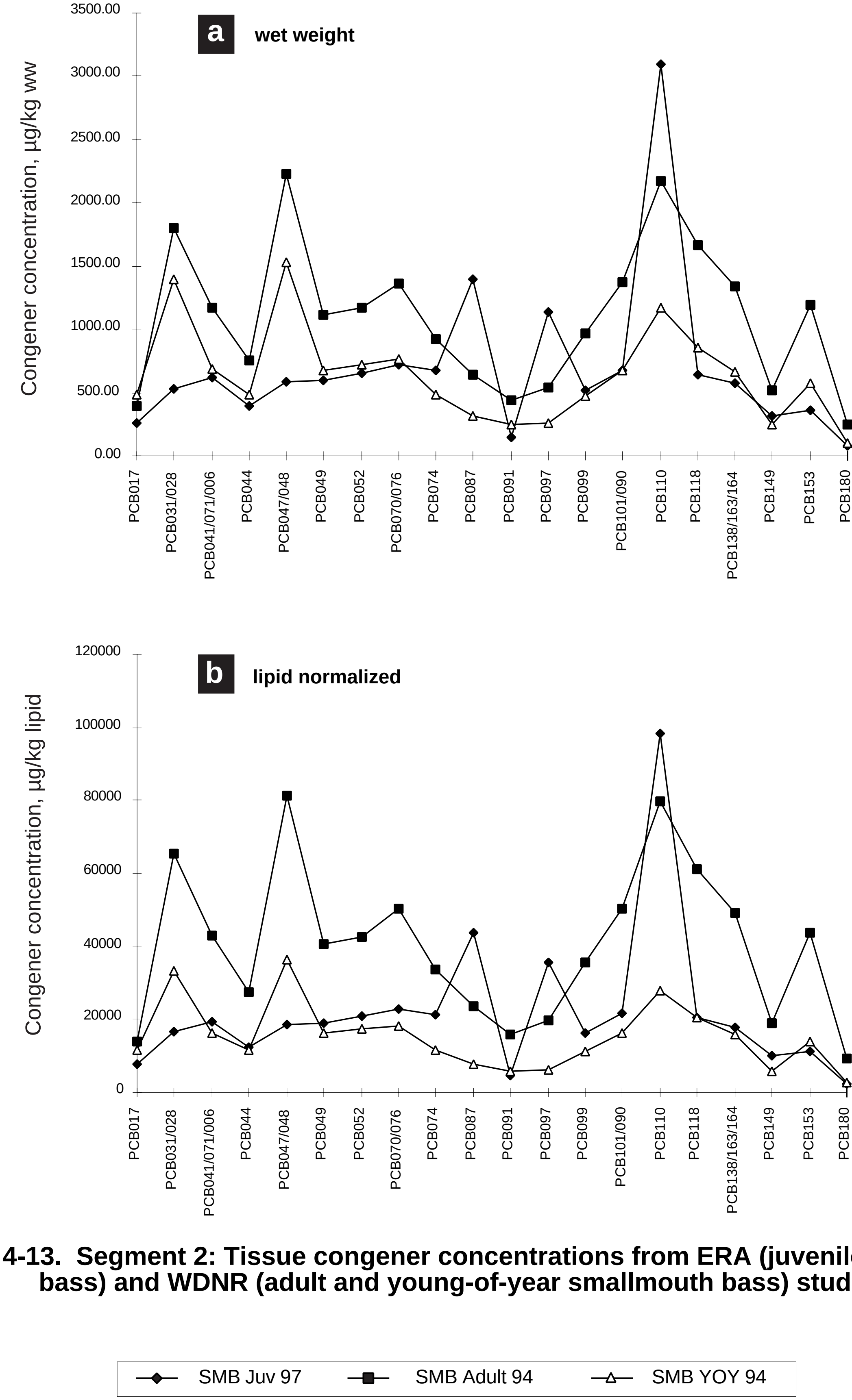


Figure 4-13. Segment 2: Tissue congener concentrations from ERA (juvenile smallmouth bass) and WDNR (adult and young-of-year smallmouth bass) studies

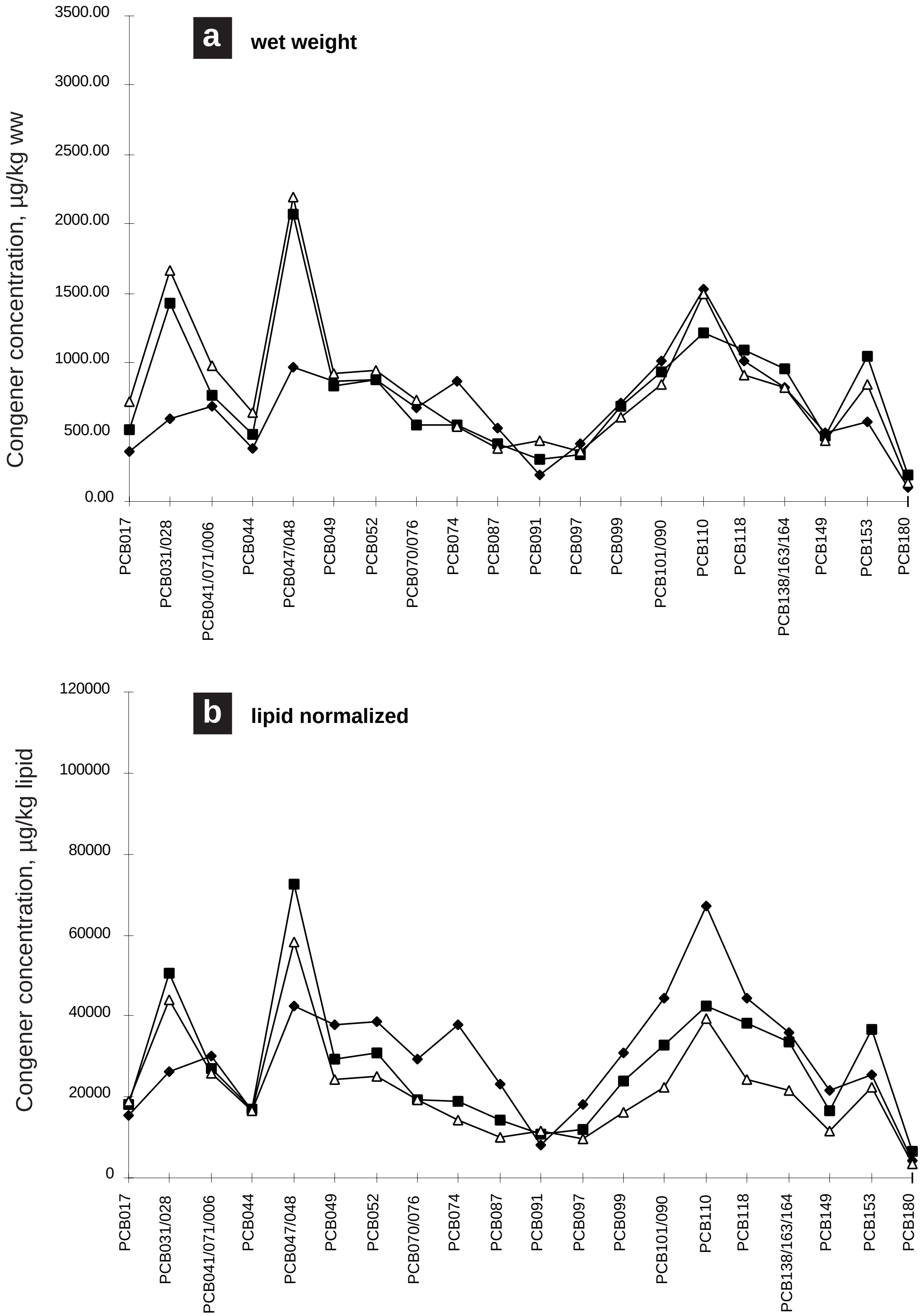
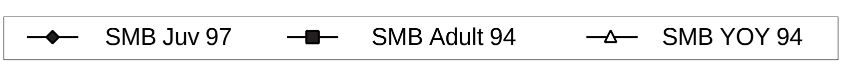


Figure 4-14. Segment 3: Tissue congener concentrations from ERA (juvenile smallmouth bass) and WDNR (adult and young-of-year smallmouth bass) studies



F:\HAZMAT.575\575-37\DELIVER\ERA\GRAPHICS\FIG.4.14

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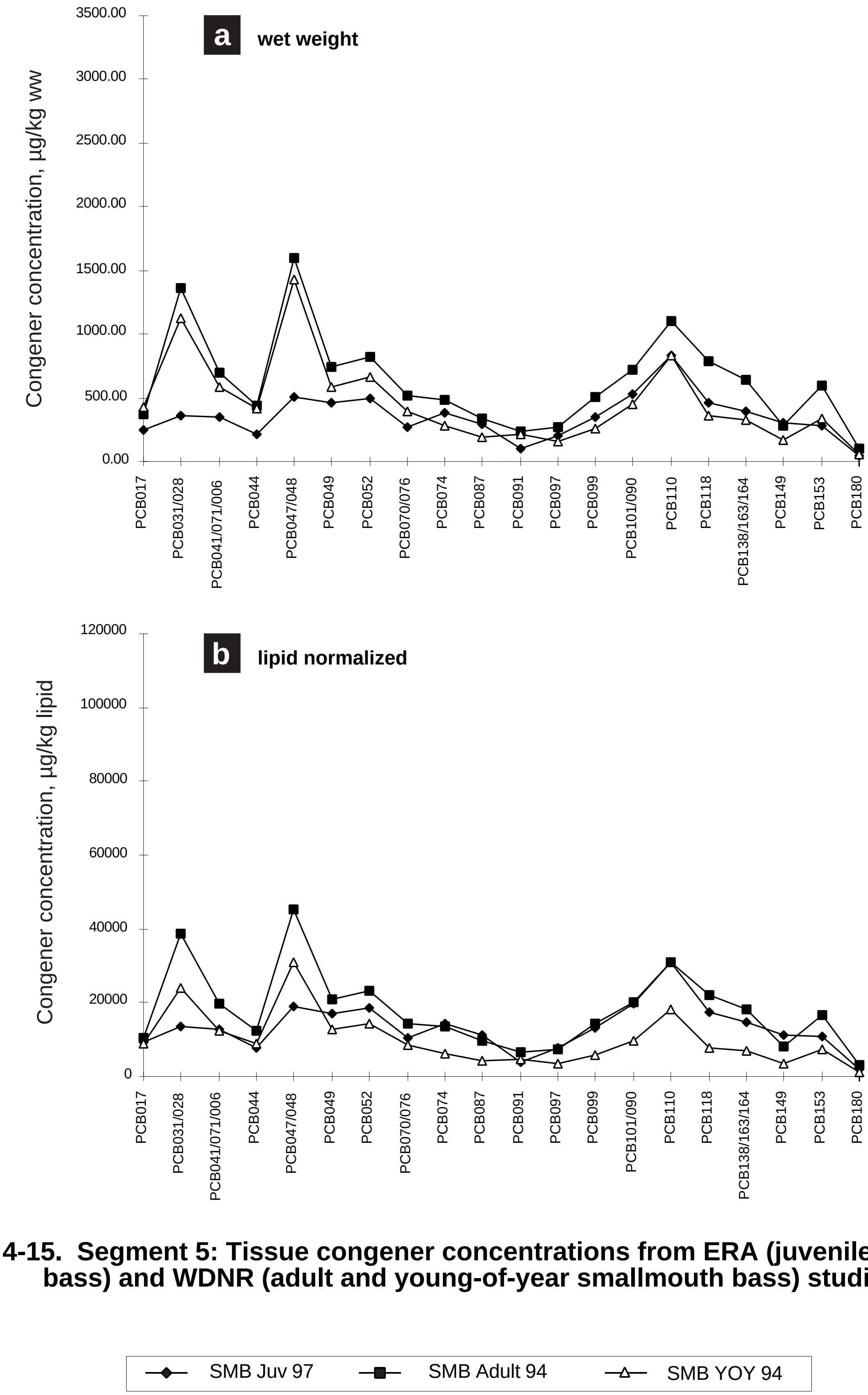


Figure 4-15. Segment 5: Tissue congener concentrations from ERA (juvenile smallmouth bass) and WDNR (adult and young-of-year smallmouth bass) studies

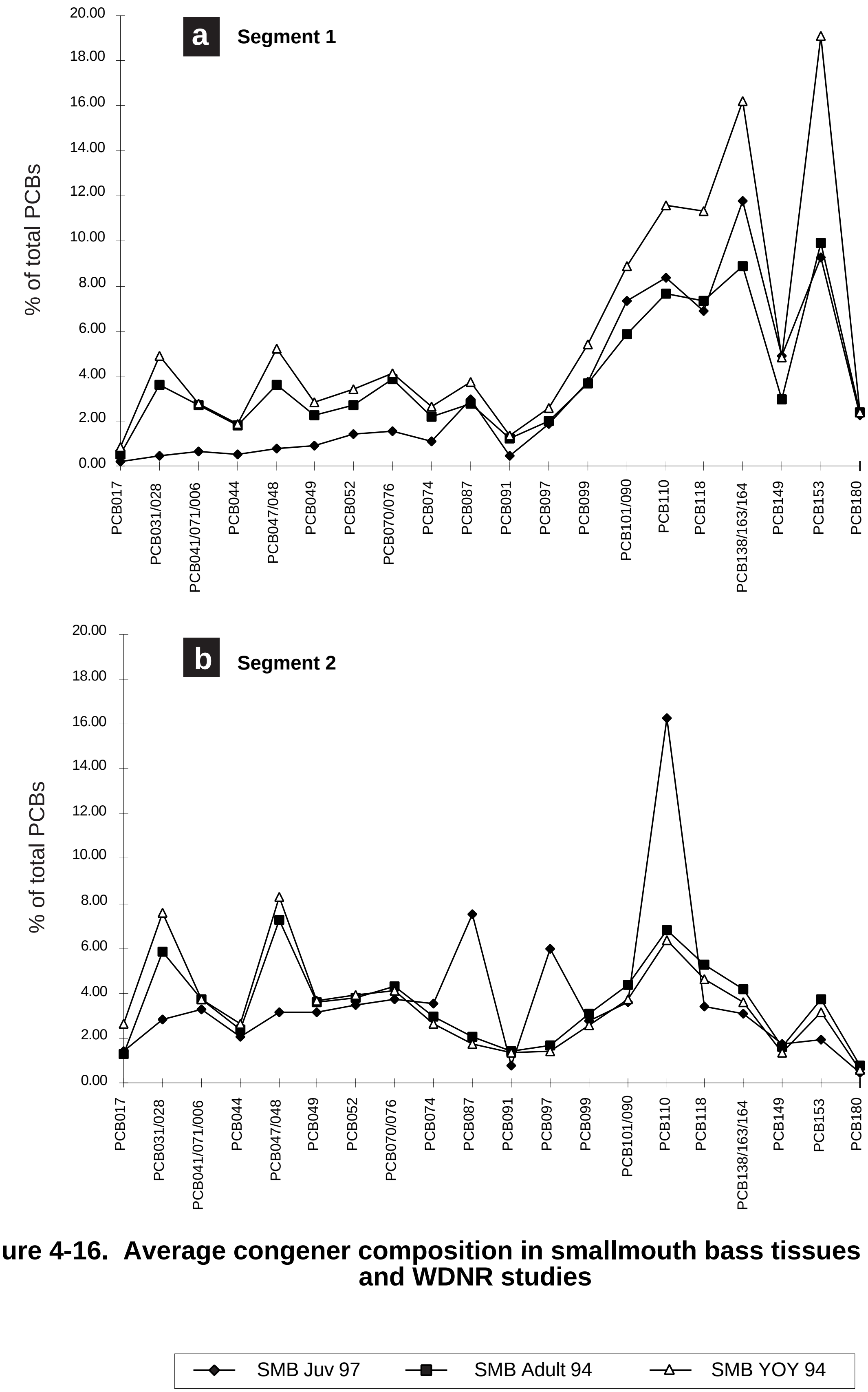
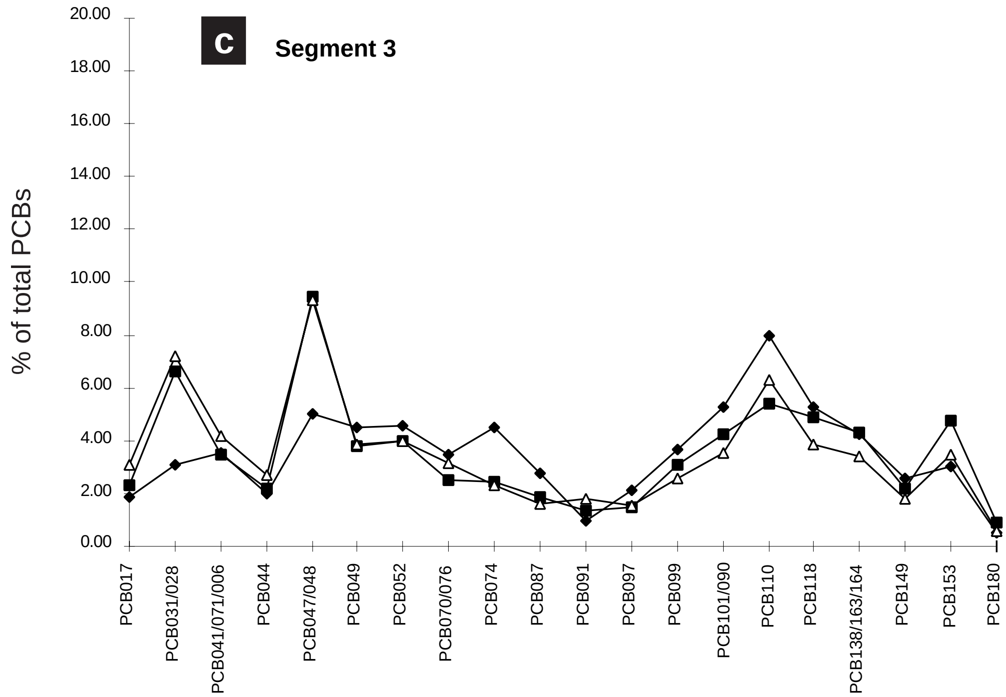


Figure 4-16. Average congener composition in smallmouth bass tissues from ERA and WDNR studies



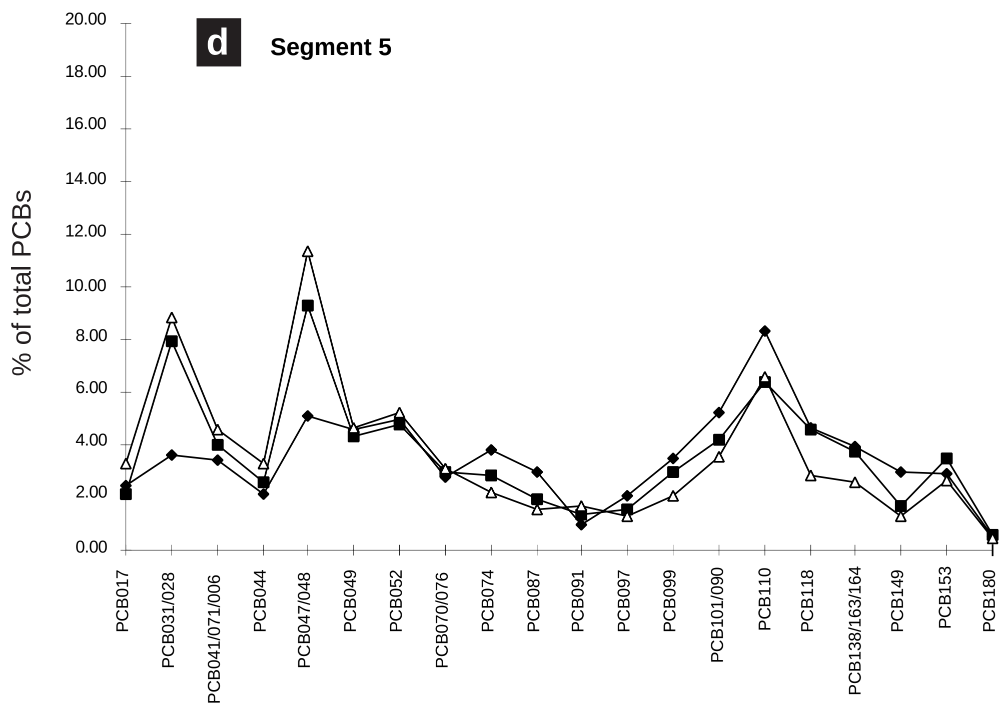


Figure 4-16, continued

SMB Juv 97 SMB Adult 94 SMB YOY 94

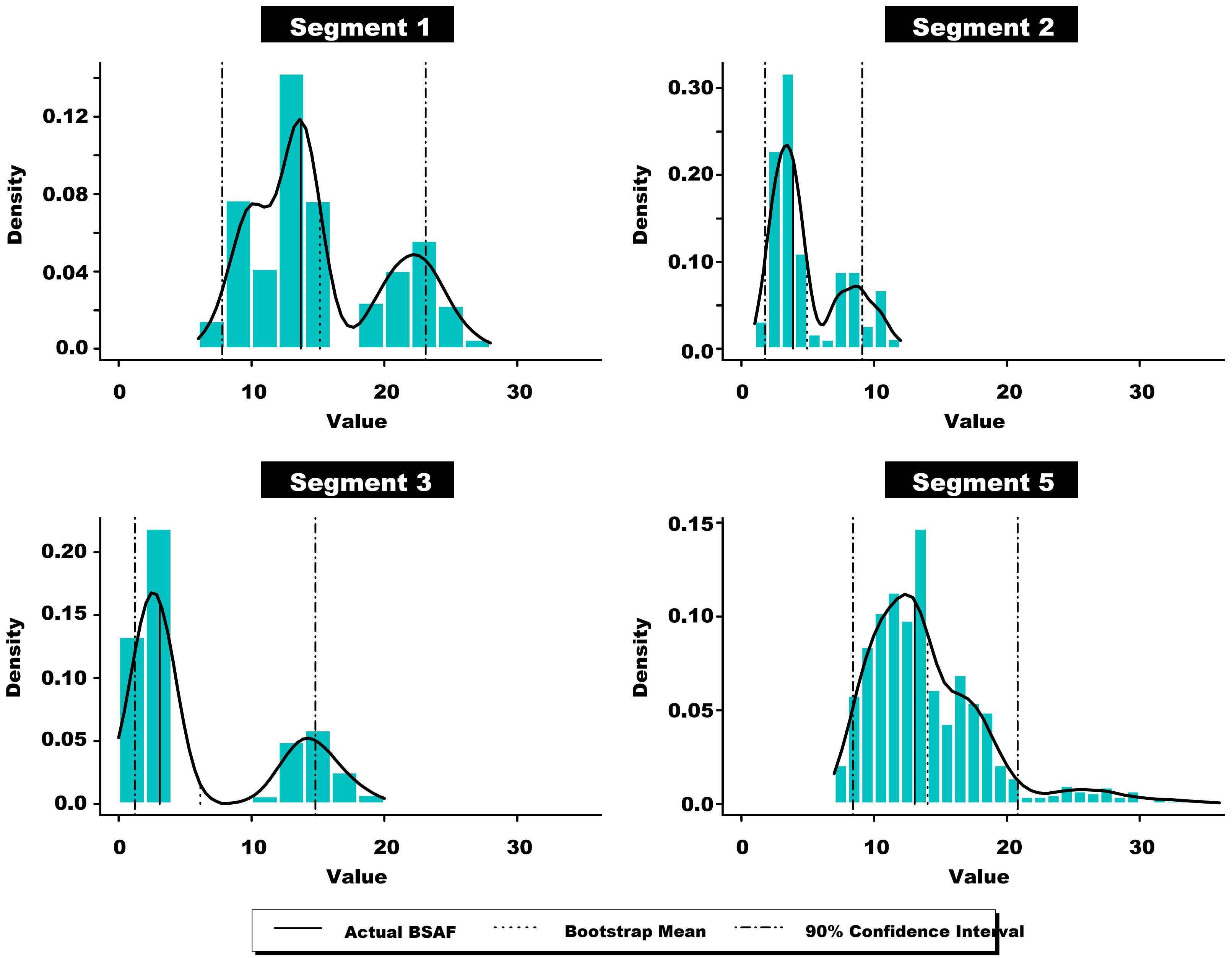


Figure 4-17. Histograms showing BSAF values found using empirical bootstrapping on 1997 ERA sediment and smallmouth bass PCB data from each river segment (n=1000)

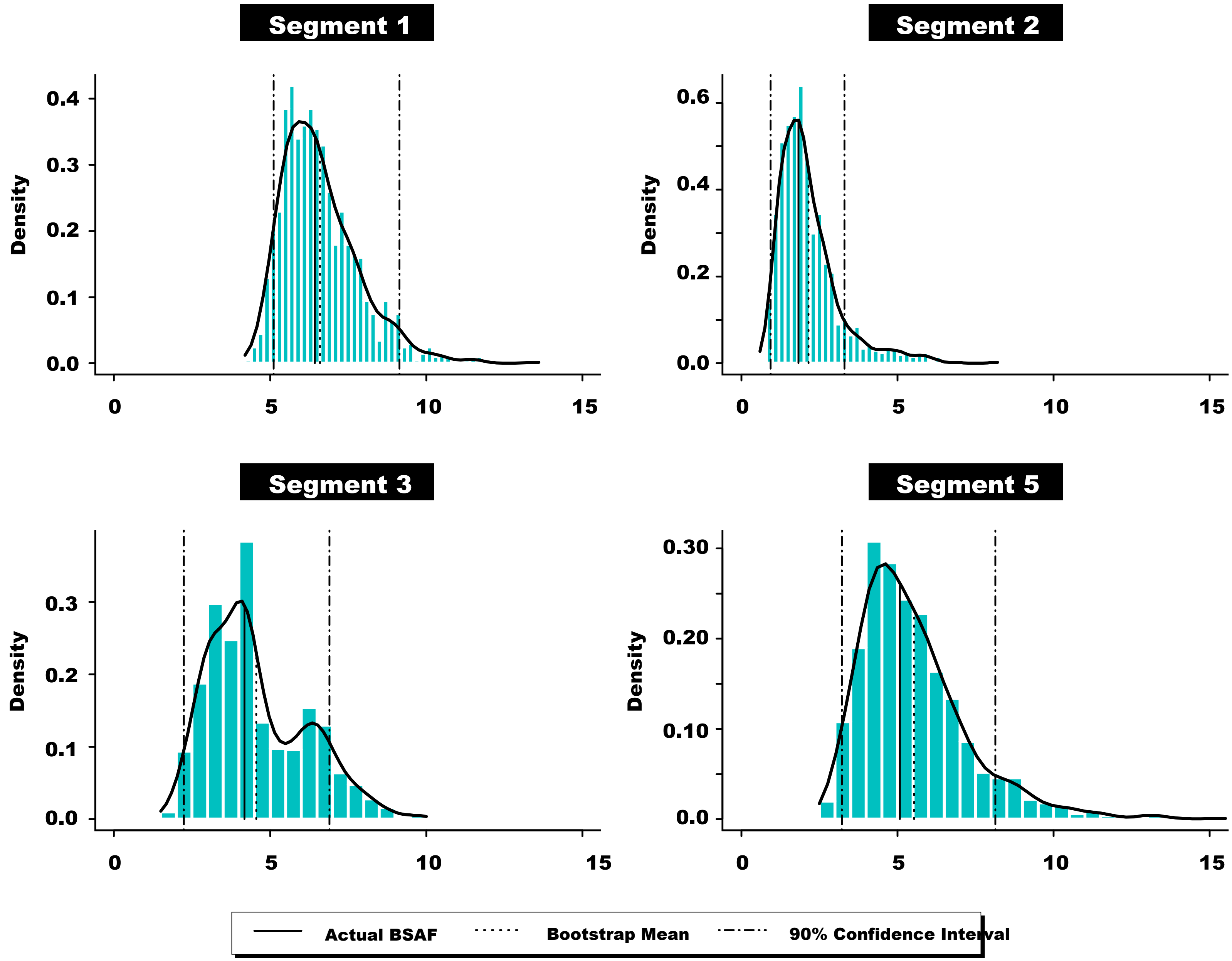


Figure 4-18. Histograms showing BSAF values found using empirical bootstrapping on combined sediment PCB data from WDNR food chain study and 1997 ERA and smallmouth bass PCB data from 1997 ERA (n=1000)

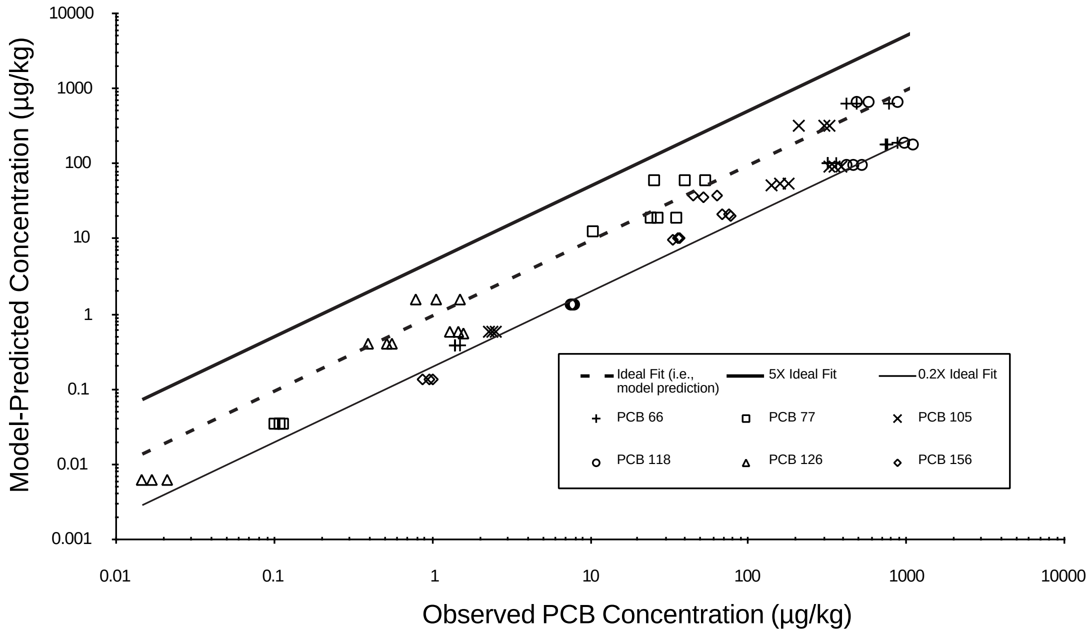


Figure 4-19. Logarithmic plot of predicted versus observed concentrations of three PCB congeners in Sheboygan River smallmouth bass, using food web bioaccumulation model

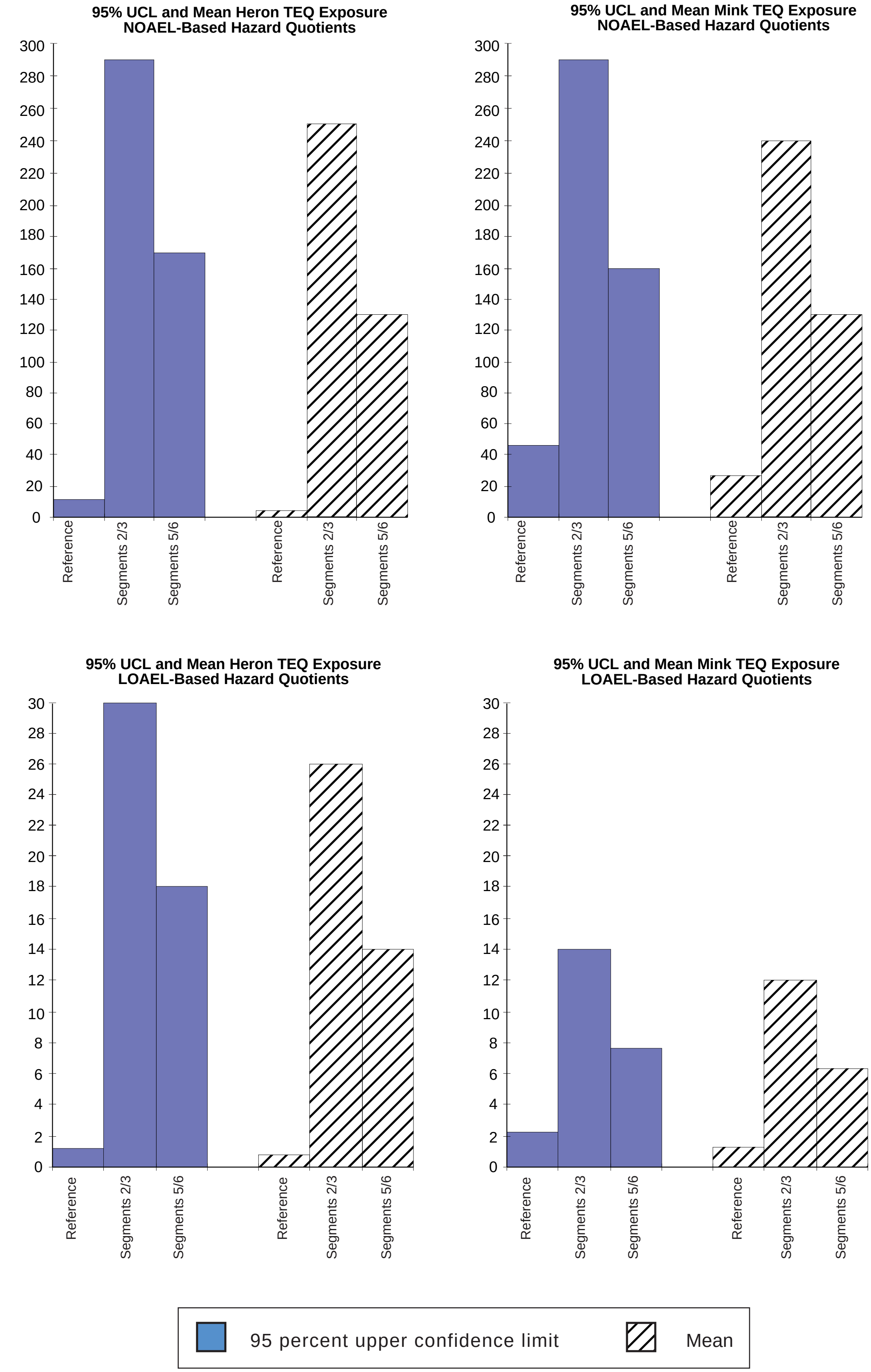


Figure 5-1. TEQ hazard quotients for mink and great blue heron

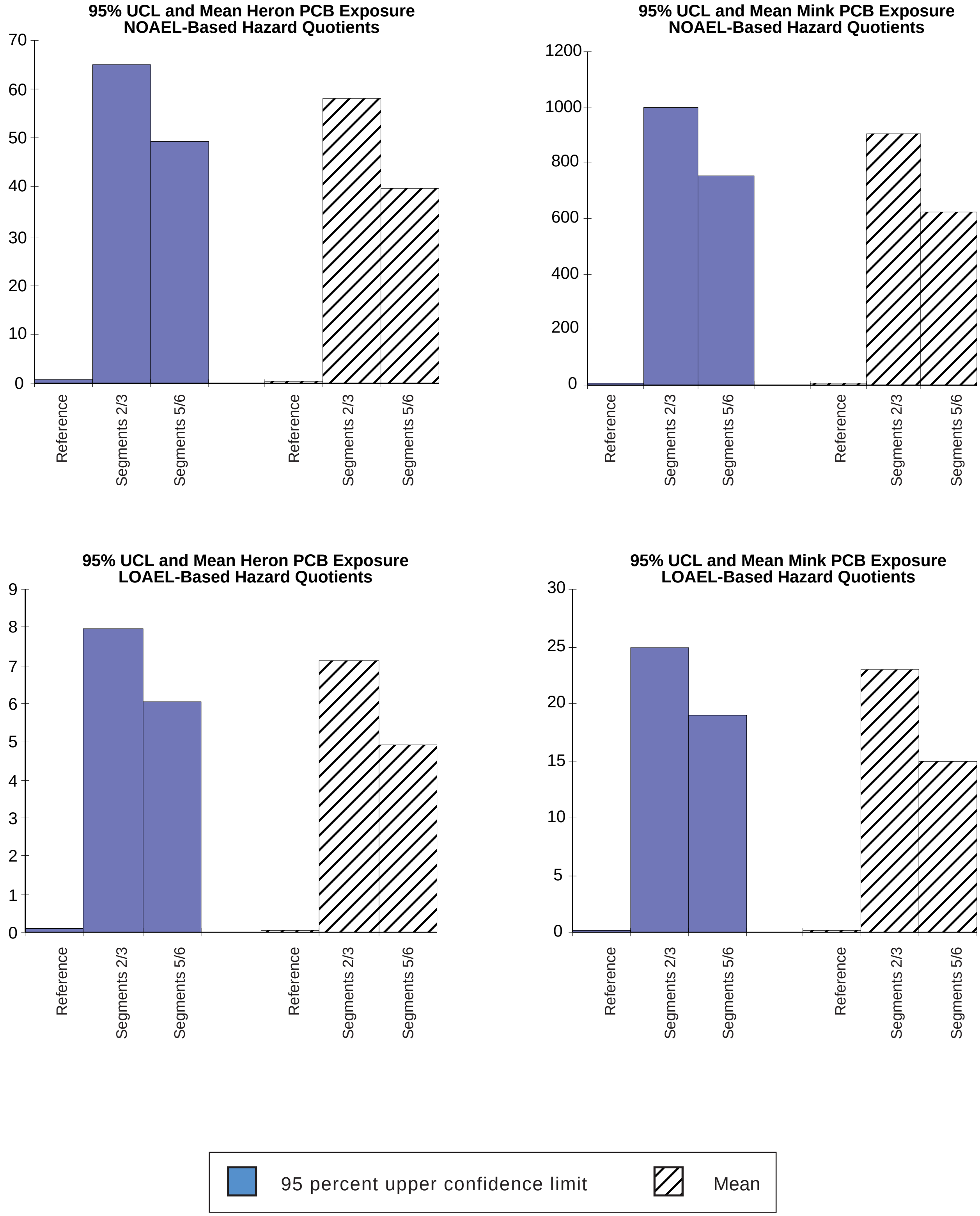


Figure 5-2. Total PCB hazard quotients for mink and great blue heron

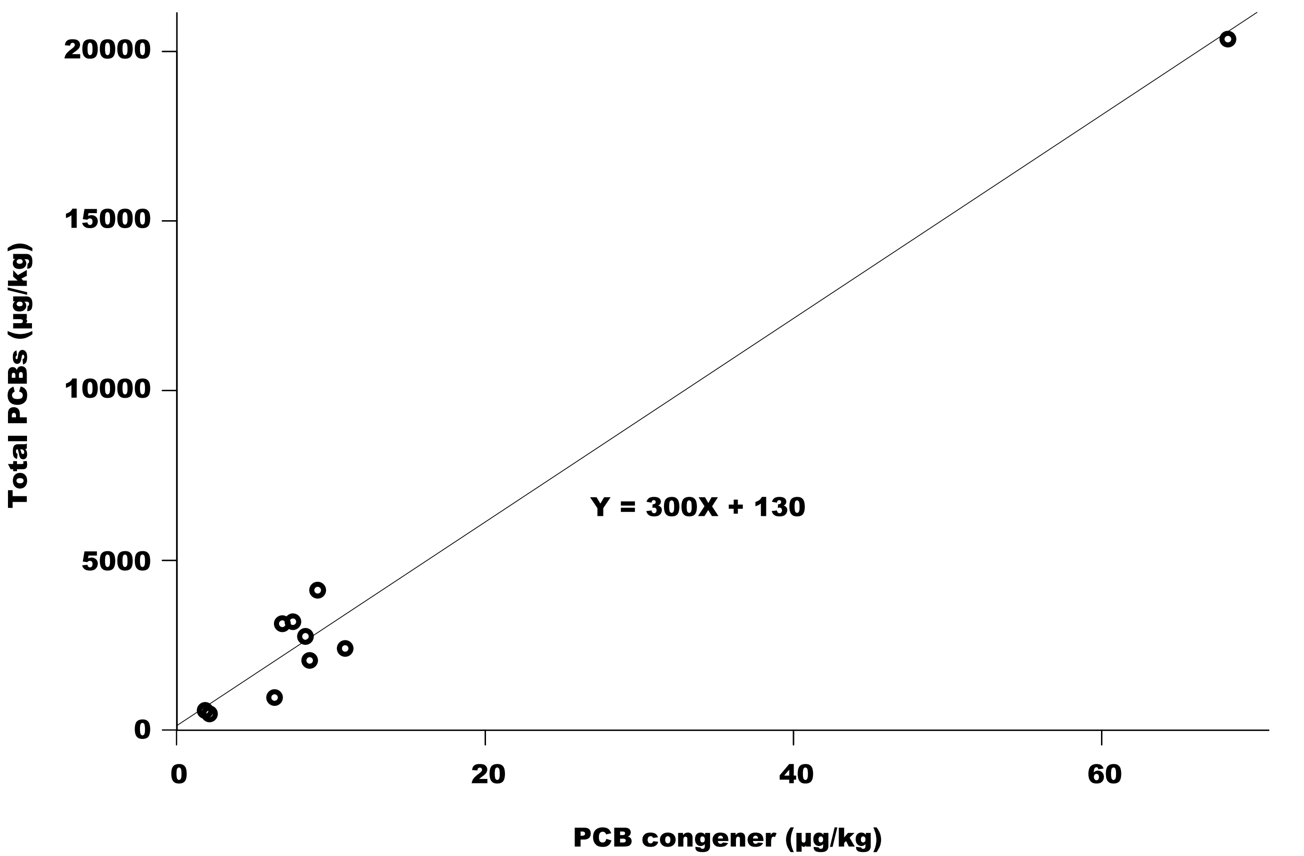


Figure 6-1. Example of linear regression for PCB Congener 77

Table 2-1. Fish species found in the Sheboygan River

		Habitat Usage			
Common Name	Scientific Name	Spawning	Nursery	Adult Forage	Migratory
Resident Fish Species					
Bass and sunfish	**Centrarchidae**				
Smallmouth bass	*Micropterus dolomieu*	♦	♦	♦	
Rock bass	*Ambloplites rupestris*	♦	♦	♦	
Bluegill	*Lepomis macrochirus*	♦	♦	♦	
Pumpkinseed	*Lepomis gibbosus*	♦	♦	♦	
Black crappie	*Pomoxis nigromaculatus*	♦	♦	♦	
Carp, minnows, suckers	**Cypriniformes**				
Common carp	*Cyprinus carpio*	♦	♦	♦	
White sucker	*Catostomus commersoni*	♦	♦	♦	
Redhorses	*Moxostoma* spp.	♦	♦	♦	
Common shiner	*Luxilus cornutus*	♦	♦	♦	
Hornyhead chub	*Nocomis biguttatus*	♦	♦	♦	
Longnose dace	*Rhinichthys cataractae*	♦	♦	♦	
Sand shiner	*Notropis stramineus*	♦	♦	♦	
Perch	**Percidae**				
Walleye	*Stizostedion vitreum*	♦	♦	♦	
Blackside darter	*Percina maculata*	♦	♦	♦	
Log perch	*Percina caprodes*	♦	♦	♦	
Catfish	**Suluriformes**				
Channel catfish	*Ictaleurus punctatus*	♦	♦	♦	
Stonecat	*Noturus flavus*	♦	♦	♦	
Other					
Northern pike	*Esox lucius*	♦	♦	♦	
Herring	**Clupeiformes**				
Alewife	*Alosa pseudoharengus*	♦	♦		♦
Gizzard shad	*Dorosoma cepedianum*	♦	♦		♦
Anadromous Fish Species[a]					
Pacific salmonids	**Salmoniformes**				
Coho salmon	*Oncorhynchus kisutch*				♦
Chinook salmon	*Oncorhynchus tshawytscha*		♦		♦
Steelhead trout	*Oncorhynchus mykiss*		♦		♦

[a] The anadromous salmonids do not spawn in the Sheboygan River; suitable spawning habitat is not present.

Table 2-2. Wildlife species associated with the aquatic and semi-aquatic habitats of the Sheboygan River

Scientific Name		
Family	Genus and Species	Common Name
Birds		
Accipiditridae	*Pandion haliaetus*	Osprey
Alcedinidae	*Ceryle alcyon*	Kingfisher
Anatidae	*Aix sponsa*	Wood duck
Anatidae	*Anas acuta*	Northern pintail
Anatidae	*Anas clypeata*	Northern shoveler
Anatidae	*Anas crecca*	Green-wing teal
Anatidae	*Anas discors*	Blue-wing teal
Anatidae	*Anas platyrhynchus*	Mallard
Anatidae	*Anas rubripes*	Black duck
Anatidae	*Aythya affinis*	Lesser scaup
Anatidae	*Aythya collaris*	Ring-necked duck
Anatidae	*Branta canadensis*	Canada goose
Anatidae	*Bucephala albeola*	Bufflehead
Anatidae	*Bucephala clangula*	Common goldeneye
Anatidae	*Lophodytes cucullatus*	Hooded merganser
Anatidae	*Mergus merganser*	Common merganser
Anatidae	*Mergus serrator*	Red-breasted merganser
Ardeidae	*Ardea herodias*	Great blue heron
Ardeidae	*Butorides striatus*	Green-backed heron
Ardeidae	*Nycticorax nycticorax*	Black-crowned night heron
Charadriidae	*Charadrius vociferus*	Killdeer
Emberigidae	*Agelaius phoeniceus*	Red-winged blackbird
Falconidae	*Falco peregrinus*	Peregrine falcon
Hirundinidae	*Hirundo pyrrhonota*	Cliff swallow
Hirundinidae	*Tachycineta bicolor*	Tree swallow
Laridae	*Larus argentatus*	Herring gull
Laridae	*Larus delawarensis*	Ring-billed gull
Laridae	*Larus philadelphia*	Bonaparte' s gull
Laridae	*Sterna caspia*	Caspian tern
Laridae	*Sterna forsteri*	Forster' s tern
Laridae	*Sterna hirundo*	Common tern
Phalacrocoracidae	*Phalacrocorax*	Cormorant
Podicipedidae	*Podilymbus podiceps*	Pied-billed grebe
Rallidae	*Fulica americana*	American coot
Scolopacidae	*Actitis macularia*	Spotted sandpiper
Scolopacidae	*Gallinago gallinago*	Common snipe
Scolopacidae	*Tringa solitaria*	Solitary sandpiper
Mammals		
Cricetidae	*Ondatra zibethicus*	Muskrat
Procyonidae	*Procyon lotor*	Raccoon
Mustelidae	*Mustela vison*	Mink
Castoridae	*Castor canadensis*	Beaver

Table 2-3. Historical concentrations of PCBs measured in wildlife collected from the Sheboygan River and Harbor

Species	PCB Concentrations (mg/kg ww)	Tissue Type	Year Collected	Location
Birds				
Mallard	3	MS	Unknown	Sheboygan River
	2	MS	Unknown	Sheboygan River
	4.6	MS	Unknown	Sheboygan River
	18	MS	Unknown	Sheboygan River
	11	MS	Unknown	Sheboygan River
	15	MS	Unknown	Sheboygan River
	0.39	MS	Unknown	Sheboygan Marsh
	3.0–18.0	MS	1985–1986	Sheboygan Falls to Lake Michigan
	214.41 ± 216.14[a]	MS	1985–1986	Sheboygan River
Wood Duck	1.3	MS	Unknown	Sheboygan Falls
Lesser Scaup	0.97	M	Unknown	Lake Michigan near Sheboygan Harbor
	0.84	M	Unknown	Lake Michigan near Sheboygan Harbor
	5.7	MS	Unknown	Lake Michigan near Sheboygan Harbor
	5	MS	Unknown	Lake Michigan near Sheboygan Harbor
	5.0–5.7	MS	1985–1986	Sheboygan Harbor
	25.42 ± 6.48	MS	1985–1986	Sheboygan Harbor
Mammals				
Mink	1.9	MF	Unknown	Sheboygan

SOURCE: BBL 1990

NOTE: M - muscle without skin or fat
MF - muscle with fat
MS - muscle with skin and fat

[a] Lipid normalized.

Table 2-4. Toxic equivalency factors used in the fish assessment

Congener	TEF WHO 1997	TEF Walker and Peterson 1991	TEF Zabel et al. 1995a	TEF Used in Fish Assessment
Dioxins				
2,3,7,8-TCDD	1	1	1	**1**
1,2,3,7,8-PeCDD	1	0.73	0.73	**0.73**
1,2,3,4,7,8-HxCDD	0.5	0.319	0.319	**0.319**
1,2,3,6,7,8-HxCDD	0.01	na	0.024	**0.024**
1,2,3,7,8,9-HxCDD	0.01	na	na	**0.01**
1,2,3,4,6,7,8-HpCDD	0.001	na	0.002	**0.002**
OCDD	na	na	na	na
Furans				
2,3,7,8-TCDF	0.05	0.028	0.028	**0.028**
1,2,3,7,8-PeCDF	0.05	0.034	0.034	**0.034**
2,3,4,7,8-PeCDF	0.5	0.359	0.359	**0.359**
1,2,3,4,7,8-HxCDF	0.1	0.28	0.28	**0.28**
1,2,3,6,7,8-HxCDF	0.1	na	na	**0.1**
1,2,3,7,8,9-HxCDF	0.1	na	na	**0.1**
2,3,4,6,7,8-HxCDF	0.1	na	na	**0.1**
1,2,3,4,6,7,8-HpCDF	0.01	na	na	**0.01**
1,2,3,4,7,8,9-HpCDF	0.01	na	na	**0.01**
OCDF	0.0001	na	na	**0.0001**
PCB congeners				
081	0.0005	na	0.00056	**0.00056**
077	0.0001	0.00016	0.00016	**0.00016**
126	0.005	0.005	0.005	**0.005**
169	0.00005	na	0.000041	**0.000041**
105	<0.000005	<0.00007	<0.00000172	**0.00000172**
114	<0.000005	na	na	**0.000005**
118	<0.000005	<0.00007	<0.00000302	**0.00000302**
123	<0.000005	na	na	**0.000005**
156	<0.000005	na	<0.00000167	**0.00000167**
157	<0.000005	na	na	**0.000005**
167	<0.000005	na	na	**0.000005**
189	<0.000005	na	na	**0.000005**

NOTE: TEF - toxic equivalency factor
na - not available

Table 2-5. Toxic equivalency factors used in the piscivore assessment

Congener	Receptor Species	
	Bird TEF[a]	Mammal TEF[b]
Dioxins		
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	1.1	1
1,2,3,4,7,8-HxCDD	na	0.1
1,2,3,6,7,8-HxCDD	na	0.1
1,2,3,7,8,9-HxCDD	na	0.1
1,2,3,4,6,7,8-HpCDD	na	0.01
OCDD	na	0.0001
Furans		
2,3,7,8-TCDF	1.1	0.1
1,2,3,7,8-PeCDF	na	0.05
2,3,4,7,8-PeCDF	na	0.5
1,2,3,4,7,8-HxCDF	na	0.1
1,2,3,6,7,8-HxCDF	na	0.1
1,2,3,7,8,9-HxCDF	na	0.1
2,3,4,6,7,8-HxCDF	na	0.1
1,2,3,4,6,7,8-HpCDF	na	0.01
1,2,3,4,7,8,9-HpCDF	na	0.01
OCDF	na	0.0001
PCB Congeners		
077	0.03	0.0001
114	na	0.0005
123	na	0.0001
156	0.001	0.0005
157	0.002	0.0005
169	0.02	0.01
189	na	0.0001
105	0.005	0.0001
118	0.001	0.0001
126	0.3	0.1
081	0.2	0.0001
167	0.002	0.00001
194	0.00005	na
128	0.001	na
138	0.001	na
170	0.0002	na
180	0.0002	na
110	0.00005	na
002	0.00001	na
012	0.0008	na
035	0.0007	na
037	0.0004	na
078	0.0001	na
079	0.004	na
080	0.00008	na
127	0.005	na
066	0.002	na
070	0.0004	na
139	0.0006	na
122	0.00002	na

NOTE: TEF - toxic equivalency factor
na - not available

[a] Kennedy et al. 1996
[b] WHO 1997

Table 2-6. Dioxin, furan, and PCB congener concentrations measured in three fish tissue samples and respective TEQ concentrations for fish

		Sample F2-1			Sample F2-2			Sample F2-3		
Analyte	**Fish TEF**	**Congener Concentration (ng/kg)**	**TEQ Concentration (ng/kg)**	**Percent of Total TEQ**	**Congener Concentration (ng/kg)**	**TEQ Concentration (ng/kg)**	**Percent of Total TEQ**	**Congener Concentration (ng/kg)**	**TEQ Concentration (ng/kg)**	**Percent of Total TEQ**
Dioxins/furans										
2,3,7,8-TCDD	1	0.19	0.19	1.2	0.19	0.19	0.90	0.19	0.19	1.7
1,2,3,7,8-PeCDD	0.73	0.13	0.095	0.61	0.11	0.08	0.38	0.005U	0.0037	0.033
1,2,3,4,7,8-HxCDD	0.319	0.06	0.019	0.12	0.01U	0.0032	0.015	0.05	0.016	0.14
1,2,3,6,7,8-HxCDD	0.024	0.11	0.0026	0.017	0.01U	0.00024	0.0011	0.1	0.0024	0.022
1,2,3,4,6,7,8-HpCDD	0.002	0.25	0.0005	0.0032	0.22	0.00044	0.0021	0.2	0.0004	0.0036
2,3,7,8-TCDF	0.028	1.88	0.053	0.34	2.14	0.06	0.28	2.2	0.062	0.56
1,2,3,7,8-PeCDF	0.034	0.18	0.0061	0.039	0.22	0.0075	0.035	0.29	0.0099	0.1
2,3,4,7,8-PeCDF	0.359	1.98	0.71	4.6	2.57	0.92	4.3	1.71	0.61	5.5
1,2,3,4,7,8-HxCDF	0.28	0.13	0.036	0.23	0.18	0.05	0.24	0.13	0.036	0.32
1,2,3,6,7,8-HxCDF	0.1	0.07	0.007	0.045	0.08	0.008	0.038	0.02U	0.002	0.018
2,3,4,6,7,8-HxCDF	0.1	0.06	0.006	0.039	0.06	0.006	0.028	0.06	0.006	0.054
1,2,3,4,6,7,8-HpCDF	0.01	0.13	0.0013	0.0084	0.1	0.001	0.0047	0.08	0.0008	0.0072
1,2,3,4,7,8,9-HpCDF	0.1	0.08	0.0008	0.0052	0.015U	0.00015	0.00071	0.02U	0.00002	0.00018
OCDF	0.0001	0.34	0.000034	0.00022	0.015U	0.0000015	0.0000071	0.02U	0.000002	0.000018
Dioxin and furan TEQ			**1.1**	**7.3**		**1.3**	**6.3**		**0.94**	**8.5**
PCBs										
077	0.00016	39,400	6.3	41	53,000	8.5	40	25,400	4.1	37
105	0.00000172	300,000	0.52	3.4	330,000	0.57	2.7	210,000	0.36	3.2
114	0.000005	28,700	0.14	0.90	32,700	0.16	0.76	24,000	0.12	1.1
118	0.00000302	570,000	1.7	11	890,000	2.7	13	480,000	1.4	13
123	0.000005	11,700	0.059	0.38	11,000	0.055	0.26	10,900	0.055	0.50
126	0.005	1,070	5.4	35	1,510	7.6	36	786	3.9	35
156	0.00000167	51,400	0.086	0.56	63,000	0.11	0.52	45,100	0.075	0.68
157	0.000005	10,900	0.055	0.36	10,500	0.053	0.25	8,160	0.041	0.37
167	0.000005	18,700	0.094	0.61	19,900	0.1	0.47	15,700	0.079	0.71
189	0.000005	2,160	0.011	0.071	2,350	0.012	0.057	1,800	0.009	0.081
Dioxin, furan, and PCB total TEQ			**15**	**100**		**21**	**100**		**11**	**100**

NOTE: TEF - toxic equivalency factor
TEQ - toxic equivalent
U - undetected congener; value represents one-half the detection limit

Table 2-7. Dioxin, furan, and PCB congener concentrations measured in three fish tissue samples and respective TEQ concentrations for mammals

		Sample F2-1			Sample F2-2			Sample F2-3		
Analyte	Mammal TEF	Congener Concentration (ng/kg)	TEQ Concentration (ng/kg)	Percent of Total TEQ	Congener Concentration (ng/kg)	TEQ Concentratio N (ng/kg)	Percent of Total TEQ	Congener Concentration (ng/kg)	TEQ Concentration (ng/kg)	Percent of Total TEQ
Dioxins/furans										
2,3,7,8-TCDD	1	0.19	0.19	0.076	0.19	0.19	0.057	0.19	0.19	0.099
1,2,3,7,8-PeCDD	1	0.13	0.13	0.052	0.11	0.11	0.033	0.005U	0.005	0.0026
1,2,3,4,7,8-HxCDD	0.1	0.06	0.006	0.0024	0.001	0.001	0.00030	0.05	0.005	0.0026
1,2,3,6,7,8-HxCDD	0.1	0.11	0.011	0.0044	0.001	0.001	0.00030	0.1	0.01	0.0052
1,2,3,4,6,7,8-HpCDD	0.01	0.25	0.0025	0.0010	0.0022	0.0022	0.00066	0.2	0.002	0.0010
OCDD	0.0001	0.86	0.000086	0.000034	0.000085	0.000085	0.000025	0.75	0.000075	0.000039
2,3,7,8-TCDF	0.1	1.88	0.19	0.076	0.21	0.21	0.063	2.23	0.22	0.11
1,2,3,7,8-PeCDF	0.05	0.18	0.009	0.0036	0.011	0.011	0.0033	0.29	0.015	0.0078
2,3,4,7,8-PeCDF	0.5	1.98	0.99	0.40	1.3	1.3	0.39	1.71	0.86	0.45
1,2,3,4,7,8-HxCDF	0.1	0.13	0.013	0.0052	0.018	0.018	0.0054	0.13	0.013	0.0068
1,2,3,6,7,8-HxCDF	0.1	0.07	0.007	0.0028	0.008	0.008	0.0024	0.02U	0.002	0.0010
2,3,4,6,7,8-HxCDF	0.1	0.06	0.006	0.0024	0.006	0.006	0.0018	0.06	0.006	0.0031
1,2,3,4,6,7,8-HpCDF	0.01	0.13	0.0013	0.00052	0.001	0.001	0.00030	0.08	0.0008	0.00042
1,2,3,4,7,8,9-HpCDF	0.01	0.08	0.0008	0.00032	0.00015	0.00015	0.000045	0.02U	0.0002	0.00010
OCDF	0.0001	0.34	0.000034	0.000014	0.0000015	0.0000015	0.00000045	0.02U	0.000002	0.0000010
Dioxin and furan TEQ			**1.6**	**0.62**		**0.0018**	**0.56**		**0.0013**	**0.69**
PCBs										
077	0.0001	39,400	3.9	1.6	53,000	5.3	1.6	25,400	2.5	1.3
105	0.0001	300,000	30	12	330,000	33	9.9	210,000	21	11
114	0.0005	28,700	14	5.6	32,700	16	4.8	24,000	12	6.2
118	0.0001	570,000	57	23	890,000	89	27	480,000	48	25
123	0.0001	11,700	1.2	0.48	11,000	1.1	0.33	10,900	1.1	0.57
126	0.1	1,070	110	44	1,510	150	45	786	79	41
156	0.0005	51,400	26	10	63,000	32	9.6	45,100	23	12
157	0.0005	10,900	5.5	2.2	10,500	5.3	1.6	8,160	4.1	2.1
189	0.0001	2,160	0.22	0.088	2,350	0.24	0.072	1,800	0.18	0.094
Dioxin, furan, and PCB total TEQ			**250**	**100**		**330**	**100**		**190**	**100**

NOTE: TEF - toxic equivalency factor
TEQ - toxic equivalent
U - undetected congener; value represents one-half the detection limit

Table 2-8. Dioxin, furan, and PCB congener concentrations measured in three fish tissue samples and respective TEQ concentrations for birds

Analyte	Bird TEF	Sample F2-1 Congener Concentration (ng/kg)	Sample F2-1 TEQ Concentration (ng/kg)	Sample F2-1 Percent of Total TEQ	Sample F2-2 Congener Concentration (ng/kg)	Sample F2-2 TEQ Concentration (ng/kg)	Sample F2-2 Percent of Total TEQ	Sample F2-3 Congener Concentration (ng/kg)	Sample F2-3 TEQ Concentration (ng/kg)	Sample F2-3 Percent of Total TEQ
Dioxins/furans										
2,3,7,8-TCDD	1	0.19	0.19	0.0038	0.19	0.19	0.0028	0.19	0.19	0.0051
1,2,3,7,8-PeCDD	1.1	0.13	0.14	0.0028	0.11	0.12	0.0018	0.005U	0.0055	0.00015
2,3,7,8-TCDF	1.1	1.9	2.1	0.042	2.1	2.4	0.036	2.3	2.5	0.067
Dioxin and furan TEQ			**2.4**	**0.049**		**2.7**	**0.040**		**2.7**	**0.072**
PCBs										
066	0.002	490,000	980	20	780,000	1,600	24	420,000	840	22
077	0.03	39,400	1,200	24	53,000	1,600	24	25,400	760	20
105	0.005	300,000	1,500	30	330,000	1,700	25	210,000	1,100	29
110	0.00005	2,800,000	140	2.8	4,200,000	210	3.1	2,300,000	120	3.2
118	0.001	570,000	570	11	890,000	890	13	480,000	480	13
126	0.3	1,070	320	6.4	1,510	450	6.7	786	240	6.4
128	0.001	130,000	130	2.6	98,000	98	1.5	88,000	88	2.4
156	0.001	51,400	51	1.0	63,000	63	0.94	45,100	45	1.2
157	0.002	10,900	22	0.44	10,500	21	0.31	8,160	16	0.43
167	0.002	18,700	37	0.74	19,900	40	0.60	15,700	31	0.83
170	0.0002	48,200	9.6	0.19	45,400	9.1	0.14	37,200	7.4	0.20
180	0.0002	82,300	16	0.32	75,400	15	0.22	72,000	14	0.37
194	0.00005	14,000	0.70	0.014	16,000	0.8	0.012	9,900	0.5	0.013
Dioxin, furan, and PCB total TEQ			**5,000**	**100**		**6,700**	**100**		**3,700**	**100**

NOTE: TEF - toxic equivalency factor
TEQ - toxic equivalent
U - undetected congener; value represents one-half the detection limit

Table 2-9. Summary of data evaluated for contaminants of concern screening

Type of Data	Reference	Analytes	Comments
Sediment			
Sediment	BBL 1990	PCBs, trace elements, PAHs (subset), pesticides (subset), dioxin/furan (1 sample only)	Sediment core samples were collected throughout the river (Sheboygan Falls to 1mi upstream from the mouth of the river) prior to removal activities in 1987 at sediment depths ranging from 0.3 to 3.5 ft.
Sediment	BBL 1990	PCBs, trace elements (subset), PAHs (subset), pesticides (subset), dioxin (1 sample only)	Sediment samples were collected from the lower river and harbor at depths of 0–0.5 ft, 0.5–2 ft, 2–4 ft, 4–6 ft, 6–8 ft, 8–12 ft, 12–16 ft, and 16–20 ft (not all depths at all locations) in 1987 prior to removal activities.
Sediment	BBL 1992	PCBs	Sediment samples were collected shortly after removal activities in 1990 and 1991.
Sediment	BBL 1995	PCBs	Sediment samples were collected from 1989 to 1991 during pre-removal and post-removal activities.
Sediment Traps	WDNR 1997	PCBs, trace elements (subset), PAHs (subset)	Sediment trap samples were collected at nine monitoring stations from 1990 to 1996.
Sediment	WDNR 1996a	PCB congeners, PAHs, metals	Samples were collected in 1994 and 1995 as part of the WDNR food chain study.
Sediment	1997 ERA (this study)	PCB congeners, PCB Aroclors, PAHs, metals	Sediment samples were collected in 1997 for the current ecological risk assessment.
Water			
Water	BBL 1990	PCBs and trace elements, filtered and unfiltered	Samples were collected in 1987 and 1988.
Water	BBL 1995	PCBs, conventional analytes	Water data were collected before, during, and after removal activities from 1989 to 1993. Water data collected during removal activities were not used for screening.
Tissue			
Resident Fish	WDNR 1997	PCBs, trace elements (subset), PAHs (subset), pesticides (subset), dioxins (subset)	Large state database of fish sampling conducted throughout the Sheboygan River from 1976 to 1994.
Resident Fish	WDNR 1996a	PCB congeners, metals, PAHs	Samples were collected in 1994 as part of the WDNR food chain study.
Resident Fish	1997 ERA (this study)	PCB congeners, dioxins (subset)	Samples were collected in 1997 for the current ecological risk assessment.
Crayfish and Insects	WDNR 1996a	PCB congeners, metals, PAHs	Chemical analyses of crayfish and adult and larval invertebrates were conducted in 1994 as part of the WDNR food chain study.

Table 2-10. Maximum concentrations of contaminants in sediment compared to threshold effects levels

		Maximum Site Concentration (mg/kg)				
Contaminant	TEL[a]	River (BBL 1990)	Lower River and Harbor (BBL 1990)	Sediment Trap (WDNR 1997 data)	Sediment Core (WDNR 1996a)	1997 ERA
Metals						
Arsenic	10.8	23	20	25	1.9	2.8
Cadmium	0.583	3.2	3.7	1.2	2.2	0.47
Chromium	36.3	140	460	35	28	79
Copper	28	160	150	63	87	35
Lead	37.2	720	720	110	63	130
Mercury	0.174[b]	0.42	0.68	0.79	0.27	0.20
Nickel	19.5	90	350	21	na	19
Silver	—	0.63	0.9	na	6	0.25
Zinc	98.1	300	370	170	na	110
Organic compounds						
Total PAHs	0.264	4.0	63	44	26[c]	7.2
Total PCBs	0.0316[b]	4,500	0.22	180[d]	460[e]	760

NOTE: na – not analyzed
— not available
TEL – threshold effects level

[a] TELs based on toxicity test data for *Hyalella azteca* using 28-day survival, growth, and reproduction endpoints (USEPA 1996a).

[b] TELs for mercury and total PCBs from Smith et al. (1996) because none available in USEPA (1996a).

[c] Total PAHs were 3,519 mg/kg at depth near the Camp Marina coal gasification site (sample 6DUPPAH).

[d] Galarneau pers. comm. 1998.

[e] Galarneau pers. comm. 1998; core taken at Rochester Park.

Table 2-11. Comparison of the site-specific 95 percent upper confidence limit contaminant concentrations in fish with the mean reference area concentrations in fish

	Segment 1 (Reference) Mean (mg/kg)	Segment 2 95% UCL (mg/kg)	Segment 3 95% UCL (mg/kg)	Segment 5 95% UCL (mg/kg)	Segment 6 95% UCL (mg/kg)
Total PCBs	0.11	26	22	12	nc
Arsenic	nd	nc	nc	nc	nd
Cadmium	nd	nc	nc	nc	nd
Chromium	nd	nc	nc	nc	nd
Copper	0.55	nc	nc	nc	0.75
Lead	nd	nc	nc	nc	nd
Mercury	0.077	nc	nc	nc	0.11
Zinc	14	nc	nc	nc	13

NOTE: nc - not collected
nd - not detected; detection limits were not available
Raw data are presented in Schrank et al. (1997)
UCL - upper confidence limit

Table 2-12. Comparison of the site-specific 95 percent upper confidence limit mercury and PAH sediment concentrations with the mean reference area sediment concentrations

	Mercury (mg/kg)		PAHs (mg/kg)							
	No. of Stations		No. of Stations	Acenaphthene	Acenaph-thylene	Anthracene	Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(e) pyrene
1997 ERA										
Reference mean	4	0.05	4	0.0029 U	0.0029 U	0.0047	0.0023	0.0029	0.031	na
Segment 6 UCL	9	0.08	9	0.032	0.016	0.082	0.38	0.41	0.44	na
Segment 5 UCL	5[a]	0.08	5[a]	0.040	0.0057	0.10	0.43	0.45	0.49	na
Segment 3 value	1	0.04	1	0.0074	0.0057 U	0.022	0.078	0.091	0.083	na
Segment 2 value	1	0.20	1	0.0058 U	0.0058 U	0.0058 U	0.029	0.034	0.047	na
WDNR food chain study										
Reference mean	5	0.08	3	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U
Segment 6 UCL	6	0.13	4	0.39	0.20	0.45	1.8	1.0	1.2	0.77
Segment 5 UCL	5	0.08	4	0.050 U	0.050 U	0.12	0.70	0.64	0.080	0.51
Segment 3 UCL	6	0.07	4	0.050 U	0.050 U	0.050 U	0.13	0.17	0.21	0.16
Segment 2 UCL	5	0.19	**3**	0.31	0.31	0.86	2.3	1.9	2.7	1.3

	PAHs, continued (mg/kg)							
	No. of Stations	Benzo(b) fluoranthene	Benzo (e) pyrene	Benzo(g,h,i) perylene	Benzo(k) fluoranthene	Chrysene	Dibenzo(a, h) anthracene	Dibenzofuran
1997 ERA								
Reference mean	4	0.031	na	0.014	0.026	0.030	0.0047	0.0029
Segment 6 UCL	9	0.44	na	0.17	0.34	0.38	0.041	0.021
Segment 5 UCL	5[a]	0.49	na	0.23	0.37	0.44	0.058	0.025
Segment 3 value	1	0.083	na	0.042	0.091	0.94	0.015	0.0057 U
Segment 2 value	1	0.047	na	0.018	0.031	0.044	0.0058 U	0.0058 U
WDNR food chain study								
Reference mean	3	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	na
Segment 6 UCL	4	1.2	0.77	0.34	0.50	1.3	0.050 U	na
Segment 5 UCL	4	0.80	0.51	0.20	0.33	0.67	0.050 U	na
Segment 3 UCL	4	0.21	0.16	0.050 U	0.050 U	0.14	0.050 U	na
Segment 2 UCL	**3**	2.7	1.3	0.069	1.2	2.1	0.31 U	na

Table 2-12, continued

	No. of Stations	Fluoranthene	Fluorene	Indeno(1,2,3-c d) pyrene	Perylene	2-Methylnaphthalene	Naphthalene	Phenanthrene	Pyrene
	PAHs, continued (mg/kg)								
1997 ERA									
Reference mean	4	0.063	0.0043	0.020	na	0.0029		0.040	0.057
Segment 6 UCL	9	0.93	0.048	0.23	na	0.026	0.025	0.44	0.077
Segment 5 UCL	5[a]	1.3	0.062	0.31	na	0.017	0.015	0.69	0.098
Segment 3 value	1	0.16	0.013	0.053	na	0.0057 U	0.0057 U	0.12	0.022
Segment 2 value	1	0.063	0.0069	0.018	na	0.0092	0.0092	0.048	0.068
WDNR food chain study									
Reference mean	3	0.050 U	0.050 U	0.050 U	0.050 U	na	na	0.050 U	0.050 U
Segment 6 UCL	4	2.5	0.31	0.43	0.28	na	na	2.0	3.2
Segment 5 UCL	4	2.4	0.050 U	0.027	0.15	na	na	0.92	2.0
Segment 3 UCL	4	0.35	0.050 U	0.050	0.11	na	na	0.020	0.27
Segment 2 UCL	**3**	6.7	0.31	0.87	0.31	na	na	4.6	5.2

NOTE: na - not available
U - undetected; value represents one-half the detection limit
UCL - upper confidence limit
Raw data are presented in Tables A1-1, A1-3, A3-2, and A3-3 in Appendix A

[a] Three stations and two duplicates.

Table 2-13. Comparison of 95 percent upper confidence limit mercury tissue concentrations in organisms collected from the Sheboygan River with mean reference area tissue concentrations

	Mercury Tissue Concentrations (mg/kg ww)				
Tissue Type	Reference Mean	Segment 2 95% UCL	Segment 3 95% UCL	Segment 5 95% UCL	Segment 6 95% UCL
Emergent insects	0.061	0.053	0.035	0.035	not collected
Larval insects	0.025	0.036	0.024	0.028	not collected
Crayfish	0.043	0.026	0.030	0.031	not collected
Fish	0.077	not collected	not collected	not collected	0.11

NOTE: UCL - upper confidence limit
Raw data are presented in Table A3-6 in Appendix A and in Schrank et al. (1997)

Table 2-14. Comparison of 95 percent upper confidence limit PAH tissue concentrations in organisms collected from the Sheboygan River with the mean reference area tissue concentrations

		PAH Concentration (mg/kg)					
Tissue Type	**Locations**	**Acenaphthylene**	**Acenaphthene**	**Fluorene**	**Phenanthrene**	**Anthracene**	**Fluoranthene**
Larval insects	Reference	0.0035 U	0.0035 U	0.0087	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.0035 U	0.0035 U	0.016	0.040	0.0035 U	0.034
Emergent insects	Reference	0.0035 U	0.0035 U	0.006	0.029	0.0035 U	0.019
	Study sites	0.0035 U	0.005	0.056	0.036	0.0035 U	0.024
Crayfish	Reference	not collected	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U
	Study sites	not collected	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U

		Pyrene	**Benzo(a) anthracene**	**Chrysene**	**Benzo(b) fluoranthene**	**Benzo(k) fluoranthene**	**Benzo(e)pyrene**
Larval insects	Reference	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.028	0.0035 U	0.0035 U	0.0098	0.0035 U	0.0035 U
Emergent insects	Reference	0.017	0.0035 U	0.015	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.023	0.014 U	0.022	0.0035 U	0.0035 U	0.0035 U
Crayfish	Reference	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U

		Benzo(a)pyrene	**Perylene**	**Indeno(1,2,3-cd) pyrene**	**Dibenzo(a,h) anthracene**	**Benzo(g,h,i) perylene**
Larval insects	Reference	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0089
Emergent insects	Reference	0.0035 U	0.0035 U	0.0035 U	0.0046	0.0047
	Study sites	0.0035 U	0.0035 U	0.0035 U	0.0073	0.0075
Crayfish	Reference	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U
	Study sites	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U

NOTE: Study sites have been combined because only 1 sample was collected per segment
U - undetected; value represents one-half the detection limit
Raw data are presented in Table A3-5 in Appendix A

Table 2-15. Benzo(a)pyrene diet benchmark calculations for mink

1. Estimate of Food Factor

$$f = F/bw$$

Parameter	Code	Units	Value
Food ingestion	F	kg/day ww	0.18
Body weight	bw	kg	0.8
Food factor	*f*	kg/kg day ww	0.22

2. Diet Benchmark Calculation (C_f)

$$C_f = \frac{NOAEL_{mink}}{f}$$

Parameter	Code	Units	Value
Mink no observed adverse effects level	$NOAEL_{mink}$	mg/kg day ww	0.10
Food factor	*f*	kg/kg day ww	0.23
Diet benchmark	C_f	mg/kg ww	0.43

SOURCES: USEPA 1993b; 1995a,b
Sample et. al 1996

Table 2-16. Estimation of food ingestion rates for mink using field metabolic rates and dietary composition

1. *Estimate of Field Metabolic Rate*

$$FMR = a(bw)^b$$

Parameter	Code	Units	Value
Metabolic multiplier	a	-	0.6167
Body weight	bw	g	550
Metabolic exponent	b	-	0.862
Field metabolic rate	FMR	kcal/day	142

2. *Normalization of Field Metabolic Rate*

$$NFMR = (FMR) / (bw)$$

Parameter	Code	Units	Value
Normalized field Metabolic rate	NFMR	kcal/g-day	0.258

3. *Estimate of Average Metabolizable Energy of Diet (ME_{avg})*

$$ME_{avg} = \Sigma (P_k \times GE_k \times AE_k) = \Sigma (P_k \times ME_k)$$

Dietary Item (k)	Percent of Diet (P_k)	Gross Energy (GE_k) (kcal/wet g)	Assimilation Efficiency (AE_k)	Metabolizable Energy (ME_k) (kcal/wet g)	Energy Contribution ($P_k \times ME_k$) (kcal/wet g)
Fish	85%	1.20	91%	1.092	0.928
Crayfish	4%	1.10	87%	0.957	0.038
Aquatic insects	0%	1.06	87%	0.922	0.000
Birds and mammals	6%	1.80	84%	1.512	0.091
Vegetation	1%	1.30	73%	0.949	0.009
Amphibians	3%	1.20	91%	1.092	0.033
Molluscs	0%	0.80	87%	0.696	0.000
Total	99%			ME_{avg} =	1.099

4. *Estimate of Total Normalized Ingestion Rate*

$$NIR_{total} = (NFMR) / (ME_{avg})$$

Parameter	Code	Units	Value
Total normalized ingestion rate	NIR_{total}	(wet g/g-day)	0.235
Total ingestion rate	IR_{total}	(wet kg/day)	0.129

SOURCES: Body weight information - USEPA 1995a,b
Metabolic, gross energy, and assimilation efficiency information - USEPA 1993b

ASSUMPTIONS: The gross energy value for crayfish is the same as the gross energy value for shrimp in Table 4-1, USEPA 1993b. AE values for mammals consuming insects are from Table 4-3, USEPA 1993b; aquatic invertebrates used 80% water and calculated a kcal/g ww for insect larvae (USEPA 1993b, Table 4-1). AE for amphibians assumed to be same as fish.

NOTE: 1% unidentified food items in diet.

Table 2-17. Estimation of food ingestion rates for great blue heron using field metabolic rates and dietary composition

1. *Estimate of Field Metabolic Rate*

$$FMR = a(bw)^b$$

Parameter	Code	Units	Value
Metabolic multiplier	a	-	1.146
Body weight	bw	g	2,230
Metabolic exponent	b	-	0.749
Field metabolic rate	FMR	kcal/day	369.0

2. *Normalization of Field Metabolic Rate*

$$NFMR = (FMR) / (bw)$$

Parameter	Code	Units	Value
Normalized field metabolic rate	NFMR	kcal/g-day	0.165

3. *Estimate of Average Metabolizable Energy of Diet (ME_{avg})*

$$ME_{avg} = \Sigma (P_k \times GE_k \times AE_k) = \Sigma (P_k \times ME_k)$$

Dietary Item(k)	Proportion of Diet (P_k)	Gross Energy (GE_k) (kcal/wet g)	Assimilation Efficiency (AE_k)	Metabolizable Energy (ME_k) (kcal/wet g)	Energy Contribution ($P_k \times ME_k$) (kcal/wet g)
Fish	94%	1.20	79%	0.948	0.891
Aquatic invertebrates	0%	1.06	77%	0.816	0.000
Crayfish	1%	1.10	77%	0.847	0.008
Amphibians	4%	1.20	79%	0.948	0.038
Birds and mammals	1%	1.80	78%	1.404	0.014
Vegetation	0%	1.30	23%	0.299	0.000
Total	100%			ME_{avg} =	0.952

4. *Estimate of Total Normalized Ingestion Rate*

$$NIR_{total} = (NFMR) / (ME_{avg})$$

Parameter	Code	Units	Value
Normalized ingestion rate	NIR_{total}	(wet g/g-day)	0.174
Total ingestion rate	IR_{total}	(wet kg/day)	0.388

SOURCES: Body weight information - USEPA 1995a,b
Metabolic, gross energy, and assimilation efficiency information - USEPA 1993b

ASSUMPTIONS: The gross energy value for crayfish is the same as the gross energy value for shrimp in Table 4-1, USEPA 1993b. AE values for mammals consuming insects are from Table 4-3, USEPA 1993b; aquatic invertebrates used 80% water and calculated a kcal/g ww for insect larvae (USEPA 1993b, Table 4-1).

Table 2-18. Derivation of mink NOAEL-based and LOAEL-based toxicity reference values for benzo(a)pyrene

ANALYTE	BENZO(a)PYRENE
Reference	Mackenzie & Angevine 1981
Form	na
NOAEL concentration	1 mg/kg bw day
LOAEL concentration	10 mg/kg bw day
Test species	mouse
Administration route	oral intubation
Endpoint/effect	reproduction
Study duration	7–16 days
Threshold	1 mg/kg day
Threshold type	chronic NOAEL (critical lifestage)
Ingestion	na
Ingestion reference	na
Body weight	0.03 kg
Body weight reference	USEPA 1988
Dose	1 mg/kg day
Test duration and/or effects conc.	1 mg/kg day
Test species NOAEL	1 mg/kg day
Test species LOAEL	10 mg/kg day
Interspecies extrapolation factor	10
NOAEL-based TRV	0.1 mg/kg bw day
LOAEL-based TRV	1.0 mg/kg bw day

NOTE: LOAEL - lowest observed adverse effects level
na - not available
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Table 2-19. Contaminants of concern selected for the ERA following screening procedure

RECEPTOR OF CONCERN	PCBs	PAHs	METALS
Benthic invertebrates	ö	ö	ö
Fish	ö	ö	
Birds	ö		
Mammals	ö		

Table 2-20. General ecotoxicity of metals to benthic invertebrates

METALS	TOXIC EFFECTS
Arsenic (Eisler 1988a; Mance 1987)	Reduced survival and reproductive impairment
Cadmium (Eisler 1985)	Reduced growth, reduced survival, reproductive impairment, respiratory disruption, and molt inhibition at low ambient concentrations
Chromium (Eisler 1986b)	Reduced survival and reproductive impairment
Copper (Mance 1987)	Mortality and reduced growth
Lead (Eisler 1988b)	Reduced survival, reproductive impairment, and reduced biomass
Mercury (Eisler 1987b; Mance 1987)	Mortality, growth retardation, and behavioral effects
Nickel (Mance 1987)	Mortality, abnormal development, and reduced larval growth
Silver (Mance 1987)	Mortality, abnormal development, and reduced growth
Zinc (Eisler 1993)	Mortality, abnormal growth and development, reproductive impairment, and reduced larval settlement

Table 3-1. Concentrations of Aroclors detected in sediment samples collected at Triad stations in August 1997

STATION	AROCLOR 1232 (mg/kg)	AROCLOR 1242 (mg/kg)	AROCLOR 1254 (mg/kg)	TOTAL PCBs[a,b] (mg/kg)
Reference				
T01	0.019 U	0.019 U	0.019 U	0.029[c]
T02	0.019 U	0.019 U	0.019 U	0.029[c]
T03	0.019 U	0.019 U	0.019 U	0.029[c]
T04	0.020 U	0.020 U	0.020 U	0.030[c]
Site Related				
T07	750	1.6 U	8.1 Y	**760**
T08	0.019 U	0.92	1.0	**1.9**
T09	0.015 U	0.078	0.22	**0.31**
T10	0.019 U	0.071	0.15	0.23
T10-FD	0.020 U	0.080	0.16	**0.25**
T11	0.019 U	0.069	0.12	0.20
T11-FD	0.019 U	0.084	0.16	**0.25**
T12	0.019 U	0.071	0.11	0.19
T13	0.019 U	0.14	0.27	**0.42**
T14	0.019 U	0.15	0.29	**0.45**
T15	0.020 U	0.12	0.24	**0.37**
T16	0.019 U	0.15	0.27	**0.43**
T17	0.019 U	0.15	0.26	**0.42**
T18	0.020 U	0.12	0.25	**0.38**
T19	0.019 U	0.17	0.27	**0.45**
T20	0.020 U	0.15	0.20	**0.36**

NOTE: Aroclors 1016, 1221, 1248, and 1260 were not detected at detection limits of 0.015 to 0.040 mg/kg in any sample except the one from Station T07, which had elevated detection limits of 1.6 to 3.3 mg/kg.
FD - field duplicate
U - undetected; value represents the detection limit
Y - raised detection limit due to interference

[a] Total PCBs were calculated by summing detected concentrations of Aroclors plus one-half the detection limit for those Aroclors that were detected in other samples. Values were rounded to two significant figures.

[b] 28-day *Hyalella azteca* probable effects level of 0.245 and threshold effects level of 0.032. **Bold** indicates exceedance of probable effects level.

[c] PCBs were not detected but total PCBs were estimated based on summing methodology described in footnote “a” above.

Table 3-2. Concentrations of PAHs in sediment samples collected at Triad stations in August 1997

Station	Acenaphthene (mg/kg)	Acenaphthylene (mg/kg)	Anthracene (mg/kg)	Benzo(a) anthracene (mg/kg)	Dibenzo(a) anthracene (mg/kg)	Benzo(a) pyrene (mg/kg)	Benzo(b) fluoranthene (mg/kg)	Benzo(g,h,i) perylene (mg/kg)	Benzo(k) fluoranthene (mg/kg)
Reference									
T01	0.0058U	0.0058U	0.0058	0.016	0.0058U	0.026	0.022	0.014	0.021
T02	0.0058U	0.0058U	0.0058	0.012	0.0058U	0.016	0.017	0.0058U	0.011
T03	0.0059U	0.0059U	0.0059U	0.0059U	0.0059U	0.0059	0.0059	0.007	0.0059
T04	0.006U	0.006U	0.010	0.060	0.010	0.068	0.080	0.030	0.064
Site related									
T07	0.0058U	0.0058U	0.0058U	0.029	0.0058	0.034	0.047	0.018	0.031
T08	0.0074	0.0057U	0.022	0.078	0.015	0.091	0.083	0.042	0.091
T09	0.015	0.0044U	0.043	0.11	0.0058	0.11	0.16	0.035	0.078
T10	0.0058U	0.0058U	0.016	0.080	0.0069	0.10	0.16	0.040	0.087
T10-FD	0.006U	0.006U	0.012	0.071	0.0072	0.092	0.12	0.057	0.089
T11	0.044	0.0075	0.12	**0.49**	0.034	**0.49**	0.55	0.25	0.38
T11-FD	0.040	0.0057U	0.093	**0.43**	0.082	**0.46**	0.48	0.24	0.41
T12	0.029	0.0057U	0.080	**0.30**	0.036	0.29	0.35	0.090	0.18
T13	0.024	0.0064	0.11	**0.44**	0.021	**0.39**	0.42	0.14	0.41
T14	0.031	0.008	0.060	**0.31**	0.017	0.32	0.44	0.12	0.27
T15	0.018	0.016	0.057	0.26	0.026	0.30	0.35	0.19	0.29
T16	0.024	0.012	0.040	0.24	0.016	0.25	0.32	0.10	0.23
T17	0.025	0.0057U	0.055	0.17	0.024	0.18	0.18	0.09	0.16
T18	0.013	0.0059U	0.030	0.15	0.017	0.19	0.20	0.13	0.18
T19	0.049	0.032	0.11	**0.58**	0.075	**0.68**	0.67	**0.26**	0.49
T20	0.011	0.0059U	0.026	0.15	0.031	0.18	0.20	0.098	0.17
TEL[b]	na	na	0.010	0.016	na	0.032	na	0.016	na
PEL[b]	na	na	0.17	0.28	na	0.32	na	0.25	na

Table 3-2, continued

STATION	CHRYSENE (mg/kg)	FLUORANTHENE (mg/kg)	FLUORENE (mg/kg)	INDENO(1,2,3,-c,d) PYRENE (mg/kg)	2-METHYL-NAPHTHALENE (mg/kg)	NAPHTHALENE (mg/kg)	PHENANTHRENE (mg/kg)	PYRENE (mg/kg)	TOTAL PAHs[a] (mg/kg)
Reference									
T01	0.027	0.055	0.0058U	0.016	0.0058U	0.0058U	0.057	0.074	0.35
T02	0.014	0.027	0.0058U	0.010	0.0058U	0.0058U	0.012	0.021	0.16
T03	0.0064	0.011	0.0059U	0.0094	0.0059U	0.0059U	0.0082	0.012	0.095
T04	0.072	0.16	0.0084	0.043	0.006U	0.006U	0.084	0.12	0.82
Site related									
T07	0.044	0.063	0.0069	0.018	0.0092	0.0092	0.048	0.068	0.44
T08	0.094	0.16	0.013	0.053	0.0057U	0.0057U	0.12	0.22	1.1
T09	0.095	0.24	0.021	0.053	0.0071	0.0062	0.19	0.17	1.3
T10	0.099	0.18	0.0098	0.069	0.014	0.0098	0.10	0.16	1.1
T10-FD	0.099	0.23	0.011	0.075	0.014	0.011	0.11	0.14	1.1
T11	**0.47**	**1.6**	0.068	**0.34**	0.0098	0.012	**0.77**	**0.86**	**6.5**
T11-FD	**0.46**	**1.1**	0.064	**0.32**	0.019	0.017	**0.70**	**1.2**	**6.1**
T12	0.24	0.50	0.039	0.14	0.012	0.016	0.36	0.41	**3.1**
T13	0.41	**1.3**	0.049	0.20	0.018	0.018	**0.50**	**0.68**	**5.1**
T14	0.35	**0.86**	0.047	0.17	0.024	0.027	**0.44**	**0.60**	**4.1**
T15	0.33	**0.80**	0.033	0.23	0.017	0.017	0.34	**0.50**	**3.8**
T16	0.27	**0.56**	0.031	0.15	0.028	0.024	0.26	0.43	**3.0**
T17	0.20	**0.42**	0.036	0.11	0.017	0.021	0.30	0.32	2.3
T18	0.19	**0.38**	0.019	0.15	0.0094	0.010	0.20	0.40	2.3
T19	**0.55**	**1.2**	0.069	**0.37**	0.041	0.036	**0.58**	**1.4**	**7.2**
T20	0.19	**0.44**	0.018	0.13	0.0089	0.0095	0.21	0.34	2.2
TEL[b]	0.027	0.032	0.010	0.017	na	0.015	0.019	0.044	0.26
PEL[b]	0.41	0.32	0.15	0.24	na	0.14	0.41	0.49	2.3

NOTE: **Bold** indicates exceedance of PEL
FD - field duplicate
na - not available
PEL - probable effects level
TEL - threshold effects level
U - undetected; value represents the detection limit

[a] Total PAHs were calculated by summing detected concentrations of individual PAH compounds plus one-half the detection limit for those compounds detected in other samples.

[b] TEL and PEL based on 28-day *Hyalella azteca* toxicity testing (USEPA 1996a).

Table 3-3. Concentrations of metals in sediment samples collected at Triad stations in August 1997

Station	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Zinc (mg/kg)	SEM[a] (mM/g)	AVS (mM/g)	SEM/AVS
Reference												
T01	0.9	0.05	7	4.4	4	0.02	5	<0.03	14.8	0.23	1.22	0.19
T02	1.4	0.23	18	15.1	13	0.08	11	<0.05	46.2	0.80	6.24	0.13
T03	0.8	0.06	9	6.5	5	0.01	6	<0.03	17.4	0.32	4.05	0.08
T04	1.9	0.25	18	16.6	16	0.08	11	<0.04	60	0.99	3.43	0.29
Site Related												
T07	2.4	0.47	78.6	29.1	47	**0.2**	15	0.25	96.1	1.67	16.53	0.10
T08	1	0.19	12.5	11.7	12	0.04	7	<0.03	38.8	0.69	14.04	0.05
T09	0.9	0.12	16.8	25.1	32	0.03	8	0.03	44.1	1.00	1.31	0.77
T10	2.4	0.41	33	36	36	0.08	19	<0.05	98.2	1.77	4.68	0.38
T10-FD	2.5	0.39	32	35.3	35	0.09	18	<0.05	96.3	1.61	7.17	0.22
T11	1.7	0.33	21.5	32	47	0.04	11	0.04	81.4	1.45	4.05	0.36
T11-FD	2.1	0.28	21.8	32	44	0.06	11	<0.04	86.3	1.20	4.05	0.30
T12	0.8	0.13	13.4	16.3	21	0.03	8	<0.03	39.5	0.84	1.25	0.67
T13	1.9	0.7	28.4	29	**128**	0.07	14	0.05	94.4	1.71	3.43	0.50
T14	1.9	0.46	26	29.6	49	0.06	12	0.05	93.2	1.67	4.99	0.33
T15	2.1	0.42	28	34.2	45	0.08	16	0.05	99	1.82	2.43	0.75
T16	2.2	0.48	30	35.4	49	0.08	18	0.06	111	1.99	5.30	0.38
T17	1.3	0.21	16.5	18.6	23	0.04	9	0.03	52.5	1.10	3.12	0.35
T18	2	0.36	27	30.9	34	0.07	15	0.05	89.9	1.82	2.74	0.66
T19	2	0.34	25	28.3	48	0.07	15	<0.04	87.2	1.54	1.28	1.21
T20	2.8	0.47	36	37	37	**0.1**	19	<0.06	112	2.08	1.25	1.66
TEL[b]	10.8	0.58	36	28	37	0.17[c]	20	na	98	—	—	—
PEL[b]	48	3.3	120	100	82	0.49[c]	33	na	540	—	—	—

NOTE: AVS - acid volatile sulfide
Bold indicates exceedance of PEL
FD - Field duplicate
PEL - probable effects level
SEM - simultaneously extracted metals
TEL - threshold effects level

[a] SEM includes simultaneously extracted concentrations of cadmium, copper, lead, nickel, and zinc.

[b] TEL and PEL based on 28-day *Hyalella azteca* toxicity testing (USEPA 1996a).

[c] 14-day *Hyalella azteca*-based TEL and PEL from Smith et al. (1996).

Table 3-4. Results of conventional parameter measurements for sediment collected from Triad stations in August 1997

Station	% Silt and Clay	% Sand	% Gravel	% Solids	% Total Organic Carbon
Reference					
T01	12	83	5	63.8	5.2
T02	48	33	19	34.2	8.3
T03	20	71	9	69.8	4.9
T04	61	36	3	36.6	5.9
Site related					
T07	60	38	2	50.3	6.3
T08	35	58	7	47.7	5.8
T09	26	73	1	64.3	4.6
T10	90	10	0	35.4	4.4
T10-FD	90	10	0	34.6	5.2
T11	45	50	5	45.9	5.2
T11-FD	44	52	4	44.6	4.6
T12	16	83	1	74.0	4.8
T13	62	34	4	47.0	5.6
T14	65	35	0	48.2	5.0
T15	79	21	0	40.6	5.5
T16	80	19	1	39.5	5.6
T17	30	67	3	58.8	5.1
T18	68	31	1	43.9	5.4
T19	58	38	4	45.2	5.4
T20	87	13	0	33.5	6.1

NOTE: FD - field duplicate

Table 3-5. Threshold effects levels, probable effects levels, and no effects concentrations as presented by USEPA (1996a)

Chemical	14-day *H. azteca*			28-day *H. azteca*		
	TEL	PEL	NEC	TEL	PEL	NEC
Arsenic	11	40	93	10.8	48	100
Cadmium	0.58	3.2	8	0.58	3.3	8
Chromium-total	48	131	95	36	120	95
Copper	28	78	55	28	100	580
Lead	34	117	69	37	82	130
Mercury	0.17[a]	0.49[a]	na	na	na	na
Nickel	28	38	38	20	33	43
Zinc	94	384	540	98	540	1300
Fluorene	0.035	0.386	0.29	0.010	0.15	3.0
Phenanthrene	0.197	0.777	1.0	0.019	0.41	20
Anthracene	0.032	0.409	0.29	0.010	0.17	2.0
Fluoranthene	0.144	0.834	1.2	0.032	0.32	10
Pyrene	0.231	0.908	1.8	0.044	0.49	9.0
Benz(a)anthracene	0.103	0.363	0.69	0.016	0.28	3.0
Chrysene	0.135	0.551	0.60	0.027	0.41	3.0
Benzo(a)pyrene	0.120	0.394	0.44	0.032	0.32	1.0
Indeno(1,2,3-c,d)pyrene	0.087	0.327	0.29	0.017	0.24	0.77
Benzo(g,h,i)perylene	0.089	0.349	0.31	0.016	0.25	1.2
Naphthalene	0.033	0.285	0.29	0.015	0.14	1.4
PAH-Total	1.59	6.74	9.24	0.264	2.27	62
PAH-Low	0.387	2.92	3.04	0.076	1.18	29
PAH-High	1.23	4.35	6.2	0.193	2.34	33
PCB-Total	0.034[a]	0.277[a]	na	0.032	0.245	0.190

NOTE: All *Hyalella azteca* 14-day and 28-day values were less than the 14-day *Chironomus riparius* TELs, PELs, and NECs.
na - not available
NEC - no effects concentration
PAH-Low - low-molecular-weight PAHs
PAH-High - high-molecular-weight PAHs
PEL - probable effects level
TEL - threshold effects level

[a] Values are from Smith et al. (1996).

Table 3-6. Summary of *Hyalella azteca* and *Chironomus riparius* sediment toxicity test results

	H. azteca						*C. riparius*					
	Survival (%)		Growth Total Biomass (mg)		Growth Individual Biomass (mg)		Survival (%)		Growth Total Biomass (mg)		Growth Individual Biomass (mg)	
Sample ID	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Negative control	97	5.2	1.15	0.356	0.118	0.0336	97	5.2	7.75	1.71	0.806	0.194
Reference												
T01	95	8.4	1.52	0.343	0.158	0.0245	95	5.5	18.0	1.41	1.90	0.182
T02	87[b]	10	1.23	0.294	0.141	0.0228	68b	18	11.8	3.65	1.71	0.249
T03	68[b]	21	1.15	0.351	0.174	0.0375	82b	17	17.3	2.23	2.16	0.248
T04	47[b]	12	0.850	0.501	0.184	0.0927	88b	7.5	14.4	2.46	1.62	0.177
Site related												
T07	0[a,b]	na	na	na	na	na	0[a,b]	na	na	na	na	na
T08	92	7.5	1.73	0.635	0.193	0.0781	92	7.5	18.4	1.73	2.01	0.177
T09	75	42	1.56	0.639	0.168	0.0438	78[b]	9.6	15.2	2.17	1.96	0.183
T10	67[b]	25	0.983	0.172	0.165	0.0600	88[b]	7.5	18.1	2.66	2.04	0.220
T11	85[b]	8.4	1.07	0.320	0.130	0.0429	78[b]	18	16.7	4.56	2.14	0.407
T12	88	12	1.03	0.207	0.119	0.0291	92	9.8	14.1	2.18	1.54[a]	0.186
T13	66[b]	28	0.750	0.536	0.086[a,b]	0.0210	85	14	13.4	2.21	1.58	0.142
T14	78[b]	15	0.783[b]	0.343	0.098a	0.0324	77[b]	23	12.1	3.43	1.62	0.172
T15	65[b]	39	1.18	0.444	0.149	0.0256	83	31	13.3	4.90	1.68	0.310
T16	62[b]	29	0.850	0.288	0.149	0.0330	87	18	12.7	4.27	1.44[a]	0.299
T17	87	12	1.37	0.423	0.160	0.0491	73[b]	27	12.0	4.13	1.70	0.337
T18	78[b]	13	0.983	0.204	0.126	0.0163	93	8.2	13.7	1.67	1.49[a]	0.146
T19	60[b]	37	1.02	0.549	0.193	0.0556	82	17	12.8	1.30	1.60	0.268
T20	63[b]	26	0.817	0.319	0.138	0.0409	83[b]	22	12.5	2.19	1.59	0.426

NOTE: na - not applicable
SD - standard deviation
See Appendix C for bioassay results

[a] Statistically significant difference compared to reference (Bonferroni multiple comparisons).
[b] Statisticallysignificant difference compared to negative control (*t*-test).

Table 3-7. Sheboygan River benthic metrics

Station	Total Abundance		Species Richness	
	Mean	SD	Mean	SD
Reference				
T01	210	82.7	8	3
T02	120	66.1	2	1
T03	217	115	8	2
T04	109	14.7	5	2
Site related				
T07	38[a]	29	9	4
T08	486	153	16	2.8
T09	431	91.2	12	2.9
T10	299	82.2	8	1
T11	298	77.5	10	3.3
T12	391	40.8	10	1.5
T13	1082	462.2	4	0.4
T14	374	98.9	5	0.8
T15	428	104	5	1
T16	305	58.0	6	2
T17	343	94.6	5	1
T18	360	61.3	4	1
T19	377	213	5	2
T20	554	101	5	1

NOTE: SD - standard deviation
See Appendix D for full benthic community data set

a Statistically significant difference compared to reference.

Table 3-8. Sheboygan River benthic macroinvertebrate species list

PHYLUM	CLASS	ORDER	FAMILY	SUBFAMILY/TRIBE	GENUS/SPECIES
PLATYHELMINTHES					
	Turbellaria				
ANNELIDA					
	Oligochaeta				
			Tubificidae		*Limnodrilus hoffmeisteri*
					Limnodrilus cervix
					Immature undetermined species
	Hirudinea				
		Rhynchobdellida			*Helobdella stagnalis*
ARTHROPODA					
	Crustacea				
		Isopoda			*Caecidotea* sp.
		Amphipoda			*Hyalella azteca*
					Gammarus sp.
	Insecta				
		Coleoptera			
			Elmidae		*Dubiraphia* sp.
					Unidentified 1
					Unidentified 2
			Gyrinidae		*Dineutus* sp.
		Ephemeroptera			
			Baetidae		*Baetis* sp.
					Baetis tricaudatus
			Caenidae		*Caenis* sp.
			Ephemeridae		*Hexagenia* sp.
			Heptageniidae		
			Tricorythidae		*Tricorythodes* sp.
		Zygoptera	Coenagrionidae		
		Plecoptera	Chloroperlidae		
		Tricoptera			
			Glossosomatidae		
			Hydropsychidae		*Hydropsyche* sp.
			Leptoceridae		Oecetis sp.
		Megaloptera			*Sialis* sp.
		Diptera	Ceratopogonidae	Ceratopogoninae	
			Chironomidae		*Ablabesmyia* sp.
					Chironomus sp.
					Cladopelma sp.
					Clinotanypus sp.
					Cricotopus sp.
					Cryptochironomus sp.
					Cryptotendipes sp.
					Dicrotendipes sp.
					Endochironomus sp.
					Eukiefferiella sp.
					Glyptotendipes sp.
					Harnischia sp.
					Microchironomus sp.
					Micropsectra sp.
					Microtendipes sp.
					Paralauterborniella sp.
					Paramerina sp.
					Paratanytarsus sp.

Table 3-8, continued

PHYLUM	CLASS	ORDER	FAMILY	SUBFAMILY/TRIBE	GENUS/SPECIES
					Paratendipes sp.
					Polypedilum sp.
					Procladius sp.
					Rheotanytarsus sp.
					Stenochironomus sp.
					Stictochironomus sp.
					Tanypus sp.
					Thienemannimyia gr.
				Chironomini	
				Pentaneurini	
				Procladiini	*Tanytarsus* sp.
				Tanytarsini	
			Pelecorhynchidae		*Glutops* sp.
			Tipulidae		*Erioptera* sp.
			Tabanidae		
Mollusca	Bivalvia	Heterodaonta	Sphaeriidae		

NOTE: See Appendix D for full benthic community data set

Table 3-9. Triad analysis endpoints for sediment quality

TRIAD ELEMENT	ENDPOINT
Sediment chemistry	Sum of PEL exceedance ratios[a] for: • PAHs • Metals • PCBs
Toxicity tests	Based on measured response for each endpoint: • *Hyalella azteca* survival • *H. azteca* growth • *Chironomus riparius* survival • *C. riparius* growth
Benthic community structure	Based on the results of each community metric: • Abundance • Taxa richness

a Exceedance ratios defined as the concentration of a chemical divided by its PEL concentration.

Table 3-10. Summary of Triad results

Site	Toxicity: *Hyalella azteca* Survival	Toxicity: *Hyalella azteca* Growth[a]	Toxicity: *Chironomus riparius* Survival	Toxicity: *Chironomus riparius* Growth[a]	Toxicity	Benthic Community: Abundance	Benthic Community: Richness	Benthic	Chemistry: PAHs	Chemistry: Metals	Chemistry: PCBs	Chemistry
T07	++	na	++	na	++	+	—	+	—	—	+	+
T08	—	—	—	—	—	—	—	—	—	—	+	+
T09	—	—	+	—	+	—	—	—	+	—	+	+
T10	+	—	+	—	+	—	—	—	—	—	—	—
T11	+	—	+	—	+	—	—	—	+	—	—	+
T12	—	—	—	—	—	—	—	—	+	—	—	+
T13	+	—	—	—	+	—	—	—	+	+	+	+
T14	+	+	+	—	+	—	—	—	+	—	+	+
T15	+	—	—	—	+	—	—	—	+	—	+	+
T16	+	—	—	—	+	—	—	—	+	—	+	+
T17	—	—	+	—	+	—	—	—	+	—	+	+
T18	+	—	—	—	+	—	—	—	+	—	+	+
T19	+	—	—	—	+	—	—	—	+	—	+	+
T20	+	—	+	—	+	—	—	—	+	—	+	+

NOTE: **Definitions:**

Toxicity: Statistically significant difference from mean of 4 reference sites or from negative control for at least one endpoint.
Benthic: Statistically significant difference from mean of 4 reference sites for at least one endpoint.
Chemistry: Total of probable effects level ratio exceedances falls outside of 95 percent reference station prediction interval, AND at least one individual analyte (or total for PCBs) exceeds the 28-day *H. azteca* probable effects level.

+ - statistically different from negative control
++ - statistically different from reference and negative control
na - not applicable; 0 percent survival + growth could not be tested
See Appendix C for full bioassay results.

[a] Growth as measured by total biomass.

Table 3-11. Station endpoint ranks[a]

	Toxicity									
	Chironomus riparius		*Hyalella azteca*		Benthic Community		Chemistry			Weighted
Station	Survival	Weight	Survival	Weight	Abundance	Richness	PAHs	metal	PCBs	Average
T01	18	16	18	16	4	13	16	18	17	14.2
T02	2	2	14.5	14	3	1	17	14	17	8.71
T03	7.5	15	9	12	5	12	18	17	17	12.2
T04	13.5	12	2	5.5	2	4	14	11	15	8.19
T07	1	1	1	1	1	14	15	2	1	4.83
T08	15.5	18	17	18	16	18	13	16	2	14.8
T09	5	13	10	17	15	17	11	12	11	12.9
T10	13.5	17	8	7.5	7	11	12	5	12	10.1
T11	6	14	13	11	6	16	2	10	13	10.1
T12	15.5	11	16	10	13	15	6	15	14	12.9
T13	11	9	7	2	18	2	3	1	6.5	6.92
T14	4	4	11.5	3	11	7.5	4	8	3.5	6.68
T15	9.5	8	6	13	14	6	5	6	9	8.60
T16	12	6	4	5.5	8	10	7	3.5	5	7.01
T17	3	3	14.5	15	9	5	8	13	6.5	8.35
T18	17	10	11.5	7.5	10	3	10	9	8	9.00
T19	7.5	7	3	9	12	9	1	7	3.5	6.99
T20	9.5	5	5	4	17	7.5	9	3.5	10	8.54

[a] Highest rank is best performance.

Table 4-1. Size and number of juvenile smallmouth bass grouped in composite samples for the 1997 ERA

Composite Sample ID	No. of Fish in Composite	Minimum (cm)	Maximum (cm)	Mean (cm)
F1-1	4	13.2	17.1	15.6
F1-2	4	17.4	18.5	18.1
F1-3	3	18.5	19.4	19.1
F2-1	5	11.6	13	12.4
F2-2	5	13.1	16.5	14
F2-3	4	16.6	17	16.8
F3-1	5	11.6	14.9	12.8
F3-2	5	15.2	16	15.8
F3-3	4	16.2	16.4	16.3
F5-1	4	15	16.1	15.7
F5-2	3	16.3	16.5	16.4
F5-3	3	17	18.3	17.8

Table 4-2. Concentrations of total PCBs in fish collected in 1994 and 1997

	Adult Smallmouth Bass 1994		YOY Smallmouth Bass 1994		Juvenile Smallmouth Bass 1997		Adult White Sucker 1994		YOY White Sucker 1994		Longnose Dace 1994	
	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)	Total PCBs (mg/kg ww)	TEQ (ng/kg ww)
Segment 1	0.58	2.8	0.065	0.016	0.11	0.12	0.13	2.6	0.05	0.0084	0.44	2.7
Segment 1	0.21	2.6	0.072	0.016	0.12	0.14	0.054	0.010	0.05	0.0093	0.12	0.025
Segment 1	0.12	2.6	0.13	2.6	0.11	0.16	0.048	0.010	0.20	2.6	0.07	0.014
Mean	**0.30**	**2.7**	**0.089**	**2.6[a]**	**0.11**	**0.14**	**0.077**	**2.6[a]**	**0.10**	**2.6[a]**	**0.21**	**2.7[a]**
95% UCL	**0.71**	**2.9**	**0.15**	**na**	**0.12**	**0.17**	**0.15**	**na**	**0.25**	**na**	**0.55**	**na**
Segment 2	37	51	20	2.9	19	14	6.5	5	9.8	1.2	8	0.96
Segment 2	36	42	18	2.4	23	20	8.0	1.5	11	1.3	9.2	1
Segment 2	23	21	18	14	14	10	17	2.3	10	7.8	18	10
Mean	**32**	**38**	**19**	**14[a]**	**19**	**15**	**11**	**2.3[a]**	**10**	**7.8[a]**	**12**	**10[a]**
95% UCL	**45**	**64**	**21**	**na**	**26**	**23**	**20**	**na**	**11**	**na**	**21**	**na**
Segment 3	22	22	23	2.6	21	18	7.7	4.7	8.5	0.79	14	1.5
Segment 3	16	13	18	2.3	19	14	9	1.5	16	1.4	17	1.8
Segment 3	30	24	31	22	18	16	13	1.7	9.2	4.8	20	7.5
Mean	**23**	**20**	**24**	**22[a]**	**19**	**16**	**9.9**	**4.7[a]**	**11**	**4.8[a]**	**17**	**7.5[a]**
95% UCL	**35**	**30**	**35**	**na**	**22**	**19**	**15**	**na**	**18**	**na**	**22**	**na**
Segment 5	17	8.5	10	0.80	9.1	5.4	3.4	3.4	4.4	0.45	20	8.8
Segment 5	19	9.2	14	1.2	9.4	6.2	15	1.8	4.1	0.44	19	2.2
Segment 5	17	9.0	15	6.6	12	6.6	5.3	0.65	5.8	4.3	14	1.5
Mean	**18**	**8.9**	**13**	**6.6[a]**	**10**	**6.1**	**7.9**	**3.4**	**4.8**	**4.3[a]**	**18**	**8.8[a]**
95% UCL	**20**	**9.5**	**17**	**na**	**13**	**7.1**	**18**	**na**	**6.3**	**na**	**23**	**na**

NOTE: na – not applicable (only one complete TEQ available)
TEQ - toxic equivalent
UCL - upper confidence limit
YOY - young-of-year
Raw data are presented in Tables A1-7 and A3-4 in Appendix A

[a] Mean represents value of single composite sample for which all relevant TEQ congeners were analyzed (others contained incomplete set).

Table 4-3. Comparison of total PCB concentrations in sediment

Location	Total PCB Concentration (sum of Aroclors, mg/kg dw)	Total PCB Concentration (sum of congener concentrations, mg/kg dw)	
	1997 ERA Sediment Quality Triad	1997 ERA Fish Assessment	WDNR
Segment 1			
T01	0.029 U	–	–
T02	0.029 U	–	–
T03	0.029 U	–	–
T04	0.030 U	–	–
S1-1	–	0.0066	–
S1-2	–	0.026	–
S1-3	–	0.0088	–
WDNR	–	–	0.016–0.021
Segment 2			
T07	760	–	–
S2-1	–	3.7	–
S2-2	–	20	–
S2-3	–	4.1	–
WDNR	–	–	2.7–15
Segment 3			
T08	1.9	–	–
S3-1	–	3.2	–
S3-2	–	38	–
S3-3	–	2.8	–
WDNR	–	–	2.1–4.6
Segment 5			
S5-1	–	2.4	–
S5-2	–	0.47	–
S5-3	–	2.1	–
S5-4	–	0.96	–
S5-5	–	0.57	–
WDNR	–	–	1.1–2.1
Segment 6			
T09	0.31	–	–
T10	0.23	–	–
T11	0.20	–	–
T12	0.19	–	–
T13	0.42	–	–
T14	0.45	–	–
T15	0.37	–	–
T16	0.43	–	–
T17	0.42	–	–
T18	0.38	–	–
T19	0.45	–	–
T20	0.36	–	–
WDNR	–	–	1.0–1.9

NOTE: Total PCB concentrations were calculated by summing individual PCB congeners or Aroclors plus one-half the detection limit of undetected congeners. Aroclors that were not detected in any sediment sample in the same study were not included in the sum. Raw data are presented in Tables A1-2, A1-6, and A3-1 in Appendix A.

U – undetected
– no sample collected

Table 4-4. Principal PCB congeners for fish tissue collected for the 1997 ERA

PCB Congener	Chlorination Level	Maximum Percent of total PCB concentration	Frequency of Detection (%)
017	3	2.86	100
031/28	3	3.85	100
041/071/006	4	3.72	100
044	4	2.33	100
047/048	4	5.81	100
049	4	5.27	100
052	4	5.72	100
066	4	4.19	100
070/076	4	4.32	100
074	4	4.53	100
085	5	3.93	100
087	5	7.97	100
091	5	2.27	100
095	5	2.79	100
097	5	6.37	100
099	5	3.90	100
101/090	5	8.08	100
105	5	2.19	100
110	5	18.2	100
118	5	7.14	100
128	6	2.79	100
138/163/164	6	13.2	100
149	6	5.20	100
153	6	10.5	100
180	7	2.47	100

NOTE: Raw data are presented in Table A1-7 in Appendix A

Table 4-5. Principal PCB congeners for fish tissue collected for the WDNR food chain study

PCB Congener	Chlorination Level	Maximum Percent of Total PCB concentration	Frequency of detection (%)
017	3	4.65	83
031/028	3	9.52	87
041/071/006	4	5.82	85
044	4	3.64	87
047/048	4	12.2	87
049	4	4.76	90
052	4	5.57	88
070/076	4	6.76	90
074	4	4.16	90
087	5	4.27	93
091	5	2.13	88
097	5	2.89	93
099	5	6.78	98
101[a]	5	10.8	100
110/077[b]	5	16.2	98
118	5	14.6	100
138/163/164	6	34.1	100
149	6	5.71	93
153/132[c]	6	42.6	100
180	7	3.44	87

NOTE: This list only includes PCB congeners that were also identified as principal congeners for fish tissue data in the 1997 ERA
Raw data are presented in Table A3-4 in Appendix A

[a] Identified as PCB 101/90 in 1997 ERA.
[b] Identified as PCB 110 in 1997 ERA.
[c] Identified as PCB 153 in 1997 ERA.

Table 4-6. Average fish TEQ concentrations per segment for 1997 juvenile smallmouth bass

PCB Congener	Segment 1 TEQ Concentration (ng/kg ww)	Segment 1 Percent of Total TEQ	Segment 2 TEQ Concentration (ng/kg ww)	Segment 2 Percent of Total TEQ	Segment 3 TEQ Concentration (ng/kg ww)	Segment 3 Percent of Total TEQ	Segment 5 TEQ Concentration (ng/kg ww)	Segment 5 Percent of Total TEQ
077	0.017	12	6.3	42	4.6	29	1.7	28
105	0.0041	2.9	0.48	3.2	0.61	3.8	0.28	4.6
114	0.0010	0.71	0.14	0.93	0.16	1.0	0.085	1.4
118	0.023	17	2.0	13	3.1	19	1.4	23
123	0.0005	0.36	0.056	0.37	0.064	0.40	0.035	0.57
126	0.088	63	5.6	37	7.2	45	2.5	41
156	0.0016	1.1	0.089	0.59	0.12	0.75	0.059	0.97
157	0.0010	0.71	0.049	0.33	0.070	0.44	0.030	0.49
167	0.0027	1.9	0.091	0.61	0.13	0.81	0.063	1.0
189	0.00031	0.22	0.011	0.073	0.015	0.094	0.0073	0.12
Total TEQ	0.14		15		16		6.1	

NOTE: Does not include dioxin/furan contribution. Toxic equivalency factors used to calculate TEQs are presented in Table 2-4, and additional TEQ data are presented in Table B1-1 in Appendix B.
TEQ - toxic equivalent

Table 4-7. Concentrations of PCBs and percent of total PCB concentration of Congeners 077, 118, and 126 in sediment collected in 1997

	Concentration (*m*g/kg dw)			Percent Total PCB Concentration		
Sample	PCB077	PCB118	PCB126	PCB077	PCB118	PCB126
Segment 1						
S1-1	0.0040	0.24	0.00051	0.06	3.64	0.01
S1-2	0.036	1.3	0.0071	0.14	5.00	0.03
S1-3	0.0087	0.24	0.0005	0.10	2.73	0.01
Segment 2						
S2-1	6.8	76	0.12	0.18	2.06	0.003
S2-2	68	710	1.8	0.33	3.46	0.01
S2-3	9.1	99	0.20	0.22	2.39	0.005
Segment 3						
S3-1	7.5	56	0.18	0.23	1.75	0.01
S3-2	11	120	0.34	0.03	0.32	0.0009
S3-3	8.3	73	0.23	0.30	2.63	0.01
Segment 5						
S5-1	11	81	0.30	0.45	3.35	0.01
S5-2	2.1	15	0.062	0.45	3.18	0.01
S5-3	8.6	73	0.28	0.42	3.53	0.01
S5-4	6.3	34	0.19	0.66	3.55	0.02
S5-5	1.8	15	0.048	0.31	2.61	0.01

NOTE: Raw data are presented in Table A1-6 in Appendix A

Table 4-8. Concentrations of PCBs and percent of total PCB concentration of Congeners 077, 118, and 126 in juvenile smallmouth bass collected in 1997

Sample	Concentration (mg/kg dw)			Percent Total PCB Concentration		
	PCB077	PCB118	PCB126	PCB077	PCB118	PCB126
Segment 1						
F1-1	0.11	7.8	0.014	0.10	6.8	0.01
F1-2	0.12	7.9	0.017	0.10	6.9	0.01
F1-3	0.10	7.5	0.021	0.09	6.9	0.02
Segment 2						
F2-1	39	570	1.1	0.21	3.0	0.01
F2-2	53	890	1.5	0.23	3.8	0.01
F2-3	25	480	0.79	0.17	3.3	0.01
Segment 3						
F3-1	35	1100	1.6	0.17	5.3	0.01
F3-2	24	970	1.3	0.13	5.2	0.01
F3-3	27	970	1.5	0.15	5.3	0.01
Segment 5						
F5-1	10	420	0.39	0.11	4.6	0.004
F5-2	10	460	0.52	0.11	4.9	0.01
F5-3	11	520	0.55	0.09	4.5	0.005

NOTE: Raw data are presented in Table A1-7 in Appendix A

Table 4-9. Average fish TEQ concentrations per segment and fish type for the WDNR food chain study data[a]

PCB Congener	Smallmouth Bass Adult: TEQ$_i$ Concentration (ng/kg ww)	Smallmouth Bass Adult: Percent of Total TEQ	Smallmouth Bass Young-of-Year: TEQ$_i$ Concentration (ng/kg ww)	Smallmouth Bass Young-of-Year: Percent of Total TEQ	Longnose Dace: TEQ$_i$ Concentration (ng/kg ww)	Longnose Dace: Percent of Total TEQ	White Sucker Adult: TEQ$_i$ Concentration (ng/kg ww)	White Sucker Adult: Percent of Total TEQ	White Sucker Young-of-Year: TEQ$_i$ Concentration (ng/kg ww)	White Sucker Young-of-Year: Percent of Total TEQ
Segment 1										
077	0.12	4.4	0.08 U	3.1	0.08 U	3.0	0.08 U	3.1	0.08 U	3.0
105	0.0093	0.34	0.0024	0.092	0.017	0.63	0.0048	0.18	0.0055	0.21
118	0.061	2.3	0.023	0.88	0.076	2.8	0.024	0.92	0.033	1.3
126	2.5 U	93	2.5 U	96	2.5 U	93	2.5 U	96	2.5 U	95
156	0.0023	0.085	0.00084 U	0.0032	0.0040	0.15	0.00084 U	0.032	0.00084 U	0.032
157	0.0025 U	0.093	0.0025 U	0.096	0.0025 U	0.093	0.0025 U	0.096	0.0025 U	0.096
167	0.0045 U	0.17	0.0045 U	0.017	0.0045 U	0.17	0.0045 U	0.17	0.0045 U	0.17
Total TEQ	2.7		2.6		2.7		2.6		2.6	
Segment 2										
077	12	32	4.6	33	2.6	26	0.64	13	1.8	23
105	1.2	3.2	0.58	4.1	0.41	4.1	0.22	4.4	0.22	2.8
118	5.0	13	2.8	20	2.2	22	0.97	19	0.94	12
126	19	50	6 U	43	5 U	50	3 U	60	4.8 U	62
156	0.25	0.66	0.090	0.64	0.073	0.77	0.045	0.90	0.037	0.47
157	0.22	0.58	0.08	0.57	0.055	0.55	0.032	0.64	0.030	0.38
167	0.30	0.79	0.12	0.86	0.095	0.95	0.065	1.3	0.050	0.64
Total TEQ	38		14		10		5.0		7.8	
Segment 3										
077	5.5	28	6.6	30	2.7	36	0.90	19	1.2	25
105	0.58	2.9	0.74	3.4	0.29	3.9	0.21	4.5	0.14	2.9
118	3.3	17	3.6	16	1.7	23	1.0	21	0.79	16
126	9.7	49	10	45	2.5 U	33	2.5 U	53	2.5 U	52
156	0.15	0.75	0.17	0.77	0.063	0.84	0.037	0.79	0.032	0.66
157	0.19	0.95	0.18	0.82	0.095	1.3	0.050	1.1	0.036	0.75
167	0.26	1.3	0.29	1.3	0.11	1.5	0.060	1.3	0.043	0.89
Total TEQ	20		22		7.5		4.7		4.8	
Segment 5										
077	2.5	28	2.2	33	3.2	36	0.37	11	1.0	23

Table 4-9, continued

	Smallmouth Bass Adult		Smallmouth Bass Young-of-Year		Longnose Dace		White Sucker Adult		White Sucker Young-of-Year	
PCB Congener	TEQ_i Concentration (ng/kg ww)	Percent of Total TEQ	TEQ_i Concentration (ng/kg ww)	Percent of Total TEQ	TEQ_i Concentration (ng/kg ww)	Percent of Total TEQ	TEQ_i Concentration (ng/kg ww)	Percent of Total TEQ	TEQ_i Concentration (ng/kg ww)	Percent of Total TEQ
105	0.40	4.5	0.29	4.4	0.45	5.1	0.069	2.0	0.10	2.3
118	2.4	27	1.4	21	2.3	26	0.42	12	0.60	14
126	3.4 U	38	2.5 U	38	2.5 U	28	2.5 U	74	2.5	58
156	0.081	0.91	0.038	0.58	0.090	1.0	0.018	0.53	0.022	0.50
157	0.053	0.60	0.034	0.51	0.13	1.5	0.013	0.38	0.028	0.65
167	0.12	1.3	0.07	1.0	0.14	1.6	0.024	0.70	0.031	0.72
Total TEQ	8.9		6.6		8.8		3.4		4.3	

NOTE: TEQ_i - Concentration of congener i x TEF for congener i.
U - Undetected; value represents one-half the detection limit.
Raw data are presented in Table A3-4 in Appendix A.

[a] Adult smallmouth bass TEQs represent averages of three composite samples. For other fish types and ages only one of the three composite samples was analyzed for the full list of congeners, so those TEQs represent only one sample.

Table 4-10a. Calculated BSAFs for total PCBs and associated confidence intervals

		BSAF	Lower Confidence Interval	Upper Confidence Interval
1997 ERA data				
Smallmouth bass, juvenile	Segment 1	14	7.8	23
	Segment 2	3.9	1.8	9.1
	Segment 3	3.1	1.2	15
	Segment 5	13	8.4	21
WDNR food chain study data				
Longnose dace	Segment 1	9.5	4.9	18
	Segment 2	0.4	0.2	1.1
	Segment 3	1.9	1.7	2.1
	Segment 5	1.6	0.9	2.4
Smallmouth bass, adults	Segment 1	18	5.7	43
	Segment 2	2.7	1.4	5.8
	Segment 3	4.9	4.0	6.2
	Segment 5	3.7	2.7	5.3
Smallmouth bass, young-of-year	Segment 1	4.4	2.9	7.0
	Segment 2	1.0	0.6	1.7
	Segment 3	4.0	3.3	4.9
	Segment 5	2.1	1.5	2.9
White sucker, adults	Segment 1	13	10	15
	Segment 2	2.8	1.4	5.6
	Segment 3	4.7	3.8	5.3
	Segment 5	2.9	1.7	4.7
White sucker, young-of-year	Segment 1	8.1	4.7	14
	Segment 2	0.8	0.5	1.5
	Segment 3	2.2	1.8	2.6
	Segment 5	1.1	0.8	1.6
Combined 1997 ERA data and WDNR food chain study data[a]	Segment 1	6.1	4.5	8.8
	Segment 2	1.6	0.89	2.9
	Segment 3	3.7	1.9	6.3
	Segment 5	4.4	2.7	7.2

Table 4-10b. Calculated BSAFs for TEQs and associated confidence intervals

		BSAF	Lower Confidence Interval	Upper Confidence Interval
1997 ERA data				
	Segment 1	14	5.3	66
	Segment 2	3.2	1.3	13
	Segment 3	12	9.3	14
	Segment 5	5.1	3.4	9.1

NOTE: All confidence intervals are 90% two-sided
BSAF - biota sediment accumulation factor
Raw data are presented in Tables A1-6, A1-7, A3-1, and A3-4 in Appendix A.

a For WDNR food chain study, young-of-year smallmouth bass data are used.

Table 4-11. Percentage contribution of individual PCB congeners to fish TEQ

STATION ID	PCB077	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156	PCB157	PCB167	PCB189	TOTAL[a]	PCB 077, PCB118, PCB126
Segment 1												
F1-1	13.9%	3.4%	0.8%	19.1%	0.4%	58.4%	1.3%	0.7%	2.0%	0.2%	100.0%	91.3%
F1-2	13.3%	3.1%	0.6%	17.3%	0.3%	61.2%	1.2%	0.7%	2.1%	0.2%	100.0%	91.8%
F1-3	10.2%	2.5%	0.9%	14.5%	0.5%	67.8%	0.9%	0.7%	1.8%	0.2%	100.0%	92.5%
Mean	**12.5%**	**3.0%**	**0.8%**	**17.0%**	**0.4%**	**62.5%**	**1.1%**	**0.7%**	**2.0%**	**0.2%**	**100.0%**	**91.9%**
Segment 2												
F2-1	44.0%	3.6%	1.0%	12.0%	0.4%	37.3%	0.6%	0.4%	0.7%	0.1%	100.0%	93.3%
F2-2	42.9%	2.9%	0.8%	13.6%	0.3%	38.2%	0.5%	0.3%	0.5%	0.1%	100.0%	94.7%
F2-3	39.9%	3.5%	1.2%	14.2%	0.5%	38.6%	0.7%	0.4%	0.8%	0.1%	100.0%	92.7%
Mean	**42.2%**	**3.3%**	**1.0%**	**13.2%**	**0.4%**	**38.0%**	**0.6%**	**0.4%**	**0.7%**	**0.1%**	**100.0%**	**93.6%**
Segment 3												
F3-1	31.0%	3.7%	0.9%	18.3%	0.4%	43.7%	0.7%	0.4%	0.8%	0.1%	100.0%	93.0%
F3-2	27.1%	4.2%	1.2%	20.3%	0.5%	44.7%	0.8%	0.5%	0.8%	0.1%	100.0%	92.0%
F3-3	27.4%	3.7%	0.9%	18.9%	0.4%	46.7%	0.8%	0.4%	0.7%	0.1%	100.0%	93.0%
Mean	**28.5%**	**3.9%**	**1.0%**	**19.2%**	**0.4%**	**45.3%**	**0.8%**	**0.4%**	**0.8%**	**0.1%**	**100.0%**	**92.7%**
Segment 5												
F5-1	30.7%	4.5%	1.3%	23.6%	0.6%	36.7%	1.0%	0.5%	1.0%	0.1%	100.0%	91.0%
F5-2	26.5%	4.4%	1.4%	22.3%	0.6%	42.0%	1.0%	0.5%	1.1%	0.1%	100.0%	90.8%
F5-3	25.3%	4.7%	1.5%	23.7%	0.5%	41.8%	0.9%	0.5%	1.0%	0.1%	100.0%	90.8%
Mean	**27.5%**	**4.5%**	**1.4%**	**23.2%**	**0.6%**	**40.2%**	**1.0%**	**0.5%**	**1.0%**	**0.1%**	**100.0%**	**90.9%**

NOTE: Based on juvenile smallmouth bass data from 1997 ERA
TEQ - toxic equivalent

[a] Total includes only TEQ from PCB congeners.

Table 4-12. Percentage contribution of individual PCB congeners to mammal TEQ

STATION ID	PCB077	PCB105	PCB114	PCB118	PCB123	PCB126	PCB156	PCB157	PCB189	TOTAL[a]	PCB 077, PCB 118, PCB 126
Segment 1											
F1-1	0.3%	7.6%	3.0%	24.8%	0.3%	45.9%	15.3%	2.7%	0.2%	100.0%	93.6%
F1-2	0.3%	7.3%	2.4%	23.0%	0.2%	49.2%	14.7%	2.7%	0.2%	100.0%	94.2%
F1-3	0.3%	6.0%	3.6%	19.7%	0.4%	55.6%	11.5%	2.8%	0.2%	100.0%	92.7%
Mean	**0.3%**	**7.0%**	**3.0%**	**22.5%**	**0.3%**	**50.2%**	**13.8%**	**2.7%**	**0.2%**	**100.0%**	**93.5%**
Segment 2											
F2-1	1.6%	12.3%	5.9%	23.3%	0.5%	43.7%	10.5%	2.2%	0.1%	100.0%	89.7%
F2-2	1.6%	9.9%	4.9%	26.7%	0.3%	45.4%	9.5%	1.6%	0.1%	100.0%	91.5%
F2-3	1.3%	11.1%	6.3%	25.3%	0.6%	41.4%	11.9%	2.1%	0.1%	100.0%	89.5%
Mean	**1.5%**	**11.1%**	**5.7%**	**25.1%**	**0.5%**	**43.5%**	**10.6%**	**2.0%**	**0.1%**	**100.0%**	**90.2%**
Segment 3											
F3-1	0.9%	10.4%	4.6%	29.2%	0.4%	42.3%	10.3%	1.9%	0.1%	100.0%	92.2%
F3-2	0.8%	10.8%	5.2%	30.0%	0.4%	39.9%	10.5%	2.2%	0.1%	100.0%	91.3%
F3-3	0.8%	9.8%	4.3%	28.7%	0.3%	42.9%	11.2%	2.0%	0.1%	100.0%	92.5%
Mean	**0.8%**	**10.3%**	**4.7%**	**29.3%**	**0.4%**	**41.7%**	**10.7%**	**2.0%**	**0.1%**	**100.0%**	**92.0%**
Segment 5											
F5-1	0.8%	11.3%	5.6%	34.0%	0.5%	31.9%	13.6%	2.1%	0.1%	100.0%	90.9%
F5-2	0.7%	11.0%	6.0%	31.5%	0.6%	35.8%	12.2%	2.2%	0.1%	100.0%	90.5%
F5-3	0.7%	11.3%	6.2%	32.7%	0.4%	34.8%	11.7%	2.1%	0.1%	100.0%	90.5%
Mean	**0.7%**	**11.2%**	**5.9%**	**32.7%**	**0.5%**	**34.2%**	**12.5%**	**2.1%**	**0.1%**	**100.0%**	**90.6%**

NOTE: Based on juvenile smallmouth bass data from 1997 ERA
TEQ - toxic equivalent

[a] Total includes only TEQ from PCB congeners.

Table 4-13. Percentage contribution of individual PCB congeners to bird TEQ

Station ID	PCB066	PCB077	PCB105	PCB110	PCB118	PCB126	PCB128	PCB156	PCB157	PCB167	PCB170	PCB180	PCB194	TOTAL[a]	PCBs 066, 077, 105, 118, 126, and 156
Segment 1															
F1-1	8.2%	8.8%	33.0%	1.4%	21.4%	11.9%	7.1%	2.6%	0.9%	2.7%	0.5%	1.4%	0.0%	100.0%	83.3%
F1-2	7.3%	9.1%	32.8%	1.1%	20.7%	13.3%	6.8%	2.6%	1.0%	3.0%	0.7%	1.5%	0.0%	100.0%	83.2%
F1-3	7.5%	8.1%	30.9%	1.3%	20.1%	17.1%	6.7%	2.3%	1.2%	3.0%	0.5%	1.3%	0.0%	100.0%	83.7%
Mean	**7.7%**	**8.7%**	**32.2%**	**1.3%**	**20.8%**	**14.1%**	**6.9%**	**2.5%**	**1.0%**	**2.9%**	**0.6%**	**1.4%**	**0.0%**	**100.0%**	**83.4%**
Segment 2															
F2-1	19.8%	23.8%	30.2%	2.8%	11.5%	6.5%	2.6%	1.0%	0.4%	0.8%	0.2%	0.3%	0.0%	100.0%	91.8%
F2-2	23.6%	24.1%	25.0%	3.2%	13.5%	6.9%	1.5%	1.0%	0.3%	0.6%	0.1%	0.2%	0.0%	100.0%	93.1%
F2-3	22.8%	20.7%	28.5%	3.1%	13.0%	6.4%	2.4%	1.2%	0.4%	0.9%	0.2%	0.4%	0.0%	100.0%	91.4%
Mean	**22.1%**	**22.9%**	**27.9%**	**3.0%**	**12.7%**	**6.6%**	**2.2%**	**1.1%**	**0.4%**	**0.8%**	**0.2%**	**0.3%**	**0.0%**	**100.0%**	**92.1%**
Segment 3															
F3-1	25.8%	15.6%	28.9%	1.3%	16.3%	7.1%	2.2%	1.2%	0.4%	0.9%	0.2%	0.3%	0.0%	100.0%	93.6%
F3-2	26.1%	12.7%	30.4%	1.3%	16.8%	6.7%	3.0%	1.2%	0.5%	0.8%	0.2%	0.3%	0.0%	100.0%	92.7%
F3-3	25.7%	13.9%	28.7%	1.2%	16.9%	7.6%	3.0%	1.3%	0.5%	0.8%	0.2%	0.3%	0.0%	100.0%	92.7%
Mean	**25.9%**	**14.1%**	**29.3%**	**1.3%**	**16.7%**	**7.1%**	**2.7%**	**1.2%**	**0.5%**	**0.8%**	**0.2%**	**0.3%**	**0.0%**	**100.0%**	**93.0%**
Segment 5															
F5-1	27.1%	13.1%	29.6%	1.5%	17.8%	5.0%	2.7%	1.4%	0.4%	0.9%	0.2%	0.3%	0.0%	100.0%	92.5%
F5-2	24.8%	12.0%	31.0%	1.6%	17.8%	6.1%	3.1%	1.4%	0.5%	1.1%	0.2%	0.4%	0.0%	100.0%	91.7%
F5-3	25.2%	11.0%	31.5%	1.6%	18.2%	5.8%	3.2%	1.3%	0.5%	0.9%	0.2%	0.4%	0.0%	100.0%	91.9%
Mean	**25.7%**	**12.0%**	**30.7%**	**1.6%**	**17.9%**	**5.6%**	**3.0%**	**1.4%**	**0.5%**	**1.0%**	**0.2%**	**0.4%**	**0.0%**	**100.0%**	**92.0%**

NOTE: Based on juvenile small bass data from 1997 ERA
TEQ - toxic equivalent

[a] Total includes only TEQ from PCB congeners.

Table 4-14. Predicted versus observed PCB concentrations in juvenile smallmouth bass tissues

PCB Congener	Composite ID Number	Number of Fish (Age 1+)	Number of Fish (Age 2+)	Predicted Concentration (Age 1+) (µg/kg)	Predicted Concentration (Age 2+) (µg/kg)	Predicted Concentration (in Composite) (µg/kg)	Observed Concentration (1997 ERA) (µg/kg)	5x Observed Concentration (1997 ERA) (µg/kg)	0.2x Observed Concentration (1997 ERA) (µg/kg)
077	F1-1	1	3	0.035	0.034	0.034	0.11	0.54	0.021
	F1-2	0	4	0.035	0.034	0.034	0.12	0.58	0.023
	F1-3	0	3	0.035	0.034	0.034	0.10	0.50	0.020
	F2-1	5	0	60	59	60	39	200	7.9
	F2-2	4	1	60	59	60	53	270	11
	F2-3	0	4	60	59	59	25	130	5.1
	F3-1	4	0	19	19	19	35	180	7.0
	F3-2	0	4	19	19	19	24	120	4.9
	F3-3	0	4	19	19	19	27	130	5.3
	F5-1	2	2	13	13	13	10	52	2.1
	F5-2	0	3	13	13	13	10	52	2.1
	F5-3	0	3	13	13	13	11	53	2.1
118	F1-1	1	3	1.3	1.3	1.3	7.8	39	1.6
	F1-2	0	4	1.3	1.3	1.3	7.9	40	1.6
	F1-3	0	3	1.3	1.3	1.3	7.5	38	1.5
	F2-1	5	0	650	670	650	570	2,900	110
	F2-2	4	1	650	670	660	890	4,500	180
	F2-3	0	4	650	670	670	480	2,400	96
	F3-1	4	0	180	190	180	1,100	5,500	220
	F3-2	0	4	180	190	190	970	4,900	190
	F3-3	0	4	180	190	190	970	4,900	190
	F5-1	2	2	97	99	98	420	2,100	84
	F5-2	0	3	97	99	99	460	2,300	92
	F5-3	0	3	97	99	99	520	2,600	100
126	F1-1	1	3	0.0060	0.0062	0.0062	0.014	0.072	0.0029
	F1-2	0	4	0.0060	0.0062	0.0062	0.017	0.085	0.0034
	F1-3	0	3	0.0060	0.0062	0.0062	0.021	0.11	0.0042
	F2-1	5	0	1.6	1.6	1.6	1.1	5.4	0.21
	F2-2	4	1	1.6	1.6	1.6	1.5	7.6	0.30
	F2-3	0	4	1.6	1.6	1.6	0.79	3.9	0.16
	F3-1	4	0	0.56	0.57	0.56	1.6	8.0	0.32
	F3-2	0	4	0.56	0.57	0.57	1.3	6.5	0.26
	F3-3	0	4	0.56	0.57	0.57	1.5	7.3	0.29
	F5-1	2	2	0.39	0.41	0.40	0.39	2.0	0.079
	F5-2	0	3	0.39	0.41	0.41	0.52	2.6	0.10
	F5-3	0	3	0.39	0.41	0.41	0.55	2.8	0.11

NOTE: Observed concentrations are reported in Table A1-7 in Appendix A

Table 4-15. Lowest tissue concentrations of PCBs associated with adverse effects in fish

SPECIES	TISSUE	PCB TYPE	FIELD COMPONENT?	STUDY CONDITIONS	EFFECTS CONC. (mg/kg ww)	EFFECTS ENDPOINT	REFERENCE	NOTE
Baltic flounder	ovary	Total PCB	yes	Eggs from field-collected fish were stripped, artificially inseminated, and incubated in lab	0.12	Viable hatch reduced ($p < 0.01$)	von Western-hagen et al. 1981	1
Lake trout	eggs	Total PCB, as 1254	yes	Hatchery fish fed diet with Lake Michigan organic contaminants	0.17 (NOAEL) 0.31	Reduced egg hatchability (29% vs. 67%) and fry survival (75% vs. 93%)	Mac and Edsall 1991	2
Starry flounder	eggs	Aroclor 1260	yes	Field fish spawned in lab	0.2	Total PCBs in eggs correlated inversely with embryological and hatching success	Spies et al. 1985	3
Rainbow trout	eggs	Aroclor 1254	yes	Observation of contaminated hatchery fish eggs	0.33	10-28% mortality prehatch and many posthatch deformities	Hogan and Braugn 1975	4
Winter flounder	eggs	Total PCB	yes	Progeny of field collected fish exposed to contaminated areas were observed	1.6 (NOAEL) 5.9	Larvae were significantly smaller in length (2.96 vs. 3.22 mm) and weight (0.018 vs. 0.022 mg)	Black et al. 1988	5
Rainbow trout	eggs	Aroclor 1254	no	Gravid females fed 200 mg/kg for 60 days	1.6	Reduced growth of fry relative to control ($p < 0.001$)	Hendricks et al. 1981	
Rainbow trout	eggs	Aroclor 1242	yes	Observation of contaminated hatchery fish eggs	2.7	Larval mortality and abnormality	Hogan and Brauhn 1975	6
Lake trout	eggs	sum of 113 congeners	yes	Observation of eggs from feral fish from southeast Lake Michigan	approx. 3 (approx. NOAEL of 2.8)	Egg hatchability	Mac and Schwartz 1992	7
Chinook salmon	eggs	Total PCB	yes	Observation and analysis of feral fish and eggs from Lake Michigan	3.7 (NOAEL) 4.2	Reduced hatching success	Ankley et al. 1991	8
Sheepshead minnow	eggs	Aroclor 1254	no	Water exposure in lab	5.1	Decreased fry survival in the first week after hatch	Hansen et al. 1974	
Adult fathead minnow	"tissue"	Aroclor 1254	yes	Exposed to PCBs in sediment for 16 weeks	5.3 (NOAEL) 13.7	Reduced fecundity and frequency of reproduction	ACOE 1988	9
Fingerling channel catfish	whole body	4 Aroclors	no	Fed 2.4-24 mg/kg in diet for 193 days	32 (NOAEL)	Growth or mortality (1254 increased thyroid activity)	Mayer et al. 1977	

Table 4-15, continued

Species	Tissue	PCB Type	Field Component?	Study Conditions	Effects Conc. (mg/kg ww)	Effects Endpoint	Reference	Footnote
Brook trout	"back muscle", eggs	Aroclor 1254	no	Water exposure of 0.2 mg/L for 21 days	32.8 (77.9 in eggs)	78% egg hatch compared to 100% in control	Freeman and Idler 1975	10
Brook trout	dead fry	Aroclor 1254	no	Water exposure of eggs to 3-13 μg/L for 10 days prior to hatch and 118 days after	125	Fry mortality; 21-100 percent mortality	Mauck et al. 1978	11
Cyprinid minnow	whole body	Clophen A50	yes	Baltic Sea fish fed PCB contaminated food for 40 days	170	Decreased number and hatchability of ova; delayed spawning; premature hatching	Bengtsson 1980	
Sheepshead minnow	fry whole body	Aroclor 1016	no	Exposed to 32 μg/L in intermittent-flow bioassay	200	Significantly reduced fry survival	Hansen et al. 1975	12
3-spined stickleback	carcass	Clophen A50	no	Fed PCB-containing chironomids for 3.5 months	289 (after spawning)	Reduced spawning success (25% vs. 80% in control, not statistically significant)	Holm et al. 1993	13
Fathead minnow	"terminal residue"	Aroclor 1254	no	PCB exposure in continuous flow aquaria water	429 (females) (mean)	Reduced spawning, but egg hatchability and fry survival were not affected	Nebeker et al. 1974	14

1. Chlorinated hydrocarbons and metals were also elevated in some fish, but did not correlate significantly with viable hatch. PCB concentration identified as a tentative threshold.
2. Eggs also contained 154 μg/kg total DDT. The source of PCBs and DDT was from a contaminated feral fish extract from southeast Lake Michigan.
3. Fish were collected from San Francisco Bay areas which also contain elevated PAHs and DDT.
4. Eggs also contained 150 μg/kg "DDT complex."
5. Wet weight concentrations were calculated from reported dry weight concentrations by assuming 85 percent moisture content in eggs.
6. Eggs also contained 90 μg/kg "DDT complex."
7. Egg hatchability was negatively correlated with total PCBs in eggs (R2=0.48, n=24).
8. Fish were collected from Lake Michigan. Study sample size was small (n= 10).
9. Sediments were collected from the Sheboygan Harbor (0.82, 14.0, and 27.0 mg/kg dw Aroclor 1254). Significant effects were observed in the two higher concentration exposures.
10. Note that none of the eggs hatched in water containing 0.2 mg/L PCBs and 3.8 mg/L Corexit 7664, which was present in a control and the PCB exposure tank.
11. Median hatching time, egg hatchability, and sac fry survival were not affected. Larval growth was initially decreased, but not by the end of the test at 118 days.
12. Fertilization success, survival of embryos to hatching, and survival of fry for 2 weeks were not affected when eggs contained up to 77 mg/kg Aroclor 1016.
13. Chemical analysis of carcass after dissection of head, viscera, and spines. Statistical significance was assessed using a chi-square test (P<0.05).
14. Assumed wet weight effects concentration.

Table 4-16. Range of NOAELs and LOAELs for 2,3,7,8-TCDD

TYPE OF FISH	ENDPOINT	EXPOSURE	NOAEL BODY BURDEN	LOAEL BODY BURDEN	REFERENCE
Lake trout	sac-fry mortality, NOAEL sac-fry mortality, LOAEL	maternal egg exposure	23 ng/kg egg	50 ng/kg egg	Walker et al. 1994
Lake trout	mortality, NOAEL mortality, LOAEL hatchability, LOAEL	eggs in water	34 ng/kg egg	55 ng/kg egg 226 ng/kg egg	Walker et al. 1991
Brook trout	sac-fry mortality, NOAEL sac-fry mortality, LOAEL	eggs in water	135 ng/kg egg	185 ng/kg egg	Walker and Peterson 1994
Lake herring	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	175 ng/kg egg	270 ng/kg egg	Elonen et al. 1998
Fathead minnow	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	235 ng/kg egg	435 ng/kg egg	Elonen et al. 1998
Channel catfish	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	385 ng/kg egg	855 ng/kg egg	Elonen et al. 1998
Zebrafish	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	424 ng/kg egg	2,000 ng/kg egg	Elonen et al. 1998
Zebrafish (female)	spawning, fry mortality, LOAEL	dietary exposure		1,700 ng/kg	Wannemacher et al. 1992
Medaka	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	455 ng/kg egg	949 ng/kg egg	Elonen et al. 1998
Coho salmon	survival, growth, NOAEL	dietary exposure	540 ng/kg		Miller et al. 1979
Rainbow trout	survival, growth, LOAEL	water exposure		1,000 ng/kg	Mehrle et al. 1988
White sucker	sac-fry mortality, growth, NOAEL growth, LOAEL	eggs in water	848 ng/kg egg	1,220 ng/kg egg	Elonen et al. 1998
Northern pike	sac-fry mortality, growth, NOAEL survival, LOAEL	eggs in water	1,190 ng/kg egg	1,800 ng/kg egg	Elonen et al. 1998

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level

Table 4-17. Measured and predicted[a] total PCB concentrations in smallmouth bass, white sucker, and longnose dace

	Measured	Predicted	Measured	Predicted		Measured	Predicted	
	Adult (mg/kg ww)	Adult to Egg (mg/kg ww)	Young-of-Year (mg/kg ww)	Young-of-Year to Adult (mg/kg ww)	Young-of-Year to Egg (mg/kg ww)	Juvenile (mg/kg ww)	Juvenile to Adult (mg/kg ww)	Juvenile to Egg (mg/kg ww)
Smallmouth bass								
Segment 1 mean	0.30	0.36	0.089	0.12	0.14	0.11	0.17	0.20
Segment 1 95% UCL	0.71	0.85	0.15	0.20	0.24	0.12	0.18	0.22
Segment 2 mean	32	38	19	25	30	19	29	34
Segment 2 95% UCL	45	54	21	27	32	26	39	47
Segment 3 mean	23	28	24	31	37	19	29	34
Segment 3 95% UCL	35	42	35	46	55	22	33	40
Segment 5 mean	18	22	13	17	20	10	15	18
Segment 5 95% UCL	20	24	17	22	26	13	20	24
White sucker								
Segment 1 mean	0.077	0.044	0.10	0.11	0.063			
Segment 1 95% UCL	0.15	0.086	0.25	0.28	0.16			
Segment 2 mean	11	6.3	10	11	6.4			
Segment 2 95% UCL	20	11	11	12	6.8			
Segment 3 mean	9.9	5.6	11	12	7.0			
Segment 3 95% UCL	15	8.6	18	20	11			
Segment 5 mean	7.9	4.5	4.8	5.2	3.0			
Segment 5 95% UCL	18	10	6.3	6.9	3.9			
Longnose dace								
Segment 1 mean	0.21							
Segment 1 95% UCL	0.55							
Segment 2 mean	12							
Segment 2 95% UCL	21							
Segment 3 mean	17							
Segment 3 95% UCL	22							
Segment 5 mean	18							
Segment 5 95% UCL	23							

NOTE: UCL - upper confidence limit
Measured concentrations are reported in Tables A1-7 and A3-4 in Appendix A

[a] For conversion equations and factors, see Section 4.6.1.

Table 4-18. Measured and predicted[a] TEQ concentrations in smallmouth bass and white sucker

	Measured	Predicted	Measured	Predicted		Measured	Predicted	
	Adult (ng/kg ww)	Adult to Egg (ng/kg ww)	Young-of-Year (ng/kg ww)	Young-of-Year to Adult (ng/kg ww)	Young-of-Year to Egg (ng/kg ww)	Juvenile (ng/kg ww)	Juvenile to Adult (ng/kg ww)	Juvenile to Egg (ng/kg ww)
Smallmouth bass								
Segment 1 mean	2.7	3.2	2.6[b]	9.4	11	0.14	0.27	0.32
Segment 1 95% UCL	2.9	3.5	nc	nc	nc	0.17	0.32	0.38
Segment 2 mean	38	46	14[b]	50	60	15	28	33
Segment 2 95% UCL	64	77	nc	nc	nc	23	44	53
Segment 3 mean	20	24	22[b]	79	95	16	30	36
Segment 3 95% UCL	30	36	nc	nc	nc	19	36	43
Segment 5 mean	8.9	11	6.6[b]	24	29	6.1	12	14
Segment 5 95% UCL	9.5	11	nc	nc	nc	7.1	13	16
White sucker								
Segment 1 mean	2.6[b]	1.5	2.6[b]	2.6	1.5			
Segment 1 95% UCL	nc	nc	nc	nc	nc			
Segment 2 mean	2.3[b]	1.3	7.8[b]	7.8	4.4			
Segment 2 95% UCL	nc	nc	nc	nc	nc			
Segment 3 mean	4.7[b]	2.7	4.8[b]	4.8	2.7			
Segment 3 95% UCL	nc	nc	nc	nc	nc			
Segment 5 mean	3.4[b]	1.9	4.3[b]	4.3	2.5			
Segment 5 95% UCL	nc	nc	nc	nc	nc			

NOTE: TEQ - toxic equivalent
UCL - upper confidence limit
Measured concentrations are reported in Tables A1-7 and A3-4 in Appendix A
nc - not calculated; 95 percent UCL values were calculated only when all relevant TEQ congeners were measured in more than one sample

[a] For conversion equations and factors, see Section 4.6.1.

[b] Mean represents single sample in which all relevant TEQ congeners were measured.

Table 4-19. Hazard quotients calculated using 10th and 50th percentile total PCB effects concentrations and predicted egg concentrations

	Adult to Egg		Young-of-Year to Egg		Juvenile to Egg	
	10th Percentile Effects Concentration	50th Percentile Effects Concentration	10th Percentile Effects Concentration	50th Percentile Effects Concentration	10th Percentile Effects Concentration	50th Percentile Effects Concentration
Smallmouth bass						
Segment 1 mean	1.9	0.16	0.74	0.064	1.1	0.091
Segment 1 95% UCL	4.5	0.39	1.3	0.11	1.2	0.10
Segment 2 mean	200	17	160	14	180	15
Segment 2 95% UCL	280	25	170	15	250	21
Segment 3 mean	150	13	190	17	180	15
Segment 3 95% UCL	220	19	290	25	210	18
Segment 5 mean	120	10	110	9.1	95	8.2
Segment 5 95% UCL	126	11	137	12	130	11
White sucker						
Segment 1 mean	0.23	0.020	0.33	0.029		
Segment 1 95% UCL	0.45	0.039	0.84	0.073		
Segment 2 mean	33	2.9	34	2.9		
Segment 2 95% UCL	58	5.0	36	3.1		
Segment 3 mean	29	2.5	38	3.2		
Segment 3 95% UCL	45	3.9	58	5.0		
Segment 5 mean	24	2.0	16	1.4		
Segment 5 95% UCL	53	4.5	21	1.8		

NOTE: 10th and 50th percentile effects are 0.19 and 2.2 mg/kg egg ww respectively
UCL - upper confidence limit

Table 4-20. Hazard quotients calculated using no effects and 10th and 50th percentile total PCB effects concentrations and measured and predicted PCB concentrations in adult fish

	Measured			Predicted					
	Adult			Young-of-Year to Adult			Juvenile to Adult		
	10th	50th	NOAEL	10th	50th	NOAEL	10th	50th	NOAEL
Smallmouth bass									
Segment 1 mean	0.012	0.017	0.057	0.0048	0.00071	0.023	0.0068	0.0010	0.032
Segment 1 95% UCL	0.028	0.0036	0.13	0.0080	0.0012	0.030	0.0072	0.0011	0.034
Segment 2 mean	1.3	0.19	6.0	0.98	0.14	4.7	1.2	0.16	5.4
Segment 2 95% UCL	1.8	0.26	8.5	1.1	0.16	5.1	1.5	0.23	7.4
Segment 3 mean	0.92	0.13	4.3	1.3	0.19	5.9	1.2	0.16	5.4
Segment 3 95% UCL	1.4	0.21	6.6	1.8	0.27	8.7	1.3	0.20	6.2
Segment 5 mean	0.72	0.11	3.4	0.68	0.099	3.2	0.60	0.088	2.8
Segment 5 95% UCL	0.80	0.12	3.8	0.87	0.13	4.2	0.80	0.12	3.8
White sucker									
Segment 1 mean	0.0031	0.00046	0.015	0.0044	0.00064	0.021			
Segment 1 95% UCL	0.0064	0.00088	0.028	0.011	0.0016	0.053			
Segment 2 mean	0.44	0.064	2.1	0.45	0.066	2.1			
Segment 2 95% UCL	0.80	0.12	3.8	0.48	0.071	2.3			
Segment 3 mean	0.40	0.059	1.9	0.50	0.073	2.3			
Segment 3 95% UCL	0.60	0.14	2.9	0.80	0.12	3.8			
Segment 5 mean	0.31	0.047	1.5	0.21	0.030	0.99			
Segment 5 95% UCL	0.72	0.11	3.4	0.28	0.040	1.3			
Longnose dace									
Segment 1 mean	0.0084	0.0012	0.040						
Segment 1 95% UCL	0.022	0.0033	0.10						
Segment 2 mean	0.46	0.069	2.2						
Segment 2 95% UCL	0.84	0.12	4.0						
Segment 3 mean	0.68	0.10	3.2						
Segment 3 95% UCL	0.87	0.13	4.2						
Segment 5 mean	0.70	0.10	3.3						
Segment 5 95% UCL	0.92	0.13	4.3						

NOTE: 10th and 50th percentile and NOAEL concentrations are 25, 170, and 5.3 mg/kg ww respectively
NOAEL - no observed adverse effects level
UCL - upper confidence limit

Table 4-21. Hazard quotients calculated using TEQ NOAEL and LOAEL and predicted egg concentrations

	Adult to Egg		Young-of-Year to Egg		Juvenile to Egg	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Smallmouth bass						
Segment 1 mean	0.14	0.064	0.48	0.22	0.014	0.0064
Segment 1 95% UCL	0.15	0.070	nc	nc	0.017	0.0076
Segment 2 mean	2.0	0.92	2.6	1.2	1.4	0.66
Segment 2 95% UCL	3.3	1.5	nc	nc	2.3	1.1
Segment 3 mean	1.0	0.48	4.1	1.9	1.6	0.72
Segment 3 95% UCL	1.6	0.72	nc	nc	1.9	0.86
Segment 5 mean	0.48	0.22	1.3	0.58	0.61	0.28
Segment 5 95% UCL	0.48	0.22	nc	nc	0.70	0.32
White sucker						
Segment 1 mean	0.065	0.030	0.065	0.030		
Segment 1 95% UCL	nc	nc	nc	nc		
Segment 2 mean	0.057	0.026	0.019	0.088		
Segment 2 95% UCL	nc	nc	nc	nc		
Segment 3 mean	0.012	0.054	0.12	0.054		
Segment 3 95% UCL	nc	nc	nc	nc		
Segment 5 mean	0.083	0.038	0.11	0.050		
Segment 5 95% UCL	nc	nc	nc	nc		

NOTE: NOAEL - no observed adverse effects level = 23 ng/kg egg ww
LOAEL - lowest observed adverse effects level = 50 ng/kg egg ww
UCL - upper confidence limit
nc - not calculated; 95 percent UCL values were calculated only when all relevant TEQ congeners wermeasured in more than one sample

Table 4-22. Sediment PAH concentrations

LOCATION		PHENANTHRENE (mg/kg dw)	FLUORANTHENE (mg/kg dw)	PYRENE (mg/kg dw)	BENZO(a) ANTHRACENE (mg/kg dw)	BENZO(a) PYRENE (mg/kg dw)
Tumor sites[a]	average	69	48	35	12	10
(Great Lakes	range	1–390	7.2–220	2.0–140	1.5–51	1.6–43
freshwater)	n	7	7	7	7	7
Triad samples	average	0.312	0.600	0.472	0.232	0.249
	range	0.048–0.770	0.063–1.60	0.068–1.40	0.029–0.580	0.034–0.680
	n	17	17	17	17	17

[a] Data taken from WDNR 1992a, provided by Paul Baumann in correspondance to A. O'Brien, WDNR, August 1990. Raw data are reported in Table A1-3 in Appendix A-1.

Table 5-1. Dietary field studies considered for the mink food web exposure model

	Estimated Percent of Diet			
	Alexander (1977)	**Alexander (1977)**	**Burgess and Bider (1980)**	**Cowan and Reilly (1973)**
Habitat type/location	River/Michigan	Stream/Michigan	Stream, riparian/Quebec	River/North Dakota
Season	Year-round	Year-round	Not specified	Summer and fall
Number of mink evaluated	10	31	40	281
Measurement	% ww stomach contents	% ww stomach contents	% volume scat (dw or ww not specified)	% dw volume in scat
Food Item				
Trout	56	52	nr	nr
Non-trout	26	6	nr	nr
Unidentified fish	3	3	7.6	nr
Crustaceans	4	11	20	6.5
Aquatic insects	nr	nr	6.3	nr
Molluscs	nr	2	nr	nr
Amphibians	3	5	12	0.5
Muskrats	nr	nr	nr	18
Waterfowl	nr	nr	nr	15
Birds and mammals	**6**	**17**	**53.9**	**57.5**
Vegetation	**1**	**nr**	**nr**	**nr**
Unidentified	1	4	0.2	1.5
Total Diet	**100**	**100**	**100**	**99**[a]
Total aquatic	89	74	33.9	6.5
Total semi-aquatic	3	5	12	33.5
Total terrestrial	7	17	53.9	57.5
Total unknown	1	4	0.2	1.5

NOTE: nr - not reported
dw - dry weight
ww - wet weight
(light shading) - aquatic
(dark shading) - semi-aquatic
Bold - terrestrial

[a] As reported in USEPA 1993c, total sums to 99 percent.

Table 5-2. Dietary field studies considered for the great blue heron food web exposure model

	Estimated Percent of Diet				
	Alexander (1977)	**Alexander (1977)**	**Alexander (1977)**	**Cottam & Uhler (1945)**	**Average**
Habitat type/location	Stream/Michigan	Lake/Michigan	River/Michigan	nr/throughout US	
Season	Spring, summer, and fall	Spring, summer, and fall	Spring, fummer, and fall	Summer	
Number of herons evaluated	15	19	38	189	
Measurement	% ww stomach contents	% ww stomach contents	% ww stomach contents	% stomach contents	
Food item					
Trout	88	59	89	24.8	65.2
Non-trout	2	39	5	43.2	22.3
Unidentified fish	nr	nr	nr	3.6	3.6
Insects[a]	4	nr	nr	8.2	6.1
Crustaceans	1	1	1	8.9	3.0
Amphibians	1	1	4	4.3	2.6
Birds and mammals	**2**	**nr**	**1**	**4.7**	**2.6**
Vegetation	**1**	**nr**	**nr**	**2.5**	**1.8**
Unidentified	1	nr	nr	nr	1.0
Total diet	**100**	**100**	**100**	**100**	
Total aquatic	95	99	95	88.7	
Total semi-aquatic	1	1	4	4.3	
Total terrestrial	3	0	1	7.2	
Total unknown	1	0	0	0	

NOTE: dw - dry weight
nr - not reported
ww - wet weight
(light shading) - aquatic
(dark shading) - semi-aquatic
Bold - terrestrial

a Assumed to be aquatic insects.

Table 5-3. Mink and great blue heron exposure parameters

PARAMETER	MINK	GREAT BLUE HERON
Body weight	0.55 kg[a]	2.23 kg[a]
Ingestion rate		
Fish[b]	0.152 kg/day ww	0.357 kg/day ww
Crayfish[b]	0.007 kg/day ww	0.004 kg/day ww
Sediment[c]	0.004 kg/day ww	na
Total ingestion[d]	0.178 kg/day ww	0.394 kg/day ww
Exposure fraction	1 (unitless)	1 (unitless)
Relative PCB bioavailability factor	100%	100%

NOTE: na - not applicable

[a] USEPA 1995a,b.
[b] Normalized ingestion rate calculation.
[c] Assumed for this assessment.
[d] Site-specific data from the WDNR food chain study and the 1997 ERA were available to evaluate 89% of diet for mink and 92% of diet for great blue heron.

Table 5-4a. Number of fish captured per species and size class by mink in north central Lower Michigan

Fish Species	Fish Length (cm)				
	< 7.6	< 10	< 12	< 15	< 18
Trout (brook, brown)	1	7	4	3	1
Sculpins	3				
Blacknose dace	2				
Creek chub	1	3			
Suckers	1				
Darters	3				
Redbelly dace	1				

SOURCE: Alexander 1977; table adapted from USEPA 1995a

Table 5-4b. Percent of fish captured per species and size class by great blue herons

Fish Species/Size	Percent of Total Number of Fish Captured
Staghorn sculpin	
< 5 cm	27.8
about 7 cm	7.6
> 14 cm	2.2
Starry flounder	
< 5 cm	15.0
about 7 cm	8.1
> 14 cm	5.2
Shiners, sea perch, penpoint gunnels	
< 5 cm	30.6
about 7 cm	3.5

SOURCE: Krebs 1974; table adapted from USEPA 1995a

Table 5-5. Concentrations of total PCBs and TEQs in crayfish collected for the WDNR food chain study in 1994

Location	Total PCBs (mg/kg ww)	Mammal TEQ (ng/kg ww)	Bird TEQ (ng/kg ww)
Reference area	0.045	51	170
Reference area	0.045	51	170
Reference area	0.061	na	na
Mean	0.050	51	170
95% UCL	0.066	51[a]	170[a]
Segments 2/3	1.9	67	580
Segments 2/3	1.8	64	500
Segments 2/3	1.8	na	na
Segments 2/3	2.5	69	520
Segments 2/3	2.4	66	440
Segments 2/3	2.2	na	na
Mean	2.1	67	510
95% UCL	2.4	69	580
Segments 5/6	1.6	63	420
Segments 5/6	1.8	65	470
Segments 5/6	1.9	na	na
Mean	1.8	64	450
95% UCL	2.0	65[a]	470[a]

NOTE: na – no data available
TEQ – toxic equivalent
UCL – upper confidence limit
Raw data are presented in Table A3-4 in Appendix A

[a] 95% UCL cannot be calculated; this value is the maximum.

Table 5-6. Concentrations of total PCBs, mammal TEQs, and bird TEQs in fish collected for the WDNR food chain study in 1994 and for the 1997 ERA

		Total PCBs (mg/kg ww)	Mammal TEQ (ng/kg ww)	Bird TEQ (ng/kg ww)
Reference area	Longnose dace	0.065	55	250
	Longnose dace	0.072	na	na
	Longnose dace	0.12	na	na
	Smallmouth bass YOY	0.051	na	na
	Smallmouth bass YOY	0.052	na	na
	Smallmouth bass YOY	0.18	51	180
	White sucker YOY	0.44	na	na
	White sucker YOY	0.12	na	na
	White sucker YOY	0.072	52	200
	Smallmouth bass juvenile	0.11	3.1	36
	Smallmouth bass juvenile	0.12	3.4	38
	Smallmouth bass juvenile	0.11	3.8	37
	Mean	**0.13**	**28**	**120**
	95% UCL	**0.18**	**50**	**200**
Segments 2/3	Longnose dace	8.0	na	na
	Longnose dace	9.1	na	na
	Longnose dace	18	230	2,900
	Longnose dace	14	na	na
	Longnose dace	17	na	na
	Longnose dace	20	150	2,300
	Smallmouth bass YOY	20	na	na
	Smallmouth bass YOY	18	na	na
	Smallmouth bass YOY	18	280	4,100
	Smallmouth bass YOY	23	na	na
	Smallmouth bass YOY	18	na	na
	Smallmouth bass YOY	31	440	5,700
	White sucker YOY	9.8	na	na
	White sucker YOY	11	na	na
	White sucker YOY	10	150	1,700
	White sucker YOY	3.5	na	na
	White sucker YOY	16	na	na
	White sucker YOY	9.1	98	1,100
	Smallmouth bass juvenile	19	250	5,000
	Smallmouth bass juvenile	23	330	6,600
	Smallmouth bass juvenile	14	190	3,700
	Smallmouth bass juvenile	21	380	6,800
	Smallmouth bass juvenile	19	320	5,800
	Smallmouth bass juvenile	18	340	5,800
	Mean	**16**	**260**	**4,300**
	95% UCL	**18**	**320**	**5,300**
Segments 5/6	Longnose dace	10	190	3,100
	Longnose dace	14	na	na
	Longnose dace	14	na	na
	Smallmouth bass YOY	4.4	na	na
	Smallmouth bass YOY	4.1	na	na
	Smallmouth bass YOY	5.8	130	2,000
	White sucker YOY	20	na	na
	White sucker YOY	19	na	na
	White sucker YOY	14	86	910
	Smallmouth bass juvenile	9.1	120	2,400
	Smallmouth bass juvenile	9.4	150	2,600
	Smallmouth bass juvenile	12	160	2,900
	Mean	**11**	**140**	**2,300**
	95% UCL	**14**	**170**	**2,900**

NOTE:
na – sufficient data not available
TEQ – toxic equivalent
UCL – upper confidence limit
YOY - young-of-year

Raw data are presented in Tables A1-7 and A3-4 in Appendix A

Table 5-7. Concentrations of PCBs, mammal TEQs, and bird TEQs in sediments collected for the WDNR food chain study in 1994 and for the 1997 ERA

		Total PCBs (mg/kg ww)	Mammal TEQ (ng/kg ww)	Bird TEQ (ng/kg ww)
Reference area	1A	0.016	6.1	21
	1B	0.018	5.6	20
	1C	0.017	5.6	19
	1D	0.021	5.6	20
	1E	0.020	5.6	20
	S1-1	0.0051	0.055	1.2
	S1-2	0.0076	0.29	2.6
	S1-3	0.0051	0.045	0.78
	Mean	**0.014**	**3.6**	**13**
	95% UCL	**0.018**	**5.5**	**19**
Segments 2/3	3A	3.3	26	406
	3B	3.0	18	318
	3C	2.1	11	188
	3D	4.6	15	317
	3E	4.4	20	360
	2A	2.7	14	261
	2B	5.3	31	568
	2C	3.5	13	252
	2D	15	65	1,043
	2E	11	54	1,211
	S2-1	2.2	16	435
	S2-2	12	184	3,869
	S2-3	2.0	19	418
	S3-1	2.4	19	363
	S3-2	17	33	645
	S3-3	1.2	31	570
	Mean	**5.6**	**36**	**701**
	95% UCL	**7.8**	**54**	**1,091**
Segments 5/6	6A	1.6	24	291
	6B	1.8	12	234
	6C	1.9	22	354
	6D	1.8	18	336
	6E	1.0	11	175
	5A	2.1	16	336
	5B	2.1	16	327
	5C	1.1	12	212
	5D	1.7	14	286
	S5-1	1.7	35	663
	S5-2	0.37	7.9	140
	S5-3	1.2	27	487
	S5-4	0.61	19	295
	S5-5	0.38	5.4	106
	Mean	**1.4**	**17**	**303**
	95% UCL	**1.7**	**21**	**370**

NOTE: TEQ – toxic equivalent
UCL – upper confidence limit
Raw data are presented in Tables A1-6 and A3-1 in Appendix A.

Table 5-8. Mink and great blue heron dietary exposure calculations for TEQs using 95 percent UCL and mean concentrations

Receptor of Concern	Data Format	Location	TEQ Concentrations: Sediment Ingestion (ng/day ww)	Fish Ingestion (ng/day ww)	Crayfish Ingestion (ng/day ww)	Total Dietary Ingestion (ng/kg bw day ww)
Mink	**95% UCL**	**Reference area**	0.014	5.5	0.26	10
		Segments 2/3	0.14	35	0.36	64
		Segments 5/6	0.054	19	0.34	35
	Mean	**Reference area**	0.009	3.1	0.26	5.9
		Segments 2/3	0.092	29	0.34	53
		Segments 5/6	0.044	15	0.33	28
Great blue heron	**95% UCL**	**Reference area**	na	73	0.66	33
		Segments 2/3	na	1,900	2.2	850
		Segments 5/6	na	1,100	1.8	490
	Mean	**Reference area**	na	44	0.66	20
		Segments 2/3	na	1,600	2	720
		Segments 5/6	na	840	1.7	380

NOTE: na - not applicable
TEQ - toxic equivalent
UCL - upper confidence limit

Table 5-9. Mink and great blue heron dietary exposure calculations for total PCBs using 95 percent UCL and mean concentrations

Receptor of Concern	Data Format	Location	Total PCB Concentrations: Sediment Ingestion (mg/day ww)	Fish Ingestion (mg/day ww)	Crayfish Ingestion (mg/day ww)	Small Mammal Ingestion (mg/day ww)	Total Dietary Ingestion (mg/kg bw day ww)
Mink	**95% UCL**	**Reference area**	0.000065	0.027	0.00047	na	0.037
		Segments 2/3	0.028	2.8	0.017	na	3.7
		Segments 5/6	0.0060	2.1	0.014	0.0029	2.8
	Mean	**Reference area**	0.000049	0.019	0.00036	na	0.026
		Segments 2/3	0.020	2.5	0.015	na	3.3
		Segments 5/6	0.0049	1.7	0.013	0.0021	2.3
Great blue heron	**95% UCL**	**Reference area**	na	0.066	0.00026	na	0.030
		Segments 2/3	na	6.7	0.0092	na	3.0
		Segments 5/6	na	5.1	0.0078	0.0014	2.3
	Mean	**Reference area**	na	0.046	0.00020	na	0.021
		Segments 2/3	na	5.9	0.0082	na	2.7
		Segments 5/6	na	4.1	0.0069	0.0010	1.8

NOTE: na - not applicable
UCL - upper confidence limit

Table 5-10a. NOAEL-based toxicity reference values for mink and great blue heron

CONTAMINANT OF CONCERN	DAILY DOSE	SOURCE
Mink		
TEQ	0.2 ng/kg bw day[a]	Heaton et al. 1995
Total PCBs	0.004 mg/kg bw day	Heaton et al. 1995
Great blue heron		
TEQ	2.9 ng/kg bw day[a]	Summer et al. 1996a,b
Total PCBs	0.046 mg/kg bw day	Summer et al. 1996a,b

NOTE: NOAEL - no observed adverse effects level
TEQ - toxic equivalent

[a] These toxicity reference values have been recalculated. See Section 5.2.

Table 5-10b. LOAEL-based toxicity reference values for mink and great blue heron

CONTAMINANT OF CONCERN	DAILY DOSE	SOURCE
Mink		
TEQ	4 ng/kg bw day[a]	Heaton et al. 1995
Total PCBs	0.146 mg/kg bw day	Heaton et al. 1995
Great blue heron		
TEQ	28 ng/kg bw day[a]	Summer et al. 1996a,b
Total PCBs	0.4 mg/kg bw day	Summer et al. 1996a,b

NOTE: LOAEL - lowest observed adverse effects level
TEQ - toxic equivalent

[a] These toxicity reference values have been recalculated. See Section 5.2.

Table 5-11. Derivation of mink NOAEL-based and LOAEL-based toxicity reference values

	Contaminant of Concern	
	TEQs	**Total PCBs**
Reference	Heaton et al. 1995	Heaton et al. 1995
Form	TEQ[a]	Aroclor 1248, 1254, 1260
NOAEL concentration	0.9 ng/kg TEQ in food	15 mg/kg food
LOAEL concentration	22.1 ng/kg TEQin food	720 mg/kg food
Test species	mink	mink
Administration route	oral in diet	oral in diet
Endpoint/effect	reproduction	reproduction
Study duration	85 days	85 days
Threshold type	Chronic NOAEL	Chronic NOAEL
Ingestion[b]	266 and 218 g/mink/day	266 and 218 g/mink/day
Ingestion reference	from study	from study
Body weight[b]	192 g and 1,075 g	192 g and 1,075 g
Body weight reference	not reported	from study
Test duration and/or effect concentration uncertainty factor	1	1
Interspecies uncertainty factor	1	1
NOAEL-based TRV	0.22 ng TEQ/kg bw day	3.65 mg/kg bw day
LOAEL-based TRV	4.0 ng TEQ/kg bw day	146 mg/kg bw day

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
TEQ - toxic equivalent
TRV - toxicity reference values

[a] Calculated using WHO toxic equivalency factors (Ahlborg et al. 1994).
[b] Control dose (LOAEL) and low dose (NOAEL).

Table 5-12. Derivation of great blue heron NOAEL-based and LOAEL-based toxicity reference values

	Contaminant of Concern	
	TEQs	Total PCBs
Reference	Summer et al. 1996a,b	Summer et al. 1996a,b
Form	TEQ[a]	Total PCBs
NOAEL concentration	51.2 ng/kg TEQ in food	0.8 mg/kg food
LOAEL concentration	512 ng/kg TEQ in food	6.6 mg/kg food
Test species	chicken	chicken
Administration route	oral in diet	oral in diet
Endpoint/effect	reproduction	reproduction
Study duration	10 weeks	10 weeks
Threshold type	Chronic NOAEL	Chronic NOAEL
Ingestion[b]	91.2 and 89.1 g/day	91.2 and 89.1 g/day
Ingestion reference	from study	from study
Body weight	1.59 and 1.57 kg	1.59 and 1.57 kg
Body weight reference	from study	from study
Test duration and/or effects conc. uncertainty factor	1	1
Interspecies uncertainty factor	1	1
NOAEL-based TRV	2.9 ng TEQ/kg bw day	0.046 mg/kg bw day
LOAEL-based TRV	28 ng TEQ/kg bw day	0.4 mg/kg bw day

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
TEQ - toxic equivalent
TRV - toxicity reference values

[a] Calculated using CEH toxic equivalency factors (Kennedy et al. 1996).
[b] Lowest dose (NOAEL) and high dose (LOAEL).

Table 5-13. Comparison of 2,3,7,8-TCDD TEQs derived using various TEF values and dioxin, furan, and PCB congener data from dietary toxicity tests

	Dietary Toxicity Test Data (ng/kg)				Dietary TEQs (ng/kg)							
	Mammal		Chicken		Mammal				Chicken			
					H4IIE TEFs		WHO TEFs[a]		H4IIE TEFs		CEH TEFs[b]	
	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
	Control (0% carp)	10% carp	3.5% carp	34% carp	Control (0% carp)	10% carp	Control (0% carp)	10% carp	3.5% carp	34% carp	3.5% carp	34% carp
Dioxins												
2,3,7,8-TCDD	nd	2	0.7	6.8	nd	2.000	nd	2.0	0.700	6.800	0.7	6.8
1,2,3,7,8-PECDD	nd	2	0.7	6.8	nd	0.840	nd	2.0	0.294	2.856	0.77	7.48
1,2,3,4,7,8-HXCDD	nd	2	0.7	6.8	nd	0.166	nd	0.2	0.058	0.564	na	na
1,2,3,7,8,9-HXCDD	nd	1	0.4	3.4	nd	0.024	nd	0.1	0.008	0.082	na	na
1,2,3,7,8,9-HXCDD	nd	1	0.4	3.4	nd	0.034	nd	0.1	0.012	0.116	na	na
1,2,3,4,6,7,8-HPCDD	5	7	2.5	23.8	0.12	0.161	0.05	0.1	0.056	0.547	na	na
OCDD	37	45	15.8	153	0.12	0.023	0.004	0.0	0.008	0.077	na	na
Furans												
2,3,7,8-TCDF	nd	2	0.7	6.8	nd	0.400	nd	0.2	0.140	1.360	0.77	7.48
1,2,3,7,8-PECDF	nd	1	0.4	3.4	nd	0.200	nd	0.1	0.070	0.680	na	na
2,3,4,7,8-PECDF	nd	4	1.4	13.6	nd	5.600	nd	2.0	1.960	19.040	na	na
1,2,3,4,7,8-HXCDF	nd	1	0.4	3.4	nd	0.020	nd	0.1	0.007	0.068	na	na
1,2,3,6,7,8-HXCDF	nd	1	0.4	3.4	nd	0.060	nd	0.1	0.021	0.204	na	na
1,2,3,7,8,9-HXCDF	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
2,3,4,6,7,8-HXCDF	nd	1	0.4	3.4	nd	0.300	nd	0.1	0.105	1.020	na	na
1,2,3,4,6,7,8-HPCDF	nd	2	0.7	6.8	nd	0.600	nd	0.0	0.210	2.040	na	na
1,2,3,4,7,8,9-HPCDF	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	na
OCDF	1	1	0.4	3.4	nd	nd	nd	0.0	nd	nd	na	na
PCB Congeners												
081	2	27	9.5	91.8	0.004	0.051	0.0002	0.0	0.018	0.174	1.89	18.36
077	11	300	105.0	1,020	0.0002	0.005	0.0011	0.0	0.002	0.018	3.5	30.6
126	5	88	30.8	299.2	0.11	1.936	0.50	8.8	0.678	6.582	9.24	89.76
169	2	5	1.8	17	0.001	0.002	0.02	0.1	0.001	0.008	0.035	0.34
123	30	920	322.0	3,128	0.0004	0.011	0.003	0.1	0.004	0.038	na	na
118	1,660	35,000	12,250.0	119,000	0.0006	0.012	0.17	3.5	0.004	0.042	12.25	119
114	30	1,200	420.0	4,080	0.00003	0.001	0.02	0.6	0.000	0.004	na	na
105	510	12,000	4,200.0	40,800	0.0041	0.096	0.05	1.2	0.034	0.326	21	204
167	110	1,100	385.0	3740	0.0010	0.010	0.0011	0.0	0.003	0.034	0.77	7.48
156	110	1,300	455.0	4,420	0.01	0.072	0.06	0.7	0.025	0.243	0.455	4.42
157	40	280	98.0	952	0.0006	0.004	0.02	0.1	0.001	0.014	0.196	1.904
189	10	200	70.0	680	0.0001	0.002	0.0010	0.0	0.001	0.007	na	na
Total TEQ					**0.3**	**12.6**	**0.9**	**22.1**	**4.4**	**42.9**	**51.2**	**497.6**

Table 5-13, continued

SOURCE: Heaton et al. 1995; Summer et al. 1996a,b, and Tillitt et al. 1996

NOTE: CEH - chick embryo hepatocyte
H4IIE - H4IIE rat hepatoma assay
LOAEL - lowest observed adverse effects level
na - no TEF available
nd - not detected
NOAEL - no observed adverse effects level
TEF - toxic equivalency factor
TEQ - toxic equivanlent

[a] Ahlborg et al. 1994

[b] Kennedy et al. 1996

Table 5-14. NOAEL and LOAEL doses calculated using dietary concentration data presented in Tillitt et al. 1996

		NOAEL TEQ Daily Dose (ng/kg bw day)	LOAEL TEQ Daily Dose (ng/kg bw day)
Mink	H4IIE TEFS	0.06	2.6
	WHO TEFs[a]	0.22	4.5
Great blue heron	H4IIE TEFS	0.3	2.4
	CEH TEFs[b]	2.9	28

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
TEF - toxic equivalency factor
TEQ - toxic equivalent
Summer et al. (1996a,b), Heaton et al. (1995), and Tillitt et al. (1996) used the same data set for their studies

[a] Ahlborg et al. 1994
[b] Kennedy et al. 1996

Table 5-15. Various TEF values available for evaluating PCB toxicity to birds and mammals

	Mammals		Birds	
Congeners	H4IIE TEF	WHO TEF (Ahlborg et al. 1994)	CEH TEF (Kennedy et al. 1996)	WHO TEF (Ahlborg et al. 1994)
Dioxins				
2,3,7,8-TCDD	1	1	1	1
1,2,3,7,8-PECDD	0.42	1	1.1	1
1,2,3,4,7,8-HXCDD	0.083	0.1	na	0.05
1,2,3,6,7,8-HXCDD	0.024	0.1	na	0.01
1,2,3,7,8,9-HXCDD	0.034	0.1	na	0.1
1,2,3,4,6,7,8-HPCDD	0.023	0.01	na	0.001
OCDD	0.000504	0.0001	na	na
Furans				
2,3,7,8-TCDF	0.2	0.1	1.1	1
1,2,3,7,8-PECDF	0.2	0.05	na	0.1
2,3,4,7,8-PECDF	1.4	0.5	na	1
1,2,3,4,7,8-HXCDF	0.02	0.1	na	0.1
1,2,3,6,7,8-HXCDF	0.06	0.1	na	0.1
1,2,3,7,8,9-HXCDF	0.2	0.1	na	0.1
2,3,4,6,7,8-HXCDF	0.3	0.1	na	0.1
1,2,3,4,6,7,8-HPCDF	0.3	0.01	na	0.01
1,2,3,4,7,8,9-HPCDF	0.02	0.01	na	0.01
OCDF	na	0.0001	na	0.0001
PCB congeners				
081	0.0019	0.0001	0.2	0.1
077	0.000018	0.0001	0.03	0.05
126	0.022	0.1	0.3	0.1
169	0.00047	0.01	0.02	0.001
123	0.000012	0.0001	na	0.00001
118	0.00000035	0.0001	0.001	0.00001
114	0.000001	0.0005	na	0.0001
105	0.000008	0.0001	0.005	0.0001
167	0.000009	0.00001	0.002	0.00001
156	0.000055	0.0005	0.001	0.0001
157	0.000015	0.0005	0.002	0.0001
189	0.00001	0.0001	na	0.00001
Total TEF	**4.3**	**3.5**	**3.8**	**4.9**
Total TEF for PCB congeners	**0.02**	**0.11**	**0.56**	**0.25**

NOTE: na – no TEF available
TEF - toxic equivalency factor

Table 5-16. Hazard quotients calculated for mink and great blue heron exposed to TEQs through dietary ingestion

Receptor Species	Data Format	Location	NOAEL-Based Hazard Quotient	LOAEL-Based Hazard Quotient
Mink	95% UCL TEQ exposure	Reference area	45	2.2
		Segments 2/3	290	14.0
		Segments 5/6	160	7.8
	Mean TEQ exposure	Reference area	27	1.3
		Segments 2/3	240	12.0
		Segments 5/6	130	6.2
Great blue heron	95% UCL TEQ exposure	Reference area	11	1.2
		Segments 2/3	290	30
		Segments 5/6	170	18
	Mean TEQ exposure	Reference area	6.9	0.71
		Segments 2/3	250	26
		Segments 5/6	130	14

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
TEQ - toxic equivalent
UCL - upper confidence limit

Table 5-17. Hazard quotients calculated for mink and great blue heron exposed to PCBs through dietary ingestion

Receptor Species	Data Format	Location	NOAEL-Based Hazard Quotient	LOAEL-Based Hazard Quotient
Mink	95% UCL PCB exposure	Reference area	10	0.3
		Segments 2/3	1,000	25
		Segments 5/6	770	19
	Mean PCB exposure	Reference area	7.0	0.2
		Segments 2/3	900	23
		Segments 5/6	620	15
Great blue heron	95% UCL PCB exposure	Reference area	0.6	0.1
		Segments 2/3	65	8
		Segments 5/6	49	6.1
	Mean PCB exposure	Reference area	0.4	0.1
		Segments 2/3	58	7.1
		Segments 5/6	40	4.9

NOTE: LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
UCL - upper confidence limit

Table 6-1. Classification of stations as toxic compared with sediment benchmark exceedances by chemical groups

	Toxic Endpoint Compared To Negative Control			Toxic Endpoint Compared To Reference			Exceedance Ratios[a,b]								
Station	*H azteca*	*C. riparius*	Toxic Sample	*H. azteca*	*C. riparius*	Toxic Sample	Metal > TEL	Metal > PEL	Metal > NEC	PAH > TEL	PAH > PEL	PAH > NEC	Total PCBs > TEL	Total PCBs > PEL	PCB > NEC
T-07	Survival	Survival	Toxic	Survival	Survival	Toxic	5.6			16			24,000	3,100	4,000
T-08										45			30	4	5.1
T-09		Survival	Toxic							56	1		10	1.3	1.6
T-10	Survival	Survival	Toxic				3.4			45			8		1.3
T-11	Survival	Survival	Toxic				2.5			260	22	2.2	7		1.2
T-12										130	7		6		1.0
T-13	Survival		Toxic				7.0	1.6	1.9	220	17		13	1.7	2.2
T-14	Survival, Growth[c]	Survival	Toxic				2.5			190	14		14	1.8	2.4
T-15	Survival		Toxic				3.6			170	9		12	1.5	1.9
T-16	Survival		Toxic				3.9			120	5		13	1.8	2.3
T-17		Survival	Toxic							98	3		13	1.7	2.2
T-18	Survival		Toxic				1.1			92	4		12	1.6	2.0
T-19	Survival		Toxic				2.4			290	26	2.8	14	1.8	2.4
T-20	Survival	Survival	Toxic				3.6			90	5		11	1.5	1.9

NOTE: Blanks indicate no individual chemical concentration exceeded the benchmark
TEL - threshold effects level
PEL - probable effects level
NEC - no effects concentration
Full bioassay results are in Appendix C and sediment chemistry results are in Tables A1-1, A1-2, and A1-3 in Appendix A

[a] Sum of the exceedance ratios (i.e., the chemical concentration measured in sediment divided by the sediment quality guideline) of the chemicals with individual exceedances.

[b] Sediment quality guidelines used to determine exceedance ratios are based on the 14-day *Hyalella azteca* test, except for the PCB guidelines which are based on the 28-day *H. azteca* test because the guidelines were not available for the 14-day test.

[c] Growth endpoint based on total biomass.

Table 6-2. Number of correctly classified samples, false positives, and false negatives, when toxicity is based on a statistical comparison to the negative control

Analyte	TEL		PEL		NEC	
	Toxic[a]	Not Toxic	Toxic	Not Toxic	Toxic	Not Toxic
Metals						
Sediment benchmarks exceeded	10	0	1	0	1	0
Sediment benchmarks **not** exceeded	2	2	11	2	11	2
Percent of samples correctly classified	86		29		29	
Type I false positive	0		0		0	
Type II false negative	14		71		71	
PAHs						
Sediment benchmarks exceeded	12	2	10	1	2	0
Sediment benchmarks **not** exceeded	0	0	2	1	10	2
Percent of samples correctly classified	86		79		29	
Type I false positive	14		7		0	
Type II false negative	0		14		71	
PCBs[b]						
Sediment benchmarks exceeded	12	2	10	1	12	2
Sediment benchmarks **not** exceeded	0	0	2	1	0	0
Percent of samples correctly classified	86		79		86	
Type I false positive	14		7		14	
Type II false negative	0		14		0	

NOTE: NEC - no effects concentration
PEL - probable effects level
TEL - threshold effects level
Type I error (false positive): Percent of samples sediment benchmarks predicted as toxic that were non-toxic
Type II error (false negative): Percent of samples sediment benchmarks predicted as non-toxic that were toxic

a Samples were considered toxic if they were significantly different than negative controls in *Hyalella azteca* survival or growth (total biomass) or *Chironomus riparius* survival or growth (total biomass); see Table 3-6 for a summary of results.

b PCB values based on 28-day *H. azteca* test. No data available for 14-day *H. azteca* test.

Table 6-3. Number of correctly classified samples, false positives, and false negatives, when toxicity is based on a statistical comparison to reference

Analyte	TEL		PEL		NEC	
	Toxic[a]	Not Toxic	Toxic	Not Toxic	Toxic	Not Toxic
Metals						
Sediment benchmarks exceeded	1	9	0	1	1	1
Sediment benchmarks **not** exceeded	0	4	1	12	1	11
Percent of samples correctly classified	36		86		86	
Type I false positive	64		7		7	
Type II false negative	0		7		7	
PAHs						
Sediment benchmarks exceeded	1	13	0	11	0	2
Sediment benchmarks **not** exceeded	0	0	1	2	1	11
Percent of samples correctly classified	7		14		79	
Type I false positive	93		79		14	
Type II false negative	0		7		7	
PCBs[b]						
Sediment benchmarks exceeded	1	13	1	10	1	13
Sediment benchmarks **not** exceeded	0	0	0	3	0	0
Percent of samples correctly classified	7		29		7	
Type I false positive	93		71		93	
Type II false negative	0		0		0	

NOTE: NEC - no effects concentration
PEL - probable effects level
TEL - threshold effects level
Type I error (false positive): Percent of samples sediment benchmarks predicted as toxic that were non-toxic
Type II error (false negative): Percent of samples sediment benchmarks predicted as non-toxic that were toxic

[a] Samples were considered toxic if they were significantly different from reference samples in *Hyalella azteca* survival or growth (total biomass) or *Chironomus riparius* survival or growth (total biomass); see Table 3-6 for a summary of results.

[b] PCB values based on 28-day *H. azteca* test. No data available for 14-day *H. azteca* test.

Table 6-4. Derivation of protective sediment concentrations in the Sheboygan River for fish health endpoint using congener-specific food-web bioaccumulation modeling

4.0% = Mean total organic carbon content of Sheboygan River sediments[a]

2.9% = Mean lipid content of juvenile smallmouth bass[b]

PCB Congener[c]	Sheboygan River Segment	Fish PCB TEF Value[d]	NOAEL TEQ[e] (ng/kg)	LOAEL TEQ[e] (ng/kg)	Congener Portion of TEQ[f]	Congener Partial TEQ[g] (ng/kg)	Egg Benchmark[h] (μg/kg)[m]	Adult SMB Benchmark[i] (μg/kg)[m]	Juvenile SMB Benchmark[j] (μg/kg)[m]	Observed in Fish[b] (μg/kg)[m]	Modeled BSAF[k] (Age 1+)	NOAEL PSC[l] (μg/kg)[m]	LOAEL PSC[l] (μg/kg)[m]	Observed Sediment[b] (mg/kg)[m]
077	1	0.00016	23	50	12.5%	2.9	18.0	15.0	7.9	0.11	2.93	3.7	8.1	0.0163
	2	0.00016	23	50	42.3%	9.7	60.8	50.7	26.7	39.3	2.93	12.6	27.3	28.05
	3	0.00016	23	50	28.5%	6.6	41.0	34.1	18.0	28.7	2.93	8.5	18.4	9.05
	5	0.00016	23	50	27.5%	6.3	39.5	32.9	17.3	10.4	2.93	8.2	17.7	5.95
118	1	0.000003	23	50	17.0%	3.9	1,303.3	1,086.1	571.6	7.7	3.057	257.9	560.7	0.5933
	2	0.000003	23	50	13.3%	3.1	1,019.7	849.7	447.2	646.7	3.057	201.8	438.7	295
	3	0.000003	23	50	19.1%	4.4	1,464.3	1,220.3	642.3	1,013.3	3.057	289.8	630.0	83
	5	0.000003	23	50	23.2%	5.3	1,778.7	1,482.2	780.1	466.7	3.057	352.0	765.2	43.6
126	1	0.005	23	50	62.5%	14.38	2.88	2.40	1.26	0.02	3.078	0.57	1.23	0.0027
	2	0.005	23	50	38.0%	8.74	1.75	1.46	0.77	1.12	3.078	0.34	0.75	0.6927
	3	0.005	23	50	45.0%	10.35	2.07	1.73	0.91	1.44	3.078	0.41	0.88	0.2487
	5	0.005	23	50	40.1%	9.22	1.84	1.54	0.81	0.49	3.078	0.36	0.79	0.1758

NOTE:
BSAF - Biota sediment accumulation factor
LOAEL - Lowest observed adverse effects level
NOAEL - No observed adverse effects level
PSC - Protective sediment concentration
SMB - Smallmouth bass
TEF - Toxic equivalency factor
TEQ - Toxic equivalent

a Mean of 1997 ERA and WDNR food chain study.

b Mean of data from 1997 ERA (see Table A1-7 in Appendix A-1).

c PCB congeners 077, 118, and 126 contributed over 90 percent of the total PCB TEQ in every segment.

d TEF scheme for fish toxicity from Walker and Peterson (1991).

e NOAEL for survival of lake trout fry is 23 ng/kg TCDD in eggs (Walker et al. 1994). LOAEL of 50 ng/kg egg based on significantly increased sac fry mortality in same study.

f Values based on mean of three composites within each river segment.

g Represents portion of total TEQ threshold attributable to a specific congener.

h Maximum acceptable egg concentration (based on NOAEL) of given congener.

i Benchmark adult smallmouth bass tissue concentrations converted from threshold egg concentrations[h] using experimentally observed ratio of contaminant in smallmouth bass eggs to fish tissue of 1.2 (Niimi 1983).

j Benchmark juvenile smallmouth bass tissue concentrations converted from adult benchmark[i] using the ratio of adult to juvenile TEQ concentrations (1.9) observed in 1997 ERA and WDNR food chain study (Section 4.0).

k Lipid and organic carbon normalized biota sediment accumulation factor determined using food-web bioaccumulation model.

l Protective sediment concentration for fish health endpoint, based on NOAEL and LOAEL.

m Units represent the concentration of an individual PCB congener.

Table 6-5. Protective fish TEQ concentrations

Receptor	Fish Ingestion (kg/day ww)	Body Weight (kg)	TEQ TRV (ng/kg day ww)	Protective Fish Concentration (ng/kg ww)
Mink	0.152	0.55	0.22	1.1
Great blue heron	0.365	2.23	3.0	18

NOTE: TEQ - toxic equivalent
TRV - toxicity reference value

Table 6-6. Derivation of protective sediment concentrations in the Sheboygan River for mammalian health endpoint using congener-specific food-web bioaccumulation modeling

4.0% = Mean total organic carbon content of Sheboygan River sediments[a]

2.9% = Mean lipid content of juvenile smallmouth bass[b]

PCB Congener[c]	Sheboygan River Segment	Mammal PCB TEF Value[d]	NOAEL TEQ[e] (ng/kg)	LOAEL TEQ[e] (ng/kg)	Congener Portion of TEQ[f]	Congener Partial TEQ[g] (ng/kg)	Fish Tissue Benchmark[h] (mg/kg)[k]	Observed in Fish[b] (mg/kg)[k]	Modeled BSAF[i] (Age 1+)[k]	NOAEL PSC[j] (mg/kg)[k]	LOAEL PSC[j] (mg/kg)[k]	Observed Sediment[b] (mg/kg)[k]
105	1	0.0001	1.14	23.7	7.0%	0.08	0.8	2.4	3.037	0.36	7.53	0.26
	2	0.0001	1.14	23.7	11.1%	0.13	1.3	280.0	3.037	0.57	11.95	146.7
	3	0.0001	1.14	23.7	10.3%	0.12	1.2	356.7	3.037	0.53	11.09	40.7
	5	0.0001	1.14	23.7	11.2%	0.13	1.3	160.0	3.037	0.58	12.06	23.8
118	1	0.0001	1.14	23.7	22.5%	0.26	2.6	7.7	3.057	1.16	24.06	0.59
	2	0.0001	1.14	23.7	25.1%	0.29	2.9	646.7	3.057	1.29	26.84	295.0
	3	0.0001	1.14	23.7	29.3%	0.33	3.3	1013.3	3.057	1.51	31.33	83.0
	5	0.0001	1.14	23.7	32.7%	0.37	3.7	466.7	3.057	1.68	34.97	43.6
126	1	0.1	1.14	23.7	50.2%	0.57	0.006	0.02	3.078	0.0026	0.0533	0.0027
	2	0.1	1.14	23.7	43.5%	0.50	0.005	1.12	3.078	0.0022	0.0462	0.693
	3	0.1	1.14	23.7	41.7%	0.48	0.005	1.44	3.078	0.0021	0.0443	0.249
	5	0.1	1.14	23.7	34.2%	0.39	0.004	0.49	3.078	0.0017	0.0363	0.176
156	1	0.0005	1.14	23.7	13.8%	0.16	0.3	0.95	3.079	0.14	2.93	0.06
	2	0.0005	1.14	23.7	10.6%	0.12	0.2	53.17	3.079	0.11	2.25	16.3
	3	0.0005	1.14	23.7	10.7%	0.12	0.2	73.70	3.079	0.11	2.27	9.0
	5	0.0005	1.14	23.7	12.5%	0.14	0.3	35.50	3.079	0.13	2.65	4.3

NOTE: BSAF - biota sediment accumulation factor
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
PSC - protective sediment concentration
TEF - toxic equivalency factor
TEQ - toxic equivalent

[a] Mean of 1997 ERA and WDNR food chain study.

[b] Mean of data from 1997 ERA.

[c] PCB congeners 105, 118, 126 and 156 contributed over 90 percent of the total PCB TEQ in every segment for 1997 ERA data.

[d] TEF scheme for mammalian toxicity, based on World Health Organization (Ahlborg et al. 1994).

[e] NOAEL and LOAEL for reproductive effects in mink are 1.14 ng/kg TEQ and 23.7 ng/kg TEQ, respectively.

[f] Values based on mean of three composites within each river segment.

[g] Represents portion of total TEQ threshold attributable to a specific congener.

[h] Maxiumum acceptable fish tissue concentration of given congener.

[i] Lipid and organic carbon normalized biota-sediment accumulation factor determined using food-web bioaccumulation model.

[j] Protective sediment concentration for mammalian health endpoint based on NOAEL and LOAEL.

[k] Units represent the concentration of an individual PCB congener.

Table 6-7. Derivation of protective sediment concentrations in the Sheboygan River for avian health endpoint using congener-specific food-web bioaccumulation modeling

4.0% = Mean total organic carbon content of Sheboygan River sediments[a]
2.9% = Mean lipid content of juvenile smallmouth bass[b]

PCB Congener[c]	Sheboygan River Segment	Avian PCB TEF Value[d]	NOAEL TEQ[e] (ng/kg)	LOAEL TEQ[e] (ng/kg)	Congener Portion of TEQ[f]	Congener Partial TEQ[g] (ng/kg) [k]	Fish Tissue Benchmark[h] (mg/kg) [k]	Observed in Fish[b] (mg/kg) [k]	Modeled BSAF[i] (Age 1+)	NOAEL PSC[j] (mg/kg) [k]	LOAEL PSC[j] (mg/kg) [k]	Observed Sediment[b] (mg/kg) [k]
066	1	0.002	17.9	177.8	7.7%	1.38	0.7	1.4	2.847	0.33	3.32	0.19
	2	0.002	17.9	177.8	22.1%	3.96	2.0	563.3	2.847	0.96	9.52	310.0
	3	0.002	17.9	177.8	25.8%	4.62	2.3	786.7	2.847	1.12	11.11	89.7
	5	0.002	17.9	177.8	25.7%	4.60	2.3	333.3	2.847	1.11	11.07	50.0
077	1	0.03	17.9	177.8	8.6%	1.54	0.05	0.1	2.93	0.02	0.24	0.02
	2	0.03	17.9	177.8	22.9%	4.10	0.14	39.3	2.93	0.06	0.64	28.1
	3	0.03	17.9	177.8	14.1%	2.52	0.08	28.7	2.93	0.04	0.39	9.1
	5	0.03	17.9	177.8	12.0%	2.15	0.07	10.4	2.93	0.03	0.33	6.0
105	1	0.005	17.9	177.8	32.2%	5.76	1.2	2.4	3.037	0.52	5.20	0.26
	2	0.005	17.9	177.8	27.9%	4.99	1.0	280.0	3.037	0.45	4.51	146.7
	3	0.005	17.9	177.8	29.3%	5.24	1.0	356.7	3.037	0.48	4.73	40.7
	5	0.005	17.9	177.8	30.7%	5.50	1.1	160.0	3.037	0.50	4.96	23.8
118	1	0.001	17.9	177.8	20.8%	3.72	3.7	7.7	3.057	1.68	16.69	0.59
	2	0.001	17.9	177.8	12.7%	2.27	2.3	646.7	3.057	1.03	10.19	295.0
	3	0.001	17.9	177.8	16.7%	2.99	3.0	1013.3	3.057	1.35	13.40	83.0
	5	0.001	17.9	177.8	17.9%	3.20	3.2	466.7	3.057	1.45	14.36	43.6
126	1	0.3	17.9	177.8	14.1%	2.52	0.008	0.02	3.078	0.0038	0.0374	0.0027
	2	0.3	17.9	177.8	6.6%	1.18	0.004	1.12	3.078	0.0018	0.0175	0.693
	3	0.3	17.9	177.8	7.1%	1.27	0.004	1.44	3.078	0.0019	0.0189	0.249
	5	0.3	17.9	177.8	5.6%	1.00	0.003	0.49	3.078	0.0015	0.0149	0.176

NOTE: BSAF - biota sediment accumulation factor
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
PSC - protective sediment concentration
TEF - toxic equivalency factor
TEQ - toxic equivalent

a Mean of 1997 ERA and WDNR food chain study.

b Mean of data from 1997 ERA (see Table A1-7 in Appendix A).

c PCB congeners 066, 077, 105, 118, and 126 contributed over 91 percent of the total PCB TEQ in Segments 2 to 5.

d TEF scheme for avian toxicity, based on Kennedy et al. (1996).

e NOAEL and LOAEL for reproductive effects in birds are 17.9 ng/kg TEQ and 177.8 ng/kg TEQ, respectively.

f Values based on mean of three composites within each river segment.

g Represents portion of total TEQ threshold attributable to a specific congener.

h Maximum acceptable fish tissue concentration (based on NOAEL) of given congener based on NOAEL.

i Lipid and organic carbon normalized biota sediment accumulation factor determined using food-web bioaccumulation model.

j Protective sediment concentration for avian health endpoint.

k Units represent the concentration of an individual PCB congener.

Table 6-8. Protective sediment concentrations for fish

PCB Congener	River Segment	Congener-Specific: NOAEL-based Protective Sediment Concentration (µg/kg dw)	Congener-Specific: LOAEL-based Protective Sediment Concentration (µg/kg dw)	Total PCBs: NOAEL-based Protective Sediment Concentration (µg/kg dw)	Total PCBs: LOAEL-based Protective Sediment Concentration (µg/kg dw)
66	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–
77	2	19	30	5.7	9.1
	3	13	20	3.9	6.2
	5	12	20	3.7	6.0
105	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–
118	2	300	480	9.2	15
	3	430	690	13	21
	5	520	840	16	**25**
126	2	0.5	0.8	5.6	8.7
	3	0.6	1.0	6.6	11
	5	0.5	0.9	5.6	9.8
156	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–

NOTE: **Bold** values are extrapolations (effects levels outside of the range of congeners measured)
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
– - not calculated; no toxic equivalency factor available

Table 6-9. Protective sediment concentrations for great blue heron

		Congener-Specific		Total PCBs	
PCB Congener	River Segment	NOAEL-based Protective Sediment Concentration (µg/kg dw)	LOAEL-based Protective Sediment Concentration (µg/kg dw)	NOAEL-based Protective Sediment Concentration (µg/kg dw)	LOAEL-based Protective Sediment Concentration (µg/kg dw)
66	2	0.96	9.5	**0.35**	**0.59**
	3	1.1	11	**0.36**	**0.64**
	5	1.1	11	**0.36**	**0.64**
77	2	0.06	0.64	**0.15**	**0.32**
	3	0.04	0.39	**0.14**	**0.25**
	5	0.03	0.33	**0.14**	**0.23**
105	2	0.45	4.5	**0.72**	**0.94**
	3	0.48	4.7	**0.72**	**0.95**
	5	0.5	5.0	**0.72**	**0.97**
118	2	1.0	10	**0.49**	**0.76**
	3	1.4	13	**0.50**	**0.86**
	5	1.5	14	**0.50**	**0.88**
126	2	0.0018	0.018	**0.34**	**0.50**
	3	0.0019	0.019	**0.34**	**0.52**
	5	0.0015	0.015	**0.33**	**0.47**
156	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–

NOTE: **Bold** values are extrapolations (effects levels outside of the range of congeners measured)
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
– - not calculated; no toxic equivalency factor available

Table 6-10. Protective sediment concentrations for mink

PCB Congener	River Segment	Congener-Specific NOAEL-based Protective Sediment Concentration (µg/kg dw)	Congener-Specific LOAEL-based Protective Sediment Concentration (µg/kg dw)	Total PCBs NOAEL-based Protective Sediment Concentration (µg/kg dw)	Total PCBs LOAEL-based Protective Sediment Concentration (µg/kg dw)
66	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–
77	2	–	–	–	–
	3	–	–	–	–
	5	–	–	–	–
105	2	0.57	12	**0.73**	1.3
	3	0.53	11	**0.72**	1.3
	5	0.58	12	**0.73**	1.4
118	2	1.3	27	**0.50**	1.3
	3	1.5	31	**0.50**	1.4
	5	1.7	35	**0.51**	1.5
126	2	0.0022	0.046	**0.34**	**0.80**
	3	0.0021	0.044	**0.34**	**0.78**
	5	0.0017	0.036	**0.34**	**0.70**
156	2	0.11	2.3	**0.050**	1.0
	3	0.11	2.3	**0.050**	1.0
	5	0.13	2.7	**0.059**	1.2

NOTE: **Bold** values are extrapolations (effects levels outside of the range of congeners measured)
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
– - not calculated; no toxic equivalency factor available

Table 6-11. Total PCB protective sediment concentrations in Segments 2, 3, and 5

PCB Congener	Fish NOAEL (mg/kg dw)	Fish LOAEL (mg/kg dw)	Heron NOAEL (mg/kg dw)	Heron LOAEL (mg/kg dw)	Mink NOAEL (mg/kg dw)	Mink LOAEL (mg/kg dw)
66	—	—	0.35–0.36	0.59–0.64	—	—
77	3.7–5.7	6.0–9.1	0.14–0.15	0.23–0.32	—	—
105	—	—	0.72–0.72	0.94–0.97	0.72–0.73	1.3–1.4
118	9.2–16	15–25	0.49–0.50	0.76–0.88	0.50–0.51	1.3–1.5
126	5.6–6.6	8.7–11	0.33–0.34	0.47–0.52	0.34–0.34	0.70–0.80
156	—	—	—	—	0.050–0.059	1.0–1.2
Overall range	3.7–16	6.0–25	0.14–0.72	0.23–0.97	0.050–0.73	0.70–1.5

NOTE: — - not calculated; no toxic equivalency factor available
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level

Sheboygan River and Harbor

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