Final Report: Concentrations of Toxic Substances in Fish from the Greater New Haven Watershed

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Introduction

There is a sizable body of data regarding the contaminant level of fish in open waters. Metals and polychlorinated biphenyls (PCBs) have been found in flounder from Long Island Sound (1,2). Less is known regarding contamination of these fish as they pass through, feed in, and are subsequently caught, in the waters of the urban environment. Other species remain resident in the urban environment for all or a significant portion of their lifespan. Organic and inorganic contaminants have been identified in sediments and waters of rivers in the greater New Haven watershed, namely, the Quinnipiac and Mill rivers, (3,4). Total PCBs in the sediment of these rivers has been reported to range between <0.01ppm to 11 PPM with an average of 0.8 ppm (3). For metals the following concentration ranges have been reported in these rivers sediment: lead 20-110 ppm, cadmium 0.6-2.8 ppm, chromium 10-70 ppm, zinc 25-175 ppm (4). Despite these findings, and the known ability of fish to bioaccumulate contaminants, these rivers continue to be used as a food resource, as evidenced by the substantial numbers of people continually fishing the rivers. Therefore, serious questions about the quality of this food resource need to be addressed. This two-year project was an attempt to address some of those questions by examining the quality of food fish caught in the New Haven watershed. Over the course of the two years 60 individual fish

were caught. Some of the smaller fish were composited so that a total of 53 separate samples of 13 species and 11 sample locations were analyzed.

The concentration of PCBs and metals in the fish was determined. This study allowed us to begin investigating the impact of this urban environment on fish caught in these areas. These concentrations were compared to other published information. The fish concentrations reported here would appear to be below FDA advisory guidelines, but might suggest some limits on fish consumption based on more restrictive consumption advisories issued by individual states.

Fish Sample Collection

Fish were sampled by angling and collected throughout the year as different species predominate during different seasons. Fish were speciated, weighed, and prepared for laboratory analysis. Data on the collection of each fish including collection date, collection location, fish weight, and species are given in Table 1 of the addendum.

Laboratory Preparation of Fish

In the laboratory the fish were dissected and prepared for analysis. Two types of tissues were obtained from the fish samples. The first was filets. This tissue represents the portion of the fish actually consumed. The second sample will consist of fish livers (only analyzed for metals). This is one of the fish tissues that shows the greatest potential for bioaccumulation of toxic contaminants. For example, Muir *et al*. (5) showed that liver concentrations of polychlorinated dibenzo-p-dioxins could be 10 to 40 times higher than muscle tissue from the same fish. Some fish samples were composited to generate sufficient tissue for analyses, these composites were limited to a single species at a

specific site. Different sites or species were not mixed. Fish tissues were split into separate portions for heavy metal analysis and PCB analysis.

Heavy Metal Sample Preparation:

The samples were prepared for metal analysis using methods that we (6,7) and others (8) have developed for use on biological materials. In brief, about 0.5-1.0 gram samples were digested in nitric acid using the closed microwave assisted extraction technique. These digestions were conducted using a MSP 1000 microwave system in our laboratories (CEM Corp.; Matthews, GA) Results on a wet weight basis were reported.

Heavy Metal Instrumental Analysis:

The Cu, Cr, Ni, and Zn content in the digests was determined by inductively coupled plasma emission spectroscopy using the Thermo Jarrell Ash Atom Scan 16 spectrophotometer in our laboratories. For the determination of As, Cd, and Pb we used our graphite furnace atomic absorption spectrometer (Perkin Elmer, PE5100) due to the greater sensitivity (lower detection limits) associated with this instrument. For quality control, check standards were run after every five determinations.

PCB Analysis:

PCBs were analyzed using the procedure developed during the first year of the project. Samples were spiked with two internal standards (decachlorobiphenyl, 2,4,5,6-tetrachloro-m-xylene) and then extracted using microwave assisted extraction (MAE),

cleaned up with Florisil and analyzed by high resolution gas chromatography (HRGC) equipped with electron capture detection. Details of the procedure are as follow: Two grams of a ground fish filet were mixed with 4 grams of Na_2SO_4 and extracted using MAE with 50 mL acetone/hexane/toluene (55/35/10) solution. The microwave was programmed to a temperature of 120 ^oC with a ramp time of 7 minutes, and a hold time of 20 minutes. The extracts were rinsed through 30 g Na_2SO_4, concentrated to 5 mL under a ratovap. The concentrated extract was loaded on a 2 cm wide chromatography column packed with 12 cm Florisil and 2 cm Na_2SO_4. The column was eluted with 200 mL of petroleum ether and the extract concentrated to 10 mL with a Kuderna-Danish concentrator. The extract was injected into a Hewlett-Packard 5890A gas chromatograph with electron capture detection using a Supelco SPB-608 30m x 0.25mm ID 0.25 μm film thickness capillary column. The GC was temperature programmed as follows: initial temperature 140^o C for 1 min, 8^o C /min to 180^o, 2^o C /min to 260 and hold 6 min. Quantitation was achieved by comparison of peak areas with that for the internal standard with response factors based on the Aroclor (PCB) standards. The samples had many PCB congeners and did not match the congener pattern of a single Aroclor. Therefore the PCBs were quantified as two different Aroclors (1248 and 1260) each of which had its own characteristic peaks. Total PCBs were the sum of these two Aroclors. PCB data were corrected for PCB contamination of Florisil blanks.

Results and Discussion

Fish sampling locations, species, and numbers of each fish type are given in Table 1. The addendum to this report contains tables containing the complete sampling

information for each fish sample along with the compiled data for each fish sampled. As can be seen in Table 1 a wide variety of fish were caught, saltwater species from the Quinnipiac River and Quinnipiac Harbor and freshwater species from the Mill River. It is likely that for each of the two rivers, the species of fish caught would swim within the entire sampling range, and therefore all data for individual species within a river were averaged. For averaging of data 0.5 times the not detected (ND) value was substituted to estimate the value when the average was a mixture of samples with quantitated values and ND values.

The average values for each species in each river are presented in Table 2. There was a fair amount of variability in the data from sample to sample as indicated by the large standard deviations. As can be seen in this table the concentration of these compounds varies from species to species within a river but both rivers show some degree of contamination. In the Mill River the smaller less predatory fish such as Sunfish and Bluegills (avg. weights of 50 and 55 g respectively) appear to have less contamination from PCBs, as compared to larger more predatory fish such as perch and largemouth bass (avg. weights of 84 and 220 g respectively). This pattern would be expected in contaminants which bioaccumulate through the food chain. Most fish in the Quinnipiac River were larger, and though bluefish were the largest (avg. weight 3.3 kg) and had the highest PCB concentrations; the menhaden (avg. weight 350 g) had more PCBs than the striped bass (avg. weight 700 g). This indicates that there are other factors besides fish size that can influence the amount of contaminants. These factors could include species specific metabolism or life cycle factors, such as proportion of life spent within the Quinnipiac River system. Such life cycle factors have previously been used to

explain variability in the concentration of PCBs in Hudson River striped bass; the fish which spent more time in saline or brackish waters were less contaminated than the bass which spent more time in the fresh water portions of the estuary (9).

It is more difficult to compare the two rivers, as there are both species and size differences in the fish caught. The data, however, seem to indicate that the fish taken from the Quinnipiac River have a greater amount of arsenic and possibly greater amounts of PCBs. This would appear to indicate that this is a more contaminated system, which agrees with the previous report on sediment from these two rivers (3).

These data can be compared to other reports for some of these contaminants. Some previously reported data for PCBs concentration in fish are given in Table 3. Several of the locations in this table (Hudson and Housatonic Rivers) are known to have locations with sediments highly contaminated with PCBs from industrial discharges. Fish taken from these locations have concentrations greater than those reported here. The other locations report concentrations of PCBs within the range reported here. For example, the three reports of PCBs in bluefish have concentration ranges of: 0.1- 0.8 ppm, 0.9-1.4 ppm and 0.4-1.3 ppm; clearly our range of 0.2-1.4 ppm is similar. Some reports on the trace concentration of various metals are given in Table 4. Again it appears that the current data is within or below the range of these reports. These observations lead us to believe that the concentrations of contaminants reported here are typical of what is now observed from other locations.

The livers of several of the larger fish in our database were separately analyzed for the same set of metals as in the filets. These data are presented in Table 5. Note how for the metals the concentration is usually enhanced in the liver. This magnification can

be quite large, for example cadmium in the Bluefish livers is enhanced by a factor of 100. In other cases the enhancement might only be in the 2x- 5x range.

These data indicate that there are some toxic compounds detectable in the edible filets of these fish. These data need to be compared to advisory guidelines. Some of these action levels are presented in Table 6, which is taken from a US FDA report (19). The tolerances for metals in this report are listed for crustaceans and mollusks rather than fish tissue. Therefore they should only be used to estimate an acceptable level. Even if the metal tolerances were lower by a factor of ten for fish tissue, the two tables show that the concentrations reported here would not exceed these guidelines. Recently Connecticut and other states have switched to a risk-based advisory approach for fish consumption based on PCB concentration (12). Under this approach Connecticut has issued advisories for consumption of both bluefish and striped bass from Long Island Sound due to PCB contamination. These advisories suggests one meal per month for fish with PCB concentration ranging from 0.2- 1.0 ppm; the data reported here fall in this range.

Conclusions

Fish in the Quinnipiac and Mill Rivers contain toxic compounds in their filets. The concentrations observed are within what might be expected for an urban watershed. Filets of the sampled fish do not exceed tolerances set by the FDA indicating that these fish can be eaten.

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Table 1. Fish Sample Summary, Number of Fish Caught.

Location	Code	Species	Code	Number
Race (in L.I. Sound)	Q1	Bluefish	B	2
Roundhouse (Quinnipiac Harbor)	Q2	Bluefish	B	3
Roundhouse (Quinnipiac Harbor)	Q2	Menhaden	C	7
Fort Nathan Hale (Quinnipiac Harbor)	Q3	Striped Bass	A	1
Long Wharf (Quinnipiac Harbor)	Q4	Striped Bass	A	5
Quinnipiac Park (Quinnipiac Harbor)	Q5	Striped Bass	A	3
Clifton Street (Quinnipiac River)	Q6	Bluefish	B	1
Middletown Ave. (Quinnipiac River)	Q7	Striped Bass	A	4
Middletown Ave. (Quinnipiac River)	Q7	Tom Cod	D	4
Middletown Ave. (Quinnipiac River)	Q7	Fluke	E	1
Mill River by Tide Gate	M1	Tom Cod	D	1
Mill River by Tide Gate	M1	Eel	F	1
Mill River by Tide Gate	M1	Mummichog	G	1
Mill River behind Wilbur Cross H.S.	M2	White Perch	I	6
Mill River behind Wilbur Cross H.S.	M2	Bluegill	K	1
Mill River by Orange Street	M3	White Perch	I	2
Mill River by Orange Street	M3	Bluegill	K	7
Mill River by Orange Street	M3	Golden Shiner	L	1
Mill River by Orange Street	M3	Brown Bullhead	M	3
Mill River by Footbridge	M4	White Perch	I	2
Mill River by Footbridge	M4	Largemouth Bass	H	1
Mill River by Footbridge	M4	Sunfish	J	2
Mill River by Footbridge	M4	Brown Bullhead	M	1

Table 2. Average concentrations ± the standard deviation of filets for each species in each river, N = Number of samples (some samples are composites of multiple fish). All data in mg/kg (PPM).

Fish Species	N	PCB 1248 mg/kg	PCB1260 mg/kg	SUM PCB mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
LI Sound											
Bluefish	2	0.021±0.0	0.25±0.11	0.27±0.11	0.26±0.16	0.001±0.001	<0.3	<0.3	<0.3	<0.03	6.2±2.4
Quinnipiac River											
Bluefish	4	0.33±0.14	0.76±0.27	1.09±0.36	0.39±0.19	0.004±0.002	<0.3	0.26±0.13	<0.3	0.035±0.04	14.1±13.4
Striped Bass	13	0.076±0.10	0.14±0.10	0.21±0.16	0.73±0.36	0.004±0.006	<0.3	0.188	<0.3	0.022±0.017	4.4±0.9
Menhaden	6	0.370±0.27	0.42±0.12	0.79±0.34	0.36±0.21	0.039±0.052	<0.3	0.63±0.49	<0.3	0.019±0.011	6.1±5.8
Tom Cod	4	0.081±0.027	0.11±0.056	0.19±0.061	1.33±0.29	0.005±0.006	<0.3	<0.3	<0.3	<0.03	9.8±2.4
Fluke	1	0.190	0.25	0.44	0.6	0.004	<0.3	0.26	<0.3	<0.03	4.8
Mill River											
White Perch	10	0.16±0.13	0.19±0.10	0.35±0.23	0.15±0.06	0.002±0.002	<0.3	0.99±0.42	<0.3	0.034±0.013	9.7±5.5
Bluegill	4	0.043±0.029	0.051±0.014	0.094±0.042	0.10±0.05	0.004±0.004	<0.3	0.29±0.17	<0.3	0.047±0.008	19.0±6.0
Sunfish	1	0.066	0.069	0.135	0.12	0.006	<0.3	<0.3	<0.3	0.01	13
Brown Bullhead	4	<0.041	0.06±0.034	0.080±0.034	<0.1	0.002±0.002	<0.3	0.28±0.1	<0.3	0.13±0.05	6.1±0.45
Golden Shiner	1	0.064	0.083	0.15	<0.1	<0.001	<0.3	0.64	<0.3	0.034	13
Largemouth Bass	1	0.057	0.32	0.38	<0.1	0.002	<0.3	<0.3	<0.3	<0.03	8.5
Eel	1	0.46	0.74	1.20	NA	NA	NA	NA	NA	NA	NA
Tom Cod	1	0.12	0.079	0.20	0.37	<0.001	<0.3	<0.3	<0.3	<0.03	9.5
Mummichog	1	0.18	0.19	0.37	0.21	<0.001	<0.3	<0.3	<0.3	0.037	19.9

NA- data not available

Table 3. Comparative PCB data all samples of edible tissue in mg/kg (PPM)

Reference	Location	Species	Concentration Range
Salama[10]	Atlantic Ocean, MA	Bluefish	0.11-0.75
Kennish[11]	Atlantic Estuaries, NJ	Bluefish	0.9-1.4
Toal[12]	Long Island Sound	Bluefish	0.4-1.3
Toal[12]	Long Island Sound	Striped Bass	1.2, (17%>2)
Baker[9]	Hudson River, NY near Troy	Striped Bass	4.0 ± 1.0
Baker[9]	Hudson River, NY near Poughkeepsie	Striped Bass	1.0 ± 1.0
Baker[9]	Long Island Sound	Striped Bass	0.5 ± 0.4
Kennish[11]	Atlantic Estuaries, NJ	Striped Bass	1.1-1.8
Grieg[13]	Long Island Sound	Winter Flounder	0.07-0.62
Kennish[11]	Atlantic Estuaries & Delaware River, NJ	Catfish	0.9-1.8
Kennish[11]	Atlantic Estuaries & Delaware River, NJ	American Eel	0.6-2.0
Newsome[14]	Great Lakes	Eel	0.75±0.36
Kennish[11]	Atlantic Estuaries & Delaware River, NJ	White Perch	0.9-1.3
Toal[12]	Housatonic River, Lake Lillinonah	Perch	1.53
Newsome[14]	Great Lakes	Perch	0.03±0.02
Toal[12]	Housatonic River, at Bull's Bridge CT	Smallmouth Bass	0.86-1.15
Newsome[14]	Great Lakes	Bass	0.39±0.08
Newsome[14]	Great Lakes	Bullhead	0.07±0.06
Toal[12]	Housatonic River, Lake Zoar	Bullhead	0.62
Toal[12]	Housatonic River, Lake Zoar	Bluegill	0.25

Table 4. Comparative Metals Data

Reference	Location	Species	As	Pb	Ni	Cr	Cd	Cu	Zn
Dabeka[15]	Canada	Marine fish	NR	.009	.041	NR	.0016	NR	NR
Dabeka[15]	Canada	Freshwater fish	NR	.014	.23	NR	.003	NR	NR
Chevreuil[16]	Seine R., France	Perch	NR	2.0*		2.5*	0.6*	4.0*	198*
Mathews[17]	Winyah Bay, South Carolina	Flounder	3.15±3.08	0.16±0.42	0.18±0.28	0.29±0.55	0.16±0.28	1.13±2.53	NR
Mathews[17]	Charleston, South Carolina	Flounder	4.80±6.26	0.59±1.36	0.42±1.43	ND	0.07±0.18	1.47±4.99	NR
Madany[18]	Bahrain, Arabian Gulf	Marine Fish	1.7	0.13	NR	NR	0.032	NR	

NR-Not Reported, * value reported is dry weight

Table 5. Concentration of Metals in Fish Livers

Fish Species	**N**	**As mg/kg**	**Cd mg/kg**	**Cr mg/kg**	**Cu mg/kg**	**Ni mg/kg**	**Pb mg/kg**	**Zn mg/kg**
LI Sound								
Bluefish	2	1.0±0.2	0.44±0.01	<0.3	4.5±0.9	<0.3	0.03±0.02	29±1
Quinnipiac River								
Bluefish	4	1.6±0.4	0.41±0.44	<0.3	4.4±4.8	<0.3	0.02±0.02	29±16
Striped Bass	13	1.2±0.3	0.05±0.03	<0.3	4.3±1.7	0.18±0.09	0.027±0.021	27±4
Menhaden	5	0.72±0.39	0.01±0.01	<0.3	1.3±0.2	<0.3	0.02±0.01	40±27
Tom Cod	1	1.23±0.29	0.03	<0.3	1.59	<0.3	NA	24
Fluke	1	0.78	0.17	<0.3	24	<0.3	<0.03	74
Mill River								
White Perch	1	<0.1	0.26	<0.3	42	<0.3	<0.03	48
Brown Bullhead	1	<0.1	0.26	<0.3	12	<0.3	<0.03	48
Largemouth Bass	1	<0.1	0.27	<0.3	3.4	<0.3	<0.03	24

Table 6. Contaminant Tolerances Edible Wet Weight Portion (US FDA, 1998 (17))

Contaminant	Tolerance (PPM)	Fish Type
Polychlorinated Biphenyls	2.0	All Fish
Arsenic	76	Crustacea / Mollusks
Cadmium	4	Crustacea / Mollusks
Chromium	12	Crustacea / Mollusks
Nickel	70	Crustacea / Mollusks
Lead	1.5	Crustacea / Mollusks

Addendum. Table I (part a). Fish Collection Data: 1997

Sample No.	Species	Weight (g)	Location	Date
QF97-1	Bluefish	1490	Race (in Sound)	10/25/1997
QF97-2	Bluefish	1870	Race (in Sound)	10/25/1997
QF97-3	Bluefish	1060	Clifton Street	10/08/1997
QF97-4	Striped Bass	640	Quinnipiac Park	11/05/1997
QF97-5	White Perch	60	Mill River by Wilbur Cross H.S.	11/05/1997
QF97-6	Bluegill	49	Mill River by Wilbur Cross H.S.	11/05/1997
QF98-7	White Perch	135	Mill River by Wilbur Cross H.S.	11/06/1997
QF97-8	White Perch	79	Mill River by Wilbur Cross H.S.	11/06/1997
QF97-9	White Perch	68	Mill River by Wilbur Cross H.S.	11/06/1997
QF97-10	White Perch	77	Mill River by Wilbur Cross H.S.	11/06/1997
QF97-11	White Perch	94	Mill River by Wilbur Cross H.S.	11/06/1997
QF97-12	Striped Bass	662	Fort Nathan Hale	12/06/1997
QF97-13	Striped Bass	828	Middletown Avenue	12/11/1997
QF97-14	Striped Bass	591	Middletown Avenue	12/11/1997
QF97-15	Tom Cod	68	Middletown Avenue	11/06/1997
QF97-16	Tom Cod	52	Middletown Avenue	11/06/1997
QF97-17	Tom Cod	60	Middletown Avenue	11/06/1997
QF97-18	Tom Cod	123	Middletown Avenue	11/06/1997
QF97-19	Tom Cod	36	Mill River by Tide Gate	11/04/1997
QF97-20	Mummichog	30	Mill River by Tide Gate	11/04/1997
QF97-21	Eel	46	Mill River by Tide Gate	11/04/1997
QF97-22	Striped Bass	723	Middletown Avenue	11/06/1997
QF97-23	Striped Bass	780	Middletown Avenue	11/06/1997
QF97-24	Striped Bass	723	Quinnipiac Park	11/06/1997
QF97-25	Striped Bass	672	Quinnipiac Park	11/06/1997

Addendum. Table I (part b). Fish Collection Data: 1998

Sample No.	Species	Weight (g)	Location	Date
QF98-1a	Bluegill	29.1	Mill River by Orange Street Bridge	07/29/1998
QF98-1b	Bluegill	31.6	Mill River by Orange Street Bridge	07/29/1998
QF98-1c	Bluegill	39	Mill River by Orange Street Bridge	07/29/1998
QF98-1d	Bluegill	54.6	Mill River by Orange Street Bridge	07/29/1998
QF98-2a	Bluegill	54.7	Mill River by Orange Street Bridge	07/29/1998
QF98-2b	Bluegill	83	Mill River by Orange Street Bridge	07/29/1998
QF98-3	Bluegill	102.3	Mill River by Orange Street Bridge	07/29/1998
QF98-4	Golden Shiner	77.6	Mill River by Orange Street Bridge	07/29/1998
QF98-5	White Perch	119.7	Mill River by Orange Street Bridge	07/29/1998
QF98-6	White Perch	147.8	Mill River by Orange Street Bridge	07/29/1998
QF98-7	Bullhead	112.4	Mill River by Orange Street Bridge	07/29/1998
QF98-8	Bullhead	136.5	Mill River by Orange Street Bridge	07/29/1998
QF98-9	Bullhead	253.3	Mill River by Orange Street Bridge	07/29/1998
QF98-10	Bluefish	4491	Roundhouse	10/09/1998
QF98-11	Menhaden	531	Roundhouse	10/09/1998
QF98-12	Menhaden	483	Roundhouse	10/09/1998
QF98-13	Menhaden	509	Roundhouse	10/09/1998
QF98-14	Menhaden	423	Roundhouse	10/09/1998
QF98-15	Menhaden	442	Roundhouse	10/09/1998
QF98-16	Bluefish	4133	Roundhouse	08/28/1998
QF98-17	Bluefish	3754	Roundhouse	07/10/1998
QF98-18	Fluke	838	Middletown Avenue	07/27/1998
QF98-19	Striped Bass	569	Long Wharf	11/10/1998
QF98-20	Striped Bass	813	Long Wharf	11/10/1998
QF98-21	Striped Bass	572	Long Wharf	11/10/1998
QF98-22	Striped Bass	1038	Long Wharf	11/10/1998
QF98-23	Striped Bass	725	Long Wharf	11/10/1998
QF98-24	Large Mouth Bass	223	Mill River by Footbridge	07/29/1998
QF98-25	Bullhead	152	Mill River by Footbridge	07/29/1998
QF98-26a	White Perch	20	Mill River by Footbridge	07/29/1998
QF98-26b	White Perch	40	Mill River by Footbridge	07/29/1998
QF98-27a	Sunfish	41	Mill River by Footbridge	07/29/1998
QF98-27b	Sunfish	59	Mill River by Footbridge	07/29/1998
QF98-28a	Menhaden	14	Roundhouse	10/09/1998
QF98-28b	Menhaden	19	Roundhouse	10/09/1998

Table II (part a). Fish Sample Concentration data, sorted by year, type and location. All data in mg/kg (PPM).

Sample No.	Fish Type	Location	PCB 1248	PCB 1260	Sum PCB*	As	Cd	Cr	Cu	Ni	Pb	Zn
QF97-12	A	Q3	0.116	0.121	0.237	0.8	0.021	<0.3	<0.3	<0.3	<0.03	5.8
QF97-24	A	Q5	0.486	0.173	0.222	0.45	<0.001	<0.3	<0.3	<0.3	<0.03	4.94
QF97-25	A	Q5	<0.041	0.026	0.046	0.47	0.005	<0.3	<0.3	<0.3	<0.03	3.31
QF97-4	A	Q5	0.323	0.210	0.533	0.07	<0.001	<0.3	<0.3	<0.3	<0.03	3.86
QF97-13	A	Q7	<0.041	0.100	0.120	0.83	0.008	<0.3	<0.3	<0.3	0.074	4.19
QF97-14	A	Q7	0.439	0.063	0.107	0.93	0.012	<0.3	<0.3	<0.3	0.027	6.57
QF97-22	A	Q7	<0.041	0.026	0.046	0.6	<0.001	<0.3	<0.3	<0.3	0.034	5
QF97-23	A	Q7	0.237	0.242	0.480	0.63	<0.001	<0.3	<0.3	<0.3	<0.03	4.29
QF97-1	B	Q1	<0.041	0.172	0.192	0.15	0.002	<0.3	<0.3	<0.3	<0.03	7.96
QF97-2	B	Q1	<0.041	0.325	0.345	0.37	<0.001	<0.3	<0.3	<0.3	<0.03	4.53
QF97-3	B	Q6	0.219	0.381	0.601	0.24	<0.001	<0.3	<0.3	<0.3	0.094	9.72
QF97-19	D	M1	0.123	0.079	0.202	0.37	<0.001	<0.3	<0.3	<0.3	<0.03	9.48
QF97-15	D	Q7	0.060	0.097	0.157	1.33	0.012	<0.3	<0.3	<0.3	<0.03	9.66
QF97-16	D	Q7	0.117	0.069	0.186	0.97	0.001	<0.3	<0.3	<0.3	<0.03	13
QF97-17	D	Q7	0.061	0.073	0.134	1.67	0.008	<0.3	<0.3	<0.3	<0.03	7.17
QF97-18	D	Q7	0.086	0.188	0.274	1.36	<0.001	<0.3	<0.3	<0.3	<0.03	9.49
QF97-21	F	M1	0.461	0.740	1.201	NA	NA	NA	NA	NA	NA	NA
QF97-20	G	M1	0.176	0.193	0.370	0.21	<0.001	<0.3	<0.3	<0.3	0.037	19.9
QF97-10	I	M2	0.417	0.379	0.797	0.15	NA	<0.3	0.79	<0.3	0.045	5.2
QF97-11	I	M2	0.223	0.167	0.390	0.21	<0.001	<0.3	1.31	<0.3	0.031	4.91
QF97-5	I	M2	0.235	0.264	0.499	NA	NA	NA	NA	NA	NA	NA
QF97-7	I	M2	0.128	0.120	0.249	0.16	0.002	<0.3	1.4	<0.3	0.035	6.4
QF97-8	I	M2	0.119	0.256	0.375	0.2	<0.001	<0.3	1.15	<0.3	0.042	6.75
QF97-9	I	M2	0.230	0.251	0.481	0.16	<0.001	<0.3	1.31	<0.3	0.044	8.27
QF97-6	K	M2	0.050	0.063	0.114	0.14	0.004	<0.3	<0.3	<0.3	0.052	11.3

*1/2 detection limit (0.02) summed in for samples reported as <0.041, NA-Data not available

Table II (part b). Fish Sample Concentration data, sorted by year, type and location. All data in mg/kg (PPM).

Sample No.	Fish Type	Location	PCB 1248	PCB 1260	Sum PCB	As	Cd	Cr	Cu	Ni	Pb	Zn
QF98-19	A	Q4	<0.041	0.083	0.103	0.57	<0.001	<0.3	0.31	<0.3	<0.03	4.7
QF98-20	A	Q4	<0.041	0.111	0.131	1.16	0.003	<0.3	<0.3	<0.3	<0.03	4.1
QF98-21	A	Q4	NA	0.363	0.383	1.53	<0.001	<0.3	0.29	<0.3	<0.03	4
QF98-22	A	Q4	<0.041	0.209	0.229	0.86	0.002	<0.3	0.34	<0.3	<0.03	3.7
QF98-23	A	Q4	<0.041	0.063	0.083	0.59	0.002	<0.3	<0.3	<0.3	<0.03	4
QF98-10	B	Q2	0.445	0.781	1.226	0.64	0.004	<0.3	0.43	<0.3	<0.03	34
QF98-16	B	Q2	0.190	0.877	1.067	0.44	0.006	<0.3	<0.3	<0.3	<0.03	5
QF98-17	B	Q2	0.454	0.999	1.453	0.23	0.004	<0.3	0.3	<0.3	<0.03	7.8
QF98-11	C	Q2	0.236	0.515	0.751	0.33	0.003	<0.3	0.33	<0.3	<0.03	4
QF98-12	C	Q2	0.401	0.353	0.754	0.35	0.085	<0.3	0.36	<0.3	<0.03	3.9
QF98-13	C	Q2	0.049	0.190	0.239	0.2	0.003	<0.3	0.69	<0.3	<0.03	3.8
QF98-14	C	Q2	0.345	0.477	0.822	0.14	0.012	<0.3	0.48	<0.3	<0.03	3.6
QF98-15	C	Q2	0.345	0.505	0.850	0.41	0.008	<0.3	0.36	<0.3	<0.03	3.6
QF98-28	C	Q2	0.853	0.449	1.302	0.75	0.122	<0.3	1.6	<0.3	0.041	18
QF98-18	E	Q7	0.187	0.247	0.434	0.6	0.004	<0.3	0.26	<0.3	<0.03	4.8
QF98-24	H	M4	0.057	0.321	0.379	<0.1	0.002	<0.3	<0.3	<0.3	<0.03	8.5
QF98-5	I	M3	<0.041	0.129	0.149	<0.1	<0.001	<0.3	0.39	<0.3	<0.03	14
QF98-6	I	M3	<0.041	0.104	0.124	<0.1	<0.001	<0.3	1.17	<0.3	<0.03	11
QF98-26	I	M4	<0.041	0.067	0.087	0.19	0.006	<0.3	0.37	<0.3	0.048	21
QF98-27	J	M4	0.066	0.069	0.135	0.12	0.006	<0.3	<0.3	<0.3	0.01	13
QF98-1	K	M3	0.081	0.062	0.143	<0.1	0.001	<0.3	0.49	<0.3	0.04	26
QF98-2	K	M3	<0.041	0.041	0.061	<0.1	<0.001	<0.3	<0.3	<0.3	0.056	20
QF98-3	K	M3	<0.041	0.036	0.056	0.14	0.01	<0.3	0.37	<0.3	0.041	19
QF98-4	L	M3	0.064	0.083	0.147	<0.1	<0.001	<0.3	0.64	<0.3	0.034	13
QF98-7	M	M3	<0.041	0.095	0.115	<0.1	0.002	<0.3	0.4	<0.3	<0.03	6.6
QF98-8	M	M3	<0.041	0.073	0.093	<0.1	0.001	<0.3	<0.3	<0.3	<0.03	5.5
QF98-9	M	M3	<0.041	0.056	0.076	<0.1	<0.001	<0.3	0.42	<0.3	<0.03	6.2

*1/2 detection limit (0.02) summed in for samples reported as <0.041, NA-Data not available