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Decrease in chemical contamination of American eels (*Anguilla rostrata*) captured in the estuary of the St. Lawrence River

P.V. Hodson, C. Desjardins, É. Pelletier, M. Castonguay, R. McLeod, and C.M. Couillard

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DECREASE IN CHEMICAL CONTAMINATION OF AMERICAN EELS (*Anguilla rostrata*) CAPTURED IN THE ESTUARY OF THE ST. LAWRENCE RIVER

BY

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ABSTRACT

Hodson, P.V., C. Desjardins, É. Pelletier, M. Castonguay, R. McLeod, and C.M. Couillard. 1992. Decrease in chemical contamination of American eels (*Anguilla rostrata*) captured in the Estuary of the St. Lawrence River. Can. Tech. Rept. Fish. Aquat. Sci. 1876:57.

American eels, *Anguilla rostrata,* are catadromous, and grow to maturity in Lake Ontario and in tributaries to the St. Lawrence River. Concern for mass mortalities of adult eels, high levels of chemical contamination, and a recent decline of recruitment prompted a study of the role of contaminants in the health of eels, the role of eels as vectors of contaminants to Beluga whales, (*Delphinapterus leucas*) and the changes in contamination since an earlier large scale survey in 1982. Mercury, PCB, mirex and pesticide levels were measured in migratory adult eels purchased weekly between September and November 1990 from a fisherman in Kamouraska, Québec. Similar analyses were conducted on two eel samples from fishermen in Cacouna and Saint-Irénée, and on a control eel sample from a small tributary of the north shore of the St. Lawrence Estuary. Dioxins, furans and PAH concentrations were also determined on a small number of fish. Results indicate that eels from the upper St. Lawrence River/Lake Ontario were much more contaminated with PCBs, mirex and pesticides than the control population; concentrations did not vary among sites on the St. Lawrence River. Levels of PCBs and mirex have declined by 68 and 56% respectively since 1982. Only 36% of eels analyzed exceeded the guidelines for PCBs in fish, compared to 80% in 1982; for mirex, the percentage declined from 52% in 1982 to 29% in 1990. Levels of PCBs, mirex and pesticides varied among weeks with a slight trend of increasing concentrations towards the end of the migration. Concentrations of PAH, dioxins and furans were usually less than their detection limits, and well below any guidelines. These results suggest that the risk of organic chemical toxicity to Belugas from consuming eels is declining from year to year. Mercury levels were constant among sites and times, indicating that accumulation originates mostly from natural sources or atmospheric deposition.

RÉSUMÉ

Hodson, P.V., C. Desjardins, É. Pelletier, M. Castonguay, R. McLeod, and C.M. Couillard. 1992. Decrease in chemical contamination of American eels (*Anguilla rostrata*) captured in the Estuary of the St. Lawrence River. Can. Tech. Rep. Fish. Aquat. Sci. 1876:57p.

L'anguille d'Amérique (*Anguilla rostrata*) est une espèce catadrome qui atteint la maturité dans le lac Ontario et dans les affluents du St-Laurent. À la suite de mortalités massives d'anguilles adultes, d'un niveau élevé de pollution chimique et d'une baisse récente du recrutement, on a décidé d'étudier le rôle des contaminants dans la santé des anguilles, le rôle des anguilles comme vecteur de contaminants pour les bélugas (*Delphinapterus leucas*) et les changements apparus dans la contamination depuis une enquête à grande échelle qui avait eu lieu en 1982. On a mesuré les teneurs en mercure, en BPC, en mirex et en pesticides chez des anguilles adultes en migration achetées chaque semaine entre septembre et novembre 1990 à un pêcheur de Kamouraska (Québec). Des analyses similaires ont été effectuées sur deux échantillons d'anguilles fournies par des pêcheurs de Cacouna et de Saint-Irénée, et sur un échantillon témoin d'anguilles provenant d'un petit affluent de la côte nord de l'estuaire du St-Laurent. On a aussi mesuré les concentrations de dioxines, de furanes et de HAP sur un petit nombre de poissons. Les résultats indiquent que les anguilles du cours supérieur du St-Laurent et du lac Ontario étaient beaucoup plus contaminées par les BPC, le mirex et les pesticides que la population témoin; les concentrations ne variaient pas d'un site à l'autre sur le St-Laurent. Les concentrations de BPC et de mirex ont respectivement diminué de 68 et de 56 % depuis 1982. Des anguilles analysées, 36 % seulement dépassaient les lignes directrices concernant les BPC chez les poissons, alors que le pourcentage était de 80 % en 1982; en ce qui concerne le mirex, le pourcentage a baissé, passant de 52 % en 1982 à 29 % en 1990. Les teneurs en BPC, en mirex et en pesticides variaient d'une semaine à l'autre avec une légère tendance à l'augmentation vers la fin de la migration. Les concentrations de HAP, de dioxines et de furanes étaient généralement inférieures aux seuils de détection, et nettement au-dessous de la teneur fixée par les directives. Ces résultats semblent indiquer que le risque de transmission aux bélugas de produits chimiques organiques toxiques par la consommation d'anguilles baisse d'une année à l'autre. Les teneurs en mercure étaient constantes d'un site à l'autre et d'une date à l'autre, ce qui indique que l'accumulation provient essentiellement de sources naturelles ou du dépôt par la voie atmosphérique.

PREFACE

This study was carried out as part of the St. Lawrence Action Plan, within the program "The State of the Environment and Ecosystems", by scientists of the Maurice Lamontagne Institute of the Department of Fisheries and Oceans. It was supported financially by the Institut Maurice-Lamontagne, by the Fish Habitat Managament Branch, Quebec Region, Fisheries and Oceans. The purpose of this publication is to make data on chemical levels in eels available to the public and to put these data into a historical and geographic perspective.

1.0 INTRODUCTION

American eels (*Anguilla rostrata*) spawn in the Sargasso Sea, migrate to coastal streams in North America, and spend the majority of their life growing to adulthood in freshwater. In the St. Lawrence drainage basin, eels can ascend as far as Lake Ontario, and may spend 13-15 years growing from a size of < 1.0 g to 4000 g. Since they are predatory, their diet can range from macro-invertebrates to small fish, and they accumulate high concentrations of the chemical contaminants commonly found in the Great Lakes ecosystem.

The accumulation of contaminants by eels may cause problems of toxicity both to the eels themselves and to predators of eels. There have been reports of mass mortalities of eels in the freshwater portions of the St. Lawrence River, deformities in eels caught by fishermen in the estuary and a diminution by 95% in the number of juvenile eels migrating upstream over the R.H. Saunders Dam towards Lake Ontario (Dutil *et al.* 1987; Homer 1986; Hendrick 1991). Mass mortalities were associated with gill damage and impaired ionoregulation, as shown by pathological and physiological examination of moribund eels (Dutil *et al.* 1987). However, a contaminant etiology was not supported since these responses were not correlated to levels of persistent chemicals such as PCBs in the flesh. The contaminant analyses did not include measures of the specific congeners of PCBs, chlorinated dioxins and chlorinated furans which are now known to be highly toxic and to occur in the aquatic environment (Eisler 1986).

Recent studies of Beluga whales (*Delphinapterus leucas*) in the estuary and the Gulf of St. Lawrence suggest that contamination of eels may have other important effects. Analyses of dead Beluga have shown PCBs, DDT, pesticides and mirex at levels far above those found in fish or in Arctic Belugas (Massé *et al.* 1986; Martineau *et al.* 1987; Muir *et al.* 1990). The exposure of marine mammals is believed to be primarily via their diet, since there is no contact of respiratory surfaces with water, which in fish permits direct chemical uptake. Therefore, the majority of contaminants in Beluga must come from prey consumed over the lifetime of each animal. Since Beluga are long-lived (20-30 y), are predatory and do not grow after 6-10 years of age, they should accumulate high levels of lipophilic, persistent compounds such as PCBs and mirex. However, concentrations measured in Beluga are so high that they cannot be explained simply on the basis of the consumption of fish from the estuary (Béland et al. 1987; Hickie *et al.* 1991). Furthermore, mirex is not found frequently in estuarine fish, but was thought to be unique to fish from the upper St. Lawrence River and Lake Ontario, the only Great Lake to receive direct inputs (Dutil *et al.* 1985; Sloterdijk 1985; Langlois and Sloterdijk 1988; Castonguay *et al.* 1989; Kaiser 1978). Since eels contain contaminants at levels 10 times higher than those of estuarine fish, and since a high proportion contain mirex due to their exposure in Lake Ontario, they may be a transport mechanism of chemicals to Belugas (Béland and Martineau 1988; Hickie *et al.* 1991; Lum *et al. 1987*).

Therefore, we collected and analyzed eels in 1990 to evaluate the role of contaminants in the health of migrating eels, the role of eels as vectors of contaminants to Beluga whales, and the changes in contamination since an earlier large-scale survey in 1982 (Desjardins et al 1983a; 1983b; Dutil *et al.* 1985; Castonguay *et al.* 1989). Since Beluga whales are found on both the North and South coasts of the estuary, we also compared contamination of eels among three estuarine sites and one uncontaminated reference stream. Samples taken at Saint-Irénée on the north shore and at Kamouraska on the south shore provide a comparison of the difference between the coasts. Sample taken at Kamouraska and at Cacouna, both on the south shore, demonstrated whether variability occured along the coast. A sample from Rivière aux Pins, the uncontaminated reference stream on the North shore, demonstrates the extent to which chemicals accumulate in fish from the St. Lawrence watershed. Furthermore, since Beluga would eat whole eels, but only gutted carcasses are analyzed in surveillance programs, we compared the levels of chemicals in whole eels to levels in specific tissues. This report presents the results of all analyses, the geometric mean levels of each chemical, and a comparison of the levels of PCBs and mirex between 1982 and 1990.

2.0 MATERIALS AND METHODS

2.1 SAMPLE COLLECTION

Random samples of about 100 live silver eels were purchased from a fisherman at Kamouraska, Quebec (Figure 1). Samples were collected weekly during the entire seven weeks of the annual fishery, between September and November 1990. During this 7-week period, live eels were also purchased once each from fishermen at Cacouna, on the south shore of the Estuary, and at Saint-Irénée, on the north shore. The eels were intercepted and trapped during their spawning migration towards the sea by commercial weirs installed at right angles to the shoreline. The origin of the majority of these eels would be the St. Lawrence watershed upstream of Quebec City (Dutil *et al.* 1985). Live eels were also captured by experimental trap nets during their seaward migration in Rivière aux Pins near Forestville. Rivière aux Pins is an uncontaminated stream that enters the sea directly from the north shore of the St. Lawrence Estuary.

All eels were returned live to the laboratory where they were held in clean, flowing salt water for 6 - 48 hours before being killed for tissue analyses. Each eel was anaesthetized in MS-222 (Tricaine methane sulfonate), the viscera and gonads were removed, and the carcass with head attached was frozen in a contaminant-free plastic bag (ARCAN Inc, Plainswell, Michigan).

After all sampling was completed, the frozen eels from each week and each site were subsampled to provide two each with an original live weight of about 300, 600, 900, 1200, 1500, 1800, 2100, 2400, 2700 or 3000 g (Table 1). For the smallest and largest weight classes, there were often missing samples due to the scarcity of these sizes. For eight additional eels, analyses were made of the head, gutted carcass, gonad and viscera (liver, stomach, intestines, etc.) to provide an estimate of the relation among whole fish and tissue contaminant levels. For PAH, dioxin and furan analyses, only a limited number of fish could be analyzed due to cost. Homogenates of two fish in the 900 g weight class were pooled to provide one sample for each of the seven sampling times at Kamouraska, and one for the fish collected at Rivière aux Pins.

2.2 SAMPLE PREPARATION

Each eel was thawed, the head removed, and the remaining gutted carcass (muscle, skeleton and skin) homogenized by a Hobart meat grinder. After each fish, the grinder was disassembled and cleaned, which included a hot water wash, scrubbing, rinsing with water and rinsing with ultra-pure hexane.

The homogenate was collected in stainless-steel bowls, re-homogenized and stored as 100 g aliquots in glass jars, using stainless steel or plastic kitchen utensils rinsed in ultra-pure hexane. The glass jars were also rinsed in hexane and a liner of hexane-rinsed foil separated the homogenate from the plastic jar lid.

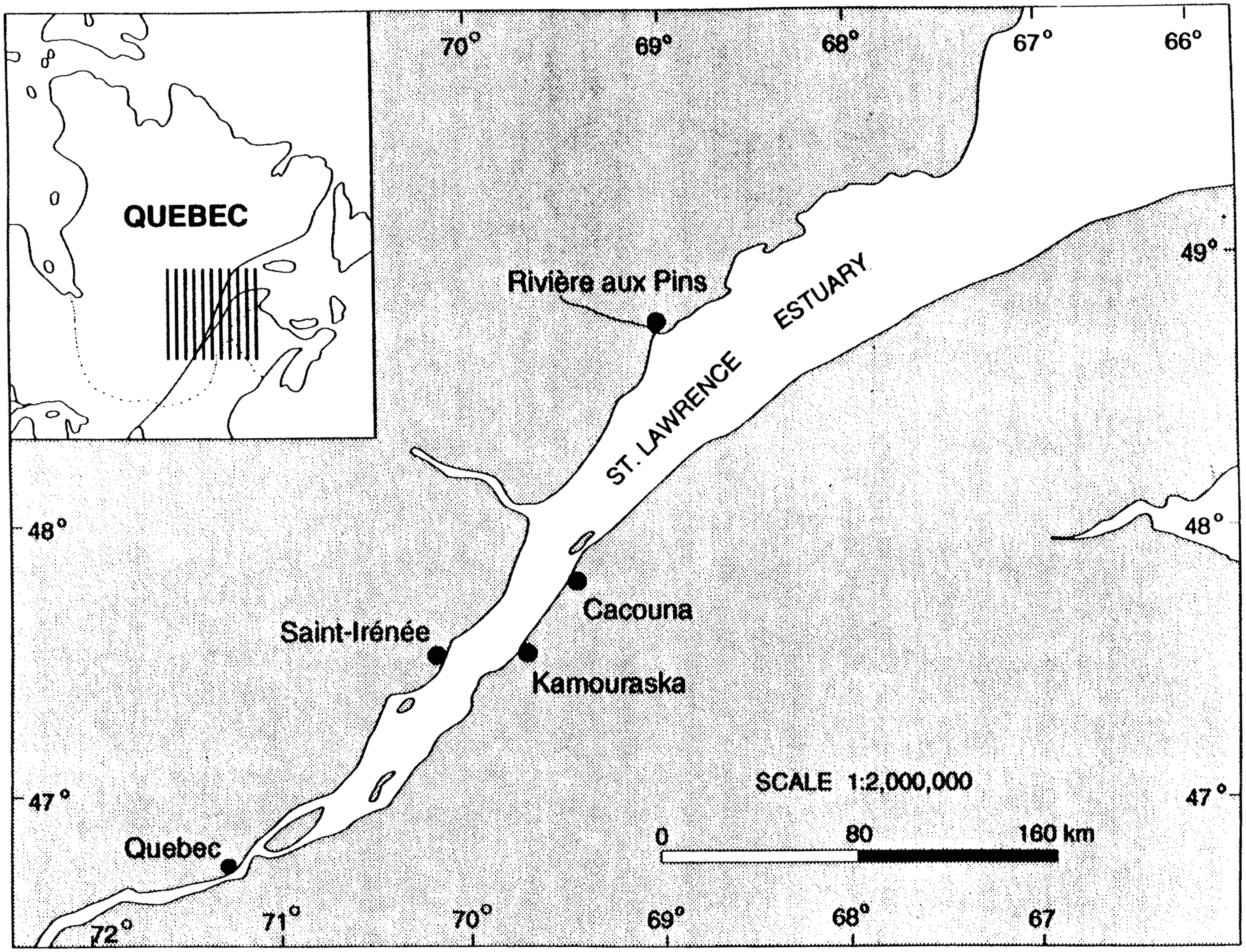

Figure 1. Location of the four sampling sites. Weirs at Kamouraska, Saint-Irénée and Cacouna were set in the estuary in salt water, while the weir at Rivière aux Pins was set in fresh water at Forestville.

Table 1. Distribution of samples by site, week, and weight. The numbers are those assigned to each sample during analysis, and the class weight is the target weight used when sorting fish for analysis. The lab numbers identify the samples in the Appendices of results.

WEEK/DATE	WEIGHT CLASS (g)										TOTAL NUMBER OF FISH
	300	600	900	1200	1500	1800	2100	2400	2700	3300	
<u>Kamouraska</u>											
1 - 19/09/90			336	354	356	357	359	360			10
			337	355		358		361			
2 - 27/09/90		362	338	364	366	368	370	372			13
		363	339	365	367	369	371				
3 - 3/10/90		376	340	378	380	382	384	386			14
		377	341	379	381	383	385	387			
4 - 9/10/90		395	342	397	399	401	403	405	407	408	16
		396	343	398	400	402	404	406			
5 - 16/10/90		418	344	420	422	424	426	428			14
		419	345	421	423	425	427	429			
6 - 23/10/90		431	346		433	435	437				10
		432	347		434	436	438				
7 - 1/11/90		443	348	445	446	448	450	452			12
		444	349		447	449	451				
<u>Rivière aux Pins</u>											
1 - 20/09/90	461	463	350		465						7
	462	464	351								
<u>Cacouna</u>											
4 - 11/10/90		467	469	471	473	475	477	478			13
		468	470	472	474	476		479			
<u>Saint-Irénée</u>											
5 - 18/10/90		491	493	495	497	499	501	503	505		15
		492	494	496	498	500	502	504			
TOTAL											124

Individual tissue samples were homogenized in the Hobart grinder (head), or in a smaller laboratory grinder (viscera and gonads) to avoid excessive loss of material. It was not necessary to empty or clean the digestive tract since eels do not feed during their migration and the stomach is partially resorbed.

All homogenates were frozen and maintained at -20° C until analysis.

2.3 SAMPLE ANALYSIS

A variety of chemicals were measured in the tissues of eels and detection limits varied according to the methods used. The methods are described in subsequent sections, and the chemicals, with their detection limits, are listed in corresponding Appendices of results.

2.3.1 Pesticides, PCBs and mirex in carcass

Samples were weighed, measured and homogenized using commercial meat grinders having a mesh width of 4 mm. For the quantification of organochlorine compounds, the homogenized aliquot was extracted by an acetone-hexane (1:1) mixture before processing in a gel permeation chromatograph using a column of SX-3 beads as described by Johnson *et al*. (1976). The eluate was concentrated before adding to a 2% deactivated Florisil column as originally described by Mills *et al*. (1972). Two fractions were collected. Fraction I eluted by hexane contained heptachlorobenzene, DDE, polychlorobiphenyls and mirex; fraction II eluted by a (50.0:0.35:49.65) mixture of hexane-acetonitrile-dichloromethane contained twelve other pesticides of interest (McLeod and Ritcey 1978; list in Appendix 3). Polychlorobiphenyls were quantified by gas chromatography / Electron capture detector (Sherma and Beroza 1980; Freeman 1981), using 2% OV-17 + 2.6% OV-210 packed columns. Three peaks were used to calculate the total Aroclor 1254 contents: DDE 127, 147, 177 (Reynolds 1971). Average recoveries were in the 90-110% range. Polychlorobiphenyls were not corrected for recovery data. The PCB congeners and the pesticides were separated on a HP Ultra-1 capillary column and quantified by peak-to-peak comparison. (Martineau *et al*. 1987)

2.3.2 Mercury in carcass

The mercury analysis method is described in the Fishery and Oceans Chemical Methods Manual (MPO 1989; Chapter 1, Section 1): The homogenized samples were digested in a (1:1) mixture of nitric and sulfuric acids at 60 °C before being oxidized by $KMnO_4$. The final quantification was done by selective reduction to the elemental mercury by $SnCl_2$ using a Technicon Auto-Analysor/ Mercury Monitor Detector as initially described in Armstrong and Uthe (1971).

2.3.3 Tissue distribution of pesticides, PCBs and PAHs

2.3.3.1 Extraction procedure for organic contaminants: The extraction procedure was the same for all tissues and for all organic contaminants analyzed, i.e. PCBs, chlorinated pesticides and PAHs. Wet samples of fish (10-12 g) were mixed with anhydrous sodium sulphate (15-25 g) to obtain dry granular samples, transferred into 500 mL erlenmeyer flasks and extracted for 8 min three times with 50 mL hexane/acetone (70/30) in an ultra-sonic bath at 35°C. Extracts were combined and the volume reduced to about 1-23 mL using a Büchi rotary evaporator at ambient temperature. Samples containing insoluble material were centrifuged before the purification procedure.

2.3.3.2 Clean-up procedure for chlorinated pesticides and PCBs congeners: Each extract was chromatographed on a gel permeation column (GPC) to separate chlorinated compounds from lipids. The GPC was prepared following the method of Norstrom *et al.* (1986) using Bio-beads S-X3^{R} (200-400 mesh) from Bio-Rad Laboratories. The column was 45-cm long and 3.5-cm wide and contained about 50 g of beads. Samples were eluted with 250 mL of dichloromethane (DCM)/hexane (50:50) mixture. The last 100 mL were collected and evaporated to 0.5 mL with a rotary evaporator.

Samples extracts were fractionated on a 20-cm Florisil column into two eluates of 45 ml; hexane (F1) and hexane:DCM (75:25) (F2). The fraction F1 contained all PCBs congeners and some pesticides such as DDT, and F2 contained the remaining chlorinated pesticides. Fraction volumes were reduced to 0.5 mL and an internal standard was added prior to the GC analysis.

2.3.3.3 Quantification method for PCBs congeners and chlorinated pesticides: Analyses were carried out on a Varian 3300 gas chromatograph equipped with an electron capture detector operating at 325°C. A 60 m x 0.32 mm J&W fused silica column coated with SE 54 was perfused with an argon/methane (90:10) mixture at a rate of 2 mL/min. The injector was operated in splitless mode at a temperature of 300°C. Column temperature was programmed from 100°C (1-min hold) to 150°C at 10°C, from 150°C to 280°C at 3°C/min and from 280°C to 300°C (15-min hold) at 10°C/min.

Compounds were identified by a comparison of retention times with authentic standards. The chlorinated pesticides standard was the Supelpreme^{R} -HC pesticides mix containing aldrin, α-BHC, β-BHC, γ-BHC, δ-BHC, 4,4'-DDT, 4,4'-DDD, 4,4'-DDE, dieldrin, endosulfan I and II, endosulfan sulphate, endrin, endrin aldehyde, heptachlor epoxide, heptachlor, endrin ketone and methoxychlor. The PCB standard was a mixture of congeners from Aroclors 1242, 1254, and 1260 (1:1:1) purchased from Supelco. Identification of congeners was made by comparison with chromatograms published by Schultz *et al.* (1989). The percent contribution of individual congeners to Aroclors 1242, 1254, and 1260, as determined by these authors, was used to calculate the response factor of each congener or group of congeners eluting as one peak. The identity of some major congeners was confirmed by GC-MS using an Ion Trap Detector from a Finnigan MAT coupled to a Perkin-Elmer gas chromatograph. Appendices 8 to 12 provide the peak number as assigned by Schultz *et al.* (1989) and the International Union of Pure and Applied Chemistry

(IUPAC) structure number for each congener (Mullin et al. 1984). Peaks containing more than one congener are identified by more than one IUPAC number. The overall variability of the method was estimated to be ≤15 % and the detection limit 0.01 μg/kg.

2.3.3.4 Clean-up procedure for PAHs: Each extract was chromatographed on GPC using the procedure described above for pesticides and PCBs. Using a 15-cm silica column activated at 225 °C for 24 h and deactivated with 3% water, samples extracts were fractioned into two eluates of 25 mL hexane (F1) and 30 mL DCM/hexane (30:70) (F2). The fraction F1 contained only aliphatic hydrocarbons and was discarded, while F2 contained PAHs and was preserved for GC analysis. Fraction volumes were reduced to 0.5 mL and an internal standard was added prior to the GC analysis.

2.3.3.5 Quantification method for PAHs: Analyses were carried out on a Varian 3400 gas chromatograph equipped with a flame ionization detector operated at 325°C. A 30 m x 0.32 mm J&W fused silica column coated with SE 54 was used. The carrier gas was helium at a rate of 4 mL/min. The septum programmable injector was programmed from 40°C to 300°C at 180°/min. Column temperature was programmed from 50°C (2-min hold) to 300°C (15-min hold) at 5°C/min.

Identification of compounds was by comparison of retention times with authentic standards purchased from Supelco (PAH Kit 610-M). The PAH standard contained acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)-fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, fluoranthene, fluorene, indeno-pyrene, naphthalene, phenanthrene and pyrene.

As frequent interference peaks were observed in most samples, all peaks identified as PAHs by the retention time method were cross-checked by GC-MS; no PAHs listed in the standard mix were detectable in any samples analyzed.

2.3.4 Tissue distribution of mercury

Total mercury was determined in eel tissues with an analytical procedure adapted from Hatch and Ott (1968). Sulphuric, nitric and hydrochloric acids were 'Instra-analyzed grade' (Hg ≤ 0.005 μg/g) and used as provided by Baker. Acid pre-digestion was carried out in round-bottom flasks using concentrated nitric acid (15 mL) at 50°C for 1 h. Two aliquots (0.1 to 5.0 mL) were transferred into 125 mL flat-bottom flasks and their volume adjusted to 8 mL with concentrated sulphuric acid. The digestion was continued at 55°C for 1 h to ensure the complete degradation of lipids and connective tissues. Total mercury was analyzed in duplicate using a Fisher HG-3 flameless atomic absorption spectrophotometer (AAS) (detection limit = 0.005 μg/g). Aqueous standards (BDH Chemicals 1000 ppm) were used for a daily standardization. The overall variability of the method was ≤ 10%.

2.3.5 Analytical procedure for other metals

Total cadmium, copper, chromium and zinc were determined in eel tissues using a method adapted from Cossa (1980). Initial attempts to digest tissues using nitric acid alone gave unsatisfactory results, mainly due to the presence of strong interferences in AAS. Homogenized samples (1.0 g) were weighed in Falcon centrifuge tubes and digested in (50%) hydrogen peroxide (H_2O_2) at 75°C for 1 h, a procedure repeated 3 times. The digestion was continued with 3 mL concentrated HNO_3 at 75°C for 2.5 h. The final volume was adjusted to 25 mL with deionized water.

Metals were analyzed in duplicates using a Perkin-Elmer AAS (model 306) equipped with a graphite furnace (model HGA 500). Aqueous standards (BDH Chemicals 1000 ppm) were used for all metals. The detection limits were 0.01 μg/g for Cd and Cr, 0.07 μg/g for Cu and 3 μg/g for Zn. The overall variability of the method was 4% for Cd, Zn and Cu, and 10% for Cr.

2.3.6 PAHs, Dioxins and Furans in pooled carcasses

2.3.6.1 Extractions: Eel homogenates were extracted under neutral conditions by polytron homogenization with dichloromethane in the presence of excess anhydrous Na_2SO_4. About 30 g of

Table 2. Isotopically-labelled surrogates added to tissue homogenates as a check on percentage recovery of the extraction procedure.

PAHs

Acenaphthene-$^{2}H_{10}$
Anthracene-$^{2}H_{10}$
Chrysene-$^{2}H_{12}$
Benzo(a)pyrene-$^{2}H_{12}$

DIOXINS and FURANS

2,3,7,8-Tetrachlorodibenzo(p)dioxin-$^{13}C_{12}$
1,2,3,7,8-Pentachlorodibenzo(p)dioxin-$^{13}C_{12}$
1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin-$^{13}C_{12}$
1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin-$^{13}C_{12}$
Octachlorodibenzo(p)dioxin-$^{13}C_{12}$

2,3,7,8-Tetrachlorodibenzofuran-$^{13}C_{12}$

sample was spiked with the surrogates listed in Table 2, mixed with Na_2SO_4, and mixed again with 100 mL of dichloromethane. The mixture was homogenized for 10 min and the dichloromethane extract decanted. The sample was homogenized with two additional portions of dichloromethane and the combined extracts concentrated to 5.0 mL. The extract was diluted with cyclohexane (5.0 mL) giving the 50/50 dichloromethane/cyclohexane solution required for clean-up by gel-permeation chromatography (GPC).

For GPC, the column contained S-X3 Bio Beads, 200-400 mesh. All extracts were centrifuged to remove fine insoluble particulates prior to loading onto the GPC injection loop. The samples were eluted with 50/50 dichloromethane/-cyclohexane at a flow rate of 0.5 ml/min over a collection time of 20-59 min. After GPC, the extracts were solvent exchanged into 2.0 mL isooctane prior to PAH and PCDD/F clean-up. The GPC conditions and recoveries were characterized for dioxins and furans prior to sample clean-up; surrogate recoveries ranged from 98 to 114%.

For PAHs, one half of the extracts were cleaned by alumina column chromatography. Basic alumina was stored overnight at 110-130°C and packed while hot into 4 x 90 mm columns. The columns were rinsed with 10 mL dichloromethane prior to loading the sample and elution with 20 mL dichloromethane. The sample was concentrated to 1.0 mL in dichloromethane prior to GC/MS analysis.

For polychlorinated dibenzo(p) dioxins and dibenzofurans (PCDD, PCDF), the extracts were cleaned by a multi-column procedure. The first column (40 cm x 24 mm ID) was multilayered and carefully filled with the following:

1.0 g of silica gel (bottom layer);
2.0 g of 33% 1 M sodium hydroxide on silica gel;
1.0 g of silica gel;
4.0 g of 44 % concentrated sulfuric acid on silica gel;
2.0 g of silica gel;
and 1 cm sodium sulfate.

Preparation of the adsorbents was performed as per the Dow methodology (Lamparski *et al.* 1979). The column was prewashed with 30 mL of hexane which was discarded. The sample extract was pipetted onto the column and was washed with two aliquots of 1.0 mL hexane which was also applied to the column. An additional 30 mL of hexane was passed through the column and the total eluate collected in a 250 mL flask. Isooctane was added to the eluate and it was concentrated to about 1 ml.

This extract was applied to a column 5 cm x 1 cm ID containing 10% $AgNO_3$ on silica gel prewet with 10 mL hexane as per the Dow methodology (Lamparski *et al.* 1979). The flask was twice rinsed with 2 mL hexane and the hexane was applied to the column. The eluate was solvent-exchanged with isooctane and rotary evaporated to about 2 mL.

The concentrated eluate was chromatographed on a 5 cm x 1.5 cm ID column of 1% waterdeactivated basic alumina. The column was prewashed with 20 mL hexane which was discarded. The concentrated isooctane eluate was applied to the column followed by three 2 mL rinses of the flask. The column was eluted with 12 mL of hexane and collected as fraction A. The receiving flask was changed and the dioxins and furans were eluted from the column using 13 mL of 50% methylene chloride in hexane. This fraction was concentrated on a rotary evaporator to about 1 mL. This eluate was concentrated to a small volume over a gentle stream of nitrogen.

Carbon (PX-21 grade) was precleaned with methanol, dried and packed in 4 x 30 mm glass columns. The columns were activated by successive elutions of 2 mL 50/50 benzene/ethyl acetate, 2 mL 50/50 dichloromethane/cyclohexane and 2 mL hexane. The columns were loaded with sample and with successive additions of 1 mL hexane, 2 mL 50/50 hexane/dichloromethane and 2 mL 50/50 benzene/ethyl acetate. The columns were allowed to drain and left untouched for 2 minutes. The columns were inverted for elution of PCDD/F congeners with 9 mL toluene in a reverse direction compared to column loading. The extract was evaporated to 'just dry' with nitrogen and taken up in 10 μl of 250 pg/μl of triphenylene-$^2H_{12}$ in isooctane as an internal standard.

Table 3. Instrument conditions for GC/MS analysis of PAH compounds.

Gas Chromatography	
Injection Mode:	Splitless
Column:	30 m DB5 X 0.25 mm ID
Column Flow:	He at 20 cm/sec.
Oven Temperature Profile:	80°C - 2 min; 80°C - 210°C @ 10°C/min; 210°C-290°C @ 16°C/min hold for 10 min.
GC/MS Interface:	Direct Couple
Transfer Area:	250°C
Mass spectrometry	
Ionization Mode:	Electron Impact
Electron Energy:	70 eV
Filament Emission:	0.5 A
Electron Multiplier:	1500 V
Scan:	Stepped ion MID

2.3.6.2 Analysis. Extracts of PAHs were analysed on a Finnigan 4500 and instrument conditions are listed in Table 3 (PAHs). The PAHs of interest and the quantification ions used are presented in Table 4 with the confirming ions next to the Quantification ions. Quantification was carried out by comparing mass spectrometric responses of selected ions to those of external standards with correction for internal response of Phenanthrene $^{2}H_{10}$. The criteria used for the identification of the PAHs required:

a) the presence of appropriate secondary ions in the mass spectrum;
b) a signal to noise of at least 3 to 1;
c) a retention time within 3 seconds of the reference standard after correction for internal standard retention times.

Table 4. Quantification and confirming ions used in the analysis of PAH compounds.

Compound	Quantification Ion	Confirming Ion
Naphthalene	128	64
Acenaphthylene	152	153
Acenaphthene	154	152
Fluorene	166	165
Phenanthrene	178	176
Anthracene	178	176
Fluoranthene	202	101
Pyrene	202	101
Chrysene	228	114
Benz(a)anthracene	228	114
Benzo(b)fluoranthene	252	126
Benzo(k)fluoranthene	252	126
Benzo(a)pyrene	252	126
Indeno(1,2,3-c,d)pyrene	276	138
Dibenzo(a,h)anthracene	278	139
Benzo(g,h,i)perylene	276	138
5-Methylchrysene	242	241
Diphenylamine	169	167
9-Phanylcarbazole	243	240
Benzo(a,c)acridine	229	
Quinoline	129	128

Dioxins and furans were measured with a VG70-VSE mass spectrometer (operating conditions in Table 5), and the elution windows were established by the injection of a mixture containing the first and last congener to elute. Quantification of 2,3,7,8-substituted dioxins and furans was performed according to external standard responses of the individual 2,3,7,8-substituted isomers. For total congener group quantification, average responses for the 2,3,7,8-substituted congeners of each congener group were used to calibrate instrument response for all isomers of that congener group. Specific dioxin and furan congeners were identified by their specific ions and ion ratios (Table 6) at an instrument resolution of 1 in 10,000. Identification was also made with a minimum signal-to-noise ratio of 3 to 1, a retention time within a 3 second window of external standards after internal standard correction, and elution within a retention window established by injection of the first and last elution mixture.

None of the dioxin and furan data were blank corrected but they were corrected for surrogate recoveries as per Environment Canada protocols for analysis of dioxin and furans in pulp and paper mill effluents.

Table 5. Instrumental conditions for polychlorinated dibenzo(p) dioxin and dibenzofuran analysis using a VG70-VSE mass spectrometer.

Gas Chromatography	
Injection Mode:	on column
Column flow:	He at 30 cm/sec.
Column:	60 m x 0.25 mm DB5
Oven Temperature Profile:	100°C - 2 min -220°C @16°C/min 220° -290° @ 12°C/min, hold 10 min
GC/MS Interface:	direct couple
Transfer Area:	300°C
Mass Spectrometry	
Ionization Mode:	electron impact
Electron Energy:	35 eV
Filament Emission:	0.5 A
Photo Multiplier:	370 Volts @ 2 x 10^5 gain
Ionizer Temperature:	300°C
Scan:	SIM (using lockmass technique) selected ion monitoring

Table 6. Selected ion masses, ion type and control limits used in the analysis of polychlorinated dibenzo(p)dioxins and dibenzofurans.

Window	Compound[1]	Quantification Ions(m/z) 1st	2nd	Ion Type	Control Limits for Isotope Ratio
1	TCDF	303.9016	305.8987	M/M^{+2}	0.65-0.89
	$^{13}C_{12}$-TCDF	315.9419	317.9389	M/M^{+2}	0.65-0.89
	TCDD	319.8965	321.8936	M/M^{+2}	0.65-0.89
	$^{13}C_{12}$-TCDD	331.9368	333.9339	M/M^{+2}	0.65-0.89
	H6CDPE	375.8364		M^{+2}	
	PFK	316.9824		Lock	
2	P5CDF	339.8597	341.8567	M^{+2}/M^{+4}	1.32-1.78
	$^{13}C_{12}$-P5CDF	351.9000	353.897	M^{+2}/M^{+4}	1.32-1.78
	P5CDD	355.8546	357.8516	M^{+2}/M^{+4}	1.32-1.78
	$^{13}C_{21}$-P5CC	367.8949	369.8919	M^{+2}/M^{+4}	1.32-1.78
	H7CDPE	409.7974		M^{+2}	
	PFK	366.9792		Lock	
3	H6CDF	373.8208	375.8178	M^{+2}/M^{+4}	1.05-1.43
	$^{13}C_{12}$-H6CDF	383.8639	385.861	M/M^{+2}	0.48-0.59
	H6CDD	398.8157	391.8127	M^{+2}/M^{+4}	1.05-1.43
	$^{13}C_{12}$-H6CDD	401.8559	403.8529	M^{+2}/M^{+4}	1.05-1.43
	08CDPE	445.7555		M^{+4}	
	PFK	380.9760		Lock	
4	H7CDF	407.7818	409.7789	M^{+2}/M^{+4}	0.88-1.20
	$^{13}C_{12}$-H6CDF	419.8220	421.8191	M^{+2}/M^{+4}	0.88-1.20
	H7CDD	423.7766	425.7737	M^{+2}/M^{+4}	0.88-1.20
	$^{13}C_{12}$-H7CDD	435.8160	437.814	M^{+2}/M^{+4}	0.88-1.20
	N9CDPE	479.7165		M^{+4}	
	PFK	430.9728		Lock	
5	OCDF	441.7428	443.7398	M^{+2}/M^{+4}	0.76-1.02
	OCDD	457.7378	459.7348	M^{+2}/M^{+4}	0.76-1.02
	$^{13}C_{12}$-OCDD	469.7780	471.775	M^{+2}/M^{+4}	0.76-1.02
	D10CDPE	513.6775		M^{+4}	
	PFK	454.9728		Lock	

1. CDF: chlorodibenzofuran; CDD: chlorodibenzo(p)dioxin; T: Tetra; P5: penta; H6: Hexa; H7: Hepta; 08: Octa; CDPE: Chlorodiphenylether; PFK: Perfluorokerosene

One problem was encountered on re-analysis of samples for dioxins and furans: the re-analysed data did not match the original data. The cause of the discrepancy was the incorrect assignment of polychlorinated diphenyl ether (PCDPE) responses as furans. Although the PCDPE ions had been monitored, the MS response on these channels did not correspond to those expected for PCDPE. For example, for hexachlorodiphenylether, where parent ions are m/z 374 and 376, a Cl2 loss corresponds to TCDF or m/z of 304 and 306. The mass abundance of this Cl2 loss is expected to be 20 to 50 % of the parent ion. In this case the ratio was about 1 %. This led to the faulty interpretation of data. The low PCDPE parent ion response was caused by anomalies in the mass spectrum instrumentation and did not correspond to normal instrument response. This anomaly was observed despite following all Environment Canada protocols to ensure that the instrument was operating satisfactorily.

The error in interpretation would not have been observed were it not for the re-extraction and re-analysis of some samples. With the awareness of the presence of PCDPE interferences in focus, all the prior PCDD/F data were re-examined and re-processed. The data reported herein corresponds to the corrected and re-processed data.

2.4 DATA PRESENTATION

All data except weights were converted to logarithms before statistical analyses due to the large ranges in values and the resultant non-normal distributions and non-homogenous variances. For many compounds, concentrations were below the detection limit and a value of one-half the detection limit was substituted for statistical analysis. This is a common convention in contaminant monitoring programs (D.M. Whittle, Great Lakes laboratory for Fisheries and Aquatic sciences, Canada Centre for Inland Waters, Burlington, Ontario, personal communication). For each contaminant at each site, the mean and standard deviation were calculated and the means were expressed both as logarithms and in arithmetic units (antilog of the means) to facilitate the understanding of trends.

For the study of tissue distribution, the 'whole body' concentrations of contaminants were calculated from the weights and chemical concentrations of the individual parts. For the eight eels tested, the carcass, viscera, gonads and head averaged 83.3, 3.1, 4.9, and 8.7% of the whole body weight. Hence, the concentration of a chemical in the whole body was calculated as:

$$C_{whole\ body} = (0.833 \times C_{carcass}) + (0.031 \times C_{viscera}) + (0.049 \times C_{gonads}) + (0.087 \times C_{head})$$

3.0 RESULTS

No eels were found with concentration of PAHs above the limits of detection of 0.01 μg/g. Hence, no tables of results are given for PAHs.

3.1 KAMOURASKA

Although only a small number of PCB congeners were measured in carcasses, they were found consistently and at concentrations well above the detection limit. Expressed as 'Aroclor 1254', a mixture of many individual compounds, PCBs ranged from 0.149 to 7.489 μg/g (Appendix 1). Congener numbers 28 and 137 were the least concentrated, and were found most frequently at levels less than 0.01 μg/g, although one sample contained 0.11 μg/g of #28. Congener numbers 52 and 101 were more concentrated than #28 but had similar concentrations to each other, ranging from 0.004 to 0.336 μg/g. These two congeners were about 1/2 to 1/3 of the concentration of congener number 180, which ranged from 0.010 to 0.524 μg/g. Congener numbers 118, 153 and 138 were most concentrated, with levels ranging from 0.001 to 0.833 μg/g. The sum of the individual congeners ranged from 0.156 to 3.033 μg/g, following the same pattern as Aroclor 1254. Expressed as Aroclor 1254, 32 of 89 (36%) fish at Kamouraska exceeded the Guideline for PCBs in fish of 2.0 μg/g (Table 7).

Mirex varied from non-detectable to 0.312 μg/g, a concentration range equivalent to PCB congeners #52 and #101. The number of fish exceeding the guideline for mirex in fish was 26, equivalent to 29% of the 89 fish analyzed. Chlorinated dioxins and furans were found only at very low concentrations, and many congeners were non-detectable (Appendix 2). The highest concentration of 2,3,7,8-TCDD, the most toxic congener, was 0.0000014 μg/g (1.4 parts per trillion - ppt), well below the guideline of 0.000020 μg/g (20 ppt) (Table 7). The only congeners detected frequently were 1,2,3,6,7,8-hexachlorodibenzo(p)dioxin, 1,2,3,4,6,7,8-heptachlordiben-zofuran, octachlorodibenzofuran and octachlorodibenzo(p)dioxin. The latter two were the most concentrated, with levels up to 0.000091 μg/g (91 ppt).

A wide range of chlorinated pesticides were detectable in migrating eels, although they varied considerably in their concentrations (Appendix 3). Lindane, heptachlor, alpha-BHC and aldrin were generally close to or below the detection limits of 0.001 μg/g, and were almost always less than 0.01 μg/g. Heptachlor epoxide, a metabolite of heptachlor, was more abundant, with concen- trations between 0.003 and 0.06 μg/g, a range that also encompassed hexachlorobenzene (HCB), oxychlordane, and for the most part, 1- and 2-chlordane and endrin. Dieldrin was measurable in all samples but one, and while concentrations were as high as 0.28 μg/g, the majority were less than 0.100 μg/g. The most concentrated pesticides were DDT and its metabolites, and the sum of all DDT congeners ranged from 0.028 to 3.312 μg/g. Dieldrin was the only pesticide to exceed the Canadian Guideline for human consumption of fish products. Of 89 fish sampled at Kamou- raska, 14 (15.7%) exceeded the guideline of 0.1 μg/g for 'Other Pesticides' (Table 7).

Table 7. A summary of Canadian Guidelines for the levels of chemicals in fishery products, and the percentage of fish that exceeded these guidelines at Kamouraska in 1982 and 1990 and at Rivière aux Pins in 1990.

	Guideline (μg/g)	Percentage of Fish exceeding the Guideline			
		All Eels 1982	Kamouraska 1982	Kamouraska 1990	Rivière aux Pins 1990
N		396	104	89	7
PCB	2.0	62	80	36	0
Mirex	0.1	31	52	29	0
2,3,7,8-TCDD	0.00002	--	--	0	0
DDT	5.0	0	0	0	0
Other pesticides	0.1	33.1	13.5	15.7[2]	0
Mercury	0.5	9.3	8.6	2.3	0

[1] The data for 1982 were derived from Desjardins *et al.* 1983a, 1983b; Castonguay *et al.* 1989; C. Desjardins, unpublished data; and this study.

[2] Dieldrin in all cases (Appendix 3).

Mercury, the only metal measured, ranged from 0.02 to 0.54 μg/g (Appendix 1), and only 2 of 89 (2.3 %) fish sampled at Kamouraska exceeded the Canadian Guideline of 0.50 μg/g for mercury concentrations in fish products (Table 7).

Chemical concentrations were not constant among weeks. Pesticides and PCBs appeared to increase over time, with peak levels in weeks 3 and 6 and lowest levels in week 1 (Appendices 1 and 3). However the trend was statistically significant only for hexachlorobenzene, heptachlor, heptachlor epoxide, mirex, aldrin and PCB congener #28 and not for other pesticides (P.V. Hodson, unpublished analyses) For most dioxin and furan congeners, there was little variation of levels from week to week with the exception of the octachloro congeners. Concentrations appeared highest in weeks 2 and 5 and least in week 4, although the statistical significance of the differences cannot be tested with only one sample per time (Appendix 2). For mercury, mean levels varied little, with no obvious trends (Appendix 1).

In general, fish weight appeared to have little influence on chemical levels. An inspection of Appendix 1 shows that the data are listed in order of increasing weight for each week's sample at Kamouraska. However, for most weeks, there is no systematic trend in levels of PCB, mirex or mercury with increasing weight (e.g. $r = 0.17$ for PCBs). The sole exceptions are weeks 6 and 7, in which PCB and mirex concentrations increase with weight, although the trend is uneven. The same patterns can be seen in pesticide concentrations (Appendix 3), since the fish are listed in the same order by weight as in Appendix 1.

3.2 OTHER LOCATIONS

The levels of PCBs, mirex and pesticides in eels collected at Saint-Irénée, on the north shore of the estuary, and at Cacouna on the south shore, were little different from levels in eels from Kamouraska caught in the corresponding weeks (Appendices 4 and 5). For example, the geometric mean level of Aroclor 1254 at Cacouna on Oct. 18, 1990 was 1.143 μg/g while the level on Oct. 16 at Kamouraska was similar at 1.359 μg/g (Appendix 1).

In contrast, contamination of eels from Rivière aux Pins by organic compounds was much lower, with the majority of PCB congeners and pesticides at concentrations at or below the detection limit. The compounds with highest concentrations were Aroclor 1254 and p,p-DDE. Nevertheless, levels of Aroclor 1254 at Rivière aux Pins on Sept. 20 were more than 50 times lower than at Kamouraska on Sept. 19, 1990. Dioxins and furans in eels from Rivière aux Pins were also low, equivalent to the lowest levels observed at Kamouraska and generally below the limit of detection (Appendix 2).

The only exception to low levels of contamination at Rivière aux Pins was mercury. Concentrations ranged from 0.13 to 0.31 μg/g, and the average was the same as at Kamouraska during the same week (Appendix 1).

3.3 TISSUE DISTRIBUTION

There were a wide variety of specific PCB congeners in every tissue examined (Appendices 8-12). Following the Schultz nomenclature for PCBs (Schultz *et al.* 1989), only 14 of 88 congeners (numbers 2, 9, 10, 18, 26, 33, 45, 60, 64, 71, 73, 76, and 78) were below the limit of detection of 0.01 μg/kg in every tissue. In contrast, there were seven congeners (numbers 35, 38, 39, 46, 50, 54 and 63) for which average concentrations exceeded 10 μg/kg in every tissue; congeners numbers 50 and 54 were most concentrated. There were few differences in the patterns of distri- bution of congeners among tissues; those that were low in one tissue were low in all tissues, and vice-versa. Total PCBs did not vary significantly among tissues, although the calculated levels in whole body were most similar to those in carcass.

The PCB congeners measured in the large number of eel carcasses collected at Kamouraska (Appendix 1) correspond to Schultz congener numbers 13, 19, 38, 50, 54, 57, 68, and 72. While these congeners account for many of those occurring at relatively high concentrations in individual tissues, there are many which were not measured but which contribute significantly to the total levels of PCBs in eel tissue.

All pesticide concentrations varied among tissues in much the same way, and are exemplified by 'Total Pesticides' (Appendix 6). Concentrations were highest in the gonads and least in the head, and the differences among tissues were parallelled by differences in tissue lipid levels. When the concentrations in whole body are calculated, they differ little from those in carcass.

Due to the high concentrations of bone in the head, difficulties were encountered in preparing extracts suitable for metals analyses. Consequently, there are only data for carcass, viscera and gonad. Whole body concentrations could not be calculated. For cadmium and copper, concentrations were highest in viscera, about 15 times higher than in carcass or gonads (Appendix 7). Chromium was also more concentrated in viscera, but the levels averaged only about 70% higher than in carcass and gonad. Zinc concentrations in viscera and gonad were the same, and more than double those in carcass. Mercury differed from all other metals, in that concentrations were highest in carcass, almost twice those found in viscera, and 10 times those found in gonads.

4.0 DISCUSSION

4.1 SPATIAL TREND

The data presented in this report clearly indicate that eels captured in the Estuary and migrating from the St. Lawrence R. drainage basin are much more contaminated with chlorinated organic compounds than those migrating from Rivière aux Pins, a small river with a forested watershed on the north shore. Levels of most chemicals were virtually undetectable in eels from this river, and those that were measured were many times lower than in eels from the Estuary. The sole exception to this obvious difference was mercury, which was as concentrated in the carcasses of eels from Rivière aux Pins as in those from the Estuary. These results indicate that the contamination of eels with organic chemicals is a function of sources of pollution in the regions in which they grew to maturity. By contrast, mercury appears to be widespread and equally distributed, suggesting either a natural source or the influence of atmospheric transport on mercury dispersion. Although the levels of mercury approach or occasionally exceed the guideline of 0.5 $\mu g/g$ in fish, this cannot be interpreted to mean that all ecosystems are heavily contaminated with mercury. Rather, it demonstrates the importance to bioaccumulation of the life history characteristics of eels, which include predatory habits, a position high in aquatic food webs, and a relatively long period of growth.

Within the Estuary, there was very little difference among sites, with PCB and pesticide levels at Saint-Irénée and Cacouna virtually the same as at Kamouraska during the corresponding week of sampling. The paired comparison of each site to Kamouraska was necessary due to obvious changes in levels of chemical contamination with time during the period of the fishery.

4.2 TEMPORAL TREND

While eels from the St. Lawrence are contaminated, the present data suggest that concentrations are declining. Compared to eels from Kamouraska analyzed in 1982, concentrations of mirex and PCBs are considerably lower. Desjardins *et al.* (1983a; 1983b) reported levels of PCB and mirex of 6.32 and 0.196 $\mu g/g$ respectively, considerably higher than the overall means (ranges) for PCB and mirex of 1.23 (0.612 - 2.133) and 0.025 (0.006 - 0.086) $\mu g/g$ found in 1990 at Kamouraska (Appendix 1). This may not be a valid comparison, however, since the 1982 samples were taken only once, on Oct. 5, 1982, and the results were reported as an arithmetic mean. When these data are re-calculated as geometric means, the appropriate means for PCB and mirex are 4.539 and 0.073 $\mu g/g$ respectively (N = 109). The differences between this sample and the levels measured on Oct. 3, 1990 of 1.432 and 0.032 $\mu g/g$ (N = 14) represent declines of 68 and 56 % for PCB and mirex, respectively. If <u>all</u> eels sampled in 1982 are considered, the geometric mean levels of PCB and mirex are 3.47 and 0.099 $\mu g/g$ respectively (N = 397). By comparison, the 1990 geometric mean levels of PCBs and mirex for all eels at Kamouraska were 1.23 and 0.025 $\mu g/g$ (N = 86), respectively 65% and 75% lower than in 1982. Since eels move and appear to mix together, these comparisons contain an unknown amount of bias due to the unknown proportional representation of eels from different freshwater ecosystems. Hence, the comparison between 1982 and 1990 for eels caught only at Kamouraska in the same week is likely the best basis for assessing temporal trends.

A second way of assessing contamination between years is to compare the percentage of fish that exceed the current Canadian Guidelines for protecting human health. For PCBs the percentage of eels at Kamouraska that exceeded 2.0 $\mu g/g$ in 1982 was 80%, far higher than the 36% that exceeded the limit in 1990. Similarly, for mirex, the prevalence of eels exceeding 0.1 $\mu g/g$ was 52% in 1982 and 29% in 1990. Clearly, there is less contamination now than in the early 1980s. A further perspective is provided by PCB levels in European eels (*Anguilla anguilla*) sampled from the River Rhone. Level of congener #138 were 1.41 $\pm$ 0.56 $\mu g/g$ lipid (Duursma *et al.* 1991) compared to values in this study that ranged from 0.003 to 0.42 $\mu g/g$ (N = 8) as calculated from lipid levels (Appendix 6) and congener #138 levels (Appendix 8).

The decline in chemical levels of eels is in sharp contrast to the relatively constant levels of contamination observed in Great Lakes forage and predatory fish. In Lake Ontario, an important area for the feeding and growth of juvenile eels, levels of PCBs, mirex and pesticides in Lake trout declined dramatically during the 1970's, but have shown little change since 1980 (EC/DFO/HWC 1991). Therefore, at Kamouraska, where samples represent a mixture of eels from many sources, the declines in contamination may reflect environmental improvements in regions outside of Lake Ontario. Alternatively, the long periods of Lake Ontario residence by eels (8-12 years) may account for the difference since the eels sampled in 1982 would represent contamination during the early seventies, when chemical concentrations in the Lake Ontario ecosystem were higher.

There were also temporal variations within a year for eels caught at Kamouraska. In the period between the first and last week of the migration, there was about a three-fold variation in the levels of total pesticides, mirex, and PCBs. The overall trend was for an increase with time, but weeks 3 and 6 stood out as having the most contaminated fish. The non-homogenous distribution appeared to be related to time only, since eels caught at other locations in the Estuary had similar levels of contamination as eels caught at Kamouraska in the corresponding week. The percentage of eels that exceed the human health guidelines varied from 0 (week 1) to 60% (week 6).

The trend of increasing levels of contamination towards the end of the eel migration corresponds to other observations of increasing frequencies of pathologies (Couillard and Hodson, unpublished observations). This could indicate that either the presence of contaminants and pathologies slows the migration of eels, or that eels migrating from areas that are particularly contaminated, such as the Great Lakes, have a longer distance to cover or are slightly delayed in starting. This latter suggestion would imply that eels from different locations are not completely mixed together and that they may migrate in cohesive groups, at least at the start of the migration.

The variation of contaminant levels with week of migration suggests that the risk of toxicity for predators such as whales that consume contaminated eels increases with time. Nevertheless, there is a considerable variability of contamination within a sample of eels. For example, in week 7, there is a 13-fold spread in levels of Aroclor 1254 (Appendix 1), so that both 'clean' and 'contaminated' eels appear to migrate together. Therefore, risk could be expressed as a variation in both the level of contamination and the percentage of eels contaminated.

Dioxins and furans were not present in high concentrations. The levels of 2, 3, 7, 8-TCDD were always far below the guideline for human consumption (Table 7) and generally equivalent to the "blank" levels measured in quality control samples). Heptachloro- and octachloro-congeners are the most commonly observed in both these and other environmental samples, but of the least concern toxicologically. They are 100-1000 fold less toxic than than 2,3,7,8-TCDD (Appendix 2), the most toxic congener. Other non-2,3,7,8-substituted tetra-, penta-, hexa- and heptachlorinated congeners were also observed, but even on the basis of total homologues, the concentrations were low relative to the guideline in Table 7.

4.4 TISSUE DISTRIBUTION

Metals were generally most concentrated in viscera of eels, which may reflect either uptake of metals from food or an excretion of metals via the viscera. Since copper, chromium and zinc are essential micronutrients, they may be concentrated in tissues where their nutrient functions are expressed. A good example is zinc, the only metal to concentrate in gonads. It is essential for protein synthesis and concentrates in gonads of other species, perhaps due to the rapid protein synthesis characteristic of developing ova. Cadmium is not a micronutrient, but follows the same pattern of distribution as copper. Since it is a metal with very similar properties and is bound and excreted by the same carrier proteins (metallothionein), its distribution may be accidental rather than in response to a specific nutritional requirement.

Mercury distribution differs considerably from that of other metals. Many studies have demonstrated a preferential accumulation in carcass due to the affinity of methylmercury, the most common form, for protein (Hodson 1988). Mercury is also unusual in that it is the only contaminant that did not vary significantly among weeks or among sites, including Rivière aux Pins. This suggests that the accumulation of mercury is not a function of point sources of pollution, but rather of the widespread distribution of relatively low levels of mercury due to natural sources or to atmospheric deposition. The relatively high levels in eel carcass (approaching or exceeding the guideline of 0.5 μg/g) is probably a result of the long life and predatory habits of eel.

The tissue distribution of lipophilic organic contaminants followed closely the distribution of lipids (Appendix 6). For example lipid levels increased in the order of 'head' < 'viscera' < 'whole-body' = 'carcass' < 'gonads', which is exactly the same rank order for total pesticides (Appendix 6) and total PCBs (Appendices 8 - 12). In contrast, none of the metals followed this rank order (Appendix 8). Metal distribution was more likely regulated for nutritional reasons, or was governed by polar bonding to proteins.

The comparison of the tissue distribution of chemicals indicates that analysis of carcass (gutted carcass, skin on) is a good basis for estimating the risk to whales of eating whole eels. This is not surprising, given that carcass makes up 83.3% of the total body mass. Despite higher levels of fat and lipid-soluble contaminants, viscera does not contribute a great deal to whole body contamination due to its small volume.

5.0 CONCLUSIONS

This report demonstrates that persistant chlorinated organic compounds can still be measured in eels migrating from the Great Lakes and St. Lawrence River drainage basin. However, it is encouraging to find that levels of some of the most important contaminants, PCBs and mirex, have declined considerably since 1982. As well, the toxic congeners of dioxins and furans are virtually absent. While the levels of chemicals in eels represent a lower risk of toxicity for predators such as Beluga whales and human beings, there is no clear link with the status of the eel population. Mass mortalities are no longer seen in migrating eels in the fresh water portion of the St. Lawrence, but the numbers of young eels swimming over the eel ladder at Cornwall appear to be declining at the same time as chemical levels are declining. Further research and data analyses are required to establish whether there are links between the health of eels, the status of their populations and the levels of chemicals in their flesh.

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APPENDIX 1. The concentrations (ug/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific congeners, in eels captured at Kamouraska in 1990. The data are listed in order of increasing fish weight within each week. The specific congeners are identified by their IUPAC numbers (Mullin et al. 1984). The detection limit was 0.001 ug/g for PCB and mirex and 0.01 µg/g for mercury.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Week 1, September 19, N = 10													
336	952	0.54	0.026	<0.001	0.025	0.028	0.090	0.128	0.009	0.119	0.062	0.461	1.004
337	955	0.19	0.042	<0.001	0.058	0.038	0.127	0.147	0.010	0.135	0.064	0.579	1.022
354	1194	0.21	<0.001	<0.001	0.023	0.027	0.031	0.040	0.003	0.034	0.022	0.180	0.288
356	1554	0.14	0.010	0.006	0.028	0.024	0.033	0.033	0.001	0.023	0.010	0.158	0.359
357	1760	0.35	0.001	<0.001	0.009	0.009	0.028	0.046	0.003	0.040	0.021	0.156	0.474
355	1760	0.18	0.004	0.003	0.009	0.009	0.029	0.052	0.003	0.031	0.030	0.166	0.361
358	1801	0.27	0.004	<0.001	0.050	0.040	0.085	0.096	0.005	0.093	0.040	0.409	0.829
359	2180	0.18	0.004	0.006	0.017	0.015	0.035	0.067	<0.001	0.060	0.046	0.246	0.493
360	2387	0.29	0.009	0.008	0.025	0.020	0.074	0.146	0.008	0.121	0.084	0.486	1.178
361	2449	0.21	0.007	0.008	0.027	0.041	0.073	0.116	0.007	0.096	0.063	0.431	0.845
log mean		-0.62	-2.236	-2.616	-1.636	-1.656	-1.282	-1.119	-2.417	-1.200	-1.427	-0.538	-0.213
log SD		0.17	0.528	0.421	0.266	0.247	0.248	0.246	0.367	0.284	0.287	0.231	0.223
antilog mean	1699	0.24	0.006	0.002	0.023	0.022	0.052	0.076	0.004	0.063	0.037	0.290	0.612
Week 2, September 27, N = 13													
362	579	0.25	0.020	0.001	0.032	0.040	0.097	0.095	0.007	0.089	0.038	0.398	0.931
363	600	0.17	0.021	0.064	0.196	0.062	0.267	0.178	0.012	0.186	0.100	1.065	2.035
338	889	0.13	<0.001	0.044	0.105	0.062	0.177	0.104	0.008	0.106	0.041	0.647	1.025
339	918	0.16	0.025	0.067	0.177	0.131	0.524	0.288	0.025	0.314	0.142	1.668	2.744
364	1197	0.11	0.016	0.011	0.069	0.040	0.133	0.108	0.006	0.117	0.062	0.546	1.161
365	1209	0.02	0.008	0.011	0.029	0.034	0.043	0.050	0.005	0.049	0.026	0.247	0.459
366	1477	0.38	0.138	0.008	0.036	0.061	0.178	0.291	0.018	0.258	0.166	1.016	2.447
367	1570	0.40	0.007	0.006	0.020	0.015	0.062	0.101	0.006	0.085	0.054	0.349	0.801
368	1779	0.26	<0.001	0.010	0.030	0.022	0.036	0.034	0.004	0.034	0.016	0.186	0.396
369	1811	0.20	0.186	0.014	0.076	0.142	0.222	0.376	0.020	0.320	0.204	1.374	2.290
370	2110	0.33	0.002	0.010	0.056	0.052	0.084	0.092	0.008	0.086	0.040	0.428	0.782
371	2130	0.26	0.147	0.009	0.053	0.128	0.193	0.304	0.019	0.262	0.175	1.143	2.872
372	2378	0.17	0.005	0.006	0.028	0.026	0.058	0.072	0.005	0.064	0.039	0.298	0.478
log mean		-0.74	-1.881	-1.929	-1.269	-1.298	-0.919	-0.899	-2.037	-0.920	-1.196	-0.238	0.056
log SD		0.34	0.769	0.484	0.314	0.303	0.340	0.323	0.268	0.317	0.350	0.306	0.308
antilog mean	1434	0.18	0.013	0.012	0.054	0.050	0.121	0.126	0.009	0.120	0.064	0.579	1.139

APPENDIX 1 (cont'd). The concentrations (µg/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific congeners, in eels captured at Kamouraska in 1990.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Week 3, October 3, N = 14													
376	580	0.10	0.025	0.005	0.027	0.021	0.094	0.112	0.007	0.100	0.045	0.411	0.852
377	620	0.13	0.030	0.009	0.043	0.023	0.089	0.102	0.006	0.100	0.054	0.426	0.909
341	891	0.40	0.069	<0.001	0.052	0.038	0.241	0.329	0.017	0.283	0.207	1.167	2.336
340	904	0.24	0.017	0.013	0.074	0.035	0.126	0.104	0.008	0.104	0.045	0.509	0.954
379	1191	0.17	0.024	0.008	0.031	0.019	0.065	0.083	0.005	0.078	0.054	0.343	0.733
378	1222	0.51	0.107	0.010	0.091	0.071	0.295	0.337	0.021	0.327	0.201	1.353	1.892
380	1498	0.24	0.179	0.013	0.059	0.111	0.224	0.348	0.021	0.316	0.221	1.304	3.680
381	1510	0.17	0.004	0.018	0.072	0.092	0.140	0.146	0.008	0.127	0.060	0.663	0.717
383	1795	0.22	0.212	0.013	0.064	0.094	0.217	0.345	0.020	0.308	0.217	1.278	3.623
382	1812	0.31	0.003	0.022	0.038	0.029	0.154	0.191	0.012	0.166	0.077	0.689	1.801
384	2095	0.19	0.148	0.013	0.057	0.095	0.194	0.280	0.017	0.264	0.179	1.099	3.538
385	2098	0.17	0.100	0.013	0.057	0.095	0.194	0.280	0.017	0.264	0.179	1.099	2.729
387	2360	0.22	0.009	0.007	0.024	0.038	0.082	0.134	0.008	0.114	0.074	0.481	0.701
386	2435	0.19	0.008	0.008	0.026	0.031	0.063	0.102	0.006	0.085	0.053	0.374	0.545
log mean		-0.67	-1.497	-2.038	-1.327	-1.328	-0.857	-0.743	-1.962	-0.784	-1.012	-0.150	0.156
log SD		0.18	0.617	0.324	0.186	0.280	0.221	0.238	0.230	0.239	0.289	0.226	0.304
antilog mean	1501	0.21	0.032	0.009	0.047	0.047	0.139	0.181	0.011	0.164	0.097	0.708	1.432
Week 4, October 9, N = 16													
395	632	0.22	0.010	0.009	0.028	0.014	0.041	0.051	0.003	0.047	0.023	0.216	0.460
396	635	0.39	0.020	0.024	0.076	0.039	0.110	0.107	0.006	0.103	0.054	0.519	1.076
342	904	0.21	0.053	<0.001	0.193	0.094	0.482	0.285	0.018	0.297	0.140	1.509	2.674
343	909	0.25	<0.001	<0.001	0.014	0.015	0.040	0.067	<0.001	0.055	0.043	0.234	0.365
398	1200	0.45	0.058	0.004	0.018	0.016	0.065	0.104	0.006	0.090	0.053	0.356	0.869
397	1233	0.38	0.002	<0.001	0.010	0.014	0.036	0.051	0.003	0.049	0.020	0.183	0.421
399	1486	0.29	0.104	0.014	0.048	0.079	0.137	0.211	0.012	0.185	0.120	0.806	1.969
400	1512	0.24	0.227	0.014	0.084	0.148	0.279	0.429	0.026	0.402	0.276	1.658	4.135
401	1778	0.38	0.058	0.007	0.029	0.048	0.123	0.184	0.011	0.152	0.082	0.636	1.633
402	1812	0.38	0.196	<0.001	0.101	0.311	0.469	0.833	0.037	0.758	0.524	3.033	7.489
404	2093	0.41	0.069	<0.001	0.028	0.040	0.099	0.150	0.008	0.129	0.077	0.531	1.380
403	2180	0.20	0.103	0.013	0.061	0.073	0.168	0.260	0.015	0.236	0.156	0.982	2.160
405	2418	0.19	0.003	<0.001	0.014	0.019	0.041	0.060	0.004	0.057	0.037	0.232	0.525
406	2428	0.11	0.003	<0.001	0.014	0.017	<0.001	0.041	<0.001	0.041	0.021	0.134	0.319
407	2743	0.09	0.007	0.009	0.031	0.019	0.043	0.063	0.004	0.054	0.036	0.259	0.763
408	3277	0.26	<0.001	<0.001	0.012	0.018	0.035	0.065	0.001	0.052	0.032	0.215	0.601
log mean		-0.59	-1.739	-2.491	-1.489	-1.438	-1.146	-0.908	-2.240	-0.952	-1.182	-0.326	0.038
log SD		0.20	0.818	0.549	0.381	0.417	0.626	0.381	0.493	0.384	0.411	0.396	0.401
antilog mean	1703	0.25	0.018	0.003	0.032	0.036	0.071	0.124	0.006	0.112	0.066	0.472	1.091

APPENDIX 1 (cont'd). The concentrations (ug/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific congeners, in eels captured at Kamouraska in 1990.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Week 5, October 16, N = 14													
418	618	0.24	0.022	0.051	0.169	0.094	0.264	0.189	<0.001	0.206	0.089	1.062	2.016
345	902	0.18	0.041	0.019	0.336	0.093	0.677	0.391	0.020	0.397	0.153	2.086	3.866
344	932	0.21	0.014	<0.001	0.018	0.015	0.049	0.059	0.002	0.057	0.023	0.223	0.454
420	1198	0.27	0.024	0.018	0.049	0.037	0.079	0.096	<0.001	0.086	0.051	0.416	0.812
421	1216	0.28	0.012	0.008	0.028	0.018	0.036	0.041	0.002	0.041	0.023	0.197	0.378
422	1488	0.45	0.083	<0.001	0.027	0.060	0.119	0.169	0.011	0.146	0.087	0.619	1.284
423	1533	0.53	0.003	<0.001	0.028	0.013	0.034	0.059	0.001	0.056	0.024	0.215	0.404
419	1618	0.22	0.035	0.110	0.200	0.069	0.216	0.182	0.013	0.180	0.122	1.092	1.608
425	1794	0.29	0.162	0.012	0.059	0.096	0.182	0.292	0.018	0.263	0.173	1.095	2.876
424	1800	0.23	0.131	0.009	0.039	0.072	0.159	0.274	0.017	0.230	0.150	0.950	2.216
427	2093	0.17	0.166	<0.001	0.056	0.091	0.213	0.353	0.019	0.315	0.189	1.236	3.656
426	2154	0.23	0.076	0.010	0.041	0.072	0.117	0.186	0.010	0.164	0.099	0.699	1.941
429	2392	0.18	0.220	<0.001	0.071	0.105	0.220	0.349	0.021	0.313	0.219	1.298	3.443
428	2398	0.14	0.005	<0.001	0.015	0.024	0.041	0.067	<0.001	0.059	0.039	0.245	0.518
log mean		-0.62	-1.431	-2.270	-1.280	-1.305	-0.918	-0.816	-2.275	-0.847	-1.101	-0.198	0.133
log SD		0.16	0.582	0.719	0.396	0.329	0.382	0.332	0.577	0.328	0.355	0.343	0.372
antilog mean	1581	0.24	0.037	0.005	0.052	0.050	0.121	0.153	0.005	0.142	0.079	0.634	1.359
Week 6, October 23, N = 10													
431	538	0.24	0.030	<0.001	0.025	0.017	0.082	0.106	0.003	0.093	0.030	0.356	1.172
432	659	0.23	0.023	<0.001	0.030	0.019	0.076	0.115	0.008	0.092	0.060	0.400	1.218
347	886	0.20	0.006	0.008	0.038	0.022	0.088	0.064	0.005	0.050	0.031	0.306	0.648
346	916	0.28	0.016	0.009	0.048	0.036	0.075	0.086	<0.001	0.080	0.038	0.372	0.673
434	1473	0.17	0.143	<0.001	0.056	0.080	0.169	0.258	0.015	0.235	0.141	0.954	2.489
433	1577	0.35	0.098	0.009	0.039	0.064	0.114	0.201	0.010	0.175	0.108	0.720	2.423
435	1833	0.27	0.473	<0.001	0.110	0.142	0.340	0.617	0.036	0.547	0.423	2.215	5.579
436	1840	0.26	0.281	0.017	0.091	0.130	0.294	0.487	0.054	0.427	0.290	1.790	4.047
438	2054	0.20	0.312	0.001	0.094	0.101	0.339	0.539	0.032	0.490	0.322	1.917	4.986
437	2131	0.23	0.201	0.021	0.113	0.159	0.311	0.452	0.028	0.417	0.269	1.770	4.614
log mean		-0.62	-1.065	-2.464	-1.250	-1.241	-0.808	-0.659	-1.950	-0.717	-0.946	-0.082	0.329
log SD		0.09	0.602	0.579	0.242	0.378	0.289	0.367	0.546	0.380	0.447	0.347	0.358
antilog mean	1391	0.24	0.086	0.003	0.056	0.057	0.156	0.219	0.011	0.192	0.113	0.827	2.133

APPENDIX 1 (cont'd). The concentrations (µg/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific congeners, in eels captured at Kamouraska in 1990.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Week 7, November 1, N = 12													
444	631	0.32	0.014	<0.001	0.018	0.018	0.088	0.096	0.004	0.099	0.040	0.363	0.976
443	659	0.37	0.040	0.008	0.053	0.031	0.120	0.148	<0.001	0.123	0.061	0.544	1.003
348	843	0.22	<0.001	0.001	0.008	0.008	0.019	0.024	0.001	0.022	0.011	0.093	0.181
349	933	0.22	0.008	0.025	0.107	0.041	0.261	0.123	0.010	0.135	0.053	0.755	1.544
445	1152	0.15	0.014	0.022	0.084	0.037	0.055	0.051	<0.001	0.054	0.021	0.324	0.508
446	1447	0.44	0.007	0.012	0.054	0.038	0.280	0.352	0.024	0.373	0.142	1.275	3.534
447	1471	0.17	0.294	<0.001	0.097	0.125	0.303	0.465	0.029	0.434	0.304	1.757	4.218
448	1762	0.29	0.004	<0.001	0.005	0.004	0.011	0.021	<0.001	0.017	0.011	0.069	0.149
449	1861	0.28	0.234	0.008	0.057	0.082	0.270	0.439	0.026	0.411	0.281	1.574	4.095
451	2125	0.25	0.131	<0.001	0.049	0.109	0.170	0.251	0.015	0.232	0.146	0.972	2.576
450	2160	0.17	0.230	<0.001	0.085	0.118	0.254	0.389	0.023	0.361	0.244	1.474	3.211
452	2340	0.35	0.168	<0.001	0.064	0.111	0.224	0.351	0.020	0.320	0.218	1.308	2.926
log mean		-0.59	-1.518	-2.531	-1.380	-1.402	-0.929	-0.830	-2.192	-0.852	-1.126	-0.224	0.124
log SD		0.15	0.822	0.597	0.434	0.483	0.485	0.484	0.640	0.493	0.534	0.475	0.512
antilog mean	1449	0.26	0.030	0.003	0.042	0.040	0.118	0.148	0.006	0.141	0.075	0.597	1.330

APPENDIX 2. Specific dioxin and furan congeners (µg/kg) measured in homogenates pooled from two eels per week or site. The detection limit was 0.001 µg/kg. 'TEFs' refer to 'Toxic Equivalent Factors' that express the toxicity of each congener as a fraction of the toxicity of 2,3,7,8-TCDD (NATO/CDSM 1988)

	Kamouraska							Rivière aux Pins	TEFs
Week	1	2	3	4	5	6	7	1	
Date	19/09/90	27/09/90	3/10/90	9/10/90	16/10/90	23/10/90	1/11/90	20/09/90	
DIOXINS									
2,3,7,8-Tetrachlorodibenzo(p)dioxin (TCDD)	<0.001	<0.001	0.001	<0.001	0.0014	<0.001	<0.001	<0.001	1.0
1,2,3,7,8-Pentachlorodibenzo(p)dioxin (PCDD)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.5
1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin (HxCDD)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin	0.0011	<0.001	<0.001	0.003	0.001	<0.001	0.0023	<0.001	0.1
1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin (HpCDD)	0.006	<0.001	0.006	0.006	0.006	0.009	0.006	0.005	0.01
1,2,3,4,6,7,8,9-Octachlorodibenzo(p)dioxin (OCDD)	0.055	0.091	0.052	0.04	0.12	0.076	0.045	0.045	0.001
Sum of TCDD	<0.001	<0.001	0.001	0.0011	0.0014	<0.002	<0.001	<0.001	
Sum of PCDD	<0.001	<0.001	<0.001	0.0008	<0.001	<0.001	<0.001	<0.001	
Sum of HxCDD	0.0011	<0.001	<0.001	0.0089	0.0024	<0.0016	0.0032	<0.001	
Sum of HpCDD	0.0073	0.0021	0.0093	0.031	0.011	0.013	0.0093	0.0076	
FURANS									
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
1,2,3,7,8-Pentachlorodibenzofuran (PCDF)	<0.001	<0.001	<0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
2,3,4,7,8-Pentachlorodibenzofuran	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.5
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	<0.016	<0.008	<0.024	<0.002	<0.003	<0.005	<0.004	<0.001	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	0.002	0.002	0.003	0.002	0.002	0.004	0.0026	0.002	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.012	0.046	0.014	0.01	0.064	0.018	0.012	0.01	0.001
Sum of TCDF	0.017	0.006	0.011	0.003	0.004	0.007	0.006	<0.019	
Sum of PCDF	0.02	0.006	0.01	0.009	0.011	0.006	0.01	<0.0039	
Sum of HxCDF	<0.046	<0.023	<0.063	<0.0099	<0.012	<0.026	<0.015	<0.0033	
Sum of HpCDF	0.002	0.002	0.003	0.002	0.003	0.004	0.003	0.0022	

APPENDIX 3. The concentrations (µg/g) of pesticides in eels captured at Kamouraska in 1990. The weight of each eel is shown in Appendix 1, and the data are listed in order of increasing fish weight at each site. The detection limit was 0.001 µg/g

Lab #	HCB	pp-DDE	pp-DDD	pp-DDT	Total DDT	Alpha BHC	Lindane	Heptachlor	Heptachlor Epoxide	Aldrin	Oxy-chlordane	1-chlordane	2-chlordane	Dieldrin	Endrin	Total Pesticides
Week 1, September 19, N = 10																
336	0.007	0.094	0.038	0.011	0.143	0.005	0.002	<0.001	0.012	<0.001	0.007	0.007	0.019	0.044	<0.001	0.249
337	0.012	0.150	0.059	0.013	0.222	0.006	0.002	<0.001	0.014	<0.001	0.006	0.003	0.018	0.057	<0.001	0.343
354	0.002	0.040	0.032	0.012	0.084	0.004	0.003	<0.001	0.003	<0.001	0.008	0.005	0.011	0.010	0.005	0.137
356	0.002	0.019	0.023	0.035	0.077	0.005	0.002	<0.001	0.004	0.006	0.005	0.005	0.011	0.017	0.006	0.141
357	0.005	0.216	0.086	0.085	0.387	0.004	0.002	<0.001	0.006	<0.001	0.008	0.005	0.015	0.008	<0.001	0.443
355	0.003	0.015	0.020	0.034	0.069	0.006	0.003	<0.001	0.006	0.002	0.005	0.005	0.008	0.018	<0.001	0.127
358	0.007	0.091	0.083	0.073	0.247	0.006	0.003	<0.001	0.019	0.006	0.024	0.026	0.076	0.043	0.013	0.471
359	0.003	0.033	0.037	0.022	0.022	0.007	0.003	<0.001	0.006	<0.001	0.003	0.006	0.012	0.026	0.005	0.095
360	0.008	0.055	0.062	0.053	0.170	0.007	0.003	<0.001	0.013	<0.001	0.010	0.014	0.033	0.037	<0.001	0.298
361	0.007	0.069	0.062	0.058	0.189	0.008	0.003	<0.001	0.009	<0.001	0.008	0.016	0.033	0.035	0.006	0.316
log mean	-2.323	-1.240	-1.347	-1.507	-0.902	-2.247	-2.593	-3.000	-2.101	-2.814	-2.141	-2.134	-1.731	-1.605	-2.593	-0.641
log SD	0.271	0.373	0.223	0.333	0.358	0.102	0.091	0.000	0.258	0.326	0.236	0.292	0.295	0.288	0.444	0.247
antilog mean	0.005	0.058	0.045	0.031	0.125	0.006	0.003	<0.001	0.008	0.002	0.007	0.007	0.019	0.025	0.003	0.229
Week 2, September 27, N = 13																
362	0.015	0.127	0.075	0.019	0.221	0.006	0.003	<0.001	0.015	0.002	0.006	0.009	0.014	0.062	0.014	0.368
363	0.006	0.095	0.063	0.025	0.183	0.007	0.002	<0.001	0.013	0.005	0.006	0.007	0.016	0.054	0.014	0.314
338	0.007	0.067	0.029	0.004	0.100	0.007	0.002	<0.001	0.013	0.003	0.004	0.004	0.010	0.049	0.008	0.208
339	0.009	0.138	0.055	0.014	0.207	0.007	0.002	<0.001	0.015	0.003	0.005	0.003	0.015	0.065	0.013	0.345
364	0.006	0.075	0.051	0.014	0.140	0.005	0.003	<0.001	0.010	0.001	0.004	0.005	0.012	0.043	0.007	0.237
365	0.004	0.111	0.057	0.004	0.172	0.005	0.002	<0.001	0.007	0.001	0.003	0.003	0.007	0.019	0.005	0.229
366	0.011	0.801	0.086	0.070	0.957	0.005	0.002	<0.001	0.011	0.001	0.011	0.006	0.026	0.046	0.013	1.090
367	0.006	0.036	0.026	0.016	0.078	0.006	0.002	<0.001	0.007	<0.001	0.006	0.007	0.018	0.023	0.004	0.159
368	0.004	0.042	0.034	0.048	0.124	0.005	0.003	<0.001	0.004	<0.001	0.002	0.006	0.009	0.011	<0.001	0.171
369	0.020	0.794	0.071	0.065	0.930	0.004	0.002	<0.001	0.011	<0.001	0.012	0.008	0.028	0.046	0.008	1.071
370	0.004	0.078	0.013	0.004	0.095	0.002	0.002	<0.001	<0.001	<0.001	0.004	0.003	0.007	<0.001	0.006	0.127
371	0.016	0.694	0.108	0.109	0.911	0.007	0.003	<0.001	0.015	0.002	0.016	0.010	0.038	0.066	0.019	1.104
372	0.004	0.037	0.029	0.015	0.081	0.005	0.002	<0.001	0.004	0.001	0.003	0.007	0.014	0.019	<0.001	0.142
log mean	-2.133	-0.904	-1.332	-1.728	-0.686	-2.282	-2.645	-3.000	-2.097	-2.814	-2.275	-2.255	-1.839	-1.556	-2.190	-0.503
log SD	0.248	0.486	0.256	0.482	0.401	0.147	0.085	0.000	0.337	0.238	0.260	0.183	0.225	0.499	0.410	0.339
antilog mean	0.007	0.125	0.047	0.019	0.206	0.005	0.002	<0.001	0.008	0.002	0.005	0.006	0.014	0.028	0.006	0.314

APPENDIX 3 (cont'd). The concentrations (µg/g) of pesticides in eels captured at Kamouraska in 1990.

Lab #	HCB	pp-DDE	pp-DDD	pp-DDT	Total DDT	Alpha BHC	Lindane	Heptachlor	Heptachlor Epoxide	Aldrin	Oxy-chlordane	T-chlordane	2-chlordane	Dieldrin	Endrin	Total Pesticides
Week 3, October 3, N = 14																
376	0.009	0.108	0.053	0.019	0.180	0.007	0.002	<0.001	0.014	<0.001	0.005	0.005	0.013	0.056	<0.001	0.294
377	0.012	0.121	0.038	0.009	0.168	0.006	0.001	<0.001	0.012	<0.001	0.005	0.003	0.010	0.049	<0.001	0.269
341	0.010	0.173	0.044	0.031	0.248	0.006	0.003	<0.001	0.013	<0.001	0.011	0.003	0.016	0.047	<0.001	0.360
340	0.009	0.121	0.054	0.013	0.188	0.005	0.002	<0.001	0.014	<0.001	0.005	0.003	0.013	0.055	<0.001	0.297
379	0.006	0.067	0.028	0.007	0.102	0.004	0.002	<0.001	0.007	<0.001	0.004	0.003	0.009	0.026	<0.001	0.166
378	0.026	0.474	0.063	0.021	0.558	0.006	0.002	<0.001	0.012	<0.001	0.007	0.004	0.015	0.054	0.012	0.698
380	0.022	1.367	0.138	0.229	1.734	0.007	0.002	<0.001	0.019	<0.001	0.023	0.014	0.057	0.088	<0.001	1.969
381	0.010	0.217	0.118	0.027	0.362	0.007	0.003	<0.001	0.008	<0.001	0.008	0.022	0.038	0.022	0.008	0.490
383	0.036	0.960	0.142	0.258	1.360	0.007	0.003	<0.001	0.022	<0.001	0.022	0.024	0.067	0.109	0.027	1.679
382	0.005	0.304	0.098	0.181	0.583	0.008	0.003	<0.001	0.009	<0.001	0.023	0.008	0.024	0.029	0.001	0.695
384	0.028	0.859	0.155	0.265	1.279	0.007	0.003	<0.001	0.023	0.004	0.023	0.019	0.060	0.108	0.021	1.576
385	0.017	0.723	0.148	0.223	1.094	0.007	0.003	<0.001	0.022	<0.001	0.024	0.017	0.055	0.101	0.016	1.358
387	0.007	0.067	0.037	0.022	0.126	0.006	0.002	<0.001	0.007	<0.001	0.005	0.007	0.015	0.024	<0.001	0.202
386	0.007	0.071	0.043	0.032	0.146	0.005	0.002	<0.001	0.007	<0.001	0.005	0.010	0.020	0.028	<0.001	0.233
log mean	-1.918	-0.618	-1.154	-1.351	-0.428	-2.208	-2.645	-3.000	-1.908	-2.957	-2.022	-2.119	-1.636	-1.311	-2.576	-0.282
log SD	0.271	0.462	0.263	0.581	0.428	0.080	0.135	0.000	0.192	0.161	0.316	0.350	0.310	0.250	0.602	0.372
antilog mean	0.012	0.241	0.070	0.045	0.373	0.006	0.002	<0.001	0.012	0.001	0.010	0.008	0.023	0.049	0.003	0.522
Week 4, October 9, N = 16																
395	0.006	0.051	0.030	0.008	0.089	0.005	0.002	<0.001	0.010	<0.001	0.004	0.005	0.003	0.039	0.005	0.170
396	0.006	0.082	0.030	0.011	0.123	0.004	0.001	<0.001	0.010	<0.001	0.005	0.003	0.011	0.034	<0.001	0.200
342	0.022	0.184	0.105	0.031	0.320	0.006	0.002	<0.001	0.016	0.001	0.006	0.006	0.014	0.067	0.015	0.476
343	0.004	0.066	0.036	0.012	0.114	0.004	0.002	<0.001	0.005	<0.001	0.004	0.004	0.009	0.015	<0.001	0.164
398	0.006	0.142	0.041	0.018	0.201	0.006	0.002	<0.001	0.011	<0.001	0.006	0.003	0.012	0.039	<0.001	0.289
397	0.003	0.072	0.028	0.013	0.113	0.004	0.002	<0.001	0.005	<0.001	0.005	0.002	0.007	0.013	<0.001	0.157
399	0.015	0.751	0.096	0.159	1.006	0.005	0.002	0.001	0.015	<0.001	0.016	0.010	0.032	0.063	<0.001	1.167
400	0.027	1.555	0.266	0.377	2.198	0.008	0.004	<0.001	0.031	<0.001	0.028	0.025	0.090	0.155	0.020	2.588
401	0.011	0.269	0.070	0.026	0.365	0.005	0.002	0.002	0.016	<0.001	0.009	0.005	0.021	0.064	0.010	0.511
402	0.010	1.063	0.230	0.132	1.425	0.004	0.001	<0.001	0.008	<0.001	0.021	0.012	0.059	0.041	0.001	1.584
404	0.011	0.199	0.060	0.025	0.028	0.007	0.002	<0.001	0.013	<0.001	0.008	0.004	0.017	0.055	<0.001	0.149
403	0.021	0.680	0.145	0.130	0.955	0.007	0.003	<0.001	0.018	<0.001	0.017	0.015	0.041	0.080	0.014	1.173
405	0.003	0.038	0.036	0.015	0.089	0.004	0.002	0.005	0.001	<0.001	0.004	0.007	0.013	0.018	<0.001	0.148
406	0.005	0.034	0.029	0.040	0.103	0.006	0.002	<0.001	0.007	<0.001	0.004	0.008	0.015	0.024	<0.001	0.177
407	0.044	0.065	0.045	0.049	0.159	0.008	0.003	0.002	0.012	<0.001	0.008	0.006	0.015	0.046	<0.001	0.305
408	0.004	0.030	0.046	0.030	0.106	0.005	0.002	<0.001	0.006	<0.001	0.006	0.008	0.019	0.024	<0.001	0.183
log mean	-2.051	-0.827	-1.220	-1.459	-0.647	-2.273	-2.696	-2.916	-2.032	-2.997	-2.118	-2.205	-1.770	-1.402	-2.667	-0.445
log SD	0.357	0.558	0.322	0.484	0.525	0.109	0.149	0.193	0.336	0.010	0.278	0.282	0.358	0.287	0.523	0.418
antilog mean	0.009	0.149	0.060	0.035	0.225	0.005	0.002	<0.001	0.009	0.001	0.008	0.006	0.017	0.040	0.002	0.359

APPENDIX 3 (cont'd). The concentrations (µg/g) of pesticides in eels captured at Kamouraska in 1990.

Lab #	HCB	pp-DDE	pp-DDD	pp-DDT	Total DDT	Alpha BHC	Lindane	Heptachlor	Heptachlor Epoxide	Aldrin	Oxy-chlordane	1-chlordane	2-chlordane	Dieldrin	Endrin	Total Pesticides
Week 5, October 16, N = 14																
418	0.007	0.124	0.052	0.019	0.195	0.006	0.002	<0.001	0.013	<0.001	0.007	0.005	0.014	0.049	0.004	0.304
345	0.011	0.193	0.084	0.016	0.293	0.005	0.003	<0.001	0.013	<0.001	0.008	0.004	0.009	0.054	0.009	0.409
344	0.009	0.069	0.039	0.007	0.115	0.004	0.002	<0.001	0.009	<0.001	0.003	0.003	0.010	0.036	<0.001	0.194
420	0.007	0.095	0.044	0.023	0.162	0.006	0.002	<0.001	0.012	<0.001	0.005	0.005	0.013	0.049	0.014	0.277
421	0.004	0.024	0.016	0.016	0.056	0.006	0.002	<0.001	0.009	<0.001	0.003	0.003	0.007	0.029	<0.001	0.122
422	0.009	0.223	0.057	0.041	0.321	0.006	0.002	<0.001	0.012	<0.001	0.007	0.004	0.015	0.049	0.009	0.436
423	0.003	0.046	0.025	0.019	0.090	0.005	0.002	<0.001	0.003	<0.001	0.004	0.004	0.009	0.011	<0.001	0.134
419	0.006	0.116	0.053	0.015	0.184	0.007	0.002	<0.001	0.012	<0.001	0.005	0.003	0.010	0.039	0.007	0.277
425	0.031	0.513	0.114	0.224	0.851	0.008	0.003	<0.001	0.037	0.002	0.026	0.038	0.110	0.163	0.024	1.294
424	0.015	0.653	0.093	0.116	0.862	0.007	0.002	<0.001	0.015	<0.001	0.015	0.009	0.036	0.063	0.019	1.045
427	0.025	0.860	0.142	0.228	1.230	0.008	0.003	<0.001	0.028	0.002	0.030	0.020	0.070	0.118	0.009	1.544
426	0.008	0.446	0.095	0.068	0.609	0.005	0.001	<0.001	0.007	<0.001	0.010	0.005	0.027	0.033	<0.001	0.708
429	0.032	0.743	0.182	0.259	1.184	0.007	0.003	<0.001	0.038	0.004	0.032	0.029	0.094	0.170	0.039	1.633
428	0.003	0.043	0.046	0.017	0.106	0.005	0.002	<0.001	0.007	<0.001	0.005	0.007	0.013	0.020	<0.001	0.171
log mean	-2.039	-0.767	-1.212	-1.414	-0.547	-2.225	-2.670	-3.000	-1.906	-2.914	-2.093	-2.180	-1.704	-1.315	-2.307	-0.376
log SD	0.338	0.507	0.290	0.521	0.444	0.088	0.125	0.000	0.296	0.184	0.355	0.370	0.404	0.329	0.586	0.392
antilog mean	0.009	0.171	0.061	0.039	0.284	0.006	0.002	<0.001	0.012	0.001	0.008	0.007	0.020	0.048	0.005	0.421

APPENDIX 4. The concentrations (µg/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific PCB congeners, in eels captured at Rivière aux Pins, Saint-Irénée and Cacouna in 1990. The data are listed in order of increasing fish weight within each site. The specific congeners are identified by their IUPAC numbers (Mullin et al. 1984). The detection limit is 0.001 µg/g.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Rivière aux Pins, Week 1, September 20, 1990, N = 7													
461	301	0.297	0.001	<0.001	<0.001	<0.001	0.001	0.005	<0.001	0.004	0.002	0.011	0.005
462	307	0.316	<0.001	<0.001	<0.001	0.001	0.002	0.002	<0.001	0.002	0.001	0.008	0.016
464	594	0.321	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	0.002	0.001	0.005	0.002
463	595	0.134	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.005	0.018
350	858	0.240	<0.001	<0.001	<0.001	<0.001	0.004	0.003	<0.001	<0.001	<0.001	0.007	0.022
351	896	0.260	<0.001	<0.001	<0.001	<0.001	0.001	0.003	<0.001	0.003	<0.001	0.006	0.019
465	1551	0.226	<0.001	<0.001	<0.001	<0.001	0.001	0.003	<0.001	0.002	0.001	0.007	0.016
log mean		-0.606	-3.000	-3.000	-3.000	-3.000	-2.871	-2.610	-3.000	-2.717	-2.957	-2.170	-1.959
log sd		0.136	0.000	0.000	0.000	0.000	0.237	0.218	0.000	0.224	0.114	0.121	0.390
antilog mean	729	0.248	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	0.002	0.001	0.007	0.011
Saint-Irénée, Week 4, October 11, 1990, N = 13													
473	1497	0.224	0.110	0.011	0.046	0.081	0.139	0.220	0.012	0.189	0.121	0.819	1.930
474	1513	0.196	0.180	0.010	0.058	0.131	0.226	0.351	0.020	0.316	0.209	1.321	3.118
471	1229	0.158	0.024	0.007	0.048	0.043	0.082	0.107	0.006	0.100	0.071	0.464	1.000
469	907	0.212	0.011	<0.001	0.025	0.018	0.048	0.060	<0.001	0.054	0.025	0.230	0.537
472	1182	0.946	0.010	0.009	0.060	0.056	0.159	0.126	0.009	0.139	0.042	0.600	1.336
478	2378	0.208	0.195	0.009	0.064	0.086	0.238	0.385	0.022	0.347	0.223	1.374	3.234
479	2440	0.329	0.478	<0.001	0.091	0.130	0.284	0.520	0.031	0.473	0.391	0.192	5.263
477	2068	0.074	0.008	0.010	0.038	0.038	0.054	0.085	0.004	0.077	0.049	0.355	0.677
475	1786	0.211	0.169	0.007	0.047	0.077	0.198	0.318	0.018	0.288	0.188	1.141	2.673
476	1801	0.160	0.109	0.009	0.051	0.079	0.142	0.220	0.012	0.201	0.114	0.828	2.014
470	901	0.476	0.044	0.008	0.048	0.076	0.167	0.181	0.010	0.161	0.088	0.739	1.503
468	617	0.190	0.023	0.055	0.140	0.071	0.215	0.148	0.009	0.151	0.076	0.865	1.292
467	649	0.150	0.022	0.011	0.044	0.025	0.065	0.077	0.004	0.070	0.034	0.330	0.677
log mean		-0.654	-1.292	-2.132	-1.271	-1.215	-0.871	-0.755	-2.043	-0.789	-1.031	-0.222	0.196
log sd		0.269	0.580	0.446	0.180	0.257	0.259	0.293	0.395	0.289	0.354	0.281	0.299
antilog mean	1581	0.222	0.051	0.007	0.054	0.061	0.134	0.176	0.009	0.163	0.093	0.600	1.570

APPENDIX 4 (cont'd). The concentrations (µg/g) of mercury, mirex and PCBs, as Aroclor 1254 and as specific PCB congeners, in eels captured at Rivière aux Pins, Saint-Irénée and Cacouna in 1990.

Lab #	Weight (g)	Mercury	Mirex	PCB #28	PCB #52	PCB #101	PCB #118	PCB #153	PCB #137	PCB #138	PCB #180	Total Congeners	PCB 1254
Cacouna, Week 5, October 18, 1990, N = 15													
491	593	0.193	0.027	0.027	0.159	0.073	0.278	0.199	0.013	0.221	0.111	1.081	2.414
492	599	0.183	0.029	0.011	0.055	0.041	0.145	0.133	0.007	0.141	0.081	0.614	1.259
494	890	0.239	0.020	0.008	0.038	0.021	0.063	0.088	0.004	0.076	0.051	0.349	0.667
493	916	0.113	0.002	<0.001	0.012	0.013	0.035	0.049	<0.001	0.042	0.021	0.172	0.371
495	1196	0.181	0.058	<0.001	0.020	0.028	0.077	0.137	0.006	0.119	0.069	0.456	1.150
496	1197	0.116	0.008	<0.001	0.024	0.042	0.100	0.139	0.007	0.132	0.095	0.539	1.105
498	1521	0.990	0.009	0.003	0.013	0.024	0.067	0.139	0.007	0.116	0.084	0.453	1.121
497	1527	0.198	0.268	<0.001	0.075	0.106	0.299	0.466	0.028	0.428	0.299	1.701	3.793
500	1807	0.150	0.337	<0.001	0.119	0.202	0.331	0.528	0.031	0.473	0.358	2.042	5.391
499	1820	0.700	0.005	0.026	0.044	0.044	0.204	0.262	0.015	0.250	0.121	0.966	2.031
502	2097	0.289	0.001	<0.001	0.004	0.006	0.010	0.021	0.001	0.017	0.001	0.070	0.142
501	2108	0.050	0.024	0.012	0.037	0.037	0.088	0.130	0.008	0.119	0.081	0.512	0.746
503	2363	0.160	0.224	<0.001	0.075	0.145	0.271	0.407	0.024	0.363	0.249	1.534	3.614
504	2409	0.052	0.004	0.004	0.013	0.013	0.038	0.087	0.004	0.071	0.056	0.286	0.699
505	2709	0.174	0.007	0.004	0.017	0.020	0.049	0.089	0.005	0.073	0.048	0.305	0.625
log mean		-0.740	-1.737	-2.497	-1.508	-1.449	-1.026	-0.852	-2.151	-0.897	-1.162	-0.276	0.058
log sd		0.345	0.763	0.552	0.431	0.415	0.428	0.371	0.449	0.390	0.601	0.393	0.415
antilog mean	1459	0.182	0.018	0.003	0.031	0.036	0.094	0.141	0.007	0.127	0.069	0.529	1.143

APPENDIX 5. The concentrations (µg/g) of pesticides in eels captured at Rivière aux Pins, Saint-Irénée and Cacouna in 1990. The weights of each eel are given in Appendix 4 and the data are listed in order of increasing weight within each site. The detection limit was 0.001 µg/g.

Lab #	HCB	pp-DDE	pp-DDE	pp-DDT	Total DDT	Alpha BHC	Lindane	Heptachlor	Heptachlor Epoxide	Aldrin	Oxy-chlordane	1-chlordane	2-chlordane	Dieldrin	Endrin	Total Pesticides
Rivière aux Pins, Week 1, September 20, 1990, N = 7																
461	0.002	0.019	<0.001	0.004	0.023	0.003	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.002	<0.001	0.038
462	0.002	0.015	0.004	0.004	0.023	0.002	0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	0.003	<0.001	0.038
464	0.001	0.018	0.002	0.002	0.022	0.002	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001	0.035
463	0.001	0.007	0.004	<0.001	0.011	0.003	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.024
350	0.001	<0.001	0.003	0.004	0.007	0.004	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	0.003	<0.001	0.023
351	0.001	0.011	0.008	0.007	0.026	0.004	0.001	<0.001	0.002	<0.001	0.001	<0.001	0.001	0.004	<0.001	0.044
465	0.002	0.020	0.003	0.003	0.026	0.004	0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	0.003	<0.001	0.043
log mean	-2.871	-2.015	-2.520	-2.510	-1.745	-2.520	-3.000	-3.000	-2.957	-3.000	-3.000	-3.000	-3.000	-2.624	-3.000	-1.468
log sd	0.161	0.463	0.280	0.271	0.222	0.135	0.000	0.000	0.114	0.000	0.000	0.000	0.000	0.198	0.000	0.115
antilog mean	0.001	0.010	0.003	0.003	0.018	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.034
Saint-Irénée, Week 4, October 11, 1990, N = 13																
473	0.021	0.680	0.073	0.076	0.829	0.005	0.002	<0.001	0.012	<0.001	0.009	0.009	0.026	0.043	0.007	0.965
474	0.023	1.121	0.091	0.113	1.325	0.006	0.002	0.001	0.013	<0.001	0.015	0.009	0.030	0.053	<0.001	1.479
471	0.007	0.071	0.024	0.007	0.102	0.005	0.002	<0.001	0.008	<0.001	0.003	0.004	0.009	0.026	<0.001	0.169
469	0.004	0.064	0.015	0.005	0.084	0.004	0.001	<0.001	0.007	<0.001	0.008	0.014	0.028	0.020	<0.001	0.173
472	0.007	0.055	0.016	0.007	0.078	0.004	0.002	<0.001	0.005	<0.001	0.006	0.004	0.011	0.016	<0.001	0.136
478	0.026	0.751	0.074	0.126	0.951	0.005	0.002	<0.001	0.019	<0.001	0.020	0.018	0.056	0.083	0.006	1.188
479	0.079	0.641	0.121	0.182	0.944	0.006	0.002	<0.001	0.028	0.001	0.024	0.025	0.087	0.125	0.012	1.334
477	0.030	0.115	0.030	0.023	0.168	0.007	0.002	<0.001	0.009	<0.001	0.004	0.004	0.012	0.030	0.003	0.271
475	0.014	0.802	0.054	0.059	0.915	0.004	0.002	<0.001	0.011	<0.001	0.011	0.006	0.022	0.043	0.008	1.038
476	0.018	0.608	0.090	0.090	0.788	0.005	0.002	<0.001	0.016	<0.001	0.012	0.009	0.030	0.063	0.010	0.955
470	0.011	0.182	0.035	0.016	0.233	0.005	0.002	<0.001	0.009	<0.001	0.005	0.003	0.011	0.033	0.004	0.318
468	0.006	0.091	0.021	0.008	0.120	0.004	0.002	<0.001	0.007	<0.001	0.002	0.003	0.007	0.029	0.005	0.187
467	0.006	0.073	0.019	0.005	0.097	0.004	0.001	<0.001	0.006	<0.001	0.002	0.002	0.006	0.022	0.004	0.152
log mean	-1.864	-0.631	-1.397	-1.571	-0.513	-2.315	-2.745	-3.000	-1.989	-2.997	-2.154	-2.192	-1.724	-1.421	-2.463	-0.359
log sd	0.364	0.508	0.320	0.592	0.488	0.081	0.113	0.000	0.212	0.011	0.356	0.333	0.352	0.256	0.407	0.416
antilog mean	0.014	0.234	0.040	0.027	0.307	0.005	0.002	0.001	0.010	0.001	0.007	0.006	0.019	0.038	0.003	0.438

APPENDIX 5 (cont'd). The concentrations (µg/g) of pesticides in eels captured at Rivière aux Pins, Saint-Irénée and Cacouna in 1990.

Lab #	HCB	pp-DDE	pp-DDE	pp-DDT	Total DDT	Alpha BHC	Lindane	Heptachlor	Heptachlor Epoxide	Aldrin	Oxy-chlordane	1-chlordane	2-chlordane	Dieldrin	Endrin	Total Pesticides
Cacouna, Week 5, October 18, 1990, N = 15																
491	0.007	0.113	0.037	0.011	0.161	0.005	0.002	<0.001	0.010	0.001	0.005	0.004	0.010	0.037	0.011	0.254
492	0.009	0.095	0.030	0.008	0.133	0.004	0.002	<0.001	0.007	<0.001	0.003	0.002	0.009	0.026	0.004	0.201
494	0.005	0.043	0.012	0.006	0.061	0.004	0.002	<0.001	0.006	<0.001	0.003	0.002	0.006	0.018	0.003	0.112
493	0.003	0.048	0.011	0.005	0.064	0.003	0.002	<0.001	0.002	<0.001	0.003	0.001	0.004	0.007	0.001	0.092
495	0.007	0.233	0.040	0.026	0.299	0.005	0.001	<0.001	0.007	<0.001	0.005	0.003	0.011	0.028	0.005	0.373
496	0.006	0.089	0.033	0.045	0.167	0.004	0.002	<0.001	0.005	<0.001	0.008	0.011	0.017	0.015	0.004	0.241
498	0.005	0.112	0.017	0.013	0.142	0.003	0.001	<0.001	0.002	<0.001	0.003	0.002	0.005	0.005	0.002	0.172
497	0.035	0.817	0.093	0.142	1.052	0.006	0.002	<0.001	0.029	<0.001	0.023	0.025	0.079	0.128	0.018	1.399
500	0.063	1.194	0.113	0.176	1.483	0.006	0.002	<0.001	0.020	<0.001	0.025	0.019	0.062	0.086	0.010	1.778
499	0.005	0.692	0.071	0.070	0.833	0.004	0.002	<0.001	0.003	0.001	0.010	0.003	0.013	0.010	0.004	0.889
502	0.002	0.047	0.010	0.003	0.060	0.004	0.002	<0.001	0.002	<0.001	0.002	0.002	0.005	0.004	0.002	0.087
501	0.024	0.130	0.031	0.027	0.188	0.006	0.002	<0.001	0.009	<0.001	0.005	0.006	0.013	0.031	0.002	0.288
503	0.031	1.182	0.087	0.104	1.373	0.007	0.002	<0.001	0.018	<0.001	0.019	0.012	0.045	0.071	0.011	1.591
504	0.006	0.061	0.018	0.011	0.090	0.005	0.002	<0.001	0.006	<0.001	0.003	0.003	0.008	0.021	0.002	0.148
505	0.005	0.046	0.016	0.009	0.071	0.005	0.001	<0.001	0.004	<0.001	0.003	0.004	0.009	0.013	<0.001	0.118
log mean	-2.067	-0.810	-1.515	-1.682	-0.675	-2.337	-2.759	-3.000	-2.207	-2.994	-2.253	-2.372	-1.904	-1.678	-2.432	-0.527
log sd	0.425	0.532	0.350	0.557	0.504	0.109	0.125	0.000	0.365	0.015	0.360	0.406	0.397	0.439	0.384	0.455
antilog mean	0.009	0.155	0.031	0.021	0.212	0.005	0.002	0.001	0.006	0.001	0.006	0.004	0.012	0.021	0.004	0.297

APPENDIX 6. The concentrations of pesticides (μg/g) and lipids (mg/g) in various tissues of eight eels captured at Kamouraska in 1990. The detection limit was 0.0002 μg/g. The values for 'whole body' are calculated from the concentrations and weights of individual tissues. 'Hep.' = Heptachlor.

Lab #	Lipid	Methoxy DDT	DDT + dieldrin	pp-DDD	pp-DDT	Total DDT	Alpha BHC	Gamma BHC	Beta BHC	Delta BHC	Total BHC	Hep.	Hep. Epoxide	Total Hep.	Endrin	Endrin Aldehyde	Endrin ketone	Total Endrin	Total Pesticides
Muscle																			
IML-67	218	0.0008	0.1833	0.0210	0.0266	0.2309	0.0408	0.0014	0.0016	<0.000	0.0438	0.0013	0.0096	0.0109	0.0173	0.0026	0.0008	0.0206	0.3071
IML-68	170	0.0102	0.7186	0.0842	0.1061	0.9087	0.0298	0.0009	0.0019	<0.000	0.0326	0.0014	0.0248	0.0262	0.0395	0.0026	0.0025	0.0446	1.0223
IML-69	205	0.0009	0.0601	0.0236	0.0120	0.0857	0.0175	0.0022	0.0031	0.0009	0.0237	0.0003	0.0115	0.0118	0.0040	0.0009	0.0003	0.0052	0.1274
IML-70	208	0.0017	0.2777	0.0329	0.0533	0.3640	0.0371	<0.0002	0.0018	<0.000	0.0388	0.0023	0.0166	0.0189	0.0264	0.0017	0.0007	0.0288	0.4522
IML-71	172	0.0003	0.1729	0.0261	0.0396	0.2386	0.0386	0.0007	0.0009	<0.000	0.0403	0.0007	0.0057	0.0064	0.0123	0.0007	<0.000	0.0130	0.2987
IML-72	226	0.0071	0.4689	0.0544	0.1162	0.6295	0.0492	0.0018	0.0019	<0.000	0.0529	0.0021	0.0336	0.0357	0.0531	0.0038	0.0016	0.0585	0.7837
IML-73	162	0.0002	0.1057	0.0086	0.0089	0.1231	0.0352	0.0003	0.0010	<0.000	0.0365	0.0016	0.0064	0.0080	0.0091	0.0005	0.0002	0.0098	0.1777
IML-74	238	0.0022	0.2945	0.0265	0.0447	0.3657	0.0212	0.0005	0.0009	<0.000	0.0226	0.0011	0.0191	0.0202	0.0224	<0.0002	0.0012	0.0236	0.4342
log mean	-0.703	-2.847	-0.668	-1.544	-1.435	-0.544	-1.494	-3.164	-2.820	-3.865	-1.463	-2.929	-1.872	-1.828	-1.752	-2.982	-3.207	-1.701	-0.436
log SD	0.084	0.5784	0.3632	0.2930	0.4021	0.3411	0.1512	0.4448	0.1862	0.3352	0.1275	0.2683	0.2753	0.2583	0.3604	0.5101	0.4509	0.3454	0.3034
antilog mean	198	0.0014	0.2147	0.0286	0.0367	0.2866	0.0321	0.0007	0.0015	0.0001	0.0362	0.0012	0.0134	0.0148	0.0177	0.0010	0.0006	0.0199	0.3668
Viscera																			
IML-75		0.0013	0.0873	0.0199	0.0100	0.1172	0.0017	0.0008	0.0010	<0.000	0.0035	0.0005	0.0071	0.0076	0.0098	0.0013	0.0008	0.0119	0.1415
IML-76	70	0.0031	0.2976	0.0322	0.0080	0.3378	0.0126	0.0002	0.0006	<0.000	0.0134	0.0015	0.0073	0.0089	0.0028	<0.0002	0.0010	0.0038	0.3669
IML-77	153	0.0004	0.0390	0.0093	0.0082	0.0566	0.0162	0.0005	0.0012	<0.000	0.0179	0.0003	0.0045	0.0048	0.0033	<0.0002	<0.000	0.0033	0.0830
IML-78	128	0.0014	1.1941	0.0231	0.1790	1.3962	0.1308	0.0003	0.0010	<0.000	0.1321	0.0071	0.0088	0.0159	0.1095	<0.0002	0.0007	0.1102	1.6659
IML-79	88	0.0003	0.0485	0.0152	0.0087	0.0725	0.0130	0.0005	0.0005	<0.000	0.0140	0.0002	0.0027	0.0029	0.0084	0.0004	<0.000	0.0088	0.0985
IML-80	287	0.0007	0.4429	0.0221	0.0589	0.5238	0.0264	0.0006	0.0010	<0.000	0.0280	0.0021	0.0124	0.0146	0.0263	0.0017	0.0006	0.0286	0.5957
IML-81	84	0.0004	0.0363	0.0060	0.0044	0.0467	0.0219	0.0004	0.0006	<0.000	0.0229	0.0008	0.0039	0.0047	0.0128	0.0004	<0.000	0.0133	0.0879
IML-82	88	0.0012	0.1828	0.0163	0.0329	0.2320	0.0108	0.0003	0.0004	<0.000	0.0116	0.0008	0.0097	0.0105	0.0221	0.0009	0.0009	0.0239	0.2792
log mean	-0.942	-3.076	-0.845	-1.794	-1.767	-0.736	-1.805	-3.371	-3.132	-3.979	-1.738	-3.044	-2.198	-2.122	-1.901	-3.430	-3.424	-1.854	-0.623
log SD	0.212	0.3479	0.5531	0.2347	0.5483	0.5183	0.5215	0.1977	0.1712	0.0185	0.4379	0.4891	0.2257	0.2587	0.5150	0.5165	0.4402	0.4877	0.4629
antilog mean	114	0.0008	0.1428	0.0161	0.0175	0.1835	0.0157	0.0004	0.0007	<0.000	0.0183	0.0009	0.0063	0.0075	0.0125	0.0004	0.0004	0.0140	0.2383
Gonads																			
IML-83	284	0.0011	0.1600	0.0221	0.0236	0.2056	0.0383	0.0012	0.0015	0.0004	0.0414	0.0012	0.0081	0.0092	0.0179	0.0025	0.0009	0.0212	0.2786
IML-84	291	0.0039	0.4811	0.0610	0.0774	0.6094	0.0267	0.0011	0.0013	<0.000	0.0291	0.0010	0.0145	0.0155	0.0275	0.0020	0.0010	0.0306	0.6886
IML-85	377	0.0003	0.0474	0.0148	0.0119	0.0741	0.0203	0.0015	0.0022	<0.000	0.0240	0.0006	0.0090	0.0096	0.0053	0.0009	<0.000	0.0062	0.1142
IML-86	346	0.0036	0.2642	0.0441	0.0548	0.3631	0.0341	0.0008	0.0018	0.0016	0.0383	0.0009	0.0159	0.0168	0.0186	0.0020	0.0013	0.0219	0.4437
IML-87	258	0.0019	0.2045	0.0710	0.0482	0.3237	0.0423	0.0019	0.0017	<0.000	0.0459	0.0008	0.0079	0.0087	0.0136	0.0025	0.0004	0.0166	0.3967
IML-88	209	0.0005	0.1401	0.0121	0.0095	0.1617	0.0421	0.0013	0.0017	<0.000	0.0451	0.0024	0.0087	0.0111	0.0079	0.0008	<0.000	0.0087	0.2266
IML-89	326	0.1263	1.6626	1.8098	0.7886	4.2610	0.0621	0.0155	0.0525	0.0366	0.1668	0.0150	0.9063	0.9213	0.2915	0.0693	0.0740	0.4348	5.7838
log mean	-0.632	-2.603	-0.620	-1.278	-1.338	-0.446	-1.444	-2.741	-2.562	-3.353	-1.344	-2.817	-1.712	-1.670	-1.688	-2.563	-3.049	-1.606	-0.326
log SD	0.085	0.8554	0.4807	0.7346	0.6428	0.5564	0.1558	0.4265	0.5702	0.9519	0.2703	0.4746	0.7464	0.7291	0.5620	0.6548	0.9496	0.5986	0.5432
antilog mean	294	0.0025	0.2400	0.0528	0.0459	0.3578	0.0360	0.0018	0.0027	0.0004	0.0452	0.0015	0.0194	0.0214	0.0205	0.0027	0.0009	0.0248	0.4716

APPENDIX 6 (cont'd). The concentrations of pesticides (µg/g) and lipids (mg/g) in various tissues of eight eels captured at Kamouraska in 1990.

Lab #	Lipid	Methoxy DDT	DDT + dieldrin	pp-DDD	pp-DDT	Total DDT	Alpha BHC	Gamma BHC	Beta BHC	Delta BHC	Total BHC	Hep.	Hep. Epoxide	Total Hep.	Endrin	Endrin Aldehyde	Endrin ketone	Total Endrin	Total Pesticides
Head																			
IML-91	81	0.0007	0.0787	0.0137	0.0071	0.0996	0.0096	0.0002	0.0009	<0.000	0.0108	0.0004	0.0049	0.0053	0.0077	0.0012	0.0003	0.0093	0.1249
IML-92	104	0.0022	0.2732	0.0613	0.0584	0.3929	0.0134	0.0005	0.0008	<0.000	0.0148	0.0011	0.0112	0.0123	0.0277	<0.0002	0.0009	0.0287	0.4487
IML-93	136	0.0003	0.0414	0.0091	0.0082	0.0587	0.0139	0.0007	0.0012	<0.000	0.0158	0.0002	0.0047	0.0049	0.0040	0.0002	<0.000	0.0043	0.0838
IML-94	95	0.0019	0.2270	0.0298	0.0434	0.3002	0.0260	0.0005	0.0012	<0.000	0.0277	0.0007	0.0118	0.0124	0.0209	0.0003	0.0003	0.0227	0.3629
IML-95	76	0.0009	0.0974	0.0336	0.0238	0.1546	0.0174	0.0005	0.0009	<0.000	0.0188	0.0006	0.0056	0.0061	0.0147	0.0003	<0.000	0.0153	0.1949
IML-96	122	0.0035	0.1902	0.0408	0.0696	0.3007	0.0196	0.0003	0.0011	<0.000	0.0211	0.0009	0.0235	0.0244	0.0322	<0.0002	0.0015	0.0337	0.3799
IML-97	127	<0.0002	0.0450	0.0081	0.0050	0.0581	0.0196	0.0006	0.0010	<0.000	0.0212	0.0011	0.0057	0.0069	0.0076	0.0008	<0.000	0.0084	0.0946
IML-98	81	0.0008	0.0962	0.0313	0.0378	0.1652	0.0173	0.0007	0.0010	<0.000	0.0190	0.0006	0.0049	0.0054	0.0130	0.0015	0.0009	0.0153	0.2060
log mean	-0.998	-3.086	-0.974	-1.638	-1.667	-0.814	-1.783	-3.317	-3.002	-3.974	-1.742	-3.218	-2.118	-2.081	-1.886	-3.336	-3.397	-1.842	-0.699
log SD	0.099	0.6036	0.3090	0.3201	0.4496	0.3220	0.1304	0.1733	0.0623	0.0167	0.1222	0.2298	0.2545	0.2467	0.3107	0.4543	0.4896	0.2969	0.2828
antilog mean	101	0.0008	0.1062	0.0230	0.0215	0.1535	0.0165	0.0005	0.0010	<0.000	0.0181	0.0006	0.0076	0.0083	0.0130	0.0005	0.0004	0.0144	0.2000
Whole body																			
	202	0.0008	0.1695	0.0203	0.0242	0.2140	0.0367	0.0012	0.0015	0.0001	0.0395	0.0012	0.0090	0.0102	0.0162	0.0024	0.0007	0.0193	0.2831
	167	0.0090	0.6529	0.0787	0.0972	0.8288	0.0276	0.0009	0.0017	0.0001	0.0303	0.0014	0.0225	0.0239	0.0366	0.0023	0.0022	0.0411	0.9240
	205	0.0008	0.0487	0.0214	0.0115	0.0816	0.0173	0.0019	0.0028	0.0008	0.0228	0.0003	0.0105	0.0109	0.0041	0.0008	0.0003	0.0052	0.1204
	202	0.0018	0.3002	0.0328	0.0563	0.3893	0.0388	0.0001	0.0017	0.0001	0.0408	0.0022	0.0158	0.0181	0.0280	0.0015	0.0008	0.0304	0.4785
	164	0.0005	0.1635	0.0286	0.0375	0.2296	0.0360	0.0008	0.0009	0.0001	0.0379	0.0007	0.0057	0.0064	0.0125	0.0008	0.0001	0.0133	0.2872
	208	0.0063	0.4112	0.0494	0.1043	0.5648	0.0434	0.0016	0.0017	0.0001	0.0467	0.0019	0.0303	0.0322	0.0477	0.0032	0.0015	0.0524	0.6961
	158	0.0002	0.0996	0.0086	0.0084	0.1166	0.0337	0.0003	0.0010	0.0001	0.0352	0.0016	0.0064	0.0080	0.0090	0.0006	0.0002	0.0098	0.1695
	223	0.0081	0.3400	0.1139	0.0801	0.5339	0.0225	0.0012	0.0034	0.0019	0.0290	0.0017	0.0610	0.0627	0.0347	0.0036	0.0047	0.0430	0.6687
log mean	-0.722	-2.774	-0.679	-1.476	-1.424	-0.543	-1.512	-3.116	-2.769	-3.709	-1.462	-2.922	-1.831	-1.789	-1.738	-2.807	-3.161	-1.680	-0.431
log SD	0.057	0.6014	0.3633	0.3557	0.4190	0.3516	0.1354	0.4061	0.1911	0.5011	0.0994	0.2672	0.3557	0.3372	0.3640	0.3086	0.6450	0.3562	0.3161
antilog mean	190	0.0017	0.2093	0.0334	0.0376	0.2866	0.0308	0.0008	0.0017	0.0002	0.0345	0.0012	0.0148	0.0162	0.0183	0.0016	0.0007	0.0209	0.3709

APPENDIX 7. The concentrations of metals (µg/g) in three tissues of eight eels captured at Kamouraska in 1990. Data for metal levels in the head were missing and therefore, whole body levels were not calculated.

Fish #	Lab #	Cadmium	Copper	Chromium	Zinc	Mercury
Detection Limits		0.010	0.070	0.010	3.000	0.005
Muscle						
1	IML-67	0.032	0.256	<0.010	48.818	0.202
2	IML-68	0.047	0.231	<0.010	40.229	0.248
3	IML-69	0.011	0.189	<0.010	29.800	0.063
4	IML-70	0.027	0.233	<0.010	40.748	0.243
5	IML-71	0.018	0.343	<0.010	36.600	0.422
6	IML-72	0.046	0.223	<0.010	42.631	0.240
7	IML-73	0.038	0.252	<0.010	44.672	0.295
8	IML-74	0.030	0.271	<0.010	31.600	0.230
	log mean	-1.523	-0.608	-2.000	1.590	-0.660
	log SD	0.168	0.075	0.000	0.073	0.239
	antilog mean	0.030	0.246	<0.010	38.909	0.219
Viscera						
1	IML-75	0.425	31.316	0.092	80.416	0.140
2	IML-76	0.906	28.266	0.022	80.497	0.259
3	IML-77	0.430	17.552	0.039	94.185	0.035
4	IML-78	0.540	35.093	0.008	112.656	0.079
5	IML-79	0.305	24.309	<0.010	68.181	0.400
6	IML-80	0.630	30.107	0.014	113.102	0.106
7	IML-81	0.402	20.748	0.007	58.238	0.140
8	IML-82	0.896	38.807	<0.010	94.295	0.148
	log mean	-0.276	1.438	-1.778	1.933	-0.882
	log SD	0.170	0.116	0.388	0.101	0.319
	antilog mean	0.530	27.438	0.017	85.696	0.131
Gonad						
1	IML-83	0.016	0.700	0.023	96.552	0.027
2	IML-84	0.019	0.510	<0.010	110.400	0.021
3	IML-85	0.016	0.310	0.008	49.982	0.062
4	IML-86	0.016	0.452	0.005	78.452	0.022
5	IML-87	0.056	1.046	0.010	135.400	0.042
6	IML-88	0.015	0.448	0.007	45.832	0.012
7	IML-89	0.014	11.933	0.044	119.816	0.013
8	IML-90	0.038	0.591	<0.010	112.691	0.015
	log mean	-1.683	-0.098	-1.947	1.943	-1.637
	log SD	0.221	0.499	0.301	0.177	0.248
	antilog mean	0.021	0.798	0.011	87.709	0.023

APPENDIX 8. The concentrations (µg/kg) of 88 PCB congeners in the muscle of eight fish from Kamouraska. The congeners are identified by the numbering scheme of both Schultz et al. (1989) and IUPAC (Mullin et al. 1984). The detection limit was 0.01 µg/g.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
1	10/4	16.02	15.81	3.58	19.34	18.61	29.81	12.44	7.46	1.1195	0.2857	13.17
2	7/9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
3	6	0.09	0.25	0.04	0.15	0.09	0.27	0.07	0.11	-0.9497	0.2786	0.11
4	8/5	1.63	2.35	0.63	1.41	1.26	3.28	0.49	1.72	0.1342	0.2748	1.36
5	19	0.25	0.42	0.11	0.29	0.20	0.53	0.05	0.23	-0.6736	0.3266	0.21
6	18/17/15	2.38	3.42	0.92	2.05	1.84	4.78	0.71	2.50	0.2974	0.2751	1.98
7	24/27	0.08	0.04	0.03	0.08	0.13	0.12	0.07	0.19	-1.0997	0.2651	0.08
8	16/32	0.13	0.12	0.03	0.07	0.07	0.10	0.10	0.05	-1.1176	0.2140	0.08
9	34	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
10	29	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
11	26	5.76	19.56	0.62	9.20	0.01	0.33	0.01	12.75	-0.0710	1.3433	0.85
12	25	0.01	0.01	0.01	0.01	2.25	18.80	1.15	5.26	-0.6990	1.4324	0.20
13	31/28	17.31	5.22	1.29	3.36	2.83	6.58	2.03	1.77	0.5523	0.3639	3.57
14	20/33/53	0.08	0.43	0.02	0.01	0.01	0.17	0.07	0.01	-1.3859	0.6308	0.04
15	51/22	0.05	0.27	0.02	0.01	0.01	0.11	0.05	0.01	-1.4785	0.5379	0.03
16	45	0.41	0.30	0.08	0.32	0.20	0.44	0.50	5.13	-0.3935	0.5131	0.40
17	46	0.01	0.01	0.09	0.42	0.13	1.19	0.01	0.01	-1.2791	0.8398	0.05
18	69	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
19	52	33.53	20.10	2.46	11.55	12.70	22.62	7.21	12.50	1.0869	0.3482	12.22
20	49	5.98	3.34	0.42	2.21	0.62	4.03	1.21	8.05	0.3318	0.4620	2.15
21	47/48/75	33.00	8.23	0.84	3.86	6.29	9.03	3.53	0.01	0.4059	1.0709	2.55
22	35	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
23	44	9.88	18.04	0.82	7.74	5.57	15.46	2.41	8.14	0.7852	0.4438	6.10
24	37/59/42	4.65	0.01	0.41	1.61	0.01	3.09	0.75	1.12	-0.3873	1.0485	0.41
25	41/64	31.94	12.13	1.15	6.17	7.21	12.80	3.74	6.22	0.8464	0.4235	7.02
26	96	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
27	40	1.69	1.12	0.29	0.64	0.44	1.04	0.41	0.44	-0.1922	0.2645	0.64
28	100/67	13.26	24.37	1.85	13.99	6.94	31.46	8.47	15.08	1.0460	0.3810	11.12
29	63	13.23	50.22	9.58	24.72	7.82	45.30	2.75	26.68	1.2015	0.4266	15.90
30	74	19.97	7.58	0.72	3.86	4.51	8.00	2.34	3.89	0.6425	0.4233	4.39
31	70	5.00	5.07	0.80	4.98	1.55	6.88	1.28	1.02	0.3935	0.3764	2.47
32	66/95	49.32	35.60	3.43	20.65	13.70	44.34	9.09	14.44	1.2495	0.3902	17.76
33	88	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
34	91	6.33	3.52	0.36	2.40	1.38	5.52	2.08	2.89	0.3682	0.3931	2.33
35	60/56/92/84	42.08	43.88	3.27	23.99	21.78	50.07	10.01	19.43	1.3109	0.3956	20.46
38	90/101	54.78	65.58	4.28	36.41	18.98	68.92	16.00	28.85	1.4411	0.4036	27.61
39	99	44.54	40.59	2.36	20.64	22.64	44.80	7.98	34.86	1.2994	0.4504	19.93
40	119	29.07	99.58	6.53	50.29	26.89	94.01	34.13	53.60	1.5804	0.3761	38.05
41	83	5.23	11.48	1.05	4.69	3.13	12.13	1.72	3.32	0.6009	0.3683	3.99
42	97	6.20	7.81	0.76	4.12	1.40	9.55	1.72	2.42	0.4908	0.3918	3.10
43	87/115	34.26	20.20	2.43	10.39	14.85	20.11	5.05	0.19	0.8374	0.7288	6.88
44	85	25.12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-1.5750	1.2021	0.03
45	136	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
46	77/110	58.86	34.70	4.16	17.84	25.51	34.55	8.67	0.32	1.0711	0.7316	11.78
47	82/151	5.19	13.74	0.63	7.24	3.69	13.94	1.01	3.56	0.5974	0.4878	3.96
48	135	25.79	15.20	1.83	7.82	11.18	15.14	3.80	0.15	0.7167	0.7225	5.21
49	107	4.14	9.68	0.27	6.25	2.18	13.39	1.67	3.13	0.5017	0.5312	3.17
50	123/149/118	133.23	104.16	9.16	51.06	64.24	101.11	28.80	35.97	1.7050	0.3797	50.70

APPENDIX 8 (cont'd). The concentrations (µg/kg) of 88 PCB congeners in the muscle of eight fish from Kamouraska.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
51	134	8.45	15.14	0.85	2.94	4.11	5.62	0.01	6.85	0.3380	1.0141	2.18
52	114/131/122	0.01	0.01	0.01	38.60	26.55	78.10	11.52	0.01	-0.2544	1.8798	0.56
53	146	16.43	20.00	0.98	10.21	12.60	21.06	3.63	6.25	0.9121	0.4540	8.17
54	132/153/105	107.15	158.35	10.41	80.33	98.48	150.74	38.89	69.30	1.8443	0.3867	69.87
55	141/179	16.67	25.74	0.11	9.68	17.12	19.26	3.97	8.42	0.8378	0.7696	6.88
56	130	4.03	5.86	0.63	3.52	3.35	7.93	0.74	2.95	0.4353	0.3966	2.72
57	176/137	4.74	7.32	0.04	2.76	4.87	5.48	1.13	2.40	0.3054	0.7341	2.02
58	160/138/158	54.05	70.93	0.62	31.71	43.06	58.98	22.01	29.95	1.3876	0.6664	24.41
59	129/126/178	25.91	39.69	2.39	21.53	20.61	47.10	5.43	17.36	1.2106	0.4393	16.24
60	175	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
61	187	24.28	24.82	1.78	10.12	18.51	20.08	5.62	5.52	1.0122	0.4066	10.28
62	183	7.13	10.18	0.63	4.83	6.74	10.21	1.53	3.40	0.6122	0.4266	4.09
63	128	27.03	63.38	2.18	31.35	14.66	62.69	9.01	25.34	1.2988	0.4822	19.90
64	167	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
65	185	1.91	3.71	0.19	2.28	2.04	5.01	0.54	1.22	0.1644	0.4629	1.46
66	174	6.65	10.23	0.70	4.85	7.90	10.31	1.77	2.64	0.6180	0.4153	4.15
67	177	11.41	10.45	0.68	3.70	8.19	7.39	2.31	1.48	0.5991	0.4449	3.97
68	202/171/156	31.52	35.93	2.00	18.11	25.79	37.28	6.70	14.56	1.1981	0.4393	15.78
69	173/157/201	12.96	15.90	1.20	7.10	8.30	16.78	2.42	4.41	0.8021	0.4094	6.34
70	172	3.97	6.10	0.37	2.70	3.87	6.03	0.92	1.93	0.3751	0.4241	2.37
71	197	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
72	180	21.20	29.25	1.85	14.01	22.18	27.39	5.81	1.65	0.9964	0.5157	9.92
73	193	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
74	191	1.19	1.97	0.07	0.77	1.56	1.67	0.35	0.77	-0.1315	0.4793	0.74
75	200	1.45	3.96	0.17	2.06	1.05	5.92	0.26	1.84	0.0971	0.5356	1.25
76	169	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
77	170/1290	22.02	46.34	1.46	23.57	24.79	43.41	6.30	23.68	1.2189	0.5010	16.55
78	198	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
79	199	5.76	5.16	0.37	2.20	4.91	4.15	1.29	1.58	0.3753	0.4096	2.37
80	203/196	7.00	7.21	0.41	3.67	6.21	7.50	1.33	3.41	0.5257	0.4476	3.35
81	189	0.56	0.14	0.04	0.16	0.51	0.62	0.13	0.08	-0.7228	0.4338	0.19
82	208/195	3.16	3.09	0.19	1.59	2.92	3.43	0.71	1.58	0.1900	0.4353	1.55
83	207	0.76	0.89	0.05	0.60	0.68	1.14	0.13	0.72	-0.3540	0.4770	0.44
84	194	4.62	5.39	0.29	2.71	4.30	5.07	1.07	0.58	0.3029	0.4891	2.01
85	205	0.55	0.57	0.03	0.30	0.36	0.65	0.13	0.19	-0.5985	0.4459	0.25
86	206	2.93	1.82	0.09	0.93	1.89	1.96	0.71	1.01	0.0092	0.4726	1.02
87	209	0.87	1.21	0.10	0.62	0.98	1.32	0.24	0.71	-0.2303	0.3874	0.59
88	TOTAL PCB	1176.15	1334.19	97.52	720.65	711.25	1427.39	319.51	564.57	2.79	0.39	613.99

APPENDIX 11. The concentrations (µg/kg) of 88 PCB congeners in the heads of eight fish from Kamouraska. The congeners are identified by the numbering scheme of both Schultz et al. (1989) and IUPAC (Mullin et al. 1984). The detection limit was 0.01 µg/g.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
1	10/4	2.76	4.56	4.10	8.31	6.57	7.91	9.11	5.45	0.7555	0.1780	5.69
2	7/9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
3	6	0.05	0.29	0.06	0.11	0.05	0.10	0.01	0.04	-1.2148	0.4201	0.06
4	8/5	0.55	0.01	0.83	1.15	0.75	1.16	0.18	0.69	-0.4058	0.6929	0.39
5	19	0.04	0.36	0.06	0.21	0.05	0.36	0.01	0.04	-1.1105	0.5453	0.08
6	18/17/15	0.80	0.01	1.21	1.67	1.09	1.69	0.26	1.00	-0.2639	0.7468	0.54
7	24/27	0.06	0.01	0.03	0.06	0.03	0.04	0.01	0.03	-1.5513	0.3037	0.03
8	16/32	0.06	0.06	0.04	0.09	0.07	0.09	0.06	0.07	-1.1831	0.1134	0.07
9	34	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
10	29	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
11	26	2.10	10.94	0.62	6.98	1.59	0.15	0.01	1.71	-0.0490	0.9778	0.89
12	25	0.01	0.01	0.01	0.01	0.01	9.95	0.79	0.01	-1.3881	1.1706	0.04
13	31/28	4.70	1.91	1.38	2.73	1.62	2.97	1.15	1.89	0.3186	0.1986	2.08
14	20/33/53	0.03	0.43	0.05	0.20	0.20	0.22	0.05	0.11	-0.9382	0.4010	0.12
15	51/22	0.02	0.27	0.03	0.13	0.13	0.14	0.03	0.07	-1.1368	0.4041	0.07
16	45	0.08	0.01	0.08	0.28	0.12	0.20	0.25	0.30	-0.9364	0.4883	0.12
17	46	0.01	0.01	0.12	0.01	0.01	0.20	0.01	0.13	-1.5632	0.6062	0.03
18	69	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
19	52	11.71	10.04	2.55	9.12	6.29	9.69	3.95	9.17	0.8476	0.2322	7.04
20	49	1.95	0.01	0.41	1.92	0.01	2.03	0.80	1.00	-0.4504	0.9853	0.35
21	47/48/75	11.75	5.04	0.84	3.04	3.32	4.92	2.42	2.79	0.5278	0.3263	3.37
22	35	0.01	0.01	0.01	0.01	0.01	1.08	1.43	2.03	-1.1880	1.1231	0.06
23	44	3.67	8.42	0.74	6.07	2.41	6.47	1.33	3.79	0.5047	0.3628	3.20
24	37/59/42	1.53	0.01	0.32	1.16	0.01	1.15	0.33	0.78	-0.5968	0.9009	0.25
25	41/64	12.64	7.89	1.14	4.83	3.72	5.21	2.19	4.09	0.6224	0.3207	4.19
26	96	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
27	40	0.37	0.59	0.30	0.53	0.22	0.29	0.27	0.37	-0.4569	0.1462	0.35
28	100/67	4.04	50.37	1.48	10.81	13.01	11.86	4.54	3.38	0.8609	0.4692	7.26
29	63	4.22	29.89	10.60	19.59	3.14	7.10	0.51	1.45	0.7044	0.5858	5.06
30	74	7.90	4.94	0.72	3.02	2.33	3.26	1.37	2.56	0.4193	0.3196	2.63
31	70	1.72	2.09	0.83	3.88	0.57	3.47	0.67	1.04	0.1504	0.3190	1.41
32	66/95	16.82	17.57	3.53	15.97	6.24	22.24	5.09	13.32	1.0244	0.2966	10.58
33	88	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
34	91	2.33	4.52	0.40	1.95	1.07	2.21	0.94	0.54	0.1242	0.3535	1.33
35	60/56/92/84	14.18	20.83	3.53	17.00	9.55	22.69	6.38	16.56	1.0760	0.2801	11.91
38	90/101	19.02	32.01	4.14	28.45	8.55	33.18	8.97	25.46	1.2084	0.3342	16.16
39	99	16.12	22.39	2.44	16.81	14.71	21.43	3.92	11.05	1.0382	0.3556	10.92
40	119	10.40	57.38	6.20	40.33	0.01	15.36	6.25	3.22	0.7080	1.1724	5.10
41	83	1.75	0.01	1.10	2.72	13.27	4.61	0.74	2.64	0.0996	0.9309	1.26
42	97	2.07	3.84	0.70	3.36	0.59	4.85	0.95	1.69	0.2417	0.3485	1.74
43	87/115	12.13	12.55	2.63	8.33	5.30	9.82	2.55	6.17	0.8045	0.2742	6.38
44	85	7.06	0.01	0.01	0.01	0.01	0.01	0.01	3.35	-1.3283	1.2468	0.05
45	136	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
46	77/110	20.84	21.55	4.51	14.31	9.10	16.87	4.37	10.59	1.0392	0.2745	10.94
47	82/151	1.57	7.28	0.67	5.47	0.01	6.51	0.66	4.55	0.1142	0.9547	1.30
48	135	9.13	9.44	1.98	6.27	3.99	7.39	1.92	4.64	0.6811	0.2741	4.80
49	107	1.07	5.18	0.31	4.76	1.80	3.00	0.64	1.60	0.2069	0.4240	1.61
50	123/149/118	48.79	54.43	9.50	42.43	31.18	56.20	16.86	37.00	1.5085	0.2729	32.25

APPENDIX 11 (cont'd). The concentrations (ug/kg) of 88 PCB congeners in the heads of eight fish from Kamouraska.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
51	134	2.00	0.01	0.01	1.25	2.87	3.13	0.97	3.92	-0.2586	1.0937	0.55
52	114/131/122	0.01	35.28	3.97	22.49	0.01	56.03	14.95	47.31	0.5120	1.5913	3.25
53	146	4.12	10.35	1.11	7.73	5.41	12.18	2.65	6.87	0.7053	0.3413	5.07
54	132/153/105	35.00	80.16	11.17	65.27	48.18	86.90	19.89	60.36	1.6265	0.3130	42.32
55	141/179	3.93	14.21	1.54	9.07	7.50	9.89	2.25	9.37	0.7608	0.3439	5.76
56	130	0.67	0.01	0.76	2.61	0.01	5.40	0.62	3.75	-0.3472	1.0799	0.45
57	176/137	1.12	4.04	0.44	2.58	2.14	2.82	0.65	2.67	0.2163	0.3425	1.65
58	160/138/158	21.07	35.37	4.93	34.14	24.45	33.70	11.82	27.36	1.3155	0.2961	20.68
59	129/126/178	5.73	20.44	2.48	11.90	8.56	26.35	3.42	15.84	0.9532	0.3681	8.98
60	175	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
61	187	6.60	12.05	1.82	6.74	7.94	11.01	2.84	4.11	0.7498	0.2865	5.62
62	183	1.90	5.08	0.67	3.14	2.79	5.15	0.77	2.36	0.3406	0.3343	2.19
63	128	8.03	34.89	2.34	26.01	12.72	28.69	4.01	9.17	1.0449	0.4204	11.09
64	167	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
65	185	0.60	0.01	0.20	1.63	0.01	2.67	0.25	1.91	-0.5754	0.9679	0.27
66	174	1.76	5.38	0.73	3.73	3.29	5.09	0.87	2.77	0.3772	0.3313	2.38
67	177	2.92	5.28	0.73	2.86	3.50	3.48	1.17	1.59	0.3579	0.2868	2.28
68	202/171/156	8.17	18.06	0.98	14.70	11.31	17.72	3.14	13.50	0.9071	0.4448	8.07
69	173/157/201	3.53	8.35	1.03	5.59	3.40	19.98	2.59	10.74	0.6883	0.4012	4.88
70	172	1.03	3.14	0.37	2.17	1.67	3.03	0.39	2.25	0.1327	0.3739	1.36
71	197	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
72	180	6.64	17.01	2.04	11.23	11.59	15.08	2.74	12.30	0.8979	0.3466	7.90
73	193	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
74	191	0.18	1.17	0.14	0.66	0.77	0.99	0.14	0.99	-0.3359	0.4072	0.46
75	200	0.30	2.33	0.17	1.62	0.37	3.27	0.18	2.33	-0.1263	0.5422	0.75
76	169	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
77	170/1290	5.75	23.12	1.64	18.77	11.26	22.68	2.92	15.69	0.9600	0.4346	9.12
78	198	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
79	199	1.32	3.00	0.40	1.67	2.28	2.08	0.62	1.07	0.1150	0.2970	1.30
80	203/196	1.56	3.52	0.47	2.86	2.44	4.62	0.61	0.81	0.2017	0.3727	1.59
81	189	0.13	0.43	0.04	0.21	0.26	0.28	0.06	0.39	-0.7621	0.3769	0.17
82	208/195	0.71	1.57	0.21	1.20	1.30	1.53	0.26	1.14	-0.0976	0.3469	0.80
83	207	0.13	1.28	0.08	0.50	0.46	0.32	0.02	0.17	-0.6847	0.5577	0.21
84	194	0.99	2.78	0.36	2.26	1.94	2.13	0.38	1.89	0.1028	0.3543	1.27
85	205	0.09	0.05	0.04	0.04	0.32	0.23	0.02	0.31	-1.0604	0.4623	0.09
86	206	0.69	0.95	0.14	0.70	0.97	0.86	0.17	0.71	-0.2737	0.3379	0.53
87	209	0.20	0.63	0.12	0.52	0.47	0.63	0.09	0.24	-0.5373	0.3324	0.29
88	TOTAL PCB	382.25	756.40	110.64	559.23	332.18	695.29	172.74	449.55	2.5633	0.2921	365.84

APPENDIX 12. The calculated concentrations (µg/kg) of 88 PCB congeners in the whole bodies of eight fish from Kamouraska. The congeners are identified by the numbering scheme of both Schultz et al. (1989) and IUPAC (Mullin et al. 1984). The detection limit was 0.01 µg/g.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
1	10/4	14.64	14.34	3.95	18.51	16.70	27.99	12.16	7.28	1.1004	0.2622	12.60
2	7/9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
3	6	0.09	0.25	0.04	0.16	0.09	0.27	0.06	0.10	-0.9597	0.2891	0.11
4	8/5	1.51	2.07	0.66	1.58	1.20	3.09	0.46	1.72	0.1226	0.2671	1.33
5	19	0.22	0.39	0.10	0.32	0.18	0.52	0.05	0.20	-0.6988	0.3284	0.20
6	18/17/15	2.21	3.02	0.95	2.30	1.74	4.50	0.67	2.50	0.2852	0.2680	1.93
7	24/27	0.08	0.06	0.03	0.10	0.11	0.11	0.06	0.16	-1.0971	0.2239	0.08
8	16/32	0.12	0.11	0.03	0.08	0.07	0.10	0.09	0.05	-1.1251	0.2008	0.07
9	34	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
10	29	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
11	26	5.35	18.33	0.63	10.02	0.32	2.17	0.13	12.26	0.3545	0.8010	2.26
12	25	0.01	0.12	0.01	0.42	1.88	16.53	1.03	4.38	-0.3939	1.1784	0.40
13	31/28	15.87	4.68	1.33	3.65	2.71	6.22	1.91	1.69	0.5366	0.3520	3.44
14	20/33/53	0.07	0.43	0.03	0.11	0.03	0.18	0.06	0.06	-1.0893	0.3916	0.08
15	51/22	0.05	0.26	0.02	0.07	0.02	0.11	0.04	0.04	-1.2742	0.3744	0.05
16	45	0.39	0.41	0.08	0.90	0.29	0.45	0.49	4.32	-0.3122	0.4858	0.49
17	46	0.02	0.01	0.10	0.38	0.12	1.08	0.01	0.02	-1.2132	0.7582	0.06
18	69	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
19	52	30.97	18.62	2.50	12.65	12.03	21.46	6.87	12.55	1.0761	0.3366	11.91
20	49	6.35	3.13	0.40	3.49	0.56	3.85	1.15	6.82	0.3339	0.4715	2.16
21	47/48/75	30.01	7.58	0.86	3.68	5.96	8.67	3.42	0.83	0.6280	0.5208	4.25
22	35	0.01	0.01	0.01	0.01	0.01	0.10	0.13	0.19	-1.5759	0.5901	0.03
23	44	9.10	16.53	0.82	8.75	5.20	14.66	2.33	8.22	0.7747	0.4379	5.95
24	37/59/42	4.22	0.07	0.40	1.51	0.01	2.92	0.71	1.03	-0.3024	0.8801	0.50
25	41/64	29.65	11.44	1.19	7.06	6.82	12.13	3.60	5.66	0.8352	0.4104	6.84
26	96	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
27	40	1.54	1.02	0.30	0.71	0.41	1.02	0.41	0.41	-0.2036	0.2533	0.63
28	100/67	12.10	25.90	1.84	14.92	7.27	29.70	8.12	14.55	1.0427	0.3801	11.03
29	63	12.14	47.26	9.86	27.40	7.19	41.86	2.55	26.31	1.1869	0.4326	15.38
30	74	18.54	7.15	0.75	4.41	4.27	7.59	2.25	3.54	0.6317	0.4095	4.28
31	70	4.62	4.60	0.80	5.38	1.44	6.57	1.22	0.98	0.3768	0.3759	2.38
32	66/95	45.35	33.09	3.47	22.54	12.83	42.42	8.86	14.95	1.2397	0.3812	17.37
33	88	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
34	91	5.86	3.64	0.39	2.95	1.31	5.22	1.97	2.95	0.3736	0.3802	2.36
35	60/56/92/84	38.73	40.58	3.37	25.60	20.32	47.68	9.63	19.72	1.2996	0.3835	19.94
38	90/101	50.47	60.91	4.32	39.22	17.82	65.83	15.27	29.39	1.4298	0.3970	26.90
39	99	40.64	38.58	2.66	22.62	20.63	42.80	7.76	34.88	1.2941	0.4281	19.68
40	119	26.79	93.68	6.64	55.32	23.90	87.27	31.37	50.67	1.5606	0.3718	36.36
41	83	4.83	10.04	1.00	4.31	3.94	11.45	1.60	3.08	0.5834	0.3600	3.83
42	97	5.72	7.12	0.76	4.51	1.30	9.15	1.65	2.22	0.4730	0.3886	2.97
43	87/115	31.56	19.73	2.42	11.73	13.74	19.18	4.78	1.55	0.9422	0.4708	8.75
44	85	22.98	0.01	0.01	0.01	0.01	0.01	0.01	0.30	-1.3952	1.2279	0.04
45	136	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
46	77/110	54.23	33.89	4.15	20.15	23.60	32.95	8.20	2.66	1.1770	0.4711	15.03
47	82/151	4.76	13.40	0.66	7.50	3.31	13.20	0.96	5.43	0.6071	0.4848	4.05
48	135	23.76	14.85	1.82	8.83	10.34	14.44	3.60	1.17	0.8190	0.4706	6.59
49	107	3.76	8.70	0.30	6.55	2.12	12.44	1.57	2.87	0.4854	0.5101	3.06
50	123/149/118	122.54	97.59	9.12	56.31	60.68	97.04	27.30	38.34	1.6973	0.3698	49.80

APPENDIX 12 (cont'd). The calculated concentrations (μg/kg) of 88 PCB congeners in the whole bodies of eight fish from Kamouraska.

Congener #		Fish #										
		1	2	3	4	5	6	7	8			antilog
Schultz	IUPAC	IML-67	IML-68	IML-69	IML-70	IML-71	IML-72	IML-73	IML-74	log mean	log SD	mean
51	134	7.71	13.31	0.77	3.72	3.94	5.40	0.09	6.09	0.4419	0.6997	2.77
52	114/131/122	0.38	6.13	0.67	35.63	22.21	76.17	11.90	9.14	0.8762	0.8042	7.52
53	146	14.73	18.35	1.03	11.01	11.58	20.24	3.51	6.02	0.8977	0.4381	7.90
54	132/153/105	98.32	148.71	10.62	88.40	92.20	145.14	36.42	74.26	1.8370	0.3789	68.71
55	141/179	14.96	24.00	0.34	11.07	15.94	18.48	3.77	9.06	0.8917	0.6016	7.79
56	130	3.62	5.15	0.62	3.31	2.98	7.70	0.72	2.89	0.4077	0.3865	2.56
57	176/137	4.25	6.82	0.10	3.15	4.53	5.25	1.08	2.58	0.3477	0.5965	2.23
58	160/138/158	49.13	66.48	1.27	36.43	40.83	57.04	20.79	32.44	1.4219	0.5550	26.42
59	129/126/178	23.41	37.16	2.42	22.57	18.84	45.32	5.17	18.07	1.1973	0.4325	15.75
60	175	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
61	187	21.94	23.08	1.81	10.92	17.12	19.27	5.24	5.72	0.9994	0.3917	9.99
62	183	6.44	9.43	0.64	5.19	6.23	9.76	1.43	3.47	0.5980	0.4171	3.96
63	128	24.61	59.40	2.23	34.61	14.80	59.83	8.37	25.16	1.2904	0.4769	19.52
64	167	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
65	185	1.74	3.31	0.20	2.13	1.80	4.79	0.49	1.19	0.1364	0.4481	1.37
66	174	6.03	9.59	0.72	5.25	7.32	9.86	1.66	2.84	0.6089	0.4026	4.06
67	177	10.30	9.56	0.70	4.06	7.60	7.04	2.16	1.43	0.5831	0.4295	3.83
68	202/171/156	28.44	33.83	1.94	19.90	23.97	35.56	6.23	15.53	1.1858	0.4364	15.34
69	173/157/201	11.70	15.04	1.19	7.92	7.67	17.03	2.36	4.78	0.7985	0.4034	6.29
70	172	3.58	5.59	0.37	2.96	3.59	5.77	0.85	2.15	0.3649	0.4161	2.32
71	197	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.01	-1.9247	0.2129	0.01
72	180	19.02	27.51	1.87	16.01	20.82	26.34	5.42	4.15	1.0358	0.4355	10.86
73	193	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
74	191	1.07	1.81	0.09	0.94	1.41	1.61	0.33	0.75	-0.1295	0.4375	0.74
75	200	1.31	4.25	0.17	2.11	0.94	5.66	0.25	1.96	0.0896	0.5421	1.23
76	169	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
77	170/1290	19.81	43.11	1.50	25.93	23.00	41.65	5.86	23.72	1.2057	0.4945	16.06
78	198	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-2.0000	0.0000	0.01
79	199	5.14	4.83	0.38	2.51	4.54	3.97	1.19	1.62	0.3644	0.3941	2.31
80	203/196	6.24	6.70	0.42	4.06	5.69	7.25	1.23	3.32	0.5099	0.4370	3.24
81	189	0.50	0.17	0.04	0.22	0.48	0.59	0.12	0.11	-0.6942	0.4027	0.20
82	208/195	2.80	2.89	0.20	1.76	2.69	3.26	0.65	1.64	0.1782	0.4203	1.51
83	207	0.67	0.92	0.05	0.65	0.64	1.06	0.12	0.72	-0.3663	0.4770	0.43
84	194	4.11	5.01	0.29	3.05	3.97	4.80	0.98	0.95	0.3137	0.4514	2.06
85	205	0.49	0.51	0.03	0.28	0.35	0.62	0.12	0.20	-0.6202	0.4337	0.24
86	206	2.61	1.71	0.10	1.04	1.76	1.85	0.63	1.08	0.0015	0.4474	1.00
87	209	0.77	1.13	0.10	0.69	0.89	1.25	0.22	0.70	-0.2485	0.3810	0.56
88	TOTAL PCB	1076.96	1258.41	100.97	783.50	662.13	1363.81	302.95	589.08	2.7797	0.3775	602.13