Fisheries and Environment Canada

POLYCHLORINATED BIPHENYLS IN THE QUEBEC ENVIRONMENT

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PREFACE

After the Environmental Contaminants Act was proclaimed on April 1, 1976, the Quebec Region of the Department of Fisheries and the Environment established the Regional Contaminants Committee, on which are represented the Environmental Protection Service, the Environmental Management Service, the Fisheries and Marine Service and the Atmospheric Environment Service.

This report was prepared for the Committee by the Environmental Management Service and the Fisheries and Marine Service, as a compilation of the available data on levels of polychlorinated biphenyls in the Quebec environment.

Part of the report was prepared with the assistance of Mr Jacques Belanger of Dimension Environnement in Montreal.

We wish to thank the federal and provincial officials who graciously provided us with the most recent data available from their departments.

TABLE OF CONTENTS

PART I CURRENT KNOWLEDGE CONCERNING POLYCHLORINATED BIPHENYLS

PART II PRESENCE OF POLYCHLORINATED BIPHENYLS IN THE QUEBEC ENVIRONMENT

PART I CURRENT KNOWLEDGE CONCERNING POLYCHLORINATED BIPHENYLS

INTRODUCTION

In this part of the report we first summarize current knowledge concerning the chemistry and industrial uses of polychlorinated biphenyls (PCBs) and the ways in which they are released into the environment. We have not attempted to cover these subjects in detail, because this will be done in future reports. Part I concludes with a discussion of the most important examples of PCB toxicity, referring to several specific studies, some conducted *in vivo*, others *in vitro*.

1.1 THE CHEMISTRY OF PCBs

Polychlorinated biphenyls are solely synthetic compounds. They consist of two phenyl rings joined by one carbon-carbon bond (figure 1), and a chlorine atom may be substituted for a hydrogen atom at any one or more of ten positions on the rings.

FIGURE 1 PCB nucleus

LEGEND

1. X = hydrogen or chlorine atom

In theory, there are 210 possible PCB compounds, but Widmark (1968, cited in Peakall and Lincer, 1970) has calculated that only 102 of them are actually likely to exist. They are usually found in mixtures, which makes them more difficult to identify.

The most distinctive physical and chemical characteristics of PCBs are their high thermal stability, high resistance to oxidation, acids, bases and other chemical agents, and their excellent dielectric (electrically insulating) capability.

PCBs have a low solubility in water but a high solubility in fats, oils and nonpolar liquids. They are generally very stable and highly resistant to biological and chemical degradation. Their chromatographic characteristics are similar to those of several organochlorine pesticides, which greatly complicates the problem of identification.

PCBs are usually classified into two groups: lower chlorinated biphenyls (LCBPs), whose molecules contain one to four chlorine atoms, and higher chlorinated biphenyls (HCBPs), whose molecules contain five or more. LCBPs are more volatile and more readily metabolized and biodegraded than HCBPs and are therefore generally less persistent and less toxic.

Information on the composition of PCB compounds is given in table 1.

TABLE 1 Empirical formula, molecular weight and per cent chlorine of polychlorinated biphenyls (from Hutzinger, Safe and Zitko, 1974)

LEGEND

1 Formula

2 Molecular weight

3 Per cent chlorine

4 Based on Cl 35.45

1.2 INDUSTRIAL USES

Since 1930, PCBs have been used in several different industries. The applications include:

- dielectric fluids in electrical transformers and capacitors;
- fluids in hydraulic systems, vacuum pumps and gas turbines;
- fluids in heat transfer systems;

- lubricants;
- ballasts for fluorescent lights;
- rubbers and synthetic resins;
- plastics;
- caulking compounds;
- paints;
- adhesives;
- waxes;
- textiles;
- carbonless copying paper;
- inks;
- dedusting agents for dirt roads;
- solvents for applying insecticides;
- cutting oils for metalwork;
- microscope immersion oils.

These applications are generally classified into two categories: long-term uses (usually in closed systems such as transformers, capacitors, heat transfer systems and hydraulic systems) and short-term uses, in which the PCBs are released into the environment more rapidly. Short-term uses include plastics, adhesives, paints and inks.

In 1972, American manufacturers voluntarily ceased production of PCBs for short-term uses (Canada, 1976). Since then, almost all PCBs produced have been used as dielectric fluid in transformers and capacitors, the use of PCBs in heat transfer and hydraulic fluids having been almost completely discontinued. The quantity of PCBs in circulation has not necessarily been reduced, however: the devices containing them may still be in operation for several years, and PCBs in long-term use are being recycled for both long-term and short-term uses.

As previously mentioned, PCBs are a group of compounds. The number of chlorine atoms and their arrangement on the phenyl rings varies from one PCB to another. Industry uses mixtures of these compounds. Almost all of the PCB used in North America is manufactured by the Monsanto Company of St Louis, Missouri; the rest is imported from Europe (Canada, 1976). Monsanto mixtures are identified by a trade name, "Aroclor", along with four digits. The first two, usually 1 and 2 or 1 and 0, indicate that the product consists of biphenyls; the second two indicate the percentage of chlorine, which can vary tremendously from one mixture to another.

The molecular composition of some Aroclor mixtures is given in table 2, the chlorine content in table 3, and a partial list of industrial uses in table 4. Table 5 lists the distinctive physiochemical properties of three PCB mixtures.

The following information from a report of the Task Force on PCBs (Canada, 1976) gives some idea of the quantities in use in Canada. Total Canadian imports of PCBs from 1957 to 1974 are estimated at 22,000 tonnes: 13,500 tonnes of Aroclor 1254/1260 types and 8500 tonnes of Aroclor 1016/1242 types. For 1973 and 1974, average annual imports of PCB amounted to 1450 tonnes, of which 70% was used in transformers and 30% in capacitors. The Task Force states that there is currently no statistic indicating the quantity of PCB contained in manufactured products imported into Canada.

TABLE 2 Molecular composition of some Aroclor preparations (from Hutzinger, Safe, and Zitko, 1974)

LEGEND

1 Molecule

2 Presence in Aroclor

3 Per cent (W/W)

4 none detected, $< 0.01\%$

TABLE 3 Chlorine content of Aroclor preparations (from Hutzinger, Safe and Zitko, 1974)

LEGEND

1 Average number of Cl atoms per molecule

2 Average molecular weight

3 Monsanto's specifications

North American production of PCBs from 1957 to 1974 totalled 352,000 tonnes, of which 65% was lower chlorinated biphenyls. Canada imports approximately 5% of the LCBP and 15% of the HCBP manufactured in the United States.

It should be noted that since 1975, Monsanto has been manufacturing Aroclor 1016, 1221, 1242 and 1254 only; production of Aroclor 1232, 1248, 1260, 1262 and 1268 has been discontinued.

TABLE 4 Uses of Aroclor preparations (from Hutzinger, Safe and Zitko, 1974)

LEGEND

1 Use
2 Aroclor types
3 Electrical capacitors
4 Electrical transformers
5 Vacuum pumps
6 Gas transmission turbines
7 Hydraulic fluids
8 Plasticizers in synthetic resins
9 Adhesives
10 Plasticizers in rubbers
11 Heat transfer systems
12 Waxes
13 Dedusting agents
14 Pesticide extenders, inks, lubricants, cutting oils
15 Carbonless copying paper

TABLE 5 Physiochemical properties of three polychlorinated biphenyl mixtures (from Mieure et al, 1976)

LEGEND

1 Property

2 Per cent chlorine

3 Density (g/ml)

4 Distillation range (^{o}C)

5 Fire point

6 None

7 Vaporization rate (mg/cm^{2}/hr at 100^{o}C)

8 Water solubility (ppm)

9 Biodegradability

10 Per cent degradation per 48 hour cycle with semicontinuous activated sludge

1.3 RELEASE AND DISPERSION IN THE ENVIRONMENT

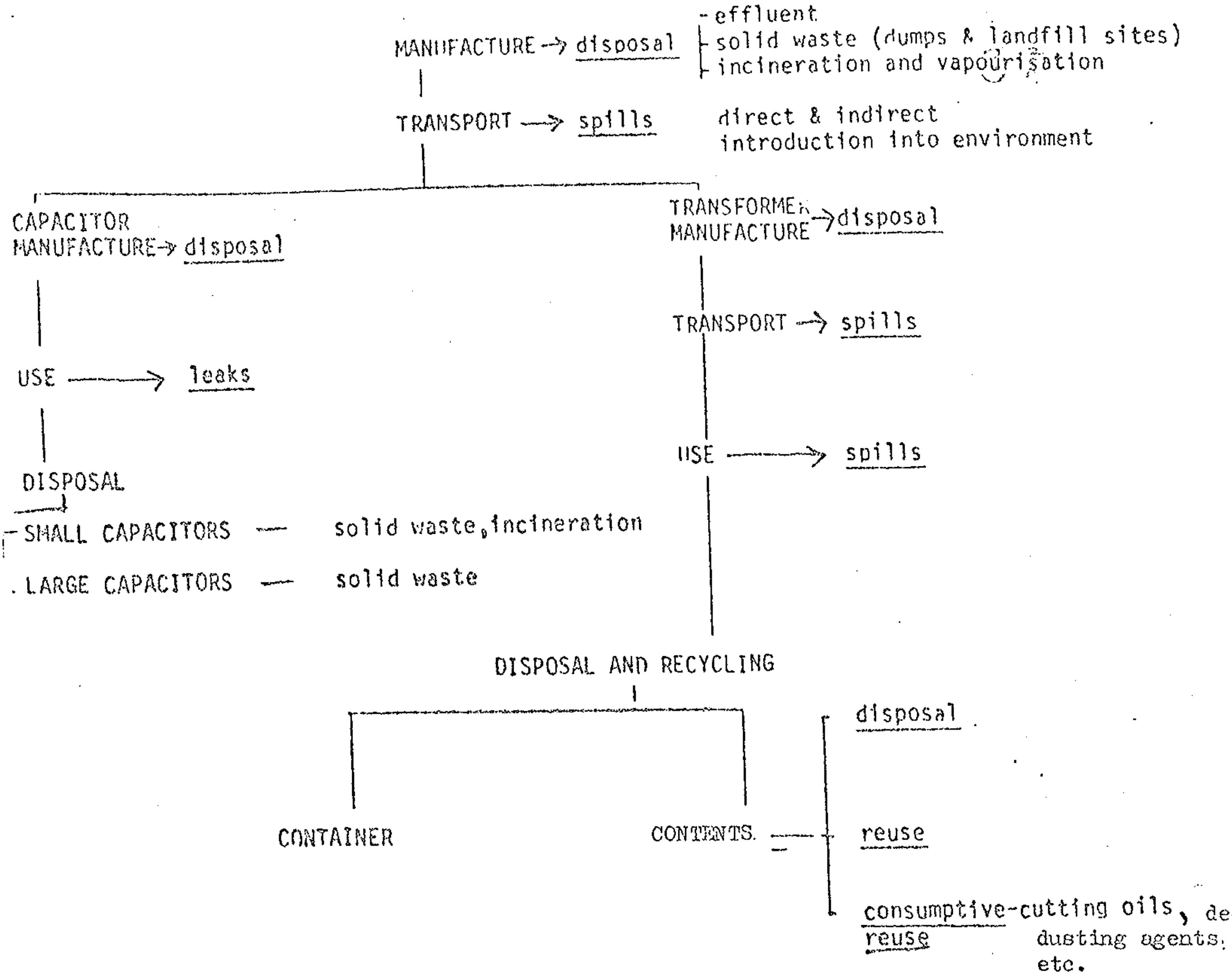
The presence of PCBs in the environment was first discovered in Sweden, in 1966, during an analysis of muscle tissue from salmon (Pearce, Gruchy and Keith, 1973). Since then, PCBs have been found in the environment throughout the world, chiefly in the highly industrialized countries. In Canada, there have been few studies dealing with PCBs, but they have been identified in a number of locations throughout the country. Little is known about the distribution of PCBs in the environment because it has only recently been learned that they are highly toxic, and because the samples were usually taken for purposes other than PCB analysis. Another reason is that qualitative and quantitative tests for PCBs require special equipment and are very costly.

The properties that make PCBs so valuable to industry are the same ones that make them dangerous: because these compounds have high thermal stability and a high resistance to biological and chemical degradation, there are very few ways to eliminate them. In the following pages, we will discuss the principal routes by which PCBs enter the environment.

First we will consider the PCBs used as dielectrics. The routes of such PCBs into the environment are represented schematically in figure 2. Plants that manufacture PCBs discharge them and they are then found in liquid form in effluent, in solid wastes at dumps and landfill sites, and even (undestroyed) in gaseous form as a result of incomplete incineration. In addition, spills may occur while these products are being transported, releasing PCBs into the environment either directly, or indirectly by way of treatment plants. Spills can also take place during the manufacture and transport of electrical capacitors and transformers. In addition, these devices may leak during use, introducing PCBs into the environment. Finally, after a period of time ranging from a few years to a few decades, such equipment has to be replaced. Used capacitors and their contents are incinerated or disposed of as solid waste. Some used transformers are recycled in the manufacture of new transformers or of products such as cutting oils and dedusting agents.

PCBs used in non-electrical applications enter the environment more rapidly, if not always more directly. PCBs employed in dedusting agents for dirt roads or as solvents in insecticides contaminate the environment within a very short time. Other products composed wholly or partially of PCBs must eventually be disposed of and, like the PCBs in capacitors and transformers, they enter the environment by way of dumps, incinerators, and effluent from wastewater treatment plants, or are released into the environment directly. When a product is disposed of at a dump or landfill site, its container eventually breaks open, the product decomposes, and the contaminants enter the soil, water and air.

FIGURE 2 Routes of PCBs from manufacturer to the environment (adapted from Canada, 1976)



Waste can be burned at dumps or in incinerators, but if combustion is incomplete, the PCBs will not be destroyed, instead being vaporized and entering the atmosphere (Nisbet, 1976; Canada, 1976). PCBs can also accumulate at wastewater treatment plants. A large percentage of the PCBs in the water entering these plants will generally still be present in their effluent; the remainder is found in the sewage sludge, which may then be burned or dumped at sea. In Ontario, if not elsewhere, sludge is also used to fertilize agricultural land (Canada, 1976). Finally, a few examples of direct losses of PCBs into the environment should be mentioned: they can be discharged into the atmosphere in hydraulic fluid from aircraft, and into the ocean when bilge water is emptied from ships after a leak in the pumping system.

Once they have been released, PCBs behave in different ways in different parts of the environment. PCBs in dumps may remain there a fairly long time before leaching out. PCBs in the air may float there until precipitated in rain, snow or atmospheric dustfall. Because PCBs have an affinity for particulate matter, a high proportion of those present in aquatic ecosystems is probably adsorbed on suspended solids. Another portion is contained in the sediments. In fact, the water in such ecosystems rarely contains more than a few parts per billion of PCBs, whereas the levels in the sediments are often much higher.

At any point after the PCBs have entered the environment, they may be "biointegrated"—taken up by terrestrial and aquatic plants and animals. Although the production of PCBs for certain uses has been halted, they are still used in fairly long-term applications, so it can be expected that the quantity of PCBs in the environment will continue to increase for many years to come.

1.4 TOXICITY

It has been well established that PCBs are ubiquitous compounds that accumulate along the entire food chain. The PCB mixtures that enter the environment are not only highly toxic, but also difficult to metabolize.

Little is known, however, about the chemistry of PCB toxicity and the specific mechanisms by which PCBs attack living tissues. We do not yet really know how toxic PCBs are and how they act synergistically with other organochlorine compounds.

The particular biochemical processes that take place in organisms contaminated by PCBs are poorly understood. Most researchers have worked with mixtures of these compounds, because that is the form in which they are always found in the environment. Information about the specific reactions of individual PCB compounds in the environment is therefore limited, but it is assumed that the mechanisms vary considerably depending on the type of biphenyl involved.

Several experiments seem to indicate that PCBs are intrinsically toxic (Risebrough et al, 1968; USA, 1973; Canada, 1976), but another study has shown that PCBs alone have no effect on the thickness of the eggshells of birds of four species belonging to different families (Pearce, Gruchy and Keith, 1973).

Some authors believe that the toxic effects of PCB mixtures are primarily due to the presence of impurities such as chlorodibenzofurans (CDBFs), which are toxic at levels of less than 10^{-9} g (Hammond et al, 1972; USA, 1973). It is not even known how CDBFs come to be present in PCB mixtures. They might be formed when the PCBs are manufactured or, others believe, when they are partially degraded by heat (USA, 1973).

According to a third hypothesis, the toxic effects of PCBs result chiefly from the PCB metabolites, such as chlorobiphenylols, that are formed in living organisms (which do have the ability to partially metabolize PCBs) (Hammond et al, 1972; Hutzinger, Safe and Zitko, 1974). It has been shown that a certain tetrachlorobiphenylol is more toxic than the tetrachlorobiphenyl of which it is a metabolite (Hutzinger, Safe and Zitko, 1974).

Finally, there is much evidence that although PCBs may be toxic in their own right, they usually intoxicate living organisms by acting synergistically with other organochlorine compounds such as pesticides (DDT and its metabolites) and mirex (Anderson et al, 1969; Pearce, Gruchy and Keith, 1973).

In the environment, PCBs are often found mixed with organochlorine pesticides. Chromatographic analysis does not always reveal trace amounts of such pesticides that are present in a sample, so it is hard to identify and quantify the PCBs.

The toxicity of PCBs seems to vary greatly, depending on the particular compound. It is generally agreed that the severity of intoxication in the organism is directly proportional to the percentage of chlorine in the PCB (Canada, 1976). The LCBPs are generally less toxic than the HCBPs because they are more readily metabolized. The latter can apparently exert a toxic effect (probably due to their continuous partial degradation) even when they remain trapped in animal fats. One known exception is that in fish, the higher the percentage of chlorine, the lower the apparent toxicity (USA, 1973). PCB toxicity varies not only according to species, but also according to the stage of development of the individual. PCBs are more toxic to salmon eggs than to juvenile salmon, and young rhesus monkeys are less susceptible to PCB poisoning than adults (Hutzinger, Safe and Zitko, 1974).

We will now describe some documented cases of PCB contamination to illustrate the toxic effects of these compounds.

In Japan in 1968, PCB containing 48 per cent chlorine leaked out of a microscopic opening in a heat transfer system and contaminated a stock of rice oil. Contamination reached a level of 2000 ppm, and caused "Yusho disease", which affected 1001 people. Some individuals absorbed 0.5 g in the space of a month, equivalent to 15 mg/day or approximately 200/μg/kg of body weight/day. This is equivalent to a concentration less than the minimum level at which PCBs have been reported to have toxic effects in mammals. The symptoms of Yusho disease were a skin disorder characterized by follicular accentuation, acneform eruption, abnormal pigmentation of the skin and nails and hypersecretion of the Meibomian glands. CDBFs were probably present in the contaminated oil (Hammond et al, 1972).

Closer to home, ranch mink that were fed fish from the Great Lakes suffered a high mortality rate, especially in the embryonic and juvenile stages. The fish were found to contain approximately 2.5 ppm of PCB, and were also contaminated with DDT (Provost, 1977). Fish-eating birds in the Great Lakes region and the Gulf of St Lawrence have been experiencing reproductive problems for the past several years (Pearce, Gruchy and Keith, 1973). In certain colonies of herring gulls, high levels of PCB are toxic to embryos and cause behavioural changes in adults sufficient to result in almost total reproductive failure (Fox et al, 1975). High rates of deformity in young common terns may be related to toxic by-products of PCBs (Pearce, Gruchy and Keith, 1973). Reproductive failures in eagles, pelicans and cormorants are associated with eggshell thinning and high concentrations of PCB residue (10 or more ppm) in the eggs. Eggshell formation in birds is closely related to the calcium metabolism, and PCBs and other organochlorines stimulate the bird liver to synthesize microsomal enzymes which, by hydroxylation, degrade the substances that regulate this metabolism: vitamin D and the steroid sexual hormones such as estrogen (Risebrough et al, 1968). Abnormal steroid metabolism can also cause delayed ovulation in certain species of birds (Risebrough and Berger, 1971). This phenomenon is particularly harmful to species nesting in the arctic and subarctic regions, because it may prevent them from reproducing before the short nesting season ends.

We will now cite several in vitro studies to illustrate the major effects of PCB contamination at various points in the food chain.

In phytoplankton, PCB levels ranging from 10 to 100 ppb can inhibit growth and photosynthesis (Hammond et al, 1972). In terrestrial insects, PCBs are not very toxic, but do increase the toxicity and persistence of several insecticides (Hammond et al, 1972).

In aquatic invertebrates, PCBs at concentrations of 1 to 10 ppb attack the gills and inhibit growth and reproduction. Short exposure to such concentrations can even be lethal to several benthic and planktonic species (Hammond et al, 1972).

In certain instances, egg mortality in salmon has apparently been related to the presence of PCBs. Residue levels of 0.4 to 1.0 ppm in the eggs, corresponding to concentrations of 2.5 to 5.0 ppm in the whole fish, caused mortalities of 16 to 100 per cent (Jensen, 1970, cited in USA, 1973).

In birds, PCB concentrations of the order of 1 μg/g (1 ppm) cause reproductive problems such as delayed ovulation, abnormal behaviour, eggshell thinning, and a high rate of deformities. During fat mobilization, the residue levels in the liver and brain may increase (Risebrough et al, 1968).

In rats, prolonged exposure to low concentrations of PCBs can cause malignant tumours of the liver and can also impair reproduction by reducing fertility and poisoning the embryos.

In monkeys, a diet containing 2.5 ppm of PCB can cause skin lesions, weight loss, reduced fertility, hair loss and liver disorders (Canada, 1976; Provost, 1977).

Finally, in humans, PCBs can cause skin lesions and increased liver enzyme activity (USA, 1973).

It should be noted that in some cases the intensity of the effects described above will increase the higher the percentage of chlorine in the PCB contaminants, while in other cases, it will decrease. Agreement has not yet been reached on the biological effects of PCBs (Pearce, Gruchy and Keith, 1973) and it will probably be several years before researchers gain a clear understanding of this problem.

PART II PRESENCE OF POLYCHLORINATED BIPHENYLS IN THE QUEBEC ENVIRONMENT

INTRODUCTION

The results of various studies dealing with the presence of PCBs in the Quebec environment are presented in this part of the report, along with a preliminary analysis.

Figure 3 is a map of Quebec showing the places for which data on environmental PCBs are available and the type of material sampled. Places where levels in fish have been studied are not indicated. As can be seen, there are many regions of Quebec for which no data have been gathered.

No rigorous comparative analysis of these findings has been attempted because the quantity of data available was limited, the samples were analysed using various methods and the results were processed in various ways.

Part II concludes with a discussion of a few studies in which no detectable levels of PCB were found.

FIGURE 3 Distribution of PCBs in the Quebec environment (Places where PCB was detected in fish are not shown. See tables 13 to 20)

LEGEND

1 E = water
2 I = invertebrates
3 L = fluid milk
4 M = mammals
5 O = birds
6 S = sediments

2.1 AIR

To our knowledge, no one has investigaged PCB levels in the atmospheric environment of Quebec. There is one study that alludes to their presence, but does not give any quantitative data: Risebrough and Berger (1971) conclude that the air is the only likely source of PCBs detected in fish from Lake Minto and the Koksoak River. If this hypothesis is correct, atmospheric transport may be an important route of PCB dispersion in Quebec, as it seems to be in Ontario, where 500 to 1000 kilograms of PCB enter Lake Erie in rainfall each year. By comparison, discharges of PCBs into the lake from municipal wastewater treatment plants amount to only 250 kilograms per year.

2.2 SOIL

There has apparently been no research on PCB contamination of soil in Quebec. In Ontario, it has been found that corn crops can take up PCBs from soil contaminated as a result of one or more applications of sewage sludge.

Another possible source of soil contamination is the precipitation of PCBs in rainfall, snow, and atmospheric fallout.

2.3 WATER

In two separate studies, PCB contamination was found in water both before and after it had been treated at municipal plants.

The first study, conducted under the Canada-Quebec St Lawrence Water Quality Agreement, revealed that raw and treated water sampled at filtration plants in Montreal, Longueuil and Lévis contained PCB concentrations ranging from 10 to 40 parts per trillion (table 6). The concentrations recorded at the three plants were similar to one another. In contrast, no PCBs were found when raw and treated water from filtration plants at Montreal, Longueuil, Lévis, Ste-Foy, Pierrefonds, Terrebonne, Pont-Viau, St Eustache and Bécancour was analysed by the Quebec Environment Protection Services between June 15 and July 25, 1977. The data given in table 6 must therefore be interpreted cautiously. All they tell us is that very low concentrations were present and they were safely within the limits of established water quality criteria (USA, 1973). They may even be attributable to interference from sources such as other organochlorine compounds during laboratory analysis.

In the second study, PCB concentrations of 0.02 to 3.0 ppb were found in wastewater from the municipality of Valcartier (tables 7 and 8). PCB levels in Valcartier were thus up to one hundred times greater than those observed in the study previously discussed.

Water analyses were also conducted in summer 1977 using samples from twenty-six stations on the St Lawrence River (Canada-Quebec, 1977). The majority of the samples contained less than 10 parts per trillion of PCBs.

TABLE 6 PCB concentrations in raw and treated water from the Montreal, Longueuil and Lévis filtration plants (Canada-Quebec, 1977)

LEGEND

1 Date of sampling

2 PCB (ppt) in raw water

3 PCB (ppt) in treated water

4 -ppt = parts per trillion

-PCB determinations are based on a mixture of Aroclor 1242, 1254 and 1260 (1:1:1)

PCB levels in influent and effluent from the municipal treatment plant of Valcartier, Quebec (Personal communication from G B Martin, Faculty of Agriculture, Laval University)

TABLE 7 Daily PCB concentrations in domestic wastewater for a five day period (values in ppb)

LEGEND

1 Date of sampling
2 Influent
3 Effluent
4 Peaks unidentifiable

TABLE 8 PCB concentrations during a twenty-four hour period (values in ppb)

LEGEND

1 Date and time of sampling
2 Influent
3 Effluent
4 -PCB measurements are based on readings of five peaks from chromatograms of Aroclor 1254.

2.4 SEDIMENTS

Two studies have revealed that the sediments of the St Lawrence River and one of its tributaries, the Richelieu, contain fairly high levels of PCB, as might be expected.

The first study was carried out by the water research centre of Laval University and dealt with the St Lawrence River between Quebec City and Trois-Pistoles (table 9). Previous research had shown that PCB contamination occurs almost exclusively in the fine fraction of sediments, and only this fraction (composed of particles measuring less than 74 microns) was analysed in the Laval study. There is evidence, however, that this procedure may have resulted in underestimation of the PCB levels (Centreau, 1975). Nevertheless, fine fraction samples from 27 out of 169 sites were found to contain PCB concentrations of 20 to 220 ppb, equivalent to a range of 4 to 175 ppb and a mean concentration of approximately 70 ppb for the sediment as a whole. Such levels are relatively high for this section of the river, because it is not one of those most likely to be affected by direct discharges and has strong currents that dilute contaminants considerably. The Laval study also revealed that PCBs account for the greatest proportion of the organochlorine compounds in the bottom sediments of this part of the river.

TABLE 9 PCB concentrations in sediments of the St Lawrence River between Quebec City and Trois-Pistoles (Centreau, 1975)

LEGEND

1 Percentage of sediment measuring less than 74 microns (fine fraction)

2 PCB concentration (ppb) in fine fraction

3 PCB concentration (ppb) in all fractions combined

4 Kamouraska Bay

5 South reef, Ile aux Lièvres

6 Isle Verte (municipality)

7 -PCB determinations based on Aroclor 1254. Sites are designed by their geographic location or the name of the closest town.

A second study of sediments was conducted by the Quebec Environment Protection Services on the Richelieu River, between its mouth and the United States border. The results ranged from "no detectable levels" up to a concentration of 91.2 ppb, with an average of approximately 17 ppb. Levels exceeding 20 ppb were found at only four of eighteen sites; at four others, no PCBs were detected. Concentrations were generally higher near fairly large towns or cities, and seemed to correlate with the amount of industry in each region (concentrations were higher in the Sorel-Tracy area). These findings suggest that PCB levels in sediments may be useful local indicators.

A brief analysis of these two studies reveals that the quantities of PCB in sediment are four times greater in the St Lawrence River than in the Richelieu. Lake Champlain, upstream from the Richelieu, acts as a sedimentation basin and may be protecting the river from contamination. The Quebec City to Trois-Pistoles section of the St Lawrence, on the other hand, is not located in a highly industrialized area but it may be receiving considerable quantities of PCB by indirect routes.

TABLE 10 PCBs in the sediments of the Richelieu River and its tributaries (St-Jean and Mamarbachi, 1975)

LEGEND

1 Site-mileage

2 PCBs (ppb dry weight)

3 Unnamed stream (?)

4 N.D. = none detected

5 Mileage given is distance from the mouth of each river or stream. PCB determinations are based on Aroclor 1254.

2.5 PLANTS AND ANIMALS

2.5.1 Invertebrates

Pearce, Gruchy and Keith found PCBs in plankton sampled well offshore in the Gulf of St Lawrence (table 11).

TABLE 11 PCB levels in plankton from the Gulf of St Lawrence, 1955-1971 (from Pearce, Gruchy and Keith, 1973)

LEGEND

1 Type of sample
2 Site
3 Number of samples
4 PCB (ppm)
5 Euphausiids
6 Bird Rocks
7 Phytoplankton and small zooplankton
8 Cabot Strait

Ware and Addison (1973) also analysed phytoplankton and zooplankton from the Gulf of St Lawrence (table 12). Having classified the plankton according to size, they found that the level of contamination in an organism was directly proportional to its surface-to-volume ratio. The highest concentration, 31 ppm, was found in very small organisms (approximately 100 microns). There were sixteen concentrations exceeding 5 ppm, the majority in samples from the smaller size groups.

TABLE 12 PCB concentrations (ppm) in Gulf of St Lawrence plankton (from Ware and Addison, 1973)

LEGEND

1 Size in microns

2 June

3 July

4 August

2.5.2 Fish

If measurements of PCB levels are to be statistically significant for a species (whose biological parameters such as age, sex, and stage of sexual maturation have been determined), twenty to twenty-five individuals of each species must be sampled at each site (Hutzinger, Safe and Zitko, 1974). In our study, the descriptions of some specimens are obviously incomplete, and for several species the number of samples is inadequate. The data gathered since 1972 do however provide an overall idea of the PCB levels in the muscle tissue of fish in Quebec.

METHODOLOGY

A review of the literature revealed agreement on one point: there is no single method of measuring PCBs that is better than the others. Analysts must use their own judgment and choose the technique most suitable for them.

Gas chromatography has proven to be an effective method of estimating the quantities of PCBs in fish muscle tissue. Although chromatograms of such PCBs are relatively easy to obtain, they are very difficult to interpret accurately. The PCBs are quantified by comparing their chromatograms with those of standards in the form of commercial PCB preparations. The standard should ideally be formulated to duplicate the composition of the sample, but will often only approximate it, because it is hard to know precisely which PCBs are present in fish muscle tissue, and even harder to know the proportions in which they are present. The chromatograms of environmental PCBs resemble those of Aroclor 1254 and Aroclor 1260, so laboratories most frequently use one of these preparations or a mixture of them as a standard.

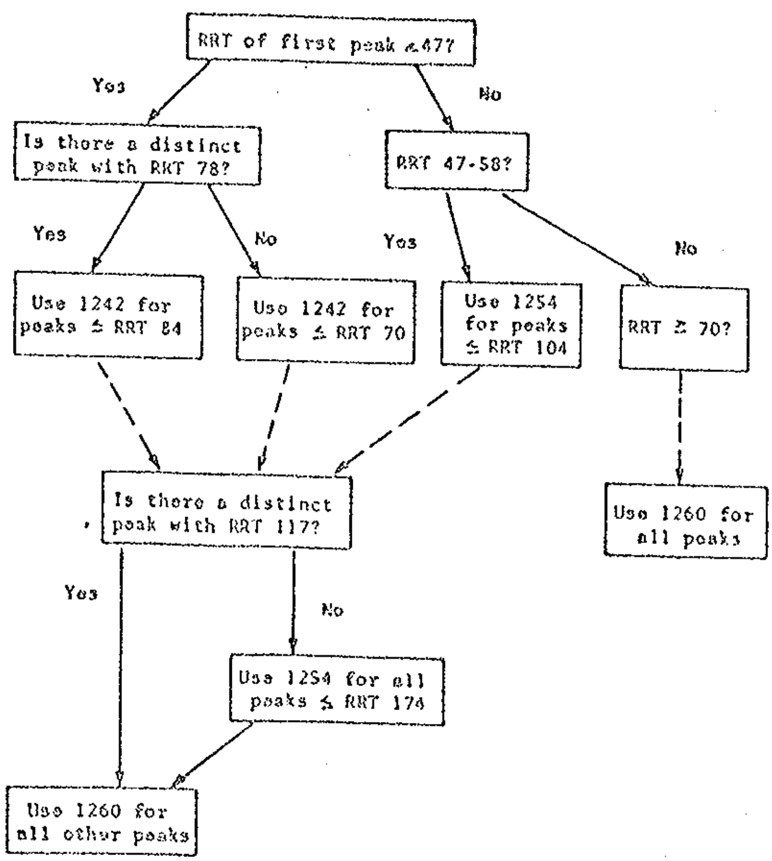
Chau and Sampson (1975), who evaluated several chromatographic methods of estimating PCB content, conclude that the technique used by Webb and McCall is the most accurate and precise. They even assert that no single peak or group of peaks can be taken as representative of the total PCB content of the samples that they chromatographed. In the Webb/McCall method, each peak is examined separately. The chromatogram is partitioned in accordance with a flow diagram developed by Webb (figure 4), and each peak is related to the appropriate standard* and quantified graphically. The quantities for all the peaks are then totalled.

In our opinion, the Webb/McCall approach is more uniform than the earlier methods, in which determinations were based either on the total area under the curve or on one, two, three or even more peaks.

The PCB levels to be discussed in the following pages are for samples analysed at the Fisheries and Environment Canada laboratories in Longueuil, and all were calculated using three chromatographic peaks. Some of the analyses were performed in 1972 using Aroclor 1260 as a standard; almost all the results from 1974 on are based on Aroclor 1254. In such a broad study, however, variations due to the use of different standards or different methods of analysing chromatograms are negligible compared to those arising from differences in the specimens' age, sex, weight, fat content and other biological characteristics, which were not taken into account.

* Chau and Sampson's wording is "the appropriate standard curve".—tr.

Figure 4 Chromatogram partitioning flow diagram (from Chau and Sampson, 1975)



RRT = relative retention time

Whereas Chau and Sampson (1975) have demonstrated that measurements of total PCB concentration based on an Aroclor 1254 standard will vary approximately five or six per cent from those based on Aroclor 1260, mean PCB levels in fatty tissue are often ten to fifteen times higher than those in muscle tissue. The walleye pickerel of the St Lawrence River have PCB concentrations of 0.20 to 3.70 ppm, but their fats have been found to contain an average of 47.92 ppm (table 21).

The work done at the Longueuil laboratories, then, provides a general assessment of PCB contamination of fish in Quebec.

Approximately 2550 samples have been analysed to date; some were taken by the Department of Fisheries and Environment from commercial catches, while others came from provincial departments[1] and various public and private agencies.

1 Most of the samples from lakes were gathered by the Quebec Department of Tourism, Fish and Game. Some of the data for the St Lawrence River come from the 1977 study by the Canada-Quebec St Lawrence River Water Quality Committee.

RESULTS

The data on PCB levels in organisms from Quebec lakes and rivers are presented in tables 13 to 20. For the sake of clarity, most of these results have been classified by drainage basin, in accordance with the map of drainage basins prepared by the Quebec Department of Natural Resources in 1975.[2] Results for the St Lawrence River are given separately, because this is the most important body of water in Quebec, and individual sets of data are also given for the Ottawa River, Lac des Deux-Montagnes, Lac St Louis, Lake St Francis, Rivière des Mille-Isles, and Rivière des Prairies, near Montreal.

To facilitate analysis of these data, the species examined have been classified according to their diet. This type of classification was chosen because ingestion in food and absorption from the water are the principal ways that aquatic organisms take up PCBs, and because bioaccumulation of PCBs is evident as one proceeds up the food chain. In the following pages, the results will therefore be discussed in terms of the following three groups of fish:

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2 A list of the bodies of water sampled in each drainage basin is available from the Fisheries and Marine Service of Fisheries and Environment Canada, Quebec Region.

1. The piscivores, such as the pike and the pickerel, whose diet consists chiefly of fish;
2. The benthivores, including the bullheads, catfish, and suckers, whose diet consists chiefly of benthic organisms such as mollusks, worms and larvae;
3. The insectivores, such as the rock bass, pumpkinseeds and yellow perch, whose diet consists chiefly of insects, small invertebrates and small fish.

The data on PCB levels in eels will be discussed separately.

Ottawa River and Lac des Deux-Montagnes

The muscle tissue of fish from these two bodies of water contained low levels of PCB, the mean concentrations ranging from 0.0 to 1.64 ppm (table 13). Fewer than 5% of the samples analysed had levels exceeding the 2.0 ppm guideline. The bullhead and the river catfish, the species that showed the greatest contamination, were represented by large specimens, whereas the pike specimens, which contained little PCB, were small.*

Lake St Francis, Lac St-Louis, Rivière des Prairies, Rivière des Mille-Isles, and La Prairie Basin

The muscle tissue of fish from these bodies of water contained the highest PCB concentrations of any specimens from the St Lawrence system (table 13). Mean levels ranged from 0.0 to 3.88 ppm, with 25% of the 515 samples analysed having concentrations exceeding 2.0 ppm. The piscivores and the benthivores had the highest contamination levels, between 1.0 and 3.88 ppm, while the insectivores had mean concentrations of no more than 1.0 ppm.

* or perhaps "the pike specimens that contained little PCB were small"

Montreal-Sorel segment of St Lawrence River, Lac St-Pierre

The PCB levels of fish in these waters were slightly lower than those in fish from Lake St Francis and Lac St Louis (table 13). The mean concentrations ranged from 0.51 to 2.42 ppm, and 20% of the 501 samples contained more than 2.0 ppm of PCBs. Here too, the piscivores and the benthivores showed the greatest contamination, while most of the insectivores had concentrations of less than 1.0 ppm.

Trois-Rivières-Quebec City segment

Mean PCB levels in fish from this part of the river, between the Trois-Rivières bridge and Quebec City, varied from 0.30 to 1.76 ppm--appreciably lower than those found farther upstream (table 13). Only 14% of the 95 samples had concentrations exceeding 2.0 ppm. The insectivores had the lowest contamination levels, never averaging more than 0.93 ppm, whereas the piscivores and the benthivores usually had concentrations of 1.0 to 2.0 ppm.

St Lawrence Estuary and Gulf of St Lawrence

PCB levels in fish and other aquatic organisms from these areas were very low, if not insignificant (table 13): mean concentrations ranged from 0.0 to 0.84 ppm, and fewer than 1% of the 157 samples were found to contain more than 2.0 ppm. It would thus appear that the organisms in the Gulf and the Estuary have experienced little PCB contamination.

Saguenay River and Lac St-Jean

Fish and other organisms in these two bodies of water also had very low levels of PCB contamination (table 13). Mean concentrations ranged from 0.0 to 0.75 ppm for 36 samples representing 11 different species. Only one sample contained more than 2.0 ppm of PCB.

Other drainage basins

The data for the other bodies of water in Quebec show that there are no other drainage basins with high levels of PCB contamination (tables 14 to 20). There are, however, four basins for which intermediate levels were found.

1. Richelieu basin Mean concentrations varied from 0.0 to 2.69 ppm (table 15). The piscivores generally had the highest contamination levels, although some benthivores had levels that were just as high. In contrast, the insectivores were never found to have high mean concentrations of PCB. Only 5% of the samples had concentrations exceeding 2.0 ppm.

2. Châteauguay basin The muscle tissue of the benthivores was contaminated,

with mean concentrations of 0.67 ppm and 2.33 ppm for the two species sampled (table 15). It should be noted however, that only six specimens were analysed. Only one of them had a concentration exceeding 2.0 ppm.

3. St-Maurice basin The mean levels were less than 2.0 ppm (table 17). Two samples of pickerel, accounting for less than 6% of the samples analysed, contained more than 2.0 ppm of PCB.

4. Batiscan basin The mean PCB levels in the fish muscle tissue ranged from 0.0 to 1.80 ppm, and the maximum level found was less than 2.0 ppm (table 17).

For the other drainage basins, PCB concentrations exceeded 0.25 ppm in fewer than 15% of the samples, and never exceeded 2.0 ppm.

Eels

The data on PCB levels in muscle tissue of eels were examined separately. High levels of contamination were apparent, even in eels taken in the St Lawrence downstream from Quebec City, a part of the river where the other fish contained very little PCB. Eels, it must be stressed, are not always representative of the quality of the environment in which they are found. Those taken in the St Lawrence may have come from the Great Lakes or any of a number of tributaries, such as the Ottawa, Richelieu and St Maurice rivers. This is especially likely to have been the case for the eels taken downstream from Quebec City, because they were captured in September and October, during their spawning migration to the Sargasso Sea. According to Vladykov (1955), eels taken at this time of year are mature females. All this would explain why PCB levels were found to vary so greatly--concentrations for the area downstream from Quebec City ranged from 0.0 to 29.7 ppm.

Another possible reason for these variations is that during migration, eels contain a high percentage of fat, which has a great capacity for concentrating PCBs (table 21). Analyses in our laboratories revealed that the muscle tissue of eels contained up to 40% fat.

DISCUSSION

According to the principle of bioaccumulation in the food chain, the piscivores should have had higher contamination levels than the other fish studied, but in some areas, in particular the Cornwall-Quebec City segment of the St Lawrence, the benthivores contained PCB concentrations that were just as high, if not higher. We hypothesize that the accumulation of PCBs in benthivores can be attributed in large part to their fat content and to the fact that they inhabit waters close to the bottom sediments.

Our data thus indicate that PCB contamination of aquatic organisms in Quebec generally occurs in the St Lawrence River between Cornwall and Quebec City, principally in the Montreal area. Of the river basins for which data were gathered, only the Richelieu, Châteauguay, St-Maurice and Batiscan contained fish contaminated by PCBs.

In the part of the river where PCB contamination is apparent, the fish most frequently and most severely affected are the American eel, pike, pickerel, sturgeon, catfish, bullhead, common sucker, carp and bass. The rock bass, pumpkinseed and yellow perch, on the other hand, contain relatively little PCB.

Translator's note: In tables 13 to 20 on the following pages, the locations where samples were taken are identified by code numbers according to the system of the Quebec Department of Natural Resources.
In table 13, the digits "00" designate the St Lawrence River hydrographic region.
In tables 14 to 20, the first two digits of the code designate the hydrographic region, and the second two digits identify the river.

TABLE 75 PCB LEVELS IN FISH FROM QUEBEC

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	>2.0 ppm	Maximum	Minimum	Mean
Ottawa River 00-A	Aroclor 1254					
	Catfish	3	0	0.40	0.00	0.23
	Bullhead	1	0	0.10	0.10	0.10
	Carp	6	0	0.80	0.00	0.55
	Pumpkinseed	7	0	0.50	0.00	0.10
	Rock bass	1	0	0.20	0.20	0.20
	Lake sturgeon	10	0	0.80	0.00	0.28
	Black crappie	1	0	0.20	0.20	0.20
	Common sucker	1	0	0.00	0.00	0.00
	Common chub	1	0	0.00	0.00	0.00
	Yellow perch	4	1	5.10	0.00	1.35
	Aroclor 1260					
	Bullhead	6	0	0.20	0.01	0.14
	Catfish	3	0	0.50	0.20	0.37
	Carp	5	0	0.21	0.01	0.12
	Pumpkinseed	2	0	0.50	0.01	0.25
	Walleye pickerel	2	0	0.21	0.18	0.20
	Lake sturgeon	5	0	0.81	0.17	0.41
	Black crappie	6	0	0.20	0.00	0.04
	Yellow perch	5	0	0.11	0.01	0.03
	Common chub	1	0	0.27	0.27	0.27
Lac des Deux-Montagnes 00-B	Aroclor 1254					
	Smallmouth bass	7	0	0.80	0.60	0.63
	Catfish	8	2	4.00	0.90	1.64
	Bullhead	11	2	4.00	0.20	1.15
	Pike	9	0	0.50	0.10	0.30
	Pumpkinseed	5	0	0.20	0.05	0.11
	Walleye pickerel	7	0	1.90	0.20	0.48
	Lake sturgeon	2	0	0.90	0.60	0.75
	Common sucker	3	0	0.80	0.40	0.56
	Yellow perch	7	1	2.90	0.20	0.74
	Northern redhorse	1	0	0.30	0.30	0.30
Lac St-Louis 00-C	Aroclor 1254					
	Largemouth bass	1	1	2.10	2.10	2.10
	Smallmouth bass	24	6	3.80	0.40	1.46
	Bullhead	35	16	3.40	0.80	1.97
	Pike	16	7	11.70	0.50	2.53
	Pumpkinseed	10	1	2.20	0.70	1.00
	Walleye pickerel	16	0	1.90	0.70	1.11
	Lake sturgeon	1	1	3.40	3.40	3.40
	Muskellunge	1	0	0.70	0.70	0.70
	Common sucker	12	1	3.10	0.70	1.15
	Yellow perch	32	0	2.00	0.40	0.97
Lake St Francis 00-D	Aroclor 1254					
	Largemouth bass	3	0	0.00	0.00	0.00
	Smallmouth bass	8	3	5.70	0.60	2.18
	American eel	3	2	8.80	1.60	4.83
	Bullhead	20	11	3.40	0.10	1.82

Fisheries and Environment Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 13--continued

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
Lake St Francis 00-D	Aroclor 1254					
	Pike	37	11	7.40	0.10	2.06
	Carp	4	0	1.27	0.38	0.75
	Pumpkinseed	20	0	0.80	0.10	0.27
	Walleye pickerel	40	20	27.00	0.00	3.39
	Mooneye	1	0	0.00	0.00	0.00
	Muskellunge	1	1	2.40	2.40	2.40
	Common sucker	17	2	2.90	0.20	1.01
	Longnose sucker	1	0	0.26	0.26	0.26
	Yellow perch	24	1	2.30	0.00	0.74
	Northern redhorse	2	1	2.30	0.50	1.40
	Aroclor 1260					
	Smallmouth bass	1	0	0.42	0.42	0.42
	Bullhead	1	0	0.21	0.21	0.21
	Carp	2	0	0.44	0.30	0.30
	Golden shiner	1	0	0.11	0.11	0.11
Rivière des Prairies 00-E-1	Aroclor 1254					
	Smallmouth bass	3	3	3.80	2.20	2.93
	Bullhead	11	1	2.40	0.90	1.32
	Catfish	1	0	1.70	1.70	1.70
	Pike	2	0	1.10	1.00	1.05
	Walleye pickerel	29	7	3.70	0.40	1.62
	Lake sturgeon	7	5	12.50	0.60	3.88
	Common sucker	10	5	3.10	0.30	1.91
	Yellow perch	15	0	1.70	0.40	0.79
	Aroclor 1260					
	Smallmouth bass	10	0	1.23	0.00	0.23
	Bullhead	4	0	1.90	0.80	1.25
La Prairie basin 00-E-2	Aroclor 1254					
	Smallmouth bass	4	1	2.20	1.00	1.48
	Bullhead	1	0	0.80	0.80	0.80
	Pike	1	0	1.90	1.90	1.90
	Rock bass	1	0	0.60	0.60	0.60
	Walleye pickerel	3	0	1.10	0.50	0.80
	Lake sturgeon	2	1	2.90	1.90	2.40
	Common sucker	16	5	3.60	0.70	1.79
	Longnose sucker	1	0	0.50	0.50	0.50
	Yellow perch	1	0	1.10	1.10	1.10
	Northern redhorse	4	1	3.60	1.20	2.03
Rivière des Mille-Isles 00-E-3	Aroclor 1254					
	Smallmouth bass	1	1	3.40	3.40	3.40
	Bullhead	5	3	4.80	1.50	3.00
	Pike	3	0	0.60	0.30	0.40
	Walleye pickerel	17	2	2.70	0.40	1.03
	Sand pickerel	5	2	5.00	0.50	1.96
	Lake sturgeon	12	4	3.10	1.10	1.82
	Common sucker	15	5	4.50	0.40	1.77
	Yellow perch	10	0	0.80	0.20	0.46

Fisheries and Environment Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 13--continued

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	>2.0 ppm	Maximum	Minimum	Mean
Montreal-Sorel 00-F	Aroclor 1254					
	Smallmouth bass	12	4	3.20	0.60	1.83
	American eel	3	3	16.00	3.20	11.00
	Bullhead	43	12	3.50	0.60	1.68
	Pike	51	10	4.00	0.00	1.24
	Carp	1	0	0.70	0.70	0.70
	Pumpkinseed	14	1	2.60	0.30	1.09
	Rock bass	3	0	1.20	0.70	0.87
	Walleye pickerel	15	5	3.30	0.70	1.87
	Lake sturgeon	43	16	15.20	0.60	2.14
	Muskellunge	1	0	1.10	1.10	1.10
	Common sucker	40	11	3.30	0.60	1.83
	Yellow perch	42	2	3.20	0.30	0.74
	Bowfin	1	0	1.60	1.60	1.60
	Aroclor 1260					
	American eel	2	2	6.70	4.15	5.43
	Pike	1	0	1.23	1.23	1.23
	Walleye pickerel	1	0	0.76	0.76	0.76
	Lake sturgeon	13	3	3.13	0.96	1.88
Lac St-Pierre 00-G	Aroclor 1254					
	American eel	144	100	37.20	0.10	6.82
	Bullhead	37	0	1.90	0.00	0.87
	Catfish	2	0	1.50	1.20	1.35
	Pike	55	13	4.40	0.20	1.30
	Carp	5	4	3.20	1.20	2.42
	Pumpkinseed	3	1	2.30	0.40	1.17
	Walleye pickerel	12	6	3.70	1.30	2.16
	Lake sturgeon	14	5	2.80	0.80	1.86
	Common sucker	2	0	1.10	1.00	1.05
	Yellow perch	34	3	2.70	0.00	0.86
	Bowfin	2	0	0.70	0.70	0.70
	Aroclor 1260					
	American eel	35	21	15.50	0.11	4.37
	Bullhead	5	0	0.92	0.16	0.51
	Pike	15	3	2.73	0.40	1.55
	Walleye pickerel	18	2	3.50	0.00	0.98
	Sand pickerel	8	1	2.47	0.00	0.64
	Yellow perch	7	0	1.27	0.21	0.64
Trois-Rivières-Deschaillons 00-H	Aroclor 1254					
	Smallmouth bass	4	0	0.60	0.00	0.35
	Bullhead	6	0	0.80	0.30	0.60
	Pike	21	4	3.40	0.00	1.21
	Carp	2	0	0.60	0.50	0.55
	Rock bass	1	0	0.50	0.50	0.50
	Walleye pickerel	36	4	3.20	0.20	0.90
	Sand pickerel	5	2	2.70	0.60	1.56
	Lake sturgeon	3	1	4.00	0.60	1.76
	Mooneye	3	1	2.30	0.90	1.40
	Yellow perch	11	1	2.80	0.10	0.93

TABLE 13—continued

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
Trois-Rivières-Deschaillons 00-H	Aroclor 1254					
	Bowfin	1	0	0.30	0.30	0.30
	Northern redhorse	2	0	0.50	0.20	0.35
Deschaillons-Quebec City 00-I	Aroclor 1254					
	American eel	14	10	13.96	0.50	4.83
	American eel (smoked)	11	11	20.00	16.00	17.52
	Aroclor 1260					
	American eel	20	18	17.24	0.60	5.51
Quebec City-Baie Ste Catherine 00-J	Aroclor 1254					
	American eel	3	3	20.85	7.66	13.90
	American smelt	11	0	1.00	0.50	0.72
	Aroclor 1260					
	American eel	9	9	15.43	2.40	7.20
	Shrimp (mixture of small crustaceans)	1	0	0.10	0.10	0.10
Tadoussac-Moisie 00-K	Aroclor 1254					
	Atlantic cod	2	0	0.39	0.00	0.20
	American plaice	2	0	0.75	0.00	0.38
	Aroclor 1260					
	Welk	5	0	0.01	0.00	0.01
	Crab	1	0	0.01	0.01	0.01
	Shrimp	3	0	0.48	0.00	0.16
	Soft shell clam	4	0	0.00	0.00	0.00
	Soft shell clam	5	0	0.59	0.00	0.23
	Atlantic cod	1	0	0.00	0.00	0.00
	American plaice	1	0	0.40	0.40	0.40
Moisie-Blanc-Sablon 00-L	Aroclor 1254					
	American eel	7	0	0.90	0.00	0.27
	Atlantic cod	1	0	0.00	0.00	0.00
	Scallop	2	0	0.00	0.00	0.00
	Aroclor 1260					
	American eel	1	1	2.61	2.61	2.61
	Crab	1	0	0.00	0.00	0.00
	Atlantic halibut	1	0	0.74	0.74	0.74
	Atlantic herring	6	0	0.71	0.01	0.13
	Atlantic mackerel	5	0	0.58	0.01	0.26
	Scallop	3	0	0.30	0.07	0.22
Quebec City-Berthier 00-M-1	Aroclor 1254					
	Smallmouth bass	2	0	0.40	0.30	0.35
	American eel	28	26	23.70	1.00	8.63
	Catfish	4	1	4.60	0.80	2.25
	Pike	5	0	0.90	0.60	0.79
	Walleye pickerel	5	0	1.00	0.30	0.44
	Common sucker	1	0	0.30	0.30	0.30

[illegible] Fisheries and Environment [illegible] Quebec Region. (January 1972 to May 1977)

TABLE 13—continued

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
Quebec City-Berthier 00-M-1	Aroclor 1260					
	American eel	25	19	21.90	0.81	7.43
Montmagny-Rimouski 00-M-2,3,4,5	Aroclor 1254					
	American eel	117	111	25.20	1.70	10.62
	American eel (smoked)	6	6	30.30	6.70	23.81
	Caplin	1	0	0.30	0.30	0.30
	American smelt	2	0	0.60	0.40	0.50
	Soft shell clam	9	0	0.10	0.00	0.00
	Aroclor 1260					
	American eel	65	57	29.70	0.53	7.90
Rimouski-Cap-Chat 00-N-1	Aroclor 1260					
	Shrimp	1	0	0.00	0.00	0.00
Ste-Anne-des-Monts-Newport 00-N-2	Aroclor 1254					
	Witch flounder	2	0	0.01	0.01	0.01
	Aroclor 1260					
	Welk	1	0	0.00	0.00	0.00
	Crab	3	0	0.08	0.00	0.03
	Shrimp	1	0	0.00	0.00	0.00
	Atlantic halibut	1	0	0.32	0.32	0.32
	Lobster	5	0	0.28	0.01	0.08
	Atlantic mackerel	5	0	0.01	0.01	0.01
	Atlantic cod	5	0	0.01	0.00	0.00
	Soft shell clam	1	0	0.00	0.00	0.00
	Scallop	1	0	0.84	0.84	0.84
	Ocean perch	1	0	0.01	0.01	0.01
	Witch flounder	3	0	0.00	0.00	0.00
Port Daniel-Pointe à la Croix 00-N-3	Aroclor 1254					
	Soft shell clam	2	0	0.00	0.00	0.00
Magdalen Islands 11-	Aroclor 1254					
	Lobster	26	0	0.26	0.00	0.03
	Ocean perch	14	0	0.01	0.00	0.00
	Aroclor 1260					
	American eel	1	1	2.10	2.10	2.10
	Atlantic herring	3	0	0.66	0.01	0.29
	Lobster	4	0	0.00	0.00	0.00
	Atlantic cod	5	0	0.18	0.01	0.04
	Soft shell clam	5	0	0.78	0.00	0.29
	Scallop	4	0	0.59	0.00	0.15
	American plaice	5	0	0.27	0.01	0.14
	Ocean perch	16	0	0.40	0.01	0.16

TABLE 13—continued

Body of water or segment of St Lawrence Region-Sector	Species	Number of samples		PCB level		
		Total	>2.0 ppm	Maximum	Minimum	Mean
Saguenay River 00-0	Aroclor 1254					
	American eel	7	3	2.90	0.50	1.63
	Golden shiner	1	0	0.70	0.70	0.70
	Shrimp	6	0	1.00	0.00	0.24
	American smelt	2	0	0.90	0.60	0.75
	Atlantic cod	1	0	0.00	0.00	0.00
	Aroclor 1260					
	American eel	5	2	3.57	0.00	1.84
	Shrimp	1	0	0.01	0.01	0.01
	American smelt	5	1	2.63	0.00	1.18
Lac St-Jean 00-P	Aroclor 1254					
	Tullibee	5	0	0.30	0.00	0.06
	Lake whitefish	2	0	0.20	0.00	0.10
	Walleye pickerel	5	0	0.20	0.00	0.04
	American smelt	1	0	0.00	0.00	0.00
	Common sucker	1	0	0.00	0.00	0.00
	Ouananiche	3	0	0.20	0.00	0.13
	American chub	2	0	0.40	0.20	0.30
	Yellow perch	1	0	0.00	0.00	0.00

(January 1972 to May 1977)

TABLE 14 PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples		PCB level		
		Total	>2.0 ppm	Maximum	Minimum	Mean
Rivière Boyer 02-30	Aroclor 1254					
	American smelt	3	0	0.50	0.40	0.47
Rivière Etchemin 02-33	Aroclor 1254					
	Speckled trout	1	0	0.00	0.00	0.00
Rivière de la Chaudière 02-34	Aroclor 1254					
	Smallmouth bass	1	0	1.00	1.00	1.00
	Walleye pickerel	1	0	0.00	0.00	0.00
	Burbot	1	0	0.00	0.00	0.00
	Common sucker	3	0	2.00	0.00	0.66
	American chub	1	0	0.00	0.00	0.00
	Yellow perch	3	0	0.00	0.00	0.00
	Rainbow trout	1	0	0.00	0.00	0.00
	Lake trout	5	0	1.00	0.00	0.30
	Brown trout	1	0	0.00	0.00	0.00
Rivière Bécancour 02-40	Aroclor 1254					
	Bullhead	1	0	0.50	0.50	0.50
	Pike	1	0	0.00	0.00	0.00
	Walleye pickerel	1	0	0.00	0.00	0.00
	Yellow perch	1	0	0.00	0.00	0.00
	Aroclor 1260					
	Pike	2	0	1.30	0.01	0.65

Fisheries and Enviro[illegible] Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 15 PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples: Total	Number of samples: > 2.0 ppm	PCB level: Maximum	PCB level: Minimum	PCB level: Mean
Rivière St-François 03-02	Aroclor 1254					
	Smallmouth bass	4	0	0.00	0.00	0.00
	Bullhead	1	0	0.00	0.00	0.00
	Pike	7	0	0.20	0.00	0.03
	Chain pickerel	1	0	0.10	0.10	0.10
	Lake whitefish	1	0	0.00	0.00	0.00
	Walleye pickerel	9	0	0.00	0.00	0.00
	Mooneye	1	0	0.10	0.10	0.10
	Yellow perch	6	0	0.00	0.00	0.00
	Brown trout	3	0	0.00	0.00	0.00
	Lake trout	2	0	0.10	0.00	0.05
Yamaska River 03-03	Aroclor 1254					
	Smallmouth bass	1	0	0.00	0.00	0.00
	Chain pickerel	4	0	0.00	0.00	0.00
	Walleye pickerel	6	0	0.00	0.00	0.00
	Yellow perch	4	0	0.20	0.00	0.05
Richelieu River 03-04	Aroclor 1254					
	American eel	32	20	26.00	0.50	4.88
	Bullhead	1	1	2.10	2.10	2.10
	Pike	3	0	1.50	0.30	0.70
	Walleye pickerel	2	0	1.87	0.74	1.30
	Aroclor 1260					
	Smallmouth bass	1	0	0.82	0.82	0.82
	American eel	1	0	0.01	0.01	0.01
	Bullhead	5	0	0.01	0.00	0.00
	Pike	4	0	0.01	0.00	0.00
	Carp	2	0	0.01	0.01	0.01
	Tullibee	2	0	1.37	0.01	0.69
	Lake whitefish	4	0	0.77	0.01	0.36
	Rock bass	1	0	0.01	0.01	0.01
	Walleye pickerel	5	0	1.40	0.97	1.18
	Freshwater drum	1	0	1.46	1.46	1.46
	Yellow perch	3	0	0.01	0.01	0.01
	Brown trout	1	1	2.69	2.69	2.69
	Pumpkinseed	2	0	0.01	0.01	0.01
Rivière Châteauguay 03-09	Aroclor 1260					
	Common sucker	3	0	0.86	0.54	0.67
	Longnose sucker	3	1	4.90	0.92	2.33

Fisheries and Enviror Canada, FMS, Quebec Region (January 1972 to May 1977)

PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples Total	> 2.0 ppm	PCB level Maximum	Minimum	Mean
Rivière Rouge 04-02	Aroclor 1254					
	Pike	2	0	0.00	0.00	0.00
	Common sucker	3	0	0.10	0.00	0.03
	Speckled trout	15	0	0.10	0.00	0.01
Rivière du Lièvre 04-06	Aroclor 1254					
	Common sucker	1	0	0.20	0.20	0.20
	Speckled trout	3	0	0.00	0.00	0.00
Gatineau River 04-08	Aroclor 1254					
	Pike	6	0	0.00	0.00	0.00
	Lake whitefish	3	0	0.00	0.00	0.00
	Walleye pickerel	6	0	0.20	0.00	0.10
	Common sucker	3	0	0.00	0.00	0.00
	American chub	1	0	0.00	0.00	0.00
	Lake trout	1	0	0.00	0.00	0.00
	Speckled trout	2	0	0.00	0.00	0.00
Rivière Coulonge 04-13	Aroclor 1254					
	American eel	1	0	0.00	0.00	0.00
	Bullhead	1	0	0.00	0.00	0.00
	Catfish	1	0	0.70	0.70	0.70
	Rock bass	1	0	0.00	0.00	0.00
	Pumpkinseed	1	0	0.00	0.00	0.00
	Walleye pickerel	2	0	0.00	0.00	0.00
	Burbot	3	0	1.20	0.00	0.40
	Black crappie	1	0	0.00	0.00	0.00
	Common sucker	1	0	0.00	0.00	0.00
	Yellow perch	1	0	0.00	0.00	0.00
Kipawa River 04-26	Aroclor 1254					
	Lake trout	1	0	0.00	0.00	0.00
Ottawa River 04-30	Aroclor 1254					
	Pike	8	0	0.90	0.00	0.11
	Tullibee	5	0	0.00	0.00	0.00
	Lake whitefish	1	0	0.00	0.00	0.00
	Mooneye	2	0	0.00	0.00	0.00
	Burbot	1	0	0.00	0.00	0.00
	Common sucker	4	0	0.40	0.00	0.13
	Longnose sucker	2	0	0.00	0.00	0.00
	Yellow perch	1	0	0.00	0.00	0.00
	Walleye pickerel	7	0	0.00	0.00	0.00

Fisheries and Envir[illegible] Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 17 PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples Total	> 2.0 ppm	PCB level Maximum	Minimum	Mean
Rivière St-Maurice 05-01	Aroclor 1254					
	Pike	14	0	1.80	0.00	0.42
	Walleye pickerel	11	2	6.53	0.00	0.92
	Speckled trout	2	0	0.00	0.00	0.00
	Aroclor 1260					
	Pike	4	0	0.30	0.00	0.07
	Lake whitefish	1	0	0.00	0.00	0.00
	Walleye pickerel	3	0	1.10	0.00	0.36
Rivière Batiscan 05-03	Aroclor 1254					
	Walleye pickerel	2	0	1.90	1.70	1.80
	Sand pickerel	1	0	0.50	0.50	0.50
	Lake sturgeon	3	0	1.20	0.60	0.90
	Muskellunge	1	0	0.40	0.40	0.40
	Common sucker	6	0	1.10	0.30	0.65
	Arctic char	3	0	0.10	0.00	0.00
	Speckled trout	11	0	0.10	0.00	0.02
	Aroclor 1260					
	Smallmouth bass	1	0	0.00	0.00	0.00
	Lake whitefish	1	0	0.01	0.01	0.01
	Walleye pickerel	2	0	0.60	0.01	0.30
Rivière Ste-Anne 05-04	Aroclor 1254					
	Atlantic tomcod	29	0	1.30	0.00	0.41
	Aroclor 1260					
	Atlantic tomcod	19	0	1.00	0.00	0.10
Rivière Jacques-Cartier 05-08	Aroclor 1254					
	Speckled trout	2	0	0.00	0.00	0.00
Rivière Maskinongé 05-26	Aroclor 1254					
	American smelt	6	0	0.96	0.01	0.30
	Aroclor 1260					
	Walleye pickerel	2	0	0.23	0.01	0.12
	American smelt	9	0	0.59	0.00	0.12
Rivière du Loup 05-28	Aroclor 1254					
	Rainbow trout (from hatchery)	1	0	0.00	0.00	0.00

Fisheries and Environme[illegible] Canada, FMS, Quebec Region (January 1972 to May 1977)

Drainage basin Region-River No	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
Chicoutimi River 06-10	Aroclor 1254					
	Speckled trout	9	0	0.00	0.00	0.00
Rivière Métabetchouane 06-15	Aroclor 1254					
	Walleye pickerel	5	0	0.00	0.00	0.00
	Common sucker	14	0	0.30	0.00	0.02
	Longnose sucker	4	0	0.00	0.00	0.00
	American chub	6	0	0.20	0.00	0.05
	Lake trout	2	0	0.00	0.00	0.00
	Speckled trout	15	0	0.40	0.00	0.03

Fisheries and Environment Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 19 PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples Total	Number of samples > 2.0 ppm	PCB level Maximum	PCB level Minimum	PCB level Mean
Rivière Harricana 08-01	Aroclor 1254					
	Bullhead	1	0	0.00	0.00	0.00
	Pike	6	0	0.00	0.00	0.00
	Tullibee	1	0	0.00	0.00	0.00
	Walleye pickerel	1	0	0.00	0.00	0.00
	Common sucker	3	0	0.00	0.00	0.00
Nottaway River 08-07	Aroclor 1254					
	Pike	46	0	0.90	0.00	0.08
	Lake whitefish	6	0	0.00	0.00	0.00
	Walleye pickerel	3	0	0.00	0.00	0.00
	Burbot	5	0	0.00	0.00	0.00
	Common sucker	4	0	0.00	0.00	0.00
	Speckled trout	1	0	0.00	0.00	0.00
Rupert River 08-10	Aroclor 1254					
	Pike	1	0	0.00	0.00	0.00
	Tullibee	9	0	0.40	0.00	0.07
	Lake whitefish	7	0	0.10	0.00	0.02
	Walleye pickerel	5	0	0.10	0.00	0.01
	Burbot	1	0	0.00	0.00	0.00
	Common sucker	10	0	0.10	0.00	0.00
	Longnose sucker	3	0	0.00	0.00	0.00
Rivière La Sarre 08-99	Aroclor 1254					
	Pike	3	0	0.15	0.00	0.05
	Tullibee	2	0	0.00	0.00	0.00
	Lake whitefish	1	0	0.00	0.00	0.00
	Walleye pickerel	1	0	0.01	0.01	0.01
	Sand pickerel	2	0	0.10	0.00	0.05
	Shad mooneye	1	0	0.01	0.01	0.01
	Common sucker	2	0	0.01	0.01	0.01
	Longnose sucker	3	0	0.01	0.01	0.01
	White-nosed sucker	1	0	0.01	0.01	0.01
	Aroclor 1260					
	Walleye pickerel	1	0	0.01	0.01	0.01
	Burbot	1	0	0.01	0.01	0.01

[illegible] (January 1972 to May 1977)

TABLE 20 PCB LEVELS IN FISH FROM DRAINAGE BASINS IN QUEBEC

Drainage basin Region-River No	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
·t George River ·-27	Aroclor 1254 Pike Lake trout	 2 1	 0 0	 0.00 0.00	 0.00 0.00	 0.00 0.00
reat Whale River ·-38	Aroclor 1254 Beluga (liver)	1	0	0.00	0.00	0.00
eaf River[1] ·27	Aroclor ---- Lake trout	4	0	0.09	0.04	0.07

1 Data from Risebrough and Berger, 1971

TABLE 21 PCB LEVELS IN FISH FATS AND OILS

Body of water	Species	Number of samples		PCB level		
		Total	> 2.0 ppm	Maximum	Minimum	Mean
St Lawrence River	Aroclor 1254 Fats from walleye pickerel	4	4	104.00	6.40	47.92
Gulf of St Lawrence	Aroclor 1260 Oil from saltwater fish	4	4	9.30	4.87	7.60
Gulf of St Lawrence	Aroclor 1254 Commercial herring oil	4	3	9.90	1.70	4.45

1 Data from Addison, Zinck and Ackman, 1972

Fisheries and Environment Canada, FMS, Quebec Region (January 1972 to May 1977)

TABLE 22 Species for which data on PCB levels appear in tables 13 to 20

French common name	English common name	Scientific name
Achigan à gde bouche	Largemouth bass	*Micropterus salmoides*
Achigan à pte bouche	Smallmouth bass	*Micropterus dolomieui*
Anguille	American eel	*Anguilla rostrata*
Barbotte brune	Bullhead	*Ictalurus nebulosus*
Barbue	Catfish	*Ictalurus punctatus*
Béluga	Beluga	*Delphinapterus leucas*
Bourgot	Welk	*Buccinum undatum*
Brochet	Pike	*Esox lucius*
Brochet maillé	Chain pickerel	*Esox niger*
Capelan	Caplin	*Mallotus villosus*
Carpe allemande	Carp	*Cyprinus carpio*
Chatte de l'Est	Golden shiner	*Notemigonus crysoleucas*
Cisco de lac	Tullibee	*Coregonus artedii*
Corégone	Lake whitefish	*Coregonus clupeaformis*
Crabe	Crab	*Chionoecetes opilio*
Crapet de roche	Rock bass	*Ambloplites rupestris*
Crapet soleil	Pumpkinseed	*Lepomis gibbosus*
Crevette	Shrimp	*Pandalus borealis*
Doré jaune	Walleye pickerel	*Stizostedion vitreum*
Doré noir	Sand pickerel	*Stizostedion canadense*
Eperlan	American smelt	*Osmerus mordax*
Esturgeon de lac	Lake strugeon	*Acipenser fulvescens*
Flétan	Atlantic halibut	*Hippoglossus hippoglossus*
Hareng	Atlantic herring	*Clupea harengus harengus*
Homard	Lobster	*Homarus americanus*
Laquaiche argentée	Mooneye	*Hiodon tergisus*
Laquaiche aux yeux d'or	Shad mooneye	*Hiodon alosoides*
Lotte	Burbot	*Lota lota*
Malachigan	Freshwater drum	*Aplodinotus grunniens*
Maquereau	Atlantic mackerel	*Scomber scombrus*
Marigane	Black crappie	*Pomoxis nigromaculatus*
Maskinongé	Muskellunge	*Esox masquinongy*

Table 22--continued

French common name	English common name	Scientific name
Meunier noir	Common sucker	Catostomus commersoni
Meunier rouge	Longnose sucker	Catostomus catostomus
Morue	Atlantic cod	Gadus morhua
Mulet à cornes	Common chub	Semotilus atromaculatus
Mye	Soft shell clam	Mya arenaria
Omble chevalier	Artic char	Salvelinus alpinus
Ouananiche	Ouananiche	Salmo salar
Ouitouche	American chub	Semotilus corporalis
Perchaude	Yellow perch	Perca flavescens
Pétoncle	Scallop	Placopecten magellanicus
Plie canadienne	American plaice	Hipoglossoïde platessoïdes
Plie grise	Witch flounder	Glyptocephalus cyanoglossus
Poisson castor	Böwfin	Amia calva
Poulamon	Atlantic tomcod	Microgadus tomcod
Sébaste	Ocean perch	Sebastes marinus
Suceur blanc	White nosed sucker	Moxostoma anisurum
Suceur rouge	Northern redhorse	Moxostoma macrolepidotum
Truite arc-en-ciel	Rainbow trout	Salmo gairdnerii
Truite brune	Brown trout	Salmo trutta
Truite de lac	Laketrout	Salvelinus namaycush
Truite mouchetée	Speckled trout	Salvelinus fontinalis

2.5.3 Birds

In a Canadian Wildlife Service study (table 23), eggs of herring gulls from the St Lawrence River and the Gulf of St Lawrence were found to contain PCB concentrations comparable to those reported by Fox et al (1975) for gulls from the Great Lakes. According to Fox, the Great Lakes gulls displayed abnormal behaviour that impaired reproduction, and the PCBs were toxic to the gull embryos.

TABLE 23 PCB levels in eggs of herring gulls (*Larus argentatus*) (Canadian Wildlife Service, unpublished, cited in Canada, 1976)

Sampling site	Year	Sample size	PCB (ppm)
St Lawrence River Notre-Dame-du-Portage	1974	10	20.7
Gulf of St Lawrence Bathurst, N.B., (Chaleur Bay)	1973	5	5.0
Brion Island (Magdalen Islands)	1973	5	5.5

Another study (table 24), cited by Pearce, Gruchy and Keith (1973), indicates that PCBs are present throughout the Gulf of St Lawrence and Chaleur Bay. PCB levels in the brains of three birds found dead or dying corresponded to those detected by means of a bioassay (Prestt, Jefferies and Moore, 1970). When a bird is dying, its fats are being depleted, and the PCB residues apparently collect in the brain.

In both studies, high concentrations of PCBs were found in the eggs. PCB levels are much lower in the muscle tissue of puffins and murres from Labrador. This is to be expected, because there is generally less PCB contamination in that region.

TABLE 24 PCB levels in fish-eating birds from the Gulf of St Lawrence and the Atlantic coast (from Pearce, Gruchy and Keith, 1973)

Species	Site	Number of samples	Tissue	PCB (ppm)
	Gulf of St Lawrence			
Gannet (*Morus bassanus*)	Bonaventure Island	10	E	5.45
	Janeville, N.B.	1*	B	81.4
	Bathurst, N.B.	1*	B	4.92
	Magdalen Islands	1*	B	35.1
Double-crested cormorant (*Phalacrocorax auritus*)	Riorden, N.B.	5	E	9.83
	Heron Island, N.B.	10	E	13.2
Ring-billed gull (*Larus delawarensis*)	Bathurst, N.B.	7	E	6.00
Common tern (*Sterna hirundo*)	Bathurst, N.B.	10	E	2.36
	Bathurst, N.B.	10	E	2.25
	Atlantic coast			
Common puffin (*Fratercula arctica*)	Labrador	10	M	0.41
Common murre (*Uria allge*)	Labrador	10	M	0.31

* Bird found dead or dying

E = egg B = brain M = muscle

The sites in New Brunswick are on the shores of Chaleur Bay.

2.5.4 Mammals

Table 25 comes from the report of the Task Force on PCB and shows PCB levels in seal blubber and lipid. As this table indicates, PCBs are found along the entire Quebec coastline, from the St Lawrence estuary, the Gulf of St Lawrence and the Atlantic Ocean to the Arctic Ocean and James Bay.

TABLE 25 PCB levels in blubber or lipid of seals from the Atlantic and Arctic ecosystems (Canada, 1976)

Species - site	Stage of development	Number	PCB (ppm)	Source
Harp seal *Pagophilus groenlandicus*				
St Lawrence River Tadoussac-Escoumains	pup	2	3	Addison & al. (I973)
	juvenile	I	3	
	adult	I5	9.2	
Gulf of St Lawrence Magdalen Islands	pup	I0	3.0	Pearce & al. (1973)
Magdalen Islands	pup	II	2.7	Frank & al. (I973)
Quebec North Shore	juvenile	I	8.0	
	adult	I2	6.I	
Atlantic coast Nfld-Labrador	pup*	6	I.2	Holden (I972)
Nfld-Labrador	pup	29	I.4	Frank & al. (I973)
	juvenile	II	2.5	
	adult	I4	6.2	
Hooded seal *Cytophora cristata*				
Gulf of St Lawrence Magdalen Islands	adult	I	3	Holden (I972)
Ring seal *Phoca hispida*				
Arctic coast James Bay	juvenile	I	I	Bowes & Jonkel (1975)
Eastern Arctic	adult	I	0.I6	

The above data are difficult to interpret, however, because they deal with contamination from various sources and with data processed in several ways.

Bowes and Jonkel (1975) detected PCBs in all types of tissue from polar bears in northwestern Quebec (table 26), which indicates that these compounds are present even in remote areas of the province. The residue level in the tissues was found to be proportional to their fat content. Milk, a PCB carrier, was the probable major source of the high concentrations in the cubs. In a study dealing with lake trout and arctic char from the Ungava region, Risebrough and Berger (1971) concluded that aerial fallout probably accounts for most of the PCB found at such high latitudes, while some contamination might also be attributable to human activities, for example, spills and discharges from ships.

TABLE 26 PCB levels in tissues of polar bears (*Ursus maritimus*) from James Bay and Hudson Bay (Bowes and Jonkel, 1975)

LEGEND

1. Tissue
2. Age
3. Number
4. PCB (ppm)
5. Fat
6. Liver
7. Muscle
8. Cub
9. Brain
10. Milk

As can be seen in table 27, PCB residues were found in milk from four dairies in the Quebec City region, as well as in a sample of unprocessed milk. The officials at the Department of Agriculture consider these levels "far from alarming".

TABLE 27 PCB levels in fluid milk from the Quebec City region (M Carbonneau, Quebec Department of Agriculture, personal communication)

LEGEND

1. Dairy
2. Sample
3. PCB (ppm)
4. These PCB determinations were based on a mixture of Aroclor 1254 and Aroclor 1260.
5. Unprocessed milk

Our last set of data (table 28) shows that the adipose tissue of Quebec residents contains almost as much PCB as that of Ontario residents.

TABLE 28 PCB levels in human adipose tissue in Canada (from Canada, 1976)

LEGEND

1. Sex

2. The figures in parentheses are the number of samples.

2.6 Other studies

In the following studies, no PCB was detected in the materials sampled:

- an Environmental Protection Service study of water from twenty-four sites on the Richelieu River;

- a Quebec Department of Agriculture analysis of maple sap from a grove in the Quebec City region;

- an Environment Canada Fisheries Inspection Branch analysis of the liver of a 9-foot beluga, *Delphinapterus leucas*, captured in Hudson Bay near the mouth of the Great Whale River. (In another analysis, however, a PCB concentration of 0.4 ppm was found in the muscle tissue of a 57.5-foot common finback, *Balaenoptera physalus*, washed ashore at Grandes-Bergeronnes.)

REFERENCES - see original