Classement CCEK

Titre BPC

Type Dossiers Environementaux

Date D'ouverture 1989

Notes

janvier 1989: Projet de programme de surveillance du lait maternel dans la région du Nunavik

27 janvier 1989: Exemplaire "Le laboratoire d'analyse des émissions des véhicules", "Le dosage des dioxines" (VA, VF)
Proposition de projet par LRTAP (VA)

15 mars 1989: Étude de la contamination de la faune par le BPC (VA)

30 avril 1989: Ministère des Pêches et Océans: document sur le BPC et autres contaminants dans le Nord québécois (VA)

mai 1989: Document "PCB's and other organochlorine contaminants in Nothern Quebec marine mammals and fish" (VA)

6 mai 1989: Prochaine réunion: le point sur le programme de surveillance sur les BPC

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KUUJJUAQ RESEARCH CENTRE

PCB's AND OTHER ORGANOCHLORINE CONTAMINANTS IN NORTHERN QUEBEC MARINE MAMMALS AND FISH

Submitted to:

Committee on Contaminants in Northern Ecosystems and Native Diets
D.I.A.N.D.

Submitted by:

Kuujjuaq Research Centre
(Makivik Corporation)
and
Environment and Resource Management Department
(Kativik Regional Government)

Kuujjuaq
May 1989

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société Makivik corporation

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INTRODUCTION

The presence of PCB's and other organochlorine contaminants such as toxaphene, chlordane and hexachlorocyclohexanes in marine mammals and fish in the Canadian arctic is now relatively well documented (Muir et al. 1989a). Highest levels are found in fatty tissues of top predators such as polar bears *(Ursus maritimus)*, narwhal *(Monodon monoceros)*, beluga *(Delphinapterus leucas)*, ringed seals *(Phoca hispida)* and Arctic charr *(Salvelinus alpinus)*. Concentrations of these organochlorine contaminants are generally lower than in comparable species inhabiting environments near industrialized areas in Europe or North America. For example, PCB levels in blubber of male arctic beluga are about 25-fold lower than in beluga from the Saint Lawrence estuary (Muir et al. 1989b). However, tissues of many arctic predators serve as traditional food of the Inuit and levels of contamination may be sufficiently high to exceed tolerable daily intake guidelines for PCB's (Kinloch and Kuhnlein 1986). It is therefore important that information on levels of organochlorine contaminants be documented in all regions of arctic Canada.

Recent reviews of contaminants in Canadian arctic marine and freshwater environments (Muir et al. 1989a, Lockhart et al.1989) found that data on spatial and temporal variation of PCB's and other organochlorines were limited. Moreover data for levels of contaminants in biota in northern Québec were lacking except for recent surveys of beluga from the east Hudson Bay stock (Muir et al. 1989b). Where information is available on spatial or geographic variation in contaminant burdens (i.e. for ringed seal and polar bears) there are indications that animals in Hudson Bay have higher levels than those in the western and central arctic regions (Norstrom et al. 1988). There are also indications from a survey of organochlorines in Arctic charr that PCB's and toxaphene are higher in charr from the eastern arctic (western Hudson Bay and Baffin Island sites) than in the western areas (Hendzel and Reiger 1987). Further sampling of marine mammals and fish from northern Québec locations would allow us to confirm these geographic trends as well as to provide information on contaminant levels which may be of value in assessing dietary intake of PCB's by Inuit.

The objectives of the current study are twofold:

1) extend our knowledge of the geographic variations of organochlorines in marine mammals and fish;

2) examine, where possible, temporal trends in contaminant levels.

The study focus will be on samples of walrus *(Odobenus rosmarus)*, ringed seal, anadromous Arctic charr, lake trout *(Salvelinus namaycush)* and landlocked Arctic charr in order to make the data fully compatible with our other surveys recently completed in the Northwest Territories.

Data collected through this project will be examined in context with results from the proposed quality surveillance program of human breast milk in Northern Québec (Dewailly 1989). Objectives of the surveillance program are fourfold:

1) provide a data base concerning levels of PCB's, dioxin's, furan's and other organochlorine's in Inuit breast milk;

2) monitor potential adverse health effects on breast-fed neonates in context of known benefits of breast-feeding;

3) conduct a dietary practices study to evaluate composition and intake of country foods;

4) conduct analyses for organochlorine levels in select transformed food items (misirak etc).

STUDY PERSONNEL

Project field sampling will be directed by Kujjuaq Research Centre biologists Stas Olpinski and Tom Boivin in collaboration with Michael Barrett and Philippe di Pizzo (Kativik Regional Government) and Mary-Kay May (CRSSS). Analytical aspects will be coordinated by Derek Muir of DFO, Winnipeg. To the best of our ability, research efforts and funding applications will be coordinated with those of Eric Dewailly and associates (CHUL), Ross Norstrom and associates (CWS) and Garth Bangay and associates (DIAND).

STUDY DESIGN

All samples will be collected by Kuujjuaq Research Centre biologists in collaboration with hunters in designated northern Québec communities (Figure 1). To date, choice of communities remains to be determined subject to consultation with respective communities. Samples will be collected either during the course of ongoing research programs conducted by the Kuujjuaq Research Centre or will be obtained as a by-product of traditional Inuit harvests. Samples will be frozen on site in the source community and shipped in a frozen state to Winnipeg via air.

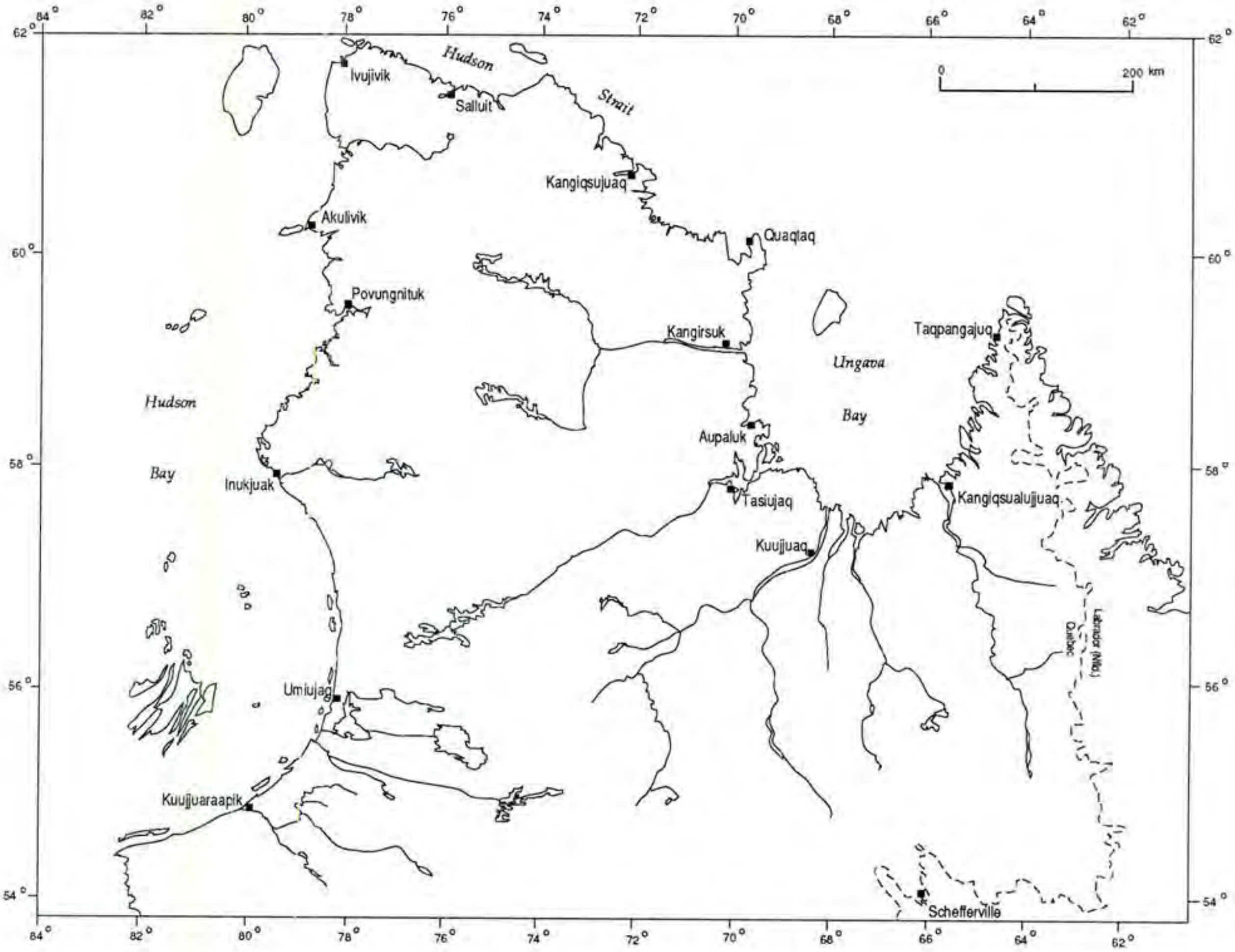

Figure 1. Nunavik communities (choice of sampling locations to be designated)

(1) Seals: Three communities, **one each on Ungava Bay, Hudson Strait and Hudson Bay** will serve as sampling locations. Primary focus will be on ringed seal with limited sampling of harp *(Phoca groenlandica)* and bearded seal *(Erignathus barbatus).* A minimum of ten ringed seal blubber and liver samples will be collected from each location. Every animal will be characterized as to sex, size (length,girth) and blubber thickness by Makivik biologists and/or DFO personnel. A jaw will be colllected so that age group may be determined. Similar age classes from all sites will be chosen to facilitate geographical comparison.

(2) Walrus: Two communities, **one each on Hudson Bay and Hudson Strait** . Ten samples of blubber and liver from each location. Characterized as described for ringed seals.

(3) Anadromous Arctic charr: Three communities as described for the seal samples. Ten samples per location. Weight and age of fish will be determined at the Kuujjuaq Research Centre.

(4) Lake trout and land locked Arctic charr: Trout/charr (n=10 samples respectively) from one or two remote lakes in the Ungava peninsula will be collected and analyzed

for organochlorine contaminants. **These samples will be compared with previous sampling programs in the N.W.T. on <u>Salvelinus</u> species, and also with the results of a small survey of PCB's and DDT in lake trout conducted in 1970 at Lake Minto, Québec (Riseborough and Berger 1971).**

Only blubber and whole fish will be analyzed for organochlorines. Liver samples would be archived for possible future analyses of heavy metals **(mercury, cadmium, etc.), probably by Dr. R. Wagemann's laboratory (DFO).**

		PCBs	Dioxins
Sample Totals: *	Ringed seal (blubber)	- 30	- 1
	Other seal spp. (blubber)	- 15	- 2
	Walrus (blubber)	- 20	- 1
	Anadromous Arctic charr (whole)	- 30	- 1
	Landlocked Arctic charr (whole)	- 10	- 1
	Lake trout (whole)	- 10	- 1
	TOTAL	**115**	**7**

*

Note: it is proposed that additional fat samples both from the forementioned species and those from other species, including polar bear, loons *(Gavia spp)*, mergansers *(Mergus spp)*, eiders *(Somateria spp)*, caribou *(Rangifer tarandus)* and fox *(Alopex lagopus; Vulpes vulpes)*, be collected opportunistically and archived at the Kuujjuaq Research Centre for future analyses. Location where analyses for these species will be conducted have been unidentified to date, however it is hoped CWS facilities will be receptive in this regard (depending on their current scheduling).

METHODOLOGY

Marine mammal blubber will be analyzed at the DFO Winnipeg for individual PCB congeners and related organochlorine pesticides using capillary gas chromatography with electron capture detection using methods identical to those for other arctic studies (Muir et al. 1988). Pooled samples of blubber from each location will be analyzed for polychlorinated dibenzo-*p*-dioxins and furans by DFO Burlington (one sample per location).

Fish will be homogenized and a portion of the homogenate analyzed at DFO Winnipeg following established methods. Extractable lipid will be determined. Age will be determined by examination of otoliths. If required, results will be converted to levels in fillet.

PROJECTED RESEARCH SCHEDULE

July '89 to June 30/90:	Sample collection.
Oct.1/89 to March 31/90:	PCB content analyses of first 50 samples collected.
March 31/90:	Preliminary report on first 50 samples.
April 1/90 to Sept.30/90:	Analysis of remaining 65 samples + 7 dioxin analyses
December 31/90:	Final report on all sample analyses and interpretation.

BUDGET

Sample analyses will be carried out by a contractor working in the laboratory of D. Muir (DFO Winnipeg). D. Muir's lab will prepare the pooled blubber samples for dioxin, furan analysis by the DFO Burlington laboratory.

Sample Collection	
-Salaries, field expenses (Makivik) @ $ 200/sample	23 000.00
-Sample shipment	2 000.00
Sub Total:	**25 000.00**
Animation of Results	
- Innuttitut translation of report (Makivik) @ $.30/word	2 000.00
PCB Analytical Expenses	
-Contractor's labour @ $200.00/sample	23 000.00
-Laboratory costs (solvents, instrument service contracts, other expendables) @ $ 150/sample	17 250.00
Sub Total:	**40 250.00**
Dioxin/Furan Analytical Expenses	
- 7 pooled samples (by species) @ $ 2000.00/sample	14 000.00
GRAND TOTAL	**$ 81 250.00**

Annual Budget Breakdown

Sample collection		20 000.00
Organochlorine analyses		17 500.00
Dioxin/furan analyses		7 000.00
	1989-90 Total:	**$ 44 500.00**
Sample collection		5 000.00
Organochlorine analyses		22 750.00
Dioxin/furan analyses		7 000.00
Animation of results		2 000.00
	1990-91 Total:	**$ 36 750.00**

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Administration Régionale KATIVIK Regional Government
P.O. Box 9, KUUJJUAQ (Fort Chimo), Quebec J0M 1C0

Le 16 mai 1989

Monsieur André Bourget
Service canadien de la faune
Environnement Canada
1141, rue de l'Église
SAINTE-FOY (Québec)
G1V 4H5

Monsieur,

J'ai le plaisir de vous inviter à participer à la quarante-troisième assemblée du Comité consultatif de l'environnement Kativik qui aura lieu le 1e juin 1989 dès 10h30 au Secrétariat aux affaires autochtones situé au Complexe H, 875 Grande-Allée à Québec.

Mis à part les sujets réguliers à l'ordre du jour, le but de cette rencontre est d'une part de faire le point sur le programme de surveillance sur les B.P.C. et autre organochlorés mis sur pied par le Docteur Éric Dewailly (Centre de toxicologie), et d'autre part de présenter une proposition d'étude sur les B.P.C. et autres organochlorés chez la faune du Nouveau-Québec préparée par l'Administration régionale Kativik et la société Makivik avec la collaboration de Derek Muir de l'Institut des eaux douces de Winnipeg. Nous aborderons également la question de l'implication financière ou autre des différents organismes dans ce projet.

Messieurs Garth Bangay (Ministère des Affaires indiennes) et Stas Olpinski (Société Makivik), ainsi que mesdames Suzanne Bruneau (C.R.S.S.S.-Kativik), Camille Mageau et Mimi Breton (Pêches et Océans Canada) ont également été invité à participer à la réunion. Je vous prie de communiquer avec moi dès que possible afin de confirmer votre présence.

Je vous prie d'agréer, Monsieur, l'expression de mes sentiments distingués.

Michael R

Michael Barrett
Chef de département
Environnement et
Gestion des ressources

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société **Makivik** corporation

May 11th, 1989

Garth Bangay, Chairman
Committee on Contaminants in
Northern Ecosystems and Native Diets
D.I.A.N.D.
Les Terasse de la Chaudiere
Ottawa, Ontario
K1A 0H4

Dear Garth:

Attached please find a copy of our proposal titled "PCB's and Other Organochlorine Contaminants in Northern Québec Marine Mammals and Fish". As discussed, we feel it most appropriate this proposal be included as a subset of the global package of research programs under your direction, formulated at examining PCB issues in the Canadian arctic.

We look forward to your comments and response and welcome any questions you may have. Thanking you in advance for your interest and cooperation.

Yours truly,

Stas Olpinski, Biologist
Kuujjuaq Research Centre
(on behalf Kuujjuaq Working Group on Environmental Pollutants)

ms/SO

c.c. Jackie Koneak, Makivik
Josepie Agma, Makivik
Lorraine Brooke, Makivik
Michael Barrett, KRG
Philippe Di Pizzo, KRG
Derek Muir, DFO
Mimi Breton, DFO
Camille Mageau, DFO
Eric Dewailly, CHUL
Birgitte Braune, CWS
Mary-Kaye May, CRSS

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société **Makivik** corporation

May 8th,1989

Dr. Derek Muir
Dept. of Fisheries and Oceans
Central and Arctic Region
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Dear Derek:

Attached please find an edited copy of the PCB proposal I received from you last week. We have made a few changes and have added our projected sampling costs.

You will notice that I suggest aging of fish and seals be conducted at the Research Centre as opposed to DFO, Winnipeg. Our research personnel have accumulated many years of both otolith and scale interpretation (surface and sectioned; using an "Isomet" microtome knife) for assorted species (primarily Arctic charr, Atlantic salmon, whitefish and lake trout). They have also received instruction for aging sectioned teeth (seal, beluga) from DFO personnel at the Arctic Biological Station, Ste Anne de Bellevue.

I have been in contact with Dr. Norstrom to discuss the scope of the project and received some valuable comments. Moreover, I have contacted Denis Vandal, biologist with MLCP, and have made arrangements to obtain samples of polar bear fat (since this species is under their mandate) which could be archived for later analyses.

In my communication with Eric Dewailly, he confirmed that their research group is in fact planning to conduct analyses of some select food items. However, the scope of their dietary practices study covers virtually every species consumed by Inuit, hence is neither directly compatible with the Kinloch and Kuhnlein study nor with data we hope to obtain from the current one. It is unfortunate you will be unable to attend the KRG Environmental Assessment meeting scheduled for June 1 as Garth Bangay, Camille Mageau, Eric Dewailly and possibly a representative from CWS will be present. This meeting will hopefully provide a forum for clarifying and better coordinating priorities for the global study.

I must apologize for getting this back to you after a weeks delay, however must direct the blame at a backlog of meetings which could not be avoided. If you could respond with your comments concerning changes to the proposal I will then submit it officially to DIAND, to be included as a subset of the PCB research package I understand Garth Bangay is administering.

Yours truly,

S. Olpinski

Stas Olpinski
Kuujjuaq Research Centre

ms/SO

c.c. Michael Barrett, KRG
Philip di Pizzo, KRG ✓
Mary Kay May, CRSSS

SUMMARY OF THE FINDINGS AND CONCLUSIONS OF THE SCIENTIFIC EVALUATION MEETING ON CONTAMINANTS IN THE NORTH HELD IN OTTAWA - FEBRUARY 28 - MARCH 2, 1989

Introduction:

There have been since the early 1970's a number of studies of contaminants in the Canadian North. These studies revealed the presence of organic, metals and radionuclide contaminants in the Arctic ecosystem.

The interdepartmental clean-up of PCBs and other wastes at Canada's abandoned Distant Early Warning (DEW) line sites in 1985 raised initial concern about contaminants in native diets. During the course of this work, surveys were carried out to determine whether any hazardous materials had escaped into the neighbouring environment. The results showed that there was only limited contamination at some of the sites.

In 1985, the Department of Indian and Northern Affairs (DIAND) established an inter-agency working group on contaminants in native diets consisting of representatives from the Departments of National Health and Welfare (NH&W), Environment (DOE), and Fisheries and Oceans (DFO) and the Government of the Northwest Territories (GNWT). The committee first conducted a baseline literature review and determined that there was a definite need to assess the extent of wildlife contamination in the north and to determine the implications for the health of northerners.

One of the first conclusions of this group was that contamination of the North was in fact serious and widespread and that it was highly unlikely that the small quantities of PCBs found at the DEW line sites were contributing to the problem.

Subsequently, a cooperative program was designed involving all of the participants. The program comprised elements of monitoring, research, and evaluation. The first phase, a comprehensive monitoring and research program was initiated four years ago to assess the extent of contamination of local food sources used by northern people.

During the four years that the committee has been investigating the problem of arctic contamination, the scope of interest has been widened to include four classes of contaminants including organochlorines, acids, metals, and radionuclides. The major effort has been on occurrences of these contaminants and not on

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biological effects. The working group also adopted an integrated ecosystem approach to assess the problem which considered all aspects of the problem from sources to transport, freshwater, terrestrial and marine systems, human exposure through diets and finally implications for human health.

The technical committee has been preparing a benchmark report summarizing the current state of knowledge on the subject based on the results of the four year research and monitoring program. A scientific evaluation meeting was held on February 28 to March 2, 1989 to critically review draft chapters of the benchmark report and identify the present limits of our knowledge and the gaps that still remain to be filled. The need to have such a meeting was a priority to ensure that a solid assessment and synthesis of the data took place. Only then can the problem be fully defined and clarified without which responsible decisions cannot be made.

Approximately 50 scientists representing a broad spectrum of interests attended the scientific evaluation meeting including a representative of each of the other seven circumpolar countries. Scientists representing the interests of native organizations were also in attendance. The meeting was divided into six sessions which included sources, sinks, and pathways of Arctic contaminants, marine, terrestrial, and aquatic ecosystem contamination, human health effects and synthesis, conclusions and recommendations. A summary of the major findings of this meeting is given below.

A. SOURCES, PATHWAYS AND SINKS

1. Metals and acids deposited in the North have been primarily derived from Eurasian sources. On an annual basis over 95% of the sulphur entering the North is from this source.

2. The source and movement of organic contaminants is less well understood.

3. Organic contaminants derived from agricultural and industrial sources have been transported to the North through the atmosphere, ocean currents and fluvial processes. Very few measurements of organic contaminants have been made in air, ocean currents and river run-off. Exact source regions are unknown but are global in nature. Some sources are likely Northern Hemispheric in origin.

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4. Deposition of radionuclides north of 60 peaked in the 1960's and has declined ever since. Chernobyl was a minor source in the Canadian Northern compared to the earlier atmospheric bomb testing.

5. Monitoring of organic contaminants in snow, ice, air, and water in the North has indicated the presence of PCBs and chlorinated pesticides such as DDT compounds, toxaphene, hexachlorocyclohexane (HCH), dieldrin, chlordane compounds and hexachlorobenzene (HCB).

B. **CONTAMINANTS IN NORTHERN BIOTA**

Organic Contaminants

1. Virtually all organochlorine contaminants found in southern Canada have been detected at lower levels in Northern biota.

2. Although sample size for species other than polar bears has been limited, the levels of organochlorine contaminants in fish, marine mammals and wildlife are similar over a wide geographic area in the North.

3. The most abundant organic contaminants found in marine mammals have been toxaphene, chlordane and PCBs. Chlordane compound residue levels in polar bear fat have been reported to be four times higher in levels measured in 1984 than in levels measured in 1969, whereas levels of DDT did not change and the other organochlorines measured have been twice as high. There is however insufficient data to suggest a trend. The highest levels of PCBs in northern biota have been detected in polar bear fat (3-8 ppm).

4. Chlorinated dioxins and furans (2,3,7,8-TCDD and 2,3,7,8-TCDF) have been detected in the Canadian Arctic. Levels of 2,3,7,8-TCDD in pooled ringed seal blubber samples from seven Arctic communities range from 2 to 37 parts per trillion.

5. PCB and DDE (a metabolite of DDT) residue levels in Arctic ringed seal blubber collected at Holman Island, NWT, were lower in 1981 than in 1972. Similar results for PCBs in ringed seals and seabirds from

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central/eastern Arctic have been reported. The DDT levels in Holman Island ringed seal blubber did not change, suggesting new inputs via long range transport.

6. The highest mean concentrations of DDT and PCBs in marine mammals have been found in narwhal blubber from Pond Inlet and Pangnirtung, NWT (both approximately 5 ppm). Beluga have somewhat lower levels (3 ppm in blubber) while ringed seals average 0.8 ppm. The levels in beluga and seals are much lower than Gulf of St. Lawrence animals.

7. Toxaphene levels in Mackenzie River burbot livers were found to be similar to levels measured in samples taken from N.W. Ontario. Toxaphene levels in Arctic char are 10 times lower than in Lake Superior (lake trout).

Metals

1. High cadmium and mercury levels have been found in Arctic marine mammals (mainly associated with kidney and liver). For example, cadmium levels in narwhal kidney averaged 63.5 ppm which was among the highest reported in marine mammals. They are, however, mainly from natural sources rather than industrial ones.

2. Lead in the Arctic region is mainly from industrial sources. This is reflected in Greenland glacial ice deposits and in mussels which show higher concentrations in recent times than in pre-industrial times.

Radioactivity

1. The Cs-137 data base for caribou and other animals is not large but what data exists indicates relatively low levels of radioactivity. Levels in caribou are much lower than during the atmospheric bomb testing period in the late 1950's.

Acids

1. Twentieth century mid-latitudinal pollution has led to enhanced deposition of acidic sulphates and nitrates in the North. Acid levels in precipitation are 10 to 20 times lower than those found in high acid-rain impact areas further south in eastern Canada.

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C. INUIT FOODS AND DIET - AN ASSESSMENT OF BENEFITS AND RISKS Findings from Contaminant Dietary Surveys in Broughton Island 1985-1988

SUMMARY

Background

In 1985, the community of Broughton Island was asked to participate in a pilot study to determine the amount of PCBs consumed in their diet, the amount of PCBs and mercury present in blood and the amount of PCBs in breast milk. Results of this study, conducted during the month of September, indicated a high intake of Inuit foods and an associated intake of PCBs which exceeded the amount considered "tolerable"* by Health and Welfare Canada (HWC) for 18.9% of study participants. Blood PCBs exceeded the unpublished HWC "tolerable" levels in 29 of 46 children (63%); 26 of 67 women of childbearing age (39%); 4 of 70 males (6%) and 7 of 24 females 45 years of age or older (29%). PCB levels in 3 of 4 breast milk samples were within the range reported in southern Canadian samples (13, 16 and 19 ppb); the fourth contained 69 ppb. The current "tolerable" level is 50 ppb. Blood organic mercury levels in Broughton Island exceeded the guideline range (under 100 ppb) in three persons, all adult males.

In companion studies, it was demonstrated that the blood and breast milk from Broughton Island residents contained up to 10 times the levels of omega-3 fatty acids found in southern Canadian controls. These fatty acids are believed to be protective against heart disease and other diseases, and to serve other important metabolic functions.

The intake of PCBs from food, blood levels for PCBs, and the organic mercury blood levels observed during the pilot survey were not considered to represent any immediate threat, but were of sufficient concern to merit additional work designed to assess seasonal variations in diet and in PCB intake. It was also felt necessary to examine in greater detail the nutritional benefits of Inuit food

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* The word tolerable in this context means the amount of contaminant which could be consumed on a daily basis over a lifetime with reasonable assurance of no adverse effects. Such a level incorporates a "safety factor" applied to the highest exposure for laboratory animals at which no adverse effect was observed.

consumption in a manner which would support a benefit-risk assessment of the diet. Inuit foods have sustained the Inuit over millennia but is now known to be contaminated by PCBs and other chemical residues.

Results of the pilot survey were presented to the Mayor and Council of Broughton Island, and permission obtained for further survey work to deal with these issues. This paper presents some early results of 7 surveys conducted over the period July 1987 to September 1988 in relation to PCB intake. Results relating to the intake of other contaminants will be reported separately.

PCBs in Inuit Foods

1. Inuit foods are used by nearly all Broughton Island residents, and are a major part of the diet for the community. Only about 12% of participants reported no consumption of Inuit foods during any of the survey periods.

2. All Inuit foods tested contain some PCBs; the smallest amounts were found in plants and fish and were higher in animals which feed on them; the largest amounts were found in narwhal and beluga blubber and in polar bear fat.

3. More PCBs are consumed by older than younger persons, and by males than by females. Marketed foods are used more by younger persons.

4. Over all survey periods, about 10% of female participants and 15% of male participants consumed more than the "tolerable" amounts of PCBs - 1 microgram per kilogram of body weight per day (ug/kg); the highest intake was about 5 ug/kg. This intake represents an erosion of the safety factor for PCB intake which is included in the calculation of a "tolerable" level. However, at this time it is not considered advisable to recommend a change in diet.

Nutritional Value of Inuit Foods

1. Inuit foods are nutritionally superior to the marketed foods used in the community.

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2. Blubber, which has the highest levels of PCBs, is rich in at least in one essential vitamin (retinol), and may be its major source in the diet. Blubber also contains high levels of omega-3 fatty acids, which are believed to provide protection against heart disease and other diseases, and to support other metabolic processes, such as the development of nerve tissue (particularly important in utero and during infancy).

3. Inuit food meats - from marine mammals, caribou and char provide large quantities of high protein, and the essential minerals iron and zinc, among other nutrients.

4. The use of Inuit foods provides a uniquely healthful, nutritionally sound diet; breast feeding and breast milk convey enormous benefits to developing infants.

Conclusions

1. The nutritional value of Inuit foods is high.

2. Substitution of Inuit foods with marketed foods currently available and consumed in the community will result in a poorer diet, with risk of damage to health.

3. Based on current information, the benefits of Inuit foods, and of breast feeding to Broughton Island residents are greater than the risk from the PCBs in Inuit foods or in breast milk.

ARCTIC CONTAMINANTS

WHAT DFO IS DOING

Fisheries and Oceans scientists have been studying contaminants in the Arctic for the past 20 years. Their focus has been to detect levels and distribution on metals, hydrocarbons, organochlorines and pesticides in marine mammals and fish.

More recently, DFO has contributed to National Health and Welfare and DIAND's dietary studies to define the dietary intake of contaminants from Arctic marine mammals and fish consumed by native people.

WHAT DFO HAS FOUND

The levels of contaminants found in the species studied are too low to result in significant impacts such as the reproductive failure observed in seals from more polluted environments. Therefore, current levels of these pollutants in the Arctic do not appear to constitute a hazard to the marine mammals and fish. Further studies are needed to determine the long-term biological effect of the presence of low levels of these contaminants on Arctic marine mammals and fish.

HOW THESE CONTAMINANTS FIND THEIR WAY INTO THE ARCTIC FOOD CHAIN

Contaminants such as organochlorines and pesticides enter the Arctic food chain through long range atmospheric transport. This process carries PCBs and pesticides as well as products of combustion over long distances. They are deposited as snow, rain or as "dry fall" on lands drained by north-flowing rivers or directly on the Arctic Ocean. Aquatic organisms feed off organic material in which contaminants are absorbed. This leads to an accumulation of organochlorines in fat-rich tissues and of metals in protein-rich tissues. Contaminants are then further concentrated as they move up the food chain from plankton and invertebrates to fish and marine mammals.

WHAT ARE THE LEVELS

Levels of contaminants in all five Arctic beluga stocks surveyed revealed low levels of metals, hydrocarbons, PCBs and pesticides. PCB levels averaged about three parts per million (ppm) in blubber of Arctic male belugas as compared to approximatly 100 ppm in St. Lawrence belugas. Concentrations of DDT in male Arctic beluga were 30 times less than those reported for the St. Lawrence population whereas chlordane levels were 50 per cent lower.

Narwhal had the highest PCB and toxaphene levels of any of the marine mammals studied. Average levels of PCB in blubber were five ppm.

Arctic ringed seal blubber was found to have mean PCB concentrations of 0.8 ppm which is 100-fold lower than levels reported in Baltic ringed seals. Similar ratios between the Arctic and Baltic Sea were found for marine fish.

The only comprehensive information on levels of organochlorines in marine fish is based on the analysis of whole Arctic char.

The major organochlorine residue in Arctic marine fish is toxaphene with concentrations of PCBs and DDT generally 10 times lower. PCB concentrations ranged from 0.004 ppm to 0.045 ppm (wet weight). Levels of all organochlorine in Arctic char were two to three times higher than those found in Arctic and Greenland Cod reflecting the older age and higher fat content.

Somewhat higher levels of organochlorine were found in freshwater fish than in marine fish with maximum concentrations occuring in the fat storing liver. The most abundant residues found in Arctic burbot liver were toxaphene, PCBs and chlordane with mean concentrations of 0.8 ppm, 0.14 ppm, 0.08 ppm, wet weight.

FUTURE PLANS

DFO investigations have documented the wide distribution of PCBs, pesticides, metals and hydrocarbons in the Arctic aquatic ecosystem. More research is needed to allow for an understanding of the trends and of the factors which influence the fate and effects of these contaminants. Fisheries and Oceans plan to extend their Arctic contaminants survey to include geographic areas and food chain levels not previously sampled. Studies will also be initiated to develop an understanding of the effects of these contaminants on the individuals and populations of animals as well as on Arctic marine and freshwater ecosystems.

9/3/84

Arctic Contaminants

A. INTRODUCTION

1. Several types of contaminants are being studied in the Northwest Territories (Fig 1). Most familiar among them are PCBs. Others are the pesticides toxaphene and DDT. Radioactivity, which is produced in nuclear reactors and explosions of atomic bombs, and metals such as mercury, cadmium, and lead are other forms of pollution

2. These contaminants are found everywhere on Earth, not just in the Northwest Territories. They are found in the atmosphere, in the water, and in the land, as well as in plants, animals, and people, and the amounts of many of these contaminants are increasing

3. Radioactivity is an example of how pollution, once it has been identified, can be successfully reduced. Radioactivity from atomic bomb testing in the atmosphere was at its highest amount in the NWT in the 1960s and has been decreasing ever since. Chernobyl was a minor source of radioactivity in the Canadian Arctic compared to this testing.

4. PCBs were first used approximately 60 years ago and have been used in a variety of ways. The first problem seen because of their use was in Japan, when oil leaked from electrical equipment into a supply of rice and many people became ill.

5. In the Northwest Territories in 1984, PCBs were identified in equipment left at the abandoned DEW line sites located across Canada's Arctic. In 1985, PCBs at those sites were cleaned up and equipment containing PCBs was sent to the United States.

6. Additional soil tests were carried out at a number of the sites in 1987 in order to confirm that there were no longer any PCBs at the sites. Only one site, at Sarcpa Lake, was found to have any contamination left. Plans are being developed to complete the clean-up at this site this year.

7. PCBs were also used in electrical equipment found in other locations in the Northwest Territories.

8. At the same time, scientists were finding PCBs and other contaminants elsewhere in the Northwest Territories.

9 In order to find out how important all of these studies were, a special working group was formed to review the available information and to conduct new studies. Members of this group come from the territorial and federal governments and universities

10 This group found that PCB contamination of the Arctic was actually more serious and widespread than had originally been thought. They concluded that the DEW line sites were not the source of this widespread contamination.

11. During the four years that the working group has been meeting, it has used an approach which considers the entire ecosystem (Fig 2) and four categories of contaminants (Fig 1)

B. Where it comes from, how it gets here, and where it ends up.

1. Most of the metals and acids deposited in the Arctic are thought to come from Europe and northern Asia. Acid deposition is 10 to 20 times lower than further south

2 Where other contaminants such as PCBs come from and how they get here are not as well understood.

3. Contaminants from agricultural and industrial sources are transported to the Arctic through the atmosphere, ocean currents, and streams and rivers. Very few measurements of these contaminants have been made in ocean currents and river run-off. Most likely, the sources of these contaminants are in the Northern Hemisphere.

C. Contaminants in Arctic plants and animals.

1. All major classes of contaminants which are a concern in southern Canada are also found in small amounts in Arctic plants and animals.

2. When snow, ice, air, and water in the Arctic were tested for contaminants, PCBs, pesticides, and other man-made chemicals were found

3. The amount of contamination in fish, marine mammals, birds and animals is about the same across regions of the Northwest Territories.

4. The most abundant contaminants found in marine mammals were toxaphene, chlordane -- another pesticide -- and PCBs. The amount of chlordane in polar bear fat was found to be four times higher in 1984 than in 1969. However, the amount of DDT did not change and the amounts of other contaminants measured were about twice as high as in 1969.

5. The amounts of PCBs and a pesticide, DDE, in Arctic ringed seal blubber collected at Holman Island in 1981 were lower than the amounts measured in1972. The amount of DDT in Holman Island ringed seal blubber did not change, which suggests that DDT is still arriving in the Arctic from sources a long distance away. Similar results have been reported for ringed seals and seabirds from the Central Arctic and Eastern Arctic.

6. Small amounts of dioxin have been found in ringed seal blubber from the Canadian Arctic. Further studies on amounts of dioxin in seal blubber are underway by the Canadian Wildlife Service and the Department of Fisheries and Oceans. In some cases, the amount of dioxin was greater than the guideline for fish.

7. The highest average concentrations of DDT and PCBs in marine mammals except for polar bears have been found in narwhal blubber. The amount found in beluga was a little less, while the amount in ringed seals was less than that. The amounts found in beluga and seals in the Arctic are much lower than in animals in the Gulf of St. Lawrence.

8. The amount of toxaphene found in fish in the Mackenzie River was less than in fish collected from the Great Lakes and the Gulf of St. Lawrence areas. The amount of toxaphene found in Arctic char is 10 times lower than the amount found in lake trout from the Great Lakes.

Metals

1. Large amounts of cadmium and mercury have been found in marine mammals. Metals are associated with the kidney and liver. However, concentrations of metals in the Arctic are mainly from natural sources rather than industrial sources

Radioactivity

1. The information available on radioactivity indicates that there are only low amounts present in animals.

INUIT FOODS AND DIET
An Assessment of Benefits and Risks

Summary of Findings from Broughton Island Surveys

Introduction

PCBs have entered the food chain in all parts of the world. They have resulted in harm to humans from accidental poisoning in which large amounts were consumed in a short time. The effects of consuming PCBs for a long time at the generally low levels found in foods are not clear.

The community of Broughton Island was asked to participate in a study to determine the amount of PCBs consumed because "harvest study" data indicated a high potential intake of Inuit foods. This summary outlines results of PCBs and nutrients in foods eaten in the community during the period July 1987 to July 1988.

PCBs in Inuit Foods

1. Inuit foods are used by nearly all Broughton Island residents, and are a major part of the food eaten in the community.
2. All Inuit foods tested contain some PCBs; the smallest amounts are in plants and fish, and higher in animals which feed on them. PCBs are stored in the fat; the largest amounts are found in sea mammal blubber and polar bear fat.
3. More Inuit food, and more PCBs is consumed by older than by younger persons, and more by males than by females; marketed foods are used more by younger persons.
4. No resident consumed enough PCBs to warrant a change in diet.

The Nutritional Value of Inuit Foods

1. Inuit foods are nutritionally better than the marketed foods used in the community.
2. Blubber, which has the highest levels of PCBs, is rich in at least one essential vitamin, and may be its major source in the diet. Blubber also contains high levels of fats which may provide protection against heart disease and other diseases.
3. Inuit meats - from marine mammals, caribou and char - provide large quantities of high quality protein, and the essential minerals iron and zinc, among other nutrients.
4. In general, use of Inuit foods provides a healthful, nutritionally superior diet.

Conclusions

1. There is reason for concern that Inuit food species, and Northern foods generally, are contaminated, as evidenced by the findings regarding PCBs.
2. The nutritional value of Inuit foods is high.
3. Substitution of Inuit foods with marketed foods now consumed will result in a poorer diet, with the risk of damage to health.
4. The benefits of Inuit foods to Broughton Island residents are greater than the possible risk from the PCBs these foods contain.

March 9, 1989

ARCTIC CONTAMINANTS

The interdepartmental clean-up of PCBs and other wastes at Canada's abandoned Distant Early Warning (DEW) line sites in 1985 raised initial concern about contaminants in native diets. During the course of this work, surveys were carried out to determine whether any hazardous materials had escaped into the neighbouring environment. The results showed that some contaminants are present in wildlife, but their type and distribution meant that known sites in the Arctic could not have been the source.

To investigate the situation further, the Department of Indian Affairs and Northern Development (DIAND) established an inter-agency working group on contaminants in native diets consisting of representatives from Environment Canada, Health and Welfare Canada and Fisheries and Oceans together with the Government of the Northwest Territories. The committee first conducted a baseline literature review and determined that there was a definite need to assess the extent of wildlife contamination in the north and to determine the implications for the health of northerners.

Subsequently, a co-operative program was designed involving all of the participants. The program comprised elements of monitoring, research and evaluation. The first phase, a comprehensive monitoring and research program, was initiated four years ago to assess the extent of contamination of local food sources used by northern people. PCBs, pesticides, metals and combustion residues of petroleum products were among the types of contaminants investigated with the major emphasis on organic contaminants. The components of the Arctic food chain that were investigated included fish, wildlife and marine mammals with emphasis on species at the top of the food chain (e.g., polar bears, whales and humans).

DIAND has continued to coordinate the research and monitoring program through the "committee on contaminants in native diets" and has provided funding to participating departments to carry out contaminant studies. The department managed and co-funded the Ice Island Contaminants Study with Fisheries and Oceans and Environment Canada in which measurable quantities of organic contaminants were found in Arctic air, snow, surface seawater, suspended sediments and invertebrates. Other studies funded by DIAND have included the MacKenzie River organochlorine contaminants in fish study, MacKenzie River native diet studies and the organic contaminants in Broughton Island native diets study.

In conjunction with Health and Welfare Canada, DIAND funded the Broughton Island study in 1985 which included collecting information from the residents on the types of foods they eat, how they prepare these foods and how much of the foods they eat. As part of the study, blood and breast milk samples were analysed for PCBs. Preliminary results showed that 18.8 per cent of the study population consumed more than the "tolerable" amount of PCBs per day and PCBs in human blood were found to exceed the guideline levels established by Health and Welfare in 63 per cent of children and 39 per cent of women of child-bearing age. The results of this study indicated the need for a more in-depth examination of the Inuit diet and the contaminants in native food sources. Subsequent surveys have been conducted at Broughton Island over the past two years and analysis of the data will be completed soon on the extent of contamination of native foods and the risk it may pose to the Inuit balanced against the nutritional value of the food.

Similar studies have been conducted on the presence of the pesticide toxaphene in MacKenzie River fish at Fort Good Hope and Colville Lake, N.W.T. Results of the study will determine how much and what sorts of foods the Inuit are eating and the amount of toxaphene in the fish.

The similarity of levels and types of contaminants found in northern foods clearly indicate that transportation by air and water over long distances, rather than local point sources of contamination, is the dominant pathway of introduction of these chemicals into the Arctic, making contamination of the Arctic a global issue.

DIAND is working with the other participating government departments to prepare a benchmark report summarizing the current state of knowledge on the subject which should identify the present limits of our knowledge and the gaps that still remain to be filled. As a follow up to this report, government strategies and policies will be developed to deal with the problem.

DIAND recognizes that Arctic contamination is an international problem and is currently working with other countries to develop long-term strategies to deal with it. For example, DIAND is co-sponsoring, with the Government of Norway, an international meeting on Arctic pollution in Oslo in September 1989.

In the meantime, DIAND will continue to coordinate the work of the inter-departmental committee while including native organizations in the discussions to keep them abreast of developments affecting their food source.

Environment Canada

ARCTIC CONTAMINANTS

BACKGROUND

In the early 1980s, Environment Canada began studying chemical contamination in the Canadian Arctic cooperatively with the federal departments of Indian Affairs and Northern Development, Fisheries and Oceans, Health and Welfare and the Government of the Northwest Territories.

Environment Canada studies focused on the long-range atmospheric transport of airborne pollutants, the presence of contaminants in mammals (polar bears and seals), and the accumulation of contaminants in surface waters and snow.

FINDINGS

Trace amounts of PCBs, pesticides and metals were found. These can be grouped into five classes of potentially toxic contaminants: industrial organics (e.g., PCBs), organic pesticides (e.g., toxaphene, DDT, chlordane), polcyclic aromatic hydrocarbons (PAHs) (e.g., naphthalenes), acids (sulphur and nitrogen compounds) and metals (lead, cadmium, mercury).

Organic compounds commonly found at mid-latitudes are present in the Arctic environment. Toxaphene, PCBs and DDT residues are present in fish, while chlordane and PCBs are found in polar bears. Toxaphene was not found to accumulate in seals or bears. Snow from the Agassiz Ice Cap and Ellesmere Island was found to contain minute quantities of organic pesticides such as toxaphene, DDT and chlordane.

PCBs and pesticides tend to accumulate in the fatty tissues of fish and marine mammals. A 1972 study and a follow-up study in 1984 revealed the presence of PCBs and other contaminants in polar bears of northern Canada. The highest levels of PCBs found in bear fat (8 ppm) were five or more times below the range known to affect reproduction in the most sensitive mammalian species -- mink. Many mammals are 100 times less sensitive.

A repeat study on polar bears will be undertaken in 1990-91 to determine PCB trends for the past six or seven years. This circumpolar study will include samples from Alaska, Greenland, Spitzbergen, and possibly the Soviet Union.

Acids and metals deposited in the Arctic are primarily derived from northern hemispheric mid-latitudes. More than 95 per cent of the sulphur entering the Arctic annually is from this source. However, acid levels were 10 to 30 times lower than those found in the areas affected by acid rain in eastern Canada.

SOURCES

The sources and movement of organic contaminants are not well understood. The contaminants derive from agricultural and industrial sources outside the region and are carried to the Arctic on atmospheric, river and ocean currents. Increased monitoring of organic compound usages, emissions and levels in the environment is needed.

Higher levels of contaminants were found in more southerly areas such as Hudson Bay, indicating the important role played by atmospheric transport from mid-latitudes.

Most of the contaminants are persistent and resist breakdown. Some volatile compounds tend to deposit on cold surfaces during winter and return to the air in warmer summer weather. Metal concentrations in the Arctic are mainly from natural sources rather than industrial sources.

CONCLUSION

It is premature to identify specific countries as sources, based on the information available to date. At least another five years of concerted research is needed on occurrence, chemical processes, emission inventories and chemical atmospheric transport.

Environment Canada will strive to locate, monitor and research the sources, extent and geographic distribution of contaminants in the Arctic. Regular updates will be made available as information is acquired from additional studies.

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Health and Welfare Canada

HEALTH RISK ASSESSMENT

The Health Protection Branch of Health and Welfare Canada is regularly called upon to assess the potential risk to Canadians of exposure to a wide variety of toxic substances. Where a health risk is determined to exist, the branch is authorized under the Food and Drug Act to take corrective action.

Canadians may be exposed to toxic substances through a variety of sources, including food, water, air, soil and consumer products. This information sheet outlines how the Branch approaches health risk assessments involving food chemical contaminants. Similar approaches are used in addressing potential health threats from other sources.

Health risk assessment of food chemical contaminants is a scientific, multi-step process.

Step One: Determining Tolerable Daily Intake

Step one of the process is to determine the toxicity of the chemical contaminant -- or its capacity to cause harm. This enables scientists to establish a quantity of the chemical that humans can consume on a daily basis, for a lifetime, with reasonable assurance that their health will not be threatened. This quantity is called the Tolerable Daily Intake, or TDI.

TDIs for humans are based on studies carried out on laboratory animals. In these studies, researchers establish a level of exposure to the chemical at which no adverse effects are observed in the animals. This level is then divided by a safety factor to derive the TDI. Depending on the extent of the laboratory studies and the adverse effects that the substance can cause, the safety factor may range from 100 to several thousand or more.

Step Two: Determining Probable Daily Intake

The second step in the health risk assessment process is to determine the Probable Daily Intake, or the PDI, of the chemical contaminant.

To do this, scientists must first identify all foods that may contain the substance being evaluated, keeping in mind that the chemical may occur naturally in some foods. It is also necessary to determine which foods, if any, can contribute more of the contaminant than others.

Food intake is the second factor that contributes to dietary exposure to a specified chemical contaminant. Collecting valid data is extremely difficult since food consumption habits vary greatly based on such factors as gender, age, demographic location, cultural background, socio-economic status. Both average and high consumption rates must be taken into account, as well as the potential exposure of specific sub-groups in the population (such as children or the elderly). Finally, consideration must be given to other potential sources of exposure, such as air and water, in order to arrive at a realistic estimate of Probable Daily Intake.

Step Three: Comparing TDI and PDI

The final step in the process is to compare the Tolerable Daily Intake and the Probable Daily Intake of the contaminant under review. If the PDI exceeds the TDI, risk management options are considered. The options include:

° establishing guidelines or promulgating specific regulations controlling the toxic substance or substances;

° restricting the sale or distribution of food produced in an area which may have been indentified as the source of the contamination;

° recommending changes in dietary habits.

Before initiating any specific action, however, the Health Protection Branch must assess its advantages and disadvantages. For example, removal of certain foods from the market or recommendations to change dietary habits could deny the people at risk of an essential source of nutrition, which might in itself cause more serious health problems than those associated with the chemical contaminant.

High Levels of PCB_s in Breast Milk of Inuit Women from Arctic Quebec

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In the last twenty years polychlorinated biphenyls (PCB_s) have been identified as major contaminants of the natural environnement (Jensen 1966). More recently, the presence of such toxic compounds was described in arctic regions (Wagemann and Muir 1984). This contamination results mainly from long range atmospheric transport (Norstrom and Muir 1986). In these regions, PCB_s have been found in water, snow, ice and air (Mc Neely and Gummer 1984). The level of PCB contamination was significantly lower than that found at midlatitudes. In the Canadian arctic food chain, the presence of PCB_s has been documented in studies carried out over the past 15 years (Addison and Smith 1974). DDT and PCB_s are the only organochlorines that have been monitored on a systematic basis in arctic marine mammals. In ringed seal, blubber concentration of PCB_s ranged from 0.9 to 3.0 mg/kg (Addison and Smith 1974). Levels of PCB_s of 0.01 to 0.1 mg/kg have been reported in arctic char muscle (Holtz and Sharpe 1985).

PCB levels are often monitored because they could also reflect exposure to several other chemical contaminants such as other organochlorines. More recently, contamination by other organochlorinated compounds such as hexachloro-hexane, chlordane, toxaphene and dieldrine have been described in ringed seal blubber and fish from the east central Canadian arctic (Muir et al. 1988). Other highly toxic compounds such as polychlorinated dibenzo-p-dioxins ($PCDD_s$) and dibenzofurans ($PCDF_s$) were found in the blubber from arctic ringed seals caught near the west coast of Spitzbergen (Oehme et al. 1988). Since the closest known sources of PCDD and PCDF were several thousands of kilometers away, these results were surprising. Concentrations of PCDD/PCDF expressed in 2,3,7,8-TCDD toxic equivalent, as proposed by Eadon (Eadon et al. 1986) ranged from 8.2 to 47.5 pg/g.

The consumption of fish and marine mammals by the Inuit people is markedly higher than in the rest of the Canadian population and in some communities, sea mammals represent a significant part of the diet. It is possible that Inuit are exposed to an undesirably high

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intake of PCB_s and other organochlorinated compounds. Levels of PCB_s in the Inuit diet were assessed in Broughton Island, North West Territories, Canada (Kinloch and Kuhnlein 1986). The major contributors of PCB intake were marine mammals such as narwhal, seal and walrus. Moreover, the estimated PCB_s daily intake exceeded the Acceptable Daily Intake (ADI) (Health and Welfare Canada) of 1 µg/kg of body weight for 19 % of the population studied (Kinloch and Kuhnlein 1986). As far as we know, only two previous studies have documented PCB levels in Inuit (Kinloch and Kuhnlein 1986; Davies and Mes 1987), but results were difficult to interpret.

The present study was designed to assess the PCB levels in the breast milk of lactating Inuit women from the Hudson Bay region of Northern Quebec and of women from Southern Quebec.

MATERIALS AND METHODS

Between September 1987 and September 1988, 24 Inuit women who had delivered at the Hudson Bay Hospital in Povungnituk provided a 30 ml breast milk sample. These women lived in six of the seven settlements of the east coast of Hudson Bay. During the same period, 19 Caucasian women from Quebec City and 29 from Baie Comeau (on the north shore of the St-Lawrence River) provided similar milk samples. All mothers were volunteers and were requested to collect a sample of their breast milk during the first month following delivery. Milk samples were frozen and sent to the laboratory of the Centre de Toxicologie du Québec. A self administered questionnaire in Inuktitut, in French or in English was used to assess dietary intake of selected foods, number of previous pregnancies and duration of past breast feeding.

PCB levels were evaluated in terms of Aroclor 1260, expressed both on a total milk volume (µg/L) and fat (mg/kg) basis. The milk sample was subjected to an alkaline hydrolysis to eliminate fats. PCB_s were then extracted with a hexane-ether mixture. The concentrated extract was purified on a Florisil column and analysed on a Varian 6000 gas chromatograph equipped with a split/splitless injector, a 30 m DB-5 capillary column and an electron capture detector. With 2 ml of milk, the detection limit is 2 µg/L.

Data were analysed using standard statistical methods (Snedecor and Cochran 1980). Mean PCB levels and other characteristics of Inuit and Caucasian women were compared by Student's t test. Statistical association between variables was assessed by Pearson correlation. The influence of parity and previous breast feeding on the PCB levels was taken into account in the analysis using multiple linear regression.

Table 1. PCB levels in breast milk of Inuit and Southern Quebec women

	No of samples	PCB levels: Whole milk (μg/L) Mean	Range	Milk fat (mg/kg) Mean	Range
Inuit	24	111.3	(16-514)	3.60	(0.5-14.7)
Caucasians	48	28.4	(5-115)	0.77	(0.3-3.2)

RESULTS AND DISCUSSION

The mean level of PCB_s in breast milk was 111.3 μg/L for the Inuit women compared to 28.4 μg/kg for the Caucasian women ($p= 0.05$) (Table 1). PCB concentrations in milk fat were 3.60 and 0.77 mg/kg respectively for Inuit and Caucasian women. This level among the Inuit was almost 5 times that of the Caucasian women, a highly statistically significant difference ($p= 0.0002$). The PCB levels in the breast milk of the Inuit women are among the highest ever reported. In the North, no significant difference was seen between settlements. For the Inuit women, the mean consumption of marine mammals, fresh water fish and sea fish was respectively 10, 18 and 9 meals per month.

The mean age of Inuit women was slightly lower (25 years) than that of Caucasian women (28 years). Inuit women had more previous children (2.5 on average) than the Caucasian women (0.7). The average cumulative duration of breast feeding was significantly higher among the Inuit (49 weeks) than among the Caucasian women (12 weeks).

Total duration of breast feeding was inversely correlated with the PCB level in breast milk but the association was weak and not statistically significant. The cumulative duration of breast feeding was 119 weeks for women with the lowest PCB concentration (0.5-2 mg/kg fat), 22 weeks for the intermediate concentration (2.1-3.9 mg/kg) and only 13 weeks for the highest level (≥ 4 mg/kg).

Multiple linear regression was used to assess the relationships between potential determinants such as age, duration of breast feeding, and dietary intake of fish and the level of PCB_s in milk fat. Because of the strong association of all above variables with ethnicity, these relationships were studied separately for the Inuit and the Caucasian women. Because of small numbers, no significant association emerged but in both data sets age and fish consumption were positively and breast feeding negatively associated with PCB levels.

Two previous studies have documented the level of PCB exposure in Inuit populations. The first study determined levels of organochlorines in the breast milk of 18 Canadian natives (including Indians and Inuit). Levels of PCB_s in whole milk averaged 12.4 µg/kg for natives compared with 15.9 µg/kg for the general population (Davies and Mes 1987). These low levels could reflect imprecision due to the small number of women selected and to the non differenciation between Indians and Inuit in a data analysis. In this study, the reported fish consumption was similar among natives and in the general population. The second study examined the blood levels among the population of Broughton Island (Kinloch and Kuhnlein 1986). Of the 46 children included in the study, 29 had blood levels of PCB_s above the tolerable level of 4 µg/kg (Health and Welfare Canada). Six samples of breast milk were analysed, and only one had an elevated level (69 µg/kg whole milk). Others had low PCB contents (10 to 18 µg/kg) compared with data from the Canadian Survey (20-30 µg/kg) (Mes et al. 1986).

In the present study, a high consumption of fishes and sea mammals is probably the main route of intake for PCB_s as proposed previously in the Broughton Island study. In Northern Quebec, large quantities of country food are eaten. Moreover, because of the amount of precipitation, Hudson Bay is probably more contaminated than the extreme north (Norstrom and Muir 1986).

An average dose of PCB_s received by infants through breast feeding was estimated assuming an average daily milk intake for infants of 120 ml/kg/day. Weight and body fat were estimated using standard pediatric tables. Elimination of highly chlorinated isomers was considered negligible since PCB blood levels decrease by only 10% over 300 to 500 days after exposure (Chen et al. 1982). Other dietary sources of PCB_s such as seal blubber which is sometimes given to babies were not considered. A gastrointestinal absorption rate of almost 100% (Allen et al. 1974), and a blood/fat partition coefficient of 1/200 (Wolff et al. 1982) were assumed.

Under these conditions, the blood level in a baby receiving milk containing 110 µg/kg of PCB_s would reach 150 µg/kg in about 18 months. If the milk concentration is 500 µg/L these blood level would be attained in three months. A blood level of 150 µg/kg has been recognized as the lowest observed adverse effect level (LOAEL) by NIOSH (NIOSH 1977). At this level, in occupational studies, clinical and biological effects (chloracne, hepatic, enzymatic induction) were observed among the most sensitive workers.

Immunotoxic response to PCB_s, $PCDD_s$ and $PCDF_s$ was described in Yusho and Yusheng accident (Kuratsune et al. 1969; Lü and Wong 1984). Both humoral and cellular immunity have been impaired. The abnormalities described involved mainly the decrease in IgA and IgM, a reduction in the skin response to antigens, a decrease in the total T-cells and active T-Lymphocytes. In the T-Lymphocyte population, the reduction involved essentially the T-Lymphocytes helpers, producing a decrease in the ratio helper/ suppressor.

Immunologic investigations of 40 healthy Inuit infants in Frobisher bay (North West Territories) have suggested that normal Inuit infants have lower total T-cell percentages and lower T-helper than control infants from the South (Reece 1987). Moreover, infection rates among children observed in Northern Quebec are 10 to 15 fold those observed in Southern Quebec.

These results suggest that toxic compounds such as PCB_s could play a role in the impairment of immunity and in the high occurrence infection among Inuit children. These relationships will be investigated in a prospective way during the next year.

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DIFFUSION RESTREINTE

SURVEILLANCE PROGRAM FOR THE QUALITY OF BREAST MILK IN NORTHERN QUEBEC

A. GENERAL INFORMATION

A1. Mother's name ______________________________

A2. Date of birth __________day __________month __________year

A3. Child's name ______________________________

A4. Date of birth __________day __________month __________year

A5. In which municipality do you currently reside

1.	Kuujjuarapik	______	8.	Kangiqsujuaq	______
2.	Umiujaq	______	9.	Quaqtaq	______
3.	Inukjuak	______	10.	Kangirsuk	______
4.	Povungnituk	______	11.	Aupaluk	______
5.	Ivujivik	______	12.	Tasiujaq	______
6.	Akulivik	______	13.	Kuujjuaq	______
7.	Salluit	______	14.	Kangiqsualujjuaq	______

DOCUMENT DE TRAVAIL

A6. How many years have you lived in this municipality ______________

A7.* How much do you weigh now __________ pounds or __________ kilos

A8.* How long did your pregnancy last? __________ weeks

A9.* Did you take any iron supplements during your pregnancy ______ yes ______ no

A10. What is the sex of your newborn child? ______ male ______ female

---

* This information must be taken in the medical file after delivery.

A11.* What was her/his weight at birth? __________ pounds or ______ kilos

A12.. How long do you plan on breast-feeding? ______ months

A13. How many children have you breast-fed? ____________

A14. For each child that you breast-fed (excluding the present one) what was?

	Year of birth (start with the oldest)	Adopted yes no	Duration of breast-feeding (months)	
1st child	19			
2nd child	19			
3rd child	19			
4th child	19			
5th child	19			
6th child	19			
7th child	19			

A15. On what date was your milk sample taken? _______ day _______ month 19___

B. DIETARY HABITS

The following questions deal with your eating habits. Please try to be as precise as possible.

* This information must be taken in the medical file after delivery.

MARINE MAMMALS

B1. For your community, what are the hunting or fishing season(s) for the following species.

SPECIES	Spring	Summer	Fall	Winter	Year Round	Not Applicable
Harp seal						
Ringed seal						
Bearded seal						
Walrus						
Beluga						
Polar bear						
Arctic fox						
Red fox						
Lake trout						
Whitefish						
Northern pike						
Salmon						
Arctic char						
Brook trout						
Sculpin						
Codfish						
Common murre						
Black guillemot						

SPECIES	Spring	Summer	Fall	Winter	Year Round	Not Applicable
Loon						
Merganser						
Eider						
Sea gull						
Sandpiper						
Arctic tern						

B2. Last year during the hunting season(s), how often did you eat

SEAL	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Harp seal meat						
Harp seal fat						
Harp seal liver						
Ringed seal meat						
Ringed seal fat						

SEAL	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Ringed seal liver						
Bearded seal meat						
Bearded seal fat						
Bearded seal liver						
Aged seal meat						

B2a. Last year, how often did you eat misirak from seal?

everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
______	______	______	______	______	______

B3. Last year during the hunting season(s), how often did you eat

WALRUS	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Walrus meat						
Walrus fat						

WALRUS	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Walrus liver						
Walrus skin						
Contents of walrus stomach						

B4. Last year during the hunting season(s), how often did you eat

BELUGA	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Beluga meat						
Beluga blubber						
Beluga liver						
Beluga skin						

B4a. Last year, how often did you eat misirak from beluga whale?

everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
______	__________	______	______	______	______

B5. Last summer, how often did you eat suvalik (fish eggs + blackberries and misirak)

everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
______	______	______	______	______	______

GAME

B6. Last year during the hunting season(s), how often did you eat?

POLAR BEAR	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Polar bear meat						
Polar bear fat						

B7. Last year during the hunting season(s), how often did you eat?

ARCTIC AND/OR RED FOX	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Fox meat						

FISH

B8. Last year during the fishing season(s), how often did you eat?

FRESHWATER, ANADROMOUS, AND SALT-WATER FISH	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Lake trout						
Whitefish						
Northern pike						
Salmon						
Salmon eggs						
Arctic char						
Arctic char eggs						
Brook trout						
Sculpin						
Codfish						

WATER FOWL

B9. Last year during the hunting season(s), how often did you eat

WATER FOWL	Everyday a week	2 to 3 times week	once a a month	2 to 3 times a month	once	never
Common murre						
Black guillemot						
Murre and guillemot eggs						

B10. Last spring and summer (1988), how often did you eat

WATER FOWL	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Loon						
Loon eggs						
Merganser						
Merganser eggs						
Eider						
Eider eggs						
Sea gull						

WATER FOWL	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Sea gull eggs						
Sandpipers						
Arctic tern eggs						

B11. Last year, how often did you eat

MOLLUSC	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Mussel						

B12. Last summer, how often did you eat?

MOLLUSC	Everyday	2 to 3 times a week	once a week	2 to 3 times a month	once a month	never
Clam						
Sea cucumber						
Sea urchin						

Government of Canada / Gouvernement du Canada
Fisheries and Oceans / Pêches et Océans

Philip Di Pizzo

DEPARTMENT OF FISHERIES & OCEANS
CENTRAL & ARCTIC REGION
FRESHWATER INSTITUTE
501 UNIVERSITY CRESCENT
WINNIPEG, MANITOBA R3T 2N6

RAPICOM 5000 (204)983-6285
OPERATOR (204)983-5031

Apr 26

April 25, 1989

Mr. Stas Olpinski,
Makivik Corporation,
P.O. Box 179
Kuujjuaq, Qué. JOM 1CO

Dear Mr. Olpinski:

As we discussed over the telephone last week my laboratory is prepared to analyse samples of marine mammal and fish from northern Québec locations for PCBs and other organochlorine contaminants. Our objectives are to extend our knowledge of the geographic variation of organochlorines in marine mammals and fish and to examine, where possible, temporal trends in contaminant levels. Ideally we would like to focus on samples of ringed seals, arctic char and lake trout (or landlocked char). This would make the data fully compatible with our other surveys recently completed in N.W.T. (including two sites in western Hudson Bay and two locations on Baffin Island). The results would also provide information on dietary contamination although this question would be best addressed by a more detailed analysis of diets like the recently completed study by Health and Welfare and Dr. Harriet Kuhnlein (McGill University) at Broughton Island.

For purposes of discussion and planning I propose the following:

(1) Ringed seal: Two or three locations, one in Ungava Bay and one or two on the Hudson Bay coast. Ten blubber and liver samples from each location. We would analyse only the blubber but there is a possibility of Dr. Wagemann's lab doing heavy metals on liver samples. The animals should be characterized as to sex, size, blubber thickness and a jaw would be obtained so that age could be determined. Similar age classes from all sites would be best for comparison.

(2) Arctic char: Two or three locations as described for the seal samples. Six to 10 samples per location would give a data set similar to the present one for NWT. Whole fish would be best for analysis. There is enough information available to convert whole fish data to levels in fillet.

(3) Landlocked char or lake trout: It would be interesting to analyse trout from 1 or 2 remote lakes (possibly in the Ungava pennisula?). We have samples of Salvelinus species on hand from lakes in NWT for comparison. Another reason for the interest is that a small survey of PCBs and DDT in lake trout was done in 1970 in some Ungava Penninsula lakes and it would be useful to resample those sites 20 years later.

Costs for the analyses would be approximately $350 per sample. Assuming 3 locations for seals and char and 1 for freshwater samples there would be about 70 samples. My lab could handle this load, with the help of a contractor to process the samples, over the next 12 months, hopefully completing the project by September 1990.

I would be pleased to discuss the proposal in more detail with yourself and with DFO Québec region colleagues at your convenience.

Yours sincerely,

Derek Muir

Derek Muir
Research Scientist

cc W.L. Lockhart
M. Breton DFO Québec
T. Smith DFO Ste. Anne de Bellevue
C. Mageau DFO Ottawa

Proposal by May 5 -
add - as many species as possible = walrus - harp - bearded seals

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société Makivik corporation

Camille Mageau
Department of Fisheries and Oceans
200 Kent St
Ottawa, Ontario
K1A 0A6

April 21, 1989

Dear Camille:

Concerning the study on source levels of P.C.B.'s (and related congeners) in northern Québec I was in contact with Derek Muir of the Freshwater Institute on April 19th. He indicated that northern Québec has certainly been identified a research priority due to a paucity of data, and agreed the issue must also be addressed in context of the elevated P.C.B. levels found amongst lactating women in the Hudson Bay area.

We discussed collaboration on this project and will be communicating further next week to establish a protocol, delineate roles and prepare a funding proposal for submission to D.F.O. under the Long-Range Transportation of Pollutants Program.

I have also been in contact with Harriet Kuhnlein (co-researcher with David Kinloch in the Broughton Island study). She has apparently been approached by Eric Dewailly (C.H.U.L.) to conduct the dietary practices aspect of this study although nothing has been finalized to date. It would therefore appear the various aspects of this project are starting to fall into place and will hopefully permit implementation of the study during the 1989 field season.

I fully appreciate the urgency of submitting a proposal in order to obtain funds and to schedule analyses within the framework of projects ongoing at the Freshwater Institute. Please rest assured we will submit a proposal in the immediate future. We would appreciate your continued support in this context and look forward to your comments.

Yours truly,

S. Olpinski

Stas Olpinski, Biologist
Kuujjuaq Research Centre

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Inukjuak, Quebec J0M 1M0 / Tél. (819) 254-8878

Camille Mageau
Department of Fisheries and Oceans

April 21st, 1989

ms/SO

c.c. Michael Barrett, K.R.G.
Tom Boivin, Makivik
Mimi Breton, D.F.O.
Lorraine Brooke, Makivik
Jackie Koneak, Makivik
Mary Kaye May, K.B.H.S.S.
Harriet Kuhnlein, McGill University
Derek Muir, Fresh Water Institute
Philippe Di Pizzo, K.E.A.C. ✓

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Administration Régionale KATIVIK Regional Government
P.O. Box 9, KUUJJUAQ (Fort Chimo), Quebec J0M 1C0

BY TELECOPIER

March 15th, 1989

Ms. Camille Mageau
Department of Fisheries
and Oceans
200 Kent
OTTAWA, CANADA
K1A 0A6

SUBJECT: Studies on contamination of wildlife by PCB's, PCDD's, PCDF's, Mercury and other heavy metals

Dear Ms. Mageau:

We are increasingly concerned by the presence of environmental contaminants in the Northern ecosystems. Over the past years, polychlorinated biphenyls (PCB's), polychloro-dibenzo-dioxins (PCDD's) and polychloro-dibenzo-furans (PCDF's) have been identified as important contaminants of the environment, originating from industrial effluents released in rivers and coastal waters, or transported as aerosols. These contaminants accumulate rapidly in the food chain, particularly in fish and sea mammals; indeed, because of their highly lipophilic nature elevated concentrations have been found recently in the body fat and in the fat fraction of the breast milk of Inuit of Baffin Island (KINLOCK, David, 1985-1988) and Northern Québec (DEWAILLY, Éric, 1988).

Recently, the Community Health Department of the CHUL (Centre de toxicologie du Québec) and the Kativik Regional Board of Health and Social Services were granted $478 920 to carry out a Quality Surveillance Program of Human breast milk in Northern Québec. General objectives of this important program include a description of the present situation (determination of average levels of impregnation by organochlorines in the Northern Québec Inuit, individual screening of breast-feeding mothers), and the evaluation of potential impacts on the breast-fed children's health by toxic agents transmitted through maternal milk.

However, this program does not intend to provide scientific data on the presence of organochlorines and other environmental pollutants in the Northern environment, and particularly in the

Ms. Camille Mageau
Department of Fisheries
and Oceans

March 15th, 1989

main species ingested by the Inuit in both the Hudson and the Ungava Bay areas (sea mammals, marine and freshwater fish, migratory birds, etc.).

A Working Group on Environmental Pollutants composed of representatives from the Kativik Regional Government, the Makivik Renewable Resources Development Department and the Kativik Environmental Advisory Committee was set up to tackle environmental aspects of a possible surveillance program. The main objective is to provide a proper characterization of the environment in regard with organochlorine compounds, mercury and other heavy metals in aquatic ecosystems (fish and marine mammals). Sampling aspects of this program could conveniently be tied into ongoing studies in the region involving walrus, beluga and arctic char conducted by Makivik, the Kativik Regional Government and the Regional Office of Fisheries and Oceans. Our study proposal could also include links with the Freshwater Institute of Winnipeg as well as other groups engaged in this area of research in other parts of the Arctic.

At the moment, these organizations do not have adequate financial and human resources to undertake such important studies, and wish to obtain adequate funding from the Department of Fisheries and Oceans under the Long-Range Transportation of Pollutants Program. To do so, we would like your assistance to present a formal proposal respecting the Program's criteria.

Please contact the undersigned should you require additional information on this matter.

Yours truly,

Michael Barrett
on behalf the Working Group

c.c. Stas Olpinski, Makivik
Tom Boivin, Makivik
Denis Audette, K.R.G.
Mary Kaye May, K.B.H.S.S.
Philippe Di Pizzo, K.E.A.C.

George Dickson
Waterloo

NEW LRTAP PROJECT PROPOSAL

~120k to Lyle's SP
– TO Resubmit in better proposal → putting-up the proposal
→ collaborating in the research + sampling

Region: Central and Arctic

Centre: Freshwater Institute

1. LRTAP Project Title, Duration:

   LRTAP Organics - Flux to Remote Lakes and Stress in Fish.

2. Project Manager: Address, Tel. No.:

   Dr. J.F. Klaverkamp
   Division Manager
   Contaminants and Toxicology Research
   Freshwater Institute
   501 University Cresent
   Winnipeg, Manitoba
   (204) 983-5003

3. Contact (State where different from Project Manager):

   Dr. W.L. Lockhart
   (address same as above)
   (204) 983-7113

4. Project Objectives (indicate main objectives and intermediate milestones):

   why not North the
   latitudinal range -

   To determine the fluxes of LRTAP organic contaminants and metals to remote freshwater lakes (including Arctic sites) and to relate flux-to-lake to contamination of fish and to the biochemical stress indicators in the fish.

5. Brief Background and Project Description:

   It has been known for at least 20 years that LRTAP is an important (i.e. the only) source of contaminants such as organochlorine pesticides and pyrogenic metals in remote areas of Canada. LRTAP also accounts for a portion of some metals in these regions. This project is to quantify the relationships linking supply process, contamination of fish and biological responses at different latitudes.

..... /2

6. Need for the Study (relate proposals to present LRTAP Program objectives):

LRTAP Organics are a problem in the inland fisheries of Canada, especially in the Great Lakes and in isolated communities where consumption of fish in the "subsistence fishery" is much higher than the national average. It is critical that we understand the supply processes and track the contaminants through to their contamination of fish and their effects on fish and habitat in order to build an effective case for control negotiations.

7. Relationship to other LRTAP Projects (consider both intra- and inter-regional):

We are sharing our extensive analytical experience in geochemistry of freshwater sediments and the analyses of tissues with LRTAP Organics researchers in the Scotia-Fundy and Newfoundland Regions.

8. Major Milestones/Outputs (by fiscal year):

1987-88 Designed and built special corer for collecting large cores of lake sediments - tested the corer at ELA; established GC/MSD analysis procedures.

1988-89 Analyzed ELA cores, tested and modified corer, collected SAQVAQJUAC cores (only data of this kind in the Arctic).

(

Reference Notes on PCB's

PCB's Polychlorinated biphenyls are synthetic chlorinated organic compounds: 213 different products depending on the way the chlore atom combines in the molecule. Highly stable compounds, with important insulation properties (used in transformers, glues, wax, pesticides, lubricants, printing inks, etc.).

Very soluble in fat, but not in water. Origin from industrial pollution and transported through the food chain from sea-dwelling plankton and algae that form the base of the chain to fish, predator then to the human. Stored in fat and blubber of mainly sea mammals and fish, and probably in the eggs of migratory birds comsumed by Inuit.

Present in traces in the blood, but in concentrations 100 to 200 times less than in the fat fractions of breast milk of human. Health and Welfare Canada recommends a maximum concentration inferior to 1,5 ppm. Concentrations are found to be higher in male than female. Excretion is only possible through breastfeeding, at the rate of 30% of PCB's ingested.

Toxic effects on human are: skin deseases, digestive problems, neurological and immune deficiencies. WHO considers PCB's as probable carcinogens. ="Yusho" desease.

PCDD's and PCDF's Polychloro dibensodioxins and polychloro dibensofurans should be part of the study in sea mammals and fish, and to a lesser extent in migratory birds and their eggs.

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comité consultatif de l'environnement KATIVIK
KATIVIK environmental advisory committee
C.P. 9, KUUJJUAQ, QUÉBEC, J0M 1C0 • TÉL.: (819) 964-2941

Le 27 janvier 1989

Cher membre,

Vous trouverez sous pli un exemplaire d'un document que Monsieur Guy Tanyan a obtenu lors d'une réunion à laquelle il a participé le 10 janvier dernier à Povungnituk.

J'aimerais obtenir vos commentaires sur la proposition du Centre de toxicologie, plus particulièrement sur les aspects environnementaux de la recherche. Ce sujet sera d'ailleurs porté à l'ordre du jour de la prochaine assemblée du Comité consultatif qui aura lieu au cours du mois de mars au Nord.

Je communiquerai avec les membres au moment opportun afin de fixer la date et le lieu exact de l'assemblée.

Je vous remercie de votre collaboration.

P. Di Pizzo

Philippe Di Pizzo
Secrétaire général

PROPOSAL FOR A QUALITY SURVEILLANCE PROGRAM OF BREAST MILK IN NORTHERN-QUÉBEC

Éric Dewailly, M.D., M.Sc

Département de santé communautaire du CHUL
Centre de Toxicologie du Québec

JANVIER 1989

English translation: Albert Nantel, M.D., M.Sc

I- DESCRIPTION OF THE PROBLEM

1.1 Environmental Contamination

1.1.1 PCB's

Polychlorinatedbiphenyls (PCB) are synthetic chlorinated organic compounds, heat stables and resistant to the majority of chemical agents. Because of their insulating properties (dielectric), PCB's have been used for more than 40 years in various industries: paints, printing inks, thermal exchange systems, lubrifying agents and in electrical transformers and condensers (1). Since 1966, PCB's have been identified as major contaminants of our natural environment (2). PCB's accumulate progressively in the food chain (3,4) and especially in fresh water fishes (5). This contamination originates from industrial effluents released in rivers and coastal waters (6). Since 1972, the use of PCB is regulated in Canada and is confined to electrical industries in controlled conditions of use and waste disposal. However, because of their persistence in the environment PCB's still represent a potential public health problem.

In Arctic regions environmental contamination by organochlorines involve mainly fishes and sea mammals. This contamination originates not only through atmospheric transport followed by contaminated particles deposition, but also by migration of these contaminants through sea currents. Many authors have illustrated the importance of this organochlorines contamination in the Arctic regions (7,8,9,10,11).

Studies have shown mean concentration of PCB's in the fat of seals of 3 to 10 µg/g (ppm) and up to 800 µg/g for some types of beluga. (12).

1.2.1. PCDD's and PCDF's

Polychlorodibenzodioxins (PCDD's) and polychlorodibenzofurans (PCDF's) have been identified in various industrial products but also in some pesticides like 2,4,5-T or in some chloro-phenoxy acids in pentachlorophenols and in PCB's. All these products have been and are still largely used in industrial countries. Incineration of household and industrial waste (13,14) and also in car combustion emissions (15), in the waste of pulp and paper companies (16) may all release traces of PCDD's and PCDF's.

These compounds have also been found in the food chain of the Great Lakes and in the Baltic Sea (17,18). Recently, seal contamination by PCDD and PCDF in the Arctic has been shown in areas where no local contamination exists and that are located at thousands of kilometers away from urban centers (19). If we extrapolate the toxicity of each homologue family to its equivalent in 2,3,7,8 tetrachlorodibenzodioxin as proposed by Eadon (20), the concentrations in the seal fat varies between 20 and 47 pg/g (ppt) of 2,3,7,8,-TCDD equivalent.

If we compare these figures with the usual daily intake from food (1 pg/kg (TEQs-TCDD), the ingestion by a 70 kg adult of 2 to 4 grammes of seal would be sufficient to reach this average level of intake.

1.2 The Inuit food supply as a potential source of PCB, PCDD and PCDF.

Various methods can be used to evaluate the significance of fish and sea mammals consumption in the Inuit food supply. The first way would be to analyze the total catches for each village and to evaluate the average consumption by inhabitant

(21,22). However, the lack of precision of such measure has raised the need for the establishment of diet surveys. Very recently a pilot study realized in the Canadian Northwest Territories (Broughton Island) made it possible to identify the main sources of PCB food intake (23). In food percentage, narwhals, seals and fishes contributed to more than 60% of the total weight of ingested food. If we calculate for each food item a probable concentration in PCB, almost 90% of all intake originate from the ingestion of narwhals, seals and walrus.

It is then probable that Inuit are exposed through their food consumptions to high levels of PCB, PCDD and PCDF. First of all the consumption of fish is much higher than elsewhere. Furthermore the ingestion of animal fat, in particular sea mammal fat is much higher than the average amount of 30 grammes/day used by Health and Welfare Canada in order to calculate the accepted concentrations from acceptable daily intake (ADI).

1.3 Human concentration

1.3.1 PCB's

Because of their high lipid solubility, PCB's concentrate in human and in animal fat (24). They are excreted mainly through stools (25). However, in the breast-feeding woman, about 30% of the PCB elimination is done through the milk (26). The average blood concentration measured in United States show values between 5 and 7 ppb (27). These concentrations are higher in male than in female and increase progressively with age, showing a progressive bioaccumulation through many years of exposition. (28).

PCB concentrations in body fats and in the fat fractions of the milk are about 100 to 2 0 times higher than in the blood (29). Since fat biopsies are most of the time unacceptable, PCB measurements in the breast milk has been used to evaluate th level of expositions of the populations. The inconvenience of this method is to limit the study to a sub-group of the population. In Michigan State high concentrations of PCB have been measured in the Great Lakes fishes and in the blood of individuals eating these fishes on a regular basis (31). A study done on 1057 samples of breast milk has shown an average value of 1.5 ppm (based on the fat fraction of the milk) (32). It has been estimated that a breast-fed child might reach after nine months a total body concentration of 1 ppm which corresponds to a daily intake 14 times higher than the acceptable limit for an adult (33). PCB blood levels in children increase with the length of breast-feeding (34) and may reach levels 10 times higher than the blood levels of their mother (35). In the Province of Quebec, PCB concentration in the fat portions of breast milk measured in 1978-79 in 154 women varied between 0 and 4.3 ppm for an average of 0.84 ppm (this excluded a sample containing 29 ppm) (36), which represents 2.5 times more than the average of 100 samples measured in a canadian study (37).

1.3.2 PCDf and PCDD

Relatively very little data is available on the breast milk contamination by these products. About 200 analyzes of PCDD/PCDF in the breast milk have been identified in the world literature (38) and many came from pooled samples (39-40). One single analysis published by Health and Welfare Canada is available for the Province of Quebec. It has been done on a pooled sample of 36 milks. (Annex). PCDD's found in human milks have chlorines substitutions in 2-,3-,7- and 8 positions. The vast majority of the isomers are octachlorinated. However, the portions of tetra and pentachlorinated are the most important in view of their toxicity. The PCDF's are characterized mainly by the penta CDF and hexa CDF.

We consider that a breast-fed child gets from this mother a daily dose of 70 to 150 pg/kg of body weight in 2,3,7,8, TCDD toxic equivalent which is considerably more than in adult (1 to 5 pg/kg/day). However, the usual short duration of breast-feeding (less than six months) is such that this part of life represents less than 5% of the total life accumulation (38). These considerations are justified only when we evaluate the carcinogenic risk for a whole life. In the case of the other short or long term toxic risks (skin lesions, immune deficiencies, liver lesions, central nervous system disfunctions), the ingestion of significant doses of these toxic agents by a new-born with an immature metabolism, should be taken into consideration.

1.4 The toxicity of PCB/PCDD/PCDF

1.4.1 Experimental studies

The toxicity of PCB has been studied in many animal species (41-44). The interpretation is made difficult by the wide diversity of isomers, homologues and congeners that we find in the family of PCB as in the other related halogenated aromatic hydrocarbons and mainly the dibenzofurans and dibenzodioxins (45-46). The acute toxicity (LD 50)by ingestion is relatively small (4-20g/kg in the rat). However, sub-acute and chronic studies have shown lesions of various organs: liver, kidney, serous membranes and skin along with modifications of the metabolism (porphyria, liver enzymatic induction), of the reproductive system (decrease in fertility, abortions, neo-natal deaths), of the immune system (thymus and lymphoid tissues atrophy, depression of the humoral immune response). There are evidence also of tumorigenic and carcinogenic effects on the liver (47) and on the stomach (48). PCB's would behave as carc nogenic promoters (45). Halogenated a omatic hydrocarbons are qualitatively simi ar in their toxi ity but quantitatively extremely variable (49). Finally, we re just beginning to understand more clearly the physiopathologic mechanisms that explain the toxicity of this class of substances (50).

1.4.2 Studies on human populations

In humans, the toxic effects of PCB have been observed following prolonged industrial exposures (51-52). The areas affected are the skin (oedema of the face and the hands, chloracne), the peripheral nervous fibers and the digestive system.

In 1968, over 1,000 Japanese have ingested a rice oil accidentally contaminated by PCB (53). They have shown objective signs: acne-like eruptions, skin and nails pigmentation along with other subjective symptoms (54). Children born from intoxicated mothers showed at their birth an hypotrophia, a skin hyperpigmentation and other abnormalities that may be related to the modification of the calcium metabolism (55). The follow-up of these children has shown evidence of various neurological and immune deficiencies (56-57).

Epidemiological studies have been carried out both in the occupational environment and in the general population. High levels of PCB in the blood have been related to abnormalities of the liver metabolism (58). Reproductive abnormalities have been observed following the "Yusho" episode (55) and a reduction in birth weight has been noted in new-borns from women occupationally exposed to PCB (59). Toxemia of pregnancy has been related to a long-term exposure to PCB. In a study comparing 18 women suffering from toxemia of pregnancy, high levels of PCB in the blood have been observed in half and none in the control group (60). Arterial hypertension has also been related to high blood levels of PCB (61).

The relation between PCB and the development of cancer has been studied in a cohort of 2560 subjects exposed to PCB. No abnormal excess of mortality by cancer has been observed (62). However, a case-control study has shown a significant increase in the fat concentration of PCB in patients suffering from cancer (63). Considering the experimental results and the uncertainties concerning the population studies, the World Health Organization (WHO) has decided to consider PCB's as "probable carcinogens" (64). More recently, an epidemiological follow-up of people suffering from Yusho has shown evidence of significant excess of lung and liver cancer in men (65).

1.4.3 The immunological deficiencies

Many experimental studies and observations have shown evidence of the potential immunotoxic effects of PCB's, PCDD's and PCDF's. The first abnormalities that were described were related to the patients poisoned during the episode of Yusho in 1968 and Yusheng in 1979. Both humoral and cellular immunity of these patients have been impaired. The abnormalities described involves mainly: the decrease in IgA and IgM, a reduction in the skin response to antigens, a decrease in the T lymphocytes (E-rosette) and active T lymphocytes. In the T lymphocytes the reduction involves essentially the T lymphocytes helpers producing a decrease in the ratio helpers/suppressors. These abnormalities have been seen since then but in an inconsistent and sometimes contradictory way (humoral immunity) in exposed workers.

II PRELIMINARY RESULTS

1. Initiation of the study - Methods

This prelimi[illegible]ary inquiry was he[illegible]d between the month[illegible] of November 1987 and the month of Sept[illegible]mber 1988. The [illegible]amples were obtained th[illegible]ough the courtes[illegible] of the mid-wives [illegible]t the Baie d'Hudson Hospital. The villages where the women participating to the study lived are shown in the map in annex.

The total amount of milk varied between 30 and 60 mL. The samples have been deep-frozen directly after sampling and sent in three batches at the Centre de Toxicologie du Québec Laboratory.

The analyzes have been done on the milk fat and then calculated for total milk after weighting the fat. The results are expressed in ppm (mg/kg) for the results in fat and in ppb (µg/kg) for the results in whole milk.

A diet survey translated in Inuktitut aimed at measuring the ingestion of sea mammals and other significant variables. (Annex).

In parallel to this inquiry we were completing for the FRSQ a preliminary feasibility study on the provincial surveillance of maternal milk. Forty-eight samples have been obtained in Quebec City and in Baie-Comeau and are now used as a comparison for this actual study.

2- Results: Breast milk contamination by PCB

(The results are compared to those obtained in Quebec City and in Baie-Comeau

	N	**PCB Whole milk (in ppb)**	**PCB Milk fat (ppm)**
Quebec City	19	27.9 (8-59)	0.76 (0.4-1.3)
Baie-Comeau	29	28.6 (5-115)	0.75 (0.1-3.2)
Northwestern Quebec	24	112.6 (16-514)	3.59 (0.5-14.7)

The fat concentrations of milk are slightly higher (3.2%) in Inuit than in the southern regions of Quebec (2.7%). The age average is slightly lower in Inuit (25 years old) than in the women from the south of Quebec (28 years old). The level of parity is also slightly higher (2.5 vs 0.7 previous children).

We then conclude that breast milk contamination by PCB in Northwestern Quebec is, in average, five times higher than in the southern part of Quebec.

In the Inuit women, the level of PCB in the milk is inversely related to the number of breast-feeding weeks that have taken place during the previous five years. The cumulative total number of breast-feeding weeks is far more elevated in the Inuit (48 weeks) than in the South (11 weeks).

3. Exposure analysis

One factor aggravates the problem of the breast milk contamination in Northwestern Quebec, it is the long duration of the breast-feeding. The last inquiries done in Hudson Bay show the following fact:

. the possibility of breast-feeding: at least 6 months is 65%
at least 12 months is 50%
at least 23 months is 30%

These figures concern 65 to 70% of the children.
(The proportion of breast feeding after birth).

Total dose received

Let us take as a reference value for the level of breast milk contamination in Northwestern Quebec, the average level (3.7 ppm in the fat) and the maximum level observed (14.7 ppm). The following table shows the total dose of PCB that can be cumulated in relation to the duration of breast-feeding.

	6 months	12 months	24 months
Average contamination (3.5 ppm)	17.2mg	38mg	109mg
Maximum Contamination (14.7 ppm)	58.8mg	152mg	450mg

We know that following the food contaminations in Yusho and Yusheng and also following occupational intoxications, a blood concentration of 150 to 200 ppb (normal of 5 to 7 ppb) is susceptible to produce observable biological or clinical effects (acne, pigmentation of the skin, hepatic disturbances, immune deficiencies) (42).

This blood concentration could be reached by a child who would absorb a total dose of 30 mg. This threshold dose at which it is possible to observe adverse effects (LOAEL) is reached in average before less than 12 months of breast-feeding and for children fed with highly contaminated milk as soon as the forth and fifth month.

In order to be able to define more precisely the risk, measurements of dioxins and furans are being done at the MAPAQ in order to evaluate if the ratio PCB/PCDD-PCDF are compatible between the No.th and the South of the Province.

4- Conclusion

1. The contamination of the Inuit breast milk seems to be five times more elevated than in the South of the Province.

2. This contamination originated probably from a diet which is rich in fat from sea mammals.

3. The total doses received by the new-borns are quite elevated partly because of the milk contamination and partly because of the usually long duration of breast-feeding.

4. These doses are susceptible to produce in some children skin, liver and immune abnormalities.

5. In order to solve this public health problem, it will be necessary to:

   a) Increase our knowledge of the level of the Inuit breast milk contamination by PCB and other organochlorine agents.

   b) A measurement of dioxins and furans in order to evaluate properly the risk.

   c) An inquiry on the food quality and eating habits in Northwestern Quebec in order to identify the most contaminated food items.

   d) A study on potential adverse effects on the health of the new-borns who are fed by contaminated breast milk .

   e) A comparison between this potential risk and the known benefits of breast-feeding.

III- **PROPOSED SURVEILLANCE PROGRAM**

1. Objectives of the program

Objective 1: To describe the situation.

To pinpoint the level of contamination of breast milk in Northwestern Quebec by organochlorine chemicals.

- To determine the average level of impregnation by organochlorine in the Northwestern Quebec Inuit.

- To set up an individual screening in order to be able to advise the mother on the management of their breast-feeding if we want to obtain the maximum of benefits and reduce to a minimum the risk for the breast-fed child.

Objective 2: To identify the sources of contamination

- To define by the way of an interview, the food intakes that are more involved with human contamination.

- To identify potential geographical variations in the level of contamination.

- To identify individual variable factors that may influence the metabolism of organochlorine agents (age, number of previous breast-feedings, physical activities).

- To help clarify the level of contamination of the Northern ecosystem (Hudson Bay and Ungava Bay) by organochlorines namely:
    - Source of t e toxic agents (tmospheric transports, ocean waters)

- Levels found in the ecosystems (namely air, water and soil).
- Level of contamination of the ingested species (seals, walrus, char....)

Objective 3: To evaluate the potential impact on the breast-fed children health by some toxic agents obtained through maternal milk

- To evaluate the dietary exposure of Inuit children by organochlorines during their first year of life through maternal and replacement or complementary food items.

- To evaluate the effects on the immune and hepatic systems.

- To evaluate the potential clinical effects (infections and skin problems).

2. Definition of the population

2.1 Level of impregnation of the Inuit population by organochlorines (Objectives 1 and 2).

Definition

The studied population will be formed by every Inuit mother living in Hudson Bay or Ungava Bay, who will give birth to a living child between February 1^{st}, 1989 and February 1^{st}, 1990 who will breast-feed their child and who wish to participate into the study.

Number of participants

For a total Inuit population of about 6,000 people and with a birth ratio of 37 for 1,000, the estimated number of births is 220. The ratio of breast-feeding varies between

60 and 70% which equates to a total number of women from which breast milk could be evaluated to 120.

2.2 Follow-up of breast-fed children

In order to obtain a control group for the breast-fed children, a similar and parallel follow-up will be done on non breast-fed children. Furthermore, children for whom their mother interrupt the breast-feeding will continue to be followed. The group of children who are being breast-fed right from their birth will include about 120 children. The control group includes 100 children.

3. General description of the surveillance program

3.1 Environmental evaluation

Even though this activity is not under the direct responsibility of the health network, it is essential to obtain a proper characterization of the northern environment in regard with the organochlorine compounds especially: PCB's, DDT and its metabolites, chlordane, hexachlorobenzene (HCB), α, β and δ isomers of hexachlorocyclohexane (HCH), dieldrine, toxaphene, Mirex, aldrine and endrine. These different substances will need to be looked for in priority in aquatic ecosystems and in particular, fishes and sea mammals. An interministerial collaboration both on the provincial and federal level will need to be set up.

This characterization will need to be done in both the Hudson and the Ungava Bays. It will need to be done in parallel with the medical surveillance. It will make possible the identification of the species and the sites that are most contaminated. Furthermore this data will make it possible to calculate a daily intake obtained through the diet and compare it to the Acceptable Daily Intake (ADI).

3.2 Diet survey

This survey will be done with the 120 mothers that are breast-feeding their children and who will have their milk analyzed. It will be done through an interview and a questionnaire produced both in English and in Inuktitut. This survey will be carried on over twelve months. Its objective will be to identify the food items involved into the toxic chemicals intake.

3.3 Surveillance of the breast milk quality

This will be done over twelve months and will concern 120 women who are breast-feeding their children. A second sample will be proposed after six months in order to evaluate the evolution of the concentrations and should involve about 30 women. The results will be transmitted to the nurses two to three weeks after the arrival of samples at the laboratory. an information program will have to be set up.

3.4 Follow-up of children

This surveillance will be done through dispensaries and the hospitals of both Hudson and Ungava Bays. The children will be seen after 2, 6 and 12 months during their routine appointments for vaccinations. The 200 children born between February 1st, 1989 and February 1st, 1990 will be followed in a prospective way during the following twelve months.

The follow-up of the child can be illustrated in the following way:

at 2 months

1. measurement of hepatic enzymes
2. immune system profile
3. clinical evaluation

at 6 months

1. measurement of hepatic enzymes
2. immune system profile
3. blood count
4. clinical evaluation
5. diet evaluation

The measurement of hepatic enzymes along with immune and hematological systems profiles are done in order to detect as early as possible potential biological abnormalities and to verify toxic origin by statistical analysis.

The clinical evaluation will identify the child infection since its birth or since the last visit. Search for abnormal skin pigmentation will also be required. The incidence of these abnormalities in the children will be compared with their intake in organochlorines. Finally, the diet evaluation which will be quite short, will aim at the 6th and 12th months to a characterization of the potential intake in organochlorine through complementary or replacement diet for maternal milk (solids, fishes, sea mammals).

4. Methods to be used for surveillance program

4.1 Surveillance of the maternal milk

4.1.1 Sampling

The sampling of milk will be done manually by the mother herself during the second or the third week following the child birth (7th or 21st day). It will be collected in a 60 mL polycarbonate NALGEN jug. The sampling of about 50 mL will be completed if possible over 24 hours then frozen either at the home or at the dispensary of the hospital. Simple instructions will be given to the mother for the sampling. Milk samples will be transmitted every two weeks from the two hospitals to the Centre de Toxicologie du Québec Laboratory where it will be analyzed.

4.1.2 Laboratory analyses

4.1.2.1 Organochlorines analysis

For the feasibility study, we have measured the concentration of PCB in the maternal milk in terms of Arochlor 1260 and the total concentration of DDt and DDE eluted through a single chromatographic peak. We have identified the less chlorinated PCB (3 and 4 chlorine biphenyls) that we find in Arochlor 1252 and 1254 and various organochlorines including hexachlorobenzene, aldrine, dieldrine and Mirex. For all those samples, the percentage of fat in milk has been measured by the method of Roese-Gottlieb.

As far as the analysis of PCB is concerned, the technique consists into an hydrolysis of the fats by sodium hydroxide and an extraction of PCB's and other organochlorines using a mixture of hexane-ethylic ether. The extract is then concentrated, purified on Florisil and analyzed by gas phase chromatography on a low polarity capillary column type DB-5 measuring 30 meters. The detection of halogenated products is done through an electron-capture detector (Ni^{63}).

(ii) Chromatograms analyzes

For each peak, the integrator gives the height, its absolute retention time and its relative relation time to 2,2',3,3', 4,5,5', 6-octachlorobiphenyl used as an internal standard. Following this, the interesting peaks are identified and quantified in comparison with the known concentrations standards of the analyzed substances.

(iii) Expression of results

The PCB levels are evaluated in terms of Arochlor 1260 which is the most persistent form of PCB in the environment. The results are expressed in microgrammes per litre of total milk and in microgrammes per gramme of fat. For a more detailed study, the results may be expressed in specific isomers found in Arochlor 1260. For this study, we have decided to measure the two most important isomers found in the maternal milk which are the 2,2', 3'4, 4'5 (# 138) and 2,2', 4,4', 5,5'-hexachlorobiphenyls (# 153). For the global study, besides these two predominant isomers, the isomers (Iupac) 28, 99, 101, 180, 181 will also be measured.

(iv) Limit of detection

- total PCB (Arochlor 1260)	1 µg/L
- PCB isomers	0,5 to 5 µg/L
- p,p' - DDE	1 µg/L
- other organochlorines	5 µg/L

(v) Quality control

For the feasibility study, an internal quality control program was set up. For each series of five maternal milks, we analyze two standards prepared the day of the analysis. These standards were prepared in cow milk and have the following content in Arochlor 1260 and DDE:

Standard I	Arochlor 1260 -	10 µg/L,	DDE: 5 µg/L
Standard II	Arochlor 1260 -	20 µg/L,	DDE: 10 µg/L

Furthermore we analyze the following controls:

Control I	Arochlor 1260 - 20 µg/L in cow milk (frozen at -80°)
Control II	Arochlor 1260 - 25 µg/L DDE: 20 µg/L in cow milk (frozen at -80°C)
Control III	Arochlor 1260 - 20 µg/L DDE: 16 µg/L in maternal milk (frozen at -80°C)
Control III	Arochlor 1260 - 20 µg/L DDE: 16 µg/L in maternal milk (frozen at -80°C)

4.1.2.2 Analysis of polychlorodibenzodioxins (PCDD) and of polychlorodibenzofurans (PCDF)

These analyzes will make it possible to evaluate more precisely the risk related to contamination of maternal milk by highly toxic substances for which very strict acceptable daily intake values exist.

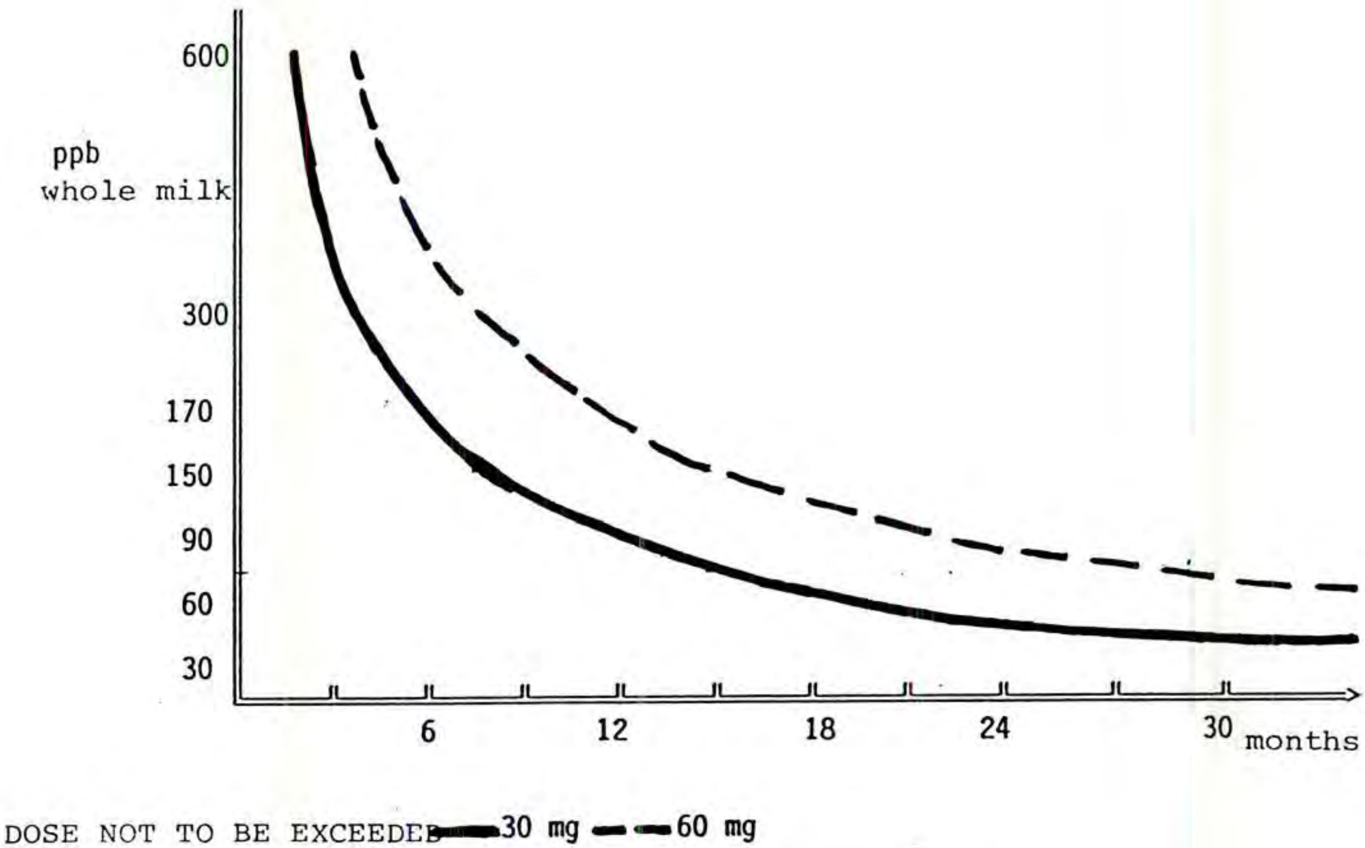
However, these analyzes require the use of highly specialized analytical techniques which are also highly expensive. Furthermore, the amount of milk required for these analyzes is between 200 and 250 mL. Finally, the source of PCDD and PCDF in the Arctic region is similar to PCB and we can presume a constant ratio PCDD, PCDF/PCB for each sample. For these different reasons, milk having similar concentration in PCB will be mixed by 5. We expect to realize 24 analyzes of this type. These analyzes will be done by an outside laboratory offering all necessary guarantees. This require the use of a high resolution gas chromatography coupled with mass spectrometry. The values found in the South of Quebec are shown in annex.

4.1.3 Handling and interpretation of results

Each result will be sent directly by Fax to the nurse in charge of the dispensary or of the perinatal department in the hospitals. The maximum delay between the arrival of the samples at the laboratory and the communication of the results will be two weeks. The nurse will contact the mother in order to inform her of the results and their interpretation.

Transmission of the results will need to be accompanied by individual recommendations. Essentially it will mean for women whose breast milk show levels of more than 2 ppm of PCB in the fat or 60 ppb in the whole milk, to suggest an advisable maximum duration of their breast-feeding and in some cases, the proposal of a combination of breast and bottle-feeding.

Estimation of the durations of breast-feeding in relation with PCB concentrations in the milk (whole milk) for a total dose not to be exceeded of 30 or 60 mgr (for a partition coefficient fat/blood of 100 to 200) and without taking into account the elimination of PCB by the child nor his intake from other food sources:



4.2 Diet as a source of PCB and individual factors

4.2.1 Interview with the mother

4.2.1.1 Diet

In order to identify the food items that may be responsible for the intake of PCB a short interview with a questionnaire both in English and Inuktitut will be proposed to each mother which is breast-feeding two months after the child birth. This interview will be done by the nurse at the second month routine visit.

The objective of the questionnaire is to measure the average amount of fishes and sea mammals ingested in a week. Precisions will have to be given if possible for the consumption of sea mammals (seals, beluga, walrus) defining the ingestions of fat, meat and giblets (liver, kidneys). This questionnaire should not have more than two pages.

4.2.1.2 Other factors

Age, number of previous pregnancies and breast-feedings (and the number of weeks for previous breast-feedings) will be collected during the same interview.

4.2.2 Information on the intake of PCB for children age 0-12 months

During the 6th and 12th months visit, some very simple informations will be collected concerning the food ingested other than milk and susceptible to increase the intake of PCB. Other questions will be asked the mother and will be included in the follow-up file of the children (see 4.3).

4.3 Follow-up of children age 2 to 12 months

The epidemiological follow-up of children age 2 to 12 months is aimed at detection of eventual biological abnormalities (hepatic, hematological and immune deficiencies) and clinical (infections, skin problems), possibly related to the presence of organochlorine compounds in the maternal milk. This follow-up will be done at the 2nd, 6th and 12th months systematic visits.

4.3.1. Medical follow-up

It will consist into an inscription on the follow-up file of children of the medical observations concerning the number of infectious episode that have supervened since birth (or the last follow-up visit) indicating the diagnosis and the duration symptoms with, when it applies, the duration of hospitalization.

Otherwise, the following cutaneo-muquous lesions will be looked for:

1. <u>folliculitis on the scalp</u>
2. comedo or acne
3. <u>skin cyst</u> (1-2mm)
4. enlargment of moebius glands and oedema of the eyelids
5. deformation of the fingernails (concave, ingrowing nail) in the feet
6. hyperpigmentation of the gums, palprebal conjunctiva (especially inferior), of the lips (inferior)
7. <u>hyperpigmentation of the nails and the skin around the nails</u>.

4.3.2. Biological follow-up

4.3.2.1 Immune system profile

The basic profile will include the evaluation of the cellular and humoral immunity. The humoral immunity includes the measurement of IgG, IgM et IgA. It requires small amount of blood which may otherwise be frozen. The measurement of the humoral immunity raises, on the other side, a particular problem. The examination of the cells has to be done in less than twelve hours on fresh blood (1-2mL) maintained at 20°C. The reading of the cells requires an equipment which is complex, cumbersome and fragile.

Considering the fact that it will not be possible because of the problem related to transport, to transfer all the samples to the CHUL in Quebec City in less than twelve hours and that having all this equipment on the site is unfeasible, it is proposed to stabilize the cells (labelled antigens) in both laboratories of Hudson and Ungava hospitals and to send, in a second step, the stabilized and stable cells to Quebec. The training required to develop the technique takes about one week. Each manipulation (whatever the number of stabilized samples) last about 2 to 3 hours. No specialized material is required on the site. The immune system profiles will be done for the 200 children at the three predicted periods which means a total of 600 analyzes.

Besides this basic program, a more elaborated profile aimed at testing the functional capacity of the immune system (inter-leukines) will be done. These tests will be done in Quebec.

4.3.2.2 Enzymatic and hematological profile

The measurement of hepatic enzymes is a standard laboratory test. It consists into measuring the following enzymes: GGT, ASAT, ALAT, alcaline phosphatase. Its objective is to detect an hepatic enzyme induction that may appear early following the hepatotoxic effect of PCB.

The hematological profile includes the blood cells numerations, the hematocrit and the iron blood level. This profile helps to identify the various types of anemia. This profile can be done in both hospitals and should be done on the 2nd, 6th and 12th months for the hepatic profile and on the 6th and 12th months for the hematological profile. The total amount of blood required is small (1-2mL).

4.3.2.2 Practical aspects

At 2, 6 and 12 months a systematic blood sample containing 4 mL of heparinized blood will be done and sent to the hospital laboratory concerned in less than 12 hours at the temperature of 20°C. Two mL will then be used for the cellular immune system profile and 2mL for the measurement of enzymatic and hematologic parameters on the site.

4.4 Analyzes of results

4.4.1 Interview

The relations between the food ingestion profiles and the maternal milk PCB concentrations will be analyzed. We will also analyze the information concerning the number of previous breast-feedings and the variations in relation with the age of the mother.

4.4.2 Follow-up of children

Once the analysis of the breast milk is done, each child will be assigned to a group exposed to PCB, according to the level of the dose ingested each day (µg/kg/day) and the duration of the breast-feeding in order to calculate a cumulated dose to which we will add if required the intake of food other than milk.

The incidence of infectious problems and cutaneous lesions will be compared between the five groups, for example:

Group 1	Non breast-fed children (n= 50-60)
Group 2	Non breast-fec children receiving solid food (20-30) (fish s)
Group	Breast-fed c ildren (slightly c ntaminated milk) (n= 60)

Group 4 Breast-fed children (moderately contaminated milk) (n= 30)

Group 5 Breast-fed children (highly contaminated milk (n= 30).

Furthernmore, correlation analyses will be done between the exposition quantitative variables (daily dose and cumulative dose) and biological parameters (immune, hepatic and hematological systems).

Finally, independently of the correlations with the PCB, the impact of the humoral and cellular immune profile of the children upon the infection will be analyzed.

5. Information to the population

The population will need to be informed in the following way:

1. Collective information:
   - To explain what are PCB's, why they are found in the Arctics, why they are found in the aquatic food chain and in the breast milk.
   - What effects they may have on the health of a new-born child.
   - Why do we monitor maternal milk.
2. To inform each mother upon the results of the analysis of her milk and the recommendations that have to follow these results.
3. To explain the meaning of the follow-up of children.

4. To inform each mother on the significance of the laboratory results (immunological, hematological, biochemical).

6. Ethical considerations

This surveillance program involves many ethical considerations.

6.1 Transmission of results

Those responsible for the surveillance program take the engagement to transmit to the nurses involved, the results along with commentaries concerning the quality of the milk in less than two weeks following the arrival of the sample at the laboratory of the Centre de Toxicologie du Québec.

6.2 Accumulation of doses above the LOAEL (Lowest Observed Adverse Effect Level)

In the case where a child

1. would cumulate a dose close to the LOAEL (between 30 and 60 mg)

AND

2. would show at least one biological or clinical abnormalities and/or repetitive infections

It would then be necessary to suggest to the mother an alternative solution to breast-feeding (maternized milk or mixed feeding).

7. Collaborations required and responsiblities involved

1. Coordination of operation on the site
   - Kuujuak : DSP
   - Povugnitul : DSP

   In collaborati n with CRSSS and Pr jet Nord.

2. Scientific responsibility

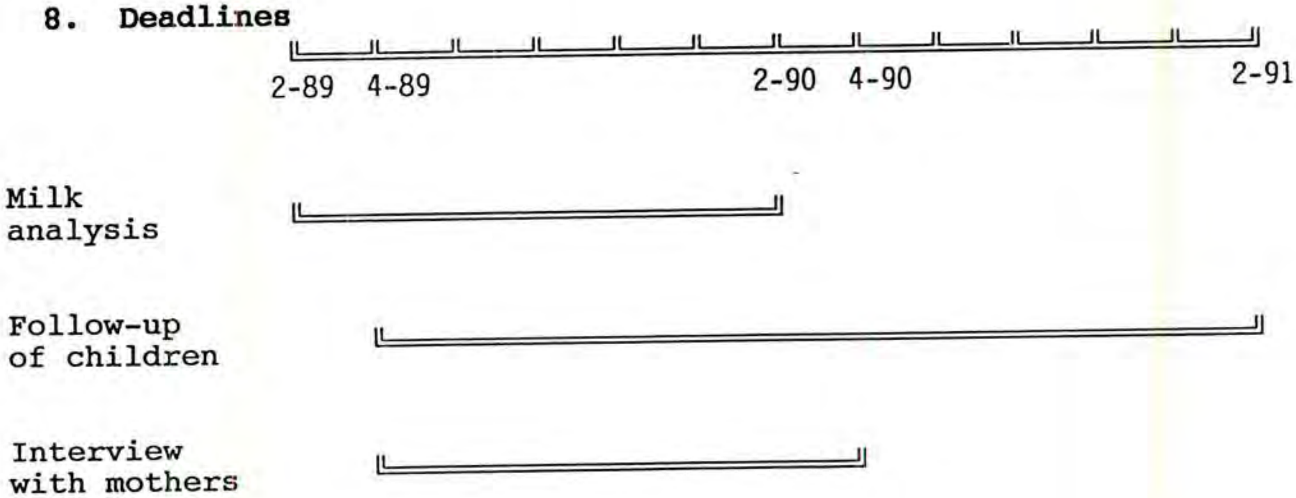
- **scientific coordinator : Eric Dewailly, m.d.**
- **co-investigator in toxicology : Albert J. Nantel, m.d.**
- **co-investigator in immunology : Jacques Hébert, m.d.**
  Raynald Roy, m.d.
- **co-investigator in toxicology: Jean-Philippe Weber, Ph.D.**

- consultant in epidemiology : François Meyer, m.d.
- consultant in pediatry : Gilles Julien, m.d.

3. Interministerial Coordination

- Marc Dionne, MSSS
- Albert Daveluy, MSSS
- Mary Kaye May, CRSSS Kativik

8. Deadlines



February 1st, 1990 = complete results on the milk

April 1st, 1990 = complete results on food sources

April 1st 1990 = results on 100% of the children cohort based on the survival follow-up of 2 to 14 months

February 1st, 1991 = results on 100% of the cohort based on the minimum survival of 12 months.

9. BUDGET

	1988-1990	1990-1991
9.1 Salaries		
. Research assistant for the program coordination in Quebec	36 000	36 000
. Research assistant in North-western Quebec (half time) (including premiums)	23 500	23 500
. Technicians (2 half times, one in each hospital)	21 500	21 500
. Analyses : . biochemical (600) . hematological (600) . toxicological prep. (200) . immunoligical manipu-lations (600) (including premiums)		
Sub-total	**81 000**	**81 000**
Side-effects	**8 343**	**8 343**
Total 1 salaries	**89 343**	**89 343**
9.2 Analyses		
. Immunoligical (600 x 100$) + 40 functional profiles	30 000 4 000	30 000 4 000
. Biochemicals (600 X 2$)	600	600
. Hematological (400 x 3$)	600	600
. Organochlorine analyses (200 X 100$) (PCB, Mirex, HCH...)	20 000	
. Analyses of PCDD and PCDF (25 pools x 2 000$)	50 000	
Total 2 analyses	**105 200**	**35 200**

9.3 Various

	1988-1990	1990-1991
. Interviews with interpretors (120 x 2 hours x 13$)	3 000	
. Cost of design, printing of questionnaires and medical files	1 500	
. Information pamphlet productions for mothers Telephone and Fax (results)	800	200
. Transport of samples (BPC,dioxins, furans, immunology)	2 000	600
. Cost for transport and residence		
- training for technician in immunology (2 x 7 days)	5 500	
- travel both ways/annual	12 000	12 000
. Translation cost (French, English, Inuktitut)	4 000	4 000
. Information pamphlets, questionnaires, follow-up files research report		
. Secretarial		
Total 3 various	**34 300**	**28 800**
Sub total general	**228 843**	**153 343**
Administration costs 15%	**34 326**	**23 001**
GENERAL TOTAL	**263 169**	**176 344**

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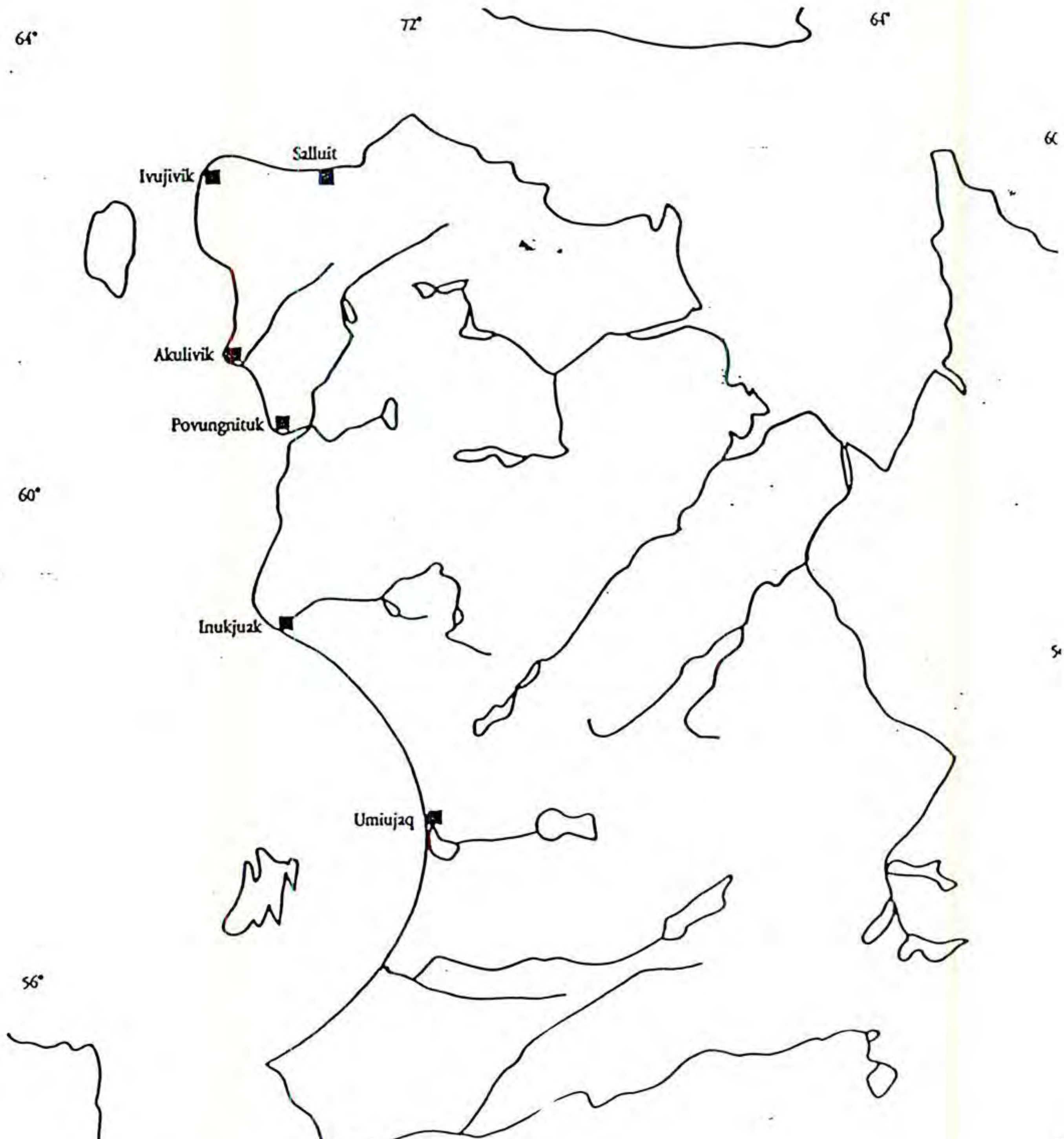
ANNEXE


64°
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Salluit
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Akulivik
Povungnituk
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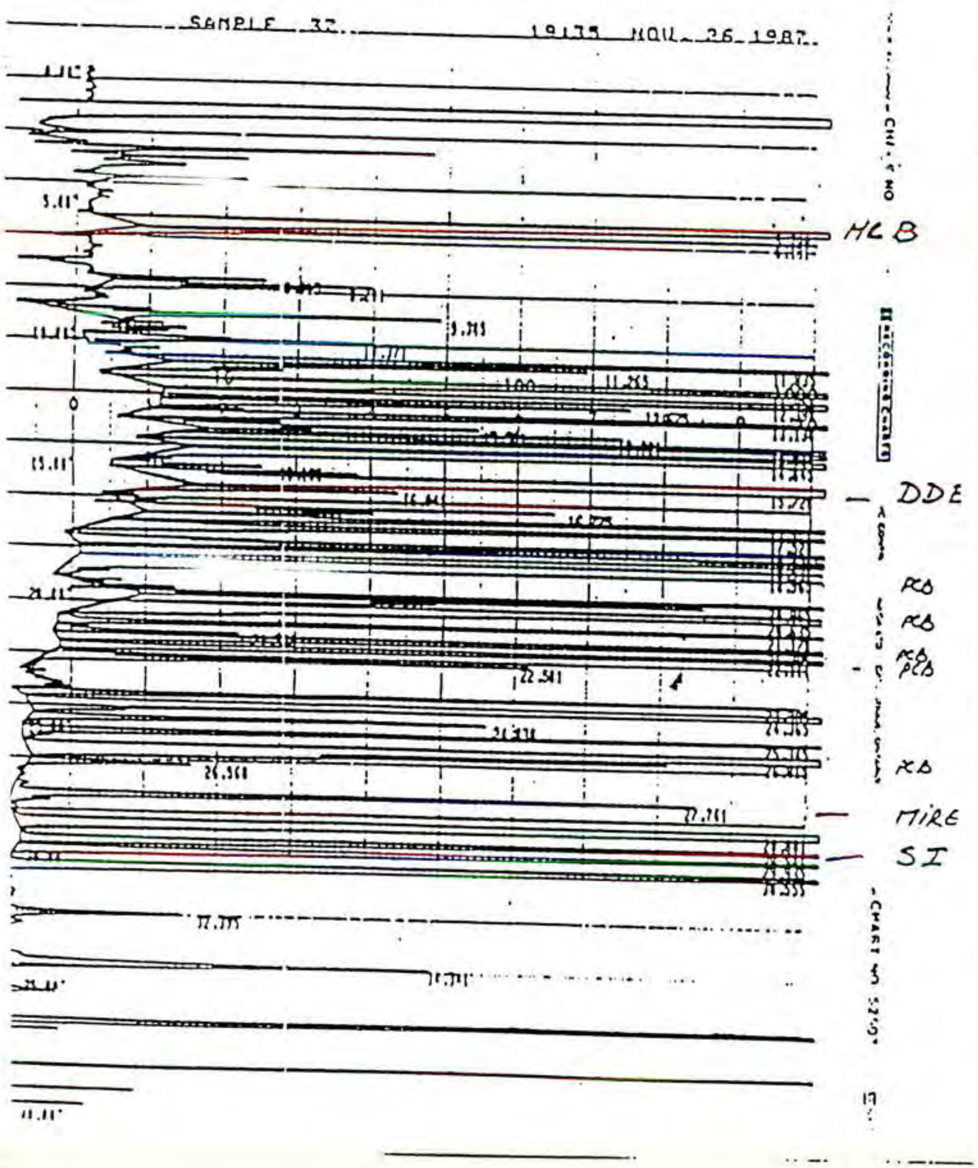
Inukjuak
Umiujaq
56°
80°
72°

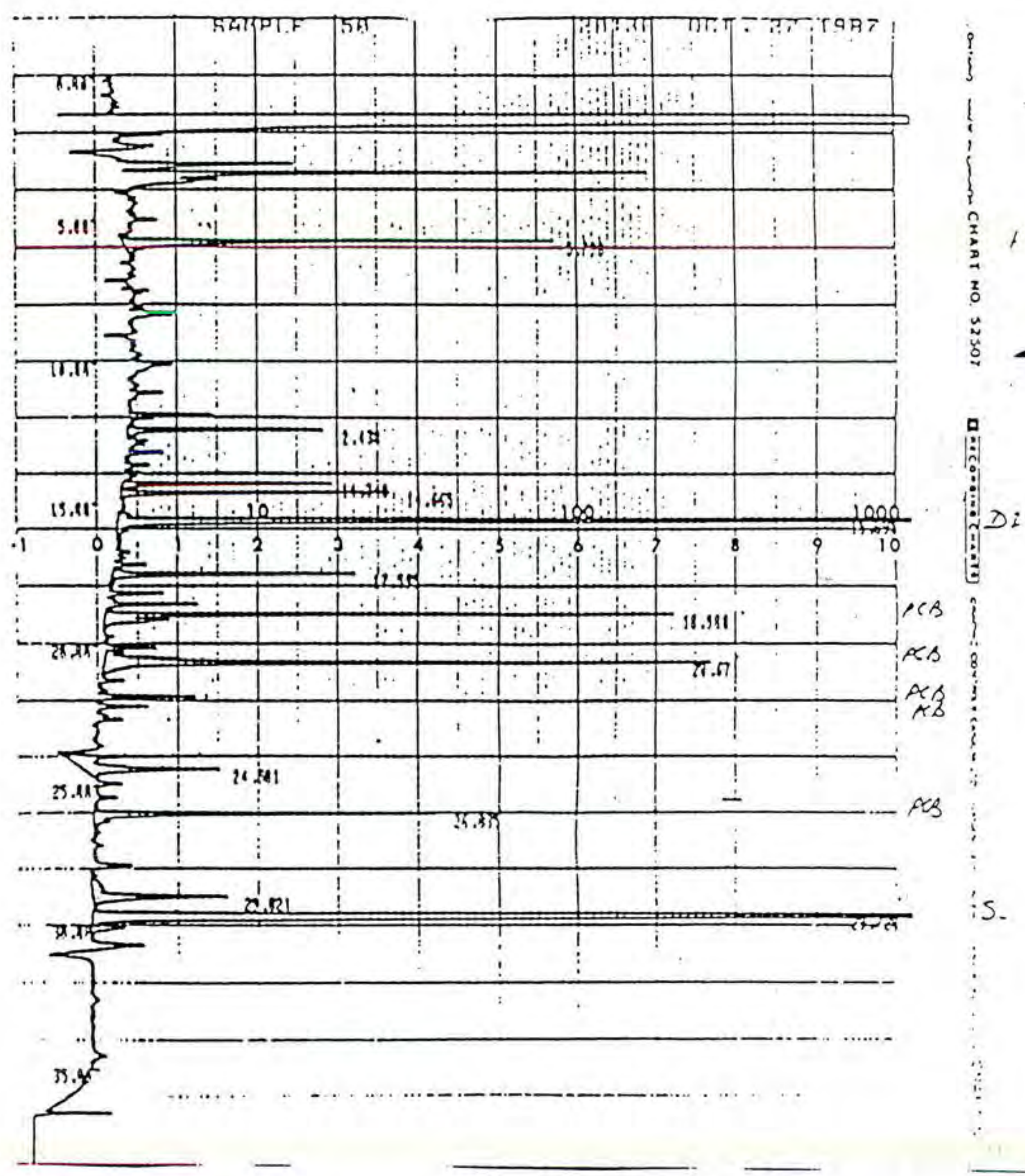
LEVELS OF PCDDs AND PCDFs IN HUMAN MILK
IN CERTAIN COUNTRIES OUTSIDE EUROPE

(ppt on fat basis)

Country/Area	CANADA					
Congener	Maritimes (pool n=19)	Quebec (pool n=34)	Ontario* (pool n=32)	Ontario** (pool n=44)	Prairies (pool n=31)	British Columbia (pool n=23)
Dioxins						
2,3,7,8 tetra	2.5	2.8	2.2	2.2	2.7	3.4
1,2,3,7,8 penta	5.9	8.1	6.5	7.4	8.1	10.2
1,2,3,4,7,8 hexa	5.1	5.6	5.2	6.9	7.6	6.3
1,2,3,6,7,8 hexa	35	41	46	42	54	63
1,2,3,7,8,9 hexa	4.8	6.8	6.6	5.7	8.7	3.1
1,2,3,4,6,7,8 hepta	63	73	68	69	75	82
octa	148	152	143	137	143	160
Furans						
2,3,7,8 tetra	8.0	4.0	2.9	1.8	5.7	2.4
1,2,3,7,8 penta	<1.0	1.7	<1.0	<1.0	<1.0	<1.0
2,3,4,7,8 penta	6.7	7.1	7.4	9.1	5.6	10.3
1,2,3,4,7,8 hexa	3.5	4.2	3.0	3.6	4.8	5.2
1,2,3,6,7,8 hexa	2.2	3.5	2.7	2.8	4.2	4.3
1,2,3,7,8,9 hexa	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,4,6,7,8 hexa	<1.0	1.3	1.5	1.5	2.0	2.2
1,2,3,4,6,7,8 hepta	5.6	6.2	3.8	5.0	6.0	7.6
octa	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Fat content %	3.6	3.9	4.0	4.0	3.9	4.5

* northern and eastern part; ** Toronto and southwestern part





CHROMATOGRAMME D'UN LAIT

FEMME INUIT

FEMME DU SUD DU QUEBEC

QUESTIONARY

STUDY ON MATERNAL MILK

NORTHERN QUEBEC, 1987-1988

1. NAME: ____________________

2. AGE: ____________________

3. BABY'S DATE OF BIRTH: ____________________

4. VILLAGE: ____________________

5. DATE-MILK SAMPLE WAS TAKEN: ____________________

6. NUMBER OF CHILDREN BORN ALIVE AND DURATION OF BREAST FEEDING FOR EACH ONE (START WITH THE ELDEST)

	YEAR OF BIRTH	DURATION OF BREAST FEEDING: (month)
1. First child	19___	______
2. Second child	19___	______
3. Third child	19___	______
4. Fourth child	19___	______

7. QUANTITY OF MEAT EATEN (seal, walrus, whale)

   Number of meals/week:_____ or Number of meals/month:_____

8. FRESH WATER FISH:

   Number of meals/week:_____ or Number of meals/month:_____

9. SEA WATER FISH:

   Number of meals/week:_____ or Number of meals/month:_____

10. QUANTITY OF OIL TAKEN (from fish or see mammals)

    _____ounce(s)/week.

ᑭᐅᔾᔪᑎᐊᓖᑦ ᖃᓪᓗᓇᑎᑐ

ᐊᐱᕐᓲᑎᑦ

ᖁᐅᔨᓴᕐᑕᐅᔫᑎᑦ ᐊᓚᓚᕐᑎᓯᓂᕐᒥᒃ

ᑯᐸᐃᒃ ᑕᕐᕋᖓᓂ, 1987-1988

1. ᐊᑎᖓ: ______________________________

2. ᐅᑭᐅᖓ: ______________________________

3. ᓄᑕᕋᐅᑉ ᐃᓄᓕᕐᕕᖓ: ______________________________

4. ᓄᓇᖓ: ______________________________

5. ᐅᓗᖓ ᐃᒻᒧᐱᑦ ᖁᐅᔨᓴᕐᑕᐅᕕᖓᑕ: ______________________________

6. ᖃᑦᓯᐅᓂᖏᑦ ᕿᑐᖓᑖᐱᓂᕐᐱᑦ ᐃᓅᔭᐱᓃᑦ ᐊᒻᒪᓗ ᖃᓄᕐᓗᐊᑎᒥᒃ ᐊᓚᓚᕐᑎᓯᓂᐱᓂᑦ ᐊᑐᓂᑦ ᕿᑐᖓᑕᐱᓂᕐᐱᑦ (ᐱᒥᐊᖃᐱᖃᓗᑎᑦ ᐊᖓᔪᕐᓯᐸᒥᒃ)

		ᐅᑭᐅᖓ ᐃᓄᓕᕐᕕᖓᑕ	ᖃᓄᕐᓗᐅᑎᒥᒃ ᐊᓚᓚᕐᑎᓯᓂᕐᖃᑕᓯᒪᔪᑎᑦ
1.	ᐊᖓᔪᕐᓯᐸᒃ	19___	______________
2.	ᑐᖓᓕᖓ	19___	______________
3.	ᐱᖓᔪᐊ	19___	______________
4.	ᓯᑕᒪᖓᑦ	19___	______________

7. ᖃᓄᐃᓗᐊᓂᖏᑦ ᓂᕿᑐᐃᓇᒥᒃ ᓂᕆᓂᑦ (ᓇᑦᓯᖅ, ᐊᐃᕙᖅ, ᕿᓚᓗᒐᖅ)
ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ/ᐱᓇᓱᐊᕈᓯᖅᒥ: ______ ᐅᑉᐸᓗᓂᑦ ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ ᑕᕐᕿᒥ: ________

8. ᑕᓯᕐᒥᒃᑕᐃᑦ ᐃᖃᓗᐃᑦ:
ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ/ᐱᓇᓱᐊᕈᓯᕐᒥ: ______ ᐅᑉᐸᓗᓃᑦ ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ ᑕᕐᕿᒥ: ________

9. ᑕᕆᐅᕐᒥᒃᑕᐃ ᐃᖃᓗᐃᑦ:
ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ/ᐱᓇᓱᐊᕈᓯᕐᒥ: ______ ᐅᑉᐸᓗᓃᑦ ᖃᑦᓯᐱᑦᓯᑎᑦ ᓂᕆᓂᕆᔭᑎᑦ ᑕᕐᕿᒥ: ________

10. ᖃᓄᐃᓗᐊᑐᒥᒃ ᒥᓯᕋᕐᑐᖃᑦᑕᓃᑦ ᐅᑉᐸᓗᓃᑦ ᐅᕐᓯᒥᒃ ᐃᓗᐃᑲᒥᒃ (ᐃᖃᓗᑉ ᐅᕐᓯᖓᓂᒃ ᐅᑉᐸᓗᓃᑦ ᐴᔪᐱᓂᕐᓂᑦ)

______ ᐅᖁᒪᐃᓂᖓ (ᕿᓗᓃᑦ) ᐱᓇᓱᐊᕈᓰᕐᒥ.

RECEIVED FROM 6439024 3.14.1989 12:09 P. 2

MAR-14-'89 11:20 ID:S S S QUE 6439024 TEL NO:418-643-4352 #08411 #509 P02

DETAILS BUDGETAIRES

PROGRAMME DE SURVEILLANCE DU LAIT MATERNEL DANS LA REGION NUNAVIK

1988-1990

OBJETS	CENTRE HOSPITALIER DE L'UNIVERSITE LAVAL (DEPARTEMENT DE TOXICOLOGIE)	CONSEIL REGIONAL KATIVIK	CENTRE HOSPITALIER DE LA BAIE D'HUDSON	CENTRE HOSPITALIER DE L'UNGAVA
Salaires				
Assistant de recherche pour la coordination du programme à Québec	36 000$			
Bénéfices marginaux	1 200$			
Assistant de recherche au Nouveau-Québec (incluant les primes)		97 000$		
Bénéfices marginaux		2 400$		
Technicien (1820 heures partagées entre les 2 établissements)			10 750$	10 750$
Analyses				
Immunologie (600 X 100$) Plus 40 bilans fonctionnels	30 000$			
Biochimie (600 X 2$)			300$	300$
Hématologie (400 X 3$)			300$	300$
Analyse organochlorés (200 X 100$) (PCB, Mirex, HCH...)	20 000$			
Analyse des PCDD et PCDF (25 pools X 2 000$)	50 000$			

DETAILS BUDGETAIRES

PROGRAMME DE SURVEILLANCE DU LAIT MATERNEL DANS LA REGION NUNAVIK

1988-1990

OBJETS	CENTRE HOSPITALIER DE L'UNIVERSITE LAVAL (DEPARTEMENT DE TOXICOLOGIE)	CONSEIL REGIONAL KATIVIK	CENTRE HOSPITALIER DE LA BAIE D'HUDSON	CENTRE HOSPITALIER DE L'UNGAVA
Logistique, équipement et manutention			4 750$	4 750$
Equipement de labo			43 300$	
Divers				
Entrevues avec interprètes (150 X 2 heures X 13$)			2 000$	2 000$
Frais de conception, impression questionnaire et fiche de suivi médical	1 500$			
Réalisation pamphlet d'information des mères		1 500$		
Téléphone et Fax	450$	450$	450$	450$
Transports des prélèvements (PCB, dioxines, furanes, immunologie)		6 000$		
Frais de transport et séjour:				
- stage de formation techniciens en immunologie (2 X 7 jours)		5 500$		
- aller et retour 1 an			6 000$	6 000$

DETAILS BUDGETAIRES

PROGRAMME DE SURVEILLANCE DU LAIT MATERNEL DANS LA REGION NUNAVIK

1988-1990

OBJETS	CENTRE HOSPITALIER DE L'UNIVERSITE LAVAL (DEPARTEMENT DE TOXICOLOGIE)	CONSEIL REGIONAL KATIVIK	CENTRE HOSPITALIER DE LA BAIE D'HUDSON	CENTRE HOSPITALIER DE L'UNGAVA
Frais de traduction (français, anglais, inuktitut) pamphlet, questionnaire, fiche de suivi rapport de recherche		4 000$		
Secrétariat sud	4 000$			
Secrétariat nord		4 000$		
Comité demandé par le CRSSS Kativik au nord		20 000$		
Transport membres du Comité		20 000$		
2 voyages ass. recherche du sud	8 000$			
Transport de l'ass. recherche du nord		12 000$		
Frais de gestion 15%		62 520$		
TOTAL:	151 150$	235 370$	67 850$	24 550$
GRAND TOTAL:				478 920$