Synopsis of Research Conducted Under the 1990/91 Northern Contaminants Program

From a Workshop in Support of the Technical and Science Managers Committees on Northern Ecosystems and Native Diets, Burlington, Ontario April 3-4, 1991

R.G. Shearer
Department of Indian Affairs and Northern Development
10 Wellington Street, 6th floor
Ottawa, Ontario CANADA
K1A 0H4
(819) 994-7484 (Tel)
(819) 994-6419 (Fax)

Forward

This report provides a summary of the results of research and monitoring studies undertaken in 1990/1991 concerning contaminants in northern Canada. This knowledge base was the subject of a scientific evaluation workshop held in Burlington, Ontario, April 3-4, 1991. Approximately 42 scientists representing a broad spectrum of interests attended the meeting. An integrated ecosystem approach was taken to assess the contaminants issue which considered all aspects of the problem from sources to transport, freshwater, terrestrial and marine systems, human exposure through diets, and finally implications to human health.

A participants list for the meeting and the workshop agenda are found in Appendices I and II, respectively.

TABLE OF CONTENTS

SUMMARY OF THE RESULTS OF 1990/91 RESEARCH AND MONITORING STUDIES - EVALUATION WORKSHOP HELD IN BURLINGTON, ONTARIO APRIL 3-4, 1991

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.

In 1985, the Department of Indian and Northern Affairs (DIAND) established an inter-agency technical committee 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.

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 six years ago to assess the extent of contamination of local food sources used by northern people.

The technical committee adopted an integrated ecosystem approach to assess the problem which considered all aspects 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 six 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 report will be published in early 1992 as a special issue of the journal "Science of the Total Environment".

In December 1989, a workshop was held in Toronto to develop a longer-term inter-agency research and monitoring strategy to deal with this problem. The strategy was designed, in collaboration with native organizations, four federal departments and two

territorial governments, around the government's responsibilities of delivering advice to northerners concerning health aspects of their country food diets, and of pursuing contaminant emission controls in the international forum. Co-ordination has been achieved through inter-agency committees at both the policy and technical levels chaired by DIAND.

The northern contaminants program has since been incorporated into Canada's Green Plan and represents a major component of the Arctic Environmental Strategy (AES). Future work will be carried out with resources from the AES/Green Plan and will focus on actions to be taken nationally and in the international forum to control contaminant emissions to the Arctic.

Approximately 42 scientists representing a broad spectrum of interests attended the scientific evaluation workshop in Burlington, Ontario, April 3-4, 1991. The workshop was divided into three sessions which were sources, sinks and pathways of northern contaminants, ecosystem contaminant uptake and health effects and human health. Similar workshops to evaluate results and progress of research and monitoring studies will be conducted annually to ensure that the results support the overall program objectives and to set and re-align program priorities.

This report provides a summary of the results of research and monitoring studies undertaken in 1990/91 concerning contaminants in northern Canada as discussed at the Burlington workshop.

SOURCES, SINKS AND PATHWAYS OF NORTHERN CONTAMINANTS

SOURCES, SINKS AND PATHWAYS

OVERVIEW

1. SOURCES

Agricultural Emissions

Models exist (AES) for input from agricultural emissions but refinements are required. Data gaps include Canada and the Communist bloc. These gaps should be filled.

2. SINKS AND PATHWAYS

Atmospheric Transport and Exchange

Currently, the level of understanding of atmospheric transport mechanisms and atmospheric transformation processes of trace organics is inadequate.

Needs for Future

- quantify deposition to land (for modelling purposes) including information on temporal and spatial variability
- long-term trends required to tie to atmospheric modelling (including perhaps simulations)
- information on air/snow exchanges and within-snow processes involving organics
- studies of behaviour of the physical/chemical properties of trace organics at sub-zero temperatures
- studies of snow metamorphosis and the effects of this process on trace organics
- any additional studies of lake sediments should be considered only after consideration of how the results might be interpreted given the possibility that level of temporal resolution routinely available may be inadequate
- if studies involving lichens, mosses or pine needles are to be used, need to do basic research on (1) spatial variabilities, (2) scavenging efficiency and retention, and (3) implications of winter decoupling of needles, etc., from atmosphere so that relevance of results can be evaluated.

- should use artificial static monitors to advantage (more data can be obtained at lower expense than by other methods)
- re: terrestrial pathways
  - losses to atmosphere must be quantified
  - composition of snowmelt
  - processes controlling organic concentrations in snowmelt
  - mass balances (large and small)

    (eventually the objective is to have the information to model runoff/loadings)
- greater emphasis on marine system
  - atmosphere versus runoff contributions
  - input to nearshore versus offshore
  - budget to tie in marine dynamics
- air/sea interaction process studies
- sedimentation data for trace organics

3. Overall, basic information is still needed to quantify inputs (compounds and rate), trajectories and how the contaminants cycle once in the Canadian north. There are two main reasons for this:

   (1) to decide whether concentrations are changing (+ or -) or staying the same

   (2) providing Canada with knowledge to be seen as a well-informed and credible leader in the area of northern contaminants

4. <u>Technical Committee</u>

   Recommendation that the decision to disband the technical committee be reviewed. It is at this level that primary information exchange/planning should occur.

NORTHERN CONTAMINANTS AIR MONITORING STUDY

(Presented at the Northern Contaminants Workshop 3-5 April 1991)

OBJECTIVE

To measure the occurrence of selected organochlorine and polycyclic aromatic hydrocarbons in the Arctic atmosphere for a period of a least a year thereby providing data for the development of realistic environmental pathways models and insight into environmental transport, transformation and surface exchange processes.

PROJECT MANAGER: L.A. Barrie Atmospheric Environment Service

INVESTIGATORS:

L.A. D.C.G. K. T.F.

Barrie, Muir, Brice and Bidleman

PLAN:

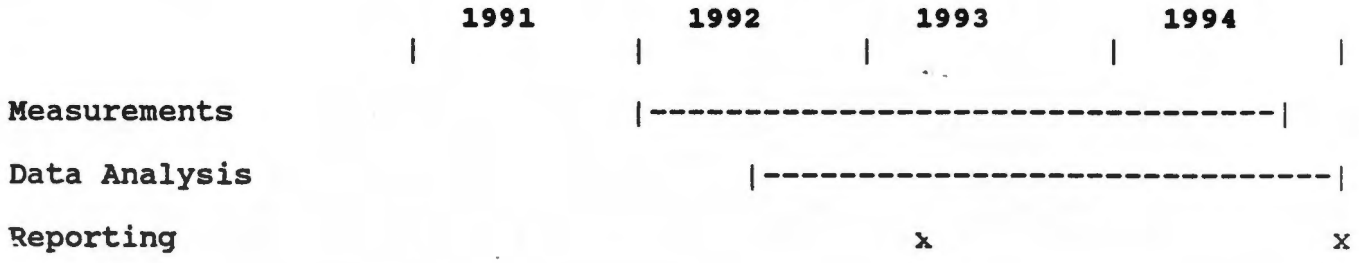
To make routine measurements on a weekly basis of particulate and gas phase constituents at selected locations in the Arctic for at least two years.

A $40000 contract to Concorde Scientific in FY 1990/91 supported by the Atmospheric Environment Service was used to develop a high volume filter/ puf-plug sampler with size-selective inlet for Arctic operation.

Once Greenplan funds are available, sampling will be instituted at at least two locations in the north. Analysis will be done under contract with quality control by experienced DOE and DFO labs.

Data analysis will be done at the Atmospheric Environment Service.

SCHEDULE:



NORTHERN HEMISPHERIC CHEMICAL TRANSPORT MODEL STUDY

(Presented at the Northern Contaminants Workshop 3-5 April 1991)

OBJECTIVE

To adapt a 3-dimensional tracer model developed and tested on the Chernobyl reactor accident to the study of the movement of atmospheric contaminants on an hemispheric scale and their exchange between the atmosphere and the Earth's surface.

PROJECT MANAGER

L.A.Barrie Atmospheric Environment Service

INVESTIGATORS

J. Pudykiewicz, A. Sirois, E. Voldner, D.J. Gregor, C.A Barrie, J.W. Bottenheim

RATIONALE:

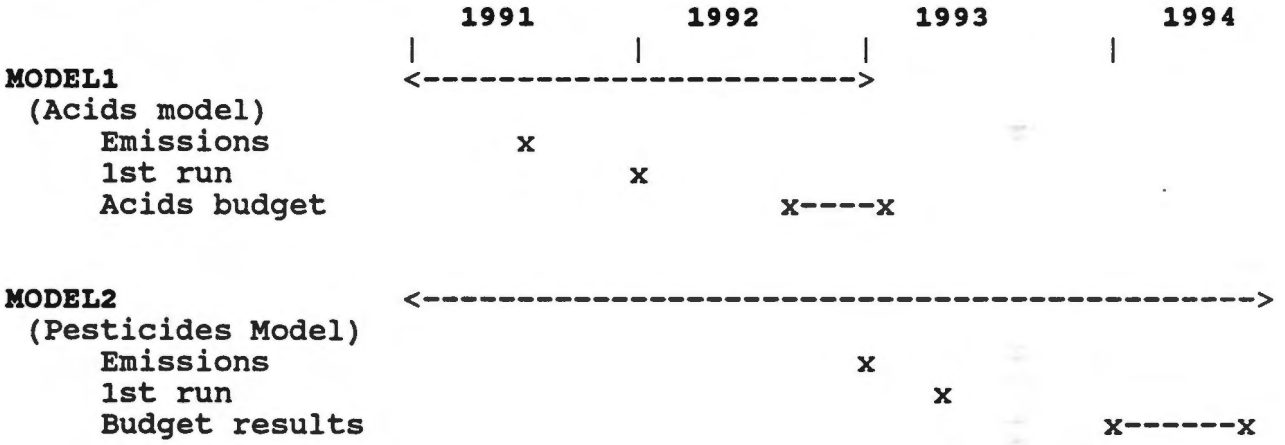
It is becoming increasingly apparent that to understand the source of many potentially toxic substances in a particular region on the globe(such as the Great Lakes watershed or the Arctic) that the problem must be studied from at least an hemispheric perspective. Because many of these substances have a lifetime in the atmosphere longer than 5 days a substantial portion of material released at any particular time travels beyound continental boundaries. Their pathways are not only governed by transport processes but by chemical transformation and interaction with the Earth's surface.

In any study of pathways, models that simulate these complex processes serve to (i) organize the available information in a quantitative way and (ii) assist in experimental design and iii) assess the origin of a substance found in a receptor. In other words, they are a key component of any research program on toxic substances.

Canada is in the forefront of the world's environmental research community in having a chemical transport model developed at the Canadian Meteorological Centre in Montreal by Dr. J. Pudykiewicz that is capable of moving substances around the northern hemisphere using observed wind fields while allowing them to interact with the Earth's surface, with model-generated clouds and precipitation and to chemically transform. This model can be run quite economically with simple parameterizations of the processes and prescribed emission scenarios. It has been developed and tested on the Chernobyl accident data and peer reviewed in two papers published in Tellus.

STRATEGY

We intend to proceed in a progressive way by first learning to do hemispheric chemical transport modelling on acids(MODEL1) whose emissions can be more quickly assembled than those of organochlorines and for which extensive atmospheric observations are available. The product will be a better knowledge of the atmospheric pathways from mid-latitudinal sources to the Arctic and an Arctic atmospheric acids budget. In parallel with this the efforts of Drs. Gregor and Voldner to assemble a global emissions inventory for agricultural pesticides will come to fruition about the time that we are becoming comfortable with hemispheric modelling through the MODEL1 exercise and that we are obtaining the first results from the northern contaminants modelling exercise. In summary, the timeline for these efforts is roughly as follows:



MODEL SPECIFICATIONS ARE ON THE NEXT PAGE

ACCOMPLISHMENTS:

Under contract to Batelle in Switzerland supported by the norther contaminants program of DIAND work has begun to assemble global usage of agricultural pesticides(see project description of Gregor and Voldner).

Under contract support from the Atmospheric Environment Service(AES) to ORTECH an effort has begun to assemble a global emissions inventory of SO_x, NO_x and VOC. This contract is to deliver the product by September 1991 in a form suitable for the model. It is also designed to connect Canada with a larger international effort under the International Global Atmospheric Chemistry(IGAC) Program to assemble global emissions for modelling purposes.

MODEL SPECIFICATIONS

GENERAL

DOMAIN:	Northern hemisphere
TIME PERIOD:	1 July 1987 to 30 June 1988
HORIZONTAL GRID SPACING:	50 - 150 km
VERTICAL SPACING:	11 levels topped at ~ 100mb (finer resolution in the boundary layer and at the tropopause)
METEOROLOGICAL INPUTS:	CMC analyzed winds
CLOUD AND PRECIPITATION:	model generated(diagnostic check using real data)

MODEL1

EMISSIONS:	SOx, NOx and VOC. Use best available acid rain program emissions from all regions of the northern hemisphere assembled under contract(see accomplishments).
TRANSFORMATIONS:	Use EMEP's chemistry module or the more sophisticated ADOM chemistry module.
WET REMOVAL:	Utilize a scavenging ratio approach or the more sophisticated ADOM module.
DRY REMOVAL:	Use a 3 layer model of resistance.

MODEL2

EMISSIONS:	HCH Emissions from Gregor/Voldner contract efforts.
TRANSFORMATIONS:	Gamma to alpha HCH in air. Best estimates from research of Bidleman and others.
SURFACE EXCHANGE:	Include active exchange with surface reservoirs including soil, oceans and snow.

TITLE: Global Emissions Inventory of Organochlorines

PROJECT MANAGER: E.C. Voldner

PRINCIPAL INVESTIGATORS:
E.C. Voldner, D. Gregor and T. Bidleman

LEAD AGENCY: DOE/AES

SUPPORTING AGENCY: DOE/IWD

OBJECTIVE:

On a global scale determine sources and atmospheric emissions of organochlorines. This study is in support of policy objective #1.

CONTRACTOR:

Battelle Research Centres, Geneva, Switzerland; IRPTC, United Nation, Geneva, Switzerland.

RATIONALE:

Estimation of contaminant source data (emission) on a global scale is required for input to models (ref. to project: Northern Hemispheric Chemical Transport Model Study) for the determination of source regions that may have an significant impact on sensitive areas such as the Arctic and the Great Lakes Basins. Establishment of source/receptor relationships and relative contribution of sources in a country to a receptor in Canada will allow assessment of control strategy scenarios and hence aid Canada in the development of international control policies. Evaluation of historical and future trends in emissions are important for understanding and predicting response time of various components of the ecosystem to changes in the atmospheric load.

STRATEGY:

PHASE I involves the compilation of information and the creation of a computerized data base of historical, present and predicted global usage or sales of persistent pesticides such as Aldrin, Dieldrin, Chlordane, DDT, Endosulfan, Endrin, HCH, Lindane, Heptachlor and Toxaphene. The information sought includes amount of use/emission; region of use/emission; mode and time of application; and physical and chemical properties of the active ingredient as well as of the technical mixture. The information will be obtained through literature survey and through contact with international agencies.

PHASE II consists of the determination of time-dependent, spatially gridded emissions inventories of the specified compounds for input to the hemispherical model. Based on the information obtained in PHASE I; regionally representative crop and soil data; as well as climatological hourly meteorological data; a time-dependent numerical model will be executed to quantify the emissions. The latter model was developed by AES for predicting the volatilization of pesticides and other toxic materials from vegetated soils.

PROGRESS:

Through contract with Battelle Research Centre a computerized data base containing information on pesticides usage by country, crop, pest and active ingredient for a number of countries have been acquired. The IRPTC of the United Nations has been approached for information of usage in the Soviet Union.

EXPECTED COMPLETION DATE: 1993

RESOURCES EXPENDED: SFR 45,000.00 for the Battelle data base.

PRESENTED AT: The Northern Contaminants Workshop 3-5 April, 1991

PROJECT SYNOPSIS - DIAND - 1990/91

TITLE: Atmosphere/snow interaction of trace organic contaminants in the Arctic

PROJECT MANAGER: D. Gregor

PRINCIPAL INVESTIGATORS: D. Gregor, L. Barrie, Wm. Strachan, D. Mckay, T. Prowse

LEAD AGENCY: DOE/IWD/NWRI

SUPPORTING AGENCY: DOE/IWD/NHRI, PCSP, AES, U. of Toronto

OBJECTIVE: To quantify the scavenging efficiency of snow fall and ice crystals and the loss of trace organic contaminants (TOC) from the snow pack during the spring/summer seasons in the High Arctic and to determine the major processes that control the rate and absolute quantity of these exchanges.

CONTRACTOR:

DESCRIPTION - RATIONALE:

TOCs are being transported over long distances in the atmosphere and are being deposited into the snow pack during the winter season for large areas of the Canadian Arctic (Gregor and Gummer, 1989). However it has not been possible as yet to specifically determine the mechanisms by which these contaminants are scavenged from the atmosphere and the fate of these contaminants upon snow melt. Previous work on the Agassiz Ice Cap, Ellesmere Island, has indicated that perhaps as much as 90 % of the organchlorine pesticides in the snow pack do not survive the summer season. This work has concluded that since only a small (usually less than 10 %) of the snow melts annually at this site and since there is no evidence for downward migration into the firn, that these pesticides are being volatilized back to the atmosphere (Gregor et al., 1990). This earlier work has also shown that PCBs apparently are not lost from the snow pack in the same manner with perhaps something of the order of 75 % of the PCBs remaining in the snow after the first summer season. Schondorf and Herrmann (1987) have shown that for snow melt water in temperate regions, that the hydrophobic compounds are present in the first melt (e.g., HCHs) while particle associated compounds such as PAHs and possibly PCBs will be present in the final melt water. These authors made no mention of volatilization losses during snow pack ripening.

It is worth noting at this point that the glacial record is the only known means of determining a detailed, long term historical record of contaminants in the Arctic and thus research in this area is worthwhile for understanding past and present deposition rates and the effect of future controls.

- ACTIVITIES: (1990/91)

Research into the scavenging mechanisms, rates and controls has not been initiated as this requires specialized equipment, both field and laboratory, which has not yet been acquired. Work, therefore has been limited to sampling fresh snow on the Ice Cap and repeating this sampling one year later. Obviously, this is a slow process and only two years (1985/86 and 1989/90) have now been thoroughly characterized in this way. The second component of this research was to undertake seasonal time series sampling of snow (repeat sampling from early May through to snow melt) from a single site in the vicinity of Resolute. This was initiated in 1989 and repeated more intensively in 1990 with replicate samples collected on May 16, May 28, June 5 and June 15. A duplicate set of samples were collected on June 5 with one set melted under natural conditions and open to the atmosphere and the other set melted and handled in the normal manner. All of these samples have now been analyzed for organochlorines and PCB congenors and will be subsequently analyzed for PAHs.

- RESULTS:

Comparison of 1985/86 season concentrations as measured in 1986 and again in 1987 and 1988/89 season concentrations as measured in 1989 and 1990 for selected chlorohydrocarbons in Agassiz Ice Cap are shown below.

compound	concentration (pg L^{-1})		
	1986 (n=5)	1987 (n=3)	residue (%)
lindane	4080	128	3
α-HCH	6576	497	8
dieldrin	1346	213	16

	1989 (n=3)	1990 (n=3)	residue (%)
lindane	430	100	23
α-HCH	440	230	52
dieldrin	530	80	15

Although the glacier data suggest that pesticide deposition in the Arctic has decreased by a factor of two between 1970 and the late 1980's, it is evident from the above table that we are observing a residue trend that may not be representative of the deposition trend due to the annual loss. Also of note is that there is an order of magnitude difference in the amount of these pesticides measured in the fresh snow in the two years. The factors controlling this annual variability and the loss from the ice cap must be better understood and quantified prior to obtaining greater confidence in the pesticide trends revealed in the glacier.

The time series data for replicate samples collected near Resolute in 1990 are presented below with the number in brackets showing the residue as a percent of the original concentration. The snow temperature is that measured at the time of sampling.

DATE	α-HCH	LINDANE	DIELDRIN	SNOW TEMP
	[pg L^{-1}]			[°C]
May 16/90	310	810	190	-5.0
May 28	60 (20)	60 (8)	140 (75)	-0.5
June 5/90 (inside)	65 (20)	70 (8)	155 (82)	-1.0
June 5/90 (outside)	500 (164)	215 (26)	110 (57)	-1.0
June 15/90 (final)	90 (28)	200 (24)	50 (29)	-1.0

Although not conclusive, these data suggest that less than 30% of the starting quantity of each compound remains in the ripened snow on June 15. By June 17, there was so much water beneath the snow that we were no longer able to sample suggesting that the quantity measured on June 15 represents the quantity of pesticide in the snow melt. The June 5 "outside" samples were melted outside, exposed to the air as oppossed to the normal method of melting sealed containers inside. Clearly, something quite different occurred here but we cannot explain this at this time.

UTILIZATION: (impact on future study design)

We are studying a phenomenon which has not been reported previously

and which is critical to understanding the fate and loadings of TOCs to the arctic aquatic ecosystem. In this regard Canada is leading the research at this time. Also, the complexities and importance of this research, as evidenced by these data argue for a more thorough and controlled investigation of the phenomenon

UTILIZATION: (continued)

which can only be achieved through intensive, controlled, laboratory simulator studies whic will begin in FY91/92 if resources are forthcoming.

EXPECTED COMPLETION DATE: 1997

RESOURCES EXPENDED: (estimates)	DIAND		$20,000
	GNWT		2,000
	PCSP		5,000
	IWD/NWRI	-salary	30,000
		-O&M	5,000
		-Cap	3,000
	Total		$65,000

FUTURE: Now that the phenomenon of loss from the snow has been verified, we propose to conduct work on two fronts in the future. The first will be to continue to conduct as much of this type of field measurement as possible (D. Gregor) while the second component will be to undertake laboratory investigations with subsequent field evaluation. Physico-chemical properties of selected compounds at sub-zero temperatures will be investigated by Dr. D. Mckay, U. of Toronto. A cold chamber will be constructed at either NWRI, Burlington or AES, Downsview for the purpose of studying scavenging and exchange under different conditions of for example temperature and humidity (D. Gregor, Wm. Strachan, L. Barrie). Finally, scanning electron microscopy will be utilized to investigate the location of pollutants on the snow crystal, morphologic changes to the snow crystal and the resultant fate of pollutants during warming (T. Prowse).

REFERENCES:

Gregor, D. and Wm. Gummer, 1989. Evidence of atmospheric transport and deposition of organochlorine pesticides and PCBs in canadian arctic snow. Environmental Science and Technology, 23:561-565.

REFERENCES: (CONTINUED)

Gregor, D.J., Dominik, J. and Vernet, J.-P., 1990. Recent trends of selected chlorohydrocarbons in the Agassiz Ice Cap, Ellesmere Island, Canada. In Proceedings of the 8th International Conference of the Comite Arctique International on Global Significance of the Transport and Accumulation of Polychlorinated Hydrocarbons in the Arctic. ed. R. Shearer and A. Bartonova, Oslo, Norway, September 18-22, 1989 (in press).

Schondorf, T. and Herrmann, R., 1987. Transport and chemodynamics of organic micropollutants and ions during snowmelt. Nordic Hydrology, 18:259-278.

PROJECT SYNOPSIS - DIAND - 1990/91

TITLE: Annual deposition and temporal trends of trace organic compounds (TOCs) in snow and glacial ice

PROJECT MANAGER: D. Gregor

PRINCIPAL INVESTIGATORS: D. Gregor, G. Brunskill

LEAD AGENCY: DOE/IWD/NWRI

SUPPORTING AGENCY: DFO/FWI, WQB/W&NR, IWD-YELLOWKNIFE, AES-WINNIPEG, MOULD BAY & EUREKA, PCSP

OBJECTIVE: This study has two objectives:

i) to measure the annual deposition of TOCs to the snowpack at representative, remote sites throughout the NWT to provide an annual estimate of deposition as well as collecting event and weekly samples throughout the winter at two sites; and,

ii) to determine the longer term (>50 years) historical trends of annual TOC deposition to the arctic using glacial records.

CONTRACTOR:

DESCRIPTION - RATIONALE:

Previous studies (Gregor and Gummer, 1989; Barrie et al., 1990) have measured the contaminant concentrations and calculated the flux of contaminants to the snow during the winter season. These data are limited to two years (1986 and 1987) and more importantly are severely restricted spatially. Additionally, the existing data show considerable annual depositional variability. Thus an expanded network, maintained for a period of at least three years, will provide an estimate of current annual deposition throughout the NWT.

Historical trends of TOCs in the arctic are very much a concern and attempts to measure this have been made with periodic measurements of tissue residues (e.g. Addison and Zinck, 1986) and coring of lake sediments. Both of these methods have limitations, not least of which is the poor temporal resolution (approximately decadal). In an attempt to determine annual historical trends, considerable effort has been directed at excavating a pit in the Agassiz Ice Cap in order to measure the seasonal deposition at this site. Although trends have proven to be illusive (see Gregor et al., 1990) it is proposed to continue this work this year to provide a profile from present time back to the 1950's. This is the only work of its kind in the northern hemisphere.

- ACTIVITIES:

A total of twenty-one sites (see attached list) were visited and snow samples were collected either by NWRI or IWD-Yellowknife personnel in April and May, 1990. In order to reduce costs and simplify logistics, many of the stations have been co-located with IWD hydrometric stations and therefore snow collection occurs simultaneous with the visit of hydrometric technicians.

The snow pit at Agassiz Ice Cap was visited May, 1990 and excavation continued to provide a record which now extends from the late 1950's to the winter of 1989/90. The pit, which had been opened in 1987 and was now ten metres deep was allowed to fill in.

In the fall of 1990, two large volume snow collectors were constructed at the AES stations at Eureka and Mould Bay and arrangements were made for AES personnel to collect the samples on an event or weekly basis. These collectors are designed to provide sufficient sample for TOC analyses with a snow accumulation of just 2 cm. Samples have been collected throughout the winter of 1990/91 and are presently stored at the weather stations awaiting analyses.

- RESULTS:

All of the 1990 snowpack samples, including the glacier, have been analyzed for PCB congenors and organochlorine pesticides, trace metals and nutrients. Subsequently, these samples will be analysed for PAH compounds. These data will be compared with the previous data and will provide the basis of the three year spatial deposition survey. The event samples from Eureka and Mould Bay will be analysed for the same suite of compounds.

UTILIZATION: (impact on future study design)

This data set will provide the first measurements for snowpack in the Mackenzie District and will indicate whether or not obvious spatial differences exist across the NWT. If warranted, the network can be expanded, in particular to include the Yukon. The snow collectors will help to determine when contaminants are being deposited and will be compared with the snowpack deposition estimates. Evaluation of these collectors will permit their refinement for later installation at other sites.

The Agassiz Ice Cap samples will provide for the first time an historical record of TOC residues in the glacier. Although the exact interpretation of this trend will remain unclear for some time until the processes are understood, the general trend should be informative and directly comparable to trends seen in lake sediments and biota. Since this trend will have been determined from samples collected from a pit excavated over a total of five years, future activities should attempt to recreate the findings at a nearby site, prior to looking at trends on other glaciers.

EXPECTED COMPLETION DATE:

- spatial snowpack quality survey	1994
- event and weekly snow samples	1996
- glacial residue trends	1997

RESOURCES EXPENDED: (estimates)

DIAND		$27,000
GNWT		10,000
PCSP		10,000
IWD-YELLOWKNIFE		NA
IWD/WQB/W&NR		4,000
AES		NA
IWD-NWRI	-salary	60,000
	-O&M	25,000
	-Cap	5,000
Total		$141,000

FUTURE:

The spatial network will be maintained and evaluated in 1994 at which time a decision will have to be made as to whether or not a monitoring network should be continued as part of an operational water quality program. Evaluation will include comparison with the large volume snow collectors (LVSC) and consideration of the air/snow exchange phenomenon. The LVSCs will be evaluated further and their applicability to a network will be considered.

The trends established for the Agassiz Ice Cap will be verified with a second pit within the same general area. The second pit will attempt to provide an annual residue record from the mid 1950's to the present with decadal or better discrimination prior to the mid-1950's. Assuming that the results from the two pits are comparable, similar investigations on other ice caps and glaciers will be undertaken.

REFERENCES:

Barrie, L.A., Gregor, D., Hargrave, B., Lake R., Muir, D., Shearer, R., Tracey, B. and Bidleman, T. Arctic contaminants: sources, occurrence and pathways. Science of the Total Environment (in press)

Gregor, D. and Wm. Gummer, 1989. Evidence of atmospheric transport and deposition of organochlorine pesticides and PCBs in canadian arctic snow. Environmental Science and Technology, 23:561-565.

REFERENCES: (continued)

Gregor, D.J., Dominik, J. and Vernet, J.-P., 1990. Recent trends of selected chlorohydrocarbons in the Agassiz Ice Cap, Ellesmere Island, Canada. In Proceedings of the 8th International Conference of the Comite Arctique International on Global Significance of the Transport and Accumulation of Polychlorinated Hydrocarbons in the Arctic. ed. R. Shearer and A. Bartonova, Oslo, Norway, September 18-22, 1989 (in press).

Addison, R.F. and M.E. Zinck, 1986. PCBs have declined more than DDT-group residues in arctic Ringed Seals (*Phoca hispida*) between 1972 and 1981. Enviromental Science and Technology, 20(3):253-256.

LIST OF 1990 NWT SNOWPACK SAMPLING STATIONS FOR TOCs

1. Akasta River
2. Back R. below Deep Rose Lake (66° 5'N 96° 30'W)
3. Thonokeid River
4. Yathkyed Lake (62° 42'N 98° 18'W)]
5. Ellice R. near mouth (67° 42.5'N 104° 8.5'W)
6. Brown River (66° 2'N 91° 50'W)
7. Great Bear River at outlet of Great Bear Lake (65° 8'N 123° 31'W)
8. Hayes River (67° 32'N 94° 5'W)
9. Baker Lake (64° 18'N 96° 5'W)
10. Nahanni River near Nahanni Butte
11. Stanwell Fletcher Lake, Somerset Island
12. Lake Hazen, Ellesmere Island
13. Agassiz Ice Cap, Ellesmere Island (80° 40'N 73° 30'W)
14. Peel River above Ft. Mcpherson (67° 13'N 134° 57'W)
15. Thelon River above Thelon Bluffs (64° 32'N 101° 24'W)
16. Cameron river below Reid Lake (62° 29'N 113° 31'W)
17. Unnamed lake near Resolute Bay (74° 42'N 94° 54'W)
18. Mould Bay, Prince Patrick Island (76°15'N 119° 16'W) (sample lost accidentally)
19. Eureka, Ellesmere Island (80°00'N 86°36'W)
20. Alert, Ellesmere Island
21. Lady Melville Lake (68°38'N 92°30'W)
22. Chartrand Lake (near Spence Bay)

ARCTIC CONTAMINANTS PROJECT SYNOPSIS

1. TITLE: Organochlorines in the Bering Strait/Chukchi Sea: USA/USSR 1990 Cruise.

2. PRINCIPAL INVESTIGATORS: P.E. Erickson, D.J. Thomas, A.G. Ethier and R.W. MacDonald.

3. OBJECTIVES: To obtain organochlorine baseline data for the Bering Strait/Chukchi Sea area to enhance the database for LRTAP issues, particularly sources/pathways/sinks.

4. CONTRACTOR: Seakem Oceanography Ltd.

5. DESCRIPTION/ACTIVITIES/RESULTS:

A joint USSR/USA oceanographic expedition was carried out in August/September 1990 in a first attempt to study the Chukchi Sea in its entirety. The Canadian portion of the cruise was to collect samples of water, water column particulates, sediment and biota for the determination organochlorine compounds (HCHs, PCBs, HCB, DDT, cycodienes and toxaphenes) on an opportunistic basis. A total of 17 high volume particulate samples, 14 plankton haul samples, 14 sediment samples and 4 high volume water samples (by Seastar INFILTREX) were collected. The <u>preliminary</u> results of the study are as follows:

1. The compounds a-HCH and b-HCH were detected at low levels in sediments. Concentrations in seawater were lower than those reported for HCHs at either the Ice Island or North Pacific. HCHs in zooplankton and benthos were generally not detectable.

2. Other organochlorine contaminants (HCB, heptachlor epoxide, dieldrin, PCBs, chlordanes and DDTs) were at or near the detection limit for these compounds in water, sediment and biota.

3. There is some evidence that the concentration of HCH may be lower in the Bering Strait area relative to areas to the north or south. This needs to be investigated further. Possible relationships with water column particulates also need be examined.

6. UTILIZATION OF RESULTS:

Results for organochlorines need to be combined with hydrographic data and then interpreted to evaluate the influence of oceanographic factors in the observations. Future objectives should include shipboard air sampling and sampling of a vertical profile in detail for a relatively abundant organochlorine (probably HCHs in this case).

7. EXPECTED PROJECT COMPLETION DATE:

Final Data Report will be available in September 1991

ECOSYSTEM CONTAMINANT UPTAKE AND HEALTH EFFECTS

ECOSYSTEM UPTAKE

OVERVIEW

CONTAMINANT LEVELS AND EFFECTS

1. Existing Information

   - considerable information on the concentrations and distribution of trace organics in Arctic marine ecosystem
   - concentrations of PCBs in ringed seals declining
   - DNA adducts not particularly useful in Arctic because concentration levels usually too low to yield strong reproducible result
   - new hot spot - DDT in Yukon lakes as well as toxphene and PCBs

2. Needs for Future

   - metals should be given greater emphasis (for example, no spatial information for metals in ringed seals. Also, Hg in Hudson Bay biota is lacking.)
   - more emphasis on coplanar PCBs (levels are high and coplanars have high inherent toxicity)
   - follow up on Yukon lakes - look for effects and evaluate which (if any) biomarker measurements could be effective and sensitive
   - food chain modelling needed to provide coherent understanding of implications of trace organics to marine ecosystem
   - generally need to emphasize studies of effects not just measurement of body burdens
   - evaluate biomarker utility for effects studies
     Candidates include:
     - metallothioneins (fish, marine mammals)
     - MFO - although MFO levels are generally low in Arctic animals, MFO provides background and is extremely sensitive to dioxins and coplanars. Should be extended to use of MFO with marine mammals not just fish. Caution is that use of MFO for marine seals may be premature in that basic understanding of MFO induction in seals may be inadequate.

     Some preliminary research may be necessary.

- PAH in marine mammals
- immune function - evidence that there might be an effect of high PCB concentrations on immune function in seals

3. **General Suggestions**

- don't disband the technical committee. If it is to be removed from administration of programme, perhaps it could be convened in parallel to a management group to satisfy the need for scientific information exchange
- re: effects of studies. Do "effects studies" in areas where effects are more likely to occur (e.g., Great Lakes) if the results or new methods can be confidently applied or extrapolated to the Arctic.?
- strive to take advantage of cooperative or other studies occurring in the Arctic. For example, DND (and separately the USAF) are conducting studies of PCB contamination at abandoned DEW line sites. This has been in progress for over a year, but the Arctic Contaminants Group has just learned of the studies. It is thought that considerable advantage to the contaminants programme could be achieved by coordinating/being aware of these studies. It was suggested that an attempt be made to contact DND re the 1991 field season in the hopes that some data could still be obtained from this source (e.g., PCB in soil cores)
- use hypothesis testing approach in the development of "effects monitoring strategies"

TITLE:
CONTAMINANTS IN NORTHERN QUEBEC MARINE MAMMALS AND FISH: PCBs AND OTHER ORGANOCHLORINES

PROGRAM LEADER: D. Muir

PROJECT TEAM MEMBERS: D. Muir, contractor B. Rosenburg and M. Segstro, B. Grift and S. Olpinsky (Makivik Research Centre, Kuujjuaq, Québec).

OBJECTIVES
1. Extend knowledge of geographic variations in marine mammals and fish to Northern Québec.
2. Provide baseline data for studies of human exposure to contaminants.

DESCRIPTION
Introduction:

Recent reviews of contaminants in Canadian arctic marine and freshwater environments (Muir et al. 1991a; Lockhart et al. 1991) found that data on spatial and temporal variation of PCBs and other organochlorines was limited. Data for levels of contaminants in biota in northern Québec was lacking except for recent surveys of beluga from the east Hudson Bay stock (Muir et al. 1991b). 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 char than PCBs and toxaphene are higher in char 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 PCBs by native people. For 1990/91 it was also proposed that heavy metals be determined in livers of seals and walrus from the region to improve the data base on geographic trends in metals in arctic marine biota.

Activities 1989/91

During the fall and winter months of 1989-90 samples of ringed seals (Phoca hispida), bearded seal ((Erignathus barbatus), arctic char (Salvelinus alpinus) and lake trout (Salvelinus namaycush) were collected at 4 locations in northern Québec. During 1990/91 additional seal and fish samples, as well as walrus blubber and liver were obtained. Sample collection, species identification and aging of fish was carried out by Stas Olpinsky and colleagues at the Kuujjuaq Research Centre of Makivik Corporation (Kuujjuaq, P.Q.) in collaboration with hunters in each community. Seals were aged by contractor B. Stewart (Winnipeg).

Samples were analysed for organochlorines and heavy metals. Methods of analysis of organochlorines have been described in the preliminary report on the study (Muir and Rosenberg 1990). Methods and results of the analysis of heavy metals in seal liver samples are given in a separate synopsis prepared by R. Wagemann.

Results

Concentrations of the four major organochlorines, total DDT-related compounds (ΣDDT), total chlordanes (ΣCHLOR), total PCB congeners (ΣPCB) and toxaphene or polychlorinated camphenes (PCC) in seals, walrus and arctic charr from Northern Québec are summarized in Table 1. Results for lake trout are reported in the "contaminant trends in freshwater biota" project.

Highest levels of the four organochlorines were found in charr from

Kangiqsualujjuaq (George River) on Ungava Bay. When expressed on a lipid weight basis, to account for differences in lipid content between locations, the male Kangiqsualujjuaq charr had about 2-fold higher levels of PCC and ΣPCBs than male charr from Hudson Strait (Salluit, Kangiqsujuaq) sites. Further assessment of the data, taking age into account, may help explain these differences.

Table 1. Concentrations of organochlorines in Northern Québec marine biota

Species	Location	Sex	N	lipid %	Concentration (ng/g wet wt) ΣCHLOR	ΣDDT	ΣPCB	PCC
Charr	Kangiqsujuaq	F	6	8.6	7.3±1.8	3.5±1.1	19±5.3	30±8.8
		M	4	8.5	14±5.9	7.3±3.6	32±10	51±20
	Kangiqsualujjuaq	M	5	10.2	23±6.8	12±4.0	53±32	78±30
	Salluit	M+F	5[1]	6.6	12±5.8	6.9±4.5	22±13	43±32
Ringed seal	Kangiqsujuaq	F	8	87.2	721±651	691±763	588±607	165±176
		M	16	86.3	801±1076	839±1543	854±1245	180±223
	Inukjuak	F	4	92.1	268±94	290±103	335±157	40±26
		M	5	79.8	777±650	639±521	757±454	152±91
	Salluit	F	2	94.3	502	616	535	87
	Kangiqsualujjuaq	F	3	80.6	194±98	179±113	432±277	79±45
		M	2	83.2	254	419	360	48
Bearded seal	Inukjuak	F	2	74.1	383	345	367	221
		M	3	68.8	514±198	501±240	388±153	276±85
	Kangiqsujuaq	M	2	80.6	416	267	415	150
Walrus	Inukjuak	F	7	81.0	3300±2750	2660±2020	5260±4600	758±494
		M	2	81.9	6930	5580	11800	1350
	Akulivik	M+F	3	84.2	506±328	194±238	446±388	363±102

[1] Four males and 1 female.

A wide range of organochlorine concentrations were seen in ringed seal blubber from Kangiqsujuaq (Wakeham Bay). ΣPCB concentrations ranged from 134 to 5288 ng/g in males. Age may be a major factor in explaining this wide range. Ages of the seals have been determined and will be discussed in the final report on the results. Male ringed seals from Inukjuaq (E. Hudson Bay) had similar mean organochlorine levels to males from Kangiqsujuaq but levels in females were about 2 fold lower. Age and extent of lactation could play a role in these differences. PCB and ΣDDT levels tend to be negatively correlated with age of adult females (Muir et al. 1988).

Male bearded seals from Inukjuaq had about 2-fold lower levels of ΣPCB than ringed seals from the same location. A similar ratio was found at Kangiqsujuaq although the sample size for bearded seals was limited. The differences may be related to food chain relationships; bearded seals may feed more extensively on benthic organisms whereas adult ringed seals feed mainly on fish.

Extraordinarily high levels of organochlorines were observed in walrus from

Inukjuak (Table 1). Levels of ΣCHLOR, ΣDDT and ΣPCB in walrus were similar to those reported in narwhal, beluga and polar bear fat and much higher than reported by Born et al. (1981) who found 360±310 ng/g PCBs in blubber of walrus from western Greenland. The levels in samples from Alulivik, further north on east Hudson Bay, were more in the range of those reported previously. The possibility that these samples were from beluga or polar bear is unlikely. Stas Olpinsky confirmed that they could only be walrus. Samples were removed from their original shipping containers in March and analysed soon after that so substitution of other samples can be ruled out. Furthermore the pattern of individual organochlorines was different to other marine mammals with higher levels of oxychlordane and lower levels of PCC than observed in narwhal.

The reason for higher organochlorine levels in walrus may be that this particular group is carnivorous and feeds on ringed seal or large fish. If this is correct the proportion of carnivores in the sample is high compared to generally accepted ratios in walrus of about 1:10 (R. Stewart, DFO Winnipeg personal communication).

Chlorinated dioxins and furans were determined in seven individual ringed seal blubber samples from Kangiqsujuaq (Table 2). Concentrations of 2,3,7,8-TCDD ranged from <1 to 5 ng/kg while 2,3,7,8-TCDF ranged from <1 to 9 ng/kg. No other dioxin/furan congeners were detectable (detection limits ranged from <1 - <7 ng/kg) in the blubber samples.

Table 2. Concentrations of chlorinated dioxins/furans in ringed seal from Kangiqsujuaq (Wakeham Bay) in Northern Quebec.

Sample #	2378-TCDD	12378-PnCDD	123478 HxCDD	OCDD	2378-TCDF	12378-PnCDF	23478 PnCDF	234678 HxCDD	OCDF
1	<1	<2	<3	<7	9	<2	<2	<2	<6
2	<1	<2	<3	<7	2	<2	<2	<2	<6
3	5	<2	<3	<7	9	<2	<2	<2	<6
4	<1	<2	<3	<7	<1	<2	<2	<2	<6
5	<1	<2	<3	<7	<1	<2	<2	<2	<6
6	<1	<2	<3	<7	<1	<2	<2	<2	<6
7	<1	<2	<3	<7	<1	<2	<2	<2	<6

CONCLUSIONS AND FUTURE DIRECTIONS:

The results indicate that marine biota from northern Québec have concentrations of major organochlorine contaminants that are within the range reported for other Canadian arctic locations. Chlordane-related compounds, ΣDDT and ΣPCB were present at almost equal concentrations in all samples of ringed seal blubber while PCC dominated in charr samples. Walrus from Inukjuak had higher than expected organochlorine levels and much higher levels than three samples from Akulivik, further north on the east coast of Hudson Bay. Further assessment of the data will be made taking into account ages of the all animals.

The dioxin/furan results confirm earlier work by Norstrom et al. (1990) that levels of 2,3,7,8-TCDD and TCDF range from 1-10 ng/kg in ringed seals in the Hudson Bay region. Higher levels of TCDF than TCDD were observed in Hudson Bay animals while the opposite trend was seen in ringed seals from the Central arctic archipelago. The reasons for these trends are not clear.

Further studies on seals, walrus and char will be carried out via other

Arctic Greenplan projects. The analyses of walrus are particularly urgent given the reported levels.

RESOURCES

	1990/91	1991/92	1992/93	1993/94	1994/95
Total*	37 K	-	-	-	-

*$16K went to analyses of metals - see separate project synopsis.

REFERENCES

Born, E.W., I. Kraul and T. Kristensen, 1981. Mercury, DDT and PCB in Atlantic walrus (Odobenus rosmarus) from the Thule District, north Greenland. Arctic, 40:255-260.

Hendzel, M. and A. Reiger. 1987. Diet study - Arctic char - 1986. Unpublished report. dept. of Fisheries and Oceans, Winnipeg, MB, Canada. 12 pp.

Lockhart, W.L., R. Wagemann, B. Tracey, D. Sutherland, and D.J. Thomas. 1991. Presence and implications of chemical contaminants in the freshwaters of the Canadian arctic. Sci. Total Environ. In press.

Muir, D.C.G., R.J. Norstrom, and M. Simon. 1988. Organochlorine contaminants in arctic marine food chains: Accumulation of specific polychlorinated biphenyls and chlordane-related compounds. Environ. Sci. Technol. 22:1071-1079.

Muir, D.C.G. and B. Rosenberg. 1990. PCBs and other organochlorine contaminants in northern Quebec marine mammals and fish. Interim report to Indian and Northern Affairs Canada.

Muir, D.C.G., R. Wagemann, B.T. Hargrave, D.J. Thomas, D.B. Peakall and R.J. Norstrom. 1991a. Arctic marine ecosystem contamination. Sci. Total Environ. In press.

Muir, D.C.G., Ford, C.A., Stewart, R.E.A., Smith, T.G., Addison, R.F. and Béland, P. 1991b. Organochlorine contaminants in beluga (Delphinapterus leucas) from the Canadian arctic. Can. Bull. Fish. Aquat. Sci., 224, 165-190.

Norstrom, R.J., M. Simon, D.C.G. Muir, and R.E. Schweinsburg. 1988. Organochlorine contaminants in arctic marine food chains: Identification, geographical distribution and temporal trends in polar bears. Environ. Sci. Technol. 22:1063-1071.

Norstrom, R.J., M. Simon and D.C.G. Muir. 1990. Chlorinated dioxins and furans in marine mammals from the Canadian arctic. Environ. Pollut. 66, 1-20.

TITLE:
CONTAMINANTS IN NORTHERN QUÉBEC MARINE MAMMALS AND FISH: LEAD AND OTHER HEAVY METALS

PROGRAM LEADER(S): R. Wagemann

PROJECT TEAM MEMBERS: R. Wagemann, contractor D. Savoie and S. Opinsky (Makivik Research Centre, Kuujjuaq, Québec).

OBJECTIVES:
1. Extend knowledge of geographic variations in marine mammals to Northern Québec.
2. Provide baseline data for studies of human exposure to contaminants.

DESCRIPTION

Introduction

Systematic data for heavy metals in marine mammals from Northern Quebec have been largely lacking, except for belugas from the east coast of Hudson Bay (Wagemann et al. 1991). Fragmentary information for ringed seals from areas in the Canadian Arctic (Wagemann and Muir 1984; Wagemann, 1989; Smith and Armstrong, 1975) indicates anomalously high mercury, cadmium and lead levels and an increase in cadmium in some marine mammals from west to east in the Canadian Arctic (Norstrom et al. 1988). This study provides an initial data base for metals for dietary calculations for Hg, Pb, Cd, Se, Cu, Zn in liver of ringed seals (and some bearded seals) from the Hudson Bay area. Additional collections from other locations over a broader time base are, however, required to develop a heavy metals data base for ringed and bearded seals from the Canadian Arctic to permit deducing, and in some cases confirming, geographical and temporal trends.

Activities

Previous Report

A synoptic report on heavy metals in walrus was submitted, March 17, 1991.

Sample Collection and Analysis

Samples were collected at 4 locations in northern Québec in 1989/90 by Makivik Corporation personnel (on contract) in collaboration with Native hunters. Morphometric data collection and species identification were also performed by Makivik Corporation staff (Stas Opinsky and colleagues) at the Kuujjuaq, P.Q., Research Centre. Tissues were excised according to established protocol. Only liver tissues, 25 - 100 g, from 40 ringed seals (*Phoca hispida*), 7 bearded seals (*Erignathus barbatus*) and 1 beluga whale (*Delphinapterus leucas*) were collected. Analyses for metals (Hg Cd, Pb, Se, Cu, and Zn) were performed on dried, ground tissue by established methods of atomic absorption and DC-plasma emission, described in detail elsewhere (Wagemann et al. 1991, Wagemann, 1989). The relatively small amount of tissue sample available did not permit duplicate analyses in most cases. Aging of animals was performed at FWI, Winnipeg, by a contractor (B. Webb).

Table 1. Mean metal concentrations in liver of ringed seals (μg/g, dry wt), mean % moisture content of liver tissue, and mean length (cm) of animals from separate locations.

WAKEHAM BAY

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	102.9	10.1	0.037	12.3	51.4	25.4	148.6	69.95
SD	14.9	9.58	0.029	18.2	24.4	28.8	21.3	1.37
n	23	23	23	23	23	23	23	23
Range	78-135	3.5-35.2	<0.005-0.13	1.2-69.1	24-103	0.74-127	107-198	67.7-72.9

INUKJUAK

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	115.5	17.9	0.050	16.2	56.2	51.8	170.1	69.66
SD	14.2	5.90	0.029	9.32	35.1	35.0	20.8	0.87
n	10	10	10	10	10	10	10	10
Range	90-131	8.1-24.5	0.017-0.098	2.2-28.4	28-152	7.3-111	150-208	68.3-71.7

GEORGE RIVER

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	129.3	23.4	0.053	40.1	68.4	47.4	168.9	69.77
SD	33.7	13.5	0.024	31.6	47.6	60.3	35.7	0.68
n	5	5	5	5	5	5	5	5
Range	121-139	12-46	0.023-0.085	14-93	17-129	2.8-149	137-226	69.2-70.9

SALUIT

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	132.5	27.5	0.024	65.5	44.7	36.8	142.9	71.28
SD	6.4	3.66	0.006	30.7	5.09	14.3	7.64	2.17
n	2	2	2	2	2	2	2	2
Range	128-137	25-30	0.019-0.028	44-87	41-48	27-47	138-148	69.7-72.8

Table 2. Mean metal concentrations in liver of ringed and bearded seals and a beluga whale (μg/g, dry wt), mean % moisture content of liver tissue, and mean length (cm) of animals from the various locations combined.

RINGED SEALS

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	110.9	14.6	0.042	19.4	54.4	35.3	156.2	69.92
SD	17.1	10.6	0.029	23.0	29.8	35.7	24.6	1.25
n	40	40	40	40	40	40	40	40
Range	78-139	3.5-45.6	<0.005-0.13	1.2-92.7	17-152	0.74-149	107-226	67.7-72.9

BEARDED SEALS

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	203.1	27.5	0.044	43.8	43.8	21.1	156.4	70.41
SD	33.7	17.7	0.014	33.9	22.7	14.7	19.3	0.82
n	7	7	7	7	7	7	40	7
Range	157-257	6.7-56.3	0.029-0.070	5.9-105	20-80	2.9-42.5	125-187	68.8-71.2

BELUGA WHALE

	Length	Se	Pb	Hg	Cu	Cd	Zn	Moisture
Mean	264.0	17.9	0.026	12.9	38.6	15.4	96.5	75.95
SD	---	---	---	---	---	---	---	---
n	1	1	1	1	1	1	1	1
Range	---	---	---	---	---	---	---	---

Table 3. Mean age, and mean mercury and copper concentrations in liver (μg/g, dry wt) of male and female ringed seals from various locations combined. Differences of means (two-tailed, T-test) were significant at $0.03 \leq P < 0.05$ for Hg, and $0.05 < P < 0.07$ for Cu, but were not significant for age.

MERCURY

	Males (0)	Females (1)
Mean	12.4	28.0
SD	13.2	29.3
n	22	18
Range	1.2-44.0	1.2-92.7

COPPER

	Males (0)	Females (1)
Mean	46.3	64.3
SD	24.1	33.6
n	22	18
Range	16.9-103	33.4-152

AGE

	Males (0)	Females (1)
Mean	4.34	4.96
SD	4.19	3.82
n	22	18
Range	0.1-14	0.1-13

Table 4. Mean morphometric data for ringed seals from separate locations.

WAKEHAM BAY

	Length (cm)	Age (Y)	Girth (cm)	Blubber Thickness (cm)
Mean	102.9	3.07	86.7	4.58
SD	14.9	3.67	11.9	1.15
n	23	23	23	23
Range	78-135	0.1-12	69-105.5	2.9-7

INUKJUAK

	Length (cm)	Age (Y)	Girth (cm)	Blubber Thickness (cm)
Mean	115.5	5.2	97.0	4.89
SD	14.2	2.9	15.8	0.89
n	10	10	10	10
Range	90-1131	1-10	67.3-116	3.8-7

GEORGE RIVER

	Length (cm)	Age (Y)	Girth (cm)	Blubber Thickness (cm)
Mean	129.3	8.4	113.7	4.82
SD	33.7	3.3	10.9	1.36
n	5	5	5	5
Range	121-139	6-14	100-128	2.6-6

SALUIT

	Length (cm)	Age (Y)	Girth (cm)	Blubber Thickness (cm)
Mean	132.5	10	119	6.0
SD	6.4	4.2	1.4	0.0
n	2	2	2	2
Range	128-137	7-13	118-120	6-6

Results and Discussion

All concentrations are expressed on a dry weight basis and can be converted to a wet weight basis by multiplying dry weight concentrations by the factor 0.30.

Mercury

Mean liver mercury concentrations ranged from a low of 12.3 μg/g (dry wt) at Wakeham Bay to a high of 65.5 μg/g (dry wt) at Saluit (3.7 and 19.6 μg/g wet wt, respectively), (summarized in Tables 1 and 2), and increased progressively in each of the 4 ringed seal groups (Wakeham Bay, Inukjuak, George River, Saluit). Mean concentrations were significantly, positively correlated with the mean age of animals (Fig. 1). Most sample sizes were, however, too small to preclude the possibility of these correlations being fortuitous rather than being true site-specific dependencies. There was a significant difference between the mean mercury concentrations of male and female ringed seals (all locations combined), Table 3, but no similar difference in ages or selenium concentrations. A differentiation of metal levels between sexes at each location was precluded by too small a sample size for most locations.

The mean liver mercury concentration of bearded seals (Table 2) did not fall on the age/Hg regression line for ringed seals but was somewhat higher (43.8 μg/g, dry wt) than for similarly aged ringed seals (Fig. 1). The diet of bearded seals is primarily benthic and that of ringed seals pelagic. Whether or not differences in metal levels between species are inherently different or are a consequence of increased contaminants accumulated in their specific diet from anthropogenic sources is a subject for further research.

The human dietary implications are that the oldest animals taken at Saluit and George River (Table 4) are least desirable, and the animals with the lowest mercury levels (12.3 μg/g, dry wt), taken at Wakeham Bay are preferable. This is not to say that anthropogenic sources of mercury are more prevalent in one area than another. Most sample sizes were too small to draw statistically valid generalizations.The lowest mean values reported here are somewhat lower than the concentration in liver of ringed seals from the Strathcona Sound area in the Canadian Arctic (24-28 μg/g, dry wt), (Wagemann, 1989), and are significantly lower than the levels in the liver of seals taken from waters around the British Isles and the German and Dutch Wadden Sea (Law et al. 1991). Comparisons with other locations in the Canadian Arctic are tentative because of the scarcity of information for ringed seals. The higher levels in seals from European waters probably do reflect greater pollution of their coastal waters than Canadian Arctic waters.

The mercury concentration in the liver (12.9 μg/g, dry wt) of the single beluga (Wakeham Bay) included with these seal samples was very much in line with previously reported mean mercury values in liver, e.g. 11.3 and 13.4 μg/g dry wt, for belugas from Nastapoka River and Eskimo Point, respectively (Wagemann et al. 1991).

Cadmium

The mean cadmium concentration (all locations combined) in ringed seal livers was 35.3 (μg/g, dry wt, Table 3). This is a relatively high concentration and very similar to what was found in walrus liver (38 μg/g, dry wt) and was second only to cadmium levels in the liver of narwhal which had some of the highest cadmium levels recorded for marine mammals. The cadmium values reported here for ringed seals greatly exceed those reported for seals from European waters (Law et al. 1991). When individual groups from the different locations are compared with means for other marine mammals, the Inukjuak and George River group means are higher than the values reported elsewhere for walrus liver (37.6 μg/g dry wt, (R. Wagemann, Northern Contaminants Research Workshop, April 3-4, 1991, Burlington, Ontario). Again, sample sizes from most locations were too small to generalize. There was no difference in cadmium concentrations between sexes nor was there any correlation between the mean cadmium concentrations and mean ages of the four groups (Fig. 2) as there was for mercury. The kidney, which is the organ of greatest cadmium accumulation, was not available for analysis. Had it been, levels 2-5 times higher than in the liver would probably have been found.

Lead

The lead concentration was lowest in ringed and bearded seals from Wakeham Bay, and highest in ringed seals from Inukjuak and George River. The latter two groups had very similar mean concentrations in the liver as some other ringed seals from the Strathcona Sound area (0.053 μg/g, dry wt) (Wagemann, 1989), in line with values for other Arctic marine mammals, e. g. belugas (Wagemann et al. 1991), but significantly lower than those reported in the past for seals from some European waters. However, some older lead data in the literature has an uncertain margin of systematic error, and comparison with such data can be misleading. There was no significant correlation of lead in liver with age or sex. Most sample sizes were too small to delineate any site differences, a deficiency not to be repeated in future sample collections.

Selenium

Selenium was highly associated (positively) with mercury with an atomic ratio of 0.86 (Hg/Se), (all locations combined), which has been commonly also found in other marine mammals in the past. The two elements track each other i.e. the higher the mercury concentration in liver the higher the selenium concentration in liver and vice versa. This correlation seems to occur generally in the liver of marine mammals, and its biochemical significance is still not fully understood. The overall average (all groups combined) of selenium in bearded seals was higher than in ringed seals (Table 2), reflecting the higher mean mercury concentration in bearded seals than in ringed seals. The mean selenium concentration of individual groups was significantly correlated with their mean age (Fig. 2), similar to that for mercury. However, the small sample sizes from most locations preclude any generalization of this relationship.

Copper and Zinc

Mean copper and zinc concentrations in liver of ringed seals ranged from 45 to 68 for copper and 143 to 170 (μg/g, dry wt) for zinc among the four groups. The highest mean concentration of both metals occurred in the George River group. The means of the two groups with the largest sample sizes (Wakeham Bay and Inukjuak) were compared statistically (two-tailed t-test) and found to differ significantly at these two locations for zinc ($P=0.014$) but not for copper. Zinc varied least from animal to animal, which is generally true also for other marine mammals. Although copper is also homeostatically controlled as zinc is, its concentration tended to vary much more from animal to animal than that of zinc, and this too is generally true also for other marine mammals (Wagemann et al. 1991). The variation for unessential metals was much greater than for the essential metals, possibly as a consequence of a large geographical and trophical variation in unessential metals in some prey and different prey preferences by individual animals. The mean copper concentration was significantly different in males and females (all groups combined) (Table 3). Whether or not this is a local phenomenon or is more generally true, and what the underlying cause or causes of this difference between males and females might be is subject to further investigation.

CONCLUSION AND FUTURE DIRECTIONS

For all locations combined, bearded seals had higher mean levels of mercury in liver than ringed seals although their mean ages were similar. Group means of mercury in ringed seals from different locations were significantly correlated with their mean ages and females had higher concentrations than males. This differentiation of mercury according to age, sex, and possibly sampling site, has obvious dietary implications for human consumption of seal tissues. Most groups were too small to permit drawing general conclusions.

The cadmium concentration in ringed seals was relatively high compared to some other Arctic marine mammals, and much higher than in some European seals. Overall means were somewhat higher in ringed seals than bearded seals. There was no correlation with age of animals.

The mean lead concentrations of groups were somewhat differentiated spatially, but overall similar to levels in other Arctic marine mammals. There was no significant correlation between lead and age of animals or other metals.

Overall selenium in bearded seals was higher than in ringed seals reflecting the higher mercury concentration in the former. Mean selenium of groups was correlated with age.

The mean copper concentration was significantly higher in females than in males; possibly a local abberation. There was no similar difference in the mean ages between males and females.

The present investigation suffered from small sample sizes. Although the data are useful as a first survey step, these cannot be used to draw general conclusions.

To elucidate trends, the data base for ringed and bearded seals needs to be broadened. The present sample of bearded seals consisted only of 7 animals, and ringed seal samples of only 2 - 10 animals except for Wakeham Bay. We already have some additional ringed seal samples from Arctic locations (liver, kidney, muscle) ready for analysis, and will carry on with work on ringed seals, funding permitting.

RESOURCES

	1990/91	1991/92	1992/93	1993/94	1994/95
Total	16 K	-	-	-	-

REFERENCES

Law, R.J, C.F. Fileman, A.D. Hopkins, J.R. Baker, J. Harwood, D.B. Jackson, S. Kennedy, A.R. Martin and R.J. Morris. 1991. Concentrations of trace metals in the livers of marine mammals (seals, porpoises and dolphins) from waters around the British Isles. Mar. Poll. Bull. 22:183-191.

Norstrom, R.J., R.E. Schweinsberg and B.T. Collins. 1986. Heavy metals and essential elements in livers of polar bears (*Ursus maritimus*) in the Canadian Arctic. Sci. Total Environ. 48: 195-212.

Smith, T. G. and F.A.J. Armstrong. 1975. Mercury in seals, terrestrial carnivores, and principal food items of the Inuit from Holman, N.W.T. Can. J. Fish. Res. Board. Can. 32:795-801.

Wagemann, R. 1989. Comparison of heavy metals in two groups of ringed seals (*Phoca hispida*) from the Canadian Arctic.

Wagemann, R., R.E.A. Stewart, P. Béland and C. Desjardins. 1991. Heavy metals and selenium in tissues of beluga whales (*delphinapterus leucas*) from the Canadian Arctic and the St. Lawrence estuary. In T.G. Smith, D.J. St. Aubin and J.R. Geraci (eds.). Can. Bull. Fish. Aquat. Sci. 224:191-206.

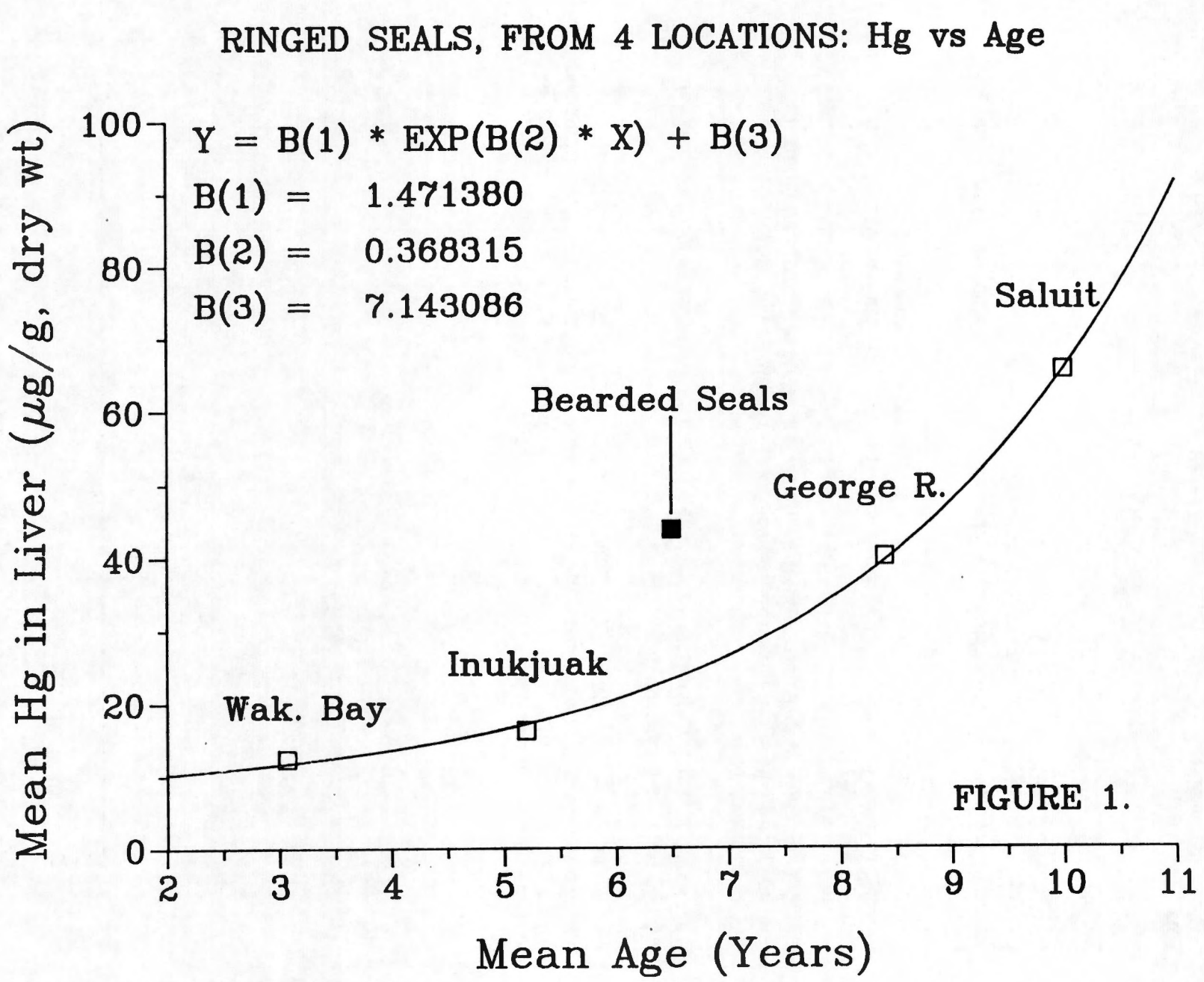

RINGED SEALS, FROM 4 LOCATIONS: Hg vs Age
Y = B(1) * EXP(B(2) * X) + B(3)
B(1) = 1.471380
B(2) = 0.368315
B(3) = 7.143086
Mean Hg in Liver (µg/g, dry wt)
100
80
60
40
20
0
2
3
4
5
6
7
8
9
10
11
Mean Age (Years)
Wak. Bay
Inukjuak
Bearded Seals
George R.
Saluit

FIGURE 1.

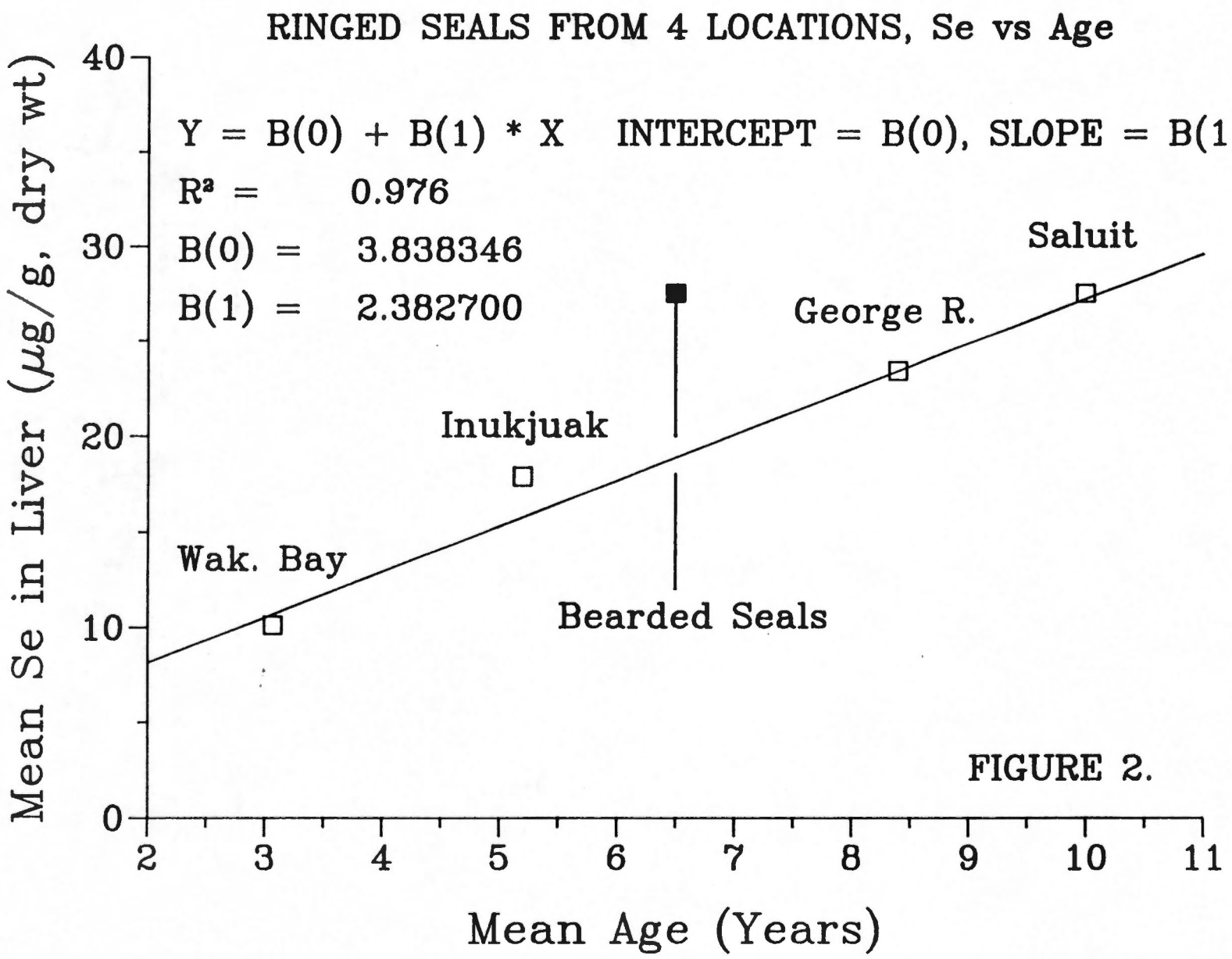

RINGED SEALS FROM 4 LOCATIONS, Se vs Age
Y = B(0) + B(1) * X INTERCEPT = B(0), SLOPE = B(1)
R² = 0.976
B(0) = 3.838346
B(1) = 2.382700
Saluit
George R.
Inukjuak
Wak. Bay
Bearded Seals
Mean Se in Liver (µg/g, dry wt)
Mean Age (Years)
0
10
20
30
40
2
3
4
5
6
7
8
9
10
11

FIGURE 2.

LEAD AND OTHER HEAVY METALS IN TISSUES OF WALRUS AND RINGED SEALS.

Project Manager: R. Wagemann
501, University Crescent, Freshwater Institute, Winnipeg, Man. R3T 2N6. Telephone: (204) 983-5207; Fax (204) 983-6285.

Principal Investigator(s): R. Wagemann
501, University Crescent, Freshwater Institute, Winnipeg, Man. R3T 2N6. Telephone: (204) 983-5207; Fax (204) 983-6285.

Collaborator(s): R. Stewart
501, University Crescent, Freshwater Institute, Winnipeg, Man. R3T 2N6. Telephone: (204) 983-5023; Fax (204) 983-6285.

Contractor: D. Savoie (laboratory assistance), 6 months 1990/91.

Project Completion Date: Phase 1 (Walrus)-1991/92; Phase 2 (Ringed seals)-1993/94); Phase 3 (Narwhal and beluga) - 1993/97.

OBJECTIVES

a. To measure and assess toxic metals (lead, cadmium, mercury) in tissues of walrus and ringed seals from the Canadian Arctic in relation to other marine mammals.

b. To obtain spacial and temporal trends, background concentrations and base-line metals data in support of studies of dietary intakes by native people.

These objectives were supported in the Arctic Contaminants planning Work Shops (Ottawa, Feb. 28 - March 2, 1989; Toronto, Dec. 11-12, 1989).

PROJECT DESCRIPTION

Introduction

Anomalously high heavy metal levels have been found in some marine mammals. Metals data are still sparse for most marine mammals from the Canadian Arctic, except for beluga for which a reasonably extensive, spatial data base (6 locations) has been published, but even these data are insufficient to deduce temporal trends.

For narwhal from the Canadian Arctic metals data for a single sample (63 animals) from the Pond Inlet area, collected in 1979, have been published as well as some data for narwhal outside the Canadian Arctic (west coast of Greenland). These data indicate that narwhal have some of the highest concentrations of cadmium in liver and kidney. The existing data are quite insufficient for deducing temporal trends.

For ringed seals from the Canadian Arctic heavy metals data for one relatively small sample (28 animals) taken in 1980 from the Strathcona Sound area as well as some earlier data for mercury and selenium in ringed and bearded seals taken in 1973-74 across the Canadian Arctic have been published. These data are insufficient to deduce temporal trends.

There were no metals data available for walrus from the Canadian Arctic prior to this work. This study will provide in the near term a data base for walrus and ringed seals for bench-mark use (e.g. Hydro-Quebec projects) and dietary intake calculations of toxic metals, and in the long term, with additional samplings in the future, temporal trends.

Completed Analyses

Liver, kidney and muscle tissues from over 100 walrus were taken at three locations in the Arctic between 1982 and 1988: Igloolik (72 animals, 1982-88), Hall Beach (16 animals, 1988), and Frobisher Bay-Iqaluit (30 animals, 1983-88). Tissues were analyzed (some repeatedly) for lead, cadmium, mercury, selenium, zinc and copper, involving well over 2000 analyses.

RESULTS

Table 1. Mean concentrations, $\mu g/g \pm SD$, wet wt, of metals in tissues of walrus.

	Pb	Hg	Cd	Se	Zn	Cu
LIVER	0.081±0.069	1.36±1.08	11.2±6.58	2.87±1.14	45.1±10.3	9.66±7.74
KIDNEY	No Data	0.31±0.12	56.6±28.5	No Data	38.7±7.66	5.27±2.43
MUSCLE	0.021±0.048	0.11±0.11	0.14±13	3.33±1.52	45.8±8.14	0.86±0.25

Lead:

Compared to some other marine mammals (Arctic belugas, narwhal) lead was relatively high in these animals, but not as high as in belugas from the St. Lawrence. There was no significant difference between the mean lead concentration among the groups from the three different locations for either liver or muscle. Kidney was not analyzed for lead.

Mercury:
Mercury levels in these animals were among the lowest in all three tissues compared to other Arctic marine mammals. There was no significant difference among the groups from the three locations for any of the tissues examined. In muscle the overall mean concentration was only 0.11 ppm, wet wt, well below the Federal guideline of 0.5 ppm, wet wt.

Cadmium:
Compared to other Arctic marine mammals cadmium was quite high in the liver and kidney of these animals, particularly in the kidney (56.6 μg/g, wet wt) where it was nearly as high as in narwhal. As for other metals, there was no significant difference in cadmium concentration between the group means from the different locations for any of the three tissues.

Selenium:
The selenium levels in walrus were similar to those found in other marine mammals. There was no significant difference between group means from different locations. As in other marine mammals there was a very significant positive correlation between mercury and selenium in the liver. The biochemical significance of this association is still not well understood. The kidney was not analyzed for selenium.

Zinc and Copper:
These metals were also measured in liver, kidney and muscle. As expected the levels in walrus tissues were quite comparable to those in other marine mammals with no significant differences among groups.

RESOURCES EXPENDED IN 1990/91 AND PLANNED UNDER GREEN PLAN

1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
26 K	35 K	30 K	30 K	35 K	30 K	10 K

FUTURE WORK

Analyses Remaining
Samples (liver, kidney, muscle) of ringed seals are in hand from 5 locations in the Arctic which we will analyzed next. Together with the published data, this will provide a substantive geographic metals data base for ringed seals.

Present data base for narwhal is insufficient to deduce temporal trends. Another sample, 30-50 animals (after more than a decade since the first sample) from the same location (Pond Inlet) will provide another reference point in time.

Additional samples of belugas will be required in 2-3 years (5-6 years after the last sampling in 1988) to deduce temporal trends.

TITLE: B3. Subproject 3.

CIRCUMPOLAR SURVEY OF PCBs IN BELUGA

PROGRAM LEADER: D. Muir

PROJECT TEAM MEMBERS: D. Muir, B. Grift, contractors C. Ford and M. Segstro

OBJECTIVES:

1. Determine temporal and spatial trends in PCBs and other organochlorines in arctic beluga whales and other marine mammals on a circumpolar basis.

2. Provide data for use in surveys of dietary contamination by circumpolar countries

DESCRIPTION:

Introduction:

As top predators in marine food chains, belugas (Delphinapterus leucas) are an excellent species for studying the presence and geographic variation of lipophilic organochlorine chemicals such as polychlorinated biphenyls (PCBs) and chlorinated pesticides. The beluga are also important to native peoples in arctic coastal communities of Canada, Greenland and Alaska who consume marine mammals as part of their traditional diets.

Our lab has recently completed a study of the geographic variation of organochlorine contaminants in beluga from Canadian arctic waters and from the Gulf of St. Lawrence (Muir et al. 1991a). The study showed that Canadian arctic beluga stocks have very similar levels of PCBs and other organochlorines in blubber suggesting rather uniform contamination of arctic marine food chains. There is little information on contaminant levels in other circumpolar beluga populations.

This study involves gathering samples from at least 4 distinct beluga stocks: (1) Western Greenland, (2) S. Beaufort/Chukchi Sea stock, (3) N. Bering Sea/Norton Sound and (4) Western Soviet arctic. The general objective is to determine levels of PCBs and other organochlorine contaminants in tissues of belugas from these locations in order to describe the circumpolar variation in levels of contaminants in arctic food chains. A second important objective and outcome of the work is the promotion of scientific exchange of samples and methodology among circumpolar countries. The specific objectives for the 1989-91 period were to analyse samples of beluga blubber from western Greenland animals as part of a collaboration with Dr. Mads-Peter Heide-Jørgensen, Greenland Fisheries Research Institue, Copenhagen.

Activities (89-91):

During 1990/91 beluga blubber samples were received from Greenland and an agreement was reached with the Mr. Aqqaluk Lynge of the Inuit Circumpolar Conference (Nuuk, Greenland) for funding the analysis of 100 samples. Blubber samples were also received from the Soviet Union (White Sea). Agreement was also reached with Dr. Paul Becker (NOAA, National Ocean Service, Office of Oceanography and Marine Assessment, Anchorage) on the analysis of Alaskan beluga samples which are archived at the National Institute of Standards and Technology, (Gaithersburg, MD).

Blubber samples from western Greenland and the White Sea region of the Soviet Union were analysed for PCB congeners and organochlorine pesticides (hexachlorocyclohexanes (HCH), toxaphene (PCCs), chlordane, and the DDT group). Methods of analysis were the same as those described in Muir et al. (1991). Twenty samples from Greenland were analysed during 1989/90 and an additional 20

during 1990/91. Results for the 1990/91 analyses are not yet complete. Three samples (probably from one animal) were analysed from the White Sea.

Results:

A total of 12 male and 8 female beluga blubber samples from Greenland have been analysed so far (Table 1) along with three samples from the Soviet Union. The samples originated from Kraulshavn (74°07N 57°04W) and Rifkol (67°57'N 54°00'W) on the west coast of Greenland and the White Sea in northern Russia.

The major organochlorine contaminants in all beluga blubber samples were PCBs, PCCs, s-DDT (mainly 4,4'-DDE) and s-CHLOR (mainly *trans*-nonachlor and oxychlordane). Hexachlorocyclohexanes (s-HCH), chlorobenzenes (tetra-, penta- and hexachloro-isomers) and dieldrin were present at lower concentrations that the 4 major organochlorine groups. In the samples from Greenland, concentrations of s-DDT and s-PCB were lower in females than in males, as is generally observed in cetaceans and pinnipeds (Aguilar 1987) but mean concentrations in males were not significantly higher (t-test, $p < 0.05$). A similar result was observed for animals from Jones Sound (Table 1 and Muir et al. 1991a) and was attributed to the absence of lactation for most of the females because of their young age. A high proportion of the females from Kraulshavn group were probably not reproductively active.

Results for organochlorines in the Greenland belugas are compared in Table 1 with those for Jones Sound, Cumberland Sound, and the White Sea. Mean concentrations of s-CHLOR, s-DDT and PCBs are similar among male beluga from Rifkol, Kraulshavn and Cumberland Sound. Lower concentrations of organochlorines in males from Jones Sound are probably due to the lower mean age of these animals compared to other locations. The samples from the White Sea had about 10-fold higher levels of ΣDDT and 8-fold higher levels of ΣPCBs than those from Greenland. These levels are comparable to those observed in blubber from dead belugas in the St. Lawrence estuary (Muir et al. 1991a). Levels of chlordanes and PCCs in the Soviet samples were within the range observed in the Canadian arctic and Greenland samples. Although three samples (separate containers) were received from the Soviet Union they all appeared to be from the same animal judging from the low standard deviations.

Table 1. Summary of concentrations of major organochlorines in blubber of belugas from Canadian, Greenland and Soviet waters (ng/g wet wt).

Location	Sex	Age (yrs)	N	s-CHLOR	s-DDT	s-PCB	PCC
Kraulshaavn	M	6.0 ± 3.7	7	2760 ± 830	5580 ± 2930	5210 ± 2130	3570 ± 1140
	F	7.0 ± 5.8	8	2698 ± 1310	4738 ± 1954	4584 ± 2066	4143 ± 2143
Rifkol	M	17.8 ± 3.7	5	2170 ± 250	6480 ± 840	5220 ± 720	3430 ± 660
Jones Sound	M	4.4 ± 2.2	8	1870 ± 440	1960 ± 320	2530 ± 570	4250 ± 1020
	F	4.6 ± 2.9	7	1840 ± 1130	2190 ± 1690	2460 ± 1980	3740 ± 2120
Cumberland Sound	M	7.3 ± 6.5	6	2380 ± 400	6830 ± 1890	4910 ± 250	5780 ± 5390
	F	8.1 ± 7.3	6	620 ± 150	400 ± 280	1150 ± 410	1770 ± 1760
White Sea	?	-	3	4841 ± 338	63910 ± 3690	37320 ± 3960	9580 ± 1630

Additional laboratory work was conducted to confirm toxaphene (PCC) in beluga and narwhal samples. We collaborated with Dr. T. Bidleman (University of

S. Carolina) who carried out negative chemical ionization mass spectrometry on toxaphene in extracts of narwhal blubber. Work began on isolation and identification of individual toxaphene peaks in order to prepare an analytical standard of the compound.

Levels of PCCs in Cumberland Sound belugas were reexamined as a result of collaboration with T. Bidleman. PCCs in Table 1 are lower than reported previously because a new method was used for quantitation. Further details on the method are given in Muir et al. 1991b.

CONCLUSIONS AND FUTURE DIRECTIONS:

The results of this study confirm that levels of organochlorine contaminants in the Canadian high arctic and western Greenland are similar over a wide geographic area. This conclusion is consistent with the view that the presence of organochlorines results from long range transport and deposition of air-borne contaminants rather than from local point sources. The results suggest that the belugas from western Greenland are part of, or feeding in the same waters as Canadian stocks. The results from the Soviet Union, although limited in sample size, suggest that there may be great variation in contaminant levels in marine mammals on a circumpolar basis depending on the extent of local industrialization.

Work on the Greenland beluga planned for 91/92 will greatly increase the number of samples analysed. It will enable age versus contaminant concentration to be assessed. Future plans include analysis of Alaskan beluga samples from the NIST archive. As contacts are developed with Soviet scientists it is hoped that additional samples will be forthcoming from the Soviet arctic. Finally, in the mid-1990's temporal trends in contaminants in Canadian beluga stocks will need to be assessed because previous analyses were on samples from the 1983-87 period.

Partners: Inuit Circumpolar Conference, Greenland Fisheries Research Institute, NOAA (Anchorage, Alaska). Collaboration with Murmansk Institute of Marine Biology and other Soviet scientists.

Resources (expended in 90/91 and planned under Green Plan)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Total	22 K	25 K	25 K	25 K	20 K	20 K	20 K

DFO provides capital equipment and PYs. ICC (Greenland) will provide $25K during 1991/92 for analysis of samples collected by Greenland Fisheries Research Institute.

REFERENCES:

Aguilar, A. (1987). Using organochlorine pollutants to discriminate marine mammal populations. A review and critique of methods. Mar. Mamm. Sci. 3, 242-263.

Muir, D.C.G., C.A. Ford, R.E.A. Stewart, T.G. Smith, R.F. Addison, M.E. Zinck and P. Béland. 1991a. Organochlorine Contaminants in Beluga (Delphinapterus leucas) from Canadian waters. Can. Bull. Fish. Aquat. Sci. 224: 165-190.

Muir, D.C.G., C.A. Ford, N.P. Grift, R.E.A. Stewart and T.F. Bidleman. 1991b. Organochlorine contaminants in narwhal (Monodon monoceros) from the Canadian arctic. Submitted to Environ. Pollut.

TITLE: C1. Subproject 2.

CO-PLANAR PCBS IN ARCTIC MARINE MAMMALS AND FISH

PROGRAM LEADER(S): D. Muir

PROJECT TEAM MEMBERS: D. Muir, contractor C. Ford, and B. Grift

OBJECTIVES
1. Provide geographic and temporal information on toxic PCB congeners
2. Compare arctic results with mid-latitude levels of co-planar PCBs
3. Provide a linkage to biomarker studies in the same fish and marine mammals and to surveys of dietary contamination.

DESCRIPTION

Introduction:

PCB congeners with 3,4,3',4'-chlorine substitution are the most biologically active and are referred to as toxic "co-planar" or "non-ortho" PCBs. They lack chlorine substituents in the 2 and 6 (or ortho) positions and can therefore assume a planar configuration. These congeners are isostereomers of 2,3,7,8-TCDD and have similar mode of action; induction of hepatic mixed function oxidase (MFO) enzymes, immunotoxicity, teratogenicity and embryotoxicity (Safe 1990). The toxicity of Aroclor mixtures (commercial PCB formulations) is thought to be due almost entirely to these co-planar PCBs (Kannan et al. 1988).

Another group having a single chlorine in the 2- position is referred to as "mono-ortho" PCBs. Some of these compounds also have MFO enzyme induction potencies which are similar to those of the co-planar molecules. Toxic equivalent factors (TEFs) of mono-ortho and non-ortho congeners, which are a measure of the biological potency relative to 2,3,7,8-TCDD, range from 0.1 for PCB-126 (3,3',4,4',5-pentachlorobiphenyl) to 0.01 for PCB-77 (3,3',4,4'-tetrachloro-biphenyl) (Safe 1990). Mono-ortho PCBs have been assigned TEFs of 0.001 (Safe 1990). These TEFs were used to calculate the contribution of co-planar PCBs to total toxic equivalents in arctic tissue samples.

Preliminary studies of diet samples from Broughton Island showed that co-planar PCBs were present in fatty tissues of ringed seal, walrus, narwhal and polar bear as well as arctic char (Muir and Ford, 1990). The results showed that co-planar PCBs account for most of the "TCDD equivalents" in arctic diet samples. The objectives of this work for 1990/91 were to broaden the survey of co-planar PCBs to a larger number of tissues, especially fish tissues. This information is needed to evaluate current risks of exposure to the toxic PCBs for human consumers and to support the biomarker studies on marine mammals and fish which will assess responses at the biochemical level to PCBs and dioxins/furans.

Activities 1989/91:

Co-planar (non-ortho and mono-ortho substituted) PCBs were determined in 10 narwhal blubber samples from Pond Inlet (NWT) and in 26 arctic char samples from Sommerset Island, Pond Inlet and Spence Bay. The method of analysis is described in more detail by Muir and Ford (1990). Fish tissues were extracted hexane:dichloromethane (1:1), lipid removed with automated gel permeation chromatography, and co-planar PCbs were isolated by carbon-enrichment. Sample extracts were then analysed by GC-MS analysis and co-planar PCBs quantified with the aid of ^{13}C-internal standards for PCB-77, 126 and 169 (3,3',4,4',5,5'-hexachlorobiphenyl). Pooled samples of char from the three sites were also sent to DFO Burlington for determination of chlorinated dioxins/furans (PCDD/PCDFs) will be made by DFO Burlington. The total PCB and PCDD/PCDF data for the char is not yet available so only results for Broughton island char are reported

here.

Results

Concentrations of co-planar PCBs in narwhal blubber are compared in Table 1 with results for other biota. Male narwhals had among the highest co-planar PCB levels detected in all marine mammal and fish samples analysed so far. Mean concentrations of PCB-126, the most toxic co-planar congener, ranged from 187 ng/kg in males (N=16) to 93 ng/kg in females (N=6). Male narwhal also had higher concentrations of PCB-77 and PCB-169 than females but the differences were not significant (t-test, $p < 0.05$). Co-planar congeners represented a higher proportion of ΣPCB in females than males because of the lower ΣPCB in the former group.

Table 1. Mean concentrations of co-planar PCB congeners and percent of ΣPCB in arctic biota.

Species	Sex	N	Concentration (ng/kg wet wt)			Percent of ΣPCB		
			77	126	169	77	126	169
Narwhal	F	6	128±70	93±68	42±30	0.005	0.004	0.002
	M	16	199±196	187±99	52±23	0.004	0.003	0.001
Arctic char	-	8	63±36	15±8	<2	0.173	0.042	<0.006
Ringed seal	M+F	4[1]	86±45	94±37	17±18	0.014	0.016	0.003
Beluga	M	6	105±106	201±127	97±29	0.002	0.004	0.002

[1] 4 pooled samples consisting of 2 pooled extracts.

Ringed seal blubber had similar mean levels of PCB-77, 126 and 169 to the narwhal samples although total PCB levels were 5 to 6-fold less (Table 1). Levels of PCB-77 and 126 ranged from 30 to 125 ng/kg and from 50 to 139 ng/kg, respectively. These four ringed seal samples had a mean age of 1.4 yrs and may therefore have lower levels of PCBs than typical levels in adult animals.

Belugas had higher levels of PCB-169 than PCB-126 unlike the (male) narwhal and the ringed seals. PCB-77 was the major co-planar congener in whole char (whole fish homogenate) from Broughton Island, ranging from 28 to 119 ng/kg. PCB-126 was also detectable in char tissue (5 - 17 ng/kg) but PCB-169 was undetectable (<2 ng/kg) in all samples. ΣPCB levels in the charr samples ranged from 15 to 65 ng/g. The range of concentration of PCB-77 and 126 in char tissues was similar to that in narwhal but ΣPCBs in the whale blubber were from 20 to 80-fold higher. Thus the proportion of co-planar PCBs to total PCBs in fish is higher. Similar results were observed by Asplund et al (1989) in fish and seal tissues from the Baltic Sea. Fish had higher levels of co-planar PCBs than ringed seal blubber although ΣPCB in the blubber was much higher than in fish.

For ringed seal blubber, beluga, and narwhal total "TCDD equivalents" were calculated using PCDD/PCDF levels reported in pooled samples from the western Davis Strait and Cumberland Sound region (Norstrom et al. 1990) . We assumed that narwhal like beluga had undetectable (<2 ng/kg) levels of 2,3,7,8-TCDD and 2,3,7,8-TCDF. PCB-126 contributed a major portion of total TCDD equivalents in all samples. The other major contribution was from PCB-105 (2,3,3',4,4'-pentachlorobiphenyl) in narwhal and beluga and 2,3,7,8-TCDD in ringed seals. In the case of ringed seal concentrations of 2,3,7,8-TCDD and TCDF were 11 and 3 ng/kg, respectively, in a pooled sample from Broughton Island analysed by Norstrom et al. (1990) and TCDD constituted 28% of total equivalents in ringed seal blubber.

Table 2. Mean toxic equivalents (TEQs of 2,3,7,8-TCDD) for co-planar PCB congeners and percent of total TEQs in arctic biota.

Species	Sex	Concentration (ng/kg TCDD)			Percent of total TEQ		
		77	126	169	77	126	169
Narwhal	F	1.3	12	2.1	3.1	21.6	3.8
	M	2.0	24	2.6	2.0	22.3	3.2
Ringed seal	M+F	0.9	12	0.7	2.2	31.8	1.9
Beluga	M	1.1	26	4.8	1.3	34.1	3.8

CONCLUSIONS AND FUTURE DIRECTIONS:

The results indicate that co-planar PCBs contribute a substantial proportion of "TCDD equivalents" in Arctic marine mammal and fish samples. In arctic char co-planar PCBs constituted a 10- to 20-fold higher proportion of ΣPCB than in seal or whale blubber. Thus further study of char and other marine and freshwater fish should be given high priority. Additional information is required on the variation of co-planar congeners with age and sex of biota. This would make it possible to predict levels in samples for which only total PCB or concentrations of selected congeners were known.

Plans for 1991/92 and subsequent years are to determine co-planar PCBs in additional marine and freshwater fish and in whale and seal tissues to develop a larger data base than is available at present. The project will also provide support for biomarker studies in fish and marine mammals and for additional surveys of dietary contamination.

Partners: The work has been performed in collaboration with CWS (Hull) who provide advice on analytical methodology.

RESOURCES (expended in 90/91 and planned under the Green Plan)

1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
24 K	36 K	30 K	30 K	30 K	30 K	18 K

REFERENCES

Asplund, L., B. Jansson, K. Litzén, K. Nylund, U. Sellström, U-B. Uvemo and U. Wideqvist. Presented at the 8th Int'l Conference of Comité Artique International on the Global Significance of the Transport and Accumulation of Polychlorinated Hydrocarbons in the Arctic. Oslo, Sept. 1989.

Kannan, N., S. Tanabe and R. Tatsukawa. 1988. Bull. Environ. Toxicol. Chem. 41:267-276.

Muir, D.C.G. and C.A. Ford. Analysis of "co-planar" PCBs in arctic dietary samples. Rewport to Government of the Northwest Territories, Health Dept. and Indian and Northern Affairs Canada, May 1990.

Norstrom, R.J., M. Simon and D.C.G. Muir. 1990. Environ. Pollut. 66:1-20.

Safe, S. Crit. Rev. Toxicol. 21, 51-88, 1990.

TITLE: B4. Contaminant trends in freshwater biota

"ORGANOCHLORINES AND PAHS IN FISH FROM NORTHERN REMOTE LAKES"

PROGRAM LEADER(S): D. Muir and W.L. Lockhart

PROJECT TEAM MEMBERS: D. Muir, B. Grift, D. Metner, B. Billeck, L. Lockhart, contractor M. Segstro

OBJECTIVES

1. Determine temporal and spatial trends in PCBs, other organochlorines and PAHs in fish from lakes and rivers in NWT and N. Quebec.
2. Provide information on contaminants to evaulate current risks of exposure to PCBs, PAH and chlorophenols via fish consumption.

DESCRIPTION

Introduction:

Reviews of contaminant data in freshwater fish from arctic and subarctic Canada (Lockhart et al. 1991; Muir et al. 1990) indicate that information on the levels and geographic variation of organochlorines and polyaromatic hydrocarbons is limited while data on temporal trends is nonexistent. Fishes from remote lakes in northern Québec and N.W.T., first monitored in 1970 by Reinke et al. (1972) and Riseborough and Berger (1971), will be studied in order to examine the general temporal trends in DDT, dieldrin and PCBs as well as investigate the presence of additional contaminants not reported in the early work. In addition comparison of contaminant levels in fishes from remote lakes in southern Canada with those in similar size lakes in the arctic will be made to provide further perspective on the extent of contamination. The focus here is on fish of dietary importance to native people in NWT, the Yukon and N. Québec.

Activities 1989 to 1991.

Lake trout, whitefish and cisco were obtained from lakes in northern Quebec in the Ungava peninsula, Gordon Lake north of Yellowknife, Fisherman Lake, south of Fort Simpson, Hawk Lake (63°39'N 90°43'W) a small headwater lake near Chesterfield Inlet. Landlocked arctic char were obtained from Amituk Lake (75°07'N 93°50'W), a small headwater lake on Cornwallis Island, and from Lake Hazen (82°N) on Ellesmere Island. Samples of whole fish or muscle were analysed for PCB congeners and other organochlorine contaminants (toxaphene (PCC), chlordane (CHLOR), and the DDT group). Fishes of known age, sex and size class were selected. A limited number of samples were set aside for analysis of co-planar PCBs and chlorinated dioxins/furans.

In the fall of 1990 samples of burbot liver and lake trout muscle from the Yukon River system where analysed. This work was undertaken in cooperation with Environmental Protection in Whitehorse, to confirm high levels of DDT, PCBs and toxaphene in fish from Lake Laberge.

Results:

Lake trout and landlocked arctic char from five locations in the Canadian arctic were analysed for organochlorine contaminants (Table 1). Highest concentrations were found in muscle of char from Amituk Lake with mean ΣPCB levels ranging from 7260 ng/g (lipid wt) in males to 2300 ng/g in females. Char from Lake Hazen also had high organochlorines, espcially PCC and ΣCHLOR, relative to lake trout from more southerly locations. Lake trout from two locations in Northern Quebec (Salluit/Wakeham Bay on the Ungava peninsula and from Inukjuak on Hudson Bay) had similar concentrations ΣCHLOR, ΣDDT, ΣPCB and PCCs when the results were compared on a lipid weight basis.

Table 1. Mean concentrations (ng/g ± SD, lipid weight basis) of major organochlorines in fish from remote Canadian lakes.

Location	Species	Sex	N	ΣCHLOR	ΣDDT	ΣPCB	PCC
Hazen Lake	A. Char	M	6	1042 ± 669	438 ± 331	1647 ± 1629	4066 ± 2064
Amituk L.	A. Char	M	5	3540 ± 2100	3630 ± 2800	7260 ± 5540	9370 ± 5960
		F	4	1820 ± 631	1210 ± 523	2300 ± 727	5700 ± 2770
Hawk L.	L. trout	M	6	409 ± 271	987 ± 909	2140 ± 1580	1090 ± 1280
		F	3	157 ± 76	387 ± 278	548 ± 200	384 ± 250
Salluit/ Wakeham Bay	L. trout	M	6	372 ± 86	533 ± 385	1055 ± 368	744 ± 175
		F	4	287 ± 117	342 ± 299	752 ± 338	855 ± 475
Inukjuak	L. Trout	M	5	268 ± 210	267 ± 266	1367 ± 303	449 ± 230

Burbot liver and lake trout from Lake Laberge (Yukon) analysed for organochlorines by our lab and by SeaKem (Sidney, B.C.). A detailed report on the work has been prepared (J. Eamer, 1991); results for burbot liver are summarized in Table 2. Results for DDT-related compounds are clearly higher than expected for a northern location based on our work in the Mackenzie River. Mean levels of HCHs, dieldrin, HCB, and PCCs from Lake Laberge are higher by a factor of 2 or less. This difference might be explained by food chain factors, i.e. diet of Lake Laberge burbot may be higher in fish than in invertebrates. The PCB results are also higher than the Mackenzie results by 2.5 to 4 times which is difficult to explain by diet alone. A local source of DDT and PCBs for Lake Laberge is suspected. The differences in results between DFO and Seakem have not yet been resolved. Seakem analysed different samples and there were some differences in methodology especially for quantifying PCCs.

Table 2. Comparison of organochlorine levels in burbot liver from Lake Laberge and the Yukon river at Dawson City with Mackenzie River results (Muir et al. 1990)

Location	Geometric means (ng/g lipid wt basis)							
	N	ΣPCB	ΣDDT	ΣCHLOR	ΣHCH	dieldrin	HCB	PCC[1]
Fort Good Hope	8	344	95	173	30	14	43	790
Fort Simpson	5	557	163	207	27	14	34	566
Lake Laberge (DFO)	6	1330	3350	293	65	21	43	2010
Lake Laberge (Seakem)	8[2]	3078	13,069	75	115	87	58	6950
Dawson City (DFO)	3	200	180	88	18	6	28	205

[1] PCC results from the Mackenzie quantified by a different procedure. They have been multiplied by 0.5 to make them equivalent to Lake Laberge results.
[2] Geometric mean of 8 composite samples analysed by Seakem Analytical Labs., Sidney, B.C.

CONCLUSIONS AND FUTURE DIRECTIONS:

Analyses of lake trout indicate that levels in this species are relatively uniform over a wide area. The organochlorine results for landlocked char in Amituk Lake and Lake Hazen were very high relative to the lake trout and to other analyses of sea-run char (see Northern Québec study). Food chain length and trophic status (i.e. eutrophic versus oligotrophic) of lakes also influence levels of organochlorines in fish (Rasmussen et al. 1990). Further analyses are required to sort out the influence of these variables on organochlorine levels in remote arctic lakes. In addition further studies are needed on lake trout and burbot in the Yukon. The results from Lake Laberge suggest that it would be prudent to study burbot and lake trout from locations near population and industrial (mining) centers in N.W.T. also e.g. Great Slave Lake and Great Bear Lake. Future work will involve analysis of fish from remote arctic lakes to look at atmospheric contributions to contamination and investigations of piscivorous fish collected near communities in N.W.T., the Yukon and N. Québec. Analysis of fish for PAHs will also be carried out. Additional work will focus on temporal trends in organochlorines in fish from selected locations where archived samples are available or where analyses have been done previously. Anticipated completion date is 1996.

Partners: DOE, Environmental Protection, (Yukon River studies); DFO Fish Inspection (Arctic char survey). J. Reist, K. Chang-Kue, B. Bond, DFO (Winnipeg) provide samples. Further cooperation with NWT Renewable Resources and the Dene will be necessary to complete the sampling program.

Resources (expended in 90/91 and planned under Green Plan)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Total	25 K	100 K	150 K	100 K	150 K	100 K	100 K

References

Eamer, J. 1991. Report on Organochlorines in Yukon Fish. Environmental Protection, Environment Canada, Whitehorse Yukon.

Muir, D.C.G., C.A. Ford, N.P. Grift, D.A. Metner and W.L. Lockhart. 1990. Geographic variation of chlorinated hydrocarbons in burbot (Lota lota) from remote lakes and rivers in Canada. Arch. Environ. Contam. Toxicol. 19:530-542.

Rasmussen, J.B., D.J. Rowan, D.R.S. Lean and J.H. Carey. 1990. Food chain structure in Ontario lakes determines PCB levels in lake trout (Salvenlinus namaycush) and other pelagic fish. Can. J. Fish. Aquat. Sci. 47:2030-2038.

Reinke, J., J.F. Uthe and D. Jamieson. 1972. Organochlorine pesticide residues in commerically caught fish in Canada - 1970. Pestic. Monit. J. 6:43-49.

Riseborough, R.W. and D.D. Berger. 1971. Evidence for aerial fallout of polychlorinated biphenyls (PCB) in the eastern Canadian arctic. Contract report CWS 7071-052. Canadian Wildlife Service, Ottawa.

TITLE: B1.
DEPOSITIONAL TRENDS OF ORGANOCHLORINES, PAHS AND METALS IN THE ARCTIC FROM LAKE SEDIMENT CORES

PROGRAM LEADER(S): G.J. Brunskill, DFO

PROJECT TEAM MEMBERS:
P. Wilkinson, E. Slavacek (contractor) (radionuclides)
L. Lockhart, B. Billeck, D. Murray, (PAHs and hydrocarbons);
D. Muir, N. Grift, M. Segstro (contractor) (organochlorines);
R. Hunt, C. Baron (metals);
H. Kling (particle morphology).

OBJECTIVES:
1. Determine spatial and temporal trends in contaminant deposition using sediment core samples from a grid of arctic headwater lakes

2. Derive recent LRTAP input rates from the core profiles and compare with past rates of supply.

3. Test the contaminant histories with known source data, other temporal trend data (e.g. lichens), and from responses to contaminant-induced in the fish from the same lakes.

DESCRIPTION:
Introduction:

This project has been ongoing since 1987-88 with funding from the DFO LRTAP program. A workshop held in Burlington (Ont) in 1987 identified long range transport of organic contaminants as an important future issue for the LRTAP program (Klaverkamp et al. 1989) and recommended increased activities especially in the Arctic. The workshops held to design the Arctic Contaminants Plan also identified dated lake sediment cores as an appropriate means of determining present and past fluxes of organic and inorganic contaminants to the Arctic. For the 1990-91 fiscal year funding for the lake sediment study was received from the joint DIAND/DFO arctic program.

Between April 1987 and March 1990 sediment cores were collected from remote lakes in NW Ontario (Experimental Lakes Area), Saqvaqjuac (66°N) and Cornwallis Island (75°N). The cores were obtained with a box corer designed for taking thin sediment slices (0.5 cm or 1.2 cm). Tow lakes were sampled in each location slices were analysed for heavy metals, PAHs, organochlorines and radionuclides. Slices dated with the profile ^{2}10Pb and ^{137}Cs.

<u>1990-91 Activities:</u>
Sediment cores from Hazen Lake, the northermost freshwater lake on Northern Ellesmere Island, during May 1990. These samples completed a latitudinal transect from 49 °N to 82 °N. The cores consisted of a single box core (0.5 cm slices) and large KB cores. All cores were sliced in the field. Slices were frozen and returned to the lab where they were freeze-dried prior to analysis. Slices were dated using ^{210}Pb and portions of the samples were analysed for metals, PAHs, organochlorines, radionuclides.

<u>Results:</u>

The total PAH profiles from the Experimental Lakes Area and Saqvaqjuac showed intermediate values in the top (recent 1960- present) sediments and

highest values in slices corresponding to the middle years of this century. Similar profiles have been reported from eastern North America and they have been interpreted as reflecting the increase early in the century and decrease after 1950 in residential coal heating in North America. PAH concentrations at Saqvaqjuac were lower than at ELA while levels from two lakes (Amituk and Sophia) on Cornwallis Island were lower. The time resolution in Amituk and Sophia Lakes was poorer due to low sedimentation rates and highest concentrations were observed in the top two slices.

The profile for PAHs in Lake Hazen sediments was very different from the other sites. PAH levels were almost as high as those at ELA and there was no evidence of the recent decline in surface sediments. Instead there was a continuous increase in PAHs throughout the century. We tentatively interpret this as indicating that Lake Hazen PAH profiles are a combination of Eurasian combustion sources (with a longer history than North American sources) combined with inputs from coal deposits in the Lake Hazen watershed.

The profiles of PCBs and other organochlorine contaminants paralleled those for total PAHs with highest concentrations in the 1950-1980 period. Highest sediment concentrations were found in ELA sediments and lowest in cores from Amituk and Sophia Lakes on Cornwallis Island. PCBs, DDT-group and toxaphene-related compounds were the major organochlorines observed. PCBs consisted mainly of tri-, tetra- and pentachloro- congeners. Hazen Lake sediments had higher PCB levels than those from Cornwallis Island sites. The PCB congeners profile at Hazen also differed from Cornwallis and Saqvaqjuac with higher proportions of penta- and hexachloro-congeners.

Heavy metals (Pb, Cd and Hg) also showed peak values in recent slices from all sites indicating anthropogenic inputs to the Arctic. Excess metal burdens ranged from 36 mg/m^2 at Saqvaqjuac to 200 mg/m^2 at the two Cornwallis Island sites.

Estimates of fluxes of total PAH, PCBs, DDT and metals are given in Table 1. Fluxes are corrected for focussing of sediments in the profundal zone of the lakes. the focussing correction is relatively well known for ELA and Saqvaqjuac lakes but could only be estimated for the other sites based on ^{210}Pb deposition (e.g. on the Agassiz Glacier). These flux estimates should be regarded as only preliminary. As noted above there are problems interpreting the PAH profile in Hazen Lake. There also have been problems with PCB background contamination in sediment cores (although flux estimates are based on background-substracted results). Recent analysis of a second core from Hazen Lake showed higher PCB and DDT levels which may lead to higher flux estimates.

Table 1. Fluxes of total PAH, PCBs, DDT and (excess) heavy metals calculated from sediment core data from remote lakes in Northwestern Ontario and N.W.T.

Location	Lat. N.	Contaminant ($\mu g/m^2$ yr)[1,2]					
		Pb	Cd	Hg	ΣPAH	ΣPCB	ΣDDT
ELA	49°	6000	130	20	200	0.9	0.6
Saqvaqjuac	63°	2500	60	7.7	5	0.8	0.1
Cornwallis Is.	75°	3500	80	8.0	4	1.0	0.4
Hazen Lake	82°	-	-	-	240	0.9	0.04

[1] Pb, Cd and Hg fluxes are estimates of anthropogenic inputs.
[2] PAH fluxes (minus perylene and retene)

CONCLUSIONS AND FUTURE DIRECTIONS

The results of this project are providing estimates of flux of anthropogenic contaminants over a north-south transect. However additional work needs to be carried out to confirm some of the initial findings. For 1991-92 we plan to collect sediment cores from lakes in the vicinty of Eureka in May to confirm results from Lake Hazen. In future years we propose to examine east-west transects in collaboration with the U.S. EPA (Corvalis) who are obtaining lake sediment cores in Alaska.

PARTNERS:

Cooperation in terms of logistical support by the Polar Continental Shelf Program and by Environment Canada (AES) has been extensive. Collaboration with J. Ford and C. Gubala (U.S. EPA, Corvallis) on contaminants in Alaskan lake sediment cores and lichen.

RESOURCES:

Operating funds (entirely Green Plan):

Budget:	1990/91	1991/92	1992/93	1993/94	1994/95
DFO/DIAND	160 K	130 K	150 K	150 K	110 K

Capital equipment - DFO A-base

Major instruments required - GC-MSD, GC-ECD, AA, Radionuclide counters

REFERENCES

Klaverkamp, J.F., S.L. Leonhard and S.R. Macdonald. 1989. Proceedings of the Workshop on Long Range Transport and Deposition of Organic Contaminants on Aquatic Ecosystems, 14-15 October, Burlington Ont. Can. Tech. Rep. Fish. Aquat. Sci. 1643.

TITLE: C.1.5 BIOCHEMICAL STRESS INDICATORS IN FISH FROM NORTHERN LAKES

PROGRAM LEADER(S): W.L. LOCKHART, DFO C&A

PROJECT TEAM MEMBERS:

B. Billeck, (field collections)
D. Metner, R. Danell, T. Kenney (contractor) biochemical analyses

OBJECTIVES:

1. Determine activities of liver mixed-function oxidase (MFO) enzymes in fish from arctic lakes and rivers as current "benchmark" for comparisons with future arctic data and with data from other locations.

2. Relate enzymatic activities to measures of contaminants with known effects on these enzymes and, where possible, to histories of contaminant inputs from core studies.

3. Relate enzymatic activities to other biological measures of the fish.

DESCRIPTION:

1987-90 progress:

- continuous updating of biochemical methods
- examined MFO activities in fish from several locations where core studies were being done NW Ontario (Experimental Lakes Area), Saqvaqjuac (66°N) and Cornwallis Island (75°N) and from other locations without core histories (Slave river)

1990-91

- collected and analyzed fish from Hazen lake (N. Ellesmere Island) forming a latitudinal transect from 49°N to 82°N for the genus Salvelinus
- collected and analyzed whitefish from Gordon Lake, N.W.T. (113 12 W, 63 10 N)
- obtained and analyzed samples from Canyonek Ck, N.W.T. supplied by DFO Operations, Inuvik

Plans for 1991-92 and subsequent years

- collection of fish from lakes in the vicinity of Eureka in May, 1991, to confirm results from Lake Hazen
- collection of fish from Lake Laberge, Yukon, where high organochlorine residues have been reported

- future directions:
- Nauyuk Lake/Steffanson Island area in 1992 to extend coverage of central arctic islands
- east-west trends samples from Mackenzie delta, Yukon, central N.W.T. and northern Quebec

PARTNERS:

Cooperation in terms of logistical support by the Polar Continental Shelf Program and by Environment Canada (AES) has been extensive. DFO Operations have supplied collections from the Mackenzie Delta. The work is parallel to similar work being started in 1991/92 under PERD project 67269, and to work being done under DIAND's (Yellowknife) Slave river study, and to the planned Canada/Alberta Northern Rivers study.

RESOURCES:

Operating funds (entirely Green Plan):

Budget:	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
DFO/DIAND	76*	100K	100*K	100K	100K	20K

* Includes $26K capital in 1991/92 and 30K in 1993/94
Other capital equipment and staff time from DFO A-base

ARCTIC CONTAMINANTS PROJECT SYNOPSIS

1. TITLE: Contaminant Pathway Modelling of Chlorinated and Non-chlorinated Hydrocarbons in the Mackenzie River and Beaufort Sea Shelf.

2. PRINCIPAL INVESTIGATORS: M.B. Yunker, M.C. Hamilton and D.J. Thomas.

3. OBJECTIVES: To use comprehensive contaminant database generated by the IOS/NOGAP studies to build a model of the natural geochemical pathways of chlorinated and non-chlorinated hydrocarbons on the Beaufort Sea Shelf.

4. CONTRACTOR: Seakem Oceanography Ltd.

5. DESCRIPTION/ACTIVITIES/RESULTS:

The basic concept central to this work is that by using the extensive sample suite of alkane and PAH hydrocarbons and geochemical biomarkers available without further (and expensive) field expeditions, one can delineate the major inputs and transport of contaminants on the Beaufort Sea Shelf and tie this into source/distribution/sink modelling. Once a model is developed for these parameters, it can be applied to other contaminants that behave geochemically in a similar manner in the marine environment, specifically chlorinated and non-chlorinated industrial organic chemicals. Information will also be provided on the flux and budget of each parameter in the Beaufort Sea and the accumulation, transport and sedimentation of natural and anthropogenic contaminants <u>via</u> the marine planktonic community. This is a unique new approach to the problem of contaminant dispersion because it gives simultaneous information on the behaviour of the ecosystems being studied.

The environmental and geochemical parameters employed in the modelling include HCH, PCBs, HCB, DDTs, cyclodienes, toxaphenes, dioxins/furans, alkanes, PAH and alkylated derivatives, hopanes and alcohols/alkenes steroids. The 1987 Beaufort Sea data set of atmospheric samples and

Mackenzie River/Beaufort Sea samples of filtered and sedimented particulates, sediments, peat, ice algae, zooplankton and *in situ* extractions of water form the primary data sources for the study. In addition, organochlorine data from samples of marine mammals from the Beaufort Shelf area are also being used in the model.

The study is on-going. Data have been produced for all samples. Data analysis/modelling is continuing.

The result of the study will be a large verified multi-variate data set. Summary statistics include the mean, standard deviation, range, maximum, minimum, etc., will be prepared for each variable in each class of sample. Data will also be plotted to check for trends and to look for outliers. These procedures will serve the dual purpose of summarizing data for interpretation and publication and highlighting any suspect or invalid data.

To aid in the analysis and interpretation, chlorinated and non-chlorinated hydrocarbon data for the suspended particulates will be merged with the physical data for concurrent water samples. This will include data on depth, salinity, temperature, nutrients, dissolved oxygen, chlorophyll, etc., and possibly on productivity.

Data will be analyzed using Cluster analysis, principal component analysis and partial least squares path modelling. The expected result is that models for the chemical signature of each chlorinated and non-chlorinated hydrocarbon source (Mackenzie River, atmosphere, peat, zooplankton, etc.) will be developed. The contribution of each source to individual Beaufort Sea locations and samples will also be modelled. When all this information is interpreted in terms of the seasonality and productivity of the Beaufort Sea Shelf, the importance of each source to the hydrocarbon geochemistry will be assessed and related to the pathways for the dispersal of contaminants. Ultimately a mass balance for contaminants on the Beaufort Shelf will be possible.

6. EXPECTED PROJECT COMPLETION DATE

September 1991

CONTAMINANTS IN WATERFOWL - NATIVE HARVEST NORTH OF 60°
Status - March 1991

Project Coordinator: Birgit Braune
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ont. K1A 0H3

(819) 953-5959

Collaborators: Indian and Northern Affairs Canada
Health and Welfare Canada

Objectives

To provide a data base on contaminants in waterfowl to Health and Welfare Canada so that the risk to human health of eatimg those waterfowl may be assessed, and so that consumption advisories may be issued, if necessary.

Project Description

As part of the survey of contaminants in wild foods currently being carried out by the Canadian Wildlife Service, the following waterfowl samples were collected from the Northwest and Yukon Territories between 1988 and 1990:

Species	N	Date	Location
Mallard	8	5/88	Lake Laberge, Yukon
Mallard	8	9-10/88	Lake Laberge, Yukon
Pintail	12	5/88	Lake Laberge, Yukon
Lesser Scaup	1	9/88	Yukon River, Yukon
Common Goldeneye	6	10/89	Yukon River, Yukon
Mallard	10	9-10/88	Stagg River, NWT
Common Eider	12	11/88	Sanikiluaq, NWT
Common Eider	8	1/90	Cumberland Sound, NWT
King Eider	11	5/89	Holman Island, NWT
Lesser Snow Geese	10	6/89	Eskimo Point, NWT
Lesser Snow Geese	10	5/89	Tuktoyaktuk, NWT
Canada Geese	10	5-6/90	Spence Bay, NWT
Canada Geese	10	?/90	Sanikiluaq, NWT
Lesser Scaup	10	5/90	near Whitehorse, Yukon
White-winged Scoter	6	5/90	near Whitehorse, Yukon
Surf Scoter	4	5/90	near Whitehorse, Yukon
Surf Scoter	5	6/90	Old Crow, Yukon
White-winged Scoter	7	6/90	Old Crow, Yukon
Lesser Scaup	8	6/90	Old Crow, Yukon
Northern Pintail	5	6/90	Old Crow, Yukon

The samples of breast muscle were analyzed by pools for organochlorines by the Great Lakes Institute, University of Windsor, Ontario, and for metals (Cd, As, Pb, Se, Hg) by Mann Testing Laboratories, Mississauga, Ontario. The following chemicals were not detected in any of the samples analyzed: 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene, pentachlorobenzene, alpha-HCH, gamma-HCH, octachlorostyrene, p,p'-DDT, and photomirex. Results to date may be found in two reports, both entitled "National Survey of Contaminants in Waterfowl - Native Harvest North of 60° -", reports to Indian and Northern Affairs Canada dated August 1990 and March 1991. Those results will be submitted as part of a national data data package to Health and Welfare Canada for evaluation of risk to human health of consumption of waterfowl.

Waterfowl collections from northern native areas will focus on the Nunavik Region of Northern Quebec in 1991 (see 1991 proposal submitted to DIAND entitled "National Survey of Contaminants in Waterfowl - Native Harvest in Nunavik Region, Northern Quebec"). Collections will be made through the Kuujjuak Research Centre, Makivik Corporation. A project proposal requesting financial support for these collections has been submitted to Indian and Northern Affairs. Other possible collections from northern sites in 1991 include Lesser Snow Geese from Eskimo Point, NWT (requested by CWS, Yellowknife), and Greater Snow Geese from Pond Inlet, NWT.

As part of the continuing survey of contaminants in wild foods being conducted by the Canadian Wildlife Service, an intensive survey of waterfowl consumed by native people in the Northwest and Yukon Territories is currently being proposed for 1993-94.

Expected Project Completion Date: Tentatively 1994

Resources Expended to Date

1989-90	$20,000.00	from DIAND
1990-91	$11,000.00	from DIAND

The Canadian Wildlife Service has absorbed all other costs to date.

Dioxins and furans in waterfowl wintering in areas of pulp mill development in British Columbia - Status March 1991

Project Coordinators:

Birgit Braune
Canadian Wildlife Service
National Wildlife Research Centre
Ottawa, Ont. K1A 0H3

Phil Whitehead
Canadian Wildlife Service
Pacific & Yukon Region
Delta, B.C. V4K 3Y3

Collaborators: Indian and Northern Affairs
Health and Welfare Canada

Objectives

To provide Health and Welfare Canada with data on dioxin and furan levels in waterfowl that may have overwintered in areas of pulp mill development so that the risk to human health of eating those waterfowl may be assessed.

Background

In 1989-90, the Canadian Wildlife Service conducted a study to determine levels of environmental contaminants, particularly polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) in selected species of diving ducks wintering in estuaries with pulp mill developments. The study was prompted by data showing that eggs of fish-eating birds, such as herons and cormorants, as well as samples of fish, shellfish and crustaceans collected near kraft pulp mills in British Columbia contained elevated levels of PCDDs and PCDFs. In April of 1989, specimens of Common Merganser, Surf Scoter, Western Grebe, Greater Scaup and Barrow's Goldeneye were collected near the mouth of the Somass River near Port Alberni. The results of that study prompted Health and Welfare Canada to issue an advisory to limit consumption of liver of the Common Merganser, Surf Scoter and Western Grebe in the Port Alberni area of British Columbia.

As many as two thousand waterfowl, including the species collected, spend from 4 to 8 months of the fall and winter in the Somass River estuary (not to mention the numbers of birds wintering in areas of other pulp mill developments). This is enough time to accumulate a substantial body burden of dioxins and furans. In the spring, most birds disperse to breeding areas on inland lakes in the interior of British Columbia, and the Yukon and Northwest Territories.

With the exception of the Western Grebe, all of the species sampled are hunted in British Columbia. Although none of the species are among the main waterfowl species taken in the fall hunt, limited information indicates that native hunters in northern British Columbia and the Yukon Territory hunt scoter, scaup and goldeneye in the spring as the birds return to their breeding grounds.

Project Description

The native people of northern British Columbia and the Yukon Territory hunt and eat various species of waterfowl including scoter, scaup and goldeneye, as the birds return to their breeding grounds in the spring. Waterfowl were sampled from the Whitehorse area (4 species: Lesser Scaup, Barrow's Goldeneye, White-winged Scoter, Surf Scoter) and the Old Crow area (6 species: Northern Pintail, Surf Scoter, White-winged Scoter, Greater Scaup, Lesser Scaup, Common Goldeneye) during end May - early June 1990 order to determine levels of PCDDs and PCDFs in those birds. Since DIAND funding for the project totalled $10,000 (of $25,000 requested), only muscle (instead of both muscle and liver) were analyzed for each of the following 7 species pools:

Date	Location	Species	N
16-25 May 1990	near Whitehorse, Yukon	Lesser Scaup	10
		Barrow's Goldeneye	2
		White-winged Scoter	6
		Surf Scoter	4
1-5 June 1990	near Old Crow, Yukon	Surf Scoter	5
		White-winged Scoter	7
		Lesser Scaup	8

All tissue preparation was carried out at the National Wildlife Research Centre, Hull, Que. Chemical analyses for PCDDs and PCDFs were carried out by a contract laboratory in British Columbia (Zenon of Burnaby, B.C.). Quality Assurance was managed by Dr. Ross Norstrom, CWS, NWRC.

At present, no further projects have been proposed to look at PCDD and PCDF levels in waterfowl north of 60°, although several projects have been proposed by CWS, Pacific and Yukon Region, for 1991-92 to look at waterfowl in areas of pulp and paper mill activity south of 60°.

Expected Project Completion Date: completed 1990 except for evaluation by Health and Welfare Canada

Resources Expended

1990-91	$10,000.00	from DIAND

The Canadian Wildlife Service has absorbed all other costs to date.

Contaminant Trends in Polar Bears

Project Manager:

R. J. Norstrom, Canadian Wildlife Service, DOE

Principal Investigators:

M. Taylor, Dept. of Renewable Resources, GNWT
M. Ramsay, U. of Saskatchewan
I. Stirling, Canadian Wildlife Service, DOE
S. Schliebe, U.S. Fish and Wildlife Service
O. Wiig, Norwegian Polar Institute
E. Born, Greenland Fisheries Research Institute
S. Belikov, All-Union Res. Inst. of Nature Conservation and Reserves, U.S.S.R.

Objectives:

1. Determine circumpolar geographical distribution of persistent organochlorine contaminants in the Polar Bear, and derive source of contamination.

2. Determine 5 year trends in contamination in the Canadian Arctic.

3. Determine exposure of polar bear fetuses and cubs to organochlorine contaminants, and assess the potential effect of these contaminants on reproduction and survival.

Contractor: C. Fraser (laboratory assistance)

Project Description:

Introduction

This project is a followup study to a survey of organochlorine contaminants and heavy metals in Polar bears in the Northwest Territories which was conducted between 1982 and 1984, and a study on the tissue distribution and effect of age on organochlorine bioaccumulation in Polar bears conducted in Hudson Bay in 1985. A proposal for a circumpolar survey of contamination in polar bear fat was approved at a meeting of the International Union on Conservation of Nature Polar Bear Specialists Group in Sochi, USSR in October, 1988. Agreement was reached to obtain samples from Wrangel Island, USSR, the Bering Sea and Arctic Ocean coasts of Alaska, the NWT and Québec in Canada, Greenland and Svalbard. Most of the samples were collected between the autumn of 1989 and the winter of 1990. Approximately 700 samples have been received, mostly from the Northwest Territories. A selection of 265 fat samples from bears shot in the NWT was made to ensure good geographical distribution, and to cut down the number of samples to a manageable size.

To supplement samples obtained from hunted bears, a number of adipose tissue samples were obtained by biopsy from tranquilized bears as part of other research projects in Viscount Melville Sound, Hudson Bay and Svalbard. Milk was also obtained from lactating females in the Canadian studies, and repeat samples (adipose tissue and milk) from the same bear at different seasons are expected.

We developed a new analytical procedure which has greatly increased the accuracy and rate of sample throughput. In the new method, a single fraction is analysed by gas chromatography/mass-selective detector. This decreases the number of injections by a factor of three. For daily instrument calibration we use a diluted extract of a standardized Polar bear fat sample from Hudson Bay, rather than synthetic standards. About 300 samples have been analyzed (see table below).

Completed Analyses

26 fat, Alaska, 1987-89, Dec.-April
30 biopsies, Svalbard, 1990, March-April
23 fat, Coral Harbour, 1989, November-December
13 fat, Coral Harbour, 1990, February-April
13 fat, Cambridge Bay, 1990, March-April
2 fat, Hadley Bay, 1990, May
6 fat, Broughton Island, 1990, January
7 fat, Dorset, 1989, October
9 fat, Clyde, 1990, December-January
6 fat, Resolute, 1990, April
61 biopsies, W. H. Bay,1990, Sept., Female/cub combinations, some males
100 fat, miscellaneous, NWT, 1989-90

296 TOTAL ANALYZED

Analyses Remaining

14 biopsies, same female ca. 6 weeks apart, H. Bay, 1989, Sept.-Oct.
30 biopsies, V. Melville Sound, 1989, May
86 fat samples, all over NWT, 1989-90
49 biopsies, H. Bay, 1990, September
32 milk samples, 1990, September
20 fat samples, Greenland, 1989-90
20 fat samples from Québec - Makivik corporation, 1990

251 TOTAL SAMPLES REMAINING TO BE ANALYZED

Preliminary Results

In the samples analysed to date, average levels of S-DDT and S-PCB increased significantly from Alaska across the NWT to Svalbard. The eastward increase in S-DDT, especially DDE, was steady, whereas S-PCB was more erratic. S-DDT and S-PCB levels were 8-10 times higher in Svalbard bears (0.5 and 20 ppm, respectively) than in bears from the Chukchi Sea on the Alaska coast. There were also significant regional differences in PCB congener patterns that probably relate to different Aroclor sources of PCBs, or to "age" of the contaminant mixture. The Alaska bears contained more of the less chlorinated congeners associated with Aroclor 1242, whereas the Svalbard bears contained more of the highly chlorinated congeners associated with Aroclor 1260. Close to 50% of S-DDT in Hadley Bay and Resolute bears was unchanged DDT, while other areas had lower (and much lower percentage) DDT. S-Chlordane levels were quite uniform, 2-3 ppm in most areas except Resolute and Svalbard, where they were 4-5 ppm.

The more volatile contaminants, S-HCH and S-CBz, had quite different distributions from the other contaminants, and varied significantly in makeup among the areas. Levels of a-HCH decreased from west to east, the opposite trend to PCBs and DDE. The highest levels were found in Bering Sea and Resolute bears. Resolute bears also had a relatively high levels of b-HCH, whereas this isomer was quite low in Bering Sea bears. These findings probably indicate the high relative importance of Asian (and Eurasian?) sources of HCH. HCBz levels were not highly variable, but tended to increase from west to east. TeCBz and PnCBz had a quite different distribution. TeCBz levels were highest in the central high Arctic, mean levels ranging from 0.1-0.2 ppm, and were lower east, west and south of this area. This geographical distribution is similar to that found for TCDD.

Some of the differences among areas may be due to low sample sizes, age distribution in the sample, condition of the bears, different diet, etc., but it is probable that the trends reflect real geographical differences in ecosystem

contamination. If so, the distribution is most consistent with North America as the major origin of S-DDT, and an important source of S-PCB. Asia is probably the dominant source of S-HCH, but there is a possibility of a transpolar (Eurasian source). S-Chlordane and HCBz are quite uniformly distributed compared to the other contaminants.

Utilization of Results

Reanalysis of specimen bank samples in a previous study indicated higher levels in pooled 1969 samples from Hudson and Baffin Bays than in 1984 samples from the same area. One interpretation of this finding is that levels had increased in the arctic marine ecosystem over this period. However, the combined 1984-85 Hudson Bay analyses provided sufficient sample size and age distribution to show that there was a significant negative correlation between PCB and chlordane levels and age. Preliminary evidence suggests that the average age in the 1969 samples was higher, which probably accounts for the lower levels. The present study will determine whether there are any recent trends, and how often a comprehensive survey should be done to follow them.

General hypotheses about the origins of contaminants will be derived from the data. Polar bear fat and liver were previously analysed along with Ringed seal and Beluga blubber for polychlorinated dibenzodioxins and dibenzofurans (PCDDs and PCDFs). The bears and seals had low levels of TCDD and OCDD, whereas the beluga had only traces of TCDF. Highest levels in seals and bears were in the central high Arctic, suggesting an arctic haze (Eurasian) source. The present study indicates that other organochlorines such as b-HCH and TeCBz may also have this origin. Asia seems to be major source of a-HCH, while DDT seems to be clearly North (Central?) American in origin. PCB, HCBz and Chlordane are widespread in the Arctic, and may be coming to some sort of equilibrium, except the North Atlantic remains higher than the other areas.

This study provides an ideal opportunity to study the influence of adipose tissue size and possibly season on the whole-body concentration of organochlorines, since weight and condition indices will be measured. Productivity in Hudson bay bears is being conducted by I. Stirling, which will facilitate risk assessment of organochlorines to polar bears, since reproductive effects and effects on young are more likely to be seen than other consequences of exposure.

The Hudson Bay samples represent a variety of opportunities for testing hypotheses. A sample was taken from a group of females about 6 weeks apart in the autumn of 1989. In 1990, there are biopsy samples of females, their cubs and milk samples. The 1990 study also contains a wide age distribution of females without cubs and males to test differences due to sex and breeding condition as well as age. At this time it is not clear whether some of the 1990 females are the same ones sampled in 1989. The data base will be queried to determine this. Continued annual sampling of bears previously sampled is recommended to allow us to obtain information on temporal trends in individuals.

Continued biopsying of bears previously sampled in Hudson Bay is highly recommended to provide a time-trend for individual bears. Similarly, if any of these bears are later shot by hunters, it would be desirable to obtain a fat sample.

Expected Completion Date: Phase 1: chemical analyses, September, 1991; report, March, 1992.

Resources Expended:

	Person Months	O&M ($'000)
- CWS	18 PM	$75
- Other (DIAND)	-	$35*

*$15K contract for laboratory assistant, $10K to I. Stirling for sample collection in Hudson Bay, $5K to Makivik corporation for sample collection in Ungava, $5K general laboratory supplies.

HUMAN HEALTH

HUMAN HEALTH SESSION

The integration of human health issues into the overall contaminants program has taken a positive direction. It is crucial to continue to work cooperatively to ensure effective research. Representatives of the GNWT pointed out that while they are responsible for health communications, program development and coordination, consultation and cooperative risk management, they can't do this work in isolation. In addition to inter-agency cooperation, cooperative intra-agency work is necessary. For example, in NH&W, different aspects of the problem will be handled by the Health Protection Branch and Medical Services Branch. Many issues will involve both branches - intra-agency communication and cooperation is needed to coordinate this multi-level research.

This process won't be viable without the continuation of a Technical Committee. Perhaps as research continues to expand the committee could be broken down into issue-related groups.

HEALTH INPUTS TO CONTAMINANTS PROGRAM

SECTION A	Input/Sinks - Radionuclides or stable isotopes should be monitored to determine trends.
SECTION B2	Computer Database - Need to include and expand on human health data.
SECTION B3, B4, B5	Contaminant trends in biota - Input is needed from health professionals in study design to ensure it relates to diet. Quality assurance and control are also necessary to ensure use of this data in other programs. A good example of use of data on biota in human health programs is data collected on radionuclides in caribou during the Chenobyl incident.
SECTION B6	Arctic Tissue Bank - Need a specimen bank for human tissues.
SECTION C1	Arctic Ecosystem Stress - There is presently no project to look at biomarkers in humans.
SECTION C3	Human Contaminant Trends
SECTION C4	Contaminant Monitoring/Health Risk Assessment
SECTION C5	Community Involvement and Training - Very important to emphasize. Studies are futile without the necessary participation which can only be ensured through public consultation.
SECTION C6	Centre for Nutrition - Important research and training component.

ISSUES

- Need human biomarker/bioindicator data to measure effects.

- Breast milk issue is very important and we must concentrate on providing feedback and information to people quickly.

- Community involvement, interest and consultation are crucial. We must report back to communities and develop ways of making data understandable. Researchers should enter into "contracts" with the community in the public health area. Risk/benefits consideration is necessary. We must consider dietary information. After providing information to communities, we must help them take action.

- Coordination is complex - have to ensure various agencies continue to cooperate. Need to have data accessible in a database.

- Integrated reporting is cumbersome but necessary to get information out to people.

Synthesis on the Contamination of the Arctic Aquatic Food Chain Project

The project is carried out at the Community Health Department of Le Centre Hospitalier de l'Université Laval (CHUL), Environmental Health Service, under Dr. Éric Dewailly, m.d., Ph.D. The principal investigators are Hélène Careau, G.Dipl., Denis Gauvin, M.Sc. and Anne Vézina, M.Sc. Hydro-Québec is participating in financially supporting this project.

The primary objectives are to:

(1) establish the contamination profile in Northern Québec and Canada;

and (2) identify the areas (type of contaminant, species, geographical zone...) where little information is available.

Description of the project

Through literature review, access to other databases, and collaboration of researchers, information was and is still being gathered on the contamination levels of the aquatic food chain of Arctic Canada, Northern Québec and Greenland. The collected data is stored within a database which uses the 4th Dimension computer package on a Macintosh system. Human and polar bear contaminations are also included within the study since they are top predators and the human aspects are of particular interest to the Community Health Department.

At present, about 10,000 card files have been generated. The database comprises more than 100 different animal species, more than 30 types of tissues and more than 80 contaminants. As a first step, a report of the level of contamination of the aquatic food chain of Northern Québec was prepared. This report elaborated on the data availability and contamination levels for fifteen priority contaminants. The choices of

species and tissues were in perspective of the food habits of native people.

The database will also be utilized in the generation of a report encompassing approximately the same parameters as the previous report, except that it will include every regions defined within the database. This report is expected to be completed for Fall 1991.

Because we understand the endless possibilities of the database system we have created, we are progressively directing our efforts to establish either a partnership or a network to help support its operation on an ongoing basis.

As an extension to this project, we will also proceed to a review of human contamination and native food consumption in the Arctic. It will establish a profile of human contamination and estimate dietary intake in native populations living in the Arctic. Harvest data and diet surveys are used to identify the animal species (part of the aquatic food chain) which are most commonly eaten by native populations

Resources Expended

Aside from the basic support of the Community Health Department of the CHUL, Hydro-Québec is the only funding source. The budget for the total project for the years 89/90 and 90/91 is amounting to an approximate total of $ 200,000. Any project of keeping the database going on a permanent basis will have to include the means of financial support.

HUMAN CONTAMINANT TRENDS IN THE NWT

This study is identified as project C3 in DIAND's five year Northern Contaminants Research Program.

PROJECT MANAGEMENT:

Lead Agency: GNWT Health; J.B. Walker (principal), F.I. Gilchrist.

Supporting Agencies: MSB, HPB, DRR, GLHEP, KATIVIK RHB, ITC, AFN, DIAND, NCC.

PROJECT OBJECTIVES:

1. To assess the exposure of Territorial residents to selected organochlorine, heavy metal, and radionuclide contaminants in representative areas of the N.W.T., through a sample of persons voluntarily participating.

2. To establish current levels of body burdens of these contaminants, which will contribute to baseline.

3. To investigate effects of exposure, using existing assessment methodologies, or developing new methodologies appropriate to the NWT.

4. To provide an indication of the geodemographic distribution of these contaminants in the N.W.T.

5. To contribute to the national and international database of comparable human health and contaminants data, by participating in the development of inter-project 'harmonization' and other information exchange. This will enable comparison of data from the N.W.T. with that from other populations, such as the Province of Quebec, those around the Great Lakes, and other circumpolar countries.

6. To identify and prioritize, in collaboration with aboriginal organizations and others, further objectives for human health/contaminants issues following on the baseline determinations.

POLICY OBJECTIVES:

This study supports policy objectives # 2,3,5 and 6.

PROJECT DESCRIPTION

Early work by Kinloch, Kuhnlein, Muir et al, has demonstrated significant contaminant levels in some individuals in a small high northern community, and has projected population body burdens on the basis of dietary consumption patterns. Studies by Dewailly and Nantel in a Quebec aboriginal population have shown elevated breast milk contaminant levels. Work by the Jacobson group in the Great Lakes area has indicated food-to-mother-to-infant contaminant transmission, and that these low-dose human exposures may affect the development of exposed children, and may be persistent.

Both as a follow up to this work, and with a view to obtaining much better clarity as to the general distribution of contaminant loads across Arctic populations, this study provides a straightforward potential for the determination of both geographic and temporal trends, as well as for the investigation of effects.

It is anticipated that the public education/information exchange and consultation components of this study will extend for the duration of the project. The preparatory phase of the study has begun; sample analyses should be completed by the middle of fiscal year 1995/96, with data interpretation, risk assessment and the final report completed by the end of 1997. These projections assume resources will be available early in fiscal year 1991/92.

Activities to date include completion of a literature review and critique to identify data gaps in the northern ecosystem literature regarding contaminants, including human health; and the development of a network with others, both nationally and internationally, investigating human health/contaminant issues, including in Canada, the Dene Nation/Assembly of First Nations, the Inuit Circumpolar Conference, the Inuit Tapirisat of Canada, Inuvialuit Regional Development Corporation, the Health Protection Branch and the Medical Services Branch of Health and Welfare Canada, Indian and Northern Affairs Canada, and several universities.

APPENDIX I

LIST OF PARTICIPANTS

Name	Agency
Richard Addison	Department of Fisheries and Oceans
Rod Allan	Inland Waters Directorate/DOE
Garth Bangay	Department of Indian Affairs and Northern Development
Leonard Barrie	Atmospheric Environment Service/DOE
Hélène Careau	Centre Hospitalier de l'Université Laval
John Carey	Inland Waters Directorate/DOE
Ralph Daley	Inland Waters Directorate/DOE
Eric Dewailly	Centre Hospitalier de l'Université Laval
Miriam Diamond	University of Toronto
Nancy Doubleday	Inuit Circumpolar Conference
Roy Erasmus	Assembly of First Nations
Jesse Ford	U.S. Environmental Protection Agency/Corvallis Oregan
Andy Gilman	National Health and Welfare
Brian Grey	Department of Indian Affairs and Northern Development
John Headley	Inland Waters Directorate/DOE
Brendan Hickie	Department of Fisheries and Oceans
Dean Jeffries	Inland Waters Directorate/DOE
Jill Jensen	Department of Indian Affairs and Northern Development
Jill Kearney	National Health and Welfare
Margie Koster	Canadian Wildlife Service
Lyle Lockhart	Department of Fisheries and Oceans
Hans Martin	Atmospheric Environment Service/DOE
Chris Metcalfe	Trent University
Steve Matthews	Government of N.W.T./Renewable Resources
Carole Mills	Assembly of First Nations
Laurie Montour	Assembly of First Nations
Derek Muir	Department of Fisheries and Oceans
Evert Nieboer	McMaster University
Ross Norstrom	Canadian Wildlife Service
Jerry Payne	Department of Fisheries and Oceans
Terry Prowse	Inland Waters Directorate
John Salminen	National Health and Welfare
Russel Shearer	Department of Indian Affairs and Northern Development
David Stone	Department of Indian Affairs and Northern Development

Name	Agency
Dave Thomas	Seakem Oceanography Ltd.
Anne Vézina	Centre Hospitalier de l'Université Laval
Eva Voldner	Atmospheric Environment Service/DOE
Rudolph Wagemann	Department of Fisheries and Oceans
Jody Walker	Government of N.W.T./Health
Frank Wania	University of Toronto
Mike Weis	University of Windsor
Brian Wheatley	National Health and Welfare

APPENDIX II
WORKSHOP AGENDA

WORKSHOP ON NORTHERN CONTAMINANTS RESEARCH AND MONITORING

Canadian Centre for Inland Waters
Burlington, Ontario

WORKSHOP AGENDA

Day 1 - April 3, 1991

09:30 - Coffee
09:45 - Introduction

- Welcome	Garth Bangay/Ralph Daley
- Housekeeping	Dennis Gregor
- Background/ Objectives	Garth Bangay

10:00 - 12:30 - Sources, Sinks and Pathways

1.	Global Inventory of the Use and Emissions of Agriculture Organics	D. Gregor, IWD and E. Voldner, AES
2.	Chemical Transport Modelling	L. Barrie and E. Voldner, AES
3.	Atmospheric Contaminants Monitoring	L. Barrie, AES
4.	Organochlorines and Atmosphere/ Snow Interaction at Agassiz Ice Cap and Resolute Bay	D. Gregor IWD
5.	Organochlorines in Snow and Glacial Ice-NWT Monitoring Network	D. Gregor IWD
6.	USA/USSR Cruise 1990- Organochlorine Sampling-Bering Strait Transect	D. Thomas Seakem Oceangraphy Ltd.

7.	Overview and Future Activities	Chairman - D. Gregor Rapporteur - L. Barrie

12:30 - Lunch
13:30 - 15:00 - Ecosystems Uptake and Health Effects

8.	Organochlorines and Metals in Northern Quebec Marine Mammals and Fish	D. Muir DFO
9.	Lead and Other Metals in Ringed Seal and Walrus	R. Wagemann DFO
10.	Circumpolar Survey of PCBs in Beluga	D. Muir DFO
11.	Temporal Trends in Organochlorines in Arctic Ringed Seals	R. Addison

15:00 - Coffee
15:20 - 17:00 - Ecosystems Uptake and Health Effects (continued)

12.	Transfer of Organochlorines to the Food Chain in the Arctic Ocean	B. Hargrave DFO
13.	Co-planar PCBs in Broughton Island Dietary Samples	D. Muir DFO
14.	DNA Adducts in Arctic Marine Mammals	J. Payne DFO

15. Organochlorines and PAHs in Fish from Northern Remote Lakes — D. Muir/L. Lockhart, DFO

17:30 - 19:30 - Reception - Venture Inn
Nelson III Room
Hosted by National Water Research Institute

Day 2 - April 4, 1991

08:15 - Coffee
08:30 - 10:00 - Ecosystems Uptake and Health Effects (continued)

16. Study of Temporal Trends of Metals and Organics in the Arctic from Lake Sediment Records — G. Brunskill, DFO

17. Biochemical Stress Indicators in Fish from Northern Lakes — L. Lockhart, DFO

18. Contaminant Pathway Modelling in Mackenzie River and Beaufort Sea — D. Thomas, Seakem Oceanography Ltd.

10:00 - Coffee
10:30 - 12:30 - Ecosystems Uptake and Health Effects

19. U.S. Arctic Contaminants Program — J. Ford, U.S. EPA

20. Contaminants in Waterfowl-Native Harvest North of 60° — R. Norstrom, CWS

21.	Dioxins and Furans in Waterfowl Wintering in Areas of Pulp Mill Developments	R. Norstrom CWS
22.	Contaminant Trends in Polar Bears	R. Norstrom CWS
23.	Overview and Future Activities	Chairman - D. Muir Rapporteur - D. Thomas

12:30 - Lunch
13:30 - 15:00 - Human Health

24.	A review of native food consumption and human contamination in the Arctic.	A. Vezina Community Health Department - Quebec
25.	Computerized Northern Contaminants Database	H. Carreaux Community Health Department Quebec
26.	Preliminary results on human milk contamination by organochlorines in the Kativik region (1990-1991)	E. Dewailly Community Health Department Quebec
27.	Human Contaminants Trends in the N.W.T.	J. Walker GNWT
28.	Protocol on Community Based Research/Community Wildlife and Health Concerns	N. Doubleday ICC