National Environmental Research Institute
Ministry of the Environment · Denmark

Contaminants in the traditional Greenland diet

NERI Tehnical Report, No. 492

[Blank page]

National Environmental Research Institute
Ministry of the Environment · Denmark

Contaminants in the traditional Greenland diet

NERI Tehnical Report, No. 492
2004

Poul Johansen[1]
Derek Muir[2]
Gert Asmund[1]
Frank Riget[1]

[1]National Environmental Research Institute
[2]Environment Canada

Data sheet

Title: Contaminants in the traditional Greenland diet

Authors: Poul Johansen[1], Derek Muir[2], Gert Asmund[1] & Frank Riget[1]
Departments: [1]National Environmental Research Institute, Department of Arctic Environment
[2]Environment Canada, National Water Research Institute

Serial title and no.: NERI Technical Report No. 492

Publisher: National Environmental Research Institute ©
Ministry of the Environment
URL: http://www.dmu.dk

Date of publication: May 2004
Editing complete: April 2004

Referee: Jesper Madsen

Financial support: The present project has been funded by the Danish Environmental Protection Agency as part of the environmental support program DANCEA – Danish Cooperation for Environment in the Arctic. The authors are solely responsible for all results and conclusions presented in the report, and do not necessarily reflect the position of the Danish Environmental Protection Agency.

DANCEA
Danish Cooperation for Environment in the Arctic
Ministry of the Environment

Please cite as: Johansen, P., Muir, D., Asmund, G. & Riget, F. 2004. Contaminants in the traditional Greenland diet. National Environmental Research Institute, Denmark. 74 pp –NERI Technical Report No. 492. http://technical-reports.dmu.dk

Abstract: This report presents and assesses contaminant concentrations in traditional human diet in Greenland. Our study has mainly included cadmium, mercury, selenium, polychlorinated biphenyls (PCB), dichlorophenyltrichloroethane (DDT), chlordane, hexachlorocyclohexanes (HCH), chlorobenzenes, dieldrin and toxaphene in the major animal species and tissues consumed by Greenlanders. A subset of samples was also analyzed for coplanar PCBs, brominated diphenyl ethers, short chain chlorinated paraffins and butyltins. In general contaminant levels are very low in terrestrial species and in muscle tissue of many marine species. High organochlorine concentrations are typically found in blubber of marine mammals and high metal levels in seabird liver and in liver and kidney of seals and whales. Except for cadmium, contaminant levels in the Greenland environment, including diet items, are lower than in more densely populated and industrialized regions of the Northern Hemisphere.

Keywords: Greenland, diet, contaminants, heavy metals, organochlorines

Layout: Hanne Kjellerup Hansen
Drawings: Grafisk værksted, Silkeborg
Cover Photo: Rune Dietz. Greenland girl eating a seabird.

ISBN: 87-7772-811-4
ISSN (electronic): 1600-0048

Number of pages: 74

Internet-version: The report is available only in elctronic format from NERI's homepage
http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR492.pdf

For sale at: Ministry of the Environment
Frontlinien
Rentemestervej 8
DK-2400 Copenhagen NV
Denmark
Tel.: + 45 70 12 02 11
frontlinien@frontlinien.dk

Contents

[Blank page]

Dansk resume

Mennesker i Grønland er i højere grad eksponeret for kontaminanter (forurenende stoffer) gennem kosten end mennesker i Europa og Nordamerika. Det skyldes, at traditionelle marine kostemner (fisk, fugle, sæler og hvaler) er af langt større betydning i den grønlandske kost samtidig med, at nogle kostemner indeholder store mængder af kontaminanter.

Tidligere fandtes en vis viden om denne problemstilling, men først i 1999 blev der iværksat en systematisk undersøgelse af forekomsten af kontaminanter i den traditionelle grønlandske kost. Denne rapport præsenterer resultaterne af undersøgelsen, som omfattede de vigtigste kostemner, hovedsagelig udvalgt på basis af kostundersøgelser i byer og bygder i det centrale Vestgrønland. Undersøgelsen har primært omfattet tungmetallerne cadmium, kviksølv og selen samt de såkaldte POP'er, (polychlorerede biphenyler (PCB), dichlorophenyltrichloroethan (DDT), chlordaner, hexachlorocyclohexaner (HCH), chlorobenzener, dieldrin og toxafen) i de vigtigste dyrearter og væv, som spises i Grønland. Et mindre udvalg af prøver blev også analyseret for coplanare PCB'er, bromerede flammehæmmere (BPDE), kortkædede chlorerede paraffiner (SCCP) og butyltin (TBT).

Undersøgelsen viser, at niveauerne af kontaminanter generelt er meget lave i terrestriske arter samt i kød fra mange marine arter. Høje POP niveauer findes typisk i spæk fra havpattedyr og høje tungmetalniveauer i havfuglelever samt lever og nyre fra sæler og hvaler.

En undersøgelse af grønlænderes indtag af kontaminanter peger på sælkød, sællever, sælnyre, sælspæk og hvalspæk som de dominerende kilder. Kontaminantniveauet i lever fra hellefisk, krabbe, kongeederfugl, ride, hvidhval og narhval samt i nyre fra hvidhval og narhval er også højt men var, bortset fra toxafen i hellefiskelever, ikke en væsentlig kilde i denne undersøgelse, fordi indtaget af dem var lavt.

Kontaminantniveauet i det grønlandske miljø, inklusiv traditionelle kostemner, er generelt lavt sammenlignet med tættere befolkede og industrialiserede områder på den nordlige halvkugle. Denne geografiske forskel er meget udtalt for PCB, DDT, dieldrin, chlordan, total toxafen, TBT, PBDE og SCCP, og i de fleste tilfælde er kviksølvniveauerne også lavere i Grønland. For HCH og HCB ser der ikke ud til at være geografiske forskelle. Derimod er cadmiumniveauet tydeligt højere i organismer fra Grønland end fra tempererede europæiske områder.

Cadmium- og kviksølvkoncentrationerne i denne undersøgelse er i de fleste tilfælde på samme niveau som i andre arktiske områder. Det er tilfældet for alle terrestriske arter og væv. For marine invertebrater og fisk er variationerne større, men der er ikke nogen entydige geografiske forskelle. POP-niveauerne i de terrestriske arter ser i de fleste tilfælde ud til at være lavere i Grønland end i andre arktiske områder, mens der ikke er tydelige forskelle i de marine arter.

Kalaallisut eqikkaaneq

Kalaallit Nunaanni inuit Europami Amerikamilu avannarlermi inunnit nerisamikkut mingutsitsinermit eqqugaaqqajaanerusarput (akoorutissat mingutsitsissutaasut) pissutigalugit. Tamatumunnga pissutaavoq nerisassat imarmiut nalinginnaanerusut (aalisakkat, timmissat, puisit arferillu) kalaallit nerisaanni pingaaruteqarneruneranut tamatumalu peqatigisaanik nerisassat akuutissanik mingutsitaangaatsiarsimasarlutik.

Siusinnerusukkut ajornartorsiut taanna pillugu ilisimasaqartoqarsimavoq, kalaallilli nerisaanni nalinginnaasuni akuutissanik mingutsitsissutaasunik aaqqissuussaasumik aatsaat 1999-imi misissuisoqalerpoq. Misissuinermi nerisat pingaarnerpaat, Kitaata qeqqani illoqarfinni nunaqarfinnilu nerisat pillugit misissuinernik tunngaveqarnerusut, misissuiffigineqarput. Misissuinermi pingaarnertut paasiniarneqartut tassaapput aatsitassat arrortikkuminaatsut cadmium, kviksølv aamma selen kiisalu POP-inik taaneqartartut, tassunga ilanngullugit polychlorerede biphenyler (PCB), dichlorophenyltrichloroethan (DDT), chlordaner, hexachlorocyclohexaner (HCH), chlorobenzener, dieldrin aamma toxaphen uumasuni pingaarnerni ipiutaasartanilu Kalaallit Nunaanni nerisarineqartuni nassaassaasut. Misissugassatut tigusat annikitsut aamma PCB-nik coplanariusunik, ikuallannaveersakkanik bromitikkanik (BPDE), paraffininik chloritalinnik naatsunik sananeqaatilinnik (SCCP) aamma butyltininik (TBT) akoqarnerinik misissuiffigineqarput.

Misissuinermi takutinneqarpoq uumasuni nunamiuni kiisalu imarmiorpassuit neqaanni mingutsitsineq nalinginnaasumik appasissorujussuusoq. POP-it qaffasissut pingaartumik miluumasut imarmiut orsuini kiisalu aatsitassat arrortikkuminaatsut timmissat imarmiut tinguini kiisalu puisit arferillu tinguini tartuinilu nassaassaapput.

Kalaallit mingutsinneqarsimasunik iisaannik misissuinermi aallaavittut pingaarnertut tikkuarneqartut tassaapput puisit neqaat, puisit tingui, puisi orsui kiisalu arferit orsui. Qalerallit, saattuat, mitit siorakitsut, taateraat, qilalukkat qaqortat qernertallu tinguini mingutsinneqarsimanera aamma qaffasippoq, qalerallilli tinguini toxafen eqqaassanngikkaanni misissuinermi mingutsitaanermut aallaavittut pingaaruteqarnatik, taakkua nerisarineqartarnerat appasippallaarmat.

Kalaallit Nunaanni avatangiisini mingutsitsisimaneq, nerisat nalinginnaasut ilanngullugit, qaffasissusaa nunarsuup affaani avannarlermi inoqarfiunerusunut suliffissuaqarfiunerusunullu sanilliullugu nalinginnaasumik appasippoq. Nunat sumiinnerat apeqqutaatillugu assigiinngissummi tassani PCB, DDT, dieldrin, chlordan, total toxafen, TBT, PBDE aamma SCCP appasissorujussuupput, amerlanertigullu kviksølvitaqassuseq Kalaallit Nunaanni aamma appasinnerulluni. HCH aamma HCB eqqarsaatigalugit nunat sumiinnerat eqqarsaatigalugu assigiinngissuseqartoqanngilaq. Akerlianik Kalaallit Nunaanni uumassusilinni cadmiumeqassuseq Europami nunanut kiannerusuniittunut sanilliullugu malunnartumik qaffasinneruvoq.

Misissuinermi tassani cadmiumip kviksølvillu annertussusaat nunani issittuni allanisulli amerlanertigut qaffasitsigiinnarput. Tamanna nunami uumasunut tamanut ipiutaasartanullu atuuppoq. Uumasuni qimerloqanngitsuni imarmiuni aalisakkanilu allanngorarneq annertuneruvoq, kisianni nunat sumiiffiini assigiinngissutsinik erseqqissunik soqanngilaq. Nunanut issittuniittunut allanut sanilliullugu Kalaallit Nunaanni uumasuni nunamiuni POP-it qaffasissussaat amerlanertigut appasinnerorpasipput, uumasunili imarmiuni erseqqissumik assigiinngissuteqarnatik.

Summary

People in Greenland are more exposed to contaminants from their diet than people in Europe and North America. The cause is that marine traditional food items (fish, seabirds, seals and whales) are much more important in the diet in Greenland, and that at the same time some of these food items contain high levels of contaminants.

Before 2000, some knowledge of contaminant concentrations in the diet of Greenlanders was available, but a study to systematically survey the traditional diet was not initiated until 1999. This study was designed to cover the most important diet items, based mainly on dietary studies conducted in towns and settlements in Central West Greenland. This report presents the contaminant data of the study. Our study has mainly included cadmium, mercury, selenium, polychlorinated biphenyls (PCB), dichlorophenyltrichloroethane (DDT), chlordane, hexachlorocyclohexanes (HCH), chlorobenzenes, dieldrin and toxaphene in the major animal species and tissues consumed by Greenlanders. A subset of samples was also analyzed for coplanar PCBs, brominated diphenyl ethers, short chain chlorinated paraffins and butyltins.

In general contaminant levels are very low in terrestrial species and in muscle tissue of many marine species. High organochlorine concentrations are typically found in blubber of marine mammals and high metal levels in seabird liver and in liver and kidney of seals and whales.

An evaluation of contaminant intake by Greenlanders points to seal muscle, seal liver, seal kidney, seal blubber and whale blubber as the dominant contributors of contaminants in the traditional diet. Levels in liver from Greenland halibut, snow crab, king eider, kittiwake, beluga and narwhal and kidney of beluga and narwhal are also high but were, with the exception of toxaphene in Greenland halibut liver, not important sources in this study, because they were eaten in low quantities.

In general, contaminant levels in the Greenland environment, including diet items, are lower than in more densely populated and industrialized regions of the Northern Hemisphere. This geographical difference is very pronounced for PCB, coplanar PCBs, DDT, dieldrin, chlordane, total toxaphene, butyl tins, PBDEs and SCCPs, and in most cases mercury levels are also lower in Greenland. For HCH and HCB there appear to be no geographical differences. In contrast, cadmium concentrations are much higher in biota from Greenland than from temperate European marine environments.

In most cases the levels of cadmium and mercury found in this study fall within the range observed in other Arctic regions. This is the case for all the terrestrial species and tissues. For marine invertebrates and fish there are larger variations, but geographical differences are not consistent. In the terrestrial species, organochlorine levels in Greenland in most cases appear to be lower than found elsewhere in the Arctic, while organochlorine levels in the marine species in most cases are within the range of levels found elsewhere in the Arctic.

1 Introduction

People in Greenland are more exposed to contaminants from their diet than people in Europe and North America. The cause is that marine traditional food items (fish, seabirds, seals and whales) are much more important in Greenland, and that at the same time some of these food items contain high levels of contaminants, i.e. metals like mercury and cadmium and organochlorines like PCBs. Within the Arctic, Greenlanders have the highest concentrations of mercury and most organochlorines (Hansen 1998, Van Oostdam & Trembley 2003), and estimated intakes of mercury and cadmium exceed "acceptable or tolerable intakes" (Johansen et al. 2000).

Before 2000, some knowledge of contaminant concentrations in the diet of Greenlanders was available, but a study to systematically survey the traditional diet was not initiated until 1999. This study was designed to cover the most important diet items, based mainly on dietary studies conducted in towns and settlements in Central West Greenland in 1995-96 (Pars 2000, Pars et al. 2001). Appendix 1 shows the list of species and tissues identified to be significant as local diet items. The focus has been on West Greenland, which is the most densely populated part of Greenland. However, during the conductance of the study it was decided to include local diet samples from Ittoqqortoormiit (Scoresbysund) in East Greenland, as this region has the highest organochlorine concentrations in Greenland (Cleeman et al. 2000a, Riget et al. 2004).

An assessment of the significance to human exposure to contaminants of the different diet items has been presented by Johansen et al. (2004b). This report presents the contaminant data from the study. In this study chemical groups analyzed include cadmium, mercury, selenium, PCB, DDT, chlordanes, toxaphene, HCH, chlorobenzenes, mirex, octachlorostyrene and endosulfan. A subset of the samples was also analyzed for coplanar PCBs, brominated diphenyl ethers, short chain chlorinated paraffins and butyltins. Some of the Greenland contaminant data used in this assessment have been published by Dietz et al. (1996) and by Johansen et al. (2003). Prior to 1999 only few analyses for organochlorines had been conducted in Greenland. We have not included these in this paper, because only few are important to human diet, and because some of the older data cannot be compared to the data obtained in the diet study initiated in 1999. Lead is not included in this study either, since lead concentrations in traditional dietary items normally are very low (Dietz et al. 1996). However, recent studies have documented that meat from birds hunted with lead shot are contaminated with lead and that in some cases the lead intake by Greenland bird eaters can exceed the tolerable daily intake (Johansen et al. 2001, 2004a).

[Blank page]

2 Methods

2.1 Study design

We designed a matrix of animal species and tissues to be included in the study (Appendix 1) based on the dietary survey by Pars (2000). Species, tissues and sample numbers were selected according to their importance as diet items. For example, more muscle than liver samples were included, because muscle is more important than liver, and more samples from thick-billed murre (Brünnich's guillemot) than from kittiwake, reflecting that murre is more important in the diet than kittiwake. At least 5 individuals, but up to 20 were analyzed, depending on the importance of the species to the diet.

Since some contaminant analyses had been conducted before the diet study was initiated, we identified data gaps, and based on this an analytical program was designed. Most samples are from Central West Greenland, mainly between Qaqortoq (60° N - 45° W) in the south to Qeqertarsuaq (69° N - 54° W) in the north. Many samples were collected in important areas and seasons for hunting. For example, samples from seabirds were obtained from hunting during winter in Nuuk as the most important region for hunting seabirds when they winter off Southwest Greenland. In this way samples are considered representative of the hunt and thereby of the human exposure to contaminants in the tissues and species in question.

2.2 Samples

Sampling was carried out during four years, 1998-2001. Most samples were collected as part of other research programs, i.e. samples of

- ringed seal, hare, spotted wolffish, snow crab, blue mussel, Iceland scallop and the East Greenland samples were collected by NERI, particularly in connection with AMAP studies
- redfish, Atlantic cod, Greenland cod, Greenland halibut, shrimp, harp seal and minke whale were collected by the Greenland Institute of Natural Resources in connection with several of their studies
- muskox, thick-billed murre, common eider, king eider, kittiwake, ptarmigan, capelin, Atlantic salmon and Arctic char were collected by (or organized by) the Directorate of Environment and Nature of the Greenland Home Rule
- caribou, sheep and berries were collected by the Department of Population Ecology, University of Copenhagen in connection with a Ph.D. study.

Sampling was by and large carried out according to the plan (Appendix 1). However, we did not succeed in getting samples from hooded seal, walrus and fin whale from West Greenland, in spite of a large effort to get these in cooperation with the Greenland Institute of Natural Resources. Appendix 2 gives an overview of the sampling carried out.

Some animals (birds and most fish) were sent frozen whole to the laboratory of NERI, where they were thawed. Biological parameters (like sex and size) were recorded and tissue samples were taken for chemical analysis. In other cases (invertebrates, some fish, caribou, muskox, seals and whales) biological parameters were recorded and tissue samples collected in Greenland. These samples were then sent frozen to the laboratory of NERI, where they were thawed and tissue samples were taken for chemical analysis. These samples were cut out from the inner part of the sample so that possible contamination of the outer exposed part caused by handling and storage was avoided.

Samples for chemical analysis were either stored to be analyzed later or prepared for analyses directly (only metals, see section 2.3). Stored samples to be analyzed for organochlorines were kept in glass jars rinsed with hexane and with the lid protected with aluminum foil and shipped frozen from NERI to the National Water Research Institute (NWRI) by airfreight or as personal luggage. At NERI or NWRI, all frozen samples were stored at –20° C in freezers equipped with monitored alarm systems.

2.3 Analytical methods and quality assurance - metals

The Department of Arctic Environment, NERI, analyzed cadmium, mercury and selenium. Approximately 1 g fresh or 300 mg dried sample and 4 ml concentrated Merck Suprapur nitric acid were added to Teflon bombs with stainless steel caps, which were then heated for 12 hours at 140° C. After cooling the dissolved samples were left uncovered until the majority of the nitrous oxides had evaporated. If nitrous oxides remain in the solutions, it is necessary to add more potassium permanganate solution in order to obtain the permanent pink color necessary to obtain reliable mercury results. The samples were then diluted in polyethylene bottles with milli Q water to approximately 25 g.

Cd

High concentrations of Cd (> 25 µg/L) were determined by conventional flame atomic absorption spectroscopy with a Perkin Elmer model Aanalyst 300 spectrophotometer using an acetylene and air flame. The apparatus was calibrated using single element commercial standards (Titrisol) in diluted nitric acid of the same strength as the samples. A Perkin Elmer Zeemann graphite tube AAS was used for the analysis of low cadmium concentrations. The recommended matrix modifiers and analytical details were those generally recommended by the manufacturer (Perkin Elmer 1991).

Hg and Se

These volatile elements were determined following reduction with sodium borohydride in a flow injection system. A dedicated instrument "Perkin Elmer FIMS" was used for mercury, whilst for selenium this instrument was coupled to the flame instrument (Aanalyst 300) with a heated quarts tube (900° C) mounted in the light path. Before analyzing for Hg, a potassium permanganate solution was added until a permanent pink color was obtained in order to maintain an oxidizing environment and prevent loss of Hg.

Quality assurance

Certified reference materials, duplicate samples and blanks were analyzed in parallel with samples. In practice two sample blanks (Teflon bomb with only nitric acid), two duplicate samples and one certified reference material were included in each batch. A batch was composed of a maximum of 26 Teflon bombs. If the blank values were higher than normally obtained by the laboratory, or if the results of analyzing the certified reference materials were incorrect (outside the control limits of the control charts), the entire batch was discarded. Subsequently the source of the error (usually a contaminated chemical) was traced, and new Teflon bomb dissolutions were made.

The reference materials most often used were DOLT-1, DOLT-2, DORM-1, DORM-2, TORT-2, PACS and MESS from the National Research Council of Canada, bovine liver 1577a from NIST (National Institute of Standards and Technology, Gaithersburg MD; http://ois.nist.gov/srmcatalog) and sewage sludge sample No. 144 from the Community Bureau of Reference of the EU (BCR).

As described above all laboratories regularly analyzed control samples in order to assess the reproducibility of the data produced. Participation in intercomparison exercises using samples of unknown concentration is however the most reliable measure of a laboratory's capabilities, and the results obtained by the laboratories in a number of intercomparison exercises are listed below.

Intercomparison exercises

The QUASIMEME laboratory performance studies included analyses of trace elements and organochlorines in sediments and biota. As described earlier, sample materials had been tested for homogenity and stability, and robust statistics applied to the data returned so as to determine assigned values. QUASIMEME also stipulated a maximum allowable error for data (Wells & Cofino 1997). In the absence of any clear guidelines from the European Marine Monitoring Programs prior to 1993, QUASIMEME stated the minimum criteria to be that a laboratory should be able to distinguish between two samples, which differed by 50 % in concentration with 95 % confidence. This meant, that the maximum allowable standard deviation (s) of the single laboratory was 12.5 %. For an easy assessment of the results a Z-score was defined:

Z = (deviation from assigned value) / (max. allowable standard deviation).

For a laboratory producing satisfactory results, 95 % of the measurements of an intercomparison exercise should be within the assigned value ±25 % ($|Z| < 2$), 5 % could differ up to ±37.5 % ($2 < |Z| < 3$) and 0.3 % could be accepted even though outside these limits ($|Z| > 3$).

In 1996, QUASIMEME modified these objectives, recognizing that the relative analytical error increased as the analytical results approached the detection limits of the methods used. A new allowable error or assigned error (E_T%) was calculated including both a relative (E_p%) and a constant error (E_c), depending on both the detection limit and the assigned value ([C]) for each compound:

$$E_T\% = E_p\% + 0.5(E_c/[C])100$$

The definition of acceptable results was changed using the Z-score and replacing the maximum allowable standard deviation of 12.5 % with the assigned error. When an assigned error reaches 50 % the assigned value is regarded as indicative value only and no Z-score is calculated (Wells & Cofino 1997). For CBs and organochlorine pesticides, for example, E_p% was defined as 12.5% and E_c as 0.10 µg kg^{-1}. An assigned value of 0.13 µg kg^{-1} then yields an assigned error of 50%.

The results of the laboratory performance studies performed by NERI are seen in Figure 1, 2 and 3. The relative deviation (%) is calculated as the deviation relative to the assigned values. For exercises where no assigned value could be set, indicative values are also plotted. The figures represent *all* reported results and should therefore reflect the true uncertainty of the analyses.

Figure 1 shows the results of cadmium analyses of the QUASIMEME biota samples. 95 % of the relative deviations can be confined to the diagram area between the curves composed of a constant error (detection limit) of 0.005 mg/kg and a relative proportional error of 25 %, the lines in Figure 1. The DANAK accreditation of the laboratory implies a constant error of 0.005 mg/kg and a relative proportional error of 23 %.

Figure 1 The relative deviation of cadmium analyses from the assigned values of QUASIMEME plotted against the assigned values.

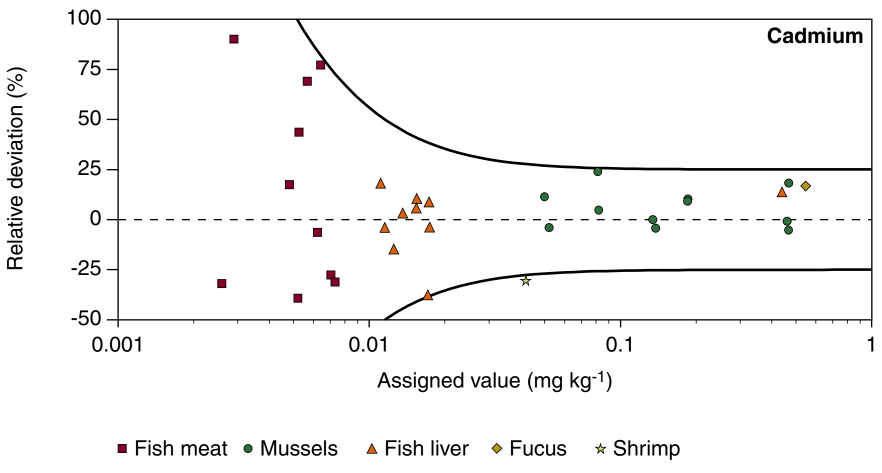


Figure 2 shows the results of mercury analyses of the QUASIMEME biota samples. 95 % of the relative deviations can be confined to the diagram area between the curves composed of a constant error (detection limit) of 0.005 mg/kg and a relative proportional error of 12 %, the lines in Figure 2. The DANAK accreditation of the laboratory implies a constant error of 0.01 mg/kg and a relative proportional error of 12.5 %.

Figure 2 The relative deviation of mercury analyses from the assigned values of QUASIMEME and Mercury Quality Assurance Program of Canadian Food Inspection Agency, plotted against the assigned values.

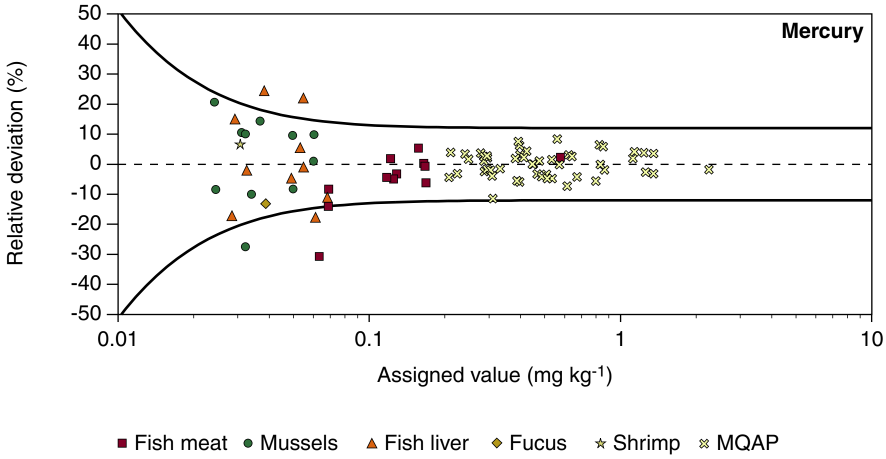
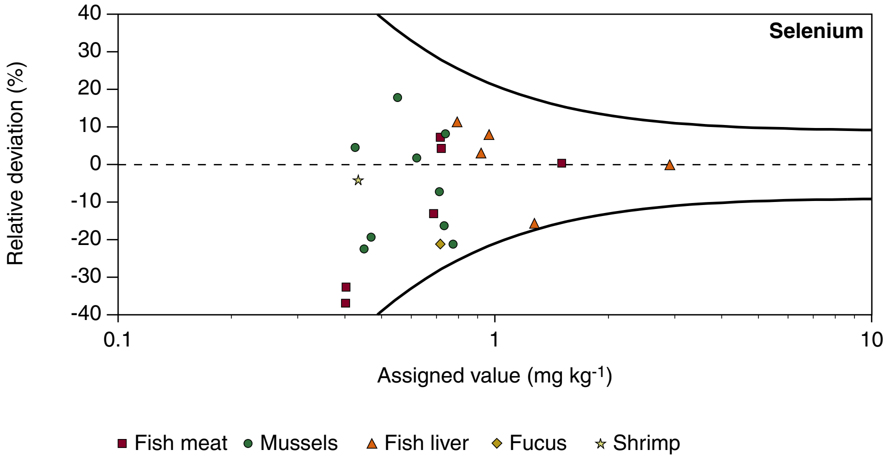


Figure 3 shows the results of selenium analyses of the QUASIMEME biota samples. 95 % of the relative deviations can be confined to the diagram area between the curves composed of a constant error (detection limit) of 0.19 mg/kg and a relative proportional error of 8 %, the lines in Figure 3. The DANAK accreditation of the laboratory implies a constant error of 0.2 mg/kg and a relative proportional error of 12.5 %.

Figure 3 The relative deviation of selenium analyses from the assigned values of QUASIMEME plotted against the assigned values.



2.4 Analytical methods and quality assurance - organochlorines

The analytes in this study are listed in Table 1.

Analytical methods

Procedures for analysis of PCBs, OC pesticides and toxaphene in fish and marine mammal tissue are those used by the National Laboratory for Environmental Testing (NLET) at NWRI. These methods are summarized here.

1. Sample preparation

Samples were homogenized prior to extraction in a small blender. Blubber samples were frozen with liquid nitrogen prior to sub sampling.

2. Extractions

Internal recovery surrogates of 1,3,5-bromobenzene, 1,2,4,5-tetrabromobenzene, delta-HCH, endrin ketone, PCB-30 and PCB 204 were added at the extraction step. Homogenized tissue was mixed with precleaned sodium sulfate to form a dry powder and Soxhlet extracted for 6 hrs with dichloromethane (DCM).

3. Removal of interferences

The DCM solution was reduced in volume to approximately 2 ml. The extract was applied to the top of a gel permeation column (GPC) to remove lipids using hexane: DCM (1:1) as elution solvent. Extractable lipids were determined gravimetrically on the first 150 ml of GPC eluate by evaporating off the solvent. The GPC eluate was reduced to small volume, quantitatively exchanged into hexane and chromatographed on activated Silica Gel (8 g in a 1.1 cm dia chromatographic column) to separate PCBs from other organochlorines including chlorinated bornanes (toxaphene). This latter procedure has been used successfully to separate 100 % of technical toxaphene from PCBs (NLET 1997). The silica gel was activated at 350° C for a minimum of 4 hrs; the sodium sulfate was cleaned by ashing at 450° C for a minimum of 4 hrs. Final extracts were stored at 4° C in a fridge. Prior to instrumental analysis they were reduced to an appropriate final volume under a gentle nitrogen stream.

4. Coplanar PCB analysis

Non-ortho PCBs (77, 81, 126 and 169) were being determined on a subset of samples. Samples were extracted and lipids removed as described previously. Following the GPC step, half of the sample was

Table 1 A list of classes and major individual analytes in the study.

Class	Components	Number of individual analytes	Samples analyzed
Organochlorine pesticides and metabolites	DDT, chlordane, HCH, or dieldrin/aldrin/endrin, mirex	24	All
Miscellaneous organochlorine byproducts:	pentachloroanisole, di-, tri-, tetra-, penta- and hexachlorobenzene, hexachlorobutadiene and octachlorostyrene	13	All
Toxaphene	total technical toxaphene + congeners including coeluters	23	All
PCB congeners	Congeners including co-eluters	104	All
Coplanar PCBs	PCB 77, 81, 126 and 169	4	107
Brominated diphenyl ethers	BDE congeners including co-eluters	32	44
Butyltins	mono-, di- and tri-butyl	3	24
Short Chain Chlorinated Paraffins	Total C10, Total C11, Total C12, Total C13	4	26

placed in a vial and sent to the laboratory of Michel LeBeuf (Institut Maurice Lamontagne). The lipid-free extracts were spiked with suitable ^{13}C-labelled surrogates, subjected to silica-gel cleanup and carbon column enrichment prior to GC-MS/MS (ion trap) analysis for coplanar PCBs (77, 126 and 169).

5. Brominated diphenyl ether and toxaphene analysis

Fraction 2 from the silica gel column was analyzed separately for BDPEs and toxaphene by electron capture negative ion (low resolution) MS without further cleanup. Selected samples of Fraction 1 were also run to check quantification of toxaphene congener P26. PBDEs were quantified using an external standard consisting of 32 congeners. Gas chromatographic conditions for the PBDEs were described by Luross et al. (2002).

6. Butyl tins

Mono-, di and tri-butyl tin were analyzed separately in marine mammal liver using the method of Chau et al (1997) and Yang et al (1998) slightly modified for mammal livers. The liver samples were ground with blender. Samples (6g) containing tripentytin (TPeT) as an internal standard (100 µl of 1µg TPeT ml -1 solution) were digested in 5 ml of 25 % aqueous solution of TMAH (tetramethylammonium hydroxide) at 600° C on a hot plate for 60 min with occasional shaking. After the addition of 10 ml of water, 5 ml of acetic acid, 6 g of NaCl and 4 ml of 0.2 % tropolone-toluene solution, the mixture was stirred for 60 min and 2 ml of toluene was removed and dried using a stream of nitrogen. The volume was brought back to 1 ml with hexane and the mixture was allowed to react with 0.5 ml of ethylmagnesium bromide (1.0M in THF) for 5 min. After the destruction of the excess ethylmagnesium bromide by 3 ml of 0.5M H_2SO_4, the organic layer was removed quantitatively and cleaned by silica gel column. After reduction of the eluate volume to 1 ml under nitrogen, 1 µl of the eluate was analyzed by gas-chromatography with flame photometric detection.

7. SCCPs

Short chain chlorinated paraffins were analyszd in Fraction 2 of the silica gel column by Dr. G. Tomy (Fisheries and Oceans, Winnipeg MB, Canada) using GC-electron capture negative ion high resolution mass spectrometry (Tomy et al. 1997). In brief, analyses were performed on a 5890 Series II gas chromatograph (Hewlett-Packard Instruments), fitted with a DB-5ms fused silica column (30 m x 0.25 mm i.d., 0.25 µm film thickness), connected to a Kratos Concept MS (Kratos Instruments Manchester UK) controlled by a Mach 3 data system. SIM was performed at a resolving power of ~12,000 (sufficient to exclude potential interferences from other organochlorines), with a cycle time of 1 sec for each window, and equal dwell times for each ion monitored.

8. Instrumental analysis

GC -electron capture detection: PCB congeners and organochlorine pesticides were determined by high resolution capillary GC with electron capture detection using a Hewlett Packard 6890 GC equipped with a 30 m x 0.25 mm, 0.25 µm film thickness DB-5 column programmed at 15° C/min to 150° C and 3° C/min to 265° C. Carrier gas was H_2 (about 1 mL/min) and make-up gas was N_2 (40 mL/min). PCB congeners and OC pesticides were quantified by GC-ECD using a series of authentic external standards.

GC-electron capture negative ion mass spectrometry (GC-ECNIMS): Toxaphene was analyzed by GC-ECNIMS using selected ion monitoring (SIM) (Swackhamer et al. 1987, Glassmeyer et al. 1999) on a Agilent 6890 gas chromatograph coupled Agilent 5973 MSD. The GC has a 30 m x 0.25 mm, 0.25 µm film thickness DB-5MS column and was operated with helium carrier gas at a linear flow of 40 cm/sec. A variable temperature ramp program from 40° C to 300° C over 60 minutes was used, and may be modified to obtain maximum resolution. The same program was used consistently for samples and standards in a given day; modifications were only made if resolution deteriorates or changes. Methane was used as the reagent gas; the source was kept at 150° C. The ion source pressure was maintained at 0.8 - 1.0 torr.

PBDE analyses were carried out using an Agilent 6890 GC-5973 MSD. The GC separation was performed on an Agilent HP5-MS capillary column (30 m x 0.25 mm x 0.25 µm). Helium was used as carrier gas, and separation was performed at a constant flow of 1.2 ml/min. Injection of 2 µl was performed in pulsed splitless mode at 25 psi for 1.0 min at an injector temperature of 250° C. The initial column temperature was 80° C for 2 min, 10° C/min to 120° C and 3° C/min to 285° C, which was held for 15 min. The mass spectrometer was operated in the NCI mode with methane as the buffer gas. The temperatures were 106, 150 and 300° C for the quadrupole, the ion source and the interface, respectively. All PBDEs were monitored at m/z 79 and 81.

Quality assurance

QA steps included method blanks, surrogate recovery spikes, and reference materials with each batch of 10 to 12 samples. In all, 39 method blanks were analyzed (15 in '99/00, 14 in '01 and 10 in '02). Results were corrected using the average blank value determined each year. Method detection limits (MDL) were calculated each year using results for method (reagent) blanks. The MDL for 95 % (MDL95 %) confidence was defined as the mean plus two standard deviations of seven or more iterations of a procedural blank, or a standard with a very low level of analyte if none was present in the procedural blanks (Keith 1991). Note that the multiplier of 2 results from the student's t-value for a one-sided 95 % confidence level for seven degrees of freedom. Average blank results and MDL's are given in Appendix 3.

Accuracy of the work was assessed by use of laboratory spike analyses, duplicate analyses, analysis of standard reference materials (SRM) and participation in interlaboratory studies. Spiked recovery samples consisted of reagents (e.g. sodium sulfate) spiked with representative levels of analyte and carried through analytical procedures similar to samples. The NIST standard reference materials cod liver oil 1588a and mussels 1974a were used along with a lake trout homogenate #EDF-2525 sold by Cambridge Isotope Laboratories, Boston MA. Criteria for acceptability were +/-30 % of certified values for all major PCB congeners and OC pesticides in each reference material. In the case of the lake trout only consensus values from an interlaboratory study were available.

During this study NLET participated in 12 QUASIMEME studies as well as 1 NIST (USA) and 3 Northern Contaminants Program (Canada) interlaboratory comparisons. Results for the QUASIMEME studies are presented herein because they were a requirement of the project. Results from the other studies are available from the laboratory.

1. Internal standard recoveries

Average recoveries of internal standards (surrogates) added to each samples were consistently > 80 %, except for dibromobenzene, indicating very low losses of all but the most volatile analytes during extraction and isolation steps (Table 2). Based on these results no correction for recovery efficiency of standards was made on the results for the diet samples.

2. Reference materials

Results for the three reference materials used during the study (NIST 1588a cod liver oil, NIST 1974a mussels and the lake trout homogenate #EDF-2525 from Cambridge Isotope Labs) showed overall good agreement with certified or consensus values (Table 3). The performance with the low concentration reference material, NIST 1974a, was particularly of interest for assessment of accuracy because of the large number of diet samples with low concentrations. Of the 32 certified analytes in 1974a, 50 % had deviations of < 21 % of the certified values (min 5 %, max 89 %) and 78 % were within 30 %. The analyte with

Table 2 Recoveries of internal standards added to each sample.

Internal standard		1999 N	1999 % recovery	2000 N	2000 % recovery	2001 N	2001 % recovery	2002 N	2002 % recovery
1,3-Dibromo-benzene	Mean	117	60.7	135	78	127	67.4	114	72.6
	SD		14.9		19		11.1		17.9
1,3,5-Tribromo-benzene	Mean	55	84.5	135	73	127	76.3	114	76.8
	SD		32.1		35		15.4		17.0
1,2,4,5-Tetra-bromobenzene	Mean	55	94.2	135	90	127	94.2	114	94.9
	SD		32.5		29		15.9		20.1
Delta-HCH	Mean	55	102	135	83	127	84.6	114	85.6
	SD		33.2		45		25.9		21.4
Endrin Ketone	Mean	117	75.9	135	80	127	99.3	114	100.1
	SD		18.6		26		23.7		28.0
PCB30	Mean	117	87.8	135	96	127	95.9	114	95.0
	SD		14.6		31		20.8		24.3
PCB204	Mean	117	95.4	135	103	127	117	114	114.9
	SD		15.4		32		28.3		28.9

maximum deviation (o,p DDE was a very minor compound). The NIST 1588a cod liver had 50 % of 39 analytes with < 21 % deviation from certified values (min 1.4 %, max 62.6 %) and 77 % were within 30 %. The high maximum result was for the coeluting PCB congener 187/182, a very minor proportion of PCBs in the cod liver sample. The lake trout reference material had no certified values, therefore consensus results from a Canadian interlab program involving 7 labs (Stokker 2003) were used. Similar to the certified materials, 50 % of 44 analytes were within 13 % deviation from certified values (min 1.4 %, max 213 %) and 77 % were within 30 %. For all 3 reference materials, mean total PCB (based on certified congeners) concentrations were within 12 % of certified or consensus values.

Table 3 Summary of results for the analysis of reference materials, NIST 1588a cod liver, 1974a mussel and 2525 whole lake trout [1].

Reference material	% of analytical results	Deviation from assigned value	Analyte (s)	Certified[2]	Measured
2525LT					
# certified			44 analytes		
Average		29 %			
Median	50 %	> 13 %			
	23 %	> 30 %			
Min		-1 %	a-HCH	1.9	1.89
Max		213 %	PCB-18	1.7	5.32
NIST 1974a					
# certified			32 analytes		
Average		26 %			
Median	50 %	> 21 %			
	22 %	> 30 %			
Min		-5 %	p, p-DDE	5.84	5.54
Max		-89 %	o, p-DDE	0.96	0.11
NIST 1588a					
# certified			39 analytes		
Average		23 %			
Median	50 %	> 21 %			
	23 %	> 30 %			
Min		1.4 %	o, p-DDT	156	158
Max		62.6 %	PCB-187-182	35.2	57.3

[1]Minimum and maximum results in the Table refer to certified and average measured concentrations (ng/g wet wt).

[2]Consensus results from an interlab study (Stokker 2003)

3. Replicates

Precision of the analyses was investigated by analysis of 11 duplicates of Greenland biota tissues (some samples were from the AMAP or "core" program). Average deviation of total PCBs for the 11 duplicates was 35 % (range 0.8 - 89 %). The precision was also investigated by calculating the % Relative standard deviation (RSD) for certified PCB congeners and OC pesticides detectable in the three reference materials (Table 4). NIST cod liver oil had median %RSD of 13 % and 19 %, for PCB congeners and OC pesticides, respectively. For the mussels 1974a median values for %RSD were 28 % for PCBs and 42 %

for OC pesticides. The higher RSD were due to poor reproducibility of minor components, o,p'DDE and o,p'DDT. In the lake trout homogenate (2525) median RSD's were 25 % for PCB congeners and 20 % for OC pesticides and again some very minor components accounted for most of the deviations.

Table 4 Median relative standard deviations of certified analytes in three reference materials.

	LT 2525 lake trout	1974a mussels	1588a cod liver
N[1]	31	15	19
PCB's	25 %	28 %	0.126166
OC pest	20 %	42 %	0.188398

[1]Number of samples used to calculate the median

4. Interlaboratory comparisons

The analytical laboratory participated in 12 QUASIMEME interlab comparisons during the three year study. Results are summarized in Figure 4 and 5 and in Table 5. Z values > 2 indicate deviations of about 30 % (or 1 SD) of the assigned value for the analyte. Results were generally acceptable for most analytes within 30 % of the assigned values with the exception of cod liver oil 434.

Table 5 Laboratory performance in the QUASIMEME interlaboratory comparisons.

QUASIMEME #, species	Number of analytes with assigned Z values	% with Z >2.0
416-common dab	14	36
416-mussel	18	39
434-cod liver	16	81
434-mussel	14	21
457-mussel	13	0
457-plaice	9	22
473-cod liver	16	13
473-mussel	11	45
510-mussel	15	40
510-salmon	18	6
536-mussel	10	20
536-salmon	17	5.9

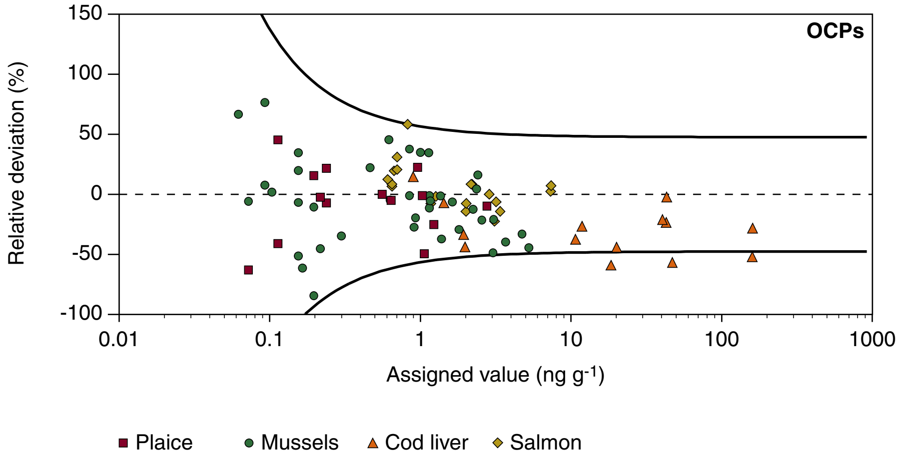


Figure 4 NLET analyses of individual organochlorine pesticides in QUASIMEME laboratory intercomparison studies. Plots of relative deviations from assigned values versus the assigned values. µg kg^{-1} wet weight. Full line ± 2Et%. Toxaphene not included.

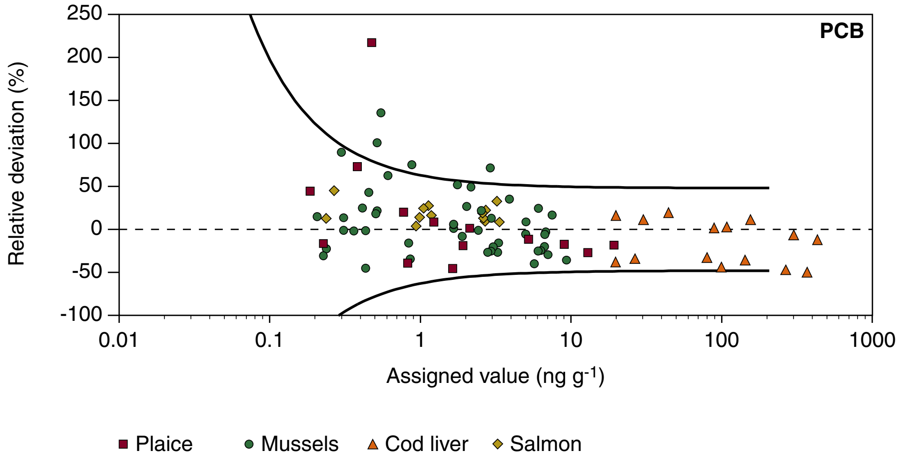


Figure 5 NLET analyses of PCB congeners in QUASIMEME laboratory intercomparison studies. Plots of relative deviations from assigned values versus the assigned values. µg kg^{-1} wet weight. Full line ± 2Et%.

5. Method blanks and detection limits

Method blanks showed that there was a significant blank problem for PCBs in samples with low levels. This blank is due to airborne contamination in the laboratory, which is a common problem in many older buildings (Wallace et al. 1996). After discussion with the NERI audit team it was decided to report *blank corrected* results in order to provide a more accurate estimate of levels in terrestrial animals, which had low levels of most organochlorine pesticides and PCBs. From 10 to 19 method blanks were available for each year of the study. This allowed calculation of a robust mean blank and standard deviation for each analyte. It should be noted that the subtraction is by *individual congener* and values < the average blank is assumed = zero in this calculation. The pattern of PCB congeners in the blank is different from that in the samples, therefore subtracting one from the other on a congener basis yields different results than subtracting the sPCB value.

Blank corrected results for all major organochlorines are shown in the result section of this report. No blank correction was done for toxaphene (method blanks were zero) or for minke whale blubber. Blank values for OC pesticides were generally low, and blank correction had little effect on levels of those compounds.

3 Results

All contaminant levels are presented on a wet weight basis with arithmetic means and standard deviations shown. This has been chosen, because the arithmetic mean will represent the average human exposure to the contaminant in question from the diet (Johansen et al. 2000), provided that the meal is selected irrespective of age, sex and region. In some cases these factors are known to affect contaminant levels, for example cadmium levels are known to increase with the age of seabirds and seals (Dietz et al. 1996). However, samples are considered representative of the human exposure to contaminants in the tissue and species in question, because these samples were collected in important areas and seasons for hunting and fishing in Greenland.

Appendices 4-11 list levels of contaminants in the species selected for this study. All organochlorine results and most metal results are from samples collected between 1999 and 2001. Some metal data are older (from the late 1980'ies and the 1990'ies; Dietz et al. 1996, 1997, 1998, Riget et al. 1997, 2000). These were extracted from a Greenland contaminant database at NERI, and all metal analyses presented in this report have been conducted by this institute using the procedures described in the methods section.

Contaminants covered are

- Cadmium, mercury and selenium (Appendix 4).
- Polychlorinated biphenyls (PCBs) presented as the total of 104 congeners, the total of 10 congeners (s10PCB) and the total of 8 congener groups (Appendix 5). Congener numbers of the different groups are shown in Appendix 5.
- Dichlorodiphenyltrichloretane (DDTs) presented as the sDDT (= sum of p,p'-DDE, -DDD, -DDT + o,p'-DDE, -DDD, -DDT) and as p,p´-DDE (major persistent break-down product of DDT) (Appendix 6).
- Chlordanes are presented as sCHL (= sum of heptachlor, heptachlor epoxide, oxychlordane, cis- and trans-Chlordane, cis- and trans-Nonachlor) and as Oxychlordane (the major metabolite of chlordane in mammals) (Appendix 6).
- Hexachlorcyclohexane (HCH) levels are presented as sHCH (= sum of α-,β and γ-HCH) and as β-HCH (the most recalcitrant isomer that predominates in mammals) (Appendix 6).
- Chlorbenzenes (CBz) levels are presented as sCBz (= sum of 1,2,3,4-tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene) (Appendix 6).
- Dieldrin (Appendix 6).
- Toxaphene levels are presented as "total" toxaphene quantified with a technical toxaphene standard, as the sum of 22 chlorobornane congeners (specified in Appendix 7) and as a sum of Parlar 26, 50, 62 (Appendix 7).
- Co-planar PCBs are presented as PCB 77, PCB 81, PCB 126 and PCB 169 (Appendix 8). Toxic equivalent concentrations (TEQ) of coplanar and mono-ortho PCBs are presented in Appendix 12.

- Organotin are presented as monobutyltin, dibutyltin and tributyltin (Appendix 9)
- Polybrominated Diphenyl Ethers (PBDEs) are presented as the sum of 32 PBDE congeners and as BDE47, BDE99 and BDE100 (Appendix 10).
- Short Chain Chlorinated Paraffins (SCCPs) are presented as Total C10, Total C11, Total C12, Total C13 and the sum of these (Σ-SCCPs) (Appendix 11).

3.1 Contaminant levels

Contaminant levels among species and tissues have been compared by grouping concentrations of cadmium, mercury, PCB, toxaphene, chlordane and dieldrin in four categories as shown in Table 6. These contaminants have been chosen because the mean human intake of them exceeded the ADI/TDI in the Greenland diet study (Johansen et al. 2004b), while this was not the case for DDT, HCH and chlorobenzenes. For comparison, Danish residue guideline concentrations (Anon. 2003, Jørgensen et al. 2000) are shown in the table. As this concentration is different among diet items the maximum residue concentration (except for PCB) is shown in the table.

The result of this grouping is shown in Table 7 (cadmium), Table 8 (mercury), Table 9 (PCB) and Table 10 (toxaphene), Table 11 (chlordane) and Table 12 (dieldrin). The grouping may be used to point to the diet items, which could be expected to be the most (or least) significant contaminant sources. When combining the category "very high concentrations" of all 4 tables, this list of species and tissues comes out as the most important potentially contaminant sources in the traditional diet:

- **liver** from Atlantic cod, Greenland halibut, snow crab, king eider, kittiwake, ringed seal, harp seal, hooded seal, beluga, narwhal
- **kidney** from ringed seal, harp seal, hooded seal, beluga and narwhal
- **blubber** from ringed seal, harp seal, minke whale, beluga and narwhal
- **skin (mattak)** from minke whale.

Table 6 Grouping of contaminant levels according to concentrations (wet weight basis) compared to Danish residue guidelines (see text).

	Very low conc.	Low-medium conc.	High conc.	Very high conc.	Highest Danish residue guideline
Cadmium (µg/g)	< 0.05	0.05-0.49	0.5-5	> 5	1
Mercury (µg/g)	< 0.01	0.01-0.09	0.1-1	> 1	1
s10PCB (ng/g)	< 5	5-49	50-500	> 500	400[1]
Total toxaphene (ng/g)	< 5	5-49	50-500	> 500	
Chlordane (ng/g)	< 1	1-99	10-100	> 100	
Dieldrin (ng/g)	< 1	1-99	10-100	> 100	200

[1] Guideline value for acceptable concentration of total PCB in fish oil.

Table 7 Grouping of cadmium levels according to concentrations (µg/g wet wt).

Very low conc. < 0.05	Low-medium conc. 0.05-0.49	High conc. 0.5-5	Very high conc. > 5
Terrestrial species			
Crowberry	Ptarmigan muscle	Ptarmigan liver	
Arctic blueberry	Hare liver	Hare kidney	
Hare muscle	Caribou liver	Caribou kidney	
Caribou muscle	Muskox kidney		
Caribou fat	Lamb liver		
Muskox muscle	Lamb kidney		
Muskox liver			
Muskox fat			
Lamb muscle			
Lamb fat			
Marine invertebrates			
Shrimp muscle		Blue mussel	Crab "liver"
Crab muscle		Iceland scallop	
Marine fish			
Salmon muscle	Arctic char liver	Redfish liver	
Capelin muscle	Salmon liver	Wolffish liver	
Capelin whole	Greenland cod liver	Halibut liver	
Atlantic cod muscle			
Atlantic cod liver			
Greenland cod muscle			
Redfish muscle			
Wolffish muscle			
Halibut muscle			
Seabirds			
	Murre muscle	Murre liver	King eider liver
	Common eider muscle	Common eider liver	Kittiwake liver
	King eider muscle		
	Kittiwake muscle		
Seals			
Ringed seal blubber	Ringed seal muscle	Harp seal liver	Ringed seal liver
Harp seal blubber	Harp seal muscle		Ringed seal kidney
	Hooded seal muscle		Harp seal kidney
			Hooded seal liver
			Hooded seal kidney
Whales			
Minke whale muscle	Narwhal muscle	Minke whale liver	Beluga kidney
Minke whale blubber		Minke whale kidney	Narwhal liver
Minke whale skin		Beluga liver	Narwhal kidney
Beluga muscle			
Beluga blubber			
Beluga skin			
Narwhal blubber			
Narwhal skin			

Table 8 Grouping of mercury levels according to concentrations (µg/g wet wt).

Very low conc. <0.01	Low-medium conc. 0.01-0.09	High conc. 0.1-1	Very high conc. > 1
Terrestrial species			
Crowberry	Ptarmigan liver		
Arctic blueberry	Hare liver		
Ptarmigan muscle	Hare kidney		
Hare muscle	Caribou liver		
Caribou muscle	Caribou kidney		
Caribou fat	Muskox liver		
Muskox muscle	Muskox kidney		
Muskox fat	Lamb kidney		
Lamb muscle			
Lamb liver			
Lamb fat			
Marine invertebrates			
	Shrimp muscle		
	Crab muscle		
	Crab "liver"		
	Blue mussel		
	Iceland scallop		
Marine fish			
Capelin muscle	Arctic char liver	Halibut muscle	
Capelin whole	Salmon muscle	Halibut liver	
Atlantic cod liver	Salmon liver		
	Atlantic cod muscle		
	Greenland cod muscle		
	Greenland cod liver		
	Redfish muscle		
	Redfish liver		
	Wolffish muscle		
	Wolffish liver		
Seabirds			
	Murre muscle	Murre liver	
		Eider muscle	
		Eider liver	
		Kittiwake muscle	
		Kittiwake liver	
Seals			
Ringed seal blubber		Ringed seal muscle	Ringed seal liver
Harp seal blubber		Ringed seal kidney	Harp seal liver
		Harp seal muscle	Hooded seal liver
		Harp seal kidney	Hooded seal kidney
		Hooded seal muscle	
Whales			
	Minke whale muscle	Minke whale liver	Beluga liver
	Minke whale blubber	Minke whale kidney	Beluga kidney
	Minke whale skin	Beluga muscle	Narwhal liver
	Beluga blubber	Beluga skin	Narwhal kidney
	Narwhal blubber	Narwhal muscle	
		Narwhal skin	

Table 9 Grouping of s10PCB levels according to concentrations (ng/g wet wt).

Very low conc. < 5	Low-medium conc. 5-49	High conc. 50-500	Very high conc. > 500
Terrestrial species			
Ptarmigan muscle			
Ptarmigan liver			
Hare muscle			
Hare liver			
Hare kidney			
Caribou muscle			
Caribou liver			
Caribou kidney			
Caribou fat			
Muskox muscle			
Muskox liver			
Muskox kidney			
Muskox fat			
Lamb muscle			
Lamb liver			
Lamb kidney			
Lamb fat			
Marine invertebrates			
Shrimp muscle	Crab "liver"		
Crab muscle			
Iceland scallop			
Marine fish			
Arctic char muscle	Arctic char liver	Halibut liver	
Salmon liver	Salmon muscle		
Capelin muscle	Cod liver		
Cod muscle	Wolffish liver		
Redfish muscle	Halibut muscle		
Wolffish muscle			
Seabirds			
	Murre muscle	Kittiwake muscle	
	Murre liver	Kittiwake liver	
	Eider muscle		
	Eider liver		
Seals			
Ringed seal kidney	Ringed seal muscle	Ringed seal blubber	
Harp seal muscle	Ringed seal liver	Harp seal blubber	
Harp seal kidney	Harp seal liver		
Whales			
	Minke whale muscle	Minke whale skin	Minke whale blubber
	Minke whale liver		Beluga blubber
	Minke whale kidney		Narwhal blubber
	Beluga muscle		
	Beluga liver		
	Beluga kidney		
	Beluga skin		
	Narwhal muscle		
	Narwhal liver		
	Narwhal kidney		
	Narwhal skin		

Table 10 Grouping of total toxaphene levels according to concentrations (ng/g wet wt).

Very low conc. < 5	Low-medium conc. 5-49	High conc. 50-500	Very high conc. > 500
Terrestrial species			
Ptarmigan muscle			
Ptarmigan liver			
Hare muscle			
Hare liver			
Hare kidney			
Caribou muscle			
Caribou liver			
Caribou kidney			
Caribou fat			
Muskox muscle			
Muskox kidney			
Muskox fat			
Lamb muscle			
Lamb liver			
Lamb kidney			
Lamb fat			
Marine invertebrates			
Shrimp muscle	Crab muscle		
	Crab "liver"		
Iceland scallop			
Marine fish			
Cod muscle	Arctic char muscle	Salmon muscle	Atlantic cod liver
	Arctic char liver	Halibut muscle	Halibut liver
	Salmon liver	Greenland cod liver	
	Capelin muscle	Wolffish liver	
	Redfish muscle		
	Wolffish muscle		
Seabirds			
	Murre muscle	Murre liver	
	Eider muscle	Kittiwake muscle	
	Eider liver		
	Kittiwake liver		
Seals			
Ringed seal kidney	Ringed seal muscle	Ringed seal blubber	
Harp seal kidney	Ringed seal liver	Harp seal blubber	
	Harp seal muscle		
	Harp seal liver		
Whales			
	Minke whale muscle	Minke whale blubber	Minke whale skin
	Minke whale kidney	Minke whale liver	Beluga blubber
	Beluga muscle	Beluga skin	Narwhal blubber
	Beluga liver	Narwhal skin	
	Beluga kidney	Narwhal liver	
	Narwhal muscle		
	Narwhal kidney		

Table 11 Grouping of chlordane (sCHL) levels according to concentrations (ng/g wet wt).

Very low conc. < 1	Low-medium conc. 1-9	High conc. 10-100	Very high conc. > 100
Terrestrial species			
Ptarmigan liver	Ptarmigan muscle		
Hare muscle	Hare liver		
Hare kidney			
Caribou muscle			
Caribou liver			
Caribou kidney			
Caribou fat			
Muskox muscle			
Muskox liver			
Muskox kidney			
Muskox fat			
Lamb muscle			
Lamb liver			
Lamb kidney			
Lamb fat			
Marine invertebrates			
Shrimp muscle	Crab muscle		
Iceland scallop	Crab "liver"		
Marine fish			
Cod muscle	Arctic char muscle	Halibut muscle	Halibut liver
	Arctic char liver	Cod liver	
	Salmon muscle	Wolffish liver	
	Salmon liver		
	Capelin muscle		
	Redfish muscle		
	Wolffish muscle		
Seabirds			
	Murre muscle	Kittiwake muscle	
	Murre liver	Eider liver	
	Eider muscle		
	Kittiwake liver		
Seals			
	Ringed seal muscle		Ringed seal blubber
	Ringed seal liver		Harp seal blubber
	Ringed seal kidney		
	Harp seal muscle		
	Harp seal liver		
	Harp seal kidney		
Whales			
	Minke whale muscle	Minke whale liver	Minke whale blubber
	Minke whale kidney	Beluga muscle	Minke whale skin
		Beluga liver	Beluga blubber
		Beluga kidney	Narwhal blubber
		Beluga skin	
		Narwhal muscle	
		Narwhal liver	
		Narwhal kidney	
		Narwhal skin	

Table 12 Grouping of dieldrin levels according to concentrations (ng/g wet wt).

Very low conc. < 1	Low-medium conc. 1-9	High conc. 10-100	Very high conc. > 100
Terrestrial species			
Ptarmigan muscle	Hare liver		
Ptarmigan liver			
Hare muscle			
Hare kidney			
Caribou muscle			
Caribou liver			
Caribou kidney			
Caribou fat			
Muskox muscle			
Muskox liver			
Muskox kidney			
Muskox fat			
Lamb muscle			
Lamb liver			
Lamb kidney			
Lamb fat			
Marine invertebrates			
Shrimp muscle			
Crab muscle			
Crab "liver"			
Iceland scallop			
Marine fish			
Arctic char muscle	Cod liver	Halibut liver	
Arctic char liver	Wolffish liver		
Salmon liver	Wolffish muscle		
Salmon muscle	Halibut muscle		
Capelin muscle			
Cod muscle			
Redfish muscle			
Seabirds			
	Murre muscle		
	Murre liver		
	Eider muscle		
	Eider liver		
	Kittiwake muscle		
	Kittiwake liver		
Seals			
Ringed seal kidney	Ringed seal muscle		Ringed seal blubber
Harp seal kidney	Ringed seal liver	Harp seal blubber	
	Harp seal muscle		
	Harp seal liver		
Whales			
	Minke whale muscle	Minke whale liver	Minke whale blubber
	Minke whale kidney	Harp seal blubber	Minke whale skin
	Beluga muscle		Beluga blubber
	Beluga liver		Narwhal blubber
	Beluga kidney		
	Beluga skin		
	Narwhal muscle		
	Narwhal liver		
	Narwhal kidney		
	Narwhal skin		

3.2 Metals

Cadmium

The mean cadmium concentration ranges from below 0.015 µg/g wet wt (the detection limit) to 40.8 µg/g (Appendix 4). In the same species levels are lowest in muscle and fat, higher in the liver and highest in the kidney. Cadmium levels are generally higher in the marine than in the terrestrial environment. In terrestrial species high cadmium levels are only found in ptarmigan (liver), hare (kidney) and caribou (kidney). In berries and in muscle, fat and skin from all animal species cadmium levels generally are low, whereas they generally are high or even very high in liver and kidney, in particular in marine mammals (Table 7).

Mercury

The mean mercury concentration ranges from below 0.005 µg/g wet wt (the detection limit) to 64.9 µg/g (Appendix 4). Except for fish, the mercury concentration is higher in liver than in muscle of the same species, and levels are generally much higher in the marine than in the terrestrial environment. Concentrations above 0.1 µg/g in general are only found in Greenland halibut, in muscle and liver from seabirds and in muscle, liver and kidney from marine mammals with the highest in liver and kidney (Table 8).

Selenium

The mean selenium concentration ranges from less than 0.2 µg/g wet wt to 21.2 µg/g (Appendix 4). In the same species the concentration is higher in the liver than in the muscle, but in whales the highest concentration is found in skin (muktuk or mattak). Selenium levels are higher in the marine than in the terrestrial environment, as is also seen for mercury.

3.3 Organochlorines

PCBs

PCB levels are presented in Appendix 5 as the sum of 104 congeners (includes co-eluting congeners as single values), as the sum of 10 congeners (s10PCB) and as the sum of 8 homologgroups with 1 to 9 chlorine atoms (termed s-mono, s-di, s-tri, s-tetra, s-penta, s-hexa, s-hepta, s-octa and s-nona in the appendix). The following comparison will be based on the s10PCB results. These 10 congeners are CB 28, 31, 52, 101, 105, 118, 138, 153, 156 and 180. This group represents most of the predominant congeners in fish and marine mammals and is consistently measured by most laboratories.

The mean s10PCB concentration ranges from 0.1 ng/g wet wt to 1,055 ng/g in the West Greenland samples (Appendix 5). In all samples from the terrestrial environment, even in fat, PCB levels are very low. In the marine environment levels are also low in muscle from marine invertebrates, in fish and in birds, except kittiwake, and in seal muscle, liver and kidney. Levels exceeding 50 ng/g are only found in Greenland halibut liver, in kittiwake muscle and liver, in minke whale skin and in blubber from all seals and whales studied (Table 9).

DDTs

DDT levels are presented in Appendix 6 as sDDT (= sum of p,p′-DDE, -DDD, -DDT + o,p′-DDE, -DDD, -DDT) and as p,p′-DDE (major persistent break-down product of DDT).

The mean sDDT concentration ranges from 0.01 ng/g wet wt to 1,622 ng/g (Appendix 6). The pattern is very similar to that seen for PCB with very low or low concentrations in all samples from the terrestrial environment, in marine invertebrates, in most fish, in seabirds and in muscle, liver and kidney from marine mammals, while levels are high in seal and whale blubber. However, DDT levels are also high in liver from Greenland halibut and in skin from minke whale.

Chlordane

Chlordane levels are presented in Appendix 6 as sCHL (= sum of heptachlor, heptachlor epoxide oxychlordane, cis- and trans-Chlordane, cis- and trans-Nonachlor) and as Oxychlordane (the major metabolite of chlordane in mammals). The mean sCHL concentration ranges from 0.02 ng/g to 1,203 ng/g wet wt. The pattern is very similar to that seen for PCB with very low or low concentrations in all samples from the terrestrial environment and most muscle tissue from marine invertebrates and fish and with high levels in seal and whale blubber. However, chlordane levels are also high in liver from Greenland halibut, Atlantic cod and in skin from minke whale.

HCHs

HCH levels are presented in Appendix 6 as sHCH (= sum of α-,β and γ-HCH) and as β-HCH (the most recalcitrant isomer that predominates in mammals). The mean sHCH concentration ranges from 0.03 ng/g to 136 ng/g wet wt. sHCH concentrations are lower than s10PCB, sDDT and sCHL concentrations, but the pattern between tissues, species and environment is similar.

Chlorobenzene

Chlorobenzene levels are presented in Appendix 6 as sCBz (= sum of 1,2,3,4-tetrachlorobenzene, pentachlorobenzene and hexachlorobenzene). The mean sCBz concentration ranges from 0.13 ng/g to 352 ng/g wet wt. sCBz concentrations are lower than s10PCB, sDDT and sCHL concentrations and higher than sHCH concentrations, but the pattern between tissues, species and environment is similar.

Dieldrin

Dieldrin levels are presented in Appendix 6. The mean dieldrin concentration ranges from less than 0.01 ng/g to 396 ng/g wet wt. Dieldrin concentrations are lower than s10PCB, sDDT and sCHL concentrations and higher than sHCH concentrations, but the pattern between tissues, species and environment is similar (Table 12).

Toxaphene

Toxaphene levels are presented as "total" toxaphene quantified with a technical toxaphene standard, as the sum of 22 chlorobornane congeners (specified in Appendix 7) and as a sum of Parlar 26, 50, 62 (Appendix 7). The mean total toxaphene concentration ranges from less than 0.1 ng/g to 3,103 ng/g wet wt. In the species and tissues with the highest levels, the concentration of the 22 toxaphene congeners is about half of the total toxaphene concentration, and the concentration of Parlar 56, 50, 62 is about half of the concentration of the 22 toxaphene congeners. In contrast to the other organochlorine pesticides studied and the PCBs, the highest level is not found in marine mammal blubber, but in Greenland halibut liver. In general total toxaphene concentrations appear somewhat higher than the s10PCB and sDDT concentration, but the pattern between tissues, species and environment is similar (Table 10). It remains unexplained why the toxaphene concentration is higher in skin than in blubber from minke whale. We would have expected the highest level in blubber as is seen for beluga and narwhal.

Coplanar PCBs

A subset of samples was analyzed for coplanar PCBs. Results are presented in Appendix 8. CB77 was the predominate non-ortho substituted (or coplanar) PCB in the 107 samples that were analyzed, ranging from 4.3 pg/g wet wt in lamb fat to 129 ng/g wet wt in beluga blubber. Highest concentrations of CB126, the congener with the greatest dioxin toxic equivalent factor (TEF), were found in blubber of ringed seal, beluga and minke whale.

Brominated diphenyl ethers

A subset of samples was analyzed for brominated diphenyl ethers. Results are presented in Appendix 9. The total PBDE concentration ranges from 0.25 ng/g wet wt in fish muscle to 58 ng/g wet wt in seal blubber. In most tissues the level is below 5 ng/g wet wt. Levels appear to be much higher in East than in West Greenland, a factor of about 15 in ringed seal blubber. The tetrabromo- congener BDE 47 predominated in all species, representing approximately 30 to 80 % of sPBDEs. The pentabromo congeners, BDE99 and BDE 100, were the next most prominent congeners. BDE 99 was present in greater concentrations than BDE100 except in Greenland halibut liver where concentrations were identical.

Butyl tin

A subset of samples (livers from marine mammals) was analyzed for butyl tins. Results are presented in Appendix 10. The mono- and tributyl concentration in most cases was below the detection limit, while dibutyl concentration was above. The highest concentration was found in minke whale. Law et al. (1999) also found that dibutyl tin was the only detectable butyl tin compound in a dead minke whale from the coast of the UK.

Short Chain Chlorinated Paraffins (SCCPs)

A subset of samples (blubber and skin from marine mammals) was analyzed for Short Chain Chlorinated Paraffins. Results are presented in Appendix 11. Marked differences are apparent, as levels are much higher in beluga and narwhal blubber than in seal blubber and minke whale skin. Chlorinated decanes predominated in all species. Tomy et al. (2000) found a similar pattern of chloroalkanes in beluga and ringed seal from the Canadian Arctic.

4 Discussion

Based on the data presented in this report, Johansen et al. (2004b) conclude that the traditional diet is a significant source of contaminants to people in Greenland. In this study, the mean intakes of cadmium, chlordanes and toxaphene significantly exceed "acceptable/tolerable intakes" (ADI/TDI) by a factor between 2.5 and 6. Mean intakes of mercury, PCB and dieldrin also exceed ADI/TDI by up to about 50 %. But as these figures are mean intakes and as variation in both food intake and contaminant levels is large, the variation of contaminant intake among individuals is also large, and some individuals will be exposed to significantly higher intakes. The mean intakes of DDT, HCH and chlorobenzenes are well below the ADI/TDI values, and it seems unlikely that the TDI for these contaminants normally is exceeded in the Greenland population.

The main reason that the human intake of some contaminants exceeds ADI/TDI values in this study is that a few diet items have high contaminant levels. The evaluation of contaminant intake in this study points to seal muscle, seal liver, seal kidney, seal blubber and whale blubber as the dominant contributors of contaminants in the traditional diet. Levels in liver from Greenland halibut, snow crab, king eider, kittiwake, beluga and narwhal and kidney of beluga and narwhal are also high but were, with the exception of toxaphene in Greenland halibut liver, not important sources in this study, because they were eaten in low quantities. However, one Greenland halibut sample (#21964) had a much higher toxaphene concentration than the other samples, and since only five samples were analyzed, the mean concentration of those may not be representative.

A way to minimize contaminant intake would be to avoid or limit the consumption of diet items with high contaminant levels. If we assume a traditional diet composition in this study without fish liver, bird liver, seal liver, seal kidney, seal blubber, whale liver, whale kidney and whale blubber, the intake of all contaminants would be below the TDI's for these. This will result in a reduction of the intake of the amount of traditional food of only 24-25 %, and it is not likely that this changed diet will result in deficiency of minerals, vitamins or other nutritional compounds (Bjerregaard, pers. comm.).

Our study has mainly included cadmium, mercury, selenium, polychlorinated biphenyls (PCB), dichlorophenyltrichloroethane (DDT), chlordane, hexachlorocyclohexanes (HCH), chlorobenzenes, dieldrin and toxaphene in the major species and tissues consumed by Greenlanders. In general the levels of these are very low in terrestrial species and in muscle of many marine species. High organochlorine concentrations are typically found in blubber of marine mammals and high metal levels are found in seabird liver and in liver and kidney of seals and whales.

In general, contaminant levels in the Greenland environment, including diet items, are lower than in more densely populated and industrialized regions of the Northern Hemisphere. This is illustrated in Table 13, which compares levels in the same species and tissues in Greenland and in temperate European waters. This geographical difference is very pronounced for sPCB, coplanar PCBs, DDT, dieldrin, chlordane, total toxaphene, butyl tins, PBDEs and SCCPs, and in most cases mercury levels are also lower in Greenland. For HCH and HCB there appears to be no geographical differences.

Cadmium is an exception to the general pattern, as cadmium concentrations are much higher in biota from Greenland than from temperate European waters. This has been observed earlier, particularly in Arctic marine mammals (Dietz et al. 1996, Wagemann et al. 1997). The difference has been explained by diet, as hyperiid amphipods rich in cadmium are common in the diet of Arctic vertebrates, but also by slow growth rates in the Arctic (Fant et al. 2001). It is also interesting, but remains unexplained why the sum concentration of toxaphene Parlar 26, 50 and 62 in fish is significantly higher in Greenland than in Danish waters. However, levels in Greenland fall within the range observed in Norwegian waters with no known point sources.

Table 13 Comparison of contaminant levels (mean or range of means, ng/g wet weight) between Greenland and temperate European waters.

Contaminant	Species & tissue	West Greenland (this study)	Baltic	North Sea or Skagerrak	Other regions, see below table	Ref., see below table
Cd	Blue mussel soft tissue	1,480			42-650[1,7]	a, i
	Iceland scallop meat	2,040			420[5]	o
	Cod muscle	< 15			< 1[1]	b
	Cod liver	49			100[7]	i
	Ringed seal liver	10,800	110-650			c
	Ringed seal kidney	40,800	780-2,800			c, j
Hg	Blue mussel soft tissue	15			2-69[1,7]	a, i
	Cod muscle	14			49-70[1,7]	b, i
	Ringed seal muscle	292	1,170			j
	Ringed seal liver	2,070	1,990-44,000			c
	Ringed seal kidney	993	4,360			j
s10PCB	Cod muscle	0.4			1.2[7]	i
	Cod liver	123	554[2]	342[2]	328[7]	b, i
	Salmon muscle	8	50[2]			b
	Blue mussel soft tissue[3]	1		8	1-10[1,7]	a, d, i
sPCB	Ringed seal blubber	549	17,000-320,000[4]			e
	Ringed seal liver	51	2,200-4,200[6]			h
Coplanar PCBs	CB77 – salmon CB126 - salmon	11 1.3	280 115			k
sDDT	Cod liver	55	720[2]	98[2]	108[7]	b, i
	Salmon muscle	10	59[2]			b
	Blue mussel soft tissue	0.5		3	0.1-1.9[1,7]	a, d, i
	Ringed seal blubber	439	13,000-340,000			e
	Ringed seal liver	8	1,000-2,550[6]			h
sHCH	Cod liver	15	40	21		b
	Salmon muscle	5	5			b
	Blue mussel soft tissue	0.6		2	0.1-0.7[1]	a, d
HCB	Cod muscle	0.1			0.1[7]	c
	Cod liver	11	19	8	13[7]	b, i
	Salmon muscle	1	1			b
Dieldrin	Cod liver	4	39	56		b
	Salmon muscle	0.4	3			b
sCHL	Ringed seal blubber	241	860-11,000			f
Total toxaphene	Ringed seal blubber	196	2,300-14,000			f
Toxaphene Parlar 26, 50, 62	Cod liver	103	28	21	56-255[7]	g, i
	Salmon muscle	9.0	2.5			g
PBDEs	Cod liver					l
	BDE 47	1.0		42		
	BDE 100	0.15		13		
	Harbour seal liver					
	BDE 47	2.0[9]		28		l
	BDE 100	0.19		1.7		
SCCP	Ringed seal blubber	10	130[10]			m
Butyl tins	Minke whale liver	10		56		n

a) Hansen et al. 2000
b) Jørgensen et al. 2000
c) Frank et al. 1992
d) Cleeman et al. 2000b
e) Blomkvist et al. 1992
f) Anderssson & Wartanian 1992
g) Fromberg et al. 2000
h) Nyman et al. 2002
i) Green & Knutzon 2003
j) Fant et al. 2001
k) Atuma et al. 1998
l) Boon et al. 2002
m) Jansson et al. 1993
n) Law et al. 1999
o) AMAP 2004a.

[1] Danish waters
[2] The 10 PCB congeners reported in Greenland and Danish waters in ref. b are not exactly equal (Greenland: congener 28, 31, 52, 101, 105, 118, 138, 153, 156, 180; Denmark: 28, 52, 101, 105, 118, 138, 153, 156, 170, 180).
[3] PCB concentration is the sum of 6-10 congeners.
[4] PCB concentration is quantified by comparison with Aroclor 1254
[5] Faroe Islands
[6] Results recalculated from ref. h assuming 5 % fat in liver. PCB concentration is quantified by comparison with Clophen A50.
[7] Norwegian reference locations. ΣPCB includes 7 congeners. ΣDDT = DDE + DDD in fish.
[9] Results for ringed seal from Greenland used for comparison
[10] Kongsfjorden (Sweden)

In Table 14 we have compared cadmium, mercury and DDT levels found in this study (West Greenland) with levels from other Arctic regions.

Metals

In most cases the Greenland levels of cadmium and mercury fall within the range observed in other Arctic regions. This is the case for all the terrestrial species and tissues. For marine invertebrates and fish there are larger variations, but they are not consistent. Some of the differences could be related to small sample sizes and differences in fish size (larger fish have higher cadmium and mercury concentrations than small). This might also explain differences observed in seabirds and marine mammals. However, in most of the cases levels in Greenland are within the range found in other Arctic regions, and there does not appear to be systematic differences, except possibly for cadmium, where concentrations appear to be higher in ringed seals from West Greenland than in the other Arctic regions. Another exception may be mercury in beluga, as levels appear to be lowest in West Greenland.

Organochlorines, PBDEs and SCCPs

As described earlier in this report the organochlorines (PCBs, pesticides and byproducts) display a similar pattern among species and tissues. Low levels are found in the terrestrial environment, in marine invertebrates, in most fish and seabirds and in muscle, liver and kidney from marine mammals, while levels are high in seal and whale blubber and in fish liver. Therefore the DDT data presented in Table 14 may be taken to represent distribution of the organochlorines in the Arctic. In the terrestrial species levels in most cases appear to be lower than found elsewhere in the Arctic, while there is no systematic pattern among the marine species. In most cases the organochlorine levels in Greenland are within the range of levels found elsewhere in the Arctic. For other organochlorines than DDT, few data from other Arctic regions are available for direct comparison with the Greenland diet data, but these show similar trends as DDT, e.g. PCB and toxaphene in ringed and harp seal blubber (AMAP 2004b). Similar to our findings in West Greenland, Hellou et al. (1997) also found very low levels of organochlorine compounds (less than 0.01-0.5 ng/g) in muscle tissue from deep-sea prawn in Eastern Davis Strait and in the Labrador Sea. From West Greenland there are only few other data to compare with. Berg et al. (1997) found significantly lower organochlorine levels in liver from Greenland halibut than in our study. Mean levels were about 5 times lower for PCB and about 10 times lower for DDT. However, in our study one Greenland halibut sample (#21964) had much higher organochlorine concentrations than the other samples, and since only five samples were analyzed, the mean concentration of those may not be representative. Concentrations of sDDT and sPCB in Greenland halibut muscle from Cumberland Sound in Southeast Baffin Island collected in the early 1990's were about 3-fold higher than those reported in this study (de March et al. 1998).

Table 14 Comparison of contaminant levels (mean or range of means, ng/g wet weight) between Greenland and other Arctic regions (AMAP 2004a, AMAP 2004b). Datasets with only one sample excluded.

Species	Tissue	Cd		Hg		ΣDDT	
		West Greenland	Other regions	West Greenland	Other regions	West Greenland	Other regions
Ptarmigan	Muscle	76	36-210	<5	<5	0.04	0.05-0.61
	Liver	2,350	330-8,940	30	6-93	0.69	1.25-1.55
Hare	Muscle	5	6-18	<2	<1-120	0.01	0.05-0.07
	Liver	186	150-530	29	2-400	0.05	0.10-0.47
	Kidney	3,810	830-23,800	52	21-112	0.18	0.09-0.13
Caribou	Muscle	< 15	10-68	8	<1-12	0.05	0.34-0.35
	Liver	387	175-1,870	90	26-635	0.02	0.42-1.34
	Kidney	1,430	450-3,670	97	85-425	0.01	0.31-0.55
	Fat					0.09	6.14
Lamb	Liver					0.39	0.23-0.43
Iceland scallop	Muscle	2,040	950	22	30		
Blue mussel	Soft t.					0.5	0.24-1.89
Arctic char (sea run)	Muscle			44	13-72	1.44	0.18-6.53
	Liver	92		18	17	6.56	5.47-6.20
Atlantic cod	Muscle	< 15		14	6[1]		
	Liver	49	136[1]	7	100[1]	55.2	37-92
Redfish	Muscle	< 15		25	70[1]		
	Liver	1,360	465[1]	25	20[1]		
Atlantic wolffish	Muscle	< 15		17	170[1]		
	Liver	659	1,670[1]	12	50[1]		
Spotted wolffish	Muscle	< 15		85	110[1]		
	Liver	532	930[1]	57	58[1]		
Greenland halibut	Muscle	< 15		154	20[1]		
	Liver	1,750	465[1]	152	20[1]		
Kittiwake	Muscle	421	117-552[1]	117	8-162[1]	30.9	40.2
	Liver	6,650	50-13,400[1]	462	70-850[1]	8.31	19.6-58.9
Common eider	Muscle	188	32	151	64	3.84	0.26-50.9
	Liver	3,220	328-5,890[1]	872	387-990[1]	5.78	0.70-47.4
King eider	Muscle	361	20-110[1]	130	60[1]		
	Liver	5,810	1,070-4,290[1]	589	210-830[1]		
Thick-billed murre	Muscle	89	40[1]-480	76	64[1]-370		
	Liver	4,990	760-5,740[1]	227	180-330[1]	8.11	26.9-33.4
Ringed seal	Muscle	252	8-90	292	110[1]-460	13.6	1.19-1.91
	Liver	10,800	2,750-9,350	2,070	930[1]-20,300	8.26	1.74-1.78
	Kidney	40,800	5,510-26,100	993	480[1]-2,750	2.15	1.26-1.28
	Blubber	< 15	20	< 5	2	439	48.1-3,200
Harp seal	Blubber					325	340-5,820
Minke whale	Muscle	< 15	27-44[1]	80	85-214[1]		
	Liver	970	980-1,110[1]	266	204-570[1]		
	Kidney	3,990	3,660-4,850[1]	183	165-560[1]		
	Blubber					951	510-3,440
Beluga	Muscle	31	20	585	1,160	29.2	28.2
	Liver	2,380	3,810	4,040	6,500-44,000	24.1	73.6
	Kidney	11,000	12,200	1,780	4,580		
	Blubber					1,558	590-5,570
	Skin	< 15		20	700		
Narwhal	Blubber					1,622	3,610-7,220

[1] Converted from dry to wet weight basis based on the factors given in Dietz et al. 1996.

Total PBDE concentrations in ringed seal blubber from West Greenland were comparable to levels found in the same species from Holman in the western Canadian arctic which averaged 4 ng/g wet wt (Ikonomou et al. 2002). However, concentrations in East Greenland ringed seals were about 15-fold higher and similar to concentrations reported by Jansson et al. (1993) for ringed seal blubber from Svalbard. Christensen et al. (2002) reported PBDEs in fish and mussels from southern Greenland. Low concentrations of BDE 47, 99 and 100 (sPBDE = 1-12 ng/g wet wt) were found in liver of shorthorn sculpin, Greenland cod, spotted wolffish liver and starry ray. Concentrations in spotted wolffish liver were about 5-fold higher (1.2 ng/g) than found in this study for wolfish muscle (0.25 ng/g).

Tomy et al. (2000) reported total SCCPs in extracts of beluga whales (collected in 1989) and walrus (collected in 1978) from western Greenland that had been previously analyzed for PCBs and OC pesticides (Stern et al. 1994, Muir et al. 2000). In beluga blubber SCCP concentrations ranged from 110 to 250 ng/g wet wt, which is comparable to results in this study. In contrast, in ringed seal blubber, SCCP concentrations were 10-15 times lower in West Greenland (this study) than in the eastern Canadian Arctic (Tomy et al. 2000). In walrus blubber, SCCP concentrations were higher in eastern Greenland (360-490 ng/g wet wt) than in other Arctic marine mammals studied (Tomy et al. 2000).

"Dioxin-like" potency of the PCBs

Toxic equivalent concentrations (TEQs) of planar PCBs were calculated by combining the coplanar PCB results with the mono-ortho PCBs for which TEFs have been promulgated (Van den Berg et al. 1998) (Appendix 12). These TEQs give an indication of the "dioxin-like" potency of the PCBs and serve to indicate which PCBs contribute to this potential toxicity. Total TEQ values were very low ranging from 0.03 pg/g in arctic char to 11 pg/g in beluga blubber. CB126 represented the greatest proportion of total TEQs in all species except narwhal. CB126 was very low in narwhal blubber (9 % of TEQ) and liver (6 % of TEQ) and mono-ortho PCBs (CB105, CB118) contributed the majority of TEQs. Ford et al. (1993) also found that CB126 represented a smaller fraction of TEQs in narwhal (~22 %) than beluga (~38 %).

Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were not determined in this study. However, previous studies of fish and marine mammals in the eastern Canadian Arctic found very low concentrations (Norstrom et al. 1990, reviewed by de March et al. 1998) compared to urban industrialized areas of Europe and North America. PCDD/Fs represented < 10 % of total TEQs (calculated with PCDD/Fs, coplanar and mono-ortho PCBs) in walrus, narwhal, and beluga. In ringed seals and char PCDD/Fs represented from 30 to 90 % of TEQ (de March et al. 1998).

Overall conclusion

The intake of contaminants from the traditional Greenland diet may be high and may exceed "acceptable/tolerable" intakes for several contaminants, because a few diet items have high contaminant levels. By avoiding these (liver, kidney and blubber) the intake of contaminants from the traditional diet in Greenland will be below the limits for "acceptable/tolerable" intakes.

Contaminant levels in the Greenland species eaten are generally within the range of levels observed elsewhere in the Arctic, whereas they typically are much lower than the same species from more densely populated and industrialized regions of the Northern Hemisphere.

5 References

AMAP 2004a. AMAP Assessment 2002: Heavy Metals in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. In press.

AMAP 2004b. AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xvi+310 pp.

Andersson, Ö. & A. Wartanian 1992. Levels of Polychlorinated Camphenes (Toxaphene), Chlordane Compounds and Polybrominated Diphenyl Ethers in Seals from Swedish waters. Ambio 21: 550-552.

Anon. 2003. Bekendtgørelse om visse forureninger i fødevarer. Fødevaredirektoratet, bekendtgørelse nr. 860, 22.10.2003.

Atuma, S., A. Bergh, L. Hansson, A. Wicklund-Glynn & H. Johnsson 1998. Non-ortho PCB levels in various fish species from the east and west coast of Sweden. Chemosphere 37: 2451-2457.

Berg, V., K.I. Ugland, N.R. Hareide, P.E. Aspholm, A. Polder & J.U. Skaare 1997. Organochlorine Contamination in Deep-Sea Fish from the Davis Strait. Marine Environmental Research 44: 135-148.

Blomkvist. G., A. Roos, S. Jensen, A. Bignert & M. Olsson 1992. Concentrations of sDDT and PCB in Seals from Swedish and Scottish Waters. Ambio 21: 539-545.

Boon, J.P., W.E. Lewis, M.R. Tjoen-A-Choy, C.R. Allchin, R.J. Law, J. de Boer, C.C. ten Hallers-Tjabbes & B.N. Zegers 2002. Levels of Polybrominated Diphenyl Ether (PBDE) Flame Retardants in Animals Representing Different Trophic Levels of the North Sea Food Web. Environ. Sci. Technol. 36: 4025-4032.

Chau, Y.K., F. Yang & M. Brown 1997. Evaluation of derivatization techniques for the analysis of organotin compounds in biological tissue. Anal. Chim. Acta 338: 51-55.

Christensen, J.H., M. Glacius, M. Pécseli, J. Platz & G. Pritzl 2002. Polybrominated diphenyl ethers (PBDEs) in marine fish and blue mussels from southern Greenland. Chemosphere 47: 631-638.

Cleeman, M., F. Riget, G.B. Paulsen, J. de Boer & R. Dietz 2000a. Organochlorines in Greenland ringed seals. The Science of the Total Environment 245: 103-116.

Cleeman, M., F. Riget, G.B. Paulsen, J. Klungsøyr & R. Dietz 2000b. Organochlorines in marine fish, mussels and sediments. The Science of the Total Environment 245: 87-102.

de March, B.G.E., C. DeWit, D.C.G. Muir, B.M. Braune, D.J. Gregor, R.J. Norstrom, M. Olsson, J.U. Skaare & K. Stange 1998. Persistent Organic Pollutants. *In:* AMAP Assessment Report. Arctic Pollution

Issues, Chapter 6. Arctic Monitoring and Assessment Program. Oslo. Norway. Pp. 183-372.

Dietz, R., F. Riget & P. Johansen 1996. Lead, cadmium, mercury and selenium in Greenland marine animals. The Science of the Total Environment 186: 67-93.

Dietz, R., P. Johansen, F. Riget & G. Asmund 1997. Data on heavy metals in the Greenland marine environment before 1994. AMAP Greenland 1994-1996. Danish Environmental Protection Agency, Environmental Project No. 356: 247-350.

Dietz, R., P. Paludan-Müller, C.T. Agger & C.O. Nielsen 1998. Cadmium, mercury, zinc and selenium in ringed seals (*Phoca hispida*) from Greenland and Svalbard. NAMMCO Scientific Publications 1: 242-273.

Fant, M.L., M. Nyman, E. Helle & E. Rudbäck 2001. Mercury, cadmium, lead and selenium in ringed seals (*Phoca hispida*) from the Baltic Sea and from Svalbard. Environmental Pollution 111: 493-501.

Ford, C.A., D.C.G. Muir, R.J. Norstrom, M. Simon & M.J. Mulvihill 1993. Development of a semi-automated method for non-ortho PCB's: Application to Canadian Arctic marine mammal tissues. Chemosphere 26: 1981-1991.

Frank, A., V. Galgan, A. Roos, M. Olsson, L.R. Petersson & A. Bignert 1992. Metal Concentrations in Seals from Swedish Waters. Ambio 21: 529-538.

Fromberg, A., T. Cederberg, G. Hilbert & A. Bückert 2000. Levels of toxaphene congeners in fish from Danish waters. Chemosphere 40: 1227-1232.

Glassmeyer, S.T., K.E. Shanks & R.A. Hites 1999. Automated toxaphene quantification by GC/MS. Anal. Chem. 71: 1448-1453.

Green, N.W. & J. Knutzon 2003. Organohalogens and metals in fish and mussels and some relationships to biological variables at reference localities in Norway. Marine Pollution Bulletin 46: 362-377.

Hansen, J.C. 1998. Pollution and Human Health. AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway: 775-844.

Hansen, J.L.S. et al. 2000. Marine områder – Status over miljøtilstanden i 1999. NOVA 2003. Danmarks Miljøundersøgelser. Faglig rapport fra DMU nr. 333. 230 pp.

Hellou, J., D. Parsons & G. Mercer 1997. Organochlorine Contaminants in the Northern Shrimp, *Pandalus borealis*, collected from the Northwest Atlantic. Marine Environmental Research 44: 99-113.

Ikonomou, M.G., S. Rayne & R.F. Addison 2002. Exponential increases of the brominated flame retardants, polybrominated diphenyl ethers, in the Canadian Arctic from 1981-2000. Environmental Science and Technology 36: 1886-1892.

Jansson, B., R. Andersson, L. Asplund, K. Litzen, K. Nylund, U. Sellstrom, U. Uvemo, C. Wahlberg, U. Wideqvist, T. Odsjo & M. Olsson 1993. Chlorinated and brominated persistent organic compounds in biological samples from the environment. Environ Toxicol Chem 12: 1163-1174.

Johansen, P., G. Asmund & F. Riget 2001. Lead contamination of seabirds harvested with lead shot – implications to human diet in Greenland. Environmental Pollution 112: 501-504.

Johansen, P., G. Asmund & F. Riget 2004a. High human exposure to lead through consumption of birds hunted with lead shot. Environmental Pollution 127: 125-129.

Johansen, P., D. Muir, G. Asmund & F. Riget 2004b. Human Exposure to Contaminants in the Traditional Greenland Diet. The Science of the Total Environment (In press).

Johansen, P., D. Muir, G. Asmund, F. Riget & R. Dietz 2003. Contaminants in subsistence animals in Greenland. *In:* Deutch, B. & J.C. Hansen (editors). AMAP Greenland and the Faroe Islands 1997-2001. Vol. 1: Human Health. Ministry of Environment. Environmental Protection Agency, Copenhagen, Denmark. 2003. Pp. 21-51.

Johansen, P., T. Pars & P. Bjerregaard 2000. Lead, cadmium, mercury and selenium intake by Greenlanders from local marine food. The Science of the Total Environment 245: 187-194.

Jørgensen, K., E.H. Larsen, A. Petersen, K.H. Lund, G. Hilbert, N.L. Andersen, T. Hallas-Møller & J.C. Larsen 2000. Kemiske forureninger. Overvågningssystem for levnedsmidler 1993-1997. Del 2. Ministeriet for Fødevarer, Landbrug og Fiskeri. Fødevaredirektoratet. 131 pp.

Keith, L.H. 1991. Environmental sampling and analysis: A practical guide. Lewis Publishers. CRC Press Inc. Boca Raton, Florida.

Law, R.J., S.J. Blake, & C.J.H. Spurrier 1999. Butyltin Compounds in Liver Tissues of Pelagic Cetaceans Stranded on the Coasts of England and Wales. Marine Pollution Bulletin 38: 1258-1261.

Luross, J.M., M. Alaee, D.B. Sergeant, C.M. Cannon, D.M. Whittle, K.R. Solomon & D.C.G. Muir 2002. Spatial distribution of polybrominated diphenyl ethers and polybrominated biphenyls in lake trout from the Laurentian Great Lakes. Chemosphere 46: 665-672.

Muir, D.C.G., E.W. Born, K. Koczansky & G.A. Stern 2000. Persistent Organochlorines in Greenland Walrus - temporal and spatial trends. Sci. Total Environ. 245: 73-86.

NLET 1997. Protocol for the fractionation and analysis of Ocs/PCB/toxaphene. National Laboratory for Environmental Testing (NLET). Protocol 97-101, 3pp.

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

Nyman, M., J. Koistinen, M.L. Fant, T. Vartiainen & E. Helle 2002. Current levels of DDT, PCB and trace elements in the Baltic ringed seals (*Phoca hispida baltica*) and grey seals (*Halichoerus grypus*). Environmental Pollution 119: 399-412.

Pars, T. 2000. Forbruget af traditionelle grønlandske fødevarer i Vestgrønland. Ph.D. Thesis, University of Copenhagen. 124 pp.

Pars, T., M. Osler & P. Bjerregaard 2001. Contemporary use of traditional and imported food among Greenland Inuit. Arctic 54: 22-31.

Riget, F., R. Dietz & P. Johansen 1997. Zinc, cadmium, mercury and selenium in Greenland fish. Medd Grønland, Biosci 48: 29.

Riget, F., R. Dietz, P. Johansen & G. Asmund 2000. Cadmium, mercury, lead and selenium in Greenland marine biota and sediments. The Science of the Total Environment 245: 3-14.

Riget, F., K. Vorkamp, P. Johansen & D.C.G. Muir 2004. Levels, spatial and temporal trends of contaminants in Greenland. The Science of the Total Environment (in press)

Stern, G.A., D.C.G. Muir, M. Segstro, R. Dietz & M.P. Heide-Jørgensen 1994. PCB's and Other Organochlorine Contaminants in White Whales (*Delphinapterus leucas*) from West Greenland: Variations with Age and Sex. Meddelelser om Grønland, Bioscience 39: 243-257.

Stokker, Y. 2003. Interlaboratory Quality Assurance for the Northern Contaminants Program. *In:* Fisk, A.T., K.E. Hobbs & D.C.G. Muir (eds.). Contaminant Levels and Trends in the Biological Environment, Canadian Arctic Contaminants Assessment Report II. Indian and Northern Affairs Canada: 111-128.

Swackhamer, D.L., J. Charles & R.A. Hites 1987. Quantitation of Toxaphene in Environmental Samples Using Negative Ion Chemical Ionization Mass Spectrometry. Anal. Chem. 59: 913-917.

Tomy, G.T., G.A. Stern, D.C.G. Muir, A.T. Fisk, C.D. Cymbalisty & J.B. Westmore 1997. Quantifying C_{10}-C_{13} polychloroalkanes in environmental samples by high resolution gas chromatography/electron capture negative ion high resolution mass spectrometry. Anal. Chem. 69: 2762-2771.

Tomy, G.T., D.C.G. Muir, G.A. Stern & J.B. Westmore 2000. Levels of C10–C13 polychloro-n-alkanes in marine mammals from the Arctic and the St. Lawrence River estuary. Environ. Sci. Technol. 34: 1615–1619.

van den Berg, M., L. Birnbaum, B.T.C. Bosveld, B. Brunström, P. Cook, M. Feeley, J. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X.R. van Leeuwen, A.K.D. Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Wærn & R. Zacharewski 1998. Toxic equivalency factors (TEF's) for PCB's, PCDD's, PCDF's for humans and wildlife. Environmental Health Perspectives 106: 775-792.

Van Oostdam, J. & N. Trembley 2003. Biological Monitoring: Human Tissue Levels of Environmental Contamintant. AMAP Assessment 2002: Human Health in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway: 31-56.

Wagemann, R., S. Innes & P.R. Richard 1997. Overview and regional temporal differences of heavy metals in Arctic whales as integrators and indicators of mercury in the Arctic. The Science of the Total Environment 186: 41-67.

Wallace, J.C., L.P. Brzuzy, S.L. Simonich, S.M. Visscher & R.A. Hites 1996. Case Study of Organochlorine Pesticides in the Indoor Air of a Home. Environ Sci Technol 30: 2730-2734.

Wells, D.E. & W. Cofino 1997. The Assessment of the QUASIMEME Laboratory Performance Studies Data Techniques and Approach. Marine Pol. Bul. 35: 18-27.

Yang, F., Y.K. Chau & R.J. Maguire 1998. Occurrence of butyltin compounds in beluga whales (*Delphinapterus leucas*). Appl. Organometal. Chem. 12: 651-656.

Appendix 1

Most important traditional diet items in West Greenland. Species marked with bold typescript were dominating in the interview survey in the Disko Bay region in 1995-96 (Pars 2000). Numbers refer to total number of tissue samples suggested for the analytical program, either metals or organochlorines.

	Muscle	Liver	Kidney	Blubber/ fat	Skin	Whole
Marine mammals						
Ringed seal	20	5	5	10		
Harp seal	20	10	5	10		
Hooded seal	10	5	5	10		
Walrus	10	5	5	10		
Beluga	20	5	5	10	5	
Narwhal	10	5	5	10	5	
Minke whale	20	5	5	10	5	
Fin whale	10	5	5	10	5	
Seabirds						
Thick-billed murre	20	10				
Common eider	10	5				
King eider	10	5				
Kittiwake	10	5				
Fish						
Spotted wolffish	5	5				
Atlantic wolffish	5	5				
Atlantic cod	10	5				
Greenland cod	5	5				
Capelin	10					10
Greenland halibut	10	5				
Redfish	5	5				
Atlantic salmon	20	10				
Arctic char	5	5				
Invertebrates						
Deep sea shrimp	20					
Snow crab	10	5				
Blue mussel						5
Iceland scallop	10					
Terrestrial species						
Caribou	5	5	5	5		
Muskox	10	5	5	5		
Sheep	10	5	5	5		
Hare	5	5	5			
Ptarmigan	5	5				
Crowberry						5
Arctic blueberry						5

Appendix 2

Overview of sampling conducted as part of the Greenland diet study.

	Region	Municipality	Year
Marine mammals			
Ringed seal	West Greenland	Qeqertarsuaq	1999
Ringed seal	East Greenland	Ittoqqortoormiit	2000-2001
Harp seal	West Greenland	Nuuk	2001
Walrus	East Greenland	Ittoqqortoormiit	2001
Beluga	West Greenland	Upernavik, Ilulissat, Uummannaq	1999-2000
Narwhal	West Greenland	Ilulissat, Uummannaq	2000
Narwhal	East Greenland	Ittoqqortoormiit	2001
Minke whale	West Greenland	Nuuk	1998
Seabirds			
Thick-billed murre	West Greenland	Nuuk	1999
Common eider	West Greenland	Nuuk	1999
King eider	West Greenland	Nuuk	1999
Kittiwake	West Greenland	Nuuk	1999
Fish			
Spotted wolffish	West Greenland	Nanortalik	2001
Atlantic cod	West Greenland	Nuuk	1999
Greenland cod	West Greenland	Nuuk	1999
Capelin	West Greenland	Nuuk	1999
Greenland halibut	West Greenland	Nuuk	1999
Redfish	West Greenland	Nuuk	1999
Atlantic salmon	West Greenland	Nuuk	1999
Arctic char	West Greenland	Nuuk	1999
Invertebrates			
Deep sea shrimp	West Greenland	Nuuk	1999
Snow crab	West Greenland	Qeqertarsuaq	1999
Blue mussel	West Greenland	Qeqertarsuaq	1999
Iceland scallop	West Greenland	Qeqertarsuaq	2000
Terrestrial species			
Caribou	West Greenland	Qaqortoq	2000
Muskox	West Greenland	Kangerlussuaq	1999
Sheep	West Greenland	Qaqortoq	1999
Hare	West Greenland	Qeqertarsuaq	1999
Ptarmigan	West Greenland	Nuuk	1999
Crowberry	West Greenland	Qaqortoq	2000
Arctic blueberry	West Greenland	Qaqortoq	2000

Appendix 3

Average blank results and MDLs[1]

Sample Info	Mean	MDL	Mean	MDL	Mean	MDL	Average mean	Average MDL
Year Analyzed	2002	2002	2001	2001	1999-00	1999-00		
# Blanks/year	10		19		15		44	
Parameters								
1,3-DCB	0.001	0.001	0.043	0.175	0.500	3.193	0.181	1.123
1,4-DCB	4.403	20.593	1.335	2.994	2.435	7.141	2.724	10.243
1,2-DCB	0.072	0.379	0.066	0.441	0.259	1.444	0.132	0.755
1,3,5-TCB	0.007	0.029	0.008	0.051	0.004	0.022	0.006	0.034
1,2,4-TCB	0.002	0.010	0.001	0.006	0.004	0.026	0.002	0.014
1,2,3-TCB	0.015	0.053	0.013	0.048	0.137	0.856	0.055	0.319
Hexachlorobutadiene	0.065	0.345	0.086	0.368	0.051	0.435	0.067	0.383
1,2,3,4-TTCB	0.003	0.008	0.000	0.001	0.018	0.042	0.007	0.017
PECB	0.001	0.005	0.002	0.006	0.007	0.034	0.003	0.015
a-HCH	0.006	0.009	0.005	0.012	0.008	0.018	0.006	0.013
HCB	0.002	0.005	0.005	0.022	0.003	0.009	0.003	0.012
Pentachloroanisole	0.004	0.011	0.003	0.011	0.004	0.015	0.004	0.012
b-HCH	0.001	0.001	0.000	0.000	0.001	0.006	0.001	0.002
g-HCH(Lindane)	0.004	0.010	0.012	0.051	0.009	0.026	0.008	0.029
Heptachlor	0.001	0.001	0.002	0.013	0.011	0.091	0.005	0.035
Aldrin	0.005	0.026	0.023	0.107	0.025	0.148	0.018	0.093
Octachlorostyrene	0.000	0.000	0.000	0.000	0.001	0.005	0.000	0.002
Heptachlor epoxide	0.000	0.000	0.001	0.004	0.001	0.003	0.001	0.003
Oxychlordane	0.004	0.014	0.001	0.006	0.002	0.008	0.002	0.009
g-Chlordane	0.002	0.007	0.002	0.009	0.062	0.387	0.022	0.134
a-Endosulfan	0.004	0.010	0.007	0.017	0.013	0.037	0.008	0.021
o,p-DDE	0.005	0.018	0.002	0.008	0.003	0.019	0.003	0.015
a-Chlordane	0.002	0.005	0.004	0.021	0.008	0.025	0.005	0.017
trans-Nonachlor	0.004	0.011	0.003	0.009	0.005	0.021	0.004	0.014
Dieldrin	0.010	0.021	0.008	0.020	0.011	0.024	0.010	0.022
p,p-DDE	0.052	0.171	0.011	0.040	0.046	0.139	0.036	0.117
o,p-DDD	0.000	0.000	0.001	0.007	0.027	0.272	0.009	0.093
Endrin	0.033	0.096	0.017	0.057	0.020	0.064	0.023	0.072
b-Endosulfan	0.011	0.038	0.004	0.011	0.019	0.116	0.011	0.055
cis-Nonachlor	0.001	0.004	0.002	0.006	0.004	0.032	0.002	0.014
p,p-DDD	0.002	0.008	0.001	0.007	0.001	0.004	0.001	0.006
o,p-DDT	0.011	0.061	0.003	0.013	0.005	0.024	0.006	0.033
p,p-DDT	0.044	0.152	0.009	0.075	0.009	0.057	0.021	0.095
Methoxychlor	0.025	0.086	0.012	0.087	0.014	0.085	0.017	0.086
Mirex	0.000	0.000	0.001	0.006	0.002	0.011	0.001	0.006

Sample Info	Mean	MDL	Mean	MDL	Mean	MDL	Average mean	Average MDL
Year Analyzed	2002	2002	2001	2001	1999-00	1999-00		
# Blanks/year	10		19		15		44	
Parameters								
BZ Number								
1	0.004	0.022	0.000	0.000	0.000	0.001	0.002	0.008
3	0.007	0.007	0.115	0.555	0.143	0.926	0.088	0.496
4-10	0.004	0.025	0.001	0.005	0.004	0.023	0.003	0.018
7-9	0.004	0.012	0.002	0.010	0.003	0.015	0.003	0.012
6	0.002	0.011	0.001	0.005	0.005	0.038	0.003	0.018
8-5	0.035	0.059	0.019	0.054	0.033	0.088	0.029	0.067
19	0.004	0.014	0.002	0.010	0.005	0.028	0.004	0.017
12-13	0.009	0.034	0.008	0.051	0.027	0.125	0.015	0.070
18	0.059	0.111	0.051	0.148	0.074	0.183	0.061	0.147
15-17	0.033	0.052	0.020	0.050	0.036	0.086	0.030	0.063
24-27	0.001	0.004	0.000	0.001	0.003	0.012	0.001	0.006
16-32	0.032	0.048	0.015	0.035	0.027	0.052	0.025	0.045
54-29	0.006	0.020	0.003	0.013	0.004	0.017	0.004	0.017
26	0.021	0.061	0.024	0.069	0.049	0.197	0.031	0.109
25	0.002	0.010	0.001	0.002	0.002	0.009	0.002	0.007
31-28	0.219	0.332	0.144	0.301	0.148	0.427	0.170	0.353
50	0.007	0.007	0.000	0.000	0.017	0.105	0.008	0.038
33-20	0.045	0.070	0.032	0.068	0.057	0.106	0.044	0.082
53	0.020	0.031	0.011	0.030	0.020	0.044	0.017	0.035
51	0.002	0.005	0.005	0.032	0.005	0.016	0.004	0.018
22	0.024	0.036	0.015	0.026	0.026	0.053	0.022	0.038
45	0.015	0.024	0.009	0.022	0.013	0.029	0.012	0.025
46	0.007	0.012	0.002	0.009	0.005	0.014	0.005	0.012
52	0.281	0.466	0.170	0.274	0.247	0.455	0.233	0.398
43	0.001	0.001	0.001	0.002	0.007	0.046	0.003	0.016
49	0.102	0.176	0.059	0.100	0.080	0.174	0.081	0.150
47-48	0.056	0.095	0.049	0.155	0.061	0.125	0.055	0.125
44	0.154	0.251	0.091	0.149	0.134	0.236	0.126	0.212
59	0.003	0.011	0.001	0.005	0.001	0.007	0.002	0.007
42	0.050	0.090	0.027	0.052	0.045	0.091	0.041	0.078
71-41-64	0.131	0.528	0.067	0.156	0.114	0.372	0.104	0.352
40	0.021	0.035	0.011	0.020	0.018	0.035	0.017	0.030
100	0.001	0.005	0.001	0.002	0.002	0.008	0.001	0.005
63	0.003	0.009	0.001	0.004	0.003	0.010	0.003	0.008
74	0.062	0.118	0.037	0.063	0.057	0.103	0.052	0.095

Sample Info	Mean	MDL	Mean	MDL	Mean	MDL	Average mean	Average MDL
Year Analyzed	2002	2002	2001	2001	1999-00	1999-00		
# Blanks/year	10		19		15		44	
Parameters								
70-76-98	0.185	0.334	0.115	0.193	0.129	0.344	0.143	0.290
66	0.071	0.144	0.043	0.082	0.062	0.134	0.059	0.120
101	0.228	0.418	0.138	0.240	0.222	0.394	0.196	0.351
99	0.103	0.215	0.055	0.098	0.090	0.161	0.083	0.158
119	0.002	0.006	0.001	0.004	0.003	0.008	0.002	0.006
83	0.025	0.081	0.013	0.055	0.024	0.083	0.021	0.073
97	0.070	0.130	0.044	0.082	0.074	0.130	0.063	0.114
81-87	0.131	0.246	0.076	0.139	0.134	0.247	0.114	0.211
85	0.032	0.093	0.025	0.069	0.030	0.100	0.029	0.088
136	0.033	0.058	0.020	0.038	0.036	0.070	0.030	0.055
110	0.165	0.299	0.104	0.189	0.180	0.329	0.150	0.272
82	0.024	0.045	0.015	0.030	0.025	0.046	0.021	0.040
151	0.040	0.073	0.024	0.043	0.042	0.085	0.035	0.067
135-144	0.035	0.060	0.021	0.037	0.050	0.131	0.035	0.076
147	0.004	0.010	0.002	0.006	0.005	0.016	0.004	0.011
107	0.007	0.015	0.004	0.010	0.009	0.023	0.007	0.016
149	0.125	0.228	0.077	0.140	0.144	0.276	0.115	0.215
118	0.093	0.168	0.063	0.120	0.108	0.199	0.088	0.163
133	0.008	0.017	0.006	0.012	0.011	0.023	0.008	0.018
114	0.003	0.007	0.001	0.004	0.002	0.006	0.002	0.006
134-131	0.008	0.019	0.002	0.006	0.006	0.017	0.005	0.014
146	0.013	0.024	0.008	0.017	0.017	0.034	0.012	0.025
153	0.087	0.159	0.060	0.116	0.109	0.214	0.085	0.163
132	0.048	0.092	0.032	0.109	0.051	0.116	0.044	0.106
105	0.032	0.069	0.019	0.045	0.033	0.069	0.028	0.061
141	0.019	0.039	0.012	0.023	0.025	0.053	0.019	0.038
179	0.045	0.108	0.012	0.027	0.022	0.045	0.026	0.060
137	0.004	0.011	0.003	0.007	0.005	0.011	0.004	0.010
176	0.006	0.015	0.003	0.008	0.005	0.013	0.005	0.012
130	0.004	0.009	0.002	0.006	0.005	0.012	0.004	0.009
163-138	0.314	0.944	0.117	0.295	0.109	0.289	0.180	0.509
158	0.011	0.022	0.006	0.014	0.013	0.031	0.010	0.022
129	0.004	0.010	0.002	0.005	0.005	0.011	0.004	0.008
178	0.005	0.012	0.003	0.008	0.006	0.014	0.005	0.011
175	0.000	0.000	0.000	0.000	0.001	0.003	0.000	0.001
182-187	0.029	0.055	0.020	0.040	0.037	0.076	0.029	0.057
183	0.010	0.023	0.006	0.014	0.018	0.036	0.011	0.024
128	0.011	0.022	0.008	0.017	0.015	0.029	0.011	0.023

Sample Info	Mean	MDL	Mean	MDL	Mean	MDL	Average mean	Average MDL
Year Analyzed	2002	2002	2001	2001	1999-00	1999-00		
# Blanks/year	10		19		15		44	
Parameters								
167	0.007	0.018	0.001	0.003	0.003	0.012	0.004	0.011
185	0.003	0.008	0.002	0.004	0.004	0.010	0.003	0.008
95	0.264	0.421	0.160	0.257	0.245	0.457	0.223	0.378
91	0.046	0.084	0.025	0.053	0.048	0.100	0.040	0.079
55	0.000	0.000	0.000	0.001	0.003	0.031	0.001	0.011
56-60	0.069	0.117	0.043	0.077	0.129	0.471	0.080	0.222
92	0.041	0.078	0.027	0.051	0.050	0.096	0.039	0.075
84	0.086	0.147	0.050	0.085	0.087	0.151	0.074	0.128
174	0.022	0.041	0.014	0.027	0.030	0.061	0.022	0.043
177	0.012	0.025	0.007	0.015	0.012	0.029	0.010	0.023
202-171	0.009	0.018	0.005	0.013	0.008	0.021	0.007	0.018
156	0.004	0.008	0.002	0.007	0.005	0.012	0.004	0.009
173	0.002	0.006	0.000	0.001	0.000	0.001	0.001	0.003
157-201 (**200*)	0.001	0.001	0.000	0.000	0.001	0.004	0.001	0.002
172	0.001	0.002	0.000	0.001	0.027	0.271	0.009	0.091
197	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
180	0.032	0.073	0.024	0.044	0.034	0.070	0.030	0.062
193	0.003	0.009	0.003	0.020	0.002	0.008	0.003	0.013
191	0.002	0.005	0.001	0.002	0.000	0.002	0.001	0.003
201(**199*)	0.001	0.004	0.000	0.001	0.002	0.006	0.001	0.004
170-190	0.011	0.022	0.006	0.014	0.011	0.029	0.009	0.022
198	0.001	0.001	0.000	0.000	0.001	0.003	0.000	0.001
200 (**201*)	0.006	0.015	0.004	0.009	0.007	0.017	0.006	0.014
203-196	0.007	0.017	0.004	0.009	0.008	0.019	0.006	0.015
189	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001
95	0.264	0.421	0.160	0.257	0.245	0.457	0.223	0.378
91	0.046	0.084	0.025	0.053	0.048	0.100	0.040	0.079
55	0.000	0.000	0.000	0.001	0.003	0.031	0.001	0.011
56-60	0.069	0.117	0.043	0.077	0.129	0.471	0.080	0.222
92	0.041	0.078	0.027	0.051	0.050	0.096	0.039	0.075
84	0.086	0.147	0.050	0.085	0.087	0.151	0.074	0.128
208-195	0.003	0.010	0.001	0.003	0.002	0.007	0.002	0.007
207	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
194	0.003	0.006	0.001	0.004	0.002	0.006	0.002	0.005
205	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.001
206	0.001	0.004	0.000	0.001	0.001	0.002	0.001	0.003
209	0.002	0.005	0.001	0.008	0.001	0.002	0.001	0.005
sPCB	4.09	6.72	2.44	4.26	3.92	9.11	3.485	6.696
s10PCB	1.29	2.28	0.73	1.28	1.02	2.13	1.012	1.897
sDDT	0.11	0.34	0.02	0.06	0.09	0.51	0.075	0.306
sCHL	0.01	0.03	0.01	0.04	0.09	0.57	0.041	0.212
sHCH	0.01	0.02	0.01	0.04	0.02	0.05	0.013	0.035
sCBz	0.01	0.01	0.01	0.03	0.03	0.09	0.014	0.043

Sample Info	Mean	MDL	Mean	MDL	Mean	MDL	Average mean	Average MDL
Year Analyzed	2002	2002	2001	2001	1999-00	1999-00		
# Blanks/year	10		19		15		44	
Parameters								
smono-di	0.07	0.16	0.16	0.67	0.22	1.22	0.147	0.680
s-tri	0.44	0.66	0.29	0.61	0.43	1.17	0.386	0.811
s-tetra	0.99	1.66	0.57	1.01	0.89	2.00	0.817	1.557
s-penta	1.61	2.86	1.00	1.86	1.63	3.45	1.411	2.722
s-hexa	0.77	1.56	0.41	0.76	0.65	1.43	0.611	1.250
s-hepta	0.20	0.34	0.11	0.22	0.22	0.71	0.177	0.422
s-octa	0.02	0.04	0.01	0.02	0.02	0.06	0.017	0.041
s-nona	0.01	0.02	0.00	0.01	0.00	0.01	0.004	0.013

[1]Blanks are based on a 10 g sample. MDL = blank + 2SD of the blank values. Average blank and MDL are the averages for the 3 years.

[2] PCB numbering differs from BZ numbers for these congeners and is shown in italics.

Appendix 4

Cd, Hg and Se concentrations (µg/g wet wt) in species from West Greenland.

		Tissue	Cd n	Cd mean	Cd sd	Hg n	Hg mean	Hg sd	Se n	Se mean	Se sd
Terrestrial	Crowberry	Berry	5	< 0.015	-	5	< 0.005	-	5	< 0.2	-
	Arctic blueberry	Berry	4	0.019	0.009	4	< 0.005	-	4	< 0.2	-
	Ptarmigan	Muscle	10	0.076	0.110	10	< 0.005	-	10	< 0.2	-
		Liver	32	2.35	2.32	32	0.030	0.016	32	< 0.2	-
	Arctic hare	Muscle	5	< 0.015	-	5	< 0.005	-	5	< 0.2	-
		Liver	5	0.186	0.021	5	0.029	0.009	5	< 0.2	-
		Kidney	5	3.81	1.71	5	0.052	0.007	5	0.841	0.174
	Caribou	Muscle	10	< 0.015	-	10	0.008	0.008	124	< 0.2	-
		Liver	38	0.387	0.319	38	0.090	0.099	38	< 0.2	-
		Kidney	43	1.43	1.00	43	0.097	0.043	43	0.714	0.159
		Fat	5	< 0.015	-	5	< 0.005	-	5	< 0.2	-
	Muskox	Muscle	29	< 0.015	-	29	< 0.005	-	8	< 0.2	-
		Liver	24	0.044	0.015	24	0.024	0.011	4	< 0.2	-
		Kidney	24	0.229	0.140	24	0.064	0.014	4	0.757	0.246
		Fat	24	< 0.015	-	24	< 0.005	-	4	< 0.2	-
	Lamb	Muscle	10	< 0.015	-	10	< 0.005	-	10	< 0.2	-
		Liver	5	0.108	0.059	5	< 0.005	-	5	< 0.2	-
		Kidney	5	0.200	0.081	5	0.012	0.011	5	0.707	0.165
		Fat	5	< 0.015	-	5	< 0.005	-	5	< 0.2	-
Marine invertebrates	Deep sea shrimp	Muscle	2	0.022	0.021	11	0.050	0.016	11	< 0.2	-
	Queen crab	Muscle	10	0.034	0.033	10	0.097	0.066	10	0.599	0.157
		"Liver"	5	5.06	1.71	5	0.075	0.023	5	3.27	1.15
	Blue mussel	Soft parts	3	1.48	0.692	3	0.015	0.005	3	0.464	0.167
	Iceland scallop	Muscle	8	2.04	0.648	8	0.022	0.002	8	< 0.2	-
Marine fish	Arctic char	Muscle				49	0.044	0.014			
		Liver	4	0.092	0.036	4	0.018	0.004	4	1.48	0.291
	Atlantic salmon	Muscle	20	< 0.015	-	20	0.040	0.011	20	0.265	0.045
		Liver	10	0.190	0.040	10	0.043	0.006	10	7.93	1.27
	Capelin	Muscle	20	< 0.015	-	20	0.009	0.002	20	< 0.2	-
		Whole	20	0.041	0.013	10	0.007	0.002	10	< 0.2	-
	Atlantic cod	Muscle	9	< 0.015	-	9	0.014	0.001	10	0.293	0.018
		Liver	5	0.049	0.024	5	0.007	0.002	5	0.779	0.146
	Greenland cod	Muscle	10	< 0.015	-	10	0.046	0.034	10	< 0.2	-
		Liver	5	0.334	0.132	5	0.023	0.008	5	1.47	0.791
	Redfish	Muscle	8	< 0.015	-	8	0.025	0.018	8	0.242	0.107
		Liver	8	1.36	0.964	8	0.025	0.007	8	2.45	1.48
	Atlantic wolffish	Muscle	3	< 0.015	-	3	0.045	0.017	1	0.303	-
		Liver	3	0.659	0.822	3	0.026	0.012	1	3.33	-
	Spotted wolffish	Muscle	23	< 0.015	-	10	0.085	0.028	10	0.336	0.104
		Liver	5	0.532	0.383	5	0.057	0.022	5	2.38	0.663
	Greenland halibut	Muscle	10	< 0.015	-	10	0.154	0.134	10	0.287	0.150
		Liver	5	1.75	1.14	5	0.152	0.152	5	1.49	0.759

		Tissue	Cd n	Cd mean	Cd sd	Hg n	Hg mean	Hg sd	Se n	Se mean	Se sd
Seabirds	Thick-billed murre	Muscle	20	0.089	0.119	20	0.076	0.021	20	0.538	0.230
		Liver	10	4.99	3.96	10	0.227	0.085	10	1.07	0.108
	Common eider	Muscle	20	0.188	0.275	20	0.151	0.080	20	1.06	0.822
		Liver	20	3.22	1.98	20	0.872	0.559	20	7.70	5.20
	King eider	Muscle	21	0.361	0.387	21	0.130	0.073	21	0.839	0.591
		Liver	21	5.81	4.13	21	0.589	0.397	21	7.71	6.05
	Kittiwake	Muscle	12	0.421	0.430	12	0.117	0.107	12	2.40	2.01
		Liver	12	6.65	4.59	12	0.462	0.413	12	8.29	6.97
Seals	Ringed seal	Muscle	53	0.252	0.223	78	0.292	0.269	22	0.253	0.179
		Liver	80	10.8	10.2	80	2.07	3.13	80	2.12	1.96
		Kidney	44	40.8	45.0	44	0.993	0.844	40	2.68	0.822
		Blubber	10	< 0.015	-	8	< 0.005	-	10	< 0.2	-
	Harp seal	Muscle	47	0.067	0.081	28	0.228	0.119	23	0.339	0.080
		Liver	47	4.00	2.70	10	1.41	1.33	10	3.13	1.65
		Kidney	49	21.9	17.1	8	0.755	0.616	7	1.33	1.16
		Blubber	10	< 0.015	-	10	0.008	0.005	10	< 0.2	-
	Hooded seal	Muscle	42	0.060	0.049	23	0.592	0.396	2	0.355	0.149
		Liver	27	6.11	8.73	2	64.9	38.1	2	21.2	12.4
		Kidney	42	29.6	31.7	2	3.59	0.438	2	2.27	0.219
Whales	Minke whale	Muscle	40	< 0.015	-	40	0.080	0.059	40	< 0.2	-
		Liver	35	0.970	0.648	35	0.266	0.322	35	1.34	0.641
		Kidney	38	3.99	2.57	38	0.183	0.175	38	1.21	0.266
		Blubber	5	< 0.015	-	5	0.012	0.018	5	< 0.2	-
		Muktuk	4	< 0.015	-	4	0.031	0.021	4	6.28	3.73
	Beluga	Muscle	40	0.031	0.028	39	0.585	0.466	39	0.245	0.261
		Liver	39	2.38	1.77	39	4.04	6.47	39	4.42	4.11
		Kidney	35	11.0	6.62	36	1.78	1.91	36	2.30	0.933
		Blubber	5	< 0.015	-	5	0.020	0.016	5	< 0.2	-
		Muktuk	5	< 0.015	-	5	0.291	0.159	5	5.68	2.27
	Narwhal	Muscle	53	0.160	0.161	53	0.896	0.357	53	0.343	0.036
		Liver	53	20.9	17.2	53	6.49	4.98	53	3.96	2.05
		Kidney	52	49.4	24.6	52	1.40	1.33	52	2.54	0.821
		Blubber	5	< 0.015	-	5	0.017	0.008	5	< 0.2	-
		Muktuk	5	0.019	0.016	5	0.431	0.146	5	5.26	0.932

Appendix 5

Concentrations of PCBs (ng/g wet weight) in biota samples from West Greenland, except marine mammals from East Greenland at the end of the table. Samples collected between 1999 and 2001. For explanation of CB groups see below the table.

Species	Tissue	N	Stat	% Lipid	sPCB	s10PCB	smono-di	s-tri	s-tetra	s-penta	s-hexa	s-hepta	s-octa	s-nona
Terrestrial														
Ptarmigan	Muscle	5	Mean	3.8	9.02	1.76	0.41	3.51	2.54	1.44	0.97	0.15	0.01	< 0.01
			SD	0.7	4.16	0.62	0.45	3.08	0.64	0.40	0.42	0.04	0.01	
	Liver	5	Mean	6.8	18.3	1.55	0.70	5.17	9.57	1.83	0.75	0.22	0.04	< 0.01
			SD	0.5	13.6	1.12	0.28	9.08	5.23	1.00	0.17	0.07	0.01	
Arctic hare	Muscle	5	Mean	3.8	1.55	0.11	0.03	0.90	0.54	0.04	0.03	< 0.01	0.01	< 0.01
			SD	2.7	1.08	0.07	0.01	0.66	1.03	0.06	0.03		< 0.01	
	Liver	5	Mean	4.1	0.44	0.10	0.01	0.19	0.07	0.13	0.02	0.03	0.01	< 0.01
			SD	0.5	0.14	0.04	< 0.01	0.09	0.03	0.05	< 0.01	0.02	< 0.01	
	Kidney	5	Mean	32.5	6.09	0.80	0.11	2.73	1.95	0.55	0.44	0.23	0.06	0.03
			SD	18.8	3.78	0.76	0.11	3.11	1.97	0.52	0.37	0.21	0.05	0.02
Caribou	Muscle	5	Mean	1.5	0.96	0.27	0.04	0.18	0.22	0.32	0.13	0.05	0.02	0.01
			SD	0.5	0.59	0.16	0.02	0.11	0.17	0.22	0.08	0.01	< 0.01	< 0.01
	Liver	5	Mean	7.4	0.96	0.10	0.03	0.07	0.53	0.15	0.07	0.08	0.02	0.01
			SD	0.7	1.52	0.14	0.02	0.06	1.10	0.24	0.12	0.05	0.01	0.01
	Kidney	5	Mean	3.5	0.89	0.19	0.03	0.06	0.22	0.36	0.12	0.07	0.02	0.01
			SD	0.2	0.88	0.23	0.02	0.05	0.22	0.41	0.14	0.08	0.01	< 0.01
	Fat	5	Mean	49.9	5.23	1.73	0.05	0.89	1.64	1.49	0.60	0.31	0.14	0.11
			SD	28.7	5.48	1.36	0.03	0.89	2.28	1.95	0.45	0.14	0.11	0.06
Muskox	Muscle	5	Mean	1.9	0.63	0.20	0.02	0.27	0.11	0.15	0.05	0.02	0.01	< 0.01
			SD	0.4	0.25	0.06	0.02	0.10	0.07	0.13	0.04	0.01	< 0.01	
	Liver	5	Mean	10.3	2.22	0.83	0.17	0.34	0.41	0.49	0.55	0.20	0.03	0.02
			SD	1.8	0.44	0.21	0.10	0.13	0.26	0.16	0.11	0.05	0.01	< 0.01
	Kidney	5	Mean	3.2	1.08	0.40	0.03	0.06	0.23	0.33	0.39	0.03	0.01	< 0.01
			SD	0.6	0.96	0.41	0.03	0.05	0.16	0.38	0.47	0.03	0.02	
	Fat	5	Mean	85.5	5.58	2.79	0.06	0.66	1.01	1.44	1.65	0.61	0.11	0.06
			SD	10.7	4.53	2.05	0.05	0.54	0.83	1.03	1.42	0.54	0.10	0.05
Lamb	Muscle	5	Mean	12.3	1.19	0.71	0.01	0.23	0.17	0.11	0.43	0.20	0.03	0.01
			SD	9.8	0.81	0.39	0.01	0.13	0.26	0.20	0.24	0.11	0.01	0.01
	Liver	5	Mean	9.6	5.33	2.04	0.03	0.32	1.29	1.77	1.36	0.49	0.05	0.02
			SD	2.0	7.45	1.93	0.04	0.50	2.27	3.37	0.98	0.32	0.03	0.01
	Kidney	5	Mean	4.2	2.31	0.51	0.27	0.32	0.66	0.68	0.29	0.07	0.01	0.01
			SD	0.4	1.82	0.33	0.36	0.31	0.53	0.42	0.22	0.05	< 0.01	< 0.01
	Fat	5	Mean	90.2	7.13	1.85	< 0.01	0.17	4.68	0.28	1.29	0.59	0.09	0.02
			SD	3.1	10.9	0.75		0.06	9.88	0.10	0.60	0.38	0.04	0.01

Species	Tissue	N	Stat	% Lipid	sPCB	s10PCB	smono-di	s-tri	s-tetra	s-penta	s-hexa	s-hepta	s-octa	s-nona
Marine invertebrates														
Deep sea shrimp	Muscle	11	Mean	0.9	1.85	0.75	0.02	0.19	0.41	0.74	0.38	0.10	0.02	< 0.01
			SD	0.1	2.97	0.87	0.01	0.24	0.83	1.14	0.60	0.18	0.02	
Queen crab	Muscle	5	Mean	0.7	3.92	1.99	0.08	0.11	0.14	1.11	1.61	0.72	0.12	0.03
			SD	0.2	2.52	1.34	0.10	0.07	0.06	0.57	1.10	0.59	0.09	0.01
	"Liver"	5	Mean	6.0	69.5	41.2	0.19	1.90	3.45	12.6	33.9	14.4	2.55	0.48
			SD	5.6	75.9	44.8	0.21	2.00	3.51	13.3	37.4	16.0	3.07	0.63
Iceland scallop	Muscle	8	Mean	0.4	2.19	0.73	0.04	0.36	0.64	0.60	0.30	0.14	0.06	0.04
			SD	0.1	3.87	1.10	0.02	0.64	1.49	1.29	0.37	0.16	0.09	0.06
Marine fish														
Arctic char	Muscle	5	Mean	3.5	1.98	0.63	0.07	0.49	0.13	0.58	0.50	0.17	0.03	0.01
			SD	2.4	1.37	0.52	0.04	0.39	0.07	0.46	0.40	0.13	0.01	0.01
	Liver	5	Mean	16.7	15.53	5.27	0.47	1.65	0.84	5.56	5.01	1.68	0.24	0.09
			SD	0.7	6.08	2.22	0.31	1.68	0.80	2.72	2.28	0.76	0.09	0.04
Atlantic salmon	Muscle	10	Mean	10.9	25.1	8.20	0.51	2.69	3.94	9.20	6.40	2.12	0.21	0.03
			SD	4.8	11.9	3.82	0.25	1.93	1.30	4.91	3.14	0.95	0.13	0.01
	Liver	5	Mean	8.8	6.99	2.10	0.77	0.71	0.79	2.30	1.58	0.73	0.08	0.06
			SD	1.6	5.39	1.83	0.57	0.96	1.10	1.53	1.04	0.38	0.07	0.04
Capelin	Muscle	10	Mean	1.8	6.38	1.89	0.97	0.51	1.28	2.18	1.15	0.27	0.01	< 0.01
			SD	0.7	1.45	0.41	0.28	0.14	0.29	0.55	0.29	0.07	0.01	
Atlantic cod	Muscle	9	Mean	0.7	4.20	1.48	0.38	0.49	1.00	1.67	0.50	0.14	0.01	< 0.01
			SD	0.1	3.30	1.87	0.25	0.64	0.71	1.66	0.39	0.09	0.01	
	Liver	5	Mean	59.3	123	38.9	7.78	13.8	18.7	41.6	31.5	8.19	0.94	0.15
			SD	3.7	57.9	20.4	1.59	5.60	12.9	25.4	17.5	4.75	0.51	0.08
Greenland cod	Muscle	5	Mean	0.7	1.65	0.71	0.34	0.18	0.21	0.24	0.56	0.07	0.03	0.01
			SD	0.1	0.88	0.36	0.12	0.20	0.26	0.36	0.39	0.07	0.02	< 0.01
	Liver	5	Mean	38.3	66.8	22.9	5.24	11.54	6.49	20.5	17.8	4.62	0.54	0.10
			SD	7.1	20.7	8.90	3.56	7.05	2.05	8.23	8.29	2.52	0.26	0.05
Redfish	Muscle	5	Mean	2.5	9.58	3.22	0.33	0.86	1.32	3.66	2.51	0.80	0.07	0.02
			SD	1.6	6.06	2.05	0.21	0.58	0.74	2.41	1.77	0.56	0.03	0.01
Spotted wolffish	Muscle	5	Mean	1.6	12.6	4.44	0.12	0.66	2.24	5.09	3.43	0.92	0.13	0.06
			SD	0.7	15.0	4.90	0.15	0.84	3.47	6.26	3.60	0.60	0.06	0.03
	Liver	5	Mean	19.2	59.0	23.6	0.44	1.62	5.19	22.1	19.8	8.04	1.19	0.62
			SD	6.3	20.3	6.86	0.17	0.49	1.73	9.79	6.77	1.83	0.23	0.23
Greenland halibut	Muscle	10	Mean	9.4	52.8	18.1	0.64	3.42	8.20	21.2	13.1	5.51	0.59	0.20
			SD	5.4	66.4	24.3	0.93	4.00	9.34	26.9	16.9	8.44	0.86	0.25
	Liver	5	Mean	33.9	1302	492	3.35	39.4	156	457	403	198	35.6	10.3
			SD	10.2	2378	921	3.97	53.3	265	820	761	386	72.8	21.0

Species	Tissue	N	Stat	% Lipid	sPCB	s10PCB	smono-di	s-tri	s-tetra	s-penta	s-hexa	s-hepta	s-octa	s-nona
Seabirds														
Thick-billed murre	Muscle	19	Mean	3.5	19.7	8.43	0.23	1.22	2.11	5.65	6.68	3.10	0.51	0.14
			SD	0.4	11.1	5.03	0.24	0.93	1.16	2.79	4.11	2.52	0.62	0.17
	Liver	5	Mean	5.4	20.2	8.81	0.18	1.20	2.38	6.45	6.66	2.85	0.39	0.11
			SD	0.7	6.10	2.95	0.11	0.63	0.54	1.74	2.60	1.16	0.26	0.08
Common eider	Muscle	10	Mean	3.9	23.0	12.9	0.04	0.75	1.85	5.42	9.52	4.67	0.65	0.13
			SD	0.8	31.2	20.0	0.08	0.91	1.04	4.09	14.8	9.35	1.48	0.27
	Liver	5	Mean	5.1	25.5	13.2	0.08	0.99	1.75	5.44	10.8	5.77	0.54	0.10
			SD	0.3	17.2	11.0	0.04	0.45	0.48	1.95	8.63	6.09	0.74	0.13
King eider	Muscle	10	Mean	3.9	14.5	6.46	0.41	2.58	1.63	3.23	4.56	1.74	0.27	0.09
			SD	1.2	5.55	2.33	0.38	1.63	0.82	1.16	1.89	0.77	0.17	0.06
	Liver	5	Mean	5.2	27.3	8.71	0.07	1.24	10.9	5.50	6.41	2.78	0.34	0.09
			SD	0.3	10.7	2.77	0.07	0.24	9.61	1.34	2.02	1.01	0.12	0.05
Kittiwake	Muscle	9	Mean	14.3	191	98.1	2.17	4.85	10.5	37.8	74.8	49.2	9.51	2.27
			SD	5.4	140	77.0	0.48	1.04	3.99	18.6	57.1	51.9	11.2	2.71
	Liver	5	Mean	6.9	126	73.8	0.63	1.42	5.35	19.2	58.0	33.0	6.37	1.71
			SD	2.3	125	73.7	0.59	1.07	4.46	17.2	58.6	34.8	6.89	1.86
Marine mammals West Greenland														
Ringed seal	Muscle	20	Mean	5.4	26.7	12.0	0.17	3.87	4.57	9.16	6.86	1.86	0.18	0.04
			SD	6.4	28.2	15.3	0.22	3.11	4.06	10.7	8.87	2.29	0.22	0.04
	Liver	5	Mean	5.5	50.7	8.57	0.10	1.90	33.2	8.19	5.36	1.75	0.22	0.05
			SD	0.6	51.5	1.50	0.12	0.54	52.0	2.11	0.99	0.47	0.05	0.02
	Kidney	5	Mean	3.8	10.2	2.59	0.13	0.96	4.78	2.45	1.44	0.37	0.05	0.01
			SD	0.5	2.80	0.17	0.07	0.34	2.23	0.43	0.08	0.03	0.01	0.01
	Blubber	10	Mean	92.2	549	287	1.40	42.4	62.1	205	183	49.5	4.60	0.75
			SD	4.9	231	132	0.34	12.8	24.1	101	77.0	19.14	1.91	0.37
Harp seal	Muscle	20	Mean	2.5	10.2	4.14	0.34	1.33	1.02	2.90	3.23	1.17	0.15	0.05
			SD	2.4	11.4	5.31	0.37	1.21	1.22	3.54	4.45	1.37	0.14	0.03
	Liver	7	Mean	6.9	14.1	5.19	0.21	0.37	1.15	3.98	5.01	2.90	0.35	0.11
			SD	1.7	5.77	2.24	0.18	0.40	0.43	1.33	2.45	1.33	0.18	0.05
	Kidney	7	Mean	3.1	1.91	0.67	0.11	0.13	0.17	0.54	0.60	0.29	0.05	0.02
			SD	0.3	1.34	0.54	0.09	0.07	0.23	0.41	0.50	0.25	0.03	0.01
	Blubber	12	Mean	88.9	539	252	1.90	11.7	47.9	163	217	82.5	11.5	3.39
			SD	2.3	450	200	1.54	11.7	52.4	156	178	63.3	9.93	3.38
Minke whale	Muscle	20	Mean	1.8	15.8	5.50	0.25	1.31	1.76	4.76	5.33	2.10	0.22	0.05
			SD	1.3	14.6	5.44	0.24	1.05	1.51	3.78	6.51	2.78	0.25	0.04
	Liver	5	Mean	6.7	47.8	17.0	0.20	1.44	5.76	15.6	16.1	7.36	1.04	0.30
			SD	1.6	12.0	4.44	0.11	0.58	2.20	5.50	3.86	1.44	0.26	0.11
	Kidney	5	Mean	3.6	24.1	6.35	0.15	1.31	8.84	5.74	5.25	2.39	0.31	0.10
			SD	0.7	21.0	3.40	0.07	0.63	14.41	3.11	3.28	1.44	0.20	0.05
	Blubber	18	Mean	69.6	3137	1055	16.3	65.4	207	994	1276	523	48.2	6.45
			SD	12.2	2738	1073	40.7	61.5	186	737	1205	613	64.6	12.8
	Skin	5	Mean	45.0	705	225	2.90	19.9	99.0	246	247	81.8	8.17	1.38
			SD	20.2	281	97.7	1.86	9.78	33.6	112	111	38.7	4.44	0.82

Species	Tissue	N	Stat	% Lipid	sPCB	s10PCB	smono-di	s-tri	s-tetra	s-penta	s-hexa	s-hepta	s-octa	s-nona
Beluga	Muscle	20	Mean	2.3	61.0	22.1	0.33	2.82	11.96	23.5	16.6	5.22	0.42	0.09
			SD	1.0	47.0	18.1	0.45	2.96	10.74	18.8	12.9	4.20	0.28	0.05
	Liver	5	Mean	6.8	57.6	20.9	0.30	2.03	9.42	23.6	17.1	4.67	0.44	0.12
			SD	3.0	25.3	8.93	0.12	0.54	4.09	10.6	7.88	2.14	0.21	0.04
	Kidney	5	Mean	4.4	79.0	26.7	0.33	2.90	11.9	31.8	25.0	6.38	0.57	0.13
			SD	2.2	72.9	24.3	0.25	1.74	9.86	29.3	24.8	6.34	0.58	0.12
	Blubber	10	Mean	87.9	2447	1020	5.75	49.0	294	1126	738	218	13.7	1.86
			SD	2.4	1126	483	2.42	26.1	136	549	344	92.9	5.71	0.68
	Skin	5	Mean	3.6	86.2	37.5	0.31	3.31	12.33	32.5	28.5	8.50	0.58	0.11
			SD	0.8	43.8	19.1	0.32	2.45	7.06	16.3	14.2	4.33	0.28	0.05
Narwhal	Muscle	7	Mean	2.3	47.6	20.4	0.15	1.90	7.71	20.0	13.3	4.10	0.38	0.05
			SD	1.2	42.8	18.6	0.17	1.02	6.88	19.1	11.6	4.19	0.39	0.07
	Liver	5	Mean	5.1	65.5	23.0	0.13	2.63	10.3	27.7	19.1	5.17	0.45	0.06
			SD	0.6	11.7	4.13	0.06	0.40	1.90	4.81	4.04	1.81	0.15	0.04
	Kidney	5	Mean	2.7	34.6	12.0	0.11	1.34	5.42	14.9	9.76	2.80	0.22	0.04
			SD	0.4	22.6	7.22	0.04	0.58	2.92	10.2	6.96	1.89	0.17	0.02
	Blubber	7	Mean	77.1	2306	752	2.93	63.6	386	933	735	172	12.3	1.29
			SD	17.4	1454	444	2.16	43.4	251	640	444	78.52	4.76	0.85
	Skin	5	Mean	3.6	100	37.2	0.25	3.30	16.3	42.8	28.5	8.31	0.57	0.06
			SD	1.7	49.8	19.4	0.18	1.26	7.87	22.4	15.2	4.35	0.22	0.04
Marine mammals East Greenland														
Ringed seal	Muscle	20	Mean	2.4	45.6	26.0	0.05	2.40	2.95	12.8	17.9	7.98	1.16	0.31
			SD	1.6	38.9	22.6	0.03	2.93	1.95	10.7	15.6	7.74	1.30	0.37
	Liver	10	Mean	5.0	38.5	20.4	0.03	1.50	3.49	11.5	14.0	6.76	1.00	0.31
			SD	1.0	14.6	6.61	0.02	0.68	1.32	3.34	5.32	4.40	1.00	0.39
	Blubber	19	Mean	101	1138	551	1.17	17.3	87.2	292	405	128	16.9	5.93
			SD	14.6	1113	380	0.83	10.7	59.9	197	302	116	15.4	10.1
	Intes-tine	5	Mean	1.5	16.0	5.77	0.28	1.69	2.98	6.17	3.60	1.13	0.16	0.05
			SD	0.3	4.71	1.45	0.24	1.09	1.09	1.90	0.81	0.19	0.05	0.01
Walrus	Muscle	6	Mean	1.2	160	102	0.39	2.31	4.81	25.7	84.2	34.7	5.81	2.03
			SD	0.7	123	81.2	0.17	0.87	2.49	17.3	67.9	28.8	4.79	1.64
	Skin	1	Mean	13.5	1912	1234	0.50	5.37	45.8	354	1045	395	52.3	13.8
Narwhal	Muscle	5	Mean	0.7	102	41.3	0.17	1.28	7.61	27.1	42.6	19.9	2.95	0.78
			SD	0.2	69.8	28.6	0.15	0.43	4.19	17.2	30.9	14.4	2.12	0.51
	Skin	1	Mean	6.5	167	67.91	0.10	0.43	9.66	42.0	74.6	34.4	5.06	1.19

s10PCB = sum of CB 28, 31, 52, 101, 105, 118, 138, 153, 156, 180
s-mono-di = sum of CB 1, 3, 4-10, 7-9, 6, 8-5, 12-13
s-tri = sum of CB 33-20, 18, 15-17, 24-27, 16-32, 54-29, 26, 25, 31-28, 22, 19
s-tetra = sum of CB 55, 56-60 ,66, 63, 74, 45, 46, 52, 43, 49, 47-48, 44, 59, 42, 71-41-64, 40, 53, 51, 50
s-penta = sum of CB 114, 105, 118, 107, 110, 82, 92, 84, 101, 99, 119, 83, 97, 81-87, 85, 95, 91, 70-76-98, 100
s-hexa = sum of CB 136, 151, 135-144, 147, 149, 133, 134-131, 146, 153, 132, 141, 137, 130, 163-138, 158, 129, 128, 156, 157-200
s-hepta = sum of CB 179, 176, 178, 175, 182-187, 183, 167, 185, 174, 177, 202-171, 172, 173, 180, 193, 191, 170-190
s-octa = sum of CB 194, 205, 198, 201, 203-196, 189, 199, 197
s-nona = sum of CB 206, 209, 208-195, 207

Appendix 6

Concentrations of organochlorine pesticides (ng/g wet weight) in biota samples from West Greenland, except marine mammals from East Greenland at the end of the table. Samples collected between 1999 and 2001.

Species	Tissue	N	Stat	% Lipid	sDDT	p,p'-DDE	sCHL	Oxychlor-dane	sHCH	β-HCH	sCBz	HCB	Dieldrin
Terrestrial													
Ptarmigan	Muscle	5	Mean	3.8	0.04	0.02	1.66	0.04	0.22	< 0.01	0.22	0.17	< 0.01
			SD	0.7	0.02	0.02	0.06	0.01	0.12		0.08	0.09	
	Liver	5	Mean	6.8	0.69	0.53	0.68	0.09	0.16	0.02	0.79	0.23	0.10
			SD	0.5	0.46	0.41	0.43	0.02	0.03	0.01	0.70	0.09	0.06
Arctic hare	Muscle	5	Mean	3.8	0.01	< 0.01	0.16	0.06	0.05	0.01	0.36	0.19	0.06
			SD	2.7	0.02		0.09	0.03	0.03	< 0.01	0.20	0.12	0.03
	Liver	5	Mean	4.1	0.05	0.01	3.41	2.72	0.05	< 0.01	0.22	0.18	1.38
			SD	0.5	0.06	0.03	2.19	2.64	0.02		0.05	0.05	0.63
	Kidney	5	Mean	32.5	0.18	0.04	0.92	0.54	0.46	0.06	2.46	2.28	0.35
			SD	18.8	0.18	0.08	0.67	0.34	0.27	0.05	1.65	1.61	0.25
Caribou	Muscle	5	Mean	1.5	0.05	0.02	0.03	< 0.01	0.03	0.01	0.13	0.12	0.01
			SD	0.5	0.01	0.01	0.01		0.01	< 0.01	0.05	0.05	< 0.01
	Liver	5	Mean	7.4	0.02	< 0.01	0.88	< 0.01	0.19	0.02	0.45	0.13	0.01
			SD	0.7	0.01	0.01	0.23		0.04	0.01	0.09	0.05	0.01
	Kidney	5	Mean	3.5	0.01	0.03	0.03	0.02	0.03	0.03	0.13	3.10	0.05
			SD	0.2	0.01	0.01	0.01	0.03	0.01	0.01	0.05	1.95	0.03
	Fat	5	Mean	49.9	0.09	0.01	0.12	0.09	0.30	0.08	3.17	0.44	0.77
			SD	28.7	0.06	0.01	0.05	0.04	0.14	0.03	1.98	0.09	0.24
Muskox	Muscle	5	Mean	1.9	0.03	0.03	0.02	< 0.01	0.08	0.05	0.24	0.22	0.02
			SD	0.4	0.04	0.04	0.01		0.01	0.01	0.10	0.09	0.01
	Liver	5	Mean	10.3	0.11	0.07	0.68	0.09	0.59	0.48	1.24	1.16	0.67
			SD	1.8	0.02	0.02	0.30	0.05	0.07	0.06	0.20	0.19	0.31
	Kidney	5	Mean	3.2	0.06	0.05	0.10	0.11	0.17	0.13	0.43	0.39	0.10
			SD	0.6	0.04	0.04	0.02	0.03	0.03	0.03	0.10	0.09	0.02
	Fat	5	Mean	85.5	0.40	0.37	0.53	0.09	0.76	0.09	5.92	5.52	0.45
			SD	10.7	0.22	0.21	0.20	0.06	0.26	0.05	3.75	3.51	0.21
Lamb	Muscle	5	Mean	12.3	0.33	0.32	0.11	0.01	0.08	0.02	0.59	0.57	0.09
			SD	9.8	0.12	0.11	0.05	0.02	0.04	0.01	0.32	0.31	0.04
	Liver	5	Mean	9.6	0.39	0.30	0.08	< 0.01	0.15	0.12	0.51	0.49	0.06
			SD	2.0	0.26	0.13	0.04		0.08	0.08	0.13	0.13	0.03
	Kidney	5	Mean	4.2	0.11	0.10	0.03	0.13	0.13	0.11	0.21	0.18	0.02
			SD	0.4	0.06	0.06	0.02	0.11	0.04	0.04	0.05	0.05	0.01
	Fat	5	Mean	90.2	1.20	1.19	0.28	0.04	0.22	0.03	1.21	1.17	0.21
			SD	3.1	0.65	0.64	0.07	0.02	0.09	0.02	0.29	0.28	0.06

Species	Tissue	N	Stat	% Lipid	sDDT	p,p'-DDE	sCHL	Oxychlor-dane	sHCH	β-HCH	sCBz	HCB	Dieldrin
Marine invertebrates													
Deep sea shrimp	Muscle	11	Mean	0.9	0.15	0.06	0.51	0.22	0.06	< 0.01	0.69	0.14	0.09
			SD	0.1	0.07	0.02	0.11	0.04	0.04		0.19	0.03	0.02
Queen crab	Muscle	5	Mean	0.7	2.15	1.88	3.52	0.35	0.36	0.03	0.48	0.32	0.75
			SD	0.2	0.82	0.80	0.87	0.11	0.16	0.02	0.18	0.12	0.28
	"Liver"	5	Mean	6.0	37.9	36.9	5.25	0.40	2.36	0.19	3.04	2.50	0.90
			SD	5.6	46.2	45.4	4.46	0.21	1.64	0.19	2.83	2.40	0.96
Iceland scallop	Muscle	8	Mean	0.4	0.06	0.01	0.07	0.03	0.14	< 0.01	1.14	< 0.01	< 0.01
			SD	0.1	0.05	0.01	0.05	< 0.01	0.15		1.92		
Marine fish													
Arctic char	Muscle	5	Mean	3.5	1.44	0.62	1.08	0.46	1.19	0.33	0.53	0.47	0.06
			SD	2.4	0.87	0.33	0.69	0.32	0.85	0.18	0.31	0.27	0.08
	Liver	5	Mean	16.7	6.56	3.55	5.65	2.17	5.57	1.65	2.61	2.37	0.29
			SD	0.7	2.21	1.60	1.87	0.36	1.63	0.64	0.56	0.54	0.19
Atlantic Salmon	Muscle	10	Mean	10.9	10.3	4.72	5.74	2.28	4.57	0.55	2.16	1.48	0.37
			SD	4.8	4.63	1.46	2.32	1.00	2.34	0.31	0.81	0.58	0.17
	Liver	5	Mean	8.8	9.11	3.39	4.01	1.76	3.32	0.41	1.56	1.25	0.01
			SD	1.6	2.80	1.68	0.96	0.25	0.81	0.12	0.36	0.09	0.02
Capelin	Muscle	10	Mean	1.8	5.63	1.14	3.39	1.40	0.45	0.07	0.92	0.83	0.28
			SD	0.7	1.01	0.26	0.68	0.40	0.20	0.03	0.25	0.21	0.08
Atlantic cod	Muscle	9	Mean	0.7	0.61	0.20	0.43	0.19	0.13	0.01	0.27	0.22	0.05
			SD	0.1	0.30	0.04	0.09	0.06	0.07	0.01	0.10	0.06	0.01
	Liver	5	Mean	59.3	55.2	23.3	47.1	14.7	13.7	1.05	12.7	11.1	4.2
			SD	3.7	40.1	15.5	28.5	7.85	2.57	0.28	6.74	6.59	3.37
Greenland cod	Muscle	5	Mean	0.7	0.22	0.14	0.24	0.10	0.12	0.01	0.40	0.11	0.01
			SD	0.1	0.14	0.10	0.13	0.04	0.02	<0.01	0.60	0.04	0.02
	Liver	5	Mean	38.3	21.0	12.3	27.1	7.35	11.6	0.85	6.25	5.11	4.23
			SD	7.1	11.1	7.59	11.6	1.74	2.25	0.14	0.78	1.05	1.93
Redfish	Muscle	5	Mean	2.5	4.75	1.84	3.46	0.97	0.66	0.06	0.92	0.81	0.37
			SD	1.6	3.96	1.41	2.77	0.77	0.57	0.05	0.69	0.61	0.29
Spotted wolffish	Muscle	5	Mean	1.6	3.01	1.29	3.20	0.40	0.22	0.04	0.69	0.62	2.16
			SD	0.7	2.04	0.59	2.14	0.28	0.10	0.01	0.25	0.23	1.60
	liver	5	Mean	19.2	37.1	15.7	38.3	3.70	4.18	0.53	7.89	7.12	25.6
			SD	6.3	21.4	7.02	25.3	2.09	1.79	0.23	3.23	3.04	19.9
Greenland halibut	Muscle	10	Mean	9.4	36.2	16.2	18.8	5.31	1.27	0.13	5.26	4.96	2.13
			SD	5.4	54.7	20.2	26.3	5.08	0.79	0.07	5.62	5.02	2.31
	Liver	5	Mean	33.9	1147	549	205	25.3	4.59	0.43	44.7	42.3	27.0
			SD	10.2	2165	1091	286	15.5	1.27	0.12	49.9	49.6	44.0

Species	Tissue	N	Stat	% Lipid	sDDT	p,p'-DDE	sCHL	Oxychlor-dane	sHCH	β-HCH	sCBz	HCB	Dieldrin
Seabirds													
Thick-billed murre	Muscle	19	Mean	3.5	6.97	6.27	4.97	2.29	0.73	0.45	3.95	3.44	1.90
			SD	0.4	5.21	4.86	5.17	2.35	0.24	0.26	2.37	2.16	3.14
	Liver	5	Mean	5.4	8.11	7.45	4.57	2.93	0.63	0.50	6.47	5.71	1.26
			SD	0.7	3.41	3.33	1.31	0.73	0.17	0.15	2.14	1.90	0.45
Common eider	Muscle	10	Mean	3.9	3.84	3.47	4.57	1.69	0.58	0.46	2.50	2.10	1.60
			SD	0.8	1.40	1.30	0.69	0.58	0.20	0.16	0.82	0.70	0.41
	Liver	5	Mean	5.1	5.78	5.12	12.8	6.34	0.81	0.77	3.63	3.15	5.60
			SD	0.3	4.14	4.00	5.55	1.34	0.23	0.23	0.95	0.91	4.81
King eider	Muscle	10	Mean	3.9	3.88	3.49	4.98	1.10	1.03	0.86	3.14	2.70	1.72
			SD	1.2	2.15	1.85	1.78	0.55	0.38	0.34	1.40	1.25	0.86
	Liver	5	Mean	5.2	5.70	4.93	16.0	6.49	1.28	1.24	4.13	3.53	7.09
			SD	0.3	2.66	2.26	9.69	2.35	0.72	0.72	1.79	1.56	5.68
Kittiwake	Muscle	9	Mean	14.3	30.9	23.7	23.9	9.28	4.08	2.79	18.8	16.5	11.2
			SD	5.4	12.1	10.6	6.46	2.22	0.73	0.35	3.37	3.11	6.27
	Liver	5	Mean	6.9	8.31	6.18	4.68	2.96	1.09	1.22	9.10	8.20	2.16
			SD	2.3	5.65	5.23	4.65	1.45	0.67	0.30	4.62	4.24	2.27
Marine mammals West Greenland													
Ringed seal	Muscle	20	Mean	5.4	13.6	11.4	7.72	1.93	3.04	0.67	0.75	0.44	4.02
			SD	6.4	20.3	17.1	11.2	2.85	5.13	1.23	1.00	0.56	6.53
	Liver	5	Mean	5.5	8.26	6.15	9.56	7.00	2.18	0.32	0.66	0.39	4.81
			SD	0.6	3.01	2.41	2.68	2.85	0.81	0.12	0.31	0.26	1.28
	Kidney	5	Mean	3.8	2.15	1.66	1.79	1.07	0.78	0.13	0.38	0.21	0.89
			SD	0.5	0.48	0.41	0.73	0.51	0.20	0.05	0.17	0.11	0.35
	Blubber	10	Mean	92.2	439	343	241	48.0	74.1	16.9	14.9	7.43	123
			SD	4.9	205	165	114	25.4	26.9	8.92	5.58	2.17	59.1
Harp seal	Muscle	20	Mean	2.5	4.66	3.67	2.49	0.44	1.14	0.07	1.55	1.37	1.04
			SD	2.4	6.73	5.38	2.46	0.58	1.15	0.10	2.02	1.84	1.31
	Liver	7	Mean	6.9	5.93	4.65	6.98	1.80	1.61	0.28	3.04	2.76	2.31
			SD	1.7	2.37	2.07	2.47	0.65	0.81	0.17	1.93	1.88	0.76
	Kidney	7	Mean	3.1	1.04	0.83	1.10	0.24	0.49	0.05	0.96	0.87	0.71
			SD	0.3	0.43	0.38	0.92	0.30	0.26	0.07	0.56	0.54	0.24
	Blubber	12	Mean	88.9	325	270	310	74.8	57.5	11.7	57.7	52.4	46.4
			SD	2.3	270	221	254	61.2	52.7	11.4	34.5	32.8	39.7
Minke whale	Muscle	20	Mean	1.8	8.57	4.92	5.55	0.60	1.53	0.68	2.31	2.28	3.83
			SD	1.3	11.2	7.73	4.60	0.56	0.91	0.25	1.93	1.90	2.82
	Liver	5	Mean	6.7	19.0	12.0	13.8	1.30	15.8	13.8	11.3	11.3	13.1
			SD	1.6	8.65	4.64	5.91	0.65	4.54	4.15	4.11	4.11	7.33
	Kidney	5	Mean	3.6	6.13	3.60	4.79	0.40	3.97	3.06	5.12	5.09	5.52
			SD	0.7	3.77	2.35	3.12	0.33	1.36	0.98	2.42	2.41	3.11
	Blubber	18	Mean	69.6	951	552	335	6.89	74.7	10.3	108	108	396
			SD	12.2	863	503	295	7.08	36.6	7.8	65.3	65.3	308
	Skin	5	Mean	45.0	489	227	329	27.9	79.1	26.3	94.1	93.7	222
			SD	20.2	251	108	143	12.4	27.1	14.3	48.5	48.3	109

Species	Tissue	N	Stat	% Lipid	sDDT	p,p'-DDE	sCHL	Oxychlor-dane	sHCH	β-HCH	sCBz	HCB	Dieldrin
Beluga	Meat	20	Mean	2.3	29.2	16.9	23.6	9.90	2.65	0.98	8.21	7.38	5.79
			SD	1.0	25.2	14.2	20.1	7.14	1.60	0.69	5.55	5.09	5.01
	Liver	5	Mean	6.8	24.1	15.9	17.4	11.4	2.62	1.13	13.3	12.2	4.51
			SD	3.0	12.1	8.41	8.59	6.77	1.22	0.65	7.96	7.56	2.29
	Kidney	5	Mean	4.4	35.2	22.7	21.3	11.8	2.50	0.93	11.0	9.7	5.30
			SD	2.2	36.5	23.7	19.0	7.35	1.99	0.70	9.28	7.94	4.31
	Blubber	10	Mean	87.9	1558	779	1203	405	136	51.2	260	234	266
			SD	2.4	765	396	624	213	72.2	24.8	158	142	144
	Skin	5	Mean	3.6	57.3	32.6	44.8	12.1	3.18	1.86	6.80	6.44	8.74
			SD	0.8	26.5	15.8	24.4	8.01	1.45	1.11	4.97	4.86	4.35
Narwhal	Muscle	7	Mean	2.3	30.7	16.1	25.5	8.94	2.31	1.28	11.1	10.7	6.06
			SD	1.2	24.8	13.7	22.1	8.00	1.85	1.21	11.6	11.3	6.07
	Liver	5	Mean	5.1	38.8	22.7	35.6	18.4	4.16	2.14	24.5	23.5	7.32
			SD	0.6	8.22	5.29	5.95	3.93	0.72	0.29	4.14	3.99	1.29
	Kidney	5	Mean	2.7	17.5	10.3	17.3	13.0	1.53	0.74	11.0	10.6	4.64
			SD	0.4	13.1	8.18	12.1	8.74	0.66	0.37	5.55	5.40	3.81
	Blubber	7	Mean	77.1	1622	770	1112	378	129	70.7	352	337	212
			SD	17.4	882	416	481	215	68.9	36.8	205	197	98.0
	Skin	5	Mean	3.6	75.0	41.7	62.4	18.5	4.64	2.89	13.4	12.9	13.0
			SD	1.7	51.7	28.9	37.7	9.34	2.79	1.92	7.86	7.72	7.42
Marine mammals East Greenland													
Ringed seal	Muscle	3	Mean	2.4	27.8	21.5	11.3	2.11	2.38	0.71	0.70	0.40	5.54
			SD	1.6	24.7	20.6	8.68	1.54	1.53	0.45	0.38	0.24	4.16
	Liver	10	Mean	5.0	15.6	12.1	13.0	7.93	2.16	0.55	1.13	0.76	7.68
			SD	1.0	4.70	4.61	4.71	3.17	1.06	0.31	0.48	0.36	3.86
	Blubber	19	Mean	101	640	457	350	149	104	28.0	19.2	10.5	86.7
			SD	14.6	324	295	293	112	62.2	18.5	12.0	6.31	85.7
	Intestine	5	Mean	1.5	2.78	1.98	1.81	0.73	0.49	0.15	0.52	0.34	0.76
			SD	0.3	0.71	0.56	0.67	0.23	0.14	0.05	0.21	0.14	0.30
Walrus	Muscle	6	Mean	1.2	27.7	22.5	36.4	30.0	3.83	2.96	0.16	0.02	11.7
			SD	0.7	21.0	16.8	26.4	22.2	2.54	2.02	0.09	0.01	7.75
	Skin	1	Mean	13.5	461	382	629	522	33.8	28.4	1.23	0.39	119
Narwhal	Muscle	5	Mean	0.7	64.1	43.0	22.2	3.33	0.63	0.38	6.34	6.25	6.00
			SD	0.2	56.9	38.1	15.6	2.68	0.27	0.21	4.19	4.19	3.77
	Skin	1	Mean	6.5	381	130	328	55.5	13.7	9.8	6.6	6.5	104

Appendix 7

Concentrations of toxaphene (ng/g wet weight) in biota samples from West Greenland, except marine mammals from East Greenland at the end of the table. Samples collected between 1999 and 2001. Contaminant groups are explained below the Appendix.

Species	Tissue	N	Stat	% Lipid	Total toxaphene	Σ-congeners	Σ-Parlar 26,50,62
Terrestrial							
Ptarmigan	Muscle	5	Mean	3.8	0.7	< 0.01	< 0.01
			SD	0.7	0.5		
	Liver	5	Mean	6.8	0.7	< 0.01	< 0.01
			SD	0.5	0.5		
Arctic hare	Muscle	4	Mean	3.8	< 0.01	0.06	< 0.01
			SD	2.7		0.13	
	Liver	5	Mean	4.1	0.5	0.05	< 0.01
			SD	0.5	0.3	0.06	
	Kidney	3	Mean	32.5	1.8	0.23	< 0.01
			SD	18.8	1.4	0.15	
Caribou	Muscle	5	Mean	1.5	< 0.01	< 0.01	< 0.01
			SD	0.5			
	Liver	5	Mean	7.4	0.1	< 0.01	< 0.01
			SD	0.7	< 0.1		
	Kidney	5	Mean	3.5	0.1	< 0.01	< 0.01
			SD	0.2	0.1		
	Fat	5	Mean	49.9	< 0.01	0.01	< 0.01
			SD	28.7		0.02	
Muskox	Muscle	5	Mean	1.9	< 0.01	< 0.01	< 0.01
			SD	0.4			
	Kidney	5	Mean	3.2	< 0.01	< 0.01	< 0.01
			SD	0.6			
	Fat	5	Mean	85.5	< 0.01	< 0.01	< 0.01
			SD	10.7			
Lamb	Muscle	5	Mean	12.3	< 0.01	< 0.01	< 0.01
			SD	9.8			
	Kidney	5	Mean	4.2	< 0.01	< 0.01	< 0.01
			SD	0.4			
	Fat	5	Mean	90.2	< 0.01	0.01	< 0.01
			SD	3.1		0.01	

Species	Tissue	N	Stat	% Lipid	Total toxaphene	Σ-congeners	Σ-Parlar 26,50,62
Marine invertebrates							
Deep sea shrimp	Muscle	11	Mean	0.9	1.6	0.93	0.6
			SD	0.1	0.6	0.22	0.2
Queen crab	Muscle	4	Mean	0.7	12.8	4.10	2.7
			SD	0.2	4.0	1.35	0.9
	"Liver"	5	Mean	6.0	7.6	5.82	3.5
			SD	5.6	6.6	5.71	3.9
Iceland scallop	Muscle	8	Mean	0.4	< 0.01	< 0.01	< 0.01
			SD	0.1			
Marine fish							
Arctic char	Muscle	5	Mean	3.5	5.0	2.88	1.1
			SD	2.4	3.6	2.17	1.2
	Liver	5	Mean	16.7	29.3	14.52	4.2
			SD	0.7	11.1	3.64	1.2
Atlantic Salmon	Muscle	10	Mean	10.9	51.7	25.67	9.0
			SD	4.8	24.0	10.41	3.5
	Liver	5	Mean	8.8	33.2	14.38	2.5
			SD	1.6	8.7	2.70	0.6
Capelin	Muscle	10	Mean	1.8	17.6	14.98	3.8
			SD	0.7	3.6	3.18	1.1
Atlantic cod	Muscle	9	Mean	0.7	1.3	0.42	0.2
			SD	0.1	1.5	0.13	0.1
	Liver	5	Mean	59.3	548.8	221.77	103.0
			SD	3.7	113.2	55.78	44.1
Greenland cod	Muscle	5	Mean	0.7	0.3	0.14	0.1
			SD	0.1	0.2	0.09	<0.1
	Liver	5	Mean	38.3	95.9	59.26	30.5
			SD	7.1	29.3	20.13	14.9
Redfish	Muscle	5	Mean	2.5	15.6	11.32	4.4
			SD	1.6	10.5	9.93	3.6
Spotted wolffish	Muscle	5	Mean	1.6	22.2	7.08	2.5
			SD	0.7	11.4	5.04	1.9
	Liver	5	Mean	19.2	194.7	116.18	39.5
			SD	6.3	138.2	74.57	24.6
Greenland halibut	Muscle	9	Mean	9.4	279.4	125.34	49.4
			SD	5.4	517.6	206.46	80.0
	Liver	5	Mean	33.9	3,103.1	1,427.36	683.6
			SD	10.2	5,388.1	2,454.48	1,270.1

Species	Tissue	N	Stat	% Lipid	Total toxaphene	Σ-congeners	Σ-Parlar 26,50,62
Seabirds							
Thick-billed murre	Muscle	19	Mean	3.5	34.4	5.39	0.3
			SD	0.4	30.3	5.22	0.6
	Liver	5	Mean	5.4	53.0	9.84	0.8
			SD	0.7	15.1	2.89	0.4
Common eider	Muscle	10	Mean	3.9	13.5	2.82	0.6
			SD	0.8	7.5	1.44	0.3
	Liver	5	Mean	5.1	12.4	4.06	0.9
			SD	0.3	4.9	1.47	0.3
King eider	Muscle	10	Mean	3.9	8.7	2.43	0.4
			SD	1.2	11.2	2.39	0.5
	Liver	5	Mean	5.2	13.5	4.68	0.3
			SD	0.3	10.2	2.63	0.2
Kittiwake	Muscle	9	Mean	14.3	96.4	10.70	3.4
			SD	5.4	32.7	18.54	4.3
	Liver	5	Mean	6.9	47.9	0.15	0.1
			SD	2.3	23.8	0.12	0.1
Marine mammals West Greenland							
Ringed seal	Muscle	18	Mean	5.4	8.6	1.88	0.1
			SD	6.4	14.5	2.87	0.2
	Liver	5	Mean	5.5	39.6	14.1	0.05
			SD	0.6	12.3	4.3	0.05
	Kidney	3	Mean	3.8	0.81	0.14	0.01
			SD	0.5	0.08	0.10	0.01
	Blubber	20	Mean	92.2	196.5	70.9	6.77
			SD	4.9	74.2	30.9	4.49
Harp seal	Muscle	20	Mean	2.5	9.2	3.33	1.3
			SD	2.4	12.7	5.74	2.3
	Liver	7	Mean	6.9	21.5	5.98	1.7
			SD	1.7	7.5	2.00	1.2
	Kidney	7	Mean	3.1	3.3	1.04	0.5
			SD	0.3	1.7	0.40	0.2
	Blubber	12	Mean	88.9	363.7	260.87	115.3
			SD	2.3	186.3	136.62	63.1
Minke whale	Muscle	19	Mean	1.8	18.8	7.90	4.0
			SD	1.3	17.3	8.53	4.1
	Liver	5	Mean	6.7	57.4	21.59	8.6
			SD	1.6	23.6	12.58	5.3
	Kidney	5	Mean	3.6	19.8	6.55	3.2
			SD	0.7	10.4	3.97	2.3
	Blubber	17	Mean	69.6	369.1	63.37	29.7
			SD	12.2	531.2	116.07	58.4
	Skin	5	Mean	45.0	1,369.9	679.79	393.5
			SD	20.2	1,240.1	589.79	338.6

Species	Tissue	N	Stat	% Lipid	Total toxaphene	Σ-congeners	Σ-Parlar 26,50,62
Beluga	Meat	20	Mean	2.3	31.7	15.10	10.9
			SD	1.0	34.5	15.77	10.1
	Liver	5	Mean	6.8	34.3	10.66	8.0
			SD	3.0	16.0	5.37	4.1
	Kidney	5	Mean	4.4	27.5	8.93	6.5
			SD	2.2	18.6	7.81	5.6
	Blubber	10	Mean	87.9	778.1	531.34	311.2
			SD	2.4	477.7	309.17	175.7
	Skin	5	Mean	3.6	166.2	49.81	42.9
			SD	0.8	148.5	48.70	39.5
Narwhal	Muscle	7	Mean	2.3	40.9	14.92	9.1
			SD	1.2	24.7	10.04	6.7
	Liver	5	Mean	5.1	87.7	28.79	17.2
			SD	0.6	16.6	7.07	4.2
	Kidney	5	Mean	2.7	41.7	11.64	8.0
			SD	0.4	24.2	6.85	5.0
	Blubber	7	Mean	77.1	1,375.7	552.96	344.0
			SD	17.4	705.2	275.64	173.0
	Skin	5	Mean	3.6	151.4	64.70	48.4
			SD	1.7	100.1	44.45	32.4
Marine mammals East Greenland							
Ringed seal	Muscle	10	Mean	2.4	10.3	2.4	0.4
			SD	1.6	11.3	2.4	0.5
	Liver	5	Mean	5.0	46.8	19.8	0.2
			SD	1.0	14.0	10.8	0.1
	Blubber	19	Mean	101	210.6	122.2	10.1
			SD	14.6	161.6	92.3	10.6
	Intestine	5	Mean	1.5	4.0	1.35	0.5
			SD	0.3	4.2	1.06	0.3
	Skin	1	Mean	13.5	495.7	143.14	98.5
Narwhal	Muscle	5	Mean	0.7	44.0	22.70	15.6
			SD	0.2	23.9	24.77	17.9
	Skin	1	Mean	6.5	471.1	313.09	210.6

"Total toxaphene" is quantified with a technical toxaphene standard.
"Σ-congeners" is the sum of 22 chlorobornane congeners (Parlar 11-12, 15, Hex-sed, 21, Hep-sed, 25, 32, P26, 31, 38, 39, 40-41, 42, 44, 50, 51, 56, 58, 59, 62, 63)
"Σ-Parlar 26, 50, 62" is the sum of Parlar 26, 50, 62.

Appendix 8

Concentrations of co-planar PCBs (pg/g wet weight) in biota samples from Greenland. Samples collected between 1999 and 2001.

Species	Region	Tissue	N	Stat	PCB 77	PCB 81	PCB 126	PCB 169
Terrestrial								
Caribou	W. Grl.	Fat	5	Mean	16.2	< 0.5	< 0.5	< 0.5
				SD	15.6			
Muskox	W. Grl.	Fat	5	Mean	5.5	< 0.5	3.6	3.2
				SD	3.2		1.3	1.1
Lamb	W. Grl.	Fat	5	Mean	4.3	< 0.5	2.4	2.8
				SD	1.8		1.1	1.1
Marine								
Arctic char	W. Grl.	Muscle	5	Mean	4.5	< 0.5	<0.5	< 0.5
				SD	1.9			
Atlantic salmon	W. Grl.	Muscle	10	Mean	11.0	< 0.5	1.3	0.8
				SD	4.0		0.9	< 0.5
Greenland halibut	W. Grl.	Muscle	10	Mean	29.8	5.5	7.5	3.1
				SD	38.5	4.7	11.6	3.5
Spotted wolffish	W. Grl.	Liver	5	Mean	59.8	2.5	21.1	1.2
				SD	34.1	3.1	9.2	< 0.5
Atlantic cod	W. Grl.	Liver	5	Mean	114.5	5.3	37.6	7.0
				SD	26.6	5.0	7.3	1.9
Ringed seal	E. Grl.	Liver	5	Mean	13.9	0.5	18.4	0.5
				SD	2.2	0.5	6.3	0.6
	W. Grl.	Muscle	5	Mean	1.9	< 0.5	1.3	< 0.5
				SD	1.3		1.2	
	W. Grl.	Blubber	10	Mean	28.7	5.8	26.3	5.0
				SD	8.9	3.3	9.8	2.2
Harp seal	W. Grl.	Blubber	15	Mean	41.7	0.8	41.3	19.5
				SD	22.9	0.6	33.8	22.0
Narwhal	E. Grl.	Muscle	5	Mean	10.1	< 0.5	0.2	< 0.5
				SD	2.0		0.5	
	W. Grl.	Blubber	7	Mean	115.8	4.4	3.7	24.8
				SD	62.4	3.9	3.9	17.2
Beluga	W. Grl.	Blubber	10	Mean	128.5	3.9	49.6	69.8
				SD	61.2	3.1	47.5	47.6
Minke whale	W. Grl.	Skin	5	Mean	78.7	19.0	87.1	24.4
				SD	52.3	25.7	84.2	21.0

Appendix 9

Concentrations of Polybrominated Diphenyl Ethers (ng/g wet weight) in biota samples from Greenland. Samples collected between 1999 and 2001. See below the appendix for an explanation of ΣPBDEs.

Species	Region	Tissue	N	Stat	BDE47	BDE99	BDE100	ΣPBDEs
Atlantic cod	W. Grl	Muscle	2	Mean	1.03	0.21	0.15	3.35
				SD	0.22	0.02	0.01	0.34
	W. Grl	Liver	3	Mean	1.79	0.32	0.25	5.13
				SD	0.20	0.07	0.04	0.85
Spotted wolffish	W. Grl.	Muscle	2	Mean	0.17	0.06	0.01	0.25
				SD	0.02	0.02	<0.01	0.04
Greenland halibut	W. Grl.	Liver	3	Mean	1.04	0.18	0.19	2.71
				SD	0.58	0.07	0.11	0.99
Thick-billed murre	W. Grl.	Liver	4	Mean	0.36	0.26	0.07	1.71
				SD	0.11	0.10	0.03	1.55
Ringed seal	E. Grl.	Muscle	2	Mean	2.08	0.21	0.19	3.78
				SD	1.68	0.12	0.13	2.99
	E. Grl.	Blubber	8	Mean	40.59	4.58	2.13	57.97
				SD	15.51	1.18	0.70	22.62
	W. Grl.	Blubber	10	Mean	2.50	0.38	0.11	3.78
				SD	0.74	0.17	0.11	1.26
Harp seal	W. Grl.	Muscle	3	Mean	0.39	0.07	0.01	0.54
				SD	0.35	0.01	0.01	0.41
	W. Grl.	Blubber	2	Mean	31.40	9.95	0.97	45.65
				SD	38.07	12.43	1.16	54.65
Walrus	E. Grl.	Skin	1	Mean	15.00	1.44	0.20	18.53
Narwhal	E. Grl.	Sskin	1	Mean	7.38	1.54	0.61	11.79
		Muscle	1	Mean	0.66	0.13	0.07	1.00
Minke whale	W. Grl.	Muscle	2	Mean	0.51	0.18	0.03	0.81
				SD	0.45	0.15	0.03	0.71

ΣPBDE is the sum of PBDE 10, 7, 11, 8, 12-13, 15, 30, 32, 28-33, 35, 37, 75, 71, 66, 47, 49, 77, 100, 119, 99, 116, 85, 155-126, 105, 154, 153, 140, 138, 166, 183, 181, 190.

Appendix 10

Concentrations of butyltin (ng/g wet weight) in livers of marine mammals. Samples collected between 1999 and 2001.

Species	Region	N	Stat	Monobutyltin	Dibutyltin	Tributyltin
Ringed seal	East Greenland	5	Mean	< 1.3	< 1.3	< 1.3
			SD			
Harp seal	West Greenland	6	Mean	< 1.3	1.5	< 1.3
			SD		0.9	
Beluga	West Greenland	5	Mean	2.3	4.0	< 1.3
			SD	1.6	1.9	
Narwhal	West Greenland	5	Mean	< 1.3	3.7	1.4
			SD		0.8	
Minke whale	West Greenland	3	Mean	< 1.3	10.4	< 1.3
			SD		3.1	

Appendix 11

Concentrations of Short Chain Chlorinated Paraffins, SCCPs (ng/g wet weight) in marine mammal samples from West Greenland. Samples collected between 1999 and 2001.

Species	Tissue	N	Stat	Total C10	Total C11	Total C12	Total C13	Σ-SCCPs
Ringed seal	Blubber	6	Mean	4.6	< 1.0	2.8	2.6	10.5
			SD	6.3		3.6	3.2	13.1
Harp seal	Blubber	5	Mean	< 0.9	< 0.9	< 0.9	1.1	2.4
			SD				1.4	1.4
Beluga	Blubber	5	Mean	141.9	79.8	26.9	33.6	282.2
			SD	71.2	37.3	14.0	18.4	140.8
Narwhal	Blubber	5	Mean	50.0	24.6	7.6	14.3	96.5
			SD	25.4	11.9	4.5	7.5	49.2
Minke whale	Skin	5	Mean	1.8	0.5	0.7	1.0	4.0
			SD	3.4	0.6	1.0	1.7	6.6

Appendix 12 Concentrations of coplanar (non-ortho) and mono-ortho-PCBs in selected samples as pg/g wet wt and pg TEQ/g wet wt[1].

Species	Region	Tissue	n		CB 77	CB 81	CB 105	CB 114	CB 118	CB 126	CB 156	CB 167	CB 169	CB 189	Total
A. Toxic Equivalents (pg TEQs/g)				TEF >	0.0001	0.0001	0.0001	0.0001	0.00001	0.1	0.0001	0.00001	0.01	0.00001	
Terrestrial															
Caribou	W. Grl.	Fat	5	Mean	0.00162			0.00026	0.00130	0.06750	0.00180	0.00006	0.00251	0.00003	0.07
				SD	0.00156			0.00041	0.00097	0.12860	0.00200	0.00007		0.00001	0.13
Musk-ox	W. Grl.	Fat	5	Mean	0.00027		0.00862	0.00061	0.00183	0.18000	0.00178	0.00011	0.01600	0.00001	0.21
				SD	0.00016		0.00531	0.00034	0.00113	0.06708	0.00109	0.00008	0.00548	0.00000	0.07
Lamb Fat	W. Grl.	Fat	5	Mean	0.00027		0.00582	0.00081	0.00086	0.12000	0.00728	0.00006	0.01400	0.00008	0.15
Marine															
Arctic char	W. Grl.	Muscle	5	Mean	0.00045			0.00033	0.00047	0.04891	0.00065	0.00006		0.00003	0.03
				SD	0.00018			0.00030	0.00045	0.00007	0.00055	0.00005		0.00000	0.03
Salmon	W. Grl.	Muscle	10	Mean	0.00110		0.05111	0.00249	0.00664	0.12996	0.00530	0.00046	0.00841	0.00003	0.20
				SD	0.00040		0.01576	0.00161	0.00230	0.08963	0.00187	0.00015	0.00010	0.00004	0.11
Halibut	W. Grl.	Muscle	10	Mean	0.00298	0.00055	0.23058	0.00400	0.02232	0.75314	0.01826	0.00156	0.03144	0.00015	1.06
				SD	0.00385	0.00047	0.30889	0.00460	0.02711	1.16475	0.02310	0.00225	0.03539	0.00020	1.56
Spotted wolffish	W. Grl.	Liver	5	Mean	0.00598	0.00025	0.19197	0.01649	0.03397	2.10817	0.05344	0.00417	0.01151	0.00056	2.43
				SD	0.00341	0.00031	0.09737	0.01162	0.00835	0.91616	0.01471	0.00120	0.00000	0.00012	1.05
Atlantic cod	W. Grl.	Liver	4	Mean	0.01193	0.00060	0.45871	0.01470	0.06179	3.90940	0.05027	0.00461	0.07575	0.00032	4.59
				SD	0.00282	0.00055	0.23949	0.01488	0.02993	0.75002	0.02555	0.00239	0.01519	0.00017	0.74
Ringed seal	E. Grl.	Liver	5	Mean	0.00139	0.00005	0.11870	0.00526	0.02952	1.84270	0.03198	0.00115	0.00460	0.00021	2.04
				SD	0.00022	0.00005	0.04810	0.00213	0.00880	0.63286	0.00931	0.00073	0.00631	0.00013	0.69
Ringed seal	W. Grl.	Blubber	10	Mean	0.00359	0.00034	1.28160	0.33493	0.59521	1.24933	0.29008	0.03432	0.14922	0.00338	3.91
				SD	0.00060	0.00035	1.31114	0.24524	0.38874	1.43088	0.14983	0.03314	0.14314	0.00232	1.73
Ringed seal	W. Grl.	Muscle	5	Mean	0.00019		0.05322	0.00736	0.01708	0.12884	0.01228	0.00031	0.00500	0.00006	0.22
				SD	0.00013		0.06782	0.00873	0.02159	0.12105	0.01706	0.00044	0.00000	0.00009	0.24
Harp seal	W. Grl.	Blubber	12	Mean	0.00366	0.00008	0.48788	0.03796	0.21632	3.59122	0.51295	0.00651	0.20199	0.00405	5.06
				SD	0.00199	0.00006	0.39970	0.04319	0.18973	2.28017	0.99953	0.00662	0.23787	0.00317	3.46
Narwhal	E. Grl.	Muscle	5	Mean	0.00101		0.07582	0.00357	0.04184	0.02031	0.01572	0.00269	0.00000	0.00074	0.16
				SD	0.00020		0.03963	0.00212	0.02650	0.04542	0.00692	0.00155	0.00000	0.00048	0.11
Narwhal	W. Grl.	Blubber	7	Mean	0.01158	0.00044	2.76834	0.57602	1.04837	0.37143	0.43102	0.06170	0.24795	0.00720	5.52
				SD	0.00624	0.00039	2.75881	0.33403	0.60087	0.39143	0.24465	0.04518	0.17163	0.00610	3.97
Beluga	W. Grl.	Blubber	10	Mean	0.01285	0.00039	3.23556	0.22101	1.13427	4.96389	0.60410	0.08207	0.69804	0.00542	10.96
				SD	0.00612	0.00031	1.56098	0.09676	0.55397	4.74943	0.23954	0.03619	0.47554	0.00248	6.01
Minke whale	W. Grl.	Skin	5	Mean	0.00680	0.00087	0.49611	0.04632	0.18067	5.00460	0.20479	0.01535	0.13786	0.00216	6.10
				SD	0.00398	0.00099	0.34926	0.04316	0.18805	5.02719	0.22688	0.01637	0.21166	0.00257	5.93

B. Concentrations in pg/g wet wt			n		CB 77	CB 81	CB 105	CB 114	CB 118	CB 126	CB 156	CB 167	CB 169	CB 189
Terrestrial														
Caribou	W. Grl.	Fat	5	Mean	16	< 0.5	< 0.5	2.6	130	0.67	18	5.9	0.3	3.0
				SD	16			4.1	97	1.29	20	7.1		0.8
Muskox	W. Grl.	Fat	5	Mean	2.7	0.0	86	6.1	183	1.8	18	11.1	1.6	< 0.5
				SD	1.6	0.0	53	3.4	113	0.7	11	7.6	0.5	
Lamb	W. Grl.	Fat	5	Mean	2.7	0.0	58	8.1	86	1.2	73	6.3	1.4	7.7
				SD	1.7	0.0	15	6.3	64	0.6	47	0.0	0.5	4.0
Marine														
Arctic char	W. Grl.	Muscle	5	Mean	4.5	< 0.5	< 0.5	3.3	47	0.5	6.5	6.5	< 0.5	2.7
				SD	1.8			3.0	45		5.5	4.5		
Salmon	W. Grl.	Muscle	10	Mean	11	< 0.5	511	25	664	1.3	53	46	0.8	3.2
				SD	4.0		158	16	230	0.9	19	15		3.6
Halibut	W. Grl.	Muscle	10	Mean	30	5.5	2,306	40	2,232	7.5	183	156	3.1	15
				SD	39	4.7	3,089	46	2,711	12	231	225	3.5	20
Spotted wolfish	W. Grl.	Liver	5	Mean	60	2.5	1,920	165	3,397	21	534	417	1.2	56
				SD	34	3.1	974	116	835	9.2	147	120		12
Atlantic cod	W. Grl.	Liver	4	Mean	119	6.0	4,587	147	6,179	39	503	461	7.6	32
				SD	28	5.5	2,395	149	2,993	7.5	256	239	1.5	17
Ringed seal	E. Grl.	Liver	5	Mean	14	0.5	1,187	53	2,952	18	320	115	0.5	21
				SD	2.2	0.5	481	21	880	6.3	93	73	0.6	13
Ringed seal	W. Grl.	Blubber	10	Mean	36	3.4	12,816	3,349	59,521	12	2,901	3,432	15	338
				SD	6.0	3.5	13,111	2,452	38,874	14	1,498	3,314	14	232
Ringed seal	W. Grl.	Muscle	5	Mean	1.9	< 0.5	532	74	1,708	1.3	123	31	< 0.5	5.8
				SD	1.3		678	87	2,159	1.2	171	44		8.7
Harp seal	W. Grl.	Blubber	12	Mean	37	0.8	4,879	380	21,632	36	5,130	651	20	405
				SD	20	0.6	3,997	432	18,973	23	9,995	662	24	317
Narwhal	E. Grl.	Muscle	5	Mean	10	< 0.5	758	36	4,184	0.2	157	269	< 0.5	74
				SD	2.0		396	21	2650	0.5	69	155		48
Narwhal	W. Grl.	Blubber	7	Mean	116	4.4	27683	5760	104837	3.7	4310	6170	25	720
				SD	62	3.9	27588	3340	60087	3.9	2447	4518	17	610
Beluga	W. Grl.	Blubber	10	Mean	129	3.9	32356	2210	113427	50	6041	8207	70	542
				SD	61	3.1	15610	968	55397	47	2395	3619	48	248
Minke whale	W. Grl.	Skin	5	Mean	68	8.7	4961	463	18067	50	2048	1535	14	216
				SD	40	9.9	3493	432	18805	50	2269	1637	21	257

[1]TEFs for the PCBs from Van den Berg et al. (1998).

National Environmental Research Institute

The National Environmental Research Institute, NERI, is a research institute of the Ministry of the Environment.
In Danish, NERI is called Danmarks Miljøundersøgelser (DMU).
NERI's tasks are primarily to conduct research, collect data, and give advice on problems related to the environment and nature.

Addresses:

URL: http://www.dmu.dk

National Environmental Research Institute
Frederiksborgvej 399
PO Box 358
DK-4000 Roskilde
Denmark
Tel: +45 46 30 12 00
Fax: +45 46 30 11 14

Management
Personnel and Economy Secretariat
Monitoring, Research and Advice Secretariat
Department of Policy Analysis
Department of Atmospheric Environment
Department of Marine Ecology
Department of Environmental Chemistry and Microbiology
Department of Arctic Environment

National Environmental Research Institute
Vejlsøvej 25
PO Box 314
DK-8600 Silkeborg
Denmark
Tel: +45 89 20 14 00
Fax: +45 89 20 14 14

Monitoring, Research and Advice Secretariat
Department of Marine Ecology
Department of Terrestrial Ecology
Department of Freshwater Ecology

National Environmental Research Institute
Grenåvej 12-14, Kalø
DK-8410 Rønde
Denmark
Tel: +45 89 20 17 00
Fax: +45 89 20 15 15

Department of Wildlife Biology and Biodiversity

Publications:
NERI publishes professional reports, technical instructions, and an annual report in Danish.
A R&D projects' catalogue is available in an electronic version on the World Wide Web.
Included in the annual report is a list of the publications from the current year.

Faglige rapporter fra DMU/NERI Technical Reports

2003

Nr. 436: Naturplanlægning - et system til tilstandsvurdering i naturområder. Af Skov, F., Buttenschøn, R. & Clemmensen, K.B. 101 s. (elektronisk)
Nr. 437: Naturen i hverdagslivsperspektiv. En kvalitativ interviewundersøgelse af forskellige danskeres forhold til naturen. Af Læssøe, J. & Iversen, T.L. 106 s. (elektronisk)
Nr. 438: Havternen i Grønland. Status og undersøgelser. Af Egevang, C. & Boertmann, D. 69 s. (elektronisk)
Nr. 439: Anvendelse af genmodificerede planter. Velfærdsøkonomisk vurdering og etiske aspekter. Af Møller, F. 57 s. (elektronisk)
Nr. 440: Thermal Animal Detection System (TADS). Development of a Method for Estimating Collision Frequency of Migrating Birds at Offshore Wind Turbines. By Desholm, M. 25 pp. (electronic)
Nr. 441: Næringsstofbalancer på udvalgte bedrifter i Landovervågningen. Af Hansen, T.V. & Grant, R. 26s. (elektronisk)
Nr. 442: Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme. Eltra PSO projekt 3141. Kortlægning af emissioner fra decentrale kraftvarmeværker. Delrapport 6. Af Nielsen, M. & Illerup, J.B. 113 s. (elektronisk)
Nr. 443: Miljøøkonomisk analyse af skovrejsning og braklægning som strategier til drikkevandsbeskyttelse. Af Schou, J.S. 43 s. (elektronisk)
Nr. 444: Tungmetaller i tang og musling ved Ivittuut 2001. Af Johansen, P. & Asmund, G. 32 s. (elektronisk)
Nr. 445: Modeller til beskrivelse af iltsvind. Analyse af data fra 2002. Af Carstensen, J. & Erichsen, A.C. 60 s. (elektronisk)
Nr. 447: Modelanalyser af mobilitet og miljø. Slutrapport fra TRANS og AMOR II. Af Christensen, L. & Gudmundsson, H. 114 s. (elektronisk)
Nr. 448: Newcastle Disease i vilde fugle. En gennemgang af litteraturen med henblik på at udpege mulige smittekilder for dansk fjerkræ. Af Therkildsen, O.R. 61 s. (elektronisk)
Nr. 449: Marin recipientundersøgelse ved Thule Air Base 2002. Af Glahder, C.M. et al. 143 s. (elektronisk)
Nr. 450: Air Quality Monitoring Programme. Annual Summary for 2002. By Kemp, K. & Palmgren, F. 36 pp. (electronic)
Nr. 451: Effekter på havbunden ved passage af højhastighedsfærger. Af Dahl, K. & Kofoed-Hansen, H. 33 s. (elektronisk)
Nr. 452: Vingeindsamling fra jagtsæsonen 2002/03 i Danmark. Wing Survey from the 2002/03 Hunting Season in Denmark. Af Clausager, I. 66 s.
Nr. 453: Tålegrænser for kvælstof for Idom Hede, Ringkøbing Amt. Af Nielsen, K.E. & Bak, J.L. 48 s. (elektronisk)
Nr. 454: Naturintegration i Vandmiljøplan III. Beskrivelse af tiltag der, ud over at mindske tilførsel af næringssalte fra landbrugsdrift til vandområder, også på anden vis kan øge akvatiske og terrestriske naturværdier. Af Andersen, J.M. et al. 67 s. (elektronisk)
Nr. 455: Kvantificering af næringsstoffers transport fra kilde til recipient samt effekt i vandmiljøet. Modeltyper og deres anvendelse illustreret ved eksempler. Nielsen, K. et al. 114 s. (elektronisk)
Nr. 456: Opgørelse af skadevirkninger på bundfaunaen efter iltsvindet i 2002 i de indre danske farvande. Af Hansen, J.L.S. & Josefson, A.B. 32 s. (elektronisk)
Nr. 457: Kriterier for gunstig bevaringsstatus. Naturtyper og arter omfattet af EF-habitatdirektivet & fugle omfattet af EF-fuglebeskyttelsesdirektivet. Af Søgaard, B. et al. 2. udg. 460 s. (elektronisk)
Nr. 458: Udviklingen i Vest Stadil Fjord 2001-2002. Af Søndergaard, M. et al. 25 s. (elektronisk)
Nr. 459: Miljøøkonomiske beregningspriser. Forprojekt. Af Andersen, M.S. & Strange, N. 88 s. (elektronisk)
Nr. 460: Aerosols in Danish Air (AIDA). Mid-term report 2000-2002. By Palmgren, F. et al. 92 pp. (electronic)
Nr. 461: Control of Pesticides 2002. Chemical Substances and Chemical Preparations. By Krongaard, T., Petersen, K. & Christoffersen, C. 30 pp. (electronic)
Nr. 462: Bevaringsstatus for fuglearter omfattet af EF-fuglebeskyttelsesdirektivet. Af Pihl, S. et al. 130 s. (elektronisk)
Nr. 463: Screening for effekter af miljøfarlige stoffer på algesamfund omkring havneanlæg. Af Dahl, K. & Dahllöff, I. 37 s. (elektronisk)
Nr. 464: Dioxin i bioaske. Dioxinmåleprogram 2001-2003. Viden om kilder og emissioner. Af Hansen, A.B. et al. 40 s. (elektronisk)
Nr. 465: Miljøundersøgelser ved Maarmorilik 2002. Af Johansen, P., Riget, F. & Asmund, G. 62 s. (elektronisk)
Nr. 466: Atmosfærisk deposition 2002. NOVA 2003. Af Ellermann, T. et al. 88 s. (elektronisk)
Nr. 467: Marine områder 2002 - Miljøtilstand og udvikling. NOVA 2003. Af Rasmussen, M.B. et al. 103 s. (elektronisk)
Nr. 468: Landovervågningsoplande 2002. NOVA 2003. Af Grant, R. et al. 131 s. (elektronisk)
Nr. 469: Søer 2002. NOVA 2003. Af Jensen, J.P. et al. 63 s. (elektronisk)
Nr. 470: Vandløb 2002. NOVA 2003. Af Bøgestrand, J. (red.) 76 s. (elektronisk)
Nr. 471: Vandmiljø 2003. Tilstand og udvikling - faglig sammenfatning. Af Andersen, J.M. et al. 157 s., 100,00 kr.
Nr. 472: Overvågning af Vandmiljøplan II - Vådområder 2003. Af Hoffmann, C.C. et al. 83 s. (elektronisk)
Nr. 473: Korrektion for manglende indberetninger til vildtudbyttestatistikken. Af Asferg, T. & Lindhard, B.J. 28 s. (elektronisk)

This report presents and assesses contaminant concentrations in traditional human diet in Greenland. Our study has mainly included cadmium, mercury, selenium, polychlorinated biphenyls (PCB), dichlorophenyltrichloroethane (DDT), chlordane, hexachlorocyclohexanes (HCH), chlorobenzenes, dieldrin and toxaphene in the major animal species and tissues consumed by Greenlanders. A subset of samples was also analyzed for coplanar PCBs, brominated diphenyl ethers, short chain chlorinated paraffins and butyltins. In general contaminant levels are very low in terrestrial species and in muscle tissue of many marine species. High organochlorine concentrations are typically found in blubber of marine mammals and high metal levels in seabird liver and in liver and kidney of seals and whales. Except for cadmium, contaminant levels in the Greenland environment, including diet items, are lower than in more densely populated and industrialized regions of the Northern Hemisphere.

492 Contaminants in the traditional Greenland diet

National Environmental Research Institute
Ministry of the Environment

ISBN 87-7772-811-4
ISSN 1600-0048