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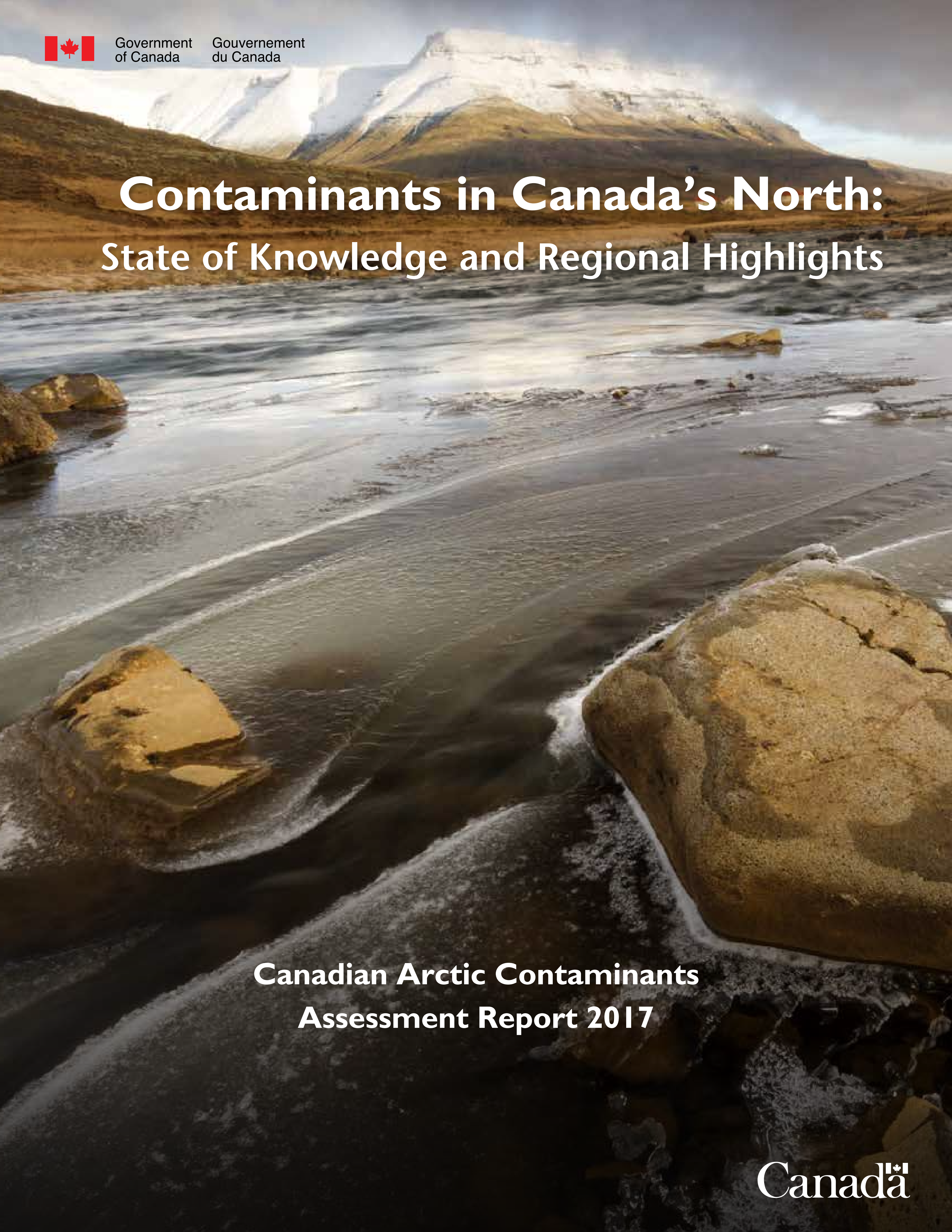

Contaminants in Canada's North: State of Knowledge and Regional Highlights

Canadian Arctic Contaminants Assessment Report 2017

Canada

Acknowledgements

This report is presented by the Northern Contaminants Program Management Committee, whose members include representatives of Inuit Tapiriit Kanatami, Dene Nation, Council of Yukon First Nations, Inuit Circumpolar Council Canada, Chairs of Regional Contaminants Committees in Yukon, NWT, Nunavut, Nunavik and Nunatsiavut, governments of Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut, and the federal departments of Indigenous and Northern Affairs, Health, Environment and Climate Change, and Fisheries and Oceans.

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FOREWORD

On the occasion of the 25th anniversary of the Northern Contaminants Program (NCP), the Program and its partners are pleased to present this Canadian Arctic Contaminants Assessment Report, Contaminants in Canada's North: State of Knowledge and Regional Highlights. This publication synthesizes the detailed scientific results presented in a series of technical reports produced over the past six years by the Northern Contaminants Program on the issue of long-range contaminants in the Canadian Arctic. These reports provide a comprehensive assessment of contaminants in Canada's Arctic, and the impact they have on Arctic ecosystems and people.

The results of monitoring and research that are contained in these reports helped to bring about the global Minamata Convention on Mercury, a legally binding treaty that comes into force in 2017, and which will help reduce global emissions of mercury, and ultimately lead to lower levels of mercury in the Arctic. NCP results also contributed to the addition of eleven new persistent organic pollutants (POPs) to the Stockholm Convention on POPs. The early detection and regulation of these chemical contaminants should prevent them from reaching dangerous levels in arctic wildlife and people.

Managed by Indigenous and Northern Affairs Canada, the NCP, which was established in 1991, is a co-operative effort involving the federal departments of Health, Environment and Climate Change, and Fisheries and Oceans; the territorial governments of Nunavut, Northwest Territories and Yukon; the governments of Nunavik and Nunatsiavut; northern Indigenous organizations including the Council of Yukon First Nations, Dene Nation, Inuit Tapiriit Kanatami, and the Inuit Circumpolar Council – Canada; and key academic networks like ArcticNet. The NCP co-ordinates monitoring and research of northern contaminants nationally and provides the research necessary to take action internationally. The NCP addresses concerns about exposure to elevated levels of contaminants in northern Indigenous peoples, as well as in fish and wildlife species that are important to the traditional diets of those peoples.

The NCP is considered a model program for conducting monitoring and research in the North in a way that engages Indigenous organizations and communities in all aspects of the program, from management decisions about program direction, to community-based monitoring of wildlife. Even so, after 25 successful years, the NCP is still finding ways to improve and to better serve Arctic Indigenous communities. In recent years this has included the initiation of a Community Based Monitoring and Research subprogram whereby community led projects have been able to address some of the more pressing contaminant related issues of importance to community members. These projects have also provided a greater opportunity for the application of Indigenous science and traditional knowledge to contaminant related issues. As the NCP looks to the future, traditional knowledge and knowledge co-production will continue to play a bigger part in the program, leading to a more holistic understanding of how contaminants and other environmental stressors are effecting the Arctic environment and Indigenous communities.

The information captured in this report reflects the hard work and valued contributions of many people and organizations, from community members across Canada's North, academic institutions, and governments over the past 25 years. A big thank you to all for those efforts.

25 YEARS ANS

Northern Contaminants Program

Programme de lutte contre les contaminants dans le Nord

EXECUTIVE SUMMARY

Contaminants in Canada's North

In Canada's North, contaminants (such as mercury and persistent organic pollutants or POPs) come primarily from sources outside Canada via the atmosphere, ocean currents, and rivers. Animals and people are exposed to mercury and POPs through the food that they eat. Contaminants enter the food chain through plants and algae, and are then passed up the food chain from prey to predator. Contaminant levels can increase over time as they "bioaccumulate" in an animal's body. A process called `biomagnification´ leads to an increase in concentration with each step up the food chain. At levels of exposure that exceed applicable guidelines, contaminants can affect the health of wildlife and people.

Many people in Canada's North, particularly in Indigenous communities, rely on traditional/country foods harvested from the land, rivers, lakes and sea, for many nutritional and cultural benefits. These benefits must be considered when developing strategies to reduce contaminant associated risks to human health to achieve a balance between the many known benefits of country foods, and the potential risks.

NCP Assessments and this report

The Northern Contaminants Program (NCP) was established in 1991 in response to concerns about human exposure to elevated levels of contaminants in wildlife species that are important to the traditional diets of Indigenous peoples. NCP assessments are carried out in order to synthesize current knowledge on contaminants in the Arctic environment and people. Assessment results are used to assess the safety of traditional/country foods, and to inform policy, in Canada and abroad, resulting in actions to eliminate contaminants from long-range sources. NCP assessments are published as *Canadian Arctic Contaminant Assessment Reports (CACAR)*, which are technical documents intended for a scientific audience. The current *Highlights* report is a plain language summary of results reported in a series of assessments published since 2012, including: *Mercury in Canada's North (2012)*, *Persistent Organic Pollutants in Canada's North (2013)*, and *Human Health (2016)*.

This assessment period was also significant for global regulatory actions that included the addition of new chemicals to the United Nations Environment Programme (UNEP) Stockholm Convention on POPs (2004), and the signing of the UNEP Minamata Convention on Mercury (2013).

Key findings

Overall, much progress has been made in Canada and abroad to reduce sources of contaminants. Despite reduced emissions, however, contaminants continue to be a concern, impacting the health and well-being of wildlife and people in Canada's North. This report identifies ten key findings that arose from the CACAR III assessment reports.

Key findings 1-3 focus on the levels of specific contaminants: *(1) Concentrations of POPs are generally going down across the Arctic*. However, large quantities are still stored in `environmental reservoirs´ that will take many years to deplete. *(2) As `new POPs´ come under regulation, their levels in the Arctic decline*. Since 2004, eleven new POPs have been added to the Stockholm Convention, which is associated with decreasing levels in the environment. *(3) Mercury levels in the Arctic are stabilizing but are still several times higher than during pre-industrial times*. Levels peaked in the mid-2000s and have since leveled off or even declined slightly in some areas.

Key findings 4 and 5 focus on the environmental processes that influence contaminants: *(4) Climate change can affect how POPs and mercury cycle in the Arctic environment and accumulate in wildlife*. Warmer air and water, longer ice-free season, increased forest fire activity, changing food web structure, are all examples of climate related changes that can influence contaminants. *(5) The complex movement of contaminants in the Arctic environment and wildlife is now better understood*. Research on environmental processes has revealed new information about mercury and POPs, including details about mercury methylation, and how processes for newer POPs differ from those of the original POPs.

Key findings 6 to 9 focus on health risks for wildlife and Northerners: *(6) Current levels of POPs and mercury may be a risk for the health of some Arctic wildlife species*. While there is no evidence of widespread biological effects in Canadian arctic wildlife, some species of fish, marine mammal and seabirds exceed threshold levels for POPs and mercury that are related to adverse effects. *(7) While exposure to most POPs and mercury is generally decreasing among Northerners, mercury remains a concern in some regions*. Decreasing concentrations are likely related to a combination of reduced levels in the environment and shifts in consumption of traditional/country foods. Mercury exposure among some Inuit women of childbearing age remains a serious concern, and highlights the need for international action on mercury. *(8) Traditional/country foods continue to be important for maintaining a healthy diet for Northerners*. The consumption of such foods is still fairly widespread and associated with improved nutritional status, but a continuing shift toward market food is drawing concern for potential implications on nutritional health and disease. *(9) Environmental exposure to contaminants in the Arctic has been linked to health effects in people*. For example, mercury and PCBs have been linked to attention deficit disorder in children at levels of exposure observed in the Canadian Arctic.

Key finding 10 focuses on international efforts: *(10) Continued international action is vital to reducing contaminant levels in the Arctic*. Arctic monitoring and research have been important to the establishment of the Stockholm and Minamata Conventions of POPs and Mercury. Monitoring results show that international action is working to decrease contaminants in the Arctic.

Regional Highlights

This report provides information on contaminants in five regions of Canada's Arctic, including: Yukon, Northwest Territories, Nunavut, Nunavik, and Nunatsiavut. Indigenous peoples, including Inuit, First Nations and Métis, make up the largest proportion of the population in Canada's North.

The main traditional/country foods consumed in indigenous communities vary across the North, and within regions, and include a variety of freshwater and marine fishes, caribou, ducks and geese, ringed seal and beluga. A wide variety of other species are also consumed, though generally to a lesser extent.

In 2007–2008, the Inuit Health Survey (IHS) assessed people's health status in many Inuit community across the Canadian Arctic. As part of this study, researchers documented the traditional/country foods that people were eating, and assessed nutrient and contaminants levels in participants and their foods. IHS results reinforced the message that the benefits of eating such foods generally outweigh the risk of contaminant exposure.

One exception is mercury, which posed varying levels of concern in all regions. For example, health advisories were issued for ringed seal liver consumption by women of child bearing age in Nunavut. Advisories were also placed on some lakes and fish in the Northwest Territories, where NCP datasets detected increasing mercury levels in fish. The long term data sets from the NCP have played an important role in bringing about the global *Minamata Convention on Mercury*.

As a result of global regulation, POPs generally declined across all regions. For example, in the Northwest Territories, monitoring results show that POPs in beluga and ringed seal have declined since the mid-1990s. However, negative health effects from some POPs are still a concern for some species of seabirds and marine mammals.

Future directions and recommendations

In light of the findings of the CACAR III assessments, the NCP and its partners, including indigenous organizations, identified a number of priorities for future work through four themes. These include activities in: (1) environmental monitoring and research, such as detecting new chemicals and researching the interacting effects of contaminants and climate change; (2) community-based monitoring and research through a new subprogram that builds science capacity in the North and optimize the use of traditional knowledge; (3) human health, such as expanding the monitoring of contaminant exposure among people from different regions; and (4) improving effective communications of research results.

The NCP further calls on broader actions to achieve its mandate and support Arctic science. For Canadian research and monitoring programs (including NCP), this includes ensuring adequate resources, properly managing and communicating information, and multidisciplinary assessments of issues, such as climate change. It further calls for better engaging northern entities, in monitoring and research and international activities.

Finally, for Arctic nations, including Canada, NCP calls for the prompt communication of national POPs information to international bodies, swift ratification of the *Minamata Convention on Mercury*, and recognition of food and water security as a priority for action. It further calls for monitoring the impacts of socio-economic and environmental change on local sources of contaminants, and considering the impacts of contaminants on ecosystems and people in developing adaptation strategies for a changing Arctic.

The Science of Northern Contaminants

Many people in Canada's North rely on foods harvested from the land and sea as an important part of their diet, particularly in Inuit and First Nations communities. These foods provide significant health, economic, social and cultural benefits; they also expose people to contaminants such as persistent organic pollutants (POPs) and mercury from long-range sources – an issue that has been studied extensively for more than two decades by the Northern Contaminants Program (NCP).

1) WHERE DO THEY COME FROM?

SOURCES/EMISSIONS

- Most of the POPs and mercury in Canada's North come from sources far away, meaning outside Canada and from other continents.
- Large-scale production of POPs began in the early 20th century. Sources have mainly been industry (e.g. PCBs) and agricultural pesticides (e.g. DDT). While some previously widely used POPs are no longer in production or use, the development of new POPs continues.
- Mercury is a naturally occurring element that has always existed in the environment. Since the beginning of the world's period of industrialization, mercury has been emitted to the atmosphere primarily through the combustion of coal. Recently, artisanal and small-scale gold mining has been identified as another major source.
- Emissions of POPs occur during their production, use or disposal. They enter either the atmosphere and/or water bodies and land surfaces (e.g. via agriculture).
- Chemicals in household products (such as flame retardants in furniture and carpets, which are ultimately disposed of in local landfills in northern communities) are an increasing source of new POPs.

2) HOW DO THEY GET TO THE ARCTIC?

LONG RANGE TRANSPORT ("pathways")

- Contaminants can travel to Canada's North through the atmosphere (the quickest way, it can take days or weeks), through ocean currents (it can take years); and via rivers, which can carry contaminants to the Arctic from within their watersheds (it can take from weeks to years).

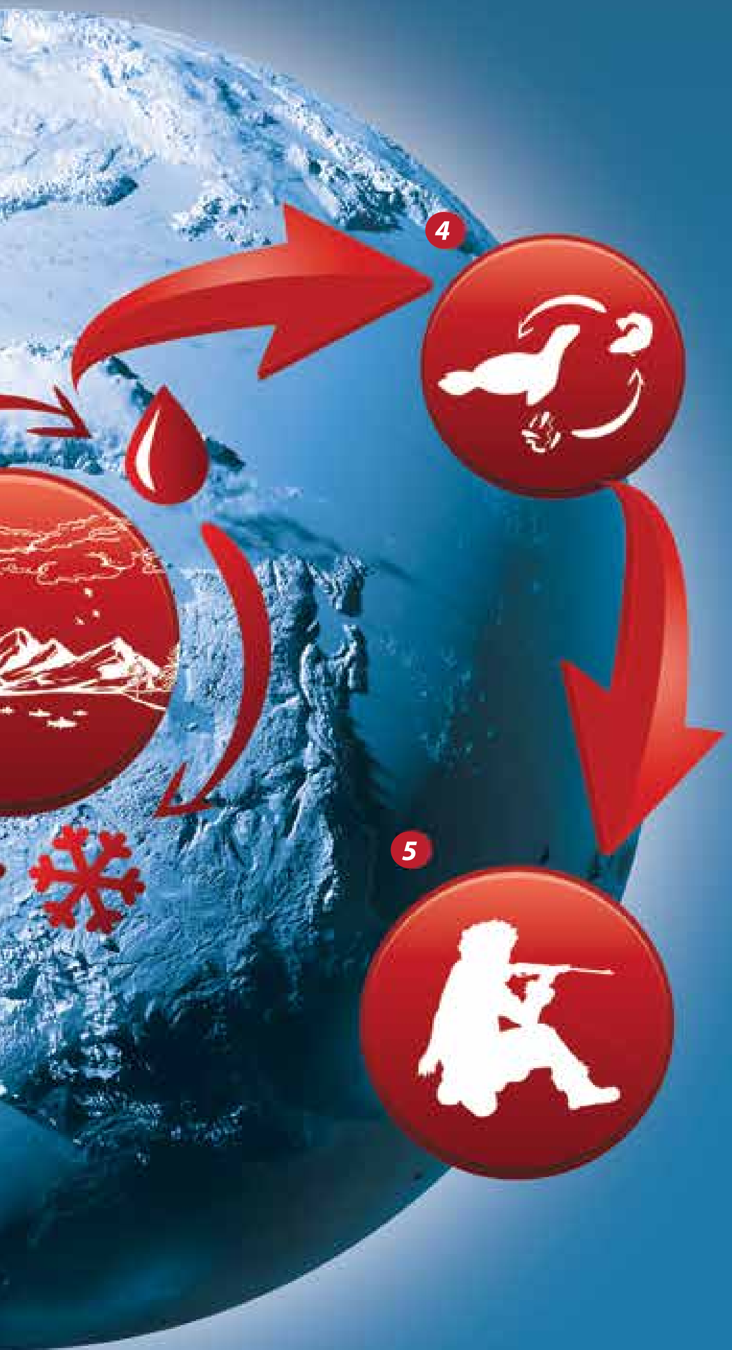
DEPOSITION

- Once in the Arctic, POPs and mercury in the atmosphere can deposit on any surface, such as land, water, ice and snow.
- Because of the cold climate and the nature of these contaminants, they tend to persist in the Arctic environment where they can be taken up into the food web.

3) WHAT HAPPENS ONCE THEY ARE IN THE ARCTIC?

CYCLING

- Contaminants can move, or cycle, between the air, water, snow and sediment.



TRANSFORMATION

- Contaminants can also change from one form to another. For example, mercury is mainly deposited in an inorganic form. However, some bacteria can methylate inorganic mercury, transforming it into organic methylmercury which is more toxic.
- POPs can naturally degrade biologically or chemically (e.g. by ultraviolet radiation in sunlight), which can eventually lead to their elimination from the environment. POPs that degrade slowly are said to be more persistent.

4) HOW DO ANIMALS AND PEOPLE BECOME EXPOSED?

FOOD WEB

- Animals and people get exposed to POPs and mercury through the food they eat. Contaminants usually first enter through the lowest (trophic) level of a food web, such as through algae, which are in turn eaten by bigger animals.
- Over time, an individual organism will bioaccumulate contaminants in its tissue (especially POPs, because they are retained in fatty tissues).
- Biomagnification leads to an increase in concentration with each step up the food chain. A top predator will therefore usually have the highest concentration.
- Most POPs tend to accumulate in fatty tissue. Mercury accumulates in protein-rich tissue such as muscle. Both accumulate in the liver.
- Animals can dispose of some contaminants in their body through natural biological processes such as metabolism, reproduction, and hair growth.

5) WHAT ARE THE HEALTH IMPACTS OF EXPOSURE TO CONTAMINANTS?

HEALTH EFFECTS AND RISK-BENEFIT ANALYSIS

- At levels that exceed applicable guidelines, both POPs and mercury can affect the health of wildlife and people. For example, mercury can affect the brain, reproduction and nervous system, and POPs can affect the immune, endocrine and reproductive systems.
- Understanding the human health implications of contaminants at levels found in Canada's North requires balancing the risks with the many benefits from a diet rich in traditional/country foods.
- Stress caused by exposure to contaminants is compounded by other stresses affecting wildlife, such as habitat loss, food shortage, disease and extremes in weather. This is often referred to as "cumulative stress".

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NCP Knowledge to Action

1) HOW ARE CONTAMINANTS STUDIED?

MONITORING AND RESEARCH

- Contaminants are measured in samples collected by scientists and community-based harvesters, and at remote, automated stations in the field, such as the air station at Alert. Increasingly, Indigenous knowledge is used alongside natural, health and social sciences to interpret results, assess impacts, and guide future studies.

ASSESSMENT

- Information on contaminant levels is used to assess ecosystem and human health risks. Concentrations are compared with known threshold concentrations for wildlife effects and with human health effects guidelines, such as Health Canada's blood guidance value for mercury. Human health risks are assessed within a benefit-risk context for traditional/country foods.

PARTNERSHIPS IN RESEARCH

- In Canada, NCP and its partners perform the monitoring, research and assessment. Key partners include federal government departments (Indigenous and Northern Affairs Canada, Health Canada, Environment and Climate Change Canada, Fisheries and Oceans Canada), university scientists, Indigenous organizations (Council of Yukon First Nations, Dene Nation, Inuit Tapiriit Kanatami and Inuit Circumpolar Council-Canada), territorial/regional governments, regional organizations, Hunters and Trappers Organizations and other members of northern communities, and other research programs (e.g. ArcticNet).
- Canadian researchers and Indigenous partners also regularly collaborate with international bodies such as the Arctic Monitoring and Assessment Programme (AMAP), and other working groups under the Arctic Council, for example, to produce Arctic Pollution Reports.

2) HOW ARE THE RESEARCH RESULTS COMMUNICATED?

COMMUNICATION

- Awareness of contaminant issues is raised through communicating results with key audiences such as Northerners, and particularly women of child-bearing age.
- Key communicators for the NCP include its Indigenous partners, the Regional Contaminants Committees, the Inuit Research Advisors and the research teams themselves.
- Health advisories are developed by territorial/regional health authorities and communicated with Northerners.
- NCP collaborates with international partners such as AMAP, Arctic Council, and the United Nations Environment Programme (UNEP) and Indigenous partner organizations to communicate results to policy makers and public audiences outside of Canada.

Photo: Lisa Loseto

3) HOW ARE RESULTS ACTED UPON?

REGULATORS AND POLICY MAKERS

- Policy-relevant science conclusions and recommendations are developed based on an evaluation of all available results and information. These are used by government to inform new and enhanced regulations that control emissions and to develop health advice that encourages informed choices and reduces contaminants exposure.
- Recommendations are also made to direct new research to fill gaps in knowledge.
- Results have been used by Indigenous organizations, governments, and international organizations in the development and ongoing support of global regulations: the *Stockholm Convention on Persistent Organic Pollutants* (entered into force in 2004), which aims to eliminate or restrict the production and use of POPs; and the *UNEP Minamata Convention on Mercury* (adopted in 2013), which aims to reduce global emissions and releases of mercury.

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4) WHAT HAPPENS NEXT?

LOWER EMISSIONS AND RISK, MORE RESEARCH

- Once regulations are in place and industry ceases to produce a particular contaminant, then emissions should begin to decline along with risks to the health of wildlife and people. However, this can take a long time to occur and depends on many factors, e.g. climate change, changing dietary habits. Ongoing monitoring is required to measure progress.
- While some chemicals have been phased out, hundreds of new chemicals enter global markets every year. It is important that NCP researchers continue to look for new chemical contaminants in samples from the Arctic.

Photo: Eric Loring

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POPs under the Stockholm Convention

The Stockholm Convention is a global environmental treaty under the United Nations Environment Programme. The purpose of the Convention is to eliminate or restrict the production and use of POPs. Twelve initial POPs (also known as the "dirty dozen") were the first to be recognized as causing adverse effects on humans and the ecosystem and listed in the Convention (2004). These have since been followed by the addition of eleven new POPs. POPs can be placed in one to three categories: pesticides ◯, industrial chemicals □, and by-products △.

For the Convention's Annex A chemicals, Parties must take measures to eliminate production and use. Specific exemptions may be made.

For Annex B, Parties must take measures to restrict production and use. Acceptable purposes and/or specific exemptions may be made.

For Annex C, Parties must take measures to reduce unintentional releases, with the goal of continuing minimization and, where feasible, elimination.

Stockholm Convention: Initial 12 POPs

○: pesticide, □: industrial chemical, △: by-product

Chemical Name	Category	Annex	Global Historical Use/Source
aldrin	○	**A**	Pesticide applied to soils to kill termites, grasshoppers, corn rootworm, and other insect pests. Used on crops such as corn and cotton. Can also kill birds, fish, and humans.
chlordane (CHL)	○	**A**	Used extensively to control termites and as a broad-spectrum insecticide on a range of agricultural crops, such as vegetables, small grains, potatoes, sugarcane, sugar beets, fruits, nuts, citrus, and cotton.
dieldrin	○	**A**	Used to control termites and textile pests. Also used to control insect-borne diseases and insects living in agricultural soils.
DDT	○	**B**	Insecticide used on agricultural crops, primarily cotton, and insects that carry diseases such as malaria and typhus.
endrin	○	**A**	Insecticide sprayed crops such as cotton and grains. Also used to control rodents such as mice and voles.
mirex	○	**A**	Insecticide used to combat fire ants, termites, and mealybugs. Also used as a fire retardant in plastics, rubber, and electrical products.
heptachlor	○	**A**	Insecticide used against soil insects and termites. Also used against some crop pests and to combat malaria.
hexachlorobenzene (HCB)	○△	**A, C**	Kills fungi (e.g. wheat bunt) that affect food crops. Also an industrial chemical used to make fireworks, ammunition, synthetic rubber, and other substances; a by-product of the manufacture of certain industrial chemicals; and an impurity in several pesticide formulations.
PCBs	□	**A, C**	Used for a variety of industrial processes and purposes, including electrical transformers and capacitors, heat exchange fluids, paint additives, carbonless copy paper, and plastics.
toxaphene	○	**A**	Insecticide used on cotton, cereal grains, fruits, nuts, and vegetables. Also used to control ticks and mites in livestock.
polychlorinated dibenzo-p-dioxins (PCDD)	△	**C**	Produced unintentionally due to incomplete combustion, and during the manufacture of pesticides and other chlorinated substances. Emitted mostly from the burning of hospital, municipal, and hazardous waste; and from automobile emissions, peat, coal, and wood.
polychlorinated dibenzofurans (PCDF)	△	**C**	Produced unintentionally from many of the same processes that produce dioxins, and also during the production of PCBs. Have been detected in emissions from waste incinerators and automobiles.

Stockholm Convention: New POPs

○: pesticide, □: industrial chemical, △: by-product

Chemical Name	Category	Annex	Global Historical Use/Source
alpha hexachlorocyclohexane (alpha-HCH)	○	**A**	Intentional use as an insecticide was phased out but this chemical is still produced as an unintentional by-product of lindane.
beta hexachlorocyclohexane (beta-HCH)	○	**A**	Intentional use as an insecticide was phased out but this chemical is still produced as an unintentional by-product of lindane.
chlordecone	○	**A**	Agricultural pesticide
hexabromobiphenyl	□	**A**	Fire retardant
hexabromocyclododecane (HBCDD)	□	**A**	Used as a flame retardant, providing fire protection during the service life of vehicles, buildings or articles, as well as protection while stored. Main global use is in polystyrene foam insulation, and in textile applications and electric and electronic appliances.
hexabromodiphenyl ether and heptabromodiphenyl ether	□	**A**	Fire retardant
lindane	○	**A**	Broad-spectrum insecticide for seed and soil treatment, foliar applications, tree and wood treatment, and against ectoparasites (e.g. fleas and lice) on people and other animals.
pentachlorobenzene (PeCB)	○△□	**A, C**	Was used in PCB products, dyestuff carriers, as a fungicide, a flame retardant, and as a chemical intermediate. Also produced unintentionally during combustion, thermal and industrial processes, and present as impurities in products such as solvents or pesticides.
perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F)	□	**B**	PFOS is both intentionally produced and an unintended degradation product of related manmade chemicals. The current intentional use of PFOS is widespread and includes: electric and electronic parts, firefighting foam, photo imaging, hydraulic fluids, and textiles.
endosulfan and its related isomers	○	**A**	Insecticide used since the 1950s to control crop pests, tsetse flies, ectoparasites of cattle, and as a wood preservative. As a broad-spectrum insecticide, endosulfan is currently used to control a wide range of pests on crops including coffee, cotton, rice, sorghum, and soy.
tetrabromodiphenyl ether and pentabromodiphenyl ether (commercial pentabromodiphenyl ether, or PBDE)	□	**A**	Fire retardant

Sources:
UNEP Stockholm Convention website, page on *The POPs*
USEPA website, page on *Persistent Organic Pollutants: A Global Issue, A Global Response*

Key Findings

KEY FINDING 1

Concentrations of POPs are generally going down across the Arctic.

KEY FINDING 2

Photo: Eric Loring

As `new POPs´ come under regulation, their levels in the Arctic decline.

KEY FINDING 3

Photo: Paul Nicklen/National Geographic Society

Mercury levels in the Arctic are stabilizing but are still several times higher than during pre-industrial times.

KEY FINDING 7

Photo: Eric Loring

While exposure to most POPs and mercury is generally decreasing among Northerners, mercury remains a concern in some regions.

KEY FINDING 8

Photo: N.Gatner

Traditional/country foods continue to be important for maintaining a healthy diet for Northerners.

KEY FINDING 4

Photo: Shutterstock

Climate change can significantly affect how POPs and mercury cycle in the Arctic environment and accumulate in wildlife.

KEY FINDING 5

Photo: Janice Lang

The complex movement of contaminants in the Arctic environment and wildlife is now better understood.

KEY FINDING 6

Photo: Eric Loring

Current levels of POPs and mercury may be a risk for the health of some Arctic wildlife species.

KEY FINDING 9

Photo: Eric Loring

Environmental exposure to contaminants in the Arctic has been linked to health effects in people.

KEY FINDING 10

Photo: Shutterstock

Continued international action is vital to reducing contaminant levels in the Arctic.

KEY FINDING 1

Concentrations of POPs are generally going down across the Arctic.

Twelve persistent organic pollutants (POPs), known as the 'Dirty Dozen' (see Table of POPs on page 16) were originally designated under the *United Nations Environment Programme Stockholm Convention* which regulates POPs globally.

The levels of many POPs in the environment and wildlife are generally going down. A rapid decline of POPs levels in the environment was first observed in the 1990s. This is because most of the Stockholm Convention's original 12 POPs were banned or regulated by many countries between the 1970s and 1990s, leading up to global regulations under the Stockholm Convention in 2004. As a result of these national and international regulations, the 'primary sources' of POPs – those produced and emitted directly to the environment by industry and agriculture (e.g. DDT and PCBs) – were essentially eliminated.

In Canada's Arctic, air monitoring has found that many POPs, such as organochlorine (OC) pesticides (most of the dirty dozen POPs are OC pesticides) and PCBs, are declining. Since 1990, the NCP has measured an approximate 50%-80% decrease in most POPs in arctic wildlife, which translates into a significant reduction in the risk of toxic effects for most species. This has been most apparent for OC pesticides and less so for PCBs and ΣCBz (total, or the sum of all chlorobenzenes). Regarding ΣDDT in marine species, annual decline rates have ranged from 2.5%/year in thick-billed murre eggs from Lancaster Sound to 11%/year in polar bear fat from western Hudson Bay.

Since the publication of CACAR II in 2003, data about POPs in fish, seabirds, and marine mammals has significantly improved. The main reason is that, in 2004, the NCP increased the sampling of key monitoring species, such as ringed seal, from about every five years to every year.

The rate of decline is slowing down

Since the rapid decline of the 1990s, the decline rate for many POPs has either decreased or stopped, with regional variations. For example, the decline rates of PCBs, ΣDDT, and ΣCHL were lower (or non-existent) in beluga, ringed seals, and polar bears in the South Beaufort compared to decline rates in the Hudson Bay and East Baffin regions. One POP, β-HCH, showed an increasing trend (*see box on next page*). At the same time, it is important to note that the overall risks of POPs for Canadian arctic wildlife health are now generally decreasing.

The slowing down can be attributed to a number of causes. `Primary sources´ of POPs from industry and agriculture emit POPs to the atmosphere or water which, in turn, can become `pathways´ and `carriers´ of POPs to the Arctic. Once in the Arctic, they become deposited to different environmental media such as the ocean, forests, soil, or ice caps. These are also called `environmental reservoirs´ by scientists. New emissions from primary sources of POPs have been virtually eliminated. However, the reservoirs have built up over many years resulting in the ongoing contamination of fish and wildlife. As POPs naturally break down, these reservoirs will eventually be depleted – as will the levels that accumulate in fish and wildlife – but this will take a long time. In addition, climate change is expected to increase the releases of POPs back to the environment from some of these reservoirs, for example, through melting ice caps and forest fires.

The levels of some POPs are decreasing faster than others. This is because certain POPs, like PCBs, are more persistent in the environment and take longer to degrade than do other POPs, such as DDT.

The type of environmental media, and size of reservoir, can influence rates of decline. For example, small freshwater bodies can process POPs faster than can a vast ocean reservoir. In turn, this has resulted in generally faster declines of POPs in freshwater fish than in marine animals. For example, PCBs in landlocked arctic char declined by 7.6%/year in Lake Hazen, Ellesmere Island, versus a 3.8% decline in marine thick-billed murres. Another example is that declines were greater for ΣHCH, ΣCHL, ΣDDT, and toxaphene in lake trout from Laberge Lake, Kusawa Lake, and the western basin of Great Slave Lake as well as in landlocked char in Lake Hazen, Char Lake, and Amituk Lake, compared to declines for these OC pesticides in seabird eggs and marine mammals.

The rise of β-HCH

HCHs (hexachlorocyclohexanes), are insecticides which have three isomers. *Isomers* have the same chemical composition but slight differences in structure, which result in different properties that cause each to behave differently in the environment. Arctic measurements show that total HCHs (the sum of all three isomers) declined in seals, beluga, and polar bears due to the rapid decline of the isomer α-HCH (e.g. 12%/year in bears). However, the β-HCH isomer increased in the same species with regional variations – e.g. large increases in South Beaufort Sea seals (16%/year at Ulukhaktok) and a decline in Hudson Bay seals (2.5%/year). What is behind the increase? The answer is that many HCHs were emitted from Asian producers to the atmosphere after which air currents carried them over the Pacific Ocean where they fell with rain, entered ocean waters, and were then transported to the Arctic via the Bering Strait. Add the fact that β-HCH isomers are far more persistent and bioaccumulative than the others. The result is a large reservoir of β-HCH that now exists in the Pacific which is travelling slowly to the Canadian Arctic. Still, β-HCH is not at toxic levels and currently poses no risk.

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KEY FINDING 2


Photo: Eric Loring

As `new POPs´come under regulation, their levels in the Arctic decline.

In addition to the 12 POPs originally included in the Stockholm Convention, some 35 chemicals of emerging concern have been added since 2000 to the list of contaminants that NCP monitors in the Arctic. Eleven of these chemicals have since been defined as POPs and added to the Stockholm Convention. While the levels of most new POPs increased rapidly once they were introduced decades ago by chemical companies, most began to decline after the mid-2000s. Declines in some POPs (e.g. PBDEs and PFOS) in air and wildlife appear to be related to the bans and voluntary phase-outs of these substances in North America and Europe over the period 2001-2004. Today's levels of most new POPs in the environment and wildlife are low when compared to the levels of the dirty-dozen POPs and do not currently pose a risk to wildlife health.

For example, analysis showed that ΣPBDEs (the sum of all PBDEs) achieved maximum concentrations in northern fulmar and thick-billed murre eggs in 2005 and 2006, respectively, and declined to levels similar to those in the early 1990s within three years. Polar bears, ringed seals, and beluga appear to have achieved maximum ΣPBDEs in the period 2000-2004 in most locations. These conclusions come mainly from scientists performing `retrospective analysis´, which involves measuring contaminant levels in samples that have been archived in specialized facilities know as specimen banks.

NCP scientists continue to discover chemical contaminants that were previously unknown in the Arctic every year. These chemicals of emerging concern, such as newer PFASs (see below), which are not regulated globally, will continue to increase until they too are subject to regulation. At the same time, the more scientists learn, the more they are able to use their accumulated knowledge to contribute to actions to regulate new chemicals. For example, if a chemical with certain properties (e.g. degree of degradation or solubility) has already been banned, then a new chemical having similar properties may not be allowed for introduction in the future. So, many new chemicals are not as `bad´ as old ones. For example, PCBs and PBDEs are both now banned, but the levels of PBDEs, which were introduced later, are declining faster than those for PCBs because PBDEs degrade faster, and it is the *persistence* of a POP in the environment which can make one particularly more `bad´ than another.

Three classes of new POPs and chemicals of emerging concern

(1) Perfluorinated and polyfluorinated alkyl substances (PFASs): PFASs are fluorine-based and used mainly in stain repellants. PFOS, often used in carpets, are the most common and best understood PFASs. The monitoring of PFASs showed an exponential increase in PFOS (now regulated under the Stockholm Convention) in wildlife up until the early 2000s, after which levels significantly decreased. Other non-regulated PFASs (e.g. PFOA) are still increasing.

This discovery of PFASs in Canadian arctic wildlife and the environment is perhaps the most surprising result of the past 10 years of arctic contaminant monitoring. This is because scientists had not expected that PFASs, and other substances with similar properties, could be as easily transported to the Arctic as other POPs. Research proved otherwise, finding that PFASs have different chemical properties than those of other POPs. One, PFASs can be transformed in the atmosphere into chemicals that are more easily transportable by air to the Arctic. Two, they are more persistent and bioaccumulative. And three, they are more water soluble, which means they can be more readily dissolved in oceans and transported via ocean currents to the Arctic.

This last finding was ground breaking because scientists had earlier focused on air currents as the main transportation pathway. The discovery that the ocean was also clearly a main transport mechanism opened the possibility that other chemicals with the same properties might also use ocean transport. As a result, scientists are now examining a broader array of chemicals for their ability to be transported to the Arctic, to help predict how similar existing compounds might behave, and to prevent the commercialization of harmful compounds. This includes a tremendous expansion in modelling the long-range ocean transport of POPs – results from which now suggest that the movement of POPs from the lower latitudes to the Arctic Ocean is ongoing and that arctic concentrations could increase for the next 10 to 20 years.


Photo: Shutterstock

(2) Brominated flame retardants (BFRs): BFRs are used, for example, in electronic products to reduce flammability. Some 20 new flame retardants have been detected by NCP, 18 of which appear to be at low levels. The two retardants at high levels are PBDEs and hexabromocyclododecane (HBCDD). The levels of PBDEs, the most widely detected BFRs in the Arctic, increased through the 1990s and early 2000s until they were banned through the Stockholm Convention and largely replaced by HBCDD. In the 1990s and early 2000s, HBCDD was undetectable in biological samples. Since then, HBCDD use increased, making it the most widely detected non-PBDE flame retardant. From 2005-2011, HBCDD levels increased well above the detection limits for burbot, lake trout, land-locked arctic char, and ringed seals in Canada's Arctic. Maximum HBCDD levels were observed somewhat earlier (2003) in polar bears in western Hudson Bay and in beluga from southern Beaufort Sea. There is no evidence to suggest that HBCDD is causing toxic effects at current levels. At the same time, these results in Canada played an important role in having HBCDD added to the Stockholm Convention in 2013. Scientists worldwide are now looking to use organophosphates to replace bromine and chlorine in flame retardants.

(3) Current use pesticides (CUPs): Lindane and endosulfan are two chlorinated pesticides which used to be observed in Canadian arctic wildlife. Recent declines in their levels were most likely driven by increased international regulation. Lindane was de-registered in Canada as a pesticide on canola seeds in July 2001 and a Canadian ban was introduced in 2004; air concentrations declined steadily as of 2001. Endosulfan concentrations declined from 2006 to 2009, possibly because of reduced use in Canada, the USA, and Europe, as this insecticide was increasingly regulated by governments and later banned under the Stockholm Convention.

CUPs, such as dacthal, PCNB, trifluralin, and chlorthalonil, have now become routinely reported in air and seawater, but it seems that most do not biomagnify, as they are currently rarely observed in wildlife – a positive outcome based on lessons learned from the use and banning of earlier CUPs.

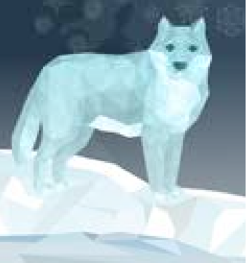
KEY FINDING 3

Photo: Eric Loring

Mercury levels in the Arctic are stabilizing but are still several times higher than during pre-industrial times.

Mercury is a natural element that has always been present in the arctic environment. Retrospective analysis found that mercury levels greatly increased during the late 1800s and early 1900s, when rapid global industrialization was fuelled primarily by coal, the largest man-made source of mercury to the atmosphere.

Mercury levels in the Arctic are still on average ten times higher than they were during the early 1800s. However, NCP monitoring of recent trends indicates that mercury levels in arctic air peaked about ten years ago and have since slightly declined. No increases in the air have been detected since, although there are only three stations monitoring mercury in the air across the Canadian North. Between 2000 and 2009, air mercury concentrations declined at both the stations in Alert, in the High Arctic, and in Kuujjuarapik, in sub-Arctic southern Hudson Bay. The rate of decline at Kuujjuarapik (about 2%/year) was comparable to non-arctic monitoring sites at lower latitudes, while a slower rate of decline was observed at Alert (about 0.9%/year). This difference between the two sites may be related to a number of factors including different climatic conditions as well as changes in the sources of mercury. For example, Alert receives a lot of mercury from Asia where an increasing amount of coal is burned for energy production. Kuujjuarapik, however, which has seen more rapid declines in atmospheric mercury, receives most of its mercury from sources in North America where new technology has dramatically reduced mercury emissions from coal-fired power plants. As for the station at Little Fox Lake (Yukon), where mercury has been monitored continuously in air since 2007, no trend was apparent.



It was recently found that artisanal small-scale gold production, especially in Third World countries, has become a bigger global source of mercury emissions than energy production. However, since these sources are almost entirely in the southern hemisphere, they are not expected to have a large impact on the Arctic – although modeling is needed to confirm this. In developed countries, while the volume of coal burned remains high, scrubbing technologies that remove mercury from power plant emissions have greatly improved.

Over the last 10 years, no consistent trend in mercury concentrations was observed in wildlife across Canada's North. Some wildlife populations have shown increasing concentrations, such as a 50% increase in freshwater fish from the Mackenzie Valley. Burbot from the Mackenzie River have seen a two-fold increase in mercury since 1985. Eggs of thick-billed murres also saw concentrations double since 1975. Meanwhile, other species, such as ringed seal and beluga, show no consistent increasing or decreasing trend.

Climate change is often associated with changes in wildlife mercury concentration levels through, for example, shifts in diet or increased methylation *(Key Finding #4)*. As a result of warmer water temperature and changes in sea-ice, thick-billed murres from North Hudson Bay have been shifting their diet from arctic cod to other species such as capelin and sand lance which are lower in the food chain and have lower mercury concentrations than arctic cod. The change in diet should have resulted in lower mercury concentrations in the eggs, however, the concentrations continued to be quite high. This suggests that other factors potentially related to climate change were increasing mercury concentrations in the lower food web.

For the future, mercury levels are anticipated to slowly decrease over the long-term with the implementation of the UNEP Minamata Convention on Mercury and associated decreases in emissions from industrial sources.

We now know more

Information about mercury concentrations in air and wildlife has improved as a result of NCP's long-term monitoring program, which is the most comprehensive in the circumpolar Arctic. Initiated by NCP in 2005, the program now monitors Arctic wildlife more frequently (annually). This has resulted in more powerful datasets and a better ability to detect changes in mercury levels in wildlife. Across the Arctic, strong evidence now exists for mercury concentrations varying between different regions and over time. Regionally specific factors and ecosystem characteristics have an important influence on mercury levels and on how they change over time. Examples include processes delivering mercury to Arctic ecosystems (e.g. deposition from the atmosphere), shifts in food web structure (e.g. introduction of new species, reduction in previous dominant species), and climate change. However, the exact ways in which these factors influence mercury levels remain unclear and more research is needed, especially at sites where mercury increases have been observed.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KEY FINDING 4

Photo: Eric Loring

Climate change can significantly affect how POPs and mercury cycle in the Arctic environment and accumulate in wildlife.

In the Arctic environment, climate change is causing rapid and profound changes, such as rising temperatures and longer ice-free periods. NCP scientists are linking those changes over time with measurements of mercury and POPs that they have taken over many years. For example, Arctic air has been continuously measured for 18 years, and lake trout, burbot, arctic char, seabirds, seals, polar bears, and beluga have been sampled intermittently for 35 to 50 years. One general observation is that climate change is altering the availability of contaminants for uptake into the Arctic food web in a variety of ways and in different environments.

In the air, rising air temperatures, due to climate change, may be causing atmospheric mercury deposition events (AMDEs) to occur earlier in the spring. This finding came primarily from the High Arctic monitoring station in Alert where, over the last two decades, maximum AMDE activity has shifted from May to April.

An increase in boreal forest fire activity, which has been linked to climate change, can re-release PCBs into the atmosphere. PCBs transported through the air can stick to the organic material contained in forests where they are stored until being re-released to the air through, for example, fires. This could explain why PCBs in air showed a decline from 1993 to 2009, followed by slower rates of decline and even slight increases in some PCBs in recent years.

Climate change is also increasing the ice-free season of the ocean. This in turn increases the exchange of POPs between the air and sea water.

In freshwater ecosystems, rising water temperatures can increase the production of algae and bacteria. This can lead to an increase in the transformation of inorganic mercury to methylmercury in a process called methylation that is carried out by bacteria. Methylmercury is more toxic and bioaccumulative for animals. In addition, inputs of mercury to Arctic lakes may be generally increasing, partially because climate change is increasing precipitation and therefore runoff and the delivery of mercury and other substances to lakes. These processes have most likely led to significantly increased levels of mercury in fish in the Mackenzie River, where mercury concentrations in burbot have nearly doubled since 1985. Climate change can also increase the erosion of sediment in rivers which can help mobilize POPs.

A significant problem is that climate change is altering food webs which can alter what an animal eats, thereby influencing its exposure to contaminants. For example, climate warming has been suggested as driving shifts in the diet and feeding areas of burbot and lake trout, causing them to feed on organisms which have different levels of POPs.

In marine ecosystems, dietary shifts appear to be leading to changes in contaminant bioaccumulation for biota such as thick-billed murres, ringed seals, and polar bears.

Thick-billed murres in north Hudson Bay have shifted their diet from arctic cod, a cold-water species associated with ice cover, to capelin and sand lance, which, as a result of increasing surface temperatures and changing ice conditions, have become more abundant. Capelin and sand lance are lower on the food chain that arctic cod, and should therefore have led to lower levels of contaminants in murres, and more rapidly declining trends in POPs, however, this was not the case. The dietary shift is actually associated with a slower rate of decline in POPs concentrations, suggesting that changes in the ecosystem have led to higher levels of POPs in the food chain than would have otherwise been predicted. `

For polar bears in western Hudson Bay, a shift in diet from ringed seals to harbor, harp, and bearded seals might be leading to higher concentrations of ΣPCB and ΣCHL. This finding was supported by scientists using `dietary tracers´ (variations in specific elements) in polar bears to help determine what types of animals or plants it consumed. Examples of dietary tracers include: nitrogen used to determine the trophic level (position in a food chain) of food consumed; carbon for whether the food was pelagic (in the water column) or benthic (bottom-dwelling); and fatty acids for tracing specific species.

Overall, large uncertainties remain in the emerging and complex science of understanding the impacts of climate change. For example, while global mercury trends have increased steadily over the past 150 years, they have recently become highly variable, in part because climate change makes it harder to detect the impact of changing global emissions. Many interconnected environmental changes are occurring in the Arctic and detailed investigations are needed to more precisely find out how these changes will alter the fate of contaminants, their storage in the environment, and movements between different environmental compartments.

Photo: Shutterstock

KEY FINDING

5

Photo: Eric Loring

The complex movement of contaminants in the Arctic environment and wildlife is now better understood.

As a result of scientific advances over the past ten years, we now have a broader understanding of how mercury and POPs move through different Arctic environmental compartments, such as air, water, snow, ice, and sediment. We also know more about how they transform between movements. This is important for furthering our knowledge about how contaminants then bioaccumulate and biomagnify among food webs, wildlife, and people. Some examples follow.

Scientists used to think that contaminants from distant sources were primarily carried to the Canadian Arctic through the atmosphere as gasses. However, recent NCP research shows that some contaminants are also carried to the Canadian Arctic by fine particles (dust) in the atmosphere. For example, elevated concentrations of decaBDE, a widely used flame retardant and POP that can stick to particles, have been detected in the Devon Island ice cap.

Ocean currents can be another important carrier of contaminants that dissolve in water. For example, perfluorinated alkyl acids or PFASs (e.g. chemicals, such as PFOS and PFOA, that repel water and oil and are resistant to heat and chemical stress) have been detected recently in arctic seawater. Once these currents reach the Arctic, ocean water can, in turn, re-release substantial amounts of contaminants to the air during the ice-free season. Given the fact that seawater moves very slowly and has such a large mass, scientists now know that arctic marine food chains can be exposed to contaminants transported by seawater for a long time. These findings have led to a tremendous expansion in the modeling of long-range ocean transport of POPs to the Arctic.

More is now known about the extent to which ocean water is an important site for the `methylation´ of mercury, whereby mercury becomes more toxic and more available for uptake and accumulation in Arctic marine food webs.

Ongoing research on `atmospheric mercury depletion events´ (AMDEs) has demonstrated that much of the deposited mercury is later released back to the atmosphere. A small amount of mercury from AMDEs, however, remains in snow and is transferred to water bodies in snowmelt. For freshwater ecosystems in particular, mercury from melting snow has been found to be an important source of mercury in the High Arctic.

Additionally, it was previously thought that all POPs accumulate in fat, but we now know that some new POPs, specifically PFASs, accumulate in protein-rich tissues such as muscle and liver.

Recent studies of the Arctic lichen-caribou-wolf food web have given scientists a better understanding of how certain types of POPs accumulate. The studies show that a wider range of chlorinated and fluorinated organic chemicals biomagnify among air-breathing animals in terrestrial food webs, compared to water breathing animals (i.e. fish). This is because all POPs are eliminated less efficiently in air via lungs than in water via gills. The result is a higher net uptake and retention of POPs in terrestrial top predators. At the same time, concentrations of new POPs and currently used pesticides (CUPs) in caribou, moose, and other terrestrial animals are still considered to be low and pose no human health risk.

Overall, these advances in knowledge help us to better understand what is happening to contaminants in the environment, and to make better predictions for the future.

Photo: Shutterstock

KEY FINDING 6

Photo: Eric Loring

Current levels of POPs and mercury may be a risk for the health of some Arctic wildlife species.

Research shows that mercury and POPs are not having widespread biological or toxic effects on Canadian arctic wildlife. However, some species may be at risk and above the threshold levels for some contaminants to cause adverse effects.

Mercury concentrations above threshold levels have been observed for some species in Canadian arctic waters, such as lake trout, landlocked char, Greenland shark, and some seabird species such as ivory gull. Effects may include cell damage, impaired reproduction, and behavioural and developmental abnormalities. Research also suggests that methylmercury exposure at current levels may affect the brains of some Arctic top predators, such as polar bears.

For PCBs, concentrations in beluga and polar bears were found to be high enough to cause possible effects to their immune system and hormones. Concentrations of PFOS (used to make fabrics stain-resistant) in polar bear livers were found to exceed safe limits while those in the livers of birds and seals were found to be far below dangerous levels. Effects from contaminants may include biochemical responses; impaired endocrine (hormonal), immune, and reproductive systems; impaired reproduction; and behavioral and developmental abnormalities.

Assessing the effects of POPs and mercury on the health of Canadian arctic wildlife is very challenging. One reason is that some animals have low exposure to contaminants that may result in subtle effects that are difficult to measure. Another is that, to assess effects, scientists need to study the tissues of wild animals: this, in most cases, is possible only after the animals have been killed. Scientists rarely get a chance to observe the living and eating habits of animals before they are killed in their natural setting, which forces scientists to make inferences or assumptions. And once animals are killed, difficulties can arise in preserving their tissues and transporting fresh samples from remote areas to laboratories. In the absence of studies on the effects on specific species, scientists often assess the *risk* of effects by comparing contaminant concentrations in wildlife tissues with concentrations derived through laboratory experiments that cause effects in non-Arctic animals such as rats.

Fortunately, the science looking into the effects of contaminants on wildlife has dramatically improved – specific Arctic species, rather than non-Arctic ones, are now being studied more often in their natural environment and in labs. For example, a recent NCP laboratory study, where seabird eggs were injected with methylmercury, determined the concentration at which certain species, such as thick-billed murres, experienced reduced egg survival, a phenomenon observed in wild birds nesting in areas impacted by pollution.

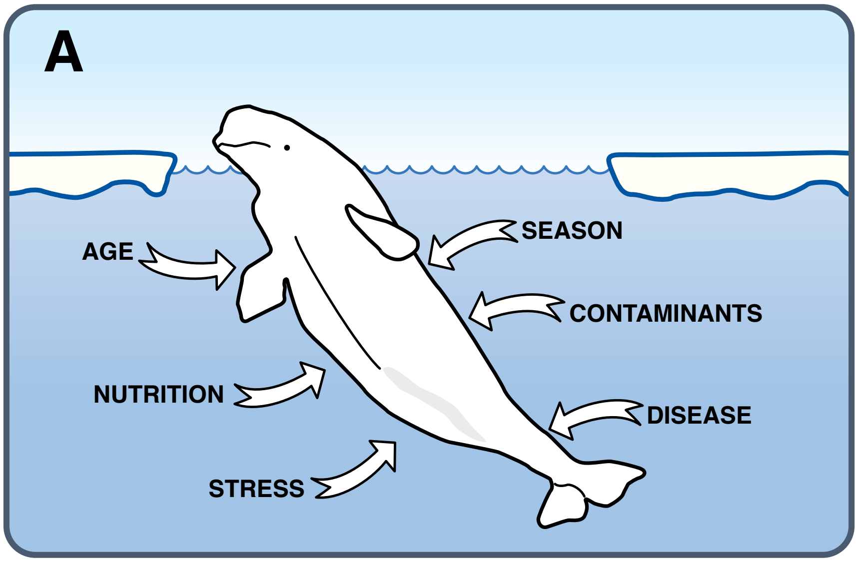
Another example involves selenium, an element known to play an important role in reducing the toxic effects of mercury in an organism. Research now suggests that the protective effect of selenium against methylmercury toxicity may be different among different species, depending on the relative amounts of selenium and mercury present in the species. For example, beluga whales that were found to have high levels of mercury also had high levels of selenium but they showed very little negative effects from that mercury – less than would be expected from an animal exposed to the same amount of mercury and no selenium.

Furthermore, new research also finds that `cumulative stress´, the combination of contaminant exposure with other factors, such as climate change, is a real threat. While difficult to assess, further research is needed to determine how multiple stressors affect populations of Arctic fish, seabirds, and marine mammals.

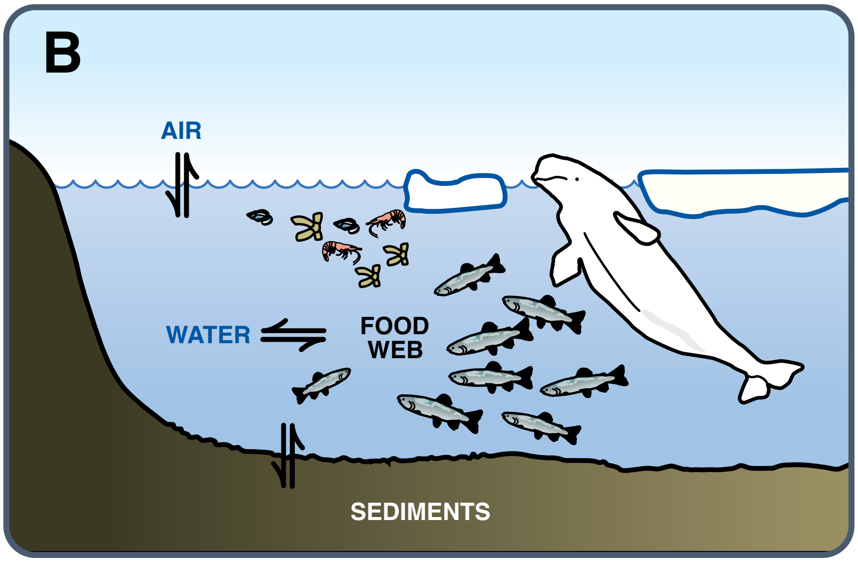
Studying beluga and exposure to contaminants

Since the 1980s, the community-based monitoring of beluga whales at the mouth of the Mackenzie River has been carried out by Inuvialuit hunters in partnership with the Department of Fisheries and Oceans. Between 2007 and 2012, this team made a detailed study of contaminant-related effects in beluga that combined the latest scientific techniques with hunter observations and traditional knowledge. The results of this study found that feeding and migratory habits have a significant effect on contaminant exposure and this resulted in the detection of subtle effects in the beluga; however, there was otherwise no evidence of significant adverse health effects. The study also revealed the important role of selenium in offsetting the potential effects of mercury exposure.

Photo: L. Loseto



A. The health of beluga whales and other arctic species is influenced by a combination of biological factors, as well as anthropogenic stresses. These factors may act independently or together, underscoring the importance of multidisciplinary studies.



B. Climate change may alter contaminant pathways and the health of beluga and other arctic species.While these changes create challenges for researchers as they strive to measure effects of contaminants on the health of long-lived species, it also presents opportunities to engage community members that can offer insight into the processes that are underway.

KEY FINDING 7

Photo: Eric Loring

While exposure to POPs and mercury is generally decreasing among Northerners, mercury remains a concern in some regions.

The NCP has been monitoring contaminant levels in Northerners for over 20 years. This monitoring allows scientists to assess the potential health risks associated with contaminants, compare contaminant levels across the Arctic, and assess changes that have taken place over time. Monitoring has focused on measuring contaminant levels in the blood of new mothers because contaminants can pass from mother to the fetus before childbirth, and this early stage of life is the most sensitive to contaminants.

Since the 1990s, exposure to POPs and mercury has generally declined among people who live in Canada's North. Levels of mercury and POPs vary among different groups of Northerners. Research has found that Inuit from Nunavik, Nunatsiavut, Nunavut, and Inuvialuit tend to have higher levels of contaminants than do Dene, Métis, and Yukon First Nations. The highest levels of POPs and mercury are associated with the consumption of marine mammals, which is highest among Inuit from Nunavik and the Baffin region of Nunavut.

The levels of POPs in maternal blood have declined substantially since the early 1990s. For example, PCB levels in pregnant women from Nunavik and Nunavut dropped by as much as 75% across studies and, as a result, fewer mothers had blood levels that exceeded Health Canada blood guidelines. Levels of mercury in maternal blood have also been significantly reduced. For example, in Nunavik the percentage of women exceeding the level of concern for mercury dropped from 73% in 1992 to 38% in 2013. However, many women still have elevated levels of mercury: for example, in 2007–2008, 44% of women of child-bearing age in Nunavut had mercury levels exceeding the Health Canada provisional blood guidance value.

Declining contaminant levels in people may reflect lower contaminant levels in traditional/country foods – an observation that is consistent with lower levels of POPs being monitored in wildlife. However, mercury levels in traditional/country foods have not declined to the same extent as in people. Another explanation could therefore be that Northerners are eating less traditional/country foods – itself a concern for health authorities in the North because traditional/country food consumption provides many benefits (e.g. nutritional and cultural) and can help improve food security.

Some newer POPs have been measured in the blood of Northerners, including a brominated flame retardant called PBDE and fluorinated surfactants (stain repellents) called PFOS. Traditional/country foods are a possible source of these new POPs, however, other sources of exposure may be more important, such as household dust and indoor air. At the same time, the levels in Northerners are relatively low compared to other populations, such as people in southern Quebec who were found to have higher levels than people in Nunavik. Furthermore, PFOS levels measured in the blood of women from Nunavik decreased in the period from 1992 to 2004.


Photo: Shutterstock

KEY FINDING 8

Traditional/country foods continue to be important for maintaining a healthy diet for Northerners.

Photo: Nicklaus Ganttner

Traditional/country foods are defined as plants, animals, and fish that are harvested locally from the land and waters. They continue to play a central and valuable role in the health, well-being, way of life, and livelihoods of Northerners, particularly Indigenous peoples, across the Canadian Arctic. Their consumption is still fairly widespread and remains an important factor in their food security.

While some contaminants can be detected in traditional/country foods, the benefits of eating these foods generally far outweigh the risks. In those cases in which contaminant levels are found to exceed blood guidelines, NCP information has been used by Regional Health Authorities to issue advice to limit consumption of a particular traditional/country food among certain members of the population (e.g. women of child-bearing age).

As in other circumpolar countries, research indicates that there has been a continuing shift over time toward more consumption of market food. There are notable regional differences in the diversity of and reliance on traditional/country foods which depend on many factors including geographic location, the age of an individual, socio-economic status, and culture. New research shows that youth in particular now tend to eat less traditional/country foods. This shift comes with a number of risks and issues. The Inuvialuit, however, appear to be reversing the trend, where women have reported eating more fish in the last ten years.

Nutritional issues

Most traditional/country foods are more nutrient-rich in comparison to much of the market food that is accessible and commonly selected in the North. Nutrient intake varies regionally, depending on what traditional/country foods are available and personal food preferences. The consumption of traditional/country foods has been associated with higher levels of the vitamins A, D, E, B6, and B12; as well as protein and iron, and omega-3 fatty acids. For example, a study of 18 Inuit communities in Canada found that greater traditional/country food consumption led to an increased intake of iron, zinc, vitamins A and E, and sometimes vitamin C. Marine mammal blubber, a traditional/country food eaten by Inuit, is a major source of omega-3 fatty acids. Similar benefits were observed in Dene children from the Northwest Territories where the intake of some nutrients was higher on days when they ate traditional/country foods. However, it has also been shown that the intake of vitamin E and other nutrients is often insufficient across the Arctic.

In comparison, much of the market food accessible in the North is more high in energy (high carbohydrate) and low in nutrients, containing unhealthy amounts of sodium, trans fat, and simple sugars. Northerners consuming more market foods and less traditional/country food tend to lower their intake of nutrients such as vitamins A, C, D, E, B6, and riboflavin, and healthy minerals including iron, zinc, copper, magnesium, manganese, phosphorus, potassium, and selenium.

Recent results from the Inuit Health Survey suggest that this dietary shift is associated with a range of nutritional health implications including micronutrient deficiencies, obesity, and an increased risk of developing diseases, such as diabetes, cardiovascular disease, and osteoporosis.

Other issues

The shift to a diet based more on market foods means that people spend less time outdoors hunting and fishing, unless these activities are replaced with other vigorous activities. Such a decline can lead to a less physical and more sedentary lifestyle which also contributes to a rising prevalence of obesity and related diseases.

Traditional/country foods are important economically because market foods are more expensive (often double the price of those in southern Canadian cities) and often less available in northern communities, especially those without road access. The significance is greater considering that up to 80% of Inuit households are considered to be "working poor" or are on social assistance.

The harvesting, processing, and sharing of fish, caribou, seals, beluga whales, and other traditional foods is also closely tied to the identity and spiritual health of Indigenous people.

NCP believes that further efforts are needed to support diet choices that include traditional/country foods, in part by reinforcing messages about the safety and benefits of traditional/country food sources.

Photo: Rodd Laing

KEY FINDING 9


Photo: Eric Loring

Environmental exposure to contaminants in the Arctic has been linked to health effects in people.

It has been known for a long time that exposure to high levels of contaminants can be harmful to peoples' health. However, only a few studies exist about the possible effects of exposure to contaminants found in the fish and wildlife that are traditionally eaten by northern peoples.

A major contributor to Canadian knowledge on the subject was the NCP-supported, long-term Nunavik Child Development Study (NCDS) of the possible effects of prenatal and childhood exposure to contaminants on infant and child development. It also investigated the impacts from nutrients in traditional/country foods, life habits during pregnancy, and other factors. Nearly 300 mothers and their infants participated. Participating children have now been assessed three times: as infants (age 6-11 months), 5-year-olds, and 11-year-olds.

Results of this ongoing study, released in 2011, suggest that there are subtle behavioral and developmental effects in children caused by specific environmental contaminants, including mercury and PCBs.

NCDS results are the basis for public health messages that are communicated through the Regional Health Authority in Nunavik. For example, the Authority advises pregnant women and women of child-bearing age to reduce their consumption of beluga meat, because of high mercury concentrations, while encouraging the consumption of other traditional/country foods that are low in contaminants and rich in nutrients (e.g. arctic char).

At the same time, messages to the public about possible health effects need to be put into a broader health context that is balanced with information about the benefits of a diet rich in traditional/country foods. In general, traditional/country foods have many important nutritional benefits, including those from omega-3 fatty acids. A higher intake of omega-3 fatty acids during pregnancy is beneficial for an infant' s birth weight, vision, ability to communicate or solve problems, and ability to sit, stand and walk.

Our knowledge is growing

The interactions between contaminants, nutrition, and lifestyle and their effects on health are complex. Moreover, conducting epidemiological studies in the Canadian Arctic is a challenge due to a variety of limiting factors. For example, it is often only possible to study groups with a small population size that may not be representational of larger populations, e.g. territory wide. Another challenge is accounting for non-contaminant risk factors, such as smoking, which can impact or "confound" health-related studies. For this reason, our knowledge of the effects of contaminant exposure at levels found in the environment is still growing. Epidemiological studies carried out in other parts of the world on PCBs, mercury, and lead have been used as much as possible for risk assessment in the Canadian Arctic. However, some of these studies may have limited relevance for the Canadian Arctic – it is therefore very important that studies in the Canadian Arctic continue.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KEY FINDING 10

Photo: Eric Loring

Continued international action is vital to reducing contaminant levels in the Arctic.

Most of the POPs and mercury that are found in Canada's Arctic originated elsewhere in the world. Mercury, for example, a true global pollutant, is carried easily over long distances through the atmosphere. Canada has made major reductions in contaminant emissions over the past 25 years, however, to ultimately reduce contaminant levels and contaminant-related health risks for people and wildlife in the North, international action and cooperation are essential.

Since 1991, NCP and its partners (e.g. Indigenous partners and the Arctic Council's Arctic Monitoring and Assessment Programme) have been using the results of NCP monitoring and research as a call to action for the international community. Early NCP results helped raise international public and political awareness about the issue of long-range contaminants by providing essential background science – such as what defines a POP, or how contaminants are carried over long distances. The NCP also helped to ensure that our Northern Indigenous Partners were engaged in the discussion – which provided a human face to the issue, and brought indigenous perspectives to the international negotiating table.

The international story

In 1979, early international success at addressing air pollution was achieved through the United Nations Economic Commission for Europe's (UNECE) *Convention on Long-Range Transboundary Air Pollution (LRTAP)*. An umbrella convention for various types of pollution (e.g. acid rain), its Protocol on POPs covers 23 POPs and its Protocol on Heavy Metals covers mercury, cadmium, and lead. Both protocols entered into force in 2003.

While regional in scope, these two protocols paved the way for more powerful global action through the United Nations Environment Programme (UNEP) *Stockholm Convention on Persistent Organic Pollutants*. Global in scope and including 23 POPs, this convention entered into force in 2004. As of February 2016, it had been ratified by 179 countries. Its main goal is to eliminate or restrict the production and use of POPs. Since the convention's first list of 12 POPs, 11 new POPs have been added.

In 2013, the UNEP *Minamata Convention on Mercury*, which aims to reduce global emissions of mercury, was opened for signature. To date, this convention has been signed by 99 countries, although it is expected that many others will follow in the years to come. It will enter into force as early as 2017, once the first 50 countries have ratified the Convention and are prepared to implement restrictions on mercury emissions. Major highlights include a ban on new mercury mines, the phase-out of existing ones, control measures on air emissions, and the international regulation of the informal sector for artisanal and small-scale gold mining (a major emerging source of atmospheric mercury emissions).

NCP contributions

NCP can take credit for helping to place some of the new POPs, including PFOS and PBDEs, onto the Stockholm Convention list. For example, NCP initially detected elevated levels of PFOS in polar bears in the Canadian Arctic, after which it monitored data over time, observed an increasing trend, and reporting it internationally. NCP also found rising levels of PBDEs.

In addition, the NCP is mandated to provide key Arctic information on POPs and mercury to support the evaluation of new POPs under the Stockholm Convention and LRTAP Convention, assessments of how effective the Stockholm Convention and LRTAP conventions have been at reducing pollution, and future effectiveness evaluations of the Minamata Convention.

International cooperation works!

Evidence that international agreements and global actions work is found in the decreasing levels of POPs found in Arctic people and wildlife in the years that follow the time when regulations take effect. This includes the observation that, following their global bans, levels for both PFOS and PBDEs have already declined in Canada's Arctic. Similar decreases in mercury levels are anticipated in the future once the Minamata Convention enters into force. Continued environmental monitoring by NCP and AMAP is critical to evaluating the effectiveness of these conventions.

Regional Summaries: Introduction

YUKON

NORTHWEST TERRITORIES


Photo: Yukon Government


Photo: Eric Loring

About Canada's Arctic regions

For the purposes of the NCP, Canada's Arctic regions, from west to east, are Yukon, Northwest Territories (including Inuit and Dene/Métis sub-regions), Nunavut, Nunavik, and Nunatsiavut. All include large Indigenous populations including Inuit, First Nations, Métis, and non-Indigenous. The only way to access, and transport food and supplies to, many Arctic communities is by airplane or seasonally by ship.

Traditional/country food in the Arctic

The hunting, fishing, sharing, and consumption of local foods are extremely important activities for Arctic populations – culturally, spiritually, economically, and nutritionally – especially for Inuit, First Nations and Métis. In many cases, these foods are needed for subsistence. Names for local foods differ across groups: `traditional foods´ for First Nations and Métis; `country foods´ for Inuit in most regions; and `wild´ foods for Inuit in Nunatsiavut. Generally, the term used by NCP is `traditional/country foods´.

Unfortunately, the ability of many Arctic groups to continue their consumption of traditional/country foods has become increasingly threatened. One reason is because access to wildlife can be limited, either because there is little to no wildlife near a community, or because a family does not include a hunter or have access to other needed resources. Some foods have become less available generally. For example, for Yukon First Nations, chinook salmon harvests have been poor over recent years – part of the general population decline of pacific salmon. Another example is caribou – many populations are down and many regions have responded by putting hunting moratoria in place, such as in Nunatsiavut for the George River herd. The exact causes of these declines are under investigation, but climate change could be a major factor in influencing the size and distribution of caribou and other wildlife populations. Climate change can also affect how people travel and hunt – for example, warmer winters result in a lack of sea ice and therefore ice conditions that are unsafe for travel. Climate change can also have an effect on contaminants and how they circulate in the environment, which could, for example, facilitate the uptake and accumulation of mercury in fish – thereby potentially making them less available for consumption.

As a result of these changes, the overall composition of traditional/country foods consumed by Northerners has likely changed since the last comprehensive dietary survey of Inuit (households) was carried out in 2008 (as part of the Inuit Health Survey). These factors also contribute to high rates of food insecurity experienced by many Northern households on a regular basis. In addition, food insecurity is influenced by the high cost and low availability of market foods which serve as nutritious alternatives to country foods. And the contamination of foods eaten by Northerners, or even the fear of contamination, can lead to heightened food insecurity.

Northern Health Surveys and Contaminants Monitoring in People

In 2007-2008, the Inuit Health Survey (IHS) was the biggest study of its kind in Canada, involving three of four Inuit regions and linked to a similar study in Greenland, and a 2004 study in Nunavik, the Nunavik Health Survey. As one of Canada's signature initiatives for *International Polar Year*, the IHS assessed the health status of individuals in Inuit communities for the first time. The study involved the research icebreaker *CCGS Amundsen* transporting doctors, nurses, and research staff to communities where residents were given complete on-board

Photo: Eric Loring
Photo: Sam Bentley
Photo: Jennifer Provencher

physicals and blood tests. Through dietary surveys, researchers documented the traditional/country foods that people were eating. They also measured the levels of contaminants (e.g. mercury and POPs) in the blood of participants compared to blood level guidelines from Health Canada, and the levels of contaminants and nutrients in their foods compared to `tolerable weekly intake´ guidelines that are relevant to diet.

IHS results reinforced the message that the benefits of eating traditional/country foods generally outweigh the risk of contaminant exposure. It further concluded that traditional/country foods provide many essential nutrients such as selenium (an essential micronutrient), polyunsaturated fatty acids, and omega-3 fatty acids that can lower the risk of chronic diseases.

Nutrients in Inuit traditional/country foods by region

	Selenium (primary sources)	Polyunsaturated fatty acids (% consumed from country foods)	Omega-3 fatty acids (primary sources)
Nunavut (Source: IHS)	Caribou meat, beluga muktuk, and arctic char	Arctic char meat (27%)	Arctic char meat
Inuvialuit Settlement Region (NWT) (Source: IHS)	Caribou meat, beluga muktuk	Caribou meat (19%)	Arctic char
Nunavik (Source: Nunavik Inuit Health Survey)	Caribou meat, beluga muktaaq, and arctic char	Mainly Arctic char, followed by beluga muktaaq and blubber	Data not available
Nunatsiavut (Source: IHS)	The primary source of all three nutrients was Arctic char, accounting for 25% or more of dietary intake. Other major sources were: caribou; ringed seal meat, fat, and liver; salmon; and cod. Jumper (Atlantic White-sided Porpoise) skin was also found to be a good source of selenium.		
Contaminants monitoring in people in the Yukon and Dene Regions was last conducted in the early 2000's (in NWT) and those results were presented in previous CACAR assessments (CACHAR-2009). There is currently a study underway in the southern NWT to measure contaminants in people and these results will be presented in future CACAR reports.			

Contaminants in Nunatsiavut


Photo: Rodd Laing


Photo: Eric Loring


Photo: Rodd Laing


Photo: Rodd Laing

On December 1, 2005, Nunatsiavut, meaning "Our Beautiful Land", was created through the Labrador Inuit Land Claims Agreement, making it a self-governing body. It includes five communities and had a population of 2,612 in 2011, 89% of which are Inuit.

The **Nunatsiavut Government Research Advisory Committee (NGRAC)** and the **Nain Research Centre** coordinate the implementation of NCP activities in the region and are the main points of contact for information about long-range contaminants. During the past decade, efforts have focused primarily on measuring contaminant levels in important wild foods, including the long-term monitoring of ringed seal and Arctic char, assessing contaminant-related human health risks, and supporting community outreach projects that engage youth.

Wild foods and health

According to the 2008 Inuit Health Survey (IHS), which included an assessment of the health status of 310 participants in five Nunatsiavut communities, the most frequently consumed wild foods were caribou (meat, dried meat, marrow, heart, and ribs), berries, char, partridge, ptarmigan, and Canada goose. Other commonly consumed wild foods were ringed seal, salmon, and cod. The IHS concluded that most Inuit adults in Nunatsiavut should have minimal concern of contaminant-related effects from wild foods. However, since the publication of results from the IHS, a ban on harvesting caribou within the region has been imposed. This has resulted in a dietary shift away from caribou towards more char and ringed seal. The effects of this transition will be captured in future CACAR reports.

Mercury and wild food

Among the IHS participants tested, the average blood mercury concentration was only 3.2 parts per billion (ppb), which is well below the Health Canada population guideline of 20 ppb. However, 2% of the participants exceeded this guideline: this small group was found to consume more wild foods in general, especially ringed seal liver (consuming 110g/week compared to 24g/week for the larger group) which contributed 62% of their total mercury intake. Ringed seal liver, according to the IHS, was the primary dietary source of mercury for Inuit adults in Nunatsiavut. Additionally, 8% of women of child-bearing age exceeded their Health Canada guideline of 8ppb.

Main dietary sources of mercury for Inuit adults in Nunatsiavut

Dietary source	% of total mercury intake
Ringed seal liver	23
Arctic char	20
Caribou meat	13
Salmon	8

Mercury concentrations in food are compared to the Health Canada guideline of 0.5 parts per million (ppm), which is used to regulate the commercial sale of fish. Ringed seal meat from Nunatsiavut had mercury levels of around 0.2 ppm whereas ringed seal liver had concentrations of around 5 ppm. Mercury concentrations in arctic char and caribou were between 10 and 100-times lower than the guideline. The reason that char and caribou meat amount to a substantial source of dietary mercury in Nunatsiavut is because they are eaten most frequently.

Source: IHS

Photo: Sam Bentley

Nunatsiavut community involvement in ringed seal research

From 2009-2012, the NCP supported a study on contaminant levels in ringed seals and their potential biological effects. The scientific study was complemented by traditional `Nunatsiavimmiut´ knowledge on ringed seal behaviour, ecology, distribution, and health, collected from local hunters. Sub-lethal effects (i.e. effects insufficient to cause deaths) were measured in ringed seal which had been exposed to PCBs around Saglek Bay, a historical source of PCB contamination. The results are particularly useful because they were derived from studying wild ringed seal which is very rare: studies of animals in the wild are more indicative of real world situations than are studies of animals in laboratories. The results – levels at which sub-lethal effects occur – can now be used to assess biological risks in wild ringed seals in other Arctic locations.

Youth Outreach Program Going Off, Going Strong

Photo: Rodd Laing

Through the *Going off, Going strong* program, Nunatsiavut youth have been paired with experienced hunters to participate in the collection of environmental samples, including ringed seal, for NCP research and other programs.

POPs and wild food

POPs measured by the IHS included PCBs, toxaphene, DDT/DDE, and chlordane. All of these are globally regulated under the Stockholm Convention and are therefore no longer widely used. The recently regulated brominated flame retardant, PBDE, was also measured.

Overall, the concentrations of all POPs, except PCBs, in adult blood were significantly lower than for other Inuit regions. In most cases, they were very similar to the Canadian national average. PCBs showed the highest concentrations in adult blood, although the average of 1.9 ppb was well below the Health Canada guideline of 20 ppb, and below the average of 2.5 ppb for all other Inuit regions in Canada. Three percent of women of child-bearing age had concentrations that were greater than the 5 ppb guideline that is specific to this sensitive population group. The IHS concluded that current PCB levels do not pose substantial health risks for most Inuit in Nunatsiavut.

Links: Nunatsiavut Government (www.Nunatsiavut.com), Kangidluasuk Student Program (www.torngatyouthcamp.com), Nain Research Centre (http://nainresearchcentre.com)

Northern Contaminants Program (www.science.gc.ca/ncp)

Contaminants in Nunavik

Nunavik means "Great land" in the local dialect of Inuktitut and the Inuit inhabitants of the region call themselves *Nunavimmiut*. Nunavik comprises the northern third of the province of Quebec. Of the inhabitants of the region, 90% are Inuit and live in 14 northern villages on the coast of Hudson Bay and Ungava Bay.

In Nunavik, NCP activities are coordinated by the **Nunavik Nutrition and Health Committee** based in Kuujjuaq. The program's focus over the past decade has been the monitoring of human exposure to contaminants, evaluating contaminant-related health effects and assessing human health risks, and communicating results.

Country foods, health, and contaminants

While diets vary across Nunavik communities, the two most frequently consumed country foods are caribou and Arctic char. Geese, wild berries, caribou nikku (dried), and ptarmigan are also popular. Beluga and ringed seal are also consumed but consumption varies widely between communities. For example, communities along the coast of Hudson Strait consume more beluga (mattaaq, meat, and blubber) than do communities in Ungava Bay and East Hudson Bay which consume more ringed seal.

NCP-funded research and monitoring such as the Nunavik Child Development Study and Nunavik Inuit Health Survey are helping to ensure the safety of country foods in Nunavik and supports the engagement of Nunavimmiut in science and outreach initiatives.

Since 1996, the long-term Nunavik Child Development Study (NCDS) has been studying the possible effects of prenatal and childhood exposure to contaminants on infant and child development (see Key Finding 9 for details).

In 2004, the Nunavik Inuit Health Survey (also known as Qanuippitaa? How are we?) assessed the health status of people in every community in Nunavik. The study was the model for the larger Inuit Health Survey which later involved all of the other Inuit regions in Canada. The Nunavik study had the research ice-breaker Amundsen visiting each community in Nunavik and giving full health assessments to community members on-board the ship. It included an assessment of dietary exposure to contaminants and the level of contaminants in blood. Preparations began in 2015 for a second Nunavik Inuit Health Survey to take place in 2017-18 which will update contaminant levels and human health risks in Nunavik.

In addition, both the studies point to sea-run Arctic char as a highly nutritious country food that is low in contaminants and high in selenium, polyunsaturated fatty acids, and omega-3 fatty acids. In fact, char is so healthy that a regional program was established to enhance its consumption by distributing char at no charge to pregnant women living in communities along the coast of eastern Hudson Bay.

Results generated by human health studies in Nunavik over the past 25 years have had a tremendous influence on global regulations, including the Stockholm Convention on POP and the Minamata Convention on Mercury by providing evidence of the prevalence of contaminants within this population and the effects that this exposure is having upon child development and behaviour.

Mercury and country food

Mercury concentrations in the blood of Nunavik residents are elevated compared to those in southern Canada and other parts of the Canadian Arctic. Approximately half of participating women of child-bearing age within the 2004 Nunavik Inuit Health Survey had blood concentrations that exceeded applicable blood guideline values. Blood mercury levels were, however, approximately 30% lower than they were in 1992.

The Qanuippitaa study found that the primary source of mercury in food for Inuit adults in Nunavik is beluga meat. In communities along Hudson Strait, about 67% of mercury in the diet was from beluga meat: in other regions, beluga meat accounted for one-third. Ringed seal, particularly ringed seal liver, was also found to be a significant source of dietary mercury, especially among people who reported consuming relatively large amounts.

The long-term monitoring of fish and wildlife, including beluga and ringed seal, from across the Canadian Arctic has shown that mercury levels vary from year to year. However, over the 20 years since monitoring began, there has been no statistically significant increase or decrease.

Health Advisory

Photo: Shutterstock

Findings from these studies led to the following advisory from the Nunavik Regional Health Authority: "Country food is generally the best food for Nunavimmiut, including for pregnant women and their children. Country food consumption has significantly decreased over the last decade. Therefore, everybody must be incited to increase their consumption of country foods, the only limitation being for child bearing-age women who should limit their consumption of beluga meat. This recommendation holds until there is an evidence of a decrease in mercury content of this specific country food."

POPs and food

The Qanuippitaa study found that the majority of people in Nunavik had concentrations of POPs in their blood that were well below Health Canada Guidelines: however, 11% of the population overall and 14% of women of child-bearing age had total PCB concentrations exceeding the acceptable levels set by Health Canada. The concentrations of all POPs measured in people's blood have been steadily decreasing in Nunavik: in 2007, they were less than half of what they were in 1992. This decrease reflects declining trends measured in wildlife as well as changing dietary habits. The most prominent POPs in Nunavik wildlife are chemicals which are now globally regulated under the Stockholm Convention. These include PCBs, toxaphene, DDT, chlordane-related compounds, HCH, and chlorobenzenes. The primary dietary source of these POPs in Nunavik is fats from marine mammals, such as beluga and ringed seal.

In the Canadian Arctic, marine mammals generally have the highest concentrations of POPs, followed by seabirds, fish, and land-based animals like caribou, which have very low levels of POPs. Some seabird species, beluga, narwhal, and polar bear have POP concentrations that might be high enough to cause `sub-lethal effects´ – those which reduce health, such as liver stress, but do not kill the animal. While POPs do not appear to be harming these animals, scientists are concerned that additional environmental stresses, such as climate change, could put them at greater risk.

Links: Nunavik Government (www.makivik.org/nunavik-government/)

Northern Contaminants Program (www.science.gc.ca/ncp)

Contaminants in Nunavut

Nunavut includes three sub-regions – Kitikmeot, Kivalliq, and Qikiqtaaluk – with 24 communities. In October 2014, its population was 36,687. About 80% are Inuit and 20% are non-Indigenous.

NCP activities are coordinated by the **Nunavut Environmental Contaminants Committee** based in Iqaluit. NCP's primary focus in Nunavut over the past decade has included monitoring contaminant concentrations in air and country foods, assessing contaminant-related human health risks, and communicating results.

Country foods, health, and contaminants

While diets vary across Inuit communities in Nunavut, the most frequently consumed country foods are caribou, Arctic char, and ringed seal, followed by beluga maqtaaq (skin and blubber), Canada goose, berries, walrus, and narwhal maqtaaq.

The Inuit Health Study concluded that most Inuit adults in Nunavut should have minimal concern of contaminant-related effects from country food consumption. The only contaminant-related health advisory issued by Nunavut Health and Social Services as a result of the study was a 2012 advisory to women of child-bearing age to avoid consumption of ringed seal liver which has high levels of mercury.

Mercury and country food

While the average blood mercury concentrations for Nunavut residents were below Health Canada guidelines, roughly two out of every five women aged 18-43 had blood concentrations that exceeded the guideline for women of child-bearing age. In light of this finding, a 2012 health advisory (still in effect) advised these women to avoid eating ringed seal liver and to eat ringed seal meat instead. On average, eating ringed seal liver contributes nearly half of the mercury intake for Inuit women of child-bearing age in Nunavut.

The long-term monitoring of ringed seal and other wildlife in Nunavut, including other marine mammals, char, and caribou, showed that mercury levels vary annually, but they had no significant increase or decrease over the 20 years since monitoring began.

POPs and food

The Inuit Health Survey found that the vast majority of Nunavut residents had concentrations of POPs in their blood that were well below general Health Canada Guidelines. However, approximately 9% of women of child-bearing age were found to exceed the Health Canada Guideline designed specifically for women of child-bearing age.

In Nunavut, marine mammals generally have the highest concentrations of POPs followed by seabirds, fish, and land-animals like caribou, which have very low levels of POPs. Some seabird species, beluga, narwhal, and polar bear have POP concentrations that might be high enough to cause `sub-lethal effects´ – those which reduce health, such as liver stress, but do not kill. While POPs do not appear to be harming these animals, scientists are concerned that the additional environmental stresses, such as climate change, could put them at greater risk.

The most prominent POPs in Nunavut wildlife are chemicals which are now globally regulated under the Stockholm Convention. These include PCBs, toxaphene, DDT, chlordane-related compounds, HCH, and chlorobenzenes. The primary sources of these POPs in the diet of Nunavut residents are beluga and narwhal blubber.

The long-term monitoring of Nunavut wildlife shows that the levels of most POPs that have been regulated have decreased by about half since monitoring began in the early 1990s. During that time, some new POPs, such as brominated flame retardants (PBDEs) and fluorinated surfactants (PFOS), which have also since been regulated by the Stockholm Convention, increased in wildlife until the mid-2000s, but have since shown signs of decreasing.

Contributing to global action on contaminants


Photo: Shutterstock

Results generated by NCP monitoring and research in Nunavut have had a tremendous impact on global regulations, including the Stockholm Convention on POPs and the Minamata Convention on Mercury. Two examples of influential projects in Nunavut are:

Contaminants and seabird eggs

NCP researchers have been measuring contaminants in eggs from several species of birds collected from Prince Leopold Island over the past 40 years. Results show that mercury concentrations in seabird eggs rose from 1975 to the mid-2000s, and appear to have levelled off in recent years. However, POPs concentrations in seabird eggs have declined by more than half over the same period of time. Among POPs, the brominated flame retardant, PBDE, increased rapidly in seabird eggs from the 1980s to 2005, but has since witnessed a rapid decrease in response to being banned.

Monitoring air in Alert

POPs and mercury in air are monitored continuously at the NCP station at Alert in the High Arctic. Built in 1993, the station is located on a military base and continuously collects air samples year-round. The station is globally significant and very rare, with only one similar station based in Svalbard, Norway. Since 2000, mercury levels began to slowly decrease at Alert, which may reflect a levelling off in global emissions. Concentrations of most POPs have been steadily decreasing since the 1990s while chemicals of emerging concern, such as new classes of fluorinated and brominated chemicals (used as stain repellents and fire retardants) as well as siloxanes (used in personal care products), are being detected.

Links: Nunavut Research Institute (www.nri.nu.ca), Nunavut Tunngavik Incorporated (www.tunngavik.com), Inuit Tapiriit Kanatami (www.itk.ca)

Northern Contaminants Program (www.science.gc.ca/ncp)

Contaminants in Northwest Territories


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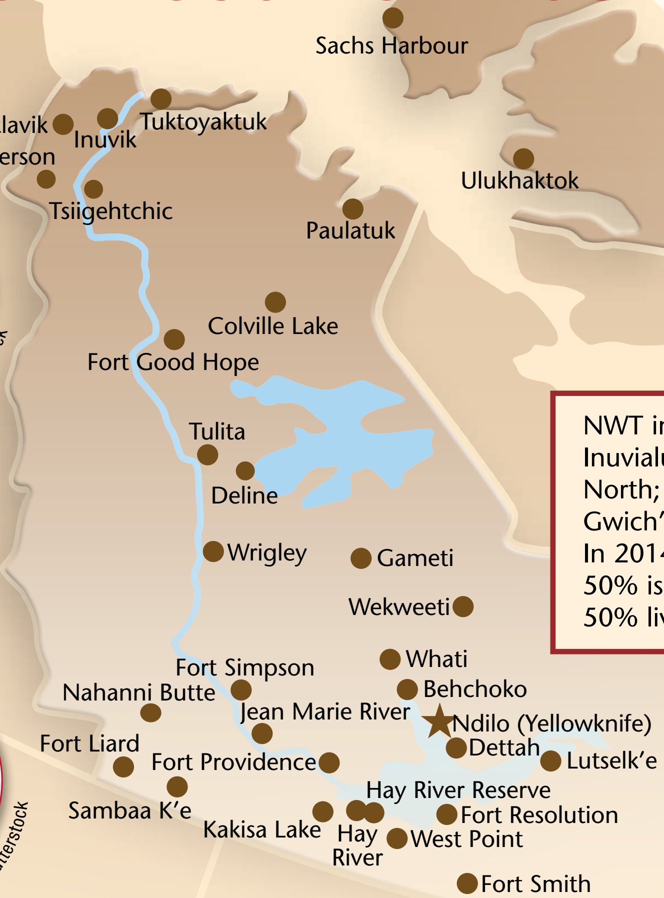


Photo: Shutterstock

NWT includes six sub-regions: the Inuit Inuvialuit Settlement Region (ISR) in the far North; and the five Dene/Métis sub-regions of Gwich'n, Sahtu, Tlicho, Akaitcho, and Decho. In 2014, the population was 43,795. About 50% is Indigenous, including Métis, and about 50% live in the capital, Yellowknife.

The **Northwest Territories Environmental Contaminants Committee (NWTECC)** coordinates NCP-related activities in the region. The program's primary focus over the past decade has included measuring contaminant levels in important traditional/country foods, including annual monitoring of lake trout, burbot, beluga, and ringed seal; assessing contaminant-related human health risks; community-based monitoring and research; and communicating results.

Country foods, health, and contaminants

Diets vary across this region, particularly between the Inuvialuit Settlement Region (populated mainly by Inuit) and Dene/Métis communities, and are based largely on what is available. Inuvialuit consume country foods taken from marine, freshwater, and terrestrial environments, while Dene/Métis traditional foods consist mostly of freshwater and terrestrial animals. Among Inuvialuit, the most frequently consumed traditional foods are caribou, berries, char, goose, whitefish, trout, and beluga. Among Dene/Métis, they are caribou, moose, whitefish, trout, inconnu, spruce hen, and ptarmigan.

Overall, the Inuit Health Survey (IHS) found that most Inuvialuit should have minimal concern for the effects of contaminants in their food. There are currently no health advisories related to contaminants in country foods in the Inuvialuit Settlement Region.

In the Dene/Métis sub-regions, contaminant levels in caribou, moose, and other terrestrial species were found to be very low. Contaminant levels in most fish were also well below guideline levels, but there were some exceptions that required health advisories for specific lakes and fish species due to high levels of mercury.

Inuvialuit Settlement Region (ISR)

Mercury and country food

Average blood mercury concentrations for Inuvialuit people were below guidelines. However, 15% of women of child-bearing age had blood concentrations that exceeded guidelines specific to this group. As part of the

2007-2008 Inuit Health Survey (IHS), a dietary study was conducted among 264 Inuvialuit to determine food sources of mercury exposure. It found that the greatest source of mercury exposure, on average, was beluga muktuk (24%), with char, caribou, and whitefish accounting for another 32%. This "average" diet resulted in mercury exposure that was below the Health Canada tolerable weekly intake. However, 50 participants who ate above average amounts of country foods, including more fish eggs, beluga muktuk, and ringed seal liver, exceeded the guidelines for tolerable weekly intake. In the ISR, mercury levels in beluga and ringed seal (monitored annually by the NCP) vary from year to year but do not show any clear increasing or decreasing trend.

POPs and food

The IHS found that the vast majority of Inuvialuit had concentrations of POPs in their blood that were well below Health Canada guidelines. However, approximately 3% of women of child-bearing age were found to exceed the PCB guideline for their group. The concentrations of POPs in terrestrial animals, such as caribou and muskox, are very low and do not represent a major dietary source of POPs to Inuvialuit. Fish have higher concentrations of POPs than do terrestrial animals but still do not represent a major dietary source for Inuvialuit people. The greatest source of POPs in the diet of Inuvialuit is marine mammals, especially their fat.

Dene/Métis

Mercury and food

Mercury levels in most fish were well below guideline levels, with whitefish having the lowest levels. There were, however, certain lakes where some species of predatory fish (e.g. lake trout, walleye, and northern pike) exceeded the Health Canada guideline for commercial sale. The NWT Department of Health and Social Services issued consumption advisories for affected lakes including (as of 2014): McGill, Deep, Fish, Ekali, Nonacho, Stark, Trout, Cli, Ste. Therese, Kelly, Giauque, and Thislewaite.

Overall, fish monitoring in the NWT has shown that mercury levels increased between 1990 and 2009. This may be due in part to increased atmospheric deposition as well as climate change which, through warmer temperatures, may promote the accumulation of mercury in fish.

For caribou and moose, mercury levels in muscle are about 100 times lower than the Health Canada guideline, and there are no risks to the animals themselves. Mercury levels varied between caribou herds across the Arctic, but did not show any strong geographic trends.


Photo: L. Loseto

Contaminants in beluga: a long-term Inuvialuit study

Scientists from the Department of Fisheries and Oceans have been working with hunters from Tuktoyaktuk to study the health of beluga whales in the Mackenzie delta for over 15 years. This study is a model for community-based research that involves the co-application of traditional knowledge and western science. This has also been one of the few studies to link subtle, non-lethal, biological effects in beluga to contaminant exposure. Ongoing work on this project is developing beluga health indicators based on traditional knowledge.


Photo: Shutterstock

Monitoring contaminants in southern NWT fish

Some of the NCP's strongest long-term datasets for contaminants in fish come from studies on burbot and lake trout from the NWT. These studies, carried out in partnership with the NWT communities of Fort Good Hope, Hay River, and Lutsel'ke, have provided strong evidence for increasing trends of mercury in NWT fish. They have also shown some of the strongest results to date for climate change-related warming which leads to increases of mercury in fish. These and other NCP results played an important role in bringing about the Minamata Convention on Mercury, a global treaty to reduce mercury pollution.

POPs and food

The NCP monitoring of NWT freshwater fish shows that concentrations of POPs have steadily decreased in burbot and lake trout from the Mackenzie River and Great Slave Lake over the past 20 years. Concentrations of POPs in NWT fish do not represent a health risk for people who consume them.

Links: Inuvialuit Regional Corporation (www.irc.inuvialuit.com), Dene Nation (www.denenation.ca), Aurora College (www.auroracollege.nt.ca), NWT Health and Social Services (www.hss.gov.nt.ca).

Northern Contaminants Program (www.science.gc.ca/ncp)

Contaminants in Yukon Territory


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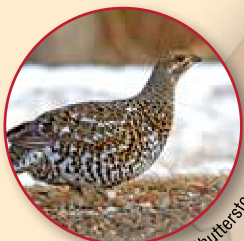
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In June 2014, the population was 36,667, including First Nations, Métis, and non-Indigenous peoples. Approximately 66% live in the capital, Whitehorse, and some 23% consists of 14 First Nations and Métis.

The **Yukon Contaminants Committee (YCC)** has been coordinating NCP activities in Yukon since 1991. Over the past decade, efforts focused primarily on the long-term air monitoring of POPs and mercury; the monitoring of contaminants in predatory fish and caribou; assessing contaminant-related health risks; and sharing results with communities, particularly through partnerships between scientists, the Council of Yukon First Nations, and the Yukon Territorial Government.

Country foods, health, and contaminants

According to dietary surveys, the top five traditional foods consumed by Yukon First Nations are moose, caribou, salmon, grayling, and trout.

The NCP continuously monitors contaminants in the atmosphere at Little Fox Lake (see box below), and annually monitors contaminants in caribou from the Porcupine herd and in lake trout from Lake Laberge and Kusawa Lake.

Overall, research has found that the levels of POPs and mercury in Yukon traditional foods are not high enough to cause concern for wildlife or human health. The only possible exception is large (and old) predatory fish, such as lake trout, that can have levels of mercury that exceed guidelines for commercial sale. Yukon has published guidelines related to the safe consumption of fish in the territory.

Mercury and country food

Since 1993, there has been no consistent increasing or decreasing trend for mercury concentrations in fish in Lake Laberge or Kusawa Lake. In 2010, in light of known mercury contamination, the Yukon government published a *Mercury in Yukon Fish Fact Sheet* (still in effect). It stated that most Yukon fish, including grayling, whitefish, inconnu, sucker, salmon, and pike, have relatively low levels of mercury: as a result, consumption does not need to be limited. Furthermore, in general, Yukon adults do not need to limit their intake of lake trout or burbot that are less than 65 cm in length. However, consuming lake trout and burbot over 65 cm was not suggested. The advisory added that women of child-bearing age and children under 12 should limit their consumption of large lake trout and burbot.

Since 1991, the monitoring of Porcupine caribou has found that mercury levels have not changed over the past 20 years. Similar concentrations of mercury were measured in woodland caribou throughout Yukon. Overall, mercury levels in both caribou and moose are low and do not represent a concern for the health of either animals or people who eat them.

POPs and food

Overall, human dietary exposure to POPs is low and does not represent a concern for human health, given the relatively low levels of POPs in Yukon fish and wildlife.

Since 1993, the concentrations of the dirty dozen POPs (e.g. HCHs, chlordanes, and toxaphene) decreased at a rate of over 5% per year in fish from Lake Laberge and Kusawa Lake. In 2011, a consumption advisory for toxaphene, in place for Lake Laberge fish since 1991, was lifted as a result of declining levels.

As for the newer POPs in Yukon lakes, some compounds were found to be decreasing (e.g. PBDEs) or stabilizing, while others chemicals of emerging concern were found to be increasing (e.g. those not yet added to the Stockholm Convention list). Overall, levels remain low in fish and are not a health concern.

Monitoring air at Little Fox Lake

Photo: Alexandra Steffen

Little Fox Lake has a hill-top station that performs long-term air monitoring of both mercury and POPs. The location was chosen because of its favourable conditions for measuring contaminants in air masses that come across the Pacific Ocean from Asia into the Canadian Arctic.

One of only three sites in the Canadian Arctic where mercury is monitored continuously throughout the year, the station has found that the concentration of mercury in air is relatively stable and consistent with global background levels. This stable trend is also consistent with the stable mercury levels noted above for fish and caribou.

Data from Little Fox Lake demonstrates that concentrations of POPs in air are generally declining, as are POPs in wildlife. POPs are also being monitored at Little Fox Lake as part of the Global Atmospheric Passive Sampling Network (GAPS) -- results show that chemicals of emerging concern, such as fluorinated alkyl substances (stain repellents) and siloxanes (personal care products), are present in air at Little Fox Lake, although at very low levels compared to other locations around the world.

Concentrations of most POPs in caribou and moose are much lower than in marine mammals and fish. However, some new POPs have been found to be higher in caribou and moose, with levels similar to what is found in top predatory fish. Further monitoring and research is planned to study these new POPs in caribou. Overall, levels are still very low and do not represent a concern for wildlife or human health.

Links: Council of Yukon First Nations (www.northerncontaminants.ca), Environment Yukon (www.env.gov.yk.ca/hunting-fishing-trapping/eatingfish.php)

NCP (www.science.gc.ca/ncp)

FUTURE DIRECTIONS AND RECOMMENDATIONS

Future Directions:

Contaminants from long-range, global sources continue to be of concern in Canada's North. These contaminants accumulate in animals that serve as foods traditionally consumed by Northerners and impact on the health and well-being of both wildlife and people. While much progress has been made in Canada and internationally to address the issue of some POPs and mercury, the problem has not been solved, particularly as many new POPs appear in the Arctic environment, and as climate and other changes (e.g. increased economic development in the Arctic) alter the dynamic nature of the problem. Work must continue on the monitoring and research of this issue to determine the risks to ecosystems and people in a changing Arctic, and to inform and develop policies that reduce Arctic contaminant exposure and improve food safety for Northerners.

In light of the findings of the CACAR III assessments, the NCP has identified the following priorities for future work.

The NCP will:

ENVIRONMENTAL MONITORING AND RESEARCH	• continue to play a critical role in the detection of new chemical contaminants of concern to the Arctic and continuously review and refine its list of contaminants of concern. • enhance the measurement of long-term trends of mercury and POPs by filling gaps in geographic coverage. • carry out more research to understand the effects of climate change and predict their impacts on contaminant dynamics and ecosystem and human health risks.
COMMUNITY BASED MONITORING AND RESEARCH	• expand community-based monitoring and research that builds scientific capacity in the North, and optimizes the use of traditional knowledge. • develop partnerships with other programs to enhance opportunities for community-based monitoring and research to address the cumulative impacts of contaminants along with other issues such as climate change.
HUMAN HEALTH	• address ongoing public health concerns related to contaminants and food safety, in partnership with territorial/regional health authorities by: – weighing the risks associated with exposure to POPs and mercury against the wide ranging benefits of consuming traditional/country foods, and – expanding monitoring of contaminant exposure among human populations across the North, and research on potential health effects in collaboration with Northern communities, to provide current information to public health officials
COMMUNICATIONS	• communicate research results and information about contaminants and risk to Northerners in the context of broader environmental (e.g. climate change) and health messages. Timely and culturally sensitive messages will be developed and communicated in association with regional health authorities and other appropriate spokespeople; these communication initiatives will be evaluated for their effectiveness. • ensure that NCP data and information is effectively communicated to key international networks, such as AMAP, and the Global Monitoring Plans under the Stockholm and Minamata Conventions for the purpose of evaluating the effectiveness of global regulations.

Recommendations:

In light of the findings of the CACAR III assessments, the NCP also calls for broader action on measures related to achieving its mandate and supporting Arctic science in general:

Canadian research and monitoring programs, including the NCP, must work together to:

- ensure long-term monitoring networks have the resources they need to continue to be operational into the future.
- ensure that northern data are properly archived, managed and made available in an open, transparent, and timely manner, e.g. through the Polar Data Catalogue, and research results are communicated in timely and culturally appropriate ways.
- ensure that programs are complementary, with results feeding into one another in a way that enables multidisciplinary assessments of cross-cutting issues, such as climate change.
- engage and empower northern communities, organizations and governments to lead and fully participate in Arctic research through capacity building initiatives, support for community-based research and shared decision-making.
- engage in international networks and multi-national monitoring and research initiatives, to the greatest extent possible, in order to address the circumpolar and global scientific challenges presented by climate change and contaminants.

Arctic Nations, including Canada must:

- communicate national POPs data and information promptly to Arctic Council/AMAP and Stockholm Convention's Global Monitoring Plan and POPs Review Committee to ensure maximum global impact.
- be encouraged to swiftly ratify the Minamata Convention, so that it may enter into force as soon as possible, leading to a reduction in mercury entering into Arctic ecosystems.
- ensure that the issue of food (and water) security, which includes the safety of traditional/country foods, is recognized by Northern policy makers in Canada and by the Arctic Council as a priority for action.
- monitor the impacts of socio-economic and environmental changes in the Arctic on local sources of contaminants to assess their potential influence on overall exposures in the Arctic.
- consider the impacts of contaminants on ecosystems and people in the development of adaptation strategies for a changing Arctic.

About the Northern Contaminants Program (NCP)

The NCP was established in 1991 in response to concerns about human exposure to elevated levels of contaminants in fish and wildlife species that are important to the traditional diets of northern Indigenous peoples. Early studies indicated that there was a wide spectrum of substances, such as persistent organic pollutants, heavy metals, and radionuclides, which were reaching unexpectedly high levels in the Arctic ecosystem, even though many had no Arctic or Canadian sources. The NCP is administered by Indigenous and Northern Affairs Canada, and directed by a multi-stakeholder Management Committee, including northern Indigenous organizations and representatives from various levels of government.

The NCP engages Northerners and scientists in research and monitoring related to long-range contaminants in the Canadian Arctic. Such contaminants are transported to the Arctic through atmospheric and oceanic processes from other parts of the world, after which they remain in the Arctic environment and build up in the food chain. The data generated by the NCP is used to assess ecosystem and human health risks, and the findings of these assessments are used to address the safety and security of traditional country foods that are important to the health and traditional lifestyles of Northerners and northern communities. The findings also inform policy, resulting in action to eliminate contaminants from long-range sources.

NCP Mandate

To work towards reducing and, wherever possible, eliminating contaminants in traditional/country foods, while providing information that assists individuals and communities in making informed decisions about their food use.

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