Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada

Synopsis of Research

Conducted under the 2014–2015 Northern Contaminants Program

Résumé de recherche

effectuées en 2014–2015 dans le cadre du Programme de lutte contre les contaminants dans le Nord

Canada

Synopsis of Research Conducted under the 2014-2015 Northern Contaminants Program

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Foreword

This report provides a summary of the progress to date of research and monitoring studies pertaining to contaminants from long-range sources in northern Canada, and related communications, outreach, capacity-building and policy activities that were conducted in 2014-2015 under the auspices of the Northern Contaminants Program (NCP). The NCP mandate is to work to reduce and, wherever possible, eliminate contaminants in traditionally harvested foods, while providing information that assists informed decision making by individuals and communities in their food use. The projects reported herein cover the broad range of topics that contribute to understanding and addressing northern contaminants issues, as outlined in the NCP strategic plans (e.g., Blueprints), including dietary contaminant exposure, effects of contaminants on the health of people and ecosystems, contaminant levels and trends in the Arctic environment and wildlife and the influence of climate change, and community-based monitoring and research.

These projects were subject to a comprehensive technical, peer and northern social/cultural review process, involving external peer reviewers, technical review teams, regional contaminants committees and the NCP Management Committee. This review process ensures that each project supports the priorities and objectives of the Northern Contaminants Program, as outlined in the NCP blueprints and the annual call for proposals. All peer reviewers, review teams and regional contaminants committees use evaluation criteria to review and rate proposals. Consultation with northern community authorities and/or Aboriginal organizations is required for all projects involving field work in the North and/or analyses of samples, as a condition of approval for funding.

Preliminary results of projects funded in the 2014-2015 year are presented here. Submission of a report for this publication ensures program transparency, allows for

Avant-propos

Ce rapport présente un résumé des progrès réalisés jusqu'à maintenant en matière de recherche et de surveillance relatives aux contaminants de sources éloignées dans le Nord du Canada, ainsi qu'en matière de communication, de sensibilisation, de renforcement des capacités et d'activités stratégiques connexes réalisées en 2014-2015 dans le cadre du Programme de lutte contre les contaminants dans le Nord (PLCN). Le mandat du PLCN consiste à réduire et, dans la mesure du possible, à éliminer les contaminants présents dans les aliments traditionnels récoltés, tout en procurant de l'information permettant aux personnes et aux collectivités de prendre des décisions éclairées au sujet de leur alimentation. Les projets dont rend compte le rapport portent sur une vaste gamme de sujets qui contribuent à mieux comprendre et prendre en compte les enjeux relatifs aux contaminants dans le Nord énoncés dans les plans directeurs du PLCN, notamment les suivants : l'exposition à des contaminants par voie alimentaire; les effets des contaminants sur la santé des individus et des écosystèmes; les niveaux de contaminants et les tendances dans l'environnement et chez les espèces sauvages dans l'Arctique; l'influence des changements climatiques; et la surveillance et la recherche communautaires.

Ces projets ont fait l'objet d'un processus exhaustif d'examen technique, par les pairs et socioculturel, auxquels ont participé des pairs examinateurs externes, des équipes d'examen technique, des comités régionaux sur les contaminants de même que le Comité de gestion du PLCN. Ce processus d'examen garantit que chaque projet appuie les priorités et les objectifs du PLCN, qui sont énoncés dans les plans directeurs du Programme et dans l'appel de propositions annuel. Pour obtenir un financement, tous les projets qui nécessitent du travail sur le terrain dans le Nord ou des analyses d'échantillons doivent faire l'objet d'une consultation avec les autorités nordiques et les organisations autochtones concernées.

timely sharing of results, and is a mandatory deliverable for all recipients of NCP project funding. These reports and any future peer-reviewed publications related to these studies will be available through the NCP Publications Database housed at the Arctic Science and Technology Information System (ASTIS) hosted by the Arctic Institute of North America (AINA) at www.aina.ucalgary.ca/ncp. Other project deliverables include submission of data/data sets/metadata to the Polar Data Catalogue at www.polardata.ca.

Further information about the Northern Contaminants Program is available on the NCP website at www.science.gc.ca/ncp

Vous trouverez ici les résultats préliminaires des projets financés en 2014-2015. La présentation d'un rapport aux fins de la présente publication assure la transparence du programme ainsi qu'une communication rapide des résultats. Il s'agit en outre d'un livrable obligatoire pour tous les bénéficiaires d'une aide financière dans le cadre du PLCN. Ces rapports et les futures publications révisées par les pairs qui touchent ces études seront versés dans la base de données des publications du PLCN, qui est hébergée par le Système d'information sur les sciences et les techniques de l'Arctique (SISTA), à l'adresse www.aina.ucalgary.ca/ncp. Les autres livrables que doivent remettre les bénéficiaires comprennent des données, des ensembles de données et des métadonnées à verser dans le catalogue des données polaires (www.polardata.ca).

Pour plus d'information sur le Programme de lutte contre les contaminants dans le Nord, voir : www.science.gc.ca/plcn.

Official Languages Disclaimer

These synopsis reports are published in the language chosen by the project leaders. The full reports have not been translated. The Abstracts and Key Messages are available in English and French at the beginning of each report. Complete individual project synopses are available in either official language, upon request. Requests for individual reports can be made to:PLCN-NCP@aadnc-aandc.gc.ca

Avertissement concernant les langues officielles

Les rapports de synthèse ont été publiés dans la langue choisie par les directeurs de projet. Les rapports complets n'ont pas été traduits, mais des résumés et des messages clés sont présentés en français et en anglais au début de chaque rapport. Des sommaires complets sur chaque projet sont disponibles sur demande dans l'une ou l'autre des langues officielles. On peut présenter une demande pour obtenir des rapports à : PLCN-NCP@aadnc-aandc.gc.ca.

Introduction

The Northern Contaminants Program (NCP) engages Northerners and scientists in researching and monitoring of long-range contaminants in the Canadian Arctic, that is, contaminants that are transported to the Arctic through atmospheric and oceanic processes from other parts of the world and which 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, 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. The NCP contributes scientific data and expertise to contaminants-related international initiatives such as the Arctic Monitoring and Assessment Programme (AMAP), and to international agreements such as the UNEP Minamata Convention on Mercury, the Stockholm Convention on Persistent Organic Pollutants, and two protocols under the United Nation Economic Commission for Europe Convention on Long-range Transboundary Air Pollution, working globally to improve the health of Arctic people and wildlife over the long term.

The NCP is directed by a management committee that is chaired by Aboriginal Affairs and Northern Development Canada (AANDC), and consists of representatives from four federal departments (Environment, Fisheries and Oceans, Health and AANDC), five territorial, provincial and regional governments (Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut), four northern Aboriginal organizations (Council of Yukon First Nations, Dene Nation, Inuit Tapiriit Kanatami and Inuit Circumpolar Council), five regional contaminants committees, and Canada's only Arctic-focused Network of Centres of Excellence (ArcticNet). The management committee is responsible for establishing NCP policy and science priorities and for making final

Le Programme de lutte contre les contaminants dans le Nord (PLCN) mobilise les résidants du Nord et les scientifiques pour qu'ils participent à la recherche et à la surveillance axées sur les contaminants dans l'Arctique canadien, c'est-à-dire les contaminants qui sont transportés jusque dans l'Arctique par voie aérienne ou par les océans, et qui proviennent d'ailleurs dans le monde; ces contaminants demeurent dans l'environnement arctique et s'accumulent dans la chaîne alimentaire. Les données produites par le PLCN servent à évaluer la santé des écosystèmes et la santé humaine, et les conclusions de ces évaluations permettent d'assurer la salubrité et la sécurité des aliments traditionnels qui sont importantes pour la santé et le mode de vie traditionnels des résidants et des collectivités nordiques. Les conclusions guident également les politiques, qui donnent lieu à des mesures visant à éliminer les contaminants de sources éloignées. Le PLCN contribue à la collecte de données et à l'apport d'une expertise scientifique dans le cadre d'initiatives internationales sur les contaminants, comme le Programme de surveillance et d'évaluation de l'Arctique (PSEA), et d'ententes internationales comme la Convention de Minamata sur le mercure du Programme des Nations Unies pour l'environnement, la Convention de Stockholm sur le polluants organiques persistants et deux protocoles conclus en vertu de la Convention sur la pollution atmosphérique transfrontalière à longue distance de la Commission économique des Nations Unies pour l'Europe. Ces contributions à des travaux internationaux visent à améliorer la santé des résidants et des espèces sauvages à long terme.

Le PLCN est dirigé par un comité de gestion présidé par Affaires autochtones et Développement du Nord Canada (AADNC). Il compte des représentants de quatre ministères fédéraux (Environnement, Pêches et Océans, Santé Canada et AADNC), de cinq gouvernements provinciaux ou territoriaux (le Yukon, les Territoires du Nord-Ouest, le decisions on the allocation of funds. Regional contaminants committees established in Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut support this national committee. Funding for the NCP's $4.1 million annual budget comes from AANDC and Health Canada. Details about the management structures and review processes used to effectively implement the NCP, and the protocol to be used to publicly disseminate health and harvest information generated by the NCP can be found in the NCP Operational Management Guide (available upon request from the NCP Secretariat).

Nunavut, le Nunavik et le Nunatsiavut), de quatre organisations autochtones nordiques (le Conseil des Premières Nations du Yukon, la Nation dénée, Inuit Tapiriit Kanatami et la Conférence circumpolaire inuite), de cinq comités régionaux sur les contaminants et du Réseau de centres d'excellence axé sur l'Arctique, ArcticNet. Le Comité de gestion est responsable de l'établissement de la politique et des priorités scientifiques du PLCN de même que des décisions finales sur l'affectation des fonds. Les comités régionaux sur les contaminants du Yukon, des Territoires du Nord-Ouest, du Nunavut, du Nunavik et du Nunatsiavut appuient ce comité national. Le financement de 4,1 millions de dollars qui est affecté chaque année à la recherche aux termes du PLCN provient d'AADNC et de Santé Canada. On trouve dans le *Guide de la gestion des opérations* du PLCN (disponible sur demande au Secrétariat du PLCN) des détails sur les structures de gestion et les processus d'examen servant à mettre en œuvre le Programme, de même que le protocole à utiliser pour diffuser publiquement l'information sur la santé et la récolte produite dans le cadre du Programme.

Background

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 Aboriginal peoples. Early studies indicated that there was a wide spectrum of substances - persistent organic pollutants, heavy metals, and radionuclides - many of which had no Arctic or Canadian sources, but which were, nevertheless, reaching unexpectedly high levels in the Arctic ecosystem.

The Program's key objective is to reduce and, where possible, eliminate contaminants in northern traditional/country foods while providing information that assists informed decision making by individuals and communities in their food use.

Under the first phase of the NCP, research was focused on gathering the data required to determine the levels, geographic extent,

Contexte

Le PLCN a été créé en 1991 en réponse aux inquiétudes que suscitait l'exposition des humains à des niveaux élevés de contaminants par les poissons et les espèces sauvages, qui composent une part importante du régime alimentaire traditionnel des Autochtones dans le Nord. Les premières études indiquaient qu'il existait un large spectre de substances – polluantes organiques persistants, métaux lourds et radionucléides – dont plusieurs ne provenaient pas de l'Arctique ou du Canada, mais étaient tout de même présents en quantités étonnamment élevées dans l'écosystème de l'Arctique.

Le Programme a pour objectif premier de réduire et, dans la mesure du possible, d'éliminer les contaminants présents dans le Nord dans les aliments traditionnels ou prélevés dans la nature tout en fournissant aux individus et aux collectivités de l'information leur permettant de prendre des décisions éclairées au sujet de leur alimentation.

and source of contaminants in the northern atmosphere, environment and its people, and the probable duration of the problem. The data enabled us to understand the spatial patterns and temporal trends of contaminants in the North, and confirmed our suspicions that the major sources of contaminants were other countries. The data, which included information on the benefits from continued consumption of traditional/ country foods, was also used to carry out assessments of human health risks resulting from contaminants in those foods. Results were synthesized in the first Canadian Arctic Contaminants Assessment Report (1997).

Extensive consultations were conducted in 1997-1998 to find the common elements between the concerns and priorities of northern communities and the scientific needs identified as critical for addressing the issue of contamination in Canada's North. As a result, research priorities were developed based on an understanding of the species that are most relevant for human exposure to contaminants in the North, and geographic locations and populations that are most at risk.

In 1998, initiatives got under way to redesign the NCP, and implement new program features which continue to this day: 1) the NCP blueprints that represent the long-term vision and strategic direction for the NCP; and 2) an open and transparent proposal review process. These features ensure that the NCP remains scientifically defensible and socio-culturally aware, while at the same time, achieving real progress in terms of the Program's broad policy objectives.

In 1998-1999, the NCP began its second phase, which continued until 2002-2003. Results of this phase were synthesized in the Canadian Arctic Contaminants Assessment Report II (CACAR II, 2003). During that time, the NCP supported research designed to answer questions about the impacts and risks to human health that may result from current levels of contamination in key Arctic food species. To ensure a balanced assessment of the risks, an emphasis was placed on characterizing and quantifying the benefits associated with traditional diets. Communications activities were also emphasized

Dans la première phase du PLCN, les recherches ont consisté à recueillir les données nécessaires pour établir la concentration des contaminants, leur portée géographique et leur source dans l'atmosphère, l'environnement et la population du Nord, de même que la durée probable du problème. Les données nous ont permis de comprendre les modèles spatiaux et les tendances temporelles de la contamination dans le Nord, ainsi que de confirmer ce que nous soupçonnions, à savoir que les contaminants provenaient principalement d'autres pays. Les données, qui comprenaient des renseignements sur les avantages associés à une consommation régulière d'aliments traditionnels ou prélevés dans la nature, ont également servi à évaluer les risques pour la santé humaine que posent les contaminants contenus dans ces aliments. Les résultats ont été résumés dans le premier Rapport de l'évaluation des contaminants dans l'Arctique canadien (RECAC) en 1997.

Des consultations complètes ont été réalisées en 1997-1998 dans le but de trouver des éléments communs entre les préoccupations et priorités des collectivités nordiques et les besoins scientifiques, éléments jugés essentiels pour s'attaquer au problème de la contamination dans le Nord du Canada. Les priorités en matière de recherche ont donc été établies à partir des espèces les plus pertinentes en ce qui concerne l'exposition des humains dans le Nord, et en fonction des lieux géographiques et des populations les plus à risque.

En 1998, des initiatives ont été mises en œuvre dans le but de revoir la conception du PLCN et de mettre en œuvre de nouveaux éléments de programme encore présents aujourd'hui : 1) les plans directeurs du PLCN, qui présentent la vision et l'orientation stratégique à long terme du Programme; et 2) un processus d'examen des propositions ouvert et transparent. Ces éléments garantissent que le PLCN demeure pertinent sur le plan scientifique et conscient des aspects socioculturels, tout en réalisant des progrès réels à l'égard de ses vastes objectifs stratégiques.

En 1998-1999, le PLCN a entrepris sa deuxième phase, qui s'est poursuivie jusqu'en 2002-2003 et dont les résultats ont été présentés and supported. Under the leadership of the northern Aboriginal organizations, the dialogue between northerners and the scientific community, which had been initiated during the early days of the NCP, continued to build awareness and an understanding of contaminants issues, and helped to support communities to deal with specific contaminant issues at the local level.

In 2009, the NCP released the Canadian Arctic Contaminants and Health Report. This report compiled research funded under the Human Health subprogram since the CACAR II release in 2003. It covered topics including health status of the Canadian Arctic population, human exposure to contaminants, toxicology, epidemiology, and risk-benefit evaluation.

Efforts on a third series of assessments got under way in 2010, leading to the release of the CACAR III: Mercury in Canada's North, in December 2012; the CACAR III: Persistent Organic Pollutants in Canada's North, in December 2013; and the CACAR III Contaminants In Canada's North: Summary for Policy Makers, in April 2015.

dans le RECAC II, en 2003. À cette époque, le PLCN soutenait la recherche qui s'intéressait à des questions concernant les répercussions et les risques pour la santé humaine associés aux niveaux de contamination chez certaines espèces largement consommées dans l'Arctique. Pour assurer une évaluation des risques équilibrée, l'accent a été mis sur la caractérisation et la quantification des bénéfices associés aux régimes alimentaires traditionnels. Le Programme a également soutenu des activités de communication. Sous la gouverne d'organisations autochtones nordiques, le dialogue entre les résidants du Nord et la communauté scientifique, initié dès le début du PLCN, a continué de favoriser la sensibilisation et la compréhension des questions relatives aux contaminants et aidé à soutenir les collectivités confrontées à des enjeux précis à l'échelle locale.

Le PLCN a publié son Rapport de l'évaluation des contaminants et de la santé dans l'Arctique canadien en 2009. Ce rapport présentait des recherches financées aux termes du sous-programme sur la santé humaine depuis la publication du RECAC II en 2003. Il couvrait notamment les sujets suivants : l'état de santé de la population dans l'Arctique canadien, l'exposition des humains à des contaminants, la toxicologie, l'épidémiologie et l'évaluation des risques et des avantages.

Une troisième série d'évaluations a été entreprise en 2010 et a mené à la publication du RECAC III sur le mercure dans le Nord canadien en décembre 2012, du RECAC III sur les polluants organiques persistants dans le Nord canadien en décembre 2013 et du RECAC III, Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs, en avril 2015.

International Impact

The NCP effort to achieve international controls of contaminants has remained strong throughout the program's history. NCP continues to generate data that allows Canada to play a leading role in the following initiatives, and contribute through cooperative actions under the Arctic Council, in particular through the circumpolar Arctic Monitoring and Assessment Programme (AMAP).

The legally binding POPs protocol, under the United Nations Economic Commission for Europe (UN ECE) Convention on Long-range Transboundary Air Pollution, was successfully negotiated and signed by 34 countries (including Canada) at the UN ECE Ministerial conference in Arhus, Denmark in June 1998. Canada ratified this agreement in December 1998.

A legally binding global instrument on POPs under the United Nations Environment Programme (UNEP) was completed with the signing of the POPs Convention in Stockholm, Sweden, May 23, 2001; the UNEP Stockholm Convention on POPs entered into force in May 2004.

The Minamata Convention on Mercury, a legally-binding agreement to cut emissions and releases of mercury to the environment, was signed by Canada in October 2013 and now includes 128 signatory nations and 12 ratifications, in an international effort to reduce global mercury pollution and protect the environment and human health. Through use of its data, information and expertise, the NCP made important contributions towards this historic signing. The Convention will enter into force 90 days after 50 countries have ratified the treaty (Canada has not yet ratified). In the meantime, preparations for the entry into force are ongoing.

Répercussions internationales

Les efforts du PLCN en vue de parvenir à un contrôle international des contaminants ont été soutenus tout au long de l'histoire du Programme. Le PLCN continue de produire des données qui permettent aux Canadiens de jouer un rôle de premier plan au sein des initiatives suivantes et de contribuer à des actions en collaboration qui relèvent du Conseil de l'Arctique, en particulier le Programme de surveillance et d'évaluation de l'Arctique (PSEA).

Le protocole sur les polluants organiques persistants (POP), qui a force de loi et relève de la Convention sur la pollution atmosphérique transfrontalière de la Commission économique des Nations Unies pour l'Europe (CEE-ONU), a été négocié et signé par 34 pays (y compris le Canada) à la Conférence ministérielle de la CEE-ONU à Arhus, au Danemark, en juin 1998. Le Canada a ratifié cette entente en décembre 1998.

Le 23 mai 2001, un outil international ayant force de loi sur les POP en vertu du Programme des Nations Unies pour l'environnement (PNUE) a été achevé avec la signature de la Convention de Stockholm sur les POP, en Suède : la Convention de Stockholm sur les POP du PNUE est entrée en vigueur en mai 2004.

En octobre 2013, dans le cadre d'un effort international visant à réduire la pollution par le mercure à l'échelle mondiale et à protéger la santé humaine, le Canada a signé la Convention de Minamata, un accord exécutoire visant à réduire les émissions et la libération de mercure dans l'environnement signé par 128 pays, et ratifié par 12. Les données, les renseignements et l'expertise issus du PLCN ont grandement contribué à la signature de cet accord historique. La Convention entrera en vigueur 90 jours après que 50 pays l'aient ratifiée (le Canada n'a pas encore ratifié la Convention). Les préparatifs en vue de l'entrée en vigueur de la Convention sont en cours.

Highlights of 2014-2015

This report provides a summary of the progress to date of research and activities funded by the Northern Contaminants Program in 2014-2015. It is a compilation of reports submitted by project teams, emphasizing the results of research and related activities that took place during the year.

Some of the program's highlights for 2014-2015 included:

- The publication Contaminants in Canada's North: Summary for Policy Makers (http://pubs.aina.ucalgary.ca/ncp/CACARIIISummary.pdf) was released in April 2015. It summarizes the integrated highlights and main findings from the recent technical assessments on mercury, persistent organic pollutants and health under the NCP. It also presents the NCP's strategic directions and proposes a series of recommendations for broader measures related to achieving the NCP's mandate and supporting Arctic science in general (see "10 Key Findings" and "NCP Future Directions" below).
- Significant contributions by NCP scientists, Aboriginal partners and the NCP Secretariat to the circumpolar Arctic Monitoring and Assessment Programme (AMAP) Working Group, as co-authors and co-chairs of scientific expert groups working on updates to circumpolar assessment reports, and as Canada's Head of Delegation and Vice-Chair to AMAP, during Canada's chairmanship of the Arctic Council (2013-2015).
- A successful pilot project on human biomonitoring for contaminants got under way in the Deh Cho Region of the Northwest Territories, where fish consumption advisories have been put in place in recent years.
- The Community-Based Monitoring sub-program expanded for the first time into all northern regions from Yukon to Nunatsiavut.

Faits saillants en 2014-2015

Ce rapport présente un sommaire des progrès réalisés jusqu'à maintenant dans la recherche et les activités financées aux termes du Programme de lutte contre les contaminants dans le Nord en 2014-2015. Il s'agit d'une compilation de rapports soumis par des équipes de projets, qui met l'accent sur les résultats de la recherche et des activités connexes qui ont eu lieu au cours de l'exercice 2014-2015.

Quelques faits saillants du Programme en 2014-2015 :

- Le RECAC III, Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs (http://pubs.aina.ucalgary.ca/ncp/CACARIIISommaire.pdf), a été publié en avril 2015. Le rapport résume les faits saillants et les principales conclusions de la dernière évaluation technique sur le mercure, les polluants organiques persistants et la santé réalisée dans le cadre du PLCN. Le rapport présente également les orientations du PLCN et propose une série de mesures pour mener à bien le mandat du Programme et appuyer les sciences de l'Arctique en général (consulter les dix conclusions clés et les orientations futures du PLCN).
- Les scientifiques du PLCN, les organisations autochtones et le Secrétariat du PLCN ont participé au Groupe de travail du Programme de surveillance et d'évaluation de l'Arctique en tant que coauteurs et coprésidents de groupes d'experts scientifiques chargés de mettre à jour les rapports des évaluations circumpolaires en plus d'assumer les rôles de chef de la délégation du Canada et de vice-président du Programme de surveillance et d'évaluation de l'Arctique durant la présidence du Canada au Conseil de l'Arctique (de 2013 à 2015).
- On a déployé, avec succès, un projet pilote de surveillance biologique chez les humains pour les contaminants dans la région du Deh Cho des Territoires du Nord-Ouest,

- Finally, long-time Director of the Northern Contaminants Program, Chair of the NCP Management Committee, Russel Shearer, retired from the public service in 2015. He will be missed by the whole NCP community.

10 Key Findings of the Northern Contaminants Program

(from *Contaminants in Canada's North: Summary for Policy Makers*, 2014)

1. Concentrations of 'legacy POPs' are generally going down across the Arctic.
2. As 'new POPs' come under regulation, their levels in the Arctic decline.
3. Mercury levels in the Arctic are stabilizing but are still several times higher than during pre-industrial times.
4. Climate change can affect how POPs and mercury cycle in the Arctic environment and accumulate in wildlife.
5. The complex movement of contaminants in the Arctic environment and wildlife is now better understood.
6. Current levels of POPs and mercury may be a risk for the health of some Arctic wildlife species.
7. While exposure to most POPs and mercury is generally decreasing among Northerners, mercury remains a concern in some regions.
8. Traditional/country foods continue to be important for maintaining a healthy diet for Northerners.
9. Environmental exposure to contaminants in the Arctic has been linked to health effects in people.
10. Continued international action is vital to reducing contaminant levels in the Arctic.

région où on a émis divers avertissements concernant la consommation de poisson au cours des dernières années.

- Le sous-programme de surveillance communautaire a pour la première fois été élargi à toutes les régions nordiques, du Yukon au Nunatsiavut.
- Pour terminer, le directeur de longue date du PLCN et président du comité de gestion du Programme, Russel Shearer, a pris sa retraite de la fonction publique en 2015. Il manquera à tous les employés du PLCN.

10 principales conclusions du Programme de lutte contre les contaminants dans le Nord

(conclusions tirées du rapport de 2014 *Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs*)

1. Les concentrations de POP hérités du passé diminuent en général partout dans l'Arctique.
2. À mesure que les « nouveaux POP » sont réglementés, leurs niveaux dans l'Arctique diminuent.
3. Les niveaux de mercure dans l'Arctique se stabilisent, mais sont encore plusieurs fois plus élevés qu'à l'ère préindustrielle.
4. Les changements climatiques peuvent avoir des incidences sur le cycle des POP et du mercure dans le milieu arctique et sur leur accumulation.
5. Le mouvement complexe des contaminants dans le milieu arctique et chez les espèces sauvages est maintenant mieux compris.
6. Les niveaux actuels de POP et de mercure représentent peut-être un risque pour la santé de certaines espèces sauvages de l'Arctique.
7. L'exposition au mercure et à la plupart des POP diminue de façon générale chez les habitants du Nord, mais le mercure reste problématique dans certaines régions.

Future Directions of the Northern Contaminants Program:

(adapted from *Contaminants in Canada's North: Summary for Policy Makers*, 2014)

In terms of *Environmental Monitoring and Research, the NCP will*

- 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.
- expand community-based monitoring that builds scientific capacity in the North, and optimizes the use of traditional knowledge.

In terms of *Human Health Research, Monitoring and Risk Assessment*, the NCP will

- 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

8. Les aliments traditionnels/prélevés dans la nature restent importants pour le maintien de la saine alimentation des habitants du Nord.
9. L'exposition aux contaminants présents dans le milieu arctique est associée à des effets sur la santé des habitants.
10. Il est essentiel de poursuivre l'action internationale pour réduire le niveau des contaminants dans l'Arctique.

Orientations futures du Programme de lutte contre les contaminants dans le Nord :

(orientations adaptées du rapport de 2014 *Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs*)

Pour ce qui est de la *surveillance environnementale et de la recherche, le PLCN* :

- continuera à jouer un rôle crucial dans la détection de nouvelles substances chimiques contaminantes préoccupantes dans l'Arctique et examinera et peaufinera continuellement sa liste de contaminants préoccupants;
- améliorera la mesure des tendances à long terme du mercure et des POP en comblant les lacunes dans la couverture géographique;
- effectuera plus de recherches pour comprendre les effets des changements climatiques et prévoir leurs incidences sur la dynamique des contaminants et les risques pour l'écosystème et la santé humaine;
- élargira la surveillance communautaire qui renforce les capacités scientifiques dans le Nord et optimise l'utilisation des connaissances traditionnelles;

Pour ce qui est de la *santé humaine, de la surveillance et de l'évaluation du risque*, le PLCN :

- en collaboration avec les autorités sanitaires régionales et territoriales, répondra aux préoccupations actuelles en matière de santé

In terms of *Communications and Outreach*, the NCP will

- 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.

publique en lien avec les contaminants et la salubrité des aliments :

– - en comparant les risques associés à l'exposition aux POP et au mercure au large éventail d'avantages que présente la consommation des aliments traditionnels/prélevés dans la nature;
– - en élargissant la surveillance de l'exposition des populations humaines de tout le Nord aux contaminants ainsi que les travaux de recherche sur les effets éventuels sur la santé, en collaboration avec les collectivités nordiques, afin de fournir de l'information à jour aux responsables de la santé publique;

Pour ce qui est de la *communication et de la sensibilisation*, le PLCN :

- communiquera les conclusions des recherches et de l'information sur les contaminants et les risques aux habitants du Nord dans le contexte de messages sanitaires et environnementaux sur des sujets plus vastes (p. ex. les changements climatiques). Des messages opportuns et adaptés à la culture des collectivités seront élaborés et diffusés en collaboration avec les autorités sanitaires régionales et les autres porte-paroles appropriés, et l'efficacité de ces initiatives de communication sera évaluée;

- veillera à ce que ses données et son information soient efficacement communiquées à des réseaux internationaux importants, comme le PSEA et les plans de surveillance mondiaux prévus par les conventions de Stockholm et de Minamata afin d'évaluer l'efficacité de la réglementation mondiale.

Human Health

Santé humaine

Development of Blood Guidance Values for Persistent Organic Pollutants for the Canadian Arctic

Élaboration de valeurs-guides relatives à la concentration sanguine des polluants organiques persistants dans l'Arctique canadien

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Abstract

The Adult Inuit Health Survey (2007-2008) collected data on blood levels of heavy metals and persistent organic pollutants in participants from the Canadian North. The population-level risks of contaminant exposures can be assessed using biomonitoring equivalents, which are the corresponding internal doses of maximum recommended intake reference standards. The purpose of this project is to develop new biomonitoring equivalents for chlordane, toxaphene, and polychlorinated biphenyls and explore the use these biomonitoring equivalents to assess of the biomonitoring data collected in the Canadian North. During the 2014-2015 fiscal year, information needed to derive biomonitoring equivalents, was collected from the literature. Several reference standards are available from organizations such as Health Canada, the Environmental Protection Agency, and European authorities. Also developed

Résumé

L'Enquête sur la santé des Inuits adultes (2007-2008) a permis de recueillir des données sur les niveaux sanguins de métaux lourds et de polluants organiques persistants chez des participants du Nord canadien. Les risques d'exposition aux contaminants pour la population peuvent être évalués au moyen d'équivalents de biosurveillance, qui sont les doses internes correspondantes des normes de référence d'apport maximal recommandé. Ce projet vise à établir de nouveaux équivalents de biosurveillance pour le chlordane, la toxaphène et les biphényles polychlorés ainsi qu'à étudier l'utilisation de ces équivalents pour évaluer les données de biosurveillance recueillies dans le Nord canadien. Durant l'exercice 2014-2015, l'information nécessaire pour déterminer les équivalents de biosurveillance a été réunie par une étude documentaire. Des organismes comme Santé Canada, l'Environmental

was a pharmacokinetic modeling strategy and identification of pharmacokinetic parameters needed to model internal contaminant behaviour based on absorption, distribution, metabolism, and excretion. The work completed in the first year of the project will be used for carrying out one-compartment pharmacokinetic modeling during the second year of the project.

Protection Agency et des autorités européennes proposent plusieurs normes de référence. Une stratégie de modélisation pharmacocinétique ainsi que d'établissement des paramètres pharmacocinétiques nécessaires pour modéliser le comportement des contaminants internes sur la base de l'absorption, de la distribution, du métabolisme et de l'excrétion ont aussi été établis. Les travaux de la première année du projet serviront à réaliser une modélisation pharmacocinétique à un compartiment au cours de la deuxième année.

Key messages

- Biomonitoring equivalents are the corresponding internal doses of intake reference standards and can be used to assess population-level risks of contaminant exposures.
- Currently there are no biomonitoring equivalents for chlordane, toxaphene, and polychlorinated biohenyls and, therefore, the purpose of this project is to develop biomonitoring equivalents for these contaminants and use them to interpret biomonitoing data of the Inuit Health Survey and the Canadian Health Measures Survey.
- Oral intake reference standards are available for technical chlordane, technical and weathered toxaphene, and polychlorinated biphenyls (dioxin-like, non-dioxin like, commercial mixtures, total) from various organizations. These values or the no-observed adverse effect level/lowest-observed adverse effect level will be used as the point of departures for deriving the biomonitoring equivalents.
- A hierarchical pharmacokinetic modelling strategy will be employed to model contaminant behaviour in the body, using a simple one-compartment model as the starting point.

Messages clés

- Les équivalents de biosurveillance sont les doses internes correspondantes des normes de référence d'apport et peuvent servir à évaluer les risques d'exposition aux contaminants pour la population.
- Il n'existe pas actuellement d'équivalents de biosurveillance pour le chlordane, la toxaphène et les biphényles polychlorés. Ce projet a donc pour but d'élaborer des équivalents de biosurveillance pour ces contaminants et de les utiliser pour interpréter les données de biosurveillance de l'Enquête sur la santé des Inuits et de l'Enquête canadienne sur les mesures de la santé.
- Diverses organisations ont établi des normes de référence sur l'absorption orale pour le chlordane technique, le toxaphène technique et altéré ainsi que les biphényles polychlorés (de type dioxine ou non, mélanges commerciaux, totaux). Ces valeurs ou la dose sans effet nocif observé/dose minimale avec effet nocif observé serviront de points de départ pour la dérivation des équivalents de biosurveillance.
- Une stratégie de modélisation pharmacocinétique hiérarchique sera utilisée pour modéliser le comportement des contaminants dans l'organisme, avec comme point de départ un modèle à un seul compartiment.

- The biomonitoring equivalents will be used to determine the percentage of the sample population that exceeds recommended guidance values.

- Les équivalents de biosurveillance serviront à déterminer le pourcentage de la population échantillon qui dépasse les valeurs indicatives recommandées.

Objectives

- Develop pharmacokinetic models for the following contaminants:
  - Chlordane (cis-chlordane, trans-chlordane, oxychlordane, cis-nonachlor, trans-nonachlor)
  - Toxaphene (Parlar No. 26, 50, and 62)
  - Polychlorinated biphenyls (PCB-153 + other representative congeners based on abundancy/toxicity)

- Derive biomonitoring equivalents based on conversions of intake reference standards (published by various organizations in Canada, United States, and Europe) to internal doses using the pharmacokinetic models.

- Compare the derived biomonitoring equivalents for chlordane, toxaphene, and polychlorinated biphenyls with biomonitoring data from the Inuit Health Survey and the Canadian Health Measures Survey to determine the percentage of Inuit adults and Canadian adults from general population exceeding guidance values.

- Use existing derived biomonitoring equivalents for dichlorodiphenyltrichloroethane/ dichlorodiphenyldichloroethylene, hexachlorobenzene, and pentabromodiphenyl ether-99 to compare with Inuit Health Survey and Canadian Health Measures Survey biomonitoring data.

- Conduct subgroup analyses for women of child-bearing age, young adults, middle-aged, and the elderly.

- Perform calculations using different threshold values.

- Present results of research to regional health authorities and the Steering Committee of the Inuit Health Survey.

Introduction

The International Polar Year Inuit Health Survey (IHS) for Adults collected data on blood concentrations of environmental contaminants in 2,595 participants from the Canadian North. Laird et al. (2013) compared the observed blood levels with those in the general Canadian population, previous Inuit environmental studies, and trigger/intervention guideline values from Health Canada, Centers for Disease Control (CDC), or Occupational Safety and Health Administration (OSHA). Guidance values were available only for polychlorinated biphenyls (PCBs, specifically Arochlor 1260), cadmium, mercury and lead. Eight percent of the study sample exceeded the lead guideline level of 100 µg/L, 70% exceeded the cadmium guideline level of 1 µg/L, 35% exceeded the mercury guideline of 5.0 µg/kg/week, and 27.9% women of child-bearing age exceeded the Arochlor 1260 guideline of 5 µg/L (Laird et al. 2013, Laird et al. 2013b). For dichlorodiphenyltrichloroethane/ dichlorodiphenyldichloroethylene (DDT/DDE), toxaphene, chlordane, and polybrominated diphenyl ethers (PBDEs), the exposure distributions were not interpretable within the context of established or evidence-formulated guidance values. Therefore, the health implications of the observed blood levels for these environmental contaminants are uncertain.

Population screening risk assessments can be made by comparing the measured biomonitoring levels to existing screening criteria such as reference dose (RfD), or tolerable daily intake (TDI). This comparison cannot be conducted directly because almost all regulatory health-based toxicity screening criteria are based on an intake level (mg/kg/day) or a concentration in an environmental medium (air, water, soil, etc.) which corresponds to an acceptable level of intake. However, the substantial effort already invested in developing these screening exposure guidelines can be leveraged through translation of these guidelines into biomonitoring equivalents (BEs) as a basis for interpreting biomonitoring results for specific chemicals in a health risk context (Hays et al. 2007, Hays et al. 2008).

Comparing biomonitoring data for a chemical with its BE provides a means for assessing whether population exposures to chemicals are within or above the levels considered safe by regulatory agencies. BEs can thus assist scientists and risk managers in the prioritization of chemicals for follow-up or risk management activities (Hays et al. 2007). BEs for more than 110 chemicals, including cadmium, benzene, chloroform, arsenic, toluene, methylene chloride, triclosan, dioxins, volatile organic compounds, and others have been derived and published (Angerer et al. 2011). Several have been developed through collaborations of scientists from the U.S. Environmental Protection Agency (EPA), CDC and Health Canada (Hays et al. 2008).

Therefore, we propose to develop guidance values to interpret the biomonitoring results using BEs for chlordane, toxaphene, PCBs, DDT/DDE, hexachlorobenzene (HCB), and pentabromodiphenyl ether-99 (PBDE-99). Associated public health action plans, according to age, sex, and level of exposure will be developed similar to the approach that was used for establishing the blood guidance values for methylmercury in Canada (Legrand et al. 2010).

Activities in 2014-2015

We have completed literature reviews for reference standards for chlordane, toxaphene, and PCBs. A pharmacokinetic modeling strategy has also been developed for these contaminants. A strategy for addressing which PCBs congeners to model has been selected based on prioritizing PCBs according to abundancy and toxicity.

A preliminary modeling exercise to calculate a BE for trans-chlordane has been carried out using a simple one-compartment model and data from a toxicokinetic study in rats. The BE calculation will undergo further refinement based on review of additional toxicokinetic studies. A similar approach will be used to derive BEs for oxychlordane, cis-nonachlor, and trans-nonachlor that have been measured in the participants of IHS.

Northern Capacity Building and Training:

This work is primarily a data analysis project and, therefore, there will be limited opportunity for training. However, we will help the regional contaminant committees to understand the process of developing the guidance values.

Traditional Knowledge:

There is no direct use of traditional knowledge due to the specialized and focused nature of the project.

Communications:

The results will be presented at NCP annual workshops and symposium. According to the results obtained, scientific articles will be submitted for publication in relevant peer-reviewed journals, and communications in international meetings will be presented. We will develop a package of communication materials under the guidance of the partners in each region. The publications will be published in English and the appropriate Inuktitut language. The communication will be coordinated with the NCP Risk Communication SubCommittee and the NCP Regional Contaminant Committees.

Results

Intake Reference Standards:

Intake reference standards of 5 x 10-4 mg/kg/d or 6 x 10-4 mg/kg/d were identified for technical chlordane from the EPA, the Agency for Toxic Substances and Disease Registry (ATSDR), and the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) (Table 1). These reference standards were based primarily on a no-observed adverse effect level (NOAEL) for hepatic toxicity in rats or mice. Health Canada also published a provisional tolerable daily intake (pTDI) of 5 x 10-5 mg/kg/d (a magnitude lower than the other standards) for the total sum of chlordane isomers and metabolites. Since reference standards are available for technical chlordane only, the standards will be multiplied by the percentage of isomers within technical chlordane (i.e. 19% cis-chlordane, 24% trans-chlordane, 2.7% cis-nonachlor, 9.7% trans-nonachlor) to derive the BEs for individual chlordane isomers (Van Oostdam et al. 2005). For the Health Canada reference standard, corresponding BEs for individual chlordane isomers will be derived by multiplying by the percentage of isomers within biological chlordane (i.e. 1.7% cis-chlordane, 1,4% trans-chlordane, 8.3% cis-nonachlor, 54.9% trans-nonachlor, and 27% oxychlordane) (Van Oostdam et al. 2005).

For toxaphene, intake reference standards are available for the technical mixture from the ATSDR, Health Canada, and Swiss authorities based on immunotoxicity in monkeys or hepatic toxicity in dogs (Table 2). The ATSDR derived the highest intake standard of 2 x 10-3 mg/kg/d whereas the standards from Health Canada and Swiss authorities were a magnitude lower (2 x 10-4 mg/kg/d and 1 x 10-4 mg/kg/d respectively). In addition, the Investigation into the Monitoring, Analysis, and Toxicity of Toxaphene in Marine Foodstuffs (MATT European project) published a pTDI for weathered toxaphene of 1.8 x 10-2 mg/kg/d based on hepatic tumours in rats and an independent review derived an RfD for the sum of Parlars 26, 50, 62 of 2 x 10-5 mg/kg/d.

For PCBs, various reference standards are available for either total PCBs, subsets of PCBs (e.g. non-dioxin-like PCBs, dioxin-like PCBs, or 6 PCB indicators in food), or commercial PCB mixtures (e.g. Arochlor 1254) based on different toxicity endpoints (Table 3). The French Food Safety Agency has derived a critical concentration threshold for total PCBs of 1.8 x 10-3 mg/g plasma lipids in non-sensitive segments of a population. For total non-dioxin-like PCBs, Health Canada has derived a TDI of 1.3 x 10-4 mg/kg/d. For dioxin-like PCBs, the Joint FAO/WHO Expert Committee on Food Additives has a TDI of 1.63 x 10-9 mg TEQ/kg/d. To derive BEs for an individual PCB congener (e.g. PCB-153), an appropriate reference standard will be chosen and multiplied by an estimate of the percentage of that congener contained in the mixture.

Pharmacokinetic Modeling Strategy:

A conceptual framework for modeling the contaminants using pharmacokinetic principles has been developed. The modeling strategy will use a hierarchical approach to explore models of various complexities. The simplest model will be a one compartment model, followed by intermediate complexity of two-compartments, and finally a full physiologically-based pharmacokinetic (PBPK) model. The one- and two-compartment models are common for chlordane, toxaphene, and PCBs. The PBPK models are tailored for each contaminant based on information about their distribution patterns and toxicity profile. Given the lipophilic nature of the contaminants, the one-compartment model assumes that all chemical is distributed into a fat compartment which consists of adipose tissue and fat of other organs. The pharmacokinetic parameters required for this model are only absorption rate constant, elimination rate constant, fraction of dose absorbed, and mass of the fat compartment. In the two-compartment model a blood compartment is added and, therefore, additional parameters of transfer rates between blood and fat are required. The PBPK models incorporate several additional compartments, such as the liver which is a target organ for toxicity and an important organ for metabolism. In these models, several pharmacokinetic parameters are required, such as fractional blood flow rates to each compartment and partition coefficients. The compartments are linked by blood flow and transfer of chemical from blood to organs is assumed to be flow-limited.

Table 1. Chlordane: reference standards

Organization	Medium	Route of Exposure	Endpoint	Reference Standard
EPA 2009	Food/Water	Ingestion	Hepatic necrosis in mice (104 week study) NOA EL: 0.15 mg/kg/d UF: 300	RfD[a]: 5.0 x 10^{-4} mg/kg/d
Health Canada 2007	Food/Water	Ingestion	Not provided	pTDI: 5 x 10^{-5} mg/kg/d
ATSDR 1994	Food/Water	Ingestion	Developmental effects in mice (7 day study) LOAEL: 1 mg/kg/d UF: 1000 Hepatic effects in rats (30 month study) NOAEL: 0.055 mg/kg/d UF: 100 Hepatic effects in rats (30 month study) NOAEL: 0.055 mg/kg/d UF: 100	MRL[b] (acute duration): 1 x 10^{-3} mg/kg/d MRL (intermediate duration): 6 x 10^{-4} mg/kg/d MRL (chronic duration): 6 x 10^{-4} mg/kg/d
JMPR 1994	Food/Water	Ingestion	Hepatic toxicity in rats (long-term study) NOAEL: 0.05 mg/kg/d UF: 100	pTDI: 5 x 10^{-4} mg/kg/d
Abbreviations: ATSDR = Agency for Toxic Substances and Disease Registry; bw = body weight; EPA = Environmental Protection Agency; FAO = Food and Agriculture Organization; JMPR = Joint FAO/WHO Meeting on Pesticide Residues; LOAEL = lowest observed adverse effect level; MRL = minimal risk level; NOAEL = no observed adverse effect level; pTDI = provisional tolerable daily intake; RfD = reference dose (oral); UF = uncertainty factor; WHO = World Health Organization				

[a] Estimate of daily oral exposure in human populations (including sensitive subpopulations) that is likely without risk of adverse noncancer effects in a lifetime (EPA confidence in this estimate: medium).

[b] Estimate of daily human exposure that is likely to be without appreciable risk of adverse non-cancer health effects (acute exposure = 1-14 days; intermediate exposure = 15-364 days; chronic exposure = 1 year or longer).

Table 2: Toxaphene : reference standards

Organization	Medium	Route of Exposure	Endpoint	Reference Standard
ATSDR 2014	Food/Water	Ingestion	Convulsions in dogs (13-week study) NOAEL: 5 mg/kg/d UF: 100	MRL[a] (acute duration): 5×10^{-2} mg/kg/d
			Depressed humoral immunity in cynomolgus monkeys (75-week study) LOAEL: 0.4 mg/kg/d BMDL1SD: 0.22 mg/kg/d (benchmark dose model) UF: 100	MRL (intermediate duration): 2×10^{-3} mg/kg/d
			N/A	MRL (chronic duration): Not derived
MATT 2012	Marine Foods	Ingestion	Liver tumours in rats using weathered toxaphene NOAEL: 1.8 mg/kg/d UF: 100	pTDI: 1.8×10^{-2} mg/kg/d (based on weathered toxaphene)
Health Canada 2007	Food/Water	Ingestion	Liver toxicity in dogs (13-week study) NOAEL: 0.2 mg/kg/d UF: 1000	pTDI: 2×10^{-4} mg/kg/d
Independent Review (Simon and Manning 2006)	Food/Water	Ingestion	Liver tumours in rats using weathered toxaphene and converted to ∑Parlars 26, 50, 62 NOAEL: 0.0021 mg/kg/d UF: 100	RfD: 2×10^{-5} mg/kg/d (∑Parlars 26, 50, 62)
Swiss Authorities 2004	Food/Water	Ingestion	Immunotoxicity in cynomolgus monkeys (75-week study) NOAEL: 0.1 mg/kg/d UF: 1000	TDI: 1×10^{-4} mg/kg/d
Abbreviations: ATSDR = Agency for Toxic Substances and Disease Registry; BMDL = benchmark dose lower confidence limit; LOAEL = lowest observed adverse effect level; MATT = Investigation into the Monitoring, Analysis, and Toxicity of Toxaphene in Marine Foodstuffs (European project); MRL = minimal risk level; NOAEL = no observed adverse effect level; pTDI = provisional tolerable daily intake; RfD = reference dose; UF = uncertainty factor				

[a] Estimate of daily human exposure that is likely to be without appreciable risk of adverse non-cancer health effects (acute exposure = 1-14 days; intermediate exposure = 15-364 days; chronic exposure = 1 year or longer).

Table 3. PCBs: reference standards

Organization	Medium	Route of Exposure	Endpoint	Reference Standard
AFSSA 2013	Body Burden	All routes	Mental and motor development of children exposure in utero	Critical Concentration Thresholda (pregnant women, women of childbearing age, breastfeeding women, and children < 3 years of age, young and teenage girls): 7 x 10-4 mg total PCB/g plasma lipids Critical Concentration Threshold (rest of population): 1.8 x 10-3 total PCB/g plasma lipids
Health Canada 2010	Food/Water	Ingestion	Locomotor activity in Rhesus monkeys NOAEL: 13 µg/kg/d UF: 100	TDIb: 1.3 x 10-4 mg/kg/d (total NDL-PCBs)
AFSSA 2007	Food	Ingestion	Based on WHO TDI of 0.02 µg/kg/d and the following PCB indicators in food, which account for 50% of PCBs in foodstuffs of animal origin: PCB-28, 52, 101, 138, 153, 180 (+/- PCB-118)	TDI: 1 x 10-5 mg/kg/d
WHO 2003	Food/Water	Ingestion	Aroclor 1254: Increased liver weight and decrease in IgG and IgM immunoglobulin response to sheep red blood cell challenge in Rhesus monkeys (55 month study) LOAEL: 5 µg/kg/d UF: 300	TDI: 2 x 10-5 mg/kg/d
JECFA 2001	Food/Water	Ingestion	Developmental effects in male rat offspring	TDI (dioxins): 2.33 x 10-9 mg TEQ/kg/d Theoretical TDI for DL-PCBs (based on 70% of dioxin mixture): 1.63 x 10-9 mg TEQ/kg/d
EPA 2000	Food/Water	Ingestion	Aroclor 1254: Dermal, ocular, and immunological effects in monkeys LOAEL: 5 µg/kg/d UF: 300 Aroclor 1016: Reduced birth weight in monkeys NOAEL: 7 µg/kg/d UF: 100	RfDc Aroclor 1254: 2 x 10-5 mg/kg/d Aroclor 1016: 7 x 10-5 mg/kg/d Aroclor: 1248: not verifiabled

Organization	Medium	Route of Exposure	Endpoint	Reference Standard
ATSDR 2000	Food/Water	Ingestion	Neurobehavioural alterations in infant monkeys exposed to congener mixture - 80% of the congeners found in human breast milk (20 week study) LOAEL: 7.5 µg/kg/d UF: 300 Immunological effects in adult monkeys - Aroclor 1254 (23 month study) LOAEL: 5 µg/kg/d UF: 300	MRLe (intermediate duration): 3 x 10-5 mg/kg/d MRL (chronic duration): 2 x 10-5 mg/kg/d
CSHPF 1991	Food/Water	Ingestion	Based on Phenochlor-DP6 and toxic effects observed in rats.	TDI: 5 x 10-3 mg/kg/d
Abbreviations: AFSSA = French Food Safety Agency; ATSDR = Agency for Toxic Substances and Disease Registry; CSHPF = French High Council for Public Hygiene; DL-PCBs = dioxin-like polychlorinated biphenyls; EPA = Environmental Protection Agency; FAO = Food and Agriculture Organization; JECFA = Joint FAO/WHO Expert Committee on Food Additives; LOAEL = lowest observed adverse effect level; MRL = minimal risk level; NDL-PCBs = non dioxin-like polychlorinated biphenyls; PCB = polychlorinated biphenyl; RfD = reference dose (oral); TDI = tolerable daily intake; TEQ = toxic equivalent; UF = uncertainty factor; WHO = World Health Organization				

[a] The critical concentration threshold is as estimate of body burden level below which risk of adverse health effects are negligible (www.anses.fr/en/content/what-are-critical-blood-concentration-levels-pcbs)

[b] TDI is an amount to which an individual can be exposed to over a lifetime without any risk to health (www.anses.fr/en/content/what-are-critical-blood-concentration-levels-pcbs)

[c] Estimate of daily oral exposure in human populations (including sensitive subpopulations) that is likely without risk of adverse non-cancer effects in a lifetime (EPA confidence in estimate for Aroclor 1254: medium and Aroclor 1016: medium)

[d] EPA deemed that the database was insufficient to derive an oral RfD.

[e] Estimate of daily human exposure that is likely to be without appreciable risk of adverse non-cancer health effects (acute exposure = 1-14 days; intermediate exposure = 15-364 days; chronic exposure = 1 year or longer).

Discussion and Conclusions

During the 2014-2015 fiscal year, we have collected the background information that will be instrumental for deriving the BEs and have also established the framework to proceed with the pharmacokinetic modeling approach. Several intake reference standards are available for chlordane, toxaphene, and PCBs. These values or the NOAEL or lowest-observed adverse effect (LOAEL) will be used as the point of departure for calculating corresponding BEs. Once the BEs are derived and validated, they will be compared against the biomonitoring survey data to evaluate the percentage of sample population that are in exceedance, which provides an indication of population-level risks of contaminant exposure.

Work to be continued in 2015-2016 fiscal year:

In 2015, BEs for chlordane, toxaphene, and PCBs will be developed using one-compartment pharmacokinetic modeling approaches. Individual isomers of these compounds will be evaluated (toxaphene Parlar No. 26, 50, 62; cis-chlordane, trans-chlordane, oxychlordane, cis-nonachlor, trans-nonachlor; PCB-153 and other selected toxic/abundant congeners). Existing BEs for DDE/DDT, HCB, and PBDE-99 will be used to compare with IHS and CHMS biomonitoring data. Subgroup analyses for women of child-bearing age and by age (young adults, middle-aged, and elderly) will be conducted. Consultations will be held with risk assessors from Health Canada, regional health authorities, and the IHS Steering Committee.

More complex pharmacokinetic modeling (multi-compartment) will be explored in 2016.

Expected Project Completion Date

03/2017

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Do country food nutrients protect against mercury toxicity and cardiometabolic diseases? Integrating data from cutting-edge science and mobilizing knowledge towards Nunavimmiut health

Les éléments nutritifs présents dans les aliments traditionnels assurent-ils une protection contre la toxicité du mercure et les maladies cardiométaboliques? Intégration des données scientifiques de pointe et mobilisation des connaissances pour la santé des Nunavimmiuts

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Abstract

Despite a decreasing temporal trend over the last decades, methylmercury (MeHg) exposure in the Inuit population of Nunavik is still high. Traditional marine foods are the major source of this exposure, but are also rich in nutrients such as selenium (Se) and omega-3 polyunsaturated fatty acids (n-3 PUFA). Through an interdisciplinary program incorporating nutrition, epidemiology, toxicology and implementation research, we are addressing the complex issue of benefits and risks of country foods in the Inuit population of Nunavik, in

Résumé

Malgré une tendance temporelle à la baisse au cours des dernières décennies, l'exposition au méthylmercure (MeHg) au sein de la population inuite du Nunavik est encore élevée. Les aliments traditionnels provenant du réseau trophique marin constituent la principale source de cette exposition, mais ils sont aussi riches en éléments nutritifs tels que le sélénium (Se) et les acides gras polyinsaturés oméga-3 (AGPI n-3). Au moyen d'un programme interdisciplinaire incorporant la nutrition, l'épidémiologie, la toxicologie et une recherche

particular with regard to cardiovascular diseases and type 2 diabetes (T2D). Early biomarkers of such diseases, i.e. branched chain amino acids and acylcarnitines, were measured in plasma obtained from participants to the 2004 Nunavik Health Survey (NHS) and their associations with biomarkers of MeHg exposure, Se status (plasma levels of Se-containing proteins determined in last year's project) and n-3 PUFA status are being examined. In addition, in view of last year's results indicating that Se accumulates disproportionally in blood cells compared to plasma of Inuit, we performed additional experiments to identify selenocompounds present in red blood cells of NHS participants and Se-rich country foods. Genetically-modified yeast was used to synthesize selenoneine, an organic form known to be present in marine foods. Using this standard, we confirmed that selenoneine is the major selenium compound present in Inuit red blood cells and in beluga muktuk. An analytical method was developed and is currently used to measure selenoneine in red blood cells of all 2004 NHS participants and Se-rich marine foods. Finally, *in vitro* experiments were conducted to further investigate the bioavailability and speciation of Hg and Se in country foods as well as examine the protective role played by selenomethionine on the bioavailability of Hg from marine foods. The integration of these much needed data will increase our understanding of the determinants of T2D and cardiovascular diseases (CVD) risk in this population. In addition, it will improve our capacity to develop and implement interventions that aim to promote the benefits of traditional marine diet, while minimizing MeHg exposure in this population.

sur la mise en œuvre, nous abordons la question complexe des avantages et des risques associés aux aliments traditionnels chez les Inuits du Nunavik, particulièrement en regard des maladies cardiovasculaires et du diabète de type 2 (DT2). Les biomarqueurs précoces de ces maladies, soit les aminoacides de chaîne ramifiée et les acylcarnitines, ont été mesurés dans le plasma obtenu auprès des participants à l'Enquête sur la santé au Nunavik (ESN) de 2004, ainsi que leurs associations avec des biomarqueurs d'exposition au MeHg. Le statut en Se (taux plasmatiques de protéines contenant du sélénium déterminé dans le projet de l'an dernier) et le statut en AGPI n3 sont examinés. En outre, compte tenu des résultats de l'année dernière indiquant que le Se s'accumule de manière disproportionnée dans les cellules sanguines par rapport au plasma des Inuits, nous avons effectué des expériences supplémentaires pour détecter les sélénocomposés présents dans les globules rouges des participants à l'ESN et les aliments traditionnels riches en Se. De la levure génétiquement modifiée a été utilisée pour synthétiser de la sélénonéine, une forme organique dont la présence est avérée dans les aliments marins. Ce critère nous a permis de confirmer que la sélénonéine est le principal composé du sélénium présent dans les globules rouges des Inuits et le muktuk de béluga. Une méthode analytique a été élaborée, et elle est actuellement employée pour mesurer la sélénonéine dans les globules rouges de tous les participants à l'ESN de 2004 et les aliments marins riches en Se. Finalement, des expériences *in vitro* ont été réalisées pour étudier davantage la biodisponibilité et la spéciation du mercure (Hg) et du Se dans les aliments traditionnels et pour examiner le rôle de protection joué par la sélénométhionine sur la biodisponibilité du Hg à partir d'aliments marins. L'intégration de ces données indispensables va augmenter notre compréhension des déterminants de DT2 et les maladies cardiovasculaires (MCV) dans cette population. En outre, il permettra d'améliorer notre capacité à développer et mettre en œuvre des interventions qui visent à promouvoir les avantages de l'alimentation de marine traditionnelle, tout en minimisant l'exposition au MeHg dans cette population. L'intégration de ces données indispensables améliorera notre capacité d'élaborer et de mettre en œuvre des interventions visant à promouvoir les avantages des aliments traditionnels qui proviennent du réseau trophique marin, tout en réduisant l'exposition au méthylmercure au sein de la population étudiée.

Key messages

- Exceptionally high blood Se levels are observed in this population, while plasma levels are similar to those of the general Canadian population
- Selenoneine, an organic form of selenium, was identified as the major Se compound in red blood cells of Inuit
- This selenocompound was also found in high concentration in beluga muktuk extracts
- Se was positively correlated with the Hg levels in whitefish, eider duck eggs, beluga nikku , and ringed seal liver
- Selenomethionine was the major selenocompound within most enzyme-digested country foods
- Selenomethionine occasionally decreases the bioavailability of Hg in vitro

Messages clés

- On observe des niveaux exceptionnellement élevés de Se dans les globules rouges de la population étudiée, tandis que les taux plasmatiques de celleci sont similaires à ceux de la population canadienne en général.
- On a déterminé que la sélénonéine, une forme organique de sélénium, était le principal composé du Se présent dans les globules rouges des Inuits.
- Ce sélénocomposé a également été retrouvé en forte concentration dans des extraits de muktuk de béluga.
- Le Se a été corrélé positivement avec les hauts niveaux de Hg dans le corégone, les œufs d'eider, le nikku de béluga et le foie de phoque annelé.
- La sélénométhionine était le principal sélénocomposé que l'on retrouvait dans la plupart des aliments traditionnels digérés enzymatiquement
- La sélénométhionine diminue parfois la biodisponibilité du Hg in vitro.

Objectives

The main objective of this interdisciplinary project is to investigate the effects of country foods on cardiometabolic diseases in Inuit adults from Nunavik. This study consists of three sections. The first section focuses on contaminant/nutrient interactions and their effects on biomarkers of early metabolic changes that are predictive of T2D risk. Specific objectives of this section are:

1. To measure total Se and Se-containing proteins levels in plasma samples of NHS participants (completed);
2. To measure recently validated early biomarkers of T2D risk issued from metabolomics studies in the same plasma samples(completed);
3. To measure concentrations of selenoneine and its metabolites in red blood cells of NHS participants;
4. To examine the associations between biomarkers of methyl mercury (MeHg) exposure, biomarkers of Se status and early biomarkers of TD2 risk (on-going);
5. To investigate links between MeHg exposure, nutrient intake, early biomarkers of TD2 risk and T2D related effects using path analyses (2015-2016).

The second section focuses on Se and Hg concentrations, speciation and bioavailability in Nunavik country foods. Specific objectives of this section are:

1. To collect selected country foods from several Nunavik villages (completed);
2. To determine the age of the animals sampled and measure total Se and Hg concentrations in the corresponding country food samples (completed);
3. To measure Se and Hg species and to study the bioaccessibility and bioavailability of Se and Hg and in these same country food samples (on-going);
4. To study the potential of other local foods to mitigate Hg bioaccessibility of selected country foods (on-going);
5. To study the ability of Se and n-3 PUFA to limit the absorption of Hg (on-going);
6. To evaluate the associations between Se and Hg bioaccessibility of country foods and biomarkers of exposure to Hg and Se, and the influence of other local food intake on these associations (2015-2016).

The third section focuses on the integration of the data from the two above sections. Specific objectives of this section are:

1. To determine whether country foods nutrients protect against Hg toxicity and cardiometabolic diseases (2015-2016);
2. To mobilize this integrated knowledge towards Nunavimmiut health (2015-2016).

Introduction

The Inuit population of Nunavik displays among the highest Se intake and blood Se status in the world since their traditional marine mammal diet is exceptionally rich in Se (Lemire et al., 2015). Se is an essential element involved in several body functions through selenoproteins expression, including regulation of oxidative stress, and immune and thyroid functions (Reeves and Hoffmann, 2009). In fish and marine mammal eating populations, high dietary Se intake may play a role in offsetting some deleterious effects of high MeHg exposure (Ayotte et al., 2011; Boucher et al., 2010; Lemire et al., 2010; Lemire et al., 2011; Valera et al., 2009). Conversely, in Europe and the United States, high plasma Se has been related to

T2D, hypercholesterolemia and hypertension (Stranges et al., 2010). Contrary to most European and North American populations, Inuit present an exceptionally high intake of n-3 PUFA, a preventive factor for CVD (Dewailly et al., 2001). They can also be highly exposed to MeHg, PCB, PFOS and trans-fat, all risk factors for CVD (Chateau-Degat et al., 2010; Counil et al., 2009; Valera et al., 2009).

While plasma or blood Se are the biomarkers most often used to evaluate the associations between Se status and health effects, several other biomarkers (e.g. selenoproteins and small selenocompounds) have been identified and these may help to better characterise Se status (Xia et al., 2010). Several selenoproteins share common metabolic pathways with glucose and insulin, and it remains unclear whether increased plasma Se and selenoproteins' activity is the cause or the consequence of the disease (Steinbrenner et al., 2011). Selenoproteins have also been postulated as the key targets of Hg toxicity; Hg exhibits a very high affinity for selenol groups in the active site of selenoproteins and high Se intake may restore their enzymatic functions (Khan and Wang, 2009). SelP may also promote MeHg demethylation and/or bind to inorganic Hg (HgII) or MeHg and reduce its availability for target proteins and organs (Khan and Wang, 2009). Others have shown that PCBs, arsenic and cadmium may also interfere with selenoprotein activity (Twaroski et al., 2001; Zwolak and Zaporowska, 2012).

According to 2004 data from the NHS, the prevalence of T2D in the Inuit population (4.8%) was low, although dietary transition may have change the situation over the last decade. Therefore, investigating relations between exposure to toxicants, nutrient intakes and T2D risk is difficult due to lack of statistical power. An alternative is to focus on biomarkers of early biochemical changes that are part of the pathogenic sequence leading to T2D. The development of metabolic profiling methods (metabolomics), especially liquid chromatography – mass spectrometry based techniques, has allowed the identifications of several endogenous compounds in biological fluids that constitute early biomarkers of T2D risk. Results from several recent epidemiological studies indicate that plasma levels of branched-chain amino acids (BCAA: isoleucine, leucine, valine), aromatic amino acids (tyrosine and phenylalanine), acylcarnitines (AC: C3 and C5) and 2-amionoadipic acid are associated to cardiometabolic diseases and may constitute early biomarkers of T2D (Newgard et al., 2009; Wang et al., 2011, 2013). Therefore, examining the relation between MeHg, nutrients and these early biomarkers of TD2 risk may reveal on-going biochemical changes that are linked to future risk of the disease.

With respect to country foods, several factors may influence their Se and Hg concentrations. In the case of Hg, the levels vary in relation to the type of ecosystem (marine, freshwater and terrestrial) and the position in the aquatic food chain (AMAP, 2011). Hg concentrations also vary between the different parts of an animal; Hg presents a very high affinity for proteins and accumulates mostly in organs and meat and much less in fat (Clarkson, 2002). Traditional food preparations can also influence contaminants and nutrients concentrations. Several Inuit country foods are eaten raw or frozen, while others are dried, fermented or cooked (Blanchet and Rochette, 2008).

In addition, the chemical forms of Se and Hg ingested may also influence Se and Hg solubilisation into the GI tract, absorption, Se bioavailability for selenoprotein synthesis, and Se and Hg related-health effects (Clarkson, 2002; Rayman et al., 2008). Although some studies on Se chemical forms have been conducted in fish species and HgII-Se complexes has been identified in seabirds and marine mammals organs (Ikemoto et al., 2004; Lemes and Wang, 2009; Yamashita and Yamashita, 2010), little information is available on Se and Hg speciation in country foods. Recently, a novel seleno-containing compound, selenoneine, has been identified as the major form of organic Se in Bluefin tuna (Yamashita and Yamashita, 2010) and in blood cells of a fish-eating population (Yamashita et al., 2013a). This Se-analog of ergothioneine, a powerful antioxidant molecule, could contribute to the scavenging of reactive oxygen species that are involved in the etiology of chronic diseases or MeHg toxicity. Different "methylated/non-methylated" ratios of selenoneine have been observed in human blood and urine, indicating their active metabolism and suggesting a promising metabolic role of these redox metabolites in humans (Klein et al., 2011).

Nutrients can also affect the bioaccessibility and bioavailability of Hg in the GI tract. We reported the relative contributions of MeHg and HgII to the bioaccessibility of Hg in foods using an in vitro model that simulates the physiological conditions of the human GI tract (Laird et al., 2009). Two recent publications also adapted these in vitro procedures to include a human intestinal epithelial cell model (Caco-2) to mimic the intestinal uptake of Hg (Hwang and Shim, 2008) and Se (Gammelgaard et al., 2012). The coupling of in vitro GI models to Caco-2 cells vastly enhances the realism of exposure estimates since they provide an integrative measure of dissolution and absorption. Furthermore, including Caco-2 cells facilitates the comparison of oxidative stress responses providing the opportunity to quantify the ability of nutritional components to offset adverse effects from dietary Hg exposure.

Activities in 2014-2015

Section 1 of the project:

In May 2014, we completed the determination of Se-containing proteins in plasma using affinity chromatography coupled to ICP-MS. Both Se and Hg signals were monitored to allow for the determination of Hg associated with each Se-containing protein. Results are now available for all NHS 2004 participants (see Tables 1 and 2). Data were analysed and interpreted by Adel Achouba who incorporated the results in his master thesis, which was completed in January 2015. One scientific article is included in the thesis and will be submitted for publication in Fall 2015.

Data on Se speciation in plasma show that Se-containing proteins represent the major part of plasma Se content, indicating that concentrations of low-molecular weight Se compounds are likely very low in plasma. Furthermore, examination of the relationship between plasma and whole blood total Se concentrations revealed that individuals with high blood levels (i.e. > 1000 µg/L) do not exhibit similarly high plasma concentrations. As discussed below, this strongly suggests that a selenocompound present in country food of marine origin, likely selenoneine, is accumulating in red blood cells in Inuit highly consuming these country foods. We therefore decided to focus our efforts on this compound. Our previous attempts to synthesize selenoneine standard having been unsuccessful, we examined the possibility of bio-synthesis using yeast. A research group in Japan recently reported the production of a genetically modified yeast strain (S. pombe) that over expresses genes involved ergothioneine and selenoneine synthesis, the latter in the presence of selenate in the culture medium (Pluskal et al., 2014). Dr. Yanagida kindly accepted to provide us this yeast strain which was used in our laboratory to produce a selenoneine standard. Substantial efforts were devoted to identifying the proper conditions for selenoneine extraction and purification from yeast lysate and designing analytical methods for selenoneine determination in red blood cells and country foods. We have conducted a limited number of analyses and will complete the analytical work for December 2015.

Section 2 of the project:

A series of chemical speciation and in vitro physiologically-based bioaccessibility and bioavailability tests were performed on a wide variety of country foods. Most of the country foods were obtained from recently archived (2008-2012) samples at the Nunavik Research Centre; however, the sample set was supplemented with country foods collected from the villages of Kangiqsualujjuaq, Ivujivik, and Inukjuak, between 2011 and 2013. The country foods selected provide a comprehensive snapshot of commonly consumed wild-harvested foods from Nunavik that are rich in selenium and/or contain elevated levels of Hg.

The speciation testing included the use of protease XIV extractions to facilitate the measurement of selenomethionine, selenocysteine, selenium methylselenocysteine, selenate, and selenite in each of the country food samples. Additionally, organomercury species within the country foods were extracted, as their bromide derivatives, using dichloromethane and sodium thiosulfate. Furthermore, country food samples underwent two physiologically-based in vitro tests. The first of these in vitro models involves the measurement of metal bioaccessibility after digesting the foods in simulated GI fluids. The second involves the measurement of metal bioavailability across a Caco-2 Transwell system, thereby simulating the transport of Hg and Se from GI fluids into bloodstream. This Caco-2 model was also used to examine whether selenomethioneine, which was commonly detected in numerous country foods, altered the in vitro bioavailability of Hg from food.

Results

Section 1 of the project

Results for total blood and plasma Se analyses as well as Se speciation analyses in plasma of 852 Inuit who participated to NHS 2004 are presented in Table 1. The mean age of the study population was 37.4 years (range = 18 to 76 years). In comparison to total blood Se concentrations, total plasma Se concentrations were 46.7-% lower (blood median level of 261 µg L^{-1} vs plasma median level of 139 µg L^{-1}) and less variable (interquartile range = 22.7 µg L^{-1} for plasma vs 166 µg L^{-1} for blood). Speciation analysis showed that SelP represented 51.6% (median) of total plasma Se (range = 32.9 to 60.9%) GPX 25% (range = 16.7 to 42.9%) and SeAlb 23% (range = 15.4 to 38.7%), and altogether Se-containing proteins represented the major part of plasma Se.

Table 1. Concentrations of total blood Se, total plasma Se and plasma Se proteins in Inuit adults from Nunavik (NHS 2004; n=852)

Selenium (µg Se L^{-1})	Mean	Median	Interquartile range	Min	Max
Total Se – blood	350	261	166	119	3550
Total Se – plasma	140	139	22.7	84.5	229
GPx3	35.6	35.0	7.47	19.6	90.7
SelP	72.4	71.6	11.2	45.9	110
SeAlb	32.6	31.9	8.08	19.2	75.6

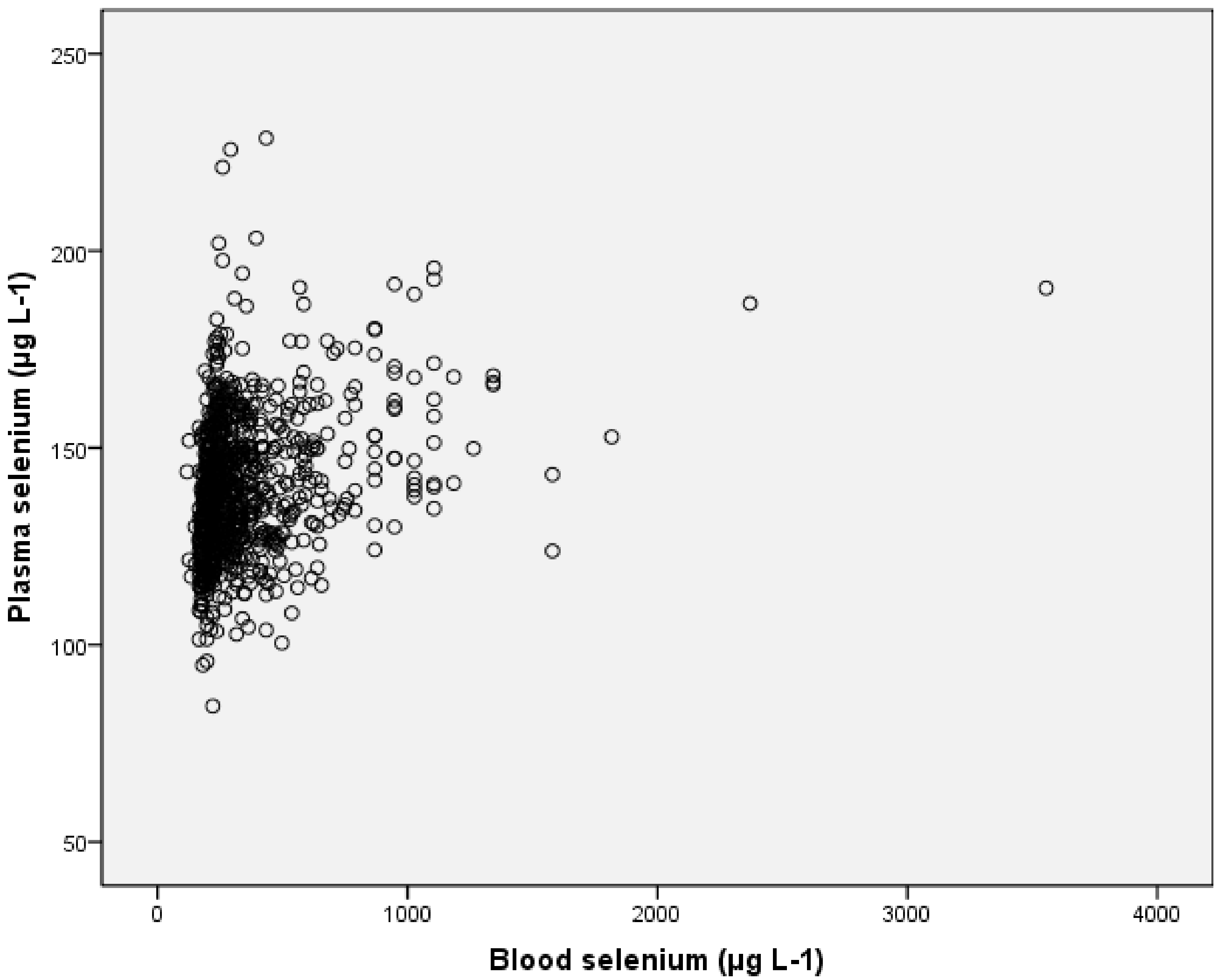
Results of total Hg and MeHg analysis in both blood and/or plasma are shown in Table 2. As expected, blood total Hg levels were higher than corresponding plasma levels in study participants. Similarly to Se, more than half of total plasma Hg (median = 53.2%; range = 3.0 to 97.7%) was associated to SelP, 20.3% to GPX (range = 0.6 to 91.3%) and 26.3% to SeAlb (range = 0.7 to 96.9%), suggesting that almost all Hg in plasma is bound to Se-proteins.

Table 2. Concentrations of total blood Hg and plasma Hg associated to Se-containing proteins in Inuit adults from Nunavik (NHS 2004; n=845)

Mercury (µg Hg L-1)	Mean	Median	Interquartile range	Min	Max
Total Hg – blood	17.9	11.2	17.9	0.08	241
MeHg – blood	18.2	10.8	18.3	0.24	221
Total Hg – plasma	2.59	1.78	2.19	0.02	24.5
Hg-GPx3	0.55	0.40	0.48	0.01	6.47
Hg-SelP	1.46	1.00	1.28	0.01	11.7
Hg-SeAlb	0.70	0.49	0.59	0.01	5.74

The relationship between total blood and plasma Se concentrations in this population was not linear (Figure 1). Plasma Se levels reach a plateau at approximately 175-200 µg L^{-1} while several individuals display blood Se levels greater than 1000 µg $L^{-1.}$

Figure 1. Relationship between blood and plasma Se concentrations in Inuit adults from Nunavik (NHS 2004; n=852).



As mentioned previously (see section on activities in 2014-2015), we obtained a genetically-modified yeast strain (S. pombe; Penmt1-egt1) to produce the selenoneine standard needed for performing selenoneine analyses in red blood cells of Inuit adults and beluga muktuk. Figure 2 presents the chromatogram obtained when analysing the purified extract of yeast lysate by anionic exchange chromatography –inductively coupled mass spectrometry (AEC-ICP-MS). The peak eluting at 3.4 min is selenoneine; no other Se compound was present in the purified extract. Its identity was confirmed by liquid chromatography- quadrupole time-of flight mass spectrometry (LC-Q-TOFMS; data not shown).

Figure 2. Anionic exchange chromatography –inductively coupled mass spectrometry analysis of purified extracts from lysate of genetically-modified Penmt1-egt1 S. pombe strain (Pluskal et al., 2014)

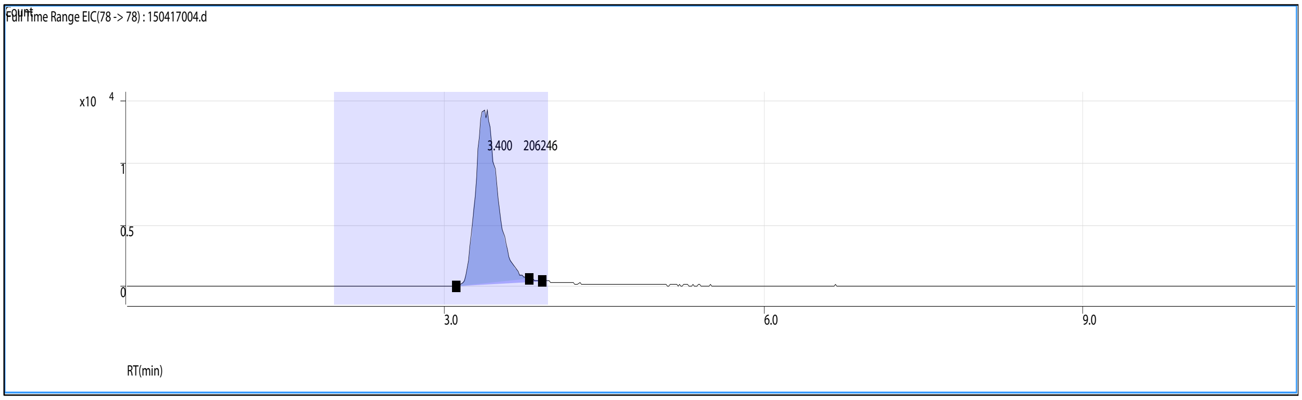


Figure 3 shows the chromatogram obtained when analysing by AEC-ICP-MS the purified extract of a red blood cell sample obtained from a NHS 2004 participant who exhibited a very high total blood Se concentration of 3550 µg L^{-1} and plasma Se concentration of 191 µg L^{-1}. Preliminary quantification indicates that selenoneine represents 68.5% of the total blood Se concentration in this participant. n addition to the major peak at 3.4 min corresponding to selenoneine, a second peak was observed at 5.1 min which likely correspond to methyl-selenoneine. The identity of both compounds was confirmed by LC-Q-TOFMS analyses (see Figure 4).

Figure 3. Anionic exchange chromatography –inductively coupled mass spectrometry analysis of a red blood cell extract from an Inuit adult (ID #519)

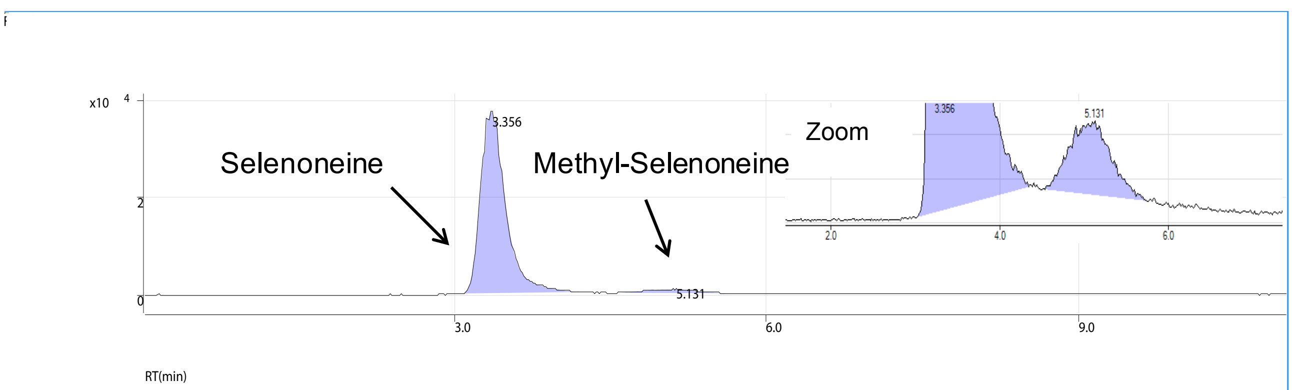


Figure 4. Liquid chromatography- quadrupole time-of flight mass spectrometry analysis of a red blood cell extract from an Inuit adult (ID #519). An HILIC column was used to separate the compounds. The exact mass values of 292.05 Da and 278.039 Da correspond to the pseudomolecular ions $(M+H)^+$ of respectively methyl-selenoneine (top panel) and selenoneine (lower panel).

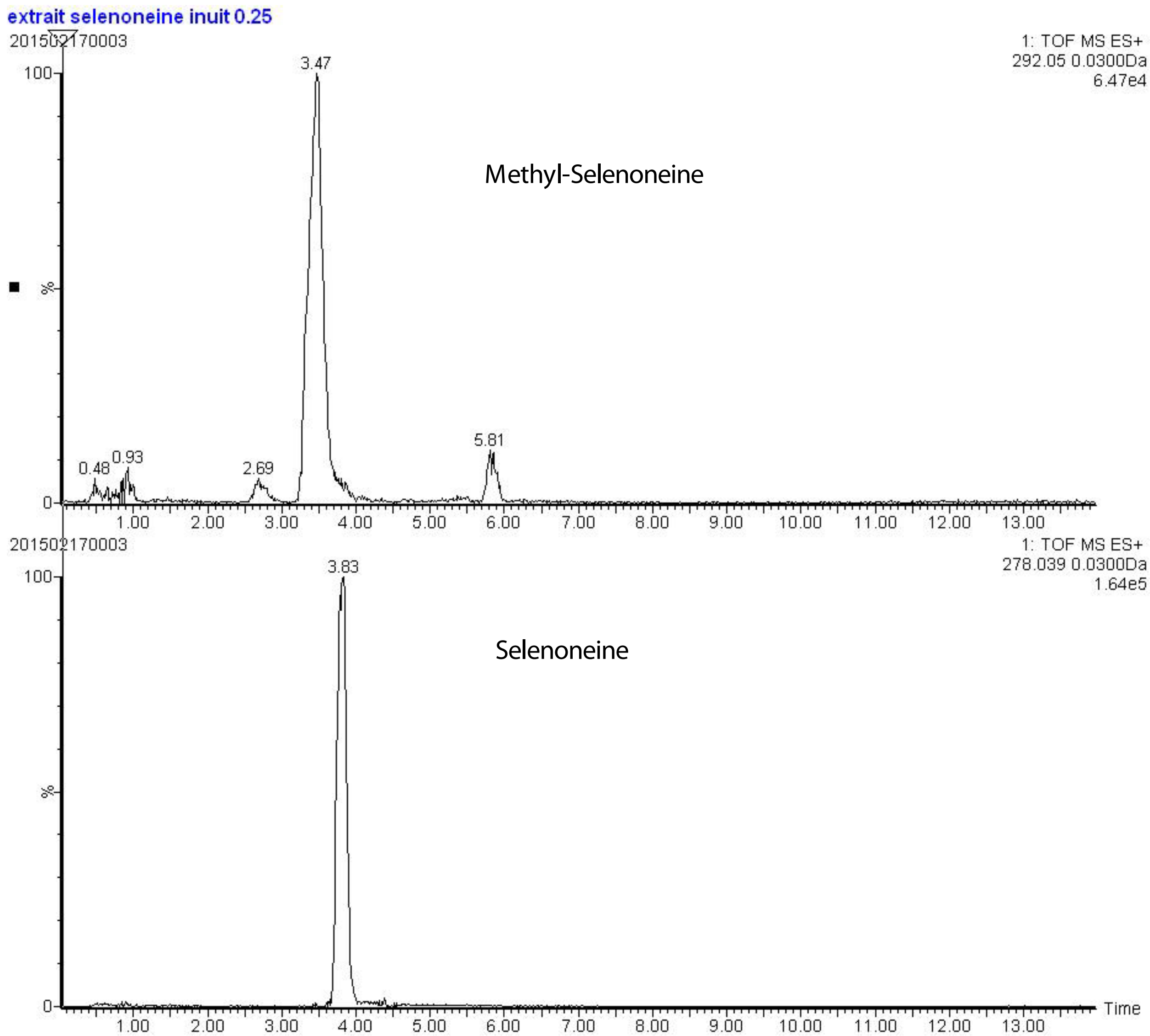
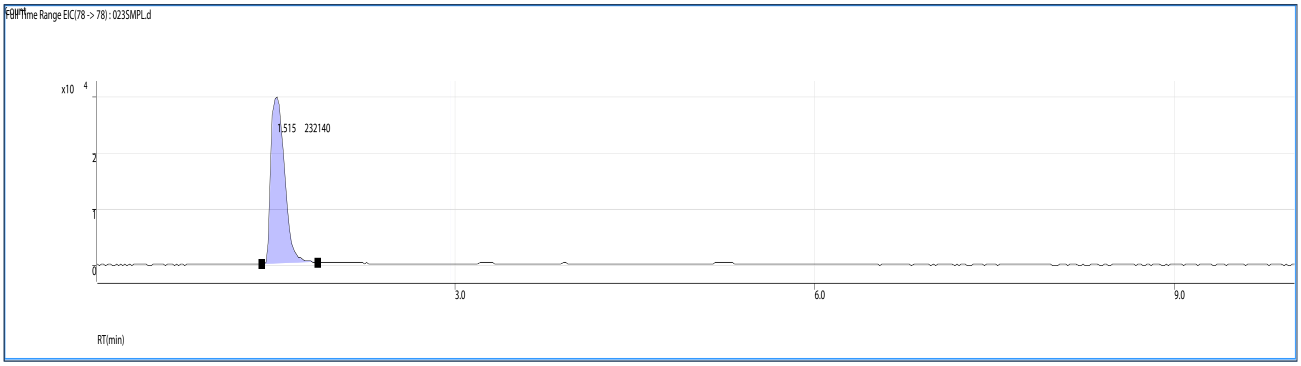


Figure 5 shows the chromatogram obtained when analysing by ion-pair LC-ICP-MS the purified extract of a beluga muktuk sample containing 5.0 ppm of Se. Preliminary quantification indicates that selenoneine represents more than 80% of the total Se concentration in this sample. The identity of selenoneine was confirmed by LC-Q-TOFMS analyses (data not shown).

Figure 5. Ion-pair liquid chromatography–inductively coupled mass spectrometry analysis of a beluga muktuk extract.



One other objective of this year's project was to determine the levels of metabolites that are known to be elevated in plasma several years prior to T2D onset. We just completed the analyses of amino acids and acylcarnitines whose levels have been associated with T2D risk. Descriptive statistics are provided in Table 3. While distributions of values for amino acids appear normal, distributions of concentrations for most acylcarnitines are skewed to the right. Associations with biomarkers of MeHg exposure and nutrient status (Se and n-3 PUFA) are underway.

Table 3. Concentrations of amino acids and acylcarnitines in plasma samples of Inuit adults from Nunavik (NHS 2004; n=859)

Amino acids (mg L^{-1})	Mean	Median	Interquartile range	Min	Max
Arginine	13	13	5.4	1.4	37
Glutamic acid	10	9.2	4.5	0.8	63
Isoleucine	8.4	8.1	3.5	0.4	31
Leucine	15	15	5.7	1.6	47
Methionine	3.8	3.7	1.4	0.3	11
Phenylalanine	9.1	9.0	2.1	1.0	21
Tyrosine	10.3	9.9	3.0	1.2	27
Valine	21	20	7.3	1.8	129
Acylcarnitines (µg L^{-1})	**Mean**	**Median**	**Interquartile range**	**Min**	**Max**
Acetylcarnitine	1710	1568	855	79	5713
Butyrylcarnitine	41	28	26	2.1	515
Carnitine	10164	9886	2956	91	23879
Glutarylcarnitine	14	13	5.4	0.6	45
Hexanoylcarnitine	13	11	7.7	0.3	313
Isobutyrylcarnitine	26	22	16	1.0	286
Propionylcarnitine	113	102	51	7.4	1666
Octanoylcarnitine	35	30	26	1.2	190

We had previously reported the total levels of Se and Hg within traditional foods and have used those concentrations to estimate metal exposure among Nunavik Inuit using a deterministic model (Lemire et al. 2015). In order to better characterize Hg and Se intakes, we are constructing a probabilistic model that generates exposure distributions among Nunavik Inuit. However, the reliability of such forecasted distributions requires information regarding the association between Hg and Se in country foods. Therefore, Spearman correlation analysis was conducted on the paired Hg and Se results provided by the Nunavik Research Center. When data was pooled across food types, there was a significant, positive correlation ($\rho = 0.32$, $P < 0.001$) between Hg and Se concentrations (Table 4). However, for the majority of the types Nunavik country foods included within this research, no such correlation was detectable. Of the studied country foods, only air-dried beluga meat, ringed seal liver, Eider duck egg whites and yolks, and lake whitefish showed significant, positive associations between Hg and Se concentrations. Interestingly, only for brook trout was a negative association between Hg and Se concentration observed. It must be noted that such correlation testing was not possible for foods types (e.g. Canada goose egg yolks and whites, Chicken egg yolks and whites, and sculpin eggs) where all the samples were below the limit of detection for total Hg and/or Se.

Table 4: Pairwise correlation analysis between Se and Hg concentrations in Nunavik Country Foods

Animal (and part)	n	Spearman's ρ
Marine Mammals		
Beluga meat	17	0.0417
Beluga meat (air-dried)	9	0.7500 *
Beluga muktuk	16	0.2649
Ringed seal liver	20	0.8737 ***
Ringed seal meat	19	-0.0202
Walrus meat and blubber	4	0.2000
Fish and Shellfish		
Arctic char	18	-0.0558
Atlantic salmon	17	-0.3080
Brook trout	24	-0.4461 *
Lake trout	19	-0.0228
Lake whitefish	20	0.5352 *
Sculpin	25	0.3132
Blue mussel	32	-0.1640
Fowl and Wild game		
Eider Duck egg white	12	0.7250 **
Eider Duck egg yolk	12	0.6830 *
Ptarmigan meat	27	-0.0208
Seagull egg white	11	0.5818
Seagull egg yolk	11	0.5364
Caribou meat	30	0.3561
Snowshoe hare leg meat	9	-0.1591
All Foods Pooled Together	395	0.3237 ***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Se:Hg molar ratios can offer insights into the extent of country foods' Hg risks relative to their nutritional benefits. Simply put, foods with higher Se:Hg molar ratios may provide greater nutritional benefits relative to their contaminant risks. Through the analysis of the Se:Hg ratios of country foods, we found that Se:Hg molar ratios varied dramatically from one food to another (Table 5). For example, total Se:Hg ratios were considerably higher in shorthorn sculpin eggs (1600 ± 460), blue mussel (220 ± 1.6) and eider duck yolk (88 ± 17) than in ringed seal liver (1.8 ± 0.3), lake trout (0.84 ± 0.43), and air-dried beluga meat (0.74 ± 0.14). This same approach of calculating Se:Hg molar ratios can also be undertaken after accounting for metal bioaccessibility. Generally, for the studied foods, accounting for metal bioaccessibility increased molar Se:Hg ratios. This observation reflected the fact that Se was generally more bioaccessible than Hg in traditional foods. Accordingly, the bioaccessible Se:Hg molar ratio was on average 5-fold higher than calculated using total metal concentrations. After accounting for metal bioaccessibility, the highest Se:Hg molar ratios were observed for sculpin eggs, goose eggs, mussels, eider duck egg yolks, and Arctic char.

Table 5. Se:Hg ratios (± standard error) according to total and bioaccessible molar concentrations (Se:Hg) in 18 traditional foods collected in Nunavik, QC.

Traditional Foods	n	Total Se:Hg	Bioaccessible Se:Hg
Marine Mammals			
Beluga nikku	3	0.74 ± 0.14	1.8 ± 0.3
Beluga meat	7	2.4 ± 0.6	4.0 ± 0.9
Beluga muktuk	15	28.0 ± 3.8	98.9 ± 26.7
Ringed seal liver	9	1.8 ± 0.3	2.4 ± 0.6
Ringed seal meat	3	5.4 ± 2.1	6.7 ± 2.3
Walrus meat & blubber	2	39.4 ± 15.2	100 ± 39.6
Fish & Shellfish			
Arctic char	3	21.8 ± 9.3	167.5 ± 107.1
Atlantic salmon	6	15.9 ± 2.3	54.5 ± 10.1
Brook trout	3	7.4 ± 2.3	20.5 ± 6.5
Lake trout	2	0.84 ± 0.43	1.0 ± 0.38
Lake whitefish	3	4.2 ± 0.3	6.8 ± 3.0
Shorthorn Sculpin	3	5.4 ± 1.0	15.4 ± 7.5
Shorthorn Sculpin (eggs)	3	1613 ± 462	3306 ± 885
Blue mussel	3	218 ± 1.56	1879 ± 1613
Wild Game			
Caribou	6	19.8 ± 2.2	61.1 ± 14.8
Eider duck egg (yolk)	3	88.2 ± 16.9	216 ± 185
Eider duck egg (white)	3	3.6 ± 0.8	2.5 ± 0.7
Canada goose egg (whole)	3	71.5 ± 12.2	2876 ± 615

In order to better characterize Inuit exposure to Se from the consumption of country foods, we investigated Se speciation within 16 food types (extracts of enzyme-digested samples). The results from this work indicated that selenomethionine (SeMet) was generally the most prevalent of the selenospecies within marine mammals, fish, wild game, and fowl (Table 6). The only exception to this trend was observed for eider duck egg yolks, for which selenocysteine (SeCys) was the predominant selenospecies. For marine mammals, fish, wild game, and fowl, after SeMet, the next most abundant selenospecies was generally SeCys, comprising up to 49% of the Se detected (Canada goose eggs). Very little of the Se was present as inorganic forms, making up on average 2% of the Se content. Interestingly, sculpin eggs, which is amongst the richest Se sources of all the studied foods, contained the most Se- methylselenocysteine (Se-MeSeCys).

Table 6. Se speciation of select Nunavik Inuit country foods.

Food Type	n	Total Se[1] (µg g⁻¹)	Contribution to Total Se (%)			
			Inorganic Se[2]	SeCys	SeMet	Se-MeSeCys
Caribou	6	0.32	0.1%	8.2%	89.3%	2.3%
Ringed Seal Liver	6	1.47	4.5%	22.6%	69.8%	3.1%
Ringed Seal Muscle	6	0.48	0.0%	5.9%	93.1%	1.1%
Beluga Meat (raw)	6	0.69	0.0%	4.9%	94.1%	0.9%
Walrus	6	0.31	2.0%	13.3%	80.0%	4.7%
Ptarmigan	6	0.43	0.0%	39.9%	60.1%	0.0%
Snowshoe hare	6	0.24	0.0%	22.6%	76.3%	1.1%
Sculpin Eggs	6	1.11	4.5%	32.0%	46.0%	17.4%
Canadian Goose eggs	4	0.22	0.0%	49.0%	49.5%	1.5%
Eider Duck egg yolk	5	0.64	4.4%	47.2%	36.0%	12.4%
Eider Duck egg white	6	0.62	3.1%	2.6%	90.8%	3.5%
Arctic Char	5	0.63	0.0%	18.9%	80.5%	0.6%
Beluga Muktuk	6	0.36	5.5%	24.6%	65.3%	4.6%
Beluga (air-dried)	6	0.61	0.0%	7.3%	92.7%	0.0%
Atlantic Salmon	6	0.28	7.8%	8.2%	84.0%	0.0%
Lake Whitefish	6	0.22	0.0%	9.4%	90.6%	0.0%

[1] Sum of selenospecies (wet weight concentration)

[2] Selenite and selenate co-eluted on the chromatogram.

Ringed seal liver, ringed seal meat, lake trout, and air dried beluga meat samples, each of which can contain elevated concentrations of Hg, were selected for further in vitro bioaccessibility (IVBA), Caco-2 bioavailability, and Hg speciation analyses. This work confirmed that only a small minority of the Hg within ringed seal liver was present as MeHg whereas over 85% of the Hg within lake trout and beluga nikku (i.e. air dried beluga meat) was present as MeHg (Table 7). When the in vitro extracts of ringed seal liver and lake trout were aliquoted into the apical chamber of a Transwell Caco-2 system, the majority (i.e. < 90%) of the Hg remained in the apical chamber after a 24 hr exposure. With ringed seal liver, 2.9% was absorbed into the cell monolayer; however, no Hg was detectable in the basolateral compartment. In contrast, for Lake trout, relatively little of the Hg that was absorbed from the apical compartment was retained within the cell monolayer (Table 7).

Table 7. Preliminary mercury bioaccessibility and Caco-2 bioavailability results of select Nunavik Inuit country foods.

Food Type[1]	Total Hg[2] ($mg\ kg^{-1}$)	Total Se[2] ($mg\ kg^{-1}$)	MeHg (%)	Hg IVBA[3] (%)	Hg IVTcell[4] (%)	Hg IVTbl[5] (%)
Ringed Seal Liver	24.2	15.2	3.6	36.2	2.9	0
Ringed Seal Meat	0.49	0.49	56.4	75.8	-	-
Lake Trout	1.10	0.21	86.6	33.4	1.8	7.0
Beluga nikku	2.87	0.81	89.0	38.2	-	-

1 Each experimental unit was a composite sample from three individual organisms

2 Wet weight Hg and Se concentration

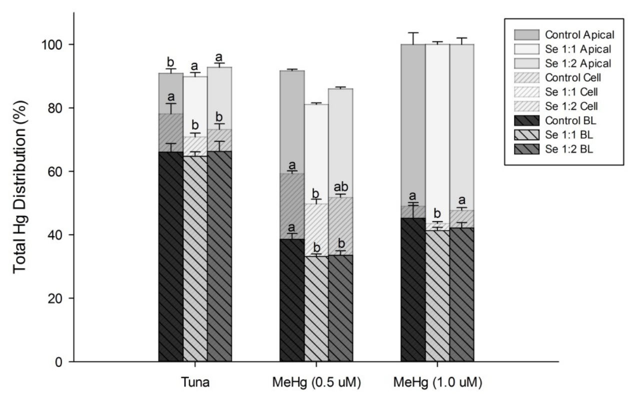
3 Percent Hg bioaccessibility from the composite sample

4 Percent Hg absorption into the cellular compartment of the Caco transwell at 24 h

5 Percent Hg absorption into the basolateral compartment of the Caco transwell at 24 h

In order to determine whether SeMet, the form of Se most prevalent in country foods, is capable of decreasing the bioavailability of Hg, we incubated MeHg treatments on the apical side of a transwell intestinal epithelial model. To these MeHg treatments, we added SeMet at 1:1 and 1:2 (MeHg:SeMet) molar ratios. The MeHg treatments without the addition of SeMet was used as a negative control. The MeHg treatments included: i) store-bought tuna that had been digested through an in vitro bioaccessibility model, ii) a 0.5 µM MeHg spike, and iii) a 1.0 µM MeHg spike. After 120h, the majority of Hg within the tuna treatment group had been transported into the basolateral compartments. In comparison, no more than 45% of Hg was basolaterally transported for the 0.5 and 1.0 MeHg treatment groups (Figure 6). The addition of SeMet increased the fraction of HgT remaining in the apical compartment and caused corresponding decreases in Hg cellular retention for the tuna samples. For the 0.5 MeHg treatment, the addition of SeMet decreased the fraction of Hg transported into the basolateral compartments. A decrease in cellular HgT was also observed; but, was only statistically significant at 1:1 MeHg:SeMet.

Figure 6. Distribution of total Hg (% ± SEM) in the apical, cell, and basolateral compartments after a 120 h incubation period with tuna in vitro extract, 0.5 µM MeHg, and 1 µM MeHg, all with or without SeMet at a Hg:Se ratios of either 1:1 or 1:2. Different superscripts denote statistical differences ($p \leq 0.05$) among treatment groups, within the same compartment and matrix.



Section 3 of the project

Our recent findings suggesting high concentrations of selenoneine in red blood cells of Inuit NHS 2004 participants led the team to invest time and efforts in the synthesis and production of selenoneine standard. Since then, our team have made great progress in developing the analytical method for selenoneine analysis in different biological samples and all red blood cell results are expected by November 2015. Still, our team met in Ottawa in November 2014, together with Michael Kwan by teleconference, to discuss all new data and collectively plan the next steps for 2014-2015. As a team, we decided to postponed knowledge sharing activities initially planned for 2014-2015 until selenoneine data are fully available and in order to ensure the full integration of all sub-project data.

Therefore, funds were reallocated to held the Qanuippitaa 2016 planning workshop in Kuujjuaq in preparation for the follow-up of the Nunavik Health Survey Qanuippitaa 2004 (How are we?). On January 27-28, 2015, the Nunavik Regional Board of Health and Social Services and researchers brought together key representatives of Inuit organizations and communities to start discussing the scope, focus and process for the of the Qanuippitaa survey. This was the first of what is proposed to be many planning discussions held on the development of the survey components, namely the adult component (adult follow-up cohort for participants that are now 30 years and above, and a completed by a transversal survey), a youth component (transversal survey for those 14 to 30 years old) and a community component, to study the determinants of healthy communities. As topics relevant to the present research, the evolution of Hg exposure and Se status in Nunavik, the status cardiometabolic health, brain health, neurologic functions and dementia (maybe related to high Hg exposure), the impacts of food transition and the need for educational tools with respect to food and health were mentioned as important topic for research/intervention for the adult component of the study. A full report of workshop discussions and participants' recommendations is available upon request. The health survey has now been renamed Qanuilirpitaa (How are we now?) and is actually in preparation for the end of summer 2016.

Discussion and Conclusions

The median plasma Se concentration documented in the present study was not exceptionally elevated for a North American population, with a median level of 139 µg L^{-1} and a maximum concentration of 229 µg L^{-1}. A similar median concentration (134 µg L^{-1}) was reported in serum samples of 917 American adults aged 40 years and older who participated to the 2003-2004 NHANES survey (Laclaustra et al., 2009). We observed a nonlinear relationship between blood and plasma Se levels, with plasma Se reaching a plateau at approximately 175-200 µg L^{-1}, whereas several participants exhibited blood concentrations exceeding 1000 µg L^{-1}. A similar relationship was previously reported in Inuit of Greenland by Hansen et al. (2004). In contrast, Lemire et al. (2012) found a linear relationship between plasma and blood Se levels in populations living in the Brazilian Amazon. This may be explained by the fact that the main dietary source of Se in the latter populations is Brazil nuts (Bertholletia excelsa), in which Se is mainly present in the form of SeMet (Dumont et al., 2006). SeMet is incorporated in albumin in lieu of methionine to form SeAlb (Jitaru et al., 2010). Therefore in this Brazilian population, the increase of Se in whole blood is accompanied by a proportional increase in plasma due to the fact that SeMet is incorporated in Alb. Conversely, in Inuit populations of Greenland and Nunavik, the main dietary sources of Se are marine mammal tissues, but little information is available on Se species present in marine foods. Lemes et al. (2011) reported that organs from beluga whales contained methylselenocysteine (MeSeCys) as a major selenocompound; however unknown Se species were detected and remained to be identified.

Despite the lack of data on Se speciation in marine foods consumed by the Inuit, several lines of evidence suggest that selenoneine might be a major selenocompound in these foods. Yamashita et al. (2010) have recently isolated from blue fin tuna blood an organic form of Se identified as selenoneine, an analog of ergothioneine. Selenoneine was shown to be present in various fish species and a major form of Se in blood cells obtained from a fish-eating population in Japan (Yamashita et al., 2013a). Selenoneine is actively transported in red blood cells via the OCTN1 membrane transporter, similarly to ergothioneine (Yamashita et al., 2013b). Such an active transport of selenoneine in red blood cells of Inuit would explain the much higher Se concentrations in whole blood compared to plasma in the present study. Thanks to the bio-synthesis of the selenoneine standard, selenoneine analyses are now possible in biological and food samples. Our limited results showing that selenoneine is the major selenocompound in red blood cells of an Inuit adult with a very high blood Se concentration lend support to this hypothesis. Further evidence will be obtained following the ongoing analyses of all red blood cell samples from NHS 2004 participants. We also found a very high level of this compound in one beluga maktak sample. Selenoneine will also be quantified in Se country foods consumed by the Inuit.

Documenting the association between Hg and Se in country foods was the first step towards the construction of a probabilistic exposure model. Our results show that the positive associations previously documented between Hg and Se concentration in several marine organisms cannot be extrapolated to other types of country foods. Our ongoing work in the Northwest Territories has also shown that Hg and Se concentrations in freshwater fish, are on occasion, negatively associated with one another. Such trends have been seen in species such as cisco, lake whitefish, and northern pike harvested from lakes in the Mackenzie Basin. Therefore, the negative association documented between Hg and Se in brook trout is not unprecedented. That being said, the biological or ecological processes that underpin the negative relationship occasionally observed between Hg and Se concentrations in freshwater fish has yet to be elucidated. It's also worth noting that the nature of the relationship between Hg and Se is not strictly species-specific. For example, Hg and Se association within lake whitefish from the Northwest Territories was negative but in Nunavik was positive.

Researchers have used molar ratios, calculated according to either total and bioaccessible concentrations, to compare the relative quantities of total Hg and Se within both store-bought and wild-harvested fish and seafood (Burger et al., 2012, Burger et al., 2013). Since higher levels of Se could provide some degree of protection against Hg toxicity, identifying foods with high Se:Hg molar ratios may have utility for the development of contaminant advisories that balance risks and benefits (Ralston and Raymond, 2010; Rayman 2000). Some scientists have asserted that so long as the Se:Hg molar ratio exceeds 1, then the Se within the food shall be sufficient to protect against Hg's adverse effects. However, the reliability of this assertion in terms of the full range of subclinical effects is not known. Further, it is not yet known whether differences in Se speciation as well as in Hg speciation between foods may alter this narrative. What is clear though with our results is that the high degree of variation within particular food types in terms of their Se:Hg molar ratios shall make it challenging to implement molar ratios as a risk communication tool.

Our study of the speciation, bioaccessibility, and bioavailability of Se and Hg within the country foods has yielded key measures needed for the refinement of metal exposure models relevant to the Inuit of Nunavik. For example, we have shown significant differences in the bioaccessibility of Hg and Se between foods. In addition, preliminary data on in vitro Hg bioavailability, as measured using a Caco-2 model, also can vary widely from one food to another. These differences in Hg bioavailability between foods appears to be driven in part by differences in Hg speciation in these foods. Interestingly, Se bioavailability from country foods has been shown to be remarkably consistent from one food to another, despite differences in the relative proportion of SeMet and SeCys in country foods digested extracts. To date, dose reconstruction models using environmental concentrations for Hg and Se exposures among Inuit have been based upon the assumption that metals in country foods are both equally and maximally bioavailable following oral exposure. Our results provide unambiguous in vitro evidence that this assumption may overestimate metal exposure by substantial margins. Future work will explore whether the use of metal speciation data and in vitro measures of country food bioaccessibility and/or bioavailability improve the association between dose reconstruction estimates and metal body burden from the 2004 NHS.

In conclusion, we found exceptionally high blood Se levels in this population, while plasma levels are similar to those of general North American populations. Selenoneine, an organic form of Se with strong antioxidant poperties, was identified as the major Se compound in red blood cells of Inuit. This selenocompound was also found in high concentration in beluga muktuk extracts. Analyses of food samples revealed that Se level was positively correlated with the Hg level in whitefish, eider duck eggs, beluga nikku (air-dried meat), and ringed seal liver. Selenomethionine was the major selenocompound found within most enzyme-digested country foods. In additional bioavailability tests, selenomethionine occasionally decreases the in vitro bioavailability of Hg.

Expected Project Completion Date

March 2016

Project website (if applicable)

If your project has a presence on the internet, including a website or social media page, please provide this here.

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Environmental contaminants, stress and behaviour: statistical analysis in late-adolescent Inuit from the Nunavik Child Cohort Study (NCCS), and in adult Inuit from the Inuit Health Survey

Contaminants environnementaux, stress et comportement : analyse statistique d'Inuits en fin d'adolescence de l'Étude sur une cohorte d'enfants du Nunavik, et d'Inuits adultes de l'Enquête sur la santé des Inuits

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Abstract

Prenatal exposure to lead, PCBs and mercury were associated to behavioural impairments in children. In the last three cohort studies conducted in Nunavik (1 year-old, 5 years-old, 11-years-old), we have assessed behavioural indicators at each stage of development and found subtle effects of lead on attention, activity, impulsivity, but also of PCBs on emotional outcomes. Although we continue to look at the association between environmental contaminants and those behavioural indicators, we have also focused on emotional outcomes, mainly stress. This focus on the stress system is based on recent scientific results showing that exposure to environmental contaminants

Résumé

L'exposition prénatale au plomb, aux BPC et au mercure a été associée à des troubles du comportement chez les enfants. Dans le cadre des trois plus récentes études de cohorte que nous avons menées au Nunavik (enfants de 1 an, de 5 ans et de 11 ans), nous avons évalué des indicateurs de comportement à chaque stade de développement et relevé des effets subtils du plomb sur l'attention, l'activité et l'impulsivité, ainsi que des BPC sur les réactions affectives. Tout en continuant d'étudier l'association entre les contaminants de l'environnement et ces indicateurs de comportement, nous nous sommes également intéressés aux réactions affectives, en particulier le stress. Notre

may impair this endocrine system, and thus impact behavioural outcomes. Furthermore, adolescence is a period at which mechanisms of hormone disruption by environmental contaminants become obvious, and at which emotional development is particularly at risk. Finally, stress is a significant risk factor of attention, activity, impulsivity levels but also of various physical and mental disorders in adolescents. For the last 2 years (2012 to 2014), we have collected data on stress (cortisol levels in saliva, n=132 and in hair samples, n=99) and on behavioural dimensions (analysis of video recordings, n=77) from the follow-up study of children at age 17 leaded by Dr. Gina Muckle. A database has been created, checked, and is currently being merged with Dr. Muckle's dataset. Results showed high variability between individuals, and associations between physiological outcomes of stress and behavioural indicators. In addition, work on the association between environmental contaminants was going on using data collected in 5 year-olds, and using data from the Inuit Health Survey.

attention s'est portée sur le système d'adaptation au stress en raison des résultats d'études scientifiques récentes indiquant que l'exposition aux contaminants environnementaux peut perturber le système endocrinien et, par conséquent, affecter le comportement. De plus, l'adolescence est une période durant laquelle les perturbations hormonales causées par les contaminants environnementaux deviennent manifestes et le développement affectif est particulièrement à risque. Enfin, le stress est un facteur de risque important tant pour les niveaux d'attention, d'activité et d'impulsivité que pour divers troubles physiques et mentaux chez les adolescents. Au cours des deux dernières années (de 2012 à 2014), nous avons recueilli des données sur le stress (niveaux de cortisol dans des échantillons de salive, n=132, et de cheveux, n=99) et sur les aspects du comportement (analyse d'enregistrements vidéo, n=77) à partir de l'étude de suivi auprès d'adolescents de 17 ans dirigée par Gina Muckle. Une base de données a été créée, vérifiée et est actuellement fusionnée avec l'ensemble des données de Gina Muckle. Les résultats ont montré une forte variabilité d'une personne à l'autre ainsi que des associations entre les effets physiologiques du stress et les indicateurs de comportement. De plus, les travaux sur l'association entre les contaminants environnementaux se sont poursuivis avec des données recueillies pour les enfants de 5 ans et l'information provenant de l'Enquête sur la santé des Inuits.

Key messages

- Data collection of bio-indicators for the assessment of the stress system is feasible, and inter-individual variability in the value of these bio-indicators indicate that it is relevant to the Inuit population
- Inter-individual variability in the value of behavioural dimensions following behavioural coding of video indicate that this way to assess attention, and emotional reactivity is still relevant in Inuit teenagers

Messages clés

- Il est possible de recueillir des données de bioindicateurs pour l'évaluation du système d'adaptation au stress. La variabilité interindividuelle quant à la valeur de ces bioindicateurs en indique la pertinence pour la population inuite.
- La variabilité interindividuelle dans la valeur des aspects du comportement à la suite du codage des comportements observés dans les enregistrements vidéo indique que le recours à cette méthode pour évaluer l'attention, l'activité et la réactivité

- Descriptive analyses of the bio-indicators of stress, and the behavioral indicators suggest an association between both
- Analyses on data from 5 year-old children dataset have shown that there are postnatal windows of development during which children are more susceptible to neurotoxicants like PCBs
- Analyses on data from the Inuit Health survey suggest that chronic stress could be associated with exposure to environmental contaminants, particularly in Inuit adults from 25-54 years of age

affective chez les adolescents inuits demeure pertinent.

- Des analyses descriptives des bioindicateurs de stress et des indicateurs de comportement permettent de croire à une association entre les deux.
- Des analyses des données provenant de l'information recueillie pour les enfants de 5 ans ont montré que les enfants sont plus susceptibles de subir les effets de substances neurotoxiques comme les BPC au cours de certaines périodes de développement postnatal.
- Des analyses de données provenant de l'Enquête sur la santé des Inuits donnent à penser que le stress chronique pourrait être associé à l'exposition à des contaminants environnementaux, en particulier chez les Inuits adultes âgés entre 25 et 54 ans.

Objectives

- To analyze the association between stress and behavioural data in 17-year old children in order to test whether the expected impairment of the stress system have influenced behaviours in Inuit adolescents
- To conduct secondary analysis on data from the previous cohort study to test whether there is any windows of vulnerability to environmental contaminants exposure in children
- To conduct secondary analysis on data from the Inuit Health Survey in order to test whether environmental contaminants play a role on chronic stress, assessed through the allostatic load index.

Introduction

In Inuit from Nunavik, adolescence is a particular period of psychological vulnerability. Indeed, the 1992 Inuit Santé Quebec survey found that 38% of a sample aged 15-24 year-olds had suicidal ideation, 22% reported having attempted suicide in their lifetime, and 13% had attempted suicide in the year before the survey (Kirmayer et al., 1998). Those results have been replicated and are even more alarming in the 2004 Inuit Health Survey. Adolescence is a period of great changes in the body and brain functioning. Hormones, called steroids, which are measurable in adolescents, mainly orchestrate these changes. Low-level exposure to environmental contaminants (ECs) are able to disrupt steroids levels and activity (Koopmanesseboom et al., 1994; Jacobson and Jacobson, 1996; Pirkle et al., 1998; Denham et al., 2005). One class of steroids has been poorly studied in relation to ECs, corticosteroids known as the stress hormones. Yet a recent review suggests that corticosteroids could be impacted by ECs, even at low-levels of exposure (Lanoix, 2013). Environmental Contaminants, even at Low Exposure Levels are known to impact on brain functioning. For example, lead exposure has been related to neurobehavioral endpoints such as attention, general activity level, emotional characteristics and social behavior in children (Thomson et al., 1989; Bellinger et al., 1994; Chen et al., 2007). The developmental toxicity of methylmercury starts being well known as well (Karagas et al., 2012). In a recent study, prenatal methylmercury has been related to ADHD symptomatology in Inuit children (Boucher et al., 2012). Perinatal exposure to PCBs has also been related to neurodevelopmental impairment, such as in the Michigan (Jacobson et al., 1990) (Jacobson and Jacobson, 2003), or the North Carolina study (Rogan et al., 1986). Our recent results suggested that background exposure to PCBs in utero may have subtle effects on emotional outcomes in 5 year-old Inuit (Plusquellec et al., 2010).

Understanding pathways by which it happens could help to prevent populations from those adverse effects. One plausible process by which environmental contaminants could impact the brain is through their action on hormonal systems, and particularly on glucocorticoids. Those steroids are produced in response to environmental stress. In wildlife, impaired ability to elevate blood glucocorticoids in response to an acute stress was related to heavy metals exposure (cadmium, Pb, mercury) and environmental organic contaminants (PCBs, solvents, pesticides) in fish,(Hontela et al., 1992; Hontela et al., 1995; Benguira et al., 2002) amphibians,(Gendron et al., 1997) birds,(Love et al., 2003) and large mammals.(Oskam et al., 2004) One study has shown that a low-level of exposure to Pb increased glucocorticoids responses to acute stress in 9-10 year-old children.(Gump et al., 2008).

The association between glucocorticoids and behavioural development, particularly emotional development are well documented(van Heeringen et al., 2000; Miller et al., 2006; Lerner et al., 2007; Susman et al., 2010). As a consequence, one possible mechanism that would explain the numerous adverse associations between environmental contaminants and behavioural and psychological outcomes would be via impairment of the glucocorticoids pathway. Glucocorticoids functioning may be assessed through two complementary ways (a) by measuring the reactivity of the stress system (increasing glucocorticoids, namely cortisol in saliva sample) to an unfamiliar situation, and (b) by measuring the levels of glucocorticoids (cortisol) in hair, which is a validated way to assess chronic stress (Kirschbaum et al., 2009; Dettenborn et al., 2010). In the present project, we assessed salivary cortisol when teenagers arrived at the lab, and 1 hour later in order to assess reactivity of the stress system, and hair cortisol to assess chronic stress. Furthermore, we extracted behavioural indicators from video recordings during their visit to the lab. These measures will allows us to answer the question of the association between glucocorticoids levels and reactivity and behavioural indicators, but also to describe those measures in order to judge about their variability. In addition, we analyse the association between environmental contaminants and chronic stress, assessed from the allostatic load index, a measure recently validated in the Inuit Health Survey in collaboration with Mylène Riva (Riva, 2014). Finally, we continue analysing data from previous cohorts in order to better understand the association between exposure to ECs and behavioural development in Inuit.

Activities in 2014-2015

In 2014-2015, we have completed physiological analysis and extraction of behavioural indicators from video recordings: behavioural indicators were available for 77 teenagers, salivary cortisol was analyzed in 132 teenagers and hair cortisol levels were determined in 99 teenagers. Our database has been created, checked and transmitted to Dr. Muckle's team in order to merge it with the full database. Since data collection is still in progress in Dr. Muckle's project, environmental contaminants have not yet been fully analyzed. We did analysis on our database, and further analyses will be done as soon as the full database is available. In order to report association between exposure to environmental contaminants and chronic stress in the Inuit population, we continue analysing data from the Inuit Health Survey. In addition, we continue analyzing database from previous cohort studies in collaboration with Marc-André Verner.

Results

From the DATA COLLECTION IN INUIT TEENAGERS, saliva samples from 132 Inuit teenagers have been analyzed for cortisol, and results show a wide inter-individual variability (Cortisol_lab arrival = 0.48 ug/dL s.d. 0.31; Cortisol lab arrival+120min = 0.34 ug/dL s.d. 0.81). Those results showed that participation of teenagers to the study does not stress them since their levels of cortisol significantly decreased across the lab visit. Hair samples from 99 Inuit teenagers have been analyzed for cortisol, and results show also a wide inter-individual variability (Cortisol_hair = 47.64 pg/mg s.d. 88.81). This wide inter-individual variability indicates that assessing stress levels with such physiological variables will allow us to statistically determine the contribution of environmental contaminants into this variability as soon as data will be available. Correlations showed that teenagers with high levels of hair cortisol (high level of chronic stress) have also high levels of salivary cortisol when they arrived at the lab ($r=0.42$, $p<.001$), but they also showed a higher decrease 2 hours later ($r=0.36$, $p<.001$).

Behavioural dimensions have been extracted through video coding of video recordings taken in two different situations: blood sampling (n=70, mean duration=285 seconds) and cognitive evaluation (n=77, mean duration=24,5 min). Results from blood sampling situation show that participants had only 0.16 negative affect per minutes. They smiled and laughed 1.27 times per minutes. Their face expressed a neutral affect 80.89% of the time, a positive affect 9.92% of the time, and there is also a high inter-individual variability. Those behavioural coding have been validated by the Inuit interpreters during our Inukjuaq trip. In the cognitive evaluation tasks, levels of attention, assessed by the percentage of time each participant did look at the computer or the research assistant reached in average 88.3% of the total duration of the cognitive evaluation (s.d. 18.04). In other words, each participant looked offtask 0.12 times per min (s.d. 0.18). Correlations between cortisol data and behavioural outcomes showed that hair cortisol levels (indicators of chronic stress) are related to decreased attention towards the cognitive task ($r=-.40$, $p<.003$), and a higher percentage of time displaying negative affect during the blood sampling ($r=.788$, $p<.00$). No association was found with salivary cortisol levels. Next step will be to continue analyzing those data with G Muckle variables including psychometric tools, but also exposure to environmental contaminants.

From the NUNAVIK INUIT HEALTH SURVEY: the study involved a cohort of 914 adult, ages from 18 to 74 years, from the 14 Inuit communities in Nunavik conducted in 2004. The aim of these analyses were to document the effect of environmental contaminants exposure on Inuit chronic stress, assessed through the allostatic load index. Allostatic load is a validated measure of chronic stress representing multi-systemic physiological dysregulations in response to environmental demands. Allostatic load index was calculated using 14 biomarkers representing neuroendocrine, immune, cardiovascular and metabolic systems. Mylène Riva recently validated this physiological index of chronic stress in the Inuit population (Riva, 2014). In our next step, we looked at the association between this allostatic load index and environmental contaminants exposure. Analyses showed that increased exposure to ECs is significantly associated with allostatic load in the adult Inuit population of Nunavik, thereby indicating that exposure to environmental contaminants triggers the chronic stress that leads to behavioural and psychological outcomes, as hypothesized. We did these analyses with 4 legacy (MeHg, Pb, PCB-153 and p,p'-DDE) and 4 emerging (BDE-47, perfluorooctanesulfonate, pentachlorophenol and toxaphenes) contaminants relevant to NCP and identified as priority contaminants by the Nunavik Inuit Health Survey. It is particularly interesting to notice that the strongest association is observed both with the legacy contaminants models and the emerging contaminants models particularly in middle-age Inuit (from 25-54 years of age) (respectively, β=0.21; p<0.001 and β=0.24; p<0.001, n=468). On the other hand, an inverse association might be observed in elders (from 55-74 years of age; β=-0.23; p<0.09). Interpretation of those data are currently in progress and those results should be published in 2015.

From the PRESCHOOLERS cohort study, and in collaboration with Marc-André Verner, we evaluate the association between prenatal and postnatal exposures to PCB-153 and the levels of inattention and activity in 5-year-old Inuits by using a validated pharmacokinetic model to estimate monthly infants' levels across the first year of life. Cord plasma PCB-153 was not associated with inattention and activity, but we found a potential windows of vulnerability to PCB exposure around 2 months of age. Indeed, each interquartile range increase in estimated infant PCB-153 levels at 2 months was associated with a 1.02% increase in the duration of inattention (95% CI: 0.04, 2.00). This study was published in a peer-reviewed international journal (Verner et al., 2015) since it adds to the growing evidence of postnatal windows of development during which children are more susceptible to neurotoxicants like PCBs.

Discussion and Conclusions

We can not provide any conclusion up to now since we need to complete statistical analysis as soon as data from Dr. Muckle's database is ready. However, association between behavioural indicators and cortisol data, and association between exposure to environmental contaminants and the allostatic load index, might suggest that environmental contaminants could indeed target the stress system.

Expected Project Completion Date

Expected project completion date will be December 2015.

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Lake Melville and Labrador Inuit: Understanding and projecting human health implications of exposure to local and long-range mercury sources

Inuits du lac Melville et du Labrador : Comprendre et prévoir les conséquences sur la santé humaine de l'exposition à des sources locales et éloignées de mercure

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Abstract

The goal of this Human Health project is to better understand how Inuit living on Lake Melville might potentially be exposed to methylmercury (MeHg) through the consumption of country foods. The study consisted of two parts: 1) a food frequency survey to find out how much fish, seal and other country foods are being consumed from the Lake Melville environment over three different seasons (Winter, Spring hunt and Fall freeze-up), and 2) collecting hair samples to measure mercury exposure. A total of 1566 surveys were conducted and 658 hair samples provided by Inuit participants in the communities surrounding Lake Melville: Rigolet, North West River, Happy Valley-Goose

Résumé

Ce projet sur la Santé humaine a pour but de mieux comprendre comment les Inuits du lac Melville peuvent être exposés au méthylmercure (MeHg) dans leurs aliments traditionnels. L'étude comprend deux volets : 1) une enquête sur la fréquence de consommation visant à établir la quantité de poissons, de phoques et d'autres aliments traditionnels issus de l'environnement du lac Melville consommée pendant trois saisons (hiver, printemps au moment de la chasse et automne lors de la prise des glaces), et 2) le prélèvement d'échantillons de cheveux permettant de mesurer l'exposition au mercure. Quelque 1 566 sondages ont été réalisés et 658 échantillons de cheveux ont été prélevés chez des participants inuits des

Bay and Mud Lake. Survey and hair sampling work was carried out by 28 local Inuit Research Assistants. Sample sizes obtained are high, with dietary survey data representing 46% of the Lake Melville Inuit population, and hair sample analysis representing 20% of the Lake Melville Inuit population.

Survey data is currently being analyzed to identify magnitudes and frequencies of country food consumed from Lake Melville by Inuit. Hair samples have been analyzed for Hg concentration, and individual results are being mailed directly to participants in May 2015. Dietary survey results are being corroborated using hair Hg biomarkers, and our research team is developing a probabilistic human exposure model based on dietary survey data and anticipated changes in MeHg levels of country foods to estimate future changes in MeHg exposures and health risks of Inuit corresponding to climate variability and flooding of the Lower Churchill River. Publication of study results will begin once individual Hg analysis has been appropriately communicated to participants, with ample time for follow-up and consultation.

collectivités du lac Melville, de Rigolet, de North West River, de Happy Valley-Goose Bay et de Mud Lake. Le travail d'enquête et de prélèvement des échantillons a été effectué par 28 assistants de recherche inuits de la localité. La taille des échantillons est importante, les données de l'enquête alimentaire représentant 46 % de la population inuite du lac Melville et l'analyse des échantillons de cheveux, 20 %.

Les données des enquêtes sont actuellement analysées pour déterminer dans quelles quantités et à quelles fréquences les Inuits consomment les aliments traditionnels provenant du lac Melville. Les échantillons de cheveux ont été analysés pour déterminer la concentration d'Hg et les résultats individuels ont été transmis par courrier directement aux participants en mai 2015. Les résultats des enquêtes alimentaires sont corroborés au moyen des marqueurs biologiques d'Hg dans les cheveux. Notre équipe de recherche élabore un modèle probabiliste d'exposition humaine basé sur les données des enquêtes alimentaires et les changements prévus dans les concentrations de MeHg dans les aliments traditionnels afin d'estimer les changements à venir dans l'exposition au MeHg et les risques sanitaires pour les Inuits associés à la variabilité climatique et à la crue du cours inférieur du fleuve Churchill. La publication des résultats de l'étude débutera après que les analyses individuelles des concentrations d'Hg auront été transmises aux participants, avec une période offrant amplement de temps pour le suivi et la consultation.

Key messages

- Inuit are concerned about the possibility of increased methylmercury (MeHg) in the foods that they harvest from Lake Melville as a result of past and future hydro development on the Churchill River as well as climate change.
- Local Inuit led the collection of dietary information over three seasons, surveying Inuit living in the Lake Melville communities of Rigolet, North West River, Happy Valley-

Messages clés

- Les Inuits sont préoccupés par la possibilité d'une concentration accrue de méthylmercure (MeHg) dans les aliments provenant du lac Melville en raison du développement hydroélectrique passé et futur sur le fleuve Churchill ainsi que des changements climatiques.
- Les données sur l'alimentation ont été recueillies durant trois saisons par des Inuits locaux, qui ont interrogé des Inuits des

Goose Bay and Mud Lake about the types of country food consumed, quantity, frequency and preparation. Inuit researchers also collected hair samples for analysis of mercury (Hg) exposure.

- Data gathered from the dietary surveys has provided insight into which country foods should be given the highest priority for monitoring of contaminants. Hair samples have been analyzed for Hg, and are being cross-validated with results of the dietary survey. Baseline levels of Hg exposure in the Inuit community have been established.
- This research complements environmental work already completed, and feeds into a human health exposure model to estimate future changes in MeHg exposures and health risks of the Inuit related to climate variability and flooding of the Lower Churchill River.

collectivités du lac Melville –Rigolet, North West River, Happy Valley-Goose Bay et Mud Lake –sur les types d'aliments traditionnels consommés, la quantité d'aliments, la fréquence de consommation et le mode de préparation. Les chercheurs inuits ont aussi recueilli des échantillons de cheveux aux fins d'analyse de l'exposition au mercure (Hg).

- Les données provenant des enquêtes alimentaires ont permis de mieux comprendre quels sont les aliments traditionnels dont il faut surveiller en priorité la teneur en contaminants. Les échantillons de cheveux ont été soumis à des analyses de l'exposition à l'Hg et les résultats sont validés avec ceux des enquêtes alimentaires. Des niveaux de base d'exposition à l'Hg ont été établis pour la collectivité inuite.
- Cette recherche complète les travaux déjà réalisés dans le domaine environnemental et alimente un modèle d'exposition de la santé humaine destiné à estimer les changements à venir dans les expositions au MeHg et les risques sanitaires pour les Inuits au regard de la variabilité climatique et des crues du cours inférieur du fleuve Churchill.

Objectives

Long-Term Research Objective:

1. To assess the magnitude of current and future human health risks to Inuit living on Lake Melville associated with methylmercury (MeHg) contamination of their country foods (mainly fish and seal), in the context of industrialization and climate change.

Short-Term (2014-15) Research Objectives:

1. Identify the magnitude and frequency of country foods consumed from Lake Melville by Inuit through dietary surveys.
2. Measure mercury (Hg) uptake in Inuit living on Lake Melville through the analysis of hair samples.
3. Corroborate dietary survey results with hair Hg biomarkers.

Introduction

Methylmercury (MeHg) is a potent neurotoxin for the developing fetus and impairs cardiovascular health in adults at high exposure levels (Grandjean et al., 1998; Roman et al., 2011). Exposure to MeHg is a major health concern for northern populations that consume large quantities of seafood and marine mammals as part of their traditional diet (Stow et al., 2011).

Lake Melville (Figure 1) is a tidal inlet on the Labrador coast with particular importance for northern populations as part of the traditional hunting and fishing territory of the Labrador Inuit. The Churchill River is the main freshwater tributary flowing into Lake Melville and comprises ~70% of the freshwater input to Lake Melville on an annual basis (Bobbitt, 1982). Elevated Hg levels in some estuarine fish from Lake Melville have been attributed to flooding of the Upper Churchill River for hydroelectric power development in the 1960s (Anderson et al., 2011). A new hydroelectric power development (Muskrat Falls) on the Lower Churchill River has been approved and flooding will proceed in 2017. Flooding associated with the creation of new reservoirs for hydroelectric development has been shown to increase bioaccumulation of mercury in fish and seals through a combination of factors that enhance methylmercury production in aquatic environments and shifts in trophic structure of food-webs (e.g., Louchouarn et al., 1993; Schetagne et al., 2000; Trembley et al., 1996). Development of a new reservoir on the Lower Churchill River is likely to affect mercury dynamics in the downstream (Lake Melville) environment. Recent research also suggests that shifts in freshwater and marine food webs are occurring in the Arctic due to climate change impacts on biological productivity, freshwater hydrology and ice cover, which also impacts mercury cycling (Stern et al., 2012).

Figure 1: Location of Lake Melville

This project assesses the magnitude of current and future human health risks to Inuit living on Lake Melville associated with methylmercury (MeHg) contamination of their country foods (mainly fish and seal), in the above context of industrialization and climate change. It was designed to complement ongoing environmental research being carried out in our multidisciplinary ArcticNet project "Our Environment, our Health", a sub-project of the Nunatsiavut Nuluak Project, which leveraged community resources to establish a monitoring program for total Hg and MeHg flowing into Lake Melville from freshwater tributaries, as well as community harvests for collection of fish and seal samples.

Dietary information collected by local Inuit is helping us to assess the magnitude and frequency of consumption of different country foods which is critical for informing contaminant exposure analysis, including MeHg. Data from over 1500 food frequency surveys has indicated which traditional/country foods should be given the highest priority for monitoring of contaminants, and analysis of over 650 hair samples for Hg is allowing us to cross-validate results of the food frequency survey and establish baseline levels of exposure in the Inuit community. This work builds on research done by the Inuit Health Survey - it captures dietary changes resulting from the ban placed on the George River caribou hunt, and provides enough power to distinguish community-level consumption patterns, as there is anecdotal evidence of substantial community-level differences. It also fills in gaps left by the fact that the Upper Lake Melville communities (North West River, Happy Valley-Goose Bay and Mud Lake, home to over 2300 Inuit) were not included in the Inuit Health Survey.

Activities in 2014-2015

Note Regarding Human Health Work Completed Prior to 2014-15:

The first phase of our Human Health Risk Assessment was conducted prior to the 2014-15 fiscal year. In February of 2014, 7 Inuit Research Assistants conducted the dietary survey with 231 Inuit in Rigolet, North West River, Happy Valley-Goose Bay and Mud Lake. This represented a 10% random sample of the Inuit population.

Dietary Survey

In June, 2014, our goal was to conduct the dietary survey with the same 10% sample as in February[1], and we achieved a rate of 62% returning

[1] Our proposal describes a 70-90% sample in June and a 10% sample in November. Feedback obtained from our Community Research Advisors, Inuit participants and Research Assistants during the February dietary survey led to changes in season and sample size, with the 10% random sample changed to June, the addition of targeted high seal consumers to the June survey and hair sampling, and the higher sample (both survey and hair sampling) changed to September, aimed to capture the summer fishing season.

participants (143 people). We also added hair sampling at this time, with a goal of obtaining samples from all consenting participants, and achieved the collection and analysis of 159 hair samples (representing 6.4% of the Inuit population). We also added a targeted group of high-seal consumers to this phase, considering that both the survey and the hair sample would capture the traditional seal hunt, and the most concentrated time of year for seal consumption (as determined by local knowledge). Seven Research Assistants were trained and hired for the June survey and sampling phase, which lasted approximately 5 weeks.

The bulk of the field work for the Human Health Risk Assessment took place in September of 2014, when the dietary survey was completed by approximately 89% of the Inuit residents of Rigolet, 64% of the Inuit residents of North West River, and 34% of the Inuit population in Happy Valley-Goose Bay/Mud Lake, for an approximate total of 1058 participants. The 1-month and 3-month recall periods captured the months of June, July and August, when the summer net-fishing season (salmon, trout), and fish consumption among Inuit is high. This phase of the study took a total of 8 weeks, with 2 Inuit Research Assistants working in Rigolet, 2 in North West River and 20 in Happy Valley-Goose Bay/Mud Lake. Representative samples of each age and gender group were obtained with male participants making up 45% of the total (all 3 seasons) sample, and female participants making up 55%, and age groups divided as follows: <18 years old (22%), 18-34 years (23%), 35-49 years (22%), 50-64 years (20%) and >65 years (13%). Tables 1-4 provide details on participation rates and sample sizes achieved in all 3 seasons. In February, surveys were conducted on paper, with an electronic survey (on tablets) developed for use in June and September, improving efficiency and aiding greatly with participant recruitment.

Hair Sampling

To cross-validate results of the food frequency questionnaire, all June and September survey participants were asked to provide hair samples for Hg analysis. Since MeHg makes up the majority of total Hg in hair (80–90%), total Hg in hair is a reliable biomarker of MeHg intake (Grandjean et al., 2002; Borum et al., 2001). Total Hg concentrations of the two-centimeter proximal end of hair samples have been analyzed at Harvard by thermal decomposition, amalgamation, and atomic absorption spectrophotometry [EPA method 7473; Milestone Direct Mercury Analyzer (Milestone Inc., Shelton, CT, USA)].

Hair samples were provided by 159 individuals (of all ages, including children over 12 months) in June of 2014, and by 499 individuals (again, of all ages) in September. Samples were cut from the middle back of the head (where it will be less obvious), as close to the scalp as possible in order to catch the most recent exposure to mercury. Each sample was approximately 30 mm thick.

With respect to hair Hg analysis, the samples obtained represent approximately 6% of the Lake Melville Inuit population in June, and 20% of the Lake Melville Inuit population in September.

Capacity Building

Survey and hair sampling work was carried out by a total of 28 local (including 26 Inuit) Research Assistants, who completed 2 days of training, and worked an approximate total of 1566 person-hours.

Communications

Community information sessions were held at the launch of the study in Rigolet, North West River and Happy Valley-Goose Bay. Additional sessions are planned for spring/summer 2015, as project results unfold. Additional community updates were provided through: 1) a pamphlet (English and Inuktitut) describing the research purpose and activities, including Frequently Asked Questions on the topic of mercury exposure, 2) a direct mail-out to June participants summarizing work to date and describing what to expect for fall survey/ hair sampling activities, and 3) frequent updates on social media, providing project updates (social media site www.facebook.com/LakeMelvilleInuitHealthStudy has 400+ followers). Posters were circulated in all communities (English and Inuktitut). Media releases resulted in local and national coverage including radio and web.

- Local and Provincial CBC: http://www.cbc.ca/news/canada/newfoundland-labrador/muskrat-falls-prompts-harvard-research-on-mercury-levels-1.2764613, television
- APTN: http://aptn.ca/news/2014/09/11/mercury-fears-labrador/

Traditional Knowledge Integration

Focus group sessions were conducted with Community Research (CR) Advisory Committees in all Upper Lake Melville communities to improve the food frequency survey during its development. Changes to survey and hair sampling dates and sample sizes were made based on the knowledge and advice provided. Likewise, the addition of local terms to the survey, and the assistance that the CR Advisors provided the Study Team in understanding local nuances related to country foods, how they are eaten and where they are obtained was invaluable to making this project a success. Informal contact with CR Advisors also assisted with participant recruitment, local transportation and project promotion.

Results

Analysis of food frequency survey data is currently ongoing. Hair sample analysis is complete: total Hg concentrations of the two-centimeter proximal end of hair samples were analyzed at Harvard by thermal decomposition, amalgamation, and atomic absorption spectrophotometry [EPA method 7473; Milestone Direct Mercury Analyzer (Milestone Inc., Shelton, CT, USA)]. We are currently preparing a mail-out of individual results to participants, and until such time that all individual participants have received their hair Hg analysis results and have had a chance to follow up with a physician should they choose to, we will not be releasing any study findings to the public in any way (including citable publications).

Sample sizes and metadata summary are provided in Tables 1-4.

Table 1: Number of Food Frequency Surveys conducted (3-month, 1-month and 24hr recall):

Month	Total number of surveys	Sample description
March 2014	231	10% random sample of Inuit population
June 2014	277	10% random sample of Inuit population, plus 30 targeted surveys of "high seal consumers"
September 2014	1058	43% of Inuit population

Table 2: Number of Hair Samples taken:

Month	Total number of hair samples	Sample description
March 2014	0	
June 2014	159	6.4% random sample of Inuit population, plus 23 targeted hair samples from "high seal consumers"
September 2014	499	20% of Inuit population

Table 3: Number of participants recruited for different rounds from the three communities of interest

Community (Inuit population)	Winter	Spring	Summer	All seasons	2 Seasons	1 Season	Unique
Happy Valley-Goose Bay/ Mud Lake (1,984)	170	200	671	97	103	543	743
North West River (247)	30	34	158	15	24	128	167
Rigolet (258)	31	43	229	27	16	190	233
Total (2,489)	231	277	1058	139	143	861	1143

Table 4: Number of participants recruited for different rounds from the three communities of interest % of each community's Inuit population

Community (Inuit population)	Winter	Spring	Summer	All seasons	2 Seasons	1 Season	Unique
Happy Valley-Goose Bay/Mud Lake (1,984)	9%	10%	34%	5%	5%	27%	37%
North West River (247)	12%	14%	64%	6%	10%	52%	68%
Rigolet (258)	12%	17%	89%	10%	6%	74%	90%
Total (2,489)	9%	11%	43%	6%	6%	35%	46%

Discussion and Conclusions

This study provides the last two fundamental components of our three year collaborative and multidisciplinary (ArcticNet and NCP funded) research and monitoring project "*Our Environment, Our Health*". The dietary data and hair Hg exposure data collected in 2014-15 are being added to previously completed monitoring and research (described below). The final task, currently underway, is to develop a probabilistic human exposure model based on dietary survey data and anticipated changes in MeHg levels of country foods to estimate future changes in MeHg exposures and health risks to Inuit corresponding to climate variability and flooding of the Lower Churchill River.

The following provides a summary description of the Hg and MeHg monitoring objectives of the *"Our Environment, our Health"* project.

i. Conduct field sampling to establish baseline levels of inorganic Hg and MeHg in Lake Melville seawater, sediments and biota and the magnitude of *in situ* MeHg production (FY 2013-2014);

ii. Establish a community-based monitoring program to assess seasonal and interannual variability in Hg and MeHg concentrations in freshwater tributaries flowing into Lake Melville (FY 2013-2014);

iii. Develop a mechanistic model for mercury cycling in Lake Melville that relates changes in inputs from atmospheric deposition and riverine inflows to concentrations in fish and seal (FY 2013-2014);

iv. Conduct a new food-frequency questionnaire to identify magnitudes and frequencies of country food consumed from Lake Melville by the Inuit and corroborate dietary survey results using hair Hg biomarkers (FY 2014-2015);

v. Diagnose the relative importance of potential changes in MeHg inputs from rivers and climate variability on MeHg levels in fish and seal (FY 2014-2015);

vi. Develop a probabilistic human exposure model based on dietary survey data and anticipated changes in MeHg levels of country foods to estimate future changes in MeHg exposures and health risks of the Inuit corresponding to climate variability and flooding of the Lower Churchill River (FY 2014-2015).

Peer reviewed publications are forthcoming in 2015-16, and work is currently underway on a final, multidisciplinary Status and Outlook Report detailing the results of this three year monitoring and research project (expected publication date of January 2016).

Expected Project Completion Date

December 2015 for fieldwork. Analysis and publications will continue into 2016.

Project website

www.facebook.com/LakeMelvilleInuitHealthStudy

Acknowledgments

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Exposure to food chain contaminants in the Canadian Arctic: spatial and time trends

Exposition à des contaminants de la chaîne alimentaire dans l'Arctique canadien : tendances spatiales et temporelles

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Abstract

Inuit are exposed to a wide range of environmental contaminants through their traditional diet, which includes significant amounts of fish and sea mammal. During the past twenty years, several studies have monitored the exposure of Nunavik Inuit to persistent organic pollutants and heavy metals as well as in other Inuit Nunangat regions. A decrease trend in human exposure has been observed for most POPs and metals in Nunavik over the last two decades. Part of

Résumé

Les Inuits sont exposés à une vaste gamme de contaminants environnementaux par l'entremise de leur régime alimentaire traditionnel, qui comprend d'importantes quantités de poissons et de mammifères marins. Au cours des vingt dernières années, l'exposition des Inuits du Nunavik et d'autres régions de l'Inuit Nunangat aux polluants organiques persistants (POP) et aux métaux lourds a fait l'objet d'une surveillance dans le cadre de plusieurs études. Pendant cette période, on a observé une tendance à la baisse au Nunavik en ce

the decrease is probably due to a decrease in environmental and food concentrations; however another part might be associated with lower traditional food consumption over time. Since the late 90's, increased emphasis was placed on health effects studies in relation to exposure to polychlorinated biphenyls, chlorinated pesticides, mercury and lead in Nunavik. These new results reemphasise the need for 1) mitigation interventions, and 2) biomonitoring activities to follow these public health interventions conducted at the local or international levels. For example, the Arctic Char program that aims at distributing Arctic Char to pregnant women from Hudson Bay was designed to decrease blood mercury levels while insuring that indices of food security such as iron deficiency anemia are improving. On the biomonitoring side, new emerging persistent organic pollutants have now reach the Arctic food chain and very little is known about their concentrations in Inuit populations. This sysnopsis report presents important new data to better understand time trends and contemporary exposure to environmental contaminants in Nunavimmiut.

qui concerne l'exposition humaine à la plupart des POP et des métaux. Cette baisse est probablement liée en partie à la baisse des concentrations de contaminants dans l'environnement et les aliments. Cependant, elle pourrait aussi être liée à une diminution progressive de la consommation d'aliments traditionnels. Depuis la fin des années 1990, les études réalisées ont été centrées sur les effets de l'exposition aux biphényles polychlorés, aux pesticides chlorés, au mercure et au plomb sur la santé des habitants du Nunavik. Ces résultats remettent l'accent sur le besoin 1) d'intervenir pour atténuer les effets et 2) de mener des activités de biosurveillance pour faire le suivi des interventions en santé publique qui sont menées à l'échelle locale et internationale. Par exemple, dans le cadre du programme visant l'omble chevalier, on distribue ce poisson aux femmes enceintes de la baie d'Hudson dans le but de diminuer les taux de mercure dans le sang tout en améliorant les indicateurs de l'insécurité alimentaire, comme l'anémie ferriprive. Pour ce qui est de la biosurveillance, de nouveaux POP ont maintenant atteint la chaîne alimentaire de l'Arctique, et il existe très peu de données sur leurs concentrations dans la population inuite. Ce rapport sommaire présente de nouvelles données importantes qui permettent de mieux comprendre les tendances temporelles et l'exposition actuelle aux contaminants environnementaux des Nunavimmiuts.

Key messages

- Data harmonisation was conducted that will allow for comparisons among different Inuit populations across Inuit Nunangat
- Analyses are underway to document human exposure to methylmercury in eight circumpolar countries at the beginning of the Minamata convention
- Crucial data on exposure to emerging POPs in Nunavik are being obtained
- Elevated prevalence of food insecurity and iron depletion was found in pregnant women living in Nunavik

Messages clés

- les données ont été harmonisées afin de permettre la comparaison des différentes populations inuites dans l'Inuit Nunangat
- Des analyses sont menées pour mesurer l'exposition humaine au méthylmercure dans huit pays circumpolaires au début de la convention de Minamata
- Des données essentielles sur l'exposition aux nouveaux POP au Nunavik sont recueillies
- Une forte prévalence d'insécurité alimentaire et de carence en fer a été observée chez les femmes enceintes au Nunavik

Objectives

The objectives were centred on monitoring activities at multiple levels: temporal, geographical and interventional levels. Targeted contaminants include the traditional suite of contaminants measured in previous projects since the mid-80s (polychlorinated biphenyls (PCBs), organochlorine pesticides, brominated flame retardants (BFRs), mercury (Hg) and lead (Pb) and emerging contaminants such as short-chain chlorinated paraffins (SCCPs), polychlorinated naphthalenes (PCNs) and new halogenated flame retardants (HFRs).

The specific objectives were:

1. Conduct joint statistical analyses of contaminants in the IHS and Qanuippitaa covering the entire Inuit Nunangat;
2. Prepare the exposure assessment protocol of *Qanuippitaa* 2015;
3. Support the international mercury exposure program among pregnant women from the 8 circumpolar countries ;
4. To retrospectively analyse emerging contaminants;
5. To analyze mercury in the Arctic Char program conducted among pregnant women;
6. To expand food security evaluation among pregnant women who participate to the Arctic Char Program (measurement of dietary indices).

Introduction

Early work conducted on Baffin Island and in Nunavik has demonstrated that because of their traditional dietary habits, Inuit people are exposed to unusually high doses of environmental contaminants, mainly toxic metals and organochorines (OCs) (Dewailly, et al. 1993, Kinloch, et al. 1992, Muckle, et al. 2001). OCs form a class of persistent organic pollutants (POPs) including polychlorinated dibenzo *p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs) and various chlorinated pesticides or industrial products. Results from most epidemiological and experimental studies on health effects related to toxic metals (Pb, Hg) and OC exposure (mainly PCBs) suggest that prenatal life is the most susceptible period for induction of adverse effects on physical and neurological development. Indeed, several studies have reported different developmental, immune and/or cognitive deficits in newborns exposed to OCs during prenatal and/or postnatal development, with some of these deficits persisting in later childhood (Dewailly et al. 2000, Guo et al. 1994, Guo et al. 1995, Jacobson and Jacobson 1997, Patandin et al. 1998, Rogan et al. 1986, Taylor et al. 1989, Winneke et al. 1998). As well, prenatal exposure to methylmercury (MeHg) has also been linked to developmental and cognitive deficits in infancy and childhood (Weihe et al. 2002).

However, studies focusing on temporal trends of these POPs in the Arctic have identified a decreasing trend during the last decades in several species (Muir et al. 2001a, Muir et al. 2001b). Decreases in body burden of these compounds in northern human populations have also been reported, for instance in Sweden (Noren and Meironyte 2000) and in Canada, on the Lower North Shore of the St. Lawrence River (Dallaire et al. 2002) and in Nunavik Inuit residing in the Hudson Bay area (Dallaire, et al. 2003).

While these legacy POPs might be of lesser concern in the Arctic if decreasing time trends are confirmed, several new compounds have emerged as potential threats to the Arctic. Emerging contaminants under scrutiny early in the new millennium were the polybrominated diphenyl ethers (PBDEs), commonly added in the composition of electronic equipments, plastics and textiles. Perfluorooctanesulfonate (PFOS) and related compounds are other emerging contaminants requiring monitoring in the Arctic. These chemicals have been produced commercially for over 40 years. PFOS is very stable, repels water and oil and was largely used as a stain repellent ("ScotchGuard"). Kannan et al. (2002) have reported widespread occurrence of PFOS in fishes, birds and marine mammals from the Mediterranean and Baltic Seas. PFOS has also been detected in marine mammals from the North American Arctic (Kannan et al. 2001). In Nunavik, PFOS plasma concentrations in Inuit adults were positively related with fish and marine mammals consumption (Dallaire et al. 2009).

Given the potential health hazards related to these environmental contaminants, worldwide agreements have been taken to make appropriate efforts to decrease the input of these substances in the environment and decrease human and wildlife exposures (i.e. Stockholm Convention, POPs and Heavy Metals Protocols of the UN/ECE Long-Range Transboundary Air Pollution Convention). Included in these conventions are measures that aim at assessing current exposure levels in human populations and to derive spatial and temporal trends for these environmental contaminants, in order to follow and understand their behaviour in the environment, as well as to evaluate the efficiency of intervention programs and undertake appropriate actions to efficiently decrease potentially hazardous human exposures (i.e. recommendations on dietary habits, etc.). Emerging POPs currently considered for inclusion in Annex A of the Stockholm convention, for which data are required, include SCCPs, PCNs and hexabromocyclododecane (HBCD), one of several HFRs that have been introduced in the market following the withdrawal of PBDEs (Chen et al. 2015).

Mercury (Hg) and mercury compounds have long been known to be toxic to humans and other organisms. Large public health crises due to mercury poisoning, such as Minamata disease and Niigata disease, drew attention to the issue already in 1956. On 20 February 2009, the 25th Governing Council of UNEP adopted a decision "to initiate international action to manage mercury in an efficient, effective and coherent manner." The Convention was adopted and opened for signature on 10 October 2013, at a Conference in Kumamoto, Japan. 86 countries and the European Union signed the Convention on the first day it was open.

The formal objective of the Convention is to protect human health and the environment from anthropogenic emissions and release of mercury and mercury compounds. The Parties agreed in Article 8 to control and "where feasible" reduce emissions of mercury and mercury compounds, (i.e. "total mercury") to the atmosphere through measures to control emissions such as coal-fired power stations and non-ferrous metal smelters. The Convention also calls for additional research on issues related to mercury. All Nordic countries as well as Canada and USA signed the Convention.

Considering that the central objective of the convention is to protect human health and, that Arctic people are among those most exposed on earth, we, the AMAP human health assessment group, representing the 8 circumpolar countries, have proposed to assess human exposure to mercury in pregnant women at the beginning of the Minamata Convention period. This work will serve later as a baseline to evaluate the effectiveness of the Minamata convention.

Taking action to modify lifestyle and dietary habits diets in order to reduce environmental exposure to POPs and toxic metals must be done carefully, taking into consideration not only the risks associated with diets including fish, seafood and sea mammal meals (exposure to contaminants), but also the benefits of such diets. Indeed, high exposure to n-3 fatty acids during prenatal life increases birth weight and visual acuity of newborns. Inuit people have very high levels of n-3 fatty acids in their blood due to their high consumption of fish and marine mammal.

In the context of limited income and the high cost of market foods in Nunavik, traditional foods have several advantages (cultural anchor, better dietary quality, etc.) and help families save money. Thus, one way to address elevated exposure to ECs, as well as improve food security and nutrition, is to promote during pregnancy the consumption of a preferred traditional Inuit food that is nutritionally rich (e.g. excellent source of omega-3 (n-3) fatty acids) and relatively contaminant-free, Arctic char (*Salvelinus Alpinus*). This fish holds historical importance to Inuit and has played an important role in the subsistence economies of the region, as Arctic Char is an abundant, accessible and predictable food source in Arctic environments.

Monitoring and supporting of a food distribution activity, such as the Arctic Char Program for pregnant Inuit women, has never been done so far in Nunavik**.** In villages along the Hudson Bay, the Inuulitsivik Health Centre, in collaboration with the Nunavik Regional Board of Health and Social Services (NRBHSS), began in September 2011 a program that distributes fish, Arctic Char, free of charge to pregnant woman. This program does not follow classical public health strategies that advise women to restrict Hg exposure during pregnancy. Instead, this program aims to promote a nutritionally rich contaminant-free food (Arctic Char) during pregnancy, and therefore, aims to replace the consumption of seals and beluga which are high in MeHg. The last two objectives of the current project pertain to the evaluation of this community intervention

Activities in 2014-2015

Objective 1.

It is important to collect baseline health status data and understand their relationship to environmental factors including contaminants and lifestyle among Inuit communities in the circumpolar region. We sought to develop an integral data platform for the heterogeneous, cross-disciplinary and multi-scale datasets collected from the three cohort studies: (1) the 2004 Nunavik Cohort Study in Canada; (2) the International Polar Year (IPY) Adult Inuit Health Survey (HIS) 2007–2008 in Canada; and (3) the Inuit Health in Transition 2005-2010 in Greenland. Data harmonization procedures were used to adjust for differences and inconsistencies among data definition, format and methods to make the data mutually compatible. While some variables were completely matching between databases, seven different techniques were used for converting data in the presence of a partial match: standardize data, restructure data, recode data categories, data extrapolation, combine data categories, one –to-many data matching.

Objective 2.

Late in 2014, the decision was taken to postpone the Qanuippitaa health survey from 2015 to 2016. Resources initially devoted to building the list of environmental contaminants to be monitored during the survey were re-allocated to the development of analytical methods for the measurement of new contaminants of interest in the North: SCCPs, PCNs and HFRs (see Objective 4).

Objective 3.

In addititon to Canada, eight circumpolar countries [Norway, Finland, Russia, Greenland (Danemark), Iceland, Alaska (USA), Faroe Island (Danemark), Sweden] have agreed to participate in this blood monitoring program to document mercury exposure in pregnant women at the beginning of the Minamata convention. In each country the target is to recruit between 50 and 100 pregnant women, at any stage of their pregnancy, and constituting as far as possible a representative sample of the reference population.

A sampling protocol was proposed to each country, and supplies provided and shipped whenever requested. An informed consent was sought from all participants, in order to have nurses in each region/country collect blood samples for total Hg analysis, and for future analyses on new POPs (plasma samples are archived). A short questionnaire is administered to document the date of birth, ethnicity, region of residence, date of blood collection, week of pregnancy at the time of blood collection, and the expected date of birth.

Data collection and laboratory analyses are either completed or ongoing in each country. Some countries had no monitoring project in place and therefore had to implement their national project, starting with seeking approval from their ethical committee. Others had already collected blood samples in the framework of an ongoing project and requested samples to be analysed in the *Laboratoire de toxicologie* (INSPQ), while still others relied on their own national laboratory to conduct the analyses. Once all data are obtained, blood Hg concentrations from approximately 1700 women will be available in the database. Statistical analyses will be performed to compare Hg concentrations between circumpolar countries, and also with concentrations measured during the 1994-1997 period in most countries. We plan the final report of this project co-funded by the Nordic Council of Ministers (Mercu-North) to be ready in early 2016.

Here is an update of the project status in each country:

Canada:

Data collection and laboratory analyses are completed. A total of 190 pregnant women were enrolled in 2012-2013. Plasma samples for the analysis of new POPs are available.

Alaska:

Data collection and laboratory analyses are completed. A total of 784 pregnant women were recruited during the period of 2000-2012. No samples for the new POPs analyses were collected.

Norway:

A total of 49 pregnant women were recruited.

Finland:

Data collection was completed and laboratory analyses are ongoing. Twenty-five participants were recruited in 2014. Plasma samples for the analysis of new POPs are available.

Russia:

Data collection and laboratory analyses are completed. Fifty pregnant women were enrolled in 2013-2014. No samples for the new POPs analyses were collected.

Greenland:

Data collection was completed and laboratory analyses are ongoing. Analyses are completed for 189 participants who were recruited from 2005 to 2014. Since analyses were conducted by their national laboratory, an inter-laboratory comparison is ongoing based on 29 samples. An additional 347 samples will be analysed at INSPQ's laboratory. No samples for the new POPs analyses were collected.

Iceland:

Data collection was completed and laboratory analyses are ongoing. Fifty women were recruited in 2014-2015. Plasma samples for the analysis of new POPs are available.

Faroe Islands:

Recruitment is ongoing.

Sweden:

Recruitment is ongoing.

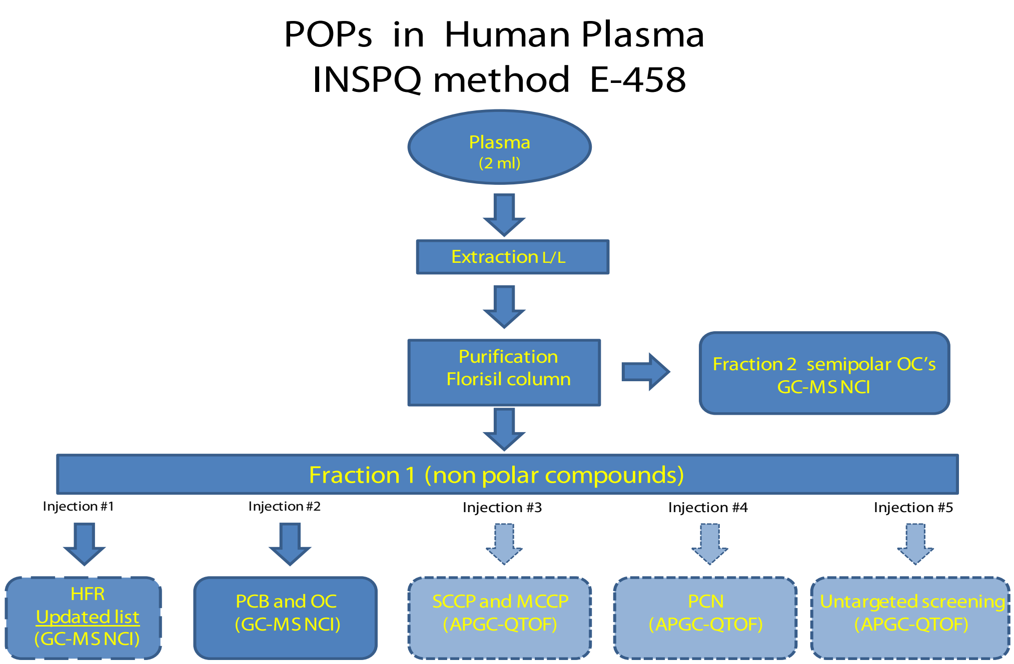
Objective 4.

In 2014-2015, INSPQ's laboratory designed a new analytical procedure for the analysis of POPs that are being considered for possible inclusion in Annex A of the Stockholm convention, and others of emerging public health interest. Our strategy was to expand the coverage our already validated and reliable method for measuring legacy POPs (E-458), by taking advantage of an innovative technology: atmospheric pressure gas chromatography (APGC) coupled to high resolution quadrupole-time of flight mass spectrometry (QTOF-MS).

Figure 1 describes the work flow of the new analytical procedure based on the existing E-458 method covering new families of emerging contaminants and legacy POPs, using the same volume of plasma as in the original method (2 mL) and no additional sample preparation steps. The following modifications to the original method were introduced:

1. Add 14 brominated or chlorinated compounds (see Table 1) to the list of halogenated flame retardants (HFRs) covered when analysing florisil fraction 1 by GC-MS NCI (injection #1);
2. Inject florisil fraction 1 onto the APGC-QTOF and perform analysis using specific conditions optimised for short- and medium-chain chlorinated paraffins (SCCPs, MCCPs) quantification (injection #3);
3. Inject florisil fraction 1 onto the APGC-QTOF and perform analysis using specific conditions optimised for polychlorinated naphthalene (PCNs) quantification (injection #4);
4. Inject florisil fraction 1 onto the APGC-QTOF and perform analysis using general conditions suitable for untargeted screening of POPs, allowing detection and identification of "new" POPs (injection #5).

Figure 1. Modified version of INSPQ's POPs method E-458 to accommodate the determination of new POPs of interest (APGC-QTOF: atmospheric pressure gas chromatography-quadrupole time-of flight mass spectrometry; GC-MS NCI: gas chromatography/mass spectrometry negative chemical ionisation; HFR: halogenated flame retardant; MCCP: medium-chain chlorinated paraffin; OC: organochlorine; PCN: polychlorinated naphthalene; PCB: polychlorinated biphenyl; SCCP: short-chain chlorinated paraffin).



We first verified the feasibility the three new quantitative methods by performing a series of preliminary tests described below, after acquiring standards for the targeted analytes and their isotope-labelled analogues when available.

- Establish the optimal instrumental conditions on GC-MS isntruments;
- Establish the appropriate data treatment for quantification;
- Construct non-extracted calibration curves;
- Evaluate the sensitivity of proposed methods for all compounds;
- Evaluate and eliminate blank method contamination if any;
- Verify if recovery is adequate (greater than 50%)

The new methods are currently being validated according to INSPQ ISO 17025 criteria which include methodological limits of detection and quantification, linearity, reproducibility (intra-day and between-day precisions), matrix effects and recovery.

Screening for new compounds is achieved using the MZmine 2 software that allows for the comparison between exposed and control groups of all deconvoluted peaks in high resolution mass spectra chromatograms obtained following analysis of plasma extracts on our APGC-QTOF instrument. Entities (retention time, exact masses of molecular ions, adducts, fragments) whose intensities are different between groups are examined for possible match with compounds in our in-house library and web-based libraries for putative identification.

Objectives 5 and 6.

During 2014-2015, we completed our follow-up of women involved in the Arctic Char Distribution Program (AC/DP) monitoring. It may be recalled that the goal of this CIHR research project was to evaluate a food distribution program aimed at women during pregnancy. The AC/DP program distributes the fish, Arctic Char, to pregnant women in villages along the Hudson Bay (intervention area), free of charge. For the moment, the distribution program is not occurring in villages along the Ungava Bay (non-intervention area). In this CIHR project, adult Inuit pregnant women were met twice: once (1st visit) at the beginning of the pregnancy (1st or 2nd trimester of pregnancy) before distribution of fish has started, and a second time at the end of pregnancy (≈ 36-40th week of gestational age) or very soon after delivery (<4 week after delivery). A total of 130 Inuit pregnant women were recruited at baseline from September 25 to November 15, 2013. Follow-up of these women for their 2nd visit occurs from January 28 to April 11, 2014. Of the 130 recruited, 44 were lost to follow-up, which left 86 women for the 2nd visit. In 2014-2015, all laboratory analyses for blood Hg and nutritional biomarkers (iron, vitamin D, selenium, and red blood cells (RBCs) fatty acids) were completed. For nutrients (objective 6) we expanded the indices of food security by measuring iron deficiency. We measured plasma iron level, plasma total iron-binding capacity, transferrin saturation, and serum ferritin level (the latter already funded by CIHR).

Results

Objective 1.

Despite the significant challenges of building the integral data platform, we successfully harmonized data from the three cohort studies, allowing access to a myriad of epidemiological information on 6777 participants covering the period 2004 to 2010 in the Inuit circumpolar region. The overall pairing process showed that 227 parameters were paired, of which 79 were classified as complete and 143 as partially matched (98% of all matches were compatible). A total of 5 matches were found impossible. Finally, the merged database resulting from harmonization encompassed a total of 222 integrated data in various disciplines. The disciplines, for which more data were compatible, were by decreasing order social networks, contaminants, clinical biochemistry, clinical tests, health status and lifestyle. Specifically for environmental contaminants, 57 chemicals were covered in the Greenland cohort, 109 in the IHS cohort and 158 in the Nunavik cohort; 57 compounds are included in the harmonized database.

Objective 2.

Because of the decision to postpone the *Qanuippitaa* health survey to 2016, this objective is no longer part of the project and will be reintroduced in a future NCP project.

Objective 3.

Mercury analyses are underway. No results are available at this time.

Objective 4.

Out of the 14 new flame retardants considered for inclusion, 13 could be successfully incorporated in our method already used for quantifying eight brominated diphenylether congeners by low resolution GC-MS with in negative chemical ionisation. The E-458 sample preparation is very efficient and allows for high sensitivity and recovery, without blank contamination (see Table 1). Unfortunately DBDPE with its very high boiling point was found to be inappropriate for the column used in the existing method and could not be included. The method is in the validation process.

Table 1. New halogenated flame retardants added to INSPQ's E-458 method

Acronym	Name	Retention Time (min)	Estimated LOD µg/L	Linearity µg/L	Recovery %
PBT	Pentabromotoluene	4.72	0.001	0.01-2.5	78
PBEB	Pentabromo-ethylbenzene	4.79	0.001	0.01-2.5	84
HBB	Hexabromobenzene	5.13	0.001	0.01-2.5	79
Dec-602	Dechlorane 602	5.72	0.003	0.01-2.5	81
EHTBB	Ethylhexyl tetrabromobenzoate	5.86	0.009	0.01-2.5	68
Dec-603	Dechlorane 603	7.18	0.011	0.01-2.5	75
HBCD Total	Hexabromo-cyclododecane	7.24	0.725	0.01-2.5	77
Dec-604A	Dechlorane 604 component A	7.72	0.007	0.01-2.5	83
BTBPE	1,2 bis tribrophenoxy ethane	8.13	0.005	0.01-2.5	87
BEHTBP	Bis ethyl-hexyl tetrabromo phthalate	8.32	0.005	0.01-2.5	86
syn-DP	syn-dechlorane	8.56	0.005	0.01-2.5	93
anti-DP	anti-dechlorane	8.84	0.003	0.01-2.5	91
OBIND	Octabromo-trimethylphenyl lindane	10.92	0.010	0.01-2.5	79
DBDPE	Decabromo-diphenylethane	ND	ND	ND	ND

The quantification of PCN by APGC-QTOF according to E-458 sample preparation is very efficient with very high sensitivity and specificity with no blank contamination and good recovery as shown in Table 2. The method can quantify 19 different PCN congeners in human plasma extracts; these congeners are those for which individual standard solutions are available (see Figure 2). The method can detect 18 other congeners (see Figure 3; IUPAC numbers not underlined) that were previously identified in technical mixtures (Jakobsson and Asplund 2000).

Table 2. Polychorinated naphthalene congeners included in INSPQ's E-458 method.

IUPAC #	Prefix	Name	Retention time (min)	Limit of detection estimated (µg/L)	Range of linearity (µg/L)	Recovery %
2	2	Chloronaphtalene	6.38	0.002	0.01-1.0	60
6	1,5	Dichloronaphtalene	8.71	0.003	0.01-1.0	77
13	1,2,3	Trichloronaphtalène	11.51	0.001	0.01-1.0	83
27	1,2,3,4	Tetrachloronaphtalene	13.78	0.001	0.01-1.0	65
28	1,2,3,5		13.51	0.001	0.01-1.0	99
35	1,2,4,8		13.97	0.001	0.01-1.0	
36	1,2,5,6		13.45	0.001	0.01-1.0	
42	1,3,5,7		13.78	0.001	0.01-1.0	
46	1,4,5,8		14.62	0.001	0.01-1.0	
50	1,2,3,4,6	Pentachloronaphatalene	15.69	0.001	0.01-1.0	
52	1,2,3,5,7		15.24	0.001	0.01-1.0	97
53	1,2,3,5,8		16.33	0.001	0.01-1.0	
60	1,2,4,6,7		15.24	0.001	0.01-1.0	
66	1,2,3,4,6,7	Hexachloronaphtalene	17.78	0.002	0.01-1.0	106
67	1,2,3,5,6,7		17.78	0.002	0.01-1.0	59
69	1,2,3,5,7,8		18.13	0.002	0.01-1.0	
72	1,2,4,5,7,8		18.29	0.002	0.01-1.0	
73	1,2,3,4,5,6,7	Heptachloronaphtalene	20.47	0.001	0.01-1.0	78
75	1,2,3,4,5,6,7,8	Octachloronaphthalene	22.52	0.001	0.01-1.0	87

Time-of-flight high resolution detection brings the required level of specificity to quantify those compounds. Limits of detection were estimated at around 0.001 µg/L (see Table 2), indicating that sensitivity is sufficient to cover the range of concentration already published in human plasma i.e. from 0.005 to 0.2 µg/L (Jakobsson and Asplund 2000). Complete validation of the method is almost achieved.

The quantification of SCCPs and MCCPs is particularly challenging. No methodologies employed so far were exempt pitfalls (Bogdal et al. 2015; Sverko et al. 2012; Van Mourik et al. 2015). APGC is a softer ionization technique than EI that produces mainly [M-2Cl]+ or [M-3Cl]+ ions. Our preliminary investigation indicates that quantification of total MCCPs and SCCPs in human plasma extracts can be achieved within a single chromatographic run, with good sensitivity, by selecting five of the most intense masses observed in different technical mixture (Figures 4, 5, 6 and 7).

Figure 2. Chromatogram obtained following the analysis of a plasma sample spiked with 19 PCN congeners by APGC-QTOF. Sample preparation is depicted in Figure 1.

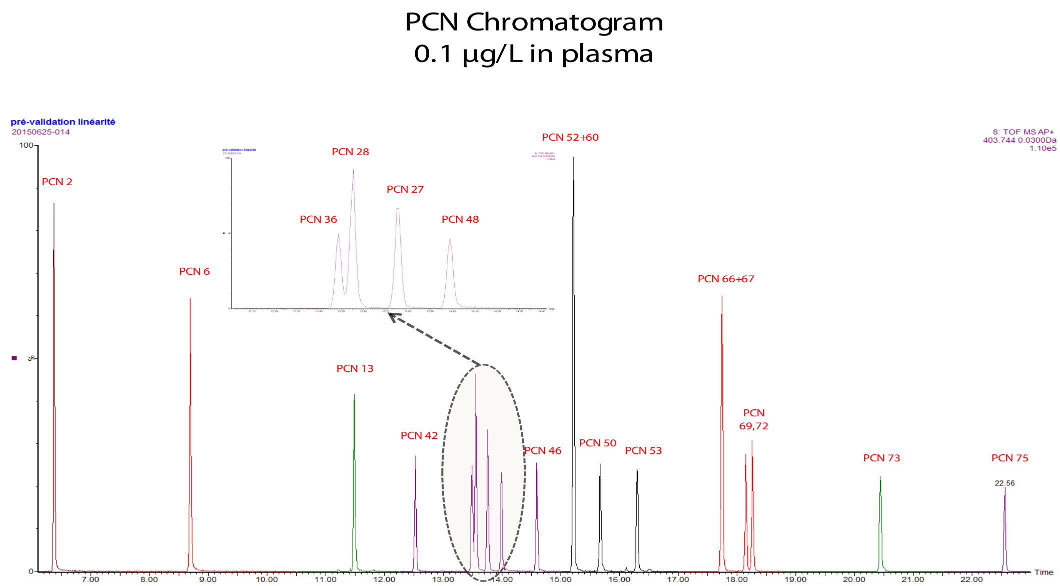


Figure 3. Chromatogram obtained following the analysis of a commercial PCN mixture (Halowax 1013) by APGC-QTOF.

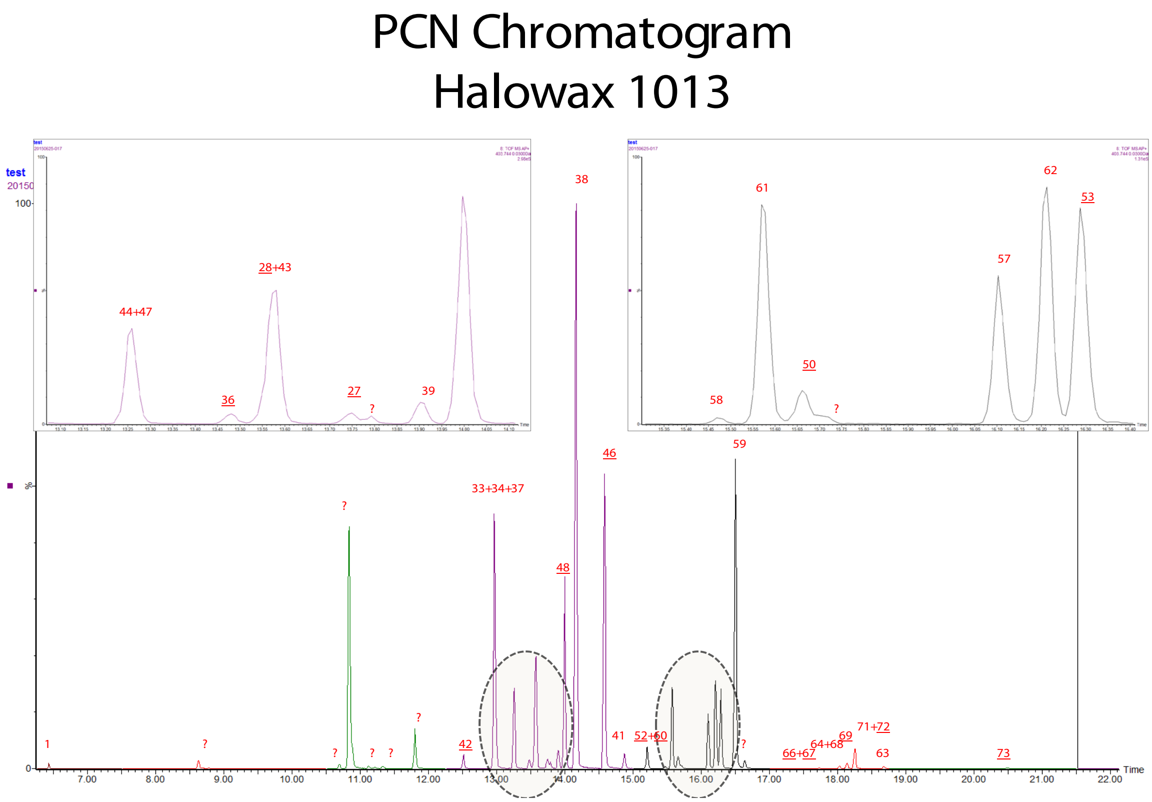


Figure 4. Chromatogram obtained following the analysis of a MCCP commercial mixture showing the selection of the five most important peaks used for quantification

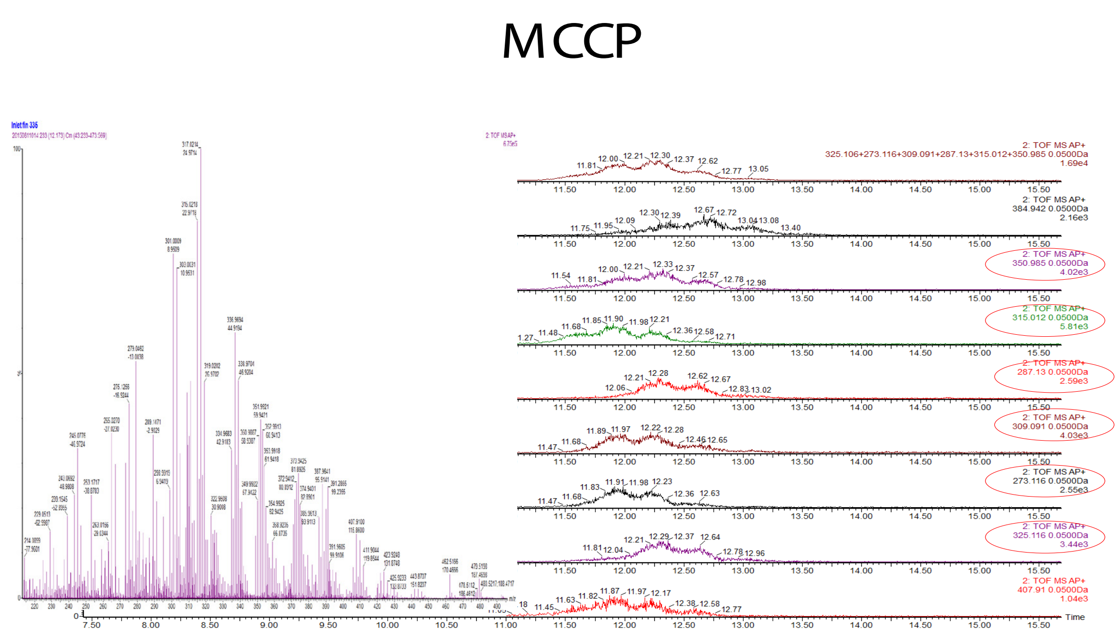
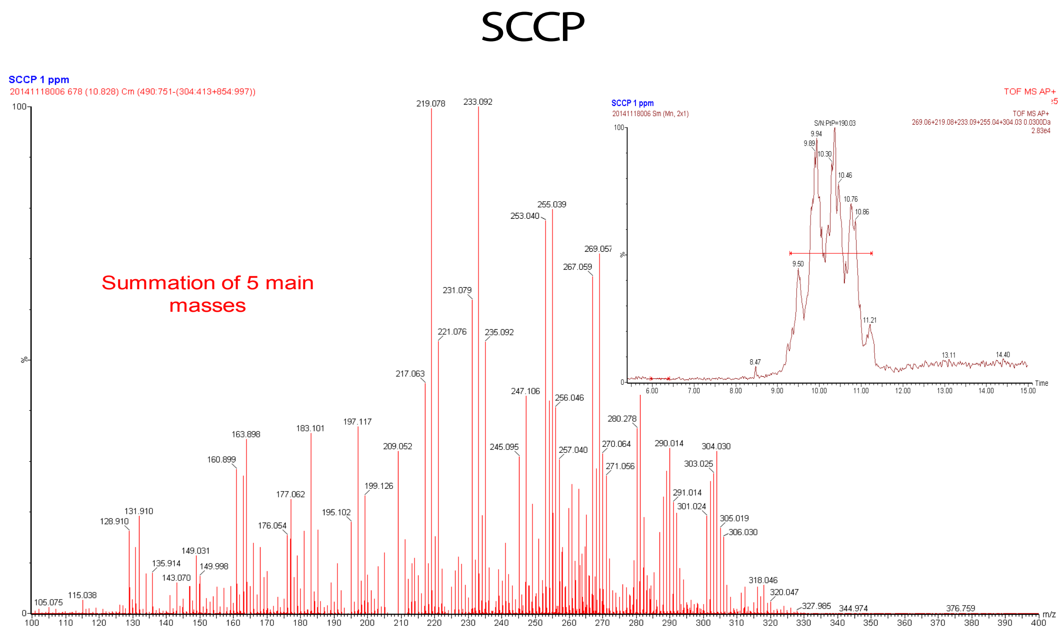


Figure 5. Chromatogram obtained following the analysis of a SCCP commercial mixture showing the selection of the five most important peaks used for quantification



We should also be able to quantify some specific homologues of SCCPs for which standards are available including $C_{10}C_{14}$, $C_{10}C_{15}$, $C_{10}C_{16}$ and $C_{12}C_{18}$ using specific mass fragments. The method is almost ready to validate, but there is some issues to resolve with regard to blank level of contamination, which have to be better defined, controlled, and minimized.

As regards targeted and untargeted screening, the instrumental conditions were defined with general chromatographic and ionisation settings in order to detect as many compounds as possible. We built an APGC high resolution mass spectra library enabling us to detect and identify 14 different classes of persistent organic pollutants including all homologues of PCBs, PBDEs, PBBs, PCNs, MCCPs, SCCPs, toxaphenes, bromo- and chlorobenzenes, polychlorinated terphenyls, PCDDs, PCDFs, 15 organochlorine pesticides, 12 HFRs and a few halogenated natural compounds, for a total of 130 chemicals so far. This tool has already been applied to detect new POPs in human plasma samples used for the development of the data treatment strategies.

Figure 6. Chromatogram for SCCPs and MCCPs obtained by APGC-QTOF. The most important masses were summed for SCCPs and MCCPs.

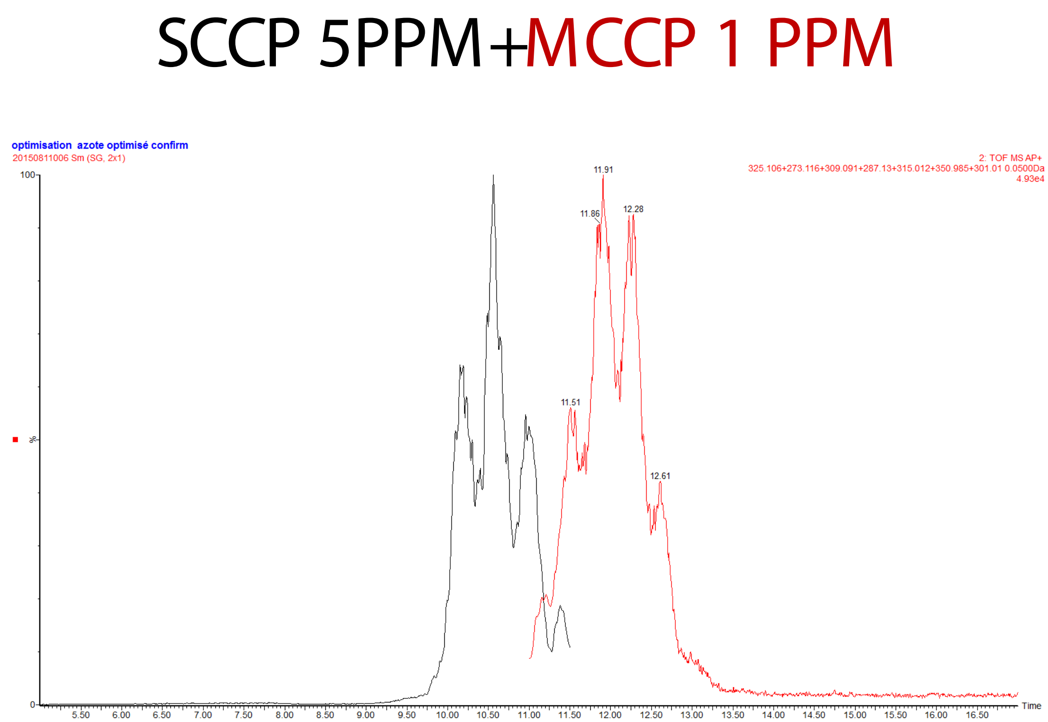
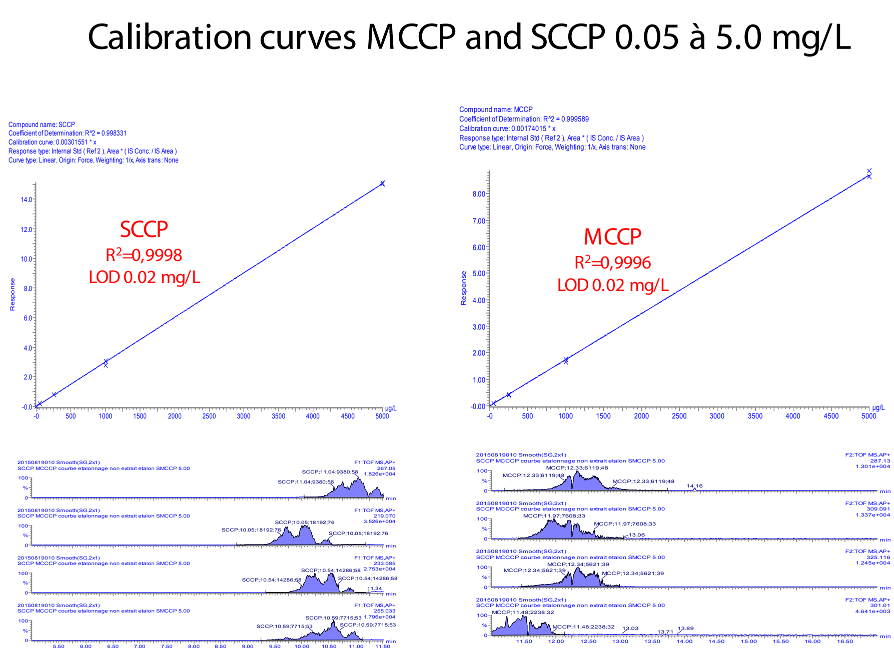


Figure 7. Calibration curves for SCCPs and MCCPs.



Figures 8 and 9 show examples of applying this method to detect polychlorinated terphenyls and a natural halogenated bipyrrole in actual sample extracts. We are still working to implement the library and to refine the data processing in order to extract the most information possible from the chromatograms.

Figure 8. Chromatograms showing the presence of polychlorinated terphenyls (PCTs) in a human plasma extract analysed by APGC-QTOF.

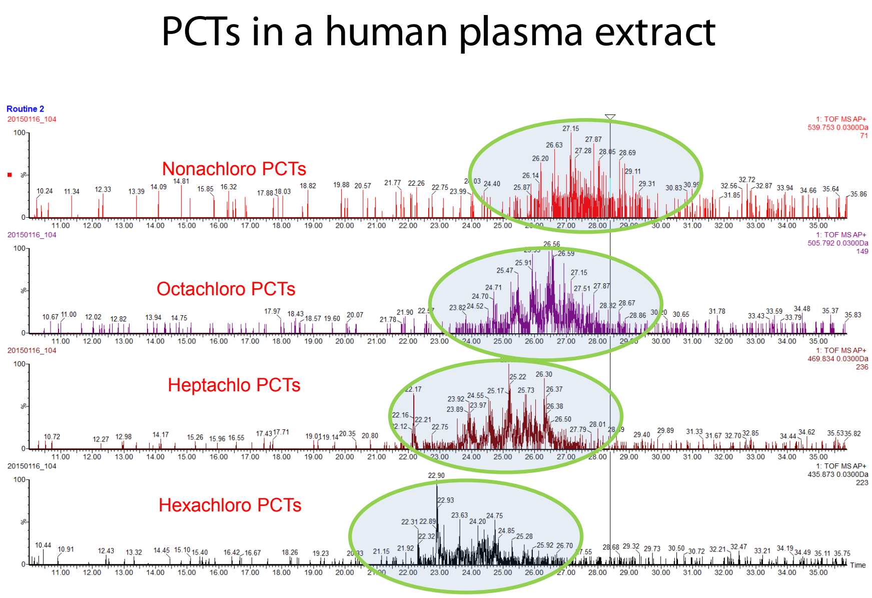
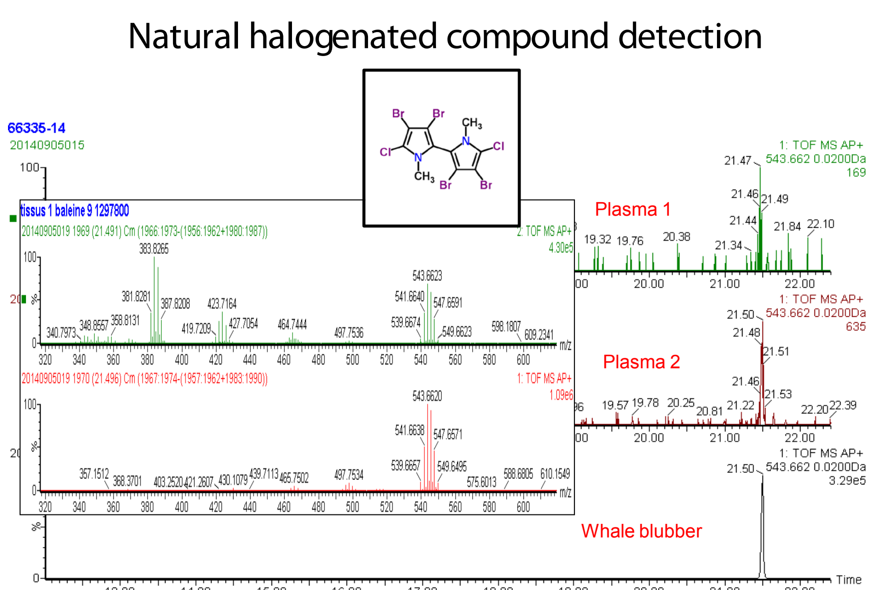


Figure 9. Chromatograms showing the presence of a natural halogenated bipyrrole in human plasma extracts and a whale blubber extract analysed by APGC-QTOF.



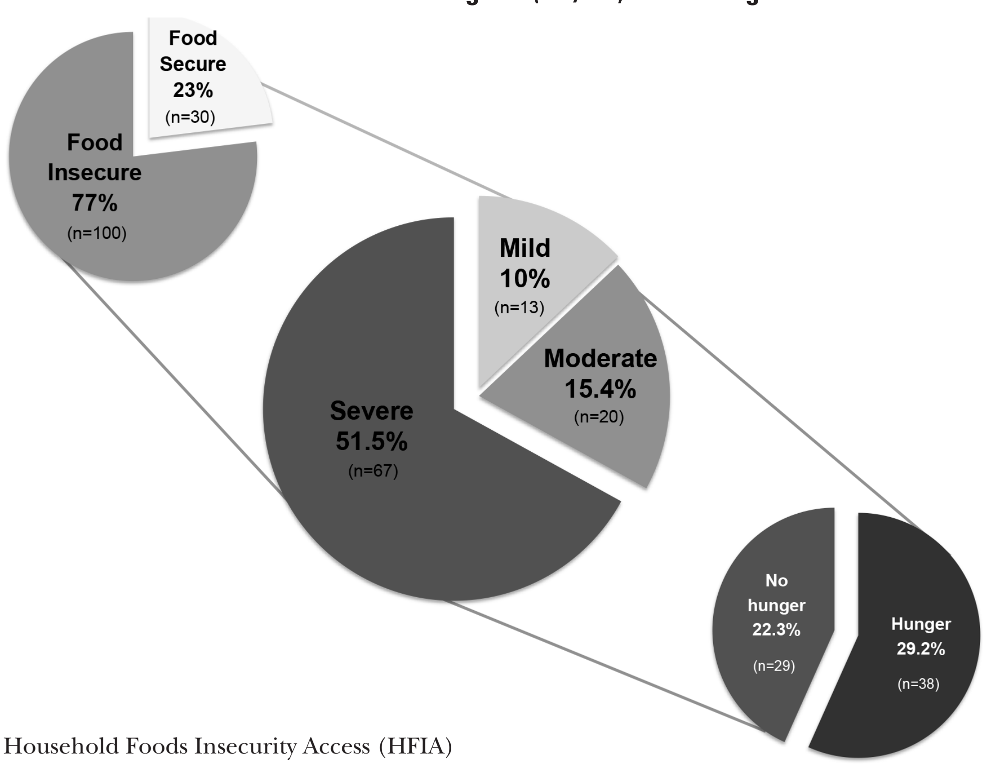
Objectives 5 and 6.

We accessed preliminary baseline data of the Arctic Char Distribution Program (AC/DP). Most women (n=120, 77%) were food insecure, with 10.0% categorized as mildly, 15.4% moderately, and 51.5% severely food insecure (Figure 10). Of those categorized as severely food insecure, 38 (29.2% of total sample) had the most severe form of food insecurity – hunger. Prevalence of food insecurity was more common among pregnant women with less than 21 years of age compared to those older than 21 years of age (96.7% vs. 71%) (data not shown). More women were food insecure on the Hudson coast compared to the Ungava coast (83.1% vs. 69.5%).

Results for blood Hg and nutritional biomarkers analyses according to visits are depicted in Table 3. Blood methylmercury was completed only among a small proportion of women at baseline (n=9) and at the end of pregnancy (n=13). Blood Hg levels and prevalence of blood Hg ≥ 100 nmol/L appear to be higher at the end of pregnancy compared to baseline values.

A trend suggesting lower concentrations of nutritional biomarkers was noted across categories of food insecurity for serum ferritin and red blood cell omega-3, but not for whole blood selenium and mercury (data not shown). As shown in Table 4, compared to food secure women, food insecure women had significantly lower serum ferritin concentrations (29.1±5.4 µg/L vs. 20.2±1.7 µg/L, P=0.04) and lower levels of long-chain polyunsaturated fatty acid omega-3 in red blood cells (7.8±0.4% vs. 6.8±0.2%, P=0.02). Although iron depletion (ferritin < 15 µg/L) was highly prevalent (n=63, 48.5%), prevalence was non-significantly higher among food insecure compared to food secure women (52% vs. 36.7%, P=0.14). Moderately and severely food insecure women had significantly lower LC-PUFA n-3 and DHA concentrations compared to food secure women. Concentrations of serum vitamin D, whole blood selenium and mercury were similar between food insecure and secure women.

Figure 10. Baseline prevalence[a] of foods security and insecurity among Nunavik pregnant women, the Arctic Char Distribution Program (AC/DP) monitoring.



[a] According to Household Foods Insecurity Access (HFIA)

Table 3. Mercury and nutritional biomarker concentrations among Nunavik pregnant women according to visits, the Arctic Char Distribution Program (AC/DP) monitoring.

Blood biomarkers	Visit #1 - Baseline (n=130)	Visit #2 - End of pregnancy (n=86)
Contaminants		
Blood mercury, nmol/L	29.2±23.7	52.7±66.2
≥ 100 nmol/L	3 (2.3%)	13 (15.3%)
Blood methyl-mercury, nmol/L	2.2±23.7	21.9±9.8
≥ 40 nmol/L	0/9 (0%)	1/13 (7.7%)
Nutritional biomarkers		
Total iron, µmol/L	15.2±7.0	12.3±10.3
Serum ferritin, mg/L	22.3±21.0	18.4±17.9
Iron depletion, <15 mg/L, n (%)	63 (48.5%)	47 (56.0%)
UIBC, µmol/L	59.4±17.5	68.4±21.8
Total iron binding capacity, mmol/L	73.9±16.7	81.1±18.5
Transferrin saturation, g/L	3.7±0.7	4.0±1.6
Serum vitamin D, nmol/L	74±48	68±33
Deficient, < 25 nmol/L, n (%)	12 (9.2%)	5 (5.8%)
Insufficient, 25-75 nmol/L, n (%)	69 (53.1%)	46 (53.5%)
Optimal, ≥75 nmol/L, n (%)	49 (37.7%)	35 (40.7%)
Red blood cell LC-PUFA n-3, %	7.0±2.0	6.8±1.7
DHA n-3, %	4.3±1.3	4.2±1.2
Blood selenium, mmol/L	3.8±2.1	4.2±3.3

Arithmetic mean ± SD (all such values).
Abbreviations: DHA, docosahexaenoic acid (22:6n-3); LC-PUFA, long-chain polyunsaturated fatty acids; n-3, omega-3 fatty acids; UIBC, unsaturated iron binding capacity.

Table 4. Baseline biomarker concentrations according to food insecurity in the Arctic Char Distribution Program (AC/DP) monitoring.

Blood biomarkers	Food Secure (n=30)	Food Insecure (n=100)	P [a]
Contaminants			
Blood mercury, nmol/L	33.0±5.8	28.1±2.15	0.33
Nutritional biomarkers			
Total iron, µmol/L	14.9±1.3	15.2±0.7	0.88
Serum ferritin, mg/L	29.1±5.4	20.2±1.7	0.04
Iron depletion, <15 mg/L, n (%)	11 (36.7%)	52 (52.0%)	0.14
UIBC, µmol/L	55.9±2.7	60.4±1.8	0.22
Total iron binding capacity, mmol/L	70.9±2.5	74.8±1.7	0.26
Transferrin saturation, g/L	3.5±0.1	3.7±0.1	0.16
Serum vitamin D, nmol/L	81±8.0	72±5.1	0.35
Red blood cell LC-PUFA n-3, %	7.8±0.4	6.8±0.2	0.02
DHA n-3, %	4.8±0.3	4.2±0.1	0.02
Blood selenium, mmol/L	4.3±0.4	3.7±0.2	0.18

Arithmetic mean ± SEM (all such values).
[a] P-value obtained from Student's t-test (continuous variables) and Chi-Square (categorical variables).

Discussion and conclusions

One objective of our project was to compare organochlorine concentrations measured in different populations of the Inuit Nunangat. In order to achieve this goal, data from different surveys had to be harmonized. The combination of compatible data across the three existing adult cohort surveys provided 222 harmonized data distributed in various disciplines. The developed new data platform of 6777 individuals thus provides a sustainable and relevant cross-disciplinary data bank and a data-sharing tool. We believe the data platform will contribute to the production of high quality documents, major assessments and recommendations regarding environmental factors and health status, and thus, ensuring knowledge to action. It is important to acknowledge the right of the Inuit partners in controlling the secondary use of the three individual dataset. Any use of the newly developed platform need to seek approval from the Inuit partners of each individual study. Finally, we hope the data platform presented here will lower the barrier of data harmonization and serve as a model for other regions for partnerships and data sharing between different institutions.

Following the adoption of the Minamata Convention, a need was identified to assess the current exposure to mercury in circumpolar countries and to monitor the effectiveness of this international measure to reduce exposure worldwide. Our project will yield key information on exposure to methylmercury in eight circumpolar countries, where some of the highest exposures are currently observed and deleterious effects on brain development were associated with *in utero* exposure (Jacobson et al. 2015). Hopefully, the adoption of the Convention will mark the beginning of a significant downward trend in methylmercury exposure among Northerners.

While methylmercury exposure is still of public health interest in the North, exposure to several legacy POPs has decreased over the last decades. However, several new compounds of interest are being scrutinized, especially halogenated flame retardants that have been introduced in the market following the ban of PBDEs. In addition, compounds that have been in commercial use for a long time but are difficult to analyse are getting the attention of researchers (i.e. PCNs, SSCPs). In addition to methods designed to measure quantitatively these compounds, there is a need to detect new compounds of interest through untargeted screening of sample extracts. In the current project, we have introduced such methods in our validated E-458 method and will be applying them to the analysis of archived plasma samples in Nunavik. These results are needed to provide supportive information for including SCCPs in Annex A of the Stockholm Convention. The new analytical methods will also likely be used in the upcoming Nunavik Inuit Health Survey.

Finally, our project yielded important information on food security in Nunavik. Preliminary results from the AC/DP research project using widely validated food security survey tool provide high prevalence estimates for food insecurity (up to 77%). We also noted that iron depletion (ferritin < 15 µg/L) was highly prevalent (n=63, 48.5%). The literature to date suggests that iron deficiency is a frequent consequence of food insecurity and in pregnant women; iron deficiency is particularly concerning because of its association with poor maternal and perinatal outcomes. Knowing that the diet and body composition of a pregnant woman can have significant implications on the future health of the child, the high rate of food insecurity and iron depletion, and the higher blood Hg at the end of pregnancy noted in this study warrant specific attention.

Expected project completion date:

December 2015.

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Tukisinirlungniq: Understandings of the Risks and Benefits of Consuming Beluga in Arviat, NU

Tukisinirlungniq : comprendre les risques et les avantages liés à la consommation du béluga à Arviat (Nunavut)

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Abstract

This goal of this project is to enhance our understanding of the factors influencing food choices in Inuit communities and the potential role that concern over contaminants, and the legacy of past health advice or advisories may play in the consumption of country food items. It is an action-oriented project co-led by the Community of Arviat, NU Wellness Centre and Trent and Washington State Universities. Since the early 1970s, residents of Arviat have been hunting beluga whales and consuming only the maaqtaq. Meat, which used to be consumed dry and fresh is now routinely given to the dogs or discarded. Arviat, like other Inuit communities, faces various food security challenges and needs current information relating to the

Résumé

Ce projet de recherche vise à accroître notre compréhension des facteurs qui influent sur les choix alimentaires dans les collectivités inuites ainsi que de l'importance que les préoccupations relatives aux contaminants et, au fil du temps, les consignes et les avis sanitaires peuvent avoir sur la consommation des aliments traditionnels. Ce projet pragmatique est codirigé par le Centre du mieux-être d'Arviat, l'Université Trent et la Washington State University. Depuis le début des années 1970, les résidents d'Arviat chassent le béluga, ne consommant que le petit lard (maaqtaq). La viande, qui était autrefois consommée sèche ou fraîche, est aujourd'hui couramment donnée aux chiens ou jetée aux rebuts. Comme

viability and feasibility of different culturally acceptable food options for its' population. This project proposes to use a mental models approach to explore the current perceptions and misperceptions regarding the safety of beluga whales as a country food item in this community. In conjunction with the generation of up to date beluga contaminants (mercury-Hg) and nutrients (selenium-Se) data from the area, this project proposes to generate updated health messages on the consumption of beluga for this population. This messaging will be developed in consideration of current perceptions and misperceptions of the safety (health benefits and risks) of consuming beluga as a country food item, current levels of Hg and Se in these food items and current diet behavior and levels of exposure to contaminants in the region. This project has value to other similar cases across the North where the legacy of past contaminant advisories is currently unknown or where uncertainty exists regarding the impacts of contaminant perception on current diet behaviour.

d'autres collectivités inuites, Arviat fait face à divers problèmes de sécurité alimentaire et doit trouver des renseignements à jour sur la viabilité et la faisabilité de différents choix alimentaires culturellement acceptables pour sa population. Ce projet propose l'utilisation d'une approche fondée sur des modèles mentaux pour étudier les perceptions actuelles et les erreurs de perception quant à la salubrité du béluga comme aliment traditionnel de la collectivité d'Arviat. En plus de procurer des données actuelles, pour la région, sur les contaminants (mercure ou Hg) et les éléments nutritifs (sélénium ou Se) présents dans le béluga, le projet propose de générer, à l'intention de la population locale, des messages s'appuyant sur des données à jour concernant les effets de la consommation du béluga sur la santé. Ces messages tiendront compte des perceptions et des idées fausses ayant cours actuellement sur l'innocuité du béluga comme aliment traditionnel (bienfaits et risques pour la santé), les concentrations actuelles de mercure et de sélénium dans le béluga, ainsi que les comportements alimentaires actuels et les niveaux d'exposition aux contaminants dans la région. Ce projet présente un intérêt pour d'autres cas similaires dans le Nord, où les répercussions des consignes sanitaires antérieures au sujet des contaminants demeurent inconnues ou dans lesquels plane une incertitude quant aux effets des perceptions relatives aux contaminants sur les comportements alimentaires actuels.

Key messages

- The goal of this research is to assess factors influencing local decisions regarding the consumption of beluga in Arviat.
- Surveys and mental model interviews have been completed in Arviat to better understand perceptions of contaminants as well as the risks and benefits of consuming beluga.
- MeHg, THg and Se were measured from locally sampled belugas (including maaqtaq, muscle, liver and dried nikku).

Messages clés

- Cette recherche a pour objet d'évaluer les facteurs influant sur les décisions prises localement quant à la consommation de béluga à Arviat.
- Des sondages ainsi que des entrevues sur les modèles mentaux ont été effectués à Arviat afin de mieux comprendre les perceptions relatives aux contaminants ainsi que les risques et les bienfaits associés à la consommation de béluga.

- Communication messages will be developed and delivered based on Arviat residents' perceptions of beluga consumption and the analysis of nutrients and contaminants in beluga samples.

- Les concentrations de MeHg, de THg et de Se ont été mesurées chez des bélugas locaux (notamment le maaqtaq, les muscles, le foie et le nikku).

- Seront communiqués des messages élaborés sur la base des perceptions des résidents d'Arviat quant à la consommation de béluga et sur l'analyse des nutriments et des contaminants trouvés dans les échantillons de béluga.

Objectives

Short term:

Using the case of beluga whale consumption in Arviat, NU this project will:

1. Gain a better understanding of factors influencing local decisions regarding the consumption of a common country food item (beluga) in one Inuit community;

2. Help explain differences in perceptions and perspectives of food safety (i.e. contaminants) between Inuit residents and scientists that may be influencing the gap between science-based health messaging and Inuit diet behaviour;

3. Update existing Hg and Se data on beluga tissues in Arviat, NU;

4. Based on an enhanced understanding of risk perception and other factors influencing food choice developed in i. and ii., as well as current exposure levels of Hg from country food consumption identify and develop updated population specific health messages and materials on the consumption of a common country food item in Arviat, NU;

Long term:

1. To enhance community and local health authority capacity in understanding diet behavior and undertaking risk communications research;

2. To provide updated information to Inuit to support informed decision making regarding the risks and benefits of consumption of specific country foods addressing current perceptions and perspectives;

3. To support the local assessment and understanding of these issues at the intersection of wildlife and human health in other Nunavut communities and elsewhere.

Introduction

Nunavut reports the highest level of household food insecurity among an Indigenous population outside the developing world (Egeland et al., 2010). Nearly 70% of all homes in which children live in Nunavut are challenged in some way in the context of having safe and secure access to adequate amounts of nutritious food on a daily basis. Currently, the Inuit diet is comprised of both elements from the local environment and those things transported long distances to the North and purchased from local stores. With increasing climate change and variability, reports of challenges to household food security are not uncommon in Nunavut and other Arctic regions. It is for this reason that communities require the most current information regarding availability, accessibility and quality (including safety) of local food resources to help address food security challenges now and in the future.

While beluga whales represent a source of mercury (Hg) exposure for Inuit through consumption in the traditional diet, they also provide benefits for Inuit health through the provision of critical elements such as selenium (Se) and protein. Small-scale commercial harvests for belugas were conducted at Arviat and Whale Cove, NU in the early 1960s. Seal meat was also processed for commercial sale by the fish plant at Daly Bay and later Rankin Inlet between 1964 and 1970. Product demand declined steadily and in 1970 when mercury levels of 0.5 ppm (wet wt.) were found in the whale and seal meat, commercial harvesting was halted (Stewart and Lockhart, 2004). According to local Elders in Arviat, historically Inuit in the community hunted beluga whales along the west coast of Hudson Bay and consumed the maaqtaq and meat in a variety of different forms (fresh, dried). However, since the early 1970s it appears that beluga meat is no longer consumed in this community. The lack of beluga meat consumption could possibly be related to a prior health advisory regarding the Hg content of this country food item. Although whales are still hunted and the maaqtaq is consumed, the meat is either given to dog teams or the carcass of the animal is deliberately sunk or discarded.

The issue of beluga whale meat consumption in Arviat, NU raises a number of critical questions pertaining to Inuit food security (availability, accessibility and quality) that demand research attention and require enhanced understanding of the factors influencing food choice behavior, risk perception and risk communication. Current disposal of beluga meat in Arviat, NU is not only potentially limiting food choices in the context of an increasingly variable and unpredictable local food supply, but is also a threat to the continuity of Inuit values and principles regarding traditional practice and respect for wildlife.

This project is using a multidisciplinary and action oriented approach to investigate the case of beluga meat consumption in the community of Arviat, Nunavut. It begins with an exploration of current Inuit perceptions and understandings of the health and safety of beluga consumption in this community and how these understandings differ from or correspond to current health and scientific knowledge. These aspects were explored through a mental models approach, employing in-depth interviews and a community survey, to better understand risk perceptions and behavior. In cooperation with local trainees, researchers have now gathered samples to update the data on Hg and Se in tissues from beluga in the area. The results of this study will generate a new understanding relevant to other cases in the Arctic related to food choice behavior, risk perceptions, and environmental health risk communication.

Activities in 2014-2015:

Research has contributed to the Arviat beluga whale sample archive. Whales were sampled by local residents who completed the Environmental Monitoring course held in Arviat in 2013. Whale samples included beluga maaqtaaq, muscle, liver, prepared dried nikku and MeHg, THg and Se were measured.

In November/December 2014, in-depth interviews were held with 30 residents (including Elders, local hunters, woman of childbearing age, wives of hunters, among other populations). Four local community members were trained on research methods and hired to work with the project. The Arviat youth media team also created a video that captured discussions about beluga harvesting, preparation, and consumption.

In February/March surveys were administered in Arviat (n=290). A total of seven local community members were hired and trained in survey research methods. All research met guidelines in accordance with the NCP protocols, Tri-Council Ethics Panel and regional authorities. The Nunavut Research Institute and Trent Research Ethics Board approved licenses for the research.

Capacity Building

For interviews, four research assistants were hired and for surveys, seven were hired. Before the surveys and interviews were administered, a research training day was held where we provided training on research methods, questions, survey tools, interview techniques, etc. Community researchers will be consulted in the development of communication strategies. As planned, the research project hired recent graduates of the Environmental Monitoring program to assist in beluga sampling required for this project.

Communications

The fieldwork in November began with a radio show and open question period to inform residents of the project and planned event, as well as to answer any questions. Local Elders and residents were consulted prior to beluga sampling and the research team has abided by and consulted the 'Arviat Research and Knowledge Translation Model.' During the first fieldwork trip, researchers introduced themselves and the project to Public Health, Arviat HTO, Arviat Hamlet Office and discussed the project with Elders.

The focus of the project in year 1 has been tool development, ethics application and collecting of beluga sampling and interviews. In year 2 we will begin developing communications and will consult NECC (including NTI and GN Health) in the development of relevant communications.

Traditional Knowledge Integration

Through close connection with community Elders and researchers, we are including IQ in the planning and conduct of project activities. Beluga samples were gathered and collected with the aid of local hunters and Elders. During mental model interviews and surveys, researchers ensured that elders were represented in the study. During the first part of the study, researchers worked with the Arviat Youth Media team to interview Elders and hunters about beluga harvesting and consumption with the ultimate goal to create a video and record knowledge about beluga for current and future generations.

Results:

We are now in the process of analyzing the survey and interview results. Beluga samples have been collected and analyzed by Dr. Gary Stern. Currently, plans are being made to discuss results of the beluga analysis and the perceptions of the risks and benefits of consuming beluga in Arviat. We will be completing reports and factsheets in spring/early summer 2015. Once these documents have been approved by GN Health and the Arviat Public Health team, research results will be delivered to identified groups.

Discussion and Conclusions

Survey and interview data for year one has now been collected and interviews have been transcribed. Beluga samples have been collected and analyzed by Dr. Gary Stern. The final results from the interviews and questionnaires, and data analysis of Hg and Se concentrations in various beluga preparations, as well as current Hg exposure levels as presented in the Nunavut IHS, will be used to determine what knowledge gaps need to be filled, what misperceptions need to be addressed and what health advice should be given to target audiences within the population regarding the consumption of beluga in Arviat, NU. Team members and partners from the research team will gather at a central location to review data from the various project components (cultural context, mental models research, beluga tissue analysis, diet/exposure behaviour and contaminant review) and recommend messaging for development and dissemination in Year 2.

Communication messages and materials will be disseminated in the community using commonly used local pathways (identified by the Arviat team members). The effectiveness of the communications will be tested through a second survey to examine if the messages reached the target population. Questions will measure any potential changes in perception and behavior re: the consumption of beluga whale (meat (dried, fresh), maaqtaq). Additional questions will focus on how risk communications can be improved. This will provide information on why (or why not) some communication strategies are successful (or not successful).

After the risk communication materials and messages have been released, a second set of mental model interviews will be completed with the original population interviewed (people originally interviewed in the 2014 mental model interviews). The same research process and question design will be used in the second set of mental model interviews. This will allow us to compare the two sets of mental models (i.e. one before hearing/seeing the messages and one after hearing/seeing the messages). This will allow us to examine if the mental models have been modified and determine the success of the message delivery. If there were still knowledge gaps, we could use these mental model interviews to understand how we could further improve message design and delivery. The addition of this final step will allow us to evaluate the communication process and the use of mental models in risk perception and communication research in the North.

Expected Project Completion Date:

March 2016

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Quantifying the effect of transient and permanent dietary transitions in the North on human exposure to persistent organic pollutants and mercury

Quantification de l'effet des transitions alimentaires provisoires et permanentes dans le Nord sur l'exposition humaine aux polluants organiques persistants et au mercure

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Abstract

Human exposure to persistent organic pollutants (POPs) in both industrialized and remote regions is strongly influenced by diet. What we eat and where these food items originate are key determinants of body burden and risks associated with chronic exposure to such compounds. It is well known that all foods are not equal with respect to contamination by POPs. This implies that contaminant exposure can be affected by changes in diet. Therefore we have investigated the impact of dietary transitions on human POP exposure, with examples of transient adjustment (e.g. if a woman who is pregnant temporarily avoids food items known to be more contaminated), and more gradual and permanent changes (e.g. if

Résumé

L'alimentation influe fortement sur l'exposition humaine aux polluants organiques persistants (POP), tant dans les régions industrialisées qu'éloignées. La nature et l'origine des aliments que nous mangeons sont des déterminants clés de la charge corporelle et des risques associés à l'exposition chronique à ces composés. Il est généralement admis que les aliments ne sont pas tous également contaminés par les POP. Un changement de régime alimentaire peut donc avoir une incidence sur l'exposition aux contaminants. Nous avons étudié l'effet des transitions alimentaires sur l'exposition humaine aux POP à l'aide de scénarios d'ajustements provisoires (p. ex. si une femme enceinte exclut temporairement de

communities gradually shift from a traditional diet of locally hunted animals to a diet that includes more imported food [IF]). We have developed a series of computer simulation-based food chain bioaccumulation models that quantify how much such dietary changes can affect exposure to contaminants. Applications range from exploring general population-wide transitions away from Northern traditional food (TF) to investigating individuals temporarily adjusting their diet during child-bearing age. Our main findings from this past year are that (1) discerning the impact of long-term dietary transitions in Canada's North on observed human POP exposure trends greatly relies on, and is currently challenged by, the quality of the data on dietary compositional trends, (2) short-term dietary transitions may appreciably affect intakes of POPs and essential nutrients in sensitive Arctic populations, and (3) traditional food preparation methods can significantly alter POP levels in these unique food items.

son alimentation les aliments réputés plus contaminés) et de changements plus graduels et permanents (p. ex. des collectivités remplacent graduellement leur alimentation traditionnelle à base de viande d'animaux chassés localement par une alimentation comprenant davantage d'aliments importés). Nous avons mis au point, par simulation informatique, une série de modèles de bioaccumulation dans la chaîne alimentaire qui permettent de déterminer quantitativement la mesure dans laquelle des changements alimentaires peuvent influer sur l'exposition aux contaminants. Les applications vont de l'étude du délaissement graduel des aliments traditionnels du Nord par l'ensemble d'une population à l'examen d'ajustements temporaires individuels du régime alimentaire durant l'âge de procréation. L'année dernière, nos conclusions principales ont été que 1) la détermination de l'impact des transitions alimentaires à long terme dans le Nord canadien sur les tendances observées quant à l'exposition humaine aux POP varie grandement selon la qualité – actuellement déficiente – des données sur les tendances dans la composition alimentaire; 2) les transitions alimentaires à court terme peuvent exercer une influence appréciable sur l'apport de POP et de nutriments essentiels chez les populations arctiques sensibles, et 3) les méthodes traditionnelles de préparation des aliments peuvent modifier considérablement les concentrations de POP dans ces produits alimentaires particuliers.

Key Messages

- Large-scale generational dietary transitions among Aboriginal Northern communities are an important factor underlying observed POP body burden temporal declines, as well as contributing to the variability within and between subpopulations.
- Associations between POP concentrations and demographic variables such as sex and age in traditional food species can help inform Northern dietary choices; for example, suggesting individuals susceptible to POP toxicity limit their consumption of

Messages clés

- Les transitions alimentaires générationnelles à grande échelle dans les communautés autochtones du Nord jouent un rôle important dans la diminution temporelle de la charge corporelle des POP observée et contribuent à la variabilité intra et interpopulationnelle.
- Les associations entre les concentrations de POP et des variables démographiques comme le sexe et l'âge des espèces consommées traditionnellement peuvent guider les choix alimentaires dans le Nord;

older male animals, as they routinely possess the greatest POP levels within wildlife populations.

- The incorporation of several new TF species models (e.g., beluga whale, narwhal, caribou, Canada goose) into our food chain bioaccumulation framework has allowed us to estimate POP exposures for women who participated in maternal biomonitoring studies in two Northern communities (Baffin Island and Inuvik). The accuracy of our predictions was highly variable between studies, and indicated that model effectiveness was directly tied to the quality of biomonitoring data and dietary survey inputs, particularly recall estimates of TF intake rates.

- Our updated model is now also capable of calculating daily intake rates of several essential nutrient groups (minerals, vitamins, and poly-unsaturated fatty acids) from TF consumption, and we have made initial calculations estimating the impact of short-term dietary transitions (i.e. during pregnancy and nursing) on POP and nutrient intakes for hypothetical Canadian Aboriginal Arctic TF replacement scenarios.

- Initial results from our field/laboratory study on the influence of food preparation on beluga blubber TF contaminant and nutrient yields suggest that different processes can substantially affect POP levels in consumed food items.

par exemple, suggérer aux personnes vulnérables aux effets toxiques des POP de limiter leur consommation d'animaux mâles âgés, chez lesquels les plus fortes concentrations de POP sont couramment observées parmi les populations fauniques.

- L'intégration de quelques nouveaux modèles d'espèces utilisées dans l'alimentation traditionnelle (p. ex. béluga, narval, caribou, bernache du Canada) à notre cadre de bioaccumulation dans la chaîne alimentaire nous a permis d'estimer les expositions aux POP de femmes ayant participé aux études de biosurveillance maternelle dans deux collectivités nordiques (île de Baffin et Inuvik). L'exactitude de nos prévisions variait largement d'une étude à l'autre et indiquait que l'efficacité du modèle était directement liée à la qualité des données de biosurveillance et des enquêtes sur l'alimentation, en particulier les estimations des taux d'absorption d'aliments traditionnels.

- Notre modèle actualisé nous donne maintenant la possibilité de calculer les taux d'absorption quotidienne de plusieurs groupes de nutriments essentiels (minéraux, vitamines et acides gras polyinsaturés) avec la consommation d'aliments traditionnels. Nos calculs initiaux permettent d'évaluer l'incidence des transitions alimentaires à court terme (p. ex. durant la grossesse et l'allaitement) sur les POP et l'absorption de nutriments selon des scénarios théoriques de remplacement des aliments traditionnels consommés par les populations autochtones de l'Arctique canadien.

- Les résultats initiaux de notre étude sur le terrain et en laboratoire de l'influence de la préparation alimentaire sur les taux de contaminants et de nutriments dans le petit lard de béluga consommé comme aliment traditionnel indiquent que des méthodes différentes peuvent influer largement sur les concentrations de POP dans les aliments consommés.

Objectives

Long-term

1. To maximize the value of existing Northern human biomonitoring data by using them in continued model evaluation.
2. To assess the effectiveness of hypothetical and realistic TF replacement scenarios on Northerners' intakes of POPs with varying physical-chemical properties (e.g. hydrophobicity, volatility, susceptibility to biotransformation), mercury and critical nutrients.
3. To build capacity for assessing human exposures in Northern communities to new and emerging chemicals of concern.
4. To develop a novel physiologically-based pharmacokinetic (PBPK) model capable of describing mammalian tissue distribution of mercury following prescribed dietary intake.

Short-term

1. To complete modeling of short-term maternal dietary change effects, during pregnancy and nursing, in reducing infant POP exposure among Northern populations.
2. To complete analytical quantification of traditional food preparation impacts on human dietary POP and nutrient intakes, focusing primarily on beluga whale blubber (or muktuk).
3. To evaluate the newly added capability of our human food chain bioaccumulation models to account for the nutritional value of various food items, such as omega-3 polyunsaturated fatty acids, vitamins (A, B, E), iron, calcium, folate, and fiber.

Introduction

The main route of human exposure to POPs in the Arctic is via traditional food consumption, principally local wildlife such as caribou, seals, toothed whales, and polar bears (Deutch et al. 2007; Donaldson et al. 2010; Kuhnlein et al. 2004). This factor may in part contribute to the ongoing dietary transition trend away from country foods and toward imported items among these communities (Deutch et al. 2007; Kuhnlein et al. 2004). Though these observed dietary transitions have correlated with increased rates of obesity and reduced nutrient intake (Deutch et al. 2007; Kuhnlein et al. 2004), they may have contributed to declining historic POP levels among Northerners (Donaldson et al. 2010), and likely will continue to affect future exposures. Interestingly, though marine mammal contamination often exceeds levels observed in imported foods (Hoekstra et al. 2005; O'Hara et al. 2005), some store-bought items (milk, fish, salmon, sardines) may possess higher organochlorine concentrations than local fish species (Arctic char, whitefish, pink salmon). Thus, transitioning from a traditional diet to more imported food would not necessarily lower organochlorine exposure in all cases.

In addition to these long-term population-wide dietary transitions among Northerners, POP exposures may also be impacted by short-term dietary transitions, such as food advisory compliance by women during pregnancy and nursing, or transient modifications to food preparation methods. As individuals are particularly susceptible to the neurocognitive effects of POPs during pre- and postnatal development (Stewart et al. 2008; Walkowiak et al. 2001), regulatory bodies often publish guidelines to promote safe maternal preparation practices, and intake levels of certain foods, mainly fish (Turyk et al. 2012). The majority of current POP dietary consumption advisories are for temperate populations, such as those in the

Great Lakes region (Bhavsar et al. 2011), while no POP-based advisories have been published specifically for Aboriginal Arctic residents consuming a traditional diet. One reason for this being that sources of local food, the amounts consumed, their preparation methods, and levels of contaminants are extremely variable throughout the Arctic (Donaldson et al. 2010). Additionally, traditional food serves as a cultural and spiritual cornerstone of community health in many Aboriginal groups. In fact, authors agree that consumption of traditional foods should continue to be recommended, and intakes monitored only for sensitive populations (children and pregnant women) (Donaldson et al. 2010).

Ultimately, dietary transitions from a traditional to an imported diet currently occurring in Canada's North, or those practiced short-term by vulnerable populations, can be problematic from a nutritional and cultural point of view. As contaminant-related dietary consumption advisories may influence dietary choices, it is important that those advisories are based on the best available science and strike a balance between the desires to reduce contaminant exposure and to maximize the nutritional and cultural value of food. Our current work allows for quantitative assessments of the efficacy of such guidelines in reducing contaminant exposure. In fact, our model of human dietary contaminant uptake, comprehensively evaluated with existing biomonitoring datasets, may eventually be used to design dietary guidelines that are effective in reducing contaminant exposure without compromising the consumption of nutritionally beneficial traditional food items.

Activities in 2014-2015

One of the main activities in the past project year was the application of our expanded ACC-Human Arctic food chain bioaccumulation model toward attempting to reproduce POP exposures measured in Aboriginal Arctic biomonitoring campaigns, building upon successful evaluation and use of our new submodels for Arctic char, beluga whale, narwhal, caribou, and Canada goose (Binnington and Wania, 2013b; Binnington and Wania 2014; Binnington et al., 2014a) The decision to develop models for char, beluga whale, narwhal, caribou, and Canada goose, to join existing models for ringed seal and polar cod, were motivated by their importance in dietary surveys among mothers in the biomonitoring campaigns from the Inuvik and Baffin Island regions (Health Canada; Government of Nunavut; Government of Northwest Territories; Government of Yukon; Inuit Tapiriit Kanatami, personal communication). Particularly, we included traditional food items important to POP exposure either due to a high frequency of consumption (char, caribou, Canada goose), or due to elevated POP contaminant levels (beluga, narwhal). Using this expanded model framework, we attempted to reproduce POP human biomonitoring results from these two Northern communities (Baffin and Inuvik) using demographic data and dietary survey information.

Secondly, we further updated our ACC-Human Arctic model to include estimates of nutrient intake rates for the TF species listed above. This was motivated by our interest in exploring the potential of short-term TF replacement scenarios to impact not only POP exposures, but intakes of essential nutrients as well. For example, can we predict whether expectant, pregnant, or nursing Aboriginal Arctic mothers that exceed Health Canada guidelines for polychlorinated biphenyl (PCB) exposure can drop below this threshold by temporarily replacing highly contaminated TFs (ex. marine mammal blubber) with less contaminated foods? And further, can we estimate how these dietary changes might impact intakes of essential nutrients from a TF diet, particularly given the increased importance of certain vitamins and minerals during these reproductive phases? Using TF nutrient level data from the Health Canada Canadian Nutrient File (http://webprod3.hc-sc.gc.ca/cnf-fce/index-eng.jsp) our model is now capable of quantifying daily intake rates of several minerals (calcium, iron, magnesium, sodium, etc.), vitamins (A, C, D, E), and polyunsaturated fatty acids (PUFAs) from TF diets. We have begun calculations using these implemented updates to assess the above questions using hypothetical TF replacement scenarios for Aboriginal Arctic women of childbearing age based on TF intake rates from the Inuit Health Survey (Laird et al., 2013).

A third major project activity was the field collection of beluga TF samples to assess food preparation impacts on POP and nutrient contents in these food items. Beluga blubber samples were collected during the 2014 summer hunting season in Tuktoyaktuk, Northwest Territories by team member Matthew Binnington with the assistance of the local Hunters and Trappers Committee. We are currently in the process of analyzing the collected samples to determine their levels of PCBs, and pesticides, having already completed perfluorinated chemical (PFC) analysis. Additionally, we are also investigating the selenium (Se) and PUFA contents of the collected samples.

Communications

The results from these three major activities have been disseminated through a variety of means during this past year. Specifically, findings from our ACC-Human Arctic model expansion activities were presented at a meeting of the Society of Environmental Toxicology and Chemistry (Binnington et al. 2014a) and our beluga TF preparation project was also presented at this meeting (Binnington et al. 2014b), as well as the 2014 ArcticNet Arctic Change Conference (Binnington et al. 2014c). Additionally, our ACC-Human Arctic model expansion work was presented at the 2014 meeting of the International Society of Exposure Science (Binnington et al. 2014d) and the 2015 meeting of SETAC Europe (Wania et al. 2015), and is currently in its final stages of internal revision prior to journal submission.

The project team also held communication meetings with our Northern partners on three separate occasions during the previous project year. In June 2014, Frank Wania, Matthew Binnington, and Meredith Curren hosted an in-person meeting/conference call in Ottawa to discuss ongoing project results, the appropriateness of planned traditional food additions to our model framework, as well as any information on existing and potential traditional food substitution scenarios. From June-August, Matthew Binnington frequently discussed project details with Tuktoyaktuk project partners during his field stay in the community. Finally in December 2014 additional informal meetings were conducted with Northern partners during the ArcticNet Arctic Change Conference.

Capacity Building

Our 2014 field study conducted in Tuktoyaktuk by Matthew Binnington to examine the impact of traditional food preparation practices on nutrient intake and POP exposure provided unique capacity building opportunities, such as visiting local elders to explain the significance of our work and our interest in assisting with issues related to local food safety and security. We also frequently participated in local activities (ex. Aboriginal Day and Canada Day festivities), volunteered, and presented our findings, as well as answered questions during this field study, and will continue to do so during all stages of the project, including future results reporting. We also plan to include in-person discussion of our research results with territorial representatives. Also we discussed our findings during several community gatherings, and Hunters and Trappers Committee meetings, and contributed to plain language summaries for the Tuktoyaktuk community describing all beluga research performed during the 2014 hunting season.

Traditional Knowledge Integration

Traditional Knowledge (TK) was incorporated during project activities over the past year through our advisement on existing or potential traditional food substitution scenarios, as well as the appropriateness of planned traditional food additions to our model framework with our Northern project partners. Furthermore inclusion of TK was critical in conducting our 2014-2015 field campaign investigating the impacts of traditional food preparation on nutrient intake and POP exposure. We also anticipate TK will continue to be very valuable in designing realistic dietary replacement scenarios for the application of our transient dietary transition approach to Northern communities.

Results and Discussion

Our first major project of 2013-2014, involving expansion of the original ACC-Human Arctic framework with additional traditional food items, and application of this framework to reproduce historic biomonitoring data from two Northern communities, demonstrated the feasibility of applying our mechanistic food chain bioaccumulation modeling approach to Aboriginal Arctic settings. Notably, there was a clear discrepancy in the direction of PCB exposure and TF intake trends in both the Inuvik and Baffin populations, as decreasing measured PCB exposures (mean Δ [PCB] Inuvik-1 to Inuvik-2 = -13.4 ng/g lipid, Baffin-1 to Baffin-2 = -131.2 ng/g lipid) coincided with increasing reported TF intakes (mean Δ total TF intake Inuvik-1 to Inuvik-2 = +11.5 g lipid/d, Baffin-1 to Baffin-2 = +9.3 g lipid/d). Interestingly, according to the reported TF intake data from Inuvik and Baffin an appreciable dietary transition in fact occurred within these communities, but in the opposite direction of, and to a greater degree than our expectations. This hampered our model's ability to reproduce PCB exposures, especially for the two follow-up campaigns, as can be seen in Figure 1, which compares the temporal trends of PCB-153 and TF intakes in Inuvik and Baffin.

Figure 1. Illustrations of temporal trends in measured and modeled PCB-153 exposures (A) and TF lipid intake rates (B) for Inuvik and Baffin biomonitoring participants. Comparisons of measured PCB-153 blood levels (unfilled bars) and PCB-153 exposure predictions (grey bars) include depictions of dataset geometric means (+), and for the modeled groups also the exposures predicted for the "average" study population mothers (Table 3). Mann-Whitney tests were performed to compare baseline and follow-up dataset mean ranks for each parameter and study population; *p < 0.05, **p < 0.01, ***p < 0.001 if the follow-up measured or modeled dataset differed significantly from its corresponding baseline.

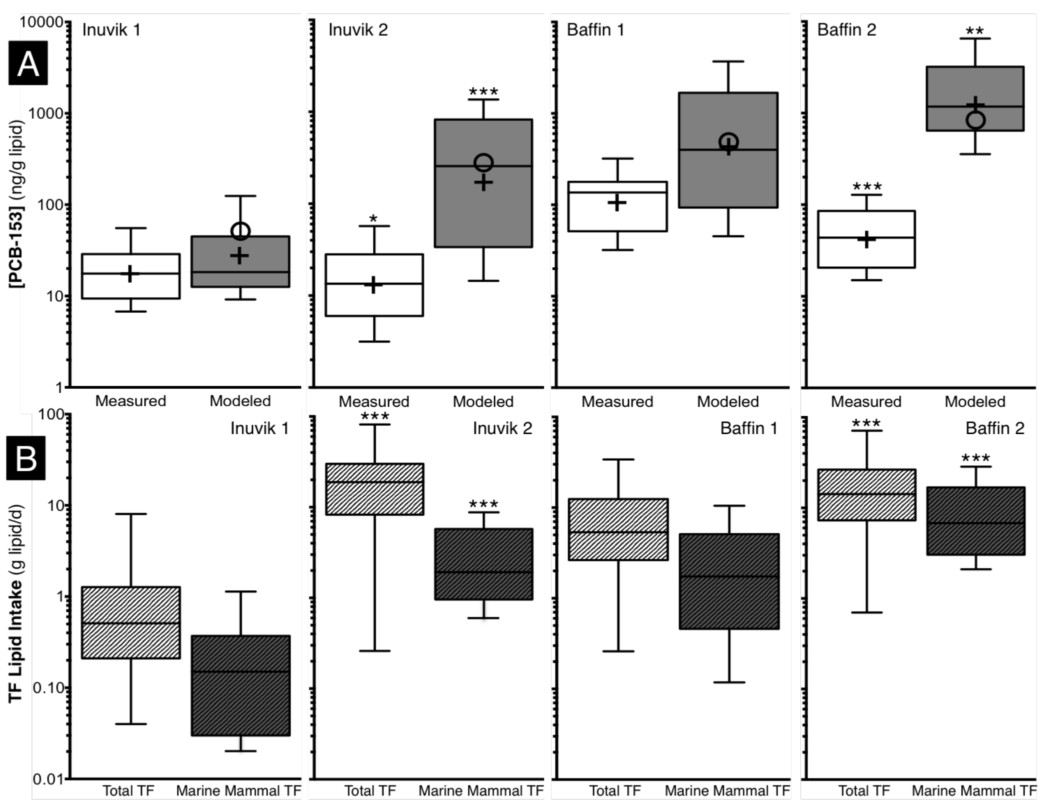
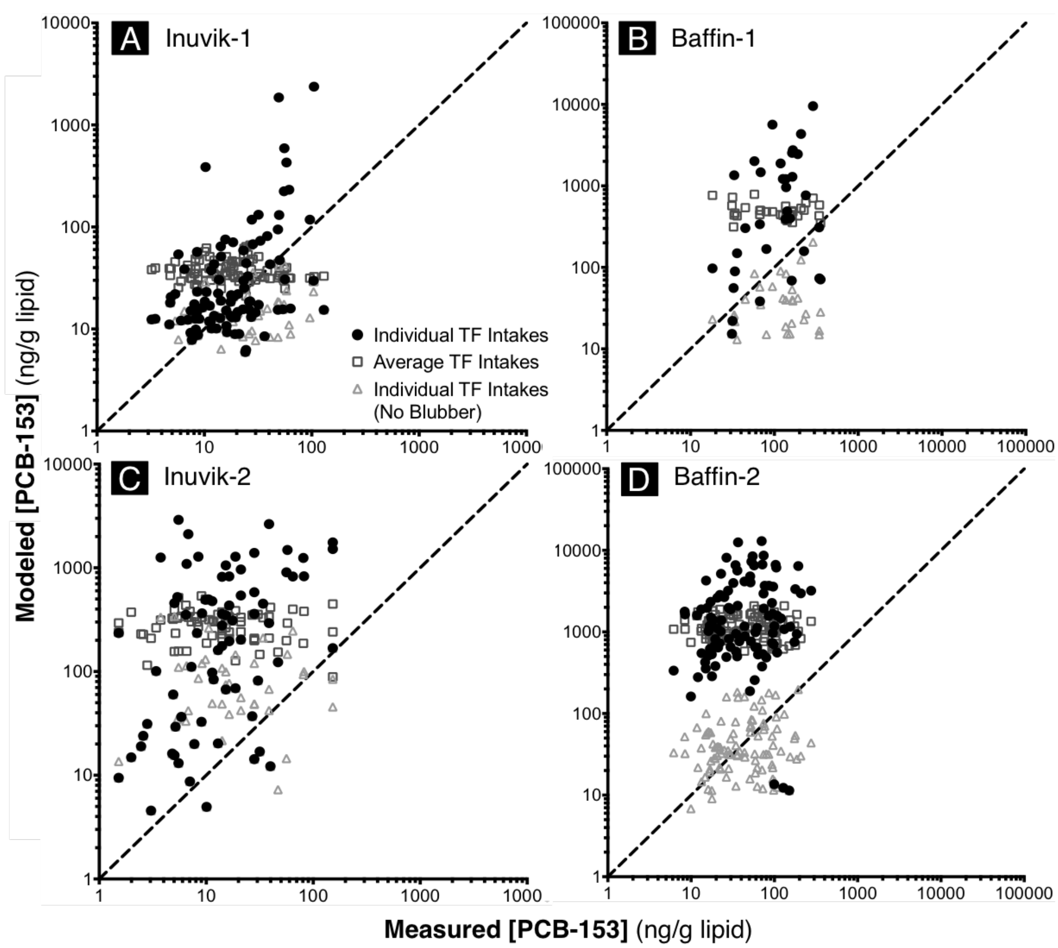


Figure 2 compares the predicted and measured concentrations of PCB-153 in each individual Inuvik and Baffin study participant. The dashed one-to-one lines represent perfect agreement between measured and modeled values. All four datasets showed appreciable model-measurement discrepancies, reaching as high as 3 orders of magnitude for each Inuvik and Baffin dataset (Figure 2A-D, black circles). Interestingly, the range of individual PCB exposures we predicted was significantly greater than the measured range. For example, measured PCB-153 concentrations ranged slightly less than 2 orders of magnitude among the Baffin-2 participants, while the predicted concentrations spanned over 3 orders of magnitude (Figure 2D). This difference was largely driven by significant model overestimates of PCB concentrations in certain subjects with middling measured exposures despite high reported marine mammal TF intakes, as we were able to more successfully reproduce levels in participants exhibiting higher measured concentrations. This reinforced our suspicion that reported TF and marine mammal consumption rates represent the main factors driving the variability in Inuvik and Baffin measured and modeled individual PCB exposure ranges.

Figure 2. Comparisons of measured PCB-153 blood concentrations to modeled PCB-153 exposure estimates for each individual participant in baseline and follow-up Inuvik and Baffin biomonitoring. Comparisons for Inuvik-1 (A), Baffin-1 (B), Inuvik-2 (C), and Baffin-2 (D) include exposures assuming participants each consumed TF items at their individual reported intake rates (black circles), assuming participants all consumed TF items at population mean intake rates (dark grey squares), assuming participants replaced all MM blubber with MM meat (light grey triangles). Dashed lines represent 1:1 measured to modeled agreement.



Two supplemental analyses also depicted in Figure 2 further illustrated the greater role of TF consumption in determining modeled, as opposed to measured individual PCB variability. The first involved estimating individual PCB exposures while assuming each biomonitoring participant consumed the corresponding population geometric mean amount of each TF item, rather than the daily amount they in fact reported (Figure 2A-D, dark grey squares). This hypothetical scenario caused modeled PCB exposure ranges to actually decline to appreciably less than measured ranges in all 4 biomonitoring campaigns. For the second analysis we plotted measured versus modeled PCB-153 exposures assuming all participants' reported MM blubber consumption was instead MM meat (Figure 2A-D, light grey triangles). In other words, modeled individuals consumed the same amount of total TF per day with MM blubber replaced entirely by meat from the same species. Generally, this scenario improved model accuracy by reducing the drastic overestimates of PCB-153 exposure among high MM consumers, particularly in the Baffin-2 group (Figure 2D).

As briefly discussed here, the fact that model performance correlated strongly with our perceived reliability of TF inputs calculated from individual reported TF consumption data, leads us to several major conclusions on the accuracy of prior dietary surveys using recall methods. For the baseline populations, the average of reported individual TF intakes may coincidentally provide a reasonable representation of true average TF intakes. However, it is also possible that average reported TF intakes for Inuvik and Baffin baseline studies only fortuitously result in model output that reasonably matches the average measured PCB exposures. Analysis of the follow-up studies served to underscore that any model is highly dependent on its key input parameters. Since we suspect that key TF intake input parameters in Inuvik and Baffin follow-up studies were over-reported and yielded consumption variables that were likely too high, our model is challenged in producing realistic results. The available TF and marine mammal intake estimates from the maternal studies in Inuvik and Baffin likely do not have sufficient accuracy to explain both measured human PCB exposure time trends and interindividual variability in exposure.

For our second major project, we performed a series of model calculations exploring POP and nutrient intake changes resulting from short-term TF replacement. As mentioned, our interest was in determining whether members of populations sensitive to POP-related toxicity (expectant, pregnant, and nursing mothers) experiencing PCB blood concentrations above the historical Health Canada level of concern (1 μg/L whole blood Aroclor 1260) could drop below this threshold by replacing certain TF items with others temporarily. Initial results suggest that replacing marine mammal (ringed seal, beluga whale, and narwhal) blubber with meat from these species, as well as Arctic char, caribou, Canada goose, or combination of all these food items is highly effective in lowering total PCB exposure when employed throughout childbearing age (18-45 y). However, these TF replacement scenarios also appreciably affected estimates of certain nutrient intakes; particularly iron, selenium, vitamin D, and the essential polyunsaturated fatty acids alpha-linoleic acid and eicosapentaenoic acid (EPA). In some cases, marine mammal blubber replacement caused maternal intake estimates of selenium and EPA to drop below Health Canada recommended dietary allowances (RDAs) for pregnant and nursing mothers. Continued work in this area will further examine the impacts of more short-term replacement scenarios (1-5 years) on PCB levels, and also explore realistic Aboriginal Arctic dietary transition cases, such as the community replacement of caribou in Nunatsiavut to alternative TFs based on sustainability issues.

For our third project, our goal was to characterize TF preparation impacts on beluga blubber nutrient and contaminant levels through time. We focused on studying fatty acids and selenium as nutrients, and PCBs, PFCs, and specific pesticides (ex. hexachlorobenzene, mirex, dichlorodiphenyltrichloroethane, etc.) through laboratory analysis. Samples from 2 beluga whales were collected, including baseline blubber immediately after whale butchering, hang-dried muktuk, boiled muktuk, roasted muktuk, muktuk aged for 2 and 5 days, and uqsuq (blubber oil) aged for 2 and 5 days. Samples were collected repeatedly from the same large blubber chunks, to remove any influence of varying nutrient and contaminant concentrations between different whale body regions (Krahn et al. 2004). For boiled muktuk, samples were cooked both traditionally in a large drum with multiple other whale pieces, and also on their own in a small pot to see whether mixing with all blubber pieces influences nutrient and contaminant levels differently. Aged uqsuq samples after 5 days consisted of both solid fat pieces, and fermented liquid oil. Our analysis is further aimed at comparing nutrient and contaminant levels between these phases, as well as with muktuk that had been stored in this mixture.

We hypothesized that the phase separation which occurs during muktuk/uqsuq aging would result in significantly different concentrations between solid blubber and the resulting liquid oil, and initial blubber analyses for PFCs demonstrated this to be the case. Generally, the concentrations of the PFC congeners consistently found in blubber (perfluorohexanoic acid, perfluoroundecanoic acid, and perfluorooctane sulfonate) varied little between solid muktuk samples cooked via different means, but grouped according to the whale of origin. However, concentrations of these ionogenic PFCs were significantly depleted from liquid uqsuq samples following 5 days of aging, presumably as a result of the extremely high lipid content in the liquid fat. Ongoing analyses are examining the levels of neutral POPs and nutrients in these same samples, and based on PFC results we suspect that levels of the neutral chemicals may become enriched in the aged uqsuq oil for similar reasons.

Conclusions

During the 2014-2015 project year we have made several significant advancements. Firstly, the determination that our current food chain bioaccumulation modeling approach is suitable to reproduce historical biomonitoring data on POP concentrations in Northern communities, indicating that this approach can be applied to additional biomonitoring datasets in the future. However, our experience with the Inuvik and Baffin datasets has demonstrated that model performance is highly dependent on the relative accuracy in biomonitoring questionnaire responses, particularly with respect to food frequency questionnaire data. Secondly, we determined the impact of hypothetical short-term TF replacement scenarios on POP and nutrient intakes in Aboriginal Arctic mothers, suggesting that substitutions of more highly contaminated TF items with those less contaminated can likely reduce dietary POP exposure during childbearing age (18-45 y) . The intakes of some critical nutrients can be affected by these dietary changes as well. Finally, we determined that distinct preparation methods appear to exert relatively minor influences on the levels of POPs in beluga blubber food items, with the exception of liquid uqsuq following phase separation. We expect that the full panel of results from this project (including neutral POPs and nutrients) may facilitate recommendation as to which beluga TFs might be preferentially consumed or avoided by populations sensitive to POP toxicity based on their chemical levels following preparation.

Current work entails further simulations using the ACC-human Arctic model to continue assessing short-term TF substitution, particularly devising scenarios accounting for TF availability differences between Arctic Canadian communities. We are also implementing the estimation of the effect of TF substitution on mercury uptake, using an approach that is similar to the one we adopted for nutrients. We will also complete our TF preparation analytical project during the present funding year. Our ultimate goal is to specifically describe the role of emissions regulation and dietary transitions in historical POP exposures. Finally, we still plan to construct a novel PBPK model to assess human exposure trends for mercury, as it is likely the most pressing contaminant-related concern in Northern Canada.

Expected Project Completion Date

August 2015

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Genetic polymorphisms to improve interpretation of contaminant exposure and risk in Inuit

Polymorphismes génétiques pour améliorer l'interprétation de données sur l'exposition aux contaminants et les risques liés aux contaminants chez les Inuits

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Abstract

The project's goal is to better understand how Inuit 'process' contaminants. The ultimate goal is to arm public health decision makers with knowledge to help identify the most susceptible subpopulations and make informed and objective risk assessments. Here, the central hypothesis was that analysis of polymorphisms in environmentally-responsive genes that help the body 'process' toxicants will increase understanding and utility of exposure biomarkers of mercury, PCBs, and other persistent organic pollutants. During the past year we studied already collected samples from some members of the Inuvialuit community

Résumé

Notre projet a pour but de mieux comprendre comment les Inuits sont touchés par les contaminants. Son objectif ultime est de fournir aux décideurs en santé publique les connaissances qui les aideront à déterminer les sous-populations les plus vulnérables et à effectuer des évaluations des risques éclairées et objectives. Notre principale hypothèse était que l'analyse des polymorphismes génétiques présents dans des gènes en interaction avec l'environnement qui aident l'organisme à « gérer » les substances toxiques augmentera la compréhension et l'utilité des biomarqueurs de l'exposition au mercure, aux BPC et à d'autres

(N=288 participants) who participated in the 2007-2008 International Polar Year Inuit Health Survey. Of the 360 genetic polymorphisms selected for study, 146 yielded statistically useful data and they hail from biological pathways associated with, for example, the transport and metabolism of contaminants and cardiovascular health. The composition of many of the genetic polymorphisms studied were different when compared against other populations such as Caucasians and Asians. Several of the genes were associated with significant changes in blood mercury levels. Next steps will be to further integrate the genetic data with the already-collected information on other contaminants, life-style and diet.

polluants organiques persistants (POP). Au cours de la dernière année, nous avons étudié des échantillons préalablement recueillis auprès de quelques membres de la collectivité des Inuvialuits (N= 288) ayant participé à l'Enquête sur la santé des Inuits menée lors de l'Année polaire internationale, en 2007-2008. Sur les 360 polymorphismes génétiques retenus pour l'étude, 146 ont produit des données utiles aux fins statistiques et proviennent de voies biologiques associées, par exemple, au transport et au métabolisme des contaminants et à la santé cardiovasculaire. La composition de bon nombre des polymorphismes génétiques étudiés différait en comparaison d'autres populations, comme les Caucasiens et les Asiatiques. Plusieurs des gènes étaient associés à des changements significatifs dans les concentrations sanguines de mercure. Les prochaines étapes consisteront à intégrer davantage les données génétiques à l'information déjà recueillie concernant d'autres contaminants, le mode de vie et le régime alimentaire.

Key messages

- 146 genetic polymorphisms were characterized from some members of the Inuvialuit community who participated in the 2007-2008 International Polar Year Inuit Health Survey
- Composition of many of the genetic polymorphisms were different when compared against other populations such as Caucasians and Asians
- Some genes are associated with changes in blood mercury levels
- Next steps will be to further analyze the genetic data with existing information on other contaminants and health measures

Messages clés :

- 146 polymorphismes génétiques ont été caractérisés chez des membres de la collectivité des Inuvialuits ayant participé à l'Enquête sur la santé des Inuits menée au cours de l'Année polaire internationale, en 2007-2008.
- La composition de bon nombre des polymorphismes génétiques différait en comparaison d'autres populations, comme les Caucasiens et les Asiatiques.
- Des gènes sont associés à des changements dans les concentrations sanguines de mercure.
- Les prochaines étapes consisteront à analyser plus en profondeur les données génétiques à la lumière de l'information existante concernant d'autres contaminants et paramètres de santé.

Objectives

1. **Long-term objective** of our research program is to better understand how Inuit process contaminants so that dietary exposure assessments can be improved

2. **Short-term goal** is to test the hypothesis that analysis of genetic polymorphisms will increase understanding and utility of exposure biomarkers of mercury, PCBs, and other persistent organic pollutants.

Introduction

A critical feature of decision-making and risk assessment is to relate biomonitoring data (i.e., blood biomarker values) to health guideline values. However, guideline values are derived to protect the entire population and thus may over- or under-protect particular segments of the population and thus lead to erroneous decisions. We illustrate this here using mercury as an example. Risk assessors assume a constant and linear relationship between dietary methylmercury exposure and body burden (i.e., hair mercury levels). In a re-analyses of several epidemiological studies, we documented that such an approach yields highly variable outcomes (Canuel et al., 2006). For example, we re-analyzed a 1992 dataset from Nunavut and found that predicted hair mercury values (18.1 ppm) in Inuit were nearly 5-times higher than the measured value of 3.8ppm. In this paper we concluded that "the relation between between methylmercury oral dose and body burden… may vary among certain ethnic groups" and "metabolic excretion rates might vary according to ethnicity", however very little is known about these topics.

Risk assessments attempt to account for variability by utilizing default uncertainty factors (Basu et al., 2014). Uncertainty factors increase the margin of safety in an effort to protect sensitive subgroups, but in doing so they may still prove to be insufficient or perhaps even over-protective. As we embark upon next-generation risk assessment (Zeise et al., 2013), there is a need to harness emerging ecogenetic approaches (e.g., genetic polymorphisms) to help increase understanding of true biological variation across and within individuals and ethnic groups so that uncertainty factors are refined and risk assessments improved. From the 2009 AMAP Human Health Assessment, "too little is known about the genetics of [Arctic] populations to elucidate the implications of contaminant-genetic interactions on health. Because the genetic background of the Inuit differs compared with Caucasians these genetic differences must … become a part of the future studies on Arctic populations because the genotype may be fundamental to the effects of exposure to environmental contaminants".

Activities in 2014-2015

This was the first year of the project, and thus a majority of the time was spent identifying and organizing the research partners, biological samples, and datasets. The larger research project will focus on two geographically separated Inuit communities for which we have detailed cross-sectional epidemiological data: the Inuvialuit community (Chan, 2012; Laird et al., 2013b) from the 2007-2008 International Polar Year Inuit Health Survey, and the Nunavik population (Dewailly et al., 2007) as part of the 2004 Qanuippitaa Survey. By studying samples collected from both studies, we will have a robust sample size of approximately 1,000 participants which would enable us to explore gene-environment interactions with greater confidence.

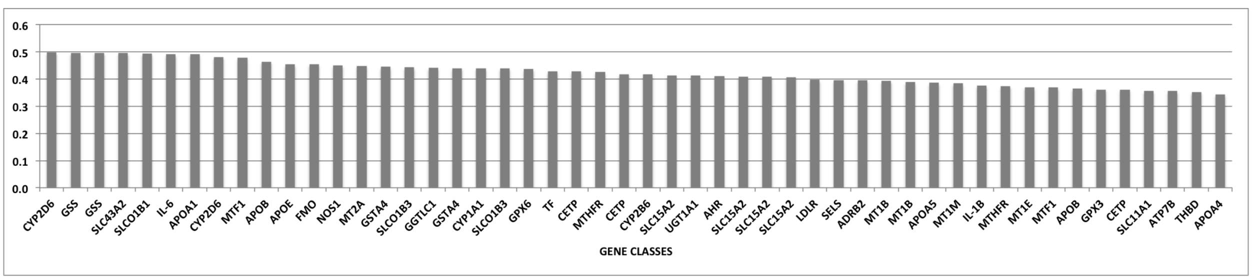
In the 2014-2015-year, we focused on the samples collected in the Inuvialuit Settlement Region (ISR) during the IHS. Already isolated genomic samples were obtained by Dr. Hegele's group at Western University, and shipped to Genome

Quebec in early 2015. Of the 288 samples sent to Genome Quebec, 285 were deemed technically acceptable for further study. A total of 360 genetic polymorphisms were initially selected for study. 146 of these yielded useful data, and they hail from biological pathways associated with the transport and metabolism of contaminants and cardiovascular health. The analysis of genetic polymorphism was completed in late March 2015. The data was matched with the existing IHS database for blood contaminant concentrations and other life-style and diet information. The merged database is now undergoing statistical analyses by Dr. Parajuli (postdoctoral fellow, McGill University) and Dr. David Hi (postdoctoral fellow, University of Ottawa). The basic analyses concerning blood mercury has been completed and is presented here.

Results

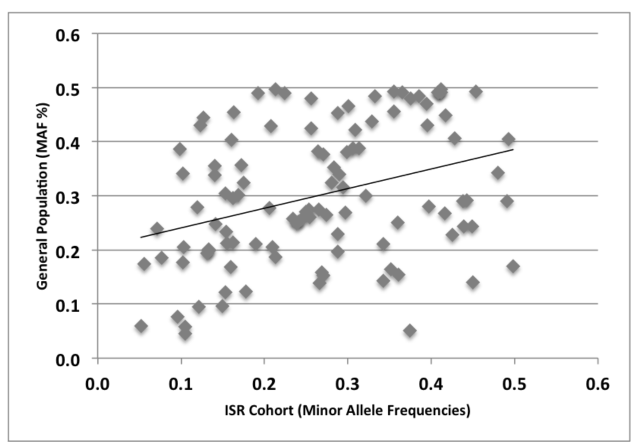
Results of the full analysis of all ISR data will be completed in mid- to late-2015, but some preliminary findings are presented in this report. Figure 1 shows the top 50 genetic polymorphisms characterized in terms of those with the highest frequencies of minor alleles (MAF %) which ranged from 34.3% to 49.8%. The composition of many of the genetic polymorphisms studied were different when compared against other populations such as Caucasians and Asians.

Figure 1. Top 50 genetic polymorphisms characterized from the current study in terms of those with the highest minor allele frequencies (MAF % on the Y-axis), organized according to gene classes.



In Figure 2, the minor allele frequencies calculated from the current study against values reported globally (i.e., from the 1000 Genomes project) were compared. The result shows that there was no strict 1:1 linear relationship (y=0.36x + 0.2). This suggests that key genes involved in the processes by which humans metabolize contaminants can vary across populations, i.e. some responses of Inuit to contaminants may be different from those of the general populations. Therefore, the understanding of such variation will be important to better interpret the true nature of the risks posed by exposure to contaminants towards Inuit health. Next steps will be to integrate the genetic data with the already-collected information on blood contaminant concentrations, life style and diet. Preliminary result for analysis on the relationship with blood mercury concentrations is presented here.

Figure 2. Minor allele frequencies calculated from the current study versus those reported as the global minor allele frequency (i.e., representative of the global population).



A total of nine polymorphisms were identified that were significantly associated with blood mercury concentrations (Table 1). In general, the mean change in blood mercury ranged from -41% to +90%. It is interesting to note that some polymorphisms previously shown to influence mercury biomarker levels from other populations were not deemed significant here (e.g., those in the glutathione or metallothionein pathway). Polymorphisms in MTRR may lead to changes of homocysteine and methionine levels in blood, which may explain the increase of mercury concentrations in the blood as mercury is known to have a high binding affinity to these sulphur-compounds. The positive associations with the transporter proteins SLC15A2 and ABCB1 suggest that mercury may stay in the blood longer in these participants before they are excreted in the urine and the intestine. More detailed analysis of the functional relationship will be conducted when the finding is validated by Nunavik data.

Table 1. Association between genetic polymorphisms and blood mercury levels (ug/L). Those yielding statistically significant changes are shown. In relation to those individuals carrying the major homozygote, the ones highlighted in red or green are minor allele cases in which blood mercury levels were significantly higher or lower, respectively.

Gene symbol	SNP	Biological Pathway	n (Gene & Hg)	MAF	Blood Hg			% Change
					Geometric mean ±SD			
					[a]Maj_Homo	[b]Heterozy	[c]Min_Homo	
MTRR	rs1801394	Folate Pathway	247	0.27	32.74±31.33d	29.11±32.83d	45.96±45.71 d	41%
MTRR	rs3776467	Folate Pathway	246	0.16	30.12±32.16e	37.52±36.52e	45.27±35.80e	50%
TXNRD2	rs1139793	Oxidative Stress	243	0.23	35.88±35.21f	26.88±29.00f	27.92±28.23f	-22%
SLC15A2	rs2257212	Transporter	243	0.41	31.94±36.01g	28.71±28.96g	39.32±28.58 g	23%
SLC15A2	rs2293616	Transporter	228	0.41	32.50±37.18h	29.82±32.60h	41.58±29.08 h	28%
ABCB1	rs3213619	Transporter	248	0.05	30.94±32.79i	44.40±35.02i	NA	44%
ABCB1	rs3842	Transporter	239	0.13	32.46±32.46j	28.95±26.93j	61.90±64.72j	90%
CYP2C19	rs4244285	Xenobiotic Metabolism	247	0.13	30.81±33.58k	39.06±32.92k	18.32±25.61k	-41%
ALAD	rs1805313	ALAD	247	0.26	34.07±37.86m	31.28±26.66m	21.91±18.34 m	-36%

Discussion and Conclusions

As indicated above, this is the first year of a larger project. The initial analysis of the ISR data (Year 1, 2014-2015) of the overall study re-affirms our stated objective that there are genetic differences between Inuit and other populations in terms of the composition of genes that handle contaminants, and that some of these may be significantly associated with altered biomarker levels. In the current analyses we were able to characterize the blood mercury levels and showed that nine genes may help explain altered blood mercury levels that are -41% to +90% of expected. In the coming year (2015-2016) we will continue to analyze the ISR dataset to characterize the influence of genetic polymorphisms on other contaminants, as well as contaminant and health measure associations, and also aim to increase the overall sample size by using already isolated DNA from Nunavik as part of the 2004 Qanuippitaa Survey. When the two studies are combined, the overall sample size will approach 1,000 and thus result a very robust epidemiological dataset that can be used to ask important questions concerning gene-contaminant interactions, with the hope that this will lead to improved risk assessments and decisions that are better tailored to Inuit.

Expected Project Completion Date

We expect to complete the ISR data analysis by the end of 2015 and will report the results to the ISR Steering Committee. We will begin the genetic polymorphism analysis of the Nunavik samples in the fall of 2015. The data analysis of the Nunavik samples will be completed by summer of 2016 and the results will be reported back to the Nunavik Steering Committee. We will continue to analyze the combined dataset mid-2016 to March 2017. The overall project that would consist of a thorough epidemiological gene-environment study involving the Inuvialuit and Nunavik cohorts is expected to take three years and finish by March 2017.

Acknowledgments

We thank all the 2007-2008 Inuit Health Survey participants from Inuvialuit. We specially thank Shannon O'Hara, the Inuit Research Advisor for the Inuvialuit Regional Corporation and member of the ISR Steering Committee, for the support of this project. Funding for this project was provided by the Northern Contaminants Program.

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Contaminant biomonitoring in the Dehcho Region: A pilot investigation of the links between contaminant exposure, nutritional status, and country food use

Biosurveillance des contaminants dans la région du Dehcho : étude pilote sur les liens existant entre l'exposition à des contaminants, l'état nutritionnel et la consommation d'aliments traditionnels

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Abstract

For this pilot project, a tablet-based dietary survey for the characterization of traditional food consumption in the Northwest Territories was designed and evaluated. This electronic dietary survey was based upon a Food Frequency Questionnaire implemented by CINE scientists in the Dehcho Region in the 1990's in order to promote consistency with previous research. In December 2015, our research team traveled to two communities (Kakisa, NT and Jean Marie River, NT) in the Dehcho Region of the Northwest Territories in order to discuss the adequacy of the survey as well as ways by which the survey could be improved. Most focus group participants were generally satisfied with the survey, commenting that they found tablet-

Résumé

Pour ce projet pilote, une enquête alimentaire sur tablette électronique portant sur la caractérisation de la consommation d'aliments traditionnels dans les Territoires du Nord-Ouest a été conçue et évaluée. Cette enquête alimentaire sur support électronique s'appuyait sur un questionnaire concernant la fréquence de consommation réalisé par des scientifiques du CENEPA dans la région du Dehcho dans les années 1990, afin de favoriser la cohérence avec la recherche antérieure. En décembre 2015, notre équipe de recherche s'est rendue dans deux collectivités de la région du Dehcho (Kakisa et Rivière Jean-Marie), dans les Territoires du Nord-Ouest, pour discuter de la pertinence

interface intuitive and easy-to-use. The focus groups provided several suggestions for the survey, including the addition of more locally-relevant names and the clarification of typical preparation and cooking methods. Additionally, participants brought to our attention several traditional foods and plants that were missing from the survey (e.g.,, elk, white-tail deer, bison, high bush cranberries, spruce gum, ratroot). Finally, focus group participants provided very useful details on the seasonal availability of particular food items. This electronic dietary survey, which was revised according to this valuable feedback, will be included within a contaminant biomonitoring project planned for the Northwest Territories in 2015-2018.

de l'enquête et des façons de l'améliorer. La plupart des participants des groupes de concertation se sont dits généralement satisfaits de l'enquête, l'interface de la tablette électronique leur semblant intuitive et conviviale. Les groupes de concertation ont formulé des suggestions pour le déroulement de l'enquête, notamment l'ajout de noms plus adaptés localement et la clarification des méthodes de préparation et de cuisson typiques. De plus, les participants ont porté à notre attention plusieurs aliments traditionnels et végétaux qui manquaient dans notre étude (p. ex. wapiti, cerf de Virginie, bison, viorne trilobée, résine d'épicéa, rat root). Enfin, les participants des groupes de concertation ont fourni des détails très utiles sur la disponibilité saisonnière de certains aliments. Cette enquête alimentaire sur support électronique, revue à la lumière de ces informations précieuses, sera incluse dans un projet de biosurveillance des contaminants dans les Territoires du Nord-Ouest prévu pour 2015-2018.

Key messages:

- Following consultation at the Return to Country Food Workshop (August, 2014) workshop participants expressed a strong interest in conducting biomonitoring research in the Dehcho Region.
- Community consultations were held in Kakisa, NT and Jean Marie River, NT in December 2014 to determine, if such a biomonitoring project should happen, what it should look like.
- An electronic dietary survey was designed and evaluated through focus groups in the Dehcho Region.
- This electronic dietary survey will be included within the biomonitoring research to be built off this pilot project.

Messages clés

- Après consultation lors de l'atelier sur le retour aux aliments traditionnels (août 2014), des participants se montrés très intéressés par la réalisation d'une étude de biosurveillance dans la région du Dehcho.
- Des consultations communautaires ont été menées à Kakisa et à Rivière Jean-Marie, dans les Territoires du Nord-Ouest, en décembre 2014 pour déterminer la forme que pourrait prendre cet éventuel projet de biosurveillance.
- Une enquête alimentaire sur support électronique a été conçue et évaluée par des groupes de concertation dans la région du Dehcho.
- Cette enquête alimentaire sera incluse à la recherche de biosurveillance à mettre au point à la lumière du projet pilote.

Objectives

The short term objectives for this pilot research were to:

- Adapt an existing dietary survey for use in the Dehcho Region;
- Hold focus groups to evaluate the relevance and understandability of the dietary survey;

The long term objectives of this research project are to:

- Execute a cross-sectional biomonitoring study that evaluates contaminant exposure and nutritional biomarkers among study participants in the Dehcho Region.
- Create a public health screening tool that can be used to characterize those most at risk of facing elevated contaminant exposures in the Dehcho Region.
- Develop public health communication strategies that promote country food reliance in order to maximize nutrient status while minimizing contaminant exposure in the Dehcho Region.

The realization of these objectives complement ongoing community-based environmental mercury monitoring research underway by co-applicants George Low and Heidi Swanson.

Introduction

Country food consumption is integral to the health, wellness, and food security of the Aboriginal communities within the Dehcho Region of the NWT [1-4]. Further, the consumption of such country foods has been associated with lower risk factors for cardiovascular disease and diabetes [5-7]. However, these food items can also pose potential chronic health risks via exposure to contaminants such as mercury (Hg) and cadmium (Cd). Elevated Hg concentrations in some fish species in some lakes in the Dehcho Region (Northwest Territories) have resulted in a series of food consumption advisories that suggested people limit their consumption of walleye, northern pike, and lake trout from specific lakes in the region [8]. Additionally, elevated Cd levels have been recorded in the organs (e.g., kidneys, livers) of moose from some parts of the territory [9]. However, the true extent of exposure for residents of the Dehcho First Nations (DFN) to these contaminants and others is not well characterized. This is because the extrapolation of human contaminant exposures from levels in foods is hindered by uncertainty in food consumption patterns as well as toxicokinetic variability between individuals. The direct measurement of contaminant levels in human tissues and fluids, termed biomonitoring, is often regarded as the gold standard for human exposure assessment because it implicitly accounts for dietary patterns and inter-individual toxicokinetic differences [10]. Therefore, a contaminant biomonitoring study has been proposed within the Northwest Territories in order to investigate the current levels of contaminant exposure among Dehcho First Nations. In order to facilitate such a biomonitoring study, we conducted pilot work developing and evaluating a dietary questionnaire to be implemented as part of the biomonitoring project. This work incorporates a risk-benefit approach to promote the use of country foods in order to improve nutrition and food security while lessening contaminant exposure among Dehcho First Nations communities.

Activities in 2014-2015:

With pilot NCP funding in 2014, we implemented a two phase strategy to lay the groundwork for contaminant biomonitoring research in the Dehcho Region, NT.

Phase 1: Dietary Survey Development (September – November 2014) A dietary survey (i.e., semi-quantitative Food Frequency Questionnaire or FFQ) was adapted to ensure relevance for DFN [11-13]. Local experts provided guidance on portion sizes, seasonality of consumption patterns, availability of particular food items, and the range of typical cooking methods. With this FFQ, we can gather information on the quantity and types of traditional foods harvested, the locations where these foods are harvested, and the frequency by which these foods are consumed in the Dehcho Region. A previously validated FFQ, used by the Centre for Indigenous Peoples' Nutrition and Environment (CINE) in 1994 [14], was used as the starting point for the dietary survey. The resulting questionnaire, which included a Species Identification Guide, was transferred to an electronic format that can be implemented on tablet technology.

Phase 2: Survey Evaluation (November-December 2014) The evaluation and revision process of the FFQ used modified focus group/sharing circle methodologies [15]. Local coordinators recruited participants (n=12) to complete the survey as a group. In each focus group, we requested input on the completeness, cultural relevance, and comprehensibility of the survey. This feedback included input on the addition of any foods missing from the survey as well as their overall satisfaction with the survey. After incorporating the revisions suggested by the focus group participants, the reliability of the e-survey was evaluated through a standard test-retest framework. For this reliability test, local research coordinators recruited 8 participants from both Jean Marie River, NT and Kakisa, NT to take the dietary survey on two occasions. The dietary survey developed through Phase 1 and evaluated through Phase 2 of this pilot research will be included within the subsequent biomonitoring research to be undertaken by the project team in 2015.

Capacity Building

Providing training and capacity building opportunities has been central to this work. For this pilot project, one local research coordinator was hired in each of Jean Marie River, NT and Kakisa, NT. These coordinators received training on the recruitment of project participants as well as the use of a Food Frequency Questionnaire to evaluate traditional food use. It is our intention to build upon this capacity building with a range of training and work opportunities within each community that takes part in the subsequent biomonitoring research.

Communications

We have held regular conversations with representatives and leadership from Kakisa, NT and Jean Marie River, NT, and Dehcho AAROM to discuss the status of the pilot research and discuss the next steps in terms of the larger biomonitoring project. Additionally, we have attempted to coordinate on these topics with Health Canada, Government of Northwest Territories Department of Health and Social Services, the Dehcho Health and Social Services Authority, and the Regional Contaminants Committee. The results from this pilot work are to be disseminated within a brief, plain-language report to be distributed to the participating communities and each of the project partners. This plain-language report will include both the preliminary dietary survey results as well as factsheets that describe the risk-benefit balance of contaminants and nutrients in country foods in the Dehcho region. Further, in collaboration with Chief Gladys Norwegian, we are building additional links between the proposed human health research and ongoing environmental contaminant monitoring and climate change research in the region.

Traditional Knowledge Integration

The project has relied on local and traditional knowledge communicated through the 2014-2015 community consultations for guiding any future return of biomonitoring results and knowledge translation. Local perspectives provided by members of the Dehcho First Nations have helped ensure that the mission and design of this research addresses the priorities and concerns of Aboriginal people within the Dehcho Region. Additionally, the project has incorporated the knowledge of local experts for the development of the dietary survey. This local knowledge will be crucial in ensuring that the dietary survey uses the species names that recognized by members of the DFN. Other important types of local knowledge that we have tried to include within the dietary questionnaire include: seasonality of food availability and consumption, and preparation methods. As suggested in the 3rd Annual Return to Country Food Workshop, we will explore ways by which traditional knowledge can be incorporated into the results dissemination at both the individual and community level.

Results

Participants of the Return to Country Food Workshop, held in Jean Marie River, NT in August 2014, expressed an interest in learning more about the nutritional benefits and contaminant risks from consuming traditional food. Participants also affirmed a desire to see a biomonitoring study take place in the Dehcho Region in order to address community concerns regarding current contaminant exposures. Further participants indicated a desire for environmental scientists and public health researchers to coordinate their efforts in order to obtain a more holistic picture of the movement, interactions, and impacts of contaminants in the Dehcho Region.

Participants of the focus groups held in December 2014 were asked how the dietary survey could be improved and/or made more relevant to communities within the Dehcho Region. Some suggestions revolved around the inclusion of local names for specific traditional foods (e.g., loche vs. burbot). Other suggested revisions included the addition of some traditional foods and plants that had been missing from the dietary survey (i.e., ratroot, elk, bison, high bush cranberries, spruce gum and whitetail deer) as well as the addition of specific organs/parts (e.g., moose tripe). We also received useful feedback on how the list of preparation/cooking methods could be clarified within the survey. These suggestions were incorporated into the dietary survey before undertaking the reliability test of the FFQ, work that is ongoing.

Discussion and Conclusions

This 2014-2015 NCP research will lay the groundwork for a subsequent biomonitoring project planned to begin in the Northwest Territories in 2015-2016. This biomonitoring project will inform the development of regionally-specific communication tools that promote the consumption of county foods in a way that improves the food security and nutrition within Dehcho communities while lowering exposure to dietary contaminants. Furthermore, the biomonitoring research will provide the information needed to create a screening tool to help identify those who are most at risk of contaminant exposure. This screening tool, which has been labeled as a critical outcome by the policy leaders on our research team, will enable contaminant risk messaging and follow-up interventions at the individual and population level to be targeted to those most at risk. The dietary survey developed and evaluated through this pilot project shall provide critical information for the identification of the most significant sources of exposure for the contaminants studied within the subsequent biomonitoring project.

Expected Project Completion Date

March 31, 2015

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Community Based Monitoring and Research

Surveillance communautaire et recherche

Mercury levels in food fish species in lakes used by Dehcho community members with a focus on choice and risk perception of eating traditional country food

Concentrations de mercure chez les poissons comestibles vivant dans des lacs utilisés par les membres de la collectivité du Dehcho, avec insistance sur le choix et la perception du risque lié à la consommation d'aliments traditionnels

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Abstract

Mercury levels in fish in some Dehcho lakes have been found to be high and increasing in some cases. The Dehcho Aboriginal Aquatic Resources and Ocean Management (AAROM) program has been collaborating with Dr. Marlene Evans of Environment Canada on her temporal study of mercury levels of fish in Dehcho Region lakes. AAROM has contracted community First Nations in the region to collect fish for sampling from fishing lakes in Dehcho territory. Environment Canada analyses the samples for mercury levels and reports results back to the Dehcho AAROM and to NCP.

Résumé

On a relevé des concentrations de mercure élevées, et parfois même croissantes, chez les poissons de certains lacs du Dehcho. Le Programme autochtone de gestion des ressources aquatiques et océaniques (PAGRAO) du Dehcho a collaboré avec la professeure Marlene Evans, d'EC, dans le cadre de son étude temporelle sur ces concentrations. Le PAGRAO a mandaté les collectivités des Premières Nations pour recueillir, à des fins d'échantillonnage, des poissons des lacs du territoire du Dehcho. EC s'occupe d'effectuer des analyses des concentrations de mercure présentes dans les échantillons et d'en soumettre les résultats

Dr. Heidi Swanson of the University of Waterloo is collaborating with Dehcho AAROM in a study titled; "Understanding and predicting fish mercury levels in the Dehcho Region using models of bio-magnification and bio-accumulation." Most of our study funding is provided by NWT CIMP, the Dehcho AAROM and in-kind from the University of Waterloo however NCP provides funding for the analysis of mercury and stable isotopes. We have completed the second year of a three year study with the sampling of Trout, Ekali, and Sanguez lakes in 2013 and Tathlina, Gargan and McGill in 2014. Kakisa, Mustard and Big Island lakes will round out the study in 2015. (Study detail is on the Polar Data Catalogue # 11918).

NCP has shared funding of our annual "A Return to Country Foods" workshop. The 2014 workshop was successful with Grand Chief Herb Norwegian speaking of the benefit of traditional and scientific knowledge complimenting each other. Forty eight First Nation and Metis leaders, environmental managers, elders and harvesters discussed various studies as presented by eight researchers and government managers. All went away with a better understanding of each other's perspectives on the mercury issues and the importance of including fish in a healthy diet. Chief Stanley Sanguez of Jean Marie River recommended that researchers design a fish-down study of Sanguez Lake to see if the population of large, old predator fish could be removed and a more normal population established. Results of this AAROM funded pilot study may be applicable to other lakes with similar population imbalances.

au PAGRAO, ainsi qu'au Programme de lutte contre les contaminants dans le Nord (PLCN) du Dehcho.

La professeure Heidi Swanson, de l'Université de Waterloo, collabore avec le PAGRAO du Dehcho dans le cadre d'une étude intitulée : *« Déterminer et prédire les concentrations de mercure dans les poissons de la région du Dehcho à l'aide de modèles de bioamplification et de bioaccumulation »*. Notre étude est financée en grande partie par le Programme de surveillance des effets cumulatifs des Territoires du Nord-Ouest (PSEC des T.N.-O.) et le PAGRAO du Dehcho, ainsi que par les contributions en nature de l'Université de Waterloo. Le Programme de lutte contre les contaminants dans le Nord (PLCN) fournit également un financement pour la réalisation d'analyses du mercure et des isotopes stables. Nous avons terminé la deuxième année de notre étude triennale en procédant à un échantillonnage des truites des lacs Ekali et Sanguez en 2013, et des lacs Tathlina, Gargan et McGill en 2014. On terminera l'étude en 2015 en effectuant un échantillonnage des lacs Kakisa, Mustard et Big Island. (Le Polar Data Catalogue n° 11918 fournit de plus amples détails sur l'étude).

Le PLCN a cofinancé notre atelier annuel sur le retour aux aliments traditionnels (*A Return to Country Foods*). L'atelier de 2014 a connu un franc succès. Le grand chef Herb Norwegian y a fait une présentation sur les avantages découlant de la complémentarité des connaissances traditionnelles et scientifiques. Quatre-vingt-huit chefs de Premières nations et de communautés métisses, gestionnaires de l'environnement, aînés et chasseurs ont discuté des différentes études qu'ont présentées huit chercheurs et gestionnaires de la fonction publique. À la fin de l'événement, ils comprenaient tous mieux les points de vue des uns et des autres à l'égard des problèmes liés au mercure, ainsi que l'importance d'intégrer le poisson à son alimentation. Le chef Stanley Sanguez, de Jean Marie River, a recommandé que les chercheurs étudient les relations trophiques entre les poissons dans le lac Sanguez afin de déterminer s'il serait possible d'éliminer les poissons prédateurs de grande taille et d'âge avancé et de faire en sorte qu'une population plus normale s'établisse dans ce milieu. Les résultats de cette étude pilote financée par le PAGRAO pourraient s'appliquer à d'autres lacs présentant les mêmes déséquilibres.

Key messages

- Mercury levels in some predatory fish in some lakes in the Dehcho Region have been found to be high and in some cases increasing.
- Fish from Dehcho lakes are being checked for mercury levels and low risk lakes and species are being identified for community fisheries.
- Heidi Swanson, a researcher from the University of Waterloo is studying the understanding and predicting of mercury levels in fish using models of bio-magnification and bio-accumulation.
- The 3rd annual Return to Country Food workshop brought together First Nation and Metis leaders, environmental managers, elders and harvesters with researchers and government managers resulting in a greater understanding of each other's mercury concerns and issues.
- A mitigation strategy for lakes with fish populations that have high mercury levels was discussed and resulted in a recommendation for Dehcho AAROM to lead a fish-down study of a representative lake with involvement of the community of Jean Marie River.

Messages clés

- On a relevé des concentrations de mercure élevées, et parfois même croissantes, chez certains poissons prédateurs de certains lacs de la région du Dehcho.
- On étudie actuellement les poissons des lacs du Dehcho afin de mesurer les concentrations de mercure qu'ils contiennent. On procède également à une identification des lacs et des espèces présentant un faible risque.
- Heidi Swanson, chercheuse à l'Université de Waterloo, mène actuellement une étude qui vise à déterminer et à prédire les concentrations de mercure chez les poissons à l'aide de modèles de bioamplification et de bioaccumulation.
- Le 3e atelier annuel *A Return to Country Foods* a réuni des chefs de Premières nations et de communautés métisses, des gestionnaires de l'environnement, des aînés, des chasseurs, des chercheurs et des gestionnaires de la fonction publique et a permis à ces derniers de mieux comprendre les problèmes liés au mercure et les préoccupations des uns des autres.
- On a discuté de la possibilité de mettre en place une stratégie d'atténuation pour les lacs qui abritent des poissons présentant des concentrations élevées de mercure, après quoi on a recommandé au PAGRAO du Dehcho de mener en collaboration avec la collectivité de Jean Marie River une étude des relations trophiques entre les poissons dans un lac représentatif du problème en question.

Objectives

1. To build an inventory of low risk fishing lakes with respect to mercury contamination by continuing to test fish in new lakes. To promote the use of low risk species such as whitefish and suckers and the selection of small predatory fish for food.
2. To study the bio-magnification and bio-accumulation of mercury in fish in Dehcho lakes in order to predict low risk lakes and find ways of mitigating mercury levels in fish populations.
3. To organize an annual workshop is to facilitate dialogue among community leaders, managers, AAROM monitors and Committee members on environmental issues and concerns. Experts invited to present at the workshops will provide technical/scientific information to increase the community participants' knowledge of contaminants.
4. To devise ways of increasing availability of country food, especially with respect to fish. Testing new fishing lakes; fishing down stocks to reduce the average size of predatory fish; informing the communities of healthy sources and low risk species of fish. Discussions to include health and wellness benefits of including country food especially fish in the diet.
5. To educate youth on the importance of traditional culture and the benefits of country food in a balanced diet and to encourage youth to enrol in post-secondary education, especially in resource management and/or environmental and biological sciences.

Introduction

- In the 1990s, a study showed that mercury levels (with long range atmospheric transport a contributing factor) were elevated in predatory fish from some inland lakes along the Mackenzie Valley (Stewart et al. 2003). These results were of concern because the study lakes were used for subsistence fishing, and because predatory species such as lake trout, walleye and northern pike were, in some cases, found to have mercury levels that exceeded Health Canada's Guidelines for commercial sale (0.5 ppm wet weight) and subsistence consumption (0.2 ppm wet weight). As a result of the perceived human health risk, <u>some</u> fish species from <u>some</u> lakes in the Dehcho region have been assigned consumption advisories and/or guidelines that aim to reduce human exposure to fish-derived mercury.
- The Dehcho First Nations AAROM program, in collaboration with Environment Canada, has been updating the data on mercury levels in fish from lakes in the Dehcho region. Mercury levels in predatory fish in some lakes are high and may be increasing due to climate change effects and other factors such as reduced harvest. Dehcho AAROM continues to collaborate with Environment Canada by collecting fish to be analyzed for mercury.
- Dehcho AAROM is also concerned that mercury studies may have contributed to the decline in fish in the diet in Dehcho communities. An AAROM survey in collaboration with Health Canada studied the apparent shift in diet from fish and other country food towards a market-based diet. People in some communities are consuming less fish and other country food than previously. **Part of the reason seems to be a perception that water and fish are no longer safe because of the presence of mercury and**

other contaminants. These perceptions need to be examined and discussed at the regional and community level in order to encourage people to return to a healthy traditional diet.

- Dr. Heidi Swanson of the University of Waterloo is investigating "why the mercury levels in some fish species and lakes have increased over the last ten or fifteen years whereas mercury levels in other fish species and lakes have remained stable. If it is possible to ascertain why mercury levels are rising in some species and lakes (slower growth, longer food chains, greater potential for methylation), the Dehcho leadership would like to know if there are mitigation strategies, and/or follow-up studies that would help to ensure safe food fishes for their members". The study is entitled " Understanding and predicting fish mercury levels in the Dehcho region using models of bio-magnification and bio-accumulation"

- **An important part of this project relates to communications, capacity building and outreach.** The third annual Return to Country Foods workshop was held in Jean Marie River in August of 2014. It provided a forum for discussions between community leaders, harvesters, elders and youth from the communities and researchers and government authorities not only on contaminant research but also on the health and wellness benefits of including fish and other traditional foods in the diet. Information from mercury studies need to weigh the benefits of eating fish against the risks from contaminants such as mercury. People need to be informed that non-predatory fish such as whitefish and suckers are usually low in mercury and that the fish from some lakes have tested as low risk and are safe to eat. The annual workshops have provided a forum for study result presentations and discussion; interface between community members, government and academic researchers and has provided guidance on future work.

Activities in 2014-2015

- Fish samples collected for Marlene's mercury analysis study collected from;
  - Trout Lake; 20 lake trout, 20 walleye
  - Cli Lake; 20 lake trout, 14 burbot, 20 whitefish
  - Fish Lake; 17 lake trout, 20 walleye

- Fred Jumbo, Charlie Tali and John Tsetso from Sanbaa K'e, Pehdzeh Ki and Liidlii Kue used their traditional knowledge and skills to collect the fish in the most effective manner from the above lakes. They became more familiar with this sort of work.

- Heidi's samples collected from Tathlina, Gargan and McGill lakes with the assistance of Melaine Simba from Ka'a'gee Tu and Angus Sanguez from Jean Marie River. The crew learned more about Heidi's project on the job. The samples were analysed for mercury and stable isotopes.

- Successful annual Return to Country Food workshop held in Jean Marie River, August 2014. Forty Eight leaders, Environmental coordinators, elders, and harvesters attended. Eight researchers and govt. managers presented. There was lively discussion all around. The workshop is a great communication event. It gets the messages to the Dehcho leadership.

- Youth Ecology Camp this year was a canoe trip down the Mackenzie River from Fort Providence to Jean Marie River. The trip was a real environmental challenge with high winds, thunderstorms and extensive forest fires (we are in a record drought) Bruce Townsend, BEAT Environmental lead the students through our science modules

Results

Lakes sampled for fish mercury levels to date;

- McGill Lake; 19 pike, 20 walleye, 3 lake whitefish
- Fish Lake; 19 pike, 5 walleye and 6 trout
- Ekali Lake; 16 pike,18 walleye, 20 whitefish; 2013 -
- Sanguez Lake; 20 Northern Pike, 20 Walleye;
- Gargan; 13 Pike, 8 Lake Whitefish
- Trout Lake; 20 Lake Trout (2011) 20 Lake Trout (2012), 20 walleye (2012), 16 Lake Trout , 20 walleye (2013)
- Tathlina Lake; 54 walleye , 20 pike; & 20 walleye (2013)
- Kakisa Lake; 20 walleye (2013)
- Willow Lake; 16 lake trout, 20 northern pike, 20 lake whitefish
- Big Island Lake; 20 lake trout, 16 northern pike, 20 burbot, 20 lake whitefish
- Mustard Lake; 8 Lake Trout, 16 Burbot, 17 Lake Whitefish, 16 Northern Pike
- Little Doctor Lake: 27 Lake Whitefish, 8 walleye, 3 Burbot, 4 Suckers.
- Mackenzie River (near mouth of Redknife River; 12 Lake Whitefish, 16 Northern Pike, 5 Inconnu, 1 Burbot, 1 Goldeye
- Cli Lake; 20 lake trout, 14 burbot and 20 lake whitefish
- Trout Lake; 20 lake trout and 20 walleye (2015)
- Fish Lake; 17 lake trout and 20 walleye (2015)
- 718 fish of various species have been sampled for length, weight, age and mercury levels from 13 lakes to date during the present multi-year study

Note that Marlene Evans reports on the results of the analysis of mercury levels in the fish supplies provided by Dehcho AAROM. GNWT, Health and Social Services are advised on mercury levels.

Second year of a three year bio- mercury study (Heidi Swanson) completed. Results will be reported in 2016.

Traditional knowledge and capacity building; TK was important in determining traditionally used lakes for this study as well as community involvement in timing and access and locations for fishing. The local Bands were contracted to do the work and they hired knowledgeable members to do the fishing. Capacity building is provided by Dehcho AAROM staff training the field workers in the science protocol necessary to collect high quality scientific data.

Third annual Return to Country Food workshop successfully completed. Forty-eight community members and eight researchers and govt. managers met to present and discuss results of various studies. The community members came away with a better understanding of mercury issues and were able to provide input to future research.

The Youth Ecology camp was a great success in spite of wild weather and forest fires. The students were immersed in cultural activities and mentoring by elders and participated in science modules about “Quicksilver Sam”

Discussion and conclusions

- One of the objectives of our mercury sampling project is to find fishing lakes for our members; lakes that have low or at least medium risk fish with mercury concentrations below 0.5 mg/g. The inclusion of whitefish and other non-predatory fish in our samples has resulted in a better understanding of low risk species which should be included in a healthy diet; Lake Whitefish, suckers and grayling. We have also found a number of waterbodies which typically have low risk fish including predators. Great Slave Lake and the Mackenzie River are low-risk as are Willow, Big Island and Mustard on the horn Plateau. We want to continue testing other lakes in the Horn Plateau area. Some lakes such as Trout Lake are borderline for trout but still high for walleye. Dene members are advised by Health and Social Services to follow guidelines for lakes with elevated levels of mercury.

- Fish-down study; over the next four years we are planning to remove a portion of the large, old predators fish (walleye and pike) from an experimental lake to see if we can promote a more normal population size distribution of walleye and northern pike. We are hoping to develop a protocol to mitigate high mercury levels in some fish populations in some lakes. The protocol would not be suitable for lake trout lakes since this species is susceptible to over-exploitation and relies on large trout for recruitment.
- Heidi Swanson's mercury study will lead to a better understanding of how "levels of mercury in fish respond to many ecological and physicochemical variables, and reflect cumulative effects of stressors such as watershed disturbance, exploitation, climate change, and transport and delivery of Hg from the watershed and atmosphere". Mercury levels are high in food fish in many lakes in the Dehcho; will these levels continue to increase. Why are levels high in some lakes and not others? Are there mitigation strategies we can apply?

The Return to Country Food workshop is our major communication vehicle.

"We have a great contingent of community delegates here today and a select group of researchers and hard-working government managers. I look forward to the presentations and discussions, I know some of the knowledge in the room is going to rub off on me. I hope it's a good experience for you as well. I like these forums. Government and university researchers have an opportunity to learn more about the issues and concerns of the Dene and Metis of the Dehcho. The workshop gives everybody the opportunity to discuss issues and network with each other. The researchers in turn bring a lot of knowledge and information to us all so that we have a better understanding of the ecosystem in which we live. I hope you find their presentations interesting and I look forward to the resulting discussions." (Opening welcome 2014)

Expected Project Completion Date

- Heidi Swanson's three year mercury study is wrapping up in July of 2016.
- Dehcho AAROM will continue collaborating with Marlene Evans testing lakes for mercury levels in fish guided by our Dene partners and researchers. We will be looking for additional sources of low risk fish for our members and also investigating changes (+/-) in lakes previously tested.
- We are committed to continue a forum such as The Return to Country Food, although it is becoming difficult as partners drop out of the funding pool. We might go to every second year.

Community-based monitoring of Arctic Char in Nunatsiavut: increasing capacity, building knowledge

Surveillance communautaire de l'omble chevalier au Nunatsiavut : développement des capacités et acquisition de connaissances

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Abstract

The diet of Labrador Inuit has shifted recently in the past 5 years from a diet consisting of mostly caribou to one that includes an increased amount of ringed seals and sea-run char. This shift in diet is due to the drastic reduction of the George River Caribou herd and subsequent ban on hunting of the herd imposed by the Newfoundland and Labrador Government during winter 2013. This community-based monitoring project expanded on previous NCP work on contaminant trends in sea-run char conducted by Environment Canada, including a capacity building component and an additional sampling location. Twenty fish were captured at two locations, Nain and Saglek Fjord, just before they returned inland from feeding in

Résumé

L'alimentation des Inuits du Labrador se composait auparavant principalement de viande de caribou, mais elle a changé au cours des cinq dernières années et comprend maintenant en quantité croissante des produits du phoque annelé et de l'omble anadrome. Ce changement découle de la baisse draconienne de la population de caribous de George River ainsi que de l'interdiction subséquente, décrétée par le gouvernement de Terre-Neuve-et-Labrador en 2013, de chasser la harde. Ce projet de surveillance communautaire a permis d'approfondir les recherches sur les tendances en matière de contaminants chez l'omble anadrome qu'EC avait menées dans le cadre du Programme de lutte contre les contaminants

the ocean. The char were caught and processed by local community members, with support from staff at the Nain Research Centre, Parks Canada and Nunatsiavut Conservation Officers. The data from this project will be used for a variety of purposes including providing needed information for dietary advice, understanding contaminant loads and how they are changing as a result climate change and increased industrial development.

dans le Nord (PLCN). Il comportait par ailleurs un volet renforcement des capacités et prévoyait l'utilisation de sites d'échantillonnage supplémentaires. Vingt poissons ont été capturés dans deux sites différents, soit Nain et Saglek Fjord, juste avant qu'ils ne retournent dans la partie continentale après une période d'alimentation dans l'océan. Les ombles ont été capturés et traités par des membres de la collectivité locale, avec l'aide du personnel du Centre de recherches de Nain, Parcs Canada et des agents de conservation du Nunatsiavut. Les données recueillies dans le cadre de ce projet seront utilisées à différentes fins et fourniront, notamment, de l'information qui permettra de formuler des conseils en matière d'alimentation, de mesurer les niveaux de contaminants et de comprendre comment les changements climatiques et le développement industriel accru influencent la façon dont ces contaminants évoluent.

Key Messages

- A regionally led community-based monitoring program was established, sampling arctic char, while building capacity and addressing contaminant concerns of Labrador Inuit
- A result of collaboration of harvesters, community members, youth, Conservation Officers, Parks Canada, Environment Canada and staff of the Nain Research Centre.
- Begins to address the recommendations of the ArcticNet IRIS report that community-based monitoring of arctic char should exist to ensure the population is monitored and healthy for consumption

Messages clés

- On a mis sur pied un programme de surveillance communautaire régional dans le cadre duquel on a procédé à un échantillonnage de l'omble chevalier, renforcé les capacités et répondu aux préoccupations en matière de contaminants des Inuits du Labrador.
- Le projet est le fruit d'une collaboration entre des chasseurs, des membres de la collectivité, des jeunes, des agents de conservation, Parcs Canada, EC et le personnel du Centre de recherches de Nain.
- On a entrepris de donner suite aux recommandations du rapport d'étude d'impact régionale intégrée (EIRI) d'ArcticNet, ces dernières préconisant la tenue d'activités de surveillance communautaire de l'omble chevalier afin de s'assurer que la population fait l'objet d'un suivi et qu'elle est propre à la consommation.

Objectives

1. Establish a regionally led community-based monitoring program of arctic char, while building capacity and addressing contaminant concerns of Labrador Inuit
2. Sample arctic char from two locations of importance for Labrador Inuit; Saglek Fjord and Nain
3. Measure the concentration of mercury and selenium in arctic
4. Understand food web dynamics through stable isotope analysis
5. Meet the recommendations of both the Inuit Health Survey and the IRIS 4 report
6. Build capacity in youth, Nain Research Centre staff and harvesters

Introduction

Residents of Nunatsiavut are concerned about the impacts of the shift in diet, from caribou to ringed seals and arctic char, and how this affects their health and wellbeing, both in terms of contaminants as well as nutrition. The Inuit Health Survey identified arctic char as the number one source of selenium, polyunsaturated fats and omega-3 fatty acids for Labrador Inuit (IHS 2008). The Integrated Regional Impact Study (IRIS) for Nunavik and Nunatsiavut identified arctic char as an important food resource that is at risk and that community-based monitoring of arctic char populations should be implemented (Allard et al, 2012).

Char are an essential part to the diet of Labrador Inuit. Torngat Fish Producers Cooperative operate a char processing plant seasonally in Nain, and in partnership with the Nunatsiavut Government, have established a Social Fishing Enterprise where 10,000 pounds of arctic char is distributed to the 5 communities within Nunatsiavut through the community freezers established in each community during freeze-up, when hunting and accessing traditional foods is the most difficult.

Understanding the overall condition of char in Nunatsiavut, including mercury and selenium concentrations, is essential to understanding Inuit health and wellbeing. As climate change continues, mercury concentrations may increase. And as the diet of Labrador Inuit continues to shift towards the consumption of substantially more arctic char, as per the recommendations of the Inuit Health Survey, it is absolutely essential that the condition of these fish are understood. The region has a responsibility to monitor the arctic char to ensure that these recommendations are improving Inuit health and wellbeing and the region needs to be able to respond to community members concerns about the impacts of consuming more arctic char.

Furthermore, as per the IRIS recommendations, community-based monitoring of arctic char needs to exist. This not only ensures that the population is monitored and healthy for consumption, but also builds capacity and provides a variety of training and partnership opportunities. This CBM project will be integrated into the Aullak, sangilivallianginnatuk (Going off, Growing strong) Youth Program as well as the proposed Youth Capacity Building and Engagement Module (C-05 Northern Contaminants Researcher). This provides multiple opportunities to educate youth about contaminants and research while providing avenues for knowledge transmission and allowing researchers to learn from harvesters and youth.

Finally, because this project is regionally led and operated, the cost of this research project is substantially smaller than similar projects based in southern Canada. This allows the region to control its research directive while meeting the goals of the Northern Contaminants Program and addressing the concerns of Labrador Inuit.

Activities in 2014-2015

Arctic Char Sampling

Char were sampled in two locations in Nunatsiavut; Saglek Fjord and Nain. Fish were collected in the fall as they were preparing to transition from the ocean environment to the freshwater streams in their respective areas. Fish in Saglek Fjord were collected through a collaboration of local harvesters, Parks Canada, Nunatsiavut Government Conservation Officers, youth and staff from the Nain Research Centre. In Nain, harvesters and youth collected fish as part of the Nunatsiavut Government's Going Off, Going Strong youth program. All samples were frozen whole and sent to Environment Canada's laboratory in Saskatoon, Saskatchewan.

Analyses

Fish were weighed, length and gender determined, and aging structures (otoliths) removed at the Nain Research Centre, in conjunction with staff and local harvesters. Stomach fullness was assessed and the contents determined at a coarse level, i.e., invertebrates and/or fish. The presence of parasites, skinniness, discolored liver, and any other abnormality was noted. At least 100 g of skin on fillet was removed from the dorsal region for metals and stable isotope (carbon and nitrogen) analyses; unused tissue will be archived for possible later analyses.

Capacity Building

The entire project is based around capacity building and training opportunities. Harvesters teach youth appropriate harvesting methods and help facilitate knowledge transmission to younger generations in the Nunatsiavut region. Staff from the Nain Research Centre and Nunatsiavut Government were present to explain the rationale behind the project and discuss the physiology and biology of the fish with the youth and harvesters.

Communications

Information for this project has been communicated via presentations at the Torngat Mountain Base Camp and Research Station, at the Nain Research Centre and through the Nain Research Centre website and social media platforms. Additionally, information was communicated at community traditional food celebration events at the Nain Community Freezer.

Traditional Knowledge Integration

Given that this project is a regionally led project that receives samples from harvesters and youth, traditional knowledge is at the forefront. Traditional knowledge is used in all aspects of the project from sampling locations, fish collection and appropriate harvest methods. The design of the project allows for the facilitation of knowledge transmission between participants.

Results

The Nunatsiavut Government is still waiting to receive results from Environment Canada for this project.

Discussion and Conclusions

Despite not having results yet, the project was a great success in terms of capacity building and training. It integrated many organizations with harvesters and youth to work towards one goal, while allowing for training and education. Furthermore, because it is a regionally led project, it results in many cost efficiencies, allowing for important data to be collected at a minimal cost.

Project Completion Date

This years project is essentially complete. It is the intention of the Nunatsiavut Government to continue to monitor these char populations.

Paulatuk Beluga whales: health and local observational indicators

Béluga de Paulatuk : indicateurs de la santé et indicateurs d'observation locaux

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Abstract

Recent changes in climate and the ice regime in Darnley Bay have changed and increased the frequency of beluga hunts by the community of Paulatuk in the Inuvialuit Settlement Region. The community of Paulatuk has many questions about the beluga being harvested, in regards to their health and how similar or different they are to whales monitored at Hendrickson Island in Mackenzie Estuary and as such have been leading a beluga monitoring program in partnership with Fisheries and Oceans Canada and the Fisheries Joint Management Committee. This summer two monitors (stationary and mobile) sampled eleven whales from the harvest. Additionally as part of the LEK/TEK indicators project they participated and collected data to

Résumé

Les récents changements dans le climat et les glaces dans la baie Darnley ont modifié et augmenté la fréquence des chasses aux bélugas par la collectivité de Paulatuk dans la région désignée des Inuvialuits. Très préoccupée par l'état de santé des bélugas chassés ainsi que par ce qui les rapproche ou les différencie des baleines surveillées à l'île Hendrickson dans l'estuaire du Mackenzie, la collectivité de Paulatuk a entrepris de mettre en place un programme de surveillance des bélugas en partenariat avec Pêches et Océans Canada et le Comité mixte de gestion de la pêche. Cet été, deux surveillants (l'un stationnaire et l'autre, mobile) ont prélevé des échantillons sur 11 baleines chassées. De plus, ils ont participé à

support the joint project. Length measurements were taken, along with jaws for ageing and tissues for mercury and stable isotope analyses. Whales were slightly smaller and younger than those landed last year, and similar to whales sampled at Hendrickson this summer. Relative to findings in 2013 mercury concentrations were low and lower than those at Hendrickson Island despite being in the same age and size classes. Further investigations using diet biomarkers such as stable isotopes may provide insight into diet and exposure variability.

un projet sur les indicateurs de connaissances écologiques locales (CEL) et de connaissances écologiques traditionnelles (CET), dans le cadre duquel ils ont recueilli des données visant à soutenir le projet conjoint. On a mesuré la longueur des individus, procédé à un examen des mâchoires afin de déterminer leur âge, et prélevé des échantillons de tissus à des fins d'analyse du mercure et des isotopes stables. Les baleines étaient légèrement plus petites et plus jeunes que celles observées l'an dernier et ressemblaient à celles échantillonnées à Hendrickson cet été. Les concentrations de mercure étaient plus faibles que celles mesurées en 2013 et que celles observées à l'île Hendrickson, et ce, même si les baleines appartenaient toutes aux mêmes catégories d'âge et de taille. D'autres examens s'appuyant sur l'utilisation de biomarqueurs du régime alimentaire, comme les isotopes stables, pourraient fournir de l'information sur la variabilité du régime alimentaire et du niveau d'exposition.

Key messages

- The community of Paulatuk had a successful harvest in the summer of 2014 that began earlier than usual, in late June. Eleven whales were harvested and sampled for the program. This year the program was merged with the Local and Traditional Ecological Knowledge Indicators project.
- Samples were sent to Fisheries and Oceans Canada to estimate age (teeth growth layer groups), measure the contaminant mercury (muscle, liver and skin), and evaluate the diet indicators, stable isotopes to better define diet and diet drivers of mercury levels.
- Preliminary results revealed Hg concentrations to be lower than those measured the previous year as well as lower than measurements obtained from whales harvested at Hendrickson Island despite being in a similar age and size class.

Messages clés

- La collectivité de Paulatuk a connu une excellente saison de pêche à l'été 2014. La saison a débuté plus tôt qu'à l'habitude, soit à la fin de juin. Onze baleines ont été chassées et échantillonnées dans le cadre du programme. Cette année, le programme a été fusionné au projet sur les indicateurs de CEL et de CET.
- Les échantillons ont été soumis à Pêches et Océans Canada afin que l'on estime l'âge des spécimens (groupes de couches de croissance des dents), mesure les concentrations de mercure (dans les muscles, le foie et la peau) et évalue les indicateurs du régime alimentaire, soit les isotopes stables, en vue mieux définir en quoi consiste leur régime alimentaire et les éléments de ce dernier qui influencent les concentrations de mercure.
- Les résultats préliminaires ont révélé que les concentrations de mercure étaient plus faibles que celles mesurées l'année

- Observations from the community and harvesters on whale health and condition were collected alongside this program to evaluate in context with measurements taken here.

précédente, ainsi que celles relevées chez les bélugas capturés près de l'île Hendrickson, et ce même si les baleines appartenaient toutes aux mêmes catégories d'âge et de taille.

- On a recueilli les observations sur la santé et l'état des baleines qu'ont réalisées les membres de la collectivité et les chasseurs en parallèle avec les activités du programme, et ce, afin d'évaluer en contexte les mesures que l'on avait prises.

Objectives

1. Enhance and build the beluga monitoring program by incorporating the local and traditional ecological knowledge (LEK/TEK) program.
2. Support similar objectives as the Local Ecological Indicators Project specifically
    a. Increase our understanding of the Beaufort Sea ecosystem through the inclusion of LEK and TEK in community-based monitoring.
    b. Record observations of beluga whales from a community perspective that are potential indicators of ecosystem changes.
    c. Engage community members in beluga sampling and documentation of observations.
    d. Provide training to community research coordinators to increase capacity within communities to lead community-based research.
3. Determine contaminant levels in beluga whales and the overall health of the whales in context with the Hendrickson Island beluga whales, as well as use the data to establish a baseline for future long term monitoring
4. Link program with Hendrickson and other ISR beluga hunt sites as well as other ecosystem monitoring (e.g. coastal and offshore BREA fish program).
5. Engage community youth in analysis of samples at the DFO (FWI) and the presentation of results at the Arctic Change conference.

Introduction

Inuvialuit lead subsistence lifestyles which include harvesting beluga whales. As such there is concern over their health and contaminant levels. As the environment changes at the global scale (climate change) and the local scale (industrial activities) we suspect beluga may be exposed to more stressors and more contaminants that require ongoing monitoring. Establishing a baseline at this time will assist with future monitoring and management.

In the last five to ten years the community of Paulatuk have been hunting whales more frequently and at higher numbers due to increased accessibility. The hunts are limited by sea ice conditions that have been changing over the years. More open water earlier in the summer has changed the beluga occurrence and accessibility. Hunters have had concerns and questions about the health and well-being of the beluga whales and their supporting ecosystems.

While these whales are from the same population as those harvested at Hendrickson Island, previous research from 2005 showed differences in mercury concentrations, diet markers and other biological measurements (Loseto et al., 2008).

This raised questions as whales collected at Hendrickson had similar mercury concentrations as those collected at other nearby harvest monitoring sites (Kendall Island, East Whitefish) that are located in the Mackenzie Estuary. The habitat near Paulatuk (Darnley Bay) is very different than the Mackenzie Estuary; the Estuary is characterized as a very shallow freshwater environment unlike the deep cold clear waters of Darnley Bay. How habitat is used by beluga differs, and may reflect different diets and exposure to beluga whales. Including the Paulatuk harvest location as a satellite monitoring site to Hendrickson will not only address community questions on health but will also enhance our understanding of these beluga on a larger scale.

Activities in 2014-2015

Capacity Building: Field-Beluga Harvest Monitoring:

Changes to the program were made to have monitors readily available to collect samples at all locations. PHTC hired 2 Beluga Monitors; one mobile Monitor as well as stationing a Monitor at Tippi along with a Summer Student, Bernadette Green and a Beluga Assistant for the Mobile Monitor for the duration of 21 days. Due to more beluga sightings, the monitors were on standby in August to enable sampling of later whales (extra $3000 funding that came from World Wildlife Fund).

Two monitors and the summer student were trained prior to heading to the field by S. Ostertag in 2014 and F. Pokiak in 2013. Monitors were based out of the traditional whaling sites. Changes in sea ice and perhaps other environmental conditions resulted in whales entering deep into Darnley Bay and some were harvested at the East areas, near the community of Paulatuk.

Samples were obtained from 11 out of 14 hunted whales this season (1 whale was harvested 25 km East of Paulatuk (Fish Camp, 5 in Browns Harbour, 2 in Tippi and 3 from deep into the Darnley bay area. Most whales had empty stomachs and 1 was reported with food in the stomach and samples were sent to the DFO for analysis. Daily observations of beluga and weather were collected. All samples were shipped down to Winnipeg where they are currently being analyzed for mercury and diet indicators (fatty acids and stable isotopes).

Traditional Knowledge: Field-Beluga Local Observations

In 2014, the 'Local Ecological Indicators Project' operated alongside the Beluga CBM in Paulatuk. In order to identify potential local and traditional ecological knowledge indicators (LEK and TEK indicators), community meetings and fieldwork were held in Paulatuk, Inuvik and Tuktoyaktuk. In Paulatuk, binders were prepared for the Beluga and Char Monitors and the summer student to support the collection of beluga observations in Darnley Bay. The PHTC provided in kind support towards the administration of this project in Darnley Bay. In total, harvester observations were recorded for over 8 whale sightings in 2013 and 45 sightings in 2014, in Darnley Bay. The local observers from Paulatuk made daily observations and recorded wildlife, bird, weather and marine mammal sightings. Five harvesters shared their observations about hunted whales in 2013, and 10 harvesters completed the questionnaires in 2014 with the assistance of the summer student.

Following the 2014 summer field season, meetings were held with community members and the PHTC to review the project and begin preparations for the 2015 field season. School presentations were also made in Paulatuk about beluga whale research taking place in the ISR and to raise awareness about opportunities for youth to be involved in beluga and ecology research in the ISR. Additional interviews were held with LEK and TEK knowledge holders that were identified by the PHTC to broaden the depth and breadth of knowledge recorded about beluga health and habitat use. These interviews have been transcribed and the information will support the development of TEK/LEK indicators.

Capacity Building - Youth:

We had a Youth Summer Student, Bernadette Green out on the field with the Beluga Monitor Brandon Green. We linked the LEK and Summer Student Program to this Beluga Program, which were all a success. Bernadette went on to Arctic Change Conference with the Monitor Brandon Green to Ottawa to assist with the presentations. Diane arranged the travel for December 8 - 12th. Bernadette continued with collecting beluga observations and interviewing and transcribing the interviews in winter 2015.

Communications:

The Community is preparing itself for the Anguniaqvia Niqiqyuam Marine Protected Area to be developed in Darnley Bay. As such the PHTC has been communicating with Government, specifically DFO about the value of long term beluga monitoring programs. Additionally, by way of the community communicating to government and co-management boards the activities occurring with this program the PHTC is proving, learning and understanding the information collected on belugas, building the foundation for the MPA and long term monitoring. Management and associated programs will be in partnership with the community who will make decisions on what research activities are priority and this beluga program is aimed to stay on top of the list. Efforts will be made not to duplicate other programs/projects already going in the ISR, but to link with them. The community of Paulatuk has communicated this to the co-management board FJMC, as well as the Game Council and Fisheries and Ocean Canada. This program has highlighted and demonstrated the capacity for the community to be involved in management and decision-making.

Communications of the program has occurred at regular co-management board meetings for the FJMC and IGC and local HTC. Additionally members from this program participated and shared results from this work at the Arctic Change conference in Ottawa in December 2014 as well as the BREA results form in Inuvik in February 2015.

Results

Length and Age:

As with previous years, the sample size (n = 11) was small. Whales hunted in 2014 ranged in length from 3.6m to 4.5m (averaging = 4.0m) and were slightly smaller than the previous year (Table 1). These whales were not significantly different in length of whales landed at Hendrickson Island ($P > 0.05$).

The average age of belugas taken near Paulatuk in 2014 was similar to those landed last year (mean = approx. 29.6 years; Table 1). Beluga age and length were significantly correlated to one another ($P = 0.009$; $r = 0.85$). There was no significant difference in age between whales landed near Paulatuk and Hendrickson Island ($P > 0.05$).

Mercury in Tissues

Note that results presented for mercury (Hg) are for a sample size of seven. Concentrations of Hg in muscle ranged from 0.9 to 2.1 µg·g-1 (ww) and averaged 1.3 µg·g-1. These concentrations were significantly lower than those observed in 2013 ($P < 0.001$; Table 1). The concentrations of Hg measured in muscle from Hendrickson Island whales (2.0 µg·g-1) were significantly higher than those measured in Paulatuk whales ($P = 0.02$; Figure 1). Muscle Hg had a weak positive relationship with length ($r = 0.38$, $P = 0.19$) and age ($r = 0.1$, $P=0.35$).

Trends for skin Hg concentrations were similar to muscle, showing a decline in concentration relative to 2013, that was not significant (Figure 1; mean = 0.56 µg·g-1). Skin Hg concentrations were not significantly different than the concentrations measured in whales sampled at Hendrickson Island (P = 0.55). Skin Hg was positively related to muscle Hg concentrations (r = 0.9, p = 0.001).

Concentrations of Hg in liver were variable as is typical for liver concentration, and ranged from 0.4 to 61.7 µg·g-1(ww) with a mean of 15.32 µg·g-1, which was significantly lower than 2013 and similar to previous year (Table 1; Figure 2). These concentrations were not significantly different than those measured at Hendrickson Island (P= 0.06). Liver Hg had a weak positive correlation with age (r = 0.39, P=0.2). Liver and Muscle Hg were not significantly related (r = 0.3; P = 0.26).

Figure 1. Concentrations of Hg in muscle (ug-g-1 ww) from belugas harvested near Paulatuk (black) and Hendrickson Island (grey) near Tuktoyaktuk. In 2014 belugas collected from Paulatuk had significantly lower concentrations than the previous year as well as those collected at Hendrickson Island.

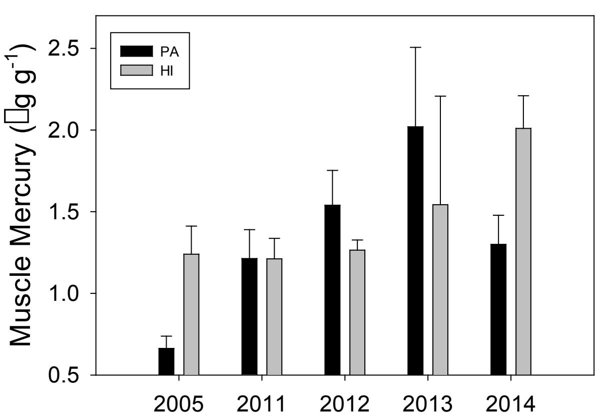
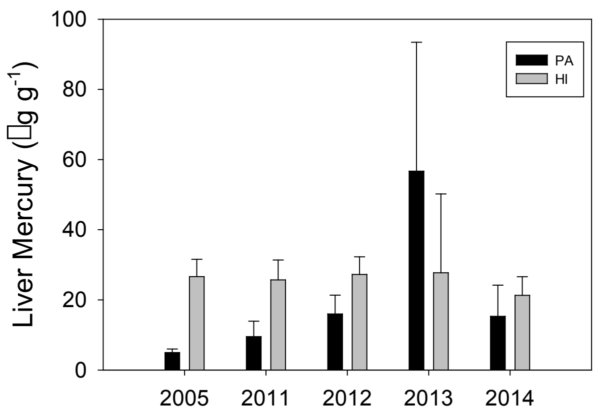


Figure 2. Concentrations of Hg in liver (ug-g-1 ww) from beluga whales harvested at Hendrickson Island (grey) near Tuktoyaktuk and near Paulatuk (black). Concentrations were significantly lower than the previous year and those measured at Hendrickson Island.



Stable Isotopes

Isotopes were used to assist with the interpretation of beluga feeding preferences that could drive contaminant levels. While the $\delta^{15}N$ revealed differences among years for muscle values, only beluga whales harvested in 2005 had significantly different (lower) $\delta^{15}N$ than other years (P<0.001;Table 1), whereas $\delta^{15}N$ in liver were significantly lower than values measured in 2013 (Table 1). Results for $\delta^{13}C$ showed values that were higher (enriched) than those observed in 2013 in both liver and muscle (Table 1). In comparing isotopic means between whales harvested at Paulatuk to those at Hendrickson Island, only $\delta^{13}C$ in liver showed a significant difference, with significantly higher (enriched) $\delta^{13}C$ levels in whales harvested near Paulatuk (P=0.001).

Table 1. Summary of data collected from harvested whales for mercury analyses. Analysis of variance (ANOVA) conducted for each variable to examine differences among years

	2005			2011			2012			2013			2014			ANOVA output	
	Mean		StD	Mean		StD	Mean		StD	Mean		StD	Mean		StD	P	r
Morphometrics																	
Length	363.8	±	66.3	403.9	±	39.9	430.7	±	32.1	427.2	±	10.1	399	±	46.7	0.01	0.5
Age	17.1	±	7.3	26	±	12.9	27.7	±	7	36.2	±	9.5	29.5	±	12.2	<0.0001	0.6
Mercury																	
Liver	5	±	3.7	9.5	±	12.5	16	±	14.2	56.7	±	37.4	15.3	±	8.87	<0.0001	0.71
Muscle	0.7	±	0.3	1.2	±	0.5	1.5	±	0.6	2	±	0.5	1.3	±	0.1	<0.0001	0.74
Skin	0.2	±	0.1	0.5	±	0.3	0.7	±	0.3	0.9	±	0.3	0.56	±	0.1	<0.0001	0.67
Stable Isotopes																	
δ15N Muscle	15.6	±	0.7	17	±	0.2	17.3	±	0.4	17.1	±	0.2	16.97	±	0.2	<0.0001	0.7
δ15N Liver	16.8	±	0.6	17.9	±	0.3	17.7	±	0.4	18.2	±	0.3	17.31	±	0.2	<0.0001	0.6
δ13C Muscle	-20.2	±	0.7	-20.4	±	0.3	-19	±	0.6	-19.7	±	0.4	-18.8	±	0.2	<0.0001	0.57
δ13C Liver	-18.2	±	0.5	-18.7	±	0.4	-20.8	±	0.1	-21.5	±	0.3	-19.9	±	0.2	<0.0001	0.53

There were no significant relationships for beluga age and length with any of the tissue stable isotope values. Muscle $\delta^{15}N$ had a significant negative relationship with muscle $\delta^{13}C$ (r = -0.83, P=0.02) and a significant positive relationship with liver $\delta^{15}N$ (r = -0.81, p=0.03). Liver $\delta^{13}C$ was negatively correlated to liver $\delta^{15}N$ (r = -0.81, p=0.03). Examining trends with Hg, only one significant correlation was found between liver Hg concentrations and $\delta^{13}C$ values in muscle (r = 0.81, p=0.05).

Discussion and Conclusions

The 2014 harvest year began earlier than in previous years likely owing to earlier ice break up and availability of beluga whales in the areas. Harvester's observations on beluga health were recorded as part of the "Enhancing community-based monitoring of ecosystem changes in the ISR through the inclusion of Local and Traditional Ecological Knowledge Indicators" and preliminary outcomes are shared within the NCP report for this project. By bringing the two projects together it is our hope to better understand changes in whale health and behaviour, and how those may relate to habitat changes, specifically linked to climate change, to further our understanding of ecosystem changes on contaminant loads.

Sample size continues to be small, making it difficult to speculate on trends or make comparisons with the Hendrickson Island program. The whales harvested in 2014 were similar in size and age to those harvested in 2013 as well as those at Hendrickson Island in 2014. Despite the similar size and age range the Hg concentrations among all tissues were significantly lower than last year and those measurements at Hendrickson Island. This highlights the variability observed among individuals for a size and age as well over years. Again it is important to note the small sample size. The study was initiated in response to observations of lower Hg levels that likely reflected the smaller size and young age from samples collected in 2005 (Loseto et al., 2008). In the more recent years of monitoring whales landed near Paulatuk the whales are more similar in size and age to those harvested at Hendrickson Island, however Hg levels typically remain lower at Paulatuk with the exception of results from 2013. A closer analysis is required for the recent data acquired for whales analyzed for Hg for the last three years to quantify the significance of differences if in fact present and the drivers of such.

Stable isotope values were largely the same as those measured in belugas harvested at Hendrickson Island, with the exception of enriched liver δ13C. The similar isotope values and the different Hg concentrations challenge us to investigate other means of defining diet to investigate impacts on Hg concentrations. Generally there were weak to no relationships between stable isotopes and beluga morphometrics and Hg in all tissues. Lack of statistical significance may reflect the low sample size. These samples have been processed for fatty acids that may provide further insight to differences in Hg and how they are driven by diet. Additionally, our partnered project work collecting LEK/TEK and observations may assist with the interpretation with the small sample size obtained at this site.

Expected Project Completion Date

The project is wrapping up an early phase and entering a second phase with support from ArcticNet funds that will focus on the use of Indicators for management and decision-making.

Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP)

Programme de surveillance de l'écosystème aquatique de Tlicho

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Abstract

The Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) continues to provide a means of addressing community concerns related to changes in the environment, and builds on work carried out from 2010-2013. A successful community-driven program, it meaningfully involves community members in conducting contaminants-related research, including the collection of samples and observations using both Tłı̨chǫ and scientific knowledge to address the question: "Are the fish and water safe to consume?"

In September 2014, a 5-day on-the-land monitoring camp was held on Lac la Martre, a large lake near the community of Whatì at a location that supports an aboriginal subsistence fishery. Elders spoke about fish and aquatic ecosystem health, and passed on their knowledge to participants. Community

Résumé

Le Projet de surveillance de l'écosystème aquatique de Tlicho s'appuie sur les travaux réalisés entre 2010 et 2013 et reste un moyen de répondre aux préoccupations de la collectivité en ce qui concerne les changements environnementaux. Couronné de succès, ce programme communautaire bénéficie d'une participation considérable des membres de la collectivité aux activités de recherche sur les contaminants, notamment au prélèvement d'échantillons et à la réalisation d'observations. Le projet s'appuie également sur les connaissances du peuple tlicho et le savoir scientifique afin d'établir si les poissons et l'eau peuvent être consommés de manière sécuritaire.

En septembre 2014, un camp de surveillance terrestre de cinq jours a été organisé au lac La Martre, un grand lac situé près de la collectivité de Whatì, à un endroit que les Autochtones

members determined where fish, water and sediment samples were taken and cooperated with scientists during the collection of samples. Methods for processing fish and collecting water and sediment samples for lab analyses were demonstrated; field sampling provided youth with hands-on experience in scientific sampling methods. A results workshop was held in Whatì in February 2015 to present results to camp participants and interested community members, including senior students from the Mezi Community School.

Fish tissue analysis indicated that mercury levels were low in both Lake Whitefish and Lake Trout, with trout having the highest concentrations overall. Neither Lake Whitefish nor Lake Trout showed levels of mercury that were considered abnormal for northern lakes, and Lake Trout had levels that were some of the lowest observed over the implementation of the TAEMP. Water and sediment samples supported the expectation that water and sediment quality is "good" (i.e. not abnormal) in Lac la Martre.

utilisent pour la pêche de subsistance. Les aînés y ont discuté de la santé des poissons et de l'écosystème aquatique, et ont partagé leurs connaissances avec les participants. Les membres de la collectivité ont déterminé à quel endroit les échantillons de poissons, d'eau et de sédiments devraient être prélevés et ont collaboré avec les scientifiques dans le cadre de la collecte d'échantillons. On a effectué une démonstration des méthodes de traitement des tissus de poissons, et de collecte d'échantillons d'eau et de sédiment en vue de l'analyse en laboratoire. De plus, les activités d'échantillonnage menées sur le terrain ont permis aux jeunes d'acquérir une expérience pratique des méthodes scientifiques d'échantillonnage. Un atelier sur les résultats s'est tenu à Whatì en février 2015 afin de présenter les résultats aux participants du camp et aux membres intéressés de la collectivité, dont des étudiants de cycle supérieur de la Mezi Community School.

L'analyse des tissus a révélé que les concentrations de mercure étaient faibles chez le grand corégone et le touladi, les concentrations globales observées chez ce dernier étant cependant les plus élevées. Le grand corégone et le touladi ne présentaient pas de concentrations de mercure pouvant être considérées comme anormales pour des lacs du Nord, et les concentrations observées chez le touladi comptaient parmi les plus faibles de toutes celles qui avaient été mesurées dans le cadre du Projet de surveillance de l'écosystème aquatique de Tlicho. Les échantillons d'eau et de sédiments ont permis de valider l'hypothèse selon laquelle la qualité de l'eau et des sédiments du Lac la Martre est « bonne » (c.-à.-d. non anormale).

Key messages

- The fish tissue analysis showed that mercury levels were low in both Lake Whitefish and Lake Trout. No contaminant levels measured in fish tissue were considered to be abnormal.

Messages clés

- L'analyse des tissus de poissons a révélé que les concentrations de mercure étaient faibles chez le grand corégone. Aucune des concentrations de contaminants mesurées dans les tissus n'est considérée comme anormale.

- Water and sediment quality results support the expectation that water quality and sediment quality are good in Lac la Martre, and that Lac la Martre is typical of other lakes in the area. No water or sediment contaminant levels were considered to be abnormal.
- Community members were pleased with the implementation of the program, citing the importance of monitoring near their community, the participation and education of youth, and the sharing and transfer of both traditional and science-based knowledge among participants.
- Community members were pleased that results of sampling were presented in Whatì in a timely fashion, and that analyses indicated that fish, water, and sediment quality were good (i.e. not abnormal) in Lac la Martre.

- Les résultats des analyses de l'eau et des sédiments ont permis de valider l'hypothèse selon laquelle la qualité de l'eau et des sédiments du Lac la Martre est bonne, et que le Lac la Martre est comparable aux autres lacs de la région. Aucune des concentrations de contaminants mesurées dans l'eau et les sédiments n'est considérée comme anormale.
- Les membres de la collectivité se sont dits satisfaits de la mise en œuvre du programme et ont souligné l'importance de la surveillance aux environs de leur collectivité, de la participation des jeunes au camp et de l'échange de connaissances traditionnelles et scientifiques entre les participants.
- Les membres de la collectivité étaient également satisfaits de la rapidité avec laquelle on a présenté les résultats à Whatì et du fait que les analyses révélaient que les poissons, l'eau et les sédiments du Lac la Martre étaient de bonne qualité (c.-à.-d. non anormale).

Objectives

1. Collaborate with TAEMP partners in the long-term implementation of a community-based monitoring program;
2. Develop long-term aquatic ecosystem monitoring datasets in Wek'èezhìı, and contribute to concurrent monitoring initiatives in the NWT;
3. Provide basic training and opportunities for knowledge transfer among Tłı̨chǫ community members, youth, elders and research scientists; and,
4. Engage schools and youth in educational opportunities related to aquatic ecosystems and environmental monitoring.

Introduction

The purpose of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) is to continue to successfully implement an aquatic ecosystem monitoring program based on Tłı̨chǫ and scientific knowledge in order to determine whether fish health, water, and sediment quality are changing over time at locations near Tłı̨chǫ communities. There are historic, currently operating, and proposed developments in the region, and there is concern in Tłı̨chǫ communities that contamination of nearby aquatic ecosystems may occur, or has already occurred. As a result of these concerns and a general lack of information, there is a need to collect information and have ongoing monitoring of the aquatic ecosystems in Wek'èezhìı in anticipation of continuing pressures on watersheds.

It is important to have Tłı̨chǫ community members (including elders and youth) directly involved in monitoring, and provide a genuine opportunity for community members to exchange knowledge with research scientists in appropriate community and on-the-land settings. By meaningfully involving community members in conducting contaminants-related research, including the collection of samples and observations using both Tłı̨chǫ and scientific knowledge, the TAEMP provides a means to help to address the question: "Are the fish safe to eat and is the water safe to drink?"

The TAEMP rotates sampling through each of the four Tłı̨chǫ communities once every four years. With the conclusion of the 2014 camp near Whatì, the TAEMP has completed its initial baseline sampling phase. In 2015, the first round of comparative sampling will begin when the TAEMP returns to the community of Behchokǫ̀. The next four years of sampling (2015-2018) will continue to build on work carried out since 2010 and allow for comparative analysis of sampling results collected in each of the four communities. The comparative sampling will provide a way in which to continue to address community concerns related to changes in the environment.

Activities in 2014-2015

Introductory / Planning Workshops

Workshops were held in July and August of 2014 to discuss the TAEMP with community members in Whatì, select the locations for sampling, and plan for the on-the–land camp. During planning meetings, selection of participants was also discussed and preliminary selection was determined based on relevant expertise. Community members who participated selected Burnt Island, approximately 14 km west of Whatì, as the camp location. The camp location was chosen as it was close to Whatì and to a number of sampling locations and local historical sites, and because it provided options for sheltering boats from the wind and ample space for tents. Community members discussed the concept of indicators and their perspectives on the health of the ecosystem with visiting researchers.

Monitoring Camp (i.e., "fish camp")

A five-day on-the-land camp was held September 2014. Final sampling locations were selected by community members (Figure 1). Though some sampling locations at the far end of Lac la Martre had initially been identified as desirable, weather/safety considerations dictated that all sampling occur in the southern portion of Lac la Martre. The 5-day camp provided various educational opportunities focused on ways of understanding aquatic ecosystems and assessing the health of the ecosystems through a variety of methods. Participants worked collaboratively to combine Tłı̨chǫ knowledge with science-based monitoring methods. The experiences shared at the camp, including youth gaining hands-on experience with sampling methods and a visit to an elder's gravesite where a ceremony was performed, were captured on video. An educational video was produced, showcasing the involvement of the youth and the value and importance of environmental monitoring and the sharing of Tłı̨chǫ knowledge and scientific perspectives.

To determine current levels of contaminants in fish tissue, samples were collected from Lake Trout and Lake Whitefish, the fish species regularly consumed by Whatì residents. Processing the fish for lab analyses was led by Golder Associates and Department of Fisheries and Oceans (DFO) biologists. Samples were collected in accordance with Environment Canada (2012) guidelines established for sampling metals in fish tissue and the Golder technical protocol 'Fish Health Assessment-Metals'. All fish captured were identified by species, measured (fork length), and weighed. Additional data collected included: gender, stage of maturity, and a general assessment of deformities/abnormalities. Samples collected and archived include otoliths (both cleaned, and sectioned and mounted on slides) and tissue samples.

Standard physical and chemical parameters were used as water quality indicators, including: temperature, pH, conductivity, clarity, turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), alkalinity, dissolved Oxygen, major nutrients, ions, and trace metals. These parameters are comparable to AANDC Water Resources' datasets for the Frank Channel on Great Slave Lake, the closest water quality monitoring station. Water sampling was led by the Tłı̨chǫ Government (TG) Wildlife Coordinator and the Wek'èezhìı Land and Water Board (WLWB) Regulatory Technician; procedures were followed to minimize contamination, such as implementation of appropriate QA/QC procedures, in accordance with Taiga Lab instructions. Sediment sampling used methods outlined in Metal Mining Technical Guidance for Environmental Effects Monitoring (Environment Canada, 2012), and samples were analyzed for standard physical and chemical properties as well as trace metals. Lake sediments were sampled using an Ekman grab sampler suitable for collecting soft, fine grained sediments typically observed in the area.

Results Workshop

A workshop was held in Whatì February 2015 to report lab results back to camp participants and interested community members. The meeting was well attended and included elders and senior students from Mezi Community School (some of whom were also camp participants), along with adult education students. The draft educational video highlighting camp activities was premiered.

Capacity Building

Elders and youth were exposed to, and participated in, scientific sampling methods typically used to monitor aquatic ecosystems, including: sediment and water quality sampling as well as fish tissue sampling for contaminant analysis. Increased understanding of standard methods and the interpretation of results allows community members to have increased knowledge with regards to activities near Tłı̨chǫ communities. Scientists and youth were exposed to Tłı̨chǫ knowledge of the area, which promoted greater understanding of the local aquatic environment to participants. A four-year rotation through Tłı̨chǫ communities allows for strong potential that community members will repeatedly participate in, contribute to, and learn from the TAEMP. Importantly, youth are exposed to, and provided basic training on standardized methods for the collection of samples. The possibility that youth may continue with more specific training is strengthened by the availability of the Marian Watershed Stewardship Program led by the TG and WLWB. Of note, during the 2014 TAEMP, a youth participant specifically voiced an interest in continuing training in environmental monitoring; the same youth also participated in a TG and WLWB-led Shotì Lake Results Workshop in March 2015.

The TAEMP involves staff from organizations inherently linked to Tłı̨chǫ communities, including the WLWB and the TG. Long-term capacity building occurs in these organizations through continued support by their trained staff, some of whom are also Tłı̨chǫ citizens living in Tłı̨chǫ communities. TG staff were key in the successful implementation of the TAEMP, and cooperated with Wek'èezhìı Renewable Resources Board (WRRB) staff on a regular basis. TG staff, specifically staff in Whatì, coordinated community meetings and assisted with planning and logistics, aiding in the successful implementation of the on-the-land camp. The TG Wildlife Coordinator also assisted with camp operations, including sample collection and youth engagement. The Coordinator's prior training and experiences with the TG–led Marian Lake Watershed Stewardship Project and the 2013 TAEMP in Gamètì were beneficial.

It should also be noted that the TG and WRRB are also referral agencies under the Mackenzie Valley Resource Management Act, and with up-to-date monitoring information on the state of the aquatic ecosystems in Wek'èezhìı, they will be better able to make informed recommendations to the WLWB, the Mackenzie Valley Land and Water Board, and the Mackenzie Valley Environmental Impact Review

Board, regarding land and water uses in Tłı̨chǫ communities and Wek'èezhìı.

Communications

Communication with Tłı̨chǫ communities is a primary focus of the TAEMP, with timely presentation of results back to communities being of utmost importance. Communications with the community of Whatì occurred primarily through the planning workshops, at the on-the-land camp, and at the results meeting. Collaboration with GNWT Health and Social Services (HSS), along with other TAEMP partners, aided the development of appropriate messaging and communication strategies. This approach helps to ensure community members are informed and educated on the status of contaminants in the fish they may be eating and that nutritional guidance is provided to ensure these foods continue to remain healthy choices (GNWT HSS, 2015). Appropriate messaging also informed all WRRB communications regarding 2014 results (e.g. newsletter, website, social media).

Social media have also provided communications channels to a wide audience. The WRRB website and Facebook page have featured a series of stories related to the TAEMP in order to build interest and provide updates. Various links have also been shared via the TG website and Facebook pages, and the WLWB and NWT Water Stewardship Strategy web pages.

Youth were interviewed by a videographer based in Yellowknife with assistance from the WRRB Communications Officer. Camp activities and TK/science highlights were captured (e.g. the visit to an elder's gravesite by participants, demonstration of fish processing), and an educational video showcasing the youth involvement was produced (see: http://www.wrrb.ca/content/new-whati-fish-camp-video-ready-viewing).

In-person presentations were given by WRRB staff at the 2015 NWT Water Stewardship Strategy Implementation Workshop, and at the Shotì Lake Result Workshop attended by Tłı̨chǫ representatives, including those who previously participated in various TAEMP on-the-land camps.

The *Common Fish of the Tłı̨chǫ Region*, a basic field guide to fish found in Wek'èezhìı, is available on the WRRB website. Plain language handouts and posters have also been developed and have been distributed at meetings.

A 2015 WRRB calendar has been produced, highlighting different aspects of the WRRB's activities and mandate. The TAEMP is the focus for the month of September and TAEMP photos are used throughout.

Traditional Knowledge Integration

Elders and other community members guide all aspects of the project, with Tłı̨chǫ knowledge (i.e. Traditional knowledge, or TK) incorporated throughout, by design. The application of Tłı̨chǫ knowledge includes: selection of participants, selection of the camp location and establishment of the on-the-land camp, direction on where samples are collected, which culturally significant places are visited, and what behaviours/practices are appropriate and respectful while at the on-the-land camp. In addition, the on-the-land component of the TAEMP provides an opportunity for youth to engage with their elders, assisting in the youth's education in observing, monitoring and understanding the aquatic ecosystem from a Tłı̨chǫ perspective. Elders and community members pass on Tłı̨chǫ knowledge to youth fostering interest in monitoring near communities and assisting with the continuation of Tłı̨chǫ knowledge of aquatic ecosystems and the traditions associated with each community. The TAEMP also offers an opportunity for researchers to learn from traditional knowledge holders in a culturally appropriate on-the-land context. This form of engagement allows for building of mutual respect and trust through exchange of TK and science-based information. Lastly, by bringing results back to communities, findings are discussed, which builds a shared appreciation of the perspectives provided by both Tłı̨chǫ knowledge and science.

Results

Lake Trout sampled (n=20) ranged from 474-821mm in length (FL) and 1020-4710g in weight, and were estimated to be 8-21 years of age. The majority of fish which had tissues analyzed for contaminants (18 of 20) were below the mercury concentration guideline of 0.5 mg/kg, (wet weight, wwt; Health Canada, 2014a); ranging from 0.2 to 0.5mg/kg (Figure 2a, Figure 3a and Figure 4a). The two fish found to be above the guideline, at 0.589 and 0.591mg/kg (wwt), were the two oldest fish sampled (18 and 21 years, respectively), and included the largest (821mm) and heaviest (4720g) fish sampled. Review of mercury concentrations in muscle tissue in relation to age, fork length, and weight suggest positive relationships (Figure 2a, Figure3a, and Figure 4a, respectively; no regression analyses performed). Of note, the mercury concentrations found in the fish sampled in Lac la Martre were some of the lowest observed in the four years of the TAEMP. No deformities/abnormalities were noted in any of the fish sampled; parasites (e.g. worms) were found in fish sampled, though not at levels considered to be abnormal.

Lake Whitefish sampled (n=20) ranged from 353-597mm fork length, 400g-2680g in weight, and were estimated to be 6-22 years of age. All of the Lake Whitefish sampled fell well below the guideline for mercury, with a range of 0.0148-0.0781mg/kg (wwt) (Figure 2b). Review of mercury concentrations in muscle tissue in relation to age, fork length, and weight suggest positive relationships (Figure 2b, Figure 3b and Figure 4b, respectively; no regression analyses performed). No deformities/abnormalities were noted in any of the fish sampled; parasites (e.g. worms) were found in fish sampled, though not at levels considered to be abnormal.

Water samples indicated the pH ranged from 8.35-8.39, and hardness levels (i.e. the mineral content) at all sites indicated that water is considered "hard", which is not unexpected given the natural occurrence of minerals in the environment (e.g. calcium and magnesium). Two samples (4.6 and 2.4ug/L) were over the CCME Guidelines for the Protection of Aquatic Life (CCME 2014) for copper (2ug/L); however, the field blank showed some contamination for copper, and therefore, the exceedances should be interpreted with caution. Considering that all remaining samples indicated low levels of copper, these two results are not considered to be of significant concern. Two samples (0.9 and 0.8ug/L) were over the Guideline for silver (0.1ug/L); however, as with copper, the travel blank showed some contamination for silver, and therefore, the exceedance should be interpreted with caution.

Mercury exceeded CCME Sediment Quality Guideline (SQG), but not the Probable Effects Level (PEL; CCME 2014) at two of the sites sampled (see Figure 1 for sampling locations). The SQG is 0.17ug/g and PEL is 0.486ug/g. Mercury samples were 0.2 and 0.3ug/g at WS-1 and WS-3, respectively. Mercury was undetectable in the water samples at these same sites. The sediment results may reflect historical deposition and are not likely of concern to human or fish health. Copper exceeded CCME SQG, but not the PEL (CCME, 2014) at three sites; WS-3, WS-4, and WS-5. The SQG for copper is 0.36ug/g and PEL is 1.97ug/g. The level of copper in the water sample at WS-3 was 0.99ug/g, and was 41ug/g at both WS-4 and WS-5. Copper in the water sample was also above CCME Guideline (2014) at WS-3 but not WS-4 and WS-5. CCME Guideline for the Protection of Aquatic Life is 2ug/L while dissolved copper was 2.4ug/L, and total copper was 4.6mg/L at WS-3. No other parameters exceeded CCME Sediment Quality Guidelines or Probable Effects Levels (2014) in the sediments analyzed.

Samples were collected near the sewage lagoon to assess bacteria (e.g. *Escherichia coli*, total Coliforms, and Fecal Coliforms). However, lab results were not obtained due to processing delays at the lab, rendering samples invalid. Samples were also collected near the community dock to address community concerns that youth were being exposed to residues from the dock. Results for benzene, ethylbenzine, toluene and xylenes were all below minimum detection levels, and hydrocarbons (total purgable) were found at 2.5mg/L.

Figure 1. Locations of the on-the-land camp, and locations where samples of fish, water, and sediment were collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near the community of Whatì (on Lac la Martre), September 2014.

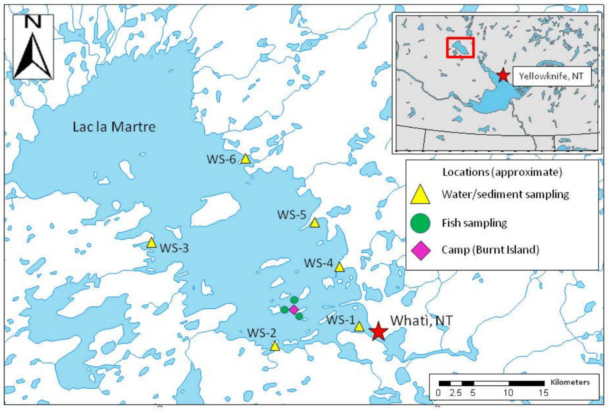


Figure 2. Relationship between mercury concentration in tissues (mg/kg; wet weight) and age (years; estimated via otolith aging) of Lake Trout (2a) and Lake Whitefish (2b) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Whatì (on Lac la Martre), September2014.

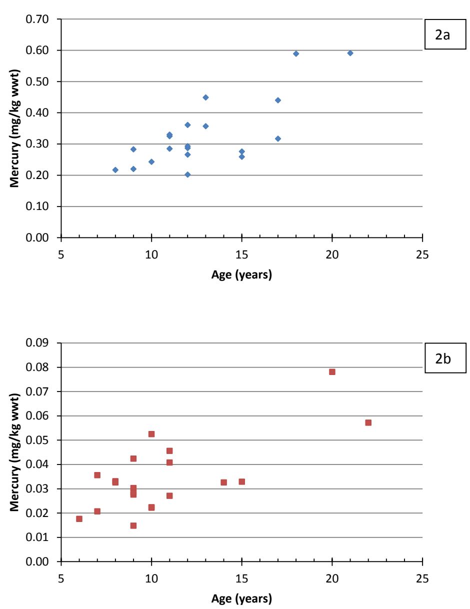


Figure 3. Relationship between mercury concentration in muscle tissue (mg/kg; wet weight) and body weight (g), of Lake Trout (3a) and Lake Whitefish (3b) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Whatì (on Lac la Martre), September2014.

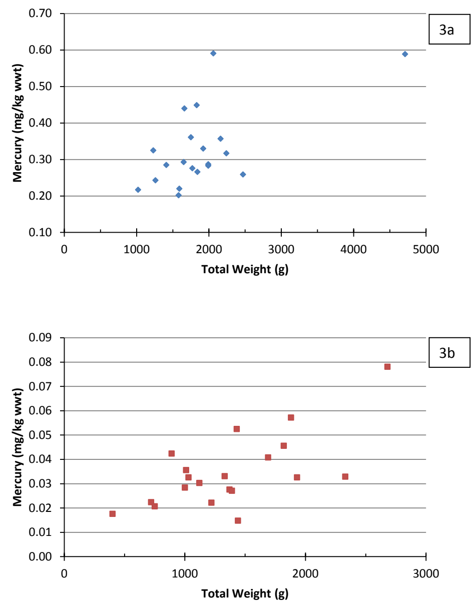
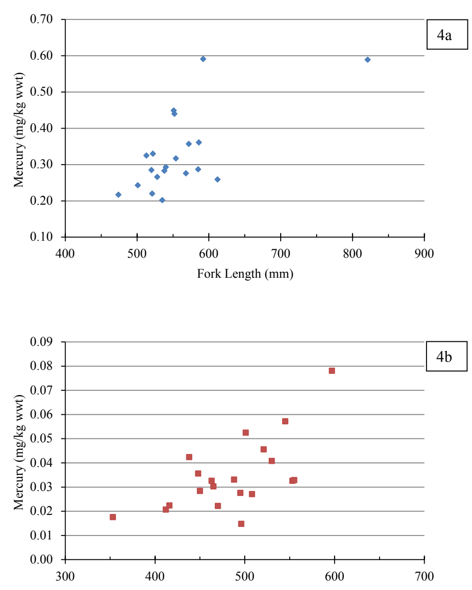


Figure 4. Relationship between mercury concentration in muscle tissue (mg/kg; wet weight) and fork length (mm), of Lake Trout (4a) and Lake Whitefish (4b) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Whatì (on Lac la Martre), September 2014.



Discussion and Conclusion

Overall, results indicated that fish are healthy and habitat is clean in Lac la Martre; no contaminant levels observed in Lake Whitefish or Lake Trout were considered abnormal. Though Lake Trout were found to have a higher mercury concentration than whitefish, this was not unexpected given that they are a large predatory fish which commonly exhibit higher levels due to bioaccumulation and biomagnification, while whitefish primarily feed on small fish and arthropods and typically show lower levels of contaminants (Health Canada, 2015, Cabana et al. 1994). No statistical analyses of mercury concentrations in muscle tissue in relation to age, fork length, and weight were conducted, given that examination of the scatter plots suggest positive relationships (as expected) and that statistical analyses will occur during development of a publication incorporating TAEMP results from 2011-2014. Of note, the mercury concentrations found in the fish sampled in Lac la Martre were some of the lowest observed concentrations observed over the four years of TAEMP implementation. This may be related to the size of Lac La Martre (largest of the lakes sampled over the implementation of the TAEMP) as larger lakes may have fish with lower mercury concentrations (Bodaly et al. 1993).

Results from the 2014 monitoring program near Whatì support the expectation that water quality and sediment quality are good in Lac la Martre. As noted previously, samples taken near the sewage lagoon for bacterial analyses were not analyzed. This lack of results is not a concern as the Community Government of Whatì must sample water quality at various locations several times per year, including the sewage lagoon, as part of their Water Licence Surveillance Network Program (SNP). In the future, program participants will work more closely with the lab to ensure that samples are received and processed within the required processing times. Hydrocarbons (total purgable) levels at the dock suggest some contamination, though likely from boats. By comparison, some Water Licences have an effluent quality criteria limit of 5.0mg/L.

There has been ongoing concern among the Tłı̨chǫ people regarding whether fish are healthy and safe to eat, and Tłı̨chǫ elders continue to emphasize that up-to-date studies documenting contaminant levels to determine the health of fish are needed. Previously, Lockhart et al. (2005) reported elevated mercury in fish collected in Marian River and Slemon Lake in 1979 and 1983 (respectively), and in Lake Trout sampled from Rae Lakes in 2000. Continued standardized sampling at Lac la Martre near Whatì and other lakes near Tłı̨chǫ communities in Wek'èezhìı will help to track environmental changes. This will help to address concerns identified by Tłı̨chǫ people, and assist other NWT decision-makers by providing locally-collected data. For example, the Marian sub-watershed (neighboring the Northeastern Great Slave Lake sub-watershed) contains the proposed Fortune Minerals NICO mine location which includes an all season access road, which may also have impact (Cott et al. 2015). The general lack of information on the fish and water quality metrics used to help determine freshwater health in various sub-watersheds in the NWT is highlighted in the WWF Freshwater Health Assessments for Watersheds in Canada (2015); the TAEMP will also help address gaps in watershed knowledge associated with Wek'èezhìı. The TAEMP broadens the geographic coverage of sampling for mercury, as recommended in the INAC (now AANDC) State of Knowledge Report (2012).

With the conclusion of the TAEMP near Whatì, baseline sampling has been completed near all four Tłı̨chǫ communities. In 2015, the TAEMP will return to Behchokǫ̀, beginning a new phase: the first round of comparative sampling. The next four years (2015-2018) will provide data that may indicate changes and provide relevant information to assist in cumulative effects analyses and informed decision-making. The TAEMP will contribute to the implementation of the NWT Water Stewardship Strategy (WSS) and Action Plan, and the continuing assessment of contaminant levels in traditional foods through collaboration with Health and Social Services and the Northern Contaminants Program. TAEMP will also complement the Tłı̨chǫ Government's ongoing Marian Watershed

Stewardship Program in establishing baseline datasets and evaluating cumulative effects that may occur due to climate change, industrial activities (e.g. Fortune Mineral's proposed NICO project), and/or natural disturbances. Finally, TAEMP continues to assist in the promotion, understanding, and protection of source water for Tłı̨chǫ communities.

Expected Project Completion Date

Whatì portion of TAEMP completed April 30, 2015.

Project website (if applicable)

See: http://www.wrrb.ca/ for TEAMP updates.

Acknowledgments

This project was guided by many elders from the community of Whatì, and we give thanks for their dedication to the project and their interest in sharing their knowledge and expertise. We thank all the participants and support staff who made the 2014 TAEMP in Lac la Martre a success. The elders who participated: Joe Champlain, Madeline Champlain, Jimmy Nitsiza, Margaret Nitsiza, Lucy Nitsiza, Francis Simpson, and Georgina Simpson. The youth who participated from Mezi Community School: Mason Beaverho, Jacintia Flunkie, Twyla Nitsiza, Anika Romie, Alexander Simpson, Isiah Zoe. Whatì Support at camp: Archie Nitsiza, John Beaverho, Lawrence Peter Nitsiza, Elizabeth Young, and Bernice Beaverho. Translation at meetings and at camp was provided by: Jonas Lafferty, and James Rabesca. Partner staff who participated: Susan Beaumont (WRRB), Roberta Judas (WLWB), Francois Larouche (DFO), Sean Richardson (TG), Boyan Tracz (WRRB), and Paul Vecsei (Golder Associates); additional partner support provided by Sarah Elsasser (WLWB), Brett Wheler (WLWB), Sjoerd van der Wielen (TG), Jody Pellissey (WRRB), Marlene Evans (EC), Elsie DeRoose (HSS) and Duane Fleming (HSS), AND Ellen Lea (DFO), . Support in Whatì was provided by Tłı̨chǫ Government staff: Shirley Beaverho, Freddie Flunkie, Alestine Nitsiza, and Ted Nitsiza. Activities at on-the-land camp were filmed and a video produced by Alan Booth of Yellowknife Films.

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Enhancing community-based monitoring of ecosystem changes in the ISR through the inclusion of local and traditional ecological knowledge indicators

Renforcement de la surveillance communautaire des changements qui surviennent dans les écosystèmes de la région désignée des Inuvialuit grâce aux indicateurs de connaissances écologiques traditionnelles et locales

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Abstract

This project was initiated in 2013 to record local observations and identify local and traditional ecological knowledge indicators of beluga health and habitat use. Beluga sightings were recorded from June to August 2014 in the coastal areas of the Inuvialuit Settlement Region (ISR), NT. Harvesters' observations were collected using semi-structured questionnaires in 2013 and 2014 at Hendrickson Island (n = 31), East Whitefish Station (n = 18) and Darnley Bay (n = 10). In addition, interviews were conducted with

Résumé

Le projet, lancé en 2013, a pour objectif de consigner les observations réalisées à l'échelle locale et de définir les indicateurs de connaissances écologiques traditionnelles et locales qui reflètent l'état de santé et l'utilisation de l'habitat des bélugas. Des observations ont été recensées entre juin et août 2014 dans les zones côtières de la région désignée des Inuvialuits (RDI) des Territoires du Nord-Ouest. En 2013 et 2014, on a recueilli les observations des chasseurs par l'entremise de questionnaires

harvesters and TEK-holders from Paulatuk (n = 8), Inuvik (n = 12) and Tuktoyaktuk (n = 13). In 2014, whales were harvested from groups that varied in terms of composition and number. Harvesters from Kugmallit Bay consistently linked whale health and condition of muktuk with blubber thickness. The condition of the meat was described based on its firmness, colour (the more black the better), texture, quantity, fat on top, the girth and weight, blemishes, taste, and amount of blood coming out of it. Visual inspection of beluga habitat selection did not suggest that the distribution of whales in Kugmallit Bay was linked to habitat characteristics. To date, 11 community members from the Inuvik, Iqaluit, Paulatuk and Tuktoyaktuk contributed to recording observations, distributing observation forms, interviewing community members, assisting with community meetings and/or co-presenting to science classes in the participating communities. In the final phase of this project, the observations and knowledge reported in 2013 and 2014 will be analysed and interpreted with TEK holders and harvesters to identify 'local ecological indicators' for beluga monitoring. In addition, the observations made about harvested whales will be analysed alongside scientific indicators to identify areas where these observations could assist with the interpretation of scientific findings. Bringing together local ecological indicators and traditional scientific knowledge may provide greater insight into how environmental change is impacting the Eastern Beaufort Sea beluga population.

semi-structurés à l'île Hendrickson (n = 31), à East Whitefish Station (n = 18) et dans la baie Darnley (n = 10). On a également mené des entrevues avec des chasseurs et des personnes possédant des connaissances écologiques traditionnelles (CET) à Paulatuk (n = 8), à Inuvik (n = 12) et à Tuktoyaktuk (n = 13). En 2014, on a chassé des baleines provenant de groupes différant les uns des autres au chapitre de la composition et du nombre. Les chasseurs de la baie Kugmallit établissaient tous un lien entre la santé des baleines et l'état du muktuk et l'épaisseur du petit lard. La description de l'état de la viande reposait sur la fermeté, la couleur (plus elle est noire, meilleure est la qualité), la texture, la quantité, le gras sur le dessus, la corpulence et le poids, les taches et le volume de sang s'en écoulant. L'inspection visuelle des habitats choisis par les bélugas ne suggérait pas que la distribution des populations de baleines dans la baie Kugmallit était liée aux caractéristiques de l'habitat. À ce jour, 11 membres des collectivités d'Inuvik, d'Iqaluit, de Paulatuk et de Tuktoyaktuk ont participé à la consignation d'observations, à la distribution de formulaire d'observation, aux entrevues avec d'autres membres de la communauté, à l'organisation de réunions communautaires ou à la présentation conjointe de cours de sciences dans les collectivités participantes. Dans le cadre de la phase finale du projet, les observations et les connaissances consignées en 2013 et en 2014 seront analysées et interprétées par des personnes possédant des CET et des chasseurs afin de définir les indicateurs de connaissances écologiques locales qui serviront à la surveillance des bélugas. On procédera également à une analyse des indicateurs scientifiques et des observations réalisées sur les baleines chassées, et ce, afin de cibler les occasions lors desquelles ces observations pourraient faciliter l'interprétation de résultats scientifiques. L'utilisation conjointe d'indicateurs de connaissances écologiques locales et du savoir scientifique traditionnel pourrait permettre de mieux comprendre la façon dont les changements environnementaux influencent la population de bélugas de la zone est de la mer de Beaufort.

Key messages

- This project was initiated to identify and record local and traditional ecological knowledge for inclusion in beluga monitoring and research.
- Potential indicators of beluga health and ecosystem change were identified through open community meetings in Inuvik, Paulatuk and Tuktoyaktuk, NT in June 2013, and led to the development of community-specific questionnaires/surveys to record beluga observations.
- More than 80 community members from the ISR participated in community meetings, interviews, questionnaires or shore-based surveys for this project.
- In general, harvesters observed that the harvested whales looked healthy and did not have signs of infection or disease.
- The distribution of whales in Kugmallit Bay did not appear to be linked to habitat characteristics.

Messages clés

- Le projet a été lancé dans le but de recenser et de consigner des connaissances écologiques locales et traditionnelles et de les utiliser aux fins de la surveillance des bélugas et de la recherche sur cette espèce.
- On a défini des indicateurs potentiels de changements dans l'état de santé du béluga et dans l'écosystème lors des assemblées communautaires ouvertes qui se sont tenues à Inuvik, à Paulatuk et à Tuktoyaktuk, dans les Territoires du Nord-Ouest, en juin 2013. Ces indicateurs ont ensuite permis d'élaborer des questionnaires/sondages axés sur la communauté et permettant de consigner les observations de bélugas.
- Dans le cadre de ce projet, plus de 80 membres des collectivités de la RDI ont participé aux assemblées communautaires, aux entrevues, et à la tenue de questionnaires ou de relevés depuis la rive.
- De façon générale, les chasseurs ont noté que les baleines chassées semblaient être en bonne santé et qu'elles ne présentaient aucun signe d'infection ou de maladies.
- La distribution des populations de baleines dans la baie Kugmallit ne semblait pas être liée aux caractéristiques de l'habitat.

Objectives

1. Record observations of beluga whales from a community perspective that are potential indicators of ecosystem changes.
2. Engage community members in beluga sampling and documentation of observations.
3. Increase our understanding of the Beaufort Sea ecosystem through the inclusion of LEK and TEK in community-based monitoring.
4. Partner with existing beluga and CBM programs in the ISR to evaluate linkages between local observations, changes in the ecosystem, and contaminant trends.
5. Provide training to community research coordinators to increase capacity within communities to lead community-based research.

Introduction

Beluga harvests have been documented since 1981 in Kugmallit Bay, Shallow Bay and Kendall Island and since 1989 in the Paulatuk area (Harwood et al., 2015). Standardized beluga monitoring documented the size, efficiency and timing of the subsistence harvest in addition to hunter-collected data on the landed whales (Harwood et al., 2015). Hunters and monitors have contributed to the program through sampling and data collection; however, traditional and local ecological knowledge (TEK/LEK) are not explicitly recorded in the monitoring process. There are many definitions of TEK, and one broad definition of TEK is "knowledge gathered and maintained by groups of people, based on intimate experience with their environment" (Huntington et al., 2004).

The knowledge about beluga whales held by the Inuvialuit is associated with decades of observations, and includes hunters' and Elders' knowledge of beluga whale behaviour and predation (Byers and Roberts, 1995). Scientific and local observations of environmental change can be brought together to identify new avenues for further exploration, compare observations from different scales and discuss potential mechanisms that explain both sets of observations (Huntington et al., 2004). The inclusion of all knowledge holders and users in developing research and management plans creates an enriched understanding of the changes occurring in arctic marine ecosystems and supports knowledge generation and sharing (Tengo et al., 2014).

This project was initiated in 2013 to record local observations and identify TEK/LEK indicators of beluga health and habitat use. Co-management boards in the Inuvialuit Settlement Region (ISR) have collected TEK/LEK to feed into decision-making and management plans (e.g. the beluga management zones and the Marine Protected Areas), thus there is much to build on. Bringing together local ecological indicators and traditional scientific knowledge may provide greater insight into how environmental change is impacting the Eastern Beaufort Sea beluga population.

This study aims to answer the following questions:

1. How can local ecological indicators of beluga be documented and analyzed to monitor changes in the Beaufort Sea?
2. What are the linkages between traditional scientific observations and local observations?
3. How can we use long-term, existing programs (e.g. Hendrickson) to enhance our data collection and knowledge in challenging areas (e.g. Paulatuk/Darnley Bay)?

Activities in 2014-2015

This project built on many years of collaborative beluga research in the ISR. The overarching goal of this research is to provide the opportunity for the knowledge and perspectives of the Inuvialuit to be recorded alongside traditional scientific data collection about the eastern Beaufort Sea beluga. In 2013, we held open community meetings in Paulatuk, Inuvik and Tuktoyaktuk for this project, which formed the platform for the 2013 and 2014 collection of local observations and Traditional Ecological Knowledge (TEK) about beluga whales. Community meetings provided a unique opportunity for northerners to contribute ideas to the beluga-monitoring program. The enthusiastic participation of community members in these meetings resulted in the development of questionnaires for community members to record TEK and LEK. These instruments were further developed in 2014 and used to record observations about beluga during harvesting activities, travel and monitoring. The analysis and interpretation of these observations will be used to identify local ecological indicators for beluga health and habitat use.

Local beluga whale observations were recorded from June to August 2014 at harvest camps (East Whitefish, Hendrickson Island, Kendall Island) and in the communities of Inuvik, Paulatuk, Tuktoyaktuk and Ulukhaktok. Harvesters' observations were collected in 2013 and 2014 at Hendrickson Island (n = 31), East Whitefish Station (n = 18) and Darnley Bay (n = 10) using a questionnaire that was administered by a member of the research team (S. Ostertag, L. Loseto), whale monitor (B. Green) or community-based research assistant (B. Green, K. Hansen-Craik).

Interviews were conducted with harvesters and TEK-holders to record observations, fill knowledge gaps and receive feedback for future beluga monitoring. Through these interviews, we increased the scope of TEK/LEK collection in 2014 to include observations made about prepared beluga and more detailed observations about beluga health. These observations were recorded via digitally recorded interviews in Paulatuk (n = 8), Inuvik (n = 12) and Tuktoyaktuk (n = 13). In addition, shore-based observations were collected in Kugmallit Bay and Darnley Bay to record beluga sightings and activities, using questionnaires generated during the 2013 community meetings.

Shore-based observations were recorded at Hendrickson Island, East Whitefish, West Darnley Bay, Tuktoyaktuk, Paulatuk and Ulukhaktok by a member of the research team (S. Ostertag, L. Loseto, D. Swainson), whale monitor (B. Green), community-based research assistant (B. Green, K. Hansen-Craik) or community member. Observations about beluga presence/absence, behavior and group composition were recorded using a daily observation log or a more detailed hourly log. Very few individuals used GPS to mark the locations of beluga in Kugmallit Bay; therefore, we relied on community mapping to identify where beluga are usually observed, and paper maps to identify where beluga were harvested. At Hendrickson Island, beluga vocalizations were captured alongside shore-based observations and physical characteristics, through the use of a hydrophone anchored 200m from shore.

Capacity Building:

To date, 11 community members were engaged as community research assistants for this project since 2013: DevaLynn Pokiak, Shaeli Pokiak, Cole Felix, Kate Snow, Kayla Hansen Craik, Bernadette Green, Glen Ruben, Ray Ruben Sr., Joe Illasiak Jr, Megan Kimiksana, and Verna Pokiak. Four youth from Inuvik, Tuktoyaktuk and Paulatuk, and one youth from Iqaluit travelled to beluga harvest camps this summer to assist with sampling and recording beluga whale observations. In addition, two youth were also hired by the DFO to assist with camp logistics at Hendrickson Island and East Whitefish, and one youth was employed in Tuktoyaktuk as a community coordinator. Specifically for this project, these individuals contributed to recording observations, distributing observation forms, interviewing community members, transcribing interviews, assisting with community meetings and co-presenting to classrooms in the participating communities. Five project participants from the ISR travelled to Ottawa for Arctic Change and contributed to a presentation on this project. In addition, two youth and two whale monitors co-presented with S. Ostertag during class visits in their communities. V. Pokiak also participated on the Arctic Change Student Day Community Cooperative Research Roundtable with S. Ostertag.

Communications:

We held community meetings in June 2014 to review the field plans for 2014 and encourage participation by community members. Follow-up community meetings were held in Tuktoyaktuk (28 participants), Inuvik (13 participants), Paulatuk (10 participants), and Ulukhaktok (30 participants) in November 2014. During these meetings, we reviewed findings, planned for future research and filled knowledge gaps on beluga habitat use and observations. In November 2014, S. Ostertag met with the Paulatuk, Inuvik and Tuktoyaktuk HTCs to discuss outcomes from the 2013 and 2014 field seasons and community visits, and to receive feedback for the proposed research. In November 2014, this project and the beluga sampling program were reviewed with the Olokhaktomiut HTC.

A community newsletter (Beluga Bulletin) was launched in October 2014 to provide fieldwork and research updates on the beluga research program in the ISR, including this project. Fall and spring issues were shared with community members and HTCs. Letters were sent to participating harvesters with their responses to the harvester questionnaires. The interview responses were returned to participants from Tuktoyaktuk in November 2014 and Inuvik and Paulatuk in June 2015. In June 2014, S. Ostertag met with S. O'Hara on how to increase the participation of youth in this project through mentoring opportunities. In January 2015, we reviewed the new NCP proposal with S. O'Hara.

Traditional Knowledge Integration:

The Local Ecological Indicators project is responding to the need to more effectively include LEK and TEK in beluga monitoring programs in the ISR. This project documented community perspectives and observations of beluga whales that may be used as indicators of beluga health and environmental change. Traditional Ecological Knowledge, as defined as "knowledge gathered and maintained by groups of people, based on intimate experience with their environment" (Huntington et al., 2004), is the focal point of this study. Meeting with community members and HTCs guided the inclusion of TEK and LEK in the selection of novel indicators in beluga monitoring. We are working alongside whale monitors and community liaisons to document observations that could serve as indicators. The results from this study were discussed with community members, including harvesters, elders, youth and FJMC staff.

Results

Observations about harvested whales:

In 2014, 28 harvesters' from Paulatuk, Inuvik and Tuktoyaktuk participated in this project. Overall, the participants had between one and 65 years of beluga harvesting experience (mean of 19 years). Harvesters' responses to the questionnaire indicated that belugas were harvested from varied groups at the different harvest camps (Figure 1). In 2014, harvested whales came from groups including all white, or various combinations of white, grey, black and yellow. In general, harvesters observed that the harvested whales looked healthy and did not have signs of infection or disease (Figure 2).

Harvesters from Kugmallit Bay frequently linked whale health to blubber thickness (33 % of responses). The health of 19 harvested whales was reported as being healthy (i.e. very healthy, good, normal, fast), and four whales were reported as being less healthy (i.e. a little thinner for this time of year, pretty thin, not as fat as expected). The condition of the muktuk was considered fair for nearly 40 percent of the harvested whales (n = 24; Figure 2). Harvesters consistently linked the condition of the muktuk to amount of blubber on the animal. In contrast to the observations about muktuk, nearly all of the harvested animals were described as having good meat condition (n = 24). The following observations about meat were described by harvesters as indicating that the meat was in good condition: firmness, colour (the more black the better), texture, quantity, fat on top, the girth and weight, blemishes, taste, amount of blood coming out of it. One harvester observed that the muktuk and meat was soft and flimsy, not as stiff as usual. One harvester reported that he would find out about the condition of the meat when he was preparing the meat. Everything seemed normal when the whales were cut up, except for one case where the harvester observed worms outside of the muscle.

Observations about beluga health:

During interviews, harvesters indicated that healthy beluga whales can be identified by looking at their bodies, for example the rolls on the body or the width of the whale reflect a healthy whale. The whale's behavior during the hunt can also indicate if the whale is healthy or wounded, based on how it is swimming and coming up for air.

When working with beluga muktuk, for example, white spots and colouration have been observed in the muktuk/blubber. Certain observations were associated with avoiding the consumption of certain parts of the beluga. For example, if brown spots are found on the muktuk, they are removed. However, if cysts or pus are seen on the intestines, the meat is not taken for food. The quantity of meat may serve as an indicator of beluga health, with the meat bulging out of the vertebrae in healthy whales.

Beluga habitat use in Kugmallit Bay: Whales were observed in Kugmallit Bay during travel and harvesting activities by the Inuvialuit from Tuktoyaktuk and Inuvik. The habitat was characterized based on the sediment type (i.e. seabed features, gravel, sandy shoal, deep channel and featureless). Visual inspection of the data did not suggest that the distribution of whales in Kugmallit Bay was linked to habitat characteristic (data not shown). The size of whale groups ranged from individual whales to groups of ten whales, with one aggregation of 'hundreds of whales' reported.

Discussion and Conclusions

Figure 1. The composition of whale groups from which whales were harvested in Darnley Bay and Kugmallit Bay (East Whitefish, EWF; Hendrickson Island, HI). Groups were made up of grey and black whales (grey + black), white and/or yellow whales (white/yellow), or white, yellow and black or grey whales (white/yellow + black/grey).

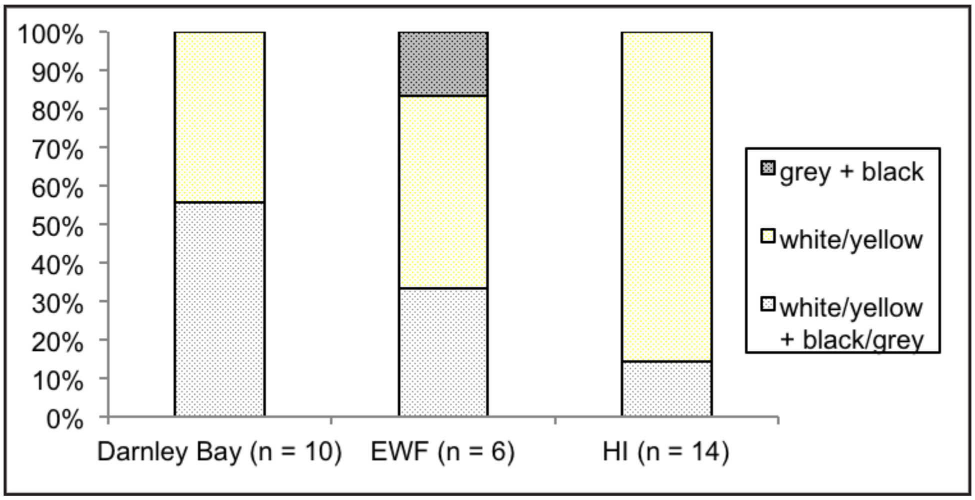
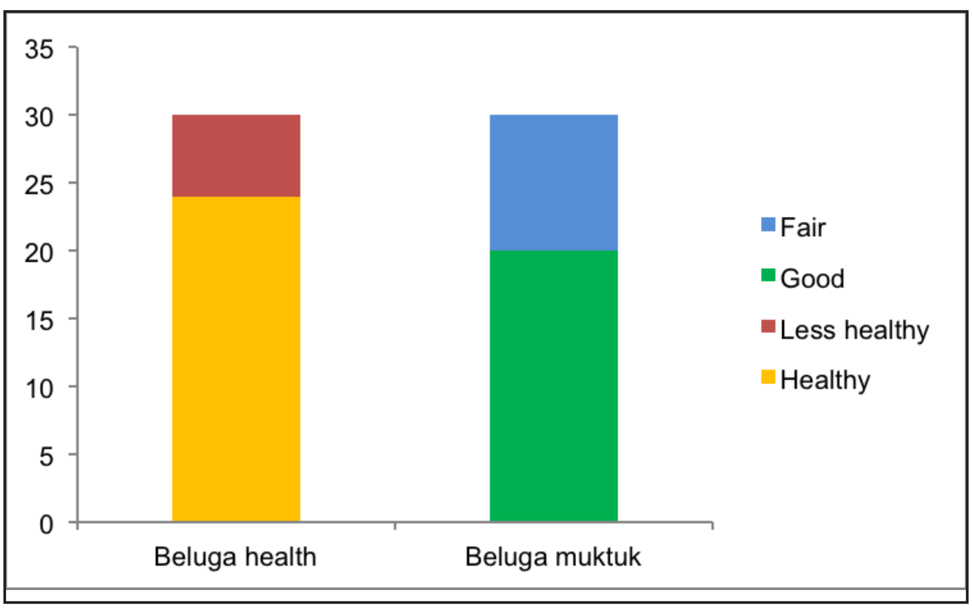


Figure 2. The health and condition of muktuk from the perspective of harvesters, for beluga whales harvested in Kugmallit Bay (East Whitefish and Hendrickson Island)



In the second year of this three year project, we demonstrated that local observations about beluga health and habitat use can be successfully documented in Kugmallit and Darnley Bays by harvesters and other community members, using paper forms, in-person interviews and community meetings. Participants in this project shared their knowledge about beluga health and habitat use through the use of questionnaires that were administered alongside regular monitoring activities. The information shared in 2013 and 2014 will analysed and interpreted with TEK holders and harvesters to identify 'local ecological indicators' that can be included in beluga monitoring. In addition, the observations made about harvested whales will be analysed alongside scientific indicators to identify areas where these observations could assist with the interpretation of scientific findings. For example, the composition of beluga groups in Kugmallit and Darnley Bays could impact feeding behaviour, which could impact contaminant exposure. The relationship between local indicators about beluga health and contaminant exposure will be explored.

We will continue this research in 2015-2016 with support from the Tuktoyaktuk, Paulatuk, Inuvik and Olokhaktomiut HTCs, the FJMC and ArcticNet. Our objectives for the final phase of this project are to:

- Record local and traditional ecological knowledge (LEK/TEK) of beluga whales as potential indicators of ecosystem changes.
- Develop online tools for recording and visualizing scientific and community knowledge
- Partner with existing beluga and CBM programs in the ISR to evaluate linkages between local observations, changes in the ecosystem, and contaminant trends.
- Provide training to community research coordinators to increase capacity within communities to lead community-based research.

Expected Project Completion Date

March 31st, 2017

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Harvest monitoring of metal bioaccumulation at Kuujjuaraapik (Nunavik): Have levels changed 20 years after the Great Whale environmental assessment?

Surveillance, pendant la récolte, de la bioaccumulation de métaux à Kuujjuaraapik (Nunavik) : Les niveaux ont-ils changé 20 ans après l'évaluation environnementale de Grande-Baleine?

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Abstract

Two decades ago, metal levels were measured in aquatic and terrestrial wildlife near Kuujjuaraapik as part of a major environmental assessment for the Great Whale hydro-electric project. The main objective of this community-based study was to measure current levels of metals in locally harvested wildlife and to compare them with previous measurements to monitor potential change. In 2014, the Sakkuq Landholding Corporation of Kuujjuaraapik organized hunter collections of tissues (muscle, liver, kidney) of 4 marine animals (ringed seal, sea urchin, blue mussel, common eider), 3 terrestrial animals (snowshoe hare, willow ptarmigan, caribou) and 2 freshwater fish (brook trout, lake whitefish). In addition,

Résumé

Il y a 20 ans, dans le cadre d'une évaluation environnementale importante du projet hydroélectrique de Grande-Baleine, on a mesuré les concentrations de métaux présentes chez les espèces aquatiques et terrestres des environs de Kuujjuaraapik. Le principal objectif de cette étude communautaire était de mesurer les concentrations actuelles de métaux chez les animaux sauvages locaux et de les comparer aux mesures précédentes afin d'effectuer un suivi des changements potentiels. En 2014, la Sakkuq Landholding Corporation de Kuujjuaraapik a organisé une campagne d'échantillonnage, par les chasseurs, des tissus (muscles, foie, reins) de quatre animaux marins (phoque annelé, oursin, moule bleue et eider à duvet),

terrestrial vegetation (crowberry, Labrador tea, bearberry, lichens) was sampled for metal levels. Animal organs generally had higher metal levels than muscle, particularly mercury in ringed seal liver and cadmium in caribou kidney. We found no overall change in levels of cadmium, copper and zinc in local wildlife as compared to levels measured for the same species between 1989 and 1991. In contrast, levels of arsenic, selenium and mercury were significantly lower in wildlife in 2014. In particular, 2014 mercury concentrations in five species were on average one-third of levels measured in 1989 to 1991. Our findings provide relevant temporal trends information for sub-Arctic Nunavik, a region undergoing significant ecosystem change.

de trois animaux terrestres (lièvre d'Amérique, lagopède des saules et caribou) et de deux poissons d'eau douce (omble de fontaine et grand corégone). On a également procédé à un échantillonnage de la végétation terrestre (camarine noire, thé du Labrador, raisin d'ours, lichen) afin d'y mesurer les concentrations de métaux. De façon générale, les organes d'animaux présentaient des concentrations de métaux plus élevées que celles observées dans les muscles, particulièrement en ce qui concerne les quantités de mercure dans le foie du phoque annelé et celles de cadmium dans les reins du caribou. Comparativement aux concentrations mesurées pour les mêmes espèces entre 1989 et 1991, aucun changement global n'a été relevé dans les niveaux de cadmium, de cuivre et de zinc présents dans la faune locale. En revanche, les concentrations d'arsenic, de sélénium et de mercure observées dans la faune locale étaient beaucoup moins élevées en 2014. De façon plus précise, les concentrations de mercure relevées chez cinq espèces en 2014 correspondaient en moyenne au tiers des niveaux mesurés entre 1898 et 1991. Nos résultats révèlent des tendances temporelles dans la région subarctique du Nunavik, laquelle connaît d'importants changements écosystémiques.

Key Messages

- Local hunters collected tissues of ringed seal, common eider, blue mussel, sea urchin, snowshoe hare, willow ptarmigan, caribou, brook trout and whitefish, as well as terrestrial vegetation, near Kuujjuaraapik in 2014 for analysis of metals.
- Organs generally had higher metal levels than muscle, particularly mercury in ringed seal liver and cadmium in caribou kidney.
- Mercury in ringed seal muscle was low compared to ringed seal monitored in other Arctic areas, suggesting relatively low mercury exposure in the local marine environment. Cadmium levels in caribou kidney were highly variable with a few elevated values compared to average levels measured by others for caribou in northern Quebec.

Messages clés

- En 2014, des chasseurs locaux ont prélevé, à des fins d'analyse des concentrations de métaux, des tissus de phoque annelé, d'eider à duvet, de moule bleue, d'oursin, de lièvre d'Amérique, de lagopède des saules, de caribou, d'omble de fontaine et de grand corégone, ainsi que des échantillons de végétation terrestre.
- De façon générale, les organes présentaient des concentrations de métaux plus élevées que celles observées dans les muscles, particulièrement en ce qui concerne les quantités de mercure dans le foie du phoque annelé et celles de cadmium dans les reins du caribou.

- Local metal levels in wildlife have remained stable (for cadmium, copper, zinc) or have declined (arsenic, selenium, mercury) in the last two decades.

- Le taux de mercure dans les muscles du phoque annelé était faible comparativement à celui observé chez les phoques annelés d'autres régions de l'Arctique, ce qui suggère que l'exposition au mercure est relativement faible dans l'environnement marin local. Les niveaux de cadmium dans les reins du caribou variaient considérablement, alors que l'on a relevé certains cas où les concentrations étaient élevées par rapport aux niveaux moyens mesurés par d'autres chez des caribous du nord du Québec.
- Au cours des 20 dernières années, les niveaux de métaux présents dans la faune locale sont demeurés stables (pour ce qui est du cadmium, du cuivre, et du zinc) ou ont diminué (pour ce qui est de l'arsenic, du sélénium et du mercure).

Objectives

1. Build local capacity for contaminants monitoring through hunter collections of wildlife near Kuujjuaraapik during the winter and summer seasons;
2. Measure concentrations of metals (including mercury, lead and cadmium) in relevant tissues (i.e. muscle, liver) of harvested animals; and
3. Determine if metal concentrations in terrestrial and aquatic animals have changed since previous measurements were conducted over 20 years ago during the environmental assessment for the Great Whale hydro-electric project.

Introduction

Trace metals are a priority of the Northern Contaminants Program (NCP) due to their long-range transport to the Arctic from global anthropogenic sources and high levels found in some traditional foods. The Arctic is undergoing rapid environmental change that may impact the transport and cycling of these metals. In addition, long-range sources of metals are shifting as a result of emissions regulations in Europe and North America, coupled with vast economic development in Asia. Long-term monitoring sites in freshwater and marine ecosystems in the Canadian Arctic indicate that, in some cases, metal levels in animals (particularly mercury but also cadmium and zinc) have been changing in recent decades (NCP, 2012; Mallory et al., 2014). The drivers and processes leading to these changes are not well understood, and more information is needed on temporal trends of metals in the Arctic environment.

Kuujjuaraapik-Whapmagoostui, on the shore of Hudson Bay in southern Nunavik, was located in the zone of impact for a proposed massive hydro-electric development project to divert the Great Whale River and form a 1667 km^2 impoundment for power generation. In the late 1980s and early 1990s, large amounts of environmental information were collected to support an environmental assessment of the proposed hydro-electric project. Included in these efforts were measurements of metals in freshwater, aquatic and terrestrial wildlife near Kuujjuaraapik. The Great Whale project was suspended in 1994, and little information on metal levels in local wildlife has been collected since then.

Locals in Kuujjuaraapik have observed ecosystem changes in recent decades including longer summers, shorter winters, and different sea ice movements (Alec Tuckatuck and Raymond Mickpegak of Sakkuq Landholding Corp., personal communication). Research at the Centre d'études nordiques in Whapmagoostui has also documented recent environmental change in the region (Bhirby et al. 2011). Located on the coast of Hudson Bay, Kuujjuaraapik is in a sub-Arctic zone where climate warming may impact the distribution and health of animals that live there (Gunn and Snucins 2010; Ferguson et al. 2010; Peacock et al. 2010). Ice conditions in Hudson Bay have been changing over the last three to four decades, with an increase in the length of the ice-free season (Hochheim et al. 2010). There is also concern that massive discharges of freshwater into James Bay from the La Grande hydro-electric complex may be altering marine currents and winter ice conditions in Hudson Bay (e.g., Déry et al. 2011). This community-based monitoring project aimed to build local capacity for contaminants monitoring in Kuujjuaraapik as well as provide relevant temporal trends information for sub-Arctic Nunavik, a region undergoing significant ecosystem change.

Activities in 2014-15

In the fall of 2014, sampling kits and record sheets were distributed to local hunters for tissue collection. Animals were collected by senior hunters and sometimes accompanied by junior hunters, with the aim to encourage youth participation and training in the project. Animals were collected in September and October in traditional hunting areas near Kuujjuaraapik. The target to collect 24 animals for the fall field program was successfully reached with 8 ringed seal, 1 bearded seal, 5 common eider, 9 whitefish, 1 brook trout, as well as 5 samples of sea urchin and blue mussel. For the sea urchin and blue mussel, 5 and 10 individuals, respectively, were pooled from each site to form a sample. Liver and muscle samples were collected for seal and common eider. Blue mussel (whole body) and sea urchin (gonads) were removed from their outer shell (exoskeleton). Local plants (crowberry, Labrador tea, bearberry, tree lichens, ground lichens) were also collected from local sites for metals analysis.

Tissues and record sheets were submitted by hunters to Raymond Mickpegak and then shipped to the National Wildlife Research Centre. Tissue samples were then homogenized and freeze-dried for metals analysis. Mercury concentrations were measured by atomic absorption spectrometry with a Direct Mercury Analyzer at the National Wildlife Research Centre. Other metals were analyzed by ICP-MS at the Alberta Innovates Technology Futures laboratory in Vegreville, Alberta. Concentrations were measured on a dry weight basis but converted to wet weight concentrations for comparison with data from the Great Whale hydro-electric project, assuming % water content information from the literature. Note that dry weight concentrations are presented in the tables while wet weight concentrations are presented in the figure. For elements (mainly lead and cadmium) where some results below the analytical detection limit, the detection limit value was used in the calculation of mean concentrations.

Statistical models were used to test if, overall, there was a change in metal levels of multiple species between the two time periods (1989-1991 vs. 2014). Linear mixed models were tested with year as a fixed factor and a random variable for the subjects, in this case animal tissues (Zuur et al. 2009). The random variable "animal tissues" accounted for non-systematic influences of individual variation among species and tissue types. The number of animal species and tissue combinations tested for each metal ranged from 4 to 7 depending on data that were available, particularly for the earlier time period. Data from the earlier time period were only included in the comparisons if the samples were collected from the same general area (coastal sites near Kuujjuaraapik). Lake whitefish from both time periods were collected in the Great Whale River.

Capacity Building

Local hunters in Kuujjuaraapik were hired by Sakkuq Landholding to harvest fish and wildlife. Their engagement was critical to the success of the project, which involved the exchange of information and dialogue between the hunters and project leaders. We obtained some information from their hunting observations, and we provided guidance on tissue collection methods for metals analysis. Each hunter was requested to conduct the harvesting with a youth of their choice (who was also hired by Sakkuq Landholding). These young hunters gained experience in the presence of a senior hunter and also learned about tissue collection for contaminants research. However, in some instances, the senior hunter preferred to hunt alone or with another experienced hunter. During the two-year project, there was substantial local interest for monitoring of contaminants, as indicated by the participation of 9 hunters in the project, by exceeding our target collection of 48 animals, and by obtaining quality submissions of tissue samples and record sheets.

Communications

In March 2015, John Chételat visited Kuujjuaraapik to attend meetings with Raymond Mickpegak and local stakeholders. We met with the board of the Sakkuq Landholding Corp. and the local hunting, fishing and trapping association (NHFTA). The objectives of these meetings were to provide an update on the project activities and main findings, as well as to obtain feedback on the project and possible future steps. A plain language PowerPoint presentation was prepared for the meetings. Project materials were also provided to the Nunavik Research Centre (Kuujjuaq) and the Nunavik Marine Wildlife Management Board to update them on our activities.

A plain language final report is being prepared in the spring of 2015 to summarize the main findings of the study and to provide the community with the metals data for potential future monitoring. A draft of the report will be reviewed by the Nunavik Regional Contaminants Committee and then translated into Inuktitut prior to distribution.

Traditional Knowledge Integration

Wildlife harvesting and sampling was organized by the Sakkuq Landholding Corporation and conducted by local hunters. This community-based monitoring was implemented using traditional knowledge of local animal population distributions and their seasonal movements. Traditional knowledge was used in the final decisions made by hunters on which particular animals would be harvested. The skills and experience of senior hunters were critical to the success of the project.

Figure 1. Comparisons of metal concentrations in animal tissues from marine, freshwater and terrestrial environments sampled near Kuujjuaraapik in 1989-91 and again in 2014. Values are presented as means ± 95% confidence intervals. Note that concentrations are presented on a logarithmic scale. See Table 4 for statistical results.

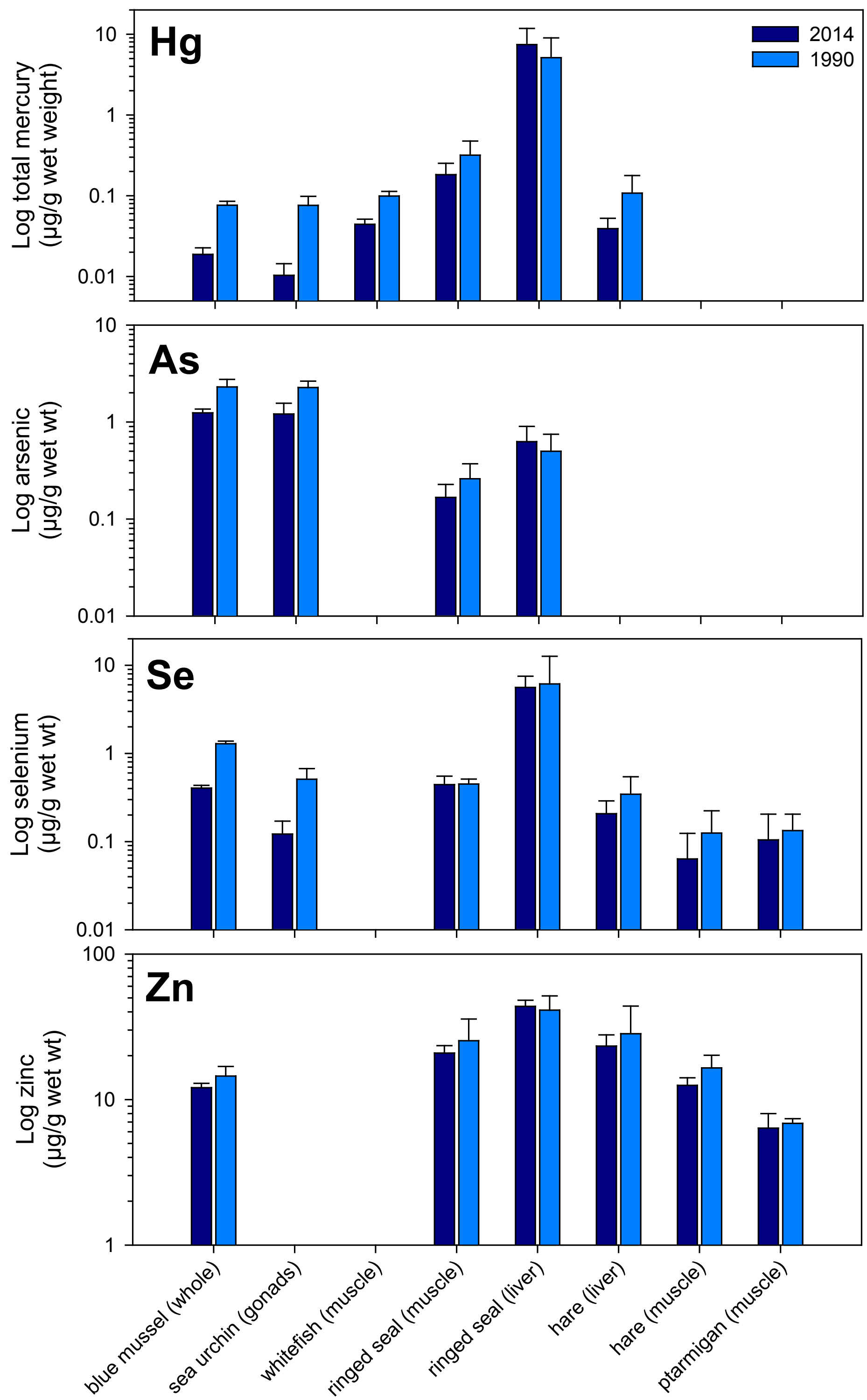

Table 1. Trace metal concentrations in tissues of marine animals collected at Kuujjuaraapik, Nunavik in 2014. All values are reported in µg/g on a dry weight basis.

Sample	Statistic	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Blue mussel (whole body)	Mean ± SD	10.4 ± 0.8	2.7 ± 0.5	5.7 ± 0.4	0.61 ± 0.17	0.16 ± 0.03	3.37 ± 0.20	101 ± 6
	Range	9.2 – 11.2	2.1 – 3.4	5.0 – 6.0	0.36 – 0.83	0.13 – 0.18	3.09 – 3.57	93 – 106
	n	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]
Sea urchin (gonads)	Mean ± SD	8.1 ± 1.9	1.1 ± 0.4	3.0 ± 1.0	0.03 ± 0.07	0.07 ± 0.02	0.81 ± 0.26	94 ± 17
	Range	4.8 – 9.4	0.7 – 1.4	1.3 – 3.9	<0.002 – 0.15	0.05 – 0.11	0.42 – 1.07	73 – 116
	n	5[b]	5[b]	5[b]	5[b]	5[b]	5[b]	5[b]
Common eider (muscle)	Mean ± SD	0.7 ± 0.3	0.04 ± 0.01	24.7 ± 5.6	2.07 ± 4.18	0.21 ± 0.08	1.39 ± 0.46	56 ± 4
	Range	0.4 – 1.0	0.02 – 0.05	17.3 – 32.4	0.05 – 9.53	0.10 – 0.31	0.79 – 1.93	50 – 62
	n	5	5	5	5	5	5	5
Common eider (liver)	Mean ± SD	1.5 ± 0.7	1.5 ± 0.3	88.1 ± 109.2	3.75 ± 8.30	0.53 ± 0.18	6.57 ± 2.78	128 ± 11
	Range	0.7 – 2.2	1.3 – 1.8	20.6 – 274	<0.002 – 18.6	0.31 – 0.77	4.03 – 10.8	115 – 141
	n	5	5	5	5	5	5	5
Ringed seal (muscle)	Mean ± SD	0.59 ± 0.37	0.24 ± 0.25	4.6 ± 0.7	0.65 ± 2.19	0.65 ± 0.42	1.57 ± 0.67	74 ± 16
	Range	0.24 – 1.43	<0.002 – 0.92	3.7 – 6.1	<0.002 – 8.53	0.30 – 1.52	0.58 – 3.14	40 – 94
	n	14	14	14	14	14	14	14
Ringed seal (liver)	Mean ± SD	2.18 ± 1.65	20.60 ± 12.47	42.0 ± 19.6	0.13 ± 0.35	25.77 ± 26.25	19.45 ± 11.57	152 ± 27
	Range	1.00 – 6.15	5.53 – 47.9	11.9 – 71.1	0.02 – 1.34	2.29 – 86.81	5.57 – 40.7	84 – 185
	n	14	14	14	14	14	14	14

[a] Each sample was a tissue pool of 10 mussels.

[b] Each sample was a tissue pool of 5 urchins.

Table 2. Trace metal concentrations in tissues of freshwater and terrestrial animals collected at Kuujjuaraapik, Nunavik in 2014. All values are reported in µg/g on a dry weight basis.

Sample	Statistic	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Caribou (muscle)	Mean ± SD	0.09 ± 0.02	0.02 ± 0.01	11.6 ± 4.0	0.02 ± 0.004	0.05 ± 0.01	0.84 ± 0.05	119 ± 91
	Range	0.07 – 0.11	0.01 – 0.04	7.0 – 14.5	0.016 – 0.024	0.04 – 0.06	0.79 – 0.87	59 – 224
	n	3[a]	3[a]	3[a]	3[a]	5	3[a]	3[a]
Caribou (kidney)	Mean ± SD	0.13 ± 0.02	66.7 ± 55.2	20.1 ± 1.7	0.44 ± 0.19	5.03 ± 1.60	5.23 ± 0.53	110 ± 16
	Range	0.10 – 0.15	17.1 - 134	17.9 – 22.3	0.27 – 0.79	3.40 – 7.47	4.41 – 5.99	94 – 128
	n	6	6	6	6	6	6	6
Willow ptarmigan (muscle)	Mean ± SD	0.02 ± 0.01	0.08 ± 0.02	12.1 ± 1.2	1.90 ± 3.23	0.01 ± 0.002	0.42 ± 0.16	25 ± 3
	Range	0.02 – 0.03	0.06 – 0.09	11.2 – 13.5	0.01 – 5.63	0.006 – 0.01	0.29 – 0.60	23 – 28
	n	3[b]	3[b]	3[b]	3[b]	9	3[b]	3[b]
Willow ptarmigan (liver)	Mean ± SD	0.04 ± 0.01	13.3 ± 3.3	19.7 ± 1.9	0.49 ± 0.77	0.09 ± 0.04	0.81 ± 0.49	97 ± 15
	Range	0.02 – 0.06	8.0 – 16.9	17.7 – 22.1	0.07 – 2.05	0.03 – 0.18	0.46 – 1.78	79 – 114
	n	6	6	6	6	9	6	6
Snowshoe hare (muscle)	Mean ± SD	0.04 ± 0.003	0.005 ± 0.004	9.1 ± 0.6	0.01 ± 0.003	0.02 ± 0.003	0.24 ± 0.09	46 ± 2
	Range	0.03 – 0.04	0.001 – 0.009	8.5 – 9.8	0.01 – 0.02	0.02 – 0.03	0.13 – 0.30	45 – 49
	n	3[c]	3[c]	3[c]	3[c]	6	3[c]	3[c]
Snowshoe hare (liver)	Mean ± SD	0.06 ± 0.02	0.53 ± 0.31	13.8 ± 3.6	0.60 ± 0.15	0.14 ± 0.05	0.77 ± 0.29	86 ± 16
	Range	0.04 – 0.08	0.32 – 1.06	10.1 – 19.0	0.38 – 0.77	0.07 – 0.20	0.50 – 1.26	62 – 107
	n	6	6	6	6	6	6	6
Lake whitefish (muscle)	Mean ± SD	6.8 ± 8.6	0.002 ± 0.002	1.2 ± 0.4	0.004 ± 0.002	0.21 ± 0.07	1.10 ± 0.10	16 ± 1
	Range	1.6 – 21.8	<0.001 – 0.006	0.9 – 1.8	0.002 – 0.006	0.12 – 0.41	0.98 – 1.22	14 – 17
	n	5	5	5	5	20	5	5
Brook trout (muscle)	Mean ± SD					0.20 ± 0.04		
	Range					0.17 – 0.25		
	n					7		

[a] Each sample was a tissue pool of 2 caribou.

[b] Each sample was a tissue pool of 3 ptarmigan.

[c] Each sample was a tissue pool of 2 hare.

Table 3. Trace metal concentrations in terrestrial plants collected at Kuujjuaraapik, Nunavik in 2014. All values are reported in µg/g on a dry weight basis. Some samples represent pools of material from 2-4 sites.

Sample	Statistic	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Zinc
Ground lichen	Mean ± SD	0.24 ± 0.34	0.006 ± 0.006	1.3 ± 0.3	1.03 ± 0.57	0.02 ± 0.004	0.16 ± 0.03	15 ± 7
	Range	0.01 – 0.48	<0.002 – 0.011	1.1 – 1.5	0.63 – 1.43	0.01 – 0.02	0.14 – 0.18	10 – 20
	n	2	2	2	2	5	2	2
Tree lichen	Mean ± SD	0.92 ± 0.08	<0.002	5.8 ± 3.1	5.00 ± 4.74	0.25 ± 0.05	0.29 ± 0.11	53 ± 50
	Range	0.86 – 0.97		3.6 – 8.0	1.64 – 8.35	0.22 – 0.29	0.21 – 0.37	18 – 89
	n	2	2	2	2	2	2	2
Bearberry ("red berry") (leaves)	Mean ± SD	0.04 ± 0.05	<0.002	3.5 ± 0.4	<0.002	0.02 ± 0.002	<0.05	27 ± 7
	Range	<0.002 – 0.07		3.22 – 3.72		0.17 – 0.20		23 – 32
	n	2	2	2	2	2	2	2
Labrador tea (leaves)	Mean ± SD	<0.002	<0.002	3.8 ± 0.8	0.01 ± 0.01	0.01 ± 0.004	<0.05	28 ± 2
	Range			3.3 – 4.4	<0.002 – 0.02	0.01 – 0.02		27 – 30
	n	2	2	2	2	4	2	2
Crowberry (leaves)	Mean ± SD	<0.002	<0.002	4.7	0.16	0.01 ± 0.003	<0.05	11
	Range					0.009 – 0.014		
	n	1	1	1	1	2	1	1

Table 4. Results of statistical tests (linear mixed models) to determine if the average concentrations of six elements have changed in animal tissues at Kuujjuaraapik between ~1990 and 2014. The number of animal and tissue comparisons for each element depended on the availability of earlier data collected around 1990 for the environmental assessment of the Great Whale hydro-electric project. Examples of the comparisons are presented in Figure 1.

Element	Has the average concentration changed between ~1990 and 2014?	Number of animal/tissue comparisons	Statistical support for trend (mixed effects model)
Arsenic	↓ Decrease	4	p=0.006, n=59
Cadmium	→ No change	5	p=0.280, n=67
Copper	→ No change	6	p=0.304, n=76
Mercury	↓ Decrease	6	p<0.001, n=136
Selenium	↓ Decrease	7	P<0.001, n=86
Zinc	→ No change	6	p=0.063, n=76

Results and Discussion

Tissue metal concentrations

Average concentrations of metals in animal tissues collected over the entire project (including winter 2014 data summarized in Chételat et al. 2014) are presented in Table 1 for the marine environment, while those from freshwater and terrestrial environments are presented in Table 2. Average metal concentrations in terrestrial vegetation are presented in Table 3. The older data on wildlife metal concentrations measured for the environmental assessment of the Great Whale hydro-electric project are not presented here but can be found in Somer Inc. (1993).

It is important to note that low levels of some metals have a biological role and are essential for wildlife. Of the elements presented in the tables, zinc, selenium, and copper are essential for animals. Arsenic may possibly be essential or beneficial in trace amounts for some animals although its role remains unclear (Eisler 1988). In contrast, non-essential metals such as cadmium, mercury and lead have no known biological role. Both essential and non-essential elements can negatively impact wildlife health at high concentrations.

A few patterns are noteworthy in the trace metal profiles of the wildlife tissues. In general, metal levels were higher in organs (liver, kidney) than in muscle of the same animal. The highest concentrations of mercury and cadmium were found in ringed seal liver (Table 1) and caribou kidney (Table 2), respectively. Arsenic tended to be higher in marine animals than terrestrial animals, probably reflecting higher exposure from seawater. The higher arsenic in muscle of whitefish from the Great Whale River suggests that those fish may be anadromous and feed partly in the marine environment. Mercury concentrations increased in relation to the trophic level of the animal as a result of biomagnification. This pattern was specifically observed in the comparison of mercury between blue mussels and urchins (primary consumers), common eider (secondary consumers) and ringed seal (tertiary consumers) in the marine environment. Biomagnification of other metals was not evident in the dataset.

In leaves of local terrestrial plants (specifically bearberry, crowberry and Labrador tea), some metals were so low as to be below the detection limit of the laboratory analysis (Table 3). Levels were comparatively higher in lichen than terrestrial plant leaves. Lichen is an important diet item for some terrestrial herbivores such as caribou and ptarmigan, and may be an important source of metals for those animals.

Overall, mercury concentrations were relatively low in tissues (<0.5 $\mu g\ g^{-1}$ wet weight or ~2.5 $\mu g\ g^{-1}$ dry weight) of animals from marine, terrestrial and freshwater environments. Two exceptions were ringed seal liver and to a lesser extent caribou kidney. The highest mercury levels were found in ringed seal liver, resulting from feeding at a high level in the food chain (biomagnification) as well as bioaccumulation in the liver over time. It is noteworthy that mercury levels in ringed seal muscle (averaging 0.65 µg/g dry weight or 0.18 µg/g wet weight) were similar to levels observed at the nearby community of Inukjuak (0.13 µg/g wet weight) and among the lowest mean mercury levels in ringed seal muscle for communities across the Canadian Arctic (range = 0.13-0.70 µg/g wet weight) (NCP 2012). This observation suggests that there is relatively low mercury exposure to wildlife in the local marine environment.

The highest cadmium levels were found in caribou kidney. High cadmium levels have also been observed in caribou kidney across the Canadian Arctic (Gamberg and Scheuhammer 1994, Robillard et al. 2002). Only six caribou were sampled in this study, with three individuals having cadmium concentrations above (91-134 µg/g dry weight) earlier reported averages for caribou in northern Quebec (mean of 40-50 µg/g dry weight) (Crete et al. 1989). The cadmium concentrations for the other three individuals (17-20 µg/g dry weight) were below the earlier reported average of Crete et al. (1989). The large cadmium variation among the 6 caribou is likely due in part to differences in age, with higher concentrations in older individuals (Gamberg and Scheuhammer 1994).

Have average metal levels changed from 1990 to 2014?

We found no overall change in levels of cadmium, copper and zinc in local wildlife collected in 2014 as compared to levels measured for the same species in 1989-1991 (Table 4). In contrast, levels of arsenic, selenium and mercury were significantly lower in wildlife in 2014 (Figure 1). In particular, 2014 mercury concentrations in five species were on average one-third of levels measured in 1989-1991. For selenium, 2014 concentrations in four species were on average half of levels measured in 1989-1991. Arsenic data for the earlier time period were only available for three species (all in the marine environment), although 2014 concentrations were on average half of levels measured in 1989-1991. Note that lead and nickel were not included in the analysis because a large number of samples had levels below analytical detection and there were insufficient data collected on those particular metals for the earlier time period (1989-1991).

Examples of the time trend comparisons are provided in Figure 1 for mercury, arsenic, selenium and zinc (note that concentrations are presented on a logarithmic scale). Overall there were lower arsenic, selenium and mercury concentrations in 2014, although not all animals or tissues showed this decline. For example, ringed seal had lower levels of mercury and arsenic in its muscle between the two time periods but similar levels in the liver. This pattern may be due to long-term build-up of arsenic and mercury in the liver, which is an organ involved in body detoxification. Likewise, ringed seal and ptarmigan muscle showed no decline in selenium between the two time periods.

Our findings suggest that, in this sub-Arctic study area, environmental exposure to metals is similar to or lower than conditions approximately two decades ago. Declining mercury concentrations in wildlife are consistent with long-term monitoring of mercury in air at Kuujjuaraapik, which indicates that air mercury concentrations have declined over the last two decades (Cole et al. 2014). Our findings contrast with monitoring of seabirds in northern Hudson Bay, which indicate recently increasing mercury, cadmium and zinc bioaccumulation in the marine environment (Braune et al. 2014, Mallory et al. 2014).

Potential biases of the study

We adopted a survey type of study design whereby small numbers of individuals for nine animal species were collected from terrestrial, freshwater, or marine environments. This approach provided a broad range of information and allowed us to compare multiple animal species from different environments, providing an overall test of differences in metal bioaccumulation between the two time periods. The sample sizes for the overall tests of temporal change were relatively large (n=59-136, Table 4). However, the sample sizes for individual animal species were sometimes low (i.e., n=3-5 per time period) and ranged from 5-20 in 2014 and from 3-32 in 1989-1991. As a result, caution is required in interpreting comparisons of metal levels between time periods for specific animals. Few measurements for some species may have limited the power to detect statistically significant differences. Further, the animals were collected from a relatively broad geographic area around Kuujjuaraapik, and results for individual animals could in part reflect spatial rather than temporal differences in metal concentrations among sampling sites.

In addition, the metal concentrations reported by Somer Inc. (1993) for the environmental assessment of the Great Whale hydro-electric project were determined using different laboratory analytical methods than those used to analyze samples we collected in 2014. It is possible that the lower concentrations of arsenic, mercury and selenium between time periods may partly reflect differences in analytical techniques rather than lower environmental exposure and bioaccumulation. However, similar concentrations of the latter metals in ringed seal liver between time periods, as well as non-significant differences for cadmium, copper and zinc suggest that potential analytical biases in the dataset were likely small.

Conclusion

We successfully completed a community-based monitoring project to update information on metal bioaccumulation in locally-harvested wildlife. Local hunter participation and the use of traditional knowledge for wildlife sample collection were essential to the success of the project. We found that, in general, metal concentrations were relatively low in representative animals from freshwater, marine and terrestrial environments. In addition, a comparison of six key metals in animals collected around 1990 and again in 2014 indicate that levels have either remained stable or declined over the last two decades. The information collected from this project will provide a baseline for future monitoring of metals by the community in this sub-Arctic environment.

Expected Project Completion Date

The project funding was completed March 31, 2015. A final plain language report is being prepared for distribution within the community in the spring of 2015.

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Mercury in fish from Old Crow

Mercure dans les poissons d'Old Crow

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Abstract

This project measured mercury levels in seven commonly harvested fish species from the Old Crow area, to determine whether they continue to be healthy food choices for northerners. The fish were collected by traditional harvesters processed by community members with the assistance of an experienced contaminant researcher. Samples are currently being analyzed. Results of the project will be presented to the community at a public meeting and in a written report including a plain language summary, anticipated for the fall of 2015.

Résumé

Le projet visait à mesurer les concentrations de mercure chez six espèces de poissons communément pêchés dans la région d'Old Crow, et ce, afin de déterminer s'ils constituent encore des choix alimentaires sains pour les résidents du Nord. Les poissons ont été pêchés par des pêcheurs traditionnels, puis traités par des membres de la collectivité avec l'aide d'un chercheur spécialisé dans les contaminants. On procède actuellement à l'analyse des échantillons prélevés. Les résultats seront présentés à la collectivité lors d'une rencontre publique, ainsi que dans un rapport qui contiendra un résumé rédigé en langage clair et dont la publication est prévue pour l'automne 2015.

Objectives

- To determine levels of mercury in commonly harvested fish from the Old Crow area so that community members may be better able to make informed choices regarding consumption of these traditional foods.
- To provide training to northerners in designing contaminant projects and in collecting and processing samples for contaminant analysis.

Introduction

Mercury in fish can be a human health concern for people in the Canadian North (Lockhart et al. 2005), depending on fish species and geographic location. The Yukon Contaminants Committee database on fish contaminants indicates that few fish from the Old Crow area have been analyzed for mercury (personal communication, Pat Roach, YCC). Muscle samples from eight chum salmon collected from the Old Crow area in 1998 averaged 0.067 mg g^{-1} wet weight while muscle from five pike collected from Cadzow Lake in 2006 averaged 0.138 mg g^{-1} wet weight, and ranged up to a maximum of 0.498 mg g^{-1} . Residents of the Old Crow area are concerned about mercury in the fish they traditionally harvest and consume and have designed this research project in their own area to determine if the local fish remain a healthy food choice, particularly for children and women of child-bearing years. Although the Vuntut Gwitch'in First Nation has limited experience in this area, working with an experienced contaminants researcher ensured the scientific validity of the project, and increased the capacity of the First Nation to conduct more of this type of research in the future.

Activities in 2014-2015

In total, 67 fish of 7 species were collected for this project in the summer of 2014 by local fishers. (See Table 1 for details of collections). Morphometrics were taken from each fish (length, weight, gender, maturity). Muscle samples were extracted and sent to the National Laboratory for Environmental Testing, Burlington, ON for total mercury analysis. All fish heads were submitted to Yukon Environment Fisheries section, where the otoliths will be extracted for aging. While the intention was to use the remainder of the collected fish for a community feast, the fish were badly freezer burned, and were unfit for human consumption. They were used as food for local sled dogs.

Table 1. Fish collected from Old Crow, summer 2014.

Species	N
Coho Salmon	7
Chum Salmon	12
Chinook Salmon	2
Loche	14
Whitefish	10
Inconnu	11
Pike	11

There was a delay in sending the samples out for analysis, since the first trip of M Gamberg to Old Crow to process the fish met with extreme cold temperatures and the working area (an Atco trailer) could not be maintained above freezing. This necessitated a second trip later in the spring when the temperature was warmer. As a result, the samples have been sent out for analysis, but results have not yet been received. We expect to have results by the fall of 2015.

Capacity Building

In January and again in April, M Gamberg travelled to Old Crow to process fish and to train a community member (Robert Bruce) in the extraction of samples for contaminant analysis and in taking fish morphometrics. The training was successful, and R Bruce will now be able to act as a resource person in Old Crow for contaminant sampling. Environment Yukon will use the fish heads from this project to train a summer student in extracting otoliths from various species of fish.

Communications

No communications have happened yet, as there are currently no results to communicate. Once results have been received, clients/partners will be sent the results of the project in the form of an NCP synopsis report, including a plain language summary. Results will also be presented to the community of Old Crow, anticipated for the fall of 2015.

Traditional Knowledge Integration

This program relies on the traditional knowledge of local Vuntut Gwitchin members when collecting the fish for this project. All fish were collected from traditional areas, at the time of year they are traditionally harvested.

Results

No results are available at this time.

Expected Project Completion Date

Fall, 2015

Acknowledgements

Many thanks to Yukon Environment for assistance in extracting otoliths from the fish. Thanks also to William Josie (Vuntut Gwitchin First Nation) and Mike Suitor (Yukon Environment), who initiated this project, and Erika Tizya and Megan Williams (Vuntut Gwitchin First Nation) who assisted with various aspects of the project. I would also like to acknowledge the efforts of all the fishers who submitted fish to this program – without them, this work would not be possible.

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Environmental Monitoring and Research

Surveillance et recherche environnementales

Northern contaminants air monitoring: Organic pollutant measurement

Surveillance atmosphérique des contaminants du Nord : mesure des polluants organiques

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Abstract

The atmosphere is the main pathway for organic contaminants to enter Arctic ecosystems. This project involves the measurement of these contaminants in Arctic air. It is part of a continuing monitoring program started in 1992. Measuring how much organic pollutants are present in Arctic air over time will provide us information on whether their air concentrations are decreasing, increasing or not changing over time; where these chemicals have come from; how much from which region and what climate conditions influence their movement to the Arctic. Results from this continuing project are used to negotiate and evaluate the effectiveness of international control agreements and to test atmospheric models that explain contaminant

Résumé

L'atmosphère est la principale voie par laquelle les contaminants organiques pénètrent dans les écosystèmes de l'Arctique. Le projet vise à mesurer ces contaminants dans l'air de l'Arctique. Il s'inscrit dans un programme continu de surveillance lancé en 1992. La mesure de la quantité de polluants organiques présente dans l'air de l'Arctique au fil du temps permettra de déterminer si les concentrations atmosphériques de ces produits décroissent, augmentent ou demeurent stables avec le temps; d'où proviennent ces substances chimiques; quelle quantité est générée par quelle région; quelles conditions météorologiques ont une incidence sur le déplacement des contaminants vers l'Arctique. Les résultats sont utilisés en

movement from sources in the South to the Arctic. In 2014-2015, weekly sampling continued at the baseline site of Alert, Nunavut, but only one out of four weekly samples were analyzed for routine trend analysis. The remaining samples were extracted and archived for future exploration of notable transport episodes and determination of emerging priority chemicals. Starting in Dec 2005, we have extended the program to screen for emerging chemicals, such as current-use pesticides, brominated flame retardants and stain-repellent-related perfluorinated compounds, in Arctic air at Alert. A passive flowthrough sampler (FTS) specifically designed for use in cold environments has been deployed at Little Fox Lake, Yukon, since August 2011. Sampling at this site is continuous and ongoing.

vue de négocier les accords internationaux de lutte contre les contaminants et d'en évaluer l'efficacité, et à faire l'essai de modèles atmosphériques qui expliquent le déplacement des contaminants à partir de points d'origine situés au sud de l'Arctique. En 2014-2015, on a poursuivi le prélèvement hebdomadaire d'échantillons au site de référence d'Alert au Nunavut, mais seulement un échantillon hebdomadaire sur quatre a été analysé de manière courante et à des fins de détermination des tendances. Les autres échantillons ont été soumis à une procédure d'extraction, puis archivés aux fins de l'examen ultérieur d'épisodes notables de transport et du dosage des nouveaux produits chimiques prioritaires. À partir de décembre 2005, nous avons élargi la portée du programme afin d'étudier dans l'atmosphère de l'Arctique canadien, à Alert, les nouveaux produits chimiques, tels que les pesticides d'usage courant, les produits ignifuges bromés et les composés perfluorés utilisés comme antitaches. Un échantillonneur passif à circulation continue spécialement conçu pour être utilisé dans un environnement froid est installé au lac Little Fox, au Yukon, depuis août 2011. Des activités d'échantillonnage sont menées sur une base continue et permanente à ce site.

Key messages

- Several emerging brominated flame retardants were detectable in air samples collected at Little Fox Lake, Yukon, from August 2011 to December 2014.
- Chlorinated flame retardants, dechlorane 602 and 604 were reported for the first time in Arctic air; and dechlorane 602 was detectable in >75% of all samples at Little Fox Lake, while dechlorane 604 was only detected since 2014.
- Potential source contribution function (PSCF) highlights Northern Canada, Pacific, East Asia as potential sources of flame retardants and organochlorines for Little Fox Lake in warm seasons, while in cold seasons, the chemicals mainly stem from the Pacific and subject to long-range atmospheric transport (LRAT).

Messages clés

- Entre août 2011 et décembre 2014, on a décelé la présence de plusieurs nouveaux produits ignifuges bromés dans les échantillons prélevés au lac Little Fox, au Yukon.
- On a détecté pour la première fois dans l'air de l'Arctique des produits ignifuges chlorés, soit du dechlorane 602 et 604. Du dechlorane 602 a été observé dans >75 % de tous les échantillons prélevés au lac Little Fox, au Yukon, alors que la présence de dechlorane 604 n'a été décelée que depuis 2014.
- Une analyse de fonction de la contribution de source potentielle (FCSP) a révélé que les produits ignifuges et les contaminants organochlorés présents dans le lac Little Fox pendant les saisons chaudes

- Short-chain chlorinated paraffins (SCCPs) measured in air at Alert in 2011 were found to be higher than those reported for 1994-1995 and the unique congener profile may imply varying sources.

pourraient potentiellement provenir du nord du Canada, du Pacifique et de l'Asie de l'Est, alors qu'au cours des saisons froides les produits chimiques dérivaient essentiellement du Pacifique et qu'ils étaient sujets au transport atmosphérique à grande distance (TAGD).

- On a constaté que les concentrations de paraffines chlorées à chaîne courte (PCCC) mesurées dans l'air d'Alert en 2011 étaient plus élevées que celles observées en 1994-1995 et que le profil unique des congénères pourrait être composé de différentes sources.

Objectives

1. To determine whether atmospheric concentrations and deposition of priority pollutants in the Arctic are changing in response to various national and international initiatives by:

    a. Continuing to measure the occurrence of selected organochlorines and polycyclic aromatic hydrocarbons in the Arctic atmosphere at Alert (measurements started in 1992).

    b. Analyzing and reporting data from Alert to provide insight into pollutant trends and sources.

2. Ensuring the effective usage of information at the international negotiating table in order to achieve the appropriate restrictions on release of pollutants of concern for the Arctic environment by:

    a. Having contributed to the assessment arising from the second phase of the Northern Contaminants Program and specifically, the revised Assessments on POP's and Heavy Metals as part of the Arctic Monitoring and Assessment Program [AMAP] Work Plan.

    b. Contributing information for the evaluation of the overall effectiveness of provisions outlined in the Stockholm Convention on POPs and the LRTAP Convention Protocols on POPs.

    c. Advising Canadian negotiators in preparing reasonable and practical strategies of control (consistent with the way contaminants move through the north).

3. To enable validation of models of toxic chemicals in the Arctic environment with atmospheric observations.

Introduction

Atmospheric measurements of persistent organic pollutants (POPs) have been conducted at Alert, Nunavut, since 1992. The atmosphere is the major and fastest route of transport for many priority pollutants to the remote Arctic. Monitoring for organic pollutant levels in arctic air can be used for evaluating time trends of atmospheric contaminant input, to determine contaminant source regions and to evaluate global long-range transport models.

Emerging priority pollutants detected in Arctic air may indicate long-range transport potential which is one of the criteria for classifying chemicals as POPs that may be subjected to global control. Current-use pesticides (CUPs), neutral per- and polyfluorinated alkylated substances (PFASs) and new flame retardants (FRs) were included in Arctic air measurements at Alert since 2006.

In this report, results of organochlorine pesticides (OCs), polybrominated diphenyl ethers (PBDEs) and other flame retardants (FRs) in air at the Yukon station of Little Fox Lake were updated to December 2014. Their possible source regions were studied by potential source contribution function (PSCF). Screening results for short-chain chlorinated paraffins measured in air at Alert is reported.

Activities in 2014-2015

Regular ground level atmospheric measurements of organochlorines (OCs)(PCB congeners, chlordane, DDT, chlorobenzenes and selected herbicides), flame retardants (FRs) [14 PBDEs, 13 other brominated FRs and 2 highly chlorinated FRs] and polycyclic aromatic hydrocarbons (PAHs) (20 priority ones) are being made at Alert, Nunavut, using a custom-made super-high-volume air sampler (super-HiVol). Measurements involve routine weekly sample collection, extraction, analysis as well as archiving. Samples are currently being analyzed in the National Laboratory for Environmental Testing (NLET, Burlington) for OCs, FRs and PAHs. Starting from 2009/10, only one out of four weekly samples were analyzed to maintain the long-term temporal trend. Particle and vapour phases are separately analyzed. The samples that are not analyzed were routinely extracted (with hexane for the vapour phase fraction and dichloromethane for the particle phase fraction) and the extracts are archived, giving us the opportunity to analyze the skipped weeks if necessary. Data quality assurance/quality control (QA/QC) of 2013 samples from Alert is currently ongoing.

Ten Alert samples collected in 2011 were screened for short-chain chlorinated paraffins (SCCPs) by HRGC/HRMS as described in Tomy et al. (1997). More analysis need to be done on the blanks to ensure that the results are above method detection limits (MDLs).

A separate high volume air sampler (PS-1 sampler), sampling with 1 glass fiber filter followed by a PUF-XAD sandwich, has been installed at Alert in November 2005 which is operating in parallel with the routine air monitoring sampler. Weekly integrated air samples have been collected to analyze for new and emerging chemicals, including PFASs and CUPs. Sampling generally occurred once per month from October to February and once every other week from March to September. Since this sampler could only collect approximately one third of the air volume normally collected with the routine super Hi-Vol, the sample has not been split and no archive has been retained. The samples were extracted and split into two portions for separate analysis: Drs. Derek Muir and Camilla Teixeira's laboratory analyzed for CUPs. Drs. Mahiba Shoeib and Tom Harner (EC) (Hazardous Air Pollutants HAPs Laboratory) analyzed these samples for PFASs. An interlaboratory comparison for CUPs has been conducted between Dr. Camilla Teixeira and Dr. Liisa Jantunen (EC). These samples will continue to be analyzed by Dr. Jantunen after FY2014/15.

An attempt to screen for OP flame retardants (OPs) in the PS-1 filters has found relatively higher blank levels for these compounds. A separate set of PS-1 filters pre-baked at 400 °C were hand-carried to Alert in November 2013 to replace those sent by the annual sealift. Filters sent by sealift were not pre-baked as pre-baked filters are fragile and more prone to damages during transportation. The pre-baked filters will be screened for OPs when they return.

A flowthrough sampler (FTS) was installed at Little Fox Lake in August 2011 and started monthly-integrated sampling for the determination of selected OCs and FRs. Sampling at this location allows for the continual investigation of trans-Pacific transport of contaminants to the western Canadian Arctic. Twelve FTS samples collected in 2014 have been extracted and analyzed by postdoctoral fellow

Dr. Yong Yu in the Organics Analysis Laboratory (OAL) located in Downsview (EC). Results are reported here.

Little Fox Lake Flowthrough Sampler (FTS)

Communications, Consultation and Capacity Building

Outreach and communication under this project is conducted in conjunction with that of the projects "Air Measurement of Mercury at Alert and Little Fox Lake" (P.I. Alexandra [Sandy] Steffen) and "Passive Air Sampling Network for Organic Pollutants and Mercury" (P.I.s Hayley Hung and Sandy Steffen).

We have set our main focus on the communication aspect of our program. Since Alert is isolated, not near any community and restricted by the military we have been challenged, in the past, to meet our capacity building and training expectations.

In 2014-2015, we continued to work with the Yukon College and the Council of Yukon First Nations (CYFN) to make the Little Fox Lake station into a combined monitoring, research and educational station. Hayley met with the Yukon Contaminants Committee (YCC) and the Ta'an Kwach'an Council (TKC) in March 2014 to discuss about communication and outreach plans. In November 2014, Sandy met with the YCC and CYFN to discuss about activities at Little Fox Lake. In February 2015, Hayley and Sandy visited the site and met with the YCC and CYFN. Arrangements were made to meet with the TKC again but did not realize due to timing issues. However, Mr. Derek Cooke of the TKC attended the meeting with the YCC and CYFN. A student seminar at the Yukon College was not conducted this year due to scheduling reasons, and we look forward to resuming the lecture in 2015-2016.

Data collected from Little Fox Lake (once interpreted) will be distributed to the CYFN and the Ta'an Kwach'an First Nation, in whose traditional territory the sampling site is located. The data generated can be used by CYFN in local, national and international issues. The Ta'an Kwach'an can use the information to keep their community informed of local effects from airborne contaminants. The applications would include their work with COP meetings and new initiatives related to POPs, mercury and climate change.

In consultation with the NECC, we have initiated a communication and capacity building plan in Nunavut. Sandy and Hayley visited Iqaluit in February to conduct a half-day guest lecture with a half-day hands-on activity session to students in the Environmental Technology Program at the Nunavut Arctic College. However, classes were cancelled twice due to poor weather conditions. We have scheduled to conduct a similar lecture in February 2016. We have met with the NECC to discuss about our communication and capacity building plan.

For three consecutive years, Hayley was invited to guest lecture at the University Center on Svalbard (UNIS) for 1 week on a graduate course titled "Arctic environmental pollution: atmospheric distribution and processes (AT-331)". UNIS is the world's northernmost institution for higher education and research, located in Longyearbyen, Spitsbergen at 78°N, and is a member of the Arctic Council endorsed University of the Arctic (UArctic). Air monitoring and trend analysis for organic pollutants under NCP and AMAP was included as part of the teaching material. In June 2014, Hayley guest lectured at the Zeppelin Mountain station, an AMAP station operated by Norway. She met with scientists operating the station and have discussed with them our continued collaboration under NCP with the Norwegian Institute for Air Research (NILU) and AMAP.

Traditional Knowledge

At this time, we are working on how best to incorporate traditional knowledge (TK) in our long term measurements at Alert and Little Fox Lake. The NECC chairs have provided us with a summary of the proceedings from an Elders conference on climate change. We will review the document and discuss how to incorporate TK within our programs. As well, the Honourable Leona Aglukkaq, Minister of the Environment, Environment Canada, has made it a priority for Environment Canada's Science and Technology Branch to incorporate aboriginal traditional knowledge (ATK) in our scientific research and monitoring activities. We have met with fellow scientists, our Assistant Deputy Minister and management to discuss this possibility. We have provided them with examples of how we have used TK in the past (e.g. during the International Polar Year (IPY) OASIS field study in Barrow) and how NCP has been working with Northerners to combine the knowledge. We are continuing this dialogue within the department.

Results

Flame Retardants and Organochlorine Pesticides in Air at Little Fox Lake (LFL)

An FTS was employed at LFL since August 2011. Monthly air samples were continuously collected to investigate the atmospheric concentrations of PBDEs, non-BDE FRs and OCs at LFL. Fourteen PBDEs (BDE-17, -28, -49, -71, -47, -66, -100, -99, -85, -154, -153, -138, -183, and -190), 14 non-BDE FRs, allyl-2,4,6-tribromophenyl ether (ATE), 2-bromoallyl-2,4,6-tribromophenyl ether (BATE), 2,3-dibromopropyl-2,4,6-tribromophenyl ether (DPTE), hexabromobenzene (HBB), hexabromocyclododecane (HBCD), 1,2-bis(2,4,6-tribromophenoxy) ethane (BTBPE), pentabromotoluene (PBT), pentabromoethylbenzene (PBEB), 2-ethylhexyl 2,3,4,5-tetrabromobenzoate (EH-TBB), bis(2-ethylhexyl)tetrabromophthalate (TBPH), dechlorane 602 and 604, syn- and anti- dechlorane plus (DP), and 25 OCs, α-, β-, γ-, δ- hexachlorocyclohexane (HCH), hexachlorobenzene (HCB), aldrin, dieldrin, endrin, heptachlor, heptachlor epoxide, trans- and cis-chlordane, trans-nonachlor, α- and β-endosulfan, endosulfan sulfate, o,p'-DDE, o,p'-DDD, o,p'-DDT, p,p'-DDE, p,p'-DDD, p,p'-DDT, methoxychlor, oxychlordane, and photomirex, were measured in 42 air samples.

The total concentration of 14 PBDEs ranged from 0.42 to 18 pg/m^3, with median value of 1.6 pg/m^3. BDE-47 and -99 were the predominant PBDEs, accounting for about 65% of total 14 PBDEs detected in the LFL atmosphere, with the median concentration of 0.65 and 0.40 pg/m^3, respectively (Fig 1a). The median concentrations of the BDE-47, -99 and -100 decrease from 2012 to 2014 showing a sharp decline in the second and third year (Fig. 1b). The median of other PBDEs significantly dropped in the second year, then much lower or seldom detected in the third year, suggesting that the phase out of penta- and octa-BDE mixtures from North America and the European Union (EU) in 2004 has led to significant decline in related congeners in Yukon air.

For the 10 non-BDE brominated FRs, PBT, HBB, DPTE and EH-TBB were detected in > 75% of the samples; PBEB was detected in 60% of the samples; TBPH was detectable in ~40% of the samples and frequently detected before 2013; ATE, BATE and BTBPE were detectable in ~25% of the samples (Fig. 2); HBCD was only found in two samples. Four highly chlorinated FRs, dechlorane 602 and 604, syn- and anti-DP, were measured in this study. The total concentrations of syn- and anti-DP ranged from 0.01 to 1.8 pg/m^3, with average of 0.11 and 0.14 pg/m^3, respectively. Dechlorane 602 was detectable in > 75% of the samples with a maximum of 0.06 pg/m^3, while dechlorane 604 was only detected since 2014.

As shown in Fig. 3, the air concentrations of 4 most abundant OCs, α-, γ-HCH, HCB and α-endosulfan, were slightly higher than those at Alert from August 2011 to December 2012. Compared with previous years at LFL, α-HCH and α-endosulfan continued to decrease during the past decade. The concentrations of HCB and γ-HCH were lower than those from 2002 to 2003 but higher than 2007 to 2009.

Screening Results for Short-chain Chlorinated Paraffins (SCCPs) in Air at Alert

Alert air samples collected from Jan to Aug 2011 were screened for SCCPs. Results showed that SCCPs were found mostly in the gas phase. Particle concentrations were similar to blank, except during the haze season (i.e. February) and summer (Fig. 4). The mean and median concentrations were 913.3 and 684.6 pg/m^3, respectively, with a range of 205.7 to 2876 pg/m^3, dominated by the C10 and C11 formula groups. The concentrations were much higher than those previously reported for 4 four-week-integrated air samples collected at Alert from Jan 1994 to Jan 1995 which were 1.07-7.25 pg/m^3 (Bidleman et al., 2001; Tomy et al., 1997). In this previous study, C12 formula group dominated (accounting for ~50% of the total), mostly with 6 and 7 chlorines.

Fig. 1. PBDEs at LFL (a) concentrations of PBDEs in air with relation to temperatures; (b) selected PBDEs over the period

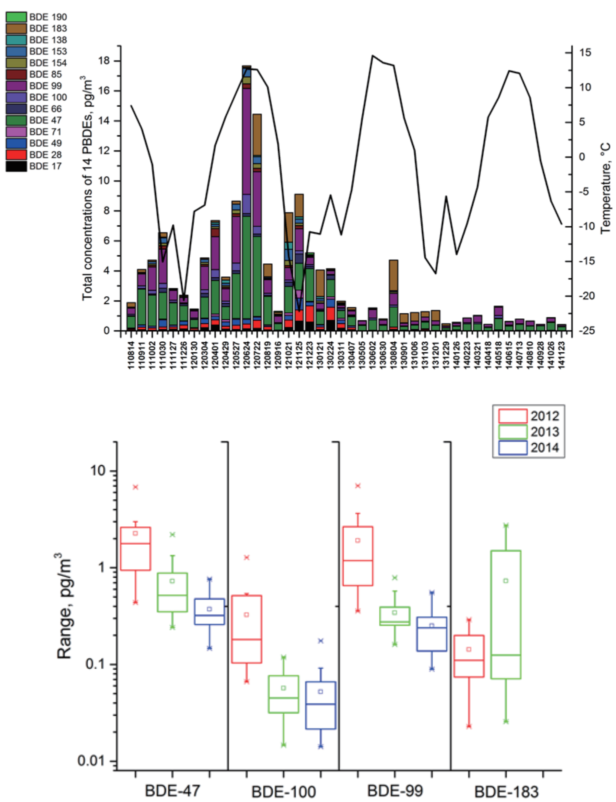


Fig. 2. Non-BDE FRs at LFL. Numbers appearing on X-axis indicate the detection frequency of the corresponding chemical in all samples

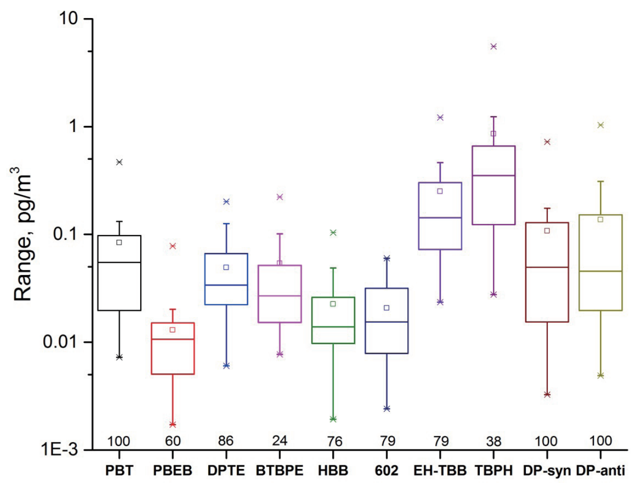


Fig. 3. Comparison of (a) LFL vs. Alert from August 2011 to December 2012; (b) LFL in different years

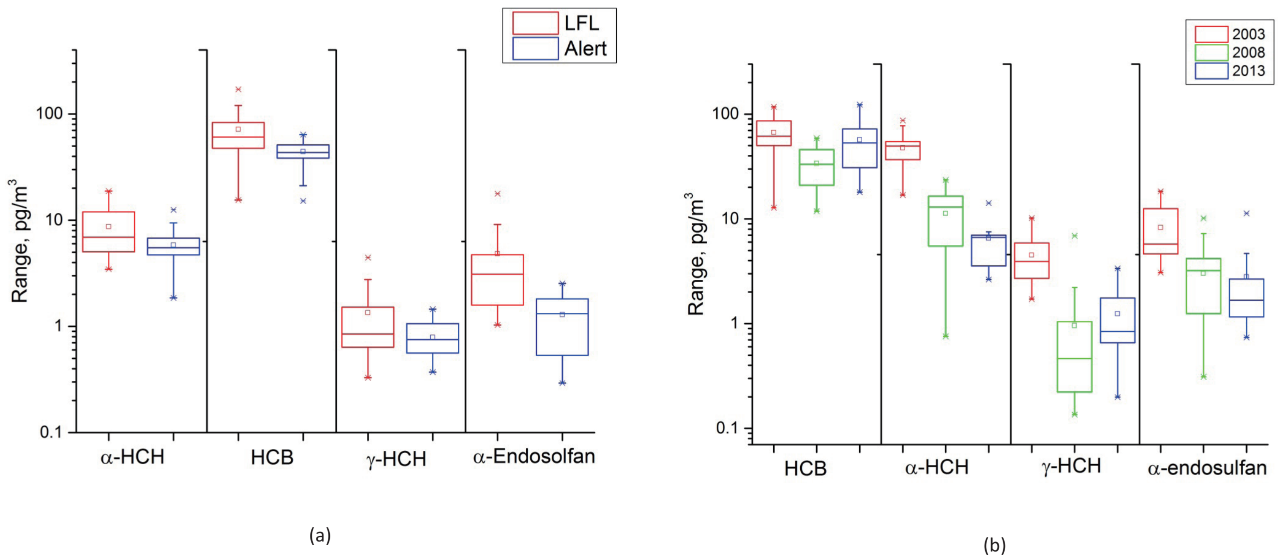


Fig. 4. SCCPs measured in air (particle phase in blue bar and vapour phase in purple bar) and temperatures (T) (red line) at Alert in 2011

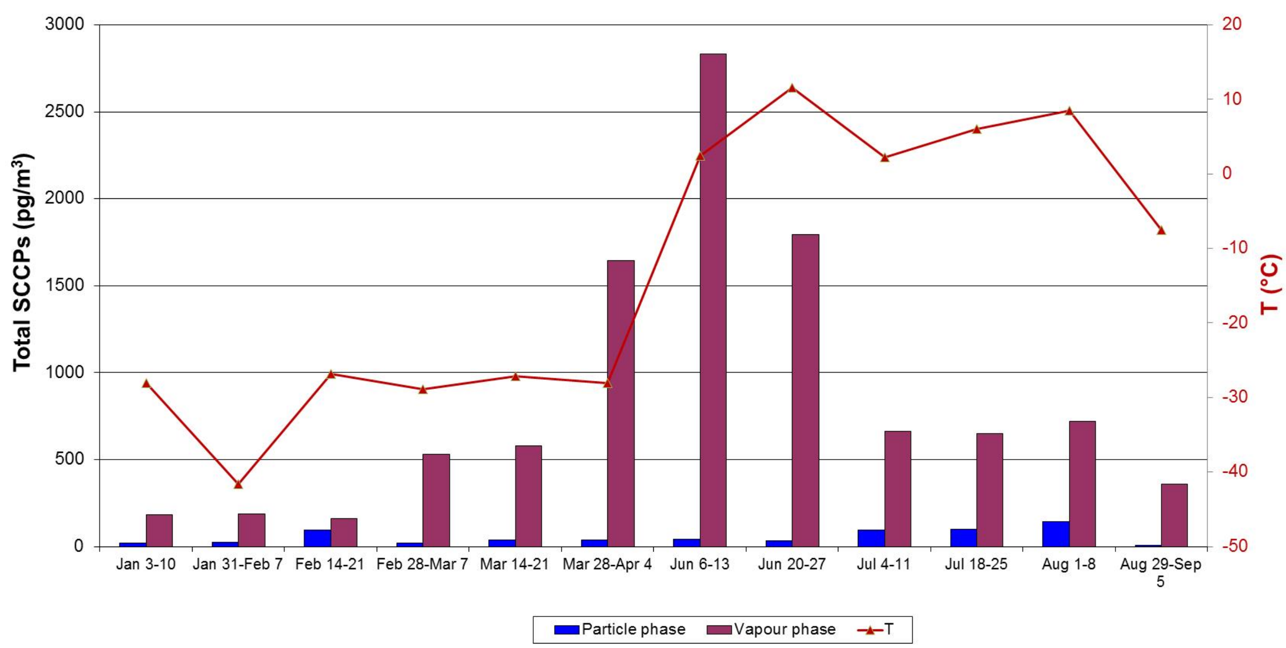


Fig. 5. PSCF maps of selected chemicals in warm and cold seasons

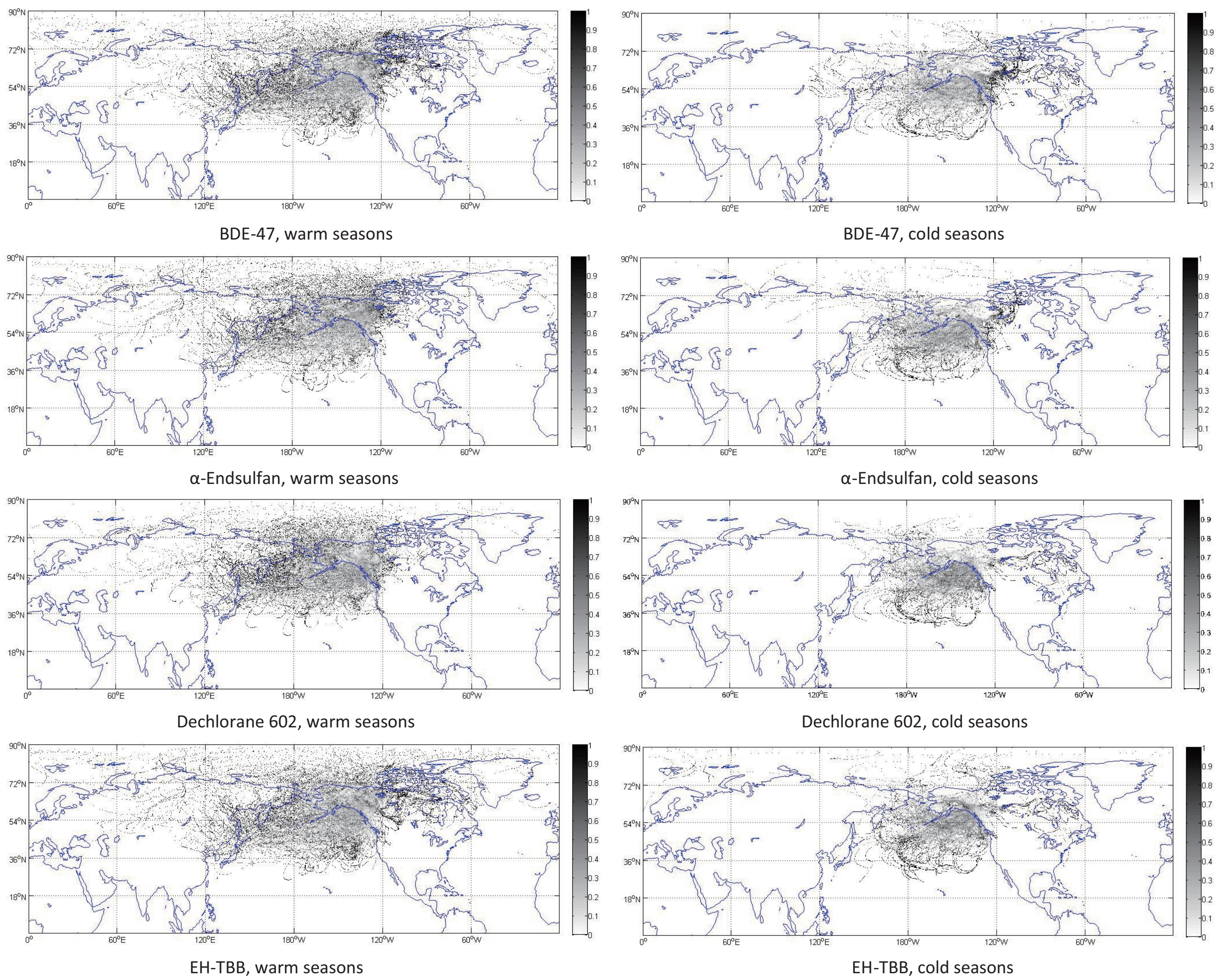
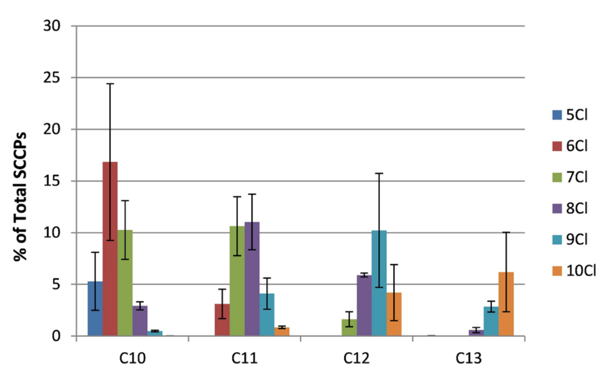


Fig. 6. Proportions of SCCP congener group profiles measured in air at Alert



Discussion and Conclusions

Flame Retardants and Organochlorine Pesticides in Air at Little Fox Lake

Back-trajectories were calculated using the US NOAA HYSPLIT model. Ten-day trajectories were calculated for air arriving at 200 m above the earth's surface starting every 6 h backwards in time. The results were combined with meteorological data to try to reveal potential source areas. Potential source contribution function (PSCF) highlights Canada's Yukon and Northwest Territories as important sources. A large portion of PBDEs and OCs come from Northern Canada, indicating that they are subject to LRAT and regional transport within Canada.

To further study the sources of the chemicals in different seasons, we separate the sampling periods into 2 parts based on temperature above 0 °C and below 0 °C. As shown in Fig. 5, selected chemicals, BDE-47, α-endosulfan, EH-TBB and dechlorane 602, mostly came from the Pacific, East Asia and Northern Canada during the warm seasons. In cold seasons, they mainly originated from the Pacific Rim. Compared with warm seasons, less BDE-47, α-endosulfan, and very few EH-TBB, dechlorane 602 came from Northern Canada. It is expected that old consumer products containing PBDEs and stockpiles will continue to be the source of these chemicals to the air despite the fact that PBDEs have been phased out from the market for several years (Wong et al., 2012). OCs could be accumulated in soil and volatilize to the air, especially during the warm seasons (Komprda et al., 2013; Kobližková et al., 2009). On the other hand, the use of non-BDE FRs has only been initiated in recent years, thus, their historical usage on products are lower (Zheng et al., 2015). Moreover, very few chemicals originated from Arctic Ocean in cold seasons. Therefore, we speculate that higher temperatures contribute to more regional revolatilization, while LRAT is more important during cold seasons.

Screening Results for Short-chain Chlorinated Paraffins (SCCPs) in Air at Alert

The total SCCP concentration found in air at Alert in 2011 (205.7 to 2876 pg/m^3) were higher than those observed at Mt. Zeppelin (Svalbard). In 2013, mean annual SCCP concentrations at Mt. Zeppelin were reported to be 360 pg/m^3, with monthly means ranging from 185.8 to 596.5 pg/m^3 (Norwegian Environment Agency, 2014). However, concentrations at both locations were much lower than those reported in air at Bear Island (situated between Svalbard and mainland Norway) which ranged from 1,800 to 10,600 pg/m^3 (Borgen et al, 2002).

The homolog pattern found in Alert air is unique (Fig. 6), dominated by C10 (36±14%) and C11 (30±0.6%) congeners, with hexachlorodecane ($C_{10}Cl_6H_{16}$) congeners accounting for about 17±7.6%. This pattern is different from that reported in UK air (C12 with 6 and 7 Cl dominant) (Peters et al., 2000) but with slight similarity to East Asian air (C10 and C11 with 5 and 6 Cl dominant) (Li et al., 2012). More analyses need to be done to confirm the seasonality, chemical profiles and trends.

Air monitoring conducted at Alert and Little Fox Lake has indicated the occurrence of some emerging flame retardants and SCCPs in Canadian Arctic air. Measurements of these compounds are continued in 2015-16 and beyond to provide additional baseline data and time trends of these substances.

Expected Project Completion Date

Ongoing

Acknowledgments

We would like to thank the Northern Contaminants Program (NCP) for supporting the atmospheric measurement at Alert and Little Fox Lake. The authors would also like to thank the Canadian Forces Station (CFS) Alert for supporting sample collection.

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Mercury measurements at Alert, Nunavut, and Little Fox Lake, Yukon

Mesures du mercure à Alert et au lac Little Fox

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Abstract

Mercury (Hg) is a global priority pollutant of concern in Arctic regions. While Canadian emissions of mercury are predicted to decrease in the coming years, global emissions are increasing. This is important because 95% of the anthropogenic mercury deposited in Canada comes from sources outside of the country. The Arctic is susceptible for receiving Hg via long range transport from source regions. The longest Arctic record of atmospheric Hg concentrations has been collected in the Canadian high Arctic at Alert, Nunavut. Trend analysis reveals that the levels are going down in the air but at a slower rate than in the high Arctic than at more southerly locations. Mercury continues to show a distinct seasonal drop in

Résumé

Le mercure (Hg) est un polluant prioritaire à l'échelle mondiale qui demeure préoccupant dans les régions arctiques. Bien qu'on prévoie une diminution des émissions de mercure au Canada, on prévoit plutôt une hausse des émissions mondiales. Ces données revêtent une grande importance, car 95 % du mercure d'origine humaine accumulé au Canada provient de l'extérieur du pays. L'Arctique est susceptible de recevoir des dépôts de mercure par le transport à grande distance en provenance des régions sources. C'est à Alert, au Nunavut, dans le Haut-Arctique canadien, que l'on a effectué le relevé le plus long des concentrations atmosphériques de mercure en Arctique. L'analyse révèle que la tendance à la

gaseous elemental Hg (GEM) in the spring. Seasonal patterns in shorter-lived mercury species (reactive gaseous Hg, or RGM, and particle-bound Hg, PHg) continues to show a peak in PHg during early spring and a peak in RGM in late spring. A new method using stable isotopes to analyze these Hg processes in the spring was validated and will be used in the future at this site. Total gaseous mercury (TGM) measurements continue to be collected in the Yukon at Little Fox Lake and seasonal variability has been revealed in the data.

baisse des concentrations de mercure est moins marquée dans l'Extrême-Arctique que dans les régions plus au sud. Le mercure élémentaire gazeux (MEG) continue de connaître une chute saisonnière caractéristique au printemps. Les profils saisonniers des espèces de mercure à plus courte durée de vie (mercure gazeux réactif, ou MGR, et mercure lié aux particules ou PHg) ont été étudiés à partir des profils des dépôts de mercure associés aux chutes de neige. Cette analyse a montré que le PHg connaissait un pic au début du printemps, et que le MGR en produisait un à la fin du printemps. On a validé une nouvelle méthode fondée sur l'utilisation d'isotopes stables pour analyser les processus du mercure au printemps. On continue de recueillir des mesures du MEG au lac Little Fox, au Yukon, et les données recueillies montrent une variabilité saisonnière.

Key messages

- Atmospheric mercury measurements have been collected at Alert, Nunavut since 1995 and at Little Fox Lake, Yukon since 2007
- The long term measurements are done to establish levels over time and predict future trends in long range transport of mercury to these Arctic regions
- Seasonal variability in the atmospheric mercury continue to be reported at both Alert and Little Fox Lake
- The data collected as part of this program will be used as Canada's contribution to the assessment of effectiveness of national and international emission reduction strategies.

Messages clés

- On recueille des mesures du mercure atmosphérique à Alert, au Nunavut, depuis 1995 et au lac Little Fox, au Yukon, depuis 2007.
- On effectue des mesures à long terme pour caractériser l'évolution des concentrations au fil du temps, et pour prédire les tendances futures en matière de transport à grande distance du mercure vers ces régions de l'Arctique.
- On rapporte toujours une variabilité saisonnière à Alert et au lac Little Fox.
- Les données recueillies dans le cadre du programme représenteront la contribution du Canada à l'évaluation de l'efficacité des stratégies nationales et internationales de réduction des émissions de mercure.

Objectives

1. Establish long-term baseline concentrations, patterns and trends of mercury in the Canadian high Arctic air. This information will be crucial in the development of Canadian strategies for national and international pollution control objectives such as those outlined in the Minamata Convention on Mercury.
2. Use measurements of atmospheric mercury species, mercury in snow, and additional complementary data to understand the cycling of mercury in the atmosphere and its subsequent deposition from the atmosphere to the arctic environment. Understanding these processes will help us to predict the effects that changes in anthropogenic emissions and changes in the Arctic climate will have on mercury deposition.
3. To assess the impact of mercury emissions from areas in the Pacific Rim to the Canadian western Arctic using measurements at the Little Fox Lake site.

Introduction

Mercury (Hg) continues to be a priority pollutant of concern in Arctic regions. This project provides long term data on the temporal trends of mercury in the air and snow, contributes to understanding the spatial variability of mercury in the High Arctic air, and assesses how the behaviour of Hg in the atmosphere may impact the pristine Arctic. Changes in the global atmospheric emissions of Hg over time and the resulting concentration changes in particular regions are still under investigation. Further, with global climate change occurring at a rapid pace in Arctic regions, changes in atmospheric dynamics and chemistry may also have an impact on how pollutants such as Hg are transported through the atmosphere and deposited to this environment. Thus, monitoring of atmospheric Hg is required to evaluate both global and regional changes to the Hg cycle.

While European and North American emissions of gaseous elemental mercury (GEM) have decreased since 1995, emissions in other regions such as Asia and Africa have increased (Streets et al., 2011). Circulation patterns show that air masses originating in Asia can enter the Canadian Arctic (Dastoor and Larocque, 2004; Durnford *et al.*, 2010) and thus the increase in Asian emissions are particularly important to the Canadian north. It has been established by modellers that the Little Fox Lake site in the Yukon is an ideal location to measure input from the Pacific Rim, and the data collected at both Little Fox Lake and Alert have been used to model source regions of Hg to these sites (Durnford *et al.*, 2010).

The annual time series of GEM at Alert shows a repetitive distinct seasonal cycling of this pollutant. Alert is a coastal site and thus is subject to intense atmospheric chemical reactions in the Arctic springtime that convert Hg in the air so that it can more easily deposit to surfaces. Alert also reports increased levels of GEM in the summer season. Neither of these phenomena is measured inland at the high altitude site in the Yukon. It is known that the Arctic Ocean plays a strong role in the atmospheric transformation and deposition of mercury, thus the cycling of mercury in the Yukon interior is different from Alert. Data from both sites are therefore complementary.

The data collected by this NCP program serves to monitor long term and seasonal trends of mercury in the high- and sub-Arctic. It provides important information on the atmospheric transport, transformation and deposition processes of this priority pollutant throughout the Polar Regions. The data collected from this program is used by chemists, modellers and those influencing policy decisions on mercury.

Activities in 2014-2015:

Research activities

Ground-based continuous atmospheric measurements of total gaseous mercury (TGM)[1], gaseous elemental mercury (GEM), reactive gaseous mercury (RGM) and particulate mercury (PHg) continued at Alert. Site visits for maintenance and calibration of all mercury instruments at Alert were made in April 2014 and November 2014, on top of regular checks by the onsite operator and student. Continuous measurements of GEM at Little Fox Lake were also carried on through 2014-2015.. Through a partnership with Pat Roach, Laberge Environmental and the Yukon College (now this partnership has been transferred to the Council for Yukon First Nations, CYFN), the contractors visit the LFL site on a weekly basis to check the instrument, download the data and do minor repairs to the instrument on site. Site visits from Environment Canada team members for instrument replacement, supplies, and operator training on the new instrument were made in November 2014 and February 2015.

Data from both sites for the year 2014 have been quality controlled and are reviewed monthly; after final review these data will be submitted to the Environment Canada Data Catalogue (ECDC) (http://donnees-data.intranet.ec.gc.ca:8080/geonetwork/home/eng) and the AMAP database. Data from previous years that had previously been submitted to the National Atmospheric Chemistry (NAtChem) database will be migrating to the ECDC in 2015[2]. Metadata from this program have also been updated in the Polar Data Catalogue (PDC); the existing link from the PDC record to the NAtChem database will be updated to the ECDC once the data have migrated.

1 TGM at Alert is considered to be almost entirely GEM at Alert

2 Currently, there are delays in the process of getting data to the ECDC and the past data is waiting to be transferred once the system is put into place.

Filter and snow samples were collected for mercury and lead stable isotopic analysis in collaboration with the University of Toronto. Preliminary results have been made for the particulate mercury samples and analysis is still pending for the snow samples, isotopes for years 2013-2014 for the mercury particulate and all years for lead particulate and snow samples. Filter samples were not collected in 2015 but some snow samples were collected.

Snow samples continued to be collected at Alert both weekly (from the ground) and on a per event basis (from a Teflon table). All snow samples collected up to the end of 2014 have been analysed at the National Water Research Institute.

Three publications including mercury data collected from Alert and Little Fox Lake were published.

Capacity Building

In keeping with past years, the NCP-funded air research projects for POPs and Mercury have combined communication and capacity-building activities because they are so closely related in terms of facilities and technical support. Hayley and Sandy travelled to Iqaluit in February 2015 to give a presentation and a hands-on demonstration at the Nunavut Arctic College. However, this year, due to poor weather, the school was closed and we were not able to meet with the students. We did meet with the NECC members and had a very good productive discussion about the work and future activities.

Communications

In November 2014, Sandy visited Whitehorse and met with some members of the YCC to discuss current plans and results of the mercury research and the planning and update on the mercury passive sampling project. In February 2014, Hayley and Sandy met with the NECC members in Iqaluit and the YCC members in Whitehorse to update and discuss the mercury research at Little Fox Lake, Alert and throughout the Arctic.

At this time, we are working on how best to incorporate TK in our long term measurements at Alert and Little Fox Lake. Leona Aglukkaq, the federal Minister of the Environment has made it a priority for the Science and Technology Branch of Environment Canada to incorporate aboriginal traditional knowledge (ATK) with our scientific processes. We have provided information to the procedure documents that have been requested but at this point we are not sure at what point this initiative is. Any progress in this will be reported to NCP.

Results

Figure 1 show the total gaseous mercury (TGM) 6 hour averages for Alert (top) from 1995 to 2014 and for Little Fox Lake (bottom) from 2007 to 2014. We have 19 years of this data for Alert and 7 years of data for Little Fox Lake. Trend analyses will be conducted for Alert at the 20 year make and for Little Fox Lake at the 10 year mark to assess trends. Figure 2 shows the monthly TGM concentrations from Little Fox Lake (including the maximum and minimum values). Figure 3 shows the long term mercury speciation data from Alert including gaseous elemental mercury (GEM), reactive gaseous mercury (RGM) and particulate mercury (PHg) from Alert from 2002 to 2014. A discussion of these results follows. These data will be used as Canada's contribution to the assessment of effectiveness of national and international emission reduction strategies.

Figure 1: Total gaseous mercury (TGM) for Alert (top) from 1995 to 2014 and for Little Fox Lake (bottom) from 2007 to 2014. The data are presented in 6 hour averages

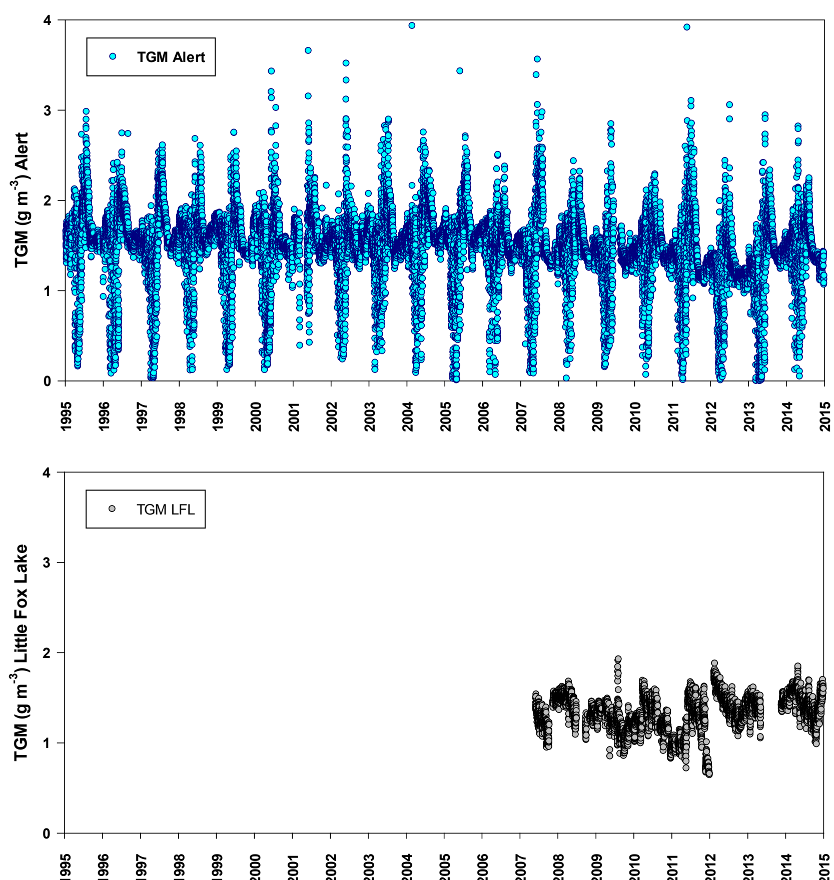


Figure 2: Monthly median TGM concentrations from Little Fox Lake (dark blue bars) for the data collected from 2007 to 2014. Maximum and minimum concentration values are shown in light blue and light red bars, respectively. The dashed line is the median TGM concentration for all the data collected during the same time period

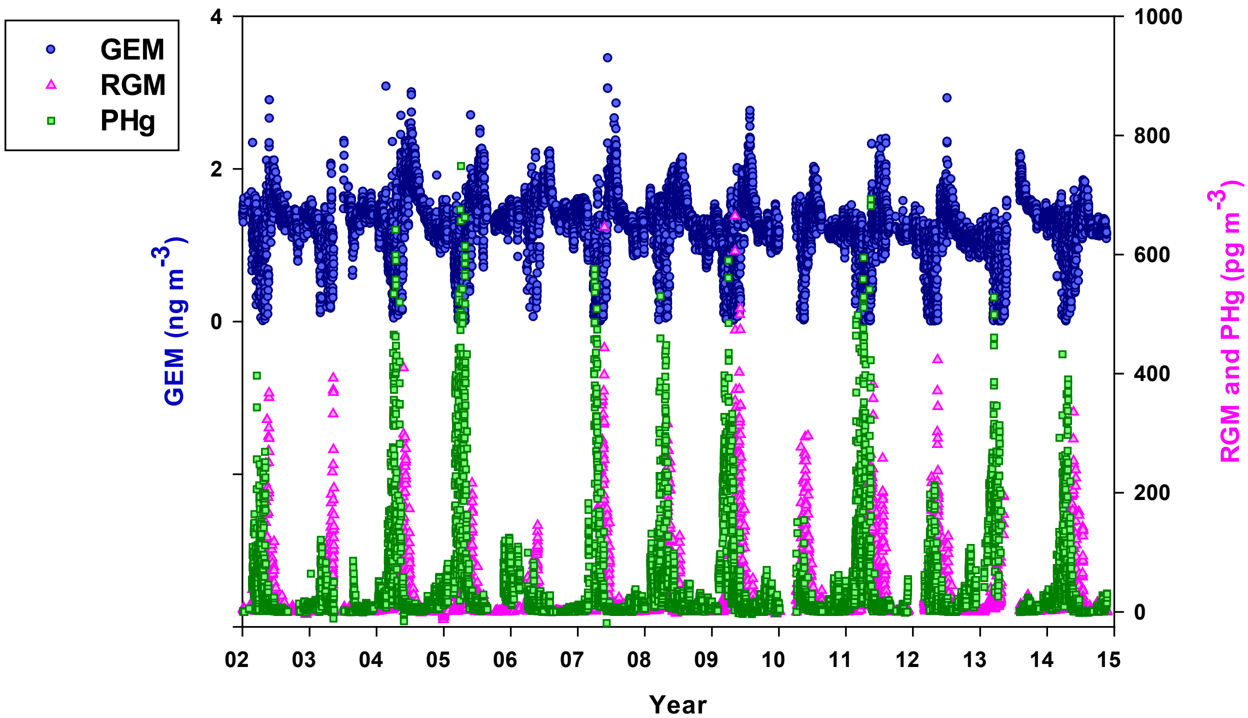
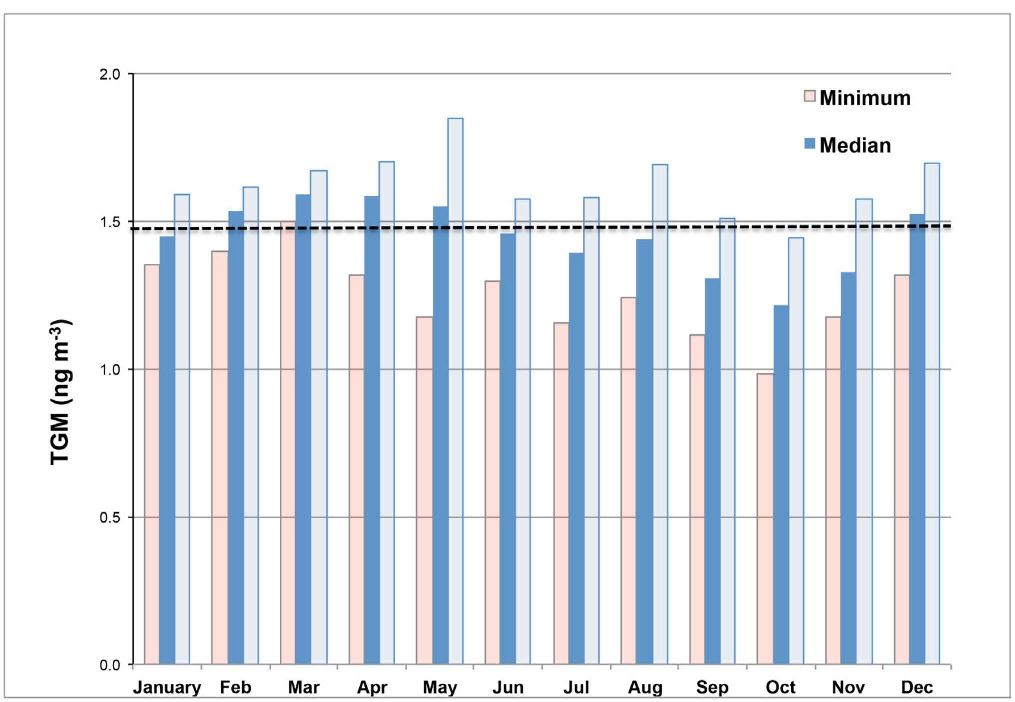


Figure 3: Long term mercury speciation data from Alert including gaseous elemental mercury (GEM), reactive gaseous mercury (RGM) and particulate mercury (PHg) from Alert from 2002 to 2014. GEM is represented by the blue circles, RGM is represented by the pink triangles and PHg is represented by the green squares



Discussion and Conclusions

The continuation of the collection of data was the primary focus of this year. Figure 1 shows the quality controlled data from both Alert and Little Fox Lake up to the end of 2014. The patterns from the GEM data at Alert continue to demonstrate the strong seasonal variability in the mercury levels at this site. As well, the data from Little Fox Lake are beginning to show a distinct seasonal cycle, unlike that seen at Alert. Figure 2 shows the monthly median concentration of TGM at Little Fox Lake including the maximum and minimum values. This graph shows that in the winter and spring months from December to May, TGM levels tend to stay higher than the total median levels (shown by the dashed line). From June to November the TGM levels are lower and below the total median level. This pattern is in keeping with high mercury levels emitted in winter months from elevated heating use, likely from long range transport. The lower levels are likely an indication of local ambient air concentration. Further, investigation into this monthly pattern will be made. Figure 3 show the most updated GEM, PHg and RGM concentrations from Alert. This data continues to reflect the known pattern of these atmospheric mercury species. To try and understand the sources and impact of this pattern a study of the isotopic fractionation of mercury on particles at Alert has been initiated. Mercury stable isotopes fractionation is a new and useful tool that can be used to help understand and distinguish the various Hg sources, transport pathways and transformations in places such as the Arctic (Bergquist & Blum, 2007; 2009; Blum, 2011).

Natural Hg exhibits a large range in mass-dependent fractionation (MDF) and several types of mass-independent fractionation (MIF). MDF is ubiquitous in nature (Blum & Bergquist, 2007; Bergquist & Blum, 2007; 2009) but, in contrast, MIF signatures are only produced in a subset of transformations (such as photochemistry which is the driving process for springtime depletions of Hg). Although there are very limited studies of Hg isotope measurements in atmospheric Hg species (Gratz et al. 2010; Chen et al. 2012; Rolison et al. 2013) and in Arctic snow samples (Sherman et al. 2010), these studies have demonstrated the potential that Hg isotopes may be useful in understanding complicated Hg sources and transformations in the Arctic. To explore the potential of using Hg isotopes to understand the springtime Hg cycling at Alert, samples of Hg and lead (Pb) isotopes have been collected on filters and in snow. Because this is a complicated methodology that requires a significant amount of Hg for analysis, we collected 2 years of test samples to show that the method is viable for looking at the springtime chemistry. Preliminary results show that this is indeed a viable method and can distinguish between MIF and MDF of Hg on the springtime particulate matter. The next phase will be to analyze the 3rd year of sampling from Alert within the 2015-16 FY. Results from this study will be forthcoming.

This year focused on the continued collection of data and not as much on the analysis of the processes since that work was done recently. Future work will include understanding the seasonal variability of the Little Fox Lake Hg levels, analysis of the stable isotope samples and analysis of the snow samples that have been collected over the past few years at Alert.

Expected Project Completion Date

ongoing

Acknowledgements

The project team would like to thank the Global Atmospheric Watch program at Alert for supplying facilities, assistance and personnel. We would like to thank the Alert operators for collecting the mercury data at Alert. As always, we thank the NCP for their continued support for this work.

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Passive air sampling network for organic pollutants and mercury

Réseau d'échantillonnage atmosphérique passif pour l'analyse des polluants organiques et du mercure

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Abstract

This project measures pollutants, namely persistent organic pollutants (POPs) and mercury, in the air at multiple locations across Canada's North. When POPs and mercury enter the ecosystem, they may affect the health of northerners. Currently, there are few locations in Canada's Arctic where these pollutants are being measured. Pollutants are carried through the air from more southerly regions to the Arctic, and expanding the number of locations where they are measured will provide more information about where they come from and how they are changing over time. In order to increase the geographical coverage so that

Résumé

Ce projet vise à mesurer les polluants atmosphériques, dont les polluants organiques persistants (POP) et le mercure, dans différents sites du Nord canadien. Lorsqu'ils entrent dans l'écosystème, les POP et le mercure peuvent influer sur l'état de santé des résidents du Nord. Actuellement, ces polluants sont mesurés à quelques endroits de l'Arctique canadien. Ils sont transportés dans l'air à partir de régions du sud de l'Arctique. En augmentant le nombre de sites de mesure, on obtiendra un plus grand nombre de données sur l'origine des polluants et sur la manière dont ils évoluent au fil du temps. Afin d'accroître la

scientists can obtain a more comprehensive picture of the levels of pollutants, passive sampling methods are used. Passive air samplers (PASs) are a low-cost, low-maintenance way to monitor air pollutants and therefore ideally suited to the Arctic environment. The simplicity of the method is also suitable for involving students or other interested persons in sample collection, enhancing communication between the project team and local communities as well as creating training opportunities for Northern students. The project will ramp up over 3-4 years, eventually producing air concentrations of multiple pollutants at a network of sites across the north. These data will help researchers determine the paths that pollutants take to get to the Arctic and, after a longer time, how changes in sources and the landscape affect how mercury and POPs travel through the air and enter the Arctic environment. Passive air sampling for POPs has been initiated in 2014-2015 at seven sites across the North. Laboratory tests for developing a passive mercury air sampler have started. Project Principal Investigators visited Iqaluit (NU), Whitehorse (YK) and Fort Resolution (NWT) to discuss with the respective Regional Contaminants Committees and community leaders about the project plans and site selections. They also conducted communication/ capacity building activities, including presentations at the Nunavut Arctic College and the Deninu School in Fort Resolution.

couverture géographique des contaminants et d'obtenir ainsi une meilleure vue d'ensemble des concentrations de polluants, on utilise des méthodes d'échantillonnage passif. Les échantillonneurs passifs de l'air sont peu coûteux, constituent un moyen exigeant peu d'entretien de surveiller les polluants atmosphériques et, par conséquent, sont bien adaptés au milieu arctique. La simplicité de la méthode favorise également la participation d'étudiants et d'autres personnes intéressées à la collecte d'échantillons. Elle améliore aussi la communication entre l'équipe de projet et les collectivités locales, et crée des occasions de formation pour les étudiants du Nord. Le projet s'échelonnera sur trois à quatre ans et permettra de compiler les concentrations atmosphériques de nombreux polluants au sein d'un réseau de sites disséminés dans le Nord. Les données résultantes aideront les chercheurs à identifier les voies d'entrée des polluants dans l'Arctique et à plus long terme, à établir comment les changements dans les sources et les paysages influent sur le déplacement du mercure et des POP dans l'atmosphère et leur entrée dans le milieu arctique. En 2014-2015, on a entrepris une campagne d'échantillonnage atmosphérique en vue de mesurer les POP dans sept différents sites du Nord. Les premiers tests de laboratoire ont été effectués afin de mettre au point un échantillonneur passif de l'air pouvant mesurer le mercure. Les directeurs du projet se sont rendus à Iqaluit (Nunavut), à Whitehorse (Yukon) et à Fort Resolution (Territoires du Nord-Ouest) afin de discuter avec les comités régionaux des contaminants et les dirigeants des collectivités des plans et du choix des sites pour le projet. Ils ont également tenu des activités axées sur la communication et le renforcement des capacités, dont des conférences au Collège de l'Arctique du Nunavut, au Collège du Yukon et à la Deninu School de Fort Resolution.

Key messages

In 2014-2015, the project team focused on coordinating the installation of passive air sampling sites, as well as communication, consultation and capacity building:

- Passive air sampling equipment has been sent to 7 arctic sites and most stations were in operation since October 2014. Remote training was provided for all site operators.
- Project Principal Investigators visited Iqaluit (NU), Whitehorse (YK) and Fort Resolution (NWT) to discuss with the respective Regional Contaminants Committees and community leaders about the science activities and communication/outreach plans under this project. They also conducted communication/capacity building activities, including producing and distributing 3 training videos on deploying passive air samplers for persistent organic pollutant measurements and gave a seminar at the Deninu School in Fort Resolution.
- Funding has been acquired from Environment Canada under a Grants and Contribution agreement and an NSERC Strategic Grant to the University of Toronto to continue the field and laboratory testing of the mercury passive air sampler that was developed with NCP seed funding in 2013-2014. When thoroughly tested, this type of sampler will be deployed at the 7 northern stations under this project.

Messages clés

En 2014-2015, l'équipe du projet s'est concentrée sur la coordination des installations des sites d'échantillonnage atmosphérique passif, de même que sur la communication, les consultations et le renforcement des capacités.

- On a envoyé de l'équipement d'échantillonnage atmosphérique passif à sept différents sites dans l'Arctique et la plupart des stations étaient opérationnelles en octobre 2014. On a offert de la formation à distance à tous les exploitants de site.
- Les directeurs du projet se sont rendus à Iqaluit (Nunavut), à Whitehorse (Yukon) et à Fort Resolution (Territoires du Nord-Ouest) afin de discuter avec les comités régionaux des contaminants et les dirigeants des collectivités respectifs des activités scientifiques ainsi que des plans de communication et de sensibilisation liés au projet. Ils ont également tenu des activités axées sur la communication et le renforcement des capacités, élaboré et distribué trois vidéos de formation sur l'installation d'échantillonneurs passifs de l'air permettant de mesurer les POP, et organisé un séminaire à la Deninu School de Fort Resolution.
- On a obtenu du financement de la part d'EC dans le cadre d'une entente de subventions et de contributions. Une subvention stratégique du Conseil de recherches en sciences naturelles et en génie (CRSNG) a également été allouée à l'Université de Toronto afin qu'elle poursuivre ses essais sur le terrain et en laboratoire sur l'échantillonneur passif de l'air permettant de mesurer le mercure, lequel a été mis au point en 2013-2014 grâce au financement de démarrage du Programme de lutte contre les contaminants dans le Nord (PLCN). Suivant la réalisation de tests approfondis, on installera un échantillonneur du même type dans les sept stations mises sur pied dans le Nord dans le cadre de ce projet.

Objectives

Short-term objectives of this project are:

1. Expand the geographic coverage of the air monitoring program by developing, installing and operating passive air sampling devices capable of operating remotely under extreme conditions at up to 7 new locations across all Arctic regions. Separate devices will be deployed for POPs and mercury.

1. Determine latitudinal gradients in air concentrations from which empirical estimates of characteristic travel distances (CTDs) of pollutants can be made.

1. Engage with and train Northern residents, likely affiliated with local colleges, for the deployment of samplers and collection of samples in order to provide training opportunities for northern students and provide local information on pollutants to northern communities.

1. Provide spatially-distributed concentration data for this under-represented region to atmospheric modellers, to assist in model validation and improvement.

Long-term objectives of this project are:

1. Provide key data to evaluate the overall effectiveness of the provisions outlined in the Stockholm Convention, the CLRTAP Protocols on POPs and Heavy Metals and the Minamata Convention.

2. Complement active monitoring at Alert and Little Fox Lake to provide a more geographically complete picture of atmospheric contamination and assess global transport pathways and sources.

3. Track long-term trends in pollutants to evaluate the effect of global and regional environmental changes at multiple Arctic locations.

Introduction

This is a new project aiming at measuring POPs and mercury in Arctic air using passive air sampling methods that will provide scientific information on the spatial distribution and input of these contaminants to the Arctic environment. For the last two decades, air monitoring programs were limited to continuous monitoring of POPs and mercury at Alert and Little Fox Lake and POPs at a few satellite stations for 1-2 years. Expanding the spatial distribution of air monitoring within the Canadian Arctic would be extremely valuable for further constraining atmospheric models of pollutant transport, chemistry and deposition, since current validation data is so sparse. This project aims to achieve this objective using passive air sampling methods which are low-cost, low-maintenance and easy to deploy at multiple locations. It builds upon the two NCP core air monitoring projects for POPs and mercury in air (M01 and M02), as well as the Global Atmospheric Passive Sampling (GAPS) network, which conducts air monitoring of POPs at 50+ sites worldwide. There are currently eight Arctic sites operating under GAPS with three in the Canadian Arctic region (i.e. Little Fox Lake, Alert, and Coral Harbour). Our additional sites would expand coverage and develop an Arctic network of passive air samplers. The other 50+ sites under GAPS will provide reference in terms of levels and context for investigating long-range atmospheric transport and spatial distributions on a global scale. The team will collaborate with the GAPS network to deploy both the XAD-based (one-year integrated sampling) and PUF-disk-based (3-month integrated sampling) PAS at 7 Arctic sites. The PUF-PAS will provide seasonal air concentration data for POPs while the XAD-PAS will be able to capture more volatile and polar chemicals [e.g. per- and polyfluoroalkyl substances (PFASs)] and is ideal for sampling in locations with relatively low air concentrations of organic contaminants, such as the Arctic.

In 2014-2015, the PASs for POPs measurements were sent out to 7 sampling sites (Iqaluit, Inuvik, Cambridge Bay, Fort Resolution, Kuujjuaq, Nain and Northwest River) and most of these sites were in operation since October 2014. The samples will be sent back to Environment Canada where they will be analyzed for priority chemicals. Results for legacy chemicals, e.g. organochlorines (OCs), and flame retardants (FRs), will be available for dissemination back to the school and participating communities. Results will be put into context with historical global results from the GAPS program.

New priority chemicals will also be investigated in these samples and reported over a longer time-frame. The XAD-PAS allows the screening of a broad range of volatile and polar chemicals, such as PFASs, current-use pesticides and some new flame retardants. New chemicals of concern can be added to the analytical list in the future.

With seed funding from NCP in 2013-2014, a prototype of a mercury PAS has been developed in collaboration with Prof. Frank Wania and Carl Mitchell at the University of Toronto Scarborough. This PAS is composed of a small cylindrical container for activated carbon inserted into a diffusion tube of the commercial Radiello® type PAS. Funding to continue development of this sampler has been acquired from Environment Canada and Natural Sciences and Engineering Research Council of Canada (NSERC).

Activities in 2014-2015

Initiation of Passive Air Sampling Sites

Equipment for the installing both the XAD-based (one-year integrated sampling) and PUF-disk-based (3-month integrated sampling) PASs were sent to the 7 sites as given above.

Passive Air Sampler (PAS) outside of Fort Resolution, NWT.

Several agencies have confirmed that they would provide the sample change service as in-kind contribution to the project. Agencies that have confirmed in-kind contribution include: Iqaluit (Jamesee Moulton, Nunavut Government); Nain and Northwest River – 2 sites (Rodd Laing, Nunatsiavut Government); Inuvik (Matthew Seaboyer, Environment & Natural Resources, Government of the Northwest Territories); Cambridge Bay (Michael Brown, Meaghan Bennett, Donald McLenan, AANDC) and Kuujjuaq (Catherine Pinard, Michael Barrett, Véronique Gilbert, Kativik Regional Government).

Mercury PAS Development

With NCP seed funding in 2013-2014, a mercury passive sampler prototype was developed. The sampler consists of a stainless steel mesh cylinder filled with activated carbon placed in a commercially produced radial diffusive barrier and housed in an polyethylene terephthalate (PET) external windshield, which doubles as a storage and transport container. Further development and field testing funding was acquired in 2014-2015 from Environment Canada under a Grants and Contribution agreement and an NSERC Strategic Grant to the University of Toronto.

Communications and Capacity Building

The team has communicated our plans and consulted with Regional Contaminants Committee (RCC) representatives and community leaders of all regions about the locations for deployment of POPs PASs.

Information packages (including standard operating procedures) related to the deployment of POPs passive air samplers were sent to potential site operators.

To train site operators on sampler deployment and sample change, the team has produced three videos which are available online:

PUF disk sampler setup (quarterly – every 3 months):

https://www.youtube.com/watch?v=8A22nvu7kbQ&feature=youtu.be

XAD tube sampler setup (annually):

https://www.youtube.com/watch?v=9vvrvpRD96k&feature=youtu.be

Temperature logger installation (annually):

https://www.youtube.com/watch?v=nkzbCzRPMyc&feature=youtu.be

Signage and notification have been provided to site operators to make sure that the communities are aware of the presence of the samplers to ensure that they are secure and would not be subjected to contamination (e.g. smoke or vehicles exhaust) and destruction (e.g. used as targets during hunting).

Hayley Hung and Amanda Cole visited Fort Resolution between Sep 9 and 11, 2014. With the assistance of the Fort Resolution Metis Council, Deninu Kue First Nation (DKFN), the Akaitcho Territorial Government (ATG) and the Hamlet, the POPs passive air sampler housings were installed on a site on Mission Island close to Fort Resolution. Hayley and Amanda gave two presentations about air monitoring of POPs and mercury in the Arctic under NCP to representatives from the DKFN, the ATG, the Fort Resolution Métis Council and the Hamlet. Hayley and Amanda gave a seminar at the local high school Grade 10 science class and the seminar was well received. The DKFN aquatics trainee (Nicole McKay) was trained on how to take air samples and she will train another technician from the Metis Council for sample deployment.

Hayley Hung and Alexandra Steffen visited Iqaluit in 10-12 February, 2015 to give a half-day lecture and half-day hands-on activity session on air monitoring of POPs and mercury in the North to students at the Nunavut Arctic College. However, classes were cancelled twice due to poor weather conditions. Hayley and Sandy met with Karlene Napayok (Iqaluit site PAS operator) to discuss about air monitoring of POPs and mercury in Iqaluit and visited the PAS sampling site. While in Iqaluit, they also met with the Nunavut Environmental Contaminants Committee (NECC) to discuss about communication/capacity building activities related to this project. In 16-18 February, 2015, the PIs performed a site visit to Little Fox Lake and met with the Yukon Contaminants Committee (YCC) and Council of Yukon First Nations (CYFN). During this trip, arrangements were made to meet with the Ta'an Kwach'an Council (TKC) but did not realize due to scheduling issue. However, Mr. Derek Cooke of the TKC attended the meeting with the YCC and CYFN.

Karlene Napayok, Iqaluit site PAS operator, with Passive Air Sampler.

Traditional Knowledge Integration

During the consultations, RCC representatives and community members contributed traditional/local knowledge of preferred site locations to ensure samples collected will be regionally representative and are not subjected to local emission influences (e.g. landfills, incinerators, mines, highway traffic etc.).

Results

Initiation of Passive Air Sampling Sites

PAS sampling equipment was sent to 7 Arctic sites. Most PUF-disk-based samplers have been deployed in Oct/Nov 2014 and XAD-based samplers deployed in Jan 2015. The station at Kuujjuaq has received permission to deploy from the land-holding corporation of Kuujjuaq in December 2014 but the samplers were not deployed due to the cold weather conditions. Samples will be deployed at this location when the winter is over in early 2015. The sampler deployed at Cambridge Bay in October 2014 has not yet been retrieved and the XAD-based sampler has not been deployed due to staff changes at the Canadian High Arctic Research Station (CHARS).

Mercury PAS Development

The cost of the mercury PAS is estimated to be less than $25 (based on subsidized labor costs at the University of Toronto machine shop). Indoor and outdoor experiments have shown promising uptake results. Further laboratory and field testing will continue in FY 2015-2016. Once thoroughly tested, we intend to deploy these mercury PASs at the 7 arctic sites under this project.

Discussion and Conclusions

In 2014-2015, the team focused on initiating the POPs passive air sampling sites and training of site operators. Samples will be sent back to Environment Canada in 2015-2016 for chemical analysis. Results will be disseminated after sample and data analysis.

Expected Project Completion Date

Ongoing project

Acknowledgments

The team would like to acknowledge NCP (AANDC) for funding the passive air sampling network. The continued support of the 5 Regional Contaminants Committees, northern community members and associations of the passive air sampling initiative is greatly appreciated. Initial seed funding for the development of the mercury PAS was provided by NCP (AANDC) in fiscal year 2013-2014. Since then further development and field testing of the sampler is supported by an Environment Canada Grants and Contribution agreement and an NSERC Strategic Grant to the University of Toronto.

Temporal trends of persistent organic pollutants and metals in ringed seals from the Canadian Arctic

Tendances temporelles des polluants organiques persistants et des métaux chez le phoque annelé de l'Arctique canadien

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b: Marine mammal biologists contributing in 2014-15:
Steve Ferguson and Brent Young, DFO Winnipeg; Aaron Fisk and Dave Yurkowski, University of Windsor.

c: Chemical analysis and sample archiving contributing in 2014-15: Ed Sverko and Enzo Barresi, Environment Canada, NLET organics, Burlington ON; Bert Francoeur and Jacques Carrier, NLET inorganics, Burlington ON; Mary Williamson and Amy Sett, Environment Canada, AEPRD, Burlington ON; Ron McLeod and Whitney Davis, ALSGlobal, Burlington ON

Abstract

The objective of this project is to determine changes in concentrations of legacy contaminants, such as persistent organic pollutants (POPs) and mercury in ringed seals. All sampling is done with the help of hunter and trapper committees in each community who are supplied with sampling kits and instructions. In 2014 samples were collected by local hunters in the communities of Arviat, Nain, Resolute and Sachs Harbour. Chemical measurements were combined with results from previous years,

Résumé

Ce projet a pour but de caractériser les variations des concentrations de contaminants qui sont présents chez les phoques annelés et hérités du passé, comme les polluants organiques persistants (POP) et le mercure. Dans chacune des collectivités visées, toutes les activités d'échantillonnage sont effectuées avec l'aide des comités de chasseurs et de trappeurs auxquels on remet des trousses d'échantillonnage ainsi que des directives. En 2014, des échantillons ont été recueillis

including samples archived from the 1970s to examine the trends over time and geographical differences. Concentrations of mercury and cadmium have declined in all regions since the mid-2000s, except at Nain where trends can't yet be determined because of a limited number of sampling years. The decline in mercury parallels what we have observed in muscle samples but was not evident in previous years due to high year to year variability. Legacy POPs in seal blubber continue to decline significantly in ringed seals from Hudson Bay and Lancaster Sound regions but show slow, non-significant trends, in the Beaufort Sea samples.

par les chasseurs des collectivités d'Arviat, de Nain, de Resolute et de Sachs Harbour. Les mesures chimiques ont été combinées aux résultats d'années antérieures, notamment des échantillons prélevés à partir des années 1970, et ce, afin d'examiner les tendances au fil du temps et les différences géographiques. Depuis le milieu des années 2000, les concentrations de mercure et de cadmium sont en déclin dans toutes les régions, sauf à Nain; l'endroit ayant fait l'objet d'échantillonnages restreints, il est encore trop tôt pour déceler des tendances. Le déclin des concentrations de mercure concorde avec nos observations des échantillons de muscles. Il n'était cependant pas facile à déceler au cours des années précédentes en raison de l'importante variabilité observée d'une année à une autre. Les concentrations de POP hérités du passé dans le petit lard de phoque continuent de diminuer considérablement chez les phoques annelés de la baie d'Hudson et des régions du détroit de Lancaster. Toutefois, les échantillons prélevés dans la mer de Beaufort révèlent que les concentrations chez les individus de cette région ont tendance à diminuer lentement et de façon non significative.

Key Messages

- Mercury and cadmium in seal liver muscle has declined in three of the four sampling regions since the mid-2000s
- POPs continue to decline in ringed seals from Hudson Bay and Lancaster Sound regions but show much slower declines samples from the Beaufort Sea region.

Messages clés

- Depuis le milieu des années 2000, les concentrations de mercure et de cadmium dans les muscles et dans le foie des phoques ont diminué dans trois des quatre régions ayant fait l'objet d'activités d'échantillonnage.
- Les concentrations de POP continuent de diminuer considérablement chez les phoques annelés de la baie d'Hudson et du détroit de Lancaster. Toutefois, les échantillons prélevés dans la mer de Beaufort révèlent que les concentrations chez les individus de cette région ont tendance à diminuer beaucoup plus lentement.

Objectives

1. Determine temporal trends of persistent organic pollutants (POPs) and new organic chemicals of potential concern, as well as mercury and other metals in ringed seals based on annual collections at 4 communities, previous data from the 1970s, 1980s and 1990s, as well as archived samples if available.
2. Identify and prioritize other new contaminants that are entering the Arctic environment and contribute information to Canadian and International assessments of new candidate POPs.
3. Provide the information on levels and temporal trends of these contaminants to each participating community and to the Nunavut Environmental Contaminants Committee, the NWT Environmental Contaminants Committee and the Nunatsiavut Health and Environment Research Committee.

Introduction

The ringed seal is the most abundant Arctic pinniped with a circumpolar distribution and has been a key biomonitoring animal for examining spatial and temporal trends of persistent organic pollutants (POPs) and mercury in the Arctic since the 1970s (Vorkamp and Muir 2015). This project began in April 2004 under NCP Phase III and follows up earlier projects on ringed seals (Muir and Lockhart 1994, Muir 1996, Muir 1997, Muir et al. 1999, Muir et al. 2001, Muir et al. 2003). Results for POPs and heavy metals including mercury are available going back to the 1980s, and earlier in some cases.

Because ringed seals are an important species harvested by hunters each year in almost all communities in Nunavut, Nunavik, Nunatsiavut, and the Inuvialuit Settlement Region, this project provides an opportunity to involve the communities in the scientific program of the NCP. Participation of hunters in each community has been consistent and the quality of the hunter based collection has generally been high.

Our 2013-14 report focused on trends of perfluorinated chemicals, legacy POPs and mercury. In this report we summarize trends in mercury and cadmium to 2014, and in “legacy organochlorine POPs” to 2013, expressed as % change per year.

Activities in 2014-2015:

Sample collection:

In 2014 ringed seal samples were successfully collected by hunters in the communities of Arviat (25), Sachs Harbour (10), Resolute Bay (N=15) and Nain (9). Collections consisted of blubber, liver, muscle, kidney, tooth/lower jaw (for aging). Essential data on length, girth, blubber thickness at the sternum, and sex was provided for almost all animals for all locations. At Resolute and Arviat, hunters also weighed the majority of the animals. Samples were stored at -20^{o}C and then shipped frozen to Burlington for processing. Large subsamples of all tissues were archived in walk-in freezers at -35 ^{o}C in sealed plastic bags (double bagged).

In 2014 tooth aging was conducted by Matson Labs (Milltown, MT). Muscle samples were sent to Wildlife Genetics International (Nelson BC) for gender confirmation using a DNA marker and to the University of Waterloo (Environmental Isotope Lab) for C and N stable isotope analysis.

Data were provided to the Arctic Monitoring and Assessment Program (AMAP) for the assessment of temporal trends of POPs listed under the Stockholm Convention.

Chemical analyses:

Analyses of OCPs and PCBs in the 2013 samples was contracted to ALSGlobal (Burlington ON) while PBDEs were determined in the same sample extracts by National Laboratory for Environmental Testing (Environment Canada). Results for 2014 are pending. Extraction and cleanup procedures followed using USEPA Method 1699 (US EPA 2007) as in previous years. Tissue samples were spiked with 13C12-PCB-133- prior to extraction. The tissues were mixed with anhydrous sodium sulphate and Soxhlet extracted overnight with dichloromethane (DCM). The extracts were cleaned by gel permeation chromatography to remove lipids and reduced to a 1mL final volume in DCM. A separate 50uL portion of each extract was removed for both OCP and PCB analyses. A suite of 13C labeled PCBs was added to the PCB extracts for target analyte quantification and retention time references. Similarly a suite of deuterated and 13C- labeled OCPs was added to the OCP extracts prior to instrumental analysis for target quantification. Sample extracts were then analysed directly by GC-high resolution mass spectrometry (GC-HRMS) for OCPs and by GC-Low resolution MS for PCB congeners. All data were recovery corrected for extraction and clean up losses relative to 13C12 PCB-133 response.

Liver was analysed for a suite of PFASs in the Muir labs at Environment Canada (Burlington) as described by Butt et al.(2008) with method modifications described in Mueller et al.(2011). Instrumental analysis was performed by liquid chromatography-tandem MS (LC-MS/MS) as described in Butt et al. (2008).

Methods for total mercury in muscle and multi-element analysis of liver were unchanged from previous years (Muir et al. 2014).

Quality assurance and statistical analysis:

QA steps included the analysis of reference materials for heavy metals and POPs and reagent blanks with each batch of samples. All results were blank subtracted. Further details are given in previous synopsis reports (Muir et al. 2011, 2012, 2013, 2014).

Both Environment Canada labs and ALSGlobal participated successfully in Phase 7 and 8 of the NCP QA program (Tkatcheva et al. 2013, Myers et al. 2014). Basic statistics, correlations and frequency distributions were determined using Systat Version 12 (Systat Software Inc, Chicago IL). Organohalogen concentrations in ringed seals were normalized to 100% lipid. For temporal trend comparisons results were first tested for normality the Shapiro-Wilk test. All contaminants data were log10 transformed to give coefficients of skewness and kurtosis <2 and geometric means (back transformed log data) were calculated. Temporal trends of POPs were analysed using the statistical program PIA (Bignert 2007).

Capacity Building:

The project very much depends on the help of local people. Because ringed seals are an important species harvested by hunters each year in almost all communities in Nunavut, Nunavik, Nunatsiavut and the Inuvialuit Settlement Region (ISR), this project is providing an opportunity to involve the communities in the scientific program in a meaningful way. The success rate of the hunter based collection has been high. Information on hunter collected data is discussed below.

Communication:

Short reports (in English and Inuktitut) on the results of the study to date were faxed or emailed to the Hunters and Trappers committee offices of each community in April 2014 for the communication and consultations in 2014 and in 2015. The report for Nunavut and the ISR was first reviewed by the Nunavut Environmental

Contaminants Committee (March 2015). Muir discussed the project with the manager of the Resolute Bay HTA during a visit in early August 2014 and Steve Ferguson and Brent Young visited the HTA in Arviat during 2014 to discuss the organization of their seal sampling program.

Traditional Knowledge Integration:

The project works directly with HTA offices in each community, and in some cases directly with hunters. At the same time this project relies heavily on the knowledge and experience of these hunters for selecting the time and place for collecting samples as part of their traditional harvesting activities.

Results

Sample collection and hunter observations: In 2014 the requested information on gender, girth, length, blubber thickness was provided for all 76 of 80 harvested animals. The identification of the gender of the seals by hunters in the field was in agreement with results for DNA markers in 75 out of 80 samples. Overall the information provided by the hunters was excellent considering the logistical challenges they face in having to harvest and dissect the animals in the field.

Trends of mercury in seal muscle: Concentrations of mercury in seal muscle have declined significantly at Arviat. Resolute and Sachs Harbour from the mid-2000s (Table 1, Figure 1). The most rapid decline was at Sachs Harbour (2006-2014) (-9.4 %/yr) based on 7 years of data. No change is evident at Nain but fewer sampling years were available.

Trends of mercury and cadmium in seal liver: Mercury declined in seal liver from Sachs Harbour (-5.8%/yr) but had no significant trend at Arviat, Nain, or Resolute over the period 2005 to 2014 (Table 1; Figure 1). Liver cadmium declined significantly at Sachs Harbour (-6.6%/yr) from 2005 to 2014 and also showed (non-statistically significant) declines at Resolute and Arviat (Table 1, Figure 1).

Trends of Legacy POPs: Measurement of all organic contaminants continued in 2014-15 but results for PCBs and other chlorinated organics including organochlorine pesticides, toxaphene, endosulfan, chlorinated paraffins and PCNs in samples collected in 2014 are pending. Temporal trends of legacy POPs were calculated to 2013 using the PIA program (Bignert 2007). As in previous years, results from nearby communities were combined because most PCB/OCs concentrations were similar for nearby communities while differing significantly among regions (see footnote in Table 2). For PCBs we used the sum of 10 major congeners (Σ10PCB) for compatibility with results from

Table 1. Time trends of mercury and cadmium in adult ringed seals (> 4 yrs old) calculated using the PIA program (Bignert 2007). Statistically significant % annual change in bold

Location	Tissue	Interval	Yrs	Mercury		Cadmium	
				% change	R^2	% change	R^2
Arviat	Muscle	03-2014	10	**-4.1**	0.72	-	-
	Liver	05-2014	9	-4.1	0.10	-6.9	0.13
Resolute	Muscle	04-2014	11	**-4.6**	0.49	-	-
	Liver	05-2014	10	-1.1	0.00	-3.2	0.10
Sachs Harbour	Muscle	06-2014	7	**-9.4**	0.56	-	-
	Liver	05-2014	8	-5.8	0.45	**-6.6**	0.70

Figure 1. Top panels: Trends of mercury in muscle of adult ringed seals (> 4 yrs old) and average nitrogen isotope ratios (δ15N) of adult seals sampled for contaminant analysis from the 1990s to 2014. Bottom panels: Trends of mercury and cadmium in liver of adult ringed seals from the 1970/80s to 2014. Symbols represent geometric mean concentrations and vertical bars are standard errors.

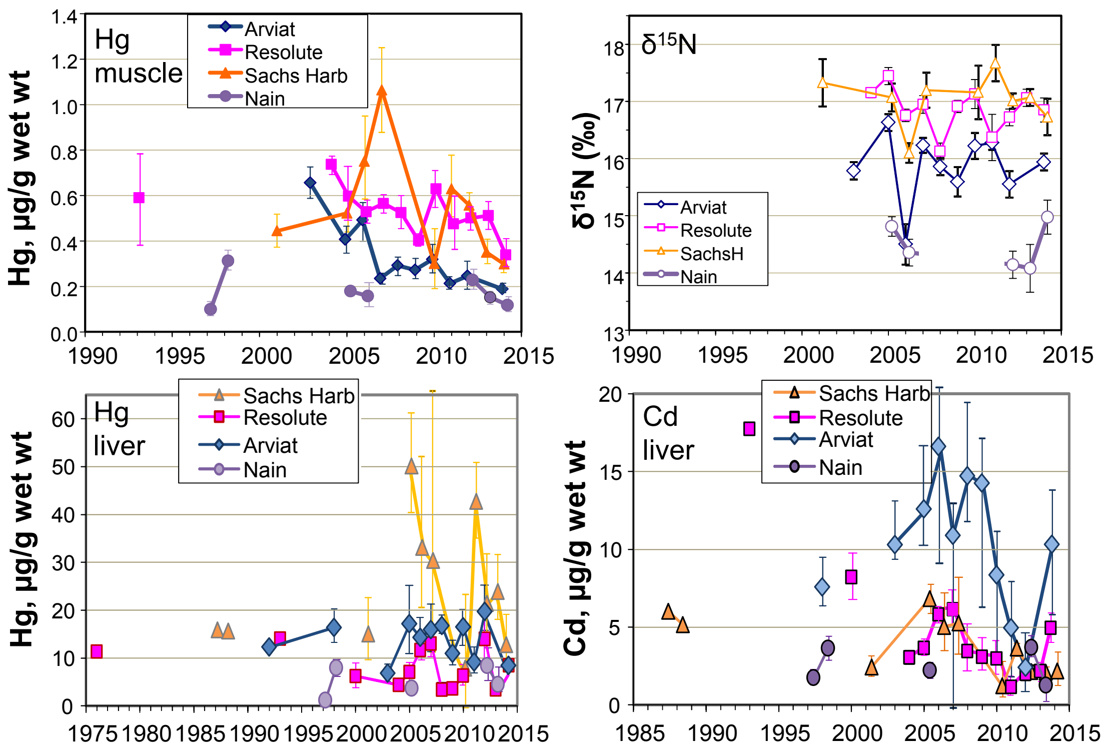

Table 2. Time trends of POPs in female and juvenile ringed seals using the PIA program (Bignert 2007). Statistically significant % annual change in bold.

Region	Interval	yrs	Statistic	α-HCH	β-HCH	HCB	Σ_{10}PCB	ΣDDT	ΣCHL	Toxaphene	ΣPBDE
Hudson Bay[1]	‘86-2013	14	**% decl or inc**	**-8.6**	-2.5	**-2.4**	**-5.6**	**-7.1**	**-6.8**	**-5.3**	
			R^2	0.78	0.09	0.32	0.61	0.74	0.65	0.59	
	‘02-2013	9	**% decl or inc**								-5.6
			R^2								0.22
Lancaster[2]	‘72-2013	18	**% decl or inc**	**-3.9**	**4.5**	-0.49	**-2.5**	**-3.1**	**-1.1**	0.30	
			R^2	0.63	0.67	0.05	0.55	0.71	0.19	-0.4	
Lancaster[3]	‘06-2013	7	**% decl or inc**							7.2	9.9
			R^2							0.17	0.25
Beaufort Sea[4]	‘88- 2013	9	**% decl or inc**	**-7.1**	1.8	-1.9	-1.9	-3.7	-0.37	-2.5	
			R^2	0.76	0.28	0.39	0.29	0.39	0.01	0.19	
	‘01-2013	8	**% decl or inc**								**4.6**
			R^2								0.68

[1] Arviat + Inukjuaq (to 2012 – samples not collected in 2013);

[2] Resolute Bay + Arctic Bay + Grise Fiord;

[3] Qikiqtarjuaq and Pangnirtung;

[4] Sachs Harbour + Ulukhaktok; samples from 2002-13 for PFOS and PFCAs

the 1970s and 80s. Overall, there are declining trends of POPs in ringed seals with the *relative* magnitude of ΣDDT (-3.1 to -7.1 %/yr) > α-HCH (-3.9 to 8.6 %/yr) > Σ10PCB (-1.9 to -5.6 %/yr). Declines were most rapid in Hudson Bay animals and least in the Beaufort Sea samples (Table 2). The trends of Σ10PCB, ΣDDT, ΣCHL and toxaphene in the Beaufort (Sachs Harbour/Ulukhaktok) were not statistically significant. Toxaphene also showed no trend at Resolute over the period 1972 to 2012 and concentrations have actually increased at Resolute over the period 2009 to 2013 although the trend was not statistically significant (Table 2).

Trends of Newer POPs: ΣPBDEs (sum of congeners 17, 28/33, 47,49, 66, 85, 99, 100, 153, 154, 183, 190) have generally increased in the southern Beaufort (+4.6 %/yr) and in Lancaster Sound (9.9 %/yr) but are declining in Hudson Bay (-5.6% from 2002 to 2013, although the trend is not statistically significant (Table 1).

Discussion and Conclusions

This study has provided new information on the temporal trends of mercury and cadmium in ringed seal liver indicating that concentrations of both metals have declined in all three sampling regions since the mid-2000s. The decline in mercury parallels what we have observed in muscle samples but was not evident in previous years due to high year to year variability. High variability of mercury in liver among seals within the same sampling year makes trends in liver difficult to follow. The reasons for the declines in mercury are unclear. They are much more rapid than declining concentrations of atmospheric mercury at Alert which is about 1% per year since the early 2000s (Cole et al. 2013). Median concentrations of mercury in liver and kidney of beluga whales from Hendrickson Island has also declined over the period 2003-2012 (Stern and Loseto 2013). Recent declines in mean concentrations of mercury (post-2010) have also been observed in eggs of black-legged kittiwakes and thick-billed murres in Lancaster Sound (Braune 2014). Changing diets of the seals would seem to be the most likely reason for lower mercury, however, only small changes were observed in nitrogen isotope ratios (Figure 1) over the past 10 years. Thus seals are feeding at the same trophic level even as mercury declines.

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Temporal and spatial trends of legacy and emerging organic and metal/elemental contaminants in Canadian polar bears

Tendances temporelles et spatiales des contaminants organiques et métalliques/élémentaires classiques et émergents chez l'ours blanc du Canada

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Abstract

The polar bear (Ursus maritimus) is the apex predator of the arctic marine ecosystem and food web. Starting in 2007 and ongoing in 2014, on a biennial or annual basis this project is assessing longer-term temporal trends and changes of NCP priority persistent organic and elemental pollutants (POPs) in polar bears from the southern and western Hudson Bay (Nunavut) subpopulations. For POPs that are currently banned or regulated (e.g. under the Stockholm Convention on POPs), annual-based sampling of adipose tissue from 2007-2014 for southern or western

Résumé

L'ours blanc (*Ursus maritimus*) est le super prédateur de l'écosystème et du réseau alimentaire marins de l'Arctique. Le projet, qui a débuté en 2007 et qui s'est poursuivi en 2014, vise à évaluer sur une base annuelle ou bisannuelle les tendances et les variations temporales à long terme qui caractérisent les polluants organiques persistants (POP) prioritaires du Plan de lutte contre les contaminants dans le Nord (PLCN) et que l'on retrouve dans les tissus des ours blancs de deux sous-populations au sud et à l'ouest de la baie d'Hudson (Nunavut). Pour ce

Hudson Bay bears are showing no temporal trend changes. In the case of western Hudson Bay bears over the longer 1991-2014 period, relative the years prior to 2001, from 2007-2014 Dichlorodiphenyltrichloroethane (SDDT) and alpha-hexachlorocyclohexane a-HCH levels were lower, and SPCB, Polyrominated diphenyl ether (SPBDE) (tetra- to octa-brominated congeners; no detectable BDE-209) and b-HCH levels were higher. Since 2009 for both subpopulation bears, SPBDE levels appear to be decreasing. For recent adipose samples, hexachlorobutadiene (HCBD), β-endosulfan and endosulfan sulfonate were not detected for all bear samples, whereas α-endosulfan and several organophosphate flame retardants were detectable with some frequency but at low ppb levels. Hexabromocyclododecane (HBCDD) and Dechlorane Plus (DP) 602 and 603 showed recent low ppb levels, whereas BB-153 was comparable to SPBDEs. Between 2007 and 2013, PFOS and SPFCAs in liver were consistently high at 500 to 2500 $ng \cdot g^{-1}$ wet weight (ww) (only SPCB and SCHL were higher), with levels in southern bears being higher than western Hudson Bay bears, although for either subpopulation the levels did not appear to be increasing or decreasing. Short-chain chlorinated paraffins (SCCPs) were found in recent (2012-2014) adipose samples at mean SSCCP levels of 160 to 500 $ng \cdot g^{-1}$ ww. Polychlorinated naphthalene (SPCNs) in the 2014 samples were at 18 to 27 $ng \cdot g^{-1}$ ww for western and southern Hudson Bay bears. Other new POPs in 2013-2014 liver samples included perfluorobutane sulfonamide (FBSA), perfluorobutane carboxylic acid (PFBA) and perfluoro-4-ethylcyclohexane sulfonic acid (PFEtCHxS) at low ppb levels. To more clearly reveal temporal trends, POP concentration variance due to confounding factors are being assessed from collected data for age, sex, body condition, time of collection, lipid content, and diet and food web structure (e.g. carbon and nitrogen stable isotope ratios). Northern peoples are integral partners as they carry out the annual harvest of polar bears and provide the collected tissue samples for this POP monitoring.

qui est des POP actuellement interdits ou réglementés (p. ex. en vertu de la Convention de Stockholm sur les POP), l'analyse des échantillons de tissus adipeux des ours du sud et de l'ouest de la baie d'Hudson que l'on a prélevés annuellement entre 2007 et 2014 n'a révélé aucun changement dans les tendances temporelles. Dans le cas des ours du sud de la baie d'Hudson, au cours de la période allant de 1991 à 2014 par rapport à celle qui va de 2007 à 2014, les concentrations observées de dichlorodiphényltrichloroéthane (SDDT) et d'alpha-hexachlorocyclohexane (a-HCH) étaient plus faibles, et celles de polybromodiphényléthers (SPCB) (SPBDE) (tétra-à-octa; aucun bromodiphényléthers-209 [BDE-209] détectés) et de b-HCH étaient plus élevées. Depuis 2009, les concentrations de SPBDE semblent avoir diminué pour les deux sous-populations d'ours. Lors d'une analyse récente des échantillons des tissus adipeux des ours, aucune trace d'hexabromocyclododécane (HBCD), de β-endosulfan ou de sulfate d'endosulfan n'été détectée, et ce pour tous les échantillons examinés, alors que l'on a détecté la présence d'α-endosulfan et de plusieurs produits ignifuges à base d'organophosphates à une certaine fréquence, mais à de faibles concentrations en partie par milliard (ppm). On a récemment observé de faibles concentrations en ppm d'hexabromocyclododécane (HBCD) et de déchlorane Plus (DP) 602 et 603 alors que les niveaux de brominobiphényle-153 (BB-153) étaient comparables à ceux des SPBDE. Entre 2007 et 2013, les quantités de perfluorooctanesulfonate (PFOS) et de perfluoroalkylcarboxylates (SPFCA) mesurées dans le foie étaient constamment élevées et se situaient entre 500 et 2 500 $ng \cdot g^{-1}$ poids frais (pf) (seuls les niveaux de Sbiphényle polychloré [BPC] et de chlordane [SCHL] étaient plus élevés). Si ces concentrations étaient plus élevées chez les ours du sud que chez ceux de l'ouest, il semble qu'elles ne diminuent ni n'augmentent chez les deux sous-populations. On a relevé des concentrations moyennes de paraffines chlorées à chaîne courte (SPCCC) dans des échantillons de tissus adipeux prélevés récemment (entre 2012 et 2014), lesquelles se situaient entre 160 et 500 $ng \cdot g^{-1}$ pf. Les quantités de naphtalènes polychlorés (SNPC) mesurées dans les échantillons de 2014 se situaient entre 18 et 27 ng·g^{-1} pf, et ce pour les ours de l'ouest et du sud de la baie d'Hudson. D'autres échantillons de foie prélevés en 2013-2014 présentaient de faibles concentrations en ppm de perfluorobutanesulfonamide (FBSA), d'acides carboxyliques perfluorés (ACPF) et d'acide sulfonique d'éthylcyclohexane perfluoro-4 (PFEtCHxS). Afin d'identifier plus clairement les tendances temporelles, on évalue les variations des concentrations des POP qui sont dues à des facteurs de confusion, et ce à l'aide des données recueillies sur l'âge, le sexe, l'état corporel, le moment de la collecte des données, la teneur en lipides, l'alimentation et le réseau trophique (p. ex. les ratios d'isotopes stables du carbone et de l'azote). Les habitants du Nord sont des partenaires indispensables du projet puisqu'ils mènent une chasse aux ours blancs sur une base annuelle et qu'ils fournissent ainsi des échantillons tissulaires aux fins de la surveillance des contaminants.

Key messages

- As of 2014, for western Hudson Bay bears, generally the levels for SPCBs, SDDTs, SCHLs, a-HCH, b-HCH and SClBzs are similar to those in samples going back to 2001. SPCBs and SCHLs continued to remain high at ppm levels.
- Since 2009, S_4PBDE levels appear to be decreasing in bears from southern (2007-2008 to 2014 period) and western (2001-2002 to 2014 period) Hudson Bay bears, although the southern subpopulation maintained consistently higher S_4PBDE levels than the western subpopulation.
- SSCCPs in adipose tissue had high mean levels of 160 to 500 ng·g^{-1} ww, SPCNs were at 18 to 27 ng·g^{-1} ww for all Hudson Bay bears, whereas HBCDD and DP 602 and 603 showed recent low ppb levels, BDE-209 was not detectable, and BB-153 levels were comparable to SPBDEs.

Messages clés

- En 2014, chez les ours de l'ouest de la baie d'Hudson, les concentrations de SPCB, de SDDT, de SCHL, de a-HCH, b-HCH et de chlorobenzène (SCBz) étaient similaires à celles observées en 2001. Les concentrations en ppm de SBPC et de SCHL sont demeurées à des niveaux élevés.
- Depuis 2009, les concentrations de S_4PBDE semblent avoir diminué chez les ours du sud (2007-2008 à 2014) et ceux de l'ouest (2001-2002 à 2014) de la baie d'Hudson; par contre, elles sont restées plus élevées chez la sous-population du sud que chez celles de l'ouest.
- On a observé des concentrations moyennes de SPCCC dans les tissus adipeux se situant entre 160 et 500 ng·g^{-1} pf, et des concentrations de SNPC se situant entre 18 et 27 ng·g^{-1} pf chez tous les ours de la baie d'Hudson, alors que les concentrations en ppm d'HBCD et de DP 602 et 603 étaient faibles récemment, qu'aucune trace de BDE-

- HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate or any other brominated flame retardant were not detectable in fat samples from any Hudson Bay bear harvested in 2014 as well as previously in 2013.
- Between 2007 and 2013, PFOS and SPFCAs in liver were consistently high at 500 to 2500 ng·g^{-1} wet weight (ww), and higher for southern bears, although for either subpopulation the levels did not appear to be increasing or decreasing.
- For both subpopulations, compared to previous years, in 2014 the total mercury (THg) concentrations may be increasing in liver.

209 n'a pu être détectée et que les niveaux de BB-153 étaient comparables à ceux des SPBDE.

- Aucune trace d'HBCD, d'α-endosulfan, de β-endosulfan et de sulfate d'endosulfan ou de tout autres produits ignifuges bromés n'a été détectée dans l'ensemble des échantillons prélevés sur les ours de la baie d'Hudson chassés en 2014, ou précédemment en 2013.
- Entre 2007 et 2013, les concentrations de PFOS et de SPFCA mesurées dans le foie étaient constamment élevées et se situaient entre 500 et 2 500 ng·g^{-1} pf. Si ces concentrations étaient plus élevées chez les ours du sud que chez ceux de l'ouest, il semble qu'elles ne diminuent, ni n'augmentent chez les deux sous-populations.
- Chez les deux sous-populations, en comparaison aux années précédentes, en 2014, les concentrations de mercure total (THg) semblaient être en croissance dans le foie.

Objectives

- For polar bears within the two management zones in Hudson Bay, in 2014-2015 to continue or establish to monitor with increased resolution, the (retrospective) temporal trends and changes of NCP priority, new and emerging POPs that are currently under review for regulatory action (e.g. Stockholm Convention on POPs).
- Using carbon and nitrogen SIs and FAs as ecological tracers, examine the influence of diet/food web structure, trophic level, sex, age, time of collection and lipid content as confounding factors on POP temporal trends in Hudson Bay polar bears.
- To provide information to Hudson Bay aboriginal communities participating in the study, as well as other communities, on the levels, changes and fate of POPs in polar bears.
- To archive the remaining polar bear tissue samples that were collected in Environment Canada's National Wildlife Specimen Bank (EC-NWSB), NWRC, Carleton University.

Introduction

Hg and a growing array of chlorinated, brominated and fluorinated POPs, have proven to be anthropogenic contaminants that have been transported to the (Canadian) Arctic and accumulate in biota (AMAP 2011; AMAP 2014; CACAR 2013; Haider et al. 2015; Letcher et al. 2010). These bioaccumulative POPs (and/or their precursors and degradation products) and

Hg are transported via global atmospheric and/or oceanic pathways and processes that result in deposition in the Arctic, and are found in Arctic endothermic top predators, and in particular in polar bears. Most known legacy and emerging POPs are lipophilic to some degree, and because lipids constitute an important energetic factor in polar marine food chains, POPs are biomagnified in the long Arctic marine food chains. POP and Hg levels are very high in polar bears in spite of their relatively high ability to bio-transform compounds via hepatic enzymatic processes and thus excrete these compounds (Letcher et al. 2009, 2010, 2014a, 2014b; Greaves et al. 2012, 2013; McKinney al. 2011a, 2011b; Routti et al. 2011, 2012; Gebbink et al. 2008).

The levels of POPs are generally the highest in the polar bear compared to other Arctic wildlife, and are an ideal wildlife receptor for the biomonitoring of spatial and temporal trends, distribution, dynamics, fate, biomagnification and potential effects of Hg and legacy and emerging POPs (AMAP 2014; Pedersen et al. 2015). In Hudson Bay polar bears, whereas levels of some legacy POPs such as PCBs decreased as of 2000 relative to previous years (Verreault et al. 2005) but have remained at relatively unchanged level up to 2013 (McKinney et al. 2010), a number of emerged environmental pollutants, such as PBDEs and perfluoroalkyl substances (PFASs; in particular the highly bioaccumulative perfluorooctane sulfonate (PFOS)) were reported, and in some cases for the first time, in the liver, fat and other tissues of polar bears (Greaves et al. 2012, 2013; Letcher et al. 2010). Temporal trends up the 2013 in e.g., Hudson Bay polar bears indicates that tissue (liver) concentrations of e.g. PFOS remain high with no obvious decreases occurring (Houde et al. 2011; Letcher et al. 2014a). In continuation of temporal studies up to 2008 (Routti et al. 2011, 2012), for Hudson Bay polar bears we also continued to measure priority heavy metals such as Hg, cadmium (Cd) and lead (Pb) as well as other bioaccumulative elements.

There are other high priority POPs under consideration by or nominated for addition to the POPs Stockholm Convention, and that have recently or are currently being reviewed by the POP Review Committee (POPRC), and for which there is a dearth of recent data for Canadian polar bears (CACAR 2013). For example, DecaBDE (BDE-209), short-chained chlorinated paraffins (SCCPs), pentachlorophenol (PCP; and transformation product pentachloroanisole (PCA)), polychlorinated naphthalenes (PCNs) and hexabromocyclododecane (HBCDD). Polar bear samples also continue to be assessed annually for PFASs such as perfluorinated carboxylates (PFCAs) and perfluorinated sulfonates (PFSAs) and precursors and new PFAS such as perfluorooctane-4-ethylcyclohexane sulfonic acid (PFEtCHxS), as temporal data sets remain restricted to a short time period going back only to 2007.

Arctic ecosystems face multiple challenges at local and regional scales, among them changes and the potential stress of changes in climate and exposure to anthropogenic chemical contaminants proven to be POPs (Dietz et al. 2015a, 2015b; Ferguson et al. 2015; McKinney et al. 2015). More recently the warming of the Arctic has been signaled by loss of multi-year sea ice and thawing of permafrost and accelerated coastal erosion. The significance of the conversion of ice to water is that it affects physical and biogeochemical pathways of POPs and other contaminants. This can result in an alteration of animal behaviour such as habitat use and diet as well as ecosystem structure including the introduction of new species and loss of existing species of biota. More recent research has shown that Arctic warming and changes in sea-ice means change in exposure to POPs and Hg to Arctic biota and particularly in the polar bear (i.e. Canadian Hudson Bay and East Greenland subpopulations) (Dietz et al. 2013a, 2013b, 2013c; Haider et al. 2015; Houde et al. 2011; Letcher et al. 2010; McKinney et al. 2010, 2011b, 2013, 2015).

From 2007 and up to the present 2014-2015 period, the monitoring activities of this NCP project continue to examine the inter-year temporal trends of various legacy, emerging and recently discovered POPs and Hg (and other trace metals/elements) in western and southern Hudson Bay polar bears.

Activities in 2014-2015

Sample collections

In late 2013, we successfully applied for and obtained a 2014 Nunavut Wildlife Research Permit (NWRP) for polar bear sample collections during the 2014 harvests by communities in Hudson Bay and Baffin Bay. In August 2014, a 2015 NWRP application was submitted and approved/signed/validated in December 2014 by the Nunavut Department of Environment (NDE). The 2014 and 2015 NWRPs were prepared and evaluated in collaboration with communities via the NDE (Wildlife Management Research: M. Dyck, M. Harte and P. Frame). As per the 2014 and 2015 NWRPs, the following Hunters and Trappers Organizations (HTOs) and associated hunters as well as Nunavut Conservation Officers (COs) (Hudson Bay and Baffin Bay communities and polar bear management zones) have been or are participants in this project.

As per the valid and approved 2013 and 2014 NWRPs, community hunters and COs collected polar bear fat, liver and/or muscle sample sets during harvests spanning very late 2013/early 2014, from n=17 western Hudson Bay (Arviat (n=10; 7 males and 3 female), Rankin Inlet (n=5 males) and Whale Cove (n=2 males)) and from southern Hudson Bay (Sanikiluaq (n=24; 9 females and 15 males) Hudson Bay bears (adults and subadults). Also, opportunistically collected where fat, liver and/or muscle sample sets were collected from a total of n=28 bears from northern Baffin Island/Bay (Clyde River (n=8; 1 female and 7 males) and Pond Inlet (n=12; 2 females and 10 males)) during the harvest period, which have now been archived in EC's National Wildlife Specimen Bank (EC-NWSB) at NWRC (Ottawa) for future considerations (e.g. future retrospective monitoring of new/emerging POPs). All of these samples were collected by local hunters in participating communities via interaction with local HTOs and COs. All samples were sent from these communities to NDE offices in Igloolik where they were documented and processed. All sample sets from these bears were ready to ship to Letcher at NWRC in Ottawa in September 2014, and were received with all available documentation in early October 2014. All polar bear samples received by NWRC were processed, and for the Hudson Bay bear samples portions were taken for POP (fat, liver), element/metal (liver), FA (fat) and SI (muscle) analysis. Remaining sample portions are currently stored and archived in the EC-NWSB at NWRC.

Contaminant and other analyses:

From the 2014-collected sample sets received for Hudson Bay bears, all sample analyses are now completed by the NWRC-OCRL, NWRC-Lab Services or via ALS or NLET. Age determinations (via bear teeth) for all harvested bears in 2014-2015 (as well as for the backlog of teeth collected from previous years harvests back to 2009) were completed via a formal Environment Contract to Matson's Laboratories (Matson's Laboratory LLC, 8140 Flagler Road Missoula MT 59802, U.S.A.; http://www.matsonslab/com). All 2014-2015 fat samples for a suite of FAs (i.e., a suite of 37 saturated and polyunsaturated, C_6-C_{24} fatty acids) will also be completed by NWRC-Lab Services by June 2015. SIs of nitrogen and carbon in muscle samples are expected to be completed by the end of May 2015, and are being determined by the lab of Dr. Aaron Fisk at the Great Lakes Institute for Environmental Research (GLIER), University of Windsor.

In time for the present Synopsis Report, all of the applicable Hudson bear fat samples were successfully analyzed for the 46 PBDE congeners 22 other FRs including total-α-HBCDD, as well as all PCB congener (74 congeners) and 25 organochlorine (pesticides) including HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate. For the total of n=35 Hudson Bay (liver or fat) samples, OPFR and PFAS analysis were completed. The analysis of SCCPs by Dr. Sverko's lab at EC's NLET in Burlington, ON, were also completed. Quality assurance/quality control (QA/QC) is monitored by NWRC Laboratory Services and the OCRL. Both the NWRC and the OCRL laboratories have participated in the NCP's QA/QC Program (recent NCP III-Phase 7 and 8 rounds in 2012-2014).

Capacity building:

Dr. Letcher had previously established with Dr. S. Atkinson (Government of Nunavut, Dept. of Environment) an Agreement of Cooperation and Contribution (ACC), which embodies this research and monitoring EC-NDE partnership. In 2014-2015, this project cooperated in building capacity and expertise in scientific sampling during the late 2013/early 2014 harvests in Hudson Bay and Baffin Bay. The participating communities and HTOs were directly involved and led in the organization and collection of fat, liver and muscle samples. As detailed in the valid 2013 and 2014 NWRPs, and in cooperation with M. Dyck and M. Harte in the NDE, as was necessary, Dr. Letcher arranged and sent directly to NDE a supplementary number of sampling kits that coincides with the number of bears required for these management zones and within the allowable hunting quota for communities involved (Hudson Bay and Baffin Bay).

For the hunters in each community, and via the HTO, each sampling kit contained simple and easy to read sampling instructions in both English and Inuktitut. In 2014, electronic copies of the sampling instructions were also sent to the Nunavut Environmental Contaminants Committee (NECC; Chair, Romani Makkik), and in direct response to the NECC social-cultural review of the 2014-2015 project year. Two files were forwarded in 2014 to the NECC, "Polar bear Sampling Instructions-English-2011.doc" and "Polar bear Sampling Instructions-Inuktitut-2011.doc", and we noted that these specific bilingual instructions have been provided to hunters every year since 2008. As we noted in the 2014-2015 mid-year status report in September 2014, which was then circulated to and reviewed by the various RCCs organized within the NCP, all polar bear harvests completed in 2014 were carried out by local hunters in the participating Nunavut communities (i.e., Arviat, Whale Cove, Rankin Inlet, Sanikiluaq, Pond Inlet and Clyde River). For these regional 2014 sample collections, the participating project team members in the NDE continued to provide training to members of the HTOs that were involved. Hunters were compensated for the sampling. In terms of other capacity building, a new graduate student, Mr. Gabriel Boisvert (MSc student, Carleton U., Ottawa) was recruited and began his graduate work Sept. 2014 on established and newly detected PFAS and precursor bioaccumulation and metabolism in ringed seals and polar bears. OCRL research technician Mr. David Blair also became an indeterminate EC employee in July 2014. Mr. Blair has been fully trained on various POP analyses in Arctic wildlife tissues, and thus fully formalizes the consistency and capacity of POP analysis for NCP-polar bear monitoring. Mr. Blair has also been instrumental is laboratory analysis training of students (e.g. Boisvert) working on polar bear projects.

Communications:

As of March 2015, publications included 7 seven papers in peer-reviewed journals (published, accepted or submitted), 6 reports, 1 book chapter as well as 9 oral and poster presentations at conferences or workshops (where 4 given by Letcher and with either invited or keynotes). For example, presentations were made at the Arctic Change 2014 conference/ArcticNet Meeting held at Dec. 9-12 in Ottawa, ON. Another Arctic –polar bear based presentation was also made on Dec. 11, 2014 at the Canadian Society of Toxicology meeting in Ottawa. An oral presentation was also made on PFAS in Arctic polar bears, ringed seals and beluga whales at the 2014 DIOXIN conference in Madrid, Spain in August 2014. The project leader (Letcher) contributed to and is a coauthor on recent Canadian reports on POPs and Hg and effects in Arctic biota. That is, Canadian Arctic Contaminant Assessment Report (CACAR 2013) on POPs, mercury, and biological effects. Portions of the CACAR 2013 on Hg were revised as journal papers and recently published (Braune et al. 2015; Scheuhammer et al. 2015). Letcher also contributed to an AMAP 2011 report on Hg (AMAP 2011). Working with project team partner M. Dyck (NDE), and with Drs. C. Sonne and R. Dietz at Aarhus University (Roskilde, Denmark), a joint study was completed that analyzed legacy and emerging POP tissue concentrations in relation to penile bone mineral density (BMD) as a key phenotype for reproductive success in 279 polar bear samples from 1999-2000 and representing animals from 8 subpopulations where 7 were Canadian (Sonne et al. 2015).

With the completion of presentations and posters at workshops and conferences, and journal publications and reports, electronic copies continued to be provided to NDE project partners that also fulfill the reporting obligations of the 2013 and 2014 NWRPs, and also to the NECC for edification and further distribution as deemed necessary. Whenever it was necessary, in 2014 the PI responded to any inquires or concerns of the participating communities and the NECC, e.g. questions after the social-cultural review of the initial 2014-2015 proposal.

The PI was committed to travel to at least one Nunavut community in 2014-2015. It was initially planned that he travel to and interface with NDE partners (Dyck and Harte) and the Igloolik community, and to communicate study findings and discuss with community and HTO representatives. Over the course of the summer 2014, the PI was working with NDE (M. Dyck) to hopefully arrange travel and a visit to Iqaluit and Igloolik in the early fall 2014. The period of Oct. 14-19, 2014 was planned. However, as of the first week of September it became abundantly clear that such travel in October would not be possible or worthwhile. Mr. Dyck was required to go on northern travel Oct. 15-18. Furthermore, Mr. Dyck mentioned to Letcher in early September that a Wildlife Contaminant Workshop (WCW) was to take place September 29-October 3 in Iqaluit, and that it would be good idea for Letcher to participate. This was the first NCP-supported WCW, but was the first time Letcher was made aware of it. The NECC recognized the communication oversight, but it was too late for Letcher to be added to the WCW 2014 speaker schedule.

As we responded to the NECC in April 2014, the NDE required that for all bears harvested, that a hunter kill return sheets be completed and submitted. On the kill sheets, the hunters have the opportunity to provide and generally made observational comments. In 2014, we provided the NECC with copies of the most current kill sheets for polar bears harvested in 2014, and to optimize information exchange and communication and as a consequent assistant capacity building and the incorporation of traditional knowledge.

The Stockholm Convention's POPRC is reviewing and assessing several NCP priority chemicals for addition to the POP convention annexes. Among these POPs, are Deca-BDE (BDE-209), PCNs, SCCPs and PCP/PCA. The last POPRC meeting was in October 2014. New (Arctic) information of high priority POPs, including for polar bears, is needed to adequately make such risk nomination recommendation to the POP Convention Annexes. The PI (Letcher) continued to communicate and discuss POPRC data needs for these priority chemicals within EC, AANDC and with ICC-AMAP Senior Advisor, Eva Kruemmel (as she attends/participates the POPRC committee meetings). In December 2014, new POP data and temporal trends for southern (2007 – 2013/2014) and western (1991-2013/2014) Hudson Bay polar bears was prepared and provided to the AMAP POPs Experts Group (led by Mr. Simon Wilson and Dr. Frank Riget), which has been converted to *.amp files to feed into a larger database to carry out Power Analysis of the data in an identical manner as for other NCP priority wildlife and fish monitoring sentinels and other Arctic compartments (e.g. air), in preparation for a new round of AMAP POP temporal trend assessment reports to be completed in the 2015-2016 time frame.

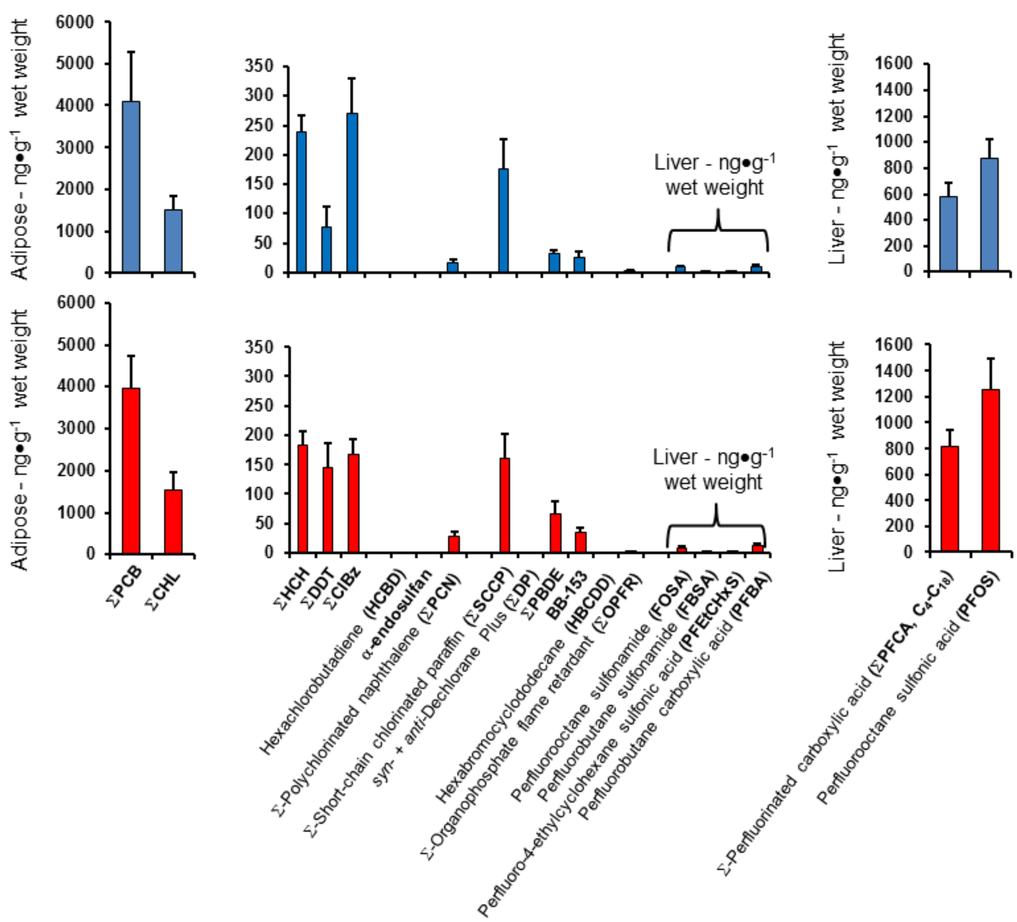
Traditional knowledge integration:

It can be a challenge to incorporate traditional knowledge on an annual basis into an ongoing contaminants monitoring program, and in particular for polar bears. However, as in past sampling for this core monitoring project, the 2014-2015 collection of samples was carried out exclusively by hunters in the participating Hudson Bay and Baffin Bay communities and in coordination with the PI and involved agencies in Nunavut. This project worked within the guidelines of the allowable hunting quotas for each of the HTOs and communities. The project therefore relies heavily on the knowledge and experience of these hunters for the sampling and for the ecological information on behaviour, condition and population numbers they provide to wildlife COs and biologists. It should be noted that polar bears are consuming country food at similar trophic levels as people in the communities. The inclusion of traditional knowledge has also facilitated the researcher's/PI's understanding of changing trends (diet and habitant), despite the link to shared resources (e.g. contaminant exposure from seal). This supports a two-way integration of knowledge.

Results

Figure 1 illustrates an overall comparison of recent data on legacy and emerging POPs (including newly screened POPs, e.g. SSCCPs, SPCNs, SOPFRs and a-endosulfan) in the tissues of polar bears (fat or liver) from Hudson Bay subpopulations, and collected in the current 2014 monitoring year. The overall view of the legacy and emerging POPs in both southern and western Hudson Bay bears shows that with the exception of the major PFASs (SPFCA and PFOS; in liver), SSCCPs, SPCNs, SPBDEs and BB-153, all other recently screened POPs (e.g. SOPFRs, a-endosulfan, HBCDD and SDP-like substances) are generally at much lower concentrations in adipose tissue compared with the legacy POPs (SPCB, SCHL, SHCH, SDDT and SClBz). Also, some priority POPs that were screened in the same adipose samples collected last year and in 2014 were not detectable with any frequency e.g. HCBD, BDE-209, b-endosulfan and endosulfan sulfate.

Figure 1. Geometric mean concentrations of individual and S-groups of major legacy and emerging POPs measured in 2013-2014 liver or fat samples of polar bears from western Hudson Bay (top, blue; n=17 individuals (except for SPCNs, n=5)) and southern Hudson Bay (bottom, red; n=24 individuals (except for SPCNs, n=5)) (R. Letcher, unpublished). Error bars are SDs. Data not corrected for sex, age or diet.



Western Hudson Bay adipose samples collected in 2012-2013 had also been screened for several DP-like, norbornene derivatives, as well as re-analyzed for syn- and anti-Dechlorane Plus (DP) flame retardant and structurally related Mirex (Dechlorane) and Photomirex (Photo-Dechlorane). Syn- and anti-DP were not detectable in any of these samples. However, DP-602 and DP-603 were quantifiable and at levels of 2.5 ± 2.4 and 0.3 ± 0.2 $ng·g^{-1}$ lw, respectively. These DP-602 and DP-603 (i.e. SDP-like substance) concentrations were the same as those of Mirex (2.8 ± 2.5 $ng·g^{-1}$ lw) and a little less than that of Photomirex (11 ± 9 $ng·g^{-1}$ lw).

Polar bear adipose and liver sample pairs from 2012-2013 collected polar bears from the western and southern Hudson Bay were screened for a suite of fifteen OPFRs. Both the liver and adipose samples contained low- to sub-ppb (ww) concentrations of tris(2-chloroethyl) phosphate (TCEP), tris(2-chloroisopropyl) phosphate (TCIPP), tributyl phosphate (TNBP), triphenyl phosphate (TPHP) and/or tris(2-butoxyethyl)phosphate (TBOEP). Detection and quantification was much less frequent in the adipose relative to their liver sample pairs. There were no obvious adipose to liver ratio relationships for any quantifiable OPFR. In 2014-collected adipose samples from both western and southern Hudson Bay bears, TCIPP and TBOEP were at the highest levels at 1.2 ± 0.7 and 3.8 ± 2.1 $ng·g^{-1}$ ww, respectively. Regardless, for all Hudson Bay bears collected 2012-2014, the mean SOPFR concentration in adipose was consistently very low compared to other emerging POPs, and exceedingly low compared to legacy POPs (Figure 1).

A suite of 24 SCCP congeners was screened previously in the adipose samples from western Hudson Bay bears harvested in 2011-2013. The SCCPs were of chain lengths of C_{10}-C_{13}, and each chain length SCCP grouping contained 5 to 10 chlorines. There was 100% frequency of detection for all the n=17 quantifiable SCCPs. The mean S_{24}SCCP concentration in the 2011-2013 samples was high at 493 ± 343 $ng·g^{-1}$ ww. In 2014-collected adipose samples for both southern (n=24) and western (n=17) Hudson Bay bears, of the 24 SCCPs analyzed for, the same pattern was found as in the 2011-2013 samples. The mean S_{24}SCCP concentration in the 2014 samples was 175 ± 100 $ng·g^{-1}$ ww and 160 ± 84 $ng·g^{-1}$ ww for western and southern Hudson Bay bears, respectively, and comparable to 2011-2013 samples, as well as being among the most concentrated POPs for bears from both subpopulations (Figure 1).

For the first time, in the present 2014-sampling year a suite of 50 mono- to hepta-chloro-PCN congeners were determined in bear adipose samples. There was a very high frequency percentage of detection for 27 of the PCN congeners in the sub-sets of n=5 adult male and female bears from each of the two subpopulations. The mean S_{27}PCN concentration in the 2014 samples was high at 17.6 ± 8.5 $ng·g^{-1}$ ww and 27.1 ± 17 $ng·g^{-1}$ ww for western and southern Hudson Bay bears, respectively. Tetra- to hexa-chlorinated congeners accounted for >95% of the S_{27}PCN concentrations, and with penta-chlorinated congeners accounting for >80% of the S_{27}PCN concentrations.

Consistent with 2011-2013 fat samples from western Hudson Bay bears, in the present 2014 collected samples SPBDE concentrations in adipose tissue were at much lower levels than legacy POPs, SPCBs and SCHLs (Figure 1). Also in 2014, BDE-209 was not detectable and consistent with not being detected with any frequency since 2007 in adipose samples.

Consistent with individual PFASs previously reported in the liver of 2013 sampled bears from both western and southern Hudson Bay, as shown in Figure 1 (in 2014-collected liver samples) the PFCAs were mostly C_9-C_{11} congeners with the PFNA (C_9) dominating. In addition to PFOS, the C_6 PFSA and several "Pre-FOS" precursors were quantifiable e.g. N-EtFOSA and FOSA at low levels, which are ultimate precursors to PFOS. Also, to our knowledge, the (low concentration) detection of C_4 perfluorobutane sulfonamide (FBSA) in polar bear liver is a first for any Arctic wildlife sample (Figure 1), although no corresponding perfluorobutane sulfonic acid (PFBS) was detectable in any 2013 to 2014 samples. In 2014 samples perfluorobutane carboxylic acid (PFBA) was measureable at low ppb levels with almost 100% frequency in all (n=17) western and (n=24) southern Hudson Bay bear livers (Figure 1). Furthermore, the cyclic analogue of PFOS, perfluoro-4-ethylcyclohexane sulfonic acid (PFEtCHxS) was quantifiable in all Hudson Bay bear liver samples from 2012-2013, and to our knowledge this is the first detection report for PFEtCHxS or FBSA in any Arctic sample (AMAP 2014; Houde et al. 2011; CACAR 2013).

Based on available samples and collection years, for 9 years over a 22 year period (1991-2013), as reported last year, the temporal trends of the geometric mean concentrations (lipid-corrected) of SPCBs, SDDTs, SCHLs, a-HCH, b-HCH and SClBzs in the fat of polar bears from western Hudson Bay generally remained unchanged over the last 12 years from 2001-2013. The same unchanging trend continued in 2014 for all of these legacy POPs (data not shown).

As of 2014, it is now possible to preliminarily reassess (uncorrected for e.g. age, sex and diet) the temporal trends of legacy POPs and several of the emerging/emerged POP classes in both western (1991-2014) and southern (2007-2014) Hudson Bay bears. In adipose, HBCDD concentrations were much lower than SPBDE concentrations in both western and southern Hudson Bay bears in all years up to 2013, but were non-detectable in 2014 samples (Figures 1 and 2). From 1991 to 2014, for the most concentrated BFRs, SPBDEs (mostly PentaBDE congeners), concentrations increased up until 2009 and then began a general decline to 2014 in western Hudson Bay bears (Figure 2, left panel). The same downward trend occurred from 2007 to 2014 in southern Hudson Bay bears (Figure 2, right panel). This is consistent with the PentaBDE and OctaBDE production phase out in the early 2000s and addition of these formulations to Annex A of the Stockholm Convention in 2009.

As of 2014, it is now possible to preliminarily reassess (uncorrected for e.g. age, sex and diet) the temporal trends of major bioaccumulative PFASs in (Canadian) Hudson Bay bears (Houde et al. 2011; Letcher et al. 2014a). Between 2007 and 2014 the mean concentrations of SPFCAs and PFOS in Hudson Bay polar bear liver was continually very high (Figure 3) and comparable to SPCB and SCHL concentrations in adipose (Figure 1). PFOS and SPFCA levels appeared to be neither increasing nor decreasing and there is no clear trend for the period of 2007-2014, despite C8 chemistry phase-out around 2002 (Houde et al. 2011).

Figure 2. Temporal trends of geometric mean concentrations of major brominated FRs in western Hudson Bay bears (left panel, 1991-2007, McKinney et al., 2010; 2008-2014, R. Letcher, unpublished) and southern Hudson Bay bears (right panel, 2008 – 2014; R. Letcher, unpublished). Error bars are SDs. Data not corrected for sex, age or diet.

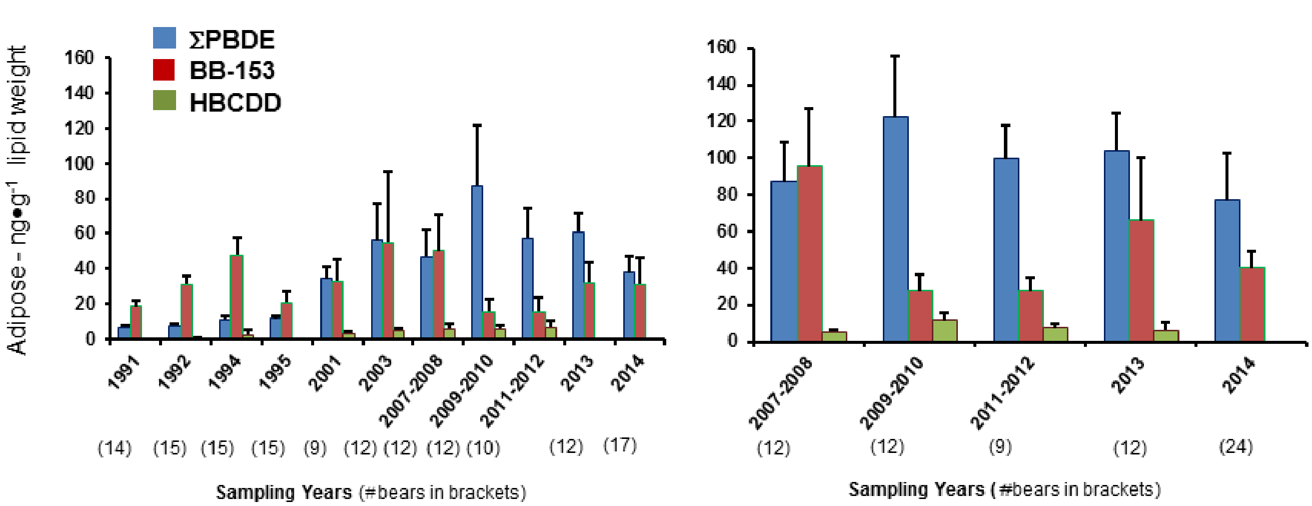
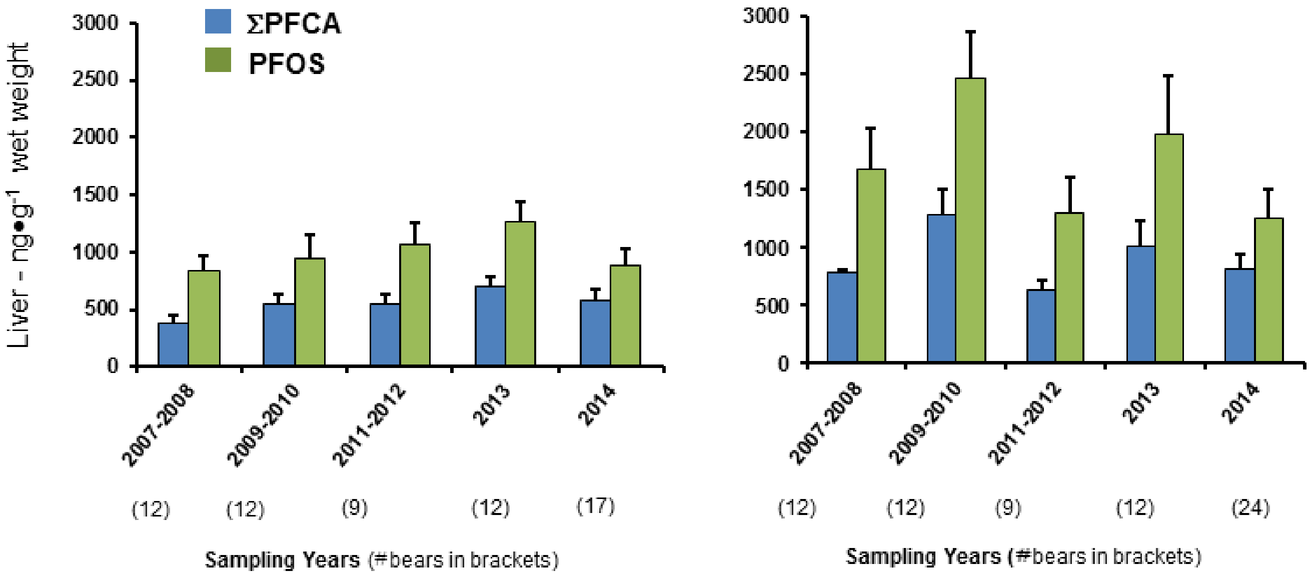


Figure 3. Temporal trends of geometric mean concentrations of SPFCA and PFOS in the liver of western Hudson Bay bears (2007-2014, left panel, R. Letcher, unpublished) and southern Hudson Bay bears (2007 – 2014, right panel, R. Letcher, unpublished). Error bars are SDs. Data not corrected for sex, age or diet.



Discussion and Conclusions

As of 2014, for western Hudson Bay bears, generally the levels for SPCBs, SDDTs, SCHLs, a-HCH, b-HCH and SClBzs were similar to those in samples and years going back to 2001 (Figure 1) (McKinney et al. 2010, 2011a, 2011b). That is, in 2014 SPCB and SCHL levels continued to remain at high ppm levels, and SClBzs remained at the 200 to 400 ng·g^{-1} lw levels. We also previously examined temporal trends of levels and congener patterns of PCBs, OCs, PBDEs, and HBCDD, PBBs and other current-use FRs, both on an individual and sum contaminant basis in bear adipose samples from western Hudson Bay (McKinney et al. 2010). Over this longer-term 17-year period (1991-2007), SDDT also decreased (–8.4%/year), α-HCH also decreased –11%/year, β-HCH also increased +8.3%/year, and SPCB and SCHL, both contaminants at highest concentrations in all years, also showed no distinct trends, and even when compared to previous data for this subpopulation dating back to 1968.

As we reported in McKinney et al. (2010) for western Hudson Bay bears, increasing S_4PBDE levels (+13%/year) over the period of 1991-2007 matched the increases in the four consistently detected congeners, BDE-47, -99, -100 and -153. Despite the phase-out of Penta- and Octa-BDEs formulations in 2002, and their addition to Annex A of the Stockholm POPs Convention, this trend reversed to a decreasing one over the years of 2007-2014 for Hudson Bay bears (Figure 2). S_4PBDE concentrations in adipose of Hudson Bay bears in general remained under 100 ng·g^{-1} lw, and were comparable to a-HCH and SDDTs, lower than β-HCH and SClBzs, and much lower than SPCBs and SCHLs (Figure 1).

Our previous analysis of 2011 and 2012 fat samples from Hudson Bay bears showed that BDE-209 and 22 non-PBDE replacement FRs were not detectable at all or with any frequency, whereas HBCDD and BB-153 were quantifiable. These findings were consistent with non-PBDE FRs and BDE-209 results we had reported on for 2007-2008 adipose samples (McKinney et al. 2011a, 2011b). For the present 2014 samples, again BB-153 was quantifiable at levels similar to 2011 and 2007-2008 (McKinney et al. 2011a, 2011b), whereas HBCDD was not detectable in any southern or western Hudson

Bay adipose samples (Figure 2). BDE-209 was not quantifiable to all Hudson Bay adipose samples from 2014, whereas BDE-47, -99, -100 and -153 accounted for 90% of the ΣPBDE concentration. The lack of BDE-209 is likely due to a combination of low exposure and uptake via the diet and to rapid metabolism and debromination. Polar bears possess a relatively high ability (compared to other Arctic mammalian and avian wildlife) to bio-transform compounds via liver enzymatic processes including BDE-209 and decabromodiphenyl ethane (DBDPE) (McKinney et al. 2011c).

PFOS and ΣPFCA levels appeared to be neither increasing nor decreasing and there is no clear trend for the period of 2007-2014, despite C8 chemistry phase-out around 2002 (Houde et al. 2011). This stresses the importance of PFCA and PFOS precursors as sources, which are transported and/or degraded in bears and/or their prey/food web. In 2014 an NCP-supported study was published that showed that Canadian ringed seal and Icelandic polar bear, but not Canadian beluga whale, could rapidly dealkylate N-EtFOSA to FOSA in vitro in liver microsomes from these Arctic species (Letcher et al. 2014b).

Clearly, known complexity of POP exposure to Hudson Bay polar bears is increasing, and is true for other circumpolar subpopulations such as for bears from East Greenland. Several high priority POPs under consideration for addition to the POPs Stockholm Convention annexes (being reviewed by the POPRC that recommends POPs for addition to the Stockholm Convention Annexes) are being detected and/or are quantifiable (in some cases at high levels) in tissue from recently harvested Hudson Bay polar bears, e.g. SCCPs, PCNs, HBCDD, DP-like substances and PFASs including replacements such as shorter chain perfluoroalkyl acids and sulfonamide precursors. These new POPs require further annual monitoring and some selective retrospective monitoring at least back to the 2007-2008 IPY year when annual NCP POP monitoring of Hudson Bay polar bears first commenced.

Expected Project Completion Date

This is an ongoing monitoring program and a core NCP biomonitoring project.

Acknowledgments

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New and emerging persistent halogenated compounds in beluga whales from Sanikiluaq (Nunavut)

Composés halogénés persistants, nouveaux et émergents, chez les bélugas de Sanikiluaq (Nunavut)

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Abstract

This study examined the temporal trends of halogenated organic chemicals in beluga whales from Sanikiluaq (Qikiqtaaluk Region of Nunavut). Our time-series for this site included animals collected from 2005, 2007, 2009, 2011 and 2013 (*n=10* in each year). The chemicals we measured include the suite of fluorinated surfactants, brominated and chlorinated flame retardants, phosphorus based flame retardants and short-chain chlorinated paraffins (SCCPs). Hexabromocyclododecane (HBCD) was detected most frequently in animals collected in 2011 with a detection frequency of 80%; mean blubber α-HBCD concentrations ranged from 1.7 – 4.5 ng/g (lw) with a mean of 2.9 ± 0.9 ng/g (lw) and γ-HBCD concentrations ranged from 1.1-10.3 ng/g (lw) for that year. None of the isomers were detected in animals collected in 2005 but the α-isomer was detected in 30% of the animals from 2007 (range: 1.2-1.8 ng/g) and 2009 (range: 2.2-3.7 ng./g). In 2013, the α-isomer was detected in 3 animals at a mean

Résumé

Cette étude visait à examiner les tendances temporelles relatives aux composés organohalogénés chez les bélugas de Sanikiluaq (région de Qikiqtaaluk, au Nunavut). Les séries temporelles pour ce site comprenaient des campagnes d'échantillonnage d'animaux menées en 2005, 2007, 2009, 2011 et 2013 (*n=10* pour chaque année). Les produits chimiques mesurés comprennent une série d'agents de surface fluorés, de produits ignifuges bromés et chlorés, de produits ignifuges à base de phosphore et de paraffines chlorées à chaîne courte (PCCC). On a le plus souvent détecté des traces d'hexabromocyclododécane (HBCD) chez les animaux échantillonnés en 2011 pour lesquels la fréquence de détection s'élevait à 80 %; les concentrations moyennes d'α-HBCD dans le petit lard se situaient entre 1,7 et 4,5 ng/g (pl), ce qui correspond à une moyenne de 2,9 ± 0,9 ng/g (pl) et les concentrations d'γ-HBCD se situaient entre 1,1 et 10,3 ng/g (pl) au cours de cette année. Aucun des isomères n'a

concentration of 2.5±0.4 ng/g (lw) and the γ-isomer detected in one animal (2 ng/g, lw). Liver based concentrations of the perfluorinated alkyl acids (PFAs) all showed declining trends. For example, perfluorooctane sulfonate (PFOS) was present in greatest amounts in animals collected in 2005 at 112±68 ng/g (ww) and by 2013 concentrations had declined to 35±17 ng/g. The annual rate of decline of PFOS in the animals measured as the slope of concentration vs collection year was estimated to be *ca.* 15 ng/g per year. Liver-based concentrations of C_9-C_{12} perflurocarboxylic acids (Σ_4PFCAs) (the C_8 acid was undetected in all the animals) also showed a decline over our study period at a rate of *ca.* 4 ng/g per year. There was a strong relationship between PFOS and perfluorooctane sulfonamide (PFOSA) concentrations suggesting that PFOSA is the dominant PFOS-precursor in the animals. The suite of other contaminants not reported on here are currently being measured in the animals.

été détecté chez les animaux échantillonnés en 2005, mais l'isomère-α a été observé chez 30 % des animaux en 2007 (écart : 1, 2 à 1,8 ng/g) et en 2009 (écart : 2,2 à 3,7 ng./g). En 2013, on a détecté l'isomère-α chez trois animaux, pour lesquels la concentration moyenne était de 2,5 ± 0,4 ng/g (pl) et l'isomère-γ chez un animal (2 ng/g, pl). On a observé des tendances à la baisse pour l'ensemble des concentrations d'acides perfluoroalkylés. À titre d'exemple, les quantités les plus importantes de perfluorooctanesulfonate (PFOS) ont été observées chez les animaux échantillonnés en 2005 pour lesquels la moyenne était de 112 ± 68 ng/g (pf); en 2013, ces concentrations étaient passées à 35 ± 17 ng/g. On a estimé que le taux de déclin annuel des niveaux de PFOS chez les animaux, lequel correspond à la pente des concentrations en fonction de l'année d'échantillonnage, était d'environ 15 ng/g par année. Les concentrations d'acides perfluorocarboxyliques en C_9-C_{12} (Σ_4APFC) dans le foie (aucune trace d'acide en C_8 n'a été détectée dans l'ensemble des animaux) ont également connu un déclin au cours de la période de l'étude, soit un taux d'environ 4 ng/g par année. On a constaté qu'il existait un lien étroit entre les concentrations de PFOS et celles de perfluorobutanesulfonamide (FBSA), ce qui suggère que le PFOSA est le principal précurseur de PFOS chez les animaux. On mesure actuellement les concentrations d'une autre série de contaminants dont on ne fait pas mention dans le présent résumé.

Key Messages

- HBCD was infrequently detected in all sampling years except for animals collected in 2011 where HBCD was detected in 80% of the animals. Total HBCD concentrations were less than 5 ng/g (lw) in the animals with no discerning temporal trend evident.
- Overall, PFAs concentrations were found to be decreasing in the animals. The rate of decline for PFOS was ca. 15 ng/g per year while for Σ4PFCAs the rate of decline was estimated to be ca. 4 ng/g per year.

Messages clés

- Pendant toutes les années d'échantillonnage, la présence de HBCD n'a été que rarement détectée, sauf en 2011 chez 80 % des animaux. Les concentrations totales s'élevaient à moins de 5 ng/g (pl) chez les animaux et aucune tendance temporelle évidente n'a été décelée.
- Dans l'ensemble, on a observé une baisse des concentrations d'acides perfluoroalkylés chez les animaux. Le taux de déclin des niveaux de PFOS était d'environ 15 ng/g

- The PFOS precursor, PFOSA, was detected at the greatest concentrations in the animals. Mean concentrations in animals collected in 2005 was 632±232 ng/g and in 2013 PFOSA concentrations were 110±30 ng/g (ww).

par année, alors que celui des Σ4PFCA était d'environ 4 ng/g par année.

- Les plus fortes concentrations observées chez les animaux étaient celles du précurseur de PFOS, soit le PFOSA. Les concentrations moyennes mesurées chez les animaux étaient de 632 ± 232 ng/g en 2005 et les concentrations de PFOSA étaient de 110 ± 30 ng/g (pf) en 2013.

Objective

1. To continue to build on our temporal trend data set for a suite of halogenated chemicals of emerging concern in beluga whales from Sanikiluaq.

Introduction

Historical environmental emissions of many anthropogenic chemicals is sparse and an approach to constructing an emission profile of a chemical is to examine concentrations in a well-defined environmental compartment. Because of their abundance, ecological significance and that they are top trophic level animals, beluga whales make an ideal bio-indicator species. The overriding assumption in using beluga whales as an indicator species to track emissions of chemicals is that changes in the inputs of any persistent chemical into the environment will be reflected by a similar concentration change in these animals. While it is thought that changes in climate could confound interpretations of temporal trend studies there is currently no method to control or correct for this variable. The aims of the current study are to (i) build a temporal trend data set in the eastern Canadian Arctic by using animals collected from Sanikiluaq and (ii) complement the temporal trend study we have for the western Canadian Arctic (Hendrickson Island).

Activities in 2014-20015

Samples investigated:

The animals selected for study were stored in the archived repository at Fisheries & Oceans, Canada in Winnipeg. Beluga collected in 2005, 2007, 2009, 2011 were selected for study. Animals from 2013 were previously analyzed in our earlier study. At all sampling years, 10 animals were available for analyses and in most cases animals were males.

Chemical analysis:

Analytical methods adopted for our study have already been published in the peer-review literature. All analyses were performed at the ultra-clean laboratory at Department of Chemistry, University of Manitoba. Hydrophobic chemicals like BDEs, HBCD, SCCPs and other brominated flame retardants were analyzed in the blubber of animals as described previously (Tomy et al., 2008;Tomy et al., 1997). BDEs and other Br-flame retardants were analyzed by gas chromatography with electron capture negative ion (ECNI) low resolution mass spectrometry. Quantification of BDE congeners were done using external standard solutions. Total BDE congeners are based on the sum of -47, -85, -99, -100, -153 and -154. BDE-209 was reported separately. Isomers of HBCD were analyzed by liquid chromatography tandem mass spectrometry in the negative electrospray ionization mode.

Total HBCD is based on the sum of the α and αdiastereoisomers. SCCPs will be analyzed by high resolution mass spectrometry in Dr. Sverko's laboratory at Environment Canada (EC). Total SCCP concentrations are based on the sum of C_{10}-C_{13} chain lengths and were analyzed by GC-high resolution mass spectrometry (GC-HRMS). Fluorinated and organophosphorus flame retardants (OPFRs) compounds were extracted and analyzed in the liver of the animals as described in Tomy *et al*. and Bestvater *et al*. (Bestvater et al. 2013, Tomy et al., 2005;Tomy et al., 2009) and will be analyzed in Dr. Chris Marvin's laboratory at EC. Fluorinated compounds investigated include perfluorooctanoate (C_8: PFOA), perfluorononanoate (C_9: PFNA), perfluorodecanoate (C_{10}: PFDA), perfluoroundecanoate (C_{11}: PFUA), perfluorododecanoate (C_{12}: PFDoDA), perfluorooctane sulfonate (PFOS) and perfluorooctane sulfonamide (PFOSA). Total perfluorinated carboxylate concentrations are based on the sum of C_8-C_{12}. Livers of ten animals from Hendrickson Island were screened for a comprehensive suite of 21 commercially available OPFRs.

Quality assurance:

Certified reference materials for BDEs in beluga blubber from the National Institute of Standards and Technology (SRM 1945) were used for each batch of 20 samples. The agreement between our measured BDE concentrations and the accepted SRM-1945 values were excellent. Procedural blanks were run with every 10 samples to check for laboratory contamination. No reference materials are yet available for HBCD, SCCPs or for the fluorinated compounds. Our laboratory also participates in the NCP Quality Assurance Program. All tissue work-up was performed in an ultra-clean laboratory at the Department of Chemistry, University of Manitoba.

Statistical analyses:

For calculating arithmetic and geometric means, non-detect concentrations were replaced with half the method detection limit. Statistical treatment of the data was done using SigmaStat.

α

γ

β

Results

HBCD. Not surprisingly, the α-HBCD was the most frequently detected HBCD isomer in beluga blubber. Except for 2005 where HBCD was undetectable, HBCD was detected in some animals from every collection year. In 2007, the α-isomer was the only isomer detected in 3 animals at concentrations of 1.2, 1.3 and 1.8 ng/g (lw). Similarly, in 2009, the α-isomer was the only isomer detected in 3 animals at concentrations of 2.2, 2.6 and 3.7 ng/g (lw). In 2011, all 3 HBCD isomers were detectable in animals at a greater detection frequency. In that year, the α-isomer was detected in 8 of the 10 animals and ranged from 1.7-4.5 ng/g and a mean of 2.9±0.9 ng/g (lw). The β- and γ-isomer were both detected in 2 animals at concentrations of 0.7 and 1.6 ng/g and 1.1 and 1.3 ng/g, respectively. Finally, in 2013, the α-isomer was detected in 5 animals at a mean concentration of 2.5 ±0.4 ng/g while the γ-isomer was detected in 1 animal at a concentration of 2 ng/g. Because of the sporadic detection of the isomers no real discerning temporal trend could be elucidated.

PFAs. The greatest concentration of the ionic PFAs was found for PFOS. Total PFCA concentrations were typically 1.5× smaller than that of PFOS. PFOS was detected in all the animals from each collection year and concentrations were greatest in 2005 where we measured mean concentrations of 113±61 ng/g (ww) in the liver. Concentrations declined from 2005 onward until 2013 where PFOS was measured at 35±17 ng/g. By regressing the measured concentration versus the sampling year we were able to estimate a linear annual rate of decline of *ca*. 15 ng/g ($p<0.05$). For the PFCAs, the rank order of concentrations was: PFUA>PFDA> PFDoDA>PFNA; PFOA was undetectable in all the animals. Similar to PFOS, there was a clear decreasing trend in PFCA concentrations over the study period. Overall, the annual rate of decline of Σ_4PFCAs was *ca.* 4 ng/g. Of the 3 monitored neutral PFOS precursors, only PFOSA was detectable in the animals. In fact, PFOSA was detected in all the animals studied and concentrations were typically 10× and 5× greater than that of Σ_4PFCAs and PFOS, respectively. PFOSA concentrations were greatest in animals from 2005 (632±232 ng/g) and smallest in animals from 2013 (110±30 ng/g). Similar to PFOS, PFOSA concentrations decreased linearly at a rate of *ca.* 60 ng/g per year. There was a strong 1:1 relationship between PFOSA and PFOS concentrations further suggesting that PFOSA is the major metabolic precursor of PFOS.

On-going Activities

There are many analyses that still need to be completed on the extracts. The delay with these analyses has been instrument availability. We are confident, however, that the samples can be analyzed by the end of the summer with a subsequent report to NCP shortly thereafter.

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Table 1. Concentrations of PFAs in beluga whale liver (ng/g, wet weight) from Sanikiluaq. Numbers reported are the arithmetic mean of 10 animals for each year ± standard deviation.

Year	PFOS	PFNA	PFDA	PFUA	PFDoDa	ΣPFCA	PFOSA
2013	35.3±17.0	2.2±0.4	4.5±2.1	13.1±3.9	1.9±0.8	21.8±5.7	109.8±29.9
2011	56.7±22.7	3.2±1.3	8.3±6.7	21.6±9.5	4.7±2.1	37.9±18.2	216.5±102.4
2009	63.6±24.5	3.5±1.7	9.2±6.3	23.4±10.41	4.6±1.2	40.7±17.6	310.2±138.6
2007	46.5±14.1	1.8±1.0	4.2±6.1	19.1±6.2	4.6±2.5	29.7±14.7	303.5±118.9
2005	112.8±61.2	4.80±3.9	15.5±10.5	38.4±18.4	8.3±4.1	67.1±35.6	632.8±232.1

Up-date on mercury levels in Hendrickson Island and Sanikiluaq beluga

Mise à jour sur les concentrations de mercure chez les bélugas de l'île Hendrickson et de Sanikiluaq

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Abstract

Samples of liver, kidney, muscle and muktuk of beluga whales collected in 2014 were analyzed for total mercury and selenium. Levels of mercury remained similar to ranges established in previous years. Of the organs analyzed in this study, liver typically had the highest concentrations of mercury, followed by kidney, muscle and muktuk. For example, the mean concentration of total mercury in 29 liver samples of beluga from Hendrickson Island in 2012 was 27.3 ± 27.0 $\mu g \cdot g^{-1}$ while that of muktuk from the same animals was 0.59 ± 0.18 $\mu g \cdot g^{-1}$. Data from these samples were added to the growing database on concentrations of these elements in organs of arctic marine mammals. The database now contains information on over 1340 arctic beluga from several locations over the period from 1977 to 2015. Mercury content varies among species, among individual animals, and among organs within an animal.

Résumé

On a analysé les concentrations de mercure total et de sélénium dans des échantillons de foie, de reins, de muscles et de muktuk du béluga prélevés en 2014. Les concentrations de mercure sont semblables aux plages du paramètre établies au cours des dernières années. Parmi les organes analysés dans le cadre de cette étude, le foie est celui qui, en général, présentait les plus fortes concentrations de mercure, suivi des reins, des muscles et du muktuk. À titre d'exemple, la concentration moyenne de mercure total dans 29 échantillons de foie prélevés en 2012 chez des bélugas de l'île Hendrickson s'élevait à 27,3 ± 27,0 $\mu g \cdot g^{-1}$, alors que celle trouvée dans le muktuk des mêmes animaux s'élevait à 0,59 ± 0,18 $\mu g \cdot g^{-1}$. Les données provenant de ces échantillons ont été ajoutées à la base de données croissante sur la présence de ces éléments dans les organes et les tissus des mammifères marins de l'Arctique. La base de données contient

This variation makes rigorous detection of differences among animals, places and times statistically difficult. Detection of differences among samples is further complicated by the fact that mercury accumulates with age so that older animals usually have higher levels than younger ones from the same location. Consequently comparison of mercury levels among different groups of beluga requires adjustment for differing ages; accurate age data are essential. The additional samples obtained each year improve the chances of detecting differences if they are real and reduce the chances of reporting apparent differences if they are not real. Usually the chemical analyses are completed prior to the age determinations and so there is a lag in interpretation of the data.

maintenant de l'information sur plus de 1340 bélugas de l'Arctique capturés à plusieurs endroits au cours de la période allant de 1977 à 2015. Le contenu en mercure varie entre les espèces, entre les individus et entre les organes d'un animal. Vu cette variation, la détection rigoureuse de différences entre les animaux, les lieux et les périodes est difficile sur le plan statistique. Le fait que le mercure s'accumule au fil du temps dans l'organisme des animaux, ce qui fait que les individus âgés présentent habituellement des niveaux plus élevés que les jeunes animaux d'un même lieu, vient compliquer davantage la détection de différences entre les échantillons. Par conséquent, la comparaison des niveaux de mercure chez les différents groupes de bélugas demande un rajustement sur le plan des différences d'âge et des données précises sur l'âge sont essentielles. Les échantillons additionnels prélevés chaque année améliorent les chances de détecter des différences si elles sont réelles, et réduisent les chances de signaler des différences apparentes si elles ne sont pas réelles. Habituellement, les analyses chimiques se font avant la détermination de l'âge, ce qui entraîne un retard dans l'interprétation des données.

Key messages

- new data were obtained on total mercury in organs of beluga from Hendrickson Island, Sanikiluaq.
- The mean level of mercury in 2014 liver samples from the HI animals was 21.28 ± 23.32 $\mu g \cdot g^{-1}$. The mean age of these same whales was 29.9 ± 8.1 years. Mercury in muscle was lower than that in liver with a mean concentration of 2.04 ± 0.89 $\mu g \cdot g^{-1}$.
- In spite of the lower values in HI muscle, all of them still exceeded 0.5 $\mu g \cdot g^{-1}$, the concentration long used to regulate the sale of commercial fish in Canada.
- Of the 3 organs analyzed in the HI animals, muktuk contained the lowest levels of total mercury with a mean 0.63 ± 0.29 $\mu g \cdot g^{-1}$. Sixty

Messages clés

- De nouvelles données ont été obtenues sur les concentrations de mercure total dans les organes et les tissus de bélugas de l'île Hendrickson et de Sanikiluaq.
- La concentration moyenne de mercure mesurée dans les échantillons de foie prélevés en 2014 chez des animaux de l'île Hendrickson était de 21,28 ± 23,32 $\mu g\ g^{-1}$. L'âge moyen des bélugas échantillonnés était de 29,9 ± 8,1 ans. Les concentrations de mercure étaient plus faibles dans les muscles que celles dans le foie, la moyenne de ces concentrations étant de 2,04 ± 0,89 $\mu g\ g^{-1}$.
- Même si les valeurs étaient plus faibles dans les muscles des bélugas de l'île Hendrickson, elles demeuraient toutes supérieures à 0,5 $\mu g\ g\text{-}1^{-1}$, soit la concentration de référence utilisée depuis longtemps pour

percent of the samples (12 of 20) exceeded 0.5 μg·g-1.

- Unlike liver, total mercury in muscle and muktuk is equivalent to MeHg (i.e. THg = MeHg). MeHg is the form of mercury that bioaccumulates and is toxic.
- The mean mercury concentration in SK liver samples was 18.93 ± 20.01 μg·g-1, Muscle levels were lower, with a mean of 1.18 ± 1.02 μg·g-1 and mercury in muktuk were lower with still with a mean concentration of 0.58 ± 0.38 μg·g-1.

réglementer la vente d'espèces commerciales de poissons au Canada.

- Parmi les trois organes et tissus analysés chez les animaux de l'île Hendrickson, c'est le muktuk qui renfermait les plus faibles concentrations de mercure total, soit en moyenne 0,76 ± 0,40 μg g-1. La valeur de 0,5 μg g-1était dépassée dans le cas de 60 % des échantillons (12 sur 20).
- Dans le muktuk et dans les muscles, le mercure total (HgT) est équivalent au méthylmercure (MeHg) (c'est-à-dire que THg = MeHg), contrairement à ce que l'on observe dans le cas du foie. Le MeHg est une forme de mercure qui est bioaccumulable et toxique.

La concentration moyenne de mercure dans les échantillons de foie provenant de Sanikiluaq était de 18,93 ± 20,01 μg·g-1. Les concentrations dans les muscles étaient plus faibles, la moyenne étant de 1,18 ± 1,02 μg·g-1, et les concentrations dans le muktuk étaient plus faibles encore, la moyenne étant de 0,58 ± 0,38 μg·g-1.

Objectives

1. To provide incremental information on concentrations of mercury and selenium in organs of beluga from selected locations in the Canadian Arctic
2. To present new data in the context of previous data from the same species and locations
3. To maintain a database of this information that will enable the more rigorous assessment of temporal and spatial changes of mercury in these animals

Introduction

Interest in levels of mercury in arctic marine mammals derives from; 1) Mercury in these unique animals as examples of mercury as a global pollutant and; 2) Dietary intakes of mercury by northern people who consume these animals and the possible health implications for the people. Recently a new factor has been discovered, namely a linkage between exposure to mercury in young adulthood and the development of diabetes later in life (He et al., 2013); this will likely foster additional interest in the intakes of mercury by northern people.

The levels of mercury in several organs of marine mammals from the Canadian Arctic have been relatively high (Wagemann et al. 1996; Lockhart et al. 2005; Loseto et al. 2015), exceeding levels in commercial fish analyzed by the Canadian Food Inspection Agency. Health

Canada has published an updated evaluation of the risks of mercury in fish for human health (Health Canada, 2007) but Health Canada did not address consumption of marine mammals. One table (Appendix III, Health Canada 2007) lists species of fish for which at least some individuals have levels over 0.5 µg·g-1. If the marine mammal organs reported here were to be included in the Health Canada tables, they would fall in this group with levels over 0.5 µg·g-1. However, mercury in fish is almost all in the toxic form of methylmercury; in marine mammals that is not the case. Recent analyses have shown that marine mammals organs vary in the way they store mercury; in liver, kidney and brain only about one quarter of the mercury is methylmercury but in muscle, most of it is methylmercury (Lemes et al, 2011).

Mercury has increased in air over the North Atlantic (Slemr and Langer, 1992) and mercury has been measured in air and in snow in the Arctic (Lu et al., 2001). Sediment core studies in arctic lakes (Hermanson, 1993; Lockhart et al., 1998) have suggested that mercury inputs have increased over the past few decades but those studies do not discriminate between inputs due to imported mercury transported by the air and inputs due to mercury already in watersheds and mobilized by, for example, climate warming. Mercury has increased in teeth from modern beluga from the Mackenzie Delta but not in teeth of walrus from Igloolik (Outridge et al., 2002). Previously, Outridge et al. (2000) showed that mercury in teeth correlates with those in liver, kidney, muscle and muktuk, and so trends in teeth were likely mirrored by trends in other organs. It is not clear what proportion of the mercury supporting these increases derives from mercury already present in the Arctic or from mercury imported into the Arctic from elsewhere.

Several recent studies have suggested that decreased ice cover has resulted in altered feeding behaviour in some arctic marine mammal populations (Stern and Macdonald, 2005; Gaden et al., 2009; Gaden and Stern, 2010) and that this influences intakes of mercury. Loseto et al. (2008) have begun to look at biological variables that reflect feeding habits of Beaufort Sea beluga to help explain their mercury content.

Selenium often correlates with mercury in various organs of marine mammals and it is hypothesized to offer protection from mercury poisoning. Recent studies by Huggins et al. (2009) have described the forms of selenium in organs of beluga from the Mackenzie Delta. In liver, the amount of selenium present as HgSe ranged from 38 to 77 per cent, while in pituitary the range was 85 to 90 per cent. These authors suggested that HgSe can serve as a bioindicator of non-toxic mercury in these animals.

Activities in 2014-2015

The NCP-funded activities have been mostly the analysis of the samples at the Freshwater Institute for total mercury and selenium. The project also provides partial support for collection/shipping of samples and for age determinations. All new samples reported this year were of Beluga whales collected at Hendrickson Island and Sanikiluaq. These whales were taken by local hunters as part of their subsistence harvests and samples of body organs were collected by trained collectors present at the hunt.

In the 2014 animal tissues, total Hg (THg) was analysed at the Centre for Earth Observation Science (CEOS) at the University of Manitoba. THg is measured by Combustion Atomic Absorption Spectroscopy (C-AAS) on a Teledyne Leeman HYDRA IIc. Samples are directly combusted in an oxygen-fed oven, followed by gold trap amalgamation and detection by AAS. Detection limits are 0.04 ng Hg (absolute; most beluga tissues have several thousand ng of Hg per 0.01 g of sample). QA/QC is accomplished using certified reference materials (CRM) from the National Research Council (NRC) Canada, using dogfish muscle (DORM-3), dogfish liver (DOLT-3) and lobster hepatopancreas (TORT-2). Recoveries are 90-110% of established values, and precision is better than 8% RSD for each of the CRM.

Results

New samples of beluga were obtained and analyzed in 2014

- Muscle, liver and muktuk samples and ages of 20 beluga from Hendrickson Island.
- Muscle, liver and muktuk samples and ages of 20 beluga from Sanikiluaq.
- As in previous years we had no success with the collection Pangnirtung samples.

The ages and mean concentrations (μg·g^{-1} wet weight) of mercury in liver, muscle and muktuk are listed in Tables 1.

Hendrickson Island 2014

Collections from Hendrickson Island are one of the most extensive with 417 samples from 18 collections taken every year since 1993 with the exception of a gap between 1996 and 2001. The mean level of mercury in liver samples in 2014 was 21.28 ± 23.32 μg·g^{-1} (Table 1). The mean age of these same whales is 29.9 ± 8.1 years. Mercury in muscle was lower than that in liver with a mean concentration of 2.09 ± 0.89 μg·g^{-1}. In spite of the lower values in muscle, all of them still exceeded 0.5 μg·g^{-1}, the concentration long used to regulate the sale of commercial fish in Canada. Of the 3 organs analyzed, muktuk contained the lowest levels of total mercury with a mean 0.63 ± 0.29 μg·g^{-1}. Sixty percent of the samples (12 of 20) exceeded 0.5 μg·g^{-1}. Unlike liver, total mercury in muscle and muktuk is equivalent to MeHg (i.e. THg = MeHg). MeHg is the form of mercury that bioaccumulates and is toxic. Retrospective data is reported by Stern et al. in the 2013 NCP synopsis report.

Sanikiluaq

Twenty samples were obtained from Sanikiluaq in 2014. Total mercury levels found in the 3 organs analyzed are listed in Table 1. Mean mercury in liver was 18.93 ± 20.01 μg·g^{-1}, Muscle levels were lower, with a mean of 1.18 ± 1.02 μg·g^{-1} and mercury in muktuk were lower with still with a mean of 0.28 ± 0.38 μg·g^{-1}. As previously reported, mercury concentrations in Sanikiluaq animal tissues (actually all eastern Arctic beluga) are significantly lower than has been measured in the western Arctic animals.

Discussion and Conclusions

Levels of total mercury in arctic beluga organs remain high when compared with fish commonly consumed by people. Of the 3 organs analyzed liver contains the highest mercury concentrations, followed by muscle and muktuk. Even with the lowest concentrations in muktuk, many of them still exceed 0.5 μg·g^{-1}, the concentration long used to regulate the sale of fish for human consumption.

The molecular speciation of mercury varies from organ to organ with liver, kidney and brain having only a small proportion present as methylmercury and muscle having most of the mercury present as methylmercury (Lemes et al, 2011). This raises the possibility that estimates of risks to consumers of these whales may have to be made organ by organ.

Table 1. Age data and concentrations of total mercury in organs of beluga (M+F) from HI and SK. Concentrations are shown in μg·g^{-1} wet weight followed by standard deviations.

Location	Year	Age	Liver	Muscle	Muktuk
Hendrickson	2014	29.9 ± 8.1	21.28 ± 23.32 (20)	2.09 ± 0.89 (20)	0.63 ± 0.29 (20)
Sanikiluaq	2014	34.7 ± 17.8	18.93 ± 20.01 (20)	1.18 ± 1.02 (19)	0.58 ± 0.38 (20)

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Expected project completion date

This study has been ongoing for several years. Interest in this study seems likely to continue as long as whales and other marine mammals are hunted and eaten by northern people. The newly discovered linkage between intake of mercury by young people and incidence of diabetes later in life is likely to maintain interest in mercury in northern fish and marine animals that are eaten by northerners.

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Temporal trends of contaminants in Arctic seabird eggs

Tendances temporelles des contaminants dans les œufs d'oiseaux marins de l'Arctique

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Abstract

Contaminants are monitored in Arctic seabird eggs as an index of contamination of Arctic marine ecosystems. Eggs of thick-billed murres and northern fulmars have been collected from Prince Leopold Island in the Canadian high Arctic since 1975 and thick-billed murre eggs have been monitored at Coats Island in northern Hudson Bay since 1993. Concentrations of the legacy organochlorines have decreased since 1975 in murre and fulmar eggs at Prince Leopold Island, and polychlorinated naphthalenes (PCNs) have also decreased in the murre eggs from Prince Leopold Island since 1975. In contrast, total mercury has increased, and polybrominated diphenyl ethers (PBDEs) increased from 1975

Résumé

On surveille les concentrations de contaminants dans les œufs des oiseaux marins en Arctique à titre d'indice de contamination des écosystèmes marins de l'Arctique. On recueille des œufs de guillemots de Brünnich et de fulmars boréaux à l'île Prince Leopold, dans l'Extrême-Arctique canadien, depuis 1975 et assure une surveillance des œufs de guillemots de Brünnich à l'île Coats, dans le nord de la baie d'Hudson, depuis 1993. Depuis 1995, les concentrations d'organochlorés hérités du passé diminuent dans les œufs des guillemots de Brünnich et des fulmars boréaux de l'île Prince Leopold et il en va de même pour les quantités de naphtalènes polychlorés (NPC) présentes dans les œufs des guillemots de Brünnich de l'île Prince

to 2003 in both murre and fulmar eggs followed by a rapid decline. Concentrations of some of the perfluorinated compounds in the murre and fulmar eggs have also declined in recent years. Arctic seabirds continue to be good indicators of changes in contaminant exposure in Arctic marine ecosystems.

Leopold. En revanche, les concentrations de mercure total ont augmenté, et les niveaux de polybromodiphényléthers (PBDE) ont augmenté entre 1975 et 2003 dans les œufs des guillemots et des fulmars, pour ensuite diminuer rapidement. Les concentrations de certains composés perfluorés dans les œufs des guillemots et des fulmars ont également diminué au cours des dernières années. Les oiseaux marins de l'Arctique restent de bons indicateurs des changements dans l'exposition aux contaminants au sein des écosystèmes marins de l'Arctique.

Key messages

- Concentrations of legacy organochlorines have decreased since 1975 in eggs of two Arctic seabird species, the thick-billed murre and northern fulmar, at Prince Leopold Island.
- Concentrations of polychlorinated naphthalenes also decreased in thick-billed murre eggs from Prince Leopold Island from 1975 to 2014.
- Polybrominated diphenyl ethers increased from 1975 to 2003 in murre and fulmar eggs followed by a rapid decline.
- Concentrations of some of the perfluorinated compounds in the murre and fulmar eggs have also declined in recent years.

Messages clés

- Les concentrations d'organochlorés hérités du passé ont diminué depuis 1975 dans les œufs de deux espèces d'oiseaux marins de l'Arctique, le guillemot de Brünnich et le fulmar boréal, à l'île Prince Leopold.
- Entre 1975 et 2014, les concentrations de NPC ont également diminué dans les œufs des guillemots de Brünnich de l'île Prince Leopold.
- Les quantités de PBDE ont augmenté entre 1975 et 2003 dans les œufs des guillemots et des fulmars, pour ensuite diminuer rapidement.
- Les concentrations de certains composés perfluorés dans les œufs des guillemots et des fulmars ont également diminué au cours des dernières années.

Objectives

1. To monitor contaminants in seabirds and their eggs as an index of contamination of Arctic marine ecosystems.
2. To examine annual variation in the temporal trend data series by collecting eggs for contaminant analyses from each of two species of seabirds (northern fulmar, thick-billed murre) from Prince Leopold Island annually starting in 2005. For comparative purposes, we are also making annual collections of thick-billed murre eggs from Coats Island in northern Hudson Bay (our Low Arctic monitoring colony since 1993) in parallel with the High Arctic collections.

Introduction

Eggs of thick-billed murres (Uria lomvia) and northern fulmars (Fulmarus glacialis) from Prince Leopold Island in Lancaster Sound, Nunavut, have been monitored for contaminants since 1975 (Braune 2007) to provide an index of contamination of the Arctic marine ecosystem and possible implications for seabird health. Early sampling of Arctic seabird eggs for contaminant analyses was opportunistic but, with NCP funding, collections were standardized to every five years starting in 1988, and then annually since 2005.

Since 1975, most of the legacy persistent organic pollutants or POPs (e.g. PCBs, DDT) in the murre and fulmar eggs have been declining whereas total mercury (Hg) has been increasing (Braune 2013), as have the perfluorinated carboxylates (PFCAs) (Braune and Letcher 2013) and, up until 2003, the polybrominated diphenyl ethers (PBDEs). However, after 2003, ΣPBDE concentrations appear to be decreasing (Braune 2012).

In order to examine the inter-year variation in contaminant data, and to improve the statistical power of the temporal trend data series for Canadian Arctic seabirds, we have been collecting eggs from each of two species of seabirds (northern fulmar, thick-billed murre) from Prince Leopold Island in the Canadian high Arctic annually since 2005. For comparative purposes, we have also been making annual collections of thick-billed murre eggs from Coats Island in northern Hudson Bay (our low Arctic monitoring colony since 1993) in parallel with the high Arctic collections. Eggs are analyzed for the normal suite of legacy POPs and total Hg, and the murre and fulmar eggs from Prince Leopold Island are analyzed for brominated compounds such as the PBDEs and hexabromocyclododecane (HBCD), as well as polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), coplanar PCBs, and per- and poly-fluoroalkyl substances (PFASs) such as the PFCAs and perfluorooctane sulfonate (PFOS). All eggs are also analyzed for stable isotopes of nitrogen (N) and carbon (C) as indicators of trophic position and diet.

Activities in 2014-2015

Sample Collection/Analysis:

Eggs were collected by hand on the basis of one egg per nest from each of two species of seabirds (northern fulmar, n=15; thick-billed murre, n=15) from Prince Leopold Island (74°02’N, 90°05’W) in Lancaster Sound as well as from thick-billed murres (n=15) on Coats Island (62°30’N, 83°00’W) in northern Hudson Bay. Eggs (n=15) were also collected from thick-billed murres on Digges Island (62°33’N, 77°50’W) near Ivujivik in northeastern Hudson Bay for comparison with eggs from nearby Coats Island should we have to switch monitoring colonies for logistical reasons in the future. Collection and analysis of eggs from Digges Island were done at no extra cost to the NCP. Eggs were analyzed for the normal suite of legacy POPs (e.g. PCBs, DDT, chlordanes (CHL), chlorobenzenes (CBz), etc.), PBDEs and HBCD in pools of 3 eggs each (15 eggs per collection = 5 pools of 3 eggs each). Murre and fulmar eggs from Prince Leopold Island were also analyzed for for PFASs in pools of 3 eggs each, as well as PCDDs, PCDFs and coplanar PCBs in pools of 5 eggs each (15 eggs per collection = 3 pools of 5 eggs each) to conform with previous analyses. Murre eggs from Prince Leopold Island were also analyzed for polychlorinated naphthalenes (PCNs) in pools of 3 eggs each. All eggs were individually analyzed for total Hg and stable isotopes of nitrogen ($^{15}N/^{14}N$) and carbon ($^{13}C/^{12}C$).

Analytical Methods:

Analyses of the legacy POPs, PBDEs, HBCD, PFASs and total Hg are carried out at the National Wildlife Research Centre (NWRC) laboratories at Carleton University in Ottawa, Ontario. The legacy POPs are analyzed by gas chromatography using a mass selective detector (GC/MSD) according to NWRC Method No. MET-CHEM-OC-06D. Analyses of the standard 14 PBDE congeners and total-a-HBCD are carried out using GC-low resolution MS run in negative ion chemical ionization (NCI) mode also according to NWRC Method No. MET-CHEM-OC-06B. PFASs are analyzed using UPLC/MS/MS in negative electrospray mode (ESI^-) according to NWRC Method No. MET-OCRL-EWHD-PFC-04. PFASs analyzed include 13 PFCAs (including PFOA), 4 PFSAs (including PFOS), and PFOSA. FTUCAs and FTOHs are no longer analyzed because they have not been detected in seabird eggs from this study in the past. Total mercury (Hg) is analyzed using a Direct Mercury Analyzer (DMA-80) for solid samples according to NWRC Method No. MET-CHEM-THg-01A. PCDDs, PCDFs and coplanar PCBs are analyzed by the Research and Productivity Council (RPC) in Fredericton, NB, which identify and quantify the compounds by high resolution gas chromatography coupled to a High Resolution Mass Spectrometer (HRGC/HRMS) using internal and external standards. The method is based on EPA Method 1613B in which specific congeners are targeted. Comparability with previous results generated by NWRC is assessed by analysis of two commercial Certified Reference Materials. PCNs are analyzed by ALS Environmental in Burlington, ON, for 75 PCN congeners using GC/HRMS isotope dilution method. Quality assurance/quality control (QA/QC) is monitored by NWRC Laboratory Services which is an accredited laboratory through the Canadian Association for Laboratory Accreditation (CALA). NWRC, RPC and ALS Environmental laboratories have all participated in the NCP's QA/QC Program. Stable isotope (C, N) analyses were carried out by G.G. Hatch Stable Isotope Laboratory at the University of Ottawa in Ottawa, ON. All samples are archived in the National Wildlife Specimen Bank at the NWRC in Ottawa.

Capacity Building:

The contaminants monitoring program at Prince Leopold Island in the Canadian high Arctic is part of a long-term, integrated seabird monitoring program which has been investigating seabird population trends and relationships with climate change and contaminants for over 35 years. In 2014, Tony Lee from Iqaluit was hired carry out field work on Prince Leopold Island. Building on earlier successful collaborations between NWRC and the Nunavut Arctic College (NAC) in Iqaluit, Guy Savard (NWRC biologist) and Jennifer Provencher (Carleton graduate student) went to Iqaluit again in 2014 with NCP support to work with NAC Environmental Technology Program students, teaching them the proper protocols for dissection of birds in the context of marine bird research including contaminants work. In 2014, the program was expanded to include a caribou component led by NCP researcher Mary Gamberg, and a science communications workshop.

Communications:

Presentations on the work that Environment Canada is doing on Arctic birds are given regularly in Resolute Bay, the closest community to Prince Leopold Island. The management of Prince Leopold Island has changed over the past year and is now done through co-management with a newly established Area Co-Management Committee (ACMC) administered through Environment Canada. The committee includes members of the Hunters' and Trappers' Organization, as well as elders and land managers from Resolute Bay. Some members of the Sulukvait ACMC made a site visit to Prince Leopold Island in July 2014. Amie Black of Environment Canada (WLSD, Ottawa), who has been involved in seabird research in the Canadian Arctic for a number of years, met with the Sulukvait ACMC and the Resolute Bay HTO in March 2015 to discuss the 2014 field activities at Prince Leopold Island and to present to them a plain-language field report (English-Inuktitut) summarizing our 2014 field activities on Prince Leopold Island. A presentation was made by Grant Gilchrist to the Coral Harbour HTO on all marine bird research being conducted in the eastern Canadian Arctic, including Coats Island, in July 2014. A poster (English-Inuktitut) on contaminant trends in seabirds was also sent as part of an information package to be displayed at a community feast in Coral Harbour in October 2014. Annual reports of the results to date are made to the NCP each year and results will continue to be published in a peer-reviewed scientific journals. Several papers were published and presentations made in 2014-15 which included data from this project (see NCP Performance Indicators).

Traditional Knowledge Integration:

It is difficult to incorporate new traditional knowledge annually into an ongoing contaminants monitoring program focussed on established seabird colonies which have been studied for many years. However, the collaborative work of Environment Canada with the Nunavut Arctic College in Iqaluit demonstrates the utilization of marine bird dissections in research.

Results

Intercolony Comparison:

There was no significant difference found (p>0.05) in concentrations of total Hg, chlordanes (SCHL), DDT metabolites (SDDT) and SPBDE in eggs of thick-billed murres collected from Digges Island and Coats Island in 2014 (Table 1). There were, however, significant differences in $d^{15}N$ values ($t_{1,28} = -5.2$, $p<0.0001$), and concentrations of chlorobenzenes (SCBz) ($t_{1,8} = 8.4$, $p<0.0001$) and $S_{35}PCB$ ($t_{1,8} = 3.5$, $p=0.008$) in murre eggs between the two colonies.

Table 1. Comparison of mean concentrations (± standard error) of d15N (‰), total Hg (mg g-1 dry weight), chlorobenzenes (SCBz), chlordanes (SCHL), DDT metabolites (SDDT) and PCBs (S35PCB), as mg g-1 lipid weight, as well as polybrominated diphenyl ethers (SPBDE), as ng g-1 lipid weight, in eggs of thick-billed murres from Coats Island and Digges Island in 2014.

	n	Coats Island		Digges Island
$d^{15}N$	15	14.4 ± 0.12		15.2 ± 0.10
Hg	15	0.88 ± 0.060		0.92 ± 0.075
SCBz	5	0.36 ± 0.018		0.22 ± 0.007
SCHL	5	0.12 ± 0.015		0.09 ± 0.005
SDDT	5	0.58 ± 0.012		0.58 ± 0.017
$S_{35}PCB$	5	0.71 ± 0.050		0.51 ± 0.035
SPBDE	5	13.8 ± 3.17		12.6 ± 1.89

n = number of individual eggs for d15N and Hg, and number of 3-egg pools for organochlorines and SPBDE

Temporal Trends:

Using the statistical program PIA (Bignert 2013), annual rates of change were calculated for total Hg, $S_{35}PCB$, SDDT and sum polychlorinated naphthalenes (SPCN) in thick-billed murre and northern fulmar eggs from Prince Leopold Island between 1975 and 2014 (Table 2). Total Hg concentrations increased by 1.6% and 1.0% annually in the murre and fulmar eggs, respectively, whereas average annual rates of decline for S_{35}PCB and SDDT ranged from -3.0% to -4.6% for the two species (Table 2). The major declines for S_{35}PCB and SDDT occurred between 1975 and 2003 with concentrations leveling off after that time (Figure 1). SPCN also decreased significantly (r = 0.89, p<0.001) in thick-billed murre eggs at an annual rate of -2.7% (Table 2).

The PIA program was inappropriate for the analysis of the PBDE ands PFAS trends because the trends changed direction over the time period examined (1975-2014). SPBDE increased exponentially between 1975 and 2003, followed by a rapid decline to mean concentrations in 2014 that were similar to those recorded in 1975 in both the thick-billed murre and northern fulmar eggs from Prince Leopold Island (Figure 2). SPFCA also increased from 1975 to 2008 in the fulmar eggs and 2010 in the murre eggs, followed by a dramatic decline in the fulmar eggs but more of a leveling off in the murre eggs (Figure 3). PFOS showed no clear directional trend between 1975 and 2007, but concentrations seemed to peak in 2008-2009 followed by a rapid and steady decrease

Figure 1. Mean (± SE) annual concentrations (mg g-1 lipid weight) of S35PCB and SDDT in eggs of northern fulmars and thick-billed murres from Prince Leopold Island, 1975-2014.

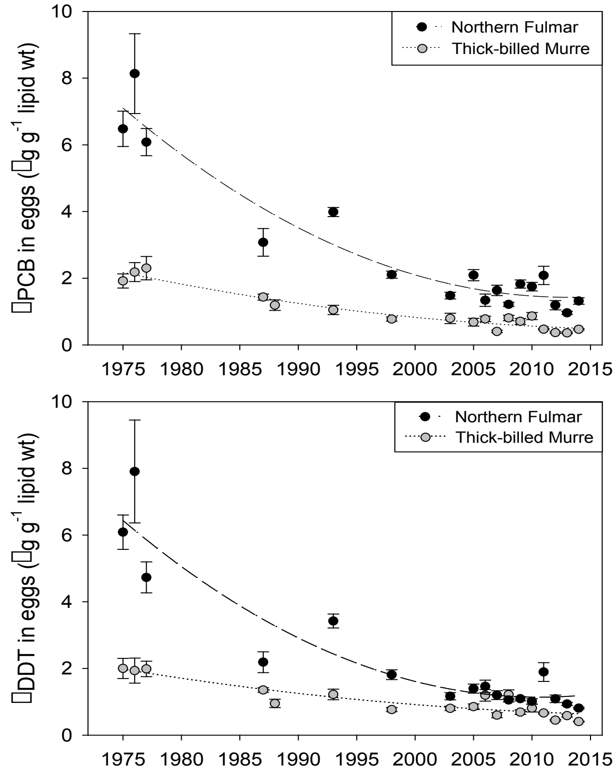


Table 2. Analysis of time trends for total mercury (THg), PCBs (S35PCB) and DDT metabolites (SDDT) in eggs of thick-billed murres and northern fulmars, as well as polychlorinated naphthalenes (SPCN) in eggs of thick-billed murres, at Prince Leopold Island using the PIA program (Bignert 2013). Percent annual change is significant in all cases (p < 0.005).

	Range of monitoring years	# years sampled	Total # Samples1	% annual increase/ decline	LDC2 (%)
THg					
Thick-billed murre	1975-2014	18	80	+1.6%	2.9%
Northern fulmar	1975-2014	17	81	+1.0%	2.3%
S35PCB					
Thick-billed murre	1975-2014	18	80	-4.0%	3.5%
Northern fulmar	1975-2014	17	81	-4.4%	3.1%
SDDT					
Thick-billed murre	1975-2014	18	80	-3.0%	3.5%
Northern fulmar	1975-2014	17	81	-4.6%	3.2%
SPCN					
Thick-billed murre	1975-2014	11	51	-2.7%	5.7%

[1] Number of 3-egg pools.

[2] Lowest detectable change in current time series at power of 80%.

in both the murre and fulmar eggs to mean concentrations in 2014 that were below those recorded in 1975 (Figure 3).

Figure 2. Mean (± SE) annual concentrations (ng g^{-1} lipid weight) of total polychlorinated diphenyl ethers (SPBDE) in eggs of northern fulmars and thick-billed murres from Prince Leopold Island, 1975-2014. SPBDE = sum of BDE-17, -28, -49, -47, -66, -100, -99, -85, -153, -138, and -183.

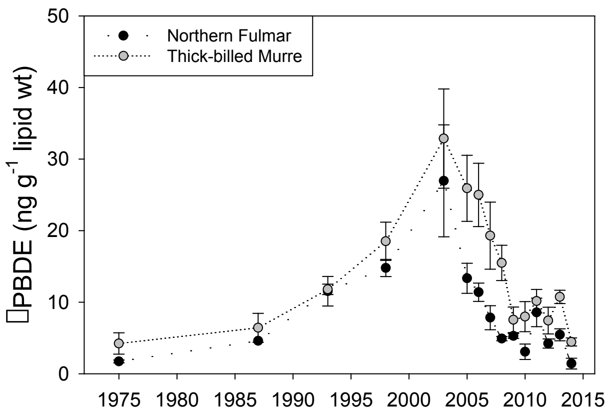
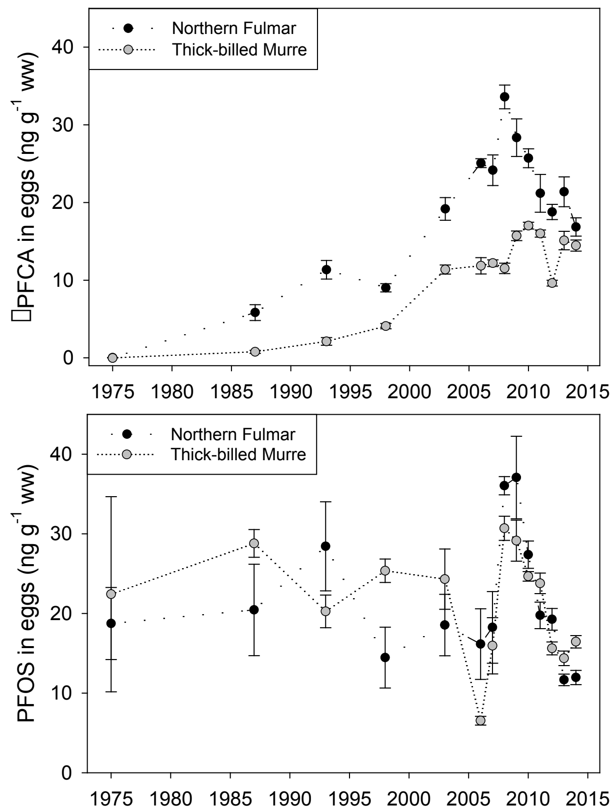


Figure 3. Mean (± SE) annual concentrations (ng g^{-1} wet weight) of total perfluorinated carboxylates (SPFCA) and perfluorooctane sulfonate (PFOS) in eggs of northern fulmars and thick-billed murres from Prince Leopold Island, 1975-2014. SPFCA = sum of C_6 to C_{14} chain lengths.



Discussion and Conclusions

No significant differences were found for total Hg, SCHL and SDDT in eggs of thick-billed murres sampled from Coats Island and Digges Island in 2014 which confirms the results from 1993 (Braune et al. 2002) suggesting that contaminant data for murres from those two colonies are comparable. A comparison of contaminant concentrations in livers of adult birds sampled from Coats and Digges Islands in 2007-2008 also showed no significant differences between the two colonies for total Hg (Braune et al. 2014a), as well as for SCBz, SCHL, SDDT, S_{59}PCB and SPBDE (Braune et al. 2014b). However, in 2014, the SCBz and S_{35}PCB levels were significantly higher in murre eggs from Coats Island than at Digges Island (Table 1). Given that the mean $d^{15}N$ value was higher for murre eggs from Coats Island than at Digges Island in 2014, the differences found in contaminants concentrations between the two colonies were likely not linked to differences in diet but may simply be an artefact of small sample size.

The increasing trends in Hg concentrations in the murre and fulmar eggs from Prince Leopold Island were discussed by Braune (2013) indicating that the trends appeared to be leveling off, a pattern also found for marine mammals (e.g. ringed seals, beluga) sampled during the 1990s and post-2000 (NCP 2012). The reasons for these differences in trends over varying time periods are likely complex, likely involving both anthropogenic and natural emissions coupled with environmental (e.g. food-web) processes which may also be affected by climate change.

The rates of annual decline for S_{35}PCB and SDDT were slightly greater in the fulmar eggs than in the murre eggs, likely because concentrations were relatively higher in the fulmar eggs, particularly in the mid-1970s (Figure 1). With the implementation of global and regional conventions which regulate or ban the use of certain persistent organic pollutants (POPs), most legacy POPs in biota have declined in the circumpolar Arctic over the past few decades (Rigét et al. 2010). Accordingly, most of the legacy POPs have decreased in eggs of thick-billed murres and northern fulmars monitored at Prince Leopold Island since 1975. SPCN also showed a significant linear decline in murre eggs from 1975 to 2014. PCNs have been proposed for listing under the Stockholm Convention on POPs but there are few temporal trend data sets available, particularly for Arctic biota (Bidleman et al. 2010, Law 2014). No statistically significant trends were found for PCNs in a variety of Arctic and sub-Arctic marine mammals sampled between 1986 and 2009 (Rotander et al. 2012). However, Ross et al. (2013) found a declining trend of PCNs in harbour seals from the Salish Sea (western Canada) during 1984-2009 and Gewurtz et al. (2009) found a declining trend in Lake Ontario lake trout during 1979-2004.

Both PBDE and PFAS trends changed direction over the time period examined. Use of the penta- and octa-BDE technical products was voluntarily discontinued in the United States in 2005 (de Wit et al. 2010) and, in 2009, both the penta- and octa-BDE mixtures were included in Annex A of the Stockholm Convention on POPs for global regulation. In North America, the increasing trends followed by decreasing trends in SPBDE, as seen in the murre and fulmar eggs from Prince Leopold Island (Figure 2), have also been recorded for bald eagle nestlings from the upper midwestern United States (Route et al. 2014) and in eggs of three species of seabirds from Canada's Pacific coast (Miller et al. 2014). These trends for North American birds are consistent with the removal of the penta- and octa-PBDE products from the North American market in the mid-2000s.

As was seen for the PBDEs, SPFCA also showed an increasing trend followed by a decrease in concentrations in the murre and fulmar eggs from Prince Leopold Island (Figure 3). The increase in SPFCA concentrations in both murre and fulmar eggs up to 2008-2010 is consistent with observed increases in other Arctic species monitored into the early 2000's (Braune and Letcher 2014). PFCAs are not regulated under the Stockholm Convention. However, the United Nations Environment Program Strategic Approach for International Chemicals Management includes an initiative to reduce emissions, particularly of the long-chain PFCAs (Martin et al. 2013). The observed declines in concentrations of SPFCA in the fulmar and murre eggs since 2008-2010 may be a reflection of this recent UNEP initiative. The recent declines in PFOS concentrations may reflect a delayed response to the manufacturing phase-out of PFOS by the 3M Company between 2000 and 2002 (Butt et al. 2010), or may simply represent variability in the temporal trend data set. Other studies from the Arctic and elsewhere have also shown recent declines in PFOS levels in response to the phase-out (Butt et al. 2010, Houde et al. 2011). Continued monitoring will determine whether or not the recent declines in PFOS and SPFCA in Arctic seabird eggs constitute a real downward trend.

Expected Project Completion Date

This is an ongoing monitoring program and a core NCP biomonitoring project.

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Temporal trends and spatial variations in persistent organic pollutants and metals in sea-run Arctic char from Cambridge Bay, Nunavut

Tendances spatiales et à long terme des polluants organiques persistants et des métaux chez l'omble chevalier anadrome dans la région de Cambridge Bay, au Nunavut

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Abstract

Sea-run char are important in the diets of many northern communities. Our study is providing information on contaminant concentrations in these fish and has confirmed that levels are low; the focus has shifted to trend monitoring. In 2014, we published a scientific paper summarizing what is known about sea-run char harvested by the various communities across northern Canada including how mercury concentrations differ from location to location and with time. We continued to investigate trends in persistent organic contaminants and detected declines in concentration of some chemicals at Cambridge Bay and Nain, but not at Pond Inlet where the record is shorter. In 2014, this sea-run char project was reduced

Résumé

L'omble anadrome est un élément important du régime alimentaire de nombreuses collectivités du Nord. Notre étude fournit de l'information sur les concentrations de contaminants présents chez ces poissons, dont elle a permis de confirmer qu'elles étaient faibles, et se concentre désormais sur la surveillance des tendances. En 2014, nous avons publié un article scientifique résumant les connaissances que l'on possède sur l'omble anadrome que pêchent différentes collectivités du Nord canadien, lesquelles portent notamment sur la façon dont varient les concentrations de mercure d'un site à un autre et au fil du temps. Nous avons poursuivi nos recherches sur les tendances des contaminants organiques persistants et observé

to a single location, Cambridge Bay, and persistent organic contaminants are no-longer being investigated. Marlene made a short visit to Cambridge Bay to discuss the project and explore opportunities with the creation of the CHARS research station. Lake trout and char were provided by community fisherman from Grenier Lake where the char provided in this study are believed to reside when not in the sea. Les Harris provided sea-run char fillet from fish caught over 2010-2014 from the Jayco, Lauchlin, and Halovik rivers for investigations of spatial differences in mercury concentrations in char between river systems and temporal trend assessments.

un déclin dans les concentrations de certains composés à Cambridge Bay et Nain, mais non pas à Pond Inlet où le dossier temporel est limité. En 2014, nous avons décidé de mener notre projet sur l'omble anadrome à un seul site seulement, soit à Cambridge Bay, et de ne plus poursuivre nos recherches sur les contaminants organiques persistants. Marlene a effectué une courte visite à Cambridge Bay afin de discuter du projet et d'examiner les possibilités découlant de la mise sur pied de la SRCEA. Nous avons obtenu des touladis et des ombles par l'entremise de la communauté de pêcheurs de Grenier Lake, endroit où semblent résider les ombles recueillis dans le cadre de cette étude lorsqu'ils ne sont pas en mer. Les Harris nous a fourni des filets d'ombles anadromes pêchés entre 2010 et 2014 dans les rivières Jayco, Lauchlin et Halovik afin que l'on puisse identifier des tendances temporelles et étudier les différences spatiales entre les différents réseaux hydrographiques en ce qui concerne les concentrations de mercure chez l'omble.

Key messages

- Mercury concentrations are very low in sea-run char across Canada.
- Mercury concentrations have decreased in sea-run char from Cambridge Bay possibly due to increasing condition factor and climate changes.
- Concentrations of legacy persistent organic contaminants are very low in sea-run char with some chemicals such as DDT, chlordane and HCH showing significant trends of decrease over the long-term record.

Messages clés

- Les concentrations de mercure sont très faibles chez les ombles anadromes de l'ensemble du Canada.
- Les concentrations de mercure présentes chez les ombles anadromes de Cambridge Bay ont diminué, ce qui pourrait s'expliquer par la hausse du coefficient de condition et les changements climatiques.
- Les concentrations des contaminants organiques persistants chez l'omble anadrome sont très faibles en ce qui concerne certains composés, comme le dichlorodiphenyltrichloroethane (DDT), le chlordane (CHL) et l'hexachlorocyclohexane (HCH), dont les quantités tendent à diminuer à long terme.

Objectives

- Determine mercury concentrations in sea-run char from the domestic fishery near Cambridge Bay and continue our trend monitoring. Also, obtain fish for mercury analyses from stock assessment studies being conducted by Fisheries and Oceans Canada to investigate differences in concentrations between river systems and, using their tissue archive, temporal trends.
- Publish a scientific paper synthesizing the mercury studies conducted as part of the larger NCP monitoring over 2004-2013.
- Participate in and contribute to trend assessments being conducted by the AMAP Expert Work Group for POPs which will be included in the next AMAP POPs report.
- Visit Cambridge Bay to discuss this study and explore the opportunities for expanding the sea-run char studies in view of the fact that the CHARS research station is being built in this community and this is the only NCP biomonitoring study at this site.

Introduction

This sea-run char study is part of NCP's Marine Ecosystems Trend Monitoring Program and was first established in 2004 to obtain spatially comprehensive data on contaminant concentrations in sea-run char across the Canadian north. Over the course of our studies, we demonstrated that mercury and POPs concentrations were low (Evans 2011, Evans and Muir 2014, Evans et al. 2015) supporting the recommendation that these fish represent a viable alternative to communities wishing to consume a traditional diet while reducing their contaminant intake. Therefore in 2014, NCP reduced the sea-run char monitoring program to a single location, Cambridge Bay, and then only for mercury and metals. The reasons for continued sampling at this location are as follows.

1. It is the site of a long-term commercial fishery for sea-run char (Day and Harris 2013).
2. A relatively extensive record exists for mercury concentrations in sea-run char from a number of populations harvested from the mouths of several river/lake systems located within ca. 100 km of the community (Lockhart et al. 2005) with a shorter record for POPs (Rigét et al. 2010).
3. With the Canadian High Arctic Research Station (CHARS) being built at this location, it is becoming a research center investigating many aspects of the freshwater and marine environment including responses to climate; many have hypothesized that mercury concentrations will increase in fish with warming.
4. This sea-run char study at Cambridge Bay is NCP's only biomonitoring program at this community.

With the growing interest in Cambridge Bay, a number of studies have been expanded including investigations of sea-run char stocks at several of the large river/lake ecosystems supporting the commercial fishery for decades; much of the historic record on mercury in fish is based on the periodic assessment of small numbers of fish from these various harvest zones (Evans et al. 2015). This has provided an opportunity for us to include mercury analyses of fish from these locations to investigate differences in mercury concentrations between sites and to take greater advantage of the historic mercury record.

The char which we are investigating are from the domestic fishery and are believed to live in Grenier Lake except during their brief migration to the sea every second year. Lake trout live in this lake along with glacial relicts including the predaceous Mysis relicta (Johnson 1962, Johnson 1964); these omnivorous invertebrates can provide an additional trophic level and greater contaminant biomagnification at the apex of the food web than lakes lacking these mysids (Cabana and Rasmussen 1994). As Grenier Lake is regularly fished by the community and will be the site of various limnological studies as part of the expanding CHARS program, the monitoring of sea-run char was broadened in 2014 to include lake trout and char from this lake. This study will add to the past research conducted on sea-run and landlocked char populations and lake trout in the broader Cambridge Bay area (Gantner et al. 2010, Swanson et al. 2010, Swanson et al. 2011).

Activities in 2014-2015

- Twenty sea-run char were provided from the domestic fishery operating out of Cambridge Bay. Length, weight, and sex were determined for all fish; liver and gonad weights were also determined and the presence of parasites and/or disease (cysts, etc.) noted. Aging structures (otoliths) were removed from each fish and submitted for analyses. Ten of the 20 fish from each location were selected for stable isotope, mercury and metals analyses; the remaining tissue was archived for possible later analyses including legacy organic contaminants and PDBE and PFC analyses.
- We contributed to the CACAR mercury assessment through the publication of our paper "Sea-run char as an alternate food choice to marine animals: a synthesis of mercury concentrations and population features" which appeared in a special issue of Science of the Total Environment arising from the CACAR mercury assessment (Evans et al. 2015).
- We contributed to the AMAP assessment of trends in POPs in sea-run char providing trend assessments for Cambridge Bay, Pond Inlet and Nain using PIA software (Bignert 2007).
- We synthesized the results of our 2004-2013 char studies and presented the highlights in a poster at the Arctic Change 2014 conference.
- In August 2014, Marlene visited Cambridge Bay and had brief discussions with the Hunters and Trappers Organization about the char study and discussed determining mercury concentrations in lake trout and char (that had not gone out to sea that year) from Grenier Lake. In December using EC funds, 20 fish from each species were harvested from the community and the fish shipped to Saskatoon. Fish could not be obtained from a second location (Keyhole Lake) due to weather considerations.
- We maintained a dialogue with Les Harris and Jean-Sébastien Moore (University of Laval) about their sea-run char stock assessments and coastal movement studies. A subset of fillet samples from these fish and archived samples were provided by Les Harris for mercury analyses.
- We established a connection with Ocean Network Canada which has a community-based oceanographic monitoring program in Cambridge Bay.
- Char monitoring at Pond Inlet was discontinued by NCP in 2014. We had discussions with another researcher working in the community on stream monitoring about continuing the sea-run char study through a new proposal submission but for various reasons this submission was postponed to another time.
- Sea-run char monitoring at Nain is continuing as a community-run project headed by Rodd Laing. We will be conducting the analyses on these fish and assisting in trend assessments as requested.

Figure 1. Average (±1 standard deviation) life history characteristics and Hg concentrations (fillet) in anadromous char investigated over 2004-2013 under our Northern Contaminants Program monitoring study. Reference lines indicate average of all locations. From (Evans et al. 2015).

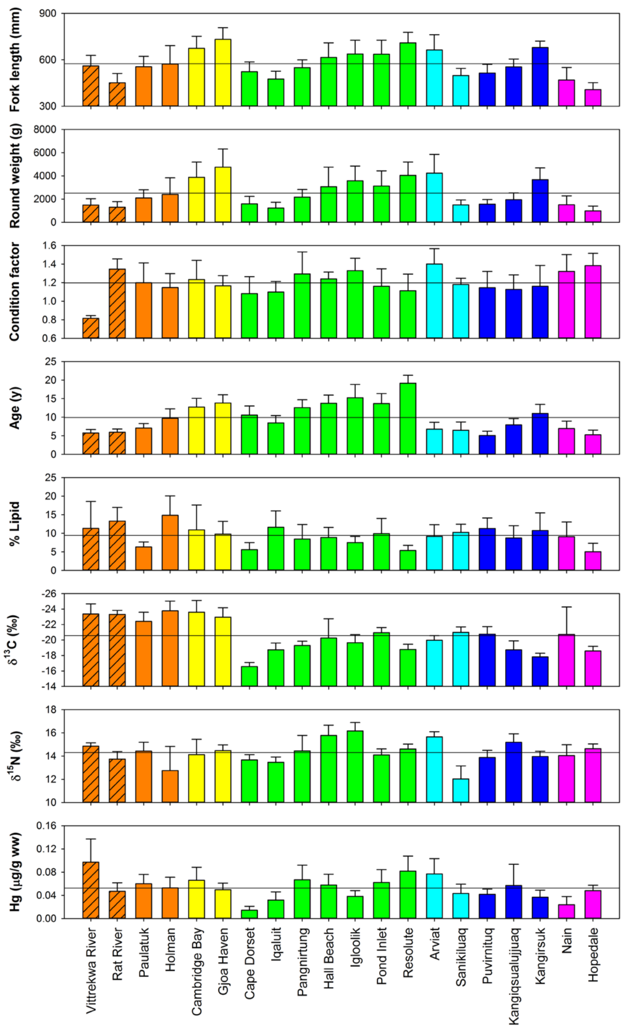

Figure 2. Temporal variability in mercury concentrations and condition factor in sea-run char harvested from Cambridge Bay over 1975-2014 (left panel) and temporal variations in mercury concentration in sea-run char collected from Cambridge Bay and three river sites over 1977-1994 (right panel).

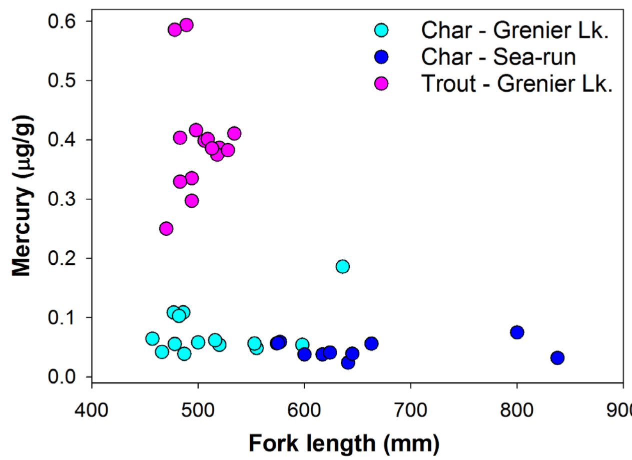

Figure 3. Mercury concentrations and fork length of char and lake trout collected from Cambridge Bay waters and Grenier Lake 2014.

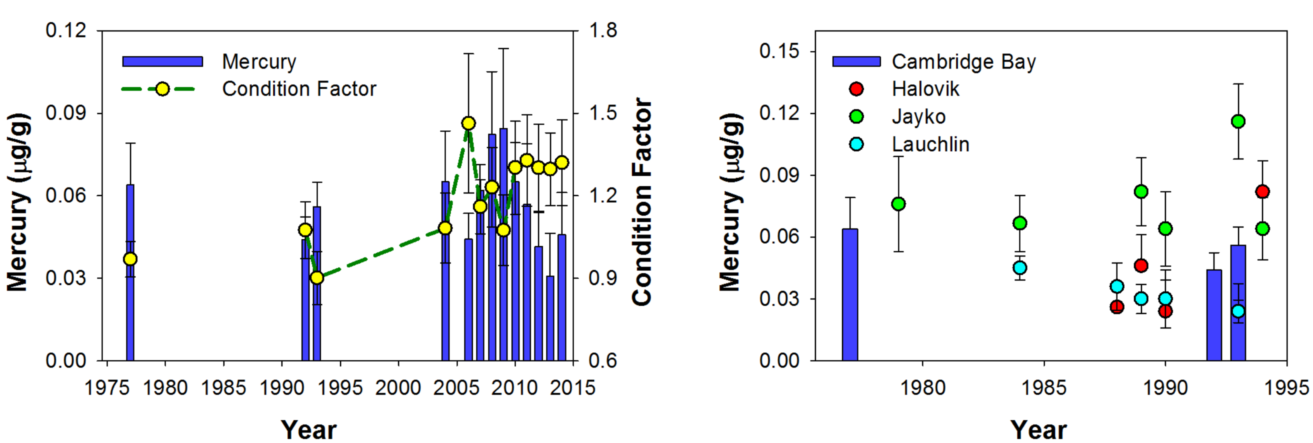

Table 1. Time trends in lipid-adjusted persistent organic contaminant concentrations in sea-run char from Cambridge Bay, Nain and Pond Inlet. Data are shown as the slope (% annual change per year) with R^2, the proportion of variance explained by the regression shown in parentheses below. Statistically significant (<0.05) slopes are in bold. Numbers in parentheses refer to the number of years of observation. Also shown are trends in log mercury concentrations (length-adjusted) and percent lipid.

Parameter	Cambridge Bay[1]		Pond Inlet[2]		Nain[3]	
	%/yr	R^2	%/yr	R^2	%/yr	R^2
% Lipid	+0.12 (8)	0.00	+1.9 (7)	0.06	+3.2	0.37
α-HCH	+0.9 (7)	0.00	-15 (7)	0.55	**-10 (5)**	**0.86**
β-HCH	+2.8 (7)	0.02	+4.4 (7)	0.11	-0.6	0.01
γ-HCH	-3.2 (7)	0.01	+7.7 (7)	0.12	**-9.5 (5)**	**0.86**
HCB	+2.4 (7)	0.16	0.6 (7)	0.01	0.6 (5)	0.05
Σ-PCB10	-7.5 (7)	0.21	-2.8 (7)	0.18	-5 (5)	0.18
CB153	-7.2 (7)	0.16	+1.6 (7)	0.04	-0.03 (5)	0.00
Σ-CHL	**-8.5 (8)**	**0.77**	3.9 (7)	0.10	+4.6 (5)	0.37
Σ-DDT	**-10 (7)**	**0.85**	-2.2 (7)	0.05	-1.2 (5)	0.03
p,p'-DDE	+16 (7)	0.43	+6.5 (7)	0.24	+2.6 (5)	0.06
Dieldrin	+1.2 (7)	0.02	0.3 (7)	0.00	-1.0 (5)	0.08
BDE 47	+7.7 (6)	0.16	-18 (6)	0.35	+11 (4)	0.07
BDE 99	-12 (6)	0.17	-31 (6)	0.28	+12 (4)	0.11

[1] Cambridge Bay record is 1987 (7 years), 2004 (6 years) to 2012, or 2004-2010 (5 years) depending on compound.

[2] Pond Inlet record is 2005-2012 (6 years) or 2005-2010 (7 years) depending on compound.

[3] Nain record is 1998 (5 years) or 2007 (4 years) to 2010 depending on compound.

Discussion and Conclusions

Over the course of this study, we examined sea-run char from 20 communities and published an overview of our findings on the biological features of these fish and spatial and temporal trends in their mercury concentrations in Evans et al. (2015). Biological features of these char (Fig. 1) were consistent with population features measured during previous stock assessment studies, i.e., Rat River, Iqaluit, and Nain area char tended to be relatively small and young while fish from the Cambridge Bay and Pond Inlet areas were larger and older. $\delta^{15}N$ ratios ranged from 7.3-19.9‰ and averaged 14.2±1.2‰ with no spatial pattern evident, while $\delta^{13}C$ ranged from -33.2 to -15.6‰ and averaged 21.1±2.5‰ with lowest ratios in the western Arctic; additional research is required on other components of the local food webs to better understand the stable isotope ratio data. Hg concentrations were low averaging 0.05±0.02 µg/g over the study area.

In Evans et al. (2015) , we reported on observed trends in mercury concentrations in char over various time intervals and across the study area. For Cambridge Bay, significant ($p<0.05$) trends of decrease were detected over 2004-2013, but not earlier time periods. When the historic record for the broader Cambridge Bay area was included in the analyses, significant trends of decrease were detected over 1977-2013, but not 1992-2013. Considering only the historic Cambridge Bay record and 2014 data, there was a weak trend of mercury decrease over 1977-2014 although the R^2 was small (0.09) and year significant at only $p=0.07$. Trends of decrease (log mercury) were observed over 2004-2014 when fork length (39.872 -0.021*Yr +0.001*FL; R^2=0.22, F=14.9) or condition factor (38.523-0.020*Yr-0.0296*CF; R^2=0.27, F=19.44) were included in the models. Overall, recent decreases in mercury concentrations in Cambridge Bay char have occurred as condition factor has increased, possibly driven by warmer temperatures, enhanced feeding and growth (Fig. 2). Mercury analyses of fillet from fish harvested from the Halovik (2011, 2014), Jayco (2010, 2014) and Lauchlin (2012) rivers are ongoing; the limited historic record suggests that mercury concentrations in Jayko River char were higher than in Halovik and Lauchlin river fish.

We have been contributing to the AMAP assessment of trends in POPs in sea-run char. The strongest databases for trend assessments are from Cambridge Bay, Pond Inlet and Nain where temporal trends in legacy and emerging POPs were examined using PIA (Bignert 2007); analyses were based on log-transformed data with %lipid as a covariate (Table 1). The longest record is for Cambridge Bay with individual fish data available for Σ-chlordane and Σ-DDT from studies conducted in 1987 (Muir et al. 1990); both compounds showed a significant trend of decline over the period of record. For Pond Inlet, investigated over 2004-2012, trends in legacy contaminant concentrations were not significant although α-HCH exhibited a weak trend of decrease ($p<0.054$). At Nain, where data are available for 1998, α-HCH and γ-HCH exhibited significant trends of decrease. Decreases in α- and γ-HCH and Σ-chlordane appear to be related to declining atmospheric concentrations (Hung et al. 2010). No time trends were detected in BDE47 and BDE99 but the number of years available for analyses is small.

Mercury concentrations have been determined in the char and lake trout provided to us from Grenier Lake. Sea run-char (Fig. 3) were larger (fork length 658 ± 90 mm) than char that had not gone out to sea (519 ± 53 mm) and lake trout (501 ± 19 mm). Mercury concentrations were lower in sea-run char (0.05 ± 0.02 µg/g) than smaller char that had not migrated (0.07 ± 0.04 µg/g) and substantially lower than the lake trout (0.40 ± 0.10 µg/g). A few lake trout had mercury concentrations exceeding 0.5 µg/g.

Expected Project Completion Date

This is a core biomonitoring project with no specified end date.

Acknowledgments

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Temporal trends of persistent organic pollutants and mercury in landlocked char in high Arctic lakes

Tendances temporelles des polluants organiques persistants et du mercure chez l'omble chevalier dulcicole de l'Extrême-Arctique

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Abstract

This long term study is examining trends over time of mercury and other trace elements, as well as legacy and new persistent organic pollutants (POPs) in landlocked Arctic char collected annually from lakes near the community of Resolute Bay on Cornwallis Island (Amituk, North, Small, and Resolute) and in Lake Hazen in Quttinirpaaq National Park on Ellesmere Island. In 2014, arctic char samples were successfully collected from all lakes. With the addition of results from 2014 we continued to observed declining trends of mercury in char in Amituk, Hazen, North, and Resolute

Résumé

Cette étude à long terme porte sur les tendances temporelles relatives au mercure et à d'autres éléments traces, de même qu'à des polluants organiques persistants (POP), hérités du passé et d'apparition récente, qui sont présents chez les ombles chevaliers dulcicoles recueillis annuellement dans des lacs près de la collectivité de Resolute Bay, sur l'île Cornwallis (lacs Amituk, Char, North, Small et Resolute), et dans le lac Hazen, dans le parc national Quttinirpaaq, sur l'île d'Ellesmere. En 2014, on est arrivé à recueillir des échantillons d'omble chevalier dans tous les lacs. Les données assemblées en

lakes. No change in mercury was found for char from Small Lake. Concentrations of fluorinated chemicals used in Teflon and in stain repellents declined in char from Hazen, Amituk and Char Lakes with the most rapid change (-26% per year) observed in Lake Hazen. The declines contrast with increasing concentrations in air of some of the precursors of these fluorinated chemicals.

2014 ont permis de déceler des tendances à la baisse du mercure chez les ombles chevaliers des lacs Amituk, Hazen, North et Resolute. Aucune variation du mercure n'a été observée chez les ombles de Small Lake. Les concentrations de composés fluorés utilisés dans le téflon et les produits antitaches ont diminué chez les ombles des lacs Hazen, Amituk et Char, le déclin le plus rapide observé étant celui du lac Hazen (- 26 % par année). Ces déclins font contraste aux concentrations croissantes présentes dans l'air de certains précurseurs de ces composés fluorés.

Key messages

- Concentrations of mercury concentrations in landlocked char have declined since 2005 in from five of six lakes for which we have long term results
- Flourinated chemicals have declined in landlocked char in remote lakes on Cornwallis and Ellesmere Island.

Messages clés

- Les concentrations de mercure chez les ombles chevaliers confinés aux eaux intérieures ont décliné depuis 2005 dans cinq des six lacs pour lesquels on dispose de résultats à long terme.
- Les concentrations de composés fluorés ont diminué chez les ombles dulcicoles des lacs isolés des îles Cornwallis et Ellesmere.

Objectives

1. Determine long term temporal trends of persistent organic pollutants (POPs) and metals in landlocked Arctic char from lakes in the Canadian high arctic islands by analysis of annual or biannual sample collections.
2. Investigate factors influencing contaminant levels in landlocked char such as the influence of sampling time, water temperature, diet and climate warming.
3. Determine levels of current POPs and metals as well as "new" potential POPs in fish from lakes of importance to the community of Resolute Bay (Qausuittuq) and provide this information on a timely basis.

Introduction

As the only top predators in most high latitude Arctic lakes (Köck et al. 2004, Power et al. 2008), landlocked char are good indicators of changes in inputs of mercury and bioaccumulation of methyl mercury. Many persistent organic pollutants (POPs) are known to have similar biomagnification potential as methyl mercury and also accumulate in Arctic lake food webs (Rigét et al. 2010). Analysis of landlocked char thus provide information on the range of chemical contaminants and time trends of these chemicals in Arctic freshwater systems which complements studies on mammals and birds from the same regions. However, there is much lake to lake and individual variation in contaminant levels which needs to be better understood. This information is also needed to help interpret temporal trends of contaminants in char.

This study has previously reported on results of annual sampling and contaminant analysis of char at Resolute, Char and Amituk lakes on Cornwallis Island as well as from Lake Hazen in Quttinirpaaq National Park on Ellesmere Island. Annual sampling has been used to try to achieve the goal of detection of a 5% change over a 10-15 year period with a power of 80% and confidence level of 95% (INAC 2005). Landlocked char annual collections have been successfully carried out in Resolute Lake since 1997 (Köck et al. 2004, Muir et al. 2005), however, in Char and Amituk, fishing has been more difficult due to low numbers (Char) and weather dependent access by helicopter (Amituk). Char collection in Lake Hazen is also a challenge mainly due the high cost of flights into the Parks Canada Hazen camp on the northwestern shore of the lake. While collections of char from Char, Amituk and Hazen have not been as consistent as in Resolute Lake, all lakes have 10 or more years of sample collections. Collection numbers have typically ranged from 7 to 25 adult fish (>200 g) per lake except in Char Lake where the range has been 3 to 10 fish annually. Further details on past results from these study lakes are given in previous synopsis reports (Muir et al. (2013), 2014a).

Collection in Char Lake was discontinued following the 2012 fishing season due to poor success for char of >200 g size (Muir et al. 2013). We have added North Lake and Small Lake to replace Char Lake because samples were already available as a result of previous food web studies on these lakes (Gantner et al. 2010a, 2010b; Kidd et al. 2012; Drevnick et al. 2013), Lescord et al. 2015a, 2015b).

Activities in 2014-15

Sample collection:

Char were successfully collected in early August 2014 from Amituk, North, Small, and Resolute lakes (Table 1). At Lake Hazen the collections were successfully carried out in mid-June by Parks Canada staff at Quttinirpaaq National Park. Fish were dissected in PCSP labs at Resolute. Samples (skin-on fillets) were frozen in Resolute and then shipped to the Environment Canada labs (Burlington, ON) and stored at -20°C until analysis. Char otoliths were removed and archived for age determinations. Age determinations were conducted by John Babaluk (Winnipeg, MB).

Chemical analysis:

Thirty-one elements were determined in Arctic char muscle (skinless) by Inductively Coupled Plasma-Mass spectrometry (ICP-MS) (NLET 2002). In brief, muscle (1 g) was digested with nitric acid and hydrogen peroxide (8:1) in a high pressure microwave oven at 200ºC for 15 minutes and the digest was analysed by ICP-MS. Mercury in char muscle was analyzed by Direct Mercury Analyser using US EPA Method 7473 (US EPA 2007).

POPs (organochlorine pesticides (OCPs), PCBs, polybrominated diphenyl ethers (PBDEs), perfluorinated alkyl substances (PFASs)) were not determined in char samples from 2014 as a result of a NCP Management decision to go to a two year cycle. However, results for 2013 became available after preparation of the report for FY 13-14 (Muir et al. 2013) and are therefore discussed below. For PFASs, we analysed Lake Hazen char muscle collected in 2014, to support interpretation of data from the Lake Hazen study (St. Louis and Muir 2014). Method details for POPs analyses are available in previous synopsis reports.

Stable isotope analyses:

Muscle from all fish analysed for mercury and POPs were analysed for stable isotopes of carbon (d13C) and nitrogen (d15N) at University of Waterloo Environmental Isotope Lab in muscle samples using isotope ratio mass spectrometry.

Quality assurance (QA):

Certified reference materials (CRMs) for heavy metals and mercury included DOLT-2, DORM-2 and TORT-2 (National Research Council of Canada) and SRM 1946 lake trout from NIST (National Institute of Standards and Technology) for PCBs, OCPs, PBDEs and PFASs. CRMs and reagent blanks were also run with each sample batch of 10 samples. Blanks for all analytes generally had non-detectable concentrations or levels <5% of measured values. No blank correction was used. Non-detect concentrations for POPs were replaced with 50% of the instrumental detection limit if analyte detection was >10%, or zero if the analytes were all nondetect.

NLET organics and metals labs, the Muir lab (mercury, PFASs) as well as ALS Global (contractor for OCP/PCBs) are participants in the NCP Quality Assurance Program (Tkatcheva et al. 2013, Myers et al. 2014) .

Statistical analyses:

Based on previous data analyses (Muir et al. 2013) results for mercury, other elements and POPs were log10 transformed in order to reduce coefficients of skewness and kurtosis to <2. Geometric mean concentrations and upper/lower standard errors were calculated with log transformed data and back transformed for graphical presentation. Results for POPs were lipid adjusted by dividing by fraction lipid.

Capacity Building:

The project depends on the help of local people in the Hamlet of Resolute. Since 2005 Debbie Iqaluk has worked on the project and enabled us to collect fish from all our targeted lakes on Cornwallis Island in a wide range of weather and ice conditions. This was particularly the case when the lakes have been ice covered, which was the case in late July 2014. In 2014 we were pleased to have Nunavut Research Institute student Joeffrey Okalik working with us for 1 week in early August. Joeffrey participated in all sampling activities and also in fish dissection.

Communications:

A summary of results of the work in 2014 was sent to the Resolute Bay HTA in late March 2015. Muir met with the Manager of the HTA office during his trip to Resolute in early August 2014 as well as informally with members of the HTA. In December 2014, Debbie Iqaluk attended the Arctic Change meeting in Ottawa and participated the poster session where she helped present a poster on the project results.

Traditional Knowledge Integration:

Although traditional knowledge integration is not formally part of the project the success of the project depends heavily on the community field team's knowledge of the fish habitat in the lakes as well as ice and water conditions. This was particularly the case when the lakes have been ice covered, which was the case in late July 2013 and again in 2014.

Results

Mercury:

Trends of mercury in char muscle, updated with results from 2014, are shown in Table 1. PIA software (Bignert 2007) was used to analyse data from six lakes for which we had 6 or more years of mercury concentrations in char muscle (Table 1). Statistically significant declines were found in length adjusted mercury in Hazen, Char, North and Resolute lakes. A declining trend was also seen in Amituk Lake but was not significant. Small Lake was the only lake with an increase in concentrations in more recent years, however, the increase was not statistically significant. Results for Resolute Lake indicate we are close to the NCP objective of detecting a 5% change with 80% power. Char Lake results were reported in previous years (Muir et al. 2014a) but are omitted this year because we ceased collections there in 2012.

NRI student Joeffrey Okalik conducts fish dissection in the PCSP lab at Resolute Bay, early August 2014.

Iqaluk and Muir collect char on Amituk Lake, early August 2014.

Photos for the report – pictures by Guenter Koeck

POPs:

Trends for legacy and newer listed POPs are based on samples collected up to 2013. Results for analysis of the 2014 samples are pending. Alpha-HCH declined more rapidly than all other POPs with an annual decline of -9.1 to -14 %/yr (Table 2). β-HCH actually increased in char from Hazen Lake, however, it makes up only 5 to 7% of ΣHCH; the other components α- and γ- HCH isomers are declining. ΣDDT, ΣCHL, and ΣPCBs declined significantly in Amituk and Hazen lakes but the decline in Resolute Lake was not statistically significant. Toxaphene concentrations declined significantly in Amituk Lake while the declines in Hazen Lake (-5.6%) was not statistically significant. In Resolute Lake, toxaphene showed an overall increasing trend due to recent higher concentrations. However, concentrations of toxaphene are lowest in Resolute Lake among the 4 study lakes. Char from Amituk Lake has the highest total toxaphene (970 ± 150 ng/g lipid wt in 2013) while in Resolute it was about 5-fold lower (216 ± 45 ng/g lipid wt).

Trends of perfluorocarboxylates (ΣPFCAs) and perfluorooctanesulfonate (PFOS) in landlocked char muscle from Lake Hazen, Char Lake and Resolute Lake are shown in Figure 1 and % declines for ΣPFCAs are included in Table 1. SPFCAs (sum of C7-C12-PFCAs) declined significantly in Lake Hazen from 2008-2014 at 26%/yr and declines (not statistically significant) were also found in char from Amituk (-8.8%; 2008-2013) and Char (-9.6%; 2007-2012). PFOS showed quite different results with increasing concentrations from 2007-2011 in Char Lake and relatively constant concentrations in Hazen and Amituk (Figure 1). Analysis of PFASs in char began in 2007 and only limited progress has been made to analyse archived samples. Analysis of archived samples from Char Lake shows higher concentrations of PFCAs and similar levels of PFOS in 1993 compared to 2007 (Figure 1). Lescord et al. (2015b) found highest concentrations of PFCAs and PFOS in chironomids and zooplankton and lowest in char muscle from Char Lake and nearby lakes. They concluded that sediments were the major source of PFASs to the arctic char food web. Concentrations of PFASs were significantly lower in char from North and Small Lake compared to Char Lake based on samples collected in 2010 (Lescord et al. 2015b).

Figure 1. Trends of perfluorocarboxylates (ΣPFCAs) and perfluorooctanesulfonate (PFOS) in landlocked char muscle from Lake Hazen, Char Lake and Amituk Lake.

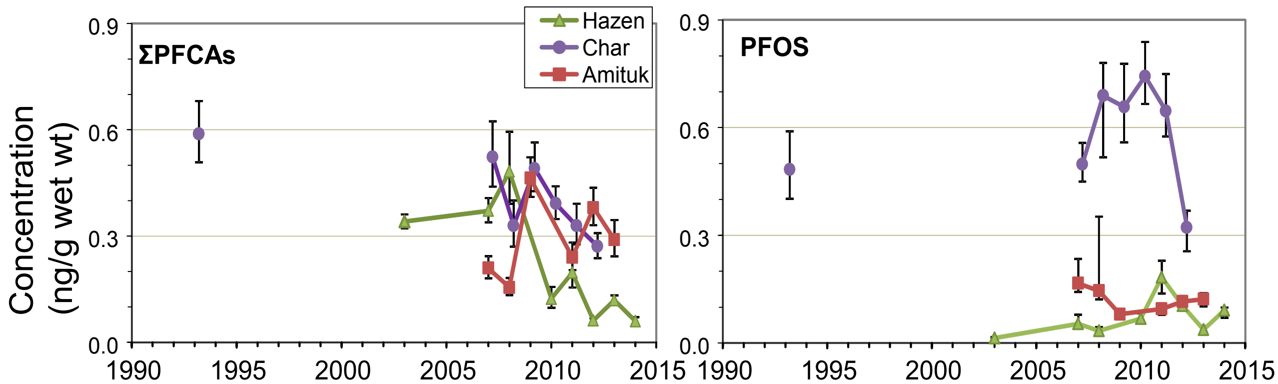

Table 1. PIA analysis of time series for recent (2005-2014) mercury concentrations in landlocked char muscle (NS = not statistically significant)

Lake		# years	Overall trend[1]	R^2	Lowest detectable change[3]	Power to detect a log-linear trend of 5%
Amituk	2005-14	9	-5.5% (NS)	0.12	27%	23%
Hazen	2005-14	8	-11%	0.54	17%	42%
North	2005-14	6	-9.5%	0.54	20%	36%
Small	2005-14	9	+2.3% (NS)	0.02	31%	20%
Resolute	2005-14	9	-8.0%	0.72	6.2%	100%

[1] Trends based on length adjusted geometric means analysed using PIA (Bignert 2007)

[2] LDC = lowest detectable change in the current time series (with a power of 80% and one-sided test)

[3] The power of the time series to detect a log-linear trend of 10% with the number of years in the current time series

Table 2. Percent annual decline (negative) and increase in selected POPs1 in arctic char from the four study lakes using the PIA program (Bignert 2007). PIA was run using lipid weight concentrations for each sample.

	Time period	Sampling Years	Toxa-phene	SPCB	SDDT	a-HCH	b-HCH	SCHL	SPFCAs
Amituk	1989-2013	13	-6.8*	-7.0*	-7.9*	-14*	-4.9	-7.0*	-
	Mid-00s-2013	3	-3.8	-	-	-	-		-8.8
Hazen	1990-2013	13	-5.6	-7.2*	-11*	-12*	6.1*	-6.0*	-
	Mid-00s-2014	8	11	-	-	-	-		-26*
Resolute	1997-2013	16	19*	-4.6*	-2.6	-9.1*	1.4	-2.0	-

[1] * indicated statistically significant trend (P <0.05)

[2] Results for toxaphene have 2 or 3 fewer years than other analytes

[3] Results for PFCAs are from 2008-2013 in Amituk and from 2008-2014 in Hazen.

Discussion and Conclusions

Mercury in landlocked char continues to decline from higher levels in the mid-2000s in almost all study lakes. The results contrast with lake trout and burbot from Great Slave Lake (Evans and Muir 2011, Evans and Muir 2012), and with burbot in the Mackenzie River, where increases in mercury may have leveled off but are showing no decline (Carrie et al. 2010, Stern et al. 2013). The exception is Small Lake which shows no trend and is the shallowest lake with higher levels of primary production based on dissolved and particulate organic carbon in water. Further analyses are underway to compare mercury trends with climate and water chemistry variables.

The declines of PFCAs in char in Amituk and Char Lakes are similar to what we have observed in ringed seals from the Resolute Bay area (Muir et al. 2014b) where declines in ΣPFCAs began in the mid-2000s. However this trend is not reflected in precursors of the PFCAs in the atmosphere such as 8:2 and 10:2 fluorotelomer alcohols, which continued to increase at Alert from 2006 to 2012 (Hung 2014). In contrast, the precursors of PFOS, MeFOSE and EtFOSE, declined in air at Alert from 2006 to 2012, but not in char from nearby Lake Hazen (Hung 2014). The disconnect between trends in air and in the lake environments may reflect the fact that direct inputs from precipitation and snow melt during the brief open water period (St. Louis and Muir 2014) are more important than gaseous concentrations. Also, as shown by Lescord et al. (2015a), the sediments represent the major source of PFASs for the food web and therefore continue to supply PFOS to char via dietary intake of chironomids and juvenile char.

Acknowledgements

We thank the Hamlet of Resolute Bay for permission to sample Char Lake and other lakes in the region, Parks Canada for their support of sampling at Lake Hazen, and Polar Continental Shelf Program for accommodation and aircraft support. We thank the staff of the NLET inorganics and organics labs for conducting all the multielement and POPs analyses during 2014. We thank Ron MacLeod and Whitney Davis at ALS Global (Burlington) for conducting POPs analysis and providing detailed data reports.

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Spatial and long-term trends in persistent organic contaminants and metals in lake trout and burbot from the Northwest Territories

Tendances spatiales et à long terme des contaminants organiques persistants et des métaux chez les touladis et les lottes des Territoires du Nord-Ouest

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Abstract

We are investigating trends in contaminant concentrations in Great Slave Lake West Basin burbot (domestic fishing zone Resolution Bay area) and lake trout (commercial fishery zone) and East Arm lake trout (domestic fishery Lutsel K'e area). In 2014, these fish were analyzed for mercury and other metals concentrations; biological measurements such as length, weight, age, percent water, and carbon and nitrogen isotopes were measured to help us investigate fish health and differences in contaminant concentrations between species, locations, and time. While not part of the NCP core monitoring, we continued our northern pike study at Fort Resolution and burbot at Lutsel K'e. Mercury concentrations continue

Résumé

Notre projet consiste à étudier les tendances des concentrations de polluants qui sont présents chez la lotte du bassin ouest du Grand lac des Esclaves (zone de pêche domestique de la région de Resolution Bay), le touladi (zone de pêche commerciale) et le touladi du bras de l'est du Grand lac des Esclaves (zone de pêche commerciale de la Première Nation Lutsel K'e). En 2014, nous avons procédé à une analyse des concentrations de mercure et d'autres métaux chez ces poissons, ainsi qu'à une analyse de variables biologiques, comme la longueur, le poids, l'âge, le pourcentage d'eau, les parasites, les isotopes de carbone et d'azote, lesquelles faciliteront l'évaluation de l'état de santé des poissons et des différences dans

to show a general trend of increase although mean concentrations remain below commercial sale guidelines. Several persistent organic pollutants also are showing evidence of decline with the rate of decline greater in West Basin than East Arm fish. We are working with the Arctic Monitoring and Assessment Program (AMAP) to characterize trends in POPs. We continue to work on the assessments of mercury concentrations in fish from smaller lakes in the Dehcho with fish provided from Cli, Fish, Tathlina and Trout Lakes; the Trout Lake study included provision of 10 normal and 10 skinny walleye. We also worked with Fort Resolution in using their domestic water intake to collect water quality data year round for Resolution Bay and track seasonal cycles in productivity.

les concentrations de contaminants en ce qui concerne les espèces, les lieux et le moment de l'échantillonnage. Bien qu'elles ne s'inscrivaient pas dans le programme de surveillance du Plan de lutte contre les contaminants dans le Nord (PLCN), nous avons poursuivi notre étude sur les grands brochets à Fort Resolution et celle sur la lotte à Lutsel K'e. Si de façon générale les concentrations de mercure ont continué d'augmenter, les concentrations moyennes sont demeurées en deçà des recommandations fixées pour la vente commerciale. Nous avons également décelé des signes de déclin des concentrations de nombreux polluants organiques persistants (POP), le taux de déclin du bassin ouest étant supérieur à celui observé dans le bras de l'est. Nous collaborons avec les responsables du Programme de surveillance et d'évaluation de l'Arctique (PSEA) afin de caractériser les tendances associées aux POP. Nous poursuivons nos activités visant à évaluer les concentrations de mercure chez les poissons des plus petits lacs du Dehcho, ces derniers provenant des lacs Cli, Fish, Tathlina et Trout. Notre échantillonnage au lac Trout comptait dix dorés jaunes de taille normale et dix autres de petite taille. Nous sommes également allés à Fort Resolution où nous avons utilisé la prise d'eau domestique afin de recueillir des données sur la qualité de l'eau tout au long de l'année à Resolution Bay et d'assurer un suivi des cycles saisonniers de production.

Key messages

- Mercury concentrations continue to show trends of increase in Great Slave Lake fish although the rates of increase are small and average lake trout and burbot mercury concentrations remain below commercial sale guidelines.
- Mercury concentrations were higher in the predatory fish in the smaller Dehcho lakes and, on average, close to or above commercial sale guidelines.
- Several persistent organic pollutants are showing evidence of decline over the past three decades with the rate of decline

Messages clés

- Si les concentrations de mercure chez les poissons du Grand lac des Esclaves continuent d'augmenter, les taux de croissance sont faibles et les concentrations moyennes de mercure chez les touladis et les lottes demeurent en deçà des recommandations fixées pour la vente commerciale.
- Les concentrations de mercure étaient plus élevées chez les poissons prédateurs des plus petits lacs du Dehcho et étaient en moyenne comparables ou supérieures aux recommandations fixées pour la vente commerciale.

possibly greater in the West Basin where the residence time is shorted and sedimentation rates greater than in the East Arm.

- Water quality monitoring at the domestic intake at Fort Resolution, if continued, may provide a better basis for investigating the relationship between annual cycles of productivity and trends of mercury in West Basin fish, particularly in the Resolution Bay area.

- Nous avons également décelé des signes de déclin des concentrations de nombreux POP au cours des trois dernières décennies, le taux de déclin étant potentiellement supérieur dans le bassin ouest, là où la période de rétention est plus courte, et le taux de sédimentation plus élevé que dans le bras de l'est.

- Les activités de surveillance de la qualité de l'eau menées à la prise d'eau de Fort Resolution, si elles se poursuivent, pourraient faciliter l'étude de la relation entre les cycles de production annuels et les tendances relatives aux concentrations de mercure dans la région de Resolution Bay.

Objectives

1. Determine mercury concentrations in lake trout harvested from two locations on Great Slave Lake (West Basin near Hay River, East Arm at Lutsel K'e) and burbot harvested from one location (West Basin at Fort Resolution) in 2014 to further extend the long-term (1993-2013) database. Also determine metals concentrations and investigate trends.

2. Investigate temporal trends in POPs concentrations in lake trout and burbot; fish were not analyzed for POPs in 2014.

3. Participate in and contribute information to AMAP expert work groups for trend monitoring for POPs.

4. Continue our investigations of mercury trends in fish in other lakes in the NWT including lakes in the Dehcho (in collaboration with G. Low). An opportunistic study of mercury concentrations in normal versus skinny walleye was initiated in Trout Lake.

5. Continue to work with Fort Resolution in their water quality and productivity monitoring of Resolution Bay waters.

6. Communicate results to communities in a timely manner.

Introduction

This study is part of NCP's Freshwater Ecosystems Trend Monitoring Program, specifically Great Slave Lake, a highly significant aquatic ecosystem in the Northwest Territories which supports a relatively large population base around its shores, a commercial fishery and several domestic fisheries (Rawson 1947, 1951, Evans 2000). With the recognition that mercury concentrations can be high in predatory fish in lakes along the Mackenzie River and in the river itself, communities are turning more to Great Slave Lake as a source of fish for domestic use. We are monitoring two species of fish with contrasting niches, i.e., lake trout which is a pelagic, hypolimnetic predator, and burbot, a benthic, more nearshore, cool water predator (Rawson 1951, Scott and Crossman 1998). We are monitoring these fish at three locations in two regions of the lake (Evans 1995, Evans et al. 2005b, Evans and Muir 2013). In the West Basin, we are monitoring lake trout from the commercial fishery operating out of Hay River and burbot from Fort Resolution, on the Slave River delta; lake trout are uncommon in the vicinity of Fort Resolution because waters are shallow and moderately warm. In the East Arm, we are monitoring lake trout at Lutsel K'e; this region is colder, deeper and less productive than the West Basin (Rawson 1955, Fee et al. 1985). This study design allows us to investigate how limnological variables affect contaminant body burdens and trends and provides us with stronger assurance that the trends we are observing are broad in nature rather than specific to a location, species and special conditions. While burbot were monitored at Lutsel K'e under NCP this was discontinued in 2008; however, we have been able to continue this program. In addition, we have been monitoring mercury trends in northern pike at Fort Resolution. This species tends to be higher in mercury than lake trout and burbot and so is more likely to exceed commercial sale guidelines for mercury. Furthermore, as a nearshore, littoral zone species, it may show greater sensitivity to factors affecting mercury trends than burbot and lake trout which live in less variable environments. We previously investigated factors contributing to elevated mercury concentrations in predatory fish in lakes along the Mackenzie River (Evans et al. 2005a) and are continuing fish mercury monitoring in lakes in the Dehcho as part of our mercury trend assessments.

Activities in 2014-2015

In 2014, 20 lake trout were collected by Lutsel K'e and from the commercial fishery at Hay River and 20 burbot from Fort Resolution and shipped to Saskatoon. As in past years, we continued burbot collections at Lutsel K'e and northern pike at Fort Resolution using other funds. In addition, 20 lake trout were collected from Christie Bay (further from the community) by Lutsel K'e and shipped to us. Length, weight, and sex were determined for all fish from each location; liver and gonad weights were also determined and the presence of parasites and/or disease (cysts, etc.) noted. Aging structures (otoliths) were removed from each fish and submitted for analyses. A fillet sample and the liver and stomach were retained from each of the 20 fish. Ten of the 20 fish and each species from each location were selected for metals and mercury analyses. No organic contaminant analyses were scheduled for 2014-2015. Subsamples from all fish were placed in our sample archive for potential analyses at a later date.

Lake trout, walleye, northern pike and lake whitefish were harvested from Cli, Fish, Trout, and Tathlina lakes in 2014 in support of George and Mike Low's assessment of mercury in country foods and our mercury trend monitoring programs. In addition, Jessica Jumbo arranged for the collection of 10 normal and 10 skinny walleye from Trout Lake. These fish are to be examined for mercury concentration and various biological metrics including disease. Tathlina Lake and Trout Lake walleye analyses are ongoing but are expected to be complete this summer.

We attended the Return to Country Food Workshop organized by George Low in August and held in Jean Marie River. There we presented our latest findings on spatial and temporal patterns in mercury concentrations in fish in small lakes in the vicinity of the Fort Simpson area. It was at this workshop that we discussed and designed the skinny walleye study with Jessica; we had previously met Jessica in 2005 when she spent a couple of weeks in our laboratory under a Cumulative Impact Monitoring Project and were pleased to be reacquainted. While on this trip, we were able to meet with representatives from other communities to discuss our NCP studies. In Hay River, Marlene met with Wally Schumann with the Hay River Metis; meetings with other community organizations in Hay River did not occur because of rescheduling. In Fort Resolution Marlene had a brief meeting with the representatives of the Metis (Kara King) and Akaitcho (Rosy Bjornson) governments with the meeting abbreviated because of a death in the community. In Lutsel K'e, Marlene met with the Environmental Committee to discuss NCP study results and the results of a second study on metals and radionuclides in Stark Lake where there are concerns with skinny trout.

We continued to work with Fort Resolution on its water quality monitoring of Resolution Bay waters using its domestic water intake. This study involved a high school student and was funded by the ASETS program.

Under persistent organic pollutants, we have been contributing to the AMAP assessment of trends in POPs in lake trout and burbot including attending an AMAP meeting as part of the Arctic Change 2014 conference and presenting a paper on observed trends in Great Slave Lake fish.

In October 2014, we were invited to provide posters to Ashley Mercer (Aurora College) for presentation at the North Slave Science Showcase which was held November 3, 2014 in Yellowknife. We submitted two posters based on our POPs and mercury Great Slave Lake studies and one on our water intake study with Fort Resolution.

In March 2014, we conducted a sediment coring trip to Great Slave Lake collecting cores from two sites (sites 12 and 19) previously investigated in 1994 and again in 2009 (Evans et al. 2013) with triplicate cores collected for mercury, metals and potentially PAH and POPs analyses. This study was supported under our Clean Air Regulatory Agenda (CARA) program where our focus has been on lakes around major mercury emitters in southern Canada. Another series of cores were collected in the North Arm in support of John Chételat's study investigating aquatic ecosystem health in Yellowknife Bay. We also obtained sediment cores from Kakisa Lake where we have been monitoring mercury trends in fish as part of George's Low's country food study and Stark Lake, a lake used by Lutsel K'e which the community has concerns regarding lake trout health. All cores have been dated and mercury analyses are ongoing.

Discussion and Conclusions

Mercury studies: Fish provided in 2014 (except Christie Bay trout and Fort Resolution northern pike) were analyzed for mercury and data updated from Evans et al. (2013). Preliminary analyses determined that when fish length was included in the regression analyses, mercury concentrations are continuing to show significant trends of increase in Hay River lake trout; burbot and large lake trout from Lutsel K'e; and burbot from Fort Resolution (Fig. 1). Average mercury concentrations remain below the 0.2 µg/g guidelines for frequent consumers of fish with the exception of West Basin lake trout where average concentrations were slightly higher (0.22 µg/g) in 2013 and 2014. While East Arm lake trout are older than West Basin fish, mercury concentrations tend to be lower possibly because mercury is less readily methylated in the East Arm and watershed. In contrast, average mercury concentrations were higher in predatory fish in the smaller Dehcho lakes (Table 1) and generally similar to the findings of previous studies (Stewart 1999, Evans et al. 2005a, Evans and Muir 2012). Some differences in mercury concentration between broad time periods may be related to differences in size of the fish analyzed whereas others may be related to a trend. For Cli Lake, similar size fish were analyzed in 2014 and in 1996 (486 ± 111 mm) as part of stock assessment studies than in the more recent studies from the domestic fishery. Statistical analyses will be conducted in the upcoming months to investigate potential time trends as in Great Slave Lake.

Persistent organic pollutants: As previously reported, we examined time trends in concentrations using PIA software (Bignert 2007) for lake trout and burbot (lipid adjusted) with data available for most compounds from 1993-2013; Hay River data for 2013 has been received. Several significant trends of decline were detected including α-HCH, γ-HCH, ∑-10 PCBs (except Lutsel K'e burbot), ∑-chlordane (except Lutsel K'e burbot and lake trout), ∑-DDT (except Lutsel K'e burbot), and dieldrin (except Lutsel K'e lake trout and burbot). Overall, HCH showed the fastest rate of decline (Fig. 2). Furthermore, the rate of decline generally was greater for West Basin than East Arm fish. While this hypothesis requires more rigorous analyses, a greater rate of decline may be expected in West Basin waters where the residence time of water is shorter (ca. 8 years versus decades) and sedimentation rates greater

Figure 1. Time trends in mean mercury concentrations (±SE) in lake trout and burbot from the West Basin and East Arm of Great Slave Lake.

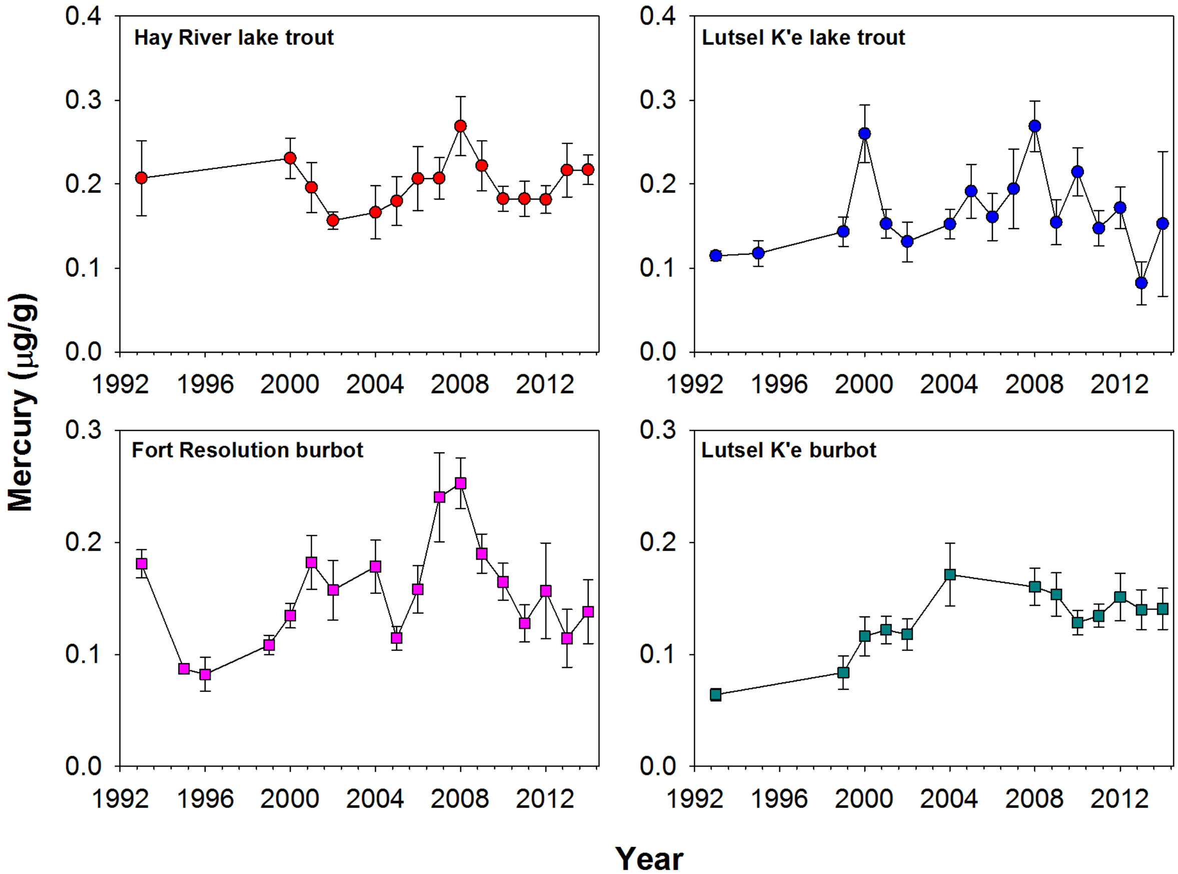

Figure 2. Rate of decrease in persistent organic contaminants in lake trout and burbot from the West Basin and East Arm of Great Slave Lake.

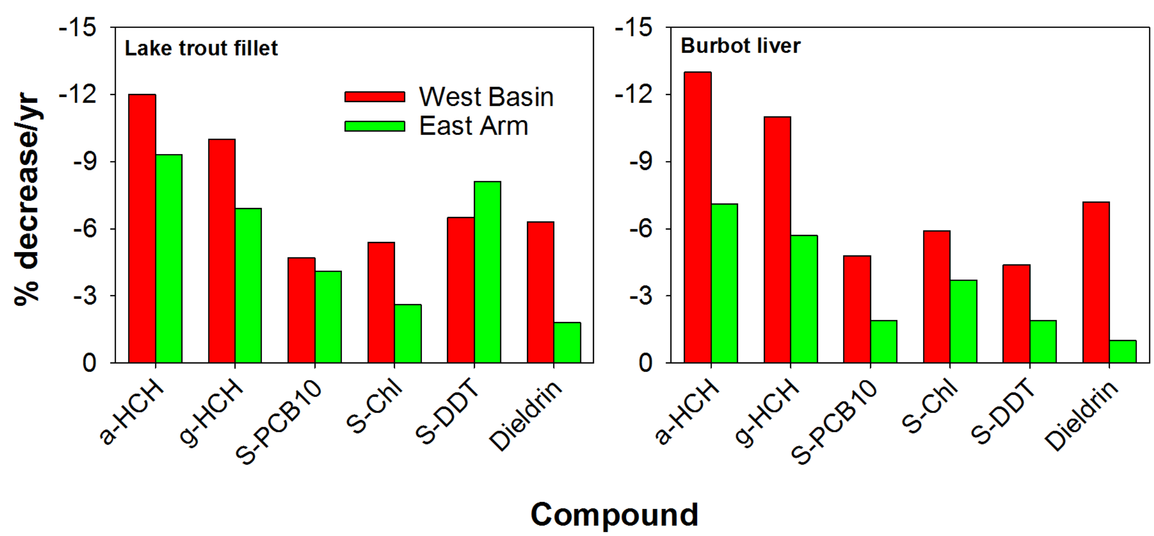

Figure 3. Seasonality in total phosphorus concentrations in Resolution Bay waters, August 2012-February 2014 (upper panel) and chlorophyll concentrations based on sampling of the water intake at Fort Resolution.

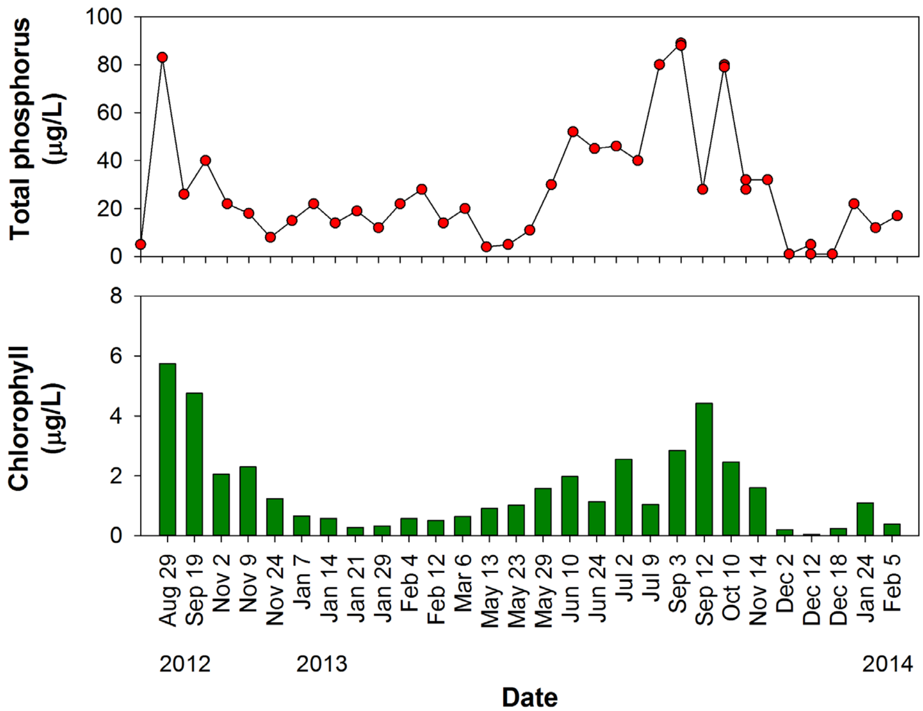

Table 1. Results of periodic assessments of mercury concentrations (wet weight) in fish collected in the Deh Cho in 2014. Length is in fork length except burbot where it is total length. Historic data are from Evans et al. (2005) and Evans and Muir (2012)

Lake/Fish	n	Length (mm)	2014 Mercury (µg/g)	Historic Mercury (µg/g)
Cli Lake				
Burbot	15	435 ± 49	0.49 ± 0.21	0.89
Lake trout	20	456 ± 60	0.43 ± 0.23	0.79 ± 0.75
Northern pike	2	648 ± 58	0.55 ± 0.26	0.23 ± 0.15
Fish Lake				
Lake whitefish	8	416 ± 67	0.07 ± 0.03	0.09 ± 0.10
Northern pike	8	764 ± 130	0.68 ± 0.38	0.67 ± 0.15
Walleye	6	532 ± 20	0.74 ± 0.24	0.91 ± 0.21
Trout Lake				
Lake trout	20	718 ± 100	0.53 ± 0.11	0.30 ± 0.07

due to suspended sediment input from the Slave River. Fish age is less likely an important factor as there are not consistent differences in fish age between the two regions, i.e., West Basin lake trout are younger and faster growing than East Arm lake trout whereas East Arm burbot are younger than West Basin burbot.

Water quality monitoring: this study with Fort Resolution began as a Cumulative Impact Monitoring Program study capacity building study to provide training in monitoring and data management. It has since evolved into using the domestic water intake to monitor various aspects of water quality on a daily, weekly or monthly basis depending on the parameter being measured. The intake study is based on the fact that domestic water intakes have been used for decades in the Laurentian Great Lakes to track trends in water quality and algal communities on a year round (Damann 1960, Makarewicz et al. 1979, Nicholls et al. 1999) basis gathering information during periods in which lake sampling is not possible because of weather and ice conditions. Beginning in August 2012, new collections have been made at approximately monthly intervals of nutrients, major ions, metals, chlorophyll, and algal communities; approximately weekly samples have been collected of total phosphorus and chlorophyll in addition to the routine monitoring conducted by the municipality. This program is providing useful information on total phosphorus concentrations and its relationship to Slave River flow and plant growth and including the beginnings of spring algal bloom during winter ice cover and peak chlorophyll concentrations in fall (Fig.3). If continued, it will allow us to more effectively test the hypothesis that increasing mercury concentrations in Great Slave fish (and fish from other regions) are related to increasing productivity. We also have worked with Lutsel K'e in providing support to their water quality monitoring in the East Arm.

Expected Project Completion Date

This is a core biomonitoring project with no specified end date.

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Temporal trend studies of trace metals and halogenated organic contaminants (HOCs), including new and emerging persistent compounds, in Mackenzie River burbot, Fort Good Hope, NWT

Études des tendances temporelles des métaux traces et des contaminants organiques halogénés, y compris des composés persistants émergents, chez la lotte du fleuve Mackenzie à Fort Good Hope (Territoires du Nord-Ouest)

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Abstract

Tissues from burbot collected at Fort Good Hope (Rampart Rapids) in December 2014 were analysed for mercury (Hg), selenium (Se) and arsenic (As). Data from this time point was combined with the existing metal data (1985, 1988, 1993, 1995, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013) together covering a time span of 29 years. No significant correlation between length and mercury concentration was observed with muscle or liver for either sex. Mean Hg concentrations in muscle and liver over the entire data sets were 0.361 ± 0.140 (n = 320) and 0.096 ± 0.083 (n = 607) mg·g-1, respectively. Muscle mercury levels are below the

Résumé

Les tissus de lotte prélevés à Fort Good Hope (rapides Rampart) en décembre 2014 ont été analysés afin de déterminer s'ils contenaient du mercure (Hg), du sélénium (Se) et de l'arsenic (As). Ces données ont été combinées à celles qui existaient sur les métaux (1985, 1988, 1993, 1995, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013), lesquelles couvrent une période de 29 ans. Aucune corrélation significative entre la durée et les concentrations de Hg n'a été observée dans les muscles et le foie des deux sexes. Les concentrations moyennes de Hg dans les muscles et le foie de la lotte pour les ensembles complets de données étaient de 0,361 ± 0,140 (n = 320) et de 0,096 ± 0,083 (n =

recommended guideline level of 0.50 mg·g-1 for commercial sale.

607) mg·g-1, respectivement. Les concentrations de Hg dans les muscles sont inférieures à la recommandation de 0,50mg·g-1 qui est fixée pour la vente commerciale.

Key messages

- Mean Hg concentrations in muscle and liver over the entire data sets were 0.361 ± 0.140 (n = 620) and 0.096 ± 0.083 (n = 607) $mg \cdot g^{-1}$, respectively.
- Since the mid-1980s, an approximate 2- and 3-fold increase in mercury concentrations has been measured in Fort Good burbot muscle and liver, respectively.
- Muscle liver and mercury levels are below the recommended guideline level of 0.50 $mg \cdot g^{-1}$ for commercial sale.

Messages clés

- Les concentrations moyennes de Hg dans les muscles et le foie de la lotte pour les ensembles complets de données étaient de 0,361 ± 0,140 (n = 320) et de 0,096 ± 0,083 (n = 607) mg·g-1, respectivement.
- Depuis le milieu des années 1980, une augmentation d'environ deux à trois fois des concentrations de Hg a été mesurée dans les muscles et dans le foie, respectivement, de la lotte de Fort Good Hope.
- Les concentrations de Hg dans les muscles et dans le foie se situent sous le seuil recommandé dans les lignes directrices, soit de 0,50 mg·g-1 pour la vente commerciale.

Objectives

To continue to assess long term trends and to maintain current data on levels of bioaccumulating substances such as mercury, organochlorine contaminants (e.g. PCBs, DDT, toxaphene) and current use contaminants (e.g. brominated flame retardants, fluorinated organic compounds) in Mackenzie River burbot at Rampart Rapids (Fort Good Hope).

Introduction

with a few exceptions, minimal or no direct temporal trend information on organhalogen (OCs/PCPs/BFRs/FOCs) contaminants and heavy metals (Hg/Se/As) in fish are available in either the Arctic marine or freshwater environments. Due to a lack of retrospective samples and of past studies, much of the temporal trend data that are available are too limited to be scientifically credible because they are based on 2 or at most 3 sampling times. In addition, much of this is confounded by changes in analytical methodology as well as variability due to age/size, or dietary and population shifts. By comparison, temporal trend data for contaminants in Lake Ontario lake trout (Borgmann and Whittle 1991) and in pike muscle from Storvindeln Sweden are available over a 15 to 30 year period.

In the Mackenzie Basin over the last 150 years a steady increase in temperatures has been recorded. In particular, over the last 35 years temperatures have increase about a degree a decade, in the centre of the basin (Rouse et al., 1997). Rising temperatures in the region may be responsible for the increasing Hg levels in the FGH burbot (see Results) for several reasons: (a) melted permafrost, increased erosion and forest fires may release increasing amounts of

Hg into the river; (b) the rate of Hg methylation processes may be increased by increasing temperature and nutrients, particularly in the wetlands and peatlands in the basin; and (c) possible changes in food web structure may have an effect on methylmercury (MeHg) biomagnification.

As outlined in the Northern Contaminants Program 2014-2015 call for proposals, the goal of temporal trend monitoring is to be able to detect a 10% annual change in contaminant concentration over a period of 10-15 years with a power of 80% and a confidence level of 95%. This requires sample collection and analysis of a minimum of 10 fish annually for a period of 10 to 15 years. Because of the importance of burbot to the subsistence diet of northerners residing in the Sahtu Region and because of the availability of current data sets and archived samples, Fort Good Hope was selected as one of the priority sampling location for long temp temporal trend studies.

FWI/UM currently maintains a very extensive archive of Fort Good Hope burbot sample tissues and data on trace metals (29 years and 20 time points; 1985, 1988, 1993, 1995, 1999, 2000, 2001, 2002, 2003 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014 and POPs (26 years and 18 time points; 1988, 1994, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014).

Activities in 2014-2015

In December 2014, 38 burbot were collected from the Mackenzie River at Fort Good Hope (Rampart Rapids) by community residents. Heavy metal and HOC analyses for these samples are now complete and the results discussed below.

Results

Hg, Se, As: Currently heavy metal (mercury, selenium and arsenic) time trend data from Fort Good Hope (Rampart Rapids) burbot tissues cover 29 years and 20 time points (1985, 1988, 1993, 1995, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014). Mean Hg concentrations in muscle and liver over the entire data sets were 0.361 ± 0.140 (n = 620) and 0.096 ± 0.083 (n = 607) mg·g-1, respectively. Mercury levels in muscle are below the recommended guideline level of 0.50 mg·g-1 for commercial sale.

Mean mercury, selenium and arsenic concentrations for burbot muscle and liver samples for each collection year are shown in Tables 1 and 2, respectively. No significant correlation between length and mercury concentration was observed with muscle or liver for either sex. Mercury trends and levels in male and female burbot muscle and liver follow quite closely from the early 1990's to 2008. Figure 1 shows an approximate 2- and 3-fold increase in mercury concentrations in Fort Good burbot muscle and liver, respectively, since the mid-1980s. For selenium and arsenic no trends were observed in either the muscle or liver (Tables 1 and 2). The highest measured As concentration, 17.16 mg·g-1, occurred in a muscle sample from a female burbot collected in 1999.

Expected project completion data

Temporal trend studies are long-term propositions and thus annual sampling is projected into the foreseeable future

Table 1. Mean (standard deviation) concentrations of mercury, selenium and arsenic in Fort Good Hope burbot muscle (mg·g^{-1}).

Collection	Sex	n	Length	Hg	Se	As
Apr-85	M	10	633 (84)	0.222 (0.035)	0.358 (0.087)	-
Dec-93	M	7	677 (109)	0.231 (0.113)	0.534 (0.163)	2.291 (3.151)
Sept-95	M	2	-	0.265 (0.035)	-	-
Dec-99	M	21	676 (107)	0.286 (0.095)	0.395 (0.107)	0.637 (0.637)
Dec-00	M	21	699 (104)	0.345 (0.097)	0.478 (0.136)	1.333 (1.944)
Dec-01	M	10	720 (164)	0.342 (0.151)	0.581 (0.272)	3.106 (3.897)
Dec-02	M	12	699 (92)	0.297 (0.139)	0.427 (0.132)	1.555 (2.746)
Jan-04	M	9	705 (79)	0.336 (0.179)	0.377 (0.061)	3.324 (4.506)
Dec-04	M	17	681 (112)	0.413 (0.130)	0.523 (0.199)	1.011 (1.680)
Dec-05	M	13	616 (67)	0.301 (0.118)	0.434 (0.420)	1.663 (2.271)
Dec-06	M	17	700 (78)	0.389 (0.118)	0.401 (0.080)	0.873 (0.913)
Dec-07	M	16	642 (61)	0.420 (0.110)	0.520 (0.132)	0.522 (0.717)
Dec-08	M	15	624 (75)	0.410 (0.115)	0.506 (0.157)	0.310 (0.294)
Dec-09	M	22	703 (94)	0.406 (0.096)	0.405 (0.094)	0.354 (0.327)
Dec-10	M	21	672 (66)	0.349 (0.126)	0.422 (0.074)	0.784 (0.905)
Dec-11	M	17	701 (112)	0.418 (0.141)	0.481 (0.112)	0.681 (0.838)
Dec-12	M	8	713 (77)	0.313 (0.074)	0.408 (0.163)	1.854 (2.797)
Dec-13	M	13	657 (91)	0.353 (0.111)	0.434 (0.133)	1.655 (2.004)
Dec-14	M	10	657 (86)	0.430 (0.137)	-	-
Apr-851	F	6	714 (140)	0.337 (0.136)	0.480 (0.126)	-
Dec-93	F	3	812 (133)	0.297 (0.035)	0.321 (0.009)	6.450 (0.984)
Sept-95	F	2	-	0.180 (0.085)	-	-
Dec-99	F	21	735 (101)	0.259 (0.108)	0.219 (0.104)1	2.626 (3.815)
Dec-00	F	15	732 (127)	0.364 (0.140)	0.460 (0.175)	1.929 (1.621)
Dec-01	F	10	747 (122)	0.336 (0.180)	0.304 (0.096)	1.098 (1.821)
Dec-02	F	17	727 (118)	0.294 (0.126)	0.400 (0.297)	2.704 (3.258)
Jan-04	F	22	726 (98)	0.254 (0.179)	0.376 (0.125)	2.827 (3.425)
Dec-04	F	18	708 (115)	0.432 (0.138)	0.451 (0.114)	1.562 (2.075)
Dec-05	F	25	710 (104)	0.350 (0.112)	0.409 (0.120)	1.587 (1.942)
Dec-06	F	21	695 (106)	0.477 (0.174)	0.435 (0.121)	0.958 (1.179)
Dec-07	F	25	671 (111)	0.376 (0.115)	0.466 (0.152)	0.533 (0.777)
Dec-08	F	22	689 (118)	0.339 (0.114)	0.433 (0.156)	0.570 (0.706)
Dec-09	F	18	701 (110)	0.402 (0.125)	0.436 (0.098)	0.471 (0.706)
Dec-10	F	18	672 (105)	0.347 (0.179)	0.414 (0.137)	0.986 (1.518)
Dec-11	F	24	725(108)	0.448 (0.106)	0.458 (0.146)	1.032 (1.355)
Dec-12	F	32	703 (119)	0.379 (0.137)	0.449 (0.148)	1.219 (2.147)
Dec-13	F	24	667 (157)	0.323 (0.123)	0.410 (0.128)	1.125 (1.965)
Dec-13	F	28	687 (109)	0.462 (0.137)	-	-

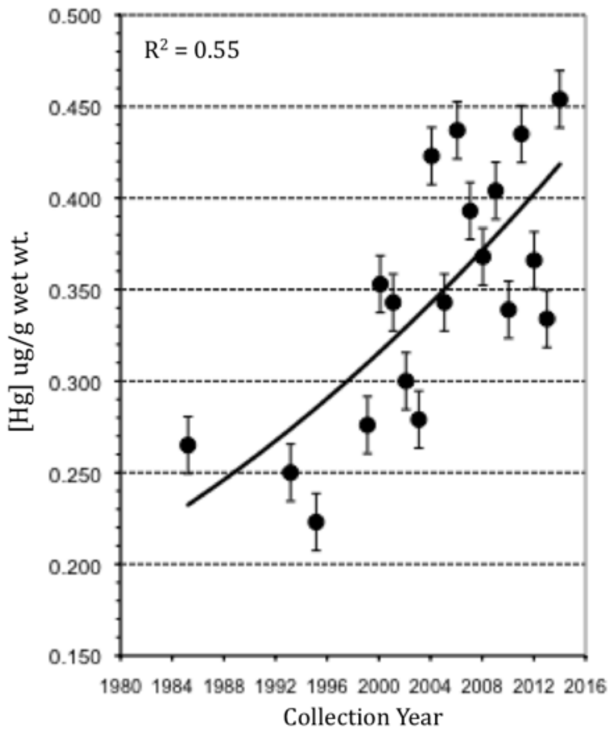
[1]n = 20

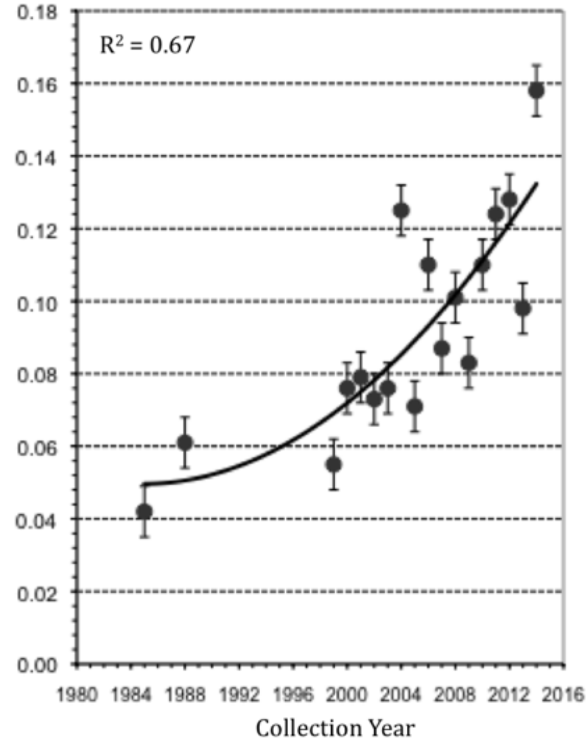
Table 2. Mean (standard deviation) concentrations of mercury, selenium and arsenic in Fort Good Hope burbot liver ($mg \cdot g^{-1}$).

Collection	Sex	n	Length	Hg	Se	As
Apr-85[1]	M	9	643 (82)	0.044 (0.019)	1.759 (0.558)	-
Dec-88	M	8	706 (84)	0.054 (0.026)	1.230 (0.555)	3.119 (1.725)
Dec-93	M	7	677 (109)	-	-	1.016 (1.328)
Dec-99	M	21	676 (107)	0.046 (0.024)	1.071 (0.628)[2]	0.607 (0.326)
Dec-00	M	21	699 (104)	0.064 (0.026)	1.646 (0.733)	0.585 (0.412)
Dec-01	M	10	720 (164)	0.063 (0.048)	1.434 (1.278)	0.839 (0.822)
Dec-02	M	12	699 (92)	0.063 (0.031)	1.437 (0.808)	0.771 (0.539)
Jan-04	M	9	705 (79)	0.126 (0.179)	1.981 (1.370)	1.994 (1.447)
Dec-04	M	17	681 (112)	0.111 (0.065)	3.267 (2.437)	0.496 (0.605)
Dec-05	M	13	616 (67)	0.053 (0.047)	1.677 (0.782)	0.527 (0.540)
Dec-06	M	17	700 (78)	0.094 (0.064)	1.939 (1.117)	-
Dec-07	M	16	642 (61)	0.076 (0.035)	2.090 (0.837)	-
Jan-09	M	15	324 (75)	0.114 (0.055)	3.416 (1.722)	0.335 (0.300)
Dec-09	M	22	703 (94)	0.064 (0.030)	2.038 (0.985)	-
Dec-10	M	21	672 (66)	0.100 (0.075)	2.571 (2.118)	0.630 (0.568)
Dec-11	M	17	701 (112)	0.119 (0.079)	2.333 (1.407)	-
Dec-12	M	8	713 (119)	0.063 (0.024)	1.946 (0.623)	0.456 (0.378)
Dec-13	M	13	657 (91)	0.095 (0.081)	2.490 (1.523)	0.487 (0.405)
Dec-14	M	10	657 (86)	0.091 (0.046)	-	-
Apr-85[1]	F	6	714 (140)	0.097 (0.098)	1.272 (0.715)	-
Dec-88	F	2	623 (86)	0.072 (0.035)	1.460 (1.529)	1.280 (1.018)
Dec-93	F	3	812 (129)	-	-	1.062 (0.546)
Dec-99	F	20	749 (77)	0.064 (0.069)	0.687 (0.552)[2]	1.353 (0.811)
Dec-00	F	15	732 (127)	0.094 (0.056)	1.203 (0.469)	0.632 (0.349)
Dec-01	F	10	747 (122)	0.098 (0.108)	1.235 (0.720)	1.074 (1.227)
Dec-02	F	17	727 (118)	0.082 (0.067)	1.488 (1.203)	1.063 (0.890)
Jan-04	F	22	726 (98)	0.057 (0.033)	1.245 (0.511)	1.522 (1.348)
Dec-04	F	17	700 (112)	0.138 (0.081)	2.616 (2.030)	0.489 (0.335)
Dec-05	F	25	710 (104)	0.080 (0.050)	1.585 (1.013)	0.489 (0.585)
Dec-06	F	21	695 (106)	0.125 (0.076)	1.906 (1.006)[3]	-
Dec-07	F	24	674 (113)	0.094 (0.098)	2.064 (1.096)	-
Jan-09	F	22	689 (118)	0.092 (0.059)	1.690 (1.095)	0.451 (0.401)
Dec-09	F	18	701 (110)	0.107 (0.141)	1.752 (1.023)	-
Dec-10	F	18	672 (105)	0.122 (0.135)	1.399 (0.688)	0.556 (0.571)
Dec-11	F	24	725 (108)	0.128 (0.043)	1.664 (0.973)	-
Dec-12	F	32	703 (119)	0.144 (0.114)	2.730 (2.410)	0.409 (0.586)
Dec-13	F	24	667 (157)	0.100 (0.072)	1.769 (1.329)	0.672 (0.905)
Dec-13	F	28	687 (109)	0.181 (0.141)	-	-

[1]Wagemann 1985; [2,3]n = 19

Figure 1. Mean Hg concentrations (SE) in muscle (left) and liver (right) from Fort Good Hope burbot (males + females).





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Trace metals and organohalogen contaminants in fish from selected Yukon lakes: A temporal and spatial study

Métaux traces et contaminants organohalogénés chez les poissons de certains lacs au Yukon : étude des tendances temporelles et spatiales

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Abstract

Lake trout muscle samples collected from two Yukon Lakes, Kusawa and Laberge, were analysed for a range of organohalogen and heavy metal contaminants. Currently heavy metal time trend data from Laberge and Kusawa Lake trout muscle cover 21 years, 18 and 16 time points, respectively. The mean mercury (Hg) levels over the entire data sets for the Laberge and Kusawa samples were 0.47 ± 0.21 (n=182) and 0.37 ± 0.23 (n=154) mg g^{-1}, respectively. In both lakes, levels are below the recommended guideline level of 0.50 mg g^{-1} for commercial sale. No significant trends have been observed in the Laberge and Kusawa length adjusted lake trout Hg levels over the last 21 and 15, respectively. Arsenic (As) was observed with the mercury, after a rapid decline, the lipid adjusted OC concentrations seem to start to increase again around 2003-2004. Significant variability in the Laberge samples is observed and as a result no temporal trends are evident.

Résumé

Nous avons analysé des échantillons de muscles de touladis prélevés dans deux lacs du Yukon, soit le lac Kusawa et le lac Laberge, afin d'en déterminer la teneur en divers contaminants organohalogénés et en métaux lourds. La série chronologique des concentrations de métaux lourds dans ces échantillons de muscles des touladis s'étend sur 21 ans; il y a eu durant cette période 18 prélèvements au lac Laberge et 16 au lac Kusawa. Pour l'ensemble des données, la concentration moyenne de mercure (Hg) est de 0,47 ± 0,21 (n=182) au lac Laberge et de 0,37 ± 0,23 (n=154) mg g^{-1} au lac Kusawa. Ainsi, dans les deux lacs, les concentrations sont inférieures à la limite de 0,50 mg g^{-1} qui est recommandée pour la vente commerciale de poisson. Aucune tendance significative n'a été observée en ce qui concerne les concentrations de Hg corrigées en fonction de la longueur chez les touladis du lac Laberge et du lac Kusawa, et ce au cours des 21 et 15 dernières années, respectivement. Comme

on l'a observé pour le Hg, suivant un déclin rapide, les concentrations d'organochlorés (CO) ajustées en fonction des lipides semblent avoir recommencé à augmenter autour de 2003-2004. On a noté une variation significative dans les échantillons prélevés au lac Laberge, ce qui fait qu'aucune tendance temporelle n'a été décelée.

Key messages

- currently heavy metal (mercury, selenium and arsenic) time trend data from Laberge and Kusawa Lake trout cover 21 years, 18 and 16 time points, respectively
- The mean Hg levels over the entire data sets for the Laberge and Kusawa samples were 0.47 ± 0.21 (n=182) and 0.37 ± 0.23 (n=154) $mg \cdot g^{-1}$, respectively. In both lakes, levels are just below the recommended guideline level of 0.50 $mg \cdot g^{-1}$ for commercial sale.
- No significant trends have been observed in the Laberge lake trout Hg levels over the last 19 years.
- No significant trends have been observed in the Laberge and Kusawa length adjusted lake trout Hg levels over the last 21 and 15, respectively.
- As was observed with the mercury, after a rapid decline, the lipid adjusted OC concentrations seem to start to increase again around 2003-2004. Significant variability in the Laberge samples is observed and as a result no temporal trends are evident.

Messages clés

- À l'heure actuelle, la série chronologique des concentrations de métaux lourds (Hg, Se et As) dans les muscles des touladis des lacs Laberge et Kusawa s'étend sur 21 ans; il y a eu durant cette période 18 prélèvements au lac Laberge et 16 au lac Kusawa.
- Pour l'ensemble des données, la concentration moyenne de Hg est de 0,47 ± 0,21 (n=182) au lac Laberge et de 0,37 ± 0,23 (n=154) mg·g-1 au lac Kusawa. Dans les deux lacs, les concentrations sont tout juste inférieures à la limite de 0,50mg·g-1 qui est recommandée pour la vente commerciale de poisson.
- Au cours des 19 dernières années, aucune tendance significative n'a été observée en ce qui concerne les concentrations de Hg chez les touladis du lac Laberge.
- Aucune tendance significative n'a été observée en ce qui concerne les concentrations de Hg corrigées en fonction de la longueur chez les touladis du lac Laberge et du lac Kusawa, et ce au cours des 21 et 15 dernières années, respectivement.
- Comme dans le cas du mercure, après un déclin rapide, les concentrations de CO ajustées en fonction des lipides semblent avoir recommencé à augmenter autour de 2003-2004. On a noté une variation significative dans les échantillons prélevés au lac Laberge, ce qui fait qu'aucune tendance temporelle n'a été décelée.

Objectives

- The objective of this project is to maintain current data on contaminants levels in lake trout from two Yukon lakes (Laberge and Kusawa) to continue to assess the temporal trends of bioaccumulating substances such as trace metals (e.g. mercury, selenium, arsenic), organochlorine contaminants (e.g. PCBs, DDT, toxaphene), selected current use chemicals such as brominated flame retardants (e.g. PBDEs), and fluorinated organic compounds (e.g. PFOS and it's precursors) so as to determine whether the levels of these contaminants in fish (health of the fish stock) and thus exposure to people who consume them are increasing or decreasing with time. These results will also help to test the effectiveness of international controls.

Introduction

Historical studies have demonstrated that halogenated organic contaminants (HOCs) and mercury levels in top predators can vary considerably from lake to lake within a small geographic region but temporal trends of these contaminants have rarely been monitored in a sub-Arctic area for a long period of time. This study examines concentrations of a wide range of HOCs and trace metals in lake trout from two Yukon lakes (Laberge, Kusawa), over a span of 19 years (1993-20013). In 2005, Ryan et al. reported that OC pesticide and PCB concentration were declining at various rates in lake trout (*Salveninus namaycush*) in three different Yukon lakes (Laberge, Kusawa and Quiet). For example, ΣDDT concentrations have decreased 39%, 85% and 84% in Kusawa, Quiet and Laberge lakes respectively. Spatial variations in OC/PCB levels were quite evident as Lake Laberge trout continued to maintain the highest levels over the 10 year period from 1992 to 2003 followed by Kusawa and then Quiet. These differences were related to a variety of factors especially the species morphological characteristics such as log age, log weights and fish lipid content. A decreasing trend in Quiet and Laberge lake trout lipid content, coupled with fluctuating condition factors and increases in body masses, suggest biotic changes may be occurring within the food webs due to fish population variations related to the cessation of commercial fishing or potentially an increase in lake plankton productivity related to annual climate variation.

Because of the importance of lake trout to the subsistence diet of northerners, the need to continue to assess the effect of climate variation on fish contaminant levels, the availability of current data sets and archived samples, Lakes Laberge and Kusawa were selected as the priority Yukon sampling location for long-term temporal trend studies.

Activities in 2014-2015

AANDC (Whitehorse)/DFO (Winnipeg) together maintain a very extensive archive of fish tissues and data for Hg, Se, As, and HOCs in Yukon lakes (see Tables 1-4). In 2014, 10 lake trout were collected each from Kusawa Lake and 20 from Lake Laberge.

Results and discussion

hg, Se, As: Currently heavy metal (mercury, selenium and arsenic) time trend data from Laberge and Kusawa Lake trout cover 20 years, 17 and 15 time points, respectively (Table 1). The mean Hg levels over the entire data sets for the Laberge and Kusawa samples were 0.48 ± 0.22 (n=162) and 0.38 ± 0.23 (n=144) $mg \cdot g^{-1}$, respectively. In both lakes, levels are just below the recommended guideline level of 0.50 $mg \cdot g^{-1}$ for commercial sale. A significant correlation between length and muscle mercury concentration was observed in the Laberge

([HgT] = m*length + b, m=0.0013, b=-0.2892, r^2 = 0.59, p<0.001, n=143) and Kusawa ([Hg] = m*length + b, m=0.0018, b=-0.5046, r^2 = 0.52, p<0.001, n=124) trout. ANCOVA was used to assess the effects of year to year collections (temporal trends), length and length*year interactions (homogeneity of the slope between length and [Hg]). No significant trends have been observed in the Laberge lake trout Hg levels over the last 20 years. In Kusuwa Lake, after a significant drop in the length adjusted mean Hg trout muscle concentrations in 2001, levels increased consistently until 2007, dropped in 2008, and are again on the rise. The current length adjusted mean Hg concentration is now at its highest level since 1999.

Organohalogens: Table 2 lists the mean wet weight HOC concentration in trout from Lake Laberge and Kusawa Lake over the 20 year time period from 1983 to 2014. Significant variability in the Laberge and Kusawa samples is observed over time and as a result no temporal trends are evident.

Major PBDE congener concentrations in Lake trout from Lakes Laberge, Kusawa and Quite are shown in Table 4. Levels in trout from Quite Lake are 1 to 2 orders of magnitude lower than those from Laberge and Kusawa.

Table 1. Mean (standard deviation) concentrations of mercury, selenium and arsenic in lake trout muscle from Laberge and Kusawa Lakes. All levels are in mg/g.

	Year	n	Length	Hg	Se	As
Laberge	1993	13	483 (110)	0.44 (0.11)	0.45 (0.08)	0.15 (0.04)
	1996	18	472 (93)	0.32 (0.10)	0.32 (0.12)	0.12 (0.06)
	1998	7	700 (125)	0.61 (0.24)	0.42 (0.07)	0.18 (0.12)
	2000	6	590 (108)	0.43 (0.21)	0.66 (0.14)	0.13 (0.04)
	2001	22	639 (92)	0.54 (0.23)	0.57 (0.13)	0.10 (0.04)
	2002	5	570 (120)	0.38 (0.15)	0.61 (0.12)	0.11 (0.05)
	2003	8	593 (98)	0.56 (0.25)	0.47 (0.10)	0.10 (0.03)
	2004	5	614 (68)	0.54 (0.23)	0.38 (0.09)	0.09 (0.04)
	2005	10	606 (97)	0.50 (0.19)	0.47 (0.09)	0.06 (0.03)
	2006	1	800	0.68	0.45	0.08
	2007	9	674 (109)	0.70 (0.27)	0.42 (0.05)	0.08 (0.03)
	2008	10	580 (78)	0.37 (0.19)	0.43 (0.07)	0.06 (0.02)
	2009	10	538 (58)	0.41 (0.18)	0.41 (0.03)	0.06 (0.02)
	2010	10	547 (49)	0.49 (0.19)	0.45 (0.07)	0.08 (0.03)
	2011	10	553 (64)	0.52 (0.29)	0.41 (0.09)	0.08 (0.04)
	2012	10	579 (47)	0.63 (0.24)	0.46 (0.06)	0.07 (0.02)
	2013	8	499 (87)	0.33 (0.13)	0.45 (0.07)	0.08 (0.03)
	2014	20	564 (64)	0.40 (0.11)	-	-
Kusawa	1993	3	535 (72)	0.54 (0.21)	0.43 (0.17)	-
	1999	14	515 (106)	0.51 (0.17)	0.46 (0.11)	0.12 (0.07)
	2001	9	551 (108)	0.29 (0.11)	0.52 (0.09)	-
	2002	10	500 (74)	0.29 (0.09)	0.55 (0.07)	0.02 (0.01)
	2003	10	487 (90)	0.35 (0.13)	0.35 (0.24)	0.03 (0.02)
	2004	9	553 (117)	0.39 (0.13)	0.64 (0.14)	0.03 (0.01)
	2005	10	510 (118)	0.43(0.31)	0.60 (0.11)	0.01 (0.01)
	2006	9	568 (168)	0.56 (0.38)	0.59 (0.17)	0.02 (0.01)
	2007	10	446 (80)	0.36 (0.24)	0.57 (0.08)	0.02 (0.01)
	2008	10	471 (94)	0.24 (0.07)	0.54 (0.08)	0.02 (0.01)
	2009	10	453 (54)	0.23 (0.08)	0.56 (0.08)	0.02 (0.01)
	2010	10	449 (97)	0.31 (0.19)	0.47 (0.09)	0.04 (0.03)
	2011	10	433 (43)	0.32 (0.06)	0.51 (0.07)	0.02 (0.01)
	2012	10	433 (47)	0.53 (0.13)	0.54 (0.13)	0.04 (0.03)
	2013	10	418 (72)	0.29 (0.08)	0.54 (0.08)	0.02 (0.01)
	2014	10	412 (42)	0.31 (0.10)	-	-

Figure 1. Length adjusted Hg concentrations in trout muscle from Lake Laberge (1993-2014) and Kusawa (1993–2014). Only Kusawa trout less than 700 mm in length were usd in the ANCOVA.

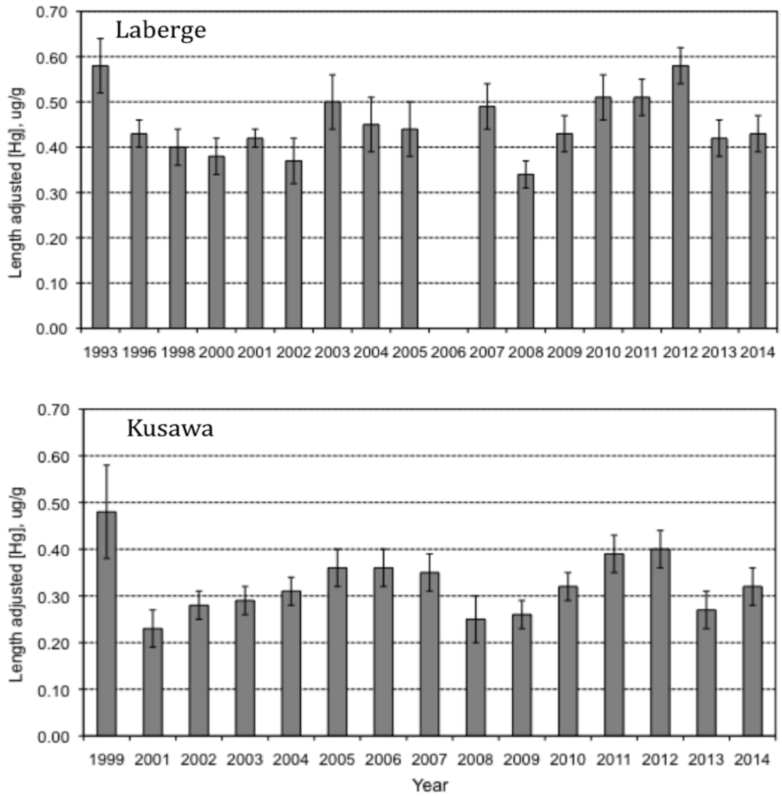

Table 2. Mean (S.D.) HOC levels (ng/g wet wt.) in lake trout muscle from Lake Laberge

Laberge	N	Age	% lipid	SPCB	SDDT	SCHL	SHCH	SCHB	SCBz
1993	24	15 (2)	7.9 (0.9)	328.28 (121.49)	391.54 (132.69)	47.60 (8.84)	4.69 (0.78)	310.96 (62.36)	3.92 (0.57)
1996	13	22 (5)	9.6 (1.4)	209.32 (52.08)	236.51 (41.39)	53.38 (13.74)	6.50 (1.79)	212.23 (28.31)	4.90 (1.24)
2000	6	12 (2)	3.7 (0.8)	138.95 (60.89)	96.46 (14.21)	22.36 (5.84)	2.30 (1.08)	207.33 (49.90)	2.26 (0.59)
2001	16	14 (2)	4.9 (0.5)	139.71 (53.75)	89.46 (14.04)	26.37 (5.14)	0.80 (0.07)	154.20 (60.46)	2.11 (0.17)
2002	5	12 (4)	4.2 (0.9)	48.60 (8.81)	54.50 (11.58)	7.26 (1.59)	1.58 (0.50)	139.23 (16.88)	1.15 (0.25)
2003	8	12 (1)	4.7 (0.8)	81.01 (29.83)	61.48 (8.55)	7.44 (2.24)	0.54 (0.10)	179.31 (42.79)	1.21 (0.28)
2004	6	12 (4)	8.7 (3.9)	48.93 (34.30)	94.09 (60.68)	7.46 (4.90)	0.19 (0.09)	79.92 (52.01)	0.49 (0.28)
2005	10	14 (7)	2.0 (1.22)	28.94 (20.27)	50.91 (30.27)	2.61 (1.28)	0.16 (0.10)	34.50 (19.97)	0.35 (0.27)
2006	1	21	1.0	25.52	31.25	4.82	0.07	76.87	0.35
2007	9	14 (5)	1.2 (0.80)	37.36 (25.89)	43.98 (29.93)	5.32 (4.05)	0.10 (0.09)	25.78 (14.58)	0.27 (0.80)
2008	10	12 (5)	2.3 (1.1)	50.23 (36.89)	70.06 (41.29)	4.04 (2.88)	0.18 (0.08)	24.48 (16.85)	0.77 (0.23)
2009	10	10 (3)	2.9 (1.1)	28.92 (14.89)	35.33 (20.81)	2.30 (1.06)	0.14 (0.06)	37.60 (19.57)	0.60 (0.34)
2010	10	9 (2)	2.3 (1.3)	12.08 (3.74)	40.43 (12.12)	1.18 (0.47)	0.12 (0.05)	24.91 (13.84)	0.29 (0.12)
2011	10	8 (3)	2.2 (1.0)	23.13 (12.65)	31.24 (13.24)	1.94 (0.93)	0.12 (0.05)	10.48 (4.09)	0.39 (0.16)
2012	10	11 (5)	2.0 (1.2)	31.80 (20.61)	20.24 (9.62)	2.14 (1.49)	0.13 (0.08)	11.57 (7.37)	0.65 (0.25)
2013	8	14 (6)	6.7 (2.8)	45.97 (26.83)	93.44 (58.44)	5.56 (4.29)	0.26 (0.16)	10.59 (9.23)	2.04 (1.00)
2014	7								

Table 3. Mean (S.D.) OC levels (ng/g wet wt.) in lake trout muscle from Kusawa Lake

Kusawa	N	Age	% lipid	SPCB	SDDT	SCHL	SHCH	SCHB	SCBz
1993	10	19 (2)	1.8 (1.6)	85.62 (26.07)	44.16 (21.50)	17.33 (2.78)	1.21 (0.36)	120.80 (24.94)	1.15 (0.28)
1999	14	18 (1)	4.6 (3.0)	91.09 (11.85)	139.16 (19.72)	17.82 (2.74)	1.68 (0.23)	148.38 (29.29)	1.52 (0.20)
2001	9	12 (1)	2.4 (1.4)	48.55 (7.91)	56.58 (15.30)	7.45 (2.35)	0.91 (0.14)	61.03 (8.55)	0.84 (0.14)
2002	10	12 (1)	1.4 (0.8)	32.45 (3.66)	26.66 (4.15)	3.01 (0.48)	0.62 (0.08)	43.47 (5.02)	0.61 (0.09)
2003	9	9 (3)	5.8 (3.6)	8.16 (5.86)	8.21 (15.67)	3.50 (2.28)	0.14 (0.08)	45.05 (32.20)	0.44 (0.30)
2004	9	13 (4)	7.9 (4.7)	11.29 (3.78)	5.70 (3.70)	4.52 (2.16)	0.15 (0.07)	49.73 (30.17)	0.50 (0.27)
2005	10	15 (6)	0.61 (0.51)	5.48 (4.84)	2.35 (3.02)	1.17 (0.88)	0.03 (0.03)	12.37 (11.57)	0.12 (0.10)
2006	9	12 (4)	1.82 (1.49)	6.28 (4.58)	2.97 (2.57)	2.49 (1.84)	0.09 (0.06)	42.63 (34.97)	0.47 (0.26)
2007	9	10 (4)	1.52 (1.43)	9.88 (9.93)	2.35 (1.88)	2.78 (2.90)	0.10 (0.06)	22.44 (23.88)	0.42 (0.33)
2008	10	9 (2)	1.16 (0.42)	18.30 (27.27)	2.35 (0.94)	1.30 (0.40)	0.13 (0.26)	22.55 (7.87)	0.47 (0.13)
2009	10	9 (1)	1.51 (1.11)	2.55 (1.59)	0.78 (0.67)	0.95 (0.72)	0.05 (0.03)	21.20 (17.20)	0.18 (0.11)
2010	10	10 (3)	1.9 (1.6)	3.20 (2.24)	2.12 (2.13)	0.93 (0.81)	0.06 (0.03)	22.00 (23.05)	0.20 (0.12)
2011	10	8 (2)	0.80 (0.51)	5.49 (2.09)	0.81 (0.35)	0.80 (0.39)	0.13 (0.07)	5.86 (3.57)	0.22 (0.10)
2012	10	10 (4)	1.5 (1.1)	8.48 (4.47)	1.70 (0.90)	1.68 (0.83)	0.15 (0.11)	13.10 (9.96)	0.74 (0.33)
2013	10	12 (5)	3.3 (3.1)	22.45 (16.32)	3.19 (2.53)	3.15 (2.53)	0.10 (0.10)	6.22 (4.80)	1.23 (0.74)
2014	7								

Table 4. Mean (S.D.) PBDE levels (pg g^{-1}, wet wt.) in lake trout muscle from Lakes Laberge, Kusawa and Quiet Lakes

	Laberge	n	% Lipid	BDE 47	BDE 49	BDE 99	BDE 100	BDE 153	BDE 154
Laberge	1993	10	2.0 (1.7)	1481 (728)	348 (112)	2943 (1531)	700 (341)	642 (491)	1530 (1009)
	2000	6	0.5 (0.3)	4900 (1680)	2100 (240)	8590 (1170)	3380 (630)	5740 (1320)	4460 (1190)
	2003	8	0.4 (0.2)	3170 (1430)	1290 (750)	5890 (2860)	2450 (1200)	3920(4050)	3200 (2810)
	2005	10	2.0 (1.2)	2659 (1977)	165 (117)	4093 (2389)	1848 (1235)	740 (580)	986 (732)
	2006	1	1.0	24920	1630	35900	11370	4120	3240
	2007	9	1.2 (0.8)	5500 (901)	1100 (1130)	9680 (1627)	6700 (5850)	200 (560)	1900 (1450)
	2008	10	2.3 (1.1)	2389 (1207)	2175 (1476)	1721 (1222)	139 (99)	258 (152)	560 (211)
	2009	10	2.9 (1.1)	1590 (1815)	1546 (1476)	2799 (1165)	1421 (729)	347 (141)	250 (355)
	2010	10	2.3 (1.3)	2907 (3266)	2640 (2525)	3124 (3989)	1271 (1457)	365 (487)	566 (646)
	2011	10	2.2 (1.0)	525 (700)	320 (280)	629 (994)	229 (339)	82 (115)	131 (193)
	2013	8	6.6 (4.1)	383 (321)	nd	685 (839)	276 (294)	98 (147)	111 (129)
	2014	7							
Kusawa	1999	10	3.0 (2.2)	4377 (2490)	nd	3636 (2011)	2573 (1623)	894 (622)	1495 (895)
	2001	10	2.8 (1.6)	700 (990)	130 (160)	720 (1090)	250 (250)	260 (480)	230 (330)
	2003	5	0.2 (1.1)	960 (1220)	360 (47)	2630 (3510)	950 (1260)	1180 (1590)	870 (1150)
	2006	9	1.8 (1.5)	1103 (1231)	66 (99)	824 (911)	446 (514)	136 (140)	202 (236)
	2007	9	1.6 (1.4)	9900 (1216)	300 (700)	12300 (1271)	3900 (5990)	1100 (830)	600 (790)
	2008	10	1.2 (0.4)	4178 (1781	648 (240)*	1653 (1394)	294 (113)	58 (103)	1653 (609)
	2009	10	1.5 (1.1)	417 (135)	73 (88)	273 (106)	121 (53)	27 (10)	69 (38)
	2010	10	1.9 (1.6)	359 (640)	231 (471)	252 (510)	138 (283)	33 (64)	65 (124)
	2011	10	0.8 (0.5)	240 (110)	70 (130)	180 (100)	80 (40)	70 (50)	60 (50)
	2013	10	3.1 (4.4)	61 (98)	nd	101 (189)	43 (76)	13 (24)	19 (34)
	2014	7							

nd = non-detect

Expected project completion date

Temporal trend studies are long-term propositions and thus annual sampling is projected until well into the future.

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Arctic caribou contaminant monitoring program

Programme de surveillance des contaminants chez le caribou de l'Arctique

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Abstract

This project studies contaminant levels in caribou in the Canadian Arctic to determine if these populations remain healthy (in terms of contaminant loads), whether these important resources remain safe and healthy food choices for northerners and if contaminant levels are changing over time. In 2014-2015 samples were collected from 2 Porcupine and 21 Qamanirjuaq caribou. Sample analyses for these collections had not been completed at the time this report was prepared. Qamanirjuaq and Porcupine caribou samples collected in the 2013-2014 year have been analyzed, and results are presented in this report. Age was positively correlated with renal cadmium and zinc in both herds and negatively correlated

Résumé

Ce projet vise à étudier les concentrations de contaminants chez les caribous de l'Arctique canadien afin de déterminer si ces populations demeurent en santé (en ce qui concerne les niveaux de contaminants), si cette ressource alimentaire importante continue d'être une source de nourriture saine et sécuritaire pour les résidents du Nord, et si les concentrations de contaminants évoluent au fil du temps. En 2014-2015, des échantillons ont été prélevés sur 2 caribous de la harde de la Porcupine et sur 21 caribous de la harde de Qamanirjuaq. Leur analyse n'était pas terminée au moment où le présent rapport a été rédigé. Les résultats concernant les échantillons recueillis en 2013-2014 chez les caribous de la Porcupine et de

with mercury in the Porcupine herd. Renal lead is declining over time in the Porcupine caribou herd, perhaps due to the reduction in use of leaded gasoline in Canada over the last two decades. Renal selenium is increasing over time in the Qamanirjuaq caribou, but not to levels of toxicological concern. The proximity of open ocean to the home range of this herd may have a significant effect on the dynamics of certain elements within that ecosystem. Levels of most elements measured were not of concern toxicologically, although renal mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed. Yukon Health has advised restricting intake of kidney and liver from Yukon caribou, the recommended maximum varying depending on herd (e.g. a maximum of 32 Porcupine caribou kidneys/year). The health advisory confirms that heavy metals are very low in the meat (muscle) from caribou and this remains a healthy food choice.

Qamanirjuaq sont fournis dans le présent rapport. On a observé chez les caribous des deux hardes une corrélation positive entre l'âge et les concentrations de cadmium et de zinc présentes dans les reins, ainsi qu'une corrélation négative entre l'âge et les concentrations de mercure chez la harde de la Porcupine. Les concentrations de plomb dans les reins des caribous de la harde de la Porcupine diminuent avec le temps, cette baisse découlant potentiellement de l'utilisation décroissante de l'essence au plomb au Canada depuis les deux dernières décennies. Les concentrations de sélénium dans les reins chez les caribous de Qamanirjuaq augmentent avec le temps, mais les niveaux atteints ne suscitent pas de préoccupations sur le plan toxicologique. Le fait que le domaine vital de cette harde se situe à proximité de l'océan pourrait avoir une incidence considérable sur les dynamiques de certains éléments au sein de cet écosystème. Les concentrations de la plupart des éléments mesurés n'étaient pas préoccupantes d'un point de vue toxicologique, et ce même si les concentrations de mercure et de cadmium dans les reins pourraient être préoccupantes dans une certaine mesure pour la santé humaine, selon la quantité de ces organes qui est consommée. Le ministère de la Santé du Yukon a conseillé aux citoyens de limiter la quantité de rognons et de foie provenant de caribous du Yukon qu'ils consomment; la quantité maximale recommandée varie selon la harde (p. ex. au maximum 32 rognons de caribous de la harde de la Porcupine par année). L'avis de santé publique confirme que les concentrations de métaux lourds sont faibles dans la viande (les muscles) des caribous et que cette dernière demeure un aliment sain.

Key Messages

- Levels of most elements measured in caribou tissues are not of concern, although kidney mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed. Caribou meat (muscle) does not accumulate high levels of contaminants and is a healthy food choice.

Messages clés

- La concentration de la plupart des éléments mesurés dans les tissus de caribous ne constitue pas une préoccupation, bien que les concentrations de mercure et de cadmium dans les reins puissent être préoccupantes pour la santé humaine, selon la quantité d'organes consommée. La viande (les muscles) des caribous n'accumule pas

- Lead appears to be decreasing over time in the Porcupine caribou, likely due to emission controls.
- This program will continue to monitor the Porcupine and Qamanirjuaq caribou herds annually to maintain confidence in this traditional food and to better understand the dynamics of contaminants within this ecosystem (particularly mercury).

de grandes concentrations de contaminants et constitue donc un aliment sain.

- Il semble que les concentrations de plomb chez les caribous de la Porcupine diminuent avec le temps, et ce potentiellement en raison des mesures de contrôle des émissions qui sont mises en place.
- Dans le cadre de ce programme, on continuera de surveiller les hardes de caribous de la Porcupine et de Qamanirjuaq sur une base annuelle, et ce afin de s'assurer que cette source alimentaire traditionnelle demeure saine et de mieux comprendre la dynamique des contaminants (en particulier du mercure) dans l'écosystème.

Objectives

To determine levels of and temporal trends in contaminants in Arctic caribou in order to:

1. Provide information to Northerners regarding contaminants in these traditional foods, so that:
    a. They may be better able to make informed choices about food consumption. This includes providing information for health assessments and/or advisories as required.
    b. Wildlife managers can assess possible health effects of contaminants on Arctic caribou populations.
2. Further understand the fate and effects of contaminant deposition and transport to the Canadian Arctic.

Introduction

Caribou provide an important food resource for Northerners across the Arctic, and have been designated in the NCP blueprint as key species for monitoring contaminants in the terrestrial Arctic ecosystem. Two barren-ground caribou herds, one from the eastern (Porcupine) and one from the western (Qamanirjuaq) Arctic, have been designated for annual sampling.

Activities in 2014-2015

Samples were collected from two Porcupine caribou in the fall of 2014 by hunters in Old Crow. Normally, Environment Yukon staff collect samples from 20 caribou as part of a Yukon Government initiative working with hunters in Old Crow to study body condition in the Porcupine caribou herd. However, this year, the migration pattern of the herd changed and the main herd did not pass through Old Crow, so no samples were taken by this group. Twenty-one samples were collected from the Qamanirjuaq caribou herd in Arviat in the fall of 2014 in cooperation with the Arviat Hunters and Trappers Organization. This was the first year of a formal agreement with this organization and it worked very well. Kidneys, liver, muscle and teeth were collected as usual. In addition, bone marrow and brains were collected from 10 caribou in response to a request from local hunters to know what contaminants were in these commonly consumed tissues.

Current-year samples are currently being analyzed for a suite of 34 elements using ICP-MS by NLET, Environment Canada, Burlington (Xiaowa Wang, Derek Muir). Liver and muscle samples were archived and incisors were used to analyze age of the animal using the cementum technique (Matson's Laboratory, Missoula, Montana). Porcupine and Qamanirjuaq caribou samples collected in the 2013/14 year have been analyzed, and results are presented here.

Although kidneys were analyzed for 34 elements, only results for 7 elements of concern were statistically analyzed in detail (arsenic, cadmium, copper, lead, mercury, selenium and zinc). The effect of gender was unable to be tested since all Porcupine caribou collected were male and all Qamanirjuaq caribou were female. The effect of year and age on element concentration was tested comparing 2013 to previous years for the same gender for each herd. In all statistical analyses, data were log-transformed, where necessary to achieve normality. If normality was not achieved by this transformation, non-parametric tests were used to analyze the data.

Capacity Building

In October, 2014, the PI participated in a wildlife contaminants workshop presented to the students of the Environmental Technology Program of Arctic College in Iqaluit, providing information on contaminants in the general environment as well as in caribou, specifically. The workshop provided the opportunity for students to dissect two caribou as part of the 'hands-on training' portion of the workshop. The students also learned how to age caribou teeth using the cementum technique. This workshop will be offered again in October, 2015.

Communications

Interviews about this project were done with CBC radio and television in Inuvik (Sept 2014) and CBC radio in Iqaluit (Oct 2014). A summary of the project was provided to the Inuit Tapiriit Kanatmi for their contaminants website, and the project was featured by SAON Canada (Sustaining Arctic Observing Networks Canada) in their bulletin (http://arcticobservingcanada.ca/SAON-Results-Bulletin-v1-2%20Dec-5.pdf). Plain language summaries were created for the Porcupine and Qamanirjuaq caribou herds separately and distributed to stakeholder groups. The Qamanirjuaq summary was also supplied in Inuktitut. Synopsis reports will be distributed to all stakeholders. Results and conclusions from this ongoing program were presented to the following groups in person:

- Beverly Qamanirjuaq Caribou Management Board, Regina. May, 2014
- North American Caribou Conference, Whitehorse. May 2014
- Inuvik High School, Sept 2014 (Grade 11 and Experiential Science classes)
- Nihtat Gwich'in Renewable Resource Council, Inuvik, Sept 2014
- Environmental Technology Program students at Arctic College, Iqaluit, NT, Sept 2014
- Issatik HTO, Whale Cove, NT, Oct 2014
- Aqigiq HTO, Chesterfield Inlet, NT, Oct 2014
- Baker Lake HTO, Baker Lake, NT, Oct 2014

Presentations were made at public meetings in the following communities:

- Fort MacPherson, NT, Sept 2014 (organized in collaboration with the Tetlit Gwich'in Renewable Resource Council; included a talk on the local radio station)
- Inuvik, NT, Sept 2014 (organized in collaboration with Aurora Research Institute)
- Tsiigehtchic, NT, Sept 2014 (organized in collaboration with the Gwichya Gwich'in Renewable Resource Council)
- Iqaluit, NT, Oct 2014 (organized in collaboration with Nunavut Research Institute)

Traditional Knowledge Integration

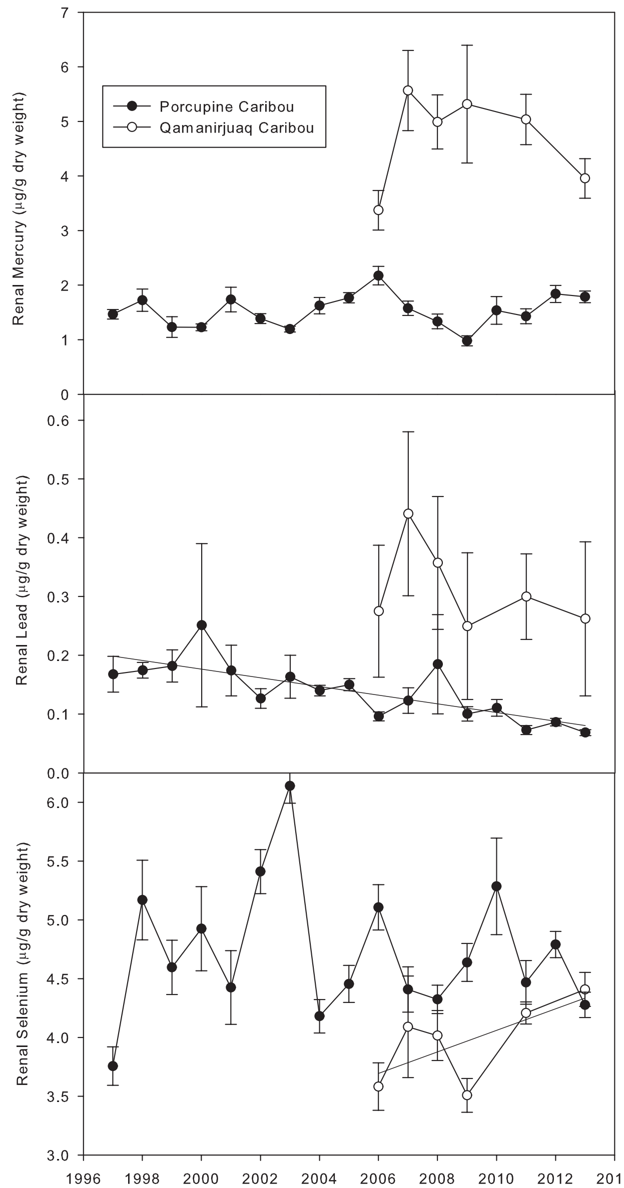
This program relies on the traditional knowledge of both Aboriginal and non-Aboriginal people when collecting samples from caribou for analysis. In all cases local hunters use traditional knowledge when hunting caribou and ultimately submitting samples as well as providing food for their families. Meetings between the PI and local HTOs provide an opportunity for the exchange of traditional and western scientific information that will enhance understanding of contaminants in caribou and facilitate the implementation of this project. In the fall of 2014, meetings with HTOs in the small communities in the Hudson Bay region, yielded the traditional Inuit knowledge that caribou commonly consume seaweed, which could be a significant source of mercury for Qamanirjuaq caribou. This information has been incorporated into the workplan for this project for the coming year.

Results

Results for the seven elements of interest are presented in Table 1. Age was positively correlated with renal cadmium and zinc in both herds and negatively correlated with mercury in the Porcupine herd.

Year was not correlated with any of the elements measured in male, fall-collected Porcupine caribou, with the exception of As and Pb. In the case of As, this is likely due to more erratic older measurements. If data collected prior to 2004 is omitted from the analysis, the relationship of As to year disappears. The same is not true of Pb, which does seem to be declining over time in this herd (Fig 1). Renal Se was positively correlated with year in the Qamanirjuaq herd (Fig 1). Renal Hg was not correlated with year in either herd (Fig 1).

Figure 1. Renal mercury, lead and selenium concentrations in fall-collected male Porcupine and female Qamanirjuaq caribou. Regression lines were added for statistically significant relationships ($p<0.05$) only.



Discussion and Conclusions

Correlations between some elements and age are common in ungulates and need to be considered when comparing element concentrations within and among caribou herds (Gamberg et al. 2005).

It is not clear why Pb appears to be declining in the Porcupine herd, but not the Qamanirjuaq, and why Se appears to be increasing in the Qamanirjuaq herd, but not the Porcupine.

Since the primary source of Pb for caribou is from atmospheric Pb absorbed by lichens consumed by the caribou, the reduction of the use of unleaded gasoline after the prohibition of leaded gasoline in Canada in 1990 may be affecting concentrations in some Arctic caribou and causing a decline in the Porcupine caribou. The proximity of the Qamanirjuaq caribou home range to the ocean may affect element concentrations in those caribou as will be discussed further with reference to Hg.

Table 1. Renal element concentrations (X + SD; mg·g-1 dry weight)

Year	N	Age	Arsenic			Cadmium			Copper			Lead			Mercury			Selenium			Zinc		
Porcupine fall-collected male caribou																							
1997	14	4.1	0.42	+	0.32	23.2	+	12.1	21.2	+	2.1	0.17	+	0.11	1.47	+	0.32	3.8	+	0.6	93.4	+	11.8
1998	14	4.7	0.19	+	0.05	26.9	+	21.0	25.6	+	3.7	0.25	+	0.28	1.76	+	0.72	5.2	+	1.2	108.4	+	16.6
1999	11	4.7	0.08	+	0.04	36.0	+	25.9	23.5	+	6.4	0.18	+	0.09	1.23	+	0.63	4.6	+	0.8	113.5	+	16.3
2000	8	4.8	0.30	+	0.11	37.4	+	17.6	25.1	+	4.3	0.25	+	0.39	1.23	+	0.18	4.9	+	1.0	121.6	+	21.5
2001	12	5.1	0.36	+	0.12	29.8	+	11.9	22.5	+	2.6	0.17	+	0.15	1.74	+	0.78	4.4	+	1.1	115.8	+	27.2
2002	9	5.6	0.18	+	0.04	26.8	+	8.4	25.1	+	3.4	0.13	+	0.05	1.39	+	0.27	5.4	+	0.6	123.3	+	14.1
2003	23	5.8	0.25	+	0.06	37.5	+	18.1	25.4	+	3.4	0.16	+	0.18	1.19	+	0.25	6.1	+	0.7	121.6	+	15.4
2004	16	4.9	0.05	+	0.01	24.2	+	13.8	22.8	+	3.0	0.14	+	0.04	1.62	+	0.59	4.2	+	0.6	121.0	+	15.9
2005	14	3.5	0.05	+	0.04	23.1	+	14.8	23.1	+	2.4	0.15	+	0.04	1.81	+	0.33	4.5	+	0.6	121.9	+	18.0
2006	9	5.1	0.07	+	0.02	41.6	+	23.7	24.9	+	3.0	0.10	+	0.02	2.18	+	0.51	5.1	+	0.6	130.6	+	14.5
2007	12	4.7	0.04	+	0.01	28.3	+	12.2	24.5	+	4.6	0.12	+	0.08	1.58	+	0.45	4.4	+	0.7	120.0	+	27.5
2008	20	6.1	0.03	+	0.02	27.3	+	16.8	26.7	+	7.1	0.18	+	0.38	1.34	+	0.60	4.3	+	0.5	138.4	+	33.7
2009	21	6.3	0.05	+	0.04	38.1	+	16.6	24.6	+	5.2	0.10	+	0.06	0.98	+	0.43	4.6	+	0.7	139.5	+	39.5
2010	4	6.8	0.07	+	0.01	26.6	+	9.9	21.3	+	1.6	0.11	+	0.03	1.53	+	0.51	5.3	+	0.8	130.1	+	17.8
2011	11	4.9	0.05	+	0.04	23.0	+	12.7	22.8	+	2.3	0.07	+	0.03	1.42	+	0.45	4.5	+	0.6	107.8	+	8.0
2012	20	6.2	0.11	+	0.11	34.7	+	21.9	22.8	+	2.1	0.09	+	0.03	1.84	+	0.70	4.8	+	0.5	107.8	+	9.3
2013	22	5.3	0.04	+	0.02	21.2	+	9.2	24.3	+	2.6	0.07	+	0.02	1.79	+	0.50	4.3	+	0.5	109.4	+	6.5
Qamanirjuaq fall-collected female caribou																							
2006	7	7.3	0.03	+	0.02	18.7	+	13.9	26.3	+	2.0	0.58	+	0.81	3.37	+	0.96	3.6	+	8.5	104.1	+	8.5
2007	10	5.1	0.04	+	0.01	24.0	+	15.7	25.1	+	8.9	0.44	+	0.15	5.57	+	2.33	4.1	+	30.5	110.1	+	30.5
2008	10	8.1	0.04	+	0.02	29.7	+	11.8	24.4	+	4.0	0.36	+	0.08	4.99	+	1.57	4.0	+	16.0	105.7	+	16.0
2009	4	0.5	0.04	+	0.02	19.8	+	14.7	21.1	+	3.4	0.25	+	0.06	5.32	+	2.16	3.5	+	11.3	94.7	+	11.3
2010	1		0.05			21.5			18.9			0.49			6.69			3.8			96.5		
2011	17	6.0	0.04	+	0.02	21.0	+	24.6	22.0	+	2.8	0.30	+	0.13	5.04	+	1.90	4.2	+	10.9	107.9	+	10.9
2013	4		0.03	+	0.01	31.1	+	35.1	27.2	+	1.8	0.26	+	0.10	3.96	+	0.72	4.4	+	0.3	120.5	+	15.8

Although there are no long term trends up or down in renal Hg in either herd, the data for the Porcupine herd clearly indicate some sort of cycle. These data will be more thoroughly analyzed in the coming year and an attempt made to identify major drivers of that cycle. A publication on this topic is anticipated by September, 2016. The higher Hg concentrations found in the Qamanirjuaq caribou (as compared to the Porcupine) may be due, at least in part, to their proximity to the ocean. A recent study in the Canadian High Arctic found that lichens closer to the coast where there was open water had higher levels of total Hg and methylmercury, than those collected inland as well as those collected on the coast where the water was frozen all year (St. Pierre et al. 2015). The Qamanirjuaq caribou have also been noted to consume seaweed, which can contain appreciable levels of Hg (van Netten et al. 2000). A community-based monitoring project to measure Hg concentrations in lichens and seaweed in the Qamanirjuaq caribou home range will be developed over the coming year.

Levels of most elements measured in the Porcupine and Qamanirjuaq caribou herds were not of concern toxicologically, although renal mercury and cadmium concentrations may cause some concern for human health depending on the quantity of organs consumed. Yukon Health has advised restricting intake of kidney and liver from Yukon caribou, the recommended maximum varying depending on herd (e.g. a maximum of 32 Porcupine caribou kidneys/year). The health advisory confirms that heavy metals are very low in the meat (muscle) from caribou and this remains a healthy food choice.

Data collected from this program continue to provide baseline data for contaminants in the Qamanirjuaq and Porcupine caribou as well as a valuable tissue archive for legacy and emerging contaminants. The ongoing nature of this program provides security and confidence for northerners using caribou as a food source and acts as an early warning system for wildlife managers. The length and consistency of this program also provides a valuable database for exploring the dynamics of particular contaminants of concern (eg. mercury) within the terrestrial ecosystem. This program will continue to collect and analyze kidney samples from the Porcupine and Qamanirjuaq caribou herds (20 animals from each) as well as two additional herds in the coming fiscal year.

Expected Project Completion Date

This program is ongoing.

Acknowledgements

Many thanks to Yukon Environment staff: Martin Keinzler, Mike Suitor and Jane Harms for providing samples from the Porcupine caribou herd, Mary Vanderkop and Meghan Larivee for laboratory support. I would also like to acknowledge the efforts of all hunters who have submitted samples to this program over the years – without them, this work would not be possible. A particular thank you goes to the Arviat Hunters and Trappers Association who assisted with organizing collections this year. This project was funded by the Northern Contaminants Program, Aboriginal Affairs and Northern Development and administered by the Yukon Conservation Society.

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Community based seawater monitoring for organic contaminants and mercury in the Canadian Arctic

Surveillance communautaire de l'eau de mer en vue d'y trouver des contaminants organiques et du mercure dans l'Arctique canadien

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Abstract

The concentrations of contaminants in seawater influence what is detected in marine mammals and seabirds and levels and time trends of the contaminants in the ocean has been identified as a knowledge gap by the NCP. The project started in May 2014 and built on previous work in Barrow Strait near Resolute in 2011 and 2012. Seawater samples were successfully collected in May-June 2014 using passive samplers (thin plastic films) deployed for 5 weeks under the ice, large volume (~300L) samples collected by pumping seawater through resin columns, and collection of smaller (1L) samples a various depths using Niskin samplers. Collection in

Résumé

Les concentrations de contaminants dans l'eau de mer ont une incidence sur les quantités détectées chez les mammifères et les oiseaux marins. On a par ailleurs constaté dans le cadre du Plan de lutte contre les contaminants dans le Nord (PLCN) qu'il existait des lacunes en matière de connaissances en ce qui concerne les niveaux de contaminants et les tendances temporelles s'y rapportant. Le projet lancé en mai 2014 s'articule autour des travaux réalisés en 2011 et 2012 dans le détroit de Barrows, près de Resolute. En mai et juin 2014, des échantillons d'eau de mer ont été prélevés à l'aide des échantillonneurs passifs (minces

August was hampered by ice conditions so that only 1L samples were collected. Samples were analysed for POPs including brominated flame retardants (BFRs), perfluorinated substances (eg PFOS) and mercury. Results for perfluorinated chemicals show that concentrations of PFOS have declined since the mid-2000s. Concentrations of BFRs were very low (picograms per liter). Passive samplers had10-20x lower BFRs than in large volume samples. Longer deployment times for the passive samplers are planned for 2015-16. Repeated sampling at the same location and time of year will help develop temporal trend information for contaminants seawater.

films plastiques) que l'on avait installés sous la glace pour 5 semaines. On a alors recueilli d'importants volumes d'échantillons d'eau (~ 300 l) en pompant de l'eau de mer au moyen de colonnes de résine, ainsi que des échantillons plus petits à différentes profondeurs à l'aide d'échantillonneurs Niskin. Les activités d'échantillonnage du mois d'août ont été ralenties en raison de l'état des glaces, et conséquemment seulement 1 l d'eau a été recueilli. On a procédé à une analyse des échantillons en vue d'y détecter la présence de polluants organiques persistants (POP), dont les agents ignifuges bromés, les composés perfluorés (comme le perfluorooctanesulfonate [PFOS]) et le mercure. Les résultats des analyses relatives aux composés chimiques démontrent que les concentrations de PFOS ont diminué depuis le milieu des années 2000. Les concentrations d'agents ignifuges bromés étaient très faibles (picogrammes par litre). Les échantillons recueillis à l'aide d'échantillonneurs passifs présentaient des concentrations d'agents ignifuges bromés de 10 à 20 fois plus faibles que celles présentes dans les échantillons de volumes importants d'eau. On prévoit d'installer des échantillonneurs passifs pour une période plus longue en 2015-2016. Le prélèvement répété d'échantillons, aux mêmes site et période de l'année, facilitera la cueillette d'information sur les tendances temporelles des contaminants dans l'eau de mer.

Key messages

- Concentrations of selected POPs and mercury were measured in seawater samples from Barrow Strait near Resolute Bay NU
- Very low concentrations of flame retardants were found in seawater using both passive samplers (plastic films) and large volume samples
- Concentrations of PFOS are showing a declining trend based on comparisons with sampling in 2005-2008 at the same location

Messages clés

- On a mesuré les concentrations de certains POP dans les échantillons d'eau de mer prélevés dans le détroit de Barrow situé près de Resolute Bay, au Nunavut.
- On a relevé des concentrations très faibles d'agents ignifuges dans les échantillons d'eau de mer que l'on a prélevés à l'aide d'échantillonneurs passifs (minces films plastiques) et dans les échantillons de volumes importants.
- Comparativement aux échantillons recueillis au même site entre 2005 et 2008, on a observé une tendance à la baisse des concentrations de PFOS.

Objectives

1. Sample seawater for hydrophobic legacy and new/emerging organic contaminants using passive methods over the spring/summer season in 2014-15 and 2015-16 in Barrow Strait/Lancaster Sound.
2. Compared with high volume "active" water samples collected during period May 2014.
3. Collect seawater profiles for perfluorinated alkyl substances (PFAS) and mercury/methyl mercury using Van Dorn or Niskin samplers
4. Combine data accumulated from previous studies in order to establish temporal trends in high central Canadian Arctic seawater

Introduction

The NCP Blueprint (2014-15) for environmental monitoring and research stated a need for Arctic seawater data in order: "1) to collect a set of baseline data for contaminants in arctic seawater against which future trends, sources and sinks in the ocean may be evaluated; 2) to collect the data in a way that will assist physical modeling of exchanges between water and the bottom of the food web.

There is a relatively large amount of published seawater data for organochlorine pesticides (OCPs) in Arctic Ocean waters (Hung et al. 2013) but information is much more limited for BDEs and alternative flame retardants (AFRs) and perfluorinated alkyl substances (PFASs).

The study by Hargrave et al.(1997) in which samples were collected monthly over an entire year at Barrow Strait is a benchmark from which other studies can be compared, particularly for OCPs. Seasonal fluctuations in the concentrations of a and g-HCHs, a-endosulfan, HCB, chlordanes, dieldrin, and other compounds were observed in the Barrow Strait. Under-ice advection (flowing south from the pole) was suggested as the major source for OCs observed to have winter maxima, when air-water exchange would be eliminated due to ice cover. Endosulfan had a fall maximum, suggesting a high deposition due to air-water exchange during the open water period when the Arctic seawater is strongly stratified and advection would be limited (Hargrave et al. 1997).

Möller et al. (2011a) reported PBDEs and AFRs in the Chukchi Sea as part of a cruise from China to 84.5 °N. In separate cruise, Möller et al. (2011b) determined PBDEs and AFRs in the East Greenland Sea. Very low dissolved (sub-pg L^{-1}) concentrations of BDE47 and BDE99 were detected in both studies. Morris et al (2015) detected dissolved BDE 47 and BDE 99 in the range of 1.0 – 5.0 pg L^{-1} in seawater of Barrow Strait during spring melt, about 10 to 100x higher than reported by Möller et al. (2011a) . Organophosphate flame retardants (OPFRs) are another group of AFRs with arctic accumulation potential. Möller et al. (2012) recently reported the first occurrence of OPFRs in the atmosphere over the Arctic Ocean and the North Pacific proving that they undergo long-range atmospheric transport toward the Arctic. Jantunen (2014) reported OPFRs in air samples at up to 400 pg m^{-3} and OPFRs in the range of 14-36 ng L^{-1}, where TCEP>TCPP>TPhP>TDCPP>EHDPP.

Recent papers have provided much new data for PFOS and other PFASs in Canadian Arctic seawater and nearby seas (Hung et al. 2013). PFOA, PFHpA and PFHxA were the major PFASs in waters of the Canadian Archipelago, Beaufort and Chukchi Seas (Benskin et al. 2012). Other shorter chain PFASs, which are degradation products of replacements for long chain (8 or more carbon chains) have not been determined in Canadian Archipelago waters.

The overall effect of ice cover and snow/ice melt on inputs of the hydrophobic organics as well as PFASs, is still not entirely clear, and how current use semi-volatile and less volatile contaminant concentrations are influenced by melt water is relatively unexplored.

Mercury concentrations in Canadian arctic seawater and adjacent seas has been extensively reviewed recently (Chételat et al. 2012, Kirk et al. 2012). Kirk et al. (2012) determined mercury species in depth profiles (0 and up to 660 m) in Lancaster Sound. Total mercury (THg) at the Barrow Strait site declined with depth from 0.45 ng/L at the surface to 0.26 ng/L at 322 m, with monomethyl Hg (MMHg) representing a large portion (35%) of the THg at depth. High proportions of MMHg and dimethyl Hg (DMHg) were found in all deep waters i.e. below 100 m in Lancaster Sound, northern Baffin Bay and Hudson Strait. Time trends for mercury in seawater are not available to our knowledge. However the three sampling years (2004, 2005 and 2007) in Barrow Strait represent the start of a time series.

Activities in 2014-2015

Field and laboratory work:

Seawater samples were successfully collected in May-June 2014 using (1) passive samplers (polyethylene membranes (PEMs)) deployed for 5 weeks under the ice, (2) large volume (~300L) samples collected by pumping seawater through XAD resin column/filter system, and (3) collection of depth profiles (1L samples) for perfluorinated alkyl substances (PFASs) and mercury/methyl mercury using Niskin samplers. Deployment of a 2nd set of passives was conducted in mid-June by lowering a mooring with an acoustic release coupler with float through a hole in the ice. The sampling sites were about 6 km south of Resolute Bay in Barrow Strait and accessed by snowmobile in May-June and by small boat during brief open water season. Collection in August was hampered by ice conditions so that only 1L depth profiles samples were collected. Passive samplers installed under the ice in June could not be found in late August despite best efforts of Peter Amaraulik, and members of Aaron Fisk's team, to retrieve them. Samples were distributed to various labs and preliminary results are available for several contaminant groups.

Capacity Building:

The field work was conducted by Peter Amaraulik and his son Jeffrey. They consulted with the other team members by phone prior to sampling. In May, Peter was assisted by Igor Lehnherr. In August Peter and Jeff worked with Steve Kessel to retrieve the passive samplers. Overall much knowledge was transferred on the operation of sampling equipment and the acoustic release device.

Communications:

A summary of project activities during 2014 and preliminary results was prepared for the Resolute Bay HTA in English and Inuktitut. Progress was made on a training video in May 2014. Igor Lehnherr was able to shoot video clips of Peter Amaraulik at work in May (also shown in photos in Figure 1). However due to camera battery failure and challenging weather conditions no further video was shot at other sampling times

Traditional Knowledge Integration:

Although traditional knowledge integration is not formally part of the project the success of the project depends heavily on the community field team's knowledge of the ice and water conditions in the area. The long term trends in ice conditions are of interest to the project and may help explain the results.

Results

PFAS profiles were determined in samples collected in May and compared with previous years (Figure 2). The profiles of PFOA and PFOS are shown because they are the major PFASs in seawater although other perfluorinated carboxylates with C4 to C10 carbon chains were also detected. All sampling times and depths are shown so that possible seasonal variation is taken into account. In most cases, the May/June sampling time shows higher concentrations in surface water and samples at 1-2 m depth while this is generally not seen in July or August. We attribute this to snow and ice melt which injects PFASs into the upper ocean. However for 2014, the sampling in May took place under colder conditions than previous years and with no ice melt. This may explain the lack of a profile. Analysis of samples from August may help explain the trends (results are pending). The higher levels of PFOA in 2011 and 2012 are so far unexplained but are not due to blanks or analytical methods which have basically remained the same for all samples. The measurements of PFASs in 2014 added to the existing data and permitted time trends to be assessed. Figure 3 shows the trends in concentrations of PFOS and PFOA (most are for 4 to 10 m).

Brominated diphenyl ethers (PBDEs) were determined in XAD resin extracts of seawater collected in May 2014 using a portable high volume pumping system (see Figure 1 for sampling pictures). PBDEs were close to detection limits in the PEMs (Table 1) with only BDE 47 quantifiable at S/N of ~3. The concentration was higher in the second PEM. Overall the concentrations were similar to previous measurements in 2012 (Table 1). Blanks in PEMs were non-detect for PBDEs. More BDE congeners were detectable in the high volume sample (Table 1). BDE 47, 99 and 100 were present at similar concentrations to those observed previously with this sampling method. BDEs were detected in XAD blanks but were <30% of measured values. The XAD column extracts filtered (~1.2 µm) seawater and therefore contains dissolved organic carbon (DOC). Analysis of seawater samples collected at the same time showed DOC concentrations of 0.4 mg/L. Assuming the PBDEs are sorbed to DOC, which may consist of very fine organic particles (<1 µm) and is trapped on the XAD column, the actual dissolved concentrations of BDE 47 are estimated to be about 1.8 pg/L based on the DOC sorption equations of Burkhard (2000). The results for PBDEs on the PEMs are much lower than in the high volume sample and indicate that the deployment time (35 days) was too short. Analyses of other contaminants in underway and results are pending.

Results for THg and MMHg in seawater and for OCPs in XAD and filter extracts are pending.

Discussion and Conclusions

The results of the study to date, combined with previous work at Barrow Strait by Morris et al. (2015) illustrate the challenges and opportunities of Arctic seawater monitoring from nearby communities. Using the ice platform, depth profiles for PFASs (also for pending results for mercury) were relatively easy to obtain from the same sample location as previous years. Large volume sampling (similar to the original work by Hargrave et al. (1997) for OCPs in Barrow Strait) also worked well in terms of sample collection. However, PBDEs concentrations were much higher than found with PEMs. Similar differences between PEMs and high volume filter/XAD extraction have been found in the Great Lakes (Ruge et al. 2015). It may be due to the collection of sub-micron sized particles that pass through the filter and are trapped on the XAD column. However, correction for DOC did not remove the difference, thus the differences need further investigation. Deployment times of the PEMs need to be lengthened to achieve high concentrations on the sampler and future work will therefore try open water deployments of up to one year for some sites where the time window for open conditions is short eg Resolute and Clyde River.

Expected Project Completion Date

An ongoing project is planned in order to develop temporal trend information.

Figure 1. Sampling photos from May 2014: Right: Setting up the high volume pumping system and XAD column. Left subsampling for water chemistry from the pump outflow.

Figure 2. Depth profiles of PFOS and PFOA in seawater from Barrow Strait (results are from de Silva and Muir, unpublished)

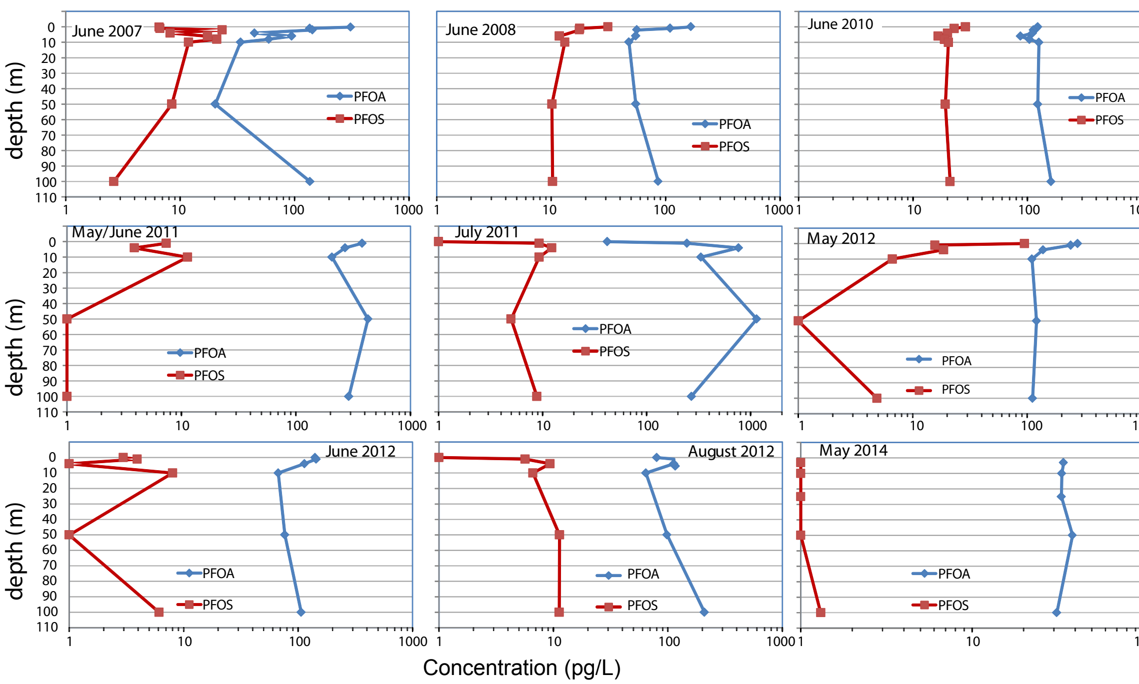

Figure 3. Time trends of PFOS and PFOA in seawater from Barrow Strait using average values for 4-10 m depth and all available sampling times from 2005 to 2014

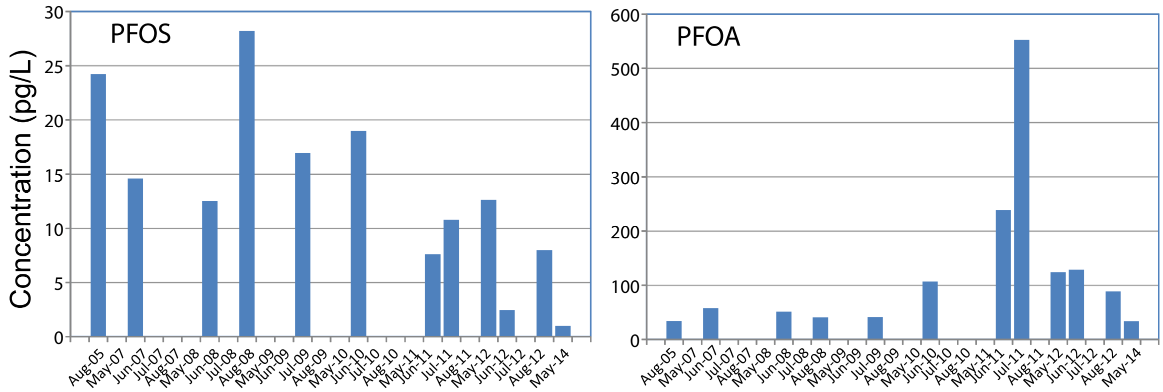

Table 1. Comparison of PBDE concentrations (pg L-1) in passive (PEM) and large volume (LV) water samples (300-400 L) using under ice sampling. Concentrations are blank corrected.

Sampler	PEM #1	PEM #2	PEM	PEM	LV (#1)	LV (#2)	LV	LV
Time	May-Jun '14	May-Jun '14	Apr-May '12	Apr-May '12	May '14	May '14	May-12	May '10
Reference	Lohmann, Unpub	Lohmann, Unpub	Lohmann, Unpub	Lohmann, Unpub	Muir & Teixeira Unpublished	Muir & Teixeira Unpublished	Muir & Teixeira Unpublished	Morris et al. 2015
BDE-2	<0.05	<0.05	0.5	0.45	<0.1	<0.1	<0.1	<0.1
BDE-8	<0.05	<0.05	0.13	0.14	5.3	6.7	<0.1	<0.1
BDE-15	<0.05	<0.05	0.35	0.3	5.2	5.1	<0.1	<0.1
BDE-28	<0.05	<0.05	0.24	0.21	<0.1	<0.1	<0.1	0.3
BDE-49	<0.05	<0.05	0.065	0.068	0.2	0.42	na	na
BDE-47	0.097	0.32	0.096	0.096	2.3	2.1	0.73	1.3
BDE-100	<0.05	<0.05	0.055	0.057	0.12	<0.1	0.27	0.08
BDE-99	<0.05	<0.05	0.15	0.13	1.0	1.8	0.9	0.7
BDE-154	<0.05	<0.05	0.11	0.11	<0.05	<0.05	0.05	<0.05
BDE-153	<0.05	<0.05	0.14	0.13	<0.05	<0.05	<0.05	<0.05
BDE-183	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05

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A latitudinal investigation of ecosystem sensitivity to methylmercury bioaccumulation in Arctic fresh waters

Étude horizontale de la sensibilité écosystémique à la bioaccumulation de méthylmercure dans les eaux douces de l'Arctique

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Abstract

Mercury is a priority contaminant of the Northern Contaminants Program (NCP) due to its prevalence in the Arctic and high levels found in some traditional food species. The main objective of this project is to investigate how climate affects methylmercury (MeHg) bioaccumulation in Arctic lakes. The study design involves a comparison of MeHg bioaccumulation in three regions along a latitudinal gradient in climate-controlled ecosystem types in the Canadian Arctic, specifically sub-Arctic taiga (Kuujjuaraapik, 2012), Arctic tundra (Iqaluit, 2013-14) and polar desert (Resolute Bay, 2014). We have investigated key aspects of MeHg bioaccumulation—MeHg bioavailability to benthic food webs and organism growth rates—

Résumé

Le mercure (Hg) est l'un des contaminants prioritaires du Programme de lutte contre les contaminants dans le Nord (PLCN) en raison de sa prévalence dans l'Arctique et des fortes concentrations observées dans certains aliments traditionnels. Le principal objectif du projet est d'étudier l'incidence du climat sur la bioaccumulation du méthylmercure (MeHg) dans les lacs de l'Arctique. Le protocole d'étude prévoyait la comparaison de la bioaccumulation du MeHg dans trois régions situées le long d'un gradient latitudinal, et ce dans des types d'écosystèmes l'Arctique canadien qui sont régulés par le climat, à savoir la taïga subarctique (Kuujjuaraapik, 2012) et le désert polaire (Resolute Bay, 2014). On a étudié des aspects clés de la bioaccumulation

as well as how watershed characteristics affect the transport of mercury and organic carbon to lakes. Our preliminary results suggest that climate has a strong influence on the ecosystem sensitivity of mercury in northern lakes through processes of watershed and lake hydrology as well as limitations on fish growth.

du MeHg – la biodisponibilité du MeHg dans les réseaux trophiques benthiques ainsi que le taux de croissance des organismes – de même que l'incidence des caractéristiques des bassins hydrographiques sur le transport du Hg et du carbone organique vers les lacs. Les résultats préliminaires obtenus laissent supposer que le climat pourrait avoir un effet marqué sur la sensibilité au Hg des écosystèmes des lacs du Nord, et cela par l'intermédiaire de processus s'opérant dans les bassins hydrographiques, de l'hydrologie des lacs et des facteurs limitant la croissance des poissons.

Key Messages

- Lake water concentrations of mercury declined with latitude along our gradient of study lakes.
- Water mercury concentrations were negatively correlated with water residence time, reflecting the importance of watershed size, lake morphometry, and regional climate (mean annual runoff).
- Muscle THg concentrations in brook trout and lake-dwelling Arctic char were related to water MeHg concentrations and fish age. The slow growth and older ages of Arctic char led to higher THg concentrations, even in lakes with low water MeHg exposure.

Messages clés

- Plus le degré de latitude sur le gradient des lacs étudiés était faible, plus les concentrations de mercure dans les eaux lacustres diminuaient.
- On a observé une corrélation négative entre les concentrations de Hg dans l'eau et la période de rétention de l'eau, ce qui reflète l'importance de la taille du bassin hydrographique, de la morphométrie du lac et du climat régional (écoulement annuel moyen).
- Il existe un lien entre les concentrations moyennes de MeHg dans les muscles des ombles de fontaine et des ombles chevaliers dulcicoles et les concentrations de MeHg dans l'eau et l'âge des poissons. La faible croissance et l'âge plus avancé des ombles chevaliers ont eu pour effet d'augmenter les concentrations de MeHg, et ce même chez les individus vivant dans les lacs dont l'exposition au MeHg est faible.

Objectives

1. The main purpose of this project is to investigate how climate affects MeHg bioaccumulation in Arctic freshwater food webs. Recent evidence indicates that inorganic mercury (Hg) loadings to Arctic lakes decline with latitude (Muir et al., 2009); however, MeHg concentrations in benthic invertebrates and fish do not similarly decline along this gradient in Hg loading (Gantner et al., 2010; van der Velden et al., 2013a). These observations suggest that regional environmental factors may play an important role in ecosystem sensitivity to Hg bioaccumulation in the Canadian Arctic.

2. During this three-year project (2012 to 2015), we have investigated three study areas that cover a latitudinal gradient in climate-related environmental factors in the Canadian Arctic. This research included non-focal sites at Kuujjuaraapik (sub-Arctic taiga) in 2012 and Iqaluit (tundra) in 2013-14, as well as NCP-monitored sites at Resolute Bay (polar desert) in 2014.

3. Using a cross-ecosystem comparison to test hypotheses of how climate controls MeHg bioavailability and bioaccumulation, we conducted the following activities for lakes and ponds from each study area:

    a. Characterize the watersheds of study sites (geomorphology and physiography) through satellite image classification and digital terrain analysis in order to examine watershed influences on measured lake physico-chemistry, particularly levels of organic carbon and Hg in sediment and water;
    b. Estimate bioavailable MeHg in sediment pore water using a novel technique (Diffusive Gradient in Thin films, or DGT);
    c. Measure MeHg concentrations in benthic food webs (algae, invertebrates and fish); and
    d. Estimate short-term growth rates in invertebrates and fish using a novel approach based on measurements of tissue nucleic acid content.

Introduction

High Arctic lakes may be more vulnerable to Hg inputs because MeHg concentrations in lake-dwelling Arctic char are at similar levels to more southern latitudes (Gantner et al., 2010; van der Velden et al., 2013a) despite lower Hg loadings at higher latitudes. Several environmental factors could affect the sensitivity of Arctic freshwater ecosystems to Hg bioaccumulation, defined here as “the ability of an ecosystem to transform inorganic Hg load to MeHg in biota” (from Munthe et al., 2007). These factors could be related to Hg transport from watersheds to lakes, net methylation of inorganic Hg in either terrestrial or aquatic environments, or uptake of MeHg in the food web (Munthe et al., 2007). A fundamental environmental gradient in the Arctic that is associated with climate is a decline in terrestrial and aquatic productivity with latitude (Vincent and Laybourn-Parry, 2008). A more severe climate at higher latitudes results in lower transport of terrestrial organic matter from watersheds to lakes and lower primary production in the lakes themselves (Vincent and Laybourn-Parry, 2008).

How climate may mediate MeHg bioavailability and bioaccumulation—Two key climate variables, temperature and precipitation, decline with latitude. These first-order variables fundamentally control terrestrial and aquatic ecosystems in the Arctic, resulting in distinct ecotypes (sub-Arctic taiga, tundra and polar desert) that decline in productivity with latitude. Thus, on a broad scale, temperature and precipitation control the productivity (organic matter production) of aquatic ecosystems and their watersheds. We hypothesize that this climate-related variation in organic matter production affects mercury bioaccumulation in Arctic fresh waters through its control on mercury bioavailability and organism growth rates. Temperature also likely directly controls the growth rates of organisms.

We hypothesize that climate-related variation in organic matter production could affect Hg bioaccumulation in Arctic fresh waters through two processes. Organic matter strongly binds Hg and reduces its availability for transfer across bacterial or algal membranes, referred to as bioavailability (Barkay et al., 1997; Gorski et al., 2008). Less amounts of particulate or dissolved organic carbon in sediment may increase MeHg bioavailability to benthic food webs through: 1) a greater portion of the inorganic Hg pool being bioavailable for microbial methylation, or 2) a greater portion of pore water MeHg being bioavailable for uptake in algae and bacteria. A second hypothesis is that growth rates of consumer organisms in High Arctic lakes are slower because of low primary production (less available food) and colder water temperatures. Slower growth rates result in higher MeHg concentrations in consumers because less biomass is produced per unit of MeHg consumed (Chen et al., 2011; Karimi et al., 2007; Ward et al., 2010).

Activities in 2014-2015

A field program was conducted at Resolute Bay and Iqaluit from July 18 to August 5, 2014 based at the Polar Continental Shelf Project (Resolute) and the research facility of the Nunavut Research Institute (Iqaluit). A total of seven water bodies at Resolute and 1 lake at Iqaluit were characterized for a variety of physical, chemical and biological variables (Table 1). Some of the water bodies were more like ponds due to their small size and the absence of fish; however, here we will refer to all water bodies as lakes.

Watershed characteristics and lake morphometries were characterized using GIS-based terrain analysis method, similar to what was conducted for the Kuujjuarapik lakes in 2012 (Chételat et al. 2013). The bathymetry of each water body was measured in a boat using a GPS-linked echosounder. Lake areas were obtained from 1:50,000 scale CANVEC National Vector hydrography dataset and the watershed area for each water body was extracted from a hydrologically pre-processed, 1:50,000 Canadian Digital Elevation Data (CDED) Digital Elevation Model using well-established methods within the System for Automated Geoscientific Analysis (SAGA) GIS software (Conrad, 2013). Watershed morphometrics were combined with climate normals (annual precipitation and potential evapotranspiration, or P and PET, respectively, in units of mm) extracted from the Canadian National Ecological Framework (Ecological Stratification Working Group, 1996), to estimate residence times of the study lakes. Residence time is calculated as the ratio of steady state inflow (or outflow) volume to the total volume of the water body itself. Mean annual runoff (MAR) from the landscape was estimated using Water Survey of Canada discharge records for nearby rivers at each site and normalizing to the associated gross drainage area. Combining this estimate with watershed area (A_{ws}), lake area (A_{lk}) and average lake depth (D_{lk}) for each waterbody (all in units of m or m^2), residence time (T_r) in days was calculated as follows):

Lake morphometry information, namely the computed watershed area to lake area ratios (WA:LA), were used to guide the initial selection of study lakes at both Kuujjuarapik and Iqaluit to help maximize differences in landscape hydrologic setting among them.

In situ measurements of specific conductance (SpC), temperature, pH and dissolved oxygen were taken with a YSI sonde. Water was collected as grab samples for analysis of THg and MeHg (filtered and unfiltered), dissolved organic carbon (DOC), UV-absorbance, nutrients, chlorophyll, anions and cations. Offshore surficial sediment was collected using an Ekman grab, and the top 1 cm of sediment was sampled for analysis of THg and percent organic matter.

To measure bioavailable MeHg in sediment porewater, we deployed DGT (Diffusive Gradient in Thin film) samplers in sediments. Offshore sediment cores were collected with a gravity corer, and the DGTs were inserted in the intact cores for an incubation period of 1-2 days. The incubations were conducted in situ to maintain environmental temperatures by sealing the cores and submersing them in shallow nearshore areas. More detail on the DGT method can be found in Clarisse et al. (2009).

Food web components (benthic algae, aquatic invertebrates, fish) were collected for Hg and stable isotope analysis. Benthic algae were collected for MeHg analysis by scraping biofilms off rocks with a nylon brush. Benthic invertebrates were collected for MeHg analysis using a kick net near shore (<1.5 m depth) or an Ekman grab for deeper waters. Zooplankton were collected in the pelagic zone using horizontal hauls with a net (mesh size 200 μm), and samples were analyzed in bulk (i.e. all taxa pooled together). Key zooplankton species (Daphnia) were also isolated at most sites for taxon-specific analyses. Lake dwelling Arctic char (Salvelinus alpinus) were captured with a gill net from Crazy Lake (Iqaluit) and, following euthanization, dissected to examine gut contents (diet characterization) and remove muscle and liver tissue (THg) as well as otoliths (for ageing). Additional char were collected from three lakes at Resolute (Small, North, Resolute) by Derek Muir, Günter Köck, and Paul Drevnick under a separate NCP-funded project.

Benthic invertebrates and fish muscle samples were collected for analysis of their nucleic acid content to estimate short-term growth rates. The growth rates of aquatic organisms, including invertebrates and fish, are strongly correlated with the amount of RNA or the ratio of RNA to DNA contents in their tissues because growth involves protein synthesis, which is facilitated by cellular RNA (Chicharo and Chicharo, 2008; Vrede et al., 2004). Tissue samples were preserved with RNAlater (a nucleic acid stabilization reagent) prior to analysis.

Northern Capacity Building and Traditional Knowledge Integration

In 2014, we partnered with the Nunavut Research Institute at Iqaluit to conduct our field program. Through collaboration with Jamal Shirley (Nunavut Research Institute) and Allison Dunn (Aboriginal Affairs and Northern Development Canada), we worked with a summer student (Joeffrey Okalik) enrolled in the Environmental Technology Program at Arctic College. From July 23-29, he assisted us with the collection of samples in local water bodies near Resolute. This collaboration provided Joeffrey with the opportunity to learn and practice a variety of environmental sampling techniques for lakes such as sediment coring, zooplankton collection, water sampling and Ekman grabs. We also hired a local from Resolute (Pilipoosie Iqaluk) although he was not available for most of the field program. We consulted with Debbie Iqaluk (Resolute), who provided us with guidance on ice conditions of local lakes and the feasibility of working on top of the lake ice in July. At Iqaluit, we hired Steven Lonsdale (a recent graduate of the ETP at Arctic College, whom we worked with in the summer of 2013) to guide and assist with field work for two days at Crazy Lake. Steven provided guidance on potential sites for char collection within the lake.

Communications

A translated report was submitted to the Sakkuq Landholding Corporation of Kuujjuaraapik in the winter of 2014. It contained a summary of results and data collected locally, including water, sediment and fish Hg levels as well as bathymetric (water depth) maps of local lakes. A similar report has been prepared for the Amarok HTA that summarizes results from Iqaluit lakes and will submitted in the spring of 2015 following review and translation into Inuktitut. A report for the Resolute Bay HTA will be prepared in 2015 once the results become available.

During our field program at Resolute, we participated in a community day (July 24, 2014) organized by the Polar Continental Shelf Project. We displayed a poster about our NCP project, which was reviewed beforehand by the Nunavut RCC, and we also conducted community outreach by showing a variety of live aquatic invertebrate specimens in the PCSP laboratory. Many youth attended the event and they were interested in looking at and learning about aquatic invertebrates from their local lakes.

In January 2015, John Chételat had a face-to-face meeting with board members of the Amarok Hunters and Trappers Association in Iqaluit. This meeting provided an opportunity to present the main findings on mercury in local water bodies and to obtain feedback on the study.

Results and Discussion

For this report, we will focus on a preliminary evaluation of latitudinal trends in water chemistry and mercury bioaccumulation in fish using data collected over the three-year project. Information is presented in Table 1 on the eight water bodies sampled in the 2014 field program at Resolute and Iqaluit using the methods described above (see section Activities in 2014-15).

A. Lake chemistry and watershed influences

Surface water concentrations of DOC, THg and MeHg were significantly different among the three study regions, as illustrated in Figure 1 and 2, and summarized in Table 2. DOC concentrations decreased with latitude and were considerably higher in Kuujjuarapik compared to Resolute and Iqaluit. THg concentrations also decreased with latitude, mirroring the geographic trends in DOC. THg concentrations were significantly different between Kuujjuarapik vs Iqaluit lakes, unlike MeHg concentrations, which were consistently low in both of the Arctic regions. Water pH and specific conductance were highest at Resolute Bay followed by Kuujjuarapik, and lastly, Iqaluit (Table 2).

Whereas trends in pH and SpC are likely reflective of geological differences among the three regions, our analysis of watershed and lake characteristics illustrate a potentially strong influence of hydrologic residence time on Hg concentrations in lakes. The average estimated residence time for Kuujuarapik lakes is 0.36 years, compared to 2.37 years and 1.39 years for Iqaluit and Resolute Bay, respectively (Figure 3). The Kuujuuarapik study lakes are very shallow 1st or 2nd order systems, resulting in rapid hydrologic turnover. Iqaluit and Resolute Bay lakes are generally larger and deeper with correspondingly longer residence times. These geographic trends in hydrologic residence times are also a function of decreasing mean annual precipitation and runoff with increasing latitude (Table 3). As seen in Figure 4, both THg and MeHg decrease with increasing lake residence times (R^2=0.41, $p<0.001$ and R^2=0.58, $p<0.001$). These relations are generally not significant for lakes within each respective study region. However, when MeHg concentrations are expressed relative to DOC concentrations (i.e. the ratio of MeHg to DOC concentration, ng mg^{-1}), the overall relationship has the highest goodness of fit (R^2=0.65, $p<0.0001$) and the within group lake trends are also significant ($p<0.05$). Overall, these strong statistical relations may reflect greater photochemically-induced losses of THg and MeHg in lakes with longer residence times. They also point to an interaction between watershed and lake morphometry (i.e. watershed area to lake-volume ratio) and regional climate (mean annual runoff) that can explain large variations in Hg concentrations in northern freshwater ecosystems. Changing temperature and precipitation regimes will likely alter hydrologic residence times of lakes across Canada, with potentially important implications for biogeochemical cycling of Hg.

B. Mercury bioaccumulation in fish

Mercury concentrations were measured in muscle of brook trout from lakes at Kuujjuaraapik (2012) and lake-dwelling Arctic char from lakes at Iqaluit (2013-14) and Resolute Bay (2014) to investigate environmental influences on bioaccumulation. These two closely related species occupied a similar trophic position in the study lakes, feeding largely on benthic invertebrates or other fish (data not shown). Although water concentrations of MeHg declined with latitude (Table 2), Arctic char THg concentrations at the more northern study sites of Iqaluit and

Resolute were similar to or higher than those in brook trout from the sub-Arctic study area (Figure 5). This pattern is related to the slower growth and older ages of the Arctic char relative to the brook trout.

A comparison of fish THg concentrations in relation to age indicates that young lake-dwelling Arctic char (i.e., age 5) had lower mercury levels than brook trout of similar age (Figure 6). However, in older Arctic char aged up to 20 years, their concentrations were at levels similar to or higher than in the younger brook trout. The effect of age reflects bioaccumulation of mercury over time due to slow elimination rates in fish. The trophic position of the char was not related to age, suggesting that the age effect was not due an ontogenetic shift in trophic position (data not shown).

A strong positive correlation was found between lake water MeHg concentration and fish muscle THg when fish concentrations were normalized to age 5 (R^2=0.92, p<0.001, Figure 7). When fish muscle THg concentrations were length-adjusted to a small size (20 cm), the relationship with water MeHg concentration was significant although much weaker (R^2=0.43, p=0.047), Figure 7). The Arctic char from Resolute were not included in this analysis because only larger, older individuals were collected in 2014. These results highlight the importance of two separate processes determining THg concentrations in northern fish: MeHg supply to the food web and slow growth (age). Thus slow growth and bioaccumulation over time can lead to elevated THg in Arctic char even though water MeHg concentrations are low. The importance of age is consistent with findings of van der Velden et al. (2013b; 2012) who concluded that age was the best predictor of THg concentrations within populations of lake-dwelling Arctic char. As climate change enhances growth conditions for Arctic char in lakes through warmer water temperatures and greater aquatic productivity, more efficient growth may decrease THg concentrations in fish muscle. On the other hand, climate-driven factors that increase concentrations of THg and MeHg in the water column of Arctic lakes, such as increased mean annual runoff (and hence shorter lake residence times) may counteract effects of increased organism growth rates.

Table 1. Location, morphometry and fish presence for eight lakes sampled at Resolute Bay and Iqaluit in the summer of 2014.

Water body	Latitude (°N)	Longitude (°W)	Lake Area (km2)	Catchment Area (km2)	CA:LA Ratio	Maximum Depth (m)	~Residence Time (days)	Fish Present?
Meretta Lake	74°41′24″	94°59′24″	0.27	5.18	18	8	330	yes
RZ2	74°43′15″	94°51′42″	0.03	1.51	59	0.75	25	no
Teardrop Lake	74°41′03″	94°59′22″	0.04	0.42	10	9	808	yes
Small Lake	74°45′33″	95°03′37″	0.15	1.56	9	8	556	yes
North Lake	74°46′37″	95°05′47″	0.63	83.65	132	20	102	yes
Resolute Lake	74°41′15″	94°56′33″	1.21	19.79	15	23	1132	yes
RZ-P3	74°44′38″	94°57′18″	0.04	1.40	35	0.75	42	no
Crazy Lake	63°51′00″	68°28′00″	4.5	41.1	9	20	1496	yes

Table 2. Summary of main water chemistry variables. Significance levels are for 1-way ANOVA based on three group means (with log transformations where required).

	Resolute Bay (n=7)	Iqaluit (n=8)	Kuujjuarapik (n=8)	Significance
Mean [DOC] (mg/L)	1.3	2.0	5.0	$p<0.0001$
Mean [THg] (ng/L)	0.57	1.05	2.30	$p<0.0001$
Mean [MeHg] (ng/L)	0.03	0.02	0.12	$p<0.0001$
Mean SpC (µS/cm)	190	48	78	$p<0.0001$
pH	8.1	6.9	7.4	$p<0.0001$

Table 3. Mean annual precipitation and runoff for the three research locales. Source: Environment Canada and Water Survey of Canada.

Region	Mean Annual Precipitation (mm)	Mean Annual Runoff (mm)
Resolute Bay, NU (polar desert, High Arctic)	161	178
Iqaluit, NU (Arctic)	403	314
Kuujjuarapik, QC (sub-Arctic)	660	460

Figure 1. Summary boxplots of (a) DOC; (b) THg; and (c) MeHg concentrations in surface waters for each study area. See Table 2 for a summary of ANOVA tests on group means.

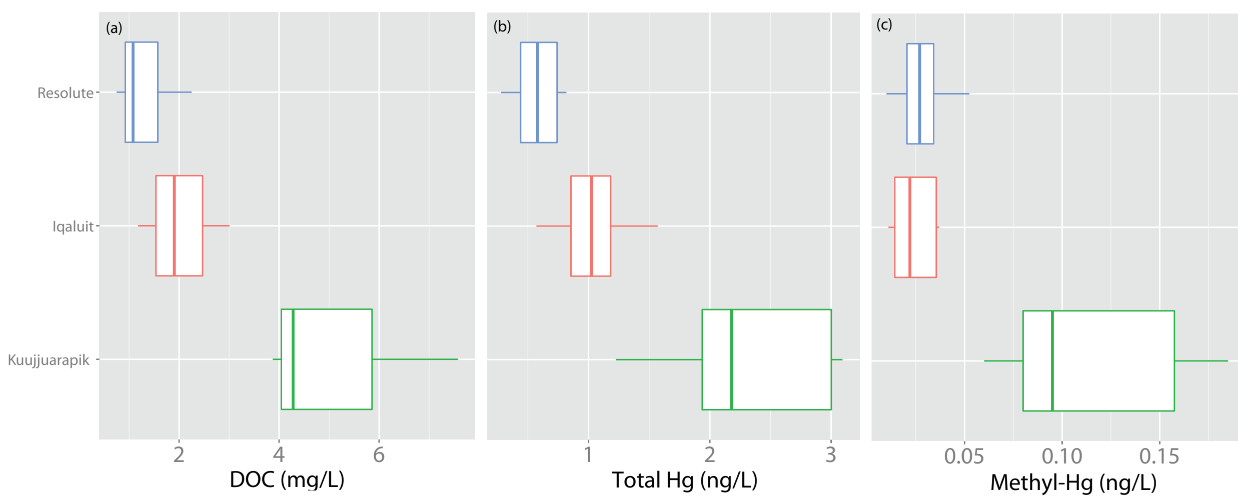


Figure 2. Bivariate relations between (a) THg and DOC; (b) MeHg and DOC; and (c) MeHg and THg. Hg and MeHg in surface waters are strongly correlated with one another and with DOC.

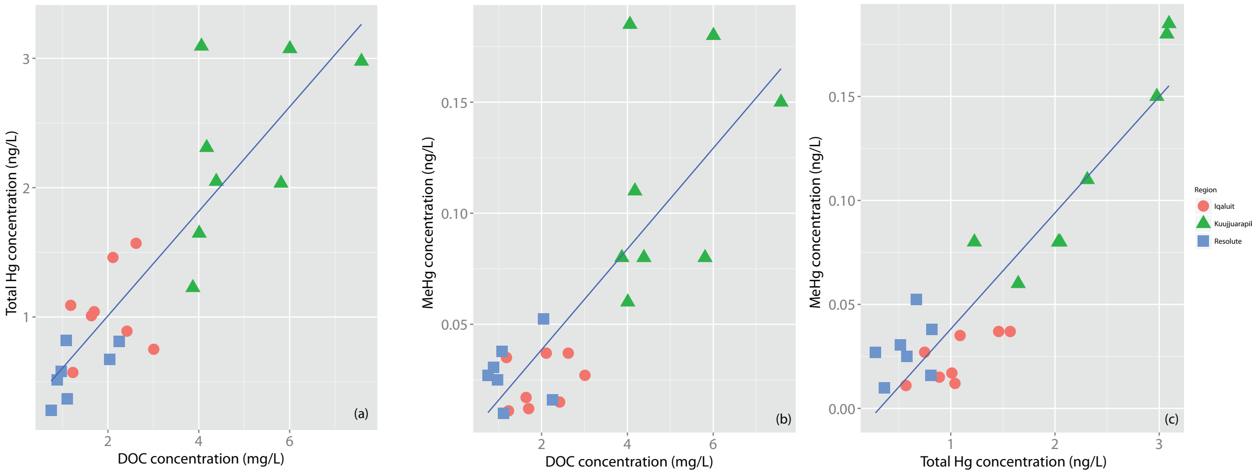


Figure 3. Residence time estimates for lakes by region. Note much shorter residence times for Kuujjuarapik lakes, reflecting shallow lake basins and higher mean annual runoff in that region.

Figure 4. Bivariate relations between lake water residence time and (a) THg, (b) MeHg; and (c) MeHg:DOC ratio in surface waters.

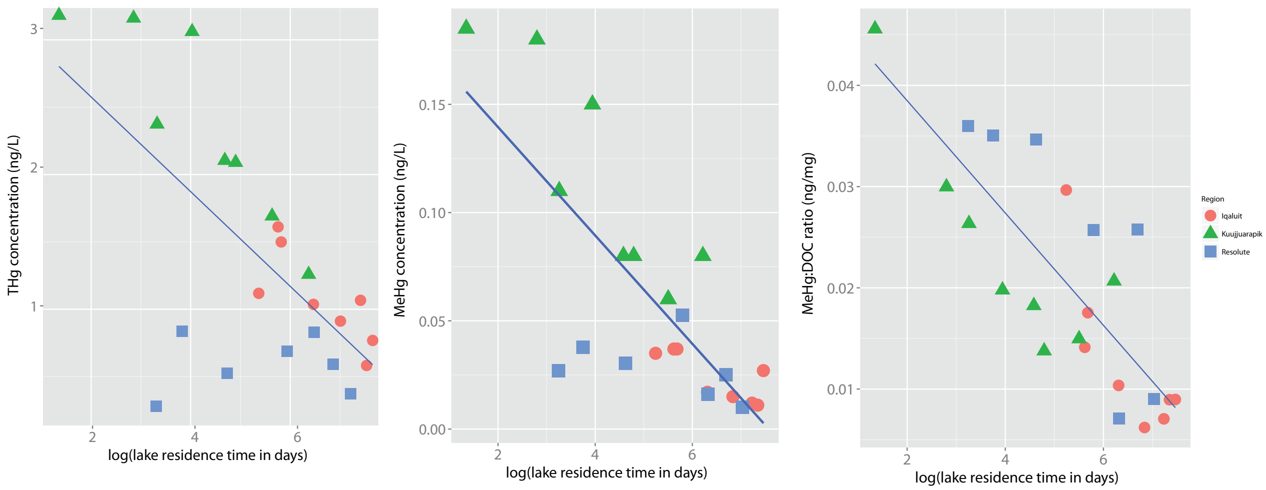


Figure 5. Average THg concentrations (± 1 standard deviation) in muscle of brook trout and lake-dwelling Arctic char collected at Kuujjuaraapik, Iqaluit and Resolute.

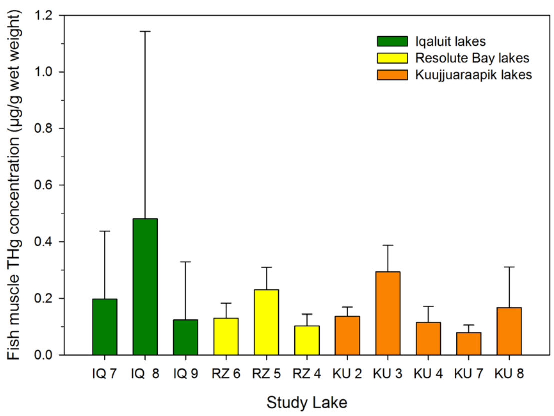


Figure 6. Relationship between muscle THg concentration and age of fish from the three study areas. Note that variables are presented on a logarithmic scale.

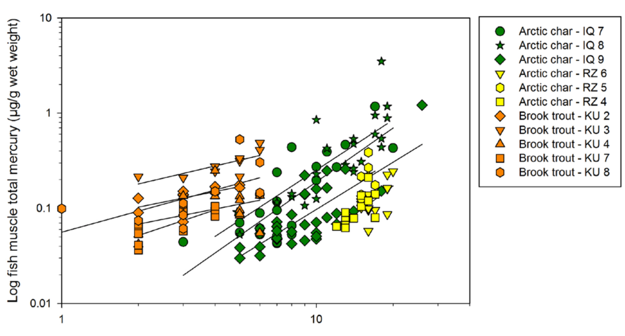
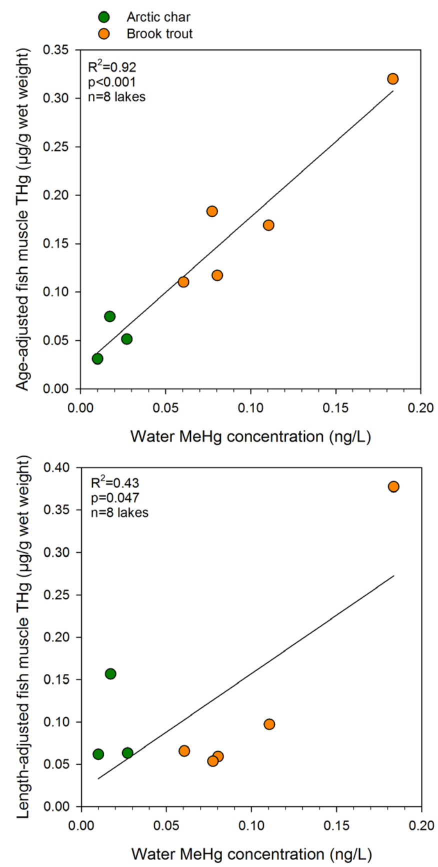


Figure 7. Relationships between water MeHg concentration and fish muscle THg concentration after normalizing for age (top panel) or for length (bottom panel). Lake mean concentrations of THg in fish were normalized to age 5 or a length of 20 cm.



Conclusions

A three-year study was conducted to investigate how climate affects MeHg bioaccumulation in Arctic freshwater food webs. Preliminary analysis of the data collected at three study areas along a latitudinal gradient in the Arctic indicates that climate affects MeHg supply to food webs through its control on lake water residence time and on growth conditions for lake-dwelling Arctic char. A large dataset was compiled during this study, and considerable data analysis remains to further examine the complex roles that climate plays in the cycling of mercury in Arctic lakes.

Expected Project Completion Date

The funding for this three year projected ended on March 31, 2015. Completion of data analysis and manuscript preparation will follow.

Acknowledgements

We thank the NCP for funding to conduct this project. Assistance for field logistics was provided by the Polar Continental Shelf Project and the Nunavut Research Institute. We are grateful to the Hunters and Trappers Association of Iqaluit and Resolute Bay for permission to conduct this research in local water bodies. We would also like to thank Joeffrey Okalik, Pilipoosie Iqaluk, and Steven Lonsdale for their hard work in the field, and Jamal Shirley, Mary Ellen Thomas and Rick Armstrong at the Nunavut Research Institute for their support of the project.

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Spatial variation in Canadian Arctic prey fish communities and contaminant levels

Variation spatiale des communautés de poissons proies et des concentrations de contaminants dans l'Arctique canadien

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Abstract

Forage fish are the main prey of arctic marine mammals, seabirds and larger marine fish, and are thus also their main source of exposure to mercury (Hg) and persistent organic pollutants (POPs). Over the last twenty years, forage fish communities have changed in the Arctic. At lower latitudes of the eastern Canadian Arctic, communities have shifted from arctic-type to subarctic-type forage fish, although this change has not yet occurred to a large extent in the high Arctic. We collaborated with Hunters and Trappers Associations in Arviat (low Arctic), Clyde River (mid-Arctic) and Resolute Bay (high Arctic), NU to collect arctic marine forage fish (arctic cod (Boreogadus saida) and sculpin (Cottoidae spp.)) and invertebrates, as well as

Résumé

Les poissons-fourrage sont les principales proies des mammifères, des oiseaux et des gros poissons marins de l'Arctique, et représentent conséquemment leur principale source d'exposition au mercure (Hg) et aux polluants organiques persistants (POP). Au cours des 20 dernières années, les communautés de poissons-fourrage de l'Arctique ont évolué. À des latitudes inférieures de l'est de l'Arctique canadien, les communautés de poissons-fourrage sont passées de type arctique à type subarctique. Cependant, ce changement ne s'étend toujours pas dans une large mesure à l'Extrême-Arctique. Entre 2012 et 2014, nous avons collaboré avec les associations de chasseurs et de trappeurs d'Arviat (Bas-Arctique), de Clyde River (centre

subarctic-type forage fish (capelin (Mallotus villosus) and sandlance (Ammodytidae spp.)) from 2012-2014. We measured tissue Hg and POP levels to assess the potential consequences of forage fish changes on predator contaminant exposures. Levels of Hg were similar across regions when the same species were compared, but levels differed among species within a given region. Nitrogen and carbon stable isotope ratios suggested that fish feeding at higher trophic positions and using benthic foraging strategies (sculpin, northern shrimp) had higher Hg levels than fish feeding at lower trophic positions and using pelagic or sympagic foraging strategies (arctic cod, capelin, sandlance). Hg concentrations in subarctic fish (sandlance and especially capelin) were lower than in arctic fish (arctic cod and especially sculpin), suggesting that increased consumption of subarctic forage fish relative to arctic forage fish may result in lower mercury exposures for arctic marine predators (e.g., ringed seal). Detailed analysis of these relationships for methylmercury, PCBs, legacy and current-use organochlorine pesticides, polybrominated diphenyl ethers (PBDEs) and emerging brominated flame retardants (BFRs) is underway.

de l'Arctique) et de Resolute Bay (Extrême-Arctique), au Nunavut, afin de pêcher des poissons-fourrage marins de type arctique (morue polaire [*Boreogadus saida*] et chabot [*Cottoidae* spp.]), des invertébrés, ainsi que des poissons-fourrage marins de type subarctique (capelan [*Mallotus villosus*] et lançon [*Ammodytidae* spp.]). Nous avons mesuré les concentrations de mercure (Hg) et de polluants organiques persistants (POP) dans les tissus afin d'évaluer les conséquences potentielles des changements qui touchent les poissons-fourrage sur le niveau d'exposition aux contaminants des prédateurs. Les niveaux de Hg observés étaient similaires pour les différentes régions étudiées lorsque l'on comparait les mêmes espèces. Les niveaux mesurés chez différentes espèces d'une même région donnée différaient cependant les uns des autres. Les ratios des isotopes stables du carbone et de l'azote observés suggèrent que les poissons s'alimentant à des niveaux supérieurs de la chaîne trophique et utilisant des stratégies d'alimentation benthique (le chabot et la crevette nordique) présentaient des concentrations de Hg plus élevées que les poissons s'alimentant à des niveaux inférieurs de la chaîne trophique et utilisant des stratégies d'alimentation pélagique ou sympagique (la morue polaire, le capelan et le lançon). Les concentrations de Hg chez les poissons subarctiques (le lançon et, tout particulièrement, le capelan) étaient plus faibles que celles présentes chez les poissons arctiques (la morue polaire et particulièrement le chabot), ce qui suggère que les prédateurs marins arctiques (comme le phoque annelé) consommant plus de poissons-fourrage de type subarctique que de type arctique seraient moins exposés au Hg. On procède actuellement à une analyse approfondie de ces relations pour ce qui est du méthylmercure (MeHg), des biphényles polychlorés (BPC), des pesticides organochlorés hérités du passé et d'usage courant, des polybromodiphényléthers (PBDE) et des nouveaux produits ignifuges bromés.

Key messages

- Small arctic marine fish and invertebrates, as well as more recently observed subarctic marine fish, were collected in low Arctic (Arviat, NU), mid-Arctic (Clyde River, NU) and high Arctic (Resolute Bay, NU) communities in 2012-2014.
- Hg concentrations were similar across regions when the same species were compared, but levels differed among species within a given region.
- Results of stable isotopes analysis suggested that fish that feed at a higher position in the food web and near shore or near the bottom (sculpin, northern shrimp) generally had higher Hg levels than fish that feed lower in the food web and in open water or under ice areas (arctic cod, capelin, sandlance).
- Hg concentrations in subarctic fish (sandlance and capelin) were lower than in arctic fish (arctic cod and sculpin), suggesting that increased consumption of subarctic fish may result in lower mercury exposures for marine mammals and seabirds.

Messages clés

- Entre 2012 et 2014, des échantillons de petits poissons marins arctiques et d'invertébrés, ainsi que de poissons marins subarctiques observés plus récemment, ont été recueillis dans les communautés du Bas-Arctique (Arviat, Nunavut), du centre de l'Arctique (Clyde River, Nunavut) et de l'Extrême-Arctique (Resolute Bay, Nunavut).
- Les concentrations de Hg observées étaient similaires pour les différentes régions étudiées lorsque l'on comparait les mêmes espèces. Les niveaux mesurés chez différentes espèces d'une même région donnée différaient cependant les uns des autres.
- Les résultats des analyses d'isotopes stables suggéraient que les poissons s'alimentant à des niveaux supérieurs de la chaîne trophique et près des côtes ou des fonds marins (le chabot et la crevette nordique) présentaient généralement des concentrations de Hg supérieures à celles observées chez les poissons s'alimentant à niveaux inférieurs de la chaîne trophique et dans les eaux libres ou sous la glace (la morue polaire, le capelan et le lançon).
- Les concentrations de Hg chez les poissons subarctiques (le lançon et le capelan) étaient plus faibles que celles présentes chez les poissons arctiques (la morue polaire et le chabot), ce qui suggère que les mammifères et les oiseaux marins consommant davantage de poissons-fourrage subarctiques seraient moins exposés au Hg.

Objectives

1. Compare the levels of mercury (Hg) and legacy and emerging persistent organic pollutants (POPs) among major marine forage fish at 3 communities in the low, mid-, and high Arctic.
2. Assess the influence of lipid content, habitat use (via carbon stable isotopes) and trophic position (via nitrogen stable isotopes) on contaminant levels among species in the three regions.
3. Investigate how the increasing presence of subarctic forage fish relative to arctic forage fish may affect predator (e.g., ringed seal) dietary exposures to bioaccumulative contaminants.
4. Provide feedback to the participating Nunavut communities of Arviat, Clyde River and Resolute Bay on the community-specific levels of contaminants in the forage fish base and potential implications for higher trophic level marine predators.

Introduction

Among arctic biota, marine predators show some of the highest levels, and thus risks of exposure-related health effects, of persistent organic pollutants (POP) and mercury (Hg) (Dietz et al. 2013; Letcher et al. 2010). Their elevated exposures are mainly due to high trophic position diets, which consist predominantly of forage fish (Chambellant et al. 2013; Marcoux et al. 2012; Pauly et al. 1998; Thiemann et al. 2007). The major forage fish in the Arctic, arctic cod (Boreogadus saida), is a schooling fish closely associated with the sea ice (Craig et al. 1982). However, as ocean temperatures have warmed and sea ice has declined over the past three decades, subarctic capelin (Mallotus villosus), sandlance (Ammodytidae spp.) and/or herring (Clupea harengus) have become very common in parts of the eastern Canadian Arctic and may be replacing arctic cod as the main forage fish (Gaston et al. 2003; Gaston et al. 2009; Provencher et al. 2012). In fact, capelin in particular have been referred to as the canaries of the sea for their rapid responses to climate change (Rose 2005). Nonetheless, the extent of these changes varies, with evidence of northward range expansion and substantial presence of these subarctic species observed mainly in low to mid-Arctic regions (Hop and Gjøsæter 2013; Provencher et al. 2012). Indeed, recent studies suggest an increase in capelin in the diets of ringed seals (Pusa hispida), beluga whales (Delphinapterus leucas) and/or arctic char (Salvelinus alpinus) in the low to mid-Arctic (Chambellant et al. 2013; Marcoux et al. 2012; Ulrich 2013).

In recent years, several studies have shown that such climate-related ecological changes can modulate contaminant levels in arctic marine biota (reviewed by McKinney et al. 2015). In this case, the first step in assessing the influence of changing forage fish on contaminant levels in marine predators is to determine the region-specific contaminant levels of the current forage fish base, including recently invading subarctic fish, if present. Although comprehensive regional comparisons have not been reported to date, arctic and subarctic forage fish may have different tissue contaminant levels due to differences in, e.g., trophic position, habitat use, migration, lipid content, body size and diet (Borgå et al. 2004). Discarded forage fish including arctic cod, capelin, sandlance and several benthic species at a thick-billed murre (Uria lomvia) breeding colony in northern Hudson Bay (low Arctic) were recently analyzed for several contaminant groups (Braune et al. 2014). The authors found significant differences in the levels of PCBs, organochlorine (OC) pesticides, polybrominated diphenyl ethers (PBDEs), polyfluoroalkyl substances (PFASs) and total Hg (THg) across species. We hypothesize that capelin and other migratory subarctic forage fish act as biovectors of certain contaminants, bringing more contaminated North Atlantic type signatures to arctic marine ecosystems and contributing to higher exposures in arctic predators. We anticipate that an analysis of emerging contaminants including current-use pesticides and non-PBDE brominated flame retardants (BFRs) will demonstrate higher levels in capelin than in arctic cod, given that capelin are highly migratory between arctic and subarctic waters and emerging contaminants have had less time to distribute into northern environments. Nonetheless, the migration patterns and ranges of subarctic forage fish that are increasingly being observed in the Canadian Arctic are not well known. In this work, we carried out a more fulsome sampling of the forage fish species in multiple 'focal" ecosystems to assess potential region-specific dietary exposure of key NCP monitoring species, such as ringed seal.

Activities in 2014-2015

Sample collections

Forage fish and invertebrates were collected in Arviat, Clyde River, and Resolute Bay in the summers of 2012-2014 (Figure 1). Sampling kits, instructions in Inuktitut and English with species' pictures, and coolers with ice packs and return address labels were sent to the HTAs. The Arviat HTA coordinated with local fishers to collect sculpin (Cottoidae spp.), amphipods (Amphipoda spp.), capelin, sandlance and a couple of other small fish species in 2014. The Resolute Bay HTA coordinated with local fisher, Debbie Iqaluk, to collect sculpin and amphipods in 2014. She reported that the arctic cod were not close enough to shore to catch in 2014. We thus used arctic cod netted by another Fisk lab member, Steve Kessel, in 2012. Debbie Iqaluk also indicated that polar cod are not common near Resolute Bay. Based on this local knowledge, we considered it unlikely that polar cod currently represents an important forage species for sampling in the area. As our mid-Arctic location, we used trawl samples previously collected by Fisk lab members (Nigel Hussey, Amanda Barkley) near Clyde River in the summer of 2013. Arctic cod, sculpin, a couple of other fish species and invertebrates (Northern shrimp, amphipods) were obtained. GPS locations were obtained for most samples in all locations. Samples were stored at -20C or lower both initially and once in the laboratory.

Laboratory analysis

In the lab, specimens were identified by visual examination and/or DNA barcoding, photographed, and had their masses and lengths recorded. Contaminant levels (PCBs, legacy and current-use OC pesticides, PBDEs, non-PBDE BFRs, total Hg (THg) and methylmercury (MeHg)), carbon and nitrogen stable isotope ratios, lipid and moisture content were determined in fish muscle tissues and whole amphipods. Analysis of PCBs, legacy and current-use OCs, THg and MeHg, lipid and moisture content was done at the Center for Environmental Sciences and Engineering at the University of Connecticut. Analysis of PBDEs and non-PBDE BFRs was done in the Tomy lab at the University of Manitoba. Analysis of stable isotopes was done in the Fisk lab at the University of Windsor. All analyses involved QA/QC procedures including blanks, duplicates, and (if available) certified reference materials.

Capacity Building

Local HTAs coordinated sample collection, and fishers were hired to carry out the whole fish and invertebrate collections. Specimen collection was successfully coordinated with Andrea Issaluuq at the Arviat HTA by phone and email. Nancy Amarualik at the Resolute HTA suggested to coordinate directly with fisher Debbie Iqaluk, who subsequently successfully collected a number of samples. We have communicated with Nancy Amarualik by phone and email and with Debbie Iqaluk by phone. In the case of Clyde River, we utilized samples previously collected during a trawl in 2013.

Communications

In the planning and sampling stages, communication with the HTAs and community fishers occurred by phone and/or email. We provided plain-language summaries of the project in Inuktitut to the participating HTAs. McKinney, along with IRA Romani Makkik, visited the community of Arviat in March 2015. During the visit, we met with members of the Arviat HTA to discuss the project and progress. We also visited the local high school and Nunavut Arctic College campus to discuss the project with students. We shared slide presentations in English and Inuktitut with the Resolute Bay and Clyde River HTAs by email.

Traditional Knowledge Integration

The project integrated knowledge and skills of local fishers in Arviat and Resolute to successfully collected the 2014 samples. We also discussed recent local observations of the forage fish community composition during our community consultation visit to Arviat and by phone with fishers/HTAs in Resolute Bay and Clyde River. We worked to obtain copies of the draft Nunavut Coastal Resource Inventory (NCRI) for Pangnirtung and Igloolik from the Nunavut Department of Environment, Fisheries and Sealing Division, and we used TK from the NCRIs to assist in generating the list of target species.

Results

Forage fish communities

Our goal was to compare arctic and subarctic forage fish as dietary contaminant exposure pathways for arctic marine predators. We thus planned to collect major types of both subarctic and arctic forage fish, as well as potential invertebrate prey, if available, in each region. In general, the HTAs and local fishers were skilled at identifying and collecting the target species. A total of 124 forage fish and 4 invertebrate (pools of amphipods) samples of interest were collected in the summers of 2012-2014 (Table 1). We obtained capelin and sandlance in Arviat, but not in Clyde River or Resolute Bay. We did not obtain herring in any community. We obtained arctic cod and sculpin in each location, with the exception of arctic cod in Arviat. We have since worked with the HTA board to clarify identifications of arctic cod versus Greenland cod and requested that local fishers again attempt to collect arctic cod near Arviat in 2015. Invertebrates were also collected in all three communities, as they may represent important dietary components for some arctic marine predators. A few other fish species that were not specifically requested were occasionally collected (Greenland cod, cisco, goiter blacksmelt, glacier lanternfish). These specimens were all analyzed, but results for these other fish are not reported here as they were not the focus of the study.

Hg concentrations

We analyzed all samples for total Hg (THg), and results are summarized in Table 2. Results for MeHg are pending. Levels of THg were generally within the ranges previously reported for these species collected in other regions (Figure 2). Analysis of variance on log-transformed THg concentrations, followed by post-hoc Tukey's HSD tests, showed significant differences among species and occasionally among locations ($F_{10,112} = 87.7$, $p < 0.001$). Concentrations of THg varied widely, with the lowest levels (0.05-0.07 $\mu g\ g^{-1}$ dw) measured in amphipods and the highest levels (0.66-1.56 $\mu g\ g^{-1}$ dw) measured in Northern shrimp and sculpin (Figure 2). Comparing within regions, in Resolute, THg levels were higher in sculpin than in arctic cod ($p < 0.001$). Similarly, in Clyde River, THg levels were higher in sculpin and northern shrimp than in arctic cod ($p < 0.001$). In Arviat, THg levels were higher in sculpin than in capelin and sandlance ($p < 0.001$), and levels in sandlance were also higher than in capelin ($p = 0.02$). Comparing among regions, THg levels were similar among amphipods in the three areas and were not significantly different between arctic cod from Clyde River and Resolute Bay ($p = 0.99$) (no arctic cod were collected in Arviat). Yet, sculpin in Clyde River had higher THg levels than sculpin in Resolute Bay and Arviat ($p < 0.001$).

POP concentrations

Results for PCBs, legacy and current-use OC pesticides and BFRs are pending. ΣPCB is the sum of 42 PCB congeners. This set includes all PCB congeners previously detected in a similar set of forage fish species collected in northern Hudson Bay in 2007-2009 (Braune et al. 2014) and also the 10 Stockholm Convention PCBs: CB- 28, 31, 52, 101, 105, 118, 138, 153, 156, 180. ΣOC is the sum of chlorobenzenes (ClBzs: 1,2,4,5-TeClBz, 1,2,3,4- TeClBz, PeClBz, hexachlorobenzene (HCB)), hexachlorocyclohexanes (HCHs: α-HCH, β-HCH, γ-HCH (lindane)), chlordanes (heptachlor, oxychlordane, t-nonachlor, c-nonachlor, heptachlor epoxide, t-chlordane, c-chlordane), aldrin, dieldrin, endrin, dichlorodiphenyltrichloroethanes (DDTs: 4,4′-DDE, 4,4′-DDD, 4,4′-DDT), endosulfans (α-endosulfan, β-endosulfan), methoxychlor, toxaphene, and mirex (mirex, photomirex).

Stable isotope ratios

All samples were analyzed for stable isotope ratios (Table 2). Ratios of both $\delta^{15}N$ and $\delta^{13}C$ were significantly different among species and occasionally among regions ($F_{10,112} = 57.5$, $p < 0.001$ and $F_{10,112} = 38.0$, $p < 0.001$, respectively). Sculpin and northern shrimp showed enriched $\delta^{15}N$ and $\delta^{13}C$ ratios relative to arctic cod, capelin and sandlance. Amphipods had the lowest $\delta^{15}N$ ratios, but widely variable $\delta^{13}C$ ratios among regions. Fish length, $\delta^{15}N$ and $\delta^{13}C$ were correlated, but only weakly ($r^2 = 0.05$ to 0.26, $p < 0.003$). In a GLM model including all fish samples and using length, $\delta^{15}N$ and $\delta^{13}C$ as independent variables, only $\delta^{15}N$ and $\delta^{13}C$ significantly explained THg levels (whole model $r^2 = 0.72$, $p < 0.001$). Levels of THg increased with both $\delta^{15}N$ and $\delta^{13}C$.

Table 1. Summary of small fish and invertebrates collected in 3 Nunavut communities from 2012-2014 for mercury, persistent organic pollutant and stable isotope determination. Species were identified based on visual and/or DNA barcoding methods.

Species	Location	Year	Tissue type	N
Arctic cod (Boreogadus saida)				
	Clyde River	2013	muscle	20
	Resolute Bay	2012	muscle	20
Sculpin (Cottoidae spp.)				
	Arviat	2014	muscle	10
	Clyde River	2013	muscle	10
	Resolute Bay	2014	muscle	10
Capelin (Mallotus villosus)				
	Arviat	2014	muscle	11
Sandlance (Ammodytidae spp.)				
	Arviat	2014	muscle	13
Northern shrimp (Pandalus borealis)				
	Clyde River	2013	muscle	10
Amphipods (Amphipoda spp.)				
	Arviat	2014	whole	1*
	Clyde River	2013	whole	1*
	Resolute Bay	2014	whole	2*
Greenland cod (Gadus macrocephalus)				
	Arviat	2014	muscle	10
Cisco (Coregonus artedi)				
	Arviat	2014	muscle	5
Goiter blacksmelt (Bathylagus euryops)				
	Clyde River	2013	muscle	4
Glacier lanternfish (Benthosema glaciale)				
	Clyde River	2013	muscle	1
TOTAL				128

*Number of pools

Table 2. Arithmetic mean (±SE) concentrations of mercury and stable isotope and biological data for marine forage fish and invertebrates collected in 3 communities in Nunavut from 2012-2014.

Species	N	Length (mm)	Mass (g)	δ13C (‰)	δ15N (‰)	THg (μg g^{-1} dw)
Arctic cod						
Clyde River	20	142 ± 5	31 ± 3	-20.7 ± 0.1	14.9± 0.1	0.16 ± 0.01
Resolute Bay	20	148 ± 3	26 ± 1	-19.9 ± 0.1	15.2± 0.1	0.14 ± 0.00
Sculpin						
Arviat	10	196 ± 10	149 ± 22	-16.6 ± 0.6	15.7± 0.3	0.66 ± 0.12
Clyde River	10	127 ± 9	77 ± 18	-19.1 ± 0.2	18.0± 0.2	1.56 ± 0.23
Resolute Bay	10	148 ± 9	78 ± 19	-17.7 ± 0.1	16.1± 0.1	0.50 ± 0.08
Capelin						
Arviat	11	104 ± 4	9 ± 1	-21.1 ± 0.3	14.7± 0.1	0.07 ± 0.01
Sandlance						
Arviat	13	96 ± 3	3.8 ± 0.2	-21.6 ± 0.3	14.2± 0.2	0.12 ± 0.01
Northern shrimp						
Clyde River	10	N/A	13 ± 1	-19.0 ± 0.1	15.8± 0.1	0.89 ± 0.05
Amphipods						
Arviat	1*	N/A	N/A	-16.5	10.0	0.07
Clyde River	1*	N/A	N/A	-21.4	13.1	0.05
Resolute Bay	2*	N/A	N/A	-17.3	13.0	0.06

*Number of pools

NCP Performance Indicators: April 1, 2014 – March 31, 2015

Engagement & Communication Indicators	Description	Date mm/dd to mm/dd	Location Town, Territory, Province	Number of people of materials	Details What was highlighted? How were they involved?
Northerners engaged in your project	Workshops				
	School visits	03/24	Arviat, NU	~20 students	Project background/ progress. Engaged in presentation and Q & A.
	Meetings				
	Consultations (with HTO)	03/24 05/27	Arviat, NU/ Pangnirtung, NU	2 HTO boards	Project background/ progress. Discussed future plans.
	Part of your project team	04/01-03/31	Arviat, NU/ Resolute Bay, NU	2 HTO managers	Planned and arranged sampling.
	Hired	~08/01-09/30	Arviat, NU/ Resolute Bay, NU	4 fishers	Performed sampling.
	Other (College visit)	03/24	Arviat, NU	~10 students	Project background/ progress. Engaged in presentation and in Q & A.
Students involved in your NCP work	Northern				
	Southern	09/01-present	Windsor, ON/ Storrs, CT	2	Sample analysis, data analysis, writing manuscripts.
Distribution of project materials/ information and results	Fact Sheets				
	Newsletters				
	Posters				
	Other, e.g., conferences, community meetings	03/24 05/27 06/16 04/14	Arviat, NU/ Pangnirtung, NU/ Resolute Bay, NU/ Clyde River, NU	3 slide presentations, 1 PSA, 4 project summaries	Project background and/or progress.

Publication & Data Indicators	Description	Date	Name Journal, Conference, Database	Number Volume Page, Data Record #	Details Links to material
Number of citable publications	Journals				
	Conference presentations				
	Book chapters				
	Other	04/30	NCP Synopsis of Research	2014-2015	
Are you aware of how your project results will be used (e.g., local/ national/ international assessments and initiatives)? If so, please describe.	Names of Assessments and Initiatives that will use your project results.				
Access to Data	Meta Data In Polar Data Catalogue	03/13		PDC Record # 12162	

Figure 1. Map indicating regional variation in recent observations of forage fish community composition (blue text; Provencher et al. 2012) and Nunavut communities that participated in the project (blue rectangles) (base map from GN-DOE).

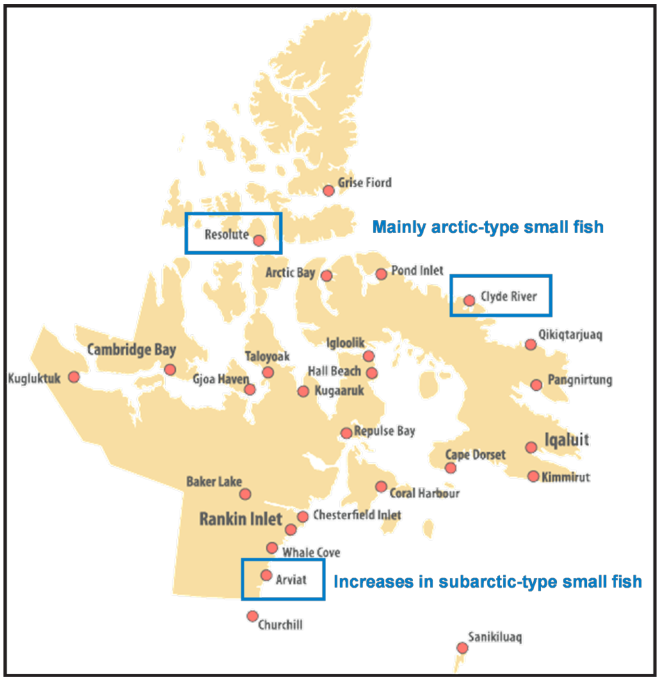
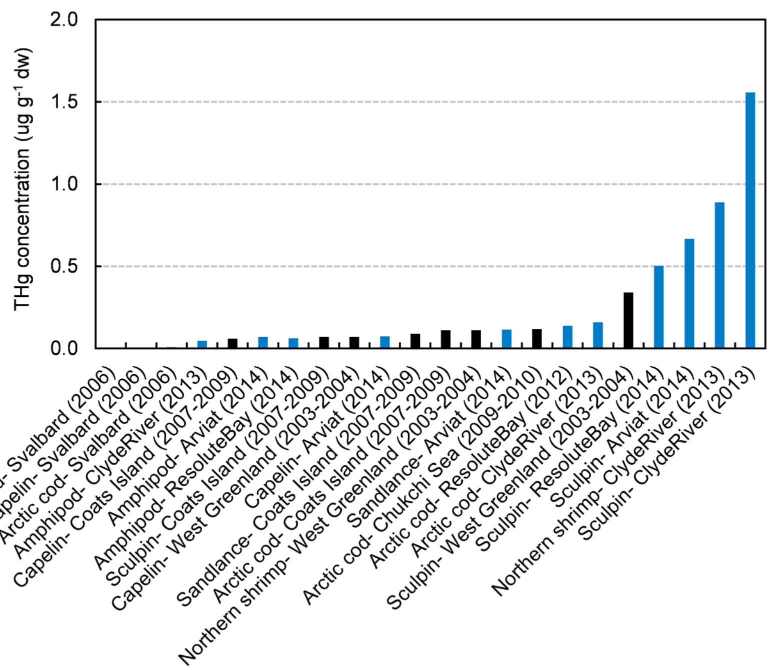


Figure 2. Total Hg (THg) concentrations (µg g-1 dw) reported in marine forage fish muscle and whole invertebrates collected across the Arctic. Blue bars denote data from the current study. Black bars denote data from published studies (Braune et al. 2014; Fox et al. 2014; Jæger et al. 2009; Rigét et al. 2007).



Discussion and Conclusions

Local fishers and/or trawl sampling failed to return capelin, sandlance or herring in Clyde River and Resolute Bay, but collected arctic cod in both regions. These observations are consistent with findings from seabird diets suggesting that these subarctic fish are still not common in higher Arctic regions where, instead, arctic cod continue to be the main forage fish (Provencher et al. 2012). Local fishers' successes in collecting capelin and sandlance near Arviat, but not arctic cod, are also consistent with seabird work suggesting that subarctic fish are now predominant in low arctic regions. Although it is possible that arctic cod are indeed now uncommon near Arviat, it is also possible that cod were collected without a specific focus on arctic cod (and thus Greenland cod were returned). A second attempt to catch arctic cod near Arviat this summer may prove informative in this regard.

Levels of THg in individual species which were sampled in two or more regions suggested similar THg contamination among the 3 regions. Comparing the present data to previous studies in other Arctic regions, levels in these eastern Canadian Arctic forage fish were higher than in fish sampled further west (Chukchi Sea) and further east (Greenland, Svalbard) (Figure 2). Yet, data on THg and MeHg levels in these important marine prey fish remain limited; further study across regions and better understanding of potential confounding factors (trophic position, fish length, foraging habitat) is needed (Braune et al. 2015). We predicted that Hg levels would be higher in species inhabiting deeper waters (Blum et al. 2013; Choy et al. 2009). Our nitrogen and carbon stable isotope ratios suggested that fish that feed not only at a higher trophic position, but also near the bottom (sculpin, northern shrimp) had higher Hg levels than fish that feed lower in the food web and in open water or under ice areas (arctic cod, capelin, sandlance).

THg levels in subarctic fish (sandlance and especially capelin) were lower than in arctic fish (arctic cod and especially sculpin), suggesting that increased consumption of subarctic fish may result in lower mercury exposures for marine mammals and seabirds. We will evaluate these relationships in detail for MeHg, as well as for legacy and emerging POPs, to more fully investigate the effects of changing forage fish communities on marine predator contaminant exposures. We anticipate that subarctic forage fish contaminant levels and profiles are influenced by seasonal migrations into more contaminated waters south of the sampling areas (i.e., North Atlantic waters). In particular, unlike for THg, we expect that within a given region, capelin relative to arctic cod will show higher levels of current-use pesticides and non-PBDE BFRs, which are contaminants more associated with temperate regions.

Expected Project Completion Date

We are in the process of finalizing all laboratory analysis aspects of the current year's objectives. Completed results and analysis of this year's work will be available in the summer of 2015, with the exception of the manuscript, which we expect to submit by the early 2016. We plan additional NCP- and/or non-NCP funded analyses in the next two years. Results of all additional aspects of the project should be available once Sara Pedro completes her PhD, expected in May 2018.

Project website

More information on this project, and related projects examining the impacts of climate-linked ecological changes on contaminant exposures in arctic marine ecosystems, can be found at mckinneylab.weebly.com.

Acknowledgments

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Metal loading and retention in Arctic tundra lakes during spring runoff

Charge et rétention des métaux dans les lacs de la toundra arctique durant le ruissellement printanier

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Abstract

Spring snowmelt is the most important hydrologic event of the year in Arctic landscapes. During this relatively short period in spring, fluxes of water and waterborne contaminants such as mercury (Hg) and other trace metals to surface waters can exceed those occurring during the remainder of the year. In this two year study, intensive monitoring of snow and surface water hydrology and metal geochemistry are being conducted at several lakes near Iqaluit, NU. The overarching goal is to produce watershed-scale hydrologic and metal mass balances to quantify the contribution of snowpack metal burdens to Arctic lakes during the annual spring freshet. Spatially extensive measurements of snow depth, density, and metal concentrations prior to the melt period are being conducted prior to the onset of melt, followed by frequent sampling of lake

Résumé

Dans l'Arctique, la fonte des neiges printanière est l'événement hydrologique le plus important de l'année. Durant cette période relativement courte, les flux de contaminants présents dans l'eau et d'origine hydrique, comme le mercure (Hg) et les autres métaux traces dans les eaux de surface, peuvent être plus importants que ceux survenant durant le reste de l'année. Cette étude biennale permet une surveillance étroite de la neige et de l'hydrologie des eaux de surface, et des analyses géochimiques des métaux sont effectuées à différents lacs situés à proximité d'Iqaluit, au Nunavut. Le principal objectif est d'établir des bilans massiques de l'eau et des métaux pour l'ensemble du bassin, et ce afin de quantifier l'incidence des métaux présents dans le manteau neigeux sur les lacs de l'Arctique durant la crue printanière annuelle. Avant le début de la fonte des neiges,

inflows and outflows. Because of logistical difficulties associated with streamflow gauging under ice during the melt period, the study design employs isotopic and hydrochemical end-member mixing using snow, stream, lake ice and lake water sampling to determine the water and metal mass balances.

All fieldwork is being conducted in partnership with Nunavut Research Institute (NRI) and Nunavut Arctic College (NAC), and several current or recently graduated NAC Environmental Technology Program (ETP) students have received field training in snow and river hydrology, limnology and aquatic geochemistry. An important objective of the project is to build the NRI's capacity to plan, coordinate, and manage, field studies of aquatic contaminants cycling and snowmelt hydrology.

Preliminary results from the 2014 field season reveal relatively high concentrations of Hg in the snowpack prior to the melt period and limited mixing of the snowmelt runoff with lake water due preferential flow directly beneath the lake ice. Our 2014 results also show that snowmelt runoff chemistry is strongly augmented by another source of water prior to entering lakes, most likely groundwater or water within the developing active layer. These findings contribute to our scientific understanding of trace metal dynamics in Arctic lakes and watersheds during the spring freshet and the mechanisms by which snowpack accumulation and melt serves to couple atmospheric sources of contaminants to aquatic environments.

on effectue également des mesures spatiales détaillées de la profondeur et de la densité des neiges, ainsi que des concentrations de métaux s'y retrouvant, après quoi on procède souvent à un échantillonnage des écoulements entrants et sortants des lacs. Compte tenu des difficultés logistiques inhérentes à la mesure du débit d'eau sous la glace durant la fonte des neiges, le protocole de l'étude prévoit l'utilisation d'un mélange de membres extrêmes isotopiques et hydrochimiques, ce qui commande de procéder à un échantillonnage de la neige, des débits, ainsi que des eaux et des glaces lacustres, et ce afin d'établir un bilan massique de l'eau et des métaux.

Toutes les activités sur le terrain sont menées en collaboration avec l'Institut de recherche du Nunavut (IRN) et le Collège de l'Arctique du Nunavut (CAN). De plus, de nombreux étudiants ou récents diplômés du Programme de technologie environnementale (PTE) du CAN ont reçu une formation sur le terrain en hydrologie de la neige, en hydrologie fluviale, en limnologie et en géochimie aquatique. L'un des principaux objectifs du projet consiste à renforcer les capacités de l'IRN en matière de planification, de coordination et de gestion des études sur le terrain qui portent sur les cycles de contaminants aquatiques et l'hydrologie de la fonte des neiges.

Les résultats préliminaires obtenus dans le cadre de la campagne sur le terrain de 2014 ont révélé que le manteau neigeux présentait des concentrations de Hg relativement élevées avant la période de fonte, et que les eaux de fonte se mélangeaient peu à celles des lacs en raison de l'écoulement préférentiel qui survient directement sous les glaces lacustres. Les résultats de 2014 démontraient également que la composition chimique des eaux de fonte est fortement alourdie par d'autres sources d'eau situées en amont des lacs, soit probablement les eaux souterraines ou les eaux présentes dans le mollisol en formation. Ces résultats nous permettent de mieux comprendre d'un point de vue scientifique la dynamique des métaux traces dans les lacs et les bassins hydrographiques de l'Arctique durant la période de la fonte des neiges, ainsi que les mécanismes par lesquels l'accumulation du manteau neigeux et la fonte des neiges permettent aux contaminants atmosphériques de migrer vers les milieux aquatiques.

Key Messages

- Concentrations of total mercury (THg), methyl-mercury (MeHg) and other trace metals in including lead (Pb) in snowmelt water leaving the snowpack were high, representing a potentially important source of metal input to catchments and lakes near Iqaluit, NU;
- Although snowmelt water was high in metals including THg, MeHg and Pb, it was low in Dissoved Organic Carbon (DOC), whereas streamflow concentrations of both metals and DOC after flowing overland and through shallow soils of the catchment; Streamflow water quality during the spring melt period therefore represents a mixture of snowmelt and terrestrial water sources;
- Water from inflowing streams, elevated in metals and DOC, did not mix strongly with lake water, and lake outflow chemistry largely tracked inflow chemistry throughout the entire melt period which is consistent with several previous studies that show that snowmelt runoff largely bypasses Arctic lakes in a thin layer below the ice surface

Messages clés

- Les eaux de fonte s'écoulant du manteau neigeux contenaient des concentrations élevées de mercure total (THg), de méthylmercure (MeHg) et d'autres métaux traces, dont le plomb (Pb), et représentent potentiellement une source importante d'apport en métaux dans les bassins hydrographiques et les lacs de la région d'Iqaluit, au Nunavut.
- Les eaux de fonte présentaient des concentrations élevées de métaux, dont le THg, le MeHg et le PB, et contenaient peu de carbone organique dissous (COD), alors que l'on a relevé des traces de métaux et de DOC dans les eaux d'écoulement après qu'elles ont pénétré dans la terre et dans les sols superficiels du bassin hydrographique. Par conséquent, la qualité des eaux d'écoulement pendant la période de fonte printanière est fonction d'un mélange d'un mélange d'eaux de fonte et de sources d'eaux terrestres.
- Les eaux provenant des affluents, dont les concentrations de métaux et de COD étaient élevées, se mélangeaient peu aux eaux lacustres, et la composition chimique des eaux en provenance de lacs était fortement similaire à celle des eaux s'y déversant tout au long de la période de fonte. Cette dernière constatation est cohérente avec celles d'études antérieures, lesquelles ont démontré que les eaux de fonte contournent les lacs de l'Arctique et qu'elles s'écoulent en une mince couche sous la glace.

Objectives

The overarching objective of this two-year project is to quantify the contribution of snowmelt runoff to the metal mass balance of Arctic tundra lakes. This will contribute new knowledge and research on pathways and processes of metals in Arctic tundra landscapes. Specifically, the proposed study will generate important insight into the role of snow hydrology in coupling atmospheric sources of trace metals, including inorganic and methyl-mercury, to Arctic freshwaters. Snow hydrology is potentially a key component of current ecosystem changes in the Arctic that may influence metal levels and trends in monitored species.

The *short-term* objective of this research is to accurately quantify snowmelt fluxes of trace metals to surface waters in the vicinity of Iqaluit, NU, including comprehensive water and metal mass balances in two nearby lakes. A secondary long-term objective is to establish a practical program of annual snow and trace metal sampling that could be undertaken annually in collaboration with the NAC Environmental Technology program. The specific scientific questions to be addressed through this research are:

1. What are trace metal loads in snowpack just prior to spring snowmelt in Arctic tundra watersheds on Southern Baffin Island and what fraction of this load is mobilized into surface waters by the spring freshet?
2. What fraction of the snowmelt trace metal load to the watershed is lost through (a) terrestrial watershed sequestration; and/or (b) export via the lake outflow?
3. How much do snowmelt loads contribute to total metal loads in Arctic tundra lakes during the annual water year (onset of spring melt to fall freeze-up)

Introduction

Arctic landscapes are snow-covered for about two-thirds of the year and as a result, snow is an important sink for atmospheric pollutants. Significant accumulation of trace metals and other contaminants can occur within the seasonal snowpack, resulting in large downstream fluxes during the spring freshet (Semkin et al., 2005, Helm et al. 2002, Loseto et al. 2004). Initial meltwater pulses can be enriched in major elements and contaminants such as Hg due to freeze-concentration and fractionation within the snowpack and through interactions with underlying soil (Semkin et al., 2005, Dommergue et al. 2003, Bales et al. 1989). The annual process of snow accumulation, melt and runoff therefore serves as an efficient mechanism by which atmospherically deposited contaminants, including trace metals such as Hg, Pb and Cd, are mobilized into surface waters.

Considerable information has been collected over the last 15 years on Hg concentrations in Arctic snow because of the discovery of atmospheric mercury depletion events (AMDEs) (e.g., Dommergue et al. 2005, St. Louis et al. 2005, 2007; Poulain et al. 2007). This research has shown that snowpack is a significant reservoir of Hg from atmospheric deposition. MeHg can also be found at relatively high concentrations in Arctic snow (St. Louis et al. 2005, 2007). Much less information is available on Arctic snowpack loads for other metals such as Pb and Cd, which remain metals of international concern. More recent research has also focused on the release of Hg from glacier melt (Zdanowicz et al. 2013) including to Lake Hazen (St. Louis et al. 2013). However, due to the logistical challenges and high frequency of sampling required, snowmelt delivery of metals to aquatic ecosystems has not been adequately studied. In the Canadian Arctic, it remains unclear how snowmelt contributes to the metal loads of lakes because of a lack of hydrological measurements taken in tandem with metal concentrations. Detailed, labour-intensive measurements of snowpack storage, snowmelt inputs and lake water storage and losses are required. Research on snowmelt contributions of trace metals to Arctic lakes is important for understanding how climate change will impact the delivery of metals to aquatic food webs. In the context of the Hg cycle, snowmelt research is also needed to determine the relative importance of watershed sources and within-lake production of MeHg, the more toxic and bioaccumulative form.

Our project builds on one particularly important study by Semkin et al., (2005) who report a comprehensive mass balance of THg for an Arctic lake during spring runoff. An important finding of this study was that, although spring snowmelt constituted an important flux of THg to a high Arctic Lake, a substantial fraction of the flux actually bypassed the lake through a thin layer of flowing water beneath the lake ice. The general lack of other such studies makes it difficult to make broader predictions of how processes such as this might influence metal cycling dynamics in response to climate and ecosystem change across Arctic landscapes. Moreover, while that study focussed on total Hg, MeHg also accumulates in Arctic snowpack (St. Louis et al 2005; Lahoutifard et al 2005), and may enter into lakes during snowmelt (Loseto et al 2004). A mass balance model for MeHg has not been published for a lake in the Canadian Arctic, which would provide critical information on the relative importance of watershed supply versus within-lake production of MeHg. Finally, the Semkin et al., (2005) study was conducted in a polar desert environment and it is unclear how well it applies to tundra lakes in the Canadian Arctic.

This two-year NCP project focuses on mass balance modelling of THg, MeHg and a suite of other trace metals for several lakes in southern Baffin Island in the immediate vicinity of Iqaluit, NU. The study will fill an important gap in the area of trace metal cycling during Arctic spring. It will also help to understand potentially broader changes to contaminant cycles in Arctic freshwaters caused by global warming, since snow hydrology is highly sensitive to weather and climate. This report includes an overview of key outcomes and results from our 2014 field season.

Activities in 2014-2015

The 2014 program was successful despite a number of logistical challenges and field sampling details requiring alternate strategies. For example, streamflow gauging was difficult in early spring due to ice conditions, and runoff contributions to lakes will require snowmelt modelling for the early part of the melt period during the 2015 field season. End member mixing analysis (EMMA), as originally proposed for six lakes, was not feasible in 2014 due to a lack of significant difference in pre- *vs.* post-melt isotopic and geochemical signature of the water columns. However, our results from one nearby lake where we conducted more extensive sampling demonstrate excellent progress towards the use of EMMA to understand source water contributions to inflowing and outflowing streams. Based on these findings we are using a revised approach to develop the hydrologic and metal mass balance for two focal lakes in 2015, in combination with hydrometric monitoring of the lake level and outflow and spatially distributed snowmelt modelling.

Snow surveying within the lake catchments proved to be very feasible with the help of NRI and ETP summer students. Snow surveying requires traversing large tracts of land to achieve representative sampling, and requires suitable land skills including skidoo travel through soft spring snow conditions. Based on our preliminary work in 2014, we are planning more work in collaboration with NRI and ETP students, and are making good progress towards building a longer-term program for annual spring snow surveys in the broader Apex River watershed, which was recently identified as supplemental potable water supply for the city of Iqaluit. Our goal is to help build snow surveying into the NAC ETP 2nd year curriculum, culminating in field based activities during the annual spring field camp at nearby Crazy Lake.

Northern Capacity Building and Traditional Knowledge Integration

Five current or recently graduated ETP students were trained in various field and laboratory activities over the course of the spring and summer field program in 2014. Ted Irniq (2013 ETP graduate), Joeffrey Okalik and Mathew Gardiner (current ETP students) were involved intensively from May until September 2014, and all 3 developed strong specialized skills related to physical and chemical limnology and snowmelt hydrology. These skill sets are not broadly covered in the current ETP curriculum, but are very useful for environmental monitoring practitioners. The students learned how to calibrate and use snow tubes to survey snow depth, density, and melt water equivalent in river catchments; calibration and use of water chemistry field sondes; use and maintenance of Kemmerer sampling devices; ultra clean techniques for trace metals sampling; salt dilution gauging for stream discharge monitoring. Students learned to fabricate and install snowmelt lysimeters, and to prepare and deeply thermistor strings to monitor lake thermal profiles. Students also learned to clean and prepare sampling equipment and to organize and maintain laboratory inventory. Sampling methods were refined with student feedback over the course of the spring/summer, and are being documented in instructional manuals which will facilitate student training and involvement in the 2015 field season and beyond.

Communications

Methods and findings from this project were communicated locally through M. Richardson's participation in the 2014 Fall contaminants workshop at NRI in the form of a short lecture and field-based activity, as well as the 2015 ETP spring field camp at Crazy Lake. Other members of the project team, including Keegan Smith and Jessica Peters, will be involved with NRI's 2015 youth summer camp. The preliminary project findings were recently presented at the Joint Assembly of the Canadian and American Geophysical Unions (May 2015) by M. Richardson. Additional communications opportunities have been planned for the 2015 field season including Keegan Smith's participation in a television documentary by China Central Television.

Traditional Knowledge Integration

During the 2014 field program, 3 of the ETP students participating in the project (D. Anavilok, T. Irniq, and J. Okalik) proved invaluable for conducting project fieldwork in the hilly precarious terrain around Iqaluit, thanks to their strong and diverse land skills and mechanical abilities. On various occasions they helped plan the most efficient and safe routes to access the various sampling lakes throughout the melt season, modifying routes frequently as needed to account for changing conditions on the ground. They repaired equipment, serviced snowmobiles, ATVs, and qamutik, maintained ice augers and other key equipment, and prepared and deployed zodiac boats for open water sampling. Their skill and experience operating ATVs also enabled them to safely access to sampling sites during the summer, navigating around and through precarious boulder fields

Results and Discussion

Snow surveys

According to local residents, 2014 was a low snow year in Iqaluit. Environment Canada reports approximately 150 cm of snowfall between the end of September 2013 to the end of May 2014, considerably lower than the mean annual (1971-2000) snowfall of 236 cm. Snow course surveys conducted in five research basins near Iqaluit, NU in late May 2014 were used to calculate an average landscape snow water equivalence of 130 cm ± 2 cm (95% confidence interval). This implies that a significant fraction of the annual SWE remained on the ground until the end of May, when the melt period began. It is important to note that gauge deficiencies can result in substantial underestimation of the annual snowfall, particularly in Arctic landscapes, due to gauge "undercatch" and blowing snow conditions (Mekis and Hogg 1999). This underscores the importance of annual snow course surveys just prior to the melt for hydrology and contaminant research in these regions. Notably, we confirmed snow depth to be a very strong predictor of SWE due to relatively small variations in snow density (R^2= 0.97, p<0.0001). This will further improve snow course survey efficiencies and results in 2015.

We observed considerable aerial depletion of the snowpack during the early melt period without a concomitant streamflow runoff response and believe that a significant fraction of the snowpack sublimated during the early melt period. Warm windy days and cold nights could result in significant loss of landscape SWE without runoff generation because the snowpack must become isothermal each day prior to the generation of meltwater output. Subsequent work in 2015 will include greater emphasis on quantifying snowpack sublimation, melt, and runoff generation at two proposed lake basins in order to develop the best possible estimates of snowmelt runoff and trace metal fluxes to the target lakes. The potential for spring weather patterns to fundamentally alter the fraction of annual SWE that sublimates has important implications for physical pathways of atmospherically deposited metals in Arctic landscapes under changing climate regimes.

Water chemistry

Boxplots showing the distributions of specific conductance (SpC), $d^{18}O$, THg, MeHg, Dissolved Organic Carbon (DOC) and Pb in Lake 1 water (at depth), Lake 1 outflow, Lake 1 Ice, Snowmelt and Streamflow are shown in Figure 1. The most important observations associated with this figure are summarized as follows:

1. Streamflow flowing into Lake 1 had a fundamentally different chemical and isotopic signature then the melting snowpack, including higher SpC, less negative d18O and higher DOC concentration, indicating substantial mixing of snowmelt with "old" water (groundwater or active layer soil water) residing within the catchment prior to the snowmelt period. This finding is consistent with other studies on streamflow sources during the spring freshet in Arctic watersheds including the Apex River watershed (Obradovic and Sklash 1986);

2. Concentrations of THg and MeHg and Pb in snowmelt were typically equal to or higher than concentrations in streams, lake water and the Lake 1 outflow;

3. SpC and concentrations of all chemical analytes in cored lake ice were very low and for MeHg, below detection limits. Melting lake ice therefore has ability to dilute lake water and/or lake 1 outflow during the melt period especially considering the volume fraction of ice relative to the entire water column at Lake 1 (i.e. ~ 2 m of ice and a mean depth of ~ 5m).

SpC and $d^{18}O$ are useful as natural tracers to determine end member contributions to streamflow, which will be used to develop mass balance models for two focal lakes in 2015. Although we have only reported on THg, MeHg and Pb here, subsequent reporting will include other trace metals that were analyzed, including Al, Cr, Mn, Ni, Zn, As, and Fe. Se and Cd were also analyzed but most samples were below analytical detection limits for these elements.

Chemical and isotopic characteristics of the Lake 1 outflow tracked those of the inflowing streams very closely over the melt period (Figure 2). This was observed not only for SpC and $d^{18}O$ which are useful conservative hydrologic tracers, but also metal contaminants of concern, notably THg and MeHg, both of which decreased in concentration over the melt period in the lake inflows and outflow. These findings are consistent with those of Semkin et al., (2005) and Bergman and Welch (1984) who found that a significant fraction of snowmelt runoff entering Arctic tundra lakes over the spring melt period can bypass the water column in a thin layer below the ice surface and subsequently discharging via the outflow.

End Member Mixing Analysis Results

EMMA is a commonly used method for calculation volumetric fractions of different water sources in streamflow (Hooper et al, 1990). Two and three component mixing models can be developed using one or two conservative tracers, respectively. Results presented in this section focus on the use of EMMA to quantify (a) the relative fractional contributions of snowmelt *vs.* groundwater/active layer soil water sources to streams flowing into focal Lake 1; and (b) the relative fractional contributions of landscape runoff vs. pre-melt lake water to the lake outflow over the melt period.

2-component EMMA was used to quantify relative contributions of "old" water (groundwater or active layer soil water) to the streams flowing into Lake 1 over the melt period using both $d^{18}O$ and SpC as independent tracers. We did not sample groundwater in 2014 so we assumed the groundwater isotopic signature based on stream samples taken during the summer baseflow period, which is a common practice when groundwater samples are not available. A mixing diagram is shown for streamflow, snowmelt and baseflow (groundwater or active layer soil water), demonstrating distinct hydrochemical and isotopic signature of snowmelt *vs.* baseflow (Figure 3). The resulting estimates of the snowmelt fraction in streamflow over time are shown in Figure 4. The results corroborate the distinct difference in hydrochemical and isotopic signature of snowmelt *vs.* streamflow shown in Figure 2. During the early melt period, snowmelt comprised ~62% to 88% of streamflow, decreasing steadily to baseflow conditions (assumed 100% groundwater) by the end of July.

The fraction of snowmelt in streamflow entering the lake can be compared to concentrations of contaminants or other analytes of interest to develop insight into the role of snowmelt in transport processes. For example, Figure 5 illustrates a positive relationship between THg and DOC in streamflow during the snowmelt period, and symbols are scaled by colour and size according to the volumetric fraction of snowmelt in the streams, derived through EMMA. Both THg and DOC concentrations increase when snowmelt contributions are high during the early melt period. This is consistent with high concentrations of THg in snowmelt shown in Figure 2. DOC concentrations in snowmelt were low, however, and are likely explained by accumulation of DOC in runoff during the early melt period as water travelled overland or through shallow soils in the developing active layer.

Three-component EMMA was also successfully applied to the Lake 1 outflow to estimate the relative contributions of "old" lake water (i.e. water that was in the lake prior to the melt period), inflowing runoff, and melting lake ice. A sample mixing diagram is provided in Figure 6 showing distinctive SpC and $d^{18}O$ signatures for these end members, for a sampling date in mid-June. In the example shown, Lake 1 outflow most closely resembles the inflowing streamwater. The estimated fractions of lake water, lake ice and stream inflows to the lake outflow on this date were found to be 24%, 28% and 48% respectively. This technique will be applied continuously over the sampling period in both 2014 and 2015 and used in combination with outflow discharge and lake volume changes to develop a complete hydrological and metal mass balance. Because of difficulties encountered with stream inflow gauging under ice during the early spring melt period, these results demonstrate that EMMA can be combined with a simpler, and more feasible set of hydrometric data (lake water level and outflow discharge) to develop a complete hydrological and chemical mass balance for Lake 1.

Figure 1: Boxplots showing chemical and isotopic compositions of different sample media in the Lake 1 watershed.

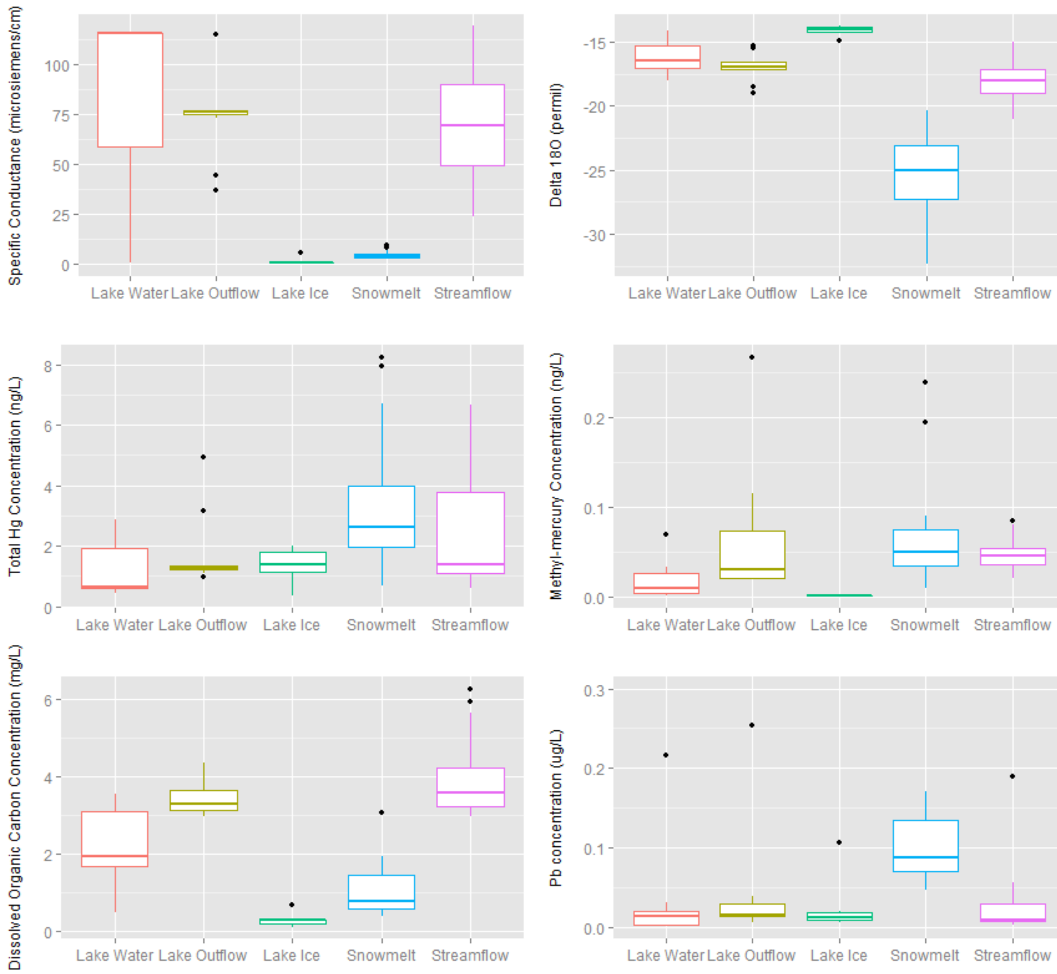


Figure 2: Times series of d18O (top left), SpC (bottom left), THg (top right) and MeHg (bottom right) for Lake 1 inflows (turquoise triangles) and outflow (red circles). The lake outflow isotopic and chemical composition closely traces that of inflowing streams throughout the melt period.

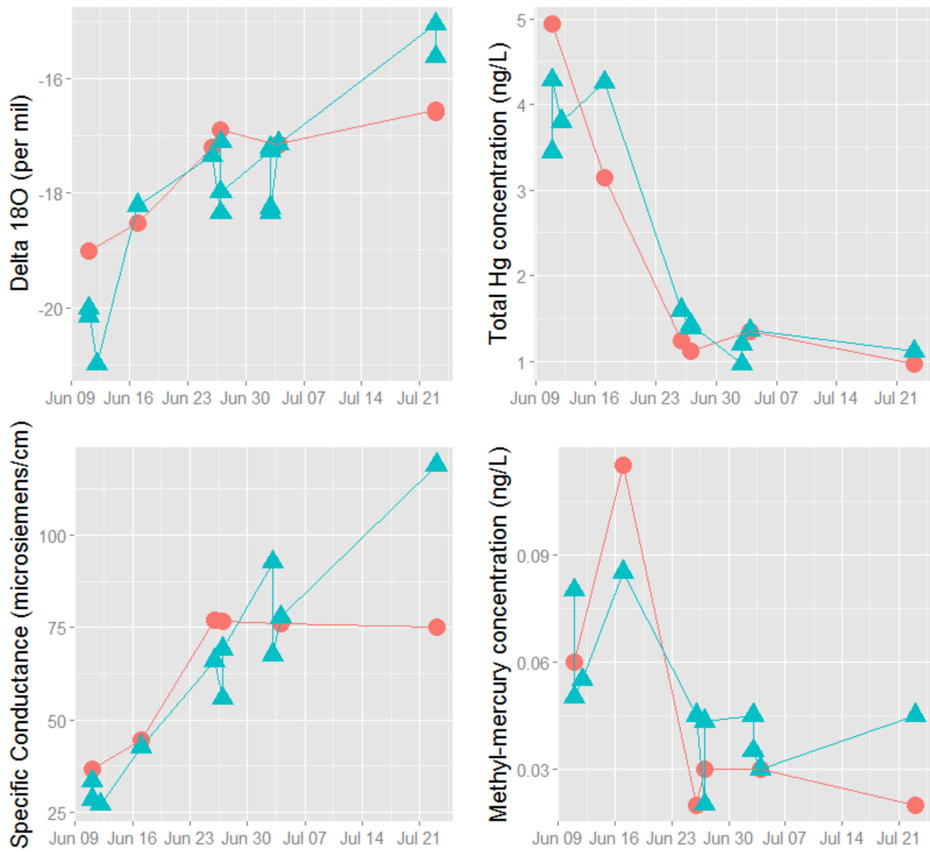


Figure 3: Mixing diagram for inflowing streams (green triangles) and contributing end members: snowmelt (red circles) and baseflow or groundwater (blue squares). Late season baseflow d18O and SpC are assumed to represent the groundwater or active layer soil water component of streamflow.

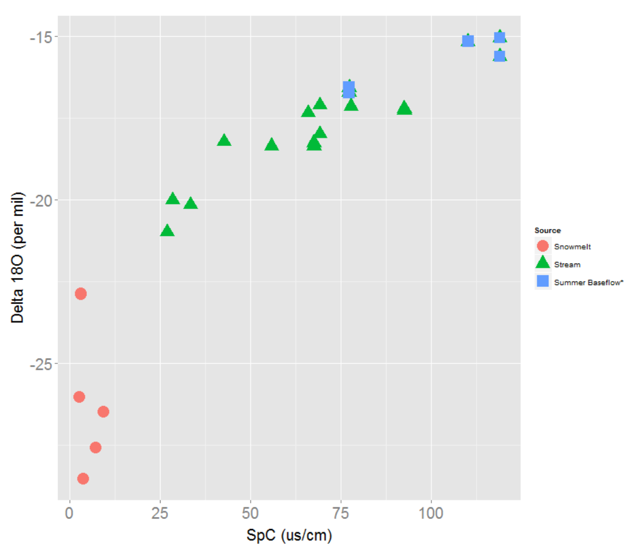


Figure 4: Results of the end member mixing analysis for inflowing streams at Lake 1 showing fractional contribution of snowmelt to streamflow over time, based on two alternate tracers, d18O (red circles) and Specific Conductivity (turquoise triangles). Both tracers show a substantial contribution of groundwater or "old water" to streamflow, increasing over the course of the melt period and throughout the summer. Early in the melt period, several streams and rivulets were samples, whereas only one was sampled later in the summer as the others ceased to flow.

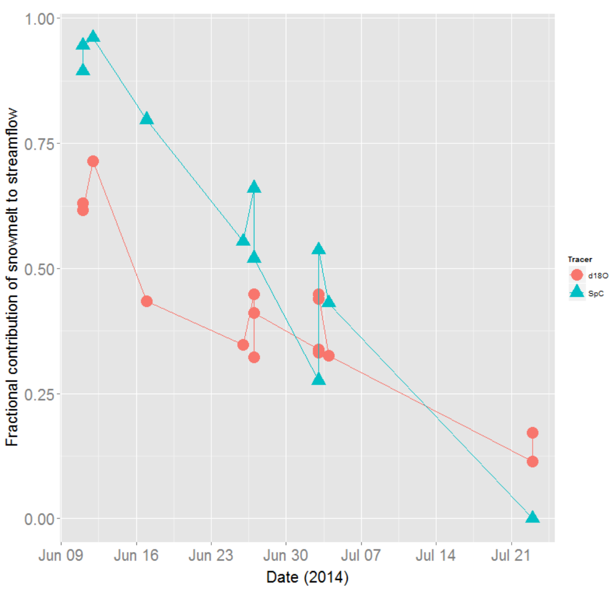


Figure 5: Total Hg vs. DOC concentration of inflowing streams, Lake 1. Dot size and colour represent the fraction of streamflow determined to be snowmelt (as opposed to groundwater) based on EMMA. As the snowmelt fraction (SM_FRACTION) increases, there is a corresponding increase in both DOC and Total Hg. Although snowmelt water is high in THg, it is low in DOC. This suggests that shallow, early spring flowpaths mobilize DOC from shallow soils of the catchment.

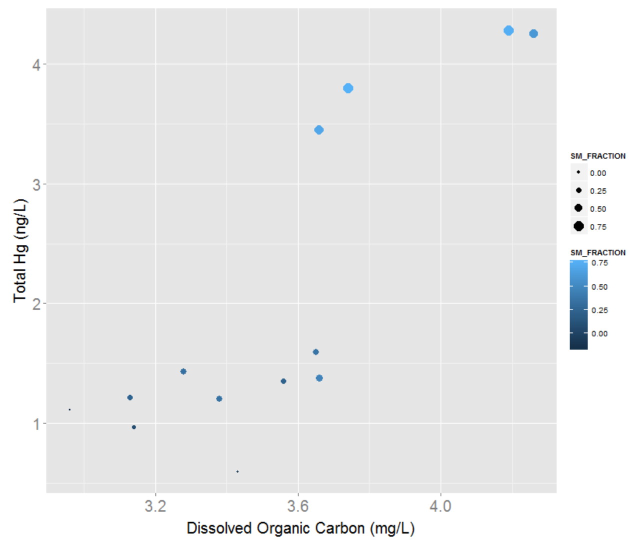
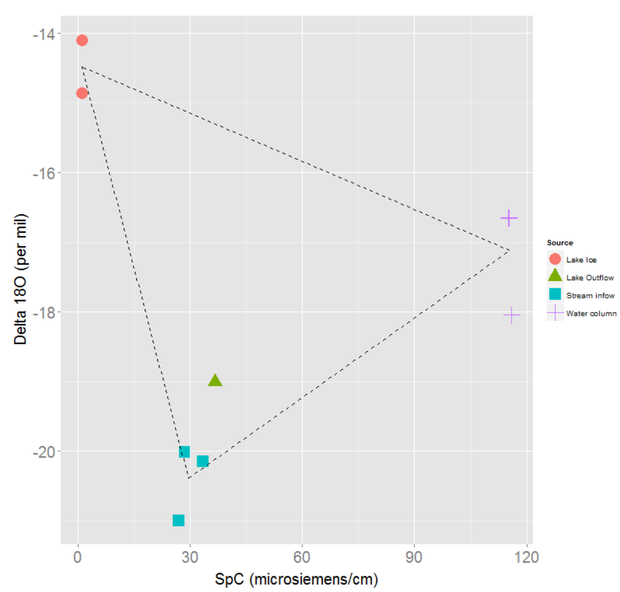


Figure 6: Three-component mixing diagram for Lake 1 outflow for a sampling date in mid-June, 2014 during the early melt period. EMMA was used to determine fractional contributions of "old" lake water, melting lake ice and stream inflows to the outflow. In this example, the fractional contributions of lake water, lake ice and stream inflows to the lake outflow were found to be 24%, 28% and 48% respectively. In 2015, this approach will be used to develop continuous estimates of lake outflow end members in combination with hydrometric monitoring of lake volume and discharge changes to develop detailed hydrologic and chemical mass balance for the two focal lakes.



Conclusions

A two year study on metal cycling in Arctic tundra lakes during the spring snowmelt period was initiated in May 2014 in the vicinity of Iqaluit, NU. The first field season involved snow surveying, streamflow and lake sampling, and hydrometric gauging at one nearby lake, and considerable progress was made in developing and refining methods, and overcoming logistical challenge associated with difficult spring snow and ice conditions. Preliminary results show elevated concentrations of THg, MeHg and other trace metals in snowmelt, but limited mixing of snowmelt runoff with the lake water column over the melt period. Our results also demonstrate strong potential to use isotopic and hydrochemical end member mixing analysis to develop mass balance models for lakes during spring melt conditions when hydrometric gauging is difficult to impossible. These methods will be further refined and implemented during the 2015 spring melt season. Finally, considerable progress was made in developing protocols for annual spring snow surveys in collaboration with NRI ETP students and staff, and the contributions of local field assistants to the field activities and planning were indispensible to the success of the 2014 field season.

Expected Project Completion Date

The funding for this two year projected ends on March 31, 2016. Completion of data analysis and manuscript preparation will follow.

Acknowledgements

We thank the NCP for funding to conduct this project. We also thank NRI and NAC ETP staff and students for logistical support and access to facilities including field and laboratory resources. In particular we thank Joeffrey Okalik, Ted Irniq and Steven Lonsdale for their hard work in the field, and Mary Ellen Thomas, Jason Carpenter and Rick Armstrong for their support of the project.

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Polycyclic aromatic compounds, flame retardants and other persistent organic pollutants in Canadian Archipelago air, water and sediment

Composés aromatiques polycycliques, produits ignifuges et autres polluants organiques persistants dans l'air et dans l'eau de l'archipel canadien

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Abstract

The Arctic has been contaminated by legacy organochlorine pesticides (OCPs) and currently used pesticides (CUPs) through atmospheric transport and oceanic currents. From research expeditions conducted between 1993-2013, time trends and air-water exchange of OCPs and CUPs were determined. Compounds determined in both air and water were trans- and cis-chlordanes (TC, CC), trans- and cis-nonachlors (TN, CN), heptachlor exo-epoxide, dieldrin, toxaphene, dacthal, endosulfans and metabolite endosulfan sulfate, chlorothalonil, chlorpyrifos and trifluralin. Pentachloronitrobenzene (quintozene) and its soil metabolite pentachlorothianisole were also found in air. Concentrations of most OCPs declined in

Résumé

L'Arctique est pollué par les pesticides organochlorés hérités du passé et par les pesticides d'usage courant qui s'y sont accumulés par l'entremise du transport atmosphérique et des courants océaniques. Les expéditions de recherche menées entre 1993 et 2013 ont permis d'identifier des tendances temporelles et les mécanismes de circulation entre l'air et l'eau des pesticides organochlorés et des pesticides d'usage courant. Les composés observés dans l'air et l'eau sont le *trans*- et le *cis*-chlordane (TC, CC), *le trans*- et le *cis*-nonachlore (TN, CN), l'heptachlore *exo*-époxide, la dieldrine, la toxaphène, le chlortal-diméthyl, l'endosulfan et métabolite sulfate d'endosulfane, le chlorthalonil, les chlorpyrifos et la trifluraline.

surface water, whereas some CUPs increased (endosulfan-I, chlorothalonil and trifluralin) or showed no significant change (chlorpyrifos and dacthal), while most compounds declined in air. Chlordane compound fractions TC/(TC+CC) and TC/(TC+CC+TN) decreased in water and air, while CC/(TC+CC+TN) and TN/(TC+CC+TN) increased, suggesting selective removal of more labile TC over time and/or a shift in chlordane sources. Water/air fugacity ratios indicated net volatilization (FR >1.0) or near equilibrium (FR not significantly different from 1.0) for most OCPs, but net deposition (FR <1.0) for toxaphene. Net deposition was shown for endosulfan-I on all expeditions, while the net exchange direction of other CUPs varied. Understanding the processes and current state of air-surface exchange helps to interpret environmental exposure, evaluate the effectiveness of International Protocols and provides insights for the environmental fate of new and emerging chemicals.

Des traces de pentachloronitrobenzène (quintozène) et de son métabolite du sol, le pentachloroanisole, ont également été relevées dans l'air. Les concentrations de la plupart des pesticides organochlorés ont diminué dans les eaux de surface, alors que les concentrations de certains pesticides d'usage courant ont augmenté (endosulfan-I, chlorthalonil et trifluraline) ou n'ont pas beaucoup varié (chlorpyrifos et chlortal-diméthyl). Par ailleurs, les concentrations de la majorité des composés chimiques dans l'air ont diminué. Les fractions de composés de chlordane, soit le TC/(TC + CC) et le TC(TC +CC + TN), ont diminué dans l'eau et l'air alors que les composés CC/(TC + CC +TN) et le TN(TC + CC + TN) ont augmenté, ce qui porte à croire que le TC labile a été éliminé de façon sélective au fil du temps ou que les sources de chlordane ont changé. Les ratios d'eau/fugacité dans l'air témoignent d'une volatilisation nette (*FR* > 1,0) d'un état d'équilibre (*FR* s'éloignant peu de 1,0) pour la majorité des pesticides organochlorés, mais d'un dépôt net (*FR* < 1,0) pour la toxaphène. On a relevé un dépôt net de l'endosulfan-I dans le cadre de toutes les expéditions, alors que la direction de l'échange net variait pour les autres pesticides d'usage courant. La compréhension des processus qui sous-tendent l'échange surface-air facilite l'interprétation de l'exposition environnementale et l'évaluation de l'efficacité de protocoles internationaux, et permet de mieux comprendre l'évolution dans l'environnement des produits chimiques nouveaux et émergents.

Key messages

- Concentrations of pesticides that are no longer used declined in Arctic surface water between 1993-2013. This includes compounds such as hexachlorocyclohexanes, chlordanes, heptachlor exo-epoxide , dieldrin and toxaphene.
- In surface waters between 1999-2013 in the Canadian archipelago, some pesticides that are currently being used increased including endosulfans, chlorothalonil and trifluralin

Messages clés

- Les concentrations dans les eaux de surfaces de l'Arctique des pesticides qui ne sont plus d'usage ont diminué entre 1993 et 2013. On compte parmi ces pesticides différents composés, dont l'hexachlorocyclohexane, le chlordane, heptachlore *exo*-époxide, le chlortal-diméthyl et la toxaphène.
- Entre 1999 et 2013, on a observé dans les eaux de surface de l'archipel canadien une augmentation des concentrations de certains pesticides d'usage courant,

while some showed no significant change, this include chlorpyrifos and dacthal.

- Most banned organochlorine pesticides declined in air between 1993-2013.
- Most current use pesticides declined in air between 1999-2013.

dont l'endosulfan, le chlorthalonil et la trifluraline, alors que les concentrations d'autres composés, comme le chlorpyrifos et le chlortal-diméthyl, ont très peu varié.

- Les quantités dans l'air de la plupart des pesticides organochlorés interdits ont diminué entre 1993 et 2013.
- Les quantités de la plupart des pesticides d'usage courant présents dans l'air ont diminué entre 1999 et 2013.

Objectives

1. To develop and continue long term trends of banned and current use pesticides and flame retardants in Canadian Arctic air.
2. To develop and continue long term trends of banned and current use pesticides and flame retardants in Canadian Arctic water.
3. To determine the direction and magnitude of the loadings due to air-water gas exchange of these compounds to the Canadian Arctic.
4. To screen for new and emerging compounds of concern in Canadian Arctic air, water and sediment.

Introduction

The Arctic has been contaminated by legacy organochlorine pesticides (OCPs) and currently used pesticides (CUPs) through the movement of air currents and oceanic water masses. Although CUPs break down more easily than OCPs, they are still found in the Arctic air, water and biota. Between 1993-2013, air and water samples were collected using consistent methods from sub-Arctic and Arctic regions to determine occurrence, levels and distribution of OCPs and CUPs. From this data, the direction and magnitude of loadings of OCPs and CUPs to the Arctic from air-water gas exchange were predicted. Understanding this process is important in order to assess human and environmental exposure, evaluate the effectiveness of International Protocols and in turn provide insight into new and emerging chemicals of concern in the Arctic. OCPs include in this study are chlordanes, dieldrin and toxaphene and CUPs include dacthal, endosulfans, chlorothalonil, chlorpyrifos and trifluralin.

During the past 20 years OCPs in Arctic air (Hung et al. 2010; Ma et al., 2011) and biota (Riget et al. 2010) have generally declined due to national and international restrictions and/or bans on usage. Long-term trends of OCPs at all global air monitoring stations, including those in the Canadian Arctic, indicate that 93% and 71% have half-lives less than 20 and 10 y, respectively (Kong et al. 2014). Atmospheric deposition has been recognized as a large and for OCPs the most important loading mechanism for persistent organic pollutants (POPs) to the world's oceans, including the Arctic Ocean (Jurado et al. 2004; 2005; Lohman et al. 2007). Air-water gas exchange of chemicals is a 'two-way street' and alternates between deposition and volatilization in response to seasonally changing air and water concentrations and temperatures (Hornbuckle et al. 1994; Jantunen et al. 2003). The reduction in air concentrations has led to re-emission of OCPs from the Arctic Ocean, the best example of this is for hexachlorocyclohexanes (HCHs) (Ding et al. 2007; Harner et al., 1999; Jantunen et al., 1995;

1996; 2008; Lakaschus et al. 2002; Wong et al. 2011). Few assessments of gas exchange have been made for OCPs and even fewer for CUPs in the Canadian Arctic.

Activities in 2014-2015

In collaboration with ArcticNet, during the summer of 2014, air, water, suspended water particles and sediment samples were collected from on board the CCGS Amundsen in the Canadian archipelago. These samples have been mostly extracted and are in the process of being analyzed for pesticides (legacy and current use), perfluorinated compounds, flame retardants and polycyclic aromatic compounds. Additionally, passive water samplers were deployed in the Beaufort Sea on oceanographic moorings, these will be left out for a year and retrieved in the summer of 2015.

The ArcticNet renewal proposal lead by Gary Stern to continue research from the CCGS Amundsen was funded for the next three years. The collaboration with ArcticNet is essential to this project as they provide a student stipend, ship time and access to hydrographic and meteorological data that enables the more effectively interpretation of the data generated.

Communications:

- A manuscript detailing the trends in air and water in the Arctic focusing on the Canadian Arctic was submitted to Environmental Science and Technology for publication:
  - Jantunen, L.M., Wong, F., Kylin, H., Helm, P.A., Stern, G.A., Strachan, W.M.J., Burniston, D.A., Bidleman, T.F. Twenty years of air-water gas exchange observations for pesticides in the western Arctic Ocean?, Environmental Science and Technology, 2015, submitted.
- Two other papers were published in peer reviewed journals that contained data generated from NCP funding:
  - Pućko, M., Stern, G.A., Macdonald, R.A., Jantunen, L.M., Bidleman, T.F., Wong, F., Barber, D., Rysgaard, S. The delivery of contaminants to the Arctic food web: why sea ice matters, Science of the Total Environment, 2015, 444–452.
  - Bidleman, T.F., Jantunen, L.M., Hung, H., Ma, J., Stern, G.A., Rosenberg, B., Racine, J. Biannual cycles of organochlorine pesticide enantiomers in Arctic air suggest changing sources and pathways, Atmospheric Chemistry & Physics, 2015, 15, 1411-1420.
- Data resulting from this project was presented at Brominated and Other Flame Retardant Workshop in June 2014 and will be presented at the Society of Environmental Toxicology and Chemistry in November 2015:
  - Liisa Jantunen, Fiona Wong, Terry Bidleman, Monica Pucko, Gary Stern and Hayley Hung, Organophosphate Flame Retardants in the Canadian Arctic.
- A flyer to be distributed to the local communities on our research activities have been created and has been reviewed by NECC, the flyer is being edited to include NECC's comments.

Capacity building:

In February 2014, I visited Iqaluit to present my Arctic work to Nunavut Arctic College. This presentation included a summary my results but also a hands on demonstrations on how air and water are sampled and how the samples are extracted and analysed. Unfortunately the class was canceled in 2015 due to inclement weather conditions. This study is a small component of a much larger ArcticNet project, which has established capacity building and training initiatives. For example, community members are frequently hired to work on the Amundsen as wildlife observers and bear monitors. In the summer of 2014 while on board the Amundsen, my student demonstrated the air, water and sediment collection techniques to the wild-life observers.

Traditional Knowledge:

TK is currently only indirectly related to this project. Given the platform that our sampling takes place on, the CCGS Amundsen and the lack of contact with local communities, applying TK to project is an ongoing challenge. We currently sample in regions of open water, so incorporating ice cover observations as done in the past no longer adds to information for interpretation of results.

Results

The results of organochlorine pesticides (OCPs) and current use pesticides (CUPs) in air and water from the western Arctic from 1993-2013 are shown in Table 1 and Figure 1A-B. Early expeditions took place in the Bering-Chukchi seas (BERPAC-1993) and central Arctic Ocean (AOS-1994). More recent campaigns took place in the Canadian Archipelago (TNW-1999, IPY-2007, IPY-2008, ArcticNet-2010, ArcticNet-2011, ArcticNet-2013), see Table 1.

OCPs in air and water have declined in the Canadian Archipelago between 1999-2013 with few exceptions. The changes in air and water concentrations (C)within the Archipelago were estimated using linear regression of log C versus year (y, $p < 0.05$). Times for 50% decrease were: 4.2 – 5.6 y for trans- and cis-chlordane, trans-nonachlor and endosulfan-II, where dieldrin decreased faster, with a time of 2.5 y and heptachlor epoxide and endosulfan sulphate had very short but significant times of 0.72 and 0.79 y, respectively. Endosulfan-I, chlorothalonil and trifluralin had times to doubling in concentrations of 11 y, 3.5 y and 2.4 y, respectively, while there was no significant change in the concentration of dacthal and chlorpyrifos.

Levels of dieldrin, chlordane, toxaphene and heptachlor epoxide are approaching current detection limits in air and water, toxaphene in 2010-2011 was estimated at <5pg/L and <5pg/m^3 in water and air, respectively. Sampling volumes were increased in 2014 to achieve lower detection limits.

All compounds with sufficient data points for air showed significant declines (y, $p < 0.05$): heptachlor epoxide (8.8 y), trans-chlordane (8.3 y), cis-chlordane (16 y), TN (23 y), dieldrin (5.5 y), endosulfan-I (19 y), dacthal (9.1 y), chlorpyrifos (1.5 y) and pentachlorothioanisole (2.9 y, this is a metabolite of the fungicide pentachloronitrobenzene). Other compounds had lower detection rates and could not be assessed. An interesting note about pentachloronitrobenzene and pentachlorothioanisole is that in December 2010, most uses of pentachloronitrobenzene were phased out in both Canada and the USA. The levels of pentachlorothioanisole in the Canadian Archipelago averaged 0.21±0.11 pg m^{-3} between 2007-2010 where levels dropped in 2011/2013 after the ban, averaging 0.051±0.020 pg m^{-3}. Reduced emissions quickly resulted in reduced levels in Arctic air.

The net direction of air-water gas exchange for the target compounds was indicated by their water/air fugacity ratios, FR = f_W/f_A, calculated from concentrations of compounds in the air and water and the Henry's law constants (adjusted for temperature and salinity). Generally the net exchange direction for OCPs was equilibrium or slight tendency towards volatilization where the CUPs were undergoing deposition with a few excursions towards equilibrium, see Figure 2.

Table 1. Concentrations of OCPs and current-use pesticides in arctic-subarctic regions[a,b], pg L^{-1}; mean and (standard deviation) of positive samples, and positive/total samples.

Expedition	Legacy OCPs						Current-use pesticides					
	Heptachlor Epoxide	trans-Chlordane	cis-Chlordane	trans-Nonachlor	Dieldrin	Toxpahene	Dacthal	Chlorothalonil	Chlorpyrifos	Endosulfan-I	Endosulfan-II	Endosulfan-Su
Water (dissolved), pg/L												
BERPAC-93[c]	3.2 (1.6) 11/11	1.2 (0.84) 11/11	0.87 (0.55), 11/11	0.55 (0.32) 11/11	3.7 (0.62) 9/11	20 (6.1) 11/11	nad	na	na	3.0 (2.2) 11/11	5.3 (2.5) 2/2	na
AOS-94	13 (4.5) 12/12	1.3 (0.52) 12/12	1.2 (0.42) 12/12	0.83 (0.37) 12/12	na	61 (23) 12/12	na	na	na	2.3 (1.1) 12/12	1.2 (1.1) 12/12	na
TNW-99	na	1.3 (0.81) 16/16	1.3 (0.71) 16/16	1.0 (0.79) 16/16	15 (2.7) 6/6[e]	114 (31) 6/6[e]	14 (8.0) 15/16	7.1 (4.0) 15/16	na	1.7 (0.78) 15/16	1.0 (0.26) 16/16	na
IPY-07/08	27 (23) 24/27	0.50 (0.29) 26/27	1.0 (0.26) 26/27	0.52 (0.16) 26/27	30 (9.4) 27/27	ndd	24 (13) 27/27	77 (74) 7/8[f]	19 (14) 18/27	4.7 (1.8) 26/27	2.2 (1.9) 27/27	23 (9.0) 18/27
ArcticNet 2010	0.58 1/6	nd	nd	nd	nd	nd	33(7.4) 6/6	278(111) 3/3	18(2.4) 3/3	4.3(1.5) 6/6	1.6(0.75) 5/6	7.9 (3.1) 6/6
ArcticNet 2011	nd	0.85 (0.22) 3/19	1.9 (0.68) 2/19	0.88 (0.85) 2/19	51 (25) 12/19	nd	11 (3.6) 17/19	1554 (1701) 9/19	16 (17) 15/19	2.7 (0.9) 17/19	0.65 (0.3) 4/19	2 (0.11) 2/19
ArcticNet 2013	nd	nd	nd	nd	nd	nd	4.6 (1.3) 5/5	343 (115)5/5	11 (3.0) 5/5	2.0 (0.58) 5/5	nd	4.3 (1.0) 5/5
Air (gaseous), pg m^{-3}												
BERPAC-93[g]	1.4 (0.26) 7/7	1.1 (0.31) 9/9	0.79 (0.20) 9/9	0.55 (0.14) 9/9	1.1 (0.36) 7/7	4.1 (1.3) 7/7	na	na	na	2.6 (1.5) 9/9[c]	na	na
AOS-94	na	0.45 (0.22) 12/12	0.61 (0.26) 12/12	0.49 (0.17) 12/12	na	na	na	na	na	5.9 (3.7) 12/12	0.11 (0.079) 10/12	na
TNW-99	1.9 (1.9) 28/43	1.0 (0.75) 34/43	1.0 (0.69) 31/43	0.57 (0.38) 32/43	2.2 (0.85) 22/33[h]	19 (8.5) 29/29e	2.1 (1.6) 38/43	0.30 (0.30) 9/19i	na	4.3 (3.7) 35/43	0.31 (0.54) 13/33[h]	na
IPY-07/08	1.9 (0.74) 31/38	0.36 (0.17) 38/38	0.67 (0.21) 38/38	0.53 (0.15) 38/38	3.3 (1.4) 32/38	nd	1.6 (2.1) 37/38	2.9 (2.9) 17/38	1.9 (1.4) 38/38	3.4 (1.5) 36/38	0.52 (0.55) 19/38	0.47 (0.08) 32/38
ArcticNet 2010	nd	0.42 (0.12) 15/17	0.55(0.17) 14/17	0.43(0.14) 15/17	6.1 (2.5) 5/17	nd	0.58(0.17) 17/17	2.0 (0.80) 10/17	0.51(0.21) 15/17	2.0(1.1) 17/17	0.16 (0.08) 5/17	0.64 (1.0) 5/17
ArcticNet 2011	0.51 (0.11) 3/19	0.16(0.07) 18/19	0.39(0.16) 19/19	0.31(0.1) 19/19	0.39 1/19	nd	0.86(0.13) 19/19	1.4(0.08) 2/19	0.26(0.08) 12/19	1.2(0.47) 19/19	0.62 1/19	0.07(0.06) 14/19
ArcticNet 2013	nd	0.12 2/7	0.24 1/7	0.62 1/7	nd	nd	0.24 (0.068) 7/7	nd	1.4 (0.31) 4/7	2.3 (1.3) 7/7	nd	nd

a) Given are the mean and (standard deviation) of positive samples, and positive/total samples.
b) abbreviations: HEPX - heptachlor exo-epoxide, TC, CC = trans-, cis-chlordane, TN = trans-nonachlor, DLD = dieldrin, TOX = toxaphene, DAC = dacthal, CHT = chlorothalonil, CPF = chlorpyrifos, ENDO = endosulfan.
c) Includes two samples collected in the Bering-Chukchi seas during AOS-94.
d) na = not analyzed, nd = not detected (<IDL).
e) east-central Archipelago only.
f) IPY-08 Leg 9 only, west Archipelago - southern Beaufort Sea.
g) Includes two samples collected in the Bering-Chukchi seas during AOS-94, HEPX, DLD and TOX not analyzed in the AOS-94 samples.
h) Resolute Bay, west Archipelago, southern Beaufort Sea only.
i) Resolute Bay only.

Figure 1A-B: A) Air trends for OCPs and CUPs between 1993-2013 in the Canadian arctic, showing arithmetic mean concentrations and standard error. Note: chlorothalonil, chlorpyrifos, endosulfan sulfate, and trifluralin were investigated starting in 2007. B) Temporal trends of legacy and current use pesticides in water in the Canadian Archipelago, pg/L. Chlorothalonil concentrations that are off scale in 2010, 2011 and 2013 are 278, 1554 and 343 pg/L, respectively.

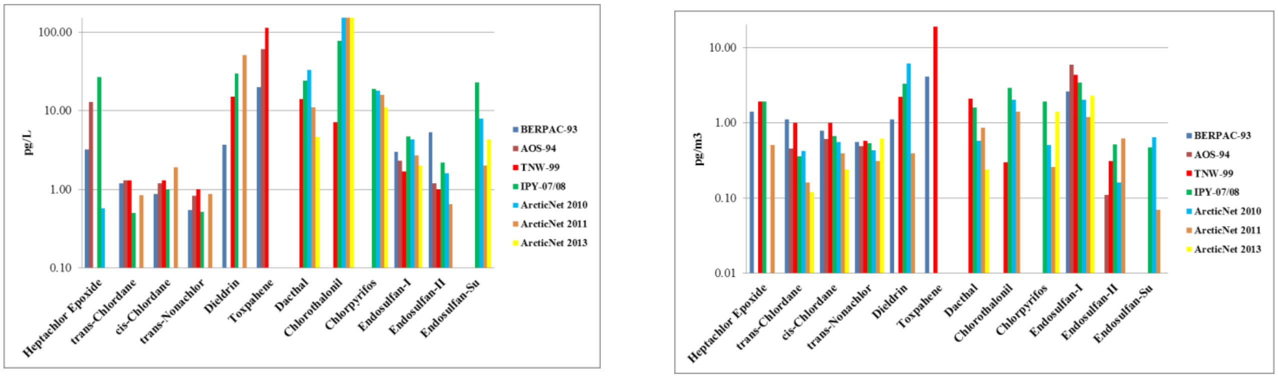
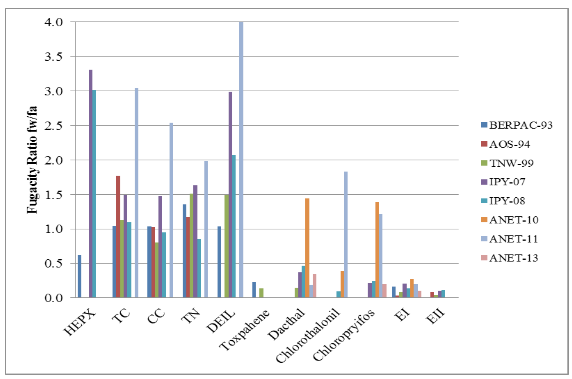


Figure 2: Fugacity ratio for OCPs and CUPs between 1993-2013, where 1.0 is equilibrium, < 1.0 and >1.0 are deposition and volatilization, respectively. Fugacity ratios between 0.7-1.3 are not significantly different from 1.0.



Discussion and Conclusions

National and international regulations have limited the usage of organochlorine pesticides, this has resulted in lower concentrations in Arctic air (this study; Hung et al. 2010; Ma et al. 2011; Kong et al. 2014) and water (this study). These lower levels in water have also resulted in decreasing levels in Arctic biota (Riget et al. 2010). Endosulfan was recently added to the Stockholm convention on persistent organic pollutants, it will be interesting in the coming years to track how the levels in Arctic air and water respond to reduced primary emissions.

Understanding the role of air-water gas exchange and the strength of this process in providing these chemicals to the base of the marine foodweb is vitally important, particularly if diminished sea-ice cover in a warmer Arctic is likely to increase the mobility of these compounds from air to water.

CUPs are more easily metabolized than OCPs but there are ongoing primary emissions of CUPs so the Arctic Ocean continues be to sink for these compounds. A study in 2010 in the Bering-Chukchi seas and Beaufort Sea also found endosulfan was depositing, chlorpyrifos was close to equilibrium or depositing and dacthal was at equilibrium or volatilizing (Zhong et al., 2011).

This project will conditionally continue in 2015-2016. Air and water samples will be collected in the eastern archipelago and the passive sample deployed in the Beaufort Sea in 2014, will be retrieved and re-deployed. Depending on the results of this year's passive water samples, a longer term water monitoring program may be proposed in starting 2016-2017.

Expected Project Completion Date

Extraction and processing of air, water and water particulate taken in 2014 is complete and chemical analysis is on-going. Sediments taken in 2014 have required some method development, the method has gone through all QA/QC procedures, currently the sediments are being extracted and analysis is on-going. This work will be completed by December 2015.

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Influence of climate warming on mercury dynamics in High Arctic lakes

Effets du réchauffement climatique sur la dynamique du mercure dans les lacs de l'Extrême-Arctique

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Abstract

Mercury (Hg) is released to the atmosphere by human activities, mostly in temperate regions, and is transported by prevailing winds to the Arctic. In lakes (and other aquatic ecosystems), microbes transform Hg into methylmercury (MeHg), which bioaccumulates in food webs, resulting in high concentrations in fish. Consumption of contaminated fish is the major source of Hg in humans and wildlife and is detrimental to health. For the NCP-sponsored char "core" monitoring project, we have collected landlocked arctic char (Salvelinus alpinus) from lakes near Resolute Bay, NU, annually for more than 15 years. As the only fish species in lakes that receive contaminants from the atmosphere, these char are good indicators for changing atmospheric inputs of Hg. Concentrations of Hg in char among lakes reflect atmospheric inputs and often exceed the Health Canada value considered safe for subsistence consumption. Over the

Résumé

Le mercure (Hg) émis dans l'atmosphère résulte de l'activité humaine, et ce, principalement dans les régions tempérées, et il est transporté par les vents dominants jusqu'en Arctique. Dans les lacs (et d'autres écosystèmes aquatiques), les microbes transforment le Hg en méthylmercure (MeHg), lequel s'accumule dans les réseaux trophiques, entraînant ainsi des concentrations élevées chez les poissons. La consommation de poissons contaminés est la principale source d'exposition au Hg chez les humains et les animaux sauvages, et s'avère néfaste pour leur santé. Dans le cadre d'un programme de surveillance de l'omble parrainé par le Programme de lutte contre les contaminants dans le Nord (PLCN), on a recueilli des ombles chevaliers (*Salvelinus alpinus*) dulcicoles dans des lacs près de Resolute Bay, au Nunavut, et ce, sur une base annuelle et pendant plus de 15 ans. Seule espèce de poisson vivant dans les lacs arctiques qui sont perturbés par les

entire period sampled, there has been no consistent increase or decrease with time, although a decline post 2005 may be becoming evident. Interestingly, Hg concentrations in char tend to track year-to-year changes in summer air temperature, similar to a pattern observed in SW Greenland. For this study, we are focused on understanding the relationship between Hg and temperature. We have preliminary evidence from our monitoring lakes that temperature increases the production of MeHg in sediment, and we thus hypothesize that this effect increases MeHg concentrations in sediments, sediment-dwelling insects (chironomids), and char that feed on the insects. From 2013 to 2015, we are intensively studying water temperature and MeHg dynamics in four lakes near Resolute Bay. Fieldwork depends on the help of local people in Resolute Bay. We will couple results from this study with monitoring data from char in a bioaccumulation model to better understand and predict how the changing sources of Hg and climate change will influence the accumulation of Hg and associated ecosystem health risks over time.

contaminants atmosphériques, les ombles chevaliers constituent de bons indicateurs des changements dans les apports atmosphériques de Hg. Les concentrations de Hg chez les ombles de différents lacs reflètent les apports atmosphériques, et dépassent souvent la valeur que Santé Canada considère comme étant sans danger dans l'optique d'une consommation à des fins de subsistance. Au cours de la période d'échantillonnage, il n'y a eu ni augmentation, ni diminution constante. On a cependant noté qu'un déclin aurait pu s'amorcer après 2015. Il est intéressant de noter que les concentrations de Hg chez les ombles ont tendance à suivre les fluctuations interannuelles de la température de l'air pendant l'été, un phénomène que l'on a aussi observé dans le sud-ouest du Groenland. La présente étude visait principalement à élucider le lien entre le Hg et la température. Selon les résultats préliminaires obtenus dans le cadre des activités de surveillance des lacs, la température fait augmenter la production de MeHg dans les sédiments, et on peut donc supposer que cet effet entraîne un accroissement des concentrations de MeHg dans les sédiments, chez les insectes vivant dans les sédiments (chironomes) et chez les ombles se nourrissant de ces insectes. De 2013 à 2015, on a étudié de manière intensive la température de l'eau et la dynamique du MeHg dans quatre lacs près de Resolute Bay. La bonne mise en œuvre des travaux sur le terrain dépend de l'aide des membres de la collectivité de Resolute Bay. Nous jumellerons les résultats de la présente étude aux données tirées de la surveillance des ombles chevaliers dans un modèle de bioaccumulation, et ce, afin de mieux comprendre et prévoir l'incidence des sources changeantes de Hg et des changements climatiques sur l'accumulation de Hg, ainsi que les risques connexes pour la santé des écosystèmes au fil du temps.

Key Messages

- We have installed temperature data loggers at many depths in four lakes (Char, Meretta, Resolute, Small) near Resolute Bay, Nunavut.
- The lakes have longer and warmer open water seasons than previously recorded.

Messages clés

- On a installé des enregistreurs de données sur la température à différentes profondeurs dans quatre lacs (Char, Meretta, Resolute et Small) près de Resolute Bay, au Nunavut.

- We are doing research to understand the effects of warmer water temperatures on net Hg methylation and the bioaccumulation of MeHg in lake food webs – including fish.
- Field work is complete for this project is complete, although temperature data loggers were redeployed to the lakes to continue collection of data. Laboratory analyses are ongoing.

- Par rapport au passé, la saison des eaux libres à ces lacs est plus longue, et les températures sont plus élevées pendant cette période.
- On effectue des recherches afin de comprendre les effets du réchauffement de l'eau sur la méthylation nette du Hg et sur la bioaccumulation du MeHg dans les réseaux trophiques lacustres – y compris chez les poissons.
- Bien que les travaux sur le terrain à exécuter dans le cadre de ce projet soient terminés, on a réinstallé des enregistreurs de données sur la température dans les lacs afin de poursuivre la collecte de données. De plus, on continue d'effectuer des analyses en laboratoire.

Objectives

The objective of the proposed research is to determine whether temperature dependence of Hg methylation and demethylation can explain why temporal trends of Hg in arctic char in "NCP focal ecosystem" High Arctic lakes tend to track year-to-year changes in summer temperature.

To accomplish our objective, we are completing the following sub-objectives in four selected lakes (Char, Meretta, Resolute, and Small) on Cornwallis Island:

1. Measure rates of Hg methylation and demethylation in sediments incubated at a range of temperatures (0˚C to 16˚C). These experiments will determine, for the first time, whether Hg methylation and demethylation in arctic lake sediments are temperature dependent.
2. Over an annual cycle:
   - continuously monitor water temperature (including lake bottom)
   - seasonally measure MeHg in sediments and chironomids (sediment-dwelling insects)

These data will be used to continue our effort to monitor climate warming-induced changes in lake thermal regimes and to understand resulting effects on MeHg production in sediment and MeHg concentrations in the primary food item (chironomids) of char from these lakes.

1. Determine, with a bioaccumulation model, whether temperature-associated variation in MeHg concentrations in chironomids can account for temporal trends of Hg in char.

Introduction

Ecosystem changes in focal ecosystem lakes

Arctic lakes are experiencing myriad changes due to climate warming (see review in ACIA 2005). Our focus for this research is on changes to the thermal regimes of lakes on Cornwallis Island.

Data from a pioneering study of arctic limnology can be used to define “reference” conditions for annual temperature cycles of lakes on Cornwallis Island. During 1968 to 1972, two lakes (Char and Meretta) near Resolute Bay (on Cornwallis Is.) were monitored at least monthly for temperature and other physical, chemical, and biological variables (Schindler et al. 1974a, 1974b). Ice covered both lakes for most or all of the annual cycle, and temperatures of the underlying water ranged from 0˚C just below the ice to 2˚C at lake bottom. During a brief (<6 wk) ice-free period in summer, the water column of each lake was isothermal with depth, with maximum temperatures of 4˚C in Char Lake and 7˚C in Meretta Lake. The major source of heat for most lakes (including these ones) is solar radiation (light), and because incident light at lake surface is likely the same for both lakes, the difference in summer temperature between lakes is a function of lake morphometry. Meretta Lake is smaller and shallower than Char Lake. Thus, light is absorbed by a smaller volume of water at Meretta Lake than at Char Lake, and the former heats more rapidly than the latter. Data from this early study were collected during the current period of climate warming (c. 1900-present; Kaufman et al. 2009), but before noticeable effects of warming on Char Lake (Michelutti et al. 2003, Drevnick et al. 2010; see next paragraph).

Recent paleolimnology studies and preliminary monitoring of water temperatures indicate climate warming is pushing these lakes into new steady states. Records of fossil diatoms in sediments from Char Lake (Michelutti et al. 2003) tell the same story as for many other lakes in the circumpolar Arctic (Smol et al. 2005). Generally, increases in annual (and especially summer) air temperatures have lengthened the ice free-season of arctic lakes. Ice limits light available to photosynthetic autotrophs underneath in the unfrozen water, and the loss of summer ice has resulted in a longer growing season. Diatoms (and presumably other algae that are not similarly preserved in sediment) have responded with increases in abundance and diversity. At Char Lake, Michelutti et al. 2003 inferred a significant reduction in summer ice cover post-1980, coincident with an acceleration of climate warming, from a shift in diatom species assemblage. As a result, increased sedimentation of algae has stimulated benthic respiration in profundal sediments (Drevnick et al. 2010). Otherwise, water quality of Char Lake changed little between 1968-1972 and 2000 (Michelutti et al. 2003). The following decade (2001-2010), however, was the warmest on record and 2011 was even warmer: 37 days during June, July, and August had air temperatures that exceeded 10˚C, with an all-time recorded high of 18.7˚C on July 9 (data from Resolute CARS). We were in Resolute Bay during July and August 2011 (for the char monitoring project) and observed that the warm temperatures extended to local lakes. Ice break-up occurred during the first two weeks of July, and water temperatures peaked soon thereafter – exceeding 10˚C in all lakes measured (Char, Meretta, North, Plateau, Resolute, Small). Shallow lakes were isothermal, and deep lakes exhibited thermal stratification. Thus, these recently amictic or monomictic lakes are now dimictic (deep lakes) or polymictic (shallow lakes).

Impacts of these changes on contaminant dynamics in the system, particularly how change might influence levels and trends in key monitoring species

The focus of our work is Hg in landlocked arctic char in High Arctic lakes. Led by Muir and Köck, our team has collected landlocked char from lakes on Cornwallis Island, as a well as from Lake Hazen on Ellesmere Island, annually for more than 15 years. As the only fish species in lakes that receive contaminants from the atmosphere, these char are “good indicators for changing atmospheric inputs of contaminants” (NCP blueprint). Concentrations of Hg in char among lakes reflect atmospheric inputs (i.e., there is a positive relationship with the watershed-to-lake area ratio) and often exceed the Health Canada value considered safe for subsistence consumption (Gantner et al. 2010a). Over the entire period sampled, there has been no consistent increase or decrease with time, although a decline post 2005 may be becoming evident (Derek Muir, personal communication).

Interestingly, Hg concentrations in char tend to track year-to-year changes in summer air temperature. Additional annual sampling is needed to confirm this relationship, but the same trend (i.e., peak Hg concentrations coincide with warm summers) has been reported for landlocked char in a lake in southwest Greenland (Riget et al. 2010). These studies fit remarkably well with a hypothesis put forth by Wang et al. (2010) that once an environmental reservoir (e.g., lake and watershed) reaches a critical influx of Hg, additional influx becomes secondary to recycling of "legacy" Hg in driving bioaccumulation. Concentrations of Hg in biota reflect changes in biogeochemical processes that (re)cycle Hg.

Activities in 2014-2015

<u>Sub-objective 1</u> – Measure rates of Hg methylation and demethylation in sediments incubated at a range of temperatures (0-16C)

<u>Progress on 1:</u> We incubated sediments during August 2013, exactly as stated in our proposal. Sediments were freeze dried, analyzed for org C, total Hg, and will be analyzed for Hg isotopes and MeHg at the Ultra-Clean Trace Elements Laboratory at the University of Manitoba.

<u>Sub-objective 2</u> – Over an annual cycle: (a) continuously monitor water temperature and (b) seasonally measure MeHg in sediments and chironomids

<u>Progress on 2a:</u> In August 2012, we deployed temperature data loggers, on "thermistor strings", in two deep lakes (Char and Resolute) and two shallow lakes (Meretta and Small). Each lake had one thermistor string set at the deepest spot. We have now recovered two years of temperature data from Char Lake, Meretta Lake, and Small Lake. We are grateful to Steve Kessel, U. Windsor, who recovered the thermistor string from Char Lake in 2014 after our fieldwork was complete. Resolute Lake has proven difficult for recovery of thermistor strings, because of ice cover during our field work in 2013 and 2014, but each year we deployed additional thermistor strings to this lake so we will have a complete temperature record by combining data from the three strings.

<u>Progress on 2b:</u> Lake waters, sediments, and chironomids were collected in August 2013 and August 2014. Unfortunately, budget restraints only allowed for annual sampling campaigns. Analyses completed or in progress include: (1) lake water: total Hg (completed), MeHg (completed), general water chemistry (completed at NLET); (2) sediment pore water: total Hg (completed), MeHg (completed), DOC (completed); (3) sediment solid phase: total Hg (completed 2013, in progress 2014), MeHg (in progress 2013 and 2014), org C (completed); (4) chironomids: identification and enumeration (completed), MeHg (to be completed).

<u>Sub-objective 3</u> – Determine, with a bioaccumulation model, whether temperature-associated variation in MeHg concentrations in chironomids can account for temporal trends of Hg in char.

<u>Progress on 3:</u> To "dissect" the relationship between Hg in char and temperature, we constructed a bioaccumulation model, with rates of uptake and loss that change with temperature. MeHg comprises nearly 100% of Hg in char, and it was the only form considered in the model:

$$C_t = \frac{k_f C_f + k_w C_w}{k_e + k_g}\left(1 - e^{-(k_e+k_g)t}\right) + C_0\, e^{-(k_e+k_g)t}$$

where C_0 is the initial MeHg concentration in the char and C_t is the concentration after

image from MRNF du Québec

duration t; C_f and C_w are MeHg concentrations in food and water, respectively; k_f and k_w are rate constants for uptake of MeHg via food and water, respectively; and k_e and k_g are rate constants for loss of MeHg via elimination and growth dilution (not a true loss, but represented as such), respectively. Values for concentrations (C_0, C_f, C_w) are from our empirical data (e.g., Gantner et al. 2010b). Mathematical functions (not shown) for rate constants are from the literature (Gobas 1993, Trudel and Rasmussen 1997, Gewurtz et al. 2006; assimilation efficiencies from Hrenchuk 2010).

Runs of the model yielded two key insights. First, if temperature is the only variable adjusted, MeHg concentrations in char change little. Increased metabolism from elevated water temperatures has little effect on bioaccumulation. This finding contrasts with that of other metals (e.g., Cd and Pb) for which temperature significantly enhances bioaccumulation because increased gill ventilation rates increase uptake of water (Köck et al. 1996). Concentrations of MeHg in natural (unpolluted) waters, such as our study lakes, are very low (parts-per-trillion to parts-per-quadrillion), and thus uptake of MeHg from water (even with high gill ventilation rates at elevated temperatures) is generally considered negligible (e.g., Trudel and Rasmussen 2006). In all runs of our model, <1% of the MeHg accumulated was from uptake via water. Uptake via food accounted for the other >99%, and increases in ingestion rate at elevated temperatures resulted in the modest effect of temperature on bioaccumulation. Second, if MeHg concentration of food is adjusted, bioaccumulation by char is highly responsive. For example, a doubling of MeHg concentration in food (especially at elevated temperatures) can account for the increases in MeHg concentrations in char observed at Resolute and Char Lakes. Thus, changes in lake/watershed processes that result in more MeHg in food are likely the reason MeHg concentrations in char tend to track year-to-year trends in summer temperature.

Capacity Building: The project depends on the help of local people from Resolute Bay. Since 2005, Debbie Iqaluk has worked on the char "core" monitoring project, enabling the collection of char from all targeted lakes on Cornwallis Island in a wide range of weather and ice conditions. In 2014, AANDC, PCSP, and NRI also arranged for Joeffrey Okalik, student in the Environmental Technology Program of Nunavut Arctic College, to contribute to field work. Joeffrey sampled sediment, water, and biota (bugs and fish) and processed samples in the laboratory.

Communications: Preliminary results from this project have also been presented at many venues: The 2013 Gananoque Environmental Science and Engineering Conferences (Gananoque ON) (platform), the 2013 Arctic Workshop (Amherst, MA, USA) (poster), the 2013 GSA Northeastern Section Meeting (Bretton Woods, NH, USA) (platform), the 2013 Ontario – Québec Paleolimnology Symposium (Ottawa ON) (poster), the 2013 Annual NCP Results Workshop (Ottawa ON) (platform), the International Arctic Change Meeting, Ottawa, ON (poster), and the University of Michigan, School of Natural Resources and Environment, Conservation Ecology Series, Ann Arbor, MI, USA (platform).

Traditional Knowledge Integration: Sample collections rely on the knowledge and experience of local people working on the project, as has been true for the char "core" monitoring project for a number of years.

Results and Discussion

Sub-objective 1 – Measure rates of Hg methylation and demethylation in sediments incubated at a range of temperatures (0-16C)

Progress on 1: We have analyzed incubated sediments for org C and total Hg (results not shown), but analyses of Hg isotopes and MeHg are yet to be completed. Hudelson will complete these analyses at the Ultra-Clean Trace Elements Laboratory at the University of

Manitoba. Our original test incubation with sediments from Small Lake (Fig 4 in the 2013-14 proposal) suggests we will see a significant effect of temperature on Hg methylation.

For the sediment incubations, we also measured dissolved inorganic carbon (DIC) pre- and post-incubation to study the effect of temperature on organic carbon mineralization. The primary product of organic carbon mineralization is CO_2, which we can measure as DIC. MeHg can also be produced (from Hg) as a consequence of this process. In all lakes, we saw an increase in DIC production with temperature, but the data are highly variable and result in non-significant results. The high variability may have been due to our lack of ability to remove all head space from the incubation vials. Fine tuning of methods is necessary.

Sub-objective 2 – Over an annual cycle: (a) continuously monitor water temperature and (b) seasonally measure MeHg in sediments and chironomids

Progress on 2a: We have now recovered two years of temperature data from Char Lake (Fig 1), Meretta Lake (Fig 2), and Small Lake (Fig 3), for a total of 121,305 data points. In August 2012, temperature profiles from the lakes aligned well with our hypothesis that during warm summers, shallow lakes (Meretta, Small) would warm to temperatures >10C, but be isothermal, whereas in deep lakes (Char) thermal stratification would occur, with warm surface waters and cold bottom waters. Following this warm summer, in all three lakes rapid cooling occurred and the lakes were ice covered beginning early September. 2013 had a cool summer and water temperatures in all of the lakes did not exceed 6C. We observed Meretta and Small Lakes fully lose ice cover in August 2013, but Char and Resolute were at least partially ice covered for all of 2013. Water temperatures during winter 2013-2014 were warmer during the previous winter, because of record low snow cover (according to weather data), and thus light penetrated through the ice (except during December to February). 2014 also had a cool summer and ice was present on the lakes during our sampling trip in July and August.

Progress on 2b: The results from lake water and sediment pore water from 2014 are in Tables 1 and 2. Interpretations from these data (i.e., whether differences with 2013 data are temperature related) would be premature, without data from sediment incubations (sub-objective 1) and data from chironomids.

Sub-objective 3 – Determine, with a bioaccumulation model, whether temperature-associated variation in MeHg concentrations in chironomids can account for temporal trends of Hg in char.

Progress on 3: This objective can only be accomplished once we have a complete dataset from the study. Once we have the data, it will be put into the bioaccumulation model to model the effect of temperature on Hg concentrations in char. The bioaccumulation model has already been useful, however, in forming hypotheses and in examining trends in Hg data from the char monitoring project. Importantly, coupling of the elimination portion of the bioaccumulation model with temperature data from the thermistors indicates that it is possible that a decrease in Hg concentration from one year to the next could really occur (i.e., not be a sampling artifact).

Expected Project Completion Date

We expect to complete all lab work by end of summer 2015. Data analysis, interpretation, and writing of manuscripts (three expected) will follow, to be completed by the end of 2016.

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Fig 1. Two years (Aug 2012-Aug 2014) of data from thermistor string deployed in Char Lake.

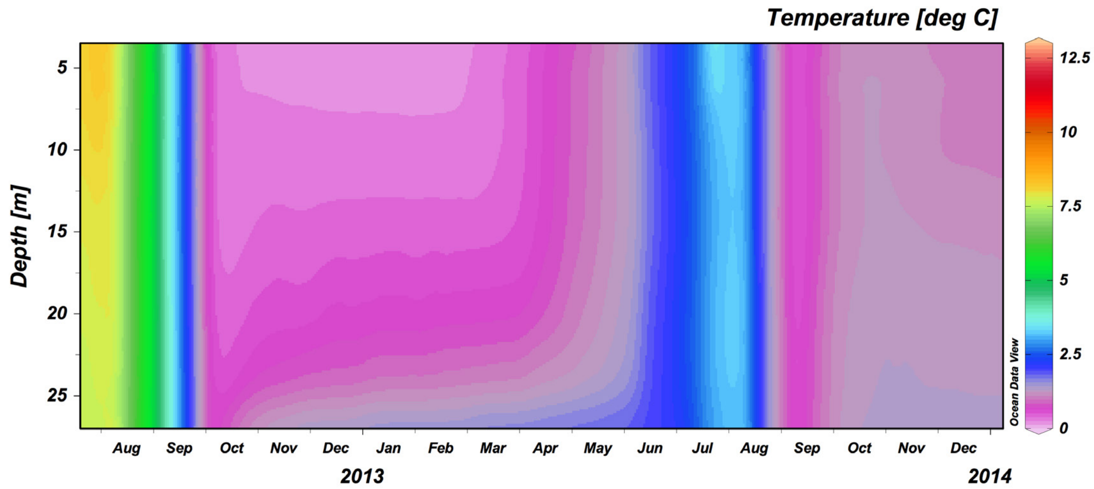

Fig 2. Two years (Aug 2012-Aug 2014) of data from thermistor string deployed in Meretta Lake.

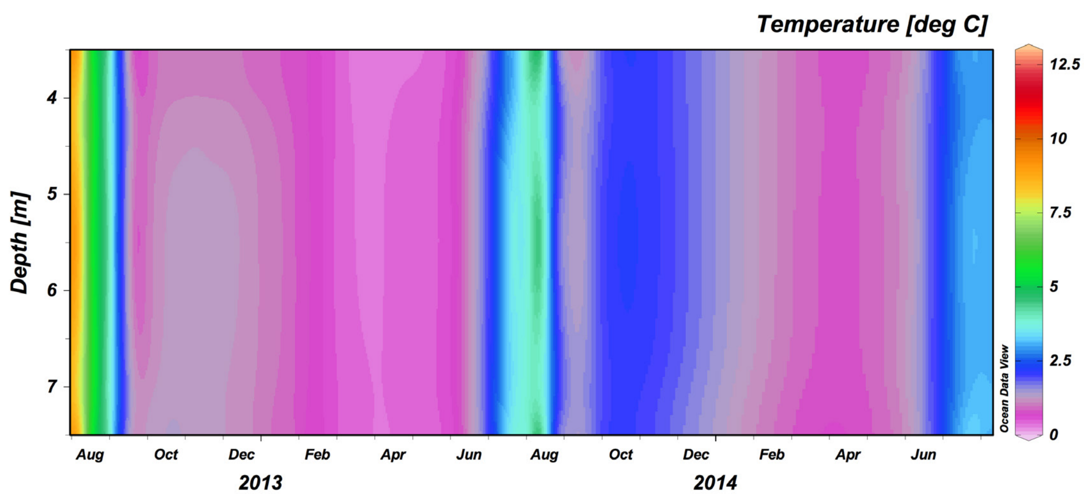

Fig 3. Two years (Aug 2012-Aug 2014) of data from thermistor string deployed in Small Lake.

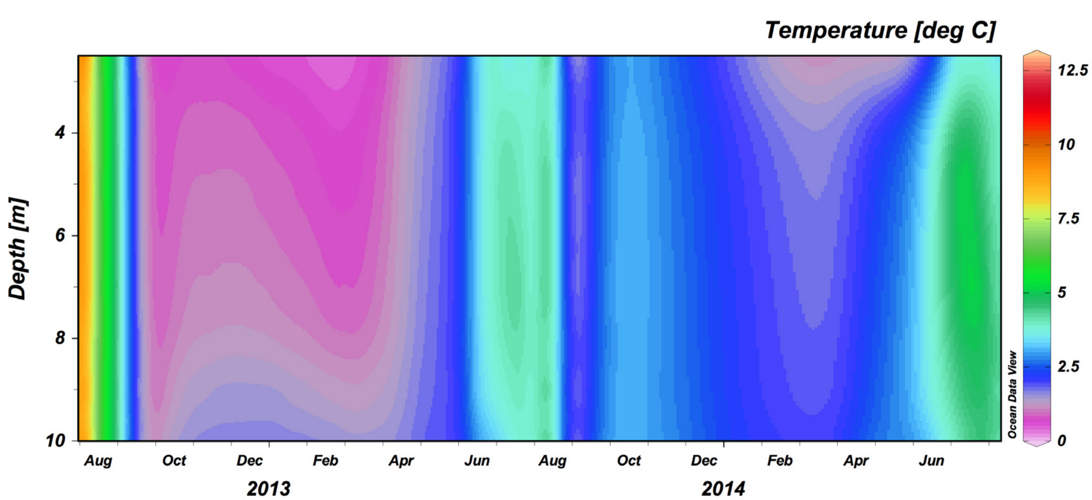

Table 1. Total Hg and methylmercury (MeHg) in surface waters collected from lakes on Cornwallis Island, August 2014. Surface waters were collected with a Niskin sampler (General Oceanics).

Lake	Sample ID	Total Hg (ng/L)	MeHg (ng/L)
Char	A	0.64	0.011
	B	0.35	0.009
Meretta	A	0.97	0.049
		0.80	0.052
Resolute	A	0.56	0.010
	B	0.65	0.016
Small	A	0.99	0.044
	B	0.84	0.042

Table 2. Total Hg, methylmercury (MeHg), and dissolved organic carbon (DOC) in sediment porewater (0-5 cm) collected from lakes on Cornwallis Island, August 2014. Porewaters were collected from intact sediment cores with Rhizons (Rhizosphere Research Products).

Lake	Core ID	Total Hg (ng/L)	MeHg (ng/L)	DOC (mg/L)
Char	A	3.96	0.499	6.4
	B	2.99	0.157	2.1
	C	3.01	0.289	1.5
Meretta	A	4.09	0.224	3.8
	B	3.30	0.195	3.9
	C	4.09	0.137	3.7
Resolute	A	3.12	0.164	4.7
	B	3.76	0.150	3.1
	C	3.61	0.102	3.7
Small	A	3.79	0.217	4.8
	B	3.83	0.250	4.9
	C	4.17	.	4.9

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Winter atmospheric loadings and springtime runoff of mercury and perfluorinated chemicals to a pristine high Arctic watershed in Quttinirpaaq National Park, Northern Ellesmere Island, Nunavut

Charges de contaminants atmosphériques en hiver et ruissellement printanier de mercure et de composés perfluorés vers un bassin hydrographique vierge dans l'Extrême-Arctique, dans le parc national du Canada Quttinirpaaq, au nord de l'île Ellesmere, au Nunavut

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Abstract

The high Arctic continues to receive a wide range of contaminants released by human activities in more southerly latitudes and industrialized nations around the world. Thankfully, due to emission regulations and bans in their usage, concentrations of certain legacy contaminants have been declining in the high Arctic. However, a number of contaminants such as mercury (Hg), as well as new, emerging and yet unregulated persistent organic pollutants (POPs), such as certain poly- and perfluorinated alkyl substances (PFASs), continue to be of priority

Résumé

L'Extrême-Arctique continue de recevoir un vaste éventail de contaminants, lesquels sont libérés par les activités humaines menées à des endroits situés à des latitudes méridionales inférieures et dans différents pays industrialisés dans le monde. Heureusement, la réglementation des émissions atmosphériques et les interdictions touchant leur utilisation ont permis de réduire les concentrations de certains contaminants hérités du passé dans l'Extrême-Arctique. Toutefois, bon nombre de contaminants comme le mercure (Hg) et les polluants organiques persistants

concerns. Furthermore, it now appears that climate change is also influencing the long-range transport, fate and bioaccumulation of contaminants like Hg and POPs in the Arctic. We are quantifying contaminant loadings in snowpacks and meltwater, water quality and climate change impacts in the pristine Lake Hazen watershed, Quttinirpaaq National Park, Northern Ellesmere Island, Nunavut. From a socio-economic perspective, understanding present-day contaminant loadings, water quality and climate change impacts is important for predicting how the abundances and quality of certain organisms used as Inuit traditional foods may be altered by future human activities. We found high concentrations of total mercury (THg; all forms of Hg in a sample), methylmercury (MeHg; the toxic and bioaccumulating form of Hg) and PFASs in snowpacks. Most of the THg and MeHg was bound to particles in the snow. Concentrations of THg, MeHg and PFASs in snowmelt runoff initially resembled those found in certain snowpacks, but declined over time as particles settled out. Snow meltwater inputs to Lake Hazen from the lake surface and the surrounding landscape more than doubled concentrations of THg, MeHg and PFASs in surface waters. Concentrations of MeHg increased slightly in zooplankton following snowmelt. This occurred when there was a spring pulse of biological activity under the lake ice.

(POP), nouveaux ou émergents et qui ne sont pas encore réglementés, comme les composés perfluoroalkyles, font toujours l'objet de préoccupations majeures. De plus, il semble maintenant que les changements climatiques aient également une incidence sur le transport à grande distance, l'évolution dans l'environnement et la bioaccumulation de contaminants, comme le Hg et les POP, dans l'Arctique. Nous procédons à une surveillance des charges de contaminants dans le manteau neigeux et les eaux de fonte, de la qualité de l'eau et des répercussions des changements climatiques dans le bassin hydrographique vierge du lac Hazen, dans le parc national du Quttinirpaaq et dans le nord de l'île d'Ellesmere, au Nunavut. D'un point de vue socioéconomique, il est important de comprendre les charges de contaminants, la qualité de l'eau et les incidences des changements climatiques afin de prédire comment les activités humaines futures pourraient nuire à l'abondance et à la qualité de certains organismes utilisés comme aliments traditionnels par les Inuits. Nous avons observé des concentrations élevées de mercure total (THg; toutes les formes de mercure dans un échantillon), de méthylmercure (MeHg; la forme toxique et bioaccumulable du Hg) et de composés perfluoroalkyles dans le manteau neigeux. La majorité des molécules de THg et de MeHg étaient fixées à des particules dans la neige. Si les concentrations de THg, de MeHg et de composés perfluoroalkyles dans les eaux de fonte étaient à l'origine similaires à celles observées dans certaines parties du manteau neigeux, elles ont diminué avec le temps, alors que les particules disparaissaient. L'apport d'eau de fonte dans le lac Hazen depuis la surface du lac et les milieux environnants a accru de plus de deux fois les concentrations de THg, de MeHg et de composés perfluoroalkyles dans les eaux de surfaces. Les concentrations de MeHg ont légèrement augmenté dans le zooplancton après la fonte des neiges. Ce phénomène est survenu alors que l'activité biologique printanière augmentait sous les glaces lacustres.

Key messages

- Concentrations of THg, MeHg and PFASs were much higher in "dirty" snowpacks than in snowpacks with much fewer particles. Approximately 95% of the THg and 80% of the MeHg was bound to particles.
- Concentrations of THg, MeHg and PFASs in snowmelt runoff from the landscape initially resembled concentrations in the light snowpack on the surface of Lake Hazen, but declined to much lower concentrations by early June, suggesting that most of the particle-bound contaminants coming off the landscape settled out quickly and were not delivered to Lake Hazen
- Snow meltwater inputs to Lake Hazen from the lake surface and the surrounding landscape more than doubled concentrations of THg, MeHg and PFASs in surface waters. This occurred when there was a spring pulse of biological activity under the lake ice.
- Concentrations of MeHg in zooplankton increased slightly after snowmelt inputs. Results for PFASs in zooplankton are pending.

Messages clés

- Les concentrations de THg, de MeHg et de composés perfluoroalkyles étaient beaucoup plus élevées dans les parties « sales » du manteau neigeux que dans celles contenant moins de particules. Environ 95 % des molécules de THg et 80 % des molécules de MeHg étaient fixés à des particules.
- Les concentrations de THg, de MeHg et de composés perfluoroalkyles présents dans les eaux de fonte et provenant des milieux environnants étaient à l'origine similaires à celles observées à la surface du lac Hazen là où le manteau neigeux était plus mince. Toutefois, le déclin beaucoup plus prononcé de ces concentrations que l'on a observé au début juin porte à croire que la majorité des contaminants fixés à des particules provenant des milieux environnants ont disparu rapidement et n'ont pas migré vers le lac Hazen.
- L'apport d'eau de fonte dans le lac Hazen depuis la surface du lac et les milieux environnants a accru de plus de deux fois les concentrations de THg, de MeHg et de composés perfluoroalkyles dans les eaux de surfaces. Ce phénomène est survenu alors que l'activité biologique printanière augmentait sous les glaces lacustres.
- Les concentrations de MeHg ont légèrement augmenté dans le zooplancton suivant l'apport d'eaux de fonte. On attend toujours d'obtenir les résultats d'analyse du zooplancton visant à détecter la présence de composés perfluoroalkyles.

Objectives

The objectives of our project were four-fold. We quantified:

1. net areal winter (September-May) atmospheric loadings of THg, MeHg and PFASs to a pristine high Arctic watershed;
2. concentrations of THg, MeHg and PFASs in snowmelt runoff in a pristine high Arctic watershed;
3. increases in THg, MeHg and PFASs concentrations in a pristine high Arctic lake due to snowmelt runoff inputs;
4. bioaccumulation of THg, MeHg and PFASs into the base of the foodweb (algae and zooplankton) during the spring pulse of production that occurs under lake ice during the snowmelt runoff period.

Introduction

The high Arctic unfortunately continues to receive a wide range of contaminants released by human activities in more southerly latitudes and industrialized nations around the world (Canadian Arctic Contaminants Assessment Report III a and b). The majority of these contaminants are known to bioaccumulate in organisms, and biomagnify as they make their way up the food web to concentrations that may be of concern to human health in organisms that are used as traditional country foods. The atmosphere is a primary source of contaminants to Arctic terrestrial and freshwater ecosystems, and atmospheric deposition is a key mechanism by which contaminants enter these sensitive ecosystems. This is particularly true for persistent organic pollutants (POPs) but also for Hg (Canadian Arctic Contaminants Assessment Report III a and b). Because of the Arctic's cold climate, atmospherically deposited contaminants initially accumulate in snowpacks during the long winter before being transferred to downstream water bodies during spring melt. Thankfully, due to emission regulations and bans in their usage, concentrations of certain legacy contaminants have been declining in the high Arctic (Canadian Arctic Contaminants Assessment Report III a and b). However, certain contaminants such as Hg, as well as new, emerging and yet unregulated PFASs, continue to be of priority concerns.

Lake Hazen is situated in Quttinirpaaq National Park on northern Ellesmere Island. With a surface area of 540 km^2 and maximum depth of 267 m, it is the world´s largest lake north of 74° latitude. Lake Hazen, with a watershed area of ~8,400 km^2, is fed by multiple glacial inflows and drained by the Ruggles River. Lake Hazen is extremely nutrient poor, with low algae and zooplankton productivity. Arctic char (*Salvelinus alpinus*) is the only fish species in the lake. Lake Hazen's remote location within a protected National Park makes it *THE* ideal lake for monitoring both past and future changes in water quality in Arctic lakes because there are no direct human impacts on the watershed itself, nor will there be as long as the National Park exists. As a result, any changes in water quality are the result of long-range transport of contaminants or nutrients to the Lake Hazen watershed from distance sources, and/or global climate change. For example, glaciers in the Lake Hazen watershed may store a legacy of pollutants that were historically deposited there, but these pollutants are likely now being released due to recent accelerated glacial melt (Gardner et al. 2011). Surprisingly, though, very little historical or present-day data water quality data exist for Lake Hazen.

There were four goals to our 2014 research program.:

1. quantify net areal winter (September-May) atmospheric loadings of THg, MeHg and

PFASs in snowpacks in the lake Hazen watershed;

2. quantify concentrations of THg, MeHg and PFASs in snowmelt runoff into Lake Hazen;
3. quantify increases in THg, MeHg and PFASs concentrations in Lake Hazen due to snowmelt runoff inputs;
4. quantify bioaccumulation of THg, MeHg and PFASs into the base of the Lake Hazen foodweb (algae and zooplankton) during the spring pulse of production that occurs under lake ice during the snowmelt runoff period.

Activities in 2014-2015

We conducted our research in Quttinirpaaq National Park from 12 May to 4 June in 2014

Goal 1: To quantify the net areal atmospheric loadings of THg, MeHg and PFASs to the Lake Hazen watershed during winter, we collected integrated snowpack samples for concentration analyses of these contaminants and general water chemistry, as well as measured the water equivalence of the snowpack and the snowpack depth distribution at our sites. There was little snow on the landscape at Lake Hazen in 2014. As a result, we were only able to sample the snowpack at 9 sites on the surface of Lake Hazen itself. However, approximately half the snowpack on the lake contained heavy loads of particulate matter, which we called 'dark snow,' so at each site, we collected snow from both light and dark regions. Standard clean field sampling protocols were used to collect all snow samples. Snow samples were returned south frozen, where they were subsequently thawed, processed and analyzed using standard protocols. All general water quality analyses were completed in the University of Alberta Biogeochemical Analytical Service Laboratory (BASL). Snow meltwater samples collected for THg and MeHg analyses were analyzed in the internationally intercalibrated University of Alberta BASL Class-100 Low-level Hg Analytical Unit using standard EPA protocols. PFASs were determined using standard protocols at the Canadian Centre for Inland Waters (CCIW) laboratory under clean room conditions (Class 10000 equivalent lab with carbon/HEPA air filtration).

Goal 2: To quantify concentrations of THg, MeHg and PFASs in snowmelt runoff in the Lake Hazen watershed, we collected runoff samples every 3 days from the mouth of the Snow Goose River, Blister Creek and Skeleton Creek during the snowmelt period and prior to the start of glacial melt. Snow Goose River is representative of the larger sub-catchments, Blister Creek is representative of a smaller sub-catchment, whereas the Skeleton Creek is representative of small overland flow sub-catchments. All runoff water samples collected for contaminants and general water chemistry analyses were immediately processed onsite in the Lake Hazen/Quttinirpaaq Field Laboratory clean room, and subsequently analysed as described above for snow meltwater.

Goal 3: To determine the impact of snowmelt and runoff on contaminant loadings to Lake Hazen, we did detailed sampling of the Lake Hazen water column in mid May prior to snowmelt and early June following snowmelt while the lake ice was still safe enough to sample from. Sampling was done at the deepest point in Lake Hazen (~260 meters). We initially deployed a YSI EXO2 sonde with dissolved O_2, pH, conductivity/temperature and total algae sensors to determine transition zones in the water column. We then sampled using an acid-cleaned 12 L niskin bottle at ~15 discrete depths, sampling the upper and lower transition zones more intensely, for THg, MeHg, PFASs and a complete suite of water chemistry as described above for the runoff samples. All water samples were collected, processed and analyzed as described above for snowmelt runoff.

Goal 4: We collected zooplankton in the top 75 meters of the watercolumn both before and after snowmelt inputs to Lake Hazen for analyses of MeHg and PFASs to determine if contaminants in snowmelt rapidly bioaccumulate into the lower levels of the aquatic food web during the spring pulse of biological activity in Lake Hazen. Zooplankton were stored frozen in appropriately clean containers until they were freeze-dried and analyzed.

Capacity Building and Communications:

We conducted our research in Quttinirpaaq National Park from 12 May to 4 June in 2014. Unfortunately Parks Canada employees, most of which are from northern communities, did not enter the Park until after our departure, so we were not able to directly involve them in our field-sampling program as we did in past years. However, we were able to conduct numerous other forms of capacity building and communications, as follows:

- Our Parks Canada field report was translated into Inuktitut and submitted to the Joint Parks Management Committee;
- We continued filming our field activities in Quttinirpaaq National Park for the production of our short documentary. We now have over 25 hours of footage;
- We attended the Arctic Change Conference (8-12 December 2014, Ottawa Ontario). Arctic scientists from around the world (including may other NCP researchers), employees of AANDC and northern community residents, to name a few, attended this diverse conference. At the conference, we presented the results from our 2012-2014 NCP-funded research programs.
- We have begun arranging with Jamal Shirley a public lecture in Iqaluit and presentation to the Arctic College Environmental Training Program in March 2016. The presentation will be focused on general contaminant cycling in the Arctic, highlighting Hg as well as some of the emerging contaminants of concern (e.g., PFASs), and some of the specialized techniques that scientists use to understand this cycling.
- Over the course of a week in May 2014, Igor Lehnherr participated in knowledge exchange with a resident from Resolute Bay (Peter Amaraulik) for sampling contaminants (including mercury and perfluorinated chemicals), to increase capacity building and provide basic training for setting up a community based monitoring program.

Traditional Knowledge Integration:

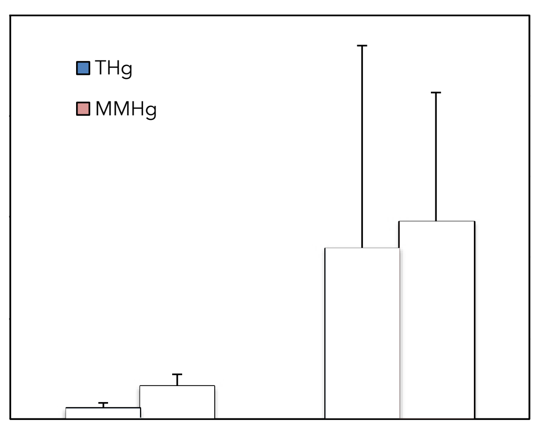
Our research and hypotheses are based on traditional knowledge, and are currently aligned with observations that Arctic Elders are making regarding the changing arctic climate. For example, our NCP research is based on the changes in lake ice cover, productivity in lakes and increase glacial melt that the Arctic Elders are witnessing, as described, for example, in the proceedings of an *Arctic Elders Conference on Climate Change*, hosted by Nunavut Tunngavik Incorporated in Cambridge Bay, Nunavut in 2001.

Results

We are happy to report that all four of our research goals were more-than successfully met! Below we describe some of our exciting results, and the initial interpretations of them.

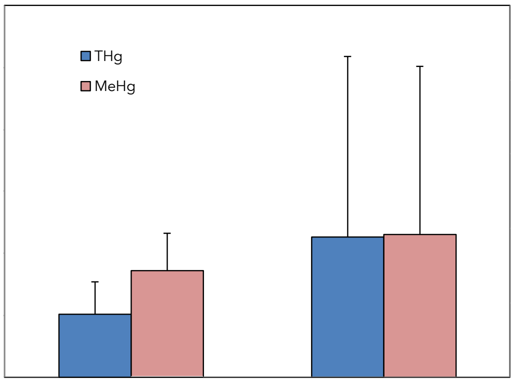
Goal 1: Concentrations of THg and MeHg were much higher in the dark regions of the snowpack than the light regions (Figure 1). Approximately 95% of the THg and 80% of the MeHg was bound to particles.

Figure 1: Mean concentrations of THg and MeHg in light and dark regions of snowpacks on the surface of Lake Hazen, May 2014 (n=18; ± 1 SD).



Loadings of both THg and MeHg were also higher in the dark snowpacks than in the light ones, emphasizing the importance of particle-bound Hg to winter watershed loadings in the high Arctic (Figure 2).

Figure 2: Mean loadings of THg and MeHg in light and dark regions of snowpacks on the surface of Lake Hazen, May 2014 (n=18; ± 1 SD).



Goal 2: Because there was little snow on the landscape, snowmelt runoff volume was low in late May/early June 2014. Concentrations of THg and MeHg in snowmelt runoff from the landscape initially resembled concentrations in the light snowpack on the surface of Lake Hazen, but declined to much lower concentrations by early June, suggesting that most of the particle-bound Hg coming off the landscape settled out quickly and was not delivered to Lake Hazen (Figure 3).

Figure 3: Mean concentrations (n=2) of MeHg and THg in snowmelt runoff from Skeleton Creek, Blister Creek and the Snowgoose River (± 1 SD).

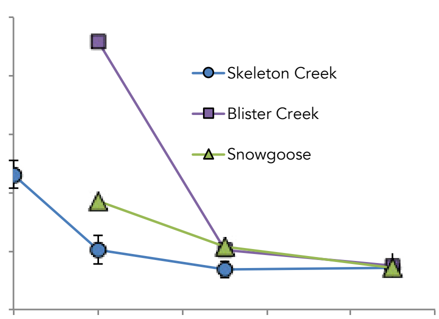
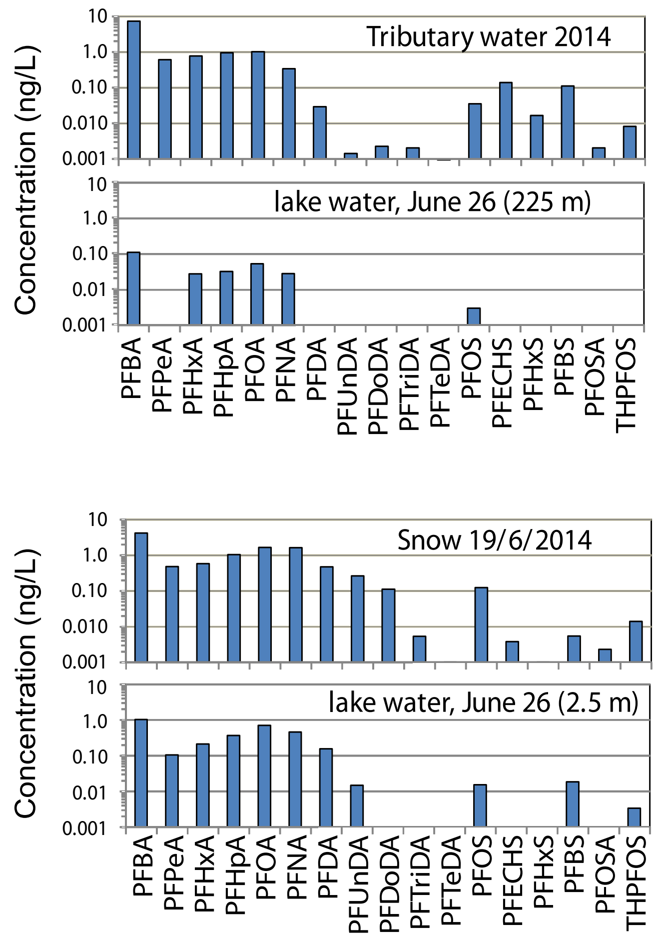


Figure 4 shows average concentrations for individual PFASs in tributary waters and snow from 2014 as well as at 2.5 m and 225 m in Lake Hazen on June 26th. The major PFCA entering the lake is PFBA, a degradation product of short chain PFASs. The profile at 225 m differs from the snow and tributary water by having 10 to 100x lower concentrations and fewer detectable compounds particularly for the perfluoroalkyl sulfonates (PFECHS, THPFOS, etc.) and longer chain PFCAs (PFDA, PFUnDA). These latter compounds are more likely to be sorbed to suspended particles and may be removed by sedimentation.

Figure 4: Concentrations for individual PFASs in tributary waters and snow from 2014 as well as at 2.5 m and 225 m in Lake Hazen of major PFCAs in snowmelt



Goal 3. Snow meltwater inputs to Lake Hazen from the lake surface and the surrounding landscape more than doubled concentrations of THg and MeHg in surface waters (Figure 5). This occurred when there was a spring pulse of biological activity under the lake ice.

Figure 5: Mean water column concentrations (n=2) of MeHg in Lake Hazen both before and after snowmelt runoff in 2014, as well as surface concentrations of MeHg before and after snowmelt in 2014 (± 1 SD).

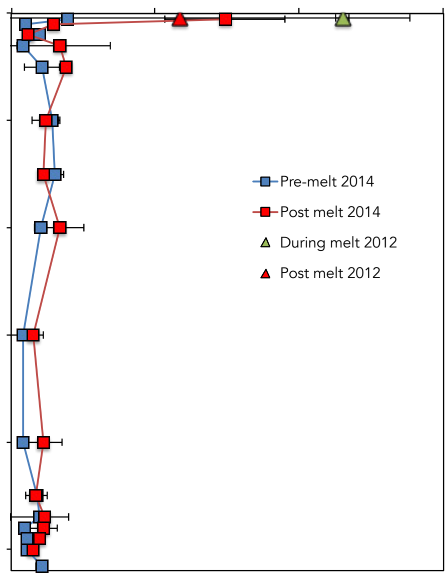
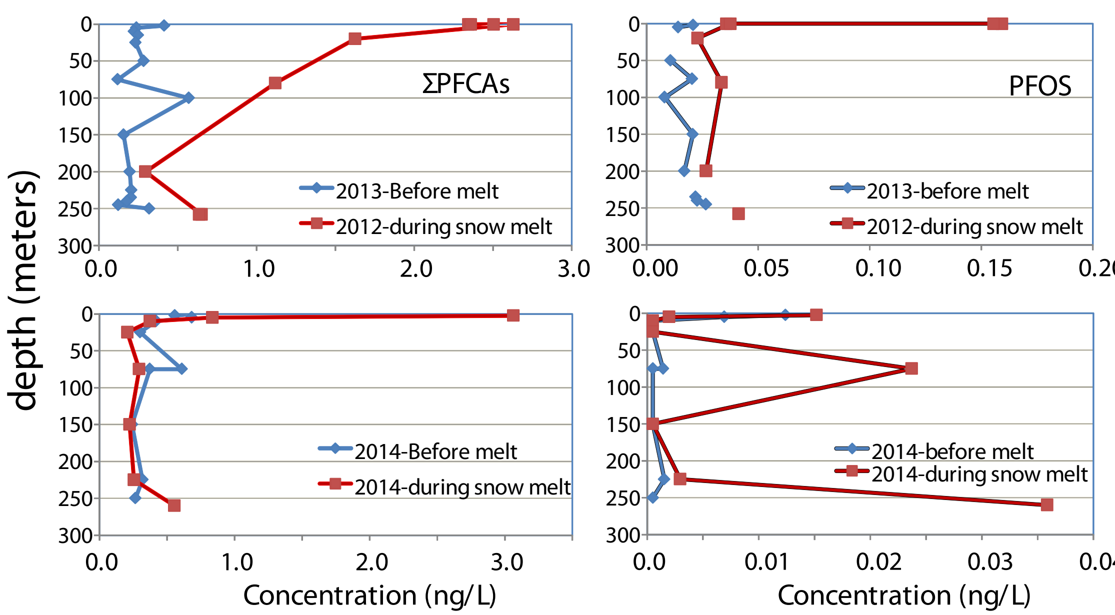


Figure 6 shows the combined results for water column profiles of major PFASs in Lake Hazen from 2012 to 2014. The importance of snowmelt is illustrated by the relatively constant concentrations before melt in 2013 and 2014, and the much higher concentrations near the surface post melt (2012 and 2014). Both PFCAs and PFOS showed this trend, although in 2014, PFOS concentrations were lower than in 2012 and near detection limits (<2 pg/L).

Goal 4: We sampled zooplankton in the top 75 meters of the watercolumn both before and after snowmelt inputs to Lake Hazen. Lake Hazen is ultra-oligotrophic (nutrient poor), resulting in very low zooplankton density. Concentrations of MeHg in zooplankton increased slightly from 3.47 ng/g before snowmelt input to 3.74 ng/g afterwards. This small increase was not surprising in hindsight, given that we sampled the upper 75 meters of the watercolumn for zooplankton, whereas water concentrations of MeHg only increased in the top 1-2 meters of the lake. Results for PFASs in zooplankton are pending.

Figure 6: Concentrations of major PFCAs and PFOS in the water column of Lake Hazen before and after snowmelt inputs. Data were collected in 2012, 13 and 14.



Discussion and Conclusions

Our overall research goal is to quantify watershed loadings of THg, MeHg, and organic contaminants such as PFASs to Lake Hazen for the 3 most common types of runoff (snowmelt, glacial melt, soil/permafrost thaw). This information will be used to construct a present-day mass-balance budget for Lake Hazen for these contaminants. Snowmelt runoff from the watershed during the 2-week melt period in early June is an important hydrological event, which we have already sampled and described above. However, 16 glacially-fed rivers are by far the dominant source of water to Lake Hazen annually from late June through August. Seasonal soil/permafrost thaw also contributes to the water budget of Lake Hazen, although the magnitude of this hydrological input to Lake Hazen is not known and likely less than snowmelt volume. Whereas snowmelt primarily supplies contaminants of contemporary atmospheric origin to Lake Hazen, enhanced glacial melt provides overwhelmingly large inputs of erosional mineral material, and possibly archived legacy contaminants previously stored in glacial ice. Water from soils/permafrost thaw can move through shallow soil active layers, small creeks, ponds and wetlands, possibly becoming rich in archived legacy contaminants before entering Lake Hazen. As such, the goals of our 2015-2016 research program are to address the following questions:

1. What are the concentrations and loads of THg, MeHg and PFASs in glacial runoff in the Lake Hazen watershed?

2. What are the concentrations and loads of THg, MeHg and PFASs in soil/permafrost thaw runoff in the Lake Hazen watershed?

3. What are the THg, MeHg and PFASs concentrations in Lake Hazen during the height of summer glacial melt and soil/permafrost thaw runoff into the lake?

4. What are the concentrations of THg, MeHg and PFASs in the base of the foodweb (zooplankton) during the height of summer glacial melt and soil/permafrost thaw runoff into the lake?

Expected Project Completion Date

We expect to fully complete our project by April 2017

Acknowledgments

We would like to thank the Northern Contaminants Program for financially supporting this research program, with further research funding provided by NSERC. We would also like to thank the Polar Continental Shelf Project and ArcticNet (Network of Centres of Excellence of Canada) for aircraft and field logistical support. We also greatly appreciated the support and field contributions of Parks Canada.

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Heavy Metal Contaminants in Caribou and Moose in the NWT

Métaux lourds contaminants chez les caribous et les orignaux des Territoires du Nord-Ouest

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Abstract

Caribou and moose are keystone species in northern Canada, and are important to the cultural, social, spiritual and economic well-being of people and communities in the Northwest Territories. Both caribou and moose are important traditional food species, and make up a significant part of the diet in northern communities. Some concerns have been raised by communities who harvest these species about exposure to naturally occurring and anthropogenic sources of contaminants, both local and long range atmospheric transport. While metals are generally found at low levels in terrestrial ecosystems, elevated levels of some metals including cadmium have been found in the kidneys of caribou and moose in some areas. Levels in muscle are very low. Periodic monitoring of both caribou and moose is important to track levels over time, and maintain public confidence in caribou and

Résumé

Le caribou et l'orignal représentent des espèces clés du nord du Canada et sont intrinsèquement liés au bien-être culturel, social, spirituel et économique de résidents et des collectivités des Territoires du Nord-Ouest. Ils sont des éléments importants de l'alimentation traditionnelle et comptent pour une grande partie du régime alimentaire des collectivités du Nord. Les collectivités qui chassent ces espèces ont exprimé certaines préoccupations quant à leur exposition aux contaminants d'origine naturelle et anthropique, lesquels migrent par l'entremise du transport atmosphérique qui s'effectue à l'échelle locale et sur de longues distances. Si, de façon générale, les concentrations de métaux sont présentes à des concentrations relativement faibles dans les écosystèmes terrestres, des concentrations élevées de certains métaux, dont le cadmium, ont été observées dans les reins des caribous et des orignaux de certaines

moose as a healthy and nutritious source of food. This program collected samples through existing regional hunter-based monitoring programs in several areas in the NWT. Samples were collected from barren-ground caribou (Bluenose-East and Beverly herds), northern mountain caribou (Mackenzie Mountains), and moose (Sahtu and South Slave regions). Liver and kidney samples were tested for 34 different metals and elements, and some samples were also tested for radionuclides and polycyclic aromatic compounds. Data is current being analysed, and an in-depth reporting will be available later in 2015.

régions. Les concentrations dans les muscles sont très faibles. Il est important de mener une surveillance périodique du caribou et de l'orignal afin d'effectuer un suivi de l'évolution des concentrations au fil du temps, et ce afin de s'assurer que ces espèces demeurent des sources d'alimentation saines et nutritives. Pour les besoins de ce projet, on a recueilli des échantillons dans le cadre des programmes régionaux de surveillance par les chasseurs qui sont actuellement en place dans différentes régions des Territoires du Nord-Ouest. On a prélevé des échantillons de caribou de la toundra (hardes de Bluenose-East et de Beverly), de caribou des bois des montagnes (Monts Mackenzie) et d'orignal (régions de Sahtu et de South Slave). On a analysé des échantillons de foie et de reins en vue d'y détecter la présence de 34 différents métaux et éléments, et certains d'entre eux ont fait l'objet de tests de détection de radionucléide et de composés aromatiques polycycliques. On procède actuellement à une analyse des données et un rapport approfondi sera publié plus tard en 2015.

Key messages

- Caribou and moose are keystone species in northern Canada, and are very important to the cultural, social, spiritual and economic well-being of many communities in the Northwest Territories.
- Previous monitoring of barren-ground caribou has found relatively low levels of most metals and other elements.
- Elevated levels of cadmium have been found in the kidneys of moose and caribou in some areas, but are generally below levels of concern.
- Periodic monitoring of contaminants in caribou and moose is important to track levels over time, and provide information to the public and decision makers.
- Caribou and moose remain a healthy and nutritious source of food for northern communities.

Messages clés

- Le caribou et l'orignal représentent des espèces clés du nord du Canada et sont liés intrinsèquement au bien-être culturel, social, spirituel et économique de résidents et de nombreuses collectivités des Territoires du Nord-Ouest.
- Dans le cadre d'activités de surveillance du caribou de la toundra menées précédemment, on a relevé des concentrations relativement faibles de la plupart des métaux et d'autres éléments.
- Bien que l'on ait observé des niveaux élevés de cadmium dans les reins des orignaux et des caribous de certaines régions, les concentrations de ce type de métal sont généralement inférieures aux niveaux préoccupants.

- Il est important de mener une surveillance périodique du caribou et de l'orignal afin d'assurer un suivi de l'évolution des concentrations au fil du temps et de fournir de l'information au public et aux décideurs.
- Le caribou et l'orignal demeurent des sources d'alimentation saines et nutritives pour les collectivités du Nord.

Objectives

- Determine current levels of 34 metals and 5 radionuclides in barren-ground caribou (Bluenose-East & Beverly herds), and compare to previous levels.
- Establish baseline levels for 34 metals in moose in the Sahtu and South Slave regions (no previous monitoring), and compare to levels in Dehcho moose.
- Establish baseline levels for 34 metals in northern mountain caribou in the Sahtu (no previous monitoring).
- Provide information on contaminant levels in caribou and moose to support wildlife monitoring, assessment and management programs.
- Provide data to GNWT Health to monitor and assess contaminant levels in two important traditionally harvested species.

Introduction

Caribou and moose are keystone species in northern Canada, and are important to the cultural, social, spiritual and economic well-being of people and communities in the Northwest Territories. Both caribou and moose are important traditional food species, and make up a significant part of the diet of northern communities. Some concerns have been raised by communities about exposure of caribou and moose to naturally occurring and anthropogenic sources of contaminants, both local and from long range atmospheric transport. While metals are generally found at low levels in terrestrial ecosystems, elevated levels of some metals including cadmium have been found in the kidneys of caribou and moose in some areas. Periodic monitoring is important to track contaminant levels over time, and maintain public confidence that caribou and moose continue to be a healthy and nutritious source of food.

Caribou: Barren-ground caribou (*Rangifer tarandus groenlandicus*) are found across northern Canada, and are a major component of the traditional diet in northern communities. Caribou have a winter diet consisting primarily of lichen, which accumulate contaminants more readily than other vascular plants because of their large surface area, longevity, and ability to bind heavy metals. Lichen can accumulate atmospheric contaminants in a non-selective manner, resulting in a contaminant load similar to atmospheric input through long-range transport (Thomas et al. 1992). Because of their diet, long-lived ungulates such a caribou can accumulate some metals such as cadmium and mercury (Froslie et al. 1986). In the early 1990's, baseline levels of metals, organochlorines and radionuclides were assessed in 10 barren-ground caribou herds across the NWT and Nunavut under the Northern Contaminants Program (Elkin and Bethke 1995; Macdonald et al. 1996). Since that time, monitoring has focused on periodic monitoring of metals and radionuclides (Larter and Nagy 2000; Gamberg et al. 2005a; Macdonald et al. 2007; Larter et. al. 2010). There has been no previous work looking at contaminants in northern mountain caribou in the NWT.

Moose: Moose (*Alces alces*) are an important traditional and cultural resource for First Nations communities, and an important traditional food. In the NWT, moose are one of the most frequently consumed traditional food species, particularly in the Dehcho, Sahtu and South Slave regions (Receveur et al. 1996). A number of communities have expressed interest in monitoring contaminants in moose, both from local and long range sources. A preliminary study in the Dehcho from 2004-2007 found elevated levels of cadmium in moose in the southern Mackenzie Mountains, resulting in a health advisory on the consumption of organs from moose harvested in that area. Moose from the Mackenzie valley had significantly lower cadmium levels. Willows (*Salix* sp.) are a preferred food for moose (Risenhoover 1989) and can accumulate cadmium from the environment, and may explain some of the exposure. While there is some variability in levels of cadmium in barren-ground caribou across the north (Gamberg 2005a; Elkin and Bethke 1995), there appears to be greater variability in levels of cadmium in moose based on location (Larter and Kandola 2010; Gamberg 2005b). Data are not available on levels of cadmium and other metals in moose in other areas of the NWT, driving interest in this current study.

Activities in 2014-2015

In 2014/15, the following work was completed:

Fieldwork

Fieldwork and sample collection for this project was done in collaboration with three existing regional hunter-based wildlife health and condition monitoring programs. Sampling targets by species/location are listed below. Samples (kidney and liver for contaminants; teeth for aging) were collected, and submitted for processing. Data collected from each animal included date and location of sampling, as well as animal age, sex, reproductive status, body condition and select morphometric indices.

Barren-Ground Caribou:

- Bluenose-East Caribou:
  20 kidneys for metal analysis
- Beverly Caribou:
  20 kidneys for metal analysis

Northern Mountain Caribou:

- Sahtu Region:
  20 kidneys for metal analysis

Moose:

- South Slave Region:
  24 kidneys for metal analysis
- 16 livers for metal analysis
- Sahtu Region:
  20 kidneys for metal analysis
- 20 livers for metal analysis

Laboratory Analysis

Samples were tested for a suite of 34 metals including cadmium and mercury by the National Laboratory for Environmental Testing (NLET) at the National Water Research Institute in Burlington, Ontario. Analyses for 33 elements were conducted using Inductively Coupled Plasma-Sector Field Spectrometry (ICP-SFMS Instrumental). Total mercury (NLET Method 02-2802) was analyzed by cold vapor atomic absorption spectrometry (CVAAS). The detection limit for most elements is 0.0001 mg·kg-1 wet weight, but varied for other specific elements. Accuracy and recovery rates were monitored using dogfish liver (DOT-4), dogfish muscle (DORM-2) and lobster hepatopancreas

(TORT-2) standards from the National Research Council of Canada.

Radionuclide testing was done on barren-ground caribou (Beverly) muscle samples by Health Canada. ^{137}Cesium was assessed by 5 days of gamma counting, and radiochemical analyses were used to measure ^{210}Po, ^{210}Pb and ^{226}Ra.

Liver samples from Sahtu moose were tested for polycyclic aromatic compounds (PACs) by Axys Analytical Services in Sidney, British Columbia. Analyses were conducted by gas chromatography - mass spectrometry for 74 parameters, including 20 unsubstituted PAC's, 28 alkylated PAC groups, and 26 alkylated PAC's.

Capacity Building

This project was done in collaboration with three existing regional hunter-based wildlife monitoring programs. Each of these programs puts a major emphasis on community engagement, involvement in project design and delivery, capacity building, education and training. Results of this work will feed back directly into these programs, providing information that will contribute to their overall wildlife monitoring objectives, and providing information on contaminant levels in these important traditional food species.

Capacity building and training was an important part of the existing regional projects (Tłı̨chǫ Community-based Caribou Health Monitoring Program, Sahtu Community-based Wildlife Health Monitoring Project, South Slave hunter-based moose monitoring program). Each regional project provided information, training, sampling kits, and follow-up to participating hunters.

Project information and training in sample collection was done for all three programs:

- Tłı̨chǫ Community-based Caribou Health Monitoring Program: An on the land workshop was held in March 2013, and 12 community members were trained on how to collect biological samples. A follow up workshop to finalize monitoring protocols was held shortly after. In 2014, numerous meetings were held in each community, increasing support for the program. A 'train the trainer' workshop was held in March 2014. An illustrated 'Field Guide for Caribou Sample Collection" was been created by the Tłı̨chǫ Government as a field sampling tool, and hunters were provided with sampling kits each winter. The Tłı̨chǫ Government Department of Culture and Lands Protection (DCLP) maintained a strong communication link with community members to promote the importance of this work and share information.

- Sahtu Community-based Wildlife Health Monitoring Project: The Sahtu program identified and trained wildlife health monitors in each community, and provided sampling kits and advice to participating hunters. A range of training and education tools (booklets, websites, "caribou atlas") have been developed as support materials. The project team planned comprehensive 'hands-on' workshops in each of the 5 Sahtu communities in 2014-2015. The program also conducts an annual school tour to provide information on wildlife and wildlife monitoring, with a focus on moose and caribou sampling in 2013/14.

- South Slave Hunter-based Moose Monitoring Program: ENR worked closely with local hunters and aboriginal organizations to collect information and samples from moose harvested in the region each year. The program has developed resource materials and standardized hunter kits to collect core information and samples, and works with individual hunters to promote and coordinate the program. The program was discussed at the 2013 South Slave regional wildlife workshop, and will be discussed at the next workshop in November 2015.

Communications

This project worked collaboratively with the three existing regional hunter-based wildlife monitoring programs, which are led by or work closely with communities, aboriginal governments and wildlife co-management partners. Initial and ongoing consultations and communications were done by the three regional programs, and this project was able to add contaminant analyses to the core monitoring programs already underway.

Once the project is completed, results will be reported back to the three regional wildlife monitoring programs, who already communicate results from their programs to the communities and hunters involved. We will work with the regional monitoring program leads (Tłįchǫ Government, SRRB/ENR in the Sahtu, and ENR in the South Slave) to develop and deliver appropriate contaminant results and messaging. This will also be done in collaboration with the NWT Regional Contaminants Committee and GNWT Health & Social Services. Opportunities for in-person presentations will be considered, including the South Slave Regional Wildlife Workshop in November 2015.

A plain language summary of the results will be developed, as well as a technical report. Results will be presented at the next NCP Results Workshop in December 2015. All data will be integrated into the existing database for Canadian Arctic moose and caribou contaminants maintained by AANDC in Whitehorse, as well as the ENR Caribou Collections database in Yellowknife.

Traditional Knowledge Integration

This project was done in collaboration with three existing regional hunter-based wildlife monitoring programs, which rely on the traditional and local knowledge of hunters for successful program delivery. Field sampling was done by local harvesters during their normal hunting activities. Traditional knowledge on caribou and moose location, behavior and harvesting contribute to the collection of samples. Data collected as part of all of these programs includes hunter knowledge and assessment of animal health and condition, which will be considered in the evaluation of the contaminant results. The project aims to address community questions and concerns about contaminant exposure in caribou and moose, two important traditionally harvested species.

Results

Laboratory analysis has been completed, and data received in March 2015. Analysis and assessment of the results is underway, and should be completed by fall 2015.

Discussion and Conclusions

Data analysis and interpretation is still underway, and a discussion of results will be available later in 2015. This study will provide baseline data on metals in moose and northern mountain caribou in areas where no previous testing has been conducted. It will also provide current levels to add to existing temporal trend data for two herds of barren-ground caribou.

This project highlighted the value of local and regional hunter-based wildlife monitoring programs, and working closely with communities, RRC's, wildlife co-management boards, and other local or regional organizations. This collaborative process helped facilitate effective communication, training, capacity building, and field project implementation to deliver a project of shared interest amongst its many partners.

Expected Project Completion Date

Laboratory analysis was completed by March 2015. Data analysis and interpretation is underway, and will be completed in summer/fall 2015. Preparation of a plain language summary will be completed by fall 2015, and communication of results will occur in fall/winter 2015. A technical report will be completed in fall winter 2015, and results presented at the NCP results workshop in December 2015.

Acknowledgments

This project relied heavily on existing regional hunter-based caribou and moose monitoring programs, and the considerable efforts of the program coordinators and local hunters. We recognize the efforts of the program coordinators in incorporating contaminant monitoring into their existing programs: Kerri Garner (Tłı̨chǫ Government), Susan Kutz (U of C), Heather Sayine-Crawford (ENR Sahtu), and Allicia Kelly (ENR South Slave). We also thank the many individual hunters for their participation and assistance in collecting samples and sharing their knowledge. Funding and support for this project was provided by the Northern Contaminants Program (NCP), the NWT Cumulative Impact Monitoring Program (CIMP), GNWT Department of Environment and Natural Resources, Tłı̨chǫ Government, and the University of Calgary.

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Communications, Capacity, and Outreach

Communication, capacités et la sensibilisation

Yukon AANDC regional office coordination 2014-2015

Coordination du bureau régional d'AADNC au Yukon en 2014-2015

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Abstract

The Yukon Contaminant Committee and AANDC Regional office Yukon have spent 24 years building an NCP database of contaminants analysis results and a tissue archive of samples. This past year the Regional representative relocated the fish archive samples to the new Environment Canada archive bank in Burlington Ontario. The bird and mammal tissue archive component is in the process of being moved to the tissue archive held by Environment Canada in Ottawa, Ontario. The database is still in the process of being integrated into the Polar Data Catalogue and a data rescue exercise is on-going to collate errant data sets from the time the original database was inoperable.

Résumé

Le Comité des contaminants du Yukon et le bureau régional d'AADNC au Yukon ont mis plus de 24 ans à bâtir une base de données du Programme de lutte contre les contaminants du Nord (PLCN), qui contient des résultats d'analyse des contaminants et des archives d'échantillons de tissus. Au cours de la dernière année, le représentant régional a déménagé les échantillons de poissons dans la nouvelle banque d'archives d'Environnement Canada à Burlington (Ontario). Les archives de tissus d'oiseaux et de mammifères sont en train d'être transférées vers les archives de tissus d'Environnement Canada, à Ottawa (Ontario). La base de données est toujours en cours

Regionally, NCP supports long term core monitoring programs for the Porcupine caribou herd, lake trout from Lakes Kusawa and Laberge and the Little Fox Lake air monitoring site for atmospheric mercury and POPs. The Regional office of AANDC facilitates this work through funding arrangements.

d'intégration au catalogue des données polaires, et un exercice de récupération des données a lieu en vue de recueillir des ensembles de données qui sont errantes depuis que la base de données initiale n'est plus en fonction.

À l'échelle régionale, le PLCN appuie des programmes de surveillance de base à long terme de la harde de caribous de la rivière Porcupine, du touladi des lacs Kusawa et Laberge, de même que du mercure atmosphérique et des polluants organiques persistants sur le site du lac Little Fox. Le bureau régional d'AADNC facilite ces travaux dans le cadre d'ententes de financement.

Key messages

- NCP Yukon Database being transferred to Polar Data Catalogue
- Yukon NCP fish tissue archive moved to Environment Canada in Burlington, Ontario
- Yukon NCP bird and mammal tissue in the process of being moved to Environment Canada in Ottawa, Ontario.
- AANDC Regional support for NCP funded projects

Messages clés

- La base de données du PLCN au Yukon est en cours d'intégration au catalogue des données polaires.
- Les archives de tissus de poissons du Yukon du PLCN ont été transférées aux archives d'Environnement Canada à Burlington (Ontario).
- Les archives de tissus d'oiseaux et de mammifères du Yukon du PLCN sont en train d'être transférées vers les archives d'Environnement Canada à Ottawa (Ontario).
- Le bureau régional d'AADNC soutient des projets financés aux termes du PLCN.

Objectives

1. Yukon resource for NCP activities
2. Point of contact for researchers working on NCP projects in the Yukon

Introduction

The Northern Contaminants Program makes use of the Territorial Contaminants Committees as conduits between the Regions and the National Program. In addition to their ongoing role as the contact between the residents of the Yukon and the NCP the YCC is responsible for reviewing all Regional proposals for socio-cultural merit, assists in Aboriginal Partner and other government agency co-ordination, and working with communications strategies within the Yukon. The Yukon has a database of NCP sample analysis going back to 1991 and a tissue archive over that same time frame.

Activities in 2014-2015

The Yukon NCP Database continues being integrated into the Polar Data Catalogue housed at University of Waterloo. The Yukon fish tissue archive of NCP samples has been transferred to a permanent archive with Environment Canada at the Canadian Centre for Inland Waters. The remaining bird and mammal samples are in the process of being transferred to the Environment Canada tissue archive maintained by the Canadian Wildlife Service in Ottawa, Ontario.

Support was also provided to the Vancouver office of Environment Canada in their CARA mercury study on Kusawa Lake, which has become a joint study with the NCP trend work taking place there.

Precipitation was collected at the Little Fox Lake air monitoring site in 2014/15 for isotope mapping in conjunction with the Yukon Research Centre.

The Committee and the Regional NCP office are considered the contact for contaminant issues in the Yukon. In 2014/15 the Regional Office continued to work with the Yukon Health authorities on contaminants in traditional food sources and the Yukon Environment office on their annual State of the Environment Report.

Results

The fish tissue archives have been transferred to Environment Canada and the remaining tissue archive is being processed for transfer in 2015/16. The Yukon contaminants database continues to be incorporated into the Polar Data Catalogue and an exercise to collect errant data is underway with the University of Waterloo.

Discussion and Conclusions

Results of the lake trout and caribou monitoring work are reported under M-13: Long term trends of halogenated organic contaminants and metals in lake trout from two Yukon Lakes; Kusawa and Laberge (Stern 2014) and M-14: Arctic Caribou Contaminant Monitoring Program (Gamberg 2014). The mercury and organic sampling being conducted at Little Fox Lake is reported under M-01 POPs in the Atmosphere (Hung 2014) and M-02 Air measurements of mercury at Alert, Nunavut and Little Fox Lake, Yukon (Steffen 2014).

Expected Project Completion Date

On-going

Acknowledgments

NCP and AANDC Region for funding and operational/administrative support.

Nunavut Environmental Contaminants Committee (NECC)

Comité des contaminants du Nunavut (CCN)

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Abstract

The Nunavut Environmental Contaminants Committee (NECC) was struck in May 2000 to provide a forum to review and discuss, through a social-cultural lens, Nunavut-based NCP-funded projects and proposals seeking NCP funding. Through its social-cultural review of all Nunavut-based NCP proposals, the committee ensures northern and Inuit interests are being served by scientific research conducted in Nunavut.In addition, the NECC aims to serve as a resource to Nunavummiut for long-range contaminants information in Nunavut. NECC's AANDC and NTI co-chairs attended the NCP Management Committee meetings in Ottawa in April 2014 and September 2014 and the Arctic Change Conference in December 2014. NECC participated in the annual Wildlife Contaminants Workshop (C-11) at the Nunavut Arctic College's (NAC) Iqaluit campus in Oct. 2014 by contributing

Résumé

Le Comité des contaminants du Nunavut (CCN) a été constitué en mai 2000 afin de permettre l'examen, selon une perspective socioculturelle, des projets financés par le PLCN, et des propositions pour lesquelles des fonds sont demandés au Nunavut. En réalisant un examen socioculturel des propositions associées au PLCN dans le territoire, le Comité veille à ce que les recherches scientifiques menées au Nunavut servent les intérêts des Inuits et du Nord. Le CCN fournit aussi aux Nunavummiuts de l'information sur les contaminants transportés sur de longues distances que l'on trouve au Nunavut. Les coprésidents du CCN, soit les représentants d'AADNC et de Nunavut Tunngavik Incorporated (NTI), ont assisté aux rencontres du Comité de gestion du PLCN tenues à Ottawa, en avril et en septembre 2014, ainsi qu'à la conférence Arctic Change, qui a eu lieu en décembre 2014. Le CCN a participé

talks to the seminar portion of the workshop. NECC provided feedback to NCP researchers on summary reports intended for community dissemination, met face-to-face with NCP-funded researchers to discuss their respective proposals/projects and attended lectures at NAC presented by NCP researchers. NECC also hosted a productive social-culture review of NCP proposals on Feb 17-18, 2015 in Iqaluit. Fifteen people participated in the face-to-face meeting and 26 NU-based proposals were reviewed. Comprehensive feedback was provided by NECC's co-chairs to all project leaders seeking NCP funding for projects taking place in Nunavut. A comprehensive consultation summary was provided to the NCP Secretariat to inform funding decisions at the April 2015 NCP Management Committee meeting.

à l'atelier annuel sur les contaminants de la faune (C-11) qui a eu lieu sur le campus d'Iqaluit du Collège de l'Arctique du Nunavut, en octobre 2014, dans le cadre de séminaires. Le CCN a fourni de la rétroaction aux chercheurs du PLCN sur des rapports sommaires devant être diffusés dans la collectivité, a rencontré en personne des chercheurs financés par le PLCN pour discuter de leurs propositions et projets respectifs, et a assisté à des exposés de chercheurs du PLCN au Collège de l'Arctique du Nunavut. Le CCN a également dirigé un examen socioculturel productif des propositions du PLCN, les 17 et 18 février 2015 à Iqaluit. Quinze personnes ont participé à la réunion en personne, au cours de laquelle 26 propositions concernant le Nunavut ont été examinées. Les coprésidents du Comité ont fourni une rétroaction complète aux chefs de projet qui cherchent du financement pour leurs projets au Nunavut dans le cadre du PLCN. Un résumé complet de cette consultation a été fourni au secrétariat du PLCN pour orienter les décisions relatives au financement lors de la réunion du comité de gestion du PLCN d'avril 2015.

Key messages

- Through its social-cultural review of all Nunavut-based NCP proposals, the Nunavut Environmental Contaminants Committee (NECC) ensures northern and Inuit interests are being served by scientific research conducted in Nunavut.
- The NECC aims to serve as a resource to Nunavummiut for long-range contaminants information in Nunavut.

Messages clés

- En réalisant un examen socioculturel des propositions associées au PLCN dans le territoire, le Comité des contaminants du Nunavut veille à ce que les recherches scientifiques menées au Nunavut servent les intérêts des Inuits et du Nord.
- Le Comité des contaminants du Nunavut fournit aux Nunavummiuts de l'information sur les contaminants transportés sur de longues distances que l'on trouve au Nunavut.

Objectives

1. Through its social-cultural review of all NU-based NCP proposals, the NECC ensures the interests of Nunavummiut are being addressed during research activities, including:

   a) Local or northern training and capacity building opportunities are pursued by Principal Investigators (PI) whenever possible;
   b) Inuit Qaujimajatugangit (IQ) is incorporated into the study design and process;
   c) Research results are appropriately communicated back to participating or nearby communities; and
   d) Meaningful community consultation is achieved.

2. Assist researchers with conversion of NCP-funded contaminant research results into plain language that is understood by Nunavummiut;

3. Assist and advise NCP-funded researchers on the relevant methods and distribution of communication materials to communities;

4. By way of GN Health representatives on the committee, provide relevant NCP-funded contaminant research results to the Chief Medical Officer of Health (CMOH)

5. Work in partnership with communities, researchers, governments, and Inuit organizations when undertaking community outreach related to communicating NCP research results;

6. When requested by the Government of Nunavut, provide support to the CMOH in GN-Health who will work in collaboration with NTI on the development, implementation and follow up of nutrition recommendations, food policies, and public health messages resulting from NCP funded contaminants research; and

7. Provide advice to communities on securing NCP funding for contaminants research.

Introduction

Multi-stakeholder Regional Contaminants Committees were established to provide a forum to discuss regional contaminant-related issues among interested stakeholders. The committees provide a link to the Northern Contaminants Program (NCP) Secretariat, which funds Northern long-range contaminants research. The NECC fosters partnerships among interested stakeholders when developing and delivering public messages concerning contaminants in relation to human health and the environment. The NECC was struck in May 2000 and since its inception, the annual social-cultural review of NCP proposals has been the committee's primary focus. Through its review of all Nunavut-based proposals, the committee ensures northern and Inuit interests are being served by scientific research conducted in Nunavut.

Activities in 2014-15

The following activities were undertaken by NECC in 2014-15:

- NCP Management Committee meetings were attended by NTI and AANDC co-chairs in April 2014 and by NTI co-chair in October 2014

- NTI co-chair attended Arctic Change Conference in Dec 2014

- Hosted three face-to-face NECC meeting/teleconferences: May 7, 2014, Sep. 22, 2014, and Oct. 30, 2014

- Provided feedback on plain language summary reports prepared by PIs for community dissemination
- Participated in Wildlife Contaminants Workshop at NAC on Sep 29-Oct 3, 2014; NECC committee members gave presentations on the NCP, role of Research Advisor and best practices for communicating results
- NTI co- chair gave a presentation on the NECC at an annual general meeting of the Kivalliq Wildlife Board in November 2014
- NECC participated in meeting Jan 22, 2015 with John Chetelat and NAC's Environmental Technology Program (ETP), regarding elevated mercury levels found in char in lakes near Iqaluit from 2013-14 project M-16
- Meeting with Hayley Hung, Alexander Steffen and NECC members (AANDC, NTI, NRI) Feb. 12, 2015 in Iqaluit to discuss community outreach plans for their respective proposals (i.e. M-01, M-02, M-03)
- Hosted face-to-face NECC social-cultural review meeting Feb 17-18, 2015 in Iqaluit; 15 people participated in the review
- Coordinated presentation by Isabelle Veillette, research nurse from NCP project (H-05) Mar. 13, 2015 to NAC Nursing program in Iqaluit, NU
- Meeting with Isabelle Veillette, research nurse from NCP project (H-05) and NECC members Mar. 13, 2015 to discuss this project
- 26 proposals were reviewed and co-chairs provided detailed feedback via email to each PI regarding their respective proposal
- Produced summary report of comments and consultations related to NU-based proposals for NCP Secretariat
- Conducted review of mid-year progress reports for NCP-funded projects
- Supported one NAC ETP student's travel to Resolute Bay to participate in NCP-funded projects (M-10, M-16, M-23) in Resolute during summer 2014
- Held sub-committee meeting to initiate work on Nunavut State of Knowledge Report May 23, 2014

Results

- Provided feedback to researchers on plain language summaries
- 2015 NECC Social-Cultural Review Summary Report

Discussion and Conclusions

The work of NECC is on-going and will continue into 2015-16. The NECC had a successful and productive year and plans to build on the contacts it's made with NCP researchers and Northern institutions to enhance collaborative efforts that will foster more opportunities for capacity building and training for Nunavummiut and more effective communications between NCP researchers and communities. To that end, NECC is committed to assist PIs with communicating research back to their partnering communities and encourages researchers to contact NECC before they embark on any community consultations or communications.

In terms of NECC's upcoming work plan, the committee aims to increase regional representation on our committee by soliciting new members from each of Nunavut's regions: Qikiqtaaluk, Kivalliq and Kitikmeot. NECC will continue with its regular annual activities, including reviewing mid-year reports and requests for additional funding at mid-year, conducting a detailed social-cultural review of 2016-17 NCP proposals, helping coordinate researcher presentations in Nunavut and providing feedback to PIs on presentations and communication products intended for community dissemination. In addition to these activities, NECC is also planning to continue a subcommittee's work to develop a statement of work for a Statement of Knowledge Report on long range contaminants in Nunavut that will provide a synopsis of NCP research conducted in Nunavut over the past 20 years, including the latest information published in the Canadian Arctic Contaminant Assessment Reports on health, mercury and persistent organic pollutants.

In addition, as part of NTI's Research Advisor (RA) work plan, NECC's NTI co-chair is planning to finalize a licensing fact sheet to guide researchers when undertaking research in Nunavut. NECC is committed to assisting with the development of this fact sheet by serving as a resource to NTI's RA and helping review and finalize the fact sheet.

Expected Project Completion Date

Work is on-going.

Nunavik Nutrition and Health Committee: coordinating and learning from contaminants research in Nunavik

Comité de la nutrition et de la santé du Nunavik : Coordination et apprentissage fondés sur la recherche sur les contaminants au Nunavik

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Abstract

The Nunavik Nutrition and Health Committee (originally named the PCB Resource Committee) was established in 1989 to deal with issues related to food, contaminants, the environment and health in Nunavik. Since its inception, the committee has broadened its perspective to take a more holistic approach to environment and health issues inclusive of both benefits and risks. Today, the committee acts as the authorized review and advisory body for health and nutrition issues in the region and includes representation from many of the organizations and agencies concerned with these issues, as well as those conducting research on them. The committee provides guidance and

Résumé

Le Comité de la nutrition et de la santé du Nunavik (qui s'appelait au départ Comité des ressources sur les BPC) a été mis sur pied en 1989, pour traiter de questions se rapportant aux aliments, aux contaminants, à l'environnement et à la santé au Nunavik. Depuis sa création, le Comité a élargi son champ d'action et a ainsi adopté une approche plus globale quant aux questions touchant l'environnement et la santé, notamment sur les plans des bienfaits et des risques. Aujourd'hui, le Comité est l'organe autorisé d'examen et de consultation en matière de santé et de nutrition dans la région. Il comprend des représentants de bon nombre d'organismes et d'agences qui s'intéressent à

acts as a liaison for researchers and agencies, from both inside and outside the region, directs work on priority issues, communicates with and educates the public on health and environment topics and research projects, and represents Nunavik interests at the national and international levels. All activities are conducted with the goal of protecting and promoting public health in Nunavik, through more informed personal decision making.

ces questions ainsi que de ceux qui effectuent des recherches à ce sujet. Le Comité donne de l'orientation et assure la liaison pour les chercheurs et les organismes de la région et de l'extérieur, dirige les travaux qui portent sur les questions importantes, transmet des renseignements au public et éduque celui-ci au sujet de l'environnement et de la santé et des projets de recherche, et représente les intérêts du Nunavik sur les scènes nationale et internationale. Toutes les activités réalisées visent à protéger la santé publique au Nunavik et à faire la promotion de cet aspect, en favorisant une prise de décisions personnelles plus éclairée.

Key Messages

- The Nunavik Nutrition and Health Committee is the key regional committee for health and environment issues in Nunavik;
- The committee advises the Nunavik Public Health Director about educating the public on food and health issues, including benefits and risks associated with contaminants and country foods;
- The committee continues to be active within the NCP, reviewing and supporting research in the region, ensuring liaison with researchers and helping in the communication of research results in a way that is appropriate and meaningful to Nunavimmiut.

Messages clés

- Le Comité de la nutrition et de la santé du Nunavik est le principal comité régional chargé des questions liées à la santé et à l'environnement au Nunavik.
- Le Comité conseille le directeur de la santé publique du Nunavik à propos des activités d'information et d'éducation concernant la nutrition et la santé, y compris les bienfaits et les risques associés aux contaminants et aux aliments locaux.
- Le Comité continue de participer activement au Programme de lutte contre les contaminants dans le Nord : il étudie et finance la recherche dans la région, assure la liaison avec les chercheurs, et favorise la communication des résultats des recherches d'une manière qui est appropriée et convenable pour les Nunavimmiuts.

Objectives

The general objective of this project is to address regional coordination and communication needs, help researchers connect with Nunavik communities and provide information necessary for the public understanding of data relevant to environmental health and contaminants issues in Nunavik. Specifically, the objectives are:

1. To interact with the NCP and other researchers working on health and environment issues and to provide the population and health workers with background information to help them understand and contextualize environmental health, nutrition and contaminants research, objectives and results;
2. To compile elements of public concern which have not been addressed to date and to steer and support research activities towards providing the data needed to address these concerns;
3. To undertake public communication of environmental health data, including results of Northern Contaminants Research Projects, and help develop regional communication and evaluation strategies for this information;
4. To prepare or collaborate on summaries on the state of the knowledge on these issues and to assist in communication and intervention activities of local health and environment officials;
5. To facilitate the NCP and other research on environmental contaminants, nutrition and health including research on risk communications and risk-perception issues;
6. To help researchers translate their data into meaningful information for the public;
7. To identify topics related to human health and contaminants to be monitored under the NCP;
8. To support partnerships in various research and intervention activities related to country foods, nutrition and health;
9. To contribute to the definition of a regional food strategy that will incorporate the issue of contaminants in country food.

Introduction

In Nunavik, a group of individuals representing different organizations concerned with health, the environment and nutrition issues has formed to address these topics and communicate with and educate the public to ensure more-informed personal decisions. This group, the Nunavik Nutrition and Health Committee, evolved from the original PCB Committee, created in 1989 and later renamed the Food, Contaminants and Health Committee. The name has changed over the years as the group has learned of the importance of focussing not only on negative impacts of contaminants but also on the need for a more holistic approach to nutrition, health and the environment, including benefits. On an ongoing basis, the committee addresses a number of issues relating to food, contaminants, nutrition and health, and the relationship with the environment.

This evolution and recognition of the NNHC places it in an important role in addressing issues related to contaminants, food, health and the environment in the region. The committee is therefore well positioned and has the necessary capacities to support research activities (through review, facilitation and communication) related to these issues under the Northern Contaminants Program as the regional contaminants committee. This report represents a synopsis of the committee's activities for the 2014-2015 year.

Activities In 2014-2015

In 2014-2015, the whole committee managed to meet three times using the additional funding allocated for two meetings considering that some members were not able to travel for each meeting. The NNHC believes it is very important to continue to meet three times a year in order to ensure regular in-person follow-up on the different files.

The first meeting took place in June 2014 in Kuujjuaq. It was a two-day meeting to discuss regular topics linked to nutrition, contaminants and Nunavimmiut health. Various projects were discussed during the meeting such as monitoring of environmental pollutants among pregnant women, the Arctic Char Program evaluation, the Berries Project (Mélanie Lemire) and Qanuippitaa 2016. Furthermore, the committee met with Mélanie Lemire, Christopher Fletcher, Cory Harris and Catherine Pirkle during the meeting. The researchers updated the committee about different ongoing projects. The committee also provided suggestions and input during a discussion around the upcoming projects of these researchers. Chris Furgal made a presentation for the NNHC about different research projects including the results of the "NCDS Communication Evaluation Research Project." We also met by telephone with Mylène Riva who updated the committee about ongoing projects and upcoming publications.

The second meeting was held in November 2014 in Kuujjuaq and lasted two days. We, once again, addressed and followed up different topics linked to nutrition, contaminants and Nunavimmiut health. We met by telephone conference with Pierre Ayotte, Laurie Chan, Brian Laird, Mélanie Lemire and Michael Kwan (Makivik) to discuss the following projects: the Se-Hg Project, new funding for CHAR (lake-trout project) and Arctic Net project proposals about lake trout in collaboration with Makivik. The topics discussed during the meeting included the Char Distribution Program, an update about the regional food-security strategy development and the new terms of reference for the NNHC (presentation by Simon Smith). Gina Muckle and Caroline Moisan met in person with the NNHC to present progress in the Nunavik Child Development Study and one new related project that will be led by a PhD student. The committee also decided that one last meeting will be organized with Huguette Turgeon O'Brien and Doris Gagné to finalize their communication tools. The results should be released by the summer 2015.

The third meeting was held in February 2015 in Quebec City and lasted three days. It focussed mainly on the review of the 2015-2016 NCP proposals for the region. The committee invited the CHUL-Public Health Unit Research team members and other researchers available to meet in person with the committee at that time so that questions raised during the proposal review could be clarified with the researchers themselves. The committee adopted this way of functioning a few years ago and feels that it is very efficient and helpful to meet researchers in person at least once a year. Researchers who are not able to travel will be met by telephone conference. On the third day, the committee discussed regular topics.

Considering that food security is an important issue in the region and that more and more research projects explore food insecurity in the region, the NNHC held a half-day meeting with a group of researchers conducting ongoing research projects in Nunavik: Chris Furgal, Gina Muckle, Michel Lucas, Catherine Pirkle and Cédric Juillet. The NNHC and the researchers had an opportunity to discuss various topics related to food security including the questionnaires used to measure food insecurity, the existing data and the results of their respective studies carried out in Nunavik. During this day, the committee also had the opportunity to meet with Mélanie Lemire (lake-trout project and guidelines for mercury exposure), Mylène Riva (project about social determinants of health in Nunavik), Paul Brassard (HPV screening project), Michael Barrett and Catherine Pinard (Renewable Resources, Environment, Land and Park Department of the KRG) and Christopher Fletcher and Marie-Claude Lyonnais (potential project about the use of social media in community health).

Summary of Regular Topics Managed by the NNHC

Below is a list of some ongoing NCP-related files managed by the NNHC and for which actions were taken in 2014-2015:

Review of Research Proposals and Liaison with Researchers

In 2014-2015, the committee reviewed all research projects to be carried out in the region or involving data from the Nunavik population proposed under the NCP. As discussed above, this review included meeting with the researchers to discuss and question aspects of their proposed work to better understand and discuss their proposals. The committee also carried out regular follow-up with researchers funded by the NCP.

Food Security

Food insecurity is a major concern in the region. The committee is seeking information to know more about the real situation of food insecurity. The NNHC will try to maximize the use of current databases to improve the knowledge on that issue. Some members of the NNHC are part of a food-security working group analyzing existing data available in the region. Because more and more research projects explore food insecurity in the region, the NNHC agreed to hold a half-day meeting with a group of researchers conducting ongoing research projects in Nunavik. For the meeting, the researchers prepared written documents gathering information about the questionnaires used to gauge food insecurity and results of their respective studies carried out in Nunavik. This meeting will help all the researchers remain on the same level and work in the same direction in matters of food security.

Regional Food Policy/Strategy

A regional food policy is one of the Public Health priorities. Nunavimmiut have various concerns relating to food and nutrition, namely access to traditional food, food insecurity, high costs, etc. The Qanuippitaa 2004 health survey revealed deterioration in the nutritional status of Nunavimmiut, linked to a decrease in country-food consumption and increase in junk-food consumption. The adoption of a Nunavik-specific regional food policy could contribute to country-food promotion, improvement of Nunavimmiut nutritional status, job creation, etc. The objective is to bring the regional actors together to develop a Nunavik-specific regional food policy/strategy. The Public Health Department is currently establishing a profile of local and regional initiatives related to food security in Nunavik to support the development of the food-security policy/strategy. The NNHC is an important partner in the development of this policy/strategy.

NNHC Members' Participation in Workshops and Meetings

Several committee members are active in research and policy issues relative to food, nutrition and health, and contaminants; they attended workshops and meetings this past year to promote the activities of the committee and its specific initiatives, learn about other regional and international initiatives and communicate the results of regional research projects. Members attended the NCP Management Committee meetings, the ITK Food Security Working Group, Nutrition North Canada meetings and the Food-Security Strategy meeting among others.

Lake Trout Project

The NNHC supports this research project, which is a partnership between the Nunavik Research Centre, a group of researchers including Mélanie Lemire, Chris Furgal and Catherine Pirkle, and the Public Health Department. The study looks at the relationship between mercury content and the age, size and weight of fish. Samples were taken from Kuujjuaraapik, Puvirnituq, Inukjuak, Salluit and Kuujjuaq. A survey will be conducted in the communities to look at the perception and the consumption of lake trout.

Results of the Contaminant-Nutrient Interaction Study in Day-Care Centres: Communication of the Results

The two factsheets that were relevant for communication to the public (vitamin D and iron) are currently in the final revision stage. The communication should be completed in early 2015. The Public Health Department and the NNHC are also collaborating on the development of recommendations for health professionals regarding those two nutrients.

Lead Shot: Action Plan

In 2011, the committee supported the work of Ariane Couture, a master's student in community health at Laval University working on the current profile of lead exposure in Nunavik to evaluate the need to repeat the intervention carried out about 10 years ago. This study revealed that ammunition containing lead pellets is back on store shelves in many Nunavik communities. The committee strongly believes there is an urgent need to address this issue with concrete regional actions. The NNHC would like to collaborate in reinstalling the ban and organizing efficient communication activities. This file will be managed by Sylvie Ricard, environmental-health officer.

Arctic Char Distribution Program

The NNHC is collaborating on the Arctic Char Distribution Program. Under this program, pregnant women on the Hudson coast receive one Arctic char per week when available.

The NNHC ensures follow-up with the researchers (Michel Lucas and Catherine Pirkle) who are conducting an evaluation of this program. In November 2014, the researchers sent an abstract of one communication they were planning to do in a conference: "Food Insecurity and Nutritional Biomarkers Relationship among Pregnant Women in Nunavik (Quebec): Baseline Data of the Arctic Char Distribution Program Monitoring." This is a sensitive issue and the NNHC felt there were some issues to clarify regarding those results that were not yet communicated to the population. For the committee, it is a priority to make sure that research results are always communicated to the population first, especially when the data are sensitive. Therefore, the NNHC requested that the researchers put a hold on all the communications planned outside Nunavik, including the topical session during the Arctic Change conference in December 2014. In February 2015, Michel Lucas and Catherine Pirkle presented the preliminary quantitative results of the research to the committee. The committee is also very interested in the qualitative results that are coming soon since they can help to improve the program.

Qanuippitaa 2016

The NNHC is collaborating in the planning of the next Nunavik health survey that will be held in 2016. Some members are also involved in advisory committees and working groups.

Monitoring Spatial and Temporal Trends of Environmental Pollutants in Maternal Blood in Nunavik

The NNHC continues to support this project, which is now under the responsibility of Pierre Ayotte and the Public Health Department.

Nunavik Child-Development Study (NCDS)

In November 2014, the committee met with Gina Muckle and Caroline Moisan. The research is now funded under the CIHR. They presented an update about the progress of the study. The data collection started in 2013 and will be completed in 2015. The recruitment is going very well and they now expect to recruit 240 participants out of the 294 children in the cohort instead of the 200 participants initially expected. Gina Muckle also has a PhD student, Marylyn Fortin, working on the social context related to alcohol consumption with the NCDS cohort.

Decision-Making Algorithm for Hg Exposure in Nunavik

The Public Health Department mandated a group of researchers, including Mélanie Lemire and Catherine Pirkle, to detail further the medical interventions for mercury especially for pregnant women but also for the rest of the population. The NNHC is collaborating on this document.

Acknowledgments

The committee would like to thank all Nunavimmiut for their ongoing participation and support in contaminants, health and environment research. Furthermore, the NNHC is grateful to the Northern Contaminants Program and the Nunavik Regional Board of Health and Social Services for ongoing support and funding of its activities related to health, contaminants and nutrition in the region.

Northern Contaminants Researcher: Increasing ownership of research development and implementation in the region while educating Nunatsiavummiut about contaminants in relation to Inuit health and wellbeing

Chercheur sur les contaminants dans le Nord : Prise en charge accrue de l'élaboration et de la mise en œuvre de recherches dans la région et sensibilisation des Nunatsiavummiuts sur les effets des contaminants sur la santé et le bien-être des Inuits

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Abstract

During 2014-2015, the Northern Contaminants Researcher (NCR) continued to be the first point of contact for contaminant related information in the Nunatsiavut region. The NCR worked directly with many contaminant-related research projects as well as other research projects that related to the wellbeing of Nunatsiavummiut. Communication was achieved through direct trips to the communities of Nunatsiavut, informing Nunatsiavummiut of the contaminant-related research projects taking place, results produced so far and discussed any potential future research projects. This direct interaction allowed local community

Résumé

En 2014-2015, le chercheur sur les contaminants dans le Nord a continué d'être le premier point de contact en ce qui concerne la prestation d'information sur les contaminants dans la région du Nunatsiavut. Il a contribué directement à plusieurs projets de recherche sur les contaminants ainsi qu'à d'autres projets sur le bien-être des Nunatsiavummiuts. La communication a été assurée dans le cadre de visites directes dans les collectivités du Nunatsiavut, afin d'informer les Nunatsiavummiuts des projets de recherche sur les contaminants en cours, des résultats obtenus à ce jour et des projets

members to ask questions and get information directly from the NCR. Other forms of communication used included social media, the Nain Research Centre website and community meetings. The NCR also sits on the Nunatsiavut Research Advisory Committee (NGRAC) and the Northern Contaminants Program (NCP) Management Committee to review research project proposals submitted to Nunatsiavut and NCP. Environment department meetings were attended to identify and overcome challenges, build better communication and collaboration and improve intradepartmental sharing. NCP management committee meetings were attended in Ottawa and Yellowknife. Teleconferences and meetings took place to funding opportunities for training and education of Labrador Inuit.

futurs. Ces interactions directes ont permis aux membres des collectivités locales de poser des questions et d'obtenir de l'information directement du chercheur. Les autres moyens de communication utilisés comprenaient les médias sociaux, le site Web du Centre de recherche de Nain, et des rencontres communautaires. Le chercheur a également siégé au Comité consultatif de la recherche du Nunatsiavut et au Comité de gestion du Programme de lutte contre les contaminants dans le Nord (PLCN). Des réunions ont eu lieu avec le ministère de l'Environnement afin de cibler et de régler les problèmes, de faciliter les communications et la collaboration, ainsi que d'améliorer la communication de l'information au Ministère. Des réunions de gestion du PLCN ont eu lieu à Ottawa et à Yellowknife, et des téléconférences et d'autres réunions ont eu lieu au sujet d'occasions de financement de la formation et de l'éducation des Inuits du Labrador.

Key Messages

- The NCR communicated information about benefits of traditional food and encouraged Nunatsiavummiut to continue to consume traditional food, as the benefits outweigh any risk associated with the current contaminant load that the food might contain.
- The NCR worked with a wide variety of contaminant related projects to build capacity in Nunatsiavut, allowing Nunatsiavut to take leadership in these areas. This included capacity building in Nunatsiavut Government employees, harvesters and youth, relating to contaminants and associated research processes.
- The NCR continued to work with researchers traveling to Nunatsiavut to ensure they understand the concerns, culture and traditions of the Inuit in Nunatsiavut. Also, the NCR encouraged the researchers to become more involved within the communities, including hiring and training local residents, helping to build capacity within our region.

Messages clés

- Le chercheur a communiqué de l'information sur les bénéfices de l'alimentation traditionnelle et a encouragé les Nunatsiavummiuts à continuer de consommer des aliments traditionnels, en soulignant notamment que les avantages de cette alimentation étant plus nombreux que les risques associés à la charge actuelle de contaminants que ces aliments pourraient contenir.
- Le chercheur a travaillé sur une grande diversité de projets sur les contaminants afin de renforcer les capacités dans le Nunatsiavut, y compris afin de permettre au gouvernement du Nunatsiavut de jouer un rôle de premier plan dans ces secteurs. Cela comprend notamment le renforcement des capacités des employés du gouvernement du Nunatsiavut, des exploitants et des jeunes en matière de contaminants, notamment des capacités associées aux contaminants et aux processus de recherche connexes.

- The NCR worked in conjunction with the Inuit Research Advisor and the Youth Outreach Worker to host community-wide traditional food events, which include a healthy traditional meal in the Nain Research Centre, while providing an informal environment for residents to access research and contaminate-related information.
- In conjunction with an educator and staff at the Nain Research Centre, the NCR developed education modules that explain contaminants in the Nunatsiavut environment, while ensuring they were compatible with the Newfoundland and Labrador curriculum
- In partnership with the Youth Outreach Program, harvesters and researchers, the NCR collected and processed samples for NCP projects, building capacity and reducing costs for the research projects.
- Worked with a wide variety of projects to build capacity in Nunatsiavut, allowing Nunatsiavut to take leadership in these areas in the future and teach employees and youth about how contaminants make their way into our environment and the impact this may have on species in the region.

- Le chercheur a continué de collaborer avec des collègues venus d'ailleurs pour veiller à ce qu'ils comprennent les préoccupations, la culture et les traditions des Inuits du Nunatsiavut. Il a aussi incité ses homologues à s'associer plus étroitement aux collectivités, notamment en embauchant des résidants et les en formant, afin de contribuer au renforcement des capacités dans la région.
- Le chercheur a travaillé en collaboration avec le conseiller en recherche inuite et l'agent de sensibilisation des jeunes pour organiser des activités communautaires liées aux aliments traditionnels, notamment un repas traditionnel santé au Centre de recherche de Nain, où les résidants ont pu obtenir de l'information sur la recherche et les contaminants.
- De concert avec un éducateur et le personnel du Centre de recherche de Nain, le chercheur a élaboré des modules éducatifs sur les contaminants environnementaux au Nunatsiavut, en veillant à ce que ces modules soient compatibles avec le programme d'enseignement de Terre-Neuve-et-Labrador.
- En partenariat avec le programme de sensibilisation des jeunes, des exploitants et des chercheurs, le chercheur sur les contaminants dans le Nord a recueilli et traité des échantillons pour les projets du PLCN, ce qui a permis de renforcer les capacités et de réduire les coûts de la recherche.
- Le chercheur a travaillé sur une grande variété de projets visant à renforcer la capacité au Nunatsiavut, afin que celui-ci assume à l'avenir un rôle de premier plan dans ces secteurs, et il a enseigné aux employés et aux jeunes comment les contaminants s'infiltraient dans l'environnement, de même que les répercussions sur les espèces dans la région.

Objectives

1. Be the first point of contact for contaminants and contaminant related information for the Nunatsiavut region;
2. Continue to inform Nunatsiavummiut about contaminants in the region as a large percentage of residents rely on traditional foods and need to be informed on what may be in their food and to allow for more informed decision making in the future;
3. Serve as liaison between Inuit and regional/ national organizations dealing with contaminants, environment and human health research in Nunatsiavut;
4. Identify contaminants, environment and health-related research needs in the region, and work towards ensuring that these needs are met through connections with NCP and the greater community and facilitation of researcher-community relationships;
5. Provide guidance/advice to the Nunatsiavut Government Department of Lands and Natural Resources and Department of Health and Social Development with regards to contaminant and health issues;
6. Work with the Nunatsiavut Inuit Research Advisor and the Nunatsiavut Government Research Advisory Committee to further develop a research support system and infrastructure in Nunatsiavut;
7. Participate on the Nunatsiavut Governments Research Advisory Committee, which reviews research proposals for the Nunatsiavut Region;
8. Participate as a member of the NCP's Management Committee
9. Assists researchers who are coming to Nunatsiavut to conduct research to directly advise and assist in any planning so that any work being done is culturally relevant to the Nunatsiavut Region;
10. Continue to promote alternative country food to caribou, including char and ringed seal;
11. Work directly with educators and schools within Nunatsiavut to educate and directly engage youth in contaminants related research;
12. Expand and manage the contaminants section of the Nain Research Centre website.

Introduction

Research in Nunatsiavut has shown that contaminants are present in traditional foods as well as water sources. It has also shown that there are drastic changes in climate, which affects the everyday life of Nunatsiavummiut. Presently, contaminant levels in country food have not been of major concern, but this needs to be continually monitored as the level of industrial development and climate change increases, causing concern in Nunatsiavut.

Climate change is changing the way that Nunatsiavummiut use the land, with reduced snow cover, thinner and less predictable sea ice and seasonally warmer temperatures. These changes have prevented Inuit in Nunatsiavut from using the traditional routes to access hunting areas and as a result, have affected the diet of Nunatsiavummiut. Furthermore, as a result in reduction of the George River Caribou Herd and the provincially imposed 5-year hunting ban, there has been a shift in diet from caribou to seal and char in Nunatsiavut.

Contaminants are making their way into the Nunatsiavut ecosystems via long-range transport, primarily from Industrial Development. Also, local source contamination such as hydroelectric development, mining and old military sites have resulted in metals, oils and PCBs being released into the environment. Being able to discern between these local source and long-range contaminants is essential for research and management of these contaminants.

The Nunatsiavut Government Research Advisory Committee has played a large role in providing information to its beneficiaries about the benefits and risks of country food, and ongoing research in Nunatsiavut. The Northern Contaminants Researcher works closely with outside researchers, Inuit Tapiriit Kanatami, NCP, Universities and the five Inuit communities to ensure that scientific research is communicated to the people in a proper and culturally relevant way. The NCR, as a member of the committee, keeps members informed about ongoing issues that affect the Inuit in their daily lives so that informed decisions are made by all parties involved.

Activities in 2014-2015

Participation in Committees

The NCR sits on the Nunatsiavut Research Advisory Committee (NGRAC) and the Northern Contaminants Program (NCP) Management Committee to review research project proposals submitted to Nunatsiavut. The NCR is the chair of the NCP Regional Contaminants Committee. Furthermore, the NCR participated in the Nunatsiavut Government Land and Resource departmental meetings to identify and overcome challenges relating to contaminants and related information.

Communications

The NCR used a variety of media to inform Nunatsiavummiut about contaminants, allowing residents to make more informed decisions as it relates to traditional. The NCR broadcasted information through the OKalaKatiget Society Regional Communication Broadcast Center, research information was presented through discussions at ArcticNet's Annual Scientific Meeting in Ottawa in December of 2014. The Nain Research Center Website was used to post information regarding how contaminants make their way into our food system and information related to any research done in our region.

Education Modules

Working directly with an educator, the Nunatsiavut Government's Community Outreach Manager, Youth Outreach Coordinator and teachers at the local school, education modules were developed. Each of these modules matched up directly with a portion of the Newfoundland and Labrador Curriculum, while allowing the NCR to address contaminant and environmental research related information. This was a very successful collaboration that brought together many departments of the Nunatsiavut Government, the local school and the Nain Research Centre while ensuring that parts of the curriculum in the school are both culturally and environmentally relevant.

Collaboration and Participation in Research.

The NCR established working relationships between Nunatsiavut and researchers of other regions that deal with contaminant-related research. The NCR collaborated with researchers coming to Nunatsiavut, holding open houses, and displaying research to the communities while handing out information to residents. The NCR worked with the Youth Outreach Program, taking samples and processing them for multiple contaminant-related projects including the NCP Blueprint sampling programs for ringed seal and arctic char. Through this project, the NCR also collected traditional knowledge from Inuit hunters and has archived all information.

Nunatsiavut Government Research Advisory Committee

The NCR continues to participate on the Nunatsiavut Government Research Advisory Committee (NGRAC) to review research proposals that are relevant to the Nunatsiavut Region. This is a chance to voice concerns as a committee to ensure that all proposals are culturally appropriate, valuable and that other researchers are not already completing similar research projects. This committee provides an opportunity to represent Nunatsiavut priorities in research.

Additionally, the NGRAC serves as the Regional Contaminants Committee, reviewing all Nunatsiavut-based NCP proposals through a social-cultural lens appropriate for the Nunatsiavut region.

Website:

www.nainresearchcentre.com

Twitter:

@NG_research

Coordination, participation and communication: Evolving Inuit Research Advisor responsibilities in Nunatsiavut for the benefit of Inuit and their communities

Coordination, participation et communication : Évolution des responsabilités du conseiller en recherche inuite du Nunatsiavut, au bénéfice des Inuits et de leurs collectivités

Project Leader:
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Project Team Members and their Affiliations:
Tom Sheldon and Colin Webb, Nunatsiavut Government.

Abstract

The Inuit Research Advisor for Nunatsiavut continues to serve as the first step in a more coordinated approach to community involvement and coordination of Arctic science and represent a new way of knowledge sharing and engagement of Inuit in Arctic science. The Nunatsiavut Government (NG) encourages researchers to consult with Inuit Community Governments in the 5 Nunatsiavut communities, Rigolet, Makkovik, Postville, Hopedale and Nain, as well as NG departments in developing more community based research proposals. Comprehensive reviews of proposals are initiated involving appropriate NG departments, Inuit Community Government(s)/Corporation(s). Together with IRAs in the other Inuit regions of Canada, the Nunatsiavut IRA works towards

Résumé

Le conseiller en recherche inuite (CRI) du Nunatsiavut demeure la première personne-ressource lorsqu'il s'agit de mieux coordonner les efforts de la collectivité et les travaux scientifiques liés à l'Arctique et de représenter une nouvelle façon de mettre en commun les connaissances et de faire participer les Inuits à la science de l'Arctique. Le gouvernement du Nunatsiavut incite les chercheurs à consulter les gouvernements des cinq collectivités inuites du Nunatsiavut (Rigolet, Makkovik, Postville, Hopedale et Nain) ainsi que ses ministères en vue d'élaborer de nouvelles propositions de recherche communautaire. L'examen complet des propositions est effectué par les ministères concernés, les administrations des collectivités inuites et les sociétés communautaires inuites.

achieving a new way of knowledge sharing and engagement of Inuit in Arctic science in the region. In addition to NCP support, the program is co-funded by ArcticNet and the Nunatsiavut Government.

De concert avec les CRI des autres régions inuites du Canada, le conseiller en recherche inuite du Nunatsiavut s'efforce de promouvoir une nouvelle façon de diffuser les connaissances et de mobiliser les Inuits en ce qui concerne les sciences de l'Arctique dans la région. Le financement des activités est conjointement assuré par le Programme de lutte contre les contaminants dans le Nord (PLCN), ArcticNet et le gouvernement du Nunatsiavut.

Key messages

- The IRA co-coordinates the Nunatsiavut Government Research Office, serving as the first point of contact for all researchers conducting work in Nunatsiavut and requiring contact with or assistance from the Nunatsiavut Government
- The IRA is the Chair and administrator of the Nunatsiavut Government Research Advisory Committee (NGRAC). The IRA has communicated with over 44 researchers from 1st April 2014 to 31st March 2015. This year the IRA has chaired 10 NGRAC meetings, one of which was a face to face meeting in Nain
- The IRA served as liaison, contact and assistant to research projects taking place in Nunatsiavut. This assistance ranged from linking the researchers with appropriate individuals and/or organizations such as NG departments and Inuit Community Governments in Nunatsiavut to providing input on research proposals and plans.
- The IRA has also served as liaison for partners such as Inuit Tapiriit Kanatami (ITK), Inuit Circumpolar Council (ICC) Canada, Nunatsiavut Inuit Community Governments/ Corporations, researchers, students, and other organizations.

Messages clés

- Le CRI coordonne le bureau de la recherche du gouvernement du Nunatsiavut, faisant office de premier point de contact pour tous les chercheurs qui mènent des travaux au Nunatsiavut et qui doivent communiquer avec le gouvernement du Nunatsiavut ou obtenir son aide.
- Le CRI est le président et l'administrateur du Comité consultatif de la recherche du Nunatsiavut. Le CRI a communiqué avec plus de 44 chercheurs entre le 1er avril 2014 et le 31 mars 2015 et, cette année, il a présidé 10 réunions du comité consultatif de la recherche au Nunatsiavut, dont une réunion en personne tenue à Nain.
- Le CRI a joué le rôle d'agent de liaison, de contact et d'assistance pour ce qui est des projets de recherche menés au Nunatsiavut. Entre autres, il a mis les chercheurs en rapport avec les personnes ou organisations pertinentes, par exemple les ministères du gouvernement du Nunatsiavut et les administrations des collectivités inuites du Nunatsiavut, et il a fait des suggestions quant aux propositions et aux plans de recherche.
- Le CRI a également assuré la liaison avec des partenaires comme l'Inuit Tapirit Kanatami, le Conseil circumpolaire inuit (Canada), les administrations des collectivités inuites et les sociétés communautaires inuites du Nunatsiavut, des chercheurs, des étudiants et divers organismes.

Objectives

1. Improving the coordination and operation of the Nain Research Center

2. Continued development and management of the Nunatsiavut Government research consultation process.

3. Direct engagement (through implementation) in several specific regionally-led research programs, rather than solely focusing on overall research coordination and facilitation. This will include evaluation of the community freezer program in Nain.

4. Improve the delivery of health messaging in the region by working directly with the Northern Contaminants Researcher, the Nunatsiavut Department of Health and Social Development and Labrador Grenfell Health to ensure appropriate health messaging related to the environment, especially messages related to valued country foods.

5. Together with the IRA coordinators, and ITK and ICC Canada, ensure that projects funded by the Northern Contaminants Program (NCP) and ArcticNet have addressed local realities and concerns, integrated Inuit knowledge and undergone sufficient and meaningful consultation with Inuit.

Introduction

The Inuit Research Advisor provides guidance and recommendations related to Inuit needs, priorities, policy development, and research to NCP and ArcticNet. The Nain Research Centre is quickly becoming a hub for community and regionally-owned research in Nunatsiavut, including contaminants related research, and requires operational coordination. Efficient coordination will result in enhanced benefits for community members with respect to research. The Inuit Research Advisor will also focus on internal capacity building by participating more directly and actively in regionally-led research initiatives. Finally, as research in the region increases, including research related to contaminants, publication of the first annual 'Nunatsiavut research compendium' will result in greater awareness of research and a better understanding of research results generally, and contaminants related issues, specifically.

Activities for 2014-2015

- Managed the Nain Research Center and served as chair of the Nunatsiavut Government Research Advisory Committee, making contact with all researchers, students and organizations visiting or wanting to conduct research in the Labrador Inuit Land Claim Area.
- Along with the IRA's in the other regions participated in numerous teleconferences and attended a two training/workshop in Ottawa.
- Attended the Inuit Circumpolar Councils general assembly in Inuvik along with the other IRA's.
- Attended Arcticnet's Inuit Advisory Committee teleconferences.
- Reviewed NCP proposals along with members of NGRAC for Nunatsiavut.
- Reviewed proposals under Health Canada's, Health Adaptation and Climate Change program.
- Reviewed proposals for Nasivvik.

- Activley participated in several specific regionally-led research programs, including evaluation of a community freezer program in Nain with associated contaminants research.
- Attended ArcticNet's, Arctic Change Conference in Ottawa and presented jointly with the other IRA's during student day activities and during the sessions.
- Numerous local presentations to a variety of audiences including community public meetings, meetings with organizations such as Inuit Community Governments and Food Security Network NL.
- Assisted researchers with hiring of local research assistants, school visits and holding open houses.

Results

The IRA program in Nunatsiavut continues to provide a coordinated process by which Inuit and researchers can become connected for more effective and meaningful research in the disciplines of environmental science, contaminants and human health.

Expected Project Completion Date

This is an on going project.

The current state of long range contaminants in the Inuvialuit Settlement Region (ISR)

État actuel des contaminants transportés sur de grandes distances dans la région désignée des Inuvialuits

- **Project Leader:**
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- **Project Team Members and their Affiliations:**
  Nellie J. Cournoyea, Evelyn Storr, and Bob Simpson, Inuvialuit Regional Corporation.

Abstract

The Inuit Research Advisor (IRA) for the Inuvialuit Settlement Region (ISR) continues to serve in the IRA capacity within Inuvialuit Regional Corporation (IRC) while also conducting projects under the Northern Contaminants Program (NCP) and other organizations that fund Inuit specific programming. These projects ensure that residents and frontline workers in the ISR are informed about research led by NCP, ArcticNet and other research led by various other organizations, governments and industry. This year, the IRA successfully completed two NCP projects, including one edition of the Inuvialuit Research Newsletter and the one Regional Community Tour where the IRA

Résumé

Le conseiller en recherche inuite (CRI) pour la région désignée des Inuvialuits (RDI) continue de servir à ce titre au sein de la Société régionale inuvialuite (SRI) tout en réalisant des projets aux termes du Programme de lutte contre les contaminants dans le Nord (PLCN) et pour d'autres organisations qui financent des programmes s'adressant spécifiquement aux Inuits. Ces projets permettent de veiller à ce que les résidants et les travailleurs de première ligne dans la RDI soient informés des recherches dirigées par le PLCN ou ArcticNet ou d'autres recherches menées par diverses organisations, par les gouvernements ou par l'industrie. Cette année, le CRI a réalisé avec succès deux projets du PLCN, à savoir la publication d'un bulletin

hosted six separate meetings in the communities of Aklavik, Inuvik, Paulatuk, Sachs Harbour, Tuktoyaktuk and Ulukhaktok. These meeting were held in conjunction with a two day proposal writing workshop funded by Health Canada, which total a three day visit in each community for training and program updates.

The IRA for the ISR also served as the Chair of the NWT Regional Contaminants Committee (NWT RCC) from February to October 2014 and was nominated again in February 2015 to serve as co-chair until 2016. Therefore, the IRA was extra busy this year with Chairing responsibilities during the call for proposals and during the consultation process, following up with each researcher conducting research in the ISR. The IRA also continues to work regularly with the other three IRA's from Nunavut, Nunavik and Nunatsiavut. We connect around one to two times a month via teleconference to discuss projects, upcoming events and annual training. Our group completed our annual training in 2014 completing a course offered at Algonquin College in Ottawa, ON called "Building and Sustaining Effective Business Relationships". From this, each IRA learned valuable lessons that apply to our positions such as how to work effectively in multi-disciplinary environments.

In addition to NCP work, the IRA also managed to secure additional funding and conducted two capacity building and training projects on behalf of IRC including a proposal writing workshop for Health Canada Climate Change and Health Adaptation Program (CCHAP) for First Nations and Inuit Communities and a Reindeer Harvesting Program funded by the NWT Anti-Poverty Fund.

d'information sur la recherche inunialuite (*Inuvialuit Research Newsletter*) et la visite des collectivités de la région, à savoir six réunions distinctes dans les collectivités d'Aklavik, d'Inuvik, de Paulatuk, de Sachs Harbour, de Tuktoyaktuk et d'Ulukhaktok. Ces réunions ont été tenues en conjonction avec un atelier sur la rédaction de propositions financé par Santé Canada. En tout, les visites dans chacune des collectivités ont duré trois jours et ont permis de présenter une mise à jour au sujet des programmes et de la formation.

Le CRI pour la RDI a assuré la présidence du Comité régional des contaminants (CRC) pour les T.-N.-O. de février à octobre 2014 et, en février 2015, il a été nommé coprésident du CRC jusqu'en 2016. Le CRI a donc été très occupé cette année puisqu'il a assumé la présidence pendant qu'avaient lieu l'appel de propositions et le processus de consultation. Il devait notamment faire un suivi auprès de chaque chercheur réalisant de la recherche dans le RDI. Le CRI a également continué de travailler régulièrement avec les CRI au Nunavut, au Nunvik et au Nunatsiavut. Ceux-ci ont communiqué entre eux par téléconférence une ou deux fois par mois pour discuter des projets, des activités à venir et de la formation annuelle. Le groupe a terminé sa formation annuelle en 2014 avec le cours sur le renforcement et le maintien de relation efficaces (*Building and Sustaining Effective Relationships*) offert par le collège Algonquin, à Ottawa. Les CRI ont ainsi appris d'importantes leçons sur la façon de travailler efficacement dans des environnements multidisciplinaires.

En plus des travaux associés aux PLCN, le CRI a également obtenu du financement supplémentaire et mené deux projet de formation et de renforcement de la capacité au nom du CRC, soit un projet d'atelier sur la rédaction de propositions aux fins du Programme sur l'adaptation et la santé liée aux changements climatiques de Santé Canada et d'un programme sur l'exploitation du Caribou financé par le Fonds anti-pauvreté du gouvernement des T.-N.-O.

Key messages

- The Inuit Research Advisor continues to monitor research in the ISR via the review of ARI research license applications. Results are then published in the Inuvialuit Research Newsletter.
- The IRA is becoming more involved with NCP Management Committee and attended the NCP Management Committee April 2014 meeting in Ottawa as the Chair of the NWT RCC.
- The IRA attended a joint NCP Management Committee/NWT RCC meeting held in Yellowknife, NT in October 2014.
- The IRA assisted all ISR based researchers this year in the role of Chair of the NWT RCC ensuring NCP had their consultation forms and letters of support. IRA also assisted researchers via review of proposals and logistical and communication plans.
- The IRA also served as a liaison for partners such as ArcticNet (Arctic Change 2014) Inuit Tapiriit Kanatami (Inuit Health Survey National Steering Committee) and Inuit Circumpolar Council-Canada (ICC General Assembly, Nagoya Protocol meetings in December).
- The IRA facilitated 6 proposal writing workshops in conjunction with NCP community tour in each of the six ISR communities.
- The IRA coordinated and managed a Reindeer Harvest that involved training youth and adults and distributing meat regionally to all six communities.

Messages clés

- Le conseiller en recherche inuite continue de surveiller la recherche qui se fait dans la RDI en examinant les demandes de permis de recherche présentées à l'Institut de recherche Aurora. Les résultats sont ensuite publiés dans le bulletin d'information sur la recherche inuvialuite (*Inuvialuit Research Newsletter*).
- Le CRI participe plus étroitement avec le Comité de gestion du PLCN et il a participé à une réunion du Comité en avril 2014, à Ottawa, à titre de président du CRC pour les Territoires du Nord-Ouest.
- Le CRI a participé à une réunion conjointe du Comité de gestion du PLCN et du CRC pour les T.-N.-O. tenue à Yellowknife en octobre 2014.
- Cette année, le CRI a apporté son soutien à tous les chercheurs basés dans la RDI à titre de président du CRC pour les T.-N.-O. en s'assurant qu'ils avaient des formulaires pour la consultation et des lettres de soutien aux fins du PLCN. Le CRI a également aidé les chercheurs en examinant leurs propositions et leurs plans logistiques et de communication.
- Le CRI a assuré les liaisons avec des partenaires comme ArcticNet (conférence sur le changement climatique de 2014), Inuit Tapiriit Kanatami (Comité directeur national sur l'Enquête sur la santé des Inuits) et le Conseil circumpolaire – Canada (Assemblée générale du CCC, réunions sur le Protocole de Nagoya en décembre).
- Le Cri a facilité six ateliers sur la rédaction de propositions et visité les six collectivités de la RDI visées par le PLCN.
- Le CRI a coordonné et géré un projet d'exploitation du caribou comprenant la formation de jeunes et d'adultes et la distribution de viande aux six collectivités.

Objectives

1. Completed one edition of the Inuvialuit Research Newsletter and distributed 870 copies regionally within the ISR, as well as online via e-mail distribution list.
2. Completed one regional community tour hosting six separate IRA meetings
3. Attend NWT RCC Social and Cultural Review meeting in Yellowknife (February 2015)
4. Attend NCP Annual Results Workshop, Ottawa, September 2014

Introduction

The work proposed and completed by the Inuit Research Advisor in the Inuvialuit Settlement Region continues to align with NCP's new blueprint and scope, while IRC utilizes the position by supporting the IRA to do projects that benefit people in the ISR in terms of communication, community based research, training and outreach activities. This also directly aligns with the other roles and responsibilities of the position to build capacity and assist communities in areas such as climate change, poverty, economy, adaptation, and other social areas. Both the community tours and Inuvialuit Research Newsletter serve as effective tools in engaging with and informing Inuvialuit about NCP researchers and projects on an annual basis. As well as, other research taking place at regional, territorial and national levels. People in communities continue to let the IRA know that they favor this type of communication by the Program, where they are given research information by a local person who is consistent and knows the issues.

Activities in 2014-2015

Capacity Building

Health Canada Proposal Writing Workshop

The IRA was able to secure funding from the Health Canada CCHAP to hold a series of six proposal writing workshops in each Inuvialuit community. Proposal workshops were held over two days using the venue the NCP meeting is held. The IRA first held the workshops over two full days (9 am-5pm) then held the NCP meeting on the third day in each community (11-2 pm). The workshop covered three PowerPoint presentations to introduce the concept and outlines of proposals and different funding applications like grants and scholarships. During the January-March workshops the ITK $5000 grant initiative to get kids to school was out and every community except Inuvik and Paulatuk worked on the grant application with the IRA as an exercise built into the workshop. The result of this project is that 4 out of 6 communities in the ISR were successful in obtaining the ITK grant and will work on innovative projects aimed at increasing youth attendance in school, specifically with youth grades 9-12 where attendance seems to decline. Paulatuk and Inuvik submitted their own grants and were also successful and represent 2 out of 6 successful applications.

IRA Training

Due to funding from ArcticNet and NCP the IRA's are able to participate in annual training to help build on the skills sets of the individual IRA's but also on how IRA's work together as a group. This year this IRA Coordinator at ITK and IRA's chose to take a course called "Sustaining Effective Business Relationships" offered by Algonquin College. The IRA's completed this training in November 2014 at the ITK Boardroom in Ottawa, Ontario. The training included lessons on.....

Reindeer Harvesting Project

From May-August 2014, the IRA and IRC's Executive Director, Evelyn Storr assisted Laurie Chan's team to plan and facilitate an Anti-Poverty Workshop in Inuvik with two representatives from each of the six Inuvialuit communities who worked on similar work or had current positions at Hunters and Trappers Committees (HTC's), Hamlets or Community Corporations (CC's). The workshop took place in August 2014 and was successful in opening up dialogue about food security issues in the ISR with communities identifying their needs to reduce poverty and discussed past projects and initiatives that have worked. As a result of the workshop, IRC took an initiative to apply for funding available through the NWT Anti Poverty Fund to conduct multiple community hunts to have the means to distribute meat regionally to elders, single parents and households with no active hunter. IRC did a reindeer harvest to supplement caribou meat, which is limited in the region. IRC chose to focus on reindeer to educate both program participants and other Inuvialuit of the history and culture of reindeer harvesting within the ISR as well as in other circumpolar countries like Russia and Finland for example. Three people, two youth and one adult from Aklavik, Inuvik and Tuktoyaktuk took part in the project. Therefore, six youth and three adults were trained in the reindeer harvest and learned about butchering, skinning, cutting and boxing of meat. At the end of the project a total of 594 boxes of reindeer meat were distributed.

New- AANDC Youth on the Frontline of Climate Change

In 2013, IRC submitted a proposal to the AANDC's Climate Change and Health Adaptation Program (CCHAP) for a project called "Youth on the Frontline of Climate Change". The objective of this project is to hire 5-6 part time youth positions in each Inuvialuit community to undertake this two year project. Once positions are filled each one will host a series of climate change workshops with other youth in community to first inform them of climate issues and then to allow them to help create a regional climate change strategy. This will happen by completing an adaption plan with each community. Fortunately a consulting company, ArcticNorth Consulting has already completed three of the Adaption Plans (AP's) for Aklavik, Ulukhaktok and Paulatuk, and the IRA has been given permission to use the plan templates to create the other three for Sachs Harbour, Tuktoyaktuk and Inuvik. Once each AP is completed, IRC will assist the youth to combine the six individual community adaptation plans and integrate them into a larger Regional Climate Change Adaption Plan, a product led by the youth of our region.

Communications

Inuvialuit Research Newsletter

The Inuvialuit Research Newsletter is one of the two main modes the IRA communicates people from inside and outside of the ISR on what research is taking place in the ISR. It includes IRA updates, a listing of licensed research, articles of research related programs and initiatives available in the region, researcher submitted articles and a listing of different news and events that have taken place regionally, territorially and nationally as it related to Inuit from across Canada.

Community Tours

Community tours are the main way that the IRA is able to get information out to beneficiaries. Each community meeting features the following; sign in sheet (with door prize ticket), brochures and hand outs table (NCP, ArcticNet), and a presentation by the IRA on the current year of research and IRA duties. This is followed by group discussions where community members voice their concerns or come up with ideas for community based research projects that could address their concerns. Each meeting is held during the day at a community venue that is usually a community hall or boardroom which is rented. Meetings are aimed to be held from 11 am-2 pm, with a lunch, snacks and refreshments served at 12 pm. Participants are also entered to win door prizes which are usually $50 gift cards for food or gas from a local store like North Mart or Stanton's.

Inuit Health Survey National Inuit Steering Committee

IRC is involved with the re-establishment of the IHS National Inuit Steering Committee, both the IRA and IRC's Executive Director attended face to face meetings in Ottawa at the University of Ottawa in May 2014. The Steering Committee is being re-formed to help direct NCP projects led by Laurie Chan and Nil Basu.

NCP presentation

During the NCP Results Workshop held in Ottawa in September 2014, the IRA's did a joint presentation on working with Inuit communities in Inuit Nunagat.

ArcticNet Student Day

During Arctic Change 2014, IRA's facilitated two workshops with ArcticNet students. We did a joint presentation and had group discussions and a question period.

ArcticNet Topical Session

During the ArcticNet Arctic Change Conference 2014, the IRA's, Romani (Nunavut) and Shannon (ISR) did a topical session presentation of adaption to climate change in Inuit regions with other panelists from Nunavut, Greenland and Alaska

Traditional Knowledge Integration

Reindeer Harvesting Project

Traditional knowledge on reindeer harvesting was used during this project with youth and adults from Aklavik, Inuvik and Tuktoyaktuk.

Results

As a result of the IRA position in the ISR, Inuvialuit are more aware of the different types of research taking place in the region and across the north. The IRA completed the following projects that lead to more capacity building, training, outreach and communication about NCP and non-NCP led projects.

- One Inuvialuit Research Newsletter (non-translated)
- One regional Community Tour: hosted 6 separate meetings in conjunction with a 2 day proposal writing workshop funded by Health Canada.

Discussion and Conclusions

The Inuit Research Advisor position has brought many positive benefits in each of the Inuit regions in which it is housed. The evolution of the position since 2004 has shown much growth and capacity building over ten years among Inuit and among IRA's. The IRA position in the ISR is a good example of how IRA's can be utilizes as resources while also leading or partnering on research that addresses training and capacity building or community based research. This and the work IRA's do in concert show the unity of Inuit regions desiring a presence and voice in helping to direct research in the arctic. Now, Inuit are able to weigh the benefits and non-benefits of research at a community or the regional level and as Inuit communities now have the power to refuse participation in research. This is a shift away from research that was conducted in the North in the past, where Inuit did not have the outlets to address their concerns and ideas about the environment and communities.

Expected Project Completion Date

March 2015 and ongoing

Acknowledgments

Translator/Interpreter: Robert Kuptana (Ulukhaktok)

Caterers: Peter Ruben (Paulatuk), Sachs Harbour Recreation Committee (Sachs), Agnes Kuptana (Ulukhaktok), Aklavik Graduate Committee-Megan Charlie (Aklavik), Sarah McKay (Tuktoyaktuk), and Brenda Bernhardt (Inuvik).

Facilitators: n/a (Paulatuk), Andrea Keogak (Sachs Harbour), Julia Ekpakohak (Ulukhaktok), Michelle Gruben, Pamela Kimiksana, n/a (Inuvik)

Staff of the Community Development Division: Evelyn Storr, John Stuart Jr. Jiri Raska, Jimmy Ruttan and Meghan Etter for their contributions and assistance in IRA projects.

Staff at HTC's, Hamlet's and Community Corporations for assisting me with hiring caters and facilitators and for helping to recruit people into the proposal writing workshops.

NCP was acknowledged at all presentation and in publications created by IRA's.

Nunavik Inuit Research Advisor

Conseiller en recherche inuite au Nunavik

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Abstract

The Nunavik Inuit Research Advisor (IRA) is part of the Renewable Resources, Environment, Lands and Parks Department of the Kativik Regional Government. The IRA works in close cooperation with the Nunavik Board of Health and Social Services (NRBHSS) and the Makivik Research Centre, and is co-funded by the NCP and ArcticNet. The aim of the IRA is to facilitate research at the regional level and assure the effective liaison between northern communities and researchers.

In order to achieve the objectives, the advisor reviews research proposals and provides relevant comments and suggestions. Attending meetings, like the Northern Contaminants Program

Résumé

Le conseiller en recherche inuite (CRI) au Nunavik fait partie du Service des ressources renouvelables, de l'environnement, du territoire et des parcs de l'Administration régionale Kativik. Le CRI travaille en étroite collaboration avec la Régie régionale de la santé et des services sociaux Nunavik (RRSSSN) et le Centre de recherche de Makivik, et il est cofinancé par le Programme de lutte contre les contaminants dans le Nord (PLCN) et ArcticNet. L'objectif du CRI est de faciliter la recherche à l'échelle régionale et d'assurer une liaison efficace entre les collectivités du Nord et les chercheurs.

Afin de réaliser les objectifs, le conseiller examine les propositions de recherche et fournit

(NCP) Results Workshop, Nunavik Nutrition and Health Committee NNHC meetings, and international scientific conferences such as the ArcticNet Annual Scientific Meeting (ASM), is part of the IRA mandate. The IRA also organizes and gives training sessions in collaboration with the three other regional IRAs, in the Inuvialuit Settlement Region, Nunavut, and Nunatsiavut).

des commentaires et des suggestions pertinents. Assister à des réunions, comme l'atelier sur les résultats du PLCN, les réunions du Comité de la nutrition et de la santé du Nunavik et à des conférences scientifiques internationales, comme la réunion scientifique annuelle d'ArcticNet, fait partie du mandat du CRI. Le CRI organise aussi des séances de formation en collaboration avec les trois autres CRI régionaux, dans la résignée des Inuvialuits, au Nunavut et au Nunatsiavut.

Key messages

- Research occurring in the North is beneficial; however, it should be done in concert with local communities to better answer their needs, values, priorities and/or concerns.
- In order to achieve that goal, communication between northern and scientific communities must be possible.
- The role of the IRA is to promote this communication and facilitate the establishment of a relationship and collaboration between northerners and the research community.
- The IRA guides and advises research projects or regional authorities in regards of Inuit needs, and communicates back to the communities the project results.

Messages clés

- La recherche effectuée dans le Nord est bénéfique; toutefois, elle devrait être effectuée de concert avec les collectivités locales pour mieux répondre à leurs besoins, leurs valeurs, leurs priorités et/ou leurs préoccupations.
- Pour atteindre cet objectif, il faut que les communications entre les collectivités nordiques et scientifiques soient possibles.
- Le rôle du CRI est de favoriser cette communication et de faciliter l'établissement d'une relation et d'une collaboration entre les résidants du Nord et le milieu de la recherche.
- Le CRI guide et conseille les responsables de projets de recherche et les autorités régionales en ce qui concerne les besoins des Inuits, et il diffuse auprès des collectivités les résultats des recherches.

Objectives

The main objectives in relation to the Northern Contaminants Program are to guide and assist researchers with their project and involve Inuit, Northern communities and local organization within those research programs.

1. Be an active member of the NNHC;
2. Liaise with national and international organizations and other Inuit regional organizations in matters related to Arctic science and research;
3. Act as a liaison between researchers and communities to facilitate research and the development of effective partnerships;
4. Collaborate with the Makivik Research Center in developing and implementing a research licensing tool for the Nunavik region; ensuring that the researchers communicate with the appropriate community representatives (and vice-versa);
5. Develop a research mentorship program for KRG and Nunavik;
6. Identify concerns and priorities of northerners, communities, and regional organizations in order to promote these to the NCP and other researchers;
7. Identify potential community or regional partnerships to be made with existing and future projects;
8. Identify opportunities for youth to become engaged in research and science;
9. Identify northern students and youth interested in participating in research activities and connecting them with appropriate research projects and training initiatives;
10. Identify Inuit-led project proposals that could apply for funding;
11. Provide information on other research activities occurring in the region;
12. Provide support and advice to communities on research from the Northern Contaminants Program;
13. Offer guidance in the production of promotion and communication materials and the distribution of these materials in each region for the research programs and individual projects;
14. Offer guidance and, where appropriate, assist with communicating research results of individual projects to relevant communities and regional organizations;
15. Gather and locate accurate and relevant contaminant materials to distribute;
16. Provide support and direction for researchers coming to work in Nunavik and help with communicating the results back (e.g. to communities, policy makers, local decision makers) in a responsible and collective manner;
17. Provide information regarding research in Nunavik and opportunities for local involvement
18. Inform and communicate with the Nunavik population about contaminants research and the results of research studies. (NNHC communication protocol differs from other regions; therefore the IRA alone may not freely communicate the research results without discussing the accuracy and terminology of research with the NNHC. If the media is used as a source of communication, the communication department of KRG must give a consent form before the results are published or announced for the region by the IRA);

Introduction

The past decade has seen a reinvestment in Arctic Science in Canada and an increased level of research activity in the Arctic. Currently a series of multidisciplinary science programs, are looking to work closer with Nunavik communities in order to better integrate Inuit concerns and needs into science and policy and to improve cooperation at community, regional and international levels.

In 2003, The Nasivvik Centre for Inuit Health and Changing Environments identified the need for coordination of research being undertaken in the North, Utilizing NCP's successful partnership model Nasivvik, in collaboration with ITK and ICC- Canada, developed the regional Inuit Research Advisor (IRA) positions. These positions were established to better coordinate research, build capacity, and encourage greater Inuit engagement in research and foster researcher and community interactions. The Nasivvik Centre is no longer able to fund the IRA positions.

The ArcticNet Network of Centers of Excellence and the Northern Contaminants Program now provide funding for an Inuit Research Advisor (IRA) in each of the four Inuit land claim regions of the Canadian Arctic. To guide Arctic research and to engage Inuit in undertaking research activities of importance to their communities. Inuit participation at the regional level is mandatory to ensure appropriate community consultation and liaison and effective communication between researchers, regions, coordinators, and liaison officers. The IRAs receive support and training to assist university and government researchers in making the appropriate connections with communities and regional organizations, to develop Inuit-led research projects, and to facilitate research in Inuit regions on contaminants, climate change and environmental health. The IRA position is a step towards a more coordinated approach to community involvement and coordination of Arctic science and represents a new way of knowledge sharing and engagement of Inuit in Arctic science.

These regionally based IRA positions receive support and coordination both nationally and internationally from Kendra Togoona and Eric Loring from ITK from Dr Scot Nickels and Carrie Grable from the Inuit Knowledge Center and from Pitsey Moss-Davies, the ICC ArcticNet Coordinator. Additional support in Nunavik, for the IRA position, will come with mentorship from Michael Barrett as well as other members in the environmental and renewable resources fields of the Kativik Regional Government and the from the NCP funded Nunavik Nutrition and Health Committee.

Activities in 2014-15

During 2014-15 the Nunavik Inuit Research Advisor, Betsy Palliser, kept in contact with the Communities, Regional Entities, Researchers and Research Institutions through telephone and internet from her office in Puvirnituq. She also worked in collaboration with the other Inuit Research Advisors including participating on monthly conference calls organized by the ITK. As a KRG appointed member of the Kativik Environmental Advisory Committee (KEAC) the IRA also provided informal updates regarding various health-related issues in Nunavik and participate on the KEAC special commission on uranium mining in Nunavik.

Travels and meetings attended include the following:

- June 4-6, 2014: Nunavik Nutrition and Health Committee meeting in Kuujjuaq
- July 8, 9 and 10, 2014: Kativik Environmental Advisory Committee 140th Meeting in Akulivik)
- July 19-25, 2014: Inuit Circumpolar Conference in Inuuvik
- August 20-21, 2014: Institut Nordique du Quebec Meeting in Kuujjuaq
- October 1 and 2, 2014: Kativik Environmental Advisory committee 141st Meeting: Quebec City)

- November 3-5, 2014: Nunavik Nutrition and Health Committee meeting in Kuujjuaq
- November 10-14, 2014: IRA meeting and training in Ottawa (Algonquin College)
- November 19- 21, 2014: Kativik Environmental Advisory Committee 142nd meeting: Kuujjuaq)
- December 8-12, 2014: ArcticNet- Arctic Change Conference in Ottawa
- February 10-12, 2015: Nunavik Nutrition and Health Committee meeting in Quebec
- March 24 and 25, 2015: Kativik Environmental Advisory Committee
- 143rd Meeting: Quebec City

As a participant of the KEAC Special Commission on Uranium Mining in Nunavik, meetings attended included:

- September 07-14, 2014: Public consultation in Quebec City (information and questioning session)
- September 23-26, 2014: Public consultation in Kangiqsualujjuaq (1st phase information and questioning session)
- December 01, 2014: Public consultation in Kuujjuaq (2nd phase preoccupation session)
- December 02, 2014: Public consultation in Kangiqsualujjuaq (2nd phase preoccupation session)
- December 03, 2014: Public consultation in Kawawachikamach
- December 15, 2014: Public consultation in Montreal

Results

The Nunavik IRA, Betsy Palliser, was again very active this year in attending many regional and international meetings. She was able to develop collaborations with researchers and helped in the development of their project. She helped in defining main concerns of those projects in relation to the Nunavimmiut priorities in terms of research. She also was able to reorient some aspects of scientific projects to better tally Northern Communities' needs. The IRA therefore initiated and simplified interactions between scientists and Northerners. Those concerns are numerous and include among other things ice safety, climate change, tourism and development, mining impacts. The investigation of those concerns is done through the gathering of community members, academic researchers and cross-cultural exchange with other arctic communities. Betsy was therefore an important pawn in first helping out to highlight main priorities in Northern communities, and secondly, to facilitate contacts between community members and researchers.

Each year, the IRA is active in advising regional authorities on various subjects like food and health issues. As a member of the Nunavik Nutrition and Health Committee, Betsy Palliser attended meetings and reviewed proposals, results, updates and recommendations.
In regards of what Betsy could observe in communities and from what Inuit were telling her, she was able again to lead the NNHC's work in the direction fitting communities' priorities and needs in terms of public's education on food and health problems. As part of the Northern Contaminants Program, the IRA was again this year really essential in advising them on policy issues, determining in what direction research should go and again making recommendations.

IRA is also contributing in various ways in education projects within communities for all age classes. The IRA was collaborating on a scientific project on little berries carried out in secondary school. This project aims to teach kids how berries can be used. They learn the whole process of transformation, from berry picking to food making. She is also involved in a project of permafrost education throughout Northern communities. With climate change, permafrost thawing is predicted to be more important leading to many problems in communities and education and guidance is needed.

The IRA was also a key link between the scientific and Northern communities. It is important that Inuit be aware of research occurring near them, the results that are coming out of them and that they are able to give feedbacks. The IRA played also a major role in decimating results for example from ArcticNet network studies. Betsy also heard communities' opinions and knowledge and tried to make recommendations on how this can be incorporated in research.

Discussion and Conclusions

With the expansion of population in the North and with the new reality of climate changes, more and more research projects are occurring in Northern communities. They are necessary to better understand what is happening in communities and their surroundings, to better understand the impacts of changing environments, resources exploitation and/or new ways of living. Therefore, those research projects are important to better manage natural, economical and human resources. However, what is important or what is interesting in terms of research projects to scientists who are strangers to the North, is not often a priority for people living in Northern communities. There is also a big gap in terms of communication between communities and researchers that is hard to fill.

The IRA therefore has a key role in Northern research projects and for Inuit's interest that should be kept. It is essential to try to gather the Northern and scientific communities. To achieve that goal, communication between the two parties must be possible. Northern communities should have the chance to express their needs, concerns and priorities in terms of research. They should be aware of past, ongoing and future research projects and associated results. They should also be able to integrate traditional knowledge within those projects. Researchers should be able to hear them, and integrate, modify, and/or adapt their studies to better answer their needs and concerns.

The IRA serves well this mission. She is there to work with communities and transfer back the information to them. She can advise, orient, and produce tools in regards to a research project to better answer communities' needs and understanding. She facilitates the development of links between scientists, local people and traditional knowledge holders that are not so evident to create. However, those links are essential to do "good research" in accordance to Inuit's priorities: this collaboration is beneficial to both parties.

In the long term and in some cases, the establishment and maintenance of relationships between scientist and community is possible without any intervention. However, it is not the majority and therefore, the IRA still serves an important role. She can help in creating the link between them by assuring communication and she can help in putting a scientific project in a broader context of Inuit's needs and concerns. In addition the IRA is trilingual with proficiency in Inuktitut, French and English, enabling her to communicate with ease in any given situation.

The IRA will therefore continue to attend various meetings and conferences in order to stay up-to-date on researches occurring in the North and their results/recommendations. She will continue to attend NCP result workshop, and NNHC meetings. She will also be participating at various conferences like the National Inuit Climate Change Committee, the ArcticNet Inuit Advisory Committee, the ArcticNet Students Association meetings, etc. Consequently, she will be able to continue advising and guiding scientists throughout their research project, and she will be able to communicate the information back to Northern communities. In sum, the IRA is essential in creating and preserving the relationship and collaboration between Northern communities and scientists to have research projects adapted and meaningful to Nunavimmiut.

Expected Project Completion Date

Throughout this extraordinarily busy, year the IRA continued to serve an important role in liaison communications between researches and communities in Nunavik. The objectives set out for 2014-2015 were realized.

The Research Advisor. Increasing Nunavut Tunngavik Incorporated's social and cultural research coordination

Conseiller en recherche : accroître la coordination de la recherche sociale et culturelle menée par la Nunavut Tunngavik Incorporated

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Abstract

In the 2014-2015 fiscal year the Research Advisor concentrated on networking and bringing more awareness about the Northern Contaminants Program (NCP) in the region through various means. First, the ongoing support and work with the Nunavut Environmental Contaminants Committee (NECC) has proven to be successful again with the participation of researchers providing their communication plans/ materials prior to distribution. This gives the committee chance to vet and approve the way the research is being shared with Nunavummiut. Second, the participation of the Research Advisor with NCP projects and assisting in community consultations was a learning experiencing in terms of challenges and benefits of community

Résumé

Au cours de l'exercice 2014-2015, les travaux du conseiller en recherche ont surtout porté sur la constitution d'un réseau et la sensibilisation au Programme sur la lutte contre les contaminants dans le Nord (PLCN) dans la région, et ce, de diverses façons. Premièrement, le soutien continu et les travaux avec le Comité des contaminants du Nunavut (CCN) ont été une réussite grâce à la participation de chercheurs qui ont fourni leurs plans de communication et leurs documents en vue de leur diffusion. Ceci a permis au Comité d'étudier et d'approuver la façon dont les travaux de recherche sont communiqués aux Nunavummiuts. Deuxièmement, la participation du conseiller en recherche aux projets du PLCN et au soutien

visits. The participation of the Research Advisor was also an opportunity her to provide presentations and inform Nunavummiut about NCP face-to-face and answer any questions community members had.

aux consultations des collectivités a été une expérience d'apprentissage concernant les défis et les avantages associés aux visites dans les collectivités. La participation du conseiller en recherche a également été l'occasion de faire des présentations et d'informer en personne les Nunavummiuts au sujet du PLCN et de répondre aux questions des membres des collectivités.

Key messages

It is important that the Research Advisor continue to liaise between Nunavummiut and NCP researchers for the benefit of the program. That NCP continue to support and encourage:

- Inclusion of community members of NCP projects where projects are happening, or within the vicinity closes to the community where research is being conducted.
- Researchers ensure they communicate with communities prior to, during and after research is conducted.
- Researchers look at various ways of contributing towards capacity building and training through their projects, and last but not least,
- Include and recognize that Inuit have knowledge of the region they live in and ask community members about how to include Inuit knowledge in their projects.

Messages clés

Il est important que le conseiller en recherche continue d'assurer les communications entre les Nunavummiuts et les chercheurs du PLCN, au bénéfice du Programme, et que le PLCN continue de soutenir et d'encourager ce qui suit :

- Les membres des collectivités doivent participer aux projets qui sont réalisés dans leurs collectivités ou près d'elles.
- Les chercheurs doivent communiquer avec les collectivités avant, pendant et après la réalisation de recherches.
- Les chercheurs doivent chercher divers moyens de contribuer au renforcement de la capacité et à la formation dans le cadre de leurs projets.
- Les chercheurs doivent prendre en considération les connaissances qu'ont les Inuits de la région où ils vivent et demander aux membres des collectivités comment ces connaissances peuvent être intégrées à leurs projets.

Objectives

1. Engage NCP researchers and other relevant partners conducting research in Nunavut;
2. Undertake relevant communications regarding NCP research in Nunavut
3. Engage and coordinate with NRI on NCP projects where appropriate;
4. Participate in NECC meetings;
5. Assist NCP researchers with making contact with community members of where they will do their projects, or with a community closes to the vicinity of their projects. (This could include but not limited to HTOs, hamlet offices, and schools that can assist researchers in finding suitable candidates that can assist in their project.)
6. Provide information to the NTI research team on NCP related activities as well as advise on Inuit Tapiriit Kanatami (ITK) research initiatives where appropriate;

Introduction

Participating in research activities associated with the NCP, ArcticNet, and independent research projects represents a significant scope of work for Nunavut Tunngavik Incorporated (NTI). The Research Advisor works in close association with NTI's research team, and the NECC to enhance research relationships.

Inuit participation at the regional level is mandatory to ensure appropriate community consultation and effective communication between researchers, regions, coordinators and liaison officers. The Research Advisor and IRA's receive support and training to assist University and government researchers in making the appropriate connections with communities and regional organizations to develop Inuit-led research projects and to facilitate research in Inuit regions on contaminants, climate change and environmental health. The Research Advisor position is a step towards a more coordinated approach to community involvement and coordination of Arctic science and represents a new way of knowledge sharing and engagement with Inuit.

In relation to the NCP program, the role of the Research Advisor and other IRA's is to provide guidance and assistance to the research programs and their researchers, as well to engage Inuit, northern communities and regional organizations in NCP research. More specifically, in Nunavut the Research Advisor will:

- Act as a liaison between NCP researchers and communities to facilitate research and the development of meaningful partnerships;
- Offer guidance and, where appropriate, assist with communicating research results of individual projects to relevant communities and regional organizations;
- Identify interests, needs, concerns and priorities of northerners, communities and regional organizations and promote these to NCP researchers;
- Identify where potential community or regional partnerships could be made with an existing project as well as Inuit-led project proposals that could apply for NCP funding.

Activities in 2014-2015

The Research Advisor continued to work with the Nunavut Environmental Contaminants Committee (NECC) in providing guidance and feedback on NCP researcher's proposed work/ communication within the Nunavut. The Research Advisor also assisted some researchers funded by NCP with their community visit, which included providing presentations on proposed work within the community. This included providing presentations on the objectives of NCP, the NECC and the Research Advisor. The contributions that the Research Advisor has been able to make include the following:

- Capacity Building:
  - Provide presentations to Environmental Technology Program (1st and 2nd year students) of the Nunavut Arctic College about NCP and its overall objects regionally, territorial, national and internationally. This was done through the ***Wildlife Contaminants Workshop*** that was organized by PI's Jamal Shirley, Jennifer Provencher, and Mary Gamberg in the fall of 2014.
  - Through the NECC, assist researchers in look at ways to improve and or add capacity building and training into their projects.
- Communications
  - Assisting researchers with their communication material prior to distribution to ensure they are no controversial messages, such as health messaging and that the context is in a way that is understandable to the public. This component is on an as and when needed basis based on plans for community meetings/ visits by researchers.
  - Provided a presentation on the proposed project by Aaron Fisk and Melissa McKinney (through discussion and agreement) on ***Spatial variations in Canadian Arctic Prey Fish in Arviat, Pangnirtung, and Resolute Bay***. Research Advisor provided a presentation in Pangnirtung to the hunters and trappers association and at a community consultation in the May of 2014. In March of 2015, the Research Advisor assisted Melissa McKinney with her community visit to Arviat, NU where presentations were made to high school students, the Nunavut Arctic College and hunters and trappers organization.
  - Provided a presentation on NCP and role of Research Advisor after the presentation of the above mentioned project.
  - Assisted Lisa Loseto with her community consultation on the proposed ***Beluga Monitoring Project*** Pangnirtung, NU in May of 2014. The role of the Research Advisor was to ensure that the community and the HTO understood the proposed project, the objectives and the expectations of the community by the PI's.
  - Presented to the Kivalliq Wildlife Board at their Annual General Meeting in September 2014 about the NCP program and the role of the Research Advisor in Rankin Inlet, NU.
- Traditional Knowledge Integration
  - Provide guidance and suggestions to NCP researchers about how they can incorporate Inuit knowledge into their project.
  - Assisted the ***Wildlife Contaminants Workshop*** in getting an elder from the hunters and trappers organization to come in and talk about his knowledge and observations of wildlife health. This included discussions on caribou health and observations.

Results

Based on the outcomes of the Research Advisor participating in the above mentioned activities, it would be recommended that NCP continue to support the Research Advisor position as it relates to bridging NCP researchers with Nunavummiut and vice a vise. That the Research Advisor continue to provide guidance, participate and be able to make recommendations to researchers as it relate capacity building and training, communication and encourage the recognition of Inuit knowledge in research. It is important that the Research Advisor continue to look at improving and bridging researchers with Nunavummiut.

Discussion and Conclusions

Overall, the year was a success in terms of networking and bringing more awareness within the region about the Research Advisor, and about NCP as a whole. The workshops, community consultations and on-going discussions between Nunavut (NECC) and researchers have been improving, and it'll only grow stronger if we continue to communicate with each other. The key will that NCP continue to support the NECC and Research Advisor when we request that researchers communicate with our region about their projects during and after they have completed their research. This will enable NECC, the Research Advisor, and researchers to work collaboratively and effectively on communication plans and distribution of such.

With that, the main highlight of the Research Advisor's proposed work for 2015-2016 will be the small research project out of Resolute Bay, NU on communication. This small research project that will give us the opportunity to see whether the community of Resolute Bay makes use of the communication they get from NCP researchers, and if so how. Through consultation with NTI's research team, and NCP secretariat we decided on Resolute Bay based on the number of research that is conducted within the region. We hope that this small project will help us determine if we need to do a bigger project and look at whether Nunavummiut make use of research results that are communicated back them, and how.

The Research Advisor will continue her duties as a liaison between Nunavummiut and researcher, and work with NECC to engage research. The Research Advisor, along with the NECC co-chair will continue to act as point of contacts to NECC to provide feedback on proposed research projects as it relates to communication, capacity building and inclusion of traditional knowledge. The Research Advisor will provide information on community contacts, such as hunters and trappers associations/ organizations, and hamlet offices, or government departments as and when needed. The Research Advisor will promote research and the NCP as opportunity arises within the region.

Expected Project Completion Date

On-going

Acknowledgments

The Research Advisor would like to acknowledge for the on-going support from NCP and NECC to make this position a success. A big thank you to NTI for the confidence in the Research Advisor to carry out presentations on various issues as it relates to research in Nunavut. Both NTI and NCP have been very understanding and giving the Research Advisor the flexibility to "work on both sides of the table" when it comes to issues and concerns of moving forward with research in Nunavut. Without their support and encouragement the Research Advisor wouldn't have been able to carry out her duties.

The Research Advisor would also like to thank the Principle Investigators that agreed to and welcomed her to assist with their NCP project. Jamal Shirley, Jennifer Provencher, and Mary Gamberg for being open to assistance and working together in preparation for your ***Wildlife Contaminants Workshop*** that happened in Iqaluit the fall of 2014. A big thank you to Melissa dMcKinney and Aaron Fisk for giving the Research Advisor the opportunity to assist in preparing for and observing during your community consultations on ***Spatial variations in Canadian Arctic Prey Fish in Arviat, Pangnirtung, and Resolute Bay***. I learned a lot from these opportunities.

Wildlife Contaminants Workshop – linking wildlife and human health through a hands-on workshop

Atelier sur les contaminants des espèces sauvages : Associer les espèces sauvages et la santé humaine dans le cadre d'un atelier pratique

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Abstract

The Northern Contaminants Program (NCP)'s blueprint for communications, capacity and outreach recommends that that the main audience for NCP communication efforts be frontline workers whom community members would regularly turn to for answers to their questions related to contaminants. We delivered an integrated contaminants communication and research training program for students of the Nunavut Arctic College's Environmental Technology Program and members the Nunavut Environmental Contaminants Committee; both of whom are critical "frontline" workers engaged in communicating contaminants information. Members of the local HTO

Résumé

Le plan d'action du Programme de lutte contre les contaminants dans le Nord (PLCN) en ce qui a trait aux communications, à la capacité et à l'éducation recommande que le public cible des communications soit les travailleurs de première ligne, à qui les membres des collectivités pourraient s'adresser pour obtenir des réponses à leurs questions sur les contaminants. Nous avons fourni de la formation intégrée sur la communication et la recherche sur les contaminants aux étudiants du programme de technologie de l'environnement du Collège de l'Arctique du Nunavut et aux membres du Comité des contaminants du Nunavut; ce sont

and Wildlife Branch also contributed to the training session. The training combined lectures, interactive lab activities, and group discussions. Students learned how contaminants trend monitoring programs are designed and conducted, are trained in specific methods for wildlife tissue sampling, and discussed contaminants communication strategies for specific target audiences in Nunavut. The training also mobilized expertise from two long term NCP supported monitoring programs, and engaged experts from the community to better link students with active researchers in the north. The long term goals of the project are to increase the capacity of Nunavut's future environmental practitioners to effectively communicate contaminants information to community members, and to build core understanding of contaminants research among Nunavut's future environmental managers and decision makers.

deux publics qui constituent d'importants travailleurs de « première ligne » en matière de communication de l'information sur les contaminants. Les membres de l'organisation locale de chasseurs et de trappeurs et de la Direction générale de la faune ont également contribué à la séance de formation, qui combinait présentations, activités interactives de laboratoire et discussions de groupe. Les étudiants ont appris comment les programmes de surveillance des tendances en matière de contamination sont conçus et réalisés; ils ont été formés sur des méthodes précises de collecte de tissus d'espèces fauniques; et ils ont discuté de stratégies de communication sur les contaminants destinées à des publics particuliers au Nunavut. On a également fait appel à des spécialistes dans le cas de deux programmes de surveillances à long terme du PLCN et mobilisé des experts de la collectivité pour faire de meilleurs liens entre les étudiants et les chercheurs dans le Nord. Les objectifs à long terme du projet sont de renforcer la capacité des praticiens de l'environnement au Nunavut en matière de communication de l'information aux membres des collectivités et d'assurer que les futurs gestionnaires de l'environnement et les décideurs au Nunavut aient des connaissances de base au sujet de la recherche sur les contaminants.

Key messages

- The Wildlife Contaminants Workshop was held at the Nunavut Arctic College during the week of September 29th to October 6th, 2014. Students from the Environmental Technology Program (first and second year), Nunavut Environmental Contaminants Committee and the wider science community in Iqaluit took part in the workshop. This year the main components covered were contaminant research in caribou and marine birds. Both marine birds and caribou dissections were done as part of the workshop.

Messages clés

- Un atelier sur les contaminants de la faune a eu lieu au Collège de l'Arctique du Nunavut du 29 septembre au 6 octobre 2014. Des étudiants du programme de technologie de l'environnement (1ère et 2e année), des membres du Comité des contaminants du Nunavut et des membres de la plus large communauté scientifique à Iqaluit ont participé à cet atelier. Les principaux éléments visés par la recherche pour cette année-là sont les contaminants chez le caribou et les oiseaux de mer.Des dissections d'oiseaux de mer et de caribous ont été effectuées dans le cadre de cet atelier.

- In total 26 students took part in the workshop
- Members from five different science/wildlife groups in Iqaluit participated in the workshop
- Ten students were paid to complete dissection over the weekend
- Three NCP projects were highlighted during the workshop (Gamberg – caribou, Richardson – water monitoring, Provencher – marine birds).
- Complete surveys were collected from 21 students that are currently being analysed as part of a program assessment component that will be expanded in 2015-2016

- En tout, 26 étudiants ont participé à l'atelier.
- Les membres de cinq groupes de travail sur la science ou la faune à Iqaluit ont participé à l'atelier.
- Dix étudiants ont été payés pour réaliser une dissection au cours de la fin de semaine.
- Trois projets du PLCN ont été mis en valeur au cours de l'atelier (Gamberg – caribou, Richardson – surveillance de l'eau, Provencher – oiseaux de mer).
- 21 étudiants ont également recueilli des échantillons qui sont actuellement analysés dans le cadre d'un volet du programme portant sur l'évaluation qui sera reconduit en 2015-2016.

Objectives

The primary goal of the workshop was to design, deliver, and evaluate an applied educational workshop on Arctic contaminants issues for students of Arctic College's environmental technology program. The workshop featured a suite of interactive lab and field activities, lectures, and group discussion exercises designed to develop applied skills and instill confidence to understand and engage in contaminants research. Core learning objectives (themes) of the workshop included:

1. the sources, pathways, fate, and effects of contaminants in the Arctic environment; including how monitoring of contaminant levels, disease and animal populations helps us understand the health of Arctic marine and terrestrial ecosystem
2. methods to dissect and sample caribou and marine birds for analysis of disease pathogens, contaminants, stable isotopes and genetics
3. use of contaminants concentration data to assess health risk and develop consumption guidelines
4. research questions, goals and approaches as they relate to contaminants in country foods and the Arctic environment
5. Inuit perspectives on wildlife health and the importance of country food
6. development and review of strategies to assess and communicate human health risks associated with contaminants in traditional foods.

Introduction

In most northern communities, "frontline workers", including wildlife and fisheries officers, HTA managers, community health workers and nurses, Inuit research advisors, RCC members, and other local professionals, play a central role in facilitating NCP research, communication, and outreach efforts. Frontline workers are frequently engaged and consulted in NCP proposal review processes and are called upon to support operational aspects of contaminants research, such as coordinating specimen collection from hunters, implementing health and dietary surveys, and providing logistic support. Frontline workers are often called upon to help translate, disseminate, and explain contaminants research results and related health advice. They are typically, the individuals who other community members turn to for information about environmental contaminants.

In the early phases of the NCP, a focused effort was made to develop and deliver contaminants training to northern frontline workers with an aim to enhance their ability to support and engage with contaminants research and communication efforts. Frontline worker training courses were delivered in Iqaluit in 1998 and in Rankin Inlet in 2000 (DIAND 2003), but similar training has not since been delivered in Nunavut. Moreover, despite their usefulness in fostering dialogue and learning among frontline workers, previous training efforts lacked any structured evaluation component to measure their impact in improving awareness and comprehension of information related to contaminants and the NCP.

The need for more frontline worker training on contaminants has consistently been identified and prioritized by the NCP. The 2014-2015 NCP blueprint for communication, outreach, and capacity, lists as a priority the need for frontline workers to receive training in "understanding of, and ability to engage in, the research undertaken in the NCP".

Previous frontline worker training targeted community professionals, elders, and youth, and did not typically include students from Nunavut Arctic College's Environmental Technology (ETP) program who are preparing to enter Nunavut's workforce as frontline workers. ETP has now been running for 26 years. The approximately 100 graduates of the program have worked in broad range of occupations including conservation officers, water and fisheries technicians, environmental policy analysts, environmental assessment practitioners, and environmental educators. ETP graduates have also worked as Inuit research advisors and have served on the Nunavut territorial contaminants committee.

The wildlife contaminants workshop is an adaptable, integrative training program tailored for the specific needs and interests of ETP students, and designed to address the training and evaluative deficits outlined above. The workshop builds on a long established outreach partnership between Nunavut Arctic College and Environment Canada, initiated during the International Polar Year (2007 – 08). This unique applied training integrates the fields of biology, wildlife management, communication, and the health sciences, to provide students with core skills and experience to engage competently in contaminants research and communication activities when they enter the workforce. The annual training is also a core part of the ETP curriculum.

From 2007 to 2013 the annual workshop focused on providing students hands-on experience dissecting marine birds as part of a long term research study to assess contaminant and parasite burdens in birds, and to document the spread of disease within bird populations. The curriculum covers basic science related to the sources, pathways, and fate, and effects of contaminants in the marine environment. Short term employment opportunities have been provided for students that show proficient dissection skills. In 2011, the Arctic College Fur Production and Design class (hereafter, the design class) also joined the workshop to learn about marine bird research in Nunavut and to teach and learn about how eider skins are used in traditional design (Provencher et. al, 2013). The workshop scope has expanded beyond pure science to include the participation of regional health authorities, and members of the Nunavut Environmental Contaminants Committee, to foster broader discussions related to human health risk assessment, country food and nutrition, and community research relationships.

In 2013, the program also included a presentation on contaminants in the

environment, with a special focus on caribou and a science communications workshop.
An important aim for the 2014-15 workshop was to build on this established program, by providing additional opportunities for other NCP researchers and local experts to share diverse knowledge and experience, and by including a structured evaluation to assess the impact of the course on students' awareness and comprehension of important information about environmental contaminants and the NCP.

Activities in 2014-2015

Monday Sept 29th – The students were given a 'pre-workshop' evaluation, to be used with a 'post-workshop' evaluation to determine the effectiveness of the workshop. They were then given an in-depth presentation on contaminants in the Arctic including the following:

- Definition of contaminants
- Where contaminants come from and how they travel to the Arctic
- Levels and trends of contaminants in Arctic wildlife

Tuesday September 30th – The presentation on contaminants in the Arctic continued with the following:

- In-depth discussion of contaminants in Arctic caribou
- Discussion of health assessments and advisories for country foods (included an exercise of calculating how much of a particular country food a person could eat based on mercury concentrations in that food).
- Local and global perspective on contaminants

After this presentation, the students broke into groups to discuss ways in which we can reduce contaminants in the environment. Each group made a formal presentation of their ideas to the class.

Students then worked with Murray Richardson (an NCP funded researcher) to learn about how contaminants move through freshwater and terrestrial habitats. Murray's presentation was part lecture in the classroom about local hydrology, and part field trip where the students went to a local stream to measure stream dynamics, and how contaminants move through freshwater systems.

Wednesday October 1st – First year students learned about marine bird research in northern Canada, and learned how to dissect and take samples from marine birds with Jennifer Provencher and Guy Savard. Second year students learned how to age caribou using their teeth and how to examine and take samples for contaminant analysis from caribou with Mary Gamberg.
In the afternoon the first and second year student reconvened together to discuss science communication. Students had to find and identify one poster in the NAC or NRI that they thought was the best, and list three reasons they thought the poster was effective. As a class students compiled a list of the attributes that worked in the posters, and areas of improvement for the posters. After students discussed communication of science through posters Joshua Kango from the Amarok Hunter and Trapper Association (Iqlauit based) joined the entire class and discussed wildlife research and contaminants.

Thursday October 2nd – Second year students learned about marine bird research in northern Canada, and learned how to dissect and take samples from marine birds with Jennifer Provencher and Guy Savard. First year students learned how to age caribou using their teeth and how to examine and take samples for contaminant analysis from caribou with Mary Gamberg. Students also completed a communications activity where science posters were examined. A list of good qualities and areas of improvement were made for posters to highlight the need to communicate clearly and effectively.

Friday October 3rd – Guest speakers were invited to talk to the students about various contaminants research in the north. Speakers included:

- Romani Makkik – Nunavut Tunngavik Inc. and a member of the Nunavut Environmental Contaminants Committee
- Christianne Lafferty – Nunavut General Monitoring Plan
- Ted Cousins – Government of Nunavut Health Department
- Gwen Healy – Qaujigiartiit Health Research Centre

Friday afternoon classes were cancelled due to a blizzard, and all the schools and the college in Iqaluit being closed.

Saturday October 4th – Twelve students helped dissect eider ducks using the techniques learned during the previous week.

Sunday October 5th – Six students helped dissect eider ducks using the techniques learned during the previous week.

Monday October 6th – students completed a final closing survey which was scheduled for Friday afternoon.

The following week, the students had the opportunity to dissect two caribou and take samples for contaminant analysis. This activity was originally planned for the week of the workshop, but transportation issues delayed the arrival of the caribou. The meat and the hides from the caribou were given to the Inuit Studies Class for distribution to local Elders.

Results

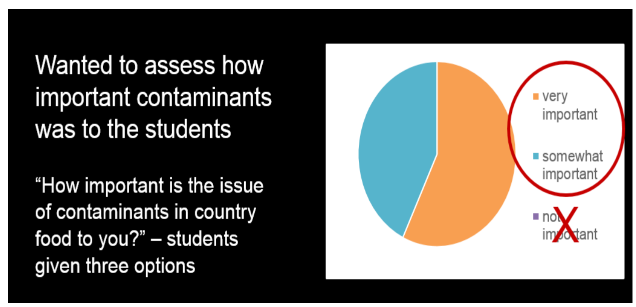
As part of the workshop the students completed entrance and exit surveys. The purpose of the surveys is to help assess the workshop objectives. Analysis of the surveys will be ongoing.

Students completed two surveys; an entrance survey and an exit survey (both first and second years). Both had open-ended and ranked numerical questions. The entrance exam was formulated to be both information to the workshop, and assess prior knowledge of the students. The exit exam was a summative survey focusing on the knowledge and how the workshop may have altered student knowledge and understanding.

A total of 21 paired survey results (both entrance and exit surveys). The breakdown of students were 11 first years, 10 second years. A total of 20 questions were asked on the entrance survey, and 21 questions on the exit survey (for a copy of the surveys please contact the authors). Both surveys were a mix of ranking and open ended questions

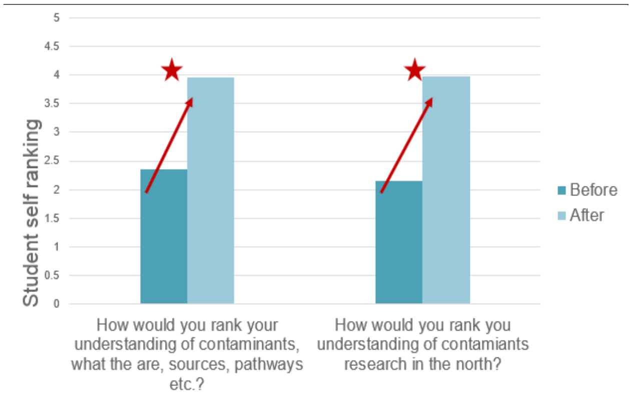
To assess how the students felt about contaminants education and knowledge in country food we asked them to rank the following statement in terms of very important, somewhat important and not important; "How important is the issue of contaminants in country food to you?" Most of the students ranked it as very important, and no students listed it as not important (Fig. 1).

Figure 1. Workshop students were asked to rank "How important is the issue of contaminants in country food to you?".



We also wanted to assess students felt that their understanding of contaminants and of contaminants research in the north increased after the workshop. To do this students were asked two questions regarding contaminants knowledge (Fig. 2) before and after the workshop. Each student was had to rank each statement given in the survey on a scale from 1 (little) to 5 (very confident). The answers in the paired surveys were then compared. Student surveys indicate that student knowledge of contaminants and contaminants research in the north increased due to their experiences in the workshop (Fig. 2).

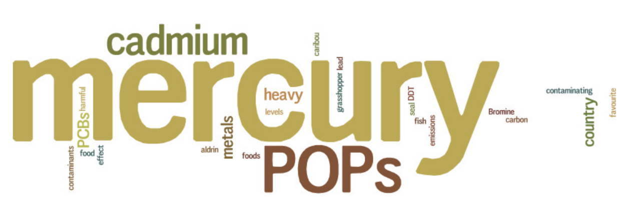
Figure 2. Paired student self-ranking results for two statements regarding contaminant knowledge in the north.



Students were also asked "What types of contaminants are you most concerned about?" as an open question in both entrance and exit surveys. The goal of this question was to assess contaminants knowledge of the students. The answers from the surveys were put into a word cloud (words used more often appear larger than those used less frequently) to examine overall patterns in the responses (Fig 3). Post workshop the class could name more contaminants as seen in the word clouds (Fig 3A and 3B). Before and after mercury is still the most named contaminant of concern. We see PCBs and POPs in both sets of responses, but in the after category we also see other contaminants listed such as cadmium, lead, black carbon, DDT and Aldrin.

Figure 3A. Word clouds of class responses to 'What types of contaminants are you most concerned about' before the wildlife contaminants workshop.

Fig 3B. Word clouds of class responses to 'What types of contaminants are you most concerned about' after the workshop contaminants workshop.



Discussion and Conclusions

Overall the wildlife contaminants workshop in 2014 was a success. We were able to once again bring together members of the scientific community to take part in this skill building workshop. Marine birds and caribou were the focal projects of the 2014 workshop. The examination of caribou teeth and the dissection of a caribou were both new in 2014, and student feedback suggested that students liked the addition of these components. Additionally, contaminant monitoring in water was added to the workshop with the participation of Murray Richardson (NCP supported project). This interaction with an ongoing project and small field trip during workshop was also commented on very positively by students. In the future we hope to integrate other NCP related projects to the workshop.

To date the initial analysis of the student surveys indicate that the workshop does help the students expand their knowledge of both contaminants related knowledge, and specifically contaminant work being undertaken in the north. In 2015-16 we will be expanding the evaluation of the project to get a better understanding of student engagement and knowledge building throughout the workshop.

In 2014 we were also able to include a member from the local Amarok Hunter and Trapper Association in the workshop. Joshua Kango spoke to the students about contaminants and wildlife health. This component was much enjoyed by the students and researchers alike. We hope to have the Amarok Hunter and Trapper Association participate again in the coming years.

Expected Project Completion Date

The workshop took place between September 29th and October 5th 2014. An initial analysis of the workshop was completed for the Arctic Change conference and presented in December 2014. As of April 2015, we are planning the workshop for September 2015, which includes a more comprehensive program assessment to be completed.

Acknowledgments

The workshop organisers and participants are very grateful to the Northern Contaminants Program for supporting this program, and allowing it to continue to build and develop as an outlet for research knowledge and capacity building in the north. We would also like to thank the Nunavut Arctic College and the Nunavut Research Institute for the continued support of this program. We would also like to thank Romani Makivik from Nunavut Tunngavik Inc. for her continued support and participation in the workshop, we would not have been able to make this year an exceptional one without her! We would also like to thank Joshua Kango from the Amarok Hunter and Trapper Association in Iqaluit, Christianne Lafferty from the Nunavut General Monitoring Plan, Ted Cousins from the Government of Nunavut Health Department and Gwen Healy from the Qaujigiartiit Health Research Centre for their participation in the workshop. Much appreciation to the northern marine bird team at Environment Canada, Carleton University and Acadia University for their continued support, especially Birgit Braune, Grant Gilchrist, Mark Forbes and Mark Mallory. JFP is also supported by the Association of Canadian Universities for Northern Studies (Weston Fellowship), Ducks Unlimited, NSERC and the Ontario Graduate Scholarship program.

Synthesis of Mercury Research for the Sahtú Region (NWT)

Résumé d'une recherche sur le mercure dans la région du Sahtú (T.N.-O.)

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Abstract

In response to community concerns raised about the status of mercury in the environment of the Sahtú Region, NWT, a literature review was undertaken to summarise research and monitoring carried out over the years. A multitude of studies have been completed or are ongoing; primarily, on fish, and to a lesser extent caribou and human health. Studies of mercury in biota are generally indicative of levels that are not of immediate human health concern, although, in some instances there are public health advisories that recommend limiting intake of certain predatory fish. Studies to date indicate caribou meat does not accumulate high levels of mercury.

Gaps related to mercury research in the region were identified:

- There is no process in place to routinely validate existing consumption advisories.
- Periodic health risk assessments are required.

Résumé

En réponse à des préoccupations soulevées par les collectivités au sujet du mercure dans l'environnement de la région du Sahtú (T.-N.-O.), une étude documentaire a été entreprise pour résumer les résultats des recherches et de la surveillance réalisés au cours des ans. Un grand nombre d'études en cours ou terminées portent sur le poisson surtout, et, dans une moindre mesure, sur le caribou et la santé humaine. Les études sur le mercure dans le biote indiquent généralement des niveaux non préoccupants dans l'immédiat pour la santé humaine, malgré que dans certains cas, des avis de santé publique recommandent de limiter la consommation de certains poissons prédateurs. Selon les études, la viande de caribou ne contient pas une forte concentration de mercure.

Des lacunes dans la recherche sur le mercure dans la région ont été ciblées :

- Aucun processus n'est en place pour valider régulièrement les avis concernant la consommation.

- There is a lack of a coordinated approach to research and monitoring.
- Communities should be better involved in developing projects and face-to-face communications with residents about results should be improved.

- Des évaluations régulières du risque pour la santé sont nécessaires.
- Il n'y a pas d'approche coordonnée pour la recherche et la surveillance.
- Les collectivités devraient être mieux intégrées aux projets d'élaboration et il faudrait améliorer les communications en personne avec les résidants.

Key messages

- Studies of mercury in biota are generally indicative of concentrations that are not of immediate human health concern, although, in some instances there are public health advisories that recommend limiting intake of certain predatory fish. Studies to date indicate caribou meat does not accumulate high levels of mercury.
- A mechanism needs to be developed for the routine and periodic evaluation of existing or outdated public health advisories.
- Reporting back to communities about the multitude of research studies carried out in the region and communicating risks should be improved.

Messages clés

- Les études sur le mercure dans le biote indiquent généralement des niveaux non préoccupants dans l'immédiat pour la santé humaine, malgré que dans certains cas, des avis de santé publique recommandent de limiter la consommation de certains poissons prédateurs. Selon les études, la viande de caribou ne contient pas une forte concentration de mercure.
- Il faut élaborer un mécanisme permettant de faire une évaluation régulière des avis de santé publique existants ou antérieurs.
- Il faut communiquer aux collectivités les résultats du grand nombre de recherches réalisées dans la région et améliorer l'information concernant les risques.

Objectives

1. Conduct a desktop review and synthesis of mercury research data for the Sahtú Region.
2. Compare research findings with guidelines and advisories to determine where concerns may exist.
3. Summarise findings of Sahtú mercury research and identify any gaps (research and communications).
4. Present findings at community meetings.

Introduction

The long-range atmospheric transport of mercury and subsequent deposition in Arctic environments is an ongoing global concern. In November 2013, after years of negotiations, a legally binding international treaty, the Minamata Convention on Mercury, to reduce harmful emissions of mercury was signed by 128 countries. Arctic ecosystems are particularly susceptible to mercury as a contaminant due to atmospheric deposition and higher rates of biomagnification in the cold and low productivity food webs (MacMillan et al, 2015).

In the NWT, and in particular in the Sahtú Region, community concern about the potential negative impacts of mercury contamination in fish, public health advisories for local lakes (e.g., Kelly Lake, Lac Ste. Thérèse), and associated human health risks remains a priority. As a result, a desk-top study was undertaken to help Sahtú communities better understand the relevance and findings of mercury studies that have been conducted in the region. The need for a compilation, analysis and synthesis of research on mercury in the Sahtú, and reporting back to front-line workers and community representatives, became apparent at the Tulít'a Research Results Workshop in November 2013, when numerous concerns were raised.

Activities in 2014-2015

The project was a desktop study to collect, review and synthesise existing literature and reports about mercury studies conducted in the Sahtú Region. As the work progressed there were several opportunities to update and present findings.

- Communications
  - November 20, 2014 – Teleconference with the Sahtú Environmental Research and Monitoring (ERM) Forum
  - January 20-22, 2015 – Presentations at the Tulít'a Results Workshop
  - March 24, 2015 – Presentation to the Sahtú ERM Forum in Yellowknife, NT

Results

A great number of contaminant studies that consider mercury have been conducted in the NWT, many of which included or focused on the Sahtú Region. Most of the research has been on fish, with some studies looking at wildlife (principally caribou) and human health risks.

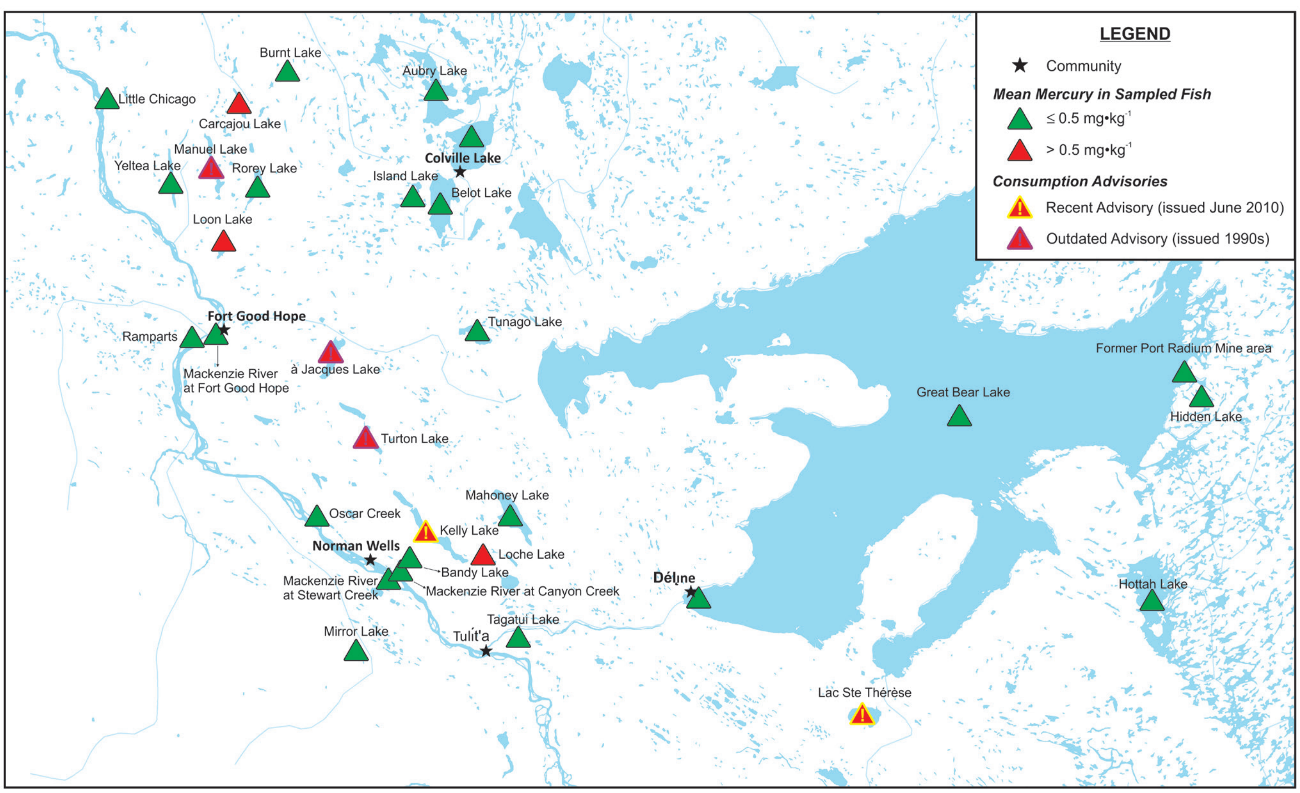
A comprehensive review of historical total mercury in edible muscle of fish from lakes in northern Canada covered over three decades of sampling (Lockhart et al., 2005). Overall, walleye, northern pike and lake trout (predatory species) were found to have the highest concentrations of mercury, with many exceeding the recommended guideline of 0.5 mg×kg^{-1} total mercury for commercial sales of fish. Mercury in burbot was often lower and lake whitefish were among the lowest of the samples assessed. A summary of concentrations for fish collected in the Sahtú Region is shown in Figure 1. Mean concentrations for predatory fish from waterbodies in the area are divided into those that are less than the guideline and those that exceed the guideline. Also shown are lakes where health advisories have been issued for consumption of fish. In addition to results presented in Lockhart et al. (2005), the figure shows findings from studies conducted at Port Radium between 2006 and 2013 (SENES Consultants Ltd, 2014) and near Déline between 2009 and 2012 (Macdonald, 2013).

Some fish studies in the NWT have noted a general increasing trend in concentrations over the years. For example, while still below the recommended guideline value of 0.5 mg×kg^{-1}, Stern (2014) reported a 2 to 3-fold increase in mercury in burbot sampled near Fort Good Hope since the mid 1980s.

Regarding human health concerns, consumption advisories for fish in two lakes in the Sahtú (Kelly Lake and Lac Ste. Thérèse) were issued by the Government of the Northwest Territories Department of Health and Social Services (GNWT HSS) in June 2010 (GNWT HSS, 2010). For Kelly Lake the advisory recommended limiting consumption of lake trout to specific weekly amounts, while for Lac Ste. Thérèse, it was recommended that no predatory fish be eaten. As shown in Figure 1 there are also outdated advisories issued in the 1990s for Manuel, à Jacques and Turton lakes (Kandola, 2013).

For caribou, a study of the Bluenose East herd (Macdonald, 2002) found that metals of concern, such as mercury and cadmium, are relatively low and are not expected to be a danger to the animals or people who hunt them for food. Similarly, through a multi-year Arctic caribou monitoring program, Gamberg (2011, 2014) studied contaminant levels in the Porcupine and Qamanirjuaq herds. This research found that levels of most contaminants measured are not of concern, although mercury and cadmium in kidneys may in some instances cause concern for human health depending on quantities consumed.

Figure 1 – Figure 1 shows a summary of mercury concentrations for fish collected in the Sahtú Region. Mean concentrations for predatory fish from waterbodies in the area are divided into those that are less than the 0.5 mg•kg-1 guideline and those that exceed the guideline. Also shown are two lakes (Kelly Lake and Lac Ste. Thérèse) where health advisories for the consumption of fish were issued in June 2010. Three outdated advisories, dating back to the mid-1990s, are also indicated for Manuel, à Jacques and Turton lakes.



Discussion and Conclusions

Studies of mercury in biota of the Sahtú Region are generally indicative of levels that are not of immediate human health concern, although in some instances there are public health advisories that recommend limiting intake of certain predatory fish. Following a hair mercury study in the community of Tulít'a, Delormier (2012) found that the risk associated with consumption levels of fish, including lake trout from Kelly Lake (where a public health advisory was issued in June 2010), was very low. While that is encouraging, community residents throughout the Sahtú continue to have concerns about contaminant levels (2015 Tulít'a Results Workshop, personal communication). This is, in part, due to lack of regular, in-person reporting back and communications with communities. More importantly, however, is the absence of an established process for evaluating consumption advisories on a periodic basis. This gap was noted by the NWT Environmental Contaminants Committee (NWT ECC) in 2005 and later by Kandola (2013). These studies acknowledge the lack of mechanism to determine if a public health advisory needs to be continued, citing outdated advisories from the 1990s for which no follow-up sampling has occurred. There was an attempt to rectify this in 2012 when a study was undertaken to sample fish from lakes with old advisories (Kandola, 2013). Unfortunately, as a result of funding issues and time constraints, only one of three planned lakes in the Sahtú was sampled (Manuel Lake). There is no communication to indicate whether any of the Sahtú Region advisories have been updated in the last five years.

This project has shown that while a lot of mercury data has been gathered for parts of the Sahtú, there are improvements that can be made with respect to its collection, dissemination and follow-up:

- There needs to be a process developed to routinely evaluate existing and outdated consumption advisories. This should be accompanied by clear and regular communications to communities.
- A more coordinated approach to contaminant research and monitoring in the Sahtú, such as through a regional study, would likely assist in broadening understanding of natural, man-made and possible cumulative changes in the region.
- Communities should be better involved in developing projects and there should be more opportunities for face-to-face communications with residents for project updates and reporting back on results.

Expected Project Completion Date

This project was a one-year study.

Acknowledgements

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Program Coordination and Aboriginal Partnerships

Coordination du programme et partenariats autochtones

National Coordination and Administration of the Northern Contaminants Program, and Facilitation of International Action related to the Long-range Transport of Contaminants into the Arctic

Coordination et administration nationales du Programme de lutte contre les contaminants dans le Nord, et facilitation de l'action internationale relative au transport à grande distance de contaminants dans l'Arctique

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Abstract

The Northern Contaminants Program (NCP) engages Northerners and scientists in researching and monitoring of long-range contaminants in the Canadian Arctic, and in making use of the data generated to: 1) assess ecosystem and human health in order to address the safety and security of traditional country foods that are important to the health and traditional lifestyles of northern communities; and 2) inform policy, resulting in action to eliminate contaminants from long-range sources. The NCP Secretariat, within Aboriginal Affairs and Northern Development Canada, provides the administrative, financial, and logistical support and coordination required to deliver the NCP within Canada, and facilitates Canada's action internationally with respect to initiatives and regulations related to the long-range transport of contaminants into the Arctic. Highlights for 2014-2015 included: (i) the release of *Contaminants in Canada's North: Summary for Policy-Makers*, summarizing the key findings from the recent Canadian Arctic Contaminants Assessment Reports III; (ii) significant contributions by NCP scientists and the NCP Secretariat to the circumpolar Arctic Monitoring and Assessment Programme (AMAP) Working Group, as co-authors and co-chairs of scientific expert groups working on updates to circumpolar assessment reports, and as Canada's Head of Delegation and Vice-Chair to AMAP, during the final year of Canada's chairmanship of the Arctic Council (2013-2015); (iii) implementation of new management processes, including new protocols and guidelines for mid-year project reporting and funding requests; and (iv) partnership further developed with the Canadian High Arctic Research Station (CHARS) [now Polar Knowledge Canada], through CHARS representation as an Observer on the NCP Management Committee, and NCP representation on the CHARS Science & Technology Advisory Committee; and (v) participation by several researchers and NCP partners in the International Arctic Change Conference in Ottawa, December 8-12, 2014, including in the special session on contaminants.

Résumé

Le Programme de lutte contre les contaminants dans le Nord (PLCN) mobilise les habitants du Nord et les scientifiques pour participer à la recherche et à la surveillance axées sur les contaminants transportés sur de longues distances, et pour employer les données obtenues aux fins suivantes : 1) évaluer les écosystèmes et la santé humaine en vue d'assurer la salubrité et la sécurité des aliments régionaux et traditionnels qui sont importants pour la santé et le mode de vie traditionnel des collectivités du Nord et 2) éclairer les politiques qui donnent lieu à des mesures visant à éliminer les contaminants des sources lointaines. Le secrétariat du PLCN, au sein d'Affaires autochtones et Développement du Nord Canada, assure la coordination et le soutien administratifs, financiers et logistiques nécessaires pour réaliser le PLCN au pays, et il facilite la participation du Canada sur la scène internationale aux initiatives et à la réglementation concernant le transport à grande distance de contaminants dans l'Arctique. Voici quelques-uns des faits saillants en 2014-2015 : i) publication du document intitulé *Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs* résumant les principales conclusions du Troisième rapport de l'évaluation des contaminants dans l'Arctique canadien rédigé récemment; ii) participation importante de scientifiques et du secrétariat du PLCN au groupe de travail circumpolaire du Programme de surveillance et d'évaluation de l'Arctique (PSEA), en tant que coauteurs et coprésidents de groupes d'experts scientifiques travaillant sur une mise à jour des rapports d'évaluation circumpolaires, et en tant que chef de la délégation du Canada et vice-président du PSEA au cours de la dernière année de présidence du Canada au Conseil de l'Arctique (2013-2015); iii) mise en œuvre de nouveaux processus de gestion, y compris de nouveaux protocoles et de nouvelles lignes directrices sur l'établissement des rapports de mi-exercice relatifs aux projets et sur les demandes de financement; iv) renforcement du partenariat avec la Station canadienne de recherche dans l'Extrême-Arctique (SCREA) [à présent baptisée Savoir polaire Canada], grâce à la participation

du SCREA au comité de gestion du PLCN en tant qu'observateur et à la participation du PLCN au Comité consultatif sur les sciences et la technologie du SCREA, et v) participation de plusieurs chercheurs et de partenaires du PLCN à la conférence internationale Arctic Change qui a eu lieu à Ottawa du 8 au 12 décembre 2014, y compris à la séance spéciale sur les contaminants.

Key Messages

- The NCP Secretariat provides the administrative, financial, and logistical support and coordination required to deliver the NCP
- The NCP facilitates international cooperation to identify the significance of long-range contaminant sources and their transport pathways and potential impacts on the environment and human health, and assists with the implementation and development of appropriate international controls on emissions and discharges of contaminants of significance to Canadian northern populations.
- The Minamata Convention on Mercury, a legally-binding agreement to cut emissions and releases of mercury to the environment, was signed by Canada in October 2013 and now includes 128 signatory nations and 12 ratifications, in an international effort to reduce global mercury pollution and protect the environment and human health. Through use of its data, information and expertise, the NCP made important contributions towards this historic signing. The Convention will enter into force 90 days after 50 countries have ratified the treaty (Canada has not yet ratified). In the meantime, preparations for the entry into force are ongoing.
- The 7th Conference of the Party (COP) of the Stockholm Convention on Persistent Organic Pollutants (POPs) took place 4 – 8 May, 2015. Three more chemicals were agreed to be added to the

Messages clés

- Le secrétariat du PLCN assure la coordination et le soutien administratifs, financiers et logistiques nécessaires pour réaliser le programme.
- Le PLCN facilite la collaboration internationale afin de déterminer l'importance des contaminants venus de loin, de leurs sources, de leurs voies de transport et de leurs incidences possibles sur l'environnement et la santé humaine, et il aide à établir et à mettre en œuvre les mesures internationales de limitation des rejets des contaminants qui importent pour les populations du Nord canadien.
- La Convention de Minamata sur le mercure, traité juridiquement contraignant qui vise à réduire les rejets de mercure dans l'environnement, a été signée par le Canada en octobre 2013. Maintenant, 128 pays l'ont signée et 12 l'ont ratifiée afin de réduire la pollution par le mercure à l'échelle mondiale et de protéger l'environnement et la santé humaine. Par ses informations et ses compétences, le PLCN a beaucoup contribué à la conclusion de cette convention historique. La Convention entrera en vigueur 90 jours après que 50 pays auront ratifié le traité (le Canada ne l'a pas encore fait). Pendant ce temps, les préparatifs pour l'entrée en vigueur sont en cours.
- La septième Conférence des Parties de la Convention de Stockholm sur les polluants organiques persistants (POP) a eu lieu du 4 au 8 mai 2015. On a convenu

Annex A of elimination at the meeting: pentachlorophenol (PCP) and its salts and esters, polychlorinated naphthalenes (PCNs: di, tri, tetra, penta, hexa, hepta, octa), and hexachlorobutadiene (HCBD)

- The *Canadian Arctic Contaminants Assessment Report (CACAR) III – Contaminants in Canada's North: Summary for Policy Makers*, released in April 2015, summarizes the integrated highlights and main findings from the NCP's three most recent assessment reports (on POPS [2013], mercury [2012], and health [2009]). A related and more detailed *Highlights Report*, with additional region-specific information, will be released in 2015.

- NCP continues as Canada's main contributor on contaminant issues to the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP), with updates being undertaken on circumpolar POPs and human health assessments during Canada's Chairmanship of the Arctic Council (2013-2015). The Chair of the NCP Management Committee continues to hold the position of Canadian Head of Delegation to AMAP and Inuit Circumpolar Council Canada continues to represent Inuit as a Permanent Participant on the AMAP Working Group.

à la réunion d'ajouter trois substances chimiques supplémentaires à l'annexe A (pour élimination) : le pentachlorophénol (PCP) ainsi que ses sels et ses esters, les polychloronaphthalènes (PCN) : di, tri, tétra, penta, hexa, hepta, octa), et l'hexachlorobutadiène (HCBD).

- Le *Troisième rapport de l'évaluation des contaminants dans l'Arctique canadien (RECAC) – Les contaminants dans le nord du Canada : Sommaire à l'intention des décideurs*, publié en avril 2015, résume les faits saillants intégrés et les principales conclusions des trois plus récents rapports d'évaluation du PLCN (sur les POP [2013], le mercure [2012], et la santé [2009]). Un *Rapport sur les faits saillants* plus pertinent, plus détaillé et contenant des renseignements supplémentaires sur les régions sera publié en 2015.

- Le PLCN continue d'être le principal intervenant du Canada au sujet des contaminants auprès du Programme de surveillance et d'évaluation de l'Arctique du Conseil de l'Arctique (PSEA), effectuant des mises à jour au sujet des évaluations de la santé humaine et des POP dans la région circumpolaire pendant la présidence du Canada au Conseil de l'Arctique (2013-2015). Le président du comité de gestion du PLCN conserve le poste de chef de la délégation canadienne du PSEA et l'Inuit Circumpolar Council Canada continue de représenter les Inuits en tant que membre permanent du groupe de travail du PSEA.

Introduction

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 Aboriginal peoples. Early studies indicated that there was a wide spectrum of substances - persistent organic pollutants, heavy metals, and radionuclides - many of which had no Arctic or Canadian sources, but which were, nevertheless, reaching unexpectedly high levels in the Arctic ecosystem.

The Northern Contaminants Program (NCP) engages Northerners and scientists in researching and monitoring of long-range contaminants in the Canadian Arctic, that is, contaminants that are transported to the Arctic through atmospheric and oceanic processes from other parts of the world and which 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, 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. The NCP contributes scientific data and expertise to contaminants-related international initiatives such as the Arctic Monitoring and Assessment Programme (AMAP), and to international agreements such as the UNEP Minamata Convention on Mercury, the Stockholm Convention on Persistent Organic Pollutants, and two protocols under the United Nation Economic Commission for Europe Convention on Long-range Transboundary Air Pollution, working globally to improve the health of Arctic people and wildlife over the long term. Reduction and elimination of contaminant input to the Arctic from distant sources outside of Canada requires comprehensive international cooperation.

Since 1991, Aboriginal Affairs and Northern Development Canada has provided the NCP with financial administration and management services to support more than 500 scientific and other northern-related projects. The department has also maintained the Chair and secretariat support of the NCP Management Committee, and the secretariat support (including some chairs) of the NCP Review Teams and other committees (e.g. Human Health, Environmental Monitoring and Research, and Regional Contaminants Committees). This management structure ensures that the program remains scientifically and socio-culturally defensible, while at the same time, achieves real progress in terms of its broad policy objectives.

National Activities and Results in 2014-2015:

NCP Management Committee: The NCP Management Committee met in April 2014 to consider the reviews and recommendations on all proposals received through the 2014-2015 Call for Proposals and to make funding decisions. A total of 55 projects were approved for funding. A brief description of each of those projects is posted on the NCP website at http://www.science.gc.ca/default.asp?lang=En&n=32DE2B2E-1. The Management Committee met again in October 2014 to review the progress of NCP projects currently under way and make policy decisions related to the management and delivery of the NCP, including approvals of changes to the NCP Blueprints, in preparation for the annual NCP Call for Proposals.

2015-2016 Call for Proposals and review process: The 2015-2016 Call for Proposals was launched by email on November 14, 2014 with subsequent posting to the NCP website. A total of 66 proposals were submitted by the deadline of January 13, 2015. All reviews (peer reviews, social/cultural review by RCCs, technical reviews by review teams) went ahead successfully as planned. The regional contaminants committees each reviewed the following number of proposals: Yukon, 7; NWT, 26; Nunavut, 30; Nunavik, 8; and Nunatsiavut, 8. Each technical review team reviewed the following number of proposals: Human Health, 8; Environmental Monitoring and Research, 26; Community-based Monitoring and Research, 14; and Communications, Capacity and Outreach, 13.

NCP Publications

1. Synopsis of Research: The *Synopsis of Research conducted under the 2013-2014 Northern Contaminants Program* was released on USB keys at the NCP booth at the International Arctic Change Conference in December 2014 in Ottawa, distributed via email on January 30, 2015 and is available online through the NCP publications database. Abstracts and key messages are also available on the NCP website (http://www.science.gc.ca/ncp). All but one NCP project were reported in the publication. Previous editions of the Synopsis reports are now available electronically through NCP Publications Database (www.aina.ucalgary.ca/ncp/).

2. Canadian Arctic Contaminants Assessment Report III – *Contaminants in Canada's North: Summary for Policy Makers*: This report is now available in hard copy and electronically via the NCP website and NCP Publications Database. This 16-page document provides a succinct and high-level overview of the issue of contaminants in the North, identifies 10 key findings, future directions and recommendations. It summarizes the integrated highlights and main findings from the NCP's three most recent assessment reports: the *Canadian Arctic Contaminants Assessment Reports III* on persistent organic pollutants (2013) and mercury (2012) and the 2009 *Canadian Arctic Contaminants and Health Assessment Report*. Production of the more detailed *Highlights Report*, with greater emphasis on region-specific results, is still under way, with its release planned to coincide with the 2015 NCP Results Workshop.

3. NCP Publications Database: The NCP Publications Database (www.aina.ucalgary.ca/ncp/) makes NCP publications more accessible by: (i) providing a bilingual website, linked to the NCP website, that allows people to search for NCP publications; (ii) making citations, abstracts, and digital copies of NCP publications available in widely-used databases, particularly the Arctic Science and Technology Information System (ASTIS); and (iii) helping people to obtain NCP publications by providing, in addition to the usual publisher or journal information, information about one or more libraries where the publication is available for interlibrary loan, and links using URLs or DOIs that provide immediate access to publications that are available online. In 2014-15, ASTIS indexed a total of 206 items for the NCP Publications Database, for a total of 3253 items in the database. ASTIS assisted 18 of 60 NCP project leaders obtain ORCID identifiers and will continue to work on this process in 2015-2016. ASTIS also completed the process of completing the storing several key NCP documents (Synopses of Research from 2005-06 to present and CACAR I, II, and III) on the server with persistent URLs. Links to these documents are available directly from the NCP website and through the NCP Publications Database.

NCP Participation in International Arctic Change Conference: As the NCP implemented a change to holding its Results Workshop every other year, efforts were made to enhance NCP participation in ArcticNet's International Arctic Change Conference in Ottawa December 8-13, 2014. This was done through: support to ArcticNet to host the conference; NCP booth; sessions on contaminants, co-chaired by Jason Stow (NCP Secretariat) and Simon Wilson (AMAP Secretariat); NCP-related presentations in other concurrent sessions and posters; and provision of financial support to NCP funded researchers and northerners for travel and other workshop-related expenses.

A total of 22 presentations were given as part of the special session on contaminants, including 16 by representatives of NCP-funded projects. NCP was featured in other sessions as well, including a session on Data Management, co-chaired by Scott Tomlinson of the NCP Secretariat, a presentation on NCP's Science to Policy Actions by Sarah Kalhok as part of a session on "The Interface Between Science and Policy in the Arctic: New Perspectives on Knowledge to Action", and several mentions of NCP in plenary sessions, for example as an example of a role model for partnership in research.

Data Management: The Canadian Polar Data Network (CPDN) and in particular, the Polar Data Catalogue (PDC) continue to act as the metadata repository for NCP funded projects. Due to the increased efforts of the PDC Data Manager, 22 new NCP metadata records were added during 2014-15, and 75 of the current 94 NCP records have been updated with new information since March 2014. Project-level metadata have also been written for 35 of the 65 NCP projects. The Data Manager has also spent considerable time working with NCP researchers to complete the NCP metadata collection and create an inventory spreadsheet. This inventory indicates that 33 out of the 65 NCP projects active between 2011 and 2015 have completed their metadata reporting, 10 projects have some metadata in the PDC, and the 22 remaining projects do not have metadata in the PDC.

In 2014-2015, efforts were focused on including the Yukon Contaminants Database (which holds over 5000 records covering from the early 1990's to approximately 2010) in the Polar Data Catalogue. New data collected from recent years in the Yukon is currently being located to bring the database up to date.

Interlaboratory Quality Assurance / Quality Control (QAQC) Program: In 2014-2015 the QAQC team successfully recruited and hired a new post-doc (Anne Myers) to coordinate the program. The previous coordinator, Victoria Tkatcheva, was able to complete the Phase 8 interlaboratory QAQC study and prepare the initial data report before Anne took over the position in the Fall of 2014. Anne finalized the Phase 8 report which was circulated to NCP Project Leaders and NCP Management Committee Members in April 2015. The QAQC team is working with individual labs to identify potential sources of analytical error and provide advice for improvement. Invitations for the Phase 9 interlaboratory study were issued and the study got under way.

International Activities and Results in 2014-2015:

1. Implementation of the 1998 Aarhus POPs and Heavy Metals Protocol under the UN ECE Convention on Long-range Transboundary Air Pollution (LRTAP)

The POPs protocol, which describes actions to be taken against an initial list of 16 substances, and the Heavy Metals Protocol were signed by 36 countries in 1998 and entered into force in October 2003. In December 2011 the Executive Body approved amendments to the Annexes of the POPs Protocol related to new substances including: PFOS, PBDEs, pentachlorobenzene, short chain chlorinated parafins, polychlorinated naphthalenes, and hexachlorosyclohexanes (including lindane). The executive body also approved the designation of hexabromocyclododecane, endosulfan and dicofol as POPs and requested they proceed to track B review of management options. At their 32nd meeting in December 2013, the Executive Body decided not to consider the addition of new POPs in advance of the Stockholm Convention considering the same new POPs. Specific to the compounds being considered since 2011, the Executive Body: (a) decided that it would not further consider HBCD and endosulfan in view of their listing under the Stockholm Convention; and (b) decided to defer the discussion of PCP/PCA, dicofol and trifluralin until after the seventh

Conference of the Parties to the Stockholm Convention in 2015.

Updates in 2014-2015: There was no work related to the UNECE LRTAP Convention in 2014-2015. The NCP continued to support the addition of new chemicals through the Stockholm Convention.

2. Implementation of the Stockholm Convention on POPs and Associated Global Actions on POPs

The UNEP Stockholm Convention on POPs entered into force in May 2004. The most recent Conference of the Parties (COP) met at COP-7 in May 2015.

Throughout the development and implementation of the Stockholm Convention, the NCP has played an important role in providing data on POPs in the Arctic. Data from the Arctic and other remote regions of Earth is recognized as particularly valuable in the assessment of POPs as global pollutants. The current focus of NCP's efforts to support the Stockholm Convention is through contributions to the Global Monitoring Plan (GMP). NCP scientists contribute important monitoring data to the GMP and are leading on several aspects of reporting for the GMP. The second GMP report is currently in preparation. Tom Harner is Canada's representative on the global coordinating group for the GMP. He also leads the Global Atmospheric Passive Sampling (GAPS) network that is a primary source of atmospheric POPs data to the GMP. Derek Muir and Hayley Hung also have leadership roles in the preparation of chapters for the report. The GMP report will be the primary source of monitoring data used for effectiveness evaluation under Article 16 of the Convention.

The NCP also plays a significant role in producing data that is used to evaluate candidate POPs. The Inuit Circumpolar Council (ICC) has been attending the annual **Persistent Organic Pollutants Review Committee** (POPRC) meetings for the last 5 years and substantially relied on NCP data to show the magnitude of contaminant exposure in the Arctic. The following chemicals are currently under review by the POPRC or have recently been added to the annexes of the Stockholm Convention:

Dicofol

Dicofol was proposed as a POP candidate by the EU in 2013, however due to opposition by one POPRC member, its progress was stalled at POPRC 9 (October 2013). At POPRC 10 it was decided to move dicofol to Annex E, which means that a risk profile will be prepared. At POPRC 11 (October 2015) it will then be determined if the risk profile can be adopted (i.e. if dicofol is a POP as defined under the Stockholm Convention). Data on dicofol in the Arctic is scarce and is needed to inform the risk profile development. This lack of data is, in part, due to the problem that dicofol breaks down during analysis. Recent NCP-funded work by Liisa Jantunen, of Environment Canada, has suggested that the breakdown products of dicofol need to be considered.

Deca-BDE

Deca-BDE (or BDE—209) was proposed by Norway in 2013, moved to Annex E at POPRC 9 (October 2013) and to Annex F at POPRC 10 (October 2014), which means that a risk management evaluation will now be prepared and discussed at POPRC 11 (October 2015). Particularly contentious issues were the bioaccumulation and biomagnification properties of Deca-BDE, and whether it debrominates to lower-congenated BDEs (which are already regulated under the Stockholm Convention) in the environment. Gregg Tomy, an NCP-funded researcher at the University of Manitoba, has contributed greatly to the understanding of deca-BDE over recent years.

Short-chained chlorinated paraffins (SCCPs):

SCCPs have been discussed at the Risk Profile stage for 6 years now, and have not been moved forward because of a lack of recent data. At POPRC 8, it was decided to wait another three years for more data on SCCPs, and to discuss the Risk Profile again at POPRC 11 (in October 2015). Chlorinated paraffins production in China has reportedly increased 30-fold to over

600,000 tons between 1990 and 2007. It is projected that if China continues to increase production at the current rate, the amount will soon exceed the entire historic worldwide usage of PCBs. To inform the review process, current data from Arctic human populations (occurrence and effects) and trends data is needed. If no compelling data is submitted before that time, it is likely that SCCPs will be formally set aside.

Pentachlorophenol (PCP)/pentachloroanisole (PCA)

PCP was proposed as a candidate by the EU at POPRC 7, October 2011 and was determined to be a POP at POPRC 9 in October 2013. At POPRC 10 (October 2014), it was recommended that PCP (and its salts and esters) should be listed in Annex A (for elimination) with some specific use exemptions. At the last Conference of the Parties (COP-7) meeting in May 2015 PCP and its salts and esters were listed in Annex A with specific time-limited exemptions for use in utility poles and cross arms. NCP-funded work by Eric Dewailly and his team show increasing PCP values in Inuit from Nunavik, as was published in the 2014 AMAP POPs Trends report.

Hexachlorobutadiene (HCBD), chlorinated naphthalenes (CNs):

At COP 7 in May 2015, both chemicals were added to Annex A of the Stockholm Convention. For chlorinated naphthalenes, a time-limited specific use exemption was added for the production of polyfluorinated naphthalenes.

Furthermore, at COP-7 the EU announced that it would nominate PFOS as a POP. The POPRC will evaluate the nomination at its next meeting in October 2015. NCP data will be an important source of information for this review, as well.

3. Contributing to the Global Actions on Mercury (The Minamata Convention)

In January 2013 the UNEP Intergovernmental Negotiating Committee reached an agreement to reduce global mercury contamination. Leaders from the UNEP Governing Council, including Canada, gathered in October 2013 in Japan to sign a new Global Mercury Agreement. This agreement, known as the Minamata Convention, is a legally-binding treaty to cut atmospheric emissions and environmental releases of mercury, in an international effort to reduce global mercury pollution and protect the environment and human health. It also addresses the direct mining of mercury, export and import of the metal and safe storage of waste mercury.

The Minamata Convention represents a major achievement for the NCP and AMAP, two organizations that contributed much of the scientific justification for global action.

As of July 20, 2015, 128 countries had signed the Convention, including Canada, and 12 countries, had ratified, including the United States (but not Canada). The Minamata Convention will enter into force 90 days after 50 countries have ratified the treaty. In the meantime, preparations for the entry into force are ongoing: INC-6 took place 3 to 7 November 2014 in Bangkok.

Overall, there were two expert groups established to help guide the preparatory work of the Minamata Convention:

1. A BAT/BEP (best available techniques/best environmental practices) Expert Group to develop guidance for Article 8 (Mercury Emissions). The Canadian member is Alison Dickson (Environment Canada). The group had three meetings so far:

   At its third meeting, the group agreed that the co-chairs would seek public comment on developing draft guidance for best available techniques and environment practices. (document is available at: http://www.mercuryconvention.org/Negotiations/

BATBEPExpertGroup/tabid/3634/Default.aspx)

2. Ad hoc working group of experts on financing: established at INC-6, to provide input for INC-7 into financial arrangements. This meeting has been tentatively scheduled from 26 to 29 October 2015 in Brazil. More info on this group: http://www.mercuryconvention.org/Negotiations/Financingexpertgroup/tabid/4534/Default.aspx

   INC-7 will be held 7 to 11 March 2016 in Jordan.

NCP and AMAP scientists are currently preparing to collect mercury baseline data in humans. This work was started by Eric Dewailly at Laval University; Pierre Ayotte is continuing his work. This will certainly be useful for Global Mercury Reports and future effectiveness evaluations.

4. Arctic Monitoring and Assessment Programme (AMAP)

The goal of AMAP is to monitor the levels and trends of, and assess the effects of, anthropogenic pollutants and climate change on all components of the circumpolar Arctic environment and human health.

The first phase of AMAP was completed with the delivery of two reports: 1) Arctic Pollution Issues - A State of the Arctic Environment Report (1997); and 2) AMAP Assessment Report - Arctic Pollution Issues (1998). The Second AMAP Assessment (focussing upon POPs, Heavy Metals, radioactivity, influence of global change on contaminant pathways and human health) was published over the period of 2002 to 2005. The ground-breaking Arctic Climate Impact Assessment (ACIA) was then published in 2004/2005) followed by the Acidification and Arctic Haze (2006) and Oil and Gas Assessments (2007-2010). Since then, AMAP delivered its fourth major comprehensive series of assessments (AMAP 2009) which included human health, persistent organic pollutants (POPs), radioactivity and an update on climate change science issues.

NCP scientists and Aboriginal partners (ICC) played an important role in the production of the AMAP mercury assessment report released at the May 2011 Arctic Council Ministerial meeting held in Nuuk, Greenland, as well as the follow-up assessments on POPs and Human Health. The Mercury Assessment, which was co-led by Canada and Denmark, had a positive influence on the outcome of the UNEP INC process that resulted in the Minamata Convention on Mercury. In 2013, AMAP released an assessment on Arctic Ocean Acidification and is now planning follow-up activities.

Updates in 2014-2015:

- An updated assessment on Trends in Stockholm Convention POPs in Arctic Air, Human media and biota was published in 2014 and an additional POPs assessment on Emerging Contaminants in the Arctic is currently being prepared.
- The *Summary for Policy-makers: Arctic Pollution Issues 2015* was published in April 2015 and is available on AMAP's website (http://www.amap.no/documents/download/2222). This document presents the policy-relevant findings of the AMAP 2015 assessments of POPs (trends), human health, and radioactivity in the Arctic.
- The *Summary for Policy-makers: Arctic Climate Issues 2015* was also published in April 2015 and is also available on AMAP's website. This document presents the policy-relevant findings of the AMAP 2015 assessments of short-lived climate forcers (methane, black carbon and ozone).
- A new, full assessment on Human Health in the Arctic is in the final stages and will be published in late 2015.

Current/ongoing AMAP Assessments and related activities include:

A. Pollution Issues

- Pollution Issues (Radioactivity/Human Health/POPs Trends) Overview Report – *expected publication in late 2015*
- Human Health Assessment Report (Scientific/technical report) – *expected publication in late 2015*
- Radioactivity Assessment Report (Scientific/technical report) – *expected publication in late 2015*
- Chemicals of Emerging Arctic Concern (Scientific/technical report) – *expected publication in 2016*
- POPs Trends update (Scientific/technical report) – work is under way
- POPs and mercury biological effects (Scientific/technical report) – work is under way
- POPs Summary for Policy-makers document – expected *publication in 2016*

B. Climate Issues

- Climate Issues (Black Carbon/Ozone and Methane) Overview Report – *expected publication in late 2015*
- Methane Scientific Assessment Report – *expected publication in late 2015*
- Black Carbon/Ozone Assessment Report – *expected publication in late 2015*

C. Adaptation Actions for a Changing Arctic (AACA)

an integrated assessment of multiple drivers of Arctic change; pilot studies in three *regions are producing information to assist local decision-makers and stakeholders in developing adaptation tools and strategies to better deal with climate change and other pertinent environmental stressors*

- AACA Bering-Chukchi-Beaufort Regional Assessment report (Scientific/technical report) – *expected publication in early 2017*
- AACA Baffin Bay-Davis Strait Regional Assessment report (Scientific/technical report) – *expected publication in early 2017*
- AACA Barents Regional Assessment report (Scientific/technical report) – *expected publication in early 2017*
- Pan-Arctic Synthesis Report – *expected publication in 2017*
- AACA Summary for Policy-makers document – *expected publication in 2017*

D. Snow, Water, Ice, Permafrost in the Arctic (SWIPA)Follow-up reporting

- SWIPA Assessment report (Scientific/technical report) – late 2016 / early 2017
- SWIPA Overview report – late 2016 / early 2017
- SWIPA Policy-makers summary product – late 2016 / early 2017
- Freshwater synthesis report (Scientific/technical Journal articles)
- Freshwater synthesis overview / SWIPA chapter – 2016

E. Arctic Ocean Acidification (AOA) follow-up

- AOA Assessment report (Scientific/technical report) – 2017
- AOA Overview report – 2017
- AOA Summary for Policy-makers document – 2017

F. Arctic Resilience Report

G. Sustaining Arctic Observing Networks (SAON)

The purpose of SAON is to support and strengthen the development of multinational engagement for sustained and coordinated pan-Arctic observing and data sharing systems.

All assessments are currently on track to meet their planned timelines and deliverables between 2015 and 2017. The NCP is contributing significantly to these assessments, particularly for emerging POPs and effects in wildlife (POPs and mercury), for which Canada co-leads. A technical report summarising results of AMAP monitoring of temporal trends of selected POPs in air, human bio-monitoring media and biota has been produced for use by the Stockholm Convention groups that are preparing the next evaluation of the effectiveness and sufficiency of that Convention. This information was developed in the AMAP updated assessments of POPs and human health which will be published in 2015.

The next major assessment activity being undertaken by AMAP is being called the integrated Adaptation Actions for a Changing Arctic (AACA) to be completed by 2017. AMAP, in cooperation with other Arctic Council working groups, is leading on a part C of the AACA (AACA-C) that focuses on environmental modeling and prediction and presenting information for use in adaptation strategies at the regional level. AACA-C will be organized around three regional assessments that include the Barents Sea, Baffin Bay/Davis Strait, and the Bering/Chukchi/Beaufort Seas. Each of these regional assessments are being coordinated by regional implementation teams. ArcticNet and NCP scientists and regional/Aboriginal partners will be contributing directly to regional assessments for the Baffin Bay/Davis Strait, and Bering/Beaufort/Chukchi regions.

Expected Project Completion Date

This is an ongoing core component of the NCP.

Project website (if applicable)

www.science.gc.ca/ncp

Council of Yukon First Nations – Northern Contaminants Program Meetings

Conseil des Premières Nations du Yukon – Réunions dans le cadre du Programme de lutte contre les contaminants dans le Nord

- **Project Leader:**
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- **Project Team Members and their Affiliations:**
  Yukon First Nations, Yukon Contaminants Committee

Abstract

Over the past year the Council of Yukon First Nations (CYFN) has continued to be active as a member of the NCP Management Committee as well as responding to requests for information, participating in regional contaminants committee activity, informing Yukon First Nations about the annual call for proposals, maintaining and updating the Yukon NCP website and working with NCP researchers active in the Yukon.

Résumé

Au cours de l'année écoulée, le Conseil des Premières Nations du Yukon (CPNY) a poursuivi sa fonction de membre du Comité de gestion du PLCN, et a répondu aux demandes de renseignements, participé aux activités du comité régional des contaminants, informé les Premières Nations du Yukon au sujet de l'appel annuel de propositions, tenu à jour le site Web du PLCN au Yukon et collaboré avec les chercheurs du PLCN qui travaillent au Yukon.

Key Messages

- Our Traditional Foods in the Yukon are safe to eat.
- Levels of contaminants are generally low in the Yukon.
- We need to continue monitoring as new contaminants are being released into the atmosphere and water which may cause problems in the future.

Messages clés

- Les aliments traditionnels au Yukon sont sans danger.
- Les concentrations de contaminants sont en général faibles au Yukon.
- Il faut continuer la surveillance, car il est rejeté dans l'atmosphère et dans l'eau de nouveaux contaminants qui sont susceptibles de poser des problèmes.

Objectives

- To enhance the confidence of Yukon First Nations in making informed decisions about traditional food consumption and other health related factors.
- Ensure that Yukon First Nations are aware of the latest research regarding the transportation of long range contaminants to the Yukon and their effects on the environment and human health.
- Ensure that the programs offered by and the research done for the Northern Contaminants Program meets the needs of Yukon First Nations.
- Ensure that Yukon First Nations are aware of the funding envelopes and calls for proposals available under the Northern Contaminants Program and that these envelopes are relevant for and accessible to Yukon First Nations.

Introduction

The Council of Yukon First Nations has been a member of the Yukon Contaminants Committee and participated in the Northern Contaminants Program as a member of the Management Committee since the program became active in the Yukon. The current Northern Contaminants Program focus is addressing northern community concerns as people are being exposed to higher levels of long-range contaminants than the rest of Canada. The Yukon is not a high priority area, but still it is important that Yukon First Nations have the information necessary to make informed decisions on the risks and benefits of consuming traditionally harvested foods.

Activities in 2014-2015

Over the past year the Council of Yukon First Nations participated in Northern Contaminants Program management committee activities. A CYFN representative attended the Management Committee meetings held in Ottawa in April to review proposals and funding recommendations made for the various envelopes and advise the Program on the Committee's recommendations. We also attended the fall Management Committee meeting held in Yellowknife in October.

Information on the Northern Contaminants Program was shared at the Council of Yukon First Nations General Assembly held in Haines Junction in June. The Circumpolar Relations Department had a display set up, talked to individuals regarding contaminants concerns and made information packages and literature available to the delegates attending the assembly. We also attend First Nations General Assemblies if invited and provide information and answer questions about contaminants issues. When the annual call for proposals was issued, we provide First Nations with information regarding the call and work with any First Nation interested in submitting a proposal.

CYFN also participates in the work of the Yukon Contaminants Committee, meeting with researchers, discussing communications on contaminants issues and doing a review of proposals submitted to NCP to conduct research in the Yukon. We also work with researchers to disseminate information on their research and ensure they engage with communities in all aspects of their work.

CYFN maintains and updates the website www.northerncontaminants.ca. The site documents activity carried out by researchers active on contaminants issues in the Yukon and provides information on contaminants of concern. Over the course of the year the site was refreshed with a new look.

We participated in the deliberations and activities of both the traditional knowledge and risk communication subcommittees. As well we reviewed and provided editing and content suggestions for both the draft CACAR III – Summary for Policy-makers and the Health Blueprint revisions.

The two Environment Canada air quality researchers operating the Little Fox Lake site in the Yukon travelled to the Yukon, Sandy Steffen twice and Hayley Hung once. They meet with the Yukon Contaminants Committee once and CYFN had a meeting with Sandy regarding Little Fox Lake on the second occasion. The Director of Circumpolar Relations also travelled to the Fox Lake site on two occasions with the Yukon Contaminants Committee chair to help with site maintenance and the delivery of supplies. Discussion also occurred regarding CYFN taking over the administration of operating expenses for Little Fox Lake and this became CYFN's responsibility as of April 1st, 2015.

Initial talks were held with Health Canada regarding the expansion of health monitoring into the Yukon, perhaps based on the work of the Inuit Health survey. An initial conference call was held between Health Canada (Shawn Donaldson), NCP (Scott Tomlinson), and CYFN (Lori Duncan, Director of Health and Social Services and Bob Van Dijken).

In December, Bob Van Dijken travelled to the International Arctic Change Conference in Ottawa, attending NCP and other sessions, as well as AMAP side meetings and the International Arctic S&T Collaboration and Engagement Workshop.

The CYFN management committee representative also helped the YCC chair with planning and coordination activities regarding Arctic Council AMAP/PAME working group meetings to be held in Whitehorse September 15 – 18, 2014.

The Yukon Aboriginal partner organization produced a newspaper ad which appeared in both the Yukon News and Whitehorse Star profiling the Little Fox Lake air quality monitoring site as well as the northerncontaminants.ca and science.ca NCP websites. The ad also highlighted the fact that the Council of Yukon First Nations was taking over the administrative task of dealing with recurrent Yukon expenses associated with the site.

Results

- Attended management committee meeting to recommend funding for research envelopes
- Communicated information on contaminants and the NCP to Yukon First Nations at the CYFN General Assembly
- Attended Yukon Contaminants Committee meetings and reviewed projects proposing to do work in the Yukon

- Attended NCP midyear management meeting
- Revised the look and content of the northerncontaminants.ca website
- Made arrangements to administer the Yukon costs of the Little Fox Lake mercury and POPs air monitoring site
- Engaged in dialogue with NCP and Health Canada regarding possible bio-monitoring programs in the Yukon
- As part of the Yukon Contaminants Committee, helped coordinate the Arctic Council's Arctic Monitoring and Assessment Programme's (AMAP) work group meeting in Whitehorse
- Meet with Environment Canada researchers Hayley Hung and Sandy Steffen about the Little Fox Lake site
- Produced a newspaper ad that appeared in two Yukon newspapers profiling the Little Fox Lake monitoring program as well as the northerncontamiants.ca website and NCP information on the federal science.ca website

Discussion and Conclusions

The NCP plays a vital role in monitoring the health of Yukon ecosystems and assuring Yukon residents that traditionally harvested foods are safe to eat. In general, levels of contaminants transported to the Yukon through the atmosphere and aquatic sources remains low, however levels of mercury may be a concern for older, larger fish in some areas. We continue to generate new chemicals on a continuous basis, some of these are now showing up in the Arctic and accumulating in animals and fish as well as in water and on the land. Long term data sets are critical to understand background levels, track changes and understand their relationship with climate change, industrial activity and other factors.

Expected Completion Date

Ongoing.

Project Website

www.northerncontamiants.ca

Dene Nation participation in Management Steering Committee and Northwest Territories Environmental Contaminants Committee

Participation de la Nation dénée aux travaux du Comité directeur de gestion et du Comité régional des contaminants des Territoires du Nord-Ouest

Project Leader:
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Project Team Members and their Affiliations:
Camilia Zoe-Chocolate, and Keyna Norwegian, Dene Nation

Abstract

In the 2014-2015 fiscal year Dene Nation received National and Regional Coordination fundingfrom the Northern Contaminants Program. This funding has allowed Dene Nation to participate on the Program's Management Committee and on the NWT Regional Contaminants Committee (NWTRCC) to help the program meet its goals. The Northern Contaminants Program's key objective is to work towards reducing and eliminating contaminants in traditional country foods, while providing information to assist individuals and communities in making informed decisions about food choices. As a national organization representing First Nations peoples, the Dene Nation is appropriate for reviewing

Résumé

Pendant l'exercice 2014-2015, la Nation dénée a reçu du financement pour la coordination nationale et régionale du Programme de lutte contre les contaminants dans le Nord. Ce financement lui a permis de participer aux travaux du Comité de gestion du Programme et du Comité régional des contaminants des Territoires du Nord-Ouest (CRCTNO), pour aider le programme à atteindre ses objectifs. Le principal objectif du Programme de lutte contre les contaminants dans le Nord est de réduire et d'éliminer les contaminants présents dans les aliments traditionnels, tout en fournissant de l'information pour aider les individus et les collectivités à prendre des décisions éclairées au sujet de leur alimentation. En sa qualité

proposals for research under the Northern Contaminants Program to ensure the research is relevant to the Dene, and proceeds in a respectful and culturally appropriate manner. During the review process Dene Nation also makes recommendations to ensure the most appropriate available resources and support systems in Oene communities are utilized, and that the goals of capacity building and incorporation of traditional knowledge are adequately addressed by researchers. In addition to participation in Management Committee and NWTRCC meetings, the NCP funding has allowed Dene Nation to participate in conference calls, email communications, other meetings, and follow-up work to ensure staff is up-to-date on the Program and other issues related to long-range contaminants in the Arctic. Dene Nation has been an active aboriginal partner in the Northern Contaminants Program, participating in the national and regional coordination of the NCP. A portion of NCP funding is established to enable aboriginal partners to participate in National Management Committee and territorial contaminant committee activities. Dene Nation acts as liaison to provide advice to the NCP on contaminant issues in the communities. Dene Nations hosts one Dene National Assembly and two leadership meetings a year within Denendeh, where NCP activity reports are presented to leaders & members of the Dene Nation with our involvement in NCP.

d'organisation nationale représentant des membres des Premières Nations, la Nation dénée est bien placée pour examiner des propositions de recherche présentées dans le cadre du Programme de lutte contre les contaminants dans le Nord, faire en sorte que les recherches soient pertinentes pour les Dénés, et qu'elles s'effectuent de manière respectueuse et adaptée à leur réalité culturelle. Pendant le processus d'examen, la Nation dénée formule aussi des recommandations pour que les ressources les plus pertinentes et les systèmes de soutien dans les collectivités dénées soient utilisés, et que les chercheurs tiennent compte adéquatement des objectifs du renforcement des capacités et de l'intégration du savoir traditionnel. Grâce au financement versé dans le cadre du PLCN, la Nation dénée a pu, en plus de participer aux réunions du Comité de gestion et du CRCTNO, participer à des téléconférences, communiquer par courriel, assister à d'autres réunions et effectuer le travail de suivi pour s'assurer que ses employés sont au fait des progrès du Programme et des autres questions liées aux contaminants transportés à grande distance dans l'Arctique. La Nation dénée est un partenaire autochtone qui participe activement au Programme de lutte contre les contaminants dans le Nord, notamment pour ce qui est de la coordination nationale et régionale du PLCN. Une partie du financement du PLCN est réservée pour permettre aux partenaires autochtones de participer aux activités du Comité national de gestion du Programme et du Comité régional des contaminants. La Nation dénée fait office d'agent de liaison pour conseiller le PLCN au sujet des contaminants dans les collectivités dénées. Elle est l'hôte d'une assemblée nationale de la Nation et de deux réunions des dirigeants par année dans le Denendeh, à l'occasion desquelles des rapports d'activité du PLCN sont présentés aux dirigeants et aux membres de la Nation dénée. On y explique aussi la participation des Dénés à ce projet.

Key Messages

- Participation on NCP Management Committee
- Participation on NWT Regional Contaminants Committee
- Provide advice to NCP on contaminant issues of the communities
- Liaison of NCP activities within Dene Nation Membership

Messages clés

- Participation aux travaux du Comité de gestion du PLCN
- Participation au Comité régional des contaminants des Territoires du Nord-Ouest
- Conseille le PLCN au sujet des contaminants dans les collectivités dénées
- Informe les membres de la Nation dénée au sujet des activités du PLCN

Objectives

The Program's key objective is to work towards reducing and, where possible, eliminating contaminants in traditional/country foods, while providing information that assists individuals and communities in making informed decisions about their food use.

Introduction

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 northern Aboriginal peoples. Early studies indicated that there was a wide spectrum of substances-persistent organic pollutants (POPs), heavy metals, and radionuclide's- many of which had no Arctic or Canadian sources, but which were, nevertheless, reaching unexpectedly high levels in the Arctic Ecosystem.

Dene Nation was awarded funding under the Northern Contaminants Program National and regional coordination envelope for 2013 -2014, these funds were distributed by the NCP Secretariat to complete our responsibilities under the human health blueprint development, monitoring blueprint development, social/cultural review of proposals, as well as for health and monitoring projects. Projects were identified by the NCP Secretariat as relevant to Denendeh. Funding enabled Dene Nation to participate in the national and regional coordination and management of the NCP review, consultation, and development of programs.

Results

The Dene National Chief, Lands and Environmental Director and Program Coordinator participated in various meetings between April1, 2014 to March 31,2015.

Discussion and Conclusions

The funding supported the administration of the program, aboriginal partnership consultation and review of NCP funded projects and national/regional coordination meetings. The budget covered salaries to continue work within NCP throughout the year. The budget supported Dene Nation Lands and Environment staff to participate in monthly teleconferences and face to face meetings as well as email and phone communications. The Dene Nation plays a key role in the Northern Contaminants Program to ensure Traditional Knowledge is considered, participated in the NCP Management Committee to review proposals and presented NCP information at Dene National General Assembly and at Leadership Meetings.

Inuit Tapiriit Kanatami NCP National Coordination

Coordination nationale de la participation d'Inuit Tapiriit Kanatami au PLCN

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Abstract

Since the beginning of the Northern Contaminants Program (NCP) in 1991, Inuit Tapiriit of Kanatami (ITK) has participated in the program as managing partners. This partnership continues to be fruitful and effective both for Canadian Inuit and to the Northern Contaminants Program (NCP). As the national political voice for Canadian Inuit, ITK continues to play multiple roles within the NCP. First, ITK provides guidance and direction to AANDC and the other NCP partners - bringing Inuit interests to the NCP management and liaison committees of which we are a member. As a result, the NCP can better respond to the needs and concerns of Inuit. Secondly, ITK is dedicated to facilitating appropriate, timely

Résumé

Inuit Tapiriit Kanatami (ITK) est partenaire de gestion du Programme de lutte contre les contaminants dans le Nord (PLCN) depuis la création du programme en 1991. Ce partenariat continue d'être fructueux et efficace pour les Inuits canadiens et pour le PLCN. Porte-parole politique des Inuits du Canada, ITK continue de jouer de multiples rôles au sein du PLCN. Premièrement, ITK fournit conseils et orientations à AADNC et à d'autres partenaires du PLCN. Il fait connaître les intérêts des Inuits à la gestion du PLCN et aux comités de liaison dont il est membre. En conséquence, le PLCN peut mieux répondre aux besoins et réagir aux préoccupations des Inuits. Deuxièmement, ITK s'emploie à faciliter des communications

communications about contaminants in the North. Thirdly, ITK are working with their Inuit partners at the Inuit Circumpolar Council (ICC)-Canada on the international stage to persuade nations to reduce their generation and use of persistent organic pollutants (POPs) and Heavy Metals (Mercury) that end-up in the Inuit diet. Lastly, ITK is now working with other research programs like ArcticNet, Nasivvik, Health Canada Climate change program, and the Chemicals Management Plan to make sure that research on contaminants is conducted in a coordinated approach. This is done mainly through the regional contaminants committee in each of the four Inuit regions of which ITK helps assist and guide. ITK involvement in contaminant committees is critical in order to deliver a consistent message to Inuit regarding the NCP and contaminants.

adéquates et opportunes au sujet des contaminants dans le Nord. Troisièmement, ITK collabore avec ses partenaires inuits au sein du CCI-Canada à l'international pour persuader les pays de réduire la production et l'emploi des polluants organiques persistants (POP) et des métaux lourds (p. ex. le mercure) qui aboutissent dans les aliments des Inuits. Enfin, ITK collabore maintenant avec d'autres programmes de recherche, comme ArcticNet, Nasivvik, le programme sur les changements climatiques de Santé Canada et le Plan de gestion des produits chimiques, afin de garantir que les recherches sur les contaminants s'effectuent de façon coordonnée. ITK le fait surtout par sa participation aux travaux des comités régionaux sur les contaminants dans chacune des quatre régions inuites, grâce à l'aide et à l'orientation qu'il fournit. Cette participation est cruciale pour livrer un message cohérent aux Inuits au sujet du PLCN et des contaminants.

Key messages

- Provide a voice for Inuit of Canada during NCP discussions
- To continue to be an active and constructive member of the NCP management structure ensuring that contaminants issue and NCP research and results are communicated to Inuit and that Inuit are represented at key regional, circumpolar and international meetings and initiatives.
- To contextualize contaminant information in a broader communication process using the Inuit Knowledge Centre
- Develop the confidence for Inuit in making informed decisions about Country food use.
- Coordinate Contaminants activities in Nasivvik, ArcticNet, Health Canada Climate Change Program

Messages clés

- Se faire le porte-parole des Inuits du Canada dans les délibérations du PLCN.
- Continuer d'être un membre actif et constructif de la structure de gestion du PLCN, et veiller à ce que les questions relatives aux contaminants et les recherches du PLCN soient communiquées aux Inuits, et à ce que les Inuits soient représentés aux principales réunions et dans les initiatives importantes à l'échelle régionale, circumpolaire et internationale.
- Mettre en contexte les renseignements relatifs aux contaminants dans un contexte général par l'intermédiaire du Centre du savoir inuit.
- Renforcer la confiance des Inuits afin qu'ils prennent des décisions éclairées au sujet de la consommation des aliments traditionnels.
- Coordonner les activités liées aux contaminants avec Nasivvik, ArcticNet et le programme sur les changements climatiques de Santé Canada.

Objectives

1. Participation in the NCP Management Committee
2. Participation in Regional Contaminant Committees
3. Participation on NCP review Team
4. Participation with Inuit Research Advisors teleconference and in person meetings
5. Participation in and Nasivvik meetings (wrap up year)
6. Participation ArcticNet AGM/RMC and BOD. Review of IRIS reports

Introduction

The story of contaminants in the arctic can be one of fear of the unknown; research carried out under NCP has shown that the contaminants of most concern for Inuit are persistent organic pollutants (POPs) and Heavy Metals like mercury. The concern of these contaminants comes from the fat-rich country marine foods diet that Inuit depended upon both for nutritious food and sustaining a lively culture. As a result there are places in the Canadian Arctic where some of the Inuit population are at risk because their dietary intake of mercury is greater than the levels that are known to be safe (NCP 2012). As well, NCP health projects out of Nunavik show that Inuit children have subtle negative effects because of prenatal exposure to PCBs and mercury. Inuit want to know and have the right to know what is happening to the health of Inuit, and to the health of the arctic environment. With these alarming data it is critical that Inuit involvement throughout the program in order to provide advice, direction and information to Inuit.

Activities in 2014-2015

Funding from the NCP to ITK comes from the funding envelop National Coordination which allows ITK to assess information and research generated by the program and to play an informed role in influencing present and future NCP management priorities through the established committees that are in place.

The focus of this year's activities is around the various NCP research committees such as the Regional Contaminant Committees (RCC's) with active participation on the NWT Regional Environment Committee (NWTRCC), Nunavut Environment Contaminants Committee (NECC) meetings, Nunivak Nutrition and Health Committee (NNHC), and the Nunatsiavut Government Research Advisory Committee(NGRAC). Also, ITK is now able to bring information forward to the National Inuit Committee on Health (NICoH) and the Inuit Knowledge Center Committee as well as the recently established Amaujaq National Centre for Inuit Education. When issues arise that have a potential human health risk we go through ITK Health and Social Economic Development Department in bringing concerns to Inuit Public Health Task Group. Last year with the new formation of the Wildlife and Environment department we are developing stronger regional wildlife contacts with Wildlife workers to vent NCP environment information through. Some of the NCP information and data was used in our Polar Bear efforts and fact sheet development to go to United Nations in Bangkok. We continue to assist and help guild ICC in their global efforts in eliminating Mercury from use.

ITK also participated in all of the NCP management meetings, as well as various review committees like the Human Health review team, the Environment Trends, Community Base Monitoring and Research and Communication and Capacity Outreach teams. Participation on these committees provide a voice for the Inuit of Canada, developed priorities and issues within NCP framework, developed confidence for Inuit in making informed decisions on their food and coordinated contaminant activities with other research programs like ArcticNet and Nasivvik to ensure that the message of contaminants are placed in a wider context and the research is conducted in a responsible manner throughout the arctic. This is also done with the Inuit Research Advisors (IRA's) that are partially funded by the NCP and are assisted by ITK. The main objective here is to provide a coordinated approach towards research and communication, to provide and Inuit "voice" and direction at the NCP management table to ultimately allow Inuit to have confidence in making good informed decisions about their food use

Another role of informing the public about issues in the north, ITK gave various presentations about the NCP general contaminants primer across Canada and the USA.

Results

Part of our responsibilities with the NCP funding is to consult with the principal investigators and communities that will be engage in research in Inuit regions. This year there was close to 40 projects that are took place in the Inuit regions. ITK involvement in these projects can range from minimum advisory role to very intensive project control. ITK has guided researcher in various environmental monitoring programs on how to communicate to communities, translating scientific information, making links to other research programs, encouraging capacity building and funding from Nasivvik. ITK will continue to assist both the researchers and the Inuit regions and communities with the conclusion of these projects.

ITK was committed to providing a coordination role for Inuit to attend the ArcticChange in Ottawa December 2014. Led by the Department of Environment and Wildlife, an internal coordination committee was formed with representatives from the Inuit Qaujisarvingat: Inuit Knowledge Centre (IQ), Health and Social Development, Communications and Finance. All activities led by ITK were a joint effort between these departments.

Over 80 Inuit were in attendance at this meeting. With coordination efforts from ITK staff and AANDC, Inuit were involved in many areas of the conference. From oral presentations and posters, to booths, crafts, and performances, the Inuit presence was noticeable and appreciated.

Discussion and Conclusions

In a time of great turn over and changing personal, ITKs engagement to the NCP committee's has been the one constant over the last 17 years. This has provided each of the contaminants committee with some record of history. This year ITK will work and help each of the four regional committee's (Nunatsiavut, Nunavik, Nunavut, and the NWT), engage with the NCP review teams, help with the development of the new Risk Communication Subcommittee, participate and help with any issues that NCP might need assistance with. ITK will continue to sit on all contaminant committees (Nunatsiavut, Nunavik, Nunavut and Inuvialuit) and NCP Management and Human Health, Community Based Monitoring, and Education and Outreach review teams and bring to these discussions and committees information learned from participation with the Inuit Public Health Task Group, Food security committee, mental wellness committees, early childhood development, Inuit Health Survey, National Inuit Committee on Health, Nasivvik, ArcticNet, FNIB community based climate change program, youth programs like NS and the National Inuit Youth Committee. Support from the NCP will allow ITK to participate in all these initiatives and be able to bring a contextualization to the NCP program and other national programs like Chemicals Management Plan and Commission for Environment Cooperation (CEC) and to Inuit regions.

Expected Project Completion Date

Ongoing

Project website

www.itk.ca

http://www.inuitknowledge.ca/

http://30214.vws.magma.ca/index.php
(Niqiit the story of contaminants)

Inuit Circumpolar Council – Canada Activities in Support of Circumpolar and Global Contaminant Instruments and Activities

Conseil circumpolaire inuit – Les activités du Canada visant à appuyer les instruments et les activités de lutte contre les contaminants circumpolaires et mondiaux

- **Project Leader:**
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- **Project Team Members and their Affiliations:**
  Duane Smith, Leanna Ellsworth, and Stephanie Meakin, Inuit Circumpolar Council – Canada; Noor Johnson, Brown University

Abstract

This report outlines ICC Canada's activities funded by Northern Contaminants Program (NCP) in the fiscal year of 2014-2015. ICC Canada is working nationally and internationally to address the issue of contaminants in the Arctic. National activities include support to the NCP in the Management Committee, blueprint and proposal reviews, the Canadian Arctic Contaminants Assessment III Highlights Report as well as the summary for policy makers. Internationally, ICC Canada continued its activities related to the United Nations Environment Programme (UNEP). Work on the Stockholm Convention on Persistent Organic Pollutants (POPs) is ongoing, with ICC Canada attending the 10th POP Review

Résumé

Ce rapport fait état des activités du Conseil circumpolaire inuit (CCI) Canada financées par le Programme de lutte contre les contaminants dans le Nord (PLCN) pendant l'exercice 2014-2015. Le CCI-Canada travaille à l'échelle nationale et internationale à régler les questions relatives aux contaminants dans l'Arctique. Parmi les activités nationales, citons l'appui offert au PLCN au sein du Comité de gestion, l'examen de plans directeurs et de propositions, la rédaction du sommaire du *Troisième rapport d'évaluation des contaminants dans l'Arctique canadien*, de même que la production du résumé à l'intention des décideurs. À l'échelle internationale, le CCI-Canada a poursuivi ses activités se rapportant au Programme des

Committee (POPRC) in October 2014. ICC Canada continued to support Arctic Council activities, such as attending meetings of and organizing webinars for the Adaptation Actions for a Changing Arctic (AACA) Integration Team and participating in the Taskforce on Scientific Cooperation. ICC Canada was very active on the Sustaining the Arctic Observing Networks (SAON) Board, the SAON Executive Committee, and continues leading the SAON task on community-based monitoring. ICC Canada has further been leading the chapter on risk communication for the upcoming AMAP Health Assessment. Communication events included the General Assembly (GA) in Inuvik, July 21st to 24th, 2014 and the Arctic Change conference December 8 – 12, 2014 in Ottawa.

Key Messages

- ICC Canada worked actively to support NCP by working on the Management Committee, Environmental Monitoring and Community-Based Monitoring technical review committees, the Canadian Arctic Contaminants Assessment Report III Highlights report and the summary for policy makers.
- ICC Canada attended the 10th POP Review Committee (POPRC) meeting, provided input in POPRC working group documents and informed the NCP about POPRC work.
- ICC Canada actively contributed to Arctic Council related work, attended the AMAP WG and Head of Delegation meetings, AACA Integration team meetings and webinars, Taskforce on Scientific

Nations Unies pour l'environnement (PNUE). Les travaux se rapportant à la Convention de Stockholm sur les polluants organiques persistants (POP) sont en cours, et le CCI-Canada a assisté à la 10e réunion du Comité d'examen des POP en octobre 2014. Le CCI-Canada a continué de soutenir les activités du Conseil de l'Arctique, notamment en assistant aux réunions, en organisant des webinaires pour l'équipe d'intégration des mesures d'adaptation pour un Arctique en évolution (Adaptation Actions for a Changing Arctic – AACA), et en participant au groupe de travail sur la coopération scientifique. Le CCI-Canada continue de participer très activement aux travaux du conseil des Sustaining the Arctic Observing Networks (SAON) et du comité exécutif des SAON, et il continue de diriger la tâche des SAON concernant la surveillance communautaire. ICC-Canada a dirigé la rédaction du chapitre sur la communication des risques du rapport d'évaluation des effets sur la santé, qui sera publié dans le cadre du PSEA. L'organisme a notamment assisté aux événements de communication suivants : assemblée générale à Inuvik, du 21 au 24 juillet 2014 et conférence Arctic Change, du 8 au 12 décembre 2014 à Ottawa.

Messages clés

- CCI Canada a travaillé activement pour appuyer le PLCN en participant au Comité de gestion, aux comités d'examen technique en matière de surveillance environnementale et surveillance communautaire, au sommaire du *Troisième rapport d'évaluation des contaminants dans l'Arctique canadien* et au résumé à l'intention des décideurs.
- CCI Canada a assisté à la 10e réunion du Comité d'examen des POP, a fourni des commentaires pour les documents du groupe de travail de ce comité et a informé le PLCN au sujet des travaux du Comité.
- CCI Canada a contribué activement aux travaux liés au Conseil de l'Arctique, a assisté aux réunions du groupe de travail du PSEA

Cooperation meetings (in Helsinki and Reykavik) and conference calls, SAON meetings, and teleconferences of the SAON Executive Committee.

- ICC participates in NCP, ArcticNet and now CHARS at the management levels and brings a level of coordination and information sharing among the circumpolar Inuit engagement to these fora.
- ICC Canada was very active in the AMAP Human Health Assessment Group (HHAG) and led the development of a chapter on risk communication for the upcoming AMAP Health Assessment.
- Work on mercury isotopes in ice cores and snow samples to identify mercury pathways and sources to the Arctic is continuing, data is being analyzed and prepared for a publication, which should be submitted in summer 2015.
- ICC had its quadrennial General Assembly (GA) in Inuvik, July 21st to 24th, 2014. At the General Assembly circumpolar Inuit leadership determines ICC's direction for the next four years, which is outlined in the Kitigaaryuit Declaration. The GA was attended by several hundred people, which included Inuit representatives from the circumpolar Arctic as well as many international guests from governments, academia, industry and civil society.

et des chefs de délégation, aux réunions et aux webinaires de l'équipe d'intégration de l'AACA, aux réunions et aux téléconférences du groupe de travail sur la coopération scientifique (à Helsinki et Reykavik), aux réunions des SAON et aux téléconférences du comité exécutif des SAON.

- CCI participe aux activités du PLCN, d'ArcticNet et, maintenant, de la SCREA au niveau de la gestion, en plus d'assurer la coordination et la diffusion des renseignements pour la mobilisation des Inuits à ces forums circumpolaires.
- CCI Canada a joué un rôle actif au sein du groupe d'évaluation de la santé humaine du PSEA, et a dirigé la rédaction du chapitre sur la communication des risques du rapport d'évaluation des effets sur la santé qui sera publié dans le cadre du PSEA.
- CCI continue d'effectuer des recherches sur les isotopes de mercure dans les carottes de glace et des échantillons de neige afin de déceler les trajets du mercure et les sources du métal en Arctique. Il analyse les données et il se prépare pour la publication d'un article qui devrait être soumis à l'été 2015.
- CCI a tenu son assemblée générale quadriennale à Inuvik, du 21 au 24 juillet 2014. Lors de l'assemblée générale, les dirigeants inuits des régions circumpolaires déterminent les orientations du CCI pour les quatre années suivantes, et les présentent dans la déclaration Kitigaaryuit. Des centaines de personnes ont participé à l'assemblée générale, notamment des représentants inuits de la région circumpolaire arctique, de même que de nombreux invités étrangers des gouvernements, du milieu universitaire, de l'industrie et de la société civile.

Objectives

Short-term objectives of ICC's activities are:

- to ensure that Inuit are aware of global, circumpolar and national activities and initiatives on contaminants;
- that Inuit viewpoints and interests are represented in contaminant-related matters, and are considered and included in relevant research, reports, assessments and meetings pertinent to policy development; and,
- to ensure that scientific research in the Arctic is addressing Inuit needs and is done with Inuit support and involvement.

Long-term goals are:

- to ensure Inuit have the capacities, resources and knowledge necessary to support their participation and involvement in national and international policy development on contaminant issues;
- to assist in the development of a framework that allows for sustained and integrated community-based research and includes the use of traditional and scientific knowledge, and, ultimately; and,
- to reduce, and where feasible eliminate, contaminants in the Arctic environment.

Introduction

Inuit are Arctic Indigenous peoples living in Russia (Chuktoka), the U.S.A. (Alaska), northern Canada and Greenland. The Inuit Circumpolar Council (ICC) was founded in 1977, when Inuit across the circumpolar Arctic recognized that they need to have a united voice to represent them internationally, and to represent circumpolar Inuit in the respective countries. Since then, ICC has been growing into an internationally renowned organization with offices in each of the four countries. ICC is working successfully to address Inuit concerns on matters and overarching issues such as health, the environment, and culture. Among ICC's principle goals are the promotion of Inuit rights and interests on an international level and the development and encouragement of long-term policies that safeguard the Arctic environment.

A very important issue for Inuit is contaminants which undergo long-range transport, bioaccumulate in the Arctic ecosystem and lead to very high concentrations in some Inuit populations, potentially impacting their health and well-being. Funding by the Canadian government, and in particular the Northern Contaminants Program (NCP) of the Department of Aboriginal Affairs and Northern Development of Canada (AANDC), has enabled ICC Canada to work effectively on addressing the issue of contaminants in the Arctic. ICC Canada is part of the NCP Management Committee, is directly involved with contaminant research in the Arctic, works within the Arctic Monitoring and Assessment Programme (AMAP) of Arctic Council, and represents Inuit at the United Nations Environment Programme (UNEP) and related meetings.

This is the year-end report on activities undertaken by ICC from April 1, 2014 - March 30, 2015, which is a delivery requirement detailed under the 2014/15 NCP contribution agreement.

Eva Kruemmel is the Senior Policy Advisor on Environment and Health for ICC Canada and is the lead on NCP and related files. Duane Smith continues to support and speak to the findings and model of the NCP in international meetings. Further assistance has been provided by Leanna Ellsworth and Noor Johnson. Natasha Latreille provides administrative support. Stephanie Meakin as Science Advisor continues to support Eva Kruemmel when needed.

Detailed activities in 2014-2015

1. NCP

Proposed activities:

a) General NCP work:

- Attendance of Management Meetings and related work. A Results Workshop was not held in 2014.

Work undertaken:

Eva Kruemmel participated in teleconferences of the Environmental Trends technical review committee, and in a face-to-face meeting of the Community-based Monitoring review committee (March 10th, 2015 in Ottawa). ICC Canada attended the NCP Research Management Meetings on April 8 – 10, 2014 in Ottawa, reviewed proposals and documents as required and provided input and comments. There was no NCP Results Workshop in 2014, but ICC Canada attended the Arctic Change conference, which included sessions from NCP scientists, and ICC Canada gave several presentations (see below). Eva Kruemmel attended the NCP Management meeting Oct 7 – 9, 2014 in Yellowknife, reviewed blueprints and provided input.

Proposed activities:

b) CACAR III Highlights report:

- Input into the highlights report preparation, work on advisory committee
- Reviewing of report/chapters as applicable
- Participation of related meetings and teleconferences

Work undertaken:

Eva Kruemmel sent comments on a new outline of the Highlights Report, commented on a key findings section, provided a paragraph on Inuit involvement in the international conventions, and reviewed and commented on a later version of the report and the summary for policy makers.

Proposed activities:

c) Participation in Risk Communication sub-committee:

- ICC Canada will participate in meetings, teleconferences and/or related work as required and possible.

Work undertaken:

The sub-committee on risk communication has not formally been established. However, there was a teleconference on contaminant communication on April 9th, 2015, that Eva Kruemmel participated in.

2. AMAP

Proposed activities:

a) General:

- The 28th WG meeting will take place in Inuvik, September 2014. ICC Canada is planning to attend the meeting.
- Contributions to reviews and other documents, as applicable and possible.

Work undertaken:

ICC Canada attended the AMAP Working Group meeting September 16 – 18, 2014 in Whitehorse, as well as the AMAP Heads of Delegation meeting February 4 – 5, 2015 in Copenhagen, Denmark, reviewed the documents and provided input during, before and after the meetings.

Proposed activities:

b) AACA:

- Attendance of one integration team meeting (likely to take place in Europe).
- Preparations for the meeting and reporting on the outcomes.

Work undertaken:

ICC Canada continues to be involved in the process, and Stephanie Meakin is a member of the integration team, organized and attended teleconferences. Stephanie Meakin participated in monthly webinars to develop the table of contents for the regional assessments and to define the boundaries of the regional assessments. ICC coordinated the participation of ICC Alaska and Alaskan Inupiat in the BBC meeting in Seattle. ICC drafted briefing notes for the ICC Executive Council. Coordinated participation of ICC Greenland in the Baffin Bay Davis Straight (BBDS) Regional Assessment workshop in Nuuk and engaged QIA and NTI regional representatives in the BBDS process. The AACA INT meeting was attended by Parnuna Egede in Ottawa in December 2014. ICC continues to participate on the AACA INT.

c) SAON:

- Attendance of relevant meetings/teleconferences of the SAON Board, Executive Committee, and the national (Canadian) group. The SAON Board meeting will take place April 10 and 11, 2014, during the Arctic Observing Summit (AOS) in Helsinki. Eva Kruemmel will attend the SAON Board meeting, and the AOS (she is co-chair of the AOS organizing committee).
- General work on SAON Board, and Executive Committee such as reviewing of documents, writing reports and meetings/teleconferences with partners.
- Work within the CBM group, participation in workshops (pending funding) and further work on related SAON tasks
- Coordination of work with partners for the task proposal, progress reports, etc.

Eva Kruemmel took part in teleconferences of the SAON Executive Committee and SAON Board, as well as the AOS organizing committee. She attended the SAON Board meeting in Helsinki April 10 – 11th, 2014, and the Arctic Observing Summit, where she co-chaired a session on stakeholder involvement. For the session, Eva Kruemmel co-organized and then moderated a panel discussion on stakeholder integration in Arctic Observation, which included perspectives from a wide array of stakeholders:

- The local community (Nellie Pokiak from the ISR, Canada)
- Science (Thomas Jung, Alfred Wegener Institut, Germany)
- Industry (Tero Vauraste, Arctia Shipping, Finland)
- Arctic government (Finn Danielsen from the Nordic Foundation for Development and Ecology, representing the Greenlandic government)
- Indigenous peoples organization/Arctic Council PP (Jim Gamble, Aleut International Association, Alaska, USA)

Nellie Pokiak's participation received a lot of positive feedback during and after the event. She talked about her experience with the NCP-funded beluga monitoring project, and the importance to work with Inuit knowledge holders. The panel has been recorded and can be viewed on the internet (http://player.vimeo.com/video/92164110).

Nellie then attended and actively participated in other activities related to the AOS, such as a high-level panel, were government representatives from Finland, Canada, Europe, the US, Russia and Japan considered needs, challenges and accomplishments with regards to Arctic observing. She was also invited to visit the Canadian embassy, where she told the Canadian ambassador to Finland and embassy staff about her region and activities with the beluga monitoring.

Eva Kruemmel was in frequent email contact and has held several teleconferences and meetings with partners on the ICC-led SAON community-based monitoring (CBM) task proposal, and sent information about the SAON developments prior to the SAON Board meeting to Permanent Participant (PP) colleagues.

The online Atlas of Community Based Monitoring in a Changing Arctic (www.arcticcbm.org), which was launched by ICC Canada and its partners in July 2013, is being further developed. With additional funding from Health Canada, ICC Canada was able to hire a summer student (Laura Petrunka), who has been assisting with work on the atlas full-time during the summer 2014, and continues to work part-time for ICC Canada. Laura specifically worked on a new layer of the CBM atlas on mental health, and presented this work during a meeting of the National Inuit Committee on Health (NICoH) in Ottawa, June 3rd, 2014.

Noor Johnson is finalizing work on the second part of ICC's SAON task proposal, which is the compilation of an in-depth review of CBM in the circumpolar Arctic. Related to this work, a paper is currently in print on the contribution of CBM and TK to Arctic observing networks (Johnson et al. 2015).

ICC Canada has been in regular correspondence with other organizations and individuals interested in CBM, and several presentations were given on the topic, for example during the Arctic Change conference in December 2014 (see below). Several presentations were given by Noor Johnson as part of the CBM work, those are listed under 6) Communications. ICC (Carolina Behe, ICC Alaska) further presented an update on the CBM atlas at CAFF's Arctic Biodiversity Congress in Trondheim, Norway, in December 2-4, 2014. A summary of this meeting was compiled by IISD and can be accessed on the internet at http://www.iisd.ca/download/pdf/sd/crsvol88num5e.pdf

For further information on ICC Canada's communication efforts also see section 6) Communications and the NCP Performance Indicator Table at the end of the report.

Proposed activities:

d) AMAP Health Expert Group (this activity was mainly funded through a contribution from Health Canada):

- Participation at relevant meetings (if possible) and consultations with the group.
- Leading work on the risk communication chapter of the AMAP Human Health Assessment, and contributions/reviews of other chapters.

Work undertaken:

ICC Canada is active in the SDWG and AMAP Health Expert Groups. In the fiscal year of 2014, ICC Canada received funding from Health Canada to lead the chapter on risk communication for the upcoming AMAP Human Health Assessment, has worked extensively on the chapter, reviewed the other chapters, provided comments, and organized the national reviews for the risk communication chapter.

ICC Canada attended the HHAG Expert Group meeting May 14 – 15, 2014 in Iceland, the chapter leads meeting August 20 – 21, 2014 in Anchorage, Alaska, and hosted HHAG meetings (chapter leads meeting und HHAG teleconference) at the ICC Canada offices December 3 – 4, 2014.

ICC Canada also attended and co-hosted with ITK a presentation by the Arctic Council's Arctic Monitoring and Assessment Program (AMAP) Human Health Assessment Group (HHAG) Chair on April 25, and circulated the presentation to the Inuit Food Security Working Group (IFSWG) representatives.

Proposed activities:

e) POPs Expert Group:

- Attendance of meetings, if possible. The next face-to-face meeting planned is May 11 – 15, 2014 in Basel, Switzerland.
- Contributions to POPs assessment chapters, review of drafts.

Work undertaken:

ICC Canada was not able to participate in the POPs Expert Group meeting in Basel due to scheduling conflicts with other meetings. However, Eva Kruemmel attended the POPs Expert Group meeting in Ottawa during the Arctic Change Conference (December 10th, 2014), reviewed report outlines and related documents and provided comments.

3. UN related

Proposed activities:

a) Minamata Convention:

- Attendance of the meetings, if applicable and funding permits (currently no participation at international meetings is planned for).
- Consultations with the government, UNEP, scientists and partner organizations, attending of teleconferences, webinars and/or local face-to-face meetings.
- Reviewing of documents, researching papers and general mercury related research.
- Development of position papers and assistance in policy development.
- Preparing of reports and press releases, as applicable.

Work undertaken:

ICC Canada was not able to attend INC-6, which took place 3 – 7 November, 2014 in Bangkok, Thailand. However, Eva Kruemmel participated in teleconferences with non-governmental organizations representatives and Environment Canada in October, and submitted comments on ICC's position on both, INC-6, as well as a discussion paper ("Proposed Elements for a Code of Practice for the Environmentally Sound Management of End-of-life Mercury-containing Lamps and Targeted Guidance for the North") to Environment Canada.

Proposed activities:

b) POPRC:

- Attendance of POPRC-10 in Rome, Italy, October 26 – 31, 2014.
- Contribution to POPRC intersessional working groups as required and possible.
- Reviewing of documents and scientific papers.
- Consultations with government, partner organizations, scientists.
- Contributions to a critical review paper on deca-BDE.
- Writing of reports, position papers etc.

Work undertaken:

Eva Kruemmel attended POPRC-10 in Rome, Italy, October 26 – 31, 2014, reviewed and commented on several POPRC documents (for example on draft Risk Profiles for decaBDE and SCCPs, an the Risk Management Evaluation for PCP) as part of the intersessional POPRC work. Eva Kruemmel updated the NCP secretariat, as well as AMAP/NCP scientists about POPRC activities. To support POPRC work, was in contact and had meetings with scientists and partner organizations to ask for data and available literature. Reports and briefing notes about the POPRC meeting were sent to ICC leadership, the NCP secretariat, NCP/AMAP scientists, and ITK.

Proposed activities:

c) LRTAP:

- Providing stakeholder comments to government when possible
- Consultations with government, partner organizations, researchers

– Reviewing documents as applicable.

Work undertaken:

There have been no opportunities for input with regards to LRTAP, and the Canadian government seems to generally focus its efforts on the Stockholm Convention now.

4. General contaminants work

- Meetings, teleconferences and consultations with researchers and partner organizations about contaminant research
- Reviewing scientific papers, reports, assessments, data and other documents to develop briefing notes, brochures and other information material
- Continued analysis of results of mercury study, preparing of publications.

Work undertaken:

ICC Canada and its partners from the University of Ottawa, Uppsala University and Trent University continued work on the data analysis for the study on mercury pathways in the Canadian Arctic (M-20: Spatial and temporal variations of Hg isotope ratios in ice cores across the Canadian Arctic, NCP funded the continuation of this work for 2012/2013 under the Environmental Trends Envelope.). Two papers have so far been published as part of this work (Zdanowicz et al. 2013 and 2014). Currently, the group is working on a third publication on the mercury isotope results of the study, which should be submitted in summer 2015. A meta-data profile was created and submitted to the Polar Data Catalogue in March 2015.

Eva Kruemmel further undertook literature searches, contacted scientists for information as needed, and reviewed publications for input into work on contaminant-related meetings, briefing notes, and other relevant items.

5. Communication/General Assembly

- Communication of contaminant-related work at the General Assembly, July 2014 in Inuvik.
- Continue communication efforts with ITK, Inuit regions/land claim organizations and other partners as appropriate
- Development of communication materials such as press releases, brochures, fact sheets, or others

Work undertaken:

ICC had its quadrennial General Assembly (GA) in Inuvik, July 21st to 24th, 2014. At the General Assembly circumpolar Inuit leadership determines ICC's direction for the next four years, which is outlined in the Kitigaaryuit Declaration. The GA was attended by several hundred people, which included Inuit representatives from the circumpolar Arctic as well as many international guests from governments, academia, industry and civil society. The NCP and/or the topic of contaminants was featured during the plenary session "Responding to Environmental Challenges" (where Russel Shearer presented), as well as during a health side event (where the former POPRC Chair, Reiner Arndt, presented, and the health portion of the CBM atlas was demonstrated).

The following communication material is available from the General Assembly:

- ICC General Assembly Website: www.ICCGA.com
- ICC YouTube Video: https://www.youtube.com/watch?v=syO0Pn3kwhQ&feature=youtu.be
- ICC General Assembly Magazine:
- http://www.inuitcircumpolar.com/uploads/3/0/5/4/30542564/icc_ga_book_ecopy_1_3.pdf

ICC Canada's communication efforts are ongoing, and ICC Canada continues to work on the improvement of its website and other presence on the internet (such as the ICC Canada Facebook-site, and Twitter account). Much of this work is done by an additional student ICC Canada was able to hire for part-time work, who also speaks Russian (Dasha Shakov).

Information is prepared and disseminated regularly through the internet, meetings (e.g. ICC Canada Board meetings, ICC Executive Council meetings, ITK national committee meetings etc.), emails and teleconferences, in form of briefing notes, meeting reports and press releases, etc., as required and possible. ICC Canada is further planning to launch a newsletter this year that will likely be prepared on a bi-annual basis.

Some specific examples where ICC Canada communicated its work within meetings with scientists, Arctic Council membership, regional Inuit organizations and/or ITK include (please note that this is not an exhaustive list):

- the Arctic Change Conference that took place December 8 – 12, 2014 in Ottawa, where ICC leadership and/or ICC staff took part in panel discussions, and presented talks in several conference sessions. The panels included: "The State of Food (In) Security in the Arctic" (Leanna Ellsworth participated), "Addressing Food Security in the Arctic" (Leanna Ellsworth participated) and the concluding plenary panel "Future Direction in International Arctic Research" (Duane Smith participated). Most of these activities were supported with funding from ArcticNet. The presentations were:

  – D Smith. Surviving and Thriving in a Changed Arctic – Inuit Visions for the Future of their Communities. Arctic Change Conference, December 11th, 2014, Ottawa, Canada.

  – L Ellsworth, L. Petrunka, N Johnson, P Pulsifer, EM Kruemmel, C Behe. Mapping Inuit Mental Health and Wellness on the Atlas of Community-Based Monitoring (CBM) and Traditional Knowledge in a changing Arctic. Arctic Change Conference, December 11th, 2014, Ottawa, Canada.

  – EM Kruemmel, N Johnson, P. Pulsifer, S. Nickels, C. Behe, L Ellsworth, L. Petrunka. The Atlas of Community-Based Monitoring in a Changing Arctic. Arctic Change Conference, December 11th, 2014, Ottawa, Canada.

- Eva Kruemmel was invited to speak on ICC Canada's work on several occasions in 2014, such as in webinars organized by APECs (Association of Polar Early Career Scientists, April 2014) and the Belmont Forum (US National Science Foundation, June 2014), and gave a guest lecture at the University of Ottawa in December 2014:

  – EM Kruemmel. Contaminant Research and International Policy Development. Invited presentation during APECS webinar "Bridging careers: from science to policy". April 1st, 2014.

  – EM Kruemmel. Invited panel presentation during Belmont Forum webinar "Arctic observing and science for sustainability". June 3rd, 2014.

  – EM Kruemmel. Using Western Scientific and Inuit Traditional Knowledge in Policy Development. Invited guest lecture in uOttawa graduate course "Evidence-informed decision making", December 1st, 2014, Ottawa, Canada.

- ICC Canada reports to the National Inuit Committee on Health (NICoH):

  – L Ellsworth and EM Kruemmel. Update to NICoH about ICC activities. December 8th, 2014, Ottawa, Canada.

  – L Ellsworth. Update to NICoH about ICC activities. September 8-9, 2014 in Iqaluit, NU.

  – EM Kruemmel and Laura Petrunka. Update to NICoH about ICC activities (included a PowerPoint presentation on ICC's Arctic Council work). June 3rd, 2014, Ottawa, Canada.

- Presentations given by Noor Johnson as part of the CBM atlas work:
  - Presentation to the US Group on Earth Observations on SAON and the Atlas of Community-Based Monitoring in a Changing Arctic. At USGEO Strategic Plan Workshop, session on the Arctic. April 20, 2015.
  - "Atlas of Community Based Monitoring in a Changing Arctic." Presentation to the Inter-Agency Arctic Policy Committee's Communities Working Group. September 15, 2014.
  - Johnson, N. "Arctic data management infrastructures and knowledge networks: Two roles for social science." Paper presented at the International Congress of Arctic Social Sciences, University of Northern British Columbia, 22 – 26 May, 2014.
  - Johnson, N., Kruemmel, E.-M., Pulsifer, Nickels, S., Behe, C., Ellsworth, L., Petrunka, L. "Community-based monitoring in a changing Arctic: A web atlas and review." Poster presented at the International Congress of Arctic Social Sciences, University of Northern British Columbia, 22 – 26 May, 2014

Results

Not applicable

Discussion and Conclusions

Not applicable

NCP Performance Indicators

Performance Indicators April 1, 2014 – March 31, 2015					
Engagement & Communication Indicators	**Description**	**Date mm/dd to mm/dd**	**Location Town, Territory, Province**	**Number of people of materials**	**Details What was highlighted? How were they involved?**
Northerners engaged in your project	Workshops				
	School visits				
	Meetings: Arctic Observing Summit	04/08 to 04/10	Helsinki, Finland	1	Panel discussion on stakeholder involvement, Nellie Pokiak spoke about her experience with the beluga monitoring in the ISR at the Arctic Observing Summit. Audience was mixed and included circumpolar Arctic Indigenous people, scientists, etc.
	Arctic Change Conference	12/08 to 12/12		1	Panel discussion and presentation given by Duane Smith.

Northerners engaged in your project	Consultations: ICC Board meetings; NICoH meetings; IQ National Committee meetings, Inuit Health Survey steering committee, Inuit Food Security Working Group etc.		variable	Board meetings: ~ 9 Board members + ~13 staff NICoH and IQNC meetings: ~10 regional members Inuit Food Security Working Group: 5 Number of materials: approximate total: 10*	Briefing notes, press releases presentations and/or discussions on NCP-related activities such as information on Minamata Convention, POPRC, SAON activities, AMAP etc. as background information for and input from regional and partner organization representatives.
	Part of your project team			1	Duane Smith is leading ICC Canada's work Other members are Inuit but currently don't live in the North
	Hired				
	Other				
Students involved in your NCP work	Northern				
	Southern: Laura Petrunka	04/28 to 08/29 and 01/06 to 03/31	Ottawa, ON	1	Helped with project contacting and input for the CBM web atlas
	Dasha Shakov	Ongoing part-time		1	Works on communication, such as the ICC Canada website, Twitter and Facebook accounts
Recipients of project materials	Fact Sheets				
	Newsletters				
	Posters				
	Other			briefing notes and/ or updates: to regional partners, ICC board members, NCP secretariat, NCP Managers,ITK national committees (NICoH and IQNC)* number of updates: 10	We sent numerous briefing notes, general information material and meeting reports out to ICC Canada Board members, government and/or regional stakeholders. It is VERY difficult to keep track of the number of materials and people that this material goes to, particularly because the information can be distributed widely. It is expected that Board members and others forward information to others within the region as they see fit.

Publication & Data Indicators	Description	Date	Name Journal, Conference, Database	Number Volume Page, Data Record #	Details Links to material
Number of citable publications	Journals	2014	STOTEN		http://dx.doi.org/10.1016/j.scitotenv.2014.04.092
	Conference presentations	Dec 2014	Arctic Change	3 panel discussions 3 presentations	
	Book chapters				
	Other	2015	AMAP Health assessment, risk communication chapter	Lead author	
Access to Data Results	Meta Data	March 2015	Meta-data profile for Hg isotope study, Polar Data Catalogue		

*It is likely that the performance indicators are underestimated because it is difficult to keep track of the number of materials sent out and to how many people they are distributed.

Expected Project Completion Date

Work is ongoing

Acknowledgments

NCP was acknowledged in all presentations prepared as part of the funded work.

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