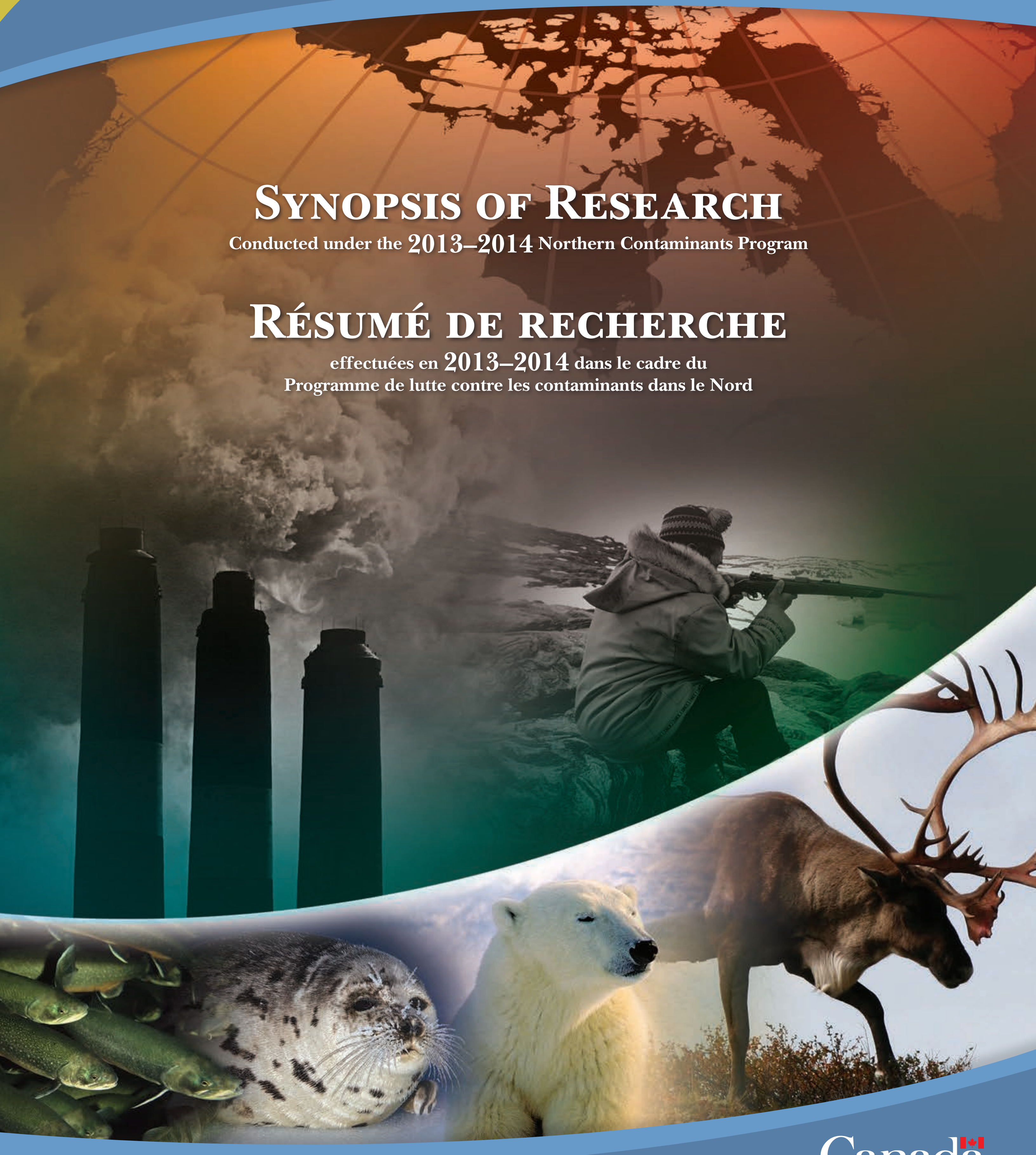
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada

Synopsis of Research

Conducted under the 2013–2014 Northern Contaminants Program

Résumé de recherche

effectuées en 2013–2014 dans le cadre du Programme de lutte contre les contaminants dans le Nord



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Synopsis of Research Conducted under the 2013-2014 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 2013-2014 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 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 RCCs use evaluation criteria and the blueprints to review and rate proposals. Written consent from the appropriate northern community authority or national-level Aboriginal organization is required for all projects involving field work in the North and/or analyses of samples as a condition of approval for funding.

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

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 2013-2014 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 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 researchers. 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 sommaires 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 Assesment 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 $4.3 million annual research budget comes from AANDC and Health Canada. Details about the management structures and review processes used to effectively implement the NCP, 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 by request from the NCP Secretariat).

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, 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

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 4,3 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.

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 radio nucléides — dont plusieurs ne provenaient par 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 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, features which continue to this day: 1) the development of blueprints that represent the long-term vision and strategic direction for the NCP; and 2) the implementation of an open and transparent proposal review process. These features of NCP's management structure 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 are 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 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.

permettant de prendre des décisions éclairées au sujet de leur alimentation.

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.

The NCP effort to achieve international controls of contaminants remained strong throughout this phase. The legally binding POPs protocol, under the United Nations Economic Commission for Europe (UN ECE) Convention on Long-range Transboundary Air Pollution, has been successfully negotiated and was 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 was completed with the signing of the POPs Convention in Stockholm, Sweden, May 23, 2001. The Convention has been signed by more than 160 countries; Canada has signed and ratified the Convention. Cooperative actions under the Arctic Council, including the circumpolar Arctic Monitoring and Assessment Programme (AMAP), are continuing. NCP continues to generate the data that allows Canada to play a leading role in these initiatives.

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 3rd series of assessments got under way in 2010, leading to the release of the CACAR III Mercury in Canada's North in December 2012 and CACAR III: Persistent Organic Pollutants in Canada's North, in December 2013.

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).

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 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 et du RECAC III sur les polluants organiques persistants dans le Nord canadien en décembre 2013.

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

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

In January 2013 the UNEP Intergovernmental Negotiating Committee reached an agreement to reduce global mercury contamination. This agreement known as the Minamata Convention, represents a major achievement for the NCP and AMAP, which contributed much of the scientific justification for global action. The Conference of Plenipotentiaries on the "Minamata Convention on Mercury" was held in Minamata and Kumamoto, Japan, from 9 to 11 October 2013 and was preceded by an open-ended intergovernmental preparatory meeting from 7 to 8 October 2013. As of April 2014, 97 countries have signed the Convention, including Canada, and one country, the United States, has ratified.

Highlights of 2013-2014

This report provides a summary of the progress to date of research and activities funded by the Northern Contaminants Program in 2013-2014. It is a compilation of reports submitted by project teams, emphasizing the results of research and related activities that took place during the 2013-2014 fiscal year. The report is divided into chapters that reflect the broad scope of the NCP: Human Health; Environmental Monitoring and Research; Community Based Monitoring and Knowledge Integration; and Communication, Capacity, and Outreach.

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 janvier 2013, le Comité de négociation intergouvernemental du PNUE a conclu une entente visant à réduire la contamination par le mercure à l'échelle mondiale. Cette entente, connue sous le nom de Convention de Minamata, est une réalisation importante pour le PLCN et le PNUE, qui ont fourni une grande partie de la preuve scientifique soumise en faveur de cette mesure internationale.
La Conférence de plénipotentiaires sur la Convention de Minamata sur le mercure a eu lieu à Minamata et à Kumamoto, au Japon, du 9 au 11 octobre 2013; elle avait été précédée d'une réunion intergouvernementale préparatoire non limitée les 7 et 8 octobre 2013. En avril 2014, 97 pays ont signé la Convention, y compris le Canada, et un pays, les États-Unis, l'a ratifiée.

Faits saillants en 2013-2014

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 2013-2014. 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

Some of the program's highlights for 2013-2014 included:

- the signing of the Minamata Convention on Mercury in October 2013, for which NCP data, information and expertise played a critical role for Canada and the Arctic Council to take a leadership role towards taking actions to control global sources of atmospheric mercury emissions;
- the release of the Canadian Arctic Contaminants Assessment Report III (CACAR III) report on Persistent Organic Pollutants in Canada's North, the first assessment report to focus exclusively on persistent organic pollutants in the Canadian Arctic;
- the 20th anniversary NCP Results Workshop, held in Ottawa in September 2013, which attracted some 200 participants to mark this special anniversary for Canada's longest standing northern monitoring and research program; and
- 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 Canada's chairmanship of the Arctic Council (2013-2015).

des activités connexes qui ont eu lieu au cours de l'exercice 2013-2014. Le rapport est divisé en chapitres qui reflètent la vaste portée du PLCN : la santé humaine; la surveillance et la recherche environnementales; la surveillance et la recherche au sein des collectivités; et les communications, la capacité et la sensibilisation.

Quelques faits saillants du Programme en 2013-2014 :

- La signature de la Convention de Minamata sur le mercure en octobre 2013, pour laquelle les données, l'information et l'expertise du PLCN ont été des éléments cruciaux qui ont permis au Canada et au Conseil de l'Arctique d'assumer un rôle de leader dans la prise de mesures visant à contrôler les sources mondiales d'émissions de mercure dans l'atmosphère;
- La publication du Rapport de l'évaluation des contaminants dans l'Arctique canadien III (RECAC III) sur les polluants organiques persistants dans le Nord canadien, le premier rapport d'évaluation portant exclusivement sur les polluants organiques persistants dans l'Arctique canadien;
- L'atelier sur les résultats du PLCN , tenu en septembre 2013 à Ottawa, a attiré quelque 200 participants et marqué le 20e anniversaire du programme le plus ancien du Canada en matière de recherche et de surveillance dans le Nord;
- Les contributions importantes des scientifiques et du Secrétariat du PLCN aux travaux du groupe de travail du Programme de surveillance et d'évaluation de l'Arctique (PSEA), dans les rôles de coauteurs et de coprésidents des groupes de spécialistes travaillant à la mise à jour des rapports d'évaluation de la région circumpolaire et dans les rôles de chef de délégation et de vice-président au PSEA, au moment où le Canada assure la présidence du Conseil de l'Arctique (2013-2015).

Dr. Eric Dewailly

Canada's Northern Contaminants Program, Inuit, circumpolar health community and Arctic Monitoring and Assessment Programme (AMAP) lost a much respected and dear friend, colleague and mentor on June 17, 2014. Dr. Éric Dewailly lost his life this summer in a tragic accident while on a family vacation on the tropical island of Réunion in the Indian Ocean.

Dr. Éric Dewailly was a pioneer in Inuit health issues and dedicated his life's work to improving the health of Inuit across all regions of Canada and the circumpolar Arctic. His ground-breaking contaminants research related to human health in the late 1980s was a major scientific contribution to the creation of the Northern Contaminants Program in 1991. Éric's continued research on Inuit human health and contaminants was also a major factor in the establishment of the global Stockholm Convention on Persistent Organic

Le Programme de lutte contre les contaminants dans le Nord (PLCN), les Inuits, la communauté de la santé circumpolaire et le Programme de surveillance et d'évaluation de l'Arctique (PSEA) ont perdu un bon ami et un collègue et mentor très respecté. En effet, le 17 juin 2014, M. Éric Dewailly est décédé dans un tragique accident survenu alors qu'il était en vacances avec sa famille à La Réunion, une île tropicale située dans l'océan Indien.

M. Dewailly est un pionnier des questions liées à la santé des Inuits. Il a d'ailleurs consacré sa carrière à améliorer la santé de cette population dans toutes les régions du Canada et de l'Arctique circumpolaire. Les recherches novatrices qu'il a entreprises à la fin des années 1980 sur les contaminants et leurs effets sur la santé humaine ont grandement contribué, sur le plan scientifique, à la création du PLCN, en 1991. Ses recherches continues

Pollutants (POPs) where he continued to contribute right up to his passing.

Éric's loss will be greatly missed by so many people at the community, regional, national and international levels. On a personal note, Éric was a wonderful, caring person with a great sense of humour. His presentations at the annual NCP Results Workshop, and other conferences and meetings such as ArcticNet's Annual Science meeting, were always entertaining, well attended and a key highlight. In addition to his family, his work and mentorship of some incredibly gifted people will be his legacy and we must continue together to improve the lives of Inuit and northerners, as Éric had envisioned.

Russel Shearer
Chair, NCP Management Committee
and Vice-Chair of AMAP

ont également joué un rôle important dans l'établissement de la Convention de Stockholm sur les polluants organiques persistants (POP), à laquelle il a contribué jusqu'à son décès.

Le départ de M. Dewailly laissera un grand vide dans la vie de bien des gens à l'échelle communautaire, régionale, nationale et internationale. Sur une note personnelle, j'ajouterais que M. Dewailly était une personne extraordinaire, attentionnée et dotée d'un grand sens de l'humour. Les présentations qu'il donnait lors des ateliers annuels sur les résultats du PLCN et à l'occasion d'autres conférences et réunions, telles que la réunion scientifique annuelle d'ArcticNet, étaient toujours divertissantes et attiraient beaucoup de monde. Outre sa famille, il laisse en héritage son œuvre et les personnes extrêmement talentueuses à qui il a transmis son savoir. Nous devons continuer ensemble d'améliorer la qualité de vie des Inuits et des résidants du Nord, comme il l'avait envisagé.

Russel Shearer
Directeur, Comité de gestion du PLCN
et vice-président du PSEA

Human Health

Santé humaine

Assessment of contaminant and dietary nutrient interactions in the Inuit Health Survey: Nunavut, Nunatsiavut and Inuvialuit - Part 1: Risk Perception and Message Evaluation Study

Évaluation des interactions entre les contaminants et les apports alimentaires dans l'Enquête sur la santé des Inuits : Nunavut, Nunatsiavut et Inuvialuit – Partie 1 : Étude d'évaluation de la perception du risque et des messages

- **Project Leader:**
  Dr. Chris Furgal and Dr. Amanda Boyd, Indigenous Environmental Studies Program, Trent University
  Tel: 705-748-1011 ext 7953, Fax: 705-748-1416, Email: chrisfurgal@trentu.ca

  Dr. Laurie H.M. Chan, Center for Advanced Research in Environmental Genomics, University of Ottawa
  Tel: (613) 562-5800 ext 6349, Fax: (613) 562-5385, Email: laurie.chan@uottawa.ca

- **Project Team Members and their Affiliations:**
  Dr. Geraldine Osborne and Dr. Maureen Baikie, Office of the Chief Medical Officer of Health Government of Nunavut, (Iqaluit); Sharon Edmunds-Potvin, Nunavut Tunngavik Inc., (Iqaluit)

Abstract

The Inuit Health Survey (IHS) was conducted in 2007-2009 and gathered information on many aspects of the health and well-being of Inuit in Nunavut. This included information about key health issues such as smoking, consumption of country foods, and other health behaviours. The research team released the results and key health messages related to country foods and contaminants to Nunavummiut in June 2012. The purpose of Part 1 of the study: *Risk Perception and Message Evaluation Study* was to determine whether key health messages from the Inuit Health Survey contaminants assessment were delivered effectively and clearly. This study explored whether messages were received, could be recalled, and what their impact was over two

Résumé

Réalisée entre 2007 et 2009, l'Enquête sur la santé des Inuits a permis de recueillir de l'information sur un grand nombre d'aspects de la santé et du bien-être des Inuits du Nunavut. De l'information a notamment été recueillie sur d'importants dossiers de santé, dont l'usage de tabac, la consommation d'aliments traditionnels et les autres comportements liés à la santé. En juin 2012, l'équipe de recherche a publié ses résultats et des messages clés relatifs à la santé, à l'intention des Nunavummiut, en ce qui concerne les aliments traditionnels et les contaminants. La partie 1 de l'étude, l'*Étude d'évaluation de la perception du risque et des messages*, visait à déterminer si les messages clés issus de l'évaluation des contaminants de l'Enquête sur la

time points. Community surveys were conducted in Arviat, Cambridge Bay and Iqaluit with Inuit residents 18 and older using tablet computers. During November 2013 to March 2014, 1,343 residents of Arviat, Cambridge Bay and Iqaluit were surveyed about their food consumption and smoking habits, their awareness of key messages released from the Inuit Health Survey, and their views of contaminants in the environment and country foods.

santé des Inuits avaient été transmis clairement et efficacement. L'étude devait permettre de vérifier si les messages avaient été entendus et retenus, en plus d'évaluer leur impact à deux moments. Des enquêtes communautaires ont été menées à Arviat, à Cambridge Bay et à Iqaluit auprès de résidents inuits de 18 ans et plus, au moyen de tablettes électroniques. Entre novembre 2013 et mars 2014, 1 343 résidents d'Arviat, de Cambridge Bay et d'Iqaluit ont été interrogés sur leurs habitudes alimentaires et de consommation de tabac, leur connaissance des messages clés publiés à la suite de l'Enquête sur la santé des Inuits et leurs perceptions au sujet des contaminants présents dans l'environnement et les aliments traditionnels.

Key messages

- Fewer than half of the respondents reported hearing the messages from the Inuit Health Survey contaminants assessment
- At least half of all participants agreed with each of the health messages resulting from the contaminants assessment done under the Inuit Health Survey
- Only 50% of participants agreed with the statement that women of child bearing age and women planning to become pregnant should reduce their consumption of ringed seal liver because of concern over mercury
- One-third of participants stated that they had changed their consumption behaviours in some way since hearing about contaminants in the country foods in Nunavut. Most reporting having reduced their consumption of ringed seal meat or fat, or increased their consumption of Arctic char
- Without some form of evaluation it is very difficult to assess the success and impact of health messaging campaigns

Messages clés

- Moins de la moitié des répondants ont affirmé avoir entendu les messages associés à l'évaluation des contaminants de l'Enquête sur la santé des Inuits.
- Au moins la moitié des participants étaient d'accord avec les différents messages relatifs à la santé qui ont été diffusés à la suite de l'évaluation des contaminants dans le cadre de l'Enquête sur la santé des Inuits.
- Seulement 50 % des participants étaient d'accord avec l'affirmation selon laquelle les femmes en âge de procréer et les femmes qui prévoient devenir enceintes doivent réduire leur consommation de foie de phoque annelé en raison des risques associés au mercure.
- Le tiers des participants ont affirmé avoir modifié leurs habitudes de consommation d'une façon ou d'une autre après avoir entendu parler de la présence de contaminants dans les aliments traditionnels au Nunavut. La plupart d'entre eux ont répondu avoir réduit leur consommation de viande ou de gras de phoque annelé, ou avoir augmenté leur consommation d'omble chevalier.
- Sans une évaluation, il est très difficile d'apprécier l'efficacité et la portée des campagnes de messages relatifs à la santé.

Objectives

1. To better understand food consumption perceptions and preferences and smoking habits.
2. To assess if Inuit in Nunavut received key health messages from the Inuit Health Survey contaminants messaging effectively and clearly.
3. To explore Nunavummiut's perspectives of contaminants in the environment and in country foods.
4. To assess perspectives of key public health messages on these topics released as a result of the Inuit Health Survey findings.

To provide recommendations to communities, organizations and territorial government about how to develop more effective health risk communication strategies.

Introduction

Since the late 1970s, the scientific and public health communities focused on the Canadian North have been learning about how to and how not to communicate with and engage Inuit and other northern Aboriginal residents on the issue of contaminants in country / traditional foods. The majority of this learning has been through a process of trial and error with reports of significant negative impacts of some communication approaches on communities' and their trust in the safety of country foods in the past (Furgal et al., 2005). It is only within the last 12 years that some focus has been given to risk perception and communication evaluation on this topic of significant importance to residents living in Nunavut and other northern regions (Donaldson, et al., 2010). The understandings and perceptions of risk among people are much richer and more complex than originally thought, and they reflect legitimate concerns that are often omitted from formal risk assessment processes. Risk perception has been shown to be influenced by a variety of factors including age, gender, education, occupation, language, world view, and culture (Slovic and Peters, 1995; Myers and Furgal, 2006; Jardine and Furgal, 2007). Prior work in the Canadian North has reported issues with the message reception, recall and comprehension of messages focused on invisible 'chemical' contaminants (Myers and Furgal, 2006). Reception has in particular been identified as being lower than desired among one key target group for these messages, that being women of child bearing age. In general, the perception of country food safety has been high, with variation in the population influenced by education, employment, marital status and hunting frequency (Furgal and Rochette, 2007). In surveys conducted in Nunavik in 1992 and 2004, approximately one quarter of respondents reported having changed some aspect of their health behaviours as a result of hearing about contaminants in country foods. While some level of compliance to health messages can be a good thing, some behavioural change reported in those studies have been potentially negative with individuals reporting a reduction in the consumption of some healthy country foods as well, and a reduction in the duration of breast feeding among some new mothers. Despite the importance of this knowledge, we still have comparatively little understanding of the duration of impact that health messaging like this has on individuals despite the many messages of this nature given in the North to date.

Part 1 of the Synopsis report describes activities under this project focused on evaluating the reception, comprehension, and impact of contaminant related health messages released as part of the Inuit Health Survey results in Nunavut and measured this impact over time with the hope of answering some of these important questions regarding health messaging on contaminants, country food and Inuit health.

Activities in 2013-2014

Risk Perception and Message Evaluation of the Inuit Health Survey Contaminates Communication in Nunavut

During November 2013 to March 2014, 798 residents of Arviat (November 12-29), Cambridge Bay (January 20-31) and Iqaluit (February 3-13) were surveyed about their food consumption and smoking habits, their awareness of key messages released from the Inuit Health Survey, and their views of contaminants in the environment and country foods. The total participants for time point 1 (n=545, 2012-13) and time point 2 (n=798, 2013-14) totaled 1,343. Participants included Inuit that were 18 and older. Table 1 provides an overview of the participants in each community for both time points.

Table 1. Overview of Participants

	Arviat	Cambridge Bay	Iqaluit
First Time Point	120	150	275
Male	42 (35%)	52 (35%)	117 (43%)
Female	77 (65%)	98 (65%)	158 (57%)
Second Time Point	262	236	300
Male	95 (36%)	92 (39%)	130 (43%)
Female	166 (36%)	142 (61%)	170 (57%)
Completed Survey During Both Time Points	79 (30%)	83 (35%)	97 (32%)
TOTAL	**382**	**386**	**575**

Interviewers utilized an iPad survey application to conduct interviews to: 1) capture quantitative measures; and 2) record open-ended questions to better understand perspectives of contaminants and country foods. The majority of the surveys were collected at the Northern or North Mart locations. Additional locations included the Boarding Home in Iqaluit; Co-Op and Wellness Centre in Cambridge Bay; and the Co-Op in Arviat. Figure 1 illustrates the timeline of the data collection during the two-year project (February 2013 to March 2014).

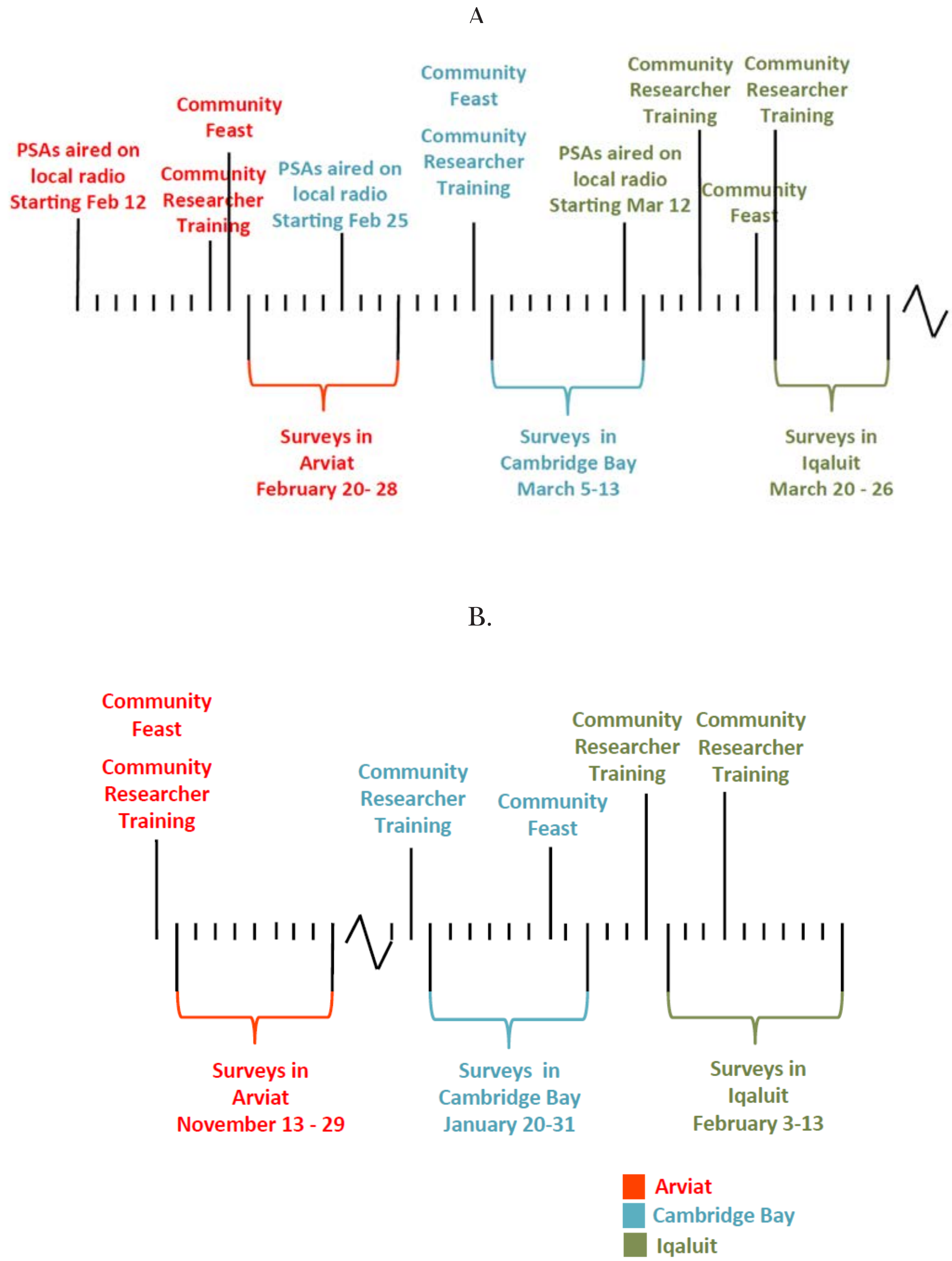
Capacity Building

During November 2013 to March 2014, 16 interviewers were hired in Arviat, Cambridge Bay and Iqaluit. Each interviewer attended a training session prior to data collection. The workshops were held on November 12, 2013 in Arviat and January 19, 2014 in Cambridge Bay. Three workshops were held in Iqaluit. The first workshop included a refresher course for researchers who previously took the course during the first data collection point; the second course included new research assistants; and the third course included nursing students from the Nunavut Arctic College who where interested in developing their research skills and training. The training session included information on: 1) the Inuit Health Survey; 2) the three primary messages from the IHS results including mercury in ringed seal liver, benefits of country food and cadmium in cigarettes; 3) the purpose of the communication evaluation study; 4) ethics and consent procedures; 5) research confidentiality; 6) iPad instruction; 7) survey methodology; and 8) the project procedures and instructions. Interviewers practiced surveying each other before interviewing others. Training took approximately 4 – 6 hours. An additional workshop was held for employees of the Arviat Wellness Center. The workshop focused on how to develop online surveys. The goal was to build capacity in survey development in order for the Wellness Center to develop their own surveys for the community.

Communications

Reports on the results for each community were created and presented to community leads in Arviat, Cambridge Bay and Iqaluit. A comparison report demonstrating the differences between communities was also presented to all community leads and project team members. Meetings with community leads (Janet Stafford, Cambridge Bay; Shirley Tagalik, Arviat) were held to discuss analysis and determine the best ways to engage with the community to deliver results. Two-page fact sheets that provided an overview of the project and brief results of the first data collection point were developed for the community. The fact sheets were translated into Inuktitut for Arviat and Iqaluit, and into Inuinnaqtun for Cambridge Bay.

Figure 1. Timeline of Communication Evaluation Project (A) February – March 2013 and (B) November 2013- March 2014



Additional Activities

In Cambridge Bay and Arviat, a feast was held prior to data collection to introduce the project and provide more information to those in attendance. Information presented at the feasts included the purpose of the surveys, when and where the surveys were taking place and where to receive more information if desired. During each feast a local Elder provided a blessing and community members were encouraged to ask questions or discuss the project with research team members in attendance at the event. The two feasts were well attended with approximately 150 in attendance in Cambridge Bay and 180 in attendance in Arviat.

In Cambridge Bay, results from the first data collection point (March 2013) were presented during a Cambridge Bay Wellness Center open house on January 28, 2014. A presentation discussing the purpose of the project and overview of results was shown and factsheets were available. Approximately 20 people were in attendance.

Results

A. Consumption of Country Foods

The participants in the three communities were asked about their consumption of country foods. Ninety-nine percept of participants in the three communities reported that they ate country foods (Arviat, n=256, 99%; Cambridge Bay, n=234, 99%; Iqaluit, n=300, 99%). As illustrated in Figure 1, the majority of participants preferred a mix of both country foods and store bought foods. Figure 2 demonstrates how frequently participants eat country foods.

Figure 3 shows how often participants eat each of the following country food items when they are available in their communities. Results from all three communities have been pooled reporting a total of 796 responses.

B. Cigarette Smoking Habits

In total, the large majority (96%) of participants in all three communities reported that they smoked cigarettes at *sometime* in their life (Arviat n=250, 96%; Cambridge Bay n=235, 94%; Iqaluit n=297, 98%). Eighty-five percent of participants reported that they *currently* smoke cigarettes (Arviat n=219, 88%; Cambridge Bay n=185, 83%; Iqaluit n=251, 85%). However, the majority (60%) of those who currently smoke cigarettes reported that they are considering giving up smoking (Arviat n=136, 62%; Cambridge Bay n=116, 63%; Iqaluit n=145, 58%).

Participants were asked to provide the reasons for why they quit. Pooled results from those respondents reporting having quit smoking (n=101) indicate the following reasons:

- I wanted to feel healthy (n=59; 39%)
- I didn't like the taste or smell (n=21; 21%)
- I quit when I was pregnant or when my partner got pregnant (n=8; 8%)
- It was too expensive (n=7; 7%)
- I quit for someone else (*e.g.*for children, for parents, for partner) (n=7; 7%)
- Other (n=20; 20%)

C. Public Health Message Recall

Community members were asked if they heard messages from the contaminants assessment components of the Inuit Health Survey. The following section provides results on survey participants' responses to questions regarding this communication process. Overall, the majority of participants reported having *not* heard that woman who are pregnant or may become pregnant should avoid eating ringed seal liver. Responses differed between communities with half of participants in Iqaluit reporting that they had heard the message, while only 21% of participants in Arviat reporting hearing the message (Figure 4). Differences between communities were also apparent when participants were asked about the Inuit Health Survey messaging regarding the consumption of ringed seal meat. In Arviat only half of participants reporting hearing the message as compared to Iqaluit where three-quarters reported hearing the message (Figure 5).

The large majority of participants in the three communities reported that they had heard the messages that eating country food has cultural and spiritual benefits (Figure 6) and that country foods are a very significant source of nutrients that are vital to promoting physical health (Figure 7).

Figure 1. Preference for Store Foods, Country Foods or a Mix of Both

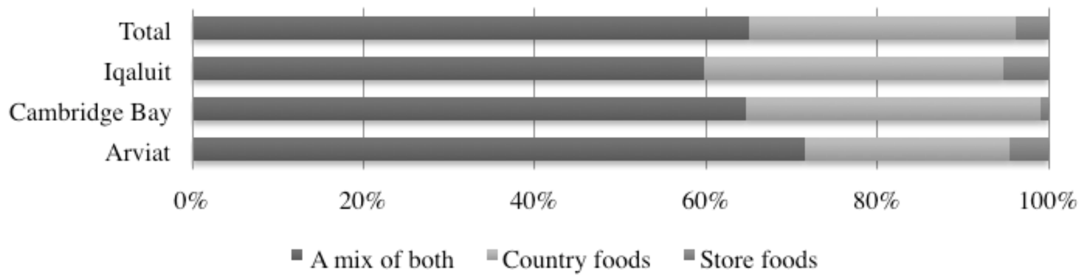


Figure 2. How often participants eat country foods (per week)

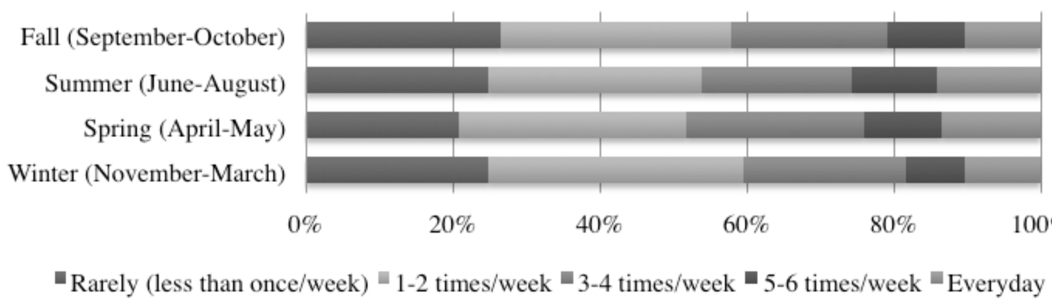


Figure 3. How often participants eat specific country food items

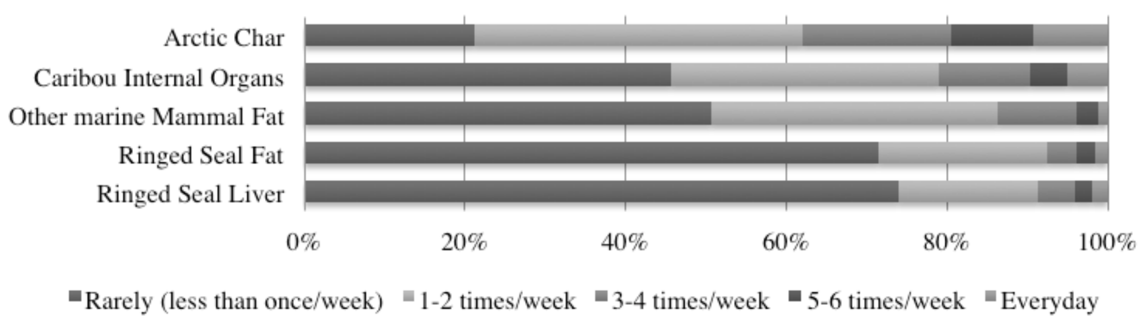


Figure 4. Question: Have you heard that woman who are pregnant or may become pregnant should avoid eating ringed seal liver?

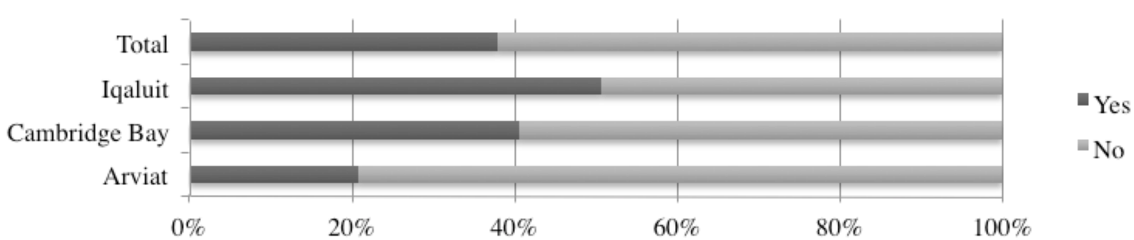


Figure 5. Question: Have you heard that ringed seal meat is still a healthy option for woman who are pregnant or who may become pregnant?

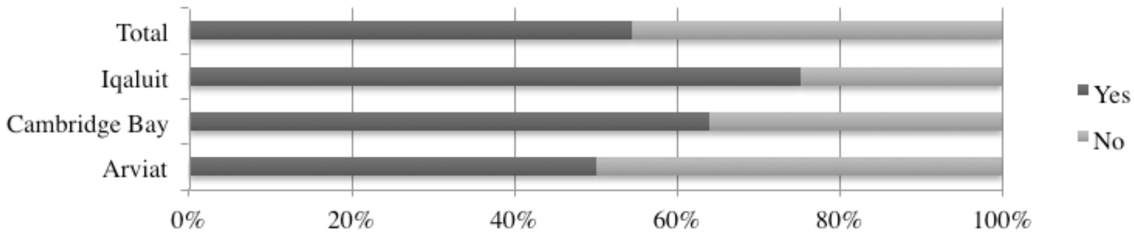


Figure 6. Question: Have you heard that eating country food has cultural and spiritual benefits?

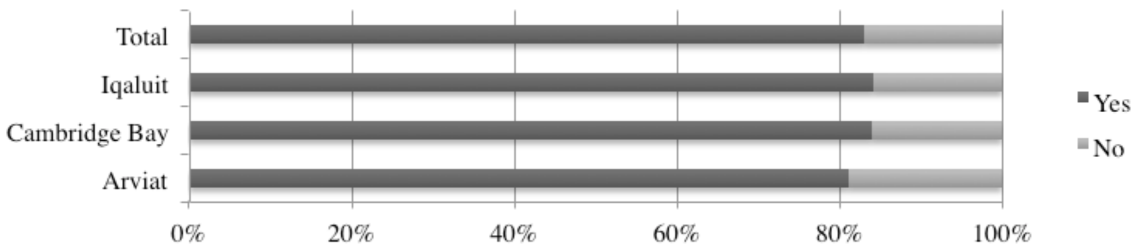


Figure 7. Question: Have you heard that eating country foods is a very significant source of nutrients that are vital to promoting physical health?

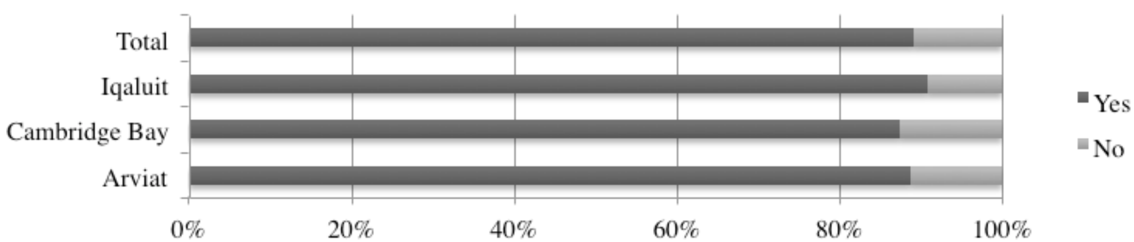
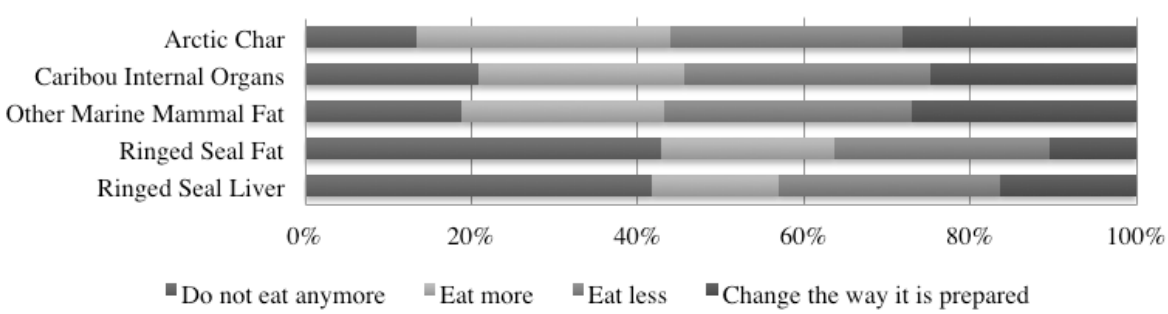


Figure 8. Question: What are some of the changes you have made regarding country food?



The sources of information where individuals heard these messages differed between communities. Some key findings include: 1) Friends or Family were cited as a 'top 3' information sources in each community for all four questions discussed in this report; 3) Radio was a common source of information in Arviat and Iqaluit; and 4) In Cambridge Bay television was often cited as a common source of information.

D. Concern about Contaminants and Environment

Seventy-two percent of respondents *did not* have any concerns about the quality or safety of the country foods they ate (Arviat n=185, 71%; Cambridge Bay n=165, 70%; Iqaluit n=182, 60%). Furthermore, the majority (63%) reporting having not heard about any contaminants in the environment previously (Arviat n=184, 71%; Cambridge Bay n=149, 63%; Iqaluit n=144, 51%). Sixty-three percent had not heard of any contaminants in country foods (Arviat n=31, 51%; Cambridge Bay n=57, 63%; Iqaluit n=113, 72%). One-third of the participants (33%) stated that they modified their eating habits after hearing about contaminants in country foods. The percentage of participants who made changes in response to hearing this information varied amongst the three communities. In Arviat 51% (n=31) stated they did not make changes, whereas in Iqaluit 72% (n=113) stated they did not make changes. Approximately 63% (n=57) participants in Cambridge Bay stated they did not make changes after they heard about contaminants in country foods. Figure 8 illustrates how respondents modified their eating habits.

E. Agreement with Health Messages

Community members were asked if they agreed or disagree with health messages from the contaminants assessment of the Inuit Health Survey. Most people (60%, n=476) *agreed* that **country foods provide essential nutrients that can lower the risk of chronic diseases**. Reasons why people agreed were that country foods provide nutrients, it is good for the heart, is low in sugar content and that it keeps Inuit from getting sick/heals sickness. Just less than one quarter (24%; n=193) disagreed with the statement and 15% (n=122) neither agreed nor disagreed. People disagreed because they stated that it depends on how it's prepared or that they generally thought it would not help prevent heart disease or lower risk of chronic disease.

Approximately half of respondents (50%, n=392) *agreed* that **most Inuit adults in Nunavut do not need to be concerned about contaminant-related effects from country food consumption**. Reasons for agreeing with the statements included: not all foods are contaminated, Inuit have been eating country foods for generations, Inuit are experienced and know what animals are contaminated and others agreed because they believed that there are no contaminants in their country foods or area. Thirty-three (n=255) percent disagreed and 17% (n=133) neither agreed nor disagreed. Some people disagreed because they reported that you need to be careful about the way it is prepared or that there is not enough information available today on what is affecting country foods. Others stated that they had an overall concern about contaminants in country foods.

Most people (59%, n=452) *agreed* that generally, **the benefits of eating country foods outweigh the risks from contaminant exposure**. Reasons for agreeing were that eating country foods is healthier than eating other food options available, if it is prepared right there will be less risk and that even though eating food that has contaminants in it, it is still better to eat country foods. Twenty-four percent (n=179) disagreed and 17% (n=130) neither agreed nor disagreed with the statement.

Approximately half of participants (52%, n=400) *agreed* **Inuit women of child-bearing age who may be pregnant, are planning to get pregnant, or are pregnant should avoid eating ringed seal liver due to its high mercury content**. People agreed for reasons such as the belief that there is too much mercury in ringed seal liver, that eating the liver may hurt the baby or fetus, or that it may hurt the pregnant woman. There were an additional 26% (n=200) who disagreed and 22% (n=171) who neither agreed nor disagreed with this health message. Some disagreed because they had not heard of mercury in ringed seal liver or thought that liver is good for the fetus, or that woman should eat more country foods when pregnant. The majority of participants (63%, n=479) *agreed* **Inuit women of child-bearing age who may be pregnant, are planning to get pregnant, or are pregnant should eat ringed seal meat because it is a healthy alternative to ringed liver**. Most people agreed because they thought ringed seal meat was healthy for the mother or fetus or that it was high in nutrients and iron. Twenty percent (n=155) disagreed with the statement and 17% (n=131) neither agreed nor disagreed.

Discussion and Conclusions

The analysis for this project is ongoing in collaboration with the participating communities and partners and projected to be completed in fall 2014. However, the descriptive results presented here already highlight some important issues with regards to communicating about contaminants and health in Inuit and other northern communities. In general, all partners and communities received the survey well and participation rates were very high. This is a testament to the level of regional support and direction the research team received and the dedication of the local researchers that were trained and carried out the survey in communities. The use of the iPad survey technology allowed for a high level of engagement, facilitated easy training and was an attractive feature of the study to local researchers and participants as well. Through the use of the iPads for the conduct of the survey and online survey software, the basic descriptive results were presented back to key partners in communities immediately following the completion of data collection.

The survey was responded to by a much higher number of women than men in each community. However, the majority of messages from the Inuit Health Survey contaminants assessment were targeted at women of child bearing age, pregnant women or young mothers because of the sensitivity of the developing fetus to contaminant exposure. Most respondents to the survey in all three communities reporting having not heard the IHS-contaminant messages and this differed between communities. In regards to all messages focused on in this survey, a greater proportion of Iqaluit participants recalled having heard the messages than in either Cambridge Bay or Arviat. In particular, there was a low level of recall of the most specific reduction-oriented country food message provided with the results of the IHS, that being for women of child bearing age and pregnant women to reduce their consumption of ringed seal liver because of the concentration of mercury contained in that item. Reasons for the differences between communities in message reception and recall are speculative at this point in time and being further investigated prior to final project results communication. However, it can be argued that the results presented here emphasize the need to conduct evaluation activities of some form following important message release, to ensure messages were released as planned and received as expected by the target audience. Significant effort went into the collection, analysis and preparation of the data and public health messages under the Inuit Health Survey. It is important to ensure that those efforts achieved the desired goals of at the least, supporting informed decision making among residents.

At least 50% or more of participants in all communities agreed with the messages released under the Inuit Health Survey contaminants assessment. Only half agreed with the message that women of child bearing age and pregnant women should reduce their consumption of ringed seal liver because of the concern over mercury in that food item. When asked if they had changed anything about their health behaviours since hearing about contaminants in country foods approximately one third of participants reported having had changed something. This was most common in Arviat and least common in Iqaluit. The most common change made among all participants was a reduction in the consumption of ringed seal liver or fat. Therefore, it appears that despite a comparatively lower agreement with the message, as compared to the agreement with other health messages released, about one third of participants reported complying with the recommended behavioural change with regards to ringed seal liver. In some cases, some individuals reporting having increased their consumption of ringed seal liver, hence the need to conduct evaluative initiatives of this nature.

The data gathered will permit us to investigate factors that may be influencing attitudes and risk perception as well as compliance behaviour in these three communities. It would appear valuable for health communicators to understand these factors to better tailor future messaging for specific audiences. Further, analysis will be possible on the stability of risk perceptions over time in these communities and in some cases, within individual participants as the survey was repeated 12 months apart. This analysis will provide insight into the potential duration and stability of impact (positive and negative) of health messaging of this nature on health behaviours and risk perceptions over time. This has been a topic around which there has been great speculation but little attention given in the past.

Expected Project Completion Date

The data has been collected for the IHS contaminants communication assessment. Analysis is now underway and will include iterative presentations and analysis with the Arviat, Cambridge Bay and Iqaluit community leads. Analysis of the data will be completed in summer 2014 to examine changes in perceptions over time and comparisons between communities. The further analysis will provide insight into the communication process and determine recommendations for improving communication strategies. Analysis and publications will continue into fall and winter 2014-15.

Acknowledgments

We thank all of the participants in Nunavut whose participation in the 2012-2014 contaminant communication assessment a success. We also thank the community leads including Shirley Tagalik; Arviat, Janet Stafford; Cambridge Bay, Sharon Edmunds-Potvin; Iqaluit and the community researchers in the three communities in Nunavut. Special thanks to NTI for regional logistics and support on the team and NRI for assistance with local project administration in Iqaluit. Funding for this project was provided by the Northern Contaminants Program.

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Assessment of contaminant and dietary nutrient interactions in the Inuit Health Survey: Nunavut, Nunatsiavut and Inuvialuit Part 2: Development of an Integral Data Platform

Évaluation des interactions entre les contaminants et les apports alimentaires dans l'Enquête sur la santé des Inuits : Nunavut, Nunatsiavut et Inuvialuit – Partie 2 : Développement d'une plate-forme de données intégrales

- **Project Leader:**
  Drs. Laurie H.M. Chan and Aline Philibert, Center for Advanced Research in Environmental Genomics, University of Ottawa, Tel: (613) 562-5800 ext 6349, Fax: (613) 562-5385
  Email: laurie.chan@uottawa.ca
- **Project Team Members and their Affiliations:**
  Dr. Kue Young, University of Toronto; Dr. Eric Dewailly, Université Laval; Dr. Peter Bjerregaard, National Institute of Public Health, Denmark

Abstract

The Inuit Health Survey (IHS) was conducted in 2007-2009. It gathered information on health status data and attempted to understand its relationship to environmental factors. Two other similar but independent cohort studies have also been conducted in the circumpolar region: (1) the 2004 Nunavik Cohort Study in Canada; and (2) the Inuit Health in Transition 2005-2010 in Greenland. The purpose of Part 2 of the study: *Development of an Integral Data Platform,* was to develop a common platform for the heterogeneous, cross-disciplinary and multi-scale datasets collected from the three cohort studies. Data harmonization procedures were used to adjust for differences and inconsistencies among data definition, format and methods,

Résumé

L'Enquête sur la santé des Inuits a été réalisée de 2007 à 2009. Par la collecte d'information sur l'état de santé, elle visait une meilleure compréhension de la relation entre l'état de santé et les facteurs environnementaux. Deux autres études de cohorte similaires mais indépendantes ont aussi été réalisées dans la région circumpolaire : l'étude de cohorte menée en 2004 au Nunavik, au Canada et l'étude de 2005-2010 sur la santé des Inuits en transition, menée au Groenland (Inuit Health in Transition 2005-2010). La partie 2 de l'étude, Développement d'une plate-forme de données intégrales, avait pour objet l'élaboration d'une plate-forme commune qui réunirait les ensembles de données

to make the data mutually compatible. The three databases have a combined total of 4288 parameters. Only 227 can be paired: 79 showed a complete match and 143 were partially matched.. A total of 5 were found impossible to match. The data platform consists of data collected from a total of 6777 participants from the three cohort studies conducted between 2004 and 2010. It consists of a combined total of 222 parameters that can be classified into 10 different categories including: health status (32); blood contaminant concentrations (57); clinical tests (39); clinical biochemistry (35); lifestyle (14); socio-demographic characteristics (13); mental health (12), food use pattern (10), social networks (6) anthropometry (4). This data platform will be invaluable for further analysis to understand the relationship between the environment and health among Inuit in Canada and Denmark. It will also facilitate the development of regional and international health promotion policies.

Key messages

- The harmonization of data resulted in some loss precision and information for each data set
- The integral data platform will enable robust and efficient cross-national comparative research on Inuit health

hétérogènes, multidisciplinaires et multi-échelles recueillis par ces trois études de cohorte. Des techniques d'harmonisation de données ont été appliquées, afin de rendre les données mutuellement compatibles en éliminant les différences et les incohérences sur le plan des définitions, des formats et des méthodes. Les trois bases de données comprennent en tout 4 288 paramètres. Seuls 227 de ces paramètres peuvent être jumelés : 79 présentent une concordance parfaite et 143, une concordance partielle. La plate-forme de données comprend les données recueillies auprès de 6 777 participants lors des trois études de cohorte réalisées entre 2004 et 2010. Elle renferme un total combiné de 222 paramètres qui peuvent être répartis en 10 catégories : état de santé (32); concentrations de contaminants dans le sang (57); épreuves cliniques (39); analyses biochimiques cliniques (35); mode de vie (14); caractéristiques sociodémographiques (13); santé mentale (12), habitudes alimentaires (10), réseaux sociaux (6) et anthropométrie (4). Cette plate-forme de données sera très précieuse pour la réalisation d'analyses plus poussées sur la relation entre l'environnement et la santé chez les Inuits du Canada et du Danemark. Elle facilitera en outre l'élaboration de politiques régionales et internationales de promotion de la santé.

Messages clés

- L'harmonisation des données a entraîné une légère perte de précision et d'information dans chaque ensemble de données.
- La plate-forme de données intégrales rendra possible la réalisation de recherches comparatives solides et efficaces sur la santé des Inuits de ces pays.

Objectives

We want to design a data platform to:

1. Store and keep the data secure
2. Enable controlled access to any subset of the three cohorts datasets
3. Facilitate that records be kept so that we know a) who is working on what data with what analyses, b) what that work produces (outputs and outcomes) and c) whether any data modifications would be fed back into the bank (improvement/enrichment)
4. Support the cooperation between research institutions, and leverage the data and findings of interdisciplinary projects

Introduction

Merging data across multiple cohort studies is providing an invaluable opportunity to improve our knowledge base of how environmental factors affect health status [1-4]. Indeed, merging data maximizes the benefits to be derived from existing cohort studies with the least effective cost, while encouraging ongoing activities and secondary analysis of data [1, 4-9]. While considerable number initiatives in pooling data have been established [1, 4-6, 10-12], there have been a few methodological tools to support comprehensive and systematic data harmonization between cross-disciplinary cohort studies [1, 4, 6, 7, 13].

To address the increasing concern on the rapidly changing environment and Inuit health transition, three health surveys were carried in the last 10 years: (1) the 2004 Nunavik Cohort Study in Canada [14, 15]; (2) the International Polar Year (IPY) Adult Inuit Health Survey (IHS) 2007–2008 in Canada [16]; and (3) the Inuit Health in Transition study, 2005-2010 in Greenland [17]. The three studies shared the same objectives of documenting the baseline health status and studying the relationship between environmental factors and health status.

Throughout the years there has been a growing interest for an Inuit Circumpolar Cohort and follow-up among academia, stakeholders and communities. In June 2012 in Kuujjuaq, Nunavik, a workshop entitled "Inuit Health in Transition Study" gathered stakeholders, collaborators and principal investigators of three health surveys carried out in Nunavik, Nunasiavut, Nunavut, Inuvialuit Settlement Region and Greenland. During this workshop it was decided to explore the possibilities for the creation, development and maintenance of the Inuit Circumpolar Cohort through a platform that will gather data from the three health surveys concerned. The main goal of this data platform is to facilitate cross-disciplinary data inventory in long-term and to ensure accessibility and sharing of data.

This Synopsis report describes activities focused on the development of the data platform.

Activities in 2013-2014

Data harmonization

To pool data across the three different data sets, a three-step procedure was used: (i) identifying equivalent information that can be shared across datasets, (ii) evaluating the degree of compatibility (complete, partial, impossible), and whenever possible, (iii) converting data using one of the conversion techniques described below.

Data conversion techniques

The data manipulation and transformation procedures used for converting data were grouped into 8 main classes. The choice of conversion techniques depended on the nature of the parameter.

A. Complete match

A total of 79 parameters had a perfect match across the three datasets, and thus, were incorporated to the data platform without any manipulation or transformation. All parameters in anthropometry (*e.g.*height and weight), clinical biochemistry (cholesterol, triglycerides and fatty acids), nutrients (except selenium) and food use patterns, were complete match. None complete match was found for contaminants.

B. Standardize unit of measurement

The simplest data conversion was to standardize the units of measurement. For example, the standardization of units in µg/L was applied to all blood metal concentrations.

C. Restructure data

It is a common practice for any parameters involving a series of measurements with no a priori standard structure. For example, parameters for carotid intima-media thickness (IMT) (n=36) needed to be transposed in one dataset to be comparable to the other 2 datasets.

D. Recode data categories

The coding of the parameters can be different between dataset. For example, using 1,2, 3 or a, b, c. Recoding is the process of harmonizing different coding systems to a unique one by assigning a standardized code.

E. Data extrapolation

It may happen that a "missing" data in one database could be indirectly inferred from other data in that same database. For example, in a questionnaire an answer maybe induced from the response to one or several other questions.

Combine data categoriesThe defined categories of answers to the same question can be different between surveys. This is most common for the parameters that are related to time periods (*e.g*,. how often do you….?). One survey offered 4 options (value 1 "never"; value 2 "rarely"; value 3 "sometimes"; value 4 "often"), while another survey had only 2 options: value 1 "Yes", value 2 "No"). In that case, the most appropriate solution for harmonizing data was to standardize the classes of time period on the "lowest common denominator",

F. G) One-to-many data matching

One-to-many matching was common when one survey was designed to obtain multiple answers using one question while the other study was designed to get the same answers using multiple questions.

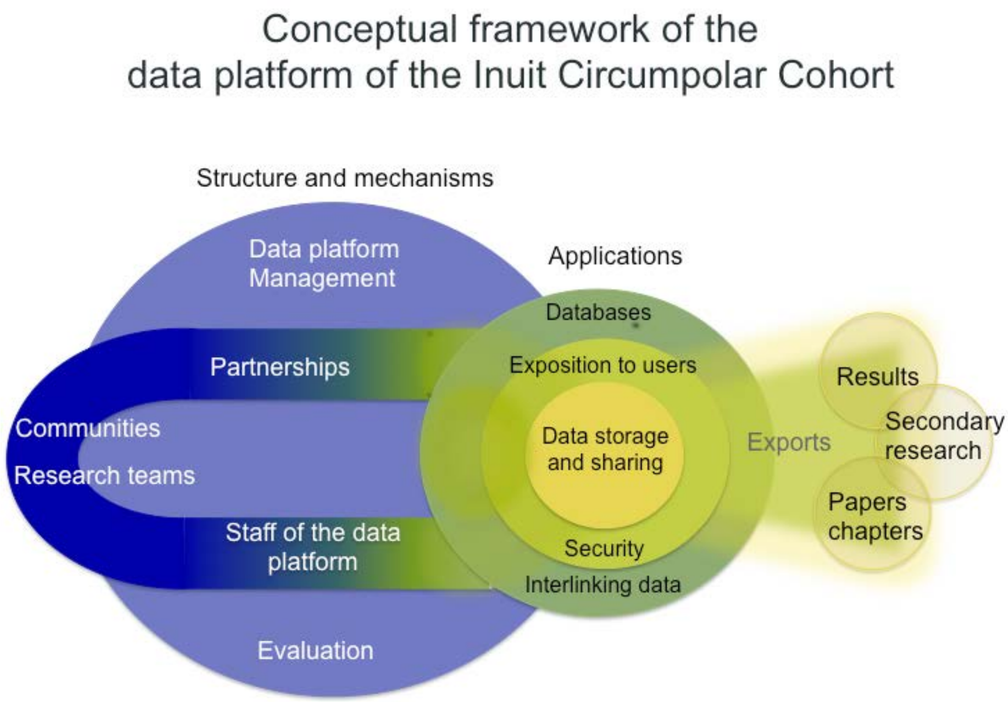
G. H) Missing values

For purposes of harmonization, coding for missing values was standardized. For example, 9,99,999, 777, 888 were all used to denote missing values in the 3 surveys and they were all standardized.

Results

The structure and mechanisms, the application and exports, as well as the different actors involved in this data platform are illustrated in Figure 1. The all-encompassing nature of the different components of the data platform reveals the integrative approach of the Inuit Circumpolar Cohort. The operationalization of such platform results in challenges that touch all ethical and functional aspects of data management; including security, storage, comparability level, access and responsibility, as well as how to respond to the ethical review and research requirements in each jurisdiction (such as licensing and approvals procedures).

Figure 1



The structure of the data platform is represented by two main components: (1) data platform management (function, content, rules and regulations) and (2) Evaluation screening and diagnostic, which aims at optimizing and maintaining the performance and sustainability of the data platform.

Harmonization of data from the three cohort studies allowed us 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. Table 1 shows the distribution of original and harmonized data per discipline. The disciplines, for which more data were compatible, were by decreasing order social networks, contaminants, clinical biochemistry, clinical tests, health status and lifestyle. Loss of information was respectively, 71% in Greenland, 78% in IHS and 91% in Qanuippitaa study. For example, direct comparisons of dietary measures across studies were not deemed appropriate due to different types of questions. Indeed, only ten data parameters (2.6%) in food use pattern (5 country food and 4 market foods) were compatible, and none regarding food security. Neither 24-hour recall record nor food security survey was carried out in the Greenland study. There was no match for medication across the three datasets. Finally, questions concerning health services were available only in the Greenland study.

Table 1. Description of the frequency of non harmonized and harmonized data per discipline in the three original datasets and in the merged one.

Categories of variables	Greenland	IHS	Qanuippitaa	Harmonized data
Socio-demographic characteristics	64	47	59	13
Health status (Current Health, health history, self-perception and maternal health)	95	73	137	32
Social networks	6	6	16	6
Lifestyle (including traditional activities)	91	72	165	14
Anthropometry	6	30	13	4
Clinical biochemistry (including parasites)	78	147	141	35
Clinical tests	67	131	158	39
Environmental contaminants	57	109	158	57
Food security	22	71	179	0
Mental health	56	121	55	12
Food use pattern (24h recall and FFQ)	166	142	849	10
Health services	49	0	0	0
Medication	8	75	569	0
Total	765	1024	2499	222

Discussion and Conclusions

The rate of retrospective data harmonization across the 3 cohort studies was only 15.5%, suggesting a loss of information of 84.5% among the overall data, while in some other platforms the rate varied between 38% and 73% [1, 6]. This can be explained by the interdisciplinary nature and the important size of each of the three datasets, while in other platforms the studies were carefully selected from key characteristics, and specific heath outcomes were targeted. However, even though the harmonization rate was low in the present study, a total of 222 parameters were harmonized. Considering that the data platform contains most of contaminants exposure and heath status (chronic diseases), there is little doubt that data harmonization in the present study will provide an great opportunity for improving our knowledge base of how environmental factors, especially contaminants and lifestyle, affect on health in the Inuit Circumpolar region [5, 18]. The vast overall sample size of the data platform (n = 6777 participants) will enhance statistical power, improve estimates, and facilitate the use of more sophisticated models, which generally require a large number of observations [18]. As mentioned in Allen et al. [5], increasing observations will enable the analyses on low prevalence outcomes, which are infrequently observed in cohort studies such as mental health outcomes (*e.g.*mental health outcomes). Although a prospective data harmonization is always recommended in an ideal word for standardizing questionnaires, measurements and methods across emerging studies[7], retrospective data have the advantage of optimizing information in already existing studies and is saving time and money [4, 13]. Finally, by encouraging robust and efficient cross-national comparative research in the Inuit circumpolar region, the new data platform will certainly encourage network efforts and develop partnerships across academics, communities, international institutions, and policy makers. Also, the data platform presented here is a great opportunity for providing data that are policy relevant and lead to concrete actions. Indeed, we hope the data will convince policy makers of recognize the issues and to invest in new projects or shape the policy to respond to the needs of the populations in the Inuit circumpolar region.

However, there are some limitations that must be highlighted. Although similar, the three cohort studies were designed at different times and with different methods, to meet different needs. Theycovered some topics at different time periods and were commissioned by different research institutions. Consequently, they were developed to a significant degree in isolation from each other, making data harmonization challenging. For example, societal and cultural differences across the different regions, and translation from local language to English, were significant challenges we had to face for understanding the true "meaning" of the data and determining if the actual concept was found "equivalent" across the datasets. In some cases, data were easily considered as equivalent (*e.g*,. age, sex), while in others the test of "equivalence" gained in complexity. For example, education levels had different meanings because the local classification systems in Greenland differed from those in Canada. Also, classifications of work activities had not always the same meaning across the three regions and categorizing them was difficult to achieve. We are aware that the lack of cohesion across the studies in design and sampling protocol (years and methods), as well as the variability of ethical, legal, social and cultural contexts, may influence the precision of results, and must be kept in mind when interpreting them.

The vast array of information collected by each individual cohort study generated an overwhelming amount of data to harmonize, and therefore, necessitated a substantial amount of time and resources to materialize the harmonization process and pooling of data. The multidisciplinary nature of data made synthesis of information and harmonization process even more challenging.

Even though confidentiality of all participants was a constant prerogative when merging the three datasets into a single one, ethics questions arose about participant agreement to participate, which was generally limited to the original study (except for Qanuippitaa). Intellectual property and material transfer agreements were thus presented to the regional committees that granted approval of the original studies.

The developed new data platform provides a sustainable and relevant cross-disciplinary data bank and a data-sharing tool.

Expected Project Completion Date

This part of the project is completed and a manuscript is ready to be submitted for publication.

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Nunavik Child Cohort Study (NCCS): follow-up with late adolescents

Étude sur une cohorte d'enfants du Nunavik : suivi en fin d'adolescence

- **Project Leader:**
  Gina Muckle, Centre de recherche du CHU de Québec; Université Laval
  Tel : (418) 656-4141 #46199; Fax (418) 654-2726, Email: Gina.Muckle@crchul.ulaval.ca
- **Project Team Members and their Affiliations:**
  Joseph L Jacobson PhD, Wayne State University; Sandra W. Jacobson PhD, Wayne State University; Eric Dewailly MD PhD, CRCHUQ; Pierre Ayotte PhD, CRCHUQ; Richard Bélanger MD, CRCHUQ; Pierrich Plusquellec PhD, CRCHUQ; Belkacem Abdous PhD, CRCHUQ

Abstract

Prenatal exposure to PCBs and mercury have been associated with growth and effects on cognitive development in children. The Inuit from Nunavik are among the populations most highly exposed to these environmental pollutants due to their consumption and bioaccumulation in fish and marine mammals. However, consumption of fish and marine mammals also provides nutrients such as omega-3 fatty acids, which are known to enhance early brain development. We have conducted four studies in Nunavik over the last 20 years, including: monitoring of prenatal exposure from cord blood sampling, an effect study with infants up to 12 months of age, and an effect study at preschool age. In 2010, we completed the follow-up of 294 11-year-old children and, during the years 2010 and 2011, we analyzed most of the 11-year data. In fall 2011, study results were presented to the Nunavik population and public health recommendations were provided by the Public Health Director of

Résumé

L'exposition prénatale aux biphényles polychlorés (BPC) et au mercure a été associée à des effets sur la croissance et le développement cognitif des enfants. Les Inuits du Nunavik comptent parmi les populations les plus exposées à ces polluants environnementaux, en raison de leur bioaccumulation chez les poissons et les mammifères marins qu'ils consomment. Toutefois, les poissons et les mammifères marins fournissent aussi des nutriments tels que les acides gras oméga-3, lesquels favorisent le développement du cerveau en bas âge. Au cours des 20 dernières années, nous avons mené quatre études au Nunavik : surveillance de l'exposition prénatale à l'aide d'échantillons de sang de cordon, et effets sur les nourrissons de 12 mois et moins et sur les enfants d'âge préscolaire. En 2010, nous avons effectué un suivi auprès de 294 enfants de 11 ans et, en 2010 et en 2011, nous avons analysé la plupart des données relatives à ces enfants. À l'automne 2011, les résultats de l'étude ont

Nunavik. Summary of study results and public health recommendations can be found at http://www.rrsss17.gouv.qc.ca. During the years 2011 and 2012, we completed the knowledge transfer activities, communicated the final study results to the Nunavik population and stakeholders and completed the analyses of the 11-year data. In 2012-2013, we launched the follow-up of the cohort at adolescence. Until now, we successfully recruited and tested 142 adolescents aged between 16 and 19 years old living in Nunavik. Data collection will continue during the next two years.

été présentés à la population du Nunavik, et des recommandations en matière de santé publique ont été formulées par le directeur de la santé publique du Nunavik. Un résumé des résultats d'études et des recommandations de santé publique est publié à l'adresse suivante : http://www.rrsss17.gouv.qc.ca. En 2011 et 2012, nous avons mené à bonne fin le transfert des connaissances, communiqué les résultats finaux de l'étude à la population et aux parties intéressées du Nunavik et achevé l'analyse des données concernant les enfants de 11 ans. En 2012-2013, nous avons amorcé le suivi de la cohorte à l'adolescence. Jusqu'à présent, nous avons recruté et soumis à des tests 142 adolescents de 16 à 19 ans vivant au Nunavik. La collecte de données se poursuivra durant les deux prochaines années.

Key Messages

- The work accomplished during year allowed testing 81 additional participants; the total number of enrolled participants is 142 participants so far
- We obtained an additional grant for funding the data collection to be held during 2014-2015 and 2015-2016 from the Canadian Institutes of Health Research

Messages clés

- Quatre-vingt-un participants ont passé des tests cette année; le nombre total de participants recrutés est de 142.
- En 2014-2015 et en 2015-2016, la collecte de données se fera au moyen d'une subvention des Instituts de recherche en santé du Canada.

Objectives

Main objective: To pursue the follow-up of the NCCS at late adolescence period in order to document the long-term effects of pre- and postnatal exposure to mercury (Hg), lead (Pb), polychlorinated biphenyls (PCBs) and chlorinated pesticides on cognitive and affective/behavioral development, body size and health related outcomes.

Specific objectives for year 2013-2014:

1. Clean up of database
2. Consultation meetings with Nunavik stakeholders from Hudson Bay
3. E n roll and test 66 additional participants during a five week data collection trip
4. Preliminary analysis with half the cohort.

Introduction

A recent review of evidence from several Canadian studies underlines an alarming burden of illness resulting from environmental exposures (Boyd and Genuis 2008). The reviewers conclude that environmental contaminants (ECs) are associated with an increased prevalence of low birthweight, respiratory diseases, asthma, cardiovascular illness and congenital anomalies. These results give rise to a plethora of important research questions including the cumulative effects of low-dose, long-term and mixed exposures, the nature and the prevalence of such effects. Past studies have demonstrated the vulnerability of fetal brain development to environmental exposures. The US National Academy of Sciences has estimated that as many as 25% of learning disabilities are due to either known toxic substances or the interactions between environmental factors and genetic predispositions. This is of particular concern when one considers that approximately 6.4% of children have a developmental or behavioural problem, 10% have a learning disability and 3.6% have a diagnosed speech problem. It is of primordial importance that the associations between ECs, health and development be elucidated. As noted by an expert committee of the World Health Organization (World Health Organization 2006), addressing such knowledge gaps requires the design and implementation of longitudinal prospective cohort studies of pregnant women, infants and children with exposure assessments at critical windows and with sensitive health end-points along the continuum of human development.

During the last 25 years, environmental monitoring and research activities have provided evidence that Inuit traditional food, whose nutritional benefits are well documented, is also the primary source of exposure to environmental contaminants (polychlorinated biphenyls (PCBs), mercury, and lead) for Northerners. With the exception of lead, these contaminants are transported by atmospheric and oceanic currents from industrial regions in the South, accumulate in the Arctic food chain, putting the population at risk for greater exposure. The primary source of lead has been the use of lead-containing ammunitions.

The first phase of the study was initiated in 1996. We investigated the role of nutrients from traditional food, life habits during pregnancy, environmental contaminants and other factors have on infant development. Almost 300 mothers and their infants from Puvirnituq, Inukjuak and Kuujjuaraapik participated in the study between 1996 and 2002. Results and implications from the first phase of this study, when infants were examined at 6 and 11 months of age, were communicated to the Nunavik population by the researchers and public health officials in 2003 and 2004. Public health recommendations were provided at that time to the population by the Public Health Director (PHD) of Nunavik.

We decided to continue the study with children at 11 years old to observe if adverse effects found during infancy would impact on child development at school age. Between September 2005 and February 2010, 294 children and their mothers from all 14 Nunavik communities participated to the follow-up. Exposure to ECs and measures of nutrients were measured in cord blood samples (for prenatal exposure) and from a blood sample taken from the child at time of testing (for current/childhood exposure). Results and implications from the second phase of this study, when infants were examined at 11 years of age, were communicated to the Nunavik population by the researchers and public health officials in 2011-2012. Public health recommendations were also provided to the population by the PHD. In order to document the long term effects of exposure to environmental contaminants, we decided to follow the cohort at 16-19 years of age. The final sample should consist of approximately 200 adolescents from the 14 Nunavik communities, which corresponds to 72% of the eligible children seen at age 11 years.

Activities in 2013-2014

1. Research activities completed after the 2013 data collection are:

   - Biological specimens have been analyzed by the collaborating laboratories;
   - Biological data have been entered in the database;
   - Child data from cognitive testing have been coded, scored and entered in the database;
   - Data obtained from child interviews including behavioral and emotional development have been scored and entered in the database;
   - Growth and other medical variables have been entered in the database;
   - Clean up the database and elaboration of a codebook;
   - In November 2013, G Muckle met with stakeholders from the Hudson Bay to inform about the next data collection to be held in 2014 in Puvirnituq and Inukjuak and about the study procedures. She also obtained additional support from the Municipal council of Inukjuak, the Municipal council of Puvirnituq, and the Director of the Inuulitsivik Health Center.

2. Research activities completed prior to the 2014 data collection are:

   - Update of the tests and questionnaires to be use with adolescents;
   - Purchase of research equipment;
   - Ethical renewal process at the CHU of Québec Research Center;
   - Completion of working agreements with hospital authorities and staff from Inukjuak and Puvirnituq;
   - Hiring and training all the research personnel: the three Inuit research professionals and the research assistant.
   - Search for and renting of a working and living place for the team in Puvirnituq and Inukjuak;
   - Shipment of the study material and equipment to Inukjuak and Puvirnituq;

3. Between January 23rd and February 26th 2014, we successfully recruited and tested 81 participants from Husdon Bay. Participants were contacted by phone, were provided with information about the study protocol, and were invited to participate in Puvirnituq or Inukjuak. Participants from other communities located in Hudson Bay coast were transported by plane to Puvirnituq or Inukjuak.

4. We obtained one grant outside the NCP for co-funding the study from the Canadian Institutes of Health Research (CIHR), 2013-2017.

Capacity Building

During the previous phase of the study, each child was evaluated by four examiners; two of these evaluators were Inuit. We have trained two Inuit women to conduct child testing; they tested all children seen at age 11years. They received a high level of training and their involvement in this study makes them very skilled and sought-after for work with school and hospital specialists on child psychology, psychiatry, pediatrics and learning disabilities. Furthermore, we have always worked with one, and sometimes two, interpreters when conducting the field work. A total of 5-6 interpreters have been trained previously to do maternal interviews.

For this current phase, we hired one Inuit woman as a research professional in Kuujjuaq in 2013. In 2014, we hired three Inuit women as research professionals from Inukjuak and Puvirnituq. All of them have previously worked with us as interpreters but their new responsibilities fall far beyond interpretation and include: recruitment and consent, scheduling appointments, arranging local transportation and coordinating flight and lodging arrangements for out of town participants and interpreter when needed.

Communications

During the data collection trip in 2014, study posters were posted in communities (*e.g.*, municipal offices, nursing stations, schools, youth house and groceries). The fact sheet presenting the main results of the 11-year follow-up and the public health recommendations provided to the population in 2011 has been given to each participating adolescent along with our study pamphlet. Participants were also informed that we created a Facebook page for them. This Facebook page was designed to share progress and results from the current and previous phases of the study, and to provide information relevant for youths.

Traditional Knowledge Integration

Pure traditional knowledge and methods were not integrated to the research protocol, but better understanding of traditional knowledge will be particularly important in examination of emotional development of adolescents. Consultation activities conducted in 2012 provided us access to the Inuit perspective with regard to adolescent development and adaptation. Based from our previous experiences, intensive fields work will provide opportunities for very informative discussions with Inuit personnel that are likely to strengthen our understanding of the adolescence period in a cultural relevant way.

Results

We are currently conducting the data entry of results from biological samples and of child assessments collected in 2014. Therefore, we do not have results to provide at this step of the data collection at adolescence. Below are the abstract of the most recent and relevant publications with regard to results from the previous phases of the study.

Boucher, O., Muckle, G., Jacobson, J.L., Carter, R.C., Kaplan-Estrin, M., Ayotte, P., Dewailly, E., Jacobson, S.W. (2014). Domain-Specific Effects of Prenatal Exposure to PCBs, Mercury, and Lead on Infant Cognition: Results from the Environmental Contaminants and Child Development Study in Nunavik. *Environmental Health Perspectives*, 122 :310-316. doi.org/10.1289/ehp.1206323. PMID: 24441767. **Background:** Polychlorinated biphenyls (PCBs), methylmercury (MeHg), and lead (Pb) are environmental contaminants known for their adverse effects on cognitive development. **Objectives:** In this study we examined the effects of prenatal exposure to PCBs, MeHg, and Pb on cognitive development in a sample of Inuit infants from Arctic Québec. **Methods:** Mothers were recruited at local prenatal clinics. PCBs, mercury (Hg), Pb, and two seafood nutrients—docosahexaenoic acid (DHA) and selenium (Se)—were measured in umbilical cord blood. Infants (n = 94) were assessed at 6.5 and 11 months of age on the Fagan Test of Infant Intelligence (FTII), A-not-B test, and Bayley Scales of Infant Development–2nd Edition (BSID-II). **Results:** Multiple regression analyses revealed that higher prenatal PCB exposure was associated with decreased FTII novelty preference, indicating impaired visual recognition memory. Prenatal Hg was associated with poorer performance on A-not-B, which depends on working memory and is believed to be a precursor of executive function. Prenatal Pb was related to longer FTII fixation durations, indicating slower speed of information processing. **Conclusions:** PCBs, MeHg, and Pb each showed specific and distinct patterns of adverse associations with the outcomes measured during infancy. By contrast, none of these exposures was associated with performance on the BSID-II, a global developmental measure. The more focused, narrow band measures of cognitive function that appeared to be sensitive to these exposures also provide early indications of long-term impairment in specific domains that would otherwise not likely be evident until school age.

Dion, L.-A., Muckle, G., Bastien, C., Jacobson, S.W., Jacobson, J.L., Saint-Amour, D. (2013). Sex differences in visual evoked potentials in school-age children: What is the evidence beyond the checkerboard? *International Journal of Psychophysiology,* 88(2): *136-142*. doi: 10.1016/j.ijpsycho.2013.03.001. PMID: 23501018. **Background:** Visual evoked potentials (VEPs) are known to be influenced by several biological variables, including sex. In adult populations studies using conventional high-contrast checkerboard have shown that females display larger amplitudes and shorter latencies than males. To date, few studies have been conducted in children; the available data suggests that girls display significantly larger amplitudes than boys but the effect on latency is absent or negligible. **Methods:** We investigated sex-related VEP differences in 149 school-age (11.3 ± 0.6 years) children from Northern Quebec using several VEP protocols: achromatic pattern-reversal VEPs at high (95%) and low contrast (30%, 12% and 4%), as well as motion-onset VEPs and isoluminant pattern-reversal VEPs. **Results:** Girls showed significantly larger amplitudes in achromatic VEPs for most of the contrast levels as well as in N2 response to motion-onset. No significant difference was found regarding the amplitude of isoluminant VEPs. In addition, girls showed shorter latencies for the achromatic N75 and a trend ($p < 0.1$) for the P100, regardless of the contrast level. Interestingly, this latency effect appeared mostly due to head size, not sex. No differences in latency were found for motion or isoluminant responses. **Conclusions:** Overall, these findings show that sex-related differences are present in children mostly in VEP amplitude not only for high contrast achromatic pattern-reversal but also for low contrast levels and motion-onset VEPs, suggesting that sex affects VEP responses in a general fashion.

Fortin, S., Jacobson, S.W., Gagnon, J., Forget-Dubois, N., Dionne, G., Jacobson, J.L., Muckle, G. (accepted, September 2013). Socioeconomic and Psychosocial Adversity in Inuit Mothers from Nunavik during the First Postpartum Year. Journal or Aboriginal Health. **Background:** The postpartum year is a crucial period for child development and mother-child attachment. In a young and prolific population such as the Inuit from Nunavik (Northern Quebec, Canada), postpartum maternal well-being is even more concerning. **Objective:** This study aims document the prevalence and the co-occurrence of socioeconomic and psychosocial risk factors, and identify specific profiles of women from these factors. **Methods:** Data collection involved 176 mothers recruited during pregnancy and interviewed 12 months after delivery. Socioeconomic (age, education, single parenting, unemployment, welfare) and psychosocial risk factors (psychological distress, suicidal thoughts and attempts, spousal abuse, drug and alcohol use) were documented. Four high-risk conditions (socioeconomic precariousness, distress, domestic violence and substance use) were computed and considered in the analysis. **Results:** Adversity was salient since most of women experience simultaneously multiple high-risk conditions (58%). Socioeconomic difficulties, distress and, spousal abuse were the most prevalent. Distinct profiles of women were identified: those without socioeconomic and psychosocial risk factor (30.8%) and those experiencing distress (69.2%). Two specific profiles of distressed mothers emerged: single women coping with socioeconomic stressors (40.1%), women with fewer financial difficulties but in an abusive relationship and more likely to use drugs or binge drink (29.1%). **Conclusions:** Our results support the need for the development of prevention and public health programs aimed to improve well-being within the population.

Desrosiers, C., Boucher, O., Forget-Dubois, N., Dewailly, E., Ayotte, P., Jacobson, S.W., Jacobson, J.L., Muckle, G. (2013). Associations Between Prenatal Cigarette Smoke Exposure and

Externalized Behaviors at School Age Among Inuit Children Exposed to Environmental Contaminants, Neurotoxicology and Teratology, 39C :84-90. doi: 10.1016/j.ntt.2013.07.010. PMID: 23916943. **Background:** Smoking during pregnancy is common among Inuit women from the Canadian Arctic. Yet prenatal cigarette smoke exposure (PCSE) is seen as a major risk factor for childhood behavior problems. Recent data also suggest that co-exposure to neurotoxic environmental contaminants can exacerbate the effects of PCSE on behavior. **Objectives:** This study examined the association between PCSE and behavior at school age in a sample of Inuit children from Nunavik, Québec, where co-exposure to environmental contaminants is also an important issue. Interactions with lead (Pb) and mercury (Hg), two contaminants associated with behavioral problems, were also explored. **Methods:** Participants were 271 children (mean age = 11.3 years) involved in a prospective birth-cohort study. PCSE was assessed through maternal recall. Assessment of child behavior was obtained from the child's class- room teacher on the Teacher Report Form (TRF) and the Disruptive Behavior Disorders Rating Scale (DBD). Exposure to contaminants was assessed from umbilical cord and child blood samples. Other confounders were documented by maternal interview. **Results:** After control for contaminants and confounders, PCSE was associated with increased externalizing behaviors and attention problems on the TRF and higher prevalence of attention deficit hyperactivity disorder (ADHD) assessed on the DBD. No interactions were found with contaminants. **Interpretation:** This study extends the existing empirical evidence linking PCSE to behavioral problems in school-aged children by reporting these effects in a population where tobacco use is normative rather than marginal. Co-exposure to Pb and Hg do not appear to exacerbate tobacco effects, suggesting that these substances act independently.

Verner, M.A., Sonneborn, D., Lancz, K., Muckle, G., Ayotte, P., Dewailly, E., Kocan, A., Palkovicová, L., Trnovec, T., Haddad, S., Hertz-Picciotto, I., Eggesbø, M. (2013). Toxicokinetic Modeling of Persistent Organic Pollutant Levels in Blood from Birth to 45 Months of Age in Longitudinal Birth Cohort Studies. *Environmental Health Perspectives*, 121(1): 131-7. doi: 10.1289/ehp.1205552. PMID : 23086694. **Background:** Despite experimental evidence that lactational exposure to persistent organic pollutants (POPs) can impact health, results from epidemiologic studies are inconclusive. Inconsistency across studies may reflect the inability of current methods to estimate children's blood levels during specific periods of susceptibility. **Objectives:** We developed a toxicokinetic model to simulate blood POP levels in children from two longitudinal birth cohorts and aimed to validate it against blood levels measured at 6, 16, and 45 months of age. **Methods:** The model consisted of a maternal and a child lipid compartment connected through placental diffusion and breastfeeding. Simulations were carried out based on individual physiologic parameters; duration of breastfeeding; and levels of POPs measured in maternal blood at delivery, cord blood, or breast milk. Model validity was assessed through regression analyses of simulated against measured blood levels. **Results:** Simulated levels explained between 10% and 83% of measured blood levels depending on the cohort, the compound, the sample used to simulate children's blood levels, and child's age when blood levels were measured. Model accuracy was highest for estimated blood POP levels at 6 months based on maternal or cord blood levels. However, loss in model precision between the 6th and the 45th month was small for most compounds. **Conclusions:** Our validated toxicokinetic model can be used to estimate children's blood POP levels in early to mid-childhood. Estimates can be used in epidemiologic studies to evaluate the impact of exposure during hypothesized postnatal periods of susceptibility on health.

Discussion and Conclusions

The follow-up at age 11 years advanced our understanding of the domains affected by exposure to PCBs, mercury and lead, and provided new insights on the long-term beneficial effects of omega-3 fatty acids. Activities planned for the current year were successfully conducted, without significant changes, and in accordance the expected timeline. The current phase of this prospective longitudinal mother-child cohort successfully started in 2013 with the recruitment of 61 participants in 2013 and 81 participants in 2014 for the follow-up of the cohort at the adolescence period. For the next year, we aim to recruit 24 participants, and by 2016, we aim to recruit 200 participants.

Expected project Completion Date

End of data collection is 2016. End of study is 2017.

Project social media page

www.facebook.com/pages/Nunavik-Child-Development-Study-NCDSEDEN/132959206872267

Publications in peer-reviewed journals

Boucher, O., Muckle, G., Jacobson, J.L., Carter, R.C., Kaplan-Estrin, M., Ayotte, P., Dewailly, E., Jacobson, S.W. (2014). Domain-Specific Effects of Prenatal Exposure to PCBs, Mercury, and Lead on Infant Cognition: Results from the Environmental Contaminants and Child Development Study in Nunavik. *Environmental Health Perspectives*, 122 :310-316. doi.org/10.1289/ehp.1206323. PMID: 24441767.

Fortin, S., Jacobson, S.W., Gagnon, J., Forget-Dubois, N., Dionne, G., Jacobson, J.L., Muckle, G. (accepté, 11 sept 2013). Socioeconomic and Psychosocial Adversity in Inuit Mothers from Nunavik during the First Postpartum Year. Journal or Aboriginal Health.

Desrosiers, C., Boucher, O., Forget-Dubois, N., Dewailly, E., Ayotte, P., Jacobson, S.W., Jacobson, J.L., Muckle, G. (2013). Associations Between Prenatal Cigarette Smoke Exposure and Externalized Behaviors at School Age Among Inuit Children Exposed to Environmental Contaminants, Neurotoxicology and Teratology, 39C :84-90. doi: 10.1016/j.ntt.2013.07.010. PMID: 23916943.

Dion, L.-A., Muckle, G., Bastien, C., Jacobson, S.W., Jacobson, J.L., Saint-Amour, D. (2013). Sex differences in visual evoked potentials in school-age children: What is the evidence beyond the checkerboard? *International Journal of Psychophysiology*, 88(2): *136-142*. doi: 10.1016/j.ijpsycho.2013.03.001. PMID: 23501018.

Verner, M.A., Sonneborn, D., Lancz, K., Muckle, G., Ayotte, P., Dewailly, E., Kocan, A., Palkovicová, L., Trnovec, T., Haddad, S., Hertz-Picciotto, I., Eggesbø, M. (2013). Toxicokinetic Modeling of Persistent Organic Pollutant Levels in Blood from Birth to 45 Months of Age in Longitudinal Birth Cohort Studies. *Environmental Health Perspectives*, 121(1): 131-7. doi: 10.1289/ehp.1205552. PMID : 23086694.

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Association between environmental contaminants, stress and observed behaviour in teenaged children from the Nunavik Child Cohort Study (NCCS), and in adults from the Inuit Health Survey.

Association entre les contaminants de l'environnement, le stress et les comportements observés chez les adolescents de l'Étude sur une cohorte d'enfants du Nunavik (ECEN) et les adultes de l'Enquête sur la santé des Inuits

- **Project Leader:**
  Pierrich Plusquellec, PhD, Centre de recherche de l'institut Universitaire en Santé Mentale de Montréal
  Tel : 514-251-4000 poste 3250, Fax: (514) 251-7968, Email : pierrich.plusquellec@umontreal.ca
- **Project Team Members and their Affiliations:**
  Gina Muckle PhD, Éric Dewailly MD PhD, Pierre Ayotte PhD, Centre de recherche du CHUQ, Université Laval; Sonia Lupien PhD, Centre de Recherche IUSMM, Université de Montréal

Abstract

Prenatal exposure to lead, PCBs and mercury have been 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 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 attention, activity and impulsivity, 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 may impair this endocrine system, and thus impact behavioural

Résumé

L'exposition prénatale au plomb, aux biphényles polychlorés (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, 5 ans et 11 ans), nous avons évalué le développement comportemental des enfants 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'examiner l'association entre les contaminants de l'environnement et l'attention, l'activité et l'impulsivité, nous nous sommes également penchés sur les réactions affectives, en particulier le stress. L'accent a été mis sur le système d'adaptation au stress en raison

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 factor of attention, activity, impulsivity levels but also of various physical and mental disorders in adolescents. For the last two years (2012 to 2014), we have collected data on stress (cortisol levels in saliva and in hair samples) and on behavioural dimensions (analysis of video recordings) from the follow-up study of children at age 17 lead by Dr. Gina Muckle. Data from the 2012-2013 collection have been generated through lab analysis and behavioural coding. Variables collected showed high inter-individual variability, which is a prerequisite to statistical analysis. Next lab analysis and behavioural coding are currently in progress for the data collected in the 77 teenagers assessed during the last data collection (February-March 2014). At the end of this process, data on stress, and on observed behavioural dimensions will be available for 134 Inuit teenagers allowing statistical analyses.

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 au cours de laquelle les perturbations hormonales causées par les contaminants environnementaux deviennent manifestes et où le développement affectif est particulièrement à risque. Enfin, le stress a une incidence marquée sur les niveaux d'attention, d'activité et d'impulsivité, en plus d'intervenir dans divers troubles physiques et mentaux touchant les adolescents. Au cours des deux dernières années (2012 à 2014), nous avons recueilli des données sur le stress (niveaux de cortisol dans des échantillons de salive et de cheveux) et sur les aspects du comportement (analyse des enregistrements vidéo) à partir de l'étude de suivi auprès d'adolescents de 17 ans dirigée par la Pre Gina Muckle. Les données issues de la collecte de 2012-2013 ont été générées par des analyses en laboratoire et le codage des comportements. Les variables recueillies révèlent une grande variabilité interindividuelle, qui est une condition préalable à la réalisation d'une analyse statistique. Les analyses en laboratoire et le codage des comportements sont en cours pour les données recueillies chez les 77 adolescents ayant participé à la plus récente collecte de données (de février à mars 2014). Au terme de cette démarche, des données sur le stress ainsi que sur les aspects du comportement observé seront disponibles pour 134 adolescents inuits, aux fins d'analyses statistiques.

Key messages

- Recruitment of Inuit teenagers that have already participated to a previous data collection (at 5 or 11 years of age) is feasible
- Assessment of the stress system through bioindicator is feasible
- Inter-individual variability in the value of these bioindicators (allostatic load, salivary cortisol, and hair cortisol) indicate that this way to assess stress is relevant to the Inuit population

Messages clés

- Il est possible de recruter des adolescents inuits qui ont déjà participé à une collecte de données antérieure (à l'âge de 5 ans ou de 11 ans).
- L'évaluation du système d'adaptation au stress au moyen de bio-indicateurs est possible.
- La variabilité interindividuelle dans la valeur de ces bio-indicateurs (charge allostatique, concentrations de cortisol dans la salive et les cheveux) confirme la pertinence de cette

- Inter-individual variability in the value of behavioural dimensions following behavioural coding of video indicate that this way to assess attention, activity or emotional reactivity is still relevant in Inuit teenagers
- Preliminary data suggest an adverse association between exposure to environmental contaminants and stress in the Inuit population

méthode pour l'évaluation du stress dans 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 confirme la pertinence de cette méthode pour évaluer l'attention, l'activité et la réactivité affective chez les adolescents inuits.
- Les données préliminaires donnent à penser qu'il existe une association défavorable entre l'exposition à des contaminants environnementaux et le stress dans la population inuite.

Objectives

1. To conduct an add-on study with 17-year old children in order to test whether sub-clinical impairments due to environmental contaminants, and observed on behavioural dimensions in previous study would persist in adolescence
2. To test whether those sub-clinical impairments could be explained by the endocrine disrupting properties of environmental contaminants on the stress system
3. 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

Adolescence is a period of great changes in the body functioning, and hormones, called steroids, which are measurable in adolescents, mainly orchestrate these changes. Because steroids are known to be disrupted by low-level exposure to environmental contaminants (ECs) (Koopmanesseboom et al., 1994; Jacobson and Jacobson, 1996; Pirkle et al., 1998; Denham et al., 2005), it is critical to study the effects of ECs on adolescents' steroids and the body and brain functions they impact on. In Inuit from Nunavik, adolescence is a particular period of vulnerability for psychological well-being. For example, 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). These results have been replicated and are even more alarming in the 2004 Nunavik Inuit Health Survey.

Environmental Contaminants, even at low exposure levels, impact brain functioning. Lead (Pb) exposure has been shown to be 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), and recent studies support the notion that there is no safe level of exposure for Pb (Bellinger et al., 1992; Canfield et al., 2003; Needleman and Landrigan, 2004). The developmental toxicity of methylmercury (MeHg) is starting to be well known. The Seychelles child development study and the Faroe Island study are the two major prospective studies that have examined the relationship between MeHg exposure and neurodevelopment (Davidson et al., 2000; Grandjean et al., 1997; Grandjean et al., 1998). 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).

One plausible process by which environmental contaminants could impact the brain is through their action on hormonal systems, and particularly on steroids. Among steroids, glucocorticoids are produced in response to environmental stress, and have been reliably shown to be impaired by environmental toxins. 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) We published a critical review: *Adverse effects of pollution on mental health: the stress hypothesis* (Lanoix, 2013).

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. Consequences of such disturbance may be assessed through two complementary way (a) by measuring the reactivity of the stress system to a physical or social threat, and (b) by measuring the levels of glucocorticoids in hair, which is a validated way to assess chronic stress (Kirschbaum et al., 2009; Dettenborn et al., 2010).

Inuit from Nunavik have been shown to be significantly more exposed to Pb, PCBs and MeHg than the general population from Southern Quebec (Muckle et al., 2001). These ECs have been shown to impair behavioural development even at low doses of exposure. Importantly, little is known about the mechanism of action of ECs in the developing human although more and more studies emphasized the endocrine disrupting properties of ECs. Thus, the next generation of studies should have the ambition to understand how these common ECs impair children's development and functioning in order to be able to precisely generate public health recommendations. In the present project, we aim to address this research question by analyzing physiological and behavioural data collected in Inuit teenagers. Furthermore, we include in the present proposal secondary analysis, which aim to strengthen the potential finding of an association between environmental contaminants and stress in teenagers by replicating it in adults from the Inuit Health Survey.

Activities in 2013-2014

In this study, we have continued collecting behavioural dimensions through video recordings, but we have also focused on biological measures of stress through two indexes: cortisol levels in saliva, which provides information on the way the stress system is able to deal with everyday stressors, and cortisol levels in hair, which provides information on the levels of stress in the three previous months, and thus which is more an indication of chronic stress.

Since ethical processes have taken a few months to reach final approbation from Laval University, first data collection in Kuujjuaq with 60 Inuit teenagers – aiming at testing our procedure of saliva and hair collections as well as for behavioural outcomes in this age group – that was programmed for fall 2012, occurred in January 2013. Biological materials (saliva and hair samples) and video recordings have thus been analyzed and coded in 2013-2014. The second data collection was done in January-February 2014. Analysis and behavioural coding of those biological materials and video-recordings are thus currently in progress.

Two research assistants are currently coding behavioural dimensions from video recordings, and coordinator of the study is currently checking inter-judge reliability for this behavioural coding, and creating the database needed to conduct statistical analysis.

At the end of this data collection process, we expect to have stress outcomes and behavioural dimensions in 134 participants, allowing us to statistically analyze the data, in order to determine potential association between exposure to environmental contaminants and stress, but also behavioural dimensions in Inuit teenagers. In the meanwhile, the coordinator of the study has started analysis about the association between environmental contaminants, and the allostatic load index in the Inuit Health Survey.

Results

From the data collection in Inuit teenagers, saliva samples from 57 Inuit teenagers have already been analyzed for cortisol, and results show a wide inter-individual variability (Cortisol lab arrival = 0.46 ug/dL s.d. 0.34; Cortisol lab arrival+120min = 0.23 ug/dL s.d. 0.15). Those preliminary 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 48 Inuit teenagers have been analyzed for cortisol, and results show also a wide inter-individual variability (Cortisol hair = 22.50 pg/mg s.d. 41.38). 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. Behavioural dimensions have been extracted through video coding of video recordings taken in two different situations: blood sampling and cognitive evaluation. Results from blood sampling situation show that participants had only 0.15 negative affect per minutes. They smiled and laughed 1.11 times per minutes. Their face expressed a neutral affect 51.67% of the time, a positive affect 35.07% of the time, and there is also a high inter-individual variability. Those behavioural coding will be validated in our next trip in Inukjuaq by the Inuit interpreters. Finally, in the cognitive evaluation task, levels of inattention, assessed by the percentage of time each participant did not look at the computer or the research assistant reached in average 23.77% of the total duration of the cognitive evaluation (s.d. 15.39). In other words, each participant looked off task 0.28 times per min (s.d. 0.35). Data for the other participants (n=60) are currently under behavioral coding or laboratory assessment.

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 the current project is 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. Our team collaborated with Mylene Riva to generate this allostatic load index. Mylene Riva is a young post-doctoral researcher, directed by Éric Dewailly, and she has shown that this physiological index of chronic stress was significantly related to overcrowding in Inuit population. This paper was published in the Journal of Epidemiology & Community Health. The next step is to look at association between this allostatic load index and environmental contaminants exposure. Preliminary analysis shows 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 have done this preliminary analysis with four legacy (MeHg, Pb, PCB-153 and p,p'-DDE) and four 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 with the emerging contaminants models in middle-age Inuit (β=0.24; $p<0.001$, n=468), since the effects of those contaminants on human health remain to be studied.

Discussion and Conclusions

We cannot provide any conclusion up to now, since we need to complete data collection and statistical analysis first. Assessing stress with physiological data from saliva sampling or hair sampling seems to be suitable and relevant to the Inuit context.

Expected Project Completion Date

Expected project completion date will be April 2015.

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Contaminant Nutrient Interaction Issues as part of a Public Health Intervention Study of Inuit Children in Nunavik: Communication of Results.

Détermination des interactions entre les contaminants et les nutriments dans le cadre d'une étude d'intervention sur la santé des enfants inuits au Nunavik : communication des résultats

- **Project Leader:**
  Huguette Turgeon-O'Brien, RD, PhD, and Doris Gagné, RD, MSc, Groupe d'études en nutrition publique, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec City
  Tel: (418) 656-2131, ext: 2314 and 8061 Fax: 418-656-3353
  E-mail: huguette.turgeon-obrien@fsaa.ulaval.ca and doris.gagne@fsaa.ulaval.ca.
- **Project Team Members and their Affiliations:**
  Julie Lauzière, RD, MSc, and Annie Bédard, RD, MSc, Groupe d'études en nutrition publique, Université Laval; Pierre Ayotte, PhD, Unité de recherche en santé publique, Centre Hospitalier Universitaire de Québec (CHUQ) and Institut national de santé publique du Québec

Abstract

As part of a broader project called the Nutrition Program in Nunavik Childcare Centres, the present study primarily aims to document the contaminant nutrient interactions in preschool Inuit children from Nunavik. From 2006 to 2010, a total of 245 children were recruited and 110 of them were seen for a follow-up visit one year later. Heavy metals and persistent organic pollutants (POPs), dietary intakes, and nutritional status were measured at both visits. Children who consumed traditional food had significantly higher intakes of proteins, omega-3 fatty acids, and many vitamins and minerals than non-consumers. Lead, PCB 153, PBDE 47, PFOS and PFOA were detected in all samples at recruitment. PBDE 47, 99 and 100 were more

Résumé

Cette étude, réalisée dans le cadre d'un projet plus vaste appelé Programme de nutrition dans les centres de la petite enfance du Nunavik, a comme objectif principal de documenter les interactions entre les contaminants et les nutriments chez les enfants inuits d'âge préscolaire au Nunavik. De 2006 à 2010, 245 enfants ont été recrutés, et 110 d'entre eux ont été revus au cours d'une visite de suivi une année plus tard. Lors des deux visites, on a mesuré les taux de métaux lourds et de polluants organiques persistants (POP), les apports alimentaires et l'état nutritionnel. Les enfants qui consommaient des aliments traditionnels avaient des apports nettement plus élevés en protéines, en acides gras oméga-3

prevalent and detected at higher levels than in Nunavimmiut adults. Thirteen percent of participants had values equal to, or exceeding the blood guidance value for methylmercury (8 µg/L), or were above the PCB level of concern (5 µg/L). Between 32% and 68% of the participating children did not meet the daily servings recommended in the *Canada's Food Guide* to Healthy Eating, depending on the food group examined. A high proportion of the participants had inadequate intakes for several nutrients. Moreover, a suboptimal nutritional status was observed in a large proportion of participants, with 65% of them having a low serum vitamin D level (<75 nmol/L 25(OH)D) and 50% suffering from iron deficiency. An inverse association was found between children's iron status and blood lead levels. In regression models, tomato products and dietary calcium intake had a protective effect against mercury and lead exposure, respectively. The 2013-2014 research funding support was requested in order to complete the development of a communication plan with the Nunavik Nutrition and Health Committee (NNHC). Key findings will be delivered to target audiences including parents and frontline workers.

et en plusieurs vitamines et minéraux par rapport à ceux qui n'en consommaient pas. La présence de plomb, de PBC 153, de PBDE 47, de PFOS et de PFOA a été détectée dans tous les échantillons prélevés au moment du recrutement. Les PBDE 47, 99 et 100 ont été retrouvés plus souvent et à des concentrations plus élevées que chez les Nunavummiut adultes. Treize pour cent des participants présentaient des valeurs égales ou supérieures à la valeur guide relative à la concentration sanguine en méthylmercure (8 µg/L) ou dépassaient le niveau de préoccupation en ce qui concerne les BPC (5 µg/L). Selon le groupe alimentaire examiné, de 32 % à 68 % des enfants participants ne consommaient pas le nombre de portions recommandé dans le *Guide alimentaire canadien* pour manger sainement. Une forte proportion des participants avaient des apports inadéquats en plusieurs nutriments. De plus, un état nutritionnel sous-optimal a été observé chez une vaste proportion des participants : parmi ceux-ci, 65 % présentaient un faible taux sérique de vitamine D (<75 nmol/L de 25(OH)D) et 50 % souffraient d'une carence en fer. Une association inverse a été observée entre le bilan en fer des enfants et les niveaux de plombémie. Selon les modèles de régression, la consommation de produits à base de tomates et un apport adéquat en calcium offrent une protection contre l'exposition au mercure et au plomb, respectivement. L'appui financier à la recherche demandé pour 2013-2014 visait l'élaboration d'un plan de communication avec le Comité de la nutrition et de la santé du Nunavik (CNSN). Les principales observations seront présentées aux publics cibles, notamment aux parents et aux intervenants de première ligne.

Key Messages

- A total of 245 Inuit preschool children from 10 Nunavik communities have been recruited between 2006 and 2010, and 110 of them were seen for a follow-up visit one year after recruitment (representing 53% of children recruited from 2006 to 2009)
- Levels of heavy metals and legacy POPs were lower in these Inuit preschool children compared to other Nunavimmiut

Messages clés

- Au total, 245 enfants inuits d'âge préscolaire provenant de 10 communautés du Nunavik ont été recrutés de 2006 à 2010, et 110 d'entre eux ont été revus au cours d'une visite de suivi une année plus tard (cela représente 53 % des enfants recrutés entre 2006 et 2009).
- Les concentrations de métaux lourds et d'anciens POP étaient inférieures

populations, while the levels of some brominated flame retardants, a class of emerging contaminants, were among the highest in the world

- A significant proportion of children did not meet the daily servings recommended in the Canada's Food Guide to Healthy Eating, which is consistent with the low nutrient intakes and the high prevalence of iron and vitamin D deficiencies observed in the present study
- Even though traditional foods represented only 36% of the children's diet on the day of the recall, they significantly improved their nutrient intakes
- Our results also showed that, for the same level of consumption of traditional foods, the consumption of healthy store-bought foods such as tomato products and calcium-rich foods reduced mercury and lead exposure, respectively
- Funding received in 2013-2014 was devoted to the preparation of communication tools for disseminating our study findings, in collaboration with the Nunavik Nutrition and Health Committee (NNHC)

chez ces enfants inuits d'âge préscolaire comparativement aux autres populations inuites du Nunavik, tandis que les concentrations de certains ignifuges bromés, une classe de contaminants en émergence, étaient parmi les plus élevées au monde.

- Une proportion importante des enfants ne consommaient pas le nombre de portions recommandé dans le *Guide alimentaire canadien* pour manger sainement, ce qui concorde avec les faibles apports en nutriments et la forte prévalence des carences en fer et en vitamine D observés dans cette étude.
- Même si les aliments traditionnels ne représentaient que 36 % de la diète des enfants le jour du rappel, ils amélioraient significativement leurs apports en nutriments.
- Nos résultats montrent également que, pour un niveau équivalent de consommation d'aliments traditionnels, la consommation d'aliments sains du commerce, tels que les produits à base de tomates et les aliments riches en calcium, atténuait l'exposition au mercure et au plomb, respectivement.
- Le financement reçu en 2013-2014 a été consacré à la préparation d'outils de communication pour diffuser les résultats de nos études, en collaboration avec le Comité de la nutrition et de la santé du Nunavik (CNSN).

Objectives

The **long-term objectives** of the project are:

1. To document the contaminant nutrient interactions in Nunavik children of preschool age.

2. To assist daycare directors, cooks and parents in making informed decisions concerning the benefits/risks of traditional/country foods among preschool children using dietary intakes, biochemical/hematological parameters and clinical information.

The **short-term objectives** of the project are:

1. To pursue the development of a communication plan to inform target audiences about the key findings of the study.

2. To communicate the key findings of the study according to the communication plan developed with an Advisory Committee composed of members of the NNHC.

3. To continue analysis of data on the relationship between blood levels of persistent organic pollutants (POPs), food components/nutrients and nutritional status of children and on changes between the initial and follow-up visit (one year later) and communicate these results as they become available.

Introduction

The harvesting, processing, sharing and consumption of traditional/country foods are beneficial to the Canadian Arctic Indigenous Peoples for cultural, social, psychological, socioeconomic and nutritional well-being (Donaldson et al. 2010). Among other benefits, consumption of one or more servings of traditional food significantly improved dietary quality in children (Gagné et al. 2012; Johnson-Down and Egeland 2010; Kuhnlein and Receveur 2007; Nakano et al. 2005). However, these multiple benefits have to be weighed against the detrimental effects of contaminants that are bio-amplified in Arctic food webs (Donaldson et al. 2010). In particular, heavy metals and POPs are recognized as significant neurotoxic agents and can lead to developmental deficiencies and learning disabilities in young children (Huntington 2009).

Results from mechanistic, experimental and observational studies suggest that various nutrients and diet components can modulate the effects of contaminants on health (Donaldson et al. 2010). Studies have documented that a higher dietary calcium intake provides a protective effect against lead exposure in children and infants (Elias et al. 2007; Lacasana et al. 2000; Schell et al. 2004; Turgeon O'Brien et al. 2014b). One possible mechanism for explaining this observation is that a diet rich in calcium could reduce lead absorption in the intestine through competition for binding sites (Blake and Mann 1983; Heard and Chamberlain 1982). Unfortunately, low calcium intakes are a concern in Inuit preschool-aged children (Turgeon O'Brien et al. 2014b). Moreover, an alarming proportion of these children had a low serum vitamin D level (El Hayek et al. 2010; Gagné et al., unpublished data) which reduces calcium absorption, thereby enhancing lead absorption and blood lead levels. In addition, lead and iron share the same transporter for intestinal absorption (Ballatori 2002). As a result, iron deficiency increases lead absorption, whereas lead exposure can produce anemia by interfering with the biosynthesis of heme (constituent of hemoglobin) in the bone marrow (Peraza et al. 1998). Studies carried out in children and teens around the world, including preschoolers attending childcare centres in Nunavik, indicate that iron deficiency is associated with higher blood lead levels (Ahamed et al. 2007; Schell et al. 2004; Turgeon O'Brien et al. 2009;

Willows and Gray-Donald 2002). Also, fruit consumption may provide a protective effect for mercury exposure in humans (Passos et al. 2003; Passos et al. 2007). Soluble fibre content of fruits and other prebiotic nutrients could be interfering with mercury absorption in the intestine (Passos et al. 2007). Furthermore, our results in Inuit preschoolers suggest a protective effect of tomato products on blood mercury levels (Gagné et al. 2013b). Nutritional factors contained in tomato products, such as the powerful antioxidant lycopene, could influence methylmercury elimination from the body.

Research is needed to examine the influence of various nutrients and diet components on contaminant exposure and toxicity in humans. This is particularly relevant in children from the Canadian Arctic in whom nutritional deficiencies or inadequate intakes have been reported for several nutrients, including iron, calcium and vitamin D (Turgeon O'Brien et al. 2014b; Gagné et al. 2012; El Hayek et al. 2010; Johnson-Down and Egeland 2010; Pacey et al. 2010).

Activities for 2013-2014

This year was mainly dedicated to the production of communication tools for dissemination of results to target audiences including parents and frontline workers in Nunavik. We also continued the analysis of our data on blood contaminant levels (mainly on PBDEs).

1. *Communications*

We worked with the Advisory Committee on a communication plan and key messages based on our research findings. The support of the Advisory Committee is important in order for the communication activities to better reflect the sociocultural background of the Nunavik population and be in agreement with the health promotion initiatives of the Nunavik Regional Board of Health and Social Services (NRBHSS) and the NNHC.

With less than a third of the funding initially requested (from the original request of $129,004 to 40,000$), we produced the following material based on our key findings:

- 5 fact sheets for parents and frontline workers on: (i) Nunavik Food Guide and country foods; (ii) Vitamin D; (iii) Iron; (iv) Mercury and lead; (v) PBDEs;
- 1 background document on vitamin D deficiency and supplementation, intended for the NRBHSS and the NNHC;
- 3 short scripts for Web-based capsules on (i) Vitamin D; (ii) Iron; (iii) Mercury and lead.

2. *Capacity Building*

Our communication activities contribute to our objective of assisting daycare directors, cooks and parents in making informed decisions concerning the benefits/risks of traditional/ country foods among preschool Inuit children.

3. Traditional Knowledge Integration

The Inuit values, beliefs and traditional knowledge about foods, nutrition and care for children are taken into account when interpreting and communicating our research findings. We made sure that our Advisory Committee included Inuit members to ensure that our results on contaminant nutrient interactions are interpreted in an appropriate manner and communicated in a way that is useful particularly to Nunavimmiut.

Results

Our main results to date can be drawn from selected abstracts of our articles published in peer-reviewed journals or in preparation.

- Citation from Turgeon O'Brien, H., R. Blanchet, D. Gagné, J. Lauzière, C. Vézina, È. Vaissière, P. Ayotte, S. Déry. (2012):

"Arctic populations are exposed to substantial levels of environmental contaminants that can negatively affect children's health and development. Moreover, emerging contaminants have never been assessed in Inuit children. In this study, we document the biological exposure to toxic metals and legacy and emerging persistent organic pollutants (POPs) of 155 Inuit children (mean age 25.2 months) attending childcare centers in Nunavik. Blood samples were analyzed to determine concentrations of mercury, lead, polychlorinated biphenyls (PCBs), pesticides, brominated flame retardants [*e.g.*, polybrominated diphenyl ethers (PBDEs)] and perfluoroalkyl and polyfluoroalkyl substances [PFASs; *e.g.* perfluorooctanesulfonate (PFOS) and perfluorooctane (PFOA)]. Lead [geometric mean (GM) 0.08 µmol/L], PCB-153 (GM 22.2 ng/g of lipid), BDE-47 (GM 184 ng/g of lipid), PFOS (GM 3369 ng/L), and PFOA (GM 1617 ng/L) were detected in all samples. Mercury (GM 9.8 nmol/L) was detected in nearly all blood samples (97%). Levels of metals and legacy POPs are consistent with the decreasing trend observed in Nunavik and in the Arctic. PBDE levels were higher than those observed in many children and adolescents around the world but lower than those reported in some U.S. cities. PFOS were present in lower concentrations than in Nunavimmiut adults. There is a clear need for continued biomonitoring of blood contaminant levels in this population, particularly for PBDEs and PFASs."

- Citation from Gagné, D., R. Blanchet, J. Lauzière, É. Vaissière, C. Vézina P. Ayotte, S. Déry, H. Turgeon O'Brien (2012):

  "OBJECTIVES: To describe traditional food (TF) consumption and to evaluate its impact on nutrient intakes of preschool Inuit children from Nunavik. DESIGN: A cross-sectional study. METHODS: Dietary intakes of children were assessed with a single 24-hour recall (n=217). TF consumption at home and at the childcare centres was compared. Differences in children's nutrient intakes when consuming or not consuming at least 1 TF item were examined using ANCOVA. RESULTS: A total of 245 children attending childcare centres in 10 communities of Nunavik were recruited between 2006 and 2010. The children's mean age was 25.0±9.6 months (11-54 months). Thirty-six percent of children had consumed at least 1 TF item on the day of the recall. TF contributed to 2.6% of total energy intake. Caribou and Arctic char were the most reported TF species. Land animals and fish/shellfish were the main contributors to energy intake from TF (38 and 33%, respectively). In spite of a low TF intake, children who consumed TF had significantly ($p<0.05$) higher intakes of protein, omega-3 fatty acids, iron, phosphorus, zinc, copper, selenium, niacin, pantothenic acid, riboflavin, and vitamin B12, and lower intakes of energy and carbohydrate compared with non-consumers. There was no significant difference in any of the socio-economic variables between children who consumed TF and those who did not. CONCLUSION: Although TF was not eaten much, it contributed significantly to the nutrient intakes of children. Consumption of TF should be encouraged as it provides many nutritional, economic, and sociocultural benefits."

- Citation from Gagné, D., J. Lauzière, R. Blanchet, C. Vézina, É. Vaissière, P. Ayotte H. Turgeon O'Brien (2013):

  "Some evidence suggests that various diet components and nutrients, including vegetables, fruit and food-derived antioxidants, could mitigate contaminant exposure and/or adverse health effects of contaminants. To examine the effect of the consumption of tomato products on blood mercury levels in Inuit preschool children, 155 Inuit children (25.0±9.1months) were recruited from 2006-2008 in Nunavik childcare centers (northern Québec, Canada). Food frequency questionnaires were completed at home and at the childcare center, and total blood mercury concentration was measured by inductively coupled plasma-mass spectrometry. Multivariate regression analysis was performed after multiple imputation. The median blood concentration of mercury was 9.5nmol/L. Age, duration of breastfeeding, annual consumption frequency of seal meat, and monthly consumption frequency of tomato products were significant predictors of blood mercury levels, whereas annual consumption frequencies of beluga muktuk, walrus, Arctic char, and caribou meat were not. Each time a participant consumed tomato products during the month before the interview was associated with a 4.6% lower blood mercury level (p=0.0005). All other significant predictors in the model were positively associated with blood mercury levels. Further studies should explore interactions between consumption of healthy store-bought foods available in Arctic regions and contaminant exposure."

- Citation from Gagné, D., R. Blanchet, É. Vaissière, J. Lauzière, C. Vézina, C. Vinet-Lanouette, H. Turgeon O'Brien (2013):

  "PURPOSE: We assessed the impact of a nutrition program implemented in Nunavik childcare centres on Inuit children's food and dietary intakes. METHODS: Two hundred and forty-five Inuit children (aged 25.0 ± 9.6 months) were recruited between 2006 and 2010 in Nunavik childcare centres. Dietary intakes were assessed using a single 24-hour dietary recall (n=217). We compared participants' energy and nutrient intakes, and the proportions who met iron requirements and Canada's Food Guide - First Nations, Inuit and Métis recommendations, depending on whether or not they attended a childcare centre during the 24-hour dietary reference period. RESULTS: Children who attended a childcare centre on the day of the recall had significantly higher intakes of omega-3 fatty acids, calcium, total iron, bioavailable iron, phosphorus, beta-carotene, folate, pantothenic acid, riboflavin, and vitamin K, while a higher proportion of them met the recommended intake for total and bioavailable iron. The proportion of children who met the recommended servings for vegetables and fruit, grain products, and milk and alternatives was also significantly higher among participants who attended a childcare centre. CONCLUSIONS: The nutrition program was effective at improving these Inuit preschoolers' diet."

- Citation from Blanchet, R., J. Lauzière, D. Gagné, C. Vézina, P. Ayotte, H. Turgeon O'Brien (2013):

  "OBJECTIVES: To assess dietary fatty acid intakes and to examine the relationship between dietary sources of n-3 and n-6 PUFA and red-blood-cell (RBC) n-3 and n-6 PUFA composition. DESIGN: A cross-sectional study. Dietary intakes were assessed with a 24 h dietary recall. A second recall was performed for 44 % of the children. Usual dietary intakes were estimated with the Software for Intake Distribution Estimation (SIDE). The fatty acid composition was measured in RBC membranes. Multivariate linear regression analyses were performed to explain RBC n-3 and n-6 PUFA concentrations. SETTING: Child-care centres in Nunavik, northern Québec, Canada. SUBJECTS: One hundred and sixty-seven Inuit children aged 11-53 months. RESULTS: A high proportion of the participants had inadequate n-3 and n-6 PUFA intakes (47·9 % and 93·5 %, respectively). Breast-feeding status and consumption of traditional food during the first 24 h dietary recall were significantly associated with RBC n-3 PUFA levels. Older children also tended to have higher RBC n-3 PUFA levels (P = 0·0528), whereas sex, infant formula status and n-3 PUFA dietary intakes were not associated with RBC n-3 PUFA concentrations. RBC n-6 PUFA concentrations were positively associated with breast-feeding status and n-6 PUFA dietary intakes, whereas age, sex and infant formula status were not. CONCLUSIONS:

The present findings highlight the fact that Inuit pre-school children are not consuming enough n-3 and n-6 PUFA for optimum health. These observations call for actions to increase traditional food intake among Inuit children and to help them and their parents make healthier store-bought food choices."

- Citation from Turgeon O'Brien, H., D. Gagné, É. Vaissière, R. Blanchet, J. Lauzière, C. Vézina, P. Ayotte (2014):

  "High blood lead levels (BLLs) can be found in Inuit from Nunavik. At the same time, various nutrients such as calcium could lower lead absorption and toxicity. We examined the effect of dietary calcium intakes on BLLs in 245 preschool Inuit children attending childcare centres in Nunavik. Calcium intake was assessed with one 24-h dietary recall and BLLs were determined by inductively coupled plasma mass spectrometry in whole blood samples. Multiple imputation was performed to deal with missing data. Median blood lead concentration was 0.08 μmol/L. A high proportion of children did not meet the Estimated Average Requirement for vitamin D intake (73 %) and, to a lower extent, for calcium (20 %). Calcium intake was negatively associated with BLLs ($p = 0.0001$) while child's age and energy intake were positively associated with BLLs ($p = 0.015$ and $p = 0.024$, respectively). Consuming traditional foods rich in calcium as well as milk and alternatives may protect against lead exposure."

- Citation from Turgeon O'Brien, H., R. Blanchet, D. Gagné D, J. Lauzière, C. Vézina (2014):

  "In infants and children, iron deficiency (ID) can have several adverse effects on health including lethargy, alterations of immune defense mechanisms and impaired growth and cognitive development. The purpose of this study was to determine the prevalence of ID in a group of preschool Inuit children attending childcare centres in Nunavik using conventional measurements of iron status and a relatively new parameter, soluble transferrin receptor (sTfR). sTfR is thought to be unaffected by infection or inflammation. Two hundred forty-five Inuit children aged between 11 and 54 months (mean (SD) = 25.0 (9.6) months) were recruited between 2006 and 2010 in 10 of the 14 Nunavik communities. About half of the children were male and 52.3% (n=128) were less than 24 months old at the time of the study. Sixty-five children were excluded because they lacked one or more of the parameters under analysis, leaving 180 subjects for the assessment of iron status. ID defined either as serum ferritin <15 mg/L, sTfR >1.55 or sTfR-ferritin index (sTfR/log ferritin) >1.5 was found in 73.2% of non-anemic subjects. Anemia (hemoglobin (Hb) <110 g/L (12-35 months old) or <112 g/L (36-59 months old)) was present in 15% of children, while 7.2% suffered from iron deficiency anemia (IDA) (ID and C-reactive protein (CRP) <6 mg/L), and 5% from IDA and coexisting anemia of inflammation (ID and CRP ≥6 mg/L). Iron deficiency constitutes a significant public health problem in these Canadian Aboriginal children. Measures to improve iron intake and bioavailability are required and consumption of traditional food rich in iron should be encouraged."

Discussion and conclusion

Arctic Indigenous Peoples face significant challenges resulting from the contamination of Arctic air, water, soil and certain traditional foods by heavy metals and POPs. Our results on heavy metals and legacy POPs are consistent with biomonitoring studies showing a decreasing trend in blood levels and a decreasing prevalence of people exceeding the levels of concern for these contaminants in Nunavik and elsewhere in the Arctic (Dewailly et al. 2007a; Dewailly et al. 2007b; AMAP 2009; Turgeon O'Brien et al. 2012). However, we observed higher levels of PBDEs in Nunavik preschoolers compared to those reported in Nunavik adults and in many children and adolescents worldwide (Turgeon O'Brien et al. 2012). This may be partially explained by a higher exposure of toddlers to PBDEs through dermal contact and dust ingestion because of their mouthing behaviour, and reflects higher quantities of PBDEs in indoor environments in Nunavik. Our results also suggest that many Inuit preschool children have an inadequate nutritional intake and/or a poor nutritional status, especially in iron, calcium and vitamin D (Gagné et al. 2013a; Gagné et al., unpublished data; Turgeon O'Brien et al. 2014a; Turgeon O'Brien et al. 2014b), which is similar to observations made in Nunavut (El Hayek et al. 2010; Johnson-Down and Egeland 2010; Pacey et al. 2010). Although traditional food (TF) represents only a small proportion of the children's diet (36% had consumed at least 1 TF item on the day of the recall), we confirmed previous studies showing that it significantly improves their nutrient intake (Gagné et al. 2012; Johnson-Down and Egeland 2010; Kuhnlein and Receveur 2007; Nakano et al. 2005). Thus, it shows the importance of exploring ways to promote the consumption of traditional foods. Finally, our results show that, for the same level of consumption of traditional foods, children who had eaten tomato products and calcium-rich foods had lower blood levels of mercury and lead exposure, respectively (Gagné et al. 2013b; Turgeon O'Brien et al. 2014b). In accordance with other observational studies, as well as experimental studies (Passos et al. 2003; Passos et al. 2007), our findings suggest that eating healthy store-bought foods in addition to traditional foods could help benefit from traditional food, while reducing contaminant exposure associated with these foods.

A large quantity of data has been collected for this project, and only a part has been analysed so far. Data analysis will continue in order to explore the relationships between blood contaminant levels, food components/nutrients and nutritional status of children, and changes between the initial and follow-up visit (one year later). These new results will be communicated to the appropriate audiences as they become available. Additional research projects are also needed in order to clarify the influence of various nutrients and diet components on contaminant exposure and toxicity in humans.

Expected Project Completion Date

Communication of results is ongoing and should be completed within the next year (2014).

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Monitoring of environmental pollutants in maternal blood in Nunavik: time trend assessment and evaluation of the Arctic Char program

Surveillance des concentrations de polluants environnementaux dans le sang maternel au Nunavik : analyse évolutive des tendances et évaluation du programme visant l'omble chevalier

Project Leader:

Dewailly Éric. MD PhD Population and Environmental Health Unit Centre de Recherche du Centre Hospitalier Universitaire de Québec (CR-CHU); Québec (Qc). E-mail: eric.dewailly@crchul.ulaval.ca

Pierre Ayotte. Ph.D, Axe en santé des populations et environnementale. CR-CHU and INSPQ. 945. rue Wolfe. Sainte-Foy. Qc. Canada. E-mail: pierre.ayotte@inspq.qc.ca

Gina Muckle. Ph.D, Axe en santé des populations et environnementale. CR-CHU de Québec. E-mail: gina.muckle@crchul.ulaval.ca

Michel Lucas. PhD, RD, Axe santé publique et pratiques optimales en santé, Centre de recherche du CHU de Québec. E-mail: Michel.Lucas@crchuq.ulaval.ca

Mélanie Lemire, PhD, Banting post-doctoral fellow, Axe santé publique et pratiques optimales en santé, Centre de recherche du CHU de Québec. E-mail: Melanie.Lemire@crchuq.ulaval.ca

Catherine Pirkle. PhD, Post-doctoral fellow, Axe santé publique et pratiques optimales en santé, Centre de recherche du CHU de Québec. E-mail: catherinepirkle@gmail.com.

Thérèse Adamou, MSc (PhD student), Axe en santé des populations et environnementale. CR-CHU de Québec.

Project Team Members and their Affiliations:

Suzanne Côté MSc, Axe en santé des populations et environnementale. CR-CHU de Québec; Marie-Josée Gauthier RN, Amélie Bouchard, Nunavik RBHSS, (Kuujjuaq) ; Derek Muir, PhD, Section Head, Environment Canada, Atmosphere, Water and Soil Contaminant Dynamics; Jonathan Verreault. PhD. Université du Québec à Montréal

Abstract

Previous studies revealed that the Inuit population was exposed to a wide range of environmental contaminants. Unfortunately, some studies showed that prenatal exposure to several of these pollutants (mercury and some Persistent organic Pollutants (POPs)) was associated with effects on growth and cognitive development in children. Over the last 20 years, several research projects were therefore implemented to 1) monitor exposure of Inuit pregnant women to environmental contaminants, 2) ensure their blood levels do not exceed the threshold limit values recommended by Health Canada and 3) facilitate the implementation of prevention programs related to this issue (at regional, national and international levels). Since 1992, through these different projects, blood samples in Inuit pregnant women from Nunavik were collected several times. However, no blood samples have been collected since 2004. The current project aimed to extend the collection of biomonitoring data on maternal contaminant blood levels to investigate temporal trends on a 20-year period. Since the beginning of this project in 2011, 112 pregnant women were recruited. In addition, 95 additional Inuit pregnant women accepted to participate this year. Preliminary temporal trend analyses suggest a marked decrease of Inuit pregnant women exposure to several metals and POPS of concern over the last two decades. Spatial trend analyses (conducted on the basis of data newly collected) suggest some differences in contaminant blood levels between residents from Hudson Bay, Hudson Strait and Ungava Bay. Contrary to previous years, data on Inuit pregnant women's food security were also collected this year. Analyses revealed that more than a half of participants interviewed in 2013 were severely food insecure.

Résumé

Des études antérieures ont révélé que la population inuite était exposée à une vaste gamme de contaminants environnementaux. Malheureusement, certaines études montrent que l'exposition prénatale à plusieurs de ces polluants (mercure et certains polluants organiques persistants [POP]) était associée à des effets sur la croissance et le développement cognitif des enfants. Au cours des 20 dernières années, plusieurs projets de recherche ont par conséquent été mis en place pour 1) surveiller l'exposition des femmes inuites enceintes aux contaminants environnementaux, 2) s'assurer que les concentrations sanguines ne dépassent pas les valeurs limites d'exposition recommandées par Santé Canada et 3) faciliter la mise en œuvre de programme de prévention à cet égard (aux échelons régional, national et international). Depuis 1992, par l'entremise de ces différents projets, des échantillons de sang ont été prélevés à plusieurs reprises chez des femmes inuites enceintes au Nunavik. Toutefois, aucun échantillon de sang n'a été recueilli depuis 2004. Le présent projet visait à poursuivre la collecte de données de biosurveillance sur les concentrations sanguines de contaminants chez les mères en vue d'étudier les tendances temporelles sur une période de 20 ans. Depuis le début de ce projet en 2011, 112 femmes enceintes ont été recrutées. De plus, 95 autres femmes enceintes inuites ont accepté de participer cette année. Les analyses préliminaires des tendances temporelles donnent à penser que l'exposition des femmes enceintes inuites à plusieurs métaux et POP préoccupants a connu une diminution marquée au cours des deux dernières décennies. Les analyses des tendances spatiales (réalisées à partir des données nouvellement recueillies) semblent indiquer l'existence de quelques différences entre les concentrations sanguines de contaminants des résidents de la baie d'Hudson, du détroit d'Hudson et de la baie d'Ungava. Contrairement aux années précédentes, des données sur la sécurité alimentaire des femmes enceintes ont aussi été recueillies cette année. Les analyses ont révélé que plus de la moitié des participantes interrogées en 2013 étaient en situation d'insécurité alimentaire grave.

Key Messages

- Lead, mercury and several legacy POPs have significantly decreased over the last 20 years (-70% of decrease) in Nunavik Inuit pregnant women's blood contents
- In 2012-2013, pregnant women from Hudson Strait presented overall higher contaminant blood concentrations than pregnant women from Hudson Bay or Ungava Bay
- 53% of pregnant women interviewed were severely food insecure, and of these, 23% had the most severe form of food insecurity

Messages clés

- Les concentrations sanguines de plomb, de mercure et de plusieurs POP utilisés par le passé ont connu une diminution importante (de l'ordre de 70 %) au cours des 20 dernières années chez les femmes inuites enceintes au Nunavik.
- En 2012-2013, les femmes enceintes du détroit d'Hudson présentaient des concentrations sanguines en contaminants globalement supérieures à celles des femmes enceintes vivant dans la baie d'Hudson ou la baie d'Ungava.
- 53 % des femmes enceintes interrogées étaient en situation d'insécurité alimentaire grave; parmi celles-ci, 23 % étaient touchées par la forme d'insécurité alimentaire la plus grave.

Objectives

The general objective of this project is to *monitor prenatal exposure to food chain contaminants in Nunavik and to evaluate the efficacy of the Arctic char distribution program*. Targeted contaminants include the traditional suite of contaminants measured in previous projects since the mid-80s [polychlorinated biphenyls (PCBs), organochlorine pesticides, brominated flame retardants (BFR), mercury (Hg) and lead (Pb)]. Emerging contaminants include non traditional flame retardants and SCCPs.

The specific objectives are:

1. To follow temporal trends for contaminants and assess the effectiveness of the Stockholm convention and the UNEP convention on Hg. At the same time, by establishing this monitoring activity, Canada will meet AMAP requirements. We will continue the monitoring in Hudson Bay and expand the program to Ungava Bay where data are missing.
2. To follow temporal trend of key nutrients from traditional diet such as omega-3 fatty acids (n-3 FA) and selenium (Se) in order to interpret contaminants trends.
3. To detect and quantify new emerging contaminants which have never been measured in maternal blood in the Arctic (chlorinated paraffins, etc.).
4. To evaluate the efficacy of the Arctic Char program in Hudson Bay
5. To use the monitoring program for evaluation purposes on neonate health (nutritional policies, alcohol consumption, smoking, etc).

Introduction

Three studies (fully or partially funded by NCP) were carried out in Nunavik to address temporal trends of POPs in Inuit populations. The first study addressing temporal trends of environmental contaminants in Nunavik was carried out on cord blood data obtained in earlier surveys and addressed POPs and heavy metals (Dallaire et al 2003). In that study, 251 cord blood samples, collected between 1993 and 1996 on the east coast of Hudson Bay (Puvirnituq Inukjuak Kuujjuaraapik) were analyzed for PCBs, chlorinated pesticides, lead and mercury. Significant decreasing trends were noted for PCBs (7.9-%/year), DDE (9.1-%/year), DDT (8.2-%/year) and HCB (6.6-%/year). Significant reductions were also found for lead and mercury although no clear trend could be established.

Between 1996 and 2001, a birth cohort was established in Nunavik; 213 pregnant women from Hudson Bay were enrolled. Pb, Hg, n-3 PUFAs and legacy POPs were measured in maternal and umbilical cord blood samples (Muckle 2004). This ongoing cohort study has already revealed that subtle developmental and cognitive deficits are related to prenatal exposure to mercury and different OCs and those beneficial effects are associated with high n-3 PUFA intake. The effects of prenatal exposure to emerging contaminants such as PBDEs and other BFRs, HPCs and PFOS have not yet been investigated.

In fall of 2004, pregnant women participating to the Nunavik Health Survey were included in a POPs monitoring study, a procedure which also prevented women to be solicited twice for different studies. Blood samples for contaminants analyses were sampled during the Nunavik Health Survey and dedicated to measurements of environmental contaminants (among other parameters pertaining to the health survey).

This project not only aimed assessing exposure to environmental contaminants through maternal blood monitoring but it also proposed to examine n-3 PUFAs and selenium content in order to interpret any change in contaminant body burdens.

Monitoring and supporting of a food distribution activity, such as the Arctic char Program for pregnant Inuit women, has not been done so far in Nunavik. This NCP project will allow us to monitor the primary outcomes of interest (blood levels of MeHg, n-3 FA and Se) among pregnant women of the experimental group (Arctic char distribution program in Hudson Bay) and the control group (Ungava Bay), at the beginning (first trimester) of the intervention. The CIHR project (Lucas M et al., December 2012 competition) will also measure outcomes of interest at the end of pregnancy in all recruited women in both projects.

Activities in 2013-2014

Data collection

The field work was prepared at the beginning of year 2013, as a research nurse was trained during summer time in Quebec City by the project coordinator. All supplies were provided to her in order to properly collect samples and data on site (vacutainers, vials, questionnaires, centrifuge, etc.), and to be as much autonomous as possible during her field work in Nunavik. Pregnant Inuit women were invited to participate and once the eligibility criteria was verified, the research nurse explained the objectives of the project, the questionnaire, the sampling procedures, risks/benefits associated with their participation to the program and the need to collect data from their medical file. Informed consent was sought from all 95 participants. The research nurse was assisted by a local recruiter/interpreter in each community. Moreover, the research nurse collected the information requested from the medical file for the 95 participants from year 2012-2013. One visit was done on site by the research nurse, between September to November 2013. Letters were sent to participants with abnormal results concerning the following analytes: vitamins A and D, folic acid, mercury and lead. We considered important a follow up on these specifics results during their pregnancy to improve the mother and foetus health status.

Analyses of emerging contaminants:

PBDEs and emerging halogenated flame retardant analysis

Human plasma samples were analyzed for 38 PBDE congeners and 16 emerging halogenated flame retardant (HFRs) in Jonathan Verreault's laboratory at the Université du Québec à Montréal (Montreal, QC). Plasma samples were ground with diatomaceous earth, spiked with five internal standards (BDE-30, BDE-156, ^{13}C-BDE-209, ^{13}C-*syn*-DP, and ^{13}*C-anti*-DP), and extracted with dichloromethane:*n*-hexane (50:50) using a pressurized liquid extraction system (PLE) (Fluid Management Systems, Watertown, MA, USA). Lipids were determined gravimetrically. Sample clean-up was achieved using a PBDE-free silica acid-basic-neutral (ABN) column followed by a PBDE-free neutral alumina column with dichloromethane:n-hexane (50:50) (Fluid Management Systems). Identification and quantification of target PBDEs/HFRs was performed using a gas chromatograph (GC) coupled to a single quadrupole mass spectrometer (MS) (Agilent Technologies 5975C Series, Palo Alto, CA, USA) operating in the electron capture negative ionization mode (GC/MS-ECNI) following methods by Gentes et al. (2012). Quantification of PBDEs/HFRs was achieved using selected ion monitoring (SIM) mode. Procedures included method blanks and injection of standard reference material (SRM) (NIST 1947 Lake Michigan fish tissue) for each batch of ten samples. Blank correction was necessary due to low concentrations determined in current plasma samples. Mean (± SD) internal standard recoveries from samples, blanks and SRM were as follows: BDE-30 (99.2 ± 13.8%), BDE-156 (90.9 ± 12.5%), ^{13}C-BDE-209 (49.4 ± 20.9%), ^{13}C-*syn*-DP (91.4 ± 10.8%) and ^{13}*C-anti*-DP (91.9 ± 11.2%). Concentrations of PBDEs/HFRs in all samples were quantified using an internal standard approach, and thus all analyte concentrations were inherently recovery-corrected. PBDE concentrations (seven congeners) determined in SRM 1947 showed less than 21.9% deviation from certified values. This laboratory has participated in an inter-laboratory comparison for these analytes with the National Wildlife Research Centre/Environment Canada (Ottawa, ON), which has been certified by the CAEAL. Method limits of detection (MLODs) and method limits of quantification (MLOQs) were based on replicate analyses (n = 8) of matrix samples spiked at a concentration of 3-5 times the estimated detection limit. MLODs (defined as S/N = 3) and MLOQs (minimum amount of analyte producing a peak with a signal to noise ratio (S/N) of 10).

SCCP analysis

Human plasma samples will be extracted at CTQ's laboratory using the same procedure as that described for legacy POPs, following the addition of the following internal standards: 13C6-hexachlorobenzene, 13C6-α-HCH, 13C10-trans-nonachlor, 13C12-dieldrin, 13C9-α-endosulfane, 13C12- p,p'-DDE, 13C12-PCB 141, 13C12-PCB 153, 13C12-PCB 180, 13C12-PCB 194, 13C12-PBDE 77 and 13C12-PBDE. The extracts will be analysed for SCCP in Ed Sverko's laboratory (Environment Canada, Burlington, ON) using high resolution GC-negative ion MS on a Thermo DFS high resolution mass spectrometer. Dr. Sverko is leading an international intercomparison on SCCP analysis.

Results AND DISCUSSION

Sociodemographic data

Average age of participants recruited in 2013 was 24.2 years. On the 95 Inuit pregnant women from Nunavik interviewed, 35.8% declared having completed elementary school or detain a higher school degree (partial schooling or diploma from a CEGEP, private college, technical institute or university). 72.3% of participants declared their marital status as "domestic partnership", 14.9% as "separated" and 3.2% as "married". Concerning incomes, a significant proportion of participants declared to not be able to estimate their personal incomes (56%) or familial incomes (81%).

Among women able to provide an approximated value of their personal earnings, 24.2% declared that their incomes were below $20,000/year and 13.6% that they ranged from $20,000 to $40,000/year. Sociodemographic data are presented in Table 1.

Contaminant temporal and spatial trends

Maternal blood concentrations in metals and several POPs measured in 2013 are presented in Table 2 (Only toxicants detected in 60% of the samples are presented). Contaminants blood levels in 2013 were globally on the same order than those reported the previous NCP synopsis. Mercury and lead blood concentrations in 2013 were respectively, 5.2 $ug.L^{-1}$ [0.3-32] and 14.1 $ug.L^{-1}$[4.2-61.2] (geometric mean; [range]).

Temporal trends: Temporal trends for selected contaminants (Hg, Pb and several legacy POPs) were investigated. Maternal contaminant blood concentrations measured in 1992 (n=11; Santé Québec Inuit Health Survey) were compared to levels measured in 2004 (n=26; Health Survey Qanuippitaa How we are?), in 2011/2012 (n=112; this project phase I & II) and 2013 (n=95; phase III). Temporal trend analyses were performed by using linear regression modeling. All models were adjusted for maternal age and region of residence (Ungava Bay or Hudson Bay). Given that all blood samples were collected during summer or autumn (*i.e.,* during hunting seasons), no adjustment for season was applied.

Statistical analyses suggest that blood levels in mercury and lead, as well as several legacy POPs, significantly decreased over the past 20 years (Table 3). The magnitude of decline seems to have been more significant from 1992 to 2004 than over the last ten years. However, contaminants blood levels of Inuit pregnant women seem to have dropped over 75% (on average) during the past 2 decades. These are very good news. However, these preliminary results have to be interpreted with caution. First, because only small sample sizes were available in 1992 (n=11) and 2004 (n=26) and secondly, because temporal trends were assessed regardless pregnancy stage, parity or the number of child breastfed.

The declines observed could result from a decrease in marine mammal food consumption by Inuit pregnant women, a reduction of environmental contamination or both (Dallaire et al, 2003). Fatty acids, including EPA, DHA+EPA, n3/n6 PFUA ratio, as well as selenium, are frequently considered as biomarkers of marine food consumption by Inuit (Jeppesen, 2012). Temporal trend analyses show no statistical significant changes in maternal blood levels for EPA, DHA+EPA, or selenium between 2004 and 2013 (data not shown). Maternal blood levels in omega 3 fatty acids (recognised for their health benefits (Boucher et al 2011)) remain very high in 2013 (data not shown).

Spatial trends: Spatial trends were also investigated. Contaminant concentrations found in blood of pregnant women residing in villages from Hudson Bay (n=104) were compared to levels measured in blood of residents from Hudson Strait (n=48) and Ungava Bay (n=54). The database was created by compiling data collected in 2011-2012 and 2013. Statistical analyses were performed by using regression linear models, after log transformation of data. All models were adjusted for mother age.

According to preliminary analyses, significant differences between pregnant women from the 3 sub-regions were observed for several metals and POPs. Overall, contaminant blood levels of participants from Hudson Strait villages were higher than those from Hudson Bay or Ungava Bay. Selenium blood concentrations of pregnant women residing in Hudson Strait were twice higher than levels of women from Hudson Bay and 1.2 higher than those from Ungava Bay. Concerning mercury, blood levels of mothers from Hudson Strait were 1.5 higher than those from Hudson Bay and Ungava Bay (Although, no statistical difference is detected: p-value=0.0841).

These results, which suggest significant differences in profiles of marine mammal food consumption, are consistent with observations made by Lemire et al. (unpublished). Further analyses are needed to identify causes of these regional variations. However, one assumption might be that differences observed are related to higher consumption of belugas in villages of Hudson strait (Lemire et al., unpublished).

Data on PBDEs and emerging halogenated flame retardants in the 15 plasma samples have been received and are currently being interpreted. *SCCP analysis:* The extraction of the 15 plasma samples is scheduled to take place by the end of May 2014 and sample extracts will be sent to Ed Sverko's laboratory early in June 2014.

Risk perception and knowledge on contaminants: A communication campaign aimed to provides result from the Nunavik Child Cohort study (NCCS) and disseminate recommendation related to country food consumption during pregnancy was launched in 2010. The recommendations especially addressed to pregnant women were 1) to decrease beluga meat consumption and 2) to increase omega 3 fatty acids intake during pregnancy (RRSSS, 2014). In 2012, 32.2% of pregnant women interviewed declared having heard about the health recommendations formulated by the RRSSS, and among these, 25% declared having modified their eating habits accordingly. In 2013, these proportions were respectively 43.6% and 9.3%. These results suggest a relative efficiency of communication tools used to reach Inuit pregnant women from Nunavik. However, they also put forward the need to provide additional efforts to encourage Inuit pregnant women to follow the RRSSS recommendations.

Food Security

Information regarding food security was also collected using questionnaires answered by 95 pregnant women recruited in 2013.

Prevalence of food Insecurity: Preliminary analyses revealed that 9% of participants were mildly food insecure, 18% were moderately food insecure and 53% were severely food insecure. Among these, 23% (22 women) had the most severe form of food insecurity - "*hunger*".

Determinants of Food Insecurity: Data suggests that access to country foods may protect against food insecurity. A greater proportion of food secure women, compared to food insecure women, were regularly able to access country foods, as well as obtain country foods from family or community members. A similar pattern was observed according to hunger status. Those categorized as *not hungry* came from households with significantly more hunters than those categorized as *hungry* (2 v.s. 1 hunter/ household).

Consequences of Food Insecurity: Women with food insecurity had lower micronutrient levels than women who were food secure. Women with hunger had lower micronutrient levels than those without hunger. These differences were marginally significant, despite the small sample size. Iron depletion was highly prevalent for the whole sample of women (60%). More food insecure women were iron deplete than secure women (63% versus 52%).

Table 1. Sociodemographic data of 95 Inuit pregnant women from Nunavik (2013)

Education level among pregnant women from Nunavik	N	%
No formal schooling	1	1.0
Elementary school completed	3	3.2
some years of secondary school	57	60
Secondary school completed	22	23.2
Partial schooling in a CEGEP. a private college or a technical institute	7	7.4
Diploma or certificate from a CEGEP. a private college or a technical institute	4	4.2
Some university (not completed)	0	0
University degree (completed)	1	1.0
Total	**95**	**100**

Marital status	N	%
Married	3	3.2
Divorced	0	0
Widowed	0	0
Domestic partnership	68	72.3
Separated	14	14.9
Never married	9	9.6
NR/R	0	0
DNK	0	0
Total	**95**	**100**

Incomes	Personal (%)	Familial (%)
Less than $ 20.000	24.2	7.4
$ 20.000 to less than $ 40.000	13.6	3.2
$ 40.000 to less than $ 60.000	1.1	1.0
$ 60.000 or more	3.2	4.2
Doesn't know	56.8	81.0
Refusal	2.1	3.2
Total	**100**	**100**

Table 2. Blood contaminant levels measured in Inuit pregnant women from Nunavik in 2013.

	N	Min	Max	Arithmetic mean	Geometric Mean [±IC 95%]
Metals (ug.L-1)					
Mercury	95	0,3	32,1	7,1	5,2 [4,3-6,3]
Lead	95	4,2	62,1	16,8	14,1 [12,5-15,9]
Selenium	95	126,4	1421,8	358,9	303,9 [271,5-340,3]
POPs (ug.kg lipid-1)					
cisnonachlor	95	0,2	28,7	8,2	5,9 [4,8-7,1]
Hexachlorobenzene	95	2	91,8	25,2	19,9 [17,1-23,2]
Mirex	95	0,5	23,5	4,4	3,1 [2,5-3,7]
Oxychlordane	95	0,9	129,3	32,6	22,3 [18,3-27,2]
p.p'-DDE	95	21,9	481,8	161,1	128,4 [111,1-148,3]
β-HCH	95	0,5	19,1	3,2	2,4 [2-2,8]
Toxaphene-26	95	0,2	47,1	8,6	5,8 [4,7-7,1]
Toxaphene-50	95	0,3	63,2	13,3	9,1 [7,5-11,2]
Transnonachlor	95	2	218,2	57,6	41,8 [34,8-50,3]
PCB 99	95	1,4	37,3	10,2	7,3 [6,1-8.7]
PCB 118	95	0,5	29,1	8,4	6,3 [5,3-7,4]
PCB 138	95	2	116,9	25,2	18,6 [15,7-22]
PCB146	95	0,5	30,8	6,9	5 [4,2-6]
PCB 153	95	3,5	323,1	57,7	40,4 [33,8-48,1]
PCB 163	95	0,5	32,3	7,3	5,1 [4,3-6,2]
PCB 170	95	0,5	52,9	8,2	5,2 [4,4-6,3]
PCB 178	95	0,5	17.3	3	2,1 [1,8-2,5]
PCB 180	95	1,7	196,1	26	16,6 [13,8-19,9]

	N	Min	Max	Arithmetic mean	Geometric Mean [±IC 95%]
PCB 183	95	0,5	23,1	3,2	2,3 [2-2,8]
PCB 187	95	0,5	53,9	12,3	9,2 [7,8-10,9]
PCB 194	95	0,5	49	4,6	2,6 [2,1-3,2]
PCB 201	95	0,5	45,1	4,5	2,9 [2,4-3,5]

Table 3. Contaminant concentrations found in blood of Inuit pregnant women from Nunavik between 1992 and 2013 (Geometric mean [± CI 95%]).

	1992 (n=11)	2004 (n=26)	2012 (n=112)	2013 (n=95)	% of decrease	P-value trend
Metals						
Hg (nmol.L-1)	59.7 [40.5.7-88.0]	41.4 [31.0-55.3]	24.8 [20.2-30.4]	25.9 [21.6-31.2]	-56.6	0.0028*
Pb (µmol.L-1)	0.20 [0.13-0.30]	0.09 [0.07-0.11]	0.06 [0.05-0.07]	0.07 [0.06-0.08]	-65	<0.0001*
Se (µmol.L-1)	NA	3.39 [2.86-4.01]	4.00 [3.58-4.48]	3.85 [3.44-4.30]	-13.57	0.1927*
POPS (ug.kg lipids-1)						
p,p'-DDE	635,7 [470,7-858,6]	242,1 [182,8-320,7]	123,4 [105,4-144,5]	128,4 [111,3-148,1]	-79,8	<0.0001*
p,p'-DDT	25,7 [16,5-40,1]	9,2 [7,2-11,7]	4,4 [3,9-4,8]	4,2 [3,8-4,7]	-83,7	<0.0001*
PCB 153	172,3 [136-218,4]	76,1 [56,2-103,2]	39,3 [32,9-46,8]	40,4 [33,9-48]	-76,6	<0.0001*
PCB 138	113,7 [88,7-145,6]	38,9 [29-52,1]	17,4 [14,7-20,6]	18,6 [15,7-21,9]	-83,6	<0.0001*
PCB 180	89,8 [70,4-114,5]	32,4 [23,6-44,4]	16,6 [13,8-20,1]	16,6 [13,9-19,8]	-81,5	<0.0001*
Trans-Nonachlor	113,6 [79,4-162,6]	68,8 [50,7-93,4]	36,7 [29,8-45,3]	41,8 [34,8-50,2]	-63,2	0.0004*
cis-Nonachlor	27,8 [19,2-40,3]	10,6 [7,9-14,2]	5,3 [4,4-6,5]	5,9 [4,8-7,1]	-78,8	<0.0001*
Hexacholorobenzene	95,4 [69,7-130,6]	35,3 [26,5-47]	17,9 [15,3-20,9]	19,9 [17,1-23,2]	-79,1	<0.0001*
Mirex	12,6 [8,9-17,8]	4 [2,9-5,4]	3 [2,6-3,6]	3 [2,5-3,6]	-76,2	<0.0001*
Oxychlordane	77,1 [51,7-115]	36,3 [26,6-49,4]	20,1 [16,4-24,7]	22,3 [18,4-27,2]	-71,1	<0.0001*
ß-HCH	12,3 [8,1-18,7]	4,4 [3,2-6,1]	2,4 [2-2,9]	2,4 [2-2,8]	-80,5	<0.0001*

* Significant difference using regressions adjusted for mother age and region of residence (Ungava bay or Hudson bay)

Table 4. Contaminant concentrations measured in 2012-2013 in blood of Inuit pregnant women from Hudson Bay, Hudson strait and Ungava Bay.

	Geometric mean [± 95% CI]			
	Hudson Bay (n=104)	Hudson Strait (n=48)	Ungava Bay (n=54)	P-value
Metals (ug.L-1)				
Mercury	4,6 [3,8-5,5]	7,1 [5,4-9,2]	4,6 [3,5-6,2]	0.0841
Lead	13,5 [12-15,1]	12,4 [10,7-14,4]	14,6 [11,89-17,8]	<0.0001*
Selenium	240,2 [222,5-259,4]	448,7 [373,8-538,5]	367,3 [313,7-430]	<0.0001*
POPS (ug.kg lipids -1)				
PCB153	40,2 [33,8-47,8]	46,9 [37,1-59,3]	33,7 [26,1-43,6]	0.1188
PCB138	16,89 [14,3-2]	21,28 [16,95-26,7]	17,3 [13,5-2]	0.22
PCB180	18,5 [15,4-22,3]	17,6 [14-22,3]	12,8 [9,8-16,8]	0.0252*
Cisnonachlor	4,8 [4-5,8]	7,7 [6,15-9,6]	5,6 [4,1-7,7]	0.0155*
ß-HCH	1,9 [1,59-2,2]	3,7 [2,9-4,7]	2,84 [2,2-3,6]	<0.0001*
Hexachlorobenzene	15,4 [13,2-18]	23,4 [19,3-28,3]	22,6 [18,3-27,9]	0.0011*
Mirex	3,3 [2,8-4]	3,5 [2,7-4,4]	2,3 [1,8-2,9]	0.0031*
Oxychlordane	19,4 [16-23,7]	30,27 [23,4-39,1]	18,07 [13,4-24,4]	0.014*
Transnonachlor	34,2 [28,4-41,2]	56,5 [44,4-71,8]	36,2 [26,2-49,9]	0.0089*
pp'-DDE	123 [105,5-143,4]	138,4 [111,7-171,6]	120,4 [97,6-148,4]	0.4837
pp'-DDT	4,1 [3,8-4,5]	4,1 [3,6-4,7]	4,9 [4,2-5,8]	0.1907
Toxaphene 26	3,9 [3,2-4,8]	7,3 [5,7-9,2]	5,9 [4,2-8,3]	0.002*
Toxaphene 50	6,2 [5,0-7,7]	11,8 [9,4-14,9]	8,9 [6,3-12,6]	0.0015*

Conclusions

Temporal trends on contaminants reported above suggest a marked decline of Inuit pregnant women exposure to mercury, lead and several legacy POPS over the last 2 decades. The decline observed could be due to 1) mostly by a reduction of environmental contamination by selected contaminants and/or 2) and a possible decrease in marine mammal food consumption by Inuit pregnant women. Although these results are consistent with conclusions provided by Donaldson et al (2010), these data have to be interpreted with great caution. Food security of pregnant women from Nunavik however appears as a significant and growing concern. More than a half of participants interviewed in 2013 were on severely food insecure. Access to traditional food was revealed as one way to protect against food insecurity. According to information presented above, efforts and initiatives aimed to promote or facilitate access of Inuit pregnant women to healthy country food should be encouraged.

Expected project completion date

March 2014

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Country foods and cardiovascular health in Nunavik: studying the complex balance between selenium and environmental contaminants (year 2)

Aliments traditionnels et santé cardiovasculaire au Nunavik : étude de l'équilibre complexe entre le sélénium et les contaminants environnementaux

- **Project Leader:**
  Pierre Ayotte, Ph.D., Centre de recherche du CHU de Québec, Université Laval and INSPQ, Québec, QC, Tel: (418) 650-5115 ext. 4654, Fax: (418) 654-2148
  E-mail: pierre.ayotte@inspq.qc.ca
- **Project Team Members and their Affiliations:**
  Mélanie Lemire, Ph.D., Banting-CIHR Postdoctoral fellow, Université Laval; Axe en santé publique et pratiques optimales en santé, Centre de recherche du CHU de Québec; Laurie Chan, Ph.D., Professor, University of Ottawa; Éric Dewailly, MD, Ph.D., Professor, Université Laval; Pierre Dumas, B.Sc., Chemist, Laboratoire de toxicologie, INSPQ; Brian Laird, Ph.D., Postdoctoral fellow, University of Ottawa; Michael Kwan, Ph.D., Nunavik Research Center (Kuujjuaq)

Abstract

Selenium (Se) is an essential element highly present in the traditional marine diet of Inuit and their exposure to this element is among the highest in the world. In fish and marine mammal eating populations, there is increasing evidence suggesting that high Se intake may play a role in offsetting some deleterious effects of methylmercury (MeHg) exposure. However, in other populations, elevated plasma Se concentrations have been recently associated to type 2 diabetes, hypercholesterolemia and/or hypertension. In addition to plasma Se levels, the most common biomarker of Se status, several other biomarkers (*e.g.*, selenoproteins and small Se molecules such as selenoneine) have been identified and these may help to

Résumé

Le sélénium (Se) est un élément essentiel très abondant dans l'alimentation traditionnelle, de source marine, des Inuits. Les Inuits figurent parmi les populations les plus exposées à cet élément au monde. Dans les populations qui se nourrissent de poissons et de mammifères marins, de plus en plus de données tendent à indiquer qu'un apport élevé en sélénium pourrait atténuer certains effets néfastes de l'exposition au méthylmercure (MeHg). Cependant, dans d'autres populations, des concentrations plasmatiques élevées de sélénium ont été récemment associées au diabète de type 2, à l'hypercholestérolémie et à l'hypertension. Outre la concentration plasmatique de sélénium, qui constitue le

better characterize Se status. Analyses of blood and plasma samples from Inuit adults revealed higher and more variable Se concentrations in blood compared to plasma. Speciation analyses using affinity chromatography/inductively coupled plasma mass spectrometry revealed that glutathione peroxidase, selenoprotein P and selenoalbumin (expressed in μg Se/L) represented on average respectively 25%, 52% and 23% of the total plasma Se concentration. In addition, a small amount of mercury (Hg) was found to coincide with each Se-containing protein. We will investigate relations between these new biomarkers of Se status and emerging health issues such as diabetes and cardiovascular diseases in Inuit adults, taking into account possible interactions with Hg and other environmental contaminants. Hg bioaccessibility (simulated solubilization of Hg into gastrointestinal fluids) ranged between 9% (Arctic char) and 95% (Ringed seal meat) whereas Se bioaccessibility ranged between 24% (Ringed seal liver) and 100% (Caribou meat). Hg bioavailability (*in vitro* absorption by intestinal enterocytes) also varied widely between types of food (Ringed seal liver 6%; Arctic char 68%). In contrast, Se absorption was remarkably consistent between food types (60 - 62%). The forthcoming data will improve our capacity to assess the risks and benefits of Se intake and the traditional marine diet in this population.

biomarqueur le plus usuel du statut à l'égard du sélénium, on a identifié plusieurs autres biomarqueurs (p. ex. les sélénoprotéines et de petites molécules contenant du sélénium, notamment la sélénonéine) qui pourraient aider à mieux caractériser le statut à l'égard du sélénium. Les analyses des échantillons de sang et de plasma d'Inuits adultes ont révélé que les concentrations de sélénium étaient supérieures et plus variables dans le sang en comparaison des concentrations plasmatiques. Des analyses de spéciation réalisées par chromatographie d'affinité/spectrométrie de masse avec plasma à couplage inductif ont révélé que la glutathion peroxydase, la sélénoprotéine P et la sélénoalbumine (exprimée en µg de Se/L) représentent en moyenne, respectivement, 25 %, 52 % et 23 % de la concentration plasmatique totale en sélénium. De plus, on a observé qu'une petite quantité de mercure (Hg) correspondait à chaque protéine contenant du sélénium. Nous étudierons les relations entre ces nouveaux biomarqueurs et les problèmes de santé qui commencent à apparaître chez les Inuits adultes (p. ex. le diabète et les maladies cardiovasculaires) en tenant compte des interactions possibles avec le mercure et d'autres contaminants environnementaux. La bioaccessibilité du mercure (simulation de la solubilisation du mercure dans les fluides gastro-intestinaux) se situait entre 9 % (omble chevalier) et 95 % (viande de phoque annelé), tandis que la bioaccessibilité du sélénium se situait entre 24 % (foie de phoque annelé) et 100 % (viande de caribou). La biodisponibilité du mercure (absorption in vitro par les entérocytes intestinaux) était elle aussi très variable selon le type d'aliment (6 % pour le foie de phoque annelé; 68 % pour l'omble chevalier). En revanche, l'absorption du sélénium était remarquablement uniforme d'un aliment à l'autre (60-62 %). Les données qui seront disponibles amélioreront notre capacité à évaluer les risques et les avantages associés à la consommation de sélénium et au régime marin traditionnel de cette population.

Key messages

- Blood selenium levels but not plasma levels are very high in some individuals, indicating selenium accumulation in blood cells (possibly as selenoneine)
- Beluga meat and nikku (air-dried) beluga and seal liver and lake trout contain very high total Hg concentrations
- Beluga mattaaq and *nikku*, walrus meat, marine mammal and caribou organs, and fish eggs are exceptionally high in total Se
- Hg bioaccessibility and bioavailability vary greatly between foods, with particularly low values observed for ringed seal liver
- Se bioaccessibility and bioavailability are generally higher than those observed for Hg

Messages clés

- Les concentrations de sélénium dans le sang, mais pas dans le plasma sont très élevées chez certaines personnes, ce qui révèle une accumulation de sélénium dans les cellules sanguines (possiblement sous la forme de sélénonéine).
- Les concentrations totales de mercure sont très élevées dans la viande de béluga, le béluga séché (*nikku*), le foie de phoque et le touladi.
- Le *mattaaq* et le *nikku* de béluga, la viande de morse, les organes de mammifères marins et de caribou, ainsi que les œufs de poisson ont une teneur totale en sélénium exceptionnellement élevée.
- La bioaccessibilité et la biodisponibilité du mercure varient considérablement d'un aliment à l'autre; les valeurs observées sont particulièrement basses dans le cas du foie de phoque annelé.
- La bioaccessibilité et la biodisponibilité du sélénium sont généralement supérieures à celles observées pour le mercure.

Objectives

The first section focuses on nutrient/contaminant interactions and their effects on cardio-metabolic health outcomes. The objectives are:

1. To measure various biomarkers of Se status [selenoproteins such as selenoprotein P (SelP), glutathione peroxidase (GPx) and thioredoxin reductase (TRxR), plasma total Se (P-Se), inorganic Se (Se+4 and Se+6), selenoneine, methylselenoneine, selenocysteine (SeCys), selenomethionine (SeMet) and selenoalbumin (SeAlb)] and determine Hg fractions [methylmercury (MeHg) and inorganic mercury (IHg)] in archived blood samples from the Inuit Health in Transition Study (on-going);
2. To examine the associations between these biomarkers, diabetes and cardiovascular risk factors, taking into consideration possible interactions with Hg, other contaminants, and omega-3 fatty acids (n-3 PUFAs).

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

1. To collect selected country foods from several Nunavik villages in collaboration with community members and the Nunavik Research Center of Makivik Corporation;

2. To determine the age of the animals sampled and measure total Se and Hg concentrations in the corresponding country food samples;

3. To measure Se and Hg species and to study the bioaccessibility of Se and Hg and Se-Hg interactions in these same country food samples using an *in vitro* model consisting of two components: (i) a bioaccessibility model that simulates the luminal physiochemical conditions of the gastrointestinal tract, and (ii) a bioavailability model that mimics the absorptive processes of human intestinal enterocytes (Caco-2 cell line). In terms of oral Hg exposure assessments, bioaccessibility describes the solubilization of Hg into gastrointestinal (GI) fluids while Hg bioavailability refers to Hg absorbed into the bloodstream.

4. To study the potential of specific locally-available foods (blueberries, blackberries, kuanniq seaweed, tomato paste and sculpin eggs) to mitigate Hg bioaccessibility of selected marine mammal-based country foods;

5. To evaluate the associations between Se and Hg bioaccessibility and bioavailability of country foods, and Se and Hg biomarkers in human.

Introduction

The Inuit population of Nunavik displays among the highest selenium (Se) intake and blood Se status in the world since their traditional marine mammal diet is exceptionally rich in Se (Lemire et al., submitted). 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 type-2 diabetes, hypercholesterolemia and hypertension (Stranges et al., 2010). Contrary to most European and North American populations, Inuit present an exceptionally high intake of n-3 PUFAs, 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 Se molecules such as selenoneine) have been identified and these may help to better characterise Se status (Xia et al., 2010) double-blind study of selenomethionine supplementation in selenium-deficient Chinese subjects. 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 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).

Several factors may also influence Se and Hg concentrations and bioavailability in country foods. 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 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 inorganic Hg-Se 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). 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 bioavailability of Hg in the gastrointestinal (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 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.

Moreover, these *in vitro* models can also offer an opportunity to test the effect of the co-consumption of other local foods such as wild berries, seaweed and other plants found in Nunavik, as well as tomato-derived products on Hg bioaccessibility and bioavailability. Indeed, previous studies in the Amazon have shown that blood Hg concentrations were significantly lower in participants reporting frequently eating local fruits compared to others, although fish intake was similar in both groups, suggesting that fruit nutrients might interfere with MeHg absorption (Passos et al., 2007). More recently in Nunavik, we observed similar results between the consumption of tomato derived-products and blood Hg concentrations in Inuit preschool children (Gagne et al., 2013). *In vitro* studies on Hg bioaccessibility in fish suggest similar effects for the co-ingestion of phytochemical-rich foods such as green or black tea (Ouedraogo and Amyot, 2011; Shim et al., 2009). We also showed that Labrador tea, frequently consumed by Inuit, modulates MeHg-mediated oxidative stress and neurodevelopmental toxicity in rats (Black et al., 2011). Phytochemicals found in seaweeds might also contribute to free radical scavenging and heavy metal chelation, thus possibly reducing Hg bioavailability or subsequent toxicity (Wang et al., 2009).

Activities in 2013-2014

Section 1 of the project:

The technique for the analysis of selenium-containing proteins in plasma (affinity chromatography coupled to ICP-MS) was developed at the *Centre de Toxicologie du Québec* (CTQ) of the *Institut National de Santé Publique du Québec* (INSPQ) by Adel Achouba and Pierre Dumas and was fully validated. Both Se and Hg signals are monitored to allow for the determination of Hg associated with each Se-containing protein. Results for close to 500 participants were available in December 2013. Plasma samples from these participants were also analysed for total plasma Se and Hg levels. The analyses for the rest of the participants will be completed in May 2014. Analyses of blood

MeHg levels are now completed. CTQ has acquired an ICP-MS/MS instrument which is coupled to an HPLC; this analytical platform is currently used by Pierre Dumas to improve the sensitivity of our method for the speciation of small Se molecules. Our colleagues at the Organic Synthesis Service (CRCHU de Québec) have attempted to synthesize selenoneine using seven different pathways, without success. There is currently no analytical standard available on the market; because of this, our progress with regard to the analysis of this compound in biological samples has been impeded. Additional efforts will be devoted to isolating selenoneine from marine species tissues in 2014-2015.

Section 2 of the project:

The list of country food to be included in the study was selected by the research team according to the discussions on country foods in the villages, the most important dietary sources of Hg or Se and/or those highly consumed in Nunavik (Lemire et al., submitted). Michael Kwan provided several recently archived samples (2008-2012) from NRC and Mélanie Lemire completed the sampling in the villages (Kangiqsualujjuaq, Ivujivik, Inukjuak) between October 2011 and August 2012 (mussels, seaweeds, etc.). The sampling is almost completed with the exception of Atlantic salmon and brook trout eggs and transformed country foods (caribou nikku).

Michael Kwan completed all total Hg and Se analysis and age determination in the currently available samples at NRC and sent the analysed samples to UOttawa (n > 400) for further Se and Hg speciation analysis, and Hg and Se bioavailability testing.

Brian Laird started the bioaccessibility analyses (Step 1 of the *in vitro* GI model) at the University of Ottawa and Sierra Palaniyandi, a M.Sc. student working under his guidance at the University of Waterloo has continued this work. Several foods listed in Table 2 have also been extracted with the *in vitro* gastrointestinal model with six specific foods (*e.g.*beluga meat, beluga mattaq, Arctic char, Lake trout, ringed seal meat, and ringed seal liver) also processed using the Caco-2 absorptive Transwell system (Step 2 of the *in vitro* GI model). In addition, beluga and ringed seal samples were re-extracted after mixing with several phytochemical- and selenium rich foods (*e.g.*blueberries, blackberries, kuanniq seaweed, tomato paste, and sculpin eggs). Paulin Junior Vanié, a MSc student under Laurie Chan's guidance at University of Ottawa is measuring Hg and Se speciation in food samples before and after digestion through the *in vitro* gastrointestinal model. All labs (Ayotte, Chan, Laird, and Kwan) are sharing methods, reference materials and standards.

Other Capacity Building, Communications, and Traditional Knowledge Integration activities:

This project has been first discussed with different Inuit authorities and elaborated in collaboration with the Nunavik Health Nutrition Committee (NNHC) of the Nunavik Regional Board of Health and Social Services (NRBHSS) and Nunavik Research Centre (NRC) in order to better address health issues related to country foods in Nunavik. The project was publicly presented on October 5, 2011 by M. Lemire in Kuujjuaq (Annual general meeting of the NRBHSS), and in Inuktitut at the radio. A visit of four other villages also took place in October 2011 (Kangiqsualujjuaq, Kangiqsujjuaq, Inukjuak and Kuujjuaraapik) to discuss the project with mayors and health authorities. The sampling campaign was further conducted in March,June ,and August 2012 in collaboration with the Hunter Support Program and the Nunavik Hunting, Fishing and Trapping Association (NHFTA) in the villages. The country foods targeted for analysis were selected based on discussions with the different community stakeholders, in order to choose those most frequently prepared and consumed in the villages. We also took into consideration our results (Table 2) and those from the 2004 Inuit Health in Transition Study on food consumption to estimate local country food sources of Hg and Se intakes and develop comprehensive guidelines and decisional algorithm for health practitioners in order to mitigate Hg exposure during pregnancy in

Nunavik (Lemire et al., submitted); Pirkle et al., in revision). Our results were also discussed with community members while visiting different villages in Nunavik for related projects on wild berry health benefits and with our collaborators at the NRC and NRBHSS in Kuujjuaq. We also plan to discuss our study results with community members and pre-test our decisional algorithm with health practitioners during our next campaign of community consultation to develop future projects related to the food system and traditional foods in May 2014 (Nasivvik, CIHR).

Results and Discussion

Results obtained to date for Se species and Hg fractions are presented in Table 1. Blood Se concentrations are elevated and highly variable in this population, with values ranging from 125 to 3555 µg/L. Plasma Se concentrations are lower and confined within a very narrow range (101 to 221 µg/L). Concentrations of GPx, SelP and SeAlb (expressed in µg Se/L) represented on average respectively 25%, 52% and 23% of the total plasma Se concentrations.

Figure 1 shows the non-linear relation between blood Se and plasma Se concentrations in this population sample. Increases in blood Se do not result in a corresponding increase in plasma Se. Similar results were previously reported by Hansen et al. (2004) in Greenlandic Inuit (see Figure 2). This contrasts with the linear relationship previously reported by Lemire et al. (2010, 2012) among adults from a fish-eating population of the Brazilian Amazon, where Brazil nuts constitute the major dietary source of Se and an important source of selenomethionine. Yamashita et al. (2013) identified selenoneine as the major Se species present in the cellular blood fraction of a fish-eating Japanese population. We speculate that in the Inuit population, a major fraction of blood Se is present as selenoneine in red blood cells. This hypothesis will be investigated in 2014-2015.

Figure 1. Relation between blood and plasma Se concentrations (µg/L) in 498 Inuit adults of Nunavik (2004 Inuit Health in Transition Study).

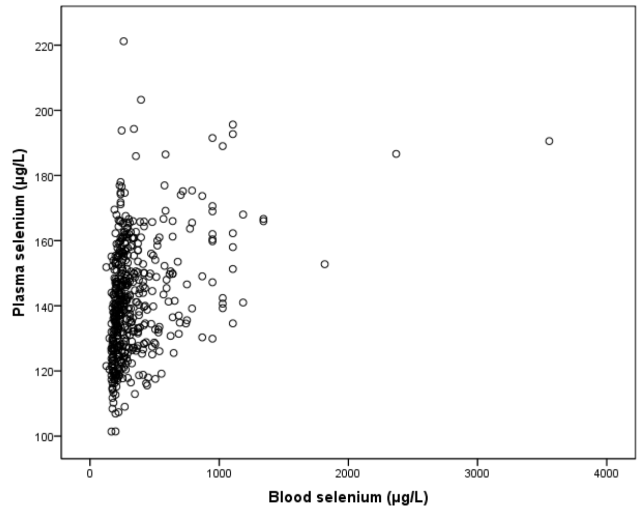
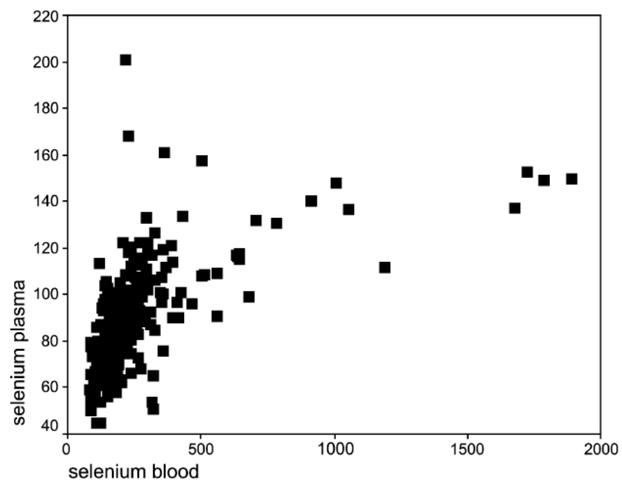


Figure 2. Blood and plasma Se (µg/L) non-linear association among Inuit adults in Greenland (Hansen et al., 2004).



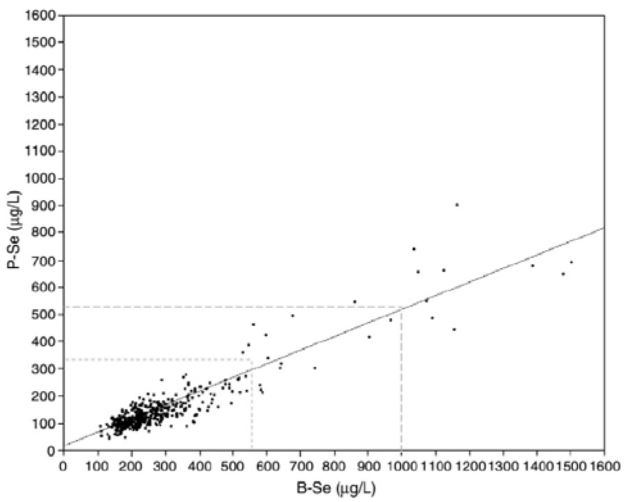


Figure 3. Blood and plasma Se linear association among adults fish-eating population of the Brazilian Amazon (Lemire et al., 2012).

Total blood Hg and blood MeHg concentrations were similar in Inuit adults (Table 1). A small amount of Hg was found to coincide with each Se-containing protein. The median plasma total Hg concentration was 5.5-fold lower than that of blood total Hg concentration (11 µg/L vs 2 µg/L, respectively). Because all Hg in blood samples was in the MeHg fraction, this indicates that plasma Hg, including Hg associated with Se-containing proteins, is also present in the MeHg form.

Results of Hg and Se analyses of country foods are shown in Table 2. Overall, they show that:

- Almost all country foods are low in Hg (< 0.2 mg/g) with the exception of beluga meat (*nikku* and raw), marine mammal organs and lake trout which present very high total Hg concentrations (> 1 mg/g). The traditional drying process of the beluga meat was shown to increase total Hg by 2 to 5 fold. Some samples of marine bird eggs presented very high Hg concentrations (> 1 µg/g).
- Although very high total Hg levels are found in marine mammal organs, their MeHg concentrations are much lower (less than 26% of total Hg).
- Beluga *mattaaq* and ringed seal meat present total Hg levels in the low-medium range (0.2 – 0.5 µg/g).
- Beluga mattaaq and *nikku*, walrus meat, marine mammal and caribou organs, and fish eggs are exceptionally high in total Se (> 1 mg/g).
- Beluga and seal meat, blue mussels and marine fish species are also good dietary sources of Se (> 0.2 mg/g).

Results of Hg *in vitro* bioaccessibility are shown in Figure 4. In summary, the maximum Hg *in vitro* bioaccessibility was observed in ringed seal meat (95%). Hg in ringed seal liver showed relatively low bioaccessibility (25%). The low Hg bioaccessibility observed in ringed seal liver may in part offset the risks posed by the high total concentration. Large variation in Hg bioaccessibility was observed between fish species (*e.g.*Arctic char 9.4%; Lake trout 42%) and the drying of beluga meat appeared to cause a small decrease in Hg bioaccessibility relative to raw beluga meat. No such effect was observed for Se bioaccessibility. The bioaccessibility of Se in country foods was typically higher than observed for Hg (Figure 5). The only two exceptions to this trend were for ringed seal meat and ringed seal liver. In particular, the Hg and Se bioaccessibility of ringed seal liver were both approximately 25% whereas Hg and Se in ringed seal meat was essentially completely bioaccessible (≥95%). The bioaccessibility of Se reached 100% for three of the 14 foods analyzed (*e.g.*ringed seal meat, Atlantic salmon, caribou meat).

Figure 4. Hg *in vitro* bioaccessibility (Step 1) of 14 Nunavik country foods. Error bars represent standard error of the mean of at least 6 replicates.

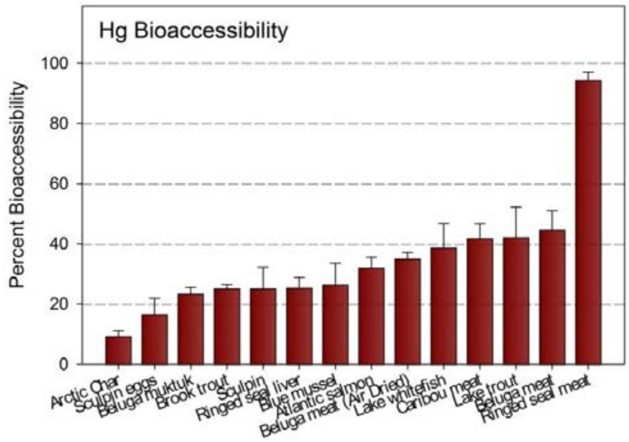
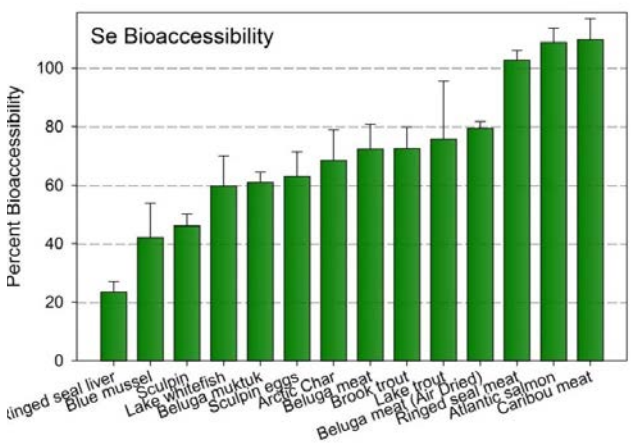
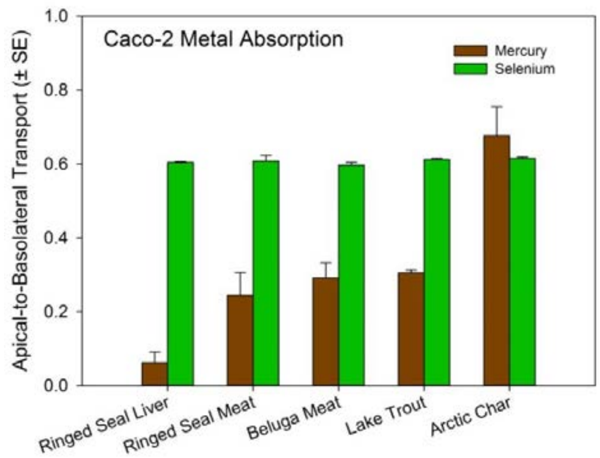


Figure 5. Se *in vitro* bioaccessibility (Step 1) of 14 Nunavik traditional foods. Error bars represent standard error of the mean of at least 6 replicates.



The bioavailability of Hg and Se using the Caco-2 cells (step 2 of the *in vitro* gastrointestinal model) was analyzed for select marine mammal and fish (Figure 6). In order of increasing Hg bioavailability: ringed seal liver, ringed seal meat, raw beluga meat, lake trout, and Arctic char. In contrast, Se bioavailability was remarkably consistent (~60%) between country foods. Unlike the results of Vazquez et al. (2013), Caco-2 cell retention of Hg was below the limit of detection.

Figure 6. Hg and Se bioavailability from country foods using the Caco-2 (Step 2) of the *in vitro* gastrointestinal model. Error bars represent standard error of the mean.



In addition to these *in vitro* bioaccessibility (Figures 4 and 5) and bioavailability (Figure 6) results, we also re-digested ringed seal liver through Step 1 of the *in vitro* model in binary mixtures with: blueberries, blackberries (labeled as crowberries), seaweed, tomato paste, and sculpin eggs. For ringed seal liver, preliminary results show that each of the phytochemical- and selenium-rich foods decreased the solubilization of Hg (Figure 7). Conversely, the addition of blueberries, blackberries, seaweed, and tomato paste appears to increase the bioaccessibility of Se ringed seal liver (Figure 8). The same procedures have been completed for ringed seal meat and beluga meat (raw and air-dried) with the results from this work currently under analysis.

Figure 7. The bioaccessibility of Hg from ringed seal liver, sculpin eggs, tomato paste, blueberries, blackberries (labeled as crowberries) and seaweed. Also plotted is the bioaccessibility of ringed seal liver digested in binary mixtures with each of the other foods. Error bars denote standard error of the mean.

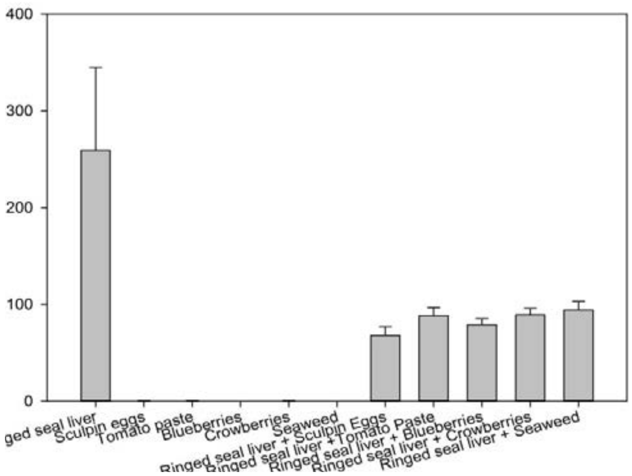


Figure 8. The bioaccessibility of Se from ringed seal liver (RSL), sculpin eggs (SE), tomato paste (TO), blueberries (BB), crowberries (CB), and seaweed (SW) (orange/blue stacked bars). Also plotted is the bioaccessibility of ringed seal liver digested in binary mixtures with each of the other foods (green bars). Error bars denote standard error of the mean.

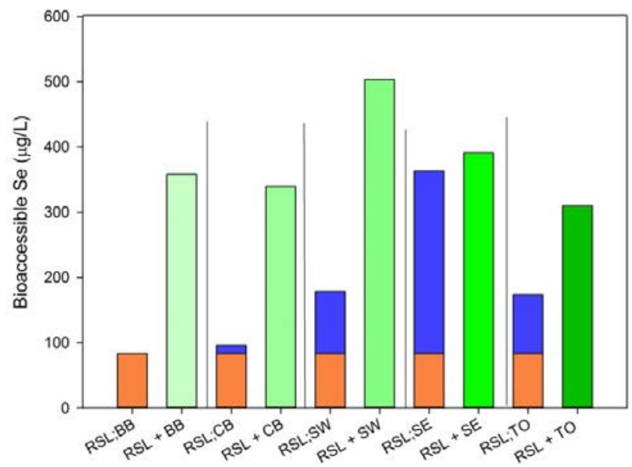


Table 1. Concentrations of Se species and Hg fractions in blood/plasma samples of Inuit adults from Nunavik (2004 Inuit Health in Transition study)

Analyte	N	Mean	Median	75th percentile	95th percentile	Maximum
Selenium (µg Se/L)						
Blood total Se	899	342.5	260.7	371.3	790.0	3555
Plasma total Se	498	141.8	140.2	153.2	171.2	221.2
GPx	498	35.8	35.2	38.9	46.5	71.8
SelP	498	72.8	71.9	78.2	86.8	109.7
SeAl	498	33.2	32.6	36.7	42.9	61.9
Mercury (µg Hg/L)						
Blood total Hg	899	17.4	10.8	22.0	52.2	240.8
Blood MeHg	899	17.7	10.6	22.1	56.1	220.6
Plasma total Hg	498	2.77	2.02	3.31	8.00	24.5
Hg-GPx	498	0.57	0.41	0.70	1.59	6.47
Hg-SelP	498	1.63	1.20	1.97	4.49	11.7
Hg-SeAlb	498	0.74	0.54	0.94	2.04	5.74

Table 2. Total Hg and Se results in country foods collected in Nunavik between 2008 and 2013

Animal	part	data origin, year	n	MeHg (µg/g)			Se (µg/g)		
				GM [a]	Min	Max	GM [a]	Min	Max
Marine mammals									
Beluga	skin	Kwan, 2011 [a]	16	0.46	0.25	1.61	4.35	2.40	7.54
	mattaaq	Kwan, 2011 [b]	16	0.38	0.21	1.29	3.52	1.96	6.07
	raw meat	Kwan, 1999, 2011, 2012	17	1.07	0.39	2.72	0.73	0.60	1.12
	air-dried meat (nikku)	Kwan, 2012	9	4.01	1.88	6.93	1.26	1.10	1.43
	average X increase	Kwan, 2012		2.5	2.1	2.8	1.8	1.6	2.0
	liver	Kwan, 1999, total Hg & Se [a]	15	10.14	2.98	28.62	6.25	3.71	14.91
	liver	Kwan, old data, MeHg (12%) [a,c]	7	1.22	0.59	3.58			
	kidney	Kwan, old data, total Hg a	9	6.39	1.33	17.49	4.70	2.92	9.65
	kidney	Kwan, old data, MeHg (8%) [a,c]	4	0.52	0.15	0.56			
Ringed seal	raw meat	Kwan, 2002 [a]	19	0.28	0.13	1.09	0.45	0.28	0.68
	liver	Kwan, 2002, total Hg & Se [a]	20	10.91	2.50	89.89	8.33	3.13	37.80
	liver	Kwan, old data, total Hg & Se	18	5.51	0.02	69.08	5.67	1.14	29.62
	liver	Kwan, old data, MeHg (11%) [c]	18	0.29	0.07	2.40			
	kidney	Kwan, old data, total Hg & Se	12	0.87	0.37	3.22	2.10	1.24	3.16
	kidney	Kwan, old data, MeHg (26%) [c]	12	0.23	0.14	0.50			
Walrus	raw meat	Kwan, 2013	8	0.07	0.04	0.11	1.53	0.72	3.38
	liver	Kwan, 2013, total Hg & Se	5	2.06	0.91	4.15	2.18	1.39	3.46
	kidney	Kwan, old data, total Hg [b]	5	0.28	0.10	0.68	3.79	3.02	5.22
	kidney	Kwan, old data, MeHg (20%) [b]	5	0.06	0.04	0.09			
Fish [e]									
Arctic char – sea run ssp.	raw meat	Kwan, 2013	15	0.03	0.02	0.09	0.24	0.17	0.35
	air-dried meat (pistik)	Kwan, 2013	11	0.13	0.06	0.37	0.69	0.47	0.95
	average X increase	Kwan, 2013		3.8	2.0	5.0	2.6	1.9	3.8
	raw skin	Kwan, 2013	11	BDL	BDL	BDL	0.24	0.16	0.35
	air-dried skin (pistik)	Kwan, 2013	11	BDL	BDL	BDL	0.94	0.59	1.24
	average X increase	Kwan, 2013		0	0	0	4.0	2.1	5.6
	raw liver	Kwan, 2013	10	0.05	0.04	0.10	0.93	0.62	1.86
	raw eggs	Kwan, 2013	8	BDL	BDL	BDL	1.12	0.72	1.64

Animal	part	data origin, year	n	MeHg (µg/g)			Se (µg/g)		
				GM [a]	Min	Max	GM [a]	Min	Max
Arctic char - landlocked ssp.	raw meat	Kwan, old data	11	0.13	0.08	0.17	0.60	0.50	0.98
Lake whitefish	raw meat	Kwan, 2013	10	0.14	0.09	0.23	0.17	0.13	0.22
	raw eggs	Kwan, 2013	10	0.03	0.02	0.04	2.14	1.69	2.56
Brook trout	raw meat	Kwan, 2011	24	0.11	0.06	0.67	0.23	0.18	0.29
Atlantic salmon	raw meat	Kwan, 2011	17	0.04	0.03	0.06	0.27	0.20	0.35
	raw eggs			NA			NA		
Fourhorn sculpin	raw meat	Kwan, 2011 a	25	0.18	0.07	0.39	0.35	0.24	0.70
	raw eggs	Kwan, 2011 a	18	BDL	BDL	BDL	1.37	1.08	1.73
Lake trout	raw meat	Kwan, 2011 a	20	1.03	0.66	1.74	0.17	0.02	0.41
Burbot (or Loche)	raw meat	Kwan, old data	18	0.27	0.15	0.67	0.27	0.22	0.40
Northern pike	raw meat	Kwan, old data	5	0.69	0.45	1.17	0.23	0.21	0.24
Seafood									
Blue mussels	raw meat	Kwan, 2012	31	0.01	0.01	0.04	0.43	0.31	0.74
Clams	raw meat			NA			NA		
Scallops	raw meat	Kwan, old data	18	0.04	0.01	0.05	0.20	0.13	0.26
Wildfowl e									
Willow ptarmigan	raw meat	Kwan, 2013	27	0.01	BDL	0.01	0.11	0.04	0.26
Canada goose	raw meat	Kwan, 2012	16	BDL	BDL	BDL	0.22	0.14	0.32
	raw liver	Kwan, 2012	16	0.02	BDL	0.03	0.75	0.43	1.02
	raw eggs	Kwan, 2013	12	BDL	BDL	BDL	0.21	0.14	0.30
Eider duck	raw meat	Kwan, old data	5	0.15	0.10	0.21	NA		
	raw eggs	Kwan, 2013	12	0.22	0.03	1.24	0.42	0.20	1.23
Sea/Herring gull	raw eggs	Kwan, 2013	11	0.22	0.03	1.97	0.59	0.30	0.93
White wing scoter	raw meat	Kwan, old data	4	0.12	0.09	0.49	NA		
Black scooter	raw meat	Kwan, old data	2/4	0.16	0.14	0.19	0.60		
Surf scooter	raw meat	Kwan, old data	9	0.17	0.07	0.29	NA		
Mammals e									
Caribou	raw meat	Kwan, 2008	15	0.03	0.01	0.05	0.20	0.10	0.29
	air-dried meat (nikku)			NA			NA		
	smoked dried meat			NA			NA		
	liver	Kwan, 2008	15	0.49			0.89		
	kidney	Kwan, 2008	15	0.86			1.39		

Animal	part	data origin, year	n	MeHg (µg/g)			Se (µg/g)		
				GM [a]	Min	Max	GM [a]	Min	Max
Polar bear	raw meat	Kwan, old data	40	0.07	0.04	0.17	0.23	0.16	0.30
	blubber			NA			NA		
Snowshoe hare	raw meat	Kwan, 2013	9	0.01	0.00	0.02	0.18	0.08	0.35
Plants									
Seaweeds	raw	Kwan, 2012; Harris, pers comm	4	BDL			0.11	0.07	0.19
Cloudberry		Kwan, 2012; Harris, pers comm	5	BDL			0.010	0.004	0.020
Blackberry (crowberry)		Kwan, 2012; Harris, pers comm	5	BDL			0.002	0.001	0.003
Blueberries (alpine bilberry)		Kwan, 2012; Harris, pers comm	5	BDL			0.000	0.000	0.000
Redberries (mountain cranberry)		Kwan, 2012; Harris, pers comm	1	BDL			0.002		
Alpine bearberry		Kwan, 2012; Harris, pers comm	5	BDL			0.000	0.000	0.000

NA: non-available, BDL: below detection limit, which is 0.008 µg/g wet weight for Hg (we used 0.004 µg/g ww in calculations)

a Age-adjusted geometric mean concentrations or geometric mean concentrations when available (Kwan data), otherwise arithmetic mean was used.

b Concentrations were estimated based on the observation that mattaq is made of beluga skin and raw blubber, and blubber represents at least 20% of a typical piece.

c Since a large proportion of total Hg is in inorganic form (>70%), the geometric mean reported here corresponds to the age-adjusted MeHg concentration.

Conclusions

Our results to date indicate that although some country foods are very high in Hg, not all of them are equivalent with regard to the proportion of the toxic metal that is available for absorption. In 2014-2015, we will complete the bioaccessibility experiments and Hg and Se speciation analyses in country foods. Our results and those recently published by Yamashita et al. (2013) indicate that we should focus our attention to the blood cell fraction of participants to the Inuit Health in Transition Study, in which selenoneine is likely present in high concentration. Additional efforts will be devoted to isolating selenoneine from blood of marine species, in order to obtain the standard required for its quantification. In addition, linking country food bioaccessibility, bioavailability and speciation to human biomarker datasets will allow a better understanding of country foods that contributes the most Hg exposure and Se status. The relation between MeHg, Se biomarkers and diabetes and cardiovascular risk factors will also be investigated. Moreover, these results will be shared and discussed with local stakeholders, and used to develop and implement interventions that aim to promote the benefits of traditional marine diet, while minimizing MeHg exposure in Nunavik.

Expected Project Completion Date

March 2015.

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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 et au mercure

- **Project Leader:**
  Frank Wania, Department of Physical and Environmental Sciences, University of Toronto Scarborough, Tel: (416) 287-7225, Email: frank.wania@utoronto.ca

  Meredith Curren, Health Canada, Chemicals Surveillance Bureau, Population Biomonitoring Section, Tel: (613) 941-3570, Email: meredith.curren@hc-sc.gc.ca

- **Project Team Members and their Affiliations:**
  Matthew Binnington, James Armitage, and Jon Arnot, Department of Physical and Environmental Sciences, University of Toronto; Laurie Chan, Department of Biology, University of Ottawa

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

Résumé

Dans les régions industrialisées ou éloignées, l'alimentation influe fortement sur l'exposition humaine aux polluants organiques persistants (POP). Les aliments que nous mangeons et leur provenance sont d'importants déterminants de la charge corporelle et des risques associés à une exposition chronique à de tels composés. Il est généralement admis que les aliments ne sont pas tous également contaminés par les POP. Par conséquent, il est possible de varier l'exposition aux contaminants en modifiant l'alimentation. Nous avons donc étudié l'effet de transitions alimentaires sur l'exposition humaine aux POP à l'aide de scénarios d'ajustements provisoires (p. ex. si une femme enceinte écarte temporairement

permanent changes (*e.g.*, if communities gradually shift from a traditional diet of locally hunted animals to a diet that includes more imported food). 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. They have been applied to general population-wide transitions away from northern traditional food, as well as to specific Aboriginal Arctic communities, also to investigation of the impacts of various wildlife demographic variables (*e.g*, age, sex, lifespan) on expected human exposure from traditional food consumption, and to temperate human populations complying with POP food consumption advisories. Our main findings are that (1) the long-term generational movement away from traditional food intake in Canada's North greatly affected observed human POP exposure trends, and (2) traditional food consumers susceptible to POP exposure toxicity (*i.e.,* pregnant or nursing mothers) may want to preferably consume younger, reproductively active female animals, as these individuals typically possess lower contaminant levels. Additionally, our initial investigation of short-term dietary transition impacts among temperate populations suggests that these may have a negligible effect on POP levels, especially for compounds exhibiting long human elimination half-lives.

de son alimentation les aliments réputés plus contaminés) et de changements plus graduels et permanents (p. ex. si des communautés remplacent graduellement leur alimentation traditionnelle à base de viande d'animaux chassés localement par une alimentation qui comprend davantage d'aliments importés). Nous avons mis au point une série de modèles de simulation informatique qui permettent de déterminer, quantitativement, dans quelle mesure de tels changements peuvent influer sur l'exposition aux contaminants. Ces modèles ont été appliqués à l'échelle de la population, dans le contexte de l'abandon des aliments traditionnels en général, ainsi qu'à des communautés autochtones précises de l'Arctique, toujours dans le but d'étudier l'incidence de différentes variables démographiques relatives aux espèces sauvages (p. ex. âge, sexe, durée de vie) sur l'exposition humaine prévue associée à la consommation d'aliments traditionnels. Les modèles ont en outre été appliqués à des populations vivant sous un climat tempéré et respectant les avis relatifs à la consommation d'aliments contaminés par des POP. D'après nos principaux résultats, (1) l'abandon à long terme des aliments traditionnels d'une génération à l'autre dans le Nord canadien a considérablement influé sur les tendances observées en matière d'exposition humaine aux POP et (2) les personnes qui consomment des aliments traditionnels et qui sont plus vulnérables aux effets toxiques des POP (c.-à-d. les femmes enceintes ou qui allaitent) pourraient consommer de préférence de jeunes animaux femelles en période d'activité reproductrice, car ceuxci présentent habituellement des niveaux inférieurs de contamination. Par ailleurs, selon nos études préliminaires sur des populations de régions tempérées, les transitions alimentaires de courte durée auraient un effet négligeable sur les concentrations de POP, surtout s'il s'agit de composés possédant une longue demi-vie d'élimination chez l'être humain.

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
- The incorporation of several new models for additional traditional food species (*e.g.*, bowhead whale, beluga whale, narwhal, caribou) into our greater food chain bioaccumulation framework has provided a more holistic representation of common traditional Aboriginal diets, and initial evaluations of expanded model performance using Aboriginal (mainly Inuit and Dene/Metis) biomonitoring data from two northern communities (Baffin Island and Inuvik) have produced promising results
- 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 older male animals, as they routinely possess the greatest POP levels within wildlife populations
- When assuming realistic periods of compliance (*i.e.,* only during a nominal 1.5 year period of pregnancy and breastfeeding), maternal food advisories are largely ineffective in reducing pre- and postnatal exposure to POPs with exceptionally long human elimination half-lives

Messages clés

- Les transitions alimentaires à grande échelle d'une génération à l'autre 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.
- L'intégration de plusieurs nouveaux modèles concernant d'autres espèces faisant partie de l'alimentation traditionnelle (p. ex. baleine boréale, béluga, narval, caribou) dans notre cadre général de bioaccumulation des POP dans la chaîne trophique a rendu possible une représentation plus globale des régimes alimentaires traditionnels courants chez les Autochtones. De plus, les évaluations initiales du rendement du modèle élargi, réalisées au moyen de données de biosurveillance chez des Autochtones (principalement des Inuits et des Dénés ou des Métis) de deux communautés nordiques (**île de Baffin et** Inuvik), ont donné des résultats prometteurs.
- Les associations entre les concentrations de POP et certaines variables démographiques, comme le sexe et l'âge des espèces consommées traditionnellement, peuvent aider à guider les choix alimentaires dans le Nord; par exemple, on pourrait recommander aux personnes vulnérables aux effets toxiques des POP de limiter leur consommation d'animaux mâles âgés, car ces derniers possèdent couramment les plus hautes concentrations de POP parmi les populations fauniques.
- Lorsque nous supposons des périodes d'observance réalistes (c.-à-d. seulement pendant la grossesse et l'allaitement, soit une période d'un an et demi), les recommandations en matière d'alimentation des mères sont en grande partie inefficaces pour réduire l'exposition prénatale et postnatale aux POP dont la demi-vie d'élimination est exceptionnellement longue chez l'être humain.

Objectives

Long-term

1. To estimate the respective contributions of declining environmental POP contamination and changing dietary consumption behaviour on human tissue POP concentrations observed in two northern communities (Baffin Island and Inuvik).

2. To assess the effectiveness of food consumption guideline compliance on northerners' exposures to POPs with varying physical-chemical properties (*e.g.*, hydrophobicity, volatility, susceptibility to biotransformation).

3. To maximize the value of existing northern human biomonitoring data by using them in the evaluation of model predictions.

4. To build capacity for assessing human exposures in northern communities to new and emerging chemicals of concern.

5. 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 model time trends of POP exposure in mothers from two northern regions (Baffin Island and Inuvik) considering both shifts in global emissions and long term dietary changes.

2. To model the efficacy of short-term maternal dietary changes, during pregnancy and nursing, in reducing infant POP exposure among northern populations.

3. To quantify analytically the effect of traditional food preparation on human dietary POP exposure focusing primarily on beluga whale blubber (or muktuk).

4. To modify our series of 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, with local wildlife examples including 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 2013-2014

One of the main activities in the past project year was the development of bioaccumulation models for several northern traditional food species, greatly expanding our Arctic version of the ACC-Human model. Specifically, models for beluga and bowhead whale were completed and evaluated, as detailed in a recent publication (Binnington and Wania 2014), while those for caribou and narwhal were also finalized (Binnington and Wania, 2013b), and evaluation is near completion. A model for an additional organism relevant to northern traditional food exposure among inland communities, the Canada goose, is currently in progress. The decision to develop models for caribou, beluga whale, narwhal, and Canada goose, to join existing models for ringed seal and polar cod, were motivated by dietary surveys and POP biomonitoring among mothers in 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 sought to include a range of traditional food items important to POP exposure due to a high frequency of consumption (caribou, Canada goose), an elevated exposure POP exposure potential due to high contaminant levels (beluga), or organisms that fulfilled both these criteria (narwhal). Using this expanded model framework, we have begun attempts to reproduce POP human biomonitoring results from two northern communities (Baffin Island and Inuvik) using population demographic data and dietary survey information.

Conversely, development of a bioaccumulation model for the bowhead whale was motivated not only due to its consumption by the same Inuvik and Baffin Island populations, but also because it is an exceptionally long-lived species. We were interested in modeling bioaccumulation in the bowhead, and other long-lived Arctic wildlife species, to further explore the factors that determine POP concentration-age relationships in cross-sectional biomonitoring studies. In fact, our second major activity was also the completion of this project; we sought to clarify POP concentration-age associations in individuals and population cross-sections among four Arctic species frequently used in wildlife biomonitoring, and possessing vastly different lifespans: polar cod (lifespan - 6 years), ringed seal (40 years), beluga whale (80 years), and bowhead whale (160 years). A manuscript describing results of this activity has recently been published (Binnington and Wania 2014).

A third major project activity was completion of our project quantifying the effect of transient dietary transitions among women of childbearing age on resultant prenatal, postnatal, and childhood exposures of their children to POPs. We initially estimated the effectiveness of fish consumption advisories in reducing exposure of infants and children in fish-eating Southern populations using the time-variant mechanistic model CoZMoMAN; the results of this activity were published earlier this year in the journal Environmental Health Perspectives (Binnington et al. 2014). Though this framework was initially applied to a temperate population, the same approach will be used for a northern group following the completion of the current Arctic ACC-Human modeling scheme.

Finally, as mercury/methylmercury (Hg/MeHg) is arguably the contaminant of greatest concern in the North, our fourth activity of the past project year was completion of a critical review of available bioaccumulation modeling approaches for mercury. This assessment was performed in preparation for a future Hg/MeHg bioaccumulation model development activity.

Communications

The results from these four major activities have been disseminated through a variety of means during this past year. Specifically, findings from our ACC-Human Arctic model expansion activity were presented at a meeting of the Society of Environmental Toxicology and Chemistry (Binnington et al. 2013a) and at the 2013 NCP Results Workshop (Binnington et al. 2013b). Our wildlife POP concentration-age study is in press at *Environmental Toxicology and Chemistry* (Binnington and Wania 2014), and was also presented at a meeting of the Society of Environmental Toxicology and Chemistry (Binnington and Wania 2013a), and the 2013 NCP Results Workshop (Binnington and Wania 2013b). Results from our temperate dietary food advisory project were published in *Environmental Health Perspectives* (Binnington et al. 2014).

The project team also held communication meetings with our northern partners on three separate occasions during the previous project year. In July 2013, 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. In August, Matthew Binnington hosted a second conference call with additional northern partners who were unable to attend the earlier Ottawa meeting; a similar agenda as described above was discussed. Finally in September 2013 additional informal meetings were conducted with northern partners during the 20th NCP Results Workshop.

Capacity Building

While specific capacity building opportunities were not included in 2013-2014 project undertakings, we expect that future work will include them. An upcoming 2014-2015 project activity will involve a field study by Matthew Binnington examining the impact of traditional food preparation practices on nutrient intake and POP exposure, in Tuktoyaktuk, Northwest Territories. This northern trip will afford unique capacity building opportunities, such as visiting local elders to explain the significance of our work and our interest in improving local food security. We also plan to make every effort to participate in local activities, volunteer, present our findings, and answer questions during this field study, as well as during all stages of the project, including planning and results reporting. We also plan to include in-person discussion of our research results with territorial representatives. Also we will create opportunities to discuss prepared plain language summaries of our research with community individuals and students, and discuss our findings during community gatherings, and Hunters and Trappers Committee meetings.

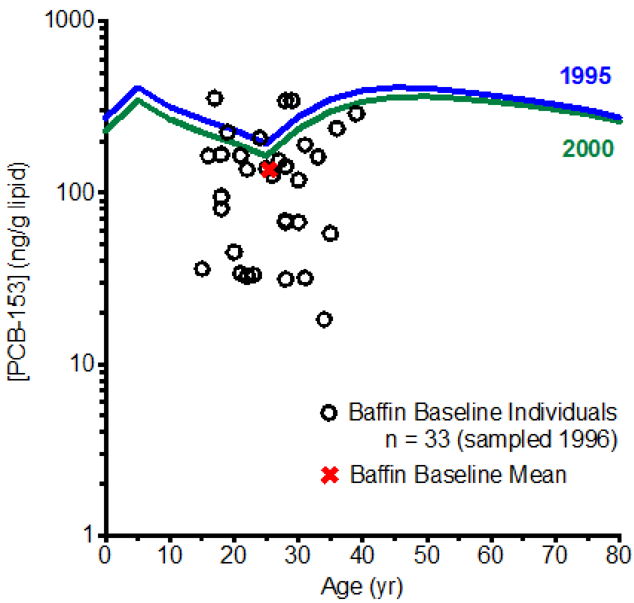
Traditional Knowledge Integration

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 will be critical in conducting our upcoming 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, has again demonstrated the feasibility of applying our mechanistic food chain bioaccumulation modeling approach to a wide range of species and settings. Evaluation of model POP concentration output consistently matched published monitoring and modeling data for each additional traditional food species, including bowhead and beluga whales (Binnington and Wania 2014; Hoekstra et al. 2002; Stern et al. 2005), narwhals (Wolkers et al. 2006), and caribou (Elkin and Bethke 1995; Kelly and Gobas 2001; 2003). Using these calculated traditional food POP concentrations as inputs to the human portion of the ACC-Human Arctic model, our initial attempts to replicate measured POP concentrations in aboriginal Arctic mothers from baseline biomonitoring studies in the communities of Baffin Island (1996) and Inuvik (1999) have been promising. Our comparison of the cross-sectional lipid-normalized concentration of PCB-153 from ACC-Human Arctic when parameterizing the model with average population demographic variables (ex. birth year, parity, traditional food intake) to specific PCB-153 measurements for each individual in the study population is displayed in Figure 1. Given that the model is performing satisfactorily, our next steps will be to attempt to reproduce POP concentrations in each baseline individual using their specific demographic characteristics, and then compare these results to individuals from follow-up studies in these communities. This will allow us to further discern the relative impacts of declining environmental POP concentrations and dietary transition behaviour on POP exposures in historic northern populations, further enhancing our previous findings based on a series of general dietary transition simulations (Quinn et al. 2012).

A



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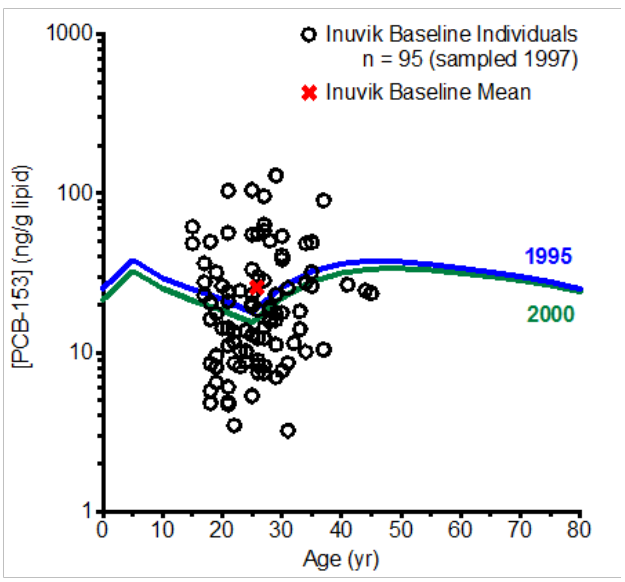

Figure 1. PCB-153 lipid-normalized concentration predictions for each measured aboriginal mother in baseline biomonitoring studies from Baffin Island (A) and Inuvik (B), compared to cross-sectional model output for an individual possessing the average demographic characteristics of the population (i.e. birth year, parity, TF intake).

For our second major project, we performed a series of model calculations exploring persistent organic pollutant (POP) bioaccumulation in a series of long-lived Arctic species frequently used in contaminant biomonitoring: polar cod, ringed seal, beluga whale, and bowhead whale. As mentioned, our interest was in determining the roles of lifespan, gender, and the temporality of sampling relative to POP emission rates on POP concentration-age trends in biomonitoring results. As in our previous study of POP concentration-age dynamics in humans (Quinn and Wania 2012), our results demonstrated that the temporal proximity of population sampling events to the studied contaminant emissions peak (termed the birth cohort effect – Figure 2) was a critical factor in determining observed age-concentration trends in biomonitoring of male animals, and one that is not always considered in the POP biomonitoring literature. However, a similar cohort effect was not found in reproductive females because of efficient POP loss via lactation; females do not retain a "memory" of their past exposure. Notably, lifespan differences were not a significant factor distinguishing POP body-burden age trends between organism populations when species were compared along an equivalent age scale. We ultimately suggested that accounting for birth cohort and sex effects is essential when interpreting trends in POP biomonitoring of long-lived species. The implication of this work relevant to northerners is the suggestion that individuals can reduce dietary POP exposure through a focus on consumption of younger animals, reproducing females, and/or short-lived species. These recommendations can further inform dietary advisories designed for subpopulations susceptible to POP-related health effects (i.e. pregnant or nursing mothers).

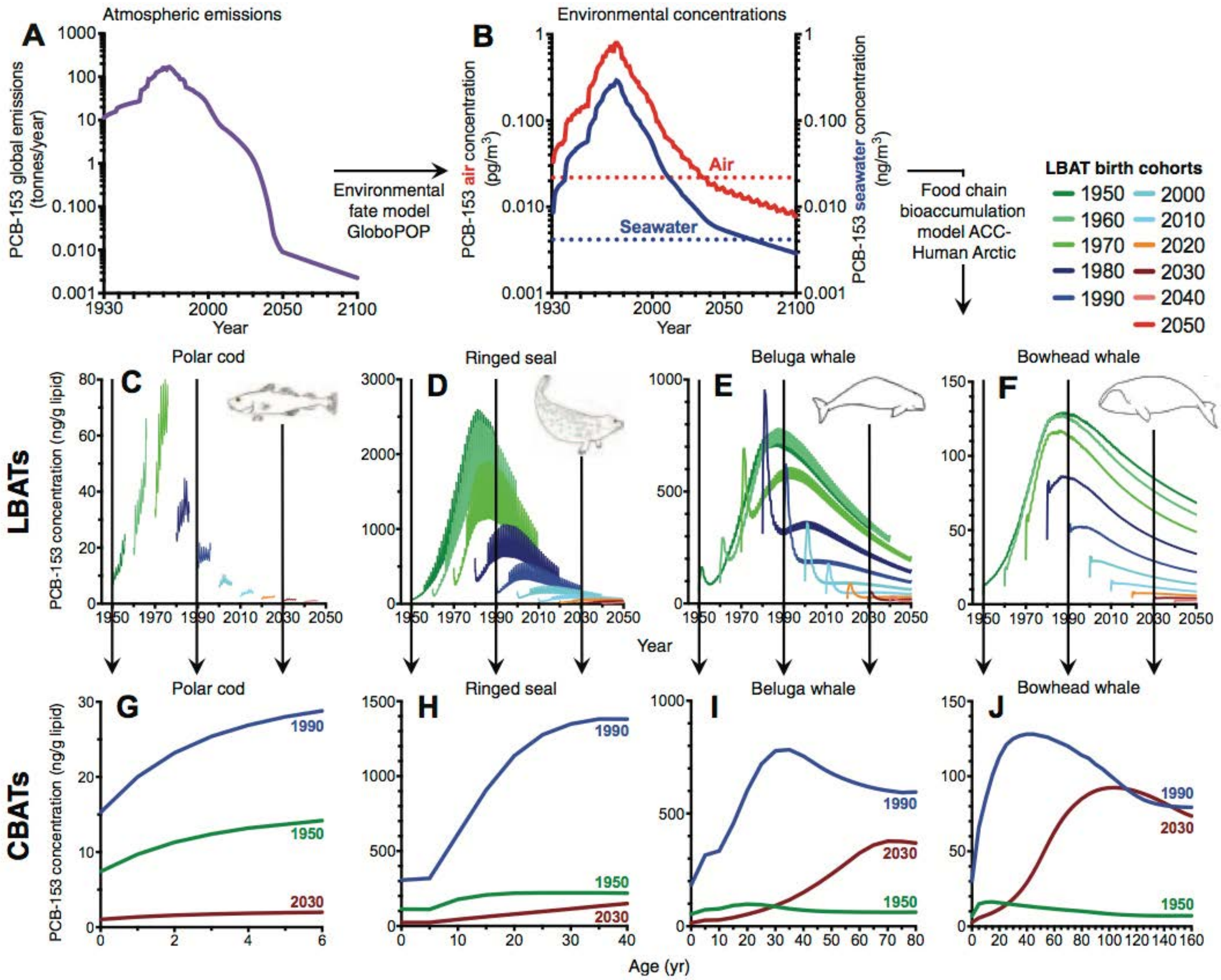

Figure 2. Overview of the schematic used to generate CBATs from ACC-Human Arctic estimates of PCB-153 bioaccumulation in male polar cod, ringed seals, beluga whales, and bowhead whales. Global PCB-153 emissions estimates (A) were input to the chemical fate and distribution model GloboPOP to derive time trends of PCB-153 concentration in Arctic air and seawater compartments (B). These environmental concentrations were combined with rates of dietary intake and body growth for each species to produce longitudinal data through time differentiated by an individual's year of birth using the food web bioaccumulation model ACC-Human Arctic (C-F). Finally, cross-sectional trends for 1960, 1990, and 2030 were calculated by "sampling" all individual longitudinal curves for polar cod, ringed seals, beluga whales, and bowhead whales (of varying ages) who possessed PCB-153 concentration values for those years (G-J).

For our third project, we assessed the effectiveness of current food consumption advisories in reducing human POP exposure by estimation and comparison of prenatal, postnatal and childhood PCB-153 levels under different scenarios of maternal guideline adherence in a Southern population. Scenarios differed in terms of length of compliance (1 vs. 5 years), extent of fish substitution (all vs. half), and replacement diet (uncontaminated produce vs. beef/dairy). We also calculated exposure reduction potential for a range of theoretical chemicals to explore how guideline effectiveness varies with a chemical's partitioning and degradation properties. When assuming realistic time periods of advisory compliance (Czub et al. 2008; Teisl et al. 2011), temporarily eliminating or reducing maternal fish consumption was found largely ineffective in reducing pre- and postnatal exposure to substances with long elimination half-lives in humans (such as PCB-153), especially during periods of decreasing emissions (Figure 3). However, advisories can be highly effective in reducing exposure to substances with elimination half-lives in humans shorter than the length of guideline compliance, such as methylmercury. Also notable was our finding that replacement food items (beef and dairy) consumed to compensate for fish reductions actually resulted in higher exposure to certain groups of environmental contaminants. Overall, we conclude that at reported levels of advisory compliance, fish consumption advisories are not effective in lowering exposure to compounds with long human elimination half-lives.

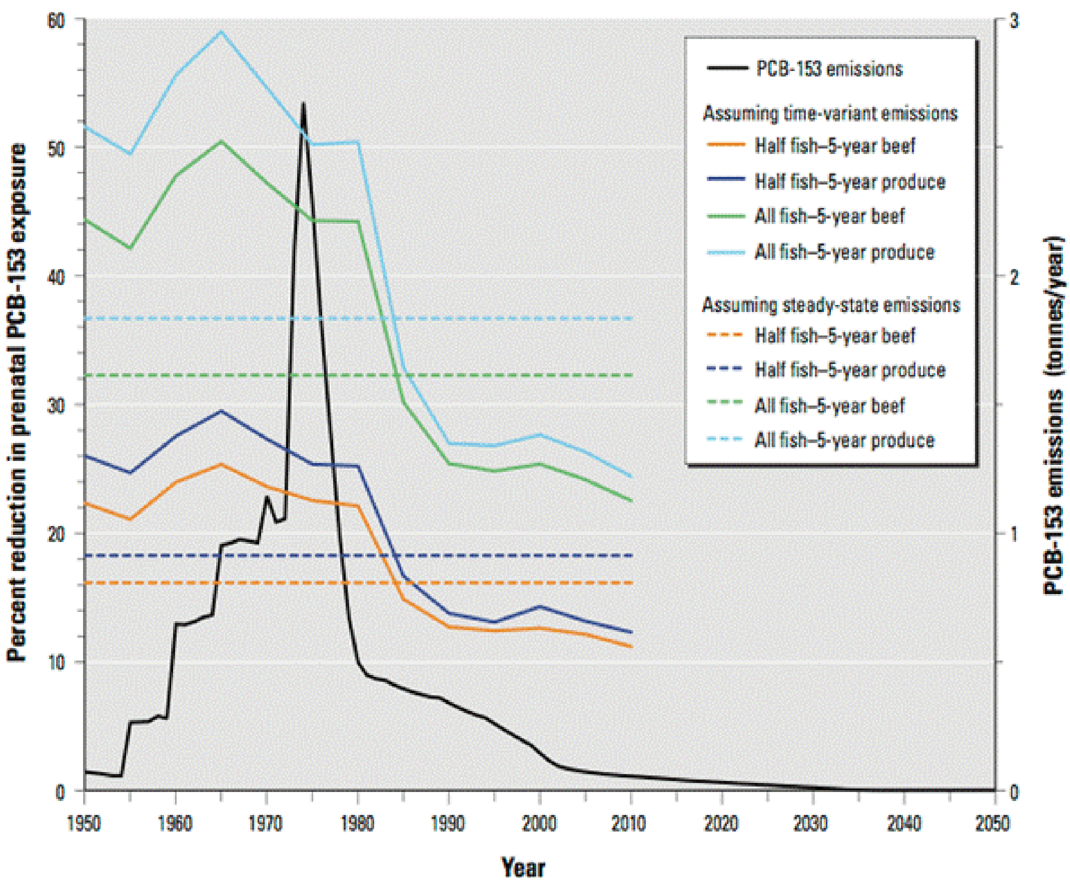

Figure 3. Percent reductions in prenatal exposure of modeled females to PCB-153 due to variation in maternal fish advisory compliance, and assuming time-variant emissions. The dotted lines represent the percent reduction in prenatal exposure for the same fish consumption scenarios described under steady state conditions. Plots are overlaid atop the time-variant emissions scenario used (Breivik et al. 2010).

Although this study is not directly relevant to northern communities, since it focused on fish-eating populations in the South, it did allow us to successfully test the feasibility of our approach; using a mechanistic human food chain bioaccumulation model linked to an environmental fate model to test the efficacy of dietary consumption guidelines. A similar approach will be used to test the efficacy of dietary consumption advisories in the North. However, this will necessitate the creation of meaningful traditional diet substitution scenarios (i.e., to what extent should one dietary item be replaced for another, and for how long?), using traditional knowledge as a guiding principle. We envision that these scenarios may explore substitutions both with dietary items imported from the South, as well as with other country foods. Considering that some dietary items of interest to northerners have very high contamination relative to others that may serve as a substitute (*e.g.*, marine mammal fat vs. terrestrial mammals) (Armitage et al. 2011; Breivik et al. 2010; Czub et al. 2008; Donaldson et al. 2010), we are presently reluctant to predict that the findings from the Southern study, namely that dietary advisories are largely ineffective in lowering exposure to long-lived pollutants, can be readily transferred to northern communities. If the substitution is much less contaminated and compliance extends for several years prior to pregnancy, notable reductions in infant exposure even to long-lived pollutants may be feasible.

For our fourth 2013-2014 activity, our review of available bioaccumulation modeling approaches for mercury indicated that current literature methods are limited in scope when compared to strategies for POPs. Particularly, it would be overly ambitious to attempt to translate our POPs modeling framework, which mechanistically estimates behaviour from emissions all the way to ultimate accumulation in top food chain consumers, to mercury. Instead, based mainly on literature reports of MeHg toxicokinetics in laboratory animals and humans from the literature (Carrier et al. 2001a; 2001b; Farris et al. 1993; Gray 1995; Young et al. 2001), as well as subsequent reports of mechanistic mercury bioaccumulation models in birds (Karasov et al. 2007; Nichols et al. 2010), we intend to focus on a model of mammalian mercury distribution. Our findings from development and application of bioaccumulation models for ionogenic organic contaminants (i.e. acids and bases) (Armitage et al. 2012; 2013; Cao et al. 2012) will help to inform this approach, and we expect this model will prove invaluable for assessment of transient dietary transition impacts on mercury exposure.

Conclusions

During the 2013-2014 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, ensuring that our greater project goal of evaluating long-term dietary transition impact in aboriginal Arctic populations remains achievable. Additionally, we were able to publish our investigation into short-term dietary transition behaviours, and their relative ineffectiveness in reducing POP exposures, especially for recalcitrant compounds in humans. However, we note that the latter finding has yet to be reproduced in northern communities. Thirdly, we determined the impact of several demographic factors on typical Arctic POP biomonitoring age trends in wildlife, indicating that individuals can likely reduce dietary POP exposure through consumption of younger reproducing female animals. Finally, we have determined that future project methods to model northern mercury bioaccumulation behaviour should be reasonably limited to simple PBPK distribution approaches, based on a critical review of the current literature.

Continuing work will consist of further expansion of the ACC-human Arctic model to include one additional species (Canada goose) important for POP exposure through traditional diets, and use of the further expanded model to replicate individual POP biomonitoring data for two northern communities, Baffin Island and Inuvik. Our ultimate goal is to specifically describe the role of emissions regulation and dietary transitions in historical POP exposures.

We will also assess the impacts of more short-term northern dietary transition behaviour, including traditional food substitution scenarios, and experimental analysis of preparation impacts. Finally, we 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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Community Based Monitoring

Surveillance communautaire

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

- **Project Leader:**
  George Low, Dehcho First Nations, Hay River
  Tel: (867) 874-1248, Email: geobarbgeo@hotmail.com

- **Project Team Members and their Affiliations:**
  Mike Low and Alison de Pelham, Dehcho First Nations; Heidi Swanson, University of Waterloo; Marlene Evans, Environment Canada; Bruce Townsend, BEAT Environmental Inc; Stan Sanguez, Jean Marie River First Nation; Dolphus Jumbo and Jessica Jumbo, Sambaa K'e Dene Band; Minnie Letcher and Allen Bouvier, Liidlii Kue First Nation; Joachim Bonnetrouge, Deh Gah Goties Band; Priscilla Canadien, Fort Providence Resource Management Board; Lloyd Chicot and Melaine Simba, Ka'a'gee Tu First Nation; Tim Lennie and Darcy Moses, Pehdzeh Ki First Nation

Abstract

The annual Country Food Workshop series is an ideal forum to increase communication between government and university researchers and the Dehcho leadership. The workshop provides an excellent opportunity for Dehcho leaders, environmental coordinators, community members, and university and government researchers to meet and share ideas and opinions. It not only provides researchers with a forum to explain their studies and present their findings but it also gives the Dehcho community delegates the chance to have their

Résumé

Les séries annuelles d'ateliers sur les aliments traditionnels sont un forum idéal pour améliorer la communication entre les chercheurs gouvernementaux et universitaires et les dirigeants des Premières nations du Dehcho. Les ateliers constituent une excellente occasion pour les dirigeants des Premières nations du Dehcho, les coordonnateurs environnementaux, les membres des collectivités et les chercheurs universitaires et gouvernementaux de se rencontrer et de partager leurs idées et avis. En plus d'offrir un forum aux chercheurs où ils

Traditional Knowledge and experience built into the process of understanding the aquatic environment.

The Dehcho Aboriginal Aquatic Resource and Oceans Management (AAROM) is working towards finding fishing lakes with acceptable levels of mercury in fish for each of the communities. This strategy will include Great Slave Lake and Mackenzie River fish that usually have low mercury levels.

The University of Waterloo mercury bioaccumulation study was designed by Dr. Heidi Swanson to answer several questions: Why do some lakes have high mercury and others low mercury levels? Why are levels in some lakes increasing while others are decreasing? Are there ways to mitigate mercury levels in fish populations? It's a complex issue which includes climate change effects as well as other factors such as harvest rates.

The Dehcho AAROM Youth program is now focused on "Clean Water, Healthy Food and Good Choices". We recognize the importance cultural and spiritual wellbeing in our youth program, and youth camps usually include Elder and harvester Traditional Knowledge as well as bush skills and safe practices.

peuvent expliquer leurs études et présenter leurs conclusions, ces ateliers donnent l'occasion aux délégués des collectivités des Premières nations du Dehcho de faire intégrer leurs connaissances traditionnelles et leur expérience au processus visant à comprendre le milieu aquatique.

Le Programme autochtone de gestion des ressources aquatiques et océaniques (PAGRAO) du Dehcho vise la découverte de lacs de pêche, dans chaque collectivité, dans lesquels les poissons présentent des concentrations acceptables de mercure. Cette stratégie comprendra les poissons du Grand lac des Esclaves et du fleuve Mackenzie qui ont généralement de faibles concentrations de mercure.

L'étude sur la bioaccumulation de mercure de l'Université de Waterloo a été conçue par M^me^ Heidi Swanson (Ph.D.) pour répondre à ces questions : pourquoi certains lacs ont-ils des concentrations élevées de mercure tandis que d'autres ont de faibles concentrations de mercure? Pourquoi les concentrations de certains lacs augmentent-elles tandis qu'elles diminuent dans d'autres lacs? Y a-t-il des moyens d'atténuer les concentrations de mercure chez les populations de poissons? Il s'agit d'un sujet complexe qui inclut les effets des changements climatiques ainsi que d'autres facteurs, comme les taux de récolte.

Le programme jeunesse du PAGRAO du Dehcho est maintenant axé sur « l'eau propre, les aliments sains et les bons choix ». Nous reconnaissons l'importance du bien-être culturel et spirituel dans notre programme jeunesse; ainsi, les camps de jeunes incluent généralement un aîné et un pêcheur, et portent sur les connaissances traditionnelles ainsi que sur les techniques de brousses et les pratiques sécuritaires.

Key Messages

- AAROM, in partnership with researchers and community monitors, are building a data set that will serve to advise our membership on low risk fishing species and lakes in the Dehcho, but will also warn them of high risk fish through GNWT-Health and Social Services consumption advisories.
- Fish species from eleven fishing lakes were checked for mercury levels during the study (2010 – 2013). In some cases, lake whitefish were checked even though this species is generally low in mercury. The purpose of this approach was to reassure our members in the Dehcho that whitefish and other non-predatory fish are a good food choice in any lake.
- Lake whitefish were found to be low in mercury in all lakes tested.
- Northern pike were found to be below 0.5 parts per million of mercury in Big Island Lake, Mustard Lake and Willow Lake, however they were over 0.5 parts per million in many of the fishing lakes.
- Walleye were found to be below 0.5 parts per million of mercury in Willow Lake.
- Lake trout were below the 0.5 mark in Big Island Lake, Trout Lake, Fish Lake and Willow Lake. However these species were found to be high in mercury in many Dehcho fishing lakes.

Messages clés

- Le PAGRAO, en partenariat avec les chercheurs et les surveillants des collectivités, **élabore** un ensemble de données qui servira à informer nos membres sur les espèces de poissons et les lacs à faible risque dans les collectivités du Dehcho, mais qui les avertira aussi des poissons à risque élevé par le biais d'avis portant sur la consommation émis par le service de Santé et Services sociaux du gouvernement des Territoires du Nord-Ouest.
- Durant l'étude (2010 – 2013), les concentrations de mercure ont été vérifiées chez des espèces de poissons provenant de onze lacs de pêche. Dans certains cas, on a analysé les grands corégones, même si les concentrations de mercure sont généralement faibles chez cette espèce. L'objectif de cette approche est de confirmer aux membres des collectivités du Dehcho que le grand corégone et les autres poissons non prédateurs sont un bon choix alimentaire, et ce peu importe le lac.
- On a constaté que les concentrations de mercure chez le grand corégone sont faibles dans tous les lacs analysés.
- On a constaté que les concentrations de mercure chez le grand brochet sont inférieures à 0,5 **partie par million dans le lac** Big Island, le lac Mustard et le lac Willow, par contre elles sont supérieures à 0,5 **partie par million dans de nombreux lacs de pêche.**
- On a constaté que les concentrations de mercure chez le doré jaune sont inférieures à 0,5 **partie par million dans le lac** Willow.
- Les concentrations chez le touladi étaient inférieures à la marque de 0,5 dans le lac Big Island, le lac Trout, le lac Fish et le lac Willow. Par contre, les concentrations de mercure étaient élevées chez ces espèces dans de nombreux lacs de pêche des collectivités du Dehcho.

Objectives

1. To organize a series of workshops (one per year) which involve the leadership and resource managers in the six communities most affected by recent consumption advisories for fish. The objective of the workshops is to facilitate dialogue among community leaders, harvesters, elders and youth on changes from a traditional country food diet to a market based diet. Discussions will include health and wellness benefits of country food in community diets. Experts invited to present at the workshop will provide technical/scientific information to increase the community participants' knowledge on contaminants.
2. To devise ways of increasing availability of country food, especially with respect to fish. Test new fishing lakes; fish down stocks to reduce the average size of predatory fish; inform the communities of healthy sources of fish.
3. To educate youth on the importance of traditional culture and the benefits of country food in a balanced diet.
4. To encourage youth to enrol in post-secondary education, especially in resource management and/or environmental and biological sciences.
5. To continue, on a *limited basis,* mercury testing in commonly-consumed fish from select water bodies.

Introduction

The Dehcho First Nations (DFN), 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 may be increasing due to climate change and other factors. New health advisories have been issued for certain fish in certain lakes by the GNWT, Health and Social Services. In some cases the new levels in fish have increased, even doubled.

This project completed the following tasks:

- Continue to sample fish for mercury levels in order to;
  - Find lakes with safe levels of mercury in various fish species for the Dehcho communities to fish for food
  - Support researchers who are studying mercury contamination and pathways in Dehcho lakes to contribute to our understanding of the problem.
  - Provide a forum for NCP researchers and others to communicate their project results to the Dehcho communities
- Kakisa Country Food Workshop 2013; Involve and inform Dehcho leaders/decision makers and Dehcho Environment managers about mercury levels in fish; and the causes; and the risks and benefits to Dehcho people of including fish and other country food in their diets. Get feedback, advise and recommendations from our community leaders.
- Discuss communication initiatives to get the message out to the Dehcho membership and promote healthy fish in the diet.
- The Dehcho AAROM program will continue to support researchers by providing logistical assistance and additional funding for the collection of fish for contaminant analysis.
- Our research emphasis is changing, from the collection and analysis of fish for mercury, towards studying 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 are being examined at the community level in order to encourage people to return to a healthy traditional diet.

Through its Dehcho AAROM (Aboriginal Aquatic Resource and Oceans Management) program, the Dehcho First Nations addressed risk perceptions about country foods over the two years. During the 2013-14 fiscal year built on the successful “A Return to Country Food” workshop held in Jean Marie River in August, 2012 with a major workshop hosted by the Ka’a’gee Tu First Nation.

Activities in 2013-2014

1. A major workshop; “The Return to Country Foods” was held in Kakisa in August of 2013. The workshop was considered a huge success; it provided an excellent opportunity for Dehcho leaders, environmental coordinators, community members, university and government researchers to meet and share ideas and opinions. The “Return to Country Food Workshop – Kakisa” report is attached. This workshop is our best effort at capacity building and communications.

2. We continued to collect and have samples analysed for mercury in lakes identified by the communities as fishing lakes. We added Mustard Lake and the Mackenzie River near Jean Marie River to our list in2013-14. Capacity building; Dehcho members are hired through Band contracts and trained by the AAROM technical Adviser to collect fish samples. We rely on traditional knowledge for location and timing of our collections

3. Youth Ecology Camp and other youth activities. This year’s youth program focused on “Clean Water, Healthy Food, and Good Choices”

   - Bruce Townsend of BEAT Environmental was contracted to deliver the mercury modules during the Dehcho Annual Youth Ecology Camp which was at Cli Lake in the Mackenzie Mountains this year.

   - Dehcho AAROM held a day-long youth camp on the last day of the “Country Food” workshop in Kakisa. Activities included; Youth participation in gillnetting activities lead by local harvesters, Fred Simba and Chris Chicot, biological fish sampling by George Low, benthic ecology activities by Heidi Swanson, Mercury modules by Bruce Townsend and traditional fish cutting by Sarah Chicot.

   - There was a similar Youth day with the whole of Charles Tetcho School in Sambaa K’e.

4. We continued to keep our Aboriginal partners in the Dehcho informed on contaminant matters. We received funding from Health Canada, Climate Change Adaptation program to survey community members on country food and diet issues related to climate change and observed increases in mercury levels in some fish in some Dehcho lakes. We conducted 415 surveys in the six most affected communities; Trout Lake, Kakisa, Jean Marie River, Wrigley, Fort Providence and Fort Simpson. Dehcho AAROM continues to work with GNWT, Health and Social Services on providing consumption advice to our members. Brian Laird of the U of Waterloo is assisting with reviewing the final report.

5. Heidi Swanson, U of Waterloo, completed the first year of field work for her three year research study on Bioaccumulation and biomagnification of mercury in the food web. Dehcho AAROM provided logistic and field assistance support. Capacity Building; Heidi explains her project to the monitors and field assistant assisting her while benefiting from their fishing experience.

6. Dehcho AAROM has contracted Marlene Evans, EC to analyse fish from Mustard, Trout, Little Doctor and the Mackenzie River this year. As a part of Heidi Swanson’s research project we collected repeat samples (2013) from Trout Lake, Ekali Lake, and Sanguez Lake.

Results

Summary of mercury concentrations in fish caught during 2010-2013 as part of the Dehcho AAROM mercury project. Also shown are historic data from Stewart et al. (2004) and Evans et al. (2005).

	Year	N	Fork length (mm)	Weight (g)	Age (Years)	Mercury (µg/g)
Big Island Lake						
Lake whitefish	2012	20	444.1 ± 30.0	1179.8 ± 354.7	9.4 ± 4.4	0.10 ± 0.04
Burbot*	2012	20	669.1 ± 48.8	2362.3 ± 509.2	14.6 ± 2.9	0.30 ± 0.13
Northern Pike	2012	16	780.5 ± 313.9	2562.8 ± 1210.9	10.4 ± 3.2	0.38 ± 0.26
Lake trout	2012	20	570.4 ± 60.1	2466.3 ± 1004.6	15.3 ± 4.7	0.38 ± 0.10
Deep Lake						
Lake whitefish	2000	28	443.5 ± 40.9	1253.1 ± 345.0	11.4 ± 2.9	0.25 ± 0.12
Lake whitefish	2010	1	474.0	1140.0		0.22
Burbot*	2010	3	414.3 ± 123.1	550.0 ± 525.7	13.7 ± 3.1	0.91 ± 0.24
Northern Pike	2000	6	583.7 ± 54.8	1420.0 ± 386.3	10.3 ± 4.3	0.67 ± 0.20
Northern Pike	2010	4	574.3 ± 117.5	1387.5 ± 809.2	9.7 ± 4.5	1.15 ± 0.30
Yellow walleye	2010	4	448.0 ± 40.2	1040.0 ± 238.5	15.3 ± 3.5	1.11± 0.35
Yellow walleye	2010	5	401.0 ± 63.6	766.0 ± 395.3	11.6 ± 5.0	1.21 ± 0.46
Ekali Lake						
Lake whitefish	1996	26	477.5 ± 70.4	1850.4 ± 807.3	7.9 ± 3.8	0.08 ± 0.04
Lake whitefish	2011	20	473.1 ± 70.2	1782.3 ± 743.8	7.6 ± 2.4	0.12 ± 0.04
Northern Pike	1996	7	577.6 ± 90.8	1534,3 ± 960.7	7.6 ± 2.2	0.30 ± 0.11
Northern Pike	2011	16	622.1 ± 95.5	1910.6 ± 1085.8	8.3 ± 2.1	0.62 ± 0.17
Yellow walleye	1996	16	411.8 ± 28.9	842.5 ± 175.8	8.3 ± 1.6	0.26 ± 0.06
Yellow walleye	2011	18	410.3 ± 42.0	738.3 ± 246.7	9.9 ± 3.3	0.54 ± 0.20
Fish Lake						
Lake whitefish	2011	25	393.2 ± 45.7	850.0 ± 299.9	8.8 ± 3.2	0.09 ± 0.03
Burbot*	2011	7	675.0 ± 48.2	2432.9 ± 218.0	8.3 ± 2.1	0.40 ± 0.10
Northern Pike	2011	20	733.6 ± 97.1	3256.0 ± 1570.7	11.8 ± 2.4	0.67 ± 0.15
Lake trout	2011	7	582.4 ± 58.5	2552.1 ± 692.8	17.7 ± 9.7	0.46 ± 0.17
Yellow walleye	2011	5	484.8 ± 40.8	1449.6 ± 385.3	17.6 ± 3.2	0.91 ± 0.21
Kakisa Lake						
Yellow walleye	2013	20	Not yet analysed			
Little Doctor Lake						
Lake whitefish	2013	20	Not yet analysed			
Burbot	2013	3				
Yellow walleye	2013	8				

	Year	N	Fork length (mm)	Weight (g)	Age (Years)	Mercury (µg/g)
Mackenzie R.						
Lake Whitefish	2013	12	Not yet analysed			
Burbot	2013	1				
Northern Pike	2013	20				
McGill Lake						
Lake whitefish	2000	3	392.2 ± 57.0	1153.3 ± 582.8	7.7 ± 2.7	0.16 ± 0.05
Lake whitefish	2010	3	419.7 ± 58.2	1168.3 ± 518.1	9.0 ± 4.0	0.10 ± 0.04
White sucker	2000	17	471.4 ± 33.3	1740.6 ± 441.7		0.21 ± 0.08
White sucker	2010	12	447.3 ± 39.6	1497.9 ± 403.4	11.6 ± 2.3	0.16 ± 0.06
Northern pike	2000	28	577.2 ± 171.3	1905.8 ± 2127.8	8.5 ± 5.6	0.71 ± 0.37
Northern pike	2010	19	664.6 ± 180.8	2870.0 ± 2556.8	10.0 ± 4.1	0.83 ± 0.38
Yellow walleye	2000	22	480.4 ± 67.4	1428.6 ± 733.2	12.8 ± 5.4	1.13 ± 0.38
Yellow walleye	2010	20	464.4 ± 29.9	1162.8 ± 252.8	12.1 ± 3.0	1.25 ± 0.39
Mustard Lake						
Lake whitefish	2013	17	Not yet analysed			
Burbot	2013	17				
Northern pike	2013	16				
Lake trout	2013	8				
Sanguez Lake						
Northern pike	1996	20	682.8 ± 84.8	2562.0 ± 985.3	9.7 ± 2.3	0.70 ± 0.18
Northern pike	2011	20	638.3 ± 50.7	1950.0 ± 471.6	9.4 ± 2.2	0.96 ± 0.22
Yellow walleye	1996	20	439.9 ± 40.4	1070.5 ± 368.9	9.4 ± 1.7	0.54 ± 0.12
Yellow walleye	2011	20	523.5 ± 44.5	1875.0 ± 507.2	8.9 ± 2.0	0.78 ± 0.25
Tathlina Lake						
Northern pike	1998	6	570.6 ± 50.1	1486.3 ± 456.3	n.d.	0.21 ± 0.04
Northern pike	2012	20	711.4 ± 85.1	3038.3 ± 1360.2	10.5 ± 2.3	0.65 ± 0.22
Yellow walleye	1998	6	417.6 ± 11.8	1040.7 ± 67.8	n.d.	0.33 ± 0.18
Yellow walleye	2012	34	417.3 ± 18.7	819.4 ± 100.8	15.3 ± 3.7	0.69 ± 0.22
Trout Lake						
Lake trout	2003	28	645.2 ± 35.5	2863.7 ± 743.0	17.2 ± 5.5	0.35 ± 0.08
Lake trout	2008	28	601.9 ± 71.0	3127.0 ± 1633.7	16.2 ± 7.7	0.61 ± 0.17
Lake trout	2011	20	680.5 ± 70.6	4394.5 ± 1632.8	14.5 ± 8.6	0.46 ± 0.08
Yellow walleye	1977	7	512.7 ± 29.4	2342.9 ± 439.1	n.d.	0.83 ± 0.18
Yellow walleye	1990	10	450.3 ± 73.2	1130.0 ± 525.7	8.8 ± 1.5	0.11 ± 0.04
Yellow walleye	1991	10	498.2 ± 52.7	1276.8 ± 345.5	10.0 ± 1.25	0.14 ± 0.06
Yellow walleye	2012	20	506.7 ± 45.0	1371.0 ± 290.9	18.9 ± 6.1	0.68 ± 0.27

	Year	N	Fork length (mm)	Weight (g)	Age (Years)	Mercury (µg/g)
Willow Lake						
Lake whitefish	1999	47	404.5 ± 44.5	993.6 ± 342.9	8.9 ± 2.7	0.10 ± 0.05
Lake whitefish	2012	20	440.2 ± 29.3	1238.5 ± 298.0	11.8 ± 1.7	0.10 ± 0.04
Northern Pike	1999	20	634.0 ± 96.0	2016.3 ± 976.2	n.d.	0.28 ± 0.15
Northern Pike	2012	20	691.1 ± 68.0	2617.3 ± 838.2	11.8 ± 3.0	0.38 ± 0.26
Lake trout	1999	32	613.7 ± 92.9	3067.5 ± 2159.9	15.8 ± 4.8	0.38 ± 0.10
Lake trout	2012	16	642.1 ± 72.4	3413.8 ± 1108.7	13.0 ± 2.2	0.38 ± 0.10

Project website

http://www.dehcho.org/aarom.htm

Acknowledgments

Dehcho AAROM thanks our Dene and Metis partners for their participation in the Kakisa, Country Food Workshop; we value their traditional knowledge input, comments and discussion and their contribution towards the development of a communication plan to keep all our members up to date and informed about mercury and other contaminants issues.

Dehcho AAROM thanks Peter Redvers for facilitating, Mike Low, Deanna Leonard, Katarina Carthew, Marlene Evans, Heidi Swanson, Bob Hanley, Mike Wilkie, Elsie De Roose and Bruce Townsend for presenting their information and fielding questions and comments.

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Paulatuk Beluga Whales: Health and Knowledge

Bélugas de Paulatuk : santé et connaissance

- **Project Leader:**
  Diane Ruben, Paulatuk Hunters and Trappers Committee
  Tel: (867) 580-3004, Fax: (867) 580-3404
  Email: phtc@live.ca
- **Project Team Members and their Affiliations:**
  Lisa Loseto, Fisheries and Oceans Canada;
  Kristin Hynes, Fisheries Joint Management Committee

Abstract

Recent changes in climate and ice in Darnley Bay have changed 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. The community of Paulatuk wanted to lead their own community-based monitoring program to assess beluga health and contaminant levels. This summer, two monitors from Paulatuk collected samples from eleven harvested whales. The hunters and monitors noted the challenges in ice and weather conditions that hampered harvests. Length measurements

Résumé

Les récents changements dans le climat et les glaces dans la baie Darnley ont modifié la fréquence des chasses aux bélugas par la collectivité de Paulatuk dans la région désignée des Inuvialuits. La collectivité de Paulatuk se pose de nombreuses questions sur les bélugas chassés, en lien avec leur santé et sur les similitudes et les différences par rapport aux baleines surveillées à Hendrickson Island dans l'estuaire du Mackenzie. La collectivité de Paulatuk voulait mener son propre programme de surveillance communautaire pour évaluer la santé des bélugas et les concentrations de contaminants chez les baleines. Cet été, deux surveillants de Paulatuk ont prélevé des échantillons dans onze baleines chassées.

were taken, along with jaws for ageing and tissues for mercury and stable isotope analyses. Whales were larger and older than those taken in 2005, and comparable to whales sampled at Hendrickson Island. Unlike previous years, the mercury concentrations in whales harvested near Paulatuk were higher than those observed in whales from Hendrickson Island. Comparisons with both Hendrickson whales and historical whales taken in Paulatuk suggest a possible shift in diet in recent years. However, given the low sample size (n=11) it is difficult to conclude on such observations. Future efforts will be placed on increased observational information collected along with harvest samples.

Les chasseurs et les surveillants ont noté les changements dans les conditions des glaces et la météo qui ont nui à la chasse. La longueur a été mesurée, les mâchoires ont été inspectées pour connaître l'âge et les tissus ont été soumis à des analyses du mercure et des isotopes stables. Les baleines étaient plus grosses et plus âgées que celles chassées en 2005, et comparables aux baleines échantillonnées à Hendrickson Island. Contrairement aux années précédentes, les concentrations de mercure chez les baleines chassées près de Paulatuk étaient supérieures à celles observées chez les baleines de Hendrickson Island. Les comparaisons entre les baleines de Hendrickson et les baleines auparavant chassées à Paulatuk donnent à penser qu'il y a peut-être eu une modification dans l'alimentation au cours des dernières années. Par contre, étant donné la petite taille de l'échantillon (n=11), il est difficile d'établir des conclusions à partir de telles observations. Les efforts futurs seront axés sur l'augmentation de l'information obtenue par des observations recueillies ainsi que sur les échantillons de récolte.

Key messages

- The community had a very successful harvest in 2013-2014. Fourteen beluga were taken, and one lost due to ice in Lessard/Brock River area to the East of Paulatuk.
- Eleven beluga were sampled and shipped to the Fresh Water Institute for analysis.
- Most samples were taken from the mouth of the Hornaday River on August 4th.Water depth here is about 20-30 feet in the main channel.
- Samples were sent to Fisheries and Oceans Canada to estimate age, measure mercury levels in muscle, liver and skin, and evaluate diet indicators.
- Preliminary results revealed mercury concentrations to be higher than those measured at Hendrickson Island, which may be driven by the larger size of whales harvested near Paulatuk. We are evaluating

Messages clés

- La collectivité a eu une très bonne récolte en 2013-2014. Quatorze bélugas ont été chassés, et un béluga a été perdu à cause de la glace dans le secteur de Lessard/Brock River, à l'est de Paulatuk.
- Onze bélugas ont été échantillonnés et envoyés à l'Institut des eaux douces à Winnipeg pour y être analysés.
- La plupart des échantillons ont été prélevés dans l'embouchure de la rivière Hornaday le 4 août 2013. À cet endroit, la profondeur de l'eau est d'environ 20 à 30 pieds (6,1 à 9,1 m) dans le chenal principal.
- Les échantillons ont été envoyés à Pêches et Océans Canada pour l'estimation de l'âge, la mesure des concentrations de mercure dans les muscles, le foie et la peau, et l'évaluation des indicateurs du régime alimentaire.

the drivers of short term (muscle) and longer term (liver) mercury accumulation in Paulatuk belugas

- Les résultats préliminaires ont révélé que les concentrations de mercure sont supérieures à celles mesurées à Hendrickson Island, ce qui peut s'expliquer par la plus grande taille des baleines chassées près de Paulatuk. Nous en sommes à évaluer les causes de l'accumulation de mercure à court terme (muscles) et à long terme (foie) chez les bélugas de Paulatuk.

Objectives

1. Move from an early pilot phase to a strengthened community lead beluga monitoring program for the community of Paulatuk in the ISR.
2. Build community capacity in monitoring and research on beluga whales and health
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 hunts sites as well as link with other ecosystem monitoring (*e.g.*offshore BREA fish program under BREA).
5. Engage community youth in analysis of samples at the DFO (FWI)

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 on going monitoring. Establishing a baseline at this time will assist with future monitoring and management.

The community of Paulatuk hunts beluga whales in the summer. 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 the hunts. Hunters have had concerns and questions about the health and well being of the beluga whales and their supporting ecosystems. While these are whales 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).

Previous work has shown whales collected at Hendrickson have similar mercury concentrations as those collected at other nearby monitoring sites (Kendall Island, East Whitefish) that are located in the Mackenzie Estuary. The habitat near Paulatuk is very different than the Mackenzie Estuary. How habitat is used differs, and may reflect different diets and processes among the 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 2013-2014

Field and Local observations:

The PHTC hired on Jody Illasiak and Brandon Green as the 2013/14 Beluga Monitors from funding that came from Northern Contaminants Program (NCP), Fisheries Joint Management Committee (FJMC), Fisheries and Oceans Canada (DFO) and World Wildlife Fund (WWF). Alongside the beluga monitoring program there was a pilot project Local In 2013, 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, one community coordinator and one local observer were hired to support the collection of beluga observations in Darnley Bay.

While training and support manuals are provided every year, this year on site training was provided at Hendrickson Island to ensure consistency. Brandon Green spent one week at Hendrickson Island and participated in sampling three whales. He learned worked closely with the Hendrickson Island monitors Frank Pokiak and Verna Pokiak as well as with the science team at the Island.

On July 7th Jody was stationed at Green's Island until harvesters were able to hunt around for whales. Brandon was stationed at Tippi. On July 13th Brandon harvested and sampled the first whale of the Season from a group of whales of about 30 which passed from Argo bay and headed Northward. The next day, 4 boats with 9 harvesters headed North to Browns Harbor and on July 15th they harvested and sampled 2 whales. Later that Month, Lessard harvested 1 whale and no samples were taken, but the basic information was taken. The weather was not cooperating this year, had mostly strong west winds, which held back harvesters that planned to go to Browns Harbor.

In early August, our Char Monitor, Ian Green herded a group of over 30 at Hornaday river system until harvesters arrived. 8 were immediately harvested and sampled. And on August 4th another 2 more were harvested but not sampled at the same location, due to rough water our Monitor Jody couldn't make it out to the 2 harvesters at the Hornday, but basic information was collected as well, as to the size and sex.

In contrast, 14 whales were harvested and 1 loss at Lessard. All were healthy, but one had a swell that looked like a tumor in the stomach area of one of the harvesters at Hornaday River. Pictures and samples were taken. Because of the lateness of the whales, the program was extended once again for another 7 days, which the monitors were more than happy to do.. The samples will be sent to Kristin Hynes in October when it's more cooler. And safest to send. She will then ship them to Winnipeg later in November just to be safe of the temperature

All equipment have been returned by the Beluga Monitors and the trapper radio will be sent back to FJMC and the log books, data sheets will also be sent as well.

Laboratory:

Samples were sent to University of Manitoba for Hg analyses as part of G. Sterns contaminant Lab transition. Ages of whales were determined from a thin section of tooth and counting individual growth layers at the Freshwater Institute (Stewart et al. 2006). Liver, skin and muscle were analyzed for total Hg 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.

Stable isotope analyses on liver and muscle samples were carried out at the University of Waterloo using ion-ratio, mass spectrometry (CF-IRMS). Lipids were removed from samples using a 2:1 chloroform:methanol wash for carbon readings.

Similar to the previous year the Paulatuk HTC hired students to participate in various projects taking place in Darnley Bay. This year…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. She went on to Winnipeg FWI with the Monitor Brandon Green. Diane has arranged the travel for December 4 - 8th and they both went down to Halifax for the ArcticNet Conference from the 9 -14th. During her week at the FWI L. Loseto and Sonja Ostertag has arranged a week of exposure to programs and laboratory work related to her field season. Bernadette and Brandon worked with E. Choy (L. Loseto's PhD student) to learn methods of fatty acid analysis on beluga blubber, B. Dunn to learn ageing methods using beluga teeth, S. Atchison to learn how fish are dissected and prepared for all analyses, S. MacPhee to learn how invertebrates from the Beaufort Sea are sampled and analyzed, L. Postma to learn about genetics analyses for beluga samples from the Beaufort, C. Willing to learn about beluga whale and ringed seal reproductive organs, and T. Halldorson/G. Tomy to learn about organic contaminants analyses and environmental chemistry. Bernadette will provide a report back to the PHTC on her experience and present a power point presentation to the school about her experience.

Results

Length and Age:

As with previous years the sample size (n= 11) is small and difficult to make general assessment about population health. Whales hunted in 2013 ranged in length from 3.7m to 4.6m (averaging = 4.3m) and were generally larger than those historically ($P<0.05$; Table 1). Relative to whales taken at Hendrickson Island that averaged 4.0m in length, the whales from Paulatuk were larger ($P<0.0001$). This is the reverse of what was observed in 2005 (Figure 1).

The average age of belugas taken near Paulatuk in 2013 were relative to previous whales landed averaging just over 27 years ($P=0.03$, Table 1). There were few young whales that were typical for previous years, ages ranged from 23 to 49. Unlike previous years age and length did not significantly relate to one another, perhaps owing to the fact whales were older and had reached their asymptote length. There was no significant difference in age between whales landed near Paulatuk and Hendrickson Island ($P=0.3$; Figure 2).

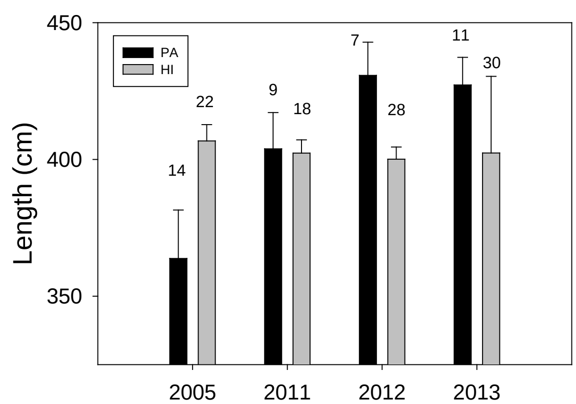

Figure 1. Beluga length (cm) over four years harvested near Paulatuk (black) and Hendrickson Island (grey) near Tuktoyaktuk. Whales did not differ in length among sites in 2011 and pattern of size shifted over time from large whales harvested at Hendrickson to largest harvested whales near Paulatuk. Sample sizes are noted in text above bars.

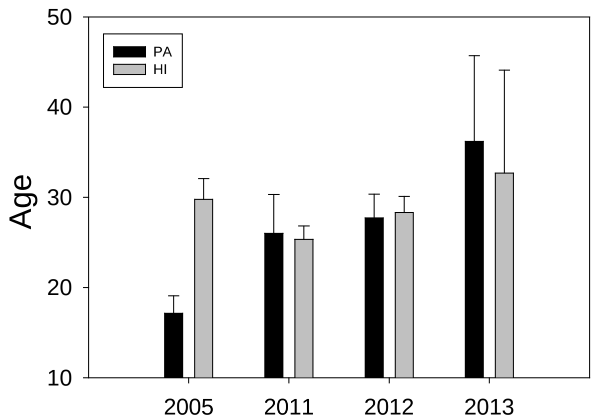

Figure 2. Estimated Beluga age (1 GLG) over four years harvested near Paulatuk (black) and Hendrickson Island (grey) near Tuktoyaktuk. Belugas harvested near Paulatuk were significantly younger than those taken at Hendrickson in 2005 with little difference between sites in subsequent years.

Mercury in Tissues

Concentrations of Hg in muscle ranged from 1.1 to 2.6ug/g (ww) and averaged 2.0ug/g. These concentrations were significantly higher than those observed in 2005 and 2011 (average = 0.7ug/g; 1.2ug/g; respectively) and similar concentrations from 2012 whales. The concentration of Hg from Hendrickson Island whales (1.5ug/g) were significantly lower lower than those measured in Paulatuk whales (P=0.02; Figure 3). Muscle Hg had a weak positive relationship with length (r = 0.35, p=0.32) and age (r = 0.37, p=0.27) unlike previous years.

Trends for skin Hg concentrations were similar to muscle, showing an increase in concentrations (average = 0.65ug/g) however they were not significantly higher concentrations measured in Hendrickson Whales (P>0.05). Skin Hg positively related to muscle Hg concentrations (r = 0.64, p=0.03).

Concentrations of Hg in liver were extremely variable ranging from 4.2 to 111.2ug/g (ww) resulting in an overall increase in the average Hg concentrations for 2013 (average = 56.7ug/g; Table 1). These concentrations were significantly higher than those measured at Hendrickson Island (average = 27.7ug/g) (P=0.03; Figure 4). Liver Hg had a weak correlation with age (r = 0.1, P=0.8). Liver and Muscle Hg were not significantly related (r=0.4; P=0.25).

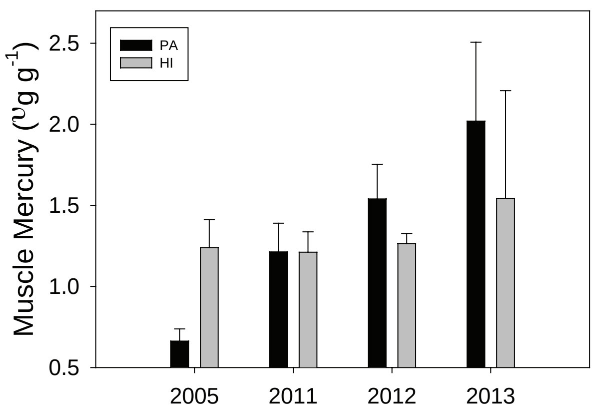

Figure 3. Concentrations of Hg in muscle (ug-g^{-1} ww) from belugas harvested near Paulatuk (black) and Hendrickson Island (grey) near Tuktoyaktuk. Belugas from Paulatuk were higher than those measured at Hendrickson for 2013 and were higher than previous years.

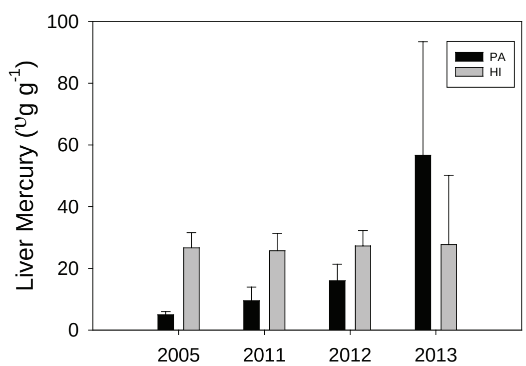

Figure 4. Concentrations of Hg in liver (ug-g^{-1} ww) from beluga whales harvested at Hendrickson Island (grey) near Tuktoyaktuk and near Paulatuk (black). Belugas from Paulatuk taken in 2013 demonstrated a significant increase and relative to previous years and were higher than those taken at Hendrickson.

Stable Isotopes

Isotopes were used as a means to interpret beluga feeding preferences driving the contaminant levels. While the $\delta^{15}N$ revealed differences among years for both muscle and liver the only year that was significantly different than all others was 2005, showing the lowest levels ($P<0.001$;Table 1). On the other hand $\delta^{13}C$ levels for 2013 were significantly lower than all years in both liver and muscle (Table 1). In comparing isotopic means among sites only $\delta^{13}C$ in muscle showed a significant difference, where by belugas harvested near Paulatuk had $\delta^{13}C$ significantly lower levels than Hendrickson whales ($P=0.007$; Figure 5).

There were no significant relations for beluga age and length with either stable isotopes. Muscle $\delta^{15}N$ had a significant negative relationship with $\delta^{13}C$ in liver ($r = -0.64$, $p=0.049$). $\delta^{13}C$ in liver and muscle were positively correlated ($r = 0.66$, $p=0.038$). Examining trends with Hg, no significantly relationships were observed with liver or muscle stable isotopes.

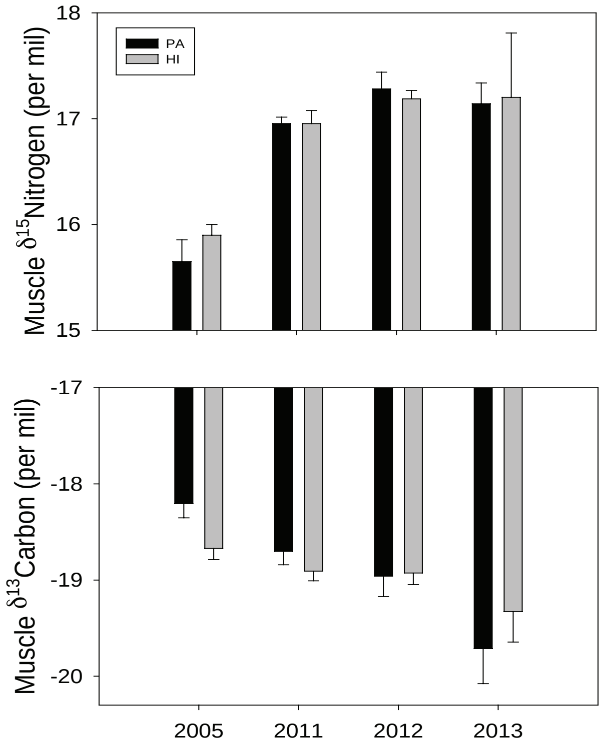

Figure 5. Muscle levels of $\delta^{15}N$ and $\delta^{13}C$ in beluga belugas harvested near Paulatuk (black bars) and Hendrickson Island (grey) near Tuktoyaktuk. The $\delta^{13}C$ show depleation in 2013 whales that are significantly lower in belugas taken near Paulatuk relative to Hendrickson belugas.

Table 1: Summary of statistics from belugas harvested near Paulatuk over four years.

	2005			2011			2012			2013			ANOVA output	
	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	0.005	0.55
Age	17.1	±	7.3	26.0	±	12.9	27.7	±	7.0	36.2	±	9.5	<0.0001	0.64
Mercury														
Liver	5.0	±	3.7	9.5	±	12.5	16.0	±	14.2	56.7	±	37.4	<0.0001	0.73
Muscle	0.7	±	0.3	1.2	±	0.5	1.5	±	0.6	2.0	±	0.5	<0.0001	0.78
Skin	0.2	±	0.1	0.5	±	0.3	0.7	±	0.3	0.9	±	0.3	<0.0001	0.72
Liver MeHg							0.9		0.57					
Stable Isotopes														
δ15N Muscle	15.6	±	0.7	17.0	±	0.2	17.3	±	0.4	17.1	±	0.2	<0.0001	0.84
δ15N Liver	16.8	±	0.6	17.9	±	0.3	17.7	±	0.4	18.2	±	0.3	<0.0001	0.80
δ13C Muscle	-20.2	±	0.7	-20.4	±	0.3	-19.0	±	0.6	-19.7	±	0.4	<0.0001	0.80
δ13C Liver	-18.2	±	0.5	-18.7	±	0.4	-20.8	±	0.1	-21.5	±	0.3	<0.0001	0.76

Discussion and Conclusions

The 2013 harvest year was unlike previous years where the majority of whales were taken at one location, near the Hornaday River Mouth. However similar to previously years this took place in late July-early August. Hunts in 2005 and 2011 occurred between July 14-25, not significantly earlier than 2013. While the whales were not harvested significantly later than previous years it is suspected whales are arriving to the Beaufort sooner due to changes in ice and open water, thus timing association with the size of whales requires further investigation.

The local observations on the whales differ by size, the smaller ones comes in first to feed in the shallow water while the bigger ones comes about 1 – 2 weeks later to molt in shallow areas. There has been success in sampling sizes from 9' to 14' whales at two different times. While the earlier whales were the smaller sizes from 9' – 11' and the larger whales are later in early August ranging from 12' to over 14'. Collecting more local observations and TEK will better help us to understand the behavior and why they tend to travel at different times. This is a new program but the past observations are a learning experience of why they migrate different times. Understanding how changes in whale size, age, behaviour, diet relate to habitat changes are important to understanding links to climate change and further how those changes will influence contaminant loads.

Similar to 2012 whales harvested this year did not very much in size and were all large and larger than those harvested at Hendrickson Island. These whales were all consistently older than whales harvested in previous years and similar to ages of whales from Hendrickson Island. The larger and older size of 2013 whales impacted the observed Hg levels in liver and muscle that were higher than previous years and higher than Hendrickson whales. These results raise new questions. 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 have been larger and older, yet Hg levels had not significantly increased relative to Hendrickson Island whales until 2013, in liver in particular.

Mercury in muscle and skin are both largely comprised of methyl mercury and reflect dietary exposure of mercury. The increased Hg concentration in muscle to levels similar to and higher than those at Hendrickson in 2012 and 2013 fit the size defined trend (Loseto et al. 2008). That is, the larger whales feed in offshore areas on higher trophic level species that have higher Hg levels thus increasing dietary exposure. However, the $\delta^{15}N$ levels in liver and muscle did not differ from Hendrickson or form 2012 and 2011 values. This would suggest a shift in trophic feeding may not explain he higher Hg levels in 2013 whales Paulatuk whales. On the other hand the $\delta^{13}C$ were significantly depleted relative to Hendrickson harvested whales which may support these whales were feeding more pelagically in the offshore. Further investigative work using fatty acids would assist to evaluate how dietary differences may explain the Hg variability.

Unlike muscle Hg, liver Hg is reflective of long term accumulation of Hg as Hg:Se overtime in the liver and thus tends to relate strongly with age. In 2013 the highest liver Hg concentrations were observed which is puzzling as they did not differ in relative to whales harvested at Hendrickson. Additionally, this is the opposite pattern in 2012 where both whales harvested at Hendrickson and Paulatuk were the same age yet Hg concentrations in liver were significantly higher in Hendrickson harvested whales. This may highlight the high variability in Hg patterns across whales or across years.

Lastly the stable isotopes provided some insight into the observed Hg trends among tissues, but in some instances were not able to directly link diet shifts with Hg patterns. Generally relationships of morphometrics and stable isotopes were weak as were the relationships with stable isotopes and Hg concentrations among tissues. Lack of statistical significance may reflect the low sample size. While linkages on defining drivers are being teased out with some of the isotope work more analyses are required to better understand the recent observations, however given the general low sample size efforts on collecting LEK/TEK and observations will assist with the interpretation of results received thus far.

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Tłı̨chǫ Aquatic Ecosystem Monitoring Project (TAEMP)

Projet de surveillance de l'écosystème aquatique de Tlicho (PSEC)

- **Project Leader:**
  John McCullum, Wek'èezhìi Renewable Resources Board, Tel: (867) 873-5740, Fax: (867) 873-5743, Email: jmccullum@wrrb.ca
- **Project Team Members and their Affiliations:**
  Kerri Garner, Jennifer Wetrade, Sean Richardson and Mason Mantla, Tłı̨chǫ Government; Susan Beaumount, Boyan Tracz, Sarah Elsasser, and Brett Wheler, Wek'èezhìı Land and Water Board; Paul Vecsei, Golder Associates Ltd.; Deanna Leonard, Fisheries and Oceans Canada; Elsie Deroose, Government of Northwest Territories; Marlene Evans, Environment Canada

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 2013, a 5-day on-the-land monitoring camp was held near Gamètì at a location that supports an Aboriginal subsistence

Résumé

Le Projet de surveillance de l'écosystème aquatique de Tlicho (PSEC) continue de fournir un moyen de répondre aux préoccupations de la collectivité en lien avec les changements dans l'environnement, et s'appuie sur les travaux réalisés de 2010 à 2013. Un programme communautaire réussi fait véritablement participer les membres de la collectivité à la recherche sur les contaminants, notamment au prélèvement des échantillons et aux observations en utilisant les connaissances du peuple tlicho et scientifiques pour répondre à la question : est-ce que les poissons et l'eau sont propres à la consommation?

fishery. Elders spoke about fish and aquatic ecosystem health, and directed where fish, water, and sediment samples should be taken. Community members, in cooperation with scientists, collected samples. The methods for processing fish tissues for lab analysis were demonstrated. A results workshop was held in Gamètì in February to present results of analyses; camp participants and community members attended.

Fish tissue analysis indicated that mercury levels were low in whitefish, and that lake trout had higher levels by comparison (with older individuals of lake trout having the highest overall). Both whitefish and lake trout did not show levels of mercury that were considered abnormal for northern lakes. Water and sediment samples indicated that water quality and sediment quality is good near Gamètì. Interestingly,Traditional Knowledge and science both acknowledged the quality of the location used for “tea water”, as water there was “softer” than found at all other locations.

Key messages

- The fish tissue analysis showed that mercury levels were low in whitefish, and that older lake trout have higher levels. No abnormal levels of contaminants were found.
- The water and sediment quality sampling results show that Rae Lakes is typical of other lakes in the area.

En septembre 2013, un camp de surveillance terrestre de 5 jours s’est tenu près de Gamètì à un endroit utilisé par les Autochtones pour la pêche de subsistance. Les aînés ont parlé de la santé des poissons et de l’écosystème aquatique, et ont indiqué à quel endroit les échantillons de poissons, d’eau et de sédiments devraient être prélevés. Les membres de la collectivité, en coopération avec les scientifiques, ont prélevé les échantillons. On a donné une démonstration des méthodes pour traiter les tissus de poissons en vue de l’analyse en laboratoire. Un atelier sur les résultats a eu lieu à Gamètì en février pour présenter les résultats des analyses; les participants du camp et les membres de la collectivité y ont assisté.

L’analyse des tissus des poissons a indiqué que les concentrations de mercure étaient faibles chez le grand corégone, et que les concentrations chez le touladi étaient plus élevées par comparaison (les individus de touladi les plus âgés ayant les concentrations les plus élevées dans l’ensemble). Le grand corégone et le touladi ne présentaient pas de concentrations de mercure considérées comme anormales pour des lacs du Nord. Les échantillons d’eau et de sédiments ont indiqué que la qualité de l’eau et des sédiments est bonne près de Gamètì. Fait intéressant, les connaissances traditionnelles et la science ont toutes deux reconnu la qualité de l’emplacement utilisé pour prélever de l’eau pour le thé, car l’eau à cet endroit y est plus « douce » (moins dure) qu’ailleurs.

Messages clés

- L’analyse des tissus de poissons a indiqué que les concentrations de mercure étaient faibles chez le grand corégone, et que les touladis plus âgés présentent des concentrations plus élevées. Aucune concentration anormale de contaminants n’a été détectée.
- Les résultats de l’analyse de la qualité des échantillons d’eau et de sédiments indiquaient que les concentrations dans les lacs Rae étaient semblables à celles des autres lacs du secteur.

- Community members were pleased with the implementation of the program, citing the importance of monitoring near their community, participation of the youth in the camp and the successful transfer of both traditional and science-based knowledge. Community members were also pleased with the timely presentation of results, and were very happy to learn that fish, water, and sediment quality are good near Gamètì.

- Les membres de la collectivité étaient satisfaits de la mise en œuvre du programme, en soulignant l'importance de la surveillance près de leur collectivité, la participation des jeunes au camp et le transfert réussi des connaissances traditionnelles comme scientifiques. Les membres de la collectivité étaient aussi satisfaits de la présentation rapide des résultats, et ils étaient très contents d'apprendre que la qualité des poissons, de l'eau et des sédiments était bonne près de Gamètì.

Objectives

- Document and combine traditional knowledge of fish in the Gamètì area with conventional fish sampling methods;
- Obtain baseline data on mercury levels in fish consumed by Gamètì residents;
- Evaluate mercury levels found in fish in terms of species and size/age relationships, habitat use, and trophic status;
- In the long-term, establish a monitoring program to identify contaminant levels and changes in levels through time for fish as part of a larger aquatic ecosystem monitoring program designed to address concerns of Tłı̨chǫ communities.

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 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 concerns and a general lack of information, there is a need to collect and update baseline information, and have ongoing monitoring of the aquatic ecosystems in Wek'èezhìı in anticipation of continuing pressures on the watershed. Further, it is important to have Tłı̨chǫ community members (including elders and youth) directly involved in the monitoring, and have a genuine opportunity for community members to exchange knowledge with research scientists in appropriate community and on-the-land settings.

Previous program results obtained from samples near Marian, Slemon and Snare Lakes indicated that mercury levels, although currently not likely posing a health risk, should be monitored for changing trends. Further, Lockhart et al. (2005) report 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. Given these recent and historic results, examination of mercury at additional locations in the Tłı̨chǫ region is warranted. Notably, Water Resources, Aboriginal Affairs and Northern Development Canada's (AANDC's) single water quality sampling station at Frank Channel does not detect mercury; however, additional water sampling locations throughout the Tłı̨chǫ region would broaden the geographic coverage for this parameter, as recommended in the AANDC State of Knowledge Report (AANDC 2012).

Activities in 2013-2014

Introductory Workshops

Workshops were held in July and August of 2013 to discuss the Program with the community, select an appropriate location and plan for the on-the–land camp. Louie and Therese Zoe's camp was selected as it was close to Gamètì, was central to sampling locations, offered a cabin for shelter and meeting, space for tents, and importantly was also a historic meeting place – prior to the establishment of Gamètì. Elders and community members also discussed the concept of indicators and their perspectives on the health of the ecosystem given their observations and knowledge.

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

A five-day on-the-land camp was held September 2012, and provided a valuable experiential learning opportunity in Tłı̨chǫ ways of understanding the aquatic ecosystem, assessing the health of the ecosystem and catching, preparing and preserving fish. Participants observed and learned about Tłı̨chǫ methods of resource management, and worked collaboratively to combine Tłı̨chǫ knowledge with science-based monitoring methods. Experiences shared at the camp were captured by Tłı̨chǫ Government staff, with an educational video produced showcasing the involvement of the youth and the value and importance of environmental monitoring from Tłı̨chǫ knowledge with scientific perspectives. Camp and sampling locations were selected by community members (Fig 1).

To determine current levels of contaminants tissue samples were collected from Lake Trout and Whitefish, the fish species regularly consumed by Gamètì residents; fish processing for lab analyses was led by DFO and Golder Associates biologists. Samples were collected under the guidelines established by Environment Canada for sampling for metals on Great Slave Lake and the Golder technical protocol 'Fish Health Assessment-Metals'. All fish captured were identified to species, measured (fork length), and weighed. Additional data collected included: gender, stage of maturity, and a general description of the contents of the stomach. Samples collected and archived include otoliths (both cleaned, and sectioned and mounted on slides) and tissue samples.

Water quality indicators included standard physical and chemical parameters, 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 Frank Channel of Great Slave Lake, the closest water quality monitoring station. Water sampling was be led by a WLWB biologist with close support provided by the TG Wildlife Monitor; procedures were followed to minimize contamination, such as appropriate QA/QC procedures according to Taiga lab instructions where analyses were conducted (located in Yellowknife). Sediment sampling used methods outlined in the Metal Mining Guidance Document for Aquatic Effects Monitoring (Environment Canada 2011) and analyzed for standard physical and chemical properties as well as trace metals at the Taiga Lab. Lake sediments will be sampled using an Ekman grab sampler which is suitable for collecting soft, fine grained sediment that is typically observed throughout the watershed.

Results Workshop

A workshop was held in February 2014 to report the lab results back to camp participants as well as interested community members - ranging from school aged youth to elders. The meeting was well attended and included 18 senior students from Jean Wetrade School (including camp participants).

Capacity Building

Tłı̨chǫ Government staff was a key driver in the successful implementation of the project, and cooperated with WRRB staff on a regular basis. TG staff coordinated and advertised community meetings, and assisted with logistics for the monitoring camp. The TG Wildlife Coordinator also assisted greatly with camp operations and the success of the fish camp – both from a sample collection as well as youth education perspective. The Coordinator's prior experience with the TG–led Marian Lake Watership Stewardship Project, and practical field knowledge were of great benefit.

Elders and youth were exposed to scientific methods of sampling and monitoring the aquatic ecosystem including sediment and water quality sampling as well as fish tissue sampling for contaminant analysis. Scientists and youth were exposed to traditional knowledge aiding their understanding of the local aquatic environment.

Youth were interviewed by a videographer working for the Tłı̨chǫ Government under Community Action Resource Team (CART). Camp activities and TK/science information were captured via filming, and an educational video showcasing the youth involvement has been produced. The video will be available on the WRRB website post final edits (early May).

Communications

Communication was achieved through planning workshops and the results meeting in Gamètì. Social media also provided a communications channel to a wider audience, as the WRRB website and Facebook page both had a series of stories related to the TAEMP; links were shared via the TG Facebook page. Presentations were given by WRRB staff at the Geoscience and NWT Annual Results workshops. Plain language handouts are available, and a fish guide has been updated.

Traditional Knowledge Integration

Elders and community members were involved in Program implementation from the preliminary introductory workshop through to the results workshop. This involved selection of community participants (elders, foreman, cooks, youth, etc.) as well as the selection of the camp site and set-up prior to the arrival of the support staff and youth. At meeting and at camp, community members had opportunities to describe the indicators they use to identify fish health and provide assessments of current fish health near their community, and their comments were captured in meeting notes and video. Elders and community members provided direction on where (and why) fish and water samples were collected, and youth were provided the opportunity to learn from their elders. An example was an initiative developed at the camp where elders and youth were brought together specifically to pass on Tłı̨chǫ knowledge, notably about the history of the area near Gamètì.

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 mutual respect and trust – as scientists and knowledge holders were able to learn from one another while both behaving "naturally" while out on the land, recognizing each other's capabilities through honest work (*e.g.*day-to-day activities required at camp, net setting / collection, fish sample processing).

Results

Lake Trout sampled ranged from 511-802mm in length (fork length) and 1510-5380g in weight, and were estimated to be 8-35 years of age. Approximately half of fish samples fell above the guideline of 0.5 mg per kg (wet weight; wwt) for mercury (Health Canada 2013a) and half below, ranging from 0.251-0.825mg per kg (wwt) (Fig. 2 and Fig. 3); notably the two largest fish did not have the highest mercury concentrations, and both were close to the Canadian Standards (maximum level) guideline. Analysis of mercury concentrations in muscle tissue in relation to both fork length and weight were not significant. Mercury concentrations in muscle tissue in relation to age of Lake Trout were found to have a significant relationship, though the adjusted r-squared values indicated a relatively weak relationship (0.41 to 0.47). Cysts (parasites) were found in all fish sampled, on

Figure 1. Locations where samples of fish, water, and sediment were collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Project (TAEMP) near the community of Gamètì (Rae Lakes), September 2013.

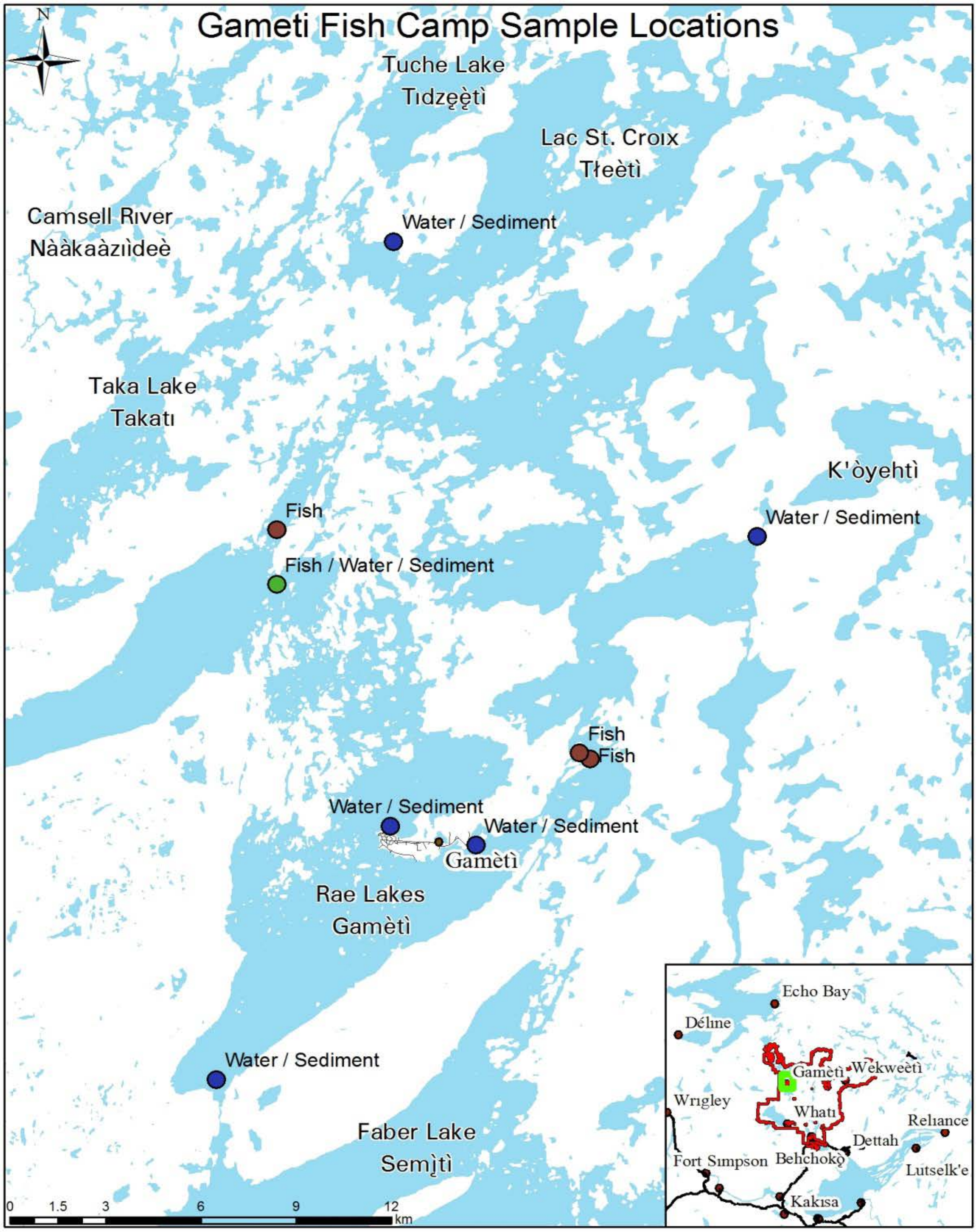


Figure 2. Relationship between mercury concentration in tissues (mg/kg; wet weight) and age (estimated via otolith aging) of Lake Trout and Lake Whitefish collected during the on-the-land component of the Tłįchǫ Aquatic Ecosystem Monitoring Project (TAEMP) near Gamètì (Rae Lakes), September 2013.

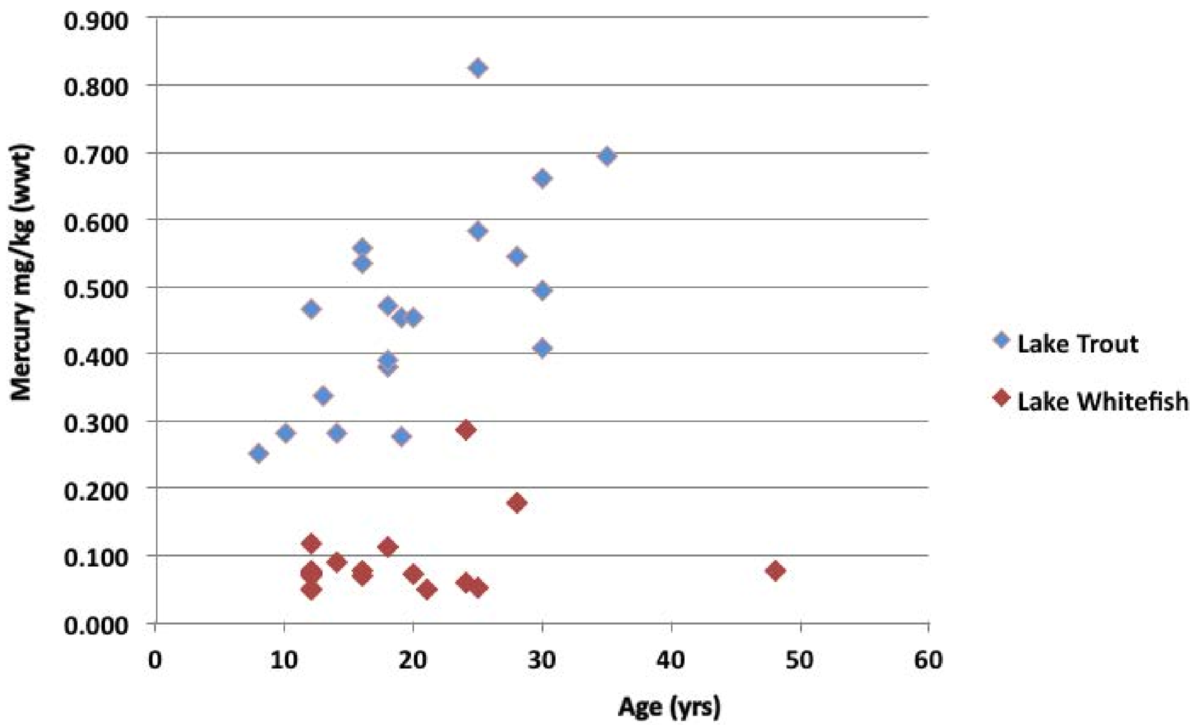
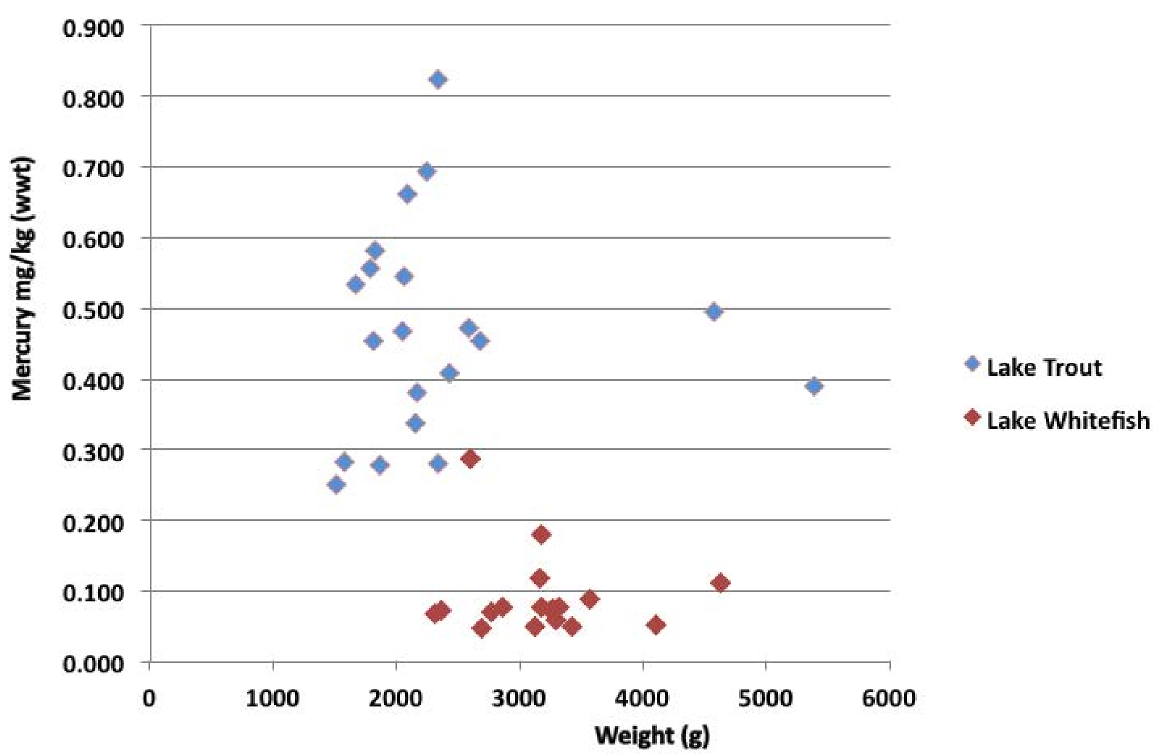


Figure 3. Relationship between mercury concentration in muscle tissue (mg/kg; wet weight) and body weight (g), and age of Lake Trout and Lake Whitefish collected during the on-the-land component of the Tłįchǫ Aquatic Ecosystem Monitoring Project (TAEMP) near Gamètì (Rae Lakes), September2013.



the outside (outer wall) of the stomach and to a lesser degree, on the upper intestine and pyloric cacae (nothing abnormal noted), with parasitic worms found in one stomach. The majority of stomachs were empty, those with contents included cisco and stickleback. No deformities were noted in any of the fish sampled.

Whitefish sampled ranged from 560-550mm in length (fork length), 2310g-4620g in weight, and estimated to be 12-48 years of age. None of the Whitefish sampled fell above the guideline for mercury, with a range of 0.0694-0.287mg per kg (wwt). Analysis of mercury concentrations in muscle tissue in relation to fork length, weight, and age were not significant. Cysts (parasites) were found in locations previously noted for Lake Trout (nothing abnormal noted). Gut contents included snails, shrimp, and invertebrates / amphipods. No deformities were noted in the fish sampled.

Guidelines for the Protection of Aquatic Life (CCME 2013) were exceeded for aluminum in 1 of 6 sampling sites (guideline: 100 ug per L, maximum level detected 150 ug per L), for mercury in 4 of 6 sites (guideline: 0.026 ug per L, maximum level detected 0.12), and exceeded / met for silver in 3 of 6 sites (guideline 0.1 ug per L, maximum detected 0.2 ug per L). Hardness levels at most sites indicated that water is considered "hard", except for the "tea water" sampling location which had quite a different profile than the other sites (considered "soft"). Bacteria (Escherichia coli (E. coli), Total Coliforms, and Fecal Coliforms) were low or not detected in the bay near the sewage lagoon.

No parameters exceeded CCME Sediment Quality Guidelines and Probable Effects Levels in the sediments analyzed. Organic carbon was higher in sediments at the sampling location furthest north from the camp. Fecal Coliforms were not detected in sediments in the lake near the sewage lagoon.

Discussion and Conclusion

Results indicated that overall fish are healthy and habitat is clean. Lake Trout had higher mercury levels than whitefish, given that they are a predatory fish which commonly exhibit higher levels due to bioaccumulation. However, levels observed were not considered to be abnormal. Whitefish were large and fatty, and as a fish targeted by the community, the low mercury levels do not provide any concern. Notably, the whitefish caught were also some of the largest that the Golder and DFO biologists had seen. Also, an otolith was estimated at 48 years, making it a "record" age for a whitefish in the NWT. Note: we plan to obtain a third opinion on the otolith, for if accurate, the age is worthy of a short note in a journal. Interestingly, the whitefish estimated to be 48 years also had one of the lower mercury concentrations among the whitefish sampled.

Results also indicated that overall water quality is good. Bacteria (Escherichia coli (E. coli), Total Coliforms, and Fecal Coliforms) were low or not detected in the bay near the sewage lagoon, suggesting that there is no contamination of the lake from the lagoon, notably as E. coli are a good indicator of fecal contamination (Health Canada 2013b). Organic carbon was higher in the sediments at the sampling location furthest north from the camp, which may be explained by the fact that a forest fire occurred during the early summer of 2013.

The "tea water" location had the highest mercury concentration (0.2 ug per L) and exceeded the Aquatic Effects guideline for mercury. However, in the north, it is not unusual for lakes to have higher than guideline values for metals (AMAP 2011). Further, the Canadian Drinking Water Quality Guideline or mercury is 1 ug/L (Health Canada 2013b). Since Gamètì drinks this water, we look to the Drinking Water Guidelines, and we also look and compare to fish results to ensure the fish is safe to eat because sometimes (*e.g.*in the case of mercury), they bioaccumulate (as previously mentioned for the Lake trout). If levels were high, this is where consumption warnings might be put in place; high mercury levels were not apparent in the Lake Trout sampled. The "tea water" sampling location also had quite a different profile than the other sampling sites. The site was located at the inlet of a very shallow stream where people go to get their tea water because the taste of the water is considered best for tea, and the water doesn't leave a residue on kettles or pots. Lab analyses clearly showed the water was "softer" than other sites, which all shared a "hardness." This provides a great example of Tłı̨chǫ knowledge identifying the special nature of a location near Gamètì, and it is a clear indication of TK and Science working together to highlight aspects of the aquatic environment near Tłı̨chǫ communities (both qualitatively and quantitatively).

Expected Project Completion Date

Gamètì portion of TAEMP completed,
May 2, 2014.

Project website

wrrb.ca for regular updates, as well as WRRB and Tłı̨chǫ Government Facebook pages

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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 dans la région désignée des Inuvialuits (RDI) grâce aux indicateurs de connaissances écologiques traditionnelles et locales

- **Project Leader:**

  Vic Gillman and Kristin Hynes, Fisheries Joint Management Committee
  Tel: (867) 777-2828, Fax(867) 777- 2610, Email: vgillman@cabletv.on.ca

  Lisa Loseto, Freshwater Institute/Fisheries and Oceans Canada
  Tel: (204) 983-5135, Fax: (204) 984-2403, Email: lisa.loseto@dfo-mpo.gc.ca

  Sonja Ostertag, Freshwater Institute/Fisheries and Oceans Canada
  Tel: (204) 984-8543, Fax: (204) 984-2403, Email: sonja.ostertag@dfo-mpo.gc.ca

- **Project Team Members and their Affiliations:**

  Jennie Knopp, Iuvialuit Settlement Region - Circumpolar Biodiversity Monitoring Program; Kate Snow, Inuvik; Eric Loring, Inuit Tapiriit Kanatami; Tuktoyaktuk Hunters and Trappers Committee; Paulatuk Hunters and Trappers Committee; Jill Watkins, Fisheries and Oceans Canada

Abstract

Beluga whales are hunted annually for food in the Mackenzie Delta estuary and Darnley Bay by Inuvialuit hunters. Monitoring of harvested whales has taken place in the Mackenzie Delta since the 1970s and in the Paulatuk area since 1989. In 2013, a new 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 in June 2013. Beluga observations were recorded

Résumé

Les bélugas sont chassés chaque année à des fins alimentaires dans l'estuaire du delta du Mackenzie et dans la baie de Darnley par les chasseurs inuvialuits. La surveillance des baleines chassées a commencé dans les années 1970 dans le delta du Mackenzie et en 1989 dans la région de Paulatuk. En 2013, un nouveau projet a été mis en branle dans le but de recenser et de consigner les connaissances écologiques locales et traditionnelles afin de les intégrer à la surveillance des bélugas et à

using shore-based and boat-based surveying techniques during the harvest season (July and August). Observations made during the beluga hunt and butchering were recorded using a semi-structured questionnaire, which was administered to harvesters immediately after the whales were flensed. Beluga observations were recorded by 16 harvesters on Hendrickson Island, 9 harvesters at East Whitefish, and 5 harvesters from Paulatuk. This project has increased dialogue between whale monitors, researchers and community organizations, which will strengthen community-based research in the ISR.

la recherche sur les bélugas. Les indicateurs potentiels des changements dans la santé du béluga et dans l'écosystème ont été déterminés par des assemblées communautaires ouvertes tenues à Inuvik, Paulatuk et Tuktoyaktuk en juin 2013. Les observations sur le béluga ont été obtenues par des relevés à partir de la terre et à partir d'une embarcation effectués durant la saison de chasse (juillet et août). Les observations faites durant la chasse et le dépeçage du béluga ont été consignées dans un questionnaire semi-structuré, qui a été rempli par les chasseurs juste après le dépeçage. Sur l'île Hendrickson, 16 chasseurs ont noté leurs observations sur les bélugas, à East Whitefish, 9 chasseurs l'ont fait et à Paulatuk, 5 chasseurs ont rempli le questionnaire. Ce projet a amélioré le dialogue entre les surveillants et les chercheurs intéressés par les baleines et les organismes communautaires, ce qui renforcera la recherche communautaire dans la RDI.

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 in June 2013.

Observations of beluga were recorded in July and August 2013, using shore-based and boat-based surveying techniques, and semi-structured questionnaires.

Dialogue and partnerships between whale monitors, researchers and community organizations was strengthened.

Messages clés

Ce projet a été mis en branle dans le but de recenser et de consigner les connaissances écologiques locales et traditionnelles afin de les intégrer à la surveillance des bélugas et à la recherche sur les bélugas.

Les indicateurs potentiels des changements dans la santé du béluga et dans l'écosystème ont été déterminés par des assemblées communautaires ouvertes tenues à Inuvik, Paulatuk et Tuktoyaktuk en juin 2013.

Les observations sur le béluga ont été obtenues par des relevés à partir de la terre et à partir d'une embarcation effectués durant la saison de chasse (juillet et août) et elles ont été consignées sur des questionnaires semi-structurés.

Ce projet a amélioré le dialogue entre les surveillants et les chercheurs intéressés par les baleines et les organismes communautaires.

Objectives

1. Increase our understanding of the Beaufort Sea ecosystem through the inclusion of LEK and TEK in community-based monitoring.
2. Develop indicators for beluga from a community perspective that are practical to monitor and enhance our understanding of ecosystem changes.
3. Partner with existing beluga and CBM programs in the ISR to evaluate linkages between local observations, changes in the ecosystem and contaminant trends.
4. Engage community youth in beluga sampling and documentation of observations.

Introduction

Beluga whales from the eastern Beaufort Sea population travel through the coastal areas of the Inuvialuit Settlement Region (ISR) in the summer and early fall. Monitoring of whales harvested from this population has taken place in the Mackenzie Delta since the 1970s and in the Paulatuk area since 1989 (Harwood et al., 2002). Beluga whale sampling in the ISR has occurred at Hendrickson Island, East Whitefish Station, Baby Island, Kendall Island and Darnley Bay. The monitoring program and associated research projects have provided valuable information about beluga growth rates (Luque and Ferguson, 2009), diet (Loseto et al., 2009), habitat use (Loseto et al., 2008), and contaminant exposure (*e.g.*Braune et al., 2005; Lemes et al., 2011; Loseto et al., 2008; Noël et al., 2014; Ostertag et al., 2013; Outridge et al., 2009: Tomy et al., 2009). Traditional ecological knowledge (TEK) has been fundamental to the success of these programs through the provision of high quality samples from harvesters' catch. In recent years, community members and funding agencies have shown increasing interest in having TEK included in arctic research and monitoring programs.

Including TEK in beluga monitoring will improve the beluga monitoring programs in the ISR by providing unique details about harvested and migrating whales. In addition, TEK and local ecological knowledge (LEK) could assist in the interpretation of laboratory results from samples collected from various locations (*e.g.*Darnley Bay and Kugmallit bay). In Tuktoyaktuk, community members encouraged the Hendrickson Island beluga research team to include local observations in beluga monitoring, because this knowledge takes years to accumulate and harvesters have a broad view of the environment around them. A strong interest was demonstrated for documenting observations of beluga whales that are made throughout harvesting activities. One elder noted that "harvesters observe animals not only on hunt, but when hunting. The younger generation is trained to observe animals." (Participant, Tuktoyaktuk, NWT). During a traditional knowledge (TK) workshop held in Inuvik, the participants identified the need for more on-the-land programs for elders, youth and monitors to gather traditional knowledge about fish and beluga. Although the breakout groups felt that TK needed to be gathered, it was acknowledged that the process of gathering, reporting and storing TK is complex and needs to be done carefully.

There is a need and interest to include LEK/TEK in beluga monitoring in the ISR. The development and documentation of traditional and local ecological knowledge indicators would complement the traditional scientific indicators currently monitored. Our hope is that findings from the pilot year can advise and feed into long term monitoring. Bringing together local observational indicators and traditional scientific knowledge may provide greater insight into how environmental change may impact the Eastern Beaufort Sea beluga population.

Future applications may feed into the Arctic Council, the Circumpolar Arctic Flora and Fauna (CAFF) Circumpolar Biodiversity Monitoring Program (CBMP) that identifies indicators for long term monitoring for Arctic biodiversity. Similar monitoring plans were created nationally for the marine plan (DFO 2012). Depending on the success of our pilot project, there may be opportunity to feed into larger scale monitoring plans. Additionally, the CBMP supported a project with Inuit Tapiriit Kanatami to complete the digitization of the land use and occupancy plans for the ISR with a focus on marine mammals and efforts have been made to evaluate how any outcomes will feed into this project.

Activities in 2013-2014

Project development

In order to identifying potential indicators of beluga health, community meetings were held in Inuvik, Paulatuk and Tuktoyaktuk in June 2013. The public meetings were advertised using the rolling channel (Inuvik), posters, Bingo channel (Tuktoyaktuk) and social media. Small breakout groups were facilitated by team leaders and community research assistants to identify potential beluga indicators based on the observations made by Inuvialuit using open-ended questions (Table 1, Appendix A). In addition, the participants discussed how local observations and knowledge could be included in beluga monitoring. In total, more than 80 community members participated in the summer and fall meetings, including directors from the Paulatuk HTC Board and members of the Inuvialuit Game Council.

Small groups focused on the following topics during the meeting:

- observations made by Inuvialuit during harvest, butchering and preparation of beluga;
- observations that could be included in beluga monitoring, and
- how community members' observations could be included in monitoring

We recorded all of the participants' observations about beluga habitat use, behaviour and health during the meeting and after each meeting; the responses were entered into Microsoft WordTM (Table 2). Questions that targeted the specific observations made by harvesters and travellers were formulated based on the observations shared in the meetings. In Paulatuk, the questions were reviewed by D. Ruben, R. Ruben Sr and D. Slavik. The outcomes from the meetings in Inuvik and Tuktoyaktuk later in June were used to modify some questions for Kugmallit Bay. Therefore, the questions that were developed for harvesters and travellers in Kugmallit and Darnley Bay were slightly different, based on the outcomes from the meetings. These questions formed the basis of semi-structured questionnaires and data sheets (Appendix B) that were prepared to record shore-based, boat-based and harvester observations in Kugmallit and Darnley Bays in 2013.

Recording local ecological observations

We recorded observations using shore-based and boat-based surveying techniques (Table 1). Observations made during the beluga hunt and butchering were recorded with a semi-structured questionnaire administered to harvesters immediately after the butchering was complete.

Shore-based observations

Observers scanned the ocean from an elevated position to search for the presence of belugas. Surveying methods varied by location and observer (Table 3). The composition of whale groupings was recorded consistently, based on the colour and number of whales observed. On Hendrickson Island, the ocean was scanned in quadrants based on visible landmarks, for fifteen minutes during low and/or high tide, from a tripod previously erected by community members. The location of whales was noted for the four quadrants, and their proximity to shore was estimated roughly (nearshore, < ~500m from shore; offshore, > ~ 500 m from shore). A description of weather and tide was also provided. At East Whitefish, daily observations were made from a small hill. In Darnley Bay, scanning for belugas was conducted from the top of a cliff (Brown's Harbour), from the shoreline (Egg Island), or from the tundra (Hornaday River). The PHTC provided in kind support for developing and running the Darnley Bay observation program. Support included hiring the observer and community coordinator, and recommending a location for the observer to stay (i.e. Egg Island).

In addition, harvesters at East Whitefish, Tuktoyaktuk and Paulatuk were invited to take cameras and GPS with them during the hunt, to capture photos and GPS waypoints for sighted belugas (prior to the hunt), which were later hunted and sampled. They also provided details about the group composition (size and colour) and beluga activity based on outcomes from the meetings and previous research findings.

Harvesters' observations

Questionnaires were completed by 16 harvesters on Hendrickson Island, 9 harvesters at East Whitefish, and 5 harvesters from Paulatuk.

Capacity Building

Training and mentoring occurred at Hendrickson Island and East Whitefish in 2013. Frank Pokiak trained Brendan Green, one of two beluga monitors from Paulatuk, on how to consistently sample and measure the whales. Brendan Green also learned about sub-sampling tissues for further lab analysis. Two youth from Inuvik who were working as summer students with the FJMC and DFO, received training at Hendrickson Island and East Whitefish Station on field logistics, shore-based and boat-based surveying, beluga sampling, and hydroacoustics monitoring. Two community members from Tuktoyaktuk assisted with the community meeting on June 22 in their community. In 2013, we were unable to employ youth on Hendrickson Island from Tuktoyaktuk due to liability concerns; however, we have established an agreement with the Tuktoyaktuk Community Corporation to employ youth as research assistants in 2014. Brendan Green and Bernadette Green, both from Paulatuk, travelled to Winnipeg, MB and Halifax NS in December 2013. They learned about beluga/marine research and Arctic research at the FWI/U of M and the ArcticNet Scientific Meeting, respectively (Appendix C).

Communications

March 2013: Lisa met with the Tuktoyaktuk and Paulatuk HTCs to review this project and the overall beluga monitoring/research program in the ISR.

June 2013: We held community meetings in Paulatuk, Inuvik and Tuktoyaktuk. These meetings provided the opportunity for more than 80 northern community members to contribute to the beluga-monitoring program through this community-based project.

October 2013: Reports were sent to HTCs, FJMC, IGC, NCP to summarize the outcomes from the summer meetings and field season.

November 2013: Open community meetings were held in Inuvik, Paulatuk and Tuktoyaktuk and separate meetings were arranged with the HTCs in all three communities. Overall, 72 individuals participated in the community meetings and 6 to 7 board members were present for each HTC meeting. Classroom presentations were given by S. Ostertag to two classes in Paulatuk and Inuvik (junior high and high school). In Inuvik, Kate Snow arranged two 45 minute classroom visits for Bertha Joe (whale monitor from East Whitefish Station) and S. Ostertag.

December 2013: S. Ostertag reviewed the project with S. Nickels and E. Loring in Ottawa. The draft proposal overview for the 2014/2015 NCP submission was sent to HTCs for review.

January 2014: Conference call with D. Ruben, J. Stowe, L. Loseto and S. Ostertag to review project plan for 2014. Presentations to FJMC; proposal reviewed by PHTC

February 2014: Meeting in Winnipeg with T. Green and N. Green from Paulatuk to review the local observations project and fish research in Darnley Bay. Meeting with J. Lennie (team member) in Winnipeg to discuss this project and the methods needed to include LEK/TEK in beluga monitoring.

March 2014: L. Loseto presented a project summary and plans for 2014 to the Inuvik and Tuktoyaktuk HTCs.

Traditional Knowledge Integration

The Local Ecological Indicators project is responding to the need to more effectively include local ecological knowledge (LEK) and traditional ecological knowledge (TEK) in beluga monitoring programs in the Inuvialuit Settlement Region (ISR). Following the summer community tour (June 2013) and field season (July – August, 2013), a follow-up tour was conducted in November by S. Ostertag and K. Hynes to receive feedback from community members and HTCs about this project. The knowledge gathered and recorded in 2013 for this project was linked to the sampling data from the beluga monitoring program. The observations recorded will be included in the interpretation of lab results from the analysis of samples collected from harvested whales. The integration of TEK, LEK and traditional scientific knowledge is described in more detail in the discussion section (below).

Results

This project built on many years of collaborative beluga research in the ISR. Community meetings provided a unique opportunity for northerners to contribute ideas to the beluga-monitoring program. The success of these meetings resulted in the development of questionnaires for harvesters, and observations to be documented during shore-based and boat-based surveys. The results from the pilot study for this project are presented below.

Harvester Observations

Observations made during hunting activities: All of the harvested whales in Kugmallit and Darnley Bays came from groups that looked healthy. The information collected in 2013 suggested that in Darnley Bay, whales were taken from larger groups (n = 5, median, range; 10, 2 – 23) whales than whales harvested in Kugmallit Bay (n = 20, median, range; 4, 1 - >100). Also, whales harvested in Darnley Bay were taken from groups that were made up of all white, all yellow of a mixture of white and yellow whales (Figure 1). In comparison, in Kugmallit Bay, whales were mostly harvested from groups made up solely of white whales, with a small number harvested from groups that included grey, black or yellow whales.

Observations during butchering: Hunters indicated that beluga muktuk was of good quality in Darnley and Kugmallit Bays, for the majority of whales that were harvested. Only three whales were reported to have 'fair' quality muktuk. In Darnley Bay, all of the belugas had good quality muktuk, and four of the five harvested whales had good quality meat. The harvesters' observations indicated that none of the harvested whales in Kugmallit or Darnley Bay had poor quality meat or muktuk. The colour of blubber varied; half of the whales harvested in Kugmallit Bay had pink-coloured blubber, and the other half had yellow or white-coloured blubber. In Darnley Bay, muktuk was either white or yellow and white.

None of the whales harvested in Kugmallit Bay between June 30 and July 22 2013 showed signs of infection or disease. One whale harvested in Darnley Bay had a large growth in its abdomen; however, a sample ID and sample were not provided for this whale. A photograph of the growth was provided but was not sufficient for a diagnosis to be made. Two whales in Kugmallit Bay had yellow fluid in their flipper joint. One whale in Kugmallit Bay had skin pox. Four of the whales in Darnley Bay had scars from bears or ice. More than half of the whales harvested in Kugmallit Bay had scars.

Shore-based and boat-based observations

Shore-based and boat-based observations provided information about the location of whales, the approximate number of whales in different areas and at different times, and the group composition of observed whales. This information may improve our understanding of when belugas arrive in Kugmallit and Darnley Bays and where they spend their time. Documenting group composition may also help understand differences between whales sampled in Darnley and Kugmallit Bays.

Discussion and Conclusions

The goal for the second phase of this project is to build on the partnerships and capacity developed in 2013-2014, to identify ecologically-relevant indicators from a local perspective that can increase our understanding of changes in ecosystem health in the Beaufort Sea. In 2013, we focused on recording a suite of observations from harvested and travelling whales based on observations that are typically made about belugas. In 2014, our goal is to assess these observations as potential indicators, through semi-structured interviews with harvesters, whale monitors, women and elders. Indicators will be evaluated based on the consensus from interviews with community members, followed by discussion during final community meetings in Inuvik, Paulatuk and Tuktoyaktuk. In addition, these observations will be evaluated scientifically, for their potential to add knowledge about samples collected, which can assist in the interpretation or analysis of results (*e.g.*Table 4). This evaluation will be made through a meeting with the research team conducting studies on belugas in the Arctic. The following criteria will be included in our evaluation of observations as potential indicators:

1. An observation that can be recorded by harvesters, beluga monitors and/or community members;
2. an observation that is considered to be important by community members based on consensual informant responses;
3. an observation that is correlated to results from scientific studies; and,
4. observations that are quantifiable and comparable between years and/or communities.

Expected Project Completion Date

August, 2015

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Table 1. Methods used to record observations through community meetings in Inuvik, Paulatuk and Tuktoyaktuk and fieldwork in Kugmallit Bay and Darnley Bay, NWT.

How knowledge was recorded	Methods used	Outcome
Community meetings	• Brief presentation • Breakout groups • Mapping exercise • Group discussion	• Summary of observations made during travel, harvest and beluga preparation • Mapping where beluga are observed
Harvesters' observations	• Questionnaire • Camera • GPS	• Harvesters' observations were documented at HI, EWF and Darnley Bay • Photos taken of harvested beluga • Location of harvested whale
Shore-based & boat-based observations	• Binoculars • GPS camera • Observation log and forms • Portable hydrophone	• Location and group composition recorded for whales in Kugmallit Bay and Darnley

Table 2. Observations that are made during harvesting activities, as shared by participants (n = ~80) during community meetings in Inuvik (I), Paulatuk (P) and Tuktoyaktuk (T).

Beluga harvesting activities	Types of observations made about beluga whales during harvesting activities
Hunting	Skinny/fat (I), float (I), shape (P,T), size (P,T,I), group composition (P), behaviour (P), blubber thickness (P), vomit (P), spouting (T)
Butchering	Scarring (I, P, T), skin pox (P), condition of meat/muktuk/blubber (I, P, T), blubber thickness (P, T), shape (P), injury (T), blister (T), colour of blubber (I), proper handling of meat and muktuk, presence of stomach contents (T)
Preparing	Colour of blubber (I, T), blubber thickness (T), preparation methods (T), health of whale (P), lesions (P), disease (P), taste (I)

Table 3. Location, dates and survey outcomes for shore-based surveys in Darnley and Kugmallit Bays.

Location		Dates	Surveys (n)	Beluga sightings (frequency)
Darnley Bay	Tippi	July 16 – August 13	104	2
	Egg Island	July 9 – July 30	76	0
	Brown's Harbour	July 8 – August 3	77	1
	Boat-based	August 3	5	1
	Hornaday River	August 4 – 8	15	4
Kugmallit Bay	East Whitefish	July 10 – 15	14	11
	Hendrickson Island	June 30 – July 19	58	31

Table 4. Potential ways for LEK/TEK indicators to add valuable information to the interpretation of key biological aspects of belugas and beluga habitat.

LEK/TEK Indicator	Scientific Observation Indicator	Interpretation
Colour of blubber, stomach contents, feeding observed, quality/quantity of blubber/meat	Fatty acids, stable isotopes, stomach contents	Diet
Signs of infection or disease	Antibodies, immunohistochemistry, viruses	Disease
Scars, behavior	Recording of orcas using hydrophone	Changes in predation
Ice scarring, timing of arrival, calving locations	Satellite images	Ice conditions
Location, group composition, activity of belugas	Presence/absence and group composition (June/August) Presence/absence (June – August)	Habitat use

Appendices

Appendix A: *Questions were asked during community meetings in June 2013*

- Where should observations be made and where are belugas observed?
  - Where and when does calving, moulting and feeding occur?
  - Have you noticed changes in beluga behavior and habitat use? If so, why do you think these changes are happening?
- What are common observations that you make about beluga whales when you are hunting, butchering, preparing or other times. Identify the observations would help to answer these questions:
  - Differences between groups of belugas that are harvested?
  - Changes in beluga health over time?
  - Differences in feeding behaviour of belugas harvested in Kugmallit and Darnley Bay?
- What types of beluga whale behavior have you seen? What differences in behavior have you observed based on the size of whale, where and when the whale is observed, and environmental conditions?
  - Identify observations that could be documented to help us understand why belugas spend time in different locations and if their behavior is changing.
- How do you see yourself and your community documenting beluga observations?

1. Appendix B: Semi-structured questionnaire administered to harvesters (Darnley Bay)

1. Where was this whale when you first saw it?

2. How many whales were with the whale that you harvested?

3. What were the whales doing when you first saw them (before you began to chase them)?

4. What colours were the whales?

- ☐ Blue/black
- ☐ Grey
- ☐ White
- ☐ Yellow
- Other ___

5. How old did the whales in this group seem?

- ☐ Young
- ☐ Old
- ☐ Very old

6. Describe the shapes of the whales

- ☐ Very round
- ☐ Love handles
- ☐ Round
- ☐ Skinny

7. Did all of the whales in this group seem healthy?

- ☐ yes
- ☐ no

Describe any animals that appeared to be sick or behaving unusually in this group

8. How did the whale act while you were chasing it?

- ☐ Hiding
- ☐ Turning
- ☐ Charging
- ☐ Aggressive
- ☐ Breathing shallowly
- ☐ Sitting on the bottom
- ☐ Vomiting

9. How thick was the blubber?

- ☐ 1 inch or less
- ☐ 1.5 - 3 inches
- ☐ 3 - 4 inches
- ☐ more than 4 inches

10. Did the whale float after you shot it?

- ☐ yes
- ☐ no
- ☐ unsure

11. Did you see any scars on the beluga's skin?

- ☐ yes
- ☐ no
- ☐ unsure

If yes, what do you think caused the scar?

12. What was the condition of the muktuk

- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Unusual

Describe anything unusual that you observed in the muktuk; take a photo if possible.

13. What was the condition of the meat?

- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Unusual

Describe anything unusual that you observed in the meat; take a photo if possible.

14. Did you see lesions, sores or skin pox on the whale?

- ☐ Yes
- ☐ No
- ☐ Unsure

If yes, please describe what you observed.

15. Was there a sign of infection or disease?

☐ Yes
☐ No
☐ Unsure

If yes, please describe what you observed.

16. Did the whale have a bent spine?

☐ yes
☐ no
☐ unsure

17. What colour was the fat/muktuk?

☐ Orange
☐ Dark yellow
☐ Pink
☐ Light yellow
☐ White

Data sheet for shore-based and boat-based beluga observations (Kugmallit Bay)

1. Where were these whales when you first saw them?

☐ Mouth of river
☐ 1-2 km from the shore
☐ Deep water
☐ Other

2. How many whales were in this group?

3. What were the whales doing when you first saw them?

☐ Traveling
☐ Feeding
☐ Playing
☐ Spouting
☐ Hiding
☐ Spyhopping
☐ Other

4. What colours were the whales?

☐ Blue/black ☐ Grey
☐ White
☐ Yellow
Other_____

5. How old did the whales in this group seem?

☐ Young
☐ Old
☐ Very old
☐ Unsure

6. Describe the shapes of the whales?

☐ Very round
☐ Love handles
☐ Round
☐ Skinny

7. Did all of the whales in this group seem healthy?

☐ yes ☐ no

Describe any animals that appeared to be sick or behaving unusually in this group:

8. Were there fish or krill in the area when the belugas were observed?

☐ yes ☐ no

What kind of fish/krill were they?

☐ Herring
☐ whitefish
☐ Krill
Other: _______

9. Did you observe the whales feeding?

☐ yes ☐ no ☐ unsure

What kind of fish/sea animals were they feeding on? ☐ whitefish ☐ Herring ☐ Krill Other: ____

12. Had the weather changed before these whales showed up?

☐ Yes
☐ No

If yes, describe the change in the weather:

13. What direction was the wind blowing?

14. Was it high tide or low tide?

15. Was the water level high or low?

16. Did the whales act as though they were afraid of something?

☐ yes
☐ no
☐ unsure

17. If yes, what do you think they were afraid of? Why?

18. Did you observe orcas or signs of orcas nearby?

☐ yes
☐ no
☐ unsure

19. Was a barge nearby in the last 24 hours?

If yes, how did the beluga react to the barge?

20. Was a coast guard ship nearby in the last 24 hours?

If yes, how did the beluga react to the coast guard ship?

21. Please show on the map approximately where the belugas were observed.

Appendix C

Youth Lab Tour and Scientific Meeting

Report prepared by Sonja Ostertag, Keely Loewen and Shannon MacPhee

Bernadette and Brandon Green travelled to the Freshwater Institute and University of Manitoba in Winnipeg, MB. They met with researchers that study fish and belugas in the Beaufort Sea, and they also learned about how samples collected in the Arctic are processed and analyzed. Following the lab tour, Bernadette and Brandon travelled to Halifax, NS, to attend the ArcticNet Scientific Meeting. This report was prepared to document what they learned in Winnipeg and Halifax.

Reproductive organs with Conny Willing, Freshwater Institute

Reproductive organs are studied in marine mammals to find out about their fertility, health, and reproductive status. Frozen reproductive organs are collected from harvested animals. Sampling properly is very important, but can be difficult in the field without proper training. Frozen samples are sent to the Freshwater Institute where Conny takes measurements and photos of all of the samples. Not all of the samples can be stored after the measurements are taken because they are too big, so it is important that she takes very good photos and measurements.

Brandon and Bernadette learned about how eggs are fertilized in belugas and seals, and they saw embryos and fetuses at different stages of development. The fetus goes through several stages of development. First, the egg must be fertilized by the sperm. Folds in the female reproductive tract make sure that the strongest and healthiest sperm make it to the egg. The fertilized egg implants into the wall of the uterus and grows into a fetus. If you look closely at the ovaries, you can count the number of white spots in the ovary (corpus albicans), which tell you how many pregnancies a beluga had. In ringed seals, these spots disappear quickly, which makes it difficult to count pregnancies.

Diseases like brucella may cause cysts to form in the reproductive tracts of belugas. These cysts are calcified nodules that surround the brucella bacteria and help keep them from spreading. These cysts need to be sent to a special lab to be analyzed.

Energetics with Emily Choy

Emily Choy talked to Brandon and Bernadette about beluga energy use. She uses blubber samples to find out what the whales eat. Her data is used to learn about how make sure that if the whales' diets change they will have enough energy to reproduce, travel, dive, and feed.

Emily showed Brandon and Bernadette how fatty acids are extracted from the blubber. Beluga blubber has four layers, which are used differently by the whales. The inner layer can be analyzed to understand the diet of the whales. Fatty acids are also extracted from all of the different fish and invertebrates that the whales might eat. The fatty acids in the whales are compared to the fish and invertebrates to find out what the whales eat. Two fish lined up with the fatty acids in beluga: arctic cod and arctic cisco.

Myoglobin is analyzed from the back muscle of belugas to measure how much oxygen is stored in the muscles. Myoglobin is a protein in heart and skeletal muscles that provides extra oxygen to the muscles. It is a very good indicator of diving ability in marine mammals.

Teeth and ageing with Blair Dunn

The age of a beluga can be found out by looking at its teeth. Knowing the age of the animal is important for understanding the results from the other studies that take place. For example, older whales may feed in different areas and have different fatty acids than younger whales. Beluga whales can live up to 50-60 years old. Belugas have only one set of teeth so the number of layers in the tooth tells you how old the animal is. Every dark layer represents one year of the whales life. If the neonatal tooth layer is visible the number of layers represents the final age of the harvested beluga.

Blair showed Brandon and Bernadette how teeth are removed from a beluga jaw. The jaws are sent to DFO and boiled. The second and fifth teeth on the right side of the jaw are removed with pliers. Then the teeth are glued onto a wooden block and cut into very thin slices with a diamond blade. The slices are preserved in 70% alcohol. The growth layers are counted using a microscope.

The size of the tooth does not represent the age of the animal. Blair showed Brandon and Bernadette that a 50 year old whale's had a smaller tooth than the 23 year old whale. Teeth from whales in Nunavut have much bigger teeth than the whales in the ISR.

It is important to label the jaws and teeth carefully. Otherwise, the information about the sample can become lost.

DNA Analysis with Lianne Postma

Lianne Postma taught Brandon and Bernadette about beluga DNA. The DNA of beluga whales is used to find out if different pods of whales are related.

DNA is made up of a four letter code, ATGC. A haplotype is a set of mutations (changes in the code) of DNA that vary in different animals. Haplotypes are inherited from a whale's mother. Whales with the same haplotype are more related than whales with different haplotypes. DNA is also what is used to make clones. On Family Guy, Stewie makes a number of clones. His last clone was an unintelligent duplicate because using the same DNA over and over weakens it.

In the lab, Brandon and Bernadette used micropipettors to measure very accurate amounts of liquid. They measured samples as small as 45 mL (100 mL is 1/10,000 of a litre). It is important to wear rubber gloves to protect the researcher from chemicals and to protect the samples from contamination. Without gloves, the researcher's DNA can end up in the sample of beluga DNA. The haplotype is determined using a machine that reads the sequence of the DNA letters. Sequences from different animals can be compared to see what kinds of mutations they share.

The DNA used in the lab comes from skin samples collected by the hunters. It is important to label the samples and keep them organized so none of the data is lost.

Bug picking with Shannon MacPhee

Researchers collected sediment samples from the ocean floor of the Beaufort Sea (250 m deep) for the BREA project. They collected samples to learn about what was in the offshore region of the Beaufort Sea. Invertebrates found in the sediments are sorted and some are sent to a taxonomist for identification. They are also analyzed to find out what they are eating, their mercury levels, and stable isotope signatures. Half of the sediments are saved to analyze the size of sediments, algae, and other characteristics.

Bernadette and Brandon Green worked with Shannon MacPhee (Aquatic Biologist, BREA) to sort invertebrates (e.g., clams, worms, amphipods) from sediment samples collected from the Cape Bathurst area. Brandon compared the invertebrates to prey items he has found in fish stomachs. The group also looked at photos and samples of epibenthos (*e.g.*, sea stars, shrimp, octopi) and talked about the role of invertebrates in Arctic marine food webs.

Fish eggs with Ben Kissinger

University of Manitoba PhD student Ben Kissinger shared his trout-rearing experiment with Bernadette and Brandon. Ben's project, linked to the coastal component of the BREA Marine Fishes Project, focusses on fishes in the Husky Lakes, NT, a unique estuary connected to the coastal Beaufort Sea. He wanted to see if egg from freshwater can survive in saltwater. Once the fish grow up he will place one in a tank with freshwater and one in saltwater to see which they prefer. One of the fish eggs had twins, but Ben was unsure if they were conjoined or separate.

Photographs of a fish hatching from its egg. Photo credit: Ben Kissinger

BREA fish with Sheila Atchison

Sheila showed Brandon and Bernadette how fish are sampled and measured at DFO. They learned how to do measurements of spine length, fork length, whole length, and weight. They checked gender and took out ear bones (otoliths). Sheila also taught them how to determine if a fish is an Arctic or Polar Cod based on their teeth and bumps on their sides. The group also discussed the role of Arctic Cod fish as a key link in the Beaufort Sea food web.

Environmental chemistry with Gregg Tomy's Group

Gregg Tomy's group talked to Brandon and Bernadette about environmental chemistry. Chemicals are produced, used, and emitted in the south. They travel to the north in the atmosphere. Gregg's group analyzes samples from animals to learn about new chemicals. They also look at how the chemicals affect the animals over time. They use cells in test tubes or fish to see the effect of chemicals on their health.

Different machines are used to find out what chemicals are in the whales. Gas chromatography is used to separate chemicals by their boiling points. The sample is heated in a column with a 0.25 mm diameter and a coating of 0.0001mm. The chemicals with lower boiling points will move through the column before chemicals with higher boiling points. Liquid chromatography mass spectrometry is used for larger compounds that do not evaporate.

Harvest Monitoring of Metal Bioaccumulation at Kuujjuaraapik (Nunavik): Have Levels Changed 20 Years After the Great Whale Environmental Assessment?

Surveillance des récoltes pour la bioaccumulation de métaux à Kuujjuaraapik (Nunavik) : les concentrations ont-elles changé 20 ans après l'évaluation environnementale pour le projet de Grande-Baleine?

- **Project Leader:**
  Raymond Mickpegak, Sakkuq Landholding Corporation
  Tel.: (819) 929-3566, Fax: (819) 929-3275, Email: rmickpegak@makivik.org

  John Chételat, Environment Canada, National Wildlife Research Centre
  Tel.: (613) 991-9835, Fax: (613) 998-0458, Email: john.chetelat@ec.gc.ca

- **Project Team Members and their Affiliations:**
  Alec Tuckatuck and Jimmy Paul Angatookalook, Sakkuq Landholding Corp., (Kuujjuaraapik)

Abstract

Twenty years ago, measurements were taken of metal levels in aquatic and terrestrial wildlife near Kuujjuaraapik as part of a major environmental assessment for the Great Whale hydro-electric project. More recent information is not available for contaminant levels in locally-harvested wildlife. However, local people have observed ecosystem changes associated with climate as well as altered marine currents from freshwater discharges of hydro-electric reservoirs into James Bay. The main objective of this community-based study is to measure current levels of metals (including mercury, cadmium and lead) in local fish and wildlife and compare them with previous measurements to monitor potential change. During the first year of this

Résumé

Il y a 20 ans, des mesures des concentrations de métaux ont été prises dans la faune aquatique et terrestre près de Kuujjuaraapik dans le cadre d'une importante évaluation environnementale pour le projet hydroélectrique Grande-Baleine. Aucune information plus récente n'est disponible pour les concentrations de contaminants chez les animaux sauvages récoltés localement. Toutefois, les populations locales ont observé des changements dans l'écosystème, soit des changements du climat ainsi que des modifications des courants marins en raison des eaux douces relâchées par les réservoirs hydroélectriques dans la baie James. Le principal objectif de cette étude communautaire est de mesurer les concentrations actuelles de métaux

project, the Sakkuq Landholding Corporation of Kuujjuaraapik organized the winter collection of ringed seal, caribou, snowshoe hare, willow ptarmigan and fish. Preliminary results indicate similar or lower levels of mercury for the animals collected, as compared to levels measured for the same species between 1989 and 1991. Laboratory analyses of other metals are on-going. Additional species will be collected during the summer of 2014 to expand the scope of wildlife sampling. This project will 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.

(dont le mercure, le cadmium et le plomb) chez les poissons et les animaux sauvages locaux et de les comparer aux mesures précédentes pour surveiller les changements potentiels. Durant la première année de ce projet, la Sakkuq Landholding Corporation de Kuujjuaraapik a organisé le prélèvement hivernal de phoque annelé, de caribou, de lièvre d'Amérique, de lagopède des saules et de poissons. Les résultats préliminaires indiquent que les concentrations de mercure chez les animaux prélevés sont semblables ou inférieures à celles mesurées chez les mêmes espèces entre 1989 et 1991. Les analyses en laboratoire des autres métaux sont en cours. D'autres espèces seront prélevées durant l'été de 2014 pour élargir la portée de l'échantillonnage des animaux sauvages. Ce projet mettra en place des capacités locales de surveillance des contaminants à Kuujjuaraapik et fournira des tendances temporelles pertinentes pour le Nunavik subarctique, une région vivant d'importants changements écosystémiques.

Key Messages

- Tissues of ringed seal, snowshoe hare, willow ptarmigan, caribou, brook trout and whitefish were collected near Kuujjuaraapik by local hunters in the winter of 2014 for analysis of metals.
- Total mercury concentrations were generally low (<0.5 µg·g-1 wet weight) in the fish and wildlife samples, although higher levels were measured in ringed seal liver and caribou kidney.
- Preliminary results for the winter animal samples show total mercury concentrations that are similar to or lower than those measured in the same species from 1989-1991 for the environmental assessment of the Great Whale hydro-electric project.

Messages clés

- Des tissus de phoque annelé, de lièvre d'Amérique, de lagopède des Saules, de caribou, d'omble de fontaine et de grand corégone ont été prélevés près de Kuujjuaraapik par des chasseurs locaux durant l'hiver 2014 pour une analyse des métaux.
- Les concentrations de mercure total étaient généralement faibles (<0,5 µg·g-1 poids humide) dans les échantillons de poissons et d'animaux sauvages, mais des concentrations plus élevées ont été mesurées dans le foie du phoque annelé et les reins du caribou.
- Les résultats préliminaires pour les échantillons d'animaux prélevés en hiver indiquent que les concentrations de mercure total sont semblables ou inférieures à celles mesurées chez les mêmes espèces de 1989 à 1991 pour l'évaluation environnementale du projet hydroélectrique de Grands-Baleine.

Objectives

1. Build local capacity for contaminants monitoring through hunter collections of fish and 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;

3. Determine if metal concentrations in terrestrial and aquatic animals have changed since previous measurements were conducted 20 years ago during the environmental assessment for the Great Whale hydro-electric project; and

4. Work with the Nunavik Board of Health and Social Services and Nunavik Regional Contaminants Committee to examine the metal concentrations in relation to established consumption guidelines that may pose a risk to human health.

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 will 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 2013-14

In the fall of 2013, sampling kits and record sheets were developed for the collection of animal tissues by local hunters. Examples of kits for Nunavik community-based wildlife monitoring were provided by Michael Kwan (Nunavik Research Centre, Kuujjuaq), which were used as a starting point to develop a prototype for our project. The prototype was presented to two local hunters who provided feedback to improve our kits before we finalized them. These kits contained individually-labelled bags (trace-metal clean), sterile gloves, a record sheet and a pencil for the collection of tissues from each animal. The record sheets were printed on small sheets (8 ½ x 5 ½ inch) of durable Rite in the RainÒ paper that can be used when wet. The required information was listed on the front of the sheets, and sampling instructions were provided on the back of the sheets (Fig. 1).

Local hunters of Kuujjuaraapik were hired in January and February of 2014 to collect fish and wildlife tissues for the winter field program. Most animals were collected by two senior hunters in the community (Jimmy Paul Angatookalook and Alec Tuckatuck), although two additional hunters (Vincent Tooktoo and Simionie Papayluk) also participated. Junior hunters (Simionie Papayluk, Joanna Fleming) sometimes accompanied the senior hunters, with the aim to encourage youth participation and training in the project.

The target to collect 24 animals for the winter field program was successfully reached with 5 ringed seal, 6 caribou, 9 willow ptarmigan, 6 snowshoe hare, 6 brook trout and 11 whitefish. Animals were collected within roughly an 80 km radius of Kuujjuaraapik. 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. The analysis of other metals by ICP-MS is currently in progress (data not yet available). Mercury was 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 (ranging from 71-79% water, depending on the species and tissue).

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 winter field program, 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. In the first year of the project, we made substantial progress in developing local interest and capacity for monitoring of contaminants, as indicated by the participation of 5 hunters in the project, reaching our target collection of 24 animals, and obtaining quality submissions of tissue samples and record sheets.

Communications—In December 2013, John Chételat visited Kuujjuaraapik to attend meetings and work with Raymond Mickpegak to initiate the sample collection of locally harvested fish and wildlife. We met with the board of the Sakkuq Landholding Corp. to discuss the project and to obtain feedback on our proposed activities. Raymond also requested the participation of several hunters, and a meeting was held to discuss the harvesting and how samples would be collected. Two hunters (Jimmy Paul Angatookalook and Alec Tuckatuck) provided feedback on the project, particularly regarding which animals were important to harvest (see Traditional Knowledge section below). Prior to initiating this community-based monitoring project, a field program was conducted at Kuujjuaraapik in July 2012 for a separate NCP project (M-16, Environmental Research and Monitoring) to study climate change impacts to mercury cycling in the Arctic. As part of the project, locally-consumed brook trout were collected for mercury analysis, which was of interest to Sakkuq Landholding because previous information was not available for this country food. A report was translated into Inuktitut and submitted to Sakkuq Landholding in February of 2014.

Traditional Knowledge Integration—During a meeting on December 6, 2013, the hunters Alec Tuckatuck and Jimmy Paul Angatookalook discussed which animals would be of interest to include in the study. Both individuals are very experienced and highly regarded hunters in the community. The following is a summary of information they provided. Merganser and seagull used to be harvested by local Inuit but they stopped after information was provided to them (from earlier environmental studies) that mercury levels were high. Weasel and squirrel used to be consumed but not anymore. Walrus has recently moved into the area. It was not hunted traditionally because it was not around before. Pintail grouse has also moved into the area. The point was raised that some caribou recently harvested by Kuujjuaraapik hunters had a green slime under their skin. A beluga was hunted last summer around Kuujjuaraapik. Although not discussed in this meeting, another discussion during the visit revealed that moose have recently been moving into the area. Black bear and porcupine were identified as local animals that are consumed by Cree and contaminant information would be of interest to the adjacent Cree community. A large number of animals were identified by Alec and Jimmy, although some key species suggested for the winter sampling were ringed and bearded seal, caribou, ptarmigan, snowshoe hare, and freshwater fish (lake trout, brook trout, northern pike, whitefish). For the summer sampling, ringed and bearded seal, freshwater fish, marine fish (cod, sculpin), sea urchin, blue mussel, goose and ducks were among the animals suggested. Many, though not all, of those animals were sampled during the Great Whale environmental assessment 20 years ago. Alec also expressed concern over the potential impact of releases of methylmercury into James Bay and ultimately Hudson Bay from the La Grande hydro-electric complex.

The record sheets in the sampling kits included the question, "Was the animal healthy? Why?" With the exception of one fish, the hunters noted that all animals were healthy. One hunter noted that a fish had a black spot on its fin. For the caribou hunting, it was noted that the herd was large. For the ptarmigan hunting, it was noted that the ptarmigan was "healthy, it was with a large flock, not loner". These observations suggest that a traditional indicator of animal health is whether the animal is found alone or in a group, and whether the group is large or small.

Results

Total mercury (THg) concentrations in muscle and liver or kidney of fish and wildlife collected near Kuujjuaraapik in the winter of 2014 are presented in Table 1. Overall, THg concentrations were relatively low in the tissues (<0.5 µg g-1 wet weight), with the exception of ringed seal liver and to a lesser extent caribou kidney. Mercury tends to accumulate more in liver and kidney than in muscle, often by a factor of at least 10. It is well known that ringed seal liver in the Canadian Arctic can contain higher concentrations of THg (NCP, 2012). For the 4 ringed seal collected near Kuujjuaraapik, THg concentrations were much lower in the muscle (mean = 0.27 µg g-1 wet weight) than in the liver (mean = 10.70 µg g-1 wet weight). Very low levels of muscle THg were found in ptarmigan, hare, caribou, brook trout and whitefish (ranging from 0.002-0.04 µg g-1 wet weight). Data are not yet available for concentrations of other metals such as lead and cadmium in these tissues.

Measurements of THg for the same species (except caribou) from approximately 20 years ago are also presented in Table 1. The data were obtained from the environmental assessment for the Great Whale hydro-electric project (Somer, 1993; Langlois and Langis, 1995). Caution is required in comparing THg concentrations between the two time periods because of low sample sizes. Few measurements for each species limit the power to detect statistically significant differences. In addition, the animals were collected from a relatively broad geographic area around Kuujjuarapik, and the results could in part reflect spatial rather than temporal differences in THg concentrations among sampling sites.

The THg results from the winter field program show concentrations that are similar to or lower than those measured in the same species 20 years ago. Ringed seal muscle THg concentrations were similar between time periods (0.27 vs. 0.32 µg g^{-1} wet weight), though liver THg concentrations were higher in 2014. The difference in liver THg between time periods was not statistically significant due to high variability measured among individual ringed seal in 2014 (Fig. 2), which was related to differences in length (0.97-1.47 m). Willow ptarmigan and snowshoe hare had lower liver THg concentrations in 2014 than in 1989-1991, although the difference was only statistically significant for ptarmigan (Table 1, Figure 2). Recent whitefish muscle from the Great Whale River had significantly lower THg levels compared to whitefish muscle from 1989-1991 (Table 1). This difference may be due to the type of whitefish collected—specifically sea-run whitefish from Great Whale River as compared to lake-dwelling whitefish from 1989 to 1991¾rather than due to temporal change. Sea-run fish in the Arctic typically have lower muscle THg concentrations than lake-dwelling fish of the same species (van der Velden et al., 2013). This may also be the case for the brook trout collected in the Second River in 2014, which were likely sea-run and had lower THg concentrations (0.04 µg g^{-1} wet weight) compared to lake-dwelling brook trout in the area (0.08-0.28 µg g-1 wet weight; Chételat et al., 2013). Overall, there is no evidence that THg concentrations have increased in the last 20 years for harvested aquatic and terrestrial animals in the area. Preliminary results suggest that terrestrial wildlife (willow ptarmigan, snowshoe hare) may be less exposed to THg in recent years although additional sampling is required to confirm this trend.

Information is not available for past THg concentrations in caribou that migrate through the region although data for the George River herd in Labrador and other herds in the Canadian Arctic can provide context for the results. The bioaccumulation of THg in caribou is typically compared using kidney concentrations on a dry weight basis (note that Table 1 shows wet weight concentrations). Caribou collected in 2014 from two locations near Kuujjuaraapik had kidney THg concentrations that averaged 5.03 µg g^{-1} dry weight (range: 3.40-7.48 µg g^{-1}). These concentrations are similar to, though on the higher end of the range in average kidney THg concentrations (1.53-6.21 µg g^{-1} dry weight) among 8 different barren-ground caribou herds (including the George River herd) in northern Canada (NCP, 2012).

Table 1. THg concentrations (µg g-1 wet weight) of fish and wildlife collected near Kuujjuaraapik in the winter of 2014. Measurements made from 1989 to 1991 for the Great Whale hydro-electric environmental assessment are included for the same species, if available (Somer, 1993; Langlois and Langis, 1995). A statistical comparison of mean THg concentrations between the two time periods was conducted using t-tests.

		2014 sampling			1989 to 1991 sampling			Comparison of means (t-test p-value)
Species	Tissue	Mean	SD	n	Mean	SD	n	
Ringed seal	muscle	0.27	0.18	4	0.32	0.19	8	0.672
	liver	10.70	11.35	4	5.12	4.64	8	0.242
Caribou	muscle	0.01	0.002	5	---	---	---	---
	liver	0.35	0.11	6	---	---	---	---
	kidney	1.12	0.36	6	---	---	---	---
Willow ptarmigan	muscle	0.002	0.001	9	<0.05	---	9	---
	liver	0.03	0.01	9	0.18	0.04	3	<0.001
Snowshoe hare	muscle	0.01	0.001	6	<0.05	---	22	---
	liver	0.04	0.01	6	0.13	0.22	9	0.341
Brook trout	muscle	0.04	0.01	6	---	---	---	---
Whitefish	muscle	0.04	0.01	11	0.16	0.09	400	<0.001

SD = standard deviation, n = sample size

Figure 1. An example of a record sheet provided in the sampling kits for animal tissue collection (in this case for ringed seal) with required information listed on the front of the sheet and sampling instructions provided on the back of the sheet.

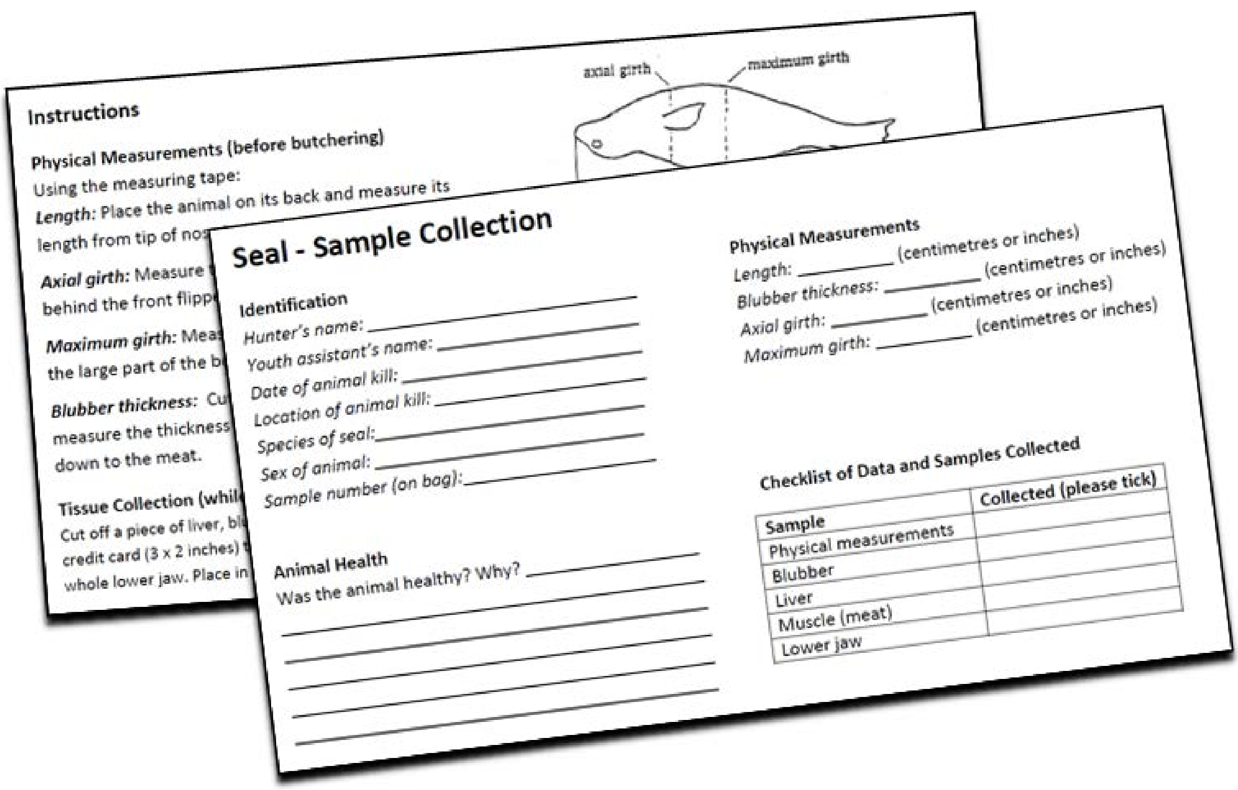
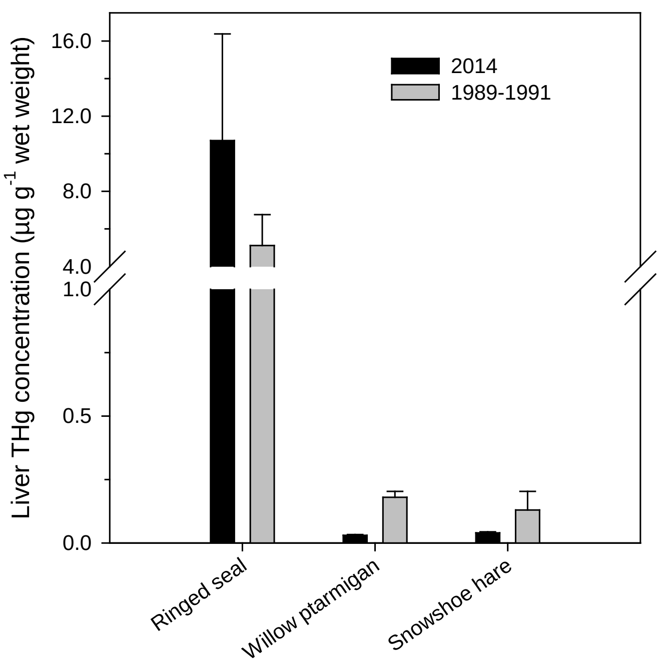


Figure 2. Comparison of liver THg concentrations (mean ± standard error) in ringed seal, willow ptarmigan and snowshoe hare collected in 2014 for this project and in 1989 to 1991 for the Great Whale hydro-electric project. Note that the scale for THg concentration (Y-axis) has a break because of the much higher concentrations in ringed seal liver. Only willow ptarmigan showed a significantly different THg concentration between the two time periods (see Table 1).



Discussion and Conclusion

In the first year of this project, we achieved our objective of engaging local hunters to collect fish and wildlife tissues for metal levels. We will build on the preliminary results presented in this synopsis report by measuring other metals concentrations (e.g., lead, cadmium) in the tissue samples and by collecting additional species of fish and wildlife in the summer field program of 2014. Species collected in the summer field program may include waterfowl, seabirds, marine crustaceans, and seal. Samples will be analyzed for nitrogen and carbon stable isotopes to interpret dietary influences on the levels of metal bioaccumulation. Sulphur stable isotopes will be analyzed in the brook trout and whitefish muscle to confirm if they are sea-run fish. Together this information will provide a summary of current metal levels in terrestrial and aquatic environments near Kuujjuaraapik. We will work with the Nunavik Board of Health and Social Services and Nunavik Regional Contaminants Committee to interpret the metal concentrations in relation to established consumption guidelines that may pose a risk to human health. In March of 2015, a community meeting will be held in Kuujjuaraapik-Whapmagoustui to present the results of the study, and a report will be prepared and translated into Inuktitut for the community.

Expected Project Completion Date

March 31, 2015

Acknowledgements

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Impacts of Global Change and Industry on Methyl Mercury Exposures and Inuit Health

Répercussions des changements mondiaux et des industries sur les expositions au méthymercure et sur la santé des Inuits

- **Project Leader:**
  Tom Sheldon, Nunatsiavut Government, Tel: (709) 922-2588, Fax: (709) 922-1040
  Email: tom_sheldon@nunatsiavut.com
- **Project Team Members and their Affiliations:**
  Community Research Advisory Committees of Rigolet, Northwest River, and Happy Valley-Goose Bay/Mud Lake; Rodd Laing and Michele Wood, Nunatsiavut Government; Trevor Bell and Brad de Young, Memorial University; Chris Furgal, Trent University; Zou Zou Kuzyk, University of Manitoba; Elsie Sunderland, Amina Schartup and Ryan Calder, Harvard University; Robert Mason and Prentiss Balcom, University of Connecticut;

Abstract

A community-based monitoring program was initiated to assess seasonal and inter-annual variability in mercury (Hg) and methyl-mercury (MeHg) concentrations in freshwater tributaries flowing into Lake Melville. This program was established to provide more localized data to our ongoing work of identifying sources of Hg and MeHg in the Lake Melville system. As results to date show a source at the western end of Lake Melville, three major tributaries feeding the Lake at this region were chosen for further monitoring: the Churchill River, Goose River and North West River. Sampling began in winter of 2014 and samples have not yet been analyzed.

Résumé

Un programme de surveillance communautaire a été lancé pour évaluer la variabilité saisonnière et interannuelle dans les concentrations de mercure (Hg) et de méthylmercure (MeHg) dans les affluents d'eau douce du lac Melville. Ce programme a été établi afin de fournir des données plus locales pour nos travaux continus de détection des sources de Hg et de MeHg dans le système du lac Melville. Comme les résultats obtenus à ce jour indiquent la présence d'une source à l'extrémité ouest du lac Melville, trois affluents importants qui alimentent le lac dans cette région ont été retenus pour une surveillance plus poussée : la rivière Churchill, la rivière Goose et la rivière North West.

Work on a Human Health Risk Assessment was initiated through the implementation of a seasonally-stratified food-frequency questionnaire process. The questionnaire, designed to identify magnitudes and frequencies of country food consumed from Lake Melville by Inuit, was completed through an interview process with local research assistants by 240 Inuit living in Rigolet, North West River and Happy Valley-Goose Bay, representing an approximate 10% sample of the population. The same survey will be conducted in June to capture the spring seal hunt and again in September to capture the summer net fishing season, and results will be corroborated using hair Hg biomarkers.

L'échantillonnage a commencé à l'hiver 2014 et les échantillons n'ont pas encore été analysés.

Les travaux d'une évaluation du risque sanitaire ont été entamés par l'implantation d'un questionnaire de fréquence de consommation des aliments en fonction des saisons. Le questionnaire, conçu pour déterminer l'ampleur et la fréquence de consommation d'aliments traditionnels provenant du lac Melville par les Inuits, a été complété suite à un processus d'entrevues par des adjoints en recherche locaux de 240 Inuits habitant à Rigolet, North West River et Happy Valley-Goose Bay, ce qui représente un échantillon d'environ 10 % de la population. Le même sondage sera réalisé en juin pour colliger les renseignements sur la chasse au phoque printanière puis de nouveau en septembre pour colliger les renseignements sur la saison de pêche au filet estivale, et les résultats seront corroborés au moyen de biomarqueurs de Hg dans les cheveux.

Key messages

- This research is part of an ongoing multi-year program to better understand the origins and presence of methyl-mercury (MeHg) in Lake Melville, Labrador. The program uses community-based monitoring and the integration of local knowledge with science to help us understand the origins and presence of methylmercury (MeHg) in Lake Melville through monitoring of seal and fish tissue, sea water and lake sediment.
- In 2013-2014, we developed and initiated a Human Health Risk Assessment (HHRA) designed to determine if there is a link between the amount and types of fish and seal that are eaten by Inuit living on Lake Melville, and the levels of mercury to which they are exposed. This included a dietary survey which covered winter consumption of country foods, particularly seal and fish. The HHRA will continue with two more rounds of dietary surveys (Spring and Summer) and hair sampling to test for MeHg exposure (Spring and Summer).

Messages clés

- Cette recherche fait partie d'un programme pluriannuel continu visant à mieux comprendre les origines et la présence de méthylmercure (MeHg) dans le lac Melville, au Labrador. Le programme est basé sur la surveillance communautaire et l'intégration des connaissances locales à la science afin de nous aider à comprendre les origines et la présence de MeHg dans le lac Melville par la surveillance des tissus du phoque et des poissons, de l'eau de mer et des sédiments lacustres.
- En 2013-2014, nous avons élaboré et lancé une évaluation du risque sanitaire (ERS) visant à déterminer s'il existe un lien entre la quantité et les types de poissons et de phoques consommés par les Inuits vivant aux abords du lac Melville et les concentrations de mercure auxquelles ils sont exposés. Cela comportait un sondage sur les habitudes alimentaires qui portait sur la consommation hivernale d'aliments traditionnels, en particulier le phoque et le poisson. L'ERS nécessitera deux autres rondes de sondages

- We continued the testing of fresh water feeding Lake Melville to better identify and understand the sources of mercury and methyl-mercury in the Lake Melville ecosystem.

- The data collected from the ongoing Lake Melville research program will enable us to 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.

sur les habitudes alimentaires (printemps et été) et un échantillonnage de cheveux pour analyser l'exposition au MeHg (printemps et été).

- Nous avons continué d'analyser l'eau douce qui alimente le lac Melville pour mieux repérer et comprendre les sources de mercure et de MeHg dans l'écosystème du lac Melville.

- Les données prélevées durant le programme de recherche en cours sur le lac Melville nous permettront d'élaborer un modèle mécaniste pour le cycle du mercure dans le lac Melville, qui fait état des changements dans les apports par dépôt atmosphérique et apports fluviaux sur les concentrations chez les poissons et les phoques.

Objectives

- Establish a community-based monitoring program to assess seasonal and interannual variability in Hg and MeHg concentrations in freshwater tributaries flowing into Lake Melville.

- 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.

- 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.

Introduction

This project uses community-based monitoring and the integration of local knowledge to strengthen our understanding of the origins and presence of methylmercury (MeHg) in Lake Melville, Labrador, and the potential exposure to this contaminant through consumption of country foods.

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). MeHg exposure 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 is a tidal inlet on the Labrador coast with particular importance for northern populations as part of the treaty-negotiated 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 inputs 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

2016. 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). Development of a new reservoir has been proposed for the Lower Churchill River and 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).

This project complements ongoing research being carried out in our multidisciplinary and collaborative ArcticNet project "Our Environment, our Health", a sub-project of the Nunatsiavut Nuluak Project. It leverages 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. Local Inuit researchers and research leads provide the community knowledge and insight required to strengthen our understanding of MeHg input and bioaccumulation, and the exposure to MeHg by Inuit through country food consumption. *This year, local Inuit led the collection of dietary information that will help assess the magnitude and frequency of consumption of different country foods and will be critical for informing contaminant exposure analysis, including MeHg. These new survey data will help indicate which traditional/country foods should be given the highest priority for monitoring of contaminants. The next step will involve the collection and analysis of hair samples for Hg to cross-validate results of the food frequency questionnaire and establish baseline levels of exposure in the Inuit community.*

Activities in 2013-2014

- We established a community-based monitoring program to assess seasonal and interannual variability in Hg and MeHg concentrations in freshwater tributaries flowing into Lake Melville. Monthly sampling from the Churchill River and seasonal (4x/year) sampling from the North West and Goose Rivers began and will continue into 2014-15. Locations were identified through integration of local knowledge, and sampling was undertaken by community members. The samples were processed and stored in the Labrador Institute North West River Research Station, and the first batch will be sent for analysis at University of Connecticut once we have accumulated a full shipment.
- We conducted a food-frequency questionnaire to identify magnitudes and frequencies of country food consumed from Lake Melville by the Inuit during the winter season. The same survey will be taken in June and September in order to seasonally stratify the data, and hair samples will be taken in order to corroborate dietary survey results with methylmercury (MeHg) exposure. A 10% random sample of the Inuit population in Rigolet (n=30), North West River (n=30) and Happy Valley-Goose Bay (n=180) were surveyed by community-based research assistants. Data was collected regarding consumption of locally-caught fish, store-bought fish and seafood, and other country foods over a 24-hour, 1-month and 3-month recall period.

Capacity Building:

- Two community members (1 Happy Valley-Goose Bay, 1 North West River) trained in the collection of river water samples for mercury analysis, TSS and salinity (1 hour training).
- 7 individuals (4 Happy Valley-Goose Bay, 1 North West River, 2 Rigolet) trained in dietary survey work (6 hour training).

Communications:

- Public meetings held in Happy Valley-Goose Bay (March 11), North West River (March 13) and Rigolet (March 19).
- Radio interview aired on CBC Labrador Morning March 12.
- Information pamphlets circulated in Inuttitut and English.
- Facebook page created and updated ("Lake Melville Inuit Health Study")

Traditional Knowledge Integration:

- Consultation with local experts regarding the safest and best place to take monthly and seasonal river water samples.
- Consultation with local advisors with regards to effectiveness of dietary survey, language used in survey, and the inclusion of all country foods consumed locally. Advice integrated into final version of survey.

Results

While there are no specific results to report to date on project activities, work on the Human Health Risk Assessment is well established and underway. The majority of Inuit who participated in the winter pulse of the dietary survey have agreed to return for the Spring and Summer pulses as well as provide a hair sample for MeHg analysis.

Discussion and Conclusions

There are no results to interpret at this time. The significance of this work is that it will contribute valuable data to the creation of 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. The Human Health Risk Assessment and freshwater monitoring work will continue in 2014-15 in tandem with other research in Lake Melville to provide a valuable baseline in preparation for the impoundment of the Muskrat Falls reservoir in 2016.

Expected Project Completion Date

The expected completion date of the Human Health aspect of this project is November 2014. The expected completion date of the freshwater tributary sampling aspect is February 2015. The expected completion date of the overall Lake Melville research program is 2016, which is the estimated date of impoundment of the reservoir on the lower Churchill River.

Project website (if applicable)

www.facebook.com/Lake Melville Inuit Health Study

www.Nainresearchcentre.com

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Environmental Monitoring and Research

Tendances Environnementales Surveillance et de Recherche

Northern Contaminants Air Monitoring: Organic Pollutant Measurement

Surveillance des contaminants atmosphériques dans le Nord : mesure des polluants organiques

- **Project Leader:**
  Hayley Hung, Science and Technology Branch, Environment Canada, Toronto,
  Tel: (416) 739-5944; Fax (416) 739-4281, E-mail: hayley.hung@ec.gc.ca
- **Project Team Members and their Affiliations:**
  Yong Yu, Mahiba Shoeib, Tom Harner, Alexandra Steffen, Derek Muir, Camilla Teixeira, Liisa Jantunen, and Ed Sverko, Environment Canada; Phil Fellin, Henrik Li, and Charles Geen, AirZOne One Ltd; Pat Roach, Aboriginal Affairs and Northern Development Canada (Whitehorse); Frank Wania, University of Toronto Scarborough; Alert Global Atmospheric Watch Laboratory Staff; Laberge Environmental Services (Whitehorse)

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 présent projet vise à mesurer ces contaminants dans l'air en Arctique. Il fait partie d'un programme de surveillance continue lancé en 1992. La mesure de la quantité de polluants organiques présente dans l'air en Arctique au fil du temps permettra de déterminer si les concentrations atmosphériques de ces produits décroissent, augmentent ou demeurent stables dans 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 de ce projet en cours sont utilisés pour négocier des

movement from sources in the South to the Arctic. This year, 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.

ententes internationales en matière de lutte contre ces contaminants, pour évaluer l'efficacité de celles-ci, et pour tester des modèles de l'atmosphère qui expliquent le déplacement des contaminants depuis les sources dans le Sud jusqu'en Arctique. Cette année, 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 à des fins de détermination des tendances. Les autres échantillons ont été soumis à une procédure d'extraction, puis ont été archivés en vue de l'examen ultérieur d'épisodes notables de transport et du dosage des nouveaux produits chimiques prioritaires. Depuis décembre 2005, on a élargi le programme afin de dépister les nouveaux produits chimiques, comme les pesticides actuellement utilisés, les produits ignifuges bromés et les composés perfluorés associés aux produits antitaches, dans l'air arctique à Alert. 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.

Key Messages

- Perfluorooctane sulphonate (PFOS) precursors show declining or unchanging trends in Arctic air at Alert, Nunavut, reflecting the voluntary phaseout of the production of PFOS, PFOA, and PFOS-related products by their largest producer 3M in 2000
- Increasing air concentration trends were observed for fluorotelomer alcohols (FTOHs), which are perfluoro alkyl carboxylate (PFCA) precursors, that were not regulated at the time of measurement
- Three BFRs, namely allyl 2,4,6-tribromophenyl ether (ATE), pentabromotoluene (PBT) and 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE), and dechlorane 604 (DP604) were frequently detected in air at Little Fox Lake, Yukon

Messages clés

- Les précurseurs de perfluorooctanesulfonate (PFOS) sont en déclin ou stables dans l'air arctique à Alert, au Nunavut, ce qui reflète l'abandon graduel, sur une base volontaire, de la production de PFOS, d'acide perfluorooctanoïque et de produits apparentés au PFOS par le plus gros fabricant de ces produits, 3M, depuis 2000.
- On a noté une tendance à la hausse des concentrations atmosphériques d'alcools fluorotélomériques (FTOH), qui sont des précurseurs de perfluoroalkylcarboxylates (PFCA), et qui n'étaient pas réglementés au moment des mesures.
- On a fréquemment détecté trois produits ignifuges bromés, c'est-à-dire de l'éther d'allyle et de 2,4,6-tribromophényle (EAT), du pentabromotoluène (PBT) et du 1,2-bis(2,4,6-tribromophénoxy)éthane (BTBPE), ainsi que du déchlorane 604 (DP604) dans l'air au lac Little Fox, au Yukon.

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, time trends of neutral PFASs measured at Alert up to 2012 are reported.

Results of organochlorine pesticides (OCPs), polybrominated diphenyl ethers (PBDEs) and other flame retardants (FRs) in air at the Yukon station of Little Fox Lake from August 2011 to December 2013 using a FTS are also reported.

Activities in 2013-2014

Measurements and Analysis

Regular ground level atmospheric measurements of organochlorines (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 2012 samples from Alert is currently ongoing.

Ten Alert samples collected in 2011 were screened for short-chain chlorinated paraffins (SCCPs). 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 in FY2014/15. Alert PS-1 samples collected from 2007 to 2009 were screened for polar PFASs by ALS Canada Ltd. but all compounds were found to be non-detectable. An extraction efficiency test for these compounds is currently being conducted at NLET.

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, FRs and CUPs. Sampling at this location allows for the continual investigation of trans-Pacific transport of contaminants to the western Canadian Arctic. FTS samples collected between August 2011 and December 2013 have been extracted and analyzed by the new postdoctoral fellow Dr. Yong Yu in the Organics Analysis Laboratory (OAL) located in Downsview (EC). Results are reported here.

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 continued to work with the Yukon College to make the Little Fox Lake station into a combined monitoring, research and educational station for undergraduate and high school students. In November, Sandy Steffen and Amanda Cole conducted an information session with the Ta'an Kwach'an Council (TKC) during a site visit to Little Fox Lake and Hayley met with the TKC in March 2014 when she visited Whitehorse. During her visit to Whitehorse, Hayley also met with the Yukon Contaminants Committee to discuss about communication and capacity building activities in the Yukon.

Following the comments and suggestions from the Nunavut Environmental Contaminants Committee (NECC), we have initiated a communication and capacity building plan in Nunavut. Sandy, Hayley and Liisa Jantunen conducted a guest lecture and hands-on training session to students in the Environmental Technology Program at the Nunavut Arctic College during the week of February 10, 2014 about Arctic air monitoring and research of organic contaminants and mercury. After this lecture, they met with the NECC to discuss about future communication and capacity activities and to obtain feedback for the guest lecture and training session.

In May 2013, Hayley was invited for a second time 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). All travel expenses were paid by UNIS. Air monitoring and trend analysis for organic pollutants under NCP and AMAP was included as part of the teaching material. In May 2014, Hayley is invited to guest lecture at the Zeppelin Mountain station, an AMAP station operated by Norway.

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

PFASs in Air at Alert

Air samples collected at Alert since August 2006 were screened for 7 perfluoro alkyl carboxylate (PFCA) and perfluorooctane sulphonate (PFOS) precursors, including 6:2, 8:2 and 10:2 fluorotelomer alcohols (FTOHs), methyl and ethyl perfluorooctane sulfonamide (MeFOSA and EtFOSA) and methyl and ethyl perfluorooctane sulfonamidoethanols (MeFOSE and EtFOSE). Time trends developed for 8:2 and 10:2 FTOHs and MeFOSE and EtFOSE are shown in Figure 1.

Brominated 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 organochlorine pesticides (OCPs), polybrominated diphenyl ethers (PBDEs) and other flame retardants (FRs) at LFL. The air volume collected by the FTS during a 1-month period depends on wind speed and ranged from 840 m^3 to 10,500 m^3. Thirty samples were collected from August 2011 to December 2013 and reported here.

Table 1 and Figure 2 summarize the concentrations of each OCP during all the sampling periods. Fifteen of 26 OCPs, including aldrin, endrin, a- and g-hexachlorocyclohexane (HCH), hexachlorobenzene (HCB), heptachlor and heptachlor epoxide, a-endosulfan, dieldrin and a- and g-chlordane, oxychlordane, t-nonachlor and DDT-related isomer were frequently detected. HCB exhibited the highest mean concentration of 73 pg/m^3, followed by a-HCH and a-endosulfan at mean concentrations of 8.4 and 4.4 pg/m^3, respectively. The total concentrations of 14 PBDEs ranged from 0.66 to 18 pg/m^3, with a mean and median value of 5.3 and 3.7 pg/m^3. BDE-47 and BDE-99 are dominant compounds, with mean concentrations of 1.7 and 1.4 pg/m^3 (Figure 3). Three BFRs, namely allyl 2,4,6-tribromophenyl ether (ATE), pentabromotolune (PBT) and 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE), and dechlorane 604 (DP604) were frequently detected.

Most OCPs had higher concentration levels in summer than in winter, suggesting a potential correlation with temperature of sampling

Figure 1. 8:2 and 10:2 FTOH and MeFOSE and EtFOSE measured in air at Alert.

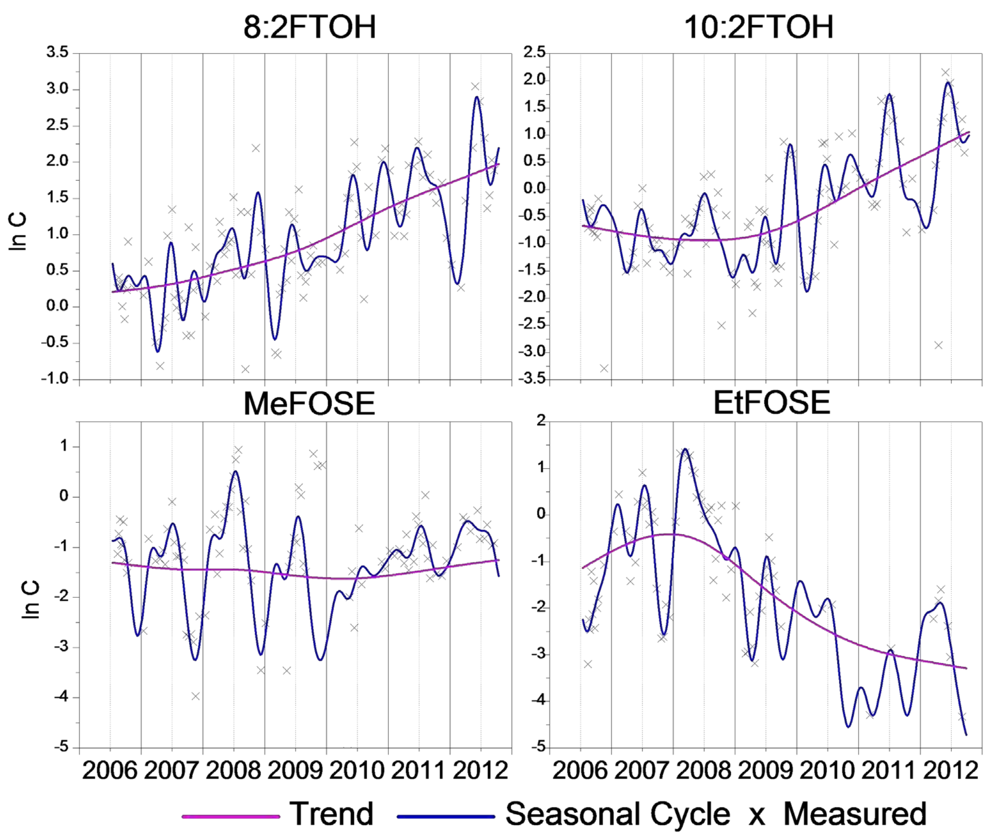


Table 1. Concentrations of OCPs at LFL from August 2011 to December 2013, pg/m³

	min	max	mean	median
aldrin	0.00	5.11	1.20	0.67
dieldrin	0.00	2.37	0.46	0.32
endrin	0.00	0.82	0.24	0.15
HCB	15.5	170	68.0	60.2
α-HCH	2.64	18.8	7.91	6.91
γ-HCH	0.00	4.45	1.12	0.83
heptachlor	0.00	1.31	0.18	0.06
heptachlor epoxide	0.16	6.31	1.54	0.92
t-nonachlor	0.00	0.56	0.16	0.10
α-endosulfan	0.74	17.7	3.89	2.67
α-chlordane	0.00	2.58	0.76	0.62
γ-chlordane	0.00	2.01	0.53	0.35
oxychlordane	0.00	0.85	0.25	0.18
o,p'-DDD	0.00	1.62	0.20	0.07
p,p'-DDD	0.00	0.72	0.12	0.05
p,p'-DDE	0.00	0.38	0.09	0.08
o,p'-DDT	0.00	0.88	0.09	0.03

Figure 2. Box-and-whisker plots of OCPs measured in air at Little Fox Lake. The center box is bounded by the 25th and 75th percentiles, and whiskers indicate the 10th and 90th percentiles. Dots are outliers of the 10th and 90th percentiles. The horizontal lines represent the mean and the little squares give the median.

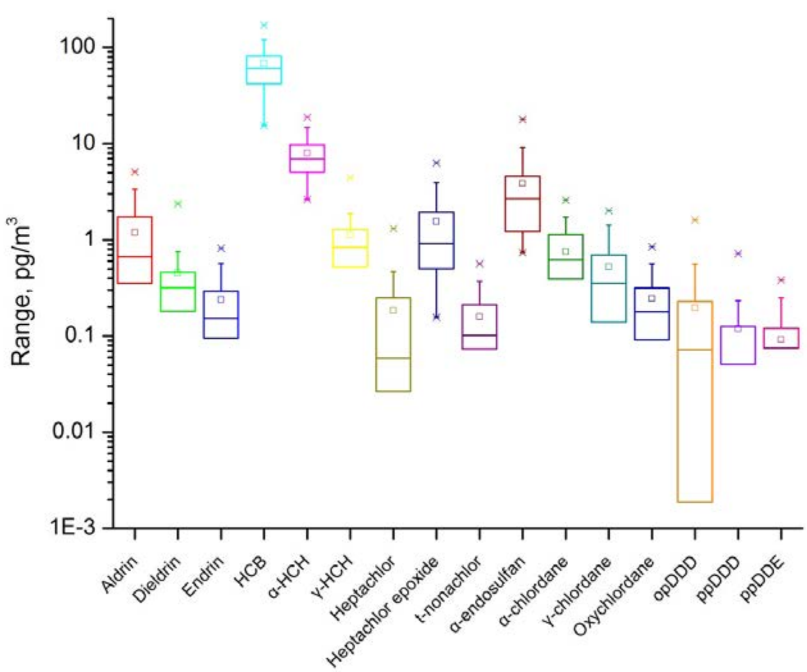
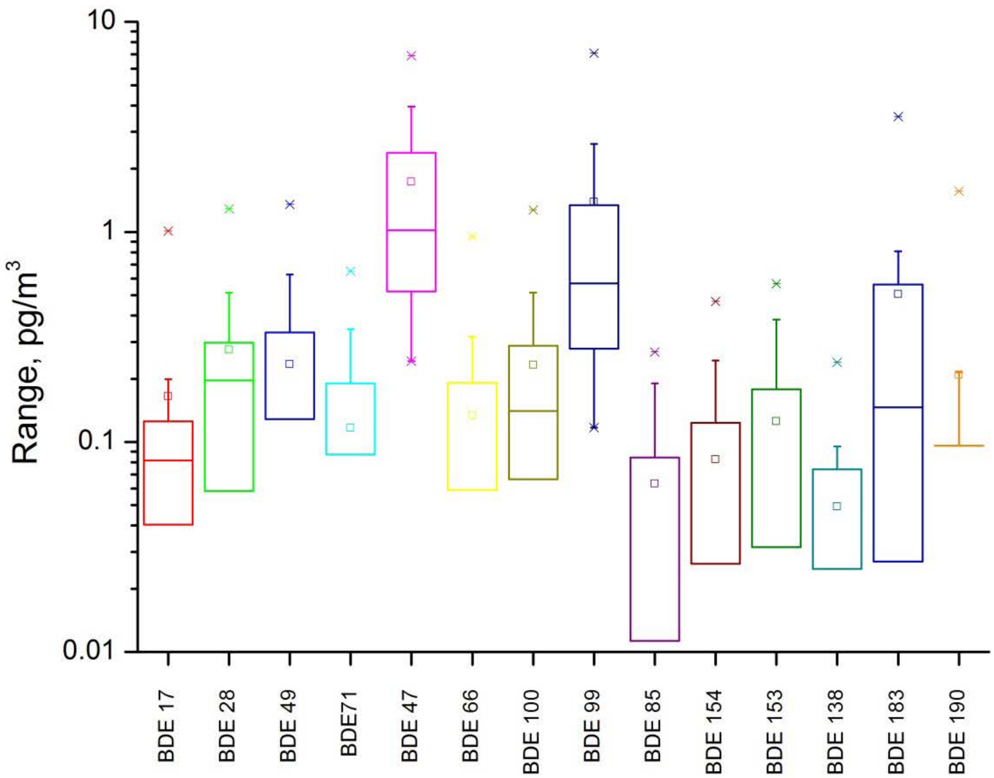


Figure 3. Box-and-whisker plots of PBDEs measured in air at Little Fox Lake. The center box is bounded by the 25th and 75th percentiles, and whiskers indicate the 10th and 90th percentiles. Dots are outliers of the 10th and 90th percentiles. The horizontal lines represent the mean and the little squares give the median.



periods. However, no obvious seasonal variation was observed for PBDEs and BFRs during these years.

Discussion and Conclusions

PFASs in Air at Alert

The 8:2 fluorotelomer alcohol (FTOH) was the most dominant compound detected in all air samples collected at Alert. This is consistent with previous cruise-based measurements performed across the North Atlantic and Canadian Archipelago in 2005 (Shoeib et al., 2006), in the Atlantic Ocean/ Southern Ocean/ Baltic Sea in 2007 and 2008 (Dreyer et al., 2009); as well as globally under the Global Atmospheric Passive Sampling (GAPS) study at land-based stations (Gawor et al., 2014). Piekarz et al. (2007) calculated the estimated atmospheric residence times for 6:2, 8:2 and 10:2 FTOH which were 50, 80 and 70 d. The relative order of these residence times coincides with their observed atmospheric concentrations which may explain the relative enhancement of 8:2FTOH in ambient air. Spring maxima were observed at Alert, particularly for methyl perfluorooctane sulfonamido ethanol (MeFOSE), which may be associated with the increase in particulate input during the Arctic Haze. Summer maxima were also apparent for FTOH and MeFOSE which may be related to volatilization due to higher temperatures. While PFOS precursor MeFOSE showed non-changing trend, declining trend was observed for EtFOSE with an apparent first order halflife, t1/2, of 1.3 y (Figure 1); reflecting the voluntary phaseout of the production of PFOS, PFOA, and PFOS-related products by their largest producer 3M in 2000. In contrast, PFCA precursors 6:2, 8:2 and 10:2 FTOHs, which were not regulated at the time of measurement, showed increasing tendencies in air at Alert with doubling times of 2.3 to 3.3 y. Air monitoring of these chemicals need to continue to assess the effectiveness of national and international regulation initiatives.

Brominated Flame Retardants and Organochlorine Pesticides in Air at Little Fox Lake

In a previous study, Westgate et al. (2013) investigated the occurrence of BFRs and OCPs from August 2007 to October 2009 at LFL, using a super-high-volume air sampler. The average concentrations of the 3 dominant chemicals in the current study were higher than the active sampling results from 2007 to 2009. Compared with the results of Alert from 2010 to 2011, the concentrations were slightly higher at LFL.

Back-trajectories were calculated using the US NOAA HYSPLIT model. Ten-day trajectories were calculated for air arriving at 50, 200 and 500 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. Possible sources were studied using the potential source contribution function (PSCF). Compare with the PSCF results from 2007 to 2009, North America contributed more OCPs during 2011 to 2013.

Expected Project Completion Date

On-going

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 and Little Fox Lake

Mesures du mercure à Alert et au lac Little Fox

- **Project Leader:**
  Alexandra Steffen, Environment Canada, Science and Technology Branch
  Tel: (416) 739-4116, Fax: (416) 739-4318, Email: Alexandra.Steffen@ec.gc.ca
- **Project Team Members and their Affiliations:**
  Amanda Cole, Patrick Lee, and Hayley Hung, Environment Canada, Science and Technology Branch; Greg Lawson and Derek Muir, Environment Canada, National Water Research Institute; Pat Roach, Aboriginal Affairs and Northern Development Canada (Whitehorse); Laberge Environmental Services (Whitehorse); Greg Skelton, Skelton Technical

Abstract

Mercury (Hg) is a global priority pollutant and continues to be of concern in Arctic regions. The longest Arctic record of atmospheric mercury concentrations has been collected in the Canadian high Arctic at Alert, Nunavut. Analysis reveals there to be less of a decreasing trend in the high Arctic than at more southerly locations. Mercury continues to show a distinct seasonal drop in gaseous elemental mercury (GEM) in the Spring. Seasonal patterns in shorter-lived mercury species (reactive gaseous mercury, or RGM, and particle-bound mercury, PHg) have been analyzed with patterns in mercury deposited in snowfall events. This analysis has shown a peak in PHg during early spring and a peak in RGM in late spring, with

Résumé

Le mercure (Hg) est un polluant prioritaire à l'échelle mondiale, et il demeure préoccupant dans les régions arctiques. 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 baisse des concentrations de mercure est moins marquée dans le Haut-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

the highest snow Hg concentrations reported in late spring. GEM measurements continue to be collected in the Yukon at Little Fox Lake but more years of data are still required to produce a valid trend.

dépôts de mercure associés aux chutes de neige. Cette analyse a montré que le PHg dessinait un pic au début du printemps, et que le MGR en produisait un à la fin du printemps, les plus fortes concentrations de Hg dans la neige ayant été enregistrées à la fin du printemps. On continue de recueillir des mesures du MEG au lac Little Fox, au Yukon, mais il faudra rassembler des données sur un plus grand nombre d'années si l'on veut dégager une tendance valide.

Key messages

- Eighteen years of atmospheric mercury measurements at Alert, Nunavut and five years of atmospheric mercury measurements have been collected at Little Fox Lake, Yukon.
- 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
- Time trends of these data were compared to other Arctic, sub-Arctic and mid-latitude sites and showed that the levels of gaseous elemental mercury in the Arctic have not gone down as much as the non-Arctic levels
- Analysis of reactive gaseous mercury and particle-bound mercury measurements at Alert reveal that particle-bound mercury is the dominant short-lived species in early spring while reactive gaseous mercury dominates in late spring. The highest levels of Hg in snow are most often in May

Messages clés

On a recueilli des mesures du mercure atmosphérique sur 18 ans à Alert, au Nunavut, et sur 5 ans au lac Little Fox, au Yukon.

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 a comparé les tendances temporelles de ces données à celles enregistrées à d'autres sites en Arctique, dans des régions subarctiques et aux latitudes moyennes; on a constaté que les concentrations de mercure élémentaire gazeux n'avaient pas autant diminué en Arctique qu'ailleurs.

L'analyse du mercure gazeux réactif et du mercure lié aux particules à Alert montre que le mercure lié aux particules est la principale espèce de mercure à courte durée de vie au début du printemps, tandis que le mercure gazeux réactif est l'espèce prédominante à la fin du printemps. Les plus fortes concentrations de Hg dans la neige sont souvent enregistrées en mai.

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 through the Minamata Convention on Mercury. Currently, Alert is an external partner for the Global Mercury Observation System (GMOS) program to initiate a global monitoring program for mercury and the potential to use this information on future plans of effectiveness evaluation of the ratification of the Minimata Convention.
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 2013-2014

Research activities

Ground-based continuous atmospheric measurements of 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 and November 2013, on top of regular checks by the onsite operator. Continuous measurements of GEM at Little Fox Lake were also carried on through 2013-2014, though instrument problems resulted in a gap in coverage from June to mid-November. To minimize future data loss, a newer model instrument was installed in November with remote control and internal data storage capabilities. Through a partnership with P. Roach, Laberge Environmental and the Yukon College, 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 February and November 2013.

Data from both sites for 2012 and 2013 have been quality controlled and 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 2014. 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.

Improved collection methods were used in spring 2013 to obtain airborne particulate samples for analysis of Hg and lead isotopes. These samples are currently at the University of Toronto pending analysis. Filter samples are currently being collected for spring 2014.

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 2013 have been analysed at the National Water Research Institute.

Long-term speciated and snow mercury measurements from Alert were analyzed and discussed in a journal article published in Atmospheric Chemistry and Physics. This article reported a consistent seasonal pattern in which PHg dominates in late winter and early spring, while RGM dominates in late spring and early summer.

Results from Alert and Little Fox Lake have also been included in atmospheric mercury chapters in two recent national assessment reports. The third Canadian Arctic Contaminants Assessment Report (CACAR III) was published in 2013 and the Canadian Mercury Science Assessment is in translation and is expected to be published in 2014.

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 Hung and Sandy Steffen travelled to Iqaluit in February 2014 to give a presentation and a hands-on demonstration at the Nunavut Arctic College and discuss future collaborations. In March 2014, Hayley Hung presented a lecture at the Yukon College. We continue to work with the Yukon College for data collection and storage efficiencies and for the development of a mercury passive sampling project.

Communications

In February 2013, Hayley Hung and Sandy Steffen gave a public seminar at the Beringia Center for the Yukon Science Institute. In November, Sandy Steffen and Amanda Cole conducted an information session with the Ta'an Kwach'an Council (TKC) to discuss mercury and POPs research at Little Fox Lake and throughout the Arctic; Hayley also met with the TKC in March 2014. Due to interest expressed by TKC members, we have directed them to the CACAR III report and mailed them copies of AMAP and IPY reports.

Traditional Knowledge

We are working on how best to incorporate TK in our long term measurements at Alert and Little Fox Lake. We have been provided a summary of the proceedings from an Elders conference on climate change through the NECC chairs. We will review the document and discuss how to incorporate TK within our programs. As well, Leona Aglukkaq, the federal Minister of the Environment has made it a priority for the Science and Technology Branch to incorporate Aboriginal Traditional Knowledge (ATK) with our scientific processes. We have met with fellow scientists, our assistant deputy minister and management to discuss this possibility. We have provided them examples of how we have used TK in the past (Barrow IPY field study) and how NCP has been working with northerners to combine the knowledge, and we are continuing this dialogue within the department.

Results

Figure 1 summarizes all the seasonal concentration data for GEM, PHg and RGM at Alert from 2002 to 2011. Figure 2 summarizes the measurements of total Hg in snow samples at Alert from 1998 to 2011. The long-term record of GEM at Alert and at Little Fox Lake is shown in Figure 3. Discussion of these results follows.

Fig. 1. Box and whisker plots of monthly gaseous elemental mer-cury (GEM-blue), particulate mercury (PHg-green) and reactive gaseous mercury (RGM-pink) from Alert, 2002–2011. GEM is in ng m^{-3} and PHg and RGM are in pg m^{-3}. Centre line in the box represents the median value, the boundaries of the box represent the 25th and 75th percentiles, the whiskers represent the 10th and 90th percentile and the dots represent the 5th and 95th percentile.

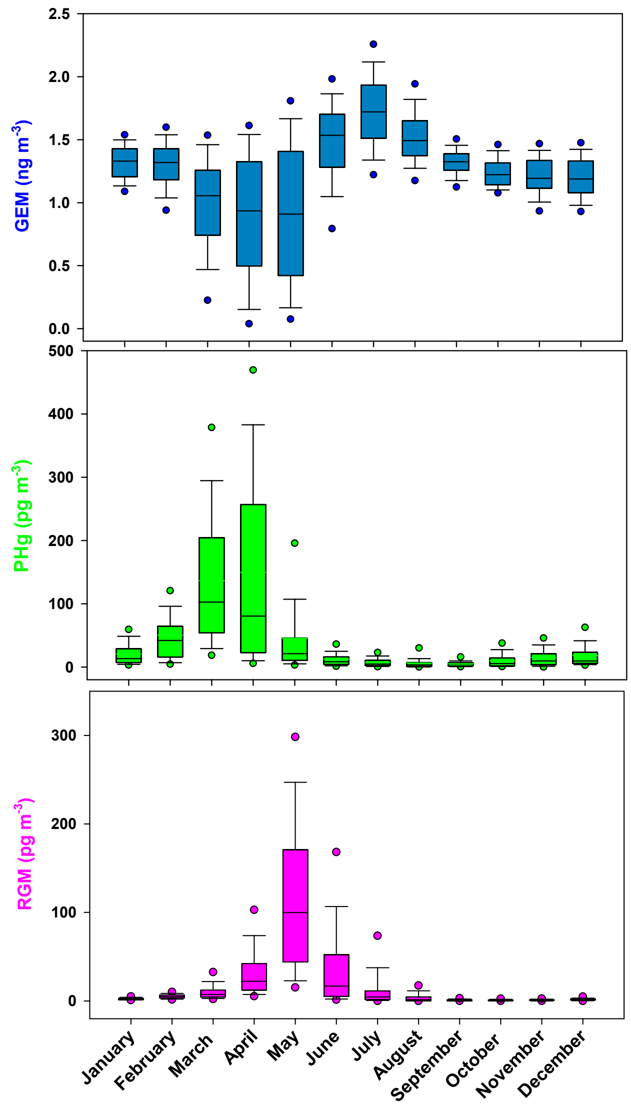


Fig. 2. Long-term snow sampling measurements at Alert from 1998 to 2011 sampled on an event basis. Samples are expressed as con-centration of mercury (pg g–1) and were collected from a Teflon® covered table (left) and from the top layer of the snow pack (right). The centre line in the box represents the median value, the boundaries of the box represent the 25th and 75th percentiles, the whiskers represent the 10th and 90th percentile and the dots represent the 5th and 95th percentile.

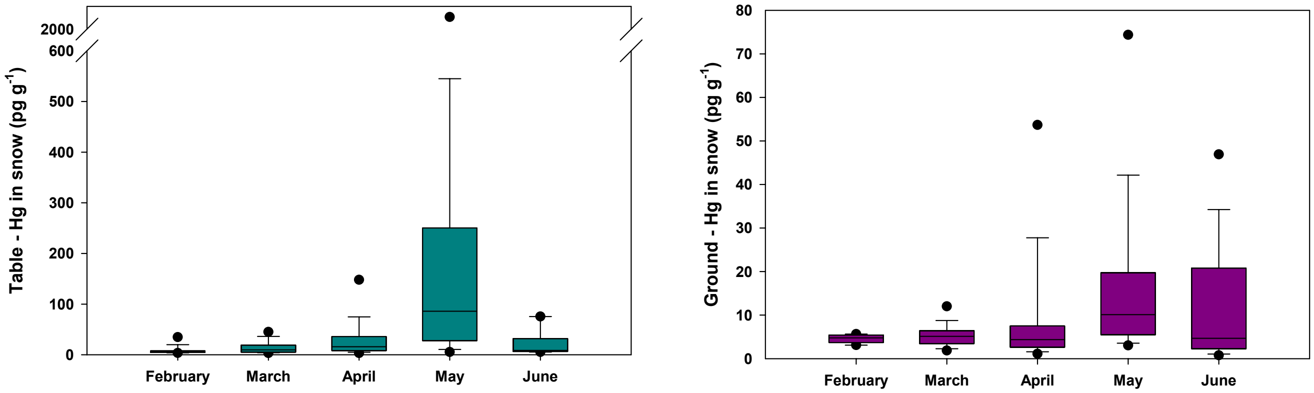
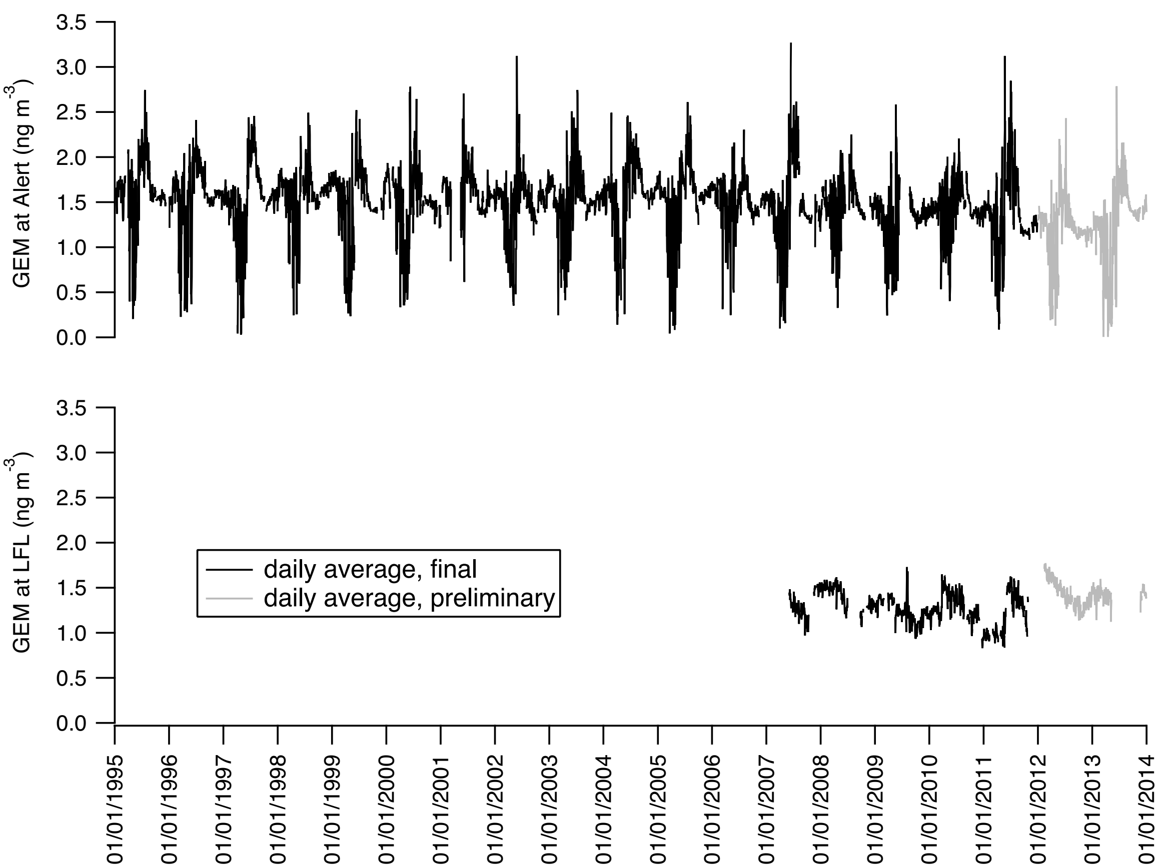


Fig. 3. Long-term record of gaseous elemental mercury (GEM) at Alert, NU (top) and Little Fox Lake, YK (bottom). Preliminary data in grey have undergone routine QC only.



Discussion and Conclusions

Atmospheric mercury processes were the focus of a paper published this year in Atmospheric Chemistry and Physics, which analyzed speciated mercury concentrations, mercury in surface snow, meteorological data and particle measurements at Alert (Steffen et al, 2014). The seasonal patterns in GEM, PHg and RGM concentrations, seen in Fig. 1, reveal the transition from PHg dominance to RGM dominance in the products of springtime GEM depletions. The relationships between Hg species and other air quality and meteorological parameters showed that low temperatures and the availability of particles (derived from sea salts and Arctic haze) are most likely responsible for how mercury is distributed in the air during spring. Further, when air chemistry and mercury levels in the snow were compared, the results revealed that the conditions in the atmosphere directly impact when the highest amount of mercury will be deposited to the snow. The highest concentrations of total Hg in snow, both in freshly fallen snow on the collection table and in the top layer of snow on the ground, were observed in May (Fig. 2), near or following the transition to RGM dominance. This interaction between the atmosphere and the snow is very important to understand so that we can predict when and under what conditions we will see the most mercury depositing to the Arctic region. This type of information was only available because we have long term measurements of both snow and air sampling. These data also provide crucial validation for models of mercury cycling in snow (*e.g.*Durnford et al., 2012; Toyota et al., 2014). Further investigations of the multi-year measurements of mercury in snow are planned for the coming years.

Monitoring at Alert and at Little Fox Lake (Fig. 3) continues to be important in order to assess global and regional changes in atmospheric mercury levels due to global emissions, transport to the Arctic, and atmospheric processes. For example, the long-term record of GEM at Alert has revealed a decline in this form of mercury in recent years (Cole and Steffen, 2010), though by less than the amount that GEM has declined in other Canadian locations (Cole et al., 2013). Measurements of RGM and PHg are more volatile and uncertain, but a preliminary analysis of the Alert data indicated that these species may have increased, not declined, over the period 2002-2009 (Cole et al., 2013). The implications of these competing trends for the deposition of mercury from the atmosphere to the Arctic environment are currently under investigation. Continued monitoring at Little Fox Lake, which is not subject to the same springtime depletion chemistry nor as affected by Arctic sea ice changes, will also help separate how much of the trend is due to these processes compared to how much is due to changes in global emissions and transport to the Arctic. The existing data also establish a baseline for GEM concentrations before the ratification of the Minamata Convention on Mercury.

Expected Project Completion Date

ongoing

Acknowledgements

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Passive Air Sampling Network for Organic Pollutants and Mercury

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

Project Leader:

Hayley Hung, Science and Technology Branch, Environment Canada, Toronto,
Tel: (416) 739-5944; Fax (416) 739-4281, E-mail: hayley.hung@ec.gc.ca

Alexandra Steffen, Environment Canada, Science and Technology Branch
Tel: (416) 739-4116, Fax: (416) 739-4318, Email: Alexandra.Steffen@ec.gc.ca

Project Team Members and their Affiliations:

Amanda Cole, and Tom Harner, Environment Canada; Pat Roach, Aboriginal Affairs and Northern Development Canada (Whitehorse); Organics Analysis Lab, Environment Canada;

Carl Mitchell, Frank Wania , and David McLagan, University of Toronto Scarborough; Chris Hawkins, Ernest Prokopchuk, Rick Steele, Stephen Mooney, Yukon College; Chris May, Mid Arctic Technology Services (Whitehorse)

Abstract

This new project aims to measure pollutants that can affect the health of Northerners, namely persistent organic pollutants (POPs) and mercury, in the air at multiple locations across Canada's North. These pollutants are carried through the air from more southerly regions to the Arctic. Expanding the number of locations where they are measured using low-cost, low-maintenance passive air samplers will provide more information about where they come from and how they are changing over time. Passive samplers are ideally suited to the Arctic environment and the simplicity of the method is also suitable for involving students or other interested persons in sample

Résumé

Ce nouveau projet vise à mesurer les polluants qui peuvent avoir un effet sur la santé des personnes vivant dans le Nord, c'est-à-dire les polluants organiques persistants (POP) et le mercure, dans l'air à divers emplacements dans le Nord canadien. Ces polluants sont transportés dans l'air à partir de régions au sud de l'Arctique. En accroissant le nombre de lieux où ces mesures sont effectuées, cela grâce à des échantillonneurs passifs de l'air peu coûteux et demandant peu d'entretien, on recueillera davantage de renseignements sur la provenance de ces substances et sur leur évolution au fil du temps. Les échantillonneurs passifs sont parfaitement adaptés à l'environnement

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. This year, the team initiated the community consultation process, aiming at deploying Passive Air Samplers for POPs at seven sites in 2014-2015. Information slides on the POPs Passive Air Samplers were sent to the Regional Contaminants Committees and potential sampling operators. The team also initiated the development of the mercury Passive Air Sampler composed of a small cylindrical container for activated carbon inserted into a diffusion tube of the commercial Radiello® type Passive Air Sampler. Project Principal Investigators visited Iqaluit (NU), Whitehorse (YK) and Nain (NL) to discuss with the respective Regional Contaminants Committees about the project plans and site selections. They also conducted communication/capacity building activities, including lectures at the Nunavut Arctic College, the Yukon College and the Jens Haven Memorial School in Nain.

arctique, et la simplicité de la méthode employée permet aussi de faire participer des étudiants et d'autres personnes intéressées à la collecte des échantillons, ce qui enrichit la communication entre l'équipe du projet et les collectivités locales, tout en créant des possibilités de formation pour les étudiants dans le Nord. Le projet s'échelonnera sur 3 à 4 ans, et permettra de compiler les concentrations atmosphériques de nombreux polluants au sein d'un réseau de sites disséminés dans le Nord. Ces données aideront les chercheurs à déterminer quelles voies les polluants empruntent pour se rendre en Arctique et, à plus long terme, à voir quel effet les changements touchant les sources et le paysage ont sur le déplacement du mercure et des POP dans l'air et sur leur pénétration dans le milieu arctique. Cette année, l'équipe a entamé le processus de consultation des collectivités, et elle prévoit installer des échantillonneurs passifs de l'air pour mesurer les POP à sept sites en 2014-2015. Des condensés d'information sur les échantillonneurs passifs de l'air destinés à mesurer les POP ont été envoyés aux comités régionaux des contaminants ainsi qu'aux personnes qui pourraient être responsables du prélèvement des échantillons. L'équipe a également entrepris de mettre au point un échantillonneur passif de l'air destiné à mesurer le mercure, composé d'un petit contenant cylindrique pour le charbon actif inséré dans un tube de diffusion de l'échantillonneur passif de l'air commercial de type RadielloMD. Les chefs du projet se sont rendus à Iqaluit (Nunavut), à Whitehorse (Yukon) et à Nain (Terre-Neuve-et-Labrador) afin de discuter avec les comités régionaux des contaminants respectifs des plans et du choix des sites pour le projet. Ils ont aussi tenu des activités axées sur la communication et le renforcement des capacités, dont des conférences au Collège arctique du Nunavut, au Collège du Yukon et à l'école Jens Haven Memorial, à Nain.

Key messages

- In 2013-2014, the project team focused on communication, consultation and capacity building, as well as initiating the development of a mercury passive air sampler:

Messages clés

- En 2013-2014, l'équipe du projet s'est concentrée sur la communication, les consultations et le renforcement des capacités, de même que sur l'élaboration d'un échantillonneur passif de l'air destiné à mesurer le mercure.

- Consulted with the Regional Contaminants Committees and community representatives on project plans and potential passive air sampling site locations.

- Project Principal Investigators visited Iqaluit (NU), Whitehorse (YK) and Nain (NL) to discuss with the respective Regional Contaminants Committees about the science activities and communication/outreach plans under this project. They also conducted communication/capacity building activities, including lectures at the Nunavut Arctic College, the Yukon College and the Jens Haven Memorial School in Nain.

- The team also initiated the development of the mercury PAS composed of a small cylindrical container for activated carbon inserted into a diffusion tube of the commercial Radiello® type PAS.

- Les comités régionaux des contaminants ainsi que les représentants des collectivités ont été consultés au sujet des plans et des possibles sites d'échantillonnage passif de l'air pour le projet.

- Les chefs du projet se sont rendus à Iqaluit (Nunavut), à Whitehorse (Yukon) et à Nain (Terre-Neuve-et-Labrador) pour discuter des activités scientifiques ainsi que des plans de communication et de sensibilisation liés au projet avec les comités régionaux des contaminants respectifs. Ils ont aussi tenu des activités axées sur la communication et le renforcement des capacités, dont des conférences au Collège arctique du Nunavut, au Collège du Yukon et à l'école Jens Haven Memorial, à Nain.

- L'équipe du projet a également entrepris de mettre au point un échantillonneur passif de l'air destiné à mesurer le mercure, composé d'un petit contenant cylindrique pour le charbon actif inséré dans un tube de diffusion de l'échantillonneur passif de l'air commercial de type RadielloMD.

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 7 new locations across all Arctic regions. Separate devices will be deployed for POPs and mercury.

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

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

4. Provide spatially-distributed concentration data for this undersampled 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. The current monitoring program is limited to continuous monitoring of mercury at Little Fox Lake, Yukon, and POPs and mercury at Alert (the longest running air monitoring station in the Arctic). 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, 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 seven 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.

The passive air samplers (PASs) will be sent to community representatives for installation and deployment. Some of these representatives may be teachers who can then demonstrate their deployment to the students while introducing the concept of contaminants in the north. The samples will be sent back to Environment Canada where they will be analyzed for priority chemicals. Results for legacy chemicals, *e.g.* polychlorinated biphenyls (PCBs), organochlorines (OCs), and some 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 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. Results for these new chemicals will also be sent back to the communities in a follow-up report.

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. Laboratory and field testing of the prototype is planned for FY2014/15.

Activities in 2013-2014

Mercury Passive Air Sampler (PAS) Development

With funding for a student at the University of Toronto, the team initiated the development of the mercury PAS composed of a small cylindrical container for activated carbon inserted into a diffusion tube of the commercial Radiello® type PAS. Initial laboratory uptake studies have been conducted with different types of activated carbon to determine the mercury uptake capability and sampling rates over time. Controlled laboratory and field testing will continue in 2014-2015.

Capacity Building, Communications, and Traditional Knowledge Integration

Consultation information was sent to all 5 RCCs in the beginning of the project which included a brief project summary and consultation plan, as well as the original proposal submitted to NCP. The team discussed the project plans and potential site selection with the RCCs and community members either over the phone, through emails or in person (timing and consultation methods given as follows in brackets):

a. Nunavut Environmental Contaminants Committee (NECC) (email communications and Feb 12, 2014 in person in Iqaluit; consultation with Jamesee Moulton, Nunavut's Department of Environment, over the phone on Mar 13, 2014);

b. NWT Regional Contaminants Committee (email communications and over the phone on Oct 25, 2013 and Mar 26, 2014);

c. Nunavik Regional Contaminants Committee (email communications and phone call on Dec 19, 2013 with Michael Barrett, Associate Director, Renewable Resources, Environment, Lands and Parks, Kuujjuaq, upon referral from the Nunavik Regional Contaminants Committee);

d. Nunasiavut Health and Environment Research Committee (email communications and Feb 4-6, 2014 in person in Nain); and

e. Yukon Regional Contaminants Committee (email communications and Mar 4, 2014 in person in Whitehorse).

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.). Future plans for communication and consultation with the specific communities were also discussed.

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

Supported with funding from Environment Canada, Hayley Hung visited Cambridge Bay (NU) on Aug 13 to scout for a suitable location for a remote atmospheric laboratory associated with the Canadian High Arctic Research Station (CHARS). During her visit, she consulted with Donald McLennan (Head - Monitoring Science, CHARS) about the possibility of deploying a POPs PAS at Cambridge Bay in 2014-15.

Project Principal Investigators Hayley Hung and Alexandra Steffen visited Iqaluit in Feb 10-12, 2014 and conducted a student lecture and a hands-on laboratory session [together with Liisa Jantunen (EC)] at the Nunavut Arctic College. In November 2013, Sandy Steffen and Amanda Cole conducted an information session with the Ta'an Kwach'an Council (TKC) during a site visit to Little Fox Lake and Hayley met with the TKC in March 2014 when she visited Whitehorse. Hayley also gave a seminar to the Jens Haven Memorial School in Nain about air monitoring of POPs and mercury on Feb 5, 2014, as well as a seminar at the Yukon College in Whitehorse on Mar 4, 2014.

Under other NCP-funded projects, 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. This effort will assist us in incorporating TK in the current project.

Results

Mercury Passive Air Sampler (PAS) Development

With the objective of producing an inexpensive and simple, yet precise and accurate PAS for gaseous elemental mercury (GEM), a prototype of this GEM-PAS has been developed which consists of a mesh cylinder filled with activated carbon sorbent inside a white Radiello® diffusive body (Figure 1). Uptake of GEM to the sorbent occurs via radial molecular diffusion. The activated carbon is analysed for elemental mercury after deployment either by acid digestion followed by cold-vapour atomic fluorescence spectroscopy (CVAFS) or cold-vapour atomic absorption spectroscopy (CVAAS), or by thermal decomposition, amalgamation, and CVAAS. Both techniques have shown sufficient sensitivity to effectively measure the low levels of elemental mercury found at remote sites distant from any point sources of GEM (~1-2 ng of mercury per m3 of air sampled).

Figure 1. Mercury PAS Prototype - activated-carbon sorbent filled mesh cylinder inside a white Radiello® diffusive body.

Initial indoor uptake experiments were conducted with two selected activated carbons (HGR and F400; Calgon Carbon Corporation). Blank testing has shown that the quantity of residual mercury on these sorbents was acceptable for ambient sampling. Uptake curves were developed in an initial indoor calibration experiment of the GEM-PAS prototype and demonstrated linear uptake over the 3 month experimental period for the HGR activated carbon.

If an application to Environment Canada's Grants and Contribution funding in 2014-2015 is successful, the prototype will be further tested under controlled conditions within the laboratory and outdoors to determine the uptake kinetics and capacity under various ambient conditions (including varying temperatures, humidity and wind speed).

Passive Air Sampling (PAS) Sites

After consultation with the 5 RCCs and community members, 7 PAS sites were proposed (Figure 2). If funding application for FY2014/15, POPs PASs will be deployed at these locations beginning October 2014 in sync with the GAPS program's deployment schedule.

Figure 2. Proposed PAS site map. Alert and Little Fox Lake are NCP long-term air monitoring sites. Currently, there are 3 GAPS sites in the Canadian Arctic, Coral Harbour, Alert and Little Fox Lake where POPs PASs are used.

Discussion and Conclusions

In 2013-2014, the team focused on consultation and communication with the RCCs and the communities to determine suitable passive air sampling sites and to identify community members who are willing to assist with sampler deployment.

Initial laboratory testing of the GEM-PAS prototype showed positive results indicating feasibility of the sampler design. Further laboratory and field testing is required to determine its suitability for GEM monitoring in the remote Arctic over extended periods of time and for GEM source identification and characterization.

Expected Project Completion Date

Ongoing project

Acknowledgments

The team would like to acknowledge NCP for funding. The continued support of the five RCCs, northern community members and associations of the passive air sampling initiative is greatly appreciated.

Temporal Trends of Persistent Organic Pollutants and Metals in Ringed Seals from the Canadian Arctic

Tendances temporelles relatives aux polluants organiques persistants et aux métaux chez les phoques annelés de l'Arctique canadien

- **Project Leader:**
  Derek Muir, Environment Canada, Aquatic Contaminants Research Division
  Tel: (905) 319-6921, Fax: (905) 336-6430, Email: derek.muir@ec.gc.ca

  Xiaowa Wang, Environment Canada, Aquatic Contaminants Research Division
  Tel: (905) 336-4757, Fax: (905) 336-6430, Email: xiaowa.wang@ec.gc.ca

- **Project Team Members and their Affiliations:**
  Qausuittuq (Resolute Bay) Hunters and Trappers; Sachs Harbour Hunters and Trappers; Arviat Hunters and Trappers; Jeff Kuptana, Sachs Harbour NT; Frank Nutarasungnik, Arviat NU;

  Tom Sheldon, Rodd Liang, and Katie Winters, Environment Division, Nunatsiavut Government; Steve Ferguson and Brent Young, Fisheries and Oceans Canada; Aaron Fisk and Dave Yurkowski, University of Windsor; Ed Sverko and Enzo Barresi, Environment Canada, NLET Organics; Bert Francoeur and Jacques Carrier, NLET Inorganics; Mary Williamson and Amy Sett, Environment Canada, Aquatic Ecosystem Protection Research Division; Ron McLeod and Whitney Davis, ALSGlobal

Abstract

The objective of this project is to determine changes in concentrations of legacy contaminants, such as Polychlorinated Biphenyls (PCBs) and other 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 2013, samples were collected by local hunters in the communities of Nain, Resolute and Sachs Harbour. Chemical measurements were combined with results from previous years, including samples archived from the 1970s to

Résumé

L'objectif de ce projet est de caractériser les variations des concentrations de contaminants hérités du passé, comme les polychlorobiphényles (PCB) et d'autres polluants organiques persistants (POP), ainsi que de mercure chez les phoques annelés. Le prélèvement des échantillons est entièrement fait avec l'aide des comités de chasseurs et de trappeurs de chaque collectivité ayant reçu des trousses d'échantillonnage et des instructions connexes. En 2013, des échantillons ont été recueillis pas les chasseurs des collectivités de Nain, de Resolute et de Sachs Harbour.

examine the trends over time and geographical differences. Average mercury concentrations in seal muscle have declined at Arviat, Resolute and Sachs Harbour since the mid-2000s but have remained at about the same level at Nain. Legacy POPs in seal blubber generally declined but the extent varied among locations. The most rapid declines for most legacy POPs were found in Hudson Bay and slowest at Sachs Harbour. Fluorinated chemicals also declined in seals from Arviat and Resolute but continued to increase slowly at Sachs Harbour.

Les mesures des produits chimiques ont été combinées avec les résultats obtenus d'années précédentes, y compris les résultats d'analyse d'échantillons archivés prélevés dans les années 1970, cela fin d'examiner les tendances temporelles et les différences géographiques. Les concentrations moyennes de mercure dans les muscles des phoques ont diminué à Arviat, à Resolute et à Sachs Harbour depuis le milieu des années 2000, mais elles sont demeurées à peu près constantes à Nain. Les concentrations de POP hérités du passé dans le petit lard de phoque ont en général décliné, mais à des degrés divers selon le lieu. Pour la plupart des POP hérités du passé, les baisses les plus rapides ont été enregistrées dans la baie d'Hudson, et les plus lentes, à Sachs Harbour. Les concentrations de composés fluorés ont également diminué chez les phoques d'Arviat et de Resolute, mais elles ont continué à augmenter lentement à Sachs Harbour.

Key project messages

- Mercury in seal muscle has declined in three of the four sampling regions since the mid 2000s.
- Fluorinated chemicals declined in seals from Arviat and Resolute but continued to increase slowly at Sachs Harbour.

Messages clés du projet

- Les concentrations de mercure dans les muscles des phoques ont décliné à trois des quatre régions d'échantillonnage depuis le milieu des années 2000.
- Les concentrations de composés fluorés ont connu une baisse chez les phoques d'Arviat et de Resolute, mais elles ont continué à augmenter lentement à Sachs Harbour.

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 using annual collections at 3 communities using 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 Territorial contaminants committees.

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. 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. The project now has a very large database consisting of results for about 680 samples for PCBs and organochlorine pesticides (OCPs) and about 700 samples for mercury in muscle. Biological data including age and carbon and nitrogen stable isotope data are available for about 550 individual seals collected in the past 10 years.

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 2012-13 report focused on trends of mercury and cadmium and trends in selected POPs to 2011. In this report we summarize trends, expressed as % change per year, in mercury and polyfluorinated substances (PFASs) to 2013 and for "legacy POPs" to 2012.

Activities in 2013-14

Sample collection: In 2013 ringed seal samples were successfully collected by hunters in the communities of Sachs Harbour (25), Resolute Bay (N=20) and Nain (10). Unfortunately collections at Arviat were not carried out for the first time in 10 years. The community prefers a fall hunt but early freeze-up in October made it dangerous to hunt at that time and the sampling was called off. Collections at the other communities 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. Samples were stored at -20oC and then shipped frozen to Burlington for processing. Large subsamples of all tissues were archived in walk-in freezers at -20 oC in sealed plastic bags (double bagged).

In 2013 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.

Short reports (in English and Inuktitut) on the results of the study to date were faxed to the Hunters and Trappers committee offices of each community in April 2013 for the communication and consultations in 2013.

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 2012 and 2013 samples was contracted to ALSGlobal (Burlington ON). Results for 2013 are pending. Extraction and cleanup procedures followed the same general procedure 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. The suite of OCPs and PCBs analysed was identical previous suite analysed by the National Laboratory for Environmental Testing (NLET) organics lab.

PCNs were also determined by ALS Global by GC-HRMS on the same extracts. The raw DCM extract was cleaned with acid/silica followed by alumina column chromatography. The cleaned extracts were concentrated to small volume (40uL in toluene) prior to the addition of a 5uL solution of 13C- labeled PCN extraction standards. These final extracts were analyzed by GC-HRMS for 68 of the 75 possible PCN congeners. PBDEs and other BFRs as well as toxaphene and endosulfan isomers were analysed on the remaining extract using GC-negative ion LRMS by the NLET organics lab.

Total mercury in muscle was determined by Direct Mercury Analyser using EPA method 7473 (US Environmental Protection Agency 2007). 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).

Thirty-two elements were determined in liver by Inductively Coupled Plasma- Mass spectrometry (ICP-MS) (NLET 2002). In brief, liver (1 g) was digested with nitric acid and hydrogen peroxide (8:1) in a high pressure microwave oven at 200 °C for 15 minutes. The digest was then analysed directly by ICP-MS. Mercury was analyzed from the same digest by using cold vapor atomic absorption spectrometry. Mercury II was reduced to elemental mercury in an automated continuous flow system by using stannous chloride.

Quality assurance and statistical analysis: Both NLET labs and ALSGlobal are certified by certified by Canadian Standards Association and have participated in the NCP Interlab comparisons. During 2013, ALSGlobal Laboratory Group, Environmental Division in Burlington participated successfully in Phase 7 of the NCP QA program (Tkatcheva et al. 2013).

PFASs were determined in the Muir lab at Environment Canada Burlington and this lab participated in the NCP Interlab comparison. The Muir lab also participated in the NCP interlab comparison for mercury for 2013-14.

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. 2008; 2009; 2010; 2011).

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).

Results and Discussion

Sample collection and hunter observations: In 2013 the requested information on gender, girth, length, blubber thickness was provided for all 43 harvested animals. The identification of the gender of the seals by hunters in the field was in agreement with results for DNA markers in 39 out of 43 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 and Resolute from the mid-2000s. At Resolute the decline (10 years; 2004-2013) is 10 %/yr (significant at P=0.029) and at Arviat (9 years; 2003-2012) it is 8.9 %/yr (P=0.019). A declining trend was also observed at Sachs Harbour (2005-2013) (-5.2%/yr; 7 years of data) although this was not statistically significant. No change is evident at Nain but again fewer sampling years were available.

Trends of Legacy POPs: Measurement of all organic contaminants continued in 2013-14 but results for PCBs and other chlorinated organics including organochlorine pesticides, toxaphene, endosulfan, chlorinated paraffins and PCNs in samples collected in 2013 are pending. Temporal trends of legacy POPs were calculated to 2012 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 1). For PCBs we used the sum of 10 major congeners (Σ10PCB) for compatibility with results from the 1970s and 80s. Overall, there are declining trends of POPs in ringed seals with the relative magnitude of ΣDDT (-2.5 to -7.1 %/yr) > α-HCH (-2.2 to 9.1%/yr) > Σ10PCB (-0.4 to -5.7 %/yr). Declines were most rapid in Hudson Bay animals and least in the Beaufort Sea samples (Table 1). 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 2012.

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 (+9.8 %/yr) and in Lancaster Sound (9.9 %/yr) but are declining in Hudson Bay (-7.3\4% from 2002 to 2012, although the trend is not statistically significant (Table 1).

PFOS concentrations continue to decline in seals from Lancaster Sound and Hudson Bay over the period 2002/03 to 2013 (Table 1) after previous rapid increases (Butt et al. 2007). ΣPFCAs (sum of perfluorononanoic acid to perfluorotridecanoic acids) are also declining in Lancaster Sound (-7.6 %/yr) and in Hudson Bay (-7.0 %/yr) although trends are not statistically significant) (Table 1). In the southern Beaufort Sea samples both PFOS and ΣPFCAs continue to increase (3.3 and 4.0 %/yr, respectively) although at slower rates than found in the 1990s-early 00s in Lancaster Sound and Hudson Bay.

Short chain chlorinated paraffins (SCCPs) were determined in selected samples from 2011 using GC-HRMS (negative chemical ionization) on a Thermo DFS instrument. Unfortunately relatively high levels were also found in blanks although with a different pattern of chlorinated alkane chain lengths. Further analysis of that data is ongoing and additional samples from 2012 which have lower blanks due to being extracted in ALSGlobal's lab are being analysed.

Figure 1. Time trends (1972-2013) of PFOS and total PFCAs in seal liver from Beaufort Sea (Sachs Harbour, Ulukhaktok), Lancaster Sound (Resolute, Arctic Bay), and Hudson Bay (Arviat, Inukjuaq). Symbols represent geometric mean concentrations and error bars are 95% confidence limits.

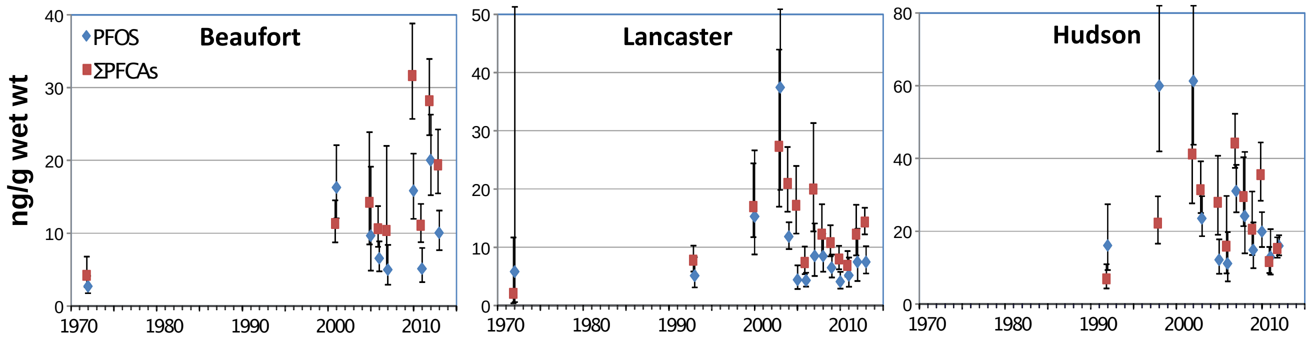

Table 1. Time trends of POPs in female ringed seals – statistically significant % annual change in bold

Region[1]	yrs	% per year	α-HCH	β-HCH	HCB	Σ10PCB	ΣDDT	ΣCHL	Toxaphene	ΣPBDE (06-12)	PFOS (02-13)	ΣPFCAs (02-13)
Hudson Bay	14	% decl or inc	**-9.1**	-3.6	-2.0	**-5.7**	**-7.1**	**-7.1**	-6.1	-7.3	-7.6[2]	-7.02
1986-2012		R^2	0.79	0.16	0.25	0.62	0.72	0.65	0.64	0.18	0.26	0.23
Lancaster	18	% decl or inc	**-4.1**	**4.5**	-0.49	**-2.3**	**-2.9**	**-0.97**	0.30	9.9	-8.6	-7.6
1986- 2011		R^2	0.84	0.05	0.26	0.53	0.57	0.45	0.55	0.32	0.22	0.31
Beaufort Sea	9	% decl or inc	**-2.2**	**5.1**	-0.62	-0.42	**-2.5**	-0.37	-2.5	**9.8**	3.3[3]	**4.0**[3]
1972-2012		R^2	0.37	0.83	0.21	0.04	0.39	0.01	0.19	0.91	0.40	0.68

[1] Hudson Bay = Arviat + Inukjuaq; Lancaster = Resolute Bay + Arctic Bay + Grise Fiord; Beaufort Sea = Sachs Harbour + Ulukhaktok (2001, 2006, 2010)

[2] Arviat: PFOS and PFCAs for the period 2002 to 2012

[3] Beaufort Sea: PFOS and PFCAs for the period 1972 to 2013

Discussion and Conclusions

This study has provided new information on the temporal trends of mercury in ringed seal muscle suggesting for the first time that concentrations have declined in all three sampling regions since the mid-2000s. However, no significant decline has been observed so far in seal livers due to the more variable (year to year and among animals) concentrations. Concentrations in liver are of special interest due to the recent advisory based on the Inuit Health Survey (Nunatsiaq online 2012).

The differences in trends for newer POPs as well as for legacy POPs between the Beaufort Sea, Hudson Bay and Lancaster Sound areas continue to raise questions about sources and transport of these contaminants. Differences between the Beaufort Sea and the Hudson Bay animals are particularly striking as illustrated by declining β-HCH, PBDEs and PFOS in Hudson Bay and increases in the Beaufort animals. The lack of the declines, decades after initial phase outs of these products, and despite the relatively large numbers of sampling years now available, suggests continued inputs.

Acknowledgments

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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 relatives aux contaminants organiques, élémentaires et métalliques hérités du passé ou d'apparition récente chez les ours blancs au Canada

- **Project Leader:**
  Robert Letcher, Environment Canada, Organic Contaminant Research Laboratory (OCRL), National Wildlife Research Centre, Carleton University, Tel: (613) 998-6696, Fax: (613) 998-0458
  Email: robert.letcher@ec.gc.ca
- **Project Team Members and their Affiliations:**
  M. Dyck, P. Frame, M. Harte, and A. Coxon, Nunavut Department of Environment (Igloolik); J. Savikataaq and J. Savikataaq Jr. (Arviat); J. Coutu-Autut and D. Kaludjak (Rankin Inlet); E. Amarook (Whale Cove); S. Levesque (Sanikiluaq); D. Blair, L.T. Gauthier, S.G. Chu, A. Idrissi, G. Savard, E. Neubauger, F. Maisonneuve, and E. Sverko, Environment Canada; E. Reiner and L. Shen, Ontario Ministry of the Environment, Laboratory Services Branch; E. Kruemmel, Inuit Circumpolar Council-Canada

Abstract

The polar bear (Ursus maritimus) is the apex predator of the arctic marine ecosystem and food web. Legacy and emerging contaminants were monitored, as well as new target persistent organic pollutants (POPs) discovered, in the liver or fat of polar bears collected in 2013 from the two territorial management zones in southern and western Hudson Bay in Nunavut. As of 2013, for western Hudson Bay bears, generally the levels for SPCBs[1], SDDTs[2], *SCHLs*[3],

Résumé

L'ours blanc (Ursus maritimus) est le prédateur qui occupe le sommet de la chaîne alimentaire au sein de l'écosystème marin arctique. On a surveillé les concentrations de contaminants hérités du passé et d'apparition récente, ainsi que les nouveaux polluants organiques persistants (POP) ciblés découverts dans le foie ou la graisse d'ours blancs échantillonnés en 2013 dans les deux zones de gestion territoriales du sud et de l'ouest de la baie d'Hudson, au Nunavut. En 2013, chez les ours blancs de l'ouest de la baie d'Hudson, les concentrations de

1 Polychlorinated biphenyls
2 Dichlorodiphenyltrichloroethane
3 Chlordanes

a-HCH[4], b-HCH[5] and SClBzs[6] are similar to those in samples going back to 2001. Since 2001 to 2013, SPCBs and SCHLs have been consistently at high levels ranging from 2,000 to 9,000 $ng \cdot g^{-1}$ lw. S4PBDE[7] levels appear to be unchanged in bears from southern (2007-2008 to 2013 period) and western (2001-2002 to 2013 period) Hudson Bay bears. Unlike previous years, BDE-209 was quantifiable in the fat of southern (1.9 to 29 $ng \cdot g^{-1}$ lw) and western (1.6 to 20 $ng \cdot g^{-1}$ lw) Hudson Bay bears, and accounted for as high as 10% of the total SPBDE concentration. For both subpopulations, compared to previous years, in 2013 the THg[8] concentrations appeared to be increasing in liver. Of 24 SCCPs[9] in 2012-collected Hudson Bay polar bear fat samples, n=17 were quantifiable with a mean SSCCP concentration of 493 ± 343 $pg \cdot g^{-1}$ lw. HCBD[10], ɑendosulfan, ɑendosulfan and endosulfan sulfate were not detectable in fat samples from any 2013 Hudson Bay bears. We conclude that as of 2013, international regulations are showing some effectiveness as legacy and emerged (i.e. PBDE) POPs are generally not increasing in polar bears from Hudson Bay, relative to historical levels. However, more recent and unregulated POPs such as BDE-209 and SCCPs are present and may be on the rise.

4 Alpha- hexachlorocyclohexane
5 Beta- hexachlorocyclohexane
6 Chlorobenzenes
7 Polybrominated diphenyl ether
8 Total mercury
9 Short-chain chlorinated paraffins
10 Hexabromocyclododecane

SPCB[1], de SDDT[2], de SCHL[3], de a-HCH[4], de b-HCH[5] et de SClBz[6] étaient en général similaires à celles mesurées dans les échantillons datant de 2001. Depuis 2001 et jusqu'en 2013, les concentrations de SPCB et de SCHL sont demeurées invariablement élevées, à des valeurs de 2 000 à 9 000 $ng \cdot g^{-1}$ lipides. Les concentrations de S4PBDE[7] semblent être restées stables chez les ours du sud (période de 2007-2008 à 2013) et de l'ouest (période de 2001-2002 à 2013) de la baie d'Hudson. Contrairement aux années précédentes, le BDE-209 était quantifiable dans la graisse des ours du sud (1,9 à 29 $ng \cdot g^{-1}$ lipides) et de l'ouest (1,6 à 20 $ng \cdot g^{-1}$ lipides) de la baie d'Hudson, et représentait jusqu'à 10 % de la concentration totale de SPBDE. Chez les deux sous-populations, comparativement aux années antérieures, en 2013, les concentrations de mercure total semblaient être en croissance dans le foie. Sur les 24 PCCC[8] présentes dans les échantillons de graisse d'ours blancs de la baie d'Hudson prélevés en 2012, 17 étaient quantifiables, et la concentration moyenne de SPCCC était de 493 ± 343$pg \cdot g^{-1}$ lipides. On n'a détecté d'HCBD[9], d'α-endosulfan, de β-endosulfan et de sulfate d'endosulfan dans aucun des échantillons de graisse prélevés chez des ours blancs de la baie d'Hudson en 2013. En 2013, on a donc observé que la réglementation internationale a une certaine efficacité puisque les concentrations de POP hérités du passé et connus (c'estàdire les PBDE) n'augmentent pas, en général, chez les ours blancs de la baie d'Hudson, par rapport à leurs concentrations antérieures. Cependant, les POP plus récents qui ne sont pas encore réglementés, comme le BDE-209 et les PCCC, sont présents et pourraient être en hausse.

1 polychlorobiphényles
2 dichlorodiphényltrichloroéthane
3 chlordanes
4 alpha-hexachlorocyclohexane
5 bêta- Hexachlorocyclohexane
6 chlorobenzènes
7 polybromodiphényléther
8 paraffines chlorées à chaîne courte
9 hexabromocyclododécane

Key messages

- *A*s of 2013, 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 parts-per-million levels.
- Based on time-point comparisons, S4PBDE levels appear to be unchanged in bears from southern (2007-2008 to 2013 period) and western (2001-2002 to 2013 period) Hudson Bay bears, although the southern subpopulation maintained consistently higher S4PBDE levels than the western subpopulation.
- Unlike 2011 and 2012, BDE-209 was quantifiable in the fat of southern (1.9 to 29 ng·g^{-1} lw) and western (1.6 to 20 ng·g^{-1} lw) Hudson Bay bears, and accounted for most of the remaining 10% of the total SPBDE concentration.
- For both subpopulations, compared to previous years, in 2013 the THg concentrations appeared to be increasing in liver.
- Of 24 SCCPs in 2012-collected Hudson Bay polar bear fat samples, n=17 were quantifiable with a mean SSCCP concentration of 493 ± 343 pg·g^{-1} lw.
- HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate were not detectable in fat samples from any Hudson Bay bear harvested in 2013.

Messages clés

- En 2013, chez les ours blancs de la baie d’Hudson, les concentrations de SPCB, de SDDT, de SCHL, de a-HCH, de b-HCH et de SClBz étaient en général similaires à celles mesurées dans les échantillons datant de 2001. Les concentrations de SPCB et de SCHL sont demeurées invariablement élevées, en parties par million.
- D’après la comparaison des valeurs enregistrées à divers moments, les concentrations de S4PBDE semblent être restées stables chez les ours du sud (période de 2007-2008 à 2013) et de l’ouest (période de 2001-2002 à 2013) de la baie d’Hudson; par contre, les concentrations de S4PBDE ont toujours été plus grandes dans la population du sud que dans la population de l’ouest.
- Alors que ce n’était pas le cas en 2011 et en 2012, le BDE-209 était quantifiable dans la graisse des ours du sud (1,9 à 29 ng·g^{-1} lipides) et de l’ouest (1,6 à 20 ng·g^{-1} lipides) de la baie d’Hudson, et représentait jusqu’à 10 % de la concentration totale de SPBDE.
- Chez les deux sous-populations, comparativement aux années antérieures, en 2013, les concentrations de mercure total semblaient être en croissance dans le foie.
- Sur les 24 PCCC présentes dans les échantillons de graisse d’ours blancs de la baie d’Hudson prélevés en 2012, 17 étaient quantifiables, et la concentration moyenne de SPCCC était de 493 ± 343 pg·g^{-1} lipides.
- On n’a détecté d’HCBD, d’α-endosulfan, de β-endosulfan et de sulfate d’endosulfan dans aucun des échantillons de graisse prélevés chez des ours blancs de la baie d’Hudson en 2013.

Objectives

1. To determine the spatial and ongoing inter-year temporal trends of legacy and emerging POPs (*e.g.*, flame retardants (FRs) and perfluoroalkyl substances (PFASs)) and degradation products, precursors and/or isomers, and metals/elements (*e.g.*, Hg) in polar bears using the appropriate tissues collected in communities within the western and southern Hudson Bay management zones in the Canadian Arctic, using appropriate tissues (fat or liver).
2. To use carbon and nitrogen SIs and FAs as ecological tracers of trophic levels and diet, and determined in polar bear tissues (muscle or fat) to examine the influence of diet and trophic level as confounding factors on POP spatial and temporal trends, in addition other influential factors such as sex, age, time of collection, and lipid content.
3. To screen and determine new and emerging, chlorinated, brominated and/or fluorinated POPs that may bioaccumulate in polar bears. Such POPs may persist in the tissues of polar bears but are not necessarily listed as a NCP, LRTAP or Stockholm Convention priority POP. New POPs may also include congeners, isomers and/or precursors and degradation products.

Introduction

Hg and a growing array of chlorinated, brominated and fluorinated POPs are anthropogenic contaminants that have been transported to the (Canadian) Arctic and accumulate in biota (CACAR III 2013a; CACAR III 2013b; 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 are biomagnified with increasing trophic level in the Arctic marine food web. As a result, 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 (Letcher et al. 2010, 2013, 2014; Greaves et al. 2012, 2013; Greaves and Letcher 2013; McKinney al. 2011a; Routti et al. 2011, 2012).

Based on samples collected up to the early to mid-2000s, several investigations and assessments compiled temporal and spatial data on levels of legacy organochlorine compounds in polar bears. Whereas levels of some legacy POPs such as PCBs seem to decrease (Verreault et al. 2005), a number of emerged environmental pollutants, such as PBDEs and 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; Greaves and Letcher 2013; Letcher et al. 2010). Temporal trends up the mid-2000s had predicted that tissue concentrations of *e.g.* PBDE and PFOS would continue to rise into future years (CACAR III 2013a). 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 III 2013a). These POPs include BDE-209, short-chained chlorinated paraffins (SCCPs), polychlorinated naphthalenes (PCNs), hexachlorobutadiene (HCBD), a- and b-endosulfan, endosulfan sulfate, and pentachlorophenol (PCP; and transformation product pentachloroanisole (PCA)).

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. 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. These results 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) (CACAR III 2013a; Dietz et al. 2014, 2013a, 2013b; McKinney et al. 2010, 2011b, 2013).

Based on fat samples collected over the period of 1991-2007, we showed that sea-ice, dietary changes and OHC contaminant patterns changes linkages for legacy OCs and newer PBDE POPs in polar bear from the western Hudson Bay subpopulation. In McKinney et al. (2010), we reported on changes in feeding ecology (1991-2007) in polar bears from the western Hudson Bay subpopulation that have resulted in increases in the tissue concentrations of several chlorinated and brominated contaminants. Differences in timing of the annual sea ice breakup explained a significant proportion of the diet variation among years. As expected from climate change predictions, this diet change was consistent with an increase in the consumed proportions of open water-associated seal species compared to ice-associated seal species in years of earlier sea ice breakup.

From 2007 and up to the present 2013-2014 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 2013-2014

Sample collections:

In addition to having a valid 2012 Nunavut Wildlife Research Permit (NWRP), in late 2012, we successfully applied for and obtained a 2013 Nunavut Wildlife Research Permit (NWRP) for polar bear sample collections during the harvests in western and southern Hudson Bay. The 2012 and 2013 NWRPs were evaluated in collaboration with communities via the Nunavut Department of Environment (NDE; Markus Dyck, Angela Coxon and Paul Frame). As per the valid and approved 2012 and 2013 NWRPs, community hunters and COs collected polar bear fat, liver and/or muscle sample sets during harvests spanning very late 2012/early 2013 (collectively called 2013 samples), from n=24 western Hudson Bay bears with n=11 from Arviat (8 adult, 1 subadult and 1 COY males; 1 subadult female), n=7 from Rankin Inlet (3 adult and 1 subadult males; 2 adult and 1 COY females) and n=6 from Whale Cove (1 adult, 1 subadult and 1 COY males; 1 adult and 2 COY females), as well as n=24 bears from Sanikiluaq in southern Hudson Bay (15 adult and 6 subadult males; 1 adult and 2 subadult females). Also, opportunistically collected where fat, liver and/or muscle sample sets from a total of n=28 bears from northern Baffin Island/Bay (Clyde River (n=8) and Pond Inlet (n=20)) during the same 2013 collection period, which have now been archived in EC's National Wildlife Specimen Bank (EC-NWSB) at NWRC (Ottawa) for future considerations. All of these samples had been collected by local hunters in participating communities via interaction with local HTOs and COs. All samples were sent from the communities to NDE offices in Igloolik where they were documented and processed. All sample sets and these bears were ready to ship to NWRC in very late 2013, and were received with all available documentation on November 12,

2013. All polar bear samples received by NWRC were processed, and for the Hudson Bay bear samples portions were taken for POP, metal/element, FA and SI analysis. Remaining sample portions are currently stored and archived in the EC-NWSB at NWRC.

Contaminant and other analyses:

From the 2013-collected sample sets received, all the adults and sub-adults were prioritized and chosen for the various analyses, so that at least n=10 (allowable as per 2013-2014 NCP funding) adult and if necessary subadult bears were included to represent each of the two subpopulations. That is, samples were analyzed for n=12 western Hudson Bay adults/subadults (Arviat (n=8 males), Rankin Inlet (1 adult male and 1 adult female) and Whale Cove (n=1 adult male and n=1 adult female) and all available n=23 bears (16 adults and 7 subadults) from southern Hudson Bay (Sanikiluaq, 3 females and 20 males). All POP and elemental analyses commenced only in late February 2014 in the OCRL and Lab Services, respectively, at NWRC. Regardless, 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-HBCD, as well as all PCB congener (74 congeners) and 25 organochlorine (pesticides) including HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate. The OCRL at NWRC recently acquired and installed a new Waters Xevo TQ-S LC-MS/MS over the course of April to June 2014. For the total of n=35 Hudson Bay (liver or fat) samples, OPFR, PCP, PCA and PFAS analysis will be completed by September 2014. The analysis of DP-like, norbornene derivatives (via the Reiner lab at the Ontario Ministry of the Environment (OMOE) in Toronto), and SCCPs by Dr. Sverko's lab at EC's NLET in Burlington, ON, will be completed within 2014. 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).

Age determinations for all harvested bears in 2013-2014 (as well as for the backlog of teeth collected from previous years harvests), will be determined in 2014 via NDE in Igloolik, but contracted out to the Matson's Laboratories (Matson's Laboratory LLC, 8140 Flagler Road Missoula MT 59802, U.S.A.; http://www.matsonslab/com). The same is true for SI determination of nitrogen and carbon in muscle samples, where the 2012/2013 (as well as for 2013/2014 and the backlog of samples from previous years harvests) are being determined by the Fisk Trophic Indicators Lab at the GLIER, University of Windsor. All FA analyses on fat samples from the n=35 bears were recently completed by the Lab Services section at NWRC for a suite of FAs (i.e., a suite of 37 saturated and polyunsaturated, C6-C24 fatty acids).

Capacity building:

Starting in 2009, Dr. Letcher had previously established at the time with Dr. S. Atkinson (Government of Nunavut, NDE) a 5-year Agreement of Cooperation and Contribution (ACC), which embodies this research and monitoring EC-NDE partnership. This project cooperated in building capacity and expertise in scientific sampling during the present 2013 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 2012 and 2013 NWRPs, and in cooperation with Markus Dyck, Angela Coxon and Paul Frame in the NDE, Dr. Letcher 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.

In late summer 2012, polar bear sampling kits were distributed to the participating Nunavut communities. 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. Sampling instructions were also sent to the Nunavut Environmental Contaminants Committee (NECC) co-chairs, i.e. Allison Dunn

(AANDC) and Romani Makkik (IRA; Nunavut Tunngavik Inc.), as well as Lilianne Arsenault (Government of Nunavut) and Andrew Dunford (Nunavut Tunngavik Inc.). Also, in response to questions from the NECC in 2013 after the social-cultural review on the 2013-2014 project activities, on behalf of this project R. Letcher addressed a concern that capacity building is being delegated to our NDE partners (Dyck, Coxon and Frame). Every effort via the NDE was made in 2013-2014 to provide such field training to HTO/community members. For example, in May 2013, Letcher travelled to Cambridge Bay and Gjoa Haven to interact and interface with hunters and the HTOs, which included sampling information and Q&As. Also, regarding questions from the NECC regarding kit and instructions, there was concern that there was no room on the instruction/sampling forms for hunters to record their observations. As we responded, the NDE requires that with all bears harvested, that a polar bear hunter kill return sheets be completed and submitted. On the kill sheets, the hunters had the opportunity to provide and generally made observational comments.

Communications:

For new POP data that has become available as of 2013-2014, presentations and dissemination of new data occurred at the 2013 NCP Results Workshop held at the end of September in Ottawa, ON. At the 2013 NCP Results Workshop, one oral (Letcher and Braune, 2013) and two poster presentations were made. Furthermore, various oral and poster presentations were made at several conferences, workshops or seminars (see NCP Performance Indicators (PI) section). With the completion of journal publications and reports, documents were provided to NDE partners and in fulfilling the reporting obligations of the 2012 and 2013 NWRPs, and the NECC for edification and further distribution as deemed necessary. Whenever it was necessary, 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 2013-2014 proposal.

As mentioned, Letcher travelled to the Cambridge Bay and Gjoa Haven communities in Nunavut. Letcher joined Dr. Peter van Coeverden de Groot (Dept. of Biology, Queens University. Letcher met with many community leaders, hunters and HTO members in both communities. In Gjoa Haven, Letcher gave a presentation on Arctic contaminants in wildlife to the Gjoa Haven HTO, and to grade 7 to 12 students and teachers at the Gjoa Haven high school (see NCP-PIs). Both presentations were well received and with much discussion, and thus was an effective and important outreach and communication activity. Letcher, or when necessary via NDE partners, continued in 2013 to circulate any copies of presentations, reports or journal papers including to the NECC.

The Stockholm Convention's POP Review Committee (POPRC) is reviewing and assessing several NCP priority chemicals which might be recommended for addition to the POP convention annexes. Among these POPs, are deca-BDE (BDE-209), PCNs, SCCPs, HCBD and PCP/PCA. Since mid-2013, as a partner in this NCP polar bear project, the PI (Letcher) has been communicating and discussing POPRC data needs for these priority chemicals with Inuit Circumpolar Council (and Canadian AMAP) Senior Advisor, Eva Kruemmel, as she attends the POPRC committee meetings and contributes to the chemical reviews. It is of high importance to obtain new (Arctic) data on these priority POPs with respect to their presence or lack thereof in Canadian polar bears. If detected, it will then be of importance to determine the retrospective and continuing trends of these substances in Canadian polar bears and other Arctic compartments.

Traditional knowledge:

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 2013-2014 collection of samples was carried out exclusively by hunters in the participating

Hudson 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. As mentioned, in spring 2013, Letcher travelled to the Cambridge Bay and Gjoa Haven communities. Letcher joined three Inuit hunters on a snowmobile trek to Gateshead Island in the M`Clintock Channel and about 300 km north of Cambridge Bay. Although there has not been a polar bear harvest quota for Cambridge Bay since 2002, the purpose of this trek was to ferry building supplies and bear hair and feces sampling materials. This gave Letcher the opportunity to learn and directly communicate with Inuit hunters who know and have experiences in the field and with polar bears, which is representative of such field activities in other Canadian Arctic communities.

Results

Temporal trends of legacy POPs in Hudson Bay polar bears: Based on available samples and collection years, for 9 years over a 22 year period (1991-2013), temporal trends of the geometric mean concentrations (lw corrected) of SPCBs, SDDTs, SCHLs, a-HCH, b-HCH and SClBzs in the fat of polar bears from western Hudson Bay are shown in Figure 1. For the years spanning 1991-2007, these data were published in McKinney et al. (2009, 2010). New concentration data is shown for 2011- and 2013-collected fat samples. As in previous years, for 2011- and 2013-collected fat samples >90% of the SPCB concentration was due to 7 congeners (CB-99, -138, -153, -170/-190, -180, -194 and -206), and where CB-153 alone accounted for ~40% of the SPCB concentration. As shown in Figure 2, compared to data from 2001, up until 2013 the SPCB, SDDT, SCHL, a-HCH, b-HCH and SClBz concentrations generally remained unchanged over this 12 year time period in the fat of bears from western Hudson Bay.

Time-point comparisons of emerged POPs in Hudson Bay polar bears: Over 11 years from 2001 up until 2013, time-point comparisons were examined for the geometric mean concentrations (lw corrected) of S4PBDE (BDE-47, -99, -100 and -153; >90% of the SPBDE concentration) in fat of western Hudson Bay bears (Figure 2). Over 6 years from 2007 up until 2013, time-point comparisons were also examined for the geometric mean concentrations of S4PBDE in fat of southern Hudson Bay bears (Figure 2). S4PBDE concentrations were generally higher in southern Hudson Bay bears for all comparative years relative to western Hudson Bay bears. For either subpopulation, over the respective time periods S4PBDE concentrations appear to be unchanged, although this has not been statistically verified (Figure 2). Of note and unlike the previous years of 2011 and 2012, for the n=23 southern Hudson Bay bears from 2013-collections, n=12 bears had quantifiable BDE-209 concentrations ranging from 1.9 to 29 ng·g^{-1} lw. Similarly, BDE-209 was quantifiable in all but one of the n=12 fat samples from 2013-collections of the western Hudson Bay bears, with concentrations ranging from 1.6 to 20 ng·g^{-1} lw.

Time-point comparisons of total mercury in Hudson Bay polar bears: Based on available samples, collection years or previous data, for 4 time-points over a 31 year period (1982-2013), comparisons were made for the geometric mean concentrations (dry weight basis) of total mercury (THg) in the liver of polar bears from western Hudson Bay (Figure 3). Over 11 years from 2002 up until 2013, 4 time-points were also compared for the geometric mean concentrations of THg in the liver of southern Hudson Bay bears (Figure 3). THg concentrations were generally the same in western and southern Hudson Bay bears for all years. For both subpopulations, the exception was 2013 where the THg concentrations appeared to increase relative to all other previous years, although this is preliminary and has not been verified statistically (Figure 2).

Targeted POP screening and discoveries in Hudson Bay polar bears: Similar to 2011- and 2012-collected samples, of the 22 non-PBDE replacement FRs that were screened for in the recent 2013-collected fat samples from all Hudson Bay bears, only 2 FRs were quantifiable (BB-153 and α-HBCDD). This excludes organophosphate FRs as they have not been determined as yet for 2013-collected samples. Similar to 2011- and 2012-collected samples, for the n=23 southern Hudson Bay bears from 2013, n=10 bears had quantifiable α-HBCDD concentrations ranging from 6.0 to 37 $ng \cdot g^{-1}$ lw. In contrast, α-HBCDD was not detectable in any of the n=12 fat samples from 2013 western Hudson Bay bears. Similar to 2011- and 2012-collected samples, all n=23 southern Hudson Bay bears from 2013 had quantifiable BB-153 with concentrations ranging from 20 to 280 $ng \cdot g^{-1}$ lw. Similarly, BB-153 was quantifiable in all of the 2013 n=12 fat samples from western Hudson Bay bears with concentrations ranging from 9.2 to 78 $ng \cdot g^{-1}$ lw.

We had reported last year on fat samples of 2012-collected Hudson Bay bears and the first screening for HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate. Of these n=20 samples, only 2 contained quantifiable but low ppb levels of HCBD. Also, α-endosulfan could be quantified at low ppb levels in 18 of the 20 fat samples, whereas both β-endosulfan and endosulfan sulfate were below detection. Similarly, HCBD, α-endosulfan, β-endosulfan and endosulfan sulfate were not detectable at all in fat samples from any Hudson Bay bear harvested in 2013.

We presently report on the first screening results for 24 SCCPs in Hudson Bay polar bears. For n=23 fat samples from Hudson Bay bears harvested in 2012, the SCCP screened for were of chain lengths of C10-C13, and for each chain length SCCPs containing 5 to 10 chlorines. For these 2012 samples, there was 100% frequency of detection for all the n=17 quantifiable SCCPs. The mean S24SCCP concentration was very low and 493 ± 343 $pg \cdot g^{-1}$ lw. For the C10 SCCPs, the mean S6SCCP concentration was 161 ± 112 $pg \cdot g^{-1}$ lw, and comprised of the Cl5-Cl8 congeners. For the C11 SCCPs, the mean S6SCCP concentration was 245 ± 170 $pg \cdot g^{-1}$ lw, and comprised of the Cl5-Cl9 congeners but mainly the Cl6 and Cl7 congeners. For the C12 SCCPs, the mean S6SCCP concentration was 77 ± 54 $pg \cdot g^{-1}$ lw, and comprised of the Cl5-Cl9 congeners but mainly the Cl6 and Cl7 congeners. For the C13 SCCPs, the mean S6SCCP concentration was 10 ± 7 $pg \cdot g^{-1}$ lw, and comprised only of the Cl5 and Cl6 congeners.

Figure 1. Temporal trends of the geometric mean concentrations (+95% CI) of legacy PCBs and organochlorines in fat tissue of polar bears from western Hudson Bay and collected from 1991 to 2007 (McKinney et al. 2009, 2010; black bars), 2011 (red bars, unpublished), and recently for 2013 (green bars, unpublished). The 2011 and 2013 data are not corrected for sex, age or diet.

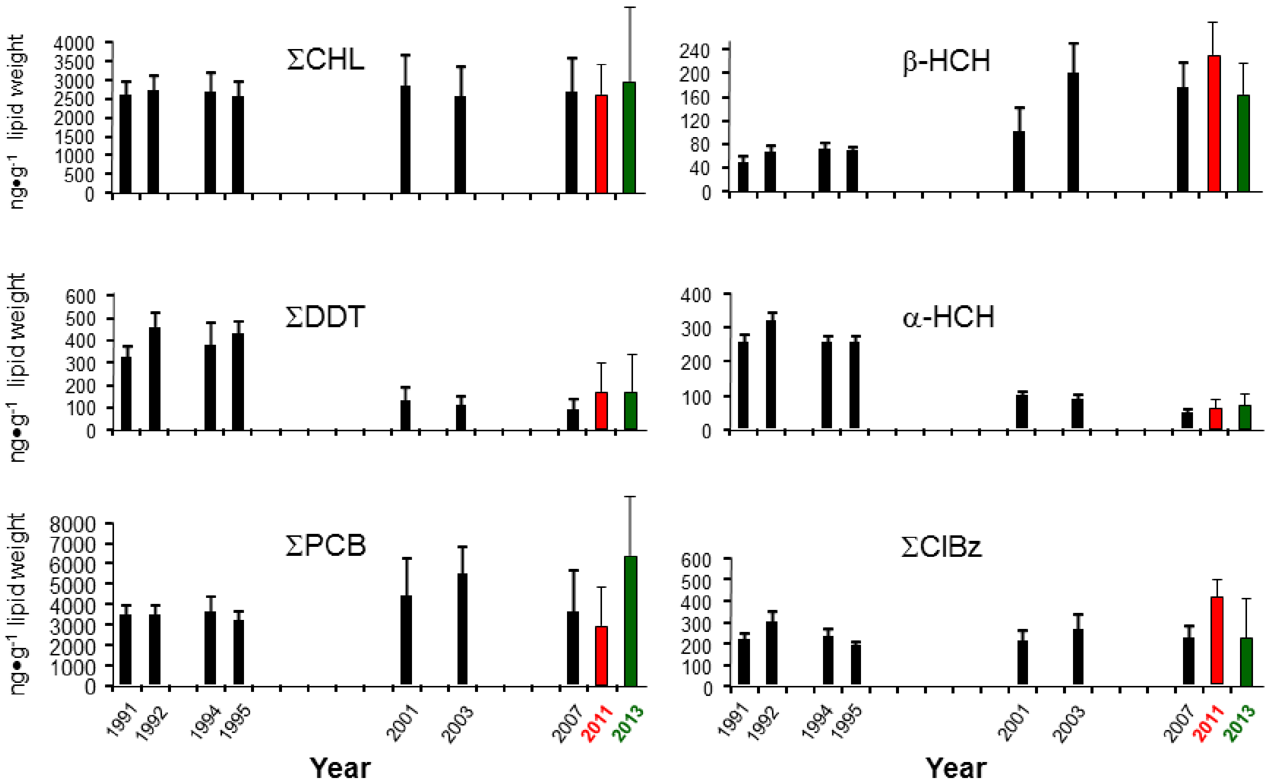


Figure 2. Time-point comparisons of the geometric mean (+95% CI) concentrations of ΣPBDE (sum of BDE-47, -99, -100 and -153) in fat of polar bears from western and southern Hudson Bay and collected in 2001-2002 (Muir et al. 2006; southern Hudson Bay data not available), 2007-2008 (McKinney et al. 2011a), 2011 (unpublished) and 2013 (unpublished). The 2011 and 2013 data are not corrected for sex, age or diet.

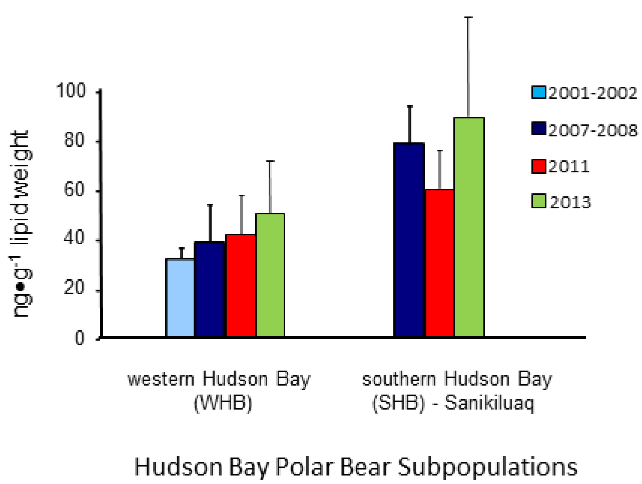
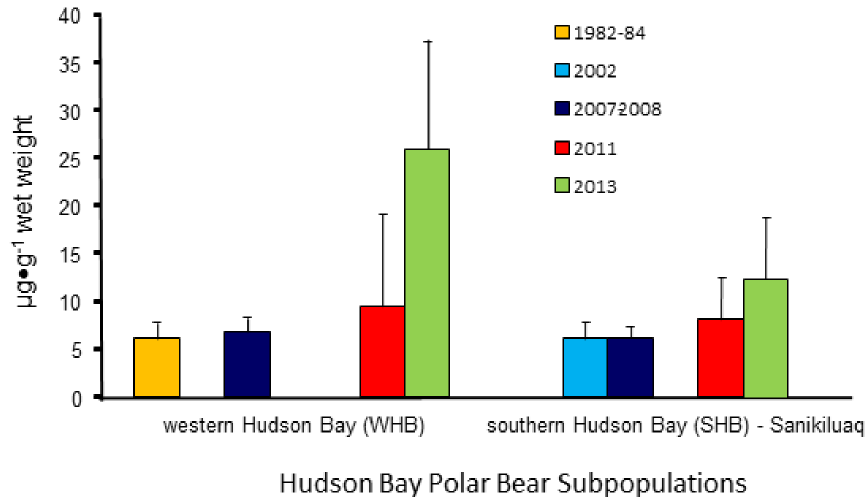


Figure 3. Time-point comparisons of the geometric mean (+95% CI) concentrations of total mercury (THg) in liver tissue of polar bears from western and southern Hudson Bay and collected in 1982-1984 (Braune et al. 1991) 2002 (Rush et al. 2008), 2007-2008 (Routti et al. 2011), and/or 2011 and 2013 (unpublished). The 2007-2013 data are not corrected for sex, age or diet.



Discussion and Conclusions

As of 2013, for western Hudson Bay bears, generally the levels for SPCBs, SDDTs, SCHLs, a-HCH, b-HCH and SClBzs are similar to those in samples and years going back to 2001 (Figure 1) (McKinney et al. 2010, 2011c). That is, in 2013 SPCB and SCHL levels continued to remain at high ppm levels, 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 emerging α-HBCDD, PBBs and other current-use FRs, both on an individual and sum-(Σ-) contaminant basis in bear fat samples from western Hudson Bay (McKinney et al. 2010). Over this longer-term 17-year period (1991-2007), ΣDDT also decreased (–8.4%/year), α-HCH also decreased –11%/year, β-HCH also increased +8.3%/year, and ΣPCB and ΣCHL, 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 Σ4PBDE 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 (Chen and Hale, 2010; Stockholm Convention, 2005), this marginal upward trends appears to be the case when comparing to 2013 harvested western Hudson Bay bears (Figure 2). Based on a two time-point comparisons between 2007-2008 (from McKinney et al. 2011c) and 2011, it appeared that S4PBDE levels for southern Hudson Bay bears may have been decreasing; however, new 2013 data suggests that S4PBDE levels may in fact have not changed over time (Figure 2). However, S4PBDE concentrations in fat of Hudson Bay bears in general remain under 100 ng·g^{-1} lw, and are 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 generally not detectable, whereas α-HBCDD and BB-153 were quantifiable. These findings were consistent with fewer non-PBDE FRs and BDE-209 results we had reported on for 2007-2008 fat samples (McKinney et al. 2011c). For the present 2013 samples, again α-HBCDD and BB-153 were quantifiable at levels similar to 2011 and 2007-2008 (McKinney et al. 2011c).

However, BDE-209 was largely quantifiable to all Hudson Bay fat samples from 2013, and whereas BDE-47, -99, -100 and -153 accounted for 90% of the ΣPBDE concentration, BDE-209 accounted for most of the remaining 10%. BDE-209 exposure to Hudson Bay polar bears via the diet must be on the rise considering also a metabolic perspective. Polar bears possess a relatively high ability (compared to other Arctic mammalian and avian wildlife) to bio-transform compounds via liver enzymatic processes including bioaccumulative POPs, *e.g.* N-ethyl-perfluorooctane sulfonamide (N-EtFOSA to FOSA (Letcher et al. 2014), and BDE-209 and decabromodiphenyl ethane (DBDPE) (McKinney et al. 2011a).

We reported in Routti et al. (2011) on THg concentrations in the liver of southern and western Hudson Bay bears harvested in 2007-2008, where the mean total Hg concentrations for both subpopulations were both in the 5-10 $mg \cdot g^{-1}$ dw range. Compared to previous years, the 2011 and new 2013 data (Figure 3) for both subpopulations suggests that liver THg concentrations are on the rise. Further THg monitoring is certainly warranted. The Minamata Convention on Hg was officially adopted and opened for signatures in October, 2013, after four years of negotiation. The Minamata Convention has been signed by 95 countries, but has only been ratified by one country so far.

Clearly, several of the NCP high priority POPs, which are also 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 at least being detected and/or are quantifiable in tissue (fat) from recently harvested Hudson Bay polar bears, i.e., BDE-209 and SCCPs. Therefore, continual monitoring to determine temporal trends in Arctic species such as polar bears is required.

Expected Project Completion Date

This is an ongoing monitoring program and a core NCP biomonitoring project.

Acknowledgments

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Time-Trend Studies on New and Emerging Persistent Halogenated Compounds in Beluga Whales from Hendrickson Island (NWT) and Sanikiluaq (Nunavut)

Études sur les tendances temporelles relatives aux nouveaux composés halogénés persistants chez les bélugas de l'île Hendrickson (Territoires du Nord-Ouest) et de Sanikiluaq (Nunavut)

- **Project Leader:**
  Gregg Tomy, University of Manitoba, Department of Chemistry, Winnipeg, Manitoba
  Tel: (204) 474-8127, Email: gregg.tomy@umanitoba.ca

  Lisa Loseto, Fisheries and Oceans Canada
  Tel: (204) 983-5135, Email: lisa.loseto@dfo-mpo.gc.ca

- **Project Team Members and their Affiliations:**
  Thor Halldorson, Lianna Bestvater, Wesley Johnson and Sophia Schreckenbach, University of Manitoba; Bruno Rosenberg, Kerri Pleskach, and Gary Stern, Fisheries and Oceans, Canada; Ed Sverko, Chris Marvin and Gordia McInnis, Environment Canada

Abstract

This long-term study examined the temporal trends of halogenated organic chemicals in beluga whales from Hendrickson Island (HI, NWT). We are also constructing a new time-series for animals collected from Sanikiluaq (Qikiqtaaluk Region of Nunavut). Our time-series for both collection sites dates back to the early 1980s for HI and early 1990 for Sanikiluaq and the resolution or frequency of our time-series is particularly strong for samples collected post-2000: in the HI animals, for example, our data-set includes collections from 1984, 1993 and every year from 2000 to 2010. For Sanikiluaq, we have a total of 14 time points sampled over 18 years (1994,

Résumé

Dans cette étude à long terme, on examinait les tendances temporelles relatives aux composés organohalogénés chez les bélugas de l'île Hendrickson (HI), dans les Territoires du NordOuest. On a également établi une nouvelle série temporelle pour des animaux prélevés à Sanikiluaq, dans la région de Qikiqtaaluk, au Nunavut. Les séries temporelles pour les deux sites d'échantillonnage remontent au début des années 1980, dans le cas de l'IH, et au début des années 1990, dans le cas de Sanikiluaq, et la résolution, ou fréquence, des séries temporelles est particulièrement élevée pour les échantillons recueillis après 2000 : par exemple, chez les animaux de l'IH, l'ensemble de données

1995, 1998, 2002-2013). 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). Brominated dipehnyl ethers (BDEs) were the dominant bromine-based flame retardant with concentrations approximately five times greater than hexabromocyclodecane (HBCD). There was a small but statistically significant increase in Σ_6BDEs in HI animals ($p<0.01$, $r^2=0.1451$) resulting in a calculated increase of 0.4 ± 0.1 $ng \bullet g^{-1}$ per year. There was no apparent trend in HBCD concentrations in HI animals. Mean concentrations of Σ_6BDEs and Σ_2HBCD in animals from Sanikiluaq (2013) were 34.5 ± 6.8 and 2.8 ± 0.4 $ng \bullet g^{-1}$ (lw), respectively, and were not statistically different to concentrations in HI collected in 2013. Liver-based concentrations of C8-C12 perflurocarboxylic acids (Σ_5PFCAs) in animals from HI showed a decline over our study period at a rate of ca. 4.5 $ng \bullet g^{-1}$ per year. Σ_5PFCAs in animals from Sanikiluaq were significantly smaller than in animals from HI collected in the same year. For PFOS, there was linear increase (0.53 ± 0.10 $ng \bullet g^{-1}$, per year) in measured concentrations between 1984 and 2000 ($r^2=0.4319$, $p<0.01$) in animals from HI. Between 2000 and 2010, PFOS concentrations were relatively stable but we observed a notable increase in 2011 followed by a decrease in 2012 and again in 2013.

comprend des prélèvements faits en 1984, en 1993 et chaque année de 2000 à 2010. Dans le cas de Sanikiluaq, on a au total 14 moments d'échantillonnage sur 18 ans (1994, 1995, 1998, 2002 à 2013). 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 (SCCPs). Les produits ignifuges bromés les plus abondants étaient les bromodiphényléthers (BDE) : leurs concentrations étaient environ cinq fois plus élevées que celles d'hexabromocyclodécane (HBCD). On a noté une hausse faible, mais statistiquement significative des concentrations de Σ_6BDE chez les sujets de l'IH ($p < 0,01$, $r^2 = 0,1451$); la valeur calculée obtenue pour cette hausse était de 0,4 ± 0,1 $ng \bullet g^{-1}$ par année. Les concentrations d'HBCD ne dessinaient aucune tendance visible chez les sujets de l'IH. Les concentrations moyennes de Σ_6BDE et de Σ_2HBCD chez les animaux de Sanikiluaq (2013) étaient respectivement de 34,5 ± 6,8 et de 2,8 ± 0,4 $ng \bullet g^{-1}$ (poids de lipides), et elles n'étaient pas statistiquement différentes des concentrations chez les animaux de l'IH échantillonnés en 2013. Les concentrations d'acides perfluorocarboxyliques en C8 à C12 (Σ_5APFC) dans le foie des animaux de l'IH ont connu un déclin d'environ 4,5 $ng \bullet g^{-1}$ par année au cours de la période de l'étude. Chez les sujets de Sanikiluaq, les concentrations de Σ_5APFC étaient statistiquement plus faibles que chez les sujets de l'IH échantillonnés la même année. En ce qui concerne le perfluorooctanesulfonate (PFOS), on a noté une augmentation linéaire (0,53 ± 0,10 $ng \bullet g^{-1}$ par année) des concentrations mesurées entre 1984 et 2000 ($r^2 = 0,4319$, $p < 0,01$) chez les animaux de l'IH. Entre 2000 et 2010, les concentrations de PFOS sont demeurées relativement stables, mais on a observé une hausse notable en 2011, suivie d'une baisse en 2012 et en 2013.

Key Messages

- Σ_6BDEs were the dominant bromine-based flame retardant with concentrations continuing to increase in animals from HI at a rate of 0.4 ± 0.1 ng•g^{-1} per year. Σ_2HBCD concentrations in animals from both locations were approximately five times smaller than those of Σ_6BDEs.
- Concentrations of Σ_5PFCAs in beluga from HI showed a significant decrease in concentrations of a rate of approximately 4.5 ng•g^{-1} per year. Concentrations of Σ_5PFCAs in animals from Sanikiluaq were 21.7 ± 2.8 ng•g^{-1} (ww) and significantly smaller than in animals from HI (70.3 ± 11.5 ng•g^{-1}, ww).
- From the 1980s to 2000, liver based concentrations of PFOS increased linearly in animals from both study sites. There was a noticeable increase in PFOS concentrations in 2011 (47.7 ± 5.7 ng•g^{-1} ww) relative to 2010 with concentrations declining to 36.2 ± 2.4 ng•g^{-1} in 2012 and 30.5 ± 4.2 ng•g^{-1} in 2013. PFOS concentrations in Sanikiluaq animals collected in 2013 were not statistically different to those from HI collected in the same year.

Messages clés

- Les Σ_6BDE étaient les principaux produits ignifuges bromés; leurs concentrations continuent de croître à un taux de 0,4 ± 0,1 ng•g^{-1} par année chez les sujets de l'IH. Les concentrations de Σ_2HBCD étaient approximativement cinq fois plus petites que celles de Σ_6BDE chez les animaux des deux sites d'échantillonnage.
- Les concentrations de Σ_5APFC chez les bélugas de l'IH ont connu un déclin significatif d'approximativement 4,5 ng•g^{-1} par année. Les concentrations de Σ_5APFC chez les animaux de Sanikiluaq étaient de 21,7 ± 2,8 ng•g^{-1} (en poids), et elles étaient significativement plus faibles que chez les sujets de l'IH (70,3 ± 11,5 ng•g^{-1} en poids).
- Entre les années 1980 et 2000, les concentrations de PFOS ont connu une croissance linéaire dans le foie des animaux provenant des deux sites visés par l'étude. On a observé une hausse notable des concentrations de PFOS en 2011 (47,7 ± 5,7 ng•g^{-1} en poids) par rapport à 2010, après quoi les concentrations sont descendues à 36,2 ± 2,4 ng•g^{-1} en 2012 et à 30,5 ± 4,2 ng•g^{-1} en 2013. Les concentrations de PFOS chez les sujets de Sanikiluaq échantillonnés en 2013 n'étaient pas significativement différentes de celles enregistrées chez les sujets de Sanikiluaq échantillonnés la même année.

Objective

To continue to build on our temporal trend data set for a suite of halogenated chemicals of emerging concern in beluga whales from Hendrickson Island (HI) and a newly proposed site at Sanikiluaq.

Introduction

Our knowledge of the contemporary and/or historical environmental emissions of many anthropogenic chemicals is sparse. One approach to constructing the 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 TL 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. This current study builds on our annual sampling campaign and chemical analyses of beluga whales for halogenated organic chemicals from two locations in the Canadian Arctic: Hendrickson Island (Western Arctic) and Sanikiluaq (Eastern Arctic).

Activities in 2013-2014

Samples investigated:

The animals selected for study were stored in the archived repository at Fisheries & Oceans, Canada in Winnipeg. Beluga from Hendrickson Island (NWT) studied were from 2011-2013 which was used to complement our time-series from 1984, 1993, 1995, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010. We also examined animals from Sanikiluaq from 2013 to determine whether or not we could detect the compounds of interest to us. Table 1 shows the number of animals analyzed from each of the collection years from HI; when available ten male animals were selected for study.

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 α-diastereoisomers. SCCPs will be analyzed by high resolution mass spectrometry in Dr. Sverko's laboratory at Environment Canada. Total SCCP concentrations are based on the sum of C10-C13 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). Fluorinated compounds investigated include perfluorooctanoate (C8: PFOA), perfluorononanoate (C9: PFNA), perfluorodecanoate (C10: PFDA), perfluoroundecanoate (C11: PFUA), perfluorododecanoate (C12: PFDoDA), perfluorooctane sulfonate (PFOS) and perfluorooctane sulfonamide (PFOSA). Total perfluorinated carboxylate concentrations are based on the sum of C8-C12. 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. The Q-test was used to remove outliers in the data-set (Dean and Dixon, 1950).

Table 1. Geometric mean (GM), maximum (max) and minimum (min) concentrations (ng•g^{-1}) of chemicals of emerging concern in beluga whales from Hendrickson Island[a].

Year	*N*		Σ_6BDEs	Σ_2HBCD	ΣSCCPs	Σ_5PFCAs	PFOS	PFOSA
1984[b]	10	GM				156.83	4.85	48.09
		min				98.35	2.23	8.47
		max				235.32	10.40	111.67
1993	10	GM	5.21	0.34	340.01	147.35	10.46	102.79
		min	3.61	0.086	114.88	71.71	4.37	65.72
		max	7.57	4.59	493.85	313.10	15.89	154.94
1995	10	GM	6.31	1.39	254.12	116.08	10.04	97.67
		min	3.76	0.88	44.02	35.01	5.0	44.19
		max	10.49	5.88	399.87	282.37	14.8	216.07
2000	10	GM	9.18	1.20	NC[c]	45.32	13.63	7.32
		min	4.27	0.095		22.92	8.58	3.87
		max	17.62	2.77		113.82	20.27	16.33
2001	11	GM	8.89	2.22	204.64	30.73	9.87	65.61
		min	1.54	0.75	30.38	6.02	5.22	31.90
		max	17.14	5.48	192.91	88.61	16.12	146.52
2002	10	GM	8.31	0.82	NC	37.17	8.08	22.26
		min	3.51	0.13		15.47	1.67	5.40
		max	18.50	1.72		78.63	24.26	51.74
2003	11	GM	11.63	2.15	NC	38.67	12.01	7.81
		min	7.02	1.28		21.68	5.71	4.56
		max	24.32	3.36		76.21	19.91	16.54
2004	10	GM	18.39	2.95	NC	21.57	11.21	6.96
		min	14.56	2.26		8.72	6.88	4.45
		max	25.94	3.68		50.32	24.12	12.05
2005	10	GM	4.77	1.70	248.98	67.16	11.91	127.01
		min	1.29	0.85	3.06	35.64	6.01	48.23
		max	15.69	3.32	430.26	122.69	23.04	228.40
2006	10	GM	8.63	1.17	3.96	9.72	7.98	22.51
		min	4.43	0.77	0.82	4.87	1.67	5.41
		max	17.10	2.98	13.90	16.03	24.26	51.74
2007	10	GM	8.91	1.37	NC	43.64	11.17	16.09
		min	1.86	0.62		29.77	4.25	7.76
		max	15.03	3.47		82.81	20.32	24.47
2008	10	GM	8.66	2.53	NC	9.88	6.71	8.59
		min	1.55	1.36		5.19	4.17	3.77
		max	22.76	3.97		21.31	11.67	14.03
2009	10	GM		1.82	NC	24.83	9.58	25.65
		min		0.62		14.89	6.26	16.14
		max		6.97		62.68	18.06	51.74

2010	10	GM		0.66	NC	34.84	10.16	15.03
		min		0.13		17.81	7.25	9.57
		Max		1.45		67.65	13.71	29.72
2011	10	GM	13.80	2.22		53.72	47.70	43.46
		Min	7.68	1.18		31.0	23.18	26.67
		Max	21.75	8.75		80.09	72.27	66.59
2012	10	GM	11.44	2.38		37.89	36.25	41.37
		Min	8.13	1.50		17.52	25.00	30.45
		Max	18.14	6.89		65.28	46.00	67.86
2013	10	GM	14.42	1.05		70.31	30.53	66.69
		Min	5.30	0.09		23.13	6.39	49.47
		max	22.12	4.22		117.76	49.21	100.26

[a] concentrations of Σ_6BDEs, Σ_2HBCD and Σ_SCCPs were determined in the beluga blubber and are expressed on a lipid weight basis. Σ_5PFCAs, PFOS and PFOSA were measured in the liver and are expressed on a wet weight basis;

[b] blubber samples were not available for this year;

[c] NC = not complete.

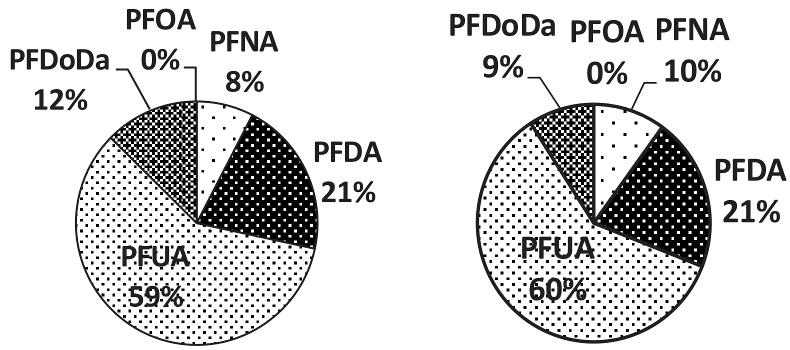
Results

Liver based concentrations of Σ_5PFCAs, PFOS, PFOSA and lipid based concentration of Σ_6BDEs, Σ_2HBCDs and ΣSCCPs in beluga whales from HI is shown in Table 1. BDEs were the dominant bromine-based flame retardant in animals. Σ_6BDEs in animals from HI showed a small but statistically significant increase (approximately 0.4 ng•g^{-1} per year) over our study period. Σ6BDEs concentrations in animals from Sanikiluaq collected in 2013 (26.9 ± 6.8 ng•g^{-1}, lw) were not statistically different to those in animals from HI collected in the same year. Interestingly the rank order of individual BDE congener concentrations in animals from HI were different to those from Sanikiluaq. For HI, the rank order was 47d100d99d154d153 and for Sanikiluaq was 99d47d100d154d153. For HBCD, there was no real discerning trend in animals from HI. Concentrations have remained relatively stable (between 1-3 ng•g^{-1}) over the study period. HBCD was detected in 5 of the 10 animals from Sanikiluaq with a mean concentration of approximately 3 ng•g^{-1}, similar to that observed in animals from HI collected in the same year.

Prior to 2000, Σ_5PFCA wet weight liver concentrations for animals collected from HI in 1984, 1993 and 1995 were 156.8, 147.3 and 116.1 ng•g^{-1}, respectively. Post-2000, Σ_5PFCA concentrations have decreased precipitously. Over the study period, the observed annual rate of decline of Σ5PFCA was ca. 4.5 ng•g^{-1} per year. Concentrations of Σ_5PFCA in animals from Sanikiluaq collected in 2013 (21.7 ± 2.8 ng•g^{-1}) were significantly smaller ($p<0.01$) than those of HI animals collected the same year. Even though the absolute concentrations of Σ5PFCA were different for the two study sites, the relative abundances of the individual PFCAs to the total were fairly consistent (see Figure 1). PFUA, for example contributed the bulk (ca. 60%) of the PFCA burden in animals from both sites. The rank order of PFCA concentrations at both study sites were PFUA>>PFDA>PFDODa@PFNA.

In animals from HI, we observed a noticeable increase in concentrations of PFOS in animals collected post-2010 relative to those collected before then. Mean concentrations of PFOS in animals pre-2010 were ca. 10ng•g^{-1}; in 2011, 2012 and 2013 PFOS concentrations were 47.7 ± 5.7, 36.2 ± 2.4 and 30.5 ± 4.2 ng•g^{-1}, respectively. PFOS concentrations in Sanikiluaq animals in 2013 (35.3 ± 8.5 ng•g^{-1}) were not statistically different to those in animals from Hendrickson Island collected in the same year.

Figure 1. Relative abundances of individual PFCAs in animals from Hendrickson Island (left) and Sanikiluaq (right).



Concurrent with the increase in PFOS concentrations in HI animals was also an increase in PFOSA concentrations. In 2011 concentrations of PFOSA increased to 43.4 ± 4.0 ng•g^{-1} from 15.9 ± 1.9 ng•g^{-1} in the previous year. There was also another increase in PFOSA concentrations in 2013 relative to the previous year. Overall, there was no clear discerning trend in PFOSA concentrations although it could be argued that concentrations are increasing based on the appearance of the profile from 2007 to present day. PFOSA concentrations in animals from Sanikiluaq were approximately two times greater than those from HI collected in 2013. There was no correlation between PFOS and PFOSA concentrations in animals from either HI or Sanikiluaq.

We were unable to detect any OPFRs in Hendrickson Island beluga liver (n=10). This was somewhat surprising as Letcher et al. were able to detect 5 OPFRs, in the sub-ng•g^{-1} range, in polar bear fat and liver samples (2011, n=23) from south Hudson Bay (Letcher, personnel communication). Because of the potential of blank issues with OPFR analyses, all our tissue work-up was performed in an ultra-clean laboratory and our blank levels were in the sub-pg range. This suggests to us that if OPFRs are present in beluga they are at least an order of magnitude smaller than in polar bears.

Acknowledgments

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Temporal Trends of Halogenated Organic Compounds in Canadian Arctic Beluga

Tendances temporelles relatives aux composés organohalogénés chez les bélugas de l'Arctique canadien

Project Leader:

Gary A. Stern, University of Manitoba, Centre for Earth Observation Science, Winnipeg MB
Tel: (204) 474-9084, Email: Gary.stern@umanitoba.ca

Lisa Loseto, Fisheries and Oceans Canada, Winnipeg MB
Tel: (204) 983-5135, Fax: (204) 984-2403, Email: Lisa.Loseto@dfo-mpo.gc.ca

Project Team Members and their Affiliations:

Alexis Burt, Centre for Earth Observation Science; Sonja Ostertag and Allison MacHutchon, Fisheries and Oceans Canada; ALS Environmental

Abstract

The objectives of this on going study are to maintain current data on contaminant levels in marine mammals and to continue to assess the temporal trends of halogenated organic compounds. This will allow us to determine whether the levels of these compounds in the marine mammals, and hence exposure to Arctic people who traditionally consume them, are changing with time. These results will also help to test the effectiveness of international controls and, in conjunction with projects such as ArcticNet, to understand the effects that climate variation may have on these contaminant levels.

Résumé

Les objectifs de cette étude toujours en cours sont de maintenir les données actuelles sur les concentrations de contaminants chez les animaux marins, et de continuer d'évaluer les tendances temporelles relatives aux composés organohalogénés. Cela permettra de déterminer si les concentrations de ces composés chez les mammifères marins et, par conséquent, l'exposition des peuples de l'Arctique qui les consomment traditionnellement, changent au fil du temps. Les résultats obtenus aideront aussi à vérifier l'efficacité des mécanismes internationaux de restriction et, conjointement avec des projets comme ArcticNet, à comprendre les effets que les variations climatiques peuvent avoir sur les concentrations de ces contaminants.

Key Messages

- In 2013, tissue samples from 44 Hendrickson Island and 12 Sanikiluaq animals were sampled and received. Samples collected and analysed to date are shown in Table 1 & 2. No samples were received from Pangnirtung.
- We now have a very unique long-term data set for halogenated organic compounds in western Arctic beluga: 17 time points spanning 24 years.
- 2013 samples were analyzed at ALS Environmental.
- No trends were observed for major organic compounds groups in the western Arctic beluga. In particular, hexachlorocyclohexane levels are not showing the declines observed atmospherically and in the Arctic Ocean since the ban in the usage of the technical mixture by China in 1983 and followed by India in 1990.

Messages clés

- En 2013, on a prélevé des échantillons de tissus chez 44 animaux de l'île Hendrickson et chez 12 animaux de Sanikiluaq. Les résultats obtenus pour les échantillons recueillis et analysés jusqu'ici sont présentés aux tableaux 1 et 2. Aucun échantillon n'a été reçu de Pangnirtung.
- On possède maintenant un ensemble de données à long terme sans pareil sur les composés organohalogénés chez les bélugas de l'ouest de l'Arctique (17 moments d'échantillonnage sur 24 ans).
- Les échantillons de 2013 ont été analysés par ALS Environmental.
- Aucune tendance n'a été observée pour les principaux groupes de composés organiques chez les bélugas de l'ouest de l'Arctique. En particulier, les concentrations d'hexachlorocyclohexane ne reflètent pas les déclins observés dans l'atmosphère et dans l'océan Arctique depuis que l'utilisation du mélange technique a été interdite par la Chine en 1983, puis par l'Inde en 1990.

Objectives

To continue to assess long term trends and to maintain the current data-base on levels of halogenated organic compounds (*e.g.*PCBs, DDT, toxaphene) in marine mammals (beluga, narwhal, walrus) from selected locations across the Canadian Arctic.

Introduction

Marine animals accumulate (relatively) high concentrations of halogenated organic compounds (HOCs). The objectives of this project, therefore, are to maintain current data on contaminant levels in marine mammals and to continue to assess the temporal trends of halogenated organic compounds (HOCs). This will allow us to determine whether contaminant levels in the marine mammals, and hence exposure to Arctic people who traditionally consume them, are changing with time. These results will also help to test the effectiveness of international controls and, in conjunction with projects such as the IPY CFL (Circumpolar Flaw Lead) System Study and ArcticNet Phase 1 and II to understand the effects that climate variation may have on the contaminant levels in these animals and the health of the stocks.

The raw data and samples from previous and ongoing investigations are archived in the Freshwater Institute and represent about 2000 marine mammals, mostly beluga, ringed seals, narwhal and walrus from 23 different locations across the Canadian Arctic. DFO scientists concerned with stock management, animal health and climate change studies obtain various samples from hunter kills and those samples form the basis of most of our analyses. For example, tissues from eastern Arctic and Hudson Bay beluga have been collected and analyzed for HOCs as part of DFOs stock management studies since 1996. In the western Arctic the collections have been supported by FJMC since 2002. The accumulating data resulting from these studies offer the means to detect both spatial and temporal trends of HOCs and heavy metals in Arctic marine mammals and most importantly to try and link the observed variation to physical and biological process and carbon and contaminants cycling within the Arctic Ocean.

Activities in 2013-2014

In 2013, tissue samples from 44 Hendrickson Island and 12 Sanikiluaq animals were sampled and received. Samples collected and analysed to date are shown in Table 1 & 2. No samples were received from Pangnirtung.

Table 1. Mean (stdev) of major HOC groups and compounds in blubber from western Arctic beluga (ng g^{-1}, wet wt).

Loc	Year	Sex	n	Age	%lipid	SCBz	SHCH	SCHL	SDDT	SPCB	SCHB	Dieldrin	Oxychlor
HL	1989	M	12	29.0 (15.0)	90.5 (3.7)	421.5 (185.9)	269.3 (111.3)	1857.6 (667.8)	2930.8 (1125.8)	3800.0 (1587.7)	4548.0 (1462.6)	297.5 (112.1)	487.7 (143.6)
HI	1994	M	10	33.4 (10.8)	93.3 (2.8)	669.6 (168.7)	215.8 (55.5)	1601.4 (495.5)	4283.8 (2591.7)	3949.1 (1819.5)	11207.4 (6735.6)	324.2 (118.4)	477.0 (109.9)
HI	1995	M	15	32.1 (10.4)	81.3 (3.3)	783.2 (380.4)	211.9 (40.6)	2076.2 (1025.8)	3907.7 (1753.7)	4176.6 (1473.3)	6701.0 (3207.3)	287.9 (141.7)	519.1 (348.2)
HI	1996	M	10	27.5 (6.8)	92.4 (4.6)	666.3 (117.5)	243.0 (23.3)	1803.1 (274.0)	4415.3 (2030.9)	4246.8 (1146.9)	10519.3 (4708.5)	397.7 (133.4)	498.3 (45.0)
HI	2001	M	18	32.3 (9.7)	82.2 (3.5)	518.7 (169.4)	205.5 (44.0)	1932.4 (808.5)	3445.1 (1633.7)	3986.7 (1737.5)	6266.4 (3634.6)	296.9 (103.9)	499.0 (225.6)
HI	2002	M	9	30.4 (8.1)	90.9 (2.2)	421.1 (109.1)	234.3 (34.8)	1408.9 (351.3)	2480.3 (1361.5)	2745.7 (1033.7)	7024.5 (3324.2)	376.0 (113.4)	439.9 (126.1)
HI	2003	M	9	27.2 (9.3)	91.3 (3.9)	518.3 (113.2)	243.1 (50.1)	1556.5 (361.5)	2736.0 (2134.3)	3084.4 (1462.9)	6188.5 (2600.1)	338.4 (100.7)	519.7 (119.3)
HI	2004	M	10	25.3 (6.0)	85.1 (6.8)	888.0 (189.0)	329.2 (50.8)	2932.8 (535.7)	3747.0 (1928.3)	4894.1 (948.8)	7554.1 (2360.1)	500.7 (99.4)	744.8 (192.5)
HI	2005	M	10	26.8 (9.6)	92.4 (3.4)	623.5 (196.3)	269.3 (68.2)	2568.5 (1715.6)	4545.8 (3595.3)	3633.1 (1906.5)	5680.1 (3776.0)	447.0 (186.8)	991.7 (684.7)
HI	2006	M	14	23.6 (7.2)	90.8 (6.2)	567.6 (197.7)	229.8 (33.6)	1498.8 (416.7)	2017.0 (851.8)	3100.2 (1081.7)	3673.6 (1614.5)	289.0 (80.4)	518.23 (162.2)
HI	2007	M	10	25.0 (19.2)	86.0 (9.9)	650.1 (251.8)	254.7 (31.9)	2236.1 (853.1)	3805.4 (2124.4)	3744.1 (1391.8)	7226.1 (3276.8)	359.3 (114.0)	698.4 (281.2)
HI	2008	M	10	35.6 (12.0)	80.1 (5.9)	392.4 (90.5)	121.5 (23.5)	1412.5 (582.7)	1348.7 (698.8)	3006.6 (1247.6)	4585.5 (2707.9)	209.2 (68.6)	290.5 (99.5)

Loc	Year	Sex	n	Age	%lipid	SCBz	SHCH	SCHL	SDDT	SPCB	SCHB	Dieldrin	Oxychlor
HI	2009	M	10	33.7 (11.8)	94.0 (3.7)	434.8 (131.1)	191.2 (88.6)	1336.7 (380.6)	4309.7 (2317.5)	3697.7 1475.1)	7268.0 (4382.7)	347.7 (99.6)	432.0 (133.4)
HI	2010	M	10	25.5 (8.0)	92.1 (3.5)	497.7 (93.8)	222.4 (48.0)	1074.5 (260.1)	2619.5 (866.3)	2397.5 (438.4)	6081.2 (2470.8)	384.0 (97.2)	522.3 (104.3)
HI	2011	M	10	25.7 (6.2)	92.4 (3.7)	590.2 (110.6)	266.8 (66.2)	1768.6 (801.6)	3084.2 (2244.8)	3690.2 (2109.7)	4394.7 (2114.6)	484.7 (175.6)	517.7 (216.7)
HI	2012	M	10	26.6 (7.2)	93.6 (2.0)	563.4 (92.7)	245.8 (53.5)	1518.8 (379.9)	4251.2 (1744.2)	3524.3 (1397.0)	7549.7 (2414.7)	380.0 (133.8)	521.0 (145.8)
HI	2013*	M	10	31.4 (8.2)	75.0 (8.4)	558.3 (248.7)	181.2 (41.6)	2113.1 (687.4)	3260.0 (1512.8)	3269.0 (1617.0)	882.4 (106.81)	311.0 (70.1)	469.0 (357.0)

HL = Husky Lakes; HI = Hendrickson Island;

DFO: ΣDDT = Sum of *p,p*'-DDT, *p,p*'-DDE, *p p*'-DDD, *o,p*'-DDT, *o,p*'-DDE and *o,p*'-DDD; ΣHCH = α- β- and γ-HCH isomers; ΣCHL = all chlordane related compounds, including heptachlor; ΣCBz = Sum of 1245TCB, 1234TCB, P5CBz, HCBz; ΣPCB = Sum of CB1, 3, 4/10, 7, 6, 8/5, 19, 18, 17, 24/27, 16/32, 26, 25, 31, 28, 33, 22, 45, 46, 52, 49, 47, 48, 44, 42, 41/71, 64, 40, 74, 70/76, 66, 95, 56/60, 91, 84/89, 101, 99, 83, 97, 87, 85, 136, 110, 82, 151, 144/135, 149, 118, 134, 114,131, 146, 153, 132, 105, 141, 130/176, 179, 137, 138, 158, 178/129, 175, 187, 183, 128, 185, 174, 177, 171, 156, 201/ 157, 172/197, 180, 193, 191, 200, 170, 190, 198, 199, 196/203, 189, 208, 195, 207, 194, 205, 206, 209'

*ALS: ΣCBz = HCB; Sum of *p,p*'-DDT, *p,p*'-DDE, *p p*'-DDD, *o,p*'-DDT, *o,p*'-DDE and *o,p*'-DDD; ΣHCH = sum of α- β- and γ-HCH isomers; ΣCHL = sum of *cis*- and *trans*-Chlordane, *cis*- and *trans*-Nonachlor; ΣCHB = sum of Parlar 26, 50, 62; ΣPCB = Sum of 1, 3, 4/10, 7/9, 6, 8/5, 12/13, 15, 19, 18, 17, 27/24, 16/32, 26, 25, 31/28, 20/33/21, 22, 37, 53, 45, 46, 73/52, 43/49, 48/47/75, 44, 59/42, 71/41/68/64, 40, 57, 63, 74/61, 70/76, 80/66, 56/60, 81, 77, 95/93, 91, 92, 84/90/101/89, 99, 83/108, 97, 86/111/125/117/87/116/115, 120/85, 110, 82, 107/109, 123, 118/106, 114, 105/127, 126, 136, 151, 135/144, 139/149, 131/165/142/146, 153, 132/168, 141, 137, 163/164/138, 158/160, 129, 159, 128/167, 156, 157, 169, 182/187, 183, 185, 174/181, 177, 171, 172/192, 180, 193, 191, 170/190, 189, 202, 199, 196/203, 195, 194, 205, 208, 207, 206, 209, 201/204.

Table 2. Mean (stdev) of major HOC groups and compounds in blubber from male and female Sanikiluaq beluga (ng g^{-1}, wet wt).

Loc	Year	Sex	n	Age	%lipid	ΣCBz	ΣHCH	ΣCHL	ΣDDT	ΣPCB	ΣCHB	Dieldrin	Oxychlor
Sk	2013	F	9	18.2 (7.9)	78.2 (3.0)	100.9 (89.4)	60.9 (22.5)	305.9 (155.7)	414 (289.6)	498.7 (296.2)	193.8 (106.81)	163.7 (102.1)	90.4 (59.3)
Sk	2013	M	1	16.0	80.2	21.20	40.1	240.5	575.3	741.6	248.6	96.1	86.8

ALS: ΣCBz = HCB; Sum of *p,p*'-DDT, *p,p*'-DDE, *p p*'-DDD, *o,p*'-DDT, *o,p*'-DDE and *o,p*'-DDD; ΣHCH = sum of α- β- and γ-HCH isomers; ΣCHL = sum of *cis*- and *trans*-Chlordane, *cis*- and *trans*-Nonachlor; ΣCHB = sum of Parlar 26, 50, 62; ΣPCB = Sum of 1, 3, 4/10, 7/9, 6, 8/5, 12/13, 15, 19, 18, 17, 27/24, 16/32, 26, 25, 31/28, 20/33/21, 22, 37, 53, 45, 46, 73/52, 43/49, 48/47/75, 44, 59/42, 71/41/68/64, 40, 57, 63, 74/61, 70/76, 80/66, 56/60, 81, 77, 95/93, 91, 92, 84/90/101/89, 99, 83/108, 97, 86/111/125/117/87/116/115, 120/85, 110, 82, 107/109, 123, 118/106, 114, 105/127, 126, 136, 151, 135/144, 139/149, 131/165/142/146, 153, 132/168, 141, 137, 163/164/138, 158/160, 129, 159, 128/167, 156, 157, 169, 182/187, 183, 185, 174/181, 177, 171, 172/192, 180, 193, 191, 170/190, 189, 202, 199, 196/203, 195, 194, 205, 208, 207, 206, 209, 201/204.

Results

As part of an ongoing whale sampling and stock identity program, supported by the Nunavut Wildlife Management Board (NWMB), FJMC, NIF and DFO, samples were collected by hunters during their subsistence hunts using standardized whale kits. Blubber, kidney, liver, ovaries and uterus, muscle and the lower jaw, as well as morphometric data were collected for each animal. All samples were shipped frozen to the Freshwater Institute and stored at - 20°C until analysis. In 2013, all OC analysis were run at ALS Environmental.

We now have a very unique long-term data set for HOCs in western Arctic beluga; 17 time points spanning 24 years. As shown in Table 1, no real trends are evident. Of particular interest is the fact that HCHs are not showing the declines observed atmospherically and in the Arctic Ocean (Li et al., 2004) since the ban in the usage of the technical mixture by China in 1983 and followed by India in 1990. As was postulated for mercury, the lack of response of HCH in western Arctic beluga to the declining levels in the Arctic atmosphere and Ocean could be, at least in part, attributed to recent changes in ice cover, which may, for example, alter the foraging of the beluga whales or their prey (Stern and Macdonald, 2005; Gaden et al. 2009, 2010; Loseto et al. 2006, 2008a,b, 2009; Kuzyk et al. 2010). First results from IPY CFL and ArcticNet Phase II field programs designed to try and determine the effects that climate change will have on the ocean-sea ice-atmosphere coupling of hexachlorocyclohexane (HCH) and transport within the western Arctic have been published (Pucko et al. 2010a,b, Pucko et al. 2011, 2012).

EXPECTED PROJECT COMPLETION DATA

This study, in conjunction with the trace metal work, is expected to be on going

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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

- **Project Leader:**
  Gary A. Stern, University of Manitoba, Centre for Earth Observation Science, Winnipeg MB
  Tel: (204) 474-9084, Email: Gary.stern@umanitoba.ca

  Lisa Loseto, Fisheries and Oceans Canada, Winnipeg MB
  Tel: (204) 983-5135, Fax: (204) 984-2403, Email: Lisa.Loseto@dfo-mpo.gc.ca
- **Project Team Members and their Affiliations:**
  Alexis Burt, Centre for Earth Observation Science; Sonja Ostertag and Allison MacHutchon, Fisheries and Oceans Canada

Abstract

Samples of liver, kidney, muscle and muktuk of beluga whales collected in 2013 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

Résumé

On a analysé les concentrations de mercure total et de sélénium dans des échantillons de foie, de reins, de muscles et de muktuk de béluga prélevés en 2013. Les concentrations de mercure étaient similaires à celles enregistrées au cours d'années antérieures. Parmi les organes et tissus analysés dans cette étude, c'est habituellement le foie qui renfermait les plus fortes concentrations de mercure; venaient ensuite les reins, les muscles et le muktuk. Par exemple, la concentration moyenne de mercure total dans 29 échantillons de foie de béluga prélevés à l'île Hendrickson en 2012 était de 27,3 ± 27,0 $\mu g \cdot g^{-1}$, tandis que la concentration moyenne dans le muktuk des mêmes animaux était de 0,59 ± 0,18 $\mu g \cdot g^{-1}$. Les

over 1300 arctic beluga from several locations over the period from 1977 to 2012. Mercury content varies among species, among individual animals, and among organs within an animal. 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.

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. À présent, cette base de données contient des renseignements sur plus de 1 300 bélugas échantillonnés à plusieurs endroits en Arctique au cours de la période de 1977 à 2012. La teneur en mercure varie selon les espèces, selon les sujets et selon les organes dans un animal donné. Ces fluctuations rendent difficile la détection rigoureuse, d'un point de vue statistique, des différences entre les animaux échantillonnés, les lieux de prélèvement et les moments d'échantillonnage. La détection des différences entre les échantillons est en outre compliquée par le fait que le mercure s'accumule avec l'âge; la concentration de mercure est donc habituellement plus élevée chez les animaux âgés que chez les jeunes animaux provenant du même endroit. Par conséquent, la comparaison des concentrations de mercure chez différents groupes de bélugas exige des ajustements en fonction de l'âge; il est essentiel de disposer de données exactes sur l'âge des sujets. Les échantillons supplémentaires recueillis chaque année accroissent les probabilités de détecter les différences réelles et réduisent celles de signaler des différences apparentes, mais non réelles. Habituellement, on effectue les analyses chimiques avant de déterminer l'âge des sujets; il y a donc un délai 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 2013 liver samples from the Hendrickson Island animals was 28.8 ± 22.9 $\mu g \cdot g^{-1}$. The mean age of these same whales was 27.7 ± 7.9 years. Mercury in muscle was lower than that in liver with a mean concentration of 1.54 ± 0.66 $\mu g \cdot g^{-1}$.

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 dans les échantillons de foie prélevés en 2013 chez des animaux de l'île Hendrickson était de 28,8 ± 22,9 $\mu g \cdot g^{-1}$. L'âge moyen des bélugas échantillonnés était de 27,7 ± 7,9 ans. Les concentrations de mercure étaient plus faibles dans les muscles (1,54 ± 0,66 $\mu g \cdot g^{-1}$) que dans le foie.

- In spite of the lower values in Hendrickson Island beluga 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 Hendrickson Island animals, muktuk contained the lowest levels of total mercury with a mean 0.76 ± 0.40 $\mu g \cdot g^{-1}$. Twenty-three percent of the samples (7 of 30) exceeded 0.5 $\mu g \cdot g^{-1}$.
- 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 3.26 ± 2.21 $\mu g \cdot g^{-1}$, Muscle levels were lower, with a mean of 0.47 ± 0.15 $\mu g \cdot g^{-1}$ and mercury in muktuk were lower with still with a mean concentration of 0.21 ± 0.11 $\mu g \cdot g^{-1}$.
- The lower mercury concentrations in the 2013 animals tissues reflect their much younger ages.

- Même si les valeurs étaient plus faibles dans les muscles des bélugas de l'île Hendrickson, elles demeuraient toutes supérieures à 0,5 $\mu g \cdot g^{-1}$, soit la concentration de référence utilisée depuis longtemps pour réglementer la vente d'espèces commerciales de poissons au Canada.
- Parmi les 3 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 $\mu g \cdot g^{-1}$. La valeur de 0,5 $\mu g \cdot g^{-1}$ était dépassée dans le cas de 23 % des échantillons (7 sur 30).
- 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 3,26 ± 2,21 $\mu g \cdot g^{-1}$. Les concentrations dans les muscles étaient plus faibles, la moyenne étant de 0,47 ± 0,15 $\mu g \cdot g^{-1}$, et les concentrations dans le muktuk étaient plus faibles encore, la moyenne étant de 0,21 ± 0,11 $\mu g \cdot g^{-1}$.
- Les concentrations plus faibles de mercure mesurées dans les tissus des animaux en 2013 reflètent le fait qu'ils étaient bien plus jeunes.

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 two sources; 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), 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 $\mu g \cdot g^{-1}$. 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 $\mu g \cdot g^{-1}$. 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 2013-2014

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 2013 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). Quality Assurance/ Quality Control 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 2013 and some ages for beluga reported previously also became available. The new data available for 2013 were:

- Muscle, liver and muktuk samples and ages of 30 beluga from Hendrickson Island in 2013
- Muscle, liver and muktuk samples and ages of 12 beluga from Sanikiluaq in 2013.
- Retrospective ages of 10 Sanikiluaq animals for each of 2011 and 2012. Animals from 2009 and 2010 have yet to be aged.

The ages and mean concentrations ($\mu g \cdot g^{-1}$ wet weight) of mercury in liver, muscle and muktuk are listed in Tables 1.

Hendrickson Island 2013

Collections from Hendrickson Island are one of the most extensive with 397 samples from 17 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 2013 was 28.8 ± 22.9 $\mu g \cdot g^{-1}$ (Table 1). The mean age of these same whales was 27.7 ± 7.9 years. Mercury in muscle was lower than that in liver with a mean concentration of 1.54 ± 0.66 $\mu g \cdot g^{-1}$. In spite of the lower values in 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, muktuk contained the lowest levels of total mercury with a mean 0.76 ± 0.40 $\mu g \cdot g^{-1}$. Twenty-three percent of the samples (7 of 30) exceeded 0.5 $\mu g \cdot g^{-1}$. 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

Twelve samples were obtained from Sanikiluaq in 2013. Total mercury levels found in the 3 organs analyzed are listed in Table 1. Mean mercury in liver was 3.26 ± 2.21 $\mu g \cdot g^{-1}$, Muscle levels were lower, with a mean of 0.47 ± 0.15 $\mu g \cdot g^{-1}$ and mercury in muktuk were lower with still with a mean of 0.21 ± 0.11 $\mu g \cdot g^{-1}$. 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. The lower mercury concentrations in the 2013 animal tissues reflects their much younger ages.

Table 1. Age data and concentrations of total mercury in organs of beluga (M+F) from HI and SK. Concentrations are shown in $\mu g \cdot g^{-1}$ wet weight followed by standard deviations. The age data from the 2011 and 2012 SK animals are new.

Location	Year	Age	Liver	Muscle	Muktuk
Hendrickson	2013	27.7 ± 7.9	28.8 ± 22.9 (31)	1.54 ± 0.66 (30)	0.76 ± 0.40 (30)
Sanikiluaq	2013	18.0 ± 7.5	3.26 ± 2.21 (12)	0.47 ± 0.15 (12)	0.21 ± 0.11 (12)
Sanikiluaq	2012	32.2 ± 11.0	11.8 ± 9.4 (12)	0.91 ± 0.40 (12)	0.45 ± 0.19 (12)
Sanikiluaq	2011	44.4 ± 9.1	16.2 ± 16.7 (13)	0.97 ± 0.78 (13)	0.50 ± 0.35 (13)

Discussion and Conclusions

Levels of total mercury in Arctic beluga organs remain high when compared with fish commonly consumed by people. Of the three 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 $\mu g \cdot g^{-1}$, 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.

Expected Project Completion Date

This study has been ongoing for several years.

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Project Title: Temporal Trends of Contaminants in Arctic Seabird Eggs

Tendances temporelles relatives aux contaminants dans les œufs des oiseaux de mer en Arctique

Project Leader:
Birgit Braune, Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa, ON, Tel: (613) 998-6694, Fax: (613) 998-0458, Email: birgit.braune@ec.gc.ca

Project Team Members and their Affiliations:
A. Idrissi, G. Savard, R. Letcher, G. Gilchrist, and A. Gaston, Environment Canada; M. Pelletier and E. Sudlovenick, Environment Canada/CWS (Iqaluit); P. Woodard, Environment Canada/CWS, (Yellowknife); K. Woo, Environment Canada/CWS (Delta); M. Mallory and N. Spencer, Biology Department, Acadia University; I. Storm, Canadian Avalanche Centre

Abstract

Contaminants are monitored in Arctic seabird eggs as an index of contamination of Arctic marine ecosystems. Eggs of three species of seabird (thick-billed murre, northern fulmar, black-legged kittiwake) have been collected from Prince Leopold Island in the Canadian high Arctic since 1975. For comparative purposes, we have also been monitoring thick-billed murre eggs from Coats Island in northern Hudson Bay since 1993 as well as two additional species (black guillemot, glaucous gull) from Prince Leopold Island. The was a significant difference in total Hg concentrations in eggs among the five monitored species breeding on Prince Leopold Island in 2013 with the highest concentrations found in the glaucous gull eggs

Résumé

On surveille les concentrations de contaminants dans les œufs des oiseaux de mer en Arctique comme indice de contamination des écosystèmes marins de l'Arctique. On recueille des œufs de trois espèces d'oiseaux de mer (guillemot de Brünnich, fulmar boréal et mouette tridactyle) à l'île Prince Leopold, dans le Haut-Arctique canadien, depuis 1975. À des fins de comparaison, on surveille également les concentrations de contaminants dans les œufs de guillemots de Brünnich à l'île Coats, dans le nord de la baie d'Hudson, depuis 1993, ainsi que chez deux autres espèces (guillemot à miroir et goéland bourgmestre) à l'île Prince Leopold. On a noté une différence significative entre les concentrations de mercure total dans

and the lowest, in the eggs of black-legged kittiwakes. Concentrations of dioxins (PCDDs) and furans (PCDFs) have decreased in the murres and fulmars at Prince Leopold Island since 1975 whereas levels of total mercury have increased.

les œufs enregistrées chez les cinq espèces surveillées ayant nidifié à l'île Prince Leopold en 2013, les plus fortes concentrations ayant été mesurées dans les œufs de goélands bourgmestres, et les plus faibles, dans les œufs de mouettes tridactyles. Les concentrations de dioxines (PCDD) et de furanes (PCDF) ont diminué dans les œufs des guillemots de Brünnich et des fulmars à l'île Prince Leopold depuis 1975, tandis que les concentrations de mercure total ont augmenté.

Key Messages

- Concentrations of dioxins and furans have decreased since 1975 in eggs of two Arctic seabird species, the thick-billed murre and northern fulmar, at Prince Leopold Island.
- Concentrations of total mercury (Hg) have significantly increased since 1975 in eggs of those same two Arctic seabird species at Prince Leopold Island with the major increases having occurred during the 1970s and 1980s.
- Significant interspecies differences were found for total Hg concentrations in eggs of five seabird species breeding on Prince Leopold Island in 2013, with the highest concentrations in the glaucous gull eggs and the lowest, in the eggs of black-legged kittiwakes.

Messages clés

- Les concentrations de dioxines et de furanes ont diminué depuis 1975 dans les œufs de deux espèces d'oiseaux de mer de l'Arctique, le guillemot de Brünnich et le fulmar boréal, à l'île Prince Leopold.
- Les concentrations de mercure total (Hg) ont augmenté de manière significative depuis 1975 dans les œufs de ces mêmes deux espèces à l'île Prince Leopold, de fortes hausses ayant été enregistrées dans les années 1970 et 1980.
- On a noté des différences interspécifiques significatives en ce qui concerne les concentrations de mercure total dans les œufs de cinq espèces ayant nidifié à l'île Prince Leopold en 2013, les plus fortes concentrations ayant été mesurées dans les œufs de goélands bourgmestres, et les plus faibles, dans les œufs de mouettes tridactyles.

Objectives

- To monitor contaminants in seabirds and their eggs as an index of contamination of Arctic marine ecosystems.
- In order to examine annual variation in the temporal trend data series, eggs are to be collected 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.
- To conform with the five-year cycle for monitoring Arctic seabird eggs, in 2013, eggs are to be collected from three additional species of seabirds (black-legged kittiwake, black guillemot, glaucous gull) breeding on Prince Leopold Island to continue the temporal trends established for those species.
- Collect adult birds for each of four species (thick-billed murre, northern fulmar, black-legged kittiwake, black guillemot) from Prince Leopold Island in 2013 to conform with the 10-year cycle to provide tissues for screening of emerging contaminants.

Introduction

Eggs of thick-billed murres (*Uria lomvia*), northern fulmars (*Fulmarus glacialis*) and black-legged kittiwakes (*Rissa tridactyla*) 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 have been standardized to every five years since 1988. In 1993, two additional species (black guillemots *Cepphus grylle*, glaucous gulls *Larus hyperboreus*) were added to the five-year egg monitoring cycle.

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 2007), 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 contaminants 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). Every five years, mostly recently 2013, eggs of three additional species (black-legged kittiwakes, black, guillemots and glaucous gulls) are analyzed for the legacy POPs, PBDEs and HBCD, as well as total Hg. All eggs are also analyzed for stable isotopes of nitrogen (N) and carbon (C) as indicators of trophic position and diet.

In their assessment of the Canadian Wildlife Service's long-term monitoring programs, Braune et al. (2003) recommended that "*Where possible, and where population numbers permit, collection of adult specimens every eight or ten years [should be made] to provide tissues for analyses of metals and new contaminants*". Based on this recommendation, collections of adult birds were made for four species of seabirds (thick-billed murre, northern fulmar, black-legged kittiwake, black guillemot) from Prince Leopold Island in 1993 and 2003-2004. To continue that sampling cycle, adult birds were again collected in 2013 to support projects: (i) to screen liver samples for non-targeted new compounds; (ii) to investigate the transfer of contaminants from adult female to her egg; and (iii) to follow-up on earlier work on ingested plastics found in the gastro-intestinal tracts of fulmars and murres (see Mallory 2008; Provencher et al. 2010).

Activities in 2013-2014

Sample Collection/Analysis

Eggs were collected by hand on the basis of one egg per nest from each of five species of seabirds (northern fulmar, n=15; thick-billed murre, n=15; black-legged kittiwake, n=15; glaucous gull, n=12; black guillemot, n=9) 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 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. All eggs were individually analyzed for total Hg and stable isotopes of nitrogen ($^{15}N/^{14}N$) and carbon ($^{13}C/^{12}C$).

Adult birds were either noosed followed by cervical dislocation (northern fulmar, n=10; thick-billed murre, n=10; black-legged kittiwake, n=10) or shot using steel shot (black guillemot, n=3). Carcasses were kept cool in the field prior to being frozen and shipped to the Nunavut Arctic College in Iqaluit where students dissected the birds under supervision as part of their study curriculum. Tissues have been archived in the National Wildlife Specimen Bank at Environment Canada's National Wildlife Research Centre in Ottawa. Of the adult birds sampled, five adult female northern fulmars and six adult female black-legged kittiwakes were collected with their respective eggs, facilitating a future investigation of the transfer of contaminants from adult female to her egg.

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-06B. Analyses of the standard 14 PBDE congeners and total-α-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 HPLC/MS/MS in negative electrospray mode (ESI-) according to NWRC Method No. MET-WTD-ORG-RES-PFC-02. PFASs analyzed include 10 PFCAs (including PFOA), 4 PFSAs (including PFOS), 3 FTUCAs, PFOSA and 3 FtOHs. Total mercury (Hg) is analyzed using an Advanced Mercury Analyzer (AMA-254) equipped with an ASS-254 autosampler for solid samples according to NWRC Method No. MET-CHEM-AA-03I. The method employs direct combustion of the sample in an oxygen-rich atmosphere. 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. 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). Both the NWRC and RPC laboratories have 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 2013, Enooyaq Sudlovenick from Iqaluit was hired to help organize field logistics and carry out field work on Prince Leopold Island. Josiah Nakoolak from Coral Harbour has been hired to help with the field work at Coats Island for more than 20 years and was hired again in 2013. Building on earlier successful collaborations between NWRC and the Nunavut Arctic College (NAC) program in Iqaluit, Nassivik funds were used again in 2013 to send Guy Savard (NWRC biologist) and Jennifer Provencher (graduate student) to Iqaluit to work with Nunavut Arctic College students, teaching them the proper protocols for dissection of birds in the context of marine bird research including contaminants work. In 2013, the program also included a presentation on contaminants in caribou (by NCP researcher Mary Gamberg) and a science communications workshop, as the first steps in expanding the scope of the program. With the addition of the caribou research component to the workshop, opportunities to integrate other northern research, other partners, and to expand the workshop to include a broader discussion of wildlife health in the north, was recognized and welcomed by the project team and the students.

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, including a presentation made by Mark Mallory (project team member) to the Resolute Bay HTA in March 2013 which gave an overall perspective on the seabird research program at Prince Leopold Island, as well as specifics on the NCP-supported work on contaminant monitoring and research in seabirds. Previous presentations on marine bird research at Coats Island, East Bay and other areas in the region were given at the school and elsewhere in Coral Harbour about every two years. Presentations were made by Grant Gilchrist (project team member) to the Coral Harbour HTO in April 2013. At the request of the community, the frequency of the presentations will be increased to anually. 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 2013-14 which included data from this project (see NCP Performance Indicators). As well, the *Coastlines* newsletter, which contains plain-language summaries of our work, was sent to HTAs, personnel at the NWMB, personnel at NRI, and personnel at the CWS in Nunavut in January 2014.

Traditional Knowledge Integration

It is difficult to incorporate new traditional knowledge annually into ongoing contaminants monitoring program focussed on established seabird colonies which have been studied for many years. In 2011, the annual marine bird dissection workshop held at the Nunavut Arctic College (NAC) was extended to include the Fur

Production and Design (FPD) class and the Inuit Studies Program from the NAC, pairing the larger program objectives with the traditional use of skins and meat. The collaborative work of Environment Canada with the NAC in Iqaluit, demonstrating the utilization of marine bird dissections in research, has been published in the journal *Arctic* (Provencher et al. 2013, see NCP Performance Indicators).

Results

Interspecies Comparison: The was a significant difference in total Hg concentrations in eggs of five species of seabirds breeding on Prince Leopold Island in 2013 ($F_{4,17}$ = 47.5, p<0.0001) with the highest concentrations found in the glaucous gull eggs and the lowest, in the eggs of black-legged kittiwakes (Figure 1, Table 1).

Intercolony Comparison

There was no significant difference found ($t_{1,28}$ = -0.93, p>0.05) in total Hg concentrations in eggs of thick-billed murres collected from Digges Island and Coats Island in 2013 (Table 1).

Temporal Trends

Total Hg concentrations adjusted for $\delta^{15}N$ have increased significantly in eggs of both thick-billed murres (r = 0.57, p<0.0001) and northern fulmars (r = 0.47, p<0.0001) at Prince Leopold Island between 1975 and 2013 but not in the eggs of black-legged kittiwakes (r = 0.52, p>0.05). Annual rates of increase as calculated by the statistical program PIA (Bignert 2013) were 1.7% and 1.0% in the murres and fulmars, respectively (Table 2). It would appear that after 2003, there was considerable inter-annual variability in the data for the murre and fulmar eggs, and that Hg concentrations were no longer steadily increasing (Figure 2). In fact, of the five seabird species that have been monitored at Prince Leopold Island since 1993, only glaucous gulls showed a significant trend for Hg concentrations in eggs (r = -0.70, p<0.01), and that was a decreasing trend between 1993 and 2013 (Figure 3). Therefore, it is clear that the major increases in Hg concentrations in seabird eggs at Prince Leopold Island occurred during the 1970s and 1980s.

Concentrations of total dioxins (SPCDD) and total furans (SPCDF) adjusted for d15N decreased significantly in eggs of both thick-billed murres (SPCDD: r = -0.68, p<0.0001; SPCDF: r = -0.67, p<0.0001) and northern fulmars (SPCDD: r = -0.93, p<0.0001; SPCDF: r = -0.92, p<0.0001) at Prince Leopold Island between 1975 and 2013 (Figure 4). Annual rates of decrease as calculated by the statistical program PIA (Bignert 2013) were -3.1% for SPCDD and -2.7% for SPCDF in the murres, and -5.0% for SPCDD and -4.3% for SPCDF in the fulmars (Table 3). The major declines occurred between 1975 and 2003 with concentrations leveling off after that time (Figure 4).

Figure 4. Mean (± SE) annual concentrations (pg g-1 lipid weight) of total PCDDs (SPCDD) and total furans (SPCDF) in eggs of thick-billed murres (bottom graph) and northern fulmars (top graph) collected from Prince Leopold Island, 1975-2013.

Figure 1. Mean (± SE) concentrations (µg g^{-1} dry weight) of total Hg in eggs of black-legged kittiwakes (BLKI), thick-billed murres (TBMU), northern fulmars (NOFU), black guillemots (BLGU) and glaucous gulls (GLGU) collected from Prince Leopold Island in 2013. Different letters indicate significantly different Hg concentrations among species.

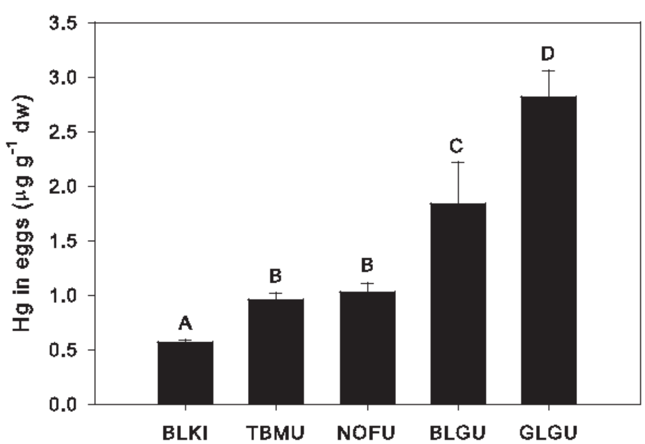

Table 1. Mean concentrations (± standard error) of total Hg (µg g⁻¹ dry weight) in eggs of black-legged kittiwakes, glaucous gulls, northern fulmars, black guillemots and thick-billed murres collected from Prince Leopold Island, Coats Island and Digges Island in 2013.

	Prince Leopold Island					Coats Island	Digges Island
	Black-legged Kittiwake	Glaucous Gull	Northern Fulmar	Black Guillemot	Thick-billed Murre	Thick-billed Murre	Thick-billed Murre
N	5	4	5	3	5	5	5
Hg	0.57 ± 0.019	2.82 ± 0.239	1.03 ± 0.076	1.84 ± 0.378	0.96 ± 0.060	0.62 ± 0.024	0.66 ± 0.033
d15N	14.9 ± 0.30	16.5 ± 0.16	13.4 ± 0.07	16.9 ± 0.15	15.6 ± 0.14	13.7 ± 0.7	14.6 ± 0.13

N = number of 3-egg pools

Figure 2. Mean (± SE) annual concentrations (µg g⁻¹ dry weight) of total Hg in eggs of black-legged kittiwakes, thick-billed murres and northern fulmars collected from Prince Leopold Island, 1975-2013.

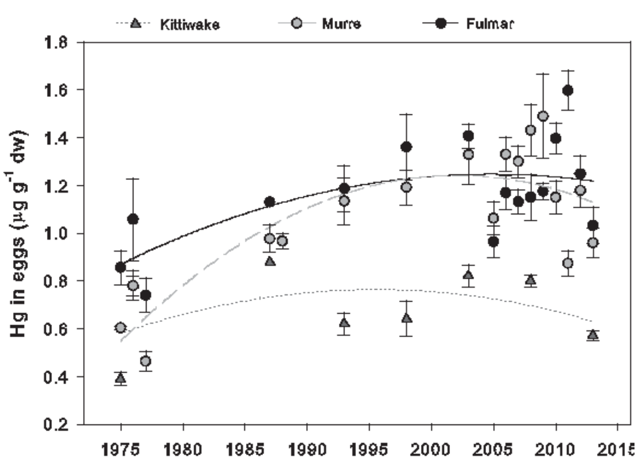

Figure 3. Mean (± SE) annual concentrations (mg g⁻¹ dry weight) of total Hg in eggs of black-legged kittiwakes, thick-billed murres, northern fulmars, black guillemots and glaucous gulls collected from Prince Leopold Island, 1993-2013.

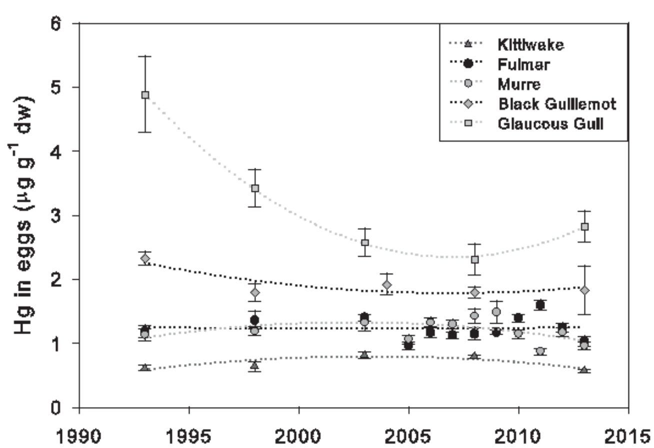

Table 2. Analysis of time trends for total mercury in eggs of three seabird species at Prince Leopold Island using the PIA program (Bignert 2013). Percent annual increase is significant ($p < 0.05$) unless otherwise noted.

Species	Range of monitoring years	# years sampled	Total # Samples1	% annual increase	LDC2 (%)
Thick-billed murre	1975-2013	17	75	+1.7%	3.2%
Northern fulmar	1975-2013	16	76	+1.0%	2.7%
Black-legged kittiwake	1975-2013	8	30	+0.4% ns3	16%

[1] Number of 3-egg pools.

[2] Lowest detectable change in current time series at power of 80%.

[3] ns = no statistically significant log-linear change ($p > 0.05$) in mean concentrations over time using the PIA program (Bignert 2007).

Table 3. Analysis of time trends for total dioxins (SPCDD) and total furans (SPCDF) in eggs of thick-billed murres and northern fulmars at Prince Leopold Island using the PIA program (Bignert 2013). Percent annual decline is significant ($p < 0.05$) unless otherwise noted.

	Range of monitoring years	# years sampled	Total # Samples1	% annual decline	LDC2 (%)
SPCDD					
Thick-billed murre	1975-2013	15	42	-3.1%	5.1%
Northern fulmar	1975-2013	14	40	-5.0%	6.1%
SPCDF					
Thick-billed murre	1975-2013	15	42	-2.7%	4.2%
Northern fulmar	1975-2013	14	40	-4.3%	5.1%

[1] Number of 5-egg pools.

[2] Lowest detectable change in current time series at power of 80%.

Discussion and Conclusions

Concentrations of total Hg varied significantly among the five seabird species sampled, with glaucous gull eggs having the highest concentrations and those of black-legged kittiwakes, the lowest (Figure 1). Differences in egg Hg concentrations among the species at Prince Leopold Island in 2013 followed the same pattern shown for those five species in 2003 and 2008 (NCP 2012). In a study including hepatic Hg concentrations for those five species sampled from the Northwater Polynya in 1998, Campbell et al. (2005) suggested that interspecies differences could be attributed to differences in trophic position with glaucous gulls feeding almost a full trophic level higher than kittiwakes. We, too, found trophic differences (as measured by d15N) among species, with the highest $\delta^{15}N$ values found for the glaucous gulls and guillemots, the two species with the highest Hg concentrations (Table 1). Many Arctic seabirds overwinter in areas far from their breeding colonies, thus diet in overwintering areas will also contribute to their exposure to contaminants. However, the situation is likely complex and involves other factors.

Total Hg concentrations have been increasing in eggs of thick-billed murres and northern fulmars from Prince Leopold Island since 1975 (Figure 2). In contrast, no significant trend was found for the black-legged kittiwakes (Figure 2) nor was there any significant trend found for any of the five species monitored since 1993 with the exception of a significant decreasing trend in the glaucous eggs from 1993 to 2013 (Figure 3). This apparent stabilization or, in some cases, decrease in Hg concentrations is also reflected in trends 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 anthropogenic and natural emissions coupled with environmental and biological (*e.g.*food-web) processes which may also be affected by climate change.

No significant difference was found for total Hg in eggs of thick-billed murres sampled from Coats Island and Digges Island in 2013 which confirms the results from 1993 (Braune et al. 2002) suggesting that contaminant data for murres from those two colonies are comparable.

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 including the PCDDs and PCDFs have decreased in eggs of thick-billed murres and northern fulmars monitored at Prince Leopold Island since 1975.

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 Char from the Canadian Arctic

Tendances temporelles et variations spatiales relatives aux polluants organiques persistants et aux métaux chez les ombles anadromes de l'Arctique canadien

- **Project Leader:**
  Marlene S. Evans, Environment Canada
  Tel: (306) 975-5310, Fax: (306)975-5143, Email: marlene.evans@ec.gc.ca

  Derek Muir, Environment Canada
  Tel: (905) 319-6921, Fax: (905) 336-6430, Email: derek.muir@ec.gc.ca

- **Project Team Members and their Affiliations:**
  Brenda Sitatak, Ekaluktutiak (Cambridge Bay) Hunters & Trappers Organization; Joshua Arreak, Mittimatalik (Pond Inlet) Hunters & Trappers Organization; Rodd Laing, Nunatsiavut Government; Jonathan Keating and Xiaowa Wang, Environment Canada

Abstract

With the exception of mercury monitoring at Cambridge Bay, this is the final year of our study investigating contaminant trends (spatial and temporal) in sea-run Arctic char. The study began in 2004 with sea-run char collected at 18 communities and Dolly Varden at two communities for investigations of mercury, other metals, and persistent organic contaminants. The overall rationale for the study was to provide high-quality and current data to support the assertion that contaminants are very low in sea-run char making them a good food choice for communities wishing to maintain a traditional diet. In 2013, sea-run char were collected from Ekaluktutiak (Cambridge Bay), Mittimatalik (Pond Inlet) in Nunavut and Nain

Résumé

À part la surveillance du mercure à Cambridge Bay, l'étude sur les tendances (spatiales et temporelles) relatives aux contaminants chez les ombles chevaliers anadromes en Arctique en est à sa dernière année. L'étude, entreprise en 2004, portait sur des ombles anadromes prélevés dans 18 collectivités et sur des Dolly Varden provenant de 2 collectivités; il s'agissait de mesurer les concentrations de mercure, d'autres métaux et de polluants organiques persistants dans ces poissons. L'objectif global de cette étude consistait à fournir des données actuelles, de haute qualité, à l'appui de l'hypothèse selon laquelle les concentrations de contaminants sont très faibles chez les ombles anadromes, ce qui en fait un bon choix alimentaire pour les membres

in Nunatsiavut and analyzed for mercury and metals. Mercury concentrations continued to be exceedingly low in char from the three locations and well below commercial sale guidelines. A previously reported significant (but weak) trend of increasing mercury concentrations at Cambridge Bay was no-longer statistically significant with the inclusion of 2013 data. Mercury concentrations in char from Nain showed no significant temporal trend over 1998-2013, while mercury concentrations in char from Pond Inlet showed a significant trend of decrease over 2005-2013. Persistent organic contaminant data were analyzed for time trends with contributions made to the next Arctic Monitoring and Assessment Programme report. No trends were evident in 12 compounds considered for Pond Inlet over 2004-2012; α and γHCH declined at Nain over 1998-2010; and Σchlordane and ΣDDT at Cambridge Bay over 1987-2013. The ability to detect time trends is severely limited by the short record, with most sites investigated only 5-7 times since 2004, and a limited historic record prior to 2004.

des collectivités qui souhaitent conserver une alimentation traditionnelle. En 2013, on a recueilli des ombles anadromes à Ekaluktutiak (Cambridge Bay) et à Mittimatalik (Pond Inlet), au Nunavut, et à Nain, au Nunatsiavut, puis on a analysé leur teneur en mercure et en métaux. Les concentrations de mercure continuaient d'être excessivement basses chez les ombles provenant de ces trois lieux, et elles étaient largement inférieures aux recommandations fixées pour la vente. Une tendance à la hausse des concentrations de mercure précédemment qualifiée de significative (quoique faible) à Cambridge Bay perdait son caractère significatif lorsqu'on incluait les données de 2013. Les concentrations de mercure dans les ombles de Nain n'ont dessiné aucune tendance temporelle significative au cours de la période de 1998 à 2013, tandis que l'on a noté une tendance à la baisse significative des concentrations de mercure chez les ombles de Pond Inlet de 2005 à 2013. On a analysé les données relatives aux contaminants organiques persistants pour y déceler des tendances, cela constituant une contribution au prochain rapport du Programme de surveillance et d'évaluation de l'Arctique. Aucune tendance n'était visible en ce qui concerne les 12 composés étudiés à Pond Inlet de 2004 à 2012; l'α- et le γHCH ont connu un déclin à Nain au cours de la période de 1998 à 2010; les concentrations de Σchlordane et de ΣDDT à Cambridge Bay ont aussi connu un déclin de 1987 à 2013. La capacité à détecter les tendances temporelles est gravement restreinte par la courte durée sur laquelle portent les relevés, la plupart des sites ayant été étudiés seulement cinq à sept fois depuis 2004, et les relevés historiques avant 2004 étant limités.

Key Messages

- Mercury concentrations were very low in sea-run char (i.e., well below the 0.5 mg·g^{-1} guideline for the commercial sale of fish).
- There was no trend in mercury concentrations in char at Cambridge Bay (1977-2013) and Nain (1998-2013) while mercury concentrations in char at Pond

Messages clés

- Les concentrations de mercure étaient très faibles chez les ombles anadromes (c'estàdire largement inférieures à la recommandation de 0,5 mg·g-1 fixée pour la vente des espèces commerciales de poissons).
- On n'a relevé aucune tendance relative aux concentrations de mercure chez les

Inlet (2005-2013) show a significant trend of decrease.

- Concentrations of legacy contaminants (DDTs, CBz, HCH, chlordane, HCB and PCBs) were low.
- The detection of temporal trends is limited by the shortness of the record and number of years (generally 5-7 years) in which fish were analyzed.

ombles à Cambridge Bay (1977 à 2013) et à Nain (1998 à 2013), tandis qu'à Pond Inlet, les concentrations de mercure dans les ombles ont décrit une tendance à la baisse significative de 2005 à 2013.

- Les concentrations de contaminants hérités du passé (DDT, CBz, HCH, chlordane, HCB et PCB) étaient faibles.
- La détection des tendances temporelles est restreinte par la courte durée sur laquelle portent les relevés et par le nombre d'années (en général cinq à sept) où des poissons ont été analysés.

Objectives

1. Determine levels of persistent organic pollutants (POPs) and metals (including mercury) as well as "new" POPs in sea-run char harvested by Arctic communities.
2. Investigate the role of factors such as fish age, trophic feeding, climate, and location in affecting contaminant body burdens and trends.
3. Contribute to AMAP and CACAR assessments of long-term trends in metals and POPs in the Arctic and subarctic and the factors affecting such trends.
4. Provide results and explain in a timely manner so that appropriate advice can be given on consuming sea-run char.

Introduction

In 2004, the Northern Contaminants Program (NCP) included sea-run Arctic char in its monitoring design in order to provide communities with essential information on contaminant levels in this species; char are of historic and continuing importance to the domestic and, in some instances, commercial fisheries. Historic data suggested that sea-run char tend to have lower concentrations of mercury and persistent organic contaminants than marine mammals and landlocked char (Johansen et al. 2004, Braune et al. 2005, Evans et al. 2005) making them good food choices for those wishing to consume country foods while limiting contaminant intake. However, data on contaminant concentrations in char were limited and confined to historic mercury analyses made as part of the fish inspection service measurements (Lockhart et al. 2005) and early persistent organic measurements (Muir et al. 1990). In both instances a small number of fish were measured; in the case of organic contaminants, analytical methods have since been improved in their sensitivity to distinguish a variety of compounds. More recent studies of char have focused on landlocked and resident char populations in systems that are not important to the domestic fishery (Gantner et al. 2010a, Gantner et al. 2010b, Swanson and Kidd 2010) or, more recently, comparisons of mercury concentrations in resident versus migratory char (Swanson et al. 2011, van der Velden et al. 2013a, van der Velden et al. 2013b).

The sea-run char monitoring program began in 2004 with char collected from six communities across the Arctic and persistent organic contaminants and metals, including mercury, were measured (Evans and Muir 2008, 2009, 2010). In 2011, the monitoring was scaled back to three communities (Nain, Cambridge Bay, and Pond Inlet) and in 2012 only Cambridge Bay and Pond Inlet contributed to the monitoring program (Evans and Muir 2012). In 2013, Nain was added again as a sampling site, but the suite of analyses reduced.

Activities in 2013-2014

In fall 2013, 20 sea-run char were harvested by local fisherman from Cambridge Bay, Pond Inlet, and Nain; fish were subsequently frozen and shipped whole to Saskatoon where sample processing began. Length, weight, age, and gender were determined on all fish from each location along with liver and gonad weight, and stomach fullness; notations were made of the presence of parasites and/or disease where appropriate. A fillet sample, as well as the liver and stomach were retained from each fish and added to our archive. Archived samples are maintained at -40°C in a walk-in freezer at the National Hydrology Research Centre which has a monitoring system overseen by commissionaires 24-hours a day, 365 days a year.

Carbon and nitrogen isotope and percent moisture analyses were performed on all fish from each location. Ten of the twenty fish from each location were selected for mercury and metal analyses. In contrast to previous years, legacy organic contaminants, PDBE and PFA analyses were not conducted in 2013.

Results of our research to date have been reported (Evans and Muir 2013); we also contributed to CACAR and AMAP expert work groups. A review and synthesis was conducted of the general state of knowledge of sea-run char populations across northern Canada with a focus on assessments of standing stocks and spatial and temporal variability in mercury concentrations (Evans et al. 2014) and contributions to a recent review manuscript on mercury in the marine environment (Braune et al. 2014). In addition, time trend analyses were conducted of 12 persistent organic contaminants in sea-run char from three locations (Pond Inlet, Cambridge Bay and Nain) and results provided to AMAP.

Results and Discussion

Spatial variations in char populations

Char provided over 2004-2012 for this study ranged in mean fork length from 408 ± 45 mm (Hopedale) to 710 ± 67 mm (Resolute; Fig. 1). Size differences appear to be related to relative harvesting pressures with smaller fish generally associated with areas of significant fishing pressures relative to fish population size, i.e., NWT communities, Iqaluit and Sanikiluaq in Nunavut, and Nain and Hopedale in Labrador. Char populations varied in age from 5.1 ± 1.1 yr at Puvirnituq (eastern Hudson Bay) to 19.2 ± 2.1 yr in the Resolute area (Creswell Bay, Cornwallis Island) with older populations associated with higher latitudes where growth rates were slow and fishing pressures light. Lipid content generally ranged from 5.0 ± 2.3 % (Hopedale) to 13.3 ± 3.7 % (Rat River) with the high lipid content for Holman fish due to the fact that ventral fillet rather than dorsal fillet was analyzed. Factors affecting variation in lipid content have not been explored but could be related to fish age (fish tend to become more lipid rich with age), local conditions affecting food availability, and climate with fish having higher condition factors and possibly lipid content during warm and early springs.

Spatial and temporal variations in mercury concentrations

Mercury concentrations (n=496) were low in char ranging from 0.001-0.62 $\mu g \cdot g^{-1}$ and averaging 0.05 ± 0.04 $\mu g \cdot g^{-1}$. Only 1.6% of the fish analyzed had mercury concentrations >0.154 $\mu g \cdot g^{-1}$; some of these fish may have been resident fish caught in the rivers as part of the return sea population (*e.g.*, Hornaday River, Vittrekwa River). Lowest site mean mercury concentrations were at Cape Dorset (0.01 ± 0.01 $\mu g \cdot g^{-1}$) and the highest at Paulatuk (0.10 ± 0.14 $\mu g \cdot g^{-1}$). Higher site mean mercury concentrations tended to be associated with larger fish and higher latitudes although mercury concentrations were relatively high in Vittrekwa River Dolly Varden despite their small size and age. These fish had a relatively low condition factor (0.82 ± 0.03).

Time trends in mercury concentrations were examined for Cambridge Bay, Pond Inlet and Nain char, the three sites investigated in 2013 (Fig. 2). Trend analyses were conducted used PIA software (Bignert 2007) and Systat 13; analyses were based on log-transformed data with fork length as a covariate. The longest record is for Cambridge Bay, the site of a long-term commercial fishery. While average mercury concentrations have declined in recent years, there was no trend over 1977-2013 when fish length was considered (Table 1). The early record is constrained by the fact that small fish were analyzed in 1977 (mean length 538 mm versus 634-756 mm over 1992-2013) and length was not determined in 1978. However, there was no significant trend in mercury concentrations in Cambridge Bay char when analyses were limited to 1992-2013. Nor was the trend significant for char at Nain over 1998-2013.

For Pond Inlet, the mercury trend of decline over 2005-2013 was significant and consistent with the decline observed for landlocked char populations on Cornwallis Island (Amituk, Char and Resolute lakes) over 2005-2013 (Muir et al. 2013). The reason for the decline in mercury concentrations in char in the northern Baffin Island-Cornwallis Island area is uncertain as the Arctic is undergoing an overall warming trend; warming trends have been related to earlier spring blooms, enhanced productivity, faster growth rates of char and higher mercury concentrations in burbot (Outridge et al. 2007, Harwood et al. 2009, Carrie et al. 2010). Muir et al. (2013) suggested that the mercury decline in landlocked char could be related to high rates of photo-methylation and less mercury being taken up by biota. However, faster growth rates with increased productivity could also result in biodilution of mercury in fish tissue. Finally, mercury concentrations could be decreasing as emissions from Europe continue to decline (Cole et al. 2011).

Spatial and temporal trends in legacy and emerging POPs

Persistent organic contaminants were low in char in our four regions investigated. The predominant legacy contaminants were PCBs, chlorobenzenes, chlordanes, DDTs, and HCHs. p,p'-DDE was a significant component of total DDT particularly for northern Quebec and Labrador. HCH concentrations were lowest in N. Quebec and Nain with αHCH predominating.

Temporal trends in legacy and emerging POPs for char from Cambridge Bay, Pond Inlet and Nain were examined using PIA (Bignert 2007); analyses were based on log-transformed data with %lipid as a covariate. The longest record is for Cambridge Bay with individual fish data available for αchlordane and αDDT from studies conducted in 1987 (Muir et al. 1990); both compounds showed a significant trend of decline over the period of record. For the other legacy compounds considered, temporal trends were not statistically significant although there was evidence of declining PCB concentrations and increasing DDE concentrations. For Pond Inlet, investigated over 2004-2012, trends in legacy contaminant concentrations were not significant although αHCH exhibited a weak trend of decrease (p<0.054). At Nain, where data are available for 1998, αHCH and αHCH exhibited significant trends of decrease. Decreases in α and αHCH and αchlordane appear to be related to declining atmospheric concentrations (Hung et al. 2010); half-lives of these compounds in the air at Alert over 1993-2001 were 5-7 years with shorter times over 2002-2005. The fact that declines have not been detected in char suggests that exposures in water and food have not declined as the same rate as in the air. Atmospheric concentrations of PCBs have also declined but these trends cannot be detected in the char populations monitored, possibly in part because these compounds are so persistent in biota and the temporal record limited. No time trends were detected in BDE47 and BDE 99 but the number of years available for analyses is small.

Figure 1. Average (± 1 standard deviation) fork length, age, percent lipid (fillet) and mercury concentrations (fillet) of sea-run char by community over 2004-2013. The horizontal line is the mean value for that parameter measured.

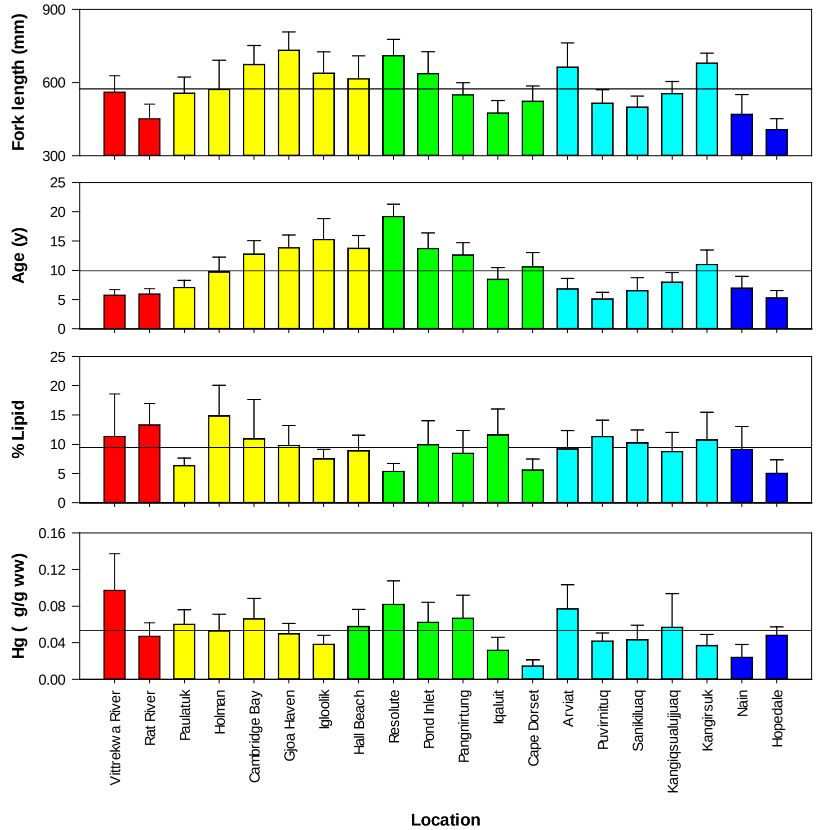

Figure 2. Temporal variations (mean ± 1 standard deviation) in mercury concentrations in sea-run char at Cambridge Bay, Pond Inlet and Nain.

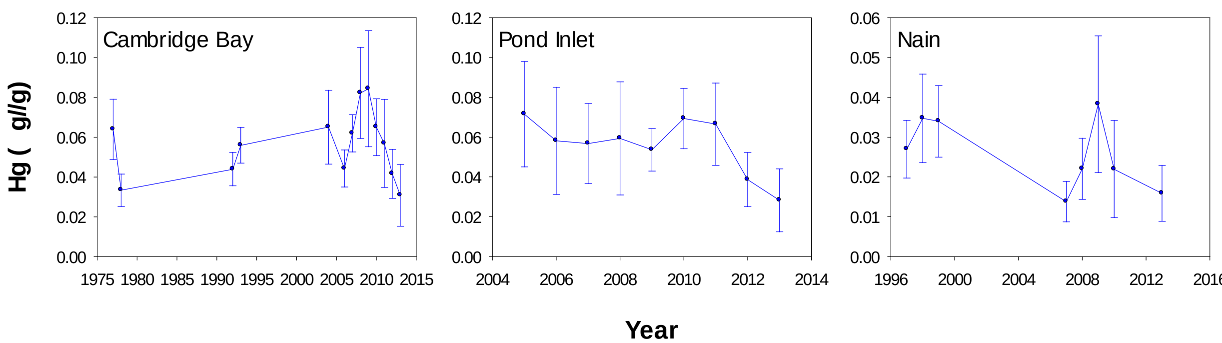

Table 2. Time trends in lipid-adjusted persistent organic contaminant concentrations in sea-run char from Cambridge Bay, Nain, and Pond Inlet. Data are shown as the slope (% annual change per year) with R^2, the proportion of variance explained by the regression shown in parentheses below. Statistically 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
Hg	-0.3	0.01	**-7.3**	**0.48**	-3.7	0.30
% Lipid	+0.12 (8)	0.00	+1.9 (7)	0.06	+3.2	0.37
αHCH	+0.9 (7)	0.00	-15 (7)	0.55	**-10 (5)**	**0.86**
αHCH	+2.8 (7)	0.02	+4.4 (7)	0.11	-0.6	0.01
αHCH	-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
αPCB10	-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
αCHL	**-8.5 (8)**	**0.77**	3.9 (7)	0.10	+4.6 (5)	0.37
αDDT	**-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).

2 Pond Inlet record is 2005-2012 (6 years) or 2005-2010 (7 years).

3 Nain record is 1998 (5 years) or 2007 (4 years) to 2010.

Table 1, Mean (± standard deviation) concentrations ($ng \cdot g^{-1}$ wet weight) of legacy and emerging organic contaminants in sea-run char collected over the 2004-2015 from the 20 community harvesting areas investigated in this study. N.d. = no data.

Parameter	NWT	Nunavut	N. Quebec	Labrador	All
% Lipid	15.73+10.22	9.73+5.2	9.49+3.63	8.14+4.06	10.37+6.14
αCBz	4.26+3.73	3.35+2.24	2.9+1.12	1.81+1.09	3.26+2.33
αCHL	5.35+4.09	4.96+3.63	4.3+2.91	3.09+1.73	4.76+3.49
Dieldrin	1.08+0.87	2.08+6.59	1.43+0.58	1.18+0.71	1.79+5.29
p,p'-DDE	0.51+0.43	0.89+0.82	1.86+1.49	1.43+0.97	1.04+1.02
αDDT	2.64+1.66	2.45+2.01	3.69+2.57	2.44+1.34	2.66+2.05
HCB	3.61+3.16	2.87+2.01	2.65+1.05	1.57+0.97	2.82+2.05
αHCH	2.15+2.04	2.01+2.45	0.90+0.66	0.91+0.51	1.77+2.15
αHCH	0.71+0.53	0.43+1.14	0.22+0.12	0.24+0.15	0.42+0.95
αHCH	0.31+0.32	0.29+0.51	0.08+0.06	0.16+0.1	0.25+0.43
αHCH	2.96+2.74	2.5+2.00	1.16+0.83	1.31+0.74	2.26+1.98
CB153	0.56+0.46	0.63+0.49	0.89+0.56	1.39+0.98	0.74+0.63
αPCB10	3.06+2.77	2.81+1.8	3.65+1.97	4.51+2.69	3.15+2.17
αPCB	11.25+9.41	10.27+7.04	12.43+6.6	13.5+7.88	11.1+7.55
αPBDE	0.65+0.81	0.73+0.82	0.88+0.82	0.42+0.34	0.72+0.79
αPFC	n.d.	0.35+0.36	n.d.	0.4+0.08	0.36+0.33

Conclusions

Mercury concentrations were low in sea-run char with the most recent analyses showing an unexpected trend of decrease at Pond Inlet. Persistent organic contaminant concentrations also were low with the detection of temporal trends limited by the shortness of the record and measurement years (generally 5-7 years). For Cambridge Bay, chlordane and DDT concentrations were significantly lower over 2004-2012 than 1987 while α and αHCH concentrations declined significantly over Nain over 1998-2010.

Expected completion date

This is a core trend monitoring project with monitoring expected to continue with the NCP program.

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Temporal Trends of Persistent Organic Pollutants and Mercury in Landlocked Char in High Arctic Lakes

Tendances temporelles relatives aux polluants organiques persistants et au mercure chez les ombles chevaliers confinés aux eaux intérieures, dans les lacs du Haut-Arctique

Project Leader:

Derek Muir, Environment Canada, Aquatic Contaminants Research Division
Tel: (905) 319-6921, Fax: (905) 336-6430, Email: derek.muir@ec.gc.ca

Günter Köck, Austrian Academy of Sciences
Tel: +43 1 51581 1271, Fax: +43 1 51581 1275, Email: guenter.koeck@oeaw.ac.at

Xiaowa Wang, Environment Canada, Aquatic Contaminants Research Division
Tel: (905) 336-4757, Fax: (905) 336-6430, Email: xiaowa.wang@ec.gc.ca

Project Team Members and their Affiliations:

Debbie Iqaluk, Resolute Bay NU; Paul Drevnick and Karista Hudelson, Institut National de la Recherche Scientifique ; Mary Williamson and Amy Sett, Environment Canada, Aquatic Contaminants Research Division; Resolute Bay Hunters and Trappers; Ed Sverko and Enzo Barresi, Environment Canada, National Laboratory for Environmental Testing Organics; Bert Francoeur and Jacques Carrier, National Laboratory for Environmental Testing Inorganics; Jane Chisholm, Alex Stubbing, and Doug Stern, Parks Canada, Nunavut Field Unit

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, Char, North, Small, and Resolute) and in Lake Hazen in Quttinirpaaq National Park on Ellesmere Island. In 2013, arctic char samples were successfully collected from all lakes except Char Lake. With the addition of results from 2013 we found declining trends of mercury in char in Amituk, Char, North, and Resolute lakes.

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 dans des ombles chevaliers confinés aux eaux intérieures 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 2013, on a réussi à prélever des échantillons d'ombles chevaliers dans tous les lacs, sauf le lac Char.

No change in mercury was found for char from Lake Hazen. Legacy POPs are continuing to decline in char in all lakes except in Resolute Lake where PCBs, DDT and chlordane-related chemicals continued to show no change, and toxaphene increased. Replacements for banned brominated flame retardants are increasing in Amituk, Char and Resolute lakes and were detected for the first time in Lake Hazen.

L'ajout des données de 2013 a permis de déceler des tendances à la baisse du mercure dans les ombles chevaliers des lacs Amituk, Char, North et Resolute. On n'a noté aucune variation du mercure chez les ombles du lac Hazen. Les POP hérités du passé continuent de décliner dans les ombles de tous les lacs, sauf le lac Resolute, où les concentrations de PCB, de DDT et de composés apparentés au chlordane demeurent stables, et où les concentrations de toxaphène ont augmenté. Les concentrations des produits de remplacement des produits ignifuges bromés interdits s'accroissent dans les lacs Amituk, Char et Resolute, et on a détecté leur présence pour la première fois dans le lac Hazen.

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.
- While most legacy POPs such as hexachlorocyclohexanes, PCBs and DDT are declining some newer flame retardant chemicals are increasing.

Messages clés

- Les concentrations de mercure dans 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.
- Alors que la plupart des POP, comme les hexachlorocyclohexanes, les PCB et le DDT sont en déclin, les concentrations de certains nouveaux produits chimiques ignifuges croissent.

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. Research in the past 5 years has provided much new information on mercury in landlocked char populations and their food webs (Gantner et al. 2009; 2010a; 2010b, Swanson and Kidd 2010, Swanson et al. 2010, Chételat et al. 2008; 2010, van der Velden et al. 2013a; 2013b, Lescord et al. 2014).

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 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 beens 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. 2009; 2010; 2011; 2012; 2013a).

Collection in Char Lake was discontinued following the 2012 fishing season due to poor success for char of >200 g size (Muir et al. 2013a). 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. 2014).

Activities in 2013-14

Sample collection

Char were successfully collected in late July 2013 from Amituk, Hazen, North, Small, and Resolute lakes (Table 1). At Lake Hazen the collections were successfully carried out 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

Methodology for organochlorine pesticides (OCPs), PCBs, polybrominated diphenyl ethers (PBDEs) in char samples was identical to that used for 2012 samples (Muir et al. 2013a). Tissue samples were spiked with $^{13}C_{12}$-PCB-133- prior to extraction. The tissues were mixed with anhydrous sodium sulfate 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 50 µL portion of each extract was removed for both OCP and PCB analyses. A suite of ^{13}C labeled PCBs was added to the PCB extracts for target analyte quantification and retention time references. Similarly a suite of deuterium and ^{13}C- 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 $^{13}C_{12}$ PCB-133 response.

Toxaphene, endosulfan isomers and endosulfan sulfate, PBDEs and hexabromo-cyclododecane (HBCDD) and bis(tribromophenoxyethane (BTBPE) were analysed by NLET organics lab with low resolution GC-negative ion mass spectrometry (GC-NIMS) using a subsample of the extract provided by ALSGlobal. Toxaphene was determined as "total" toxaphene using a technical toxaphene standard and also by quantification of individual chlorobornanes (Muir et al. 2004). Perfluorinated alkyl substances (PFASs) in char muscle were analysed in the Muir lab as described in Reiner et al. (2012).

Thirty-two 32 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 200°C for 15 minutes and the digest was analysed by ICP-MS. Mercury was analyzed from the same digest by using cold vapor atomic absorption spectrometry.

Stable isotope analyses

Muscle from all fish analysed for mercury and POPs were analysed for stable isotopes of carbon (d^{13}C) and nitrogen (d^{15}N) 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 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, and PBDEs. 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.

NLET organics and metals labs as well as ALS Global (Burlington) are participants in the NCP Quality Assurance Program and are accredited by the Standards Council of Canada through Canadian Environmental Analytical Laboratory program. PFASs were determined in the Muir lab at Environment Canada Burlington and this lab participated in the NCP Interlab comparison. The Muir lab also participated in the NCP interlab comparison for mercury for 2013-14.

Statistical analyses

Based on previous data analyses (Muir et al. 2013a) results for all elements and POPs were log10 transformed in order to reduce coefficients of skewness and kurtosis to <2. Geometric mean concentrations and upper/lower 95% confidence intervals were calculated with log transformed data and back transformed for graphical presentation. Results for POPs were lipid adjusted by dividing by fraction lipid. Non-detect concentrations were replaced with a random number between 10% and 50% of the instrumental detection limit.

Results

Mercury

Trends of mercury in char muscle, updated with results from 2013, 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 Amituk, Char, North, and Resolute lakes. 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 have achieved the NCP objective of detecting a 10% change with 80% power.

POPs: Trends for legacy and newer listed POPs are based on samples collected up 2012. Results for analysis of the 2013 samples are pending. Alpha-HCH declined more rapidly than all other POPs with an annual decline of -6.5 to -12 %/yr (Table 2). αHCH actually increased in char from Hazen Lake, however, it makes up only 5 to 7% of ΣHCH; the other components β and γ HCH isomers are declining. ΣDDT, ΣCHL, and ΣPCBs declined significantly in Char, Amituk and Hazen lakes but the decline in Resolute Lake was not statistically significant. Toxaphene concentrations declined significantly in Amituk Lake while declines in Char and Hazen Lakes were not statistically significant. In Resolute Lake, toxaphene showed an overall increasing trend due to recent higher concentrations. Since this increase only occurred at Resolute Lake it may be related to a local source within the watershed which is an area that includes Resolute airport and the former Department of Transport "North Base" (Douglas and Smol 2000). On the other hand, there is no evidence for local contamination of Resolute Lake by toxaphene. Mean concentrations of toxaphene over the period 2003-2009 were highest in Amituk and Char Lake and lowest in Resolute Lake (Muir et al. 2013b).

Trends for ΣPBDEs (sum of 14 BDEs; major congeners 47, 99, and 100) in landlocked char vary widely among lakes. ΣPBDE concentrations increased overall in all lakes compared to the 1990s but are now declining in Amituk and Resolute lakes (Table 2). No decline of ΣPBDEs has been observed in char from Char Lake. ΣPBDE concentrations continue to increase in Lake Hazen char, although the trend from 2001 to 2012 is not statistically significant.

New POPs: HBCDD and BTBPE, which are both replacements for PBDE flame retardants, have continued to be detected in char muscle from Amituk, Char and Resolute lakes at low ng/g (lipid weight) concentrations. BTBPE was also detected in Lake Hazen char for the first time in 2012 at low levels (geometric mean (N=10), 0.33 ng/g lipid wt) while HBCDD remained below method detection limits (<0.1 ng/g lipid weight).

Short chain chlorinated paraffins (SCCPs) were detected in Resolute Lake char samples from 2010 at low concentrations (geometric mean = 0.12 ng/g wet wt, N=8). This was part of a preliminary survey of arctic fish extracts previously analysed for legacy POPs. Cl_5-Cl_6-undecanes were the predominant SCCP chain length group in the char. These SCCPs concentrations in char are relatively low compared to lake trout from lakes across Canada which had mean SCCP concentrations ranging from 2.2 to 9.6 ng/g wet weight (whole fish homogenates) (Saborido-Basconcillo et al. 2014).

Figure 1. Mercury concentrations (mean and 95% confidence intervals) in landlocked char muscle from Resolute Lake along with average monthly maximum temperatures for June-July each year and average monthly temperatures for May-August each year.

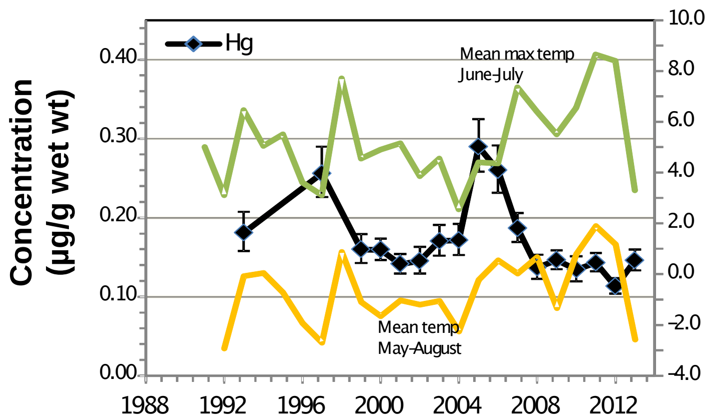

Table 1. PIA analysis of time series for recent (2005-2013) mercury concentrations in landlocked char muscle (NS = not statistically significant)

Lake	Interval	# years	Overall trend	R2	LDC 2	Power 3
Amituk	2005-13	8	-7.8%	0.48	14%	53%
Char	2005-12	7	-19%	0.65	27%	20%
Hazen	2005-13	8	-1.3% (NS)	0.01	31%	16%
North	2005-13	6	-6.3%	0.41	10%	35%
Small	2005-13	8	+3.7%	0.03	47%	10%
Resolute	2005-13	8	-7.4%	0.82	4.3%	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 POPs[1] in arctic char from the four study lakes using the PIA program (Bignert 2007). PIA was run using wet weight concentrations and adjusting for mean lipid value

	Time period	Sampling Years	Toxa-phene2	SPCB	SDDT	a-HCH	b-HCH	SPBDEs3
Amituk	1989-2012	12	-6.9*	-7.8*	-8.8*	-12.0*	-6.4	60
	2003-2012	3	-	-	-	-	-	-7.4
Char	1993-2012	12	-2.7	-7.2*	-8.6*	-10.0*	-4.0	-3.8
Hazen	1990-2012	12	-5.4	-5.4*	-9.3*	-6.5*	3.6	2.5*
	2001-2012	8	-	-	-	-	-	10
Resolute	1997-2012	15	24*	-7.5	-4.2	-7.0*	-0.13	13*
	2005-2012	6	-	-	-	-	-	1.7

[1] * indicated statistically significant trend (P <0.05)

[2] Results for toxaphene have 2 or 3 fewer years than other analytes

[3] Results for PBDEs generally from the 1990s to early-00s; dates shown in the time period column

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). Riget et al (2010) found that length adjusted mercury concentrations in landlocked char from a lake in southwestern Greenland increased significantly over the period 1994 to 2008 (6 sampling years) and was tentatively linked to increasing mean monthly air temperature during May to August although correlations were not statistically significant due to small number of sampling times. Preliminary analyses of the mercury in char for Resolute Lake does not show a significant relationship to mean monthly May-August temperatures or to mean maximum June-July temperatures based on data from the Resolute Bay weather station (Figure 1)

The detection of SCCPs for the first time in landlocked char may reflect long range transport and deposition. Tomy et al. (1999) and Stern et al. (2005) previously showed that SCCPs were present in remote Arctic lake sediments. However, in the case of Resolute Lake, local sources cannot be ruled out so follow-up work will be done using fish from other lakes. In the case of HBCDD and BTBPE, the detection in Amituk Lake which is remote from sources on Cornwallis Island makes it clear that the source is atmospheric deposition. The detection of BTBPE in Lake Hazen for the first time in 2012 will be followed up to determine if this is the beginning of an increasing trend as observed in Resolute, Char and Amituk (Muir et al. 2013b). Unfortunately the shift to sampling every two years will mean that the next analyses for these new chemicals will be in 2015. Thus our ability to detect changes in these replacements for PBDEs will be more limited in the future.

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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 tendances à long terme relatives aux contaminants organiques persistants et aux métaux chez les touladis et les lottes des Territoires du Nord-Ouest

- **Project Leader:**
  Marlene S. Evans, Environment Canada
  Tel: (306) 975-5310, Fax: (306) 975-5143, Email: marlene.evans@ec.gc.ca

  Derek Muir, Environment Canada, Aquatic Contaminants Research Division
  Tel: (905) 319-6921, Fax: (905) 336-6430, Email: derek.muir@ec.gc.ca

- **Project Team Members and their Affiliations:**
  Rosy Bjornson, Diane Giroux, and Patrick Simon, Akaitcho Territory Government (Fort Resolution, NT); Sonya Almond, Mike Tollis, and Steve Ellis Lutsel K'e Dene First Nation (Lutsel K'e, NT); George Low and Mike Low, Aboriginal Aquatic Resource and Oceans Management Program (Hay River, NT); Xinhua Zhu, Fisheries and Oceans Canada; Jonathan Keating, and Xiaowa Wang, Environment Canada

Abstract

Our Great Slave Lake study is investigating temporal trends in mercury and persistent organic pollutants (POPs) in lake trout provided from the commercial fishery operating in the West Basin and the Lutsel K'e domestic fishery in the East Arm. Burbot are being monitored from the domestic fishery at Fort Resolution, located at the Slave River inflow. We also have been collecting Fort Resolution northern pike and Lutsel K'e burbot for mercury trend monitoring. Mercury concentrations show significant trends of increases for lake trout and burbot but not for northern pike: average mercury concentrations for a given species, year and location are well below the 0.5 μg·g^{-1} commercial sale guideline for

Résumé

Cette étude, menée au Grand lac des Esclaves, porte sur les tendances temporelles relatives au mercure et aux polluants organiques persistants (POP) chez les touladis provenant de la pêche pratiquée à des fins commerciales dans le bassin ouest et de la pêche pratiquée à des fins domestiques par la collectivité de Lutsel K'e dans le bras est. On a surveillé les lottes issues de la pêche pratiquée à des fins domestiques à Fort Resolution, à l'*embouchure de la rivière des Esclaves*. On a aussi prélevé des grands brochets à Fort Resolution de même que des lottes dans la collectivité de Lutsel K'e, cela pour y surveiller les tendances relatives au mercure. On a relevé des tendances à la hausse significatives pour le mercure chez les

fish. Contributions were made to the CACAR mercury assessment report and review papers. With respect to POPs and Great Slave Lake, we contributed to the AMAP POPs assessment report by examining trends and the statistical power of our data sets. Many POPs are declining in concentration with trends most evident in West Basin fish and burbot in particular. We continued to work with George Low under the Deh Cho Aboriginal Aquatic Resource and Oceans Management mercury assessment program in small lakes in the Fort Simpson area; mercury concentrations are higher than in Great Slave Lake with some evidence of temporal increases. Community interactions remain strong including contributions to the AAROM workshop and to Fort Resolution's water intake monitoring program. We contributed to a study of mercury and radionuclides in lake trout from Stark Lake (near Lutsel K'e) and collected sediment cores from western Great Slave Lake, Stark Lake and Kasika Lake in March 2014.

touladis et les lottes, mais pas chez les grands brochets : les concentrations moyennes de mercure pour une espèce, une année et un lieu donnés sont largement inférieures à 0,5 $\mu g \cdot g^{-1}$, qui est la recommandation fixée pour la vente des espèces commerciales de poissons. On a contribué à l'évaluation du mercure dans le Rapport de l'évaluation des contaminants dans l'Arctique canadien (RÉCAC) et à des articles de synthèse. En ce qui concerne les POP et le Grand lac des Esclaves, on a contribué à l'évaluation des POP dans le cadre du Programme de surveillance et d'évaluation de l'Arctique par l'examen des tendances et de la puissance statistique des ensembles de données dont on disposait. La concentration de bien des POP est en déclin; c'est chez les poissons du bassin ouest, particulièrement les lottes, que ces tendances sont le plus évidentes. On a continué de travailler avec George Low dans le cadre du programme d'évaluation du mercure dans de petits lacs de la région de Fort Simpson, en lien avec le Programme autochtone de gestion des ressources aquatiques et océaniques (PAGRAO) de Deh Cho; les concentrations de mercure y sont plus élevées que dans le Grand lac des Esclaves, et certains éléments indiquent des hausses au fil du temps. Les interactions avec les collectivités demeurent importantes; on peut citer la participation à l'atelier du PAGRAO et au programme de surveillance de l'eau d'approvisionnement de Fort Resolution. On a contribué à une étude du mercure et des radionucléides chez les touladis du lac Stark (près de la collectivité de Lutsel K'e) et on a prélevé des carottes de sédiments dans l'ouest du Grand lac des Esclaves, dans le lac Stark et dans le lac Kasika en mars 2014.

Key messages

- Mercury is showing a trend of increase in Great Slave Lake burbot and lake trout although average concentrations remain below commercial sale guidelines (0.5 $\mu g \cdot g^{-1}$).

Messages clés

- On enregistre une tendance à la hausse du mercure chez les lottes et les touladis du Grand lac des Esclaves, même si les concentrations moyennes demeurent inférieures à la recommandation fixée pour la vente des espèces commerciales de poissons (0,5 µg·g-1).

- Persistent organic contaminants occur in relatively low concentrations in lake trout (fillet) and burbot (liver) with concentrations greater in burbot liver than lake trout fillet; in general contaminants are higher in East Arm fish.
- Many POPs are showing evidence of temporal decline, particularly in burbot liver. Declines are more commonly observed in West Basin than East Arm lake trout.
- Mercury concentrations are higher in predatory fish in the small lakes west of Great Slave Lake with some evidence of temporal trends of increase.

- Les contaminants organiques persistants sont présents en concentrations relativement faibles chez les touladis (filet) et les lottes (foie); les concentrations de ces substances sont plus élevées dans le foie de lotte que dans le filet de touladi. De manière générale, les concentrations de contaminants sont plus fortes chez les poissons du bras est.
- On note des signes de déclin des concentrations de nombreux POP au fil du temps, en particulier dans le foie de lotte. C'est chez les touladis du bassin ouest et du bras est que ces baisses ont été observées surtout.
- Les concentrations de mercure sont plus élevées chez les poissons prédateurs des petits lacs à l'ouest du Grand lac des Esclaves, et certains éléments indiquent des tendances à la hausse au fil du temps.

Objectives

- Determine mercury and persistent organic contaminant concentrations in lake trout harvested from two locations (West Basin near Hay River, East Arm at Lutsel K'e) and burbot harvested from one location (West Basin at Fort Resolution) in Great Slave Lake to further extend the long-term (1993-2012) database. Also determine metals (30) concentrations and assess biological features of the fish being analyzed (size, age, feeding, etc.).
- Investigate temporal trends in mercury and POP concentrations in lake trout and burbot and prepare a scientific paper based on the mercury findings; participate in and contribute to AMAP expert work groups investigating POP trends. Contribute to CACAR mercury assessments.
- Continue to contribute to investigations of mercury trends in fish in the smaller lakes to the west of Great Slave Lake. Synthesize these studies and begin to work on a scientific paper presenting these findings.
- Continue to work with Fort Resolution in their water quality and productivity monitoring of Resolution Bay waters. Work with Lutsel K'e in developing a similar program for the East Arm as part of their CIMP program and as requested.
- Communicate results to communities and the commercial fisheries in a timely manner.

Introduction

This study is part of NCP's Freshwater Ecosystems Trend Monitoring Program, specifically Great Slave Lake. The overall objective of this program is to measure long-term trends in contaminant concentrations in Arctic biota including lake trout and burbot in Great Slave Lake; these two species have been regularly monitored since 1999 with data sets also existing from earlier studies. This study provides the necessary data sets for evaluating the support to success of the Stockholm Convention on POPs, the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution Protocols on POPs and heavy metals and the more recent Minamata Convention for mercury in reducing global emissions and the presence of these chemicals in biota (Rigét et al. 2011, Rigét et al. 2013). Great Slave Lake is the major aquatic ecosystem in the Northwest Territories, supporting 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 is a pelagic fish and responsive to events occurring in the water column whereas burbot are more sedentary and may respond more to conditions at the sediment water interface (Rawson 1951, Scott and Crossman 1998). Two regions of the lake are being monitored (Evans 1995, Evans et al. 2005a, Evans et al. 2005b, Evans and Muir 2013); the productive West Basin which is profoundly affected by Slave River inflow, and the deeper, less productive East Arm (Rawson 1955, Fee et al. 1985). This allows us to investigate how limnological variables affect contaminant 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. We also have been monitoring northern pike at Fort Resolution as mercury concentrations tend to be higher in this species than lake trout and burbot.

Activities in 2013-2014

i. Twenty lake trout were collected from Lutsel K'e and Hay River and 20 burbot were collected from Fort Resolution in the autumn and shipped whole to Saskatoon. We continued our burbot collections at Lutsel K'e and northern pike at Fort Resolution using other funds. 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 from each location were selected for metals, legacy organic contaminants and PDBE and PFC analyses, with our sample archive consisting of various tissue samples from all 20 fish per location; northern pike were submitted for mercury analyses only. Only mercury analyses have been completed.

ii. A scientific paper (Evans et al. 2013) was published on mercury trends in Great Slave Lake burbot, lake trout, and northern pike (West Basin) based primarily on NCP-supported studies but also earlier programs; this paper included sediment core results from sampling conducted in 2009 with NCP support.

iii. Trends in POPs have been examined using PIA software developed as described by Bignert (2007). Contributions have been made to the AMAP POPs assessment report and to the CACAR mercury report.

iv. We worked with George Low in the assessment of mercury concentrations in fish in lakes to the west of Great Slave Lake and presented findings at a community workshop in August 2013. Other poster presentations were given at various meetings.

v. Water quality monitoring at the water intake at Fort Resolution continued as part of a capacity building and monitoring study. Three posters were given on the study findings.

vi. A study was conducted of mercury and radionuclides in lake trout from Stark Lake.

vii. Sediment cores were collected from two locations in the West Basin, Stark Lake and Kakisa Lake in March 2014.

viii. Community (Fort Resolution, Hay River) visits took place in August 2013 and March 2014.

Results and Discussion

Our mercury investigations in Great Slave Lake have determined that there are statistically significant increases in mercury concentration in lake trout and burbot; no trend was detected in northern pike (Fig 1). Our results are similar to the findings of Carrie et al. (2010) who reported increases in mercury concentrations in Mackenzie River burbot and related these increases to a warming trend. However, we found that mercury increases were negatively related to annual air temperature suggesting that higher mercury concentrations occurred in fish in cooler years. . In March 2014, sediment cores were collected in the West Basin to assess more recent trends in mercury (and other chemicals of concern) flux and metrics of lake productivity.

Other metal data were examined to assess trends and compared against daily intake established by Health Canada and the U.S. Food and Nutrition Board. Some metals such as chromium, iron and manganese showed evidence of trends of increase over 2004-2012 (Fig. 1). Metals in fish fillet overall were within the allowed daily intakes where we could locate such records (Health Canada 1986, 1990, 2006). Arsenic concentrations sometimes exceeded 0.2 µg/g particularly in lake trout; this concentration has been highlighted in recent RAMP reports as potentially being of concern for consumers of fish (Regional Aquatics Monitoring Program 2011). A review was initiated on metals in fish in general; a presentation was given at a scientific conference on metals in fish, sediments and water in the Mackenzie River Basin, including Great Slave Lake.

We contributed to AMAP assessments of trends in POPs in lake trout and burbot. Time trends were examined using PIA software (Bignert 2007) for lake trout and burbot (lipid adjusted). Significant trends of decline were detected for several compounds in burbot (liver) from Fort Resolution burbot with declines less evident for lake trout, particularly at Lutsel K'e (Table 1). Declines are particularly evident for αHCH, αHCH and σDDT. Additional analyses considering other influencing variable may reveal trends not yet observed.

Overall, POPs concentrations tend to be low with higher concentrations in the more lipid-rich burbot liver than lake trout fillet (Table 2). Concentrations also tend to be higher in the East Arm than West Basin fish, possibly because the lower productivity of the former waters does not allow for substantial contaminant dilution on particulates.

We continued to work with George Low in then monitoring of mercury in fish in smaller lakes in the Deh Cho and west of Fort Providence including presenting results at a workshop held at Kakisa in August 2013. Many of these lakes were investigated in the late 1990s and early 2000s with earlier data available from lakes which support small commercial fisheries (Lockhart et al. 2005). Highlights of this study are:

Gargan is a small (1.1 km^2) riverine lake with previously high reported mercury concentrations in northern pike (0.59 ± 0.29 µg/g; fork length 668 ± 81 mm); concentrations were higher in February 2013 (0.82 ± 0.55 µg/g; fork length 679 ± 214 mm) than in 1996. Mercury concentrations were low in lake whitefish (0.13 ± 0.05 µg/g; fork length 440 ± 64 mm) and slightly higher than previously measured (0.10 ± 0.05 µg/g; fork length 482 ± 58 mm).

Little Doctor Lake is a moderate size lake (21 km^2) with a large watershed with historically high mercury concentrations in its northern pike and walleye (Evans et al. 2005a, Lockhart et al. 2005). Walleye collected in March 2013 had high mercury concentrations (0.70 ± 0.23 µg/g; fork length 407 ± 11 mm) as did the single lake trout (0.57 µg/g; 575 mm) and burbot (0.80 ± 0.34 µg/g; length 442 ± 99 mm). Moreover, mercury concentrations were higher in lake whitefish (0.22 ± 0.06 µg/g; fork length 420 ± 23 mm) than previously measured (0.12 ± 0.05 µg/g; fork length 406 ± 29 mm).

Mustard Lake is located on the Horne Plateau and had not been previously studied. Mercury concentrations averaged 0.05 ± 0.02 µg/g (fork length 435 ± 29 mm) in lake whitefish, 0.23 ± 0.12 µg/g in burbot (length 650 ± 37 mm), 0.44 ± 0.17 µg/g (fork length (574 ± 96 mm) in lake trout and 0.46 ± 0.16 µg/g (fork length 693 ± 125 mm) in northern pike.

Tathlina Lake walleye are being monitored for mercury trends, building on a record created as part of the commercial fishery on this lake (Lockhart et al. 2005). Mercury concentrations in fish caught in 2012 (0.47 ± 0.18 µg, length 419 ± 23 mm) and 2013 (0.62 ± 0.18 µg, length 414 ± 19 mm) were greater than the historical average but fish were larger. Data analyses are ongoing.

Mercury concentrations are being monitored in Trout Lake. Mercury concentrations in 2012 (0.35 ± 0.14 µg, length 428 ± 36 mm) were above the historic average. Data analyses are ongoing.

Mercury concentrations were measured in walleye harvested from Kakisa in December 2013. Concentrations (0.47 ± 0.18 µg, length 419 ± 23 mm) but similar to the historic range reported for this lake over 1981-1998 by (Lockhart et al. 2005), i.e., annual mean concentrations ranged from 0.25-0.45 µg/g and fish length from 285-416 mm. A sediment core was collected in this lake in March 2001 to assess trends in mercury deposition.

We provided contributions to two studies of community concern. First, we continued to work with Fort Resolution on its water quality (including plant nutrients, chlorophyll, phytoplankton, pH, dissolved organic carbon etc.) of Resolution Bay waters using its domestic water intake. This began as a capacity building study to provide training in monitoring, data management, and project management but we are hopeful that this program will continue its evolution to provide valuable data to complement this fish contaminant trend monitoring program. A number of poster presentations were given on this work. We also conducted a small study of radionuclides and mercury in lake trout from Stark Lake. This study was funded by AANDC - Contaminants and Remediation. A sediment core was collected from this lake in March 2014.

Figure 1. Upper panels: measured versus modeled Hg concentration in a) West Basin lake trout and b) West Basin burbot where modeled is based on Table 3 coefficients, c) measured Hg concentrations in burbot at Fort Good Hope (Carrie et al. 2010) and annual air temperatures at Norman Wells. Lower panels: d) modeled Hg concentrations in 600-mm fork length lake trout and annual air temperatures at Yellowknife and e) modeled Hg concentrations in 650-mm total length burbot and annual air temperatures at Hay River. From Evans et al. (2013).

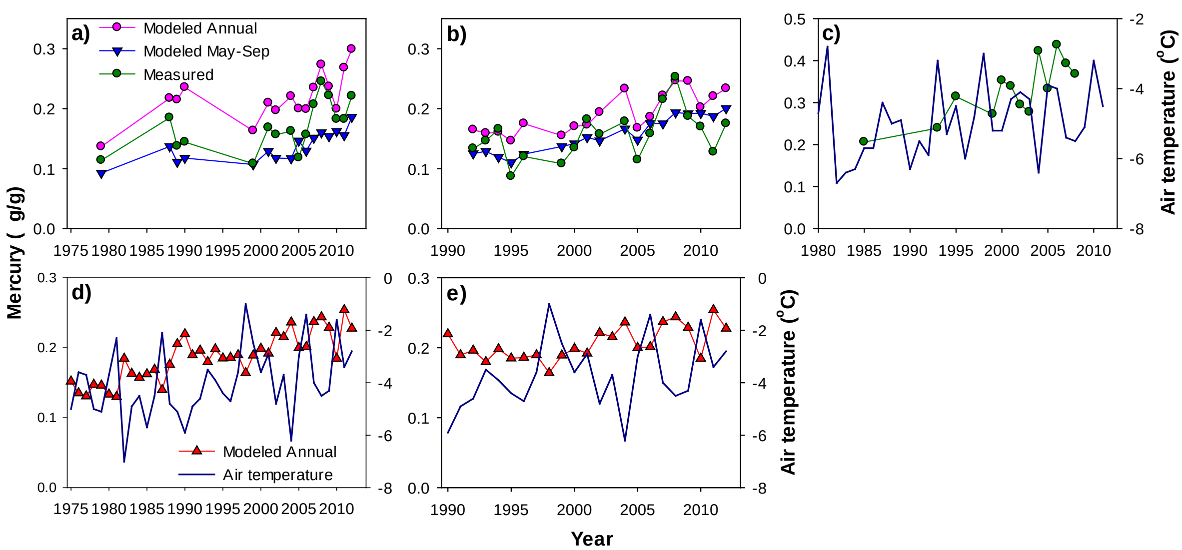

Figure 2. Time trends in chromium (Cr) and iron (Fe) in lake trout and burbot from the West basin of Great Slave Lake.

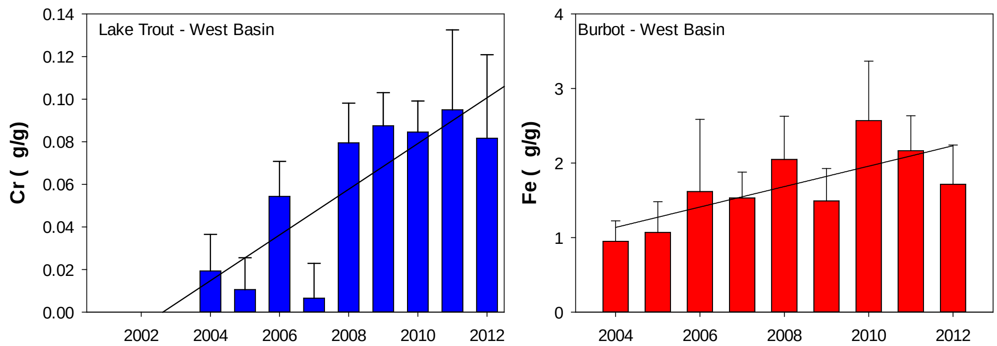

Table 1. Time trends in lake trout (fillet) from the commercial fishery at Hay River and Lutsel K'e and in burbot (liver) from Fort Resolution. Data are shown as the slope (% annual change per year) with R^2, the proportion of variance explained by the regression shown in parentheses below. Statistically significant (<0.05) slopes are in bold. Numbers in parentheses refer to the number of years of observation. Burbot data are lipid adjusted

Site	Lake trout Hay River		Burbot Fort Resolution		Lake trout Lutsel K'e	
Parameter	%/yr	R^2	%/yr	R^2	%/yr	R^2
% lipid	-0.20 (13)	0.00	+2.3 (15)	0.15	-1.9 (15)	0.05
αHCH	-12 (13)	0.68	-13 (15)	0.79	-9.9 (15)	0.73
αHCH	19 (13)	0.28	+5.5 (15)	0.10	-4.1 (15)	0.02
αHCH	-10 (13)	0.44	-11 (15)	0.54	-8.3 (15)	0.52
HCB	2.6 (13)	0.10	-2.6 (15)	0.10	2.1 (15)	0.06
α10 PCB	-5.0 (13)	0.24	**-5.3 (15)**	**0.38**	-3.8 (15)	0.24
CB153	-7.2 (13)	0.16	**-4.5 (15)**	**0.29**	-2.7 (15)	0.14
αCHL	**-5.4 (13)**	**0.36**	**-6.7 (15)**	**0.41**	-2.8 (15)	0.16
αDDT	-6.5 (13)	0.47	-5.0 (15)	0.36	-7.9 (15)	0.69
p,p-DDE	-1.8 (13)	0.02	**-3.7 (15)**	**0.33**	-3.3 (15)	0.07
Dieldrin	**-6.3 913)**	**0.28**	**-8.0 (15)**	**0.31**	-2.8 (15)	0.09
BDE 47	-1.1 (8)	0.0	-7.0 (5)	0.27	0.74 (8)	0.00
BDE 99	2.3 (8)	0.01	-9.9 (5)	0.25	-2.5 (8)	0.01

Table 2. Mean and standard deviations of POPs concentrations (ng/g wet wt) in lake trout fillet and burbot liver from the East Arm and West Basin. Data from1993-2012.

	Lake trout fillet		Burbot liver	
Values	**East Arm**	**West Basin**	**East Arm**	**West Basin**
Lipid (%)	5.21 ± 3.84	9.12 ± 4.62	27.42 ± 11.93	33.69 ± 12.76
ΣPCB	20.17 ± 8.28	12.64 ± 12.39	98.71 ± 61.08	90.09 ± 56.14
ΣDDT	4.89 ± 4.72	2.99 ± 2.86	24.78 ± 18.70	23.06 ± 15.24
ΣCHL	9.38 ± 7.55	5.17 ± 4.67	46.79 ± 28.61	43.35 ± 28.28
ΣHCH	0.72 ± 0.71	0.74 ± 1.07	4.51 ± 3.58	2.76 ± 2.59
ΣCBz	2.04 ± 1.38	2.19 ± 1.46	14.01± 7.37	12.61 ± 9.22
Toxaphene	46.73 ± 58.39	15.09 ± 17.19	318.31 ± 326.86	133.76 ± 139.62
ΣPBDEs	1.21 ± 0.92	0.91 ± 0.66	50.57 ± 39.91	10.48 ± 6.00
ΣPFCA	0.97 ± 2.28	0.17 ± 0.18	3.59 ± 2.88	2.16 ± 2.23

Expected completion data

This is a core monitoring project with end date not established.

Acknowledgements

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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 sur les tendances temporelles relatives aux métaux traces et aux contaminants organohalogénés, y compris les nouveaux composés persistants, chez les lottes du fleuve Mackenzie, à Fort Good Hope (Territoires du Nord-Ouest)

- **Project Leader:**
  Gary A. Stern, University of Manitoba, Centre for Earth Observation Science, Winnipeg MB
  Tel: (204) 474-9084, Email: Gary.stern@umanitoba.ca
- **Project Team Members and their Affiliations:**
  Jesse Carrie and Alexis Burt, University of Manitoba, Centre for Earth Observation Science; Fort Good Hope Renewable Resource Council and community members.

Abstract

Tissues from burbot collected at Fort Good Hope (Rampart Rapids) in December 2013 were analysed for organohalogen contaminants (OCs/PCPs/BFRs/FOCs[1]) and heavy metals (Hg/Se/As). Data from this time point was combined with the existing metal and OC data together covering time spans of 28 and 25 years, respectively. 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 0.355 ±

1 Organic Compounds/Polychlorinated Biphenyls/Brominated Flame Retardants/Fluorinated Organic Compounds

Résumé

On a prélevé des tissus de lottes à Fort Good Hope (Rampart Rapids) en décembre 2013, et on a déterminé leur teneur en contaminants organohalogénés (CO/PCB/PIB/COF[1]) et en métaux lourds (Hg/Se/As). Les données recueillies à ce moment ont été combinées aux données existantes sur les métaux et les CO, pour couvrir ensemble des périodes de 28 et de 25 ans, respectivement. Aucune corrélation significative n'a été observée entre la longueur du sujet et la concentration de mercure, que ce soit dans les muscles ou dans le foie, peu importe le sexe du sujet. Selon les ensembles de

1 Contaminants organohalogénés/polychlorobiphényles/produits ignifuges bromés/composés organofluorés

0.137 (n = 582) and 0.092 ± 0.078 (n = 569) mg g-1, respectively. Muscle mercury levels are below the recommended guideline level of 0.50 mg g-1 for commercial sale. Major PBDE[2] congener levels have increase significantly over the 19 year period from 1988 to 2008 but, are currently still about one order of magnitude less than those of PCBs[3]. Since 1986, a consistent decline was observed in both PFOA[4] and PFOS[5] concentrations. Conversely, PFDA[6] concentrations show a consistent increase overtime. PFNA[7] and PFUA[8] levels peaked in 2003.

Key Messages

- Mean Hg concentrations in muscle and liver over the entire data sets were 0.355 ± 0.137 (n = 582) and 0.092 ± 0.078 (n = 569) mg 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 g^{-1} for commercial sale.
- Significant declines, 10- and 4-fold, occurred for both a- and g-HCH[9] over 23 year time period between 1988 and 2013.
- PBDE concentration seems to have peaked in the mid-2000s, and are now on the decline.

2 Polybrominated Diphenyl Ether
3 Polychlorinated Biphenyl
4 Perfluorooctanoic Acid
5 Perfluorooctane Sulfonate
6 Perfluorodecanoic Acid
7 Aerfluorononanoic Acid
8 Aerfluoroundecanoic Acid
9 Hexachlorocyclohexane

données entiers, les concentrations moyennes de mercure dans les muscles et dans le foie sont respectivement de 0,355 ± 0,137 (n = 582) et de 0,092 ± 0,078 (n = 569) mg g-1. Les concentrations de mercure dans les muscles sont inférieures à la recommandation de 0,50 mg g-1 fixée pour la vente des espèces commerciales de poissons. Les concentrations des principaux congénères de PBDE[2] ont augmenté de manière significative au cours de la période de 19 ans écoulée entre 1988 et 2008, mais elles sont encore actuellement environ 10 fois moins élevées que celles de PCB[3]. Depuis 1986, on a enregistré une baisse constante des concentrations d'APFO[4] et de PFOS[5]. À l'inverse, les concentrations d'APFD[6] dessinent une hausse continue au fil du temps. Les concentrations d'APFN[7] et d'APFU[8] ont culminé en 2003.

Messages clés

- Selon les ensembles de données entiers, les concentrations moyennes de mercure dans les muscles et dans le foie sont respectivement de 0,355 ± 0,137 (n = 582) et de 0,092 ± 0,078 (n = 569) mg g-1.
- Depuis le milieu des années 1980, les concentrations de mercure ont respectivement plus ou moins doublé et triplé dans les muscles et le foie des lottes prélevées à Fort Good Hope.
- Les concentrations de mercure dans les muscles et dans le foie demeurent inférieures à la recommandation de 0,50 mg g-1 fixée pour la vente des espèces commerciales de poissons.
- On a enregistré des déclins importants, soit par un facteur 10 et un facteur 4, de l'a- et

2 Polybromodiphényléther
3 Polychlorobiphényle
4 Acide perfluorooctanoïque
5 Perfluorooctanesulfonate
6 Acide perfluorodécanoïque
7 Acide perfluorononanoïque
8 Acide perfluoroundécanoïque

- Current SPBDE levels are approximately one order of magnitude less than those of PCBs.
- Since 1986, a consistent decline was observed in both PFOA and PFOS concentrations. Conversely, PFDA concentrations show a consistent increase overtime. PFNA and PFUA levels peaked in 2003.

du gHCH[9] sur la période de 23 ans écoulée entre 1988 et 2013.

- La concentration de PBDE semble avoir culminé au milieu des années 2000, et être à présent en déclin.
- Les concentrations actuelles de SPBDE sont environ 10 fois moins grandes que celles de PCB.
- Depuis 1986, on a enregistré une baisse constante des concentrations d'APFO et de PFOS. À l'inverse, les concentrations d'APFD dessinent une hausse continue au fil du temps. Les concentrations d'APFN et d'APFU ont culminé en 2003.

9 Hexachlorocyclohexane

Objectives

To continue to assess long term trends and to maintain current data on levels of bioaccumulating substances such as trace metals (*e.g.*mercury, selenium, arsenic, lead and cadmium), organochlorine contaminants (*e.g.*PCBs, DDT, toxaphene) and new 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 contaminants (OCs/PCPs/BFRs/FOCs) 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 2013-2014 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 (1986-2008), Fort Good Hope was selected as one of the priority sampling location for long temp temporal trend studies.

Fresh Water Institute/University of Manitoba currently maintains a very extensive archive of Fort Good Hope burbot sample tissues and data on trace metals (28 years and 19 time points; 1985, 1988, 1993, 1995, 1999, 2000, 2001, 2002, 2003 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2102, 2013 and POPs (25 years and 17 time points; 1988, 1994, 1999, 2000, 2001, 2002, Jan04 (2003), 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013).

Activities in 2013-2014

In December 2013, 37 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 27 years and 18 time points (1985-2013). Mean Hg concentrations in muscle and liver over the entire data sets were 0.355 ± 0.137 ($n = 582$) and 0.092 ± 0.078 ($n = 569$) $\mu g\ g^{-1}$, respectively. Mercury levels in muscle are below the recommended guideline level of 0.50 $\mu g\ g^{-1}$ 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 $\mu g\ g^{-1}$, occurred in a muscle sample from a female burbot collected in 1999.

Organohalogens: Tables 3-6 list the mean wet weight of major HOC group concentration for collection periods between 1988 and 2013 After lipid normalization, significant declines, 10 - and 4-fold, occurred for both a- and g-HCH over this 25 year time period (Table 4). b-HCH concentrations were below the detection limit in most samples. ΣPCBs and ΣDDT concentration increased significantly since the mid-1990s (see Carrie et al. 2010) but, seem have declined over the last two years.

Major PBDE congener and homologue concentrations in selected burbot liver samples are listed in Table 5 (1988 to 2010). PBDE 47 is the most predominant PBDE congener residue in the burbot liver followed by PBDE 99, 100, 153 and 154. In general, PBDE concentrations seemed to have peaked in the mid-2000s and are now on the decline. Results for perfluoroalkyl compounds are shown in Table 6.

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)
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)

1n = 20

Table 2. Mean (standard deviation) concentrations of mercury, selenium and arsenic in Fort Good Hope burbot liver (mg g^{-1}).

Collection	Sex	n	Length	Hg	Se	As
Apr-851	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)
Apr-851	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)

[1] Wagemann 1985; 2,3n = 19

Figure 1. Mean Hg concentrations in muscle (left) and liver (right) from Fort Good Hope burbot (males + females).

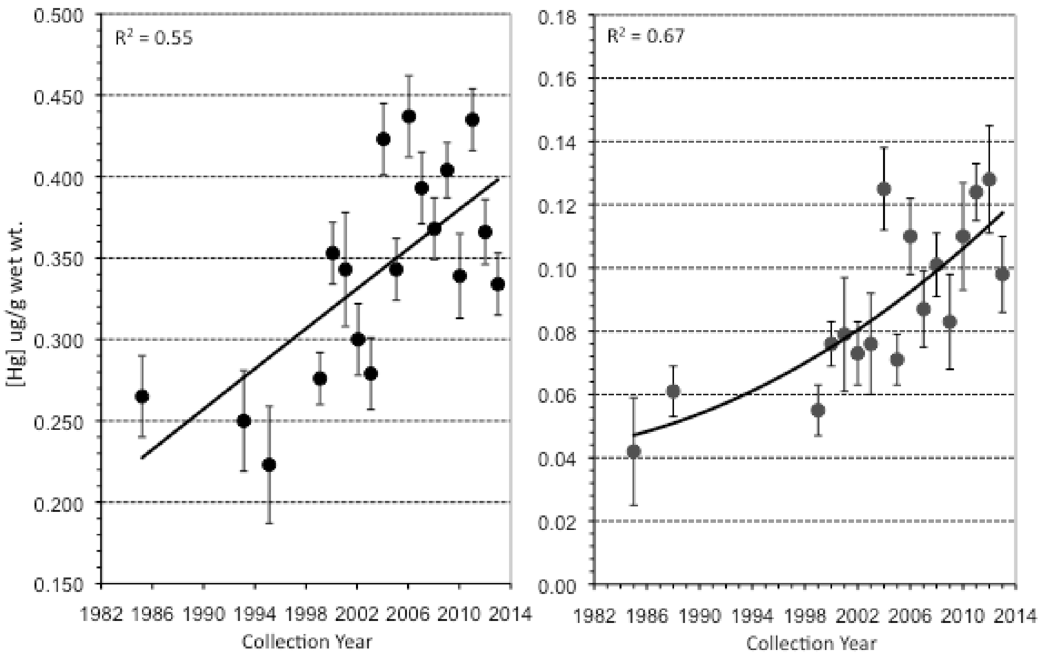

Table 3. OCs in Burbot liver from Fort Good Hope (mean and standard deviation, ng g^{-1}, ww)

Year	sex	n	% Lipid	SCBz	SHCH	SCHL	SDDT	SPCB	SCHB	HCBz	Oxychlor
1988	M + F	10	30.20 (13.47)	13.63 (4.21)	5.53 (1.71)	23.83 (7.37)	16.17 (5.25)	58.11 (18.45)	121.66 (38.62)	13.07 (4.06)	9.46 (1.58)
1994	M + F	9	30.56 (11.59)	8.63 (2.63)	5.13 (1.53)	17.34 (6.14)	18.96 (8.28)	50.05 (17.55)	93.70 (28.92)	8.17 (2.48)	9.23 (1.42)
1999	M + F	21	42.10 (13.31)	10.04 (3.81)	3.78 (1.38)	21.00 (8.04)	22.84 (8.59)	62.77 (22.29)	108.06 (40.74)	5.43 (2.17)	8.49 (1.70)
2000	M + F	20	36.22 (15.22)	8.72 (5.24)	3.29 (1.98)	19.02 (12.50)	21.24 (14.92)	54.62 (36.25)	94.02 (58.08)	4.78 (2.89)	8.28 (2.44)
2001	M + F	20	30.14 (15.00)	6.36 (3.06)	3.79 (1.67)	13.68 (6.99)	8.99 (5.96)	41.88 (21.26)	75.36 (48.54)	4.33 (1.90)	10.60 (2.67)
2002	M + F	12	27.33 (16.06)	4.69 (2.93)	1.40 (0.94)	17.83 (10.10)	22.18 (12.19)	37.97 (16.50)	143.61 (119.82)	4.54 (2.85)	17.64 (14.33)
2003	M + F	10	24.90 (5.77)	3.83 (3.08)	1.62 (0.57)	17.25 (18.71)	15.19 (12.72)	29.95 (21.29)	118.13 (109.79)	3.80 (3.00)	12.82 (11.27)
2004	M + F	8	25.57 (13.71)	2.25 (1.89)	0.42 (0.22)	17.32 (18.06)	20.39 (14.77)	32.48 (19.12)	127.90 (116.51)	2.16 (1.85)	3.26 (3.28)
2005	M + F	10	24.50 (12.12)	4.71 (2.14)	1.09 (0.61)	22.16 (12.40)	19.46 (9.28)	29.23 (8.49)	110.33 (67.35)	4.42 (2.01)	42.50 (23.38)
2006	M + F	10	32.74 (15.87)	3.77 (1.99)	1.00 (0.46)	21.42 (19.01)	35.53 (15.68)	61.84 (44.44)	158.00 (149.07)	3.59 (2.00)	5.25 (4.86)
2007	M + F	10	32.83 (10.10)	4.78 (2.93)	0.55 (0.38)	20.85 (24.11)	27.71 (17.08)	105.94 (54.79)	107.32 (138.18)	4.42 (2.72)	4.48 (4.36)
2008	M + F	9	35.35 (14.46)	8.42 (2.56)	1.13 (0.45)	14.79 (9.52)	37.62 (16.83)	99.48 (52.60)	274.87 (201.36)	5.96 (2.33)	3.28 (2.44)

Year	sex	n	% Lipid	SCBz	SHCH	SCHL	SDDT	SPCB	SCHB	HCBz	Oxychlor
2009	M + F	10	37.64 (12.16)	5.80 (2.20)	0.72 (0.29)	16.21 (12.45)	27.13 (18.18)	45.59 (25.64)	114.65 (92.19)	5.27 (2.04)	2.85 (2.64)
2010	M + F	9	44.44 (12.54)	2.31 (0.89)	0.69 (0.28)	10.67 (9.28)	16.06 (13.03)	37.22 (26.41)	115.87 (112.18)	2.01 (0.82)	1.68 (1.38)
2011	M + F	9	42.85 (11.47)	5.47 (3.58)	1.02 (0.42)	20.63 (16.24)	20.26 (24.86)	51.90 (40.81)	114.06 (96.09)	5.22 (3.49)	6.03 (4.64)
2012	M + F	9	32.44 (6.67)	5.45 (5.31)	1.04 (0.74)	17.85 (21.18)	21.40 (31.35)	48.55 (53.13)	159.62 (185.33)	5.20 (5.15)	4.25 (4.96)
2013	M + F	8									

Table 4. Lipid normalized OCs concentrations in Burbot liver from Fort Good Hope (mean and standard deviation, ng g^{-1})

Year	sex	n*	SCBz	SHCH	a-HCH	g-HCH	SCHL	SDDT	SPCB	SCHB	Oxychlor
1988	M + F	10	48.50 (9.02)	19.67 (3.61)	16.19 (3.00)	3.48 (0.62)	84.67 (15.40)	57.34 (11.15)	206.05 (37.45)	215.97 (40.74)	9.46 (1.58)
1994	M + F	9	30.29 (8.48)	17.66 (3.03)	14.05 (2.51)	3.61 (0.52)	58.92 (11.35)	61.55 (6.42)	168.80 (22.62)	160.38 (27.00)	9.23 (1.42)
1999	M + F	21	23.55 (3.87)	9.12 (2.61)	7.64 (2.31)	1.10 (0.25)	49.18 (8.10)	53.58 (7.76)	148.85 (28.67)	126.74 (22.84)	8.49 (1.70)
2000	M + F	20	22.40 (5.31)	8.64 (2.09)	7.41 (1.79)	0.91 (0.26)	47.77 (13.83)	52.98 (16.76)	137.50 (40.16)	119.41 (32.92)	8.28 (2.44)
2001	M + F	19	21.05 (3.64)	12.76 (2.31)	11.34 (2.14)	1.42 (0.35)	44.58 (7.37)	27.52 (6.72)	138.19 (7.59)	117.55 (21.82)	10.91 (2.34)
2002	M + F	12	15.63 (11.88)	3.89 (1.96)	2.66 (1.56)	1.02 (0.48)	80.63 (64.60)	95.62 (67.66)	162.67 (107.09)	487.58 (523.81)	17.64 (14.33)
2003	M + F	10	14.59 (9.64)	6.34 (1.08)	4.63 (0.82)	1.71 (0.38)	63.29 (58.34)	57.27 (41.69)	113.99 (62.86)	446.99 (350.00)	12.82 (11.27)
2004	M + F	8	8.37 (1.66)	1.69 (0.16)	1.32 (0.12)	0.38 (0.12)	66.92 (22.01)	84.11 (18.34)	128.73 (28.13)	441.62 (145.54)	12.69 (3.78)
2005	M + F	8	18.81 (8.02)	4.63 (1.69)	3.08 (1.24)	0.94 (0.39)	83.67 (41.03)	69.12 (36.06)	103.47 (46.49)	408.43 (208.31)	42.50 (20.38)
2006	M + F	8	16.62 (4.37)	3.20 (0.95)	2.30 (0.74)	0.85 (0.29)	62.22 (54.07)	112.70 (80.80)	151.22 (105.33)	445.42 (410.90)	15.04 (13.90)
2007	M + F	10	13.77 (4.84)	1.53 (0.67)	0.85 (0.59)	0.36 (0.32)	58.65 (55.31)	85.34 (41.78)	327.05 (140.00)	291.59 (321.48)	12.73 (9.75)
2008	M + F	8	23.04 (5.10)	3.03 (0.75)	1.69 (0.38)	0.96 (0.78)	41.20 (27.52)	102.71 (52.23)	283.38 (200.07)	803.57 (648.64)	9.54 (8.29)
2009	M + F	9	15.69 (4.96)	2.00 (0.53)	1.37 (0.26)	0.54 (0.34)	45.98 (31.32)	80.36 (39.42)	138.68 (87.32)	321.38 (222.39)	8.17 (7.42)
2010	M + F	10	5.79 (3.02)	1.75 (0.94)	1.24 (0.74)	0.22 (0.09)	26.53 (23.94)	43.87 (43.62)	101.13 (93.38)	289.96 (284.94)	4.23 (3.67)
2011	M + F	9	12.42 (6.55)	2.40 (0.74)	1.39 (0.29)	0.63 (0.54)	49.36 (35.55)	60.01 (68.37)	136.85 (125.72)	276.71 (222.36)	14.41 (10.14)
2012	M+F	9	15.59 (11.06)	3.07 (1.46)	2.62 (1.46)	0.45 (0.21)	57.73 (79.68)	72.71 (124.51)	155.87 (196.88)	503.32 (671.88)	13.90 (19.19)
2013	M + F	8									

*only liver samples with lipid > 10 % included.

Table 5. Major PBDE congener concentrations in Burbot liver from Fort Good Hope (mean and standard deviation, pg g^{-1} ww)

Year	Sex	n	% Lipid	PBDE 47	PBDE 99	PBDE 100	PBDE 153	PBDE 154
1988	M + F	10	30.2 (13.5)	226.3 (280.3)	84.5 (130.6)	35.2 (46.7)	29.4 (44.7)	20.5 (28.9)
1999	M + F	4	35.0 (9.6)	582.8 (522.3)	370.1 (269.6)	207.7 (154.6)	161.3 (124.8)	157.5 (116.4)
2000	M + F	11	33.3 (13.1)	620.3 (628.9)	319.7 (273.9)	180.5 (182.7)	135.2 (133.9)	81.3 (84.2)
2002	M + F	10	24.8 (14.5)	680.5 (305.4)	383.3 (258.3)	200.6 (87.1)	111.9 (74.2)	191.4 (95.7)
2003	M + F	10	28.1* (11.5)	814.7 (618.9)	745.3 (583.2)	297.7 (190.9)	435.5 (330.1)	311.4 (216.0)
2005	M + F	10	17.3 (9.4)	718.4 (370.7)	516.0 (248.9)	210.7 (102.9)	111.7 (60.2)	170.1 (62.2)
2006	M + F	9	21.7 (16.3)	1822.9 (1914)	1281.5 (717.7)	1010.4 (522.9)	539.6 (359.8)	529.7 (344.7)
2007	M + F	9	23.56 (6.03)	800.4 (878.0)	709.1 (967.0)	361.8 (314.4)	86.8 (192.8)	72.7 (39.0)
2008	M + F	9	39.1 (9.74)	498.5 (228.0)	105.1 (110.7)	48.3 (62.7)	21.4 (25.6)	264.7 (64.1)
2009	M + F	9	30.68 (14.59)	808.7 (521.6)	926.4 (244.1)	476.8 (244.1)	242.0 (114.5)	191.2 (136.8)
2010	M + F	10	33.2 (13.8)	1054 (1381)	774.1 (932.6)	513.3 (804.8)	296.4 (509.3)	282.0 (483.4)
2011	M + F	9	42.9 (11.5)	910.0 (1180)	722.5 (1008)	311.3 (434.5)	249.8 (306.8)	181.0 (306.7)
2012	M + F							

*Some sample not the same as for OCs in Table 3

Table 6. FOC levels in Burbot liver from Fort Good Hope (mean and standard deviation, ng g^{-1} ww)

Year	Sex	n	PFOA	PFNA	PFOS	PFDA	PFUA	Total
1986	M + F	10	4.59 (6.84)	0.89 (0.72)	10.44 (5.90)	1.91 (2.13)	2.25 (4.90)	20.08
1999	M + F	10	4.03 (6.57)	3.89 (9.29)	9.89 (10.16)	1.20 (1.73)	1.44 (2.92)	20.45
2000	M + F	10	1.58 (5.01)	0.98 (3.11)	5.62 (7.81)	2.59 (2.66)	0.75 (1.65)	11.52
2001	M + F	10	1.44 (2.62)	1.57 (3.00)	4.52 (7.75)	36.85* (94.21)	0.70 (1.71)	45.08*
2003	M + F	10	2.03 (3.28)	7.97 (8.03)	9.88 (10.16)	4.28 (3.96)	5.31 (3.96	29.47
2006	M + F	10	1.07 (1.10)	4.71 (4.47)	1.93 (0.78)	8.27 (9.39)	mdl	15.98
2007	M + F	9	0.44 (0.99)	1.01 (1.13)	1.39 (1.25)	7.47 (7.52)	1.36 (1.42)	11.67
2008	M + F	10	0.76 (0.97)	6.74 (7.21)	2.07 (1.75)	7.07 (6.94)	mdl	16.64
2009	M + F	10	0.35 (0.67)	1.18 (1.93)	1.27 (1.39)	1.10 (1.98)	1.10 (1.07)	4.90
2010	M + F	10	mdl	mdl	1.88 (1.83)	0.30 (0.49)	2.43 (3.61)	4.61
2011	M + F	10	1.26 (2.10)	1.96 (3.24)	1.65 (1.58)	5.01 (5.96)	0.92 (2.39)	10.8
2012	M+F	10	7.62 (7.32)	4.52 (8.19)	4.31 (8.19)	6.83 (6.76)	0.93 (1.38)	24.21
2013	M + F	8						

PFUA (mdl = 0.05); *Higher value due to one sample with a measured concentration of 304.24 ng g^{-1}. If this value is excluded then the mean value for PFDA and total FOCs for the 2001 samples are 7.15 (7.47) and 15.38 ng g^{-1}, respectively.

Expected project COMPLETION DATA

Temporal trend studies are long-term propositions and thus annual sampling is projected into the foreseeable future.

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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

- **Project Leader:**
  Gary A. Stern, University of Manitoba, Centre for Earth Observation Science, Winnipeg MB
  Tel: (204) 474-9084, Email: Gary.stern@umanitoba.ca
- **Project Team Members and their Affiliations:**
  Pat Roach, Aboriginal Affairs and Northern Development Canada (Whitehorse); Bob van Dijken, Council of Yukon First Nations (Whitehorse); Alexis Burt, University of Manitoba, Centre for Earth Observation Sciences; ALS Environmental

Abstract

Lake trout muscle samples collected from two Yukon Lakes, Kusawa and Laberge, were analysed for a range of organohalogen (OCs/PCBs/BFRs/FOCs[1]) and heavy metal (Hg/Se/As) contaminants. Currently heavy metal time trend data from Laberge and Kusawa Lake trout muscle cover 20 years, with 17 and 15 time points respectively. 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) μg g^{-1}, respectively. In both lakes, levels are below the recommended guideline level of

1 Organic Compounds/Polychlorinated Biphenyls/Brominated Flame Retardants/Fluorinated Organic Compounds

Résumé

Des échantillons de muscles de touladis prélevés dans deux lacs du Yukon, le lac Kusawa et le lac Laberge, ont été analysés pour en déterminer la teneur en divers contaminants organohalogénés (CO/PCB/PIB/COF[1]) et en métaux lourds (Hg/Se/As). À l'heure actuelle, les données sur les tendances temporelles relatives aux métaux lourds dans les muscles des touladis des lacs Laberge et Kusawa couvrent une période de 20 ans, et on a prélevé des échantillons à 17 et à 15 moments, respectivement, dans ces lacs. Selon les ensembles de données entiers, les concentrations moyennes de mercure

1 Contaminants organohalogénés/polychlorobiphényles/produits ignifuges bromés/composés organofluorés

0.50 µg g^{-1} for commercial sale. No significant trends have been observed in the Laberge lake trout Hg levels over the last 19 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. 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.

dans les échantillons du lac Laberge et du lac Kusawa sont de 0,48 ± 0,22 (n = 162) et de 0,38 ± 0,23 (n = 144) mg g1, respectivement. Dans les deux lacs, les concentrations sont inférieures à la recommandation de 0,50 mg g-1 fixée pour la vente des espèces commerciales de poissons. Aucune tendance significative n'a été observée en ce qui concerne les concentrations de mercure chez les touladis du lac Laberge au cours des 19 dernières années. Dans le lac Kusuwa, après une baisse significative de la concentration moyenne de mercure dans les muscles de touladi ajustée en fonction de la longueur des sujets en 2001, les concentrations ont augmenté de manière constante jusqu'en 2007, chuté en 2008, et elles sont maintenant de nouveau en hausse. La concentration moyenne de mercure dans les muscles de touladi ajustée en fonction de la longueur des sujets est actuellement à sa valeur la plus élevée depuis 1999. 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 note une variabilité significative dans le cas des échantillons prélevés dans le lac Laberge et, par conséquent, aucune tendance temporelle ne se dégage.

Key Messages

- Currently heavy metal (mercury, selenium and arsenic) time trend data from Laberge and Kusawa Lake trout cover 20 years, with17 and 15 time points respectively.
- 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) µg g^{-1}, respectively. In both lakes, levels are just below the recommended guideline level of 0.50 µg g^{-1} for commercial sale.
- No significant trends have been observed in the Laberge lake trout Hg levels over the last 19 years.
- In Kusuwa Lake, after a significant drop in the length adjusted mean Hg trout muscle concentrations in 2001, levels increased

Messages clés

- À l'heure actuelle, les données sur les tendances temporelles relatives aux métaux lourds (mercure, sélénium et arsenic) dans les touladis des lacs Laberge et Kusawa couvrent une période de 20 ans, et on a prélevé des échantillons à 17 et à 15 moments, respectivement, dans ces lacs.
- Selon les ensembles de données entiers, les concentrations moyennes de mercure dans les échantillons du lac Laberge et du lac Kusawa sont de 0,48 ± 0,22 (n = 162) et de 0,38 ± 0,23 (n = 144) mg g1, respectivement. Dans les deux lacs, les concentrations sont inférieures à la recommandation de 0,50 mg g-1 fixée pour la vente des espèces commerciales de poissons.

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.

- 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.

- Aucune tendance significative n'a été observée en ce qui concerne les concentrations de mercure chez les touladis du lac Laberge au cours des 19 dernières années.
- Dans le lac Kusuwa, après une baisse significative de la concentration moyenne de mercure dans les muscles de touladi ajustée en fonction de la longueur des sujets en 2001, les concentrations ont augmenté de manière constante jusqu'en 2007, chuté en 2008, et elles sont maintenant de nouveau en hausse. La concentration moyenne de mercure dans les muscles de touladi ajustée en fonction de la longueur des sujets est actuellement à sa valeur la plus élevée depuis 1999.
- 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 note une variabilité significative dans le cas des échantillons prélevés dans le lac Laberge et, par conséquent, aucune tendance temporelle ne se dégage.

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 (1993-2013). 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 2013-2014

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 2013, 10 lake trout were collected each from lakes Kusawa, 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) μg g^{-1}, respectively. In both lakes, levels are just below the recommended guideline level of 0.50 μg 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: Tables 2 and 3 list the mean wet weight HOC concentration in trout from Lake Laberge and Kusawa Lake, respectively, over the 20 year time period from 1993 to 2013. 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.

FOC levels in Kusawa and Laberge lake trout liver are noted below:

Laberge

2006 (n=1); PFOS = 2.18 ng g^{-1}, wet wt.

2007 (n=9); PFOS = 2.47 (1.86); PFNA = 5.78 (6.33); PFDA = 32.40 (30.34) ng g^{-1}, wet wt.

2008 (n=10); PFOS = 1.28 (2.31); PFNA = 0.06 (0.14); PFOSA = 1.31 (1.24) ng g^{-1}, wet wt.

2009 (n=10); PFOS = 1.93 (1.60); PFNA = 1.39 (1.48); PFDA = 4.87 (6.55) ng g^{-1}, wet wt.

2010 (n=10); PFOS = 2.66 (3.93); PFNA = 3.11 (6.01); PFDA = 1.65 (2.86) ng g^{-1}, wet wt.

2011 (n=10); PFOS = 1.61 (1.62); PFNA = 3.86 (7.45); PFDA = 1.11 (1.57) ng g^{-1}, wet wt.

2012 (n=10); PFOS = 1.98 (1.89); PFNA = 5.61(12.17); PFDA = (non detect) ng g^{-1}, wet wt.

2013 (n=10); PFNA = 0.90 (0.20); POFSA = (1.15 (0.40) ng g^{-1}, wet wt.

Kusawa

2006 (n=9); PFOA = 2.93 (7.78) ng g^{-1}, wet wt.

2007 (n=9); PFOS = 0.50 (0.54); PFNA = 0.36 (1.08); PFDA = 12.78 (16.93) ng g^{-1}, wet wt.

2008 (n=9); PFOS = 0.44 (0.88); PFNA = 0.06 (0.14); PFDA = 0.10 (0.24); PFOSA = 0.32 (0.65), wet wt.

2009 (n=10); PFOS = 0.55 (0.60); PFNA = 0.40 (0.14); PFDA = 3.76 (5.24) ng g^{-1}, wet wt.

2010 (n=10); PFOS = 0.19 (0.60); PFNA = 2.93 (3.48); PFDA = 3.85 (5.25) ng g^{-1}, wet wt.

2011 (n=10); PFOS = 0.21 (0.40); PFNA = 1.53 (2.51); PFDA = 5.68 (5.71) ng g^{-1}, wet wt.

2012 (n=10); PFOS = 0.31 (0.67); PFNA = 3.51(4.12); PFDA = 1.37 (4.23) ng g^{-1}, wet wt.

2013 (n=10); PFUA = 1.25 (0.51) ng g^{-1}, wet wt.

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)
Kusawa	1993	3	535 (72)	0.54 (0.21)	0.43 (0.17)	na
	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)	na
	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)

Figure 1. Length adjusted Hg concentrations in trout muscle from Lake Laberge (1993-2013) and Kusawa (1993–2013). Only Kusawa trout less than 700 mm in length were used in the ANCOVA.

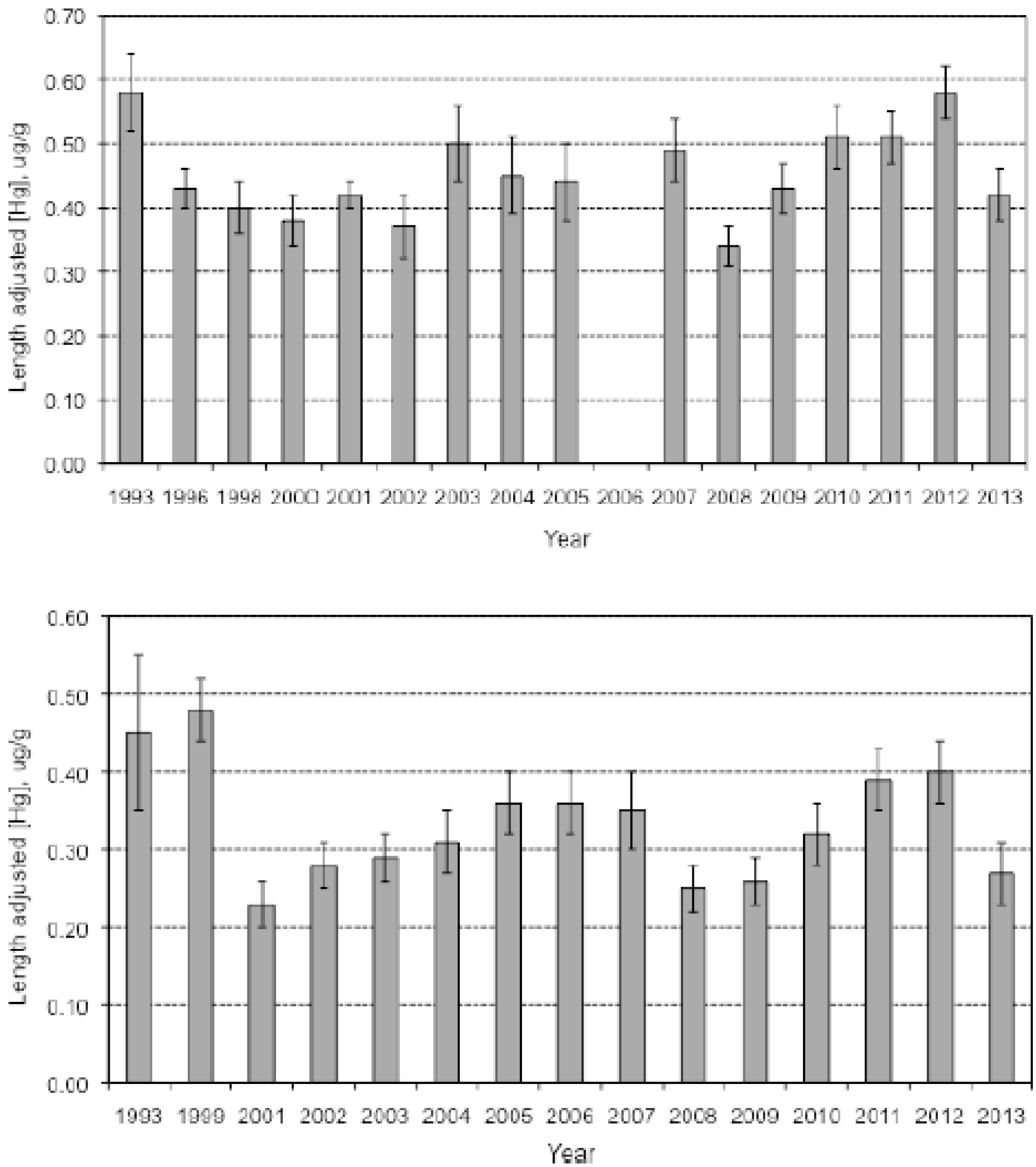

Table 2. Mean (S.D.) HOC levels (ng/g wet wt.) in lake trout muscle from Lake Laberge

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)

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)

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)	3790 (3220)	nd	6790 (8410)	2730 (2940)	980 (1480)	1100 (1290)
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)	1230 (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)	600 (985)	nd	990 (1850)	420 (740)	130 (230)	180 (330)

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 les caribous de l'Arctique

- **Project Leader:**
  Mary Gamberg, Gamberg Consulting, Whitehorse, Yukon
  Tel: (867) 334-3360, Email mary.gamberg@gmail.com
- **Project Team Members and their Affiliations:**
  Mike Suitor and Martin Keinzler, Yukon Environment; Xiaowa Wang and Derek Muir, Environment Canada; Mitch Campbell, Government of Nunavut.

Abstract

This project studies contaminant levels in caribou in the Canadian Arctic to determine their contaminant loads, whether these important resources remain safe and healthy food choices for northerners and if contaminant levels are changing over time. In 2013-2014 samples were collected from 20 Porcupine and 4 Qamanirjuaq caribou. Samples analyses had not been completed at the time this report was prepared. Qamanirjuaq samples collected in the 2012-2013 year have been analyzed, and results are presented in this report. Renal cadmium, mercury, selenium and zinc concentrations were positively correlated with age in the Qamanirjuaq caribou collected in 2012. No differences were seen between the

Résumé

Dans ce projet, on étudie les concentrations de contaminants chez les caribous de l'Arctique canadien afin de caractériser la charge de contaminants présente chez ces animaux, de déterminer si cette ressource alimentaire importante continue d'être une source de nourriture saine pour les habitants du Nord, et de voir si les concentrations de contaminants évoluent au fil du temps. En 2013-2014, des échantillons ont été prélevés sur 20 caribous de la harde de la Porcupine et 4 caribous de la harde de Qamanirjuaq. L'analyse des échantillons n'était pas terminée au moment où le présent rapport a été rédigé. Les échantillons recueillis dans la harde de Qamanirjuaq en 2012-2013 ont été analysés, et les résultats

sexes for any of the elements tested, contrasting with significantly higher concentrations of arsenic, cadmium and mercury in females from previous collections from this herd in the fall. This suggests transplacental transfer of at least cadmium and mercury from the pregnant female to the fetus in the Spring. Temporal trend analysis using the 2012 Spring data is not possible because there are only two years of Spring-collected data (2010 and 2012). We can only conclude that renal lead concentrations were lower while selenium and zinc concentrations were higher in 2012. In all cases, the differences between years are small and likely not of biological significance. 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.

obtenus sont exposés dans le présent rapport. Les concentrations de cadmium, de mercure, de sélénium et de zinc dans les reins étaient en corrélation positive avec l'âge chez les caribous de la harde de Qamanirjuaq échantillonnés en 2012. On n'a noté de différence selon le sexe pour aucun des éléments analysés, ce qui contraste avec le fait que l'on avait enregistré des concentrations significativement plus élevées d'arsenic, de cadmium et de mercure chez les femelles lors des prélèvements effectués antérieurement dans cette harde à l'automne. Cela laisse supposer un transfert transplacentaire des femelles gravides à leurs fœtus au printemps. Il n'a pas été possible de procéder à une analyse des tendances temporelles à partir des données du printemps 2012 parce que des données n'ont été recueillies au printemps que sur deux années (2010 et 2012). On peut seulement conclure que les concentrations de plomb dans les reins étaient plus basses en 2012, tandis que les concentrations de sélénium et de zinc étaient plus élevées. Dans tous les cas, les différences d'une année à l'autre étaient faibles, et elles ne sont vraisemblablement pas significatives, d'un point de vue biologique. Les concentrations de la plupart des éléments mesurés n'étaient pas préoccupantes, d'un point de vue toxicologique, 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 sanitaire confirme que les concentrations de métaux lourds sont très faibles dans la viande (muscles) de caribou, et que cette source de nourriture demeure un choix alimentaire 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.
- There is evidence that some cadmium and mercury are transferred from the pregnant female to the fetus before birth. This results in somewhat lower concentrations in females than males in the spring.
- 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 (particularly mercury) within this ecosystem.

Messages clés

- Certains éléments indiquent que le cadmium et le mercure sont transférés de la femelle gravide au fœtus avant la naissance du petit. En raison de ce phénomène, les concentrations sont dans une certaine mesure plus faibles chez les femelles que chez les mâles au printemps.
- On continuera de surveiller les hardes de caribous de la Porcupine et de Qamanirjuaq sur une base annuelle dans le cadre de ce programme, cela 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

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 2013-2014

Samples were collected from 20 Porcupine caribou in the fall of 2013 by Environment Yukon staff as part of a Yukon Government initiative working with hunters in Old Crow to study body condition in the Porcupine caribou herd. Only four samples were collected from the Qamanirjuaq caribou herd in Arviat in the

Fall of 2013 due to poor weather conditions and changes in the herd's migration close to that community. Community hunters will try to collect the remaining 16 samples in the Spring of 2014.

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 (Angela Milani, Yukon Government). Qamanirjuaq samples collected in the 2012/13 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 on element concentration was tested using 2012 data (10 F: 10M) and the effect of year was tested using results from female caribou from 2010 and 2012 (the only years in which caribou were collected in spring). In all statistical analyses, age was tested as a cofactor, and where necessary data were log-transformed to achieve normality. If normality was not achieved by this transformation, non-parametric tests were used to analyze the data.

Capacity Building

The collection of samples from the Porcupine caribou herd was carried out by Yukon Environment biologists in coordination with local hunters in Old Crow. As part of this project, a program has been developed with the high school class at Chief Zaeh Gittlit School in Old Crow. The students were taken out on hunting trips to participate in the harvest, and at the same time were shown how to take measurements and samples for a variety of purposes, including contaminants analyses.

In October, 2013, 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 specifically in caribou. This workshop will be offered again in October, 2014 with the opportunity for hands-on training in extracting contaminant samples from caribou.

Communications

Results and conclusions from this ongoing program were presented in poster format at the NCP Results Workshop in Ottawa, YT in September, 2013, to the students of the Environmental Technology Program of Arctic College in Iqaluit in October, 2013, to the Hunters and Trappers Association in Aklavik NT in January, 2014 and to the local high school, students of the BEAHR program and the Hunters and Trappers Association in Arviat in February, 2014. Synopsis reports and plain language summaries will be shared with all stakeholders.

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 providing food for their families. Meetings between the PI and local Hunters and Trappers Associations 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.

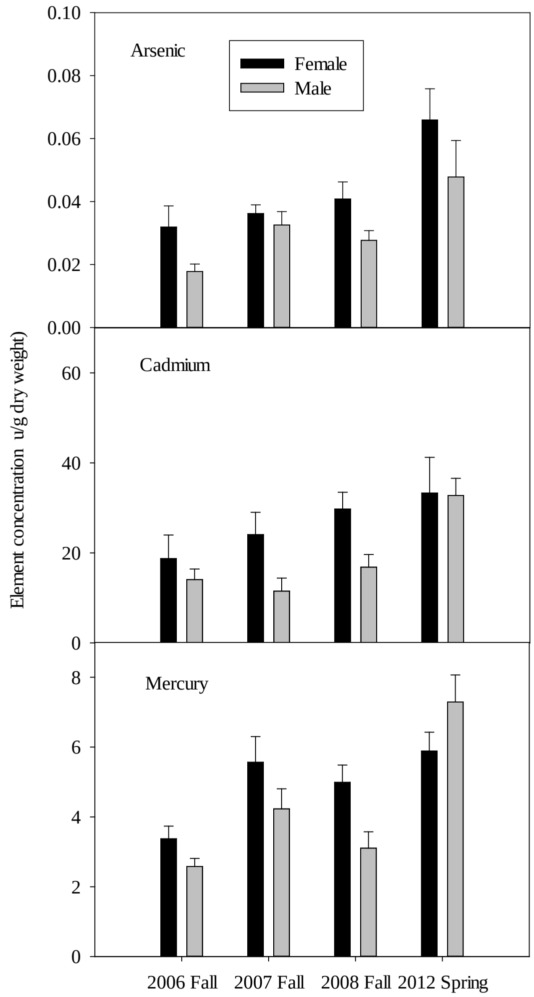
Results

Results for the seven elements of interest are presented in Table 1. Renal cadmium, mercury, selenium and zinc concentrations were positively correlated with age in the Qamanirjuaq caribou collected in 2012 and no differences were seen between the sexes for any of the elements tested. Renal lead concentrations were lower in female spring-collected caribou from 2012 than in 2010 while selenium and zinc concentrations were both higher in 2012 (Fig. 1).

Table 1. Renal element concentrations (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
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	+	###	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	+	###	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	+	###	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	+	###	107.9	+	10.9
Qamanirjuaq spring-collected caribou																										
2008 Female	1		0.04			16.2			20.9			0.51			###			4.4			94.0		
2010 Female	8	7.0	0.07	+	0.01	40.1	+	15.7	19.1	+	8.9	0.45	+	0.15	7.12	+	2.33	4.0	+	0.4	99.3	+	9.2
2012 Female	10	7.3	0.07	+	0.02	33.3	+	24.6	19.0	+	2.8	0.37	+	0.13	5.89	+	1.90	4.7	+	0.8	113.8	+	14.2
2012 Male	10	6.8	0.05	+	0.04	32.7	+	12.1	21.0	+	2.1	0.44	+	0.11	7.29	+	2.45	5.3	+	0.6	115.3	+	9.7

Figure 1. Renal arsenic, cadmium and mercury concentrations in Qamanirjuaq caribou.



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.

The lack of statistically significant differences in element concentrations between the sexes in 2012 is interesting because female caribou had consistently higher concentrations of renal arsenic, cadmium and mercury concentrations in fall-collected animals from the same herd (Figure 1). In spring-collected animals, arsenic was still higher in female caribou, although the high variation made the difference statistically insignificant.

Cadmium concentrations in spring-collected caribou were very similar between the sexes whereas levels in females were higher in fall-collected caribou. Previous research on the Porcupine caribou herd has indicated that caribou get most of their cadmium from lichens which are consumed almost exclusively in the winter. This results in higher concentrations in the spring than in the fall after they have switched to eating low-cadmium grasses, sedges and flowering plants over the summer (Gamberg et al. 2005). The relative drop of cadmium in females in the spring suggests a sex-specific reduction in intake or method of elimination over the winter season. Previous research on the Porcupine caribou herd indicates that females tend to have higher concentrations of cadmium than males because they must eat a larger proportion of food (including lichens) relative to their body weight to support pregnancy and lactation (Gamberg 2009). This would preclude the possibility of a reduction of intake of cadmium over the winter and suggests a transplacental transfer of cadmium from the mother to the fetus. This has been documented in other species (Goyer 1995).

Mercury concentrations in males actually exceed those in females in spring-collected caribou from the Qamanirjuaq herd (Fig. 1). The same rationale used to explain cadmium dynamics can be used to explain this difference, with the aspect of transplacental transfer of mercury likely playing a larger role in providing a route of elimination for pregnant females. This has been well-documented for mercury (World Health Organization 2008).

Temporal trend analysis using the 2012 spring data is not possible because there are only two years of spring-collected data (2010 and 2012). We can only conclude that renal lead concentrations were lower while selenium and zinc concentrations were higher in 2012. In all cases, the differences between years are small and likely not of biological significance.

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. This tissue archive has recently been accessed to assess whether Porcupine caribou were affected by fallout from the recent nuclear accident in Fukushima, Japan (NCP project: Monitoring of Radioactivity in Caribou and Beluga in response to the Fukushima accident) and to provide samples for a caribou genetics study at the University of Saskatchewan. 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) in the coming fiscal year.

Expected Project Completion Date

This program is ongoing.

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A latitudinal investigation of ecosystem sensitivity to methylmercury bioaccumulation in Arctic fresh waters

Étude de la sensibilité des écosystèmes à la bioaccumulation du mercure dans les eaux douces de l'Arctique selon la latitude

- **Project Leader:**
  John Chételat, Environment Canada, National Wildlife Research Centre
  Tel: (613) 991-9835, Fax: (613) 998-0458, Email: john.chetelat@ec.gc.ca

  Murray Richardson, Department of Geography and Environmental Studies, Carleton University
  Tel: (613) 520-2600 ext. 2574, Fax: (613) 520-4301, Email: murray_richardson@carleton.ca

- **Project Team Members and their Affiliations:**
  Holger Hintelman, Trent University; Gwyneth MacMillan, Université de Montréal and Marc Amyot, Université de Montréal; Doug Crump, Environment Canada; Jamal Shirley and Steven Lonsdale, Nunavut Research Institute (Iqaluit)

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), Arctic tundra (Iqaluit) and polar desert (Resolute Bay). During this second year of the project (2013-2014), we partnered with the Nunavut Research Institute to conduct a

Résumé

Le mercure est un contaminant prioritaire dans le cadre du Programme de lutte contre les contaminants dans le Nord (PLCN) en raison de son caractère répandu dans l'Arctique et des fortes concentrations de cet élément présentes chez certaines espèces traditionnellement utilisées à des fins alimentaires. Le principal objectif du présent projet est d'examiner 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 dans des types d'écosystèmes régulés par le climat, dans l'Arctique canadien, à savoir la taïga subarctique (Kuujjuaraapik), la toundra

field program at Iqaluit. We investigated key aspects of MeHg bioaccumulation—MeHg bioavailability to benthic food webs and organism growth rates—as well as how watershed characteristics affect the transport of mercury and organic carbon to lakes. Our preliminary results suggest that climate may have 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. The information on mercury cycling in sub-Arctic and tundra lakes will be compared to polar desert lakes investigated in 2014 to further validate our analysis of climate influences on MeHg bioaccumulation in aquatic food webs of the eastern Arctic.

arctique (Iqaluit) et le désert polaire (Resolute Bay). Pendant la deuxième année du projet (2013-2014), on a travaillé en partenariat avec l'Institut de recherche du Nunavut pour mener à bien un programme de terrain à Iqaluit. On a étudié des aspects clés de la bioaccumulation 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 mercure et du carbone organique vers les lacs. Les résultats préliminaires obtenus laissent supposer que le climat pourrait avoir un effet marqué sur la sensibilité des écosystèmes au mercure dans les lacs du Nord, cela par l'intermédiaire de processus en jeu dans les bassins hydrographiques, de l'hydrologie des lacs et des facteurs limitant la croissance des poissons. On comparera les renseignements sur le cycle du mercure dans les lacs de la région subarctique et de la toundra avec les données sur les lacs dans le désert polaire étudiés en 2014 afin de valider l'analyse de l'incidence du climat sur la bioaccumulation du MeHg dans les réseaux trophiques aquatiques de l'est de l'Arctique.

Key Messages

- Dissolved organic carbon was important in explaining differences in surface water total mercury concentrations between the sub-Arctic taiga (Kuujjuaraapik) and Arctic tundra (Iqaluit) study regions but not within each region.
- Surface water concentrations of MeHg were strongly and positively correlated to THg concentrations, implying strong control of inorganic mercury supply.
- Surface water concentrations of THg and MeHg decreased logarithmically as function of lake residence time, suggesting that in-lake processing of THg and MeHg may reduce their ambient concentrations.
- Sediment concentrations of bioavailable MeHg (measured using Diffusive Gradient in Thin Film samplers) were, on average,

Messages clés

Le carbone organique dissous était un facteur important pour expliquer les différences entre les concentrations de mercure total dans les eaux de surface étudiées dans la taïga subarctique (Kuujjuaraapik) et ces concentrations dans les eaux de surface étudiées dans la toundra arctique (Iqaluit), mais pas pour expliquer les différences au sein de chaque région étudiée.

Les concentrations de MeHg dans les eaux de surface sont en forte corrélation positive avec les concentrations de mercure total (HgT), ce qui suppose une forte régulation de l'approvisionnement en mercure inorganique.

Les concentrations de HgT et de MeHg dans les eaux de surface décroissaient de manière logarithmique en fonction du temps de séjour dans le lac, ce qui semble indiquer que la transformation du HgT et du MeHg dans les lacs similar between the sub-Arctic and Arctic study regions.

- Concentrations of MeHg in the water column explained half of the variation in MeHg bioaccumulation of zooplankton in the sub-Arctic and Arctic lakes.
- Lake-dwelling Arctic char from Arctic lakes had the same or higher THg concentrations compared with brook trout from sub-Arctic lakes that were exposed to higher water MeHg concentrations.

pourrait réduire les concentrations ambiantes de ces produits.

Les concentrations de MeHg biodisponible dans les sédiments (mesurées à partir du gradient de diffusion dans des échantillonneurs sur couche mince) étaient, en moyenne, similaires dans les régions subarctiques et arctiques étudiées.

Les concentrations de MeHg dans la colonne d'eau expliquaient la moitié de la variation de la bioaccumulation de MeHg dans le zooplancton des lacs subarctiques et arctiques.

Chez des ombles chevaliers provenant de lacs de l'Arctique, on a mesuré des concentrations de HgT similaires ou supérieures à celles enregistrées chez des ombles de fontaine provenant de lacs subarctiques exposés à des concentrations de MeHg plus fortes dans l'eau.

Objectives

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. 2013). These observations suggest that regional environmental factors may play an important role in ecosystem sensitivity to Hg bioaccumulation in the Canadian Arctic.

During this three-year project (2012 to 2015), we will investigate three study areas that cover a latitudinal gradient in climate-related environmental factors in the Canadian Arctic. This research will include non-focal sites at Kuujjuaraapik (sub-Arctic taiga) in 2012 and Iqaluit (tundra) in 2013, as well as NCP-monitored sites at Resolute Bay (polar desert) in 2014.

Using a cross-ecosystem comparison to test hypotheses of how climate controls MeHg bioavailability and bioaccumulation, we will conduct the following activities for a minimum of eight lakes and ponds from each study area:

- 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;
- Estimate bioavailable MeHg in sediment pore water using a novel technique (Diffusive Gradient in Thin films, or DGT);
- Measure MeHg concentrations in benthic food webs (algae, invertebrates and fish); and
- 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. 2013) 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 (Karimi et al. 2007, Ward et al. 2010).

Activities in 2013-2014

A field program was conducted at Iqaluit in July 2013 based at the research facility of the Nunavut Research Institute. A total of eight water bodies 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 (approximating steady-state inflow conditions) from the landscape was estimated from mean annual P minus ET. Combining this estimate with watershed area (Aws), lake area (Alk) and average lake depth (Dlk) for each waterbody (all in units of m), residence time (Tr) in days was calculated as follows):

$$T_r = \left(\frac{A_{lk} * D_{lk}}{(A_{ws} + A_{lk}) * (P - PET)/1000} \right) * 365$$

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. Correlation and regression analyses were used to identify relationships between watershed/ lake characteristics and these various water and sediment chemistry variables for lakes from both Kuujjuarapik (2012) and Iqaluit (2013).

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, Chaoborus) were also isolated at most sites for taxon-specific analyses. Lake dwelling Arctic char (Salvelinus alpinus) were captured with a gill net from two lakes 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 the two lakes and a third lake during a winter field program (February 2014) to supplement the initial fish collection.

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 (Vrede et al. 2004, Chicharo and Chicharo 2008). Tissue samples were preserved with RNAlater (a nucleic acid stabilization reagent) prior to analysis.

Northern Capacity Building and Traditional Knowledge Integration

In 2013, we partnered with the Nunavut Research Institute at Iqaluit to conduct our field program. Through collaboration with Jamal Shirley, we worked with a summer student (Steven Lonsdale) enrolled in the Environmental Technology Program at Arctic College. For two weeks, he assisted us with the collection of samples in local water bodies near Iqaluit. Steven has extensive experience on the land, and his knowledge of the local landscape and guiding skills were critical to the success of the field program. The Amarok Hunters and Trappers Association was also consulted for information on the study area. Steven was keen to learn field sampling techniques, and we provided training in the collection of water samples, sediment cores, benthic invertebrates by Ekman grab, and fish for metals analysis, as well as water column profiling using a YSI sonde and bathymetric measurements by echo sounder. This training on sampling techniques provided a beneficial experience for future work in aquatic environmental monitoring and research. After the field program was finished, Steven demonstrated autonomy in the field by continuing to collect additional fish in August of 2013 and again in the winter (February 2014) using methods he had learned.

Communications

The first report containing community-specific information generated from this project was prepared in the autumn of 2013. The report contained results from the field program at Kuujjuaraapik in northern Quebec, specifically raw data for Hg concentrations in water, sediment, invertebrates and fish, as well as bathymetric maps of the local study sites. In February 2014, the report was submitted to our local partner, the Sakkuq Landholding Corporation of Kuujjuaraapik, following review by the Nunavik RCC and translation into Inuktitut. A similar report is planned for submission to the Amarok HTA and NRI in Iqaluit in 2014-15. Metadata on this NCP project were submitted to the Polar Data Catalogue in November 2012 and updated in the autumn of 2013.

Results and Discussion

For this report, we will present a preliminary evaluation of differences in lake chemistry, watershed characteristics, MeHg bioavailability, and Hg bioaccumulation between the study regions sampled in the first two years of the project: sub-Arctic taiga lakes near Kuujjuaraapik and tundra lakes near Iqaluit. A more detailed description of sites and results specific to Kuujjuaraapik can be found in Chételat et al. (2013).

A. Lake chemistry and watershed characteristics

The eight lakes sampled at Kuujjuarapik in 2013 were shallow (mean depth = 1.2 m), first- or second-order lakes with short residence times ranging from approximately ten days to two years (Chételat et al. 2013). In contrast, the eight lakes sampled at Iqaluit in 2014 were deeper (mean depth = 5.2 m), with residence times ranging from approximately 1.2 to 6.8 years (Table 1). Within either locale (i.e. Kuujjuarapik or Iqaluit) differences in residence times reflect differences in lake depths and WA:LA ratios. Between regions, climatic differences also influence these residence time estimates. At Kuujjuarapik, mean annual P minus PET (an estimate of mean annual runoff from the landscape, see methods) equates to 280 mm, compared to only 192 mm for Iqaluit. The deeper lakes at Iqaluit combined with lower mean annual runoff results in substantially longer residence times.

Surface water concentrations of THg and MeHg were significantly higher at Kuujjuarapik than Iqaluit lakes based on non-parametric Wilcoxon rank sum test ($p < 0.001$) (Fig. 1). The median THg concentration was higher in Kuujjuarapik by a factor of ~2, whereas MeHg concentrations were higher by a factor of ~4, relative to Iqaluit (Fig. 2). The median DOC concentration of Kuujjuarapik lakes was approximately 2.5 times higher than that of Iqaluit lakes (Fig. 2).

Surface water concentrations of MeHg were strongly and positively correlated to THg concentrations in both Kuujjuuarapik and Iqaluit lakes (Fig. 3). This relationship is particularly strong when all 16 study lakes are pooled ($r2 = 0.91$, $p < 0001$), but is also apparent among Kuujjuarapik ($r2 = 0.84$) and Iqaluit ($r2 = 0.54$) lakes when considered as independent groups. These relationships imply that THg supply may be one of the most important variables regulating MeHg concentrations in both groups of lakes, both within and between locales.

Given the strong correlation between THg and MeHg among the 16 study lakes and the potentially limiting role of THg on net-MeHg production, the sources of variation of THg among lakes warrants further consideration. We originally hypothesized that DOC would play a fundamental role in regulating THg supply to lakes, both within and between our different study locales. The results illustrated in Figure 3 indicate that THg is strongly correlated to DOC in surface waters when the lakes are pooled from both Kuujjuarapik and Iqaluit ($r2 = 0.67$, $p < 0.001$). When each locale is considered separately, however, this relationship between THg and DOC does not hold (Fig. 3). Therefore, broad-scale, cross-ecosystem differences in DOC supply between sub-Arctic vs. Arctic lakes may influence THg mobility, but at the scale of individual lakes, other factors may also play an important role.

Our subsequent analyses suggest that watershed and lake hydrology, as mediated by climate, landscape setting and lake morphometry, can help explain these inter-lake differences in THg and MeHg concentrations, both within and between the two research locales. Specifically, Figures 4 and 5 illustrate that surface water concentrations of THg and MeHg in the 16 study lakes decreased logarithmically as function of lake residence time ($r2 = 0.85$ and 0.84, for THg and MeHg, respectively, $p < 0.001$). When lakes from either Kuujjuarapik or Iqaluit are considered in isolation, the relationship is approximately linear. These findings imply that in-lake processing of THg and MeHg, such as sedimentation, photoreduction, and photodemethylation may reduce ambient concentrations of THg and MeHg. Photoreduction and photodemethylation, in particular, are important loss mechanisms for inorganic Hg and MeHg in freshwater ecosystems, including Arctic lakes (Douglas et al. 2012, Lehnherr et al. 2014). Among our study lakes, in-lake processing of THg and MeHg likely causes greater removal of THg and MeHg in lakes with longer residence times compared to lakes with shorter residence times. These findings suggest that lake throughflow is an important mechanism by which climate can mediate surface water concentrations of THg and MeHg in sub-Arctic and Arctic landscapes. Our analysis is based on long-term climate normal data and may not reflect shorter-term hydroclimate dynamics that may influence delivery and in-lake processing of Hg in these lakes. Nevertheless, these preliminary results may suggest that climate regimes that increase runoff magnitudes may lead to shorter residence times in these lakes and could result in higher ambient surface water concentrations of THg and MeHg.

B. Estimates of sediment MeHg bioavailability using DGTs

Surface sediment THg concentrations were significantly higher in sub-Arctic lakes at Kuujjuaraapik (mean = 0.109 ng g-1 dry wt) than in tundra lakes at Iqaluit (mean = 0.060 ng g-1 dry wt) (Fig. 6; t-test, $p < 0.001$, $n = 48$). In contrast, there was no significant difference in average bioavailable MeHg concentrations (measured using DGT samplers) between study regions at the sediment-water interface (t-test, $p = 0.936$, $n = 37$) or for pore-water in the top 6 cm of sediment (t-test, $p = 0.195$, $n = 35$). There was a large range of DGT-measured MeHg concentrations among sites, which suggests that within each study region, local environmental conditions have a strong influence on sediment potential for MeHg production (Fig. 7). A similar frequency distribution of MeHg concentrations at the sediment-water interface was observed when comparing lakes at Kuujjuaraapik with those at Iqaluit (Fig. 7). There was no correlation between lake-mean concentrations of THg in surface sediments and MeHg concentrations at the sediment-water interface, within each study region or when all lakes were pooled together ($p = 0.427$, $n = 16$).

It is surprising that similar bioavailable MeHg concentrations were found in sediments between study regions, given the lower THg concentrations (Fig. 6) and lower water temperatures at Iqaluit sites (3-7°C) versus Kuujjuaraapik (10-17°C). This observation may not necessarily reflect similar MeHg production rates among study regions; other factors such as lower demethylation rates, lower dissolved organic matter resulting in less MeHg complexation, or lower sediment-water fluxes could result in comparable standing pools of MeHg. In contrast with sediment, water-column MeHg concentrations were significantly lower in Iqaluit than in Kuujjuaraapik lakes. The sediment DGT measurements are consistent with significant benthic exposure to MeHg in Arctic lakes despite low water column concentrations of MeHg.

C. Food web bioaccumulation of MeHg

In 2012, the MeHg concentrations measured in bulk zooplankton from eight sub-Arctic lakes at Kuujjuaraapik ranged from 63.9–154.7 ng g-1 dry wt. In 2013, the MeHg concentrations in bulk zooplankton from seven tundra lakes at Iqaluit ranged from 25.5–80.8 ng g-1 dry wt. A recent literature review shows that these concentrations fall within the range of MeHg concentrations previously measured in freshwater zooplankton from the Canadian Arctic (3–269 ng g-1 dry wt) (NCP 2012). Overall, average MeHg concentrations in bulk zooplankton were significantly lower in the Iqaluit sites (mean = 51.5 ng g-1 dry wt) than in the Kuujjuarapik sites (mean = 93.0 ng g-1 dry wt) (t-test, $p = 0.009$, Fig. 8). Combined data from both sample years ($n = 15$) show a significant positive correlation between unfiltered MeHg concentrations in lake surface waters and MeHg concentrations in bulk zooplankton (Fig. 9). These results show that the concentrations of MeHg in the water column partly explain the variation in MeHg bioaccumulation among zooplankton in lakes at these different latitudes.

Muscle THg concentrations of lake-dwelling Arctic char in two Iqaluit lakes were similar or higher than those of brook trout collected at five Kuujjuaraapik sites (Fig. 10). Twenty-two percent of the fish collected at Iqaluit sites (6 of 27 fish) in July 2013 exceeded Health Canada's guideline for the commercial sale of fish (0.5 µg g-1 wet wt), while less than 1% of fish from Kuujjuaraapik sites (1 of 61 fish) exceeded this limit. The highest THg concentrations in Arctic char (0.85-1.18 µg g-1 wet wt) were measured in larger, older fish. An additional 30 char were collected from the two Iqaluit lakes this winter, although the THg data are not yet available. A multiple regression analysis showed that the THg concentrations in Arctic char and brook trout ($n = 78$, pooled across species) were correlated with fish length (partial $r2 = 0.34$, $p < 0.001$), fish age (partial $r2 = 0.05$, $p < 0.001$) and water MeHg concentration (partial $r2 = 0.17$, $p < 0.001$). The Arctic char and brook trout had a similar range in trophic position, and it was not a significant variable in the multiple regression.

Lake-dwelling Arctic char from the Iqaluit study area had the same or higher THg concentrations compared with brook trout from Kuujjuaraapik that were exposed to higher water MeHg concentrations (Fig. 10). This finding is significant because it supports the hypothesis that ecosystem conditions (related to climate) result in greater bioaccumulation in higher latitude lakes. The reason(s) for this are still under investigation, although larger sizes and older ages of the char are likely contributing factors. Fish growth rate, prey MeHg concentrations and sediment bioavailable MeHg concentrations (using DGTs) have been or are being measured to determine the importance of these factors in explaining greater bioaccumulation in higher latitude lakes (not all of the data required for this analysis are available yet).

Investigations into the application of tissue RNA content as a proxy for organism growth rate are on-going. Preliminary results for aquatic invertebrates (amphipods and chironomid larvae) from the two study regions indicate that invertebrate size (determined as the mean mass of individuals in a sample) is negatively correlated with their RNA content (Fig. 11). This observation is consistent with the established relationship of slower specific growth rates for larger organisms (Peters 1983). After correcting for the influence of size, there was no significant difference in RNA content of amphipods between study regions ($p = 0.936$) but chironomid larvae had significantly lower RNA content in Iqaluit lakes ($p = 0.008$) (Fig. 11). Assuming that higher RNA content reflects a faster growth rate, these observations suggest that on average amphipods had similar growth rates in the two study regions while chironomid larvae had slower growth rates in the more northern study region. Once MeHg analyses of benthic invertebrates are completed, correlations between RNA content and MeHg concentrations will be conducted to examine the potential influence of growth. Study is on-going to investigate the influence of water temperature and phylogeny on RNA content and its application as a proxy for growth rate.

Table 1. Location, morphometry and fish presence for the eight lakes sampled at Iqaluit in July 2013.

Water body	Latitude (°N)	Longitude (°W)	Lake Area (km²)	Catchment Area (km²)	WA:LA Ratio	Mean Depth (m)	~Residence Time (days)	Fish Present?
IQ1	63°47′49″	68°32′46″	0.03	0.21	7.1	1.8	~470	no
IQ2	63°45′29″	68°26′38″	0.08	2.00	25.3	6	~450	no
IQ3	63°39′07″	68°17′49″	0.27	4.03	15.0	12	~1500	yes
IQ4	63°47′53″	68°32′17″	0.37	1.87	3.7	5	~2500	no
IQ5	63°44′56″	68°23′53″	0.12	3.66	5.1	6	~2200	no
IQ6	63°54′58″	68°34′23″	0.12	3.7	18.4	3	~300	no
IQ7, Iqalugaajuruluit Lake	63°41′06″	68°22′34″	0.70	3.7	5.3	8	~2800	yes
IQ8	63°49′30″	68°36′14″	0.56	14.2	25.5	12	~880	yes

Figure 1. Box plot comparison of THg (upper panel), MeHg (middle panel) and DOC (lower panel) concentrations in lake surface waters in sub-Arctic lakes at Kuujjuaraapik and tundra lakes at Iqaluit (n = 8 lakes per study region).

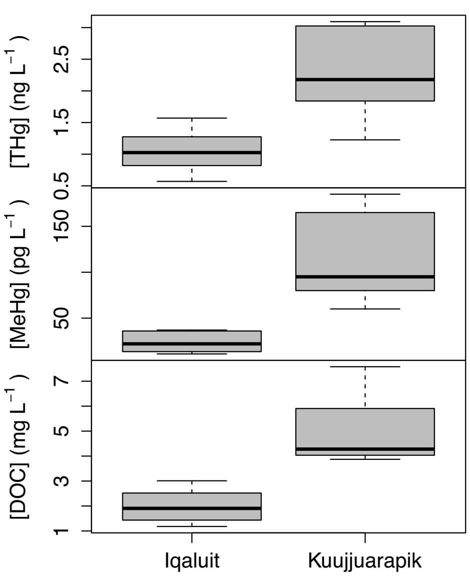


Figure 2. Water column MeHg concentrations vs. THg concentrations in Kuujjuarapik and Iqaluit lakes, showing a strong positive correlation.

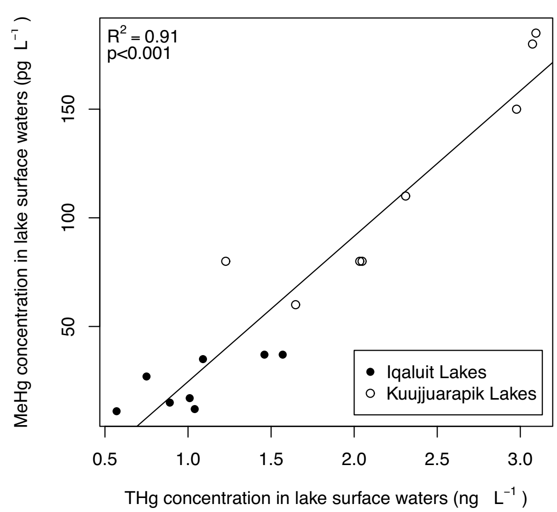


Figure 3. Water column THg concentrations vs. DOC concentrations in Kuujjuarapik and Iqaluit lakes, showing a strong positive correlation when all lakes are pooled from both regions. Note the lack of correlation between THg and DOC for Iqaluit lakes only, and the relatively weak correlation for Kuujjuarapik lakes.

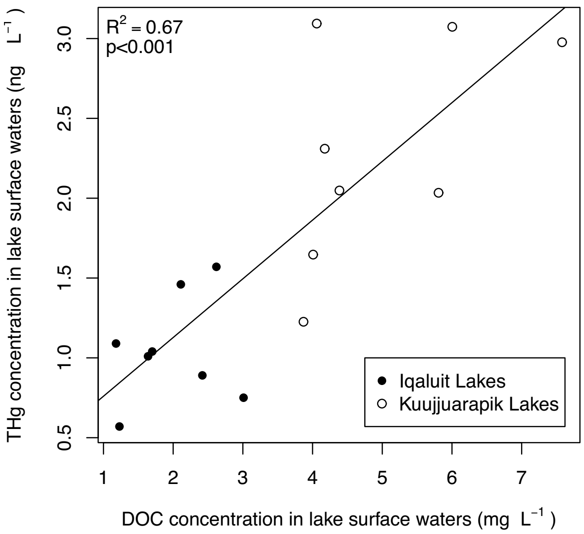


Figure 4. Water column THg concentrations vs. estimated lake residence times for Kuujjuarapik and Iqaluit lakes showing strong logarithmic decay. According to the relationship shown here, lake residence time explains both inter- and intra-regional variability in surface water THg concentrations.

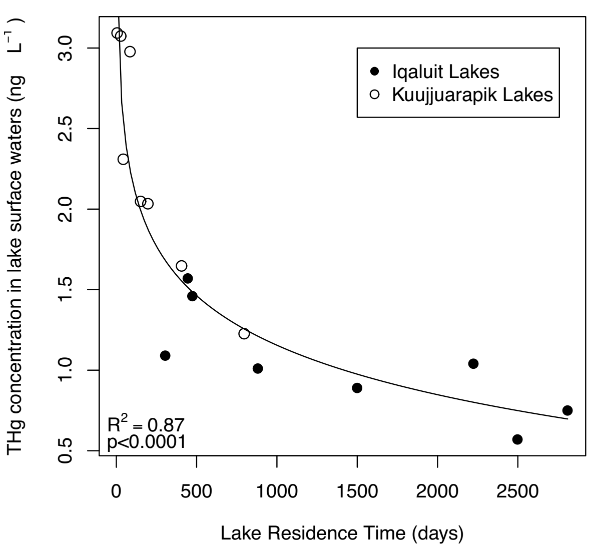


Figure 5 Water column MeHg concentrations vs. estimated lake residence times for Kuujjuarapik and Iqaluit lakes showing strong logarithmic decay. According to the relationship shown here, lake residence time explains both inter- and intra-regional variability in surface water MeHg concentrations, similar to what is shown in Figure 4 for THg.

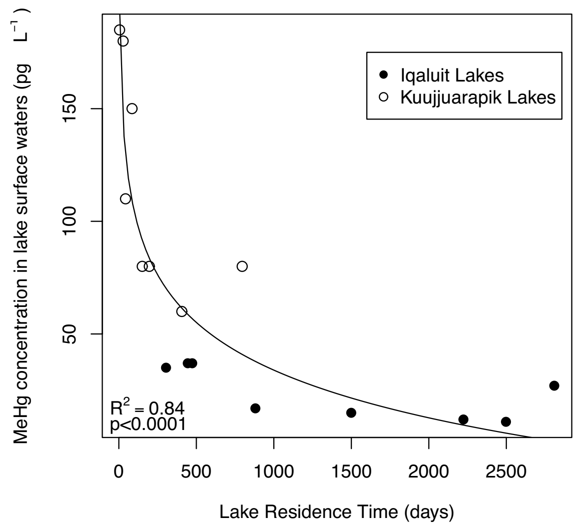


Figure 6. Box plot comparison of THg concentrations in surfaces sediments of eight sub-Arctic lakes at Kuujjuaraapik and eight tundra lakes at Iqaluit. Triplicate samples were collected in each lake and are presented here (n = 24 per region).

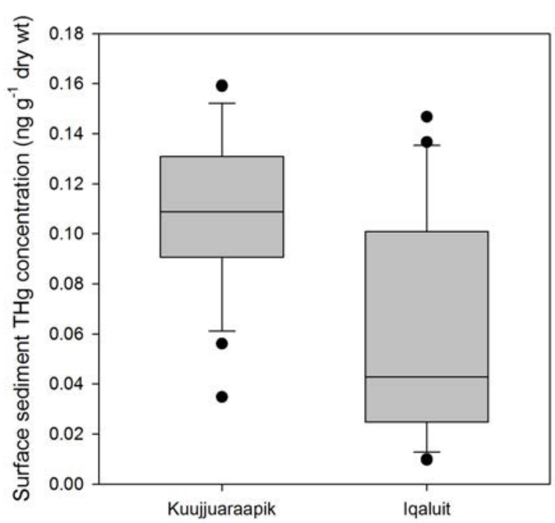


Figure 7. Frequency distribution of bioavailable MeHg concentrations at the sediment-water interface measured with DGT samplers in eight sub-Arctic lakes at Kuujjuaraapik and eight tundra lakes at Iqaluit. Duplicate or triplicate measurements were made in each lake (n = 21 and 16, for Iqaluit and Kuujjuaraapik, respectively).

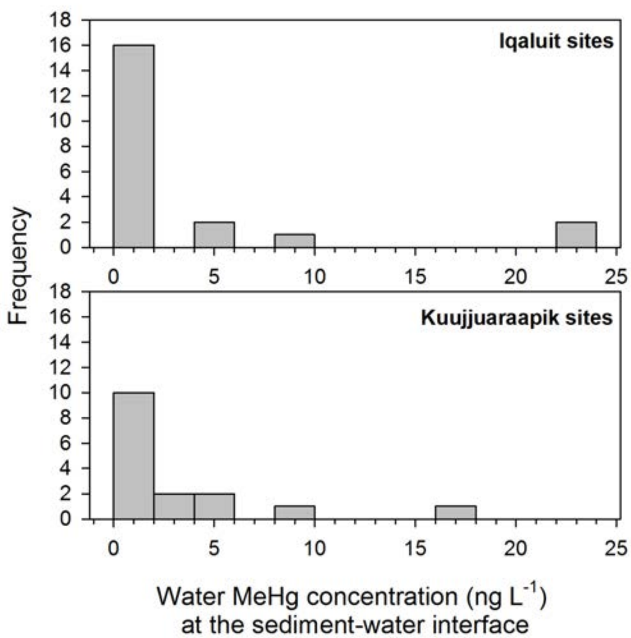


Figure 8. Box plots of MeHg concentrations in bulk zooplankton (ng g^{-1} dry wt) measured in eight lakes at Kuujjuarapik and seven lakes at Iqaluit.

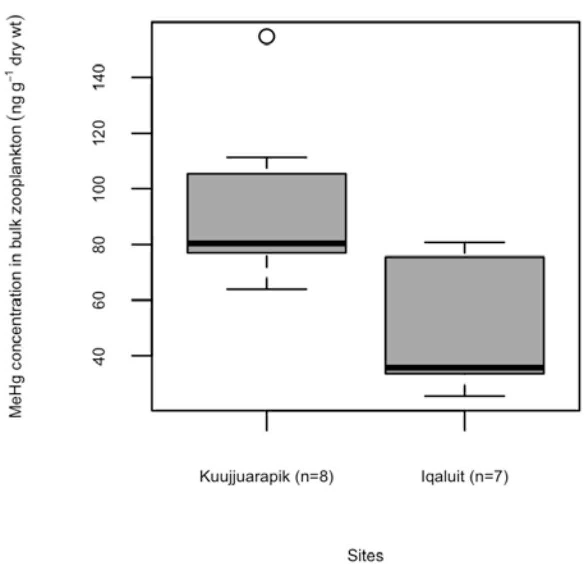


Figure 9. Correlation between MeHg concentrations (unfiltered) in lake surface waters and MeHg concentrations measured in bulk zooplankton from lakes sampled in sub-Arctic taiga at Kuujjuarapik (open triangles) and in tundra at Iqaluit (cross symbol).

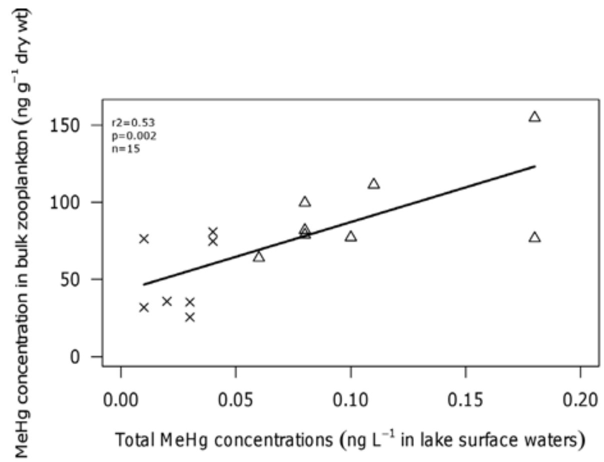


Figure 10. Relationship between unfiltered water MeHg concentrations and muscle THg concentrations of individual lake-dwelling Arctic char from Iqaluit (n = 27) and brook trout from Kuujjuaraapik (n = 61). The correlation between water MeHg and brook trout muscle THg concentrations was significant ($r^2 = 0.39$, $p < 0.001$). The dotted horizontal line represents Health Canada's THg guideline for commercial sale of fish (0.5 µg g^{-1} wet wt).

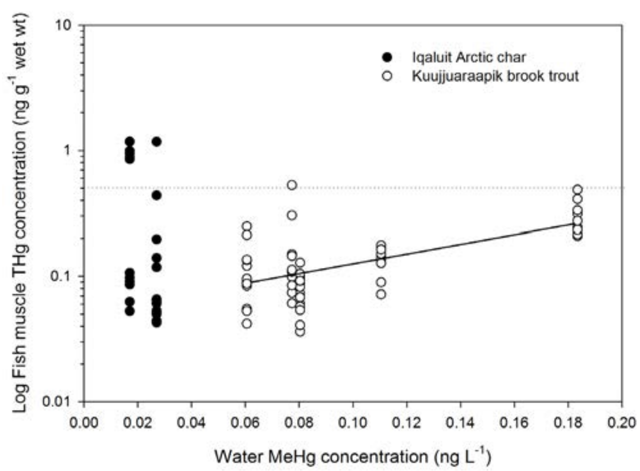
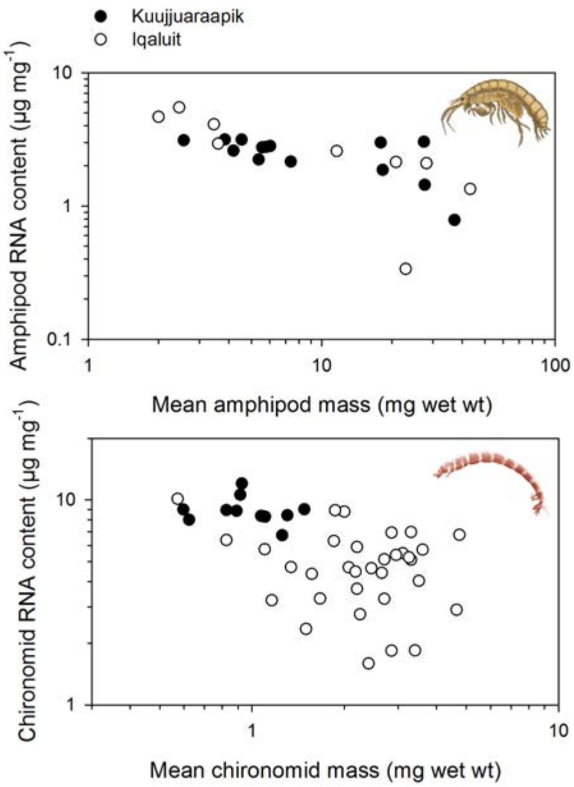


Figure 11. Relationship between invertebrate size and tissue RNA content for amphipods (top panel, n = 23) and chironomid larvae (bottom panel, n = 53) from eight lakes at Kuujjuaraapik and eight lakes at Iqaluit.



Conclusions

We conducted a preliminary comparison of mercury cycling in lakes in sub-Arctic taiga at Kuujjuaraapik and Arctic tundra at Iqaluit. Our results show that watershed and lake hydrology has a strong influence on surface water concentrations of THg and MeHg. Dissolved organic carbon was important in explaining surface water THg concentrations between the study regions but not within each region. Surface water concentrations of THg and MeHg decreased logarithmically with lake residence time, suggesting that in-lake processing of THg and MeHg may reduce their ambient concentrations. Sediment concentrations of bioavailable MeHg were highly variable among lakes, although average concentrations were similar between study regions. Local environmental conditions appear to have a strong influence on sediment potential for MeHg production. Water concentrations of MeHg explained lower zooplankton MeHg in Iqaluit lakes compared with those at Kuujjuaraapik. However, lake-dwelling Arctic char from Iqaluit lakes had the same or higher THg concentrations compared with brook trout from Kuujjuaraapik lakes that were exposed to higher water MeHg concentrations, likely due in part to the larger size and older age of the char. The information on mercury cycling in these systems will be compared to polar desert lakes investigated in 2014 to further validate our analysis of climate influences on MeHg bioaccumulation in aquatic food webs of the eastern Arctic.

Expected Project Completion Date

The anticipated completion date for project activities (i.e. sample collection, laboratory analyses and data compilation) is March 31, 2015. Completion of data analysis and manuscript preparation will follow.

Acknowledgements

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Host-Parasite-Mercury Interactions in a Marine Bird

Interactions hôte-parasite-mercure chez un oiseau marin

- **Project Leader:**
  Grant Gilchrist, Environment Canada, Science and Technology Branch, National Wildlife Research Centre, Tel: (613) 998-7364, Fax: (613) 998-0458 , Email: grant.gilchrist@ec.gc.ca

  Jennifer Provencher, Department of Biology, Carleton University, Tel: (613) 998-8433, Fax: (613) 998-0458, Email: jennifer.provencher@ec.gc.ca
- **Project Team Members and their Affiliations:**
  Mark Forbes, Carleton University; Birgit Braune, Environment Canada; Mark Mallory, Acadia University

Abstract

Natural sources of mercury (Hg) have changed little over the last 150 years, but anthropogenic sources have increased dramatically due to industrialization. Due to both atmospheric and oceanic currents, Hg released from developing areas is deposited in northern North America. As Hg is a known neurotoxin that affects both survival and development, this represents a potentially negative impact for wildlife in the area. Marine bird species in northern Canada are of particular concern not only as ecosystem indicators, but also because they are important source of country food for many northerners. Through collaborations with Hunter and Trapper Associations in Nunavut (Cape Dorset, Coral Habour, and Sanikiluaq), we collected northern common eider ducks (Somateria

Résumé

Les sources naturelles de mercure (Hg) ont peu changé depuis les 150 dernières années, mais les sources anthropiques ont connu un accroissement considérable avec l'industrialisation. À cause des courants atmosphériques et océaniques, le Hg libéré dans les régions développées se dépose dans les régions nordiques de l'Amérique du Nord. Comme le Hg est connu pour être une neurotoxine ayant une incidence sur la survie et sur le développement, il pourrait avoir des effets néfastes sur les espèces sauvages de ces régions. Les espèces d'oiseaux marins du Nord canadien sont particulièrement préoccupantes, de ce point de vue, non seulement parce que ce sont des indicateurs écosystémiques, mais parce qu'ils constituent une importante source de nourriture prélevée dans la nature pour de

mollissima) for parasitological and Hg analysis. Although we found no inter-annual variation in breast muscle Hg concentrations within sites, Hg concentrations significantly differed between the sampling locations. Blood Hg concentrations in breeding females were also determined at an eider breeding colony in northern Hudson Bay. Using historical samples collected from the same colony in 1997-1998 we found that blood Hg concentrations in female eiders was significantly lower in 2013 than in the 1990s sample. Other detailed analyses examining the interactions between gastro-intestinal parasites and Hg on both arrival condition and reproduction of eiders are still underway.

nombreux habitants du Nord. En collaboration avec des associations de chasseurs et de trappeurs du Nunavut (à Cape Dorset, Coral Habour et Sanikiluaq), on a prélevé des échantillons chez des eiders à duvet (Somateria mollissima) en vue d'analyses parasitologiques et du dosage du mercure. On n'a relevé aucune variation interannuelle des concentrations de Hg dans les muscles de la poitrine des sujets prélevés à un même site; par contre, les concentrations de Hg étaient significativement différentes d'un site d'échantillonnage à l'autre. On a également mesuré les concentrations de Hg dans le sang des femelles en âge de se reproduire au sein d'une colonie d'eiders nidifiant dans le nord de la baie d'Hudson. À partir d'échantillons antérieurs prélevés dans la même colonie en 1997-1998, on a constaté que les concentrations de Hg dans le sang des eiders femelles étaient significativement plus basses en 2013 que dans les échantillons des années 1990. D'autres analyses approfondies concernant les interactions entre les parasites gastrointestinaux et le Hg de même que le lien de celles-ci avec l'état des eiders à leur arrivée et leur reproduction sont en cours.

Key messages

- Hg concentrations in eider tissues were found to be below levels of concern for bird health across sampling years and locations.
- Although no inter-annual differences was found in breast muscle mercury concentrations in common eiders collected in 2011 and 2012 from Cape Dorset, Nunavut, Hg concentrations in breast muscle did differ between sites suggesting that different drivers may be influencing Hg concentrations in eiders across their geographic range.
- Blood mercury concentrations in eider ducks were significantly lower in 2013 as compared with levels observed in the 1990s.

Messages clés

- Les concentrations de Hg dans les tissus des eiders étaient inférieures aux valeurs préoccupantes pour la santé des oiseaux à tous les sites d'échantillonnage, toutes les années où des échantillons ont été prélevés.
- On n'a relevé aucune variation interannuelle des concentrations de Hg dans les muscles de la poitrine des eiders à duvet prélevés en 2011 et en 2012 à Cape Dorset, au Nunavut; par contre, les concentrations de Hg dans les muscles de la poitrine étaient différentes d'un site d'échantillonnage à l'autre, ce qui laisse supposer que des facteurs distincts pourraient déterminer les concentrations de Hg chez les eiders selon l'endroit où ils se trouvent, dans leur aire de répartition géographique.
- Les concentrations de mercure mesurées dans le sang des eiders en 2013 étaient significativement plus faibles que celles enregistrées dans les années 1990.

Objectives

1. Investigate inter-annual variation in northern common eider (*Somateria mollissima*) breast muscle mercury concentrations.

2. Compare mercury concentrations in northern common eider breast muscle among different locations, including areas occupied by two different sub-species (*Somateria mollissima borealis* and *Somateria mollissima sedentaria*).

3. Investigate if mercury concentrations in common eiders at East Bay Island, Nunavut have changed over time (1990s versus 2013).

4. Investigate the relationship between mercury and gastrointestinal parasites on bird condition in the northern common eider during migration.

5. Investigate the relationship between mercury and gastro-intestinal parasites in common eiders during the reproductive period.

Introduction

Due to global atmospheric wind currents, elemental mercury (Hg) from industrial activities in Asia is transported across the Pacific and deposited in the North American Arctic (Pacyna et al., 2010). As a result, Hg from industrial sources continues to enter ecosystems and impact a wide range of biota including those in the Arctic (Riget et al., 2011). Additionally, changing climatic conditions in the north may also be exacerbating Hg release and wildlife uptake of Hg (Provencher et al., 2014). This is a cause for concern as Hg is a known neurotoxin that negatively affects wildlife survival and reproduction, including marine birds (Evers et al., 2004; Wayland et al., 2007).

Marine bird populations may be negatively affected not only by contaminants but also by naturally occurring parasites (Sures, 2008). While contaminants can have negative effects on health, reproduction and survival, parasites can also harm host health, locomotion and immunity (Marcogliese and Pietrock, 2011; Poulin, 2007). As a result, the need to assess wildlife populations within the context of both parasites and pollutants is required to gain a better understanding of how these two burdens may be interacting in wildlife (Marcogliese and Pietrock, 2011).

In Canada's North, the northern common eider duck (*Somateria mollissima*; hereafter referred to as eider duck) is a widely distributed and important harvest species, and much is known about its breeding ecology (Goudie et al., 2000; Mallory et al., 2004). Eiders can vary greatly in their Hg and endoparasite burdens (Wayland et al., 2001), and across Nunavut and Nunavik it is possible to collect samples through local community participation (Mallory et al., 2004). Additionally, in Canada 's North, two sub-populations of common eiders are found; the migratory *Somateria mollissima borealis* found throughout much of the eastern Canadian Arctic, and the non-migratory *S. m. sedentaria* sub-species which spends the entire year in southern Hudson Bay around the Belcher Islands (Mallory et al., 2004). This research takes advantage of these factors and uses the eider duck as an avian model to explore host-parasite-contaminant dynamics.

This project has two main objectives. The first objective was to take advantage of a large sample of eiders that were collected in 2011, 2012 and 2013 for parasitological study to examine these same birds for Hg. This sample of birds allowed us to examine Hg concentrations for inter-annual variation and inter-subspecies differences in eider ducks.

The second objective of the project was to assess blood Hg concentrations in female eiders at

East Bay Migratory Bird Sanctuary as part of a parasite-contaminant manipulation to test how both gastro-intestinal parasites and Hg may affect eider duck reproduction. This sampling also provided us with an opportunity to compare contemporary Hg concentrations to historic samples from the same colony dating back to the 1990s (Wayland et al., 2001).

Activities in 2013-2014

Field work – Field work was conducted in May to July 2013 on East Bay Island, Nunavut. Work consisted of carrying out an experimental manipulation of female common eiders as they arrived at the island breeding colony. In addition to being banded and measured, all females were also alternatively given either an anti-parasite treatment (PANACUR) or a placebo treatment (distilled water). PANACUR is a broad spectrum anti-parasite treatment (active ingredient is fenbendazole) that has been shown to be effective against nematodes, lungworms and cestodes in birds, as well as acanthocephalans in monkeys (Norton et al., 1991; Weber and Junge, 2000; Yazwinsky et al., 1992; Yazwinsky et al., 1993). Those females designated for the anti-parasite treatment were given 0.5 ml (50 mg fenbendazole, 26 mg/kg body mass) oral dose of 10% PANACUR® (Hoechst Roussel Vet GmbH; Bustnes et al., 2006; Hanssen et al., 2003). Placebo treated females were given 0.5ml of distilled water. At the time of treatment a 1ml blood sample was also taken via the jugular vein to assess mercury burden. Whole blood samples were frozen within 2 hours of sampling. After being released female eiders were then subsequently monitoring within the colony to assess reproductive metrics.

Additionally, a small set of male common eiders were also used to test the efficacy of the PANACUR treatment on eliminating or reducing the load of gastro-intestinal parasites. These birds were also sampled for breast muscle Hg burdens.

Laboratory work

In total, 435 samples from common eiders sampled in 2011, 2012 and 2013 were analyzed for Hg. This includes 329 breast muscle samples from eider ducks (analyzed for Hg and stable isotopes) collected by hunters in Cape Dorset, Coral Harbour and Sanikiluaq NU. Analysis of the breast muscle tissue was done at the National Wildlife Research Centre in Ottawa, with the stable isotopes completed at the University of Ottawa (Hatch Lab). Additionally, 106 blood samples were analyzed from female eider collected at East Bay Island. All blood samples were shipped to RPC laboratories in Fredericton, NB for analysis.

Capacity Building

In October 2013 the annual Marine Bird Dissection Workshop was again held at the Nunavut Arctic College in Iqaluit. Twenty-four students participated in the two-day event that taught the students about marine bird research in the north, and the skills needed to dissect marine birds to collect tissues for interdisciplinary research. Birds collected by hunters in Cape Dorset and East Bay were used to teach the students about marine bird dissection techniques, including the chemically clean techniques used in contaminant studies.

Beyond the workshop efforts at the Nunavut Arctic College several other students were also involved in the project. Alannah Kataluk-Primeau (Iqaluit), Terry Noah (Grise Fjord), Maxim Rivest (Ottawa) and Jessica Laplante (Montreal) all assisted in the preparation and analysis of the breast muscle samples at the National Wildlife Research Centre in Ottawa over the year. Lastly, Angut Pedersen, a student from the Nunavut Arctic College's Environmental Technology Program attended the ArcticNet conference to co-present the annual marine bird dissection workshop along with Jennifer Provencher. In this role he also co-moderated the session "Education and Outreach Part 2" with Jennifer. His travel was administered by our team in collaboration with the Nunavut Research Institute, and supported by funds awarded to the Gilchrist team by the Nasivvik Centre for Inuit Health and Changing Environments.

Communications

The work supported by NCP was been presented over the year in a number of venues. Project posters in both English and Inuktitut were presented at the NCP results workshop in Ottawa in September 2013. The poster describing the science project was awarded the Inuit Involvement Award at the NCP meeting. At the annual ArcticNet Science Meeting Provencher and Angut Pedersen presented the workshop project, including the contaminants work in a talk titled "How wildlife research can be used to promote wider community participation in the North". Posters outlining the project, both in English and Inuktitut were also posted at the Nunavut Research Institute. Additionally, the work was featured in an essay by Provencher (2013) in the *Arctic*.

Traditional Knowledge Integration

During the Marine Bird Dissection Workshop in 2013 all the carcasses were donated to the Inuit Studies class at the Nunavut Arctic College. The class used the birds for both food preparation classes, and other traditional uses of marine birds. Past years (i.e. 2011) birds sampled (and analyzed under this project) have also been used by the Fur Production and Design class for traditional textile projects.

Results

In total over the 2011, 2012 and 2013 field seasons, 329 common eiders were collected in collaboration with local Hunter and Trapper Associations in Coral Harbour, Cape Dorset and Sanikiluaq, Nunavut (Table 1). We found that breast muscle Hg concentrations were in the middle of range for values previoulsy found in Arctic seabirds, and waterfowl in other areas (Fig 1).

The Hg concentrations in the breast muscle sampled at Cape Dorset were log transformed to approximate both a normal distribution, and equal variances between the two sample years (2011 and 2012). No inter-annual differences were found between eider ducks collected in 2011 (n=176) and 2012 (n=66) in the Cape Dorset area (linear model; $F_{1, 240} = 1.29$, $p>0.05$).

Log transformations would not normalize the distribution of breast muscle Hg concentrations among the sites so a non-parametric test was used to explore for differences between sample locations. When the Hg concentrations in breast muscle tissue was compared across the three sample sites (Cape Dorset, Sanikiluaq and East Bay Island) a significant difference was detected (Kruskal-Wallis; $chi^2_{\ 2} = 13.967$, $p = 0.0009$; Fig 2).

Blood Hg concentrations from females captured on East Bay Island in 2013 were log transformed to approximate a normal distribution and equal variances between time periods (the 1990s and 2013). The blood Hg concentrations in females sampled in 1997/1998 (n=28) were significantly higher than those sampled at the same breeding colony in 2013 (n = 106; linear model; $F_{1, 132} = 15.12$, $p = 0.0002$; Fig 3).

Table 1. Summary of common eiders collected in Nunavut in 2011, 2012 and 2013 for mercury assessment.

Year	Location	Tissue type	N
2011			
	Cape Dorset	breast muscle	176
2012			
	Belcher Islands	breast muscle	13
	Cape Dorset	breast muscle	66
2013			
	Belcher Islands	breast muscle	62
	East Bay Island	breast muscle	12
	East Bay Island	blood	106
		TOTAL	**435**

Figure 1. Breast muscle Hg concentrations (µg·g^{-1} dry weight) reported for bird species. Grey bars represent the values reported in this study, black bars represent previous studies (Atwell et al., 1998; Braune and Malone, 2006; Campbell et al., 2005; Donaldson et al., 1997; Kalisinska et al., 2013; Lucia et al., 2008; Mallory et al., 2004; Tsipoura et al., 2011).

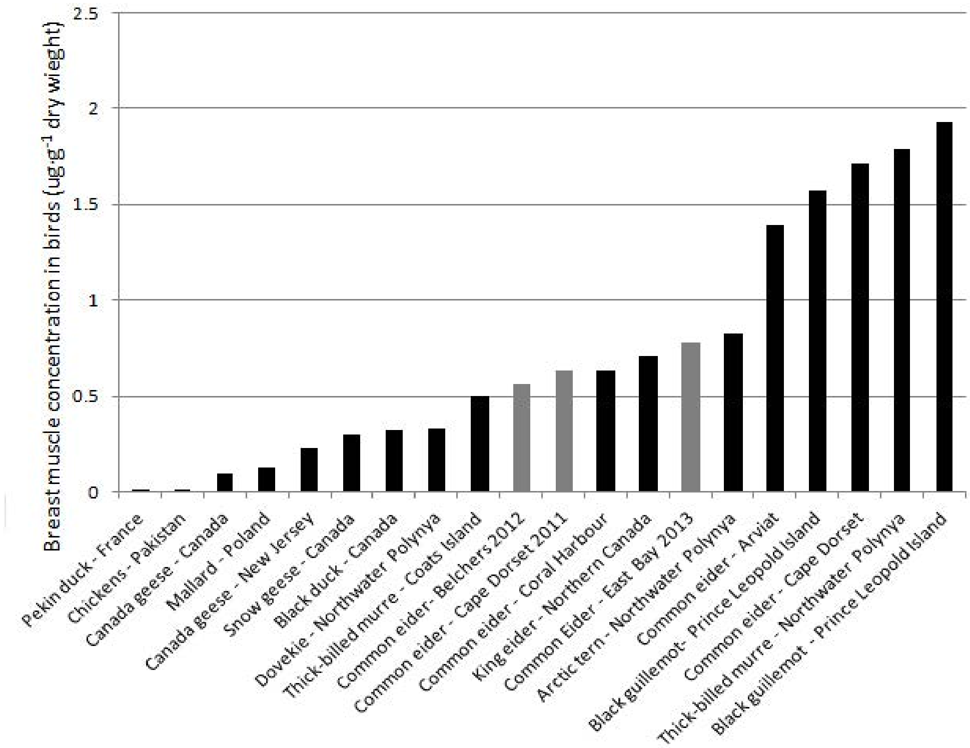


Figure 2. Mercury concentrations (µg·g^{-1} dry weight) in northern common eider duck breast muscle from the Belcher Islands (n=76, S.m. sedentaria), Cape Dorset (n=242; S. m. borealis) and East Bay Island (n=11; S. m. borealis) over the 2011-2013 time period.

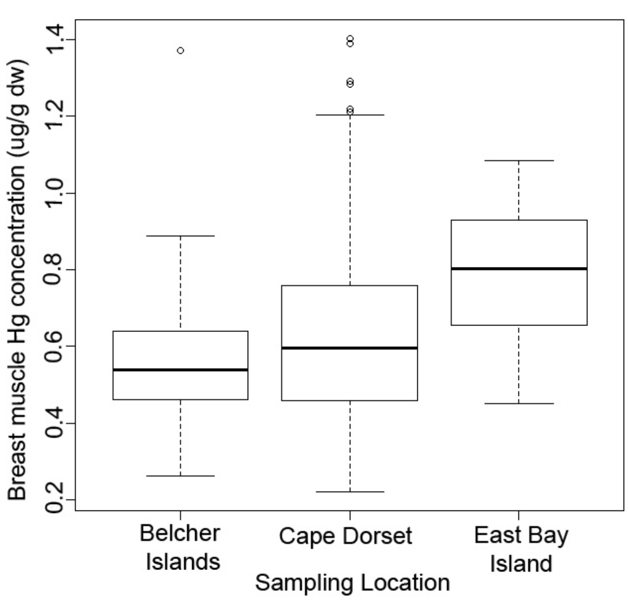
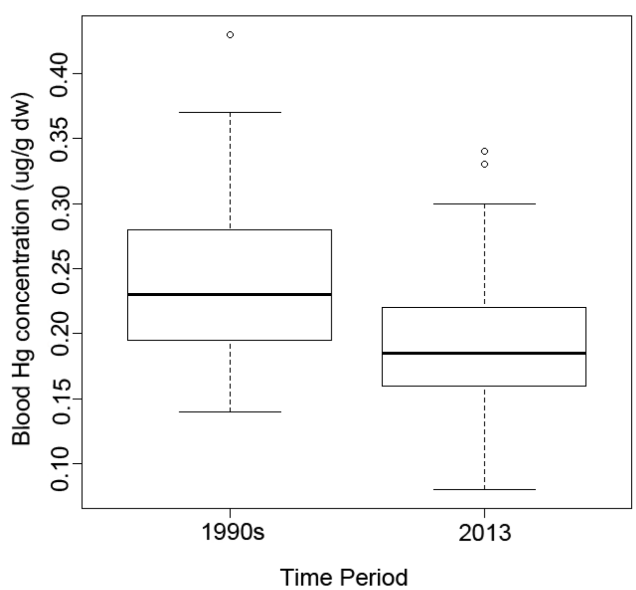


Figure 3. Blood mercury concentrations (µg·g^{-1} dry weight) in breeding female northern common eider ducks at East Bay Island, Nunavut in 1997/98 (n=28) and 2013 (n=106).



Discussion and Conclusions

Common eider breast muscle Hg concentrations found in this study were within the range of previously reported values (Mallory et al., 2004). The Hg concentrations in the eider meat was also below levels thought toxic to wildlife (Shore et al., 2011).

Although inter-annual differences in eider duck muscle Hg concentrations appear to be minimal in the Cape Dorset area, significant differences are found among sites in the Hudson Bay/Hudson Strait area. This suggests that different processes may be influencing the deposition, or the uptake to the food chain, of mercury within the region. The apparent site difference may also be due to the collections being done at slightly different time periods, in reality a seasonal difference. More work is needed to understand if these are truly regional differences, or caused by other factors across the seasons.

Blood Hg concentrations from breeding females at East Bay Island were significantly lower in 2013 than in the late 1990s. Blood is likely indicative of mercury intake over the period of days or weeks, so these levels likely indicate that females in East Bay took in lower levels of Hg in 2013 versus 1997/98. This could be indicative of changing mercury depositions in the region. The difference in concentration between the two sampling time periods may also be due to differences in local conditions in Hg availability in the ecosystem at this time of year related to seasonal snow melt and release of Hg (Provencher et al., 2014; Zdanowicz et al., 2013). Other marine birds in the area have shown similar inter-annual differences in Hg concentrations even over very short time spans (McCloskey et al., 2013), suggesting that local drivers may be influencing Hg in marine birds in the region.

Although the Hg analysis for all samples is now complete, the detailed analysis of the interactions between gastro-intestinal parasites and Hg in both migrating and breeding birds is still underway. The work completed to date under the NCP has laid the ground work for a more intensive analysis of the dual stressors that eider ducks, and other northern wildlife, may be experiencing under changing climatic and industrial processes.

Expected Project Completion Date

Further results and analysis from this work will become available upon the completion publishing and completion of Jennifer Provencher's doctoral work. Her expected PhD completion date is May 2016.

Project website

More information about this project, and the larger overall research objectives, can be found on jenniferprovencher.com.

Acknowledgments

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Evaluating the Accumulation of Persistent Organic Pollutants in Arctic Cod in the Beaufort Sea Using Samples from The BREA Program.

Titre du projet : Évaluation de l'accumulation des polluants organiques persistants chez la morue polaire de la mer de Beaufort à partir d'échantillons prélevés dans le cadre de l'Évaluation environnementale régionale de Beaufort

- **Project Leader:**
  Brendan Hickie,Environmental & Resource Studies Program,Trent University
  Tel: (705) 748-1011 ext 7623, Fax: (705) 748-1569, Email: bhickie@trentu.ca

  Gary A. Stern,Centre for Earth Observation Science (CEOS), Department of Environment and Geography, University of Manitoba, Tel: (204) 474-9084, Email: Gary.stern@umanitoba.ca
- **Project Team Members and their Affiliations:**
  Liisa Jantunen, Air Quality Research Division, Environment Canada

Abstract

Arctic cod are widely recognized as a keystone species in Arctic marine food webs where they serve as a prime conduit of energy and hence contaminants from planktonic organisms to upper trophic level species including marine mammals and seabirds that northern people rely on for food. Despite this, there is little data characterizing contaminant concentrations in Arctic cod and factors affecting their accumulation. We are measuring both legacy Persistent Organic Pollutants (POPs) and newer organic contaminants in a large sample of cod (n=60) collected from both in-shore and off-shore areas of the Beaufort Sea that will also allow us to characterize the effects of size and age, lipid content. Analyses were delayed due to

Résumé

Il est largement admis que la morue polaire est une espèce clé au sein des réseaux trophiques marins de l'Arctique puisqu'elle constitue un important axe de transfert de l'énergie – et, donc, des contaminants – des organismes planctoniques vers les espèces des niveaux trophiques supérieurs, notamment les mammifères marins et les oiseaux de mer dont les peuples du Nord se nourrissent. Malgré cela, il existe peu de données caractérisant les concentrations de contaminants dans la morue polaire et les facteurs qui régissent leur accumulation. On mesure les concentrations de polluants organiques persistants (POP) hérités du passé et de contaminants organiques plus récents dans un vaste échantillon de

the closure of the Fisheries and Oceans Canada Winnipeg contaminants laboratory, and are now being conducted through Environment Canada. Analyses will be completed by the end of 2014 for polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), brominated flame retardants (BFRs), current use pesticides (CUPs).

morues (n = 60) provenant de zones côtières et extracôtières de la mer de Beaufort; cela permettra de caractériser les effets de la taille, de l'âge et de la teneur en lipides. Les analyses ont été retardées par la fermeture du laboratoire d'analyse des contaminants de Pêches et Océans Canada à Winnipeg; elles sont en train d'être réalisées par l'intermédiaire d'Environnement Canada. D'ici la fin de 2014, on aura terminé l'analyse des polychlorobiphényles (PCB), des pesticides organochlorés (POC), des produits ignifuges bromés (PIB) et des pesticides actuellement utilisés (PAU).

Key messages

- Analyses for PCBs, BFRs, OCPs and CUPs are being conducted for 60 samples of Arctic cod from the Beaufort Sea that will allow us to determine whether concentrations of these chemicals vary with location (near-shore versus off-shore), age/size and lipid content.
- This research will fill a significant data gap in helping us better characterize the bioaccumulation of these chemicals into beluga whales and ringed seals in this region.

Messages clés

- On est en train de doser les PCB, les PIB, les POC et les PAU dans 60 échantillons de morue polaire provenant de la mer de Beaufort. Cela permettra de déterminer si les concentrations de ces produits chimiques varient en fonction du lieu (zones côtières par rapport aux zones extracôtières), de l'âge et de la taille, et de la teneur en lipides.
- Ces travaux de recherche combleront une grave lacune dans les données en permettant de mieux caractériser la bioaccumulation de ces produits chimiques chez les bélugas et les phoques annelés de la région.

Objectives

- To measure concentrations of legacy (POPs) and new chemicals in Arctic cod collected from several locations in the Beaufort Sea during the Beaufort Regional Environmental Assessment sampling program in the summer of 2012.
- To determine whether concentrations or patterns of contaminants in Arctic cod differ between near-shore and off-shore locations in the Beaufort Sea.
- To examine the effects of size, age and trophic position (based on stable isotopes) on contaminant levels will also be examined.
- To compare whether contaminant concentrations in Arctic cod collected in 2012 differ from samples collected in 1997/98 farther offshore during the SHEBA project.
- To better characterize dietary exposure concentrations of contaminants for beluga from the region and to calculate cod:beluga biomagnification factors using data from the NCP beluga contaminant monitoring project.

Introduction

Arctic cod (Boreogadus saida) are widely recognized as a keystone species in Arctic marine food webs where they serve as a prime conduit of energy and hence contaminants from planktonic organisms to upper trophic level species (Bradstreet and Cross, 1982, Muir et al. 1988, Welch et al. 1992, Fisk et al. 2001, Hop et al. 2002) including marine mammals and seabirds. The study by Welch et al (1992) showed that Arctic cod were the dominant mid trophic level planktivore in Lancaster Sound, mainly feeding on copepods and, in turn, being preyed upon by beluga and ringed seals (and other marine mammals) and by northern fulmars and thick-billed murres. It is noteworthy that these marine mammals and seabirds are all used in the NCP-funded long-term contaminant trend monitoring program. Recent work by Loseto et al (2006, 2008a,b, 2009) has shown that the western Arctic beluga population (undergoes a size-related habitat segregation in the summer months in the Beaufort Sea that results in differences in mercury concentrations in liver and muscle even though Arctic cod was the primary prey of the segregated groups. This raises the question whether levels of mercury and other contaminants also vary spatially in Arctic cod from the Beaufort Sea.

In this study we will measure a suite of legacy POPs (including PCBs, HCHs, Chlordanes, DDTs), BFRs and current use pesticides in Arctic cod which are the primary prey of both beluga and ringed seals. The fish were collected in an extensive sampling effort in 2012 with funding from the Beaufort Regional Environmental Assessment program (BREA) and Environmental Studies Research Funds. Despite their importance in Arctic marine food webs, publications characterizing contaminant concentrations in them are relatively sparse or are based on small sample sizes (Muir et al. 1988, Fisk et al. 2001, Hop et al. 2002, Hoekstra et al. 2003)

Activities in 2013-2014

Sixty Arctic cod samples were selected for contaminant analysis from the BREA collection of several thousand fish collected in 2012. The selected fish were from two locations and spanned as wide range of sizes as possible.

With the closing of the contaminant analysis laboratories at DFO-Winnipeg the samples were to be analyzed by a contract laboratory that had met preliminary quality assurance and quality control standards. This laboratory, however, had difficulty in measuring the relatively low concentrations of PCBs and organochlorine pesticides found in Arctic cod, which has caused us to seek alternative analytical support. Our samples are currently being analyzed in Dr. Liisa Jantunen's laboratory (Environment Canada - Air Quality Research Division). While this change in laboratories has delayed the completion of this project we are certain that we will produce quality results by working with and will also be able to report on a wider range of contaminants than was included in the original project proposal.

Capacity Building, Communications, and Traditional Knowledge Integration:

This project was new in 2013-14 and relied on access to previously collected samples of Arctic cod. As such, there was no direct interaction with communities, nor opportunities to train northern community members or students.

Results

Owing to the delays encountered in analysis of samples, no results are available from this project at this time. Analyses are currently in progress in Dr. Jantunen's laboratory and will span a wider range of chemicals than was included in the original proposal. Chemicals to be measured include: PCB congeners, organochlorine pesticides (α-,β-,ɑ,HCHs,

HCB, p,p'-DDE, Σchlordanes (trans- and cis-chlordane and trans-nonachlor (TC,

CC, TN), heptachlor epoxide (HEPX)), dieldrin), brominated flame retardant congeners, and current use pesticides (dimethoate, malathion, endosulfan, trifluralin, dacthal, chlorothalonil, chlorpyrifos, endosulfans, dicofol, and pentachloronitrobenzene).

Discussion and Conclusions

Results will be presented and discussed in the 2014-15 NCP Synopsis of Research.

Expected Project Completion Date

Expected completion of the Arctic cod analyses is December 2014. Analyses of other species from the Beaufort Sea food web collected during BREA cruises was proposed as an extension of this project.

Acknowledgments

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Polycyclic Aromatic Compounds, Flame Retardants and Other Persistent

Composés aromatiques polycycliques, produits ignifuges et autres polluants organiques persistants dans l'air et dans l'eau de l'archipel canadien

Project Leader:
Liisa M. Jantunen, Centre for Atmospheric Research Experiments, Environment Canada
Tel: (705)4 58-3318, Fax: 705-458-3301, Email: liisa.jantunen@ec.gc.ca

Project Team Members and their Affiliations:
Mahiba Shoeib, Hayley Hung, Nick Alexandrou and the OAL Team, Environment Canada; Gary Stern and Monica Pucko, University of Manitoba; Miriam Diamond and Emma Goosey, University of Toronto; Brendan Hickie, Trent University

Abstract

Air and water samples were collected in the Canadian Archipelago during September 2013 as a part of ArcticNet to determine occurrence and levels of persistent organic pollutants. This includes banned organochlorine pesticides (OCPs), current use pesticides (CUPs) and flame retardants (specifically the organophosphate flame retardants [OPFRs]). Temporal trends were assessed for these compounds since levels of OCPs in air and water in the Canadian Archipelago have been measured by our group starting in 1992, CUPs since 1999 and air samples for OPFRs were taken from the archive back to 2007.

Résumé

En septembre 2013, on a recueilli des échantillons d'air et d'eau dans l'archipel canadien par l'intermédiaire d'ArcticNet, cela afin d'y mesurer les concentrations de polluants organiques persistants (POP), dont des pesticides organochlorés (POC) frappés d'interdiction, des pesticides actuellement utilisés (PAU) et des produits ignifuges (de manière plus précise, les produits ignifuges à base d'organophosphates [PIOP]). On a évalué les tendances temporelles relatives à ces composés puisque les concentrations de POC dans l'air et dans l'eau de l'archipel canadien sont mesurées par notre groupe depuis 1992, et les concentrations de PAU, depuis 1999; de plus, des échantillons d'air

Levels of OCPs in air and water continue to decline and are approaching detection limits; this trend is also being seen at other arctic air monitoring sites. In general, CUPs have remained constant in air and water except dacthal that is decreasing. Dicofol was also screen and detected in the air and water samples, this is an important compound because it is being reviewed by the Stockholm convention on POPs but reported data in the arctic environment is lacking.

These measurements of OPFRs air are the first for the Canadian Arctic and the OPFRs measurements in water are the first reported values in the entire Arctic. OPFRs concentrations very high compared to the other compounds sought and are orders of magnitude higher than the brominated flame retardants. OPFRs in Arctic air are quite varied so spatial and temporal trends were not apparent but lower concentrations were observed in air samples taken at Alert compared to the central and southern archipelago.

remontant jusqu'en 2007 ont été pris dans les archives pour l'analyse des tendances relatives aux PIOP. Les concentrations de POC dans l'air et dans l'eau continuent de décliner et s'approchent des limites de détection; cette tendance a également été observée à d'autres sites de surveillance atmosphérique en Arctique. De manière générale, les PAU sont demeurés constants dans l'air et dans l'eau, sauf le dacthal, dont les concentrations décroissent. Les analyses visaient aussi à dépister et à mesurer le dicofol dans les échantillons d'air et d'eau; il s'agit là d'un composé important puisqu'il est en cours d'examen dans le cadre de la Convention de Stockholm sur les POP, mais on manque de données sur sa présence dans l'environnement arctique. Ces mesures des PIOP dans l'air sont les premières à être effectuées dans l'Arctique canadien, et les mesures des PIOP dans l'eau sont les premières à être publiées pour l'Arctique dans son entier. Les concentrations de PIOP sont très élevées par rapport à celles des autres composés analysés, et elles sont des dizaines de fois plus grandes que celles des produits ignifuges bromés. Les PIOP dans l'air arctique sont assez variés; il n'a donc pas été possible de dégager des tendances spatiales ou temporelles, mais on a enregistré des concentrations plus faibles dans les échantillons d'air prélevés à Alert que dans les échantillons provenant du centre et du sud de l'archipel.

Key messages

- High levels of organophosphate flame retardants and plasticizers (OPFRs) were found in Canadian archipelago air, water and zooplankton.
- These are the first reports of organophosphate flame retardants in Arctic water and Canadian Arctic air.
- The levels of OPFRs in air, water and zooplankton are magnitudes higher than brominated flame retardants including the poly brominated diphenyl ethers (PBDEs).
- Levels of banned organochlorine pesticides in air and water continue to decline.

Messages clés

- On a mesuré des concentrations élevées de produits ignifuges et de plastifiants à base d'organophosphates (PIOP) dans les échantillons d'air, d'eau et de zooplancton prélevés dans l'archipel canadien.
- Il s'agit des premières concentrations de produits ignifuges à base d'organophosphates signalées dans les eaux arctiques et dans l'air de l'Arctique canadien.
- Les concentrations de PIOP dans l'air, dans l'eau et dans le zooplancton sont des dizaines de fois plus élevées que celles de

- Levels of the in use pesticides determined remain constant except dacthal which is declining.

produits ignifuges bromés, y compris les polybromodiphényléthers (PBDE).

- Les concentrations de pesticides organochlorés frappés d'interdiction continuent de décliner dans l'air et dans l'eau.
- Les concentrations de pesticides actuellement utilisés sont demeurées constantes, sauf celles de dacthal, qui décroissent.

Objectives

To collect a set of baseline air concentration data for new and emerging chemicals in the Arctic against which future trends, sources and sinks may be evaluated; focusing on new flame retardants (FRs) and polycyclic aromatic compounds (including polycyclic aromatic hydrocarbons).

To assess the feasibility of collecting air samples for PACs from a diesel burning ship, to assess the PACs combustion signature of that ship and to make a first estimate of the impact of increased marine traffic on the archipelago air quality.

To continue time trends of POPs in air and water as a mechanism for assessing the impact of regulatory decisions and climate change on arctic contamination; and to apply the ocean contaminant data to the design of a practical monitoring strategy for Canadian Arctic waters including assessing the feasibility of passive water sampling.

Introduction

Air and biota monitoring results from the Canadian arctic indicate that most legacy POPs including DDT, hexachlorocyclohexanes (HCHs) and polychlorinated biphenyls (PCBs) are declining (Becker et al. 2012; Hung et al. 2010; Su et al. 2008; Ryan et al. 2013; Riget et al. 2010). However, these declines maybe buffered by climate change, which results in increased surface air temperature and reduced ice cover, and thereby facilitates the release of contaminants from the water into the air.

Some recently banned compounds have peaked and are now declining in the arctic environment as a result of national and international regulations. This includes PFOS and PBDEs, levels in seabirds, seals and beluga whales peaked in the late 1990s to early 2000s and are now declining and declines in PBDEs have also been seen in air at Alert (NCP 2103).

OPFRs are current use high volume chemicals and have been used for a wide variety of applications including: flame retardants (FRs), plasticizers, in hydraulic fluids and levelers in floor waxes. As other FRs are banned/restricted the usage of OPFRs has increased. These potentially toxic chemicals are on the Canadian Chemical Management Plan risk assessors high priority list.

Air is a core medium and water monitoring is a secondary medium for monitoring under the Stockholm Convention's Global Monitoring Plan (GMP) for Persistent Oganic Pollutants (POPs): (UNEP, 2011). Water is an important media to study as oceanic movement maybe the dominate transport process in to the arctic for the more water soluble compounds; this includes some PFCs, some OPFRs and b-HCH.

Since polycyclic aromatic hydrocarbons and compounds (PAHs and PACs) can migrate from emission source regions to the arctic, they have been listed in the United Nations Economic Commission for Europe Aarhus Protocol, where PAHs are classified as a POP. The Convention on Long Range Transboundary Air Pollution states emissions of PAHs are to be reduced to below 1990 levels. As marine traffic, mining and oil/gas exploration increases in the archipelago, the local emissions of PACs is also expected to increase.

Activities in 2013-2014

Sample Collection

Air, water and water particulate samples were collected on board the CCGS Amundsen in September 2013. Due to the helicopter accident while at sea the cruise ended without completing the sample collection. Samples were collected between Resolute Bay and Banks Island in Barrow and McClure Straits. The following samples were collected: air (5 taken where 12 were proposed), surface water (dissolved (5/8) and particulate (5/4), more were taken than proposed)) and depth water (11/30). No moorings were deployed so no passive water samples were installed. Funding that was not used in 2013-2014, was used to prepare for sampling in 2014-2015. All the samples have been extracted and processed, some instrumental analysis has been completed (OCPs, CUPs and OPFRs) and other analysis is one going (PACs, FPCs and brominated flame retardant). Additionally, archived air samples collected as part of IPY, CFL, ArcticNet and from Alert between 2007 to 2011, were analyzed for new and emerging compounds, including OPFRs.

Results

OPFRs: OPFRs were determined in air samples taken as part of the Northern Contaminants Program (NCP) and ArcticNet between 2007-2013. We identified and determined for the first time in the Canadian arctic concentrations of OPFRs in air. This information provides baseline concentrators for OPFRs in which future trends can be gauged. Such temporal information is vital in determining whether a new chemical is a candidate for national and international regulations.

OPFRs identified in arctic air were: tris-chloroethyl phosphate (TCEP), tris-chloropropyl phosphate (TCPP), triphenyl phosphate (TPhP), ethyl-hexyl diphenyl phosphate (EHDPP) and tris-dichloropropyl phosphate (TDCPP). Generally, TCEP had the highest concentration found, followed by TCPP, TPhP, TDCPP and EHDPP had the lowest concentration, although relative levels were found to fluctuate. The levels of OPFRs are much higher than the sum of PBDEs at arctic monitoring stations (Figure 1). Levels found here compare well with levels found by Moller et al. (2012) in the North Pacific and Chukchi Sea area, shown in red in Figure 1.

OPFRs were also sought in water in 2011 and 2013 as part of ArcticNet and at Resolute Bay in 2012. Concentrations of the S-OPFRs in the water range from 14-36 ng·L, where TCEP>TCPP>TPhP>TDCPP>EHDPP. There was also no spatial distribution of the OPFRs from the western archipelago in 2013 to the central in 2011 and 2012 and in the east in 2011.

Current Use Pesticides:

CUPs have been analyzed in air samples from the Canadian Archipelago by our group since 1999 and endosulfan since 1992, see Figure 2 and 3. A new compound added to the target list this year is dicofol; it is under review by the Stockholm Convention and CLRTAP. Dicofol data is sought after because there is little arctic data available in the literature to justify its inclusion in the Stockholm Convention (personal communications with Jason Stow and Eva Kruemmel). Analytical methods for determining dicofol have been modified and air and water samples have been screened, average levels of dicofol in air was 1.9 pg·m3 where it was below detection limits in water (<1pg·L). Endosulfans, chlorpyrifos and trifluralin were found in arctic air at similar levels found in previous studies. Dacthal levels are consistently decreasing over time and chlorothalonil on first screening was not detected in air.

In our studies, the levels of most CUPs in water in Canadian archipelago were generally increasing since 1999 but more recently seem to be leveling off or decreasing in the last couple sampling campaigns (Figure 3). This maybe a real decrease or may be due to the fact that the water samples were collected in different parts of the archipelago. An uneven distribution of contaminants was seen for HCHs in the archipelago, which show decreasing concentration from west to east in Canadian arctic.

Organochlorine Pesticides:

OCPs in air and water have declined between 1992-2013, see Figure 3. HCHs, chlordanes, dieldrin and toxaphene have all significantly decreased in water ($p<0.01$), where heptachlor epoxide results are variable so it has not significantly changed over time ($p>0.05$).

Levels of dieldrin, chlordanes, toxaphene and heptachlor epoxide are approaching current detection limits, toxaphene in 2010-2013 was estimated at <5pg·L and <5pg·m3 in water and air, respectively.

Perfluoroaklyl Compounds (PFASs):

Our group has been measuring PFASs in arctic air since 2007, the earlier studies have been published (Shoeib et al. 2006; Ahrens et al. 2011). Figure 4 shows data from 2010-2011, the 2011 study was funded by NCP.

In 2011, water samples were collected for PFAS, including eight depth profiles. Concentrations did not significantly vary with depth, indicating the upper 50-100 m is well mixed for the PFAS. PFCAs had the highest concentrations, particularly PFBA, PFPeA and PFNA. Additionally, there also is not a spatial distribution of PFAS, except lower concentrations were observed in Baffin Bay compared to the archipelago. This is the first report of parallel air-water sampling in the arctic for PFASs.

Air Water Gas Exchange:

Generally, the legacy OCPs in the air and water are at equilibrium with net fluxes are not significantly different from zero. Since we started doing estimates of gas exchange for CUPs in 1999 (1992 for endosulfan), flux directions have been depositional, ie from the air into the water. In 2010, the flux direction changed to equilibrium for dacthal and chlorpyrifos, where the net flux magnitude became less depositional for chlorothalonil. This was due to generally declining air concentrations coupled with water concentrations that were increasing or holding steady, leading to a shift in the flux magnitude towards reduced in depositional fluxes. Although by 2013 all the fluxes had returned to very depositional.

Endosulfan-I has been determined in sub-arctic and arctic air and water since 1992, the flux direction, except in 2007, has been strongly depositional.

Zooplankton:

Themisto, Calanus and Euchaeta zooplankton were collected in 2011. The OPFRs were dominated by EHDPP which was detected in all samples, had low blank values and ranged in concentration from 0.02-4.9 ug·g lipid weight (0.012-1.1ug·g dry weight). EHDPP was found in low concentrations in air and water but it is one of the abundant OPFRs in house dust (Shoeib and Jantunen, 2013). TPhP and TCEP were also detected in about one half of the samples but blanks were high which leads to uncertainty in the data. Samples that passed the blank screening criteria of the blank + 3*stdev of the blank were blank corrected and ranged from 0.14-1.8 ug·g (n=12/27) and 0.038-1.7 ug·g lipid weight (n=9/27) for TPhP an TCEP, respectively.

CUPs in zooplankton found were pentachloronitrobenzene (PCNB) > chlorpyrifos > endosulfans > dacthal > trifluralin. With levels averaging 5.0, 2.2, 0.58, 0.46 and 0.21 ng·g lipid weight and 1.0, 0.44, 0.19, 0.12 and 0.07 ng·g dry weight, respectively.

Figure 1: Average concentrations of OPFRs in the Canadian Arctic air, 2007-2013. ArcticNet 2007: shipboard August in the Labrador Sea and Hudson Bay areas; ArcticNet 2008: shipboard Beaufort Sea in May-June; Alert 2008/09: land based Dec 2008 to Aug 2009 (blank problems for TPhP); Pacific Arctic 2010: ship based Bering-Chukchi-Beaufort Seas summer of 2010 is from Moller et al., 2012; ArcticNet 2011: shipboard central and east archipelago; Resolute Bay: land based July 2012 and ArcticNet 2013: ship board in Barrow Strait and McClure Strait. Compared to the sum-PBDEs in Greenland, Ny Alesund and the Alert monitoring station (see Xiao et al., 2012 for references).

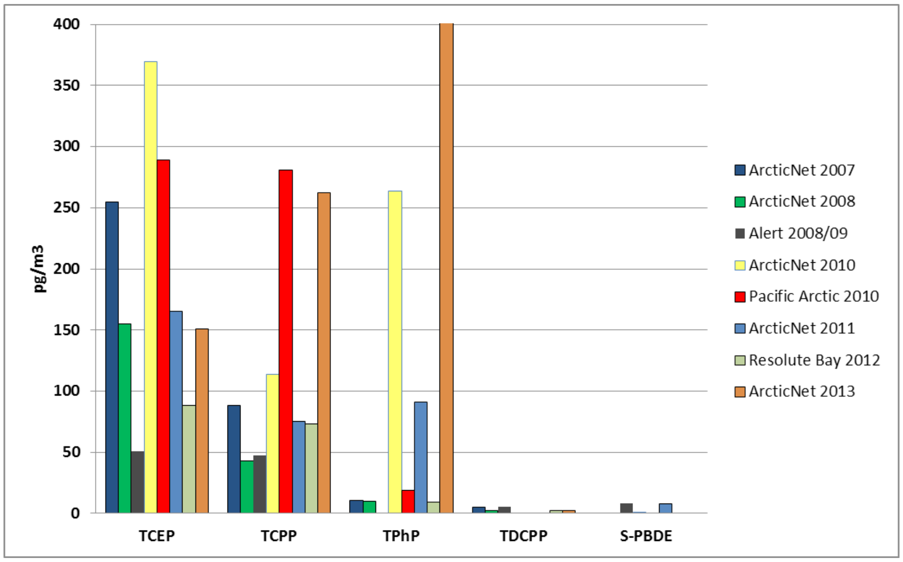


Figure 2: Temporal trends of current use pesticides (CUPs) in air in the Canadian arctic between 1999-2013, showing arithmetic mean concentrations in pg·m3.

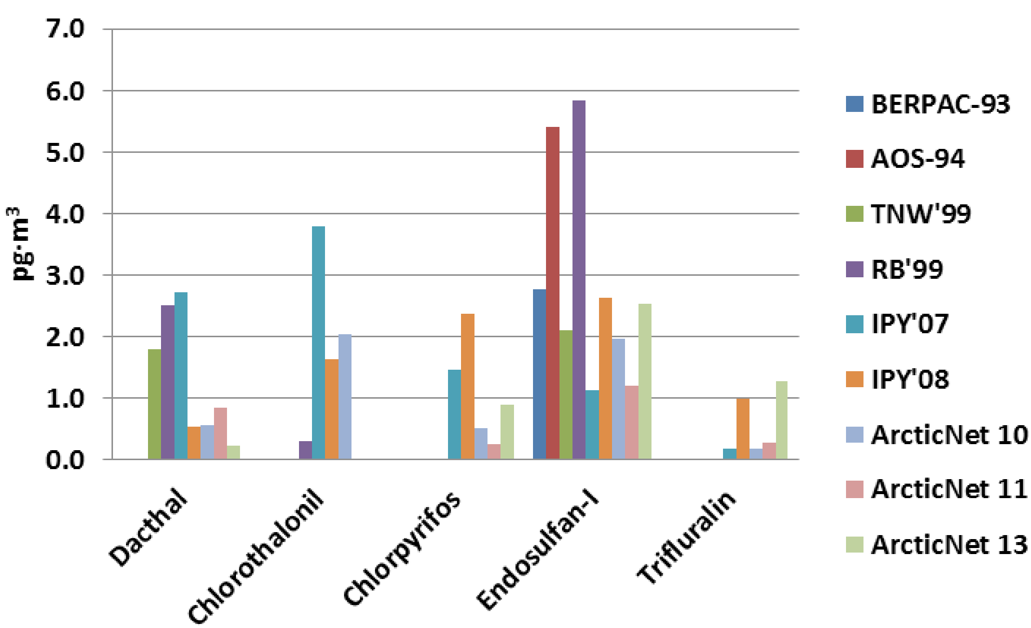


Figure 3: Temporal trends of legacy and current use pesticides in water in the Canadian Archipelago in pg·m3. Heptachlor epoxide, dacthal and chlorothalonil were not investigated in 1992, where chlorpyrifos was not investigated in 1992 and 1999.

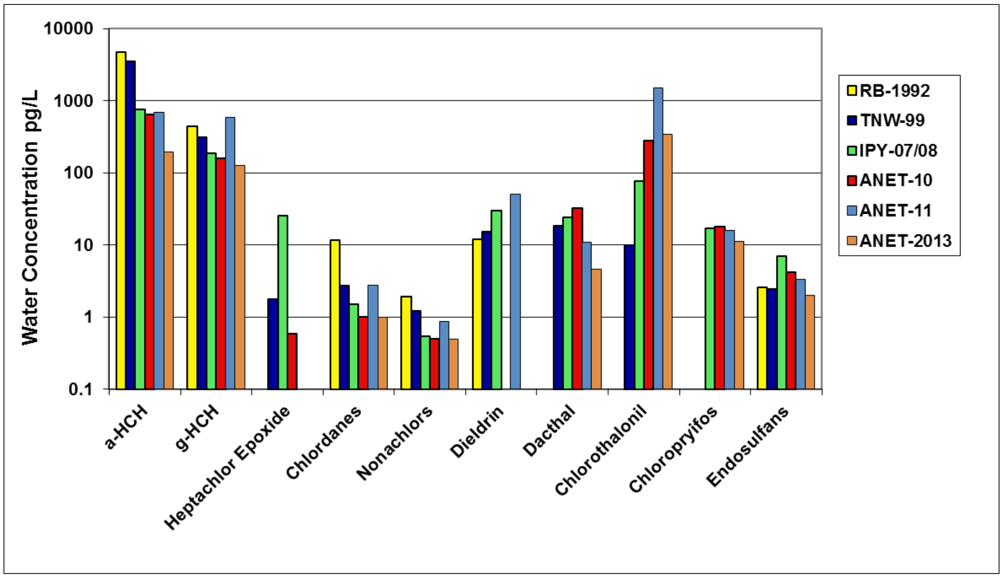
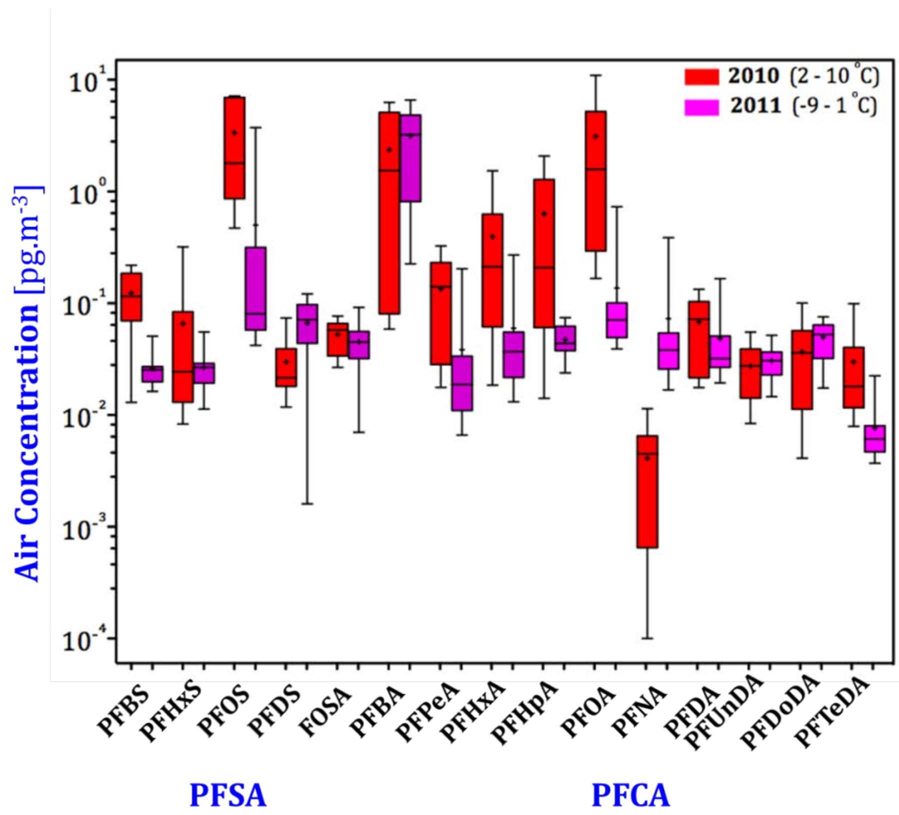


Figure 4. Box and whiskers plot of PFAS concentrations for PFSAs and PFCAs in air (sum of particle and vapour phases) where boxes correspond to the interquartile range (25th and 75th percentiles), whiskers to 5th and 95th percentiles. Non-detects were randomly assigned 1/3 - 2/3 IDL.



Discussion and Conclusions

OPFRs

OPFRs reported here are in the same range that has been seen in the North Sea (Möller et al. 2012) and the Bering and Chukchi Seas (Möller et al. 2011). Levels found in arctic air are lower than those over lakes Superior and Erie (Jantunen et al. 2013) and much lower than in urban air in Toronto and at a sewage treatment plant in southern Ontario (Shoeib et al. 2013). Sum-PBDEs in these southern locations show the same trend as in the arctic with levels of individual OPFRs 10-100 times higher than the sum-PBDE.

Although the concentration of OPFRs in arctic water are high compared to PBDEs, organochlorine and current use pesticides in water, the levels are considerable lower than open water concentration in the Great Lakes, where concentrations are in the 100s ng·L and up to 4000 ng·L urban tributaries (Jantunen et al. 2013).

Although transport and fate models predict the OPFRs will not be long range atmospherically transported to the arctic, our study and another study by Moller et al. (2012) found OPFRs in the arctic atmosphere. The models used to predict the atmospheric half-life of OPFRs only used gas phase OPFRs, where we found OPFRs are only found on particles. When sorbed to particles, OPFRs have much longer life-time in the atmosphere (Lui et al. 2013).

OPFRs are a significant contaminant in the arctic environment and more studies on the uptake by biota and their toxicity are needed to assess the exposure and risk these chemicals pose to northerners.

CUPs

CUPs are important to study in the arctic because several have been found in arctic biota including endosulfans, pentachloronitrobenzene and dacthal (Tomy et al. 2009) and endosulfan has been found to be bioaccumulative (Weber et al. 2010). Since air concentrations of endosulfan from this study have no temporal trend, the restrictions on endosulfan usage in Europe and North America (Health Canada 2011) and its recent addition to the Stockholm convention is not yet reflected in the levels in arctic air. It is important to continue to monitor endosulfan to ensure international regulations are affective. Additionally, as more CUPs become legacy pesticides, it is important to monitor potential replacement chemicals to ensure they are safer alternatives and do not undergo long range transport and impact the arctic environment.

The data on CUPs in seawater reported here are important because only a few other studies of CUPs in seawater have been published (Hoferkamp et al. 2010; Zhong et al. 2011). Endosulfan and lindane (g-HCH) are the most frequently reported CUPs in Arctic Ocean water (Weber et al. 2006).

OCPs

Declines of OCPs in arctic air and water found in this study have also been found at in air at other arctic monitoring sites (Hung et al. 2010; NCP 2013) and in declines in biota have also been observed (Riget et al. 2012; NCP 2013). National and international regulations of these compounds have produced the desired outcome, reduction in environmental levels thus a reduction in exposure those living in the north and the south.

PFCs

The main transport pathway of PFASs to remote regions has not been conclusively characterized to date. Transport processes that bring PFASs to the Arctic include transport in air or water and/or of the precursors that can undergo transformation to the ionic form (PFOS and PFCAs). The global fate and transport of PFCAs and PFOS have also been modeled using available emission estimates and provide insight into the relative importance of directly emitted PFCAs and PFOS in comparison to precursor sources (Armitage et al. 2009; Stemmler and

Lammel 2010; Wania 2007). These studies found that oceanic transport of directly emitted PFOA and PFOS is the dominant source of these compounds to the Arctic ocean and with continued transport from lower latitudes PFOA and PFOS is expected to increase over the next 1-2 decades years. However, with the regulation of some per-fluorinated compounds emissions will decrease and lead over time to reduced levels in the arctic environment.

Generally, levels are declining in arctic air and the levels of PFAS found in the arctic are about 3 times lower than in urban areas like Toronto, Canada and Hamburg, Germany (Shoeib et al. 2006; Jähnke et al. 2007).

Gas Exchange

Air-water processes and their evolution over the last couple of decades, are really only well characterised for the HCHs (and to a lesser extent for chlordanes) and very little is known about atmospheric loadings to surface waters for newer, emerging contaminant groups such as the CUPs, PFASs, PACs and alternate FRs. Understanding the role of air-water 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 exacerbate the transfer from air to water for some chemicals.

With the restriction on usage of endosulfan in North America and Europe and with the anticipated decline of endosulfan in arctic air, the gas exchange direction may approach equilibrium or reverse to where the water is a source of endosulfan to the overlying air. A study in 2010 in the Bering-Chukchi seas and Beaufort Sea, they also found endosulfan was depositing, chlorpyrifos was close to equilibrium or depositing and dacthal was at equilibrium or volatilizing (Zhong et al. 2011).

2014-2015

This project will continue in 2014-2015 and air, water and water particulate sampling will continue in the summer of 2014 on board the Amundsen. Additionally, surface sediment will be collected and passive water samples will be deployed on moorings. We will continue to collect samples for OPFRs as these compounds are found in high concentrations and risk assessors and risk managers from the Chemical Management Plan are very interested in the data as inputs to their assessment reports and decisions on regulations and usage restrictions. Also in 2014, we will team with John Abbott and Jennifer Murphy to assess the viability of taking air samples for PAHs/PACs from a diesel burning ship by pairing on air measurements.

Expected Project Completion Date

Analysis of samples from this project are expected to be complete by December 2014.

Acknowledgments

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Influence of Climate Warming on Mercury Dynamics in High Arctic Lakes

Effet du réchauffement du climat sur la dynamique du mercure dans les lacs du Haut-Arctique

Project Leader:

Paul Drevnick, INRS-ETE, Université du Québec
Tel: (734) 763-6280, Email: drevnick@umich.edu

Project Team Members and their Affiliations:

Karista Hudelson, Institut national de la recherche scientifique - Centre Eau Terre Environnement; Alicia Manik, and Debbie Iqaluk (Resolute Bay); Derek Muir, Environment Canada; Günter Köck, Austrian Academy of Sciences and University of Innsbruck; Carl Lamborg, Woods Hole Oceanographic Institution

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 possibly high concentrations in fish. Consumption of contaminated fish can be a major source of Hg in humans and wildlife and is detrimental to health. For the NCP-sponsored char 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

Résumé

Le mercure (Hg) est émis dans l'atmosphère par les activités humaines, 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 microorganismes transforment le Hg en méthylmercure (MeHg), lequel se bioaccumule dans les réseaux trophiques, ce qui peut entraîner la présence de concentrations élevées chez les poissons. La consommation de poissons contaminés peut constituer une source importante de Hg pour les humains et les espèces sauvages, et elle est néfaste pour la santé. Dans le cadre d'un programme de surveillance de l'omble parrainé par le Programme de lutte contre les contaminants

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 period sampled, there has been no consistent increase or decrease with time, perhaps reflecting that atmospheric inputs are leveling off with time. Interestingly, Hg concentrations in char tend to track year-to-year changes in summer air temperature, similar to a pattern observed in South West 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.

dans le Nord, on a recueilli des ombles chevaliers (Salvelinus alpinus) confinés aux eaux intérieures dans des lacs près de Resolute Bay, au Nunavut, sur une base annuelle pendant plus de 15 ans. Ces ombles sont de bons indicateurs des fluctuations des apports de Hg en provenance de l'atmosphère. Les concentrations de Hg dans les ombles des différents lacs reflètent les apports atmosphériques, et dépassent souvent la valeur que Santé Canada considère comme sans danger dans l'optique d'une consommation à des fins de subsistance. Sur la période d'échantillonnage, on n'a noté aucune hausse ou baisse constante au fil du temps, ce qui indique peut-être que les apports atmosphériques se stabilisent avec le temps. 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 provenant des lacs ayant fait l'objet d'une surveillance, 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. Les travaux sur le terrain dépendent de l'aide des membres de la collectivité de Resolute Bay. On soumettra les résultats de cette étude et les données de surveillance des ombles à un modèle de la bioaccumulation à des fins de couplage, cela pour mieux comprendre et prédire l'effet des variations des sources de Hg ainsi que du changement climatique sur l'accumulation de Hg et sur 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.
- 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.
- Data collection and laboratory analyses are ongoing.

Messages clés

- On a installé des enregistreurs de données sur la température à diverses profondeurs dans quatre lacs (Char, Meretta, Resolute, Small) près de Resolute Bay, au Nunavut.
- 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 pour 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.
- La cueillette de données et les analyses en laboratoire sont en cours.

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
    a. temperatures (0˚C to 16˚C). These experiments will determine, for the first time, whether
    b. Hg methylation and demethylation in arctic lake sediments are temperature dependent.
2. Over an annual cycle:
    a. continuously monitor water temperature (including lake bottom)
    b. seasonally measure MeHg in sediments and chironomids (sediment-dwelling insects)
    c. These data will be used to continue our effort to monitor climate warming-induced
    d. changes in lake thermal regimes and to understand resulting effects on MeHg production
    e. in sediment and MeHg concentrations in the primary food item (chironomids) of char
    f. from these lakes.

3. Determine, with a bioaccumulation model, whether temperature-associated variation in
    a. 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 period sampled, there has been no consistent increase or decrease with time, perhaps reflecting that atmospheric inputs are leveling off with time (Cole et al. 2012). 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 2013-2014

Sub-objective 1 – Measure rates of Hg methylation and demethylation in sediments incubated at a range of temperatures (0-16C)

Progress on 1: We incubated sediments exactly as stated in our proposal. Sediments were freeze dried and are being analyzed for Hg isotopes (in progress at Woods Hole Oceanographic Institution), MeHg (in progress at Woods Hole Oceanographic Institution), total Hg (in progress at INRS-ETE), and org C (in progress at INRS-ETE).

Sub-objective 2 – Over an annual cycle: (a) continuously monitor water temperature and (b) seasonally measure MeHg in sediments and chironomids

Progress on 2a: In August 2012, we installed thermistor chains in two deep lakes (Char and Resolute) and two shallow lakes (Meretta and Small). Each lake had one thermistor chain set at the deepest spot. Char Lake had an additional thermistor chain set in the littoral zone. In August 2013, a challenging time for field work because of extensive (and not necessarily safe) lake ice, we recovered thermistor chains from Char (littoral zone only), Meretta, and Small Lakes. Data were downloaded from the thermistors, batteries were replaced, and the chains were redeployed to the same locations. Because of unsafe ice, we were not able to recover the other thermistor chains from Char and Resolute Lakes. Instead, we deployed new thermistor chains near the original sites in each lake, so if the batteries run out on the first-year chains, we will have a complete temperature record by combining data from the chains from each lake.

Progress on 2b: Lake waters, sediments, and chironomids were collected in August 2013. Analyses completed or in progress include: (1) lake water: total Hg (completed), MeHg (completed), general water chemistry (in progress at NLET); (2) sediment pore water: total Hg (completed), MeHg (completed), DOC (completed); (3) sediment solid phase: total Hg (in progress at INRS-ETE), MeHg (completed, but failed QA and must be analyzed again), org C (in progress at INRS-ETE); (4) chironomids: identification and enumeration (in progress), MeHg (to be completed).

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: 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:

$$C_t = \frac{k_f C_f + k_w C_w}{k_e + k_g} \left(1 - e^{-(k_e+k_g)t}\right) + C_0 \, e^{-(k_e+k_g)t}$$

image from MRNF du Québec

where C_0 is the initial MeHg concentration in the char and Ct is the concentration after duration t; Cf and Cw are MeHg concentrations in food and water, respectively; kf and kw are rate constants for uptake of MeHg via food and water, respectively; and ke and kg are rate constants for loss of MeHg via elimination and growth dilution (not a true loss, but represented as such), respectively. Values for concentrations (C0, Cf, Cw) 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 2013, we also hired Alicia Manik, a secondary student from Resolute Bay, for field work. Alicia was trained to (1) use a sonde to measure physicochemical properties of water, (2) sample sediment, water, and biota (bugs and fish), (3) recover, download data, and redeploy environmental sensors, (4) process samples for later analyses (*e.g.*, filter lake water, extract sediment pore water, dissect fish, pick bugs), and (5) perform incubations to understand the effects of temperature on sediment respiration processes.

Communications

We presented written reports in English and Inuktitut to Resolute Bay HTA. We participated in the annual PCSP Open House in August 2013; we demonstrated sediment coring, fish dissection, and let kids look at larval chironomids through the microscope. Preliminary results from this project have also been presented at scientific conferences:

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), and the 2013 Annual NCP Results Workshop (Ottawa ON) (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: The results are too preliminary to present or to interpret. However, 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 CO2, 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: From the three thermistor chains recovered in August 2013, we have 57,136 temperature measurements. In August 2012, all three lakes, Char, Meretta, and Small Lakes (see Figures 1, 2, 3), had water columns that were isothermal and greater than 8C. Rapid cooling occurred during August, and the lakes were ice covered from early September to the end of the record (early August 2013). 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.

Progress on 2b: The results from lake water and sediment pore water are in Tables 1 and 2. At this point, little information regarding the effects of temperature on MeHg concentrations can be drawn from a single sampling. From the porewater data, we can look at associations among MeHg, total Hg, and organic carbon. There is no relationship between MeHg and total Hg ($r = 0.34$, $P = 0.28$), perhaps indicating that other factors (temperature and org C) have stronger influences on Hg methylation. Organic carbon has a significant positive relationship with total Hg ($r = 0.63$, $P = 0.027$). Organic carbon also is related to MeHg concentration, in the form of a Gaussian distribution (bell-shaped curve; Figure 4). It could be interpreted that on the left side of the curve, organic carbon is limiting net MeHg production (i.e., lack of electron donors for methylating microbes), the top is optimal, and on the right side of the curve, elevated organic carbon levels bind to Hg and reduce its bioavailability to methylating microbes. All of the datapoints on the left side of the curve are from pristine lakes, while all of the points (except one) on the right side of the curve are from nutrient-polluted Meretta Lake.

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.

Fig 1. Data recovered from thermistor chain set in littoral zone of Char Lake, Aug 2012-Aug 2013.

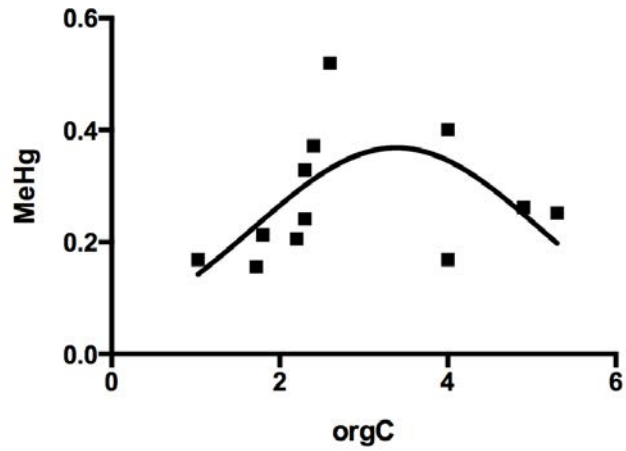

Fig 2. Data recovered from thermistor chain set in Meretta Lake, Aug 2012-Aug 2013.

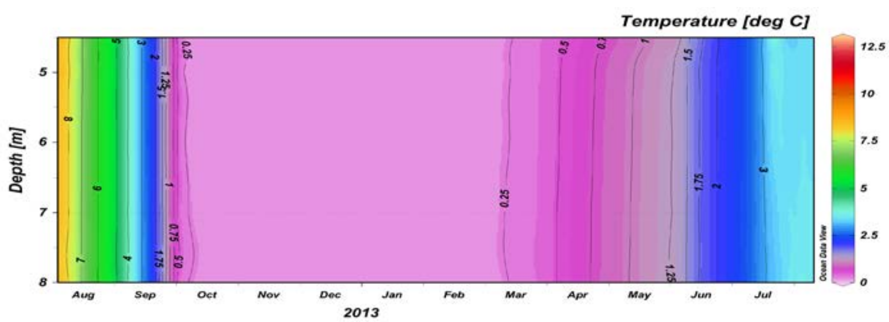

Fig 3. Data recovered from thermistor chain set in Small Lake, Aug 2012-Aug 2013.

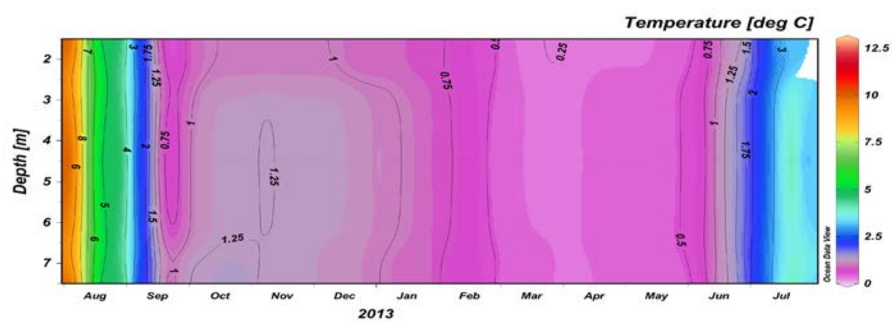

Fig 4. Organic carbon (orgC; mg/L) versus methylmercury (MeHg, ng/L) in sediment porewaters from four lakes on Cornwallis Island. See discussion of the Gaussian distribution in the text.

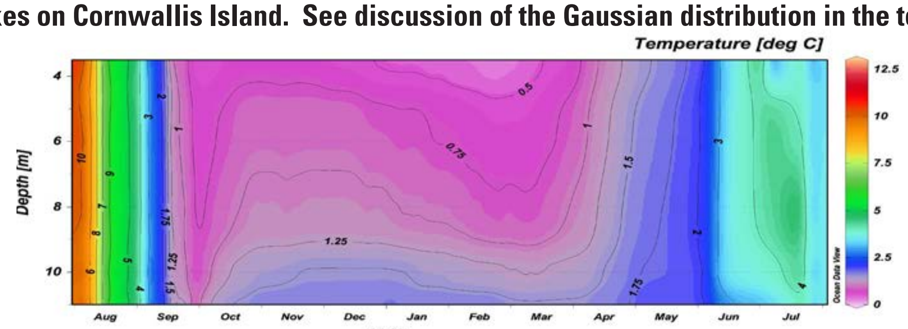

Table 1. Total Hg and methylmercury (MeHg) in surface waters collected from lakes on Cornwallis Island, August 2013. Surface waters were collected with a Niskin sampler (General Oceanics).

Lake	Sample ID	Total Hg (ng/L)	MeHg (ng/L)
Char	A	0.34	0.019
	B	0.27	.
Meretta	A	0.73	0.082
Resolute	A	0.85	0.037
	B	0.85	0.046
Small	A	0.69	0.038
	B	0.73	0.038

Table 2. Total Hg, methylmercury (MeHg), and dissolved organic carbon (DOC) in sediment porewater (0-5 cm) collected from lakes on Cornwallis Island, August 2013. 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	0.66	0.169	1.03
	B	0.66	0.206	2.20
	C	0.49	0.156	1.72
Meretta	A	1.67	0.252	5.30
	B	1.21	0.262	4.90
	C	0.99	0.401	4.00
Resolute	A	1.12	0.329	2.30
	B	1.21	0.213	1.80
	C	0.72	0.169	4.00
Small	A	0.79	0.372	2.40
	B	1.10	0.520	2.60
	C	0.70	0.242	2.30

Expected Project Completion Date

We expect to complete the project by September 2015.

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Quantifying Contaminant Loadings, Water Quality and Climate Change Impacts in the World´s Largest Lake North of 74° Latitude (Lake Hazen, Quttinirpaaq National Park, Northern Ellesmere Island, Nunavut)

Quantification des charges de contaminants, de la qualité de l'eau et des effets du changement climatique sur le plus grand lac au nord du 74e parallèle (lac Hazen, parc national Quttinirpaaq, nord de l'île d'Ellesmere, Nunavut)

- **Project Leader:**
  Vincent L. St.Louis, Department of Biological Sciences, University of Alberta
  Tel: (780) 492-9386, Fax: (780) 492-9234, Email: vince.stlouis@ualberta.ca

  Derek M. Muir, Environment Canada, Aquatic Contaminants Research Division
  Tel: (905) 319-6921, Fax: (905) 336-6430, Email: derek.muir@ec.gc.ca
- **Project Team Members and their Affiliations:**
  Igor Lehnherr and Katherine French, University of Waterloo; Craig Emmerton and Kyra St. Pierre, University of Alberta; Charles Talbot, Amila de Silva, and Christine Spencer, Environment Canada; John Smol and Neil Michelutti, Department of Biology, Queen's University

Abstract

Human activities have elevated atmospheric concentrations of greenhouse gases to levels that have resulted in an unequivocal warming of the Earth's climate. This is especially true in the high Arctic, where in the past century average annual temperatures have increased at almost twice the global rate. Such warming is anticipated to result in numerous ecological impacts, including permafrost thaw and glacial melt, increased surface runoff, and enhanced productivity on landscapes. Human activities have also resulted in unprecedented releases of contaminants to the atmosphere, many

Résumé

Les activités humaines ont fait grimper les concentrations atmosphériques de gaz à effet de serre jusqu'à des valeurs qui ont provoqué un réchauffement incontestable du climat de la Terre. Cela est particulièrement vrai dans le Haut-Arctique, où les températures annuelles moyennes ont crû presque deux fois plus vite qu'à l'échelle mondiale au cours du dernier siècle. On s'attend à ce que ce réchauffement ait de nombreuses répercussions sur l'écologie, et qu'il entraîne notamment une fonte du pergélisol et des glaciers, un accroissement du ruissellement et une hausse de la productivité des

of which make their way to the high Arctic. Unfortunately in many regions of the high Arctic, it is largely unknown how much change has already occurred since the beginning of industrialization and what the current state of Arctic ecosystem health is in general. We are monitoring contaminant loadings, water quality and climate change impacts (*e.g.*, levels of productivity) in the world's largest lake north of 74° latitude (Lake Hazen, 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.

paysages. Les activités humaines ont également généré des rejets sans précédent de contaminants dans l'atmosphère, dont une grande partie atteint le Haut-Arctique. Malheureusement, dans bien des régions du Haut-Arctique, on ignore dans une large mesure le degré de changement qui s'est produit depuis le début de l'industrialisation, et l'état global de santé actuel des écosystèmes de l'Arctique. On surveille les charges de contaminants, la qualité de l'eau et les effets du changement climatique (p. ex., le degré de productivité) dans le plus grand lac au nord du 74e parallèle (lac Hazen, parc national Quttinirpaaq, nord de l'île d'Ellesmere Islande, Nunavut). D'un point de vue socioéconomique, il est important de comprendre les charges de contaminants, la qualité de l'eau ainsi que les effets du changement climatique à l'heure actuelle si l'on veut prédire comment l'abondance et la qualité de certains organismes exploités par les Inuits comme sources traditionnelles de nourriture pourraient être perturbées par les activités humaines futures.

Key messages

- Mercury (Hg) and perflourinated contaminants (PFCs) found in snow are entering Lake Hazen during spring melt and potentially entering the food web at the rapid onset of lake productivity at that time.
- Due to warming surface temperatures of glaciers in the Lake Hazen watershed during the past 7 years, glacier melt has accelerated, resulting in more rapid flushing of water through, as well as delivery of contaminants to, Lake Hazen.
- Lake Hazen is becoming ice-free in the summer more frequently, and is staying ice-free longer into the autumn.
- Lengthening of the ice-free season is resulting in changes in algae productivity in Lake Hazen.

Messages clés

- Le mercure (Hg) et les contaminants perfluorés (CPF) mesurés dans la neige pénètrent dans le lac Hazen lors de la fonte printanière et pourraient s'introduire dans le réseau trophique lors de la hausse rapide de la productivité du lac à ce moment.
- En raison de la montée des températures de surface des glaciers dans le bassin hydrographique du lac Hazen au cours des sept dernières années, la fonte des glaciers s'est accélérée, ce qui fait que le passage de l'eau dans le lac Hazen est plus rapide, tout comme l'entraînement de contaminants vers ce dernier.
- La glace à la surface du lac Hazen fond plus fréquemment qu'avant pendant l'été, et le plan d'eau demeure libre de glaces pendant une période plus longue, à l'automne.
- L'allongement de la période sans glace entraîne des modifications de la productivité algale dans le lac Hazen.

Objectives

The overarching objective of our research program was to quantify past and present-day contaminant loadings, water quality and climate change impacts in Canada's high Arctic Great Lake (Lake Hazen).

In 2013, our particular objectives were to:

1. quantify the net areal atmospheric loadings of total Hg (THg; all forms of Hg in a sample), methyl Hg (MeHg; the toxic form of Hg that biomagnifies through foodwebs) and new and emerging perfluorinated chemicals (PFCs) to the Lake Hazen watershed in snow;
2. further quantifying present-day freshwater quality in Lake Hazen;
3. collect and analyse sediment cores from the deepest zone of Lake Hazen;
4. build on past sampling efforts, as well as put in place a long-term water quality monitoring program for Lake Hazen that will help assess impacts of climate warming and contaminant deposition in the high Arctic.

Introduction

Freshwater lakes, ponds, wetlands, and streams can be very productive systems on the polar landscape, and provide valuable resources to many organisms, including waterfowl, fish and humans. Unfortunately, human-induced climate change is altering polar ecosystems at unprecedented rates. Current climate models predict that the Canadian Arctic will become significantly warmer and wetter by the middle of this century (Climate Change 2007), but how freshwater systems will respond is currently not known. By studying both water chemistry and sediment cores, Arctic lakes can provide both short- and long-term perspectives on environmental change, including trends in long-range atmospheric transport and deposition of contaminants.

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 km2, 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.

The 1st goal of our 2013 research program was to collect water samples at numerous depths throughout the water column in Lake Hazen, and analyse them for a suite of contaminant and water chemistry parameters to provide a detailed baseline dataset from which all future water monitoring of Lake Hazen can be compared. Our 2nd goal was to analyse sediment cores collected from the deepest zone of Lake Hazen, to provide a long-term record of environmental change, including trends in long-range atmospheric transport and deposition of contaminants, rates of glacial melt in the Lake Hazen watershed, and changes over time in algal community composition and redox conditions in Lake Hazen. Our 3rd goal was to quantify the net areal atmospheric loadings of contaminants such as THg, MeHg and PFCs to the Lake Hazen watershed during winter by analyzing snow for these contaminants just prior to snowmelt in spring. And finally, our 4th goal was to put in place a long-term water-quality monitoring program for Lake Hazen that will help assess impacts of climate warming and contaminant deposition in the high Arctic well into the future.

Activities in 2013-2014

We were at the Lake Hazen field site from 12-22 May 2013. During that time period, we were able to collect all the samples we required to accomplish our research goals, as follows:

Goal 1: A number of water quality parameters (temperature, pH, dissolved oxygen [O2], turbidity, conductivity, algal abundance) were measured continually throughout the deepest part of the water column using a calibrated YSI-EXO sonde instrument. We also collected water samples from 15 depths at the deepest point in Lake Hazen for a wide range of chemical (*e.g.*, nutrients, dissolved organic carbon [DOC]) and contaminant (*e.g.*, THg, MeHg and PFCs) analyses. Samples were immeadiately processed and preserved in the clean room of the Lake Hazen/Quttinirpaaq Field Laboratory designated for water-chemistry research, prior to being shipped south for analyses.

All general water quality analyses were completed in the University of Alberta Biogeochemical Analytical Service Laboratory (BASL). The BASL holds a proficiency laboratory status with CALA, an accreditation body in Canada for ISO 17025. Water 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. PFCs were determined using standard protocols at the Canadian Centre for Inland Waters (CCIW; Burlington, ON) laboratory under clean room conditions (Class 10000 equivalent lab with carbon/HEPA air filtration).

Goal 2: We collected 5 undisturbed sediment cores from the deepest point of Lake Hazen. Three of the sediment cores were section on-site, whereas two cores were stabilized and kept intact. Subsequent analyses were as follows:

- Subportions of two cores were dated using 210Pb and 137Cs profiling to determine the age of each core section over the past 150 years;
- One core that was kept intact was scanned for element composition, as well as analysed for changes in algal communities (including diatoms) over time;
- One core was analyzed for stable isotopes of carbon and nitrogen, as well as organic carbon content to determine changes in productivity in the lake;
- the final cores have been submitted for contaminant analyses, including THg, stable isotopes of Hg, and a wide range of contaminants, including PCBs, legacy POPs and BFRs, PFCs, Hg and multi-elements like lead, cadmium and aluminum. All analyses will be done using standard protocols as describe above for water.
- All remaining core material will be archived at Environment Canada's CCIW for potential future analyses.

Goal 3: To quantify the net areal atmospheric loadings of contaminants such as THg, MeHg and PFCs to the Lake Hazen watershed during winter, from 9 sites in total (7 on Lake Hazen ice and 2 over land), we collected integrated snowpack samples for concentration analyses of these contaminants, as well as measuring the water equivalence of the snowpack and the snowpack depth distribution at our sites. 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 as describe above for water.

Capacity Building and Communications:

We conducted our research in Quttinirpaaq National Park from 12-22 May in 2013. 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 2012. However, we were able to conduct numerous other forms of capacity building and communications, as follows:

- Upon return to Resolute Bay from Quttinirpaaq National Park in 2013, we visited the Resolute Bay Hunters and Trappers Association/Organization (HTA/HTO) to talk about the research we had just completed in the Park, as well as donate the frozen food we had left over from our field trip;
- We also visited the Principal at Qarmartalik School in Resolute Bay to discuss the types of lesson that we could provide to their young students in spring 2014. Based on that conversation, we have since developed a few interactive lessons that we will present to the students when we return to Resolute Bay this coming spring;
- 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 13 hours of footage;
- We attended the NCP Results Workshop from 24-26 September 2013 in Ottawa. NCP researchers, employees of AANDC and northern community residents, to name a few, attended this diverse Workshop. At the Workshop we presented the results from our 2012 and 2013 NCP-funded research programs. We also showed the 5-minute trailer we produced for our upcoming documentary;
- Derek Muir presented a lecture to the Environmental Technology Program students at Arctic College in Iqaluit in March 2014.

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

Goal 1: Although being deep, cold, extremely nutrient poor, and ice-covered for a large portion of the year, Lake Hazen is biologically quite active (Fig. 1). Our under-ice sampling of the water column in mid-May in 2013 show that in the colder upper reaches of the water column, there were high concentrations of chlorophyll-a and dissolved O2, suggesting a spring pulse of algal production, which is likely important for jumpstarting energy flow through the Lake Hazen food web following the long Arctic winter. However, O2 decreased, and nitrate (NO3-) and dissolved carbon dioxide (CO2) increased, in the bottom 50 m of the water column, suggesting very microbially-active lake sediments. Concentrations of methane (CH4), though, were highest under lake ice, suggesting a build-up of CH4 there from CH4 bubbling up from the lake sediments.

In 2013, concentrations of THg were quite low (less than 0.4 ng/L), and concentrations of MeHg were below our detection limit of 0.015 ng/L, throughout the water column (Fig. 2). However, in 2012, concentrations of THg were high in water we collected just below the ice surface (Fig. 2). More importantly, concentrations of MeHg, the toxic and bioaccumulative form of Hg, were also relatively high at 0.12 ng/L just under the ice surface in 2012. During the 3-day period over which we sampled the water column in 2012, the snow on the surface of the lake melted, and the melt water drained into the lake through our sampling hole. The higher concentrations of THg and MeHg in the surface waters suggested that there is a very significant load of THg and MeHg in snowpacks. This was confirmed when we did not see elevated concentrations of either THg or MeHg (below detection) in surface waters when we repeated the profile in May 2013 before snowmelt. This is of potential concern because this snowpack load of MeHg gets flushed into Lake Hazen during the onset of the spring peak in biological productivity, initiating the bioaccumulation process.

PFC concentrations in the water column in 2013 were quite low, ranging from 0.120 to 0.240 ng/L for total perfluorocarboxylates (ΣPFCAs) and 0.008 to 0.027 ng/L for perfluorooctdane sulfonate (PFOS) (Fig. 3A & B). In 2012, samples were taken while snow was melting on the lake surface, as described for THg and MeHg. Much higher concentrations of ΣPFCAs, averaging 7.5-fold greater, were found in the upper 100 m of the water column in 2012. PFOS concentrations were also higher in 2012 during snow melt, although differences were smaller, only about 3-fold (Figure 3B).

About 50% of ΣPFCAs in near surface lake waters (and snow; see below) consisted of perfluorobutanoate (containing 4 fluorinated carbons), which is an atmospheric degradation product of the polyfluoro telomer alcohols used to make currently and widely used fluorinated stain repellents and other consumer products.

Goal 2: The Lake Hazen watershed has been undergoing rapid change in the past decade. MODIS satellite imaging of the watershed has revealed 2006-2012 summer glacier surface temperatures up to 1.25oC warmer than during 2000-2005, and a decline in ice cover duration on the lake itself. This has resulted in recent ~10-fold increases in glacial runoff into Lake Hazen (from ~ 0.4 km3 in 2004 to ~4.4 km3 in 2011, measured at the hydrologically-gauged outflow of Lake Hazen, the Ruggles River). Not surprisingly, sedimentation rates measured on the sediment cores we extracted from the lake have also increased 10-fold, from ~0.3 kg/m2/yr in 1995 to 3.0 kg/m2/yr in 2012.

Analyses of algal communities (including diatoms) preserved over time in sediment cores show that there has been a major shift in the species of diatoms thriving in Lake Hazen. For example, historically diatoms were absent in Lake Hazen. That was followed by a period of time when only benthic (bottom) dwelling species were found in the lake, likely coinciding with the period when only an open-water moat would form around the shores of Lake Hazen in the summer. As the lake became ice-free more frequently, and for longer periods of time, the benthic diatoms were replaced by a proliferation of planktonic (open water) forms of algae (Fig. 4).

We are currently analysing the cores for contaminants to determine if the recent increased sedimentation rates and open water seasons have resulted in higher depositional loads of contaminants to Lake Hazen.

Goal 3: Preliminary snow sampling in 2013 has confirmed that contaminants such as THg, MeHg and PFCs build up in Lake Hazen watershed snowpacks over the September to May Arctic snow accumulation period, and get flushed into Lake Hazen during the important spring peak in aquatic productivity. We found that concentrations of THg, MeHg and PFCs in snowpacks were indeed higher than concentrations found in the Lake Hazen watercolumn (Fig. 5), and interestingly, concentrations of all three groups of contaminants were higher in snow packs over land than on lake ice. What was most intriguing, though, is that MeHg concentrations were quite high in all snowpacks, which has not previously been observed for inland regions in the Arctic, and the origin of this MeHg remains an important unresolved question.

Higher concentrations of PFCs in snow over land appear to be due to contributions from soil and vegetation, which are entrained in the snow pack or picked up during sampling. Previous work has shown that PFC concentrations in arctic vegetation (lichen, willow) in the Bathurst Inlet area ranges from 0.02-0.26 ng/g or 20 to 260 ng/kg (Mueller et al. 2012), so much higher than snow. Thus small plant or soil particles could contribute to elevated levels in snow.

Figure 1: Chemical and physical parameters measured throughout the Lake Hazen water column.

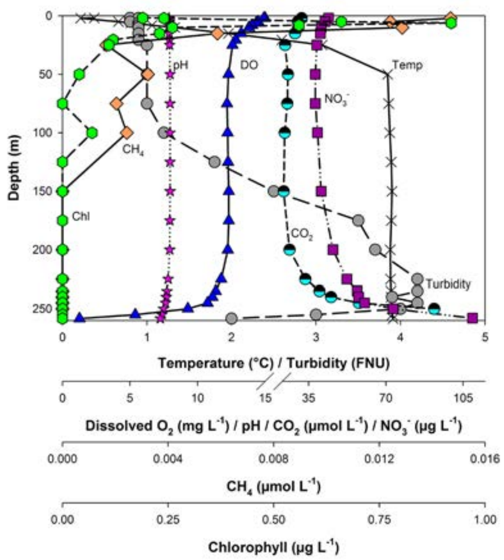
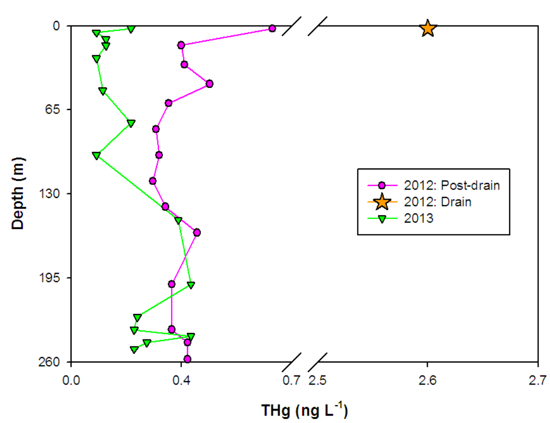


Figure 2: Concentrations of total Hg (THg) throughout the Lake Hazen water column in 2012 and 2013.



Discussion and Conclusions

Four major questions have already arisen from our 2012 and 2013 NCP sampling campaigns:

What are the relative contributions of THg, MeHg and PFAs found in snow (*e.g.*, direct atmospheric deposition vs soil particles)? What is the distribution of these contaminants between dissolved and particulate phases, assuming that the dissolved contaminants might be more bioavailable for accumulation than those bound to particles?

Do concentrations of THg, MeHg and PFCs increase as snow melt moves across the landscape, interacting with surface soils, compared with snow melt on lake ice that drains directly into the lake?

How much does snowmelt increase concentrations of THg, MeHg and PFCs in the water column of Lake Hazen, or the flux of these contaminants into Lake Hazen sediments?

Is this snowmelt pulse of THg, MeHg and PFCs into Lake Hazen initiating bioaccumulation of these contaminants into the base of the food web during the initial pulse of biological activity in the productive Arctic springtime? We know that PFOS has increased in char from Lake Hazen from 2005 to 2011 (Muir et al. 2013).

These are some of the questions that we plan to address during our return trip to Lake Hazen in May/June 2014 in order for us to fully understand our previous results, and why concentrations of THg and certain PFCs in Lake Hazen Arctic char are either no longer declining, or actually increasing.

However, snow melt runoff is only a small portion of the annual water loadings to Lake Hazen. As mentioned earlier, glaciers in the Lake Hazen watershed are now melting at unprecedented rates, and potentially contributing much higher loads of nutrients and legacy contaminants to Lake Hazen than snow melt. As a result, during the summer of 2015, we hope to concentrate our research efforts on understanding glacial inputs of nutrients and

Figure 3. A. Concentrations of perfluorocarboxylates (PFCAs) and B. PFOS in Lake Hazen. Samples in 2013 were taken before snow melt. In 2012 samples were taken during snow melt.

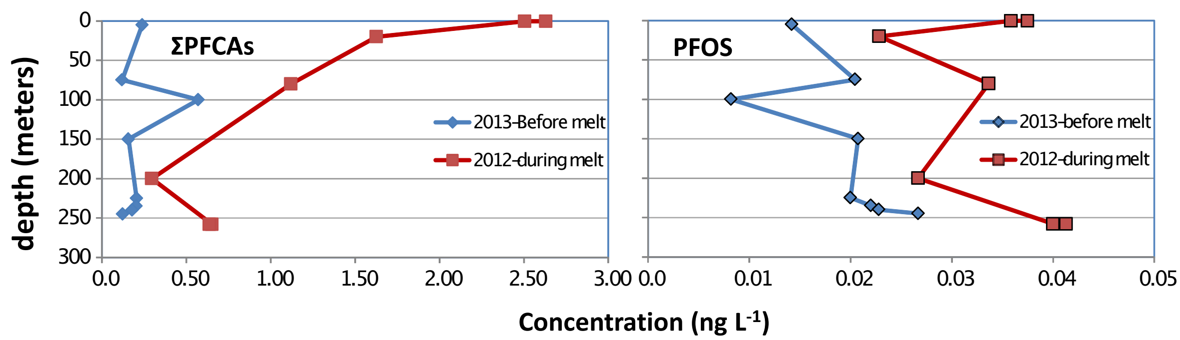


Figure 4: Relative abundance of diatom forms found in Lake Hazen sediments.

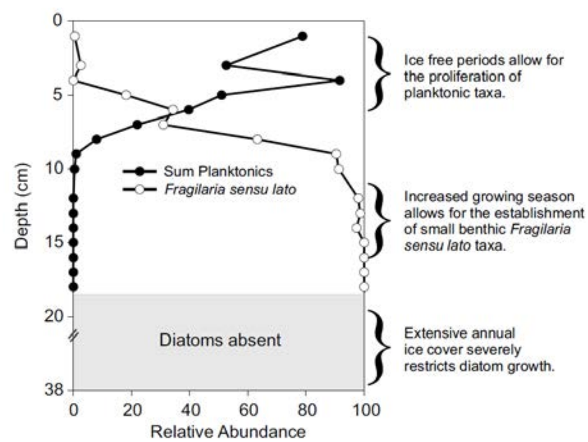
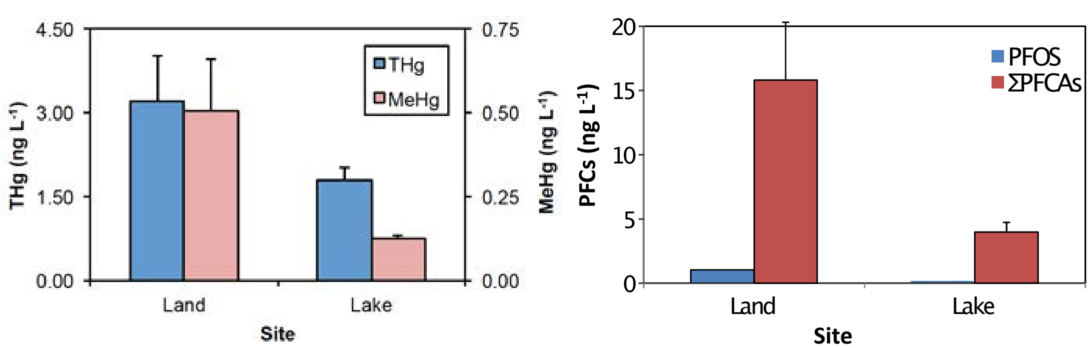


Figure 5: Concentrations of total Hg (THg), methyl Hg (MeHg) and PFCs in May snowpacks (2013) on land and on the ice at Lake Hazen.



contaminants to Lake Hazen, and how those summer inputs alter the water quality of Lake Hazen itself during the open-water season.

Addressing these questions will enhance our current knowledge of contaminant loadings, water quality and climate change impacts in high Arctic freshwater ecosystems, including:

a greater understanding of current levels of contaminant deposition and "ecosystem health" in certain regions of Nunavut, that will also provide a baseline from which all future monitoring can be compared;

a greater understanding of the current sources of contaminants that may be impacting the quality of traditional country foods such as Arctic char;

the establishment of collaborations/training between northern communities, governments and universities for moving forward into the future with successful monitoring programs;

a library of baseline data on accessible databases and in the peer-reviewed scientific literature;

opening of better dialogue between researchers and northern beneficiaries of the research results.

Expected Project Completion Date

We expect to fully complete our project by July 2016.

Project website (if applicable)

Not applicable at this time.

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Profiling the distribution of total and methylated mercury in the Canadian Arctic Seawater

Établissement du profil de distribution du mercure total et du mercure méthylé dans l'eau de mer de l'Arctique canadien

- **Project Leader:**
  Dr. Feiyue Wang, Professor, Centre for Earth Observation Science (CEOS), Department of Environment and Geography, University of Manitoba
  Tel: (204) 474-6250, Fax: (204) 272-1532 , Email: wangf@ms.umanitoba.ca
- **Project Team Members and their Affiliations:**
  Gary Stern, Alex Hare, Kang Wang, and Breanne Reinfort, CEOS, Department of Environment and Geography, University of Manitoba

Abstract

Mercury, especially its organic form methylmercury, is one of the primary contaminants of concern in the Arctic marine ecosystems. It is, however, not until recently have we started to appreciate the processes governing mercury distribution and speciation in Arctic seawater. Of particular importance is the recent discovery of sub-surface methylmercury production, which could be a major source of methylmercury to the Arctic ecosystems and ultimately to humans. Building upon our recent work on total and methylated mercury distribution in the Beaufort Sea, this three-year project aims to map the present-day "baseline" vertical concentration profiles of total and methylated mercury in seawater from various

Résumé

Le mercure, en particulier sous sa forme organique, c'est-à-dire le méthylmercure, est l'un des principaux contaminants préoccupants dans les écosystèmes marins de l'Arctique. Ce n'est cependant que récemment que l'on a commencé à comprendre les processus régissant la distribution du mercure et les formes chimiques sous lesquelles il se trouve dans l'eau de mer en Arctique. La découverte récente de la production de méthylmercure sous la surface, qui pourrait constituer une source importante de méthylmercure pour les écosystèmes arctiques et pour les humains, est particulièrement importante. S'appuyant sur nos récents travaux au sujet de la distribution du mercure total et du mercure méthylé dans la

regions of the Canadian Arctic Ocean, and to develop a practical strategy for future long-term monitoring of total and methylated mercury in the Canadian Arctic seawater. In Year 1, we have critically reviewed and compiled existing data on vertical distribution profiles of total and methylated mercury in seawater from the Canadian Arctic Ocean, with the understanding that it would lead to Year 2's objective for the development of the practical monitoring strategy. As this project has been terminated at the end of Year 1, no further development will be forthcoming.

mer de Beaufort, le présent projet, d'une durée de trois ans, a pour objectif de cartographier les profils verticaux « de référence » actuels des concentrations de mercure total et de méthylmercure dans l'eau de mer, cela dans diverses régions de l'océan Arctique canadien, et d'élaborer une stratégie pratique pour la surveillance future à long terme du mercure total et du mercure méthylé dans l'eau de mer de l'Arctique canadien. Au cours de la première année, on a procédé à un examen critique et à une compilation des données existantes sur les profils de distribution verticaux du mercure total et du méthylmercure dans l'eau de mer de l'océan Arctique canadien, cela dans le but d'élaborer une stratégie de surveillance pratique.

Key messages

- High-resolution distribution profiles of methylated mercury in the Beaufort Sea suggest in situ production of methylated mercury in the sub-surface of the water column
- There is a genuine lack of high quality data on seawater methymercury in other regions of the Canadian Arctic Ocean.
- It remains unknown to which extent this sub-surface source of methylmercury contributes to methylmercury burdens in Arctic marine ecosystem
- Long-term monitoring of total and methylated mercury in the Canadian Arctic Ocean, in combination with the existing and ongoing air and biological monitoring, is needed to allow for the study of the sources, processes, and sinks of mercury in the Arctic Ocean, and for the modeling and projection of how Arctic mercury will respond to changes in mercury emission under a changing climate.

Messages clés

- Les profils de distribution haute résolution du méthylmercure dans la mer de Beaufort laissent supposer la production in situ de méthylmercure dans la colonne d'eau, sous la surface.
- On manque véritablement de données de haute qualité sur le méthylmercure présent dans l'eau de mer dans d'autres régions de l'océan Arctique canadien.
- On ne sait toujours pas dans quelle mesure cette source sous-marine de méthylmercure contribue à la charge en méthylmercure des écosystèmes de l'Arctique.
- Il est nécessaire d'exercer une surveillance à long terme du mercure total et du méthylmercure dans l'océan Arctique canadien, en combinaison avec la surveillance actuelle de l'air et des paramètres biologiques, pour être en mesure d'étudier les sources et les puits de mercure de même que les processus mettant cet élément en jeu dans l'océan Arctique, et pour pouvoir modéliser ainsi que prévoir la façon dont le mercure de l'Arctique répondra aux changements des émissions de mercure sous un climat en évolution.

Objectives

Our goal is to build a long-term time-series on the distribution of total and methylated mercury in Arctic seawater to study the sources, processes, and sinks of mercury in the Arctic Ocean, and to project how they will respond to changes in mercury emission under a changing climate. The specific objectives of the proposed 3-year project are to:

- Critically review and compile existing and ongoing data on vertical distribution profiles of total and methylated mercury in seawater from the Canadian Arctic Ocean and Hudson Bay.
- Develop a practical monitoring strategy for future long-term monitoring of total and methylated mercury in the Canadian Arctic seawater to allow for model development and projection; and,
- Test and refine the aforementioned strategy in partnership with the recently funded Canadian Arctic GEOTRACES project.

Introduction

Despite major research efforts on the monitoring of mercury in the Arctic air ("source") and biota ("receptor") (*e.g.*, AMAP, 2011), little is known about the processes governing the distribution and speciation of mercury in the Arctic seawater, which is the primary exposure pathway of mercury to the Arctic marine ecosystems. The first indication of considerable amount of methylated mercury in the Arctic seawater came from Kirk et al. (2008) and St Louis et al., 2007) which showed elevated methylmercury concentrations at mid- and bottom depths of the water column in Hudson Bay and the Canadian Arctic Archipelago

By obtaining the first high-resolution seawater profiles of total and methylated mercury in the Beaufort Sea region of the Canadian Arctic Ocean, we have recently reported the presence of a sub-surface methylmercury peak in the oxycline layer of the water column (Wang et al., 2012), suggesting a water-column source of methylmercury, similar to what have been reported in other oceans (Cossa et al., 2009; Cossa et al., 2011; Hammerschmidt and Bowman, 2012; Heimbuerger et al., 2010; Mason and Fitzgerald, 1990; Sunderland et al., 2009). One major difference from the other oceans is that the methylmercury peaked in the Arctic Ocean at a depth where there is a substantial amount of dissolved oxygen. Several important questions remain:

- How widespread is such sub-surface methylmercury production in the Arctic seawater?
- How is inorganic mercury methylated in oxic, sub-subsurface Arctic seawater?
- How much does this sub-surface source of methylmercury contribute to methylmercury burdens in Arctic marine ecosystem? and,
- How does this sub-surface source of methylmercury change under a changing climate?

Activities in 2013-2014

As per the original proposal, Year 1's activity was centered on the retrieval and critical review of the existing data. As such, there was no associated fieldwork.

Results

All the total mercury and methylmercury data for the Canadian Arctic seawater obtained since 2008 were retrieved. The ship position data and ancillary data (salinity, temperature, dissolved oxygen, nutrients, chlorophyll, δ18O) were also retrieved from the data archives and from our ArcticNet colleagues. Data published from other research programs related to the Canadian Arctic Ocean were also included in the review. These data were critically reviewed following a set of guidelines similar to what have been used in the GEOTRACES program (Lamborg et al., 2012). The reviewed data were then compiled and coded into the Ocean Data View (version 4.5) database (Schlitzer, 2002).

In total, data from 59 stations in the Canadian Arctic Ocean including Hudson Bay were compiled. Figure 1 shows locations where critically reviewed total or methylated mercury data were compiled.

Water column concentration of total mercury in the Canadian Arctic ranged from below the detection limit to 1.13 ng·L-1, with an average of 0.237 ng·L-1 (standard deviation: 0.148 ng·L-1) and a median of 0.198 ng·L-1.

Much less data are available for total methylated mercury. The limited data available shows a range from below the detection limit to 0.3 ng·L-1, with an average of 0.048 ng·L-1 (standard deviation: 0.056 ng·L-1) and a median of 0.037 ng·L-1.

Discussion and Conclusions

- Total mercury typically shows enrichment in the surface seawater, with the highest enrichment at open-water stations, suggesting the modification of atmospheric mercury deposition in the presence of sea ice and snow cover.
- Total methylated mercury in the Beaufort Sea shows lower concentrations near the surface and higher concentrations at depth. At most stations, the total methylated mercury exhibits a peak between 50 and 160 m in apparent association with the nutrient maximum and lower dissolved oxygegn, suggesting the coupling between mercury methylation and organic carbon remineralization.
- There is a major data and knowledge gap on methylmercury distribution in other parts of the Canadian Arctic Ocean and in winter and spring.
- This was Year 1 of the originally proposed three-year project to address the above gap. As the funding of this project discontinued at the end of Year 1, further continuation of this research will not be possible. This will be the last report of this project.

Expected Project Completion Date

The expected project completion date was March 2016. However, it has been terminated unexpectedly in March 2014 due to the discontinuation of the funding.

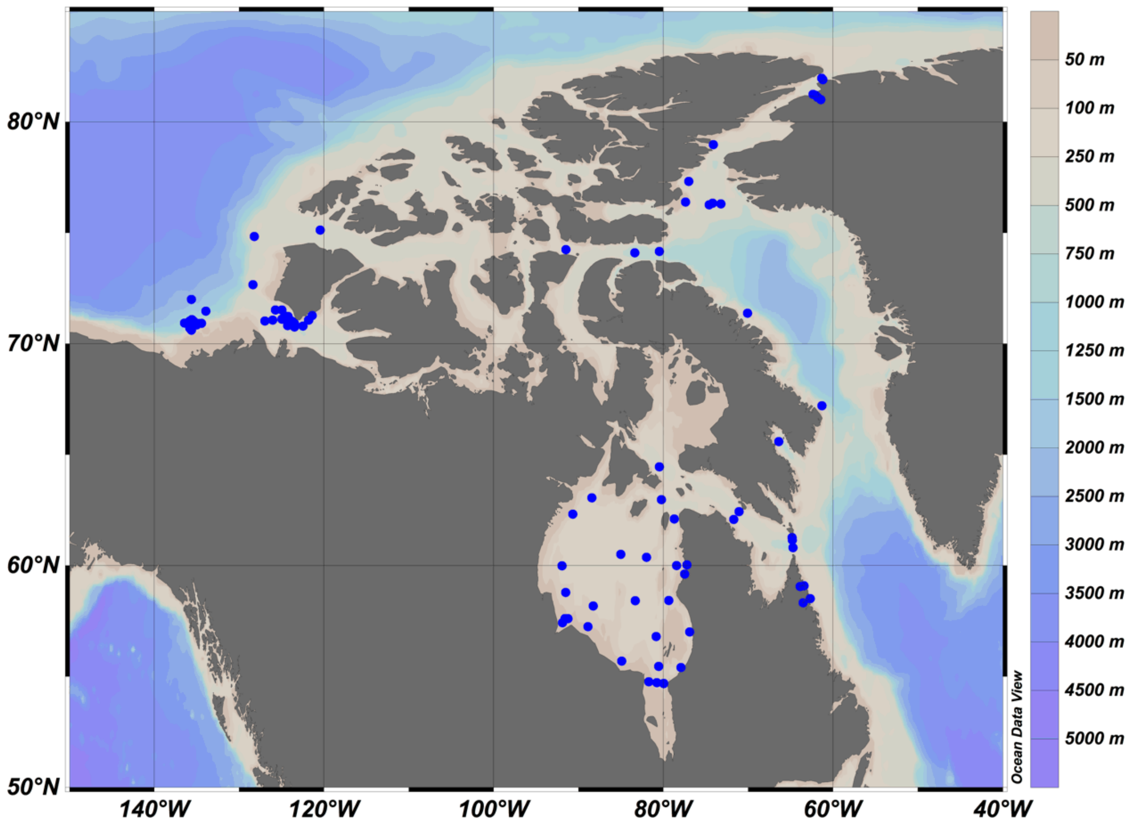
Project website (if applicable)

Not applicable.

Acknowledgments

- Northern Contaminants Program
- ArcticNet
- Circumpolar Flow Lead Systems Study (an International Polar Year project)

Figure 1. A map showing locations where critically reviewed total or methylated mercury profile data for the Canadian Arctic seawater have been compiled.



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Communications, Capacity, and Outreach

Communication, capacités et la sensibilisation

Yukon Contaminants Committee and AANDC Regional Office Coordination 2013-2014

Coordination du Comité des contaminants du Yukon et du bureau régional d'Affaires autochtones et Développement du Nord Canada en 2013-2014

- **Project Leader:**
  Pat Roach, Aboriginal Affairs and Northern Development Canada
  Tel: (867) 667-3283, Fax: (867) 667-3861, Email: pat.roach@aandc.gc.ca
- **Project Team Members and their Affiliations:**
  Yukon Contaminants Committee including: Council of Yukon First Nations, Yukon Government, Yukon Conservation Society, and Fisheries and Oceans Canada

Abstract

The Yukon Contaminant Committee and AANDC Regional office Yukon have spent over 20 years building an NCP database of contaminants analysis results and a tissue archive of samples. This past year the regional representative spent time trying to find a permanent home for the tissue archives and worked with the Yukon Research Centre and the NCP Secretariat to integrate the Yukon database into the upcoming NCP Database at University of Waterloo. Regionally, the program supports contaminants monitoring of the Porcupine caribou herd and lake trout from Lakes Kusawa and Laberge, as well as atmospheric mercury monitoring at the Little Fox Lake site. This site

Résumé

Le Comité des contaminants du Yukon et le bureau régional d'AADNC au Yukon ont mis plus de 20 ans à bâtir une base de données du PLCN qui regroupe des résultats d'analyses des contaminants et des archives de tissus. Au cours de la dernière année, le représentant régional s'est efforcé de trouver un centre permanent pour les archives de tissus et a travaillé avec le Centre de recherche du Yukon et le secrétariat du PLCN pour l'intégration de la base de données du Yukon dans la base de données en ligne Polar Data Catalogue. À l'échelle régionale, le Programme appuie la surveillance des contaminants touchant la harde de caribous de la rivière Porcupine et le touladi des lacs

is also part of the passive monitoring program for organic compounds, led by Environment Canada.

Kusawa et Laberge, ainsi que la surveillance du mercure atmosphérique sur le site du lac Little Fox. Ce site fait aussi partie du programme de surveillance passive pour les composés organiques, dirigé par Environnement Canada.

Key messages

NCP Yukon results database is maintained.

Over 20 years of archived tissues is maintained.

AANDC regional support for research compliments NCP-funded projects in the Yukon.

Messages clés

- La base de données du PLCN au Yukon, qui contient 20 années de résultats, est en voie d'être intégrée dans la base de données en ligne Polar Data Catalogue.
- On recherche un centre de stockage permanent pour des archives d'échantillons de tissus prélevés sur une période de 20 ans.
- Soutien à la recherche par le bureau régional d'AADNC afin de compléter les projets de surveillance financés par le PLCN au Yukon.

Objectives

- Yukon resource for NCP activities
- Point of contact for researchers working on NCP projects in the Yukon
- Maintains the Yukon Contaminants Database and the sample tissue archive for NCP.

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 also has a database of sample analysis that it is integrating into the new NCP Database to be housed at University of Waterloo and part of the Polar Data Catalogue. The Yukon tissue archive of samples goes back to 1990 and the Region is seeking a permanent home for these samples as the current facilities will be closed in 2015.

Activities in 2013-2014

Yukon Region AANDC continues to support funding for archive freezer repairs beyond that provided by NCP. It has also supported an active research program at Kusawa Lake to evaluate the effects of climate change on the cycling of mercury in the Lake's food web. This work is now linked to the University of Manitoba, University of Ottawa and the University of Upsala in Sweden. 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 continues to be collected in the Whitehorse area for rainfall isotope analysis and this work will be expanded to the Little Fox Lake air monitoring site in 2014. This work is in conjunction with the Yukon Research Centre and the University of Victoria.

The Committee and the Regional NCP office are considered the contact for contaminant issues in the Yukon. In 2013/14 the Regional Office continued to work with the Yukon Health authorities on contaminants in traditional food sources. The Yukon Contaminants Database is in the process of becoming part of the new NCP Database for all NCP generated data. The existing freezer archive was maintained and the investigation to find a permanent home for the tissues continues.

Results

The archive freezers are being maintained and with the new process of sending whole fish to the lab, no additions to archive were made. The Yukon contaminants database was broken into components for transfer to a more robust database at the University of Waterloo in 2014. There is also a data rescue planned for the 2014/15 NCP season, where data gaps in the old corrupt database are filled with Yukon data saved in other locations.

Discussion and Conclusions

Results of the Caribou and Lake Trout 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 2013) and M-14: Arctic Caribou Contaminant Monitoring Program (Gamberg 2013). The mercury and organic sampling being conducted at Little Fox Lake is reported under M-01 POPs in the Atmosphere (Hung 2013) and M-02 Air measurements of mercury at Alert, Nunavut and Little Fox Lake, Yukon (Steffen 2013).

Expected Project Completion Date

On-going

Acknowledgments

NCP and AANDC Region for funding and operational/administrative support.

Nunavut Environmental Contaminants Committee

Comité des contaminants du Nunavut

Project Leader:

Allison Dunn, Aboriginal Affairs and Northern Development Canada
Tel: (867) 975-5280, Fax: 867-975-4560; Email: Allison.Dunn@aandc.aadnc.gc.ca

Romani Makkik, Nunavut Tunngavik Inc. (NTI)
Tel: (867) 975-4926, Fax: (867) 975-4949, Email: rmakkik@tunngavik.com

Project Team Members and their Affiliations:

Natalie Plato, AANDC (Iqaluit); Simon Smith, AANDC; Wanda Joy and Linnea Ingebrigtson, GN-Health (Iqaluit); Zoya Martin, Department of Fisheries and Oceans (Iqaluit); Lilianne Arsenault, Jamessee Moulton, Janelle Kennedy, GN-Environment (Iqaluit); Paddy Aqiatusuk, Resolute Bay Hunters and Trappers Association (Resolute); Jamal Shirley, Nunavut Research Institute (Iqaluit); Eric Loring, Inuit Tapiriit Kanatami; Andrew Dunford, NTI (Iqaluit)

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 socio-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 co-chairs attended the NCP Management Committee meetings in Ottawa in April 2013 and September 2013, as well as the Results Workshop in September 2013. Through Nunavut Research Institute's financial support, NECC coordinated the participation of two Nunavut Arctic College (NAC) Environmental

Résumé

Le Comité des contaminants du Nunavut 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 Comité fournit aussi aux Nunavummiuts de l'information sur les contaminants transportés sur de longues distances que l'on trouve au Nunavut.

Les coprésidents du Comité des contaminants du Nunavut ont assisté aux rencontres du Comité de gestion du PLCN tenues à Ottawa en avril 2013 et en septembre 2013, ainsi qu'au 20e atelier sur les résultats du PLCN en

Technology Program (NAC-ETP) students participation at the 2013 Results Workshop.

NECC participated in the annual bird dissection workshop at Nunavut Arctic College's Iqaluit campus in Oct. 2013, by contributing three talks to the workshop. NECC also helped expand the content of the workshop by facilitating the participation and inclusion of another NCP researcher's work into the seminar portion of the workshop.

NECC provided feedback to NCP researchers on five summary reports intended for community dissemination, met face-to-face with 11 NCP-funded researchers to discuss their respective proposals/projects, attended four lectures at NAC presented by six NCP researchers and coordinated one NCP researcher's presentation at NAC.

NECC also hosted a productive socio-culture review of NCP proposals in March 2014 in Iqaluit. Eighteen people participated in the face-to-face meeting, including two NAC-ETP students; 28 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 consultation summary was provided to the NCP Secretariat to inform funding decisions at the April 2014 NCP Management Committee meeting.

septembre 2013. Avec le soutien financier de l'Institut de recherche du Nunavut, le Comité des contaminants du Nunavut a coordonné la participation de deux étudiants du Programme de technologie environnementale (PTE) du Collège de l'Arctique du Nunavut (CAN) à l'atelier sur les résultats.

Le Comité des contaminants du Nunavut a participé à l'atelier annuel sur la dissection d'oiseau qui a eu lieu sur le campus d'Iqaluit du Collège de l'Arctique du Nunavut en octobre 2013, en donnant trois exposés lors de l'atelier. Le Comité des contaminants du Nunavut a aussi aidé à élargir le contenu de l'exposé en facilitant la participation et l'inclusion des travaux d'un autre chercheur du PLCN dans le volet séminaire de l'atelier.

Le Comité des contaminants du Nunavut a donné de la rétroaction aux chercheurs du PLCN sur cinq rapports sommaires devant être diffusés dans la collectivité, a rencontré en personne 11 chercheurs financés par le PLCN pour discuter de leurs propositions/projets respectifs, a assisté à quatre exposés au CAN présentés par six chercheurs du PLCN et a coordonné une présentation d'un chercheur du PLCN au CAN.

Le Comité des contaminants du Nunavut a également dirigé un examen socioculturel productif des propositions du PLCN en mars 2014 à Iqaluit. Dix-huit personnes ont participé à la réunion en personne, dont deux étudiants du PTE du CAN, pendant laquelle 28 propositions basées au Nunavut ont été examinées. Les co-présidents du Comité ont fourni une rétroaction complète à tous les chefs de projet qui cherchent à faire financer leurs projets menés au Nunavut par le PLCN. Un résumé des commentaires d'examen 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 2014.

Key messages

- Through its socio-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. At the request of the Government of Nunavut, provide support to the CMOH and GN-Health in 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 have been operating in each of the territories and Nunavik since the early 1990's and more recently in Nunatsiavut (2007). These 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 has been funding Northern long-range contaminants research since 1991, and foster 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 modelled after the NWT Environmental Contaminants Committee. Prior to May 2000, discussions related to contaminant research and issues concerning Nunavut were vetted through this latter committee. Since the NECC's 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 2013-14

The following activities were undertaken by NECC in 2013-14:

- NTI and AANDC co-chairs attended April 2013 and Sept. 2013 NCP Management Committee meetings and Sept. 2013 Results Workshop
- Coordinated participation of 2 Nunavut Arctic College Environmental Technology Program (NAC-ETP) students participation at Sept. 2013 NCP Results Workshop (financial support provided by NRI)
- Hosted two face-to-face NECC meeting/ teleconferences: May 29, 2013 and Oct. 2, 2013
- Revised committee's Terms of Reference and committee name June 2013
- Meeting with John Chetelat and Murray Richardson and NECC members (AANDC, NTI) July 3, 2013 regarding project M-16
- In collaboration with NTI's Research Advisor, helped finalize '*Research in Nunavut-What You Need to Know*' factsheets and distributed to NCP Nunavut research community
- Provided feedback on five plain language summary reports prepared by PIs for community dissemination
- Meeting with Norm Halden and NECC members (AANDC, NTI, GN-Environment) Aug. 14, 2013 in Iqaluit to discuss project M-20
- Participated in Jennifer Provencher's bird dissection workshop related to the core seabird monitoring project (i.e. M-08) at NAC on Oct. 24-28, 2013; NECC committee members, Allison Dunn, Romani Makkik and Jamal Shirley gave presentations on the NCP, role of Inuit Research Advisor and best practices for communicating results, respectively
- Coordinated Mary Gamberg's (M-14) participation in NAC bird dissection workshop
- NTI co- chair gave a presentation on the NCP and ArcticNet programs at a research priority setting meeting of the Qikiqtani Wildlife Board in November 2013
- Provided letter of support for Building Environmental Aboriginal Human Resource (BEAHR) Occupation Environmental Monitoring Coordinator Training course
- Helped coordinate Mary Gamberg's participation in Environmental Monitoring Coordinator Training course offered in Arviat March, 2014
- Teleconference Jan. 31, 2014 with John Chetelat, NCP Secretariat, Health Canada and NECC committee members (AANDC, NRI, GN-Health, NTI) regarding elevated mercury levels found in char in lakes near Iqaluit from 2013-14 project M-16

- Meeting with Hayley Hung, Alexander Steffen and Liisa Jantunen and NECC members (AANDC, NTI, NRI) Feb. 12, 2014 in Iqaluit to discuss community outreach plans for their respective proposals (i.e. M-01, M-02, M-03, M-22)
- Meeting with Shirley Tagalik, Chris Furgal and Amanda Boyd with NECC members (AANDC, NTI, ITK, GN-Health) March 5, 2014 to discuss 2014-15 proposal (H-06)
- Coordinated presentation by Derek Muir (M-04, M-10) to NAC's ETP students March 5, 2014
- Hosted face-to-face NECC social-cultural review meeting March 3-4, 2014 in Iqaluit; 18 people participated in the review, including two NAC-ETP students
- 28 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
- AANDC co-chair participated and represented NECC in Ringed Seal Workshop March 6-7, 2014 in Iqaluit

Results

- NECC Terms of Reference finalized June 2013
- May 29, 2013 and Oct. 2, 2013 meeting minutes
- *Research in Nunavut* factsheets finalized and sent to NCP researchers Sept. 2013
- Provided feedback to researchers on five plain language summaries
- Letter of support to NRI for Environmental Monitoring Coordinator course
- 2014 NECC Social-Cultural Review Summary Report

Discussion and Conclusions

The work of NECC is on-going and will continue into 2014-15. 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, NECC 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 2015-16 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 strike a subcommittee 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 develop 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

- **Project Leader:**
  Elena Labranche, Nunavik Regional Board of Health and Social
  Tel: (819) 964-2222 (ext. 229), Fax: (819) 964-2711
  Email: Elena_labranche@ssss.gouv.qc.ca

- **Project Team Members and their Affiliations:**
  Amélie Bouchard, Serge Déry/Françoise Bouchard, Jean-François Proulx, Léa Laflamme, and Sylvie Ricard, Nunavik Regional Board of Health and Social Services; Suzanne Bruneau, Institut national de santé publique du Québec; Chris Furgal, Nasivvik Centre for Inuit Health and Changing Environments; Manon Simard, Nunavik Research Centre; Marie-Ève Guay, Tulattavik Health Centre; Margaret Gauvin, Julie-Ann Berthe, and Betsy Palliser, Kativik Regional Government; Eliana Manrique, Kativik School Board; Eric Loring. Inuit Tapiriit Kanatami

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

On a mis sur pied le Comité de la nutrition et de la santé du Nunavik (qui s'appelait au départ Comité des ressources sur les BPC) en 1989 afin qu'il traite des 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 éclairées.

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.

Facilitating a transition - continuing to arm Nunatsiavummiut with information related to contaminants and health while increasing ownership of research development and implementation in the region.

Faciliter la Transition – Continuer à donner de l'information aux Nunatsiavummiuts sur les contaminants et la santé tout en augmentant la propriété du développement et de la mise en œuvre de la recherche dans la région

- **Project Leader:**
  Colin Webb, Nunatsiavut Government
  Tel:(709) 922-2942 ext: 257, Fax: (709) 922-2931
  Email: colin_webb@nunatsiavut.com
- **Project Team Members and their Affiliations:**
  Tom Sheldon, Rodd Liang, Carla Pamak, Jamie Brake, Michelle Davies, and Michelle Wood, Nunatsiavut Government

Abstract

During 2013-2014, the Northern Contaminants Researcher (NCR) continued with work that informs the public about contaminant-related research and other projects regarding the wellbeing of Nunatsiavummiut. The NCR also continued to educate and communicate about contaminants information, research activities, the benefits of wild foods and any health related issues that affect Nunatsiavummiut on a daily basis. Communication was achieved through a variety of means, including a community tour that informed Nunatsiavummiut of the contaminant-related research projects taking place, results produced so far and explained any upcoming research projects. Other forms of communication used included social

Résumé

En 2013-2014, l'agent de recherche sur les contaminants dans le Nord a continué à effectuer des travaux qui informent le public sur la recherche portant sur les contaminants et sur d'autres projets concernant le bien-être des Nunatsiavummiuts. L'agent de recherche sur les contaminants dans le Nord a également continué à sensibiliser les Nunatsiavummiuts aux contaminants et à leur donner de l'information sur les contaminants, les activités de recherche, les bienfaits des aliments sauvages et les diverses questions de santé qui les touchent au quotidien. La communication a été assurée par divers moyens, dont une visite des collectivités qui a informé les Nunatsiavummiuts des projets de recherche sur les contaminants en cours,

media, the Nain Research Center website and community meetings. A tour of Nunatsiavut's five communities allowed for the dissemination of contaminants information and results as well as an opportunity for each community to raises concerns relating to contaminants and research in their region. Community feasts were held at the Nain Research Centre to promote the benefits of traditional food, while providing an informal opportunity to discuss concerns about contaminants and research. Finally, the NCR assisted many researchers and research projects by connecting them to local residents.

des résultats obtenus à ce jour, et des projets de recherche à venir. Les autres moyens de communication utilisés comprenaient les médias sociaux, le site Web du centre de recherche de Nain et des rencontres communautaires. Une tournée des cinq collectivités du Nunatsiavut a permis de diffuser de l'information sur les contaminants et les résultats et cela a permis à chaque collectivité de faire part de ses préoccupations concernant les contaminants et la recherche dans leur région. Des repas communautaires ont été donnés au centre de recherche de Nain pour faire la promotion des bienfaits des aliments traditionnels, tout en présentant une occasion informelle de discuter des préoccupations sur les contaminants et la recherche. Enfin, l'agent de recherche sur les contaminants dans le Nord a aidé de nombreux chercheurs et projets de recherche en les mettant en rapport avec les résidants locaux.

Key Messages

- The Northern Contaminants Researcher 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, including Nunatsiavut Government employees, harvesters and youth.
- 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.
- The Nunatsiavut Health and Environment Research Committee traveled to the communities of Nunatsiavut to discuss and disseminate information relating to

Messages clés

- L'agent de recherche sur les contaminants dans le Nord a travaillé sur une grande diversité de projets portant sur les contaminants afin de renforcer les capacités dans le Nunatsiavut, y compris parmi les employés du gouvernement du Nunatsiavut, les exploitants et les jeunes.
- L'agent de recherche sur les contaminants dans le Nord 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. L'agent de recherche sur les contaminants dans le Nord a aussi incité ses homologues à s'associer plus étroitement aux collectivités, notamment en embauchant et en formant des résidants, afin de contribuer au renforcement des capacités dans la région.
- Le Comité de recherche sur la santé et l'environnement du Nunatsiavut s'est rendu dans les collectivités du Nunatsiavut pour discuter et pour diffuser de l'information portant sur les contaminants, la recherche et le Programme de lutte contre les

contaminants, research and the Northern Contaminants Program. This also provided an opportunity for feed back from the individual communities relating to contaminants and related research.

- 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 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.

contaminants dans le Nord. Cela a aussi permis aux collectivités de faire des commentaires sur les contaminants et la recherche connexe.

- L'agent de recherche sur les contaminants dans le Nord 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 façon informelle de l'information sur la recherche et les contaminants.
- En partenariat avec le programme de sensibilisation des jeunes, les exploitants et les chercheurs, l'agent de recherche 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 en vue de la recherche.

Objectives

The objective for the NCR through the NCP is to build communication and capacity, and continue to inform Nunatsiavummiut about contaminant information and research needs.

- Be the first point of contact for contaminants and contaminants related information for the Nunatsiavut region.
- Inform Nunatsiavummiut about contaminants in our region as a large percentage do rely on traditional foods and they need to be informed on what may be in their food and to allow for more informed decision making in the future.
- Promote alternative country food from species in decline or that may be affected by contaminants.
- Serve as liaison between Inuit and regional/national organizations dealing with contaminants, environment and human health research in Nunatsiavut
- 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
- 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

- 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
- Participate on the Nunatsiavut Governments Research Advisory Committee, which reviews research proposals for the Nunatsiavut Region
- Participate as a member of the NCP's Management Committee
- 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
- Continue to develop effective communication skills to keep Nunatsiavummiut informed.

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 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 Health, Environment and Research 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 effect the Inuit in their daily lives so that informed decisions are made by all parties involved.

Activities in 2013-2014

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 assisted to inform Nunatsiavummiut of better decision making of traditional foods by using different types of communication to reach community residence and inform them of contaminant-related topics; The NCR contributed articles to the Tugapvik Nunatsiavut Newsletter, broadcasted information through the OKalaKatiget Society Regional Communication Broadcast Center, research information was presented through posters and oral presentations at ArcticNet's Annual Scientific Meeting in Halifax in December of 2013. The posters from ArcticNet's meetings were also posted in Nain's research center for residence to view them. 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.

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 Health and Environment Research Committee

The NCR along with the other members of the Nunatsiavut Health and Environment Research Committee toured the coastal communities to present research projects, talk about persistent organic contaminants, mercury and the difference between long-range and local contaminants. The importance of wild foods was discussed and the NHERC listened to the concerns of community members, students and Inuit Community Governments.

Nunatsiavut Government Research Advisory Committee

The NCR continues to participate on the Nunatsiavut Government Research Advisory Committee 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.

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:
Carla Pamak, Nunatsiavut Government
Tel: (709)922-2942 ext. 225, Fax: (709) 922-2931
Email: carla_pamak@nunatsiavut.com

Project Team Members and their Affiliations:
Tom Sheldon, and Colin Webb, Nunatsiavut Government

Abstract

The Inuit Research Advisor (IRA) for Nunatsiavut continues to serve as the first step in a more coordinated approach to community involvement and coordination of 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 personneressource lorsqu'il s'agit de mieux coordonner les efforts de la collectivité et les travaux scientifiques liés à 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 Nasivvik Centre for Inuit Health and Changing Environments.

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 Centre pour la santé des Inuits et les changements environnementaux de Nasivvik.

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 37 researchers from 1st April 2013 to 31st March 2014. This year the IRA has chaired 10 NGRAC meetings.
- The IRA, along with other members of the Nunatsiavut Health and Environment Review Committee travelled to the 5 Nunatsiavut communities to meet with high school students and community members to inform them of research in the area of contaminants. This committee also reviewed NCP-funded proposals for the region.
- 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.

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 37 chercheurs entre le 1er avril 2013 et le 31 mars 2014, et il a présidé 10 réunions du comité consultatif de la recherche au Nunatsiavut.
- Le CRI et d'autres membres du Comité d'examen de la santé et de l'environnement du Nunatsiavut se sont rendus dans cinq collectivités du Nunatsiavut afin de rencontrer des élèves du secondaire et des membres des collectivités pour les informer de la recherche concernant les contaminants. Le Comité a aussi passé en revue les propositions financées par le PLCN pour la région.
- 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.

- 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, *International Polar Year (IPY), researchers, students, and other organizations.*

- 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, les chercheurs de l'Année polaire internationale, les étudiants et divers organismes.

Objectives

- Improving the coordination and operation of the Nain Research Center

- Continued development and management of the Nunatsiavut Government research consultation process.

- 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 as well as its expansion to three other Nunatsiavut communities.

- 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.

- Together with the IRA coordinators, and ITK and ICC Canada, ensure that projects funded by the Northern Contaminants Program (NCP), ArcticNet and Nasivvik Centre 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, ArcticNet and Nasivvik. 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 2013-2014

- 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 Kuujjuaq and Ottawa.
- Attended Arcticnet's Inuit Advisory Committee teleconferences.
- Reviewed NCP proposals along with members of NHERC for Nunatsiavut.
- Reviewed proposals under Health Canada's, Health Adaptation and Climate Change program.
- Activley participated in several specific regionally-led research programs, including evaluation of a pilot community freezer program in Nain with associated contaminants research.
- Attended the NCP Results workshop in Ottawa and presented jointly with the other IRA's and the IRA coordinator.
- Attended ArcticNet's, Annual Scientific Meeting in Halifax and presented jointly with the other IRA's during student day activities and during the sessions.
- Attended the Canadian Association of Suicide Prevention conference in Winnipeg and co presented on The Going Off, Growing Strong program.
- Visited the five Nunatsiavut communities along with NHERC to do presentations on NCP funded research in the region.
- 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.

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 Western Arctic

État actuel des contaminants transportés sur de grandes distances dans l'Arctique de l'Ouest

Project Leader:
Shannon O'Hara, Inuvialuit Regional Corporation
Tel: (867) 777-7026, Fax: (867) 777-7001, Email: sohara@inuvialuit.com

Project Team Members and their Affiliations:
Nellie J. Cournoyea and Evelyn Storr, Inuvialuit Regional Corporation

Abstract

All work under the proposal "*The Current State of Long Range Contaminants in the Western Arctic*" was completed in 2013-14 by the Inuit Research Advisor (IRA) at the Inuvialuit Regional Corporation (IRC). This included projects such as an NCP promotional brochure, one edition of the Inuvialuit Research Newsletter and one community tour to all six Inuvialuit communities in the Inuvialuit Settlement Region (ISR). The IRA has found that conducting this work is essential to informing Inuvialuit of what NCP does and what the IRA does in relation to the NCP and it's mandates. IRC believes it is important for Inuvialuit beneficiaries to know about northern food security and contaminant messaging, as it has a long lasting impact on the

Résumé

Tous les travaux dans le cadre de ce projet ont été terminés en 2013-2014 par le conseiller en recherche inuite (CRI) de la Société régionale inuvialuite (SRI). Les activités réalisées ont compris l'élaboration d'un dépliant promotionnel sur le Programme de lutte contre les contaminants dans le Nord (PLCN) et d'un numéro du bulletin d'information sur la recherche inuvialuite, et une visite des six collectivités inuvialuites de la région désignée des Inuvialuits (RDI) pour communiquer de l'information sur le PLCN aux membres des collectivités. Le CRI a constaté qu'il est essentiel d'effectuer ce travail pour informer les Inuvialuits de ce que le PLCN fait et sur le travail du CRI en lien avec le PLCN et son

North and how Inuit make informed dietary choices. Additionally, the Inuvialuit Research Newsletter informs beneficiaries of what is happening with research in the ISR and other Inuit regions in Canada on an annual basis. The newsletter informs beneficiaries of NCP-related work, and provides a venue for NCP researchers to share their experiences about working in the Inuit regions. This year's publication outlined research that took place in 2013. The brochure will no doubt help the IRA to better explain the program and the roles of the regional committees and management committee to frontline workers and communities.

mandat. Le CRI croit qu'il est important que les bénéficiaires inuvialuits soient informés sur la sécurité alimentaire dans le Nord et qu'ils reçoivent des messages sur les contaminants, car ils ont une incidence de longue durée dans le Nord et sur la façon dont les Inuits font des choix alimentaires éclairés. De plus, le bulletin d'information sur la recherche inuvialuite informe sur une base annuelle les bénéficiaires sur la recherche effectuée dans la RDI et les autres régions inuites au Canada. Le bulletin informe les bénéficiaires des travaux en lien avec le PLCN et offre une tribune aux chercheurs du PLCN pour partager leurs expériences de travail dans les régions inuites. La publication de cette année présentait la recherche qui a eu lieu en 2013. Le dépliant aidera sans aucun doute le CRI à mieux expliquer le programme et les rôles des comités régionaux et du comité de gestion aux travailleurs de première ligne et aux collectivités.

Key Messages

- IRC now has a promotional brochure that can be shared with frontline workers and community members to better promote the NCP and the work that IRC does through the Inuit Research Advisor.
- The Inuvialuit Research Newsletter continues to have a far reaching impact in the ISR as it is the only publication that informs beneficiaries of research in the region and throughout other Canadian Inuit regions.
- The community tour continues to be the way that the IRA engages and communicate what NCP and the IRA program do annually. It is one of the main ways the IRA solicits recommendations and discussions about research in the region.

Messages clés

- La SRI a maintenant un dépliant promotionnel qui peut être partagé avec les travailleurs de première ligne et les membres des collectivités pour mieux promouvoir le PLCN et le travail que fait la SRI par le biais du conseiller en recherche inuite.
- Le bulletin d'information sur la recherche inuvialuite continue d'avoir une incidence de longue portée dans la SRI, car c'est la seule publication qui informe les bénéficiaires de la recherche effectuée dans la région et dans l'ensemble des autres régions inuites du Canada.
- La visite des collectivités reste le moyen par lequel le CRI consulte les collectivités et leur communique les travaux du PLCN et du programme de CRI annuellement. Il s'agit d'un des principaux moyens par lequel le CRI sollicite des recommandations et des discussions sur la recherche dans la région.

Objectives

The objectives of this proposal included:

- To make NCP more familiar to frontline workers and beneficiaries in the Inuvialuit Settlement Region through the development of communication materials.
- To inform Inuvialuit of current research initiatives while also educating them about research processes and activities taking place in ISR and Inuit Nunangat.
- To plan undertake consultation with regional frontline workers and community members on how contaminants messaging should happen.

Introduction

This proposal and associated work was developed in relation the newly amended NCP blueprint and the project work to address the new scope of NCP work now and into the future. The IRC decided to continue to do what works and what has been a successful for several years in the ISR, including the IRA continuing to conduct the annual community tours and to write and publish the Inuvialuit Research Newsletter. A new project this year, which the IRA believes was needed to better promote the NCP while also creating new communication materials, is the national NCP brochure outlining the Program and its relationship with IRA's from across Inuit regions. This brochure is a means to provide up to date information about NCP, which has not been done in quite a few years, at least for the ISR. Having current information available to people in the region can only help to allow people to not only understand the program but become engage in the work being done. One of the objectives this year was to also try to establish a regional working group to address contaminants messaging however due to the business of several organizations this year, this was not possible. Although this working group would have been an asset to the region this year with the pre-mature release of research results on toxoplasmosis in beluga whale. This situation really brought to light the real need to have a group assembled like this in the ISR and in other regions where similar situations may arise. Thankfully, the beluga researchers in the region and several organizations that would of been part of this working group did end up getting together over teleconference and e-mail anyway proving that it is possible, with funding available, to have a permanent process like this in place to deal with these types of media issues.

Activities 2013-2014

Two separate NCP proposals were submitted by IRA's this fiscal year. The first are individual IRA proposals and the other is a joint IRA proposal submitted by ITK on behalf of all Inuit regions.

The IRA proposal from ISR

- **The Community tour** was undertaken by the IRA in two phases. The first phases were to visit coastal communities in the fall and early winter and inland or delta communities in winter and spring. The IRA visited Sachs Harbour in July, Ulukhaktok in August and Paulatuk in September. The IRA then visited Aklavik in October, Tuktoyaktuk in November and held the meeting in Inuvik in January. All meetings featured a lunch meeting held at an Inuvialuit organization office or community hall. Each meeting featured lunch, door prizes, an IRA presentation, group discussions and information materials were distributed to those who attended.
- **The Inuvialuit Research Newsletter** is developed throughout the year. Beginning in April, the IRA begins to compile and plan

out the content of the newsletter. The IRA then request articles and pictures from IRA partner organizations, internal regional sources and from researchers. Once the content has been decided upon the IRA then searches throughout news websites for regional, national and international news that would be of interest to readers. This process takes about 6 months on its own, and then the rest of the year is spent compiling the information and determining what needs to be reported on. In addition to articles, the newsletter also contains healthy recipes, contaminants in focus section and a section of "what is research"?. Each section here is meant to inform readers of the context of research in the ISR and across the north and is included as educational resources. Once the content to newsletter is determined, the text is sent to local translators to be translated into one of the three Inuvialuktun dialects. This process takes about 1-2 months, depending on the length of the publication and experience of the translators. Once translated the newsletter is then sent to the design and printing company for final approval and printing for distribution.

IRA Joint proposal- Training workshop and IRA national promotional poster

- **A training workshop** was held in June 2013 in Kuujuuaq, Quebec. The team was able to identify a trainer who was willing to come up north to conduct a public speaking course to all IRA's and the IRA coordinator. The workshop took place over 3 days and covered many topics pertinent to the IRA position, including identifying your audience needs, conducting mock presentations, how to engage the audience and how to structure group presentations.
- **A promotional NCP poster** was developed by the IRA's working together for several months (June-November) via teleconference and webinars. This project went very well with IRA's and the IRA coordinator meeting every couple of weeks to go over content, photos and the message of the poster. Next, we worked alongside a professional designer based out of Ottawa to create the look and feel of the final product. The poster was then sent out the each region to be translated into Inuktitut and Inuvialuktun by local people. The poster was finalized in December 2013 but was not ready to bring to any meetings or events. Instead, the group decided to wait until both version of the poster were completed to begin the distribution process. The poster was distributed to Inuit organizations and partners in the south in April 2014.

In addition, to proposed projects the IRA`s also did several activities to promote NCP and community based research and monitoring.

- Arctic Observing Summit (Shannon only), Vancouver, April 2013
- NCP Annual Results Workshop, Ottawa, September 2013
- Community Based Workshop, Cambridge Bay, Nunavut, November 2013
- ArcticNet Annual Scientific Meeting, Halifax, December 2013
- Inuit Health Survey National Steering Committee meeting, Ottawa, March 2014

Outside of NCP activities: (IRA roles and responsibilities)

- The IRA attended Health Canada Inuit Selection Committee meeting, Ottawa, February 2014 to review this year's proposal submitted to the Climate Change and Health Adaptation Program for First Nations and Inuit Communities.
- The IRA attended Inuit Qaujisarvingat National Committee meeting in Ottawa in March 2014 to discuss research updates, and future work.
- IRA assisted several non-NCP affiliated researchers to undertake consultation in the

ISR for their research (i.e. Laura Medrano, David Atkinson).

- The IRA contributed to reviewing the ArcticNet IRIS 1 draft report meeting with the group over teleconference every 3 months.

Results

- The Inuvialuit Research Newsletter was successfully distributed to 868 Inuvialuit beneficiaries living within the six Inuvialuit communities and to southern cities where beneficiaries reside. In addition, several digital copies of the newsletter are requested and sent to Inuit organizations, researchers and other IRC partners.
- The brochure was sent to each of the following regional organizations: 5 Hamlet offices and the Town of Inuvik, 6 Hunters and Trappers offices, and 6 Community Corporation offices. In addition, the brochure was also circulated throughout IRC, the Inuvik Regional Hospital, Health Centres, Youth Centres and Schools totalling 600 copies. The brochure was also sent electronically to ITK and the NWT Regional Contaminants Committees.
- The community tour and subsequent meeting were all successfully held in the region between September 2013 and January 2014.

Discussion and Conclusions

IRC will continue conduct projects that help beneficiaries and other northerners understand the importance of continuing to monitor and research long range contaminants in the north.

Expected Project Completion date

March 31, 2014

Acknowledgements

IRC just wants to acknowledge the researchers and Inuit organizations who contributed to the newsletter this year through articles and photos. In addition, the IRA would like to especially thank the Inuvialuit elders, Albert Elias and Roy Goose who worked on the translation of the text into Siglit dialect. Final acknowledgement go to the printing company in Edmonton, RR Donnelley who always does great work putting the newsletter together and designing the look of the publication.

Nunavik Inuit Research Advisor

Conseiller en recherche inuite au Nunavik

Project Leader:
Michael Barrett, Kativik Regional Government
Tel: (819) 964-2961 #2271, Fax: (819) 964-0694
Email: mbarrett@krg.ca

Catherine Pinard, Kativik Regional Government
T Tel: (819) 964-2961 #2400, Fax: (819) 964-0694
Email: cpinard@krg.ca

Betsy Palliser, Kativik Regional Government
Tel: (819) 988-2198, Fax: (819) 964-0694
Email : bpalliser@krg.ca

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, ArcticNet and the Nasivvik Centre for Inuit Health and Changing Environments. 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,

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), ArcticNet et le Centre pour la santé des Inuits et les changements environnementaux de Nasivvik. 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.

like the Northern Contaminants Program (NCP) Results Workshop, with the Nunavik Nutrition and Health Committee 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.

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.

Afin de réaliser les objectifs, le CRI examine les propositions de recherche et fournit 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 des activités du CRI. Le CRI organise aussi des séances de formation en collaboration avec les trois autres CRI de la région.

Messages clés

- La recherche effectuée dans le Nord est bénéfique et elle devrait être effectuée de concert avec les collectivités locales pour mieux répondre à leurs besoins, leurs valeurs, leurs priorités et/ou leurs préoccupations.
- Le rôle du CRI est de favoriser la 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 offre des conseils aux chercheurs et aux autorités régionales sur les besoins des Inuits, et offre de l'aide pour communiquer les résultats des projets aux collectivités.

Objectives

The objectives of the Nunavik Inuit Research Advisor project are essentially similar to those of last year, this year being the continuation of the project. The main ones 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.

- Training of the IRA;
- Be an active member of the NNHC;
- Liaise with national and international organizations and other Inuit regional organizations in matters related to Arctic science and research;
- Act as a liaison between researchers and communities to facilitate research and the development of effective partnerships;
- 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);
- Develop long term capacity for research needs in Nunavik;
- Develop a research mentorship program for KRG and Nunavik;
- Facilitate and foster more community-based research;
- Assist in the development of local research capacity;
- Identify concerns and priorities of northerners, communities, and regional organizations in order to promote these to the NCP and other researchers;
- Identify potential community or regional partnerships to be made with existing and future projects;
- Identify opportunities for youth to become engaged in research and science;
- Identify northern students and youth interested in participating in research activities and connecting them with appropriate research projects and training initiatives;
- Identify Inuit-led project proposals that could apply for funding;
- Provide information on other research activities occurring in the region;
- Provide support and advice to communities on research from the Northern Contaminants Program;
- 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;
- Offer guidance and, where appropriate, assist with communicating research results of individual projects to relevant communities and regional organizations;
- Gather and locate accurate and relevant contaminant materials to distribute;
- 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;
- Provide information regarding research in Nunavik and opportunities for local involvement

- 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);
- Provide information to the ITK Research Team, the Inuit Nipingit: the National Inuit Committee on Ethics and Research (NICER); the Inuit Qaujisarvingat: The Inuit Knowledge Centre;

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, including the Northern Contaminants Program (NCP), the Northern Ecosystem Initiative, ArcticNet and Nasivvik) 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, Nasivvik 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, and began the development of the regional Inuit Research Advisor (IRA) positions. These positions were established to better coordinate research, build capacity, and encourage greater Inuit engagement and foster researcher and community interaction of these Arctic research programs.

The ArcticNet Network of Centers of Excellence, Nasivvik and the Northern Contaminants Program 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, Eric Loring from ITK and 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 2013-2014

During 2013-14 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.

Travels and meetings attended include the following:

June 11-14, ITK sponsored training workshop with the other IRAs held in Kuujjuaq.

Week of June 17, Kativik, Environmental Advisory Committee meeting in Umiujuaq with members named by the Government of Canada, the Government of Quebec and the KRG.

September 25-26, Northern Contaminants Program Annual Meeting. She was again able to meet with researchers and learnt the future directions of science in diverse fields.

October 16-17, Betsy was in Kangiqsujuaq to participate in the implementation of a collaborative research project developing the "Observatoire Homme Milieu International" (OHMI) interacting with researchers from France and the INRS/CEN. This is still a young project in Nunavik and Betsy helped in communications between the researchers and Kangiqsujuaq community members.

Week of November 17, Nunavik Nutrition and Health Committee held in Quebec.

Week of November 24, Health Canada workshop part of the Climate Change and Health communications training held in Ottawa. This included a "webinar" training session.

Week of December 9, ArcticNet's 9th Annual Scientific Meeting (ASM2013) held in Halifax. Activities included In addition to attending the presentations and workshops, hosting with the other IRAs a poster session and participating in the meeting of the Inuit Advisory Committee.

January 22-24 Kativik Environmental Advisory Committee KEAC meeting in Kuujjuaq

the February 12-13 Nunavik Nutrition and Health Committee (NNHCmeeting in Quebec where she met with researchers and contributed advice on their research avenues.

March 3-6, Parnasimautik Youth Consultation with representatives from all Nunavik communities held in Kuujjuaq.

March 13-14, Kativik Environmental Advisory committee meeting held in Quebec.

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. One good example for this is the role that she played in the implementation and development of the OHMI project. The aim of this project is to investigate concerns within Northern communities. 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 really active also in terms of 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/or she can help in putting a scientific project in a broader context of Inuit's needs and concerns.

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

This project is a long-term one: the IRA in Nunavik has an important role and should not be abandoned. Therefore, it is impossible to tell a completion date; at the moment, the longer the IRA is in position, the better it is for research in collaboration with Northern communities.

The Research Advisor: Increasing Nunavut Tunngavik Incorporated's Social and Cultural Research Coordination

Conseiller en recherche : accroître la coordination de la recherche socioculturelle menée par la Nunavut Tunngavik Incorporated

Project Leader:
Natan Obed, Nunavut Tunngavik Inc., Tel: (867) 975-4900, Fax: (867) 975-4949
Email: nobed@tunngavik.com

Romani Makkik, Nunavut Tunngavik Inc., Tel: (867)-975-4926, Fax: (867) 975-4949
Email: rmakkik@tunngavik.com

Project Team Members and their Affiliations:
Sharon Edmunds-Potvin, and Andrew Dunford, Nunavut Tunngavik Inc

Abstract

The Research Advisor (RA) participates in activities with the Northern Contaminants Program (NCP), ArcticNet, and previously with Nasivvik, including but not limited to projects that are identified as research priorities by Nunavut Tunngavik Inc (NTI). The RA works closely with NTI's research team, Nunavut communities, and researchers funded by NCP, ArcticNet and previously Nasivvik, to enhance research relationships in Nunavut. The RA also has the responsibility of being the co-chair of the Nunavut Environmental Contaminants Committee (NECC). As such, the RA position at NTI directly contributes to NTI's and NCP's capacity building as it relates to participation in NCP-related activities.

Résumé

Le conseiller en recherche (CR) participe aux activités du Programme de lutte contre les contaminants dans le Nord (PLCN), d'ArcticNet et de Nasivvik, y compris mais sans s'y limiter aux projets qui sont désignés en tant que priorités de recherche par la Nunavut Tunngavik Inc (NTI). En 2013-2014, le CR a travaillé étroitement avec l'équipe de recherche de la NTI, les collectivités du Nunavut et les chercheurs financés par le PLCN, ArcticNet et Nasivvik pour améliorer les relations de recherche au Nunavut. Le CR avait aussi la responsabilité de coprésider le Comité des contaminants du Nunavut. Ainsi, la position du CR à NTI a directement contribué à renforcer les capacités de la NTI et du PLCN

The RA works directly with researchers to improve their projects in Nunavut as they relate to communication, capacity building, and inclusion of Traditional Knowledge. The RA assists in connecting researchers with community members, such as Hunters and Trappers Organizations or the hamlet offices in the Nunavut communities, depending on the researcher's. This role also includes assisting the NECC to provide recommendations for improvement of projects that researchers are proposing to do in Nunavut. The RA also keeps the Inuit Tapiriit Kanatami (ITK) up to date on NCP-related activities in the territory.

en lien avec sa participation aux activités concernant le PLCN.

Le CR a travaillé directement avec les chercheurs à améliorer la communication, le renforcement des capacités et l'inclusion des connaissances traditionnelles de leurs projets au Nunavut. Le CR a aidé à établir des rapports entre les chercheurs et les membres des collectivités, comme les organisations de chasseurs et de trappeurs ou les bureaux de hameaux des collectivités du Nunavut. Ce rôle a aussi aidé le PLCN à offrir des recommandations concernant des améliorations aux projets dans le Nunavut. Le CR tient aussi la Inuit Tapiriit Kanatami (ITK) à jour sur les activités en lien avec le PLCN dans le territoire.

Key messages

- The Research Advisor continued building relationships and enhancing regular communication with NCP researchers working in Nunavut.
- The Research Advisor actively participates in the Nunavut Environmental Contaminants Committee, including promoting Inuit interests in the socio-cultural review of NCP proposals.
- The Research Advisor regularly reviews communication materials from researchers, and provides feedback from a socio-cultural perspective. This includes promoting incorporation of traditional knowledge in research projects as well as greater involvement of Inuit at all levels of research, including project development.

Messages clés

- Le conseiller en recherche a continué à renforcer les relations et à améliorer la communication régulière avec les chercheurs du PLCN travaillant au Nunavut.
- Le conseiller en recherche participe activement au Comité des contaminants du Nunavut, notamment en faisant la promotion des intérêts des Inuits par l'examen des aspects socioculturels des projets du PLCN. Pour ce faire, il encourage la prise en compte des connaissances traditionnelles dans les projets de recherche ainsi qu'une participation accrue des Inuits à toutes les étapes de la recherche, y compris l'élaboration de projets.
- Le conseiller en recherche procède à l'examen périodique des documents de communication des chercheurs, et fourni de la rétroaction sur les aspects socioculturels.

Objectives

1. **Short Term Objectives:**

- Engage NCP researchers and other relevant partners conducting research in Nunavut;
- Undertake relevant communications regarding NCP research in Nunavut;
- Participate in Nunavut Environmental Contaminants Committee (NECC) meetings;
- Participate in ArcticNet Inuit Advisory Committee (IAC) meetings;
- Engage and coordinate with NRI on NCP projects where appropriate;
- Engage with the NTI research team in the development of a NTI research agenda as well the implementation of Nunavut-specific research protocols.

2. **Long Term Objectives:**

- In collaboration with the NTI research team identify strategies that will develop long term research capacity in Nunavut as it relates to contaminants;
- Provide information to the NTI research team on NCP related activities as well as advise on ITK research initiatives where appropriate;
- In association with the NTI member on the Inuit Knowledge Centre Steering Committee, provide information and Nunavut-specific guidance to the ITK Inuit Knowledge Centre and ITK where appropriate concerning research;
- Where possible engage in a larger community-regional-national-international research network.

Introduction: The Research Advisor participates in research activities that are funded by, but not limited to the Northern Contaminants Program (NCP), ArcticNet, and previously with Nasivik. The Research Advisor also works with NTI's research team on projects as they relate to NTI's research priorities within the region. It is through funding from NCP, ArcticNet, and NTI, the Research Advisor acts as a liaison between researchers funded by the programs under NCP and ArcticNet and the communities within Nunavut. More importantly, through funding from NCP, the Research Advisor position is a pathway towards capacity building as it relates to participation in Northern Contaminants Program-related activities. The research advisor will work in close association with NTI's research team and Nunavut communities to enhance research relationships as well as implement a Nunavut-specific research agenda that also includes priorities related to the NCP, NECC, and GN's Health and Social Services department represented by the Chief Medical Officer of Health.

The research advisor position in Nunavut will be housed by NTI. This position was previously titled Inuit research advisor (IRA). The position has been reconfigured to ensure the person has a more general authority and ability to assist communities, researchers, as well as provide advisory support to NTI and its research team on the development and implementation of a NTI-specific research agenda. The research advisor will continue to provide research assistance to communities (*e.g.*review and conduct adjudication of proposals submitted to NCP) and provide advice about contaminants, research results and provide policy support for those responsible for risk communication in the territory such as the Government of Nunavut and the Northern Contaminants Program.

Activities in 2013-2014

September 2013:

The RA attended the NCP annual workshop to get an update on NCP funded projects in all 4 regions of Inuit Nunagat, Nunatsiavut, Nunavik, Nunavut, and the Inuvialuit Settlement Region. Prior to the workshop, the RA attended a workshop with other Inuit Research Advisor (IRA) on presentation skills which was organized by Inuit Tapiriit Kanatami's Environmental Policy Analyst, who also works as the main point of contact between the IRA's and the funders NCP, ArcticNet, and Nasivvik. This workshop was beneficial as the RA had to present on the number of projects taking place in Nunavut, and number of researchers that have been in contact with the position. The RA also participated in a panel on Traditional Knowledge. The group discussed the importance of including Inuit on research projects in the north.

October 2013:

The RA participated in a presentation to the Environmental Technology Program students which was organized in collaboration with the Nunavut Arctic College, Nunavut Research Institute, and researchers looking at contaminants in marine birds, and contaminants in caribou. These two researchers had been funded by NCP, and Nasivvik to do their research in the north.

November 2013:

Attended a Community Based Monitoring Workshop, From Promises to Action which was hosted by Oceans North Canada, which "promotes science and community-based stewardship of North America's Arctic Ocean and the resulting well-being of indigenous residents who rely upon its natural wealth" (Oceans North). At the workshop, delegates discussed what community-based monitoring means to Inuit/ northerners.

The RA, along with the Senior Research Advisor had the opportunity as well to introduce the research team of NTI to the Qikiqtaaluk Wildlife Board (QWB) at their AGM which was held in Iqaluit. Here, they provided on their roles as Research Advisors, and provide examples of types of project the research team is involved in, such as the Inuit Health Survey, and NCP, and ArcticNet.

The RA also attended a workshop with Health Canada's Climate Change and Health Adaptation, in collaboration with Nasivvik. This was after a call-for-proposals was released by Health Canada's Climate Change and Health Adaptation for 2014-2015 fiscal year. At the workshop the group looked at impacts of climate change on Inuit, and what kind of projects can be funded through the program. Projects such as changes in hunting patterns, changes to family relations due to less time on the land were mentioned as examples of projects that could be funded.

December 2013:

As per funding agreements with ArcticNet, the RA attends the annual ArcticNet Scientific Meeting (ASM), and this year the ASM was held in Halifax. At the ASM, partners of ArcticNet get a chance to get an update on projects funded by ArcticNet. It also provides for the RA to meet current researchers and potential researchers in Nunavut. It is a chance to engage, and provide feedback on how to improve research in the north for the benefit of Inuit as well.

January 2014:

The Research Advisor had the opportunity to attend a workshop with the Nunavut Wildlife Board (NWMB) on Habitat Management and Protection in Nunavut. Here delegates had the opportunity to discuss what protection means in the context of wildlife management within Nunavut. It is a great opportunity for the RA to engage with Hunter's and Trapper's Associations/ Organization members in Nunavut. It also provides the opportunity to learn about Inuit priorities of research in Nunavut.

Communicated with various NCP researchers to discuss community outreach activities and communications as well as incorporation of traditional knowledge into research. Facilitated communication between researchers/research community and Nunavut communities. Provided feedback to NECC and NCP researchers to assist in the development and review of community communications materials. In total there were approximately 27 research proposals that were reviewed by the Research Advisor,

February 2014:

The RA had the opportunity to attend a workshop the Qikiqtani Inuit Association (QIA), and its partners which comprise of the Nunavut Anti-Poverty Secretariat, Nunavut Literacy Council, Qujigiartiit Health Research Centre, and Nunavut Tunngavik Inc. and community researchers from Igloolik, Cape Dorset, Pond Inlet, and Clyde River. We will look at community based research on impacts of the Mary River Project within their communities. This will include but not limited to how social cohesion is changing within the communities because of the Mary River Project.

In response to the call-for proposals that were released by Health Canada's Climate Change and Health Adaptation in November, the RA, along with the Environmental Policy Analyst attended a gathering to review proposals submitted to them. Representatives from Nunatsiavut, Nunavik, Nunatsiavut, and the Inuvialuit Settlement Region (ISR) were in attendance, the group had consensus on which projects were approved for funding, and on allocation of monies. This gathering was successful with 8 out of 10 projects being approved for funding.

Results: The research advisor's activities are ongoing and coincide with the activities of NTI's Social and Cultural Development department's research team. Specific to NCP activities, the research advisor and NTI's research team continue to work closely with the Nunavut Environmental Contaminants Committee and NCP researchers. NTI's research team continues to represent Inuit interests in NCP-funded projects, including promoting community engagement, Inuit participation and incorporation of traditional knowledge. NTI's involvement in the social-cultural review of NCP project proposals offers guidance to researchers to ensure that Inuit are engaged in meaningful ways.

The research advisor was contacted by and communicated with representatives from approximately half of the research teams that were granted funding from NCP in 2013-2014. Communications with researchers focussed on reviewing communication materials that were being prepared for communities as well as input on community engagement and outreach activities. This also included requests for assistance with Inuktitut and Inuinnaqtun translation sources as well as approval of content included in communication materials.

Discussion and Conclusions: Aside from attending NCP results workshop in September 2013, and other workshops through ArcticNet and Nasivvik, the Research Advisor has been working towards engaging more with Nunavummiut through attending meetings. Due to the large geographic region of Nunavut, the Research Advisor has limited means to connect with Nunavummiut, but has made some progress in the 2013-2014 fiscal year. The Research Advisor has attended some workshops that were organized by other Non-governmental organizations such as the Nunavut Wildlife Management Board (NWMB), Qikiqtaaluk Wildlife Board (QWB), and the Qikiqtani Inuit Association (QIA).

Much of the workshops have been related to wildlife management, hunters, and trappers meetings, but also workshops discussing community based research. These are ways for the Research Advisor to network with Nunavummiut who researchers from NCP, and ArcticNet may want to connect with one day, depending on their projects. The Research Advisor has also started making connections with community representatives who work with regional Inuit Associations, such as the QIA. These are great ways to introduce the role of the Research Advisor, the role of NCP program, and NTI's research team. To date, there has been positive response from community representatives from Hunters, and Trappers Associations/ Organizations, and employees from NWMB, and QWB. It is hoped that these networking opportunities will be available in the future to maintain the relationship, and continue building working relations with these organizations.

Expected Project Completion Date

On-going multi-year annual funding through NCP, ArcticNet, and the host organization, Nunavut Tunngavik Incorporated.

Acknowledgments

As the RA I ensure that when I go and give presentations about my role within NTI, I always make it clear that my position is funded by NCP, ArcticNet, previously Nasivvik, and our host organization NTI. With that, it is often reiterated that the RA works directly with NCP, ArcticNet researchers, and or their associates when it comes to community engagement, capacity building, and communications.

Building Continued Capacity Among Inuit Research Advisors

Renforcement continu de la capacité des conseillers en recherche inuite

- **Project Leader:**
  Kendra Tagoona, Inuit Tapiriit Kanatami, Tel: (613) 238-8181, Fax: (613) 234-1991
  Email: ktagoona@itk.ca
- **Project Team Members and their Affiliations:**
  Shannon O'Hara, Inuvialuit Regional Corporation; Romani Makkik, Nunavut Tunngavik Incorporated; Betsy Palliser, Kativik Regional Government; Carla Pamak, Nunatsiavut Government

Abstract

This past year, the Inuit Research Advisors (IRAs) identified a need for further training and outreach. Each year, the IRAs hold either a face to face meeting, or take part in training relating to the skills needed for work expected of them from their funders: NCP, ArcticNet and the Nasivvik Centre for Inuit Health and Changing Environments. The focus of the 2013 training workshop, held in Kuujjuaq, QC, was on developing better presentation skills. This workshop helped the IRAs prepare for upcoming speeches at the NCP Results Workshop (September, 2013) and the ArcticNet Annual Scientific Meeting in Halifax (December, 2013). Public speaking events are important

Résumé

Au cours de la dernière année, les conseillers en recherche inuite (CRI) ont constaté la nécessité d'approfondir la formation et de mener davantage d'activités d'information. Chaque année, les CRI tiennent une réunion en personne, ou bien ils prennent part à une formation portant sur les compétences nécessaires pour le travail attendu d'eux par leurs bailleurs de fonds : PLCN, ArcticNet et Centre pour la santé des Inuits et les changements environnementaux de Nasivvik. L'atelier de formation de 2013, tenu à Kuujjuaq, au Québec, était axé sur le perfectionnement des techniques de présentation. Cet atelier a aidé les CRI à se préparer à donner des

avenues for the IRAs to spread awareness of who they are, and their roles within their regions. The IRAs also developed a national poster targeted to both researchers and Inuit, which has been distributed to every community in all four regions. They also developed a national brochure to hand out at conferences and events.

discours futurs lors de l'atelier sur les résultats du PLCN (septembre 2013) et de la réunion scientifique annuelle d'ArcticNet à Halifax (décembre 2013). Les conférences publiques sont des tribunes importantes qui permettent aux CRI de se faire connaître et de faire connaître leurs rôles dans les régions. Les CRI ont aussi créé une affiche nationale destinée autant aux chercheurs qu'aux Inuits, qui a été distribuée à chaque collectivité dans les quatre régions. Ils ont aussi élaboré un dépliant national qui sera distribué lors des conférences et des activités.

Key messages

- An expert-led training workshop provided the IRAs with better presentation skills.
- Posters and a brochure were developed for distribution to all Inuit communities in the IRAs home regions.

Messages clés

- Un atelier dirigé par des experts a donné des techniques de présentation améliorées aux CRI.
- Des affiches et un dépliant ont été élaborés aux fons de distribution aux huit collectivités des régions des CRI.

Objectives

- Develop an 11x17 poster to be distributed to Inuit communities and posted/handed out at meetings and events where Inuit and visiting researchers can learn about the Inuit Research Advisor positions
- IRA training to help develop IRA's confidence and abilities to support programs such as NCP, ArcticNet and Nasivvik

Introduction

After the development of the IRA manual and IRA meetings, it was identified by the IRA's that they required some training in order to fufill their roles and responsibilities within the NCP. The need for training for the IRA's has been a mandate of the program and for the IRA's. The success of this position has been demonstrated with many IRA's going on to hold higher positions within Inuit organizations. To some, it may appear as high turn over, but in fact it is proof that the IRA role is a successful stepping stone position. Each year, IRA's identify needs for training which target areas of need related to their IRA roles. This led to the submission of a proposal to NCP, through their lead IRA coordinator, to co-fund high quality training workshops, and the development of a national poster that would be distributed to every Inuit community in all four regions, along with an IRA brochure.

Activities in 2013-2014

- A three day workshop was held in June 2013 in Kuujjuaq Nunavik with all of the IRA's, IRA coordinator and their workshop leader Brent Borgunvaag from CTE Solutions
- Over the course of the year, posters were developed a translated into four dialects
- An IRA Brochure was also developed to complement the posters

Capacity Building: These projects have been instrumental in building the capacity of the IRA's which resulted in increased confidence through each stage of development and presentation of a speech. They were involved in each step of developing communications materials from working with the designer to sending it off to print.

Communications: All completed projects include a form of communications. Presentations at conferences and in communities are important to help bridge gaps and understanding between IRAs, researchers and local communities. Posters and brochures are a great tool to communicate their roles within research.

Traditional Knowledge Integration. TK was built into both the workshop and the development of the posters and brochure. The IRA's and their coordinator worked closely with the workshop leader to ensure topics were of relevance to the IRA's and Inuit. The IRA's were responsible for choosing culturally appropriate language and images for the poster and brochure.

Results

IRA Training in Kuujjuaq, QC Presentation Skills

For the first time in IRA history, the IRAs received enough funding to hire a professional workshop facilitator from a reputable training school, who was able to travel to Kuujjuaq to deliver the workshop. Each year, the IRAs choose a different region to hold either a face to face meeting or training workshop, and that year, they chose Nunavik. The training was held from June 11-13, 2013 within the Kativik Regional Government office and consisted of interactive presentations from the workshop leader, presentation skills practice and games, and the development of a draft speech. The IRAs felt that preparation and practice was needed for their upcoming speech at the NCP Results Workshop that fall, therefore within the three days they developed a draft speech, worked on their PPT and spent many hours practicing, rehearsing and learning better presentation skills. They also took part in a tour at the Makivik Research Institute and Kativik Regional Corporation.

IRA Outreach: National IRA Poster and Brochure

Over the years of the IRA program, there has been one challenge that has been an ongoing problem for the IRAs, and that is the issue of researchers contacting and connecting with them regarding their research projects. The IRAs felt greater outreach was needed to spread awareness about their positions within northern communities, as well as, at conferences and events.

The IRAs now have an 11.5'14 poster that describes the benefits of contacting an IRA. The audience is geared towards both researchers and community members. Every community in all four regions has received these posters. The IRAs also plan to continue to distribute the posters over the next few years as they do community visits. The poster was primarily done in English, and translated into all four regional dialects.

The second piece to their outreach plan was to develop a brochure. This brochure is designed to target researchers and can be distributed at upcoming conferences such as the ICC General Assembly and ArcticNet Arctic Change 2014. The IRAs have regionally specific brochures, but did not have a more general IRA brochure that talks about all four regions with details of the IRA program as a whole. The IRAs plan to distribute these anywhere they can over the next 1-2 years.

Inuit Research Advisors with Coordinator at the NCP Results Workshop 2013

Discussion and Conclusions

"The presentation skills workshop in Kuujjuaq was beneficial for me and my professional development. I appreciated the constructive criticism and guidance throughout the time frame of the course. I have gained a better understanding of and confidence in my own presentation skills and will take lessons learned with me moving forward. The instructor's open and fun personality made the course all the more enjoyable." (IRA – Nunavut).

Expected Project Completion Date

Project concluded for this year. Additional support may be requested in future years for additional training workshops.

Project website

www.itk.ca

Acknowledgments

We would like to thank the NCP and ArcticNet for their generous support, and to Nasivvik for their in-kind support for both projects.

National/Regional Coordination and Aboriginal Partnerships

Coordination nationale et régionale 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

- **Project Leader:**
  Russel Shearer, Northern Science and Contaminants Research Directorate, Aboriginal Affairs and Northern Development Canada, Gatineau, QC; Tel: 819-994-6466; Fax: 819-934-1390; Email: Russel.Shearer@aadnc-aandc.gc.ca

  Sarah Kalhok Bourque, Northern Science and Contaminants Research Directorate, Aboriginal Affairs and Northern Development Canada, Gatineau, QC; Tel: 819-934-1107; Fax: 819-934-1390; Email: Sarah.Kalhok@aadnc-aandc.gc.ca

- **Project Team Members and their Affiliations:**
  Members of the NCP Management Committee (Council of Yukon First Nations, Dene Nation, Inuit Circumpolar Council – Canada, Inuit Tapiriit Kanatami, Aboriginal Affairs and Northern Development Canada, Environment Canada, Health Canada, Fisheries and Oceans Canada, Government of Yukon, Government of the Northwest Territories, Government of Nunavut, Kativik Regional Government, Nunatsiavut Government, ArcticNet), NCP Secretariat, Yukon Contaminants Committee, NWT Regional Contaminants Committee, Nunavut Environmental Contaminants Committee, Nunavik Nutrition and Health Committee, Nunatsiavut Health and Environment Research Committee, Arctic Monitoring and Assessment Programme Secretariat, Arctic Institute of North America, and Canadian Polar Data Network

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

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

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 2013-2014 included: (i) the signing of the Minamata Convention on Mercury in October 2013, for which NCP data, information and expertise played a critical role for Canada and the Arctic Council to take a leadership role towards taking actions to control global sources of atmospheric mercury emissions; (ii) the release of the Canadian Arctic Contaminants Assessment Report III (CACAR III) report on Persistent Organic Pollutants in Canada's North, the first assessment report to focus exclusively on persistent organic pollutants in the Canadian Arctic; (iii) the 20^{th} anniversary NCP Results Workshop, held in Ottawa in September 2013, which attracted some 200 participants to mark this special anniversary for Canada's longest standing northern monitoring and research program; and (iv) 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 Canada's chairmanship of the Arctic Council (2013-2015).

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 2013-2014 : (i) la signature de la Convention de Minamata sur le mercure, en octobre 2013 – les informations et les compétences du PLCN ont étaient déterminantes pour le rôle moteur assumé par le Canada et le Conseil de l'Arctique en vue de maîtriser les sources mondiales d'émissions atmosphériques de mercure, (ii) la publication du Rapport de l'évaluation des contaminants dans l'Arctique canadien, phase III (RECAC III), qui constitue la première évaluation à porter exclusivement sur les polluants organiques persistants dans l'Arctique canadien, (iii) l'atelier sur les résultats du PLCN , tenu en septembre 2013 à Ottawa, a attiré quelque 200 participants et marqué le 20e anniversaire du programme le plus ancien du Canada en matière de recherche et de surveillance dans le Nord et (iv) les contributions importantes des scientifiques et du secrétariat du PLCN aux travaux du groupe de travail du Programme de surveillance et d'évaluation de l'Arctique (PSEA), dans les rôles de coauteurs et de coprésidents des groupes de spécialistes travaillant à la mise à jour des rapports d'évaluation de la région circumpolaire et dans les rôles de chef de délégation et de vice-président au PSEA, au moment où le Canada assure la présidence du Conseil de l'Arctique (2013-2015).

Key Messages

- The NCP Secretariat provides the administrative, financial, and logistical support and coordination required to deliver the NCP

Messages clés

- Le secrétariat du PLCN assure la coordination et le soutien administratifs, financiers et logistiques nécessaires pour réaliser le programme.

- 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 100 signatory nations, 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 CACAR III – Persistent Organic Pollutants in Canada's North, released in December 2013, reports the results of monitoring and research activities conducted under the NCP, synthesizes the latest science, and evaluates our current understanding of POPs in the Canadian Arctic. The report demonstrates that international action on POPs is working to reduce pollution in the Arctic and improve the health of Northerners; however, some new chemicals that are not covered by international agreements are being detected in the Arctic environment at increasing concentration and require further study.

- The NCP's milestone 20th anniversary Results Workshop provided a venue to reflect on the accomplishments and challenges of the NCP since its inception in 1991 and prepare for its future directions. This included summarizing scientific findings to date, celebrating partnerships that have been developed, and noting the ways in which NCP data and partners have galvanized action on the issue of contaminants in Canada's North.

- 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, 100 pays l'ont signée, unis dans un effort pour réduire la pollution par le mercure à l'échelle mondiale et 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.

- Le RECAC III sur les polluants organiques persistants (POP) dans le Nord canadien, publié en décembre 2013, présente les résultats des activités de recherche et de surveillance menées dans le cadre du PLCN, résume les dernières avancées scientifiques et fait le point sur ce qu'on connaît des POP dans l'Arctique canadien. Le rapport montre que l'action internationale à l'égard des POP contribue à réduire la pollution dans l'Arctique et à améliorer la santé des habitants du Nord; cela dit, certains nouveaux produits chimiques qui ne sont pas visés par des accords internationaux sont détectés dans l'environnement de l'Arctique à des concentrations croissantes, et ils nécessitent une étude approfondie.

- L'atelier sur les résultats du PLCN, qui a marqué le 20e anniversaire du programme, a donné l'occasion de réfléchir aux réalisations et aux défis qui ont jalonné l'histoire du PLCN depuis sa création en 1991 et de se préparer à ses nouvelles orientations. On a notamment résumé les résultats scientifiques jusqu'ici, salué les partenariats qui ont été établis et souligner les façons dont les données et les partenaires

- NCP continues as Canada's main contributor on contaminant issues to the Arctic Council's Arctic Monitoring and Assessment Programme, with updates being undertaken on circumpolar POPs and human health assessments.

du PLCN ont poussé à agir face aux contaminants dans le Nord canadien.

- 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, effectuant des mises à jour au sujet des évaluations de la santé humaine et des POP dans la région circumpolaire.

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 Assesment 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 2013-2014

NCP Management Committee: The NCP Management Committee met in April 2013 to consider the reviews and recommendations on all proposals received through the 2013-2014 Call for Proposals and to make funding decisions. A brief description of each of the funded projects was posted on the NCP website at www.science.gc.ca/ncp. The Management Committee met again in September 2013 to review the progress of NCP projects currently under way and make policy decisions related to the management and delivery of the NCP.

20th NCP Results Workshop: The NCP held its milestone 20th anniversary results workshop in Ottawa on September 24 and 25, 2013. More than 180 participants took part in two days of presentations, panel discussions and poster presentations, as well as an evening reception and cultural event. To mark this special anniversary for Canada's longest standing northern science program, the event provided a venue to reflect on the accomplishments and challenges of the program since its inception in 1991, and prepare for its future directions. This included, in particular, summarizing the scientific findings to date, celebrating the partnerships that have been developed, drawing attention to the organizations and people who have shaped the NCP over the years, and noting the ways in which NCP data and partners have galvanized action on the issue of contaminants in Canada's North and contributed to the successful launch of international conventions aimed at reducing environmental contaminants.

The workshop program consisted of overviews and main highlights from the recently published Canadian Arctic Contaminants Assessment Reports III on Mercury in Canada's North and Persistent Organic Pollutants in Canada's North, and , and overview presentations on human health issues facing Canada's northern populations. Additional presentations covered a range of important topics in the NCP, from the role of Inuit Research Advisors, to community based monitoring and knowledge integration, to contaminants trends and other detailed science, and policy impacts of NCP work. Three panel discussions brought together diverse perspectives on (i) future directions for NCP health research, (ii) future directions for NCP environmental monitoring and research, and (iii) utilizing Traditional Knowledge in the NCP.

A record 52 poster presentations were viewed during a poster session on the afternoon of the first day, with 2 awards presented.

As a special feature to celebrate the 20th anniversary of the NCP, a series of (videos) were shown throughout the workshop. Each vodcast featured individuals associated with the NCP who provided a personal perspective on the NCP, its principles, approaches and impacts.

All participants were invited to provide feedback on the workshop through an online questionnaire initiated by the NCP Secretariat. The 9-part questionnaire sought to gain a better understanding of participants' reasons for attending, their expectations, and the degree to which they found the workshop to be interesting, effective and valuable. Results of this survey are available from the NCP Secretariat and will be of use in planning for future NCP workshops.

2014-15 Call for Proposals and review process: The 2014-15 Call for Proposals was launched by email on November 15, 2013 with subsequent posting to websites. A total of 69 proposals were submitted by the deadline of January 13, 2014. 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, 9; NWT, 29; Nunavut, 29; Nunavik, 11; and Nunatsiavut, 11. Each technical review team reviewed the following number of proposals: Human Health, 9; Environmental Monitoring and Research, 29; Community-based Monitoring and Research, 9; and Communications, Capacity and Outreach, 16.

Synopsis of Research: The Synopsis of Research conducted under the 2012-2013 Northern Contaminants Program was released on memory sticks at the 20th NCP Results Workshop in September 2013. The 2011-2012 version is available electronically on the NCP website (abstracts & key messages only), and upon request (for full report). 95% of projects were reported in the publication.

Canadian Arctic Contaminants Assessment Report III – Mercury in Canada's North: This assessment reports on monitoring and research activities conducted under the NCP and evaluates our current understanding of the environmental fate of mercury in the Canadian Arctic. The assessment provides much new information on the sources and long-range transport of mercury to the Arctic, its cycling within marine, freshwater and terrestrial environments, its bioaccumulation in and effects on the biota that live there, and the complex ways in which climate change is affecting mercury cycling in the Arctic. The report, which had been released in electronic format at the 2012 ArcticNet Annual Science Meeting (Vancouver), was distributed to an international audience in July 2013 at the International Conference on Mercury as a Global Pollutant in Edinburgh, Scotland. Hard copies of the report were also distributed in September at the NCP Results Workshop in Ottawa. An electronic copy of the report (in .pdf format) has also been posted on the Northern Contaminants website hosted by CYFN (www.northerncontaminants.ca/done/index.html) and will also be available online later in 2014 through the NCP Publications Database (www.aina.ucalgary.ca/ncp/).

Canadian Arctic Contaminants Assessment Report III – Persistent Organic Pollutants in Canada's North: This assessment reports the results of monitoring and research activities conducted under the NCP, synthesizes the latest science, and evaluates our current understanding of POPs in the Canadian Arctic. The report demonstrates that international action on POPs is working to reduce pollution in the Arctic and improve the health of Northerners; however, some new chemicals that are not covered by international agreements are being detected in the Arctic environment at increasing concentration and require further study. The This report was released on memory sticks at the 2013 ArcticNet Annual Science Meeting (Halifax) and is currently available in .pdf format on the Northern Contaminants website hosted by CYFN and will also be available online later in 2014 through the NCP Publications Database. A limited number of hard copies will be distributed in 2014-15.

Vodcasts: Eight videos featuring NCP researchers, partners, managers and Secretariat staff (Laurie Chan, Chris Furgal, Lisa Loseto, Derek Muir, Russel Shearer, Duane Smith, Jason Stow and Bob Van Dijken) were prepared and presented at the 20th NCP Results Workshop. An additional 3 videos (Hayley Hung & Sandy Steffen; Inuit Research Advisors (Carla Pamak, Betsy Palliser, Shannon O'Hara, Romani Makkik), and Eric Loring) were prepared based on interviews at the Results Workshop itself. These videos will be available online in 2014-15, with links to be established from the NCP website.

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. In 2013-2014, individuals from the Polar Data Catalogue actively engaged NCP researchers to ensure pre-existing meta data records are up to date and to assist the researchers in the creation of new records. The Canadian Polar Data Network has also initiated a pilot study to archive contaminants data currently held in the Yukon Contaminants Database. This study is a joint effort between the CPDN, Yukon College and AANDC. This work will contribute towards the development of processes and procedures to archive NCP data in the future.

Interlaboratory Quality Assurance Program: This initiative assesses data variability through interlaboratory studies on legacy as well as emerging organic chemicals and heavy metals using standards and certified reference materials. Valuable information is provided to the NCP science managers and northern residents to compare data between different laboratories and to make informed decisions regarding the sources of contaminants and their effects on the Arctic environment and on human health. This information also ensures that scientifically sound data is contributed by NCP and AMAP to international agreements and controls to protect the health of the Arctic ecosystem and northerners. Specifically, this initiative ensures that contaminant data produced by the laboratories meets the data quality objectives set by the management committee and that participating laboratories will be able to assess and improve their performance. To date, 8 phases of the QA/QC Program III have been completed. The Phase 7 QAQC report was completed in November 2013 and distributed to participating labs and the AMAP Secretariat. The Phase 8 interlaboratory comparison study got under way, with samples mailed to participating labs in January and February 2014. Further details/reports are available upon request from NCP Secretariat.

NCP Publications Database: Work on the NCP Publications Database began in 2002-03. 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. With the cooperation of more than 65 NCP researchers and Secretariat staff members, 3113 NCP publications have been identified so far, and the database now includes more than 3100 records. As a new feature in 2013-14, the NCP Secretariat worked with ASTIS and poster presenters from the NCP Results Workshop to put posters from the Results Workshop into the database in pdf.

International Activities and Results in 2013-2014

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.

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 Conference of the Parties (COP) met at COP-6 at the beginning of May 2013.

At the conclusion of COP-5, 10 new POPs were added to the Convention (9 under COP-4 and one under COP-5). Nine of the 10 POPs are contaminants of concern to the Arctic. The

Parties agreed to a Global Monitoring Plan which was strategic and cost-effective and based on advice prepared by the Stockholm Convention Secretariat in collaboration with Canada, AMAP and UNEP Chemicals. Canada regards Article 16 as a high priority and was instrumental in obtaining an agreement at COP-2 and COP-3 amongst various countries, particularly between developed and developing countries. The first report on effectiveness evaluation and the global monitoring plan was presented at COP-4. This report was heavily influenced by Canada, particularly through the participation of Tom Harner of EC, who sat on the Western Europe and Others Group (WEOG) as well as the global coordinating group that was responsible for the report. NCP and AMAP information was prominent in both reports. WEOG, with substantial support from AMAP, is now preparing a report on temporal trends to support effectiveness evaluation under Arctic 16 of the Convention. This report will contain a large amount of NCP data.

The **Persistent Organic Pollutants Review Committee** (POPRC) met in October 2013 to review data on chemicals that have been nominated as substances to be added to the Convention and that are still under review.

3. Contributing to the Global Actions on Mercury being Orchestrated by UNEP

In January 2013 the UNEP Intergovernmental Negotiating Committee reached an agreement to reduce global mercury contamination. This agreement known as the Minamata Convention, represents a major achievement for the NCP and AMAP, which contributed much of the scientific justification for global action. The Conference of Plenipotentiaries on the "Minamata Convention on Mercury" was held in Minamata and Kumamoto, Japan, from 9 to 11 October 2013 and was preceded by an open-ended intergovernmental preparatory meeting from 7 to 8 October 2013. To date, 97 countries have signed the Convention, including Canada, and one country, the United States, has ratified.

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 groundbreaking 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. The 2009 AMAP Human Health Assessment report was released alongside the NCP Human Health Assessment in the summer of 2009 in Iqaluit. The latest assessment on climate change and the cryosphere (Snow, Water, Ice and Permafrost in the Arctic (SWIPA) was completed in 2011 and released at the Arctic Council Ministerial meeting held May 12, 2011 in Nuuk Greenland.

Most recently NCP scientists 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. 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.

Finally, in 2013 AMAP released an assessment on Arctic Ocean Acidification and is now planning follow-up activities which will be discussed at a scoping workshop that will take place in May 2014.

Ongoing AMAP Assessment activities include updates on POPs, Radioactivity, Human health, and Short-lived climate forcers (black carbon / tropospheric ozone, and methane). 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 POPs and Human Health, for which Canada co-leads, as well as radioactivity. 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 report on the Global Monitoring Plan as well as the 2nd report on evaluation of the effectiveness of the Convention. This information will be further developed in the AMAP update assessments of POPs and human health that are currently under preparation.

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 climate modeling and prediction and other drivers of change in the Arctic which will contribute to the development of regional adaptation strategies. AACA-C will be organized around three regional assessments that include the Barents Sea, Baffin Bay/Davis Strait, and the Bering/Beaufort/Chukchi Seas. Each of these regional assessments will be coordinated by regional implementation teams that will be holding regional assessment workshops in 2014.

Expected Project Completion Date

This is an ongoing core component of the NCP.

Project website

www.science.gc.ca/default.asp?lang=En&n=7A463DBA-1

Council of Yukon First Nations – Northern Contaminants Program Meetings

Activités du Conseil des Premières Nations du Yukon à l'appui du Programme de lutte contre les contaminants dans le Nord

Project Leader:
Bob Van Dijken, Council of Yukon First Nations
Tel: (867) 393-9237, Fax: (867) 668-6577
Email: Bob.VanDijken@cyfn.net

Project Team Members and their Affiliations:
Yukon First Nations; Yukon Contaminants Committee

Abstract

Over the past year the Council of Yukon First Nations 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 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 font des recherches au Yukon.

Key Messages

- Our traditional foods in the Yukon are safe to eat.
- Levels of contaminants in traditional foods are generally low in the Yukon.
- We need to continue monitoring for contaminants, as new chemicals 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 dans les aliments traditionnels au Yukon.
- Il faut continuer de surveiller les contaminants, car il est rejeté dans l'atmosphère et dans l'eau de nouveaux produits chimiques 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 2013-2014

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 2013 to review proposals and funding recommendations made for the various envelopes and advise the Program on the Committee's recommendations. We also attended the Management Committee meeting and results workshop held in Ottawa in September. CYFN also secured funding to allow representatives from the Ta'an Kwäch'än Council and the Tr'ondëk Hwëch'in to attend the results workshop.

Information on the Northern Contaminants Program was shared at the Council of Yukon First Nations General Assembly held in Whitehorse 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.

Information on the Northern Contaminants Program and the call for proposals was shared with the 60+ participants in the Our Changing Climate, Our Changing Health workshop held in Whitehorse October 16 – 18, 2013.

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. Further content was added to the website at the request of the program office to enable international partners and researchers to have access to it in a timely manner.

We participated in the deliberations and activities of both the traditional knowledge and risk communication subcommittees.

One of the two Environment Canada air quality researchers operating the Little Fox Lake site in the Yukon (Hayley Hung) travelled to the Yukon to do outreach over the winter. 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.

CYFN prepared a discussion paper regarding the changing presence on the NCP program in northern communities resulting from budget cuts and travel restrictions (reduced frequency of results workshops, no more results workshops or management committee meetings held in the north). This discussion paper was discussed with the NCP program office in Ottawa in February 2014.

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.

Initial discussions were also held with the NCP program manager as well as the YCC chair regarding Arctic Council AMAP/PAME working group meetings to be held in Whitehorse in September 2014.

CYFN submitted a NCP proposal to research the development of a Local Environmental Observer (LEO) network in the Yukon. http://www.anthc.org/chs/ces/climate/leo/about.cfm This proposal was not funded.

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
- Participated in NCP subcommittee on traditional knowledge
- Maintained and updated 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 Committee and Northwest Territories Environmental Contaminants Committee

Participation de la Nation dénée aux travaux du Comité de gestion et du Comité régional des contaminants des Territoires du Nord-Ouest

- **Project Leader:**
  Camilia Zoe-Chocolate, Dene Nation
  Tel: (867) 873-4081, Fax: (867) 920-2254
  Email: czoechocolate@denenation.com
- **Project Team Members and their Affiliations:**
  Keyna Norwegian, Dene Nation

Abstract

In the 2013-2014 fiscal year, Dene Nation received funding from the Northern Contaminants Program to build Aboriginal Partner Capacity within Denendeh (Northwest Territories). 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.

As a national organization representing First Nations people, Dene Nation is suited to reviewing proposals for research under the NCP to ensure that research is relevant to the Dene, and that it proceeds in a respectful and culturally-appropriate manner. During

Résumé

Dans l'exercice 2013-2014, la Nation dénée a reçu du financement du Programme de lutte contre les contaminants dans le Nord pour renforcer les capacités des partenaires autochtones du Denendeh (Territoires du Nord-Ouest). Ce financement lui a permis de participer aux travaux du Comité de gestion du PLCN et du Comité régional des contaminants des Territoires du Nord-Ouest, pour aider le programme à atteindre ses objectifs.

En sa qualité d'organisation nationale représentant des Premières Nations, la Nation dénée est bien placée pour examiner des propositions de recherche présentées dans le cadre du PLCN et faire en sorte que les

the review process Dene Nation makes recommendations to ensure the most appropriate available resources and support systems in Dene communities are utilized, and that the goals of capacity building and incorporation of Traditional Knowledge are adequately addressed by researchers.

Dene Nation is an active Aboriginal partner in the NCP. Dene Nation acts as liaison to provide advice to the NCP on contaminant issues in Dene communities. Dene Nation hosts one Dene National Assembly and two leadership meetings per year within Denendeh, at which NCP activity reports are presented to leaders and members of the Dene Nation.

recherches soient pertinentes pour les Dénés et qu'elles s'effectuent de manière respectueuse et adaptée à leur réalité culturelle. Elle formule 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.

La Nation dénée est un partenaire autochtone actif du PLCN. Elle fait office d'agent de liaison pour conseiller le PLCN au sujet des contaminants dans les collectivités dénées. La Nation dénée est l'hôte d'une assemblée 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.

Key Messages

- Dene Nation participates on the NCP Management Committee and Northwest Territories Environmental Contaminants Committee.
- Dene Nation provides advice to NCP on contaminant issues of the Dene communities.

Messages clés

- La Nation dénée participe aux travaux du Comité de gestion et du Comité régional des contaminants des Territoires du Nord-Ouest.
- La Nation dénée conseille le PLCN au sujet des contaminants dans les collectivités dénées.

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 projects and monitoring projects. Projects were identified by 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 National Chief, Lands and Environmental Director and Program Coordinator participated in various meetings between April 1, 2013 to March 31, 2014.

Discussion and Conclusions

The funding went to administering the program; aboriginal partnership consultation and review of NCP funded projects and national/regional coordination and meetings. The budget includes 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.
Dene Nation has participated on the NCP Management Committee to review proposals, provide information and bring forward concerns of the Dene. We also presented NCP information at Dene National General Assembly and at Leadership Meetings.

Expected Project Completion Date

The project ends on March 31, 2014.

Inuit Circumpolar Council – Canada Activities in Support of Circumpolar and Global Contaminant Instruments and Activities

Conseil circumpolaire inuit – activités du Canada en appui aux activités et aux outils visant les contaminants circumpolaires et mondiaux

- **Project Leader:**
  Eva Kruemmel, Inuit Circumpolar Council – Canada
  Tel: (613) 563-2642, Fax: (613) 565-3089
  Email: ekruemmel@inuitcircumpolar.com
- **Project Team Members and their Affiliations:**
  Duane Smith, Leanna Ellsworth, Pitseolalaq Moss-Davies, and Stephanie Meakin, Inuit Circumpolar Council - Canada

Abstract

This report outlines ICC Canada's activities funded by Northern Contaminants Program (NCP) in the fiscal year of 2013-2014. 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, reviews of program blueprints and proposals, Results Workshop participation, and work on contributions for the Canadian Arctic Contaminants Assessment Highlights Report III. 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 9th POP Review Committee (POPRC) in October 2013. ICC

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 2013-2014. Le CCI Canada travaille à l'échelle nationale et internationale à régler les questions relatives aux contaminants dans l'Arctique. À l'échelle nationale, les activités comprennent le soutien au PLCN au sein du Comité de gestion, l'examen des plans directeurs et des propositions du programme, la participation à l'atelier sur les résultats et la contribution à la Synthèse du Rapport de l'évaluation des contaminants dans l'Arctique canadien, phase III. À l'échelle internationale, le CCI Canada a poursuivi ses activités se rapportant au Programme des Na-

Canada continued to support Arctic Council activities, such as attending meetings and organizing webinars for the Adaptation Actions for a Changing Arctic (AACA) Integration Team. ICC Canada continues to be 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 is leading the chapter on risk communication for the upcoming AMAP Health Assessment, and gave a poster and platform presentation on its health-related activities during the Arctic Frontiers conference in Tromsø, Norway.

tions Unies pour l'environnement (PNUE). Les travaux se rapportant à la Convention de Stockholm sur les polluants organiques sont en cours, et le CCI Canada a assisté à la 9^{e} réunion du Comité d'examen des POP en octobre 2013. Le CCI Canada a continué de soutenir les activités du Conseil de l'Arctique, notamment en assistant aux réunions et 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). 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. Le CCI Canada dirige la rédaction du chapitre sur la communication des risques du rapport d'évaluation des effets sur la santé qui est établi dans le cadre du PSEA, et il a offert une communication et une affiche sur les activités se rattachant à la santé au cours de la conférence des Frontières de l'Arctique à Tromsø, en Norvège.

Key Messages

- ICC Canada worked actively to support NCP by working on the Management Committee, Environmental Trends and Monitoring Subcommittee, and the CACAR III reports.
- ICC Canada assisted in the organization of the NCP Results Workshop (September 2013) and presented an Inuit Partnership Award to the NCP.
- ICC Canada attended the 9th POP Review Committee meeting and provided input in POPRC working group documents.
- ICC Canada actively contributed to Arctic Council related work, attended the AMAP Working Group meeting, AACA Integration team meetings, SAON Board meetings, and teleconferences of the SAON Executive Committee.

Messages clés

- Le CCI Canada a soutenu activement le PLCN en participant aux travaux du Comité de gestion et du sous-comité de recherche et de surveillance environnementale, et à l'établissement du RECAC III.
- Le CCI Canada a aidé à organiser l'atelier sur les résultats du PLCN (septembre 2013) et a remis un prix du partenariat avec les Inuits au PLCN.
- Le CCI Canada a assisté à la 9^{e} réunion du Comité d'examen des POP et contribué à l'établissement des documents des groupes de travail du comité.
- Le CCI Canada a participé activement aux travaux en lien avec le Conseil de l'Arctique et il a assisté à la réunion du groupe de travail du PSEA, aux réunions de l'équipe d'intégration des mesures d'adaptation pour un Arctique en évolution, aux réunions du conseil des SAON et aux téléconférences du comité exécutif des SAON.

Objectives

Short-term objectives of ICC's activities are:

1. to ensure that Inuit are aware of global, circumpolar and national activities and initiatives on contaminants
2. 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
3. to ensure that scientific research in the Arctic is addressing Inuit needs and is done with Inuit support and involvement

Long-term goals are:

1. 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,
2. 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,
3. to reduce, and if 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, 2013 - March 30, 2014, which is a delivery requirement detailed under the 2013/14 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 Pitseololaq (Pitsey) Moss-Davis, as appropriate and necessary. Yvonne Moorhouse provides administrative support. Stephanie Meakin as Science Advisor continues to support Eva Kruemmel when needed.

Detailed activities in 2013-2014

1. NCP

Work undertaken:

Eva Kruemmel participated in teleconferences of the Environmental Trends technical review committee, attended the NCP Research Management Meetings on April 16 – 18, and on September 26 – 27, 2013 in Ottawa, reviewed proposals and documents as required and provided input and comments.

Eva Kruemmel participated in a teleconference to discuss terms of references for a panel on local and traditional knowledge June 18th, 2013, provided input and sent the secretariat a paper on traditional knowledge use within Arctic Council that ICC had developed.

ICC Canada participated in the NCP Results Workshop September 24 -25: Duane Smith gave a presentation on NCP partnerships (local, national and international) and chaired a panel on communications, community-based monitoring and knowledge integration. Eva Kruemmel was on a panel on future directions for NCP health research and gave a presentation about the mercury in Arctic glaciers, which included results from ICC Canada's mercury study. ICC Canada also organized the poster awards that were given out during the NCP Results Workshop by Pitsey Moss-Davis and Eric Loring. ICC Canada also organized a 20-year NCP anniversary event celebrating the partnership with Inuit (see below).

Proposed activities:

a) Special session at NCP Results Workshop:

- highlight the successes of the NCP-Inuit partnership in the last 20 years
- showcase Inuit culture
- present awards for young scientists

Work undertaken:

ICC Canada assisted in the organization of the NCP Result Workshop, which took place September 24 – 25, 2013. ICC Canada organized and awarded (together with ITK) poster prizes for young scientists, and a special session to celebrate 20 years of successful partnership with the NCP. At that session, Duane Smith presented an Inuit partnership award to Russel Shearer (consisting of a plaque and an Inuit carving), to highlight the successful work of NCP in partnership with Inuit. The session also featured Inuit throat singers and drummers.

Proposed activities:

b) CACAR III: Scientific reports and the highlights report

- Input into the highlights report preparation, work on advisory committee
- Reviewing of reports/chapters as applicable
- Participation of related meetings and teleconferences

Work undertaken:

Until this date, there have not been any further activities on the highlights report. Eva Kruemmel reviewed and commented on a proof of the first chapter of the POPs report.

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 had a teleconference just prior to the NCP Results Workshop which ICC Canada was not able to participate in. Eva Kruemmel reviewed the outcomes of the teleconference and is planning to participate in any subsequent meetings of the group.

4. AMAP

Proposed activities:

a) General:

- The 27th WG meeting will take place in Tórshavn, Faroe Islands 15/16 - 18 September, 2013. ICC Canada is planning to attend the meeting.
- Contributions to reviews and other documents, as applicable and possible.
- Participation in AACA activities, if funding is available.

Work undertaken:

Eva Kruemmel (along with Parnuna Egede from ICC Greenland) participated at the 27th WG meeting in September in the Faroe Islands.

ICC Canada was part of the organization group of the AACA activities previously, and participated at both the Arctic Resilience Report (ARR) and AACA meetings. ICC Canada (Stephanie Meakin) now is part of the AACA Integration team. She attended the AACA Integration team (INT) meetings in Quebec City (October 2013) and Washington (January 2014) and set up three INT webinars (Feb, March, April 2014), which she also participated in. Stephanie also was a member of the INT Communications Committee and has reviewed and commented on the workplan and 2 page summary. ICC Canada communicated with all Inuit regional organizations to inform and seek experts to participate in the Regional Integration Team Meetings and briefed the ICC President and Executive Council on AACA activities.

Eva Kruemmel presented at and co-chaired a AMAP/ArcRisk contaminant session “Health & Environment in the Arctic” at the Arctic Frontiers Conference on January 23rd and 24th, respectively, in Tromsø, Norway (also see 6) Communication).

Proposed activities:

b) SAON:

- Attendance of relevant meetings/ teleconferences of the SAON Board, Executive Committee, and the national (Canadian) group. So far, 2 SAON Board meetings are planned for in the next year: April 2013 and October 2013. The SAON Board meeting in April will take place April 29th, prior to the Arctic Observing Summit (AOS). Eva Kruemmel will attend the SAON Board meeting, and the AOS. Duane Smith has been asked to give a plenary address at the AOS and is planning to attend the meeting. Travel support will be provided by the AOS organizers (for Duane Smith) and AMAP (for Eva Kruemmel). The dates and place for the SAON Board meeting in October still have to be determined.
- 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.

Work undertaken:

Eva Kruemmel participated in Executive Committee teleconferences and led the development of a white paper on community-based monitoring within SAON. She 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. She attended the Sustaining the Arctic Observing Network (SAON) Board meeting held April 29th in Vancouver, presented the outcomes of the CBM white paper at the meeting, and provided updates on activities for the ICC SAON task.

In preparation for the Arctic Observing Summit (AOS), Eva Kruemmel contacted AOS organizers as well as indigenous organizations to ensure that the conference will have good representation from indigenous peoples. Unfortunately, Duane Smith was not able to make it to the AOS due to conflicting meetings.

Eva Kruemmel and Noor Johnson (the task lead for the ICC-led SAON proposal) attended the AOS in Vancouver April 30th – May 2nd and organized side-sessions on CBM to inform interested conference participants about the SAON task (in particular the development of the CBM web atlas), and to get feedback about CBM activities and perspectives in the Arctic. Over 40 people attended the side-session (participant lists and a meeting summary are available from ICC Canada). Eva Kruemmel (along with Carolina Behe from ICC Alaska) also participated at a panel on perspectives on Arctic observing needs during the AOS. The panel session has been recorded and can be viewed on the internet:

(http://www.youtube.com/watch?v=9t3nQMt_TdI&list=PLpF7Ffs4byuKyQovFLi8XG2sAQvSNHOB9).

Eva Kruemmel was named a co-chair of the organizing committee for the second AOS taking place in April 2014 in Helsinki, participated in numerous teleconferences and meetings of the organizing committee (including a face-to-face meeting during the Arctic Frontiers Conference in January 2014 in Tromsø) and co-led the organization of a stakeholder session.

In July 2013, ICC Canada and its partners launched the online Atlas of Community Based Monitoring in a Changing Arctic (www.arcticcbm.org), and work to populate the atlas is ongoing. ICC Canada was able to hire an Inuk summer student (Lindsay Moorhouse), who has been assisting with this work during July and August 2013. Noor Johnson is now starting 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. ICC Canada has been in regular correspondence with other organizations and individuals interested in CBM, which led to the planning of two CBM related workshops for this fall: "Community-based Monitoring of the Marine Environment" workshop, held in Cambridge Bay, Nunavut, 19-21 November, 2013, and "Symposium on the Use of Indigenous and Local Knowledge to Monitor and Manage Natural Resources," held in Copenhagen, 2-3 December, 2013. Noor Johnson participated in the CBM workshops, which will further assist in the continued development of the SAON task. She also gave a presentation about the atlas at a workshop in Kautokeino, Norway, "Global Change, Indigenous Community-Based Observing Systems and Co-Production of Knowledge for the Circumpolar North," held 25 to 27 March 2014.

ICC Canada (Pitsey Moss-Davies) further presented an update on the CBM to the CAFF management board as well as CAFF observers in Kuujjuaq, QC, February 2014.

Information about the CBM web atlas and SAON activities have been communicated to the ICC leadership, PP partner organizations, as well as ITK and Canadian Inuit regions (for example during meetings of the Inuit Knowledge Centre National Committee (IQNC), April 1st, 2014 in Ottawa, in correspondence to each of the regional Inuit Research Advisors, and at a meeting of the National Inuit Committee on Health (NICoH) – also see 6) Communications).

Proposed activities:

c) AMAP Health Expert Group:

- Participation at relevant meetings (if possible) and consultations with the group.
- Reviewing and contributing to papers produced by the group. Funding proposals to contribute to the report on risk communication will be coordinated with Health Canada.

Work undertaken:

Unfortunately ICC Canada was not able to attend the 38th meeting of the Human Health Assessment Group (HHAG) that took place June 30 – July 1st in Petropavlovsk, Kamchatka. Leanna Ellsworth and Eva Kruemmel had several preparatory meetings with Shawn Donaldson (Health Canada), and one detailed preparatory meeting with Lars-Otto Reiersen and Jay van Oostdam (AMAP), Russel Shearer (AANDC), Shawn Donaldson and Constantine Tikhonov (Health Canada) at the ICC Canada office. At that meeting, it was also discussed what ICC Canada may contribute to the upcoming AMAP Health Assessment, and ICC Canada proposed to take the lead for the risk communication chapter, which was supported earlier this year by Health Canada (FNIHB, Constantine Tikhonov). Eva Kruemmel then took the lead for the risk communication chapter and had several meetings (in person and per teleconference) with Health Canada and Andy Gilman who has been contracted by Health Canada to compile the draft chapter. Eva drafted the outline for the chapter which was sent to HHAG in September, and ICC Canada (Leanna Ellsworth) participated in a teleconference of HHAG on September 13th, where the Health Assessment was discussed. Andy Gilman compiled the first draft, which was sent to HHAG members on January 16th. Eva Kruemmel organized and led a meeting with HHAG contributors on January 21st in Tromsø and participated in the HHAG meeting the same day. At the meeting, it was decided that the draft chapter needs to be cut considerably, and that country information needs to be added. In the following weeks, Eva compiled further information sent by HHAG members, as well as information from ICC's risk communication reports, and studies published in international journals, summarized the information and added it to the draft, compiled her own and comments from Anne Regine Lager (HHAG secretariat) on the draft chapter, and sent the material to Andy Gilman for further revisions and editing. Eva had further teleconferences and meetings with Andy Gilman and Health Canada to continue to revise the chapter and to implement comments from Health Canada.

Eva Kruemmel also provided comments to the Arctic Human Biomonitoring report to UNEP's Global Monitoring Programme that was compiled on behalf of HHAG by Jay Van Oostdam.

4. UN related

Proposed activities:

a) Global mercury agreement:

- Attendance of the Ministerial meeting in Japan, October 2013 if applicable and funding permits
- Consultations with the government, UNEP, scientists and partner organizations, attending of teleconferences and 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 the Ministerial conference in October in Japan. However, Eva Kruemmel participated in a face-to-face meeting with three non-governmental organizations representatives and Environment Canada on May 15th where both, outcomes of the Stockholm Convention COP-6 and questions related to mercury and Canada's status for signing the Minamata Convention were being discussed. Eva Kruemmel also has been in email contact with Environment Canada about information with regards to mercury-containing products and waste, as well as mercury export.

Proposed activities:

b) Stockholm Convention on POPs:

- Monitoring of activities that take place at COP-6 in Geneva, May 6 – 9, 2013

- Consultations with the government, scientists and partners, attending of teleconferences/meetings
- Reviewing of documents, researching papers for background information
- Writing of reports, position papers, press releases, as applicable

Work undertaken:

Eva Kruemmel monitored activities with regards to the Stockholm Convention and participated in de-briefing meetings with Environment Canada, such as the face-to-face meeting mentioned above, and a de-briefing webinar on Thursday, July 11, 2013 - 1:00 p.m. to 4:00 p.m.

Proposed activities:

c) POPRC:

- Attendance of POPRC -9, in Rome, Italy, October 14 – 18, 2013
- Contribution to POPRC intersessional working groups as required and possible
- Reviewing of documents and scientific papers
- Consultations with government, partner organizations, scientists
- Writing of reports, position papers etc.

Work undertaken:

Eva Kruemmel reviewed and commented on several POPRC documents (for example on draft Risk Profiles for pentachlorophenol, the Risk Management evaluations for chlorinated napthalenes, and the draft Risk Profile for decaBDE) as part of the intersessional POPRC working groups. Eva Kruemmel was in contact and had meetings with scientists and partner organizations to ask for data and available literature to support her work, and attended the 9th POPRC meeting October 14 – 18 in Rome. Eva then initiated a follow-up teleconference with Environment Canada, Health Canada (PMRA) and other NGO partners that took place November 29th, 2013. She has also been in contact with Rob Letcher, Derek Muir and other scientists to organize a literature review on the bioaccumulation of decaBDE that would provide input into the POPRC review process. Reports and briefing notes about the POPRC meeting were sent to ICC leadership, the NCP secretariat, NCP/AMAP scientists, and ITK.

Proposed activities:

d) LRTAP:

- Providing stakeholder comments to government when possible
- Consultations with government, partner organizations, researchers
- Reviewing documents

Work undertaken:

There have been no opportunities for input so far with regards to LRTAP.

5. Other mercury and POPs related work

Proposed activities:

- 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

Work undertaken:

ICC Canada and its partners from the University of Ottawa and Trent University continued work on the sample- and data analysis for the study on mercury pathways in the Canadian Arctic that was funded last year (M-20: Spatial and temporal variations of Hg isotope ratios in ice cores across the Canadian Arctic). Eva Kruemmel prepared and submitted the contribution about the study for the Synopsis report, and gave a presentation about preliminary results at the NCP Results Workshop on September 25th. She was also engaged in drafting a manuscript that was recently accepted for publication in the journal Science of the Total Environment: "A glacial record of recent (1970-2010) and pre-industrial atmospheric deposition of sulfate and mercury from Baffin Island, Canada", by Christian Zdanowicz, Eva M. Krümmel, David Lean, Alexandre Poulain, Christophe Kinnard, Emmanuel Yumvihoze, JiuBin Chen and Holger Hintelmann.

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.

6. Communication

Proposed activities:

- 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 Canada's communication efforts are ongoing, and ICC Canada continues to work on the improvement of its website and presence on the internet (such as the ICC Canada Facebook-site). 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 additional examples where ICC Canada communicated its work within meetings with scientists, Arctic Council membership, regional Inuit organizations and/or ITK include:

- Inuit Health Survey Steering Committee Meeting at the University of Ottawa, March 13-14, 2014. ICC Canada explained the POPRC work and why there is a need for new POP candidates to be analyzed in left-over samples.
- NICoH meeting in Inuvik, March 4-5, 2014. ICC Canada reported on the CBM web atlas and the new health layer mapping project that will be undertaken with funds from Health Canada.
- CAFF Board meeting, 11 – 13th February 2014, PowerPoint presentation and demonstration by Pitsey Moss-Davies on the SAON task/CBM web atlas.
- Leanna Ellsworth and Eva Kruemmel attended the Arctic Frontiers Conference in Tromsø, Norway, January 20 – 24, 2014, and presented a poster about ICC Canada's health-related activities, as well as a talk about ICC's risk communication work, respectively. NICoH was informed about the conference and ICC Canada's involvement in an email on December 12th, 2013.

Expected Project Completion Date

Work is ongoing

Acknowledgments

NCP was acknowledged in all presentations prepared as part of the funded work.

Inuit Tapiriit Kanatami National Coordination

Coordination nationale d'Inuit Tapiriit Kanatami

Project Leader:

Eric Loring, Inuit Tapiriit Kanatami
Tel: (613) 238-8181 x234, Fax: (613) 234-1991
Email: loring@itk.ca

Project Team Members and their Affiliations:

John Cheechoo, Scot Nickels, Elizabeth Ford, and Terry Audlu, Inuit Tapiriit Kanatami; Inuit Circumpolar Council-Canada; Nunavut Environment Contaminants Committee; NWT Regional Contaminants Committee; Nunatsiavut Government Research and Advisory Committee; Nunavik Nutrition and Health Committee

Abstract

Since the beginning of the Northern Contaminants Program (NCP) in 1991, Inuit Tapiriit of Kanatami (ITK) has participated in the program as a managing partner. This partnership continues to be fruitful and effective both for Canadian Inuit and to the Northern Contaminants Program. As the national political voice for Canadian Inuit, ITK continues to play multiple roles within the NCP. First, ITK provides guidance and direction to the NCP and its 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.

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 au PLCN et à ses partenaires, en faisant connaître les intérêts des Inuits au Comité de gestion du PLCN et aux comités régionaux dont il est membre. En conséquence, le PLCN peut mieux répondre aux besoins et réagir aux préoccupations des Inuits.

Secondly, ITK is dedicated to facilitating appropriate, timely communications about contaminants in the North. Thirdly, ITK is working with its Inuit partners at the Inuit Circumpolar Council (ICC)-Canada at the international level to persuade nations to reduce the production and use of persistent organic pollutants (POPs) and heavy metals (*e.g.*, mercury) that end up in the Inuit diet.

Lastly, ITK works with other research programs like ArcticNet, the Nasivvik Centre for Inuit Health and Changing Environments, Health Canada Climate Change and Adaptation Program and the Chemicals Management Plan to make sure that research on contaminants is conducted in a coordinated approach. This is done mainly through ITK's participation on the regional contaminants committee in each of the four Inuit regions. ITK involvement in these regional contaminant committees is critical in order to deliver a consistent message to Inuit regarding the NCP and contaminants.

Deuxièmement, ITK s'emploie à faciliter des communications adéquates et opportunes au sujet des contaminants dans le Nord.

Troisièmement, ITK collabore avec ses partenaires inuits au sein du CCI Canada à l'échelon 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 avec d'autres programmes de recherche, comme ArcticNet, le Centre pour la santé des Inuits et les changements environnementaux Nasivvik, le programme Changement climatique et adaptation sanitaire 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. Cette participation est cruciale pour livrer un message cohérent aux Inuits au sujet du PLCN et des contaminants.

Key messages

- ITK provides a voice for the Inuit of Canada during NCP discussions.
- ITK continues to be an active and constructive member of the NCP, ensuring that contaminants issues and NCP research are communicated to Inuit, and that Inuit are represented at key regional, circumpolar and international meetings and initiatives.
- ITK contextualizes contaminant information in a broader communication process using the Inuit Knowledge Centre.

Messages clés

- ITK se fait le porte-parole des Inuits du Canada dans les délibérations du PLCN.
- ITK continue d'être un membre actif et constructif du PLCN, et veille 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.
- ITK contextualise les renseignements relatifs aux contaminants dans un contexte général par l'intermédiaire du Centre du savoir inuit.

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. The fear portion comes from reports derived from data that shows 73 percent of Inuit women have PCB blood levels above (and up to five times higher than) the guideline value set by Health Canada as a "level of concern". For other POPs, up to half of the Inuit in the studies have intakes exceeding Health Canada intake guidelines. Not only do many Inuit exceed the blood level and intake guideline levels, they are also exposed to mixtures of chemicals which recent Health Canada studies show may magnify the effects (*e.g.*child growth and hormone disruption) of individual chemicals. The mercury story is equally scary, High levels of mercury are found in some of Inuit preferred and most consumed country foods. 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 reports and data it is critical that Inuit involvement within the program to what advice, direction and information should be provided in context with regional priorities and concerns in the delivery of this sensitive information.

Activities in 2013-2014

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 new Inuit Knowledge Center Committee. Last year with close working ties developed with ITK Health and Social Economic Development Department we were able to bring forward NCP concerns to Inuit Public Health Task Group. This 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.

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.

ITK was also able to participate in CEC meetings and the discussion of vulnerable communities due to environment contaminants. ITK was able to bring to the table NCP research and modes of operations that allows for community and regional involvement and engagement. ITK was also able to participate in the National Chemical Management Plan again bringing forward NCP voice and data. ITK also participated on Metal Mining Effluent Regulations.

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 ITK responsibilities with the NCP funding is to consult with the principal investigators and communities that will be engage in research in Inuit regions. Last year there was over 21 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 as in the Inuit Health Survey.

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 both the ArcticNet AGM in Halifax December 2013 and the Northern Contaminants Program Results Workshop in Ottawa. 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 these two meetings. 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 16 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 and Education communication 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 to Inuit regions.

Expected Project Completion Date

Ongoing

Project website (if applicable):

www.itk.ca
http://www.inuitknowledge.ca/

Aboriginal Affairs and Northern Development Canada
10 Wellington Street,
Gatineau, Quebec K1A 0H4