The Need for a Sustainable Arctic Wildlife Health Observation Network

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Executive Summary

Healthy wildlife populations are essential for ensuring integrity of arctic ecosystems, providing nutritious food, a source of sustainable income, and a focus for cultural activities for northern peoples. The health of wildlife is directly influenced by recent climate change and the accelerated rate of anthropogenic landscape disturbance around the North. Monitoring and surveillance programs for wildlife health are essential to: (i) detect and track alterations in individual animal and population level well-being, (ii) detect emerging pathogens, disease syndromes, and contaminants, and (iii) identify zoonotic diseases and food safety concerns, (iv) assemble new and existing findings from disparate scientific areas to identify species and populations at risk from multiple stressors.

Data from such programs may be analyzed and communicated to decision makers in public health and wildlife management, and directly to stakeholders. This information can be used to implement effective and adaptive public health measures for food safety, and to promote wildlife and ecosystem health, cultural integrity, and in the case of subsistence species, food security. Specimens and data need to be deposited into permanent repositories that are managed and accessible to the broader scientific community.

The goals and methodologies of previous and existing monitoring programs have varied, and these programs generally operate independently from each other. Examination of these programs to determine how they interact, where there are redundancies and deficiencies, and if they effectively meet the current and future needs of northern residents, wildlife managers, and public health officials, is warranted. A Sustainable Arctic Wildlife Health Observation Network could bring together existing wildlife health monitoring programs, develop new ones where critical gaps exist, facilitate communication and sharing of expertise between programs including implementation of standardized and comparable methodologies, and provide mechanisms and support for efficient data and specimen archiving and retrieval.

Changing wildlife health in the Arctic

Wildlife, including fish, birds, and mammals within terrestrial, freshwater and marine environments, are integral components of northern ecosystems and provide a source of food and a focus for cultural activities for circumpolar peoples. Healthy wildlife populations are thus essential for ecosystem integrity, food safety and food security across the Arctic.

Recent and ongoing environmental perturbations, associated with climate change and industrial development, are having significant impacts on the health and sustainability of wildlife(Kutz *et al.*, 2009, Wasser *et al.*, 2011). Climate warming in the Canadian Arctic has reduced the life cycle of the muskox lungworm from a two to one year transmission period(Kutz *et al.*, 2005). In Finland, unusually warm summers have lead to amplification of the nematode parasite *Setaria* in reindeer populations resulting in substantial morbidity, mortality, and meat condemnation(Laaksonen *et al.*, 2007). In Norway significant pneumonia die-offs in muskoxen are linked to unusually warm summers coupled with anthropogenic stressors (Ytrehus *et al.*, 2008).

In addition to emergence and spread of disease associated with existing pathogens, invasion of new pathogens to the arctic ecosystems, either on their own or with their southern hosts, is occurring. The recent northward range expansion of the winter tick, *Dermacentor albipictus,* in moose and caribou is attributed to landscape change (fires) together with climate warming (Kutz et al., 2009). In the late 1980's a devastating epidemic in seals caused by seal distemper virus (PDV) in Europe was linked with incursions of harp seals south of their normal range due to unusual ice conditions and changes in prey distribution (McGourty 1988). With the projected decrease in sea ice cover in Arctic Canada, the potential for eastern Arctic pinnipeds, in which PDV is now endemic, to contact western species where the virus has not been detected, will be enhanced (Duignan et al., 1994, 1995, 1997; Burek et al., 2005). Similarly, increased anthropogenic activity, such as the northward movement of humans with their pets and livestock, increased tourism (e.g., cruise ships and ballast water) and increasing shipping traffic, threaten to transport new pathogens into naïve arctic ecosystems.

For some wildlife mortality events, the association or interaction between climatic perturbations, pathogens and anthropogenic factors are less certain. Recent mid-summer mass mortality events of muskoxen on Banks and Victoria Islands in arctic Canada (PROMED 2012) may be linked to opportunistic pathogens and unseasonally warm weather. Similarly, the cause of the recent morbidity (characterized by lethargy, abnormal molt and varying degrees of erosive and ulcerative dermatitis) and mortality among ringed, spotted and bearded seals and Pacific walrus spreading from the North Slope in Alaska to Russia and the Canadian Arctic remains enigmatic (NOAA 2013). Since spring 2012 approximately 28% of polar bears sampled at three locations in Alaska were also found to have alopecia and ulcerative skin lesions (NOAA 2013). Whether this indicates the emergence of a novel pathogen affecting several species in the region or exposure to a common environmental influence is as yet unknown. Finally, viruses have entered marine ecosystems through mutation and/or spillover from terrestrial hosts, and have caused unusual mortality events such as the outbreak of avian H3N8 influenza in harbor seals in 2011 (Anthony et al 2013).

In addition to the changing climate, global circulation of contaminants, habitat fragmentation, changing oceanic currents with altered ice regimes, and the increasing exploration and development of renewable (e.g., tourism) and non-renewable (oil, gas, minerals) resources across the Arctic are all potentially significant stressors to arctic wildlife(Fisk *et al.*, 2005, Gamberg *et al.*, 2005, Wasser *et al.*, 2011). Seismic exploration and associated noise has been implicated in unusual ice entrapment and mortality events in narwhal (Heide-Jorgensen et al 2013). Stochastic events, such as the 2012 Japanese tsunami that resulted in radionuclide contamination of fish in the North Pacific (Madigan et al 2012) and the volcanic activity in Iceland in 2010, may also exacerbate the stresses on Arctic wildlife.

Ultimately, how animals respond to the rapidly changing arctic environment will depend on a number of factors and complex interactions between the animals, the environment, and pathogens. The resultant health and sustainability of wildlife populations will in turn have tremendous impact on the health and livelihoods of Arctic people who depend on wildlife for food, economy, and maintenance of cultural traditions. **Thus the resilience of arctic wildlife to change is critical for healthy ecosystems and healthy human communities, and monitoring wildlife health in a systematic manner is essential in order to predict, detect, and respond to change.**

Why observe wildlife health?

Healthy wildlife populations are critical for ecosystem integrity and human physical (food security), social, and economic health throughout the circumarctic. Infectious disease, contaminants, and stress can have severe impacts on sustainability of wildlife populations (Albon *et al.*, 2002), yet in the Arctic there remain numerous knowledge gaps regarding wildlife health. New genera and species of pathogens are being identified regularly across a wide range of host taxa, and their effects on individual animals and people, and how they interact with contaminants, are not well known (Gamberg *et al.*, 2005, Hoberg *et al.*, 2012, Kutz *et al.*, 2007, Kutz *et al.*, 2012, Van Bressem et al., 2009, Verocai *et al.*, 2012). Other baseline measures of animal health, including genetic health and physiological stress, are lacking for most arctic wildlife species, but are essential for tracking changes over space and time, providing critical information to inform wildlife management strategies. Health monitoring goes beyond the routine population censuses, and provides information on the status of wildlife from year to year, across geographic regions, generating insights into key factors which drive population dynamics, food web interactions, and potential risks for people. When individual animals fail to adapt to stressors they are exposed to, there can be related effects to reproductive performance, immunological responses and overall fitness, thus the potential exists for decreases in population abundance without observable fatal effects. Importantly, health monitoring may also be used as a tool to anticipate changes in population dynamics and thus implement management strategies in a timely manner (e.g.,Wu *et al.*, 2012).

The safety and security of country foods is closely linked to wildlife health. Many northerners depend on wildlife for food (Wesche & Chan, 2010) but have limited or no access to the expertise of trained meat inspectors. Although in the past traditional knowledge on food safety was passed from elders to the youth, breakdown in transfer of this knowledge to younger generations, together with emergence of new disease syndromes, means that the local hunter's knowledge of disease and food safety is sometimes dated or deficient. Thus, new disease monitoring systems that simultaneously educate local stakeholders and engage them in the monitoring process may be required to ensure safety of, and confidence in, country foods (Brook *et al.*, 2009).

Effective and efficient programs for observing wildlife health in the rapidly changing landscape are thus important for species survival and conservation as well as human health and welfare(Hoberg *et al.*, 2008, Kuiken *et al.*, 2005). Such programs can (i) establish baselines and detect and track alterations in individual animal and population level well-being, (ii) detect emerging pathogens, disease syndromes, and contaminants, and (iii) identify zoonotic diseases and food safety concerns. Data generated can be used to anticipate changes and/or threats to wildlife population health and trajectories, food web dynamics, and ecosystem health and provide critical information on which to base decisions that guide safety and security of country foods. A coordinated wildlife health observation network for the Arctic can also assemble new and existing findings from disparate scientific areas to identify species and populations at risk from multiple stressors. This may include toxin burdens and related physiologic changes, changes in genetic diversity and resilience of populations, pathogen emergence and changes in range and hosts due to climate change, changes in environment and food availability, and effects of chronic stress on immune and reproductive function.

Existing monitoring programs

A number of different types of wildlife health monitoring programs of short and longer duration exist in the Arctic. These programs are initiated by a variety of individuals, groups or agencies and range from informal to highly standardized. They have different goals and objectives ranging from basic data collection with specific objectives to in-depth comprehensive species specific research programs. Mechanisms for monitoring vary from broad geographic community-based sampling to focused intensive researcher-based sampling. Data and sample archiving, access, and ultimate use vary substantially.

Here we highlight a few existing programs for illustrative purposes (Table 1). We see that programs can be categorized as species or theme based, range in their geographic scope, and vary with respect to the ultimate use of the data. Our list is North American biased and is far from a comprehensive list of wildlife health observation initiatives around the Arctic. Our goal is to illustrate the diversity of programs and some key strengths and gaps in existing programs (Table 2). Using this framework we can then move forward to discuss if there is a need, and mechanism for, improving circumarctic wildlife health observation.

Canadian Cooperative Wildlife Health Centre (CCWHC, www.**ccwhc**.ca):
The CCWHC was established in 1992. It is a non-governmental agency with a mandate for wildlife disease surveillance across Canada. Its main goals are to detect and diagnose disease in all wildlife species, including fish, recommend management actions, and provide educational materials on wildlife health. It also coordinates targeted surveillance programs on wildlife diseases such as avian influenza, chronic wasting disease and West Nile virus. It has regional offices distributed at all 5 veterinary schools in Canada and each office hosts at least one wildlife disease specialist whose primary role is to detect, diagnose, and report back on wildlife disease. Samples for diagnostics are submitted by members of the public as well as wildlife and public health agencies, and results are reported directly to the submitter. All data are entered into a centralized database and are accessible through data access agreements.

CircumArctic Rangifer Monitoring and Assessment Network (CARMA, http://caff.is/carma)
CARMA is a network of researchers, managers and community people who share information on the status of the world's wild *Rangifer* (reindeer and caribou) populations, and how they are affected by global changes, such as climate change and industrial development. During International Polar Year the CARMA network established and implemented standardized *Rangifer* health monitoring protocols (Kutz *et al.*, 2013). These protocols, together with online supporting videos and powerpoint presentations, provide detailed directions on different levels of sampling and processing, including basic community-based sampling by subsistence hunters and intensive researcher-based comprehensive sampling. This has facilitated broad comparisons of health across circumarctic herds and over time (Ducrocq *et al.*, 2012a, Ducrocq *et al.*, 2012b, Forde *et al.*, 2012). Ongoing *Rangifer* health observations require full commitment of regional wildlife agencies for sample collection and data summary and communication.

Northern Contaminant Program (NCP http://www.aadnc-aandc.gc.ca/eng/1100100035611/1100100035612)
The Northern Contaminants Program was created in 1991 to study contaminant level exposure and effect on health of wildlife and humans. Its mandate is to reduce or eliminate contaminants in country foods and provide information to assist policy makers and the general population in decision making. This is a federal program funded by the Government of Canada and involves researchers from many Canadian universities. The funds provided are supporting projects in human health research, communication, capacity and outreach, national/regional coordination and aboriginal partnerships, community based monitoring research, and environmental monitoring and research.

Nunavik Trichinellosis Prevention Program (NTPP)

The Nunavik Trichinellosis Prevention Program is a community-based program available to all 14 communities of Nunavik since 1997. Its aim is to provide a diagnostic service for the detection of *Trichinella nativa* in walrus meat in order to prevent trichinellosis associated with consumption of raw walrus meat. This service is provided to all walrus harvesting communities and results are given within 24h of sample arrival to Kuujjuaq. The program is led by Nunavik stakeholders (Makivik Corporation, Regional Board of Health and Social Services, and the Kativik Regional Government) and includes scientists and wildlife technicians from the Nunavik Research Centre (NRC), walrus hunters, doctors and mayors. This on-going monitoring of walrus meat has eliminated trichinellosis cases due to walrus meat since 2000, it also permits long term data collection. Special projects on walrus can be added to the sampling program. All data are archived at the Nunavik Research Centre, Makivik Corporation in Kuujjuaq.

Eastern Canadian Arctic Seabird Ecology and Health (ECASEH)

Building on a pre-existing long-term seabird ecology monitoring program which began in 1996 by Environment Canada, a multidisciplinary, multi-agency research team was assembled in 2007 in response to the emergence of avian cholera in the eastern Canadian Arctic. The goal was to investigate the ecology of this pathogen at the individual, population, community, and larger geographic scales, with the objective of identifying ultimate origins and proximate sources (i.e., avian or environmental reservoirs) of the pathogen; investigating the impacts and spread of the disease in the eastern Canadian Arctic; and the interactions and roles with stress and climate. This work is conducted with significant community involvement, through consultations, community-based surveillance, and reporting back to communities through meetings, pamphlets, radio, and outreach programs. This research collaboration has been largely successful, and will continue to use integrative approaches to explore similar types of questions (e.g., responses to climate, industrial development, multi-stressor effects, etc.) of relevance to wildlife health and conservation, and food safety and security for community stakeholders.

Table 1: Examples of some existing monitoring programs

Program	Species/ Scope	Geographic Region	Health measures collected	Sample or Data Collection mechanism	Sample storage	Data storage	End-user
Canadian Cooperative Wildlife Health Centre (CCWHC) Not-for-profit	All wildlife	Canada	Infectious and non-infectious disease	• Passive by public • Active for targeted programs (WNV, AI, CWD)	Paraffin blocks, occasionally frozen tissues	National CCWHC database	Decision and policy makers (Wildlife management, public health) Local stakeholders
Circumpolar Arctic Rangifer Monitoring and Assessment Network (CARMA) Researchers, Government	*Rangifer* only	Circumpolar	Variable, but standardized protocols. (Infectious disease, physiological condition)	Researcher/Manager directed. Subsistence hunters or researcher collection	University/government researchers. Some parasite specimens archived in national museums.	Individual researcher databases	Researchers, Decision and policy makers (wildlife management, public health) Local stakeholders
Northern Contaminants program Canadian Government	Traditional foods	Arctic and sub-Arctic Canada	Contaminants in wildlife and humans	Researcher and community-based sample collection	University researchers. NGO. Tissues frozen and archived.	Individual researcher databases	Decision and policy makers (Public health, governments) Researchers Local stakeholders
Nunavik Research Center, Makivik Corporation *Trichinella* program Non-governmental organization	Walrus	Nunavik (over the 55th parallel), Quebec	Tongue and possibility of other samples depending on other programs.	• Active sample collection by walrus hunters and short-term research projects.	Parasite archiving at CFIA. Short term archiving until sent to end user.	NRC database	Walrus hunters. Decision and policy makers (Wildlife Management and Public health).

Table 1 (continued): Examples of some existing monitoring programs

Program	Species/ Scope	Geographic Region	Healthmeasures collected	Sample or Data Collection mechanism	Sample storage	Data storage	End-user
Nunavik Research Center, Makivik Corporation Food safety Non-governmental organization	Traditional foods	Nunavik (over the 55th parallel), Quebec	Variable tissue samples for different programs	Passive sample collection (community members) Active sample collection for projects (beluga, seals) Active for short term projects (fox, polar bears)	Serum frozen, Archives of small samples (DNA tissue, parasites) at Makivik Corporation. Archiving at DFO or universities or CFIA.	NRC database and CCWHC database.	Decision and policy makers (Wildlife Management and Public health) Local and regional stakeholders.
Eastern Canadian Arctic Seabird Ecology and Health Environment Canada, university researchers	Primarily seabird	Eastern Canadian Arctic, collaboration (e.g., Greenland)	*Live bird surveillance/ hunter-killed/found dead*: infectious pathogens, physiological condition, stress hormones, blood parameters, survival, reproductive success, contaminants	Active and passive. Researcher directed, Researcher and/or community collected	Serum, swabs, tissues, feathers, DNA samples, bacterial isolates, fixed parasites at universities, and tissues and wings (hunted/dead birds) at National Wildlife Specimen Bank	Individual databases for different components, and single database merging all datasets, managed by Environment Canada	Researchers, Decision and policy makers (Wildlife Management and Public health) Local community stakeholders
Alaska Dept. of Fish &	Mamma	Alaska	Infectious and	Passive and active	Serum and	Departmen	Research, Decision

Game Wildlife Health Surveillance Program State Government	ls		non-infectious disease, nutritional indices/body condition, ectoparasites	collection of carcasses Active collection from capture/ release Targeted for specific diseases	blood ultralow frozen archive, frozen tissue, paraffin blocks, ETOH fixed parasites in department	tal statewide electronic database	and policy makers (Wildlife Management and Public health) Local stakeholders?

Table 2: A preliminary look at the strengths and opportunities of selected monitoring programs

PROGRAM	Strengths	Opportunities
CCWHC	• Ongoing disease detection • National network of wildlife disease expertise • Broad geographic and species scope • Sophisticated database • Some tissue archiving • Wildlife disease information documents on the web	• Focus is on disease, end point is determining cause of death • Most tissue archiving restricted to paraffin blocks. • Southern facility, sample shipment is logistically challenging and costs are high, diagnostic results take long to receive up North • Lack of generalizability to larger populations • Limited presence in the North and few samples submitted
Northern Contaminants Program	• Broad range of Arctic locations and species sampled • Long term and systematic sampling	• Samples collected for contaminants only • Need to connect knowledge of contaminants with diseases and other environmental factors when possible. • Archives are at different locations
Nunavik Trichinella Prevention Program	• Located in the North • Results provided within 24h • Database available • Regional stakeholders involved • Based on public health action • Diagnostic testing is easy and inexpensive	• Very specific program (one species)No routine tissue archiving • Parasites are archived at CFIA Saskatoon. • Only needed in regions where Trichinellosis is a problem • Need dedicated facilities, with personnel.
CARMA	• Circumarctic network • Standardized protocols	• No centrally managed permanent data repository • Archiving of specimens depends on individual network participants

	• Regular in-person network meetings • Broad definition of health integrating many disciplines, agencies, community members • Results interpreted in context of other population and ecosystem conditions	• Mechanisms for data use and data sharing not clearly established
Eastern Canadian Arctic Seabird Ecology and Health (ECASEH)	• Examines wildlife health at the individual, population, community, and inter-continental levels • Numerous measures of health are evaluated • Thousands of samples archived • Multidisciplinary and international collaboration • Community consultations, community-based surveillance, reporting and outreach • Central database merging multiple databases of key researchers	• Archiving of specimens, measures of health analyzed, and data collected depend on individual researchers, shifting research priorities, and available resources • Primarily avian focus, emphasis on seabirds (e.g., common eider ducks). • Eastern Canadian Arctic focus – Nunavut, Northern Quebec (Nunavik)

The role of a Sustainable Arctic Wildlife Health Observation Network

The above-mentioned programs, and many others not included here, are generally successful at meeting their stated goals. The question then becomes whether current programs adequately meet the needs of wildlife health observation in a rapidly changing North, or if we can do better? We believe that there are thematic and species deficits, and that even successful existing programs would benefit from a Sustainable Arctic Wildlife Health Observation Network (SAWHON). Such a network could serve as a catalyst and support system to promote maximum efficiency and success of existing and future monitoring programs. It could provide a forum for interaction and discussion between programs to share knowledge, skills, and methodologies, identify gaps in existing programs, and understand further/alternate uses of data. This could lead to improved efficiency, effectiveness and standardization of existing efforts and facilitate working out data sharing agreements, jurisdictional and confidentiality concerns. This collaborative approach may greatly enhance existing observation programs, ultimately improving surveillance and management of arctic wildlife, human and ecosystem health.

An Arctic Wildlife Health Observation Network: a forum for discussions, collaborations, knowledge and technology transfer

A forum for defining health

Many wildlife health monitoring programs have a restricted discipline-based definition of health. Such an approach ignores complexity and only provides a small window on animal health. The diversity of expertise provided by a broader SAWHON would allow revisiting and expanding the health definition to include measures of health identified by local stakeholders including traditional and local knowledge, as well as indices of pathogens, contaminants and non-infectious diseases, genetic, and physiological measures of health. Such an approach recognizes the human value system as well as the complex interplay among host genetics, climate, environmental stressors, infectious and non-infectious diseases, contaminant burden and body condition, stage of reproduction, etc. Analyzing any of these factors in isolation will not adequately address the complexity of animal health and the capacity for resilience. Within the SAWHON there would exist considerable expertise to appropriately gather and analyze a wide range of key health indicators for wildlife including, but not limited to:

<u>Traditional knowledge and perceptions:</u> Northern aboriginal people have a long term and close relationship with wildlife – much longer and closer than most wildlife biologists and researchers. Through this they have developed their own definition of what healthy individuals and populations are. Capturing this knowledge in a socially responsible and scientifically rigorous manner provides new insights into health and contributes important historical and ongoing information to a health observation program.

<u>Genetics</u>: Understanding the genetic diversity and intrinsic ability of a species to cope with environmental variability and infectious disease is a key component to evaluating the health and resilience of wildlife. Genetic health may be altered through historical and contemporary factors including isolation, habitat fragmentation, and bottlenecks, as well as differential exposure to pathogens and other selective pressures. Documenting and tracking genetic health over a broad geographic region will provide essential information on local and global diversity and resilience and may be incorporated into management recommendations.

Pathogens: Pathogens, including parasites, bacteria and viruses, can cause significant subclinical and clinical disease in individuals and ultimately impact host population dynamics. Additionally, several wildlife pathogens are zoonotic and/or may influence meat quality and taste. Monitoring abundance and diversity of pathogens ensures detection of emerging pathogens and provides essential information for advising on food safety and security, and wildlife conservation and management activities.

Contaminants and non-infectious diseases: Heavy metals (e.g., mercury, selenium, cadmium, lead), PCBs, and POPs influence food safety and wildlife conservation. Accelerated mining exploration and development activities across the North are increasing the potential risk of wildlife exposure and related diseases. Additionally, monitoring animal health for other non-infectious diseases, such as neoplasia, endocrine disorders, deformities may reflect genetic health concerns for individual animals and serve as indicator species for possible human exposure to carcinogenic or endocrine disrupting compounds.

Physiological measures of health: There are several important physiological measures of health that should be considered in a monitoring program. Physical measurements (e.g., body size, mass, body condition), life history stages (e.g., reproductive status, age), and physiological measures such as immune function, measures of stress (e.g., glucocorticoids in blood, fecal, skin, fur, or feather samples; RNA expression etc.), infection status or previous exposure to pathogens (antibodies, pathogen genome), and other measures where relevant can all serve as important indicators of individual and population health. Measures of stress may reflect environmental conditions as well as other stressors or conditions requiring increased energetic demands (e.g., food stress, predation risk, infectious disease, etc.) and are useful as longterm population health monitoring tools. Stable isotope techniques can also be used to understand changes in food webs over space and time.

A network for optimizing animal use and community time

Small sample sizes and the opportunistic study design of many programs brings generalizability of results back to populations across a broad divergent landscape, into question. Programs may also lack an overall ecosystem approach necessary to understand and monitor animals and pathogens across their range. By bringing people together, resources and research outcomes can be optimized. For example, if the contaminants and infectious disease researchers working on the same species use the same animals, multiple measures of health can be gathered for a substantially reduced financial cost and animal usage cost. This can also contribute to increased sample sizes, broader geographic or temporal scope of sampling, reduced time and costs associated with community consultations, and reduction in community ‘research fatigue’ caused by multiple consultations. Programs that collaborate can also leverage funding and in-kind support.

A forum for sharing of protocols and methodologies

As demonstrated through the CARMA network there is incredible benefit to standardizing sampling, diagnostic and analytic protocols to ensure comparability of information across populations and time(Kutz *et al.*, 2013). Lack of standardization of methods within and across programs and species limits secondary uses of data, as well as comparability between programs, regions and over time. By bringing people together, a SAWHON would allow sharing of protocols and experience. New innovations in sampling methodologies specific to northern environments, for example collection of blood for disease testing on filter papers(Curry *et al.*, 2011), can also be shared. Advanced analytic techniques may be required for disease modeling, spatial analysis, and multilevel modeling to correctly control for the hierarchical structure and dependencies of observations over time and space. With epidemiologists and biostatisticians as part of a SAWHON, common problems associated with arctic wildlife field sampling could be discussed and analytic methodologies shared.

A mechanism for consolidating and improving training and capacity building

Currently, most monitoring programs are based in southern academic or government institutions and this often leads to deficiencies in knowledge translation and implementation of recommendations. Increasingly, northern residents want to be involved in design, implementation and interpretation of research projects. Ideally, we should aim to build northern capacity and encourage the establishment of monitoring programs that are coordinated, designed and implemented in the North. A limitation of this process is that as the amount of northern research accelerates there are increasing demands on the few individuals in the communities. This results in a piecemeal approach with participating community members pulled in multiple directions and not always able to focus on improving their individual skills. Through collaboration across projects, efficiency of community engagement and training could be greatly improved and benefits to northerners optimized. For example, specific competencies, knowledge and skill sets that are needed across a variety of monitoring programs could be incorporated into formal training programs, thus producing highly qualified individuals with recognized skill sets which could be more broadly applied.

The diversity of a SAWHON would also benefit the next generation of scientists. SAWHON would provide rich transdisciplinary experiences and training opportunities for researchers and undergraduate and graduate students.

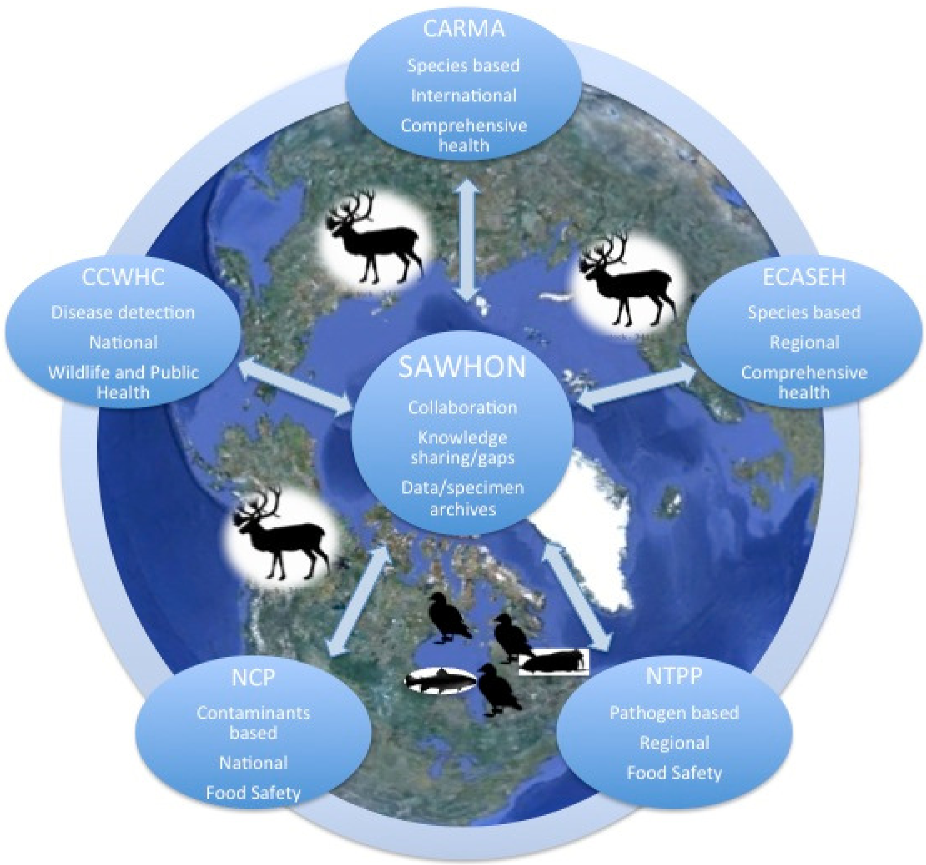
Effective communication of results

Communication of results to local stakeholders is as important as generating the results themselves. Wildlife health is of high concern to arctic residents for safe food consumption. For zoonotic diseases, rapid and accurate communication of health risks, and changes in risk, to these user groups first, is critical, and must be consistent with regional public health messaging and prevention measures. In cases with less urgency, reporting to communities can be coordinated among monitoring programs to concentrate community meetings and reduce research fatigue. A SAWHON may be able to improve effectiveness of communications both for zoonotic and non-zoonotic diseases by developing synergies in information technology and communication strategies.

An Arctic Wildlife Health Observation Network can provide guidance and mechanisms (and human resources) for centralized data storage, data access, and specimen archiving

One of the most important, and often the most neglected, considerations in any wildlife health observation and surveillance program is how data and specimens are stored longterm. In many programs data are stored in individual databases, are not publically accessible and may be lost when the data collector moves on. Similarly, specimens, once examined, are often discarded or inappropriately archived, and not available for future users. Individual researchers are around for a finite time, and it is therefore essential that data and specimens linked to the data are archived in a manner that allows long term access by the broader scientific and stakeholder communities. These databases and repositories could be centralized, regional, or project specific. A key role of a SAWHON would be to facilitate appropriate data and specimen archiving, sharing and access agreements, and retrieval.

Fig 1. Sustainable Arctic Wildlife Health Observation Network Schematic: In this conceptual diagram we illustrate the inter-relations among the SAWHON and other monitoring or research programs from Table 2. The SAWHON provides a forum for exchange of information, technology, and expertise, and an opportunity to coordinate sampling, consultations, training, and knowledge translation among a variety of programs. Theme (CCWHC, NCP, NTPP) and species (ECASEH, CARMA) specific programs can share access to specimens and data. For example, CARMA can contribute samples to NCP for contaminants testing, and abnormal tissues to CCWHC for disease testing. All programs are directly linked to the SAWHON, and may feed metadata and sampling methodologies to the Network, while the Network provides collaborative opportunities and support to ensure data and specimen archiving.



Conclusion

Healthy and sustainable wildlife populations are essential for healthy arctic ecosystems, and healthy northern human communities. Several different types of wildlife health monitoring programs are active around the Arctic. Although most of these are successful programs that contribute substantially to our understanding of animal health in a changing Arctic, there is room for improvement, synergies, and a role for a broader umbrella of a Sustainable Arctic Wildlife Health Observation Network. Such a network could provide an important forum for information and technology exchange, collaborations, and identification of information gaps at a circumarctic scale. A key role may be to evaluate the current scope of programs and identify critical gaps in themes (e.g., standardized monitoring impacts of industrial development on wildlife communities), species (e.g., few or no long term health monitoring programs for small-medium mammals etc.), and geographic coverage. Longterm sustainability for many programs may be lacking, particularly if the program was initiated with a specific research question, and a SAWHON may be able to provide support and leverage to continue such programs and/or make sure the data are not lost. A SAWHON would provide support to develop scientifically sound project designs including improved standardization of sampling methodologies within species and themes and across geographic regions, thus permitting broader comparisons and secondary uses of data and samples, and encouraging trans-disciplinarity. Support could also be available for advanced data analysis and interpretation. Furthermore, SAWHON could serve as a central body to facilitate safe and long term archiving and accessibility of valuable data and specimens and would also help identify potential secondary uses for data and specimens. The Circumarctic is experiencing unprecedented climate and landscape change which threatens the health of a broad range of wildlife species, and through this, the health of northerners who depend on wildlife for subsistence and income. A Sustainable Arctic Wildlife Health Observation Network will substantially improve our collective ability to effectively track the health and resilience of arctic species, develop science-based management and mitigation actions, and conserve health ecosystems in rapidly changing Arctic.

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