Sustaining Arctic Observing Networks (SAON) Canada, in partnership with the Canadian Polar Commission, is collaborating with the Association of Polar Early Career Scientists (APECS) to present results of monitoring efforts in the Canadian North, including the Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut.
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Edited by: Ann Balasubramaniam, PhD Candidate, University of Waterloo
LONG-TERM WARMING AND SEA ICE LOSS LEAD TO LARGE-SCALE REDUCTIONS IN ICE SHELVES ALONG ELLESMERE ISLAND

Summary

- Long-term atmospheric warming can lead to unexpected large-scale change in Arctic environments as freeze-thaw thresholds are crossed. Predictive models can underestimate such sporadic activity, requiring continuous monitoring of cryosphere and climate trends to fill in data gaps.

- While estimates have suggested that there will be a total loss of the Petersen Ice Shelf by the 2040s, the Laboratory for Cryospheric Research at the University of Ottawa has predicted that recent record calving events may accelerate this process.

- Atmospheric warming and reductions in multi-year sea ice are the two main processes leading to a ~61% loss of total area of the Petersen Ice Shelf along Ellesmere Island, Nunavut over the past decade alone.

- Understanding of glacier and ice shelf calving events is important for reducing collision risks for shipping and offshore oil development.

CONTEXT:

Ice shelves are unique features in the Canadian Arctic along the shores of Ellesmere Island north of 82ºN and can inhibit freshwater from mixing into marine waters. Long-term atmospheric warming since 1948 (+0.5ºC per decade), and rapid recent sea ice loss, has led to record ice shelf break-up and calving events in the last decade. For example, there has been a 61% loss in area\(^1\) of the Petersen Ice Shelf and a complete loss of the Ayles Ice Shelf since 2005\(^2\). Calving events can produce ice islands (very large icebergs), which can range up to hundreds of square kilometres in surface area. These floating ice features can pose a threat to offshore development and shipping.

Through the use of several long-term climate data analyses, Dr. Luke Copland’s Laboratory for Cryospheric Research at the University of Ottawa has demonstrated a relationship between these recent and sudden dramatic changes in ice shelf stability to historical warming trends.

\(^{1}\)Ice shelves” are permanent floating ice platforms that form where a glacier flows into the ocean and/or where very old sea ice accumulates to great thicknesses. In the Arctic they typically range in thickness from 50-100 m. In contrast, sea ice is formed by sea water and is generally less than 3 m thick.
RESULTS & IMPLICATIONS

Analysis of long-term climate records, aerial photography and satellite images (1959-2012) of the Petersen Ice Shelf along the northern coast of Ellesmere Island, NU, indicated that recent record ice calving events over the last decade occurred due to 1:

- Complete loss of supporting >50 year old landfast sea ice that stabilized the ice shelves and protected them from the impact of winds and waves from the open ocean;
- Long-term warming of surface air temperatures; and,
- Long-term reductions in upstream glacier input.

Future estimates suggest:

- Complete loss of the Petersen Ice Shelf by the 2040s, based on current rates of surface melt and glacier input, which will lead to continued large-scale calving of ice islands.
- However, this process may occur much sooner if the rapid and recent calving events in the last decade continue.

These results highlight how long-term warming can lead to sudden and rapid change in the Arctic, leading to record losses of ice shelves. Additionally, cascading losses may occur as the loss of multi-year landfast sea ice leads to the break-up of ice shelves, which in turn may lead to the loss of glaciers upstream 3. Thus, decreasing sea ice will likely accelerate losses of both ice shelves and glaciers.

POLICY LINKAGES:

- Long-term monitoring of Canadian ice shelves has documented accelerating melt trends and possible cascading effects between sea ice, ice shelf and glacier losses.
- Continued long-term monitoring of the Arctic cryosphere and climate trends is a necessity now more than ever, as rapid and sudden changes can occur.
- Understanding of glacier and ice shelf calving events is important for reducing collision risks for shipping and offshore oil development.

RESOURCES:


Author: Adam Houben, PhD Candidate, University of Ottawa
DIVERSITY AND DISTRIBUTION OF ARCTIC MARINE BENTHOS: IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

**Summary**

- Changes to the Arctic region associated with climate warming are revamping interest for industrial exploration of Canada’s Arctic marine waters and this has implications for the biodiversity of marine ecosystems.

- Monitoring of marine benthos in the Canadian Arctic by ArcticNet’s Marine Biological Hotspots project and the Canadian Healthy Oceans Network (CHONe) is providing important baseline datasets to improve fisheries management and support impact assessments of development initiatives.

- Results suggest that Arctic benthic biodiversity is more complex than previously hypothesized and generalization on large scales (100-1000 km) is not recommended.

- The Beaufort Shelf (depth <80-100m) is a hotspot for biodiversity and development planning should consider the impacts on large invertebrates, which are a fundamental component of the marine food web.

**CONTEXT:**

Benthic species are a fundamental component of marine ecosystems that sustain commercially relevant fish species through the food web and can be valuable themselves. Development and exploitation of Canada’s northern coast may pose a threat to Arctic benthic biodiversity (i.e., number of species, their identity and abundance), which has traditionally been considered to be poor, uniformly distributed and similarly affected by environmental conditions (e.g. temperature, depth, light) throughout the Arctic.

ArcticNet’s Marine Biological Hotspots project and Canadian Healthy Oceans Network (CHONe) conducted a joint multi-year (2007-2014) monitoring program to determine the diversity of marine benthic invertebrate fauna in the Canadian Beaufort Sea and understand which factors drive the abundance and distribution of benthic fauna in the Canadian Arctic (i.e., Mackenzie Delta, Beaufort Sea, Arctic Archipelago, and Baffin Bay). Research has been supported also by BP Exploration Operating Company Limited and Imperial Oil. Importantly, this research represents a significant contribution to the knowledge of marine ecosystems of the central and eastern Arctic since these areas are largely unmonitored.

**What is benthos?**

Benthos is the group of species that lives in close relationship with the seafloor. Benthic species include: algae, mobile (e.g. shrimps) and non-mobile (e.g. mussels) invertebrates and fish (e.g. turbot, halibut).
RESULTS & IMPLICATIONS

Results from an analysis in June 2014 of data obtained during campaigns in the Beaufort Sea (2009-2011)\(^3\) and the Canadian Arctic\(^4\) (2007-2011) indicated the following:

- Megafauna (invertebrates with body size >2mm) such as sea stars, brittle stars and crustaceans, prefer inhabiting the species rich shelf habitats located along the seafloor in regions shallower than 80-100m. The Beaufort Shelf and slope also host different megafauna species.\(^3\)
- Composition of benthic faunal communities can be highly variable between locations. Overall, the total number of rare species is greater than the total number of common species. Additionally, rare species can be found in abundance in selected benthic habitats.\(^3\)
- Benthic community composition was affected by varying meso (10-100 km) and local scale (<10 km) processes (e.g. water circulation, organic carbon sedimentation) and environmental factors (e.g. bottom substratum, amount of terrestrial nutrients inputs). Large scale (100-1000 km) processes are of secondary relevance.
- The Mackenzie Shelf emerges as a unique region where benthic communities are mainly influenced by riverine inputs.

These monitoring results demonstrate that the biodiversity of benthic fauna is more complex than previously hypothesized and that generalization of benthic communities’ composition at large scales is not recommended. Development activities occurring on the shelf such as industrial fishing and oil and gas exploration will impact megafauna populations which are a major component of the food web and may cause consequences for higher trophic level commercial species (e.g. fish and mammals). Additionally, the unique Mackenzie Shelf benthic community will likely be impacted by changes in water quality of the Mackenzie River. Consequently, particular attention is needed in the management of the Mackenzie River watershed.

The joint Marine Biological Hotspots and CHONe initiative has since ended and further data will be analyzed and published in years to come.

POLICY LINKAGES:
- Marine benthos form the basis of marine food webs, and monitoring their distribution and understanding their community structure can provide valuable information that can improve impact assessments and ensure the sustainable development and long-term availability of Arctic marine resources.
- Results highlight the need to extend coverage and enhance spatial resolution (i.e., to 10-100 km) of monitoring efforts through the Canadian Arctic.
- Results also highlight the Beaufort Shelf to be a hotspot of megafauna biodiversity. Attention is needed in this area in terms of measures to promote continued biodiversity in the face of increasing development.
RESOURCES:
LONG-TERM MONITORING ESSENTIAL TO UNDERSTANDING LINKS BETWEEN CLIMATE CHANGE AND TUNDRA WILDLIFE

Summary
- Clear long-term warming trends have been measured in Canada’s Arctic tundra, but how tundra species (plant and animal) will respond to climate warming is uncertain.

- To further understand the effects of climate warming on species at different trophic levels, a research group at Centre d’études nordiques at Université Laval and Université du Québec à Rimouski is engaged in a multi-decadal study on Bylot Island, Nunavut.

- Results have demonstrated that climate driven changes in snow dynamics and season length can cause varied responses among Arctic species, which can then cause cascading effects in the food web. These non-linear species responses, in combination with inter-annual variability, make it difficult to broadly identify the effects of climate warming on living organisms.

- In order to be able to assess species responses to climate warming, it is important to ensure monitoring and conservation efforts address a broad range of ecosystem components, rather than individual species, over long periods of time.

CONTEXT:
As the Arctic continues to warm at an amplified rate\(^1\), understanding the associated repercussions on wildlife populations, whose survival is often dependent on availability of niche habitats, becomes a pressing issue\(^2\). The fate of wildlife in the Arctic is a big question in the discussion of climate change and, as such, detailed field monitoring is critical to fully understand the effects of climate change on ecosystems.

Long-term Arctic studies that report clearly on the impacts of climate warming at multiple trophic levels are lacking. The inclusion of species from all levels of the food web is invaluable as the effects of climate warming on Arctic species may be indirect—first affecting food sources and eventually individual species\(^2\).

A research group at the Centre d’études nordiques at Université Laval and Université du Québec à Rimouski has been monitoring the responses to climate change of several Arctic vertebrates as well as primary producers, for up to 24 years. This type of long-term study is crucial for identifying trends and understanding the complex connections between Arctic wildlife and the changing environment.

Studying the complete food web is vital to comprehend the impacts of climate change on individual species as some impacts may be indirect.
RESULTS & IMPLICATIONS

A long-term study of vertebrates as well as of plants, or primary producers, conducted on Bylot Island, NU found a varied response to observed climate warming in this region over a span of up to two decades. This study indicates that:

- Spring and summer air temperatures are increasing and the winter season has shortened by 9 days in two decades. Average winter snow depth has increased by nearly 50% and snowmelt is occurring nearly 6 days earlier.
- Climate warming could negatively impact certain species and changes to lower food web species could have cascading effects on species further up the food web.
  - For example, very early snowmelt could lead to decreased growth of snow goose goslings as they hatch before their main food source—graminoid plants, are at their peak growth and highest nutrient content.
  - Also, if lemming populations were to decrease as a result of changes to snow cover, Arctic foxes, which are further up the food chain, would be impacted as they rely on lemmings as a primary food source.

These results demonstrate that plants, herbivores and predators respond differently to climate change in the Arctic tundra. While the specific reasons for divergent responses are unknown, it is possible that large inter-annual variability exists in these Arctic ecosystems and long-term trends are cloaked by annual fluctuations in populations. In order to obtain a comprehensive picture of the impacts of climate warming on a particular ecosystem, numerous ecosystem components, from plants to herbivores to predators, need to be included in a particular study. Additionally, while two decades is often considered a “long-term” data set, especially in the Arctic, it may not be long enough to identify strong trends in the data.

POLICY LINKAGES:

- Datasets such as this one from Bylot Island illustrate the need for conservation efforts that address a broad range of ecosystem components rather than individual species.
- This monitoring program demonstrates the importance of long-term monitoring in Arctic ecosystems.

RESOURCES:


Author: Silvie Harder, PhD Candidate, McGill University
DETERMINING POLAR BEAR POPULATION TRENDS IN M’CLINTOCK CHANNEL, NUNAVUT USING GENETIC MARK-RECAPTURE

Summary
- The M’Clintock Channel polar bear subpopulation was previously surveyed from 1998—2000, which indicated marked population declines, leading to a moratorium on hunting.

- To provide updated information regarding population viability, status and trends, a new 3-year survey using less invasive, genetic mark-recapture methods was initiated by the Government of Nunavut with local Hunter and Trapper Organizations in 2014.

- Biopsy results report success in sampling 127 of 155 observed polar bears and genetic assays. Upcoming field seasons (2015 and 2016) will provide data needed to estimate population dynamics and update total allowable catch.

- This new monitoring program can provide needed information to evaluate the current management plan and develop future management plans to promote a healthy polar bear population.

CONTEXT:
The last M’Clintock Channel (MC) polar bear subpopulation study (1998—2000) indicated a population decrease due to habitat changes\(^1\), human activity\(^1\) and/or overharvest\(^2\) and a moratorium was implemented to reduce total allowable harvest that continues today. Due to commitments under the MC polar bear memorandum of understanding and the desire of local communities to harvest more bears due to recent safety concerns, the Government of Nunavut initiated a new genetic mark-recapture survey in 2014 with Cambridge Bay, Gjoa Haven, and Taloyoak Hunter and Trapper Organizations to understand current population trends and status.

Previously, polar bear populations were surveyed through aerial mark-recapture, where bears were physically tagged via lip tattooing and ear tagging. In this monitoring program new methods are being used that do not involve physical capture, which was not always supported by Inuit communities; instead, DNA is isolated from biopsy dart samples to genetically “mark” each individual bear.

Biopsy darts are designed to collect small skin samples and fall to the ground upon impact, allowing for sample collection with minimal impacts on bears from physical handling.
This ongoing survey will lead to possible revisions of sustainable harvest rates in this area\(^3\), and determine the utility of genetic mark-recapture as a less invasive alternative to physical capture for any polar bear survey.

**RESULTS & IMPLICATIONS**
In September 2014, the Government of Nunavut released an interim report\(^4\) of the 2014 survey. The report indicated that:

- 155 polar bears (55% of the 1998–2000 population estimate) in 119 groups across all age classes and sexes were observed.
- Skin biopsy samples were collected from 127 bears from about 75-80% of the MC geographical area.
- MC bears appear well fed and exhibit high adult survivorship, which might be explained by male-biased harvests and low hunting pressure over the last 10 years.

While weather delays and logistical constraints limited sampling across the entire MC study area, these preliminary results indicate the success of the new sampling method. Numbers of individual bears and inferences on whether the population has increased or decreased await genetic results and subsequent survey sampling (in 2015 and 2016). Data will be available in 2017.

**POLICY LINKAGES:**
- This monitoring program is critical to evaluating the efficacy of the current polar bear management plan, and informing future management approaches.
- These new survey methods will provide frequent, updated data that decision-makers can use to inform total allowable harvests to promote the sustainable harvests of polar bears.

**RESOURCES:**
4. Please contact Eric Blair (Communications; eblair@gov.nu.ca) for more information and/or access to the report

Author: Pamela Wong, PhD Candidate, University of Toronto and Royal Ontario Museum
CIRCUMPOLAR WORKING GROUP ASSESSING EMERGING CLIMATE-SENSITIVE INFECTIONOUS DISEASES

Summary
- Occurrences of infectious diseases that can be transmitted between humans and animals are expected to increase as the Arctic warms.

- A Climate Change and Infectious Disease Working Group, with members from various public health and academic institutions from the circumpolar Arctic, was established in 2011 to assess the potential emergence and health impacts of such climate-sensitive infectious diseases.

- Several potential diseases that warrant increased monitoring efforts including Brucellosis, Toxoplasmosis, Trichinellosis, Echinococcosis and Botulism, have been identified and there is a need for more baseline information and surveillance systems to better understand the associated risks.

- Forthcoming results from the group will provide public health, wildlife and food security organizations with information necessary to better manage and communicate health risks.

CONTEXT:
Habitat range extensions of southern insects and animals into Arctic regions due to climate warming is expected to increase the prevalence of some climate-sensitive, zoonotic infectious diseases. This imposes an important health risk to Arctic residents who rely on subsistence hunting, fishing and gathering of food. The magnitude of human health risks associated with this expanding ecological range of pathogens has not been fully assessed.

“Azoonic” refers to a category of infectious diseases that can be transmitted between animals and humans either directly by wild or domestic animals or indirectly by water, soil, and insects.

A Climate Change and Infectious Disease Working Group was established in 2011 as part of the International Circumpolar Surveillance of Emerging Infectious Diseases (ICS) project of the Arctic Council’s Sustainable Development Working Group. The Climate Change and Infectious Disease Working Group includes members from academic and public health institutions including the Public Health Agency of Canada, and is working to assess the potential emergence and health impacts of climate sensitive infectious diseases. This includes identifying diseases that are likely to have the greatest health impact and associated collaborative surveillance and research activities including enhancing capacity to monitor their prevalence, and determining conditions that influence their transmission.
RESULTS & IMPLICATIONS
In September 2014, the working group published an article identifying some potential infectious diseases that warrant increased monitoring:

- Brucellosis, Toxoplasmosis, Trichinellosis, Echinococcosis and Botulism.

The need for more baseline information and more adequate surveillance systems was also noted in order to better understand risks to human and animal populations.

Forthcoming results from the group can be used to:

- Quantify risk levels in specific regions;
- Forecast health impacts and guide early detection; and
- Develop communication strategies and interventions.

POLICY LINKAGES:
Future activities of the Climate Change and Infectious Disease Working Group can assist organizations that have public health, wildlife or food security responsibilities in Arctic communities to better understand risks associated with climate-sensitive infectious diseases to human and animal populations. Key activities of the Working Group include:

- Enhancing community-based monitoring and surveillance of the zoonotic diseases;
- Determining baseline levels of infection by conducting prevalence surveys in both human and animals populations; and,
- Better quantifying the relationship between climate, weather and disease patterns.

RESOURCES:

Author: Kiley Daley, PhD Student, Dalhousie University