The Arctic: a virtual special issue of multidisciplinary research

Resources: The challenges of energy production and transportation

By Ramesh Singh, author of *Arctic Pipeline Planning* (Elsevier, 2013)

Ramesh Singh, MS, IEng, MWeldI (UK)

The growing need for energy to support human activities of the modern day requires that scientists and engineers are constantly a step ahead of the demand. The geologists are constantly scanning and exploring the earth, ocean, wind solar and nuclear options. The engineers are similarly challenged to produce designs for more efficient and less environmentally-damaging designs.

The need for exploration and development of energy resources in newer frontiers is paramount. The energy companies are eager to develop new fields for the production and to transport the produce to the rest of the consumers around the world. This is true even with the current downward movement of oil and gas prices.

This trend and need for newer fields for exploration is not limited to traditional hydrocarbons like oil and gas; the recent developments in alternative energy resources like wind, solar, ocean floor and ocean currents are in the same direction. Countries and companies are gigging and diving deeper – literally – and in more remote parts of the world to position themselves in a leading position in the field. The recent decision of Denmark and Greenland to explore uranium in their remote tundra is in same league: that is, to position themselves as uranium suppliers for nuclear energy production, achieve a status of uranium supplier nation and add capacities for nuclear power generation.

These forays into remote and difficult-to-work corners of the universe involve the frozen tundra, where thick layers of permafrost have their own challenges. In these environmental conditions, people and materials are put to extreme tests.

The challenge of design, construction and maintenance is more serious in the Arctic, especially because of the elements of its nature. The working conditions and the terrain are very unforgiving. With temperatures often reaching -74°F (-58.8^{o}C) and the wind chill, the common comparator of feeling at this temperature, is equivalent to instant ice-cream headache. The extreme cold limits the ability of man and machine. Movement is impaired, and reflectivity is reduced, raising the possibility of mistakes leading to accidents and mishaps that could cause injuries and even death.

The main characteristics of Arctic construction and transportation are determined by the features of climatic conditions of a given territory:

- Low radiation balance
- Summer average zero temperature
- Annual average subzero temperature
- Large areas of permafrost
- Wet lands and plenty of swamps in plains

The exploration facilities are extended over the frozen land mass and in frozen ocean, and the pipelines carrying oil

and gas traverse these challenging conditions.

The Arctic is beautiful and environmentally extremely sensitive and vulnerable; at the same time, it has huge resources that society will want to take advantage of.

The Arctic is beautiful and environmentally extremely sensitive and vulnerable; at the same time, it has huge resources that society will want to take advantage of. The resource exploration companies are nowadays highly aware of the possibility of environmental damage, extremely sensitive about it, and are firmly supervised, by both government regulatory authorities, interest groups, and members of general public.

The pioneering, work especially of oil transportation from the Arctic, was the 1,300-kilometer Trans-Alaska Pipeline, proposed about 40 years ago. This followed BP's discovery of 25 barrels of oil in Prudhoe Bay oil field near the Arctic Ocean coast in 1968. The pipeline was proposed to bring the exploitation to the people through a pipeline. Prior to its construction, only pipelines of short lengths had been constructed in places such as Siberia and close to Norman Wells on the Mackenzie River in Canada.

The typical challenges include the geotechnical problems, most of which are linked to the flow of water and heat. Some of the distinguishing challenges of working in an Arctic environment are the unique composition of the land and soil. Soil when frozen is very strong and can support large loads. On the other hand, if the fluid in a pipeline or process heat is conducted through to the soil, the frozen soil would thaw. If the thawing soil has a large ice content, it will turn into soft mud, which lacks the strength of the frozen soil and cannot support the same load as in frozen conditions; in fact, it can hardly support any load, resulting in the section of the construction and machinery sinking. The amount of ice in frozen soil varies enormously; this variation is not uniformly distributed even over quite short horizontal distances, and therefore the amount of sinking would also vary. As a result of sinking construction machinery, equipment and a pipeline in thawing soil, a structure might become severely bent, and in extreme cases might even buckle and crack.

The challenge is to protect the structure and its integrity from unstable soil. A majority of the sections of structures constructed in the Arctic region are constructed on pile supports. Associated with these engineering challenges are the environmental challenges to construct without disturbing the lives and native habitat of wildlife, and to protect the fragile ecosystems – for example, the reindeer or Caribou migration routes and the food resources of polar bears. The lifestyle of the native population also needs to be understood and preserved. Furthermore, marine life must also be protected, preserving habitat, migration routes and breeding areas.

Changing temperature can cause stresses that are normally not experienced in the warmer areas. The property of material to bear stress in such low temperature is a key point to consider.

The key factor for design for the Arctic would be lower temperature and materials' properties and behaviors under such conditions. Changing temperature can cause stresses that are normally not experienced in the warmer areas. The property of material to bear stress in such low temperature is a key point to consider.

With exploration and production of new resources, we have these and more reasons for in-depth research and understanding in the fields of materials, construction and maintenance procedures. This approach can make working in Arctic safe and profitable while preserving the pristine environment.

The Editor

Ramesh Singh is a consultant working as Senior Principal Engineer at Nadoi Management Inc. in Katy, Texas. He specializes in the management of materials, welding and corrosion. Singh has an MS degree in engineering management from California Coast University and has gained his basic metallurgical education from the Air Force

Technical Institute in India. He is a registered engineer with the British Engineering Council and a member of The Welding Institute in the UK.

He has authored several books, published articles in industry journal articles and presented papers.His Elsevier books include *Corrosion Control for Offshore Structures* (2014), *Arctic Pipeline Planning* (2013) and *Pipeline Integrity Handbook* (2013).

Articles

**The Extractive Industries and Society* 2 (1), 2015: C. Vestergaard "Greenland, Denmark and the pathway to uranium supplier status"

Building and Environment 81, 2014: M. Kotol, C. Rode, G. Clausen, T.R. Nielsen "Indoor environment in bedrooms in 79 Greenlandic households"

Building and Environment 46 (8), 2011: S.P. Bjarløv, P. Vladykova "The potential and need for energy saving in standard family detached and semi-detached wooden houses in arctic Greenland"

Reliability Engineering & System Safety 95 (8), 2010: X. Gao, J. Barabady, T. Markeset "An approach for prediction of petroleum production facility performance considering Arctic influence factors"

Reliability Engineering & System Safety 93 (3), 2008: M.A. Maes, M. Dann, M.M. Salama "Influence of grade on the reliability of corroding pipelines"

Building and Environment 42 (3), 2007: M. Khoukhi, H. Yoshino, J. Liu "The effect of the wind speed velocity on the stack pressure in medium-rise buildings in cold region of China"

**Proceedings of the Combustion Institute* 35 (3), 2015: H.F. Farahani, X. Shi, A. Simeoni, A.S. Rangwala "A study on burning of crude oil in ice cavities"

*Ocean Engineering*92, 2014: H.S. Kim, C.H. Ryu, K.D. Park, J. Lee "Development of estimation system of ice resistance with surface information of hull form"

Cold Regions Science and Technology 109, 2015: J.P. Wilkinson, T. Boyd, B. Hagen, T. Maksym, S. Pegau, C. Roman, H. Singh, L. Zabilansky "Detection and quantification of oil under sea ice: The view from below"

Safety Science 74, 2015: S. Kum, B. Sahin "A root cause analysis for Arctic Marine accidents from 1993 to 2011"

*Free access

> *The Arctic, long avoided as an unyielding frozen expanse or romanticized as an unspoilt paradise, is increasingly attracting attention from beyond its borders.*

These are the words of Prof. Philip Steinberg, Associate Editor of *Political Geography* and one of five editors of this virtual special issue on the Arctic. The issue was created to showcase and celebrate the growing body of research on Arctic issues and to stimulate discussion and broaden understanding across a wide range of disciplines, from geography to civil engineering, food sciences and environmental science.

Kay McArdle

Kay McArdle

The Arctic region is being studied with a sense of ever greater urgency today, as climate change effects become increasingly serious and better understood, and as new threats emerge. For ease of navigation, we have divided this collection of published Elsevier papers into four categories:

1. People — Life in the Arctic

2. Politics — Whose Arctic?

3. Resources — The challenges of energy production and transportation

4. Environment — Physical properties, Arctic warming, biodiversity and chemical contaminants

Under the headings below, you will find an introduction to each area by a journal editor, summarizing the papers and current debates. We hope these resources prove interesting and useful and give insight into new ideas and contributions normally restricted to specific disciplines. Selected articles are freely available to access for three months until the end of June 2015.

Please read on and discover what's happening in the Arctic Circle.

— Kay McArdle (@GPD_Publisher), Geography Planning and Development Publisher, Elsevier

People: Life in the Arctic

By Wolfgang Haider, PhD, and Ulrike Pröbstl-Haider, PhD, Co-Editors-in-Chief of the *Journal of Outdoor Recreation and Tourism*

Ulrike Pröbst-Haider, PhD

Wolfgang Haider, PhD

This collection of articles provides snapshots of some of the major issues confronting Artic livelihoods and people. In one form or another, each paper contributes to an emerging picture of the "New Arctic." The Arctic has been inhabited for millennia, yet modern society, dominated by Western ideas, usually perceives and portrays the Arctic as one of the final frontiers, to which the modern way of life has been introduced recently. Climate change further accelerates these changes, especially with ever more open access by sea routes (Doel *et al*, 2014). All papers in this collection provide evidence for the rapidly changing living conditions in the Arctic.

The New Arctic will not emerge along a simple trajectory of modernization. Instead, the dichotomy of traditional and modern will define the New Arctic in many ways, as traditional ways of life and traditional rights meet with modern technology and economic opportunities. The emerging New Arctic will be a combination of traditional livelihoods adapting to new opportunities, traditional society defining ancient rights in new ways, and the emergence of new economic sectors and employment opportunities. From that perspective, each of the eight articles contributes insights into this dynamic unfolding before us.

Two papers document very different examples of lesser known and understood types of traditional adaptation by indigenous people to the Arctic environment. Hidiroglou, *et al*(2008) report that samples of traditional food items collected across the Canadian Arctic contained significant amounts of water-soluble vitamins. Wilson (2014) explores the concept of indigenous water governance in one Alaskan community. This concept is so far not well understood, and certainly not adequately recognized by modern government. Yet, the definition and operationalization of indigenous governance, and asserting the associated sovereignty, has significant implications for communities across the North American Arctic.

Linking the small coastal communities across this vast region with each other and their respective service centers further south is a significant challenge. Freight services by shipping lines are one essential component. Brooks and Frost (2012) analyze shipping lines in Greenland, which is mostly serviced from Europe by one single company, while in Canada operations suffer from lack of investment and a piecemeal approach among the oligopoly of several companies.

In many peripheral areas in the world, tourism development is or will become a major economic factor.

In many peripheral areas in the world, tourism development is or will become a major economic factor and has even been described as the new staple economy (Gunton, 2003). Compared to other industries, tourism is supposed to create economic and social benefits in an ecologically and socially sustainable manner. However, given the fact that tourism in the Arctic is often based outdoors, and visitors travel to very remote and fragile places and communities, social and environmental issues can arise quickly. Furthermore, it is becoming clear by now that many Arctic regions will be especially vulnerable to climate change.

In this special issue, Ólafsdóttir and Runnström (2013) analyzed the ecological effects of increasing numbers of visitors in two popular hiking destinations in the interior highlands of Iceland. The increasing number of international visitors leads to increasing trail erosion, especially on the sensitive volcanic substrates of the island. A short hiking season in the summer further compounds the impacts. They suggest that such a high number of visitors can only be accommodated with a thorough monitoring program, combined with effective planning for the most vulnerable sections of trail, and management of the infrastructure.

In a study of another wilderness activity – canoeing – Grimwood *et al* (2015) suggest that this form of guided tour, combined with no trace travel, actually reinforces “post-colonial” perspectives, as the product is purely focused on nature and wilderness while ignoring the long traditions and modern adaptations of indigenous people to these environments. Consequently they advocate the adaptation of more sensitive norms towards local cultures in the development of images for these products.

Cruise ship tourism represents the other extreme of this industry – mass tourism. When cruise ships dock in remote Arctic communities, a clash of cultures is almost inevitable. Stewart *et al* (2011) undertook one of the few studies on the attitudes of residents in Arctic communities towards tourism. Their case studies in Pond Inlet and Cambridge Bay, both in Nunavut, Canada, show that the majority of residents have high expectations from tourism, although these attitudes are very heterogeneous and also depend on the type of tourism product. Therefore, the authors suggest that further case studies would be required before conclusions could be drawn on the effects of tourism on Arctic communities.

While climate change will definitely improve access to the Arctic and provide more days with moderate temperatures for visitors, Forland *et al* (2013) observe that long-term climate models for Northern Norway also predict more precipitation, which will not necessarily make the locations more attractive for visitors.

In summary, the New Arctic will become an economically more active region than it ever was before. In addition to resource extraction, nature-based tourism will be one major growth sector in the region and provide many opportunities for employment. The articles in this collection remind us that in order to derive benefits from tourism, especially for the residents and indigenous peoples of the Arctic, the tourism sector needs to be managed well.

The Editors

Dr. Wolfgang Haider is Co-Editor-in-Chief of the *Journal of Outdoor Recreation and Tourism*. He is Professor and Director of the School of Resource and Environmental Management at Simon Fraser University in Vancouver, Canada, and writes widely on the human dimensions in resource management.

Dr. Ulrike Pröbstl-Haider is Co-Editor-in-Chief of the *Journal of Outdoor Recreation and Tourism*. She is Professor of landscape development, recreation, tourism, and conservation planning at BOKU University of the Life Sciences in Vienna. She specializes in rural development and climate change.

Articles

*_Geoforum_ 57, 2014: N.J. Wilson "Indigenous water governance: Insights from the hydrosocial relations of the Koyukon Athabascan village of Ruby, Alaska"

*_Journal of Historical Geography_ 44, 2014: R. E. Doel, U. Wråkberg, S. Zeller "Science, Environment, and the New Arctic"

Research in Transportation Business & Management 4, 2012: M.R. Brooks, J.D. Frost "Providing freight services to remote arctic communities: Are there lessons for practitioners from services to Greenland and Canada's northeast?"

Journal of Outdoor Recreation and Tourism 3-4, 2013: R. Ólafsdóttira, M.C. Runnström "Assessing hiking trails condition in two popular tourist destinations in the Icelandic highlands"

Annals of Tourism Research 50, 2015: B.S.R. Grimwood, O. Yudina, M. Muldoon, J. Qiu "Responsibility in tourism: A discursive analysis"

Journal of Hospitality and Tourism Management 18 (1), 2011: E.J. Stewart, J. Dawson, D. Draper "Cruise Tourism and Residents in Arctic Canada: Development of a Resident Attitude Typology"

Tourism Management 36, 2013: E.J. Førland, J.Kr.S. Jacobsen, J.M. Denstadli, M. Lohmann, I. Hanssen-Bauer, H.O. Hygen, H. Tømmervik "Cool weather tourism under global warming: Comparing Arctic summer tourists" weather preferences with regional climate statistics and projections"

Journal of Food Composition and Analysis 21 (6), 2008: N. Hidiroglou, R.W. Peace, P. Jee, D. Leggee, H. Kuhnlein "Levels of folate, pyridoxine, niacin and riboflavin in traditional foods of Canadian Arctic Indigenous Peoples "

*Free Access

Politics: Whose Arctic?

By Phil Steinberg, PhD, Associate Editor of *Political Geography*

Philip Steinberg, PhD

The Arctic, long avoided as an unyielding frozen expanse or romanticized as an unspoilt paradise, is increasingly attracting attention from beyond its borders. Over the past decade, climate change and technological innovation, as well as relatively high oil and gas prices and relatively low geopolitical tension, have changed perceptions of the circumpolar north. Increasingly, Arctic residents and outsiders alike have come to appreciate the region as a site of *potential*. And where there is potential there is politics, as debates over who gets what take on a new urgency.

Notwithstanding this consensus of an emergent Arctic, there is little agreement about just what sort of potential – and hence what sort of politics – is solidifying as the ice melts. As Dittmer *et al* (2011) note in this section's lead article, narratives that posit a singular unitary trajectory for the region miss the complicated dynamics that drive political projects there. Images of the region as unformed and ripe for transformation are inspiring those who seek to develop new forms of politics in which the territorial interests of individual states are subsumed to principles of indigeneity, circumpolarity, or the global communities of corporations, scientists, or states (see, for instance, Bravo,

2009; Nicol, 2010; Numminen, 2010). However, these efforts to designate the Arctic as having a *different* sort of politics also mark it as ripe for affirmations of state power. Thus, the record of politics as actually practiced in the North frequently reaffirms a world in which the sovereign, territorial state is supreme (Dodds, 2010; Wegge, 2015).

Even if the long-term future of the Arctic can be predicted as one of increasingly normalized state power, the route toward this destination is sure to have numerous twists, turns, and diversions.

But even if the long-term future of the Arctic can be predicted as one of increasingly normalized state power, the route toward this destination is sure to have numerous twists, turns, and diversions. Even as state actors use performances of "flag-planting and finger-pointing" to place the Arctic within the realm of state authority (Dodds, 2010), these performances are themselves sites where meaning is contested (Steinberg, 2010). Likewise, the global debate over climate change, which so often underpins narratives of the region's 'opening', is not simply an arena for debating competencies of global governance. It also serves as a platform for an underlying contest regarding who can claim a voice as beneficiary, victim, agent, or interpreter of climate change (Bravo, 2009).

As Powell (2010) notes, our understanding of Arctic politics is often tainted by adherence to an ideal of "Arctic exceptionalism" wherein the Arctic is understood as a space *without* politics, or *beyond* politics. From this perspective, states use the Arctic to express antagonisms and alliances that are rooted elsewhere. Indigenous peoples, if they figure in the story at all, are pre-political victims, who merely react to externally-generated changes. And yet, as Powell asserts, the antidote to exceptionalism, wherein the Arctic is understood as an exemplary region wherein normative political dynamics unfold, is equally pernicious. If one considers the Arctic not as an "exception" but as a "case study" is one just trading one form of academic imperialism for another?

A key message, then, of Powell's piece, and of several of the other contributions as well, is that writing on the Arctic is invariably mediated. This mediation is all the more apparent when the author claims not academic objectivity but a journalist's insider knowledge. In her review of three semi-popular journalistic-style books on the politics of an emergent Arctic, Nyman (2012) finds that all too often journalists use new data to confirm old divisions, between "past" and "present," between "normal" and "exceptional," "West" and "East," "South" and "North," and even between academic disciplines. Nonetheless, she concludes, scholars looking for new perspectives for understanding Arctic politics can learn from this genre of writing where authors strive to fuse intimate understanding with critical distance. This is a goal to which we all can aspire as we follow the contributors to this virtual special issue in understanding the emergent politics of the circumpolar north.

The Editor

Dr. Philip Steinberg (@Philbey2) is Associate Editor of *Political Geography* and Professor of Political Geography at Durham University. He is Director of the university's Centre for Borders Research and coordinates the ICE LAW Project (the Project on Indeterminate and Changing Environments: Law, the Anthropocene, and the World).

Dr. Steinberg's research focuses on the projection of social power onto spaces whose geophysical and geographic characteristics make them resistant to state territorialisation – spaces that include the world-ocean, the universe of electronic communication, and the Arctic. He has published numerous books and articles. His most recent book is *Contesting the Arctic: Politics and Imaginaries in the Circumpolar North* (IB Tauris, 2015).

Articles

*_Political Geography_ 30 (4), 2011: J. Dittmer, S. Moisio, A. Ingram, K. Dodds "Have you heard the one about the disappearing ice? Recasting Arctic geopolitics"

*Political Geography*29 (2), 2010: K. Dodds "Flag planting and finger pointing: The Law of the Sea, the Arctic and the political geographies of the outer continental shelf"

Political Geography 29 (2), 2010 – Commentaries:

Journal of Historical Geography 35 (2), 2009: M.T. Bravo "Voices from the sea ice: the reception of climate impact narratives"

**Marine Policy* 51, 2015: N. Wegge "The emerging politics of the Arctic Ocean. Future management of the living marine resources"

*Political Geography*31 (6), 2012: E. Nyman "Understanding the Arctic: Three popular media views on the north"

*Free access

Environment: Physical properties, Arctic warming, biodiversity and chemical contaminants

Arctic warming is the major driver in a changing Arctic

By Robert Letcher, PhD, Review Editor of*Environment International*

The body of scientific evidence from recently published research in Elsevier journals tells a tale of a changing Arctic linked to unprecedented climatic warming. Over the past half century, the Arctic has warmed at about twice the global rate.

Robert Letcher, PhD

Robert Letcher, PhD

The dramatic decline in Arctic sea ice cover is anticipated to influence atmospheric temperatures and circulation patterns. These changes will affect the terrestrial climate beyond the boundary of the Arctic and consequently modulate terrestrial snow cover.

There is evidence that atmospheric water vapor, a greenhouse gas, has increased in the Arctic over the past several decades. The dramatic decline in Arctic sea ice cover is anticipated to influence atmospheric temperatures and circulation patterns. These changes will affect the terrestrial climate beyond the boundary of the Arctic and consequently modulate terrestrial snow cover. Snow depth, rather than snow cover, has a climatic memory that impacts hydrothermal processes during the following summer season. The strong reduction in Arctic sea ice anticipated in the future also suggests a potential long-range impact on Arctic snow cover. Ocean heat fluxes into the Arctic from the North Atlantic and North Pacific have also contributed to the Arctic warming through a reduction of sea ice. A study reconstructed the thawing of the permafrost in Arctic Siberia during the termination of the Little Ice Age, and the subsequent Recent Warming period, and defined increased permafrost thawing during the last 170 years. Also, the combined effects of ocean acidification and ultraviolet radiation were studied in kelps from Kongsfjorden (Svalbard) in order to assess their potential to thrive in a changing environment.

The additional challenges from changing Arctic conditions in relation to sea ice include impacts on biota. For example, hooded seals (*Cystophora cristata*) have been harvested for centuries in the North Atlantic. However, in the Greenland Sea whelping areas, predictions indicate an 8% decrease of the population over the next 10 years, with possible reasons for this negative trend including climate change and predation. Changes in the Arctic ecosystem and the reliance of indigenous people on marine mammals for subsistence makes urgent the need for a comprehensive marine mammal health monitoring program linked to regional ocean observing systems. An Arctic-focused Marine Mammal Health Map framework has recently been described and would support a more holistic understanding of climate change impacts to ocean ecosystems, and aid in the prioritization of management to

mitigate impacts to marine mammals.

With declining sea ice conditions in Arctic regions owing to changing climate, the large prospective reservoirs of oil and gas in places like Baffin Bay and Davis Strait in the Canadian Arctic are increasingly accessible, and the interest in offshore exploration and shipping through accessible Arctic regions has increased. Both of these activities are associated with the risk of hydrocarbon releases into the marine ecosystem. Hydrocarbon concentrations in sediment cores collected from northern Baffin Bay indicated that petrogenic sources dominate over combustion sources, and thus long-range atmospheric transport is less significant than inputs from weathering. With decreased Arctic ice due to global warming, the polar sailing route will be open for greater periods of the year. This is likely to increase the pollution load on the pristine Arctic due to large vessel traffic from specific contaminant groups, such as polycyclic aromatic hydrocarbons (PAHs). Furthermore, a well-documented baseline for PAH concentrations in the biota in the remote Arctic regions is generally limited. PAH levels were found to be low in blue mussels (*Mytilus edulis*) from the remote Arctic sites, which indicated limited impacts on the environment.

Systematic monitoring of persistent organic pollutants (POPs) in the Arctic has been conducted for several years. A new study summarized the empirical evidence that is currently available of those new compounds in the Arctic that are not commonly included in chemical monitoring programmes. In another study, global emissions were quantified for emerging Arctic POPs, per- and poly-fluoroalkyl substances (PFASs), during the life-cycle of products. Global annual emissions of PFASs steadily increased in the period 1951-2002, followed by a decrease and another increase from 2002-2012. Atmospheric Mercury (Hg) Depletion Events (AMDEs) occur in Arctic and Antarctic regions during polar sunrise. In one study, Hg and halogens were measured in lichens hanging in tree branches around Hudson Bay (Canada) where AMDEs were reported. The latitudinal Hg gradient observed in lake sediments suggested that AMDEs were active in the Hudson Bay area during the last 90 to 200 years. Another study reported that given that changes in climate will impact ecosystems, it is plausible that these climate variables are important in explaining beluga Hg trends.

There remains a dearth of data on true POP exposure related, cause-effect relationships in Arctic wildlife and fish. Indications of co-exposure effects are largely based on correlations between biomarker endpoints (e.g., biochemical processes related to the immune and endocrine system, pathological changes in tissues and reproduction and development) and tissue residue levels of POPs. In connection with Arctic warming, other factors affecting POPs include seasonal ice changes, food web changes, nutrition, disease and species invasion.

One study assessed the relationship between climatic oscillations, POPs and the modelling of wildlife physiological and morphological responses. Examples of responses were bone mineral density (BMD) and body size, where both have decreased in East Greenland polar bear males over the past 120 years. Some POPs were reported in Svalbard polar bears to influence thyroid hormone levels and potentially act via mechanisms on the hypothalamic–pituitary–thyroid (HPT) axis. Temporal trends of POPs in arctic foxes (*Vulpes lagopus*) from Svalbard showed a relationship to feeding habits and seasonal food availability. The results suggested that climate-related changes in diet are likely to influence contaminant (POP) concentrations and patterns in Arctic biota. Changes in Hg exposure as well have been reported to be impacting the health of specific fish or wildlife populations in the Arctic. Marine top predators exhibit recent concentrations of Hg in their tissues and organs that are believed to exceed thresholds for biological effects. Toothed whales appear to be one of the most vulnerable groups, with high concentrations of Hg recorded in brain tissue with associated signs of neurochemical effects.

It is clear from the body of recently published evidence that changes are occurring in all compartments in the Arctic environment ...

It is clear from the body of recently published evidence that changes are occurring in all compartments in the Arctic environment, whether it be physical properties, biodiversity, or anthropogenic or natural chemical contaminants. These changes are happening at rates or in ways that are considered abnormal and with consistent linkages to Arctic warming. Despite the growing body of findings, there is consistent reiteration of the knowledge gaps that remain, and thus more research is required.

The Editor

Dr. Robert Letcher is Review Editor of *Environment International* and Senior Research Scientist in the Ecotoxicology and Wildlife Health Division of the Science and Technology Branch of Environment Canada. He heads a research laboratory and a staff and student group at the Carleton University in Ottawa as Associate Coordinator of the Ottawa-Carleton University Chemical and Environmental Toxicology Program. His research focuses on the environmental chemistry and (eco)toxicology of legacy and emerging contaminants, e.g., in top predator and trophic level wildlife and their aquatic food webs/ecosystems.

Dr. Letcher has authored over 250 peer-reviewed research publications as well as review papers and book chapters. One of his recent publications is "Comparative hepatic in vitro depletion and metabolite formation of major perfluorooctane sulfonate precursors in polar bear, ringed seal and beluga whale"(*Chemosphere*, 2014). Last year, Thomson-Reuters named Dr. Letcher to its "*World's Most Influential Scientific Minds in 2014.*"

Articles

a) Physical properties of the Arctic

*Marine Policy*50(A), 2014: M. Knol, P. Arbo " Oil spill response in the Arctic: Norwegian experiences and future perspectives"

Renewable and Sustainable Energy Reviews 31, 2014: O. Salo, S. Syri "What economic support is needed for Arctic offshore wind power?"

Biological Conservation 172, 2014: T.A. Øigård, T. Haug, K.T. Nilssen "Current status of hooded seals in the Greenland Sea. Victims of climate change and predation?"

*Ecological Indicators*34, 2013: C. Sonne, T.Ø. Bechshøft, F.F. Rigét, H.J. Baagøe, A. Hedayat, M. Andersen, J.-E. Bech-Jensen, L. Hyldstrup, R.J. Letcher, R. Dietz "Size and density of East Greenland polar bear (Ursus maritimus) skulls: Valuable bio-indicators of environmental changes?"

Quaternary Science Reviews 79, 2013: S.T. Belt, J. Müller "The Arctic sea ice biomarker IP25: a review of current understanding, recommendations for future research and applications in palaeo sea ice reconstructions"

Polar Science 7 (2), 2013: H. Park, J.E. Walsh, Y. Kim, T. Nakai, T. Ohata " The role of declining Arctic sea ice in recent decreasing terrestrial Arctic snow depths"

Marine Pollution Bulletin 87 (1-2), 2014: A. Mjelde, K. Martinsen, M. Eide, Ø. Endresen " Environmental accounting for Arctic shipping – A framework building on ship tracking data from satellites"

Deep Sea Research Part II: Topical Studies in Oceanography 102, 2014: E.S. Hersh, D.R. Maidment "Extending Hydrologic Information Systems to accommodate Arctic marine observations data"

Ocean & Coastal Management 102 (Part A), 2014: S.E. Moore, F.M.D. Gulland " Linking marine mammal and ocean health in the 'New Normal' arctic"

Science of The Total Environment 506-507, 2015: K.L. Foster, G.A. Stern, J. Carrie, J.N.-L. Bailey, P.M. Outridge, H. Sanei, R.W. Macdonald "Spatial, temporal, and source variations of hydrocarbons in marine sediments from Baffin Bay, Eastern Canadian Arctic"

*Free Access

b) Environment: Arctic warming and impacts

Journal of Plant Physiology 173, 2015: F.J.L. Gordillo, J. Aguilera, C. Wiencke, C. Jiménez " Ocean acidification modulates the response of two Arctic kelps to ultraviolet radiation"

Soil Biology and Biochemistry 68, 2014: M.E. Brummell, R.E. Farrell, S.P. Hardy, S.D. Siciliano "Greenhouse gas production and consumption in High Arctic deserts"

**Global and Planetary Change* 117, 2014: J.E. Walsh "Intensified warming of the Arctic: Causes and impacts on middle latitudes"

Global and Planetary Change 98–99, 2012: A.P. Fedotov, M.A. Phedorin, I.V. Enushchenko, K.E. Vershinin, M.S. Melgunov, T.V. Khodzher"A reconstruction of the thawing of the permafrost during the last 170 years on the Taimyr Peninsula (East Siberia, Russia)"

Deep Sea Research Part I: Oceanographic Research Papers, 58 (2), 2011: Benjamin Rabe, M. Karcher, U. Schauer, J.M. Toole, R.A. Krishfield, S. Pisarev, F. Kauker, R. Gerdes, T. Kikuchi "An assessment of Arctic Ocean freshwater content changes from the 1990s to the 2006–2008 period"

Ocean Modelling 40 (2), 2011: H. Zuo, R.I. Mugford, K. Haines, G.C. Smith " Assimilation impacts on Arctic Ocean circulation, heat and freshwater budgets"

*Free Access

c) Environment: biota, ecosystems and biodiversity

International Journal for Parasitology: Parasites and Wildlife 3 (2), 2014: S.J. Kutz, E.P. Hoberg, P.K. Molnár, A. Dobson, G.G. Verocai: "A walk on the tundra: Host–parasite interactions in an extreme environment "

Marine Policy 44, 2014: R.R. Reeves, P.J. Ewins, S. Agbayani, M.P. Heide-Jørgensen, K.M. Kovacs, C. Lydersen, R. Suydam, W. Elliott, G. Polet, Y. van Dijk, R. Blijleven "Distribution of endemic cetaceans in relation to hydrocarbon development and commercial shipping in a warming Arctic"

Environmental Research 137, 2015: C. Sonne, M. Dyck, F.F. Rigét, J.-E. Beck Jensen, L. Hyldstrup, R.J. Letcher, K. Gustavson, M.T.P. Gilbert, R. Dietz "Penile density and globally used chemicals in Canadian and Greenland polar bears"

*Free Access

d) Environment: chemical contaminants and stressors in a changing Arctic

Chemosphere 119, 2015: Y. Maa, Z. Xie, C. Halsall, A. Möller, H. Yang, G. Zhong, M. Cai, R. Ebinghaus " The spatial distribution of organochlorine pesticides and halogenated flame retardants in the surface sediments of an Arctic fjord: The influence of ocean currents vs.glacial runoff"

*Science of The Total Environment*506–507, 2015: M. Pućko, G.A. Stern, R.W. Macdonald, L.M. Jantunen, T.F. Bidleman, F. Wong, D.G. Barber, S. Rysgaard "The delivery of organic contaminants to the Arctic food web: Why sea ice matters"

Environment International 70, 2014: Z. Wang, I.T. Cousins, M. Scheringer, R.C. Buck, K. Hungerbühler "Global emission inventories for C4–C14 perfluoroalkyl carboxylic acid (PFCA) homologues from 1951 to 2030, Part I: production and emissions from quantifiable sources"

Science of The Total Environment 493, 2014: H.Ó. Jörundsdóttir, S. Jensen, K. Hylland, T.F. Holth, H. Gunnlaugsdóttir, J. Svavarsson, Á. Ólafsdóttir, H. El-Taliawy, F. Rigét, J. Strand, E. Nyberg, A. Bignert, K.S. Hoydal, H.P. Halldórsson "Pristine Arctic: Background mapping of PAHs, PAH metabolites and inorganic trace elements in the North-Atlantic Arctic and sub-Arctic coastal environment"

Chemosphere 111, 2014: K. Vorkamp, F.F. Rigét "A review of new and current-use contaminants in the Arctic environment: Evidence of long-range transport and indications of bioaccumulation"

**Science of The Total Environment* 509–510, 2015: A. Scheuhammer, B. Braune, H.M. Chan, H. Frouin, A. Krey, R. Letcher, L. Loseto, M. Noël, S. Ostertag, P. Ross, M. Wayland "Recent progress on our understanding of the biological effects of mercury in fish and wildlife in the Canadian Arctic"

Chemico-Biological Interactions 206 (2), 2013: J. Kleinteich, S.A. Wood, J. Puddick, D. Schleheck, F.C. Küpper, D. Dietrich "Potent toxins in Arctic environments – Presence of saxitoxins and an unusual microcystin variant in Arctic freshwater ecosystems"

Science of The Total Environment 443 (15), 2013: R. Dietz, C. Sonne, N. Basu, B. Braune, T. O'Hara, R.J. Letcher, T. Scheuhammer, M. Andersen, C. Andreasen, D. Andriashek, G. Asmund, A. Aubail, H. Baagøe, E.W. Born, H.M. Chan, A.E. Derocher, P. Grandjean, K. Knott, M. Kirkegaard, A. Krey, N. Lunn, F. Messier, M. Obbard, M.T. Olsen, S. Ostertag, E. Peacock, A. Renzoni, F.F. Rigét, J.U. Skaare, G. Stern, I. Stirling "What are the toxicological effects of mercury in Arctic biota?"

Environment International 37 (4), 2011: G.D. Villanger, B.M. Jenssen, R.R. Fjeldberg, R.J. Letcher, D.C.G. Muir, M. Kirkegaard, C. Sonne, R. Dietz "Exposure to mixtures of organohalogen contaminants and associative interactions with thyroid hormones in East Greenland polar bears (Ursus maritimus)"

Environment International 37 (4), 2011: L.S. Haug, S. Huber, G. Becher, C. Thomsen "Characterisation of human exposure pathways to perfluorinated compounds — Comparing exposure estimates with biomarkers of exposure"

Atmospheric Environment 44 (35), 2010: J. Carignan, J. Sonke " The effect of atmospheric mercury depletion events on the net deposition flux around Hudson Bay, Canada"

Science of The Total Environment 408 (15), 2010: R.J. Letcher, J.O. Bustnes, R. Dietz, B.M. Jenssen, E.H. Jørgensen, C. Sonne, J. Verreault, M.M. Vijayan, G.W. Gabrielsen "Exposure and effects assessment of persistent organohalogen contaminants in arctic wildlife and fish"

Science of The Total Environment 509-510, 2015: B. Braune, J. Chételat, M. Amyot, T. Brown, M. Clayden, M. Evans, A. Fisk, A. Gaden, C. Girard, A. Hare, J. Kirk, I. Lehnherr, R. Letcher, L. Loseto, R. Macdonald, E. Mann, B. McMeans, D. Muir, N. O'Driscoll, A. Poulain, K. Reimer, G. Stern " Mercury in the marine environment of the Canadian Arctic: Review of recent findings "

Science of The Total Environment 511, 2015: M.S. Andersen, E. Fuglei, M. König, I. Lipasti, Å.Ø. Pedersen, A. Polder, N.G. Yoccoz, H. Routti "Levels and temporal trends of persistent organic pollutants (POPs) in arctic foxes (Vulpes lagopus) from Svalbard in relation to dietary habits and food availability"

Science of The Total Environment Volumes 509–510, 2015: A. Steffen, I. Lehnherr, A. Cole, P. Ariya, A. Dastoor, D. Durnford, J. Kirk, M. Pilote "Atmospheric mercury in the Canadian Arctic. Part I: A review of recent field measurements"

Science of The Total Environment Volumes 509–510, 2015: L.L. Loseto, G.A. Stern, R.W. Macdonald "Distant drivers or local signals: Where do mercury trends in western Arctic belugas originate?"

*Free Access