

ABSTRACTS TROMSØ NORWAY 20-24 JANUARY

# 2014 ARCTIC FRONTIERS

HUMANS IN THE ARCTIC

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# Arctic Frontiers 2014

## *Conference Main Partners*

- Troms County
- ConocoPhillips
- Akvaplan-niva
- The Research Council of Norway
- The Norwegian Barents Secretariat
- The University of Tromsø
- Institute of Marine Research
- SpareBank 1 Nord-Norge
- SINTEF
- ICE - Centre for Ice, Climate and Ecosystems, Norwegian Polar Institute
- NORUT - Northern Research Institute
- University of the Arctic
- FRAM - High North Research Centre for Climate and the Environment
- ARCTOS - The Arctic Marine Ecosystem Research Network
- Arctic Net
- APECS – Association of Polar Early Career Scientists
- Tromsø municipality
- Norwegian Ministry of Foreign Affairs
- UNIS

## *Steering Committee*

- Salve Dahle (Chair), Director, Akvaplan-niva;
- Secretary: Ole Øvretveit, Akvaplan-niva;
- Anne Husebekk, Rector, University of Tromsø;
- Ivan C. Burkow, Director, Northern Research Institute;
- Ole Lindefjeld, Research Director, ConocoPhillips;
- Kirsten Broch-Mathiesen, Department leader, Research Council of Norway;
- Rune Rafaelsen, Director, Barents Secretariat;
- Lars Otto Reiersen, Secretary, Arctic Assessment and Monitoring Programme;
- Alf Håkon Hoel, Institute of Marine Research;
- Paul Wassmann, Leader, ARCTOS;
- Jan Gunnar Winther, Director, Norwegian Polar Institute;
- Marina Kalinina, Deputy Vice-Rector of International Cooperation, Northern Arctic Federal University (NArFU) and Steering Committee member representing the University of the Arctic (UArctic);
- Are Johnsen, CEO Framsenderet;
- Stig-Arne Engen, Director communication SpareBank 1 Nord-Norge
- Gunnar Sand, Project Director, SINTEF.
- Ivan C. Burkow, Director, Northern Research Institute
- Ole Arve Midsund, Director, UNIS

- Nils Arne Masvie, Vice President, DNV
- Gerlis Fugman, Director, APECS
- Pål Brekke, Senior Advisor, Norwegian Space Centre

### *Advisory Board*

- Hans Corell, Ambassador (ret.), Former Under-Secretary-General for Legal Affairs and the Legal Counsel of the United Nations, Sweden;
- Martin Fortier, Executive Director, ArcticNet Inc., Canada;
- Priscilla Wohl, The Northern Forum, Alaska, USA;
- Bente Aasjord, Norwegian Union of Municipal and General Employees, Norway;

### *Science conference organizers*

Matias Langgaard Madsen, Akvaplan-niva AS

Salve Dahle, Akvaplan-niva AS

Ole Øvretveit, Akvaplan-niva AS

### *Scientific committees*

Live, work and stay healthy in the Arctic

- Leader: Professor Torkjel Tveita (Convener), University of Tromsø & University Hospital of North Norway, Norway
- Professor Jon Øyvind Odland (Convener), AMAP & University of Tromsø, Norway
- Professor Anne Husebekk, University of Tromsø, Norway
- Dr Valery Chashchin, Northwest Public Health Research Centre, Russia
- Marney Paradis, APECS, Simon Fraser University, Canada
- Professor Gary Sieck, Mayo Clinic Rochester, USA
- Executive Director Martin Fortier, Arctic Net, Canada
- Professor Hannu Rintamäki, Finnish Institute of Occupational Health, Physical Work Capacity team. Institute of Biomedicine, Department of Physiology, University of Oulu, Finland

Health & environment in the Arctic

- **Leader:** Executive Secretary Lars-Otto Reiersen (Convener), AMAP & ArcRisk, Norway
- Research manager Anita Evenset, Akvaplan-Niva & The Fram Centre, Norway
- Professor Michael Depledge, European Centre for Environment and Human Health, UK
- Professor Ian Cousins, University of Stockholm & ArcRisk, Sweden
- Vice President of Research John Munthe, Swedish Environmental Research Institute & ArcRisk, Sweden

- Deputy Executive Secretary Janet Pawlak, AMAP & ArcRisk, Norway
- Professor Jozef Pacyna, Norwegian Institute of Air Research & ArcRisk, Norway
- Research Development Manager Dan Bloomfield, Met Office, UK
- Research professor Arja Rautio, University of Oulu & ArcRisk, Finland
- Deputy Executive Secretary Simon Wilson, AMAP & ArcRisk, Netherlands
- Frigga Kruse, APECS & Arctic Centre, University of Groningen, Netherlands
- Professor Crispin Halsall, Lancaster Environment Centre, Lancaster University, UK

### Shipping & offshore in the Arctic

- Leader: Professor Tor Einar Berg (Convener), Marintek/SINTEF, Norway
- Tor Husjord, Maritimt Forum/Norwegian Shipowner Association, Norway
- Eija Kanto, Wegia Enviro Oy, Finland
- Managing Director Østen Mortvedt, Troms Offshore, Norway
- Professor Egil Pedersen, University of Tromsø, Norway
- Senior advisor Gunnar Sander, Fram Centre, Flagship Polhav, Norway
- Senior advisor John Evensen, Kystverket, Norway
- Manager Frigg Jørgensen, AECO, Norway
- Mia Bennett, APECS & University of Cambridge, UK

### Arctic search and rescue (SAR)

- Leader: Program manager Erik Dyrkoren (Convener), Maritim 21, Norway
- Tor-Are Vaskinn, Fiskebåt, Norway
- Vice director Nils Arne Masvie, DNV, Norway
- Professor Odd Jarl Borch, University of Bodø, Norway
- Senior advisor Kjell Røang, The Research Council of Norway, Norway
- Research Associate Dr. Nataly Marchenko, The University Centre in Svalbard (UNIS), Svalbard
- Research Engineer Riikka Matala, Aker Arctic, Finland
- Senior Legal Adviser Svana Margrét Davíðsdóttir, Ministry of the Interior, Iceland
- Piotr Graczyk, APECS & University of Tromsø, Norway

## *Convenors*

### Live, work and stay healthy in the Arctic

- Professor Torkjel Tveita, University of Tromsø & University Hospital of North Norway, Norway

### Health & environment in the Arctic

- Executive Secretary Lars-Otto Reiersen, AMAP & ArcRisk, Norway

### Shipping & offshore in the Arctic

- Professor Tor Einar Berg, Marintek/SINTEF, Norway

Arctic search and rescue (SAR)

- Program manager Erik Dyrkoren, Maritim 21, Norway

## *Introduction*

The 8th Arctic Frontiers conference,

### **Humans in the Arctic,**

will address two main themes: I) Health, Society and Environment, and II) Offshore Maritime Challenges.

Theme I explores how living conditions for humans inhabiting the Arctic are being influenced by changing climate, migration and industrial and business development. What will the cumulative effect of these changes be on human health, wellbeing and working conditions, and what will the effect be at a societal level?

Theme II addresses the fact that increasing business and recreation activities in the Arctic will require a strong maritime sector. Arctic Frontiers calls for discussion on how the main challenges connected to offshore and shipping activities can be met, including the need for a more extensive search and rescue system.

#### Health, society and environment

The environment of the Arctic is changing, and this affects the conditions for humans living in the Arctic for better and for worse. Climate change will lead to less ice and permafrost and thus, increased tourism, fishing, petroleum activities and mining. These activities in the High North will give opportunities and impact socio-economy, demography and traditional lifestyle as well as increase contamination and disturb the natural environment. The cumulative impact may affect life, wellbeing, culture and ultimately the health of people living in the region. Healthy adaption to the changes must be planned. The latest advances in technology and innovative communication are potentially very effective tools with which to reduce risk related to living and working in the Arctic and also maximize the benefits, thus ensuring sustainable development. How can this be done? Arctic Frontiers 2014 will address the scientific challenges ahead.

#### Maritime operational challenges

The growth in offshore petroleum activities in the Arctic and the renewed interest in cargo transport north of the American and Eurasian continents require improved or new logistic and transport solutions, better guidance to ships and an extended emergency response service including Search and Rescue (SAR). This is also the case for increasing tourism and fishery activities in the Arctic. A wide range of challenges are facing the operations

due to the extreme distances, climatic and weather conditions, as well as winter darkness. Low temperatures, summer fog, long distances to shore-based resources require a robust communication infrastructure, new warning systems, survival kits, lifesaving equipment, rescue units and operating procedures. The aim of the conference is to discuss these arctic challenges, and to present innovative and viable solutions in order to reduce risk, build resilience and secure commercial operations.

The science conference will kick off with a half-day of keynote addresses, and then split into four parallel parts where these issues are discussed in greater detail.

## ***Structure of conference***

To discuss these major questions there is a need for solid scientific evidence and documentation. This is why the policy section and the scientific section of the *Arctic Frontiers Conference* are organised back to back. The scientific presentations will serve as a knowledge base for the discussions during the policy section. To elucidate major opportunities and challenges for future development within the Arctic region, four research themes have been chosen. These themes will be presented during four parallel sessions of the science section of the conference:

- Live, work and stay healthy in the Arctic
- Health & environment in the Arctic
- Shipping & offshore in the Arctic
- Arctic search and rescue (SAR)

To further bridge between the first two days of politics and the following three days of science, and also to link between the four different research parts, Arctic Frontiers has invited one key note speaker from each of the four parts to give a popularised presentation. These presentations will be given in a plenary session on Wednesday January 22<sup>th</sup> and will be moderated by the science section conveners, Torkjel Tveita, Lars-Otto Reiersen, Tor Einar Berg and Erik Dyrkoren.

## ***Plenary keynote presentations***

- Michael Tipton - Occupational Health in the North: dealing with cold injury and cold immersion
- Arja Rautio - Changing Arctic - Challenge for Human Health
- Aldo Chircop - Regimes in Transition: Regulating International Navigation and Shipping in the Arctic
- Ásgrímur L. Ásgrímsson - The need for search and rescue hubs in the Arctic

## *Four parallel sessions*

### *Live, work and stay healthy in the Arctic*

The scientific committee of Part 1 is proud to present a variety of high level scientific presentations from Arctic human health. The topics are from clinical care, emergency medicine, prehospital care, public health, epidemiology, and more methodology related issues in this scarcely populated area of the world. Even if we are few people, we have many excellent scientists, especially among the young people. This conference is a unique opportunity to present the best people, and bring the best people together, to create new networks and discuss new ideas. The Arctic University of Tromsø wants to play an important role in all health research and public health issues for the next generation of the Arctic. We are proud to present our Russian neighbours, based on a 25 years collaboration with a growing quality and quantity of projects and publications. Even so, all eight Arctic countries have common challenges, still with a lot of health inequality to be solved. So, please sit down, listen, and give your critical appraisal to the best of all Arctic health research in the years to come.

### *Health & environment in the Arctic*

This part addresses contaminants and their associated health outcomes in human residents, including indigenous peoples, in the Arctic as well as in selected areas in Europe, Russia, and North America. It also addresses the potential influence of climate change on future exposures to environmental contaminants. Many of the presentations report results from the EU FP7 project ArcRisk (Arctic Health Risks: Impacts on Health in the Arctic and Europe owing to climate-induced changes in contaminant cycling), for which this session serves as the final conference.

The session includes presentations on the long-range transport of contaminants to the Arctic via the atmosphere and oceans and the results of model projections of the influence of climate change on this transport and ultimate levels of legacy contaminants in Arctic environmental media. Uptake of contaminants into Arctic biota and their transfer through food chains as well as the potential influence of climate change on these processes are also considered, giving an indication of future changes in human dietary exposures to contaminants via traditional Arctic foods. The results of a number of studies to try to relate human health outcomes to contaminant exposures and body burdens in Arctic residents, and also some comparison areas in Europe, will also be presented. Each sub-session contains a mix of presentations on these topics to provide a broad overview of results.

Sessions:

Overview of environmental contaminant exposures and health outcomes

This session explores the key drivers of marine dispersion of persistent pollutants (POPs) in the Arctic and the influence of climate change on contaminant exposure in various environmental media, including on the bioaccumulation of contaminants in Arctic food



webs. Human exposures to persistent organic pollutants in Arctic and comparison populations and associated health effects are reported.

Trends of POPs and mercury in the environment and humans and their effects

This session reports on temporal trends of POPs in the atmosphere and the possible influence of climate change as well as geographical trends of POPs on Greenland. It also considers a case study on PCBs in a changing Arctic, from input to ultimate exposure of humans. A perspective is given on the communication of health risks from contaminants is given, together with successful results of dietary recommendations in the Faroe Islands. Comparisons of human burdens of POPs in Mediterranean populations and their health outcomes are also provided.

Distribution of environmental contaminants in the Arctic and human exposures

The potential influence of climate change on long-range transport and environmental distribution of POPs and mercury in the Arctic will be considered. New results on POPs in the Canadian Arctic will be presented and the influence of on-going climate change, including the loss of sea ice, in the Arctic on the environmental distribution of contaminants will be described. A case study on mercury in a changing Arctic will be presented and results of studies of POPs in relation to cancer and human fertility will be provided.

Sub-session 4 – Arctic contaminant occurrence and effects in a changing Arctic

Additional results of the atmospheric transport of POPs to the Arctic under climate change will be considered. The session will also present results of studies of perfluoroalkyl substances in the Arctic environment and a human population and the results of a retrospective study of past exposure to mercury in a sub-Arctic population. The session will end with a synthesis of the results of the ArcRisk project.

## ***Shipping & offshore in the Arctic***

This part addresses specific aspects of regulation and technology for shipping and offshore activities in Arctic waters. There is an increasing interest for cargo ships using present and future polar shipping routes (Northeast Passage-Northern Sea Route, Northwest Passage and Transpolar Sea Route) as well as exploring offshore oil and gas resources. The safety and environmental challenges following the increasing activity have lead governments and international organizations like IMO to revise their regulatory frameworks. New technologies for design and operation of vessels, offshore units and supporting services are needed to meet new requirements. Conversely, the ambitions and content of new regulations will be influenced by the performance of available technologies and the related costs.

The session discusses how the additional safety risks and special environmental challenges present during operations in polar waters can be addressed. Presentations will analyze international and national rules and regulations for operation in Arctic waters and

options for further developments. Safety challenges related to sea ice and other Arctic factors will be explored together with state of the art and further development needs in sea ice observations, risk assessment and improved communication technologies. Environmental aspects of maritime operations will be presented, focusing on emissions to air, aquatic noise and marine invasive species. This part is divided into seven sub sessions:

- Technological challenges and IMO Polar Code
- Observational systems for sea ice
- Risk assessment
- Arctic shipping and vessel design
- Environmental aspects
- Communication
- National regulations and policies on shipping
- Arctic search and rescue (SAR)

Maritime activities in Arctic waters are on the rise. This is due an increase in cruise traffic, the development of new oil and gas fields, extraction and export of minerals as well as an increase in destination and transit transport of goods. Changing ice conditions open new regions that give way for even more commercial activity. The combination of increased activity and challenging environmental conditions such as severe weather, fog, cold temperatures, darkness and huge distances, call for additional capacity and tailor-made resources for effective search and rescue operations in these areas. The main question is: what level of search and rescue capability shall each Arctic nation reach for, and what does it take to achieve that level?

### *Arctic search and rescue (SAR)*

This part of the Arctic Frontiers conference will address these challenges in three themes; each provided with an invited speaker. The themes covered are:

Session 1: Future Activities – New Needs, New Methods, New Technologies

This session will draw a broad picture of SAR requirements with respect to industrial development in the Arctic as well as the planned support functions and preparedness from the governmental side.

Session 2: Covering the distance – being there on time

In this session we will hear how traffic surveillance and remotely operated aircrafts can be utilized to compensate for the enormous distances that have to be covered in the Arctic.

Session 3: Organization, cooperation, and mutual aid

The discretionary nature of rescue operations, and possibly trans-boundary character – like accidental oil spills – require that people and technologies work together on short notice, over great distances, across borders, and on tasks that very seldom are needed. This requires planning, organization and international cooperation. In several countries,

the government is evaluating the institutional platform for their search and rescue organizations, implementing organizational improvements among others as to cooperation among institutions to meet the new challenges in the North. In this session we will hear more about some initiatives for masterplans and multilateral cooperation.

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## Keynote presentations

### Science conference opening by

**Dr. Martin Fortier,  
Executive Director ArcticNet, Canada**

### Moderators

**Professor Torkjel Tveita  
University of Tromsø & University Hospital of North Norway, Norway**

**Executive Secretary Lars-Otto Reiersen  
AMAP & ArcRisk, Norway**

**Professor Tor Einar Berg  
Marintek/SINTEF, Norway**

**Program manager Erik Dyrkoren  
Maritim 21, Norway**



# **Occupational Health in the North: dealing with cold injury and cold immersion**

Mike Tipton

Extreme Environments Laboratory Department of Sport & Exercise Science  
University of Portsmouth, Portsmouth, UK

As the recent cold weather in North America has again demonstrated, cold can represent a severe threat to life, particularly in those who are unaccustomed to dealing with it, but also to those with experience. Many individuals with years of experience of working and playing in cold environments acquire cold injuries.

The primary threats associated with operating in a cold air environment remain freezing and non-freezing cold injury and, to a lesser extent, hypothermia. The lack of knowledge surrounding the pathophysiology and diagnosis of non-freezing cold injury can cause problems for those employing people who work in the cold as well as the employees. The major threats associated with cold water immersion are drowning, cardiac problems and hypothermia. It is now believed that cardiac problems are a greater risk than once thought on submersion and in other cold-related scenarios.

In his presentation, Professor Tipton will briefly describe the current knowledge relating to the hazardous responses associated with exposure to cold air and water. He will outline ways of minimising the risk of injury through assessment of the environment and the selection, preparation and protection of those entering cold environments. Professor Tipton will end with a few comments on the search and rescue of cold casualties.

## Acknowledgement

This presentation is dedicated to the memory of Surgeon Rear Admiral Frank Golden OBE. Royal Navy and Consultant advisor in physiology to the University of Portsmouth (1936-2014).

## References

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2. Tipton, M. J. (2005) Environmental Factors. Chapter in: ABC of Sports Medicine, Oxford University Press (2014 Edition in press).
3. Shattock, M & Tipton, M. J. (2012) "Autonomic conflict": a different way to die on immersion in cold water? *Journal of Physiology*. 5, 590: 3219-30.

# Changing Arctic - Challenge for Human Health

Arja Rautio

University of Oulu, Oulu, Finland

Human health and wellbeing are not equal among the populations living in the different countries and regions across the circumpolar North. Especially indigenous people in some regions still have poorer health status compared to the majority populations in the Arctic countries. Globalization and climate change are big challenges for living conditions of rural and urban communities. Among emerging threats for human health and well-being are the effects of warming climate (resulting in worsening food and water insecurity; changes in the pattern of infectious diseases, and impact on health care infrastructure) and mental health problems including suicide, accidents and domestic violence. There exist already several monitoring programs, joint educational and research projects and networks, which will support the efforts for good life in the changing Arctic. Multidisciplinary research projects, like ArcRisk, are important when estimating future health risks. Collaboration between authorities, research communities, and local people are needed when improving health, subjective well-being and quality of life.

# **Regimes in Transition: Regulating International Navigation and Shipping in the Arctic**

Aldo Chircop

Dalhousie University, Halifax, Nova Scotia, Canada

The history of international maritime regulation demonstrates that major milestones in maritime regulation have frequently followed in the wake of major technological developments and accidents. While on the one hand the maritime and resource industries are opening new economic opportunities in the Arctic, their activities are outpacing the development of appropriate regulatory regimes. There is reason to be concerned because of a wide range of risks. Large areas of navigable Arctic waters are remote and cannot be easily serviced (e.g., for provision of salvage and search and rescue), have few if any navigation aids poor communications access, may not be adequately charted or have charts that are not up to date, among other constraints and risks. Side by side the development of appropriate regulatory regimes is the need to develop the maritime infrastructure. Much of the international regime for safe, secure and environmentally acceptable navigation was developed for marine environments that pose different operational conditions and risks. While current international regulatory initiatives aim to be proactive, in reality there have already been several groundings, collisions, pollution, and search and rescue incidents involving vessels of various sizes that can be ascribed to maritime safety failures.

The address discusses the current work of the International Maritime Organization (IMO), Arctic Council and Comité Maritime International, among others, in their attempts to scale-up standards and services for polar navigation. The efforts of Canada and the Russian Federation, the only two coastal States in the region with polar-specific regulation of navigation and shipping, are also addressed. The approaches to international and national regulatory efforts raise interesting questions regarding policy priorities, perceptions of risk, modes of distributing risk (using public and private law approaches), costs as compared to perceived benefits, the role of technology, the limitations of national regulation, and the need for regional and global cooperation. The address concludes with the message that, despite the extensive current regulatory effort, maritime safety and marine environmental regulation will remain unfinished business and that the IMO and Arctic coastal States will need to work on harmonization and continually review standards in response to changing perceptions of risk, technological and commercial change, and lessons learned from navigational incidents.



# **The need for search and rescue hubs in the Arctic**

Ásgrímur Lárus Ásgrímsson

Icelandic Coast Guard, Reykjavík, Iceland

The Arctic is a remote area where suitable facilities are few for staging of a large scale search and rescue or environmental operation can be done from. Suitable locations will have to be identified and built up in the future with respect to gathering and servicing rescue units, personnel, lodging, capacity of medical care, triage, mass transportation of patients and survivors and other factors as activity increases in this part of the world. Iceland is a suitable location for such a frontier as personnel and equipment may be flown both from North America and Europe in few hours and facilities are available for a large and long ranging operation. The exercise SAREX 2012 and 2013 have put this to a test and reviled the necessity of operation hubs in the remote Arctic.

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## Live, work and stay healthy in the Arctic

### Scientific committee

Leader:

Professor **Torkjel Tveita** (Convener), University of Tromsø & University Hospital of North Norway, Norway

Professor **Jon Øyvind Odland** (Convener), AMAP & University of Tromsø, Norway

Dr **Valery Chashchin**, Northwest Public Health Research Centre, Russia

**Marney Paradis**, APECS, Simon Fraser University, Canada

Professor **Gary Sieck**, Mayo Clinic Rochester, USA

Executive Director **Martin Fortier**, Arctic Net, Canada

Professor **Hannu Rintamäki**, Finnish Institute of Occupational Health, Physical Work Capacity team. Institute of Biomedicine, Department of Physiology, University of Oulu, Finland

# Work and well-being in cold

Hannu Rintamäki<sup>1,2</sup>

***<sup>1</sup>Finnish Institute of Occupational Health, Oulu, Finland, <sup>2</sup>Institute of Biomedicine, Department of Physiology, University of Oulu, Oulu, Finland***

Good body heat balance is one of the basic requisites for human well-being, performance and health. As a part of the everyday life it may be unrecognized or considered as an unavoidable stress factor. However, the components of human body heat balance can be analyzed in details and the possible problems in heat balance or local skin temperatures can be solved accordingly. Humans need fairly high temperature in the microclimate, the nearest thermal surrounding, starting from 27°C at rest and lowering from that when physical activity increases. According to the definition, cold work starts at 10°C, when the extremities start to cool in light physical work. The three basic factors affecting human heat balance in cold are environmental cold strain (especially low temperature and wind), thermal insulation of clothing and physical activity (metabolic heat production). Environmental cold strain can be assessed by wind chill index and the need for thermal insulation in a given environment and work level can be assessed by IREQ (Insulation Required, ISO 11079) which serves also as an indicator of cold stress. The need of thermal protection of extremities (hands and feet) has to be assessed separately. When there is need to touch cold surfaces, ISO 1732-3 gives guidelines for risk assessment. In addition to adequate clothing, sustainment of good body heat balance in cold usually requires certain level of physical activity, as otherwise the need for the thermal insulation of clothing becomes so high that the clothing would be impractically bulky for work. When core temperature exceeds 37.6°C (corresponding to moderate physical work, ca. 50 % of maximal aerobic capacity), the cold induced vasoconstriction usually decreases and the peripheral body parts start to warm up. Due to several factors in cold, the lowering of ambient temperature by 1°C increases the daily energy expenditure by ca. 1%. Cooling causes thermal discomfort and impairs manual, neuromuscular and psychomotor performance and hence the productivity and increases the risks for accidents. Therefore, adequate cold protection by clothing, physical activity, auxiliary heaters, shelters, selection of suitable tools, development of working habits and use efficient recovery periods is always profitable.

# **Treatment of severe cold trauma in the coldest region of the world.**

Mikhael Innokentevich Tomsy

***Yakutia Research Center for Complex Medical Problems SB RAM.,  
Yakutsk, Sakha Republic, Russia***

The presentation will be given focusing on the advanced treatment of cold trauma in the coldest region of the world, The Sakha Republic. During a period of almost 50 years professor Alekseev has developed new principles of treatment of severe cold trauma. The PhD presented by professor Alekseev «The clinical characteristics, treatment of the hands cold trauma in Northern regions» was defended in Aktubinsk, Russia, 1973. The last couple of years approximately 125 papers are published in Russian and international peer reviewed journals with focus on the most severe extremity trauma of people who are below 30°C at the starting time of the treatment. The success rate is up to 90 % for saving of life and limbs, using the special principles developed during Alekseevs period in the Research Institute of Yakutsk. The results and principles behind them will be described in detail during the Invited presentation.

# The challenge of cardiovascular disease in Russia

David Leon<sup>1,2</sup>

***<sup>1</sup>London School of Hygiene & Tropical Medicine, London, Norway,***

***<sup>2</sup>Department of Community Medicine, University of Tromsø, Tromsø, Norway***

Cardiovascular disease mortality rates in Russia are the highest in the world, explaining much of the very substantial difference in life expectancy between Russia and countries such as Norway and the UK. The reasons for this excess are not fully understood, although they include issues to do with lifestyle (smoking and heavy alcohol drinking in men), diet and the effectiveness of medical interventions. This presentation will outline some of the unusual features of cardiovascular disease in Russia that suggest that aspects of it may differ from that seen in many other industrialised countries. It will then describe a major new international research project starting in 2014 that will compare the nature of cardiovascular disease in Russia with that in Norway and other countries. Its aim is to improve our understanding of this serious health problem and in so doing provide a better evidence base for reducing the high burden of cardiovascular disease in Russia.

# **Advancing Life Saving further: Improving the Chain of Survival from the Village to the Hospital in remote areas**

Mads Gilbert<sup>1,2</sup>

***<sup>1</sup>Division of Emergency Medical Services, University Hospital of North Norway, Tromsø, Norway, <sup>2</sup>Department of Clinical Medicine, The Arctic University of Norway., Tromsø, Norway***

A significant fraction of the global burden of disease represents emergency medical situations such as acute cardiovascular diseases and trauma, where time is a critical factor for mortality as well as morbidity. A well-developed system with pre-planned interaction between lay people, local community medical resources (basic ambulances, community health workers), advanced logistical resources (ground and air ambulance systems), and well prepared emergency hospital services, can reverse a large number of otherwise life-threatening conditions, save lives and reduce morbidity. "Buying time" to expand the window of physiological opportunity is the core metaphor when building efficient and cost-effective emergency medical systems (EMS). Time, momentum and lives are lost if development of a reliable prehospital EMS is not given priority also in rural areas, or if focus remains on increasingly sophisticated, expensive urban hospital systems. Understanding underlying pathophysiology and time constraint is mandatory to build efficient prehospital emergency systems over long distances with often unreliable weather and light conditions such as in the sub-Arctic. In our rich part of the world, comprehensive emergency medical care is considered an indicator of a human healthcare system. A good healthcare system would provide all citizens access to such care on a 24-hour basis regardless of your address, age, gender, race, individual social status and economic power. With narrow "windows of opportunities", we need well prepared 7/24/365-organized pre- and intrahospital "chains-of-survival", if favorable patient's outcomes are to be achieved. In sparsely populated rural areas, such as sub-arctic North-Norway this requires efficient logistics as well as a trained population, robust public emergency phone numbers, a qualified medical dispatch system and decentralized medical staff, health care facilities and local emergency hospitals. North Norway has about 250,000 inhabitants; of the total land territory, but only 9,5% of the population, yielding 4,2 inhabitants/km<sup>2</sup> compared to the national average of 15,5. We have systematically combined a strategy of decentralized education, training and certification of ambulance paramedics and local GPs with advanced medical equipment to the village level - and highly sophisticated communication systems with a dense network of public air ambulance bases. This system is medically driven. Increasing wilderness tourism and our long and rugged coastline with extensive pelagic as well as coastal fisheries pose additional challenges to the medical preparedness, as does the increasing offshore drilling and maritime transportation of

petrochemicals. The current land-based medical preparedness is not developed to match the risks and requirements of the increasing oil activities in our region.

# Medical Support in Kara Sea: Implementing Innovative Solutions

Bruno Sicard<sup>1</sup>, Frédéric Marouzé<sup>2</sup>, Thomas Pouget<sup>3</sup>, Sylvain Bussery<sup>1</sup>, Pierre Julien Valli<sup>1</sup>, Anne Sailliol<sup>3</sup>

**<sup>1</sup>PMSm, Aix en Provence, France, <sup>2</sup>CGG, Massy, France, <sup>3</sup>CTSA, Clamart, France**

The authors were involved in the planning and implementing innovative mitigation measures to cope with challenging medevac conditions during a maritime survey mission conducted in Arctic Area during summer 2013. It was assessed that in the worst case scenario, up to 5 days might be necessary for a patient to reach the nearest ashore medical facility from the deployment area in Kara Sea.

To reduce medical risks for the seafarers, related to this extreme remoteness, and to limit unnecessary medevac, carrying its own risks, the standard of quality of care was upgraded through the following medical support diagnostic and therapeutic devices and process:

Medical imaging (mobile X-Ray and portable ultrasonography) and mobile laboratory equipment was added, while the level of skills, training, and qualification of the medical team was build up to match the expected medical challenges and to properly use these medical devices not usually found in the Oil and Gas environment.

Fresh whole blood transfusion was implemented, including volunteers' blood screening and informed consent, training and drills for the medical providers.

Deployment of Lyophilized Plasma, produced by French Military Blood Transfusion Center, for the first time outside NATO military environment.

Costs/benefits of these medical upgrades to support a seismic crew are discussed by the authors, illustrated by the lessons learned from this deployment in Kara Sea, including specific medical facility requirements to integrate new equipment, training, and experience requested from the medical providers, regulatory and litigation aspects related to contingency blood management.



# Capacity Building through Health Research and Education.

Gert Mulvad

***Greenland Center for Health Research, University of Greenland, Nuuk, Greenland***

What are the main challenges to addressing critical shortages of health professionals (nurses, doctors, etc.) in Arctic communities?

Capacity building through Health Research and Education is of importance to reach the challenges.

Specialist Education for Medical Doctors in Greenland as General Practice have been a possibility through the last decade and have shown its importance for capacity building in the Health Care Services.

Greenland Center for Health Research was established in 2008 and connected to University of Greenland in 2013.

The vision for the Center is to improve the health status in Greenland through initiation and coordination of health research.

Through increasing coordination among research institutions.

Develop, exchange, disseminate and apply scientific knowledge.

Create national and international networks.

Build local capacity through mentoring and PhD programs.

Improve community involvement and local partnerships.

Greenland Center for Health Research focuses on network between Universities in the Arctic Region.

The mission of the Network on Health and Well-being in the Arctic is to improve the sustainable development of health and wellbeing in circumpolar regions by promoting research projects on health people, and by organizing research training and by distributing scientific information.

The main task of the network is to increase the quantity and quality of scientific research carried out at the circumpolar area by the means of the graduate school and the international Master and PhD programs for Circumpolar Health and Wellbeing.

The program focuses on health and wellbeing of the residents of the circumpolar region, health culture and the delivery of health care and wellbeing services in the North.

# Occupational exposure and airway symptoms in the North Norwegian red king crab industry

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## Introduction

Fishing and processing of the red king crab along the coast in the most northern part of Norway has increased in the last 10 years. The crabs are delivered to land based processing factories in Finnmark County. Workers in the seafood industry are commonly exposed to bioaerosols; aerosols containing particles of biological origin. Increased prevalence of general and work related respiratory symptoms have been described in previous studies done on seafood processing workers. In Canada and Alaska, crab processing has been associated with occupational health problems such as asthma and asthma-like symptoms.

## Objectives

The main aim of this project is to characterize occupational exposure to bioaerosols and the prevalence of general and work related respiratory symptoms among workers in the Norwegian red king crab industry.

## Methods

Personal air samplers collected bioaerosols produced during king crab processing activities. Workers as well as a non -exposed control group answered questionnaires about their general health and respiratory symptoms they experienced at work. The air samples were analyzed for total proteins, allergens and endotoxins. The questionnaire

results were compared to the non-exposed control group to see if king crab workers reported more work related respiratory symptoms.

## Results

Total protein, allergens and endotoxins were found in all samples collected in the factories. Studies in other occupational settings have reported a connection between exposure to these agents and airway symptoms. The levels of exposure in our samples were higher than in most other studies in the seafood industry. Questionnaire results showed a higher prevalence of respiratory symptoms during work compared to a non-exposed control group.

## Conclusions

The workers are exposed to biologic active agents in the bioaerosol during processing of king crab. They also report a higher prevalence of respiratory symptoms than non exposed workers.

# Clothing challenges – working environment in Arctic climate (some results from the cold wear project)

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**<sup>1</sup>Statoil asa, Stavanger, Norway, <sup>2</sup>SINTEF, Trondheim, Norway**

Oil and gas exploration are expanding into the Barents Sea and the High North. The cold and harsh climate represents a challenge to operational safety, human performance, occupational health and comfort. Development in design solutions like remote controls and shielding of weather exposed workplaces can reduce the need for outdoor operations. However, enclosure of areas have limitations because they can increase the explosion loads or complicate material handling. Outdoor human work will therefore still be needed in normal operations and sometimes during extreme weather conditions.

Progress in smart clothing materials and instrumentation offers great potential for clothing that can significantly improve working conditions.

The purpose of the ColdWear project (2008-2012) was to create the knowledge and scientific background for developing new clothing solutions that enable an increase in performance and safety of operations in the High North. The project was an outcome of a multidisciplinary strategic initiative in SINTEF, SmartWear, including co-operation between work physiology, design, material science and sensor technology. The ColdWear project addressed the fundamental mechanisms of how the interaction between environmental exposure, clothing, work load, and physiological regulatory system affects the worker. Furthermore, the project included studies on textile performance and how to integrate sensors in clothing to improve user safety without reducing comfort and performance.

One part of the project focused on Work in the cold, with special focus on petroleum workers in the Northern Regions. On site measurements were performed at the Statoil Melkøya LNG facility and questionnaire surveys were done at several offshore installations. The studies revealed that the clothing assembly used by e.g. Statoil have improvement possibilities that can be used by the industry for new developments. The field tests shows that there are special need for focus on the protection of the extremities; hand, feet and head, and on better learning programs and clothing recommendations related to working in cold climate.

A staff of ten researchers, two PhD students and seven master students at NTNU and SINTEF was involved in the project. Workers and HSE staff in Statoil contributed with onsite user experience and suggestions for development.

The project was financed by the Norwegian Research Council and the KMB partners; Statoil, Total E&P Norway, Swix Sport, Kwintet AS, Janusfabrikken AS.

# Assessing Unconventional HSE risks in the Arctic

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**<sup>1</sup>TOTAL SA, Pau, France, <sup>2</sup>TOTAL SA, Paris La Défense, France**

The Arctic is known to exhibit harsh environmental conditions for people living or working in this area. One of the responsibilities for companies operating in this perimeter is to ensure that all risks have been correctly assessed, and that prevention and protection measures have been adopted to reduce these risks at an "acceptable" level, for the environment, the populations, and the workforce. This is in particular the case for occupational health and safety risks. Risks usually discussed for workers in the Arctic are: extreme low temperatures and wind chill, slips, trips and falls, polar lows, icing and snow falls, and darkness in winter time. However, very little is known about possible exposure to other kinds of risks which appear to be specific to the Arctic.

Such risks, called in this study "unconventional health and safety risks", have been analysed and classified into two main groups: anthropogenic and natural risks. The former are mostly related to long-range transport of contaminants such as persistent organic pollutants and heavy metals, anthropogenic radioactivity and tropospheric ozone. Natural risks cover a rather wide range of topics such as: geomagnetic storms, electrostatic fields, UV radiations / albedo, naturally occurring radon, atmospheric pressure and oxygen content, biological or circadian cycles' perturbations and gas hydrates occurrence.

This paper shows some preliminary risk evaluation results, based on literature data recovery and analysis. Geographical information system has been used to map some of the contaminants occurrence from measurements in various substrates (atmosphere, soils, rivers, marine, fauna, flora, humans), with regards to likelihood of possible impact for operational sites. Consequences are analysed in terms of environmental pollution and human health impact. Some safety issues as well as possible impact of climate change for some of the risks treated are also discussed. For each of the potential risks analysed, some mitigation measures tracks for further operational or medical recommendations are proposed. The latter could also lead to possible recommendations at the international level, either in terms of environmental monitoring or human health exposure regulation. Current limitations of the study and gaps to be filled are also discussed. In particular, updated and additional data as well as contaminants transport modelling are necessary to move forward on the subject.

# **Understanding workers' health in the Russian mining towns of the Barents Euro-Arctic Region**

Andrian Vlakhov

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The study is based on the fieldwork conducted by author in the towns of Kostomuksha (Republic of Karelia), Nickel and Zapolyarny (Murmansk oblast). One of the main features of the environmental discourse is the public health. While the mining industry makes the plants workers prosperous, it also affects their health, causing a wide range of judgments to emerge. Since the plant workers are men for their most part, the discourse is for the most part about the male health. Main motives are the decrease of the lifespan and the development of the various diseases. Nearly all the informants repeat the same words about the lifespan of 50 years for the male plants workers and about their emasculation after several years at the plant. These narratives, as it often happens, do not correspond with the plants statistics and the position of the plant officials, causing the official and the unofficial discourse to come into conflict. The aim of the talk is to present the notions of two different sides of the debate, illustrating them by the quotes from the interviews, and to explore the possible origins of such controversy. I suggest approaching it from the perspective of the Russian stereotypes about men and their health, which are being put into Arctic conditions and under industrial environmental impact. The official position seems to be blindly transferring the standard stereotypic image of the strong worker to the very special conditions of Arctic mining plant; the grass-roots position of the workers and their families has its basis in the modern environmental discourse borrowed from the West. The base differs, the results differ: it happens that two sides of the argument have different ideas, aims and words, causing the conflict between two different health perceptions to emerge. The possible solution is the adoption of the unified discourse framework that would be acceptable for both sides.

# **Mechanisms Responsible For Myocardial Dysfunction Following Hypothermia/Rewarming**

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Rewarming patients suffering from profound hypothermia (14-19°C) may result in acute heart failure and high mortality (50-80%). However, underlying pathophysiological mechanisms are largely unknown. We characterized cardiac contractile function in the temperature range of 15-30°C by measuring intracellular Ca<sup>2+</sup> concentration ([Ca<sup>2+</sup>]<sub>i</sub>) and twitch force in intact left ventricular (LV) rat papillary muscles. Muscle preparations were loaded with Fura-2 AM and electrically stimulated during cooling at 15°C for 1.5h before rewarming to baseline temperature at 30°C. Following hypothermia/rewarming, peak twitch force decreased by 30-40%, but [Ca<sup>2+</sup>]<sub>i</sub> was not significantly altered. In addition, we assessed maximal Ca<sup>2+</sup>-activated force (F<sub>max</sub>), and Ca<sup>2+</sup> sensitivity of force in skinned papillary muscle fibers. F<sub>max</sub> was decreased by ~30%, whereas the pCa required for 50% of F<sub>max</sub> (pCa<sub>50</sub>) was reduced by ~0.14. In rewarmed papillary muscle, both total cTnI phosphorylation and protein kinase A (PKA)-mediated cTnI phosphorylation at Ser23/24 were significantly increased compared to controls. We conclude that following hypothermia/rewarming, myocardial contractility is significantly reduced as evidenced by reduced twitch force and F<sub>max</sub>. Reduced myocardial contractility is attributed to a decrease in Ca<sup>2+</sup> sensitivity of force rather than reduced [Ca<sup>2+</sup>]<sub>i</sub> itself, resulting from increased cTnI phosphorylation at Ser23/24.



# **Long-distance commuting among petroleum workers in the Russian Far North: their perceptions of labor conditions**

Gertrude Eilmsteiner-Saxinger

***University of Vienna, Vienna, Austria***

Since the 1980s, and especially over the last two decades, long-distance commute work (LDC) has become increasingly important for the provision of workforce in the oil industry in the Russian North. Resource exploitation, which is occurring in areas ever more remote from urban agglomerations, demands increasing mobility and consequently a multi-local lifestyle. Furthermore, LDC is cheaper than recruiting from among the local population along with expanding resource communities. This makes LDC attractive for the industry that is involved in the dynamics of a globalized neo-liberal market economy. This paper discusses contemporary labor conditions in the oil industry in the remote Russian Sub-arctic, while looking back at the Soviet era legacy, and attempt to explain the perceptions of employees today on their working conditions. The quality of labor conditions is variously perceived by employees and depends to a great extent on whether people work with large corporate companies or in one of the many sub-contracting firms. Furthermore, a large portion of workers work under conditions of so-called wild commuting (*dikaya vakhta*). In these many cases companies bypass labor laws, safety and security regulations, or do not pay the salaries agreed. My argument in this paper is that current conditions for mobile work in the oil sector - which vary from excellent to what my informants call "slavery-like" - result from the contemporary economic and political constellation in the Russian Federation. On the one hand, the number of neo-liberal mechanisms like sub-contracting and labor out-sourcing by large (former state-owned) companies is gradually increasing and is resulting in precarious conditions; on the other, ever-increasing state control over the natural resources sector and the companies involved in it pertains to non-human assets only. It neglects the value of the labor force. Moreover, I will argue, crucially, that neo-liberal market arrangements in the Russian north have combined with a weak judicial system and strong corruption. This provides the sector leeway with which to progressively reduce working conditions (which are primarily perceived as weaker than in the Soviet Union), leaving workers with limited power. This paper will critically discuss the interlinked notions of post-socialism and labor conditions on the basis of ethnographic data from the Russian Far North (Western Siberia).

# Psychological risks of shift personnel in the Arctic

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In parts of the Arctic concentration of high minerals, development and production are conducted mainly in shifts. The shift work is accompanied by a voltage shifts of functional reserves and adaptive body systems professionals. During of professional activity the shift personnel increased emotional stress, emotional burnout, the level of conflict, aggression, and develop a sense of social exclusion, isolation and social jet lag. The emergence of these adverse functional states and the development of destructive personality traits leads to a decrease in productivity, efficiency and reduces the level of mental health of shift workers. Currently, formed the direction that studies physiological, psychological, socio-psychological aspects of shifts: identified vocational important qualities needed for the personnel, conducted professionedchesky analysis for groups of occupations, etc. In order to predict the performance of the personnel of the need to determine the probability of occurrence of negative psychological states, properties and qualities that will prevent its implementation. This goal can be achieved with the use of a risk-based approach, which is widely used in medicine and economics. Psychological risk in the profession – is the probability of occurrence of a professional personal destruction and the formation of unfavorable functional states of employees when performing job functions due to the prolonged negative impact of social and occupational factors in the lack of personal and environmental resource. The criterion of maximum negative psychological structures are among the personnel of the professional destruction, as they represent a change in the existing structure and activity of the individual, negatively affecting the productivity of labor and cooperation with other actors.

The choice of the criteria of psychological risks of adverse functional states of personal and professional destructions due to the large number of studies that mark their presence in the forms of shift workers working in Arctic conditions.

# **Human exposure to persistent organic pollutants and associated health effects: A 10-year follow-up study in the coastal indigenous population in the Arctic Russia.**

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The high dietary exposure to persistent toxic substances experienced by indigenous populations in the Arctic Russia has already caused serious health concern. Severe adverse effects were observed in those indigenous people heavily exposed to lead, mercury, and polychlorinated biphenyls. The effects include the immune suppression as well as a number of adverse pregnancy outcomes, such as increased perinatal mortality, spontaneous abortions, birth defects, still births, premature births, altered sex ratio and low birth weight. Higher human exposure to polychlorinated biphenyls and lead is proved to be capable of deteriorating the clinical progression and outcomes of some viral infections including HIV presumably due to immune suppressive effect.

A cohort of indigenous people comprising 320 adults and 101 “mother-child” pairs residents of coastal communities has been monitored from 2001 to 2011.

The arctic indigenous communities face exposures to multiple environmental contaminants and other non-chemical stressors including climate change impact. They also have unique activities and cultural traditions influencing the human exposure and susceptibility to persistent contaminants.

The phenomenon of climate change is capable of modifying significantly the intensity of human exposure to the contaminants from both distant sources and local industrial wastes disposed in permafrost land that is being increasingly thawed.

Serum concentrations (geometric means) of the globally transferred persistent pesticides that never been used locally such as chlordanes, mirex, toxaphen were increased by up to a 4-fold in men and by 30% in women. The observed increase in human exposure as measured by serum concentrations of these contaminants has been found to tightly associate with frequencies and magnitudes of natural disasters affected South-East Asia such as hurricanes, flooding, and tsunami during the monitored period of time.

The pesticides of high health importance are found to be mainly transported from areas of intensive agricultural and industrial activities of South- East Asia to the Arctic Russia due to their displacement and biomagnification in the food chain including migratory birds, fish, marine animals.

# Physical strain of mast and pole workers

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## Introduction

Mast and pole work is defined as erecting and pulling down masts and poles, putting up and taking down antennas, installing and transposing air traffic guiding lights, installing pipes and cables and carrying out their maintenance. The work contains several features that can induce significant muscular, cardiorespiratory and thermal strain such as climbing onto high masts (with tools, up to 140 m), working on an uneven and soft terrain (e.g. snow coverage, woodland and marshland), exposure to harsh weather conditions (especially winter) and use of protective gear. Since physical strain during mast and pole work is not known, this study evaluated the level of muscular, cardiorespiratory and thermal strain of mast and pole workers with special emphasis on winter.

## Methods

Fourteen voluntary and healthy male mast and pole workers participated in the study. We measured their muscular strain using electromyography (EMG, ME6000, Mega Electronics Ltd, Finland), expressed as percentage in relation to maximal EMG activity (%MEMG). We indirectly estimated VO<sub>2</sub> from HR (Polar Sport tester, Polar Electro Ltd, Finland) measured during work (using individual VO<sub>2</sub>-HR relationship measured in the laboratory) and expressed it as percentage of maximum VO<sub>2</sub> (%VO<sub>2</sub>max). To quantify thermal strain skin and deep body temperatures were measured using temperature sensors (NTC DC95, type 2252 Ohm, Digi-Key, USA) and telemetric pill (Jonah™ Temperature capsule, Respironics Inc, USA) and receiver VitalSense, Respironics Inc, USA), respectively.

## Results and Discussion

We found the highest average muscular strain in the wrist flexor (24%MEMG) and extensor (21%MEMG) muscles, exceeding the recommendation of 14%MEMG. Average cardiorespiratory strain was 48%VO<sub>2</sub>max. Nearly half (40%) of the subjects exceeded the recommended 50%VO<sub>2</sub>max. Winter condition increased both muscular and cardiovascular strain on average by 4 and 2 %, respectively. Deep body temperature varied between 36.8 and 38.0°C and mean skin temperature between 28.6 and 33.4°C indicating possible occasional superficial cooling. Cooling was most pronounced in extremities during winter. Lowest single temperatures in middle finger, hand and big toe varied between 6.4 and 18.5, 9.4 and 24.9 and 15.4 and 24.6°C, respectively.

## Conclusion

In conclusion, this field study shows that workers may be at risk for local and/or systemic muscular and cardiorespiratory overloading (the winter enhancing this effect slightly) and

thus for excessive fatigue, reduced work efficiency and increased risk for musculoskeletal symptoms. Generally, thermal strain remained at a tolerable level.

# An Arctic Medical Education?

Torsten Risor, Siv Kvernmo

***University of Tromsø, Tromsø, Norway***

Medical education and medical schools in the Arctic region develops within the context of each of the Arctic nation states, although often with inspiration from neighboring countries and international educational trends. Each of the eight Arctic countries has medical schools in – or with a particular focus on – the northern parts of the country in question.

As of today there is no systematic collaboration between the arctic medical schools, no active platform for sharing experiences and no organizational structures to facilitate communication on collective interests. The quality and the mission of each medical school is developed and evaluated locally and nationally, but with little more than incidental learning between the medical faculties across national borders. With a population of about five million people in the Arctic, but eight different systems of medical education, we risk fragmentation and lack of coherence in the competencies of medical professionals working in the region.

The growing list of shared concerns for the arctic nations have implications for medical education and may provide momentum for change. Indeed, all the issues listed for Part I and Part II of this conference is a powerful demonstration of this: We share conditions of dispersed multilingual populations, limited infrastructure, small and vulnerable communities, indigenous peoples with historical trauma, and the challenge to recruit and retain health professionals. We share the consequences of the changes resulting from climate change, industrial interest and production, and from migration. We would argue that time has come to facilitate a greater level of communication and learning between arctic medical schools and toward the organizational support for this interaction.

In this presentation, we give a short descriptive tour of the medical schools with an arctic profile and the initiatives already at work that may facilitate a shared curriculum. We also outline some of the main challenges between now and a future with a shared arctic medical curriculum in it. We present the shared concerns we believe to provide an excellent curriculum framework for future physicians in this region, and we invite you to discuss how a shared effort between the arctic medical schools may turn this potential into reality.

# **Hypothermia prevention by pre-hospital coverings in maritime conditions**

Kirsi Jussila, Sirkka Rissanen

***Finnish Institute of Occupational Health, Oulu, Finland***

Maritime traffic in the Arctic will highly increase in the future. In case of accidents or disasters in maritime conditions pre-hospital care to prevent hypothermia is required in seriously ill or injured casualties. To prevent body cooling and hypothermia during the transportation, pre-hospital covering requires adequate thermal insulation and protection against wind, moisture and splashes. The aim was to determine thermal protection of different types of pre-hospital covers in different wind conditions and to evaluate which methods would be adequate for use under difficult ambient conditions and especially for maritime pre-hospital transportation.

The study consisted of two parts: 1) definition and comparison of protective properties of different pre-hospital coverings in laboratory and 2) evaluation of the chosen covering during maritime casualty transportation. In the first part thermal insulation properties of ten different pre-hospital coverings were measured using a thermal manikin in a climate chamber in calm (0.3 m/s) and windy (4 m/s) conditions. The second phase consisted of measurements of skin and core temperatures, heat flux from seven male test subjects during maritime pre-hospital transportation by a motor boat.

The results revealed that traditional blankets, used together with a reflective sheet, had 33-45% higher thermal insulation in windy conditions than blankets alone. In calm conditions the difference was not so significant. In windy conditions (4 m/s) thermal insulation of the blankets reduced to about 56% of the original insulation capacity, whereas the rescue bags consisting padding reduced to about 69-89% of the original capacity. During maritime transportation mean skin temperature decreased slightly below thermoneutral level when the chosen rescue bag with layered clothing was used.

In conclusion, the assessed pre-hospital coverings from a traditional blanket with lightweight and open fabric structures to a windproof rescue bags, can be used for prehospital care against casualty cooling depending on the ambient temperatures and transporting duration. Windproof and waterproof rescue bag is suitable for maritime casualty transportation even if the casualty is in an uncovered motor boat. Estimated safe maritime transportation time with the used covering method would be at least 60 min at temperature of -5°C.



# Food and health security in the Norwegian, Finnish and Russia border region: linking local industries, communities and socio-economic impacts

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Although small, the border regions between Norway, Finland, and Russia are very important to local communities for both food availability and economic stability. Spanning over several political jurisdictions, environmental management of this region is of the utmost importance and provides the unique opportunity for integration of research projects among the neighbouring countries.

Contaminant exposures in many Arctic communities are complex with both long-range transport and local sources acting as inputs for contaminants. A number of local industrial sources are present in this area and with planned increased activity. This has raised concerns from the local population regarding food safety and potential risks to health through consumption of food from this region. Contamination of local food could also have large economic implications in terms of export since the reputation on food quality is essential for this region. Thus, there is a need to study relevant contaminants in food and investigate effects and consequences for human health with increasing economic and industrial development.

Although elevated concentrations of numerous contaminants (i.e., metals, dioxins) have been reported in various environmental media from this region, limited data exists on contaminants in important food items and their potential risk to human health.

The objective of the project is to assess industrial impact on food safety and human health in highly populated Norwegian, Finnish, and Russian border region specified in the Kolarctic ENPI CBC 2007-2013 Programme. Integration of contaminant results with monitoring of key human health endpoints can be implemented in future human risk assessments and food safety management. Assessment of results will be communicated to stakeholders within participating countries (i.e., general public, government, and industry) where both the socio-economic benefits of increased industrial activity will be weighed against potential food safety and human health risks.

Questionnaires have been circulated in all countries and blood and food samples are being collected on all sides of the border. Analyses are completed for pregnant women on the Norwegian side of the border and on the way in Russia and Finland. The project will end December 2014.

Results from this project will be presented at the Arctic frontier meeting.

# Myths and facts about sleep in the Arctic. An overview.

Trond Bratlid

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All life within the Arctic and Subarctic regions are exposed to marked seasonal changes,

Extreme shifts in the ratio of light to darkness during the course of the year are prominent features in these areas, ranging from the polar night to the midnight sun. There is rich evidence that these fluctuations affect plant and animals, but there is less research about the degree to which humans are affected.

Numerous disturbances in sleep patterns are reported among the general population in all age groups, especially during the dark period of the Arctic winter. Some also report low mood symptoms and lack of energy and drive. As sleep has important homeostatic functions, sleep deprivation and sleep problems are a stressor that has consequences for the brain and mental functions (subjective alertness and performance), as well as many body systems. Many different long term health outcomes have been linked to short sleep duration; increased mortality, type 2 diabetes, obesity, cardiovascular disease, depression, and even cancer (shiftwork).

Sleep and sleep-wake rhythms are controlled by biological clocks/clock genes in the brain.

Since our inherent sleep-wake rhythm by nature usually is slightly longer than 24 hours, the internal clock must be "set" each day to be in line with the social clock, work, obligations and surroundings. The strongest and probably the most important time cue for setting the internal clock is daylight and the light/darkness cycle which influences through specific photoreceptors in the retina, but temperature, health conditions, nutrition, meals and social and work schedules are also important time cues.

The last cross-sectional population study in Tromsø (Tromsø 6) showed that other factors than daylight may be more important in the regulation of sleep patterns for people in the subarctic. There were no significant seasonal differences in mental distress, but sleeping problems were most prevalent in winter. Short sleepers had 80% increased risk of being overweight, and men had a doubled risk of having abdominal obesity.

Although some people in the subarctic clearly are mentally affected by the darkness in winter, the negative impact of winter on mental distress for the population is not conclusive. The human circadian clock is very sensitive to light, and we do not know enough about how indoor light (computers) and light pollution outdoors affect people. Together with strict working schedules they could mask seasonal differences in sleep patterns.

# Hypothermia and diving: Does reduced core temperature increase the risk of bubble production and decompression sickness?

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Background: Diving under cold conditions may increase bubble production and decompression sickness (DCS). It is still unclear to what extent thermal status effects DCS risk, but it is believed that cold conditions induce cardiovascular changes affecting inert gas uptake and removal. The effects of mild and moderate hypothermia on bubble production and DCS risk were studied.

Methods: In anesthetized rats cardiovascular changes were monitored with a Millar pressure-volume catheter in the left ventricle and the femoral artery. Rats were randomly assigned to be normothermic controls, to perform a hyperbaric dive at constant core temperature of 37°C (CC), a mild hyperbaric dive with a core temperature of 35°C (MIH) or a moderate hyperbaric dive with a core temperature of 32°C (MOH) during decompression and the early post dive period before re-warmed to 37°C. Spontaneous air-breathing rats were compressed to 600kPa, maintained for 45 min breathing air, and decompressed linearly to the surface at a rate of 50kPa/min in the MIH group and at a rate of 25kPa/min in the MOH group. Immediately after surfacing, right ventricle and pulmonary artery were insonated for bubble detection using ultrasound. In the MIH hearts were snap frozen for Western Blot analysis of cTNI.

Results: Rats subjected to MOH dive showed increased bubble production compared to the CC dive group, while the MIH group did not. Both MIH and MOH had decreased stroke volume and cardiac output that did not come back to baseline levels during re-warming to

37°C. In the MIH protocol, both MIH and CC showed increased phosphorylation of cTNI compared to controls.

Conclusion: A reduction in core temperature of 5°C in MOH increased venous bubble production compared to CC. Along with the reduced cardiac function seen after both mild and moderate hypothermia, these data indicate that precautions should be taken during cold diving.

# **Mitochondrial Disruption during Hypothermia and Rewarming in the Adult Rat Heart**

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Recovery from accidental hypothermia (14-19°C) is often unsuccessful due largely to heart failure upon rewarming. Although the causes for heart failure following hypothermia/rewarming remain elusive, studies at the cellular level have revealed alterations in cytoplasmic and mitochondrial calcium regulation (overload) as well as a decrease in calcium sensitivity of force generation via enhanced phosphorylation of troponin I. Normally, in response to stimulation there is a transient increase in cytoplasmic and mitochondrial calcium levels associated with excitation-contraction coupling. While cytoplasmic calcium initiates contraction, an increase in mitochondrial calcium stimulates the timely regeneration of ATP levels needed as the energy source for contraction. However, excessive mitochondrial calcium levels become disruptive in at least two respects: 1) excessive reactive oxygen species (ROS) generation leading to oxidative stress and 2) mitochondrial cytochrome c release, which may trigger cell death. Therefore, given evidence of mitochondrial calcium overload during hypothermia/rewarming, this study investigated the hypothesis that hypothermia/rewarming of cardiomyocytes leads to excessive ROS generation resulting in mitochondrial rupture and cytochrome c release.

In order to test this hypothesis, isolated cardiomyocytes from adult male Sprague-Dawley rats were subjected to a 30-min period of hypothermia (1 hour cooling to 15°C) followed by rewarming (1 hour rewarming to 37°C). During hypothermia/rewarming, the cardiomyocytes were imaged by confocal microscopy to assess mitochondria (using MitoTracker Green or Red) and ROS generation using the fluorescent indicators CM-H<sub>2</sub>DCFDA (cytoplasmic ROS) and MitoSOX (mitochondrial ROS). Mitochondrial membrane potential was also measured using the fluorescent indicator TMRM to determine the incidence of mitochondrial membrane rupture, coinciding with cytochrome c release. In addition, Western blot was used to examine the expression of cytochrome c in mitochondrial versus cytoplasmic cell fractions. Our results show that cytoplasmic and mitochondrial ROS generation increases during hypothermia/rewarming. Furthermore, there is mitochondrial rupture and cytochrome c release associated with hypothermia/rewarming. Together, these results suggest that calcium overload associated with hypothermia/rewarming induces an increase in ROS generation leading to mitochondrial disruption.

# **Young People and Snowmobiling in Northern Norway and Svalbard: Accidents, Injury Prevention, Focuses and Strategies**

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Object:

This study analyses how young people understand and explain snowmobile accidents, injury prevention and safety precautions, and outlines elements of a preventive strategy based upon the young people's perspectives. Focus group discussions were conducted with 17 groups segregated by gender. Thirty-one girls and 50 boys from high school, aged 16-23 years, were interviewed. Gender differences were observed with regard to driving behaviour, risk assessment and safety precautions. Both genders make some basic preparations before trips. Accidents occurred in situations with poor risk assessment, careless driving or mishaps. Girls want knowledge of outdoor life, navigation techniques and how to handle external risks. Boys want to learn more about search and rescue in avalanches, and areas where they can practise and drive freely. A community-based approach to reduce injuries is discussed. A public health strategy should combine legislative and structural measures with local knowledge, and invite young drivers, snowmobilers' organizations and the community to define problem areas, set priorities and develop and implement preventive measures.

Keywords. snowmobile, accidents, injury prevention, young people, community-based, drinking and driving, safety precautions, night driving, risk assessment.

# Surveillance and monitoring health in North Norway: The Tromsø Study

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In the mid-1970s, one in five Norwegian men died of myocardial infarction before the age of 75, and the situation in North Norway was worse. The Tromsø Study was initiated in 1974 with the primary aim of studying determinants of cardiovascular diseases and of developing ways to prevent them. The Tromsø Study is an epidemiologic and prospective study of health problems, symptoms and chronic diseases, and a resource for the surveillance of disease risk factors. The study was gradually expanded to include many other diseases, such as renal, endocrinological, neurological, rheumatic, dermatological, gastro-intestinal and mental diseases, cancer, chronic pain and osteoporosis. Information on exposure data is obtained by repeated population surveys. So far, six surveys have been carried out 6-7 years apart, referred to as Tromsø 1-6. All surveys comprise the collection of questionnaire data, the sampling of biological specimens and a number of clinical measurements. Whole birth cohorts and random samples of other birth cohorts are invited, and the study design ensures repeated measurements of a large number of Tromsø residents. Since Tromsø 4 and onwards, the study design also involves a second visit with more extensive examinations of selected subgroups of participants. Fit Futures (FF) 1 and 2 are repeated Tromsø study surveys in a youth cohort and includes questionnaire data, clinical and dental examinations, and biological specimens.

Table: <https://www.dropbox.com/s/p6ngq2npzy4n49t/Table.pdf>

Participation rates have always been high in the Tromsø study, and in most age groups more than three quarters of those invited attend.

Tromsø 7 starts in 2015. We plan to follow up on previous research areas will invite the FF cohort and all individuals 40-79 years. New research priority areas will be dementia, mental and dental health, as well as environmental contaminants and human health.



# Effects of dextran on cardiovascular function during rewarming from experimental hypothermia.

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## Background

"Rewarming shock" characterized by low cardiac output (CO) and fall in mean arterial pressure (MAP) is common upon rewarming from accidental hypothermia. In this study we wanted to elucidate whether volume loading with crystalloids or colloids could improve cardiovascular function and prevent rewarming shock.

## Methods

A rat model for circulatory studies during experimental hypothermia was used. Thermodilution was used to measure cardiac output (CO), stroke volume (SV) and peripheral resistance (TPR). Three groups of animals were used. Group 1 was the control group, group 2 received a saline infusion of 25mL/kg and group 3 received a dextran infusion of 12mL/kg. All infusions were given over a period of 30 minutes at the start of rewarming.

## Results

Both saline and dextran significantly improved cardiac output (CO) and left-ventricular stroke volume (SV) and reduced total peripheral resistance (TPR) during the early stage of rewarming. CO and SV were significantly improved in the dextran-group compared to the saline group during the whole rewarming period. The dextran group showed significantly better relaxation (measured by dP/dt min) at early stage of rewarming and better contractility (measured by dP/dt max) at late stage of rewarming compared to control hypothermic group. Both volume-loading groups had significantly reduced levels of intracellular calcium [Ca<sup>2+</sup><sub>i</sub>] compared to the control group.

## Discussion

There were no significant differences in HR or mean arterial pressure among the groups. However, stroke volume (SV) was increased in the volume-loading groups, and with it

cardiac output (CO). The increase of CO in the dextran group was significantly higher than in the saline group. We saw a reduction in peripheral resistance (TPR) in these groups with the result that arterial pressure (MAP) does not differ among the groups. Contractility, measured by  $dP/dt_{max}$ , was significantly increased in the dextran group. In this study calcium levels, although elevated in the volume loading groups, are significantly reduced compared to hypothermic controls. The explanation for this might be that the Frank-Starling forces, which are calcium independent, allow the heart to pump with increased force, whereas the control group with a diminished intravascular volume are more dependent on increased activation of the cross-bridges by calcium ions.

## Conclusion

Volume loading improves hemodynamics during rewarming from profound hypothermia. A sustained effect was seen in dextran which improved hemodynamics after the infusion period. Dextran is preferable to saline and may prevent rewarming shock. The dextran effects on leucocyte sequestration in the microcirculation may have a positive impact on revascularisation after hypothermic centralization of circulation.

# Chronic lifestyle diseases; Diabetes mellitus type 2 and metabolic syndrome in Northern Norway

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## Objectives

We wanted to evaluate the prevalence of metabolic syndrome and diabetes type 2 and some health outcomes in relation to gender, age and ethnicity.

## Material and methods

SAMINOR I that was carried through in 2003 - 2004 include 16 538 men and women aged 36-79 years, a response rate of 61 %. More women than men participated in the survey, 65.6 % versus 56.6 %. In total 15612 contributed with blood samples and gave consent to their blood being used in medical research. Sami affiliation was reported in 5141 people (35%).

## Results

The study demonstrated a high prevalence of overweight and obesity in this population. Almost 80 % of the participants had BMI above 24.9 kg/m<sup>2</sup>. Obesity rates were somewhat higher in women than men, 21.5% versus 17.4% respectively. Obesity and central obesity was most pronounced in Sami women. The prevalence of self-reported diabetes type 2 was 4.3% for men and 4.4% for women. Almost 19% of the women and 12% of men had metabolic syndrome.

## Conclusions

The results from our analyses clearly demonstrated high prevalence of overweight and obesity in this population. Metabolic syndrome was pronounced especially among women. This syndrome is a cluster of unfavourable health factors that are all metabolically related cardiovascular risk factors which also predict a high risk of developing diabetes.

# Adverse elevation of myocardial calcium ( $[Ca^{2+}]_i$ ) after Diltiazem during rewarming from experimental hypothermia in vivo.

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## Introduction

Rewarming from hypothermia is often complicated by hypothermia-induced cardiac dysfunction, characterized by decreased stroke volume (SV) and cardiac output (CO). The pathophysiological mechanisms have yet to be described in its completion. Additional studies have shown; alteration of mitochondrial function, contractile filament dysfunction and myocardial calcium  $[Ca^{2+}]_i$  overload. In this study we investigated effects of a  $Ca^{2+}$ -channel blocker diltiazem to reduce calcium overload after rewarming from hypothermia.

## Methods

A rat model designed to monitor left ventricular cardiac function and femoral artery pressure (MAP) during experimental hypothermia (4h at 15°C) and rewarming (1h) was used. To measure  $[Ca^{2+}]_i$  the animals were injected with  $^{45}Ca^{2+}$ , a radioactive isotope of  $Ca^{2+}$ . The intervention group received a low dose diltiazem the last hour of stable hypothermia (15°C) and during rewarming. A control group received diltiazem- placebo. Two additional groups infused with diltiazem or placebo served as time-matched normothermic controls.

## Results

After rewarming to 37°C both the intervention and the placebo group demonstrated hypothermia-induced cardiac dysfunction; reduced SV and CO. With respect to hemodynamics only MAP (87 mmHg ffl 6,1 vs. 108,1 mmHg ffl 2,0) and total peripheral resistance (153,8 ffl 10 vs. 179,1 ffl 10 mmHg/L/min) were significantly reduced in the diltiazem group when compared to the placebo group. Both rewarmed groups showed a significant increase in  $[Ca^{2+}]_i$  when compared to normothermic controls, but in addition  $[Ca^{2+}]_i$  was significantly increased in diltiazem treated animals when compared to placebo (2,80  $\mu$ mol/mg ffl 0,15 vs. 1,06  $\mu$ mol/mg ffl 0,53). There were no differences in  $[Ca^{2+}]_i$  between the normothermia groups.

## Discussion:

The hemodynamic data show that the use of a low dose diltiazem during rewarming does not improve cardiac function. The reduction in MAP can be explained by the peripheral vasodilator effect of diltiazem. Interestingly the calcium data show a significant increase in  $[Ca^{2+}]_i$  in rewarmed rats treated with diltiazem. Other researchers report diltiazem-mediated increase in mitochondrial calcium under certain conditions. The mechanism is explained as diltiazem-induced inhibition of the mitochondrial  $Na^+/Ca^{2+}$ -exchanger which will reduce calcium efflux from the mitochondria. The present results indicate that the use of diltiazem during hypothermia has no beneficial effects on hypothermia-induced hemodynamic dysfunction and may in addition aggravate a hypothermia-induced myocardial calcium overload.

# Efficacy of Prolonged Cardiopulmonary Resuscitation (CPR) on Oxygen Transport during Experimental Hypothermia

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Introduction: Over the last years victims of accidental hypothermia have repeatedly been reported to survive prolonged (up to 6hrs) pre-hospital CPR with complete restitution of cerebral function after in-hospital rewarming. To investigate efficacy of CPR on global oxygen transport (DO<sub>2</sub>), regional oxygen uptake (VO<sub>2</sub>), and blood pressure generation during hypothermia (3hrs at 27°C) a closed chest pig model was used. Methods: 12 anesthetized juvenile piglets were surface cooled to 27°C before cardiac arrest was introduced. DO<sub>2</sub>, VO<sub>2</sub>, and organ blood flow were calculated using the radioactive microsphere technique before cooling, at 27°C during spontaneous circulation and repeatedly during 3h of continuous CPR. 4 pigs were used as normothermic controls and were followed during 1h of CPR. Results: In response to progressive cooling to 27°C gradual decrease in DO<sub>2</sub> and VO<sub>2</sub> were observed. During 3hrs of cardiac arrest and CPR at 27°C DO<sub>2</sub> and VO<sub>2</sub> persisted at the same reduced levels as during spontaneous circulation. DO<sub>2</sub> remained significantly higher than VO<sub>2</sub> and central venous oxygen content (SvO<sub>2</sub>) remained unaltered during 3hrs of CPR indicating sufficient global oxygen transport. Likewise perfusion pressure (MAP), cardiac output (CO) and carotid blood flow decreased insignificantly after 3hrs of CPR and were similar to those levels at the start of CPR. Compared to their pre-hypothermic values organ blood flow measurements showed a temperature-induced reduction of blood flow to heart, kidneys, liver, small intestine and brain during spontaneous circulation at 27°C, but flow remained unchanged during 3hrs of hypothermic CPR. In contrast, normothermic controls demonstrated decreased oxygen transport already after 15 minutes of CPR with equal DO<sub>2</sub> and VO<sub>2</sub> values and significantly decreased SvO<sub>2</sub>. Compared to baseline values at 38°C blood flow in small intestine and brain was significantly reduced after 15 minutes, and no blood flow was detectable in any organs following 45 minutes of CPR. Conclusions: Our findings show that during 3hrs of hypothermic CPR sufficient DO<sub>2</sub> is provided. This is in striking contrast to normothermic CPR where DO<sub>2</sub> was significantly reduced compared to during spontaneous circulation already after 15 min with absence of DO<sub>2</sub> after 45 min in concert with no detectable regional blood flow. Our experiment indicates that due to hypothermia-induced reduction of tissue VO<sub>2</sub> continuous 3h CPR can provide sufficient organ DO<sub>2</sub>. This new knowledge is fundamental to encourage early and continuous CPR during rescue and transport of accidental hypothermic patients to hospitals capable of introducing extracorporeal blood rewarming.

# Hypothermic solutions cause reduced contractility in ventricular cardiomyocytes following rewarming

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Rewarming patients following accidental hypothermia can cause cardiovascular collapse, evident by a reduction in cardiac output (CO) and a sudden fall in arterial blood pressure. Clinically referred to as 'rewarming shock', there continues to be a high mortality rate (~50-80%) despite improvements in medical therapy in recent years. Cooling the heart of an anaesthetised rat to 15°C and maintaining the temperature for 5 hours before gradual re-warming reduced the CO to ~50% of control (Kondratiev, 2006). Despite the substantial reduction in CO, heart rate, blood pressure and oxygen supply were maintained. The cellular basis for this behaviour is unknown. The aim of this study was to determine whether rewarming-induced shock could be invoked in vitro. Methods: Hearts were removed from Wistar rats after cervical dislocation and perfused in Langendorff mode with a Ca<sup>2+</sup> free Krebs solution with type 1 collagenase (250IU/ml) to dissociate single ventricular myocytes. Isolated cells were field stimulated (1Hz; 40V; 2ms duration) at 16°C for 4 hours (1.8mM Ca<sup>2+</sup>). As a measure of contractility, fractional shortening (FS) was recorded before and after hypothermic incubation at 2, 3 and 4 hours using light microscopy and video based edge detection. All cells were gradually rewarmed to 37°C over 10 minutes prior to these measurements. A control group of ventricular cardiomyocytes underwent the same dissociation and stimulation protocol and were maintained at 37°C for 4 hours. Data are expressed as mean±SEM and compared by repeated measures ANOVA, with post hoc analysis using Tukeys test. P<0.05 was regarded as significant. Results: This study indicated that myocytes stimulated at 16°C for up to 4 hours displayed a reduced FS when compared to freshly isolated cells (P<0.05). Immediately following dissociation, FS was 8.05±0.47%. Following hypothermia (16°C) and re-warming to 37°C, a reduction in FS was seen at 2 (4.72±0.53%, P< 0.01), 3 (2.56±0.67%, P< 0.001) and 4 (3.78±1.05%, P< 0.01) hours when compared to fresh cells. Cardiomyocytes stimulated for at 37°C for 4 hours showed no significant differences in FS. Conclusion: Stimulation of cardiomyocytes at 16°C then rewarmed to 37°C showed reduced FS. The reduction in contractility suggests that rewarming induced shock in vivo can be simulated in vitro. The cellular basis of this effect is unknown, but measurements of intracellular Ca<sup>2+</sup> will determine which aspect of E-C coupling is predominately affected by hypothermia.

# Moderate hypothermia induces pro-arrhythmic changes in cardiac electrophysiology

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Rewarming patients following accidental hypothermia can cause cardiovascular collapse, evident by a reduction in cardiac output (CO) and a sudden fall in arterial blood pressure. Clinically referred to as 'rewarming shock', there continues to be a high mortality rate (~50-80%) despite improvements in medical therapy in recent years. Cooling the heart of an anaesthetised rat to 15°C and maintaining the temperature for 5 hours before gradual re warming reduced the CO to ~50% of control (Kondratiev, 2006). Despite the substantial reduction in CO, heart rate, blood pressure and oxygen supply were maintained. The cellular basis for this behaviour is unknown. The aim of this study was to determine whether rewarming-induced shock could be invoked in vitro.

**Methods:** Hearts were removed from Wistar rats after cervical dislocation and perfused in Langendorff mode with a Ca<sup>2+</sup> free Krebs solution with type 1 collagenase (250IU/ml) to dissociate single ventricular myocytes. Isolated cells were field stimulated (1Hz; 40V; 2ms duration) at 16°C for 4 hours (1.8mM Ca<sup>2+</sup>). As a measure of contractility, fractional shortening (FS) was recorded before and after hypothermic incubation at 2, 3 and 4 hours using light microscopy and video based edge detection. All cells were gradually rewarmed to 37°C over 10 minutes prior to these measurements. A control group of ventricular cardiomyocytes underwent the same dissociation and stimulation protocol and were maintained at 37°C for 4 hours. Data are expressed as mean±SEM and compared by repeated measures ANOVA, with post hoc analysis using Tukeys test. P<0.05 was regarded as significant.

**Results:** This study indicated that myocytes stimulated at 16°C for up to 4 hours displayed a reduced FS when compared to freshly isolated cells (P<0.05). Immediately following dissociation, FS was 8.05±0.47%. Following hypothermia (16°C) and re-warming to 37°C, a reduction in FS was seen at 2 (4.72±0.53%, P< 0.01), 3 (2.56±0.67%, P< 0.001) and 4 (3.78±1.05%, P< 0.01) hours when compared to fresh cells. Cardiomyocytes stimulated for at 37°C for 4 hours showed no significant differences in FS.



**Conclusion:** Stimulation of cardiomyocytes at 16°C then rewarmed to 37°C showed reduced FS. The reduction in contractility suggests that rewarming induced shock in vivo can be simulated in vitro. The cellular basis of this effect is unknown, but measurements of intracellular  $\text{Ca}^{2+}$  will determine which aspect of E-C coupling is predominately affected by hypothermia.

# **Ambulance helicopter contribution to air based search and rescue in North Norway during 2000–2010**

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Background: Search and rescue (SAR) operations constitute an important proportion of the Norwegian helicopter emergency medical service (HEMS) operations. Several helicopter resources contribute to SAR in our area, and there is no common database or definition of in use.

Methods: We searched the mission databases for the dedicated SAR and HEMS bases and the Joint Rescue Coordination Centre (North) for helicopter-supported SAR operations within the potential operation area of the Tromsø HEMS base in 2000–2010. We defined SAR operations as all missions: above sea within 10 nM from the coast, with rescue hoist or static rope, with an initial search phase, and all avalanches.

Results: There were 769 requests in 639 different SAR operations, and 600 missions were completed. The number increased over the study period, from 46 in 2000 to 77 in 2010. The Tromsø HEMS contributed with the highest number of missions and experienced the largest increase, from 10 % in 2000 to 50 % in 2010. Simple terrain operations or sea operations dominated, and avalanches accounted for as many as 12 % of all missions. Static rope or rescue hoist was used in 141 of the 639 operations.

Conclusions: We have described all helicopter supported SAR operations in our area by combining databases and employing a common SAR definition. The local HEMS service experienced the greatest increase in workload. Increased availability is one possible explanation.

# North Norwegian Avalanche Victims. A retrospective observational study

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Background: Rescue and treatment of Norwegian avalanche victims is based on international guidelines from Central European and North American studies. However, the distribution of death causes in avalanches in our country has never been investigated earlier. For this reason we studied the 30 avalanches with fatal outcome in North Norway and Spitzbergen during 1996-2012. We wanted to assess the feasibility of retrospective record research to study the causes of death.

Methods: We searched reports from the rescue teams and the medical records from institutions that received the avalanche victims to determine the most likely cause of death.

Results: During the 16 years studied, 48 persons died in 30 avalanche accidents. 39 of these (81%) were killed during outdoor recreational activities, 5 (10%) in vehicles on roads and 4 (8%) in buildings. Only 5 (10%) casualties underwent autopsy. Asphyxia was the most common cause of death with 22 (46%) of the fatalities. Trauma was the main cause of death in 8 (16%) cases, drowning in 5 (10%), and the diagnosis mors subita was used in 2 cases (4%). We could not find appropriate documentation from 9 (19%) fatalities. The majority of the casualties in the outdoor activity group were men (77%) and the mean age was 38 years. The study shows a correlation between being caught in topographical traps and severe trauma, and between not being buried in the snow and trauma. 35 casualties were pronounced dead at the scene, and the clinical documentation of these cases was in several cases not sufficient to reassess the cause of death.

Conclusions: Despite some missing data, we conclude that the incidence of severe trauma in Norwegian avalanche casualties is higher than previously expected. This may suggest that a relatively high proportion of the fatalities cannot be rescued alive, even with rapid extrication from the avalanche. A prospective national systematic registry, focused on the pathophysiology of avalanche injuries with post mortem imaging studies and autopsies could help to improve our knowledge of death mechanisms in the future.

# Time to change the focus of out-of-hospital cardiac arrest?

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Survival from out-of-hospital cardiac arrest (OHCA) remains low. Despite decades of improving "chains of survival", many communities with well-developed emergency medical systems (EMS) and CPR-trained population still only see around 5% of patients discharged alive after OHCA. Increased survival in Sweden the last 14 years was found to be most marked in OHCA-patients with shockable first rhythm and cases witnessed by ambulance-crews. In North Norway, long "chains of survival" for OHCA are needed to compensate a sparse population and long distances.

In 2000, we changed our prehospital focus from onset of collapse and early CPR in OHCA, to onset of chest pain in acute coronary syndromes (ACS) and early prehospital thrombolysis (PHT). We hoped more OHCA-patients could be saved with fewer delays to dispatch, diagnosis and first defibrillation if OHCA would occur in ACS-patients. An aggressive prehospital chest-pain-protocol was implemented; dispatch nurses, paramedics and MDs were trained to handle ACS-patients, to take and transmit prehospital 12-leads ECG, and to give early PHT to relevant STEMI-patients. We stressed time factors, used defibrillation-pads in all ACS-patients, and engaged the population through media stunts.

First 5-years, 10,5% of OHCA-patients were discharged alive; during second period, this doubled to 22,3% ( $p < 0,05$ ). Initial shockable rhythms increased. In patients with witnessed arrest of cardiac aetiology and shockable first rhythm, survival to discharge increased from 21,4% to 44,2 % ( $p < 0,05$  ). CPR was started by lay bystanders before ambulance arrival in 68,2% of patients, increasing to 76,3% during the second period. By moving system attention from OHCA to chest pain, survival to discharge doubled. Mortality from STEMI decreased well above 30%. Experiences from this change of focus may prove useful when organising further emergency systems in Arctic regions.

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# Bridging the global gap in emergency care: train local teams!

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Acute medical, obstetrical and trauma conditions contribute to the global gaps in access to healthcare and health inequities. High incidences of trauma, chronic illness, communicable diseases and maternal and child mortality constitute daily life for large populations in low- and middle-income countries (LMIC). Nearly 90 % of global deaths from injuries occur in LMIC, with prehospital emergency care and organized "chains of survival" often lacking. Large populations therefore suffer avoidable deaths, reduced life expectancy and quality of life. Those at risk in LMIC lack access to simple, cost-effective interventions that can prevent many premature deaths. Pre- and in-hospital emergency care is often delivered under difficult circumstances by inexperienced staff denied relevant training in basic life-saving procedures. Training local medical teams in resuscitation and emergency care can significantly reduce death and disability from common emergency conditions, but the reservoirs of important local experience and expertise in local communities are not utilized to build even basic systems. Based on longstanding experiences from decentralized teaching in emergency medicine at local village level in The rural High North of Norway, we found that a culture-sensitive, practical training program targeting rural community health workers and lay first responders was affordable, highly efficient and sustainable. There is an urgent need to share knowledge to bridge the deep global rifts and improve emergency care for those denied "chains of survival", also outside the global North and wealthy countries.

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# Birth registries as a tool in maternal and child health in the Arctic

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## Objectives

To assess the creation and implementation of the Kola Birth Registry and the strategy for implementation in other areas of the Arctic.

## Material and methods

A preliminary registry was created in Monchegorsk, Murmansk County, to assess delivery outcomes in a population basically involved in the nickel industry. Based on this experience, a registry of all deliveries at the Kola Peninsula is included in a comprehensive database from 2005-2006 until recently, with more than 30 000 registered deliveries.

## Results

The registry has shown its power to assess different maternal conditions, delivery outcomes, complications, and associations to occupation, life style, and socioeconomic conditions. The strength of the registry has created a basis for development of a compatible registry in Arkhangelsk County, and a new registry in Yakutia is under development.

## Conclusions

The results from the registry provides opportunities for implementation of public health strategies in pregnancy care and preventive measures to improve the pregnancy quality and delivery outcomes for the Arctic populations. The methodology is robust and possible to implement, independent of geographical, cultural, or political differences. Examples of different scientific data extracted from the registry will be demonstrated.

# What can the Tromsø Study tell us about health and illness at 69°N?

Inger Njølstad

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Back in 1974, cardiovascular mortality in Norway was among the highest worldwide, and mortality in the northernmost region was almost 50% above the national average. Since then, cardiovascular mortality in Norway has declined tremendously while other life style related conditions have emerged. During the last 40 years, the Tromsø Study has carried out a total of six population based surveys among adults and two surveys among teenagers, with more than 40,000 participants altogether. Using data from the Tromsø Study, this overview will present scientific results regarding wellbeing, health and disease in the Tromsø population, including secular and seasonal changes in cardiovascular risk factors and disease, vitamin D status, sleep and mental stress, and other issues that are of relevance to our geographical position in the High North.

# Health & environment in the Arctic

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# Present and Future Contamination of the Arctic with Persistent Chemicals

Henry Wöhrnschimmel<sup>1</sup>, Matthew MacLeod<sup>2</sup>, Konrad Hungerbühler<sup>1</sup>

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The Arctic has been identified as a vulnerable environment where persistent, bioaccumulative and toxic substances from source regions in the south accumulate and persist on longer time scales. Uncertainties in the chemicals' properties, their emission history and environmental processes make it challenging to forecast future concentrations, and in particular the effectiveness of regulatory measures like the Stockholm Convention on Persistent Organic Pollutants (POPs). Furthermore, processes of global change, like current and future exploitation of Arctic resources and climate change-induced impacts introduce additional uncertainty, becoming an imminent threat to the Arctic environment.

This presentation provides an overview of the modeling studies carried out within the ArcRisk project from the European Community's Seventh Framework Programme. These studies had the objective to model pollutant transport to, fate in, and interaction with the Arctic and the impact of global climate change on these processes. Selected examples will be discussed in more depth: The future fate of legacy pollutants like HCHs and PCBs; the importance of secondary emissions; the impact of climate change on environmental concentrations; the impact of climate change on future emissions of industrial and agricultural chemicals.

# **Climate change -good or bad for persistent organic pollutants in the environment?**

Pernilla Carlsson<sup>1,2</sup>

***<sup>1</sup>AMAP, Oslo, Norway, <sup>2</sup>UNIS, Longyearbyen, Svalbard and Jan Mayen***

The Arctic dilemma of healthy food versus pollutants is recognized by many people, but the effects of changing climate on persistent organic pollutants (POPs) in Arctic food items are not well known. The ArcRisk project has contributed to an increased understanding of the principles behind climate change-related influences on transport processes of contaminants. Selective environmental uptake processes for persistent organic pollutants (POP) in Arctic food webs have been investigated to elucidate these processes. POPs bioaccumulate in the food web in the Arctic. Highest levels are found in animals feeding at high trophic levels, which also serve as sources of food for humans. Processes concerning contaminant transfer in abiotic media and at lower trophic levels as well as in Arctic local foods are therefore of high importance for understanding the effects and risks for humans in the Arctic. Levels of legacy and emerging POPs in food items consumed by Arctic indigenous people will also be discussed in this presentation.

# **Twenty-five years of scientific progress on contaminants and health in the Arctic.**

Eric Dewailly, Pierre Ayotte, Gina Muckle, Mylene Riva, Michel Lucas, Mélanie Lemire

***Laval University Medical Center, Quebec, Canada***

Since 1985 and our discovery of unexpectedly high concentrations of PCB's in Inuit breast milk, to the present day program on Arctic Charr, our group has worked to simultaneously collect, disseminate and take action on environmental health issues at the local, national and international level. In almost 30 years of active participatory and clinical research we have learned a great deal about the nature of these Arctic contaminants; where they come from, the exposure pathways and relative levels between and within various populations, and the associated health consequences related to these.

There is still a great deal of work to be done but thankfully today public health intervention is now more targeted, efficient and better communicated.

We have also learned to work better, in tandem, with Inuit communities.

Recognizing the strength and uniqueness of their knowledge and understanding the value of food from the land and the sea has benefited our relationships and is a gift from the Inuit to the global society.

For contaminants, we have learned together how to use science to convince the world community to adopt international conventions. We have also made good local decisions to mitigate the impact of contaminants on human health, especially to the most vulnerable.

Inuit have faced many environmental changes in the past. In some ways they will probably be able to adapt to a warming climate as they have done before.

But Inuit are now facing a more insidious enemy: Globalization. Huge changes in their way of living are accelerating. Disruption of the society, violent deaths, dietary changes and emergence of chronic and infectious diseases put a great many challenges and responsibilities in front of this generation of Inuit leaders.

How will Inuit survive the 21st century?

Will they contract as a society with their territories under the pressure of mining and other industries? Or will they be able to manage this positively, take what is best from globalization while keeping a strong culture?

All societies today face and share this challenge but not many face it in as stark a way as the Inuit.

Working together still has challenges. However, now more than ever, the importance of scientific information gathered by Inuit and occidental scientists presents us with opportunities. The enlightened solutions sought by the Inuit matter not only to the Inuit but also to the world.

# **Environmental and human biomonitoring as a tool for assessment of mobility and reactivity of mercury**

Milena Horvat, David Kocman

***Jožef Stefan Institute, Ljubljana, Slovenia***

Due to the very complex behaviour and cycling of mercury (Hg) in the environment, actual vulnerability of the ecosystem to Hg contamination can vary a lot, depending largely on mercury's mobility and reactivity in individual system. However, there are no agreed and harmonised methods/tools available that would enable such characterisation. Therefore, this contribution discusses environmental biomonitoring, including human biomonitoring, as a more convenient and cost-effective way for assessment of spatial and time trends of mercury pollution, measured by its change in reactivity and (bio)availability. Possible use of biomonitoring as an early warning system for humans and other biological entities will also be addressed. Results as available from selected case studies will be placed in the context of known sources of Hg, both anthropogenic and natural, with a special emphasis on a new knowledge regarding aquatic Hg releases and fate on a global scale. Overall, a need for the standardization of methodologies that would enable biomonitoring to be applied widely and to ensure international comparability of data, was recognised.

# **Exposure of the global environment by PCBs and DDT in the 21st century - relative importance of climate and primary emissions**

Irene Stemmler<sup>1,2</sup>, Gerhard Lammel<sup>1,3</sup>

***<sup>1</sup>Max Planck Institute for Chemistry, Mainz, Germany, <sup>2</sup>University of Hamburg, CEN, Institute for Hydrobiology and Fisheries Science, Hamburg, Germany, <sup>3</sup>Masaryk University, Research Centre for Toxic Compounds in the Environment, Brno, Czech Republic***

Persistent organic pollutants (POPs) are of great concern because of their long residence time and long-range transport potential in the environment and because they are readily bioaccumulated along food chains and toxic for wildlife and humans. Recovery of the environment from exposure to widespread and persistent chemical pollution is determined by the spatiotemporal emission pattern and storage capacity of and transports in environmental compartments. We studied the 3D exposure of the global environment changing over time in response to historic and future emissions of polychlorinated biphenyls (PCB) and dichlorodiphenyltrichloromethane (DDT), 1950–2099 using the multicompartment chemistry-transport model MPI-MCTM, which encompasses atmosphere (ECHAM5) and ocean general circulation models (MPIOM), dynamic sub-models for atmospheric aerosols and the marine biogeochemistry, two-dimensional surface compartments (topsoil, vegetation surfaces, ice, and temporal snow cover) and intercompartmental mass exchange process parameterisations [1–3]. Future climate evolves in response to the projected greenhouse gas emissions of the SRES A1B scenario (control simulation from fixed 1950s emissions). Future PCB emissions are used as estimated by Brevik et al. [4]. DDT primary usage is assumed to phase out in 2020. Exposure of the global environment by PCBs and DDT in the 21st century is analysed by means of spatio-temporal and compartmental distributions, and long-range transport indicators. By comparing the A1B simulation to the control run the relative importance of future primary emissions on one hand side and a changing climate on the other hand side for POP cycling is discussed.

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# Organic pollutants as important markers for environmental changes in the Arctic

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The effect of climate change on the global distribution and fate of persistent chemical pollutants (POPs) is of growing interest to both scientists and administrative leaders. First significant signs for environmental changes are currently documented and observed for Arctic environments. The unprecedented loss of summer ice coverage in the Arctic is expected to cause tremendous changes to the ice-associated highly specialised Arctic food webs. Currently, the long-term pollutant monitoring programs coordinated by the Arctic Monitoring and Assessment program (AMAP) are picking up already unusual atmospheric pollutant distribution patterns obviously caused (directly or indirectly) by regional climate change in the North. The levels of selected persistent organic pollutant levels (POPs) in biota and in abiotic environmental compartments previously considered as well regulated and on a decreasing trend are recently on the rise again. In this presentation, I will examine and assess environmental pollutant research in the light of the currently observed environmental changes in the Arctic. My evaluations will draw extensively from AMAP long-term monitoring data as well as results from the currently finalised FP7 ArcRisk project “Arctic Health Risks: Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling”. In addition, I will examine evidence of changing chemical processes for a number of environmental compartments and the indirect effects of climate change on contaminant emissions and behaviour. In general, the current situation indicates that the indirect consequences of climate change (i.e. shifts in ecosystem composition, resource exploitation opportunities etc.) will have a more marked impact on contaminants distribution and fate than direct climate change in the Arctic.



# Atmospheric Transport of Persistent Organic Pollutants to the Arctic under Climate Change

Mega Octaviani<sup>1</sup>, Irene Stemmler<sup>1,2</sup>, Gerhard Lammel<sup>1,3</sup>

**<sup>1</sup>Max Planck Institute for Chemistry, Mainz, Germany, <sup>2</sup>University of Hamburg, Institute for Hydrobiology and Fisheries Sciences, Hamburg, Germany, <sup>3</sup>Masaryk University, Research Centre for Toxic Compounds in the Environment, Brno, Czech Republic**

Persistent organic pollutants (POPs) are of great concern not only because they are toxic for human and wildlife but also by virtue of their long residence time and long-range transport potential in the environment. Despite mostly declining primary emissions, there have been reported discernible POP levels in the Arctic abiotic environment during 20th century, thus increasing awareness of climate change impact on their transport to the region. This study is aimed to estimate potential change for the Arctic environment in response to historical and future emissions of three selected POPs, namely polychlorinated biphenyls (PCB28 and PCB153) and dichlorodiphenyltrichloromethane (DDT), using the multicompartiment chemistry-transport model MPI-MCTM [1]. The components of this model include a coupled atmosphere-ocean general circulation model (ECHAM5/MPI-OM), dynamic sub-models for atmospheric aerosols and marine biogeochemistry, two-dimensional surface compartments (topsoil, vegetation surfaces, ice, and temporal snow cover), and inter-compartmental mass exchange process parameterizations. The simulation period was 1950-2100, forced with SRES-A1B emissions scenario from 2000 onwards. As inputs to the model, this study used DDT application dataset from a compilation of global agricultural usage during 1950-1990; no primary emissions were considered after 1990. PCB emissions were based on estimates from [2]. Simulated mass fluxes of POPs into and out of the Arctic for present-year (1970-1999) and future-year (2070-2099) climatic conditions were quantified and localized. In addition, we analyzed simulated changes in the degree of coincidence between POP transport and two large-scale climate patterns, i.e., Arctic Oscillation (AO) and North Atlantic Oscillation (NAO). Our findings revealed that import (export) fluxes are generally passing through Europe, Alaska, and Greenland (west Canada and far east Russia), noted here as the most consistent patterns across POPs towards end of 21st century. The results showed regional dependencies in the transport linkages with AO and NAO, which are mainly characterized by significant positive correlations ( $r > 0.2$ ,  $p < 0.05$ ) over Greenland during winter and spring and negative over Norwegian Sea. There is a trend of an increasing correlation by 0.1-0.2 from present to the future, except for PCB153.

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# Literature reviews on the association between environmental exposures and health outcomes

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Background: A major problem in evaluating and reviewing the published findings of studies on the association between a quantitative environmental exposure variable and a quantitative health outcome is that the results are analyzed and reported in many different ways. The main purposes of this study are as follows: 1) to point out the complexities and potential problems in a critical review of association between a quantitative response variable and one primary quantitative explanatory variable, and 2) to present an effect size approach based on standardized regression coefficients.

Methods: We have carried out systematic literature reviews to ensure comprehensive summaries of the available evidence about the effect of maternal exposure to PCBs and mercury on the birth outcomes of their children. The health outcomes included sex ratio, birth weight and child development variables. The nature of the main finding (effect magnitude and statistically significant or non-significant), the statistical methodology and reporting were reviewed in the case of each article. We outline the complexities involved in synthesizing the associations. We also describe a method how it is possible to transform the findings into a common effect size index which is based on standardized regression coefficients.

Results: The total number of articles reviewed that reported original findings based on statistical analysis was 120. The evaluation showed that there was variation in variable measurement methods, transformations, descriptive statistics and inference methods. Analyses of papers related to environmental mercury and child development revealed multiple comparison problems in several of the original research articles. According to our meta-analysis there was no strong or moderate indication that parental exposure to PCBs alters the sex ratio of the children. Research syntheses were performed summarizing regression coefficients to estimate the effect of PCBs on birth weight. A birth weight decline related to increase in PCB level was found.

Conclusions: Comparison of the effect sizes produced by different statistical techniques is a challenge for readers, reviewers and especially those wanting to carry out a meta-analysis. Our approach based on standardized regression coefficients provides a workable effect size index when inference about the size and strength of effects in published studies are sought. The proposed method can be useful in quantitatively reviewing published

studies when different exposure measurement methods are used or differential control of potential confounding factors is not an issue.

# Enrichment of perfluoroalkyl substances in Arctic sea-ice

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Perfluoroalkyl substances (PFAS) are industrial contaminants that are subject to long range transport and have been reported in the Polar Regions. Here we report concentrations of C4-C12 perfluoroalkyl acids (PFAs) and other PFAS measured in the Barents Sea and the coastal areas of Svalbard in the Norwegian Arctic, as well as the Beaufort Sea region of the Canadian Arctic. Samples of snow, sea-ice and beneath-ice seawater were collected at each site and care was taken to avoid contamination during fieldwork operations. Method detection limits generated from field blanks were generally low (~ND-40 pg L<sup>-1</sup> of meltwater or seawater). C8-PFOA and C9-PFNA dominated the PFA profile in the late-season snowpack averaging 237 and 333 pg L<sup>-1</sup> (snowmelt), respectively. However, in the sea-ice (multi-year ice) a wider number of PFAS were detected and the concentrations were higher than in snow. In the case of PFOA, concentrations in bulk ice exceeded 3500 pg L<sup>-1</sup>, >10-fold higher than levels observed in snow or seawater and differences were also apparent between the upper and lower sea-ice. Enrichment factors of ~30-150 were apparent between 'old' snow and lower sea-ice for density-corrected concentrations, with C6-C12 PFA concentrations in ice-rafted snow and seaice significantly higher than levels in beneath-ice seawater. For coastal fiord ice, the overlying snow showed the highest PFA concentrations whereas the levels in the ice (~30 cm thick) were comparable to those in the water, implying that PFAS enrichment occurs as seaice ages and thickens. Data from the Canadian Arctic also indicate an enrichment of PFAs in fresh snow and seasonal seaice. Significant accumulation of PFAS occurs in sea-ice and in turn this may be driving the concentrations observed in surface seawater in ice-affected regions of the Arctic. Furthermore, the timing of ice melt and associated release mechanisms will play an important role in controlling the exposure of these chemicals to the lower marine food web. Possible mechanisms accounting for chemical enrichment in ice will be presented.

# Persistent organic pollutants in males in the Tromsø study 1979-2007

Therese Haugdahl Nøst<sup>1,2</sup>, Vivian Berg<sup>1,2</sup>, Robin Vestergren<sup>2,4</sup>, Ole-Martin Fuskevåg<sup>3</sup>, Evert Nieboer<sup>1,5</sup>, Jon Øyvind Odland<sup>1</sup>, Torkjel Manning Sandanger<sup>1</sup>

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Introduction: Human exposure to both newer and legacy persistent organic pollutants (POPs) has changed during the last century. Emissions of different POPs have changed over time, and the exposure routes have been through diet for the legacy POPs, whereas other routes have also been important for newer POPs. The legacy POPs were often observed to increase with age in cross-sectional studies and this association was likely reflecting birth-cohort differences in duration and intensity of exposure to these compounds. For newer POPs, conclusions of associations to age have not been consistent. Repeated measurements of individuals offer insight into changes with age, calendar time or birth cohort.

Methods: The present study presents five repeated serum samples from 53 men in the period 1979-2008 analyzed for a variety of POPs (PCBs, organochlorine pesticides, brominated flame retardants, and fluorinated substances). These archived samples originate from the Tromsø Study, which is a population-based health survey in Tromsø, Northern Norway.

Results: The summed concentrations of PCBs and pesticides decreased by 22%, 52%, 54%, and 68% from 1979 to 1986, 1994, 2001, and 2007, respectively. Whereas for the fluorinated substances, the median summed PFAS burdens increased 5-fold from 1979 to 2001 and decreased by 21% from 2001 to 2007. Thus, the composition of POPs in serum has changed over these almost thirty years. Brominated substances constituted little of the POPs burden relative to the other POPs analysed. The assessments of age, calendar time and birth cohort effects showed that calendar time was the dominating influence.

Conclusions: The observed trends during 1979 to 2007 likely reflect the overall trends in use and emissions of the different POPs, and the serum burden of the POPs analysed

increased to 2001 and decreased to 2007. Trends for POPs likely differ depending on their changing emissions in combination with different persistences in sources, environment and humans.

## **The ArcRisk mercury (Hg) case study**

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One of the major objectives of the EU ArcRisk project is to prepare strategies for adaptation and for the prevention of adverse health outcomes related to climate-mediated changes in Hg exposure in human populations in the Arctic and in Europe. These strategies should be proposed in the context of the responses to the main question defined in the project, namely; how will climate change affect the transport of contaminants both to and within the Arctic, as well as their human health impacts in the Arctic in relation to exposed local populations. To address this question, the research components of the ArcRisk project are organized around research work packages comprising (i) the utilization of models to investigate contaminant transport under present and future climate scenarios, (ii) process studies to investigate key parts of the chain linking environmental contamination to human exposure under climate-mediated influences, and (iii) the investigation of available epidemiological databases and human health statistics, in particular those based on cohort studies in both the Arctic and selected areas of Europe, to attempt to resolve the influences on health of contaminants and climate change from the many other determinants of health.

As a good example of integration of data, a case study was prepared for Hg. The case study investigates whether climate change results in an increase or decrease in exposure to Hg in the Arctic and in selected parts of Europe, and if this in turn would affect the risks related to its harmful effects. In order to do so, it outlines the state-of-the art of knowledge on atmospheric Hg emissions from anthropogenic sources worldwide, the long-range transport to the Arctic, environmental fate, human and environmental exposure and effects of Hg in the Arctic under changing climate parameters. It also presents likely synergy effects (e.g., co-benefits) current and new climate change policies and mitigation options might have on Hg emissions reductions in the future.

The ArcRisk results add to the conclusions of the previous research, particularly studies carried out within the AMAP, that Arctic populations are particularly vulnerable to increase exposure to Hg as a result of the climate change in the near future.



# Community-based biomonitoring to detect and monitor climate-sensitive threats to food security in Alaska

James Berner

***Alaska Native Tribal Health Consortium, Anchorage, Alaska, USA***

Alaska has warmed significantly since 1970, with changes in every part of the ecosystem, particularly in the northern and western regions. Changes include warming ocean temperatures; changes in atmospheric transport of anthropogenic contaminants from lower latitude sites; deepening of the active layer of permafrost and freshwater temperatures; movement of species previously found in more southern regions of Alaska into more northern regions; changes in summer and winter ranges of terrestrial species; and the presence of new animal pathogens capable of infecting humans (zoonotic pathogens) into the circumpolar north. These changes have resulted in new human and wildlife health threats in the northern and western Alaska. The economic fragility of Alaskan villages has meant that residents have continued to utilize traditional subsistence species more than any other US population, both for cultural reasons, and in many cases, for reasons of economic sustainability. The results of these changes are potential increases in tissue accumulation of contaminants with adverse effects on health outcomes in animals and human consumers, including immune suppression, and potential exposure to more sick animals, and new pathogens. The dependence of residents on consumption of wildlife, particularly apex predator marine mammals, means residents are exposed to the same risk as the wildlife.

The Alaska Native Tribal Health Consortium has developed a village-based environmental monitoring program, the Rural Alaska Monitoring Program (RAMP), with village residents as environmental observers and biosamplers, using filter paper sampling techniques developed for use with animal blood at the time of harvest, for measurement of antibodies to zoonotic pathogens and mercury in animals. This information enables eventual development of village-specific threat assessment and adaptation strategies. Data from the RAMP will have four outcomes: 1. Continued use of the traditional diet, with the associated cultural, public health and economic benefits; 2. Strategies for risk reduction and identification of emerging threats; 3. trends in contaminant and pathogen prevalence in local and transboundary species for regional, state, federal and international wildlife management agencies; 4. Development of models for predicting the impact of climate regime change on the movement of contaminants and pathogens in the Arctic. These topics, as well as lessons learned from RAMP development, preliminary data, and future development of organic contaminant analysis using filter paper sampling will be presented.

# Community-based biomonitoring to detect and monitor climate-sensitive threats to food security in Alaska

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# Overview of the FP7 project Arctic Health Risks: Impacts on Health in the Arctic and Europe owing to Climate-induced Changes in Contaminant Cycling (ArcRisk)

Janet Pawlak

*AMAP Secretariat, Oslo, Norway*

The EU-funded FP7 project ArcRisk (Arctic Health Risks: Impacts on Health in the Arctic and Europe owing to Climate-induced Changes in Contaminant Cycling) started in June 2009 with 21 partners from 12 countries to study the influence of climate change on contaminant transport and the resultant risk to human populations in the Arctic and other areas of Europe. The project has focused on three main areas: 1) the ways in which climate change will affect the long-range transport and fate of selected groups of contaminants in the Arctic, and possible implications for the re-distribution of contaminants (geographically and between relevant environmental media), involving modelling utilizing the existing information base on the distribution of relevant contaminants in the Arctic and other areas of Europe; 2) investigating the impacts that climate change will have on contaminant transfer and fate in aquatic and terrestrial environments and on contaminant uptake and transfer within food webs, leading to traditional foods consumed by humans in the Arctic, as determined by modelling, experimental work and process studies; 3) evaluating the current levels of contaminant exposure and potential health implications in Arctic populations and selected exposed populations in Europe based on meta-data analysis of large numbers of health studies and several relevant cohort studies, and estimating how climate-mediated changes in the environmental fate of selected groups of contaminants will result in changes in the exposure of human populations in the Arctic. An overview of the methodologies used in the project and the final results will be presented, including a summary of the key scientific messages and lessons learned in the project. Another important aspect of the project has been to bring together the individual results of the three main areas studied in the project into an overall synthesis. As part of this synthesis, case studies have been prepared for mercury and PCBs, following these contaminants from emission, through transport to the Arctic, transfer through environmental media ultimately to the health effects on human populations. Based on the synthesis products, gaps in our knowledge have been identified and policy-relevant messages have been prepared for decision-makers.

# Experiences in communicating contaminant risk in the circumpolar Arctic and internationally

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In the circumpolar Arctic, Inuit populations continue to be exposed to elevated levels of long-range transported contaminants through consumption of some country foods that make up their traditional diet. Communicating the risk of contaminant exposure through the consumption of those foods in the Arctic is of great importance. It is often the only short-term tool at hand for local health officials to achieve reductions in contaminant exposures of local people. However, experience within the last 20 years has shown that communicating contaminant risk is a very sensitive issue that may do more harm than good. For example, poor risk communication practices may result in fear and confusion among local people and can impact healthy lifestyles and behaviors that are associated with the consumption of country foods.

An added complication of communicating contaminant risk arises from the need to address various target audiences which originally may require different messages. However, due to the advancement of the internet, these messages may now reach all audiences at the same time. The different target audiences may include local people that need to change their behavior to avoid contaminant exposure, as well as policy makers, the international communities, and industry representatives that can change processes and/or develop policies to eliminate the possibility of contaminant releases in the first place.

In this paper, the Inuit Circumpolar Council will summarize its experiences with the communication of contaminant risk in the international arena, for example when representing the Inuit perspective at the Stockholm Convention on Persistent Organic Pollutants (POPs), or during the negotiations of the Minamata Convention on Mercury. Perspectives and experiences within Inuit Nunaat, (the four countries that comprise the Inuit homeland) from Alaska, Canada, Greenland and Chukotka, will also be presented.

# Long-term temporal trends of persistent organic pollutants (POPs) at global atmospheric monitoring stations including in the Arctic: effectiveness of control strategies and possible influence of climate change

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Atmospheric concentrations of POPs can be affected by climatic conditions. Therefore, it has previously been hypothesized that time series of atmospheric POPs contain climate change (CC)-signals, and further that CC might inhibit the effectiveness of global control actions, especially in regions where CC is more apparent and pronounced such as in the Arctic. The long-term time series of atmospheric POPs monitored at numerous stations worldwide provide an opportunity to test this hypothesis. In this study, three statistical methods that have been used previously to identify temporal trends and/or attempt to extract CC-signals from time series of atmospheric POPs were critically evaluated. The methods are: log-linear regression, digital filtration (DF), and the improved Mann-Kendall (iMK) test. Results suggest that the DF and iMK methods are more robust for identifying the average long-term temporal trends in time series, and that the DF method is most advantageous to estimate the average long-term halving/doubling times. We applied the DF and iMK methods to a total of 748 time series of atmospheric POPs. Significantly decreasing trends were identified in 560 of the 748 time series collected from the Arctic, North America and Europe, indicating that the concentrations of most POPs in the atmosphere are generally decreasing, which would be consistent with the control actions enacted to restrict or eliminate manufacture, use and emissions being effective in most cases. We applied the same two statistical methods to remove the linear and nonlinear temporal trends from synthetic time series in an attempt to extract CC-signals. Results suggested that previous studies that used the iMK test to infer that trends of atmospheric POPs were affected by CC-driven revolatilization in Arctic regions suffered from methodological artefacts. Results further suggested that the DF method is also not suitable for extracting CC-signals from time series of POP concentrations. We conclude that these statistical methods alone are not suitable for demonstrating the relationships between CC and changes in temporal trends of time series of POPs in any environmental

media. CC-induced effects on POP concentrations may still be observed in the future when longer time series become available, especially in the Arctic.

# Significant reduction in mercury and POP concentrations in pregnant women due to dietary recommendations in the Faroe Islands

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Pilot whale meat and blubber has for centuries been a part of the Faroese diet. The Faroese body burden of pollutants due to pilot whale consumption is high seen in an international perspective. The latest analyses show that the mercury concentration of pilot whale remains high with an average of about 2 micrograms per gram. In the EU, the highest limit value of 1 microgram per gram is only applicable to the most contaminated species of fish. This limit is exceeded by most pilot whales. If we rely on the U.S. Environmental Protection Agency's limit for total dietary intake at 0.1 microgram mercury per kilogram body weight (which is based upon the research carried out in the Faroes), an adult person weighing 70 kg can consume only 3.5 gram of pilot whale meat per day to reach the limit value. Blubber still contains high levels of several persistent organic compounds, such as PCBs and DDE. The average concentrations of both PCB and DDE are higher than 10 microgram per gram of blubber. In regard to PCB, there are several limit values. Most of the limit values regarding PCB are below 1 microgram per gram. It can therefore be concluded that pilot whales today contain contaminants to a degree that neither meat nor blubber would comply with current limits for acceptable concentrations of toxic contaminants. The growing scientific documentation has, during recent years, given rise to the anticipation that the time was approaching when it would be appropriate to recommend against any human consumption of pilot whale meat and blubber. In 2008 the chief medical officer recommended the general population to stop consuming pilot whale. Recent studies have shown that pregnant women eat much less pilot whale meat and blubber than before. This change has resulted in a significant decrease in mercury and POP concentration in the blood of pregnant women. The demonstrated great reduction must be considered a successful outcome of two decades public health communication regarding marine pollutants.

# Are high levels of environmental contaminants in the Arctic impairing human fertility: studies of semen quality and time to pregnancy.

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Background Exposure to persistent organic pollutants as well as some industrial chemicals with short biological half-lives is high in Inuit people. Experimental in-vitro and in-vivo evidence raise concern that these environmental contaminants may impair the fertility but epidemiological evidence is very limited and precludes causal inference.

Objective To examine functional and biological measures of human fertility according to blood concentrations of widespread contaminants.

Methods Within the framework of EU FP5 and FP7 R&D projects (INUENDO and CLEAR) we consecutively enrolled pregnant women and their spouses in Greenland, Warsaw and Kharkiv until a sample size of approximately 600 couples was obtained at each of the three sites. Concentrations of 15 contaminants including POCs, PFCs, PBMPs, phthalate metabolites, bisphenol A, lead, mercury and cadmium were measured in blood samples in women and men. Data on time-to-pregnancy and menstrual cycle characteristics were obtained by interview with the women. Reproductive hormones were measured in plasma and 200 men provided semen samples at each site. Associations between contaminant levels and outcomes including time-to-pregnancy and 22 biological measures of male reproductive function were analysed by logistic and linear regression stratified by region and with adjustment for a fixed set of covariates.



Results Among a total of 310 analyses of cross-sectional exposure-outcome associations a few noteworthy associations appeared when taken consistency across regions, dose-response and multiple comparisons into account. Increased time-to-pregnancy and increased risk of long menstrual cycles were observed in Inuits with the highest exposures to PFOS and PFOA, respectively. In men, PFOS was related to subtle changes of semen quality such as an increased proportion of sperm with abnormal morphology but sperm counts and motility were not affected. The most consistent effects across countries included inverse associations between several phthalate metabolites and testosterone.

Conclusions Overall the study does not indicate that adult exposure to current levels of environmental contaminants including the higher levels in Inuit people have marked influence on male and female fertility. Although these findings are reassuring subtle acute effects with limited reproductive health implications seem to occur.

# Predictors of per- and polyfluoroalkyl substances in a maternal population from Northern Norway

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## Background

Determining maternal concentrations of per- and polyfluoroalkyl substances (PFASs) and the relative impact of various demographic and dietary predictors is important for assessing foetal exposure and for developing proper guidelines for pregnant women in regards to lifestyle.

## Objectives

The aims of the study were to investigate: i) maternal PFAS concentrations and their important predictors in years when emissions of several PFASs decreased, ii) how the dietary composition predicts PFAS concentrations, after regarding the effects of demographic- and time-related predictors.

## Methods

Blood from 391 pregnant women was collected in the period 2007–2009 and serum measurements of 26 ionic PFASs were conducted. Associations between PFAS concentrations, sampling time, and demographic- and dietary-variables were evaluated by multivariate analysis and linear models taking important co-variables into account.

## Results

The number of children was the strongest significant predictor for all the investigated PFASs, where nulliparous women had greater concentrations compared to multiparous women (14 ng/mL versus 6.4 ng/mL in summed PFAS, respectively). The time of sampling was significantly associated with PFHxS, PFHpS, PFOS, PFOA and PFNA, where concentrations decreased throughout the recruitment period. PFNA, PFDA and PFUnDA concentrations were significantly correlated with age. Comparing the highest and the

lowest intake groups of different food stuff demonstrated significantly elevated concentrations of several PFASs in the high consumer groups where; i) high consumption of marine food were significantly associated with concentrations of PFOS, PFNA, PFDA and PFUnDA, ii) high consumption of game was significantly associated with concentrations of PFHxS, PFHpS and PFNA, iii) high consumption of white meat was significantly associated with concentrations of PFHpS and PFOS, iv) while high consumption of salty snacks and beef were significantly associated with PFOA concentrations.

## Conclusions

Individual variations in PFAS concentrations in the present study were predicted primarily by parity, lactation, sampling time and maternal birth year and to a lesser extent by diet. Diet is an increasingly important contributor to human PFAS exposure, but human PFAS burdens are affected by the total dietary composition and not by single food items. Changes in intensity of PFAS emissions have likely lead to predictors with different importance over time.

# **Computational Model of the Inuit Food System in Canada**

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The second half of the twentieth century has witnessed profound change to the environment and food system of Inuit communities across Canada's North. Increasingly, wildlife species consumed as country food are experiencing pressure from anthropogenic stressors, including climate change and the presence of toxic compounds. As the market and traditional dimensions of the Inuit food system are not mutually exclusive, reduced participation in traditional diets – together with the consumption of low nutrient-dense market food alternatives – stands strongly to manifest food insecurity, malnutrition, and disease in Inuit communities. Although a consensus among academics has acknowledged the role of environmental integrity for dietary sustenance and nutritional adequacy, this assertion is often described in exclusively qualitative terms, and would benefit therefore from quantitative support. Drawing on data from the Inuit Health Survey (2007-2008), and previously compiled country food and market food databases (e.g. CINE Nutribase), a linear programming (LP) model was developed to model quantitatively, dynamics of dietary change with respect to environmental, economic and cultural constraints. Preliminary results from the study suggest that for most nutrients, strengthening country food restrictions resulted in a progressive decrease in the nutrient quality of the diets selected by linear programming. This trend was exacerbated by a food budget constraint, with important implications for how environmental change may act synergistically with socioeconomic status, to compound nutritional insufficiencies in Inuit communities. This LP model may be used to develop baseline food security determinations and counsel the public in designing diets that respect cultural norms of palatability, minimize contaminant exposure from traditional food sources, and reflect household economic constraints.

# Arctic contaminant occurrence and effects in a changing climate - a synthesis of the ArcRisk project results

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The ArcRisk project was aimed at quantifying how climate change affects occurrence and effects of contaminants in the Arctic. The research activities included field measurements in various environmental media, modelling of fate and transport as well as assessment of human exposure and effects. The research was focused on a set of contaminants representing both legacy pollutants and newer compounds: PCBs, HCHs, DDTs, Mercury, Perfluorinated compounds, BFRs and other organochlorine pesticides. For these compounds, modelling and/or measurement activities were performed to increase the knowledge of their distribution and fate in the Arctic and to predict the changes induced by climate change. The main research tool for assessment of climate change effects was multi-media modelling and models covering different geographical scales and compounds were applied. The overarching conclusion of the project is that climate change will not have any drastic general effect on the occurrence and impacts of contaminants in the Arctic, although local impacts may vary considerable. Many processes are affected by a warmer climate such as air-sea partitioning, transfer from melting snow and ice to water and chemical degradation, but the overall effect on e.g. presence of contaminants in biota consumed by humans is small to moderate. In the case of banned legacy contaminants such as PCB and HCH, increased partitioning to air will increase the transport to the Arctic but this effect will be offset by future reductions in emissions. Apart from direct effects of climate change, exposure and effects will also depend on potential changes in ecosystem structure, food chain bioaccumulation to species consumed by humans, but these changes were not evaluated in the current project. Another conclusion from the project is that the complexity of contaminant cycling, and the lack of basic information on emission sources, processes related to occurrence and fate introduces large uncertainties in some aspects of the assessment of future transport and bioaccumulation. Uncertainties in estimating the human health risks are also large due to the diversity and complex mechanisms of exposure and impacts of mixtures, and in some cases due to inconsistencies in published experimental and epidemiological research. This is the case for not only new and "emerging" contaminants but also legacy pollutants such as PCB. For improved assessment of future trends and risks, dedicated research and monitoring

programs are needed where selected substance groups are traced from emissions via atmospheric and marine transport and transportation to food chain bioaccumulation, exposure and effects.

# Abiotic and biotic drivers of Arctic food web contaminant bioaccumulation in a changing climate

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Seasonality in Arctic marine food web contaminant concentrations is known from separate empirical and modeling studies, but the link between the two is missing. The aim of the present study was to identify drivers of seasonal contaminant accumulation pattern in the Arctic marine food web, and to use this knowledge to make predictions of food web accumulation in a changing climate. The effect of the annual cycle of exposure, temperature, lipid content and food web structure on  $\alpha$ -HCH, PCB-52 and PCB-153 concentrations and bioaccumulation in an Arctic marine food web (zooplankton, fish and seabirds) from Kongsfjorden, Svalbard, was modeled using the AQUAWEB bioaccumulation model. Results were compared to measured data in the same food web from 2007. The Danish Eulerian Hemisphere Model (DEHM) estimated temperature and contaminant concentrations in air and water in 2007 using real meteorological input data, and projected results for the decade 2090-2099 using climate meteorological data.

When varying only contaminant exposure seasonally, delayed peak concentrations moving into the year and up the food web was found, as also documented with empirical data. Modelled bioaccumulation metrics (trophic magnification factor TMF) however, did not correspond with the observed pattern when only exposure and temperature was seasonally varied. Best fit scenario between modelled and measured bioaccumulation metrics was the scenario with highest ecological relevance, allowing also lipids to vary. In the best fit scenario, food web biomagnification varied seasonally, with lowest TMFs in spring, and highest in summer and autumn, as also found in the empirical 2007 study. As the empirical study hypothesised that trophic changes explained seasonal variation in TMFs, the best fit scenario was expanded to include seasonal variation in trophic relations. Preliminary results indicate that lipid is not the only important ecological driver of seasonal contaminant accumulation (as previously hypothesised for the Barents Sea), but also food web relations and diet composition (as previously hypothesised for the Arctic).

In the future Arctic climate a century ahead, simulated bioaccumulation metrics were marginally higher than at present. Thus, results show that seasonal variation in bioaccumulation is greater than alteration as a response to predicted climate change. As

the best fit seasonal scenario included the annual cycle in lipid content and trophic relations, these physiological and ecological factors are crucial for making sound predictions of contaminant food web bioaccumulation for the future. Changes in abiotic drivers alone are not sufficient to explain food web bioaccumulation on a temporal scale.



# **PCBs in a changing Arctic: Towards understanding their input, transfer and uptake into Arctic biota and humans under climate change - A case study within the ArcRisk-project**

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This presentation will give a review of the current status of emissions, pathways, levels, trends, behaviour and exposure of polychlorinated biphenyls (PCBs) in the Arctic. Levels and distribution processes of PCBs affected by climate change will be discussed based on the measurements and modelling results from the ArcRisk project. PCBs are among the most investigated persistent organic pollutants (POPs) and have been studied extensively as Arctic environmental pollutants for more than three decades. PCBs are also among the best-understood POPs in terms of physical-chemical properties, emissions, pathways and observed environmental concentrations. Therefore, they are valuable as a case study for evaluating the performance of the models and as a benchmark for assessment of how other substances are influenced by climate change. In addition, PCBs have been observed in a variety of Arctic matrices (air, snow, seawater and biota) and human health-related data for the Arctic are available.

The overall aim of our PCB case study is to link sources, pathways/inputs to transfer processes and uptake in biota and finally to assess human exposure and effects - all within a pan-Arctic perspective. This assessment will also include the evaluation of the influences of climate change on the above processes.

In terms of policy issues, even though PCBs have been banned for three decades already, they are still present in large quantities in the environment and they will remain there for at least a century. On-going primary emissions in source regions, as well as secondary emissions combined with 're-cycling' of PCBs accumulated in environmental reservoirs

(sediment, water, soil, snow and ice) will determine the rate of decline of PCBs in the global atmosphere.

Climate change is expected to modify the global transport and fate of PCBs. The forecasted increase in temperature is expected to enhance degradation of PCBs, and increase volatilization from primary sources and environmental surface media, such as oceans and soils. Climate change in the Arctic is expected to add additional uncertainties to the estimates of bioaccumulation potential, as it may not only affect the physical and biological environment, but may also affect the distribution of POPs and their bioaccumulation and biological effects in several ways.

# Body mass index and motor development in young school age children in relation to organochlorine compounds in early life: a prospective study.

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Background and objective: Indications of negative effects of prenatal exposure to organochlorine compounds have been described. Possible associations between early postnatal exposure to organochlorines and child health outcomes have been hypothesized but studies are scarce. Thus, the aim of this study was to investigate the association between maternal pregnancy and estimated infant postnatal serum concentrations of the organochlorines 2,2',4,4',5,5'-hexachlorobiphenyl (CB-153) and 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene (p,p'-DDE) and developmental milestones in infancy and motor development and body mass index (BMI) z-scores in young school-age children.

Methods: Within the framework of European Collaborate R&D projects (INUENDO and CLEAR) maternal sera from the birth cohort (2002-2004) comprising 1 109 mother-child pairs from Greenland, Kharkiv (Ukraine) and Warsaw (Poland) were analysed for CB-153 and p,p'-DDE, using gas chromatography-mass-spectrometry. A physiologically based pharmacokinetic model was used to estimate the first 12 months cumulative exposure to the compounds (N= 1 047). Children were grouped into three groups using tertiles of prenatal and postnatal exposures for statistical analyses. Associations between these compounds and developmental milestones in infancy and motor development and child age- and sex-specific BMI z-scores were calculated at follow-up (2010-2012), using multiple linear regression analysis.

Results: No associations were observed between the tertiles of measured pregnancy and estimated postnatal concentrations of CB-153 and p,p'-DDE and developmental milestones in infancy or the motor skills or child BMI z-scores at young school age. In Ukraine, high pregnancy p,p'-DDE concentration as well as a medium postnatal p,p'-DDE

concentration was associated with lower BMI z-scores at five to nine years in comparison with low concentrations.

Conclusions: This follow-up study of Polish, Ukrainian and Greenlandic populations showed no clear association between pregnancy and estimated postnatal exposure to p,p'-DDE and CB-153 and developmental milestones in infancy or motor development or BMI z-scores at young school age.

# Comparison of human, ringed seal and atmospheric data from Greenland and analysis of geographical trends in exposure to persistent organic contaminants

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Background: Environmental contaminants released to the environment can be transported over large distances via atmosphere, water- and ocean currents. The contamination and uptake of environmental chemicals into the biological food webs and the accumulation in animals and humans are affected by many factors. Generally it is assumed that there is a relationship between contaminant concentrations in the atmosphere, the food chain and human exposure and body burden. For the very first time we present data from the same Greenlandic districts on environmental biota and human together with model calculations of the atmospheric load to the environment.

Methods: This study included: i) Human data for the period 1994 to 2006 from the six Greenlandic districts Ittoqqortoormiit, Tasiilaq, Nuuk, Qeqertarsuaq, Ilulissat and Qaanaaq; and ii) data from ringed seals for the period 1986 to 2010 from Ittoqqortoormiit, Qeqertarsuaq and Avanersuaq / Qaanaaq. Temporal trend analyses for polychlorinated biphenyls (PCBs), 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane (DDT) and its metabolites, chlordanes (CHL), hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), toxaphen, mercury (Hg) and selenium (Se) were performed using linear regression. For atmospheric concentrations, selected persistent organic pollutants (POPs) were measured at Station Nord. Model calculations of  $\xi_{945}$ -HCH and selected PCBs in the air were carried out using the Danish Eulerian Hemispheric Model (DEHM).

Results: For both humans and ringed seals the highest level of PCBs and several other contaminants were found in Ittoqqortoormiit. Also for the atmosphere, the highest PCB concentrations were determined in Ittoqqortoormiit. A significantly annual trend decrease

in contaminant levels were observed for humans from Nuuk and the Disco Bay area and for ringed seals from Qeqertarsuaq (Disco Bay) and Ittoqqortoormiit. The trend decreases were similar for humans (5.7% to 18.4%) and ringed seals (3.2% to 10.0%) for several of the contaminants. Also the emissions of selected PCBs and HCH to the atmosphere were found to decrease from 2000 to 2010. The only significant increase in annual trend for the studied period was found for Se in both humans (7.3%, Disco Bay) and ringed seals (3.5%, Ittoqqortoormiit).

Conclusions: For the analysed period 1986 - 2010 a relation was observed between contaminant concentrations in the atmosphere, the food chain (seals) and human body burden in Greenland as well as yearly decreasing trends for several studied POPs except for Se that had increased.

# Polymorphisms in Phase I and Phase II genes and breast cancer risk and relations to persistent organic pollutant exposure: a case-control study in Greenlandic Inuit women

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Background: The incidence of breast cancer (BC) has traditionally been low among the Inuit, but since 1970's a considerable increase has been observed in Greenland although to a level approximately 60% of the incidence in e.g. Denmark. Previously, we reported that chemicals belonging to the persistent organic pollutants (POPs) such as perfluorinated compounds (PFCs) and polychlorinated biphenyls (PCBs) are risk factors in Breast Cancer (BC) development in Greenlandic Inuit women. Genetic polymorphisms in genes involved in xenobiotic metabolism and in oestrogen biosynthesis and metabolism might modulate the individual susceptibility to environmental carcinogens in relation to developing BC.

Aims: The present case-control study aimed to investigate the effect of polymorphisms in the genes CYP1A1, CYP1B1, COMT and CYP17, CYP19 and the BRCA1 founder mutation in relation to BC risk and to explore possible interactions between the gene polymorphisms and serum POP levels on BC risk in Greenlandic Inuit women.

Methods: The study population consisted of 31 BC cases and 115 matched controls, with information on serum levels of PFCs, PCBs and organochlorine pesticides (OCPs). Genotyping was conducted for CYP1A1 (Ile462Val; rs1048943), CYP1B1 (Leu432Val; rs1056836), COMT (Val158Met; rs4680), CYP17A1 (A1- $\xi$ gt;A2; rs743572); CYP19A1 (C- $\xi$ gt;T; rs10046) and CYP19A1 ((TTTA)<sub>n</sub> repeats) polymorphisms and BRCA1 founder mutation using TaqMan allelic discrimination method and polymerase chain reaction based restriction fragment length polymorphism. The Chi-test was used to compare categorical variables between cases and controls and the odds ratios were estimated by unconditional logistic regression models.

Results: We found an independent association of CYP1A1 (Val) and CYP17 (A1) with BC risk. Furthermore, an increased BC risk was observed for women with high serum levels of PFOS and PFOA and carriers of at least: one CYP1A1 variant Val allele; one variant COMT Met allele; or the common CYP17 A1 allele. No combined effects were seen between PFC exposure and CYP1B1 and CYP19 polymorphisms. The risk of BC was not significantly associated with exposure to PCBs and OCPs, regardless of genotype for all investigated SNPs. The frequency of the Greenlandic founder mutation in BRCA1 was as expected higher in cases than in controls.

Conclusions: The BRCA1 founder mutation and genetic polymorphisms in CYP1A1 (Val) and CYP17 (A1) can increase the BC risk among Inuit women and the risk increase with higher serum levels of PFOS and PFOA. Serum PFC levels were a consistent risk factor of BC, but inter-individual polymorphic differences might cause variations in sensitivity to the PFC/POP exposure.



# Influence of climate change on atmospheric transport of persistent organic pollutants and mercury to the arctic

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We have applied the Danish Eulerian Hemispheric Model (DEHM) to study the impact of climate change on atmospheric transport of Persistent Organic Pollutants (POPs) to the Arctic as well as investigating the major source areas for the transport to the Arctic. The study represents a sensitivity analysis in order to investigate the response of the model system due to climate change.

DEHM is a 3-D atmospheric chemistry-transport model modelling the atmospheric transport of four chemical groups: a group with SO<sub>x</sub>-NO<sub>x</sub>-VOC-ozone chemistry, a group with primary particulates group, a mercury chemistry group, and finally a group with Persistent Organic Pollutants (two HCH isomers and 11 PCB congeners). The model domain covers the Northern Hemisphere and thus includes all important source areas for the Arctic. The spatial horizontal resolution of the model system in this work is 150km x 150km and the model includes 20 vertical levels up to approximately 15km above the surface.

The model system was run with meteorology obtain from ECHAM5/MPI-OM (SRES A1B scenario) for two decades: 1990-1999 and 2090-2099. In this climate scenario the global mean temperature is predicted to increase by 3°C by the end of 2100 relative to the period 1971-2000. The same emissions were applied for the two simulations. It is thus possible to investigate the response of DEHM to a changed climate on e.g. the atmospheric transport of POPs to the Arctic.

Higher temperature leads to a shift of POPs from the surface media to air. Higher temperatures also lead to larger degradation in air as well as in the surface media. This results in lower modelled masses for the 2090s than for the 1990s within the entire model domain for all modelled species. The higher atmospheric concentrations also result in larger atmospheric transport to the Arctic. For the least chlorinated PCB congeners the increased transport is counteracted by the increased degradation and the result is thus approximately 10% less mass within the Arctic in the 2090s compared to the 1990s. The mass of the more chlorinated PCB congeners with a larger affinity to aerosols (and thus less degradation) is up to 20% higher in the 2090s than in the 1990s. The mass of the HCH isomers within the Arctic is up to 30% higher in the 2090s than in the 1990s due to a larger ice free ocean and increased wet deposition.

# Impact of dietary exposure to food contaminants and genetic heterogeneities on the risk of Parkinson's disease

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This study aimed to determine whether dietary exposure to polychlorinated biphenyls (PCBs) and methylmercury (MeHg) increase the risk of developing Parkinson's disease (PD) in the Faroe Islands, where the prevalence is about twice as high as expected. Among suspected environmental causes, exposures to MeHg and PCBs are increased due to the tradition of eating pilot whales that bioaccumulate these neurotoxicants. Further we investigated whether the genetic variants of CYP2D6 and hemochromatosis (HFE) gene are more frequent in PD patients compared with controls in a population, where the prevalence of these variants are increased.

A total of 79 clinically verified idiopathic PD cases and 154 controls matched by sex and age were examined in this case-control study in the Faroe Islands. Blood and hair samples were collected and a questionnaire recorded lifetime information on residence, dietary habits, smoking history, and occupational exposure to solvents, pesticides, and metals

Increased ORs for dietary intakes of whale meat and blubber during adult life were statistically significant. Current serum concentrations of sumPCB and related contaminants suggested slightly increased ORs, although only beta-hexachlorocyclohexane ( $\beta$ -HCH) was statistically significant. The frequency of CYP2D6 poor metabolizers among the patients was not higher compared with the control group. Neither was a difference in HFE genotype or allele frequencies found between the patients and the controls. In conclusion, increased intake of whale meat and blubber in adult life was significantly associated with PD, thus suggesting a positive association between previous exposure to marine food contaminants and development of

PD. However, the study does not support an association between PD and mutations of the CYP2D6 and HFE genes.

# The New Canadian Arctic Contaminants Assessment Report on POPs: Overview and Highlights

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This presentation will focus on highlights and conclusions from a recently completed assessment of persistent organic pollutants (POPs) in the Canadian Arctic conducted by the Northern Contaminants Program (NCP). The assessment is a companion to assessments of Mercury (Chételat and Braune NCP 2013) and Human Health (Donaldson et al. STOTEN 2010). It draws on results from monitoring of POPs under the NCP (2003-2011) as well as on any other published or unpublished studies up to early 2013. This 10 year reporting period has seen much new knowledge developed on temporal trends of legacy POPs and new/emerging POPs in air and biota, including species of dietary importance to aboriginal people, as well as on ocean transport to the Arctic. Over this period the list of individual compounds analysed was expanded particularly for perfluorinated chemicals, brominated flame retardants and current use pesticides. About 35 chemicals or groups that were not previously reported or for which only limited measurements were available in the previous assessment have been detected. Results for air monitoring indicate that many legacy POPs i.e. organochlorine pesticides (OCPs) and PCBs, are declining. Results for air sampled at Alert, on Northern Ellesmere Island, indicate that the rates of decline for the legacy POPs were generally more rapid in the period 1993 to 2001 compared to 2002 to 2009 (the most recent year reported). While overall trends (1993 -2009) for PCBs in air show a decline, the rates have slowed and some more highly chlorinated congeners have increased slightly in recent years. The declining trends in concentrations in biota are most apparent for OCPs and less evident for PCBs. Percent annual declines of DDT ranged from 2.5%/year in thick-billed murre eggs to 11%/year in polar bear fat. New POPs such as PBDEs and PFOS generally increased in seals, seabirds, beluga, and polar bears from the 1990s until the early 2000s and are now declining. Hexabromocyclododecane was undetectable in biological samples from the 1990s but increased during 2005-2012 for freshwater fish, ringed seals, and polar bears. Annual sampling has been instrumental in demonstrating the rise and fall of new POPs, improving the statistical power of trends of legacy POPs, as well as in allowing investigations of the effect of climate change. Results of the assessment demonstrate the effectiveness of international regulations such as the Stockholm Convention and also provide valuable information on new POPs for addition to the Convention.

# The 2013 Minamata Convention and Protection of the Arctic Environment: Mercurial Promises and Challenges

David VanderZwaag

*Dalhousie University, Halifax, Nova Scotia, Canada*

The Minamata Convention on Mercury, adopted at a diplomatic conference in Japan 9-11 October 2013, aims to curb the long-range transport of mercury into the Arctic. After highlighting the role of Arctic Council States in laying the scientific and political foundations for negotiation of the new treaty, this presentation will review what might be described as two mercurial realities in the wake of the Convention, the offering of substantial mercury pollution reduction promises and the raising of numerous implementation challenges.

Promising approaches of the Minamata Convention to be described include:

- Phasing-out of primary mercury mining for each Party
- Restricting exports of mercury to non-Parties
- Phasing-out by 2020 listed mercury-added products, such as batteries (except for certain button batteries), switches and relays, some fluorescent lamps, and cosmetics and soaps
- Prohibiting the use of mercury in listed manufacturing processes, specifically, in chlor-alkali and acetaldehyde productions (by 2025 and 2018 respectively)
- Restricting the use of mercury in various manufacturing processes such as the production of vinyl chloride and polyurethane
- Requiring national action plans to reduce and where feasible to eliminate the use of mercury and the releases of mercury from artisanal and small-scale gold mining
- Controlling and reducing mercury emissions to the atmosphere for listed point source categories, such as coal-fired power plants and waste incineration facilities

Key implementation challenges to be highlighted include:

- Getting countries to ratify the Convention in a timely manner with 50 ratifications/acceptances required for the Convention's entry into force
- Ensuring adequate financial and technical assistance to developing countries in light of the Convention's overall voluntary funding approach
- Phasing-out primary mercury mining in a timely way since the Convention allows a 15 year phase-out period from the time of entry into force of the Convention for a Party
- Controlling the use of exemptions available to Parties to delay by five years and possibly 10 years the phase-out dates for mercury-added products and using mercury in chlor-alkali or acetaldehyde production
- Ensuring effective reduction of mercury emissions and releases in light of the broad flexibility and discretion left to Parties in taking management measures
- Developing guidance on what constitutes best available

techniques and best environmental practices for controlling emissions and releases• Forging national implementation plans as implementation plans are optional under the Convention

The presentation will conclude with an overall assessment of the Minamata Convention and its potential for protecting human health and the environment in the Arctic.

# Environmental exposure to widespread contaminants

Bo Jönsson<sup>2</sup>, Christian Lindh<sup>2</sup>, Lars Rylander<sup>2</sup>, Gunnar Toft<sup>3</sup>, Birgit Bjerre Høyer<sup>3</sup>, Henning Sloth Pedersen<sup>1</sup>, Jens Peter Bonde<sup>4</sup>, Marcello Spáno<sup>5</sup>, Valentyna Zvezda<sup>6</sup>

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Background: People worldwide are exposed to a large number of environmental contaminants. Many of these may have an impact of the human health. However, the knowledge about the exposure levels of these chemicals in many countries is still insufficient or even unknown which limits the possibility for risk assessment and risk management.

Aim: To measure the concentrations of several different environmental contaminants in blood serum from people living in three different areas of the world.

Methods: In the European Union financed project Inuendo and Clear we have monitored the levels of many different environmental contaminants in serum from pregnant women and their men from three different populations, one Polish, one Ukrainian and Inuits on Greenland. The contaminants monitored were the PCB CB-153, the DDT metabolite p,p'-DDE and hexachlorbenzene (HCB), eight brominated flame retardants, eight perfluorinated chemical (PFCs), six metabolites of the phthalates from diethylhexyl phthalate and diisononyl phthalate, bisphenol Results and Comments: The CB-153 levels in the Inuits were among the highest reported in the world but low in Poland and Ukraine. In Ukraine the levels of p,p'-DDE was about two times those in Poland and the Inuits. However, the exposure was much lower than in regions where DDT is still used. The levels of HCB were high in Inuits and in Ukraine but low in Poland. The exposure to brominated flame retardants were higher in the Inuits than in Poland and Ukraine but low than those found in the US. Inuit men showed levels among the highest reported in a general population in the world for several PFCs, e.g. perfluorooctane sulfonate (PFOS). The PFC levels found in Poland were similar to other western countries while those in Ukraine were lower. The levels of phthalate metabolites were similar in the three regions and also to the rather few studies performed in the US and Europe. Amazingly high levels of bisphenol A were found

in the Inuits compared to the other populations and elsewhere in the world. This has to be further investigated. Smoking was frequent in the Ukraine and among the Inuits.  
Conclusion: Exposure to several environmental contaminants seems to be particularly high in the Inuit population whereas the Polish and Ukrainian population seem to have an exposure in the same range as many western countries.



# Mercury exposure in a sub-arctic population 80 years ago

Marthe T. S. Jenssen<sup>1,2</sup>, Thorjørn Larssen<sup>1</sup>, Hans Fredrik Braaten<sup>1</sup>, Inger Njølstad<sup>2</sup>

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Mercury exposure to humans from consumption of fish and sea food is a global concern. Mercury releases to the environment from human activities have increased over the past several hundred years. Along with the historical increase in releases, concentrations of mercury in the environment has also increased. As mercury undergo long range transport, elevated concentrations can be found in the environment far from the sources, including in the Arctic. Samples from museum collections, such as, teeth from humans and marine mammals, hair from polar bears and feathers from birds, have shown that mercury concentrations increased rapidly from around 1900.

Historical samples of biological material are scarce and usually only available from a very limited number of individuals . We have come across a set of several hundred human hair samples from a remote population in sub-arctic Norway (a coastal village in Finnmark County) collected as part of a tuberculosis study in the period 1928-1932. A sub set of 218 samples covering all age groups and both sexes was analysed for methyl mercury.

Mean hair methyl mercury concentration was 1.5 mg kg<sup>-1</sup> (median 1.3 mg kg<sup>-1</sup>; range 0.3-6.1 mg kg<sup>-1</sup>). A comparable modern day population (sampled in Tromsø in 2007-2009) had mean hair mercury concentration 1.3 mg kg<sup>-1</sup> (median 1.0 mg kg<sup>-1</sup>; range 0.02-11.9 mg kg<sup>-1</sup>; n=4973). The relatively similar mean concentrations in the data from around 1930 and from 2007-2009, despite that concentrations of mercury in fish around 1930 were considerably lower than today, are probably due to higher fish intake and hence similar total mercury exposure 80 years ago.

Contrary to the modern day population, the data set from around 1930 shows no differences between sex or age groups. Modern day data typically show increasing concentrations with age and higher concentrations in men than women. The differences between sex and age groups in the modern day population can be explained by food consumption habits. The lack of differences between sub groups in the old data probably shows that there were minor differences in food consumption habits, related to high dependency on local fish and limited choice of food due to poverty and relative geographical isolation at the time.

# Marine dispersion of pollutants in the Arctic Ocean: identification of key drivers

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A dominant factor in the dispersion of marine pollutants is the ocean circulation. In the Arctic Ocean the upper ocean circulation is governed by the anticyclonic Beaufort Gyre and the Transpolar drift. The strength and position of these circulation systems determine pathways, vertical distribution, concentration, residence times and exposure of dissolved substances, and itself are subject to strong variability on the pentadal to decadal timescale. Depending on the spatial input function (e.g. marine point sources or atmospheric deposition) and the chemical/physical characteristics of pollutants, additional factors like suspended matter distribution and transport, ice transport and ice melt pattern play an equally important role.

Unveiling the key drivers of the relative role of these processes is essential to understand past and present day distribution and exposure patterns of pollutants, as well as to enable a well-founded interpretation of potential future scenarios. This holds for remote source of pollutants like those stemming from West European sources, as well as local sources, e.g. releases from ships or fixed installations in the Arctic.

We present examples of numerical simulations for the dispersion of different classes of pollutants as they were subject to investigation e.g. in the EU FP7 project ArcRisk (PFOA, PCB153) and contrast them with the dispersion of Iodine-129, an anthropogenic radionuclide released in West European waters, the distribution of which is reasonably well enough documented in the central Arctic Ocean to allow for model validation. We identified regional and large scale windstress patterns (surface stress curl, AO and NAO indices) and ice drift and melt pattern changes which determine the fate of these pollutants.

The hindcast simulations we present are performed with the well validated regional coupled ice-ocean model NAOSIM. The results serve as baseline studies for the interpretation of fully coupled climate models of present and future climate states, the implications of which will be discussed.

# Human concentrations of persistent organic pollutants and health outcomes in the Mediterranean region. Comparison to Arctic exposures and effects.

Joan Grimalt

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The present study summarizes the information available on exposure to persistent pollutants organic compounds of human populations living in the Mediterranean area, from 2000 to present. The report also describes the current knowledge on the effects of these pollutants on human health. A substantial part of the information included in this study is related to the research activities of scientists participating in the ArcRisk project.

In addition to information on adult populations, data on newborns has specifically been considered. Infants in the initial formation stages are particularly sensitive to chemical insults because their metabolism and tissues are under development, e.g., the nervous system. Thus, metabolic interferences by pollutants may have serious effects on their future health.

The report is concerned with the most abundant persistent pollutants. These include pentachlorobenzene (PeCB), hexachlorobenzene (HCB), hexachlorocyclohexanes ( $\alpha$ -,  $\beta$ - and  $\gamma$ -;-HCH isomers), DDT and metabolites and polychlorinated biphenyls (PCBs). These compounds are responsible for a large proportion of the known deleterious health effects attributed to chronic exposure to organic chemicals.

Other pollutants of recent use and public health concern such as the polybromodiphenyl ethers (PBDEs) have also been considered. Like PCBs, they also constitute complex mixtures of congeners and the report includes a large number of them, including BDE209 in which all hydrogen atoms are entirely substituted by bromine atoms. This congener is the dominant compound in the commercial mixture of deca-bromo-PBDEs. The other congeners selected are main constituents of the penta- and octa-bromo-PBDE commercial mixtures but several of them may also originate by degradation of more highly brominated diphenyl ethers.

In most cases, the samples considered for study are serum from venous blood in adults and serum from cord blood in newborns. The pollutant concentrations in these materials are representative of the body burden of these compounds. Serum cord blood concentrations reflect the in utero exposure of children. Data available on organochlorine compounds in human milk has also been considered.

The irregular geographical coverage of the populations from the Mediterranean region constitutes one obvious difficulty when compiling this report. A combination of studies on

blood serum and breast milk allows a better spatial description of Mediterranean countries.

The concentrations observed in the Mediterranean areas have been compared to those from other populations, particularly those from Arctic regions. The differences between diverse populations included in these two groups have been explained in relation to environmental and diet factors.

# Risk Communication in the Arctic: an International Perspective

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The Arctic Monitoring Assessment Program (AMAP) was established in 1991 to monitor identified pollution risks and their impacts on Arctic ecosystems. Special priority has been placed on the potential impacts of contaminants on the health of Arctic residents (both indigenous and non-indigenous to the region) in response to concerns about human exposure to elevated levels of contaminants in fish and wildlife that are important to the traditional diets of northern peoples. In 2009, the AMAP Human Health Assessment Report included a Risk Communication chapter describing health advisories to communities within many of the circumpolar countries, as well as the types of methodologies and impact of risk communication messages.

The Arctic Monitoring and Assessment Program (AMAP) Human Health Assessment Group (HHAG) has recently completed a circumpolar risk communication research report in an effort to update and expand upon the risk communication research presented in the 2009 AMAP Human Health Assessment Report. A comprehensive review of literature on circumpolar risk communication was conducted. The report also looked at risk communication practices of some non-arctic agencies concerning contaminants and food.

The purpose of this presentation is to highlight opportunities for future risk communication activities and share experiences and lessons learned from different perspectives and agencies, based on the risk communication work conducted under the AMAP HHAG.

# Shipping & offshore in the Arctic

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## Scientific committee

Leader: Professor Tor Einar Berg (Convener), Marintek/SINTEF, Norway  
Tor Husjord, Maritimt Forum/Norwegian Shipowner Association, Norway  
Eija Kanto, Wega Enviro Oy, Finland  
Managing Director Østen Mortvedt, Troms Offshore, Norway  
Professor Egil Pedersen, University of Tromsø, Norway  
Senior advisor Gunnar Sander, Fram Centre, Flagship Polhav, Norway  
Senior advisor John Evensen, Kystverket, Norway  
Manager Frigg Jørgensen, AECO, Norway  
Mia Bennett, APECS & University of Cambridge, UK

# Satellite Communications in the Arctic

## User requirements and possible technical solutions

Hege Lunde

### ***Telenor Satellite Broadcasting AS, Oslo, Norway***

Activity in the Arctic is increasing, and ranges from shipping, oil and gas, seismology, fisheries, search and rescue services, environmental monitoring, meteorology, travel and tourism, and research, to activities by the authorities and public administration.

Increased activities in the High North mean that there is a growing demand for broadband coverage. Large parts of the Arctic are currently not covered by communications satellites capable of satisfying future data communications needs.

Telenor Satellite Broadcasting AS and the Norwegian Space Centre are running a joint project in order to look into user requirements and satellite communications solutions for the Arctic and High North. The project 'Arctic Satellite Communications' (ASK) is intended to run for two years and started in the fall of 2012.

Communications in the Arctic today

In the high north, the following communications services are available:

- Satellite voice telephony
- Radio and weather forecast
- marine radio and emergency calls
- narrowband 0,1 mbps

The High North does not have

- Broadband
- Military data capacity
- Capacity to send:
  - maps
  - photos
  - videos
  - seismic data
  - environmental data
  - weather data

## Challenges at the top of the globe - satellites the only solution

- Satellites in orbit over the equator do not cover the Arctic because of the curvature of the earth. Coverage is poor from 72°N, and there is no coverage whatsoever north of 78-79°.
- Oil: New exploration blocks on the Russian side, such as those in the perseyevsky Field, are in a satellite shadow. This is also the case for large areas of the Fisheries protection Zone around Svalbard. Marine traffic density is highest in Norwegian waters (as much as 80% of the marine traffic in the High North is in Norwegian waters)

In the presentation we would like to address the results from the work on user requirements so far, including the key results from a study completed by Marintek. We will also address the possible technical solutions that have been identified.



# **Technology related challenges for shipping and offshore operations in Arctic waters**

Sören Ehlers

***NTNU, Trondheim, Norway***

Arctic shipping and offshore operations must be safe to ensure a sustainable use of the sensitive Arctic environment. However, the required safety level is not yet known in spite of a continuous increase of shipping and operations in this region. This increase is significantly influenced by the current trend of diminishing ice coverage, which extends the operational window in areas inaccessible in the past due to ice coverage. Consequently, the challenges associated with Arctic shipping and operations, such as the lack of design relevant load data or long distances must be surpassed in order to identify and ensure adequate safety and economical feasibility. Consequently, this presentation seeks to present selected challenges and identify their influence on the vessel design.

# **Status, Gaps and Outlook of Marine Infrastructure in Arctic Littoral States**

Kathrin Keil<sup>1,2</sup>

***<sup>1</sup>Institute for Advanced Sustainability Studies (IASS), Potsdam, Germany, <sup>2</sup>The Arctic Institute, Washington, DC, USA***

In order to know which adaptations and new investments are necessary in Arctic maritime infrastructure in reaction to increasing business and recreation activities in Arctic waters, a thorough overview and assessment of existing infrastructure assets is inevitable. This paper, as part of the research project "The Arctic Infrastructure Survey" currently conducted by The Arctic Institute, provides an overview of key infrastructure in the six littoral Arctic states, which include the US, Canada, Greenland (Denmark), Iceland, Norway, and Russia.

The most significant economic activities in the years ahead are indeed maritime activities. These concern in particular extraction of oil and gas resources on Arctic continental shelves, Arctic shipping especially along north-eastern routes as well as expansion of Arctic tourism, and potentially increasing activities in traditional fishing areas (exclusive economic zones) but possibly also in Arctic international waters. These activities are inextricably linked: increasing exploitation of offshore oil and gas resources requires equipment and new and extended transport options to bring these resources to markets, for example in form of LNG tankers or underwater pipelines. Fishing activities are necessarily linked to shipping, for capturing, processing and transport. Additionally, new trading routes and growing Arctic tourism increase shipping activity in the Arctic. Appropriate and efficient maritime infrastructure is often also dependent on onshore (especially coastal) infrastructure such as onward-transport systems, airports and runways, and supply and storage facilities.

This paper provides an overview of the present state of oil and gas, shipping and fishing infrastructure in the six countries, including maritime as well as relevant onshore assets. This in turn provides the basis for a gap and outlook analysis. Although there are huge variations between the Arctic states in the current status of their infrastructure, their oil and gas, shipping, and fishing infrastructure are areas that will hold an exceptionally prominent role in any Arctic activities in the coming decades.

The paper argues generally that predicted increases in human activity will place new, more strenuous demands on the infrastructure required to achieve both safe economic activity and protection of the environment. In most areas in the Arctic infrastructure is currently insufficient to meet the expected demands of economic development. It is likely that public/private cooperation, as well as continued international cooperation among the Arctic states, will be needed to provide and sustain this infrastructure.

# IMO e-navigation and the Arctic challenges

John Erik Hagen, Ole Kristian Bjerkemo

***Norwegian Coastal Administration, Haugesund, Norway***

IMO e-navigation and the Arctic challenges

Navigation in Arctic waters - special conditions

As the environment of the Arctic is changing, we will see increasing activities within offshore petroleum activities, cargo transport along The Northern Sea Route as well as in fishery and tourism. The Polar Regions cover large areas and is navigationally considered as remote. The distances between the settlements or special purpose stations are large and the lack of infrastructure and suitable ports along the route renders ships unable to receive timely assistance in case of mechanical breakdowns or damage. The consequences of an accident may be greater in a polar area compared to more densely navigated waters, where search and rescue facilities are seldom far away. In addition to this, an accident could have a serious impact on the vulnerable polar environment.

Increasing maritime activities along remote and less populated areas require greater focus on vessel safety and also places new demands on communication infrastructure to support safe marine shipping, protection of the environment and response to emergencies.

The development of the IMO e-navigation concept has identified a lack of seamless communication means for exchanging navigation information in these areas. An e-navigation workshop last year, which carried out a trial voyage with the Norwegian Coastal Express ship "Fram", while on a cruise in the Arctic, confirmed that there is a crucial need to improve the infrastructure for communication to exchange electronic information and thereby ensure safety and efficiency in the polar region.

e-navigation is a concept to support and improve decision-making through maritime information management and it aims to:

Facilitate the safe and secure navigation of vessels by improved traffic management, and through the promotion of better standards for safe navigation.

Improve the protection of the marine and coastal environment from pollution.

Enable higher efficiency and reduced costs in transport and logistics.

Improve contingency response, - and search and rescue services.

Enhance management and usability of information onboard and ashore to support effective decision making, and to optimize the level of administrative workload for the mariner.

# Winterization of ships and offshore units for safe Arctic operations

Knut Espen Solberg, Ann Christin Hovland, Steven Sawhill

***DNV GL, Høvik, Norway***

Operations in Arctic waters subject ships and offshore units to the adverse effects of ice, icing, freezing and wind chill. New players with less cold climate experience are entering the Arctic, and they need guidance on how they in an efficient and safe manner can operate in waters where there are additional Arctic challenges.

DNV GL helps the maritime and offshore sector through its guidelines on ice strengthening and winterization. This year, DNV GL released two new standards for winterization. They were developed to ensure that vessels and offshore structures are capable of and suitably prepared for operations in low temperatures. This is provided for by setting requirements to important systems, equipment intended to be in operation in the specified design environmental condition. These standards are valuable for new actors with less experience to reach the safety level required for operating in the Nordic Arctic Region. Shipyards, sub-contractors and owners should all have a common understanding and platform reflecting the additional Arctic challenges and the operational and design solutions that need to be implemented to reduce this Arctic challenges down to as low as reasonable practicable level.

There is still a need for innovation to further improve the safety and efficiency of operating in the Nordic Arctic Region. DNV GL is currently engaged in several initiatives. These include:

Safe Arc - JIP to assess utilization of podded propulsion in ice covered waters with regards to the need for updating the current regulatory framework and efficient design

ColdTech - Research project to investigate the challenges related to marine activities in Arctic waters, with a special focus on iceridges.

MarIce - Research project to further understand the physics of marine icing

DYPIC - JIP to assess the ability of dynamic positioning systems to predict and counter the effects of moving sea ice and to function in sub-zero temperatures.

# Options for Regional Regulation of Merchant Shipping Outside IMO, with Particular Reference to the Arctic Region

Erik Molenaar

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The main objective of the United Nations Convention on the Law of the Sea (LOS Convention) on the international legal regime for merchant shipping is to ensure global uniformity in the regulation of international shipping. 'Competent international organizations' are given a key role in implementation by means of standardsetting. These are primarily global bodies.

The LOS Convention safeguards the primacy of global regulation by allowing unilateral coastal state prescription in only a few situations, for instance certain types of standards in the territorial sea, a broader range of standards in ice-covered areas and - provided IMO approves - various standards in various maritime zones. Moreover, general international law - as confirmed by the LOS Convention - grants foreign vessels no general right of access to ports and recognizes a port state's wide discretion in exercising prescriptive and enforcement jurisdiction.

While the mandate of IMO has gradually expanded since its establishment in 1958, it is by no means comprehensive. IMO's efforts in the domain of fostering compliance have also been modest and at any rate do not preclude action at the regional level. Finally, while the LOS Convention gives IMO a broad mandate for implementation and for adjusting the jurisdictional balance to the adjusting needs and interests of the international community, various law of the sea issues that are closely related to merchant shipping have so far not been dealt with by IMO.

The mandate of the Arctic Council pursuant to the 1996 Ottawa Declaration is very broad and also encompasses merchant shipping. Key Arctic Council outputs are the 2009 Arctic Marine Shipping Assessment (AMSA) and the 2013 Arctic Ocean Review (AOR) project. The policy and regulatory recommendations contained in both have, among other things, led to two regional legally binding instruments - thereby giving rise to the so-called Arctic Council System (ACS) - and others are still being implemented.

In view of the jurisdictional balance of the LOS Convention as well as the mandate of IMO and the extent to which that mandate has been utilized so far, the following are the main options for regional regulation of merchant shipping in the Arctic region:

- (a) Regional implementation of global instruments;
- (b) Exercising uniform, residual flag, coastal and port state prescriptive jurisdiction in concert;

(c) Initiatives to enhance compliance with IMO and other instruments; and

(d) Resolving the main regional law of the sea disagreements & disputes relevant to merchant shipping.

# Maritime Safety Measures in the Norwegian Arctic Waters

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Analysis of maritime monitoring data shows that the major part of the vessel traffic in the Arctic area is concentrated in the waters near the Svalbard Islands. Norway is implementing a number of risk-reducing measures in the Barents Sea and in the Svalbard area.

Following a maritime risk analysis of the Svalbard area, Norway implemented mandatory pilotage at Svalbard in 2012 in a step-by-step approach where full implementation is reached in 2015. This includes a Pilotage Exemption Certificate regime, giving Norwegian authorities control of the navigators knowledge and qualification.

In 2007 Norway established Vardø VTS as a monitoring and VTS service for the Norwegian EEZ. The Svalbard Fisheries Protection Zone is included in the Vardø VTS area of responsibility. Since 2010 the VTS has been supported by satellite based maritime monitoring in the area through use of the unique Norwegian AIS satellite. Vardø VTS operates NAVAREA IX, monitors IMO mandated routing measures and controls the Tug emergency preparedness as part of its mission.

Building on the Røst to Vardø ship traffic separation system established in 2007, the Russia-Norway co-operative IMO Mandatory Ship Reporting system – Barents SRS – was made operational in June 2013 and enables VTS authorities at Vardø and Murmansk to improve monitoring of high risk vessels passing through the southern Barents Sea.

Charts related to glaciers have unknown dangers, as the glacier front might change the seafloor, or retract and reveal uncharted territory. Glaciers also deposits mud and sand on the bottom, affecting underwater clearance for ships. These factors also change over time. The Norwegian Coastal Administration and the Norwegian Hydrographic service has jointly investigated ways to facilitate more effective mapping in Arctic areas; where narrow corridors along some relevant shipping lanes are mapped, while the surrounding areas are not prioritized.

Norway is building the Barents Watch, a comprehensive monitoring and information sharing system for ocean and coastal areas. The Norwegian Coastal Administration (NCA) has established a system that automatically generates statistics from AIS and transfers this into a database, identifying trends in ship traffic in the Norwegian waters. Satellite AIS data is now included in the system, and an Arctic module is released soon.

The presentation will give an overview of these measures. It will offer operational experience on some aspects and discuss their overall effects on reducing the maritime risk



in the area. Maritime safety is a continuous mission, and some additional measures for future implementation will be discussed in the perspective of the National Transport Plan.

# Managing and communicating the broader Arctic risk picture by linking risk perceptions and risk assessments

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***DNV GL, Høvik, Norway***

For the oil and gas industry, the Arctic represents the convergence of many of the challenges it can expect to face in the coming decades, including harsher environments, a more complex stakeholder picture, and stronger public scrutiny on the industry's safety and its impact on the environment. The same holds for the maritime industry, which will need to ensure reliable operation, minimal environmental impacts, and vessel, cargo and passenger safety in increasingly hostile and remote environments.

Regulators and policymakers need a better decision basis for understanding the risks associated with Arctic development. The Arctic is not a monolithic area – it is highly variable with regards to resources and conditions – yet it much more complex, sensitive and harsher than any area in the world. Therefore, in addition to managing the technical and operational risks, operators must understand and adapt to stakeholders' perceived risks throughout the Arctic value chain. At the end it will be society's perception of risks in the Arctic that will define the industry's license to operate. In parallel, the industries must provide trust that they can manage the risks. The work performed in the Barents2020 Harmonisation of HSE standards for the Barents Sea will be used as an example for approaching the issue of risk management in the arctic region.

The paper presents findings from a public survey on attitudes to maritime and petroleum activities in the Arctic conducted among the population in Alaska (N=520) and Norway (N=779) in the Autumn of 2013, and discusses how knowledge on risk perception and attitudes can be used to improve communication about risk in the Arctic and hence lead to a better decision basis.

The paper also presents a GIS based risk tool as a communication platform for risk, mapping, analyzing and visualizing ice and metocean data, biological data and activity data. The multivariable approach helps us to assess the individual variables layer by layer, or for a particular grid cell. An integrated approach is suggested, combining visualization capabilities, analyzing methods, algorithms, and structured integrated databases. The application is focused on giving support when considering operations in different Arctic areas and communicating risk issues to a diverse audience.

The paper also discusses discrepancies between risk perceptions and risk studies, using maritime and offshore activities as a case. The paper concludes with suggestions on how to close these gaps. The paper includes a brief description of risk assessment methodology.

# **Institutional interplay in Arctic shipping governance role of the Arctic Council in the development of the IMO's Polar Code**

Piotr Graczyk

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Shunning regionally fragmented regulations is a predominant policy of key actors in marine shipping. This has been evinced both in the UN Convention on the Law of the Sea (UNCLOS) and within numerous treaties under the International Maritime Organization (IMO). Although these global institutions and instruments constitute a foundation and source of shipping regime on the World Ocean, they also envisage specific arrangements for distinctive regions such as the Arctic. This, in turn, instigates efforts of policy harmonization and coordination among the region's states to ensure that regulations on the global level are consistent with their interests. Probably the most efficient way is to utilize multilateral collaborative structures.

Primary forum for intergovernmental cooperation in the region is the Arctic Council (AC). The body continuously develops its capacity in Arctic shipping governance, what has been signified i. a. by the AC's Arctic Marine Shipping Assessment (AMSA) and more recently the Arctic Ocean Review (AOR) report as well as the follow-up actions on implementation of AMSA and AOR recommendations. Some of them are followed up upon in the AC and others are consigned to appropriate international institutions, such as the IMO. One of the most salient points in this process is work on the mandatory International Code for Ships Operating in Polar Waters (Polar Code) that is expected to address safety and environmental concerns related to marine transport in Arctic conditions.

This presentation will examine how the AC has attempted to influence the Polar Code process and will identify the main features of the interaction mechanism between a regional soft law body and an UN specialized agency. Following a brief account on the hitherto activities related to shipping in Arctic waters and implementation of the AMSA recommendations, it will examine both formal and informal possibilities for interplay between the two institutions. In this endeavor it will draw on the theoretical concepts of regime (institutional) interplay and regime complexes in an issue area governance. Furthermore, the AC's ability to influence Arctic states' actions and policies in other institutions will be characterized. This, in conclusion, will form a more general picture of the AC's role in governance of shipping in the Arctic and its broader consequences for international relations in the Arctic.

# Arctic Shipping Challenges

Nataliya Marchenko

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For many decades people have tried to master the Northern East Passage; this route from Europe to Asia and contrariwise is much shorter and faster than south ways via Suez or around Africa. In recent years the interest has grown significantly due to rising of oil/gas activity in the North, forecasts of global warming, and the risk of pirate's attacks in South Regions. Moreover the set of recent actions of Russian Government (new tariff policy; new Federal Law on Northern Sea Route (NSR), July 2012; new rules for navigation, January 2013; establishing of NSR administration, April 2013) has opened the Northern East Passage for foreign ships and transit navigation. Subsequently traffic increased dramatically. By mid-October 2013 NSR administration issued 610 permissions to sail in NSR water area; 40 voyages have been completed and transported cargo has reached one million ton.

Despite the expectation of ice free Arctic, ice conditions in 2013 were rather difficult and Vilkitsky Strait was closed by ice for nearly the entire navigational season. There are strong demands for vessels to sail NSR regardless of the many accidents which have occurred in 2012-2013. Two tankers had been dented by ice in 2012; one tanker got a hole and the real danger of leakage and ecological disaster existed in September 2013.

Arctic Shipping is a big challenge due to heavy ice conditions not only in winter. Sea ice can significantly affect shipping, drilling, handling of platforms and terminals. It is therefore essential to have appropriate knowledge of sea ice properties and operations in ice conditions to analyze previous experience.

Four seas of NSR (Kara, Laptev, East Siberian, Chukchi) and ice induced ship accidents in XX century have been examined in the book [1]. An additional investigation has been performed for more recent accidents and for the Barents Sea. The main complications with navigation in the Barents Sea are due to icing, storms and icebergs in the north. The ice massifs and ice jets are the most dangerous phenomenon along the NSR. The accidents in the Arctic Seas have been classified, described and connected with weather and ice conditions. Behaviour of the crew is taken into consideration. The main reasons for shipwrecks and damages are collisions with of ice floes, ice compression and drift.

Such investigation is important for safety and environment stability in the Arctic.

[1] Marchenko N A, 2012. Russian Arctic Seas. Navigation conditions and accidents. Springer, 278 p.

# **How to Govern Risk in the Barents Sea: Deciphering Structural Challenges to Harmonization of Health, Safety, and Environmental Standards in the Offshore Oil & Gas Sector.**

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Barents 2020, a joint Norwegian-Russian project was established to "assess the standards needed for safeguarding people, environment and asset values in the Barents Sea." (DNV 2013) It has been generally regarded as a successful and innovative initiative capable of serving as a model for multi-level international cooperation in the oil and gas sector. Barents 2020 achieved unprecedented breadth and width of collaboration by bringing Russian and Norwegian government agencies, oil and gas industry, scientific, and research institutions together. The participants assessed and selected the HSE standards that would not necessarily be the best fit for a particular company or state; rather, they developed recommendations tailored to the risks unique to the entire Barents Sea region. Despite the overall success of the project, several questions remain about its further implementation, as well as its potential duplication in the remaining Arctic littoral states and other shared non-Arctic maritime regions. One of the more critical questions is whether such HSE standards can be incorporated as integral components of national legal and regulatory systems. Potential non-compatibility of a national system and the HSE standards threatens the very idea of harmonization of the rules by which companies and states operate in the Arctic. This paper focuses on risk, a foundational principle behind many HSE standards and regulations. In particular, it explores ways and the extent to which the Russian and Norwegian offshore oil and gas legal and regulatory regimes incorporate various phases of risk governance. The paper highlights potential institutional challenges to further implementation of Barents 2020 recommendations in the Russian Federation and expansion of similar harmonization efforts among the Arctic Five and beyond. The paper concludes with a set of recommendations directed at bridging risk-related structural differences among the national legal and regulatory regimes.

# The Polar Code and other developments at IMO

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The objective of the paper is to present the status of the Polar Code and provide a preliminary assessment of its adequacy to Arctic shipping. The Polar Code is expected to be adopted during 2015 and to enter into force in 2016. According to the latest draft the Polar Code it will consist of two main sections; maritime safety and pollution prevention. Both will include binding and non-binding components. The section on maritime safety includes 14 chapters, setting out construction, design, equipment and manning requirements in more detailed form than the existing guidelines. Vessels are inter alia required to have a Polar ship certificate and a Polar water operational manual to be able to operate in these waters. The Polar Code seems to highlight the human element. The pollution prevention sections includes chapters corresponding to some of the annexes of MARPOL 73/78. The mandatory parts of the Code will be provided through amendments of SOLAS 74 and the relevant MARPOL 73/78 annexes. Questions may be raised on the legal status of the introductory section of the Polar Code which includes its overall objective, definitions and the risk based approach. The Code does not include provisions on navigation such as use of convoys or ice breaker assistance. Some provisions presuppose the use of such measures. It may provide for the adoption of navigational regulations for specific areas both under SOLAS 74 and/or by the Arctic coastal States. The presentation will look into the legal relationship between the Polar Code and Coastal state regulations.

An interesting feature to be investigated further is the normative design of the Polar Code. It is to have both a goal-based and risk-based approach. The goal-based approach means that each of the chapters will have an objective which is to be met, detailed through functional requirements and more specific requirements. This provides for necessary under the different and changing conditions in polar waters but poses also implementation and compliance challenges to be addressed in the paper.

Developing the environmental protection section of the Polar Code has probably been the most controversial part of the negotiations. Under the latest draft many of the proposals are not included or have been watered out in the recommendatory part of the section. The IMO member states are sceptical to introducing a ban on transport and use of heavy oil fuel in Arctic waters. The paper will look into alternative regulations through IMO.

# Assessing collaboration for the Northern Sea Route development: actors, interests, obstacles

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Recent geopolitical transformations in the Arctic region are associated with the emerging prospective for economic activity, including shipping through the Northern Sea Route (NSR). In 2012 46 ships transported through the NSR over a million tons of cargo, increasing volumes of cargo transportation by 53 percent in comparison with the year 2011. Researchers estimate that around 50 million tons of cargo will be shipped through the NSR by 2020. With the emerging economic opportunities for time reduction, the shipping through the NSR poses also serious challenges to environmental and human security, and to the Russia's national security and sovereignty.

The Russian state links the prospective increase of shipping through the NSR with national economic growth and with the Northern territories development by including the regions into the united economic and security space. One of the core goals of the Strategy for the Development of the Arctic zone of the Russian Federation and National Security for the period up to 2020, released in February 2013, is a development of an integrated Arctic transport system of the country as a national marine route, operating all the year round. However, the question concerning the main financial contributors to the NSR development still remains as a critical issue in Russia. During the latest APEC Summit the Russian president Vladimir Putin called the Asian countries for participation in the NSR development projects.

The paper represents an analysis of the Russian policy implications towards development of shipping through the Northern Sea Route. The paper will focus on the analysis of occurring changes in the Russian legislation on shipping and government's and energy companies' interests and approaches towards the Northern Sea Route development. The paper will also discuss the prospective for the Asian states (first and foremost China) participation in the NSR development, including existing security challenges and legal barriers for foreign involvement into the Arctic shipping projects.

In the study qualitative method will be applied. In addition, the research will be explanatory case study in nature.

In summary, the paper therefore will provide insights about economic and political motivations of different stakeholders, as well as legal and security consequences of the prospective foreign involvement in the Russian shipping development in the North.



# Ballast water treatment at low temperatures – An important limiting condition explored

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As of today, some 80 different ballast water management systems (BWMS) have been developed to treat ballast water used by ships. The efficacy of these systems is evaluated according to IMO and USGC guidelines at land-based test facilities. Due to the requirements for organism density during these tests, these test facilities are mainly based in the temperate climate zone where productivity during spring and summer ensures sufficient high organism densities. Shipping, however, occurs year-round worldwide, and a significant increase of shipping activity into Arctic waters has recently been recorded. A review of techniques used for ballast water disinfection showed that low temperatures may seriously affect the efficacy of a number of treatment techniques. As a first step, the sensitivity of natural temperate plankton communities to ballast water biocides throughout the year are currently evaluated. These results will be compared with the sensitivity of Arctic plankton communities to ballast water biocides during the Arctic summer. The preliminary results of the temperate study and the first field season at Svalbard will be presented and discussed.

# Arctic ocean noise: towards a responsible use of the marine environment

Michel Andre

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The growing scientific and societal concern about the effects of underwater sound on marine ecosystems has been recently recognized through the introduction of several international initiatives aiming at measuring the environmental impact of ocean noise on large spatial and temporal scales. From a regulatory perspective, the European Marine Strategy Framework Directive includes noise as one of eleven descriptors to determine Good Environmental Status of the oceans. The Directive specifically requires Member States to provide a measure of annually averaged noise. The ACCESS (Arctic Climate Change, Economy and Society) EU FP 7 funded project includes several tasks that directly address noise issue under the MSFD perspective: effects of noise from shipping (descriptor 11.2) and Oil & Gas operations (descriptor 11.1) on the marine fauna, particularly marine mammals, in the area of the Barents Sea. This paper will review our current knowledge on underwater noise impact as well as the ACCESS project approach to provide future Arctic Ocean users with monitoring and mitigation tools to help ensure a responsible use of this unique marine environment.

# Operation criteria for offshore vessels

Bjørn Ola Berge, Tor Einar Berge, Ørjan Selvik

***MARINTEK, Trondheim, Norway***

It is well known that the meteorology forecasts for Arctic waters are less accurate than forecasts for North Sea and Norwegian Sea. Forecast quality is a parameter when defining weather windows for many marine operations. In most cases operational limits are based on the parameter significant wave height. In some cases wind speed is another limiting parameter. From a scientific point of view, operation criteria should be based on specified limits for motions, velocities or accelerations during critical parts of a marine operation. Significant wave height or wind speed does not give any information about the ship motions during a marine operation, which are the real limitation. By applying the proposed method the operation limits will be ship specific.

Seakeeping performance is closely connected to the main dimensions of the vessel, but clever detail design can for instance reduce slamming forces or improve ice performance. A good early design process to clarify pros and cons on a ship's dynamic characteristics is important to take into consideration the vessel's operation environment. But to be able to optimize as good as possible, high quality metocean data is also critical. One knows that the environment is different in for instance the Barents Sea compared to the Norwegian Sea.

Another important parameter is the calm water performance, i.e. some design parameters that improve seakeeping might increase power consumption in transit speed.

In areas which are not covered by seasonal ice, main dimensions for open water characteristics should be optimized. In areas which are covered with seasonal ice, ice breaking capabilities should also be considered where clever detail design becomes more important.

This presentation will describe how to investigate site specific operational limits based on a vessel's dynamic characteristics and the actual wave, wind and current characteristics for an open water location in Arctic waters. The method will be exemplified using a construction and intervention vessel designed for operation in the Olga Basin east of Svalbard. The example will highlight the variation in the operability of the vessel based on available weather statistics and the need for new long-term observations of meteorology and oceanography parameters. The new way of defining operational limits will be compared with present practice and recommended practice prepared by classification societies.

# Remote sensing of the Arctic waters: where are we?

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The High North is estimated to hold a considerable share of the world's remaining undiscovered reserves of oil and gas, and these are expected to be located offshore. The decrease of the Arctic sea ice makes these resources more easily accessible, but seasonal sea ice in different Arctic regions will remain a challenge for human activities. The melting of sea ice may also increase the attractiveness of the Arctic as a transit route for goods between Asia, the North America and Europe. However, the increased maritime activities represent big threats to the sensitive Arctic environment. Large sea ice floes, ice ridges and icebergs are major threats to oil installations and ships, and oil spills during oil and gas production may become an enormous disaster. The future activities in the Arctic hence put new demands on the automation, accuracy, robustness, and the spatial and temporal resolution of operational monitoring systems and forecasting models. Remote sensing from satellites and airborne platforms will in this respect be a key technology. In this presentation we will give a state-of-the-art description of sea ice remote sensing platforms, and discuss how Earth observation data (spaceborne, airborne and in-situ), combined with fine scale drift models, can assist maritime operations in the Arctic

# A new tool for analyses of actual Arctic shipping

Eirik Mikkelsen<sup>1</sup>, Jon-Arve Røyset<sup>2</sup>

***<sup>1</sup>Norut, Tromsø, Norway, <sup>2</sup>Norwegian Coastal Administration, Ålesund, Norway***

Recent reports have shown that the number of transit sailings across the Northern Sea Route has more than quadrupled over the last 4 years, based on data from Russia's Rosatomflot and Northern Sea Route Administration. Getting easy access to reliable data on all types of sailings for all of the circumpolar Arctic is a large challenge. A new system and database that is established will hugely improve the situation. A database is established that collect and process data on actual sailings in the circumpolar area north of 60-62 degrees North, from AIS-data received by a Norwegian satellite. Included are sailing statistics for 13 different ship classes, several ship size classes, different marine regions, ports and key passing lines. This presentation will give an overview of the database and available data, and sketch some possibilities for management and research that open with the availability of this new tool.

# Monitoring the ice for operations near the ice edge

Annekatrien Debien, Hans Eilif Larsen, Jan Petter Pedersen

***Kongsberg Satellite Services, Tromsø, Norway***

Shipping in the Arctic is a challenging task, and with the melting of the Arctic sea ice, ship traffic is expected to increase over the next years. Dangers include icebergs, drift ice in areas of interest, and the lack of communication satellite coverage. The danger is not only connected to operating inside the ice, but also near the ice edge. The melting of the Arctic ice has opened up many areas of interest for oil and gas, fishing and transportation. However, not all ships or rigs in these areas have the capacity to deal with moving ice, resulting in damage to vessels and Search and Rescue operations that could have been avoided. Monitoring the ice edge and forecasting its movement is therefore of great importance for these operations. Kongsberg Satellite Services (KSAT), in cooperation with University of Sheffield, has developed an algorithm to quickly detect the edge between open and safe water, and drifting ice, based on SAR imagery. This ice edge is available in less than 15 minutes after image acquisition. As ships and oil rigs operate near the ice edge, they can rely on this ice edge to get fast, accurate and frequently updated information about its location and plausible movement. The ice edge has been tested and approved so far in the Barents Sea, the Fram Strait and the Kara Sea, and has proven to be of use for fishing vessels and oil companies operating in or near the ice edge. One of the major challenges is to get this information out to the ships in near real time. In the Arctic, coverage by satellite broadband is limited, with even Iridium failing occasionally. The ICEMAR system will be able to send data over low bandwidth to the ships, without loss of data when the connection goes down. This should enable the users to get hold of the data they want, when they want it, even at 80 degrees north near the coast of Greenland.

# Does routing matter? Radiative forcing and temperature responses to Arctic transit shipping versus traditional Suez route

Stig Dalsøren<sup>1</sup>, Jan Fuglestad<sup>1</sup>, Bjørn Samset<sup>1</sup>, Terje Berntsen<sup>2,1</sup>, Gunnar Myhre<sup>1</sup>, Lars Ingolf Eide<sup>3</sup>, Magnus Eide<sup>3</sup>, Trond Flisnes Bergh<sup>3</sup>, Glen Peters<sup>1</sup>, Karianne Ødemark<sup>1</sup>

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The Arctic sea ice is melting which opens new shipping routes and extends the shipping season in the Arctic region. Transit between Europe and Asia through the Arctic is shorter compared to the traditional Suez route. We developed emission scenarios for 2030 and 2050 and find significant saving in fuel and reduction in CO<sub>2</sub> emissions. In addition to CO<sub>2</sub>, ships emit a number of gases and aerosols with both cooling and warming effects operating on a range of time scales. The climate impact of these components depends strongly on location and timing of emissions. Here we compare, by detailed modeling of chemical and radiative responses, the climate impacts of the northern transit route vs the Suez route in terms of radiative forcing and global mean temperature response. In addition to CO<sub>2</sub>, we include effects of NO<sub>x</sub>, CO, VOC on tropospheric ozone and methane, as well as the aerosols sulfate, nitrate, OC and BC (in air and deposited on snow). Due to the significant contributions from the short-lived forcing components, the difference between the Arctic and the Suez route depends strongly on time horizon.

# Canada and the Governance of Arctic Shipping: Navigating between Unilateralism and International Cooperation

David VanderZwaag

*Dalhousie University, Halifax, Nova Scotia, Canada*

This presentation will highlight the first commercial bulk cargo carriage through the Northwest Passage in late September-early October 2013 and review Canadian approaches and challenges in developing and managing Arctic shipping. The voyage of the Nordic Orion, a 225-metre, ice-strengthened bulk carrier, which transported a load of coal from Vancouver to Pori, Finland will first be described. This transit of the Northwest Passage not only demonstrates cost and time savings to be enjoyed by using the Passage route but also shines the spotlight on the preparedness of Canada to ensure safe and environmentally acceptable shipping.

Canada's numerous unilateral measures to control Arctic shipping will then be surveyed. Measures adopted pursuant to the Arctic Waters Pollution Prevention Act include zero discharge standards for oil, garbage and most wastes deposits in Arctic waters, and special construction, design, equipment and crewing standards for ships operating in the Arctic. On 1 July 2010 Canada imposed mandatory reporting requirements for certain classes of vessels, for example, vessels of 300 gross tonnage or more and vessels carrying as cargo a pollutant or dangerous goods, that wish to navigate within the Northern Canada Vessel Traffic Services (NORDREG) Zone. The resultant tussle between Canada and other States over whether Canada could rely on Article 234 of the Law of the Sea Convention to justify its decision to act unilaterally without working through the International Maritime Organization will be briefly summarized.

Canada's efforts to facilitate international cooperation in addressing Arctic shipping will next be emphasized. Those efforts include: negotiating the 1988 Agreement on Arctic Cooperation between Canada and the United States whereby the two countries agreed to set aside their jurisdictional dispute over the status of the Northwest Passage; co-leading the publication of the Arctic Council's Arctic Marine Shipping Assessment (2009) with its influential 17 recommendations; and actively participating in the drafting of the Polar Shipping Code.

The presentation will conclude with a summary of major challenges still confronting Canada in the quest for effective shipping governance in the Arctic. Those challenges include: developing and implementing mandatory vessel routing measures for ecologically or culturally significant Arctic waters; articulating clear policy positions for future development and management of the Northwest Passage; bolstering northern



marine infrastructures; and determining the extent to which Canada's national regulations should be harmonized with the new Polar Code.

# COINOR – Communications in the High North and other remote areas

Fritz Bekkadal, Kay Endre Fjørtoft

***MARINTEK, Trondheim, Norway***

Maritime operations in Arctic waters are challenging. The weather can quickly change from calm to extremely rough conditions. Weather information is frequently unavailable, as is also reliable data on ice conditions. The lack of adequate infrastructure and qualified data for navigational purposes is crucial. In this paper vital aspects of the oil and gas (O&G) industry requirements versus availability of communication and navigational infrastructure and technology in the High North are analyzed. Additionally, technological opportunities for remote monitoring and control of on-board equipment from shore-based locations are identified – all in a safety perspective.

The primary objective of the COINOR project is to minimize the knowledge gap on telecommunications in the High North, in order to provide sound recommendations on how to alleviate the current lack of infrastructure and technological solutions. This applies both to the Arctic user community, the O&G sector, and the associated suppliers of communication products and services, as well as the public authorities. The main objective is achieved by addressing specific operational needs and requirements as regards data and information exchange, and the associated technical demands on telecom systems. The operations to be investigated will cover both the planning, exploration and production phases in different geographical areas.

As essential accomplishments in its endeavors to close the knowledge gaps:

COINOR will develop a methodology and show examples that combine the operational requirements as regards telecom needs – i.e. how factors like bandwidth, availability, robustness, latency (delay) etc. affect operational constraints.

COINOR will investigate how new (near future) telecom solutions (including Hybrid Satellite Earthbound (HSE) and Hybrid Fibre Earthbound (HFE)[1] access networks) may be used to meet the operational needs for telecom support in the High North.

The Arctic environmental impacts on communication signals will be investigated to its full extent. COINOR will address these issues prior to the implementation of new communication systems, in order for the real Quality-of-Service (QoS) requirements from demanding operations and high end users in the Arctic can be met.

Understanding the procedural requirements in the High North, where the IO concept is to be assessed, and where use of telecom is a crucial tool in the operations. COINOR will address possibilities for collaboration in remote areas, such as the High North, where limited bandwidth is often the case.

[1] In this context 'earthbound ' is designating both terrestrial (land-based) and (offshore) platform-based wireless systems

# Arctic marine shipping – Russian scenario

Alexander Skaridov

***Admiral Makarov State University of Maritime and Inland Shipping, St. Petersburg, Russia***

Russia has announced a longstanding strategy towards the development of its Arctic coast infrastructure and marine shipping. The strategy asserts that in the long term the attention of Russian international policy will be focused on accessing energy reserves, including those on the continental shelf in the Barents Sea and other parts of the Arctic.

Russian legislation, in the context of developing measures for coastal states in the High North areas, is still developing. During the last 3 years Russia has adopted new laws and others were revised. New regulations will be adopted in the near future.

The developing laws and regulations will be focused on measures which should provide a legal base for state security (Russian Arctic zone development strategy for national security up to 2020 (draft law)); the safety of the transportation of goods in sea ice conditions and the protection of the environment. The regulations "On Northern Sea Route", which was accepted in the early 2013, and some other rules, will be developed to be more appropriate to local practice and international shipping standards; new liability and insurance requirements, and applicable to all users within the limits of the Russian EEZ and continental shelf. Generally new "Russian Arctic law", should prioritise modern Russian Arctic policy to create an internationally acceptable legal environment for the development of modern economic infrastructure that is able to accelerate marine shipping and to create conditions for safe exploration and exploitation of Arctic resources.

# **Arctic Sea-Ice seasonal cover prediction. Application to the North East and North West Passages.**

Jean-Claude Gascard

***University Pierre et Marie Curie/CNRS, Paris, France***

Reanalysis of satellite remote sensing data concerning sea-ice concentration all over the Arctic Ocean during the past 30 years, revealed a profound and systematic difference between the Atlantic and Pacific sides of the Arctic Ocean. Break up started much earlier on the Atlantic side of the Arctic Ocean than on the Pacific side and freeze up was delayed by the same amount. Every year each sides of the Arctic Ocean experienced a one to two days advance of the breakup season and a similar delay during the freeze up season. Reanalysis of atmospheric data regarding air temperatures above sea-ice over the past 30 years revealed a significant increase of winter temperatures equivalent to a loss of 2000 freezing degree days, potentially responsible for a sea-ice loss of about 10 000 km<sup>3</sup>. The coldest area was never centred around the North Pole but rather North of Greenland and above the Canadian Archipelago. That explained why the North West passage was lagging behind the North East passage as far as shipping activities were concerned. Arctic sea-ice experienced significant changes during the past 30 years and in particular during the past 10 years. It became younger, moved faster, got thinner and the Arctic seasonal sea-ice zone increased drastically. This makes momentarily short and medium term sea-ice prediction more and more difficult since Arctic sea-ice became much more vulnerable and more exposed to extreme meteorological events in particular during summer time. Prediction will become more reliable when Arctic seasonal sea-ice would occupied the whole Arctic Ocean like it does around Antarctica. This situation is expected to occur before mid century..

These new results are significant and important for anticipating Arctic shipping activities during coming years and decades. Arctic sea-ice retreat increased by one month during the past 30 years. The North East Passage is opening to navigation much earlier than the North West Passage. Both Passages are subjected to large scale seasonal weather patterns as well as regional trends. With no surprise, the trends are easier to predict than the inter-annual variability. A main result regarding Arctic shipping activities is an increase of opportunities for navigating across the Arctic Ocean and not necessarily along expected pathways (passages) as illustrated by the recent years since 2007. These results were acquired during the recent European ACCESS project (Arctic Climate Change, Economy and Society).

# Regulation as Learning: Spread of Norwegian Offshore Knowledge to the Faroe Islands, Greenland and Iceland

Rasmus Gjedssø Bertelsen<sup>1</sup>, Auður H. Ingólfssdóttir<sup>2</sup>, Jens Christian Svabo Justinussen<sup>3</sup>, Berit Kristoffersen<sup>4</sup>, Coco Smits<sup>5</sup>

**<sup>1</sup>Aalborg University, Aalborg, Denmark, <sup>2</sup>Bifröst University, Borgarnes, Iceland, <sup>3</sup>University of the Faroe Islands, Tórshavn, Faroe Islands, <sup>4</sup>University of Tromsø, Tromsø, Norway, <sup>5</sup>Royal HaskoningDHV, London, UK**

Developing offshore energy resources is central to North Atlantic socio-economic development. Norway has amassed great wealth through offshore oil and gas exploration, which has affected Norwegian society profoundly during the last four decades. Norway has combined the very high level of human development, democracy and egalitarianism with very substantial oil- and gas-exploration and resource rents. Norway with its strong state, high level of human development and strong human capital has developed a knowledge-based sector around offshore oil- and gas-exploration and related activities. Norway is therefore increasingly exporting this knowledge to emerging offshore oil- and gas-producing countries.

The North Atlantic very small states, the Faroe Islands, Greenland and Iceland have and are consciously pursuing energy resource development as an economic development strategy for greater economic diversification. The Faroe Islands have pursued hydrocarbon exploration since the early 1990s, and it is remarkable how the islands have built an industry with strong human capital around the expectation of finding hydrocarbons, which has not happened yet. Greenland has its eyes set on hydrocarbons as an important part of financial independence with substantial exploration activity. When formulating its current regulation on hydrocarbon development, it has taken Norway as one of its most important examples. Now that exploration activities increase year by year, connections with Norway have also been established on a practical level by exchange of students and knowledge. Iceland has gone through the first licensing round and commercial hydrocarbon exploration is expected soon in the Dreki area. Iceland is keen to add hydrocarbons to its portfolio of energy resources and to build up a knowledge-based sector in the area.

Norway is a key source of know-how for the Faroe Islands, Greenland and Iceland. One important area of development for emerging oil and gas producers is regulation. This paper will look at transnational learning in the field of offshore oil and gas regulation. How

have the Faroe Islands, Greenland and Iceland learned from Norway in the field of regulation? What are the processes of learning in this North Atlantic space? How do societies with very small populations and no previous experience with offshore oil and gas exploration build capacity in this area? How is regulation formulated and enforced? How is human capital on regulation in a new field created in very small institutions? How do very small regulatory agencies cope with such a new field? How is postcolonial dependency in human capital (Greenland) overcome?

# Reducing the risk of offshore activities with Integrated Environmental Monitoring

Ludivine Le Granvalet

***Kongsberg Oil & Gas Technologies, Oslo, Norway***

With a challenging and sensitive environment the development of activities in the Arctic region will generate additional safety risks which need to be understood and predicted in order to avoid or reduce any potential negative impact.

In parallel with efforts deployed by the oil and gas industry to develop the best technology guidelines and regulations are put in place by authorities and contribute to set a framework which will ensure the most efficient and sustainable development. Discharges are regulated at a national level through discharge permits based on the Pollution Control Act and at an international level through the Oslo-Paris Convention (OSPAR). In Norway the Petroleum Safety Authority has set a requirement for remote monitoring to "provide sufficient information to ensure that acute pollution from the facility is quickly discovered and mapped" (Activity Regulations §57).

Today's technology can help reducing the risks associated with oil and gas activities in the North through proactive and integrated monitoring of the environment which will allow detection of events as soon as they might occur.

The vision of Integrated Environmental Monitoring (IEM) is to minimize impact on all compartments of the water column and the sea bed through real time monitoring, analysis, assessment of risks and early detection of incidents during all phases of an offshore operation. Developed with Statoil, IBM and DNV, IEM is based on a real-time sensor monitoring coupled with software applications for analysis and visualization of environmental data and selected operational data.

Three applications have so far been in focus: - Real time monitoring of drilling discharges, to deposit it securely on the seabed, providing a continuously updated risk picture through models of dispersion and sedimentation- Real-time monitoring of fish resources and mammals, to stop / restart operations when they enter / exit the predefined security zones- Early detection of leaks from underwater to enable the operator to take preventive actions almost immediately.

Tight coupling between environmental monitoring and daily operations will improve understanding of environmental risks and increase situation awareness. More research is needed to understand the environmental risks better, and IEM will give the oil industry, government and research institute crucial information through high-resolution data. IEM can help reducing the environmental footprint that activities in the Arctic could generate and is among the best available technology to control discharges and prevent incidents that could have a negative impact on the environment.



# Future climate impacts of trans-Arctic shipping

Scott Stephenson<sup>1</sup>, Steven Davis<sup>2</sup>, Charles Zender<sup>2</sup>,  
Laurence Smith<sup>1</sup>

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Recent rapid sea ice loss and increased resource demand in east Asia have recast the Arctic as an international trade space offering potential alternative pathways for global maritime trade. Several studies have examined inventories of greenhouse gas and black carbon (BC) emissions from future marine vessel traffic in the Arctic. However, the net impact of these emissions on climate forcing in the region is not well understood. Here we present several scenarios of climate forcing driven by 21st-century trans-Arctic shipping emissions. Vessel transits between east Asian (China, Japan, Korea) and European (Germany, Netherlands) ports are simulated from present day to mid-century according to projected sea ice conditions, trends in cargo export volumes, and vessel ice class. Sea ice data are represented by a 7-model ensemble mean from CMIP5 under two forcing scenarios (RCP 4.5/8.5). Emissions from simulated transits (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, SO<sub>2</sub>, BC) are used as input in a regional GCM to obtain net climate forcing. BC is expected to increase high-latitude warming by reducing ice and snow albedo, while SO<sub>2</sub> from high-sulfur fuels may lead to net cooling. Results illustrate a range of potential warming futures in the Arctic owing to differences in vessel accessibility, trade volume, route paths, and emissions factors.

## Arctic search and rescue (SAR)

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### Scientific committee

Leader: Program manager Erik Dyrkoren (Convener), Maritim 21, Norway

Tor-Are Vaskinn, Fiskebåt, Norway

Vice director Nils Arne Masvie, DNV, Norway

Professor Odd Jarl Borch, University of Bodø, Norway

Senior advisor Kjell Røang, The Research Council of Norway, Norway

Research Associate Dr. Nataly Marchenko, The University Centre in Svalbard (UNIS), Svalbard

Research Engineer Riikka Matala, Aker Arctic, Finland

Senior Legal Adviser Svana Margrét Davíðsdóttir, Ministry of the Interior, Iceland

Piotr Graczyk, APECS & University of Tromsø, Norway

# **The operational challenges of SAR operations in the Arctic**

Tore Wangsfjord

***Joint Rescue Coordination Centre North-Norway, Bodø, Norway***

JRCC North-Norway

- Responsibilities, operations

Challenges in the Arctic

- From a SAR/JRCC point-of-view

International cooperation

- International agreements, real-life cooperation

Future requirements

- More activity in the Arctic, focus on SAR/safety, SAR-systems needs to evolve

# Maritime Arctic Operations from an insurance point of view

Stein Are Hansen<sup>1</sup>

***<sup>1</sup>Norwegian Naval Accademy, Bergen, Norway, <sup>2</sup>Tromsøe Hoyskole, Tromsøe, Norway***

With over 9000 insured vessels and energy objects NHC ranks as the largest pure marine insurance company in the world. NHC see over 1700 accidents/claims every year, where over 30 are ranked as major accidents. The Client Service Team job is to assist owners in handling the major cases and also transfer lessons learnt from the cases to the client base.

As NSR commercial transits and arctic operations have increased dramatically, NHC follow and assist their insured units in making sure that risk mitigation is thoroughly conducted and barriers are implemented in accordance with national and international rules and regulations.

Based on a 175 year long history within marine insurance NHC know that accidents take place due to the human element, so making everyone understand human and cultural factors have become increasingly important.

The presentation will therefore focus on the human element within the Arctic environment at sea and how future SAR systems could create a safer environment for humans operating in this region.

# **Oil spill response in the Arctic: Cooperation and innovation in Norway**

Maaïke Knol, Peter Arbo

***University of Tromsø, Tromsø, Norway***

With the northwards expansion of petroleum activity in Arctic states, there is increasing concern about the adequacy of emergency response systems. Petroleum activity in these areas is challenging due to harsh weather conditions, darkness, ice, large distances and lack of infrastructure. In addition, the politically controversial nature of Arctic oil and gas exploitation makes improvements in oil spill preparedness an 'obligatory passage point' for the oil industry to get a license to operate in these areas. We analyze the characteristics and development of the Norwegian oil spill response system in the light of the northwards expansion of the petroleum industry. We address the Norwegian case from a pan-Arctic perspective, and look at the different scales at which emergency response networks are organized. The preparedness theme turns out to be a meeting point for environmental and business interests and provides opportunities for innovation and economic development. Despite ongoing developments and improvements in response systems, we discuss the challenges ahead in Arctic oil spill preparedness. These challenges are addressed from a local, state and international level simultaneously, involving public institutions, private companies, and public-private constellations. While implementation takes place at the national and local level, the Arctic Council has a potentially important role in harmonizing standards and regulations across Arctic countries.

# **Evacuation and rescue in the Northern Barents Sea EER perspective and challenges for Arctic oil & gas operations**

Steingrim Bosheim<sup>1</sup>, Rune Bråthen<sup>2</sup>

**<sup>1</sup>Statoil ASA, Porsgrunn, Norway, <sup>2</sup>Statoil ASA, Stavanger, Norway**

The oil and gas exploration is expanding into the Barents Sea and the high north. The cold and harsh climate with potential for ice represents increased challenges to the industry.

This paper is describing the main Arctic challenges related to evacuation and rescue that are different from the North Sea. Arctic climate itself represents challenges for both people and equipment due to long periods of subzero temperatures, polar lows, the possibilities of icing, the long period of darkness and the very limited infrastructure. All these factors are of importance to an evacuation and rescue solution.

There are several activities going on to manage the different challenges through development of technical means for installations and for evacuation and rescue, particularly designed for operation in these areas. Ongoing activities both with a short and a longer time horizon will be presented.

The cost for Arctic exploration and production can be high and one way to reduce cost is cooperation. Companies operating in these areas may want to coordinate their activities and have joint support systems for emergency response etc.

Another challenge is to have standardized codes across the borders so that the evacuation system in one country can be accepted also for other Arctic countries. These codes will be discussed as well.

# Mapping the Polar Skies: Transpolar Flights and Search and Rescue Capabilities

Mia Bennett<sup>1,2</sup>

**<sup>1</sup>University of California, Los Angeles, Los Angeles, CA, USA, <sup>2</sup>Foreign Policy Association, New York, NY, USA**

When it comes to transportation developments in the Arctic, increased shipping activity is generally at the front and center of discussions. Yet concurrently, transpolar flights have also grown in number since the early 2000s. Climate change is not responsible for the re-opening of these routes, once popular in the 1950s: instead, impetus lies with the opening of Russian airspace after the collapse of the USSR and growing economic activity between places in Asia, Europe, and North America, and also between Arctic destinations and the rest of the world. Transpolar flights, such as the New York-Hong Kong or Reykjavik-Anchorage journey, shave hours off of previous routes, saving fuel and cutting emissions. But north of 82°N, since satellite communication is often no longer available, pilots must rely on high-frequency radio, which solar radiation storms can disrupt. In sum, thousands of jumbo jets are passing through the circumpolar north each year, carrying far more passengers than the more visible cruise ships that transit Arctic waters each year. Although the risk of an aviation disaster is lower than that of a cruise vessel, emergencies can and do happen: in 2002, SAS Flight 937 from Copenhagen to Seattle had to make an emergency landing in Kangerlussuaq, Greenland due to a bomb threat. While the pilot was able to successfully land the flight without any casualties, this example demonstrates the need for increased readiness for polar air emergencies. Actual search and rescue (SAR) capabilities remain few and far between, although the adoption of the Arctic Council's 2011 SAR Agreement is a step in the right direction. Admittedly, it is difficult to justify investing in greater SAR capabilities for transpolar flights, which do not deliver any economic benefits to the Arctic residents they fly over from nearly 10,000 meters in the sky. In this paper, I first examine the growth of transpolar air routes in the past decade. Then, using data from OpenFlights verified against each airline's information, I map the existing flight routes that cross north of 78°N, along with the existing airports and runways on the ground below. Finally, I identify possibilities for adapting current SAR capabilities to be able to manage transpolar flight-related disasters.

# Meteorological Services for Maritime Search and Rescue in the Arctic

Lars-Anders Breivik, Bruce Hackett

*Norwegian Meteorological Institute, Oslo, Norway*

SAR operations are highly weather and sea-state dependent. Efficient operations require high quality meteorological and oceanographic information at small scale in near real time. The Norwegian Meteorological Institute has an operational capacity to serve these needs. The key components are high resolution numerical weather, ocean, sea ice and wave prediction models capable of utilizing large scale forecasts as well as observations. Downstream to this are trajectory models specialized for oil spill, ship drift and SAR. New developments focus on employing ensemble prediction methods in order to provide probabilistic predictions of the relevant weather and ocean parameters, as well as drift trajectories. The presentation will give an overview of state of the art and future developments and needs focused on Arctic conditions.



# Predicting near future vessel traffic conditions in the Arctic using data from AISSat-1

Øystein Olsen, Andreas Nordmo Skauen, Øystein Hellenen

***Forsvarets forskningsinstitutt, Kjeller, Norway***

AISSat-1 is a Norwegian nano-satellite built as a demonstrator to provide extended Automatic Identification System (AIS) coverage in the Norwegian Arctic and adjacent waters. The satellite was funded by the Norwegian Space Centre, while the Norwegian Defence Research Establishment (FFI) has been responsible for the mission implementation. The cost of the satellite was around 5 million US dollars including the ground segment and launch.

The initial design goal was to operate the satellite for the approximately 15 minutes every orbit for up to three years although no life time requirements were set. It was launched on July 12th, 2010 from India to a low Earth orbit, and has since then been collecting AIS messages from vessels in the Arctic. Optimization of the operations allowed the satellite to operate continuously since the summer of 2011.

The proposed paper summarizes the observed seasonal changes in the Arctic vessel traffic conditions during these three years. In particular fishing vessels and cruise ships have significant seasonal variations. Furthermore, the regional distribution of the fishing vessels during a year changes from one year to another, which will affect planning of search and rescue readiness activities.

Melting of sea ice in Arctic will probably open the Northern Sea Route for regular commercial cargo transport during the summer. The amount of traffic will depend on how fast the summer sea ice is melting and on how early there will be infrastructure in place to service in this traffic. A few vessels have already used this route. AISSat-1 tracked those vessels and demonstrated the value of satellite data in areas with limited land based infrastructure.

Finally, the paper presents the observed trends in the vessel activity since launch. Although the data interval is relatively short, we attempt to predict the activity level in the near future using this data together with planned exploratory and operational oil and gas activities.

# Forecasting the Drift of Oil and Objects in the Arctic Ocean

Knut-Frode Dagestad, Lars Robert Hole, Cecilie Wettre

***Norwegian Meteorological Institute, Bergen, Norway***

The Norwegian Meteorological Institute has developed and operates a suite of models for forecasting the drift of objects and oil spills at sea. The oil drift model (OD3D) includes a module for oil chemistry and weathering processes (developed by SINTEF), whereas the search and rescue model (LEEWAY) takes into account the specific drifting characteristics of several types of floating objects, such as boats, containers and persons in water. Both models utilise operational forecasts of wind, ocean current and waves to determine the most probable drift path, as well as its spatial probability. A recent development (BAKTRAK) allows running the LEEWAY model also backwards in time, for determining the origin of a drifting object after it being located. An overview of the capabilities and plans for future development will be presented, with focus on applications in the Arctic.

# Survival suits for Arctic conditions

Hilde Færevik, Tore Christian Storholmen, Ole Petter Næsgaard, Øystein Wiggen, Maria Suong Tjønnås, Mariann Sandsund

***SINTEF Technology and Society, Department of Health Research, Trondheim, Norway***

The cold and harsh climate of the Arctic represents a challenge to protection and survival in emergency situations. Accidental immersion in cold water represents a considerable survival risk due to drowning and/or hypothermia. Low sea and air temperatures, strong winds, waves and sea state are crucial factors in determining body heat loss during cold water immersion and are associated with significantly shorter survival times. The more severe conditions expected in the Barents Sea compared to North Sea requires survival suits adapted to these harsh conditions.

The aim of this project was to identify the areas of improvements and to develop a new survival suit for use in arctic conditions. A user-centred design process was adopted in the project. In the first stage of the project we gained insight from end-users and the companies (ENI, Total, Nexen, Dong Energy ect.) to define the specifications of requirements and identify the areas of improvements. A realistic laboratory study was accomplished to evaluate thermal and functional properties of existing survival suits and identify possible weaknesses during exposure to low air (-11°C) and water (0°C) temperatures, wind (5 m·s<sup>-1</sup>) and waves (40-50 cm). The following areas of improvements were identified: thermal protection of hands and feet, visibility and the usability of spray hood and buddy line. Based on the identified requirements, workshops were arranged in order to come up with improved solutions. Concept development and prototyping were performed in close collaboration with the manufacturer of the survival suit. The new design solutions were preliminary tested in climatic chambers and test pools. The final prototype was tested in a controlled laboratory study at SINTEF SeaLab in Trondheim, Norway. The new suit includes several new solutions; extended cuffs with improved thermal protection of fingers and hands, increased insulation in the boots and boot lining that improved the thermal protection of the feet and improved usability of buddy line and spray hood to ensure that necessary operations can be performed in an emergency situation in arctic waters. A demonstration of the new suit was held outside Hammerfest 13-14 November 2012. Eni Norge received the 2013 Emergency Preparedness Award for Innovation and Development in recognition of their leading role in the development of the survival suit adapted for use in the Barents Sea. The new suit is manufactured by Hansen Protection AS.

The project was financed by ENI Norge.

# Future Satellite Communication in SAR Operations – The SatCom4Mar Project

Beate Kvamstad<sup>1</sup>, Fritz Bekkadal<sup>1</sup>, Simon Plass<sup>2</sup>, Yasmine Ibnyahya<sup>3</sup>, Nazzareno Marchese<sup>4</sup>

***<sup>1</sup>MARINTEK, Trondheim, Norway, <sup>2</sup>DLR (German Aerospace Center), Oberpfaffenhofen, Germany, <sup>3</sup>Inmarsat, London, UK, <sup>4</sup>CIRM, Rome, Italy***

SatCom4Mar is a European Space Agency (ESA) founded project aiming at providing an answer to the following fundamental questions:

Which upcoming satellite communication system could contribute to fulfil the future requirements of maritime user applications?

Are there any technological gaps requiring new technology developments?

How could the integration/coexistence between upcoming satellite communication systems, upcoming terrestrial wireless systems and legacy ones be addressed bearing in mind the ultimate goal of reducing the burden on the navigator (in terms of amount of radio equipment and related procurement and service costs)?

The current and planned communication system will be evaluated. Furthermore, the statutory maritime communications requirements are identified. In a next step demands are derived, followed by the opportunity for satellite systems, services and technologies.

SatCom4Mar will have special focus on Search and Rescue (SAR) related maritime operations, including SAR operations in the Arctic. Existing SAR systems will be evaluated, as well as the status of SAR requirements and their possible implementations.

At Arctic Frontier we will give a presentation of the project, including preliminary findings and a review of satellite communications in the future statutory and commercial maritime communications market.

# BarentsWatch – More than the Sum of its Parts

Geir Schulstad, Øyvind Michael Olsen, Vasco Pinhol

## ***BarentsWatch, Tromsø, Norway***

The 20th century saw the rise and fall of conflicting ideas, too often translated into deadly destruction. All human conflict arises from the incapacity - or unwillingness - to understand and reason with each other. In the society of information, countries will still be able to exercise their right of unwillingness to reason, but will find it harder to argue incapacity to understand through deficit of knowledge.

Norway believes that access to integrated information – both in its open public form and in its closed specialized system format – will be a driving force of the citizenship of the 21st century. This will be exercised through use of tools of knowledge, which integrate the data compiled by government agencies and research institutes and present it through a single and highly functional working data solution; in it, the user will be allowed to superimpose layers of information in new and innovative ways, for a deeper, more useful understanding of the world.

BarentsWatch organizes and provides data and results produced by 30 different governmental and research institutions – creating an integrated holistic system for gathering information and monitoring the oceanic and polar interests of Norway and of the larger polar region. Launched in May 2012, it has already produced relevant results in security, safety, weather advisory, naval traffic and port systems and services. One of the most recognizable results was the forecasting of dangerous polar weather events, known as polar lows. On 23 October 2012, BarentsWatch issued Norway's first forecast of polar lows based on a graphical presentation of probabilities, which was used for planning and conducting salvage of a ship in the Barents Sea.

BarentsWatch is a tool that provides real-time analytical power through superimposition of multiple information layers; a tool that can help create and validate real-time enduring solutions to real-life problems. It will increase our understanding of impact on security, safety, economy or environment; increased knowledge and interagency cooperation will enhance active control, safeguarding responsibilities and rights in an effective and just way.

BarentsWatch is a platform, which can rise as a lingua franca for all systems that exercise their work on the larger Norwegian oceanic area. For the first time, we are using a common language clearly understood by all systems and all specialists, with the single purpose of creation of value through knowledge. BarentsWatch is more than the sum of its parts.

# Masterplan for Escape, Evacuation and Rescue System

Mark Longree, Sven Hoog

*IMPaC, Hamburg, Germany*

In turn of the global warming and driven by the constant need for resources an increasing number of commercial and scientific activities conquer the Arctic in order to benefit from almost untouched resources like oil and gas but also from the overwhelming nature. These activities are accompanied by a steadily increasing number of vessels transporting goods but also operating personnel, scientists or tourists. Especially the number of tourists visiting the Arctic can reach far more than 1000 per vessel, resulting in growing headaches for the responsible safety and security authorities in the Arctic surrounding countries. Up to now no suitable Escape, Evacuation and Rescue (EER) concept is in place to cope with these challenges when it comes to hazardous situations. In this context IMPaC developed a new and appropriate EER concept for the Arctic, exceeding the currently dominant small and isolated settlements along the coastlines in Denmark (Greenland), Norway, Russia, Canada and the US. One question seems to be central: Is there any requirement and benefit beyond the currently used small rescue station? Yes, we strongly believe that there is a growing demand for suitable infrastructure coming from various industries. Beyond rescue objectives there is a demand for people working and living in this area all year long, for a few days, weeks or months using these settlements for their specific needs. This led us to the idea of the provision of a common-use infrastructure for multiple industries. The commonly used infrastructure maximizes the use of the remote and very expensive infrastructure and minimizes the impact on the environment in this part of the world. Potential users of this infrastructure would be: • Oil & Gas Industry, driven by the increased world energy demand • Marine Transport & Tourism Industry, driven by declined arctic ice and new sea routes via the Arctic sea • Fishery Industry • Scientific community Any EER concept for the Arctic has to cope with several specific environmental and spatial challenges as addressed by the EU joint research project ACCESS (<http://access-eu.org/>), where IMPaC participates. The paper introduces the new EER concept and focuses especially on its beneficial, efficient and safe operability in the Arctic recording an increasing number of commercial and scientific activities.

# An analytical approach for ensuring operational capabilities for SAR resources

Even Ambros Holte, Lone Sletbakk Ramstad

***MARINTEK, Trondheim, Norway***

Oil and gas operations are becoming more global and geographically dispersed, venturing further into more remote and fragile areas. The Arctic is one such region. Among other things this has been enabled by technological breakthroughs, allowing companies to re-organize how resources are utilized, both within and across company borders. Moreover, operating in the Arctic is synonymous by handling extreme weather conditions. This coupled with the prospect of increasing marine and maritime activities and presence by the oil and gas industry, further intensifies the importance of developing the right operational capabilities allowing 'license to operate'. As a consequence, it becomes even more important to ensure that Search and Rescue (SAR) operations have the necessary operational capabilities to handle this growth in activity. Both for today and tomorrow. Recognizing the good work that has been done in revealing challenges related to Arctic SAR operations, the authors claim that there still are some key learning points that can be transferred from operations in the North Sea. As such, the concept of Integrating Planning (IPL) within the oil and gas industry is a means to improved understanding of how the interplay between human, technological and organizational capabilities impact on safety and environment. This in order to support the design of safer operations by assisting organizations in developing targeted SAR capabilities, and identifying arenas for coordination of critical resources across organizational boundaries and information systems. Thus, based on the Integrated Planning (IPL) model, this paper will from a holistic point of view analyze critical needs for human, technological and organizational capabilities necessary to handle the revealed challenges related to Arctic SAR operations. In addition some concrete example will be presented to illustrate the conceptual and prescriptive value of the IPL concept, containing analysis of events similar to the Grounding of "Viktor Koryagin" at Fisherman's Peninsula in December 2007. This will be further supported by relevant examples from onshore - offshore operations from the North Sea. The implications the IPL model has on key topics for developing robust and resilient SAR operations for the Arctic will be further discussed.

# Remotely Piloted Aircraft In Arctic Search and Rescue Operations

Douglas Marshall<sup>1,2</sup>, Meghan Marshall<sup>2</sup>

**<sup>1</sup>New Mexico State University, Las Cruces, NM, USA, <sup>2</sup>TrueNorth Consulting LLC, Grand Forks, ND, USA**

Anyone seeking to develop modern maritime systems faces the clash between long-standing international maritime laws and the technological advances that seek to address emerging issues. While new and exciting technologies may ignite the fervor of the scientific community, these innovations could be rendered useless if existing regulations will not permit them to be practically implemented. The laws governing the oceans are not contained in a single document, but instead consist of an interlocking and overlapping patchwork of regulations and guidelines for the acceptable utilization of the seas. Signed and ratified by nearly every nation, UNCLOS details the acceptable uses of both coastal and high seas areas, and most areas in between. As the Arctic region transitions from unbreakable ice to navigable waters, due to the emerging and rapid effects of climate change, the Arctic Ocean will face re-classification and claims from the coastal states for protected status in some of the regional waters. Emerging technologies to aid search and rescue efforts include Unmanned Aerial Systems (UASs), designed to launch from vessels and to vastly extend the eyes of the crew onboard. These systems are already in use for resource exploration, climate monitoring, and marine scientific research, among others. They are potentially more effective than a single or even multiple vessel search and rescue team because they can conduct persistent surveillance and observation, with long endurance, and offering the capability of flying below cloud layers near the ocean or ice surface. UASs provide surveillance capability beyond ship's radar and lookouts, with EO/IR to see through clouds or at night, choice of launch and recovery sites onboard ship, on an ice flow or on land, and in areas where airports might not be accessible, even in severe weather. Precise regulation governing this type of use does not exist, so before the technology outpaces the policy, the variables in the existing international regulatory system must be addressed, whether by regional agreements or multi-lateral treaties.

This paper develops the history of the regulations and laws regarding remotely piloted aircraft and the existing regulatory authority over aviation activities on the high seas and over international waters. Conflicting interpretations of the maritime and aviation law will be analyzed in the context of known and anticipated UAS SAR operations in the global airspace and oceans, and the current law in these domains will be summarized with recommendations for further regulatory clarification and a roadmap towards international harmonization.



# **Support functions and emergency preparedness challenges in the South-East Barents Sea. A background study for the Environmental Impact Assessment (EIA) for the opening of the South-East Barents Sea prepared for the Storting (Meld.St.2012-2013).**

Espen Hoell, Cato Vivelid Nilssen, Erik Wale, Geir Nødland, Bjørn Hoff

***Proactima AS, Stavanger, Norway***

The study was conducted as one of the background studies for the EIA as part of the opening process of the South East Barents Sea in 2013. The purpose was to clarify challenges related to the extreme conditions which the Petroleum Industry will face when operating in the High North. In particular the focus was on the challenges for operating with high standard emergency preparedness in these areas. The study had its attention to the safety of the personnel present on the installations which may be exposed to accidents and harmful conditions. Thus requirements to oil spill emergency preparedness was covered by other studies.

The presentation will highlight the challenges posed to the petroleum industry by the physical environment experienced; darkness in several months of the year, low temperatures both in the air and water in combination with wind, drifting sea ice with highly variable conditions, the forcing of drifting ice on the installations, possibilities for icebergs that may threaten their integrity, icing on vessels and structures, polar lows giving strong winds and high waves within a few hours, low visibility both due to snow storms in winter and fog in summer, partly lack of satellite communication, geomagnetic storms disrupting communication, and finally by the remoteness and lack of infrastructure in large parts of the area. In particular the presentation will focus on the limitations that these conditions will represent for year around safe emergency preparedness.

Will it be possible to maintain the same high standard of emergency preparedness in these areas as in other areas of the Norwegian Continental shelf? What are the constraints and how could they be solved? Will it be possible to operate petroleum installations without compromising with safety?

The presentation will address these questions.

# **Integrated Surveillance and Control System for Maritime Traffic along the Italian Coasts and its Evolution for the Emerging Requirements of the Arctic Environment**

Mauro Varasi, Pietro Bruno, Michele Fiorini

*Finmeccanica, Roma, Italy*

The prevention, monitoring and protection of the sea environment is becoming more and more significant for all the Governments to answer concretely to all the risks connected with the marine activities.

In this sector Italy has a long-standing expertise both from the technological and operational points of view. In particular the Italian Coast Guard is operating a system known as VTMS (Vessel Traffic Monitoring System) which through the integration of different sensors, mobile units, and command and control centers at various levels (local, regional and national) provides a comprehensive capability in terms of: environment protection, navigation in narrow waters, port approach control, support to search and rescue operations, control of dangerous cargo and prevention of illegal activities.

This system is the base for a more integrated and comprehensive "system of systems", called IMSA (Integrated Maritime Surveillance Assistance), that is capable to provide wide-scope integration of innovative technologies to guarantee, in coastal and deep waters, the safety and security of marine activities and the protection of sea environment against all the different types of requirements.

The IMSA system aims at providing maritime surveillance and assistance to commercial ships such as cargos, cruisers, fishing boats. etc., at the same time it can be utilized also to assist, control and protect the Offshore Gas and Oil Installations.

It is based on a Command and Control Centre receiving data from Short and Medium Range Coastal Radars (such as SELEX ES's Argos and Lyra, S and X band systems based on fully solid-state technology), Earth Observation Satellites (such as the four Italian Cosmo Sky-med satellites, equipped with X band Synthetic Aperture Radar, exploiting advanced Active Electronically Scanned Array antennas), and the existing Automatic Identification Systems (AIS).

The Command and Control Centre communicates with and dispatches Patrol Vessels, Helicopter-Carrying Vessels, Maritime Patrol Aircraft (such as Alenia Aermacchi's ATR 42MP), Unmanned Aerial Vehicles, , and Search and Rescue Helicopters (such as

AgustaWestland's AW101, AW139 and AW189), as needed to carry on emergency activities.

The IMSA system, conceived by the Finmeccanica Group, that has already developed, built and deployed the current VTMS in Italy, in the Arctic Environment is capable to provide a comprehensive, effective and modular solution to fulfil the emerging requirements and guarantee the highest safety and security of marine activities on the Arctic Sea, such as navigation, off-shore exploration, iceberg monitoring, search and rescue also in remote areas, and many others.

# Shell Remote Health Care strategy – a game changer

Christian Gorgas<sup>1</sup>, Hans Berg<sup>1</sup>

***<sup>1</sup>Shell, Haag, The Netherlands, <sup>2</sup>As Norske Shell, Stavanger, Norway***

"Shell aims for an HSSE & SP performance it can be proud of to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development. Therefore, amongst other goals, we pursue the goal of no harm to people, a lead role in promoting best practice in our industries, respect our neighbours and contribute to societies in which we operate. With the advent of operations in the Arctic, Shell Health has aimed to meet these goals by developing a widely encompassing remote health care strategy. At the core of our strategy lies the aim to provide hospital care for our staff and contractors within 4 hours of an incident irrespective of location or circumstances in our pursuit of no harm to people

We would like to demonstrate how we have employed novel medical and communication technology to achieve this goal, what we have done to date to promote best practice in the industry for the Arctic region and how we have collaborated with local partners. We would also like to suggest how this strategy can promote sustainable development and be employed to improve health care delivery in the region. This is based on an early experience elsewhere in the world where the area of operations is not necessarily remote but where health care can be equally difficult to access."

# Unmanned Aircraft for SAR in the Arctic: Opportunities and Challenges.

Rune Storvold<sup>1,2</sup>

*<sup>1</sup>Norut, Tromsø, Norway, <sup>2</sup>NTNU, Trondheim, Norway*

SAR in the Arctic meets challenges with large distances, severe weather conditions, darkness in winter and few local assets available. Use of unmanned aircraft systems (UAS) both from ships and land bases could play an important role in a future Arctic SAR system. The technology has advantages when it comes to crew safety and endurance, and challenges when it comes to safe integration into the Arctic airspace, all weather operability, sensors, and communication infrastructure. There is a number of ways UAS can be used in SAR. Today's unmanned aircraft systems varies from 16 grams to 16 tons. Maturity and cost with respect to use in SAR depend strongly on the scenario, this presentation will look at scenarios where unmanned aircraft could play an important role in the near future and the roadmap for how the challenges will be mitigated in the future with regard to technology, communication, and airspace access.

# The New Sea King

Steve Powell

***AgustaWestland, Yeovil, UK***

Configuration, including cabin layouts

Equipment description

Timeline for delivery

Support solution

Training

Examples of long-range AW 101 operations

Ensuring a seamless transition to the new aircraft

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## Live, work and stay healthy in the Arctic

### Scientific committee

Leader:

Professor **Torkjel Tveita** (Convener), University of Tromsø & University Hospital of North Norway, Norway

Professor **Jon Øyvind Odland** (Convener), AMAP & University of Tromsø, Norway

Dr **Valery Chashchin**, Northwest Public Health Research Centre, Russia

**Marney Paradis**, APECS, Simon Fraser University, Canada

Professor **Gary Sieck**, Mayo Clinic Rochester, USA

Executive Director **Martin Fortier**, Arctic Net, Canada

Professor **Hannu Rintamäki**, Finnish Institute of Occupational Health, Physical Work Capacity team. Institute of Biomedicine, Department of Physiology, University of Oulu, Finland

# Traditional clothing for work in cold climate

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Work in cold climate requires warm and comfortable clothing. The Indigenous Sami people of the north of Scandinavia still use traditional clothing when herding their reindeer during the cold climate season. We have interviewed active reindeer herders in the county of Finnmark, Norway and will report on the status with regarding the use of traditional clothing.

We will emphasis on the reaction of the body to cold temperatures and the importance of avoiding hunger and dehydration while keeping the body warm and dry. Then we will inform about clothing that is still considered comfortable and useful by the Sami community, even compared to clothes made from from modern fibers available today. Comfortable clothing allowing full blood circulation and good functionality for the activity to be carried out is important. We will also emphasis that clean clothing insulates far better than dirty clothing.

A layered approach to clothing is implemented where woolen clothing is used near to the body to keep the body warm and dry, then clothing made from the skin of the reindeer is used. Bellingers made from the skin on the reindeers' legs protect the human legs and the pesk is pulled over the body to protect from the cold wind. Hands are protected by the gistát (the glove) filled with moisture absorbing sennagress (*carex aquátilis*, which also has an insulating effect) to keep the hands warm and dry.

Of particular importance is to keep the feet warm and dry by use of goikkehat (skaller) filled with the moisture absorbing sennagresss.

Traditional Sami clothing is best suited to the very cold and dry inland climate. In the moister offshore climate, some of the traditional clothing may easily become wet and may not be suitable. The use of sennagress in some way could, however, potentially be considered. This could be a future research area for the medical profession.



# About LEO, the Local Environmental Observer Network – A community-based system for surveillance of climate, environment, and health events

Michael Brubaker, James Berner, Moses Tceripanoff

***Alaska Native Tribal Health Consortium, Anchorage, Alaska, USA***

Climate change is resulting in a range of impacts to environment and the health of animals and people. But in the Arctic, systems for monitoring are limited. This is changing however, and the Alaska Native Tribal Health Consortium has developed a system for sharing community information on environmental impacts and community health effects.

The Local Environmental Observer (LEO) Network documents events and facilitates communication between communities, academic institutions and resource agencies. The purpose is to increase understanding about climate and other drivers of change and to develop appropriate adaptation strategies. To achieve this, LEO connects traditional knowledge, western science, and modern technology to achieve a robust and effective surveillance system.

LEO is composed largely of environmental and health professionals who share observations that are unusual or unique and locally relevant. The participants post text, photos and video using simple web-based surveys. Content is reviewed for quality and then posted to Google maps organized by month and topic.

LEO participants decide within their own organizations, what events they want to share. Once posted, the information is public and accessible by anyone with internet access. The participants are then connected with topical experts via phone and email, and the resulting exchanges and outcomes are captured within the related map posting. Updates are provided weekly via the Climate and Health E-News and monthly webinars provide an opportunity to discuss the observations and to engage with topical experts.

Since the program was initiated in January 2012, over 100 communities have enrolled across Alaska and in western Canada. The network has compiled a database of observations on topics including extreme weather, floods, erosion, ice change, permafrost, invasive species, infrastructure, contamination, and changes fish and wildlife. In some cases, the network has detected and informed wildlife and human health agencies about significant ecological events.

With the likelihood that climate change will continue to grow as a global health challenge, it is important that communities have the capacity to monitor, respond, and adapt to new events, impacts and health effects. Developing effective systems for accessing locally relevant information is a large part of this challenge. Improvements in communication

provide an opportunity for community-based observers to easily share information. The LEO Network provides a model for engaging communities to perform surveillance and connect with technical experts and resources. It is a powerful tool for documenting local events and developing effective adaptation strategies for our changing communities.

# **The elusive social and energy sustainability: Debates from the Barents energyscape**

Hanna Lempinen

***Arctic Centre, University of Lapland, Rovaniemi, Finland***

Projected growth in global energy demand, dwindling resources at known production sites, warming climate and technological developments are pushing energy extraction further towards the previously inaccessible remote Northern areas. In this process, also the Barents region has become a target of international attention. Home to an estimated fifth of the world's remaining hydrocarbon resources, the region has been nicknamed the world's new energy province. The projected increase in activities of extractive and other industries are expected to dramatically alter the regional economic landscape, the local environment and lives of the local population.

As past energy extraction activities in Northern areas have an uneven track record and political and popular discussions tend to focus on the economic and environmental dimensions related to energy developments, this presentation takes an explicit focus on tracing the sidelined and elusive social dimension in these debates. The presentation discusses and challenges the implicit and taken-for-granted understandings of the 'social' in terms of conceptual and theoretical discussions related to the broader sustainability debate as well as in the specific context of energy sustainability. Through projecting the case study focus on the Barents energyscape against the theoretical backdrop of the social as "more-than-human", the presentation highlights the contradiction between the general and vague definitions of the 'social' and the divergent, situated views of the social dimension and its status and contents at play in the Barents energyscape.

Keywords: energy, sustainable development, social sustainability, Barents region

# **Safety and security development in the Arctic: future challenges and recent experiences**

Niko Niemisalo, Ari Karjalainen, Pekka Livari

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European Union has raised the search and rescue capabilities, including environmental disasters, in the Arctic as key safety and security indicator in its policy towards the arctic region. The same focus is included in the Arctic strategies of the 8 Arctic states, as well as in the regional action plans. Finland has been active in national and regional level, in developing the capacities and services in responding search and rescue tasks and environmental disasters. Furthermore, Finland has been active in developing international cooperation regarding search and rescue capacities in the Arctic, where the Barents Rescue cooperation and participation to Joint Committee on Rescue Cooperation in the Barents Region since 2001 has been key activity.

The paper addresses the recent practical experiences on safety development in the Arctic, and discusses on good practices that have emerged in the field. The paper also takes into account the foresight point of view, and brings out the future challenges that might be important in the development of safety and security in the sparsely populated areas. Furthermore, the specialists presenting the paper are interested in hearing other conference participants' opinions and experiences in the field, and to build future cooperation to tackle these challenges.

For more information, see: <http://matkailu.luc.fi/Hankkeet/Turvallisuus/en/Home>

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# Ethnic difference in the prevalence of angina pectoris in Sami and non-Sami populations: The SAMINOR study

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## Objective

To assess the population burden of angina pectoris symptoms (APS), self-reported angina and a combination of these, and explore potential ethnic disparity in their patterns. If differences in APS were found between Sami and non-Sami populations, we aimed at evaluating the role of established cardiovascular risk factors and educational attainment as mediating factors.

## Design

Cross-sectional population-based study

## Methods

A health survey was conducted in 2003-2004 in areas with Sami and non-Sami populations (SAMINOR). The response rate was 60.9%. The total number for the subsequent analysis was 15,206 men and women aged 36-79 years (born 1925-1968). Information concerning lifestyle was collected by two self-administered questionnaires and clinical examinations provided data on waist circumference, blood pressure and lipid levels.

## Results

This study revealed an excess of angina pectoris symptoms (APS), self-reported angina, and a combination of these in Sami relative to non-Sami women and men. The OR for APS

in Sami women was 1.42 ( $p < 0.001$ ) and for men 1.62 ( $p < 0.001$ ) after controlling for age. When including relevant biomarkers and conventional risk factors, little change was observed. When also controlling for moderate alcohol consumption and leisure-time physical activity, the OR in women was reduced to 1.24 ( $p = 0.06$ ). Little change was observed in men.

## Conclusion

This study revealed an excess of angina pectoris symptoms (APS), self-reported angina, and a combination of these in Sami women and men relative to non-Sami women and men. Established risk factors explained little or none of the ethnic variation in APS. In women however, less moderate alcohol consumption and leisure-time physical activity may explain the entire ethnic difference.

# **The fulfilment of Norway's legal obligations to the Sámi - assessed by three current examples**

Øyvind Ravna

***UiT The Arctic University of Norway, Faculty of Law, Tromsø, Norway***

Based on the Sámi Right Committee investigations, Norway has undertaken several legal commitments for protecting Sámi culture and way of life, which by the end of last century gave Norway a reputation as "the best boy in the class". The 1987 Sámi Act, the 1988 Sámi Article of the Constitution, Norway's ratification of the 1989 ILO Convention no. 169 concerning Indigenous and Tribal Peoples in Independent Countries as the first country worldwide in 1990, and the 2005 Finnmark Act are results of this.

In this presentation, it will be discussed how Norway complies with its international and national obligations to the Sámi people, based on three actual examples: The land based renewal resources, the maritime resources and mineral resources.

# Respiratory protective devices in the mining industry – fit factor testing

Merethe Larsen

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Respiratory protective devices in the mining industry - Fit factor testing

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Key words: fit factor, respiratory face piece, particles, quartz.

## Introduction

We focus on the FFP3 respiratory face piece; disposable mask and half masks. There are several different models available, all CE-approved and comply with EN149:2001. The performance of FFP3 masks, however, relies heavily on good contact between the wearer's skin and the face seal.

## Objectives

Our objective is to introduce a quantitative fit testing method for disposable masks and half masks used in the mining industry. Factors to consider are shape of the face, beard, weight decrease/increase and dental surgery that affect the face form. In our project we decided to include one disposable mask and two models of half masks. The mining company used three type of masks; two halfmasks in which one is a Powered Air Purifying Respirator (PAPR) system and one disposable mask. Testing in the mining industry though included two disposable masks and three half masks.

## Method:

The equipment used was TSI PortaCount Pro Respirator Fit tester and the TSI Particle generator (HSE OC282/28; Fit testing of Respiratory Protective Equipment Facepieces). During testing we measure salt particles in the room and inside the respirator. A person, wearing the mask to be tested, carry out 7 tasks; normal breathing, deep breathing, turning head side to side, moving head up and down, talking, bending over and normal breathing while doing a stepping exercise. The quantitative Fit test result is given as "Passed" or "Not Passed".

## Results:



The disposable mask (P3) used by the mining company protected 2 of 29 persons (6, 9%) while our disposable mask protected 25 of 41 (60, 9%). The half mask used by the mining company protects 52 of 53 (98%). The other two half masks performed nicely but very few persons got tested.

Conclusion:

The disposable mask used by the mining company performed very poorly. Our disposable mask performed better. The half mask model used by the mining company performed very well in which 98% passed the test. A minor group of employees preferred our other model of half mask.

Based on our results the mining company decided to replace the disposable mask with our recommended one.

# Our practice of health preservation of indigenous peoples in the North of Russia

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We carry out social-hygienic and medical examinations of the indigenous population of the Russian northern territories. The peculiarities of the Nenets autonomous area's indigenous people public health state revealed by the doctors and medical scientists during the longterm expedition studies, the worked out, approved and introduced new forms of the roaming population's medical service organization allow to solve many medical-social problems of the northern indigenous peoples small in number.

Peculiarities of work, life and diet of families of wandering reindeer breeders were studied. The main medico-social problems are: small availability of medical aid to the wandering population; absence of the adapted criteria of a complex estimation of health of children of wandering reindeer breeders; preparation and adaptation of children to school are not solved; partial or full isolation of children from parents in boarding schools; education in the conditions which are not taking into account features of culture, physiology and psychology; change of a meal; destruction of the ecological environment; the state cease the most necessary forms of rendering of medical aid.

The results of the carried out longterm scientific and practical work for studying and preservation of health of the northern indigenous peoples small in number ground the necessity of organization of a new direction in medicine - ethnic medicine.

Ethnic medicine – a system of scientific knowledge and practical activity (work) aimed at strengthening and preservation of unique (isolated) ethnic community health, life prolongation, prevention and treatment of diseases. In order to fulfil this tasks ethnical medicine study peculiarities of constitution, vital activity processes, cast of mind and peoples behaviour depending on social, economical, political, natural and other factors; mode of living, peculiarities of pathology (their causes, mechanism of occurrence, flow and outcome of disease, symptoms), and possibilities in use of different factors to detect, prevent, treat diseases and rehabilitate. Recommendations developed on basis of rational mode of live, work and rest regime, meals; exposure methods, means of prophylactic and treatment different diseases, and organisation of medical aid to ethnic groups in special forms.

Training doctors, who are practicing on the North or facing with treating persons of various northern ethnos, in different clinical profiles and edition of the special literature should represent organizational registration of ethnic medicine.

# Qualitative improvement of health services for indigenous people in remote areas in the Nenets Region of Russia

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The Nenets Autonomous Area (NAO) is characterized by vast and inaccessible regions, and problems with recruiting and maintaining qualified health professionals in the rural areas. The main mode of transport is by air, also for health purposes. Telemedicine has been, and still is, considered as an appropriate tool to provide health care services to people living in rural areas connecting local health facilities to central hospitals.

Telemedicine in NAO started 13 years ago. The number of telemedicine consultations has been steadily increasing. The aim of the new regional program "Development of telemedicine in the NAO" is to develop a telemedicine network within NAO, linking remote health facilities (health-posts) with high-speed communication channels. In 2011, telemedicine equipment was installed at the seven local hospitals and the eight health-posts in NAO. The investment was made to improve the health service provision in the region, make it more accessible to its people. NAO have the technique and technology in place for 15 distant locations, plus one at the central clinic and three regional hospitals in Naryan-Mar. Of the 15 remote locations, five were chosen as a kind of "base" for people who work with reindeer and for their families. These group of people especially need systems for health monitoring.

The overall aim of our program is to improve health and social situation for people living in the remote regions of Nenets, especially the nomad indigenous population. The sub-objectives are the following: to strengthen the primary health care service to the population of remote settlements and the indigenous people in the Nenets region; to support the programme of health monitoring of pregnant women and infants in their first 12 months of life; to develop and implement a telemedicine training programme for health professionals at the remote health facilities; to develop a package for legal, financial and organizational policy and incentives for health professionals to support the use of telemedicine; to ensure that the technology in use at the health facilities are adapted and tested; to establish a professional international network on eHealth in inaccessible regions.

The aim of this work-package is to improve the accessibility and quality of primary healthcare services to people living in remote settlements and the nomad indigenous population.

# The Incidence and Immunological Reactivity at Working in the Conditions of the Arctic

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The climate of the North for accommodation of the person is discomfortable on deficiency of heat, deficiency of illumination, intensity of ionomagnitny indignation and extraordinary extent of change of climatic parameters. In the conditions of the Arctic very high repeatability (till 316 days in a year) discomfortable types of the weathers assuming possibility of cooling of the person. The thermal discomfort leads to considerable level of decline in production of work (from 35 to 200%), causes development of diseases of heart and respiratory system, holodovy traumas. Excess of incidences in the Arctic over that on the average across the Russian Federation fluctuates within 6-9% at adults, especially it concerns primary incidence (for 9-12%). Most sharply influence of climate affects higher incidence, on levels of diseases of blood and the haematogenic bodies (44-51%), diseases of respiratory organs (11-22%) and urinations (27-31 %). By inspection of 100 almost healthy faces it is established that the frequency of registration of various options of an immunodeficiency at working in the Arctic made 73%, including deficiency of the content of local (secretary) immunoglobulin's - 67%, functional insufficiency of T-lymphocytes of 73%, deficiency of fagotsitarny protection made 39%, the raised level of the content in blood of a cancer and embryonic anti-gene - in 19%. The immunodeficiency with a combination of the 3rd and more defects of immune protection is revealed at 48% surveyed, activation cellular the mediated cytotoxicity with increase in the maintenance of cytotoxic T-cages (CD8+), natural killers (CD16+) and concentration regulatory of cytokines IL-6, TNF- $\xi$ 945; is observed at 32%. Frequency of activation of antitelozavisimy reactions with increase in the maintenance of serum IgM and IgG, and also circulating immune complexes was higher (at 47 of 100 surveyed people), including at 23 surveyed observed reactions from IgE, in 26 cases revealed an autosensibilization with a wide range of autoantitel (cardolipin, to two-spiral DNA, the RNA complex and phospholipids). For improvement of a state of health of the population within 20 years we actively introduce the program of prevention of ecologically dependent immunodeficiency's, based on the principles of sorption therapy, antioxidants and stimulation of receptor activity of a cage. Efficiency of a complex reaches 90%, the increase in efficiency of medical measures makes nearly 85%, the quantity of aggravations of a chronic course of inflammatory processes is reduced by 2,5 times, the period of remission increases practically by 3 times (on supervision during 2 years).

# **Social Baseline Study as Guideline for coordinated CSR performance in Greenland**

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Greenlandic regulations require oil companies to carry out a Social Impact Assessment before undertaking exploration drilling. A key part of this is a Social Baseline Study, which provides descriptions of existing social conditions, development trends and development goals in the communities potentially affected by exploration drilling in the area. Five oil and gas companies operating offshore of North-West Greenland, NunaOil A/S, Cairn Energy PLC, ConocoPhillips, Maersk Oil Kalaallit Nunaat A/S and Shell Greenland will potentially all be active in the same sphere of operations (2014-2017), therefore the companies agreed to undertake a collaborative social baseline study (SBS) in 2013. The overall objective of the co-operative SBS was to build a strong base for managing potential negative impact and enhancing potential positive impact of the activities to be undertaken in the area. The aim was also to achieve coherent and coordinated community engagement and limit the potential for stakeholder fatigue. An inter- company collaboration such as the one described is the first of its kind in Greenland and was unconventional as far as the standard process described by Greenlandic requirements and guidelines is concerned. This collaborate approach although not identified by Government of Greenland requirements and guidelines, was supported by the authorities.

This paper presents the process of conducting a cooperative SBS from concept to final SBS report. This includes organization, scope of work, timing and execution. The paper discusses pros and cons related to the common approach. It also discusses whether the objectives were met, and identifies recommendations for future operations based on the experiences. Further the paper describes how the cooperation on the SBS has led to further cooperation between the companies to serve as guidance for coordinated CSR performance in Greenland.

# IMPROVING THE HEALTH PROTECTION OF HIGH NORTH MINERS

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Background: Working in mines is associated with elevated risk of traumatic injuries and disease from occupational exposure. More knowledge is required about the health of mine workers, their exposures and associated risk factors. Working in the high north also exposes workers to cold climate.

Aim: Study the prevalence and character of musculoskeletal health problems in high north miners, investigate its associations with occupational exposures and develop better prevention practices.

Material and methods: 3530 Russian mine workers participated in a cross sectional study in 2010 on low back pain (LBP) and occupational exposures: vibration, heavy lifting, ergonomic factors and working in cold climate with wet clothes. From 2012 mine workers from four high north countries were included in the cohort for studies (MineHealth) on the health and psychosocial impact from climatic, occupational and societal exposure factors in mining, as well as laboratory testing.

Results: Levels of whole body vibration (WBV) were above action values. Cold was the most prevalent exposure factor. Drivers, blasters and drill rig operators reported most LBP. Wet clothing, cold working conditions, heavy lifting, and previous work as a driver were more strongly associated with LBP than WBV. Driving the LHD trucks and underground trains were the only exposures from heavy vehicles associated with LBP.

Discussion: LBP prevalence was higher than previously reported, and driving-related WBV was not associated except for drivers of LHD trucks and underground trains who also have a twisted working position combined with low temperature in the open cabins.

Conclusion: 1. For better prevention of LBP, improved cabin conditions and clothing should be addressed. 2. A follow-up study will be done through 2013-14, in the MineHealth project [minehealth.eu](http://minehealth.eu), to develop improved prevention strategies, standards, clothing and education.



# Ethical Issues in Community-Based Participatory Research in the North: Challenges and Opportunities

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Interest and experience in community participatory research projects that address health has been growing for some time in the North, yet lessons learned from these complex and still evolving community academic partnerships for health are still rarely shared. As many know who have been engaged in such partnerships, it is often the process of engagement between diverse partners, and the local strategies created to address inevitable tensions that arise within such collaborations, which provide deeper understandings of shared health issues, and support novel interventions and outcomes. The recognition of potential ethical challenges unique to this type of engaged, adaptable and flexible community participatory research is also growing. However this too is still fairly rare in the literature on health research in the Arctic. A Special Issue of the International Journal of Circumpolar Health was planned and implemented in 2010-2012. The original intent and call was for original research papers, as well as expository and survey papers that should inform our shared understanding of at least one of the following aspects of Community Based Participatory Research (CBPR), with a particular focus on northern communities and projects: defining partnerships and communities; issue identification; data collection and methods; Interpretation and dissemination of results; social action/advocacy; and ethical challenges and lessons learned. This presentation will share the experience of planning and publishing this Special Issue, including the challenge of building the evidence-base for informed and collaborative research in our sparsely populated and culturally diverse Arctic region, and discuss a potential opportunity for contributing to the development of updated and expanded guidelines for ethical community based participatory health research in the circumpolar region.

Learning Objectives: 1. Describe unique circumpolar context of community based participatory research in the arctic region (Alaska-US, Canada, Denmark, Finland, Greenland, Iceland, Norway, Russia, Sweden)

2. Discuss challenges and strengths of local and/or tribal/indigenous review processes for community-based participatory health research

3. Describe at least two lessons learned from the experience of developing a special issue of the International Journal of Circumpolar Health devoted to addressing ethical challenges in community based participatory research

4. Discuss at least one opportunity to develop ethical guidelines for community based participatory research in the Arctic with a particular focus on emerging indigenous models and approaches.

# Seasonality in sleep across three seasons at 69° north

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Abstract: If bright morning daylight is an important zeitgeber for entraining the human circadian sleep/wake rhythm to a 24h clock cycle, variations in sleep patterns should be more present at northern compared with southern latitudes across seasons due to the larger variations in daylight. A prospective study (N=200) collecting data on sleep in August and January in Tromsø/Norway (69°) and in Accra/Ghana (5°), found support of a delayed sleep phase during the dark period in Tromsø only. Sleep efficiency was reduced, and physical and mental fatigue were more pronounced. Sleep duration or quality was not affected (Friborg, Bjorvatn, Amponsah, & Pallesen, 2012) as expected. The individual differences in the northern latitude with regard to phase delays (i.e., going to bed later, later chronotype) was however very large (ffl 90 minutes, 68% confidence interval) (Friborg et al., 2012). In other words, a significant number of individuals are prone to develop so-called social jet-lag problems (i.e., mismatch between circadian and social rhythms) and to build up sleep debt during workdays during the winter months. In the present project we examined the role of daily eating habits, depression and psychological self-regulatory measures as statistical moderators in a new university student sample in Tromsø only (N=150), and across three seasons (September, December and Mars). Seasonal differences in sleep patterns and phase delay were again confirmed. However, only depression played a slight, but very weak role, in explaining the large individual differences in sleep phase and timing. The search for others moderators should be continued as this information would be helpful for providing evidence-based recommendations on how to prevent significant sleep phase delays during the deark period in Tromsø.

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# Test of respiratory protection devices in cold climate

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Statoil has completed a study for testing the performance of respiratory protection devices in cold climate. The aims of the study were to check if the protection factor of different respirator masks was influenced by the temperature during use and if the user experience was influenced by the temperature during use. Further, the test was designed to address which of the respirators performed best at low temperature (if any difference occurred), and if ice formation or water condensation in- or outside the mask was an issue.

Three different respiratory devices, half-face mask and full-face mask with negative pressure and full-face mask with fan assistance, have been tested at the temperatures +20, +5, -10 and -25°C. The tests were carried out in a climate chamber at the vendor facility (IFKAN) with fully controlled environmental conditions. The performance involved three test persons representing different facial dimensions (anthropometric data), who performed standardized tasks inside the climate chamber in accordance with a procedure (EN 136: 1998). The fit testing was performed using aerosol of salt particles, in order to use non-toxic test compounds. The particle concentration were monitored inside and outside the respirators simultaneously with a particle counter (TSI CPC 3007), and the activities were documented on video (ParticleView software). The test subjects filled out a questionnaire regarding their user experiences.

The results show that in general, the full-face mask with fan assistance had good protection factor during all the tests, had no condensation on sight glass, and its performance was not affected by temperature. However, the user friendliness was low when cold air was sweeping against unprotected face skin, it was uncomfortable at +5°C, and it was unbearable at -10°C. The half-face and full-face masks had acceptable protection factor, but introduced other effects like affected by anthropometric variance and affected by handling. Further, the full-face mask had low visibility below +5°C due to condensation. Clearly, the fan assisted respiratory protection device was the most robust device. However, there is a need to look into how to pre-heat the air to improve the user friendliness before a recommendation of use in cold climate.

# **The cure for what ails you: rural and remote nursing in the Arctic.**

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The difficulty of effectively delivering nursing services to promote the health of indigenous residents of the circumpolar region is a challenge that the Arctic nations have failed to address. Chronic disease maintenance, preventative care services, and public health education all suffer in the absence of adequate nurse staffing in the North, with indigenous populations faring far worse due to recurring issues of poverty, isolation, education access, food insecurity, and discrimination.

A formal literature review has shown that there is very little information that has been written specifically about nursing health care delivery in the Polar north. Some of the few relevant articles found were focused on nursing in Greenland (Hounsgaard et al. 2013), on nursing in rural and remote areas in general (Baernholdt et al. 2010; Baernholdt & Mark 2012), and about the professional difficulties facing rural and isolated practice nurses (MacLeod 2008; Penz 2007).

This paper is an analysis of the challenges of nursing in rural and remote areas with an indigenous majority, with suggestions for increasing access to nursing services for Arctic indigenous residents. By comparing analogous situations where indigenous peoples are in the majority in a given region [Greenland, Canada (Nunavut/Nunavik), the United States (Alaska), Australia (Queensland), and New Zealand], this paper discusses four themes that were found after an analysis of the extant literature: recruitment and retention of nurses, rural and remote nursing challenges and risks, transcultural nursing and cultural competence, and strategies for improved rural and remote healthcare delivery.

Using a combination of telehealth and visiting nurse protocols, with an additional emphasis on recruitment of local residents as both nurses and community health care workers, the rural and remote practice nursing profession in the Arctic can provide meaningful health care to a far greater indigenous population than the current system of strained and underfunded health care. By improving the profession's ability to have an impact beyond the local, the nurse can dramatically improve the health and wellbeing of the indigenous residents of the circumpolar region.

# Practical health co-operation – the impact of a referral template on quality of care and health care co-operation: study protocol for a cluster randomized controlled trial

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## Background

The referral letter plays a key role both in the communication between primary and secondary care, and in the quality of the health care process. Many studies have attempted to evaluate and improve the quality of these referral letters, but few have assessed the impact of their quality on the health care delivered to each patient.

## Methods and design

A cluster randomised trial, with the GP office as the unit of randomisation, has been designed to evaluate the effect of a referral intervention on the quality of health care delivered. Referral templates have been developed covering four diagnostic groups: (1) dyspepsia (2) suspected colonic malignancy (3) chest pain and (4) chronic obstructive pulmonary disease (COPD). Of the 14 GP offices primarily served by University Hospital of North Norway Harstad seven were randomised to the intervention group. The primary outcome is a collated quality indicator score developed for each diagnostic group. Secondary outcomes include: (1) quality of the referral (2) health process outcome such as waiting times and (3) adequacy of prioritisation. In addition, information on patient satisfaction will be collected using self-report questionnaires. Outcome data will be collected on the individual level and analysed by random effects linear regression.

## Discussion

Poor communication between primary and secondary care can lead to inappropriate investigations and erroneous prioritisation. This study's primary hypothesis is that the use of a referral template in this communication will lead to a measurable increase in the quality of health care delivered.

## Trial registration

This trial has been registered at [ClinicalTrials.gov](https://clinicaltrials.gov). The trial registration number is:  
NCT01470963

# Views of Southeast Alaska Native Young Adults toward media and non-media-based smoking cessation interventions

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Background: The young Southeast Alaska Native adult (ages 19-29) smoking rate is 70% as compared to the statewide adult smoking rate of 21%, the Alaska Native adult rate of 41%, and the overall young adult rate of 32%. The Southeast Alaska Regional Health Consortium, the non-profit Alaska Native tribal health consortium of Southeast Alaska, collaborated with investigators at the University of Alaska Fairbanks and the University of Alaska Anchorage in conducting a formative qualitative study to inform a smoking cessation intervention tailored to young adults. This research study used a social marketing approach, examining barriers to change, benefits of smoking, and attitudes toward quit support methods. This study also examined stakeholders' use of electronic communication and their reactions to potential media and non-media-based interventions.

Methods: Twenty-three Southeast Alaska Native young adults, who were current or former smokers ages 19 - 29, participated in a total of five focus groups and four individual interviews. Participants were asked about the forms of electronic communication they favored and why. They were also asked to describe their reactions to poster boards depicting a series of cessation support aids, including three media-based cessation methods (texting, a smartphone based video game, and a smartphone based app) and one traditional cessation method (counseling with an option for pharmaceutical quit aids). Qualitative data were analyzed using a grounded theory approach with the aid of qualitative data analysis software (ATLAS.ti).

Results: Among the three media-based cessation methods, participants reported being most favorable towards texting support and the smartphone app, and least favorable toward the smart phone video game. Despite a strong desire to quit, there was high ambivalence regarding the use of traditional cessation methods. Reactions to the traditional non-media based intervention, counseling and pharmaceutical quit aids, were strongly supportive among those who had tried it compared to those who had not.

Almost all participants had cell phones, most of which were smartphones. They reported heavy use of texting and favored cell phone over computer access to the Internet. Most



non-work and non-school related electronic messaging was conducted via Facebook and not email.

Conclusions: This sample of current or former smokers among young Alaska Native adults in Juneau, Alaska, was most favorable toward smartphone app-based and texting-based cessation intervention. All were comfortable with electronic communication, most especially texting and Facebook. A cessation intervention designed for this priority population should consider incorporating some media-based components to enhance its effectiveness.

# Guidelines for working in cold climate.

## Risk management of work in cold climate

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The growth in petroleum exploration and production in the Barents Sea and the Arctic region offers new challenges to health and safety. Factors that might influence safe and efficient operations due to the cold climate in the Arctic include both risks due to human error and risks to the physical and psychological well-being of individuals.

The scope of work in a study by SINTEF on behalf of Statoil has been to improve the understanding of the need for better protection against the weather, negative effects on health, surveillance systems, and risk assessments for workers in the Arctic. There are normative and regulative standards related to work in cold climate that gives much knowledge and guidelines to the industry, but as pointed out in this and other studies there are need for a further development of guidelines to improve the protection of the workers' health and safety.

An import part of the work have been to draft/design guidelines for recommended use of the wind chill factor to help decide when to use different type of weather protection, recommended work/reheat period and special protection equipment (PPE). The study has concluded that the classification of risk categories from ISO 11079 should be used as a basis guideline for cold stress. Further a model has been developed as a suggested guide to the industry.

The protective clothing tested in this project provides sufficient thermal protection with regard to maintaining body and core temperature. The level of metabolic heat production is often more crucial than the insulation value of the protective clothing as a means of maintaining thermal balance during a work shift. At low metabolic heat production workers will experience substantial cold stress after approximately 1.5 hours at -5 °C and 5 m/s wind. With moderate heat production, an ambient temperature of -20 to -25 °C and similar wind speed is tolerable for 1.5 hours of exposure.

A recommendation is to establish a cold workplace team that should be responsible for continuous follow-up of cold-related issues. The management system should consider human factors such as experience, training, night-time operations (year-round in some cases), etc. A cold-risk management plan should be developed as a part of the general occupational safety plan of the individual workplace.

# **Northern Shift of Species: Effects of Mackerel Processing in Iceland; Social- and Economical and adaptability analysis of the Municipality of Vopnafjörður at the North- East Coast of Iceland.**

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In the recent years mackerel has been migrating more northwest into Icelandic waters where it is believed to be due to climate change. This has benefitted the town of Vopnafjörður, which is a small village of almost 700 people in North East Iceland. The town had experienced cutbacks in fish processing and in 2004 the situation was quite bad. Due to outside investment in the main processing factory, the town feared that the factory and the local trawler would be laid down and sold from the municipality. Without the fisheries industry the survival of the society would be greatly threatened. However a new investor come into the society and built up the pelagic processing. In addition to that a mackerel processing started from the year 2010 and came as an addition into the processing. All previous investments made the processing company were made for herring and capelin, and only minor changes to previous facilities were needed for the processing of mackerel. This has become a very important addition for the company and the municipality. It has resulted in a longer processing period, creating employment for the people in the municipality. The mackerel processing is also quite labor intensive and the staff almost doubles during the mackerel season. This has let the company having to rely on outside labor. In 2012 the total landings of mackerel was around than 16 thousand tons with the catch value of 4,9 million euros. This leaves significant value within the community in form of wages for the staff, increased tax income for the municipality, increased income through harbor fees and other fees related to the activity of the mackerel processing. This has resulted in better economic prosperity of the people living in the community as well as increasing revenue for the municipality. For the municipality of Vopnafjörður, this has been a great success story, where they have experiences the positive sides of climate change. This has come with some costs, where the social live in the municipality has suffered due to increased economic activity along with the losing the control of the local fish processing company. However, the community has shown a great deal of resilience by adapting to the changing environment in the fishing industry in the town.

# Growing up in the Arctic – no disadvantage for bone. *Fit Futures, The Tromsø Study*

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## Introduction

The highest incidences of osteoporotic fracture are reported from Norway. Bone mineral density (BMD) is a strong predictor of future fracture risk. Low BMD levels in adolescence may reflect higher fracture risk in later life. BMD is modifiable by lifestyle factors as body mass index (BMI) and physical activity in adults, and may influence achievement of peak bone mass in adolescents. The aim of this study was to compare BMD levels in Norwegian adolescents (15-18 years) with international references ranges, and explore the association between physical activity, BMI and BMD at the hip.

## Methods

In 2010-2011 all first year comprehensive school students in the Tromsø region were invited to participate in Fit Futures 1, an expansion of the Tromsø study. 1038 participants (508 girls) attended the survey (attendance rate > 90 %). BMD at total hip and femoral neck was measured as g/cm<sup>3</sup> by DXA (GE Lunar prodigy). Height and weight were measured, BMI calculated and adjusted according to Cole's cut off points for adolescents and children. Lifestyle variables were collected by self-administered questionnaires and interviews; leisure time physical activity by the Gothenburg instrument. Multiple regression analyses explored the association between physical activity and BMD across BMI levels. The analyses included 469 girls and 492 boys.

## Results

Mean Z-score for BMD at total hip and femoral neck were all positive, indicating that in Fit Futures participants 16 years of age, BMD values were higher than the Lunar pediatric reference ( $p < 0.001$ ). When we explored relationships between BMD and physical activity

in a regression model adjusting for age, BMI, sexual maturation, smoking and alcohol consumption, we found that higher levels of physical activity were associated with increased BMD in both sexes ( $p < 0.001$ ), the highest activity levels more than 1 SD higher, which corresponds to a 50% reduction of fracture risk in the elderly. Stratified for BMI levels, physical activity was significantly associated with BMD in the underweight and normal weight girls ( $p < 0.01$ ). By contrast, in boys who were normal weight and overweight for age ( $p < 0.05$ ).

## Conclusion

BMD appears higher in Norwegian adolescents compared to age-matched European peers, which is promising for future fracture incidence. BMI and physical activity levels explain a significant proportion of the variation in BMD at the hip in both sexes, but differently across BMI classes in males and females. High levels of physical activities continued into adulthood, will be favorable for bone health.

# Wellbeing in adapting to a changing north

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Communities in northern Norway are faced with rapid changes in interlinked climatic, environmental, demographic and social conditions. Communities in Northern Norway are actively developing their responses to these changing conditions. In adapting to these changes it is necessary to pay attention to local contexts, and ensure wellbeing of communities in the adaptation processes. How will changes affect wellbeing, and how ensure that local wellbeing is integrated in adaptation processes?

Wellbeing can be a goal for individuals, communities or a policy goal at various levels. Wellbeing can also provide an analytical lens with which to understand local processes of change, determined by interlinked material, relational, and subjective conditions ([www.welldev.org.uk](http://www.welldev.org.uk)). It includes aspects such as human health, wealth, happiness, a sense of fate control and community capacity (Kofinas and Chapin, 2009).

Research in Northern Norway shows how communities adapt to sustain a way of life and to improve their wellbeing. Wellbeing can be seen as synonymous with quality of life. Aspects of quality of life specific to two municipalities in Northern Norway are nature, community, activities, connectivity. Of particular relevance in this context is the importance of nature and natural resources, most importantly for employment, but also as a significant aspect of relational and subjective dimensions of wellbeing. It is found that attachment to place acts as a motivation to maintain aspects of quality of life. In the adaptation process communities are strengthening and redefining places in order to increase the wellbeing of the communities. One way in which they are doing this is through cross-community voluntary groups, which are working to emphasise the positive aspects to make inhabitants proud of their own place and to encourage an active local community. There is also an active focus on developing more tourism and outdoor recreation activities to attract more visitors, and more importantly, more inhabitants. This paper will discuss how a wellbeing approach may provide an analytical approach to include material, relational and subjective aspects of wellbeing, and to understand how communities can move towards this goal.

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# Creating competitive edge from the Arctic conditions

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The Arctic is often defined and characterized in various ways. A number of these characteristics are in a way negative; harsh climate, long distances and the sparse population. Therefore living and succeeding in the Arctic has always required special expertise that has formed around these aspects that we see as negative or challenging. We end up speaking of the arctic know-how, snow-how, cold climate expertise or expertise in arctic or extreme conditions etc.

Finland is an arctic country and Lapland as its northernmost county, is also Finland's most arctic region. The arctic conditions have created space and need for completely new kind of innovations in services and technology in Lapland. In order to support the local businesses to take advantage of the arctic conditions, Arctic Power laboratory was opened in 2003.

Now, ten years later, Arctic Power is show-casing numerous concrete examples which can elaborate on how the arctic is a testing and development surrounding for new innovations. Currently, as more than a laboratory surrounding, Arctic Power is a center of expertise for cold and winter. As part of Lapland University of Applied Sciences, the Arctic Power is also a learning environment for the students.

The presentation will mainly focus on elaborating shortly on numerous concrete case examples that have helped in boosting the competitiveness of the region by taking advantage of the arctic conditions. Secondly the presentation will give conclusions from Arctic Power's point of view on what kind of special know-how and support has been needed by the business community and what are the future challenges for us to stay competitive and make a living on the Arctic. The concrete examples are:

The eSled, the first electric snowmobile equipped also with hydrogen fuel cell, for tourism purposes

Intelligent Road system for demonstrating road-weather technology for arctic conditions

Thermal insulation testing for clothing

Snow and ice construction technologies as an export product

Hydrogen fuelling station in sub-zero conditions

Bringing cold technology into new and innovative arctic wellness services in the tourism context

# Single-industry towns in the Russian Arctic: social aspects of sustainability

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Abstract. In the paper social sustainability aspects of single-industry towns development in contemporary Russian Arctic are discussed. As a point of departure, a typology of these towns by criteria of population dynamics and by industrial specialization of town-forming enterprises is proposed. The typology reveals that most of Arctic single-industry towns in Russia officially recognized as mono-profiled settlements are mainly based on mining industries.

To discuss social sustainability issues of single-industry towns in the Russian Arctic we consider such aspects as trends in demographic developments and living standards, situation at labor markets, provision with the basic social services for local population, practices of social responsibility of oil and gas corporations, as well as that of mining companies acting in the Russian Arctic. On the base of the analyzes we elaborate set of proposals for solving most acute social problems of single-industry towns in the Russian Arctic, as necessary preconditions for transition towards their socially sustainable development.



# Barents Peace Education Network (BPEN)

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Barents Peace Education Network (BPEN) The Centre for Peace Studies at UiT, The Arctic University of Norway, wishes to present the newly established Barents Peace Education Network (BPEN). The overall objective of BPEN is to establish a sustainable network between universities in the Barents region with the purpose of developing and promoting peace education, and to highlight relevant High North issues through research and cross-border knowledge exchange.

BPEN has three legs; education, research and practical peace work, and aims to serve as a much needed arena for knowledge exchange. Competence building in peace education and peace studies in the Barents region can enhance and improve conflict resolution capacities in individuals, communities as well as in community-state and cross-border relations. By targeting and cooperating with both academia and with CSOs in an academic setting, BPEN offers a new niche for cross-border knowledge and competence building.

The first BPEN conference will take place in Petrozavodsk in October 2013. Participants are representatives from both academia and CSOs, and the focus is on practical peace work in terms of mediation, dialogue and restorative practices. The next step is a conference in Tromsø in November 2013 with focus on both education and research, where the main object is to establish cross-border research groups.

Main BPEN goals are:

- To offer additional ways and venues for mutual competence building and cross-border knowledge exchange between universities in the Barents region
- Competence building in practical conflict resolution, and implementation of conflict management educational programs in the North West of Russia (Petrozavodsk, Murmansk, Arkhangelsk)
- To facilitate cooperation between CSOs and academia on peace education and practical peace work
- Research development and dissemination on topics deemed most relevant by project participants within the frames of:
  - o "Cross-border Knowledge"
  - o "The History of Arctic Peace"
  - o "In/Tolerance"
  - o "Restorative Practices, Mediation and Dialogue"

BPEN partners are:- Petrozavodsk State University (Karelia, Russia)- Northern (Arctic) Federal University (Arkhangelsk, Russia)- Murmansk State Humanities University (Murmansk, Russia)- UiT, The Arctic University of Norway (Tromsø, Norway)

# State of Knowledge of Canada's North: implications for the wellbeing of Northerners

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Part of the mandate of the Canadian Polar Commission is to monitor and periodically report on the state of knowledge of the polar regions. Following significant investments in knowledge creation over past seven years, including IPY, and before the launch of the research program of the Canadian High Arctic Research Station (CHARS), we have undertaken an assessment of the numerous knowledge gains recently achieved in Canada's North, and the gaps that remain, with a particular focus on those that are most important to Northerners themselves. We are identifying opportunities to address some of their most important needs with a special interest in collaborative research endeavours.

Much new knowledge has been created in a broad range of disciplines. However, the issues of greatest concern to Northerners are mainly multi- or trans-disciplinary in nature, and related to their wellbeing. Consequently, our assessment is also trans-disciplinary. Four overarching themes have been identified through an analysis of cross-cutting elements of identified issues, research gaps and opportunities to collaborate.

The first theme is Increasing community sustainability, which includes knowledge of the development and delivery of housing, community services, infrastructure, and transportation systems; reducing cost of living; energy security; water security; increasing food security; and supporting appropriate economic development. Understanding and adapting to a changing environment includes local and regional monitoring, modeling and predicting climate change impacts; identifying associated adaptive measures for humans and the built environment (i.e., housing, infrastructure and transportation systems); and understanding and adapting to environment-related impacts on food security. Preparing for large-scale resource development includes knowledge that ensures appropriate governance structures are developed and implemented; that communities are able to benefit; supporting education, labour and workforce opportunities; ensuring adequate housing, infrastructure and transportation is in place; and understanding and addressing associated environmental impacts of economic activities. The final theme, Strengthening resilience includes knowledge related to coping with intergenerational and environmental change; addressing mental health and overall health and wellbeing; ensuring transfer of traditional knowledge; and supporting community-based research and monitoring for capacity building.

Our findings serve as a basis for new research collaborations that address the most significant needs of Northerners. We will strengthen our efforts to engage knowledge creators and encourage beneficial new collaborations.

# **Self-rated health among Greenlandic Inuit and Norwegian Sami adolescents: associated risk and protective correlates.**

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Objectives: Self-rated health (SRH) and associated risk and protective correlates were investigated among two indigenous adolescent populations, Greenlandic Inuit and Norwegian Sami.

Design: Cross-sectional data were collected from "Well-being among Youth in Greenland" (WBYG) and "The Norwegian Arctic Adolescent Health Study" (NAAHS), conducted during 2003-05 and comprising 10th and 11th graders, 378 Inuit and 350 Sami.

Methods: SRH was assessed by one single item, using a 4-point and 5-point scale for NAAHS and WBYG respectively. Logistic regressions were performed separately for each indigenous group using a dichotomous measure with "very good" (NAAHS) and "very good/good" (WBYG) as reference categories. We simultaneously controlled for various socio-demographics, risk correlates (drinking, smoking, violence and suicidal behavior) and protective correlates (physical activity, well-being in school, number of close friends and adolescent-parent relationship).

Results: A majority of both Inuit (62%) and Sami (89%) youth reported "good" or "very good" SRH. The proportion of "poor/fair/not so good" SRH was three times higher among Inuit than Sami (38% vs. 11%,  $p < .001$ ). Significantly more Inuit females than males reported "poor/fair" SRH (44% vs. 29%,  $p < .05$ ), while no gender differences occurred among Sami (12% vs. 9%,  $p < .08$ ). In both indigenous groups suicidal thoughts (risk) and physical activity (protective) were associated with poor and good SRH, respectively.

Conclusions: In accordance with other studies of indigenous adolescents, suicidal thoughts were strongly associated with poorer SRH among Sami and Inuit. The Inuit-Sami differences in SRH could partly be due to higher "risk" and lower "protective" correlates among Inuit than Sami. The positive impact of physical activity on SRH needs to be targeted in future intervention programs.

# **Social trust as an indicator of social capital and its effect on depression**

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Introduction: Research indicate that social capital can have a substantial effect on the development of depression. Social capital is however not a simple phenomenon and the explanatory power of different types of social capital with regards to depression trajectories can vary substantially. The objective of this research is to explore the role of social trust as an indicator of social capital in explaining depression using an Icelandic large scale dataset.

Material and methods: This research is based on a longitudinal dataset from the Health and Well-being surveys, collected in Iceland in 2007 and 2009. The number of valid observations was 3.211. Depression was measured with DASS. Trust was divided into two factors; particularized trust was measured with four items regarding trust towards specified groups and generalized trust was measured with six items referring to trust elements towards unspecified others.

Results: Generalized and specified trust explain 7.6% of the distribution of depression. Specialized trust explains a larger share of the distribution of depression. Specialized and generalized trust explain depression beyond being depressed at an earlier point in time and about as much as people's estimation of their physical health.

Conclusions: Results indicate that trust significantly explains depression. The share of specialized trust is larger than that of generalized trust, indicating importance of social support as coping resource when dealing with depression. However, the explanatory share of generalized trust is independent, indicating the positive effect of social capital on the development of depression. Authors call for continuing research on the effect of social capital on the development of depression and comparable data from other Nordic counties. The importance of this is especially salient in view of predicted changes in the distribution of economic resources and it's hypothesized effect on social capital.

# **Walking on Thin Ice: Extractive Industries and Indigenous Peoples in the Russian Arctic**

Anna Varfolomeeva

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The confrontations between indigenous population and manufacturers over land and natural resources have often been a complicated issue. Extensive mining, as well as oil and gas extraction, create the possibilities for economic growth and employment in the region of industry; at the same time, they influence the established lifestyle of indigenous communities and in many cases also damage their habitat. This situation is typical for the Russian Arctic, an extremely appealing region for extractive industries: 80% of Russia's explored reserves of natural gas are located there, and the estimated amount of oil could meet the needs of the world for three years. However, it is also a unique ecosystem and the home for 17 indigenous peoples who are deeply worried about the future of their land.

The current situation of small-numbered peoples of the North caught among governmental claims and the ambitions of large corporations is in the focus of this paper. Two of the indigenous peoples of the Barents region - Sami and Nenets peoples - were chosen for in-depth analysis. Both of them have a long history of negotiations about extractive industries influencing their traditional territories. Now, with the current prospects of establishing new oil extraction platforms in Russian Arctic, this problem is becoming vital again. In 2012 the representatives of Sami and Nenets peoples joined the collective claim of indigenous peoples to the Russian government demanding to forbid oil extraction in the Arctic region and to consult indigenous communities on the issues of industrial land use. The problem was widely discussed in media during the four-month termination of the activity of RAIPON (Russian Association of Indigenous Peoples of the North) in 2012-2013 which could be caused by their position regarding oil extraction in the Russian Arctic.

The paper examines the history of extractive industries in the Russian North influencing the lifestyles of Sami and Nenets peoples, as well as the current situation with oil extraction prospects. The case studies are analyzed in the context of existing practices of indigenous peoples' relations with industrial corporations in Russia. International and Russian legislative acts on land and natural resources use are discussed, as well as the materials of Barents working group on indigenous peoples and Sami and Nenets NGOs.

# Training of specialists for underwater work in the Arctic zone of the Russian Federation

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More than 25% of undiscovered oil reserves, according to experts, will be produced on the shelf, including the northern seas. Promising hydrocarbon reserves are areas in the Barents, Kara and White seas, where identified large structures and features 10 oil and gas fields, including 4 giant on their reserves: Stockman, Leningrad and Rusanovskoe Prirazlomnoe condensate and oil and gas condensate field. The construction and operation of offshore structures in almost all phases of construction and operation requires the use of underwater work. Expertise to carry out such work is prepared in various educational institutions of the Russian Federation. However, the imminent construction of offshore platforms for the development of the Shtokman and other hydrocarbon deposits on the Arctic shelf, where there are adverse climatic and ice conditions, the lack of close ups of building bases and other factors, makes it possible for specialists which will require another, higher level, with additional skills to work under the ice cover. Such experts should be prepared taking into account these features directly on the basis of having similar climate where students will perform in the preparation of training dives under the ice cover. Easier to tolerate such people diving, adapted to northern climates, ie residents of northern latitudes, or people that are adapted to such conditions. It is known that the physiological characteristics of the cardiovascular and respiratory systems, the mechanisms of regulation and exercise performance in people arriving for work in extreme conditions at high latitudes, where there is a cold factor in the process of adaptation to climate-geographical conditions of the Arctic is a deep adaptive adjustment, expressed in build-up load on the cardiovascular and respiratory system, increasing the activity of sympathetic nervous system and the reduction of the functional reserves of the body. Against this background, the additional constraints inherent divers when working in the northern seas in icing conditions, will contribute to more rapid fatigue, leading to a greater risk of occupational diseases and reduce the time spent underwater. Available skills working specialties will reduce the additional physical and psychological costs of the organism to performance of work under water. For more practice began implementing in Arkhangelsk.

# Is walking to school beneficial for bone? Fit Futures, The Tromsø Study

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## Introduction

Osteoporotic-related fractures in the elderly constitute a major health burden in western societies. Bone mineral density (BMD) is a strong predictor of future fracture risk. BMD in the elderly is a result of peak bone mass (PBM) achieved during childhood and adolescence and subsequent bone loss. There is growing awareness on maximizing the genetic potential for BMD in early days as a preventive strategy for primary osteoporosis later in life. Previous research suggests that physical activity has a positive influence on PBM, but the necessary level has not been determined. The impact of walking on BMD status in adolescence is not known. The aim of this population-based study was to explore the relationship between self-reported physical activity, transportation type to school and BMD-levels of Norwegian adolescents.

## Methods

In 2010–2011 we invited all first comprehensive school students in Tromsø and Balsfjord to participate in the Fit Futures study, a part of the Tromsø study. 508 girls and 530 boys attended. The attendance rate was 93%. We measured total body-, total hip-, and femoral neck BMD as g/cm<sup>3</sup> by DXA (GE Lunar prodigy). Physical activity and lifestyle variables were assessed by self-administered questionnaires, including indication of usual transport type to/from school during both summer and winter season with alternatives walking, cycling, bus or car/motor cycle/moped and the dichotomous question: "Are you actively doing sports or physical activity outside school hours?" We included 469 girls and 492 boys, 15–18 years of age, in analysis.

## Results



In bivariate analysis reported physical activity was associated with higher BMD levels at all three measured sites for boys and girls ( $p < 0.001$ ). Reported walking to school both summer and winter compared to not walking were significantly associated with higher BMD at femoral neck in girls ( $p = 0.01$ ). When stratified into active and inactive adolescents associations between higher BMD levels in total hip ( $p = 0.019$ ) and femoral neck ( $p = 0.013$ ) and walking were found in girls, but only in the inactive group. For femoral neck and total hip the relationship with walking stayed robust in a linear multiple regression model when adjusting for possibly confounding variables like age, menarche age and body mass index.

## Conclusion

Our results confirm existing hypothesis of skeletal benefits of physical activity. For adolescent girls who are not physically active outside school, walking both seasons to and from school seems to exert a positive impact on femoral BMD levels and is highly recommended.

# The ways of connection with “the mainland” among hunters and reindeer herders in the Extreme North of Russia

Vera Kuklina

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The questions of transportation are among the most important topics as a main challenge and the biggest item in the local budget in remote places such as northern regions and mountainous areas. Location far away from the center gives some advantages of cultural autonomy but the challenges of being excluded from shopping centers, medical care and educational institutions look overwhelming for an "outsider". Based on the field trips in the northern villages and taiga in Irkutskaya oblast, Republic of Sakha (Yakutiya), and Republic of Tyva the author will examine connections between "center" and "periphery". Using ANT-theory (Latour, 2012) the main actants that connect the hunters and reindeer herders with their families in the villages and with "the center" will be followed. The author will discuss the practices, things, technologies, and animals that hunters and reindeer herders use to build those connections. Besides traditional means of indigenous peoples the Soviet practices and technologies, and circumstances provided by new extractive companies will be explored, including military vehicles, geological profiles, new dirt roads, pipelines, plane routes, Internet, and satellite connections. Although new barriers for connections induced by extractive companies are also in the focus of the paper.

# The Indigenous People of Krasnoyarsk Region. Past and Present.

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Introduction. The Krasnoyarsk region is one of the biggest regions of Russian Federation. 1\4 of its territory is situated in High North area. Since the earliest times of its exploration by Tzar's Government, this place was a home for different people, including indigenous people of the Arctic territory and Turk's tribes. Starting from the period of first explorers to come to this part of Siberia the need for trade and peaceful coexistence led to creating new forms of unique economical rules and new system of law regulating the relations between Russian new-comers and indigenous population of Northern Part of Eastern Siberia. The main point of my research is to demonstrate the evolution of the relationship between these two different, both in cultural and numerical meaning, groups of people. Another goal is to demonstrate today's situation in Krasnoyarsk region, good and productive relations with indigenous peoples living there, to describe their self-government system and give listeners the understanding of economical interaction between Northern part of the region and the rest of the territory, supportive programs aimed onto the improvement of life conditions, education level etc. In this report presents a short historical excursion of exploration of Arctic parts of the regions (from the Tsar's times till now), descriptions of Indigenous people's ethnic groups living on the territory and their particularities. Then the audience is provided with the information helping to understand the quality and the results of the local government's programs developed to preserve the culture of indigenous people, increase their population, to help those, who want to deal with traditional crafts. Part of the report is dedicated to the work of Local Parliament, which includes representatives of indigenous people and their contribution into the development of the region.

# **To be or not to be: the single-industry city as one of the ways to work and live in the Arctic**

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The postindustrial evidences of the rapid climate change have put forward a lot of concerns including the increasing access to the Arctic. This access along with the obvious benefits (increasing exploration of the vast Arctic resources to maintain humankind lifetime) will bring negative outcomes as well. Due to the growing world demand for natural resources, the new exploration era is on the way. One of the central places in the industrial perspective within Russian Arctic holds the development of single-industry cities and settlements which has a long-standing historical background. It is projected (Nordregio, 2012) that due to the increasing exploration of natural resources within the Arctic territory of Russia, new single-industry cities as the historically successful models of resources exploration will be developed. The 'monocity' (single-industry city) is the city or settlement with the one main township-forming enterprise (mining and other extractive industries, shipping, fishery, oil production etc.) the development of which determines and influences all the aspects of economic and social activities within the settlement as well as contributes greatly to the state of the surrounding environment and ecosystems. According to the recent interviews, the top most problems residents of these cities highlight are the high unemployment rate (due to the low diversification of economy), low wages, bad quality of drinking water, bad physical and occupational health, and contamination of the environment. It's important to understand all those problems to predict the future development of these cities. As mentioned above, the successful development as well as depressive scenarios of development of the single-industry cities depends on the set of interconnected social, ecological and economic factors. From the exploration history of the Arctic it is known that development of these cities can follow mainly 3 scenarios with progressive or depressive ways of development or even become an abandoned settlements (e.g. Pyramiden). We aim to examine social (along with administrative) and ecological problems that face single-industry cities of the Russian Arctic to predict the possible ways for the future sustainable development of these model cities as they are an important element for the future of the Arctic region and people's well-being.

# **The Arctic Indigenous peoples and their involvement at different levels of decision-making**

Michal Symonides

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In addition to the involvement of Arctic Indigenous peoples on a local level, it is interesting to study their mobilization in the context of international cooperation. Indeed, this action allows them to strengthen the application of their rights through the support of international law among others tools. Indigenous peoples have voiced their interest through a major role they play in the UN fora, but also through cooperation at the regional level or, even more interesting, at the transnational level.

Each of these levels deserves to be precisely described as each of them serves a unique role and allows, in its own way, a more efficient action for the indigenous cause. Briefly, at the transnational level, Indigenous peoples use their own structures which are the emanation of their combined national interests. These specific organizations (for instance both the ICC and the Saami Council) permit them to be represented at the international level. At such level, it is important to differentiate the regional action, where indigenous peoples are interacting with Arctic counterparts but also with other major actors of the region (the Arctic Council is the best illustration), and the organizations with a global vocation in which there is important indigenous activism, such as in the UN fora.

Thus, an obvious observation is that Arctic Indigenous peoples are present at many levels of cooperation in different structures through which they interact with diversified actors, such as Arctic States. This presence allows them to maintain dialogue and as well as a flexibility of action (contexts and topics). Such mobilization on their subjects of concern and their presence at all levels of decision-making allow them to ensure and foster their situation at the local level and to improve their daily lives.

With regard to the role of the indigenous action we can say that it is complementary. At the transnational level, Indigenous peoples share their national concerns to a higher level and they wish to homogenize the protection of their cultural identity. At the international level, the demands and expectations are formulated through organs of cooperation to have an impact on the lives of indigenous peoples in their national frameworks. Thus, the international framework allows to mobilize common demands to all indigenous peoples (international level) or specific ones (regional level) for common actions, programs or order to create a new normative framework. This action can also encourage States to proceed to changes.

# **APECS Traditional Knowledge Working Group: A platform to communicate urgent issues**

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Traditional Knowledge has many definitions; however the core definition is well described by an elder from Tuktoyaktuk in the Inuvialuit Settlement Region: Traditional Knowledge is the pride in knowing your culture and knowing how to survive in your surroundings. Traditional Knowledge is a rich knowledge base, it is knowledge gained from the experience of living on the land and knowledge passed down by ancestors, and it takes a holistic approach to understanding the environment. As science often takes a reductionist approach to understanding the environment, using Traditional Knowledge and scientific knowledge together creates a more in-depth understanding. As the climate warms, people living in the Arctic face many challenges. By combining both scientific and Traditional Knowledge, researchers can better understand the urgent issues that all Arctic residents face and develop more appropriate solutions. The Association of Polar Early Career Scientists (APECS) have created the Traditional Knowledge web resource and Working Group to assist Early Polar Career Scientists (EPCS) in incorporating Traditional Knowledge into their research. We have also created the web resource to facilitate the meeting of EPCS and northern communities can meet to discuss research ideas and research needs. In addition, we are currently developing: (1) ideas and methods for northern community consultation and research involvement, (2) ideas and methods for use of Traditional Knowledge in research, (3) a map of Inuit regions across the Circumpolar Arctic, (4) resources for documenting Traditional Knowledge, (5) northern community contacts for initiating community-driven and community-based research and the incorporation of Traditional Knowledge into research projects, and (6) an online meeting place where northern communities and EPCS can post profiles, research ideas and research needs and where EPCS and northern communities can “meet” with each other. The TK Working Group works hard to develop all of these resources in collaboration with northern communities.

# Sweet dreams and good mornings: High North parenting of sleep transitions for extreme sleep-type children

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Evidence on the importance of normative sleep for developing children has been linked to school performance, health, and cognitive and physical growth. Further, sleeping habits of children have been noted to influence family functioning, with adverse sleeping behaviors exacerbating parent-child conflict. An estimated 30% of all children have been shown to struggle with a sleep issue of some kind (falling asleep, staying asleep or awakening), and these disturbances tend to be persistent. Therefore, parental management of children's sleep routines may be an important aspect of healthy family functioning and positive parent-child relations. What are the relations between preferred sleep-wake patterns, cultural patterns surrounding sleep, and family functioning? Might factors as cultural demands and extreme qualities in our physical environment, such as light, influence children's sleep routines? The key question in this study centered on whether children's bedtime/waking patterns and ability to meet daily schedule demands were influenced by seasonal variations in direct sunlight exposure during two different school weeks, with no other notable changes in their daily routines. We studied the sleeping patterns of elementary-aged children in the High North (the circumpolar region north of the Arctic Circle) in a town where people experience extreme fluctuations in light every year; for two months they experience 24 hours of direct sunlight daily (the light time), and for two months they experience no direct sunlight at all (the dark time). There, like everywhere, some of the children are extreme morning types in their sleep-wake habits and others extreme evening types. In our first analysis from the project, we found that children's sleep patterns are, contrary to what one might predict, relatively impervious to extreme light effects. Rather, non-seasonally-based routines like school obligations, a timed constant in their daily lives, proved to be more associated with sleep patterns and conflicts with parents over daily routine demands than seasonal shifts in light. However, if light does matter for sleep patterns, as others have found before, could it be that light has minimal impact on children, at least in part, because of how parents differentially help their children manage their sleep transitions in those times of extreme dark and light? This session will describe patterns in how parents reported managing their children's sleep transitions, and discuss how the use of adaptive parenting strategies helps extreme morning- and evening-type children meet the daily demands of the school schedule in relatively stable ways, regardless of light conditions.

# Arctic hearts – Seasonal variation in cardiovascular disease risk factors in the Tromsø Study 1979–2008

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**Background** A seasonal pattern with winter peak in cardiovascular diseases (CVD) like myocardial infarction (MI) and risk factors is observed in studies worldwide. Seasonal changes in CVD risk factors may be due to exposure to changing environmental factors like temperature and light or behavioral patterns in physical activity and diet. Investigating the seasonal pattern of risk factors should help determine the causes of the seasonal pattern in CVD. Several previous studies have methodical limitations and few are performed in populations living in cold climate areas. The Tromsø Study is an ongoing population-based cohort study consisting of more than 40,000 individuals living in Northern Norway, in a subarctic climate with large seasonal variation in daylight. The cohort members have been examined up to nine times in six repeated health surveys in the years between 1974 and 2008. Data on CVD risk factors have been collected throughout follow-up. In this population we have observed a small increase in MI incidence during the darkest winter months and, in the elderly, after cold temperatures and heavy snowfall. The aim of the present study is to assess the effect of season in CVD risk factors using repeated measurements.

**Methods** We investigated the seasonal pattern in systolic and diastolic blood pressure, body weight, total cholesterol, triglycerides and high-density lipoprotein cholesterol. Measurements came from 38,037 participants in the Tromsø Study, examined up to eight times from 1979 to 2008. Individual and population seasonal patterns were estimated using a cosinor in a mixed model.

**Results** All risk factors had a highly statistically significant seasonal pattern with a peak time in meteorologically defined winter, except for triglycerides (peak in autumn). The sizes of the seasonal variations were clinically modest.

**Conclusions** Although we found statistically significant individual seasonal patterns for all CVD risk factors, the sizes of the changes were likely too small to contribute to acute CVD events. This is consistent with our previous findings with small effects of season and meteorological factors on MI incidence in this population. The findings implies that,



compared to populations in warmer climates, this subarctic population is little effected by season and weather, probably due to long-term adaption to the harsh local climate, mainly through behavioral protection like clothing and housing standard.

# Gambling Behavior and Problem Gambling Reflecting Social Transition?

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## Introduction

An increase in social pathologies is a key feature in indigenous populations undergoing transition. The Greenland Inuit are a large indigenous population constituting a majority in their own country, which makes it possible to investigate differences within the population. This led us to study gambling behavior and problem gambling among Greenland Inuit in relation to the ongoing social transition and traumatic events during childhood.

## Material and methods

A large representative cross-sectional study was conducted among Greenland Inuit (n = 2,189). Data was collected among adults (18+) in 9 towns and 13 villages in Greenland from 2005 to 2010. Problem gambling, gambling behavior and traumatic childhood events were measured through a self-administered questionnaire. The lie/bet screen was used to identify past year and lifetime problem gambling. Social transition was measured as place of residence and a combination of residence, education and occupation.

## Results

The lifetime prevalence of problem gambling was 16 % among men and 10 % among women ( $p \leq 0.0001$ ); and higher in towns (19 %) compared to the capital of Nuuk (11 %) and in villages (12 %) (men only,  $p = 0.020$ ). Lifetime problem gambling was associated with social transition ( $p = 0.023$ ), alcohol problems in childhood home ( $p = 0.001/p = 0.002$ ) and sexual abuse in childhood (women only,  $p = 0.030$ ).

## Discussion

A comparably high prevalence of lifetime problem gambling among Greenland Inuit adds problem gambling to the list of social pathologies in Greenland. A significant association between lifetime problem gambling, social transition and traumatic childhood events suggests people caught between tradition and modern ways of life are more vulnerable to gambling problems.

# **International Migration in the Arctic**

Timothy Heleniak

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People have been migrating to the Arctic regions from outside for centuries. However, in recent decades there has been an increase in international migration into the Arctic states because of globalization defined as increased and lower-cost transportation and communications. Megaprojects aimed at the extraction of Arctic resources have drawn in large numbers of foreign workers. This paper starts by examining the size, origins, and destinations of international migrants in the Arctic. This is based on information from a variety of different data sources. It then looks at the labor market and other roles played by international migrants and the social impact that they are having. Policies of both sending and receiving states regarding international migration are reviewed. A final section speculates as to possible future impact of international migrants in the Arctic. The author is the lead author of the chapter "Population and Migration" in the forthcoming Arctic Human Development Report. This paper is an extension of the research done for that chapter.

# **The Dislocation of Maternal and Reproductive Health Care in Canada's North**

Rachel Kohut

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Access to services in Canada's North remains evermore contested due to the unique geographical, political, social and cultural characteristics of the region. Yet, with high fertility rates noted in many Northern regions, limited up-to-date surveillance, increased centralization of health care services and inconsistent maternal and reproductive health care legislation across the region, the need to re-evaluate maternal and reproductive health care services in Canada's North could not be more warranted.

Maternal health care has been dislocated from the geographical, political, social and legal context in which it should be situated. Consequently, efforts have been made to re-localize and return services back to Northern regions. This dislocation is not merely in a physical sense; the dislocation of the birthing process from traditional, cultural, spiritual and societal practices will also be discussed, as well as its' efforts of relocation. As such, the multi-faceted nature of the issue is illuminated. The exploration of the multi-faceted nature of maternal and reproductive health care in Canada's North facilitates a conceptualization of how the birthing process and the provision of maternal and reproductive health care can become more viable, sustainable and culturally safe for Northern Canadian women, families and children.

The power of returning birth back to communities, in its' many facets, should not be underestimated in discussions moving forward. To unveil its' ultimate potential, trans-jurisdictional discussions must be fostered, so as to learn from the lessons of regional and circumpolar neighbours. Such a discussion would facilitate the creation of a dialogic space that evaluates the existing system, and imagines and realizes the creation of a system that is inclusive, participatory and culturally respectful, resituated within its' respective locale(s).

# How can the built environment support living in Northern conditions?

Essi Oikarinen

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The poster presents approaches to understanding northern climatic conditions and notably winter as factors in planning northern cities. It is predicted that the world's economic and political focus will turn towards north within the next 50 years due to climate change, demographic changes, limited natural resources and increasing global integration. Augmenting activity in regions like Alaska, Canada, Scandinavia and Russia will change northern urban structure, require adjustment of existing cities and even lead to establishment of new settlements. Urban environment has not been widely researched in the context of northern communities, "winter cities", yet when designing in northern conditions, special knowledge and approaches are needed in order to achieve a sustainable outcome.

A winter city has been defined as a northern community where negative effects of climate are mitigated while positive aspects are reinforced. The poster explores these approaches through reviewing winter city actions made by so far in a timeframe from 1960s to present and actions' relation to livability. The issue is approached from four integral components constituting the lived environment: functions, structure, sensory environment and values. Approaches identified through this framework represent spatially and temporally differing viewpoints: winter as a premise for planning has been given different meanings from an either positive or negative extreme weather condition to a seasonal cycle or an attitudinal factor.

Concepts identified in the poster open up viewpoints on northern city planning. In some respects conflicting concepts help to understand the complexity of the issue: the relevance and desirability of different approaches changes when viewing the issue from different standpoints. Winter-related challenges and opportunities are extensively connected to each other and to practically all development taking place in the north. Therefore, the connection between built, urban environment and northern conditions holds some exploitable potential. Identified concepts found through this state-of-art research can be applied in understanding the current handling of winter-related issues and in finding tacit knowledge, hence being of help in shaping new, creative approaches to planning livable, healthy and sustainable cities in the north. Which new interfaces and combinations could be formed?

# Eni Norge AS sustainability approach in the northern region of Norway

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Eni Norge AS has the Barents Sea as a prioritized area for further growth. Activities in the Barents Sea imply a strong focus on environmental and socio-economic issues in a region with little experience with oil and gas development. Those activities also require high level of stakeholder communication and management.

The paper summarizes the approach adopted by Eni Norge in the northern regions of Norway, in accordance with the governmental requirements, aimed at promoting a sustainable local development and at enhancing company visibility and reputation.

Based on experience from the Goliat Development Project, Eni Norge recently decided to focus its approach related to Indigenous People and socio-economic issues in local communities in the northern regions of Norway, developing and implementing a strategy able to:

1. strengthen the visibility of the company through communication to targeted stakeholders and long term presence in the Northern Region;
2. plan, implement and monitor social projects, responding to the community needs, sustainable in the medium-long term and aligned with similar project that Eni is conducting in the Arctic and aligned with Eni's overall policies related to indigenous people;
3. respect the rights of Indigenous People acting in line with national and international regulations and standards, and implementing the Eni Norge Policy on indigenous people.

The paper summarizes the approach and tools, the Logical Framework Approach and Logframe Matrix, adopted to define the above-mentioned strategy and it describes the main contents of the strategy, illustrating activities planned for the period 2013-2015.

The implementation period is on-going, hence an accurate impact evaluation of the strategy is not feasible yet. In spite of this, the application of the described methodology and the definition of the strategy led to clearly define the activities supported by Eni Norge in the northern region of Norway, thus offering a clear and widely shared definition of the objectives and the expected results that the company would like to achieve. Eni Norge believes that this approach will be able to answer to the communities' needs, to promote a local, fair and sustainable development in the northern region and finally to consolidate reputation of the company.

# The influence of lifestyle factors on vitamin D levels in an adolescent population living at 69° North

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**Aims:** Vitamin D is central in calcium homeostasis and bone health, and globally, UVB-radiation from sunlight is the main source of vitamin D in human by inducing vitamin D production in the skin. We wanted to study which lifestyle factors that were related to vitamin D levels in an adolescent population living at high latitude of north, where UVB radiation is below the threshold of vitamin D production for half the year.

**Methods:** We present data from Fit Futures - a part of the Tromsø Study, which includes adolescents in the first year of high school in the municipality of Tromsø and Balsfjord. The first survey took place during the school year 2010/2011. In total, 1038 (92% of the invited) participated. Questionnaires and blood samples were collected, and serum 25-hydroxyvitamin D (25(OH)D) were analysed using LC-MS/MS. Linear regression models were used to study the associations between life-style related factors and serum 25(OH)D.

**Results:** We present the results from those ranging between 16 to 18 years (median age 16.0) with available serum 25(OH)D measurements and who responded to questions regarding the different risk factors for vitamin D deficiency (n = 811). Life style factors that were independently positively associated with serum 25(OH)D levels were ( $p < 0.05$ ): consumption of semi-skimmed milk (fortified with vitamin D), use of cod liver oil or vitamin/mineral supplement, exercise in leisure time, sunbathing holiday last 2 months and use of solarium last 4 weeks. Screen time (time spent with computers or TV) was negatively associated with serum 25(OH)D levels. Intake of fat fish, smoking, snuffing and overweight were not independently associated with serum 25(OH)D level in this population. The model explained 32% of the variation in 25(OH)D levels.

**Conclusion:** In a Norwegian adolescent population at high latitude both vitamin D fortification and supplementation through diet, and sun-seeking behaviour are independently associated with serum 25(OH)D levels.

# Working environment and health in the Norwegian fishing fleet – challenges and health promoting factors

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Unfavorable exposures for workers in the fishing fleet, such as a cold, noise, heavy lifting, inconvenient working hours, long work days and excessive strain are factors that may negatively affect health and work participation. Combinations of these exposures are often found on board fishing vessels. Moreover, workers on fishing vessels deal with constant and often unpredictable vessel movements, vibration and exposure to airborne particles of biologic origin (bioaerosols). There is a lack of knowledge about the interaction between work, working environment and working health in the fishing fleet.

The main objective of this project is to study the interaction between these factors in the Norwegian fishing fleet. We aim to provide knowledge about which work-related factors might affect health and work participation negatively, and which factors might promote good health, foster job satisfaction and participation in working life.

An interdisciplinary approach combining qualitative and quantitative perspectives will be applied to provide a deeper understanding of the questions at hand. The project is divided into five work packages (WP) and data will be drawn from several sources, including register studies, questionnaire surveys, interviews, field,- and laboratory studies. WP1 will determine the most widespread diagnoses for all Norwegian fishers by use of register data. In WP2 and 3 field studies will focus on association between workplace-related exposures and working health, such as exposure to organic materials during fish processing and associations with airway symptoms and allergies, exposure to low ambient temperatures and associations with symptoms from muscles and airways. The crew of 4-5 deep-sea fishing vessels (approximately 100 persons) will be included. WP4 focuses on self-reported health status, and a combination of interviews and a questionnaire study distributed to a representative selection of fishers in different parts of the Norwegian fishing fleet will be used. In WP5 an integrated analysis, combining data from all work packages will be performed. Results are expected to be of significant value to the prevention of occupational diseases and withdrawal from working life at sea, and provide implementation loci for health-promoting measures in the fishing fleet.

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# Nutritional status among Northern Swedish school children 1929-1931 - a unique baseline for future multigenerational epidemiology

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Background:

In 1929-1931, physicians in northernmost Sweden collected social and health information and dietary intake questionnaires from approximately 4000 school children as part of a large-scale health investigation, Norrlandsundersökningen (the NU cohort). Health information included measures such as hemoglobin status and a physician's estimate of general health and nutritional status. From these data, it was concluded that the northern Swedish population had a diet very low in both quality and in quantity, and obesity was essentially nonexistent. To date, no systematic, long-time follow up of the NU participants has been done.

Objectives:

As a first step toward evaluating the feasibility of a longitudinal follow up of the NU cohort, this study compared anthropometric NU measures among school children at the time of survey with present-day WHO guidelines for children.

Methods:

NU questionnaires from 3999 school children 7-17 years of age were digitalized. After excluding children aged 15-17 years (n=50), children with missing data (n=76), and outliers (n=32), data from 3841 school children (1916 boys and 1925 girls) were included in the

analysis. Body height, body weight and BMI were compared with present-day WHO guidelines by the LMS model. The data presented are preliminary.

#### Results:

In the 1930's, mean height, weight and BMI among school children 7-14 years old in northernmost Sweden were lower than present-day WHO standards, but largely within the recommended interval, i.e. LMS z-score -1.0 to 1.0. Z-scores were lowest for height in both boys and girls. In 10-year-old boys, weight and BMI were below WHO standard means [mean weight 30 kg, SD 4, LMS z-score=-0.24, mean BMI 16.1 kg/m<sup>2</sup>, SD 1.3, LMS z-score=-0.34], whereas height approached the criterion for under height [mean 134 cm, SD 6, LMS z-score=-0.98]. 10 year old girls were approximating criteria for underweight [mean 28 kg, SD 4, LMS z-score=-0.78], fulfilling criteria of under height [mean 134 cm, SD 6, LMS z-score=-1.2], and had a correspondingly low BMI [mean 15.9 kg/m<sup>2</sup>, SD 1.6, LMS z-score=-0.52].

#### Discussion:

The relatively short stature of school children in northernmost Sweden in the 1930's suggests persistent low energy intake. A longitudinal follow up of these results could contribute to the growing base of knowledge concerning the importance of early nutrition for health later in life. The variability in these anthropometric measures appears to be of sufficient magnitude to allow long-time follow up of the NU cohort, addressing health-related endpoints from both individual and multigenerational perspectives.

# Alcohol use and sleeping problems in the High North: Results from the Tromsø Study

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Sleeping problems are related to numerous other health complaints – amongst others alcohol use disorders. However, exactly how alcohol use and sleeping problems are related is not clear. Some studies find that higher alcohol use is related to increased risk of sleeping problems, whereas other studies find no such relationship. Findings of previous research have suggested that a little alcohol may be related to improved sleep, whereas greater amounts of alcohol are related to impaired sleep. If this is true, specific statistical techniques are necessary to detect a relationship, and the discrepant findings of previous research may be explained by having analysed a non-linear relationship as linear. Correctly identifying the function of the relationship is essential for understanding the mechanisms behind the relationship, which in turn may prove important in treatment and prevention respects. What's more, information on the function of the relationship may be informative as to threshold values in which the risk of sleeping problems increases. Sleep is affected by seasonality – sleeping problems is more frequently experienced in winter compared to summer. The polar night and long winters in the arctic makes it reasonable to assume that sleep related problems, such as increased alcohol use, may be more common in the arctic regions compared to the sub-arctic regions. Thus, investigating the function of the relationship may be particularly important in the arctic regions.

The present study investigates the possible non-linear function of the relationship between alcohol use and sleeping problems using general population data from the sixth wave of the Tromsø study (Tromsø 6). The study was conducted in 2007 and 2008 and consists of about 13,000 (about 65% response rate) adult inhabitants of the municipality of Tromsø in Northern Norway. Alcohol use and alcohol problems were measured by the AUDIT, whereas sleeping problems were measured by items asking for the prevalence of sleeplessness, seasonality of sleeplessness and sleeping habits. We hypothesize that the function of the relationship is essentially non-linear, with no alcohol related to more sleeping problems compared to a little alcohol, whereas the relationship between alcohol use and sleeping problems is expected to increase exponentially with higher doses. The relationship will be adjusted for a variety of potential confounders, such as mental and somatic health problems, smoking and chronic pain conditions. Results of the study will be available by the end of 2013 and presented at the Arctic Frontiers conference.

# **Navigating local knowledge: Understanding continuity and change within the traditional healing practices of Northern Norway.**

Mona Anita Kiil

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Unofficial health practices exist in many North Norwegian communities, consisting of traditional healers which people actively use or would consider to use when facing illness or crisis. The municipality of Nordreisa in Northern Troms is commonly described as "where the three tribes meet" - the indigenous Sami people, the Kven and Norwegians - for this reason the region has historically been considered a cultural melting pot. Despite this cultural diversity, the notion of culture is somewhat problematic and connected to ambiguities - particularly concerning the Sami identity. Nevertheless, this diversity is expressed through a widespread use of traditional healing practices such as reading.

Patients at an mental health care outpatient clinic in Nordreisa find themselves between these traditional practices, as well as conventional treatment offered by the clinic in question.

The aim is to explore the continuity and change of the traditional healing practices as a form of local knowledge, through the experiences of patients representing different generations.

The study is performed as an ethnographic fieldwork.

The empirical and theoretical analysis will explore the encounters between different medical and cultural contexts, both at an individual and structural level.

# A call for urgent monitoring of food and water security based on relevant indicators for the Arctic

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This presentation argues for an urgent need to monitor a set of twelve concrete, measurable indicators of food and water security in the Arctic over time. Such a quantitative indicator approach may be viewed as representing a reductionist rather than a holistic perspective, but is nevertheless necessary for actually knowing what reality aspects to monitor in order to accurately understand, quantify and be able to project critical changes to food and water security of both indigenous and non-indigenous people in the Arctic. More relevant indicators may be developed in the future, taking us further towards reconciliation between reductionist and holistic approaches to change assessment and understanding. However, the potential of such further development to improved holistic change assessment is not an argument not to urgently start to monitor and quantify the changes in food and water security indicators that are immediately available and adequate for the Arctic context.

Preliminary data on the relative cost of a healthy food basket in different Arctic areas will be presented as a concrete example of this.

# Single-industry towns in the Russian Arctic: social aspects of sustainability

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Abstract. In the paper, social sustainability aspects of single-industry town development in the contemporary Russian Arctic are discussed. As a point of departure, a typology of these towns by criteria of population dynamics and by industrial specialization of town-forming enterprises is proposed. The typology reveals that most of the Arctic single-industry towns in Russia officially recognized as mono-profiled settlements are mainly based on mining industries.

To discuss social sustainability issues of single-industry towns in the Russian Arctic we consider such aspects as trends in demographic developments and living standards, the situation of labor markets, the provision of basic social services for local populations, practices of social responsibility of oil and gas corporations, as well as that of mining companies operating in the Russian Arctic. On the basis of this analyses we elaborate a set of proposals for solving the most acute social problems of single-industry towns in the Russian Arctic as necessary preconditions for transition towards their socially sustainable development.

# Food- and waterborne diseases in the Russian Arctic, Siberia and the Far East, 2000-2011

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Background: The food- and waterborne disease situation in Russia requires special attention. Poor quality of centralized water supplies and sewage systems, biological and chemical contamination of drinking water, as well as contamination of food products, promote widespread infectious diseases, significantly exceeding nationwide rates in the population living in the two-thirds of Russian northern territories.

Objectives: The general aim was to assess the levels of food- and waterborne diseases in selected regions of Russian Arctic, Siberia and the Far East (for the period 2000\_2011), and to compare disease levels among regions and with national levels in Russia.

Study design and methods: This study is the first comparative assessment of the morbidity in these fields of the population of 18 selected regions of Russian Arctic, Siberia and the Far East, using official statistical sources. The incidences of infectious and parasitic food- and waterborne diseases among the general population (including indigenous peoples) have been analyzed in selected regions (per 100,000 of population, averaged for 2000-2011).

Results: Among compulsory registered infectious and parasitic diseases, there were high rates and widespread incidences in selected regions of shigellosis, yersiniosis, hepatitis A, tularaemia, giardiasis, enterobiasis, ascariasis, diphyllbothriasis, opistorchiasis, echinococcosis and trichinellosis.

Conclusion: Incidences of infectious and parasitic food- and waterborne diseases in the general population of selected regions of the Russian Arctic, Siberia and the Far East (2000\_2011) are alarmingly high. Parallel solutions must be on the agenda, including improvement of sanitary conditions of cities and settlements in the regions, modernization of the water supply and of the sewage system. Provision and monitoring of the quality of the drinking water, a reform of the general healthcare system and the

epidemiological surveillance (including gender-divided statistics), enhancement of laboratory diagnostics and the introduction of preventive actions are urgently needed.



# Clothing integrated sensors for monitoring of workers in the cold.

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**Introduction:** Extreme environmental conditions in the Arctic place new challenges for outdoor work and protective clothing. To improve decision support and safety for workers in these environments, there is a need for improved monitoring systems. The ColdWear project has developed a demonstrator jacket with integrated sensors that provide information about the activity of the user, the ambient conditions at the site of the worker, the microclimate inside the jacket as well as local cooling of extremities. We hypothesized that the clothing integrated sensors provide valid information about ambient conditions and hand skin temperature.

**Methods:** Six healthy males participated in the study. The aim of the experimental protocol was to simulate a typical work shift (75 minutes) with alternating ambient conditions (-15 °C and 22 °C) and various work intensities. One infrared temperature (IR) sensor is located in the lower sleeve of the right arm, and measures skin temperature of the dorsum side of the hand. Another sensor is integrated outside the jacket and measures ambient temperature and relative humidity. Reference sensors measuring skin and ambient temperature and relative humidity were used.

**Results:** The IR sensor measured a higher hand skin temperature compared to the reference sensor during the first period in the cold chamber, while measuring a lower temperature during the rest of the test. This can be due to change of emissivity of the skin during sweating and different sensor location. Both the integrated ambient sensor and the reference sensor measured a higher temperature than the ambient temperature in the cold chamber, but the reference sensor had a consistently lower deviation. The reason is that the integrated ambient sensor is located in the clothing surface air layer that acts as insulation and is more influenced by the heat flow from the body than the bare reference sensor. The higher ambient temperature of the clothing surface air layer also affects the relative humidity. These micro layers of warm air create challenges for clothing integrated sensors, especially in the cold.

**Conclusion:** The skin temperature, ambient temperature and relative humidity obtained from the jacket sensors were significantly different from the reference values. Physiological and environment monitoring can provide useful information but further

development and refinement of the integrated sensors is needed before this can be used as a valid tool for monitoring of workers in the cold.

# Towards reduced impacts on Arctic communities: socio-economic impact indicators

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Climate change is happening faster in the Arctic than elsewhere in the World. The melting of sea ice opens up previously inaccessible areas; this leads to more interest in mining and oil and gas explorations in sensitive Arctic areas. Millions of people live within the Arctic circle. Around 10% of these people belong to indigenous groups, who often still have the knowledge and culture to rely on renewable resources only. However, their ways of life are changing as a consequence of globalisation, climate change, resource exploitation, large scale forestry, mining, oil and gas extraction and related shipping activities. Also, young generations within these communities long for a different life style compared to their ancestors. New activities have to be sustainable, according to the Arctic nations, and companies who want to become active in the Arctic have to do environmental and socio-economic impact assessments. The challenge is to integrally map impacts together with communities and other stakeholders in order to feed the international dialogue with objective information so joint decisions can be taken on a more sustainable approach in the Arctic. Thus, there is an urgent need to develop impact assessments that take into account the needs, interests and views of indigenous and local communities. A well-researched approach facilitates also in the acknowledgement that environments and communities are highly diverse in the Arctic. As a consequence the perceived impacts can also differ from community to community. In this research we develop a number of indicators for impact assessments from the local point of view.

# Pre-hospital fluid infusion and oxygen administration in cold climate

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If an accident happens in a remote place, rescue and medical treatments (e.g. intravenous infusion and supplemental oxygen administration) may have to be taken place on an accident site. Intravenous (IV) fluids are administered to trauma patients as treatment for hypovolemia, hypotension, shock, dehydration or hypothermia. General recommendation is to use warmed (37 - 42 °C) IV fluids in the treatment of trauma patients. Supplemental oxygen is of great benefit to a patient with severe trauma and/or hypothermia. Oxygen gives a cooled heart a better chance of survival and lessens the risk of arrhythmias. Large volume of cold fluid or cold oxygen may result in lowering of body heat content and the risks should be recognized. The purpose of the study was to examine the effects of cold environment on 1) infusion fluid temperature when different infusion line protective covers are used and 2) upper respiratory track temperature when supplemental oxygen is administered.

The measurements were carried out in the ambient temperatures of -20, 0 and 20°C. Fluid bags (1000 ml) were either pre-warmed to 37°C or kept at room temperature. Three different infusion line covers were compared while infusion line without protection was a control measurement. Fluid temperature in the infusion bag and in the tip of line was measured. Fluid was allowed to flow at full speed. Seven healthy volunteers participate in the oxygen administration study. They were exposed to -20, 0 and 20°C. Air temperature in the nasal cavity was measured in two depths as well as in the mask and the tube. Gas flow in the mask was set to 15 l/min and the subjects were instructed to breath through the nose. Duration of the measurements was 9 min.

Temperature of un-warmed IV fluid without protection decreased below 10°C and pre-warmed approximately to 20°C at the exposure temperature of -20°C. Temperature of pre-warmed IV fluid with infusion line covers decreased approximately to 30°C. Oxygen mask acted as a heat and moisture exchanger and therefore air temperature inside the mask was above 0°C even at -20°C with precooled oxygen. Air temperature inside the nasal cavity was stable being 25-30°C.

In conclusion, IV fluid with high heat capacity is a risk for trauma patient and line protection should be used in the cold conditions. Gas has low heat capacity and therefore low temperature of oxygen is not a thermal risk for a patient.

# **“Bridging Early Career Researchers and Indigenous Peoples in Nordic Countries”: Building Nordic Networks**

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For years, the increasing impacts of climate change across the Nordic Polar regions have been observed, documented and analyzed by Nordic residents and researchers. To gain a better understanding of these rapid changes, the inclusion of local traditional knowledge is of vital importance. Maintaining existing connections and strengthening communication between local communities in the Northern Nordic countries as well as Sami and non-Sami researchers is therefore critical for current and future research projects. Especially for early career researchers from both the Nordic countries and elsewhere getting a better understanding of these connections and the communication with each other and local residents will be essential for their future research careers.

This comprehensive Association of Polar Early Career Scientists (APECS)-led 18-month research project seeks to focus on the communication and enhanced engagement between Sami and non-Sami early career researchers as well as northern communities in Nordic countries. Funded through the Nordic Council of Ministers (Norden) and leveraging the collaboration, education and outreach experience of APECS, this research initiative seeks to address research collaboration challenges in several ways: through the launching of an online APECS Nordic Network and database, a survey for ECRs and northern residents in Nordic countries and a 6-week Webinar Series featuring key Nordic researchers and Sami leaders. The project will be concluded by a two-day workshop at the Arctic Science Summit Week (ASSW) in Helsinki 7 - 8 April 2014 featuring mentors, researchers and Indigenous participants from across the Nordic region. Early career researchers and Nordic indigenous youth and elders are encouraged to visit the APECS Nordic project website to learn more about and join this exciting research initiative.

# Human thermal responses in cold during reindeer safaris

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Finnish Lapland in the Arctic Circle in northern Scandinavia has become a popular travel destination with its unique northern environment. In harsh weather conditions pleasure and thermal comfort can be affected by thermal stress and tourists can feel cold very stressful. Skin, hand and feet cooling can cause discomfort, pain or cold injuries. Cold can have effects on general health or it can worsen the symptoms of the existing disease. Despite the cold environment tourist experiences should be memorable in a positive way, and degree of discomfort and cold induced pain should stay in an acceptable level, especially when customers have limitations in performance.

In order to maintain the high quality and safety of the provided tourist outdoor services we conducted a risk questionnaire to survey the possible risks, requirements and thermophysiological challenges related to tourist services in the cold in reindeer herding enterprises in Northern Finland.

To determine the human thermal balance and the physiological risks related to the winter outdoor activities, the human thermal responses were measured in natural conditions during reindeer safaris in Lapland, Rovaniemi (N 66° 30' E 25° 44'), Finland.

We measured thermoregulatory responses of the customers, customers with diabetes mellitus and safari guides working in cold conditions during the reindeer safaris. Local skin temperatures, body core temperature, physiological strain, heart rate, thermal sensations, thermal comfort, evaporation and clothing insulation were measured and recorded. Ambient temperature and wind speed were monitored. All the participated healthy adult test subjects were voluntary and well informed in the benefits and risks related to the research.

Our results show that cooling of the extremities to the level which may cause discomfort and moderate performance degradation can occur during the outdoor activities even in mild weather conditions.

KEYWORDS: thermal physiology, winter tourism, cold risks, safety, reindeer herding

# **Bringing in the child: looking at the experienced involvement of children's participation in life situations**

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Looking at experienced involvement gives a more balanced picture of children's participation. This is particularly applicable in an education and social welfare setting where considerable recent political effort has been expended to ensure children are present in life situations (e.g. including children with disabilities in mainstream schools, making them active players in social welfare settings). Little has however been done relating to how children are engaged once in a situation. Granlund et al. (2012) propose using the subjective experience of involvement as a measure of the involvement part of the participation experience. Maxwell, Augustine, and Granlund (2012) propose that this measure can be constructed using an index of the subjective experience of involvement using measures of concentration, control, involvement, and motivation. Choice is considered influential as knowledge about why an activity is undertaken affects involvement. Additional findings from Maxwell et al. (2012) also suggest that increased subjective experience of involvement gives better psychological health and wellbeing. The index Maxwell et al. (2012) propose can be used to give an accurate measure of the experience of involvement and one way to operationalize this is through the ICF/ICF-CY (WHO, 2007). However, the way that the ICF/ICF-CY is currently theoretically constructed and practically executed is flawed. There is a discrepancy between the theoretical construction of participation, where it is considered a unique concept, and the practical operation of it within the coding framework where it is together with activity. A second version of the ICF may address this, but until this is produced further research is needed to provide confirmation and clarity on both the theoretical construct of the subjective experience of involvement, and the practical operation of it into some kind of useful tool (e.g. the ICF).

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# **Combined exposures to hand–arm vibration and cold: additive, synergistic or antagonistic effects on workers' hands?**

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Workers in construction, mining, gas and oil exploration, forestry, agriculture, fishing, reindeer herding and military are commonly exposed to cold during winter time. Cold exposure impairs the blood circulation and causes changes in neurological and neuromuscular responses. This aggravates cooling, impairs the tactile sensitivity and manual performance and can eventually cause cold injuries in the hand. Moreover, the risk of accidents increases. Exposure to hand–arm vibration (HAV) from hand–held vibrating tools occurs in several industries such as construction, maintenance or the mining industry. Prolonged exposure to HAV could eventually cause impairment of blood circulation, neurological, and musculoskeletal injuries in hand and arm. Consequently, both cold and HAV exposures affect the same components of human physiology. Cold is also a known trigger for constriction of the blood circulation in the fingers among people with vibration induced white fingers (VWF). VWF is a vascular and neurological injury in the fingers caused by long time exposure to HAV. However, it is not clear if combined exposure to cold and HAV have an additive, synergistic effect or even if vibration has an antagonistic effect to cold exposure. Earlier epidemiological studies suggest an increased risk of VWF among construction workers who were exposed to both cold and HAV. There is still a lack of knowledge on the physiological effect on hand and arm from combined exposure to cold and HAV. Therefore, as a joint effort of Umeå University and Finnish Institute of Occupational Health, an experimental setup for simultaneous exposures to cold and vibration has been constructed to explore the physiological effects in the hand and arm from combined exposure to cold and HAV. Pilot measurements are going on. The subjects will be exposed to thermoneutral and cold temperatures and also to HAV. Blood circulation, neurological, and neuromuscular responses and the information on the recovery time for these physiological responses will be measured. Recovery time will give information about the safety limits after exposures to HAV and cold. Moreover, work capacity will be measured by determining the accuracy in grip and push forces during the exposures.

# Melatonin, mood and daylight in the Arctic

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## Background

Whereas diurnal variations in melatonin concentrations are well documented, studies concerning seasonal variations according to latitude are rather scarce. Despite limited knowledge from polar areas, there is more evidence for seasonal changes in the circadian phase of melatonin than for changes in the duration of its secretion. A Norwegian study of midwinter insomnia supported the delayed phase hypothesis. To our knowledge, the present study is the first one to compare concentrations of melatonin in residents above and below the Arctic Circle based on regular measurements throughout one year.

## Material and methods

We conducted this pilot study between 1997 and 2000. In total, 1196 citizens of Karmøy (Rogaland), Rødøy (Nordland), and Gamvik (Finnmark) were invited to participate, of whom 479 responded positively. The response rate was 78.4% in Gamvik, and 29.9 % in Karmøy and Rødøy. The participants were asked to deliver a sample of saliva and to fill in a two pages questionnaire each season during one year. The saliva samples should be collected between 22:00 and 23:00. After exclusions, we included 474 subjects who contributed between one and four saliva samples and completed questionnaires. We applied a generalized linear mixed model with a gamma link function to estimate the variation in level of melatonin according to season, location, and reported seasonal changes in mood and behavior.

## Results

We observed significant seasonal variations in level of melatonin, with differing patterns according to location. In Gamvik, the average concentration declined steeply from the highest measured level in autumn to the lowest level in winter among the three locations. While the proportion reporting seasonal changes in mood and behavior remained quite stable across seasons in Karmøy (25-28%) and Rødøy (19-22%), the proportion within the Gamvik sample varied from 35% at the first wave in spring to 19% in autumn, and 30% in winter. The seasonal variations in mood were significantly associated with a decreased level of melatonin, which still persisted after controlling for location.

## Discussion

If the finding of a decreased level of melatonin during the polar night is true, the crucial question is whether it reflects a delay or a depletion of the diurnal circadian rhythm in the secretion of the hormone. A delay may cause sleeping disturbances, while a depletion may

affect the risk of certain diseases as well. In order to address this important question we need data from a larger study covering diurnal measurements within each season.

# **Arctic healthcare: Contextual approach to adaptation and wellbeing of short-term visitors**

Svetlana Usenyuk

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The presentation introduces the planning collaborative research, anchored in design, anthropology and health studies, and devoted to the issues of human adaptation and wellbeing under extreme environmental conditions, with reference to the Arctic. While significant investments are being made into healthcare infrastructure for permanent residents of remote Polar Regions, there is also a rapidly growing sector of short-term visitors, such as fly-in/fly-out workers, tourists, students, etc., whose adaptation and healthcare needs have not yet been considered from a research and business perspective as a specific field of investigation and further innovations.

The novelty of the research lies primarily in acknowledging the variety of adaptation potentials of Arctic visitors, as well as in considering specific risks for their physical and mental health during short-term stay in the High North. The potential of this kind of contextual approach coupled with design has not been explored before in developing the concept of healthcare for short-term visitors in remote and severe natural settings.

The test areas for developing this concept are suggested to be in Finnish Lapland (tourists) and Yamal Region of Russia (FIFO workers). From the research perspective, both sites are unique natural-social laboratories, where a complex of environmental, social, economic and technological conditions has been modeled for developing and testing technologies and services in order to facilitate physical, social and cultural adaptation of different groups of visitors, at the micropopulation level.

Finally, the vision of the 'Arctic Healthcare' system will be outlined, based on the following statements:

- The system should provide a new experience of 'being healthy' instead of yet another medical product for treating 'sickness';
- At a practical level, it should be a flexible system of devices and interfaces applicable to any extreme, isolated and remote environment;
- In the field of social innovations, the system should originate and facilitate physical and virtual communities where users could set support for their psycho-emotional relaxation from each other (peer-support).

# **Social and psychological peculiarities of shift work in the Far North**

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***Northern (Arctic) Federal University named after M.V. Lomonosov, Archangelsk, Russia***

Shift work is widely used during development of new territories, as a rule, in remote areas and areas with extreme natural and climatic conditions, such as the Arctic conditions. Meanwhile, shift work in the Far North is accompanied by the influence of factors causing unfavorable functional status such as stress, psychentonia, performance decrement, fatigue, etc. (A.P. Avtsyn, V.M. Ahmetov, A.S. Vetoshkin, L.I. Gapon, G.N. Degteva, V.A. Matukhin, A. Parkinson, B.A. Raevich, N.P. Shurkevich). Apart from extreme climatic, geographical and working conditions, a complex of unfavorable socialdaily factors influence shift workers (A.N. Silin, N.N. Simonova, et al.). They include group isolation, social desynchronosis, reduced variability of recreation areas, etc. In our opinion, the most important social and psychological factor is group isolation during the shift that in its turn highlights for psychological analysis not only a particular specialist, but also a group of people - team labor subject. Group isolation is a compulsive stay of a group in constrained space and is characterized by scarcity of sensory stimuli and compelled regular communication with the same people. There is also identifies a range of factors negatively influencing interpersonal attitudes of isolated groupmembers: nervous system asthenization, expressed in increased irritability, hot temper, periodical accumulation of negative emotions and their later discharge in conflict situations; information exhaustion; publicity of the stay leading to constant control of emotions and tendency to hide actual feelings and motivations. During the shift there is observed personal space narrowing, lack of possibility to stay alone, compulsive cooperation with colleagues both during working hours and free time independently of preferences, interests and personal characteristics accompanied by restrictions in choosing social network. All the listed peculiarities of social interaction during shift work can negatively influence shift staff. Irritability, aggressiveness, intolerance, proneness to conflicts, narrowing of social network, etc. can be dangerous in group isolation environment during the shift. In these conditions there is observed a perceptible mixing of formal and informal structure of the shift brigade. Negative development of informal relations can lead to destruction of the formal structure and difficulties in staff resource management. Such circumstances can negatively influence shift brigades' performance. Correspondingly, a shift work subject needs psychological support for maintaining optimal conditions of vital activity in group isolation environment as well as stabilizing and maintaining of shift brigades' labor efficiency.

# Death after trauma in the Rural High North

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Introduction. Finnmark County, the northernmost county of Norway, has for decades had a high rate of death from injury compared to the national average. In international literature, rural areas have been shown to have a higher death rate from injury than urban areas. Objectives. We wanted to describe the trauma deaths in the area, and highlight challenges specific to this region. We also wanted to see whether high rural trauma mortality was present also in Norway. Methods. All fatalities after injury occurring in Finnmark in the period 1995-2004 and Hordaland in the period 2003-2004 were identified from the National Registry of death. Intoxications were excluded. Data were extracted from case records, police, and autopsy reports and compared between the counties. To assess the effect of rurality Hordaland was divided into a rural and an urban group for comparison and compared to Finnmark. Results. During the 10-year study period 327 deaths in Finnmark were included, while 217 deaths were included in the 2-year study period in Hordaland. Finnmark had an injury death rate of 33,1 per 100 000 inhabitants, 80 % were male and median age was 40 years. Urban Hordaland had 18.8 and Rural Hordaland 23.7 deaths per 100 000, and both were comparable in gender distribution with 75 % male, and age (median 50 years). Deaths occurred under the influence of drugs or alcohol in 40 % of cases in Finnmark, 53 % in Urban Hordaland and 39 % in Rural Hordaland. The most common modes of trauma overall were low falls in elderly (24%), suicide (24 %), and RTAs (15%). Mode of trauma followed a typical rural pattern and was similar in Rural Hordaland and Finnmark, except that Finnmark had more deaths from snow-mobile injuries and machinery. Finnmark's death rate from injury declined through the period and approached the national mean, though no decline was seen in the major subgroups of trauma, nor in the overall epidemiological pattern.

Finnmark  
Rural Hordaland  
Urban Hordaland  
Prehospital death  
85 %  
82 %  
72 %  
RTA rate  
206 / 100 000  
245 / 100 000  
269 / 100 000  
Deaths per RTA  
3.5 / 100  
2.45 / 100  
0.64 / 100

Conclusions. Finnmark's high injury mortality is likely partially tied to its rural nature. Snowmobile injuries, and drunk-driving are areas of specific concern. First aid by laypeople may be of importance. To further reduce mortality prevention measures is the ultimate measure.

# Circumpolar Inuit Health Priorities: Best Health Practices and Research

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This report, *Circumpolar Inuit Health Priorities: Best Health Practices and Research*, documents and assesses a comprehensive range of best practice programs and relevant studies which have been implemented across the Arctic in the main health areas of mental health and wellness, service delivery, food security and chronic disease. Together, the material provides an important collection of information on the health practices and challenges which impact on the health and wellbeing of Inuit living across four countries - in Canada, Greenland, Alaska and Chukotka (Russia).

This report is the second part of the Inuit Circumpolar Council (ICC) Canada's overall effort to identify and document the range of health and wellness experiences, studies and practices that impact on Inuit directly and indirectly. The first part of this work was a review of the different Inuit health systems which Inuit access in the four different countries. That report, *Health Systems serving Inuit communities across the Arctic*, was completed in 2011. This second report completes the task of documenting the experiences.

A major finding is that each of the four countries has responded differently to the four main health areas in terms of the effort or investment of resources applied to a particular health area. For example, of the four health areas covered in this report, service delivery appeared to be the top priority for health programs in Greenland but ranked second in Alaska, third in Canada and not at all in Chukotka.

However, in considering the material in this report, it is important to note that of the 284 best practice programs and studies found; it is not an exhaustive compilation of all best programs and studies being conducted. Instead, it reflects the extent of the search undertaken by ICC Canada from July 2011 to February 2012. In addition, the very limited availability of Inuit-specific data notably in Alaska and Russia has also influenced the type and breadth of the information collected. Related to this is the abiding overall constraint in accessing relevant data on indigenous health overall. This is a common concern globally, which is frequently cited as a major constraining factor in understanding better the major issues impacting on indigenous health.



# Parasitosis as an aspect of global warming in circumpolar area

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According to the Russian Assessment Climate Change Report of “Roshydromet” the average surface air temperature in Circumpolar area will continue to increase till the mid of the XXI century. The period with stable snow cover is expected to reduce. Increased rainfall, river flow and temperature rise of water in the reservoirs could lead to negative consequences for ecosystems, especially coastal areas, public health and traditional life-style.

The warming of the air and water in the northern rivers will increase the parasitic diseases exposure of residential populations in coastal areas.

The Nenets Autonomous Okrug (NAO) is a district of residence of indigenous peoples of the North.

The wide spread of parasitic diseases among the indigenous population is explained by more intensive contact with the natural environment. Local people used to eat raw meat, raw fish, and the blood of slaughtered deer. They often use melt water for drinking and artisanal tanned hides of infected animals. There are more than 30 species of fish in the rivers and lakes of the NAO, and around 50 species of marine fish in the coastal seas. Pathogens worm diseases of fish have very important epidemiological and epizootic value (Diphyllobothriasis, tetrakotillesis, anisakidosis, opistorhosis, etc.). For example, the infestation of diphyllobothriasis in 2000 reached 56.1%, tetrakotillesis to 86.4 %. It was found up to 25 species of parasites in some species of fish from the Pechora River, both in the larval stage and adults.

Infection by endoparasites of whitefish in Pechora has more than doubled in the last 20 years.

Prevalence of Diphyllobothriasis in the NAO in 1989-1999 was 55.8 per 100 thousand population, which is more than 5 times higher than the average rate.

The results of the serological study (2009-2012), performed in areas of the NAO, with mostly indigenous population demonstrated the prevalence of 4 species of parasites (L. Intestinalis, T. Sanis, O. Felineus, E. Granulosus). Diagnostic screening of 1,632 people detected giardiasis in 16.5 %, opistorhosis - in 11.5%, toxocariasis - in 18.4 %, echinococcosis - at 5.6%, ascaridiasis - at 4.0%, toxoplasmosis - at 24.0%.

Low information content of the existing method of research (microscopic examination of stool for ova) was one of the reasons for the low detection rate of parasitic infestation. Another factor was the removal of the requirement of compulsory helminthological

Population Survey from 2000. This was followed by lowering detection of diphyllbothriasis.

# **Medical examinations as a basis for the prevention of disease shift workers in the Arctic**

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Labor activity in the Arctic makes greater demands on the level of the employee's health and opportunities for conservation. Staff working in shifts working in the Arctic, a greater risk of disease due to the harsh climatic and geographical conditions, the availability of harmful and dangerous factors of production, social isolation during the watch. When applying for a job at the company officer oil and gas companies do not rarely are any variations in health status that do not affect employment at the beginning of the professional activities, but with the passage of time or likely to result in complications of the disease, or switch to a more pronounced step, which is a contraindication to operate in the Arctic. According to the results of periodic medical examinations and use of health care most often before others suffer cardiovascular system, respiratory system, identifies diseases of the musculoskeletal system, the endocrine system, the genitourinary system, the eye and its appendages. Factors that affect the overall rate of shift workers in the Arctic, are: - the presence / absence of bad habits (smoking, excessive alcohol consumption), - presence of chronic diseases when applying for a job, including hours including morbid obesity (II-III degree of obesity), - the place of residence of the employee (at constant residence vanii workers in southern Russia on the incidence of 36-37% higher than that of shift workers, resident in the northern climatic zone). Possible directions reduce the development of disease in shift workers are the extension program of periodic inspections on the basis of the data analysis of the periodic medical examinations, the formation on the basis of examination of prophylactic group clinical supervision, planning and implementation of prevention programs and rehabilitation strong motivation for a healthy lifestyle.

# Physical activity patterns in Greenland: A country in transition

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Introduction: Indigenous populations in the circumpolar north have experienced a rapid cultural and social transition with changes in many aspects of everyday life.

Aims: To examine differences in physical activity patterns among Inuit in Greenland in relation to the social transition and to analyse the contribution of different intensities of physical activity (PA) on daily life PA.

Material and Methods: Physical activity patterns were assessed by the International Physical Activity Questionnaire (IPAQ-long version) and combined accelerometry and heart rate monitoring. Data were collected in a country-wide cross-sectional population survey among Inuit (18+years) in Greenland during 2005-2010 (n=1545). The population was divided into six groups according to different stages of social change, measured on the basis of education, residence and occupation.

Results: Among participants in towns, with longer vocational or academic education (more modern lifestyle) less time was spent on occupational, domestic (women only) and transportation-related PA and more time was spent on sedentary PA compared with hunters and fishermen in villages (more traditional lifestyle). No difference was found for time spent on leisure time PA across transition groups. The overall time spent on PA did not decrease linearly, but a linear trend for decreasing physical activity energy expenditure (PAEE) with stages of social transition was found for men. No significant linear trend was identified for time spent at different intensities of PA, although a borderline significant trend was found for decreasing time spent at vigorous intensity PA across transition groups, for men only ( $p=0.08$ ). A very limited amount of time was spent at vigorous intensity PA, but the relative contribution to total PAEE was substantial.

Conclusion: Physical activity patterns have changed as a result of the social transition both for men and women, but had an impact on total physical activity energy expenditure for men only. Light intensity physical activity contributed to a substantial part of daily life PA. The transition groups only work as a proxy for longitudinal information; hence, changes must be interpreted with caution. Knowledge on changes in physical activity patterns in relation to social changes in Greenland can help to differentiate and target the promotion of PA and is important in the prevention of obesity and type 2 diabetes.

# The Sámi rights and the status of reindeer herding in Finland in planning and start-up phases of mining projects

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The Sámi are the only indigenous people in the European Union. In Finland, their status as an indigenous people is acknowledged by the constitution which provides protection for Sámi livelihoods such as reindeer herding. As part of the recent global rise on mining, the area inhabited by the Sámi is also facing a build-up of mining activities. In 2011, after lengthy preparatory work, new legislation on mining was introduced in Finland, in particular the revised Mining Act (621/2011). In this presentation we discuss the relationship between the constitutional status of the Sámi and their status as seen in the Mining Act. The presentation focuses on the hearing procedures prescribed in the Mining Act where the Sámi as an indigenous people - now for the first time - are mentioned as a party to be consulted with during the planning stage of a mining project. The aim of our research is, first, to compile and analyze the legal rules that govern this relationship. It is a complex matter in the sense that the norms are spread out in separate legislation that relate to mining, constitutional rights of the Sami people as indigenous people, status of reindeer herding as a livelihood per se, environmental issues, and administrative acts. Secondly the research task is to suggest guidelines to how the relationship between the Sámi and the mining industry should legally be interpreted, and how it should be taken into account and enforced in practice, when planning mining operations in the Finnish Lapland. So far, no legal cases where the Sámi rights would have been challenged by mining enterprise, have been taken to court in Finland but as the mining boom seems to strengthen, this may be only a matter of time. In this context, we hope that our research can provide valuable information for all parties concerned.

# **Climate Change and infectious diseases emergence in the circumpolar north: Actions to be undertaken to improve knowledge, disease detection and prevention and control.**

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The Arctic, like most other parts of the world, has warmed substantially over last few decades. Observed changes include: increasing ambient temperature, particularly in winter; more precipitation, but dryer summers; longer growing season; increase in trees and shrubs and loss of tundra; and changes in marine and land mammal, bird and fish migratory patterns. Temperature and humidity affects the incidence of many infectious diseases in both animal, insect and bird species. Warmer temperatures may allow infected host species to survive winters in larger numbers, increase in population and expand their range of habitation thus increasing the opportunity to pass infections on to other animals and humans. The impact of these changes on human disease in the Arctic has not been fully evaluated but there is clear potential for climate change to shift the geographical distribution of certain vector-borne, parasitic and other zoonotic diseases. Pathogens of circumpolar concern include Brucella, Toxoplasma, Trichinella, Botulism, Tularemia, and West Nile virus, while Puumalavirus, Tick borne encephalitis and borreliosis caused by Borrelia burgdorferi, are of particular concern in Sweden, Norway, Finland, and northern regions of the Russia Federation. The impact of climate change on the incidence of Echinococcosis, rabies, Giardiasis, Cryptosporidiosis are of concern in the US Arctic (Alaska) and northern Canada, while the reemergence of Anthrax and leptospirosis remain a risk in some regions of northern Russian Federation. Forecasting the effects of ongoing climate and landscape change on the transmission and impact of zoonotic infectious diseases in the north is challenging because there is a lack of knowledge on the diversity and distribution of these agents in these regions. Ecosystem health, wildlife health and human health are interconnected. There is a need to develop actions that will improve knowledge, disease detection and enhance prevention and control. These actions include the need to: 1) enhance the capacity to monitor potentially climate-sensitive infectious diseases that are likely to have the most impact on human and animal populations, 2) promptly investigate outbreaks that may be climate related, 3) conduct research into the relationship between weather, climate and infectious disease emergence to guide early detection and intervention, 4) improve and implement diagnostics and molecular typing methods, 5) establish baseline levels of infection, 6) develop communication strategies targeting human and animal care providers, the public and veterinary health, and

indigenous communities and, 7) expand community based and circumpolar networks to improve information exchange at the local and global levels.

# **A Case Study of Community Based Participatory Research (CBPR) to Evaluate the Effectiveness of a Sexual and Reproductive Health Intervention for Youth in the Arctic: The Intersection of Western and Indigenous Research Methodologies**

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Background: There is limited knowledge in the Arctic regarding research methods used to design, implement and evaluate the effectiveness of sexual and reproductive health programs for indigenous youth in remote circumpolar north communities. Cultural differences along will affect the generalizability of research results in Arctic indigenous communities. Inuulluataarnej (Having the Good Life) was a three-year sexual and reproductive health intervention designed to reduce sexually transmitted infection rates in two communities in Greenland. Inuulluataarnej's objects included: 1) Increase Greenlandic youth's overall knowledge about STDs and sexual health; 2) Increase parent/guardian-youth communication about topics related to STDs and sex; and 3) Increase consistent condom use among Greenlandic youth. Methods: The study used a quasi-experimental research design to develop, implement and evaluate Inuulluataarnej. To ensure local acceptability and sustainability of the intervention and its evaluation, Inuulluataarnej was conducted under the framework of community based participatory research (CBPR) and was delivered using a community outreach worker model. Results: Inuulluataarnej produced two major areas of knowledge for future sexual and reproductive health research in the Arctic. First, results indicate that the influence of having a parent/guardian to speak with about topics related to sex reduces STIs among Greenlandic youth. Second, Inuulluataarnej demonstrated that using CBPR to design, implement and evaluate an intensive short-term education and skill building delivered by a trained community member is an effective intervention method among young populations who live in small isolated Arctic communities. Conclusion: Our research provides insights into the challenges of using western research methodologies with Arctic indigenous populations even with the use of CBPR as a methodological framework and sets the stage for areas of future health research with indigenous peoples using indigenous research methods.



## Learning Objectives

1. Describe the CBPR strategies used to implement a community based sexual and reproductive health intervention in small and isolated Arctic communities.
2. Describe the development and the process used to design the intervention's educational materials, data collection instruments and biological samples.
3. Identify the challenges encountered by the communities and the research team in implementing Inuulluataarnej.
4. Identify future areas of research in the Arctic with indigenous peoples that address health research using western and indigenous research methodologies.

# **Occupational exposure and health among workers in a North Norwegian mine**

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Background: Working as a miner is associated with increased risk for adverse health effects. In addition, working in cold climate increases the prevalence of musculoskeletal and respiratory symptoms. The mining industry is expanding in the high north. Increased knowledge and understanding of the health risks facing mine workers in cold environment is vital to enhance the protection of workers' health.

Aim: Study the prevalence of health effects of mine workers in North-Norway and find effective methods to prevent potentially harmful exposure. The aim is to find and present cost-effective and easy to use preventive methods for the workers.

Material and methods: Slightly more than one hundred mine workers participated in a descriptive study mapping exposure to cold climate, dust, whole body vibration, hand-held vibrating tools, ergonomic factors and reported health effects (musculoskeletal disorders, altered cold perception, skin problems, airway symptoms and stress). In addition, data on the utility of protective equipment was collected. The collection of data was performed in October 2013. Part of the information was self-reported by validated questionnaires. Health data was also collected by objective methods and by physician's examination.

Results: Results from the study will be presented at the conference.

Integration into practice: Our findings will be disseminated to the mining industry and occupational health services to promote strategies and solutions that prevent adverse health effects.

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# **Informed Adaptation: how a combination of telecommunications and sentinel surveillance is promoting local adaptation to climate change in Alaska**

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Background: Anthropologists have long proposed that a key component of human evolution is climactic variability. Human technological flexibility, from the hand-axe to the satellite phone, has allowed our species to adapt to environmental challenges over the millennia. Today, residents of the circumpolar north must adapt to the environmental effects of climate change by leveraging local knowledge and technological solutions. In this presentation, I describe the development, implementation, and evaluation of adaptations to mitigate the health effects of climate change in rural and isolated communities in Alaska.

Methodology: A cohort of more than 60 study participants representing eight communities across Alaska provided monthly surveillance surveys from April or May of 2011 to March or April of 2012. The survey's structured thematic sections included community observations on local weather, hunting and harvesting, food and water safety, and general health and air quality. Open-ended text fields for each theme and for general observations were included. Surveillance results were presented in each community, and climate change vulnerabilities and adaptation strategies were assessed in a participatory manner using a qualitative value-jury approach.

Findings: Community participants selected two or more of three primary environmental hazards with priority health sequelae. These were extreme or unusual weather events associated with unintentional injuries, threats to food security associated with a host of adverse health outcomes including paralytic shellfish poisoning, and reduced indoor/outdoor air quality associated with respiratory complaints. Participants requested time-sensitive communications warning of extreme weather events, temperature trends, and adverse air quality forecasts in their communities. Residents may use these communications to modify traditional travel times or routes, practice safe subsistence consumption of shellfish or game, and avoid areas affected by air quality warnings. The second round of surveillance data will assess the utility of these risk communications and associated adaptive practices.

Conclusions: This study demonstrates the effectiveness of telecommunication and sentinel surveillance systems, in combination with preference elicitation exercises such as the value-jury approach, for climate change adaptation. Community-based assessments of vulnerabilities associated with climate change can inform strategic planning by

community stakeholders. Community surveillance networks can also provide a readily-identifiable network for disseminating risk communications to reduce morbidity and mortality from climate change.

# **Sleep disturbance and chronic pain in northern Norway**

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Surveys indicate a relatively high prevalence of chronic pain in Norway compared to other European countries. Musculoskeletal pain disorders are a major reason for patients seeking help from the health care system. Patients with chronic pain often experience additional problems including sleep disturbance, fatigue, depression, and a range of other psychosocial problems. These additional problems represent a major challenge in the treatment of pain.

The Pain Department at the University Hospital of North Norway (UNN) is an out-patient clinic serving the two northernmost counties of Norway, Troms and Finnmark. Assessment and treatment is offered by a multi-disciplinary team including a physician, nurse, physiotherapist and a psychologist. Patients may often experience seasonal variations of their symptoms, including worsening of pain, sleep disturbance and fatigue in the autumn and in the following months with lower temperatures and shorter daylight. We present preliminary findings from a quality assurance project at the Pain Department at UNN. The present study identified key psychological factors associated with sleep disturbance and pain. Patients admitted 2010-2012 (N= 294) completed a questionnaire prior to their first consultation at the outpatient pain clinic. Data included measures of pain (Numerical Rating Scale - NRS), sleep disturbance (a single question), mental distress (The Hopkins Symptom Checklist - HSCL-25), and basic demographics. Mean age was 45 (15-87), 58 % was female. Mean pain intensity NRS was 6,4 (SD=1.8), HSCL25 mean score was 1,96 (SD=0.59). Mean sleep disturbance was 3,0 (SD=0.9), and 34% reported severe sleeping problems (4 on the 1-4 scale).

Sleep disturbance is frequent among patients with chronic pain, and associated with depression and anxiety as well as pain. Further analysis and studies may reveal seasonal variations in pain and sleep disturbance among this patient population in northern Norway.

# Circumpolar Health Research Network (CHRN)

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The Circumpolar Health Research Network (CirchNet) was formed in 2012 with the coming together of two international circumpolar health organizations — the International Network for Circumpolar Health Research (INCHR) and the International Association of Circumpolar Health Publishers (IACHP). This new association aims to:

- Promote cooperation and collaboration among health researchers engaged in research in the circumpolar region.
- Facilitate the exchange, communication and dissemination of research results and other health data.
- Support the training and development of researchers in circumpolar health.
- Publish the International Journal of Circumpolar Health and other scholarly publications.
- <http://circhnet.org/>

# Professional markers safe behavior of shift workers in the Far North

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Today safety labor world over is among the the most significant social problems. In the world each year about 250 million accidents occurs at work according to the International Labour Organization. Of these, 210,000 - the cases were fatal.

Occupational injuries pose a serious danger to the health and life of people, especially employees of dangerous production facilities. Thus, the level of accidents and injuries in the industry of mining and processing of hydrocarbons and gas companies have a high figure. Accidents at hazardous oil and gas facilities have severe social, economic and environmental impacts.

Analysis of the literature showed that all the factors that influence the safety behavior of the subject activities are divided into two groups: objective and subjective.

In academic writings are the following subjective or personal factors that contribute to human susceptibility to accidents: characteristics of temperament, intellectual development, level of adaptation, features of construction of the process of motivation and the working environment, functional changes in the body, locus of control, especially emotional stability, sensory deficiencies, inexperience, carelessness, fatigue, state of distress, lower functional capacity under the influence of biological rhythms, atmospheric effects, etc.

In addition, there are also objective factors of safety of the subject activities t, which should also include features professional activities employee.

Professional activities of workers in shifts in the far north can be classified as an extreme form of labor. Because of their vital activity and work place during a special klimateicheskikh natural and socio-environmental conditions. This can lead to the development of professional undesirable qualities, maladjustment, professional destruction that can make employees work in shifts ineffective, lead to the commission of errors in production, improve employee susceptibility to accidents.

Thus, accidents and injuries in the enterprises of the gas industry, the causes of which were incorrect or untimely actions of a human- operator, it demonstrates the complexities of work and the development of carrier labor and the development of scientific principles to enhance its reliability and safety. Therefore, there is a need to explore and identify markers of shift workers safe behavior in the Far North, in consideration of their personal qualities, what may influence the development of professional destruction in the profession, as well as in the study changes occur in the structure of the personality in isolation workers shifts.

# **Blueprinting resilience of future Arctic communities?**

Tobias Luthe, Romano Wyss

***University of Chur, Chur, Switzerland***

Live in the Arctic is existent in both indigeneous and non-idigeneous communities. Increasing political and industrial pressure for energy and tourism challenge life in the Arctic; while this development may threaten traditional life and the environment, it may also provide for new opportunities of economic development and social wellbeing. We assess resilience to environmental change in the Arctic community of Longyearbyen on Svalbard (Norway), and reflect on potential pathways for other, indigeneous communities. In Longyearbyen, there are no indigeneous people, and there are only few permanent residents in part due to the isolation and extreme environment, in part due to the fact that noone can privately own land. The economy is based on coal mining, research and a fast growing tourism industry. Most tourism industry staff go there for adventure and quick money, while only a few business owners have been living there for 20 to 40 years. One consequence is a lack of attachment to the place.

What can we learn from resilience of a community that is existent only for business and fun? Does the increasing global pressure for energy and tourism push indigeneous communities into a similar direction, thus making Longyearbyen somewhat a blueprint for future Arctic communities? Where are the threats, where the opportunities for anticipating change and resilience in other Arctic communities?



# Food Security: From Traditional to Western Diet – Is It a Viable Option? A Discussion Based on the Results of the Bering Sea Sub Network (BSSN): A Distributed Human Sensor Array to Detect Arctic Environmental Change.

Victoria Gofman<sup>1,2</sup>, Lilian Alessa<sup>3</sup>, Patricia Cochran<sup>4</sup>, Andrew Kliskey<sup>3</sup>, Becky Quinlan<sup>2</sup>, Rebecca Hulme<sup>2</sup>

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As Arctic environment continues to change at an unprecedented rate, the Arctic social and economic landscape is being transformed as well, creating new opportunities and challenges. For small indigenous communities around the Arctic, this new reality may signify prosperity or demise of their societies. How can new scientific knowledge be used to provide a solid foundation for policies needed to assure food security of Arctic peoples?

BSSN is a means for remote indigenous villages around the Bering Sea to communicate their observations on the environment and subsistence harvest. Their perspective, based on a keen understanding of the local environment and how it affects their well being, improves our understanding of coupling of social and bio-physical environment at a local scale. BSSN brings together researchers and local residents in co-production of science, which is place-based and relevant to the societal needs.

The project was launched during IPY 2007-2008 and was funded for a five-year phase II (2009-2014) by the U.S. National Science Foundation ([www.bssn.net](http://www.bssn.net)).

BSSN observations are gathered in a semi-structured survey of local residents of the eight member-communities, three in Russia and five in Alaska. Survey is purposive and is focused on interviewing experienced hunters and fishermen with at least 15 years of uninterrupted harvesting in the area.

The gathered data, in part, demonstrate the significance of subsistence harvest for wellbeing of the communities. While statistics show that almost 100% of harvest is used to feed the residents, the qualitative data provides a deeper insight on the role of traditional foods, as illustrated in this comment made by a Yupik hunter from Gambell, Alaska: “We

are used to this food, our system is used to this food, we need this food; it makes us healthy.”

This presentation will explore how diverse BSSN communities respond to changes in the availability of subsistence species, what concerns they express, and how the results of this project can inform policy makers.

# UNIS` Risk management of students and scientists fieldwork in the high arctic.

Fred Skancke Hansen, Martin Indreiten

## ***UNIS, Longyearbyen, Svalbard and Jan Mayen***

The University Centre on Svalbard, UNIS, educates more than 450 individual students through the year. Together with scientists from UNIS, guest lectures and cooperating scientist we perform teaching and science all over Svalbard, the whole year through.

UNIS perform both marine and terrestrial science, and many of our students and staff participate in scientific cruises and excursions with large scientific vessels, as well as smaller boats. A large part of our activity takes place during the dark period of the year.

Travelling in a high arctic climate, especially during the dark period of the year, could be very challenging and potentially dangerous. UNIS get students and staff to the institution who has very limited or no experience, from working in a cold dark environment with threats and challenges they normally do not relate to.

UNIS has taken the consequence of this and has created safety courses, safety seminars and a set of rules and policies that ensure that students and staff are able to operate safely on and around Svalbard.

The first and biggest challenge in introducing new students and scientist to possible dangers on Svalbard is hazard recognition. There are no road signs or information boards out in the high arctic nature. When introduced to the possible dangers, it is then important to learn how to avoid accidents and minimize the risk. Finally, students and staff need to learn accident management.

On Svalbard, we define these challenges as particularly important to be aware of;

- The exotic and potentially wildlife, such as the polar bear and the walrus.
- Travelling on sea ice.
- Travelling on glaciers
- Travelling in avalanche prone areas.
- An extreme environment characterised by low temperatures on land and in the sea, darkness, strong winds and fast changing conditions.
- Lack of communication.
- Scattered population.

- Limited SAR and medical capacity.

The HSE regime at UNIS makes sure that students and staff get thorough information and training in handling these, and other, challenges. The main safety course at UNIS, in January each year, counts more than 130 participants and lasts for 6 days. UNIS arranges, in addition to this, more than 100 different tailor made safety courses and seminars through the year. In total more than 1500 individuals follow the UNIS safety training through a year.

# **Accomplishment of the first study of HSE in the Arctic in connection with MARKOM2020; ASHE – 201, at UNIS in November 2013.**

Fred Skancke Hansen, Martin Indreiten

## ***UNIS, Longyearbyen, Norway***

The maritime initiative MARKOM2020 aims at strengthening maritime education in Norway. MARKOM2020 includes the higher education institutions that offer 3 year bachelor programs in nautical science:

- Ålesund University College
- Stord/Haugesund University College
- Vestfold University College
- UiT The Arctic University of Norway

Increased maritime activities in the High north imply a need for special expertise for the naval officers operating ships in arctic waters. Safe maritime operations call for knowledge about the special conditions and challenges in the Arctic, including vulnerable environment, long distances, weak infrastructure and cold climate.

In cooperation with the University Centre in Svalbard (UNIS), UiT The Arctic University of Norway has developed a half year study program focusing on issues related to maritime operations in the High North.

The study program includes three separate 10 ETCS subjects;

- Maritime operations in the Arctic
- Emergency preparedness in the Arctic
- HSE in the Arctic

The study HSE in the Arctic is running for the first time on Svalbard in November 2013. The main goal of the study is to get "hands on experience" in factors that are especially important when planning and accomplishing marine operation in the high Arctic. Topics that will be emphasized during the study on Svalbard are;

- The human factor related to working and living in a cold, dark environment.

- Risk management of special challenges found in the high Arctic.
- Practical exercises in managing risk scenarios and surviving in a maritime, high Arctic area.
- Planning of maritime operation.

The student will stay 14 days on Svalbard in the dark period of the year and will be exposed to the Arctic environment through excursions with smaller boats and survival exercises in the sea and on the shoreline. The course will also give the student a solid, theoretical overview of witch factors that are important to plan with in a safety perspective. UNIS use staff from its scientific departments, as well as experience technicians to teach the course. In addition, specialist from these institutions contributes to the study.

- The Governor's office on Svalbard.
- NTNU
- Airlift AS
- Longyearbyen Hospital.
- Kystverket; lostjenesten.
- Store Norske Spitsbergen Kullkompani, SNSK.
- AECCO
- The Norwegian Coast Guard.
- Statoil

# The Nunavut Inuit Health Survey: Understanding its influence and legacy

Natan Obed, Sharon Edmunds

***Nunavut Tunngavik Inc, Iqaluit, Nunavut, Canada***

The recent release of Nunavut Tunngavik, Inc.'s (NTI) 2011/2012 Annual Report on the State of Inuit Culture and Society focuses on two main topics, the 2007-2008 Inuit Health Survey and the role of research in Inuit communities. The Survey itself provides a wealth of information about the diverse factors impacting Inuit physical and mental health and the findings have the potential to inform the development of effective health policy. An issue that's arisen with IHS is that its results have generally been disseminated for an academic audience in isolated fragments rather than showing how the results fit into a larger picture of Inuit health. Related to research generally, is the important role research can play in positive change in Inuit communities, particularly within a policy context. Research has a tainted legacy in Nunavut, characterized by uneven power relationships between Inuit and researchers. Unfortunately aspects of this legacy can be seen in the way IHS was carried out. Thus, this presentation aims to explore what was successful about the IHS as well as shortcomings that future research and researchers can learn from. Further, guidelines will then be described that support ethical considerations and helps ensure reciprocity and cooperative research relationships between Inuit communities and researchers. Finally, a new model for research in Nunavut is then described based on an exploration of research practices involving indigenous communities elsewhere in the circumpolar north.

# An extraordinary avalanche winter 2012-13. A season report from Troms county, Norway

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The 2012-13 season in Troms:

The average number of avalanche fatalities in Norway increased from 3/year to 8/year the last four years. At the same time, Troms has seen a fourfold rise, from 2 to 5 fatalities/year. The number was extraordinarily high during the 2012-13 winter in Troms county (North Norway). The Avalanche rescue team in Troms was called out to 17 incidents, and three fatal avalanches occurred within 10 days. Two were skier triggered and close to the city of Tromsø, and the largest avalanche was in Tromdalen (Senja), killing three snowmobilers in a remote area.

Most of the avalanches, and all the fatal events, occurred within a short timeframe in March/April. Snow profile analyses suggest that a similar continuous weak snow layer may have been important. The fatal avalanches were probably all triggered by human activity. In addition numerous large avalanches were triggered by heavy snow loads, and numerous road closures affected daily life and several cars and buildings were destroyed.

The Tromdalen Avalanche:

Three men were reported missing from a snowmobile tour. Tracks leading in to a large avalanche in a narrow V-shaped valley, and a snowmobile and a helmet were found after initial search. Severe weather conditions with increasing avalanche danger forced the rescuers to retreat. Due to a continuous danger for new avalanches, a terrain trap, the remote location, and bad weather, the scene was closed for ten days by the police. During the stand-down snowfall continued and natural avalanches were observed in adjacent areas.

Local crisis management teams, police and health authorities arranged community meetings to provide information and to prevent dangerous spontaneous rescue attempts by local citizens. Prior to search, the area was cleared using 750 kg of explosives. New avalanches were triggered, loading the initial scene with more snow, before RECCO search, avalanche dogs and probe-lines were started. The snow pack was compact and icy, and alternating clearing of search strips, by first probing and then removing the top 1-1.5 m layer with snowcats and excavators, was necessary to clear the avalanche. Two victims



were located on the 4th day and one on the 5th day of the search. All three were buried at approximately 6 m.

The operation involved almost 300 people, half of these in searching the avalanche area. This is the largest avalanche search and rescue operation ever in Norway.

## Health & environment in the Arctic

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# **A millennium of changing environment in the Kangersuneq and the Kapisillit fjord system, West Greenland: Interdisciplinary analyses of climate variability and settlement patterns**

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**<sup>1</sup>Greenland Climate Research Center, Nuuk, Greenland, <sup>2</sup>University of Greenland, Nuuk, Greenland**

This PhD project is an interdisciplinary study drawing on both natural and social sciences to analyze and improve our understanding of long-term climate variability in Greenland. It explores the links between variations in past and present sea ice, climate conditions, changing environments and Arctic human societies. The Godthåbsfjord region has been the most densely populated part of Greenland, both in the past and present. Climatic and environmental variations in this area are significant, resulting in different patterns of human habitation and settlement (past and present Inuit cultures, or medieval Norse farmers). In the past, links between variations in sea ice, climate variations, and changing environments had significance for the dynamics of Arctic human societies. Each of these cultures were dependent on the natural setting in their own specific way and therefore likely responded to climatic and environmental change in equally particular ways. Their uniqueness was their adaptation to cold winters with snow and ice, but also summers with vegetation and a wider spectra of animals and plants gathered and hunted. But it was their cultural heritage and belief systems that influenced resource use, as well as flexibility and mobility in responding to changing environmental conditions. This project aims to understand such changing human-environment relations in the Kangersuneq and Kapisillit fjord system, particularly in relation to perceptions of resources and the environment and with reference to movement and settlement. Furthermore, it also has relevance in terms of understanding climate change within the context of social and cultural change, changing settlement patterns and mobility, transformations in resource use, and local concerns over the development of large-scale industries. In this way, the project aims to contribute innovative theoretical and methodological approaches to understanding issues of pressing contemporary change.

These theoretical and methodological approaches are the foundation of this paper, thoughts, perceptions and interpretations. It is here demonstrated how this interdisciplinary study, being both natural and social scientific, also can give its input to the understanding of climate and environmental change within the context of social and

cultural change, mobility, transformations in resource use, perception, discourses and the general well-being of the society.

# Public health in Russian Arctic and Climate Change: Results of the first studies

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The first few studies of climate change impacts on public health in Russian Arctic have published preliminary estimates of health risks associated with climate change, developed forecasts of health consequences of climate change until the end of the 21 century, and proposed adaptation strategies. There are three main causative links between climate change and public health:

1. Climate change creates more favorable conditions for propagation of infectious diseases: TBE, borreliosis, malaria, and others. The reported cases of tick bites in Archangelsk region increased from 200-350 in the 1980s to 1500 in early 1990s, and to 6000 in 2007. Time series analysis of tick bites showed that temporal trends in annual numbers of tick bites closely followed the trends in annual temperatures. Northward expansion of *I. persulcatus* has been confirmed in Komi Republic. During 1998-2011, TBE morbidity rates rapidly increased both in the south districts and in the northern districts of Komi Republic.

The correlation between monthly temperatures and the rates of enteric fever and salmonellosis have been observed in Archangelsk region. The probable links to climate change include more frequent breakdowns of drinking water supply and sewerage infrastructure and thawing of Siberian anthrax cattle burials in the result of permafrost melting.

2. Global warming causes more frequent heat waves associated with elevated mortality. Excess mortality from all non-accidental causes, coronary heart disease, strokes, respiratory diseases and all external causes among age groups 30-64 and 65+ caused by the current distributions of heat waves has been estimated in four northern cities: Archangelsk, Murmansk, Yakutsk and Magadan. A meta-analysis of site-specific risks has been conducted. A 80% increase in heat-wave days was predicted in Archangelsk regions by 2041-2060.

3. Climate change has already negatively affected traditional lifestyle of indigenous peoples of North. Their traditional means of subsistence have been undermined by changing migration routes of deer, depletion of habitats of sea mammals and, and other factors.

A strategy of adaptation to climate change was developed and is being implemented in the pilot WHO region – Archangelsk. This strategy includes strengthening of inter-sectoral

cooperation, epidemiological surveys, development of medical services in remote areas, and other elements. Special attention is being paid to vulnerable population groups.

# Spatial and temporal investigation of enantiomeric fractions for pesticides in *Calanus* spp. from three Arctic fjords

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Depending on the three-dimensional structure, chiral pesticides can be expressed as two or more stereoisomers (enantiomers) which are not superimposable. Enantiomers have the same physical-chemical properties and should therefore behave similarly in the physical environment. However, since biochemical processes and pathways are composed by enantiomers (of amino acids, peptides etc), enantiomers of pesticides may undergo enantiomer specific accumulation, transformation and transport in biological systems. This includes microbial transformation processes in sea water and sediments. Enantiomer specific transformation and enrichment processes usually result in deviations from the (usually) racemic original enantiomer distribution expressed as enantiomeric fraction ( $EF = [E1]/([E1]+[E2])$ ). The EFs can be preserved through the food web, or reflect changes of enantiomer specific accumulation and transformation processes.

In the present study, levels and enantiomeric fractions (EFs) of chiral pesticides ( $\alpha$ -hexachlorocyclohexane ( $\alpha$ -HCH), trans-, cis- and oxychlordanes) were determined in Arctic zooplankton, mainly *Calanus* spp. collected during 2007-11 from Svalbard fjords (Kongsfjorden, Liefdefjorden and Rijpfjorden) and from the pack-ice of the Marginal Ice Zone (MIZ) North of Svalbard. All zooplankton species and chiral pesticides showed a characteristic deviation from racemic EFs ( $EF=0.50$ ), although the spatial and temporal variation varied. Oxychlordanes showed a preferred enrichment of (+)-oxychlordanes at all stations ( $EF 0.53-0.86$ ), most likely as a result of enantioselective degraded trans- and cis-chlordanes. Deviations from racemic cis-chlordanes were reflected in the deviation from racemic EFs among oxychlordanes. The biochemical degradation of trans-chlordanes had only minor influence on the enantiomer selective transformation (to oxychlordanes) compared to cis-chlordanes.

A spatial investigation in 2011 showed low EFs of trans-chlordanes in Kongsfjorden in 2011 (0.29). The ice station in the same year showed similar, but slightly higher EFs (0.35). Both stations were influenced by Atlantic water masses. However, the Arctic water mass dominated Rijpfjorden, situated at the northern parts of Svalbard showed a higher EF of trans-chlordanes that year (0.47).  $\alpha$ -HCH is more volatile than the chlordanes and was affected by ice cover to a higher extent, as observed at the ice stations. Enantiomeric

selective analyses can add more information about processes regarding contaminant exposure and pathways, in relation to climate change related influences on Arctic ecosystems.



# Contaminants in Greenlandic food and chiral pesticides as indicators for selective uptake processes

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Hunting and catching traditions of marine mammals and fish are important for the cultural identity of Arctic indigenous people. These food items are readily available, nutrient-rich food resources. Unfortunately, these food items also contain high levels of persistent organic pollutants (POP).

Contamination levels were determined for selected legacy pesticides, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and perfluorinated alkylated substances (PFASs) in traditional Greenland seafood items, purchased from the local market in Nuuk (West Greenland), 2010. The samples selected were raw and smoked fish filet (salmon and halibut), whale and seal meat and narwhal mattak (skin and blubber). In addition, enantiomer selective analyses were performed on  $\alpha$ -hexachlorocyclohexane ( $\alpha$ -HCH), trans-, cis- and oxychlordanes to elucidate selective uptake processes of chiral pesticides in marine food items. The enantiomeric fractions ( $EF = [E(+)] / (E(+) + E(-))$ ) were non-racemic ( $EF \neq 0.5$ ) for all samples except for  $\alpha$ -HCH in narwhal, trans-chlordane in whale and smoked salmon and cis- and oxychlordanes in seal.

The EFs for  $\alpha$ -HCH were  $<0.5$  for all fish samples, but  $>0.5$  for the mammal samples. This deviation from racemic EF indicates different enantiomer selective accumulation and transformation mechanisms in the mammal and fish samples. The EFs in seals were racemic for most of the chiral pesticides. The narwhal showed non-racemic EFs for all chiral pesticides analysed. There were no general enantiomer selective transformation/accumulation trends found for chlordanes. This indicates that enantiomer specific properties are an important prerequisite for the interaction of the chiral contaminant with internal metabolic processes.

The daily intake of PCB, PBDE, PFAS, organochlorine pesticides was assessed. The presented levels of contaminants, in combination with earlier food intake studies, suggest that the daily exposure was below the tolerable daily intake (TDI) threshold for all compounds.

BDE-47 was the only PBDE-congener detected in all food items, except in smoked halibut. The levels of BDE-47 varied from below detection limits (smoked halibut), to 21 ng/g lw in

whale beef. PCB were lowest in smoked halibut (37 ng/g lw) and highest in narwhal mattak (1146 ng/g lw). Perfluorooctane sulfonate (PFOS) was the most common of the PFAS substances.  $\Sigma$ PFAS were below detection limits in most fish filet samples, and varied from 2.9 ng/g ww in whale beef to 13.5 ng/g ww in seal beef.

This study shows that exclusion of food items such as intestines and blubber may reduce POP levels in traditional Greenlandic food, without considerably reducing the health benefits associated with traditional food.

# The deposition and fate of perfluoroalkyl substances (PFAS) and other persistent chemicals in the seasonal snowpack: implications for spring runoff

Crispin Halsall

*Lancaster University, Lancaster, UK*

During the EU 7FP programme 'ArcRisk' a number of field campaigns were undertaken to assess the role of the seasonal snowpack in accumulating atmospherically-derived persistent organic pollutants. For areas where the seasonal snowpack contributes significantly to catchment hydrology, such as remote northerly catchments, then contaminant accumulation in snow and subsequent diffusive entry to first and second-order streams is likely to be significant. Furthermore, changes to snowfall patterns with climate change, including earlier or altered seasonal melt, will affect contaminant behaviour and subsequent loadings to meltwater runoff. The work presented here examines the accumulation of a variety of chemicals including PCBs, OC pesticides and PFAS in the late-winter snowpack and examines their fate following initial snowfall, snow ageing and subsequent melt. Importantly, the properties of the chemical and the features of the snowpack play an important role in dictating the fate of the chemical and its release either back to the atmosphere (via volatilisation), its in-situ deposition to the underlying base of the snowpack or loss via meltwater runoff. Marked differences in behaviour are apparent between different chemical groups. The input and fate of PFAS in the snowpack is interesting, as late winter snowfall events (when air temperatures were relatively warmer) showed higher concentrations than during the previous colder period. Furthermore, some of these chemicals are retained in the snowpack (with increasing concentrations) as the pack diminished during melt. Attempts are made to demonstrate the relevance of the seasonal snowpack as a source of chemical contaminants to Arctic/sub Arctic systems.

# The ArcRisk results web site - communicating research results to a broader audience

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The ArcRisk results website is one of several products communicating the results of the project. The main purpose of this website is to allow open and transparent dissemination of the key results, and explain how they were obtained and interpreted. It is intended to serve the wider audience of interested public, policy- and decision- makers and also the scientific community. The website contains results organized under four main headings: Emissions and pathways; Occurrence and environmental fate; Human exposure and effects; and What can we do about it? Under each heading, key results from the project are presented according to 3-4 levels of detail, where the top level provides an overview in layman language and lower levels are increasingly more scientific and technical. For the scientific audience, information is included about methods, key references to research publications and contacts for further information. The ArcRisk results website will also act as a storage facility for project results after the project is completed.

Visit: [www.arcrisk.eu](http://www.arcrisk.eu)

# Small plastics – big problem? Microplastics in Arctic Marine Environments

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Plastic litter is a very important environmental problem and poses a risk for the health of marine ecosystems. The extent of the problem is, however, largely unknown, especially in Arctic marine environments. How this plastic behaves and how it affects Arctic marine ecosystems is the key to understanding the short and long-term effects. A new initiative from several FRAM Centre Institutes studies how small plastic debris, so-called microplastics, influence Arctic marine food webs. In this project we aim to integrate research activities across Fram Centre Institutes, enhance communications between the scientists involved, initiate new collaborations within and beyond the Fram Centre and contribute to education and outreach in relation to marine litter. We have collected field samples from different Arctic locations, habitats and trophic levels, including beaches, marine plankton, sediments, fish and seabirds to determine microplastics size distribution, polymer composition and chemical additives. Experiments with selected model organisms, ranging from plankton at the base of the Arctic marine food chain to top predators such as seabirds and fish, will help to estimate the effects of microplastics on Arctic marine biota. Investigation into plastic distribution, composition, abundance and interactions with biota will increase our knowledge on the behaviour and impact of plastic in Arctic ecosystems. The results will help to develop tools for improved seafood safety and socio-economic assessments of plastic pollution in Northern areas.

# Adaptive changes in fatty acid compositions of whitefish *Coregonus lavaretus* L. under long-term oil pollution

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Among arctic contaminants oil pollution is the most widespread in the arctic water ecosystems and can affect indigenous health and wellbeing. The Pechora River is located in the Timano-Pechorskaya oil-and-gas province and oil pollution is one of the most pressing problems for the ecosystem. This study was aimed to investigation of fatty acid composition in gonad and liver of fish under oil pollution. Up to 30 components in the fatty acid spectrum with high content of polyenoic acids (up to 40% of the total content) was found. Comparative analysis of sites with different pollution levels testifies to the redistribution in the fatty acid spectrum and changes of their ratios with increasing of toxicological effect. It was found that the total content of saturated and monoenoic acids in the liver decreased with pollution, whereas the total polyenoic acid content increased due to considerable growth of arachidonic and docosahexaenoic acids. The opposite changes were observed in the gonads where monoenoic acids were increased, but saturated and polyenoic acids (particularly arachidonic and oleic) that play an important role in compensating adverse effect were decreased with pollution. The w3/w6 ratio was not changed that testifies to the stable functional status of biomembranes within the range of the body compensatory potential. The final goal of an organism is formation of valuable oocyte supplied with an energy and structural material for an embryo development. So redistribution of fatty acids observed in whitefish from polluted sites is quite justified. The growth of monoenic acids in the gonad is connected with their active utilization at yolk synthesis in developing oocyte. The increase of arachidonic level in the liver, which is a precursor of prostaglandins, suggests that this acid, indirectly affecting the hormone level, is involved to successful maturation of fish from polluted site. The increased level of docosahexaenoic in the liver is determined with their active utilization at biosynthesis of phospholipids which are included in vitellin. Thus, quantitative changes in fatty acid composition of whitefish from the Pechora River support successful maturation and forming of viable generation under strong anthropogenic impact.

# Dietary exposure to dioxins and PCBs in pregnant Norwegian women: Results from the Norwegian Mother and Child Cohort study

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## Background

Dioxins and PCBs are persistent lipophilic substances that accumulate in the food chain, and diet is the most important source. The concentrations of dioxins and PCBs blood are biomarkers of long term dietary exposure and body burden. The latter determines the exposure to the foetus, which is the most sensitive life stage for effects of dioxin and PCB.

## Aims

To 1) describe dietary exposure to dioxins and PCBs in a large group of pregnant women, 2) characterize important sources to dietary exposure, and 3) identify maternal characteristics related to high dietary exposure to dioxins and PCBs.

## Methods

Dietary exposure to dioxins (sum of TCDD equivalents (TEQ) from dioxin-like (dl) compounds) and PCB-153 in 83524 pregnant women (weeks 17-22) who participated in the Norwegian Mother and Child Cohort Study (MoBa) during the years 2002-2009 was calculated based on a food frequency questionnaire (FFQ) and a database of dioxin and PCB concentrations in Norwegian food.

## Results

The calculated median intake of PCB-153 was 0.81 ng/kg bw/day. Intakes of PCB-153 (ln-transformed) showed two normal distributions, a larger one below (n= 81435) and a smaller one above (n=2089) the 97.5 percentile of the total range. The main difference between the two groups was that the women with higher exposure consumed seagull eggs and/or fish roe/liver pate. For dl-compounds, median intake was 0.56 pg TEQ/kg bw/day. Among the 2.4% exceeding the tolerable weekly intake TWI, roe liver pate and seagull eggs were the most important sources of exposure. Adjusted analysis showed that a higher dietary exposure was significantly associated with increasing maternal age, maternal education, weight gain during pregnancy, being a student, and alcohol consumption during

pregnancy, while a lower exposure was related to increasing pre-pregnancy BMI and being a smoker.

### Conclusions

High dietary exposure to PCB-153 or total TEQ was mainly explained by consumption of seagull eggs and/or roe liver pate.



# Estimation of health risk by using toxicokinetic modelling: A case study of polychlorinated biphenyl PCB153

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To assess the potential PCB153-associated human health effects and risks, it is necessary to model past exposure. Blood concentrations of PCB153, obtained from the AMAP biomonitoring programme, in Inuit women covering the years 1994–2006 at Disko Bay, 1999–2005 at Nuuk, and 1992–2007 at Nunavik were used to extrapolate body burden and exposure during the whole lifespan of the population by the one-compartment toxicokinetic model. By using risk characterization modelling, calculated Hazard Quotients were higher than 1 between the years 1955 and 1987 for the 90th population percentile and during 1956–1984 for the 50th population percentile. Cancer risk for overall exposure of PCB153 ranged from  $4.6 \times 10^{-5}$  to  $1.8 \times 10^{-6}$  for the 90th percentile and  $3.6 \times 10^{-5}$  to  $1.4 \times 10^{-10}$  for the 50th percentile between 1930 and 2049, when central estimates or upper-bound slope factors were applied. Cancer risk was below  $1 \times 10^{-6}$  for the same time period when a lower slope factor was applied. In the future, the research requirements to improve health risk characterization include, among others, larger sample sizes, better analytical accuracy, fewer assumptions in exposure assessment, and consequently, a better choice of the toxicity benchmark used to develop the hazard quotient.

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# **Xenobiotic metabolism in vitro – implications for chemical risk assessment in biomedical research**

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Protecting public health is the primary reason why risk assessment of xenobiotics, e.g. agrochemicals, is of utmost importance. Humans are inevitably exposed to pesticides via different routes, at different dose levels and for varying periods of time. Exposure to pesticides is a global challenge to risk assessment. Risk assessment needs reliable scientific information and one type of information is the metabolic fate and toxicokinetics of compounds.

Toxicokinetics refers to the movement of a xenobiotic into, through, and out of the body and is divided into several processes including absorption, distribution, metabolism, and excretion. Metabolism is one of the most important factors that can affect the overall toxic profile of a pesticide. During metabolism, the chemical the first reaction is typically catalyzed by phase I enzymes, usually by the cytochrome P450 (CYP) enzyme system, and then conjugated to a more soluble and excretable form by phase II conjugating enzyme systems.

The CYP enzymes comprise a large multigene family of hemethiolate proteins which are of considerable importance in the metabolism of both xenobiotics and endobiotics. Hepatic clearance is a principal way of elimination for xenobiotics, including drugs. CYP enzymes in humans as well as in other species have been intensively studied over decades. It is now possible to characterize metabolic reactions and routes, metabolic interactions, and to assign which CYP is involved in the metabolism of a certain compound by different in vitro approaches. In general, these enzymatic reactions are beneficial in that they help to eliminate foreign compounds. Sometimes, however, these enzymes transform an otherwise harmless substance into a reactive form – a phenomenon known as metabolic activation.

The aim of our studies is to incorporate in vitro hepatic model systems currently employed to study xenobiotic metabolism to elucidate metabolic factors and interactions of benfuracarb as a case study in human and animal in vitro hepatic models, to extrapolate in vitro data to in vivo situation, and to incorporate toxicokinetic data into human health risk assessment process.

# **The levels of Toxic and essential elements in human blood in Northern Finland and its health implications**

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Scientific risk assessment of chemicals is scientific evaluation of the probability of human health effects resulting from hazardous exposure. Biomonitoring, by e.g. analysing blood levels of compounds is an important tool for evaluating total exposure and internal dose of environmental contaminant for a more precise and realistic human health risk assessment. From Northern Finland 1966 Birth Cohort (NFBC 1966) biobank, 250 blood samples (127 male and 123 female) were selected for the analysis of toxic and essential elements. The selection criteria were based on individual persons born and living the last 5 years in the Eastern or Western part of Lapland. Blood samples were investigated for concentrations of toxic elements such as mercury, arsenic, cadmium, lead, as well as essential elements such as manganese, copper, zinc, and selenium. The aim of this study is to assess those elements in Lappish population, and to compare the results with European and other populations. In addition, it is the aim to compare the biomonitoring data with safety limits and health parameters. The concentration of mercury ranged from 0.23 to 14.54 µg/L, with a median value of 2.06 µg/L. Arsenic level ranged from 0.15 to 18.02 µg/L, with a median value of 0.53 µg/L, cadmium level from 0.11 to 4.03 µg/L, with a median value of 0.49 and lead level from 2.06 to 145.5 µg/L, with a median value of 13.6 µg/L. Two "toxicological" cut-off points were used. In the case of mercury 8.8%, of the studied population were higher than the average of the normal population values, while 21%, were higher than toxicological values established by international organizations. The corresponding percentages for arsenic, cadmium and lead levels were 6.8%, 46%, and 1.6% higher values than in normal population, and 0%, 0% and 2%, higher than international reference values, respectively. No differences neither between males and females, nor between Eastern and Western part of Lapland were observed. As expected, significant correlations between mercury and fish consumption (correlation coefficient 0.424), as well between cadmium and smoking (0.368) were seen.

# Organic anion transporter 4 (OAT4) modifies placental transfer of perfluorinated compounds PFOS and PFOA

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Perfluorinated compounds (PFCs) are widely used in industry and consumer products. Many of these compounds are found widely in the nature and humans. For instance perfluorooctane sulphonate (PFOS) and perfluorooctanoate (PFOA) are found in human blood and they are known to affect human health. The main route for exposure is dietary, but their almost ubiquitous presence in the environment leads to continuous exposure through various routes. The presence of PFCs in umbilical cord blood also suggests fetal exposure to these compounds. The fetus is more vulnerable to xenobiotics than adult and the health is under concern.

Transporter proteins are widely expressed in barrier tissues of human body. They have a role in both absorption and excretion of both physiological and xenobiotic compounds. Placenta plays a key role in fetal exposure to xenobiotics. In human placenta both organic anion transporter (OAT4) and ATP-binding cassette transporter G2 (ABCG2) transporter proteins are highly expressed. ABCG2 has been shown to protect fetus from xenobiotics and also OAT4 is suspected to have a similar function based on localization and function.

In this project the placental kinetics of PFOS and PFOA was studied ex vivo using dual recirculating human placental perfusion methodology. PFC concentrations were analyzed using mass spectrometry (LC-MS/MS).

Placental OAT4 and ABCG2 transporter protein expressions were studied using immunoblotting and transporter protein expressions were correlated with transplacental transfer rate of PFCs.

Both PFOS and PFOA crossed placenta during 4-hour perfusions with average fetal to maternal concentration ratios of 0.26 and 0.20, respectively. OAT4 and ABCG2 were expressed in all of the studied placentas and as expected the expression levels showed person to person variation. Interestingly, OAT4 expression correlated significantly with PFOA transfer ( $R=0.95$ ,  $p=0.027$ ) and there was also a trend that OAT 4 affects PFOS transfer ( $R=0.88$ ,  $p=0.059$ ) although the correlation was not statistically significant. ABCG2 expression did not correlate with PFC transfer.

In conclusion, the transfer of PFOS and PFOA through human placenta is slow, but fetus is significantly exposed. Furthermore, our data suggests that placental transporter protein OAT 4 has fetoprotective functions against PFC exposure in human placenta.

# **Ocean current transportation of sediments and heavy metals in Ingøydjupet, SW Barents Sea**

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The increasing petroleum activity in the Barents Sea will lead to increased release of drill cuttings into the ocean bottom in the future. Drilling mud consists of both drilling fluid with contaminants and fine sediments. This increasing discharge of drill cuttings provides a need for further knowledge of ocean current transportation of both contaminants and fine sediment particles (clay and silt) and the prediction of their accumulation areas.

In this study we concentrate on four multicore locations in the trough of Ingøydjupet in order to study the sediments of the last 130 years. We determine the modern sedimentation rates based on the <sup>210</sup>Pb dating, we analyze sediments grain-size including sortable silt mean grain-size (SS), smectite clay mineral, heavy metal contents and also the total organic carbon (TOC).

The nearshore stations are influenced mainly by the Norwegian Coastal Current (NCC) while the offshore station is influenced mainly by the North Atlantic Current (NAC). Sediment accumulation rates in Ingøydjupet decrease with distance offshore from 2.4 to 1.0 mm/year. According to stable SS and the fine sediment contents (clay and silt) the calmest and most stable bottom currents are associated with the offshore station. Fine sediment particles originating from farther afield are transported to this region by the NAC. The cores closest to continent are under the influence of NCC which leads to larger variation in bottom currents over time. The core in the middle of Ingøydjupet is affected by both NCC and NAC based on stronger bottom currents (SS) and also higher TOC contents. In contrast to the offshore station, stations under the predominant influence of the NCC, exhibit a trend of decreasing fine sediment supplies and increasing sand content toward present day that is strongly linked to an increase in SS. This indicates an overall increase in bottom current strength over time. Heavy metal contents show mainly similar patterns to clay-silt fraction in the sediments. Variation in the grain-size and heavy metal contents during time can be explained by changes in the speed of the NCC and the NAC. Potential stable accumulation areas for drill cuttings are mainly depending on water depth and the influence of NAC or NCC.

# **Exploring pathways of strategic communication within the Distributed Biological Observatory (DBO) of the Pacific-Arctic Region**

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The marine ecosystems of the Pacific Arctic region are undergoing environmental change at an accelerated pace, presenting scientists with the challenging task of investigating and effectively communicating their research results to multiple audiences. Rapid spatial and temporal alterations in seasonal sea ice cover and warming surface ocean temperatures have brought into question how marine ecosystems will respond as a result of these shifting physical drivers. Areas of the northern Bering and Chukchi Seas are some of the most productive marine ecosystems in the world, supporting species that are dependent upon the seasonal presence of sea ice in this region. Widespread changes to the timing of breakup, freeze-up and extent of sea ice cover could profoundly affect primary production and result in cascading effects throughout higher trophic levels. In an effort to better understand the larger biological response to sea ice retreat and its associated changes to the marine environment, scientists from several countries are participating in a new Distributed Biological Observatory (DBO) that includes observations in five regional biological “hotspots” across a latitudinal gradient, spanning from the northern Bering Sea to the eastern Chukchi Sea north of Alaska. The DBO is transformative opportunity for coordinated national and international shipboard observations of the effects of climate change in the Pacific Arctic region. Knowledge gained from the DBO has the potential to greatly impact future marine resource policy decisions on state, federal, and international levels. Examination of the strategic communication needed among scientists, stakeholders, and policy liaisons is a key element in structuring a successful transfer of scientific knowledge to serve policy and management needs.

# **Benthic foraminifera as indicators of natural variability and anthropogenic impact - environmental change in the SW Barents Sea**

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Petroleum production will expand in the Barents Sea in the coming years, raising the chance for increased industrial releases into the environment. Macrofauna is traditionally used to bio-monitor to state of the ecosystem. However benthic foraminifera have large potential for bio-monitoring additionally, due to their specific environmental preferences and fast turnover rates. Their tests stay preserved in the sedimentary archive enabling the reconstruction of pre-impacted conditions. The use of foraminifera as bio-monitoring tool is however complicated by the natural variability of the area of interest. Therefore detailed site specific studies are needed to understand the range of natural variability and to establish pre-impacted baseline conditions. The outcome of this study might contribute to the development of a bio-monitoring tool based on benthic foraminifera for the SW Barents Sea. The study maps both the spatial and temporal range of natural variability in the Tromsøflaket-Ingøydjupet area in the SW Barents Sea, located close to petroleum fields. Both surface samples and sediment cores were investigated on benthic foraminiferal assemblages, sediment properties and concentrations of metals. Relationships between habitat characteristics and foraminiferal assemblages were established using a set of statistical methods. Present day metal concentrations never exceed levels considered as harmful to the environment indicating that the area reflects pre-impacted conditions. A slight increase can be observed in the deeper Ingøydjupet area. This might indicate that Ingøydjupet serves as a trapping zone of contaminants related to discharges from petroleum drilling sites nearby. The living benthic foraminiferal assemblages can be grouped into three associations reflecting different habitat characteristics. The first association is dominated by epifaunal species and is more frequently observed on the shallow Tromsøflaket. The species are associated to the high bottom current activity and coarse grained sediments prevailing on Tromsøflaket. The second association is dominated by infaunal species and is more abundant in the relatively deep Ingøydjupet. The species reflect the fine sediments, relatively high organic matter availability and calm bottom current conditions prevailing in Ingøydjupet. The third association has no clear habitat preference, and is therefore not considered to be useful for bio-monitoring. In sediment cores, covering the last 150 years, species associated to temperate water masses dominate. Changes in down core foraminiferal distribution



patterns are mainly attributable to changes in strength and dominance of the two water masses of the study area. Additionally, the foraminiferal assemblages might reflect climatic oscillations on both millennial and decadal scale time scales.

# Microscale variations in a blue mussel *Mytilus edulis* population: Morphometry and oxidative stress

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Anthropogenic activities are increasing in the Arctic and sub-Arctic environments along with an increasing risk for both accidental oil spill and continuous diffuse pollution. In order to implement environmental monitoring programmes in this remote region, there is a need to select indicator species and study their baseline biological responses to this specific environment. Bivalves, such as the blue mussel (*Mytilus edulis*) are known to be good sentinel species for monitoring of pollutants, as they filter large quantities of water and accumulate high levels of contaminants. In the present study, we studied variations in biological responses within a mussel bed in Kvalsundet, near Tromsø. Mussels along a vertical (subtidal-intertidal) and horizontal (land versus river side) axes of the mussel bed were compared according to their morphometry, levels of oxidative damage (lipid peroxidation, DNA strand breaks) and antioxidant levels (total carotenoids). Significant differences in size and shape of the blue mussels were observed along both axes. Intertidal mussels showed significantly larger height of the shell than subtidal mussels, while on the horizontal axis, significant size differences in both length and width were found. Increased shell height in intertidal individuals may be a morphological adaptation to increase shell volume and play a role as temperature and oxygen regulator. Differences in length and width along a horizontal axis may be explained either by differential growth or age structure as a response to different environmental conditions (water column mixing, water temperature and predation). In addition, levels in antioxidants and oxidative damage were following similar pattern and variations on both axes. For instance, intertidal mussels showed higher carotenoid levels and lipid peroxidation in the mantle compared to subtidal mussels. Ongoing analysis of DNA damage will also be conducted and presented. Variations in shape and prooxidant/antioxidant balance suggest that mussels from a same bed but experiencing different microhabitats and environmental conditions, are subjected to different energy trade-offs between growth and other metabolic processes. This study is important in understanding variations in the biology of this intertidal species and adds further insight into their use as sentinel species. A profound knowledge of their response to their environment is critical for a sound interpretation of their biological responses in the context of environmental monitoring.

# Organotin distribution in sediments of harbours around Svalbard

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Due to sea ice retreat Arctic areas are opening up for increasing economic activities such as oil and gas exploration, shipping and harbour developments.

Organotin compounds are toxic chemicals that are applied in anti-fouling paints used on boat hulls to prevent the attachment of algae, molluscs and other organisms, which increases drag and fuel consumption of vessels. These compounds also leach into the marine environment where they pose a risk to aquatic organisms.

The International Maritime Organisation (IMO) International Convention on the Control of Harmful Anti-Fouling Systems (AFS Convention) banned the application of TBT coatings on ships with effect from 1 January 2003 followed, as of 1 January 2008, by the elimination of active TBT coatings from ships. However not all countries have ratified this ban. Therefore, there are still vessels coated with organotin containing paints.

To assess current organotin concentrations in sediments of Svalbard, samples have been collected in and near the harbours of Longyearbyen, Svea, Pyramiden, Barentsburg and Ny-Ålesund. These organotin concentrations as well as an estimation for the date of input (fresh or more historic) will be reported. The results will form a background for the assessments of impacts from future shipping activities in this region

# **Development of ARctic Biological INDicators for the impact assessment of (new) human activities: the ARCIND Project**

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Due to sea ice retreat Arctic areas are opening up for economic activities such as oil and gas exploration and shipping. Impacts of oils spills and chemicals released during Oil & Gas exploration and exploitation and shipping on Arctic ecosystems are currently largely unknown. Measuring effects and contaminant concentrations in benthic organisms can form an important tool for assessing and monitoring impacts of these activities on marine Arctic ecosystems.

This poster presents the outline and scope of the ARCIND PhD project (2012-2016) that aims to develop a signalling system based on biological indicators for the prediction, assessment and reduction of impacts emerging from the increase of economic activities in the Arctic.

# **Comparative analysis of human impact on the environment in Arctic settlements Longyearbyen and Barentsburg (Spitsbergen)**

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Longyearbyen and Barentsburg are exclusive examples of settlements with industrial development, existing coal mining centers, scientific and tourism activities in Arctic zone. The main purpose of the research is environmental and geochemical assessment of ecosystems in these two towns.

In both towns the main sources of contaminants and disturbance of the Arctic ecosystems are the following industrial facilities: heating plant; seaport; coal mines; storehouses and industrial estates; residential areas; infrastructural facilities. But dissimilar types of landscapes and mining production make difference in environmental response.

Field investigation of disturbance in the Arctic ecosystems due to human activities was organized in May-June 2013. In both towns the snow, soils and surface water sampling has been performed in the centers of industrial activities and also in unaffected areas. In total 35 snow-samples and 27 soils samples had been collected. Several surface water samples from the head and outfall of local rivers had been obtained. These samples had been analyzed on such types of contaminants as heavy metals, total petroleum pollution. Organic matter, pH, anions/cations composition had been determined. The comprehensive landscape description had been done including the investigations of soil profiles on different geomorphologic levels. Landscape descriptions and results of chemical analysis explain the migration of contaminants in different landscape's types, and reveal the level of human impact on the environment. This allows us to make the landscape map and the map of anthropogenic disturbance of landscapes.

Comparative analysis shows that Longyearbyen and Barentsburg have many similar effects of human activities and local features at the same time. In both towns structural and geochemical changes in ecosystems occurred due to industrial development. The soil-vegetative cover in industrial and mine zones had been damaged, removed or consolidated. Simultaneously there are some distinctive particularities in these towns. Thus, in Barentsburg some areas are covered by mining dumps as far as in Longyearbyen these areas are smaller. The old mining dumps cause increase surface soil temperature and effect on permafrost. The slope landscapes on bedrock with transeuvial regime are

prevail in Barentsburg while the valley landscapes on fluvial sediments of with accumulative regime are dominate in Longyearbyen.

The performed research might be useful for understanding of geochemical features of Arctic landscapes under industrial pressure and for development of methodology of comparative analyze of human effects on the ecosystems in cold conditions. That is very important for sustainable industrial development in the Arctic.

# **C:N:P Stoichiometry as an indicator of nutrient limitation on an Arctic hillslope**

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Hillslopes are topographical features in the Arctic tundra which have been shown to impact contaminant and nutrient uptake and transfer pathways. Arctic ecosystem dynamics and food webs are affected due to the down-slope movement of dissolved nutrients. Nitrogen (N) and phosphorus (P) may show contrasting patterns of movement downslope, which could alter their relative availability and potentially influence primary productivity and stoichiometry of plant tissue. Despite the prevalence of these topographic features at a range of scales, few studies have examined changes in nutrient limitation along hillslopes. In this study, foliar samples from Arctic plant functional groups including deciduous shrubs, graminoids, and evergreens were collected from five transects along a hillslope alongside a stream in Healy, Alaska. Stoichiometric nutrient ratios were used to infer changes in relative availability of N and P between plant functional groups and assess the likelihood of a shift in the identity of the limiting nutrient from N to P. Deciduous shrubs and graminoids contained significantly higher levels of N and P by weight than evergreens ( $p < 0.0001$ ), indicating the potential of microscale nutrient patches to affect vegetation type composition. Nutrient recycling rates and interspecies competition may also play a role in the significant C:N and C:P variation between plant functional groups. We found N:P ratios for all plant species to be below 20, suggesting that plant growth is most likely limited by N at all hillslope locations. We also found an increase in foliar N:P ratios downslope, potentially signifying an increase in N availability. Furthermore, N:P of *Betula nana*, the only species present at every site along the hillslope, was positively correlated with increased soil moisture content ( $R^2 = 0.2704$ ). Soil moisture was also negatively correlated with thaw depth ( $R^2 = 0.6417$ ), which calls for further research on the interplay between nitrogen availability and increased thaw depth as a result of permafrost degradation. Studying the effects of topography on foliar C:N:P ratios is a critical step towards understanding tundra nutrient dynamics in Arctic ecosystems increasingly impacted by climate change.

# Identification of environmental sources of lead exposure in Nunavut, Canada

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Background: Blood lead levels (BLL) were investigated in the adult Inuit population of Nunavut, northern Canada, during the Inuit Health Survey (IHS) in 2007-2008. Approximately 10% of the participants had BLLs over the Health Canada's guidance of 100 µg/L.

Objectives: 1) To repeat the measurement of BLL in the participants with high BLL and in their children; 2) to measure lead (Pb) concentrations in environmental samples to identify potential sources and 3) to explore how Pb from environmental samples contribute to BLL.

Methods: Blood samples were collected from 100 adults and 56 children in 2012. A total of 172 environmental samples (tap water, house dust, paint, country food, soil, and ammunition) were collected from 14 houses from three communities where the participants had the highest BLL. Total Pb concentrations and Pb isotope mass balance were determined by inductively coupled plasma-mass spectrometry (ICP-MS). Lead isotope ratio (LIR) analyses and discriminant analyses of the relative isotopic compositions of the samples were performed to characterize the potential relationship between Pb in environmental and blood samples. The Human Research Ethics Review Board of the University of Ottawa approved the project.

Results: The geometric mean of BLL was 43.1 µg/L; BLL increased with age and was higher in adults than children (71.1 vs. 17.5 µg/L,  $p < 0.0001$ ). Mean Pb concentrations in water (14.7 µg/L) and dust (507.9 µg/m<sup>2</sup>, for wiped dust, 108.5 mg/kg for coarse dust, and 433.1 mg/kg for fine dust) were generally higher than in other parts of Canada. Mean Pb concentrations of food, paint chips, soil coarse and fine fractions, and ammunition were 71.7 µg/kg, 76.8 mg/kg, 10.2 mg/kg, 16.8 mg/kg, and 431.4 g/kg respectively. Higher BLL values were found in households with elevated Pb levels in dust. LIR analyses suggest that Pb in paint and ammunition contributed to increased Pb in house dust, which was identified to be the major source of Pb in the households with the highest BLL.



Conclusion: LIR analysis is a useful technique to identify the routes of exposure to Pb and to contribute to the development of effective public health programs.

## **Working with communities: tools offered by APECS to engage early career researchers**

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As the second largest Arctic nation, Canada has developed a Northern Strategy that emphasizes leadership in science and technology through a research paradigm that is collaborative, interdisciplinary, and reflective of northern priorities. This is best accomplished by engaging northern communities in a variety of ways to establish strong community-researcher partnerships. This can, however, be a difficult task for early career researchers (ECRs) that are often restricted by time and lack the knowledge of how to effectively build relationships with northern communities and employ collaborative research paradigms. To address these knowledge gaps and create a tool-kit of 'best-practises' for ECRs to effectively work with communities, a break-out session was held during the IPY Early Career Researchers workshop, hosted by the ArcticNet Student Association (ASA) and the Association of Polar Early Career Scientists (APECS), to catalyze dialogue between ECRs. The "Working with Communities" workshop brainstormed ideas on how to develop tangible and meaningful relationships with northern communities and identified the need for additional resources and training processes for ECRs.

To move the discussion forward, a special series of "Working with Communities" webinars was held as part of the APECS Canada Webinar Series. The APECS Canada Webinar Series aims to provide resources and venues for early career researchers to discuss, learn, and share about topics relating to polar research. The Working with Communities webinar was held as a two-part series that featured northern residents and experienced researchers who shared advice and information on how to prepare for working in northern communities prior to arrival in the field (part 1) and how to sustain research partnerships

while in the field and afterwards (part 2). The pre-arrival webinar focused on how to respectfully interact and build relationships with northern communities: including getting initial contact protocols, ethical research methods, and acquiring appropriate licenses. The post-arrival webinar stressed the importance of continued respect, on-going dialogue with community partners, and continuing investment of time to nurture positive relationships.

These discussions revealed several key themes to consider when conducting northern research: 1) relationships, presence and trust, 2) communicating and reporting back, 3) genuine collaborative efforts, 4) knowledge exchange, 5) listening, 6) dedicating time, and 7) learning local history. Our poster reviews these themes, and highlights what early career researchers identified as potential pitfalls and tools to overcome these, in order to strive towards positive and meaningful partnerships with northern communities.

# Occurrence of antibiotic resistance in marine sediments and fauna along an exposure gradient in Arctic Greenland

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The release of antibiotic/antimicrobial substances in the marine environment may accelerate bacterial antibiotic resistance (AR), and affect natural bacteria community structure and function. Resistant bacteria associated with marine organisms can potentially travel along marine food chains and reach commercial species, e.g. shellfish, fish and mammals. Mapping AR in different habitats is thus urgent to understand the extent and role of environmental resistance reservoirs. Sewage treatment is generally lacking in Greenland and municipal wastewater is discharged directly into the ocean potentially creating strong gradients of pharmaceuticals in general along town coasts.

During the summers of 2009 and 2010, sediment, mussels and fish were collected at the different sites around the town of Sisimiut, Greenland. Bacteria were cultured from animal gut tissues and sediment samples and tested for resistance towards a range of antibiotics. There was a strong gradient of resistance from point sources to more open waters for all antibiotics, but the magnitudes of resistance and resistance fingerprints differed among sites. There was also a parallel gradient in the controls with respect to the number of colony forming units, indicating a lower bacterial gut content in fish and mussels closer to sewage outlets. Resistant bacteria from samples collected closer to the sewage outlet were more often identified as human enterobacteria than resistant bacteria obtained further from the source.

Results indicate a strong human impact on bacterial AR development in the marine environment around Greenland. Since Greenlandic people traditionally depend heavily on sea-food as a food source, the presence of AR bacteria found in guts of fish and shellfish poses a health threat to the people.

# Methylmercury biomagnification in an Arctic food web

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The Arctic is considered an important area for mercury accumulation, because of long-range atmospheric transport and deposition. Following transformation to organic mercury (e.g. methylmercury, MeHg) the toxicity and bioaccumulative potential in Arctic biota is high. In the International Polar Year project "Contaminants in Polar Regions" (COPOL), the aim was inter alia to study how prospective climate changes may affect the dynamics of environmental contaminants in Arctic marine food chains. This aim was addressed by scrutinising bioaccumulation of contaminants across years, seasons and locations (i.e. locations affected by Arctic or Atlantic water masses). In the COPOL project we have shown that trophic magnification of lipid soluble organohalogen contaminants may vary across species, seasons and locations in an Arctic food web. The enrichment in organic contaminant concentrations from plankton to higher trophic organisms did, for instance, increase throughout the year, and the time for concentration peak differed between plankton, fish and birds, with a delay up through the food chain. In the present work, the food web biomagnification of mercury and methylmercury, and its comparability to organic halogens, was analysed.

Organisms of the marine pelagic food web (species of zooplankton, fish and seabirds) were collected in Kongsfjorden, Svalbard (Norwegian Arctic) in 2007 (May, July and October) and 2008 (July). Samples were analysed for stable isotopes of nitrogen ( $\delta^{15}\text{N}$ , for determination of relative trophic level), total mercury (TotHg) and methyl mercury (MeHg). As expected, tissue concentrations of MeHg increased with increasing trophic level (biomagnification) in an exponential manner. However, the increase was steeper than observed in several earlier studies of MeHg (a trophic magnification factor, TMF, of ~10). Preliminary results indicate similar trophic magnification factors (TMFs) among seasons, with a trend towards slightly higher TMF in July, than in May and October. Highest TMFs in July were previously observed for organochlorine contaminants. There was strong correlation between the MeHg and the TotHg content through the food web as a whole, showing an average proportion of ~65% MeHg (of TotHg) in all organisms studied. Thus although MeHg has a much higher bioaccumulative potential than inorganic mercury, measures of MeHg and TotHg depict similar trends.

# Quantitative Approach for Decision Making to Adaptation Strategy for Expected Climate Change According to IPCC-2007 Scenarios

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Decision making (DM) problem is of great practical value in many areas of human activities. Most widely used DM methods are based on probabilistic approaches. Well-known Bayesian theorem for conditional probability density function (PDF) is a background for such techniques. It is due to some uncertainty in many parameters entered in any model described functioning of many real systems or objects. Uncertainty in our knowledge might be expressed in alternative form. I offer to employ appropriate confidential intervals for model parameters instead of relevant PDF. Thus one can formulate a prior uncertainty in model parameters by means of a set of linear constraints. Related cost or goal function should be defined at corresponding set of parameters. That leads us to statement of problem in terms of operational research or mathematical linear programming. It is more convenient to formulate such optimization problem for discrete or Boolean variables. The DM might be performed by means of the discrete optimization algorithms. If the DM variables are all required to be integers, then the problem is called an integer programming (IP). The "0-1" IP is the special case of integer programming where variables are required to be 0 or 1 (rather than arbitrary integers). The IP is a most convenient form for decision maker use. The "1" value means that a given scenario is accepted, the "0" value means that a given scenario is rejected. To illustrate suggested approach the "branch and bound" technique was implemented to the IPCC-2007 climate change scenarios A1, B1, B2 for the global surface air temperature (SAT) and carbon dioxide concentrations. Output of this study is an optimal human made carbon dioxide emission strategy till 2050 in order to achieve closest agreement with the IPCC-2007 scenarios for global SAT. These scenarios provide full information for admissible annual global emissions distributed for range 2011-2050 years. Thus it might be considered as a tool for the political DM and as a background for international agreement on carbon dioxide emission strategy till 2050.

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# Influence of changing climate and emissions on mercury deposition in the Arctic

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We have applied the Danish Eulerian Hemispheric Model (DEHM) to study both the impact of climate change and the influence of future emissions changes on atmospheric transport of Mercury to the Arctic. The study represents a sensitivity analysis in order to investigate the response of the model system due to climate change, emission change and both simultaneously.

DEHM is a 3-D atmospheric chemistry-transport model, which consist of four chemical groups: a SO<sub>x</sub>-NO<sub>x</sub>-VOC-ozone chemistry group, a primary particulates group, a mercury chemistry group, and finally a Persistent Organic Pollutants group. The model covers the entire Northern Hemisphere and all important source areas for the Arctic are included in the model domain. The spatial horizontal resolution of the model system is 150 km x 150 km and the model includes 20 vertical levels up to approximately 15 km above the surface.

The model system was run with meteorology obtained from ECHAM5/MPI-OM (SRES A1B scenario) for two decades: 1990-1999 and 2090-2099. In this climate scenario the global mean temperature is predicted to increase by 3 °C by the end of 2100 relative to the period 1971-2000.

Four different global emission inventories were used (see Pacyna et al, 2010): Basic 2005 scenario and three different emission scenarios for the target year of 2020, the 'Status Quo' (SQ) scenario, the 'Extended Emissions Control' (EXEC) scenario, and the 'Maximum Feasible Technological Reduction' (MFTR) scenario. Finally the most extreme scenario, "zero anthropogenic emissions", was also applied.

The results show that there is a decrease of mercury deposition over the Arctic Ocean from 1990-1999 to 2090-2099 due to climate change alone. The main reason for the decrease over the Arctic Ocean is due to changed ice cover. This will influence the atmospheric mercury depletion events, as parameterized in the DEHM model, where the gaseous elemental mercury is oxidized to reactive gaseous mercury, which has a high deposition rate to the surface.

According to the model simulations, the decrease of the Hg deposition due climate changes are smaller than the decrease due to emission changes in the MFTR and "zero emission" scenarios; 18% vs. 20% or 37%, respectively. If MFTR and "zero emission" were combined with the predicted deposition changes due to changed climate input, the model



system predicts total decreases of the Arctic Hg deposition of 33% for MFTR and 47% for "zero emission" in the end of the 21st century compared to end of 20th century.

# Is meconium useful to predict fetal exposure of organochlorines and hydroxylated PCBs?

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The objective of this study was to compare meconium and maternal serum as biomarkers of fetal exposure to organochlorines (OCs). A subset of 40 meconium samples and complementary maternal sera from The Northern Norway mother-and-child contaminant cohort study (MISA1) were selected. Meconium samples were collected at the earliest opportunity (median 9.0 hours postpartum, range 0–61) and maternal serum in the 2nd trimester (median 19.0 gestational weeks, range 13–34) and analysed for OC contaminants selected from the Arctic Monitoring and Assessment Programme's (AMAP) suite of OCs and selected hydroxylated metabolites. Eight compounds with detection frequencies  $\geq 70\%$  in both media (criterion for inclusion) were included in the statistical analyses. Median concentration ratios for p,p'-DDE, HCB, trans-Nonachlor and cis-Nonachlor favoured meconium, and PCB 138 and 153 and OH-PCB 146 and 172 were higher in maternal serum.

All inter-media correlations were significant (Spearman's rho) for wet-weight concentrations and improved when concentrations in a small subset of 15 meconium and serum samples were both lipid-adjusted; only OH-PCB 146 now slightly favoured maternal serum. Multivariable linear regression modelling confirmed that maternal serum was the most consistent predictor of meconium concentrations, with gestational age and time of meconium sampling improving the models. Although more challenging to analyse, lipid-adjusted OC concentration in meconium is viewed as a sensitive and informative fetal exposure index when taking into account gestational age and its postpartum sampling time.

The Norwegian title of the project is: Miljøgifter i svangerskapet og i ammeperioden (MISA)

# Semen quality in faroese men – a cross-sectional population-based study of 482 men

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Objectives: To determine semen quality and reproductive hormone levels in young Faroese men.

Design: Descriptive cross-sectional study of Faroese men compared with Danish men.

Setting: Faroese one-center study.

Participants: 484 men born from 1981 to 1987 and investigated from 2007 to 2010.

Outcome measures: Sperm concentration, semen volume, total sperm count, sperm motility, sperm morphology and reproductive hormones levels.

Results: Sperm concentrations for the Faroese men were lower than for the Danish (crude median 40 mill/mL vs. 48,  $p < 0.0005$ ). Semen volume was higher, and thus total sperm counts did not differ (159 vs. 151 mill,  $p = 0.2$ ). Motility and morphology did not differ between Faroese and Danes. Inhibin B/FSH ratio for the Faroese men were lower than for Danes (64 vs. 76,  $p = 0.001$ ). Similarly, lower total testosterone/LH ratio (4.6 vs. 6.0,  $p < 0.0005$ ) and lower calculated free-testosterone/LH ratio (94 vs. 134,  $p < 0.0005$ ) were detected for Faroese men.

Conclusions: Semen quality among Faroese men is at the same low level as reported for Danish men, and the reproductive hormone levels furthermore indicated a lower Leydig cell capacity for testosterone production. The influence of environmental exposure and genetic factors on the semen quality has to be studied further.

# Half-life of Persistent Organic Pollutants in Human

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Cross-sectional biomonitoring data for persistent organic pollutants (POPs) are often collected by national health institutes in many countries around the Europe. In Czech Republic, human biomonitoring is routinely established since 1994 by National Institute of Public Health. Data can serve for many purposes, with simple monitoring of the population contamination, being the usually the first one.

Breast milk data, together with dietary exposure data, can be used to estimate human elimination half-life for POPs by using the pharmaco-kinetic framework presented by Ritter et al. (2009). Half-life of POPs in humans is parameter of great importance, which scarce for risk assessment purposes of many chemicals. Parameters like age, smoking habits, residence and others can also influence half-lives. We have estimated elimination for PCBs and some organochlorine pesticides (OCPs) with respect to above-mentioned confounding factors.

According to the Article 16 of the Stockholm Convention (SC) we have also evaluated its effectiveness in Czech Republic by using the time-trend of the body burden of POPs, with respect to all available data from various sources.

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# European populations and mercury exposure

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Mercury (Hg) exposure and effects in European populations were addressed. Based on the literature review, focus was on various Hg exposure pathways including analysis of the European fish market and fish consumption, use of Hg in dentistry, direct exposure due to the proximity of Hg sources in the living environment, and indirect exposure due to site-specific ecosystem characteristics. Various studies that were taken into account were recruiting different population groups at different levels of exposure, using different protocols, addressing different potential routes of Hg exposure, and were using different biomarkers; which makes results difficult to compare. However, analysis of the spatial distribution trends of Hg in various biomarkers (hair, blood and urine) clearly confirmed that the highest exposure levels are found in coastal populations who consume more fish in their diet compared to inland populations. Mercury levels in fish can vary greatly according to species and its origin; of these widely caught fish has higher concentrations than aqua-cultured, and the highest values of mercury are reported in the wild catches of the Mediterranean region. Fewer studies addressed exposure to other Hg compounds, mainly elemental Hg through inhalation of Hg in air and inorganic Hg in food, particularly in highly contaminated areas. Overall, at the currently low exposure levels of Hg prevalently found in Europe further studies are needed to confirm the risk to European populations taking into consideration exposure to various Hg compounds and mixtures of stressors with similar end-points, nutritional status, as well as a detailed understanding of Hg in fish present on European markets.

# Environmental and human biomonitoring as a tool for assessment of mobility and reactivity of mercury

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Due to the complex behaviour and cycling of mercury (Hg) in the environment, actual vulnerability of the ecosystem to Hg load can vary a lot, depending largely on mercury's mobility and reactivity in individual environmental compartments. However, there are no agreed and harmonised methods/tools available that would enable such characterisation. Therefore, this contribution discusses environmental biomonitoring, including human biomonitoring, as a convenient and cost-effective way for assessment of spatial and time trends of mercury pollution, measured by its change in reactivity and (bio)availability. Possible use of biomonitoring as an early warning system for humans and other biological entities will also be addressed. Results as available from selected case studies in wider European scale will be placed in the context of known sources of Hg, both anthropogenic and natural, with a special emphasis on a new knowledge regarding aquatic Hg releases and fate on a global scale. Overall, a need for the standardization of methodologies that would enable biomonitoring to be applied widely and to ensure international comparability of data, will also be addressed.

# Toxicokinetic modeling of selected POPs in human breast milk: Prediction of chronic daily intake and health risks for Czech women in 1994–2009.

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Persistent organic pollutants (POPs) are known for their harmful effects on the environment, where they can accumulate and pass through food-chains into humans. This study is focused on the risks assessment of the non-carcinogenic human health outcomes for pregnant women in the Czech Republic (1994–2009) connected to the exposure of POPs. Samples of breast milk of selected POPs (PCBs, HCB, HCHs, DDT, DDE and DDD) were collected and measured in the biological monitoring of National Institute of Public Health in the Czech Republic. The calculations of health risks were carried out using modified PBPK model developed by Trapp et al. The primary route for exposure in PBPK model was assumed to be through the dietary intake. Model was reversed to predict chronic daily doses from the biological data. The final predicted doses, in the form of chronic daily intakes (CDImilk), were compared with the Czech food consumption and contamination databases (CDIfood). The highest non-carcinogenic risks in form of hazard quotients were estimated for PCBs. Predicted CDImilk were generally over 2 orders of magnitude higher than predicted doses from the food consumption. These facts might indicate new, unknown exposure, which will be discussed.

# Temporal trends of persistent organic pollutants in ringed seals in the Canadian Arctic

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The ringed seal is the most abundant Arctic pinniped with a circumpolar distribution and has been a key biomonitoring species for examining spatial and temporal trends of persistent organic pollutants (POPs). In the Canadian Arctic temporal trends of legacy POPs and new/emerging POPs can be assessed using sample collections that started in the 1980s in Hudson Bay (Arviat) and Cumberland Sound (Pangnirtung), in the 1970s in Lancaster Sound (Resolute) and in the southeastern Beaufort Sea (Sachs Harbour and Ulukhaktok). Results for new POPs, polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCDD), perfluorinated alkyl substances (PFAS), and endosulfan, along with carbon and nitrogen stable isotope data, have been added to samples collected since 2001 and on selected archived samples from the 1970s and 1990s. Sample collections consisting of 10 to 25 adult ringed seals are carried out by hunters each year (June–October) as part of their traditional hunting. Sample analysis follows previously published methods for neutral POPs in blubber and liver (for PFASs only). At most locations only blubber of females and juveniles are analysed to limit the influence of age. Results show that there are declining trends for legacy POPs in all locations with the relative magnitude of  $\Sigma\text{DDT} > \alpha\text{-HCH} > \Sigma\text{10PCB} > \Sigma\text{CHL}$ . Largest declines are in Hudson Bay ( $\Sigma\text{10PCB} = 5\%/yr$ ;  $\Sigma\text{DDT} = 7\%/yr$ ) and lowest in Sachs Harbour ( $\Sigma\text{10PCB} = 1.5\%/yr$ ;  $\Sigma\text{DDT} = 3.3\%/yr$ ). An exception is  $\alpha\text{-HCH}$  which has been increasing particularly at Sachs Harbour and Ulukhaktok. PBDEs increased in concentrations in the 1990s to 2012 at Resolute and Sachs Harbour while in Hudson Bay they have declined over the period 2005–2012. PFASs also increased until 2003–2005 in all locations but have declined over 2005–2012. Endosulfan, HBCDD, and bis(tribromophenoxy)ethane are present at low concentrations in seal blubber (0.01–2.0 ng/g) and appeared to increase in concentration over the period 2005–2012. Proximity to North American source regions for the Hudson Bay population, and the influence of Pacific Ocean seawater transport through the Canadian archipelago for the Sachs Harbour/Ulukhaktok and Lancaster Sound populations, may explain regional differences. Overall the trends of legacy POPs, PBDEs and PFASs in ringed seals do appear to reflect predicted declines in use and emissions resulting from past bans and phaseouts in the Northern Hemisphere.



# Local risk perceptions on contamination in the Russian–Finnish–Norwegian border area

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Regions of the Arctic are contaminated to different degrees. Pollution comes from local and regional sources as well as long-transported. The pollution situation in the area around the joint Russian–Finnish–Norwegian border, the Nickel–Zapolyarny and the Pasvik–Inari regions, has received substantial interest over the years, and specially the emissions from the mining and metallurgical industries in the region. Heavy-metal levels in soil, plants, fish and animals there are elevated. An ongoing project is investigating, among other issues, how the local population perceives the local pollution situation, the health risks associated with the pollution, and how their risk perception affects consumption of local food and outdoor activities. Also, what sources of information groups with differences in risk perception rely on are investigated. The risk perception of the local population will be compared to experts' assessment of the risk. Results from the project will be useful for understanding how different groups of the local population assess and are affected by local pollution and to improve risk communication to the different groups. This presentation will give information on study aims and design, as well as preliminary results from a survey to the population in all three countries in the border region.

# Placental transporter proteins and fetal exposure to environmental contaminants using in vitro models

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The environmental conditions that are experienced in early life can profoundly influence human biology and long-term health. Currently, there is a major concern about prenatal exposure to environmental contaminants and the health of developing fetus later in life. Experimental studies have associated perinatal exposure to environmental contaminants with multiple conditions such as cancer, diabetes, metabolic syndrome and obesity. The placenta maintains fetal growth environment by performing a wide range of physiological functions. Over the past decades several ex vivo and in vitro models utilizing delivered human placenta to predict placental functions including the transport through the placenta have been developed. The use of models originating from human placenta to study transplacental transfer and related mechanisms is an attractive option because human placenta is relatively easily available for experimental studies. After delivery placenta has served its purpose and is usually disposed of. The developed methods include e.g. continuous cell lines, primary cell cultures, villous explant cultures, subcellular fractions and ex vivo perfusion of human placenta. Recently we have focused on the interactions between environmental contaminants and placental transporter proteins. Placenta is known to express multiple transport systems which maintain polarized transport across the placenta. These transporters also interact with environmental contaminants. Using ex vivo perfused human placenta we showed that placental transfer of a food borne carcinogen, PhIP, correlates with ABCG2 transporter expression and transfer of selected perfluorinated compound with OAT4 transporter levels in the placenta. Our results are the first to show that expressions may result in person to person variation in placental transfer of environmental contaminants in humans. Furthermore, we have shown that several environmental contaminants affect placental transporter function and expression level using in vitro models. For instance recently, we discovered that cadmium inhibits the function of ABCG2 transporter leading to increased cellular accumulation of PhIP. In conclusion, our findings support the notion that the fetus is significantly exposed to environmental contaminants during pregnancy if mother is exposed. In addition, our findings suggest that environmental contaminants interact with placental transporter proteins, which may modify fetal exposure levels. The clinical significance of these findings is still unclear. However, our data implicates that transporter protein function may cause person-to-person variation in fetal exposure levels.

# **Enhancing Aboriginal Content and Delivery in Environmental Studies**

Marney Paradis

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Northern Indigenous students in Canada often hold perspectives of natural environment that do not reflect the contemporary positioning of Eurocentric beliefs. The historical implications of separating the student from communities and families has led to a distrust of centralized figures, including those who self-identify as neutral or falling within natural science studies. The coupling of alternative perspectives with Indigenous solidarity has resulted in K-12 and post-secondary classrooms being required to approach environmental science from a more holistic, community-centered perspective. Through the process of negotiation and accommodation, educators can further immerse relevant Indigenous members into the academic sphere, offering science-based, culturally relevant teachings in a manner that engages the broader community in science and environmental discourse.

# Dietary mercury exposure in a population with a wide range of fish consumption - Self-capture of fish and regional differences are important determinants of mercury in blood

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Human, low level, chronic exposure to mercury (Hg) from fish is of concern because of potential neurodevelopmental and cardiovascular toxicity. The purpose of the study was 1) to characterise dietary exposure to total mercury (THg) in a population group with a wide range of seafood consumption, 2) to characterise dietary sources, 3) to investigate the relationship between dietary THg with THg in blood (BTHg), including factors that can explain the variance in BTHg concentrations, and 4) to assess the intake and blood concentration in relation to tolerable intake values.

The participants (n=184) filled in an extensive food frequency questionnaire which was combined with a database on THg concentrations in Norwegian food, and donated blood and urine. Median consumption of seafood was 65 g/day (range 4 to 341 g/day). The calculated mean dietary THg exposure was 0.35 (median 0.30)  $\mu\text{g}/\text{kg}$  body weight/week. Seafood contributed on average 95 % to the exposure. The JECFA Provisional Tolerable Weekly Intake (PTWI) of 1.6  $\mu\text{g}$  MeHg/kg bw/week was not exceeded by any of the participants.

BTHg ranged from 0.6 - 30  $\mu\text{g}/\text{L}$ , with a mean of 5.3 (median 4.0  $\mu\text{g}/\text{L}$ ). There was a strong relationship between total seafood consumption and BTHg concentrations ( $r=0.58$  95%CI: 0.48, 0.67) and between estimated THg dietary exposure and BTHg ( $r=0.46$  95%CI: 0.35, 0.57). Fish consumption, sex, catching >50% of their seafood themselves, and living in coastal municipalities were significant factors in linear regression models with  $\ln\text{BTHg}$ .

Including urinary Hg in the regression model increased the explained variance from 54% to 65%. In a toxicokinetic model, the calculated dietary intake appeared to moderately underestimate the measured BTHg among the participants with the highest BTHg. Only two of the participants had BTHg slightly above a value equivalent to the JECFA PTWI, but none of them were women in fertile age.

# Climate change response of PCB cycling in the Arctic under present-day and future climate - simulations by two dynamic multicompartment chemistry-transport models

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Persistent organic pollutants (POPs) are compounds that are persistent in one or more environmental media, bioaccumulating, have harmful effects on human or wildlife and a potential to be transported far from the sources, e.g. to the Arctic. A future warmer climate with higher temperatures and changed precipitation patterns will influence the environmental fate of POPs. In this study we have compared the results from two dynamic multicompartment chemistry-transport models simulating the effect of climate change on the atmospheric transport of a range of PCB congeners to the Arctic and the resulting fate within the Arctic.

The two multicompartment chemistry-transport models are MPI-MCTM and DEHM. The MPI-MCTM is a coupled atmosphere-ocean general circulation model (ECHAM5/MPI-OM) with dynamic sub-models for atmospheric aerosols and marine biogeochemistry, two-dimensional surface compartments (topsoil, vegetation surfaces, ice, and temporal snow cover), and inter-compartmental mass exchange process parameterizations. DEHM is a detailed 3-D atmospheric chemistry-transport model with full SO<sub>x</sub>-NO<sub>x</sub>-VOC-ozone chemistry as well as primary particles and two-dimensional surface compartments (soil, vegetation, ocean water and a dynamic temporal snow cover) with inter-compartmental mass exchange process parameterizations. In this study DEHM is driven by climate data from ECHAM5/MPI-OM.

The simulation covers the period 1950-2100, forced with emissions from the SRES-A1B emissions scenario from 2000 onwards. Two simulations were performed with DEHM covering the periods 1990-1999 and 2090-2099 with initial environmental media concentrations of the studied PCB congeners from the MPI-MCTM as input. Total PCB burdens and related trends in the Arctic as well as the compartmental distributions in the Arctic as predicted by the two models are compared.

# Influence of climate change on the Arctic Contamination Potential

Kaj M. Hansen, Jesper H. Christensen, Jørgen Brandt

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Using the Danish Eulerian Hemispheric Model (DEHM) we have calculated the Arctic Contamination Potential (ACP). ACP is defined as the sum of masses in the arctic surface compartments (soil, vegetation, snow and water) at the end of a ten year simulated period normalised either with the total mass within the model domain or with the total amount emitted into the atmosphere during the ten year simulation. In this study we use the emission normalized ACP termed eACP. We have calculated the eACP for the physical-chemical phase space spanned by compounds with log  $K_{oa}$  between 3 and 12 and log  $K_{aw}$  between -4 and 3 and for each point in this phase space grid we have included a perfectly persistent compound in the model.

DEHM is a 3-D atmospheric chemistry-transport model modelling the atmospheric transport of four chemical groups: a group with SO<sub>x</sub>-NO<sub>x</sub>-VOC-ozone chemistry, a group with primary particulates group, a mercury chemistry group, and finally a group with Persistent Organic Pollutants with 2-d surface compartments (soil, vegetation, ocean water and a dynamic temporal snow cover) with inter-compartmental mass exchange process parameterizations. The model domain covers the Northern Hemisphere and thus includes all important source areas for the Arctic. The spatial horizontal resolution of the model system in this work is 150km x 150km and the model includes 20 vertical levels up to approximately 15km above the surface. The model system was run with meteorology obtain from ECHAM5/MPI-OM (SRES A1B scenario) for two decades: 1990-1999 and 2090-2099.

Highest potential (12%) for reaching the Arctic surface compartments for the 1990s is seen for compounds with low log  $K_{oa}$  and low log  $K_{aw}$  values. These are relative water soluble compounds referred to as "swimmers". For the 2090s, the overall pattern of the ACP phase space is similar to the pattern for the 1990s. ACP is generally larger for the 2090s than for the 1990s, with a maximum of 15%.

# Organochlorine compounds and pbdes in Southern Europe: Concentrations and temporal trends

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Patterns of exposure to persistent organic pollutants such as organochlorine compounds and PBDEs are different between populations, and they have changed along decades. Past and present usage, dietary differences and geographical situation are important determinants for differences in concentrations found between different populations. High latitude areas have been reported to be affected by global distillation processes of persistent organic pollutants. As a consequence, its levels in the environment have been found to be higher than expected for places where there are not important local sources for these pollutants. Therefore, population living in these areas may be exposed to them, especially if their diet is composed by fatty fish, which has been reported to have high levels of some pollutants such as PCBs. On the other side, southern Europe populations have been historically exposed to organochlorine compounds either by past agricultural usage of pesticides and industry. Although these compounds have been banned for three decades they are still found in these populations, although levels have significantly decreased since its banning. Regarding PBDEs, scarce data on environmental and human levels in the arctic is available. Comparison between levels of organohalogen compounds in different regions are interesting. In the present study, we compared our data on concentrations of organochlorine compounds and PBDEs from mother and children cohorts located around Spain, all of them coming from INMA research network (Children and Environment), with those reported elsewhere, namely in high latitude regions. In general, levels of PCBs in maternal serum from circumpolar regions were higher than those in Southern European cohorts. 4,4'-DDE concentrations were also higher but not in all populations, and difference between both groups of population were not as significant as that found for PCBs. Greenland population was the one with the highest levels of both groups of compounds. Referring PBDEs, fewer studies are available, and levels are slightly lower in arctic than in Mediterranean cohorts. As a conclusion, global distillation processes and diet in arctic populations seem to have an influence on higher levels of organochlorine compounds than those found in Southern European populations, where there has been an important exposure in the past from agricultural and industrial usage. PBDEs seem not to be affected by these processes and Southern European populations may have been highly exposed to these flame retardants.



# Organohalogen compounds in the deep areas of the Barents Sea

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Organohalogen compounds (OCs), such as polychlorobiphenyls (PCBs), chlorinated pesticides and polybromodiphenyl ethers (PBDEs), constitute a group of persistent organic pollutants of major concern due to their toxic effects. OCs are transported over long distances through the atmosphere being incorporated to the marine systems by atmospheric deposition and particle sedimentation. Besides common pelagic settling, dense shelf water cascading (DSWC) may actively flush particles to deep waters in continental shelf marine areas.

The Barents Sea provides a good case for the study of the relevance of these processes for OC and particle transport to deep waters. OCs have been studied in sediment cores collected in the Storfforden area in July 2010 and July 2011 and sediment traps were deployed in this area between these two dates.

Samples of sinking particles were collected monthly by sediment traps moored at four water column depths (1040, 1121, 1500 and 2011 m). This array collected particles during common settling processes and particles transferred to deep waters by DSWC. Moreover, sediment cores were collected at these water depths. Sediment and sediment trap stations were located in the same sites except in the station at 500 m.

Higher settling fluxes of all compounds were observed during DSWC in comparison with pelagic sedimentation, showing the highest fluxes of total OCs at 1040 m station in March 2011 (19 ng•m<sup>-2</sup>•d<sup>-1</sup>). The most abundant compounds in the sediment trap samples were HCB, 4,4'-DDE, ̑#945;-HCH and ̑#947;-HCH.

Historical trends of the above mentioned compounds were determined in four 210Pb characterized sediment cores. HCB and 4,4'-DDE were the highest OCs and BDE-209 the maximum PBDE congener in all samples. Levels of OCs presented a similar temporal tendency in all cores with peak values during the late 1980s, 10-15 years after the maximum production of these contaminants in many countries. The delayed peaks in this study reflect the transport time for these contaminants to migrate to high latitudes and are consistent with the global fractionation model. BDE-209 fluxes also increased during late 1980s, corresponding to the beginning of its large scale production and suggesting a larger potential for long-range atmospheric transport than anticipated on earlier model evaluations. DDTs and PBDEs except BDE-209 showed higher inventories during 1970-1990 than in 1990-2010. Nevertheless, PCBs, HCHs, CBzs and BDE-209 presented higher

depositions during the recent two decades. These results evidence the yet continuous inputs of organohalogen compounds to the Arctic.

# Particle size-specific partitioning of the atmospheric pollutants on the spatial and temporal scales: Potential role of atmospheric particles in long-range transport.

Krzysztof Okonski, Celine Degrendele, Lisa Melymuk, Linda Landlova, Pavel Cupr, Jana Klanova

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A presence of the particulate matter in ambient air (especially of the particles with less than 10  $\mu\text{m}$  in the diameter) has a negative impact on human health as it can induce various respiratory diseases. The fine and ultrafine particles are of a special concern as they can penetrate the lungs to the greatest extent and even enter the blood stream. Another factor that has to be considered when assessing the human respiratory risks are persistent chemicals that are associated with the atmospheric particles and represent additional risk when released in human bodies. Size-specific distribution of these chemicals is an important parameter determining their behavior, fate and effects. Size-specific partitioning of organic chemicals between various fractions of the atmospheric particles has been previously studied for polyaromatic hydrocarbons and it has been demonstrated that they are mostly associated with the fine and ultrafine fraction. However, there is not much known about other groups of compounds, especially emerging pollutants. As such distribution affects the fate of compounds not only from the toxicological point of view but also from the point of the long-range transport of pollutants to the pristine environments, new data are desperately needed. This study assessed seasonal and spatial variability of size-specific particle-gas partitioning behavior of selected groups of legacy and emerging pollutants. Samples have been collected from the urban and rural sites using a high volume air sampler equipped with a six-stage cascade impactor.

# **Herbivore-plant-fungal interactions in the subarctic tundra**

Karoliina Huusko

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During past few years autumnal and recently also winter moths have defoliated about 400 km<sup>2</sup> of mountain birch forests in Utsjoki and Nuorgam area. Expansion of the latter insect herbivore is assumed to be connected with climate change. Moth outbreaks at the forest-tundra ecotone cause drastic vegetation state changes, both in terms of extensive death of birch trees, but also in the understory vegetation which shifts from dwarf-shrub dominated to grass-dominated communities. The extent of change in the understory depends on the initial state of the forest; the strongest effect takes place in oligotrophic communities. The shift in the understory vegetation cause cascading impact on key-stone herbivores; the abundance of grass eating rodents is facilitated, whereas reindeer appear to avoid forest that are most impacted by moth outbreaks. Also soil microbial communities as well as soil nutrient and carbon cycles are strongly affected.

Mycorrhizal fungi have an essential role in carbon and nutrient allocation in northern forest ecosystems, and changes in availability of these resources are likely to have a great impact on mycorrhizal fungal communities and their functioning. Forest soil microbes are generally considered as carbon limited. Thus, reduction in carbon flux from the host plant often negatively affects also mycorrhizal fungi. During massive insect herbivore outbreaks, trees may benefit from increasing amount of dissolved soil nutrients from faecal output of moth larvae and increased amount of dead organic matter, while at the same time their mycorrhizal fungal symbionts are declining. We have found decreased sporocarp production of mycorrhizal fungi as well as altered root fungal communities associated with severely defoliated mountain birch trees. Effects of moth feeding on mycorrhizal colonization and communities of mountain birch and the dominating dwarf shrub mountain crowberry are studied in a controlled moth-feeding field experiment near Kevo Research Station. This work is part of the NCoE TUNDRA. Results can be applied to reindeer herding practices.

# Exploring technologies and policy for reducing pollutants to air and sea from Arctic Shipping.

Jennifer Austin

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The Arctic environment provides a unique habitat for a variety of species of flora. However, these species are subjected to increasing environmental stressors in the form of changes outside of the observed Polar Ocean. Environmental stressors can negatively impact on ecosystems, resulting in organisms becoming less resilient to impacts of climate change .

Increased shipping activity will increase stressors on a unique environment already being pushed beyond known parameters. In addition to the climate change stressors in the Arctic of changing temperature, ice-cover and ocean pH; increasing physical stressors of ships traffic, mineral exploration, disturbance of the water column; as well as increasing pollutants including gas and black carbon emissions and associated combustion by-products, oil spills and anti-fouling paint are likely to have an impact on Arctic ecology and it's resilience to environmental change.

Some of the environmental and ecological changes might be irreversible resulting in permanent detrimental consequences of loss of ecological habitat and species, which may impact on the food chain and ultimately fish stocks. How will the addition of these pollutants affect the toxicity of chemicals already in the Arctic human food supply? The arctic is already a sink for chemical pollutants that hop to the poles. What impact will increased shipping have on concentration of pollutants in the Arctic. What impact will changing environmental conditions such as increasing temperatures and melting ice have on mobilisation of these chemicals in the air and waters of the Arctic. Will these changes and increased concentrations mobilise contaminants to move around within the Arctic environment, giving potential increased exposure of these chemicals to wildlife and ultimately human populations?

This study will review the current pollutants, how climate change might affect their mobilisation and review what current technologies exist to firstly reduce emissions and secondly to mitigate to break the exposure pathway to humans and wildlife against these pollutants? There will also be an examination of chemical components of pollutants on ships sourced from various countries, the concerns of each component chemical, for example China who have used DDT in anti-fouling paint. There will also be a look at what policy and regulations currently exist in various countries on anti-fouling paint regulations and other pollution mitigation control measures. And what policies and guidelines could be considered for implementation to reduce these pollutants? What will the consequences be of successful implementation vs. not regulating?

## Shipping & offshore in the Arctic

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### Scientific committee

Leader: Professor Tor Einar Berg (Convener), Marintek/SINTEF, Norway  
Tor Husjord, Maritimt Forum/Norwegian Shipowner Association, Norway  
Eija Kanto, Wega Enviro Oy, Finland  
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Senior advisor John Evensen, Kystverket, Norway  
Manager Frigg Jørgensen, AECO, Norway  
Mia Bennett, APECS & University of Cambridge, UK

# **e-Navigation in Polar and arctic regions – joint international efforts make it possible. Geir Lyngheim Olsen, Senior Product Manager, Jeppesen Commercial Marine, MNI.**

Geir Lyngheim Olsen

*Jeppesen Norway, Egersund, Norway*

As IMO e-Navigation concept as well as the IMO Polar Code is going from a vision to reality, in parallel with the Polar Regions being opened up for commercial shipping – questions arise about the challenges and possible solutions for navigation safety in the areas.

Potential for both improved natural/fossil resource extraction, considerably shorten the Europe – East Asia route, as well as avoiding high security threat areas such as the Indian Ocean are just some of the incentives making shipping operators aware of the potential now opening up. However, marine operations in Polar and arctic regions are facing considerable challenges. Remote areas, communication, icing of vessels, technology development, and access to information and so on, are just some of the issues that need to be addressed. As not only cargo shipping, but also tourist cruises are increasing in numbers.

The paper addresses ongoing work within IMO for an effective eNavigation and Polar/arctic strategy, together with ongoing efforts from the industry to support safer and more effective information exchange in Polar and Arctic regions. It also addresses challenges especially in communications – latest addressed in an IMO eNavigation workshop in Haugesund, 2012 as well as IMO COMSAR.

# **Offshore Security Risk and Legal Analysis: Human Factors in the Arctic - the Shifting Concern from Terrorism to Civil Disobedience**

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Evaluation of physical security risks to energy infrastructure traditionally focused on onshore installations and pipelines. Recent events reposition offshore risks to the forefront of operators', insurers', governments' and even the public's concerns. The increasing importance of offshore operations coupled with the unique nature of the offshore Arctic environment present additional vulnerabilities warranting consideration in today's paradigm-- especially in light of recent regional offshore contingencies.

Risks associated with offshore operations in the Arctic region are unique. It is an area marked by effects of climate change, race for resources, territorial disputes, and the subsequent potential for re-militarization. Short days, complete darkness, cold temperatures, and incredibly isolated locations pose additional challenges to offshore support crews. Distance from mainland centers restricts response time of rescue or clean-up should anything go wrong.

Unlike offshore installations in parts of Africa and the Middle East, however, Arctic installations do not regularly face threats of terrorism, piracy, kidnapping, or sabotage. Although drilling platforms, extraction units, offshore terminals, and vessels are still vulnerable to such potential malicious threats, recent events have shifted the concern to matters of 'civil disobedience' such as Greenpeace's attempted boardings of Gazprom's Prirazlomnoye platform in the Barents Sea.

This presentation seeks to evaluate legal aspects concerning attacks on offshore installations and government responses to such. No matter the motive, any attack on or approach to an offshore installation, terrorism and civil disobedience alike, is dangerous and usually illegal as platforms are generally, despite public misconception, within a country's maritime security jurisdiction. Offshore platforms are high-hazard installations and any unauthorized activities should be considered a security threat, having the potential to damage the installation, with subsequent increased risk to the rig itself, personnel onboard, and regional ecosystem overall.

Regulations concerning offshore installations differ from country to country as well as in international law generally. Using international law of the sea, other relevant international



legal basis, as well as domestic policies (mostly Russian, Norwegian, American, and British), the author will elucidate the regulatory aspects of managing offshore risk in relation to human factors, chiefly terrorism and civil disobedience.

The presentation will then examine offshore unconventional threat mitigation and response lessons learned from other regions (West Africa) and indicate how these can be modified and implemented, if need be, in the Arctic. Specific emphasis will be placed not only on how countries are cooperating for enhanced security, but how public and private sectors are as well.

# Polar lows and their implications on marine operations

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The oil resource potential in the Arctic/sub-Arctic regions is estimated to be as high as that 25% of the world's yet-to-be-found. Nevertheless, operating in above-mentioned regions is more complicated and expensive than the ones in the North Sea. One of the most important aspects to consider in operating in these Arctic regions is the presence of polar lows and arctic fronts and storms. These extreme events and implications of them on the marine operations were the main focus of this study.

While the maximum polar low-sourced wind speeds for 10-, 20- and 100-year return periods are estimated to be 55.37, 60.93 and 73.52 knots, the maximum polar low-sourced wave heights for 10-, 20- and 100-year return periods are calculated as 5.71, 6.66 and 8.82 meters, respectively.

It is found out that polar lows weather conditions do not normally represent design values (survival conditions); however, they represent operational limitations.

We conclude that operations lasting longer than 72 hours shall be designed for a rougher weather than the polar lows lead to (survival mode).

For operations of duration less than 72 hours, the weather forecast is crucial and it must also be possible to abort the operation within a short period if one is close to a polar weather front as a polar low may appear very quickly.

# **Barrier management – influence from the human factor in the arctic**

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In recent years several serious near-misses with major hazard accident potential have occurred on the Norwegian Continental Shelf, many of them hydrocarbon leaks. Investigations have shown that the majority of these are initiated by manual intervention. Despite this fact, the current focus in QRAs is on technical systems. This has been the main focus for a long time, despite recent trends showing no significant decline in risk level. A higher focus on barriers and operational conditions is encouraged by the PSA and with upcoming production installations in the Barents Sea and arctic waters where operational conditions can be much harder, this must be a priority. Due to the remoteness and lack of infrastructure, a major hazard accident in these areas will most likely have a higher consequence both in regards to environmental impact but also in regards to loss of lives.

Based on this, the work in this thesis is an attempt to take the work done on human factors and transfer it into an arctic operational environment. The focus is on how to apply this in a barrier management perspective, by using the quantitative Risk OMT method.

By using relevant theory on cold climate exposure and legislation demands, two new RIFs are suggested for cold climate operations. The first is weather exposure and is named wind chill factor, and the second representing other cold climate factors and exposures named fitness for duty. Risk reducing measures by using sensors and Ex-safe screens are also simulated. The thesis also suggests how to incorporate the result from Risk OMT into a barrier display, and further suggestions are made towards establishing a more real-time version of the model. This is due to the rapidly changing nature of the risk influences. It also addresses the shortcomings within the field of human, operational, and organizational performance standards and performance requirements.

The thesis shows that there is a risk increase induced by the new RIFs based on the arctic operational environment, and Risk OMT appears suitable to measure the human factor under such conditions. By use of importance measure and other output from the Risk OMT, better decision support for implementation of risk reducing measures could be provided.

Key words:

Barrier management, Risk OMT, arctic, human factor, barrier display, risk management, operational factors, organizational factors, risk influencing factors (RIF), and major hazard accident.

# Seasonal variations in vulnerability of Arctic ecosystems towards oilspill

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High global demand for energy has led to increasing interest in the exploration and use of Arctic resources. Due to melting of sea ice and predicted richness of petroleum resources, there is an increasing interest and activity in Arctic regions both for shipping and the oil&gas industry. Operations in the Arctic represent specific challenges due to both physical and biological environmental factors. Arctic development creates many dilemmas that business and society must address in order to be able to balance the need for energy with the need to protect the environment

The seasonal variability and extreme physical environment have resulted in specific adaptations of Arctic species, like extensive seasonal migrations and aggregations in large numbers to feed, mate and nurture their young that make them particularly vulnerable in certain periods and areas. Due to the low temperatures, Arctic species are also particularly vulnerable to contamination to oil that will affect their insulating layers of feather or fur.

All activities represent a certain risk. To sanction shipping and oil&gas activities in the Arctic will require acceptance of the associated environmental risk level. Stakeholders need to understand what creates the risk level, and on which facts, assessments and assumptions it is made. In this paper we have produced an interactive map to illustrate how activity associated with oil&gas and shipping in the Arctic overlap with important biological resources. By combining pan- Arctic seasonal distribution patterns of arctic species at vulnerable life stages with ship traffic obtained from Automatic Identification System (AIS) data, existing oil and gas activity, and statistics on data related to the physical environment (ice coverage and features, temperature, etc.) we have constructed a map based risk matrix in order to communicate to key stakeholders and support their most important decisions. The map conveys that the Arctic is not a uniform environment and that the environmental vulnerability is continuously changing with seasons. Responsible activities in the Arctic must understand and adapt to this dynamic combination of risk factors.

# Networks, research and development for sustainable vessel operations in ice-covered waters based in northern Norway

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Operations in polar waters are subject to particular safety risk and environmental challenges. Some of these challenges are addressed in networks, research and development programs based in northern Norway. Currently, operations in ice-covered waters are addressed in three programs that include stakeholders in industry, interest groups and research institutes with circum-Arctic partnerships. Tight interconnection and exchange of ideas is exemplified by partners participating across several programs. Aktisk Maritim Klynge (AMK) is a network with strong industry participation to develop and implement equipment, design, and processes for arctic maritime operations. The Network on Safe and Economic Operations in Seasonally Sea Ice-Covered Waters (OpSIce) is a circum-Arctic partnership to promote exchange and cooperation between research and industry at regional, national, and international scale. It focusses on the development of longer-term applied research projects. ColdTech is an international, industry co-sponsored research program based in north Norway working toward the development of sustainable cold climate technologies, including technologies relevant to arctic shipping. The value of approach, scope and potential of these programs will be presented with respect to opportunities given by functional standards and technology development.

# Quality of navigation and communication services at high latitudes (MARENOR project)

Beate Kvamstad, Ørnulf Jan Rødseth

**MARINTEK, Trondheim, Norway**

The presentation will describe the main objectives and early achieved results from the MARENOR project. MARENOR is financed by the Research Council of Norway as well as Norwegian industry partners from oil and gas (EM survey company EMGS), fisheries (shipping company and shrimp trawler Remoy), positioning and navigation suppliers (Kongsberg Seatex and Polar Science Guiding) and telecommunication service suppliers (Telenor Satellite Broadcasting). Academic partners are MARINTEK, SINTEF ICT, University of Svalbard and Wroclaw University of Technology.

MARENOR was kicked off in February 2012 and will end in February 2015. Test equipment for measuring system performance of navigation and communication systems in the High North has been installed at two vessels (Atlantic Guardian and Remoy) and at Kjell Henriksen Observatory at Svalbard. The data to be measured include performance parameters from navigation and communication systems, ionospheric parameters, atmospheric parameters, ship movements and positions.

The presentation will be of interest to all offshore or maritime companies who are doing, or are planning to run operations in the Arctic, especially in areas above 70 degrees north. In areas below 75 degrees north one usually has access to several VSAT communication systems. However, already at 70 degrees North one can experience instability and abruptions, which have unwanted consequences for advanced and expensive marine operations. Raised awareness about the communication challenges and proposed solutions to overcome these challenges will be the main outcome for the reader of the paper.

The main results and major conclusions to be presented are:

Overview of navigation and communication challenges in the High North versus user needs

External influencing factors on navigation and communication system performance

Coverage areas of different satellite communication systems in the High North

First available data sets from measurement campaigns

# Measuring the threat of ballast water-mediated species invasion in the high-Arctic

Inger Greve Alsos<sup>1</sup>, Chris Ware<sup>1,2</sup>, Loic Pellisier<sup>3</sup>, Jørgen Berge<sup>4</sup>, Jan H Sundet<sup>5</sup>, Jamie B Kirkpatrick<sup>2</sup>, Anders Jelmert<sup>6</sup>, Mary Wisz<sup>3,7</sup>

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Climate change and an increasing human presence in the Arctic is expected to increase the region's vulnerability to the impacts of invasive species. A major challenge exists, however, in identifying the magnitude of threats associated with the establishment of new species. Two aspects to this challenge are particularly problematic in the context of marine species invasion: the difficulty of identifying immature developmental stages of transported organisms, and determining the likelihood that, if introduced, organisms will establish and become invasive. In this study, we address both aspects in attempting to determine the potential for marine species invasion in the high-Arctic archipelago Svalbard. We sampled ballast water tanks of ships arriving in Svalbard to measure the density and diversity of organisms transferred to the archipelago. Morphological identification of sampled organisms was supplemented with genetic identifications (DNA barcoding methods) of 250 organisms that presented taxonomic challenges owing to their life-stage and size. To evaluate establishment likelihood, where sufficient information describing the physiological tolerances and distribution of identified organisms was available, we used these data to model species' potential niches as a means for determining their capacity for survival and reproduction in Svalbard waters. Species distribution models (SDMs) were constructed using a range of modeling approaches (generalized linear and additive models, boosted regression trees, random forests, and maximum entropy), and were then used to predict potential ranges under differing climatic (2050, 2100 RCP8.5 emissions scenario) conditions based on an ensemble of different models. Our results demonstrate a range of primers designed for three loci (CO1, 12S, and 16S) were required for DNA amplification and identification of sample organisms. Our methods produced an overall identification success rate of 36% which is in the range of rates reported by similar initiatives elsewhere. Forty-four different taxa were identified, with strong differences evident in the success rate between taxonomic groups (e.g. Cummacea - 0%; Cirripedia 74%). PCR failure and the amplification of non-target DNA reduced the identification success rate. Nevertheless, barcoding uncovered the presence of 20 non-native species in our samples. Current work is focused on using species distribution models (SDMs) to evaluate the establishment and reproductive potential of identified organisms.



Preliminary results suggest the reproductive barrier is presently limiting for most organisms, but will diminish in strength as predicted climate warming proceeds. The results of this work will provide the first comprehensive evaluation of marine species invasion risk for an Arctic region.

# Technological challenges for Arctic shipping

Victoria Gribkovskaia<sup>1</sup>, Beate Kvamstad<sup>2</sup>, Tor Einar Berg<sup>2</sup>

<sup>1</sup>*MARINTEK, Bergen, Norway*, <sup>2</sup>*MARINTEK, Trondheim, Norway*

Shipping and offshore activities in Arctic waters are increasing. In addition to shipping companies with experience from Arctic operations a number of inexperienced operators are looking for commercial opportunities for their vessels. There is need for investigation of challenges for shipping in these waters. This presentation highlights selected aspects of the A-LEX project phase 2 which builds upon the results from the A-LEX case, a study of a thought Arctic grounding. Phase 2 is the next step in an interdisciplinary research of challenges related to shipping in the Arctic exemplified by the European Arctic. The main objective of the project is to establish a common integrated knowledge base of the political, legal, environmental and technological challenges related to shipping in the Arctic. The work on technological challenges focuses on investigating the kinds of systems and technologies that need to be developed to maintain safety and environmental sustainability of maritime operations in the European Arctic. The focus on technological challenges at this point would be limited to the areas of communication, navigation, and search and rescue (SAR). It is almost common knowledge that there is lack of infrastructure for broadband communication north of 75°N. We study the availability of communication services ranging from shore based radio systems to satellite systems. The existing infrastructure of emergency support resources as well as communication and coordination between the different systems is of vital importance in the Arctic. We provide examples of technologies ensuring robustness and stability of vessels under harsh operational conditions. The interdisciplinarity of this work is supported by the investigation of acting rules and guidelines relating to vessel design, communication and navigation requirements for vessels operating in the European Arctic. Some preliminary results on the availability of navigational charts and hydrographic information is presented.

# **A-LEX: Regulating Arctic Shipping: Political, legal, technological and environmental challenges. An interdisciplinary study of increased Arctic shipping. Work package 2: Environmental implications.**

Kjetil Sagerup, Lars-Henrik Larsen

***Akvaplan-niva AS, Tromsø, Norway***

Shipping in a region of challenging climate and poor infrastructure expose the environment to risks. WP 2 includes a study of risk factors and an assessment of the environmental risk associated with increased shipping activities in the European Arctic Seas. The basic research carried out in ice covered waters still holds insufficiencies, and basic knowledge of distribution, abundance and sensitivity of marine resources is poor. The risk assessment will address both operational and unplanned events related to increase shipping. Operational events include emissions to air and sea, while accidents span from strikes of marine mammals to complete wreckages. A wreckage will result in loss of any types of cargoes, ballast water and propulsion fuels into the marine environment. Due to distances and sparse infrastructure, SAR and cleaning-up operation will likely have prolonged mobilisation times. A-lex has developed a scenario involving navigation through the Norwegian and Barents Seas, which will be a starting point for experimental and theoretical assessments of the described events. The scenario includes loss of light fuel oil from grounding. There seems to be an agreement that the lighter propulsion fuels as gasoline and diesel is immediately more toxic than heavier oils. However, evaporation, dispersion and dissolution are much faster in gasoline and diesel. To investigate the properties and sensitivities of organisms representing ecosystems occurring along current and future shipping routes, laboratory experiments testing non-lethal effects of marine diesel will be performed. The first experiment will be carried out November 2013, and will mimic a grounding scenario with releases of marine diesel in a semi exposed, shallow coastal environment. The diesel will be weathered by evaporation to mimic a spill scenario prior to leakage into the water column. Two species of mussels, Icelandic scallops (*Chlamys islandica*) and blue mussel (*Mytilus edulis*), will be exposed to the water soluble fraction of the diesel. Trophic transfer of oil components will be studied by feeding contaminated mussels to red king crab (*Paralithodes camtschaticus*). The results are expected to increase the understanding of lighter propulsions fuel effects on Arctic mussel and crustaceans, and answer some tropic transfer and recovery questions.

# Optimising situational awareness in the Arctic through integrated space technologies – ARCTICSAT

Kay Fjørtoft, Kim C. Partington, Fritz Bekkadal, Beate Kvamstad, Tony Bauna

***MARINTEK, Trondheim, Norway***

The Arctic region is in many senses a frontier environment for human activities, driven by global economic demand for resources and made possible in part by climate change. The Arctic is experiencing increasing pressure from higher levels of shipping, oil & gas exploration and tourism. Well documented changes in Arctic sea ice extent are prompting new efforts to exploit natural resources and alternative shipping routes. This new economy is expected to grow over coming years, bringing with it new regulations to ensure safe and efficient operations in this remote, hazardous and environmentally sensitive region. Operational information and monitoring for this vast region will necessitate increased access to reliable methods based on full and effective use of space technologies.

ARCTICSAT is a concept for situational awareness in the Arctic in which a virtual operations room supports intensive operations (navigation, emergency response, dynamic risk assessment) and is built around state of the art space assets and technologies. The Operations room is supported by SatCom and acts as a hub for earth observation and positioning information. This then includes the functional elements required for situational awareness in the Arctic

Our own initial assessment suggests that situational awareness depends on three critical applications of space technologies, namely:

Effective communications to enable a complete virtual view of operations based on standards, compliant protocols and availability of all required data sources and information, allowing efficient and effective decision making, effectively mitigating the remoteness of the activities.

The ability to access existing and locally forecasted met-ice-ocean conditions (including hazards) over the field of operations, and upstream where potential hazards exist for dynamic risk assessment;

To monitor and be able to act upon the positions of all players, so that these can be deployed and monitored effectively for situational awareness, particularly in relation to efficiency and safety, emergency preparedness and compliance with relevant agreements and legislation

At the ArcticFrontier we will present the ideas behind the project as well as organising a workshop regarding situational awareness in the Arctic waters.

# ESA Integrated Application Programme and the Norwegian Ambassador Platform

Beate Kvamstad<sup>1</sup>, Kay Fjørtoft<sup>1</sup>, Tony Sephton<sup>2</sup>

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The key objective of the European Space Agency Integrated Application Programme (ESA IAP) is to facilitate the creation of viable applications and services that demonstrates the benefits of utilising and integrating space assets. The fact is that most of the stakeholders along the value chain of such services are not part of the traditional space community increases the magnitude of this challenge.

One important part of the ESA IAP is the awareness programme. The goals of the IAP awareness programme are:

Identifying user communities and their needs, especially those needs that are at present not adequately met, which could potentially be fulfilled by space assets;

Identifying space capabilities and their potential added value, that can enable new innovative services or improve the quality and scope of existing services;

Informing and educating potential users/stakeholders about space assets and how they can bring added value to solutions and services;

Influencing decision makers and facilitating cooperation among them, especially where solutions require standardized interfaces or involve cross-border complexities;

Fostering and organizing user demand, and federating user communities where necessary;

Paving the way for partnership agreements, especially where stakeholders and users may be third parties providing support, in addition to solution providers;

Promotion through direct interface with institutions.

A key tool in reaching out to stakeholders is the Ambassador Platforms, a number of centres in different European countries that can be an ambassador for the Integrated Application Program. In Norway, MARINTEK (The Norwegian Marine Technology Research Institute) has the role as ESA IAP ambassador. As ESA IAP ambassadors MARINTEK will focus upon identifying stakeholders within the maritime and oil and gas communities operating in the Arctic, who will benefit from a more optimal use of the space segments (communication, navigation and observation satellites). MARINTEK will bring stakeholders together and support them in the work of initiating relevant projects that can bring forward new products and services aiming at improving the safety and efficiency of operations in the Arctic.

The presentation will be informative for the Arctic Frontier audience for two reasons:

They will receive information about the possibilities of getting their project proposals funded by the ESA IAP, and

They will receive information about MARINTE role as the Norwegian ESA IAP Ambassador, and the possibility of receiving assistance in approaching ESA IAP with a project proposal.

# **Expedition cruise tourism around Svalbard: a joint science–industry approach to identifying and tackling challenges and knowledge needs**

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The interest in Svalbard as a cruise tourism destination has increased substantially over the past decades, leading to a range of opportunities and challenges for marine and terrestrial ecosystems, communities, and regulatory systems on Svalbard and elsewhere in the Arctic (e.g. Greenland, Iceland, Russia). At the same time the Arctic region is affected by global environmental change and consequently increasing interests from other industries, such as oil and gas exploitation, mining, fisheries, and marine transport. Global environmental change will likely affect the Svalbard expedition cruise sector through its effects on the biophysical, social and regulatory environment, but more knowledge is needed about the cumulative or combined impacts on biodiversity and habitat, access, safety, experience, as well as attitudes toward wilderness management. The current strict wilderness management scheme of Svalbard has the potential to alleviate impacts, but whether the increasing and combined local and global impacts will pose challenges for the conservation of the Svalbard wilderness, still remains unanswered. Research efforts are undertaken but in a fragmented manner (e.g. tourist landings, shipping emissions), by researchers and institutes from different countries, funded and supported from different sources. To avoid duplication of research and achieve a more effective use of research funding, to increase the quality and usefulness of research results, to gain an integrated understanding of the interactions between global, regional and local impacts and policies, and to strive towards a sustainable Arctic cruise tourism practice, polar tourism researchers and the Arctic expedition cruise tourism sector have decided to join forces for the development of a collective approach.

This paper reports and discusses the results of a joint science–industry workshop, organised on 2–3 October 2013 in Oslo and funded by the Svalbard Science Forum, which brought together a range of industry leaders and experts. The workshop aimed to collectively identify the main industry challenges, the associated knowledge needs, and potential joint strategies to address these challenges. The workshop particularly highlighted the importance of understanding the governance challenges of operating and improving expedition cruises, the costs and benefits of expedition cruising for nature and heritage conservation and communities, and the risks involved in current and future operational practices in Svalbard and the European Arctic. Next to a joint research



agenda, the workshop resulted in strengthened connections between members of the science and industry, and a shared conviction that a joint approach is mutually beneficial.

# Helicopter borne ICE camera system for retrieval and analysis of small scale sea ice topography.

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A new thin-ice Arctic paradigm requires reconsideration of the set of parameterizations of mass and energy exchange within the ocean-sea-ice-atmosphere system used in modern coupled general circulation models (CGCMs) including Earth System Models (ESM), the primary type of models of the ACCESS project. Such a reassessment would require a comprehensive collection of measurements made specifically on first-year pack ice with a focus on summer melt season when the difference from typical conditions for the earlier multi-year Arctic sea ice cover becomes most pronounced. Previous in situ studies have demonstrated a crucial importance of smaller (i.e. less than 10 m) scale surface topography features for the seasonal evolution of pack ice including summer melt and break-up. During 2011-2012 NPI developed a helicopter borne ICE stereocamera system intended for mapping the sea ice surface topography and aerial photography. The hardware component of the system comprises two Canon 5D Mark II cameras, combined GPS/INS unit by "Novatel" and a laser altimeter mounted in a single enclosure outside the helicopter. The unit is controlled by a PC mounted inside the helicopter cabin. The ICE stereocamera system was deployed for the first time during the 2012 summer field season. The hardware setup has proven to be highly reliable and was used in about 30 helicopter flights over Arctic sea-ice during July-September. Being highly automated it required a minimal human supervision during in-flight operation. The deployment of the camera system was mostly done in combination with the EM-bird, which measures sea-ice thickness, and this combination provides an integrated view of sea ice cover along the flight track. The results of the data analysis are intended to aid in improving the CGCMs sea ice scheme with a focus on the period of summer melt. In particular it applies to the spatial and temporal distribution and depth of melt ponds, ridge width distribution and coverage as well as smaller scale ice floe size distribution. These parameters were found to be of particular importance for the rate of summer melt of ice pack. Improved numerical predictions of the state of summer ice cover, in turn, will have implications for a range of issues relevant for environment and society.

# Laboratory study of oil slick behaviour in sea water in cold weather conditions: Improving the oil spill response system for the Barents Sea

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Volumes of oil and oil products transported in the Barents Sea and Kola Bay as well as through the North-East Sea Route increase every year and, according to near term forecast, will continue to grow several times. The increased number of oil carrier vessels will escalate the risk of oil spills in the Barents Sea. Oil spill is a series of natural processes including spreading, evaporation, formation of oil-water emulsion, dispersion of oil in water. In 2006, the Murmansk State Regional Centre for Standardization, Metrology and Testing (MCSM), in cooperation with Statoil, established a laboratory to determine chemical characteristics and analysis of weathered oil. The laboratory is outfitted with equipment for the determination of physico-chemical parameters of oil (density, viscosity, flash point, pour point, hydrocarbon composition, etc.) and a "cold room" to research the interaction of oil with sea water in the temperature range of 5-15°C. Studies of oil are carried out in conditions simulating the presence of oil on sea. The objective is testing samples of different oil types, study their physical and chemical properties when released into the sea water, the oil slick behaviour depending on weather conditions, as well as the interaction of chemical dispersants with different types of oil. The samples used in this study were collected from oil terminals and tanker carriers. The test performance data of oil samples will be further used to create a computer model in order to predict changes in oil properties under a particular weather condition (sea water temperature, wind velocity, sea waves) and determining the efficiency of dispersant use. This will allow forecasting how a particular type of oil will behave during the spill and aid in devising a strategy for oil spill clean-up. In case of an accident, the oil sample from the carrier tankers will be tested to identify oil type. Further, the databank will forward oil specific data to Hydrometeorology services for forecasting oil spill behaviour, which, in turn, can help determine rescue services, instruments, force and means to react adequately and work efficiently during the elimination of oil spill. The research is conducted within the Kolarctic ENPI-CBC project titled "Improvement of the system to respond to spills of oil and oil products through the creation of a data bank of oil".

# **Profitability of container and dry bulk shipping via Northern Sea Route in 2010's**

Tuomas Kiiski

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The Northern Sea Route (NSR) is a shipping route connecting Europe and Asia that passes through Russia's Arctic regions. The main potential advantage of the NSR is linked to its significantly shorter geographical distance between Northern Europe and Asia base ports leading to possible savings in fuel and time based costs.

Currently, the NSR is a target of thriving interest among the shipping industry because the climate change has improved its viability by decreasing the extent of polar ice-caps and subsequently lengthening its annual navigational season. In parallel to this development, Russia has reconstructed the NSR administration system including admittance criteria enabling bigger and less ice-strengthened ships to enter the route.

These developments have resulted gradual increase of NSR traffic volumes. Cargoes have consisted mainly on bulk and liquid transported commodities. The Arctic natural resources located along the route, offer additional incentive to increase interest in the Arctic region as a whole, and provide natural additional volumes to be transported via NSR.

This paper is a quantitative assessment of the NSR's competitiveness against Suez Canal Route (SCR) in container and dry bulk shipping. Calculations are based on a single roundtrip in container and dry bulk shipping on various routes both via SCR and the NSR. The analysis relies on a detailed-level cost calculation model to assess the effects of various cost components to the profitability of shipping company operating this trade. In addition to the cost calculation analysis, the constraints hampering the NSR's viability as well as the potential cargo flows in NSR during the 2010's are evaluated.

The key results are as follows:1. Currently, dry bulk shipping in Northern Sea Route can be profitable and competitive against the conventional routes under right circumstances.2. Container shipping is not likely to be profitable or viable in the near to medium term. The main reasons are, for example, the short annual operating window, missing cargo base and (currently) high ice-related extra operational costs.

# Shipping in the Arctic: a multidisciplinary summer school in Svalbard 2013

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The Nansen NVP summer school "Shipping in Arctic Water: The interaction of sea ice, ship technology, climate change, economy and other operational conditions" was organised by the Norwegian Scientific Academy for Polar Research in Longyearbyen from 18 to 26 August 2013. The summer school convened students, researchers, and experts on Arctic issues for lectures, discussion, presentations of research findings, and the collaborative writing of a study report. Multidisciplinary discussions were the key elements of the Summer School, helping the participants to gain new insights into the various disciplines affecting Arctic shipping. The summer school addressed not only the most critical elements within the relevant areas of research, but also the connections between related fields, will increase the likelihood that research in any one area achieves societal relevance. For example, geopolitical thinking in the Arctic can be better understood through the analysis of resource availability and the economic realities of bringing resources to market. The potential for viable long-term economic development in the Arctic based on resource extraction is directly linked to future scenarios of climate change, governance regimes, and impacts on communities and the environment. The interdisciplinary approach has been valuable both in helping to understand the extent and prognosis of climate changes in the Arctic as well as providing an introduction to the capacitive realities faced by business ventures and local communities. The linkages between the social, environmental, and technological aspects of shipping will pose some of the more compelling and valuable research questions in the future.

# **Effects of cruise ship tourism on the remote town of Ísafjörður, Iceland**

Caroline Coch

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The global Cruise Ship Tourism industry has been continuously growing at a rate of approximately 7% per year (Cruise Lines International Association 2011). This is particularly noticeable in Ísafjörður, a town in the Westfjords of Iceland with 3000 inhabitants, where the number of tourists in town exceeds the number of residents on some days. This study approaches the impacts of cruise ship tourism from a geographical perspective looking at environmental, economical and social effects. By applying qualitative and quantitative research methods, a first attempt to characterize the potentials and problems of cruise ship tourism in Ísafjörður will be made.

It has been investigated that environmental problems are likely to exist with regard to emissions and ballast water. The development of a monitoring system is recommended in order to assess the environmental impacts on the pristine nature quantitatively. The seasonal concentration of cruise shipping activity (June until August) has challenging implications for its management. Infrastructure needs to be enhanced to cope with high passenger numbers, for example by offering a larger variety of excursions but also activities for passengers staying in town. There is further a demand for public transportation and local markets providing crafts and arts. Improvements in cooperation and communication within the town's businesses are needed. This involves the provision of reliable information about ship sizes and schedules and also the extension of opening hours. The overall economic contribution of cruise ship tourism to the region can be considered to be rather small as just a few stakeholders benefit to a greater extent. However, passengers could be regarded as a marketing support bringing potentially new visitors to the region.

Finally, the controversial discussion of how to design and whether to limit cruise ship tourism in the future has been raised. Conflicts arise at different levels: the local community determined by fishing industry that faces a overcrowded town during the summer; a few businesses relying on the cruise shipping industry on the one hand and the overall small economic benefit for the region on the other hand. The discussion of sustainability and risk minimization is and will be crucial to define a common future.

# **Navigating in ice is nothing new, but.... The insurance branch as an actor in developing the use of the Northern Sea Route. Preliminary results.**

Anne Katrine Normann, Eirik Mikkelsen

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Shipping in the Arctic, specifically along the Northern Sea Route, has seen a great increase the past few years, in relative terms. Climatic and political conditions influence commercial interests, and Chinese actors, as an example, are planning for a massive increase in the country's use of the Northern Sea Route.

There are predictions that point in several directions: we have seen predictions of at least a tenfold increase within the next decade, while other prediction show that it will increase only moderately, and some even predict that due to reversing climate conditions, the use of the Northern Sea Route will slow down.

In any case, the insurance branch is an important actor in the development of the use of the Northern Sea Route. Based on interviews with Norwegian and international insurance actors, both for hull and P&I insurance, as well as with commercial ship owners who plan for yearly cross-Arctic voyages with their ships, we study the role of the insurance branch, and the potential challenges for ship owners getting insurance. Further, we ask whether the insurance branch has an active role towards Russian authorities and interests in improving infrastructure for salvation and rescue along the Northern Sea Route.

# **The Arctic Ocean Review, the Arctic Voice, and Dealing with the Interplay of Global and Regional Regimes**

Marc-Andre Dubois

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Evidence from earlier regime effectiveness studies and niche-oriented analysis suggests that the Arctic Council and its member-states should use the Council's work to influence and shape action in other regional and international fora. The article highlights the need for the Arctic Council and its members to move beyond knowledge-building and norm-building to actively support regulatory advances in broader institutions by the establishment of a coordinated Arctic voice enabling Arctic states to provide collective leadership in global instruments with an Arctic agenda, such as finalizing the Polar Code. Such an approach would also be consistent with the recent Ministerial declaration of the Arctic Council. The Council's Arctic Ocean Review recommendations will serve as the example to illustrate the opportunities for member states to provide collective leadership in addressing those recommendations in international fora.



# Assessment of the feasibility of the future Arctic shipping routes

Janne Valkonen

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Decreasing summer sea ice extent and the rising commercial interest has opened new opportunities for sea transportation in the Arctic. The possibility of using a shorter route between Europe and Asia may result in considerable savings for the shipping industry. Particularly, the new routes crossing the Arctic Ocean closer to the North Pole, which may open in the future, have the potential of cutting transit distances between Europe and Asia for the summer season.

In this paper, we describe methods to assess the potential of new Arctic routes. At first, the possible future Arctic routes are viewed against the required ice class for prevailing ice conditions. This provides the basis for evaluating the structural risk level and ice class requirement for the ice conditions along the routes. Secondly, the ship's performance is estimated by simulating ship performance along the new routes. This is done by using a probabilistic simulation model for ship's ice and open water performance. This analysis reveals the ship's capability to transit in ice conditions with acceptable structural risk. The main outcome from the simulations is a distribution of possible transit times for a given route. The distribution of transit time is then used as an input for analyzing the fuel consumption, emissions and the economics of a transit through the Arctic. The simulation allows a probabilistic techno-economical assessment of different ship concepts for a given transport task.

The length of the sailing season is an important factor for the economic assessment of the Arctic shipping routes. Ship's ice class and performance for a given route are separately assessed against monthly predictions of ice conditions to see how the length of the sailing season might change in coming two decades. Based on these three separate assessments, conclusions on ship type and design for sailing the new future routes are drawn. The results reveal the new routes stretching towards the pole and possible expenses for using these routes. The analysis of the future Arctic routes combined with simulating ship performance can be used to evaluate the economic benefits of the different Arctic routes. It can be used in the design phase of a ship as a basis for selecting a ship concept or fleet of ships for a given trade.

# A University of Arctic Coast Guard Functions

Harri Ruoslahti

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The Northern circumpolar region and its ice covered ocean, the Arctic constitutes the fringes of Europe, Asia, and North-America, with increasing economic and human activity. The climate of the Arctic is warming and Russia, for example, is building an Arctic gateway of the Northeast Passage and its traffic will continue increasing.

European Maritime policy will seek to respond to challenges facing the European maritime domain in an integrated and cross sectorial manner. The recent Arctic Council agreement on Cooperation in Aeronautical and Maritime Search and Rescue in the Arctic is an important indicator of coast guard related development.

As the Arctic Council is the most important international cooperation forum, the University of the Arctic an important form of collaboration of scientific research networks on Arctic issues. This paper concludes that as activity in the Arctic will increase a need for higher level coast guard cooperation will be needed.

While the European Union looks at more integrated maritime surveillance, and improved implementation of platforms (EUROSUR and CISE), more unified requirements should apply to educational institutions in the field. Present national Coast Guard education systems serve operational targets; leaving post-graduate, and post-doctoral, levels of education lacking.

This paper argues that a network forming a University of Arctic Coast Guard Functions - adding communication and cooperation through cross sectorial and regional research and development in common awareness, risk pictures, preparation against disaster, joint capacity building, resource pooling, etc. - will benefit all sectors aiming towards a safer and more secure Arctic maritime domain.

The University of Arctic Coast Guard Functions will help create long term programs, which change the current status quo of unlinked programs and systems. It can demonstrate new knowledge on how a cooperation should work in the future - not only technically, but also as a process to change the current mind-sets to cooperate more and share information to benefit the security and safety of living, transport, and economic use in the Arctic environment.

This paper concludes that the University of Arctic Coast Guard Functions should be a multi-disciplinary network bringing security and safety management, and coast guard functions oriented researchers and institutions together. The University of Arctic Coast Guard Functions should also award multi-disciplinary higher post-graduate, and doctoral, levels of education with have a more defined scope and focus on coast guard

functions than the University of the Arctic, and a broader focus than existing coast guard Institutions.

# Safety and maintenance management of marine operations in the Arctic – learning from fisheries

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The harsh climate and vulnerable environment of the Arctic create new challenges for the oil and gas industry when moving their activities to the high north. The rigs and technology for exploring and producing energy resources has to be designed for the colder environment, and the long distances to shore make it necessary to develop new solutions when it comes to transport of supplies and people, as well as emergency preparedness. Furthermore, the risk levels are in general higher because the consequences of an accident may be far more severe than in warmer climates. The IMO is now constructing a new Polar Code for shipping, and it is expected to place additional demands on future operations in Polar waters, in areas such as design, outfitting, operational planning and management systems, as well as competence and crewing. IMO's work with the Polar Code will also cover the new-built fishing vessels under its current draft format. This has raised the need for a safety and maintenance management tool that contains specially designed modules for preplanning and management of operations in the Arctic.

This project aims to develop a maintenance and safety management tool for vessels and installations engaged in marine operations in the Arctic, including the fisheries. The system functions will be based upon requirements derived from state of the art knowledge on safe and environmental friendly operations in the high north waters, as well as requirements in the Polar Code and other relevant regulations for commercial activities in the Polar Regions.

Needs and requirements to a computer-based management system for Arctic operations have been gathered through workshops and interviews with representatives of the user groups. Present and new regulations applicable in the Arctic have been studied. While the oil and gas companies are newcomers in the area, the fishing fleet has been operating in the Arctic region for decades. The project has aimed to gather important learning points from experienced fishing vessel skippers, and has also mapped the preplanning and operation management procedures implemented on board trawlers. Requirements for the Arctic module for safety and maintenance management will be presented.

The project is funded by The Research Council of Norway through the MAROFF programme.

# **Cooperation between states in the Arctic - why is it difficult?**

Marcel Sachse

***FernUniversitaet, Hagen, Germany***

In the recent years, the Arctic has developed into an international political arena. Promising shipping routes and energy resources in the Arctic ocean are key interests in this polar region. As a result, Arctic littoral states are in a security dilemma, in which it is increasingly difficult and expensive to protect national interests and sovereignty over seabed and shipping routes, such as the Northwest Passage. This presentation analyses this scenario using a realist theory. It becomes clear, that the past decades have seen a power transition in the Arctic, where today also non-state actors, international institutions and multi-governmental organisations exert a big influence on the future of the Arctic. State governments are therefore challenged to find innovative solutions to balance power in the region. A challenge that not only questions the governments ability to innovate but also seeks security in cooperation among states, rather than an ever increasing national military capacity.

# **Risk analysis of oil spill in the Arctic Ocean**

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The observed decrease in sea-ice and change from multi-year ice to first-year ice in the Arctic Ocean opens up for increased maritime activities. These activities include transportation, extraction of oil and gas, fishing and tourism. The expected growth in marine shipping in the Arctic region also increases the potential threat of accidents. Within this project we aim to provide information about the potential geographical distribution of oil pollution along prospective future shipping lanes in the Arctic.

Using a combination of remote sensing products and a risk analysis thought-process we develop a method that tracks a potential oil spill from release to clean-up. Furthermore, the method includes the biogeochemical impact of the spill on the environment. We intend to use synthetic aperture radar (SAR) images and to provide input data about the changes in the Arctic sea ice cover, including regional shifting from multi-year ice to seasonal ice, sea-ice concentration and information on the wind patterns over open water at 10 meters height. Combining this data with information about ocean currents we will make estimates on the redistribution and spread of oil pollution scenarios. Different size of oil spills and spills with different type of oil will be included and we aim at including ecotoxicological effects of low concentrations of oil for possible future economic assessment of the environmental impact.

The movement of sea ice is also of uttermost importance during clean-up work as sea ice drift may hinder the work. Both from a safety prospective for those working with the clean-up but also prevent ship movements. On the other hand sea ice might prevent an oil spill from reaching the coast and potentially vulnerable areas. In such a scenario it might be preferable to protect the open water. The complexity of the Arctic region is one of the reason for adopting the risk assessment approach in order to ensure a more comprehensive understanding of the system.

# **Sustainable and safe solutions for arctic and cold climate technology**

Jaakko Heinonen

***VTT Technical Research Centre of Finland, Espoo, Finland***

The presentation introduces Arctic research and technical solutions for sustainable and safe operations and structures in the Arctic. The following topics are presented: winter navigation and maritime operations, ship propulsion in ice, wind energy in cold environment, construction and material technology for cold environment, ice physics and mechanics, ice-structure interaction simulation and structural performance of offshore structures in ice-covered waters. Also, the main challenges and research needs are addressed.

# The new Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic

Ole Kristian Bjerkemo

## ***Arctic Council working group EPPR, Horten, Norway***

On the occasion of the Seventh Meeting of the Arctic Council in Nuuk Greenland in May 2011, the Arctic Council ministers, representing the 8 Arctic States, decided to establish a Task Force, to develop an international instrument on Arctic marine oil pollution preparedness and response.

The Task Force which included participants from the Arctic states, Permanent Participants of the Arctic Council, observers, industry representatives and invited experts, held their first meeting in Oslo October 2011. After the Oslo meeting, the Task Force held 4 meetings. In St.Petersburg Russia in December 2011, in Girdwood, Alaska in March 2012, in Helsinki, Finland in June 2012 and the final meeting in Reykjavik, Iceland in October 2012.

The Task Force agreed in their first meeting that the goal for the negotiations should be a binding agreement between the Arctic States. The objective of the Agreement is to strengthen cooperation, coordination and mutual assistance among the Parties on oil pollution preparedness and response in the Arctic in order to protect the marine environment from pollution by oil.

This Agreement shall apply with respect to oil pollution incidents that occur in or may pose a threat to any marine area over which a State whose government is a Party to the Agreement exercises sovereignty, sovereign rights or jurisdiction, including its internal waters, territorial sea, exclusive economic zone and continental shelf, consistent with international law. In the Agreement the detailed coordinates of the area of the agreement is described.

Further the Agreement describes authorities and identifies Contact Points for Oil Pollution Preparedness and Response in each of the 8 Arctic nations, and it describes obligations regarding notification, monitoring, requests for assistance and Coordination and Cooperation in Response Operations, movement and removal of resources across Borders, reimbursement of Costs of Assistance, Joint Review of Oil Pollution Incident Response Operations, Cooperation and Exchange of Information, Joint Exercises and Training, Meetings of the Parties, Resources, Relationship with Other International Agreements and how non Parties of the Agreement can contribute to activities envisaged in the Agreement. In addition there is an important appendix named Operational Guidelines. The Operational Guidelines was developed by EPPR working group. The Agreement was signed at the Eight Meeting of the Arctic Council in Kiruna, Sweden in May 2013. The first exercise is planned in Canada in 2014.



# Winter sea ice thickness product from Envisat Radar Altimeter 2

Eero Rinne

***Finnish Meteorological Institute, Helsinki, Finland***

Sea Ice Thickness (SIT) is considered as one of the essential climate variables. Sea ice has an impact on different fluxes between ocean and atmosphere. In consequence changes in sea ice affect the climate system. In order to better understand and forecast the changing climate and validate models, observations of the sea ice thickness are needed.

One of the major outcomes of the Sea Ice Climate Change Initiative (CCI) project is an open source Radar Altimeter (RA) processor prototype to produce SIT products from RA data. The main input data for the processor are SGDR data from Envisat satellite. The output of our processor is a monthly SIT product in 100 km by 100 km grid for the winter months 2002–2012. Our processor will rely heavily on the existing RA SIT retrieval methodology developed by University College of London but will also utilise the recent results from the SICCI round robin exercise. The prototype processor will be an important step towards operational SIT processing in the phase 2 of the CCI program.

I will also present the preliminary time series of winter SIT estimates as well as some technical aspects of our sea ice thickness prototype processor.

# **Northern (Arctic) Federal University: Staffing of the shipbuilding industry of the Arctic region**

Mark Ivlev

## ***Northern (Arctic) Federal University, Arkhangelsk, Russia***

The report deals with the problem of staffing shipbuilding enterprises of the Arctic region of the Russian Federation. Defines the role of Russia as one of the leading countries in the present and the future of the Arctic, in the design, construction and maintenance of civil and military fleet, which places special demands on the level of training is able to solve related problems.

Brief information on the Northern (Arctic) Federal University (NArFU) as an educational institution that provides training for the shipbuilding industry as the Arctic region and, to a large extent, for Russia as a whole, and its core business units - the Institute of Shipbuilding and Marine Arctic technology, which is the core of the education cluster in the city of Severodvinsk.

The system of research and education cluster is an academic base of multilevel continuous training of specialists for the shipbuilding industry. The strategic goal of science education cluster NArFU is to provide a professional level of training of technical specialists for the shipbuilding industry enterprises of JSC "United Shipbuilding Corporation", capable of solving strategic problems of the shipbuilding industry in the Russian Federation.

The system of continuous education presented a number of educational programs: Pre-university training-Secondary professional education-Applied bachelor degree-Applied master program-Postgraduate study, implemented on an integrated approach to the formation of professional competencies to meet the needs of businesses for specialists of different levels (highly skilled workers, technicians, engineers, technicians and managers).

The uniformity of approaches to the development of a multi-level system of continuous training is based on its practical (applied) orientation, the system is a practice-oriented. The system is a practice-oriented training system "factory-university", combining full-time and part-time course of study. This system is a number of advantages over the traditional full-time training, which are reflected in the report. The effectiveness and the need for further development of this form of training is confirmed demand for graduates in the labor market production sector not only in the region but in the whole of the Russian Federation. The report describes the main stages of the implementation of educational technology.

The report concludes that the great potential of development and improvement realized in NArFU tiered system of education for ship-building and development of the Arctic, as well as the possibilities and prospects of international cooperation in the field of vocational education and skills development, suggesting possible areas of cooperation with foreign university partners.

# **Managers and economists' training in NArFU as an important direction in the Arctic development**

Alexey Novikov

***Northern (Arctic) Federal University, Arkhangelsk, Russia***

Economic efficiency is one of the most important problems of the Arctic exploration. For this reason it should be given the highest priority to the production companies' human resources problem, especially to managers and economists. These areas of training are regarded in the Northern (Arctic) Federal University (NArFU) as a foreground activity.

"Institute of Shipbuilding and Marine Arctic Engineering" is an institution in NArFU where specialists of different shipbuilding profiles are being trained. Department of "Economics and Management" of this institute specializes in problems of economic efficiency of shipbuilding production, where the students of "Economics and Management in mechanical engineering" profile are being taught for decades. For this time more than a thousand economists and managers came out of the walls of the university, some of which are really talented and they work effectively at the enterprises of our city, region, etc. (in particular, they are in great demand in St. Petersburg, Murmansk, abroad).

In 2013, there were two regular destinations of graduates "Economics and Management of Engineering"; it was marked a number of student graduation papers, which can be effectively applied in practice or make a scientific novelty.

Equally important activity of "Economics and Management" department is participation in training future shipbuilders in disciplines related to the organization of production, shipbuilding enterprise management, planning, personnel management. The Institute is actively involved in research activities related to the economics and management issues with shipbuilding enterprises, including those in "Joint Shipbuilding Corporation" - in the field of strategic management, production, companies' human resources improvement, innovations introduction, etc.

The great advantage of many economic developments of NArFU in the field of shipbuilding is their comprehensive nature, when the methods of management have strong support in the form of economic and institutional mechanisms for the management procedures implementation. Many of them were made just for the shipbuilding sphere, therefore they can be very useful in Russia and other countries associated with the development of the Arctic.

Also, one of the priorities of NArFU in managers and economists training is the active international cooperation development, experience exchange, teaching students and training teachers, development of joint courses, joint research projects participation in the field of economics and management with researchers in other Arctic region countries. Only joint efforts can ensure effective implementation of development programs in the region, the full use of the potential of science and practice in this area.

## Arctic search and rescue (SAR)

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### Scientific committee

Leader: Program manager Erik Dyrkoren (Convener), Maritim 21, Norway

Tor-Are Vaskinn, Fiskebåt, Norway

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# Implications of an increasing Search and Rescue requirements in the Arctic. How should the Arctic community respond?

Jennifer Austin

*Independent, Salisbury, UK*

It is generally accepted by the scientific community, based on monitoring records and climate model predictions that, due to increased greenhouse gases increasing global air and ocean temperatures, ice cover across the Arctic Ocean during the summer season has been and will continue to decrease over time.

Predictions of when an Ice-free Summer will occur vary for example 2013, 2040 . However irrespective of when, Ice Free Arctic summers occur, Arctic Shipping lanes are the current "Hot Topic" of the maritime world due to the potential savings for shipping businesses on time and fuel overheads.

Companies have been long planning to use previously inaccessible Arctic shipping routes and in August of this year, a Chinese company attempted it's maiden voyage journeying from a port in North East China through the Arctic Bearing Strait toward Rotterdam in Europe, in an attempt to successfully save 15 days travelling time.

The projected rush by shipping companies to access the Arctic will increase shipping traffic and bring, aside of the environmental implications, challenges in regards to capabilities to rapidly respond rapidly to emergencies in an extremely harsh and hostile environment .

The 'International Convention on Maritime Search and Rescue (1979)' places a responsibility on International SAR organisations to respond and rescue persons in distress . As a greater number of shipping companies increasingly access the Arctic, what implications will this increased traffic have on Arctic SAR organisations? How will geographical implications of time and distance be overcome in meeting Search and Rescue objectives?

With increasing use of Arctic Waters this requires a response from organisations responsible for governing those waters. Multipurpose ships are being built in Finland , And in Russia an icebreaking multipurpose emergency and rescue vessel for use in Arctic Seas

This study will explore environmental factors affecting 'person overboard' survival such as temperature. What is known of predicted weather patterns that a changing Arctic Environment and how these potential changes will affect frequency of incidents and SAR call outs?

This study will also look at how the Arctic community has responded so far in terms of opening up access to Arctic Shipping lanes and responding to Search and Rescue requirements. It will also assess survival technologies, do new technologies need to be created to protect casualty life at sea? Given potential lengthy times to access incident sites? Should there be a "tax" to cover the increased cost on SARs?



# Remotely piloted aircraft for offshore search and rescue

Stian Solbø<sup>1</sup>, Rune Storvold<sup>1</sup>, Trond Arthur Christensen<sup>2</sup>

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In rough seas, it is difficult to see people or objects floating in the ocean from the bridge of a ship. In extreme cases, the wave height can be of the same order of magnitude as the height of the bridge, and consequently it will then only be possible to observe the objects in the immediate vicinity. In an emergency, valuable time can be wasted by maneuvering a large ship in a search pattern, or for manning and launching a tender for search. A snapshot taken from the air merely provides instant overview over large areas and can provide valuable, time-critical information to the ship's crew at critical events such as man overboard and cleanup of oil spills.

In this paper we present a remotely piloted aircraft (RPA) developed to be deployed from a ship in emergency situations, and provide an aerial view. This is a concept that we named ASSUR (Airborne Ship Safety Using Robots). ASSUR consists of small electric airplanes equipped with infrared cameras and an autopilot that can be sent in the air immediately and controlled from the bridge of a ship or rig. These aircrafts have a multi-role capability that will solve many time-critical security challenges facing the maritime industry.

To be useful for the shipping industry, one of the main ideas behind ASSUR is to be so easy to operate that it does not require additional personnel onboard. Hence, the system is designed to be intuitive and autonomous, so that the amount of training required for the ship's crew must be kept to a minimum. Since the proposed system has the greatest usefulness in extremely bad weather, so the risk of loss of the system should be minimal, not to mention the cost of lost aircraft should be low.

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